

JEEP® ENGINES

3rd Edition

- ★ Performance Modifications
- ★ Racing Secrets
- ★ Engine Blueprinting

Many part numbers are listed in this book for reference. They may not be currently available. For part numbers with the letter P prefix, refer to the latest Mopar Performance Parts Catalog. For part numbers without the letter P prefix, contact your local Chrysler-Plymouth-Dodge-Jeep dealer.

Mopar Performance Parts Technical Assistance Hotline

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Acknowledgements

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— L. S. Shepard

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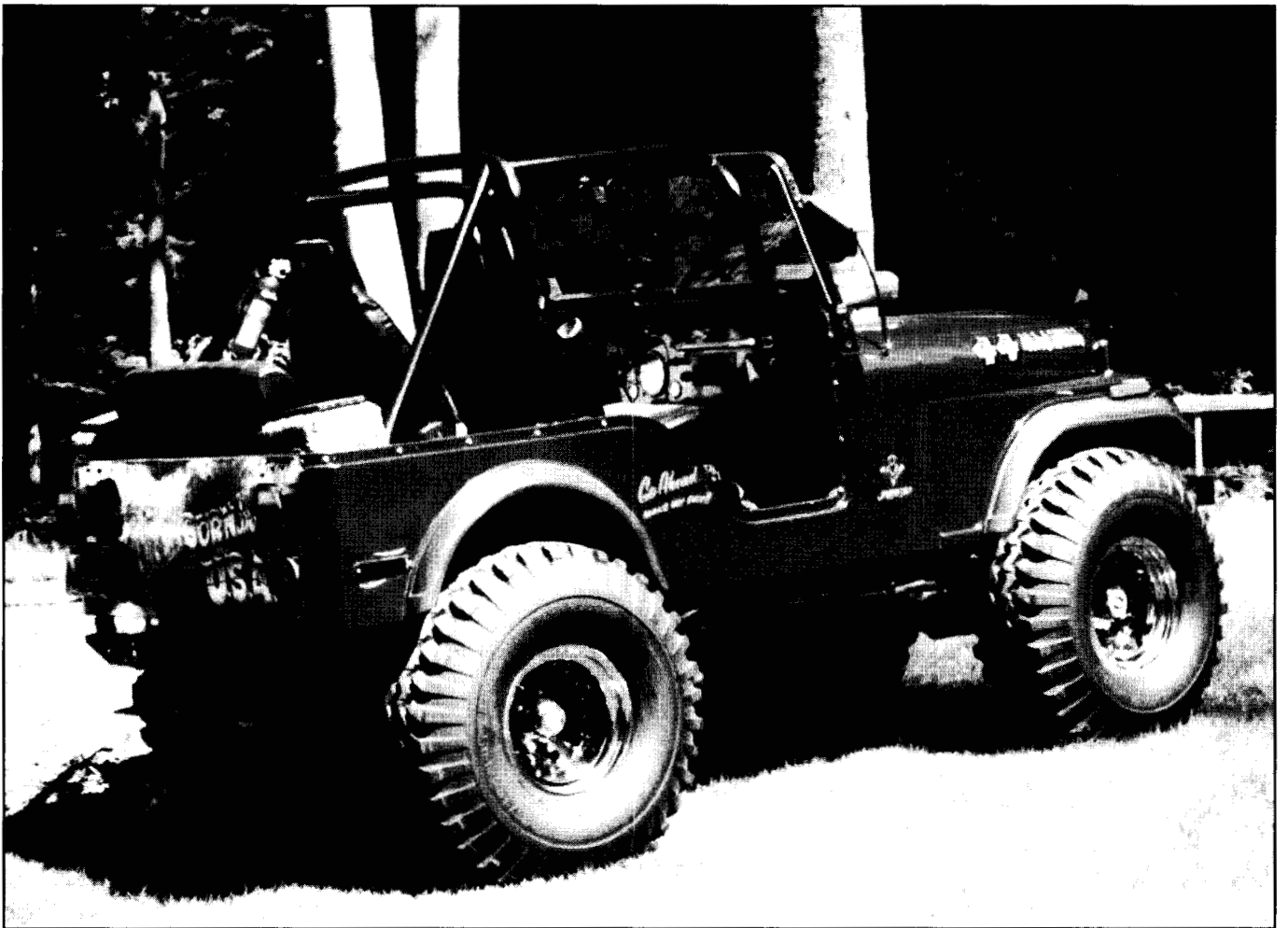
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Introduction



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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Introduction

WELCOME

Welcome to *Jeep Engines-3rd Edition*.

This performance book has been prepared as a guide for those enthusiasts who are interested in everything from mild performance gains to building highly competitive racing vehicles and is intended to compliment the service manual for your particular vehicle and/or engine. Therefore, to avoid any possible problems and/or headaches, Mopar Performance Parts highly recommends that the proper service manual for your vehicle and/or engine be obtained.

This performance book builds on the service manual information. Service manuals tell you how to take your engine apart and put it back together; *Jeep Engines-3rd Edition* tells you how to modify your engine and increase its performance. If you find that you need further assistance or have any performance and/or modification questions you would like to ask, you can contact Mopar Performance Parts Technical Assistance.

Mopar Performance Parts Technical Assistance

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Oxford, Michigan 48371-0597

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Mopar Performance Parts hopes that this book satisfies any needs and/or desires that you have pertaining to your Jeep engine. We firmly believe that the performance tips enclosed within these pages will prove to be truly invaluable to you.

OVERVIEW

The primary emphasis of this book is on the 4.0L Power Tech In-Line 6 cylinder engine, the 4.2L In-Line 6 cylinder engine, the 2.5L Power Tech In-Line 4 cylinder engine, and the 360 AMC V-8 engine. The 2.46L In-Line 4 cylinder engine is also covered, but because of the limited number of performance parts available, it is discussed only briefly. We have also included a special chapter which highlights our new all-aluminum 4.7L V-8 engine that debuted in 1999. This new engine is certain to play an important role in our future Jeep performance parts program. Magnum engines have their own book; therefore, they are not covered in this book.

Note: For complete Magnum V-10, V-8, V-6, and 4-cylinder engine information, refer to *Magnum Engines* (P4876668), as well as the appropriate service manual.

The total amount of information we possess regarding all of these Jeep engines could have easily filled a book many times the size of this one, so we had to prioritize based on what our racers and enthusiasts were requesting. If there is anything that you need to know or have questions about that is not covered in this book or your service manual (or you simply can't find the answer), call Mopar Performance Parts Technical Assistance. They will be glad to help you any way they can.

Jeep Engines-3rd Edition is divided into nine distinct chapters, as follows:

Chapter 1: Jeep History

Chapter 1 presents a brief history of Jeep, from the early 1940s through today. However, because this chapter could easily fill an entire book of its own, not every event or person involved in the Jeep program is discussed.

Because so much information has already been published regarding the history of Jeep, we chose to include lesser-known information that could only come from DaimlerChrysler. Photographs from deep within our archives highlight this history of arguably the most successful off-road vehicles ever built.

Chapter 2: 2.5L Power Tech In-Line 4

Chapter 2 is the most comprehensive and detailed discussion of the 2.5L Power Tech In-Line 4 cylinder engine ever published by DaimlerChrysler. Both race-only and dual purpose engine build-up strategies and performance modifications are covered. The information is presented along with hundreds of detailed figures, photographs, tables, and charts. When used in conjunction with the appropriate service manual, this chapter provides the most up-to-date technical information on the 2.5L engine available anywhere.

Please note that much of the information contained in Chapter 4 is generic to all Jeep performance engines. Therefore, in addition to this chapter, 2.5L engine owners should read Chapter 4 in its entirety. The appropriate service manual should also be consulted.

Chapter 3: 2.46L In-Line 4

Chapter 3 presents a summary of selected features of the 2.46L In-Line 4 cylinder engine. Due to the limited number of performance parts available, the chapter is very brief. However, much of the information contained in Chapter 2 applies directly to the 2.46L engine. In addition, much of the information contained in Chapter 4 is generic to all Jeep performance engines. Therefore, in addition to this chapter, 2.46L engine owners should read Chapters 2 and 4 in their entirety. The appropriate service manual should also be consulted.

Chapter 4: 4.0L Power Tech In-Line 6

Chapter 4 is the centerpiece of *Jeep Engines-3rd Edition*. It is the most comprehensive and detailed discussion of the 4.0L Power Tech In-Line 6 cylinder engine ever published by DaimlerChrysler. Both race-only and dual purpose engine build-up strategies and performance modifications are covered. The information is presented along with hundreds of detailed figures, photographs, tables, and charts. When used in conjunction with the appropriate service manual, this chapter provides the most up-to-date technical information on the 4.0L engine available anywhere. The authoritative source for all your 4.0L engine racing needs.

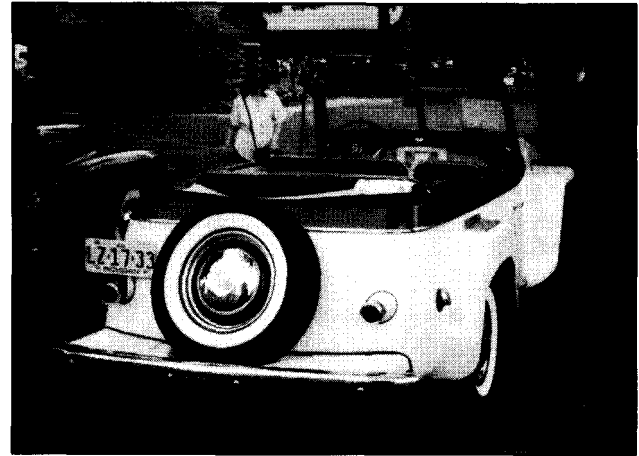
Chapter 5: 4.2L In-Line 6

Chapter 5 presents a summary of selected features of the 4.2L engine, as well as a great deal of information on our popular multi-point fuel injection conversion kit. Please note that much of the information contained in Chapter 4 applies directly to the 4.2L engine. Therefore, in addition to this chapter, 4.2L engine owners should read Chapter 4 in its entirety. The appropriate service manual should also be consulted.

Chapter 6: 4.7L Power Tech V-8

Chapter 6 highlights our new 4.7L Power Tech V-8 engine which was introduced in 1999. This technologically advanced, all-aluminum powerplant represents the future of DaimlerChrysler V-8 engine technology, and will play an important part in our future Jeep performance parts development program.

Due to the present lack of performance parts available for this brand-new engine, this chapter is brief. However, much of the information contained in Chapter 4 is generic to all Jeep performance engines. Therefore, in addition to this chapter, 4.7L V-8 engine owners should read Chapter 4 in its entirety. The appropriate service manual should also be consulted.



Chapter 7: 360 AMC V-8

Chapter 7 presents the most comprehensive and detailed discussion of the 360 AMC V-8 engine ever published by DaimlerChrysler. The information is presented along with dozens of detailed figures, photographs, tables, and charts, providing the most up-to-date technical information on the 360 AMC V-8 engine available anywhere.

Please note that much of the information contained in Chapter 4 is generic to all Jeep performance engines. Therefore, in addition to this chapter, 360 AMC V-8 engine owners should read Chapter 4 in its entirety. The appropriate service manual should also be consulted.

For additional information on small block engine performance modifications, refer to *Small Block 'A' Engines* (P4876826).

Chapter 8: Off-Roading and Racing

Chapter 8 is for everyone interested in off-roading and/or racing their Jeep-powered vehicle. It contains information on our ever-popular Jeep Jamboree and Camp Jeep events, as well as the basics of off-roading, how to get started in racing, safety, driving tips, performance engine package recommendations, and more. Chapter 8 also includes a listing of all the books and catalogs currently available through Mopar Performance Parts, along with how and where to contact various DaimlerChrysler/Mopar sources. A must read for anyone interested in off-roading or racing a Jeep-powered vehicle.

Chapter 9: Additional Information

Chapter 9 provides racing (mathematical) formulas and a Metric-to-English conversion table we thought might come in handy.

Chapter 1

Jeep History



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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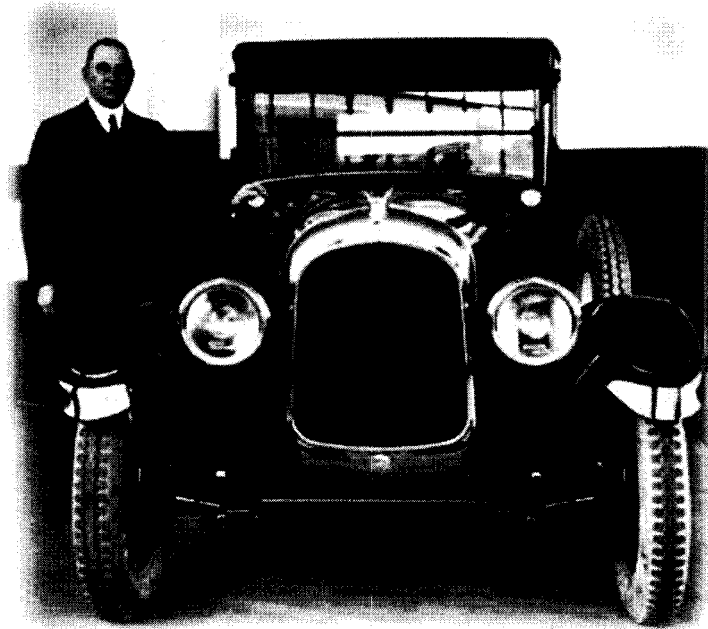
Jeep History

The Jeep has evolved from utilitarian military vehicle, to sun-and-fun off-roader, to popular boulevard cruiser. It has been produced for better than 50 years, exported worldwide and is arguably one of the most recognizable vehicles ever made. It is sought after by collectors and fans, and widely regarded as a leader in the sport/utility and off-road markets. Compact and full-size pickup trucks and SUVs have carried/now carry the Jeep nameplate, placing Jeep in many different categories in the industry. But were it not for the intervention of Walter Chrysler to aid the Willys-Overland Company, and events relating to the Second World War, the Jeep may never have existed.

Willys-Overland

In 1929, John North Willys sold his interest in the Toledo, Ohio-based Willys-Overland Company to become U.S. Ambassador to Poland. He returned to Willys-Overland the next year as active head of the company. Unfortunately, his company was now facing the same financial hardship that had befallen many other companies following the 1929 Stock Market Crash.

By 1933, the Willys-Overland Company was in serious financial trouble and might have shut down operations were it not for the generosity of John North Willys' good friend, Walter P. Chrysler. Chrysler allowed Willys to use the Chrysler-created "floating power" principles for engine balance.



Walter P. Chrysler (pictured here with his original 1924 Chrysler Six)

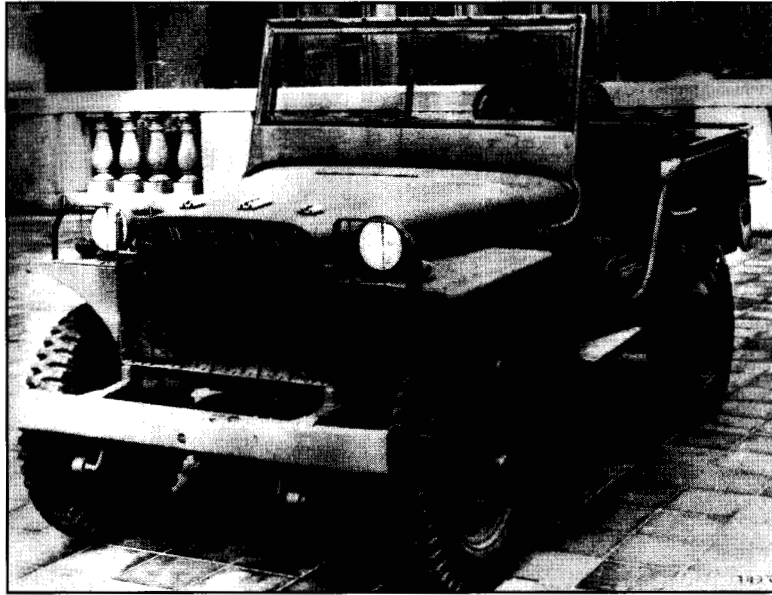
"Floating power" had first appeared in late 1932 on the 1933 Plymouth Series PA, but had originally been developed by Chrysler engineers during the first few years of the company's existence. Floating power reduced noise and vibration by adding a third main bearing to the crankshaft. A floating platform spring supported the front of the engine while rubber pads

and bushings helped to absorb shock and eliminate the metal-on-metal contact at the rear. This innovation was one of the earliest uses of rubber to reduce engine vibration, and allowed a four or six cylinder engine to maintain operating smoothness comparable to an eight cylinder engine.

Chrysler patented the floating power principle, but allowed Willys-Overland to use the system in the 1933-36 Willys 77. This was a small, four cylinder economy car whose sales helped to keep Willys-Overland in business, as they had gone into receivership in 1933. John North Willys died shortly after the production of the Willys 77 in 1937, at the age of 64.

Birth of the "Quad"

Dating back to World War I, the U.S. Army had been looking for a fast, lightweight all-terrain reconnaissance vehicle. The horse cavalry and sidecar motorcycles used before were now antiquated. In addition, the Axis powers were beginning to score victories in Europe and Northern Africa. The Army now needed rapid development of this vehicle. In the summer of 1940, automobile manufacturers were called upon to produce a running prototype for such a vehicle in just 49 days, and 70 production vehicles in 75 days.



Willys-Overland MA (Prototype)

Additionally, the Army had very tight specifications for their vehicle:

Cooling System: Able to allow a sustained low speed without overheating the engine

Weight: Approximately 1,300 lbs.

Four-wheel-drive

Engine (power): 85 lb-ft of torque

Wheelbase: Not more than 80"

Tread: Not more than 47"

Ground Clearance: Minimum of 6.25"

Payload: 600 lbs.

Manufacturers scrambled to put together mock-ups in effort to secure the contract. Many different vehicles were submitted for approval ranging from a rolling platform to heavily armored trucks. Due to the constrictive 49-day development deadline, many manufacturers were eliminated. Ultimately, only Willys-Overland, the Bantam Car Company, and to an extent Ford Motor Company were involved in the project.

The Bantam Car Company had worked to supply reconnaissance vehicles to the Army in the past and felt able to meet the deadline (Willys-Overland requested additional time for completion). With the help of engineer Karl Probst, Bantam developed a prototype which would later evolve into the Jeep. The Army forwarded plans for the Bantam prototype to Willys-Overland and Ford, who submitted their own prototypes based on the Bantam design. Willys-Overland's vehicle, the "Quad," came in over the weight limits (at 2,400 pounds), due in large part to its more powerful engine, the "GoDevil." The Go Devil had been tried and tested in the Willys American, and its torque rating of 105 eclipsed that of the Bantam and Ford engines at 83 and 85 respectively.

With all three prototypes in hand, the Army ordered 1,500 vehicles from each of the manufacturers to be field tested. Probably due to their pleasure with the power of the Go Devil, the Army raised the weight requirement to 2,160 pounds. This meant the Quad still needed to shed weight.

Knowing that the engine, as heavy as it was, was the strength of the Quad, Willys-Overland decided to keep the same engine under the hood and trim the weight elsewhere. The Quad was completely disassembled, part by part, and evaluated for possible use of lighter materials. Bolts were shortened, material was trimmed, and the final product came in 7 oz. under the weight limit.

Delivery of the first 4,500 vehicles (1,500 each from Willys-Overland, Bantam and Ford) came in June, 1941. After careful study and testing, the Army decided to standardize one basic design. Based on its lower bid and Bantam's shaky financial and manufacturing position, the Army awarded an all-or-nothing contract to Willys-Overland to produce 16,000 vehicles at the rate of 125 per day. Securing the contract allowed continued business operation for Willys-Overland.

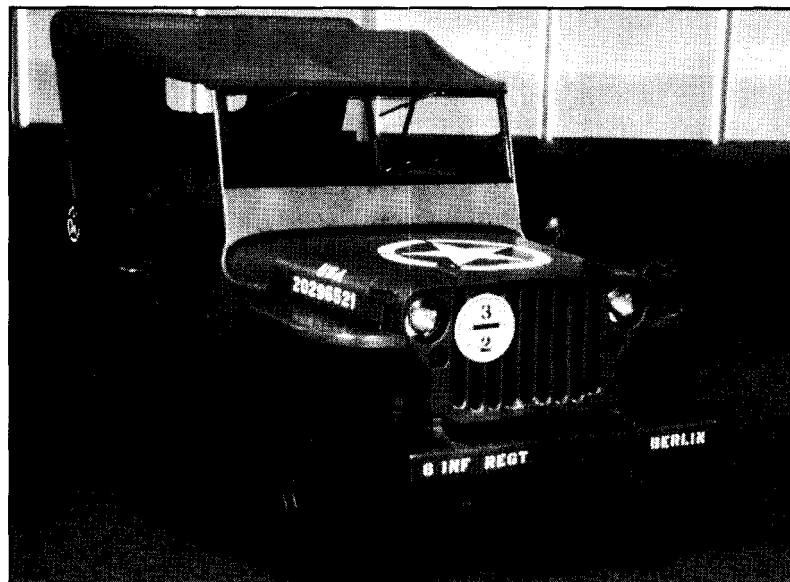
As the war grew in intensity, the demand for the Quad also grew. Willys-Overland was ordered to turn over designs to Ford so they could produce 15,000 of the same vehicle. During World War II, Willys-Overland and Ford produced more than 600,000 Jeep vehicles, with Willys-Overland accounting for 330,000 units.

A Jeep By Any Other Name...

Sometime after Willys-Overland began production of this all-purpose military vehicle, the name Jeep came on board. At first, the vehicle was designated the MA, and later in 1941 the MB. The name Jeep became synonymous with it at that time and soon became a household word. Although no one really knows the name's true origin for certain, everyone has a favorite theory.

Some say the Jeep name came from the slurring of the acronym G.P. which was a Ford engineering term, "G" for a government contract vehicle, "P" for 80-inch wheelbase reconnaissance car. Another explanation is that the name was used in Oklahoma as early as 1934 to designate a truck equipped with special equipment for drilling oil wells. Others claim the vehicle was called a Jeep in reference to the character "Eugene the Jeep" in the 1936 Popeye comic strip by E.C. Edgar. Eugene the Jeep was a small, impish looking animal that had the power to travel back and forth between dimensions and could solve all sorts of problems. Yet another version is that Irving "Red" Haussman, a Willys-Overland test driver who tested the first pilot model picked up the Jeep name that some soldiers at Camp Holabird had been using. Shortly thereafter, Red gave a demonstration ride to a group of dignitaries in Washington, D.C. Among the group was Katherine Hillyer, a reporter for the *Washington Daily News* who wrote an article about the vehicle that was published in February, 1941 with the photo caption headline, "Jeep Creeps Up Capitol Steps." This was perhaps the first reference to the vehicles' Jeep name by the media. In 1950, Willys-Overland obtained a U.S. Trademark Registration for the Jeep trademark. There are currently over 1,100 registrations for the Jeep® trademark throughout the world.

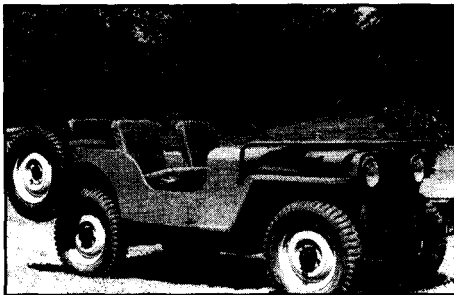
From their inception, Jeep vehicles have captured the attention and admiration of people everywhere. They served their country in the war in Europe and the Pacific, helping to defeat the Axis powers and bring peace to the world. The strength and durability of the Jeep was soon realized. War correspondent Ernie Pyle characterized the Jeep vehicle in this way. "I don't think we could continue...without the Jeep. It's as faithful as a dog, as strong as a mule and agile as a goat. It constantly carries twice what it was designed for and still keeps going." Jeep vehicles were used by every division of the U.S. military, and large numbers were also shipped to the Allied Forces of Canada, Britain, Australia and New Zealand. Jeep vehicles became a vital part of all action on land. They were used to lay telephone communications, to transport the wounded, and as taxis to carry battle commanders, generals, prime ministers and presidents. They were crated and freighted, broken down and built-up, modified, converted and moved about by sea, rail, road and air. Transport crews could load a complete Jeep vehicle into a C-47 cargo plane to be easily and rapidly deployed on the front lines where they were needed most.



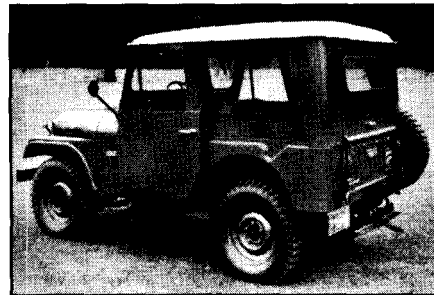
Willys-Overland MB



Jeep in action



1946 Jeep CJ-2A (Prototype)



1953 Jeep CJ-3B

Civilian Life

As early as 1942, long before the war in Europe or the Pacific came to an end, Willys-Overland recognized that the popular Jeep vehicles could serve the civilian market as well. The phrase “the Jeep in Civvies” often appeared in Willys-Overland magazine and newspaper ads published on the homefront during and just after World War II. Other ads touted the heroic exploits of the Jeep vehicles in the war, declaring “the power and the stamina of the versatile Jeep will serve many needs in the years of reconstruction ahead.” Willys-Overland began to promote the versatility of the Jeep vehicle as a delivery, work and recreational vehicle with quotes like “When I get back I’ll get a Jeep. It’ll make a swell delivery car,” “A Jeep can beat a team of horses all hollow,” and “Gee, wouldn’t it be swell to have a Jeep at the lake after the war? Are you Jeep planning too?” The first civilian Jeep (CJ) vehicle, the CJ-2A, was produced in 1945. Advertisements proclaimed it to be “A Powerhouse on Wheels,” again selling it as a work vehicle for farmers and construction workers. The CJ-2A came with a tailgate, side-mounted spare, larger headlamps, an external fuel cap, chrome trim, and many more items that its military predecessors did not include. Intended primarily as a work vehicle, it maintained a spartan profile including round military-type gauges and instrumentation.

The postwar U.S. economy and industries afforded many opportunities for the Jeep. It was capable of hauling workers and materials to remote worksites, through desert gullies, even knee-high water, further proving the Willys-Overland design. Farmers and ranchers found a multitude of agricultural uses for the small, powerful 4x4. The rugged design of the CJ-2A was obvious. It had a durable engine with good low-end torque, a rear axle designed for much larger trucks, and a transmission and transfer case sufficient to pull heavy loads through varying terrain.

Perhaps one of the most common and recognizable uses for the Jeep was U.S. mail delivery. Postal officials, impressed by the performance of Jeeps during the war, decided to harness that strength for mail delivery. These strong, agile vehicles could stand up to the rigors of delivering the mail in any weather and on any road. The postal service purchased both left and right-hand drive Jeeps for their carriers. Unlike previous postal vehicles, which were painted a drab shade of olive green, Jeeps and other vehicles purchased in the 1950s were painted red, white, and blue. The Postal/Dispatch Jeep was made in two basic models, the DJ-3A and the DJ-5. The DJ-3A was a flat fender Jeep similar to the CJ model except it was two-wheel-drive and had a side sliding door for ease of loading/unloading. It was produced from 1956 until 1965 (manufactured by Kaiser-Jeep who purchased Willys-Overland in 1953). The DJ-5 was introduced in 1965 which is the postal Jeep most people are familiar with today. Also produced from 1965-1968 was a long version, the DJ-6. The DJ-5 was made by Jeep into the early 1970s and production continued under AM General (AMC purchased Kaiser-Jeep in 1970). For over 40 years Postal workers have delivered mail through "rain, sleet and snow" with the aid of their trusty Jeep.

The Great Outdoors

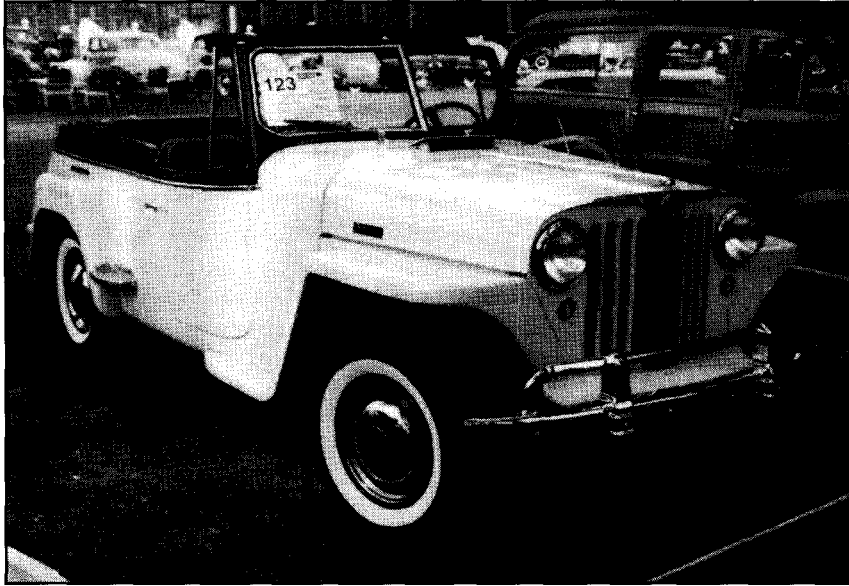
Among the public attracted to Jeep 4x4s were a growing number of outdoor enthusiasts. Already proven capable of handling the outdoors, the CJ-2A and surplus MBs brought primitive back country fishing, hunting, rock collecting and exploring easily within reach. They gave families access to remote camping and numerous other outdoor activities. There was a zest for life in postwar America contrasting the lean Depression and World War II years. This created a greater interest in recreation. Additionally, fuel costs were low, and the cost of living was relatively inexpensive. The Jeep provided a means for those weekend getaways.

The recreation aspect caught on quickly and has flourished. Today, there are many organizations which host activities and events for Jeep owners, fans, and aficionados. The Camp Jeep and Jeep Jamboree groups for example, set up off-roading events, car shows, picnics, clinics, etc., to bring together Jeep lovers worldwide. These events are wildly popular and attended religiously by some owners.

But Jeep's growing popularity was not limited to the U.S. The popular 4x4 was sought by many worldwide no doubt due to its high visibility in wartime activities. It maintains a healthy worldwide appeal today, and there exist many clubs, societies, and groups dedicated to ownership, history, racing, etc., of the Jeep.



Getting away!



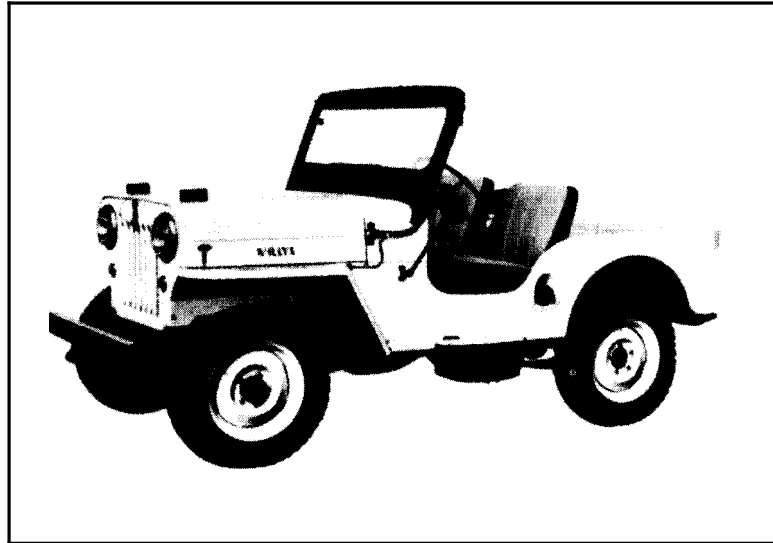
1948-51 Willys-Overland Jeepster

Beyond the Quad

In 1946, Willys-Overland introduced the auto industry's first all-steel station wagon and sedan delivery vehicles. These two-wheel-drive vehicles featured seven-passenger capacity and reached a top speed of 65 mph. When four-wheel-drive and a Willys six cylinder engine were added in 1949, the Jeep All-Steel Station Wagon truly became the forerunner of the modern-day Jeep Cherokee. The new Jeep station wagon had pressed-steel framing and three-tone paintwork which simulated the natural wood look. It used the Jeep running gear and MB-style front sheet metal and was designed to compete against the "real" wood wagons still being manufactured by Detroit's Big Three. The new vehicle chassis was also available in a sedan delivery truck. Four-wheel-drive would become available in these models in 1949 along with the 148 cubic-inch "Lightning" six cylinder engine.

From 1948-1951, Willys-Overland produced probably its most stylish vehicle to that point – the Jeepster VJ-2 and VJ-3. A two door, two-wheel-drive, low-slung convertible, the Jeepster was unique in styling to other American vehicles of the time. Unfortunately, the Jeepster was also underpowered with a four cylinder engine, and less desirable to the public without four-wheel-drive. It posted only modest sales and was never able to find a market niche. Popular opinion holds that if a larger six cylinder engine had been offered, the Jeepster may well have survived longer. Interestingly enough, a similar version was released during the sixties under Kaiser ownership, and enjoyed good success.

The CJ model was updated in 1953, becoming the CJ-3B. It was the first Jeep CJ with noticeable body changes from its military predecessor. It had a taller body grille and hood to accommodate the new Hurricane F-Head four cylinder engine. Although it had the same displacement as the original "Go Devil" engine, the "Hurricane" featured a revised valve train. It first appeared in the 1951 M38A1 military model. The CJ-3B remained in production until 1968, and a total of 155,494 were manufactured in the U.S.



1953 Jeep CJ-3B

Kaiser-Jeep

In April, 1951, Willys-Overland was sold to the Henry J. Kaiser interests for \$60 million. The name was changed to Willys Motors. This would be the beginning of Kaiser's influence on the future of 4WD sport utility as the company began extensive research and development that would seek to broaden Jeep product appeal in this area.

Kaiser introduced the 1955 CJ-5 whose production and popularity would reach all the way into the 1980s. It was slightly longer and wider than the Jeep CJ-3B, as it had an increased wheelbase. Constant improvements in power plants, axles, transmissions and seating comfort made the Jeep CJ-5 the ideal vehicle for the public's increasing interest in off-road activities. Although very similar to the **CJ-2A** that it replaced, it featured softer styling lines, including rounded body contours.

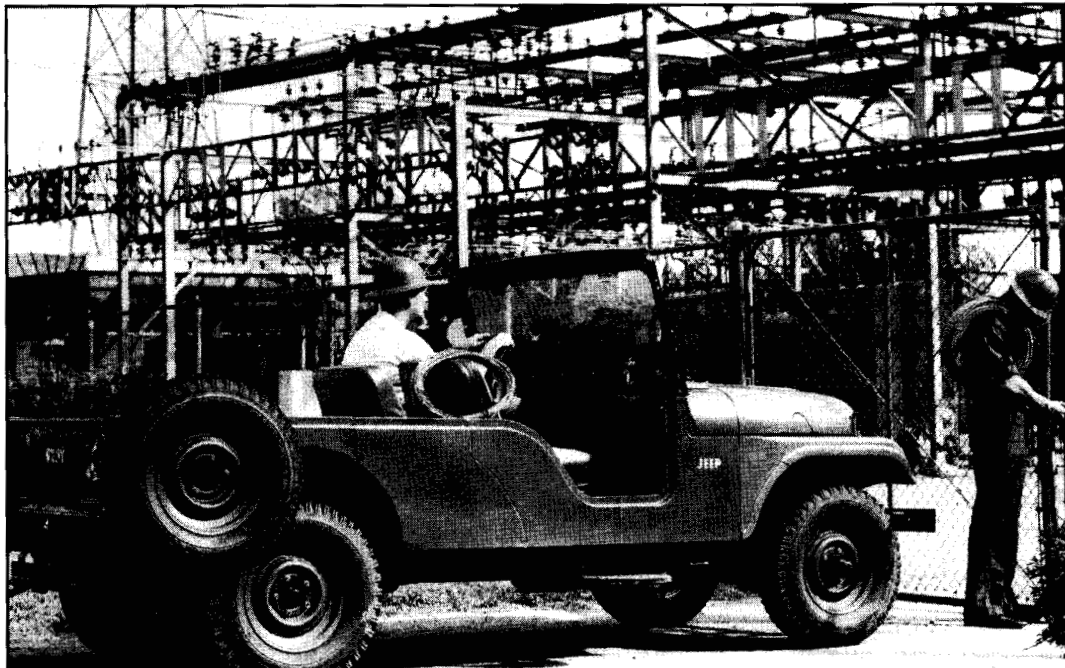
Model year 1956 saw the introduction of the CJ-6 work truck. Though there were many fans of the CJ-5, it was limited by its 81 inch wheelbase. The CJ-6 maintained the CJ-5 powertrain (F-head 134), but had a wheelbase which was a full 20 inches longer, and sheetmetal inserts ahead of the rear wheel openings. This made it even more attractive as a work vehicle. Kaiser continued to produce both models mirroring powertrain changes and upgrades.

For 1957, Kaiser released two cab-forward control models, the FC150, and the FC170. Styling was similar between the two, but the 170 was slightly larger with a longer wheelbase. It also featured a six cylinder engine. The 150 received the F-head 134 four cylinder. The powertrains were spun off from earlier Jeep models, but styling was unique and was aimed at the utility market. Unfortunately, both models yielded only modest customer interest and were soon discontinued.

Throughout the fifties production continued on the "Hurricane" engine which was then the most economical and powerful engine in its class. This was the standard engine on the wagon with the "Lightning," the optional V-6.

Also during this time, Kaiser expanded the production Jeep CJ into a truly international symbol. In the 16 years of Kaiser ownership, manufacturing facilities were established in some 30 foreign countries, and Jeep vehicles were marketed in more than 150 countries around the world.

By March 1963, Kaiser saw fit to change the company name to Kaiser-Jeep. For that same model year Kaiser-Jeep released its first full-sized vehicles.



1956 Jeep CJ-6



1949 Jeep All-Steel Station Wagon

Birth of the Sport Utility Vehicle

In anticipation of burgeoning growth in the crossover four-wheel-drive truck market, Kaiser-Jeep made bold advances in this area. Targeting rural and suburban markets, they introduced the full size Gladiator J-trucks and Wagoneers. These models were built to the wheelbase specifications of other U.S. truck manufacturers. This was a major departure from the lighter, smaller vehicles produced under Willys-Overland and Willys Motors.

The Wagoneer, powered by the first modern, mass-produced, overhead-cam six cylinder truck engine (known as the “Tornado-OHC” six), could also be had with an industry-first automatic transmission on a four-wheel-drive vehicle and independent front suspension. A larger V-8 engine produced by American Motors Corporation (AMC) was also available by 1965. The Wagoneer was offered in two and four-wheel-drive versions. This vehicle was bigger than the station wagon and the first of what could properly be called a sport-utility vehicle. The second-generation Wagoneer also included a Super Wagoneer Station Wagon that featured three-tone body striping, vinyl roof, chrome roof rack, full wheel hubcaps and white-walled tires. It came with four-wheel-drive and power supplied from a 327 cubic inch V-8 engine, and, said Kaiser-Jeep, “constituted a unique and dramatic approach to the station wagon market...designed for the prestige buyer who is rapidly becoming aware of the advantages of four-wheel-drive. While being the ultimate in detailed elegance, the new vehicle still has all the traditional versatility and ability of Jeep vehicles to go on or off-road.”

This, along with the J-series “Gladiator” pickup, was the first fresh non-military design from the company since the all-steel station wagon and sporty two-wheel-drive Jeepster. Both the Wagoneer and the Gladiator found a huge market with construction, agricultural and military buyers, and evolved into a niche with everyday retail buyers who wanted a good looking all-terrain vehicle for fishing, skiing, hunting, hauling and off-highway adventuring.

Ford, Chevrolet, and Dodge lagged far behind Jeep in this market, unable to offer any direct competition until the late sixties. At the time, they only offered cumbersome work-oriented **4x4** pickups, and Chevrolet’s bland Suburban. Kaiser-Jeep had advanced in all areas of design with the Wagoneer and Gladiator. Power accessory options never seen on a “truck” were now available, as well as luxury appointments and a high style factor.

In the fall of 1965, the new “Dauntless” V-6 engine was introduced as an option on both the 81-inch wheelbase CJ-5 and 101-inch wheelbase CJ-6. The 155 horsepower engine almost doubled the output of the standard Hurricane four cylinder engine. It was the first time a Jeep CJ could be equipped with a V-6, but would be only the beginning of available six cylinder engines that would come in the years to follow.



1972 Jeep Commando



1989 Jeep Grand Wagoneer Limited

For 1967, the Jeepster was reintroduced, and (as mentioned earlier) enjoyed much success. The timing was right for a small sport-utility vehicle, as other manufacturers were shifting focus to this new market. The Jeepster was built on the CJ-6 wheelbase and offered four-wheel-drive and the Dauntless V-6 (rated at an impressive 160 hp).

The original Jeep had always enjoyed little or no direct competition until International produced the first Scout model, and Ford produced its Bronco in the mid-sixties. Both of these models however were considerably more expensive, so Jeep sales were not severely impacted.

Similarly, the Wagoneer and Gladiator models were alone in their niche market until GM produced upscale versions of the Suburban, Blazer and Jimmy models in 1969. Chrysler would produce the Ramcharger and Trailduster, but not until 1974.

American Motors Corporation (AMC)

In 1970, after two decades of growth and international expansion, Kaiser-Jeep was bought by AMC. Recognizing the value of the Jeep trademark, AMC created a division for it—the Jeep Corporation. They also split civilian and military vehicle production, proving to be a wise decision as four-wheel-drive vehicles became more popular than ever in the civilian market. By 1978, total Jeep vehicle production was up to 600 vehicles a day, over three times what it had been at the start of the decade.

AMC's connection to Jeep dates back to 1965 when they produced engines for Kaiser-Jeep (the 327 cubic inch V-8 and the 232 cubic inch in-line six). They would go on to eliminate the Dauntless V-6 and previously available GM 350 cubic inch V-8 from their lineup. In their place would come a 258 cubic inch (4.2L) in-line 6, and 304 and 360 cubic inch V-8s.

Through 1971, AMC/Jeep models remained largely unchanged from Kaiser designs. However, AMC engineering changes appeared on 1972 models as shifts in engine technology and styling changes were implemented to meet marketing goals.

AMC chose to market the CJ and Commando (Jeepster) vehicles from a strength and durability angle using tag lines such as “with the guts to come on stronger than ever,” and “if a new Jeep vehicle can't take you there, maybe you ought to think twice about going.” All Jeep CJs came equipped with AMC-built engines, and all were available with 304 or 360 cubic inch V-8 engines. More stringent emissions standards in 1972, along with the availability of high torque in-line six engines, ended production of the F-head 134. AMC also equipped both the CJ-5 and CJ-6 with heavier axles, brawnier brakes, a wider track, and higher-capacity heater/defrosters. Of particular interest was the CJ-5 “Renegade” package. It boasted a standard 304 cubic inch V-8, rollbar, full gauges, and identification trim. It also came with its own tag line – “Jeep—The toughest four-letter word on wheels.”

The Wagoneer continued to endure competition from Ford and GM and maintain a sizeable hold on the sport-utility market. Trim and accessory options were on par with **luxury** automobiles, and the Wagoneer's reputation garnered many repeat buyers. In 1972, the Wagoneer was outfitted with the largest standard engine in the 4WD station wagon field – a 258 cubic-inch, AMC-built OHV 6-cylinder. In 1974, the Cherokee became the two-door version of the Wagoneer, and there was also the larger Custom Wagoneer. A four-door model of the Cherokee would be available by 1977. Also introduced to the Wagoneer line during the 1970s was Quadra-Trac®, an automatic full-time 4WD system. This was another industry first.

In 1976, 35 years after the production of the original Jeep, AMC introduced the seventh generation of the civilian Jeep, the CJ-7. For the first time, the CJ-7 offered an optional molded plastic top and steel doors and came standard with a fully boxed frame to bolster chassis strength.

The full size J-trucks progressed during this time as well to stay competitive with the Big Three. The 401 cubic inch V-8 was offered in 1976. Prior to that engine availability ranged from the 232 cubic inch in-line six up to the 360 cubic inch V-8. The big 401 was healthy on torque and horsepower and easily kept pace with the other manufacturer's offerings of the time.

By the mid-seventies, the family of big V-8s was available across the entire Jeep line. Two and four barrel carburetor options were also available, giving the customer a choice based on application or desire. However this availability, would be short-lived. Toward the late-seventies, emissions regulations became considerably stricter, rendering large displacement engines impractical to produce. The 401 was discontinued, and heavy duty/towing applications had to be reconfigured with 360 cubic engines. In addition to this, taller rear axle ratios were used to meet EPA/CAFE standards. Subsequently, full size truck performance diminished across the board with all manufacturers.

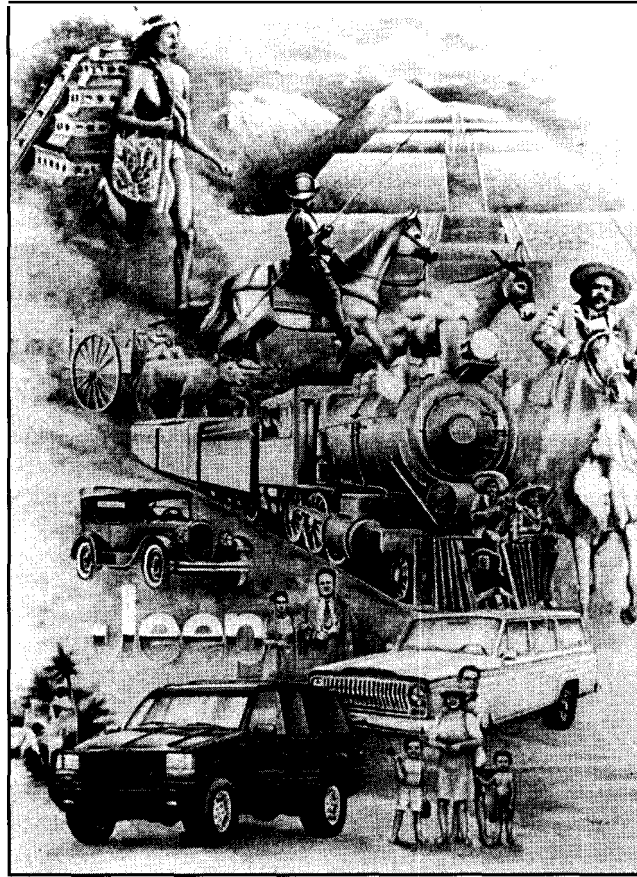
During this time, AMC released the CJ-8 Scrambler for the 1981 model year. It was a small pickup truck based on the CJ-7, and would compete against the new compact pickups being produced by GM and various foreign automakers.

Full-size trucks and sport-utilities were not the only victims of the new emissions regulations. In 1982, AMC was forced to drop the 304 cubic inch V-8 option for CJ models as they were not able to achieve acceptable performance levels under the new regulations.

With all the new restrictions in place, light truck engineering was heavily impacted. Across the board, manufacturers had to utilize weight-saving body panels, lighter powertrain components and taller rear axle ratios. This resulted in lowered engine performance and durability. The lighter parts met the restrictions, but did not last in service. The "rough, powerful" image of the American truck suffered damage, and the late-seventies/early eighties proved to be an awkward time for U.S. truck makers.



1988 Jeep Cherokee Limited



Beyond the weight-saving measures, and low-performance engines/gearing CJ models suffered further. The CJ-5, noted for its off-road prowess and tight maneuverability, came under media scrutiny during the 1983 model year. Initially designed for all-terrain use, the CJ-5 had a high overall ground clearance and center of gravity. Additionally, its short wheelbase offered a good tight turning radius—all considered desirable in an off-road situation. During a period of impassioned consumer advocacy and public resentment toward American automobiles and manufacturers, the CJ-5 was attacked for alleged rollover vulnerability. While the allegations were never reasonably proven, AMC chose not to become involved in a large-scale, high-visibility legal battle over the issue. Instead, they opted to discontinue the CJ-5, and continue production of the longer wheelbase, lower center of gravity CJ-7 and CJ-8 models.

1984 Cherokee Redefines the SUV

A market research program undertaken by American Motors Corporation culminated in the birth of the modern Cherokee. Their research found that future markets lay in compact sport-utility vehicles. AMC then invested \$250 million into the design and production of the new compact Cherokee and Wagoneer sport wagons for the 1984 model year. They were introduced to the press in late 1983 and immediately received rave reviews. Additionally, despite the backlash directed toward the now-discontinued CJ-5, the new Cherokee exceeded all sales and marketing expectations. In retrospect, AMC's decision to abandon the CJ-5 proved wise. Further controversy would likely have detracted from the new Cherokee. Instead, despite the impassioned pleas of hard-core back country four wheelers who protested the CJ-5's passing, hordes of recently converted four wheelers rushed to buy the new compact wagon.

The new Cherokee was a unique and revolutionary vehicle. It measured in 21 inches shorter, 6 inches narrower, 4 inches lower and weighed 1,000 pounds less than the Jeep Wagoneer (SJ) first introduced in 1962. It was the only compact sport utility to offer two-door and four-door models at that time. It was built as a uniframe body rather than using a traditional chassis and frame construction. Different four-wheel-drive systems, including Command-Trac and Selec-Trac®, offered either part-time or full-time four-wheel traction. Various interior and exterior styling, comfort and off-road performance packages were also offered. The model line continued largely unchanged into the 1990s, although many revisions and improvements were made during that time.

Interior appointments were on par with the new competition (GM's S Blazer and Ford's Bronco II). The Cherokee was ultimately named "4x4 of the Year" by three magazines in 1984.

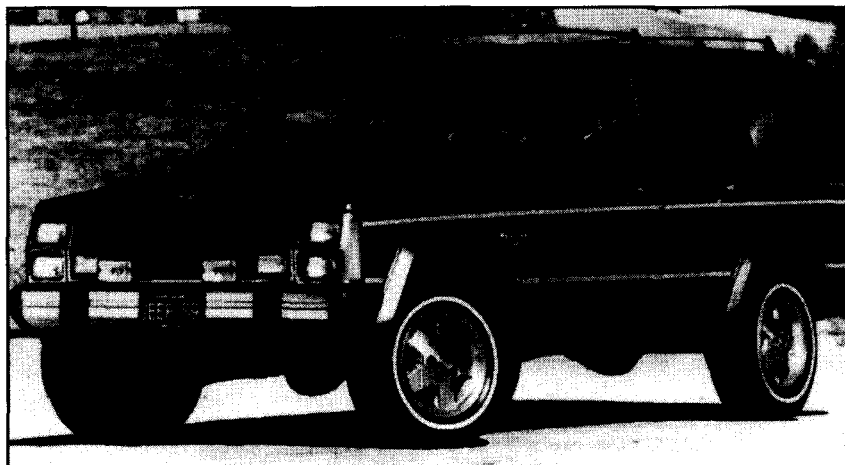
Consumers immediately liked the new package, especially the four doors. American tastes and purchasing trends had changed and were now geared toward a more practical vehicle. The awkward rear seat entry was a complaint of the two door utility models for some time. With four doors, the Cherokee allowed for easier access, and supplanted many family station wagons. Four-wheel-drive was also popular for its perceived added safety and ability to better navigate poor roads and winter conditions.

The Cherokee's standard powerplant was the 150 cubic inch in-line four cylinder. This engine had been used previously in CJ models. Given the Cherokee's relatively light curb weight of around 3,000 pounds, this engine offered decent performance. The optional 2.8L V-6 engine offered modest horsepower gains, but with a negative trade-off.

The V-6 was plagued with a marginal performance carburetor and a poorly designed rear main seal that was prone to leaks. Worse than the leak, the cure for the main seal involved engine removal and block machining to properly seat the upgraded seal. Even with these setbacks, Cherokee sales were still high, and it became AMC's premier model. Recognizing the need for better performance and to stay on par with the competition's growing powerplants, a 4.0L in-line six cylinder engine was made available for the 1987 Cherokee.

A direct descendant of the carbureted 4.2L in-line six introduced in 1971, the new 4.0L engine offered multi-point fuel injection and produced a healthy 177 horsepower. AMC also offered this powerplant in their new for 1987 Comanche pickup. Based on the Cherokee, it was built on the same platform. The powerful six cylinder proved to be both an engineering and marketing success for AMC. Sales increased and AMC claimed a majority market share from GM and Ford.

The Cherokee and Comanche had also gained wide popularity in racing circles. As part of Jeep Motorsports, the two vehicles (and to a limited extent the CJ models) participated in both on and off-road racing events. Jeep vehicles were posting wins in thousand mile long desert Baja-type competitions, as well as 24-hour endurance challenges. Of course, it might be expected for Jeep to have a good showing in these events because of their inherent off-road design, but they performed well on street courses as well.



1989 Jeep Wagoneer Limited

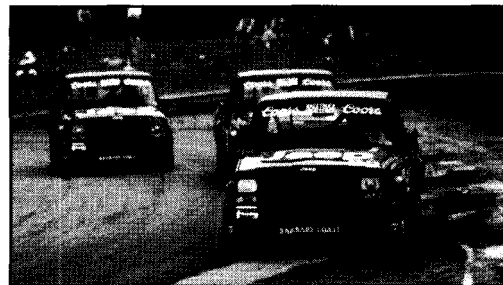
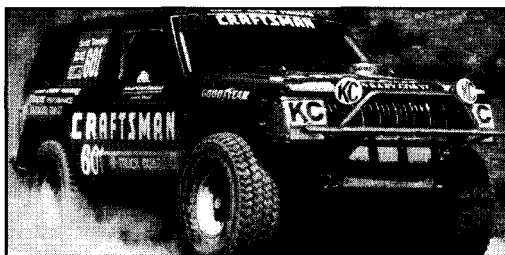


1987 Jeep Wrangler

Enter The Wrangler

The 1987 model year also saw the redesign of the CJ model. While the growing market for compact 4WD vehicles still sought the utilitarian virtues of the Jeep CJ series, consumers also were seeking more of the “creature features” associated with the typical passenger car. AMC responded to this market demand by discontinuing the CJ series and by introducing the 1987 Jeep Wrangler (YJ). The Wrangler had nearly the same wheelbase of the CJ-7 and shared its familiar open-body profile. Similarities to the CJ ended there, as the Wrangler contained few common parts with its famous predecessor. In fact, mechanically, the Wrangler had more in common with the Cherokee (XJ) than the CJ. Due to the CJ-5 controversy, the Wrangler was given a wider stance and a lower center of gravity. This caused low ground clearance and inhibited trail use to a degree, but did not seriously impact sales.

With the Wrangler, AMC was able to improve the comfort, ride quality and appearance while preserving the durability and unrivaled off-road prowess of the Jeep CJ model. It now appealed to an entirely new buyer. Relying on the CJ heritage and off-road image, the new Wrangler was still a back country rover, but now also an urban sportster. A typical Wrangler, while still off-road capable, spent more time on the highway and in the city. It could serve all transportation needs, and found a new niche with active youthful customers. Like the Cherokee, Wrangler had a long list of options offering more than the austere stark style of the earlier CJs. Its upscale interior, solid doors, full instrumentation, and full power options reflected the tastes of the modern Jeep buyer.



Chrysler Corporation Buys AMC

While the 1987 model year saw changes in AMC's vehicle lineup, the 1987 calendar year saw greater changes at the corporate level. Jeep trucks were the success story at AMC. Despite awkward mergers and partnerships with foreign automakers, the Jeep division provided great profit and worldwide recognition. On August 5, 1987, a little more than a year after the introduction of the Wrangler, American Motors Corporation was sold to Chrysler Corporation and the popular Jeep brand became a part of the Jeep/Eagle Division of Chrysler. Jeep vehicles now benefited from a worldwide dealer network and support, as well as a highly advanced parts network (Mopar).

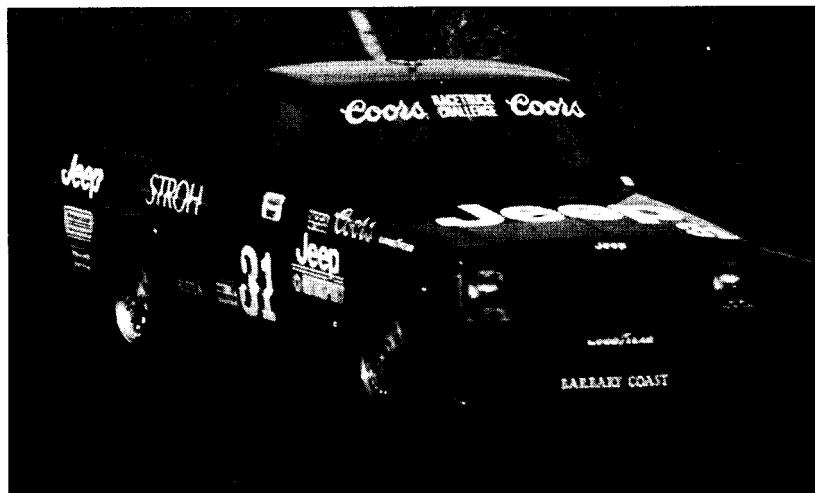
Ironically, if Walter P. Chrysler had not allowed John North Willys the use of floating power to build his *Willys 77*, Willys-Overland probably would have folded and AMC would not have had Jeep to buy in 1970. Without Jeep, perhaps there would have been no incentive for Chrysler Corporation to purchase AMC.

The Jeep models underwent minor changes and revisions under Chrysler in the late eighties and early nineties. The Wrangler benefited from the large 4.0L in-line six as an option, giving it one of the most powerful engines in its class. New interior and exterior trim levels were offered. As a result, Jeep sales remained steady under the new ownership.

In the early nineties Jeep engineers developed a right-hand drive version of the Cherokee. This produced a model that made it possible to sell to domestic mail fleets and to export markets in Britain, Australia and Japan. Jeep engineers had one more model to add to this winning new range: the Grand Wagoneer Limited. It was introduced as the ultimate luxury performance model, powered by an electronically fuel-injected 360 cubic inch V-8 engine. But with the introduction of the 1993 Grand Cherokee, the Grand Wagoneer Limited was discontinued.



1988 Jeep Comanche



Loosely based on the modern Cherokee (XJ), the Grand Cherokee was slightly larger, with a more rugged appearance. A practical four-door model, it offered varying trim levels, powertrain options, and four-wheel-drive configurations. It also inherited the SUV-pioneering uniframe construction. The 4.0L six cylinder remained the standard powerplant, with a large displacement 5.2L V-8 as an option. A 5.9L V-8 was even offered as a limited edition, giving the Grand Cherokee loads of performance and horsepower.

Wrangler and Cherokee styling were redesigned and refined for the 1997 model year (production on the 1996 Wrangler was cancelled due to the reworking). As a result, Petersen's *4-Wheel & Off-Road* named Wrangler its "4x4 of the Year," and *Four Wheeler Magazine* named Cherokee its "Four Wheeler of the Year" in 1997.

The current (1999) Grand Cherokee has received some upgrades as well. Subtle exterior styling changes give it a more rounded, smooth look. A new V-8 engine, the 4.7L Power Tech, offers increased durability, greater horsepower, faster acceleration, and better fuel economy increased durability than its 5.2L predecessor. It even weighs less by approximately 54 pounds. New steering linkage, a new steering gear, and optimized steering geometry improve ride and handling and afford more precise steering response and improved vehicle control.





1994 Jeep Grand Cherokee



1999 Jeep Grand Cherokee

DaimlerChrysler and Beyond

In 1998, Chrysler Corporation merged with Daimler-Benz to become DaimlerChrysler. It's difficult to guess what direction Jeep models may head toward in the future, but they continue to be sales and industry leaders. The current versions combine better than 50 years of engineering and technological excellence with classic styling and practicality. Whatever the future may hold, it's safe to say that Jeep's place in automotive history has already been assured.

Additional Jeep Information

For more information on Jeep history, as well as information helpful when shopping for your first (or second?) Jeep, visit the Jeep website at www.jeepunpaved.com or consult the following publication:

Jeep Owner's Bible

Automotive writer Moses Ludel has assembled a 335 page 'bible' of Jeep information, including everything from the history and development of the legendary Jeep, to tune-up, maintenance and repair procedures. Ludel's manual also covers high performance tuning and off-road driving tips.

P5249431 *Jeep Owner's Bible*



Jeep Commander Concept Vehicle



1998 Jeep Wrangler Sahara

Chapter 2

2.5L Power Tech In-Line 4



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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Note: The following procedures for the 2.5L Power Tech In-Line 4 cylinder engine are intended to be performed in-vehicle, on a dynamometer, or as an individual change/modification.

In addition to the information contained in this chapter, much of the information contained in Chapter 4, *4.0L Power Tech In-Line 6*, is generic to all Jeep engines (including the 2.5L). Therefore, in addition to this chapter, we highly recommend that all 2.5L engine owners read Chapter 4 in its entirety.

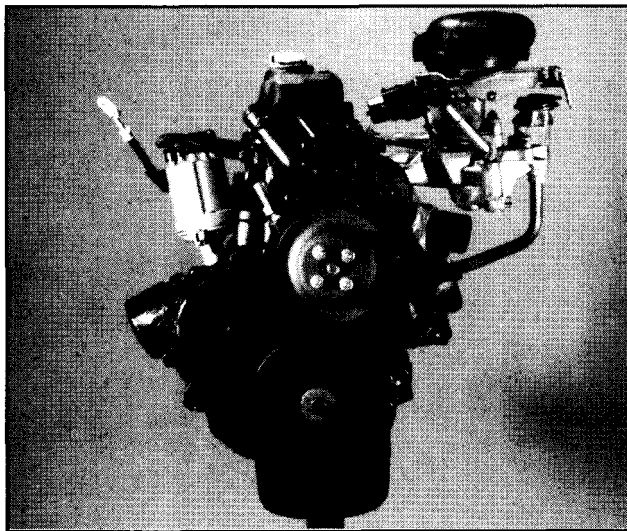
For additional 2.5L engine general service information, refer to the proper service manual.

Introduction

The Jeep 2.5 liter (150 cubic inch displacement) engine is a cast iron, overhead valve, In-Line 4 cylinder design. It has a standard bore and stroke of 98.45 x 80.97 mm (3.876 x 3.188"), and a 9.2:1 compression ratio.

The 2.5L has a liquid cooled, forced circulation cooling system with a capacity of 9.5L (10 quarts – MJ/XJ vehicles); 8.5L (9 quarts – YJ vehicles). The cylinders are numbered 1 through 4 from front to rear. The firing order is 1-3-4-2 (Figure 2-1).

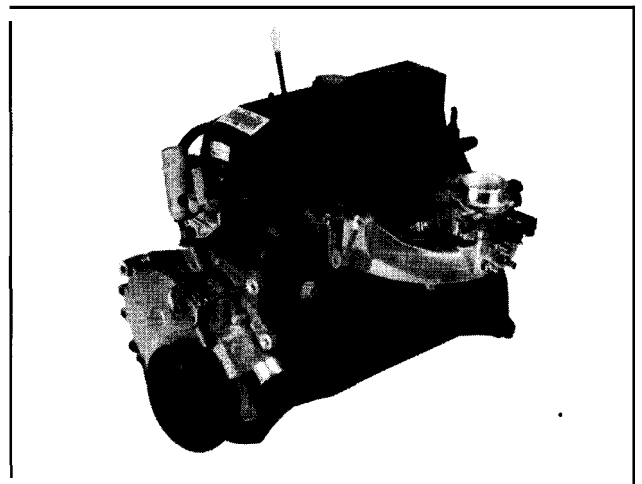
For more information, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.

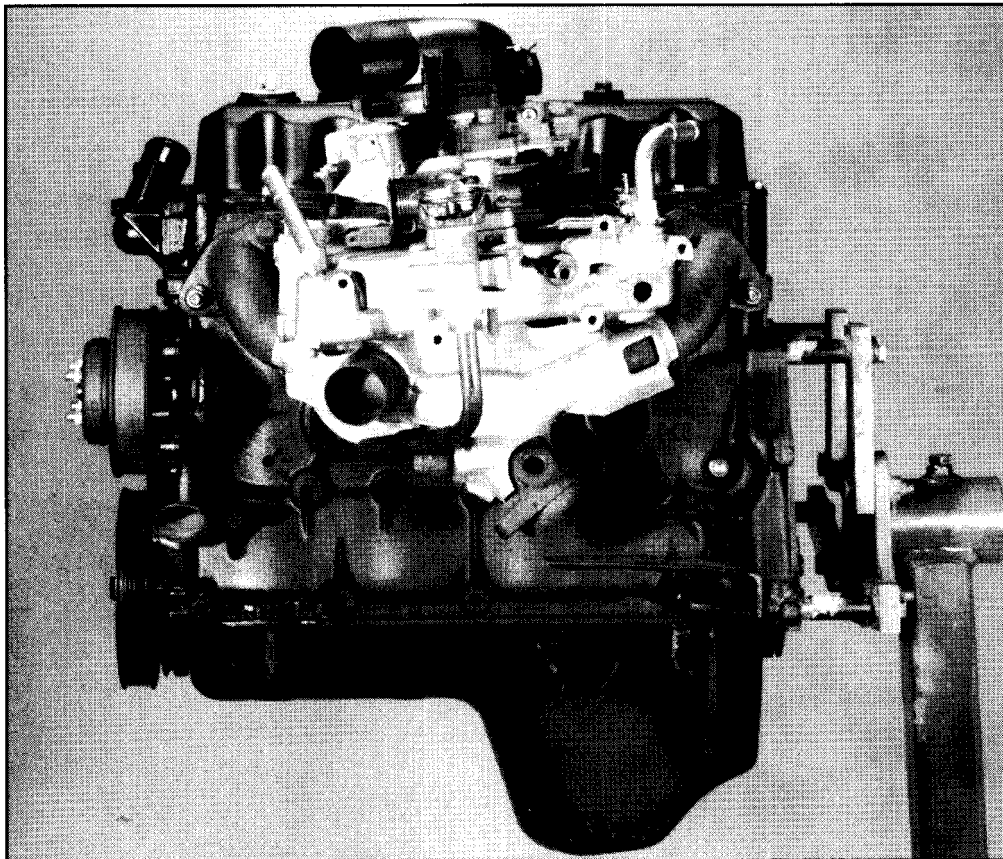
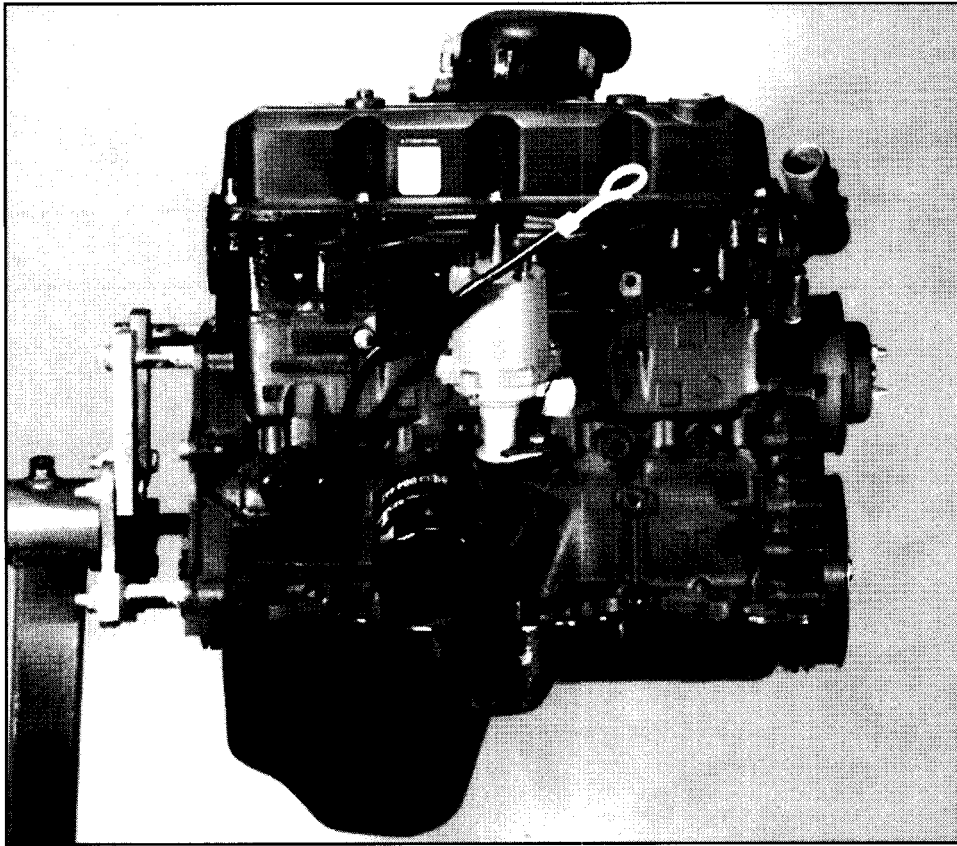


2.5L Engine General Specifications

Note: The following information has been reprinted from the *1999 Jeep Wrangler Service Manual*.

Engine Type	In-Line 4-cylinder
Bore and Stroke	98.4 x 81.0 mm (3.88 x 3.19")
Displacement	2.5L (150 CID)
Compression Ratio	9.1:1
Firing Order	1-3-4-2
Lubrication	Pressure Feed-Full Flow Filtration
Cooling System	Liquid Cooled-Forced Circulation
Cylinder Block	Cast Iron
Crankshaft.	Cast Nodular Iron
Cylinder Head.	Cast Iron
Camshaft	Cast Iron
Pistons	Aluminum Alloy
Combustion Chamber	Dual-Quench
Connecting rods	Cast Malleable Iron





Block

Flywheel Attaching Package

Bolts required to attach flywheel and clutch to new engine assembly. Includes 6 flywheel bolts, 6 clutch bolts, and a pilot bearing.

P4529667 Flywheel attaching package.

Drive Plate Attaching Package

Bolts required to attach torque converter drive plate to the crankshaft and to attach the torque converter to the drive plate. Includes 6 flywheel bolts and 4 torque converter bolts.

P4529249 Drive plate attaching package.

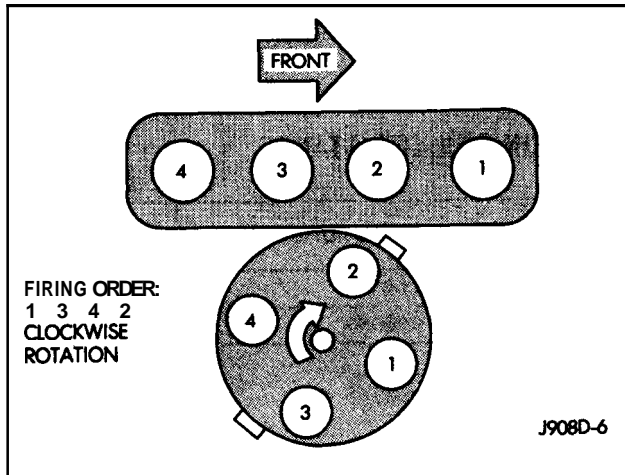


Figure 2 - 1

DISASSEMBLY AND ASSEMBLY PROCEDURES

Short Block Disassembly

1. Drain the engine oil. Remove and discard the oil filter.
2. Remove the water pump and distributor from the cylinder block.
3. Remove the vibration damper using vibration damper removal tool (Figure 2-2).
4. Remove the timing case cover (Figure 2-3) and lay upside down.
5. Position a drift punch into the slot (Figure 2-4) in the back of the cover and tap the old seal out.
6. Remove the timing chain bumper (Figure 2-4).
7. Remove the oil slinger from the crankshaft.
8. Remove the camshaft retaining bolt and remove the sprockets and chain as an assembly (Figure 2-5).

9. Remove the camshaft (Figure 2-6).
10. Remove the oil pan, gaskets and seals.
11. Remove the timing chain tensioner (Figure 2-7).
12. Remove the front and rear oil galley plugs.
13. Remove the connecting rods and the pistons. Remove the connecting rod and piston assemblies through the top of the cylinder bores
14. Remove the crankshaft.

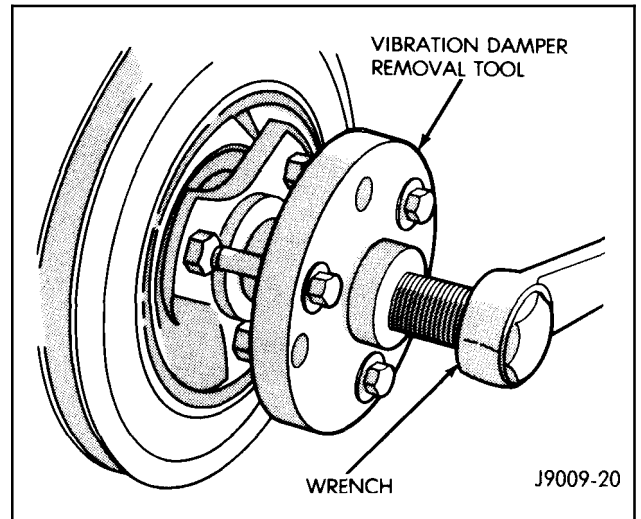


Figure 2 - 2

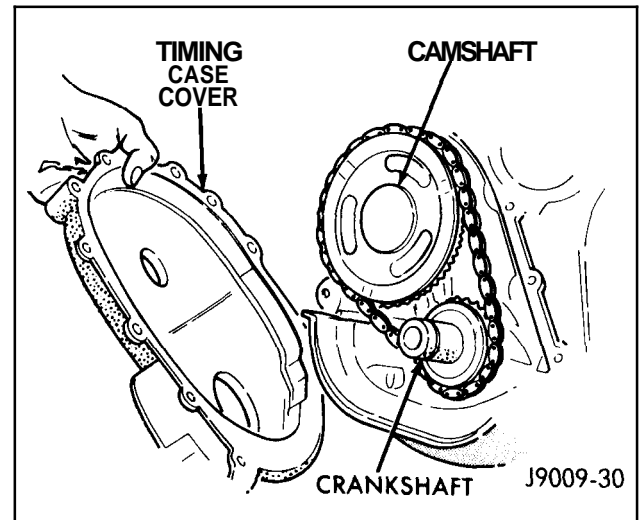


Figure 2 - 3

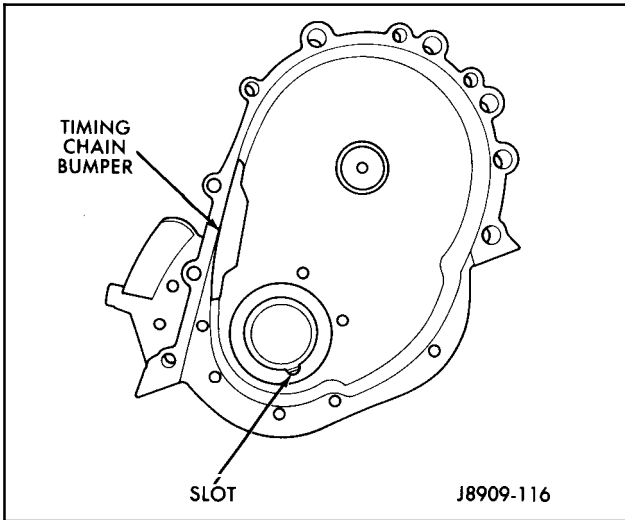


Figure 2 - 4

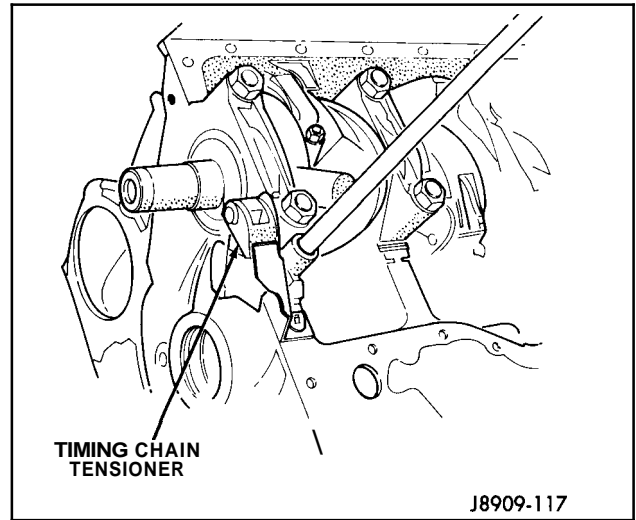


Figure 2 - 7

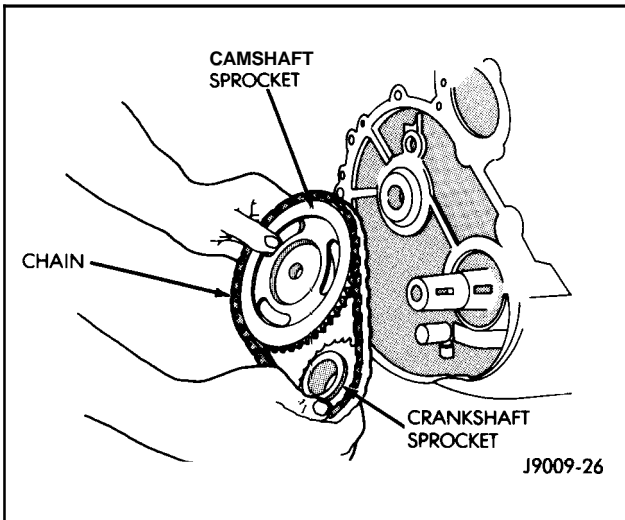


Figure 2 - 5

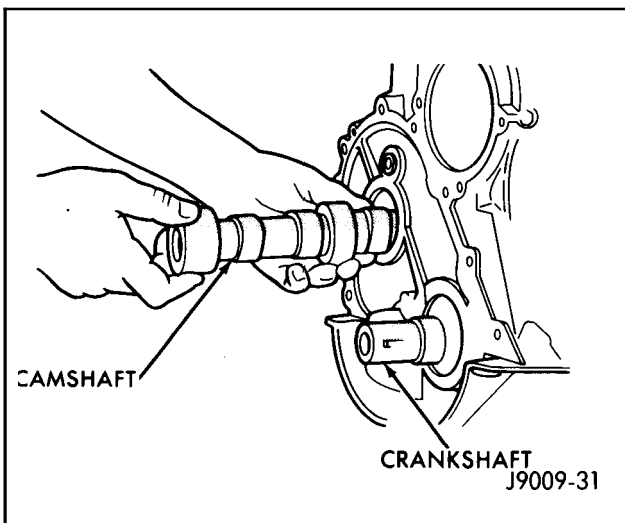


Figure 2 - 6

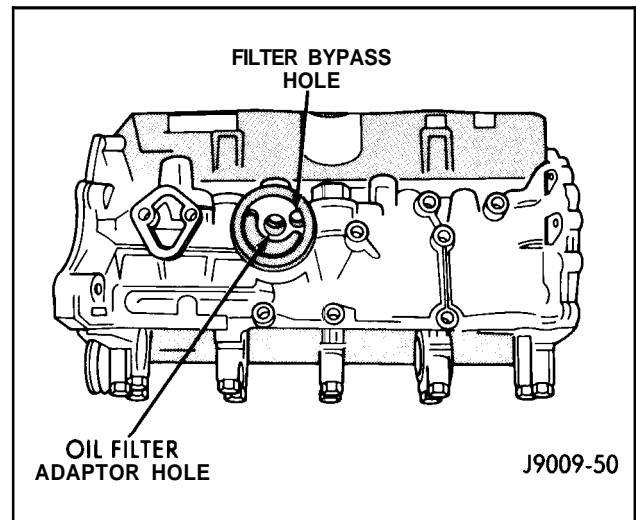


Figure 2 - 8

Cleaning

Thoroughly clean the oil pan and engine block gasket surfaces.

Use compressed air to clean out:

- The galley at the oil filter adapter hole, the filter bypass hole (Figure 2-8)
- The front (Figure 2-9) and rear (Figure 2-10) oil galley holes
- The feed holes for the crankshaft main bearings

Once the block has been completely cleaned, apply Loctite PST pipe sealant with Teflon 592 to the threads of the oil galley plugs and tighten them to 41 N•m (30 ft-lbs) torque.

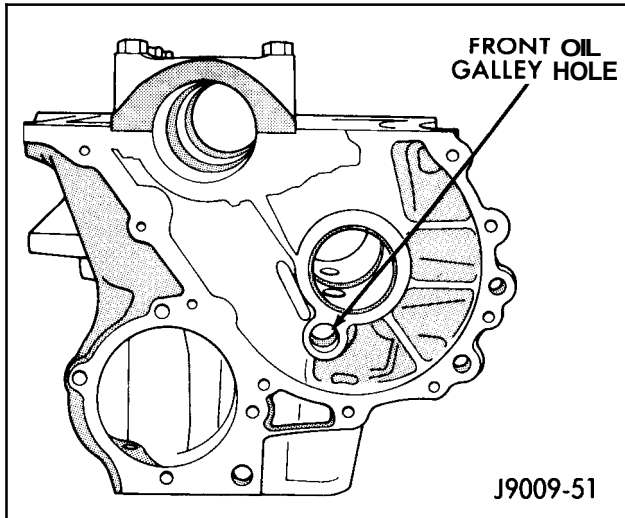


Figure 2 - 9

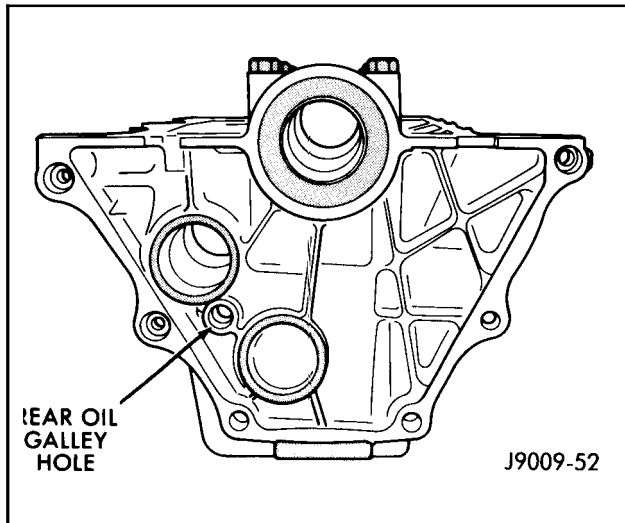


Figure 2 - 10

Cylinder Bore Measurement

1. It is mandatory to use a dial bore gauge to measure each cylinder bore diameter (Figure 2-11). To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") INCREMENTS is required. If a bore gauge is not available, DO NOT use an inside micrometer.
2. Measure the inside diameter of the cylinder bore at three levels below top of bore. Start perpendicular (across or at 90 degrees) to the axis of the crankshaft and then take two additional readings.
3. Measure the cylinder bore diameter crosswise to the cylinder block near the top of the bore. Repeat the measurement near the middle of the bore, then repeat the measurement near the bottom of the bore.

4. Determine taper by subtracting the smaller diameter from the larger diameter.
5. Rotate measuring device 90° and repeat steps above.
6. Determine out-of-roundness by comparing the difference between each measurement.
7. If cylinder bore taper does not exceed 0.025 mm (0.001") and out-of-roundness does not exceed 0.025 mm (0.001"), the cylinder bore can be honed. If the cylinder bore taper or out-of-round condition exceeds these maximum limits, the cylinder must be bored and then honed to accept an oversize piston. A slight amount of taper always exists in the cylinder bore after the engine has been in use for a period of time.

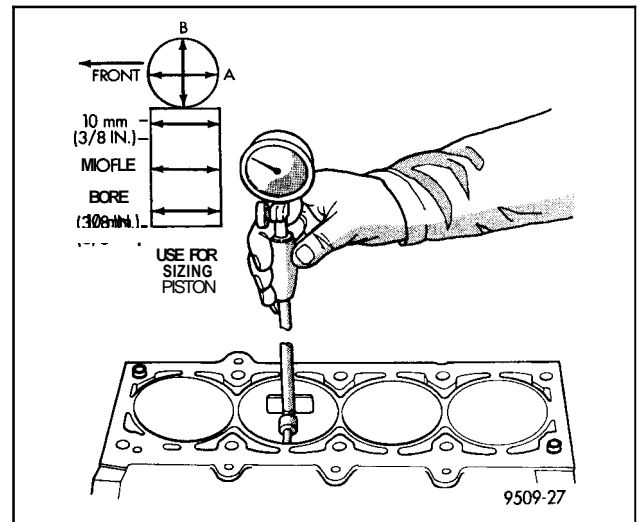


Figure 2 - 11

Cylinder Bore Reconditioning

Caution: DO NOT use rigid type hones to remove cylinder wall glaze.

1. Use an expanding type hone on the cylinder bore to remove glaze for faster piston ring seating. Move the hone down and up (stroke) at sufficient speed to produce a uniform 60° angle crosshatch pattern on the cylinder walls. DO NOT use more than ten (10) strokes per cylinder (*one stroke is one down-and-up movement*).
2. Scrub the cylinder bores clean with a solution of hot water and detergent.
3. Immediately apply light engine oil to the cylinder walls. Wipe with clean, lint-free cloth.

Short Block Assembly

1. Install the crankshaft.
2. Install the connecting rods and the pistons through the top of the cylinder bores.
3. Install the front and rear oil galley plugs.
4. Install the timing chain tensioner.
5. Install the camshaft.
6. Install the sprockets and chain as an assembly.
7. Install the oil slinger to the crankshaft.
8. Install the timing chain bumper.
9. Install the timing case cover seal.
10. Install the timing case cover.
11. Install the oil pan gasket and oil pan.
12. Install the vibration damper.
13. Install the water pump. Tighten the mounting bolts to 31 N•m (270 in-lbs) torque.
14. Remove the distributor from the cylinder block.
15. Lubricate the oil filter seal with clean engine oil. Tighten oil filter to 18 N•m (13 ft-lbs) torque.
16. Install the engine into the vehicle.
17. Fill the engine with clean lubrication oil.
18. Fill the cooling system.



Crankshaft

INTRODUCTION

The 2.5L engine uses a cast nodular iron crankshaft that rotates within five (5) main bearings and has a standard bore and stroke of 98.45 x 80.97 mm (3.876 x 3.188"). Crankshaft rotation is clockwise, when viewed from the front of the engine.

The crankshaft has a main bearing journal diameter of 63.489-63.502 mm (2.4996-2.5001"), and main bearing journal widths of (No. 1) 27.58-27.89 mm (1.086-1.098"), (No. 2) 32.28-32.33 mm (1.271-1.273"), and (Nos. 3, 4 and 5) 30.02-30.18 mm (1.182-1.188").

The crankshaft has a connecting rod journal diameter of 53.17-53.23 mm (2.0934-2.0955") and a connecting rod journal width of 27.18-27.33 mm (1.070-1.076").

For more crankshaft specifications, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.

High Performance Crankshaft

Factory engineered high performance crankshaft is carefully inspected and magna-fluxed. Includes bearings. Stock stroke length. For 2.5L engine only.

P4529646 High performance crankshaft.

CRANKSHAFT MAIN BEARINGS

Street Performance Bearings

These production style main bearings are made from AL6 aluminum. Package includes complete engine set. Standard size. For 2.5L engine only.

P4529648 Street performance bearings.

Removal

1. Disconnect the battery negative cable.
2. Remove the spark plugs.
3. Raise the vehicle.
4. Remove the oil pan and oil pump as outlined in the 'Oiling System' section of this chapter.
5. Remove only one main bearing cap and lower insert at a time (Figure 2-12).
6. Remove the lower insert from the bearing cap.
7. Remove the upper insert by loosening (DO NOT remove) all of the other bearing caps and inserting a small cotter pin tool in the crankshaft journal oil hole.

Bend the cotter pin as illustrated to fabricate the tool (Figure 2-13). With the cotter pin tool in place, rotate the crankshaft so that the upper bearing insert will rotate in the direction of its locking tab.

Note: Because there is no hole in the No. 2 main journal, use a tongue depressor or similar soft-faced tool to remove the bearing insert (Figure 2-13). After moving the insert approximately 25 mm (1"), remove it by applying pressure under the tab.

8. Using the same procedure just described, remove the remaining bearing inserts (one at a time) for inspection.

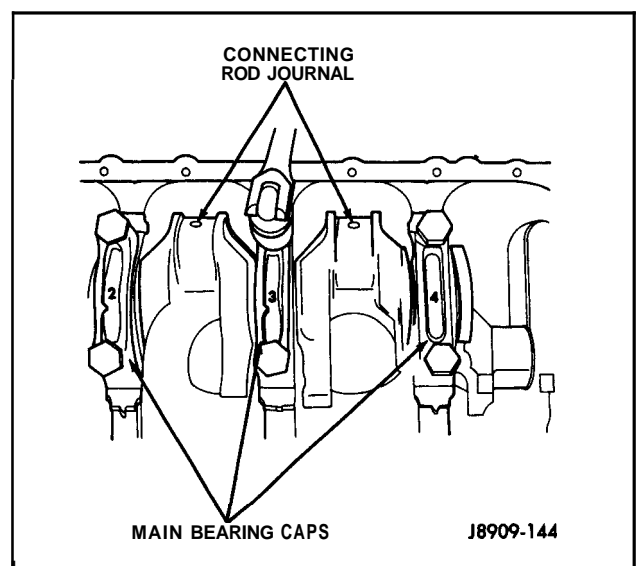


Figure 2 - 12

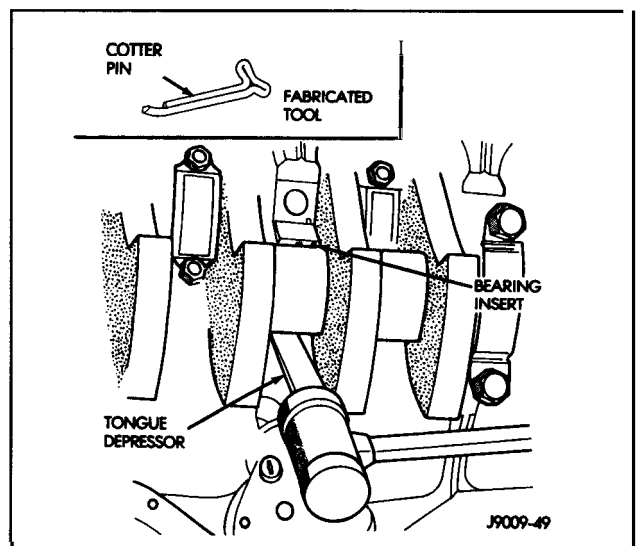


Figure 2 - 13

Inspection

- Wipe inserts clean and inspect for abnormal wear patterns and for metal or other foreign material imbedded in the lining. Normal main bearing insert wear patterns are shown in Figure 2-14.

Note: If any of the crankshaft journals are scored, remove the engine for crankshaft repair.

- Inspect the back of the inserts for fractures, scrapings, or irregular wear patterns.
- Inspect the upper insert locking tabs for damage.
- Replace all damaged or worn bearing inserts.

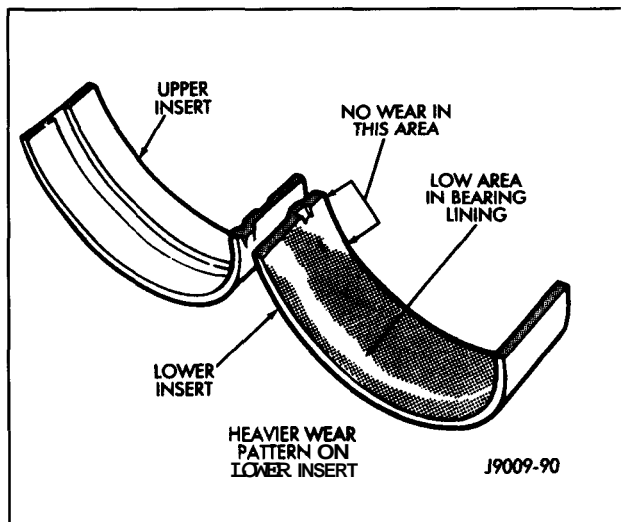


Figure 2 - 14

Fitting

The main bearing caps, numbered (front to rear) from 1 through 5 have an arrow to indicate the forward position. The upper main bearing inserts are grooved to provide oil channels while the lower inserts are smooth. Crankshaft end play is controlled by the thrust bearing which is flanged and installed at the No. 2 main bearing position.

Each bearing insert pair is selectively fit to its respective journal to obtain the specified operating clearance. In production, the select fit is obtained by using various sized, color-coded bearing insert pairs as listed in the *Main Bearing Fitting Chart* (refer to the proper service manual). The bearing color code appears on the edge of the insert.

Note: The size is not stamped on bearing inserts used for engine production.

The main bearing journal size (diameter) is identified in production by a color-coded paint mark on the adjacent cheek toward the flanged (rear) end of the crankshaft, except for the rear main journal. The paint mark that identifies the rear main journal diameter is on the crankshaft rear flange.

Refer to the *Main Bearing Fitting Chart* (refer to the proper service manual) to select the proper bearing inserts to obtain the specified bearing clearance. Refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct main bearing clearances.

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce the clearance by 0.013 mm (0.0005"). Refer to Figure 2-15.

Note: Never use a pair of bearing inserts with greater than a 0.025 mm (0.001") difference in size.

Example: When replacing inserts, install the odd size inserts either all on the top (in cylinder block) or all on the bottom (in main bearing cap).

Insert	Correct	Incorrect
Upper	Standard	Standard
lower	0.025 mm (0.001 in.) Undersize	0.051 mm (0.002 in.) Undersize

J9109-179

Figure 2 - 15

Main Bearing-to-Journal Clearance—Crankshaft Installed

When using Plastigauge, check only one bearing clearance at a time.

- Install the grooved main bearings into the cylinder block and the non-grooved bearings into the bearing caps.
- Install the crankshaft into the upper bearings dry.
- Place a strip of Plastigauge across full width of the crankshaft journal to be checked.
- Install the bearing cap and tighten the bolts to 108N•m (80 ft-lbs) torque.

Note: DO NOT rotate the crankshaft. This will cause the Plastigauge to shift, resulting in an inaccurate reading. Plastigauge must not be permitted to crumble. If it is brittle, obtain fresh stock.

- Remove the bearing cap. Determine the amount of clearance by measuring the width of the compressed Plastigauge with the scale on the Plastigauge envelope (Figure 2-16). The correct clearance is 0.0254 to 0.0635 mm (.0010 to .0025") for all main bearing journals, with 0.051 mm (0.002") preferred.

Plastigauge should indicate the same clearance across the entire width of the insert. If clearance varies, it may indicate a tapered journal or foreign material trapped behind the insert.

If the specified clearance is indicated and there are no abnormal wear patterns, replacement of the bearing inserts is not necessary. Remove the Plastigauge from the crankshaft journal and bearing insert. Proceed to Installation.

If the clearance exceeds specification, install a pair of 0.025 mm (0.001") undersize bearing inserts and measure the clearance as described in the previous steps. The clearance indicated with the 0.025 mm (0.001") undersize insert pair installed will determine if this insert size or some other combination will provide the specified clearance.

Example: If the clearance was 0.0762 mm (0.003") originally, a pair of 0.0254 mm (0.001") undersize inserts would reduce the clearance by 0.0254 mm (0.001"). The clearance would then be 0.051 mm (0.002") and within the specification. A 0.051 mm (0.002") undersize bearing insert and a 0.0254 mm (0.001") undersize insert would reduce the original clearance an additional 0.0127 mm (0.0005") and the clearance would then be 0.0381 mm (0.0015").

Caution: Never use a pair of inserts that differ more than one bearing size as a pair. For example, DO NOT use a standard size upper insert and a 0.051 mm (0.002") undersize lower insert.

If the clearance exceeds the specification using a pair of 0.051 mm (0.002") undersize bearing inserts, measure the crankshaft journal diameter with a micrometer. If the journal diameter is correct, the crankshaft bore in the cylinder block may be misaligned, which requires cylinder block replacement or machining to true bore.

If the diameter for journals 1 through 5 is less than 63.4517 mm (2.4981"), replace the crankshaft or grind the crankshaft down to accept the appropriate undersize bearing inserts.

Once the proper clearances have been obtained, remove the crankshaft and proceed to *Installation*.

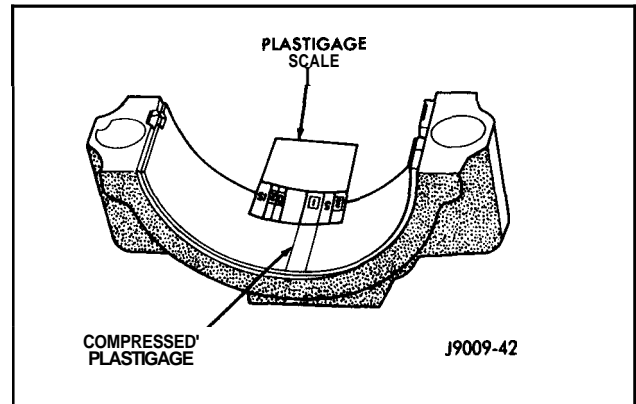


Figure 2 - 16

Main Bearing Journal Diameter—Crankshaft Removed

Clean the main bearing journal of oil.

Determine the maximum diameter of journal with a micrometer. Measure at two locations 90° apart at each end of the journal.

The maximum allowable taper and out of round is 0.013 mm (0.0005"). Compare measured diameter with the journal diameter specification listed in the *Main Bearing Fitting Chart* (refer to the proper service manual) and select inserts required to obtain the specified bearing-to-journal clearance.

Installation

1. Lubricate the bearing surface of each insert with engine oil.
2. Loosen all the main bearing caps. Install the main bearing upper insert(s).
3. Install the lower bearing inserts into the main bearing caps.
4. Install the main bearing cap(s) and lower insert(s).
5. Clean the rear main bearing cap (No. 5) mating surfaces.
6. Apply Mopar Gasket Maker (or equivalent) to the rear bearing cap (Figure 2-17). The bead should be 3 mm (0.125 in) thick. DO NOT apply Mopar Gasket Maker (or equivalent) to the lip of the seal.
7. Install the rear main bearing cap. DO NOT strike the cap more than twice for proper engagement.
8. Tighten the bolts of caps 1, 3, 4 and 5 to 54 N•m (40 ft-lbs) torque. Now tighten these bolts to 95 N•m (70 ft-lbs) torque. Finally, tighten these bolts to 108 N•m (80 ft-lbs) torque.
9. Push the crankshaft forward and backward. Load the crankshaft front or rear and tighten cap bolt #2 to 54 N•m (40 ft-lbs) torque. Then tighten to 95 N•m (70 ft-lbs) torque, and finally tighten to 108 N•m (80 ft-lbs) torque.

10. Rotate the crankshaft after tightening each main bearing cap to ensure the crankshaft rotates freely.
11. Check crankshaft end play. Refer to *Crankshaft End Play*, in this section, for the procedure.
12. If the crankshaft was removed, install the crankshaft into the cylinder block.
13. Install the oil pan.
14. Install the drain plug. Tighten the plug to 34 N·m (25 ft-lbs) torque.
15. Install new rear main seal.
16. Lower the vehicle.
17. Install the spark plugs. Tighten the plugs to 37 N·m (27 ft-lbs) torque.
18. Fill the oil pan with engine oil to the safe mark on the dipstick.
19. Connect the battery negative cable.

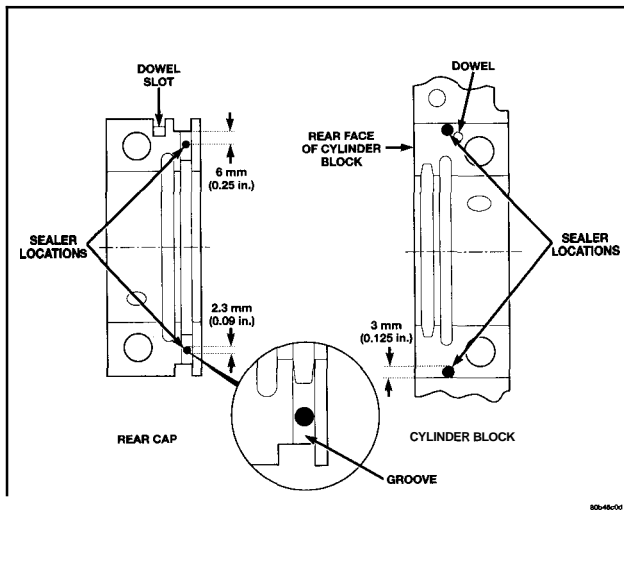


Figure 2 - 17

Crankshaft End Play

1. Attach a magnetic base dial indicator to the cylinder block at either the front or rear of the engine.
2. Position the dial indicator rod so that it is parallel to the centerline of the crankshaft.
3. Pry crankshaft forward and position dial indicator to zero.
4. Pry the crankshaft forward and backward. Note the dial indicator readings. End play is the difference between the high and low measurements (Figure 2-18). Correct end play is 0.038 to 0.165 mm (0.0015 to 0.0065"). The desired specifications are 0.051 to 0.064 mm (0.002 to 0.0025").

5. If end play is not within specification, inspect crankshaft thrust faces for wear. If no wear is apparent, replace the thrust bearing and measure end play. If end play is still not within specification, replace the crankshaft.

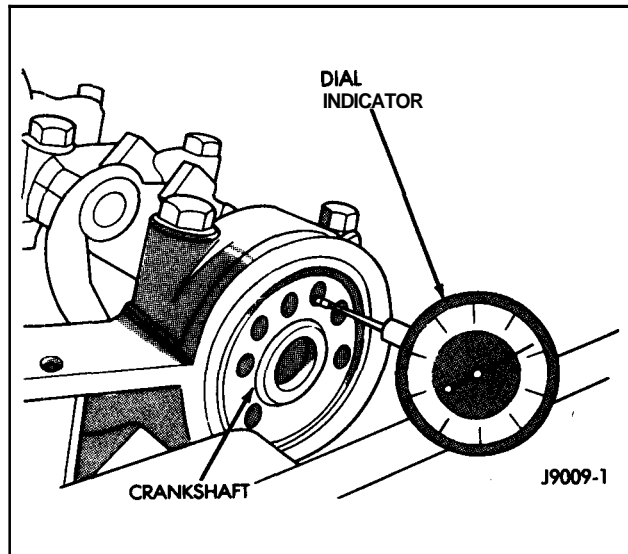


Figure 2 - 18

ENGINE DAMPER

(Refer to Figure 2-19.)

Removal

1. Disconnect the battery negative cable.
2. Remove the top and bottom damper nuts.
3. Remove the outer retainers and bushings.
4. Remove the top damper bracket nut and bolts.
5. Remove the bracket, inner retainers, bushings and the damper.

Installation

1. Install the damper on the lower bracket with the lower inner retainer and bushing in place.
2. Install the upper inner retainer and bushing on the top of the damper.
3. Position the upper damper bracket over the damper and install the stud nut and bolts.
4. Tighten the stud nut to 23 N·m (17 ft-lbs) torque and tighten the bracket bolts to 61 N·m (45 ft-lbs) torque.
5. Install the bushing, upper outer retainer and damper nut.
6. Install the bushing, lower outer retainer and damper nut.
7. Tighten the upper and lower damper nuts.
8. Connect the battery negative cable.

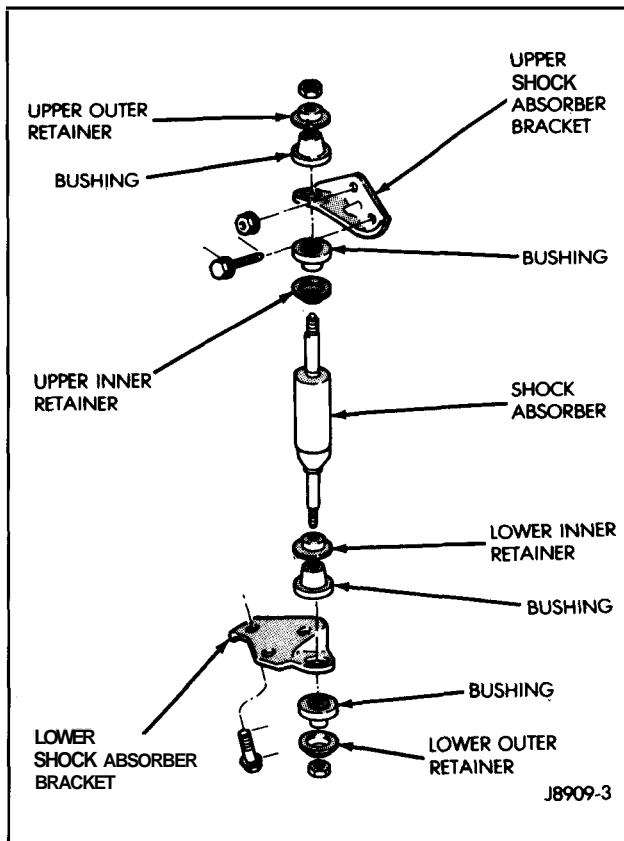


Figure 2 - 19

VIBRATION DAMPER

Vibration Damper

Production-type replacement vibration damper compatible with production crankshaft and piston-rod weight. For 2.5L engine only.

P4529669 Vibration damper.

Damper Attaching Package

Includes bolt, washer, oil slinger, and three keys. For 2.5L and 4.0L engines only.

P4529677 Damper attaching package.

Removal

1. Disconnect the battery negative cable.
2. Remove the drive belt(s) and fan shroud, if equipped.
3. If equipped with a crankshaft pulley for accessory drive belts, remove the retaining bolts and separate the crankshaft pulley from the vibration damper.
4. Remove the vibration damper retaining bolt and washer.
5. Use a vibration damper removal tool to remove the damper from the crankshaft (Figure 2-2).

Installation

1. With the key in position, align the keyway on the vibration damper hub with the crankshaft key and tap the damper onto the crankshaft.
2. Install the vibration damper retaining bolt and washer.
3. Torque the damper retaining bolt to 108 N•m (80 ft-lbs).
4. If equipped with a crankshaft pulley for the accessory drive belts, install the crankshaft pulley and retaining bolts.
5. Tighten the bolts to 27 N•m (20 ft-lbs) torque.
6. Install the drive belt(s) and tighten to the specified tension.
7. Connect the battery negative cable.

TIMING CASE COVER

(Refer to Figure 2-20.)

Removal

1. Disconnect the battery negative cable.
2. Remove accessory drive belts.
3. Remove the accessory drive brackets that are attached to the timing case cover.
4. Remove the fan and hub assembly and remove the fan shroud.
5. Remove the A/C compressor (if equipped) and alternator bracket assembly from the cylinder head and move to one side.
6. Use a vibration damper removal tool to remove the damper from the crankshaft (Figure 2-2).
7. Remove the oil pan-to-timing case cover bolts and cover-to-cylinder block bolts.
8. Remove the timing case cover front seal and gasket from the engine.
9. Cut off the oil pan side gasket end tabs and oil pan front seal tabs flush with the front face of the cylinder block and remove the gasket tabs (Figure 2-21).
10. Clean the timing case cover, oil pan and cylinder block gasket surfaces.
11. Remove the crankshaft oil seal from the timing case cover (Figure 2-20).

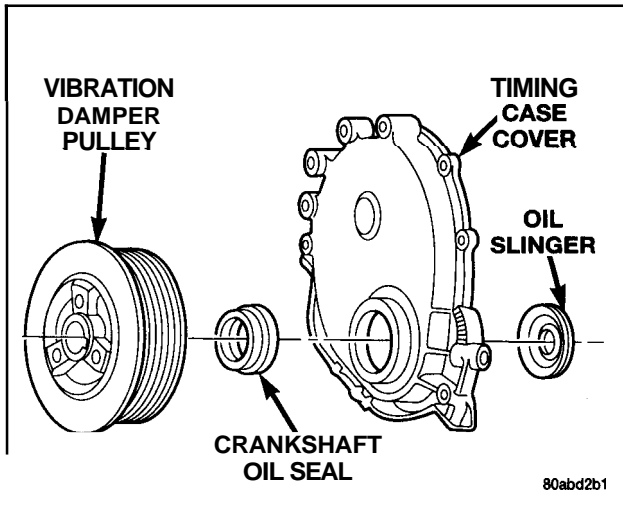


Figure 2 - 20

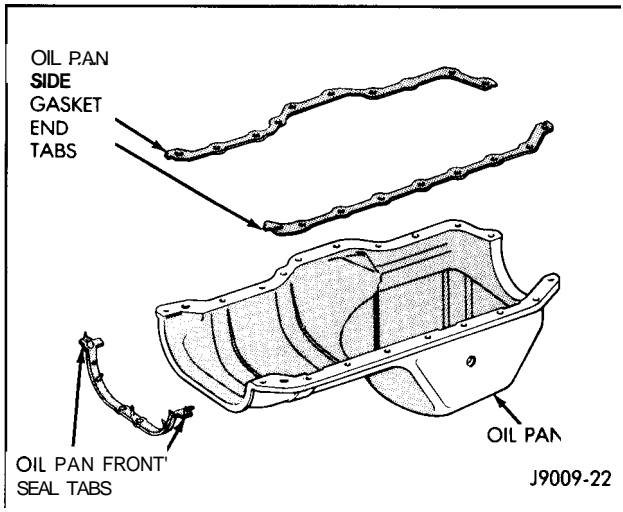
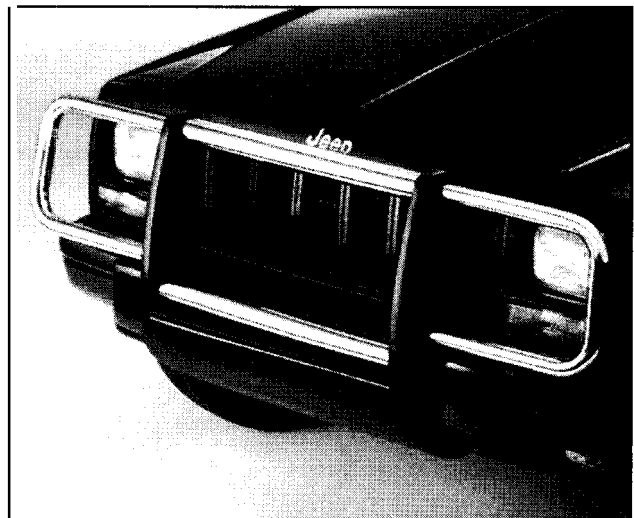


Figure 2 - 27

Installation

1. Install a new seal in the timing case cover using a seal installation tool (Figure 2-22).
2. Apply sealing compound (Mopar Gasket-in-a-Tube, or equivalent) to both sides of the replacement timing case cover gasket and position the gasket on the cylinder block.
3. Cut the end tabs off the replacement oil pan side gaskets corresponding to those cut off the original gasket (Figure 2-21). Attach the end tabs to the oil pan with cement.
4. Coat the front cover seal end tab recesses generously with RTV sealant (Mopar Gasket-in-a-Tube, or equivalent) and position the seal on the timing case cover.
5. Apply engine oil to the seal-to-oil pan contact surface.

6. Position the timing case cover on the cylinder block.
7. Insert timing case cover alignment and seal installation tool in the crankshaft opening in the cover (Figure 2-22).
8. Install the cover-to-cylinder block bolts and the oil pan-to-cover bolts.
9. Tighten the cover-to-cylinder block bolts to 7 N•m (62 in-lbs) torque and the oil pan-to-cover bolts to 13 N•m (11 ft-lbs) torque.
10. Remove the cover alignment tool and position a replacement oil seal on the tool with the seal lip facing outward. Apply a light film of Perfect Seal or equivalent on the outside diameter of the seal. Lightly coat the crankshaft with engine oil.
11. Position the tool and seal over the end of the crankshaft and insert a draw screw tool into the seal installation tool (Figure 2-23).
12. Tighten the nut against the tool until it contacts the cover.
13. Remove the tool and apply a light film of engine oil on the vibration damper hub contact surface of the seal.
14. With the key inserted in the keyway in the crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt to 108 N•m (80 ft-lbs) torque.
15. Install the crankshaft pulley. If equipped with a serpentine drive, the pulley is integral with the damper and they are installed as a unit. Tighten the bolts to 27 N•m (20 ft-lbs) torque.
16. Install the A/C compressor (if equipped) and the alternator bracket assembly.
17. Install the engine fan and hub assembly and shroud.
18. Install the drive belt(s) and tighten to obtain the specified tension.
19. Connect the battery negative cable.



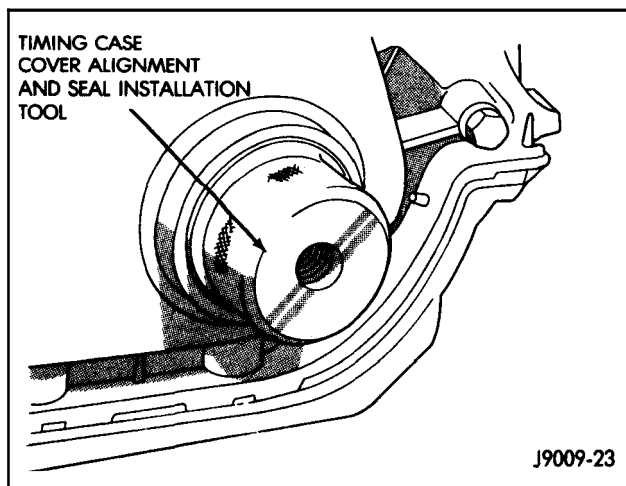


Figure 2 - 22

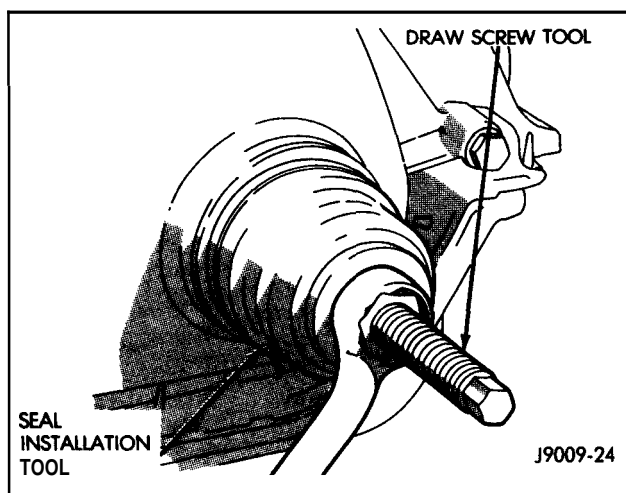


Figure 2 - 23

TIMING CHAIN AND SPROCKETS

The timing chain tensioner reduces noise and prolongs timing chain life. In addition, it compensates for slack in a worn or stretched chain and maintains the correct valve timing.

Timing Chain and Sprockets Set

This kit is the ideal service replacement package for Jeep 2.5L 4-cylinder engines. The package includes single roller timing chain and sprockets.

P4529822 Timing chain and sprockets set.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

All-out Race Chain and Sprockets

Cloyes matched sprockets and double roller chain for all-out race applications. Has three matched keyways to adjust cam timing. Kit includes Magna-fluxed sprockets and roller timing chain. For 2.5L and 4.0L engines only.

P5249519 All-out race chain and sprockets.

Removal

1. Disconnect the battery negative cable.
2. Remove the fan and shroud.
3. Remove the drive belt(s).
4. Remove the crankshaft vibration damper and the pulley (Figure 2-2).
5. Remove the timing case cover.
6. Rotate the crankshaft until the zero timing mark on the crankshaft sprocket is closest to and on a centerline with the timing mark on the camshaft sprocket (Figure 2-24).
7. Remove the oil slinger from the crankshaft.
8. Remove the camshaft retaining bolt and remove the sprockets and chain as an assembly.
9. To replace the timing chain tensioner, the oil pan must be removed. Refer to *Oil Pan Removal*, 'Oiling System' section of this chapter for the procedure.

Installation

1. Turn the tensioner lever to the unlock (down) position (Figure 2-25).
2. Pull the tensioner block toward the tensioner lever to compress the spring. Hold the block and turn the tensioner lever to the lock (**up**) position (Figure 2-25).
3. Apply Mopar Silicone Rubber Adhesive Sealant to the keyway in the crankshaft and insert the key. With the key in the crankshaft keyway, install the crankshaft/camshaft sprockets and timing chain. Ensure the timing marks on the sprockets are properly aligned (Figure 2-26).

4. Install the camshaft sprocket retaining bolt and washer and tighten the bolt to 108 N•m (80 ft-lbs) torque.

To verify correct installation of the timing chain, turn the crankshaft to position the camshaft sprocket timing mark at approximately the one o'clock position (Figure 2-26). This positions the crankshaft sprocket timing mark where the adjacent tooth meshes with the chain at the three o'clock position. Count the number of chain pins between the timing marks of both sprockets. There must be 20 pins.

5. Turn the chain tensioner lever to the unlocked (down) position (Figure 2-25).
6. Install the oil slinger.
7. Replace the oil seal in the timing case cover.
8. Install the timing case cover and gasket.
9. With the key inserted in the keyway in crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt to 108 N•m (80 ft-lbs) torque.
10. Install the fan and shroud.
11. Connect negative cable to battery.

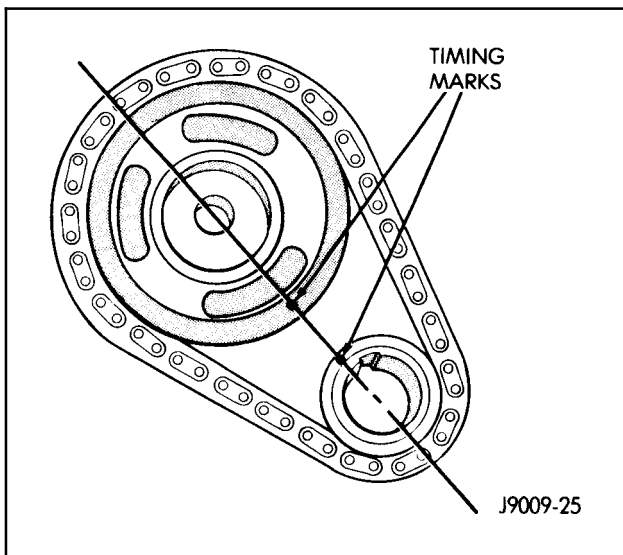


Figure 2 - 24

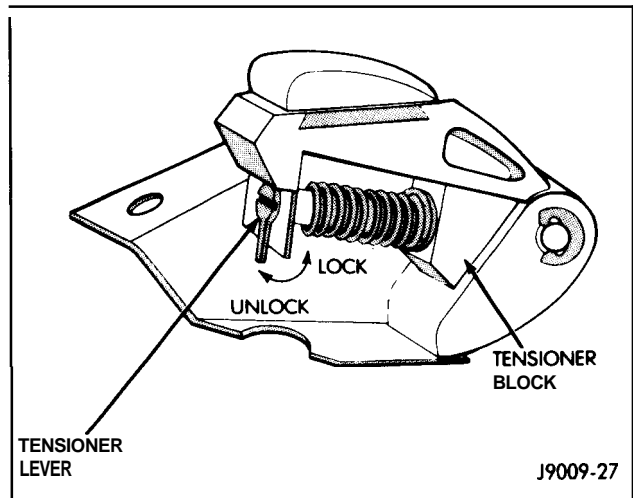


Figure 2 - 25

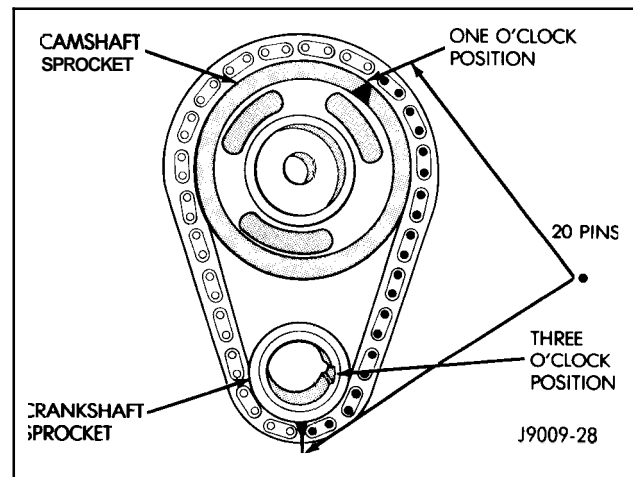


Figure 2 - 26

TIMING CASE COVER OIL SEAL REPLACEMENT

Timing Case Cover Removed

1. Disconnect the battery negative cable.
2. Pry oil seal out of cover from front with a large pry tool.
3. Install the replacement seal so that the open end of the seal is toward the inside of the cover.
4. Support the cover at the seal area while installing the seal and force it into position with seal installation tool (Figure 2-22 and Figure 2-23).
5. Connect the battery negative cable.

Timing Case Cover Installed

1. Disconnect the battery negative cable.
2. Remove the drive belts.
3. Remove the vibration damper (Figure 2-2).
4. Remove the radiator shroud.
5. Remove the oil seal using oil seal removal tool (Figure 2-27).
6. Position the replacement oil seal on the timing case cover alignment and seal installation tool (Figure 2-22) with seal lip facing outward. Apply a light film of Perfect Seal, or equivalent, on the outside diameter of the seal. Lightly coat the crankshaft with engine oil.
7. Position tool and seal over the end of the crankshaft and insert a draw screw tool into seal installation tool (Figure 2-23). Tighten the nut against the tool until it contacts the cover.
8. Remove the tools. Apply a light film of engine oil on the vibration damper hub contact surface of the seal.
9. With the key inserted in the keyway in the crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt to 108 N•m (80 ft-lbs) torque.
10. Install the crankshaft pulley. Tighten the bolt to 27 N•m (20 ft-lbs) torque.
11. Install the drive belt(s) and tighten to the specified tension. If equipped with a serpentine drive, the pulley is integral with the damper and they are installed as a unit.
12. Install the A/C compressor/alternator bracket assembly.
13. Connect the battery negative cable.

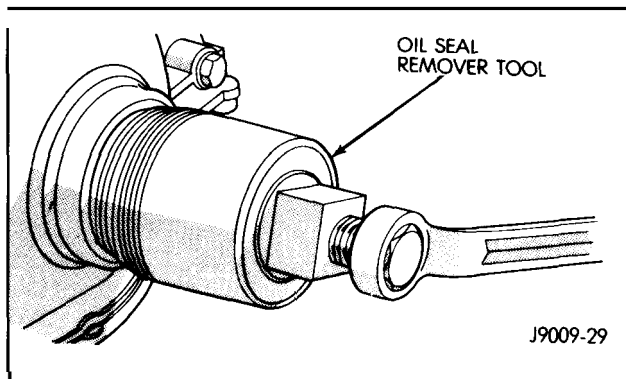


Figure 2 - 27

REAR MAIN OIL SEAL

Removal

To replace the rear main oil seal, the transmission must be removed. Refer to service manual for the proper procedure.

1. Remove flywheel or torque converter drive plate. Discard the old bolts.
2. Pry out seal from around crankshaft flange (Figure 2-28).

Installation

1. Coat the outer lip of the replacement rear main bearing seal with engine oil.
2. Carefully position the seal into place. Use rear main seal installer tool to install the seal flush with the block.

Caution: The felt lip must be located inside the flywheel mounting surface. If the lip is not positioned correctly the flywheel could tear the seal.

3. Install the flywheel or torque converter drive plate. New bolts **MUST** be used when installing the flywheel or torque converter drive plate. Tighten the new bolts to 68 N•m (50 ft-lbs) torque. Turn the bolts an additional 60°.
4. Install the transmission. Refer to service manual for the proper procedure.

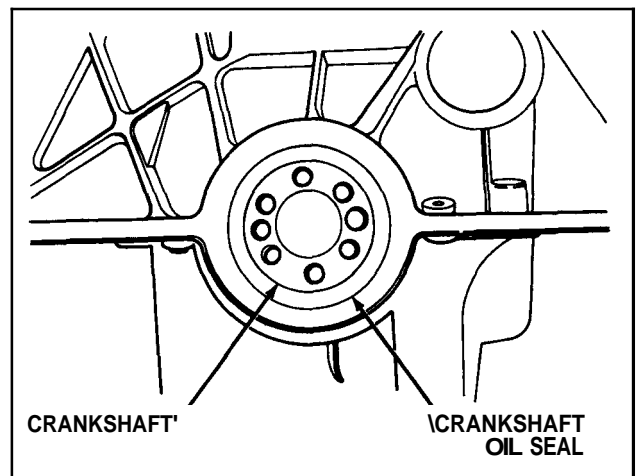


Figure 2 - 28

Connecting Rods

INTRODUCTION

The 2.5L engine's connecting rods are made of cast nodular iron with a total weight (less the bearings) of 657-665 grams (23.2-23.5 oz.), and a total length (center-to-center) of 155.52-155.62 mm (6.123-6.127"). Connecting rod journal diameter is 53.17-53.23 mm (2.0934-2.0955"). Connecting rod journal width is 27.18-27.33 mm (1.070-1.076").

For connecting rod removal and installation procedures, refer to *Piston and Connecting Rod Assembly*, 'Pistons and Rings' section of this chapter.

Connecting Rod

These heavy duty forgings are shot-peened and Magna-fluxed. Includes high strength bolts. Can be used as heavy duty stock replacement. For 2.5L and 4.0L engines only. (Sold individually.)

P4529209 Connecting rod.

Connecting Rod Bearings

These connecting rod bearings are made of production-style material. Available in standard and two undersizes. For Jeep 2.5L and 4.0L engines only. (Sold individually.)

P4529208 Connecting rod bearings, standard size.

P4529236 Connecting rod bearings, .001" undersize.

P4529238 Connecting rod bearings, .010" undersize.

Basic Preparation

1. Rods should be checked for alignment; bores should be parallel. Check big and small ends for size. Use only a Sunnen rod reconditioner for this purpose.
2. Using a small file, deburr rods, paying particular attention to the mating surfaces and the tab groove. You need the clamping effect of a 60 micro bore. The sides should be polished by hand on a flat plate using #600 paper.
3. In an engine that is to be used in a high rpm situation, the rods and rod bolts should be Magna-Glo checked for cracks or forging flaws.
4. A race engine should use the heavy duty rod bolts and nuts.
5. The rod bearing clearances should be 0.03-0.06 mm (0.001-0.0025").
6. The rod bolt head should be seated against the flat, machined surface in the rod.

7. For a race engine, the big end rod should be sized to the minimum diameter to get the maximum crush from the bearing.
8. Shot-peening the rods is recommended if they haven't been already.
9. Clean all parts before proceeding.

Rod Ratio

For all-out modified race engines, it is recommended that a rod ratio (length of the rod divided by the stroke) of 1.75 to 1.85 be maintained (if possible) for best performance. (The stock 2.5L engine has a rod ratio of 1.92—this is considered long.) Side clearance should be 0.25-0.48 mm (0.010-0.019").

Inspection

1. Connecting Rod Bearings

Inspect connecting rod bearings for scoring and bent alignment tabs (Figure 2-29 and Figure 2-30). Check the bearings for normal wear patterns, scoring, grooving, fatigue and pitting (Figure 2-31). Replace any bearing that shows abnormal wear.

Inspect connecting rod journals for signs of scoring, nicks and burrs.

2. Connecting Rods

Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicates the probability of a misaligned connecting rod, inspect it for correct rod alignment.

Replace misaligned, bent or twisted connecting rods.

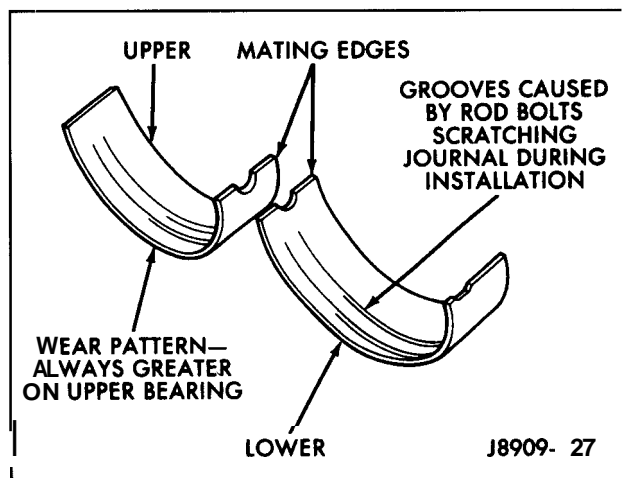


Figure 2 - 29

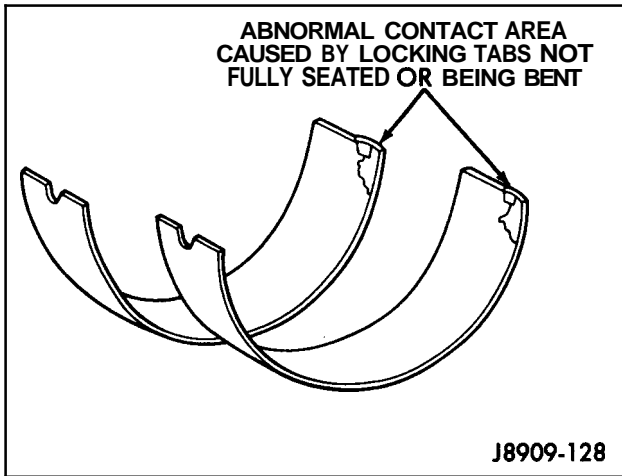


Figure 2 - 30

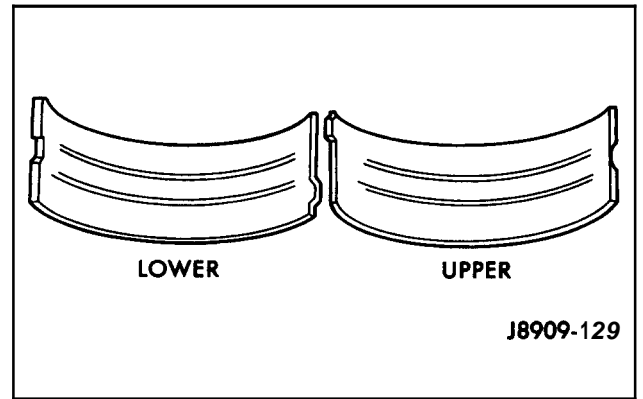


Figure 2 - 31

		Upper Insert Size	Lower Insert Size
Yellow	— 53.2257-53.2079 mm 2.0955-2.0948 inch Standard	Yellow — Standard	Yellow — Standard
Orange	— 53.2079-53.1901 mm 2.0948-2.0941 inch Undersize (0.0178 mm or 0.0007 inch)	Yellow — Standard	Black — Undersize 0.025 mm 0.001 inch
Black	— 53.1901-53.1723 mm 2.0941-2.0933 inch Undersize (0.0356 mm or 0.0014 inch)	Black — Undersize 0.025 mm 0.001 inch	Black — Undersize 0.025 mm 0.001 inch
Red	— 53.9717-53.9539 mm 2.0855-2.0848 inch Undersize (0.254 mm or 0.010 inch)	Red — Undersize 0.254 mm 0.001 inch	Red — Undersize 0.254 mm 0.001 inch

Figure 2 - 32

J9009-43

Measuring Bearing-to-Journal Clearance

1. Wipe the journal clean of oil.
2. Use short rubber hose sections over rod bolts during installation. (For more information, refer to *Connecting Rod Bolt Protectors*, 'Connecting Rods' section of Chapter 4.)
3. Lubricate the upper bearing insert and install in connecting rod.
4. Use piston ring compressor to install the rod and piston assemblies with the oil squirt holes in the rods facing the camshaft and the arrow on the piston crown pointing to the front of the engine (Figure 2-37). Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons face the front of the engine.
5. Install the lower bearing insert in the bearing cap. The lower insert must be dry. Place a strip of Plastigauge across the full width of the lower insert at the center of bearing cap. Plastigauge must not crumble in use. If brittle, obtain fresh stock.
6. Install bearing cap and connecting rod on the journal and tighten nuts to 45 N•m (33 ft-lbs) torque. DO NOT rotate crankshaft. Plastigauge will smear, resulting in inaccurate indication.
7. Remove the bearing cap and determine the amount of bearing-to-journal clearance by measuring the width of compressed Plastigauge using the scale on the Plastigauge envelope (Figure 2-16). The correct clearance is 0.0381 to 0.0635 mm (0.0015 to 0.0025").

Note: Plastigauge should indicate the same clearance across the entire width of the insert. If the clearance varies, it may be caused by either a tapered journal, bent connecting rod, or foreign material trapped between the insert and cap or rod.

8. If the correct clearance is indicated, replacement of the bearing inserts is not necessary. Remove the Plastigauge from crankshaft journal and bearing insert. Proceed with installation.
9. If bearing-to-journal clearance exceeds the specification, install a pair of 0.0254 mm (0.001") undersize bearing inserts and measure the clearance as described in the previous steps.

10. The clearance measured with a pair of 0.0254 mm (0.001") undersize bearing inserts installed will determine if two 0.0254 mm (0.001") undersize inserts or another combination is needed to provide the correct clearance (see the *Connecting Rod Bearing Fitting Chart*, Figure 2-32).

Example: If the initial clearance was 0.0762 mm (0.003"), 0.0254 mm (0.001") undersize inserts would reduce the clearance by 0.0254 mm (0.001"). The clearance would be 0.002" and within specification. A 0.0508 mm (0.002") undersize insert would reduce the initial clearance an additional 0.0127 mm (0.0005"). The clearance would then be 0.0381 mm (0.0015").

Measuring Side Clearance

Slide snug-fitting feeler gauge between the connecting rod and crankshaft journal flange. The correct clearance is 0.254 to 0.482 mm (0.010 to 0.019"). Replace the connecting rod if the side clearance is not within specification.

Note: Too much side clearance will cause the engine to have a high oil demand, resulting in either low or very low oil pressure.

Pistons and Rings

Cast Pistons and Rings for Jeep 2.5L Engines						
Part Number	Bore	Stroke	Rod	CR	Dome	Rings
P5249902	3.905"	3.19"	6.125"	9.2:1	Dish	P4876962

PISTONS

The 2.5L engine uses aluminum alloy pistons (with struts) that weigh (less pin) 563-567 grams (19.86-20.00 oz.) each. The piston combustion cavity is a single quench design.

For more piston (and piston ring) specifications, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.

Piston Fitting (Non-Coated Pistons Only)

1. Micrometer Method

- Measure the inside diameter of the cylinder bore at a point 58.725 mm (2-5/16") below the top of the bore.
- Measure the outside diameter of the piston. Because pistons are cam ground, measure at right angle to piston pin at centerline of pin (Figure 2-33).

Note: The difference between cylinder bore diameter and piston diameter is piston-to-bore clearance.

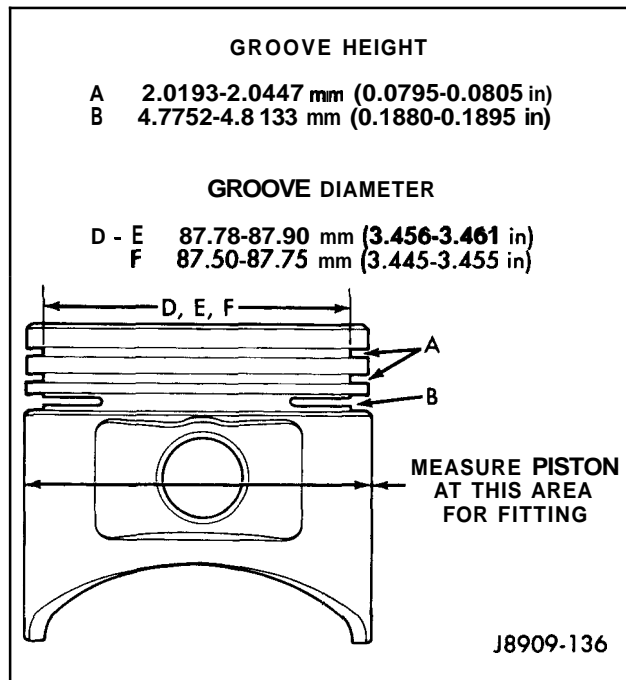


Figure 2 - 33

2. Feeler Gauge Method

(Not recommended for racing.)

- Remove the rings from the piston.
- Insert a long 0.025 mm (0.001") feeler gauge into the cylinder bore.
- Insert the piston, top first, into cylinder bore alongside the feeler gauge. With entire piston inserted into cylinder bore, the piston should not bind against feeler gauge.
- Repeat steps with a long 0.051 mm (0.002") feeler gauge. The piston should bind.
- If the piston binds on a 0.025 mm (0.001") feeler gauge, the piston is too large or the cylinder bore is too small. If the piston does not bind on a 0.051 mm (0.002") feeler gauge, the piston is too small for cylinder bore. Pistons up to 0.102 mm (0.004") undersize may be enlarged by knurling. Replace pistons that are 0.102 mm (0.004") or more undersize.

Piston Fitting (Coated Pistons Only)

1. Bore Gauge Method

To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") INCREMENTS is required. If a bore gauge is not available, DO NOT use an inside micrometer.

- Measure the inside diameter of the cylinder bore at a point 49.5 mm (1-15/16") below top of bore. Start perpendicular (across or at 90 degrees) to the axis of the crankshaft at point A and then take an additional bore reading 90 degrees to that at point B (Figure 2-34).
- Coated pistons, piston pins and connecting rods are pre-assembled. The coated piston and connecting rod assembly can be used to service previously built engines; however, they MUST be replaced as complete sets. Tin-coated pistons should not be used as replacements for coated pistons.

- c. The coating material is applied to the piston after the final piston machining process. Measuring the outside diameter of a coated piston will not provide accurate results. Therefore measuring the inside diameter of the cylinder bore with a dial bore gauge is MANDATORY. To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") increments is required.
- d. Piston installation into the cylinder bore requires slightly more pressure than that required for non-coated pistons. The bonded coating on the piston will give the appearance of a line-to-line fit with the cylinder bore.

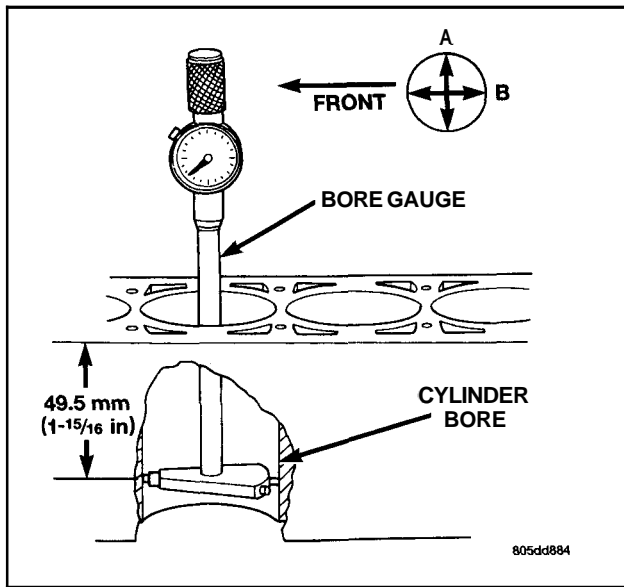


Figure 2 - 34

2. Coated Piston Size Chart

Cylinder Bore Size	Piston Letter Size
98.438 to 98.448 mm (3.8755 to 3.8759")	A
98.448 to 98.458 mm (3.8759 to 3.8763")	B
98.458 to 98.468 mm (3.8763 to 3.8767")	C
98.468 to 98.478 mm (3.8767 to 3.8771")	D
98.478 to 98.488 mm (3.8771 to 3.8775")	E
98.488 to 98.498 mm (3.8775 to 3.8779")	F

PISTON AND CONNECTING ROD ASSEMBLY

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover*, 'Cylinder Head' section of this chapter for the procedure.
2. Remove the rocker arms, bridges and pivots. Refer to *Rocker Arms*, 'Camshaft and Valve Gear' section of this chapter for the procedure.
3. Remove the pushrods. Refer to *Pushrods*, 'Camshaft and Valve Gear' section of this chapter for the procedure.
4. Remove the cylinder head. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter for the procedure.
5. Position the pistons one at a time near the bottom of the stroke and use a ridge reamer to remove the ridge from the top end of the cylinder walls. Use a protective cloth to collect the cuttings.
6. Raise the vehicle.
7. Drain the engine oil.
8. Remove the oil pan, gaskets and seals. Refer to *Oil Pan*, 'Oiling System' section of this chapter for the procedure.
9. Remove the connecting rod bearing caps and inserts and retain in the same order as removed to facilitate installation in the original locations. The connecting rods and caps are stamped with the corresponding cylinder number (Figure 2-35).
10. Lower vehicle until it is about two (2) feet from the floor.
11. Have an assistant push the piston and connecting rod assemblies up and through the top of the cylinder bores (Figure 2-36).

Caution: Ensure that the connecting rod bolts don't scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the rod bolts will prevent damage to the cylinder bores and crankshaft journals.

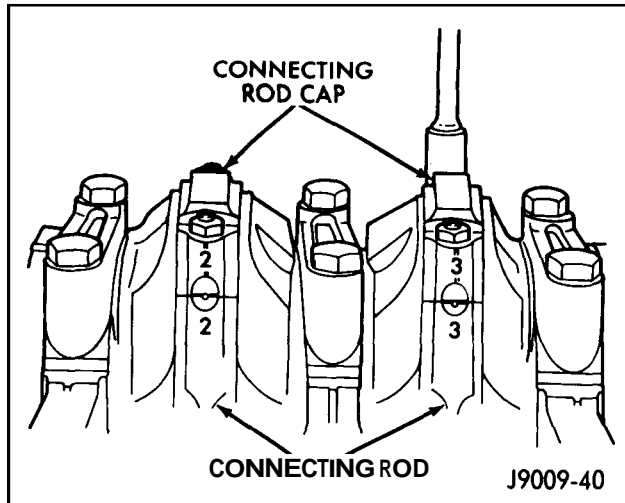


Figure 2 - 35

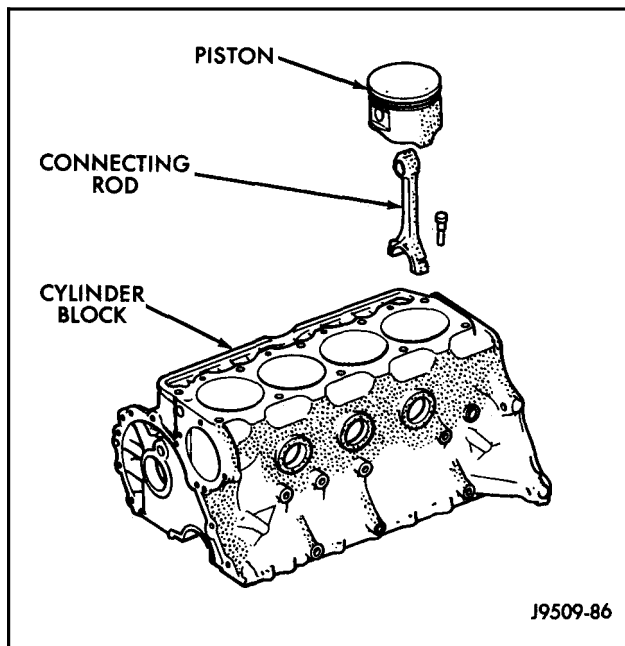


Figure 2 - 36

Installation

Each bearing insert is selectively fit to its respective journal to obtain the specified operating clearance between the bearing and the journal. In production, the select fit is obtained by using various sized, color-coded bearing inserts as listed in the *Connecting Rod Bearing Fitting Chart* (Figure 2-32). The color code appears on the edge of the bearing insert. The size is not stamped on inserts used for production of engines.

The rod journal is identified during engine production by a color-coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. The color codes used to indicate journal sizes are listed in the *Connecting Rod Bearing Fitting Chart* (Figure 2-32).

When required, upper and lower bearing inserts of different sizes may be used as a pair (see *Connecting Rod Bearing Fitting Chart*, Figure 2-32). A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce clearance 0.013 mm (0.0005").

Caution: DO NOT intermix bearing caps. Each connecting rod and its bearing cap are stamped with the associated cylinder number on a machine surface adjacent to the oil squirt hole that faces the camshaft side of the cylinder block (Figure 2-35).

1. Clean the cylinder bores thoroughly. Apply a light film of clean engine oil to the bores with a clean lint-free cloth.
2. Install the piston rings on the pistons if removed. Refer to *Piston Ring Fitting*, this section, for the proper procedure.
3. Lubricate the piston and rings with clean engine oil.
4. Use a piston ring compressor to install the connecting rod and piston assemblies through the top of the cylinder bores (Figure 2-36).

Caution: Ensure that connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.

5. Ensure the arrow on the piston top points to the front of the engine (Figure 2-37).

Note: For racing applications, refer to *Reversing Pistons with Offset Pins*, 'Pistons and Rings' section of Chapter 4.

6. Raise the vehicle.
7. Install the connecting rod bearing caps and inserts in the same positions as removed.

Caution: Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons face the front of the engine.

8. Install the oil pan and gaskets as outlined in the installation procedure.
9. Lower the vehicle.
10. Install the cylinder head, pushrods, rocker arms, bridges, pivots and cylinder head cover as outlined in the installation procedures in this chapter.
11. Fill the crankcase with engine oil.

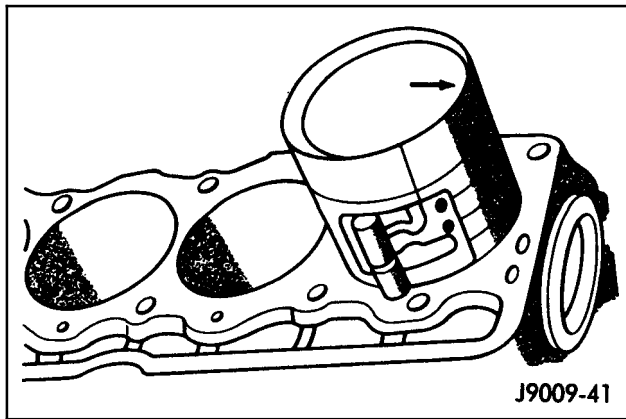


Figure 2 - 37

Piston Ring Fitting (Non-Coated Pistons Only)

- Carefully clean the carbon from all ring grooves. Oil drain openings in the oil ring groove and pin boss must be clear. DO NOT remove metal from the grooves or lands. Doing so will change ring-to-groove clearances and will damage the ring-to-land seating.
- Measure the ring side clearance with a feeler gauge fit snugly between the ring land and ring (Figure 2-38). Rotate the ring in the groove. It must move freely around the circumference of the groove.
- Place ring in the cylinder bore and push down with inverted piston to position near lower end of the ring travel. Measure ring gap with a feeler gauge fit snugly between ring ends (Figure 2-39). The correct compression ring end gap is 0.25-0.51 mm (0.010-0.020"). The correct oil control ring end gap is 0.381-1.397 mm (0.015-0.055").
- Refer to Figure 2-44 for position of ring gaps when installing piston rings.
- Install the oil control rings according to instructions in the package. It is not necessary to use a tool to install the upper and lower rails. Insert expander ring first, then side rails.
- The two compression rings are different and cannot be interchanged (Figure 2-40). The top ring is a moly ring (the scraping edge is gray in color). The second ring is a black cast iron ring (the scraping edge is black in color when new).
- The second compression ring (black cast iron) has a chamfer on the BOTTOM of the inside edge (Figure 2-41). This ring may also have two dots located on the top surface.
- Using a ring installer, install the ring with the chamfer facing down (Figure 2-42). If the ring has dots, the dots will be facing up.
- The top compression ring (the scraping edge is gray in color) has a chamfer on the TOP of the inside edge (Figure 2-43). This ring may also have one dot located on the top surface.
- Using a ring installer, install the top ring with the chamfer facing up. If the ring has a dot, the dot will be facing up.
- Position the ring end gaps on the piston as shown (Figure 2-44).

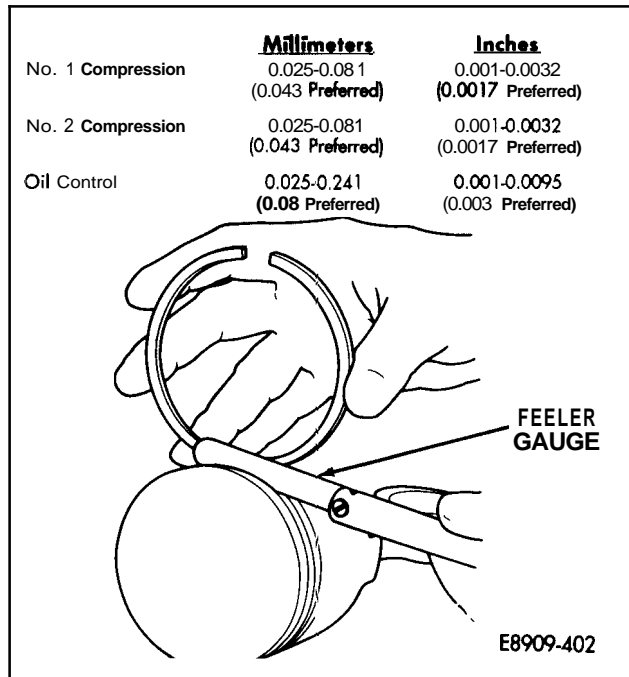


Figure 2 - 38

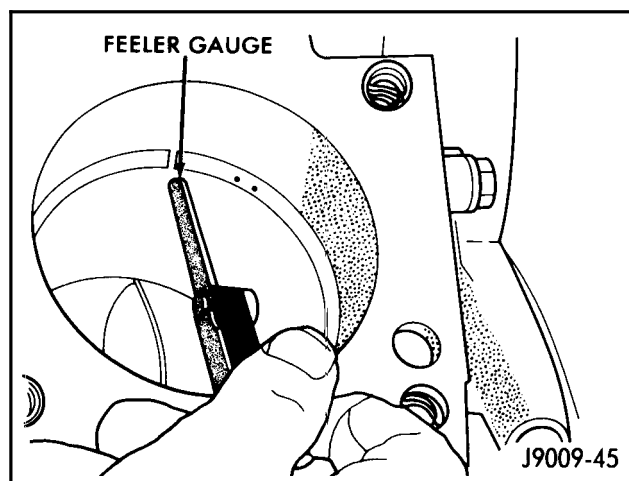


Figure 2 - 39

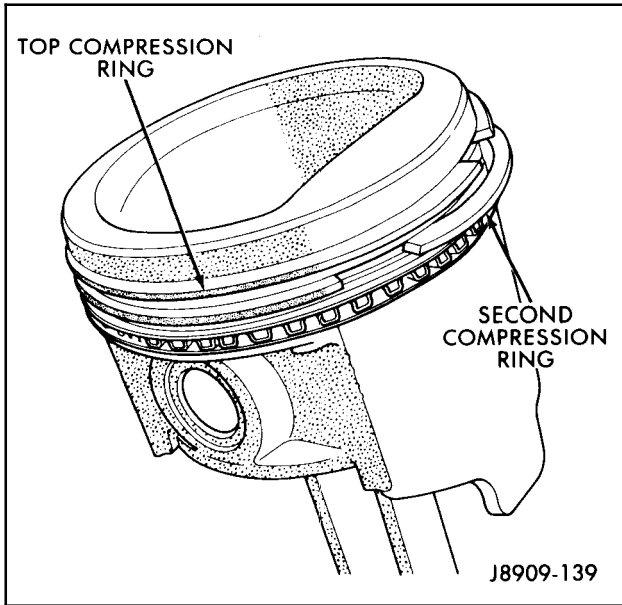


Figure 2 - 40

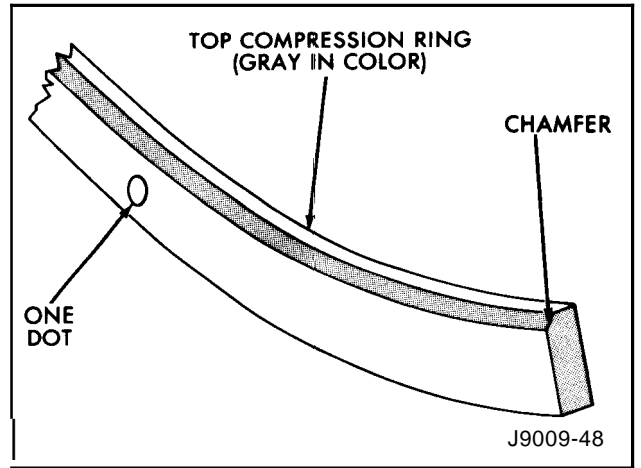


Figure 2 - 43

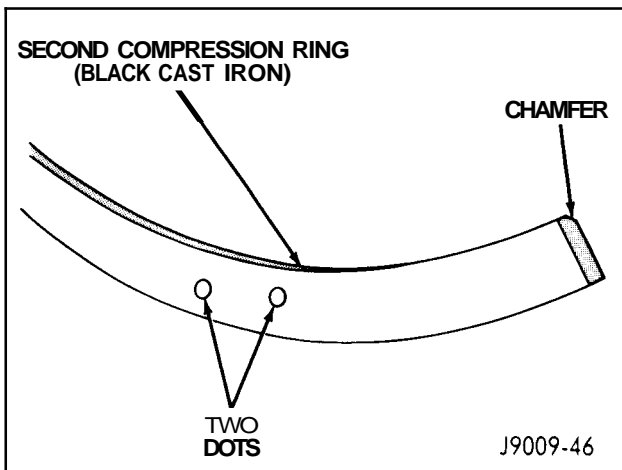


Figure 2 - 41

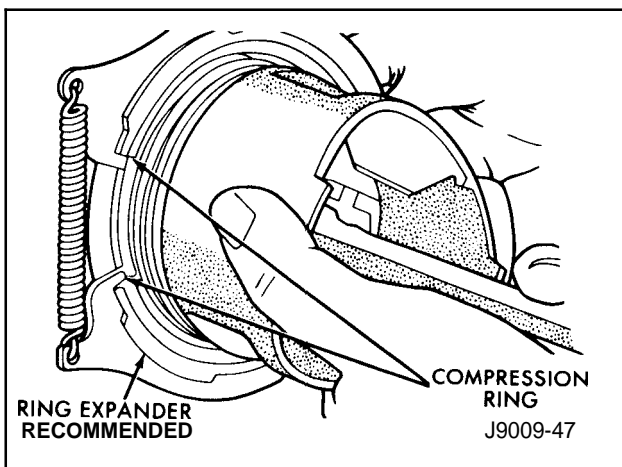


Figure 2 - 42

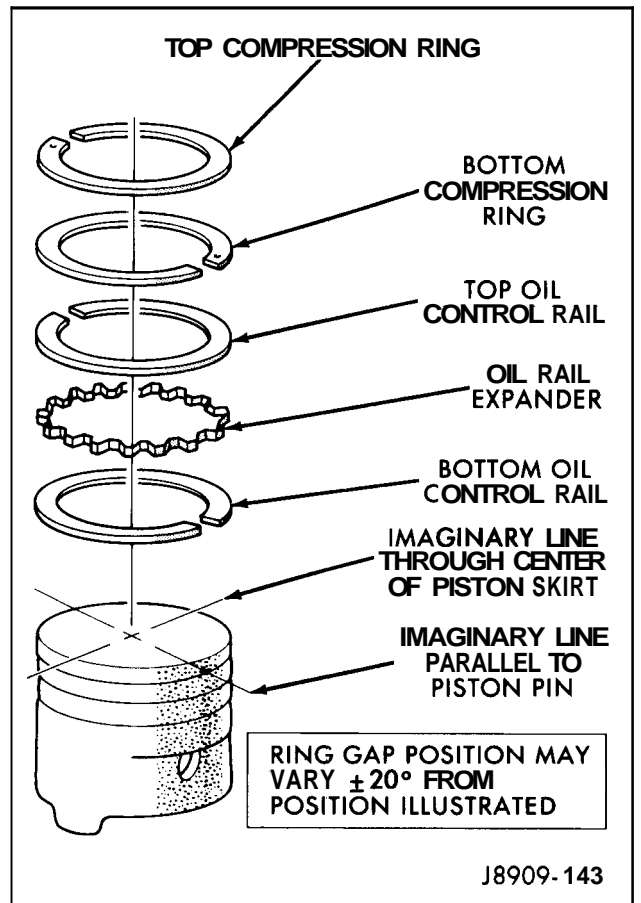


Figure 2 - 44

Piston Ring Fitting (Coated Pistons Only)

- Carefully clean the carbon from all ring grooves. Oil drain openings in the oil ring groove and pin boss must be clear. DO NOT remove metal from the grooves or lands. This will change ring-to-groove clearances and will damage the ring-to-land seating.
- Be sure the piston ring grooves are free of nicks and burrs.
- Measure the ring side clearance with a feeler gauge fit snugly between the ring land and ring. Rotate the ring in the groove. It must move freely around circumference of the groove.

Ring	Side Clearance Measurement
Top Compression Ring (0.0017 to 0.0033")	0.042 to 0.084 mm
Second Compression Ring (0.0017 to 0.0033")	0.042 to 0.084 mm
Oil Control Ring (0.0024 to 0.0083")	0.06 to 0.21 mm

- Place ring in the cylinder bore and push down with inverted piston to position near lower end of the ring travel. Measure ring gap with a feeler gauge fitting snugly between ring ends (Figure 2-39).

Ring	Gap Measurement
Top Compression Ring	0.229 to 0.610 mm (0.0090 to 0.0240")
Second Compression Ring	0.483 to 0.965 mm (0.0190 to 0.0380")
Oil Control Ring	0.254 to 1.500 mm (0.010 to 0.060")

- The oil control rings are symmetrical, and can be installed with either side up. It is not necessary to use a tool to install the upper and lower rails. Insert oil rail spacer first, then side rails.
- The two compression rings are different and cannot be interchanged. The top compression ring can be identified by the shiny coating on the outer sealing surface and can be installed with either side up (Figure 2-45).
- The second compression ring has a slight chamfer on the bottom of the inside edge and a dot on the top for correct installation (Figure 2-46).

- Using a ring installer, install the second compression ring with the dot facing up (Figure 2-47).
- Using a ring installer, install the top compression ring (either side **up**).

Ring Gap Orientation

- Position the gaps on the piston as shown in Figure 2-48.
- Oil spacer - Gap on center line of piston skirt.
- Oil rails - gap 180° apart on centerline of piston pin bore.
- No. 2 Compression ring - Gap 180° from top oil rail gap.
- No. 1 Compression ring - Gap 180° from No. 2 compression ring gap.

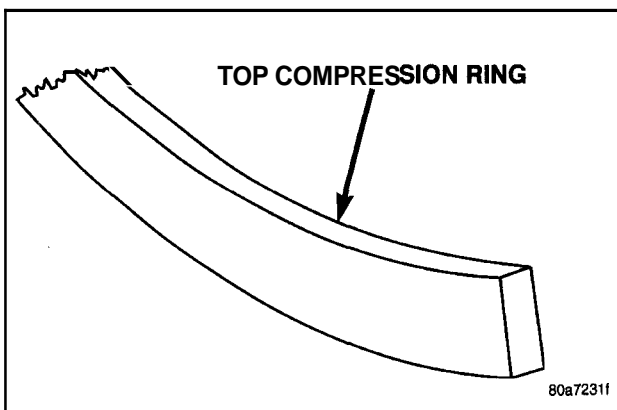


Figure 2 - 45

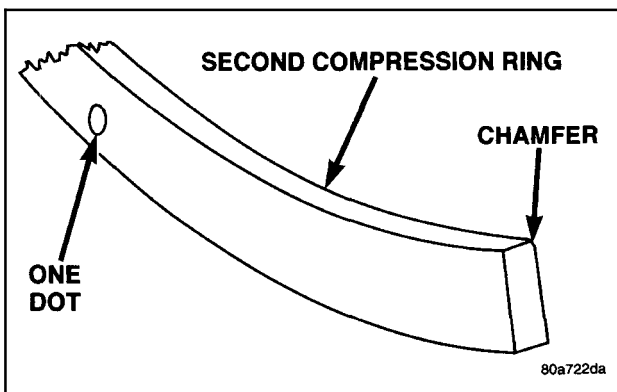


Figure 2 - 46

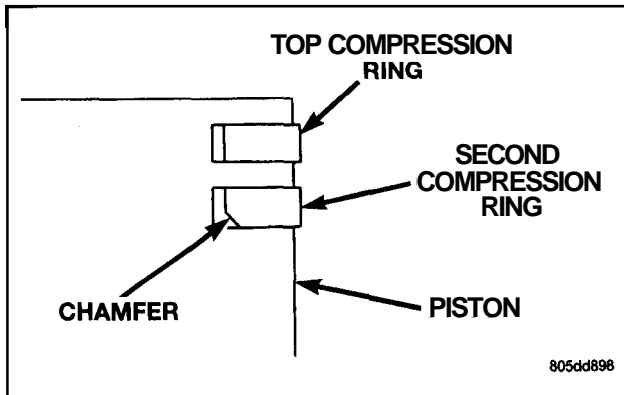


Figure 2 - 47

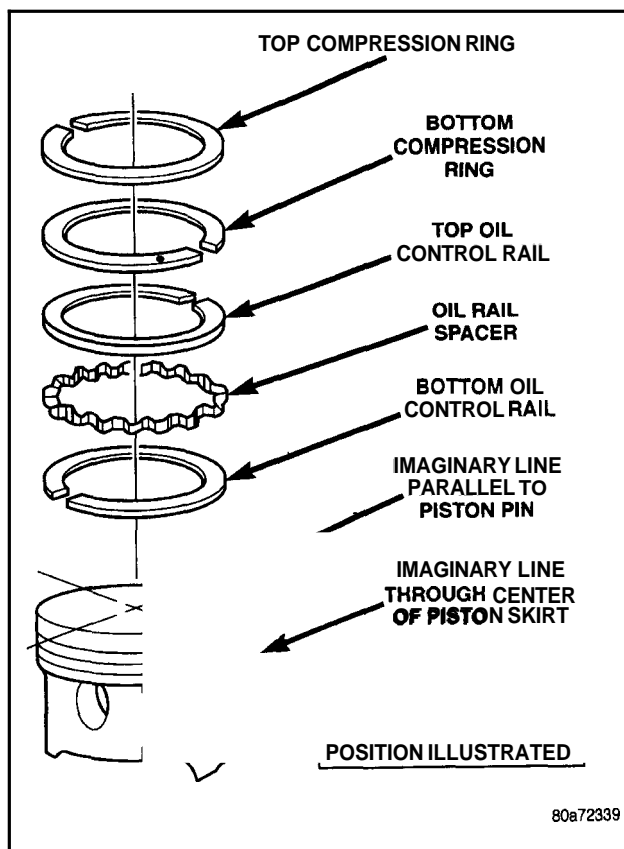


Figure 2 - 48

PISTON PIN

The 2.5L engine's piston pins have a diameter of 23.632-23.645 mm (0.9304-0.9309") and piston-to-pin clearance of 0.010-0.015 mm (0.0004-0.0006") (preferred - loose 0.015 mm [loose 0.0006"]).

The piston pins are press-fit into the connecting rods and DO NOT require a locking device.

Removal

1. Position the piston and connecting rod assembly on an arbor press.
2. Apply force to a piloted driver and press the pin completely out of the connecting rod and piston assembly (Figure 2-49). Note position of the pin through the gauge window of removal support tool.

Inspection

1. Inspect the piston pin and bore in the connecting rod for nicks and burrs. Remove as necessary. Never reuse a piston pin after it has been installed in and removed from a connecting rod.
2. With the pin removed from the piston and connecting rod, clean and dry the piston pin bore and the replacement piston pin.
3. Position the piston so that the pin bore is in the vertical position. Insert the pin in the bore. At room temperature, the replacement pin should slide completely through the pin bore in piston by force of gravity.
4. Replace piston if pin jams in the pin bore.

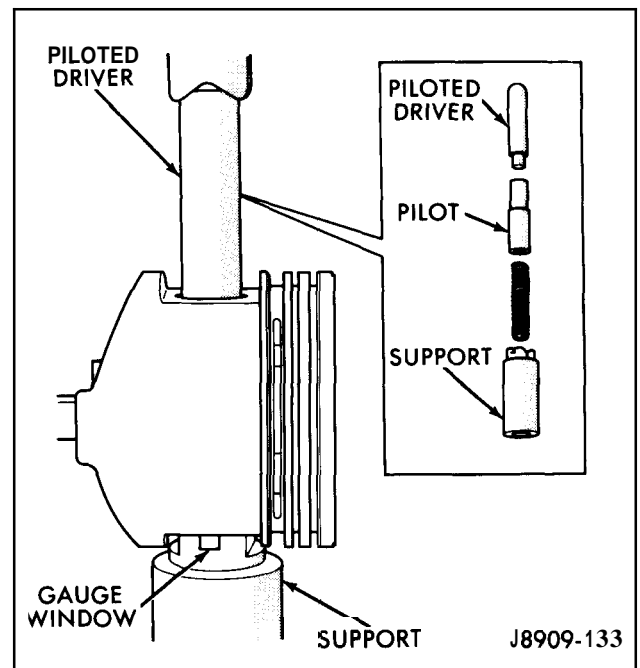


Figure 2 - 49

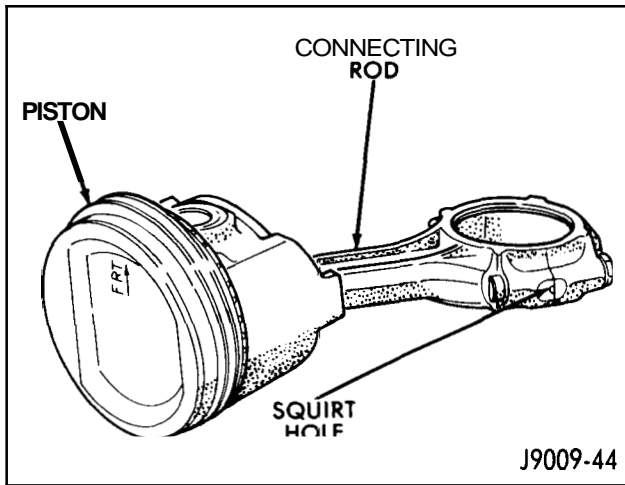


Figure 2 - 50

Installation

1. Insert the piston pin pilot through the piston and connecting rod pin bores. Ensure that the arrow on the piston crown is pointing up (Figure 2-50).
2. Position the pin pilot, piston and connecting rod on a support with the squirt hole of the connecting rod to the left-hand side (Figure 2-50).
3. Insert the piston pin through the upper piston pin bore and into the connecting rod pin bore (Figure 2-49).
4. Position the piloted driver inside the piston pin (Figure 2-49).
5. Using an arbor press, press the piston pin through the connecting rod and piston bores until the pin pilot indexes with the mark on the support. The piston pin requires an 8900 N (2,000 pounds) press-fit. If little effort is required to install the piston pin in the connecting rod, or if the rod moves laterally on the pin, the connecting rod must be replaced.
6. Remove the piston and connecting rod assembly from the press. The pin should be centered in the connecting rod (± 0.792 mm or ± 0.0312 ").



Cylinder Head

INTRODUCTION

The 2.5L engine uses a cast nodular iron cylinder head with a combustion chamber volume of 49.9-52.9 cc (3.04-3.23 cu. in.). The cylinder head has dual quench-type combustion chambers that create turbulence and fast burning of the air/fuel mixture, which results in good fuel economy. Valve lengths are (for intake) 124.435-125.070 mm (4.899-4.924"), and (for exhaust) 125.120-125.755 mm (4.927-4.952").

One of the most important parts of any engine assembly is the cylinder head. It holds the key to making power. It also offers the opportunity to make more horsepower. Camshafts, headers, and carburetion can only go so far making horsepower without the cylinder head. Cylinder heads can be expensive; however, this may be one place in the engine where spending the extra money is worth it.

For more cylinder head specifications, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.

Heavy Duty Head Gasket

This heavy duty head gasket is designed for the 2.5L (only). Can be used as replacement for production. Factory approved and engineered for durability.

P4529662 Heavy duty head gasket.

REMOVAL AND INSTALLATION PROCEDURES

Removal

(Refer to Figure 2-51.)

1. Disconnect negative cable from battery.

Warning! DO NOT remove the cylinder block drain plugs or loosen the radiator drain cock with the system hot and pressurized because serious burns from the coolant can occur.

2. Drain the coolant and disconnect the hoses at the engine thermostat housing. DO NOT waste reusable coolant. If the solution is clean and is being drained only to service the engine or cooling system, drain the coolant into a clean container for reuse.
3. Remove the air cleaner assembly.
4. Remove the engine cylinder head cover. (Refer to procedure in this section.)
5. Remove the capscrews, bridge and pivot assemblies and rocker arms.

6. Remove the pushrods. Retain the pushrods, bridges, pivots and rocker arms in the same order as removed.
7. Loosen the accessory drive belt at the power steering pump bracket (if equipped) or at the idler pulley bracket.
8. If equipped with air conditioning, perform the following:
 - a. Remove the bolts from the A/C compressor mounting bracket and set the compressor aside.
 - b. Remove the air conditioner compressor bracket bolts from the engine cylinder head.
 - c. Loosen the through bolt at the bottom of the bracket.
9. If equipped, disconnect the power steering pump bracket. Set the pump and bracket aside. DO NOT disconnect the hoses.
10. Perform fuel pressure release procedure (refer to the proper service manual for procedures).
11. Remove the latch clip and disconnect the fuel supply hose.
12. Remove the intake and engine exhaust manifolds from the engine cylinder head (refer to 'Fuel Delivery and Fuel Injection Systems' and 'Exhaust System' sections of this chapter for procedures).
13. Number and disconnect the ignition wires and remove the spark plugs.
14. Disconnect the coolant temperature sending unit connector.
15. Remove the engine cylinder head bolts.
16. Remove the engine cylinder head and gasket.
17. If this was the first time the bolts were removed, put a paint dab on the top of the bolt. If the bolts have a paint dab on the top of the bolt or it isn't known if they were used before, discard the bolts.
18. Stuff clean lint free shop towels into the cylinder bores.

Note: If valves, springs, or seals are to be inspected/replaced at this time, refer to *Valves and Valve Springs*, 'Camshaft and Valve Gear' section of this chapter for proper procedures.

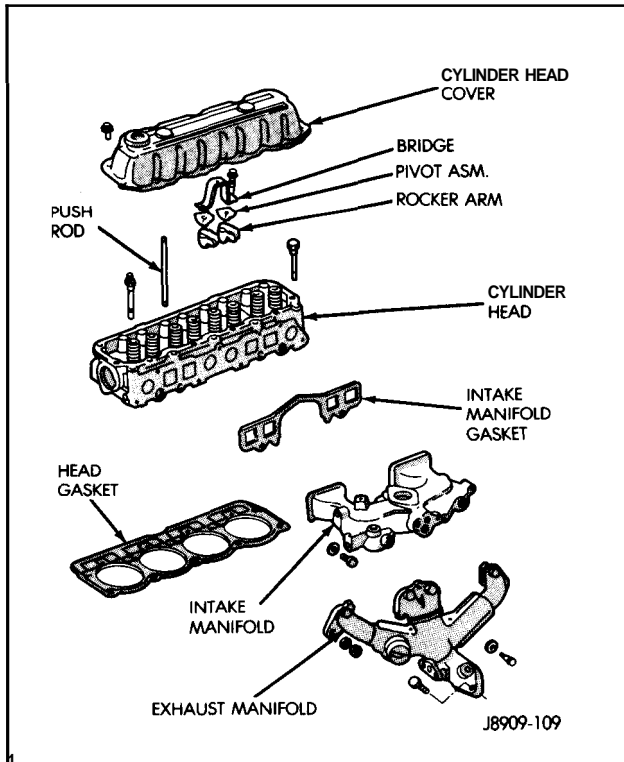


Figure 2 - 51

Cleaning and Inspection

Stuff clean lint free shop towels into the cylinder bores while the head is removed.

Thoroughly clean the cylinder head and cylinder block mating surfaces. Clean the intake and exhaust manifold and cylinder head mating surfaces. Remove all gasket material and carbon.

Check to ensure that no coolant or foreign material has fallen into the tappet bore area.

Remove carbon deposits from the combustion chambers.

Installation

The cylinder head gasket is a composition gasket. The gasket is to be installed DRY. DO NOT use a gasket sealing compound on the gasket.

If the cylinder head is to be replaced and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems. Remove all carbon buildup and reface the valves.

1. Fabricate two engine cylinder head alignment dowels from used head bolts (Figure 2-52). Use the longest head bolt. Cut the head of the bolt off below the hex head. Then cut a slot in the top of the dowel to allow easier removal with a screwdriver.

2. Install one dowel in bolt hole No. 10 and the other dowel in bolt hole No. 8 (Figure 2-53).
3. Remove the shop towels from the cylinder bores. Coat the bores with clean engine oil.
4. Place the engine cylinder head gasket (with the numbers facing up) over the dowels.
5. Place the engine cylinder head over the dowels.

Caution: Engine cylinder head bolts should be reused only once. Replace the head bolts if they were used before or if they have a paint dab on the top of the bolt.

6. Coat the threads of bolt No. 7, only, with Loctite PST sealant (or equivalent).
7. Install all head bolts, except No. 8 and No. 10.
8. Remove the dowels.
9. Install No. 8 and No. 10 head bolts.

Caution: During the final tightening sequence, bolt No. 7 will be tightened to a lower torque than the rest of the bolts. DO NOT over tighten bolt No. 7.

10. Tighten the engine cylinder head bolts in sequence according to the following procedure (Figure 2-54):
 - a. Tighten all bolts in sequence (1 through 10) to 30 N•m (22 ft-lbs) torque.
 - b. Tighten all bolts in sequence (1 through 10) to 61 Nom (45 ft-lbs) torque.
 - c. Check all bolts to verify they are set to 61 N•m (45 ft-lbs) torque.
 - d. Tighten bolts (in sequence):
 - Bolts 1 through 6 to 149N•m (110ft-lbs) torque.
 - Bolt 7 to 136N•m (100ft-lbs) torque.
 - Bolts 8 through 10 to 149 N•m (110 ft-lbs) torque.
 - e. Check all bolts in sequence to verify the correct torque.
 - f. If not already done, clean and mark each bolt with a dab of paint after tightening. Should you encounter bolts which were painted in an earlier service operation, replace them.
11. Connect the coolant temperature sending unit connector.
12. Install the spark plugs and tighten to 37 Nom (27 ft-lbs) torque. Connect the ignition wires.
13. Install the intake and exhaust manifolds (refer to 'Fuel Delivery and Fuel Injection Systems' and 'Exhaust System' sections of this chapter for proper procedures).

14. Install the fuel supply line. Push until a “click” is heard. Reinstall latch clip.
15. If equipped, attach the power steering pump and bracket.
16. Install the pushrods, rocker arms, pivots and bridges in the order they were removed.
17. Install the engine cylinder head cover.
18. Attach the air conditioning compressor mounting bracket to the engine cylinder head and block. Tighten the bolts to 40 N•m (30 ft-lbs) torque.
19. Attach the air conditioning compressor to the bracket. Tighten the bolts to 27 N•m (20 ft-lbs) torque.

Caution: The accessory drive belt must be routed correctly. Incorrect routing can cause the water pump to turn in the opposite direction causing the engine to overheat.

20. Install the accessory drive belt and correctly tension the belt (refer to proper service manual for the procedure).
21. Install the air cleaner and ducting.
22. Connect the hoses to the thermostat housing and fill the cooling system to the specified level (refer to proper service manual for the procedure).
23. Install the coolant temperature sending unit connector.
24. Connect negative cable to battery.
25. Connect the upper radiator hose and heater hose at the thermostat housing.
26. Fill the cooling system. Check for leaks.

Warning! Use extreme caution when the engine is operating. DO NOT stand in direct line with the fan. DO NOT put hands near the pulleys, belts or fan. DO NOT wear loose clothing.

27. Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.

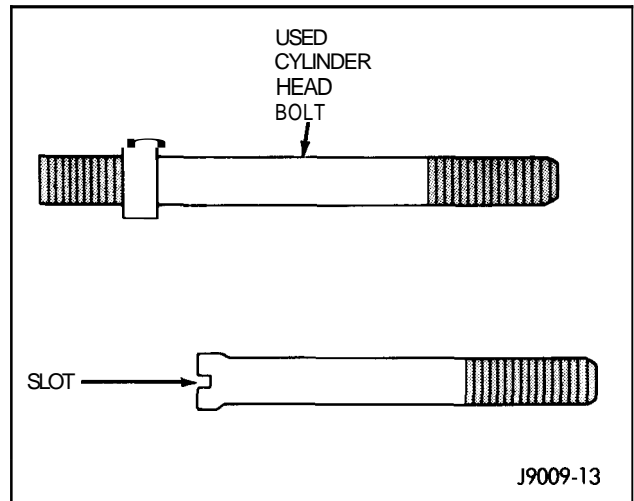


Figure 2 - 52

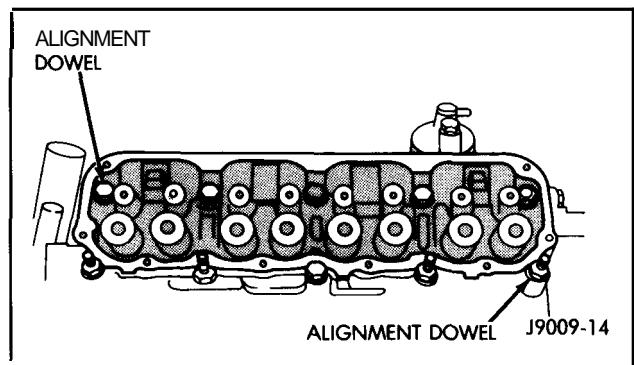


Figure 2 - 53

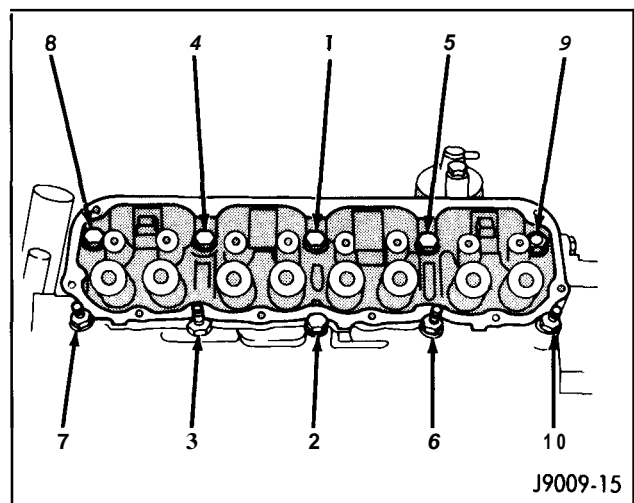


Figure 2 - 54

CYLINDER HEAD COVER

The following procedure can be performed with the engine in or out of the vehicle.

Crankcase Breather

A universal high performance re-usable crankcase breather (must have stand pipe on valve cover). Washes clean with P4529392 cleaning fluid for **extra** miles of service.

P4529394 Crankcase breather.

Removal

1. Disconnect the battery negative cable.
2. Disconnect the Crankcase Ventilation (CCV) vacuum hose (MJ and XJ Vehicles - Figure 2-55) or the Positive Crankcase Ventilation (PCV) vacuum hose (YJ Vehicles - Figure 2-56) from the cylinder head cover.
3. Disconnect the CCV (Figure 2-55) or the PCV (Figure 2-56) fresh air inlet hose from the cylinder head cover.
4. Remove the cylinder head cover mounting bolts.
5. Remove the cylinder head cover.

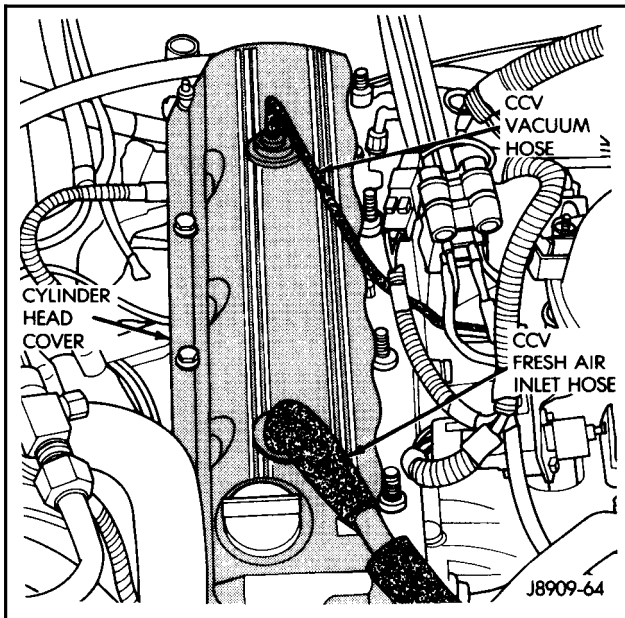


Figure 2 - 55

Inspection

Inspect the cylinder head cover for cracks. Replace if cracked.

Installation

The cylinder head cover has a cured gasket attached to it.

1. Thoroughly clean the sealing surface of the cylinder head and the seal on the cylinder head cover.
2. Install cylinder head cover. Tighten the mounting bolts to 8 N•m (70 in-lbs) torque.
3. Connect the CCV hose (Figure 2-55) or the PCV hose (Figure 2-56).
4. Connect the battery negative cable.

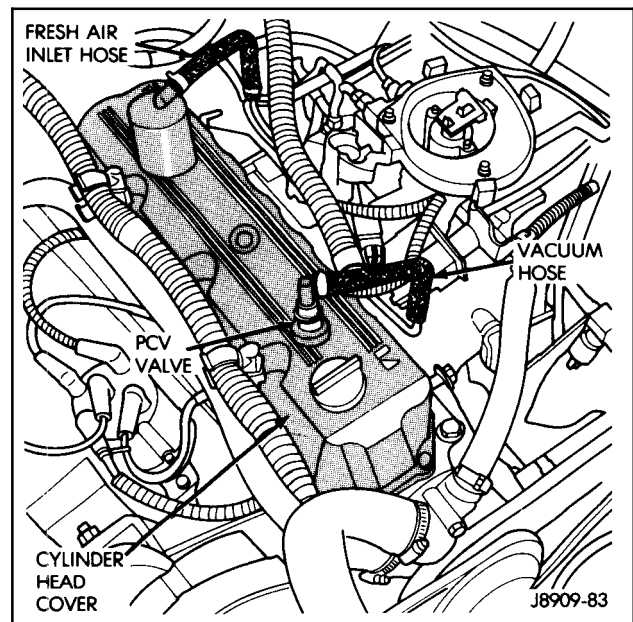


Figure 2 - 56



Camshaft and Valve Gear

CAMSHAFT

The Jeep 2.5L engine uses a cast nodular iron camshaft with intake and exhaust valve lifts of 10.770 mm (0.424"), intake and exhaust cam lobe lifts of 6.731 mm (0.265"), and intake and exhaust durations of 270°.

The camshaft rotates within four steel-shelled, Babbit-lined bearings that are pressed into the cylinder block and then line reamed. The camshaft bearing bores and bearing diameters are not the same size. They are stepped down in 0.254 mm (0.010") increments from the front bearing (largest) to the rear bearing (smallest). This permits easier removal and installation of the camshaft. The camshaft bearings are pressure lubricated.

Note: It is not advisable to attempt to replace camshaft bearings unless special removal and installation tools are available.

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear. The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face.

To advance or retard camshaft centerline, the 2.5L engine uses offset bushings. For more information on centerlining as well as offset bushings, refer to the 'Camshaft and Valve Gear' section of Chapter 4.

For more camshaft specifications, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.

Camshaft Bearing Set

Made of production material. Complete engine set for Jeep 2.5L and 4.0L engines.

P4529226 Camshaft bearing set.

Timing Chain and Sprockets Set

This kit is the ideal service replacement package for Jeep 2.5L engines. The package includes single roller timing chain and sprockets.

P4529822 Timing chain and sprockets set.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

All-out Race Chain and Sprockets

Cloyes matched sprockets and double roller chain for all-out race applications. Has three matched keyways to adjust cam timing. Kit includes Magna-fluxed sprockets and roller timing chain. For 2.5L and 4.0L engines only.

P5249519 All-out race chain and sprockets.

Camshaft Offset Bushing Set

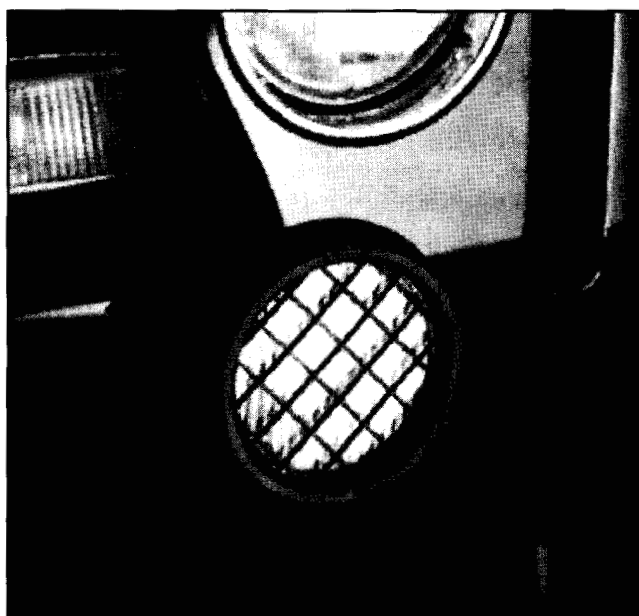
For centerlining camshafts, all engines. Includes five bushings: 2, 4, 6, and 8 degree offset, plus one on-center bushing. Installs in camshaft sprocket. For all Jeep 4.0L and 2.5L engines.

P3690936 Camshaft offset bushing set.

0-90-180-90-0 Degree Wheel

Durable Mopar Performance Parts aluminum plate degree wheel for centerlining camshafts, finding TDC, etc. Features step-by-step instructions printed on the back side.

P4452990 0-90-180-90-0 degree wheel.



Jeep 2.5L Hydraulic Camshaft Specifications Chart

Part No.	Advertised Duration	Overlap	Centerline	Lift	Recom. Spring	Applications & Comments
P4529656	2401240"	24"	108°	.430/.430"	P45292 14	Mild Comp.
P4529657	2481248"	32"	108°	.440/.440"	P4529214	Mild Comp.
P4.529658	2561256"	40°	108°	.450/.450"	P5249464	Mild Comp.

Performance Level	Best Choice		4x4 Auto & Man	Street Rod Auto & Man
	Manual	Automatic		
Stock	Stock	Stock	---	---
Phase I	P4529656	P4529656		
Phase II	P4529657	P4529657	P4529656	P4529656
Phase III	P4.529658	P4529658	P4529657	P4529657

Removal

1. Disconnect the battery negative cable.

Warning! The coolant in a recently operated engine is hot and pressurized. Release the pressure before removing the drain cock, cap and drain plugs.

2. Drain the cooling system. DO NOT waste reusable coolant. If the solution is clean, drain it into a clean container for reuse.
3. Remove the radiator or radiator and condenser, if equipped with A/C.
4. Scribe a mark on the distributor housing in line with the lip of the rotor.
5. Scribe a mark on the distributor housing near the clamp and continue the scribe mark on the cylinder block in line with the distributor mark.
6. For ease of installation, note the position of the rotor and distributor housing in relation to adjacent engine components.
7. Remove the distributor and ignition wires.
8. Remove the engine cylinder head cover.
9. Remove the rocker arms, bridges and pivots.
10. Remove the pushrods.
11. Remove the hydraulic valve tappets from the engine cylinder head.
12. Remove the vibration damper.
13. Remove the timing case cover.

14. Remove the timing chain and sprockets.

15. Remove the camshaft (Figure 2-6).

Inspection

1. Inspect the cam lobes for wear.
2. Inspect the bearing journals for uneven wear pattern or finish.
3. Inspect the bearings for wear.
4. Inspect the distributor drive gear for wear.
5. If the camshaft appears to have been rubbing against the timing case cover, examine the oil pressure relief holes in the rear cam journal. The oil pressure relief holes must be free of debris.

Installation

Note: When installing a new camshaft, ALWAYS use new lifters.

1. Lubricate the replacement camshaft with Mopar Engine Oil Supplement, or equivalent.
2. Carefully install the camshaft to prevent damage to the camshaft bearings (Figure 2-6).
3. Turn the tensioner lever to the unlocked (down) position.
4. Pull the tensioner block toward the tensioner lever to compress the spring. Hold the block and turn the tensioner lever to the lock (up) position (Figure 2-25).
5. Install the timing chain, crankshaft sprocket and (camshaft)sprocket with the timing marks aligned.

6. Install the camshaft sprocket retaining bolt and washer. Tighten the bolt to 108 N•m (80 ft-lbs) torque.
7. Release the timing chain tensioner by moving the lever to the unlocked (down) position (Figure 2-25).
8. Install the timing case cover with a replacement oil seal (Figure 2-3).
9. Install the vibration damper
10. Install the hydraulic valve tappets.
11. Install the pushrods.
12. Install the rocker arms, bridges and pivots.
13. Install the cylinder head cover.
14. Install the distributor and ignition wires.
15. Properly position the distributor rotor as follows:

Note: Always rotate the crankshaft clockwise (the direction of normal rotation). DO NOT rotate the crankshaft backward to align the timing marks.

- a. Remove No. 1 spark plug. Hold your finger over the spark plug hole and rotate the crankshaft until compression pressure is felt. Slowly continue to rotate the crankshaft until the timing index on the vibration damper pulley aligns with the top dead center (TDC) mark (0°) on the timing degree scale.
- b. Using a flat blade screwdriver, rotate the oil pump gear so that the gear slot on the oil pump shaft is slightly past the three (3) o'clock position (Figure 2-57).
- c. Turn the distributor shaft until the rotor tip points in the direction of No. 1 terminal in the distributor cap. Turn the rotor $1/8$ turn counterclockwise past the position of No. 1 terminal.
- d. With the distributor cap removed, start the distributor into the cylinder block with the rotor located at the five (5) o'clock position (Figure 2-58).
- e. Slide the distributor shaft down into the engine and position the distributor vacuum advance mechanism housing in approximately the same location (in relation to adjacent engine components) as when removed. Align the scribe mark on the distributor housing with the corresponding scribe mark on the cylinder block. It may be necessary to rotate the oil pump shaft with a long flat-blade screwdriver to engage the oil pump drive tang, but the rotor should align with the position of No. 1 terminal when the distributor shaft is down in place.
- f. Install the distributor hold-down clamp and bolt, but DO NOT tighten the bolt.

- g. When the distributor is fully engaged in its correct location, the rotor should be at the six (6) o'clock position (Figure 2-59).
- h. If the distributor is not properly installed, or if it is removed later, then the complete installation procedures must be repeated.

16. Install the radiator and condenser (if equipped with A/C).
17. Fill the cooling system.
18. Connect the battery negative cable.

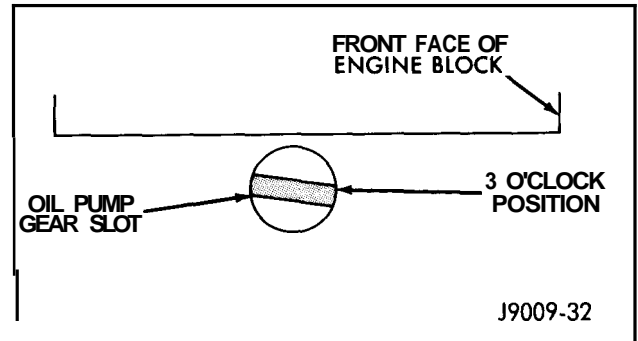


Figure 2 - 57

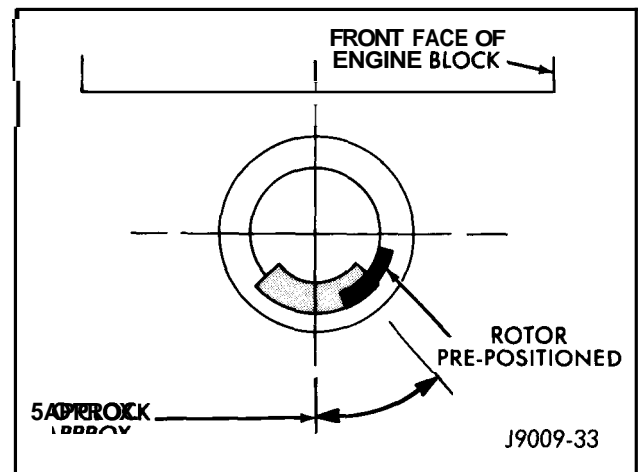


Figure 2 - 58

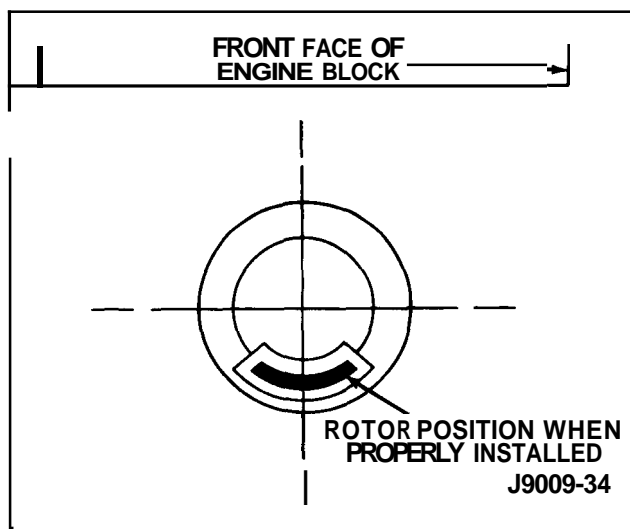


Figure 2 - 59

CAMSHAFT PIN REPLACEMENT

Removal

1. Disconnect the battery negative cable.

Warning! DO NOT loosen the radiator draincock with the system hot and pressurized because serious burns from coolant can occur.

2. Drain the radiator. DO NOT waste reusable coolant. If solution is clean, drain it into a clean container for reuse.
3. Remove the fan and shroud.
4. Disconnect the radiator overflow tube, radiator hoses, and automatic transmission fluid cooler pipes (if equipped).
5. Remove the radiator.
6. If equipped with air conditioning:
 - a. Remove the A/C compressor drive belt idler pulley.
 - b. Disconnect and remove the alternator.

Caution: DO NOT loosen or disconnect any air conditioner system fittings. Move the condenser and receiver/drier aside as a complete assembly.

- c. Remove the A/C condenser attaching bolts and move the condenser and receiver/drier assembly up and out of the way.
7. Remove the drive belt(s).
 8. Remove the crankshaft vibration damper and pulley.
 9. Remove the timing case cover. Clean the gasket material from the cover.
 10. Rotate the crankshaft until the zero degree (0°) timing mark on the crankshaft sprocket is closest to and on the centerline with the timing mark on the camshaft sprocket.

11. Remove camshaft sprocket retaining bolt.
12. Remove the crankshaft oil slinger.
13. Remove the sprockets and chain as an assembly (Figure 2-60).

Caution: The following procedural step must be accomplished to prevent the camshaft from damaging the rear camshaft plug during pin installation.

14. Inspect the damaged camshaft pin.
15. If the pin is a spring-type pin, remove the broken pin by inserting a self-tapping screw into the pin and carefully pulling the pin from the camshaft.
16. If the pin is a dowel-type pin, center-punch it. Ensure the exact center is located when center-punching the pin.

Caution: Cover the opened oil pan area to prevent metal chips from entering the pan.

17. Drill into the pin center with a 4 mm (5/32") drill bit.
18. Insert a self-tapping screw into the drilled pin and carefully pull the pin from the camshaft.

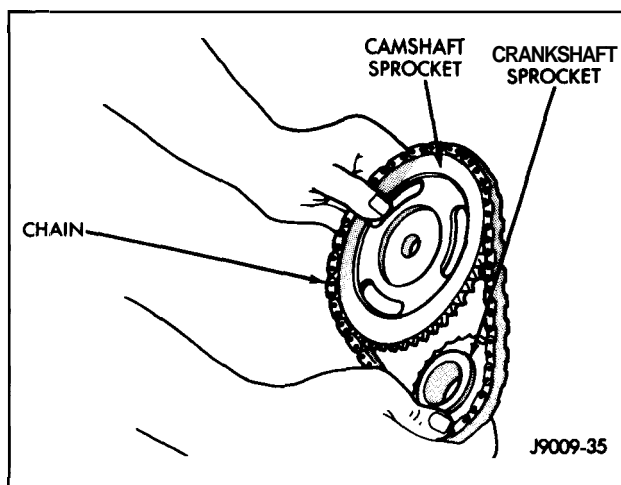


Figure 2 - 60

Installation

1. Clean the camshaft pin hole.
2. Compress the center of the replacement spring pin with vise grips.
3. Carefully drive the pin into the camshaft pin hole until it is seated.
4. Install the camshaft sprocket, crankshaft sprocket and timing chain with the timing marks aligned.

5. To verify correct installation of the timing chain, turn the crankshaft to position the camshaft sprocket timing mark at approximately the one o'clock position. This positions the crankshaft sprocket timing mark where the adjacent tooth meshes with the chain at the three (3) o'clock position. Count the number of chain pins between the timing marks on both sprockets. There must be 20 pins.
6. Install the crankshaft oil slinger.
7. Tighten the camshaft sprocket bolt to 108N•m (80ft-lbs) torque
8. Check the valve timing.
9. Coat both sides of the replacement timing case cover gasket with gasket sealer. Apply a 3 mm (1/8") bead of Mopar Silicone Rubber Adhesive Sealant, or equivalent to the joint formed at the timing case cover and cylinder block.
10. Position the timing case cover on the oil pan gasket and the cylinder block.
11. Place timing case cover alignment and seal installation tool in the crankshaft opening of the cover (Figure 2-22).
12. Install the timing case cover-to-cylinder block bolts. Install the oil pan-to-timing case cover bolts.
13. Tighten the 1/4" cover-to-block bolts to 7 N•m (60 in-lbs) torque. Tighten the 5/16" front cover-to-block bolts to 22 N•m (192 in-lbs) torque. Tighten the oil pan-to-cover 1/4" bolts to 14 N•m (120 in-lbs) torque. Tighten the oil pan-to-cover 5/16" bolts to 18 N•m (156 in-lbs) torque.
14. Remove the cover alignment tool and install a replacement oil seal into the cover.
15. Install the vibration damper on the crankshaft.
16. Lubricate and tighten the damper bolt to 108 N•m (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt torque value is attained, the crankshaft can be prevented from turning by placing two, 5/16 x 1-1/2" bolts into the damper front pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
17. Install the damper pulley, if applicable.
18. If equipped with air conditioning:
 - a. Install the A/C compressor drive bell idler pulley.
 - b. Install the alternator.
 - c. Install the A/C condenser and receiver/drier assembly.
19. Install the drive belt(s) on the pulleys and tighten.
20. Install the radiator. Connect the radiator hoses and automatic transmission fluid cooler pipes, if equipped. Fill the cooling system.

21. Install the fan and shroud.
22. Connect the battery negative cable.

VALVES AND VALVE SPRINGS

Removal—Cylinder Head Removed

This procedure is for the removal/installation of the valves and valve springs with the cylinder head removed from the cylinder block.

1. Remove the cylinder head from the cylinder block (refer to 'Cylinder Head' section of this chapter for procedure).
2. Use valve spring compressor tool and compress each valve spring (Figure 2-61).
3. Remove the valve locks, retainers, springs and valve stem oil seals. Discard the oil seals.
4. Use an Arkansas smoothstone or a jewelers file to remove any burrs on the top of the valve stem, especially around the groove for the locks.
5. Remove the valves, and place them in a rack in the same order as removed.

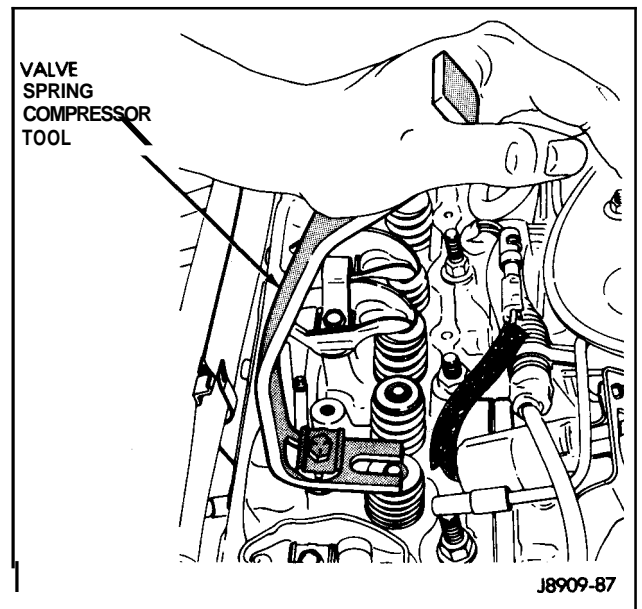


Figure 2 - 61

Removal—Cylinder Head NOT Removed

This procedure is for the removal of valve springs and oil seals with the cylinder head installed on the cylinder block.

Each valve spring is held in place around the valve stem by a retainer and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

1. Remove the cylinder head cover (refer to 'Cylinder Head' section of this chapter for procedure).
2. Remove capscrews, bridge and pivot assemblies and rocker arms (Figure 2-62) for access to each valve spring to be removed. Alternately loosen each capscrew one turn at a time to avoid damaging the bridge.
3. Remove pushrods (Figure 2-62). Retain the pushrods, bridges, pivots and rocker arms in the same order and position as removed.
4. Inspect the springs and retainer for cracks and possible signs of weakening.
5. Remove the spark plug(s) adjacent to the cylinder(s) below the valve springs to be removed.
6. Install a 14 mm (1/2") (thread size) air hose adapter in the spark plug hole. An adapter can be constructed by welding an air hose connection to the body of a spark plug with the porcelain removed.
7. Connect an air hose to the adapter and apply air pressure slowly. Maintain at least 621 kPa (90 psi) of air pressure in the cylinder to hold the valves against their seats. For vehicles equipped with an air conditioner, use a flexible air adapter when servicing the No. 1 cylinder.
8. Tap the retainer or tip with a rawhide hammer to loosen the lock from the retainer. Use valve spring compressor tool to compress the spring and remove the locks (Figure 2-61). Use an old rocker arm pivot and the supplied bolt to attach the tool.
9. Remove valve spring and retainer (Figure 2-63).
10. Remove valve stem oil seals (Figure 2-63). Note the valve seals are different for intake and exhaust valves. The top of each seal is marked either INT or EXH. DO NOT mix the seals.

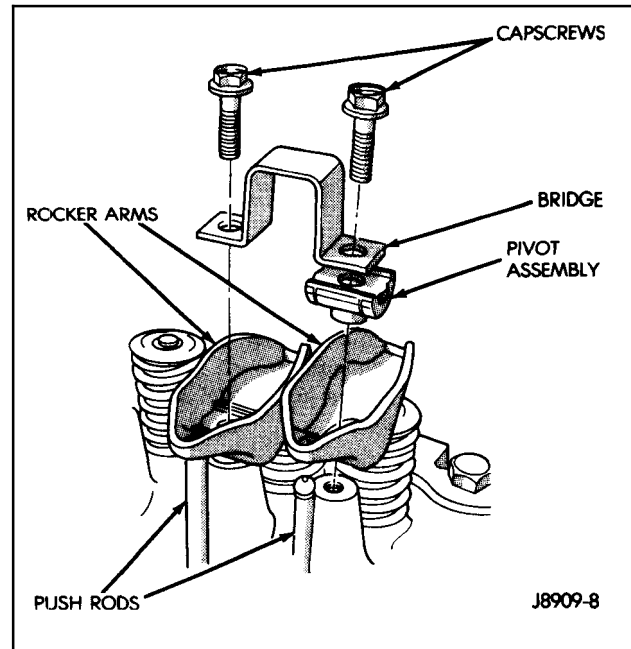


Figure 2 - 62

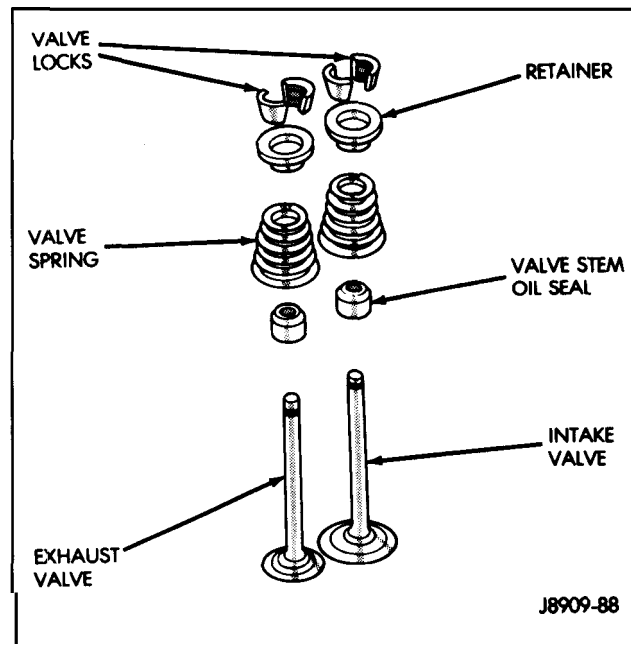


Figure 2 - 63

Cleaning

1. Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and cylinder head.
2. Clean all grime and gasket material from the cylinder head machined gasket surface.

Inspection

1. Inspect for cracks in combustion chambers and valve ports.
2. Inspect for cracks on exhaust seats.
3. Inspect for cracks in the gasket surface at each coolant passage.
4. Inspect valves for burned, cracked or warped heads.
5. Inspect for scuffed or bent valve stems, especially the grooves. An Arkansas smoothstone should be used to remove nicks and high spots. Replace valves displaying any damage.

Valve Refacing

1. Use a valve refacing machine to reface the intake and exhaust valves to the specified angle. After refacing, at least a 0.787 mm (1/32") margin must remain (Figure 2-64). If not, replace the valve.
2. The valve stem tip can be resurfaced and rechambered when worn. DO NOT remove more than 0.25 mm (0.010").

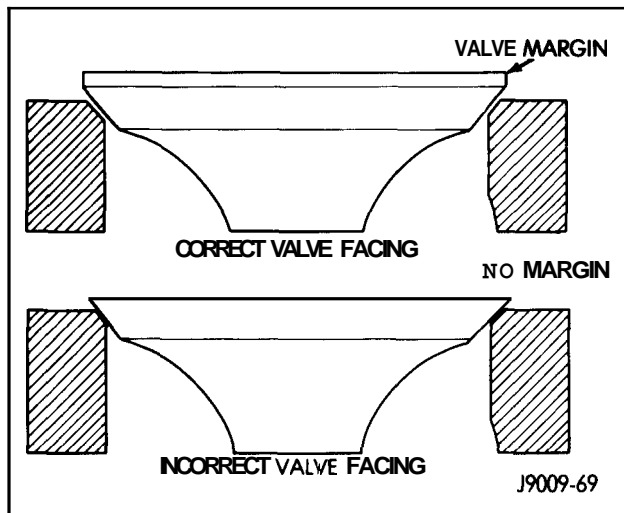


Figure 2 - 64

Valve Spring Tension Test

The 2.5L engines use a conical valve spring (Figure 2-65). Use a valve spring tester and a torque wrench (Figure 2-66) to test each valve spring for the specified tension value. (Refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter, for valve spring tension values.) Replace valve springs that are not within specification.

Installation – Cylinder Head Removed

1. Thoroughly clean the valve stems and valve guide bores.
2. Lightly lubricate the stem and install the valve in the original valve guide bore.

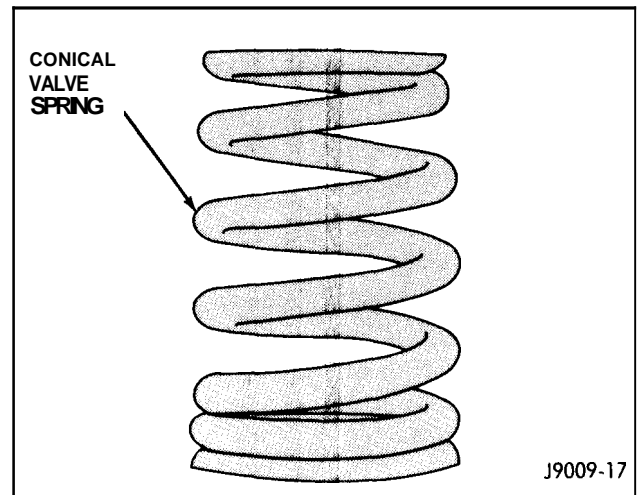


Figure 2 - 65

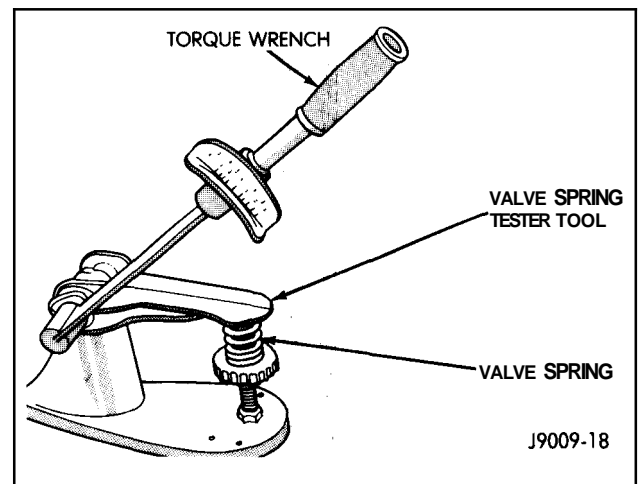


Figure 2 - 66

3. Install replacement valve stem oil seals over the valve stems and onto the valve guide boss.

Note: If valves with 0.381 mm (0.015") oversize stems are used, oversize oil seals are required.
4. Position the valve spring and retainer on the cylinder head and compress the valve spring with valve spring compressor tool (Figure 2-61). Install valve locks and release the tool.
5. Lightly tap the valve spring from side-to-side with a rubber hammer to ensure the spring is properly seated on the cylinder head.
6. Install the cylinder head to the cylinder block (refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter, for the procedure).

Installation—Cylinder Head NOT Removed

Caution: Install oil seals carefully to prevent damage from the sharp edges of the valve spring lock groove.

1. Lightly push the valve seal over the valve stem and valve guide boss. Be sure the seal is completely seated on the valve guide boss.
2. Install valve spring and retainer.
3. Compress the valve spring with valve spring compressor tool (Figure 2-61) and insert the valve locks. Release the spring tension and remove the tool. Tap the spring from side-to-side with a rubber hammer to ensure that the spring is seated properly on the cylinder head.
4. Release air pressure and disconnect the air hose. Remove the adapter from the spark plug hole and install the spark plug.
5. Repeat these procedures for each remaining valve spring to be removed.
6. Install the pushrods. Ensure the bottom end of each rod is centered in the plunger cap seat of the hydraulic valve tappet.
7. Install the rocker arms, pivots and bridge at their original location.
8. Tighten the bridge capscrews alternately, one at a time, to avoid damaging the bridge. Tighten the capscrews to 28 N•m (21 ft-lbs) torque.
9. Install the cylinder head cover (refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure).

Jeep 2.5L Valve Specifications Chart

Part Number	Location	Diameter	Length	Material	Modification
P4529212	Intake std.	Std.	Std.	Std.	Back-cut, 8 mm
P4529213	Exhaust	Std.	Std.	Std.	Back-cut, 8 mm
P5249875	Intake	1.92"	4.91"	Stainless	8 mm stem
P5249877	Intake	1.97"	4.91"	Stainless	8 mm stem
P5249879	Exhaust	1.50"	4.93"	Stainless	8 mm stem
P5249880	Exhaust	1.56"	4.93"	Stainless	8 mm stem

Jeep 2.5L Valve Spring Specifications Chart

Part Number	Installed Ht.	Description	O.D.	Wire Diameter	Lift Range	Material
P4529214	1.64"	Cylindrical	1.31"	.177"	.350/.430"	Prod.
P4529215	1.64"	Conical	Prod.	Prod.	.350/.430"	Prod.
P5249464	1.64"	Single w/damper	1.42"	.187"	.400/.525"	Chrome-sil

Jeep 2.5L Valve Spring Retainer Specifications Chart

Retainer	Material	Locks	Valve Stem Size	Valve Spring
P4529216	Steel	8°	8 mm	Single-Std.
P4529217	Steel	8°	8 mm	Conical

r**Jeep 4 and 6 Cylinder Engine Keepers (Locks)**

Part Number	Valve Stem Size	Angle	Hardened	Groove	Use With Retainers	Sets
P4529218	8 mm	8°	Std.	Single	P4529216, P4529217	24 Pieces

VALVE TIMING

1. Disconnect the spark plug wires and remove the spark plugs.
2. Remove the engine cylinder head cover.
3. Remove the capscrews, bridge and pivot assembly, and rocker arms from above the No. 1 cylinder.
4. Alternately loosen each capscrew, one turn at a time, to avoid damaging the bridge.
5. Rotate the crankshaft until the No. 4 piston is at top dead center (TDC) on the compression stroke.
6. Rotate the crankshaft counterclockwise (viewed from the front of the engine) 90°.
7. Install a dial indicator on the end of the No. 1 cylinder intake valve pushrod. Use rubber tubing to secure the indicator stem on the pushrod.
8. Set the dial indicator pointer at zero.
9. Rotate the crankshaft clockwise (viewed from the front of the engine) until the dial indicator pointer indicates 0.305 mm (0.012") travel distance (lift).
10. The timing notch index on the vibration damper should be aligned with the TDC mark on the timing degree scale.

If the timing notch is more than 13 mm (1/2") away from the TDC mark in either direction, the valve timing is incorrect.

If the valve timing is incorrect, the cause may be a broken camshaft pin. It is not necessary to replace the camshaft because of pin failure. A spring pin is available for service replacement.

VALVE STEM OIL SEALS

Valve stem seals are installed over each valve stem and valve guide boss preventing oil from entering the combustion chamber through the valve guides. There are separate seals for intake and exhaust valve stems. Seals marked INT are for intake valve stems, seals marked EXH are for exhaust valve stems. Replace valve stem seals when service is performed or if the seals have deteriorated.

Viton Valve Stem Oil Seal Set

Viton heavy duty umbrella seals are specially designed to withstand high temperatures. Helps prevent oil seepage down valve guides. Good for dual purpose high performance engines. Includes 4 intake and 4 exhaust seals. Not recommended for dual valve springs. Fits 2.5L engine valves with 8 mm stems only.

P4529661 Viton valve stem oil seal set.

Race Valve Stem Oil Seal Sets

Perfect Circle valve stem oil seals for use with dual valve springs in race applications. Set of 16 seals. Includes installation tool.

P3690963 Race valve stem oil seal set, 3/8" inside diameter.

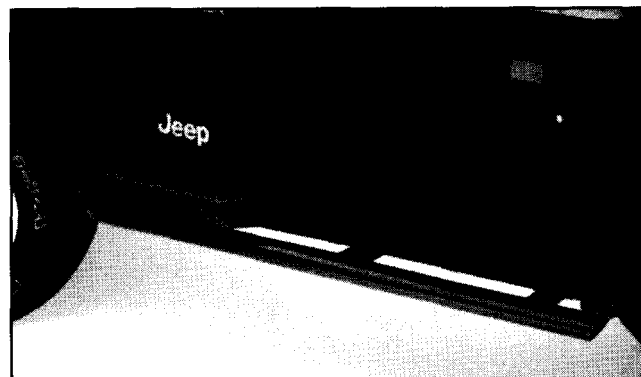
P4876099 Race valve stem oil seal set, 11/32" inside diameter.

P4876100 Race valve stem oil seal set, 5/16" inside diameter.

VALVE GUIDES

The valve guides are an integral part of the cylinder head and are not replaceable. When the valve stem guide clearance is excessive, the valve guide bores must be reamed oversize. Service valves with oversize stems are available in 0.076 mm (0.003") and 0.381 mm (0.015") increments. Corresponding oversize valve stem seals are also available and must be used with valves having 0.381 mm (0.015") oversize stems.

Note: If the valve guides are reamed oversize, the valve seats must be reground afterwards to ensure that the valve seat is concentric to the valve guide.



Valve Stem-to-Guide Clearance Measurement

Valve stem-to-guide clearance may be measured by either of the following two methods.

1. Preferred Method

- Remove the valve from the head.
- Clean the valve stem guide bore with solvent and bristle brush.
- Insert a telescoping gauge into the valve stem guide bore approximately 9.525 mm (3/8") from the valve spring side of the head with contacts crosswise to the cylinder head (Figure 2-67). Remove and measure telescoping gauge with a micrometer.
- Repeat the measurement with contacts lengthwise to cylinder head.
- Compare the crosswise to lengthwise measurements to determine out-of-roundness. If the measurements differ by more than 0.0635 mm (0.0025"), ream the guide bore to accommodate an oversize valve stem.
- Compare the measured valve guide bore diameter with specifications (7.95-7.97 mm or 0.313-0.314"). If the measurement differs from specification by more than 0.076 mm (0.003"), ream the guide bore to accommodate an oversize valve stem.

Note: Valve seats must be reground after reaming the valve guides to ensure that the valve seat is concentric to the valve guide.

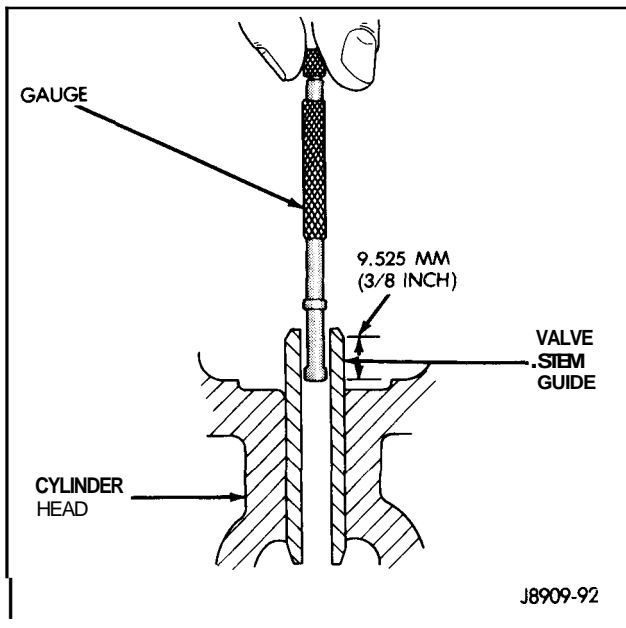


Figure 2 - 67

2. Alternate Method

- Use a dial indicator to measure the lateral movement of the valve stem (stem-to-guide clearance). This must be done with the valve installed in its guide and just off the valve seat (Figure 2-68).
- Correct clearance is 0.025-0.0762 mm (0.001-0.003"). If indicated movement exceeds the specification, ream the valve guide to accommodate an oversize valve stem.

Note: Valve seats must be reground after reaming the valve guides to ensure that the valve seat is concentric to the valve guide.

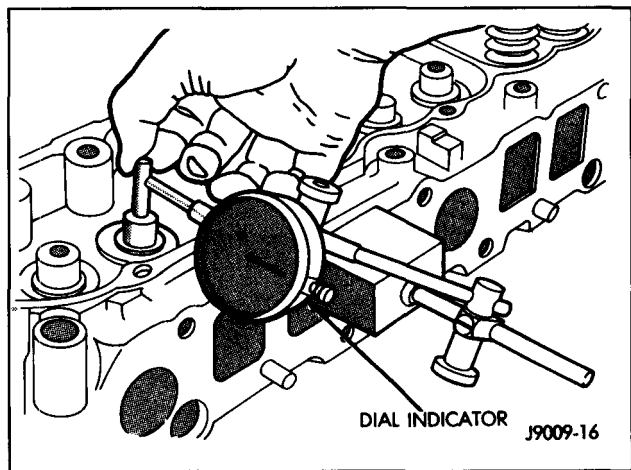


Figure 2 - 68

VALVE SEATS

With cast iron cylinder heads, all the valve seats are machined into the head material. (Aluminum heads use valve seat inserts.) One of the most important items in a high output engine is the valve job.

Valve Seat Refacing

1. Install a pilot of the correct size in the valve guide bore and reface the valve seat to the specified angle with a good dressing stone (Figure 2-69). Remove only enough metal to provide a smooth finish.
2. Use tapered stones to obtain the specified seat widths when required.
3. Control valve seat run-out (Figure 2-70) to a maximum of 0.0635 mm (0.0025").

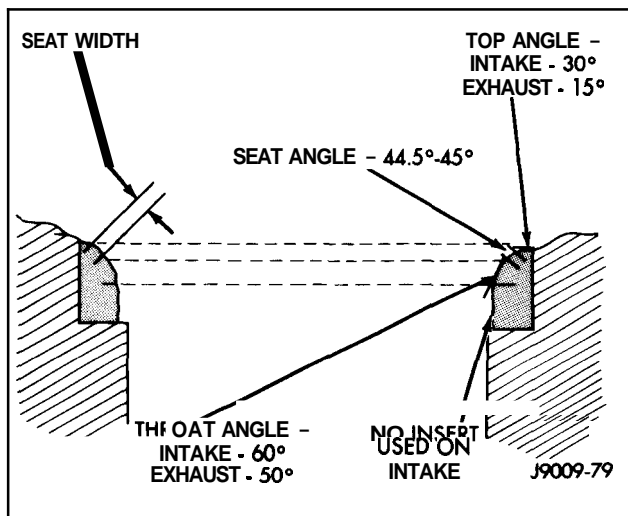


Figure 2 - 69

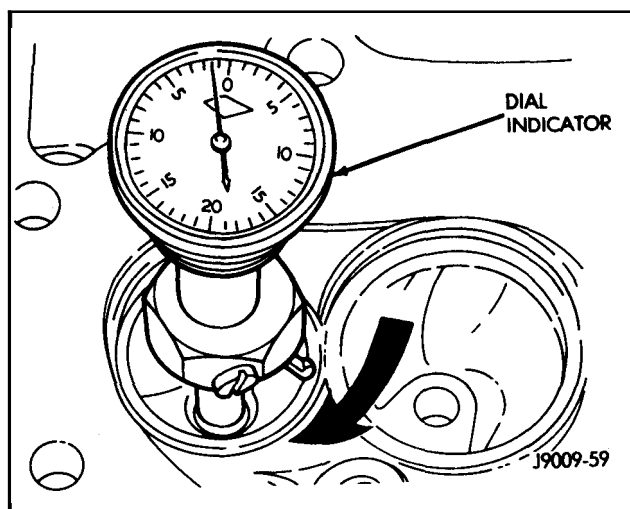


Figure 2 - 70

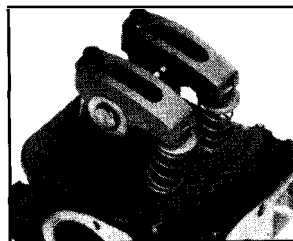
ROCKER ARMS

Heavy Duty Rocker Arm

Heavy duty stamped rocker arms for use with hydraulic cams (only). Right and left rockers are the same. Can be used to service stock engines. For all 2.5L and 4.0L Jeep engines. (Sold individually.)

P4529221 Heavy duty rocker arm.

Roller Rocker Arm Set



Fits all 2.5L and 4.0L engines. (Must use a spacer for valve cover clearance.)

- Contains one cylinder set of two rockers, two support stands, rocker shaft and screws.
- Extruded aluminum rockers, anodized blue.
- Can be used with hydraulic, mechanical or roller camshafts.
- Roller tip and center pivot to reduce internal friction.
- Provides exact geometry; 1.6:1 ratio.
- Adjustable, oil through pushrod style.

P4529885 Roller rocker arm set.

Aluminum Rocker Assembly Lube

When you use aluminum roller rockers, don't take a chance with a substandard lubricant. Mopar Performance Parts assembly lube is a must to complete the job right.

P5249099 Aluminum rocker assembly lube.

Removal

The following procedure can be performed with the engine in or out of the vehicle.

1. Remove the cylinder head cover (see *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure).
2. Remove the two capscrews at each bridge and pivot assembly. Alternately loosen the capscrews one turn at a time to avoid damaging the bridges.
3. Check for rocker arm bridges which are causing misalignment of the rocker arm-to-valve tip area.
4. Remove the bridges, pivots and corresponding pairs of rocker arms and place them on the bench in the same order as removed.
5. Remove the pushrods and place them on the bench in the same order as removed.

Cleaning and Inspection

1. Clean all the components with cleaning solvent and use compressed air to blow out the oil passages in the rocker arms and pushrods.
2. Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted, cracked or excessively worn.
3. Inspect the valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted.
4. Inspect each pushrod end for excessive wear and replace as required. If any pushrod is excessively worn because of lack of oil, replace it and inspect the corresponding hydraulic tappet for excessive wear.
5. Inspect the pushrods for straightness by rolling them on a flat surface or by shining a light between the pushrod and the flat surface.
6. A wear pattern along the length of the pushrod is not normal. Inspect the cylinder head for obstruction if this condition exists.

Installation

1. Lubricate the ball ends of each pushrod with Mopar Super Oil Conditioner (or equivalent) and install pushrods in their original locations. Ensure that the bottom end of each pushrod is centered in the tappet plunger cap seat.
2. Lubricate the area of the rocker arm that the pivot contacts with Mopar Super Oil Conditioner (or equivalent) and install rocker arms, pivots and bridge above each cylinder from where they were originally removed.
3. Loosely install capscrews through each bridge.
4. At each bridge, tighten the capscrews alternately, one turn at a time, to avoid damaging the bridge. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
5. Install the cylinder head cover (see *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure).

PUSHRODS

The valve train of the Jeep 2.5L engine is oiled through the pushrods. Jeep engine pushrods (all Jeep engines) are hollow so that oil can pass through them to oil the valve train.

Warning! Because the 2.5L engine valve train is oiled through its hollow pushrods, SOLID SHAFT PUSHRODS CANNOT BE USED.

Standard Length Pushrod

This is a fully assembled, stock diameter hydraulic pushrod. It is hollow to provide valve train oiling (same as production pushrod). Factory approved and engineered for rebuild or repairs. For all 2.5L and 1987-2000 4.0L engines. (Sold individually.)

P4529219 Standard length pushrod.

Standard Length Pushrod Set

Complete set of factory original pushrods for 2.5L engines (only). These are fully assembled, stock diameter pushrods. They are hollow to provide valve train oiling (same as production). Complete set of eight (8).

P4529674 Standard length pushrod set.

HYDRAULIC LIFTERS (TAPPETS)

Note: The following removal and installation procedures can be performed with the cylinder head installed on the engine.

Hydraulic Tappet

For use with general purpose, high performance hydraulic camshafts. Can be used as a production replacement. (Sold individually.)

P4529220 Hydraulic tappet.

Removal

1. Remove the cylinder head cover (refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure).
2. Remove the bridge and pivot assemblies and rocker arms by removing the two capscrews at each bridge. Alternately loosen each capscrew one turn at a time to avoid damaging the bridge.
3. Remove the pushrods. Place them on a workbench in the same order as removed to facilitate installation in their original locations.
4. Remove the tappets through the pushrod openings in the cylinder head with a hydraulic valve tappet removal/installation tool (Figure 2-71). Place them on a workbench in the same order as removed to facilitate installation in their original locations.
5. Inspect the tappets for wear. If worn, check the cam lobes for wear. Replace if wear is found.

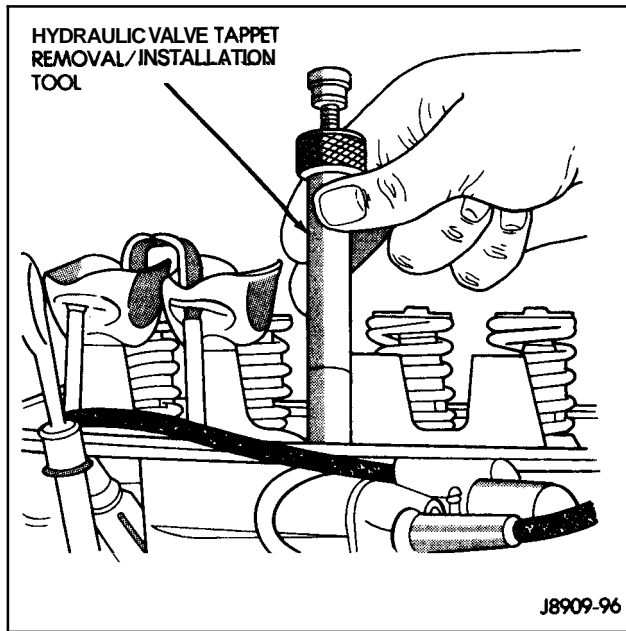


Figure 2 - 71

Disassembly and Cleaning

1. Release snap ring and remove the plunger cap, metering valve, plunger, check valve assembly and plunger return spring from the tappet body (Figure 2-72). Retain components of each tappet separately.
2. Clean the components of each tappet assembly in cleaning solvent to remove all varnish, gum and sludge deposits.
3. Inspect for indications of scuffing on the side and base of each tappet body.
4. Inspect each tappet base for concave wear with a straightedge positioned across the base. If the base is concave, the corresponding lobe on camshaft is also worn. Replace the camshaft and defective tappets.

Assembly

1. Install the plunger return spring, check valve assembly, plunger, metering valve and plunger cap in the tappet body.
2. Compress the plunger assembly by exerting force on the plunger cap with the pushrod and install the snap ring.

Installation

Note: It is not recommended to fill the tappets with oil as this may make the engine difficult to start. The tappets will charge themselves within three to eight minutes once the engine has been started.

1. Coat each tappet assembly in Mopar Super Oil Conditioner, or equivalent.

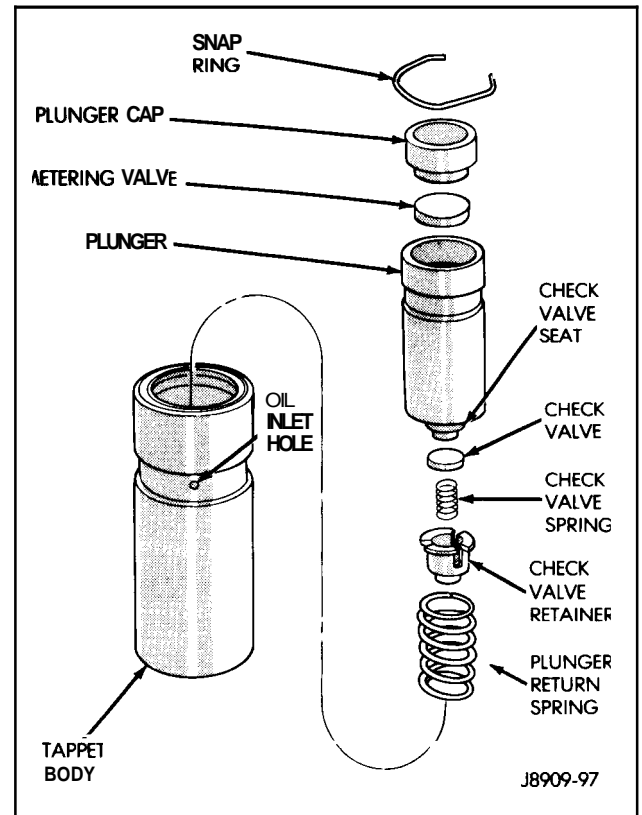


Figure 2 - 72

2. Use a hydraulic valve tappet removal/installation tool to install each tappet in the same bore from where it was originally removed.
3. Install the pushrods in their original locations.
4. Install the rocker arms and bridge and pivot assemblies at their original locations. Loosely install the capscrews at each bridge.
5. Tighten the capscrews alternately, one turn at a time, to avoid damaging the bridges. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
6. Pour the remaining Mopar Super Oil Conditioner (or equivalent) over the entire valve actuating assembly. The Mopar Super Oil Conditioner (or equivalent) must remain with the engine oil for at least 1600 km (1,000 miles); however, it does not need to be drained until the next scheduled oil change.
7. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.

Oiling System

INTRODUCTION

(Refer to Figure 2-73.)

The 2.5L engine uses a pressure feed, full flow filtration oiling system utilizing a positive displacement, gear-type oil pump driven by the distributor shaft. The oiling system has a capacity of 3.8L (4 quarts). (For more oiling system specifications, refer to *2.5L Engine Specifications*, 'Engine Assembly' section of this chapter.)

A gear-type positive displacement pump is mounted at the underside of the block opposite the No. 4 main bearing. The pump draws oil through the screen and inlet tube from the sump at the rear of the oil pan. The oil is driven between the drive and idler gears and pump body, then forced through the outlet to the block. An oil galley in the block channels the oil to the inlet side of the full flow oil filter. After passing through the filter element, the oil passes from the center outlet of the filter through an oil galley that channels the oil up to the main galley which extends the entire length of the block.

Galleries extend downward from the main oil galley to the upper shell of each main bearing. The crankshaft is drilled internally to pass oil from the main bearing journals (except No. 4 main bearing journal) to the connecting rod journals. Each connecting rod bearing cap has a small squirt hole. Oil passes through the squirt hole and is thrown off as the rod rotates. This oil throw off lubricates the camshaft lobes, distributor drive gear, cylinder walls, and piston pins.

The hydraulic valve tappets receive oil directly from the main oil galley. Oil is provided to camshaft bearings through galleys. The front camshaft bearing journal passes oil through the camshaft sprocket to the timing chain. Oil drains back to the oil pan under the No. 1 main bearing cap.

The oil supply for the rocker arms and bridged pivot assemblies is provided by the hydraulic valve tappets which pass oil through hollow pushrods to a hole in the corresponding rocker arm. Oil from the rocker arm lubricates the valve train components, then passes down through the pushrod guide holes in the cylinder head past the valve tappet area, and returns to the oil pan.

Oil Pressure Requirements

Oil pressure requirements for the 2.5L engine are as follows:

- At Idle Speed (800 rpm) 25-35 psi 172-241 kPa
- At 1,600+ rpm. 37-75 psi 255-517 kPa
- Oil Pressure Relief 75 psi. 517 kPa



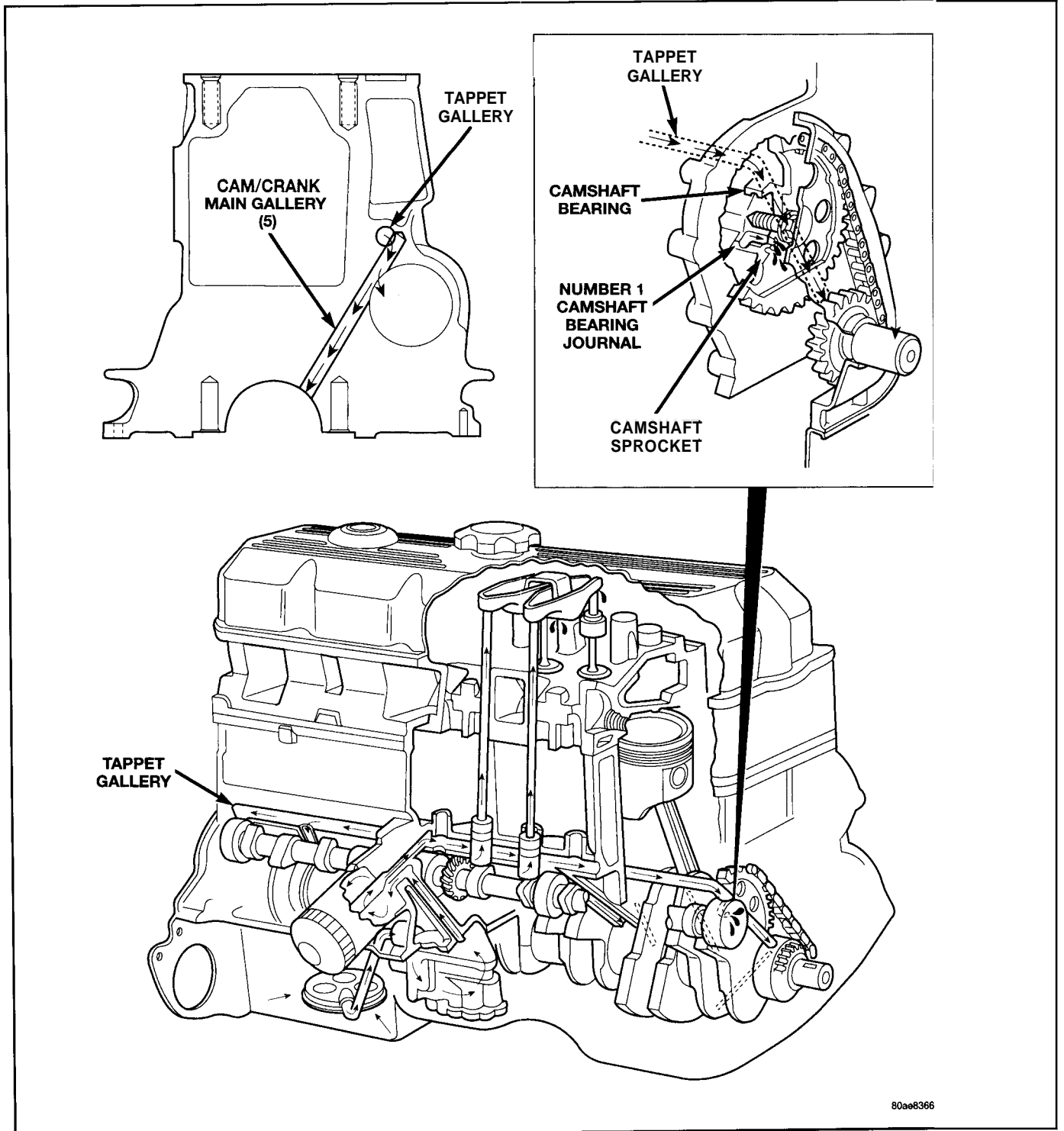


Figure 2 - 73

OIL PAN**Oil Pan Gasket Set**

Includes both sides and the ends. For 2.5L engines only.

P4529664 Oil pan gasket set.

Removal

1. Disconnect the battery negative cable.
2. Raise the vehicle.
3. Remove the oil pan drain plug and drain the engine oil.
4. Disconnect the exhaust pipe at the exhaust manifold (if necessary – check clearances first).
5. Disconnect the exhaust hanger at the catalytic converter and lower the pipe (if necessary – check clearances first).
6. Remove the starter motor.
7. Remove the converter/flywheel housing access cover.
8. Position a jack stand directly under the engine vibration damper.
9. Place a piece of wood (2 x 2) between the jack stand and the engine vibration damper.
10. Remove the engine mount through bolts.
11. Using the jack stand, raise the engine until adequate clearance is obtained to remove the oil pan.
12. Remove transmission oil cooling lines (if equipped).
13. Remove the oxygen sensor wiring supports that are attached to the oil pan studs (if equipped).
14. Remove the oil pan bolts and carefully remove the oil pan and gasket.

Cleaning

1. Clean the block and pan surfaces to remove gasket material and sealant.
2. Remove all sludge and grime from the oil pan sump.

Installation

1. Fabricate 4 alignment dowels from 1/4" x 1-1/2" bolts. Cut the head off the bolts and cut a slot into the top of the dowel. This will allow easier installation and removal with a screwdriver (Figure 2-74).
2. Install two dowels in the timing case cover. Install the other two dowels in the cylinder block (Figure 2-75).
3. Apply Mopar Silicone Rubber Adhesive Sealant on cylinder block to rear main bearing cap corners and cylinder block-to-front cover joints (four places). (Refer to Figure 2-76.)

4. Slide the one-piece gasket over the dowels and onto the block and timing case cover.
 5. Position the oil pan over the dowels and onto the gasket.
 6. Install the 1/4" oil pan fasteners (Figure 2-77). Tighten these fasteners to 9 N•m (7 ft-lbs) torque. Install the 5/16" oil pan fasteners (Figure 2-77). Tighten these fasteners to 15 N•m (11 ft-lbs) torque.
 7. Remove the dowels. Install the remaining 1/4" oil pan fasteners and tighten to 9 N•m (7 ft-lbs) torque.
 8. Lower the engine until it is properly located on the engine mounts.
 9. Install the through bolts and tighten the nuts to 65 N•m (48 ft-lbs) torque.
 10. Lower the jack stand and remove the piece of wood.
 11. Install the flywheel/torque converter housing access cover.
 12. Install the starter motor.
 13. Connect the exhaust pipe (if removed) to the hanger and the exhaust manifold.
 14. Install transmission oil cooling lines (if removed) and oxygen sensor wiring supports that attach to the oil pan studs (if removed).
 15. Install the oil pan drain plug using a new gasket (Figure 2-77). Tighten the plug to 34 N•m (25 ft-lbs) torque.
 16. Lower the vehicle.
 17. Connect the battery negative cable.
 18. Fill the oil pan with engine oil to the specified level
- Warning!** Use extreme caution when the engine is operating. DO NOT stand in direct line with the fan. DO NOT put your hands near the pulleys, belts or fan. DO NOT wear loose clothing.
19. Start the engine and inspect for leaks.



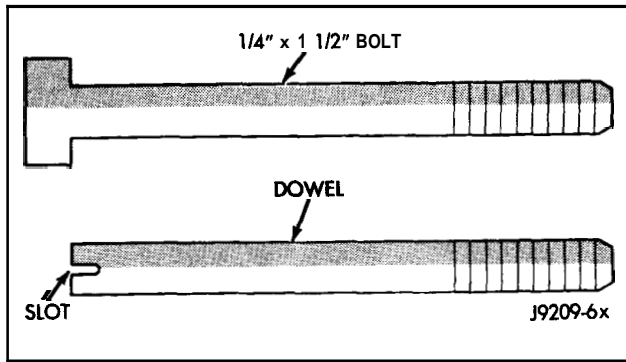


Figure 2 - 74

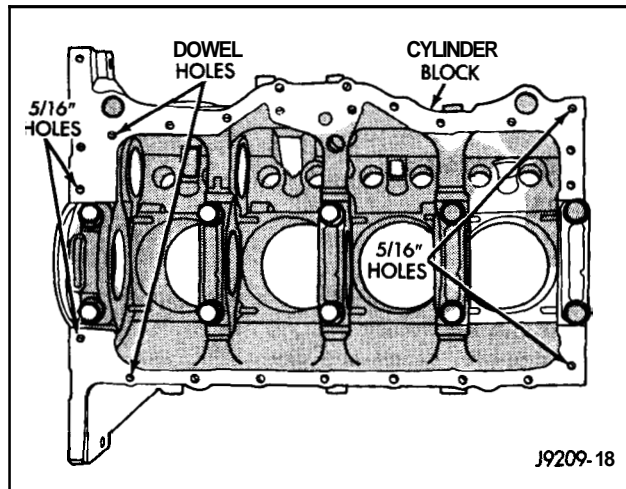


Figure 2 - 75

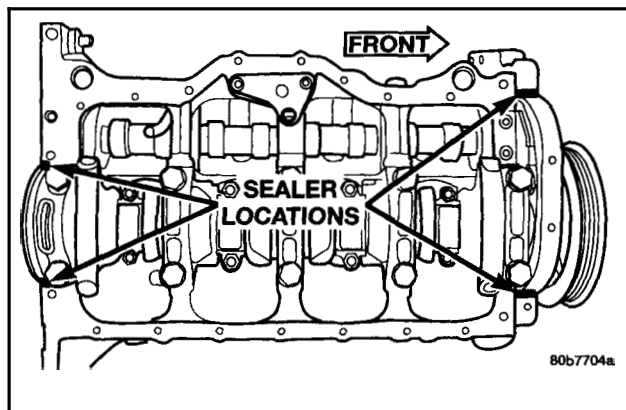


Figure 2 - 76

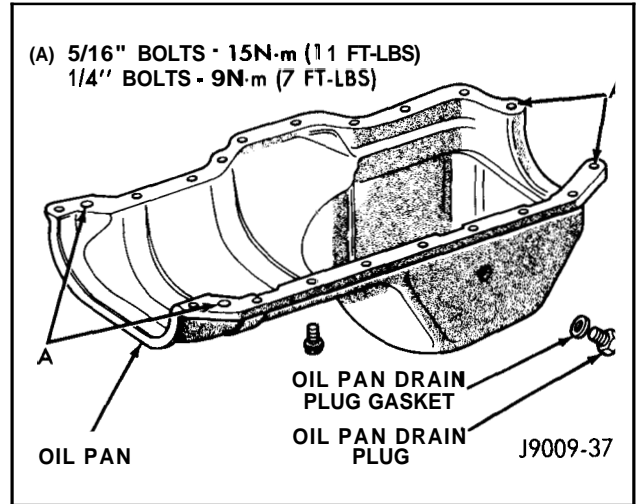


Figure 2 - 77

OIL PUMP

The positive displacement, gear-type oil pump is driven by the distributor shaft which is driven by a gear on the camshaft. Oil is siphoned into the pump through an inlet tube and strainer assembly that is pressed into the pump body. The pump incorporates a non adjustable pressure relief valve to limit maximum pressure to 75 psi (517 kPa). In the relief position, the valve permits oil to bypass through a passage in the pump body to the inlet side of the pump.

Oil pump removal or replacement will not affect distributor timing because the distributor drive gear remains in mesh with the camshaft gear.

Removal

1. Remove the oil pan as outlined in the removal procedure in this section.

Caution: If the oil pump is not to be serviced, DO NOT disturb position of oil inlet tube and strainer assembly in pump body. If the oil inlet tube is moved within the pump body, a replacement tube and strainer assembly must be installed to assure an airtight seal.

2. Remove the pump-to-cylinder block attaching bolts and remove the pump assembly with gasket (Figure 2-78).

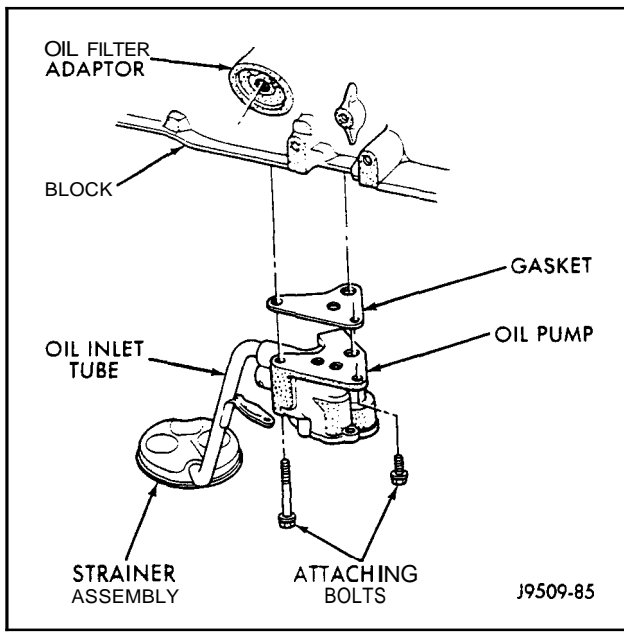


Figure 2 - 78

Gear End Clearance Measurement

Remove the cover retaining screws and cover from the pump body.

1. Preferred Method

- Place a strip of Plastigauge across the full width of each gear (Figure 2-79).
- Install the pump cover and tighten the bolts to 8 N•m (70 in-lbs) torque.
- Remove the pump cover and determine the amount of clearance by measuring the width of compressed Plastigauge with scale on the Plastigauge envelope.

Correct clearance by this method is 0.051-0.152 mm with 0.051 mm preferred (0.002-0.006" with 0.002" preferred). If gear end clearance is excessive, replace the oil pump assembly.

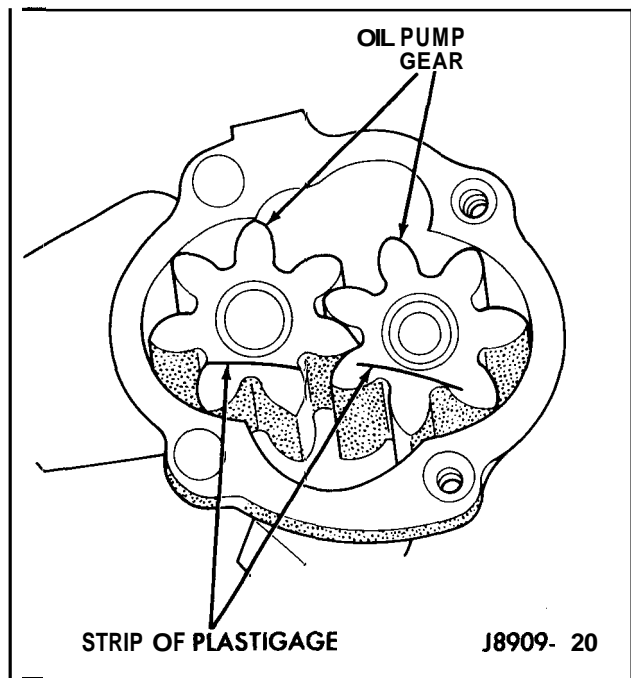


Figure 2 - 79

2. Alternate Method

- Place a straightedge across the ends of the gears and the pump body.
- Select a feeler gauge that fits snugly but freely between the straightedge and the pump body (Figure 2-80).

Correct clearance by this method is 0.051-0.152 mm with 0.051 mm preferred (0.002-0.006" with 0.002" preferred). If gear end clearance is excessive, replace the oil pump assembly.

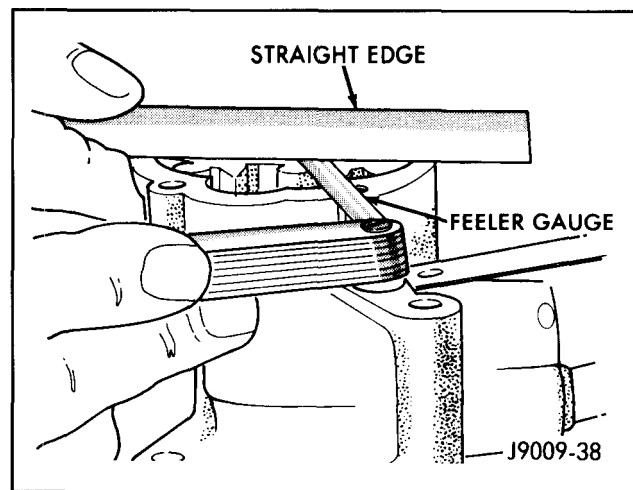


Figure 2 - 80

Gear-to-Body Clearance Measurement

With both gears in place, measure the gear-to-body clearance by inserting a feeler gauge between the gear tooth and the pump body inner wall, directly opposite the point of gear mesh (Figure 2-81). Select a feeler gauge which fits snugly but freely. Rotate gears to measure each tooth-to-body clearance in this manner.

Correct clearance is 0.051-0.102 mm with 0.051 mm preferred (0.002-0.004" with 0.002" preferred). If the gear-to-body clearance is more than specified, replace the oil pump.

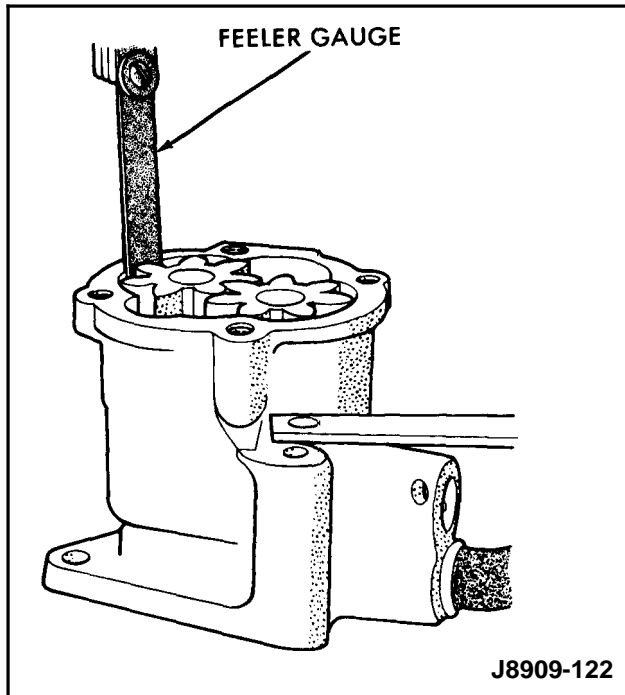


Figure 2 - 81

Disassembly

Remove the cotter pin and slide the spring retainer, spring and oil pressure relief valve plunger out of the pump body. Inspect for binding condition during disassembly. Clean or replace as necessary.

Note: The oil inlet tube and strainer assembly must be moved to allow removal of the relief valve. Install a replacement inlet tube and strainer assembly.

Assembly

Two relief valve plunger sizes (standard and oversize) are available. When replacing the valve, assure correct replacement valve, standard size or 0.254 mm (0.010") oversize plunger diameter, is obtained and installed.

1. Install the oil pressure relief valve plunger, spring, retainer and cotter pin.

2. If the position of inlet tube in the pump body has been disturbed, install a replacement inlet tube and strainer assembly. Apply a light film of Permatex No. 2 sealant, or equivalent, around the end of the inlet tube. Use an oil pump inlet tube installation tool to drive the inlet tube into body (Figure 2-82). Ensure the support bracket is properly aligned.
3. Install the idler gear and drive gear assembly.
4. Spin the drive gear shaft to assure a binding condition does not exist before installing the oil pump.
5. To assure self-priming of the oil pump, fill pump with petroleum jelly before installing the oil pump cover. **DO NOT** use grease.
6. Apply a thin bead of Loctite 515 (or equivalent) to the top of the pump housing and install the **pump** cover screws with 8 N•m (70 in-lbs) torque.

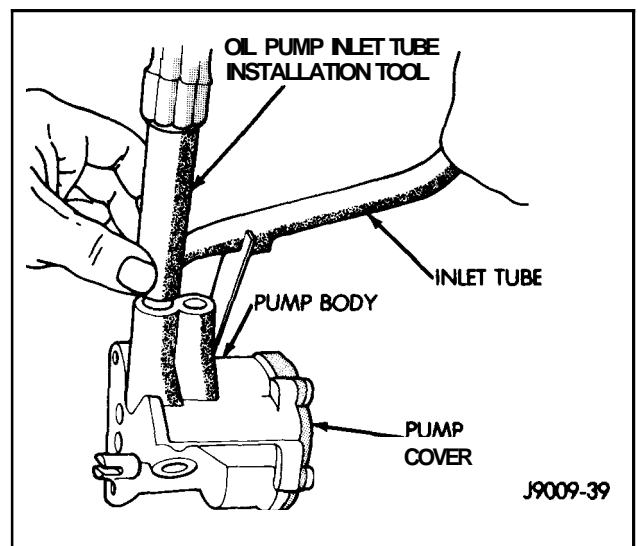


Figure 2 - 82

Installation

1. Install the oil pump on the cylinder block using a replacement gasket. Tighten the short bolt to 14 N•m (10 ft-lbs) torque and the long bolt to 23 N•m (17 ft-lbs) torque. (Refer to Figure 2-78.)
2. Install the oil pan. (Refer to *Oil Pan Installation*, in this section, for the procedure.)
3. Fill the oil pan with oil to the specified level.

Fuel Delivery and Fuel Injection Systems

Note: Older, carbureted versions of the 2.5L engine will not be discussed in this chapter. However, service parts for these older carbureted models are still available through your local Chrysler-Plymouth-Dodge-Jeep dealer. If you have an old 2.5L carbureted engine, refer to the 'Induction System' section of Chapter 7, *360 AMC V-8*, for general carburetor information, as well as the correct service manual for your vehicle/engine.

MULTI-POINT FUEL INJECTION (MPI) SYSTEM

Newer 2.5L engines use a sequential Multi-Point Fuel Injection (MPI) system (vehicle specific—refer to your service manual). Fuel is injected into the intake manifold before the intake valve in precise metered amounts through electrically operated injectors. The injectors are fired in a specific sequence by the Powertrain Control Module (PCM). The PCM constantly adjusts the amount of fuel injected to meet changing operating conditions by controlling injector pulse width (the length of time the injector is energized). The PCM also adjusts ignition timing by controlling the ignition coil operation through the Ignition Control Module (ICM). The PCM determines air-fuel mixture and ignition timing based on inputs it receives from various sensors that monitor engine operating conditions.

The PCM receives inputs from sensors that react to exhaust gas oxygen content, coolant temperature, manifold absolute pressure, engine speed (crankshaft position), throttle position, battery voltage, intake manifold air temperature, engine knock and transmission gear selection. These inputs represent the engine's instantaneous operating conditions. Air-fuel mixture and ignition timing calibrations for various driving and atmospheric conditions are pre-programmed into the PCM. The PCM monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. The Engine Control System is comprised of (1) the sensors and switches that provide input to the PCM, (2) the PCM itself, and (3) the PCM outputs (engine control devices that the PCM constantly adjusts). The Engine Control System consists of:

- Battery Voltage
- Manifold Absolute Pressure (MAP) Sensor
- Coolant Temperature Sensor
- Manifold Air Temperature (MAT) Sensor
- Exhaust Oxygen (O²) Sensor
- Engine Speedcrankshaft Position Sensor
- Throttle Position Sensor
- Injector Synchronization Signal
- A/C Select Signal

- A/C Request Signal
- Neutral Safety Switch
- Knock Sensor
- Fuel Pump Relay
- Fuel Injectors
- Idle Speed Stepper Motor
 - B+ Latch Relay
- Oxygen Sensor Heater Relay
- EGR Valve Solenoid
- Ignition Control Module
- Shift Indicator Light (manual transmissions only)
 - A/C Clutch Relay

Powertrain Control Module (PCM)

The Powertrain Control Module (PCM) is a digital microprocessor. Air-fuel mixture calibrations for various driving and atmospheric conditions are pre-programmed into the PCM. The PCM monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. As operating conditions change, the PCM adjusts injector pulse width and ignition timing for optimum performance and fuel economy.



PCM Inputs

The PCM is powered by the vehicle's battery. When the ignition is turned to the ON or START position, the following inputs are supplied to the PCM:

- Battery Voltage
- Manifold Absolute Pressure (MAP) Sensor
- Coolant Temperature Sensor
- Manifold Air Temperature (MAT) Sensor
- Exhaust Oxygen (O²) Sensor
- Engine Speed/crankshaft Position Sensor
- Throttle Position Sensor
- Injector Synchronization Signal
- A/C Select Signal
- Neutral Safety Switch (gear selection – automatic transmission)
- Knock Sensor
- Start Signal

PCM Outputs

Based upon signals from various input sensors and switches, the PCM adjusts the following components (PCM outputs):

- Fuel Pump Relay
- B+ Latch Relay
- Oxygen Sensor Heater Relay
- A/C Clutch Relay
- Fuel Injectors
- Idle Speed Stepper Motor
- EGR Valve Solenoid
- Ignition Control Module (ICM)
- Shift Indicator Light (manual transmission only)

Modes of Operation

As input signals to the PCM change, the PCM adjusts its response to the output devices. For example, the PCM must calculate a different injector pulse width and ignition timing for idle than it does for wide open throttle. There are eight different modes of operation that determine how the PCM responds to the various input signals.

Modes of operation are of two different types: OPEN LOOP and CLOSED LOOP.

During OPEN LOOP modes the PCM receives input signals and responds only according to preset PCM programming. Input from the oxygen (O₂) sensor is not monitored during OPEN LOOP modes.

During CLOSED LOOP modes the PCM does monitor the O₂ sensor input. This input indicates to the PCM whether or not the calculated injector pulse width results in the ideal air-fuel ratio (14.7 parts air to 1 part fuel). By monitoring the exhaust oxygen content through the O₂ sensor, the PCM can 'fine tune' the injector pulse width to achieve optimum fuel economy combined with low emission engine performance.

The MPI system has the following modes of operation:

- Ignition Switch ON
- Engine Start-up (Crank)
- Engine Warm-up
- Idle
- Cruise
- Deceleration
- Wide Open Throttle
- Ignition Switch OFF

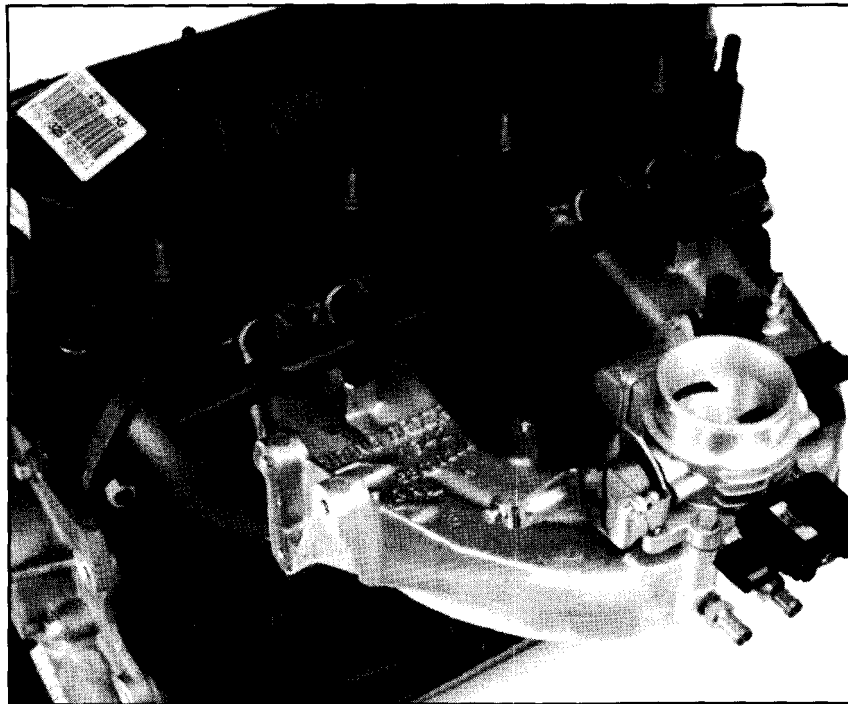
The ignition switch ON, engine start-up (crank), engine warm-up, deceleration, and wide open throttle modes are OPEN LOOP modes. The idle and cruise modes, *with the engine at operating temperature*, are CLOSED LOOP modes.

Throttle Body

Filtered air from the air cleaner enters the intake manifold through the throttle body. Fuel does not enter the intake manifold through the throttle body. Fuel is sprayed into the manifold by the fuel injectors. This throttle body, mounted on the intake manifold, contains an air bypass passage that is used to supply air for idle conditions, and a throttle valve for above idle conditions.

The throttle position sensor and idle speed stepper motor are attached to the throttle body. The accelerator cable is connected to the throttle valve through a bellcrank and linkage mounted to the intake manifold.

There are different throttle bodies for automatic and manual transmission equipped vehicles. The throttle valve is not controlled by the PCM.



Fuel Rail/Fuel Damper

The fuel rail supplies the necessary fuel to each individual fuel injector and is mounted to the intake manifold (Figure 2-83). A fuel damper is located at the front of the fuel rail (Figure 2-83). The damper is used only to help control fuel pressure pulsation. This pulsation is the result of the firing of the fuel injectors. It is not used as a fuel pressure regulator. The fuel pressure regulator is not mounted to the fuel rail on any engine. It is located on the fuel tank mounted fuel pump module.

Depending on vehicle model/engine, the fuel rail may/may not be equipped with a fuel pressure test port. Refer to the proper service manual for additional information.

The fuel rail is not repairable.

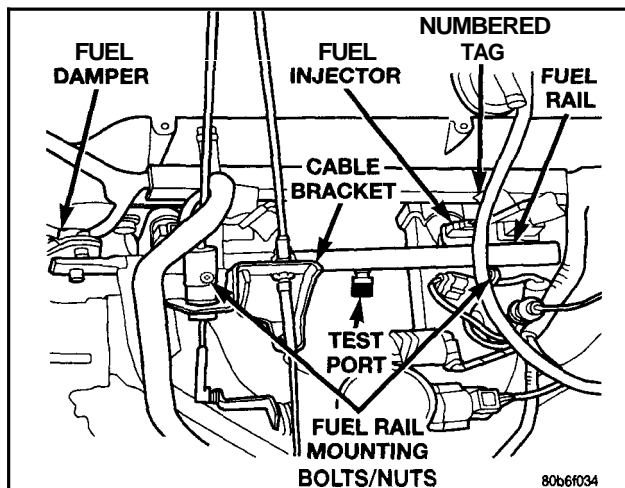


Figure 2 - 83

Fuel Pressure Regulator

The fuel pressure regulator used with the MPI fuel system is a vacuum assisted, non-adjustable type. The regulator is mounted on the output end of the fuel rail and is connected to intake manifold vacuum. The regulator is calibrated to maintain fuel system pressure at approximately 214 kPa (31 psi) with vacuum applied while the engine is at idle. Fuel pressure will be 55-69 kPa (8-10 psi) higher if vacuum is not applied to the regulator.

The pressure regulator contains a diaphragm, calibrated spring and fuel return valve. Fuel pressure operates on the bottom side of the diaphragm while spring pressure and intake manifold vacuum operate on the top side of the diaphragm. Spring pressure tries to force the return valve closed. Fuel pressure, with assistance from manifold vacuum on the spring side, acts against the spring pressure to open the return valve. Thus, *system fuel pressure* is the amount of fuel pressure required to force against spring pressure and unseat the fuel return valve.

Without vacuum applied to the spring side of the regulator, the spring is calibrated to open the fuel return outlet when the pressure differential between the fuel injectors and the intake manifold reaches approximately 269 kPa (39 psi). Since manifold vacuum varies with engine operating conditions, the amount of vacuum applied to the spring side of the diaphragm varies. For this reason, fuel pressure varies depending upon intake manifold vacuum. With low vacuum, such as during wide open throttle conditions, minimal vacuum assistance is available and full spring pressure is exerted to seal the fuel outlet causing system pressure to increase. With high vacuum, such as during idle,

fuel pressure on the bottom of the diaphragm is assisted by intake manifold pressure on the spring side of the diaphragm, resulting in lower system fuel pressure. The fuel pressure regulator is not controlled by the PCM.

Racing Modifications

By their nature, unlike carbureted engine set-ups, fuel injection systems deliver fuel equally among all four cylinders. It's because of this excellent fuel distribution characteristic that fuel injection is preferred over carburetors, even over high performance 2 and 4-Bbl. carburetors.

And don't disconnect those stock fuel injection sensors! Today's engines run a lot hotter because they run a lot leaner; because of this, fuel injection temperature is very critical. It is something that has to be constantly monitored and stabilized to keep the fuel injection and the power level in their proper places. Mopar Performance Parts recommends the use of all sensors, even in high-performance racing set-ups. These sensors constantly input vital information to the PCM, and the PCM corrects the mixture accordingly.

And don't abandon that oxygen sensor, either. Since racing set-ups don't use catalytic converters, use an EGT probe to locate the hottest spot in the exhaust system and install the oxygen sensor there.

Crankcase Ventilation System

All 2.5L 4-cylinder engines are equipped with a Crankcase Ventilation (CCV) system (Figure 2-84). The CCV system performs the same function as a conventional PCV system, but does not use a vacuum controlled valve.

A fitting on the driver's side of cylinder head (valve) cover contains the metered orifice. It is connected to manifold vacuum.

A fresh air supply CCV tube (hose) from the air cleaner is connected to the rear cover.

When the engine is operating, fresh air enters the engine and mixes with crankcase vapors. Manifold vacuum draws the vapor/air mixture through the fixed orifice and into the intake manifold. The vapors are then consumed during combustion.

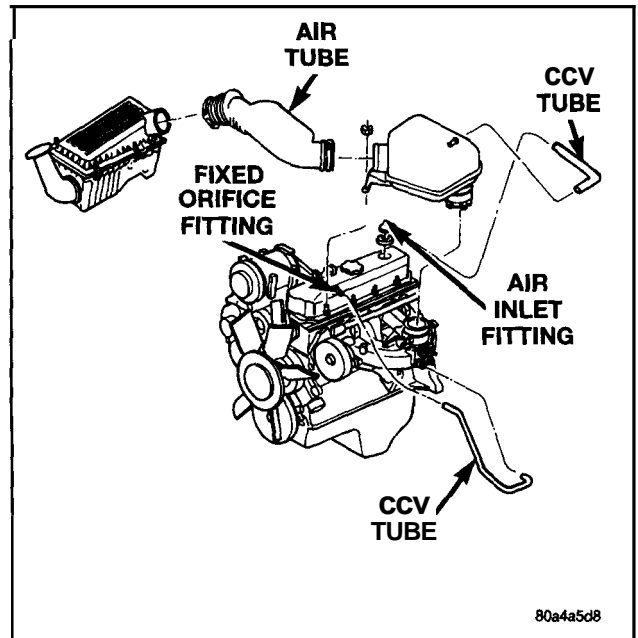


Figure 2 - 84

THROTTLE BODY (SINGLE POINT) FUEL INJECTION (TBI)

Throttle Body Fuel Injection (TBI) is a single point, pulse time system that injects fuel through an electrically operated fuel injector into the throttle body above the throttle plate.

The fuel injection pulse width (period of time that the injector is energized causing fuel to be released into the throttle body) is controlled by the engine's Electronic Control Unit (ECU). The ECU accomplishes this by opening and closing the ground path to the injector. By controlling fuel injector pulse width, the ECU is able to meter the amount of fuel to the engine and constantly adjust the air-fuel ratio.

The ECU receives inputs from sensors that react to exhaust gas oxygen content, coolant temperature, manifold absolute pressure, engine speed (crankshaft position), throttle position, battery voltage, and air-fuel temperature. These inputs represent the engine's instantaneous operating conditions. Based on these inputs, the ECU adjusts air-fuel ratio and ignition timing for the current operating conditions. The engine control system is comprised of (1) the sensors and switches that provide input to the ECU, (2) the ECU itself, and (3) the ECU outputs (engine control devices that the ECU constantly adjusts).

The engine control system consists of

- Coolant Temperature Sensor (CTS)
- Manifold Air Temperature (MAT) Sensor
- Manifold Absolute Pressure (MAP) Sensor
- Engine Speed /Crankshaft Position Sensor (CPS)
- Throttle Position Switch (TPS)
- Exhaust Oxygen (O²) Sensor
- Battery Voltage (B+)
- A/C Select Signal
- A/C Request Signal
- Wide Open Throttle Switch (model specific—check your service manual)
- Closed Throttle Switch
- Neutral Safety Switch
- Power Steering High Pressure Switch
- Starter Motor Relay
- Electronic Control Unit (ECU)
- Fuel Pump Relay
- B+ Latch Relay
- Idle Speed Actuator (ISA)
- Ignition Control Module
- Fuel Injector
- EGR/Evaporative Canister Purge Solenoid (model specific—check your service manual)
- EGR Valve Vacuum Solenoid (model specific—check your service manual)
- A/C Compressor Clutch Relay (model specific—check your service manual)

Air-fuel mixture calibrations for various driving and atmospheric conditions are programmed into the ECU. The ECU monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. As operating conditions change, the ECU adjusts injector pulse width and ignition timing for optimum performance and fuel economy.

Electronic Control Unit (ECU)

The ECU controls the fuel injector pulse width and ignition timing based on inputs received from sensors that react to exhaust gas oxygen content, air-fuel temperature, coolant temperature, manifold absolute pressure, battery voltage, crankshaft position (engine speed), throttle position and inputs from switches that are triggered by power steering pump output pressure, wide open throttle conditions, and transmission gear selection (automatic transmissions only). Battery voltage is also monitored to determine injector pulse width. These sensors and switches are considered ECU inputs.

ECU Inputs

The ECU is powered by the vehicle's battery. When the ignition is turned to the ON or START position, the following inputs are supplied to the ECU:

- Start Signal
- Engine Coolant Temperature
- Intake Manifold Air-Fuel Temperature
- Intake Manifold Absolute Pressure
- Engine Speed (Crankshaft Position)
- Throttle Position
- Exhaust Gas Oxygen Content
- Battery Voltage
- A/C Select and Request
- Wide Open Throttle Switch (model specific—check your service manual)
- Closed Throttle Switch
- Neutral Safety Switch
- Power Steering Pressure Switch

ECU Outputs

The following are controlled by the ECU:

- Electric Fuel Pump Relay
- B+ Latch Relay
- A/C Compressor Clutch Relay
- Idle Speed Actuator (ISA) Motor
- Ignition Power Module
- Fuel Injector
- EGR/Evaporative Canister Purge Solenoid (model specific—check your service manual)
- EGR Valve Vacuum Solenoid (model specific—check your service manual)
- Shift Indicator Lamp—Manual Transmission Only

Modes of Operation

As input signals to the ECU change, the ECU adjusts its response to the output devices. For example, the ECU must calculate a different injector pulse width and ignition timing for idle than it does for wide open throttle.

Modes of operation are of two different types: OPEN LOOP and CLOSED LOOP.

During OPEN LOOP modes, the ECU receives input signals and responds only according to preset ECU programming. Input from the oxygen (O_2) sensor is not monitored during OPEN LOOP modes.

During CLOSED LOOP modes the ECU does monitor the O_2 sensor input. This input indicates to the ECU whether or not the calculated injector pulse width results in the ideal air-fuel ratio (14.7 parts air to 1 part fuel). By monitoring the exhaust oxygen content through the O_2 sensor, the ECU can 'fine tune' the injector pulse width to achieve optimum fuel economy combined with low emission engine performance.

The TBI system has the following modes of operation:

- Ignition Switch ON
- Engine Start-up
- Engine Warm-up
- Cruise
- Deceleration
- Wide Open Throttle
- Ignition Switch OFF

The Ignition Switch ON, Engine Start-up (crank), Engine Warm-up, Deceleration, and Wide Open Throttle modes are OPEN LOOP modes. The Deceleration and Cruise modes, *with the engine at operating temperature*, are CLOSED LOOP modes.

Throttle Body

The throttle body is mounted on top of the intake manifold and contains the fuel injector, fuel pressure regulator, and throttle valve. The fuel inlet and return tubes are connected to the throttle body by pressure fittings. The **ISA** motor and throttle position sensor (TPS) are also mounted to the throttle body.

FUEL PUMP

The fuel pumps used for carbureted and fuel injected vehicles are different. Carbureted vehicles have a mechanical fuel pump driven by an eccentric lobe on the engine's camshaft. Fuel injected engines (such as the 2.5L) have a gear/rotor type pump driven by a permanent, magnetic 12 volt electric motor that is immersed in the fuel tank. This electric pump is integral with the fuel sender unit and is also installed inside the fuel tank.

Note: Electric fuel pumps used for Throttle Body Injection and Multi-Point Injection systems, though similar in appearance and function, are different and CANNOT be interchanged.

TBI Fuel Pump

The TBI fuel pump has a check valve at the outlet end that consists of a steel ball held against a seat by force applied from a spring. When the pump is operating, fuel pressure overcomes spring pressure and forces the **ball** off its seat, allowing fuel to flow. When the pump is not operating, spring pressure forces the ball back against the seat preventing fuel back flow through the pump.

Voltage to operate the TBI fuel pump is supplied through the fuel pump relay when the relay is grounded by the engine's Electronic Control Unit (ECU).

TBI system fuel pressure is 97-103 kPa (14-15 psi) while the pump is operating, and zero (0) when the pump is not operating.

FUEL FILTER

The fuel filter protects the fuel injector(s) from dirt, water and other foreign matter. The filter is located under the vehicle along the driver's side frame rail. Replace filter at intervals specified on the Maintenance Schedule in the service manual.

Caution: Fuel filters designed for carbureted systems are NOT interchangeable with filters designed for fuel injection systems. Using fuel filters designed for carbureted systems on fuel injection systems will cause damage to system components and/or fuel system shut down. For proper fuel injection system fuel filter availability and pricing, contact your local Chrysler-Plymouth-Dodge-Jeep dealer.

INTAKE MANIFOLD

Removal

1. Disconnect the battery negative cable.
2. Remove the air inlet hose and resonator from the throttle body and air cleaner housing (Figure 2-84).
3. Loosen the accessory drive belt tension and remove the belt from the power steering pump. (Refer to the proper service manual for correct procedure.)
4. Remove the power steering pump and brackets from the water pump and intake manifold. Support power steering pump and bracket with wire attached to the radiator upper crossmember.
5. Perform the fuel pressure release procedure. (Refer to the proper service manual for correct procedure.)
6. Disconnect fuel supply tube from the fuel rail. (Refer to the proper service manual for correct procedure.)

7. Disconnect the accelerator cable from the throttle body and cable bracket.

Caution: When disconnecting the speed control connector at the throttle body, DO NOT pry the connector off with pliers or screwdriver. Use finger pressure only. Prying the connector off could break it.

8. Disconnect the speed control and transmission line pressure cable from the throttle body and cable bracket (if equipped).
9. Disconnect the following electrical connectors. Pull the harnesses away from the manifold.
 - Throttle Position Sensor
 - Idle Air Control motor
 - Coolant Temperature Sensor at the thermostat housing
 - Manifold Air Temperature sensor at the intake manifold
 - Fuel injector(s)
 - Oxygen (O₂) sensor
10. Disconnect the crankcase ventilation (CCV) vacuum hose and Manifold Absolute Pressure sensor vacuum hose connector at the intake manifold.
11. Disconnect HVAC supply vacuum hose from the intake manifold.
12. Disconnect the CCV hose at the cylinder head cover (Figure 2-84).
13. Remove the molded vacuum harness.
14. Disconnect the vacuum brake booster hose at the intake manifold.
15. Remove bolts 2 through 5 securing the intake manifold to the cylinder head (Figure 2-85). Loosen but DO NOT remove exhaust manifold bolt No. 1 and nuts 6 and 7.
16. Remove the intake manifold and gaskets. Drain the coolant from the manifold.

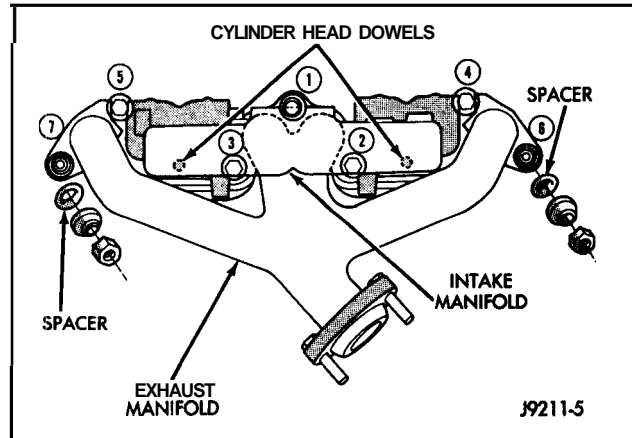


Figure 2 - 85

Installation

1. Clean the intake manifold and cylinder head mating surfaces. DO NOT allow foreign material to enter either the intake manifold or the ports in the cylinder head.
2. Install the new intake manifold gasket over the locating dowels.
3. Position the manifold in place and finger-tighten the mounting bolts.
4. Tighten the fasteners in sequence and to the specified torque (Figure 2-85).
 - Fastener No. 1—Tighten to 41 N•m (30 ft-lbs) torque.
 - Fastener No. 2 through No. 7—Tighten to 31 N•m (23 ft-lbs) torque.
5. Before connecting the fuel line to the fuel rail, inspect the fuel line O-rings and replace them if necessary. Connect the fuel supply tube to the fuel rail inlet. Push tube until a click is heard.
6. Pull on fuel supply line to verify that it is properly connected. Install latch clip.
7. Connect the molded vacuum hoses to the vacuum port on the intake manifold and the cylinder head cover.
8. Connect the electrical connectors.
 - Throttle Position Sensor
 - Idle Air Control motor
 - Coolant Temperature Sensor at the thermostat housing
 - Manifold Air Temperature sensor at the intake manifold
 - Fuel injector(s)
 - Oxygen (O₂) sensor

9. Connect the brake booster vacuum supply hose.
10. Connect the CCV hose and MAP sensor vacuum hose connectors to the throttle body.
11. Install the power steering pump and bracket assembly to the water pump and intake manifold. Torque power steering pump bolts to 28 N•m (21 ft-lbs). Torque bracket to water pump bolts to 47 N•m (35 ft-lbs).

Caution: Ensure that the accessory drive belt is routed correctly. Failure to do so can cause the water pump to turn in the opposite direction resulting in engine overheating. (Refer to the proper service manual for correct procedure.)

12. Install and tension the accessory drive belt. (Refer to the proper service manual for correct procedure.)
13. Connect the accelerator cable to the bracket and the throttle lever.
14. Connect the speed control and transmission line pressure cable (if equipped) to the bracket and throttle lever.
15. Install the air inlet hose and resonator to the throttle body and the air cleaner.
16. Connect the battery negative cable.
17. Start the engine and check for leaks.

AIR FILTERS

High Performance Air Filter Element

Special reusable filter element for high performance. Increases air flow versus stock filters which increases engine output.

P52499 18	High performance air filter element, 1986-96 Jeep Wrangler 2.5L only.
P4876273	High performance air filter element, 1997-98 Jeep Wrangler 2.5L only.
P4876272	High performance air filter element, 1987-96 Jeep Cherokee 2.5L only.

Air Filter Cleaning Fluid

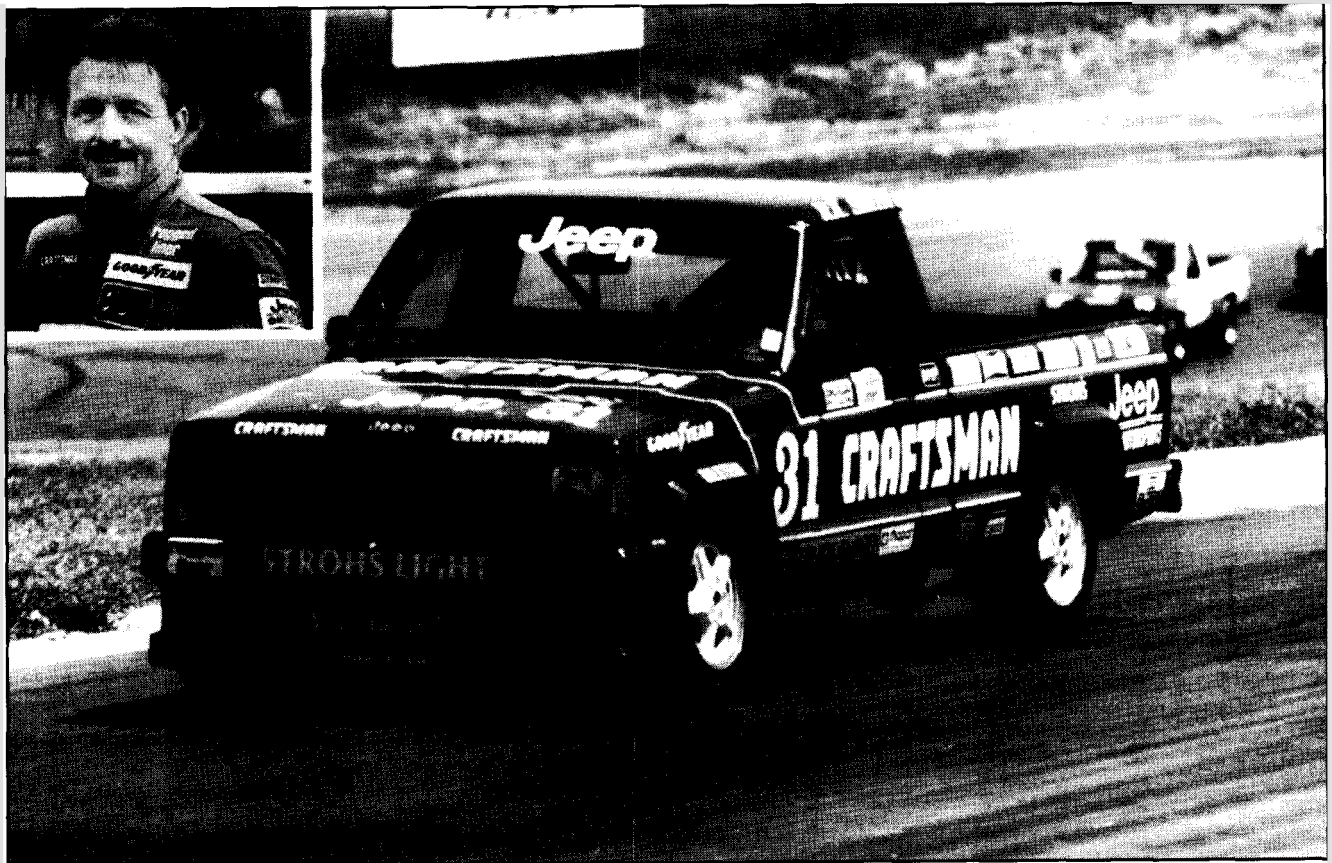
Mopar Performance Parts long-life high performance air filters are reusable. This cleaning fluid is designed to remove dirt to extend the life of the filter.

P4529392	Air filter cleaning fluid.
----------	----------------------------

Air Filter Oil

Long life, high performance air filters trap dirt with a special oil on the filter. After cleaning air filters, re-oil them with this special fluid.

P4529393	Air filter oil.
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Exhaust System

EXHAUST SYSTEM

The basic exhaust system on all vehicles consists of an exhaust manifold, front exhaust pipe, catalytic converter, heat shield(s), muffler and tailpipe (Figure 2-86).

Vehicles with the 2.5L engine use a single muffler exhaust system with a single, monolithic-type catalytic converter.

The exhaust system must be properly aligned to prevent stress, leakage, and body contact. If the system contacts any body panel, it may amplify objectionable noises originating from the engine or body.

When inspecting an exhaust system, critical items to inspect for are cracked or loose joints, stripped screw or bolt threads, corrosion damage, and worn, cracked or broken hangers. Replace all components that are badly corroded or damaged. **DO NOT** attempt to repair. When replacement is required, use original equipment parts (or their equivalent). This will assure proper alignment and provide acceptable exhaust noise levels.

All exhaust systems should be checked for leaks. A leak in the exhaust system is unsafe and will cost you power.

Caution: Avoid application of rust prevention compounds or undercoating materials to exhaust system floor pan heat shields. Light overspray near the edges is permitted. Application of coating will result in excessive floor pan temperatures and objectionable fumes.

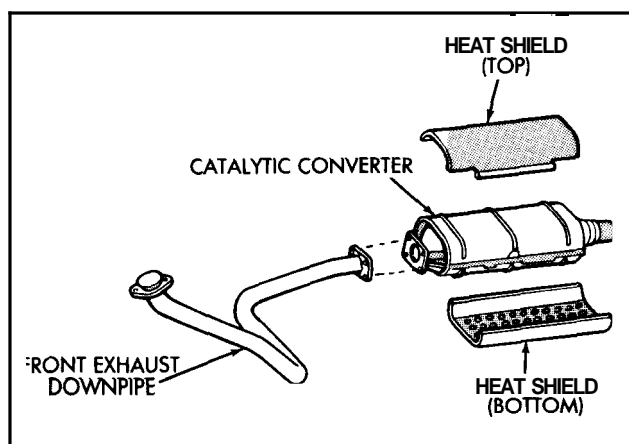


figure 2 - 86

Intake/Exhaust Manifold Attaching Package

Package of factory original nuts and bolts to attach intake and exhaust manifolds. Includes five bolts, seven washers, four studs, two pins, two spacers, and three plugs. For Jeep 2.5L carbureted engines only.

P4529679 Intake/Exhaust manifold attaching package.

Intake/Exhaust Manifold Gasket

The 2.5L engine uses a common intake and exhaust manifold gasket. This gasket is designed for original replacement. For Jeep 2.5L engine only.

P4529663 Intake/Exhaust manifold gasket.

Exhaust Gas Recirculation (EGR)

To assist in the control of oxides of nitrogen (NO_x) in engine exhaust, all engines are equipped with an exhaust gas recirculation (EGR) system (Figure 2-87). The use of gas to dilute incoming air/fuel mixtures lowers peak flame temperature during combustion, thus limiting the formation of NO_x .

Exhaust gases are taken from openings in the exhaust gas crossover passage in the intake manifold. Refer to the service manual for a complete description, diagnosis and proper service procedures.

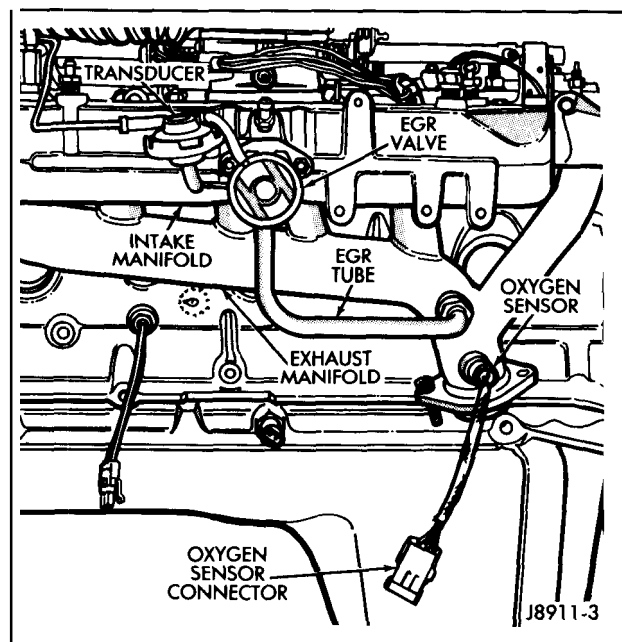


Figure 2 - 87

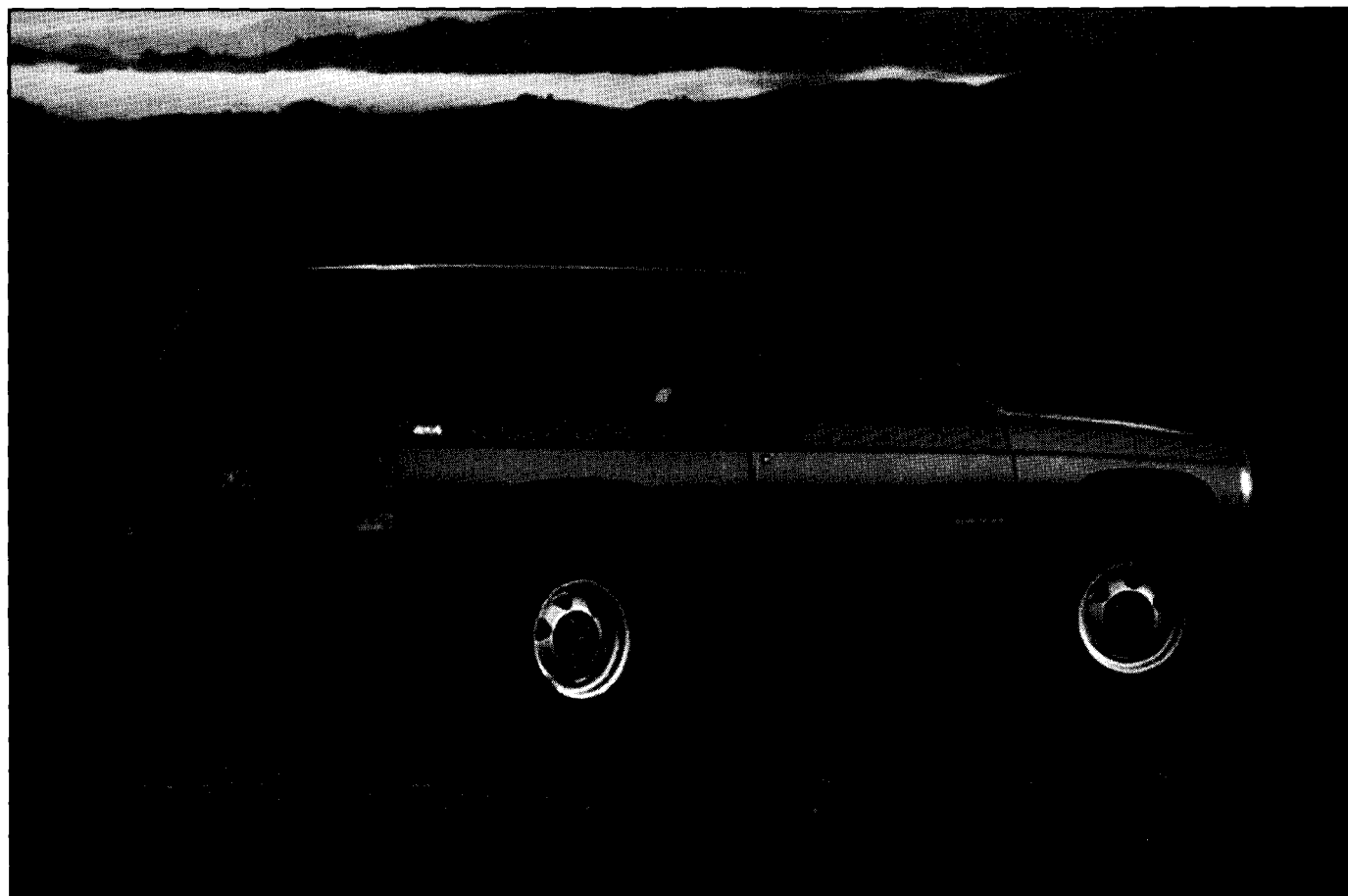
Exhaust System Troubleshooting Chart

Condition	Possible Cause	Correction
EXCESSIVE EXHAUST NOISE	(a) Leaks at pipe joints. (b) Burned or blown-out muffler. (c) Burned or rusted-out exhaust pipe. (d) Exhaust pipes leaking at manifold flange. (e) Exhaust manifold cracked or broken. (f) Leak between manifold and cylinder head. (g) Restriction in muffler or tailpipe.	(a) Tighten clamps at leaking joints. (b) Replace muffler assembly. (c) Replace exhaust pipe. (d) Tighten connection attaching nuts. (e) Replace manifold. (f) Tighten manifold to cylinder head stud nuts or bolts. (g) Remove restriction, if possible, or replace, as necessary.
LEAKING EXHAUST GASES	(a) Leaks at pipe joints. (b) Damaged or improperly installed gaskets.	(a) Tighten U-bolt nuts at leaking joints. (b) Replace gaskets as necessary.
ENGINE HARD TO WARM UP OR WILL NOT RETURN TO NORMAL IDLE	(a) Heat control valve frozen in the open position. (b) Blocked crossover passage in intake manifold.	(a) Free-up manifold heat control valve using a suitable solvent. (b) Remove restriction or replace intake manifold.
HEAT CONTROL VALVE NOISY	(a) Thermostat broken. (b) Broken, weak or missing anti-de spring.	(a) Replace thermostat. (b) Replace spring.

18911-2

Exhaust System Torque Specifications

COMPONENTS	ENGINES	TORQUES
Air Injection Manifold Fittings	5.9L	52 N•m 38 ft-lbs
Air Pump Adjustment Strop	5.9L	27 N•m 20 ft-lbs
Air Pump Mounting Bolts	5.9L	27 N•m 20 ft-lbs
Carburetor Mounting Nuts	5.9L	19 N•m 14 ft-lbs
Catalytic Converter-to-Muffler Clamp Nuts	4.2L & 5.9L	61 N•m 45 ft-lbs
Downpipe-to-Catalytic Converter Nuts	4.2L	34 N•m 25 ft-lbs
Downpipe-to-Catalytic Converter Clamp Nuts	5.9L	61 N•m 45 ft-lbs
Downpipe-to-Exhaust Manifold Nuts	2.5L & 4.0L	31 N•m 23 ft-lbs
Downpipe-to-Exhaust Manifold Nuts	4.2L & 5.9L	27 N•m 20 ft-lbs
Downstream Tube-to-Catalytic Converter Clamp	4.2L	5 N•m (44 in-lbs)
Exhaust Manifold Bolts/Nuts	2.5L	41 N•m 30 ft-lbs
Exhaust Manifold Middle Nuts	4.0L & 4.2L	41 N•m 30 ft-lbs
Exhaust Manifold Outside Nuts	4.0L & 4.2L	31 N•m 23 ft-lbs
Exhaust Manifold Center Two Bolts	5.9L	34 N•m 25 ft-lbs
Exhaust Manifold Outer Four Bolts	5.9L	20 N•m 15 ft-lbs
EGR Tube Nuts	2.5L, 4.0L & 4.2L	41 N•m 30 ft-lbs
EGR Tube Bolts	2.5L	19 N•m 14 ft-lbs
Intake Manifold Bolts	2.5L, 4.0L & 4.2L	31 N•m 23 ft-lbs
Intake Manifold Bolts	5.9L	58 N•m 43 ft-lbs
Oxygen Sensor	2.6L, 4.0L & 4.2L	48 N•m 35 ft-lbs



EXHAUST MANIFOLD

Removal

1. Disconnect the battery negative cable.
2. Raise the vehicle.
3. Disconnect the exhaust pipe from the engine exhaust manifold.
4. Lower the vehicle.
5. Remove the intake manifold. (Refer to *Intake Manifold Removal*, 'Fuel Delivery and Fuel Injection Systems' section of this chapter.)
6. Remove fasteners 2 through 5 and remove the intake manifold (Figure 2-85).
7. Remove fasteners 1, 6 and 7 and remove the engine exhaust manifold (Figure 2-85).

Installation

1. Clean the intake and engine exhaust manifolds and cylinder head mating surfaces. **DO NOT** allow foreign material to enter either the intake manifold or the ports in the cylinder head.
2. Install a new intake manifold gasket over the alignment dowels on the cylinder head.

3. Install the engine exhaust manifold assembly. Exhaust manifold must be centrally located over the end studs and spacer (Figure 2-85).
4. Tighten bolt No. 1 to 41 N•m (30 ft-lbs) torque (Figure 2-85).
5. Install the intake manifold on the cylinder head dowels (Figure 2-85).
6. Install bolts 2 through 5 (Figure 2-85). Tighten these bolts to 31 N•m (23 ft-lbs) torque.
7. Install new engine exhaust manifold spacers over the engine exhaust manifold mounting studs in the cylinder head (Figure 2-85).
8. Tighten nuts 6 and 7 to 31 N•m (23 ft-lbs) torque (Figure 2-85).
9. Install all components to the intake manifold.
10. Raise the vehicle.
11. Connect the exhaust pipe to the engine exhaust manifold. Tighten the bolts to 31 N•m (23 ft-lbs) torque.
12. Lower the vehicle.
13. Connect the battery negative cable.
14. Start the engine and check for leaks.

Ignition System

THROTTLE BODY FUEL INJECTION (TBI) IGNITION SYSTEM

The 2.5L engine TBI ignition system is controlled by the Electronic Control Unit (ECU). The ignition system consists of

- Ignition Control Module (ICM)

The solid-state Ignition Control Module (ICM) consists of a solid-state ignition circuit and an integrated ignition coil that can be removed and serviced separately if necessary.

Ignition advance/retard is controlled electronically by the Electronic Control Unit (ECU). Electronic signals from the ECU to the ICM determine the amount of ignition timing advance or retard needed to meet various engine load requirements.

The ECU provides an input signal to the ICM. The ICM has only two outputs:

- Tachometer signal to the tachometer and diagnostic connector
- High voltage from the coil to the distributor cap

- Electronic Control Unit (ECU)

The ECU controls the fuel injector pulse width and ignition timing based on inputs received from sensors that react to exhaust gas oxygen content, air-fuel temperature, coolant temperature, manifold absolute pressure, battery voltage, crankshaft position (engine speed), throttle position and inputs from switches that are triggered by power steering pump output pressure, wide open throttle conditions, and transmission gear selection (automatic transmissions only). Battery voltage is also monitored to determine injector pulse width. These sensors and switches are considered ECU inputs. For more information, refer to 'Fuel Delivery and Fuel Injection Systems' section of this chapter.

- Distributor

The 2.5L engine distributor does not have built-in centrifugal or vacuum assisted advances. Ignition timing/advance is controlled by the Electronic Control Unit (ECU). Because ignition timing is controlled by the ECU, base ignition timing is not adjustable on any of these engines. The distributor is locked in place by an ear on the distributor housing that a hold down bolt passes through when the distributor is installed. Because the distributor position is locked when installed, its rotational position cannot be changed. DO NOT attempt to modify the distributor housing to get distributor rotation.

Distributor Cap and Rotor Set

Distributor cap and rotor for 2.5L engines only.

P4529685 Distributor cap and rotor set.

MULTI-POINT FUEL INJECTION (MPI) IGNITION SYSTEM

The 2.5L engine MPI ignition system is controlled by the Powertrain Control Module (PCM).

The MPI ignition system consists of

- Spark Plugs
- Ignition Coil
- Secondary Ignition Cables
- Distributor (contains rotor and camshaft position sensor)
- Powertrain Control Module (PCM)
- Crankshaft Position, Camshaft Position, Throttle Position and MAP Sensors

Camshaft Position Sensor

The camshaft position sensor is located in the distributor.

The sensor contains a hall effect device called a sync signal generator to generate a fuel sync signal. This sync signal generator detects a rotating pulse ring (shutter) on the distributor shaft. The pulse ring rotates **180** degrees through the sync signal generator. Its signal is used in conjunction with the crankshaft position sensor to differentiate between fuel injection and spark events. It is also used to synchronize the fuel injectors with their respective cylinders.

When the leading edge of the pulse ring (shutter) enters the sync signal generator, the interruption of magnetic field causes the voltage to switch high resulting in a sync signal of approximately 5 volts.

When the trailing edge of the pulse ring (shutter) leaves the sync signal generator, the change of the magnetic field causes the sync signal voltage to switch low to 0 volts.

Distributor

All MPI engines are equipped with a camshaft driven mechanical distributor containing a shaft driven distributor rotor. All distributors are equipped with an internal camshaft position (fuel sync) sensor (Figure 2-88). This sensor provides fuel injection synchronization and cylinder identification.

The distributor does not have built in centrifugal or vacuum assisted advance. Base ignition timing and all timing advance is controlled by the Powertrain Control Module (PCM). Because ignition timing is controlled by the PCM, base ignition timing is not adjustable on any of these engines.

The distributor is locked in place by a fork with a slot located on the distributor housing base. The distributor hold down clamp bolt passes through this slot when installed. Because the distributor position is locked when installed, its rotational position can not be changed. DO NOT attempt to modify the distributor housing to get distributor rotation.

Distributor position will have no effect on ignition timing. The position of the distributor will determine fuel synchronization only.

All distributors contain an internal oil seal that prevents oil from entering the distributor housing. The seal is not serviceable.

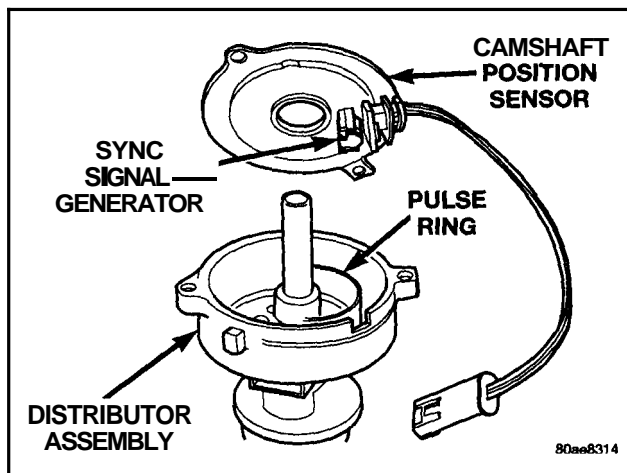


Figure 2 - 88

Distributor Cap

Remove the distributor cap and wipe it clean with a dry lint free cloth. Visually inspect the cap for cracks, carbon paths, broken towers or damaged rotor button (Figure 2-89 and Figure 2-90). Also check for white deposits on the inside (caused by condensation entering the cap through cracks). Replace any cap that displays charred or eroded terminals. The machined surface of a terminal end (faces toward rotor) will indicate some evidence of erosion from normal operation. Examine the terminal ends for evidence of mechanical interference with the rotor tip.

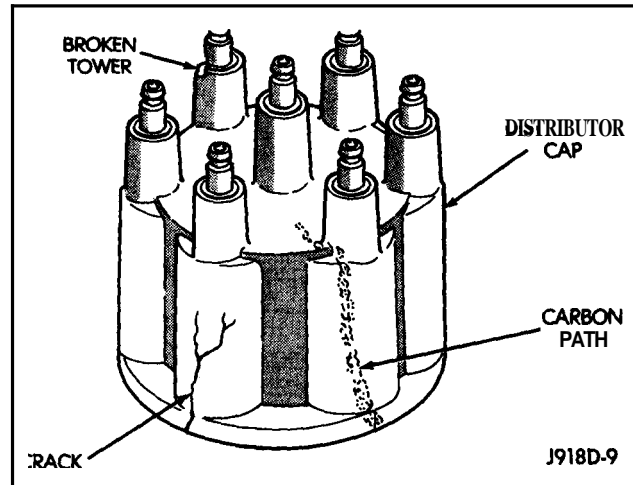


Figure 2 - 89

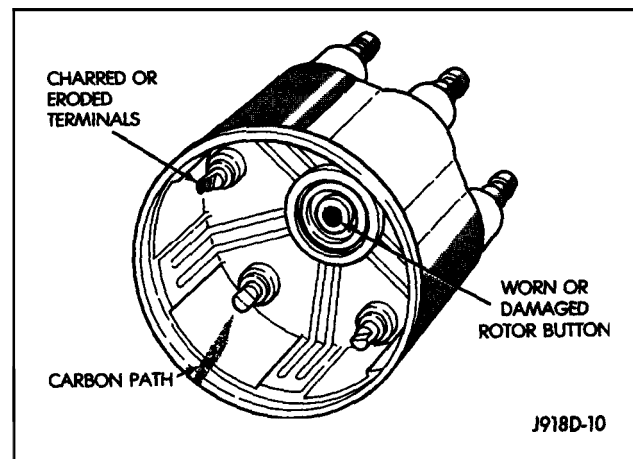


Figure 2 - 90

Distributor Rotor

Visually inspect the rotor (Figure 2-91) for cracks, evidence of corrosion or the effects of arcing on the metal tip. Also check for evidence of mechanical interference with the cap. Some charring is normal on the end of the metal tip. The silicone-dielectric varnish compound applied to the rotor tip for radio interference noise suppression will appear charred. This is normal. DO NOT remove the charred compound. Test the spring for insufficient tension. Replace a rotor that displays any of these adverse conditions

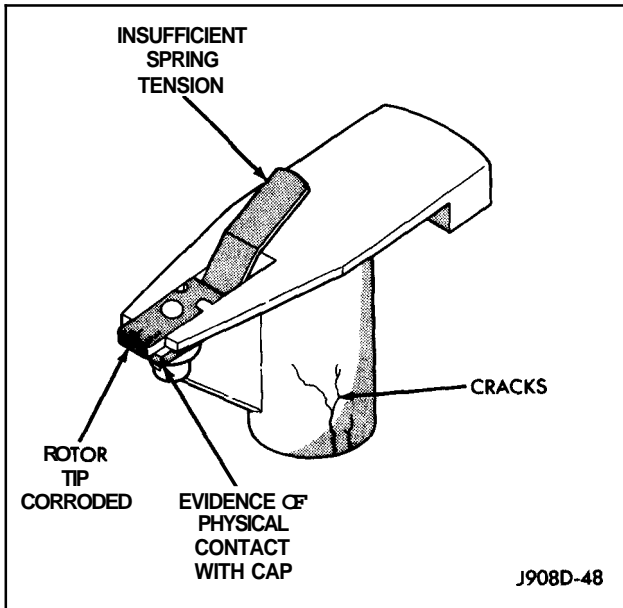


Figure 2 - 91

Ignition Coil

The ignition coil is an epoxy filled type. If the coil is replaced, it must be replaced with the same type.

1. Removal

The ignition coil is mounted to a bracket on side of engine (to rear of distributor) (Figure 2-92).

- Disconnect ignition coil secondary cable from ignition coil.
- Disconnect engine harness connector from ignition coil.
- Remove ignition coil mounting bolts (nuts are used on back side of bracket on some coils).
- Remove coil from vehicle.

2. Installation

- Install ignition coil to bracket on cylinder block with mounting bolts (and nuts if equipped). If equipped with nuts and bolts, tighten to 11 N•m (100 in-lbs) torque. If equipped with bolts only, tighten to 5 N•m (50 in-lbs) torque.
- Connect engine harness connector to coil.
- Connect ignition coil cable to ignition coil.

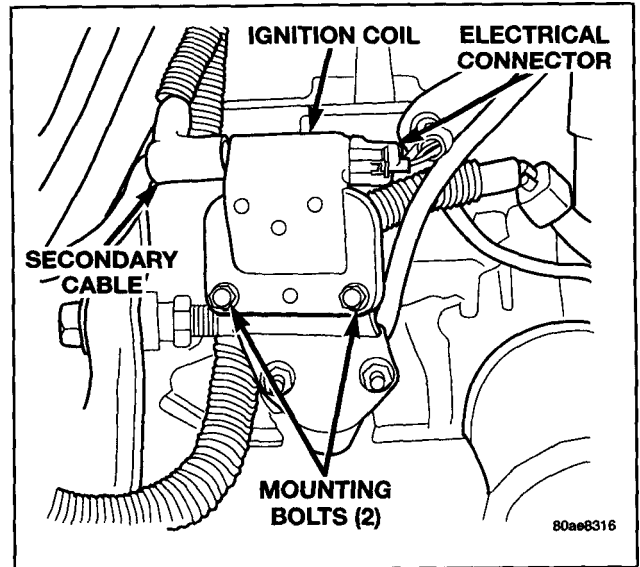


Figure 2 - 92

SPARK PLUGS

Spark Plug and Ignition Wire Removal

Remove the ignition wire by grasping it at the spark plug boot, and then turn (1/2 turn) and pull it straight back in one steady motion.

- Prior to removing the spark plug, spray compressed air around the spark plug hole and the area around the spark plug.
- Remove the spark plug using a quality socket with a rubber or foam insert.
- Inspect the spark plug. Refer to 'Ignition System' section of Chapter 4 for information.

Specifications

Engine	Spark Plug Type	Electrode Gap	Tightening Torque
2.5L	RC-12 LYC	0.89 mm (0.035")	37 N•m (27 ft-lbs)

Gap Adjustment

Check the spark plug with a gap (feeler) gauge. If the gap is not correct, adjust it by bending the ground electrode. The gap for 2.5L engines is 0.89 mm (0.035").

Installation

- Start the spark plug into the cylinder head by hand to avoid cross threading.
- Tighten the spark plug to 37 N•m (27 ft-lbs) torque.
- Install ignition wires over spark plugs.

Always tighten spark plugs to the specified torque. Over tightening can cause distortion resulting in a change in the spark plug gap. Tighten all **spark** plugs to 37 N•m (27 ft-lbs).

When replacing the ignition wires, route the wires correctly and secure them in the proper retainers. Failure to route the wires properly can cause ignition noise radio reproduction, cross ignition of spark plugs, or short-circuit the wires to ground.

STARTER MOTOR

The starter motor is mounted with two screws to the right rear corner of the engine block.

The starter motor incorporates several features to create a reliable, efficient, compact, lightweight and powerful unit. The electric motor of the starter has four brushes contacting the motor commutator. The starter motor uses four permanent magnets for the field poles, and is rated at 1.2 kilowatts (about 1.6 horsepower) output at 12 volts.

The starter motor is serviced only as a unit with its starter solenoid, and cannot be repaired. If either component is faulty or damaged, the entire starter motor and starter solenoid unit must be replaced.

Mopar Performance Parts Spark Plugs

NEW! These spark plugs are specifically designed for the optimum performance of your Mopar engine. Each package contains 4 spark plugs.

Race & Tuning Application Plugs (J-Strap Type)

Pack PIN	Cross Reference	Application
P4876939	C 63C	All except 'B-RB' engines
P4876940	C 61C to C 59C	All except 'B-RB' engines
P4876941	C 57c to C 55c	All except 'B-RB' engines
P4876942	C 53c to C 51C	All except 'B-RB' engines
P4876943	C 51C	All except 'B-RB' engines
P4876944	C 61C to C 59C	All except 'B-RB' engines
P4876945	C 57c to C 55C	All except 'B-RB' engines

Professional Race Plugs

Pack PIN	Cross Reference	Application
P4876928	C 61C to C 59C	All Race Applications
P4876929	C 57c to C 55c	All Race Applications
P4876930	C 53C to C 51C	All Race Applications
P4876931	C 51C	All Race Applications
P4876932	S 61C to S 59C	All Race Applications
P4876933	S 57c to S 57c	All Race Applications
P4876934	S 53c to S 51c	All Race Applications
P4876935	S 51C	All Race Applications

Operation

The starter motor is equipped with a planetary gear reduction (intermediate transmission) system. The planetary gear reduction system consists of a gear that is integral to the output end of the electric motor armature shaft that is in continual engagement with a larger gear that is splined to the input end of the starter pinion gear shaft. This feature makes it possible to reduce the dimensions of the starter. At the same time, it allows higher armature rotational speed and delivers increased torque through the starter pinion gear to the starter ring gear.

The starter motor is activated by an integral heavy duty starter solenoid switch mounted to the overrunning clutch housing. This electromechanical switch connects and disconnects the feed of battery voltage to the starter motor and actuates a shift fork that engages and disengages the starter pinion gear with the starter ring gear.

The starter motor uses an overrunning clutch and starter pinion gear unit to engage and drive a starter ring gear that is integral to the flywheel (manual transmission) or torque converter drive plate (automatic transmission) mounted on the rear crankshaft flange. Shims are available and can be used to adjust the starter motor mounting position to correct for improper starter pinion gear-to-starter ring gear engagement.

Removal

1. Disconnect and isolate the battery negative cable.
2. Raise and support the vehicle.
3. While supporting the starter motor with one hand, use the other hand to remove the two screws that secure the starter motor to the engine block (Figure 2-93).
4. Lower the starter motor from the engine block far enough to access and remove the nut that secures the solenoid wire harness connector eyelet to the solenoid terminal stud. Always support the starter motor during this process. **DO NOT** let the starter motor hang from the wire harness.
5. Remove the nut that secures the battery cable harness connector eyelet to the solenoid battery terminal stud. Always support the starter motor during this process. **DO NOT** let the starter motor hang from the wire harness.
6. Remove the battery cable and solenoid wire connector eyelets from the solenoid terminal studs.
7. Remove the starter motor and any starter motor shims (if used) from the engine compartment.

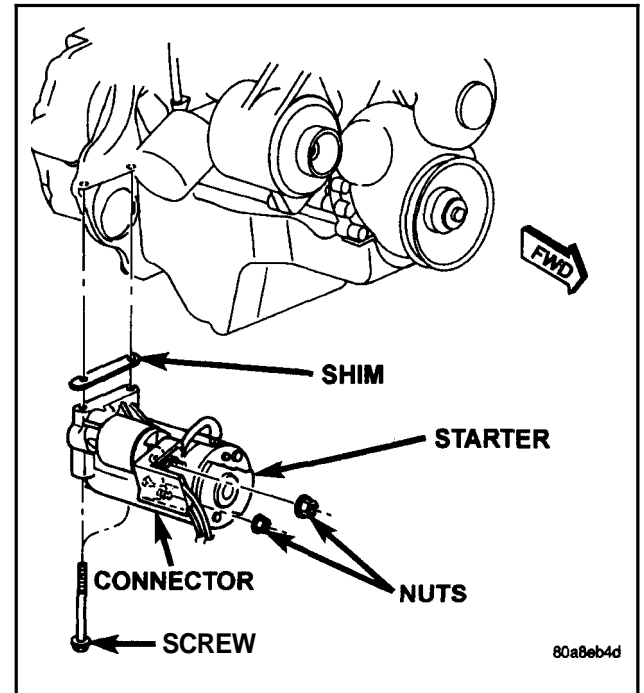


Figure 2 - 93

Installation

1. Position the starter motor in the engine compartment.
 2. Install the battery cable and solenoid wire connector eyelets onto the solenoid terminal studs.
 3. Install and tighten the nut that secures the battery cable harness connector eyelet to the solenoid battery terminal stud. Tighten the nut **to** 10 Nm (90 in-lbs). Always support the starter motor during this process. **DO NOT** let the starter motor hang from the wire harness.
 4. Install and tighten the nut that secures the solenoid wire harness connector eyelet to the solenoid terminal stud. Tighten the nut **to** 6 Nm (55 in-lbs). Always support the starter motor during this process. **DO NOT** let the starter motor hang from the wire harness.
 5. Position the starter motor and any starter motor shims that were removed **to the engine block** and loosely install both of the mounting screws.
- Note:** Shim thickness available is 0.381 mm (0.015"). Refer to the proper service manual for more information.
6. Tighten both of the starter motor mounting screws to 45 Nm (33 ft-lbs).
 7. Lower the vehicle.
 8. Reconnect the battery negative cable.

MOPAR PERFORMANCE PARTS ELECTRONIC IGNITION COMPONENTS

High Performance Electronic Control Units

For a hotter spark and more rpm capability, use one of Mopar Performance Parts' high performance ECUs. For general high performance and usage up through 6,000 rpm, use the Orange Box ECU. For higher rpm output requirements up through 8,000, select the Chrome Box ECU.

P4120505	Orange Box ECU.
P4120534	Chrome Box ECU.

Super Gold Electronic Control Unit

The Super Gold Electronic Control Unit is the culmination of eight years of high performance ignition systems development. Designed to out perform any ignition unit previously offered to Mopar racers, it will handle the high current demand by the P3690560 (Accel) high performance coil, while keeping dwell variation to less than 1° from 1,000 to 10,000rpm. Dwell is set for maximum spark output at low and high engine speeds. The Super Gold ECU provides outstanding performance from idle to 12,000rpm.

P4120600	Super Gold ECU – race only.
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Ballast Resistor – Electronic Distributor

P2444641	Use with mechanical advance distributor using P3690560 coil. 1/4 Ohm.
P5206436	Use with electronic ignition systems using P4120505 Orange Box ECU and production coil, or with P4120889 coil. 1 Ohm.

Ignition Coils

P4120889	Accel Super Coil for all 12-volt applications. Not recommended for engine speeds over 6,500 rpm. (Use with ballast resistor P5206436.)
P3690560	Accel Race Coil specifically designed to be used with race electronic ignition kits. Designed for racing applications only. Not recommended for continued operation at speeds below 3,000 rpm for more than 30 minute periods. (Use with ballast resistor P2444641.)

Control Wiring Harness Kit for Electronic Ignitions

Kit used to convert to a new electronic ignition system.

P3690152	Control wiring harness kit for electronic ignitions.
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Chrome Ignition Coil Bracket

Another underhood piece to dress-up your engine compartment. Includes special clamp screw.

P4286728	Chrome ignition coil bracket.
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Tach Adapter

Designed for applications when high capacitive discharge coils interfere with tachometer or fuel injection signals. This device provides a clear 12 volt square wave signal output with a 30% duty cycle.

P4876738	Tach adapter.
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Engine Assembly

Note: For engine assembly information, performance modifications and tips, refer to 'Engine Assembly' section of Chapter 4. 4.0L Power Tech In-Line 6.

1990, 2.5L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the *1990 Jeep Wrangler Service Manual*.

Cylinder Block		
Deck Height	236.7.3 mm	9.320 in.
Deck Clearance	0.000 mm	0.000 in.
Cylinder Bore Diameter (Standard)	98.42-98.48 mm	3.8751-3.8775 in.
Maximum Taper	0.025 mm	0.001 in.
Maximum Out-of-Round	0.025 mm	0.001 in.
Tappet Bore Diameter	23.000-23.025 mm	0.9055-0.9065 in.
Cylinder Block Flatness	0.03 per 25 mm	0.001 per 1 in.
	0.05 per 152 mm	0.002 per 6 in.
Main Bearing Bore Diameter	68.35-68.38 mm	2.691-2.692 in.
Combustion Chamber		
Combustion Chamber Volume	49.9-52.9 cc	3.04-3.23 cu. in.
Valve Arrangement	E-I-I-I-E-I-I-E	
Valve Guide ID (Integral)	7.95-7.97 mm	0.313-0.314 in.
Valve Stem-to-Guide Clearance	0.02-0.07 mm	0.001-0.003 in.
Intake Valve Seat Angle	44°30'	
Exhaust Valve Seat Angle	44°30'	
Valve Seat Width	1.02-1.52 mm	0.040-0.060 in.
Valve Seat Runout	0.064 mm	0.0025 in.
Cylinder Head Flatness	0.03 per 25 mm	0.001 per 1 in.
	0.05 per 152 mm	0.002 per 6 in.
Oil Pressure		
At Idle Speed (800 rpm)	172-241 kPa	25-35 psi
At 1600+ rpm	255-517 kPa	37-75 psi
Oil Pressure Relief	517 kPa	75 psi
Oil Pump		
Gear-to-Body Clearance (Radial)	0.051-0.102 mm	0.002-0.004 in.
Preferred	0.051 mm	0.002 in.
Gear End Clearance - Plastigage	0.051-0.152 mm	0.002-0.006 in.
Preferred	0.051 mm	0.002 in.
Gear End Clearance - Feeler Gouge	0.1016-0.2032 mm	0.004-0.008 in.
Preferred	0.1778 mm	0.007 in.
Rocker Arms, Push Rods and Tappets		
Rocker Arm Ratio	1.6:1	
Push Rod length	241.300-241.808 mm	9.500-9.520 in.
Push Rod Diameter	7.52-8.00 mm	0.312-0.315 in.
Hydraulic Tappet Diameter	22.962-22.974 mm	0.904-0.9045 in.
Tappet-to-Bore Clearance	0.03-0.05 mm	0.001-0.0025 in.

Camshaft

Tappet Clearance	Zero lash (hyd.) tappets	
End Play	Zero (engine operation)	0.001-0.003 in.
Bearing Clearance	0.025-0.076 mm	
Bearing Journal Diameter		2.028-2.030 in.
No. 1	51.54-51.56 mm	2.019-2.020 in.
No. 2	51.28-51.31 mm	2.009-2.010 in.
No. 3	51.03-51.05 mm	1.999-2.000 in.
No. 4	50.78-50.80 mm	
Base Circle Runout	0.03 mm max.	0.001 in. max.
Cam Lobe Lift		
Intake	6.731 mm	0.265 in.
Exhaust	6.731 mm	0.265 in.
Valve Lift		
Intake	10.770 mm	0.424 in.
Exhaust	10.770 mm	0.424 in.
Intake Valve Timing		
Opens	12° BTDC	
Closes	78° ABDC	
Exhaust Valve Timing		
Opens	56° BBDC	
Closes	34° ATDC	
Valve Overlap	46°	
Intake Duration	270°	
Exhaust Duration	270°	

Connecting Rods

	657-665 grams	23.2-23.5 oz.
Total Weight (Less Bearings)		6.123-6.127 in.
Total Length (Center-to-Center)	155.52-155.62 mm	6.128-6.129 in.
Piston Pin Bore Diameter	23.59-23.62 mm	
Connecting Rod Bore (Less Bearings)	50.98-50.99 mm	2.008-2.085 in.
Bearing Clearance		0.0015-0.0020 in.
Preferred	0.044-0.050 mm	0.010-0.019 in.
Side Clearance	0.25-0.48 mm	
Maximum Twist	0.001 mm per mm	0.001 in. per in.
Maximum Bend	0.001 mm per mm	0.001 in. per in.

Crankshafts

End Play	0.038-0.165 mm	0.0015-0.0065 in.
Main Bearing Journal Diameter	63.489-63.502 mm	2.4996-2.5001 in.
Main Bearing Journal Width		
No. 1	27.58-27.89 mm	1.086-1.098 in.
No. 2	32.28-32.33 mm	1.271-1.273 in.
No. 3-4-5	30.02-30.18 mm	1.182-1.188 in.
Main Bearing Clearance	0.03-0.06 mm	0.001-0.0025 in.
Preferred	0.051 mm	0.002 in.
Connecting Rod Journal Diameter	53.17-53.23 mm	2.0934-2.0955 in.
Connecting Rod Journal Width	27.18-27.33 mm	1.070-1.076 in.
Maximum Out-of-Round (All Journals)	0.013 mm	0.0005 in.
Maximum Taper (All Journals)	0.013 mm	0.0005 in.

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Pistons

Weight (Less Pin)	563-567 grams	19.86-20.00 oz.
Piston Pin Bore		
Centerline-to-Piston Top	40.67 mm	1.601 in.
Piston-to-Bore Clearance	0.033-0.053 mm	0.0013-0.0021 in.
Piston Ring Gap Clearance –		
Compression (Both)	0.25-0.51 mm	0.010-0.020 in.
Piston Ring Gap Clearance –		
Oil Control Steel Rails	0.381-1.397 mm	0.015-0.055 in.
Piston Ring Side Clearance		
No. 1 Compression	0.0254-0.0813 mm	0.001-0.0032 in.
No. 2 Compression	0.254-0.241 mm	0.001-0.0032 in.
Oil Control	0.254-0.2032 mm	0.001-0.0085 in.
Piston Ring Groove Height		
Compression (Both)	2.019-2.045 mm	0.0795-0.0805 in.
Oil Control	4.78-4.80 mm	0.188-0.1895 in.
Piston Ring Groove Diameter		
No. 1 and No. 2	87.78-87.90 mm	3.456-3.461 in.
Oil Control	87.50-87.75 mm	3.445-3.455 in.
Piston Pin Bore Diameter	23.624-23.655 mm	0.9308-0.9313 in.
Piston Pin Diameter	23.632-23.645 mm	0.9304-0.9309 in.
Piston-to-Pin Clearance	0.010-0.015 mm	0.0004-0.0006 in.
Preferred	Loose 0.015 mm	Loose 0.0006 in.
Piston Pin-to-Connecting Rod	8.9 kN Press-fit	2000 lbs.-f Press-fit

Valves

Valve length (Tip-to-Gauge Dim. Line)		
Intake	124.435-125.070 mm	4.899-4.924 in.
Exhaust	125.120-125.755 mm	4.927-4.952 in.
Valve Stem Diameter	7.89-7.98 mm	0.311-0.312 in.
Stem-to-Guide Clearance	0.02-0.05 mm	0.001-0.003 in.
Intake Valve Head Diameter	48.38-48.6 mm	1.905-1.915 in.
Intake Valve Face Angle	45°	
Exhaust Valve Head Diameter	37.97-38.6 mm	1.495-1.505 in.
Exhaust Valve Face Angle	45°	
Maximum Allowable Removed for		
Tip Refinishing	0.25 mm	0.010 in.
Valve Springs Free Length	49.962 mm	1.967 in.
Valve Spring Tension Closed	355-400 N @ 41.656 mm	80-90 lbs @ 1.640 in.
Valve Spring Tension Open	890 N @ 30.886 mm	200 lbs @ 1.216 in.

1990, 2.5L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1990 Jeep Wrangler Service Manual*.

Component	Torque	
A/C Bracket-to-Block/Head Bolts	40 N·m	30 ft-lbs
A/C Compressor-to-Bracket Bolts	27 N·m	20 ft-lbs
Alternator Adjusting Bolt	27 N·m	20 ft-lbs
Alternator Pivot Bolt/Nut	38 N·m	28 ft-lbs
Alternator Mounting Bracket-to-Engine Bolts	38 N·m	20 ft-lbs
Alternator Mounting-to-Head Bolts	45 N·m	33 ft-lbs
Block Heater Nut	1.8 N·m	16 in-lbs
Camshaft Sprocket Bolt	108 N·m	80 ft-lbs
Connecting Rod Bolt Nuts	45 N·m	33 ft-lbs
Converter Plate Bolts	68 N·m + 60°	50 ft-lbs + 60°
Crankshaft Main Bearing Bolts	108 N·m	80 ft-lbs
Crankshaft Pulley-to-Damper Nut	27 N·m	20 ft-lbs
Crossmember-to-Sill - Front Bolts	88 N·m	65 ft-lbs
- Rear Nuts	41 N·m	30 ft-lbs
Cylinder Block Oil Galley Plugs	41 N·m	30 ft-lbs
Cylinder Head Bolts (#1-7 & #9-10)	149 N·m	110 ft-lbs
(#8)	136 N·m	100 ft-lbs
Cylinder Head Cover Bolts	8 N·m	70 in-lbs
Drive Plate-to-Torque Converter Bolts	54 N·m	40 ft-lbs
Engine Shock Damper Stud Nut	23 N·m	17 ft-lbs
Exhaust Manifold-to-Downpipe Nuts	31 N·m	23 ft-lbs
Flywheel Bolts	68 N·m + 60°	50 ft-lbs + 60°
Front Support Bracket-to-Cylinder Block	61 N·m	45 ft-lbs
Front Support Cushion-to-Mount (Thru Bolt)	65 N·m	48 ft-lbs
Front Support Cushion-to-Sill Bracket	40 N·m	30 ft-lbs
Fuel Pump Bolts	22 N·m	16 ft-lbs
Oil Pan Bolts - 1/4-20	9 N·m	7 ft-lbs
- 5/16-18	15 N·m	11 ft-lbs
Oil Pan Drain Plug	34 N·m	25 ft-lbs
Oil Pan-to-Timing Case Cover Bolts	13 N·m	11 ft-lbs
Oil Pump Attaching Bolts (Short)	14 N·m	10 ft-lbs
Oil Pump Attaching Bolts (Long)	23 N·m	17 ft-lbs
Oil Pump Cover Bolts	8 N·m	70 in-lbs
Power Steering Pump Pressure Hose Nut	52 N·m	38 ft-lbs
Rear Support Cushion-to-Brocket Bolts	43 N·m	32 ft-lbs
Rocker Arm Assembly-to-Cylinder Head	26 N·m	19 ft-lbs
Spark Plugs	37 N·m	27 ft-lbs
Starting Motor-to-Cylinder Block Bolts	45 N·m	33 ft-lbs
Timing Case Cover-to-Block Bolts	7 N·m	62 in-lbs
Vibration Damper Bolt (Lubricated)	108 N·m	80 ft-lbs

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1999, 2.5L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the *1999 Jeep Wrangler Service Manual*.

Engine Type In-line 4-cylinder	Main Bearing Journal
Bore and Stroke . . . 98.4 x 81.0 mm (3.88 x 3.19 in.)	Width No. 1 27.58 to 27.89 mm
Displacement 2.5L (150 c.i.)	(1.086 to 1.098 in.)
Compression Ratio 9.1:1	Main Bearing Journal
Firing Order. 1 — 3 4 2	Width No. 2 32.28 to 32.33 mm
Lubrication Pressure Feed—	(1.271 to 1.273 in.)
Full Flow Filtration	Main Bearing Journal
Cooling System Liquid Cooled—	Width No. 3-4-5 30.02 to 30.18 mm
Forced Circulation	(1.182 to 1.188 in.)
Cylinder Block Cast Iron	Main Bearing Clearance 0.03 to 0.06 mm
Crankshaft Cast Nodular Iron	(0.001 to 0.0025 in.)
Cylinder Head. Cast Iron	Main Bearing Clearance (Preferred) . . . 0.051 mm
Camshaft Cast Iron	(0.002 in.)
Pistons Aluminum Alloy	Connecting Rod Journal
Combustion Chamber Dual-Quench	Diameter. 53.17 to 53.23 mm
Connecting rods Cast Malleable Iron	(2.0934 to 2.0955 in.)
	Connecting Rod Journal
	Width 27.18 to 27.33 mm
	(1.070 to 1.076 in.)
	Out-of-Round (Max. All Journals) 0.013 mm
	(0.0005 in.)
	Taper (Max. — All Journals) 0.013 mm
	(0.0005 in.)
Engine Specifications	Cylinder Block
Camshaft	Deck Height 236.73 mm (9.320 in.)
Hydraulic Tappet Clearance Zero Lash	Deck Clearance 0.000 mm (0.000 in.)
Bearing Clearance 0.025 to 0.076 mm	Cylinder Bore Diameter—
(0.001 to 0.003 in.)	Standard. 98.45 to 98.48 mm
	(3.8759 to 3.8775 in.)
	Cylinder Bore Diameter—
	Taper (Max.) 0.025 mm (0.001 in.)
	Cylinder Bore Diameter—
	Out-of-Round (Max.) 0.025 mm (0.001 in.)
	Tappet Bore Diameter 23.000 to 23.025 mm
	(0.9055 to 0.9065 in.)
	Flatness 0.03 mm per 25 mm
	(0.001 in. per 1 in.)
	Flatness 0.05 mm per 152 mm
	(0.002 in. per 6 in.)
	Flatness Max. 0.20 mm for total length
	(0.008 in. for total length)
	Main Bearing Bore Diameter 68.3514 to
	68.3768 mm (2.691 to 2.692 in.)
Bearing Journal Diameter	
No. 1 51.54 to 51.56 mm (2.029 to 2.030 in.)	
No. 2 51.28 to 51.31 mm (2.019 to 2.020 in.)	
No. 3 51.03 to 51.05 mm (2.009 to 2.010 in.)	
No. 4 50.78 to 50.80 mm (1.999 to 2.000 in.)	
Base Circle Runout 0.03 mm - max.	
(0.001 in. - max.)	
Camshaft Lobe Lift	
Exhaust 6.579 mm (0.259 in.)	
Intake 6.477 mm (0.255 in.)	
Valve Lift	
Exhaust 10.528 mm (0.4145 in.)	
Intake. 10.350 mm (0.4075 in.)	
Intake Valve Timing	
Opens 15.4" BTDC	
Closes 58" ABDC	
Exhaust Valve Timing	
Opens 52.8 BBDC	
Closes 26.2" ATDC	
Valve Overlap 41.6"	
Intake Duration 253.3"	
Exhaust Duration 259."	
Crankshaft	
End Play 0.038 to 0.165 mm	
(0.0015 to 0.0065 in.)	
Main Bearing Journal	
Diameter 63.489 to 63.502 mm	
(2.4996 to 2.5001 in.)	

Connecting Rods

Total Weight (Less Bearing) . . .	657 to 665 grams (23.17 to 23.45 oz.)
Length (Center-to-Center) . . .	155.52 to 155.62 mm (6.123 to 6.127 in.)
Piston Pin Bore Diameter	23.59 to 23.62 mm (0.9288 to 0.9298 in.)
Bore (Less Bearings)	56.08 to 56.09 mm (2.2080 to 2.2085 in.)
Bearing Clearance	0.025 to 0.076 mm (0.001 to 0.003 in.)
Bearing Clearance (Preferred) . . .	0.044 to 0.050 mm (0.0015 to 0.0020 in.)
Side Clearance	0.25 to 0.48 mm (0.010 to 0.019 in.)
Twist (Max.)	0.001 mm per mm (0.001 in. per inch)
Bend Max.)	0.001 mm per mm (0.001 in. per inch.)

Cylinder Compression Pressure

Ratio	9.1:1
Pressure Range	827 to 1,034 kPa (120 to 150 psi)
Max. Variation Between Cylinders	206 kPa (30 psi)

Cylinder Head

Combustion Chamber.	49.9 to 52.9 cc (3.04 to 3.23 cu. in.)
Valve Guide I.D. (Integral)	7.95 to 7.97 mm (0.313 to 0.314 in.)
Valve Stem-to-Guide Clearance	0.025 to 0.076 mm (0.001 to 0.003 in.)
Intake Valve Seat Angle	44.5"
Exhaust Valve Seat Angle	44.5"
Valve Seat Width.	1.01 to 1.52 mm (0.040 to 0.060 in.)
Valve Seat Runout	0.064 mm (0.0025 in.)
Flatness	0.03 mm per 25 mm (0.001 in. per 1 in.)
Flatness	0.05 mm per 152 mm (0.002 in. per 6 in.)
Flatness Max.	0.15 mm for total length (0.006 in. for total length)

Rocker Arms , Push Rods & Tappets

Rocker Arm Ratio	1.6:1
Push Rod Length	241.300 to 241.808 mm (9.500 to 9.520 in.)
Push Rod Diameter	7.92 to 8.00 mm (0.312 to 0.315 in.)
Hydraulic Tappet Diameter	22.962 to 22.974 mm (0.904 to 0.9045 in.)
Tappet-to-Bore Clearance	0.025 to 0.063 mm (0.001 to 0.0025 in.)

Valves

Length (Tip-to-Gauge Dimension Line)	
Intake	124.435 to 125.070 mm (4.899 to 4.924 in.)
Length (Tip-to-Gauge Dimension Line)	
Exhaust	125.120 to 125.755 mm (4.927 to 4.952 in.)
Valve Stem Diameter	7.899 to 7.925 mm (0.311 to 0.312 in.)
Stem-to-Guide Clearance.	0.025 to 0.076 mm (0.001 to 0.003 in.)
Valve Head Diameter—Intake	48.387 to 48.641 mm (1.905 to 1.915 in.)
Valve Head Diameter—Exhaust	37.973 to 38.227 mm (1.495 to 1.505 in.)
Valve Face Angle—Intake	45°
Valve Face Angle—Exhaust	45"
Tip Refinishing (Max. Allowable)	0.25 mm (0.010 in.)

Valve Springs

Free Length (Approx.)	47.65 mm (1.876 in.)
Spring Tension—Valve Closed.	316 to 351 N @ 41.656 mm (71 to 79 lbf. @ 1.64 in.)
Spring Tension—Valve Open.	898.6 to 969.7 N 30.89 mm (202 to 218 lbf @ 1.216 in.)
Inside Diameter	21.0 mm to 21.51 mm (0.827 to 0.847 in.)

Pistons

Weight (Less Pin)	417 to 429 grams (14.7 to 15.1 oz.)
Piston Pin Bore (Centerline to Piston Top)	40.61 to 40.72 mm (1.599 to 1.603 in.)
Piston-to-Bore Clearance	0.018 to 0.038 mm (0.0008 to 0.0015 in.)
Ring Gap Clearance— Top Compression Ring	0.229 to 0.610 mm (0.0090 to 0.0240 in.)
Ring Gap Clearance—2nd Compression Ring	0.483 to 0.965 mm (0.0190 to 0.0380 in.)
Ring Gap Clearance—Oil Control Steel Rails	0.254 to 1.500 mm (0.010 to 0.060 in.)
Ring Side Clearance—Compression Rings	0.042 to 0.084 mm (0.0017 to 0.0033 in.)
Ring Side Clearance—Oil Control Ring	0.06 to 0.21 mm (0.0024 to 0.0083 in.)
Piston Ring Groove Height—Compression Rings	1.530 to 1.555 mm (0.0602 to 0.0612 in.)
Piston Ring Groove Height—Oil Control Ring	4.035 to 4.060 mm (0.1589 to 0.1598 in.)
Piston Ring Groove Diameter—No. 1 Compression Ring	88.39 to 88.65 mm (3.48 to 3.49 in.)

Piston Ring Groove Diameter—No.2 Compression Ring **87.63 to 87.88 mm (3.45 to 3.46 in.)**
 Piston Ring Groove Diameter— Oil Control Ring **89.66 to 89.92 mm (3.53 to 3.54 in.)**
 Piston Pin Bore Diameter . . **23.650 to 23.658 mm (0.9312 to 0.9315 in.)**
 Piston Pin Diameter **23.637 to 23.640 mm (0.9306 to 0.9307 in.)**
 Piston-to-Pin Clearance **0.0102 to 0.0208 mm (0.0005 to 0.0009 in.)**
 Piston-to-Pin Connecting Rod (Press Fit) . . **8.9 kN (2000 lbf.)**

Oil Pump

Gear-to-Body Clearance (Radial) **0.051 to 0.102 mm (0.002 to 0.004 in.)**
 Gear-to-Body Clearance (Radial) (Preferred) **0.051 mm (0.002 in.)**
 Gear End Clearance—
 Plastigage . **0.051 to 0.152 mm (0.002 to 0.006 in.)**
 Gear End Clearance— Plastigage (Preferred) **0.051 mm (0.002 in.)**
 Gear End Clearance—Feeler Gauge. . . **0.1016 to 0.2032 mm (0.004 to 0.008 in.)**
 Gear End Clearance— Feeler Gauge (Preferred) **0.1778 mm (0.007 in.)**

Oil Pressure

Min. Pressure (600 rpm) **89.6 kPa (13 psi)**
 At Idle Speed (800 rpm) 172 to **241 kPa (25 to 35 psi)**
 At 1600 rpm & Higher 255 to **517 kPa (37 to 75 psi)**
 Oil Pressure Relief **517 kPa (75 psi)**



1999, 2.5L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1999 Jeep Wrangler Service Manual*.

DESCRIPTION	TORQUE	DESCRIPTION	TORQUE
A/C Compressor Bracket-to-Engine		Main Bearing Cap	
Bolts	34 N·m (25 R. lbs.)	Bolts	108 N·m (80 R. lbs.)
A/C Compressor		Oil Filter	
Mounting Bolts	27 N·m (20 R. lbs.)	Adaptor Bolt	102 N·m (75 R. lbs.)
Block Heater		Connector	68 N·m (50 ft. lbs.)
Nut	1.8 N·m (16 in. lbs.)	Filter	18 N·m (13 ft. lbs.)
Camshaft Sprocket		Oil Galley	
Bolt	108 N·m (80 R. lbs.)	Plug	41 N·m (30 R. lbs.)
Clutch Cover to Flywheel		Oil Pan	
Bolts	31 N·m (23 R. lbs.)	1/4-20 Bolts	9.5 N·m (84 in. lbs.)
Connecting Rod Cap		5/16-18 Bolts	15 N·m (132 in. lbs.)
Nuts	45 N·m (33 R. lbs.)	Drain Plug	34 N·m (25 R. lbs.)
Cylinder Block		Oil Pressure Sending Unit	
Drain Plugs	41 N·m (30 R. lbs.)	Sending Unit	15 N·m (130 in. lbs.)
Cylinder Head		Oil Pump	
Bolts #1-10 & #12-14	149 N·m (110 R. lbs.)	Short Attaching Bolts	23 N·m (204 in. lbs.)
Bolt #11	135 N·m (100 ft. lbs.)	Long Attaching Bolts	23 N·m (204 in. lbs.)
Cylinder Head Cover		Cover Bolts	8 N·m (70 in. lbs.)
Bolts	13 N·m (115 in. lbs.)	Power Steering Pump Pressure Hose	
Dipstick Tube Bracket to Cylinder Block		Nut	52 N·m (38 R. lbs.)
Bolt	19 N·m (168 in. lbs.)	Rocker Arm Assembly to Cylinder Head	
Distributor Hold-Down Clamp		Capscrews	28 N·m (21 R. lbs.)
Bolt	23 N·m (204 in. lbs.)	Spark Plugs	
Engine Mounts—Front		Plugs	37 N·m (27 ft. lbs.)
Insulator Bracket Bolts	81 N·m (60 R. lbs.)	Starter Motor	
Insulator Bracket Nuts	47 N·m (35 ft. lbs.)	Mounting Bolts	45 N·m (33 ft. lbs.)
Insulator Thru-Bolt	81 N·m (60 R. lbs.)	Tensioner Bracket of Cylinder Block	
Engine Mounts—Rear		Bolts	19 N·m (168 in. lbs.)
Support Cushion/Crossmember Nuts	22 N·m (192 in. lbs.)	Thermostat Housing	
Support Cushion/Bracket Nuts	46 N·m (34 R. lbs.)	Bolts	18 N·m (156 in. lbs.)
Transmission Support Bracket Bolts	43 N·m (32 ft. lbs.)	Throttle Body	
Transmission Support Bracket/ Cushion Bolt	75 N·m (55 R. lbs.)	Bolts	10 N·m (90 in. lbs.)
Transmission Support Adaptor Bracket Bolts	75 N·m (55 R. lbs.)	Vibration Damper	
Exhaust Manifold/Pipe		Bolt	108 N·m (80 R. lbs.)
Nuts	27 N·m (20 R. lbs.)	Water Pump to Block	
Flywheel/Converter Housing		Bolts	31 N·m (23 ft. lbs.)
Bolts	38 N·m (28 R. lbs.)		
Flywheel to Crankshaft			
Bolts	143 N·m (105 R. lbs.)		
Front Cover to Block			
Bolts 1/4-20	7 N·m (60 in. lbs.)		
Bolts 5/16-18	22 N·m (192 in. lbs.)		
Generator			
Adjusting Bolt	24 N·m (18 R. lbs.)		
Pivot Bolt/Nut	38 N·m (28 R. lbs.)		
Mounting Bracket-to-Engine Bolts	38 N·m (28 R. lbs.)		
Mounting/Head Bolts	45 N·m (33 ft. lbs.)		

Chapter 3

2.46L In-Line 4



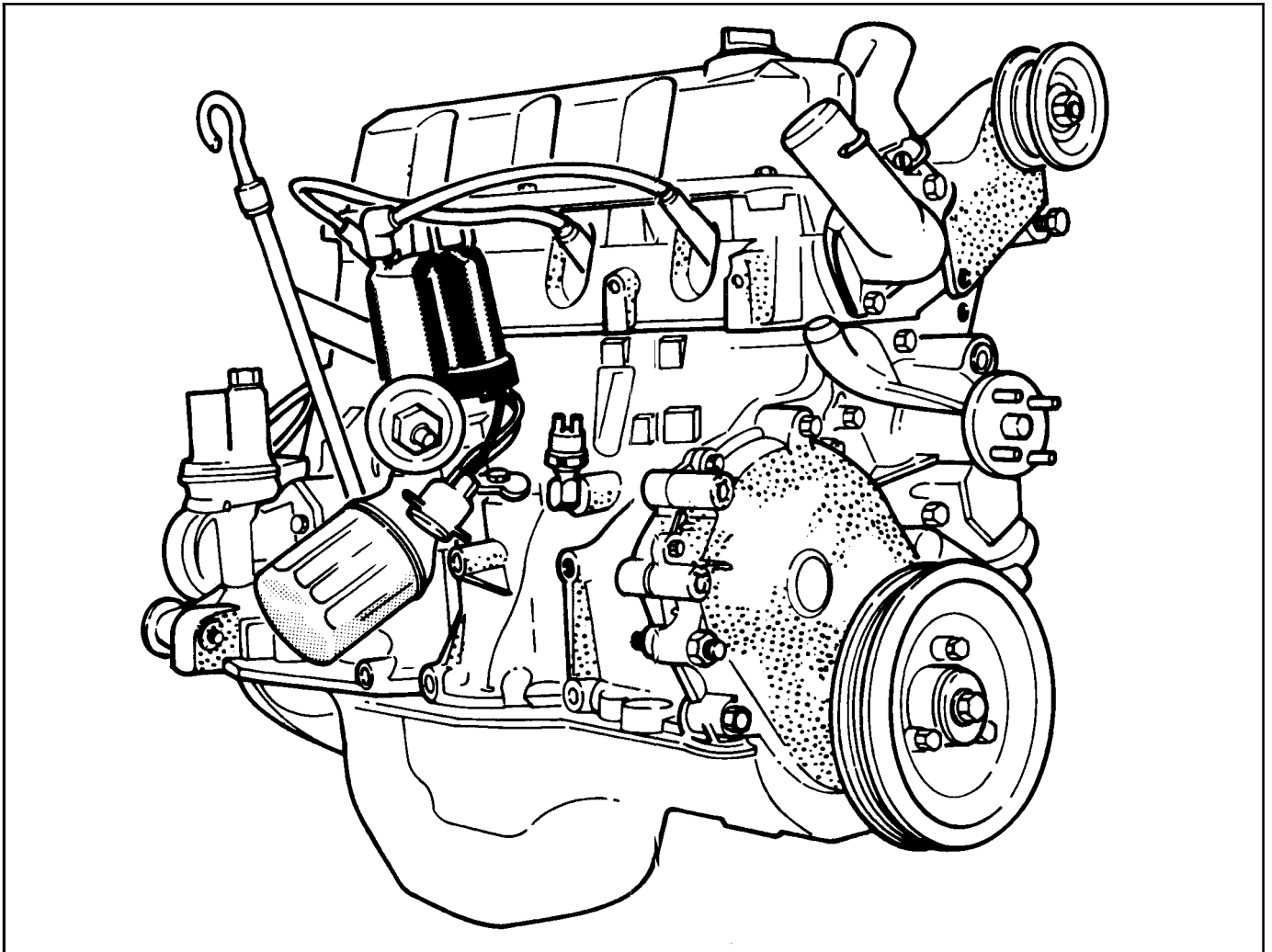
TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

Block	104
Crankshaft	105
Connecting Rods	109
PistonsandRings	111
Cylinder Head	112
Camshaft and Valve Gear	116
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Note: Due to the similarity of 2.46L and 2.5L Jeep engines, only those procedures specific to the 2.46L engine will be covered in this chapter. All other 4-cylinder procedures, techniques and modification tips can be found in Chapter 2, *2.5L Power Tech In-Line 4*.

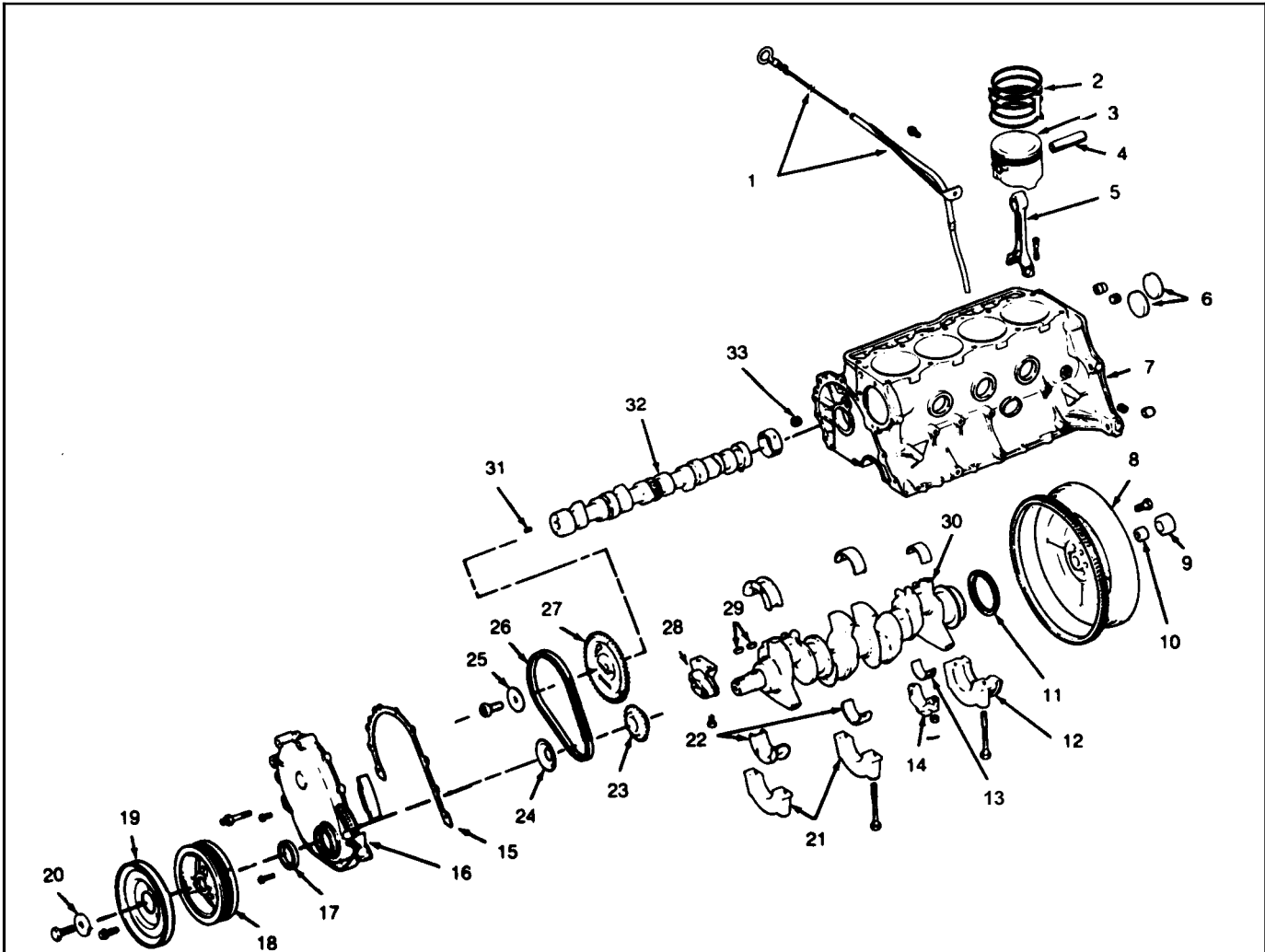
In addition to the information contained in this chapter and Chapter 2, much of the information contained in Chapter 4, *4.0L Power Tech In-Line 6*, is generic to all Jeep engines (including the 2.46L). Therefore, in addition to this chapter and Chapter 2, we highly recommend that all 2.46L engine owners read Chapter 4 in its entirety.

For additional 2.46L engine general service information, refer to the proper service manual.



Block

2.46L CYLINDER BLOCK (EXPLODED VIEW)



- 1. Oil Level Gauge (Dipstick) and Tube
- 2. Ring Set
- 3. Piston
- 4. Pin Set
- 5. Connecting Rod
- 6. Plugs
- 7. Cylinder Block
- 8. Flywheel and Ring Gear (W/Manual Transmission)
- 9. Pilot Bushing (With Manual Transmission)
- 10. Bushing Oil Wick (With Manual Transmission)

- 11. Main Bearing Cap Seal Kit (Rear)
- 12. Main Bearing Cap (Rear)
- 13. Connecting Rod Bearing
- 14. Connecting Rod Bearing Cap
- 15. Gasket
- 16. Timing Case Cover
- 17. Seal
- 18. Vibration Damper
- 19. Vibration Damper Pulley
- 20. Washer

- 21. Main Bearing Caps
- 22. Main Bearings
- 23. Crankshaft Sprocket
- 24. Oil Shedder (Slinger)
- 25. Washer
- 26. Timing Chain
- 27. Camshaft Sprocket
- 28. Timing Chain Tensioner
- 29. Keys
- 30. Crankshaft
- 31. Pin
- 32. Camshaft
- 33. Oil Channel Plug

Crankshaft

INTRODUCTION

The Jeep 2.46L (258 CID) engine uses a cast nodular iron crankshaft that rotates within seven (7) main bearings and has a standard bore and stroke of 3.750-3.753" x 3.895". Crankshaft rotation is clockwise, when viewed from the front of the engine.

The crankshaft has a main bearing journal diameter of 2.4986-2.5001", and main bearing journal widths of (No. 1) 1.086-1.098", (Nos. 2, 4, 5, 6, and 7) 1.182-1.188", and (No. 3) 1.271-1.273".

The crankshaft has a connecting rod journal diameter of 2.0934-2.0955" and a connecting rod journal width of 1.073".

For more crankshaft specifications, refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter.

CRANKSHAFT MAIN BEARINGS

Removal

1. Remove the spark plugs.
2. Disconnect the battery cables.
3. Raise and support the vehicle.
4. Drain the engine oil.
5. Remove the oil pan. Refer to *Oil Pan Removal*, 'Oiling System' section of this chapter.
6. Remove the oil pump. Refer to *Oil Pump Removal*, 'Oiling System' section of this chapter.
7. Remove the first main bearing cap and lower insert.
8. Remove the lower bearing insert from the bearing cap.
9. Remove the upper bearing insert by loosening all of the other bearing caps and inserting a small cotter pin tool in the crankshaft journal oil hole.
10. Bend a cotter pin as illustrated in Figure 2-13 to fabricate the tool.

Note: A tongue depressor may also be used to remove the bearing insert.
11. With the cotter pin tool in place, rotate the crankshaft so that the upper bearing insert will rotate in the direction of its locking tab.

Note: Because there is no hole in the No. 3 main journal, use a tongue depressor or similar soft-faced tool to remove the bearing insert. After moving the insert approximately 25 mm (1"), it can be removed by applying pressure under the tab.

12. Using the same procedure described above, remove (as necessary) the remaining bearing inserts one at a time for inspection.

Installation

1. Lubricate the bearing surface of the inserts with engine oil.
2. Loosen all the main bearing caps. Install the main bearing upper insert.
3. Install the main bearing cap and lower insert.
4. Tighten the bolts with 54 N•m (40 ft-lbs) torque. Then, tighten with 95 N•m (70 ft-lbs) torque. Finally, tighten with 108 N•m (80 ft-lbs) torque.
5. Rotate the crankshaft after tightening each main bearing cap to ensure that the crankshaft rotates freely.

Note: When installing a crankshaft kit (crankshaft plus bearing inserts), measure each bearing-to-journal clearance with Plastigauge to ensure a proper fit.
6. Install the oil pump with a replacement gasket. Refer to *Oil Pump Installation*, 'Oiling System' section of this chapter.
7. Install the oil pan with replacement seals and gaskets.
8. Tighten the drain plug securely. Refer to *Oil Pan Installation*, 'Oiling System' section of this chapter.
9. Fill the oil pan with engine oil to the FULL MARK on the dipstick.

CRANKSHAFT (FRONT) OIL SEAL REPLACEMENT—COVER INSTALLED

1. Remove the drive belt(s) and fan shroud.
2. Remove the vibration damper with vibration damper removal tool (Figure 2-2).
3. Remove the vibration damper and key.
4. Remove the crankshaft oil seal with timing cover oil seal remover tool.
5. Position a replacement oil seal on timing case cover alignment and seal installation tool with the seal lip facing outward.
6. Apply a light film of Perfect Seal, or equivalent, on the outside diameter of the seal.
7. Lightly coat the crankshaft oil seal contact surface with engine oil.
8. Position the timing case cover alignment and seal installation tool with seal over end of crankshaft (Figure 2-22).

9. Install seal into timing chain cover by gently tapping with rubber or plastic mallet.
10. Remove the timing case cover alignment and seal installation tool.
11. Apply a light film of engine oil on the vibration damper hub contact surface of the seal.
12. With the key inserted in the keyway on the crankshaft, install the vibration damper, washer and bolt.
13. Lubricate and tighten the bolt with 108 N•m (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt tightening torque value is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.

14. Install the damper pulley. Tighten the bolts with 27 N•m (20 ft-lbs) torque.
15. Install the drive belt(s) and tighten to the specified tension.

REAR MAIN BEARING OIL SEAL

The crankshaft rear main bearing oil seal is a one piece, single-lip seal that fits tightly between the cylinder block and the crankshaft.

Note: When replacing the rear main bearing oil seal, the transmission must be removed. Refer to your service manual for installation procedures.

Removal

1. Remove the flywheel or torque converter drive plate.
2. Remove the seal from the crankshaft flange by prying around the crankshaft flange.

Installation

1. Coat the inner lip of the replacement rear main bearing seal with engine oil.
2. Carefully insert the seal into place and gently tap it flush with the cylinder block with a rubber or plastic mallet.
3. Install the torque converter drive plate or flywheel with replacement bolts. Refer to the service manual for removal and installation procedures.
4. Install the transmission. Refer to the service manual for the procedure.

VIBRATION DAMPER

Removal

1. Remove the drive belt(s).
2. Remove the retaining bolts and separate the vibration damper pulley from the vibration damper.
3. Remove the vibration damper retaining bolt and washer.
4. Use vibration damper removal tool to remove the damper from the crankshaft (Figure 2-2).

Installation

1. With the key in position, align the key slot in the vibration damper hub with the crankshaft key and tap the damper onto the end of the crankshaft.
2. Install the vibration damper retaining bolt and washer. Tighten the bolt with 108 N•m (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt tightening torque value is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
3. Install the damper pulley and retaining bolts. Tighten the bolts with 27 N•m (20 ft-lbs) torque.
4. Install the drive belt(s) and tighten to the specified tension.

TIMING CASE COVER

Removal

1. Remove the drive belt(s), engine fan and hub assembly, fan shroud, vibration damper, pulley, and key.
2. Remove the oil pan-to-timing case cover screws and cover-to-cylinder block bolts.
3. Remove the timing case cover, crankshaft oil seal, and gasket from the cylinder block.
4. Cut off the oil pan side gasket end tabs flush with the front face of the cylinder block and remove the gasket tabs.
5. Clean the timing case cover, oil pan, and cylinder block gasket surfaces.
6. Pry the crankshaft oil seal from the timing case cover with a large pry tool.

Installation

1. Apply sealing compound (Perfect Seal, or equivalent) to both sides of the replacement timing case cover gasket and position the gasket on the cylinder block.

2. Cut the end tabs off of the replacement timing cover gasket corresponding to those cut off the original gasket.
3. Coat the front seal end tab recesses generously with RTV sealant (Mopar Gasket-in-a-Tube, or equivalent) and position the seal on the timing case cover.
4. Apply engine oil to the seal-oil pan contact surface.
5. Position the timing cover on the cylinder block.
6. Place timing case cover alignment and seal installer tool in the cover crankshaft opening.
7. Install the cover-to-cylinder block bolts and the oil pan-to-cover screws.
8. Tighten the cover-to-cylinder block bolts with 7 N•m (5 ft-lbs) torque and the oil pan-to-cover screws with 13 N•m (11 ft-lbs) torque.
9. Remove the cover alignment tool and position a replacement oil seal on the tool with the seal lip facing outward.
10. Apply a light film of Perfect Seal, or equivalent, on the outside diameter of the seal.
11. Lightly coat the crankshaft with engine oil.
12. Position the timing case cover alignment and seal installer tool with seal over the end of the crankshaft (Figure 2-22). Insert draw screw tool (Figure 2-23). Install seal into timing chain cover by gently tapping with a rubber or plastic mallet.
13. Tighten the nut against the tool until the tool contacts the cover (Figure 2-23).
14. Remove the tools and apply a light film of engine oil on the vibration damper hub contact surface of the seal.
15. With the key inserted in the keyway on the crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt with 108 Nom (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt tightening torque value is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
16. Install the damper pulley. Tighten the bolts with 27 N•m (20 ft-lbs) torque.
17. Install the engine fan and hub assembly.
18. Install the fan shroud.
19. Install the drive belt(s) and tighten to the specified tension.

TIMING CHAIN

Removal

Note: The timing chain tensioner reduces noise and prolongs timing chain life. In addition, it compensates for slack in a worn or stretched chain and helps to maintain the correct valve timing.

1. Remove the fan and shroud.
2. Remove the drive belt(s).
3. Remove the crankshaft vibration damper and pulley.
4. Remove the timing case cover. Refer to *Timing Case Cover Removal*, in this section, for the procedure.
5. Remove the crankshaft oil slinger.
6. Rotate the crankshaft until the zero degree (0°) timing mark on the crankshaft sprocket is closest to and on the centerline with the timing mark on the camshaft sprocket.
7. Remove the camshaft sprocket retaining bolt.
8. Remove the sprockets and chain as an assembly.

Installation

1. Turn the tensioner lever to the unlocked (down) position (Figure 2-25).
2. Pull the tensioner block toward the tensioner lever and compress the spring. Hold the block and turn the tensioner lever to the locked (up) position (Figure 2-25).
3. Install the camshaft sprocket, crankshaft sprocket and timing chain with the timing marks aligned (Figure 2-26).

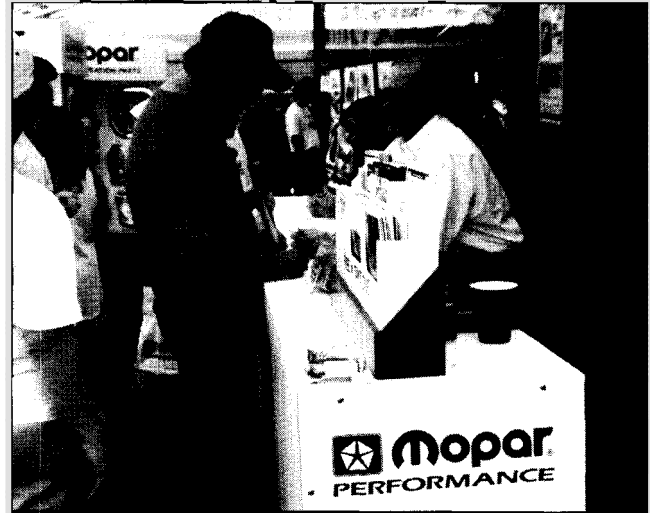
Note: To verify correct installation of timing chain, turn the crankshaft to position the camshaft sprocket timing mark at approximately the one o'clock position (Figure 2-26). This positions the crankshaft sprocket timing mark where the adjacent tooth meshes with the chain at the three o'clock position. Count the number of chain pins between the timing marks on both sprockets. There must be 20 pins.

4. Tighten the camshaft sprocket bolt with 108 N•m (80 ft-lbs) torque.
5. Release the timing chain tensioner lever.
6. Install the crankshaft oil slinger.
7. Install the timing case cover. Refer to *Timing Case Cover Installation*, in this section, for the procedure.
8. Install the vibration damper on the crankshaft.

9. Lubricate and tighten the damper bolt with 108 N•m (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt tightening torque value is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.

10. Install the vibration damper pulley.
11. Install the drive belt(s) on the pulleys and tighten.
12. Install the fan and shroud.
13. Tighten the fan and hub assembly nuts with 24 N•m (18 ft-lbs) torque.



Connecting Rods

PISTON AND CONNECTING ROD ASSEMBLY

The 2.46L engine's connecting rod journal diameter is 2.0934-2.0955". Connecting rod journal width is 1.073".

For more connecting rod specifications, refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter.

Note: The following procedure is used to service the piston and connecting rod assemblies with the engine installed in the vehicle and the cylinder head already removed.

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
2. Remove the capscrews, bridge and pivot assemblies and rocker arms.
Caution: Alternately loosen the capscrews one turn at a time to avoid damaging the bridges.
3. Remove the pushrods.
Note: Retain bridge and pivot assemblies, rocker arms and pushrods in the order removed to facilitate installation at their original locations.
4. Remove the spark plugs.
5. Remove the intake manifold, gasket, exhaust manifold, cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter.
6. Position the connecting rods and pistons two at a time near the bottom of the stroke and use a ridge reamer to remove the ridge from the top end of the cylinder walls. Use a protective cloth to collect the cuttings.
7. Drain the engine oil.
8. Remove the oil pan, gaskets and seals. Refer to *Oil Pan Removal*, 'Oiling System' section of this chapter.
9. Remove the bolts, oil pump and gasket.
10. Remove the connecting rod bearing caps and bearing inserts. Retain them in the same order as removed to facilitate installation in their original locations. Refer to *Connecting Rod Bearings Removal*, in this section, for the procedure.

Note: The connecting rods and caps are stamped with the corresponding cylinder number.

Caution: Ensure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during removal.

11. Remove the connecting rod and piston assemblies through the top of the cylinder bores.

Installation

1. Clean the cylinder bores thoroughly. Apply a light film of clean engine oil to the bores with a clean, lint-free cloth.
2. Install the piston rings on the pistons, if removed.
3. Lubricate the pistons and rings with clean engine oil.
Caution: Ensure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.
4. Use a piston ring compressor to install the connecting rod and piston assemblies from the top of the cylinder bores. Ensure that the arrow on each piston top points to the front of the engine (Figure 2-37).
Note: Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons point to the front of the engine.
5. Raise and support the vehicle.
6. Install the connecting rod bearing caps and inserts at their original locations. Refer to *Connecting Rod Bearings Installation*, in this section, for the procedure.
7. Install the oil pump with a replacement gasket. Refer to *Oil Pump Installation*, 'Oiling System' section of this chapter.
8. Install the oil pan with replacement seals and gaskets.
9. Tighten the drain plug securely. Refer to *Oil Pan Installation*, 'Oiling System' section of this chapter.
10. Lower the vehicle.
11. Install a replacement gasket and the cylinder head. Refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter.
12. Install the exhaust manifold, a replacement gasket and the intake manifold. Refer to the service manual for installation procedures.
13. Tighten the mounting bolts to 31 N•m (23 ft-lbs) torque using the torque sequence outlined in the service manual.
14. Install the EGR tube assembly.
15. Install the pushrods, rocker arms, bridge and pivot assemblies, and capscrews.

Caution: Alternately tighten the capscrews at each bridge, one turn at a time, to avoid damaging the bridges.

16. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.
17. Install the spark plugs.
18. Fill the oil pan with engine oil to the FULL MARK on the dipstick.

CONNECTING ROD BEARINGS

Removal

1. Drain the engine oil.
2. Remove the oil pan, seals and gaskets. Refer to *Oil Pan Removal*, 'Oiling System' section of this chapter.
3. Remove the bolts, oil pump and gasket. Refer to *Oil Pump Removal*, 'Oiling System' section of this chapter.
4. Rotate the crankshaft as required to position two of the connecting rods at a time at the bottom of the stroke.
5. Remove the connecting rod bearing caps. Remove the lower bearing inserts. Remove the upper bearing inserts by rotating/sliding them out of the connecting rods.

Note: DO NOT intermix the bearing caps. Each connecting rod and its bearing cap are stamped with the corresponding cylinder number on a machined surface adjacent to the oil squirt hole that faces the camshaft side of the cylinder block.

Installation

1. Lubricate the bearing surface of each insert with clean engine oil.
Caution: Use care when rotating the crankshaft with the bearing caps removed. Ensure that the connecting rod bolts DO NOT accidentally come into contact with the crankshaft journals and scratch the surface. Bearing failure would result. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.
2. Install the connecting rods, bearing inserts and caps around the journals and secure them with the retaining nuts. Tighten with 45 N•m (33 ft-lbs) torque.
3. Install the oil pump with a replacement gasket. Refer to *Oil Pump Installation*, 'Oiling System' section of this chapter.
4. Install the oil pan with replacement gaskets and seals. Tighten the drain plug securely. Refer to *Oil Pan Installation*, 'Oiling System' section of this chapter.
5. Fill the crankcase with engine oil to the FULL MARK on the dipstick.

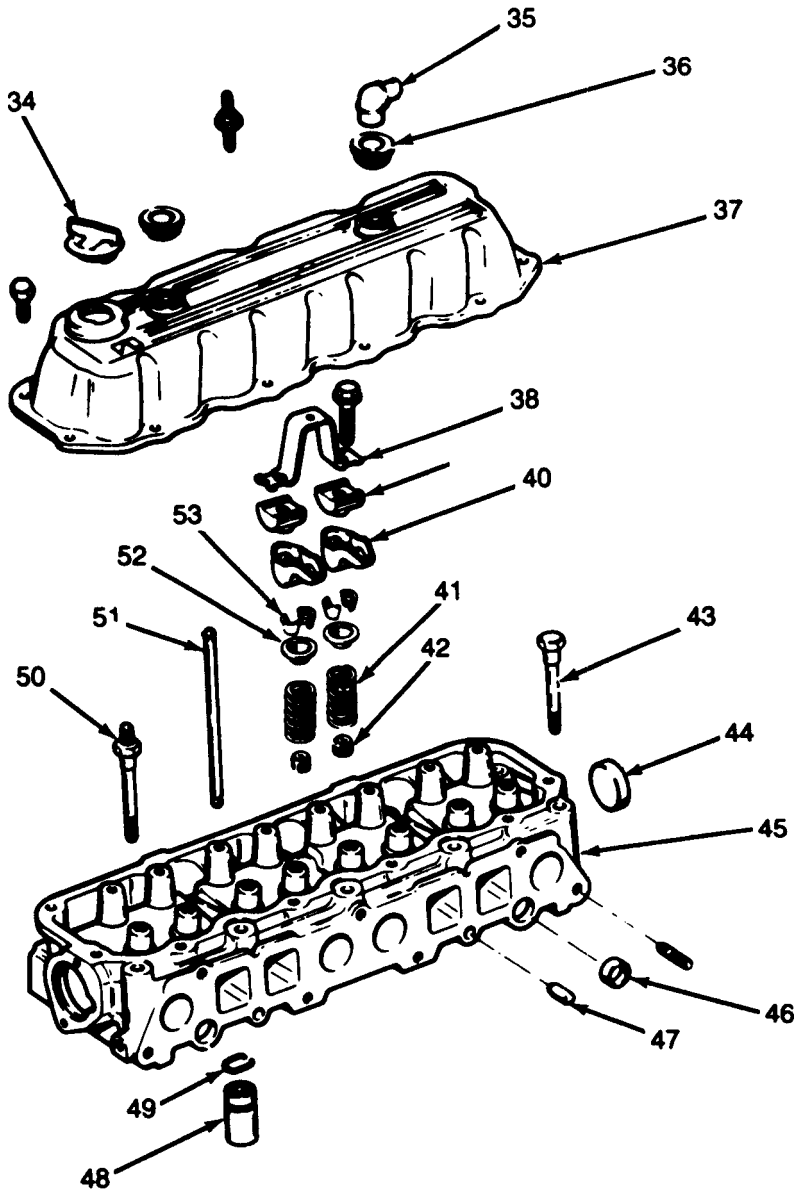
Pistons and Rings

Note: There is no piston or piston ring specific information for the 2.46L engine. All procedures and performance tips can be found in the 'Pistons and Rings' section of Chapter 2. For piston and ring specifications, refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter.



Cylinder Head

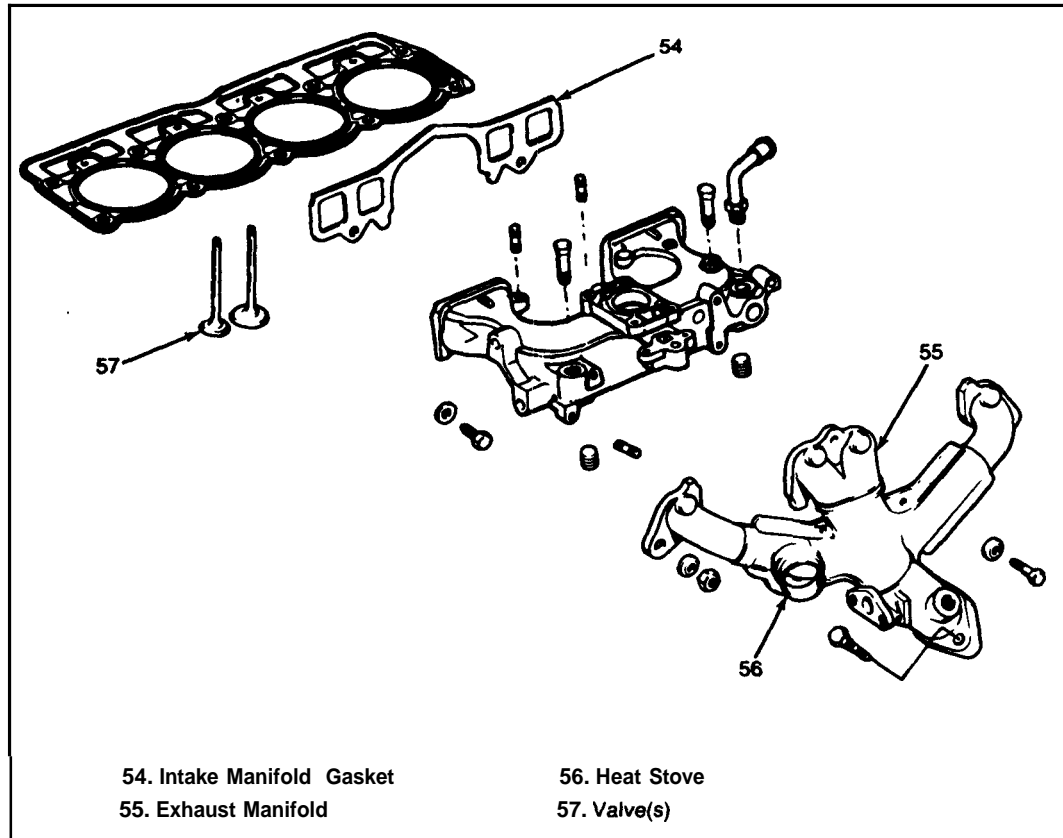
2.46L CYLINDER HEAD (EXPLODED VIEWS)



- 34. Oil Filler Cap
- 35. Ventilation Valve
- 36. Grommet
- 37. Cylinder Head (Rocker) Cover
- 38. Bridge
- 39. Pivot
- 40. Rocker Arm

- 41. Valve Spring
- 42. Oil Deflector
- 43. Cylinder Head Bolt
- 44. Cylinder Head Core Plug
- 45. Cylinder Head
- 46. Plug

- 47. Dowel Pin
- 48. Tappet
- 49. Snap Ring
- 50. Cylinder Head Stud
- 51. Push Rod
- 52. Retainer
- 53. Valve Locks



REMOVAL AND REPLACEMENT PROCEDURES

For cylinder head specifications, refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter.

Removal

1. Disconnect the battery negative cable.

Warning! DO NOT remove the cylinder block drain plugs or loosen the radiator draincock with the system hot and pressurized because serious burns from the coolant can occur.

2. Drain the coolant and disconnect the hoses at the thermostat housing.

Note: DO NOT waste reusable coolant. If the solution is clean and being drained only to service the engine or cooling system, drain the coolant into a clean container for reuse.

3. Remove the air cleaner.
4. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, in this section, for the procedure.
5. Remove the rocker arms and bridge and pivot assemblies. Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
6. Remove the pushrods.

Note: Retain the pushrods, bridges, pivots and rocker arms in the same order as removed to facilitate installation in the original locations.

7. Disconnect the power steering pump bracket. Set the pump and bracket aside. DO NOT disconnect the hoses.
8. Remove the intake and exhaust manifolds from the cylinder head.
9. Remove the intake manifold gasket. Refer to the service manual for the procedures.
10. Disconnect the ignition wire connectors and remove the spark plugs.
11. Disconnect the temperature sending unit wire connector and battery negative cable.
12. Remove the cylinder head bolts, cylinder head and gasket.

Cleaning and Inspection

1. Thoroughly clean the machined surfaces on the cylinder head and block. Remove all gasket material and cement.
2. Remove any carbon deposits from the combustion chambers and from the top of the pistons.
3. Use a straightedge and feeler gauge to check the flatness of the cylinder head and block mating surfaces. For tolerances, refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter.

Installation

1. If the cylinder head is to be replaced and the original valves used, measure the valve stem diameter.
2. Only standard size valves can be used with a service replacement cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems.
3. Remove all carbon buildup and reface the valves.
4. Install the valves in the cylinder head with replacement valve stem oil deflectors.

Caution: DO NOT install the temperature sending unit until the system is filled with coolant. This permits trapped air to escape from the cylinder block and head.

5. Transfer all the attached components from the original cylinder head that are not included with the replacement cylinder head.

Caution: DO NOT apply sealing compound on the cylinder head and block gasket surfaces. DO NOT allow sealing compound to enter the cylinder bore.

6. Apply an even coat of Perfect Seal sealing compound, or equivalent, to both sides of the replacement cylinder head gasket and position the gasket on the cylinder block with the word TOP facing up.
7. Install the cylinder head. Tighten the bolts in the sequence illustrated in Figure 3-1 with 115 N•m (85 ft-lbs) torque.

Note: Coat the threads of the stud bolt in the No. 8 sequence position with Loctite 592 sealant (or equivalent) and tighten with 102 N•m (75 ft-lbs) torque.

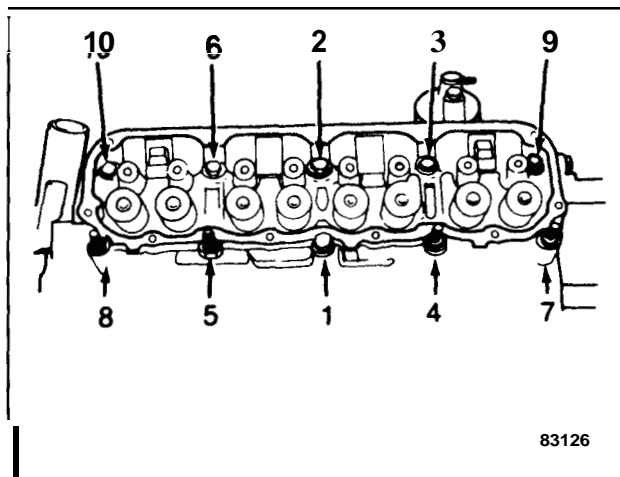
Note: The cylinder head gasket is made of aluminum-coated embossed steel and does not require that the cylinder head bolts be re-tightened.

8. Connect the battery negative cable.
9. Install the spark plugs and connect the ignition wire connectors.
10. Install the intake and exhaust manifolds. Use the correct tightening sequence. Refer to the service manual for the procedures.
11. Install the alternator belt and adjust the tension.
12. Install the power steering bracket and pump, if equipped. Adjust the belt tension.
13. Install the pushrods in their original locations.

14. Install the rocker arms and the bridge and pivot assemblies at their original locations. Loosely install the capscrews for each bridge and tighten alternately, one turn at a time, to avoid damaging the bridge.
15. Tighten the capscrews with 26 N•m (19 ft-lbs) torque.
16. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, in this section, for the procedure.
17. Connect the hoses to the thermostat housing and fill the cooling system to the specified level.
18. Install the temperature sensor unit and connect the wire connector.
19. Connect the fuel lines.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or fan. DO NOT wear loose clothing.

20. Operate the engine with the radiator cap off.
21. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.
22. Install the air cleaner.



CYLINDER HEAD COVER

Crankcase Breather

A universal high performance re-usable crankcase breather (must have stand pipe on valve cover). Washes clean with P4529392 cleaning fluid for extra miles of service.

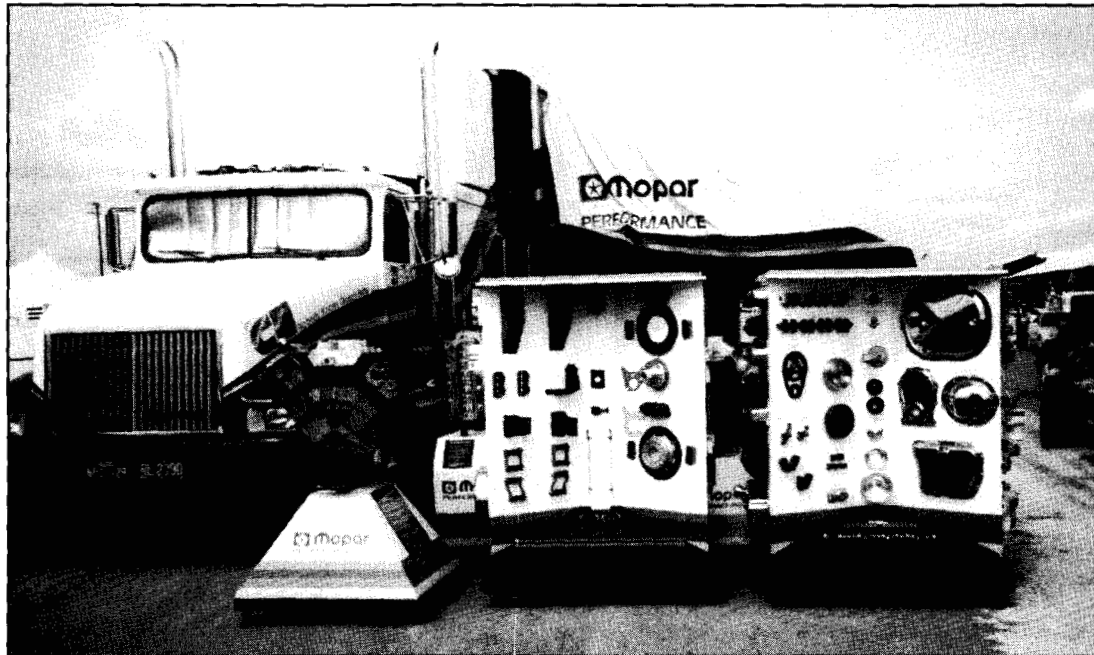
P4529394 Crankcase breather.

Removal

1. Remove the air cleaner and the PCV valve molded hose.
2. Disconnect the PCV valve from the grommet in the cylinder head cover.
3. Disconnect the PCV shutoff valve vacuum hose.
4. Remove all the necessary vacuum and air hoses to provide clearance for the cylinder head cover.
5. Remove the cylinder head cover retaining screws.
6. Detach the cover from the cylinder head by separating the RTV sealant with a putty knife or razor blade.
7. DO NOT pry the cover upward until the seal has been completely broken.
8. Pry the cover up at the pry ramps that are identified by the words PRY HERE.
9. Inspect the cylinder head cover for cracks.

Installation

1. Either a standard gasket or a room temperature vulcanizing (RTV) silicone rubber sealant may be used for cylinder head cover installation.
2. Use Mopar Gasket-in-a-Tube, or equivalent, for a formed-in-place gasket.
3. Remove the original sealant (or gasket and adhesive) from the sealing surface area of the cylinder head and cover.
4. Thoroughly clean the sealing surfaces on the cylinder head and cover.
5. Apply a 3 mm (1/8") bead of RTV sealant along the entire length of the cylinder head sealing surface.
6. Before the sealant begins to cure, position the cover on the cylinder head.
7. DO NOT allow the sealant to come into contact **with** the rocker arms or other valve assembly components.
8. Install the cylinder head cover retaining screws and tighten the screws with 6.2 N•m (55 in-lbs) torque.
9. Reposition and/or connect all the air and vacuum hoses that were moved for cover removal clearance.
10. Connect the PCV valve and the PCV shutoff valve hose.
11. Install the air cleaner and hoses.



Camshaft and Valve Gear

CAMSHAFT

The 2.46L engine uses a cast iron camshaft with intake and exhaust cam lobe lifts of .254", and durations of (intake) 259°, (exhaust–Nationwide) 259°, and (exhaust–California) 289°. Valve lengths are (for intake and exhaust) 4.7895–4.8045".

For more camshaft specifications, refer to 2.46L; *Engine Specifications*, 'Engine Assembly' section of this chapter.

Removal

Warning! The coolant in a recently operated engine is hot and pressurized. Release the pressure before removing the draincock, cap and drain plugs.

1. Drain the cooling system.

Note: DO NOT waste reusable coolant. Drain the coolant into a clean container.

2. Remove the radiator.
3. Remove the drive belt(s).
4. Remove the distributor and ignition wires.
5. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
6. Remove the capscrews, bridge and pivot assemblies, and rocker arms. Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
7. Remove the pushrods.

Note: Position all components on a workbench in the same order as removed to facilitate installation in the original positions.
8. Remove the tappets using hydraulic valve tappet remover. Refer to *Hydraulic Valve Tappet Removal*, in this section, for the procedure.
9. Remove the pulley (if applicable), vibration damper and timing case cover. Refer to *Timing Case Cover Removal*, 'Crankshaft' section of this chapter.
10. Remove the crankshaft and oil slinger.
11. Remove the camshaft sprocket retaining bolt.
12. Rotate the crankshaft until the zero degree (0°) timing mark on the crankshaft sprocket is closest to and on the centerline with the timing mark on the camshaft sprocket.
13. Remove the timing chain and sprockets as an assembly.
14. Remove the camshaft.

Installation

Note: The camshaft MUST be centerlined to ensure proper installation. Refer to the 'Camshaft and Valve Gear' section of Chapter 2 for complete details.

1. Lubricate the camshaft with Mopar Engine Oil Supplement, or equivalent.
2. Install the camshaft carefully to prevent damaging the camshaft bearings.
3. Turn the tensioner lever to the unlocked (down) position (Figure 2-25).
4. Pull the tensioner block toward the tensioner lever to compress the spring. Hold the block and turn the tensioner lever to the locked (up) position (Figure 2-25).
5. Install the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks aligned (Figure 2-26).

Note: To verify correct installation of the timing chain, turn the crankshaft to position the camshaft sprocket timing mark at approximately the one o'clock position (Figure 2-26). This positions the crankshaft sprocket timing mark where the adjacent tooth meshes with the chain at the three o'clock position. Count the number of chain pins between the timing marks on both sprockets. There must be 20 pins.

6. Install the camshaft sprocket retaining bolt and tighten with 108 N•m (80 ft-lbs) torque.
7. Install the crankshaft oil slinger.
8. Release the timing chain tensioner by turning the tensioner lever to the unlocked (down) position.
9. Install the timing case cover and a replacement oil seal. Refer to *Timing Case Cover Installation*, 'Crankshaft' section of this chapter.
10. With the key inserted in the keyway on the crankshaft, install the vibration damper, washer and bolt.
11. Lubricate and tighten the damper bolt with 108 N•m (80 ft-lbs) torque.

Note: If the crankshaft turns before the damper bolt tightening torque value is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper pullet holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
12. Install the damper pulley.

13. Install the fan assembly and shroud.
14. Install the drive belt(s) and tighten to the specified tension.
15. Install the distributor, distributor cap and ignition wires by rotating engine No. 1 cylinder piston until it is at Top Dead Center (TDC) in the compression stroke.
16. Using a flat blade screwdriver, rotate the oil pump gear so that the gear slot on the oil pump shaft is slightly past the three o'clock position (Figure 2-57).
17. With the distributor cap removed, install the distributor with the rotor located at the five o'clock position (Figure 2-58).
18. When the distributor is fully engaged in its correct location, the rotor should be at the six o'clock position (Figure 2-59).

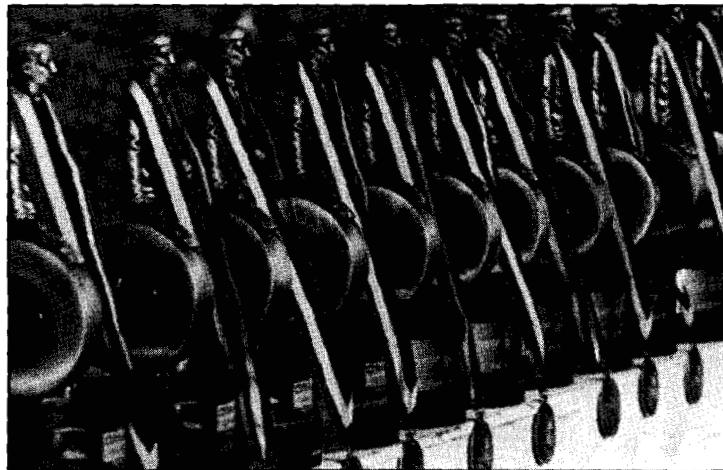
Note: If the distributor is not installed correctly, or if it is removed later, the complete installation procedure must be repeated.

19. Install the tappets using hydraulic valve tappet installer.
20. Install the pushrods.
21. Install the rocker arms and bridge and pivot assemblies. Tighten each of the two capscrews for each bridge alternately one turn at a time to avoid damaging the bridge.

Note: Lubricate the hydraulic valve tappets and all valve actuating components with Mopar Engine Oil Supplement (EOS), or equivalent, during installation. The EOS must remain with the engine oil for at least 1,609 km (1,000 miles), but need not be drained until the next scheduled oil change.
22. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.
23. Install the radiator. Connect the hoses and fill the cooling system to the specified level.
24. Check the ignition timing and adjust as necessary.

Measuring Cam Lobe Lift

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
2. Remove the bridge and pivot assemblies and rocker arms. Alternately loosen each capscrew, one turn at a time, to avoid damaging the bridges. Disconnect the spark plug wire connectors and remove the spark plugs.
3. Install a dial indicator with a piece of rubber tubing between the dial indicator plunger and the pushrod.
4. Rotate the camshaft until the heel of the cam lobe (pushrod in the down position) is under the valve tappet. Set the dial indicator pointer at zero.
5. Rotate the crankshaft until the pushrod is at its maximum upward position.
6. Note the travel distance on the dial indicator. Refer to *2.46L Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct cam lobe lift.
7. Repeat the procedure for each remaining cam lobe.
8. Install the rocker arms and bridge and pivot assemblies. Alternately tighten the capscrews at each bridge one turn at a time to avoid damaging the bridges.
9. Install the spark plugs and connect the wire connectors.
10. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.



VALVE SPRING AND OIL DEFLECTOR

Note: Each valve spring is held in place around the valve stem by a retainer and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
2. Remove the capscrews, bridge and pivot assembly, and rocker arms for access to each valve spring to be removed. Alternately loosen each capscrew one turn at a time to avoid damaging the bridge.
3. Remove the pushrods.

Note: Retain the pushrods, bridges, pivots and rocker arms in the same order and position as removed.

4. Remove the spark plug(s) adjacent to the cylinder(s) below the valve springs to be removed.
5. Install a 14 mm (1/2") (thread size) air hose adapter in to the spark plug hole.

Note: An adapter can be constructed by welding an air hose connection to the body of a spark plug with the porcelain removed.

6. Connect an air hose to the adapter and maintain at least 621 kPa (90 psi) of air pressure in the cylinder to hold the valves against their seats.

Note: For vehicles equipped with an air conditioner, use a flexible air adapter when servicing the No. 1 cylinder.

7. Use a valve spring compressor tool to compress the spring and remove the locks.
8. Remove the valve spring and retainer.
9. Remove the valve stem oil deflector.

Installation

Caution: Install the deflector carefully to prevent damage from the sharp edges of the valve spring lock groove.

1. Use an 11 mm (7/16") deep socket and small hammer to gently tap the oil deflector onto the valve stem.
2. Install the valve spring and retainer.
3. Compress the valve spring with valve spring compressor tool and insert the valve locks. Release the spring tension and remove the tool.

Note: Tap the spring from side-to-side to ensure that the spring is seated properly on the cylinder head.

4. Disconnect the air hose. Remove the adapter from the spark plug hole and install the spark plug.
5. Repeat the procedure for each remaining valve spring to be removed.
6. Install the pushrods. Ensure the bottom end of each pushrod is centered in the plunger cap seat of the hydraulic valve tappet.
7. Install the rocker arms, pivots and bridge at their original location.
8. Tighten the bridge capscrews alternately one turn at a time to avoid damaging the bridge.
9. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.

ROCKER ARM ASSEMBLY

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
2. Remove the two capscrews at each bridge and pivot assembly. Alternately loosen the capscrews one turn at a time to avoid damaging the bridges.
3. Remove the bridges, pivots and corresponding pairs of rocker arms and place them on the bench in the same order as removed.
4. Remove the pushrods and place them on the bench in the same order as removed.

Cleaning and Inspection

1. Clean all the components with cleaning solvent and use compressed air to blow out the oil passages in the rocker arms and pushrods.
2. Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted or excessively worn.
3. Inspect the valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted.
4. Inspect each pushrod end for excessive wear and replace as required. If any pushrod is excessively worn because of lack of oil, replace it and inspect the corresponding hydraulic tappet for excessive wear.
5. A wear pattern along the length of the pushrod is not normal. Inspect the cylinder head for obstruction if this condition exists.

Installation

1. Install the pushrods in their original locations. Ensure that the bottom of each pushrod is centered in the tappet plunger cap seat.
2. Install the rocker arms, pivots and bridge above each cylinder from where they were originally removed.
3. Loosely install the capscrews through each bridge.
4. At each bridge, tighten the capscrews alternately one turn at a time to avoid damaging the bridge. Tighten with 26 N•m (19 ft-lbs) torque.
5. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.

HYDRAULIC VALVE TAPPETS (LIFTERS)

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter.
2. Remove the bridge and pivot assemblies and rocker arms by removing the two capscrews at each bridge. Alternately loosen each cap screw one turn at a time to avoid damaging the bridge.
3. Remove the pushrods.

Note: Retain all the components in the same order as removed to facilitate installation in the original position. Tappets must be re-installed on the same lobe or they will wear out.

4. Remove the tappets through the pushrod openings in the cylinder head with a hydraulic valve tappet removal and installation tool.
5. Retain the tappets in the same order as removed to facilitate installation in the original locations.

Note: It is not necessary to charge the tappet assemblies with engine oil. They will charge themselves within a very short period of engine operation.

Installation

1. Coat each tappet assembly with Mopar Engine Oil Supplement (EOS), or equivalent.
2. Use a hydraulic valve tappet removal and installation tool to install each tappet in the same bore from where it was originally removed.
3. Install the pushrods in their original locations.
4. Install the rocker arms and bridge and pivot assemblies at their original locations. Loosely install the capscrews at each bridge.
5. Tighten the capscrews alternately one turn at a time to avoid damaging the bridges.
6. Pour the remaining EOS over the entire valve actuating assembly.

Note: The EOS must remain with the engine oil for at least 1,609 km (1,000 miles), but need not be drained until the next scheduled oil change.

7. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.

Oiling System

OIL PAN

Removal

1. Raise and support the vehicle at the side sills.
2. Drain the engine oil.
3. Remove the starter motor.
4. Remove the flywheel housing access cover.
5. Remove the oil pan screws.
6. Remove the oil pan by sliding it to the rear.
7. Clean the gasket and seal surfaces. Remove all sludge and grime from the oil pan sump.

Installation

1. Install a replacement oil pan front seal on the timing case cover and apply a generous amount of RTV sealant (Mopar Gasket-in-a-Tube, or equivalent) to the recesses in the tab ends.

Note: Either one of two sealing methods may be used. An RTV sealant such as Mopar Gasket-in-a-Tube, or equivalent, may be used instead of a gasket. If a gasket is used, coat both sides with a quick drying adhesive such as Mopar Spray-a-Gasket, or equivalent.

2. Coat the inside curved surface of the replacement oil pan rear seal with soap. Apply a generous amount of RTV sealant to the gasket contacting surface of the seal end tabs.
3. Install the seal in the recess of the rear main bearing cap. Ensure it is fully seated.
4. Cement the replacement oil pan side gaskets into position on the cylinder block.
5. Apply a generous amount of RTV sealant to the end tabs of the gaskets.
6. Apply engine oil to the oil pan contacting surface of the front and rear oil pan seals.
7. Install the oil pan. Tighten the screws and the drain plug securely.

Note: Tighten the 1/4-20 oil pan screws with 9 N•m (7 ft-lbs) torque and tighten the 5/16-18 oil pan screws with 15 N•m (11 ft-lbs) torque.

8. Install the starter motor.
9. Install the flywheel housing access cover.
10. Raise the vehicle.
11. Remove all sill supports.

12. Lower the vehicle.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put hands near the pulleys, belts or fan. DO NOT wear loose clothing.

13. Fill the oil pan with engine oil to the specified level. Start the engine and inspect for leaks.

OIL PUMP

Note: A gear-type oil pump is located at the underside of the cylinder block opposite the No. 3 main bearing.

Removal

Note: Oil pump removal and replacement will not affect distributor ignition timing because the distributor drive gear remains in mesh with the camshaft gear.

1. Drain the engine oil.
2. Remove the oil pan. Refer to *Oil Pan Removal*, in this section, for the procedure.

Caution: DO NOT disturb the position of the oil inlet tube and strainer assembly attached to the pump body. If the tube is moved within the pump body, a replacement tube and strainer assembly must be installed to assure an airtight seal.

3. Remove the oil pump retaining screws, oil pump and gasket.

Installation

Note: To ensure self-priming of the oil pump, fill the pump with petroleum jelly before installing the oil pump cover. DO NOT use grease.

1. Apply a bead of Loctite 515 sealant, or equivalent, and install the pump cover. Tighten the cover screws with 8 N•m (70 in-lbs) torque.

Note: Rotate the gears to ensure that a binding condition does not exist before installing the oil pump.

2. Install the oil pump with a replacement gasket. Tighten the short screw with 14 N•m (10 ft-lbs) torque, and the long screw with 23 N•m (17 ft-lbs) torque.
3. Install the oil pan with replacement gaskets and seals. Refer to *Oil Pan Installation*, in this section, for the procedure.
4. Fill the oil pan with replacement engine oil to the specified level.

Engine Assembly

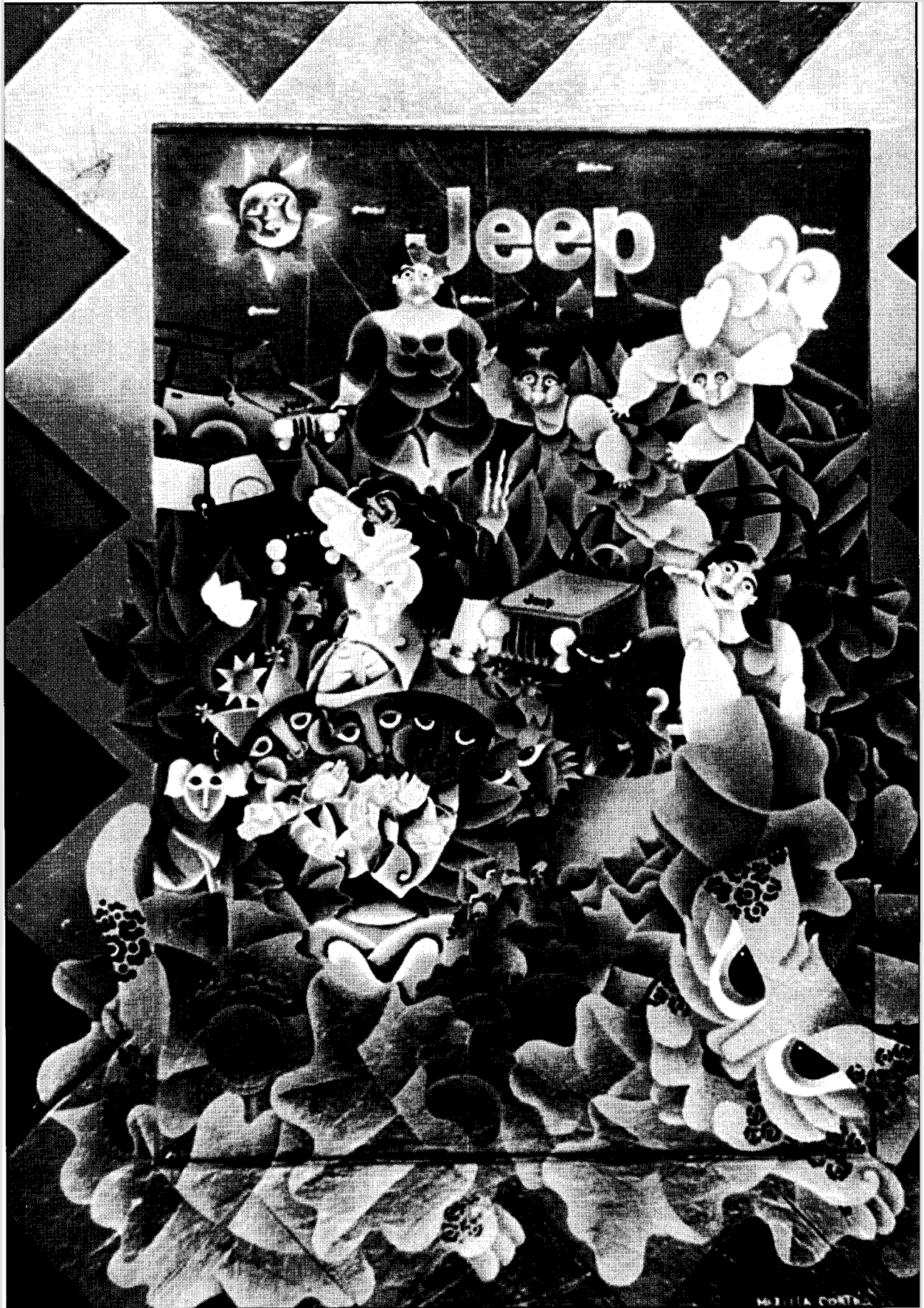
Note: For engine assembly information, performance modifications and tips, refer to 'Engine Assembly' section of Chapter 4, *4.0L Power Tech In-Line 6*.

2.46L ENGINE GENERAL SPECIFICATIONS

Note: The following information has been reprinted from the 1983 *Jeep Service Manual*.

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified		(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Type	In Line, OHV, 4-Cylinder		Side Clearance.....	0.010-0.019	0.25-0.48
Bore	3.876	98.45	Maximum Twist.....	0.001 per in.	0.025 per 25.4 mm
Stroke.....	3.188	80.97	Maximum Bend.....	0.005 per in.	0.0127 per 25.4 mm
Displacement	150 cu. in.	2.46 liter			
Compression Ratio.....	9.2:1		Crankshaft		
Compression Pressure.....	155-185 psi	1068-1275 kpa	End Play.....	0.0015-0.0065	0.038-0.165
Maximum Variation Between Cylinders.....	30 psi	206 kpa	Main Bearing Journal Diameter.....	2.4996-2.5001	63.489-63.502
Firing Order.....	1-3-4-2		Main Bearing Journal Width		
Taxable Horsepower.....	24.04 bhp	17.9 kw	No. 1.....	1.086-1.098	27.58-27.89
Fuel.....	Unleaded		No. 2.....	1.271-1.273	32.28-32.33
			No. 3-4-5.....	1.182-1.188	30.02-30.18
Camshaft			Main Bearing Clearance.....	0.001-0.0025 (0.002 Preferred)	0.03-0.06 (0.051 Preferred)
Fuel Pump Eccentric Diameter.....	1.615-1.625	41.02-41.28	Connecting Rod Journal Diameter....	2.0934-2.0955	53.17-53.23
Tappet Clearance.....	zero lash (hyd.) tappets		Connecting Rod Journal Width.....	1.070-1.076	27.18-27.33
End Play.....	zero (engine operation)		Maximum Out-of-Round (All Journals).....	0.0005	0.013
Bearing Clearance.....	0.001-0.003	0.025-0.076	Maximum Taper (All Journals).....	0.0005	0.013
Bearing Journal Diameter			Cylinder Block		
No. 1.....	2.0292 0.030	51.54-51.56	Deck Height.....	9.337-9.343	237.15-237.31
No. 2.....	2.019-2.020	51.28-51.31	Deck Clearance.....	0.020 (below deck)	0.508 (below deck)
No. 3.....	2.009-2.010	51.03-51.05	Cylinder Bore Diameter (standard)...	3.8751-3.8775	98.42-98.48
No. 4.....	1.999-2.000	50.78-50.80	Maximum Taper.....	0.001	0.025
Base Circle Runout.....	0.001 max	0.03 max	Maximum Out-of-Round.....	0.001	0.025
Cam Lobe Lift.....	265	6.73	Intake Valve Bore Diameter.....	0.9055-0.9065	23.000-23.025
Valve Lift.....	424	to 7	Cylinder Block Flatness.....	0.011/1.0-0.002/6.0	0.03/25-0.05/152
Intake Valve liming			Cylinder Head		
Opens.....	12° BTDC		Combustion Chamber Volume.....	49.9-52.9 cc	
Closes.....	258° ATDC		Valve Arrangement.....	E-I-I-E-E-I-I-E	
Exhaust Valve liming			Valve Guide ID (Integral).....	0.313-0.314	7.95-7.97
Opens.....	236° BTDC		Valve Stem-to-Guide Clearance.....	0.0014-0.003	0.02-0.07
Closes.....	34° ATDC		Intake Valve Seat Angle.....	44° 30'	
Valve Overlap.....	46°		Exhaust Valve Seat Angle.....	44° 30'	
Intake Duration.....	270°		Valve Seat Width.....	0.040-0.060	1.02-1.52
Exhaust Duration.....	270°		Valve Seal Runout.....	0.0025	0.064
			Cylinder Head Flatness.....	0.011/1.0-0.002/6.0	0.03/25-0.05/152
Connecting Rods					
Total Weight (less bearings).....	657-665 grams				
Total Length (center-to-center).....	6.123-6.127	155.52-155.62			
Piston Pin Bore Diameter.....	0.9288-0.9298	23.59-23.62			
Connecting Rod Bore (less bearings)...	2.2080-2.2085	56.08-56.09			
Bearing Clearance.....	0.001-0.003 (0.0015-0.002 Preferred)	0.03-0.08 (0.044-0.05 Preferred)			

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified		(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Lubrication System					
Engine Oil Capacity.....	4 qts. w/w/o	3.8 liters w/w/o			
	filler change	filler change			
Normal Operating Pressure.....	13 psi at 600 rpm 37-75 psi (max.) at 1600 + rpm	89.6 kpa at 600 rpm 255.1-517.1 kpa (max.) at 1600 + rpm			
Oil Pressure Relief.....	75 psi (max.)	517.1 kpa (max.)			
Gear-to-Body Clearance (Radial).....	0.002-0.004 (0.002 Prof.)	0.0510-1.02 0.051 Prof.)			
Gear End Clearance, Plastigage.....	0.002-0.006 (0.002 Prof.)	0.051-0.152 (0.051 Prof.)			
Gear End Clearance, Feeler Gauge.....	0.004-0.008 (0.007 Ref.)	0.1016-0.2032 (0.1778 Ref.)			
Pistons					
Weight (less pin).....	563-567 grams				
Piston Pin Bore Centerline-to-Piston Top.....	1.651-1.655	41.94-42.04			
Piston-to-Bore Clearance.....	0.0009-0.0017 (0.00120-0.0013 Preferred)	0.023-0.043 (0.030-0.033 Preferred)			
Piston Ring Gap Clearance — Compression (both).....	0.010-0.020	0.25-0.51			
Piston Ring Gap Clearance — Oil Control Steel Rails.....	0.010-0.025	0.25-0.64			
Piston Ring Side Clearance					
No. 1 Compression.....	0.0017-0.0032 (0.0017 Prof.)	0.043-0.081 (0.043 Prof.)			
No. 2 Compression.....	0.0017-0.0032 (0.0017 Prof.)	0.043-0.081 (0.043 Prof.)			
Oil Control.....	0.001-0.008 (0.003 Prof.)	0.03-0.20 (0.08 Prof.)			
Piston Ring Groove Height Compression (both).....	0.0795-0.0805	2.0192-0.45			
Oil Control.....	0.188-0.1895	4.78-4.80			
			Piston Ring Groove Diameter		
			No. 1 and No. 2.....	3.456-3.461	87.78-87.90
			Oil Control.....	3.445-3.455	87.50-87.75
			Piston Pin Bore Diameter.....	0.9308-0.9313	23.624-23.655
			Piston Pin Diameter.....	0.9304-0.9309	23.632-23.645
			Piston-to-Pin Clearance.....	0.0003-0.0005 (Loose 0.0005 Preferred)	0.008-0.013 (Loose 0.013 Preferred)
			Piston Pin-to-Connecting Rod.....	2000 lbs.-f Press-fit	8.9 kN Pres.-fit
			Rocker Arms, Push Rods and Tappets		
			Rocker Arm Ratio.....	1.6:1	
			Push Rod Length.....	9.640-9.660	244.856-245.364
			Push Rod Diameter.....	0.312-0.315	7.92-8.00
			Hydraulic Tappet Diameter.....	0.904-0.9045	22.962-22.974
			Tappet-to-Bore Clearance.....	0.001-0.0025	0.03-0.05
			Valves		
			Valve Length		
			(Tip-to-Gauge Dim. Line).....	4.822-4.837 Int. 4.837-4.852 Exh.	122.47-122.85 122.85-123.24
			Valve Stem Diameter.....	.311-.312	7.89-7.98
			Stem-to-Guide Clearance.....	.001-.003	0.02-0.05
			Intake Valve Head Diameter.....	1.905-1.915	48.38-48.6
			Intake Valve Face Angle.....		44°
			Exhaust Valve Head Diameter.....	1.495-1.505	37.97-38.6
			Exhaust Valve Face Angle.....		44°
			Maximum Allowable Removed for Tip Refinishing.....	0.010	0.25
			Valve Springs		
			Frw Length.....	1.82	46.22
			Spring Tension		
			Valve Closed.....	66-74 lbs. at 1.625	294-329 at 41.28
			Valve Open.....	205-220 lbs. at 1.200	912-979 at 30.48
			Inside Diameter.....	0.948-0.968	24.08-24.5



2.46L ENGINE GENERAL TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1983Jeep Service Manual*.

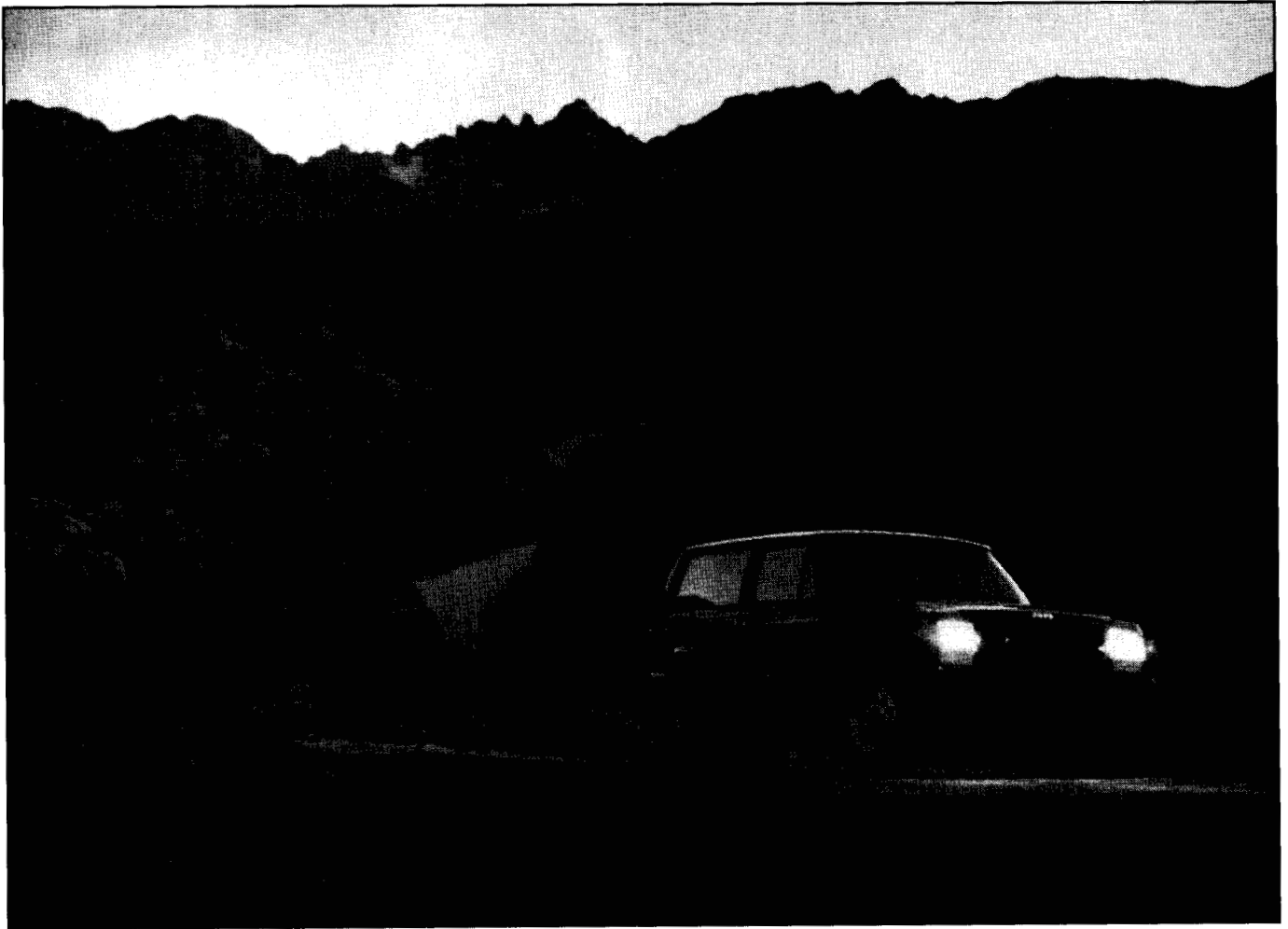
Component	Service Set-To Torque	Service Recheck Torque
Alternator Pivot Bolt or Nut	38 N·m (28 ft-lbs)	27-47 N·m (20-35 ft-lbs)
Alternator Adjustment Bolt	24 N·m (18 ft-lbs)	20-27 N·m (15-20 ft-lbs)
Alternator Mounting Bracket-to-Cylinder Block Bolt	38 N·m (28 ft-lbs)	31-41 N·m (23-30 ft-lbs)
Alternator Mounting Bracket-to-Cylinder Head Bolt	45 N·m (33 ft-lbs)	41-47 N·m (30-35 ft-lbs)
Block Heater Nut	1.8 N·m (16 in-lbs)	1.5-2.1 N·m (14-19 in-lbs)
Camshaft Sprocket Screw	68 N·m (50 ft-lbs)	61-75 N·m (45-55 ft-lbs)
Carburetor Hold-Down Nuts	19 N·m (14 ft-lbs)	16-27 N·m (12-20 ft-lbs)
Coil Bracket-to-Body Screws	9.6 N·m (85 in-lbs)	6.7-10.1 N·m (60-90 in-lbs)
Connecting Rod Bolt Nuts	45 N·m (33 ft-lbs)	41-47 N·m (30-35 ft-lbs)
Cylinder Head Capscrews	115 N·m (85 ft-lbs)	108-122 N·m (80-90 ft-lbs)
Cylinder Head Cover Nuts	6.2 N·m (70 in-lbs)	5-8.5 N·m (45-75 in-lbs)
Crankshaft Pulley-to-Damper	27 N·m (20 ft-lbs)	20-34 N·m (15-25 ft-lbs)
Clutch Housing-to-Block Screws	75 N·m (55 ft-lbs)	65-84 N·m (48-62 ft-lbs)
Clutch Housing Cover Screws	29 N·m (21 ft-lbs)	22-35 N·m (16-26 ft-lbs)
Differential Housing-to-Left Engine Mount Bolt	54 N·m (40 ft-lbs)	47-68 N·m (35-50 ft-lbs)
Dipstick Tube Bracket Bolt-to-Cylinder Block	19 N·m (14 ft-lbs)	13-24 N·m (10-18 ft-lbs)
Distributor Clamp Bracket Screw	18 N·m (13 ft-lbs)	14-27 N·m (10-20 ft-lbs)
Drive Plate-to-Converter Screw	30 N·m (22 ft-lbs)	27-34 N·m (20-25 ft-lbs)
EGR Valve Tube Nuts	41 N·m (30 ft-lbs)	34-47 N·m (25-35 ft-lbs)
EGR Valve Bolts	18 N·m (13 ft-lbs)	12-24 N·m (9-18 ft-lbs)
Exhaust Manifold Bolts	31 N·m (23 ft-lbs)	24-38 N·m (18-28 ft-lbs)
Exhaust Pipe-to-Manifold Bolts	23 N·m (17 ft-lbs)	20-25 N·m (15-19 ft-lbs)
Fan and Hub Assembly Bolts	24 N·m (18 ft-lbs)	16-34 N·m (12-25 ft-lbs)
Flywheel-to-Crankshaft Bolts	68 N·m (50 ft-lbs) Plus 60"	
Front Crossmember-to-Sill Bolts	88 N·m (65 ft-lbs)	75 N·m (55 ft-lbs) min
Front Support Bracket-to-Cylinder Block Bolts	60 N·m (45 ft-lbs)	54-68 N·m (40-50 ft-lbs)
Front Support Cushion-to-Bracket Bolts	45 N·m (33 ft-lbs)	36-52 N·m (27-38 ft-lbs)
Front Support Cushion-to-Crossmember Bolts	50 N·m (37 ft-lbs)	41-61 N·m (30-45 ft-lbs)

Component	Service Set-To Torque	Service Recheck Torque
Fuel Pump Screws	22 N·m (16 ft-lbs)	18-26 N·m (13-19 ft-lbs)
Idler Arm Bracket-to-Sill Bolts	68 N·m (50 ft-lbs)	47-81 N·m (35-60 ft-lbs)
Idler Pulley Bracket-to-Front Cover Nut	9 N·m (7 ft-lbs)	5-12 N·m (4-9 ft-lbs)
Idler Pulley Bearing Shaft-to-Bracket Nut	45 N·m (33 ft-lbs)	38-52 N·m (28-38 ft-lbs)
Intake Manifold Coolant Fittings	27 N·m (20 ft-lbs)	20-34 N·m (15-25 ft-lbs)
Intake Manifold Heater Screws	9 N·m (7 ft-lbs)	7-12 N·m (5-9 ft-lbs)
Intake Manifold Screws	31 N·m (23 ft-lbs)	24-38 N·m (18-28 ft-lbs)
Main Bearing Capscrews	108 N·m (80 ft-lbs)	95-115 N·m (70-85 ft-lbs)
Oil Filter Adapter	65 N·m (48 ft-lbs)	57-75 N·m (42-55 ft-lbs)
Oil Level Sensor in Oil Pan	33 N·m (25 ft-lbs)	27-40 N·m (20-30 ft-lbs)
Oil Pan Drain Plug	34 N·m (25 ft-lbs)	27-41 N·m (20-30 ft-lbs)
Oil Pan Screws – 1/4 in – 20	9 N·m (7 ft-lbs)	7-15 N·m (5-11 ft-lbs)
Oil Pan Screws – 5/16 in – 18	15 N·m (11 ft-lbs)	12-20 N·m (9-15 ft-lbs)
Oil Pump Cover Screws	8 N·m (70 in-lbs)	7-11 N·m (60-100 in-lbs)
Oil Pump Attaching Screws (Short)	14 N·m (10 ft-lbs)	11-18 N·m (8-13 ft-lbs)
Oil Pump Attaching Screws (Long)	23 N·m (17 ft-lbs)	16-27 N·m (12-20 ft-lbs)
Oxygen Sensor	48 N·m (35 ft-lbs)	43-52 N·m (32-38 ft-lbs)
Power Steering Pump Adapter Screw	31 N·m (23 ft-lbs)	24-38 N·m (18-28 ft-lbs)
Power Steering Pump Bracket Screw	58 N·m (43 ft-lbs)	50-64 N·m (37-47 ft-lbs)
Power Steering Pump Mounting Screw	38 N·m (28 ft-lbs)	34-47 N·m (25-35 ft-lbs)
Power Steering Pump Pressure Hose Nut	52 N·m (38 ft-lbs)	41-61 N·m (30-45 ft-lbs)
Power Steering Pump Pulley Nut	79 N·m (58 ft-lbs)	54-88 N·m (40-65 ft-lbs)
Rear Crossmember-to-Side Sill Nut	41 N·m (30 ft-lbs)	27-47 N·m (20-35 ft-lbs)
Rear Support Bracket-to-Transmission Bolts	45 N·m (33 ft-lbs)	37-52 N·m (27-38 ft-lbs)
Rear Support Cushion-to-Bracket Bolts	41 N·m (30 ft-lbs)	34-46 N·m (25-35 ft-lbs)

Component	Service Set-To Torque	Service Recheck Torque
Rear Support Cushion-to-Crossmember Bolts	24 N·m (18 ft-lbs)	16-34 N·m (12-25 ft-lbs)
Rocker Arm Assembly-to-Cylinder Head Bolts	26 N·m (19 ft-lbs)	22-35 N·m (16-26 ft-lbs)
Spark Plug	37 N·m (27 ft-lbs)	30-45 N·m (22-33 ft-lbs)
Starter Motor-to-Cylinder Block Bolts	45 N·m (33 ft-lbs)	38-51 N·m (28-38 ft-lbs)
Tensioner Bracket-to-Cylinder Block Bolt	19 N·m (14 ft-lbs)	13-20 N·m (10-18 ft-lbs)
Timing Case Cover-to-Block Screws	7 N·m (5 ft-lbs)	5-12 N·m (4-9 ft-lbs)
Timing Case Cover-to-Block Studs	22 N·m (16 ft-lbs)	18-26 N·m (13-19 ft-lbs)
Torque Converter Drive Plate-to-Crankshaft Bolts	54 N·m (40 ft-lbs) Plus 60	
Thermostat Housing Bolt	18 N·m (13 ft-lbs)	14-24 N·m (10-18 ft-lbs)
Vibration Damper Bolt (Lubricated)	108 N·m (80 ft-lbs)	95-135 N·m (70-100 ft-lbs)
Water Pump Bolt	18 N·m (13 ft-lbs)	13-24 N·m (10-18 ft-lbs)

Chapter 4

4.0L Power Tech In-Line 6



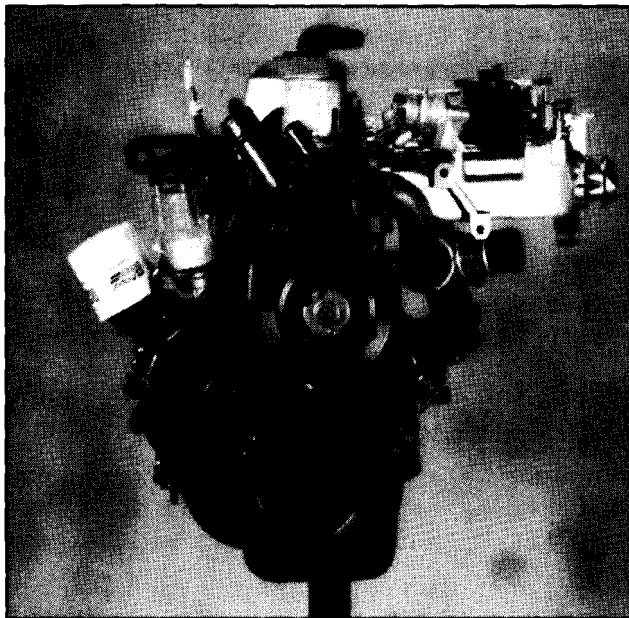
TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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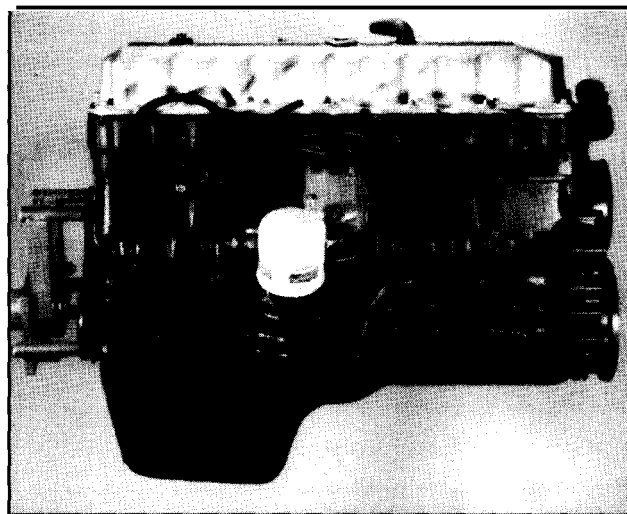
Note: The following procedures for the 4.0L Power Tech In-Line 6 engine are intended to be performed in-vehicle, on a dynamometer or as an individual change/modification. For out-of-vehicle servicing (engine stand generally), disassembly and assembly of the engine as a whole, refer to the 'Engine Assembly' section of this chapter. For additional 4.0L engine general service information, refer to the proper service manual.

Introduction

This chapter has been prepared as a guide for the customer who wants added performance or reliability from his 4.0L Power Tech In-Line 6 engine. Included are tips covering several different types of racing. The procedures outlined in this chapter represent those that have been tested by DaimlerChrysler Engineering (working both at the race track and on the dynamometer) as part of its continuing performance development program. This development program serves as the foundation for the Mopar Performance Parts program



The chapter gives specific detail regarding each major component of the 4.0L engine, as well as detailing recommended engine assembly and performance modification procedures. It is recommended that you read this chapter in its entirety before you begin your six cylinder engine project. Also, much of the information included in this chapter is generic to all racing engines, so the owners of other DaimlerChrysler engines are encouraged to read this entire chapter. It is also recommended that you obtain the proper service manual for your engine so that you will have complete service information on hand when you begin your project. Good luck—and have fun!



Block

INTRODUCTION

The Jeep 4.0L Power Tech engine is a cast iron, In-Line 6 cylinder design. The cylinder block is drilled forming galleys for both oil and coolant. It has a standard bore and stroke of 98.4 x 87.4 mm (3.88 x 3.44”).

The 4.0L has a liquid cooled, forced circulation cooling system with a capacity of 11.4L (12 quarts).

The cylinders are numbered 1 through 6 from front to rear. The firing order is 1-5-3-6-2-4 (Figure 4-1).

The crankshaft rotation is clockwise, when viewed from the front of the engine. The crankshaft rotates within seven main bearings. The camshaft rotates within four bearings.

For more information, refer to *4.0L Engine Specifications*, ‘Engine Assembly’ section of this chapter.

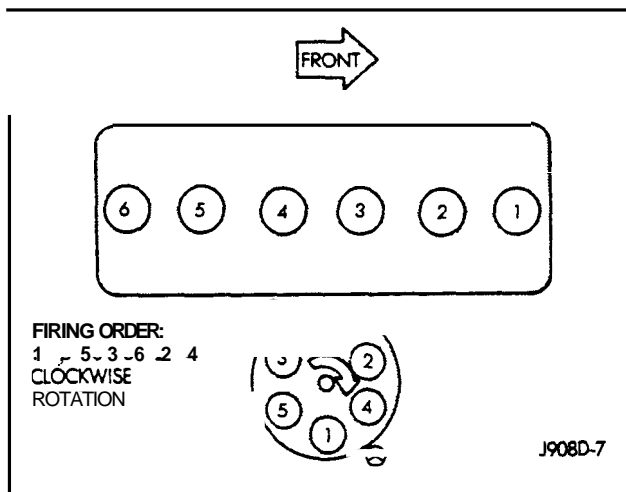


Figure 4 - 1

Engine Block Hardware Package

Includes cam bearings, various freeze/core plugs and locating pins. For use when block is tanked/stress relieved and machined. For 1987-89 4.0L engines only.

P4529673 Engine block hardware package.

Engine Teardown Gasket Set

Designed for bearing check, bore check, or cylinder head modifications/teardown only. Gaskets include: cylinder head, oil pan, intake/exhaust manifold and front cover gaskets. For 4.0L engine only.

P4529245 Engine teardown gasket set.

Flywheel Attaching Package

Bolts; required to attach flywheel and clutch to new engine assembly. Includes 6 flywheel bolts, 6 clutch bolts, and a pilot bearing.

P4529247 Flywheel attaching package.

Torque Converter Drive Plate

The torque converter drive plate connects the crankshaft to the torque converter and also carries the starter ring gear. For 4.0L engine only. Not SFI approved.

P4529248 Torque converter drive plate.

Drive Plate Attaching Package

Bolts required to attach torque converter drive plate to the crankshaft and to attach the torque converter to the drive plate. Includes 6 flywheel bolts and 4 torque converter bolts.

P4529249 Drive plate attaching package.

Build Date Code

The engine Build Date Code is located on the machined surface on the right side of the cylinder block between the No. 2 and No. 3 cylinders (Figure 4-2).

The digits of the code identify:

1. 1st digit—the year (e.g., 4 = 1994).
2. 2nd and 3rd digits—the month (01-12).
3. 4th and 5th digits—the engine type/fuel system/compression ratio (MX = a 4.0L 8.7:1 compression ratio engine with multi-point fuel injection system).
4. 6th and 7th digits—the day of the month of engine build (01-31).

Example: Code “401MX12” identifies a 4.0L engine with a multi-point fuel injection system, 8.7:1 compression ratio, built on January 12, 1994.

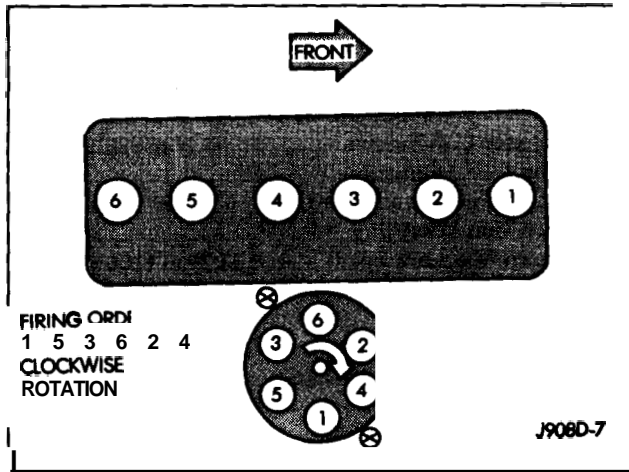


Figure 4 - 2

Oversize and Undersize Component Codes

Some engines may be built with oversize or undersize components such as:

- Oversize cylinder bores
- Oversize camshaft bearing bores
- Undersize crankshaft main bearing journals
- Undersize connecting rod journals

These engines are identified by a letter code (Figure 4-3) stamped on a boss between the ignition coil and the distributor.

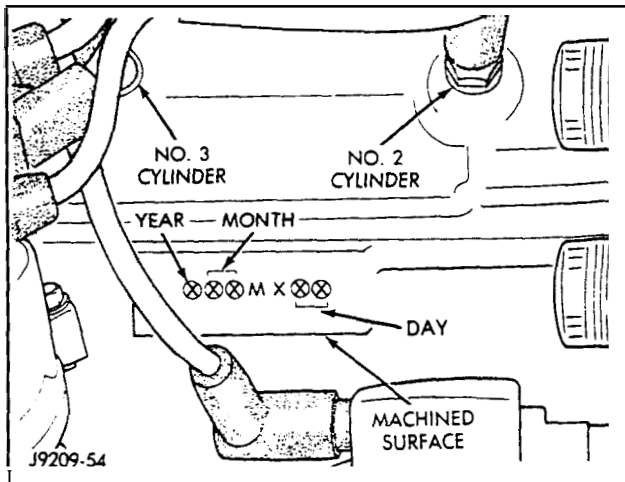


Figure 4 - 3

Block Hardness

With any cast iron block, there is a relationship between hardness and strength. The harder it is, the stronger it is. The assumption is that a stronger block can make more power. However, if the basic design of the block is weak, then it will break frequently. Standard production blocks are not designed as strongly as “race” blocks. So if you double or triple the power output of a standard production engine with high performance parts, you will have problems.

We know that hard blocks don’t break and soft ones do. Racers therefore want hard blocks. If you add a strong design to a hard material, you will have a race block. This means that the block will last longer and make more power for longer periods of time. Chrysler-Plymouth-Dodge-Jeep has always used a high nickel material in its cast iron blocks. This makes them harder.

Rough Bored Blocks

Rough bored blocks have the cylinder bores roughed-in but not finished—the surface finish on the bore is rough but machined. That means that each cylinder must be bored-to-size and then honed. The bore-to-size operation is referred to as the *finish bore*. As an engine builder, you must leave enough material on the finish bore operation to allow for the finish hone to size the bore correctly.

The advantage of rough bored blocks is you have a greater selection of bore sizes available to you. Most race engine builders DO NOT want a production hone, so why pay extra for it if you are going to change the bore size? By omitting the finish bore and honing operations, the block can be purchased for less money.

CYLINDER BLOCK PREPARATION

The first step in preparing the block for all-out racing is to stress-relieve it (typically not required for new race blocks or many used blocks). For more details, refer to *Stress-Relieving*, in this section.

After the block has been stress-relieved, new camshaft bearings and core plugs should be installed. The old main cap bolts should be thrown away. The block should be re-honed and the deck flatness checked. A light cut should be taken if it is not perfectly flat. The main bearing bores will also have to be checked and align-bored or align-honed if out of alignment. New camshaft bearings will also be required.

Block-to-Head Distortion

(Refer to *Head Distortion*, ‘Cylinder Head’ section of this chapter.)

Stress-Relieving

Note: The following is not required for thermally-cycled, used engine blocks, except for align boring and honing, which may be required on any new or used engine.

The first step in obtaining straight and round bores is to select a stress-relieved block. Only 426 Hemi engine blocks were stress-relieved in production. However, a block will stress-relieve itself with use; that is, a used block has already been stress-relieved (thermal cycles are the key).

Heating up and cooling down is the ideal cycle—again and again, which means that an engine block used in an around-town commuter vehicle is better than a block used in a long-haul truck or police car, which is infrequently shut off.

Blocks will also stress-relieve themselves in racing applications. A block can be built into a race engine and run several hundred times. It can then be rebuilt into a better engine because the bores will be straighter and will move less with use. The straighter the cylinder bore, the more power the engine will make. Once you've got a good one, keep it.

Once the engine is disassembled, the first step in preparing the block is to remove the main bearings caps, clean all joining faces, reassemble and torque to specifications. The stress-relieving process consists of heating the block and main caps to 1050°F and holding at that temperature for two hours. It should then be furnace cooled to 500°F at a cooling rate not to exceed 200°/hr. The block can then be air cooled to normal air temperature.

After the block has been stress-relieved by the 'oven' method (not by thermal cycling), new camshaft bearings and core plugs should be installed. The old main cap bolts should be thrown away. The block should be re-honed and the deck flatness checked and a light cut taken if it is not flat. The main bearing bores will also have to be checked and align-bored or honed if out of alignment. New camshaft bearings will also be required.

Sonic Testing

If the block is to be used in serious racing applications, it should be "Magna-checked" (sonic tested). With this process, the thickness of the cylinder bore walls can be checked nondestructively. This will indicate how good your particular block is, or it will allow you to select the best block of several available, if you have the option. It is highly recommended that you have more than one block tested so you don't invest your time in a weak or "flexi-block."

If you only have one block, the bore-wall thickness check really only serves as base information and a general performance indicator. Write this measurement down and keep it in your engine build-up file.

However, if you have several blocks to choose from, the best engine will be the block with the least amount of core shift (bores with the same thickness all the way around), or the block with the core shift in the "major thrust" direction. The major thrust direction is to the passenger side of the cylinder bore as the block is installed in the vehicle.

Core Shift

It seems as though every racer you talk to uses the term "core shift." It's used so frequently it seems to be the cause of every engine problem in racing! Obviously, this isn't correct. Without making it too complicated, let's look into this subject a little closer.

First of all, to discuss core shift we must have a casting. It can be of any material (aluminum, iron), but it has to be a casting. Second, the casting must have a "core" in it. In an over-simplified explanation, a "core" is used to cast an internal passage in a casting. This internal passage could be a water jacket in a head or block, or an intake runner in a manifold. Not all castings use cores. Core shift is most often discussed relative to cylinder blocks, so we'll concentrate on them. On any given **part**, there may be more than one core. This varies from one manufacturer to another. Cores are generally made of sand. The sand is held together with a bonding agent.

The cylinder block is the largest casting that we make. The main core in the block is the water jacket. In this case, core shift would occur if the water jacket core moved relative to the main tooling. Since the water jacket core is set inside the main tooling, it is possible for this core to be shifted in position. In most cases, this shift is caused when the molten metal hits the core and moves or *offsets/deflects* it.

The core could move up or down, fore or aft, but the important direction is left or right. Left or right shifts move the core in the major or minor thrust direction. This makes the cylinder bore either thick or thin on the major thrust side. Having the core shifted so that the major thrust side is somewhat thicker is superior to being perfectly round. Consequently, having the major thrust side too thin is NOT desired. To find out if this has occurred, the block must be sonic tested.

Most of the confusion relating to core shift occurs because racers try to find a "quick" way to determine if a block has core shift without sonic testing! Remember that not all core shift is bad. Looking at the front or rear of the block will not tell you if the block has core shift because you're not looking at the water jacket. The only way to see the water jacket is to look down the holes in the top of the block. These holes are quite small and don't allow you to visually judge for core shift.

So that brings us back at sonic testing. Sonic testing measures the thickness of the cylinder bore in the major and minor thrust directions. Technically speaking, all the bores should have the material shifted in the same direction.

Surfacing (“Decking”)

Perhaps this topic would be more properly labeled “resurfacing” because the block already has a deck surface. Sometimes this operation is called “decking” the block. In either case, the top surface of the block, called the deck, is milled. This operation decreases the block’s height.

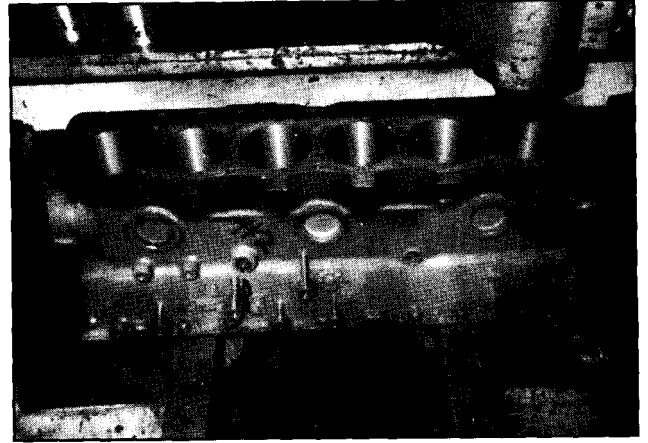
Why would you “deck” (surface) the block? One possibility is to increase the compression ratio. Another is to take weight out of the block/engine assembly. Most engine builders DO NOT feel the production machining to be acceptable in the area of flatness. The engine builder may want to remove the production tolerance of the decks. Usually a race machine shop will machine the stock deck of a new block .020" to .040". They will take very light cuts to gain the desired specifications. If it is a used engine that has seen a lot of heat, they may have to increase these numbers to get it flat enough. In decking the block, the machine shop must be very careful that it does not make the resulting deck surface too smooth or the cylinder head gasket will not seal.

Let’s look at an example. The 4.0L engine has a block height of 9.45". A race engine builder may machine 0.020" off the deck surface to gain flatness, which gives a final block height of 9.43". Never make calculations based on average numbers like the 9.45". Or, if you have to, leave enough stock so that you can get exactly where you want to without scrapping parts (.040" is preferred). What if the crank has a stroke that is .010" too long, or a connecting rod that is .005" too long, or a piston that is .005" too tall? It wouldn’t be the block that is wrong, but the block can fix them all with no problem if we left our engine builder with a .040" cushion.

Honing

Before the honing operation is started, the cylinder walls should be inspected for cracks or pits and the bores checked for taper and roundness. A cylinder bore is most accurately measured using a dial-bore gauge. For the actual honing operation, approximately .004" (.002" per side of material) should have been left after boring. (The size of the piston and the piston design are other factors determining the bore size and the piston-to-wall clearance.) The hone used to gain the desired surface finish is stipulated by the choice of piston rings, but regardless of the actual finish (perfectly smooth or slightly rough), it should have a 45° crosshatch pattern. (Moly rings, 10-15 micro inches; chrome or stainless steel, 15-25 micro inches. A 30 micro finish is fairly rough and is close to the hone finish on a production engine. A 5 micro finish is very smooth.) After honing, the bores should be straight (no taper) and round within $\pm .002$ ".

Having a STRAIGHT bore that is ROUND with NO TAPER is THE single most important step in building a race engine that produces good horsepower, high rpm, and/or high specific output.



1. Honing Plates

For a serious all-out race engine, the use of a honing plate is strongly recommended. It should be made of a 1 to 1-1/2" thick steel plate. The honing plate is held on by capscrews. The screws should be torqued to the same specifications as the standard head bolts.

Thickness of the honing plate and installation torque are very important, but of equal importance (and an item often overlooked) is the depth of thread engagement. Bolts should be turned all the way in and then backed off one turn for proper thread depth.

2. Why a Honing Plate?

At the beginning of the race season when you’re rebuilding your tried-and-true race engine or building a new engine for the upcoming season, the block should be honed using a honing plate. This is the only way to make the bores straight and round with the throttle wide open. If the bores aren’t straight and round at W.O.T. (wide open throttle), the engine won’t make any horsepower. If you’re building several engines, or plan to do so over the next few years, it will pay to get your own honing plate. Most people/engine builders and machine shops don’t have honing plates for Chrysler-Plymouth-Dodge-Jeep engines. Honing plates don’t wear out. Cast iron plates are less expensive but can break if mishandled or dropped. Billet steel plates are much stronger and more durable.

3. Honing Plate Thread Engagement

The honing plate should be held on to the block with the same thread length as the head. This sounds easy enough, but how do you get the two to be the same? Since cylinder head distortion is what you’re trying to match, the first step starts with the head after machining. The head bolts with washers, if they are to be used with the head on final assembly, are inserted into the head and the length of bolt protruding out the bottom of the head is measured. We’ll assume that this measurement is .900". The bolts that are going to be used with the honing plate are inserted into the plate.

The amount that sticks out of the bottom of the plate has to be adjusted to .900". If the first pass yielded a length of 1.200", then hardened washers can be installed under the bolt head. Hardened washers run around .100". So, in this example, three hardened washers would be used to get the correct length. (For more information refer to *Block-to-Head Distortion*, 'Cylinder Heads' section of this chapter.)

Boring and Milling Specifications

Because it is a thin wall casting design, the 4.0L can only be over-bored .030" (maximum), although .020" (maximum) is preferred. Regardless of the amount of overbore, if the engine is to be used for high output racing purposes, the cylinder wall thickness should be checked to be sure the block doesn't have a bad case of core shift. The cylinder wall thickness should be the same all the way around or thicker on the major thrust side of the cylinder bore; that is, passenger side (as installed in the vehicle).

1. When machining cylinder head and deck, be sure they're perfectly flat.
2. When milling cylinder head and deck, don't make them too smooth or you could have gasket sealing problems. A typical production surface (100 micro-inches) should be your guide.

The milling of the intake manifold gasket surface can be done on the intake manifold itself instead of the head.

Cylinder Bore Measurement

1. It is mandatory to use a dial bore gauge to measure each cylinder bore diameter (Figure 2-11). To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") INCREMENTS is required. If a bore gauge is not available, DO NOT use an inside micrometer.
2. Measure the inside diameter of the cylinder bore at three levels below top of bore. Start perpendicular (across or at 90 degrees) to the axis of the crankshaft and then take two additional readings.
3. Measure the cylinder bore diameter crosswise to the cylinder block near the top of the bore. Repeat the measurement near the middle of the bore, then repeat the measurement near the bottom of the bore.
4. Determine taper by subtracting the smaller diameter from the larger diameter.
5. Rotate measuring device 90° and repeat steps above.
6. Determine out-of-roundness by comparing the difference between each measurement.

7. If cylinder bore taper does not exceed 0.025 mm (0.001") and out-of-roundness does not exceed 0.025 mm (0.001"), the cylinder bore can be honed. If the (cylinderbore taper or out-of-round condition exceeds these maximum limits, the cylinder must be bored and then honed to accept an oversize piston. A slight amount of taper always exists in the cylinder bore after the engine has been in use for a period of time.

CYLINDER BLOCK ASSEMBLY

Head Bolts

All cylinder head bolts should be screwed into the block without the cylinder head. Visually inspect the rows of bolts for any that may be bent, or for bolts with holes drilled at any angle, or for holes that are not drilled deep enough. When the head bolts are screwed in, the depth of thread engagement should be checked and recorded.

Note: It is recommended that new cylinder head bolts and main cap bolts always be used (if possible) when rebuilding an engine.

Bottoming Tap

A bottoming tap should be run down all head and main bearing bolt holes. The head bolt holes should be chamfered slightly to prevent the top thread from pulling up when the head bolts are torqued.

Main Bearing Bores

Main bearing bores must be checked for both specified diameter and alignment with each other. If either is off, an align-boring machine should be used to align-bore the block. A crankshaft-turning tight spot indicates bores are out of alignment.



Deck Height

Once the main bearing bores are known to be in alignment, the deck surface of the block should be checked to make sure it is parallel with the axis of the crankshaft. The distance from the centerline of the crankshaft to the deck surface of the block should be exactly the same at the front and rear. If not, the deck surface will have to be milled. At this time the deck height can be machined to the proper dimension.

Note: Deck heights that are above the block surface will be increased by milling the block. Check the engine's blueprint specifications before milling. The resulting machined surface of the deck must be on the rough side to produce a good gasket seal and prevent the head gasket from moving.

Dowel Pins

Ensure that all dowel pins used for aligning purposes are the proper height (not too high), and that the dowel pins locate the head properly so that combustion chambers are properly centered over cylinder bores. Check to be sure that the dowel pins don't hold the head up off the block.

Note: Check without a head gasket.

Rear Main Bearing Oil Seal

The rear main bearing oil seal machined groove should be roughed slightly with a center punch and the rope seal must be seated all the way in. The rubber rear main seal should be held in place with Permatex (RTV) behind the seal.

Camshaft Bearings

When installing camshaft bearings, make sure that the oil holes in the bearings line up with the oil holes in the block. DO NOT replace the camshaft bearings unless they are bad or the block has been tank cleaned in acid.

Deburring

Use a small, fine file to remove burrs and break all sharp edges in the main bearing bores and around the cylinder bore chamfers, as well as other sharp edges on the block.

Tappet Bores

The tappet bores may be shined with #400 paper to remove any rough spots or burrs. A brake cylinder hone may also be used with care. Tappet bore clearance is very important. If it is too tight, the lifters will stick. Use .0015" for flat tappets and over .0015" to .003" for rollers. High clearance can cause low oil pressure if the tappet bores are "wet."

If a big, flat-tappet camshaft that requires .100" oversize mushroom lifters is going to be used, the bottom of the lifter bore should be spot-faced to a slightly larger diameter than the diameter of the mushroom lifter bottom. A back spot-facing tool is required to do this.

Notching the Cylinder Bore for Connecting Rod Clearance

If you are attempting to install a crankshaft from a 4.2L engine into a 4.0L engine, you may have to notch the bottom of the cylinder bores (as required) to obtain .100" clearance (Figure 4-4).

There are many variables associated with this popular modification (too numerous to go into detail here). For more information, call the Mopar Performance Parts Technical Assistance Hotline at 1-248-969-1690, or fax them at 1-248-969-3342. They'll be glad to help you.

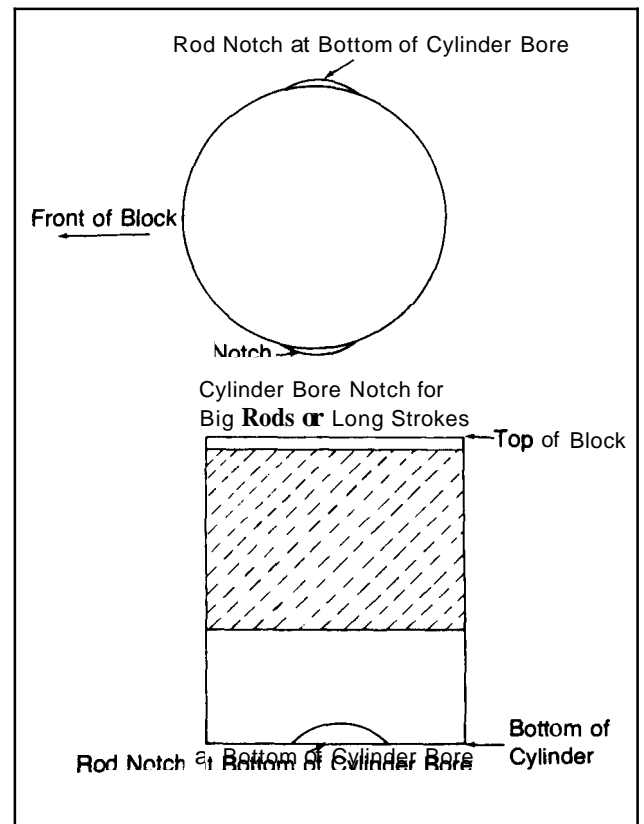


Figure 4 - 4

CC'ing the Block

For complete information, refer to *Measuring 1/2" Down Fill Volume*, 'Pistons and Rings' section of this chapter.

ADDITIONAL CYLINDER BLOCK PREPARATION AND ASSEMBLY TIPS

Building a high performance engine requires a lot of machining and assembly. Getting the bores straight, round, and with no taper is very important to making horsepower. However, there are several little items that are often overlooked in engine building until it's too late.

First, we strongly recommend that the engine builder read completely this chapter before any engine work is started. Before the engine is assembled, all the basic parts (block, crankshaft, head, etc.) should be cleaned, and then cleaned again! The bearing clearances should be checked with Plastigauge (P42868 19) or micrometers (inside and outside).

Before reassembling, gather all the chemical products likely to be needed such as RTV, Loctite, etc. If any parts are to be stored after they are machined and/or cleaned, they should be sprayed with a rust preventive, wrapped in newspaper and covered with plastic bags.

When the camshaft and lifters are installed, a camshaft break-in oil should be used on the camshaft lobes and journals and the outside of the lifters. The camshaft break-in oil should come with the camshaft kit. If you need camshaft break-in oil, order Lubrizol.

Before totally disassembling the block, check the deck height of the pistons. Deck height is the distance from the top of the piston to the top of the deck surface of the block. This is an important dimension since it has a direct influence on compression ratio. If the piston is a flat-top type, it will usually be below the deck and this is the distance that must be measured. A domed piston will stick up above the deck surface and the distance is measured from the deck to the flat of the piston, not the top of the dome. Mark this figure down for future reference and completely disassemble the block. On a new block, wait until the block is bored to size before measuring the deck height.

When all machine operations are complete, the block should be thoroughly washed out with solvent. Use bottle brushes of suitable size to clean out all bolt holes, oil passages, etc. Finish off with another thorough washing, using a good, common detergent and warm water. Blow or wipe dry and oil to prevent rust. Engine parts can't be too clean. Many early engine failures can be traced to dirt or foreign objects (metal chips, etc.) that were left in the engine when it was reassembled.

MAIN CAPS

Hardened Washer Sets

For use with head bolts and main cap bolts.

- P4120456 Comprised of: (20) - 3/8" washers.
- P4120457 Comprised of (20) - 7/16" washers
- P4120458 Comprised of: (20) - 1/2" washers.

We all know an engine must have a set of main caps to function. If you have a used engine block, it probably has its own main caps, but some blocks may have broken or lost caps. Main caps should be replaced in sets. Most used engine blocks should have the mains align bored before the engine is assembled into a "race" engine.

Let's assume your main caps are O.K. and you have them all. We'll also assume that you are building a race or high output engine. The problem with main caps is that they are too simple. If they look like the right caps and we have enough, then we'll probably use them even if they aren't from this particular block. We have already stepped over the line in this last sentence. We'll explain shortly.

You may be asking, "If my caps aren't broken and I have enough, why should I change?" or, "Why should I install new caps?" These two questions are not the same! First, remember that if the main caps are changed, then the block **MUST** be align-bored. Always! If you are building a race engine, you also **MUST** align-bore the engine. (The only exception is if the engine was align-bored on its last rebuild, then it should be alright.) Remember our "over-the-line" sentence regarding using caps that weren't from our particular block? In this case we must also align-bore the block.

Remember that a weak cap doesn't necessarily fail itself. An engine failure will more likely occur with the bearings, crankshaft, bolts, or even the bulkhead. A cap failure would only occur in the most extreme cases. But it does occur. You'd like to find it when you are routinely checking the bearings, but you don't always get that lucky!

Note: It is recommended that new main cap bolts always be used (if possible) when rebuilding an engine.

FREEZE PLUGS

Every block used in production uses freeze plugs. They are pressed into the sides and ends of the block. If they do their job correctly, you will probably never know they are there. If they fail, things can go wrong very quickly.

If you are building a race engine, it is highly recommended that the block be thoroughly cleaned before you start. To clean a block thoroughly, you need to remove the freeze plugs. If you have the block hot-tanked, then the freeze plugs **MUST** be replaced because they have lost their "press" and will fall out as soon as there is any pressure in the water jacket.

Freeze plugs can't be re-used, so once you take them out, you need a new set.

Crankshaft

INTRODUCTION

The 4.0L engine uses a cast nodular iron crankshaft that rotates within seven (7) main bearings and has a standard bore and stroke of 98.4 x 87.4 mm (3.88 x 3.44"). Crankshaft rotation is clockwise, when viewed from the front of the engine.

The crankshaft is a cross-shaped four throw design with eight counterweights for balancing purposes. The crankshaft is supported by seven select main bearings with No. 3 serving as the thrust washer location. The main journals of the crankshaft are cross drilled to improve rod bearing lubrication. The select fit main bearing markings are located on the crankshaft counter weights. The crankshaft rear oil seal is a two piece design. The front oil seal is one piece design retained in the timing chain cover.

The crankshaft has a main bearing journal diameter of 63.489-63.502 mm (2.4996-2.5001"), and main bearing journal widths of (No. 1) 27.58-27.89 mm (1.086-1.098"), (No. 3) 32.28-32.33 mm (1.271-1.273"), and (Nos. 2, 4, 5, 6 and 7) 30.02-30.18 mm (1.182-1.188").

The crankshaft has a connecting rod journal diameter of 53.17-53.23 mm (2.0934-2.0955") and a connecting rod journal width of 27.18-27.33 mm (1.070-1.076").

For high performance racing engines, Mopar Performance Parts recommends a forged crankshaft. Forged crankshafts allow you to specify to your grinder exactly what stroke you want, and cost less to have finished than billet crankshafts. And for those of you who want an oversize bore engine, a custom ground forged crankshaft is the way to go.

For more crankshaft specifications, refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.

High Performance Crankshaft

This Mopar Performance Parts high performance crankshaft has a 3.41" stroke and has been carefully inspected and Magna-fluxed. 4.0L engine only.

P4529205 High performance crankshaft.

Balanced and Unbalanced Crankshafts

When describing crankshafts, we use words such as "balanced" and "unbalanced." However, what is physically different about the crankshafts is not as obvious as the words may imply.

Since the unbalanced crankshaft is easier to understand, we'll start with that one. Unbalanced crankshafts have **SOLID** journals. That means there are no holes through the first and last crankshaft journals. Racers like this because they can offset grind the crankshafts if desired. Other racers

who use superchargers and/or alcohol fuel like solid journals because they see them as being stronger (because there are no holes in them). These are called "unbalanced" or "solid journal" crankshafts.

To spin-balance a typical crankshaft that has solid journals, you have to add Mallory metal. This can be expensive. Therefore, production crankshafts have a machined hole through the first and last journals. These are balance holes. Racers call them "balanced" crankshafts, so we call them balanced crankshafts. The name **ONLY** refers to the large 1-1/16" hole (approximately) through the first and last journal. The crankshaft should still be balanced with its specific connecting rods and pistons like any other race engine crankshaft. However, the big holes usually eliminate or cut down the use of Mallory metal.

Crank Bolt

The crank bolt is often used to turn the engine over by hand, but this is only a convenience item. Its real function is to hold the vibration damper on. That is why it is put on with so much torque. If the interference fit on the damper hub is not there and the crank bolt is not torqued, the damper can't do its job. This will cause the crank to eventually fail.

To hold the damper on properly there is a special large, hard washer that is used. We have included this special washer in our damper attachment package (P4529677).

BASIC PREPARATION

When preparing a crankshaft for racing applications, the following steps should be performed:

1. Crankshaft bearing journals should be checked for specified diameter and clearance. If it is a hardened crankshaft, it shouldn't be ground for clearance. These crankshafts are hard only to a depth of .0003". The main bearing clearances should be 0.03-0.06 mm (0.001-0.0025"). The best way to measure crankshaft journals is with a micrometer. To measure main bearing clearances, the bearings can be installed, the bolts torqued to specification, and the inside diameter of the bearing measured 90 degrees to the parting line with an inside micrometer or snap-gauge. The difference between these two measurements is the bearing clearance. Plastigauge is accurate enough for most race applications (P4286819 – includes all 3 sizes).
2. The bearing journals may be polished by hand, first with #400 and then with #600 paper. Any nicks, burrs or scratches should be polished out. Chamfer oil holes in journals and use a wet stone to break edges. Check the oil passages to each journal.

Caution: With the nodular cast iron crankshafts used it is important that the final paper or cloth polish after any journal regrind be in the same direction as normal rotation in the engine.

3. Crank alignment may be checked by installing the upper bearing shells in the block (at each end of the crank *only*) as well as the main caps (at each end of the crank *only*).
4. Before assembly, make sure crankshaft, including internal oil passages, is clean. Also be sure all oiling passages are drilled through!
5. When assembling the crankshaft into the block, oil the bearings and journals.
6. When installing the crankshaft, locate the main caps carefully so that the crankshaft spins freely, and torque all caps to specifications. Then spin the crankshaft by hand through several revolutions before installing the rear main seal. It should be fairly free, requiring very little effort. Remove the caps and check for any burrs. If present, they can be removed by gently scraping with a bearing knife. When installing the rear main seal, make sure it is properly seated; improper seating can cause the crankshaft to bind.
7. For better race engine oiling with a high capacity oil pump, 360° main bearing oiling is desired. 360° fully grooved main bearing sets should be used. It is NOT recommended that the crankshaft itself be grooved because grooves weaken the crankshaft.
8. A degreed damper is a must for racers since they must set their timing by total degrees advanced at a fairly high rpm (for example, 35° total at 2,500 rpm). A degreed damper is the easiest, most accurate, and most convenient tool for doing this. It also aids in setting the valve lash by giving 90° reference marks.

Note: Damper degree timing tape is P4529070.

9. There are several additional items that should be checked during your build-up that will be helpful later:
 - a. Measure the actual stroke of the crankshaft. We suggest that the extra time be invested and that two cylinders per crankshaft throw be measured. **All** measurements should be written in your engine building notes.
 - b. Measure the deck height using a representative connecting rod and piston along with the actual crankshaft to be used. Be sure to oil the bearings in this step.
 - c. Check the crankshaft end play.
 - d. Check the connecting rod side clearance on each journal. Refer to 'Connecting Rods' section of this chapter for instructions. Always clean all parts used before proceeding to the next step.

10. Care must be exercised when tightening the bearing caps. When the cap bolts have been torqued to 80 ft-lbs, check to make sure that the oil pump can be inserted without binding on a main bolt hex head. If it binds, tighten the main cap bolt just enough more (no more than 1/6 turn) so the oil pump will clear the bolt with no binding.

SPECIAL CRANKSHAFT PROCEDURES

Measuring Main Bearing Clearances

There are two methods that can be used to measure crankshaft main bearing clearances: the Plastigauge method and the Direct Measurement method.

1. *Plastigauge Method*

When using Plastigauge (P4286819), check only one bearing clearance at a time.

- a. Install the grooved main bearings into the cylinder block and the non-grooved bearings into the bearing caps.
- b. Install the crankshaft into the upper bearings dry. Place a strip of Plastigauge across the full width of the crankshaft journal to be checked.
- c. Install the bearing cap and tighten the bolts to 108 N•m (80 ft-lbs) torque.

DO NOT rotate the crankshaft. This will cause the Plastigauge to shift, resulting in an inaccurate reading. Plastigauge must not be permitted to crumble. If it is brittle, obtain fresh stock.

- d. Remove the bearing cap. Determine the amount of clearance by measuring the width of the compressed Plastigauge with the scale on the Plastigauge envelope (Figure 2-16). The correct clearance is 0.03 to 0.06 mm (.0010 to .0025") for all main bearing journals, with 0.051 mm (0.002") preferred.

Plastigauge should indicate the same clearance across the entire width of the insert. If clearance varies, it may indicate a tapered journal or foreign material trapped behind the insert.

- e. If the specified clearance is indicated and there are no abnormal wear patterns, replacement of the bearing inserts is not necessary. Remove the Plastigauge from the crankshaft journal and bearing insert. Proceed to *Main Bearing Installation*, in this section.
- f. If the clearance exceeds specification, install a pair of 0.025 mm (0.001") undersize bearing inserts and measure the clearance as described in the previous steps.

The clearance indicated with the 0.025 mm (0.001") undersize insert pair installed will determine if this insert size or some other combination will provide the specified clearance.

Example: If the clearance was 0.0762 mm (0.003") originally, a pair of 0.0254 mm (0.001") undersize inserts would reduce the clearance by 0.0254 mm (0.001"). The clearance would then be 0.0508 mm (0.002") and within the specification. A 0.0508 mm (0.002") undersize bearing insert and a 0.0254 mm (0.001") undersize insert would reduce the original clearance an additional 0.0127 mm (0.0005") and the clearance would then be 0.0381 mm (0.0015").

Caution: Never use a pair of inserts that differ more than one bearing size as a pair. For example, DO NOT use a standard size upper insert and a 0.051 mm (0.002") undersize lower insert.

If the clearance exceeds the specifications using a pair of 0.051 mm (0.002") undersize bearing inserts, measure the crankshaft journal diameter with a micrometer. If the journal diameter is correct, the crankshaft bore in the cylinder block may be misaligned, which requires cylinder block replacement or machining to true bore.

If the diameters for journals 1 through 6 are less than 63.4517 mm (2.4981"), or journal 7 is less than 63.4365 mm (2.4975"), replace the crankshaft or grind it down to accept the appropriate undersize bearing inserts.

Once the proper clearances have been obtained, remove the crankshaft and proceed to *Main Bearing Installation*, in this section.

Plastigauge

When reassembling your engine you'll need a variety of Plastigauge to measure bearing clearances. This popular assortment includes one blue strip for .004" - .009" tolerances, two red strips for .002" - .006" tolerances, and two green strips for .001" - .003" tolerances. Each strip is 12" long.

P42868 19 Plastigauge assortment.

2. Direct Measurement Method

The most accurate way of measuring crankshaft main bearing clearances is directly.

- Clean the main bearing journal of oil.
- Determine the maximum diameter of the journal with a micrometer. Measure at two locations 90° apart at each end of the journal.
- Compare the measured diameter with the journal diameter specification listed in the *Main Bearing Fitting Chart* (Figure 4-9), and select inserts required to obtain the specified bearing-to-journal clearance.

Top Dead Center (TDC)

One of the most important basics in engine building is being able to find Top Dead Center (TDC). To do this, you need a dial indicator and a bridge, which is a U-shaped bracket that will hold the dial indicator perpendicular to the piston top. The indicator should be placed over the flat part of the piston.

1. Finding TDC

- Place the dial indicator (minimum 1/4" travel) on top of the piston and rotate the piston to its maximum upward travel. This is TDC. On some engines this may be done without removing the head by inserting the indicator through the spark plug hole. Be sure the indicator is rigidly mounted.
- Affix a 360° protractor (or degree wheel P4452990) on the crankshaft with a pointer. Place the pointer as close to "0" (TDC) as you can by watching the indicator.

Note: The Mopar Performance Parts 0-180-0 degree wheel is easy to read because 100+ degrees read directly.

- Rotate the crankshaft (clockwise when facing the front of the engine) until the dial indicator reads exactly .030" before TDC. Stop. Take reading from the degree wheel. Write it down. Reverse rotation (counterclockwise) until the piston comes up again and the dial indicator reads .030" exactly. Stop. Take reading from the degree wheel. This reading should be the same number of degrees from "0" (TDC) as the first reading, only on the other side of "0". If it is not, move the pointer half the difference in degree readings in the direction of the minimum degree reading.

Note 1: The .030" selected was for explanation purposes only. Any measurement of .015" or greater is acceptable.

Note 2: The reason for reversing direction to obtain the second degree reading is to take out any clearance in the connecting rod bearing and pin.

Example: With the degree wheel, pointer, and dial indicator in position, rotate the crankshaft (clockwise) until .025" is read on the indicator. (If you go past, just start again. DO NOT back up—go all the way around.) The degree wheel reads 8". Reverse rotation (counterclockwise) until the indicator reads .025" again. The degree wheel reads 350" (or 10" depending on the degree wheel). Move the pointer on the degree wheel 1° to read 351°. Repeat the procedure. At .025" the degree wheel should now read 9" and 351". Now the pointer is reading 0" at TDC exactly.

TDC Indicator Tool

This is a handy, positive-stop tool for determining exact top dead center (TDC) when centerlining camshafts. This tool, made of hardened steel, is extremely accurate and can be used on all DaimlerChrysler six cylinder engines. It takes the guesswork out of finding TDC.

P4349737 TDC indicator tool.

Degree Wheel

Durable Mopar Performance Parts aluminum plate 0°-180°-0° degree wheel for centerlining camshafts. Features step-by-step installation instructions printed on back side.

P4452990 Degree wheel.

2. *Timing Mark*

Note: This procedure requires the timing chain case cover be bolted to the partially-assembled short block.

The timing mark is composed of two lines or marks, one on the crankshaft damper and the other on a tab on the timing chain cover, that indicate TDC. Once you have located TDC with the dial indicator, this true position should be checked against the indicated timing mark. Any deviation from the true TDC mark should be noted and the correction made permanently on the crankshaft damper. The new mark should be very visible. An error in basic timing of only 2° can be very costly in terms of performance and/or engine damage. A 2° error in timing can result in a pre-ignition failure or light to heavy compression ring scuffing which results in increased blow-by and lower horsepower output.

Mallory Metal

Mallory metal is typically used in race engines to balance crankshafts (refer to Figure 4-5). Many machine shops don't like to use it because it makes the balancing process somewhat more complicated. However, as a racer, it's important to know what Mallory metal is and what it's used for.

Mallory metal is heavier than lead, which makes it much heavier than steel or cast iron. It can be welded to steel. It can be machined similar to steel. Although lead is somewhat soft, Mallory metal is hard. These characteristics make it much like very "heavy" steel. Although not chemically correct, this is an adequate "simple" description.

Now the question becomes, "Why do we want heavy steel?" Since we are racing, "heavy" doesn't sound like something we would want to use other than for ballast. On the surface this is true. Looking at the general description of heavy metal, we might guess that we could use it to add weight to something in the same sense that we ballast the vehicle for better weight distribution. If this was your guess, you'd be pretty close. Mallory metal is used to add weight to the crankshaft.

The next question becomes, "Why would we want to add weight to a racing crankshaft?" First, this is related to the fact that we typically race modified production engines. Most production engines since the early 1970s have used a cast iron crankshaft. Many of these cast iron crankshafts are externally balanced. The reason that these assemblies are externally balanced is that cast iron is slightly lighter than steel. Since the piston and connecting rod stay the same in any given engine assembly, any loss of weight from the crank's counterweights can cause the engine to be unbalanced. To fix this, production engineers add offset weights to the vibration damper and torque converter (or flywheel), making the engine externally balanced. In this case, "external" indicates outside of the short block assembly.

Having offset-weighted vibration dampers and torque converters (or flywheels) can be a problem in racing. Vibration dampers may have to be SFI approved for the class that you run. Torque converters are a commonly changed performance part. Flywheels can offer unique problems. Balancing the engine internally solves all of these problems. To accomplish this, we must add weight to the crankshaft in selected areas. Since the crankshaft is made of cast iron, the material we add must be heavier than cast iron—Mallory metal.

In NHRA and IHRA Stock and Super Stock classes, balancing is legal. It clearly states so in the rule book. NHRA technical people consider Mallory metal a 100% legal part of balancing. We (DaimlerChrysler/Mopar Performance Parts) have been doing this for many years.

Adding Mallory metal to the crankshaft sounds like we are going to increase its weight and inertia. Actually, the total weight stays the same. The weight that is added to the crankshaft is removed from the torque converter. If the problem was the damper (having to use an SFI approved damper), then the weight added would come off the damper. Total weight would remain basically the same. Crankshafts are balanced dynamically, or by spinning. This means that a balanced crankshaft has the same inertia (assuming we kept the same pistons, connecting rods, etc.). Actually, because Mallory metal is heavier than steel or cast iron and you add it near the outside diameter of the crankshaft where it has the maximum effect, the balanced assembly may be slightly lighter (in weight—at the same inertia).

To take this one step further, let's look at actually lightening the crankshaft. One of the methods is called "knife-edging" the crankshaft. Generally, this process is NOT legal in Stock or Super Stock classes. It is legal in Modified/Competition classes, but read the rule book first for any given class. Knife-edging removes a lot of weight from the crankshaft; however, you can quite easily make the crankshaft too light. Mallory metal will again balance this knife-edged crankshaft. However, if found in a Stock or Super Stock engine, it will be illegal. The Mallory metal isn't illegal, the knife-edging is!

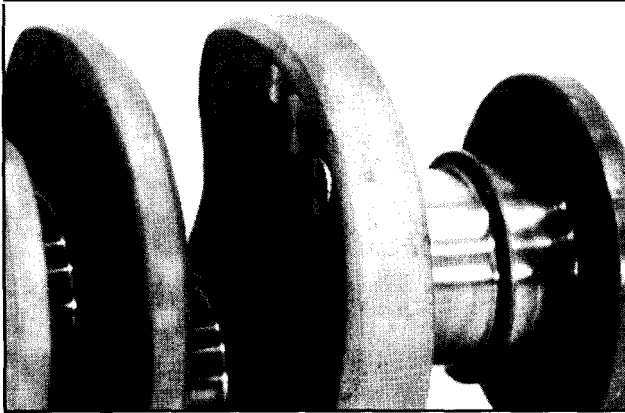


Figure 4 - 5

Tuff-Triding and Nitriding

Tuff-triding is a crankshaft surface treatment. It is a patented process that can only be done under license. It is also an older process which is not as popular with racers today as it once was. The popular surface hardening process today is generically called *nitriding*. There are several versions of it. While many people think that nitriding turns a crankshaft black, it may actually be gray. Therefore, color is not a good means of process identification. (Other types of metal treatments can result in similar colors.)

4.2L Engine Crankshaft Installation

If you are attempting to install a crankshaft from a 4.2L engine into a 4.0L engine, you may have to notch the bottom of the cylinder bores (as required) to obtain .100" clearance (Figure 4-4).

There are many variables associated with this popular modification (too numerous to go into detail here). For more information, call the Mopar Performance Parts Technical Assistance Hotline at 1-248-969-1690, or fax them at 1-248-969-3342. They'll be glad to help you.

MAIN JOURNALS

Crankshaft main journals should be checked for excessive wear, taper and scoring. Limits of taper or out-of-round on any crankshaft journal should be held to 0.013 mm (0.0005"). Journal grinding should not exceed 0.305 mm (0.012") under the standard journal diameter. DO NOT grind thrust faces of No. 3 main bearing journal. DO NOT nick crankshaft pin or bearing fillets. After grinding, remove rough edges from crankshaft oil holes and clean out all oil passages.

Caution: With nodular cast iron crankshafts it is important that the final paper or cloth polish after any journal regrind be in the same direction as normal rotation in the engine.

MAIN BEARINGS

Street Performance Bearings

These production style main bearings are made from AL6 aluminum. Package includes complete engine set. Standard size. For 4.0L engine only.

P4529207 Street performance bearings.

Main Bearing Material

Basically, there are three types of material used in main bearings: Babbit, aluminum and Tri-Metal. Babbit is considered a soft bearing material, while Tri-Metal is considered hard.

For all-out drag racing use, Babbit bearings are recommended. Babbit bearings should be checked regularly.

Maximum duty aluminum bearings are advisable for medium duty racing applications, and are actually preferred by some engine builders.

For constant high load, high rpm use such as in oval track racing, hard bearings made of F-77 Tri-Metal material are recommended. If Tri-Metal bearings are used with a cast crankshaft, they should be checked frequently and replaced regularly, even though they are hard, high load bearings.

High load, high rpm engines require maintenance. Pushing the bearing replacement cycle too far, or ignoring it, will usually cause an expensive failure. The cost doesn't justify the gamble.

Removal

1. Disconnect the battery negative cable.
2. Remove the spark plugs.
3. Raise the vehicle.
4. Remove the oil pan and oil pump as outlined in the 'Oiling System' section of this chapter.
5. If equipped, remove the main bearing cap brace (Figure 4-6).
6. Remove one main bearing cap and lower insert.
7. Remove the lower insert from the bearing cap.
8. Remove the upper insert by loosening (DO NOT remove) all of the other bearing caps and inserting a small cotter pin tool in the crankshaft journal oil hole. Bend the cotter pin as illustrated to fabricate the tool (Figure 2-13). With the cotter pin tool in place, rotate the crankshaft so that the upper bearing insert will rotate in the direction of its locking tab.

Note: Because there is no hole in the No. 3 main journal, use a tongue depressor or similar soft-faced tool to remove the bearing insert. After moving the

insert approximately 25 mm (1"), remove it by applying pressure under the tab.

- Using the same procedure just described, remove the remaining bearing inserts (one at a time) for inspection.

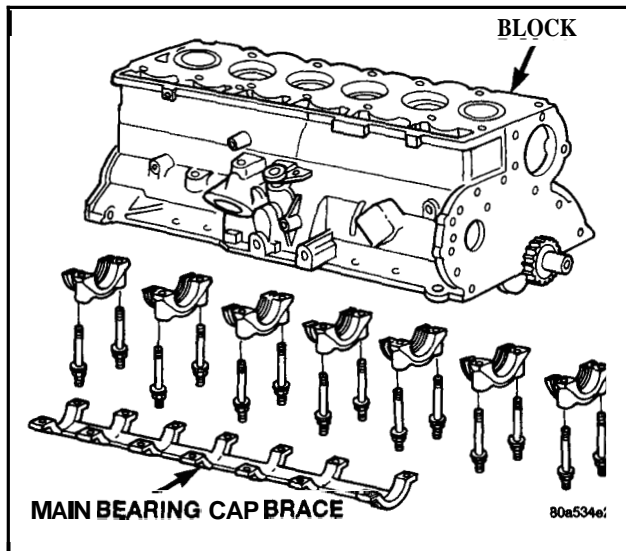


Figure 4 - 6

Inspection

- Wipe inserts clean and inspect for abnormal wear patterns and for metal or other foreign material imbedded in the lining. Normal main bearing insert wear patterns are shown in Figure 2-14.

Note: If any of the crankshaft journals are scored, remove the engine for crankshaft repair.

- Inspect the back of the inserts for fractures, scrapings, or irregular wear patterns.
- Inspect the upper insert locking tabs for damage.
- Replace all damaged or worn bearing inserts.

Fitting

(Refer to the *Main Bearing Fitting Chart* [Figure 4-91].)

The main bearing caps, numbered (front to rear) from 1 through 7 have an arrow to indicate the forward position. The upper main bearing inserts are grooved to provide oil channels while the lower inserts are smooth. Crankshaft end play is controlled by the thrust bearing which is flanged and installed at the No. 3 main bearing position.

Each bearing insert pair is selectively fit to its respective journal to obtain the specified operating clearance. In production, the select fit is obtained by using various sized, color-coded bearing insert pairs as listed in the *Main Bearing Fitting Chart* (Figure 4-9). The bearing color code appears on the edge of the insert. The size is not stamped on bearing inserts used for engine production.

The main bearing journal size (diameter) is identified in production by a color-coded paint mark (Figure 4-7) on the adjacent cheek toward the flanged (rear) end of the crankshaft, except for the rear main journal. The paint mark that identifies the rear main journal diameter is on the crankshaft rear flange.

Refer to *Main Bearing Fitting Chart* (Figure 4-9) to select the proper bearing inserts to obtain the specified bearing clearance. Refer to *4.0L Engine Specifications*, 'Engine Assembly' section, for the correct main bearing clearances.

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce the clearance by 0.013 mm (0.0005"). Never use a pair of bearing inserts with greater than a 0.025 mm (0.001") difference in size (Figure 4-8).

Note: When replacing inserts, install the odd size inserts either all on the top (in cylinder block) or all on the bottom (in main bearing cap).

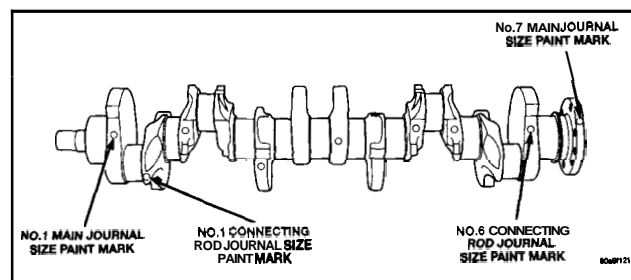


Figure 4 - 7

Insert	Correct	Incorrect
Upper	Standard	Standard
lower	0.025 mm (0.001 in.) Undersize	0.051 mm (0.002 in.) Undersize

J9109-179

Figure 4 - 8

Installation

- Lubricate the bearing surface of each insert with engine oil.
- Loosen all the main bearing caps. Install the main bearing upper inserts.
- Install the lower bearing inserts into the main bearing caps.
- Install the main bearing caps and lower inserts.

Note: Rotate the crankshaft after tightening each main bearing cap to ensure the crankshaft rotates freely.

5. Tighten the bolts of caps 1, 2, 4, 5, 6, and 7 to 54 N•m (40 ft-lbs) torque, then tighten to 95 N•m (70 ft-lbs) torque. Finally, tighten the bolts to 108 N•m (80 ft-lbs) torque.
6. Push the crankshaft forward and backward. Load the crankshaft front or rear and tighten No. 3 cap bolts to 54 N•m (40 ft-lbs) torque, then tighten to 95 N•m (70 ft-lbs) torque. Finally, tighten the bolts to 108 N•m (80 ft-lbs) torque.
7. Check the crankshaft end play. Refer to *Crankshaft End Play*, later in this section.
8. If the crankshaft was removed, install the crankshaft into the cylinder block.
9. If equipped, install the main bearing cap brace and tighten the nuts to 47 N•m (36 ft-lbs) torque.
10. Install the oil pump assembly and tighten the attaching bolts to 23 N•m (17 ft-lbs) torque.
11. Install the oil pan with replacement gaskets and seals. Refer to the proper service manual for the procedure.
12. Tighten the drain plug securely.
13. Lower the vehicle.
14. Install the spark plugs. Tighten the plugs to 37 N•m (27 ft-lbs) torque.
15. Fill the oil pan with engine oil to the full mark on the dipstick level.
16. Connect the battery negative cable.



Main Bearing Fitting Chart

Crankshaft Journals #1 - #6		Corresponding Crankshaft Bearing Insert	
Color Code	Diameter	Upper Insert Size	lower Insert Size
Yellow	63.5025-63.4898 mm (2.5001-2.4996 in.)	Yellow - Standard	Yellow - Standard
Orange	63.4898-63.4771 mm (2.4996-2.4991 in.) 0.0127 mm (0.0005 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Yellow - Standard
Blue	63.4771-63.4644 mm (2.4991-2.4986 in.) 0.0254 mm (0.001 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Blue - Undersize 0.025 mm (0.001 in.)
Green	63.4644-63.4517 mm (2.4986-2.4981 in.) 0.0381 mm (0.0015 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Green - Undersize 0.051 mm (0.002 in.)
Red	63.2485-63.2358 mm (2.4901-2.4896 in.) 0.254 mm (0.010 in.) Undersize	Red - Undersize 0.254 mm (0.010 in.)	Red - Undersize 0.254 mm (0.010 in.)

Color Code	Diameter	Upper Insert Size	lower Insert Size
Yellow	63.4873-63.4746 mm (2.4995-2.4990 in.)	Yellow - Standard	Yellow - Standard
Orange	63.4746-63.4619 mm (2.4990-2.4985 in.) 0.0127 mm (0.0005 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Yellow - Standard
	63.4619-63.4492 mm (2.4985-2.4980 in.) 0.0254 mm (0.001 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Blue - Undersize 0.025 mm (0.001 in.)
Green	63.4492-63.4365 mm (2.4980-2.4975 in.) 0.0381 mm (0.0015 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Green - Undersize 0.051 mm (0.002 in.)
	63.2333-63.2206 mm (2.4895-2.4890 in.) 0.254 mm (0.010 in.) Undersize	Red - Undersize 0.254 mm (0.010 in.)	Red - Undersize 0.254 mm (0.010 in.)

J9409-29

Figure 4 - 9

Crankshaft End Play

Refer to Figure 2-18.

1. Attach a magnetic base dial indicator to the cylinder block at either the front or rear of the engine.
2. Position the dial indicator rod so that it is parallel to the centerline of the crankshaft.
3. Pry the crankshaft forward; position the dial indicator to zero.
4. Pry the crankshaft forward and backward. Note the dial indicator readings. End play is the difference between the high and low measurements. Correct end play is 0.038-0.165 mm (0.0015-0.0065"). The desired specifications are 0.051-0.064 mm (0.002-0.0025").
5. If end play is not within specification, inspect crankshaft thrust faces for wear. If no wear is apparent, replace the thrust bearing and measure end play. If end play is still not within specification, replace the Crankshaft.

REAR MAIN OIL SEAL

The crankshaft rear main bearing oil seal consists of two half pieces of neoprene with a single lip that effectively seals the rear of the crankshaft (Figure 4-10). Replace the upper and lower seal halves as a unit to ensure leak-free operation.

Removal

To replace the rear main oil seal, the transmission must be removed. Refer to the service manual for the procedure.

1. Remove the flywheel or torque converter drive plate.
2. Remove the oil pan. Refer to the proper service manual for the procedure.
3. Remove the rear main bearing cap (No. 7).
4. Push the upper seal out of the groove. Ensure that the crankshaft is not damaged.
5. Remove the lower half of the seal from the bearing cap.

Installation

1. Wipe the seal surface area of the crankshaft until clean.
2. Apply a thin coat of engine oil.
3. Coat the lip of the seal with engine oil.
4. Position the upper seal into the groove in the cylinder block. The lip of the seal faces toward the front of the engine.
5. Place the lower half of the seal into the bearing cap (Figure 4-10).
6. Coat both sides of the lower seal end tabs with Mopar Gasket-in-a-Tube, or equivalent. DO NOT apply sealant to the lip of the seal.

7. Coat the outer curved surface of the lower seal with soap and the lip of the seal with engine oil.
 8. Position the lower seal into the bearing cap recess and seat it firmly.
 9. Coat both chamfered edges of the rear main bearing cap with Mopar Gasket-in-a-Tube, or equivalent.
- Caution:** DO NOT apply sealant to the cylinder block mating surfaces of the rear main bearing cap because the bearing-to-journal clearance would be altered.
10. Install the rear main bearing cap.
 11. Torque all main bearing bolts to 108 N•m (80 ft-lbs).

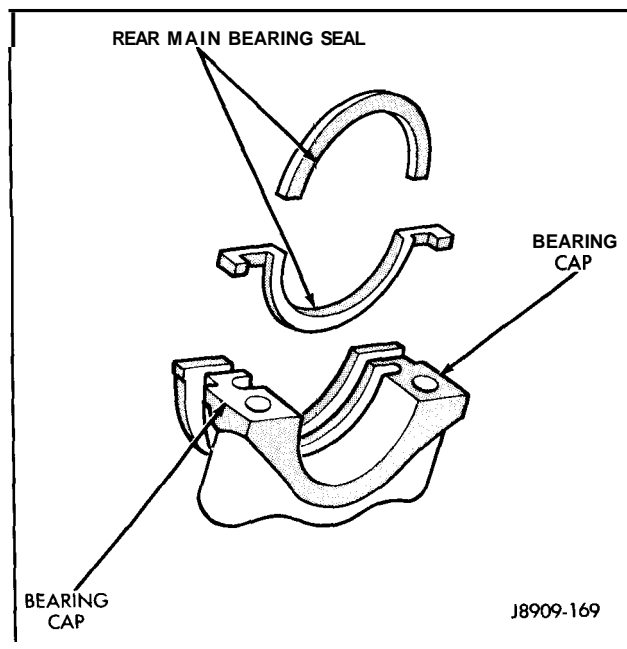


Figure 4 - 10

VIBRATION DAMPER

The reason for a vibration damper on an engine is to dampen the frequencies and/or harmonics that are created when the engine runs (rotates). In simplified terms, to "dampen" means to *soften* or *decrease the effect*. This keeps the crankshaft from breaking, helps it last longer, and helps bearing durability. In some engines you could even fail blocks because of excessive vibration. That's why a solid hub damper (or no damper at all) breaks the crankshaft quicker. This durability effect is greater in an oval track racing vehicle than a drag racing vehicle, and greater in a bracket racer than a Super Stocker (for example).

In the past, we've discussed the weight factor in rubber dampers. To summarize, the heavier the damper ring, the more effective the damper is. Therefore, on oval track vehicles, Chrysler-Plymouth-Dodge used a much larger damper to maintain durability.

Currently, the NHRA requires an SFI approved vibration damper as mandatory equipment in Comp Eliminator, Super Stock, Super Comp, Super Gas, and Super Street. They are also permitted in Stock Eliminators. Since January 1991, these SFI dampers have been mandatory on all E.T. bracket vehicles that run 10.99 and quicker. If you run a fast vehicle, you should be aware of these special dampers.

There are basically three vibration damper approaches that can be used. You can use a solid hub damper, a fluid/viscous damper, or a rubber-style damper. **DO NOT USE A SOLID HUB DAMPER.** It breaks crankshafts. This leaves the comparison between rubber and viscous dampers. Realize that production (stock) dampers work fine in stock condition, but they are not legal in fast vehicles; i.e., they are not **SFI** approved. Now the question becomes which one to use?

The first consideration is cost. Rubber dampers tend to be less expensive. However, this is like selecting a cast iron intake manifold over an aluminum one because the cast iron manifold costs less. There's more to it than that.

The second consideration is inertia. This translates into a damper's rotational weight. Without getting into fancy terms with a rubber damper, everything has to rotate with the crankshaft and at the same speed (rpm) as the crankshaft. This isn't true of a fluid/viscous damper. A large part of the viscous damper's weight doesn't follow the engine's rpm exactly. It works something like a viscous fan. This can be a big advantage in a drag engine or short track engine where engine speeds change quickly and by large amounts.

One of the characteristics of a rubber damper is that it has to be tuned to a selected rpm band of operation. This means that, for any given engine package, the damper is tuned to a specific rpm. The viscous damper does a better job at a wide range of frequencies (rpms). This again is a big advantage for the racer who races under many different conditions, rpms, track lengths, etc.

The only real "problem" with rubber dampers is that the rubber can deteriorate. This can manifest itself in the outer ring slipping. This causes the timing mark to move. At this point the damper should be replaced.

In summary, we recommend that a steel ring (SFI approved) vibration damper be used for general high performance (dual purpose) vehicles, and a viscous/fluid vibration damper be used for race-only drag, oval track, or endurance vehicles.

Damper Attachment Package

Attaching bolt package necessary to attach damper to crankshaft.

P4529677

Damper attachment package.

Vibration Damper Failure

Basically, vibration dampers keep the crankshaft from breaking. Longer stroke crankshafts work the vibration damper harder. So do higher rpm and more output to a lesser degree. Lighter dampers don't do as good a job as heavy dampers. Racing engines today are getting larger with longer strokes. We need the best damper we can get to keep the crankshaft from breaking. Without extensive testing, the best rule is the heavier the better. The production weight damper is another good guideline since there has been more testing on it than any other.

Most crankshaft failures are the result, not the cause. The damper causes the crankshaft to fail, not the other way around. If a crankshaft fails, always look to oiling first, then the damper. You can't blame an oiling failure on the damper. But you also have to select the damper that allows the crankshaft to work. If you take weight out of the damper and the crankshaft fails, you know you went too far!

Vibration Damper Performance Tips

We have covered the advantages of a good race vibration damper. Like any race piece, there are always little problems that crop up as you get into actual racing, such as notching pistons for a big camshaft and matching ports on the intake manifold. Vibration dampers are no exception.

First of all, always double check the timing mark. Double check it against actual top dead center (TDC). This tip really has nothing to do with the damper itself. We (DaimlerChrysler) have told racers over and over again to check the timing marks on their dampers. Check, check, and recheck! You should never switch dampers without checking the timing mark. Remark your damper as required. (Refer to *Top Dead Center (TDC)*, in this section, for complete information.)

Another tip concerns pulley spacing. Proper spacing has been a problem on every high rpm engine built. Aluminum pulleys add to the complexity of the problem. There is no easy solution. Aligning the various pulleys so that all the belts run true takes a little bit of patience and some measuring, but it must be done.

Removal

1. Remove the drive belt(s).
2. Remove the retaining bolts and separate the vibration damper pulley (V-belt ONLY) from the vibration damper.
3. Remove the vibration damper retaining bolt and washer.
4. Use a vibration damper removal tool to remove the damper from the crankshaft (Figure 2-2).



Installation

1. With the key in position, align the key slot of the vibration damper hub with the crankshaft key and tap the damper onto the crankshaft.
2. Install the vibration damper retaining bolt and washer. Tighten the bolt to 108 N•m (80 ft-lbs) torque. If the crankshaft turns before the damper bolt torque value is attained, the crankshaft can be prevented from turning by placing two 5/16" x 1-1/2" bolts into the damper front pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
3. Install the damper pulley (V-belt only) and retaining bolts. Tighten the bolts to 27 N•m (20 ft-lbs) torque.
4. Install the drive belts(s) and tighten to the specified tension. Refer to the service manual for the proper specifications and procedures.

TIMING CHAIN AND SPROCKETS

Installation of the timing chain with the timing marks on the crankshaft and camshaft sprockets properly aligned ensures correct valve timing. A worn or stretched timing chain will adversely affect valve timing. If the timing chain deflects more than 12.7 mm (1/2"), replace it. The correct timing chain has 48 pins. A chain with more than 48 pins will cause excessive slack. For removal and replacement procedures, refer to the proper service manual.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

All-out Race Chain and Sprockets

Cloyes matched sprockets and double roller chain for all-out race applications. Has three matched keyways to adjust cam timing. Kit includes Magna-fluxed sprockets and roller timing chain. For 2.5L and 4.0L engines only.

P5249519 All-out race chain and sprockets.

Installation Tips

1. Be extremely careful to apply full torque to the camshaft sprocket attaching bolts. It is also advisable to apply Loctite. If these precautions aren't taken, engine torsional vibration may cause the camshaft bolts to loosen and the camshaft will turn. If the bolts loosen, the locating dowel will shear off because it is not intended as a load carrying member. As an extra added measure, use at least Grade 8 bolts.
2. The bushings in the timing chain rollers will deteriorate with hard usage. Change the timing chain when it becomes stiff and the links DO NOT move freely, as this indicates bushing breakage.

Also, replace camshaft and/or crankshaft sprockets if there is any evidence of teeth being bent through dropping or other mishandling. Bent teeth may break off causing the chain to break.

Note: When installing a new camshaft or reassembling the engine after an overhaul, coat the camshaft lobes and tappets liberally with Mopar Engine Oil Supplement (or equivalent). This aids camshaft and tappet break-in and helps prevent scuffing.

Connecting Rods

INTRODUCTION

The 4.0L engine's connecting rods are made of cast malleable iron with a total weight (less bearings) of 657-665 grams (23.2-23.5 oz.), and a total length (center-to-center) of 155.52-155.62 mm (6.123-6.127").

Connecting rod bore diameter (less bearings) is 56.09-56.08 mm (2.2085-2.2080").

For more connecting rod specifications, refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.

Connecting Rod

These heavy duty forgings are shot-peened and Magna-fluxed. Includes high strength bolts. Can be used as heavy duty stock replacement. For 2.5L and 4.0L engines only. (Sold individually.)

P4529209 Connecting rod.

Connecting Rod Bearings

These connecting rod bearings are made of production-style material. Available in standard and two undersizes. For Jeep 2.5L and 4.0L engines only. (Sold individually.)

P4529208 Connecting rod bearings, standard size.

P4529236 Connecting rod bearings, .001" undersize.

P4529238 Connecting rod bearings, .010" undersize.

BASIC CONNECTING ROD PREPARATION AND INSTALLATION TIPS

Note: The following information is for the preparation of steel connecting rods only.

1. Connecting rods should be checked for alignment; bores should be parallel. Check big and small ends for size.
2. Using a small file, deburr the connecting rods, paying particular attention to the mating surfaces and tab groove. You need the clamping effect of a 60 micro bore. The sides should be polished by hand on a flat plate using #600 paper. Proper side clearance should be 0.25-0.48 mm (0.010-0.019"). DO NOT increase side clearance past .019" as this increases the oil demand of the engine. It will also allow too much oil on the cylinder walls which will overload the rings and allow excess oil in the combustion chambers.
3. In an engine that is to be used in a high rpm situation, the connecting rods and connecting rod bolts should be Magna-Glo checked for cracks or forging flaws.
4. A race engine should always use heavy duty connecting rod bolts and nuts.

5. The connecting rod bearing clearance is 0.25-0.76 mm (0.001-0.003"). Preferred bearing clearance is 0.044-0.050 mm (0.0015-0.0020").
6. The connecting rod bolt head should be seated against the flat, machined surface in the connecting rod.
7. For a race engine, the big end of the connecting rod should be sized to the minimum diameter to get the maximum crush from the bearing.
8. Shot-peening the rods is recommended if they haven't been already.
9. Some race engines use floating piston pins. On these engines, the pin-to-connecting rod clearance should be checked. On standard production engines that use a pressed pin, the amount of interference should be checked. (Refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.)
10. Connecting rods with full floating pins to be used in racing applications should have the small end of the connecting rod drilled with a small hole (approximately 3/32") for increased piston pin oiling. The best location for this oiling hole is the top of the connecting rod above the pin (Figure 4-11). Pin oiling holes in the sides (5 o'clock or 7 o'clock, for example) weaken the connecting rod itself and therefore are NOT recommended. One hole in the top does the best job of oiling the pin and maintaining the connecting rod's strength.

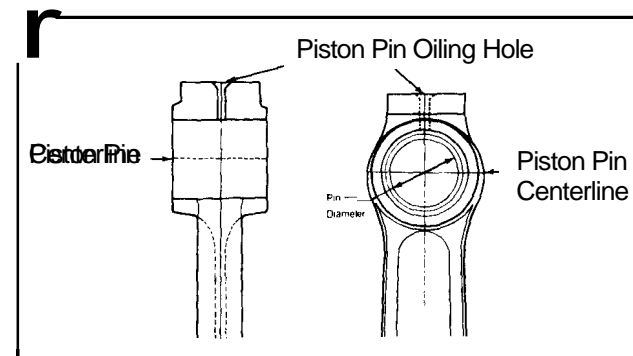


Figure 4 - 11

SPECIAL CONNECTING ROD INSTALLATION PROCEDURES

Rod Ratio

For all-out modified race engines, it is recommended that a rod ratio (length of the rod divided by the stroke) of 1.75 to 1.85 be maintained if possible for best performance. (The stock 4.0L engine has a rod ratio of 1.78—this is considered the best overall choice.) Side clearance should be 0.25-0.48 mm (0.010-0.019”).

Measuring Side Clearance

Slide snug-fitting feeler gauge between the connecting rod and crankshaft journal flange. The correct clearance is 0.25-0.48 mm (0.010-0.019”). DO NOT increase connecting rod side clearance (two rods) beyond specifications. Replace the connecting rod if the side clearance is not within specification.

Note: Excessive side clearance increases the oil demand of the engine as a result of excessive oil leakage past the connecting rods. Increasing oil demand reduces the oil available for lubrication and cooling at high engine speeds.

Excessive side clearance also increases the amount of oil sprayed on the cylinder walls overloading the oil rings. The excessive oil then ends up in the combustion chamber and can cause pre-ignition. (By definition, oil is a very low octane fuel!)

Cap Alignment

Sometimes the simplest questions can be the hardest to answer. In some cases you assume that everyone knows the answer already. For example, someone asks the question, “Can you reverse the cap on a connecting rod?” The answer is, “No!” Although this is correct, the follow-up question (“why?”) is not so easy to answer. During engine assembly we line up the numbers on the sides of the connecting rods. Therefore, if we reversed the caps, the numbers would not line up. Sounds good, but is it the complete answer?



Since we (Mopar Performance Parts) are in the parts business, we should have an answer to this question. After all, there are no numbers stamped on the side of service connecting rods or Mopar Performance Parts connecting rods (or any aftermarket connecting rod for that matter). Therefore, the numbers can't be used to tell us why. Does this mean that the caps can be reversed? How about on a service connecting rod? The answer is still “No!” We'll have to look deeper to find out why.

Connecting rod cap tab slots are a feature that you may think will lead to the “why?” answer. There is a slot in the cap and one in the connecting rod that align the bearing shells. These two tabs (or slots) have to be together. This would mean that the two slots would be next to the same bolt. Although this is true, it is NOT the complete answer. (It is only coincidence!)

If you take the cap off the connecting rod assembly, you will notice that there is a V-groove across the parting face of the cap. You will note that the V-groove is on the opposite side from the bearing tab slot. There is also a small V-notch in the bearing shell which should be installed to line up with the V-groove in the cap. This groove provides lubrication of the cylinder wall on the opposite bank. We're getting warmer!

In racing and other very high performance engines, the connecting rod caps may not have a V-groove. Extremely high rpm applications don't need any more oil on the cylinder walls, so the V-groove may be omitted. Even though the V-groove isn't always there, the fact that it is designed to oil the opposite wall leads us to the correct answer. The groove-to-wall relationship means that how the connecting rod fits into the crankcase is important.

The key to all of this is to notice that the chamfer on the big end of the connecting rod is not the same on both sides. There is a big chamfer on one side and a small chamfer on the other. The big chamfer goes toward the crankshaft while the small chamfer goes toward the other connecting rod. If the cap gets reversed, then there would be a small chamfer on the connecting rod and a large chamfer on the cap. This is how you can tell that a cap had been reversed. DO NOT assume that a used engine did not have some of its caps reversed. The proper way to install the connecting rod into the engine is that the right cylinder bank (#2, 4, 6) should have the large chamfer toward the rear of the engine. The connecting rods on the left bank (#1, 3, 5) should have the large chamfer toward the front of the engine. The service manual ties the direction of the chamfer to the “notch” in the top of the piston. In racing we may reverse the pistons or have no offset and therefore no notch or arrow. Therefore it is best to install connecting rods by chamfer and cylinder location. The service manual also says that you should fit all connecting rod and piston assemblies on one bank until complete. This is important. DO NOT alternate from one bank to another.

We began this discussion trying to find out how to tell if a cap had been reversed. We now know how to locate the cap and how to install the connecting rod assembly in the engine. These two items are closely related because the method of determining main cap orientation and the key to installing connecting rods are the same. It is important to know both because once the connecting rod and piston are assembled, the cap still has to be removed one more time to get the connecting rod on to the crankshaft. One more chance to reverse the cap or the connecting rod. Our main check on the assembly at this point is usually the valve notch on the top of the piston. However, it is also a good idea to double check the chamfer-crankshaft relationship after the connecting rod/piston installation to verify that a cap didn't get reversed in the last step.

Connecting Rod Bolt Protectors

In every engine assembly or build-up, the piston and connecting rod assembly must be installed into the block and on to the crankshaft. During this phase of engine build-up, the connecting rod bolts have to be protected. This is because when the connecting rod cap is removed to allow for the installation of the connecting rod and piston assembly and the bearing shells, the connecting rod bolts pressed into the connecting rod are left sticking out unprotected. Aluminum connecting rods have the connecting rod bolts threaded into the connecting rod beam and are, therefore, one of the few exceptions to this condition. In any case, the bolts that stick out must be protected during installation.

To protect the bolts, cover the connecting rod bolt threads. There are several choices for protectors. The "Pros" tend to use threaded brass rods. Another option is simply a piece of rubber fuel line. Our favorite is neoprene (clear plastic) line. Lengths are somewhat optional, but should be at least 9" - 12" long for the top bolt. The second piece, for the bottom bolt, could be as short as 3" - 4" long, but 9" - 12" long is recommended,

The main reason the threads need to be covered is to protect the crankshaft journal during piston-connecting rod installation. If you don't use protectors, it's very easy to scratch the connecting rod journal with the end or threads of the connecting rod bolt. Crankshafts are much more expensive to repair or replace than connecting rod bolts.

A secondary function of connecting rod bolt protectors is to guide the connecting rod over the crankshaft journal during installation. This is only true if you use at least one long protector. If you use short ones (or none at all), then the connecting rod can easily end up on the wrong side of the journal, which can result in other damage.

The proper procedure for installing the connecting rod and piston assembly begins with the crankshaft's rod throw at the bottom of its travel, or BDC (Bottom Dead Center). Generally, the cylinder that you are working on should be

tipped on its side. This makes slipping the connecting rod, piston and ring assembly into the block easier. In this configuration, the long protector should go over the top of the connecting rod journal. Before you make an error, remember that the piston **MUST** be installed into the block in its proper orientation for pin offset, valve notches, etc. So the first task is to determine this orientation **BEFORE** you install the connecting rod bolt protectors. Now put the long protector on the top bolt as installed. Somewhat confused? Now you can see why using two long protectors might be easier to work with and is the recommended choice.

As soon as the piston and connecting rod assembly is seated against the crankshaft journal, the connecting rod bolt protectors are removed.

ALUMINUM CONNECTING RODS

Note: Aluminum connecting rods should be used **ONLY** in conjunction with lightweight pistons.

Aluminum connecting rods are a race-only piece. Although most standard production connecting rods are designed for pressed-pins, most race pistons are designed for full floating pins. When building a race engine, the pistons would generally be replaced before the connecting rods. For an all-out race engine there are advantages to the full floating pin. (Be sure to check pin clearance in the connecting rod upon assembly.)

If you broke a steel connecting rod, you'd probably buy a new one, rebuild it and put everything back together. Aluminum connecting rods aren't quite that easy. (By "breaking" we mean a partial failure like a scuffed big end, overheated, bent or nicked from handling. If the connecting rod breaks in two, there won't be much left to "put back together.") With aluminum connecting rods, if you drop one and nick it, you can replace it with a new one. However, if after several runs you scuff it, overheat it, bend it, etc., you don't want to just replace it. Your best bet is either to replace all six connecting rods or to send the five good pieces back to the manufacturer and have them "rebuilt" and matched to the sixth. We strongly recommend keeping any instruction sheet or other manufacturer information that might come with your specific set of connecting rods to help you contact the manufacturer at a future date.

The main advantage of aluminum connecting rods is their lighter weight. However, they do require some special considerations. These special considerations are primarily clearances, which may be slightly different from steel connecting rod numbers. These differences can be important. Be sure to check with the manufacturer for correct specifications.

CONNECTING ROD BEARINGS

For racing purposes there are two special connecting rod bearings materials used: Babbit and Tri-Metal. In general, Tri-Metal is preferred for oval track racing, Babbit for drag racing.

Installation

Fit all connecting rods on one cylinder bank until completed. DO NOT alternate from one bank to another, because when the rods are assembled to the pistons correctly, they are not interchangeable from one bank to another.

The bearing caps are not interchangeable and should be marked at removal to ensure correct assembly.

Each bearing cap has a small V-groove across the parting face. When installing the lower bearing shell, make certain that the V-groove in the shell is in line with the V-groove in the cap. This provides lubrication of the cylinder wall in the opposite bank.

The bearing shells must be installed so that the tangs are in the machined grooves in the rods and caps.

Limits of taper or out-of-round on any crankshaft journals should be held to 0.0254 mm (0.001"). Bearings are available in 0.025 mm (0.001"), 0.051 mm (0.002"), 0.076 mm (0.003"), 0.254 mm (0.010") and 0.305 mm (0.012") undersize. (Contact your local Chrysler-Plymouth-Dodge-Jeep dealer for ordering information.)

Note: Install connecting rod bearings in matched pairs. DO NOT use a new bearing half with an old bearing half. DO NOT file the rods or bearing caps.

Measuring Connecting Rod Bearing Clearance

1. Wipe the journal clean of oil.
2. Use short rubber hose sections over rod bolts during installation.
3. Lubricate the upper bearing insert and install in connecting rod.
4. Use a piston ring compressor to install the rod and piston assemblies with the oil squirt holes in the rods facing the camshaft and the arrow on the piston crown pointing to the front of the engine (Figure 2-37). Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons face the front of the engine.
5. Install the lower bearing insert in the bearing cap. The lower insert must be dry. Place a strip of Plastigauge across the full width of the lower insert at the center of bearing cap. Plastigauge must not crumble in use. If brittle, obtain fresh stock.

6. Install bearing cap and connecting rod on the journal and tighten nuts to 45 N•m (33 ft-lbs) torque. DO NOT rotate crankshaft. Plastigauge will smear, resulting in inaccurate indication.
7. Remove the bearing cap and determine the amount of bearing-to-journal clearance by measuring the width of compressed Plastigauge by using the scale on the Plastigauge envelope (Figure 2-16). The correct clearance is 0.025 to 0.076 mm (0.001 to 0.003"). Plastigauge should indicate the same clearance across the entire width of the insert. If the clearance varies, it may be caused by either a tapered journal, bent connecting rod, or foreign material trapped between the insert and cap or rod.
8. If the correct clearance is indicated, replacement of the bearing inserts is not necessary. Remove the Plastigauge from crankshaft journal and bearing insert. Proceed with installation.
9. If bearing-to-journal clearance exceeds the specification, install a pair of 0.0254 mm (0.001") undersize bearing inserts. All the odd size inserts must be on the bottom. Service replacement bearing insert sizes are stamped on the backs of the inserts. Measure the clearance as described in the previous steps.
10. The clearance measured with a pair of 0.0254 mm (0.001") undersize bearing inserts installed will determine if two 0.0254 mm (0.001") undersize inserts or another combination is needed to provide the correct clearance. (Refer to *Connecting Rod Bearing Fitting Chart* [Figure 4-15].)

Example: If the initial clearance was 0.0762 mm (0.003"), 0.025 mm (0.001") undersize inserts would reduce the clearance by 0.025 mm (0.001"). The clearance would be 0.002" and within specification. A 0.051 mm (0.002") undersize insert would reduce the initial clearance an additional 0.013 mm (0.0005"). The clearance would then be 0.038 mm (0.0015").
11. Repeat the Plastigauge measurement to verify your bearing selection prior to final assembly.
12. Once you have selected the proper insert, install the insert and cap. Tighten the connecting rod bolts to 45 N•m (33 ft-lbs) torque.

Pistons and Rings

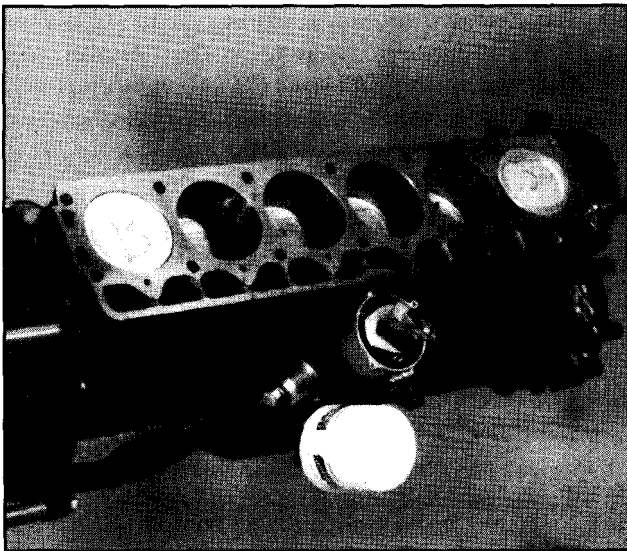
Cast Pistons and Rings for Jeep 4.0L Engines

Part Number	Bore	Stroke	Rod	CR	Dome	Rings
P4876962	3.905"	3.41"	6.125"	9.2:1	Dish	P4876961

PISTONS

The 4.0L engine uses high strength aluminum alloy pistons with an anodized top ring groove and crown. Piston skirts are coated with a solid lubricant (Molykote) to reduce friction and provide scuff resistance. A pressed fit piston pin is used to attach the piston and connecting rod. The piston combustion cavity is a single quench design. For more piston (and piston ring) specifications, refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.

In summary, the secret with pistons is that they be lightweight and have smooth, round tops if they are domed. The secret with piston rings is to get them to seal to the piston and the bore at W.O.T. (wide open throttle).



Piston Compression Ratio Ratings

Pistons are usually described by their bore or overbore size and their rated compression ratio. This compression ratio rating seems to get people confused. Generally there are 8.0:1, 9.0:1, 10.5:1, 11.5:1, and even 12.5:1 pistons. There are dished and domed pistons. Generally domed pistons have a high compression ratio rating and dished pistons have a low compression ratio rating. However, the piston doesn't have a compression ratio by itself. It has to be installed into an engine.

In an effort to help clarify this situation and help racers know what they are basically getting, most piston manufacturers rate their pistons by compression ratio. To do this, they assume that the engine is at blueprint or *nominal* specifications. For example, Mopar Performance Parts has a line of 9.2:1 pistons. If your engine had a nominal compression ratio of 8.2:1 from the factory and you installed these pistons, then you would have a 9.2:1 compression ratio.

The confusion comes in because most engines don't have the actual nominal compression ratio. It might be 8.2:1. It might be 8.0:1, or possibly 7.8:1. If your engine really has a 7.8:1 compression ratio and you install 9.2:1 pistons, you'll actually have an 8.8:1 compression ratio. The piston is only one of many factors that contribute to the exact compression ratio. There is cylinder head volume (cc) and gasket thickness. There is also the deck height which takes into account connecting rod length changes, stroke variations, and block height machining tolerances. (Valve notches, chamfers, dish/dome volumes, and pin height are assumed to be part of the piston.)

So when you change the piston design and move the pin down to increase the compression ratio (or add a dome), you are only changing the piston. Let's assume that the deck tolerances are .020" to .030" below the cylinder head, and the cc range is from 68 to 72. The piston itself can't change variations in these other parts. On any given engine, the difference is between the rated compression ratio for the pistons and the engine's actual nominal compression ratio.

For example, if the engine's actual nominal compression ratio is 8.2:1, then 9.2:1 pistons increase the compression ratio one point ($9.2 - 8.2 = 1$). Therefore, if the engine's actual nominal compression ratio is 7.8:1, then the resulting compression ratio after installing 9.2:1 pistons is 8.8:1. The only way to determine if your engine has an 8.2:1 or **7.8:1** compression ratio is to measure it. This requires you to cc the heads, measure the deck heights with a micrometer or similar device, and check the compressed thickness of the gaskets.

All pistons share this problem. If you don't make the required measurements, you won't ever know you're exact compression ratio. And there are still other variations. The only way to remove all these variations is to blueprint the engine.

Piston Shape

Not all pistons are the same “shape.” Each engine has a piston shape and resulting combustion chamber shape that will provide the best engine output at a given compression ratio. The simplest way to solve this problem in wedge engines is to use a flat piston. Typically, an engine with 11.0:1 compression ratio will make more power with a flat piston than it will with a domed piston.

For higher compression ratios, a domed piston must be used and, therefore, the shape becomes important. The spark plug relief needs to be enlarged, the top of the dome should be “radiused” with as large a radius as possible, and all sharp edges usually located around the valve notches should be removed and smoothed as much as possible, especially in the piston notch and spark plug relief areas. **Also**, don’t use any more dome height than is required. Stated another way—keep the dome as low as possible. In summary, a low, round and smooth shape is best for maximum power.

The vast majority of production engines use flat pistons. Many high performance racing engines use a domed piston. The problem is that the domed piston isn’t always best for performance. The flat piston engine typically makes as much power as the domed piston engine, if not more. Why?

First, a typical domed piston is heavier than a typical flat piston. The higher compression ratio of the domed piston engine means that you have to use racing gasoline rather than “pump” gas or “blends.” Without racing gas, the higher compression ratio is wasted and actually results in lower output. Domed pistons can be made to work, but the actual shape of the dome is very important. Each engine family uses a different shape. If reshaping is not done, then the flat piston will provide more power.

In summary, for most racers and most racing engines, flat pistons are the best performance choice. However, if good racing gas is used and the dome is properly shaped, then domed pistons can be beneficial.

Piston-to-Head Clearance

When putting an engine back together, the most often overlooked clearance is the distance between the piston and the cylinder head at top dead center. The minimum piston-to-head clearance should be .040" (low) and .060" (high). Piston-to-head clearance becomes very important in high compression ratio engines, especially with domed pistons.

This isn’t a good place to gamble. If the piston hits the cylinder head, it can cause the piston skirts to fail and the pin locks to beat-out or fail. In some cases, it can cause the head gasket to blow. Blowing the head gasket or failing a pin lock isn’t a big failure by itself, but what happens next can be!

The easiest and most reliable way to check piston-to-head clearance is to put the piston at TDC with the head installed and then remove or loosen the connecting rod cap. With a dial indicator installed parallel to the connecting rod centerline, the connecting rod and piston assembly can now be pushed up until the piston touches the cylinder head. The indicator will read precisely the amount of clearance. If the clearance is measured without a head gasket, then add in the gasket thickness for the total installed clearance. Flat pistons are easier to measure than domed pistons. Modeling clay can also be used to measure the clearance, but you should leave an extra .025" clearance (i.e., .080" total) just to be safe, especially if you like to cut it close.

Valve-to-Piston Clearance

Valve-to-piston clearance is equally important. Engines that must race in conjunction with 4 or 5-speed manual transmissions should have the following valve-to-piston clearances: Intake 0.100" minimum; Exhaust 0.100" minimum. The valve-to-piston clearance is usually measured by placing modeling clay on the piston, manually turning the engine over with the head bolted on, the cam, lifters, pushrods, etc., adjusted to zero lash, and the cam properly centerlined. The thickness of the clay left on the piston is then measured by sticking a steel scale in at the thin spots. A dial indicator can also be used by using a light, ‘checking’ spring and measuring the actual clearance at each point in one degree increments from 10 degrees before TDC to 10 degrees after. This second method is more accurate but takes a little longer. Also keep in mind that if you change the camshaft centerline, you’ll change valve-to-piston clearance. Generally, if the centerline is advanced toward TDC (actual centerline moved from 110° to 106°, for example), you’ll end up with less clearance. This clearance should always be measured with a new camshaft at the proper centerline.

Piston Race Preparation

The performance secrets for pistons are that they be light in weight and also have a smooth, round top (if it’s a domed piston). The secret to performance in rings is to get them to seal to the piston and to the cylinder bore at W.O.T. (Wide Open Throttle).

For obvious reasons, pistons are not interchangeable between various engines. Factory pistons have the pin offset to reduce piston slap. By reversing the offset (reversing the piston), you can reduce engine friction.

High compression pistons have a large dome that sticks into the combustion chamber. In some cases this dome will strike the spark plug and close it up. Therefore, the end of the plug should be given 1/4" clearance in the shape of a spherical cup. This will also aid in flame propagation because the plug will be less shrouded.

Because of gasoline limitations, compression ratios should not exceed 12.5:1 for competition; 10.5-11.0:1 for general off-road use, unless you have access to high quality premium fuel (103 octane).

The most important consideration about pistons is weight. Forged pistons are stronger than stock cast pistons and tend to be equal to or heavier than stock pistons. For racing purposes, lighter weight is where the performance is. Forged racing pistons at less than 500 grams can be obtained. However, they have to be custom made and are more expensive. Once the piston is lighter, the pin can be lighter, the rod lighter and the balanced crankshaft lighter. A word of caution, however! You can go too far and weaken the piston in a vital area, causing it to fail. This type of failure tends to make an expensive mess.

There are many clearances related to a racing piston. We have outlined most of these clearances, such as piston-to-wall, valve-to-piston, etc. However, many engine builders forget about the piston-to-head clearance. We suggest .040" (low minimum) and .060" (high minimum). The problem is that if the engine builder cuts it too close, say .030", the piston will hit the cylinder head. This can result in a blown head gasket, broken pistons, broken pins or pin locks. The clearance becomes very important in high compression ratio engines, especially with domed pistons.

Reversing Pistons With Offset Pins

(Refer to *Offset Pins* later in this section.)

CC'ing the Block

With an ordinary flat-top piston, the block is not cc'd. The need for cc'ing the block arises only if the piston is domed or if the valve clearance notches or reliefs are quite large.

COMPRESSION RATIO

Almost everyone talks about compression ratio, but very few non-professionals really know what it is. The following procedures show you how to make compression ratio measurements, plus how to calculate your actual compression ratio.

The formula for determining compression ratio is as follows:

$$\text{Compression Ratio} = \frac{\text{VBDC}}{\text{VTDC}}$$

The first step is to look at the cylinder volumes. (See Chart 1.) This is the volume of one cylinder in cc's.

En	Bore x Stroke	Cyl. Head Vol. (cc)
2.5L 4 cyl.	3.876 x 3.188	616.45
4.0L 6 cyl.	3.88 x 3.44	666.52
4.2L 6 cyl.	3.75 x 3.895	704.95
5.9L, (360 CID) V-8	4.08 x 3.44	737.00

The volume above the piston at BDC (Bottom Dead Center) is equal to the piston displacement plus the chamber volume. (Chamber volume is the volume above the piston at TDC [Top Dead Center].)

Next, break down the volume above the piston at TDC into its separate parts. This volume is the total combustion chamber volume. It consists of four basic parts: cylinder head volume, gasket volume, piston deck clearance and piston dish or dome. The head volume is typically measured separately with the head off the engine. The gasket volume is a function of its thickness, and that is measured using a micrometer. Head gasket volumes run in the 10-15 cc range. (We'll discuss that in more detail shortly.) The deck clearance and dish or dome measurements are best lumped together and measured under the 1/2" down fill volume. In short.,as long as you have a *completely flat piston* (no dish, dome or notches), you can measure deck clearance with a dial indicator and treat it as another (or thicker) gasket. It's a quick and easy method, *but it only works with a flat piston.*

The 1/2" down fill volume method for measuring the piston dish or dome is based on a calculated volume. Refer to Chart 2.

Enaine	1/2" Fill Down Volume	Typical Head cc's
2.5L	96.68	49.9
4.0L	98.85	64.5
4.2L	90.50	64.5
5.9L (360 CID)	107.12	58.6

With the 1/2" down fill volume method, the piston is brought to TDC using a dial indicator placed in the middle (flat spot) of the piston. The piston is then lowered in the cylinder bore .500" (1/2").

Example: If the original deck clearance was .022" at TDC, then the piston is lowered to .522" below the deck surface.

Now the piston is sealed and the cc's are measured similar to the cylinder head. Once you have the actual, measured 1/2"down fill volume, you can compare it to the one listed in Chart 2.

The best way to show the aspects of this number is by example. Let's assume that you have a 4.0L In-Line 6 cylinder engine which shows a 98.85 cc volume for its 1/2" down number. If you have a flat piston at zero deck, you would measure 98.85 cc for your 1/2" down fill volume. If you have a 15 cc dish in the piston, you would measure 113.85 cc. On the 4.0L, the typical (stock) deck clearance is .022" below, which calculates to 4.35 cc. Therefore, if your dished piston was actually .022" down, then the measured volume would be 118.2 cc.

If you have valve notches in addition to these other features that are large enough to hold 3 cc for the intake and 2 cc for the exhaust, then the total volume would be 123.2 cc. If you switch pistons to a 10 cc dome design and keep your 3 and 2 cc valve notches and the .022" below deck (deck clearance is measured to the flat of the piston, not the top of the dome), what is your resulting volume? First, the 98.85 stays the same. The 15 cc dish disappears and is replaced by a negative 10 cc (-10) resulting in 88.85. The deck is the same so that adds 4.35, and the notches are the same at 5 cc total. Therefore, the end result would be 98.2 cc.

Now run through a compression ratio calculation. (Use the 4.0L engine and the 15 cc dished piston example just discussed.) You measured 123.2 cc for your 1/2" down fill volume (ordinarily you don't know how big the dish is or how large the notches are, so the total volume is all you know). List your measurements (known data): Head - 64.5 cc, Cylinder volume - 666.52 cc, Gasket thickness -.065", 1/2" down fill volume - 123.2 cc.

First you need to convert the gasket thickness into a cc volume. This is easily done by multiplying the gasket thickness by the 1/2" down fill volume, and then multiply that answer by 2. (In this example, $.065 \times 98.85 \times 2 = 4.35$ cc.) The piston volume is found by subtracting the two 1/2" down fill volumes ($123.2 - 98.85 = 24.35$). This is a 'positive' volume since it is larger than the calculated volume from Chart 2. The total combustion chamber volume is $64.5 + 4.35 + 24.35 = 93.20$ cc. This is the volume above the piston at TDC. The volume above the piston at BDC is equal to $666.52 + 93.20 = 759.72$ cc. Therefore, the actual compression ratio for this example is $759.72 \div 93.20 = 8.15$.

Measuring 1/2" Down Fill Volume

With an ordinary flat top piston, the block is not cc'd. The need for cc'ing arises only if the piston is domed or if valve clearance notches or reliefs on the piston top are quite large. The same basic technique is followed in either case. Assuming that part of the piston protrudes above the block, choose some common measurement, say 1/2" (.500"), and rotate the crankshaft until the piston (with piston rings installed) has lowered itself from top dead center (TDC) by this amount. (If not 1/2", a measurement must be chosen that will ensure that the entire piston is below the block's deck.) This amount should be measured very accurately by

a dial indicator. The piston should now be sealed to the cylinder wall with a thin film of light grease, being careful not to have any grease extend past the top of the piston. A flat piece of Plexiglas with a hole drilled through it should now be placed over the cylinder bore and also sealed with a thin film of light grease. With a burette (graduated in cc's) containing colored fluid, fill the cylinder. By knowing the cc's that were added to the cylinder, and by knowing the amount that the piston was lowered from TDC, the volume of piston's dome (or "dish") can be calculated.

PISTON RINGS

Note: For piston ring availability and recommended usage, refer to the *Cast Pistons and Rings* chart earlier in this section.

The subject of piston rings seems to come and go as a hot spot for performance activity. Piston rings obviously have to do their job if the engine is going to do its job—make power. By the same token, piston rings cause very few problems by themselves. If there's a problem with a ring, it's usually caused by something else such as the engine builder. We've all broken rings trying to get them on to the piston or when putting the whole assembly into the engine. We'll be more careful next time, but we still broke the ring. This isn't the ring's fault. With the ring causing so few problems once installed, why try to fix it? New inventions burst upon the scene and everyone tries them. They then fall back into their position and everything quiets down again. Rings today are in this position.

Basically there are three styles of "trick" race rings: Dykes, Headland and gas ports. A Dykes ring is an L-shaped ring that we've used in Hemi engines since the 1960s. The Headland is a bigger section Dykes that's located right at the top of the piston. They're usually used with flat-top pistons. Both require custom cut ring grooves, so they typically require special pistons. Gas ports are typically used with very thin rings—0.043" or .031". Gas ports do work, but they load the cylinder walls very heavily and tend to wear out quickly. The Headland ring works best at lower speeds. The Dykes ring works best at high speeds. The moly-coating works best on any of the rings, but you cannot butt the ring ends under load or the ring seal will be gone. You can't take chances with too tight a ring gap with a moly-coated ring. In spite of this, moly-coated rings are still preferred.

The main action today in piston rings by volume is in the 5/64" and 1/16" designs. They are NOT interchangeable. The 5/64" is the production ring and fits on the production piston. The 1/16" ring is a race/performance ring and only fits on aftermarket race/performance pistons that are cut for that style ring. Typically, all domed pistons use this ring style.

One of the characteristics of the ring that is often overlooked is the clearance of the ring in the piston's ring groove. It is important to keep this to a minimum. Also, check the side view of the groove to be sure that it hasn't been worn into a V-shape where the clearance is at a minimum.

In summary, the secret with piston rings is to get them to seal to the piston and the bore at W.O.T. (wide open throttle).



Basic Piston Ring Preparation

The basic preparation of the piston rings should consist of the following steps.

1. Check ring grooves for burrs, then for proper side clearance. Side clearance of the ring in the piston groove is very important and can be checked with a feeler gauge. Be sure that a used piston's groove isn't worn in the shape of a wedge. It doesn't do any good to seal the ring to the cylinder wall if it isn't sealed to the piston groove.
2. Check ring end gap against specification. DO NOT in any case exceed specifications as this will allow too much blow-by, causing power loss and/or allowing too much oil to reach the combustion chamber which can cause detonation. The ring gap ends must be square and parallel.
3. Use a fine stone to deburr rings and to just barely break edges on end gaps. Break the edges using #600 paper, but DO NOT chamfer.
4. DO NOT install rings that were made for a larger bore. A special .005" oversize ring is best for lowering the ring end gap. In stock-type rings, low tension is important to lowering engine friction and increasing the engine's output. When you are gapping the rings in the bore, light-check them for being oval. Oval rings in a round bore will only seal in a couple of places, and therefore the engine won't make any power. Oval rings are the result of installing rings that are .020" (or more) larger than the bore.
5. Clean all parts before proceeding.

PISTON PIN

The piston pin rotates in the piston only, and is retained by the press interference fit of the piston pin in the connecting rod.

Removal

Piston pins are press fit into the connecting rods and require no locking device.

1. Position the piston and connecting rod assembly on an arbor press.
2. Apply force to a piloted driver and press the pin completely out of the connecting rod and piston assembly (Figure 2-49). Note position of the pin through the gauge window of removal support tool.

Inspection

1. Inspect the piston pin and pin bore in the connecting rod for nicks and burrs. Remove as necessary. Never reuse a piston pin after it has been installed in and then removed from a connecting rod.
2. With the pin removed from the piston and connecting rod, clean and dry the piston pin bore and the replacement piston pin.
3. Position the piston so that the pin bore is in a vertical position. Insert the pin in the bore. At room temperature, the replacement pin should slide completely through the pin bore in the piston by force of gravity.
4. Replace piston if pin jams in the pin bore.

Installation

1. Insert the piston pin pilot through the piston and connecting rod pin bores. Ensure that the arrow on the piston crown is pointing up (Figure 2-50).
2. Position the pin pilot, piston and connecting rod on a support with the squirt hole of the connecting rod to the left-hand side (Figure 2-50).
3. Insert the piston pin through the upper piston pin bore and into the connecting rod pin bore (Figure 2-49).
4. Position the piloted driver inside the piston pin (Figure 2-49).
5. Using an arbor press, press the piston pin through the connecting rod and piston bores until pin pilot indexes with the mark on the support. The piston pin requires an 8900 N (2,000 pounds) press-fit. If little effort is required to install the piston pin in the connecting rod, or if the rod moves laterally on the pin, the connecting rod must be replaced.
6. Remove the piston and connecting rod assembly from the press. The pin should be centered in the connecting rod (± 0.792 mm or ± 0.0312 ").

Offset Pins

It's commonly known that you can turn pistons around. The piston, when originally made, had an offset pin. This offset pin makes the engine run quieter. By reversing the piston (the arrow on the top of the piston now points *to* the rear of the engine instead of the front [stock] installation position), you reverse the centerline placement of the pin. This makes the engine noisier, but it will also produce a little more torque.

This is a gray area for most types of racing because the rules usually state only that stock pistons must be used, not whether or not their installed positions can be changed. Being a political situation, it's **up** to the racer to decide if he wants to chance it.

Pin Coatings

Special coatings on engine parts are becoming more and more popular. On low stressed or non-moving parts these coatings don't seem to cause any problems. However, their actual value can be debated.

The top of the piston has been a popular area to apply coatings to, as have headers. For the most part, these two don't cause problems. Problems seem to come in relative to highly stressed, moving parts such as piston pins and connecting rods. There are some areas such as valve tips, rocker arms, and rocker shafts that could benefit from coatings, but we know of no specific one for the job that's proven successful at this time. There are so many, it's hard to evaluate them all.

One problem area, however, can be the piston pin. Most people wouldn't coat their connecting rods with anything other than engine oil and would be wary of any connecting rod that they found to be coated if it looked or felt different. This same sharpness and attention doesn't seem to apply to the pin. The pin may not move as much as the connecting rod, but it sure is highly stressed! We all know what happens if the pin fails. To us this sounds like a bad area to gamble in. In general, piston pin failures are pretty rare, and Mopar Performance Parts has never recommended "coating" the pin. We still don't, but let's analyze what the coatings will do to the pin. We'll keep it general because of the number of possible coatings.

Since the pin is made of steel or tool steel and the piston is aluminum, the ends of the pin that ride in the piston aren't likely to be affected from a lubrication standpoint. A coating could affect the metallurgy of the pin and weaken it, but this is hard to cover in a general discussion. With a floating pin, there's a bushing in the small end of the connecting rod. Given proper clearance with the connecting rod and the characteristics of the bushing material, coatings shouldn't cause any problems with a floating pin.

However, with a pressed pin, an interference fit between the steel connecting rod and the steel pin is what holds the pin in place. Engine coatings are usually designed for friction reduction. Heat barrier coatings are used on pistons, but

shouldn't be considered for piston pins (we hope)! Applying a coating to a pressed pin weakens the interference fit and allows the pin to slide out with the obvious disastrous results. More interference might help, but now the small end of the connecting rod may become overstressed due to the excessive press. You may even break the parts (pin and/or connecting rod) on assembly.

Probably the easiest way to visualize this is the old "STP test." Anyone can pick up a blade-type screwdriver between their fingertips. Apply STP and it slides out. Apply a coating to the pin and the pin slides out also. Solution—don't apply coatings to piston pins. Engine oil (or STP, etc.) is not a coating. Moral of the story—if you use trick coatings and have an engine failure, don't blame the engine parts!

Pin Oiling

There are many ways to oil a piston pin. There are also two types of piston pins: pressed and full floating. The piston may oil the pin with a vertical hole in the pin tower, a slot in the pin bore, or a hole from behind the O-ring groove, along with several other designs. Each piston manufacturer has its favorite. There is no right or wrong way to do it. But there has to be some pin oiling. If you don't have enough, the pin will scuff. This may mean that the hole isn't big enough, not that the hole or slot is in the wrong place. Over the last 20 years we have rarely seen pin scuffing if good oil is used and the engine is properly maintained. Full floating pins seem to be less likely to scuff in the piston. They will scuff if the pin clearance is too small. They will also scuff if a poor/bad oil is used or run for long periods of time.

The most likely area for problems related to pin oiling is on supercharged engines, turbocharged engines and perhaps engines with big loads of nitrous oxide. Talk to the actual piston manufacturers (TRW, Venolia, Ross, etc.) for more details on why the company chose its particular style.



PISTON AND CONNECTING ROD ASSEMBLY

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter for the procedure.
2. Remove the capscrews, bridge and pivot assemblies and rocker arms. Alternately loosen the capscrews, one turn at a time, to avoid damaging the bridge. Retain them in the same order and position as removed to facilitate installation in their original locations.
3. Remove the pushrods. Retain them in the same order and position as removed to facilitate installation in their original locations.
4. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter for the procedure.
5. Position the pistons one at a time near the bottom of the stroke and use a ridge reamer to remove the ridge from the top end of the cylinder walls. Use a protective cloth to collect the cuttings.
6. Drain the engine oil.
7. Remove the oil pan, gasket and seals. Refer to the proper service manual for the procedure.
8. If equipped, remove the main bearing cap brace (Figure 4-6).
9. Remove the connecting rod bearing caps and inserts. Retain them in the same order as removed to facilitate installation in their original location. The connecting rods and caps are stamped with a corresponding number or letter combination.

Caution: Ensure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose, slipped over the connecting rod bolts, will provide protection during removal.

10. Remove the connecting rod and piston assemblies through the top of the cylinder bores (Figure 4-12).

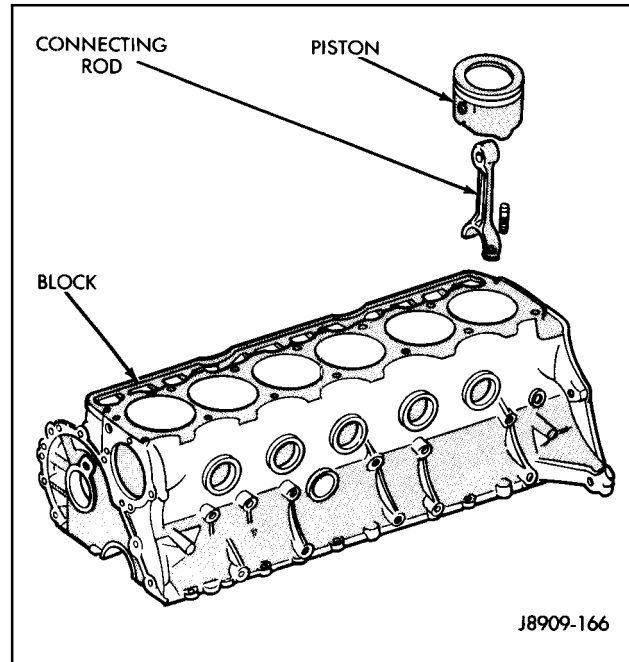
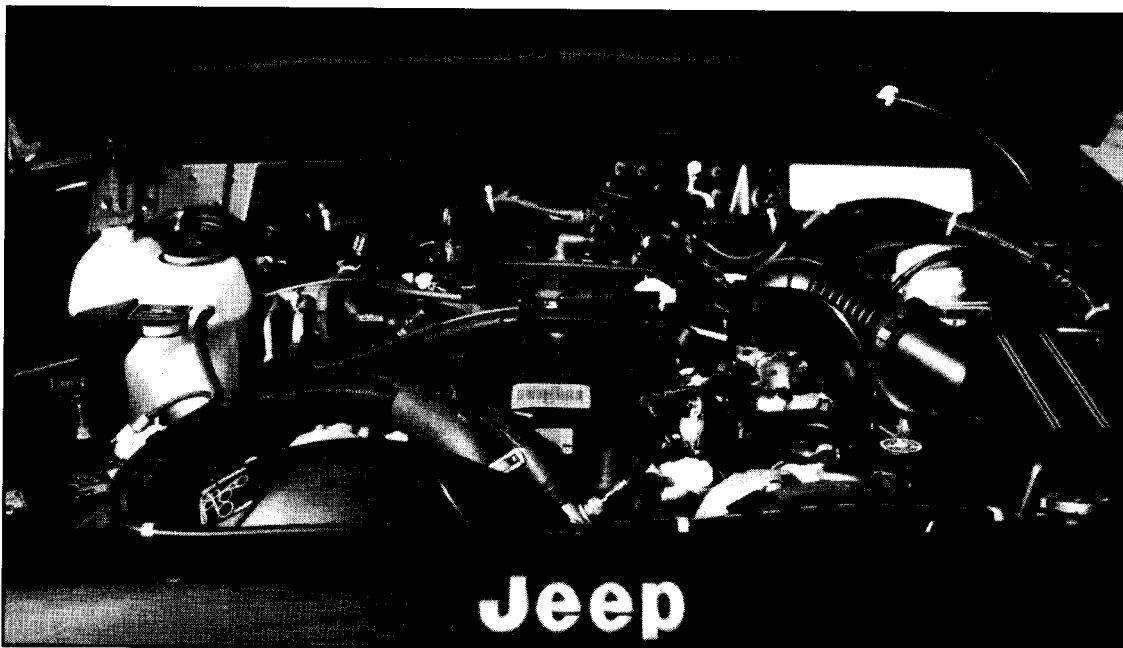


Figure 4 - 12



Inspection

1. *Connecting Rod Bearings*

Inspect the connecting rod bearings for scoring and bent alignment tabs. Check bearings for normal wear patterns, scoring, grooving, fatigue and pitting. Replace any bearing that shows abnormal wear.

Inspect the connecting rod journals for signs of scoring, nicks and burrs.

2. *Connecting Rods*

Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicate the probability of a misaligned connecting rod, inspect it for correct rod alignment.

Replace misaligned, bent or twisted connecting rods.

Cylinder Bore Measurement

Refer to 'Block' section of this chapter for the procedure.

Fitting Pistons—Bore Gauge Method

To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") INCREMENTS is required. If a bore gauge is not available, DO NOT use an inside micrometer.

1. Measure the inside diameter of the cylinder bore at a point 49.5 mm (1-15/16") below top of bore. Start perpendicular (across or at 90 degrees) to the axis of the crankshaft at point A and then take an additional bore reading 90 degrees to that at point B (Figure 2-34).
2. Coated pistons, piston pins and connecting rods are pre-assembled. The coated piston and connecting rod assembly can be used to service previously built engines; however, they MUST be replaced as complete sets. Tin coated pistons should not be used as replacements for coated pistons.
3. The coating material is applied to the piston after the final piston machining process. Measuring the outside diameter of a coated piston will not provide accurate results. Therefore measuring the inside diameter of the cylinder bore with a dial bore gauge is MANDATORY. To correctly select the proper size piston, a cylinder bore gauge capable of reading in 0.003 mm (.0001") increments is required.
4. Piston installation into the cylinder bore requires slightly more pressure than that required for non-coated pistons. The bonded coating on the piston will give the appearance of a line-to-line fit with the cylinder bore.

Piston Size Chart

Cylinder Bore Size	Piston Letter Size
98.438 to 98.448 mm (3.8755 to 3.8759")	A
98.448 to 98.458 mm (3.8759 to 3.8763")	B
98.458 to 98.468 mm (3.8763 to 3.8767")	C
98.468 to 98.478 mm (3.8767 to 3.8771")	D
98.478 to 98.488 mm (3.8771 to 3.8775")	E
98.488 to 98.498 mm (3.8775 to 3.8779")	F

Fitting Rings

1. Carefully clean the carbon from all ring grooves. Oil drain openings in the oil ring grooves and pin boss must be clear. DO NOT remove metal from the grooves or lands. Doing so will change ring-to-groove clearance and will damage the ring-to-land seating.
2. Measure the ring side clearance with a feeler gauge fit snugly between the ring land and ring (Figure 4-13 and Figure 4-14). Rotate the ring in the groove. It must move freely around the circumference of the groove.

Ring Side Clearance Measurement

Top Compression Ring	0.042 to 0.084 mm (0.0017 to 0.0033")
Second Compression Ring	0.042 to 0.084 mm (0.0017 to 0.0033")
Oil Control Ring	0.06 to 0.21 mm 0.0024 to 0.0083")

3. Place ring in the cylinder bore and push down with an inverted piston to position near lower end of the ring travel. Measure ring gap with a feeler gauge fit snugly between ring ends (Figure 2-39).

Ring Gap Measurement

Top Compression Ring	0.229 to 0.610 mm (0.0090 to 0.0240")
Second Compression Ring	0.483 to 0.965 mm (0.0190 to 0.0380")
Oil Control Ring	0.254 to 1.500 mm (0.010 to 0.060")

4. Refer to Figure 2-48 for position of the ring gaps when installing piston rings.
5. The oil control rings are symmetrical, and can be installed with either side up. It is not necessary to use a tool to install the upper and lower rails. Insert oil rail spacer first, then side rails.
6. The two compression rings are different and cannot be interchanged. The top compression ring can be identified by the shiny coating on the outer sealing surface and can be installed with either side up. (Figure 2-45).
7. The second compression ring has a slight chamfer on the bottom of the inside edge and a dot on the top for correct installation (Figure 2-46).
8. Using a ring installer, install the second compression ring with the dot facing up (Figure 2-47).
9. Using a ring installer, install the top compression ring (either side up).
10. Position the gaps on the piston as shown in Figure 2-48.

Ring Gap Orientation

- Oil spacer-Gap on centerline of piston skirt.
- Oil rails-gap 180° apart on centerline of piston pin bore.
- No. 2 Compression ring-Gap 180° from top oil rail gap.
- No. 1 Compression ring-Gap 180° from No. 2 compression ring gap.

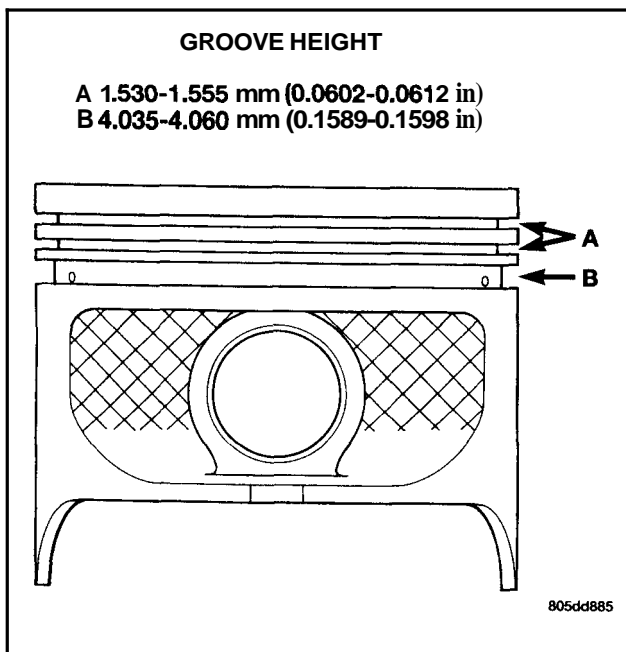


Figure 4 - 13

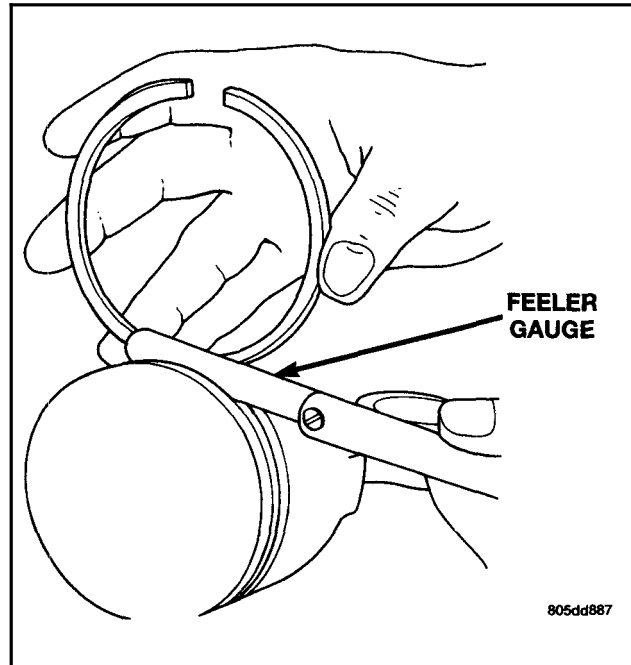


Figure 4 - 14

Installation

Each bearing insert is selectively fitted to its respective journal to obtain the specified operating clearance between the bearing and the journal. In production, the select fit is obtained by using various-sized, color-coded bearing inserts as listed in the *Connecting Rod Bearing Fitting Chart* (Figure 4-15). The color code appears on the edge of the bearing insert. The size is not stamped on inserts used for production of engines.

The rod journal is identified during the engine production by a color-coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. The color codes used to indicate journal sizes are listed in the *Connecting Rod Bearing Fitting Chart* (Figure 4-15).

When required, upper and lower bearing inserts of different sizes may be used as a pair. (Refer to *Connecting Rod Bearing Fitting Chart* [Figure 4-15].) A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce clearance 0.013 mm (0.0005").

Caution: DO NOT intermix bearing caps. Each connecting rod and its bearing cap are stamped with either an associated cylinder number or letter combination on a machined surface adjacent to the oil squirt hole that faces the camshaft side of the cylinder block.

1. Clean the cylinder bores thoroughly. Apply a light film of clean engine oil to the bores with a clean, lint-free cloth.
2. Install the piston rings on the pistons if removed. Refer to *Piston Ring Installation*, in this section for the proper procedure.
3. Lubricate the piston and rings with clean engine oil.
Caution: Ensure that connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.
4. Use a piston ring compressor to install the connecting rod and piston assemblies through the top of the cylinder bores.
5. Ensure the arrow on the piston top points to the front of the engine.

Note: For racing applications, refer to *Reversing Pistons with Offset Pins*, in this section.

6. Raise the vehicle.
7. Install the connecting rod bearing caps and inserts in the same positions as removed.
Caution: Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons face the front of the engine.
8. If equipped, install the main bearing cap brace (Figure 4-6). Torque nuts to 47 N•m (35 ft-lbs).
9. Install the oil pan and gaskets. Refer to the proper service manual for procedure.
10. Lower the vehicle.
11. Install the cylinder head, pushrods, rocker arms, bridges, pivots and cylinder head cover. Refer to 'Cylinder Head' and 'Camshaft and Valve Gear' sections of this chapter for procedures.
12. Fill the crankcase with engine oil.

CONNECTING ROD BEARING FITTING CHART

		CORRESPONDING CONNECTING ROD ARIN INSERT	
Color Code	Diameter	Upper Insert Size	Lower insert Size
Yellow	53.2257-53.2079 mm (2.0955-2.0948 in.)	Yellow - Standard	Yellow - Standard
Orange	53.2079 - 53.1901 mm (2.0948 - 2.0941 in.) 0.0178 mm (0.0014 in.) Undersize	Yellow - Standard	Blue - Undersize 0.025 mm (0.001 in.)
Blue	53.1901 - 53.1724 mm (2.0941 - 2.0934 in.) 0.0356 mm (0.0014 in.) Undersize	Blue - Undersize 0.025 mm (0.001 in.)	Blue - Undersize 0.025 mm (0.001 in.)
Red	52.9717 - 52.9539 mm (2.0855 - 2.0848 in.) 0.254 mm (0.010 in.) Undersize	Red - Undersize 0.254 mm (0.010 in.)	Red - Undersize 0.254 mm (0.010 in.)

Figure 4 - 15

Cylinder Head

INTRODUCTION

One of the most important parts of any engine assembly is the cylinder head. It holds the key to making power. It also offers the opportunity to make more horsepower. Camshafts, headers, and carburetion can only go so far making horsepower without the cylinder head. Cylinder heads can be expensive; however, this may be one place in the engine where spending the extra money is worth it.

The 4.0L engine uses a cast iron cylinder head with a combustion chamber volume of 64.45-67.45 cc. It contains twelve valves made of chrome plated heat resistant steel, valve stem seals, springs, retainers and keepers. The cylinder head, valve seats and guides can be resurfaced for service purposes.

The cylinder head has a quench-type combustion chamber that creates turbulence and faster burning of the air/fuel mixture, resulting in good fuel economy. Valve lengths are (for intake) 122.4-122.8 mm (4.822-4.83"), and (for exhaust) 122.8-123.2 mm (4.837-4.852").

For more cylinder head specifications, refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.

SELECTION

Fifteen years ago, cylinder head selection was very limited, so the picking process was pretty easy. Today, this situation has reversed. Aftermarket suppliers today offer many types of cylinder heads with different materials, different valves, bigger ports, different valve gear, unique combustion chambers, revised valve angles and locations, etc. The good news is the engine builder or racer has more to choose from, but the bad news is he must make a choice!

With so many heads to choose from, we have to find a method of choosing the head that we want. Descriptions such as "Race," "Street," or "Stock" are no longer adequate. There are many comparisons that can get a customer to choose the wrong head, or spend money that he didn't have to. We can't solve all these problems, but we can help clarify the situation.

One of the biggest mistakes that a racer can make is to mix-and-match features. This approach can be very expensive and is best left to the professional engine builder. So for this discussion, we will assume that we can do valve work or even porting, but we don't want to re-machine our cylinder heads.

The key to making any major selection for a race engine (such as a cylinder head) is to list your priorities. To keep it simple, answer the question, "Why do you want new heads and what do you think they are going to do for you?" The answer should be your top priority. The second thing to consider is sequence. If you have five questions or concerns (1 through 5) and you ask them in sequence (1 through 5), you may end up with an answer. However, if you reverse the process and ask the same questions in the reverse order (5 through 1), you may end up with more questions! Mopar Performance Parts wants to help you pick the best head for your application. Other sources/articles want to sell you the head that they happen to have or are discussing. That is the trap that you tend to fall into when you look at the specifics on any given head. But now that there are so many, you need to look at the overall picture.

Regarding cylinder heads, the FIRST decision that you should make is material: cast iron or aluminum? There are so many of both kinds with so many different features that you need to make this choice up-front. Aluminum heads are lighter, more expensive, and offer repairability. Cast iron heads are less expensive, more durable, heavier, and put up with more abuse. In general, aluminum heads take heat out of the combustion chamber, so an engine will act like it has lost 1.5 to 2 points of compression ratio. Therefore, if you had an 8.0:1 compression ratio cast iron head engine, you would have to run an aluminum head at 10.0:1 (estimated).

The second decision is combustion chamber shape. Most cast iron heads have the same chamber shape as production, but there are exceptions. Almost all aluminum heads are different. The trick here is the piston. If the piston has a dome on it or if it sticks above the deck surface, then you MUST have a head that will work with your dome. Most domed pistons are designed for a production cast iron combustion chamber. If you have a flat piston, then you are OK. 'Yes, you can replace the pistons, but this is an added expense and could cost up to \$1,000 or more. If in doubt, go back to your priorities list and write down the cost.

The third decision is valves. There are several aspects of valves, but the most obvious is diameter. Bigger is better, right? Well, almost! Bigger also means bigger valve notches in the piston. This is a machining operation that can be added to the piston, but cost must be considered. Add the cost to your list. Bigger diameters can also hit the bore wall. Bore walls can be notched, but this is not your first choice. You also get more shrouding if you use big valves on small bore sizes. Valve location and valve angle must also be considered. Not only is the dome related to these valve aspects, but also the valve notches. They must be fixed to give the proper clearance. Even a flat piston can be a problem if there is no material under the piston top where you want to put the new notches.

The most popular performance aspect of cylinder heads is air flow or cfm. Although you should consider both intake *and* exhaust flow when evaluating a head, only the intake tends to be considered by most racers. Additionally, mid-lift flow and “area under the curve” numbers are more important than the peak flow number, although peak flow is the “popular” number. (Refer to *Evaluating Cylinder Head Air Flow*, later in this section, for more information.)

Valve gear is a very complicated area. You must have something that works. Since it must work with the head and the block that you are using, you must consider it. Heads can be very expensive. If you are building a new engine, you can get any system you want, it just costs money. But if you have a valve gear system already that you want to use, or you have an existing engine that you want to install the head on to, then you should consider the valve gear. New valve gear could cost as little as a few hundred dollars or as high as \$2,500 (or more). Although the valve gear for cast iron heads tends to be the most readily available and the least expensive, there may be aluminum heads also available that can use all or some of the same hardware.

Intake manifolds can also be very expensive. Big intakes take big intake manifolds. Exhaust port flanges may change. Standard production intake/exhaust gaskets (P4529243) are readily available from Mopar, or easily modified from existing parts. If a special gasket is required and it is only available from one, non-Mopar source, be careful.

Although the valve cover is not changed very often (because of the added expense and complexity), there are cases where the valve cover shape was changed and the old cover will NOT fit on a new head. Be sure to check this out before you buy!

Cylinder head attaching hardware is rarely changed. However, in some cases the head bolts may have been changed. Find out before you buy—this can be a hidden expense.

The cylinder head must get oil under pressure. Some cases require external oiling. Oil returns are never talked about but are necessary. Drag racers don’t usually consider oil returns, but they should.

An aluminum head is about 20 pounds lighter than a typical cast iron head. Most cast iron heads for a given engine weigh the same. A heavier cast iron head would certainly not be desired. Some aluminum heads may only be five to ten pounds lighter than a production cast iron head, but this is usually caused by added “features.”

Finally, we have the camshaft. You might ask what the camshaft has to do with the cylinder head. The camshaft determines how much lift you are going to use. If you use .600” or less, then you don’t want big port windows and extra big valves. If the vehicle is heavy, you also DO NOT want big ports and big valves. If you have large

displacements, then you almost have to have large ports and big valves. There are solutions to some of these problems, but they cost more money.

What does all this mean? If you make the material choice first (aluminum or cast iron) then consider pistons and camshaft lift, the decision is made by adding up the costs. Refer the total cost back to your priorities list and you should have the best answer for you and your race vehicle. There are so many ways to get high flow today that you cannot consider air flow only and expect to choose the right head. As more heads come on to the market and more features are added to each version, this process will become even more important.

CYLINDER HEAD REMOVAL AND INSTALLATION PROCEDURES

Removal

The following procedure can be performed with the engine in or out of the vehicle.

Warning! DO NOT remove the cylinder block drain plugs or loosen the radiator draincock with the system hot and pressurized because serious burns from the coolant can occur.

1. Drain the coolant and disconnect the hoses at the thermostat housing. DO NOT waste reusable coolant. If the solution is clean and is being drained only to service the engine or cooling system, drain the coolant into a clean container for reuse.
2. Remove the air cleaner.
3. Remove the fuel pipe and vacuum advance hose.
4. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, in this section for the procedure.
5. Remove the capscrews, bridge and pivot assemblies and rocker arms. Alternately loosen each capscrew one turn at a time to avoid damaging the bridge.
6. Remove the pushrods. Retain the pushrods, bridges, pivots and rocker arms in the same order as removed to facilitate installation in their original locations.
7. Loosen the alternator drive belt and remove the alternator bracket-to-cylinder head mounting bolt. The serpentine drive belt tension is released by loosening the alternator.
8. Disconnect the power steering pump bracket. Set the pump and bracket aside. DO NOT disconnect the hoses.

9. Remove the intake and exhaust manifolds from the cylinder head. Refer to the service manual for the proper procedures.
10. If equipped with air conditioning, perform the following:
 - a. Remove the air conditioner compressor bracket bolts from the cylinder head.
 - b. Remove the bolts from the A/C compressor mounting bracket and set the compressor aside.
 - c. Loosen the through bolt at the bottom of the bracket.
11. Disconnect the ignition wires and remove the spark plugs.
12. Disconnect the temperature sending unit wire connector and battery negative cable.
13. Remove the ignition coil and bracket assembly.
14. Remove the cylinder head bolts. Bolt No. 14 cannot be removed until the head is moved forward (Figure 4-16). Pull bolt No. 14 out as far as it will go; then suspend the bolt in this position (tape around the bolt).
15. If this was the first time the bolts were removed, put a paint dab on the top of each bolt. If the bolts already have a paint dab on the top or you don't know if they were used before, discard the bolts.
16. Remove the cylinder head and gasket (Figure 4-16).

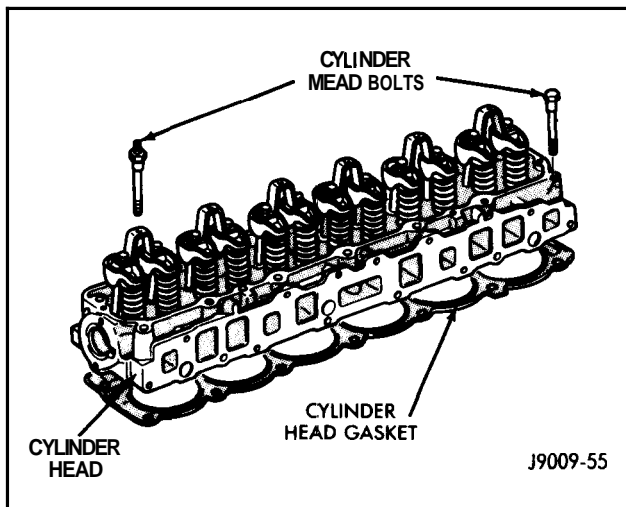


Figure 4 - 16

Cleaning and Inspection

Thoroughly clean the machined surfaces of the cylinder head and block. Remove all gasket material and cement.

Remove any carbon deposits from the combustion chambers and top of the pistons.

Use a straightedge and feeler gauge to check the flatness of the cylinder head and block mating surfaces. Refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter, for more information.

Heavy Duty Cylinder Head Gasket

The single, heavy duty head gasket is designed for the 4.0L engine (only). Can be used as replacement.

P4529242 Heavy duty cylinder head gasket.

Preparation

The basic cylinder head preparation should be checked out and reworked in accordance with the following procedures.

1. The cylinder head should be "cc'd" and the volume compared to specifications. Any milling that is required should be done, and the chamber volume rechecked.
2. The head should be checked for squareness and for any cracks or flaws. The valve guides should also be checked for wear and replaced if necessary.
3. Heads with a seat runout of less than .001" should have a valve job done. Refer to 'Camshaft and Valve Gear' section of this chapter for more information.
4. The head should be installed on the block without the head gasket to check dowel pin height. Dowel pins should NOT hold the head up off the block surface; they should only locate the head over the cylinder bores.
5. When high lift camshafts are installed in production-based engines, the keepers may hit the valve guide. This should be checked at the cam's maximum lift. The guide should be shortened to give .100" clearance between the top of the guide and the bottom of the keepers.
6. When dual valve springs are used, the inner spring seat may have to be cut down flush with the outer spring seat.
7. Check the cylinder head oiling hole. Be sure that it is open and that the drill didn't break off and remain in the hole. Check the block for a similar hole, both sides. The camshaft bearing holes should line up with the cylinder head oiling holes and not restrict them. It is NOT recommended that oil to cylinder heads and valve gear be restricted.

8. To ensure engine gasket sealing, proper surface preparation must be performed, especially with the use of aluminum engine components and multi-layer steel cylinder head gaskets.

NEVER use the following to clean gasket surfaces:

- A metal scraper
- An abrasive pad or paper
- A high speed power tool or wire brush

Note: Multi-Layer Steel (MLS) head gaskets require a scratch-free sealing surface.

ONLY use the following for cleaning gasket surfaces:

- Mopar Brake and Parts Cleaner (or equivalent)
- A plastic or wood scraper

9. The latest tech trend in Stock and Super Stock racing is to “cc” the ports –both intake and exhaust. This isn’t a technique to increase performance; rather, it’s a measurement technique used by the NHRA and IHRA at the tech barn. They have a cc number for the port volume and your cylinder heads will be checked against that number.

Installation

If the cylinder head is to be replaced and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems. Remove all carbon buildup and reface the valves. Refer to *Valve Refacing*, ‘Camshaft and Valve Gear’ section for the proper procedure.

1. Install the valves in the cylinder head using replacement valve stem oil seals (Figure 4-17). There are markings on the top of the seals indicating intake valve (INT) or exhaust valve (EXH). Refer to *Valve and Valve Spring Removal and Installation*, ‘Camshaft and Valve Gear’ section of this chapter for the proper procedures.
2. Transfer all attached components from the original cylinder head that are not included with the replacement head. DO NOT install the temperature sending unit until coolant is installed. This permits trapped air to escape from the cylinder block and head. Refer to the service manual for the proper procedure.

Caution: DO NOT apply sealing compound on the cylinder head and block gasket surfaces. DO NOT allow sealing compound to enter the cylinder bore.

3. Coat the cylinder bores with clean engine oil.

4. Install the cylinder head. Tighten the bolts in sequence (Figure 4- 18) as follows:

Caution: Cylinder head bolts should be reused only once. Replace head bolts if they have either a paint dab on the top of the bolt, or it is unknown if they were previously used.

- a. Coat the threads of the stud bolt in the No. 11 position with Loctite 592 sealant, or equivalent, before installation.
- b. Tighten all cylinder head bolts to 29 Nom (22 ft-lbs) torque using the tightening sequence.
- c. Tighten all cylinder head bolts to 61 N•m (45 ft-lbs) torque using the tightening sequence.
- d. Recheck all cylinder head bolts at 61 Nom (45 ft-lbs) torque using the tightening sequence.
- e. Tighten all cylinder head bolts (except No. 11) to 149 N•m (110 ft-lbs) torque, and tighten bolt No. 11 to 135 N•m (100 ft-lbs) torque using the tightening sequence.

Note: Clean and mark each bolt with a dab of paint after tightening. Should you encounter a set of bolts which were painted during an earlier servicing operation, *replace them!*

Cylinder Head Bolts

POSITION	DESCRIPTION
1,4,5,12,13	1/2 in.-13 BOLT
8,9	1/2 in.-13 BOLT WITH DOWEL POINT
2,3,6,7,10,11,14	1/2 in.-13 WITH 7/16 in.-14 STUD END

5. Connect the battery negative cable.
6. Install the ignition coil and bracket assembly.
7. Install the spark plugs and connect the ignition wires. Tighten the spark plugs to 37 N•m (27 ft-lbs) torque.
8. Attach the air conditioner compressor mounting bracket to the cylinder head, if removed.
9. Install the intake and exhaust manifolds. Use the correct tightening sequence. Refer to the service manual for the proper procedures.
10. Install the alternator bracket bolt on the head. Install the alternator belt and adjust the tension.
11. Install the power steering bracket and pump. Adjust the belt tension. Refer to the service manual for drive belt (including serpentine) adjustment procedures.
12. Install the pushrods in the order removed.

13. Install the rocker arms and the bridge and pivot assemblies in the order removed. Loosely install the capscrews for each bridge and tighten alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 28.5 N•m (21 ft-lbs) torque.
 14. Install the cylinder head cover.
 15. Connect the hoses to the thermostat housing and fill the cooling system to the specified level. Refer to the service manual for the proper procedure.
 16. The automatic transmission throttle linkage and cable must be adjusted after completing the cylinder head installation. Refer to the service manual for the proper procedure.
 17. Install the temperature sending unit and connect the wire connector.
 18. Connect the fuel pipe and vacuum advance hose.
- Warning!** Use extreme caution when the engine is operating. DO NOT stand in direct line with the fan. DO NOT put hands near the pulleys, belts or fan. DO NOT wear loose clothing.
19. Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.
 20. Install the air cleaner.

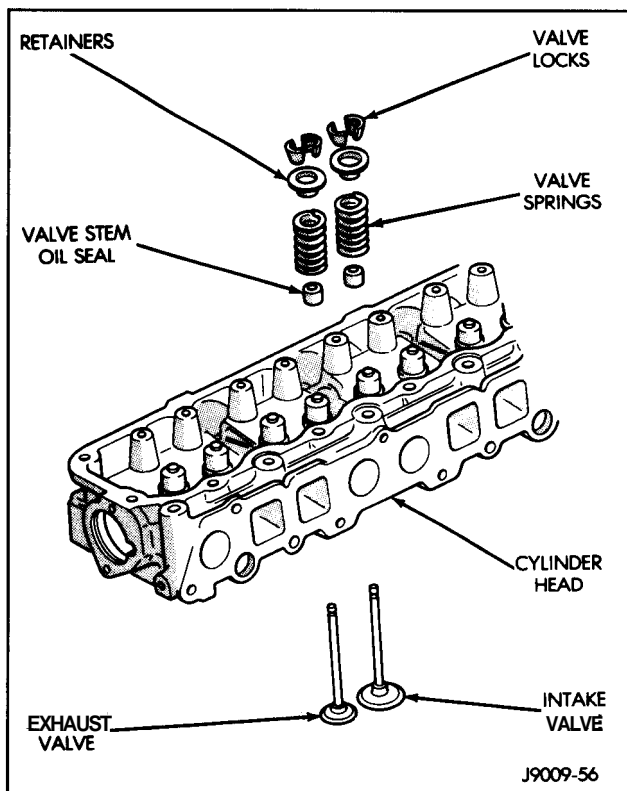


Figure 4 - 17

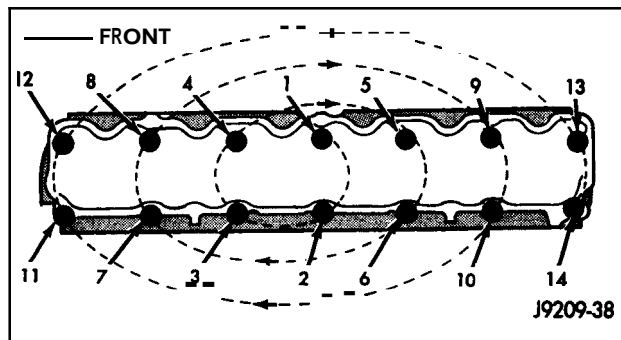


Figure 4 - 18

CYLINDER HEAD PERFORMANCE AND ASSEMBLY TIPS

Alignment

With the crankshaft and piston removed, check the alignment of the combustion chamber over the cylinder bore. If it needs to be corrected, use offset dowel pins in the block.

Piston-to-Head Clearance

(Refer to *Piston-to-Head Clearance*, 'Pistons and Rings' section of this chapter.)

Oil Restriction

We DO NOT recommend restricting oil to the cylinder heads. Leave all the passages stock size and be sure that they are unobstructed.

Valve-to-Valve Clearance

Valve-to-valve clearance is measured with both valves "on the seat." Being a wedge head design and having the valves parallel allows this clearance to be minimum—around .020" to .030". Check with your valve grinder to be sure. For more information, refer to *Valve Clearances*, 'Camshaft and Valve Gear' section of this chapter.

Measuring Cylinder Head Combustion Chamber Volume

Cylinder head milling and cc's are closely related and are very important when blueprinting. Cylinder head cc'ing is the volume of the combustion chamber in cubic centimeters. Milling the head is to remove metal from the head gasket surface to decrease the combustion chamber volume. This operation should only be done by an experienced machine shop.

After grinding valve seats, it is recommended that the actual volume of the combustion chambers be measured. The seats need to be ground to get them to the final height and to be sure that they'll seal. Measuring the volume can be done by placing the head, chambers up, on a level surface. Valves should be in place and spark plugs should be threaded all the way in. Coat the area around the chamber being measured with light grease to provide a seal, then place a piece of Plexiglas over the chamber.

The Plexiglas should have a hole in it large enough to permit the entry of the checking fluid and the exit of air. A burette, graduated in cubic centimeters with a capacity of at least 100 cc, makes an excellent checking vessel. Plain water, colored with a touch of Mercurochrome (to make it easier to read) may be used as a checking fluid.

Fill the chamber with fluid; make sure all air is out of the chamber and that the chamber is completely full; then read the volume on the burette. If the volume is too large, the compression ratio will be less than specified and the volume will have to be reduced. This can be done by referring to the individual engine specification to determine how much will have to be milled from the head surface to reduce it to the desired number of cubic centimeters. DO NOT reduce below the specified minimum and DO NOT, under any circumstances, sink the valves in an attempt to equalize chamber volumes. Sinking the valves disturbs the air flow characteristics of the valve port and seat with a subsequent horsepower loss. Sharp edges and burrs should be removed from any area in the combustion chamber to prevent hot spots that could cause detonation or pre-ignition. Be sure to write all your measurements down.

Block-to-Head Distortion

Block-to-head distortion is a concern anytime the head has been removed. Even just taking it off to put a new head gasket on will allow it to distort. **Also**, the length of the motor in conjunction with a cast iron cylinder head actually distorts the block. Because of this, the re-application of the

head is very critical. If it's not done using a specific technique, the distortion between the block and head will be different from when it was manufactured.

There are many reasons why distortion occurs. When the engine is new it has bolts and holes that have never been used. When the engine is being re-assembled, the head has already taken a heat set from being used. Even if you use new bolts, you're still threading them into used holes. There's no way you can have the same torque value on a reinstalled head as you do on a brand new build-up.

Also, you have four bolt holes around each cylinder, which is a fairly wide spread of bolts. Many V-8 engines have 5 around each cylinder, but most 4 and 6 cylinder engines have only four. So, because of the length of the engine, when you take a cast iron cylinder head and bolt it to the top of the block, it actually creates distortion on each of the head bolts. And of course these bolts are connected to the block and they go through to the main web, so they could distort the main web also.

Because of this, any operation done to the block should use either a honing plate (preferred) or an actual cylinder head mounted on to the block (not a simulated cylinder head, but a specially modified one to accept clearance of the boring bar and the hone so you or your machine/race shop can bore and hone through the bottom of the block with the cylinder head actually mounted on it). Also, any work that is done to the main web and bores should be done with either a honing plate or specially modified cylinder head bolted on the block.

This technique was originally used on In-Line 6 cylinder engines (because of their length), but is now recommended for all engines. This technique is so reliable and there have been so few problems with distortion that almost all race teams use it on every engine they build. The only procedure you wouldn't have the head bolted on for is to cut the deck of the block.

It's attention to details such as this that makes the performance difference!



Spring Seats and Valve Guides

We typically discuss big camshafts in simple terms. We talk about valve springs, retainers, pushrods, and tappets. Hidden in all this is the assumption that you can physically lift the valve as high as the camshaft selected dictates. The valve spring is specially selected, based on the lift of the camshaft and the manufacturer's recommendations. Once you've made that choice, what else could there be? There are two basic problems – spring seats and valve guides.

With hydraulic camshafts the valve guide is the main problem. With stock heads, if the camshaft has more than .500" lift, the valve guide will have to be shortened. This is caused by inadequate keeper-to-guide clearance at maximum camshaft lift. As a general rule, it's always a good idea to check this clearance anytime a higher lift camshaft is installed.

With high lift mechanical camshafts, the racer usually installs dual springs. Dual springs typically require the inner spring seat to be "cutdown" even with the outer spring seat. Dual springs can also cause a related problem with the guide. The inner spring in a dual spring has a substantially smaller inside diameter than that of a stock spring. This may require the outside diameter of the guide to be reduced.

To increase installed height, the spring seat may be milled down a maximum of .050"; however, this should NOT be done unless all other methods of increasing the installed height have already been used.

Diagnosing Valve Seat Insert Failures

Cast iron heads have the valve seats machined directly into the cast iron. Although you can use a valve seat insert in a cast iron head, it is usually done only as a repair. Valve seat insert failures in cast iron heads are not very common. In a regular cast iron head, the valve seat doesn't tend to "fail," but it can wear out.

Valve seat inserts are used in almost all aluminum heads. It is common to use a different material for intake and exhaust seat inserts.

Seat inserts take a lot of abuse. Certainly, seat inserts are not very exciting and probably are not noticed in a casual look at a head. In a cast iron head, it can be almost impossible to tell if it has inserts or not; it is much easier to tell in aluminum because of the slight difference in color of the two materials. Inserts tend to be made out of a special cast iron, or in some cases, beryllium-copper. They are very strong and are designed to work in high temperatures. These valve seat inserts are "pressed" into the aluminum head. There are different techniques that use liquid nitrogen "cooling" of the seat with a mild heating of the aluminum head. It is all calculated to give a specific "press" into the head. Once installed, it isn't going to come out unless something changes – a failure.

A common mistake made during an aluminum cylinder head failure analysis is to notice a valve seat insert missing and assume that the insert failed. Usually, this is the wrong assumption!

Under normal operation, it is pretty hard to fail a seat insert. This is not to say that you can't break a seat insert. To analyze a seat failure, it is best to start with as many facts as possible. One of the problems is that there is probably very little left of the seat insert itself. There may be six or six hundred pieces. In an aluminum head, if you fail one seat, you will probably fail two in the same cylinder – intake and exhaust. In an oval track head, it is very common to see both seats "fail" at once.

If you see that both seats are gone, what do you think failed? Both inserts fell out at the same time? Not too likely! Whether you see one or two inserts missing, the best bet is that the seat insert did not fail first. However, because it is gone, the most popular guess is that it failed. But if it didn't fail, what happened?

Although not common anymore, a seat insert can fall out. For it to fall out, it must not have had enough press on it at installation. If this is true, then it will fall out almost immediately. However, an improper installation is more likely than not to be caught by the head assembler when the heads are being put together.

Once it gets past the first thermal cycle or two, the only known cause of seat insert failure is heat. If the engine gets too hot, the seat takes a real beating.

If we get past the mistakes category and can rule out too much heat, the best bet is that the valve is hitting the seat insert at an angle. You could call this a "bent valve," but it may not be bent very much or it may not be as bent like you would think. It may also be caused by foreign material getting between the valve and the seat insert. Once the valve and piston strike the seat insert like a ball-peen hammer, it will crack. From there it is only a very short time before a second crack appears, a third, etc. Once cracked through, the insert loses its press and a small piece can come out. As soon as the first small piece is out, then they are all going to come out and crack into more pieces, leaving you with one seat insert hole and lots of little pieces. As soon as the first insert is gone, its mate will quickly follow because it now takes all the abuse even though it was not part of the first failure. Both seat inserts gone. The cylinder head will also be a mess. Summary? Head failure – not very likely. Insert failure – not too likely. Valve failure – very likely. Bent valve – most likely. Foreign material – maybe. Valve gear – possible (more facts or observations required to rule this out).

Aluminum Head Threads

Racers are familiar with cast iron cylinder heads and intake manifolds. These cast iron parts may be heavy, but they are strong and durable. For performance purposes we typically replace the cast iron intake manifold with an aluminum one. You probably don't take any special precautions with these manifolds. This could start causing problems because you should be more careful with aluminum threads than you are with cast iron threads. You may have developed some bad habits with cast iron parts that are going to cause you to cross-thread, strip, or pull threads out of aluminum heads. For example, if the intake manifold doesn't fit, you can't just use the intake manifold bolts to "pull" it into place. You must be careful with any screw or bolt that is threaded into aluminum. You should also use hardened washers between the head of the bolt and the aluminum part. This is especially true of head bolts. Although not mandatory, it will make the heads last longer. It also helps the bolt/screw retain its torque. Torque sequences and specifications should always be followed exactly.

Hardened Washer Sets

For use with head bolts and main cap bolts.

P4120456	Comprised of (20) - 3/8" washers.
P4120457	Comprised of (20) - 7/16" washers.
P4120458	Comprised of (20) - 1/2" washers.

Weeping

This is one of those titles that is very misleading. On the surface you might think that we are going to talk about broken engines or other "sad" times. Actually, *weeping* refers to slow gasket leaks.

All engines have weeping problems. How much depends on their use and how much strain they are under. Most professional engine builders have found solutions to weeping they apply to every engine they build. Before we get into the fixes, let's define the problem a little better before we assume that it's something that it isn't and jump in the wrong direction!

A gasket is designed to seal two surfaces or parts together. For example, a head gasket is designed to seal the cylinder head to the block. The intake manifold gasket is designed to seal the intake manifold to the cylinder head. In either case, there are at least two aspects to this "sealing" problem. For example, the head gasket must seal the compression that is built up in the cylinder. It must also seal the water between the head and the block. Although you might think the tough problem is sealing the compression and that sealing the water is easy, the reverse is probably more common. Today, this water sealing problem is most commonly seen as weeping. Many years ago (back in the 1950s and 1960s), this situation was probably reversed and sealing the

compression was the more difficult problem. Gasket technology has come a long way. However, when building or rebuilding engines, there are several gasket installation tips you should follow. Some are common to all engines, and some are unique to the type of engine being built.

Some high performance race engines use an O-ring and a copper gasket. It is common to use copper gaskets on aluminum heads. Copper gaskets like to weep, so you must follow the gasket manufacturer's instructions "to-the-letter." If not, the engine will leak water!

One tip common to all engines is to put the gasket that is going to be used on the engine block to be sure that everything "lines up." Be sure that this check is done with the gasket in the "top" position. In many cases you will notice that this check will show certain holes in the block that are not in the gasket. This has to do with water flow and "steam" holes. Each gasket design may be different in this aspect.

The next thing to check with the gasket on the block is the water sealing around the water holes that go through the deck surface. Each hole in the deck should be ringed with a sealing lip or bead. Larger water holes are especially important. In some engines, the water holes are very large and the gasket may overhang the holes. The gasket overhang itself is not a problem, but if the bead gets close to the edge of the water hole then it will probably weep. The solution, if observed, is to ring the hole with a small bead of RTV on the top and bottom sides of the gasket. Big water holes that are cast into the block's deck surface are hard to control because they are not generally machined surfaces. If in doubt, add RTV.

PORTED CYLINDER HEAD

Using ported cylinder heads is a very popular way of increasing an engine's performance. However, ported heads aren't cheap. At this point, think how much you'd pay for ported heads for your race engine. Write it down now before reading the rest of this section.

Ported heads could be worth 20 to 50 hp more than standard heads. But, unlike camshafts and valves, you can't put a specification on a ported head to tell how good it is. A camshaft has lift and a valve has diameter, both of which you can use as guides. Ported heads are more related to "who did them." Visual inspections don't seem to help. "Pretty ones" may not make any power at all, or they may be great. Even cost isn't a good guide. You can take your heads to a porting service and be charged \$500 to \$5,000, or even more depending upon how much work is done. Just spending a lot of money on heads doesn't mean that they will go fast. You can say that if you want better heads they'll cost you more, but the total dollars spent in relation to value isn't totally reliable.

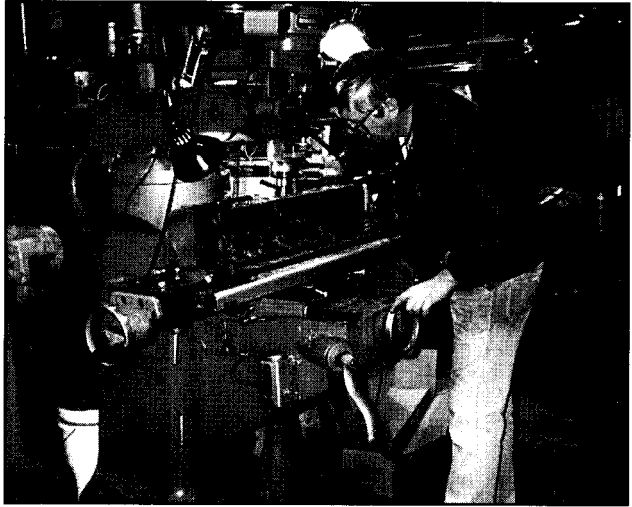
There are some pretty straightforward reasons for this. First, ported heads are all hand labor. The fancier you get, the longer it takes. Extra time costs extra money. You also have to factor in flow bench time and the knowledge of "where-the-thin-spots-are." If you port your own heads (cast iron), it's a good bet that you'll ruin at least one head by breaking through into the waterjacket. A porting service will usually take one head and cut it **up** to find where the thin spots are before porting the actual set. All of this has to be factored into the price.

The performance that ported heads offer varies a lot. If you do your own you might be looking at 5-15 hp. An econo porting service could give 15 to 25 hp. New ported heads could yield between 35 and 55 hp. The performance gains look good, but let's look at price.

Ported head assemblies can cost as much as \$900 to \$1,200 each. On the surface this sounds like a lot. Looking at the power numbers, getting a higher output, higher quality piece may be worth the extra money. In truth, it's a much better deal than that. With a porting service, you provide the head casting (probably used), valves, etc. With a new ported head assembly, you receive it fully assembled - valves, springs, retainers, and new castings. A new casting costs as much as \$350. This again sounds high, but there are a couple tricks.

First, this is a new head casting—not used or rebuilt! Second, you can get a used casting for half this price, but you'll have to install bronzewall guides and regrind the seats before you get a good head. The problem is that horsepower potential is directly proportional to the number of valve jobs done on the head. In other words, the more valve jobs done, the less power the engine makes. A new casting has the absolute minimum number of valve jobs—one.

Now, if you add \$300 (on the average) for new valves, springs, retainers, seals and locks, add the cost of the new casting (about \$350) and the porting costs (on average, \$150 - \$200 for one head), you could wind up spending \$1,000 - \$1,250 for a race prepared head. However, a new ported head assembly typically costs between \$900 - \$1,200, and comes fully assembled with *brand new parts*. Often times, a new ported head assembly is the best deal. *Cost vs. performance* is the key. Do your homework first and then decide where best to spend your money.



Swirl Ports

The term "swirl port" was introduced in 1986-87 and was popularized by the press and racers. We use it in our *Mopar Performance Parts Catalog* relative to many of our cylinder head castings. Many standard production cylinder heads have swirl ports and they have a swirl port intake shape. Their ports were designed using swirl port technology. **All** these statements are true. The confusion seems to come in relative to the combustion chamber shape.

There are many wedge-shaped combustion chambers and it's (difficult to put them into specific categories. One of the latest is the heart-shaped chamber. The term was first used by us in reference to our small block 318 V-8 'A' engine swirl-port head (approximately 1986-87 production). This seems to be where the tie-in comes. Since the 318 had both swirl ports and a heart-shaped chamber, some people assumed that the chamber was the "swirl." It wasn't!

The press (primarily performance magazines) hasn't helped the situation. They tend to misuse the term "swirl" in articles on horsepower development, cylinder heads and airflow. This isn't totally the fault of the press. Racers also tend to misuse the term. Since it (swirl) is the latest "trick," every racer has swirl heads. This all leads to confusion. To try and clarify this situation, we'll need to back up and give an explanation based on technology rather than "hype."



First, let's define "swirl." In its simplest sense, *swirl* is how the air flow enters the combustion chamber. In a more technical sense, swirl is the flow around the center of the cylinder (as viewed from the top). A problem arises from trying to attach the definition of swirl to a shape. For example, the 318 'A' engine swirl port (intake) is tall and skinny. However, there are tall, skinny ports that don't swirl. There are also square and round ports that do.

In practice, the press and racers seem to use a different definition for swirl. They don't write it down or explain it this way, but their usage would imply that swirl means high flow! This isn't technically correct, so Mopar Performance Parts will stay away from it. Just realize that in press articles if you see "swirl" written, just substitute the term *high flow* and you should have a better understanding of what is being reported.

Remember, today's engines are compromises. The production compromise relative to heads is higher flow, improved output, better emissions, more fuel economy, and (the latest) less noise. Swirl became an important design factor in cylinder heads because auto manufacturers were looking to improve emissions. The emissions-improving swirl port led to higher flow which led to better output and more fuel economy. However, many swirl port designs can lead to less output, so it's up to the racer/engineer to pick the best one for his application.

Porting

The most important part of the port is the bowl area between the valve seat and the radius on the floor. Blending the machined bottom cut into the cast surface gives a large increase in port flow. If you use porting templates, DO NOT remove more metal than is required to fit the templates. Excess metal removal, especially on the floor, can cause very poor flow.

For all-out modified racing, a professional porting service should be contracted.

Flow Bench

Stated simply, a flow bench is an air pump that allows you to measure the amount of air that passes through a given orifice.

Flowing cylinder heads is what most flow benches are used for, and to this end they can provide very useful data. To a porting service professional a flow bench can be invaluable. It's unrealistic for one racer to own a flow bench to flow one cylinder head. Flow bench services are offered by many speed shops. The problem comes in relative to the average racer. He may want his head "flowed" because the pros do it. Unfortunately, the engine isn't going to go any faster with a "flowed" head unless some modification is done. Having the flow chart is interesting, but in high gear it's no match for oversize valves or a bracket valve job.

Where flow benches become very useful is in making modifications to cylinder heads. How big a valve to install? What shape to make the port? Valve seat angles? All ports flowing equally? Obviously, these are questions the professional cylinder head service needs answered. Once he knows the answers, the racer is paying for modifications to the head, not the flow chart. As a racer, don't end up racing flow benches!

As a general rule, don't flow your cylinder head unless the shop is making a change or modification to the head and you want to see the resulting gain. Also, don't get into absolute number comparisons. A flow bench is only a tool. As a tool it's helpful in making modifications, but it's hard to turn a flow bench into a race vehicle!

Evaluating Cylinder Head Air Flow

Cylinder head air flow is a popular topic because it is generally believed that more air flow leads to more power. Although this is true in some cases, there are many exceptions. The purpose of this discussion is to give you some tips that will help you evaluate cylinder head air flow.

First, let's look at the current situation. All racers want to know how much air their heads flow, and then they will tell you their heads flow "X" cfm. That's it! All racers seem to use this "one number system" to discuss their heads. Although this seems quite simple, it can lead to much confusion. So let's clarify a few things before we move on. The one number system assumes that the number is the "peak number" for the intake port of the head. Although no pressure drop is typically mentioned, you can probably assume that it is 28 inches. (Although many people actually flow at pressure drops of 3, 10, or 25 inches, 28 gives you the biggest number, so that has become the "standard.")

There is a chart that allows you to use a correction factor to correct flow data from one pressure drop to another. Since different flow benches DO NOT give the same flow numbers for the same head, we recommend you not get too

hung-up on absolute numbers and try to do all your flow testing on the same flow bench. This tip really relates to the flow bench itself. For now we will assume that you have a flow curve comparison and want to figure out which curve is best. Let's look at some typical flow curves.

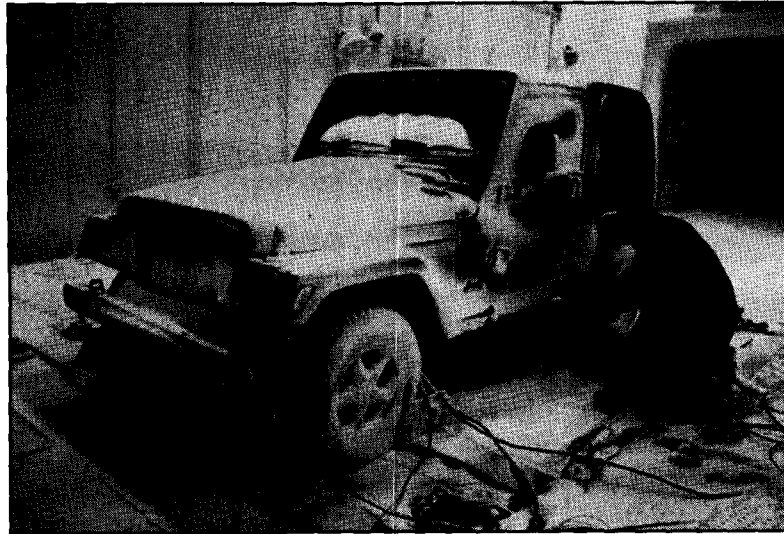
In Figure 4-19 you see the typical flow curve of an intake port. In this curve, we are comparing cylinder head "A" to cylinder head "B." This is somewhat typical of a standard production head being compared to a race head. Head "A" is obviously better. It has more "area under the curve." It outflows head "B" at both high lift and low lift. This one is too easy!

Figure 4-20 is perhaps more common. In this example, head "B" flows 290 cfm (peak) and head "A" flows 285 cfm (peak). In this case, head "B" has the higher number or better peak flow. However, head "A" has more area under the curve. *Area under the curve* is the area formed by the X-axis (or valve lift line) and the flow curve line for the head. In this case, head "B" only exceeds head "A" at one point (.700" lift), while head "A" wins at .300", .400", and .500" lifts.

To evaluate area under the curve properly, you have to do some calculating. However, the performance press hasn't yet come up with a common, acceptable-to-all formula for calculating area under the curve, and there are no readily available numbers for what this "area" is supposed to be. No one gives "area" numbers. However, area under the curve is what you really want to know! In our example, head "A" will win. It will make the vehicle quicker at the drag strip and it will make more power on the dyno.

Now let's back up. Let's assume you have been using head "A" on your current race engine and you bought head "B" because it flowed more air. Figure 4-20 shows "B" with 290 cfm at peak, so it does flow more air. You install this new head and your vehicle goes slower. Now you are probably upset! Statements like "high flow heads don't work," "big ports go slow," etc., are made. But high flow heads do work – if they are done like head "A".





Heads must have more area under the curve if they are going to work in a drag or oval track vehicle; that is, *area under the curve is more important than peak flow*. Other items such as big intake ports are harder to tie to specific flow characteristics. If head “A” has bigger ports, then they work. Bigger valves and bigger ports generally help the high lift part of the curve. However, some big ports help both ends of the curve.

In Figure 4-21, we have another common flow curve. This is typical of a head that has been ported, or one that had big valves installed. Head “A” is assumed to be a big valve, ported version of head “B”. Head “A” has more area under the curve and has more peak flow. Now let’s assume that you are building (choosing) this head for a dual purpose application and you are only using a .425" lift hydraulic camshaft. Remember that .425" is a design number and our actual rocker ratio may be 1.46, rather than 1.50 (for example). Plus we have deflections and geometry to consider. So the at-the-valve lift may be closer to .410". At the .410" lift point on the flow curve it looks like a tie. If that were true, then head “B” should be the “winner” because it is less expensive for the same performance.

Now let’s go back to Figure 4-19. If you again restrict the valve lift to .410", head “A” still wins. It still has more area under the curve than head “B” and has more peak flow. It is important to note that just because you restrict the valve lift that is being used, you DO NOT always change which head is the better choice.

If you installed head “A” from Figure 4-19 on your race engine, it would make more power than head “B” whether you used a .700" or a .600" lift camshaft. Actually, the power curves would look very similar to the flow curves. This means that a dyno power curve would show head “A” making more power at each rpm greater than the torque peak.

Now, assuming that you have a race engine and have used typical race engine parts (4-Bbl. carburetor, non-restrictive exhaust system, etc.), we’ll assume that the head “A” power

peak is 700 hp at 7,500 rpm. If you restrict the rpm to 5,000, head “A” still makes more power. Because head “A” flows so much more air, you could say it is a high rpm head. That is true, but it also makes more power at lower rpm. Now if you switched to the heads in Figure 4-20, the more you restricted head “A”, the greater the winning margin. This gets us back to the area under the curve.

A cylinder head selected by the area under the curve method will generally win. Since this is so important in making the right selection for a race vehicle (and finding the area is not easy), we have a short-cut method. Compare the flow rates at a point that is half your actual peak valve lift. For example, if you are going to use a camshaft that has an actual valve lift of .700", then look at the flow rates at .350" lift. If you are going to use a .600" lift camshaft, then compare them at .300" lift. Remember this half lift number is more important than the peak lift number in making your selection. This number is considered your mid-lift flow and is the most important number on the flow chart! If you hurt this number, you will probably slow the vehicle down.

So far we have only discussed the intake side. This will also get us into trouble. Having a good intake side with a bad exhaust side will also make the vehicle go slower. However, because the exhaust side always has a smaller peak number, everyone only talks about the intake side. The exhaust side is certainly just as important. You would like to have the exhaust side flow about 80 percent of the intake, although this tends to be an ideal since few exhaust ports are actually this good. (Production heads tend to run about 65 percent.) If you have a good exhaust port, then you can trade some of its performance for more on the intake side.

At this point you could have good intake ports but bad exhaust ports, so now which head would you pick? This is a much more complicated question! There is no single answer. Remember Figure 4-20. The best choice was the one that had the best area under the curve. A complete head comparison gives you two port areas to consider, therefore you also have two mid-lift flow points to consider.

If they all point in the same direction, you have a winner! If they don't (which is more likely), you have to make choices. Pick the best intake based on area and the best exhaust based on area or mid-lift flow. Multiply the intake's peak flow by .80 and compare to that head's exhaust flow. For example, in Figure 4-20, head "A" was selected as the better head and it had a peak flow of 285. The 80 percent number would be 228 for the exhaust side on this head. The 70 percent number would be 200 cfm. You would want the actual exhaust flow to be between 200-228 cfm.

If you had two heads that both flowed 285 cfm on the intake side, then the head that flows better up to the 80 percent number on the exhaust side is the best choice. This sounds like it's easy to get to 80 percent on the exhaust side. Nothing could be further from the truth. Remember, the exhaust side gets the smaller valve. The typical production valve area comparison between intake and exhaust valve diameters gives the exhaust valve 65-70 percent of the area of the intake. To get 80 percent flow out of a valve area that is 30-35 percent smaller means the exhaust port has to actually be a better flowing port than the intake.

Putting in bigger exhaust valves will limit the size of valve we can put on the intake side. That is why the exhaust side is so important. You want to get the flow out of the port itself, not out of a bigger valve.

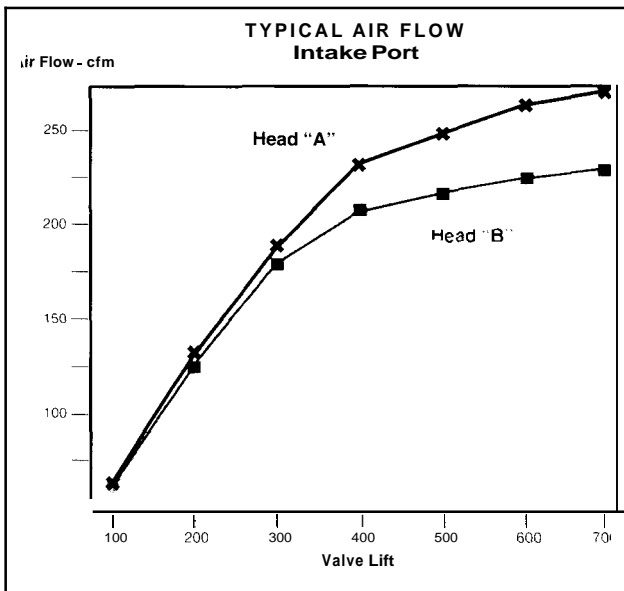


Figure 4 - 19

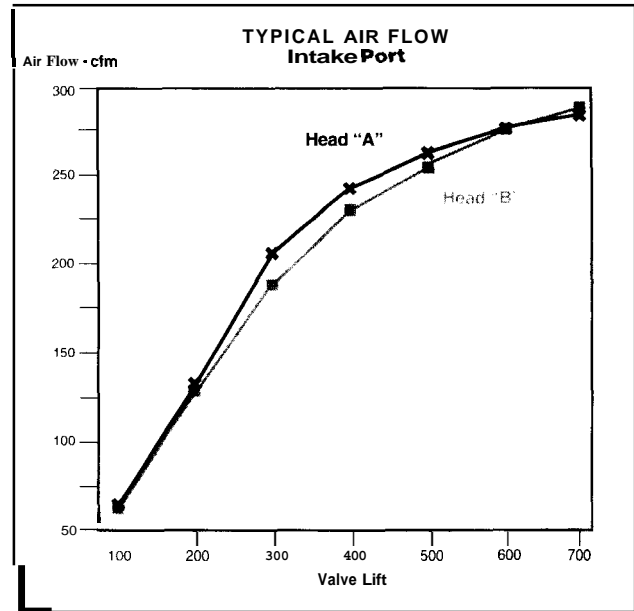


Figure 4 - 20

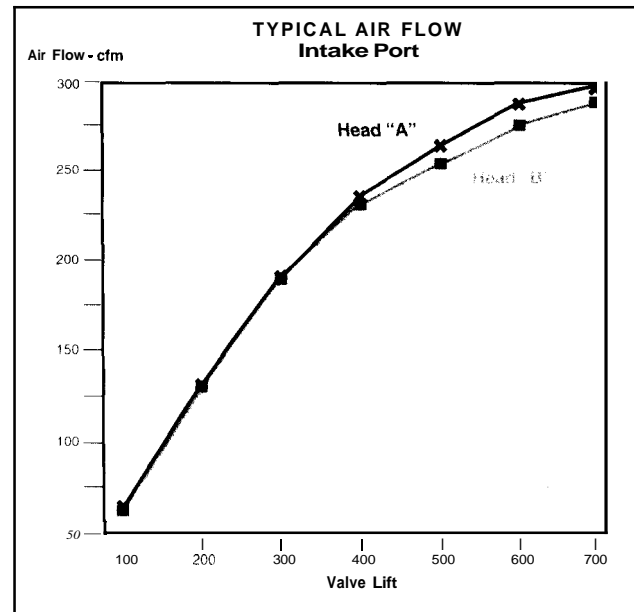


Figure 4 - 21

Oversize Valve Seats and Guides

In some cases, cylinder head porting has to be done to change some design characteristic of the head. In other cases, it must be done because heads are worn-out or have become damaged due to a bent valve, etc. In a cast iron head, the seats and guides are machined directly into the cast iron. There is no seat or guide insert. (There are instances where inserts are used in cast iron heads, but this tends to be the exception.)

In aluminum heads, the seats and guides are always inserts. The insert (seat or guide) must be "pressed" into the material of the cylinder head. The amount of "press" is called the interference fit because the insert itself is actually larger than the machined hole into which it goes. The amount of press is measured in thousandths of an inch (.001"). On a given part it may be .002" or .003". The trick comes when you remove a seat or guide. You cannot put in the same size that you just took out. You must use an oversize seat or guide. The inside diameter can be the same size if desired, but the outside diameter has to be larger.

When you remove a seat or guide, the hole left is slightly larger than before and it may not be perfectly round anymore. The same size seat or guide installed in this larger hole will have less press than before, or perhaps no press at all. This means the seat or guide can "fall out" or break (as it falls out). It would be bad for the head in either case!

This situation is somewhat like honing the block. When we re-hone it, the bores will actually become larger (oversized). Therefore, once you remove a seat or guide, you **MUST** install an oversize part as the replacement. If the head has been repaired or modified already, then you must move up to the next size oversize. Each oversize part requires that the head be machined (sized) properly prior to installation. At this point, the head is only as good as the machine shop that did the work.

CYLINDER HEAD COVER

Crankcase Breather

A universal high performance re-usable crankcase breather (must have stand pipe on valve cover). Washes clean with P4.529392 cleaning fluid for extra miles of service.

P4529394 Crankcase breather.

Removal

1. Remove PCV molded hoses from the cover (Figure 4-22).
2. Remove the cruise control servo, if equipped (Figure 4-22).
3. Remove cylinder head cover retaining bolts.
4. Lift and remove the cover. The cylinder head cover utilizes a pre-cured RTV sealer that is attached to the cover. Inspect the sealer for cracks and/or damage that may have occurred during removal.
5. Small cracks in the sealer are allowed and can be repaired by applying RTV sealer to the cracked area before cylinder head cover installation.

Cleaning and Inspection

Replace the cover if it is cracked or damaged in any way. If the pre-cured RTV seal is damaged, replace the cover.

If a replacement cover is installed, transfer the **PCV** valve grommet and oil filler cap from the original cover to the replacement cover.

Remove any original sealer from the cover sealing surface of the cylinder head and clean the surface using a fabric cleaner. Remove all residue from the sealing surface using a clean, dry cloth.

Installation

1. Clean the cover and cylinder head sealing surface using a clean dry cloth.
2. Install the cover and retaining bolts. Tighten the retaining bolts to specification.
3. Install the cruise control servo (if removed).
4. Install the PCV molded hoses to the cylinder head cover.

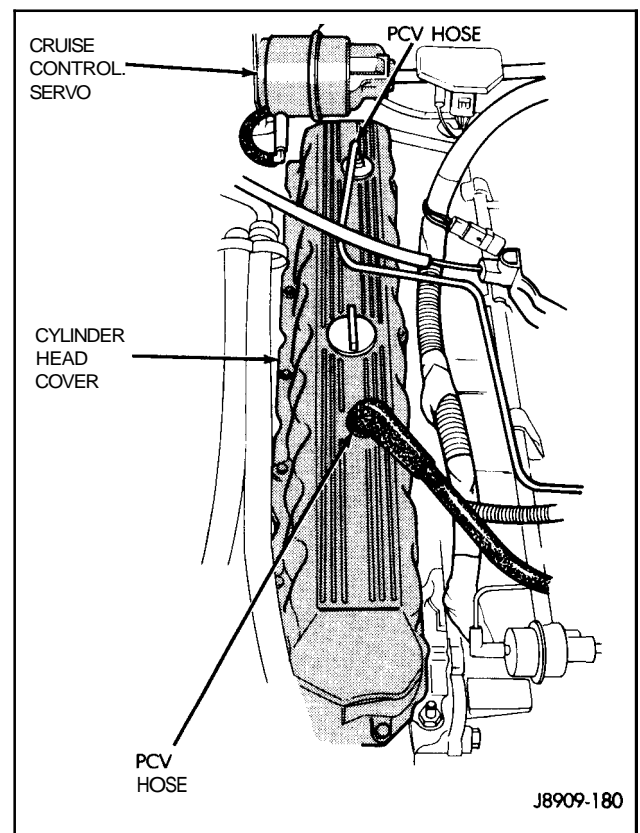


Figure 4 - 22

Camshaft and Valve Gear

CAMSHAFT

The 4.0L engine camshaft is made of cast iron with twelve machined lobes and four bearing journals. The camshaft has intake and exhaust valve lifts of 10.29 mm (0.405"), intake and exhaust cam lobe lifts of 6.43 mm (0.253"), and intake and exhaust durations of 270°.

For racers, choosing the correct camshaft to match the compression and carburetion of the engine is the most critical performance area to consider. The "3 C's" of engine building (compression, carburetion, and camshaft) must always be decided upon before the engine is built or, more importantly, money is spent. In fact, one of the most common errors among racers is to choose a "hot" camshaft without considering the compression ratio and carburetion set-up to be used, all of which must work in complete harmony for the engine to perform at its peak level at all times.

The racer's camshaft choice will also dictate the rest of the valve gear. The important areas in camshaft and valve gear are profile selected by application, installation centerline, clearances (especially valve-to-piston and clearance at coil bind), and valve spring loads. We'll cover these items in later sections.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

Camshaft Bearing Set

Made of production material. Complete engine set for Jeep 2.5L and 4.0L engines.

P4529226 Camshaft bearing set.

Jeep 4.0L Hydraulic Camshaft Specifications Chart

Part No.	Advertised Duration	Overlap	Centerline	Lift	Recom. Spring	Applications & Comments
P4529228	240/240°	24°	108°	.430/.430"	P4529214	Mild Comp.
P4529229	248/248"	32°	108"	.440/.440"	P4529214	Mild Comp.
P4529230	256/256°	40"	108°	.450/.450"	P5249464	Mild Comn.

Jeep 4.0L Hydraulic Camshaft Application Chart

Performance Level	Best Choice		4x4 Auto & Man	Street Rod Auto & Man
	Manual	Automatic		
Stock	Stock	Stock	—	—
Phase I	P4529228	P4529228	P4529228	P4529228
Phase II	P4529229	P4529229	P4529228	P4529229
Phase III	P4529230	P4529229	P4529229	P4529230

CAMSHAFT SELECTION

There are literally thousands of camshaft designs to choose from. Picking the correct one for you and your engine without spending too much money is a very tough job. Selecting the type of camshaft (hydraulic, mechanical, roller) is usually the hardest job.

Keep in mind that these basic decisions should be made before you go to the track, while you're building the engine. Once built, the engine will dictate many of the cam's characteristics. This choice does affect the valve-to-piston clearance.

The easiest way to identify the type of camshaft is by lift—each category has a lift range in which it works best.

LIFT	TYPE	COMMENTS
0-.520"	Hydraulic	Low maintenance, inexpensive, simplest installation and setup.
.490-.620"	Mechanical	Higher rpm, simple.
.620-.700"	Mechanical-Mushroom	High output without roller's expense.
.600-.750"	Roller	Ultimate power, most expensive, most complicated, highest maintenance.

The preceding chart can be used to generalize your camshaft selection, although there is some overlap as well as some special considerations. It is very general. Your choice may be already made for you by your local race sanctioning body (check the rule book). Roller and mushroom camshafts are commonly ruled "out," and sometimes camshafts are limited to any hydraulic or any flat-tappet.

Racing Camshaft Selection

In mid-race season, many racers are looking to upgrade their engine's performance. The camshaft is one part that is often changed. The question is, what direction to go? To answer this, we have to back up to how we made our original or existing choice. To this end, let's review some general selections.

A camshaft can be selected by knowing the performance level desired for the vehicle and track-type. This is the best way to select a camshaft, but we have to know how fast the vehicle is going to go. As we're building the engine and selecting our initial camshaft, this performance estimate is somewhat of a guess. Once we've run the engine at the track, we can improve upon this guess.

Camshafts can be selected based on many different aspects. The best sources of information for selecting camshafts are as follows, listed in order of importance:

- Dyno curve—in vehicle test
- This book
- Camshaft lift
- Overlap
- Advertised duration
- Duration at fifty

We hope you will read this entire book to gain as much knowledge as you can. But say you need more information to narrow your choice. Now what do you do? Camshaft specifications can be used to indicate some engine performance characteristics and potential. Although not as good or reliable as actual tests, camshaft specifications can indicate trends in an engine's performance. Let's look at the various specifications in order of importance.

1. Lift

Has a direct effect on power, especially under .600". More lift, more power (less torque).

2. Overlap

Affects idle quality and driveability.

3. Duration

Not too useful in general. For lifts under .600", the advertised duration can be useful as long as all the camshafts being considered are from the same manufacturer. If more than one manufacturer is involved, go back to lift. Duration at fifty (.050") is useful in hard core, all-out race camshafts and camshafts with lifts over .600".

Studying this list closely you'll notice that, of all the camshaft specifications available, lift is the one to use if test results or Mopar Performance Parts recommendations are not available.



CAMSHAFT REMOVAL AND INSTALLATION PROCEDURES

Removal

Warning! The coolant in a recently operated engine is hot and pressurized. Release the pressure before removing the draincock, cap, and drain plugs.

1. Disconnect the battery negative cable.
2. Drain the cooling system. DO NOT waste reusable coolant. If the solution is clean, drain it into a clean container for reuse.
3. Remove the radiator. Refer to the service manual for the proper procedure.
4. Remove the air conditioner condenser and receiver/drier assembly as a charged unit, if equipped. Refer to the service manual for additional information pertaining to the A/C system.
5. Remove the distributor cap and mark the position of the rotor.
6. Remove the distributor and ignition wires.
7. Remove the front fascia/bumper and/or grille, as required.
8. Disconnect camshaft position sensor electrical connector and remove camshaft position sensor (if equipped).
9. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
10. Remove the capscrews, bridge and pivot assemblies and rocker arms. Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
11. Remove the pushrods. Position all components on a workbench in the same order as removed to facilitate installation at the original locations.
12. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter, for the procedure.
13. Remove the hydraulic valve tappets.
14. Remove the vibration damper. Refer to *Vibration Damper Removal*, 'Crankshaft' section of this chapter, for the procedure.
15. Remove the timing case cover. Refer to the proper service manual for the procedure.
16. Remove the timing chain and sprockets. Refer to the proper service manual for the procedure.
17. Remove the two thrust plate retaining screws and thrust plate (if equipped).
18. Remove the camshaft.

Inspection

1. Inspect the cam lobes for wear.
2. Inspect the bearing journals for uneven wear pattern or finish.
3. Inspect the bearings for wear.
4. Inspect the distributor drive gear for wear.
5. If the camshaft appears to have been rubbing against the timing case cover or the camshaft thrust surface appears to have excessive wear, examine the oil pressure relief holes in the rear cam journal to ensure that they are free of debris.

Installation

1. Lubricate the camshaft with Mopar Engine Oil Supplement, or equivalent.
2. Carefully install the camshaft to prevent damage to the camshaft bearings.
3. If equipped, position camshaft thrust plate and install retaining screws. Tighten screws to 24 N•m (18 ft-lbs).
4. Install the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks aligned. Refer to the proper service manual for the procedure.
5. Install the camshaft sprocket retaining bolt and tighten to specified torque (varies by year—refer to proper service manual for correct torque specification).
6. Install the crankshaft oil slinger.
7. Install the timing case cover with a replacement oil seal. Refer to the proper service manual for the procedure.
8. Install the vibration damper.
9. Install the damper pulley, if removed.
10. Install the fan assembly and shroud.
11. Install the drive belt(s) and tighten to the specified tension. Refer to the proper service manual for the procedure.
12. Rotate the crankshaft until the No. 1 piston is at the TDC position on the compression stroke.
13. Install the distributor, cap and ignition wires. Install the distributor so that the rotor is aligned with the mark made during removal. The rotor should be aligned with the No. 1 cylinder spark plug terminal on the cap when the distributor housing is fully seated on the cylinder block.
14. Install the hydraulic valve tappets.

Note: Lubricate the hydraulic valve tappets and all valve actuating components with Mopar Engine Oil Supplement, or equivalent, during installation. Mopar Engine Oil Supplement must remain with the engine oil for at least 1,609km (1,000miles); However, it does not have to be drained until the next scheduled oil change.



15. Install the cylinder head. Refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter for the procedure.
16. Install the pushrods.
17. Install the rocker arms and pivot and bridge assemblies. Tighten each of the two capscrews for each bridge alternately one turn at a time to avoid damaging the bridge.
18. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter for the procedure.
19. Install the A/C condenser and receiver/drier assembly, if equipped. Refer to the service manual for additional information pertaining to the A/C system.

Caution: Both service valves must be opened before the air conditioning system is operated.
20. Install the radiator, connect the hoses and fill the cooling system to the specified level. Refer to the service manual for the proper procedure.
21. Check the ignition timing and adjust as necessary.
22. Install the grille and bumper, if removed.
23. Connect the battery negative cable.

CAMSHAFT INSTALLATION TIPS

1. When installing the camshaft sprocket, use at least Grade 8 bolts with Loctite and safety wire. It is possible for high speed engine harmonics to cause these bolts to loosen if precautions aren't taken. (Not required while centerlining the camshaft.)
2. Because of the production tolerances mentioned earlier, it is possible for the crankshaft-to-camshaft relation to be several degrees off, either advanced or retarded. It is important that this timing be correct to produce maximum performance.
3. While the engine is still without heads, the timing marks on the crankshaft damper and the timing chain cover should be checked for accuracy of the "0" TDC mark.
4. Advancing or retarding a camshaft should only be done to install the camshaft at its designed centerline. It is very important *to* have the centerline correct. Most camshafts will have the design centerline stated as part of the specifications along with duration and lift. If it isn't given, it can be calculated. Advancing or retarding a camshaft from its designed centerline is not recommended because it will cut down on the overall efficiency of the engine (although there are exceptions to this general rule).
5. Before installation, the camshaft and tappets should be liberally coated with Mopar Engine Oil Supplement. This lubricant will stick to the surface without draining off and will prevent scuffing when the engine is fired up for the first time. It has been determined that this is when most camshaft damage takes place.

CAMSHAFT INSTALLATION TROUBLESHOOTING

For a performance enthusiast and an engine builder, installing a camshaft is one of the most common operations. Camshafts are changed frequently and for many reasons. It's just about the most popular thing to do to an engine.

We have discussed how to centerline your camshaft for many years. We put the instructions on the back of our degree wheel (P4452990). We put the instructions on the back of every camshaft card that goes into every camshaft package we sell. We recommend that you use the camshaft centerline method when installing the camshaft. We explain what this method is and how to do it. (You need two tools: and degree wheel and a dial indicator.) Getting the camshaft into the block is NOT the problem. The problem comes when we attach it to the crankshaft. This is why we talk about "centerline" (the relationship between the crankshaft and the camshaft).

In the past few years we have learned that there are no problems with the camshaft. There are no problems with the instructions. Problems typically occur because the instructions "were lost." Another problem is using the "no tools" approach (no degree wheel or dial indicator). Bad plan! A degree wheel is very inexpensive and very easy to obtain. Dial indicators can be borrowed or rented.

Here are some simple guidelines you should always follow whenever possible:

1. Always centerline the camshaft.
2. If you are not going to use a degree wheel and dial indicator, DO NOT use multi-keyed sprockets or sprockets with offset bushings. If you already have a multi-keyed sprocket or offset bushing camshaft sprocket, then get a new sprocket set.
3. With a stock, single key sprocket, line up the dots as best you can.
4. If the engine runs poorly, DO NOT blame the camshaft. Obtain a degree wheel and a dial indicator and find the actual TDC and camshaft centerline. For more information, refer to *Camshaft Centerline*, later in this section.

SPECIAL CAMSHAFT THEORIES

Camshaft Duration

We have all discussed camshaft duration at one time or another. Duration is commonly used to describe any given camshaft. "It's a 280 degree camshaft," is a typical statement. In the past, we have discussed duration relative to using it as the method by which to choose a camshaft. The conclusion was that duration is the *poorest* specification to use for selection purposes. Lift is the most valuable camshaft specification.

Then we have "duration at 50." This is commonly used in reference to race and other aftermarket camshafts. Production camshafts use an "advertised duration" to refer to their camshafts. Advertised duration is also used by all the aftermarket camshaft grinders for virtually all camshafts with less than .600" to .650" lift (at the valve).

This is beginning to get confusing! We have more durations than we know what to do with. So to this end, let's *see* what we really know about duration. First, duration is measured in degrees. Second, camshaft duration is generally a number that's greater than zero but less than 360. Third, there are two crank degrees for each camshaft degree. (To simplify, we'll consider everything in crank degrees.)

This duration topic isn't as easy as you probably thought! With our camshaft selection hanging in the balance, let's examine a typical camshaft card and see if we can gather some more data. An aftermarket camshaft card will list information similar to the following: lift, advertised duration, duration at 50 (.050"), overlap, centerline, intake opening, intake closing, exhaust opening, exhaust closing, and valve spring requirements.

Intake and exhaust opening and closing points are given in degrees. These four numbers are generally considered the *events*.

Overlap is the relation between the intake and exhaust lobes, and *centerline* is the relation of the intake lobes to TDC (top dead center) or to the exhaust lobe. In either case, although they are both measured in degrees, neither overlap nor centerline is specifically "duration."

To help define duration, let's focus on the intake lobe (we could have selected the exhaust lobe). Looking only at the intake lobe, one of the unique features of duration becomes obvious; that is, the sum of the intake opening, the intake closing, plus 180, equals the duration. Therefore, if the intake opens at 30 degrees BTDC (before top dead center) and closes at 50 degrees ATDC (after top dead center), then the duration is 260 degrees (30 + 50 + 180 = 260).

Intake Duration = I.O. + I.C. + 180

The same basic equation also works for the exhaust side:

Exhaust Duration = E.O. + E.C. + 180

What's different about the exhaust lobe is when the event occurs; for example, the exhaust opens BBDC (before bottom dead center) and the exhaust closes ATDC. (Refer to Figure 4-23.)

Looking at Figure 4-23, we can see the layout (plot) of a typical camshaft with the intake and exhaust lobes shown. You can tell it's a fairly mild camshaft because it has just under .300" lift (.450" at the valve). This plot shows the overlap and centerline relationships to TDC, but we're concerned with duration.

In simple form, duration is the width of the "hump" of the bell-shaped curve at a given lift point. The further up (height) you go from the "zero" lift line, the narrower the curve gets. To explain, draw a straight line from the .100" lift mark on the left. Where this line intersects the curve gives us the timing events. (Refer to Figure 4-24.)

On the exhaust lobe, these points are E.O. = 30 BBDC and E.C. = 30 BTDC. Applying a little math we find that this lobe's duration at .100" is 180 degrees. Drawing a similar line from the .050" lift mark yields these events: E.O. = 40 BBDC and E.C. = 20 BTDC. Therefore, duration at 50 (.050") = 200.

This comparison shows the many aspects of duration. It can be measured at any lift that you'd like. It could be .020", .050", .100", or any other number. The duration at .020" is larger than the duration at .050". The duration at .050" is larger than the duration at .100".

Advertised duration is a little more complicated. It is generally measured between zero lift and .025" lift. However, it is not a constant. Different manufacturers use different numbers. Generally, this number is determined by the computer software that generates the curve (i.e., lift table). Since most aftermarket and OE manufacturers use somewhat different computer software programs, the advertised duration number comes out different even if the actual profiles are the same. Generally, the advertised duration is larger than the duration at .050".

Going back to our earlier discussion, intake and exhaust opening and closing event numbers aren't the same between advertised and .050" duration numbers. However, most aftermarket manufacturers are consistent with their numbers; for example, 1.0. at 30 degrees and .050". If you're not sure, simply add the numbers for the events and compare to the two duration numbers.

We hope this helps you to understand duration and why there are so many duration numbers. However, always keep in mind that duration is not as good as lift for comparing or selecting camshafts.

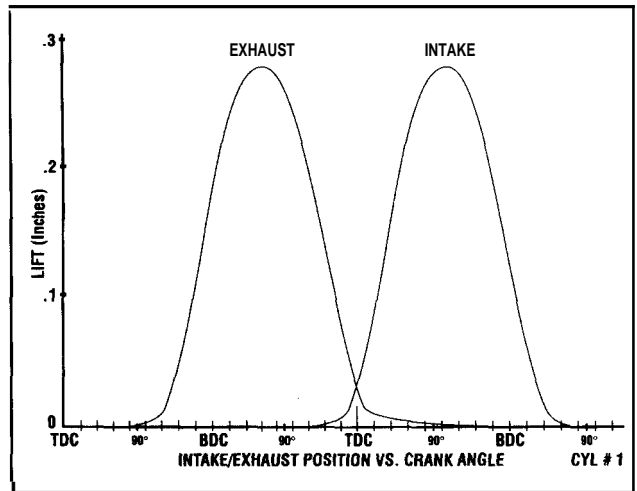


Figure 4 - 23

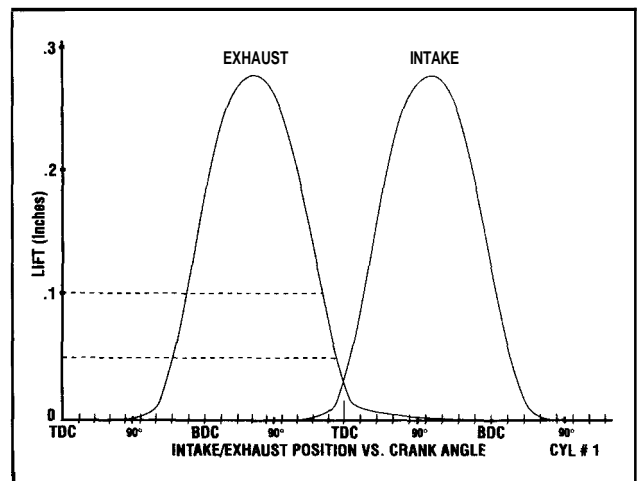


Figure 4 - 24

Camshaft Centerline

There are three ways of checking a camshaft for correct installation. A common method is to "line-up-the-dots." This is acceptable for standard vehicles, but is not recommended for performance camshafts. A second method, recommended by many shops and some camshaft grinders, is to check the intake and exhaust valve opening and closing events against TDC (top dead center). This is better than the "dots" system, but we don't feel it's as accurate as the "centerline" method. The centerline method is also much easier to understand.

If you're going to swap camshafts, you've spent good money for a new camshaft and you want to improve on the stock one or whatever is currently in the engine. If you DO NOT centerline, then you DO NOT get the full value of your investment and you probably won't achieve the desired improvement. Once the engine is disassembled to the point of installing the camshaft, centerlining the camshaft costs very little and only takes a few minutes to do. If you have a problem with the engine's performance after assembly, you will ultimately need to centerline the camshaft. Centerlining may be a minor problem of a few degrees or a major problem of a tooth or two on the camshaft sprocket. Usually the problem isn't with the camshaft itself, except relating to installation; i.e., centerline. By centerlining the camshaft at installation, you can concentrate on carburetors, ignition, and assembly problems (such as gasket leaks) to identify any problem. But if you didn't centerline the camshaft, you can't say for sure that it is the carburetor, ignition, etc. To centerline the camshaft with the engine together requires partial disassembly. This is a lot of extra work. One added benefit of centerlining relates to advancing or retarding the camshaft for improved performance. You don't know which direction or the number of degrees to change if you don't know the original centerline first.

Note: When checking camshaft centerline, ALWAYS rotate the engine clockwise from the front. This is the normal direction of engine rotation. By rotating the engine in this manner, the clearances in the camshaft drive system (chain, sprockets, keys, etc.) will be taken up just as they are when the engine is firing, and your measured camshaft centerline will be what the engine sees when it is firing.

The procedure is as follows:

- With the camshaft in place, insert the intake valve tappet for the No. 1 cylinder.
- Place a dial indicator on the tappet parallel to the tappet centerline or on the retainer parallel to the valve centerline.
- Install a degree wheel (P4452990) so its pointer indicates TDC when the No. 1 piston is at TDC.
- Turn the engine over (clockwise from the front) until the dial indicator is at maximum camshaft lift. Zero the indicator at this point.
- Turn the engine over (clockwise from the front) until the indicator reads .025" *before* reaching maximum lift. Stop. Read the degree wheel and write down the number of degrees. Continue rotating the engine in the same direction (clockwise) past maximum lift (zero indicator reading) until .025" is read again on the indicator. Stop. Read the degree wheel. Write it down. Add the two degree wheel readings and divide by two. The answer is the camshaft centerline.

Note: The .025" was used for illustration. Any measurement above .020" is acceptable.

Example: Let's assume that you are going to use a camshaft with a centerline of 110". Now let's go through the installation procedure with this camshaft. We'll install this 110" camshaft at 108" centerline.

The camshaft and timing chain or gear drive are installed. The lifter is installed on the No. 1 intake lobe. The degree wheel is bolted to the crankshaft and set to read TDC correctly with a pointer. The dial indicator is zeroed at the maximum lift of the camshaft. Now, rotate the engine clockwise and approach the indicator reading of .020" carefully, since you must not reverse the direction of rotation. At .020" the degree wheel reads 90". Record the reading and continue to rotate the engine clockwise through zero until the indicator reads .020". The degree wheel now reads 134". Add 90° plus 134° and divide by two. Answer: 112". Thus, you must advance the camshaft 4" in order to have the centerline at 108". Offset bushings (P3690936) are used for this purpose. (360 AMC V-8 engines use offset keys.) Use the proper offset bushing (or key) so that the centerline of the camshaft is moved forward (advanced) in the direction of its rotation.

Now repeat the steps with the advanced camshaft position. You should read 86° at .020" before maximum lift on the indicator and 130° at .020" after maximum on the indicator. Add 86° to 130°. Answer 216°. Divide this by two. Answer 108°. The camshaft is now installed correctly. If .040" was selected instead of .020" for the indicator reading, the last step would be as follows. You would read 70° at .040" before maximum lift and 146° at .040" after maximum lift. The two numbers added together yield 216° and this divided by two gives 108°.

Note: Changing the camshaft centerline 1° will not be seen in engine performance.

If you DO NOT have a degreed damper, damper degree timing tape (P4.529070) is recommended.

Damper Degree Timing Tape

Improve timing accuracy of your engine with this timing tape package. Marked in 90° increments. Self-adhesive strip adheres to crankshaft vibration damper for clear identification of marks. Permits initial total spark advance up to 60° instead of only 10°-15° as on chain case timing tab. Works on all 7-1/4" diameter non-grooved vibration dampers.

P4.529070 Damper degree timing tape.

TDC Indicator Tool

This is a handy, positive-stop tool for determining exact Top Dead Center (TDC) when centerlining camshafts. This tool, of hardened steel, is extremely accurate and can be used on all DaimlerChrysler engines. It takes the guesswork out of finding TDC.

P4349737 TDC indicator tool.



I. Degree Wheels

Building a new engine (or rebuilding an old one) typically means installing a camshaft or checking things such as TDC and camshaft centerline. These operations will require a degree wheel to do accurately.

The most popular use of degree wheels is for centerlining camshafts. Secondary uses related to TDC and setting valve lash are very straightforward and tend to use the "0" position, or TDC, and the point 180 degrees from zero; that is, there are no calculations.

However, calculations are required to find the camshaft centerline. This brought about a unique feature of the Mopar Performance Parts degree wheel (P4452990). Most degree wheels on the market are numbered 0-90-0-90-0. The Mopar Performance Parts degree wheel is 0-90-180-90-0. The reason for this is camshaft centerlining. A typical camshaft centerline is 108 degrees. On the ordinary degree wheel, the actual position is 18 degrees past the 90 degree point, or an actual degree wheel reading of 72 degrees. Confused? Confusion on this is very common and is another place for errors, which you don't want when you're installing the camshaft. The Mopar Performance Parts degree wheel will read 108 degrees directly. Also, using .035" below maximum lift as the measuring point, the typical

centerline measurements of 70 degrees and 146 degrees (that is, $70 + 146 = 216 \div 2 = 108$) will read directly. This feature should make camshaft centerlining easier to understand and execute correctly. The Mopar Performance Parts degree wheel also has instructions printed on the back side.

That doesn't look too tough—right? For fun, let's run through the same measurements using a non-Mopar Performance Parts degree wheel. The first measurement will stay the same at 70. But the second measurement will now be 34 degrees on the 0-90-0-90-0 style wheel. Now what do you do? Add the two readings and divide by two. That gives 104 divided by two, which is 52. But we know that the correct centerline is 108 degrees. Confusing, isn't it? Now you can see some of the advantages of the 0-90-180-90-0 Mopar Performance Parts degree wheel.

Degree Wheel

Durable Mopar Performance Parts aluminum plate, 0°-90-180°-90-0° degree wheel for centerlining camshafts. Features step-by-step installation instructions printed on back side.

P4452990

Degree wheel.

2. Offset Camshaft Bushings

We have our engine built and we're off racing. We now find some little problems. The vehicle doesn't launch as hard as we thought it would! Maybe the camshaft is too big or at least seems to be! Now what do we do? The usual solution to these problems is to change the camshaft centerline. This is physically accomplished by using an offset camshaft device.

Once the camshaft manufacturer machines the drive end of the camshaft, the "straight-up" position can't be easily changed. You can always have the problem of being a "tooth off," but that's an installation mistake. We'll assume that we centerlined the camshaft properly and everything is where the manufacturer recommends it. As mentioned, after we run the vehicle we may find that we want to change the centerline (advance or retard) to improve the performance of our specific package. There are two basic methods: offset keys and offset bushings.

Jeep 4.0L and 2.5L engines use offset bushings. (The 360 AMC V-8 uses offset keys.) The relationship of the camshaft drive to the camshaft is controlled by a dowel pin in the end of the camshaft. This dowel pin fits into a hole in the camshaft sprocket and properly locates the camshaft. If you want to change this relationship you use an offset bushing. To do this you drill out the sprocket hole to the outside diameter of the bushing and insert the bushing into this hole. The inside diameter of the bushing fits over the dowel pin. With this system you do need a zero offset bushing to get back to standard. These offset bushings come in package P3690936.

Camshaft Offset Bushing Set

For centerlining camshafts, all engines. Includes five bushings: 2, 4, 6, and 8 degree offset, plus one on-center bushing. Installs in camshaft sprocket. For all Jeep 4.0L and 2.5L engines.

P3690936 Camshaft offset bushing set.

Calculating Duration at Fifty

Many engine wizards and scientists discuss camshafts in terms of "duration at fifty" (actually .050" or fifty thousandths). This is acceptable for roller/race camshafts with lifts over .620" and/or advertised durations over 320 degrees. For hydraulic and small mechanical camshafts it has little value and, if used, will almost surely lead to selecting the wrong camshaft. As a camshaft selection specification, it rates last! It can be very valuable for race camshafts, but small camshafts are better off using lift and advertised duration, or even overlap.

All this aside, some racers still want to know what the duration at fifty is. We haven't published it because it has no value and will lead the racer to select the wrong camshaft. However, in an effort to satisfy the "scientist" in all racers, we're going to give you an equation that you can use to calculate the duration at fifty for our various small camshafts. (It does not apply to camshafts with over .620" lift.)

To calculate the duration at fifty number for a production camshaft, you multiply the advertised duration by .777. For a Mopar Performance Parts camshaft you multiply the advertised duration by .850. For example, a production camshaft with an advertised duration of 260 degrees has a calculated duration at fifty of 202 degrees. Keep in mind that if you use this information to select a camshaft for your engine you are almost guaranteed to get the wrong one! This information is "for reference only," as they say in engineering!

Base Circle

The term "base circle" describes one of the characteristics of camshafts. Because the base circle does not directly contribute to the horsepower potential of the camshaft/engine combination, it is a term that isn't well-known or understood. Duration, lift, and overlap are the "popular" terms.

In reality, the tappet (cam follower) spends more time on the cam's base circle than it does lifting the valve. Also, whenever you discuss camshaft lift or lobe lift, you are indirectly discussing the base circle. The nose height or maximum lift of the camshaft lobe/profile is generally understood and can be pointed out on an actual camshaft to a beginning "student" by most of us "knowledgeable racers."

The base circle is located 180" (or the opposite side) from the nose of the camshaft. The lobe lift or camshaft lift is defined as the difference between the nose height and the base circle.

Let's look at several examples of how to use the cam's base circle.

First let's look at a 300 degree duration camshaft (advertised, not at .050"). We know that the camshaft rotates at 1/2 the crankshaft speed, or that the crankshaft rotates twice for one revolution of the camshaft. Camshaft duration numbers are given in crankshaft degrees. This means that our 300 crankshaft degree camshaft really has a lobe that extends around the camshaft for 150 degrees (300 divided by 2). Since a full circle has 360 degrees, the base circle on our 300 degree camshaft extends for 210 degrees (360-150). Miscellaneous trivia: the 210 degree base circle is larger than the 150 degree camshaft lobe profile that lifts or opens the valve.

Second, the base circle is measured as a "height" or distance from the center of camshaft. On a typical V-8 camshaft (for example) this height might be .750". If this camshaft had a lobe lift of .333" (valve lift of .500"), then the nose height would be 1.083" (.750 + .333). This height would also be measured from the center of the camshaft. The important thing to remember is that the nose height basically doesn't change for any given engine. The base circle has to change from one lift profile to another.

This oddity of the nose height staying constant and the base circle changing is caused by a special physical condition in overhead valve engines. The nose of the camshaft must fit in through the camshaft bearings in which the camshaft journals ride. This essentially defines the maximum height of the nose of the camshaft. If the nose height were any higher, it couldn't be installed through the camshaft bearings. (This is not a problem on overhead camshaft engines.)

Question: If the nose of the camshaft can't be increased, then how are higher lift profiles made? Answer: By grinding down the base circle. There really isn't any other choice. This may sound bad for high lift camshafts, but even a .750" lift, all-out race hydraulic camshaft only requires the base circle to be actually "cut-down" .160" from a .500" lift.

There is one small error in this discussion that can lead to confusion. We converted our 300 degree camshaft (advertised) to 150 camshaft degrees and compared it to the 210 degree base circle. A 300 degree camshaft is typical of high performance hydraulic or a mild mechanical camshaft. However, we left something out to simplify the discussion. We left off the ramps!

Although not the same, hydraulic and mechanical camshafts both have ramps. Ramps are defined and designed differently by different manufacturers and for different applications. They could run 20 to 30 degrees per side which adds to the cam's physical duration and increases it to 170-180 degrees. This makes the base circle and the "lift" profile itself almost equal in duration. This sounds like a small detail, but it should not be passed over too quickly. Remember, our example is basically a mild, high performance hydraulic design, perhaps 235-240° duration at .050".

Many people in the field like to check the cam's lift outside of the engine by using a dial vernier (or micrometer) and measuring across the nose and across the flanks (sides). Actually, they measure from the base circle to the nose of the camshaft. In our example, this measurement would be 1.833" (1.083 + .750). In theory, the steps of measuring across the sides would measure from base circle to base circle. In our example, this would yield 1.500" (.750 + .750). If we subtracted these two numbers, we'd get the cam's lobe lift (1.833 - 1.500 = .333"). *Numbers can be magic!* Nice theory, and it actually works well on stock camshafts. However, in high performance designs, we have a small "built-in" error.

In the second measurement (across-the-sides), we actually measure from ramp to ramp. By nature, the ramp moves or lifts slowly so we may only be picking up .010" per side for the ramp lift. In more radical camshafts, this number gets much higher. In our mild example, the .010" ramp error would mean that we measured from .760" (.750 + .010) to .760 or a total measurement of 1.520". Now this doesn't seem like much of an error, so why the big fuss?

The problem comes about relative to the camshaft lift calculation. In our example, we'd now incorrectly calculate that the cam's lift is .313" (1.833" - 1.520"). Still not sure why so small an error is important? The whole reason for making these measurements is to identify the camshaft. In many cases, we don't know what the actual lift is. We are trying to use the actual, measured lift to identify the camshaft. Therefore, we'd multiply the measured camshaft lift by 1.5, and find that the camshaft has .470" (.313 x 1.5) of valve lift. Comparing this to a camshaft lift table, we'd pick/identify the wrong camshaft.

Note: Always measure a performance or race camshaft with a micrometer to ensure accuracy.

VALVE GEAR

This section is designed to tie all the valve gear information for the 4.0L Power Tech engine together in one place. The valve gear—especially camshaft and valve spring selection and their effect upon the remaining components—is one of the most important areas in the performance of your engine next to the induction system. The valve train area has been expanding rapidly in recent years which has led to a lot of confusion. Deciding what piece to use, where and with what other parts has become very complicated. Add to this the similar parts available from Mopar Performance Parts, Crane, Competition Cams, Isky, etc., and it becomes almost hopeless to sort it all out.

In this chapter we will concentrate on the 4.0L Power Tech engine which is a wedge. We will stay strictly in the valve train area. Related subjects and areas such as engine blueprinting and individual engine part numbers and specifics are covered in separate sections.

Some of the information that will be covered has been stated in other sections of this book. Valves, cylinder heads, and camshafts are closely related areas, and much of the information overlaps. We will put all this currently published information together in this section. We'll also add some new parts, part numbers and information that have become available, but things are changing quickly. Please keep in mind that the information gathered in this section contains the latest recommendations and that other (older) sources may differ.

General Valve Gear

We will begin by familiarizing ourselves with the general valve gear or valve train system. Valve gear is generally divided into two separate groups: hydraulic and mechanical.

1. Hydraulic Valve Gear

The hydraulic valve gear is usually production or standard on any particular engine (such as the 4.0L). The parts that are unique to the hydraulic valve gear are the stamped steel rocker arm, the double-male pushrod and the hydraulic lifter.

Jeeps have a unique hydraulic valve gear arrangement that could be considered a *ball stud* valve gear arrangement. Though not to a great extent, this ball stud valve gear allows Jeeps to have some adjustment in the valve gear via the unique twin rocker/pushrod arrangement.

2. Mechanical Valve Gear

The second group of valve gear is generally lumped together under the "mechanical" heading. It could also be called adjustable valve gear because the major visual difference of this group is the adjustable rocker arm. This would be descriptive but somewhat of a misnomer since adjustable rocker arms can be used with a hydraulic camshaft. However, it is mandatory that mechanical camshafts use adjustable rocker arms. Mechanical valve gear is also used with roller camshafts.

Valve Gear Selection

Once the camshaft and valve spring are selected, the rest of the valve gear can be selected. The camshaft, whether hydraulic or mechanical, will select the lifter, pushrod and rocker arm. The valve spring will dictate the valve seal. The only independent left is the valve. This is also selected by application. (Refer to *Valves*, later in this section, for complete information.)

Note: The full valve gear must be considered if the camshaft is to be changed. Whether the camshaft is to be changed or not is left up to the individual to decide.

VALVE GEAR PERFORMANCE AND ASSEMBLY TIPS

1. If mushroom lifters are to be used, install them and check to see that they all hit the surface which you ground evenly on the bottom of the lifter bore. There should be no high spots. Also, check for clearance to the camshaft bearing shell. Grind clearance notch in the camshaft bearing where required.

2. If roller lifters are to be used, the bar (or other locating device) should be checked for block clearance after installation. Some roller lifter setups require block grinding to allow the two lifters and bar locator to go up and down freely.
3. Valves should be measured to be sure they are the proper size and should be inspected for flaws or other damage. Measure the actual outside diameter of the valves to be used and record the information.
4. Valve springs should be load checked. Weak ones will have to be replaced. Record loads and height checked at.

Note: Not all spring testers are the same. Many are not maintained and calibrated on a frequent basis. This makes the absolute value of spring loads quite unreliable. However it is a very good comparative tool; i.e., measuring all springs on the same tester or measuring the same spring new and used. The bigger advantage of load checking is to see if the springs have "gone away" or to see if a second set of the same spring is as "strong" as the first set which worked well.

5. With the valves, keepers and retainers installed, check the valve spring height. This should be compared to the spring load information and the correct thickness shim chosen to get the same installed spring load on each valve. Spring installed height must be carefully controlled to avoid "coil bind" by providing at least .100" more height at maximum valve lift than the solid height of the spring.
6. With the same spring height setup as #5, measure the outer valve spring height, the inner valve spring height, and the keeper-to-valve guide clearance. The camshaft lift (lift of the camshaft measured at the lobe or lifter) multiplied by the rocker arm ratio plus .050" should be less than the keeper-to-guide clearance in the valve closed position or the guide will have to be shortened. Measure the "solid height" of both the inner and outer springs. This solid height plus .100" plus the valve lift (camshaft lift multiplied by the rocker arm ratio) should be equal to or less than the installed height for each spring.



7. Check rocker arm-to-valve tip relationship for alignment. Improper alignment can place undue side loads on valves, causing rapid valve guide wear.
8. Check valve tip for scuffing or high wear.
9. Check the pushrods for straightness and for length. If they are too short, they can't be adjusted to work properly. If they are too long, they will over-angle the rocker arm and, with high lift camshafts, hit the bottom of the rocker.
10. With the camshaft in the block and the head installed, the actual valve lift measured at the valve retainer can be checked. The camshaft lift multiplied by the design rocker arm ratio should yield the valve lift. However, this is not the case in an actual engine. The actual rocker arm ratio will be less than the design rocker ratio, which is typically 1.5 for wedge engines. This will cause the valve lift to be less than the number that is calculated. This is due to the rocker arm ratio itself plus the effect of the geometry of the head. "Blueprinted" mechanical rocker arms (those with the exact design ratio) are available for most engines from various high performance machine shops.
11. With larger diameter valve springs and heavy duty mechanical pushrods used with high lift racing camshafts, it is common to have to grind retainer clearance and pushrod cup clearance on the rocker arm. The resulting notch should be kept to an absolute minimum because it weakens the rocker arm.
12. To optimize rocker arm geometry, a cut-to-length pushrod kit is recommended, but only to the very serious racer, or for engines with large amounts of head milling and block decking. Custom pushrod lengths are used to obtain ideal rocker arm geometry which allows the best performance from a given camshaft.

13. The proper adjustment (ideal) for a mechanical rocker adjusting screw is to have only one thread showing below the rocker arm with the valve lash set properly (two may be OK, three shaky, etc., but high rpm makes only one thread showing more desirable). This obviously requires custom length pushrods for every engine. If you've "smoked" your pushrods and you had all the threads showing below the rocker (i.e., pushrod is too short), more oil to the valve gear won't cure the problem. Only longer pushrods will do the job.

14. Write down all measurements made.

SPECIAL VALVE GEAR THEORIES

The valve gear is attached to the cylinder head and very closely related to it as part of the total performance team. There are several theories (engineering considerations) concerning the cylinder head-valve gear area that are interesting to discuss. Since each theory could have its own chapter, the discussion will be brief.

Valve Gear Oiling

Oiling the valve gear in a standard engine is virtually automatic, as long as the engine has oil pressure. In a modified, high performance engine it can be another story. When recommendations are followed, most racers will have no oiling problems. When oiling problems do develop, they generally manifest themselves as burned rocker arms, broken pieces, etc. Unfortunately, the pieces that look the worst aren't usually the cause of the problem. In the majority of cases relating to valve gear oiling, it's not a matter of what you should do, but what you should *not* do. The problems mentioned are the result of poor oiling, assuming the engine is being oiled properly; that is, no foaming, correct oil pressure, etc.

The first thing to check is to be sure a camshaft bearing hasn't "turned" so that its oiling hole(s) aren't lined **up** with the hole(s) in the block. Next, be sure the passage from the camshaft to the block's deck isn't blocked or restricted. This is usually done with a long handled bottle brush.

At the deck surface of the block it is common for racers to install a restrictor. **THIS IS NOT RECOMMENDED** and, if found, should be removed. If you have "smoked out" your pushrods or scuffed the valve tips, this is probably the cause. Next, check the head gasket and cylinder head for oiling hole alignment.

At this point you can have two different types of problems depending on whether your engine uses hydraulic rockers or mechanical rockers. A problem with hydraulics is most likely caused by an oil leak that prevents the oil from reaching the rockers. Spacers used between the rocker stand and the rocker shaft will, over an extended period, cause these problems because of leakage. Also, the rocker shaft could be installed incorrectly (upside down, reversed, etc.). Adjustable hydraulic pushrods can help solve length problems with hydraulic valve gear.

Problems occurring with mechanical rockers can be much more complicated. Since there is no need to put spacers between the rocker shaft and the pedestal, a leak there would be unusual. Rocker shaft installation is very critical. Banana grooves are usually added to mechanical valve gear shafts to improve oiling of the rocker itself. Bushed rockers are more tolerant of low oil conditions, but standard mechanical rockers should be adequate for most applications. At this point, with oil to the rocker, it must be distributed to the valve tip and the pushrod tip. Accomplishing this is very tricky. Exactly where and how these holes are located is very critical, and each engine is unique.

Valve Train Geometry

The valve train is everything that connects the valve to the tappet. *Valve train geometry* involves knowing where all these parts are located and how they fit together. Geometry itself is not easy to explain, even if you have taken math courses in college. Understanding geometry and applying it to an engine is even more difficult to explain. Although it is quite complicated to work out, DaimlerChrysler/Mopar valve trains are well sorted-out systems, as are most production systems.

Weight is very important to ultimate engine speed as are valve spring loads. Geometry itself can yield rpms with the same valve spring loads.

Valve train geometry directly affects valve train oiling which, in the long run, is the most important consideration. If the valve gear doesn't oil properly, you may smoke-out or bum the pushrod ends, valve tips, etc. Titanium valves or increased valve spring pressure will not solve these problems.

To help you, we have come up with several valve train geometry "tips." However, these tips are only to help you build your engine, they are not blueprinting (inspection) standards. Blueprinting standards apply to one part and one aspect of that part. As you begin to put various parts together, you have a problem that is called "stack-up of tolerances." Predicting, keeping track of, and controlling stack-up of tolerances is what good engine building is all about.

As stated earlier, valve train geometry is related to how parts fit together and where they are located; for example, the number of adjuster threads showing below the rocker arm, or the valve tip-to-rocker arm relationship. Although this may sound relatively straightforward, everything affects these relationships: the cylinder head, block, camshaft, valves, valve job, etc. Yes, you can make it perfect for each set of parts, but that would cost thousands of dollars. And you wouldn't go any faster! However, there are ways to cut down this expense.

You could hand select the block, head, etc., but the best solution is to use cut-to-length pushrods. Custom cut-to-length pushrods solve all these problems without all the expense. Pre-made pushrods work fine but, if you want an exact relationship (geometry) between the rocker arm and the adjusting screw, you'll need a cut-to-length pushrod kit.

The valve tip-to-rocker arm relationship isn't as easy. Usually the factory set-up is close. Valve lift is a big factor. Valve lengths and valve jobs also make a big difference. The cylinder head must also be considered. A little compromise is best used here. If the rocker arm pad is on the valve tip with the valve closed, and is still on the valve tip at maximum lift, consider yourself lucky. We don't recommend cutting the valve tip for any reason. It will remove the hardness on the valve tip and make it soft. With very mild camshafts and soft springs, the problem may not be as obvious, but it's there!

Dynamics

Dynamics is defined as the engine speed (rpm) potential of a given camshaft profile when used with a specific valve spring and valve gear set-up.

A high performance hydraulic camshaft in a 2-Bbl. engine might have an ultimate engine speed of 6,400 rpm, but with a high performance spring the engine speed becomes 6,900 rpm. Obviously a 2-Bbl. engine with a stock camshaft isn't going to go 6,400, which means the valve gear is better than the rest of the engine pieces. This is strictly a valve gear test. In many cases the ultimate speed may be 7,500, but false motion may occur at 6,000 or 6,500. The engine will not achieve the ultimate speed. In any case, the camshaft dictates the engine's output, and a valve spring must be chosen that will allow the camshaft to do its job.

A Super Stock engine might run 6,000 rpm while a Late Model engine might run 7,500 rpm—the same valve spring can't be used even if the camshaft is the same. Concentration on ultimate speed can lead to overkill results.

Note: Titanium valves are usually used to obtain *ultimate* engine speed, but this would be overkill in most cases.

VALVES

The 4.0L Power Tech engine standard production valves are made of heat resistant steel and have chrome plated stems to prevent scuffing. All valves use a three bead lock keeper to retaining the valve spring and promote valve rotation.

The important considerations when choosing valves are diameter, length, stem size, weight, number of lock grooves (Figure 4-25) and valve head shape or profile (Figure 4-26).

Jeep 4.0L Valve Specifications Chart					
Part Number	Location	Diameter	Length	Material	Modification
P4529212	Intake std.	Std.	Std.	Std.	Back-cut, 8 mm
P4529213	Exhaust	Std.	Std.	Std.	Back-cut, 8 mm
P5249875	Intake	1.92"	4.91"	Stainless	8 mm stem
P5249877	Intake	1.97"	4.91"	Stainless	8 mm stem
P5249879	Exhaust	1.50"	4.93"	Stainless	8 mm stem
P5249880	Exhaust	1.56"	4.93"	Stainless	8 mm stem

Length changes the installed spring height and rocker arm geometry. Stem size affects the guide. A smaller stem valve can be installed in wedge heads by installing the proper size valve guides. Smaller stem valves are lighter. Less valve weight increases the engine speed with a given valve spring, but weaker valves break in expensive failures. Therefore, lightweight valves are made of stainless steel or titanium material. Lock groove changes require new keepers.

That leaves valve head diameter and profile. Valve head diameter is selected by the performance desired as it is related to the other parts used. There are two basic valve head profiles: tulip and nail-head. See Figure 4-26. Actual production valves are halfway in between.

Wedge heads perform better with nail head valves. They also perform better if the valve seat is high in the head making the valve sit high. Sinking wedge valves hurts performance. The valve job should be done with only the minimum amount of material removed. One of the big performance advantages to oversize valves is that the seat can be brought up after it has been sunk by repeated valve jobs with the smaller valve. The valve tips should not be ground to shorten them or to even them up because the tip hardness is removed. If they are ground or cut, the tip should be rehardened or the valve tip will wear poorly and mushroom over.

In high output race engines we highly recommend installing bronzewall valve guides. If the head to be raced is a used piece, bronzewall guides are almost mandatory. Once the bronzewall guides have been installed, the valves and seats can be ground more accurately and held to closer tolerances (narrower seats, etc.) without sacrificing durability.

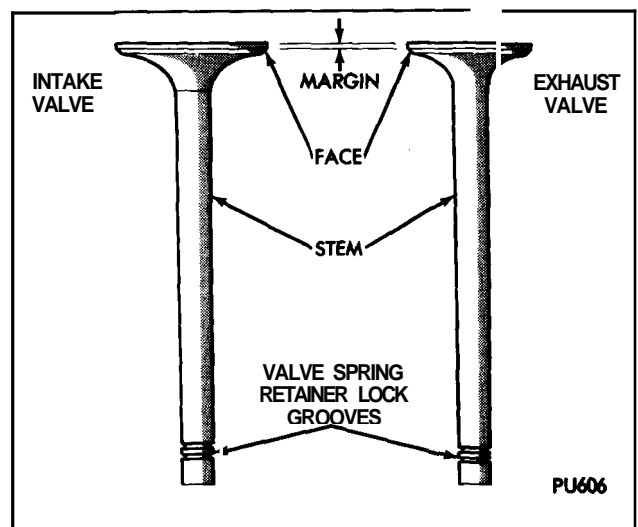


Figure 4 - 25

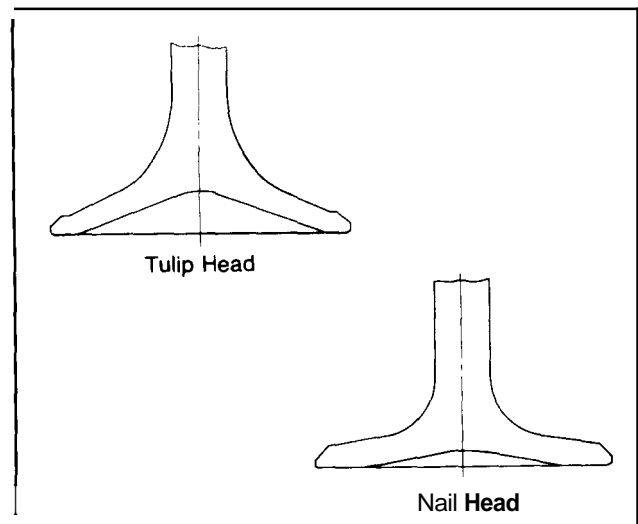


Figure 4 - 26

Stainless Steel Valves

After much research Mopar Performance Parts has introduced a new line of swirl-polished, stainless steel valves. Most wedge valves have a "ski jump" on the underhead part of the valve, which was best removed by backcutting. Our new valves DO NOT have this so you get better flow right out of the box! (Refer to *Jeep Engine Valve Specifications Chart* for more information.)

Better part, pay more money? Well, in this case Mopar Performance Parts was able to offer all these advantages and take about \$3 per valve out of the list price (and a similar cut in the dealer price). That's a price reduction of approximately 31 percent!

Valve Grinding (Valve Job)

It is very important that the following specifications are met: both seat and face angles for intakes and exhausts are 45°; seats should be .050" - .070" wide and kept as close to the outer edge of the valve as possible; seat approach angle is 70°. See Figure 4-27 for basic production valve job.

1. Basic Performance Valve Job

It is very important that the valve seat specifications shown in Figure 4-28 be carefully followed. If valve face and seat run-out is less than .0015", it is best to leave the seats alone until 50 to 75 hard runs have been made. Then, touch-up valves and seats according to the specifications. Remember that the further the valve seats sink into the ports, the less horsepower the engine will produce. Never sink valves to equalize combustion chamber volume. DO NOT grind the valves or valve seats excessively and DO NOT narrow the valve seats below specifications. (See Figure 4-29.)

2. NHRA Stock and Super Stock Valve Job

For a NHRA Stock or Super Stock valve job, the following rules apply:

The valve must be faced at factory specification angle, and the seat angle must also meet factory specifications. The valve seat may be narrowed from the top with any angle less than the seat angle, but not to exceed 1/4" larger than the valve head (see Figure 4-29). The seat may be narrowed from the bottom with up to a 70° angle. The maximum width for valve seat and bottom cut may not exceed 1/4" when measured together (top of seat to bottom of cut).

3. Bracket Valve Job

In bracket racing there are no rules regarding valve work, so we can have a special bracket valve job, sometimes referred to as a competition valve job. The valve part is relatively easy. Production wedge valves have a small ski-jump on their backside just below the seat itself. The back cut removes this (see Figure 4-30).

Backcut angles vary from 20 to 35 degrees depending on the engine. Backcutting the valve tends to make the valve seat narrower, for which we strongly recommend that bronzewall valve guides be installed in the head.

Modification of the valve seat in the head is not as easy to explain. The valve seat itself is 45 degrees, standard. The throat (or approach) angle is 70 degrees, but sometimes 65 degrees is used because the orbital grinder used to grind the seats occasionally will "chatter" at 70. The 70 degree cut in the throat removes a lot of material, which leaves a sharp edge where the cut transfers to the "as cast" port. (See Figure 4-30 and Figure 4-31.) This sharp edge should be removed very carefully with a hand grinder so that it blends smoothly into both the cast port and the 70 degree machined cut. It is very important to keep to a minimum the metal removed and to maintain the 70 degree cut, although it may be narrower than it was originally. Extra caution should be used on the port's "short side" to keep as much radius as possible.

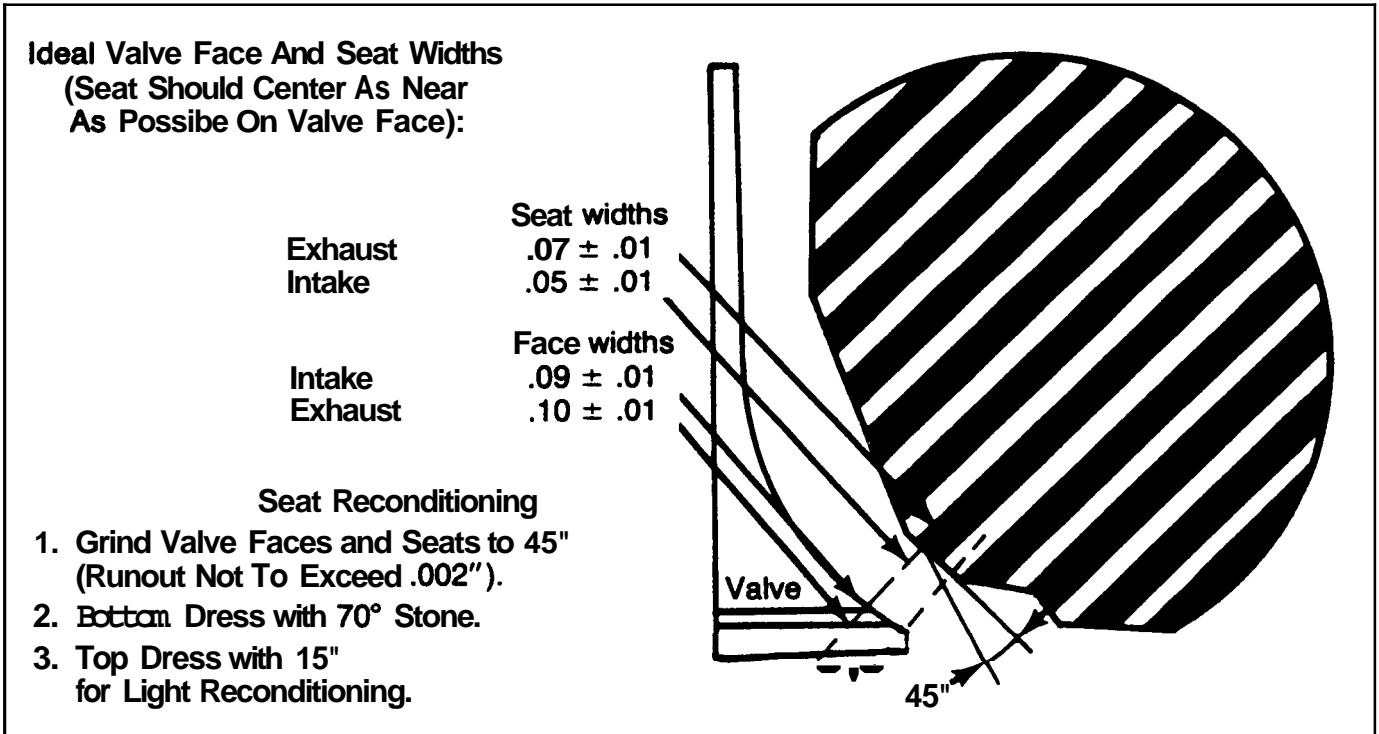


Figure 4 - 27

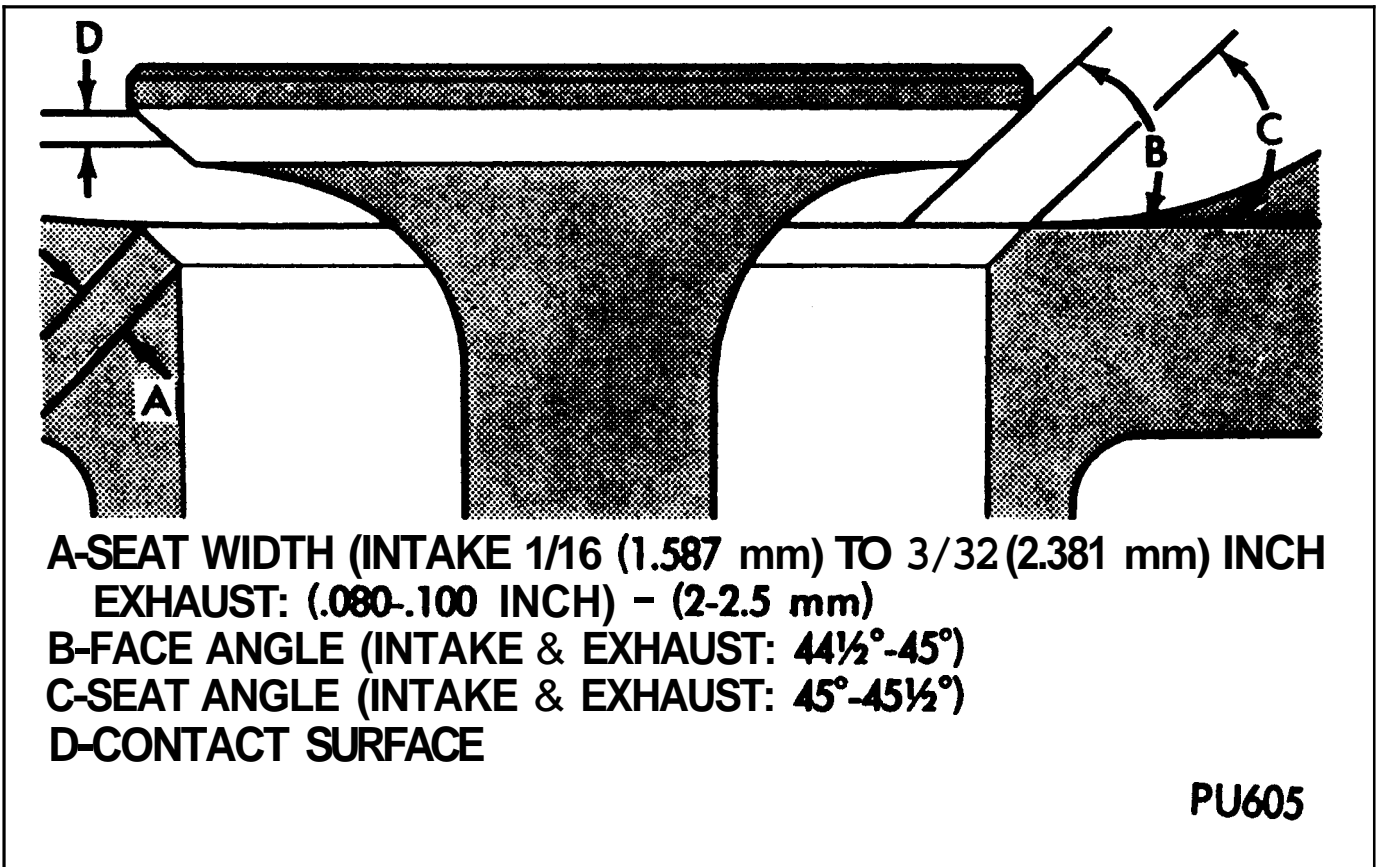


Figure 4 - 28

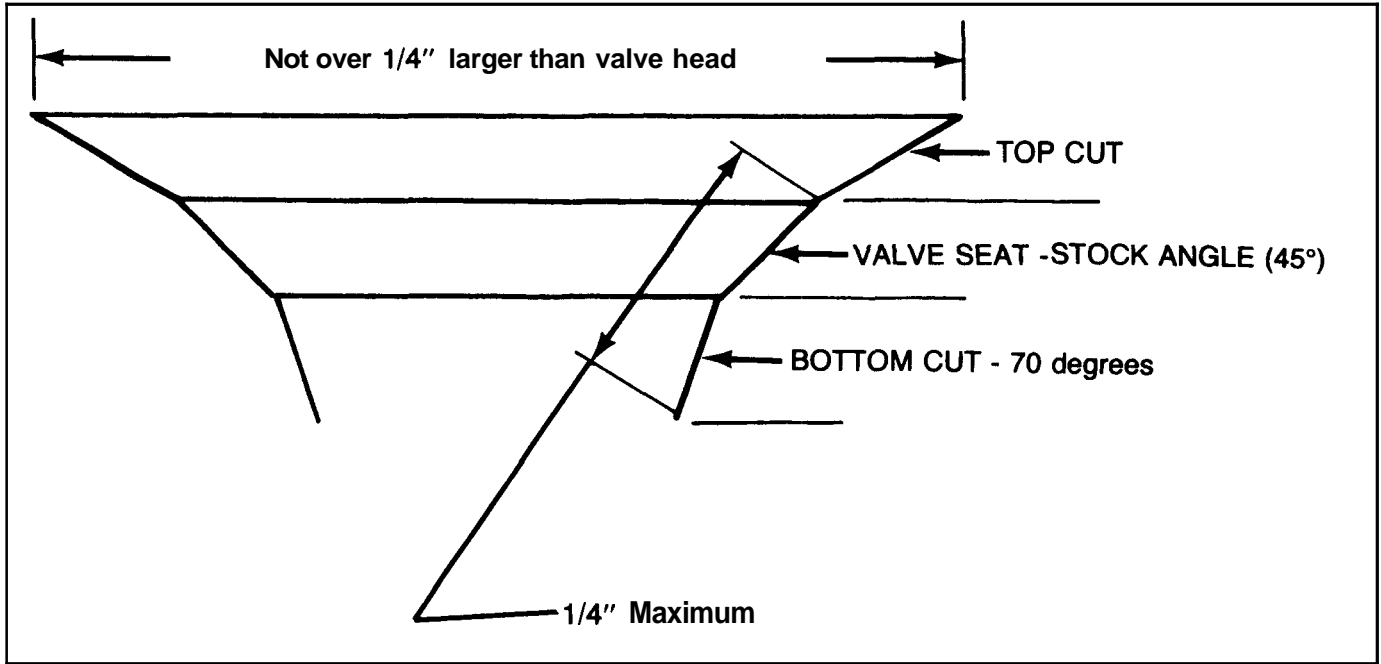


Figure 4 - 29

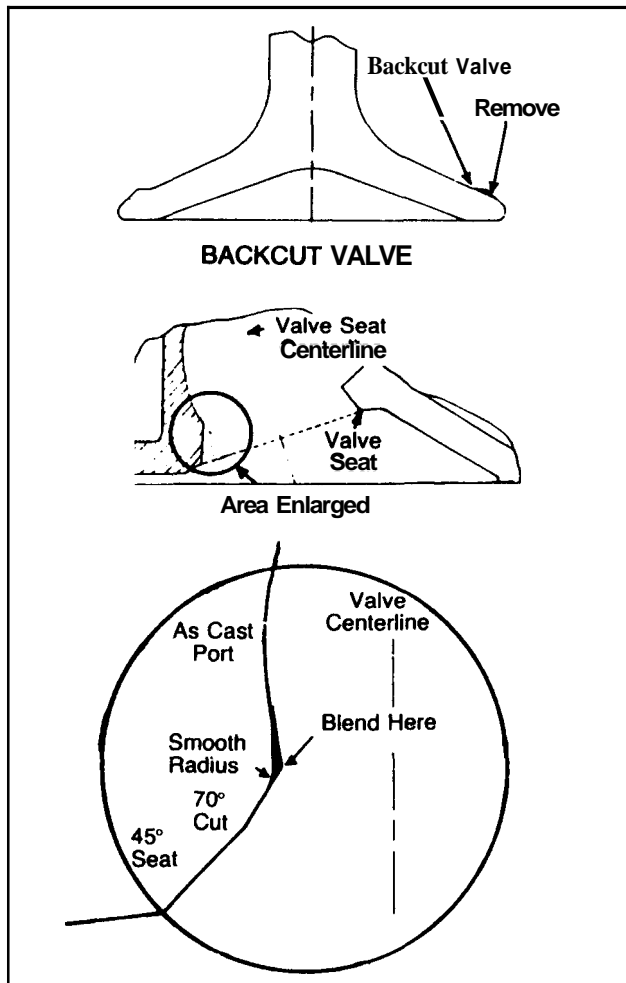


Figure 4 - 30

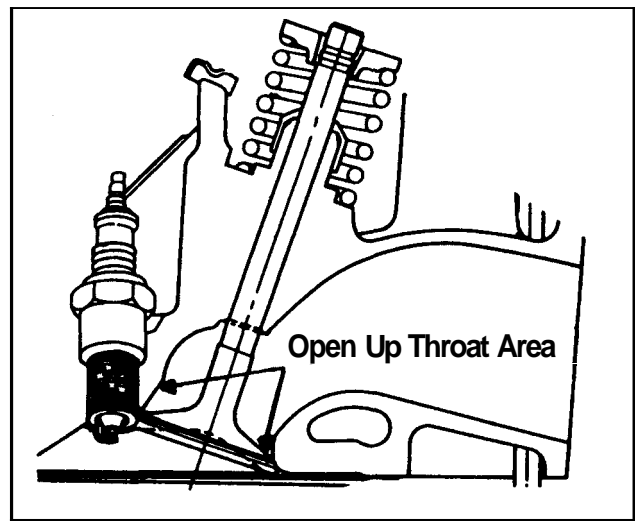


Figure 4 - 31

Valve Timing

1. Disconnect spark plug wires and remove spark plugs.
2. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
3. Remove the capscrews, bridge and pivot assembly, and rocker arms from above the No. 1 cylinder. Alternately loosen each capscrew one turn at a time to avoid damaging the bridge.
4. Rotate the crankshaft until the No. 6 piston is at top dead center (TDC) on the compression stroke.

5. Rotate the crankshaft counterclockwise (viewed from the front of the engine) 90°.
6. Install a dial indicator on the end of the No. 1 cylinder intake valve pushrod. Use rubber tubing to secure the indicator stem on the pushrod.
7. Set the dial indicator pointer at zero.
8. Rotate the crankshaft clockwise (viewed from the front of the engine) until the dial indicator pointer indicates 0.305 mm (0.012") travel distance (lift).
9. The timing notch index on the vibration damper should be aligned with the TDC mark on the timing degree scale.

If the timing notch is more than 13 mm (1/2") away from the TDC mark in either direction, the valve timing is incorrect.

If the valve timing is incorrect, the cause may be a broken camshaft pin. It is not necessary to replace the camshaft because of pin failure. A spring pin is available for service replacement.

Polished Valve Stems

For many years, we have told racers to polish their valve stems. This recommendation comes originally from Mr. Tom Hoover, generally accepted as the father of the 426 Hemi. His quote was, "Like a mirror!" This process is quite simple and doesn't take very long. You start with very smooth sand paper—400 to 800 grit. Then you move up to finer cloths. Remember, you don't want to remove any material, you just want to make the stem smooth. You can start the process by hand, but a drill press or similar machine is generally used for the final polishing. Care should be exercised to make sure that the valve is securely chucked in the drill press and at the same time no marks are left in the valve stem by the drill press chuck jaws. This should be done to every valve prior to installation.

For most of us, this is just good engine building procedure. For some of us, it may reduce valve guide wear, increase cylinder head and engine durability, and reduce oil consumption. In rare cases it even keeps valve guides from being destroyed, which would also destroy valve seats resulting in a very expensive head repair or replacement.

Valve Stem Lash Caps

Mopar Performance Parts valve stem lash caps have the following features:

- Hardened steel for improved rocker tip durability
- Fit between the end of the valve and the rocker arm tip
- Larger area than stock valve tip to help spread the rocker loads
- Sold in sets of 16 pieces

Valve Stem Lash Caps

P4120626	Valve stem lash caps, 3/8" stem.
P4120635	Valve stem lash caps, 5/16" stem.
P4529839	Valve stem lash caps, 11/32" stem.

VALVE STEM OIL SEALS

Most expensive, professional race car engines don't use valve stem oil seals because they are rebuilt after every race. For the rest of us, valve stem oil seals are very important. The 4.0L engine standard production valve stem oil seals are made of rubber and incorporate a garter spring to maintain consistent lubrication control.

Valve stem oil seals control oil flow down the valve stem. If they fail to do their job, oil will get into the combustion chamber. This will cause your oil consumption to go up. Oil is poor fuel, so burning it in the combustion chamber will lower the amount of heat made in the combustion cycle and therefore lower the amount of power made. Oil is also a poor fuel in that it lowers the overall octane of the fuel mixture in the combustion chamber and can cause detonation problems. Detonation problems can lead to spark plug fouling, which may be misinterpreted as an ignition problem.

For anyone but the "pros," a valve seal should be used. The question is, which one? The keys to answering this question are the valve spring and the camshaft.

The best valve seal is the Mopar Performance Parts Viton seal (P4529240). It is called an "umbrella" seal. It is made of a special high temperature Viton rubber and slips over the valve stem. The "umbrella" drops over the top of the valve guide. This requires the inside diameter of the seal to be larger than the outside diameter of the valve guide. In this manner, the seal shrouds the valve stem from the oil. However, the larger outside diameter of the seal means that it can't be used with dual valve springs.

If you use dual valve springs, you have to use a Perfect Circle race seal. It attaches to the top of the valve guide itself. Therefore, the guide may have to be sized to get the seal to fit properly. Unlike the umbrella seal which moves up and down with the valve, the Perfect Circle race seal doesn't move. The valve stem slides by and the seal "wipes off" the oil. Since umbrella seals have no relative movement to the valve stem, they are used in production engines for maximum mileage/durability. The Perfect Circle seal is not used in production engines but is recommended with dual springs.

Valve stem size is the major determining factor when selecting valve stem seals. All standard production 4.0L valves (including oversize) are 8 mm stem. For a single spring with damper, use heavy duty Viton seals (P4529240). They work well for camshafts up to .510" lift.

For camshafts with more lift (over .510"), a dual spring is required. Viton seals can't be used with dual springs because there's not enough room; Perfect Circle seals (P3690963, P4876099, P4876100) must be used. They are not as durable as Viton seals; however, with new bronzewall valve guides, they are acceptable.

Replace valve stem oil seals whenever valve service is performed or if the seals have deteriorated.

Race Valve Stem Oil Seal Sets

Perfect Circle valve stem oil seals for use with dual valve springs in race applications. Set of 16 seals. Includes installation tool.

P3690963	Race valve stem oil seal set, 3/8" inside diameter.
P4876099	Race valve stem oil seal set, 11/32" inside diameter.
P4876100	Race valve stem oil seal set, 5/16" inside diameter.

Viton Valve Stem Oil Seal Set

Viton heavy duty umbrella seals are specially designed to withstand high temperatures. Helps prevent oil seepage down valve guides. Good for dual purpose high performance engines. Includes 6 intake and 6 exhaust seals. Not recommended for dual valve springs. Fits 4.0L engine valves with 8 mm stems only.

P4529240	Viton valve stem oil seal set.
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VALVE GUIDES

Valve guides are an integral part of the cylinder head and are not replaceable; however, they are serviceable.

When the stem-to-guide clearance is excessive, the valve guide bores must be reamed to accommodate the next larger oversize valve stem.

Oversize stem service valves are available in 0.0762 mm (0.003"), 0.381 mm (0.015"), and 0.762 mm (0.030") stem sizes. Ream valve guide bores in steps, starting with the 0.0762 mm (0.003") oversize reamer and progress to the size required.

Valve Stem-to-Guide Clearance Measurement

Valve stem-to-guide clearance may be measured by either of the following two methods.

1. *Preferred Method*
 - a. Remove the valve from the head. Refer to *Valve Removal* section of this chapter for the procedure.
 - b. Clean the valve stem guide bore with solvent and a bristle brush.

- c. Insert the telescoping gauge into the bore of the valve stem guide approximately 9.525 mm (.375") from the valve spring side of the head with contacts crosswise to the cylinder head (Figure 2-67).
- d. Remove and measure the telescoping gauge with a micrometer.
- e. Repeat the measurement with contacts lengthwise to the cylinder head.
- f. Compare the crosswise measurement to the lengthwise measurement to determine out-of-roundness. If the measurements differ by more than 0.0635 mm (0.0025"), ream the guide bore to accommodate the oversize valve stem.
- g. Compare the measured valve guide bore diameter with the diameter listed in *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter. If the measurement differs from the specification by more than 0.0762 mm (0.003"), ream the guide bore to accommodate the oversize valve stem.

Note: Valve seats must be reground after reaming the valve guides to ensure that the valve seat is concentric to the valve guide.

2. *Alternate Method*

- a. Use a dial indicator to measure the lateral movement of the valve stem (stem-to-guide clearance) with the valve installed in its guide and just off the valve seat (Figure 2-68).
- b. The correct clearance is 0.0025-0.0762 mm (0.001-0.003"). If the indicated movement exceeds the specification, ream the guide bore to accommodate an oversize valve stem.

Note: Valve seats must be reground after reaming the valve guides to ensure that the valve seat is concentric to the valve guide.

VALVE SEATS

With cast iron cylinder heads, all the valve seats are machined into the head material. (Aluminum heads use valve seat inserts.) One of the most important items in a high output engine is the valve job.

Valve Seat Refacing

1. Install a pilot of the correct size in the valve guide bore and reface the valve seat to the specified angle with a good dressing stone. Remove only enough metal to provide a smooth finish.
2. Use tapered stones to obtain the specified seat width when required.
3. Control seat runout to a maximum of 0.0635 mm (0.0025"), using a dial indicator (Figure 4-32).

Part Number	Installed Ht.	Description	O.D.	Wire Diameter	Lift Range	Material
P4529214	1.64"	Cylindrical	1.31"	.177"	.350/.430"	Prod.
P4529215	1.64"	Conical	Prod.	Prod.	.350/.430"	Prod.
P5249464	1.64"	Single w/damper	1.42"	.187"	.400/.525"	Chrome-sil

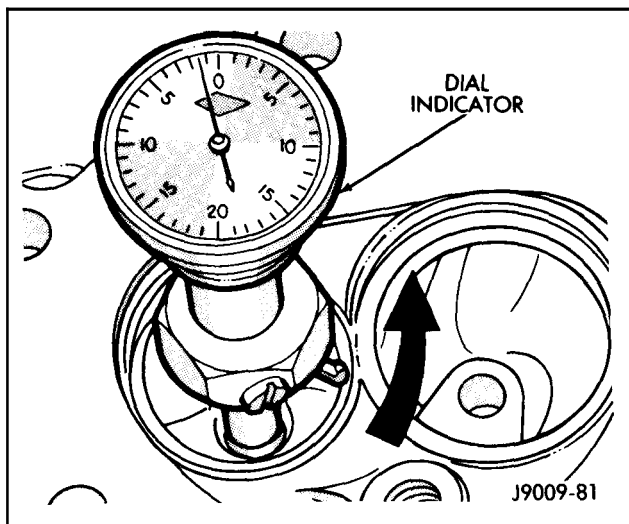


Figure 4 - 32

VALVE SPRINGS

The 4.0L engine standard production valve springs are made of high strength chrome steel. The springs are common between intake and exhaust applications. The valve spring seat is integral with the valve stem seal.

Valve springs are very closely tied to the camshaft and, next to the camshaft itself, are the most important valve gear performance parts. The important valve spring selection considerations are camshaft lift and profile, spring outside diameter, loads, engine rpm, and solid height.

Valve springs come in many shapes and sizes for many different applications. Some are interchangeable with production pieces and some are not. Some fit only on specific engines. Most stock production engines use a single spring; high performance production engines use a single spring with damper; race engines use either a dual spring (inner, outer, plus damper) or a triple spring (inner 1, inner 2, outer, without a damper). With so many considerations, we wanted to separate the springs into smaller groups to simplify the discussion. We chose installed height. For valve spring specifications, refer to the *Jeep Engine Valve Spring Specifications Chart*. A typical race valve spring is shown in Figure 4-33.

A valve spring should never seat directly against an aluminum head. A steel spring cup should be used. The spring seat in a cast iron head should not be cut to increase the installed height (.030" maximum for clean up).

It's best to select valve springs by camshaft choice. The spring height should be measured after the valve job is done and with the retainer that is going to be used.

Valve spring spacers are used to decrease the installed height of the spring, thereby raising the closed load of the spring.

Valve Spring Shim Packages

Valve spring shims are an aid in the assembling of performance or race cylinder heads. Shims are placed under each valve spring to equalize the installed height and pressure among springs. On aluminum heads, spring shims are required to prevent the valve spring from galling the aluminum spring seat. The cup-type shims are used to prevent valve spring movement (walk) about the spring seat. Mopar Performance Parts offers these shims in packages of 16. For all engines with inner spring seat removed - .645" inner seat inside diameter.

- P5249180 Valve spring shim package, .015" thick.
- P5249181 Valve spring shim package, .030" thick.
- P5249182 Valve spring shim package, .060" thick.
- P5249183 Valve spring shim package, .060" thick, cup-type.

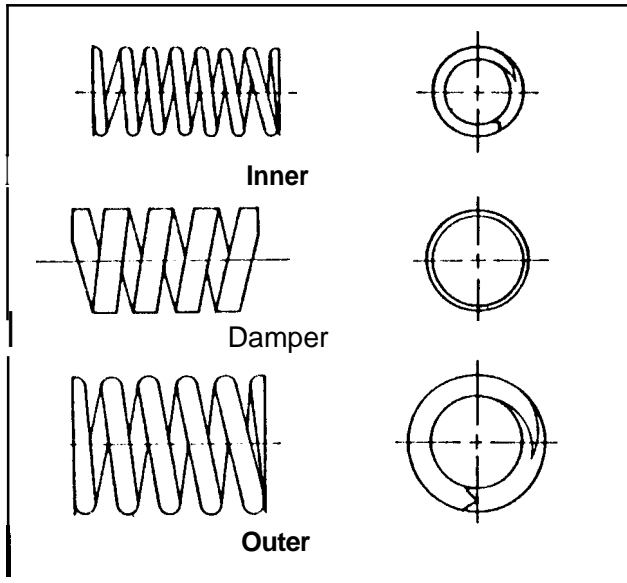
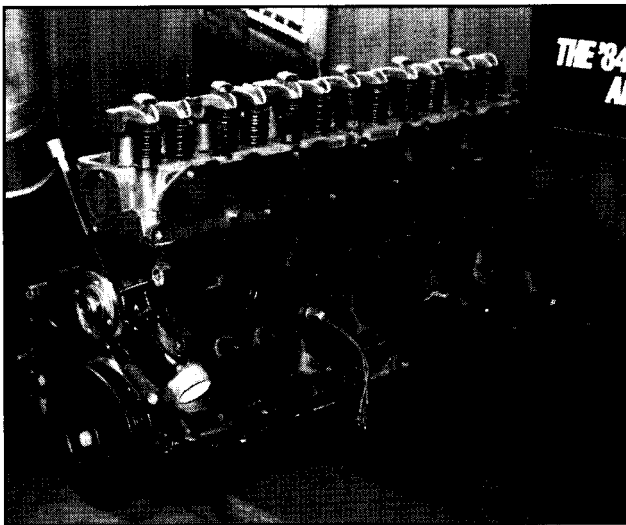


Figure 4 - 33



Big Camshaft Valve Spring Considerations

Engine builders have a tendency to forget some basics when they are changing camshafts. Camshafts are so easy to change and are changed so frequently it's easy to miss an item. The most common mistake is to forget to replace the valve springs.

This can be a problem when bigger camshafts are installed or when smaller camshafts are swapped in. One common problem occurs when a stock hydraulic camshaft or small RV design is replaced with a big, high lift unit. If you don't replace the valve springs so they match the new camshaft, you'll have problems ranging from lost performance to broken parts.

Another problem—too much valve spring can be even worse. This is usually arrived at in one of two ways. First is the racer who wants the BEST valve spring, and works

under the “if it's good for Super Stock, it must be good for me” theory. The second way is to have a big camshaft in the engine with its required big valve spring, and then remove it and swap in a medium-sized hydraulic camshaft and forget about replacing the valve springs. Either of these approaches on a hydraulic camshaft, or even a small mechanical camshaft, can cause failures such as scuffed camshafts, worn out tappets, and broken rocker arms. The springs that worked well with a high lift roller just don't work and cause all kinds of failures when used with smaller profiles. Always refer to our camshaft application charts for proper valve spring usage.

Valve Spring Installation Performance Tips

At first thought, the installation of valve springs sounds too simple to even consider. The valve spring sits between the retainer and the spring seat in the head. For performance applications, there are some tricks to this simple system which should be considered. Racers can use single springs, dual springs, or triple springs, each one having special challenges.

Production engines typically use single springs, which sometimes include a damper. The most important item relative to valve springs is the installed spring height—the distance between spring seat in the head to the underside of the valve spring retainer. With a single spring, such as used in production, you can use stock retainers, keepers and good umbrella (Viton) valve seals (P4529240). Checking the installed height assures that it is installed correctly.

The next most important item is to select the spring that's right for the camshaft. Each Mopar Performance Parts camshaft has a specific valve spring, listed by part number, that should be used. If it is not a Mopar Performance Parts camshaft, then the camshaft lift must be known to select the proper valve spring. Once the proper spring is selected and the installed height checked, all that remain are some quick tips.

1. Basic Guidelines

The following are some basic guidelines to follow whenever you install valve springs in your performance engine:

- a. Valve springs should be load checked. Weak ones will have to be replaced. Record loads and height checked at.

Note: Not all spring testers are the same. Many are not maintained and calibrated on a frequent basis. This makes the absolute value of spring loads quite unreliable. However it is a very good comparative tool; that is, measuring all springs on the same tester or measuring the same spring new and used.

The biggest advantage of load checking is to see if the springs have “gone away” or to see if a second set of the same spring is as “strong” as the first which worked well.

- b. With the valves, keepers, and retainers installed, check the valve spring height. This should be compared to the spring load information (1a) and the correct thickness shim chosen to get the same installed spring load on each valve.
- c. Valve spring installed height must be carefully controlled to avoid "coil bind" by providing at least .100" more height at maximum valve lift than the solid height of the spring.

Caution: DO NOT check solid height with a spring that you intend to use in the engine. Compressing a valve spring to solid height will overstress it and cause premature load loss or spring breakage.

- d. With the same spring height setup as 1b, measure the outer valve spring height, the inner valve spring height, and the keeper-to-valve guide clearance. The camshaft lift (lift of the camshaft measured at the lobe or lifter) multiplied by the rocker arm ratio plus .050" should be less than the keeper-to-guide clearance in the valve closed position or the guide will have to be shortened. Measure the "solid height" of both the inner and outer springs. This solid height plus .100" plus the valve lift (camshaft lift multiplied by the rocker arm ratio) should be equal to or less than the installed height for each spring.

2. Dual Springs

Dual springs are unique in that they are two springs separated by a damper. These are the most common valve springs used in racing. Because the second spring is installed inside, the inside diameter of this spring must be measured.

Typically the spring seat in a stock production head is only machined for an outer spring. This requires that the spring seat be machined down flush with the outer spring surface. In some cases, the inside diameter of the inner spring is less than the outer diameter of the valve guide. This requires the guide to be machined down in outside diameter.

With the inner spring seat in the head machined even with the outer, the inner spring usually will go "solid" after the outer, so the outer spring is still the critical measurement. However, DO NOT overlook the inner. The same thing is true of the damper. It is unusual, but it could go solid before the outer. However, its length can be trimmed to give the necessary clearance. **For** the inner spring, a new retainer would have to be used unless the inner spring seat wasn't flush. To check the solid height of the inner spring, it should be removed from the dual spring assembly, leaving the outer and the damper together. The solid height of the damper

can be checked in the outer and then removed. The outer can be checked alone. These two measurements should be the same.

Dual springs usually require a performance-type retainer, but many single springs can be used on dual spring retainers. The retainer and valve dictate the keeper style and type. However, the keeper-to-guide clearance should be measured and compared to the camshaft's maximum lift. The guide clearance, including the seal (if used) should be at least .050" greater than the camshaft lift. Dual springs DO NOT allow good umbrella (Viton) valve seals to be used; special Perfect Circle valve seals must be used.

3. Triple Springs

Triple spring are the most complicated. They consist of three separate springs: two wound in one direction and a middle spring wound in the opposite direction. Many people interpret a dual spring with damper as a triple spring, but it's not. Triple springs require a special retainer. Otherwise, they install similar to dual springs. They may require a smaller outside diameter on the valve guide. If not a Mopar Performance Parts triple spring, check the seal outside diameter against the inside diameter of the inner spring. Here you have three installed heights and three solid heights to check. The outer is again the most critical and most likely to cause problems, but don't overlook the inner two.

VALVES AND VALVE SPRING REMOVAL AND INSTALLATION

(Refer to Figure 4-34.)

Removal

Note: This procedure can be done with the cylinder head installed on the block.

Each valve spring is held in place by a retainer and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

1. Remove the engine cylinder head cover.
2. Remove capscrews, bridge and pivot assemblies and rocker arms for access to each valve spring to be removed.
3. Remove pushrods. Retain the pushrods, bridges, pivots and rocker arms in the same order and position as removed.
4. Inspect the valve springs and retainers for cracks and possible signs of weakening.
5. Remove the spark plug(s) adjacent to the cylinder(s) below the valve springs to be removed.

6. Connect an air hose to the adapter and apply air pressure slowly. Maintain at least 621 kPa (90 psi) of air pressure in the cylinder to hold the valves against their seats. For vehicles equipped with an air conditioner, use a flexible air adapter when servicing the No. 1 cylinder.
7. Tap the retainer or tip with a rawhide hammer to loosen the lock from the retainer. Use a valve spring compressor tool to compress the spring and remove the locks (Figure 4-35).
8. Remove valve spring and retainer (Figure 4-34).
9. Remove valve stem oil seals (Figure 4-34). Note the valve seals are different for intake and exhaust valves. The top of each seal is marked either INT (intake) or EXH (exhaust). DO NOT mix the seals.
10. Remove the valves and place them in a rack in the order in which they are removed.

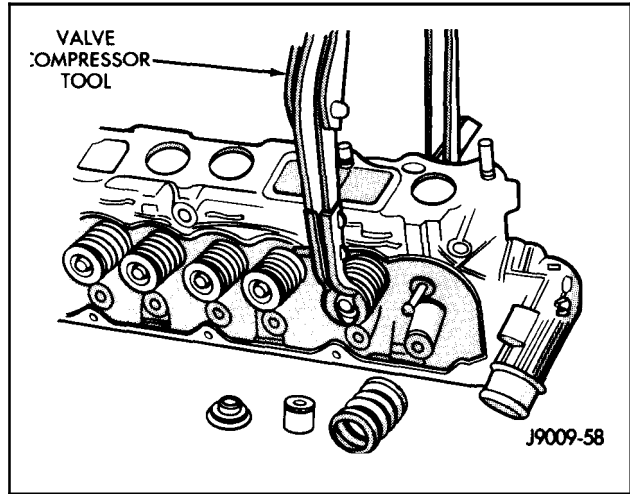


Figure 4 - 35

Cleaning

1. Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides, and cylinder head.
2. Clean all grime and gasket cement from the cylinder head machined gasket surface.
3. Inspect for cracks in combustion chambers and valve ports.

Inspection

1. Inspect for cracks on the exhaust seats.
2. Inspect for cracks in the gasket surface at each coolant passage.
3. Inspect the valve for burned, cracked or warped heads.
4. Inspect for scuffed or bent valve stems.
5. Replace valves displaying any damage.

Valve Clearances

Proper valve clearances in a race engine are very important to prevent bent or broken valves.

1. The valve-to-valve clearance should be checked first. This is done with both valves on the seat. This is important in all engines.
2. Piston-to-valve clearance is equally important. The piston-to-valve clearance is usually measured by placing modeling clay on the piston and manually turning the engine over with the head bolted on and camshaft, lifters, pushrods, etc., adjusted to zero lash.
3. The clearance between the valve and the block is usually only considered when installing oversize valves. In some cases, a notch in the side of the cylinder bore below the valve is required.

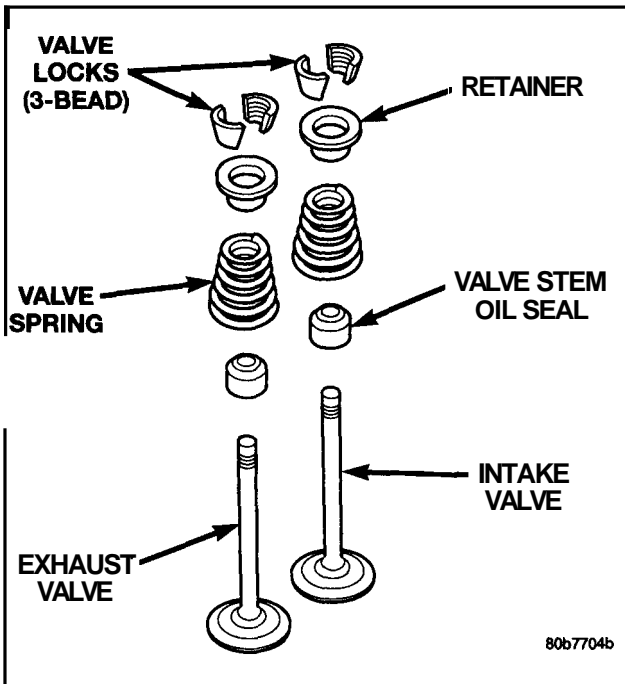


Figure 4 - 34

4. Check rocker arm-to-valve tip relationship for alignment. Improper alignment can place undue side loads on the valves, causing rapid valve guide wear. Rocker shaft spacers or grinding the rocker can be used to move the rocker arm up or down the shaft to align it on the valve tip.

Valve Refacing

1. Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.
2. After refacing, a margin of at least 0.787 mm (0.031") must remain (Figure 4-36). If the margin is less than 0.787 mm (0.031"), the valve must be replaced.

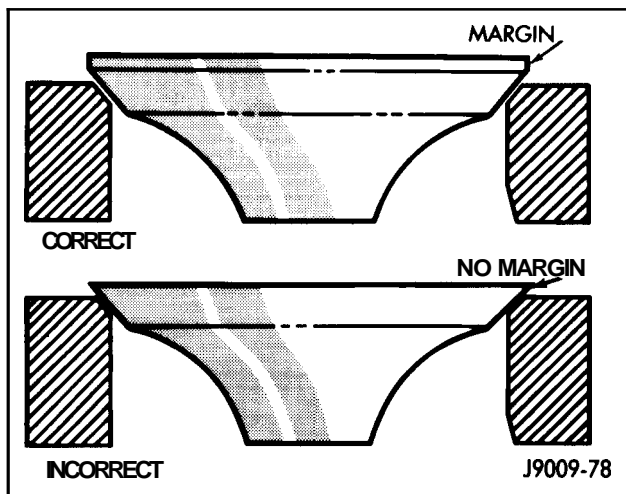


Figure 4 - 36

Valve Spring Tension Test

Use a valve spring tester and a torque wrench (Figure 2-66) to test each valve spring for the specified tension value. (Refer to 4.0L *Engine Specifications*, 'Engine Assembly' section of this chapter, for valve spring tension values.)

Replace valve springs that are not within specification.

Note: Most people in the performance industry use a simpler, more common valve spring tester that does not require a torque wrench to arrive at the tension (load). These simpler to use valve spring testers allow you to compress the spring to the height (open or closed) that you want to measure and then read the load directly off a scale that is on the tester itself. The key to valve spring testers is to obtain the correct installed height.

Installed Height and Guide

The installed height can be checked quite easily. However, with high lift camshafts, more care should be taken than just measuring the outer spring height. The inner spring should be checked, too. The solid height of the outer spring, inner spring and the damper should also be checked. Most springs, including production and dual springs (outer) will go solid at 1.1-1.2". Race springs will go solid at 1", while dual springs (inner) will go solid at less than 1".

Note: Be sure to check inner and outer springs separately.

While measuring the installed spring height, also check the keeper-to-guide clearance. If inadequate clearance is found, the guide will have to be shortened. The easiest way to do this is by grinding it. If dual springs are used, the inner spring seat may have to be dropped even with the outer spring seat, and the outside diameter of the guide itself decreased for the inner spring to fit over it.

Installation

This procedure can be done with the cylinder head installed on the block.

Caution: Install oil seals carefully to prevent damage from the sharp edges of the valve spring lock groove.

1. Thoroughly clean valve stems and valve guide bores.
2. Lubricate the stem lightly.
3. Install the valve in the original valve guide bore from where it was removed.
4. Lightly push the valve seal over the valve stem and valve guide boss. Be sure the seal is completely seated on the valve guide boss.
5. Install valve spring and retainer.
6. Compress the valve spring with a valve spring compressor tool and insert the valve locks. Release the spring tension and remove the tool. Tap the spring from side-to-side to ensure that the spring is seated properly on the cylinder head.
7. Release air pressure and disconnect the air hose. Remove the adapter from the spark plug hole and install the spark plug.
8. Repeat the procedures for each remaining valve spring to be removed.
9. Install the pushrods. Ensure the bottom end of each rod is centered in the plunger cap seat of the hydraulic valve tappet.

Jeep 4.0L Valve Spring Retainer Specifications Chart				
Retainer	Material	Locks	Valve Stem Size	Valve Spring
P4529216	Steel	8°	8 mm	Single-Std.
P4529217	Steel	8°	8 mm	Conical

Jeep 4 and 6 Cylinder Engine Keepers (Locks)						
Part Number	Valve Stem Size	Angle	Hardened	Groove	Use With Retainers	Sets
P4529218	8 mm	8°	Std.	Single	P4529216, P4529217	24 Pieces

10. Install the rocker arms, pivots and bridge at their original location.
11. Tighten the bridge capscrews alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 28.5 N•m (21 ft-lbs) torque.
12. Install the cylinder head cover.

VALVE SPRING RETAINERS AND KEEPERS (LOCKS)

Valve spring retainers are a pretty simple engine part. They come in steel, chrome-moly, aluminum, and titanium. Keepers (or locks) are the mating piece between the valve stem and the retainer. The usual design consideration is the number of lock grooves on the valve stem—one, two, or three. The valve stem size affects both the keeper and retainer.

One specification that hasn't been mentioned, which affects both the keeper and retainer, is the seat angle. For years we've used 8 degrees as the angle of standard and high

performance keepers and retainers. Other manufacturers call theirs 7 degrees. There really isn't any difference between these two labels. The actual angle is greater than 7 but less than 8. Effectively it's the same. However, this isn't true of the special 10 degree keeper-retainer system. The top width of the 10 degree system is much wider than the 7-8 degree system. In either case, keepers and retainers can only be swapped as a total system. You can't use 8 degree keepers with 10 degree retainers or vice versa. Be careful. This isn't as obvious to spot as it sounds.

The retainer should be light and strong. Stock production steel retainers are acceptable for most applications. A serious race engine with a high lift camshaft should use titanium retainers.

Note: NEVER sink the valves deliberately to increase the installed height. This results in reduced performance.

Mopar Performance Parts valve keepers (locks) are made from hardened steel and are available in single and triple groove styles to meet your application requirements



8" Versus 10" Retainers and Keepers (Locks)

Valve spring retainers are attached to the valve by "keepers" or locks. All standard production 4.0L engine valve keepers were an 8° design. The production retainers, likewise, were an 8" design. Currently there are 10° keepers and retainers available, but they are used only in racing. In a high rpm race engine, an 8" keeper can "pull through" the retainer. In an expensive race engine this can be disastrous. The 10° keeper and retainer system is a hard-core racer part that is designed to keep this from occurring. The 10° retainer cannot be used with 8" keepers (locks) and vice-versa.

One note of caution. DO NOT assume that you have 10" keepers or retainers. If you accidentally tried to use 10" keepers with 8" retainers, you would instantly recognize that something was wrong. However, if you were to use 8" keepers with 10" retainers, it would not be so obvious, but the results would be as disastrous. Always be sure to check the valves that you'll be using for stem diameter and number of lock grooves before ordering keepers and/or retainers.

Note: Keep in mind that if you have trouble with outer spring coil bind, you have to increase the installed height. But if the damper inside the outer spring goes solid, the simplest solution is to trim the damper for the added clearance.

ROCKER ARMS

Jeep 4.0L engine standard production rocker arms are made of stamped steel and have a operational ratio of 1.6:1. When the pushrods are forced upward by the camshaft lobes the pushrod presses upward on the rocker arms, the rocker arms pivot, forcing downward pressure on the valves forcing the valves to move downward and off from their seats.

The most important considerations in rocker arms are strength and durability. Strength is required to minimize deflections and transfer the camshaft motion to the valve accurately. The most important item regarding a high performance hydraulic camshaft is that the higher valve spring loads required by the camshaft puts more load on the rocker arms, which causes the pushrods to have a tendency to pierce the rocker arm. Thicker material in the pushrod ball or cup area is the only solution to the problem. These heavy duty hydraulic rocker arms are available from Mopar Performance Parts.

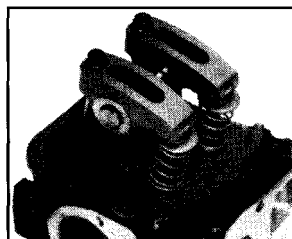
To optimize rocker arm geometry, a cut-to-length pushrod kit is recommended, but only to the very serious racer or for engines with large amounts of head milling and block decking. The rocker arm **tip** should contact squarely over the tip of the valve.

Heavy Duty Rocker Arm

Heavy duty stamped rocker arms for use with hydraulic cams (only). Right and left rockers are the same. Can be used to service stock engines. For all 2.5L and 4.0L Jeep engines. (Sold individually.)

P4529221 Heavy duty rocker arm.

Roller Rocker Arm Set



Fits all 2.5L and 4.0L engines. (Must use a spacer for valve cover clearance.)

- Contains one cylinder set of two rockers, two support stands, rocker shaft and screws.
- Extruded aluminum rockers, anodized blue.
- Can be used with hydraulic, mechanical or roller camshafts.
- Roller tip and center pivot to reduce internal friction.
- Provides exact geometry; 1.6:1 ratio.
- Adjustable, oil through pushrod style.

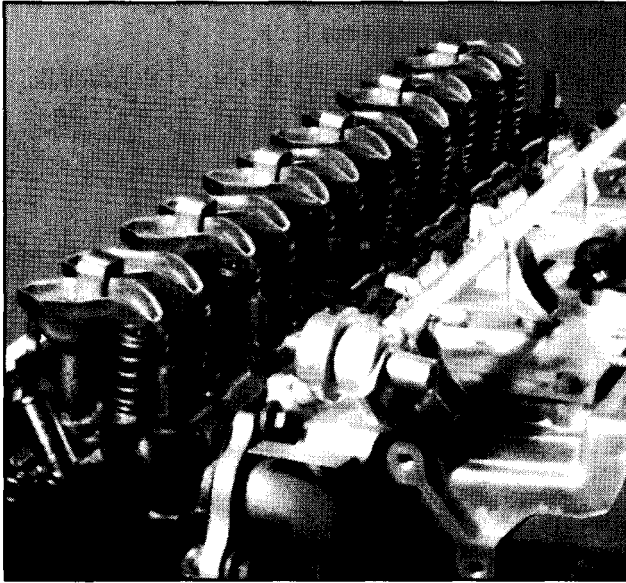
P4529885 Roller rocker arm set.

Aluminum Rocker Assembly Lube

When you use aluminum roller rockers, don't take a chance with a substandard lubricant. Mopar Performance Parts assembly lube is a must to complete the job right.

P5249099 Aluminum rocker assembly lube.





Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
2. Remove the two capscrews at each bridge and pivot assembly (Figure 2-62). Alternately loosen the capscrews one turn at a time to avoid damaging the bridges.
3. Remove the bridges, pivots and corresponding pairs of rocker arms and place them on a bench in the same order as removed (Figure 2-62).
4. Remove the pushrods and place them on a bench in the same order as removed (Figure 2-62).

Cleaning and Inspection

Clean all the components with cleaning solvent and use compressed air to blow out the oil passages in the rocker arms and pushrods.

Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted or excessively worn.

Inspect the valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted.

Inspect each pushrod end for excessive wear and replace as required. If any pushrod is excessively worn because of lack of oil, replace the pushrod and inspect the corresponding hydraulic tappet.

A wear pattern along the length of the pushrod is not normal. Inspect the cylinder head for obstruction if this condition exists.

Installation

1. Install the pushrods in their original locations. Ensure that the bottom end of each pushrod is centered in the tappet plunger cap seat.
2. Install the rocker arms, pivots and bridge above each cylinder from where they were originally removed.
3. Loosely install the capscrews through each bridge.
4. At each bridge, tighten the capscrews alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 28.5 N•m (21 ft-lbs) torque.
5. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.

PUSHRODS

Length, strength, and weight are the most critical items for pushrods, especially the first two. Length affects geometry and valve gear oiling. Strength keeps deflections minimized and weight helps engine speed, but a weight loss that causes a strength loss will result in a performance loss.

The valve train of the Jeep 4.0L engine is oiled through the pushrods. Jeep engine pushrods (all Jeep engines) are hollow so that oil can pass through them to oil the valve train.

Warning! Because Jeep engine valve trains are oiled via hollow pushrods, *solid shaft pushrods cannot be used.*

Standard Length Pushrod

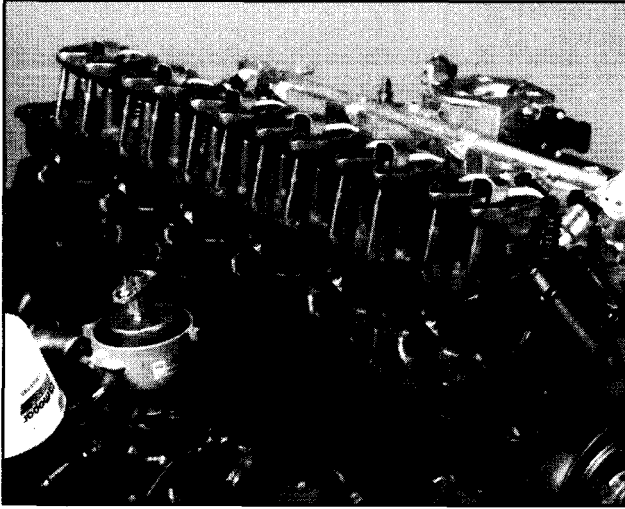
This is a fully assembled, stock diameter hydraulic pushrod. It is hollow to provide valve train oiling (same as production pushrod). Factory approved and engineered for rebuild or repairs. For 1987-2000, 4.0L and all 2.5L engines. (Sold individually.)

P4529219 Standard length pushrod.

Standard Length Pushrod Set

These are fully assembled, stock diameter pushrods. They are hollow to provide valve train oiling (same as production pushrods). Complete set of twelve (12). For 1987-2000, 4.0L engines only.

P4529675 Standard length pushrod set.



Hydraulic Pushrods

Since 1964, most Chrysler-Plymouth-Dodge-Jeep engines have been built using hydraulic camshafts. This means the tappets are hydraulic. It also means the rocker arms are non-adjustable. (There are a couple exceptions to this general rule, but it holds true for the majority.) The hydraulic camshaft, tappet, and non-adjustable rocker require a special pushrod. The hydraulic pushrod has two male ends. Length isn't critical here as long as the lifter can adjust for the change.

Hydraulic camshafts use a zero valve lash setting. The actual adjustment is done by the hydraulic tappet. If the pushrod doesn't bend, it does its job without problems and the engine runs fine.

As long as the engine remains "stock," this holds true. That is because the hydraulic tappet has a lot of adjustment built-in. This adjustment takes care of production variations, with some adjustment room to spare. The total adjustment is approximately .180" and it operates normally in the middle of its travel. You'll have trouble if you get too close to the end of travel (up or down), so the last .010" isn't usable. Production tolerances will take another .030", which leaves approximately .050" in either direction or .100" total. This is more than enough cushion for a stock engine. However, it may not be enough for modified engines.

"Modified engine" really means rebuilt or non-stock, not necessarily "race." The modification could be a bigger camshaft, milled or straightened head or deck surface, different tappets from those recommended, different valves, different head, or a change to the rocker stand or its attachment. This assumes that "broken" pieces such as bent pushrods, scuffed valve tips, bent rocker shafts, worn pushrod socket in the rocker, scuffed rocker tips, etc., are found and corrected. This is quite a list and obviously not easy to check out. Do not despair. The pushrod length required for your "modified" engine can be checked fairly easily. The hydraulic tappet must be disassembled and

drained of oil to check the tappet's collapsed height as installed. From this basic measurement you can determine your "free lash" (too much or not enough) and know how long your pushrod needs to be and if a stock (production) one will work.

Realistically, most racers don't do this. They quickly put the engine together and worry about it when they find a problem trying to start the engine. At this point they'll probably blame the camshaft or the lifters. Assuming that the lifters get oil pressure and they're recommended Mopar Performance Parts lifters, these pieces aren't likely to be at fault. Assuming the camshaft choice is up a step or two from stock and that it is either a production unit or Mopar Performance Parts design, the camshaft isn't the problem either. In truth, the "why" can be very difficult to determine. This sounds like a problem, but it really isn't. The reason is that no matter why there's a "free lash" problem, the cheapest and easiest solution is adjustable hydraulic pushrods. Using these pushrods can solve all kinds of problems with mismatched parts.

LIFTERS/TAPPETS

There are three types of lifters: hydraulic, mechanical-flat tappet, and roller. Their use is dictated by the camshaft. There are two types of mechanical tappets: standard and mushroom.

The Jeep 4.0L standard production engine valve lash is controlled by hydraulic tappets located inside the cylinder block, in tappet bores above the camshaft. The tappets have a hole in the **tappet** body. Oil from the cylinder block main bore enters and flows through the tappet exiting the top of the tappet. Oil that exits the tappet enters the hollow pushrod, travels up the pushrod and exits through a small hole in the rocker arm where it enters the cylinder head and returns to the oil pan.

Hydraulic Tappet

Mopar Performance Parts hydraulic tappets are for use with general purpose, high performance hydraulic camshafts. Can be used as production replacement. (Sold individually.)

P4529220 Hydraulic tappet.

Hydraulic Liftersnappets

Hydraulic tappets are standard in all 4.0L Power Tech engines.

1. Preliminary Check

- a. Before disassembling any part of the engine to correct tappet noise, read the oil pressure at the gauge (install a reliable gauge at pressure sending unit). The pressure should be between 255-517 kPa (37-75 psi) at 1,600rpm and higher. If vehicle has no oil pressure gauge, check the oil level in the oil pan.

- b. The oil level in the pan should never be above the “full” mark or below the “add oil” mark on the oil dipstick. Either of these two conditions could be responsible for noisy tappets. Check the oil level after the engine reaches normal operating temperature. Shut off the engine, allow 5 minutes to stabilize oil level, then check the dipstick. Make sure the vehicle is on level ground.

i. Oil Level Too High

If the oil level is above the “full” mark on the dipstick, it is possible for the connecting rods to dip into the oil while the engine is running and create foam. Foam in the oil pan would then be fed to the hydraulic tappets by the oil pump, causing them to lose length and allowing valves to seat noisily.

ii. Oil Level Too Low

Low oil level may allow the oil pump to take in air which, when fed to the tappets, causes them to lose length and allows valves to seat noisily. Any leaks on the intake side of the pump through which air can be drawn will create the same tappet action. When tappet noise is due to aeration, it may be intermittent or constant, and usually more than one tappet will be noisy. When oil level and leaks have been corrected, the engine should be operated at fast idle for sufficient time to allow all of the air inside of the tappets to bleed out.

2. *Tappet Noise Diagnosis*

To determine the source of tappet noise, operate the engine at idle with valve covers removed. Feel each valve spring or rocker arm to detect noisy tappet. The noisy tappet will cause the affected spring and/or rocker arm to vibrate or feel rough in operation.

Note: Worn valve guides or cocked springs are sometimes mistaken for noisy tappets. If this is the case, noise may be dampened by applying side thrust on the valve spring. If noise is not appreciably reduced, it can be assumed the noise is in the tappet. Inspect the rocker arm pushrod sockets and pushrod ends for wear.

Valve tappet noise ranges from light noise to a heavy click. A light noise is usually caused by excessive leak-down around the unit plunger which will necessitate replacing the tappet, or by the plunger partially sticking in the tappet body cylinder. A heavy click is caused either by a tappet check valve not seating, or by foreign particles becoming wedged between the plunger and the tappet body causing the plunger to stick in the down position. This heavy click will be accompanied by excessive clearance between the valve stem and rocker arm as the valve closes. In either case, the tappet assembly should be removed for inspection and cleaning.

3. *Removal*

Retain all components in the same order as removed to facilitate installation in their original positions.

- a. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, ‘Cylinder Head’ section of this chapter, for the procedure.
- b. Remove the bridge and pivot assemblies and rocker arms by removing the two capscrews at each bridge (Figure 2-62). Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
- c. Remove the pushrods (Figure 2-62).
- d. Remove the intake and exhaust manifolds. Refer to the service manual for the proper procedure.
- e. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, ‘Cylinder Head’ section of this chapter, for the procedure.
- f. Remove the tappets through the pushrod openings in the cylinder block.

4. *Disassembly, Cleaning and Inspection*

Place the components of each tappet in a separate location. This will greatly assist in the installation operation.

- a. Release the snap ring (Figure 2-72).
- b. Remove the following from the tappet body (Figure 2-72):
 - i. Plunger cap
 - ii. Metering valve
 - iii. Plunger
 - iv. Check valve assembly
 - v. Plunger return spring
- c. Clean the components of each tappet assembly in cleaning solvent to remove all varnish, gum and sludge deposits.
- d. Inspect for indications of scuffing on the side and base of each tappet body.
- e. Inspect each tappet base for concave wear with a straightedge positioned across the base.
- f. If the base is concave, the corresponding lobe on the camshaft is also worn. Replace the camshaft and tappets.

5. *Assembly*

- a. Install the following into the tappet body:
 - i. Plunger return spring
 - ii. Check valve assembly
 - iii. Plunger
 - iv. Metering valve
 - v. Plunger cap
- b. Compress the plunger assembly by exerting force on the plunger cap with the pushrod and install the snap ring.

6. *Installation*

Note: It is not necessary to charge the tappets with engine oil. They will charge themselves within a very short period of engine operation.

- a. Coat each tappet in Mopar Super Oil Conditioner, or equivalent.
- b. Install each tappet in the same bore from where it was originally removed.
- c. Install the exhaust and intake manifolds. Refer to the service manual for the proper procedure.
- d. Install the cylinder head and gasket. Refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter, for the procedure.
- e. Install each pushrod in the same location from where it was removed.
- f. Install the rocker arms and bridge and pivot assemblies at their original locations.
- g. Loosely install the capscrews through each bridge. Tighten the capscrews alternately one turn at a time to avoid damaging the bridges.
- h. Pour the remaining Mopar Super Oil Conditioner over the entire valve actuating assembly. The Mopar Super Oil Conditioner must remain with the engine oil for at least 1,609km (1,000 miles); however, it does not have to be drained until the next scheduled oil change.
- i. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.

Hydraulic Tappet Installation Tips

If you have a hydraulic camshaft, then you must have hydraulic tappets. That's pretty easy, but what do you do with them? Dip the outside in Lubrizol (camshaft break-in oil) and drop them in the engine, right? Sometimes, but this method can cause problems that will affect all camshafts, including stock production camshafts.

The important thing to keep in mind is that there isn't a problem with the camshaft or the tappet individually. The hydraulic tappet is a sophisticated device. If it has oil inside, then it won't collapse or adjust. If you deliberately fill the inside of the tappet with oil, it won't collapse. Some sources recommended that you fill it with oil before installation. For racing or performance we don't. This has nothing to do with applying break-in oil on the outside of the tappet. Before installation we recommend draining any oil that may be inside the tappet first by carefully disassembling the tappet itself. Once drained, the pushrod pivot inside the tappet can be pushed down manually against the tappet's internal, light spring. Now you can put oil on the outside and drop it into the engine for assembly. But be prepared. When the engine is started all 12 tappets will make noise—ticking and clattering like very loose mechanical tappets. As soon as the engine's oil pressure comes up, the noise goes away. (Priming the engine before starting helps minimize the noise.) Easy enough, but why go to the extra trouble?

Generally the engine starts a little easier (less effective camshaft duration) and you know that the tappets are working properly. But the trick isn't what this method gives you, but what problems this method can avoid. With the lifters pumped up, you'll generally hold the valves off the seat for 360° (all the time). This can cause the valves to hit the pistons or the pushrods to bend. The tappets will bleed-down but it can sometimes take a while.

With the valves partially off their seats, you don't get much cranking compression, which will make the engine hard to start. If it starts, it won't want to run at idle until the tappets bleed-down, which could take some time. If you get a tight one that won't bleed-down, then you have to disassemble the engine down to the tappets and manually drain the tappet, if you can determine which one it is. Locating the exact tappet is not easy to do. Otherwise, you'll have to drain them all. To us, this approach is not a good gamble. Many people manually fill their tappets before installation and have no problems. Stock camshafts and very mild camshafts have a lot of valve-to-piston clearance, which helps if the valve is off the seat all the time. Think about it—why take the chance?'

Mushroom Liftersnappets

If mushroom lifters are used, the underside of the lifters should be spotfaced. This will require a back-spotfacing tool. Mushroom lifters should only be used with mushroom camshafts because they have narrowed lobes.

Oiling System

INTRODUCTION

The 4.0L engine uses a pressure feed, full flow filtration oiling system utilizing a gear-type positive displacement pump is mounted at the underside of the block opposite the No. 4 main bearing (Figure 4-37). The pump draws oil through the screen and inlet tube from the sump at the rear of the oil pan. The oil is driven between the drive and idler gears and pump body, then forced through the outlet to the block. An oil galley in the block channels the oil to the inlet side of the full flow oil filter. After passing through the filter element, the oil passes from the center outlet of the filter through an oil galley that channels the oil up to the main galley which extends the entire length of the block. The oiling system has a capacity of 5.7L (6 quarts). (For more oiling system specifications, refer to *4.0L Engine Specifications*, 'Engine Assembly' section of this chapter.)

Galleys extend downward from the main oil galley to the upper shell of each main bearing. The crankshaft is drilled internally to pass oil from the main bearing journals (except No. 4 main bearing journal) to the connecting rod journals. Each connecting rod bearing cap has a small squirt hole. Oil passes through the squirt hole and is thrown off as the rod rotates. This oil throw-off lubricates the camshaft lobes, camshaft position sensor drive gear, cylinder walls, and piston pins.

The hydraulic valve tappets receive oil directly from the main oil galley. Oil is provided to the camshaft bearing through galleys. The front camshaft bearing journal passes oil through the camshaft sprocket to the timing chain. Oil drains back to the oil pan under the No. 1 main bearing cap.

The oil supply for the rocker arms and bridged pivot assemblies is provided by the hydraulic valve tappets which pass oil through hollow pushrods to a hole in the corresponding rocker arm. Oil from the rocker arm lubricates the valve train components and then passes down through the pushrod guide holes in the cylinder head, past the valve tappet area, and returns to the oil pan.

The stock lubrication system will be adequate for normal passenger car operation. However, in any case where DaimlerChrysler engines are subjected to unusually high crankshaft rotational speeds (over 6,000 rpm), acceleration, deceleration, or cornering loads, special precautions must be taken with the engine's oiling system. Not only must an engine's oiling system be modified for adequate lubrication, but it must also be modified to achieve optimum engine power output.

Troubleshooting

Oiling the valve gear in a standard engine is virtually automatic, as long as the engine has oil pressure. In a modified, high performance engine, it can be another story.

When recommendations are followed, most racers will have no oiling problems. When oiling problems do develop, they generally manifest themselves as burned pushrod tips, scuffed valve tips, scuffed and burned rocker arms, broken pieces, etc. Unfortunately, the pieces that look the worst usually aren't the cause of the problem. In the majority of cases relating to valve gear oiling, it's not a matter of what you should do, but what you should not do. The problems mentioned are the result of poor oiling, assuming the engine itself is being oiled properly (no foam, no zero psi, etc.).

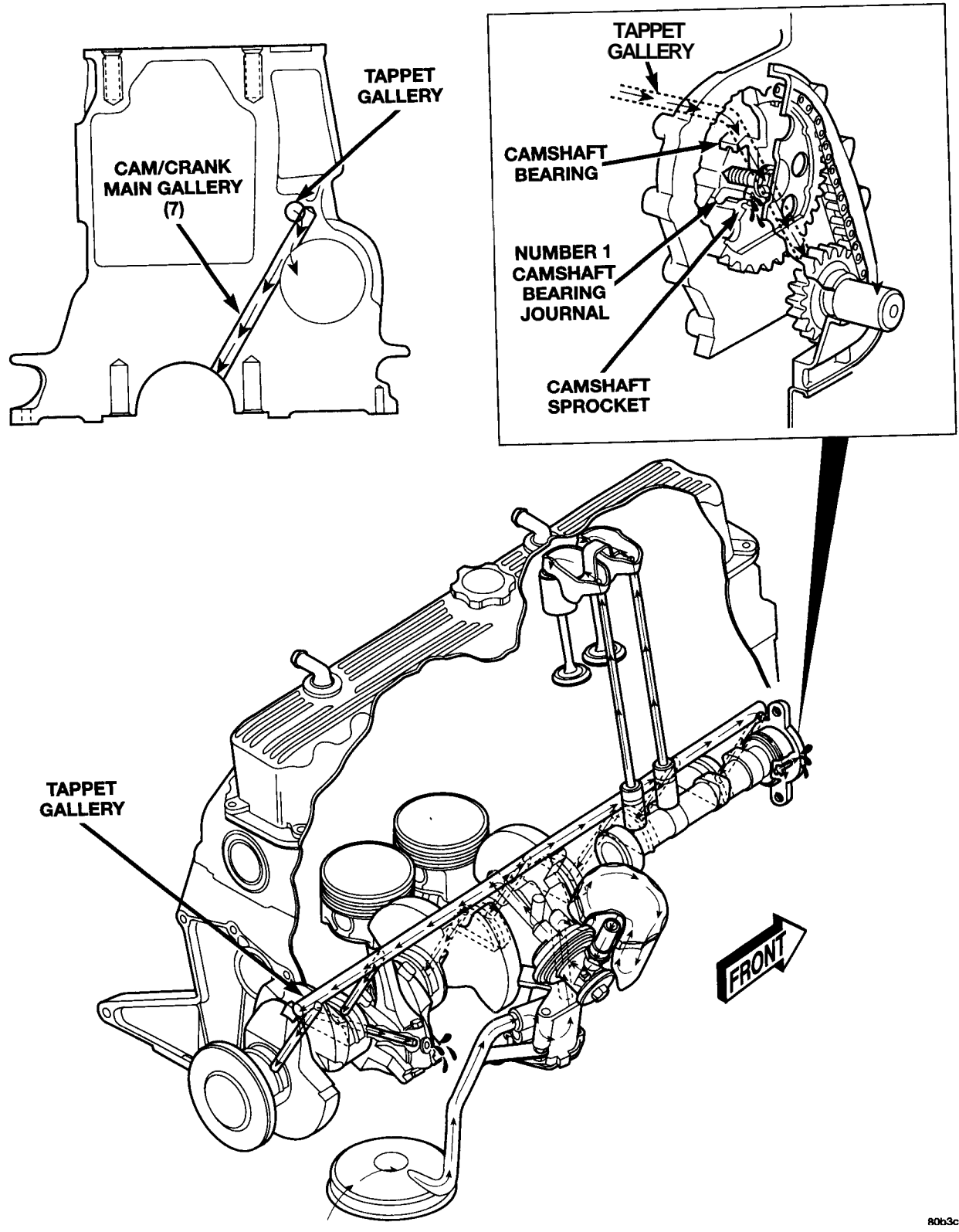
The first thing to check is that a camshaft bearing hasn't "turned" so that its oiling holes aren't lined up with the holes in the block. Next, be sure the passage from the camshaft to the block's deck isn't blocked or restricted. This is usually done with a long handled bottle brush.

At the deck surface of the block, it is common for racers to install a restrictor. This is not recommended and, if found, should be removed. If you "smoked out" your pushrods or scuffed the valve tips, you've probably found the cause. Next, check the head gasket and cylinder head itself for oiling hole alignment.

At this point you can have two different types of problems depending on whether your engine uses hydraulic rockers or mechanical rockers. A problem with hydraulics is most likely caused by an oil leak that prevents oil from reaching the rockers. Spacers used between the rocker stand and the rocker shaft will, over an extended period, cause these problems because of leakage. Also, the rocker shaft could be installed incorrectly (upside down, reversed, etc.).

Problems occurring with mechanical rockers can be much more complicated. Since there is no need to put spacers between the rocker shaft and the pedestal, a leak there would be unusual. Rocker shaft installation is very critical. Banana grooves are usually added to mechanical valve gear rocker shafts to improve oiling of the rocker itself. Bushed rockers are more tolerant of low oil conditions, but standard mechanical rockers should be adequate for most applications. At this point, with oil to the rocker, it must be distributed to the valve tip and the pushrod tip. Accomplishing this is very tricky. Exactly where and how these holes are located is very critical and each engine is unique.

There is another "trick" with mechanical rockers that should be considered. The proper (ideal) adjustment for the rocker adjusting screw is to have only one thread showing below the rocker arm with the valve lash set properly (two may be okay, three shaky, etc., but high rpm makes one thread showing the most desirable). This requires custom length pushrods for every engine. If you've "smoked" your pushrods and you had all the threads showing below the rocker (i.e., pushrod too short), more oil to the valve gear won't cure the problem. Only longer pushrods will do the job.



80b3c728

Figure 4 - 37

OILING SYSTEM PERFORMANCE CONSIDERATIONS

Choosing the Correct Oiling System

The oiling system to be used on a high performance engine is determined by the output level of the engine and the type of application that the engine is going to be used for. Oil capacity is the first consideration in a basically stock system used for high performance. This means that the first step for bracket racing is to deepen the stock pan 2" along with lowering the pick-up the same amount. The next step is a Super Stock race pan and high volume oil pressure pump. The last step is a dry sump which is particularly important in oval track and high performance drag race vehicles that are built low to the ground. During your engine build-up, after the camshaft has been chosen and the engine's application is known, the oiling system type should be decided on so that any block modification (especially if a dry sump and roller lifters are to be used) can be done before the block is assembled and it's too late.

Oiling System Passage Requirements

It is important to note that oil pump performance at high engine speeds can be most easily improved by reducing restrictions on the suction side of the oil pump. Reducing flow restriction on the suction side of the pump is much more significant than reducing flow restriction on the pressure side of the pump. Oil pump suction pipe diameter should be very generous.

Caution: Modified oil pump suction pick-ups must be fitted with a protective screen to prevent the pump from ingesting debris such as metal shavings, broken valve spring tips, etc.

Oil Flow to Connecting Rod Bearings

For increased oil flow to connecting rod bearings, 360° fully grooved main bearing sets should be used.

Note: It is NOT recommended that the crankshaft be grooved because that will weaken the crankshaft.

Oil Restriction

It seems that some magazine article or book is always recommending that an engine's oil be restricted in some way. Some suggestions have no real effect, but those restricting oil to the upper valve gear can be quite harmful. We DO NOT recommend restricting oil flow to the upper valve gear. Leave all the passages stock size and be sure that they are unobstructed.

The usual result of oil restriction to the upper valve gear is "smoked out" pushrod tips, scuffed valve tips, scuffed or burned rockers, or scuffed valve guides. These are expensive ways to find out what doesn't work. Full roller rocker arms can cut down on the valve gear's oil requirement but are generally expensive. In racing, as the

rpm is increased, the valve gear needs more oil. If you have extra time available in your engine building process, helping the oil in the cylinder head return to the pan can be beneficial. Helping the oil return past the crankshaft without getting on to the crankshaft is the best place to spend your time.

Restricting oil to the tappet galley with roller lifters is a very common practice (and required for 3.9L V-6 engines with high lift roller camshafts). However, restricting oil to the upper valve gear is NOT recommended. The oil is fed to the upper valve gear through mating passages in the block and head. Restricting these passages cuts down on the amount of oil available to the valve gear (valves, rockers, pushrods). This causes two problems. At high rpm, rocker arms like to "shake off" the oil that is used to lubricate valves and pushrod tips. In most cases, the engine needs all its designed oil flow to keep its durability high and to minimize parts wear. The other problem occurs at low speed where the oil pressure drops to its minimum. In this condition, the valve gear, being the furthest from the oil pump, gets very little (if any) oil. The loads are low but with so little oil, any less can cause accelerated wear. In either case, scuffed valve tips, burned pushrod ends, and galled rockers can be the result, which is why oil restriction to the heads is not recommended.

OIL PUMP

A gear-type oil pump is mounted at the underside of the cylinder block opposite the No. 4 main bearing (see Figure 2-78).

Oil pump removal or replacement will not affect distributor timing because the distributor drive gear remains in mesh with the camshaft gear.

The stock oil pump is adequate for normal operation if it is up to specifications. The pump must turn freely when assembled.

Heavy Duty Oil Pump

When the going gets tough, you'll want to be sure and supply as much oil to your engine as possible. This heavy duty high volume pump will do the job and take the most severe punishment. For 4.0L engines only.

P4529227 Heavy duty oil pump.

High Volume Oil Pump Assembly

For many years, Mopar Performance Parts has supplied parts for oiling systems. Our previous parts have come as kits that the racer had to put together himself, in many cases using a stock oil pump as a starting point. Mopar Performance Parts now offers a high volume, high performance oil pump assembly for 4.0L Power Tech engines (P4529241). It offers a 25% increase in volume over the stock pump and comes fully assembled and ready to bolt on the engine.

High Volume Oil Pump

This Mopar Performance Parts high volume oil pump is similar to the heavy duty oil pump (P4529227), except that it has larger rotors for a 25% increase in capacity. For 4.0L engine only.

P4529241 High volume oil pump.

Oil Pressure Requirements

Oil pressure requirements for the 4.0L engine are as follows:

At Idle Speed (600 rpm) 13 psi 89.6 kPa

At 1,600+ rpm 37-75 psi 255-517 kPa

Oil Pressure Relief 75 psi 517 kPa

Oil Pump Priming

After an engine build (or re-build), the lubrication system should be checked to ensure that it is supplying pressure to the bearings before any attempt is made to start the engine. If the engine is running without oil pressure even for a few seconds, there will be extensive damage done to the engine.

After installing a mechanical oil pressure gauge (only if your vehicle is not already equipped with an oil pressure gauge), remove all the spark plugs in order to relieve the compression in the cylinders and to prevent the engine from starting. The engine should be turned over with the starter motor until the oil pressure gauge shows a reading of over 10 psi.

Once you have determined that the engine does have oil pressure, the spark plugs may be reinstalled and the engine may be started. When the engine starts, the gauge should show a minimum reading of 89.6 kPa (13 psi) at 600 rpm (idle speed).

Warning! If the gauge does not register any pressure when the engine is cranked with the starter motor, DO NOT TRY TO START THE ENGINE. Running an engine with no oil pressure for even a couple of minutes can cause serious damage.

If the gauge does not register any pressure when the engine is cranked with the starter motor, go through your lubrication system and check it carefully. Make sure there is sufficient oil in the pan. Also be sure that the pickup is connected and that the oil pickup is fully submerged. Make sure the pickup tube does not have any leaks where air might be entering the system. Make sure the oil pump is working properly.

OIL PUMP SERVICE PROCEDURES

Removal

1. Drain the engine oil.
2. Remove the oil pan. Refer to the proper service manual for the procedure.

Caution: DO NOT disturb the position of the oil inlet tube and strainer assembly in the pump body. If the tube is moved within the pump body, a replacement tube and strainer assembly must be installed to ensure an airtight seal.

3. Remove the oil pump retaining bolts, oil pump and gasket.

Gear End Clearance Measurement

Remove the cover retaining bolts and cover from the **pump** body.

1. *Preferred Method*
 - a. Place a strip of Plastigauge (P4286819) across the full width of each gear (Figure 2-79).
 - b. Install the pump cover and tighten the bolts to 8 N•m (70 in-lbs) torque.
 - c. Remove the pump cover and determine the amount of clearance by measuring the width of compressed Plastigauge with the scale on the Plastigauge envelope.

Correct clearance by this method is 0.051-0.152 mm (0.002-0.006"). The preferred measurement is 0.051 mm (0.002"). If the gear end clearance is excessive, replace the oil pump assembly.

Plastigauge

When reassembling your engine you'll need a variety of Plastigauge to measure bearing clearances. This popular assortment includes one blue strip for .004" - .009" tolerances, two red strips for .002" - .006" tolerances, and two green strips for .001" - .003" tolerances. Each strip is 12" long.

P4286819 Plastigauge assortment.

2. *Alternate Method*

- a. Place a straightedge across the ends of the gears and the pump body.
- b. Select a feeler gauge that fits snugly but freely between the straightedge and the pump gears (Figure 2-80).

Using this method, the correct clearance is 0.051-0.152 mm (0.002-0.006"), with the preferred measurement being 0.051 mm (0.002"). If the gear end clearance is excessive, replace the oil pump assembly.

Gear-to-Body Clearance Measurement

1. Measure the gear-to-body clearance by inserting a feeler gauge between the gear tooth and the pump body inner wall directly opposite the point of the gear mesh (Figure 2-81).
2. Select a feeler gauge which fits snugly but freely.
3. Rotate the gears to measure each tooth-to-body clearance in this manner.
4. The correct clearance is 0.051-0.102 mm (0.002-0.004"). The preferred clearance is 0.051 mm (0.002").
5. If the gear-to-body clearance is more than specified, replace the idler gear, idler shaft and drive gear assembly.
6. Remove the cotter pin and slide the spring retainer, spring and oil pressure relief valve plunger out of the pump body.
7. Inspect for binding condition during disassembly.
8. Clean or replace as necessary.
9. The oil inlet tube and strainer assembly must be removed to allow removal of the relief valve. Install a replacement inlet tube and strainer assembly.

Assembly

Note: Two relief valve plunger sizes (standard and oversize) are available. When replacing the valve, ensure that the correct replacement valve and either the standard size or 0.254 mm (0.010") diameter oversize plunger is obtained and installed.

1. Install the oil pressure relief valve plunger, spring, retainer, and cotter pin.
2. If the position of the inlet tube in the pump body has been disturbed, install a replacement inlet tube and strainer assembly. Apply a light film of Permatex No. 2 sealant, or equivalent, around the end of the tube.
3. Use an oil pump inlet tube installer tool to drive the tube into the body (Figure 2-82). Ensure that the support bracket is properly aligned.
4. Install the idler gear and the drive gear assembly. Inspect the gears to ensure that a binding condition does not exist before installing the oil pump.
5. To ensure self-priming of the oil pump, fill the pump with petroleum jelly before installing the oil pump cover. **DO NOT use grease!**
6. Apply a bead of Loctite 515, or equivalent, and install the pump cover.
7. Tighten the cover bolts to 8 N•m (70 in-lbs) torque.

Installation

1. Install the oil pump with a replacement gasket. Tighten the bolts to 23 N•m (17 ft-lbs) torque. (Refer to Figure 2-78.)
2. Install the oil pan with replacement gaskets and seals. Refer to the proper service manual for the procedure.
3. Fill the oil pan with clean engine oil to the specified level.

OIL PICK-UPS

An oil pick-up is used in virtually every engine. It's not a fancy device and doesn't get much attention by the average racer. In spite of this, the pick-up is very important to your engine. If it does not do its job, then the engine is in real trouble and could very easily fail.

Once the pan is removed from the engine, the pick-up sticks out away from the crankshaft and bottom of the block. As such, it is very vulnerable and can be easily damaged. Removing it from the block, which has to be done to allow the engine to be rebuilt, can also be tricky and cause the pick-up to be damaged. One common damage is to bend it. Typically, when you try to bend it "back into place" you will break or crack it. A crack will allow air to get into the oil system and be fed directly to the bearings which will cause the obvious failure. A crack can also cause the oil pump's "prime" to be lost. Used pick-ups can also be very difficult to clean. For any of these situations, obtaining new parts will solve your problem. Remember, they are designed to work in the stock pan. If the pan is changed, you may have to modify the pick-up, but now you will have a new part to start with for your modification.

OIL PAN

The 4.0L engine standard production oil pan is made of laminated steel and has a single plane sealing surface. The oil pan gasket is a one piece steel backbone silicone coated gasket. Removal and replacement procedures vary depending on vehicle type and model year. Refer to your service manual for removal and replacement procedures.

Oil Pan Gasket Set

Includes both the sides and the ends. For 4.0L engine only.

P4529244 Oil pan gasket set.

OIL PAN PERFORMANCE CONSIDERATIONS

Windage Losses

Every engine that uses oil for lubrication has windage losses. Controlling windage loss can help make more power. This holds true for any engine. The more engine speed that you use, the worse the windage loss becomes. Remember, less windage means more horsepower!

So what is windage and why does less of it make more power? *Windage* is the friction caused by the crankshaft and connecting rod assembly rotating through an air-oil mixture. *Windage trays* are designed to "scrape" the oil that is thrown off the crankshaft away from the crankshaft and into the pan, and keep the oil that is in the pan from coming up for the crankshaft to drag through. Each connecting rod and main bearing has oil and oil pressure in it and, because of the oil pressure, some will leak out and get in the way of the rotating crankshaft assembly. Then there's the oil that goes to the head to lubricate the valve gear that has to get back to the pan somehow. This usually means that it falls back past the tappets and on to the crankshaft. Smart racers will work extra hard to install special drains so that the return oil doesn't fall on to the crankshaft.

Windage Tray

Every high performance engine should have a windage tray. It goes between the oil pan and the block. Only the windage tray and two oil pan gaskets are required for installation. The only time a windage tray should not be used is with a custom-made race oil pan. With a custom-made race pan, the windage tray should be removed resulting in increased vehicle performance. If the vehicle slows down when the tray is removed, the pan has been compromised too much and the tray should always be used with that particular pan.

Stock (Production) Oil Pan Modifications

The standard pan can be helped by reworking the sump so it is 2" deeper. A longer oil pick-up must also be installed at the same time. A deepened pan can also be used. With this pan the pick-up must also be lengthened, or a strainer and pipe assembly, which is designed for use with the deepened pan, should be purchased. With any oil pan capacity or shape change, the dipstick should be carefully recalibrated. Be sure to fill the oil filter before calibrating!

With either of these pans installed, the ground clearance will be reduced and the pan will no longer be protected. For added pan protection, a skid plate should be added and the vehicle should be driven with increased care.

In a stock pan, especially a deepened pan, the rear acceleration baffle is very important. It keeps oil from running up into the rear cylinders and slowing down the last rod journal with increased drag. The rear acceleration baffle must be sealed to three walls of the sump (back and two sides) or it becomes useless.

DRY SUMP OILING SYSTEM

For drag racing, a dry sump system should only be considered for vehicles that have almost no ground clearance. However, dry sump oiling systems can be very advantageous in an oval track vehicles. Dry sumps provide more ground clearance so the vehicle can sit lower. This is because dry sump pans are very shallow. This allows the centerline of the crankshaft to get closer to the ground while maintaining the same actual ground clearance. (Ground clearance is usually specified and enforced by the sanctioning body.)

All production (stock) oil pans are wet sump designs. With a dry sump, the oil that is being stored in preparation for being pumped back into the engine is stored outside the engine (or remotely), usually in a separate tank (with baffles, etc.) located ahead of the engine. A race wet sump pan would have a large capacity rear sump located directly under the crankshaft.

Production wet sumps are small and may be located in the center, front or rear. A race wet sump ideally designed would be 9 to 10 inches deep. But many professionally-built race vehicles are built so low to the ground that there is no room for this style pan. Enter the dry sump. However, a properly designed dry sump system is expensive. Therefore, a racer who doesn't have the crankshaft dragging on the ground doesn't need a dry sump because it's money spent for no gain. Here, look closely at a race wet sump. There is performance in a good wet sump system race pan.

A dry sump oil system should be used whenever a deep oil pan cannot be used. There is approximately 40 hp lost to a shallow, wet sump pan.

The dry sump system consists of an oil tank, scavenge pump, and a pressure pump. The oil pump used is a multi-stage, external assembly with two or three stages for scavenge and a pressure stage. Drag race engines require two scavenge stages, oval track engines require three. The pump should be run at .5 to .6 engine speed.

The oil tank for drag racing use can be as small as 5 qts., while an oval track racing tank should be 3 gallons.

Now that we know all the parts, let's see how it works. The pressure stage picks oil up from the tank, then sends it to an external oil filter, and then to the engine. The engine then gets oiled and dumps the oil back in the pan where the scavenge stages pick up the oil and return it to the tank. The tank is vented to the valve cover to equalize pressures. Contact Weaver Brothers for further details and *dry* sump hardware.

Weaver Brothers
1980 Boeing Way
Carson City, NV 89706

OIL COOLERS

Engine Oil Cooler

This specially engineered, finned radiator design oil cooler prevents engine oil from overheating, thus ruining its lubricating characteristics. This cooler is ideally suited for endurance-type engine applications and utilizes 1/2" pipe thread fittings. Measures 11" x 12" x 1-1/2".

P3690956 Engine oil cooler.

Heavy Duty Engine Oil Cooler

This heavy duty steel, full flow oil cooler is the best way to ensure peak engine oil cooling efficiency under heavier than normal driving conditions. It is thermostatically controlled to provide continuous cooling of your engine's oil. Install in oil filter circuit. Oil circulates in a continuous loop from the pan, through the pump, then to the cooler. Includes built-in relief valve. Designed for simple installation. Cooler is 1-1/2" thick. Measures 6" W x 18" L.

P4876917 Heavy duty oil cooler.

Universal Oil Cooler Packages

Special universal coolers mount between engine and oil filter to circulate heater core coolant to reduce oil temperatures.

P4529690 Universal oil cooler package, standard.

P4529691 Universal oil cooler package, extra cooling.

OIL

Use only high detergent and additive engine oil. The oil must meet Mil Spec MS-DG. DO NOT use viscosity improver oil additives. The only oil additives you should consider using are anti-scuff additives, such as Mopar Engine Oil Supplement. Anti-scuff additives should be used only for running in and should be drained from the oiling system before racing (be sure to re-fill the engine oil to the correct level before re-starting the engine).

SAE Viscosity

An SAE viscosity grade is used to specify the viscosity of engine oil. Use only engine oils with multiple viscosity such as 5W-30 or 10W-30. These are specified with a dual SAE viscosity grade which indicates the cold-to-hot temperature viscosity range. Select an engine oil that is best suited to your particular temperature range and variation (Figure 4-38).

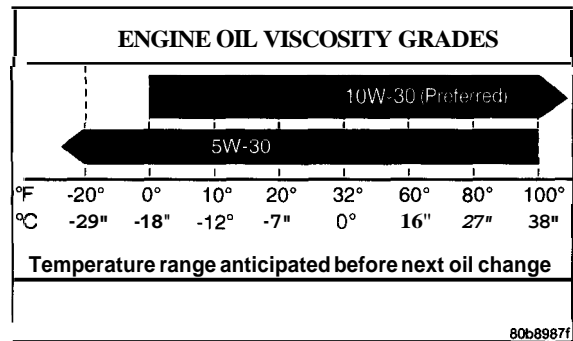


Figure 4 - 38

Oil Level Inspection

Caution: DO NOT overfill crankcase with engine oil, pressure loss or oil foaming can result.

Inspect engine oil level approximately every 800 kilometers (500 miles). Unless the engine has exhibited loss of oil pressure, run the engine for about five minutes before checking oil level. Checking engine oil level on a cold engine is not accurate.

To ensure proper lubrication of an engine, the engine oil must be maintained at an acceptable level. The acceptable levels are indicated between the ADD and SAFE marks on the engine oil dipstick.

1. Position vehicle on level surface.
2. With engine OFF, allow approximately ten minutes for oil to settle to bottom of crankcase, remove engine oil dipstick.
3. Wipe dipstick clean.
4. Install dipstick and verify it is seated in the tube.
5. Remove dipstick, with handle held above the tip, take oil level reading.
6. Add oil only if level is below the ADD mark on dipstick.

Engine Oil Change

Change engine oil at mileage and time intervals described in Maintenance Schedules of your owners or service manual.

Run engine until achieving normal operating temperature.

1. Position the vehicle on a level surface and turn engine off.
2. Hoist and support vehicle on safety stands.
3. Remove oil fill cap.
4. Place a suitable drain pan under crankcase drain.

5. Remove drain plug from crankcase and allow oil to drain into pan. Inspect drain plug threads for stretching or other damage. Replace drain plug if damaged.
6. Install drain plug in crankcase.
7. Lower vehicle and fill crankcase with specified type and amount of engine oil described in this section.
8. Install oil fill cap.
9. Start engine and inspect for leaks.
10. Stop engine and inspect oil level.

ENGINE OIL FILTER

All engines are equipped with a high quality full-flow disposable type oil filter. DaimlerChrysler recommends a Mopar or equivalent oil filter be used.

Removal

1. Position a drain pan under the oil filter.
2. Using a suitable oil filter wrench, loosen the filter.
3. Rotate the oil filter counterclockwise to remove it from the cylinder block oil filter boss.
4. When filter separates from adapter nipple, tip gasket end upward *to* minimize oil spill. Remove filter from vehicle.
5. With a wiping cloth, clean the gasket sealing surface (Figure 4-39) of oil and grime.

Installation

1. Lightly lubricate oil filter gasket with clean engine oil.
2. Thread filter onto adapter nipple. When gasket makes contact with sealing surface (Figure 4-39), hand tighten filter one full turn. **DO NOT** over tighten.
3. Add oil, verify crankcase oil level and start engine. Inspect for oil leaks.

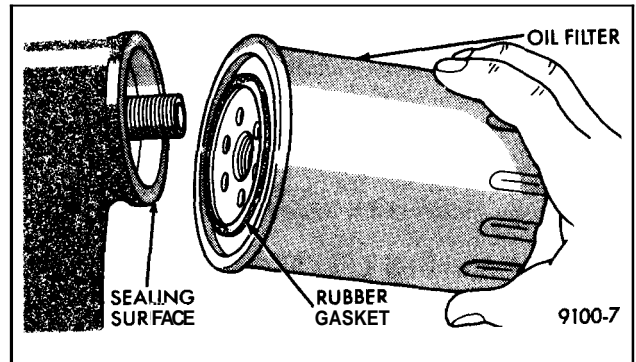


Figure 4 - 39



Cooling System

INTRODUCTION

The cooling system (Figure 4-40 and Figure 4-41) regulates engine operating temperature. It allows the engine to reach normal operating temperature as quickly as possible. It also maintains normal operating temperature and prevents overheating.

The cooling system also provides a means of heating the passenger compartment and cooling the automatic transmission fluid (if equipped). The cooling system is pressurized and uses a centrifugal water pump to circulate coolant throughout the system.

The cooling system consists of

- Radiator
- Mechanical cooling fan
- Fan shroud
- Radiator pressure cap
- Thermostat
- Coolant reserve/overflow system
- Transmission oil cooler (if auto. trans. equipped)
- Coolant
- Water pump
- Hoses and hose clamps
- Accessory drive belt

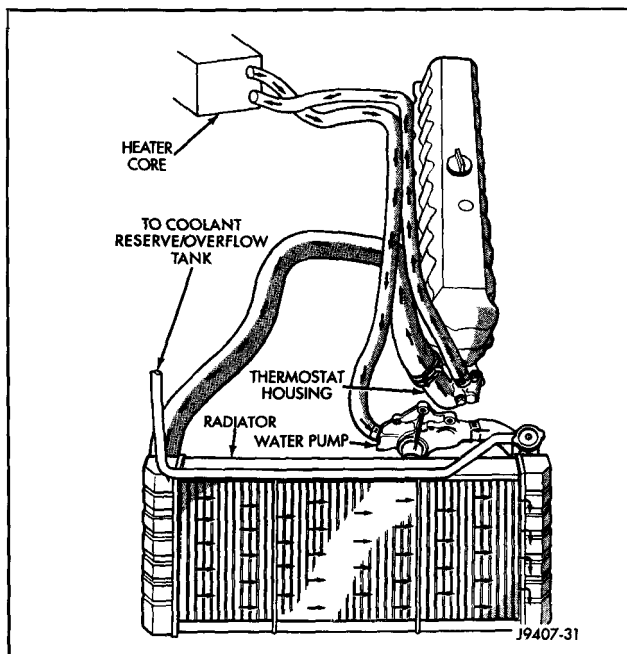


Figure 4 - 40

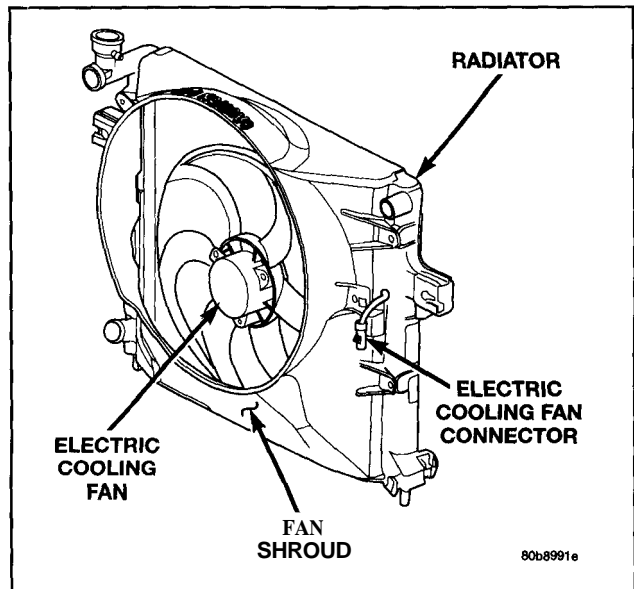


Figure 4 - 41

Cooling System Capacity

Caution: Vehicle may be equipped with long life coolant. Extended life coolant is identified by an orange color. Normal coolant is identified by a greenish color. DO NOT mix the two types of coolant. Refer to your service manual for coolant recommendations.

4.0L 12.3 liters (13.0 quarts)"

* Includes 2.2 liters (2.3 quarts) for coolant recovery bottle.

Coolant Reservoir/Overflow System

This system works along with the radiator pressure cap. This is done by using thermal expansion and contraction of the coolant to keep the coolant free of trapped air. It provides:

- A volume for coolant expansion and contraction.
- A convenient and safe method for checking/adjusting coolant level at atmospheric pressure. **This is** done without removing the radiator pressure cap.
- Some reserve coolant to the radiator to cover minor leaks and evaporation or boiling losses.

As the engine cools, a vacuum is formed in the cooling system of both the radiator and engine. Coolant will then be drawn from the coolant tank and returned to a proper level in the radiator.

The coolant reservoir/overflow system has a radiator mounted pressurized cap, an overflow tube and a plastic coolant reservoir/overflow tank mounted to the right inner fender (typical).

Troubleshooting

The 4.0L Power Tech engine standard production cooling system is adequate at keeping operating temperatures at accepted levels. However, several components may be changed to reduce power losses in the system.

Not surprisingly, race engine cooling problems arise during the summer and tend to disappear in the fall. There are various causes: flex-fans, water pumps, radiator size and functioning shrouds, grille openings, and fan blade diameter and number. The not so obvious areas are improper spark advance and too lean fuel mixture.

Now, what happens if a racer has fixed all of these problems and he still overheats or runs too hot? What could this problem be? Some people feel this means there is some mysterious design problem with the engine. This is a witch hunt! Generally, engines don't have an overheating problem. Big engines make more heat than small engines, but this just requires a bigger radiator. Put simply, engines make heat; cooling systems get rid of heat. Nothing fancy! If your engine overheats, that means the balance between these two functions has been lost somewhere.

COOLING SYSTEM HOSES

(Refer to Figure 4-40.)

Rubber hoses route coolant to and from the radiator, intake manifold and heater core. The lower radiator hose is spring-reinforced to prevent collapse from water pump suction at moderate and high engine speeds. When performing a hose inspection, inspect the radiator lower hose for proper position and condition of the internal spring.

Warning! Constant tension hose clamps are used on most cooling system hoses when removing or installing, use only tools designed for servicing this type of clamp. Always wear safety glasses when servicing constant tension clamps.

Caution: A number or letter is stamped into the tongue of constant tension clamps. If replacement is necessary, use only an original equipment clamp with matching number or letter.

Inspect cooling hoses at regular intervals. Replace hoses that are cracked, feel brittle when squeezed, or swell excessively when the system is pressurized.

In areas where specific routing clamps are not provided, be sure that hoses are positioned with sufficient clearance. Check clearance from exhaust manifolds and pipe, fan blades, drive belts and sway bars. Improperly positioned hoses can be damaged, resulting in coolant loss and engine overheating.

SERPENTINE DRIVE BELT

Correct drive belt tension is required to ensure optimum performance of the belt driven engine accessories. If specified tension is not maintained, belt slippage may cause engine overheating, lack of power steering assist, loss of air conditioning capacity, reduced generator output rate, and greatly reduced belt life.

It is not necessary to adjust belt tension on the 4.0L engines. These engines are equipped with an automatic belt tensioner. The tensioner maintains correct belt tension at all times. Due to use of this belt tensioner, DO NOT attempt to use a belt tension gauge on 4.0L engines.

Diagnosis

When diagnosing serpentine drive belts, small cracks that run across ribbed surface of belt from rib to rib (Figure 4-42) are considered normal. However, cracks running along a rib (not across) are not normal (Figure 4-42). Any belt with cracks running along a rib must be replaced. Also replace the belt if it has excessive wear, frayed cords or severe glazing.

Refer to the *Serpentine Drive Belt Diagnosis Chart* for further belt diagnosis.

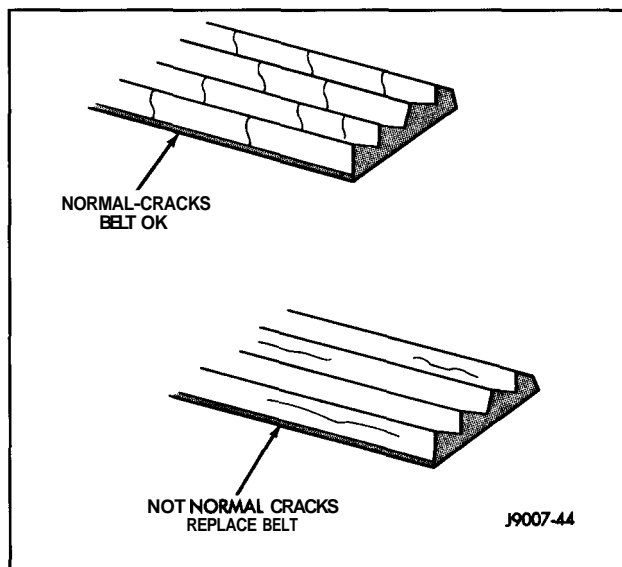


Figure 4 - 42

SERPENTINE DRIVE BELT DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
RIB CHUNKING (ONE OR MORE RIBS HAS SEPARATED FROM BELT BODY)	<ol style="list-style-type: none"> 1. Foreign objects imbedded in pulley grooves. 2. Installation damage. 	<ol style="list-style-type: none"> 1. Remove foreign objects from pulley grooves. Replace belt. 2. Replace belt.
RIB OR BELT WEAR	<ol style="list-style-type: none"> 1. Pulley(s) misaligned. 2. Abrasive environment. 3. Rusted pulley(s). 4. Sharp or jagged pulley groove tips. 5. Rubber deteriorated. 	<ol style="list-style-type: none"> 1. Align pulley(s). 2. Clean pulley(s). Replace belt if necessary. 3. Clean rust from pulley(s). 4. Replace pulley. 5. Replace belt.
LONGITUDINAL BELT CRACKING (CRACKS BETWEEN TWO RIBS)	<ol style="list-style-type: none"> 1. Belt has mistracked from pulley groove. 2. Pulley groove tip has worn away rubber to tensile member. 	<ol style="list-style-type: none"> 1. Replace belt. 2. Replace belt.



SERPENTINE DRIVE BELT DIAGNOSIS		
CONDITION	POSSIBLE CAUSES	CORRECTION
BELT SLIPS	<ol style="list-style-type: none"> 1. Belt slipping because of insufficient tension. 2. Incorrect belt. 3. Belt or pulley subjected to substance (belt dressing, oil ethylene glycol) that has reduced friction. 4. Driven component bearing failure. 5. Belt glazed and hardened from heat and excessive slippage. 	<ol style="list-style-type: none"> 1. Replace automatic belt tensioner. 2. Replace belt. 3. Replace belt and clean pulleys. 4. replace faulty component bearing. 5. Replace belt.
"GROOVE JUMPING (BELT DOES NOT MAINTAIN CORRECT POSITION ON PULLEY)	<ol style="list-style-type: none"> 1. Belt tension either too high or too low. 2. Incorrect belt. 3. Pulley(s) not within design tolerance. 4. Foreign object(s) in grooves. 5. Pulley misalignment. 6. Belt cord line is broken. 	<ol style="list-style-type: none"> 1. Replace automatic belt tensioner. 2. Replace belt. 3. Replace pulley(s). 4. Remove foreign objects from grooves. 5. Check and replace. 6. Replace belt.
BELT BROKEN (NOTE: IDENTIFY AND CORRECT PROBLEM BEFORE NEW BELT IS INSTALLED)	<ol style="list-style-type: none"> 1. Excessive tension. 2. Incorrect belt. 3. Tensile member damaged during belt installation. 4. Severe misalignment. 5. Bracket, pulley, or bearing failure. 	<ol style="list-style-type: none"> 1. Replace belt and automatic belt tensioner. 2. Replace belt. 3. Replace belt. 4. Check and replace. 5. Replace defective component and belt.
NOISE (OBJECTIONABLE SQUEAL, SQUEAK, OR RUMBLE IS HEARD OR FELT WHILE DRIVE BELT IS IN OPERATION)	<ol style="list-style-type: none"> 1. Belt slippage. 2. Bearing noise. 3. Belt misalignment. 4. Belt-to-pulley mismatch. 	<ol style="list-style-type: none"> 1. Replace belt or automatic belt tensioner. 2. Locate and repair. 3. Replace belt. 4. Install correct belt.

WATER PUMP

A centrifugal water pump (Figure 4-43) circulates coolant through the water jackets, passages, intake manifold radiator core, cooling system hoses and heater core. The pump is driven from the engine crankshaft by a single serpentine drive belt on all engines.

The water pump impeller is pressed onto the rear of a shaft that rotates in bearings pressed into the housing. The housing has two small holes to allow seepage to escape. The water pump seals are lubricated by the antifreeze in the coolant mixture. No additional lubrication is necessary.

Caution: All 4.0L Power Tech engines are equipped with a reverse (counterclockwise) rotating water pump and thermal viscous fan drive assembly. REVERSE is stamped or imprinted on the cover of the viscous fan drive and inner side of the fan. The letter R is stamped into the back of the water pump impeller. Engines from previous model years, depending upon application, may have been equipped with a forward (clockwise) rotating water pump. Installation of the wrong water pump or viscous fan drive will cause engine over heating.

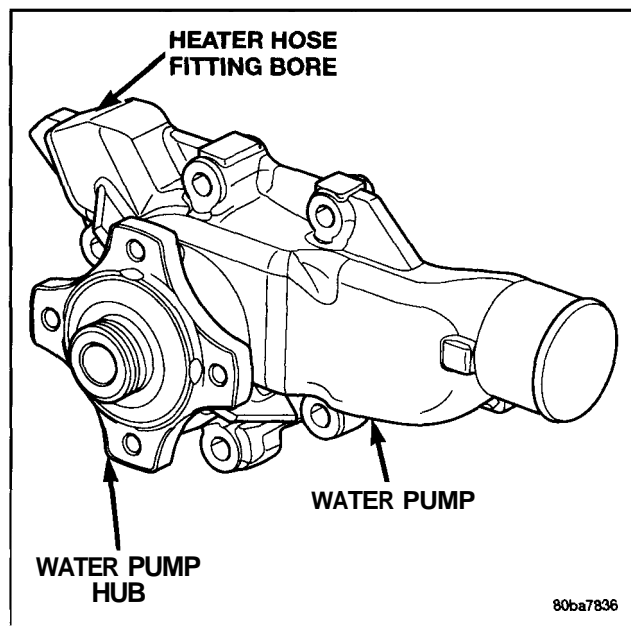


Figure 4 - 43

Performance Tips

The water pump is the heart of the cooling system. It is responsible for pumping coolant through the engine block, cylinder heads, heater core and radiator.

For most high performance off-road applications, high engine temperature is undesirable. For these applications, install a 160°F thermostat. It will help the engine run cooler.

Caution: 160°F thermostats should NOT be used in other than high endurance racing vehicles. Use of 160°F thermostats in vehicles other than this can result in serious engine damage.

For high speed race engines, a small diameter crankshaft pulley and large diameter alternator and water pump pulleys are desirable. Aftermarket sources have these pulleys available and they feature a deep groove design.

For drag strip use only, the water pump can be cut down .200" for less friction and horsepower loss. There are also aftermarket electric fan-water pump kits which replace the standard fan belt so that the power that is needed to operate the water pump doesn't come from the crankshaft, increasing the engine's horsepower output. (A mechanical water pump requires about 10 hp at 7,000rpm.) If legal, an electric drive water pump should always be used.

Water Pump Flow Test

A quick flow test to tell whether or not the pump is working is to see if the heater warms properly. A defective pump will not be able to circulate heated coolant through the long heater hose.

Another flow test to help determine pump operation is as follows:

1. Remove radiator cap.

'Warning!' DO NOT remove radiator cap if the cooling system is hot or under pressure.
2. Remove a small amount of coolant from the system. Start the engine and warm up until the thermostat opens. With the thermostat open and coolant level low, you will see if the water pump is pumping coolant through the system.

Water Pump Inspection

Replace water pump assembly if it has any of the following conditions:

- The body is cracked or damaged.
- Water leaks from shaft seal. This is evident by traces of coolant below vent hole.
- Loose or rough turning bearing. Also inspect viscous fan drive.
- Impeller rubs either the pump body or the cylinder block.

WATER NECK

The water neck is also called the thermostat housing. However, many racing vehicles DO NOT use a thermostat, so it might be confusing to name it after something that is not used. The typical water neck exits straight up. The upper radiator hose fits over the water neck.

90 Degree Water Neck Outlet

The purpose of the 90 degree outlet is to drop the upper radiator hose down and allow its angle to be changed. Stock outlets have the water exiting straight up (as installed on the engine). This type of exit requires the top radiator hose to make a quick 90 degree bend to get to the radiator. In this configuration, it is common to get kinks in the hose, especially replacement hoses. Stock Mopar hoses are molded with the sharp bend. However, the hose will still interfere with any blower drives that may sit on top of the manifold. By having the 90 degree bend in a rigid housing rather than a rubber hose, you can turn the corner much tighter. This allows for a lower hood line (which can also be helpful in circle track vehicles). It also looks neater and cleaner—a plus for show vehicles.

An additional feature is that it has three positions: straight ahead, approximately 30 degrees to the right, or 30 degrees to the left, enabling the housing to be rotated to point more directly at the top radiator inlet. This allows for more options in clearance items/accessories at the front of the engine. It also makes for a straighter and smaller hose and therefore a cleaner looking engine compartment.

90° Water Neck Outlet

Cast aluminum, 90° water neck outlet provides greater flexibility in routing cooling system hoses. Three directional capability ideal for compact engine compartments. Improves the appearance of the engine compartment.

P5249191 90" water neck outlet.

THERMOSTAT

The engine thermostat is a wax pellet driven, reverse poppet choke-type. It is located on the front of the engine (radiator side) in the thermostat housing/engine outlet connector located in the flange (Figure 4-44). An O-ring for sealing is incorporated on it. There is a relief in the thermostat housing/outlet connector for the O-ring (Figure 4-45).

An arrow, plus the word UP is stamped on the front flange next to the air bleed. The words TO RAD are stamped on one arm of the thermostat. They indicate the proper installed position.

The engine thermostat is designed to provide the fastest warm-up possible by preventing leakage through it and to guarantee a minimum engine temperature of 82 to 91°C (180 to 195°F). It also automatically reaches wide open so it does not restrict flow to the radiator as temperature of the coolant rises in hot weather to around 104°C (220°F). Above this temperature the coolant temperature is controlled by the radiator, fan, and ambient temperature, not the thermostat.

The thermostat's primary purpose is to maintain engine temperature in a range that will provide satisfactory engine performance and emission levels under all expected driving conditions. It also provides hot water (coolant) for heater performance. It does this by transferring heat from engine metal and automatic transmission oil cooler (if equipped) to coolant, moving this heated coolant to the heater core and radiator and then transferring this heat to the ambient air.

The same thermostat is used for winter and summer seasons. An engine should not be operated without a thermostat, except for servicing or testing. Operating without a thermostat causes other problems, including longer engine warm-up time, unreliable warm-up performance, increased exhaust emissions and crankcase condensation. This condensation can result in sludge formation.

The most common type of thermostat failure, usually found on high mileage vehicles, is a thermostat failed in the shut position. The temperature gauge (if equipped) will give an indication of this condition. Depending upon length of time that vehicle is operated pressure cap may vent. This will expel steam and coolant to coolant reserve/overflow tank and the ground below vehicle.

For most high performance off-road applications, high engine temperature is undesirable. For these applications, install a 160°F thermostat. It will help the engine run cooler.

Caution: 160°F thermostats should NOT be used in other than high endurance racing vehicles. Use of 160°F thermostats in vehicles other than this can result in serious engine damage.

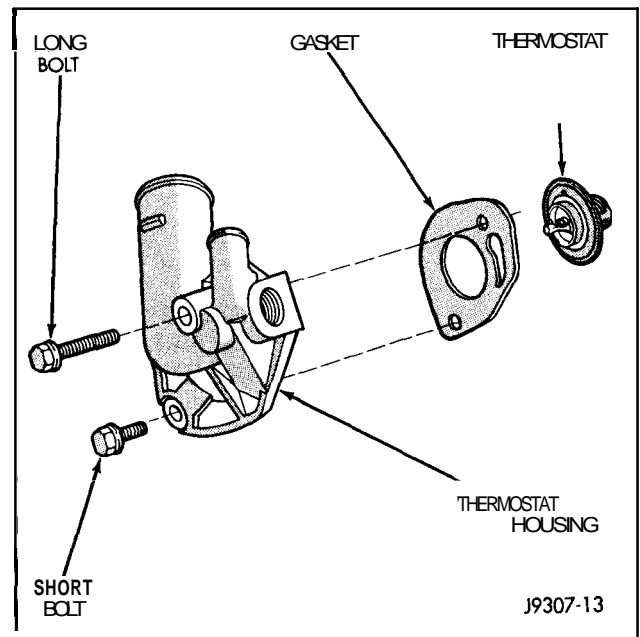


Figure 4 - 44

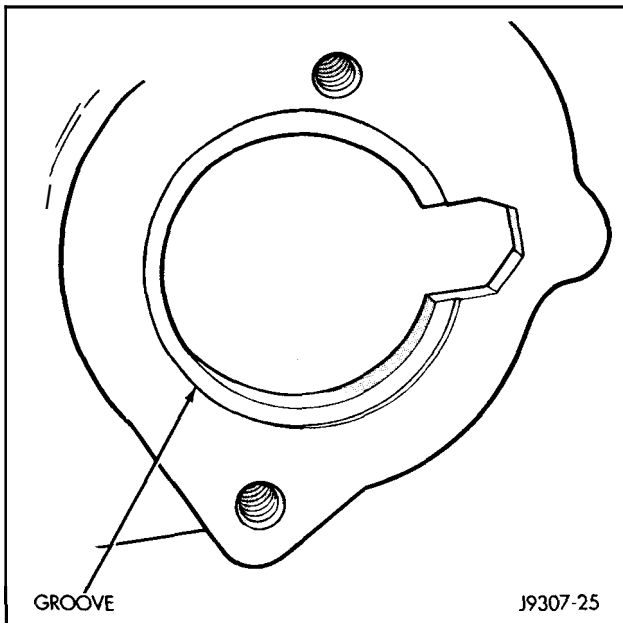


Figure 4 - 45

COOLANT

The presence of aluminum components in the cooling system requires strict corrosion protection. Maintain coolant at specified level with a 50/50 mixture of antifreeze and water. If coolant becomes contaminated or loses color, drain and flush cooling system and fill with correctly mixed solution.

Caution: DO NOT use coolant additives which claim to improve engine cooling.

FANS

Viscous Fan Drive

On 4.0L engines, an electric fan is standard and a thermal viscous fan is added on trailer tow packages only. The thermal viscous fan drive (Figure 4-46) is a silicone fluid-filled coupling used to connect the fan blades to the water pump shaft. The coupling allows the fan to be driven in a normal manner. This is done at low engine speeds while limiting the top speed of the fan to a predetermined maximum level at higher engine speeds.

A thermostatic bimetallic spring coil is located on the front face of the viscous fan drive unit (Figure 4-46). This spring coil reacts to the temperature of the radiator discharge air. It engages the viscous fan drive for higher fan speed if the air temperature from the radiator rises above a certain point. Until additional engine cooling is necessary, the fan will remain at a reduced rpm regardless of engine speed.

Only when sufficient heat is present will the viscous fan drive engage. This is when the air flowing through the radiator core causes a reaction to the bimetallic coil. It then increases fan speed to provide the necessary additional engine cooling.

Once the engine has cooled, the radiator discharge temperature will drop. The bimetallic coil again reacts and the fan speed is reduced to the previous disengaged speed.

Caution: Engines equipped with serpentine drive belts have reverse rotating fans and viscous fan drives. They are marked with the word REVERSE to designate their usage. Installation of the wrong fan or viscous fan drive can result in engine overheating.

Caution: If the viscous fan drive is replaced because of mechanical damage, the cooling fan blades should also be inspected. Inspect for fatigue cracks, loose blades, or loose rivets that could have resulted from excessive vibration. Replace fan blade assembly if any of these conditions are found. Also inspect water pump bearing and shaft assembly for any related damage due to a viscous fan drive malfunction.

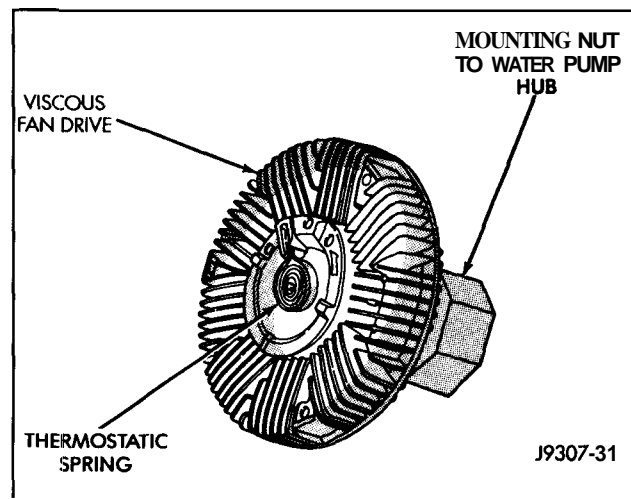


Figure 4 - 46

Mopar Performance Parts Viscous Fan Package

Mopar Performance Parts has carried a viscous drive fan package for years. Viscous drives allow the engine to run at a higher rpm than the fan: that is, the fan slips at high speed. The purpose of a viscous drive is to save horsepower.

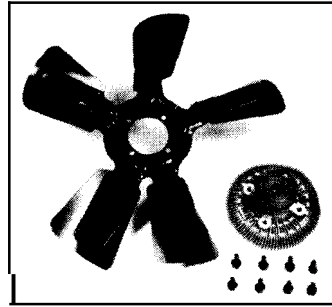
We receive many calls concerning fans and cooling. A large number of viscous fans have been introduced in the aftermarket over the last few years. This situation caused us to throw some parts on the dyno. The dyno allows us to know exactly what's going on. We selected several viscous units and several different fans. Some of the new fans look very nice – six blade, symmetrical. The one we've shown in our parts catalog for years is a five blade, asymmetrical design, which we've always considered to look "funny."

The new ones were bound to do better. Well, so much for style! The Mopar Performance Parts viscous fan package won! It was 5 to 10 horsepower better than the other viscous fans. Each was run separately so that we didn't miss any possible combination.

That was reassuring. But the real shocker was the Mopar Performance Parts viscous drive compared to a plastic flex fan. Everyone had always assumed that these two types of units were about the same in performance. Additionally, the plastic flex fans are sold as a performance piece and they have always looked trick. Well so much for looks! The Mopar Performance Parts viscous drive package was 10 horsepower and 13 lb-ft of torque better than the flex fan. The flex fan could be as good as some of the other viscous drives, but the Mopar Performance Parts unit is substantially better for performance.

Note: Although the viscous fan package listed will fit your 4.0L Power Tech engine (bolt spacing is the same), care must be taken to assure sufficient fan-to-radiator clearance is maintained (minimum 1/2" from the leading edge of the fan to the back edge of the radiator; 3/4" preferred).

Viscous Fan Package



Most late 1960s and early 1970s Chrysler-Plymouth-Dodge muscle cars were equipped with viscous fans for cooling purposes. DaimlerChrysler engineers have determined through dyno testing that this viscous fan is the best replacement package. It provides thermostatically controlled cooling, includes a lightweight balanced fan and takes the least amount of horsepower from the engine.

P4120758

Viscous fan package.

Electric Fans

12 volt electric cooling fans are highly efficient auxiliary bolt-ons for Street Rods, Street Machines, race cars, trucks, and compact or medium sized vehicles. They can be installed in front or in back of your radiator quickly and easily. Unlike conventional belt drive fans, an electric fan will not rob engine horsepower.



Induction System

INTAKE MANIFOLD

The 4.0L engine standard production intake manifold is made of cast aluminum and uses eleven bolts to mount to the cylinder head (Figure 4-48). This mounting style improves sealing and reduces the chance of leaks.

Removal and Installation

The engine intake manifold and exhaust manifolds must be removed and installed together. The manifolds use a common gasket at the cylinder head. Refer to *Exhaust Manifolds*, 'Exhaust System' section of this chapter for more information.

MULTI-POINT FUEL INJECTION (MPI)

The 4.0L engine uses a sequential Multi-Port Fuel Injection (MPI) system. Fuel is injected into the intake manifold before the intake valve in precise metered amounts through electrically operated injectors. The injectors are fired in a specific sequence by the Powertrain Control Module (PCM). The PCM constantly adjusts the amount of fuel injected to meet changing operating conditions by controlling injector pulse width (the length of time the injector is energized). The PCM also adjusts ignition timing by controlling the ignition coil operation through the Ignition Control Module (ICM). The PCM determines air-fuel mixture and ignition timing based on inputs it receives from various sensors that monitor engine operating conditions.

The PCM receives inputs from sensors that react to exhaust gas oxygen content, coolant temperature, manifold absolute pressure, engine speed (crankshaft position), throttle position, battery voltage, intake manifold air temperature, engine knock and transmission gear selection. These inputs represent the engine's instantaneous operating conditions. Air-fuel mixture and ignition timing calibrations for various driving and atmospheric conditions are pre-programmed into the PCM. The PCM monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. The Engine Control System is comprised of (1) the sensors and switches that provide input to the PCM, (2) the PCM itself, and (3) the PCM outputs (engine control devices that the PCM constantly adjusts). The Engine Control System consists of

- Battery Voltage
- Manifold Absolute Pressure (MAP) Sensor
- Coolant Temperature Sensor
- Manifold Air Temperature (MAT) Sensor
- Exhaust Oxygen (O₂) Sensor

- Engine Speed/crankshaft Position Sensor
- Throttle Position Sensor
- Injector Synchronization Signal
- A/C Select Signal
- A/C Request Signal
- Neutral Safety Switch
- Knock Sensor
- Fuel Pump Relay
- Fuel Injectors
- Idle Speed Stepper Motor
- B+ Latch Relay
- Oxygen Sensor Heater Relay
- EGR Valve Solenoid
- Ignition Control Module
- Shift Indicator Light (manual transmissions only)
- A/C Clutch Relay

Powertrain Control Module (PCM)

The Powertrain Control Module (PCM) is a digital microprocessor. Air-fuel mixture calibrations for various driving and atmospheric conditions are pre-programmed into the PCM. The PCM monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. As operating conditions change, the PCM adjusts injector pulse width and ignition timing for optimum performance and fuel economy.

Jeep High Performance Computer

Mopar Performance Parts computer provides more spark advance and increased fuel flow for off road racing applications. This computer will enhance other performance modifications. For 1987-90, 4.0L engines only.

P4529334 Jeep high performance computer.

PCM Inputs

The PCM is powered by the vehicle's battery. When the ignition is turned to the ON or START position, the following inputs are supplied to the PCM:

- Battery Voltage
- Manifold Absolute Pressure (MAP) Sensor
- Coolant Temperature Sensor

- Manifold Air Temperature (MAT) Sensor
- Exhaust Oxygen (O₂) Sensor
- Engine Speed/crankshaft Position Sensor
- Throttle Position Sensor
- Injector Synchronization Signal
- A/C Select Signal
- Neutral Safety Switch (gear selection— automatic transmission)
- Knock Sensor
- Start Signal

PCM Outputs

Based upon signals from various input sensors and switches, the PCM adjusts the following components (PCM outputs):

- Fuel Pump Relay
- B+ Latch Relay
- Oxygen Sensor Heater Relay
- A/C Clutch Relay
- Fuel Injectors
- Idle Speed Stepper Motor
- EGR Valve Solenoid
- Ignition Control Module (ICM)
- Shift Indicator Light (manual transmission only)

Modes of Operation

As input signals to the PCM change, the PCM adjusts its response to the output devices. For example, the PCM must calculate a different injector pulse width and ignition timing for idle than it does for wide open throttle. There are eight different modes of operation that determine how the PCM responds to the various input signals.

Modes of operation are of two different types: OPEN LOOP and CLOSED LOOP.

During OPEN LOOP modes the PCM receives input signals and responds only according to preset PCM programming. Input from the oxygen (O₂) sensor is not monitored during OPEN LOOP modes.

During CLOSED LOOP modes the PCM does monitor the O₂ sensor input. This input indicates to the PCM whether or not the calculated injector pulse width results in the ideal air-fuel ratio (14.7 parts air to 1 part fuel). By monitoring the exhaust oxygen content through the O₂ sensor, the PCM can 'fine tune' the injector pulse width to achieve optimum fuel economy combined with low emission engine performance.

The MPI system has the following modes of operation:

- Ignition Switch ON
- Engine Start-up (Crank)
- Engine Warm-up
- Idle
- Cruise
- Deceleration
- Wide Open Throttle
- Ignition Switch OFF

The ignition switch ON, engine start-up (crank), engine warm-up, deceleration, and wide open throttle modes are OPEN LOOP modes. The idle and cruise modes, *with the engine at operating temperature*, are CLOSED LOOP modes.

Throttle Body

Filtered air from the air cleaner enters the intake manifold through the throttle body. Fuel does not enter the intake manifold through the throttle body. Fuel is sprayed into the manifold by the fuel injectors. This throttle body, mounted on the intake manifold, contains an air bypass passage that is used to supply air for idle conditions, and a throttle valve for above idle conditions.

The throttle position sensor and idle speed stepper motor are attached to the throttle body. The accelerator cable is connected to the throttle valve through a bellcrank and linkage mounted to the intake manifold.

There are different throttle bodies for automatic and manual transmission equipped vehicles. The throttle valve is not controlled by the PCM.

Fuel Rail

The fuel rail supplies fuel to the injectors and is mounted to the intake manifold (Figure 4-47). The fuel pressure regulator is attached to the rail and the fuel pressure test port is integral with the rail. The fuel rail is not repairable.

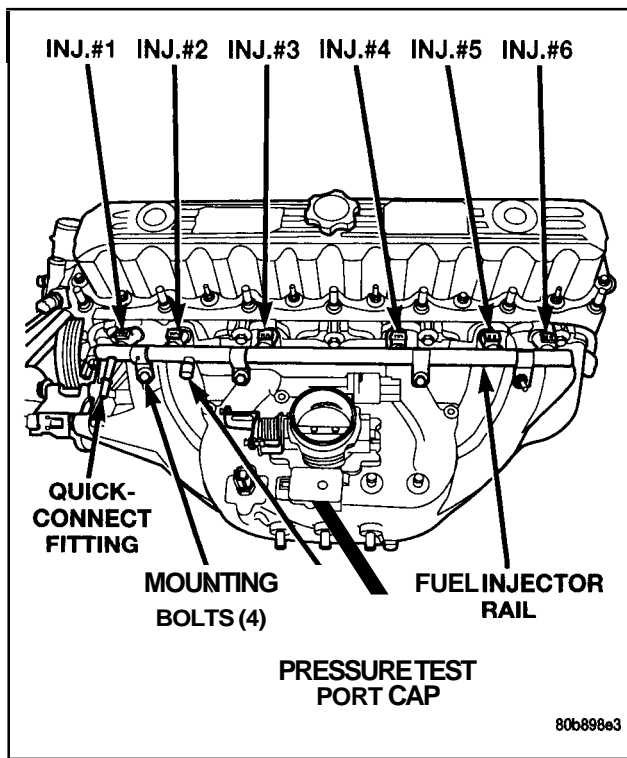


Figure 4 - 47

Fuel Pressure Regulator

The fuel pressure regulator used with the MPI fuel system is a vacuum assisted, non-adjustable type. The regulator is mounted on the output end of the fuel rail and is connected to intake manifold vacuum. The regulator is calibrated to maintain fuel system pressure at approximately 214 kPa (31 psi) with vacuum applied while the engine is at idle. Fuel pressure will be 55-69 kPa (8-10 psi) higher if vacuum is not applied to the regulator.

The pressure regulator contains a diaphragm, calibrated spring and fuel return valve. Fuel pressure operates on the bottom side of the diaphragm while spring pressure and intake manifold vacuum operate on the top side of the diaphragm. Spring pressure tries to force the return valve closed. Fuel pressure, with assistance from manifold vacuum on the spring side, acts against the spring pressure to open the return valve. Thus, *system fuel pressure* is the amount of fuel pressure required to force against spring pressure and unseat the fuel return valve.

Without vacuum applied to the spring side of the regulator, the spring is calibrated to open the fuel return outlet when the pressure differential between the fuel injectors and the intake manifold reaches approximately 269 kPa (39 psi). Since manifold vacuum varies with engine operating conditions, the amount of vacuum applied to the spring side of the diaphragm varies. For this reason, fuel pressure varies depending upon intake manifold vacuum. With low vacuum, such as during wide open throttle conditions, minimal vacuum assistance is available and full spring

pressure is exerted to seal the fuel outlet causing system pressure to increase. With high vacuum, such as during idle, fuel pressure on the bottom of the diaphragm is assisted by intake manifold pressure on the spring side of the diaphragm, resulting in lower system fuel pressure. The fuel pressure regulator is not controlled by the PCM.

Racing Modifications

By their nature, unlike carbureted engine set-ups, fuel injection systems deliver fuel equally among all six cylinders. It's because of this excellent fuel distribution characteristic that fuel injection is preferred over carburetors, even over high performance 2 and 4-Bbl. carburetors.

And don't disconnect those stock fuel injection sensors! Today's engines run a lot hotter because they run a lot leaner; because of this, fuel injection temperature is very critical. It is something that has to be constantly monitored and stabilized to keep the fuel injection and the power level in their proper places. Mopar Performance Parts recommends the use of all sensors, even in high-performance racing set-ups. These sensors constantly input vital information to the PCM, and the PCM corrects the mixture accordingly.

And don't abandon that oxygen sensor, either. Since racing set-ups don't use catalytic converters, use an EGT probe to locate the hottest spot in the exhaust system and install the oxygen sensor there.

AIR FILTERS

High Performance Air Filter Element

Special reusable filter element for high performance. Increases air flow versus stock filters which increases engine output.

P5249792	High performance air filter element, 1993-97 Jeep Grand Cherokee 4.0L only.
P5249918	High performance air filter element, 1991-96 Jeep Wrangler 4.0L only.
P4876273	High performance air filter element, 1997-98 Jeep Wrangler 4.0L only.
P4876272	High performance air filter element, 1987-96 Jeep Cherokee 4.0L only.

Air Filter Cleaning Fluid

Mopar Performance Parts long-life high performance air filters are reusable. This cleaning fluid is designed to remove dirt to extend the life of the filter.

P4529392	Air filter cleaning fluid.
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Air Filter Oil

Long life, high performance air filters trap dirt with a special oil on the filter. After cleaning air filters, re-oil them with this special fluid.

P4529393 Air filter oil.

TURBOCHARGING

Turbocharging is not for the amateur. People who want turbochargers on their race vehicles are those looking for an added amount of horsepower to their already well-running engines.

Turbocharging is not a new engineering feature. It has been used for many years in many applications. Even some production models of the mid-1960s had a turbocharging option. However, after a year or two in production, these options were dropped.

Over the past several years, interest in turbocharging has increased rapidly. Much of this interest is centered around the Street Machine, Street Rod, and recreational vehicle segments of the automotive high performance scene. We have been evaluating the turbocharging of Jeep engines for several years. We have been primarily interested in gaining experience and knowledge in the area and have left the marketing of kits, etc., to the aftermarket manufacturers.

Turbocharging is best suited to small engines with low compression ratios because of the quality of gasoline currently available. Turbochargers can add a lot of power to an engine without having to change engine displacement, swap engines, or disassemble the engine. Most aftermarket systems just bolt right on. Jeep engines are particularly well-suited to turbocharging because of their heavy duty construction and reliability.

Choosing a turbocharger can be a complicated task which is beyond the scope of this discussion. For details, we suggest that you contact the various turbo manufacturers. In general, small engines should use small turbochargers. Also, small turbochargers are best suited for general purpose use. The larger turbochargers are designed for high engine speeds and high outputs, which make them best suited for actual racing applications. The boost pressure from the turbocharger for a general purpose application would be in the 5 to 10 psi range. For boost pressures over 10 psi and/or higher compression ratios (over 8.0:1), water and/or alcohol injection is needed. For general purpose use, a conservative camshaft is an advantage because it improves low speed response. Also, for general purpose use, water injection is not recommended because if the water is allowed to run out, excessive detonation and engine failure would quickly result.

In a turbocharging application, the most likely parts to fail in an engine are the pistons and/or rings, which will fail from detonation. Therefore, low compression ratios and lower boost pressures are recommended for general purpose use, and water injection should be used in racing applications. For general purpose turbocharger applications, a spark advance retard system sensitive to positive manifold pressure should be added to the distributor.

Some general tips on turbocharging are as follows. A wastegate increases the engine's performance, especially at lower engine speeds. A turbocharger unit needs to be oiled from the engine. It should also have a much larger oil return line to the sump than the line that is used to supply the oil to the turbo under pressure.

If you have further questions on turbocharging, we suggest that you contact the manufacturer of the turbocharging system you are interested in.

SUPERCHARGING

Supercharging is not for the amateur. People who want superchargers on their race vehicles are those looking for an added amount of horsepower to their already well-running engines.

There are many types of superchargers on the market. There are roots blowers and centrifugal blowers. There are names like Paxton, Latham, Judson, B & M, Weiland, and many others. But to most racers and performance enthusiasts, the blower that they want on either their race or dual purpose vehicle is a 6-71. It is a roots blower, but it's better known as the blower the pros have used in Top Fuel and Funny Car racing dating back to the late 1960s.

The 6-71 roots blower makes power (and torque) by putting a positive pressure in the intake manifold. In a typical dual purpose application, this pressure is in the 5 to 7 psi range.

6-71 blowers were designed and built originally for diesel engines. They have never been standard production on any gasoline engine. However, they have become very popular additions for Street Machines and Street Rods. These "automotive" units are remanufactured and/or specially built for racing/high performance purposes.

There are two general types of 6-71 blowers for high performance applications – Gas/Fuel "pro" racing and dual purpose. These two look the same externally but are different internally and use a different drive arrangement. We'll leave the "Gas/Fuel" racing blowers to the pros. They are much more expensive.

Dual purpose 6-71 blowers bolt to a specially modified intake manifold usually based on a carbureted intake for the specific engine. In some cases, it is a unique casting.

Once you have the special intake manifold, the blower can be bolted on to your engine. After the carburetor or fuel injection is added to the top of the blower, a hole is cut in the hood, fuel lines and throttle linkage added, and everything is done except for the blower drive, which is added to the front of the engine. The adaptation of the blower to the intake for your specific engine and the blower drive itself are best left to the dual purpose blower specialists that make the kits.

Note: Due to the increased air flow, supercharging an engine requires a large increase in fuel delivery. Production fuel injection systems are not capable of meeting this fuel demand. To supercharge an engine which has production fuel injection, the injection system must be substantially modified or else removed and a carburetion system installed.

Sources

The various engine builders and suppliers in the supercharging area are very important people to keep in touch with to be able to keep up-to-date. Their addresses are listed below

Keith Black Racing Engines
 11120 Scott Avenue
 South Gate, California 90280

Milodon Engineering Co.
 20716 Plummer Street
 Chatsworth, California 91311

B & M
 9142 Independence Avenue
 Chatsworth, California 91311
www.bmracing.com

Crane Cams
 530 Fentress Boulevard
 Daytona Beach, Florida 32114
www.cranecams.com



Fuel Delivery System

INTRODUCTION

The fuel delivery system must supply gasoline to the carburetor/fuel injectors under very hard acceleration, potentially as high as two G. The best carburetor/fuel injection and intake manifold set-up can't do its job if it doesn't receive the proper supply of fuel. Getting fuel to the carburetor/fuel injectors efficiently for off-road (racing) applications is the subject of this section.

Note: For more information on fuel injection systems, refer to 'Induction System' section of this chapter.

Drag Racing Fuel System

A good electric fuel pump, such as the Carter 4.594 (P4007038), should be used to make sure that the engine doesn't have any fuel starvation problems. It should be hooked up so that it only works when the key is in the "ON" position. A separate switch in conjunction with the ignition key is optional. See *Mopar Chassis-8th Edition* (P5249441) for more complete details.

In Stock Eliminator, one electric pump is sufficient. In faster categories such as Super Stock or Modified Production, two Carter electric fuel pumps (P4007038) in parallel should be used. Parallel means having two inlets and two outlets rather than one pump feeding into a second pump. The mechanical pump should also be used.

Also available from Mopar Performance Parts for race vehicles is a high capacity, high pressure Holley electric fuel pump (P4120227—regulator included) and Holley pressure regulator (P4120228). The Holley pump requires the Holley regulator. With the Holley pressure regulator and electric fuel pump, you don't use a mechanical pump. This means the pump could be left on with no fuel lines attached, or the pump could be removed and the hole left in the block covered with a chrome fuel pump block-off plate (P4529404). The latter approach is recommended.

For the majority of bracket racing applications we recommend an electric fuel pump be added next to the gas tank in addition to the mechanical fuel pump. For a dual 4-Bbl. tunnel ram system, we recommend two Holley electric fuel pumps (P4120227) with a pressure regulator (included with pump) at each carburetor.

You should always have at least one fuel filter in the line. DO NOT use a glass or plastic fuel filter. Use only a metal fuel filter. Glass and plastic filters may be convenient, but they are usually not legal for racing and are definitely *not safe*.

Warning! Plastic or glass fuel filters will either melt or break in an accident or fire, causing a major fuel fire. MOPAR PERFORMANCE PARTS DOES NOT RECOMMEND THE USE OF GLASS OR PLASTIC FUEL FILTERS AT ANY TIME.

Carter Electric Fuel Pump

In Stock Eliminator, one pump is sufficient. In faster categories, two pumps can be used in parallel. Provides 72 gph @ 7.0 psi.

P4007038 Carter electric fuel pump.

Holley Electric Fuel Pump

High capacity, high pressure. Can be used in parallel without mechanical pump for multiple carburetor applications. Regulator included. Provides 70 gph at 9.0 psi.

P4120227 Holley electric fuel pump.

Holley Fuel Pressure Regulator

To service Holley fuel pump P4120227.

P4120228 Holley fuel pressure regulator.

High Capacity Electric Fuel Pumps

High capacity, high pressure electric fuel pump can be used singularly or in parallel with mechanical pump. Designed for drag race applications.

P5249781 110 gph.

P.5249782 140 gph.

P5249783 250 gph.

Oval Track Fuel System

The fuel system has to keep fuel supplied in adequate volume and pressure to allow the carburetor/fuel injectors to function properly at W.O.T. (wide open throttle). If it doesn't, the engine will run lean, overheat and fail **parts**, or not run at all.

Caution: Due to the extreme safety hazards that electric fuel pumps can cause in oval track racing, Mopar Performance Parts does NOT recommend the use of electric fuel pumps for oval track vehicles. Refer to Chapter 8, *Off-Roading and Racing*, for more details.

Generally, electric pumps are not allowed by circle track sanctioning bodies/tech officials. This means that the rest of the fuel system has to be “right.” The mechanical pump has to be in top shape. Be sure to use a high volume pump. The fuel lines must be as straight as possible without kinks, flat spots, pinches, or diameter changes. From the tank to the carburetor, only one size fuel line should be used. Once you split the main fuel line down from one line to multiple carburetor entries (such as a dual-feed Holley carburetor), you can drop a size in fuel line diameter.

You should always have at least one fuel filter in the line. DO NOT use a glass or plastic filter. Use only a metal fuel filter. Glass and plastic filters may be convenient, but they are usually not legal for racing and are definitely *not safe*.

Warning! Plastic or glass fuel filters will either melt or break in an accident or fire, causing a major fuel fire. MOPAR PERFORMANCE PARTS DOES NOT RECOMMEND THE USE OF GLASS OR PLASTIC FUEL FILTERS AT ANY TIME.

If you are constructing new fuel lines, they should go under the floor pan. And don't forget the gas tank vent. It should be designed to work both on the level ground of the pits/garage and on the banked/high G comers on the race track itself. Keep in mind that, in the comers at race speeds, all the gas in the tank is “piled up” on the right side (passenger side) of the tank. (This obviously assumes that the race car always turns left.)

FUEL PUMP

The fuel pumps of carbureted and fuel injected vehicles are different. Carbureted vehicles have a mechanical fuel pump driven by an eccentric lobe on the engine's camshaft. Fuel injected engines (such as the 4.0L) have a gear/rotor type pump driven by a permanent, magnetic 12 volt electric motor that is immersed in the fuel tank. This electric pump is integral with the fuel sender unit and is also installed inside the fuel tank.

Note: Electric fuel pumps used with Throttle Body Injection (TBI) and Multi-Point Injection (MPI) systems, though similar in appearance and function, are different and CANNOT be interchanged.

MPI Fuel Pump

The MPI fuel pump has a check valve at the outlet end that consists of a steel ball held against a seat by force applied from a spring. When the pump is operating, fuel pressure overcomes spring pressure and forces the ball off its seat, allowing fuel to flow. When the pump is not operating, spring pressure forces the ball back against the seat preventing fuel back flow through the pump.

MPI Fuel Pump Controls

The fuel pump circuit of the MPI system is equipped with a ballast resistor to reduce fuel pump noise. Voltage to operate the fuel pump is supplied through the fuel pump relay, except during engine starting (cranking) and wide open throttle conditions. Ground for the fuel pump relay is controlled by the engine's Powertrain Control Module (PCM). During engine starting, the fuel pump relay and ballast resistor are bypassed and voltage is supplied to the fuel pump through the starter relay. During wide open throttle conditions the fuel pump relay and ballast resistor are again bypassed and voltage is supplied to the fuel pump through the oxygen (O²) sensor relay.

MPI system fuel pressure is maintained at 214 kPa (31 psi) when the pump is operating and vacuum is supplied to the fuel pressure regulator. If vacuum is not supplied to the fuel pressure regulator because of a broken or clogged vacuum line, fuel pressure will be 55-69 kPa (8-10psi) higher. When the fuel pump is not operating, system fuel pressure of 131-269 kPa (19-39 psi) is maintained by the fuel pump outlet check valve and the vacuum assisted fuel pressure regulator.

FUEL TANKS AND FUEL CELLS

For the majority of race vehicles, the standard gasoline tank should be adequate. The typical production gas tank has a 15-20 gallon capacity. The stock-type fuel tank will perform best full or close to full. The only real shortcoming of the production fuel tank is the tank vent, especially on newer vehicles. The quick, economical solution to this is to put a .25" hole through the gas cap.

Warning! DO NOT put a hole through the gas cap with the gas cap on the vehicle. Severe personal injury may result.

On a high output race vehicle, an auxiliary tank vent should be added at the top-front and inside-left edge of the tank. The typical upside-down “J” vent will spill gasoline on hard deceleration with a full tank. The vent should also be self-draining or it will be inoperative. An upward spiral vent will do this best if space permits.

Note: If the stock gas tank is used, check the gas tank support strap(s) and attaching bolts. If you only have one strap, add a second. If you have two, consider double thickness straps. If the straps are rusted, replace them. Use Grade 8 bolts to attach the tank support straps to the chassis/frame.

On gas tanks that are rear fill, the cap will sometimes leak under hard acceleration. This should be corrected with a leak-proof cap or relocated filler before the vehicle is raced, or replace the tank with a fuel cell.

If an all-out race vehicle is going to have the gas tank size, filler tube, or pick-up modified, then a fuel cell is highly recommended. Fuel cells are safer and feed the fuel line better for the same amount of work. Before installing a fuel cell, check with your local track and sanctioning body to see if they are legal. We highly recommend them for both racing function and safety.

FUEL LINE

Fuel lines should be metallic, not rubber. Rubber fuel lines should only be used for vibration connections (such as going from the body/frame to the engine).

Note: Fuel injected engines use specially constructed rubber fuel lines. Only fuel lines marked EFM/EFI should be used. Rubber fuel lines should be replaced every couple of years to avoid cracking. Whenever possible, it is recommended that rubber fuel lines be replaced with steel braided lines.

Fuel lines should always be routed outside the frame rails in the bellhousing area. At all times try to use the vehicle's frame to protect fuel lines. **DO NOT** place any fuel line on the bottom of a frame rail. In addition, fuel lines should **NEVER** pass through the driver's compartment at any point.

When installing rubber fuel lines, ensure that they are routed away from contact with other vehicle components that could rub against them and cause failure. Avoid contact with clamps or other components that cause abrasions or scuffing. Ensure that all rubber fuel lines are properly routed and avoid heat sources. Only use hose clamps which have rolled edges. Other types of clamps may cut into the hose and cause high pressure fuel leaks. Rubber fuel lines on race vehicles should be replaced every couple of years to avoid cracking.

FUEL FILTER

The fuel filter protects the fuel injectors from dirt, water and other foreign matter. The filter is located under the vehicle along the driver's side frame rail. Replace filter at intervals specified on the Maintenance Schedule in the service manual.

Caution: Fuel filters designed for carbureted systems are **NOT** interchangeable with filters designed for fuel injection systems. Using fuel filters designed for carbureted systems on fuel injection systems will cause damage to system components and/or fuel system shut down. For proper fuel injection system fuel filter availability and pricing, contact your local Chrysler-Plymouth-Dodge-Jeep dealer.

FUEL HOSES AND CLAMPS

Inspect all hose/clamp connections for completeness and ensure that no leaks are present. Hoses that are cracked, scuffed, swollen, have rubbed against other vehicle components or show any other signs of wear that could lead to failure must be replaced.

When installing hoses, ensure that they are routed away from contact with other vehicle components that could rub against them and cause failure.

Quick Connect Fuel Tube Fittings

MPI fuel injected engines utilize quick-connect fuel tube fittings at the ends of nylon reinforced hoses. These fittings consist of two O-rings, a spacer (installed between the O-rings) and an O-ring retainer.

Note: The O-ring and spacer assembly must be replaced whenever the quick-connect fittings are disassembled.

On MPI equipped vehicles, the fittings are used at the inlet side of the fuel rail, the pressure regulator end of the fuel rail, and at the end of the tube/hose assembly that connects the pressure regulator to the return tube (located below the EGR valve transducer).

FUEL

Fuel Definitions

There are many types of fuels. The following are the most popular or common in racing. It is important to note that not all fuels are hydrocarbons (a compound of carbon and hydrogen). There are others such as butane, benzene, and aniline which are sometimes used in small quantities for special applications. Then there are the fuels that carry their own oxygen which are considered "super fuels." This is a field that is rapidly changing. Racing has always been a leader in the fuel development field.

- Gasoline

A hydrocarbon. The most common fuel used in racing.

- Methanol

The simplest alcohol, commonly called wood alcohol. It is a colorless, flammable liquid used as an anti-freeze, solvent, fuel, and denaturant for ethanol. The most commonly used alcohol fuel in racing.

- Ethanol

Commonly called grain alcohol. This is the alcohol that is added to "pump" gas, especially in the Midwestern United States.

- Propane

Either a gas or a liquid, propane is used in some fleet vehicles that operate within large cities. Typically requires a special tank and throttle body to convert a standard vehicle.

- Nitromethane

Generally considered a nitrate in the same family as nitroglycerin. It has nitrogen and oxygen added to the base carbon and hydrogen compound. Because it has its own oxygen in the compound, it is a "super fuel" since it can give up the oxygen in the combustion process and drastically increase an engine's output. Nitromethane is used in NHRA Top Fuel and Funny Car racing. It is generally not legal to use outside of drag racing.

- Hydrazine

A nitrogen and hydrogen compound commonly called "rocket fuel." Very dangerous! Was used in NHRA Top Fuel racing in the late 1960s and early 1970s. Has since been banned for automotive use.

- Toluene

A hydrocarbon generally used as an additive to gasoline. Tends to reduce engine "knocking" by increasing the fuel's octane rating or number.

- Propylene Oxide

Another gasoline additive; usually used in small amounts. Just as with Nitromethane, it carries its own oxygen which will make gasoline burn like a "super fuel." Used to increase horsepower.

FUEL ECONOMY

The first "energy crisis" occurred in late 1973 through 1974 with subsequent gasoline shortages. This resulted in, for the first time, serious considerations being given to fuel economy by the American car-buying public. The 1973-74 crisis started Americans *thinking* about fuel economy, but it didn't convince buyers that they needed to double their fuel economy or purchase 30 to 40 mpg small cars. 1979 was the year of giant gas lines, closed gas stations, odd-even rationing, and minimum-or-maximum sales limits. The "energy crisis" of 1979 resulted not only in shortages, but greatly increased prices as well. In 1978 a gallon could be purchased for 50-60 cents, which most people already felt was too high. In 1979 the price went past \$1.00 per gallon quickly, and on up to \$1.30 per gallon or higher. (For the last several years prices have stabilized, but they could shoot up again at any time.) These two aspects of the 1979 crisis made fuel economy the number one buyer interest. This was a new area for the American buyer that never thought about fuel economy before. Some buyers fell back on 10-20 year old information that foreign cars had the best fuel economy. American companies countered with comparison ads showing better fuel economy for American cars. The fuel economy contest was on and shows no signs of letting up.

To this end, we have prepared the following tune-up tips which will help you optimize the fuel economy of your DaimlerChrysler vehicle. Keep in mind that a good tune-up and constant maintenance are the best choices for good fuel economy. All the "trick" gadgets that the market now has to offer together are worthless on a poorly tuned and maintained vehicle.



Engine

Note: The following information refers to all engines as a group, unless specifically stated otherwise.

Complete engine fuel economy performance is a very complicated and lengthy topic. Therefore, this section is split into three subsections: 1) simple tune-ups that don't require any nonstandard parts; 2) minor rework and modification requiring some nonstandard parts; and, 3) a more extensive rework which requires removal of the cylinder head and the installation of some nonstandard parts.

1. *Tune-up and Check-Out*

There are many times when fuel is wasted or used at a greater rate than is desirable because the engine is in need of a simple tune-up. There are also a few simple adjustments and changes that can be made to improve your engine's fuel economy. We will cover these simple tune-up items first before moving onto the more complex and expensive modifications. The recommendations in this section should be studied first regardless of what further modifications are considered.

a. Spark Plugs and Ignition Cables

New spark plugs should always be installed when performing a major tune-up. Examine the old plugs carefully. They can tell you a lot about the condition of your engine and/or ignition system. Spark plugs should be a light tan color. If they are black, they are probably misfiring. Oily black indicates oil fouling. Sooty black generally indicates ignition problems or the fuel-air mixture is too rich. Always check the plug gap when installing new spark plugs.

While changing the plugs, inspect the ignition cables and ends carefully to see that they are in good condition. If any plug condition indicates that the ignition cable may be broken, or if any ignition cable or end looks cracked or in poor condition, that cable should be replaced.

There are sophisticated electrical instruments available in some tune-up shops that can tell if the plugs are firing efficiently or if the plug wires need to be replaced. These instruments can be a big aid in doing tune-ups.

b. Distributor Cap and Rotor

The distributor cap and rotor are the next items to check. Inspect the distributor cap's terminals for corrosion or pitting and the cap itself for cracks or carbon tracking. If any of these conditions are found to exist, the cap should be replaced. When installing a new cap, be sure it fits securely against the distributor housing.

The distributor rotor should also be checked for pitting or corrosion and should fit tightly on the end of the distributor shaft. The rotor should be replaced if it does not meet these requirements.

c. Air Filter

The air cleaner filter element should be removed, checked, and replaced if dirty. Even if it looks clean but has been used, blow it out from the inside with compressed air.

d. Fuel Leaks

Check the carburetor/throttle body and fuel lines for external fuel leaks with the air cleaner removed. The fuel pump and fuel filter connections should also be checked for leaks. All leaks should be repaired.

e. Carburetor Adjustments

After the engine has been thoroughly warmed, the choke should be "off" or perfectly vertical. This can be checked by removing the air cleaner while the engine is idling. If the choke blade isn't vertical, adjust it so it is. With the engine shut-off and the air cleaner removed, inspect the accelerator pump linkage. On most vehicles there are three adjustment holes in the pump arm. The best driveability will be obtained with the linkage in the hole closest to the arm's pivot. The best economy will be obtained using the hole farthest away from the pivot. The economy setting may make the engine "stumble" or "pause"; i.e., make the driveability poorer. If the poorer driveability is objectionable, try the adjustment in the center hole on the pump arm as a compromise.

The idle circuit usually has an "enrichment" screw on the outside of the carburetor. This screw has a restricted adjustment range to enable the engine's idle to be set as smoothly as possible. Be careful that this screw wasn't over adjusted. This would result in poor fuel economy.

Check the trap doors in the air cleaner snorkels to ensure that they open once the engine is warmed up. Also check the air cleaner and carburetor for vacuum leaks, cracked hoses (especially vacuum hoses), or hoses that have come off.

f. Ignition Timing (if adjustable)

Ignition timing or spark advance is very important to fuel economy. It is very important that it be set correctly. Most late model vehicles have a tag in the engine compartment that provides the correct spark advance setting for that vehicle's engine. This initial timing should be set at the specified idle speed and with the vacuum advance hose disconnected. In the interest of fuel economy, you should always run the maximum allowable spark advance.

g. Light Engine Oils

Running a light engine oil will also help fuel economy. Caution must be used with light oil as it may not lubricate the engine properly under high load or temperature conditions. It is most important that a multi-viscosity, high quality oil be used. Avoid aftermarket additive "viscosity improvers" and heavy oils such as SAE 40W or 50W. Engine oils lighter than SAE 10W30 are not generally recommended for six cylinder cast iron engines. If in doubt, check your owners or service manual.

2. *Rework (Simple Modifications)*

With the basic tune-up and check-out operations performed, we have a solid foundation for making further improvements. These improvements require special parts but offer further fuel economy gains over the best stock package. Since these changes do use new and different parts, be sure to check your warranty and local track regulations BEFORE you make any change.

3. *Rebuild (Major Modifications)*

With all the easy to reach items completed, further improvements can be obtained by more extensive modifications, which will require greater time and effort. These modifications require removing the cylinder head and/or intake manifold. If you do your own work, the cost of these modifications is relatively low.

a. Blueprint Compression Ratio

Blueprinting the engine compression ratio will provide an increase in fuel economy. To blueprint the compression ratio, the cylinder head must be removed and milled at a machine shop. After the head is removed from the engine, clean it and volume check combustion chamber volumes.

b. Valve Job

A good valve job is very important to fuel economy. The valve job and cylinder head milling should be done at the same time for simplicity and to reduce cost. The head will have to be taken to a machine shop or valve grinder to have the valves ground, providing the best possible cylinder sealing. Any valve in poor condition should be replaced. Always reassemble the head with new valve stem seals.

c. Camshaft

Changing camshafts rarely improves fuel economy. If a high performance camshaft has been installed in the engine, better fuel economy may be obtained by using the standard production camshaft that came with the engine. Since most production engines are built with mild camshafts, there is very little, if any, fuel economy advantage in replacing the production camshaft.

In general, when trying to compare camshafts from different sources, cam lift is the most valuable piece of information. More lift, more performance (horsepower); less lift, less performance (but more fuel economy). For more information, refer to 'Camshaft and Valve Gear' section of this chapter.

Chassis

With the engine adjustments and modifications covered, we can turn our attention to the rest of the vehicle.

1. *Tire Pressure*

The air pressure in a tire affects fuel economy. Generally, higher tire pressures will provide better fuel economy by reducing the tire's rolling resistance.

2. *Fluid Levels*

Operating the transmission and rear axle at less than their "full" fluid capacity will help fuel economy. An automatic transmission can be run one pint below full while a manual transmission and rear axle can be run a 1/2 pint below full. Caution must be used. Lowering fluid levels below these recommendations may cause transmission or axle damage.

3. *Front End Alignment*

Having the vehicle's front end aligned properly will provide improved fuel economy and reduced tire wear. The vehicle's front end toe-in/toe-out condition has the greatest effect on fuel economy. It is important that the tires point straight ahead when the vehicle is traveling in a straight line. Stock caster and camber settings should also be used.

4. *Weight*

Any increase in vehicle weight will adversely affect fuel economy. The vehicle's basic weight is hard to decrease; therefore, it is important not to carry any unnecessary weight. While any weight reduction is beneficial in terms of improved fuel economy, weight differentials of less ~~than~~ 100 lbs. will provide improvements too small for the average driver to notice.

5. *Torque Converters*

High stall torque converters are a detriment to fuel economy. If a special high stall converter has been installed, reinstalling the stock converter will result in improved fuel economy.

6. *Manual Transmission*

A 4 or 5-speed manual transmission will provide better fuel economy than an automatic. However, the conversion of an automatic transmission vehicle to a manual transmission is extremely complicated and not recommended.

Cost Effectiveness

Increasing a vehicle's fuel economy "at any cost" can result in an expensive project and one that is a poor investment. Basic rebuild modifications and tune-ups are always a good buy because they not only increase your fuel economy, they also increase the usable life of the **engine/vehicle**. Cost effectiveness should be considered in modifications that cost over \$200. These modifications fall into three groups: drivetrain parts, engine swap, or a vehicle rebuilt from the ground-up.

Driving

All of the previously discussed engine and chassis modifications will improve your overall fuel economy. However, the single most important factor in overall mileage is the driver. The subject of "how to drive economically" can be discussed at great length. There are, however, only three primary considerations to be kept in mind: speed, acceleration, and braking.

Only accelerate as hard as is necessary to keep up with traffic and to attain your desired speed; drive slowly and use your brakes as little as possible, yet maintain safety. Jack rabbit starts and jerky, on and off the accelerator driving wastes gasoline. Slower vehicle speeds will result in better mileage. For example, a car or truck will get better fuel economy at 65 mph than it will at 75 mph. Finally, coasting to a stop rather than braking hard will result in improved mileage. Obviously, this requires that you allow more distance between you and the vehicle ahead. It also requires you to plan further down the road in order to anticipate occasions which may require braking. The ultimate fuel economy improvement is smooth, steady, slower driving. Your trips should also be planned such that short, single trips are avoided.

There are many other books and pamphlets from other sources that offer fuel economy tips. If you are serious about fuel economy, we suggest that you obtain as many of these as possible because they contain many good suggestions.



Exhaust System

INTRODUCTION

The basic exhaust system consists of an exhaust manifold, exhaust pipe with oxygen sensor, catalytic converter, heat shield(s), muffler and tailpipe.

The 4.0L engine uses a seal between the exhaust manifold and exhaust pipe to assure a tight seal and strain-free connection, a single muffler, and a single, monolithic-type catalytic converter.

The exhaust system must be properly aligned to prevent stress, leakage, and body contact. If the system contacts any body panel, it may amplify objectionable noises originating from the engine or body.

When inspecting an exhaust system, critical items to look for are cracked or loose joints, stripped screw or bolt threads, corrosion damage, and worn, cracked or broken hangers. Replace all components that are badly corroded or damaged. DO NOT attempt to repair. When replacement is required, use original equipment parts (or their equivalent). This will assure proper alignment and provide acceptable exhaust noise levels.

All exhaust systems should be checked for leaks. A leak in the exhaust system is unsafe and will cost you power. DO NOT, under any circumstances, use flexible tubing anywhere in the exhaust system as the efficiency of the flow will be reduced.

Caution: Avoid application of rust prevention compounds or undercoating materials to exhaust system floor pan heat shields. Application of coating will result in excessive floor pan temperatures and objectionable fumes. Light overspray near the edges is permitted.

Intake/Exhaust Manifold Gasket

The 4.0L engine uses a common intake and exhaust manifold gasket. This gasket is designed for original replacement. For 4.0L engine only.

P4529243 Intake/Exhaust manifold gasket.

Intake/Exhaust Manifold Race Gasket

Made from special high temperature material for added durability in racing. Can be used as a service replacement. 4.0L engine only.

P4876112 Intake/Exhaust manifold race gasket.

Intake/Exhaust Manifold Attaching Package

Package of factory original nuts and bolts to attach intake and exhaust manifolds. Includes 15 bolts, 12 washers, two studs, two spacers, two pins and one tube. For 1986-89, 4.0L engines only.

P4529680 Intake/Exhaust manifold attaching package.

Catalytic Converter

There is no regularly scheduled maintenance on any DaimlerChrysler catalytic converter. If damaged, the converter must be replaced.

The stainless steel catalytic converter body is designed to last the life of the vehicle. Excessive heat can result in bulging or other distortion, but excessive heat will not be the fault of the converter. A fuel system, air injection system or ignition system malfunction that permits unburned fuel to enter the converter will usually cause overheating. If a converter is heat-damaged, correct the cause of the damage at the same time the converter is replaced. Also, inspect all other components of the exhaust system for heat damage.

Caution: Due to exterior physical similarities of some catalytic converters with pipe assemblies, extreme care should be taken when selecting replacement parts. For availability and pricing, contact your local Chrysler-Plymouth-Dodge-Jeep dealer.

The combustion reaction caused by the catalyst releases additional heat in the exhaust system, causing temperature increases in the area of the reactor under severe operating conditions. Such conditions can exist when the engine misfires or otherwise does not operate at peak efficiency. DO NOT remove spark plug wires from plugs or by any other means short out cylinders if exhaust system is equipped with a catalytic converter. Failure of the catalytic converter can occur due to temperature increases caused by unburned fuel passing through the converter.

Unleaded gasoline MUST be used to avoid poisoning the catalyst core. DO NOT allow engine to operate above 1,200 rpm in neutral for extended periods over 5 minutes. This condition may result in excessive exhaust system/floor pan temperatures because of no air movement under the vehicle.

CONDITION	POSSIBLE CAUSE	CORRECTION
EXCESSIVE EXHAUST NOISE	<ol style="list-style-type: none"> 1. Leaks at pipe joints. 2. Burned or blown out muffler. 3. Burned or rusted-out exhaust pipe. 4. Exhaust pipe leaking at manifold flange. 5. Exhaust manifold cracked or broken. 6. Leak between exhaust manifold and cylinder head. 7. Restriction in muffler or tailpipe. 8. Exhaust system contacting body or chassis. 	<ol style="list-style-type: none"> 1. Tighten clamps at leaking joints. 2. Replace muffler assembly. Check exhaust system. 3. Replace exhaust pipe. 4. Tighten connection attaching nuts. 5. Replace exhaust manifold. 6. Tighten exhaust manifold to cylinder head stud nuts or bolts. 7. Remove restriction, if possible. Replace muffler or tailpipe, as necessary. 8. Re-align exhaust system to clear surrounding components.
LEAKING EXHAUST GASES	<ol style="list-style-type: none"> 1. Leaks at pipe joints. 2. Damaged or improperly installed gaskets. 	<ol style="list-style-type: none"> 1. Tighten/replace clamps at leaking joints. 2. Replace gaskets as necessary

Heat Shields

Heat shields are needed to protect both the vehicle and the environment from the high temperatures developed in the vicinity of the catalytic converter. The combustion reaction facilitated by the catalyst releases additional heat in the exhaust system. Under severe operating conditions, the temperature increases in the area of the reactor. Such conditions can exist when the engine misfires or otherwise does not operate at peak efficiency. DO NOT remove spark plug wires from plugs or by any other means short out cylinders. Failure of the catalytic converter can occur due to a temperature increase caused by unburned fuel passing through the converter.

DO NOT allow the engine to operate at fast idle for extended periods (over five minutes). This condition may result in excessive temperatures in the exhaust system and on the floor pan.

Exhaust Gas Recirculation (EGR)

To assist in the control of oxides of nitrogen (NO^x) in engine exhaust, all engines are equipped with an exhaust gas recirculation (EGR) system. The use of gas to dilute incoming air/fuel mixtures lowers peak flame temperature during combustion, thus limiting the formation of NO^x .

Exhaust gases are taken from openings in the exhaust gas crossover passage in the intake manifold. Refer to the service manual for complete description, diagnosis and proper service procedures.

EXHAUST AND INTAKE MANIFOLDS

The two exhaust manifolds are log style and are made of high silicon molybdenum cast iron. The exhaust manifolds share a common gasket with the intake manifold. The exhaust manifolds also incorporate ball flange outlets for improved sealing and strain free connections.

Removal

Note: The engine intake and exhaust manifold must be removed and installed together. The manifolds use a common gasket at the cylinder head.

1. Disconnect the battery negative cable
2. Remove air cleaner inlet hose from throttle body assembly.
3. Remove the air cleaner assembly.
4. Remove the throttle cable, vehicle speed control cable (if equipped) and the transmission line pressure cable (if equipped).
5. Disconnect the following electrical connections and secure their harness out of the way:
 - Throttle Position Sensor
 - Idle Air Control Motor

- Coolant Temperature Sensor (at thermostat housing)
 - Intake Air Temperature Sensor
 - Oxygen (O₂) Sensor
 - Crank Position Sensor
 - Six (6) Fuel Injector Connectors
6. Disconnect the MAP sensor, HVAC, and brake booster vacuum supply hoses at the intake manifold.
 7. Perform the fuel pressure release procedure. (Refer to the proper service manual for correct procedure.)
 8. Disconnect and remove the fuel system supply line from the fuel rail assembly. (Refer to the proper service manual for correct procedure.)
 9. Loosen the accessory drive belt and tensioner. (Refer to the proper service manual for correct procedure.)
 10. Remove the power steering pump and bracket from the intake manifold and set aside.
 11. Raise the vehicle.
 12. Disconnect the exhaust pipe from the engine exhaust manifold. Discard the seal.
 13. Lower the vehicle.
 14. Remove the intake manifold and engine exhaust manifold.

Installation

If the manifold is being replaced, ensure all fittings, etc., are transferred to the replacement manifold.

1. Install a new engine exhaust/intake manifold gasket over the alignment dowels on the cylinder head.
2. Position the engine exhaust manifold to the cylinder head. Install fastener Number 3 and finger tighten at this time (Figure 4-48).
3. Install intake manifold on the cylinder head dowels.
4. Install washer and fastener Numbers 1, 2, 4, 5, 8, 9, 10 and 11 (Figure 4-48).
5. Install washer and fastener Numbers 6 and 7 (Figure 4-48).
6. Tighten the fasteners in sequence and to the specified torque (Figure 4-48):
 - Fastener Numbers 1 through 5 - Tighten to 33 N•m (24 ft-lbs) torque.
 - Fastener Numbers 6 and 7 - Tighten to 31 N•m (23 ft-lbs) torque.
 - Fastener Numbers 8 through 11 - Tighten to 33 N•m (23 ft-lbs) torque.

7. Install the power steering pump and bracket to the intake manifold. Tighten the belt to specification. (Refer to the proper service manual for correct procedure.)
8. Install the fuel system supply line to the fuel rail assembly. Before connecting the fuel supply line to the fuel rail inspect the O-rings and replace if necessary. (Refer to the proper service manual for correct procedure.)
9. Connect all electrical connections on the intake manifold.
10. Connect the vacuum hoses previously removed.
11. Install the throttle cable and vehicle speed control cable (if equipped).
12. Install the transmission line pressure cable (if equipped). (Refer to the proper service manual for correct procedure.)
13. Install air cleaner assembly.
14. Connect air inlet hose to the throttle body assembly.
15. Raise the vehicle.
16. Using a new exhaust manifold seal, connect the exhaust pipe to the engine exhaust manifold. Tighten the bolts to 31 N•m (23 ft-lbs).
17. Lower the vehicle.
18. Connect the battery negative cable.
19. Start the engine and check for leaks.

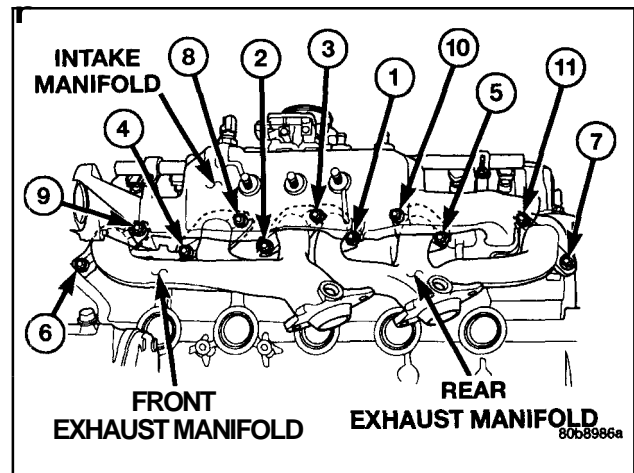


Figure 4 - 48

EXHAUST SYSTEM MODIFICATIONS

Using straight-through type mufflers and steel tubing headers on your stock vehicle doesn't mean that you will gain horsepower. Today's car and truck exhaust systems are specifically tuned to the engines they come with. In other words, the best all-around, dual purpose exhaust set-up is the stock set-up that came with your vehicle. OK, you might gain 5 extra horsepower by using a header and a straight-through type muffler, but the noise level, the disturbance in engine back pressure (via the exhaust system) and the high cost of these performance parts do not justify making these modifications. However, if the vehicle is to be raced and the modifications to that vehicle include a high performance camshaft and valve train set-up, then a header and straight-through type muffler can be very beneficial, and the cost justified.

Note: All exhaust systems should be checked for leaks. A leak in the exhaust system is unsafe and will cause you to lose power.

Headers

Steel tubing headers are a very popular exhaust system modification. When shopping for headers, the most important thing to remember is to match the headers to both the engine AND the vehicle. This will save you a lot of time when installing the headers.

Mopar Performance Parts Exhaust Headers

Bolt on a set of our Mopar Performance Parts headers and feel the power. Manufactured from heavy 14 gauge tubing with 3/8" thick flanges, mandrel bent, and triple nickel-chrome finish makes these headers the most durable on the market. Each header is engineered to achieve minimum back pressure and maximum flow, resulting in increased horsepower and torque. Headers carry a lifetime warranty and are emissions exempt. Kits include all necessary installation hardware. For 4.0L engines only. (Vehicle application as listed.)

P5249972	Wrangler, 1995.
P4876260	Wrangler, 1997-98.
P4529530	Wrangler (all), stainless steel.
P4876918	Cherokee, 1986-91.
P5249971	Cherokee and Grand Cherokee, 1996-98.

Exhaust Collector and Feeder Gaskets

These exhaust collector and feeder gaskets are made from special extra high temperature material for added strength and durability. For use with Mopar Performance Parts headers.

P4876351	Exhaust collector gasket, 2-1/2", 3-bolt.
P4876352	Exhaust collector gasket, 3", 3-bolt.
P4876353	EGR feeder gasket (1995 and prior models).

Mufflers

Cat-Back Performance Exhaust

Our Mopar Performance Parts cat-back exhaust systems are specifically engineered to fit your vehicle – no modifications are required. These kits simply bolt into the OE hangers and brackets. Features include heavy wall, 16 gauge aluminized tubing with true mandrel bends allowing for maximum flow and minimum back pressure. A low restriction, aluminized case, flow-through muffler with a 3" core produces a deep mellow exhaust tone. No fiberglass packing to burn out. Kits include all necessary installation hardware. For 4.0L engines only.

P5249739	Cat-Back performance exhaust, 1993-95 Wrangler.
P4876277	Cat-Back performance exhaust, 1997-98 Wrangler.
P4876359	Cat-Back performance exhaust, 1986-96 Cherokee.
P4876089	Cat-Back performance exhaust, 1997-98 Cherokee.
P4876627	Cat-Back performance exhaust, 1993-98 Grand Cherokee.

Note: For maximum performance, this system should be used in conjunction with Mopar Performance headers.

Ignition System

INTRODUCTION

Note: Some newer 4.0L Power Tech engines (model specific—check your service manual) use a distributor-less ignition system. For information on this system, refer to *Distributorless Ignition System*, later in this section.

For any type of racing, a good electronic ignition system is a must. The Mopar Performance Parts Chrome Box Ignition Control Module (P4120534) is perfect for those of you racing low to moderately high performance engines. For extreme high performance, the Super Gold ICM (P4120600) is the preferred choice.

The area of ignition systems and components has been changing rapidly in the last few years. Further development is expected to continue well into the future, providing Jeep racers with the best high performance ignition systems available for their race vehicles.

Older ignition systems, such as point-type, will not be covered because we no longer produce or recommend these pieces for high performance race vehicles. We will try to cover all the new electrical modifications, systems and hardware that have been developed recently for race vehicle use.

Ignition Energy

The purpose of the ignition system on an internal combustion engine is to start the combustion of the fuel/air mixture. It must ignite a flame that will be self-sustaining and it must ignite it at the proper time so that combustion will be completed at the proper time for best engine efficiency.

One way of comparing ignition systems is by the amount of energy that they can deliver to the spark plug. There are several different types of energy “curves.” The two most important characteristics are *peak energy* and *duration (time)*. Capacitive-discharge systems tend to have very high peak energy but very short duration. Multi-fire systems have long durations and fire the plug several times per revolution. Chrysler-Plymouth-Dodge-Jeep ignition systems, such as the Super Gold ICM (P4120600), feature high peak energy, long duration, and one of the highest total energies (area under the curve) delivered to the plug because they don’t go to zero during their duration in an effort to fire the plug more than once. Race engines need high total energy systems to deliver maximum power, especially at high rpm.

Variations in fuel composition, air-to-fuel ratio, distribution, internal turbulence in the cylinder, and combustion chamber shape are a few of the factors that can make the combustion process less than ideal. They all have the common characteristic that poor fuel burning may result. The factors mentioned produce effects that, although

they can’t be corrected by a more powerful ignition system, may be overcome by one. In other words, an ignition system will not change these factors (air/fuel ratio, turbulence, etc.), but the proper system can cause ignition of the mixture in spite of their presence. A production system is called on to do this to some extent; however, as more severe requirements are placed on the engine, the production system will quickly reach its limit.

A general rule of thumb is that at least 30 millijoules of energy are required to ignite the typical mixture. Most systems exceed this amount (even production systems) in the lower rpm ranges. However, this is for a typical condition. As more performance and higher speeds are demanded of an engine, these conditions are no longer true. There are many indications that a stronger spark is needed. Many replacement systems are available that try to answer some of these requirements.

With some of the less than ideal mixture conditions mentioned, there will be times when the mixture is not ignitable no matter how much energy is pumped into the spark plug. Multiple Spark Discharge is the answer to the problem. It not only produces a very strong first spark, but it also repeats this spark. This is important because if the lack of ignition is caused by such things as turbulence or non-uniform distribution of the mixture in the cylinder, then eventually an ignitable mixture will be available in the region of the plug. One of the MSD repetitive sparks will ignite the mixture.

ELECTRONIC IGNITION SYSTEM

The 4.0L engine is a multi-point fuel injected engine. The electronic ignition system used consists of the following components:

- A solid-state Ignition Control Module (ICM) to generate the voltage for spark plug firing
- An Powertrain Control Module (PCM) to process input information to fire the ICM
- An engine speed sensor with flywheel trigger to input crankshaft position for the PCM
- A synchronization pulse (stator) for firing order input to the PCM

Note: Ignition timing (advance/retard) is controlled by the PCM and is not adjustable.

Powertrain Control Module (PCM)

The 4.0L engine ignition system is controlled by the engine's Powertrain Control Module (PCM). The PCM is a digital microprocessor (computer). Air-fuel mixture calibrations for various driving and atmospheric conditions are pre-programmed into the PCM. The PCM monitors and analyzes its various inputs, computes engine fuel and ignition timing requirements based on these inputs, and controls fuel delivery and ignition timing accordingly. As operating conditions change, the PCM adjusts injector pulse width and ignition timing for optimum performance and fuel economy.

Jeep High Performance Computer

Mopar Performance Parts computer provides more spark advance and increased fuel flow for off road racing applications. This computer will enhance other performance modifications. For 1987-90, 4.0L engines only.

P4529334 Jeep high performance computer.

Ignition Control Module (ICM)

The Ignition Control Module (ICM) is mounted to the ignition coil. Based on control system inputs, the PCM triggers the ignition coil via the ICM. The PCM is able to advance or retard ignition timing by controlling the ignition coil through the ICM.

The ICM consists of a solid-state ignition circuit and an integrated ignition coil that can be removed and serviced separately if necessary.

The PCM provides an input signal to the ICM. The ICM has only two outputs:

1. Tachometer signal to the tachometer and diagnostic connector
2. High voltage from the ignition coil to the distributor cap

Ignition Coil

The ignition coil does not require special service other than maintaining the terminals and connectors.

When an ignition coil is suspected of malfunctioning, test it on the vehicle. A coil may "break down" after the engine has heated it to a high temperature. It is important that the coil be at operating temperature when tested. Perform the test according to the test equipment manufacturer's instructions.

Distributor

The 4.0L engine distributor does not have built-in centrifugal or vacuum assisted advances. Ignition timing advance is controlled by the Powertrain Control Module (PCM). The distributor is locked in place by an ear on the distributor housing that a hold down bolt passes through when the distributor is installed.

For those of you who are contemplating an ignition system modification for racing, we will briefly discuss distributors in more detail.

There are two different electronic distributors, one for vacuum advance models and one for mechanical tach drive models. The vacuum advance model has a vacuum control unit on the side. Interior parts (such as the reluctor) are not interchangeable between the two distributors.

Referring to the two types of distributors as being "mechanical" or "vacuum" is somewhat of a misnomer since the two distributors function basically the same. The mechanical distributor refers to the mechanical tach drive take-off that this distributor features. It has no vacuum advance unit. The mech-tach units are commonly referred to as "race" units. They also feature a more accurate regulator and a faster advance curve (full advance by 1,200 rpm). The vacuum advance distributor has the vacuum advance unit and must be used with an electrical tach (because it does not have the mech-tach drive feature). Vacuum advance units are less expensive and are designed for dual purpose applications. The advance curve offers more flexibility than the "race" unit, not being fully advanced until 2,000 rpm.

The advance curve in the distributor is important to both performance and economy. There are two advance springs, one light and one heavy, in production units to reach this curve. Some high performance vacuum advance models have only the light spring in the distributor and the advance curve is reshaped to give more advance at lower engine speed.

As a general rule, a multi-purpose high performance machine should have a fast advance curve. This means full centrifugal advance by 2,000 rpm of engine speed. For a full-race drag car such as a Pro Stock, a faster curve can be used.

Note: At this time, Mopar Performance Parts does not offer a vacuum advance distributor for the 4.0L engine. Since the mechanical distributor (stock on the 4.0L) is the preferred racing piece, we recommend not modifying the system to a vacuum advance system, but rather that emphasis be placed on obtaining a higher performance Powertrain Control Module (PCM) or Ignition Control Module (ICM).

Electronic Ignition Distributor

This replacement electronic ignition distributor comes complete with cap and rotor. For 1987-90, 4.0L engines with MPI only.

P4529683 Electronic ignition distributor.

I. *Distributor Cap*

Remove the distributor cap and wipe it clean with a dry, lint free cloth. Visually inspect the cap for cracks, carbon paths, broken towers, white deposits on the inside (caused by condensation entering the cap through cracks), or damaged rotor button. Replace any cap that displays charred or eroded terminals. The machined surface of a terminal end (faces toward rotor) will indicate some evidence of erosion from normal operation. Examine the terminal ends for evidence of mechanical interference with the rotor tip.

If replacement of the distributor cap is necessary, transfer spark plug wires from the original cap to the new cap one at a time. Ensure that each wire is installed into the tower of the new cap that corresponds to its tower position in the original cap. Fully seat the wires into the towers.

2. *Distributor Rotor*

Visually inspect the rotor for cracks, evidence of corrosion and the effects of arcing on the metal tip, and evidence of mechanical interference with the cap. Some charring is normal on the end of the metal tip. The silicone dielectric compound applied to the rotor tip for radio interference noise suppression will appear charred. This is normal. (DO NOT remove the charred compound.) Test the spring for insufficient tension. Replace a rotor that displays any of these adverse conditions. Coat the tip of a replacement rotor with Mopar Performance Parts Silicone Dielectric Compound or equivalent.

Distributor Cap and Rotor Set

Replacement cap and rotor set. For 4.0L engine only.

P4529686 Distributor cap and rotor set.

Mopar Performance Parts Electronic Ignition Components

High Performance Electronic Control Units

For a hotter spark and more rpm capability, use one of Mopar Performance Parts' high performance ECUs. For general high performance and usage up through 6,000 rpm, use the Orange Box ECU. For higher rpm output requirements up through 8,000, select the Chrome Box ECU.

P4120505 Orange Box ECU.

P4120534 Chrome Box ECU.

Super Gold Electronic Control Unit

The Super Gold Electronic Control Unit is the culmination of eight years of high performance ignition systems development. Designed to out perform any ignition unit previously offered to Mopar racers, it will handle the high current demand by the P3690560 (Accel) high performance coil, while keeping dwell variation to less than 1" from 1,000 to 10,000 rpm. Dwell is set for maximum spark output at low and high engine speeds. The Super Gold ECU provides outstanding performance from idle to 12,000 rpm.

P4120600 Super Gold ECU – race only.

Ballast Resistor – Electronic Distributor

P2444641 Use with mechanical advance distributor using P3690560 coil. 1/4 Ohm.

P5206436 Use with electronic ignition systems using P4120505 Orange Box ECU and production coil, or with P4120889 coil. 1 Ohm.

Ignition coils

P4120889 Accel Super Coil for all 12-volt applications. Not recommended for engine speeds over 6,500 rpm. (Use with ballast resistor P5206436.)

P3690560 Accel Race Coil specifically designed to be used with race electronic ignition kits. Designed for racing applications only. Not recommended for continued operation at speeds below 3,000 rpm for more than 30 minute periods. (Use with ballast resistor P2444641.)

Control Wiring Harness Kit for Electronic Ignitions

Kit used to convert to a new electronic ignition system.

P3690152 Control wiring harness kit for electronic ignitions.

Chrome Ignition Coil Bracket

Another underhood piece to dress-up your engine compartment. Includes special clamp screw.

P4286728 Chrome ignition coil bracket.

Tach Adapter

Designed for applications when high capacitive discharge coils interfere with tachometer or fuel injection signals. This device provides a clear 12 volt square wave signal output with a 30% duty cycle.

P4876738 Tach adapter.

DISTRIBUTORLESS IGNITION SYSTEM

Some newer 4.0L Power Tech engines use what is referred to as a distributorless ignition system (model year specific—check your service manual). This system is comprised of a one-piece coil rail containing three independent coils.

Although cylinder firing order is the same as 4.0L engines of previous years, spark plug firing is not. The 3 coils dual fire the spark plugs on cylinders 1-6, 2-5 and/or 3-4. When one cylinder is being fired (on compression stroke), the spark to the opposite cylinder is being wasted (on exhaust stroke). The one-piece coil bolts directly to the cylinder head. Rubber boots seal the secondary terminal ends of the coils to the top of all 6 spark plugs. One electrical connector (located at the rear end of the coil rail) is used for all three coils. Because of coil design, spark plug cables (secondary cables) are not used. A distributor is also not used.

The ignition system consists of

- Spark Plugs
- Ignition Coil(s)
- Powertrain Control Module (PCM)
- Crankshaft Position Sensor
- Camshaft Position Sensor
- The MAP, TPS, IAC and ECT also have an effect on the control of the ignition system.

Powertrain Control Module (PCM)

The ignition system is controlled by the Powertrain Control Module (PCM).

The PCM opens and closes the ignition coil ground circuit to operate the ignition coil(s). This is done to adjust ignition timing, both initial (base) and advance, and for changing engine operating conditions.

The amount of electronic spark advance provided by the PCM is determined by five input factors: engine coolant temperature, engine rpm, intake manifold temperature, manifold absolute pressure and throttle position.

Ignition Coil

A one-piece coil rail assembly containing the individual coils is used on the 4.0L engine (Figure 4-50). The coil rail must be replaced as one assembly. The bottom of the coil is equipped with 6 individual rubber boots (Figure 4-50) to seal the 6 spark plugs the coil. Inside each rubber boot is a spring. The spring is used for a mechanical contact between coil and the top of the spark plug. These rubber boots and springs are a permanent part of the coil and not serviced separately. One electrical connector (located at the rear of the coil) is used for all three coils (Figure 4-51).

Although cylinder firing order is the same as Jeep engines of previous years, spark plug firing is not. The 3 coils dual-fire the spark plugs on cylinders 1-6, 2-5 and/or 3-4 (Figure 4-49). When one cylinder is being fired (on compression stroke), the spark to the opposite cylinder is being wasted (on exhaust stroke).

Battery voltage is supplied to the three coils from the ASD relay. The Powertrain Control Module (PCM) opens and closes the ignition ground circuit for ignition coil operation.

Base ignition timing is not adjustable. By controlling the coil ground circuit, the PCM is able to set the base timing and adjust the ignition timing advance. This is done to meet changing engine operating conditions.

The ignition coil is not oil filled. The windings are embedded in an epoxy compound. This provides heat and vibration resistance that allows the ignition coil to be mounted on the engine.

Because of coil design, spark plug cables (secondary cables) are not used. The cables are integral within the coil rail.

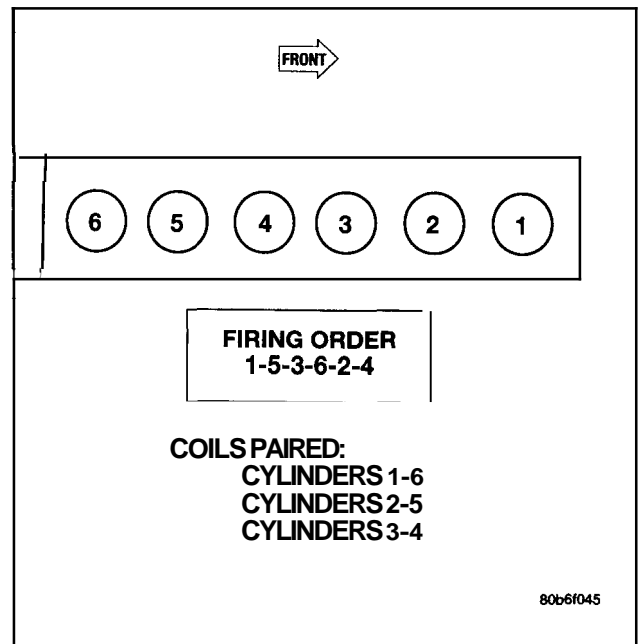


Figure 4 - 49

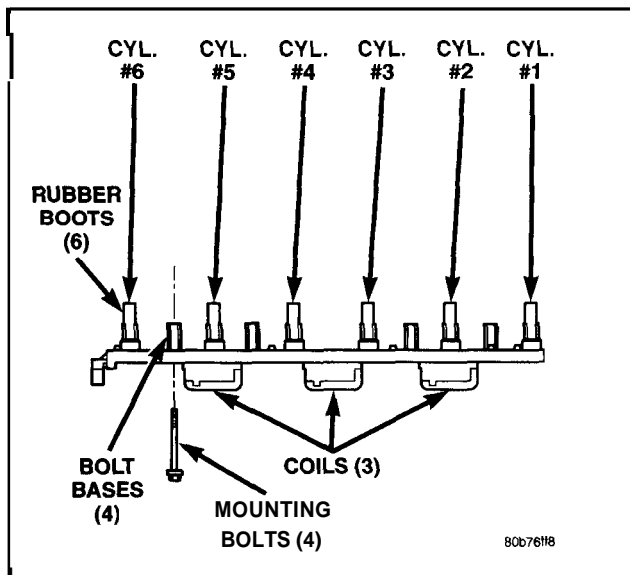


Figure 4 - 50

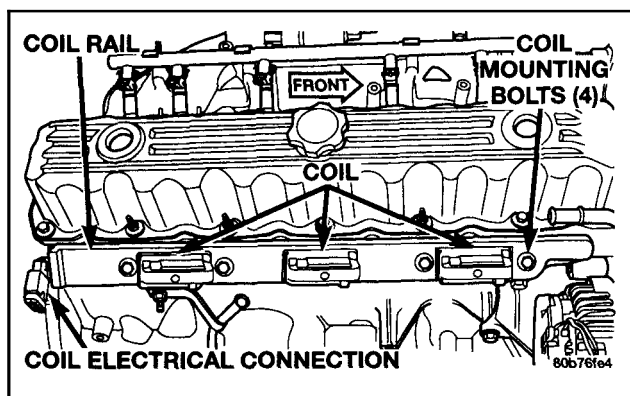


Figure 4 - 51

Automatic Shutdown (ASD) Relay

The Automatic Shutdown (ASD) relay is located in the Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

As one of its functions, the ASD relay will supply battery voltage to the ignition coil(s). The ground circuit to operate the ASD relay is controlled by the Powertrain Control Module (PCM). The PCM regulates ASD relay operation by switching its ground circuit on and off.

Crankshaft Position Sensor

Engine speed and crankshaft position are provided through the crankshaft position sensor. The sensor is a hall effect device combined with an internal magnet. The sensor generates pulses that are sent to the Powertrain Control Module (PCM). The PCM interprets the sensor input to determine the crankshaft position. The PCM then uses this position, along with other inputs, to determine injector sequence and ignition timing.

The engine will not operate if the PCM does not receive a crankshaft position sensor input.

Camshaft Position Sensor

The camshaft position sensor contains a hall effect device called a sync signal generator to generate a fuel sync signal. This sync signal generator detects a rotating pulse ring (shutter) on the oil pump drive shaft. The pulse ring rotates 180 degrees through the sync signal generator. Its signal is used in conjunction with the crankshaft position sensor to differentiate between fuel injection and spark events. It is also used to synchronize the fuel injectors with their respective cylinders.

SPARK PLUGS

Spark plugs tend to be taken for granted. Once installed in the engine, they all look the same. Plugs are sold by everyone, not just auto parts stores and dealers, and therefore are readily available. We assume that anything that fits, works. We extend this assumption to include that, if it fits and works, then that's all the plug can do. In a stock engine used for "stock" purposes this may be true. In a performance engine, it's a long way from the truth and can lead directly to problems. It's obvious in a race engine that if the plug doesn't do its job, we have trouble. We'll probably blame the ignition system first and then the carburetor (if equipped). These can be expensive misdirections. Before we get into these problem areas, let's back up and identify our plug.

Each plug has a "part number" reference or an I.D. number. The basis of this numbering system is the heat range of the plug. Unfortunately, all manufacturers don't use the same numbering system for their various heat ranges. This makes it difficult to understand. However, Chrysler-Plymouth-Dodge-Jeep has used mostly Champion plugs and Champion is our current production source. All of our tech books base their recommendations on Champion plugs. All the other manufacturers compare their heat range to Champion's. With the common base of heat range information being Champion's, we'll concentrate on this group for our discussion. A typical Champion plug for a DaimlerChrysler-built engine would be an RN12YC. The heat range is 12, but what do the letters mean? Let's look at them one at a time. We'll concentrate on the letters that are used on DaimlerChrysler applications. There are many more "specials" which are available from Champion.

The first letter "R" stands for resistor. Most newer plugs are "R" rated as well as all production plugs. The resistor cuts down on radio interference. If there is no letter in this position, then it's a standard plug. Today, standard plugs are only used in racing.

The second letter, or the first one before the two digits of the heat range, defines the “reach” of the plug. This is dictated by the number of spark plug threads in the cylinder head. For most engines there are only three. The “N” stands for the “long-reach” plug (.750”), the “J” is the “short-reach” plug (3/8”), and the combination prefix BL or single V stands for a .460” reach plug. There are special plugs available from Champion that use 10 and 18mm threads, also.

The two number digit used in the middle is the heat range of the plug. The heat range is basically its performance number. This is what determines whether the plug is going to perform at its best in your application. For the moment we’ll skip over the discussion of heat ranges and return to it later.

The first letter to the right of the heat range defines the “nose shape” or configuration. There are three basic types –regular, retracted, and projected. The projected core nose (electrode) is defined by a “Y.” All our plugs are “Y”s –projected nose.

On older, standard design plugs, the last position is blank. Most of the newer plugs use a “C” which stands for “Copper Plus Design.” This copper feature can’t be seen by casually looking at the plug, but it allows the plug to be more versatile. “C” plugs are able to cover more heat ranges or, stated somewhat differently, the “C” allows the plug of a given heat range to do its job plus the job (performance characteristics) of a one or two step colder plug.

That brings us back to the heat range. Before we get into the practical side of heat ranges, let’s cover the theory. There are three basic heat range groups that are used for specific applications. The numbers from 1 to 25 are used for automotive applications. Numbers 26 to 50 are used for aviation, and 51 and up are used for racing, competition, and other special applications. Since we’re concerned with automotive racing and performance, we only have to concern ourselves with the first and last categories.

Basic heat ranges are quite easy to figure out—the higher the number the hotter the plug, the lower the number the colder the plug. For example, a J10Y plug is colder than a J12Y. The exception to this is racing plugs. ALL racing plugs are colder than production plugs although they have bigger numbers. Once into the racing plug category, the “lower the number the colder the plug” rule still holds.

Why all the fuss about heat range? In performance applications, the heat range is key to the plug’s overall performance. The hotter the plug’s heat range, the better it performs at low speed. The hotter plug offers better driveability. On the other hand, the colder plug offers better high rpm operation. The colder plug performs better in high output engines and at W.O.T. (wide open throttle). Cold plugs used on the “street” (low rpm use) will foul quickly. Hot plugs used at high rpm or high output will “miss” and cause the engine not to put out its peak power or allow it to reach peak rpm.

So, how do you pick the best heat range? It can be done by trial and error. DaimlerChrysler racing books give various recommendations as to the best performance approach. DaimlerChrysler service and owners manuals specify production plugs. In general, if you don’t have more specific information available, a performance engine should use plugs two heat ranges colder than the production recommendation. A race engine should be one or two steps colder than the performance plug.

Re-gapping standard spark plugs to a wide gap can be done easily with the Accel plug gapping tool. If this tool isn’t used, extreme care should be used when opening up a large plug gap. The best way is to file down the center electrode. This approach has the drawback of short plug life. Champion makes plugs specially designed for the larger gaps. Otherwise, use the Accel tool.



Mopar Performance Parts Spark Plugs		
NEW! These spark plugs are specifically designed for the optimum performance of your Mopar engine. Each package contains 4 spark plugs.		
Race & Tuning Application Plugs (J-Strap Type)		
Pack PIN	Cross Reference	Application
P4876939	C 63C	All except 'B-RB' engines
P4876940	C 61C to C 59C	All except 'B-RB' engines
P4876941	C 57c to C 55c	All except 'B-RB' engines
P4876942	C 53C to C 51C	All except 'B-RB' engines
P4876943	C 51C	All except 'B-RB' engines
P4876944	C 61C to C 59C	All except 'B-RB' engines
P4876945	C 57c to C 55c	All except 'B-RB' engines
Pack P/N	Cross Reference	Application
P4876928	C 61C to C 59C	All Race Applications
P4876929	C 57c to C 55C	All Race Applications
P4876930	C 53C to C 51C	All Race Applications
P4876931	C 51C	All Race Applications
P4876932	S 61C to S 59C	All Race Applications
P4876933	S 57c to S 57c	All Race Applications
P4876934	S 53C to S 51C	All Race Applications
P4876935	S 51c	All Race Applications

Spark Plug and Ignition Wire Removal

Remove the ignition wire by grasping it at the spark plug boot, and then turn (1/2 turn) and pull it straight back in one steady motion.

1. Prior to removing the spark plug, spray compressed air around the spark plug hole and the area around the spark plug.
2. Remove the spark plug using a quality socket with a rubber or foam insert.
3. Inspect the spark plug. (Refer to *Inspection*.)

Inspection

Faulty and fouled plugs may perform well at idle speed, but at higher engine speeds they frequently fail. Faulty plugs can be identified in a number of ways: poor fuel economy, power loss, decrease in engine speed, hard starting and, in general, poor engine performance. Spark plugs also malfunction because of carbon fouling, excessive air gap, or a broken insulator.

Examine the spark plugs for burned electrodes and fouled, cracked or broken porcelain insulators. Keep plugs arranged in the order in which they were removed from the engine. An isolated plug displaying an abnormal condition indicates that a problem exists in the corresponding cylinder. Replace spark plugs at the intervals recommended on the Maintenance Chart in the service manual.

Spark plugs that have low mileage may be cleaned and reused if not otherwise defective. After cleaning, file the center electrode flat with a small point file or jewelers file. Adjust the gap between the electrodes to the specified dimensions.

Specifications

Note: Due to model year differences, refer to the proper service or owners manual for spark plug type, gap, and tightening specifications.

Gap Adjustment

Check the spark plug with a gap (feeler) gauge. If the gap is not correct, adjust it by bending the ground electrode. Refer to the proper service or owners manual for spark plug gap specifications.

Installation

1. Start the spark plug into the cylinder head by hand to avoid cross threading.
2. Tighten the spark plug to specified torque. Refer to the proper service or owners manual for torque specifications.
3. Install ignition wires over spark plugs.

Always tighten spark plugs to the specified torque. Over tightening can cause distortion resulting in a change in the spark plug gap. Tighten all spark plugs to 35 N•m (27 ft-lbs).

When replacing the ignition wires, route the wires correctly and secure them in the proper retainers. Failure to route the wires properly can cause ignition noise radio reproduction, cross ignition of the spark plugs or short-circuit the wires to ground.

SPARK PLUG CABLES (IGNITION WIRES)

Check spark plug cable connections for good contact at the ignition coil, distributor terminals, and spark plugs. Terminals should be fully seated. The nipples and spark plug covers should be in good condition. Nipples should fit tightly. Spark plug boot should completely cover the spark plug hole in the cylinder head cover. Install the boot until the terminal snaps over the spark plug. A snap must be felt to ensure the spark plug cable terminal engaged the spark plug.

Loose cable connections will corrode, increase resistance, and permit water to enter. These conditions can cause ignition malfunction. Plastic clips in various locations protect the cables from damage. When cables are replaced, the clips must be used to prevent damage to the new cables.

If you don't have top quality ignition wires you aren't conducting maximum spark. Production spark plug wire is 7 mm. For dual purpose and race-only applications, we recommend larger 7.5 mm spark plug wires. Mopar Performance Parts high performance 7.5 mm spark plug wires (P4286742) feature high quality insulation and boots (ends). If more insulation is required, neoprene hose of the proper inside diameter is recommended.

Note: Using spark plug wires larger than 7.5 mm is NOT recommended because of potential compatibility problems with on-board computers and electronics.

High Performance 7.5 mm Ignition Wire Set

This special high performance plug wire set features larger wire while maintaining compatibility with on-board computer and electronics found in current production vehicles. Package uses high tech production-style boot ends at both the distributor and plug end of the wire. Wire is imprinted with the Mopar Performance Parts name. This complete set is pre-cut and fits all 1991-97 Jeep 4.0L engines (only).

P4286742	High performance 7.5 mm ignition wire set.
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Accessories

Usually, once the spark plug wire is installed, pulling on the wire to remove the boot from the plug is the most common cause of failure. This is especially true of non-standard production or “cheap” wires. Using the Mopar Performance Parts spark plug wire boot puller (P5249718) will help plug wire removal without damaging the connector. The boot puller will probably double the wire life, making it one of the best deals in the ignition area.

Mopar Performance Parts spark plug wires have straight ends at the spark plug, which is the most common style. Having been in racing for many years, we know that straight ends are not best for all applications, especially with headers. In an effort to solve this problem, we have introduced vari-angle plug adapters (P4286742) which adjust easily from straight to right angles.

Our plug wire separator package (P4007667) keeps the wires separated from the cap to the plug. This helps performance by preventing cross firing and makes the engine compartment look much more organized.

Spark Plug Wire Boot Puller

Here’s the tool you need for easy removal of spark plug wires without pulling the wire out of the terminal end and boot. Saves on knuckles, too.

P5249718 Spark plug wire boot puller.

Vari-Angle Plug Adapters

Here’s a convenient way to steer spark plug wires around headers, brackets, and other tight areas, in any direction you want. Vari-angle plug adapters have a built-in swivel device which maintains the position you bend them in. A handy set-up for any racer. Sold two per set.

P4286742 Van-angle plug adapters.

Ignition Wire Separator Set

Ignition wire separators. 8 pieces per set.

P4007667 Ignition wire separator set.

IGNITION SWITCH

In race vehicles, the production ignition switch is sometimes replaced by a toggle switch. This can cause problems if a high-amp rated switch (such as P3690282) isn’t used. P3690282 is an 18-20 amp rated switch, while most readily available switches are 14-16 amp rated. The lower rating causes more resistance in the ignition circuit, which cuts down on the voltage available to the ignition’s control unit. The lower voltage can cause the ignition system to perform poorly or develop a miss which can be very difficult to analyze.

Ignition Switches

P3690282 “On-Off” micro switch assembly (20 amp).

P3690823 Push button starter switch assembly.

GENERAL IGNITION SYSTEM PERFORMANCE TIPS

One of the most important items in ignition is to check the TDC timing mark on the vibration damper to be sure that it reads zero when the piston is at TDC.

Problems such as “pinging,” flat spots, poor idle and misfires can be caused by a bad ignition system, but they may also be caused by problems with the MPI system. Problems caused by a poor fuel system or ignition system have many similar symptoms. There is no substitute for a good mechanic when these problems are encountered.

On any vehicle that is being converted to a race vehicle, we strongly recommend the steering column lock be removed. If things go wrong with the engine with the vehicle moving and the column lock is working, the driver wouldn’t be able to steer and could have an accident.

Grounds are very important, especially in a race vehicle. The engine should be grounded to the body and to the frame. The control box should be grounded to the engine. Painted surfaces make poor grounds—sand paint or other surface material off and ground metal-to-metal.

There are 2 special switches that are helpful in wiring a race vehicle: “On-Off” Micro Switch Assembly (20 amp—P3690282); and, Push Button Starter Switch Assembly (P3690823). The “On-Off” Micro Switch Assembly is the most important. Other “econo” switches aren’t rated as high on amperage and therefore put resistance between the battery and the ignition and can cause misfiring.

A volt meter is recommended for a race vehicle so that the battery’s power can be checked frequently. If the battery’s voltage gets to be less than 12.0 volts, the ignition system may function inadequately resulting in poor performance and lost races. Also measure what the voltage is at the ignition system itself.

Starting System

INTRODUCTION

The starting system is designed to provide the vehicle operator with a convenient, efficient and reliable means of cranking and starting the internal combustion engine used to power the vehicle and all of its accessory systems from within the safe and secure confines of the passenger compartment. The starting system consists of the following components:

- Battery
- Starter relay
- Starter motor (including an integral starter solenoid)
- Ignition switch
- Park/neutral position switch
- Wire harnesses and connections (including the battery cables).

Operation

The starting system components form two separate circuits. A high-amperage feed circuit that feeds the starter motor between 150 and 350 amperes, and a low-amperage control circuit that operates on less than 20 amperes. The high-amperage feed circuit components include the battery, battery cables, the contact disc portion of the starter solenoid, and the starter motor. The low-amperage control circuit components include the ignition switch, the park/neutral position switch, the starter relay, the electromagnetic windings of the starter solenoid, and the connecting wire harness components.

Battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the momentary Start position. The park/neutral position switch is installed in series between the starter relay coil ground terminal and ground. This normally open switch prevents the starter relay from being energized and the starter motor from operating unless the automatic transmission gear selector is in the Neutral or Park positions.

When the starter relay coil is energized, the normally open relay contacts close. The relay contacts connect the relay common feed terminal to the relay normally open terminal. The closed relay contacts energize the starter solenoid coil windings.

The energized solenoid pull-in coil pulls in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter motor. This engages the starter overrunning clutch and pinion gear with the starter ring gear on the automatic transmission torque converter drive plate.

As the solenoid plunger reaches the end of its travel, the solenoid contact disc completes the high-amperage starter feed circuit and energizes the solenoid plunger hold-in coil. Current now flows between the solenoid battery terminal and the starter motor, energizing the starter.

Once the engine starts, the overrunning clutch protects the starter motor from damage by allowing the starter pinion gear to spin faster than the pinion shaft. When the driver releases the ignition switch to the On position, the starter relay coil is de-energized. This causes the relay contacts to open. When the relay contacts open, the starter solenoid plunger hold-in coil is de-energized.

When the solenoid plunger hold-in coil is de-energized, the solenoid plunger return spring returns the plunger to its relaxed position. This causes the contact disc to open the starter feed circuit, and the shift lever to disengage the overrunning clutch and pinion gear from the starter ring gear.

Following are general descriptions of the major components in the starting system.

STARTER MOTOR

(Refer to Figure 4-52.)

The starter motor incorporates several features to create a reliable, efficient, compact, lightweight and powerful unit. The electric motor of the starter features four electromagnetic field coils wound around four pole shoes, and four brushes contact the motor commutator. The starter motor is rated at 1.4 kilowatts (about 1.9 horsepower) output at 12 volts.

The starter motor is serviced only as a unit with its starter solenoid and cannot be repaired. If either component is faulty or damaged, the entire starter motor and starter solenoid unit must be replaced.

Operation

The starter motor is equipped with a planetary gear reduction (intermediate transmission) system. The planetary gear reduction system consists of a gear that is integral to the output end of the electric motor armature shaft that is in continual engagement with a larger gear that is splined to the input end of the starter pinion gear shaft. This feature makes it possible to reduce the dimensions of the starter. At the same time, it allows higher armature rotational speed and delivers increased torque through the starter pinion gear to the starter ring gear.

Starter Motor and Solenoid	
Manufacturer	Mitsubishi
Engine Application	2.5L, 4.0L
Power Rating	2.5L - 1.2 Kilowatt (1.6 Horsepower) 4.0L - 1.4 Kilowatt (1.9 Horsepower)
Voltage	12 Volts
Number of Fields	4
Number of Poles	4
Number of Brushes	4
Drive Type	Planetary Gear Reduction
Free Running Test Voltage	11.2 Volts
Free Running Test Maximum Amperage Draw	90 Amperes
Free Running Test Minimum Speed	2.5L - 2600 rpm 4.0L - 2500 rpm
Solenoid Closing Maximum Voltage Required	7.8 Volts
*Cranking Amperage Draw Test	2.5L - 130 Amperes 4.0L - 160 Amperes

*Test at operating temperature. Cold engine, tight (new) engine, or heavy oil will increase starter amperage draw.

Figure 4 - 52

The starter motor is activated by an integral heavy duty starter solenoid switch mounted to the overrunning clutch housing. This electromechanical switch connects and disconnects the feed of battery voltage to the starter motor and actuates a shift fork that engages and disengages the starter pinion gear with the starter ring gear.

The starter motor uses an overrunning clutch and starter pinion gear unit to engage and drive a starter ring gear that is integral to the torque converter drive plate mounted on the rear crankshaft flange.

STARTER RELAY

The starter relay is an electromechanical device that switches battery current to the pull-in coil of the starter solenoid when the ignition switch is turned to the Start position. The starter relay is located in the Power Distribution Center (PDC) in the engine compartment. See the fuse and relay layout label affixed to the inside surface of the PDC cover for starter relay identification and location. The starter relay cannot be repaired or adjusted and, if faulty or damaged, it must be replaced.

BATTERY

It is very important that the battery be fully charged in racing applications with an electronic ignition. A volt meter should be used to check the battery voltage before the vehicle is raced. The voltage should not be allowed to drop below 12.0 volts. Lower voltage will cause poor ignition performance such as misfires and will result in slowing the vehicle down. It may also cut down on the electric fuel pump's efficiency.

Brass Battery Terminals

Here's a variety of brass terminals in different styles that offer maximum conductivity. Feature positive threaded attachments. Designed for large gauge wire used in battery relocation kits with features best liked and required by racers.

P4349575	Battery terminal with left or right cable connection - 1 gauge wire.
P4349576	Ring terminal, 3/8" eye - 1 gauge wire.
P4349577	Battery terminal with left or right cable connection - 4 gauge wire.
P4349578	Ring terminal, 3/8" eye - 4 gauge wire.
P4349579	Quick disconnect "positive" battery terminal with 3/8" stud.
P4349580	Quick disconnect "negative" battery terminal with 3/8" stud.

Battery Relocation

Most race vehicles begin life with the battery in the engine compartment.

Mounting the battery in the trunk of a RWD race vehicle helps by shifting weight over the drive wheels (improving traction) and by making the engine compartment less cluttered. But there's more to a trunk mounted battery kit than just putting the battery in the trunk. Physically moving the battery is easy. The problem is that the battery must still operate the engine's ignition and fuel delivery systems, and with the battery eight feet away from the ignition system (usually a high output electronic race unit), minimizing voltage drop is critical.

To minimize voltage drop, the Mopar Performance Parts trunk mounted battery kit (P4349500) uses #1 gauge wire, while the competition uses #4 gauge. The smaller the gauge number the bigger the wire size. The bigger the wire size the less voltage drop occurs. To provide the best electrical conductor available, Mopar Performance Parts supplies copper wire—the competition uses aluminum. Copper is a better electrical conductor than aluminum. The better the conductor, the less voltage drop occurs in the same distance; that is, trunk to engine compartment. Hand-crimped terminals can lead to problems such as voltage losses, loose connections, and so on. That's why the Mopar Performance Parts cable has factory-installed threaded brass terminals.

Some people feel that a full length ground cable is required. This is acceptable, but it adds a lot of weight and isn't necessary. The engine is already grounded from the block to the firewall of the body/frame (unibody). Check to be sure. The Mopar Performance Parts package includes a ground strap to ground the battery to the frame in the trunk area. The Mopar Performance Parts package also includes many convenience items such as starter to relay and solenoid wires, terminals, firewall grommets, and battery cover. Other kits don't include these items. However, it does not include a battery.

Trunk Mounted Battery Kit

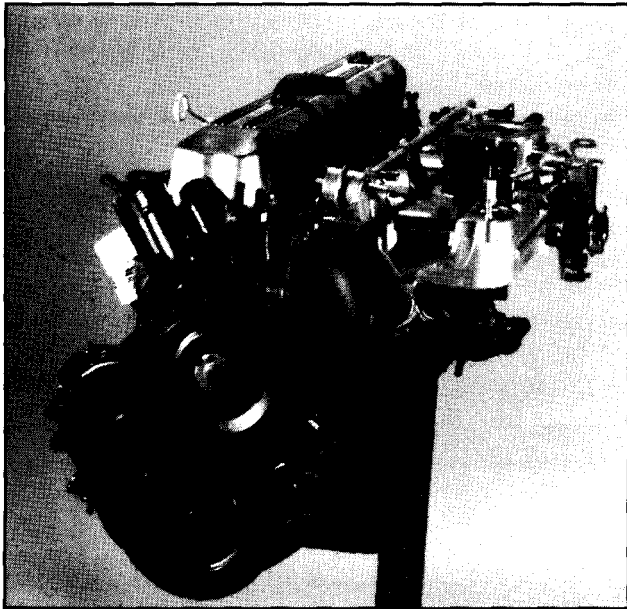
This improved kit is designed for moving the battery to the trunk. Improves weight distribution which is so important for drag racers. It means less clutter in the engine compartment, and helps provide better traction. It will even contribute to improved braking and less understeer in hard turns for oval trackers and rallyers. Kit will fit nearly any vehicle. Does not include battery.

P4349500 Trunk mounted battery kit.



Engine Assembly

In this section we will review the entire engine building procedure. This includes detailed blueprinting techniques, as well as all start-up, tune-up and troubleshooting procedures necessary.



INSPECTION AND TESTING

Cylinder Compression Pressure Test

The results of a cylinder compression pressure test can be utilized to diagnose several engine malfunctions.

Ensure the battery is completely charged and the engine starter motor is in good operating condition. Otherwise the indicated compression pressures may not be valid for diagnosis purposes.

1. Disconnect ignition coil tower electrical connectors and remove ignition coil towers.
2. Remove spark plugs.
3. Clean spark plug recesses with compressed air.
4. Secure the throttle in the wide-open position.
5. Disable the fuel system. (Refer to the proper service manual for correct procedure.)
6. Insert a compression pressure gauge and rotate the engine with the engine starter motor for three revolutions.
7. Record the compression pressure on the 3rd revolution. Continue the test for the remaining cylinders.

Refer to *4.0L Engine Specifications*, later in this section, for the correct engine compression pressures.

Cylinder Head Gasket Failure Diagnosis

A leaking engine cylinder head gasket usually results in loss of power and/or coolant and engine misfiring.

An engine cylinder head gasket leak can be located between adjacent cylinders or between a cylinder and the adjacent water jacket.

- An engine cylinder head gasket leaking between adjacent cylinders is indicated by a loss of power and/or engine misfire.
- An engine cylinder head gasket leaking between a cylinder and an adjacent water jacket is indicated by coolant foaming or overheating and loss of coolant.

Cylinder-to-Cylinder Leakage Test

To determine if an engine cylinder head gasket is leaking between adjacent cylinders, follow the procedure outlined in *Cylinder Compression Pressure Test*. An engine cylinder head gasket leaking between adjacent cylinders will result in approximately a 50-70% reduction in compression pressure.

Cylinder-to-Water Jacket Leakage Test

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or the fan. DO NOT wear loose clothing.

Remove the radiator cap. Start the engine and allow it to warm up until the engine thermostat opens.

If a large combustion/compression pressure leak exists, bubbles will be visible in the coolant. If bubbles are not visible, install a radiator pressure tester and pressurize the coolant system. If a cylinder is leaking combustion pressure into the water jacket, the tester pointer will pulsate with every combustion stroke of the cylinder.

Cylinder Combustion Pressure Leakage Test

The combustion pressure leakage test provides an accurate means for determining engine condition. Testing will detect exhaust and intake valve leaks (improper seating), leaks between adjacent cylinders or into water jacket, as well as any causes for combustion/compression pressure loss.

1. Check the coolant level and fill as required. DO NOT install the radiator cap.
2. Start and operate the engine until it attains normal operating temperature, then turn the engine OFF.
3. Disconnect ignition coil tower electrical connectors.
4. Remove ignition coil towers.
5. Remove spark plugs.

6. Remove the oil filler cap.
7. Remove the air cleaner.
8. Calibrate the tester according to the manufacturer's instructions. The shop air source for testing should maintain **483 kPa (70 psi)** minimum, 1,379 kPa (200 psi) maximum (552 kPa [80 psi] recommended).
9. Perform the test procedures on each cylinder according to the tester manufacturer's instructions. While testing, listen for pressurized air escaping through the throttle body, tailpipe and oil filler cap opening. Check for bubbles in the radiator coolant.

All gauge pressure indications should be equal, with no more than 25% leakage.

Example: At 552 kPa (80 psi) input pressure, a minimum of 414 kPa (60 psi) should be maintained in the cylinder.

Refer to the *Cylinder Combustion Pressure Leakage Test Diagnosis Chart*.

Oil Leak Inspection

Begin with a thorough visual inspection of the engine, particularly at the area of the suspected leak. If an oil leak source is not readily identifiable, the following steps should be followed:

1. DO NOT clean or degrease the engine at this time because some solvents may cause rubber to swell, temporarily stopping the leak.
2. Add an oil soluble dye (use as recommended by manufacturer). Start the engine and let idle for approximately 15 minutes. Check the oil dipstick to make sure the dye is thoroughly mixed as indicated with a bright yellow color under a black light.
3. Using a black light, inspect the entire engine for fluorescent dye, particularly at the suspected area of oil leak. If the oil leak is found and identified, repair per service manual instructions.
4. If dye is not observed, drive the vehicle at various speeds for approximately 24 km (15 miles), and repeat inspection.
5. If the oil leak source is not positively identified at this time, proceed with the *Air Leak Detection Test Method*.

CYLINDER COMBUSTION PRESSURE LEAKAGE DIAGNOSIS CHART

CONDITION	POSSIBLE CAUSE	CORRECTION
AIR ESCAPES THROUGH THROTTLE BODY	Intake valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary
AIR ESCAPES THROUGH TAILPIPE	Exhaust valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary
AIR ESCAPES THROUGH RADIATOR	Head gasket leaking or cracked cylinder head or block	Remove cylinder head and inspect. Replace defective part
MORE THAN 50% LEAKAGE FROM ADJACENT CYLINDERS	Head gasket leaking or crack in cylinder head or block between adjacent cylinders	Remove cylinder head and inspect. Replace gasket, head, or block as necessary
MORE THAN 25% LEAKAGE AND AIR ESCAPES THROUGH OIL FILLER CAP OPENING ONLY	Stuck or broken piston rings; cracked piston; worn rings and/or cylinder wall	Inspect for broken rings or piston. Measure ring gap and cylinder diameter, taper and out-of-round. Replace defective part as necessary

Air Leak Detection Test Method

1. Disconnect the breather cap to air cleaner hose at the breather cap end. Cap or plug breather cap nipple.
2. Remove the PCV valve from the cylinder head cover. Cap or plug the PCV valve grommet.
3. Attach an air hose with pressure gauge and regulator to the dipstick tube.

Caution: DO NOT subject the engine assembly to more than 20.6 kPa (3 psi) of test pressure.

4. Gradually apply air pressure from 1 psi to 2.5 psi maximum while applying soapy water at the suspected source. Adjust the regulator to the suitable test pressure that provide the best bubbles which will pinpoint the leak source. If the oil leak is detected and identified, repair per service manual procedures.
5. If the leakage occurs at the rear oil seal area, refer to *Inspection for Rear Seal Area Leaks*.
6. If no leaks are detected, turn off the air supply and remove the air hose and all plugs and caps. Install the PCV valve and breather cap hose.
7. Clean the oil off the suspect oil leak area using a suitable solvent. Drive the vehicle at various speeds approximately 24 km (15 miles). Inspect the engine for signs of an oil leak by using a black light.

Inspection for Rear Seal Area Leaks

Since it is sometimes difficult to determine the source of an oil leak in the rear seal area of the engine, a more involved inspection is necessary. The following steps should be followed to help pinpoint the source of the leak.

If the leakage occurs at the crankshaft rear oil seal area:

1. Disconnect the battery.
2. Raise the vehicle.
3. Remove the torque converter or clutch housing cover and inspect the rear of the block for evidence of oil. Use a black light to check for the oil leak:
 - a. Circular spray pattern generally indicates seal leakage or crankshaft damage.
 - b. Where leakage tends to run straight down, possible causes are a porous block, camshaft position sensor seal, camshaft bore cup plugs, oil galley pipe plugs, oil filter runoff, and main bearing cap-to-cylinder block mating surfaces.
4. If no leaks are detected, pressurize the crankcase as outlined *Air Leak Detection Test Method*.

Caution: DO NOT exceed 20.6 kPa (3 psi).

5. If the leak is not detected, very slowly turn the crankshaft and watch for leakage. If a leak is detected between the crankshaft and seal while slowly turning the crankshaft, it is possible the crankshaft seal surface is damaged. The seal area on the crankshaft could have minor nicks or scratches that can be polished out with emery cloth.

Caution: Use extreme caution when crankshaft polishing is necessary to remove minor nicks and scratches. The crankshaft seal flange is especially machined to complement the function of the rear oil seal.

6. For bubbles that remain steady with shaft rotation, no further inspection can be done until disassembled.

BUILDING A NEW ENGINE

Sooner or later you'll build a new engine for your race vehicle. Mopar engines typically last a long time, even in racing. Our Mopar Performance Parts racers will use the same engines for two or three years. The GM racers always have two or three at any one time and build or rebuild them all at least once during the race season. We all know why they need so many! However, the point is that some day you'll build a new engine. We'll assume that you want a basic engine, nothing fancy. In the early steps you'll need to check over the basic parts – block, head, crankshaft. You'll need to gather your technical information – service manuals, parts catalogs, and racing books – and then lay out a plan for horsepower level and determine which parts you must use. (This book will help answer these questions.) No matter which parts you use, the engine must be prepped and built. This is where racers tend to make errors – in the form of spending money on the wrong things.

On your engine build-up plan, list all the basic building blocks (big parts) of your engine: block, crankshaft, head, etc. Under each item list the major operations that have to be done to that piece. (For example, the block has to be bored, honed, milled.) Then, on a separate piece of paper, make two columns: operations that you can do and operations that must be sent out. Next to each item on the "send out" list, put down an estimated cost. Then add up all the costs and compare the total to your basic budget.

The "send out" column generally consists of machining, milling, boring, etc. The most important of these is block honing. You must have a dial-bore gauge to hone. You also must have a honing plate for your engine. So, when you send your block out to be honed, pick a shop that has a honing plate for your engine or supply the honing plate with the block.

The crankshaft can be polished at home, using extra care. If it's used and is scratched up and needs to be ground undersize, it will have to be sent out.

On the cylinder head, the valve work is the most important aspect and is usually sent out. The special equipment that is required to do valve jobs is not usually found in the home shop. This is an area where the extra money spent will result in more Performance. Like the block, the head will be sent out for milling. If new guides or seats are required in the head, these operations should also be sent out to a qualified shop. (Not all valve grinders do guides.) Lapping the valves can be done at home but, a word of caution—if too coarse a lapping compound is used, you'll destroy a good valve job. It's best left to the head/valve expert.

Once the machine operations are performed, assembly of the engine can be done at home. Certain basic tools are required. Take your time and be extra careful. Never hurry or try to build an engine quickly. Leave that to the professionals.

What Parts to Use

The most commonly asked question in the engine performance business is, "What parts should I use?" Typically, the question is asked in the following manner: "I've got a 4.0L Power Tech engine—what parts do you recommend?" Obviously, there is more than one answer. In reality, the answers are almost infinite. The parts in question are the induction system, exhaust manifolds, camshaft, and ignition system. The easiest way to answer this general question is to refer to earlier sections of this chapter.

To develop a list of general engine parts recommendations, the important questions to answer are as follows:

- What type of fuel is going to be used?
- What's the engine's compression ratio?
- What type of transmission is to be used?
- What type of induction system is desired?
- Do you want to use headers?

The answer to the fuel question (typically gasoline) will dictate the maximum compression ratio that can be used and is the most important of the five questions. It will determine which piston can be used and how the heads and block can be modified, if at all. The transmission type (manual or automatic) will affect both the carburetor and the camshaft. Remember that automatic transmission pieces will work with a manual, but manual transmission pieces won't work with an automatic without other changes. The induction system can be fuel injection or carburetion. If carburetion is selected, an intake manifold that will work with the carburetor must be selected. Most performance applications will use exhaust headers. The ignition system should always be a high performance electronic. In general terms that gives you the "what parts to use" answer, except for the camshaft, which is covered in its own section of this chapter.

Engine Torque vs. Horsepower

Torque and horsepower relative to performance engines are not the same thing, but they are very closely related. The actual equation is as follows:

$$\text{Bhp} = T \times \frac{\text{rpm}}{k}$$

Bhp = brake horsepower

T = torque in lbs-ft

rpm = engine speed in revolutions per minute

k = constant

In racers language, horsepower refers to the high rpm scale and torque refers to the low rpm scale. Usually, the dividing line for mild performance engines is 3,000 to 3,500 rpm.

Unfortunately, in practice, parts that help horsepower generally hurt torque and vice-versa. This is true when only one engine part is changed, keeping the rest of the engine the same. Racing engines with drastically modified rpm scales are much too complicated to analyze in this manner. However, it can be useful for dual purpose machines.

Let's choose a specific example—camshafts. Here the rule is: the bigger the camshaft, the more horsepower it makes. However, this can also be stated as: the bigger the camshaft, the less torque it makes. The question you should ask yourself is, "Does my engine need more torque or more horsepower?" You can answer this question easily by deciding whether you want to improve your performance above 3,500 rpm or below 3,500 rpm. Keep in mind that an improvement in one area comes at the expense of another; that is, more torque, less horsepower (and vice versa). These simple guidelines can be very helpful in making many parts selections, but remember that you must have a baseline—some standard you want to compare against. (The most common baseline is some version of a stock engine.)

Before You Start

When an engine building project is in its early stages, there are several basic decisions that must be made or at least considered early on. The most important of these decisions is whether the engine is going to be built from the ground up, so-to-speak, or will it just have pieces bolted-on; that is, swapped. A camshaft change or intake manifold swap obviously doesn't require a complete engine rebuild. We do suggest strongly that even the racer who is just in the bolt-on stage read this book completely, without skipping the engine building information, so that he is sure to have all the facts and information required for a more complete understanding of his modification.

The next consideration is how the engine is going to be used; that is, drag racing, off-road racing, or dual purpose? Special aspects of each type are covered in Chapter 8, *Off-Roading and Racing*.

Please keep in mind that a good engine in one area of racing has many things in common with good engines from other areas of racing. They are not completely different. Some specific parts may change, but the technique of good engine building will be the same.

Other areas to which thought and planning should be devoted are the overall budget that is available, the amount of time that you can devote to the project, and the manpower that you have at your disposal. Plan to match your basic components such as axle ratio, transmission, and overall vehicle weight to your engine package, or vice versa.

Reference Material

One of the most important items to have before you start is a service manual for your particular engine. A current *Mopar Performance Parts Catalog* is also strongly recommended. A notebook in which you can write all your measurements, part numbers, plans, etc., is also recommended.

Equipment

Having the proper engine building equipment is as important as what you plan to do to the engine. Once the reference material has been obtained and read, the rest of the equipment consists of tools such as an engine stand, dial indicator and base, degree wheel (P4452990), valve spring compressor, steel scale, cc'ing equipment and burette, dial-bore gauge, torque wrench, quality hone, basic sockets and wrenches, snap gauges, micrometers, and Plastigauge (P4286819).

A dial-bore gauge is a very useful tool in precision engine building. If you are going to hone the engine yourself, then a dial-bore gauge is an absolute necessity. If you don't have one, the block should be honed at a reputable machine shop, or by a professional engine builder. It is very important that the bores be straight (without taper) and round.

It is also recommended that you or your selected machine shop have a honing plate. It is one of the most important tools you can use. (For more information, refer to 'Block' section of this chapter.)

Plastigauge

When reassembling your engine you'll need a variety of Plastigauge to measure bearing clearances. This popular assortment includes one blue strip for .004" - .009" tolerances, two red strips for .002" - .006" tolerances, and two green strips for .001" - .003" tolerances. Each strip is 12" long.

P4286819 Plastigauge assortment.

Degree Wheel

Durable Mopar Performance Parts aluminum plate 0°-180°-0° degree wheel for centerlining camshafts. Features step-by-step installation instructions printed on back side.

P4452990 Degree wheel.

Records

One of the most important items in engine building is the keeping of accurate records of how each engine was built. All clearances such as bearings, ring gaps, etc., and all the other measurements such as head cc's, 1/2" down fill volume, etc., should be carefully written down. All machining operations such as head milling, piston notches, etc., as well as all items, part numbers, or special parts used should be recorded. No item should be omitted. These records will help in building future engines and also in solving engine failure problems (as well as preventing them in future engines).

ENGINE BLUEPRINTING

To obtain maximum performance and durability for a production engine, it is necessary to first "blueprint" the engine to provide a solid foundation for subsequent modifications. "Blueprinting" is the term used to describe the process wherein every part of the engine is checked for conformity to its specified dimensions. If it is a moving part, it will also have a specified working clearance which must be checked. This is necessary because all dimensions and working clearances have a plus and minus tolerance which allows them to function properly even though the figure may not be quite exact. These tolerances are what make the almost fully automated modern production line possible, allowing for the huge volumes that are produced today.

This production line system is more than adequate for stock passenger vehicle engines. However, an engine that will be used for performance work requires more precision. Blueprinting provides this precision by ensuring that all dimensions, working clearances, and settings are brought to the point where they produce the best results, both from performance and reliability standpoints. The worth of this procedure has been proven many times on the dynamometer and the race track, with fully blueprinted engines always producing more horsepower than their production line counterparts.

It is now time to make the final decisions on your basic engine racing plan. A lot of consideration should be given to the camshaft, carburetion system, and actual compression ratio that are going to be used in the engine. These three decisions will greatly influence many aspects of the basic preparation. Waiting until the last minute to make these decisions may result in extra work, added cost, or poor engine performance.

Keep in mind as you build your engine that there are places to spend your time that are very important to your engine's performance. However, there are also many areas that DO NOT affect engine performance, and some that may adversely affect it. The two most important considerations in engine building are to have straight and round cylinder bores and to have these bores in a "good" block. Cleanliness is also very important. Therefore **ALL** used and new parts should be cleaned before anything further is done.

Compression Ratio to be used _____ Intake System to be used _____ Camshaft: Type _____ Lift _____ Duration _____

One problem with identifying production camshafts for a given engine is that all are ground from the same casting. At this point, camshaft identification is best done by measuring the camshaft lift at the lifter. The usually reliable casting number fails on camshafts.

Casting numbers and forging numbers are as valuable for new parts as they are for old ones. Write both in your notebook.

Block casting number _____ Cylinder head casting number _____ Intake manifold number _____ Rod forging number _____ Crankshaft number (if available) _____
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Dynamic Balancing

Dynamic balancing of an engine assembly seems to be a lost art. Many racers appear to be trying to build their engine deliberately without balancing it. This seems counter-productive. Balancing is strongly recommended for racing engines and performance purposes, but it requires the engine to be totally disassembled to allow you to balance it. There are several "stages" to consider.

Balancing is a dynamic process. However, it begins with many static processes that can generally be classified as weighing. Each piston, pin, and both the small and big end of each connecting rod is weighed. Once weighed, each individual piece is lightened-down to the weight of the lightest piece in the set. Once matched sets are created, the balance shop adds a "bob-weight" to the crankshaft rodthrows. Now the crankshaft and vibration damper (if desired) can be spun and balanced dynamically. Heavy pieces (connecting rods or pistons) and externally balanced production engines will require weight to be added. Lightweight pieces will typically require weight to be removed.

Any serious race engine, especially a high rpm version, should be internally balanced as an assembly. There is performance to be gained from balancing the engine. It also helps the engine last longer. Cast crankshaft engines are externally balanced and therefore should be balanced with the offset vibration damper, which is a stock part of the package. It is recommended that if the engine is externally balanced it also be internally balanced, which will require Mallory metal (see Figure 4-5). (For more information, refer to 'Crankshaft' section of this chapter.)

Note: It is common on cast crankshaft engines to offset balance the torque converter (or flywheel) as part of the overall balance; however, this is not recommended.

When production parts are used, no balancing is required if the engine is being used in a production-style application. In this case, production balance is adequate. In some production engines the engine is externally balanced. If you plan to balance these engines, balance them as an assembly with any external balancing components, such as dampers, torque converters, and flywheels included, or adjusted for. You can't really balance (spin) torque converters with the engine, but you can do the flywheel and damper.

For a low-cost race engine, production balance is acceptable as long as the original parts haven't been switched, mixed, or modified.

Nominal Numbers

Numbers are fun to play with. However, they can be used in more than one way. We all know what a number is, so what is a *nominal number*? A nominal number is similar to an average. Nominal numbers are used to describe specifications that are found in production manufacturing. In the automotive industry, we use them to describe engine specifications such as compression ratio. The advertised compression ratio of any production engine is a nominal number. If you measure the size of the combustion chamber in cc's for hundreds of production engines, you end up with a nominal number for the combustion chamber. If you measure the size of the intake port (port volume) for hundreds of production engines, you end up with a nominal number for the intake port (port volume).

A nominal number does not mean that it is the biggest or smallest, just the most common. Although it isn't a true average, it indicates the range that you can expect. The key to all this is not to consider nominal numbers as absolute. They can go up or down (plus or minus). In most cases, much of the total variation (or observed variation) is not due to the part itself. For example, let's assume that the nominal (or advertised) port volume for a head is 170 cc's. Let's also assume that you want a large port volume for your race engine, and the reason that you bought this head is because of the 170 number. You measure it at the shop and your new head measures 170.1 cc's. You're happy and take the part home. A week later you measure the same port in the same head again in your own shop at home and find 165 cc's. Now you're mad! What happened? Temperature? Maybe. Different burette? Maybe. Most likely you switched valves. Originally you measured it with a nail-head or flat valve, but at home you measured it with a stock valve which was semi-tulip (for example). The port didn't change. Valve shape changes can affect the measurement of the combustion chamber. A nail-head or flat valve makes the chamber smaller, and an undercut tulip valve makes the chamber larger.

Remember, nominal numbers are for reference only. For complete accuracy, measure the part itself with all the parts that you are actually going to use in the final engine assembly. If you change parts at a later date, don't forget to measure again!

Dynamometers (Dynos)

Dynamometers (dynos) allow you to measure an engine for horsepower and torque output without putting it in a vehicle. This has many advantages but it also has many shortcomings. You don't want to end up "racing dynos" because dyno testing can be very expensive and uses up lots of parts.

A short example may help illustrate the point. If you built an engine that made 200 horsepower and you took it to Dyno service A and it made 225 hp, you'd be pleased. If you took the same engine to Dyno service B and it made 245 hp, you'd be even more pleased. Dyno service C—260 hp. But if you took it back to Dyno service A and it made 225 hp you'd be disappointed. Unfortunately, you have now spent thousands of dollars, used up your engine, and learned nothing. You've been racing dynos. However, all is not lost. If you stay at one dyno service and make your changes, relative gains should translate to real at-the-track performance gains. You just can't get too hung up on absolute numbers.

DISASSEMBLY

Before the engine assembly and blueprinting procedure is started, the engine has to be disassembled. This disassembly procedure is usually considered only a necessary evil and is, therefore, usually done as quickly as possible. This is not recommended. The correct way to disassemble an engine is slowly. During teardown you should check for fluid contamination (mixing of oil and water), cross-threaded or stripped bolts and nuts, bolt holes that aren't tapped deep enough, and be sure to turn the crankshaft without connecting rods (but with all the main bearings in place) to see if there are any tight spots. Careful disassembly can give you a lot of clues as to what has to be fixed, replaced, or changed in the engine when you rebuild it.

Things to Check

When building a new engine assembly, which for most of us really means rebuilding a used assembly with some new parts, there is a lot of information the parts can tell us that will help us with our project. Unfortunately, we have to check these things ourselves. To this end, there are several measurements that should be made during disassembly, or when the new parts are received, which should be recorded in the notebook that you should keep on each engine that you build. They will be helpful when the engine is rebuilt. Some of these measurements are crankshaft end play, connecting rod side clearance, deck height (top of piston to top of block), camshaft lift, and actual installed camshaft centerline. You should check the camshaft lobes and valve guides for excessive wear and check the pushrods for straightness.

Crankshaft End Play_____
Rod Side Clearance _____
Deck Height: Above _____ Below _____
Camshaft Lift
At Valve: Intake _____ Exhaust _____
At Camshaft: Intake _____ Exhaust _____
Installed Camshaft Centerline_____
Camshaft I.D.
(or part number, if available)_____

At this point we'll assume that we're rebuilding the engine for added power and that there was nothing wrong with it on its last pass; that is, it isn't broken. So why are these measurements important?

Let's look at each one individually. Crankshaft end play can indicate that the crankshaft is worn and needs to be replaced. It may also indicate that you have an engine/drivetrain mount problem that needs to be fixed before you break the engine. If the connecting rod side clearance is high, you may need connecting rods or the crankshaft journal may be worn. Deck height affects the piston selection and directly relates to the engine's compression ratio.

The easiest way to identify a camshaft by measuring the lift both at the valve and at the camshaft lobe. This allows us to calculate the rocker arm ratio. The camshaft centerline check allows us to put the camshaft in the engine in the exact same location as before. If we don't do this, we can lose some power/performance with the same pieces we had. The camshaft I.D. is sometimes stamped on the end of the camshaft that goes into the engine. This is sometimes helpful with aftermarket grinds. But, if it isn't there, then the camshaft lift will get us what we need. One of the most important items is to write this information down.

Part Identification

Casting numbers can be used to identify new or used cylinder heads and cylinder blocks, even new or used intake manifolds. Forging numbers can be used to identify connecting rods. In either case, these numbers cannot be used to purchase the part from a dealer, speed shop, etc. In most cases, the service number (number used to obtain the item) will be one or two digits different from the casting-forging number. This doesn't usually cause a problem, only confusion, except for production camshafts. Camshafts have a casting number, but it's of no use in identifying the camshaft except to tell you which engine it came out of, which you usually already know.

The problem is that all production cams (2 to 3 designs in a given year) for a given engine are *all* ground from the same casting. At this point, cam identification is best done by measuring the cam lift at the lifter. This is much more reliable than casting numbers.

Otherwise, casting numbers and forging numbers are as valuable for new parts as they are for old ones. Write both in your notebook.

INSPECTION AND PREPARATION

Cylinder Block

The basic block should be checked and reworked in accordance with the following procedures:

1. Before disassembling the block, the deck height of the pistons must be checked. Deck height is the distance from the top of the piston to the top of the deck surface of the block. This is an important dimension since it has a direct influence on compression ratio. If the piston is a flat top style, it will usually be below the deck and this is the distance that must be measured. A domed piston will stick up above the deck surface and the distance is measured from the deck to the top of the dome. Mark this figure down for future reference and completely disassemble the block.

Optional Step: *Stress Relieving* (refer to 'Block' section of this chapter).

2. All the head bolts should be screwed into the block without the head. Visually inspect the rows of bolts for any that may be bent, drilled at any angle, or for holes that are not drilled deep enough. When the head bolts are screwed in, the depth of thread engagement should be checked and recorded.
3. The main bearing bores must be checked for both specified diameter and alignment with each other. If either is off, a Tobin-Arp align boring machine (or any similar type machine) must be used to align bore the block. A crankshaft-turning tight spot indicates that the bores are out of alignment.
4. *Sonic Testing* (refer to 'Block' section of this chapter).

5. Once the main bearing bores are known to be in alignment, the deck surfaces of the block should be checked to make sure they are parallel with the axis of the crankshaft. The distance from the centerline of the crankshaft to the deck surface of the block should be exactly the same in the front and rear. If not, the deck surfaces will have to be milled. At this time the deck height can be machined to the proper dimension.

Note: Deck heights that are above the block surface will be increased by milling the block. Check the blueprint specifications on the engine before milling. The resulting machined surface of the deck must be on the rough side to produce a good gasket seal and prevent the head gasket from moving.

6. A bottoming tap should be run down all head and main bearing bolt holes. The head bolt holes should be chamfered slightly to prevent the top thread from pulling up when the head bolts are torqued.
7. Use a small, fine file to remove burrs and break all sharp edges in the main bearing bores and around the cylinder bore chamfers, along with other sharp edges on the block.
8. The tappet bores may be shined with #400 paper to remove any rough spots or burrs. A brake cylinder hone may also be used with care.
9. If a big flat-tappet camshaft that requires .100" oversize mushroom lifters is going to be used, the bottoms of the lifter bores should be spot-faced to a slightly larger diameter than the diameter of the mushroom lifter bottom.
10. Ensure that all cylinder head dowel pins used for aligning purposes are the proper height (not too high), and also check to be sure that the dowel pins locate the head properly so that the combustion chamber is centered over the cylinder bore. Check to be sure that the dowel pins don't hold the head up off the block.
11. *Honing* (refer to 'Block' section of this chapter).
12. *Honing Plates* (refer to 'Block' section of this chapter).
13. The rear main bearing oil seal machined groove should be roughed slightly with a center punch, and the rope seal must be seated all the way in. The rubber rear main seal should be held in place with Permatex (RTV).
14. A chemical kit belongs in every workshop before you start building the engine. It will be useful in coping with life's mechanical frustrations, such as baked-on gaskets, assuring proper seal, assembly lubing, freeing up nuts, and dozens of other uses. Chemical products to be used frequently are: Silicone RTV, Gasket Remover, Lubriplate, Spray White Lube, Anaerobic Gasket Maker, Lock 'N Seal, Brake and Carburetor Cleaner, Penetrating Fluid, Spray Gasket Adhesive, Thread Sealant with Teflon, and Hand Cleaner. Everything you'll need to spare a headache!

15. When installing camshaft bearings, make sure that the oil holes in the bearings line up with the oil holes in the block. **DO NOT** replace camshaft bearings unless they are bad.
16. When all machine operations are complete, the block should be thoroughly washed out with solvent. Use bottle brushes of suitable size to clean out all bolt holes, oil passages, etc. Finish off with another thorough washing using a good, common detergent and warm water. Blow or wipe dry and oil to prevent rust. Engine parts can't be too clean. Many early engine failures can be traced to dirt or foreign objects (metal chips, etc.) that were left in the engine when it was reassembled.

Crankshaft

1. Check crankshaft end play (refer to *Crankshaft End Play*, 'Crankshaft' section of this chapter).
2. Crankshaft bearing journals should be checked for specified diameter and clearance. If it is a hardened crankshaft, it shouldn't be ground for clearance. These crankshafts are hard only to a depth of .0003". The main bearing clearances should also be checked. The best way to measure crankshaft journals is with a micrometer. Main bearing clearances can be measured directly or by using Plastigauge. The main bearing clearances should be 0.03-0.06 mm (0.001-0.0025"). For complete procedure, refer to *Measuring Main Bearing Clearances*, 'Crankshaft' section of this chapter.
3. The bearing journals may be polished by hand, first with #400 and then with #600 paper. Any nicks, burrs or scratches should be polished out. Chamfer oil holes in journals and use a wet stone to break edges. Check the oil passages to each journal.

Caution: With nodular cast iron crankshafts, it is important that the final paper or cloth polish after any journal regrind be in the same direction as normal rotation in the engine.

4. Before assembly, make sure crankshaft, including internal oil passages, is clean. Also be sure all oiling passages are drilled through.
5. When assembling the crankshaft into the block, oil the bearings and journals.
6. When installing the crankshaft, locate the main caps carefully so that the crankshaft spins freely, and torque all caps to specification. Then spin the crankshaft by hand through several revolutions before installing the rear main seal. It should be fairly free, requiring very little effort. Remove the caps and check for any burrs. If present, they can be removed by gently scraping with a bearing knife. When installing the rear main seal, make sure it is properly seated improper seating can cause the crankshaft to bind.

7. For better race engine oiling with a high capacity oil pump, 360° main bearing oiling is desired. 360° fully grooved main bearing sets should be used. It is NOT recommended that the crankshaft itself be grooved because grooves weaken the crankshaft.
8. A degreed damper is a must for racers since they must set their timing by total degrees advanced at a fairly high rpm (for example, 35° total at 2,500 rpm). A degreed damper is the easiest, most accurate, and most convenient tool for doing this. It also aids in setting the valve lash by giving 90° reference marks.

Note: Damper degree timing tape is P4529070.

Measuring Main Bearing and Connecting Rod Bearing Clearances

(Refer to 'Crankshaft' and 'Connecting Rods' sections of this chapter for detailed instructions.)

Cylinder Head

1. The cylinder head should be "cc'd" and the volumes compared to specifications. Any milling that is required should be done, and the chamber volumes rechecked.
2. The cylinder head should be checked for squareness and for any cracks or flaws. The valve guides should also be checked for wear and replaced if necessary.
3. The cylinder head should have a valve job done if the seat runout does not meet specifications: 0.064 mm (0.0025"). Refer to 'Camshaft and Valve Gear' and 'Cylinder Head' sections of this chapter for more information.
4. The cylinder head should be installed on the block without the head gasket to check dowel pin height. Dowel pins should NOT hold the cylinder head up off the block surface; they should only locate it over the cylinder bores.
5. When high lift camshafts are installed in production-based engines, the keepers may hit the valve guide. This should be checked at the cam's maximum lift. The guide should be shortened to give .100" clearance between the top of the guide and the bottom of the keepers.
6. When dual valve springs are used, the inner spring seat may have to be cut down flush with the outer spring seat.
7. With the crankshaft, pistons, and connecting rods removed, check the alignment of the combustion chamber over the cylinder bore. If it needs to be corrected, use offset dowel pins in the block.
8. The latest tech trend in Stock and Super Stock racing is to "cc" the ports—both intake and exhaust. This isn't a technique to increase performance; rather, it's a measurement technique used by the NHRA and IHRA

at the tech barn. They have a cc number for the port volume and your cylinder head will be checked against that number. Refer to the 'Cylinder Head' section of this chapter for complete information.

Connecting Rods

Note: The following information is for the preparation of steel connecting rods only.

1. Connecting rods should be checked for alignment; bores should be parallel. Check big and small ends for size.
2. Using a small file, deburr the connecting rods, paying particular attention to the mating surfaces and tab groove. You need the clamping effect of a 60 micro bore. The sides should be polished by hand on a flat plate using #600 paper. Proper side clearance should be 0.25-0.48 mm (0.010-0.019"). DO NOT increase side clearance past .019" as this increases the oil demand of the engine. It will also allow too much oil on the cylinder walls which will overload the rings and allow excess oil in the combustion chambers.
3. In an engine that is to be used in a high rpm situation, the connecting rods and connecting rod bolts should be Magna-Glo checked for cracks or forging flaws.
4. A race engine should always use heavy duty connecting rod bolts and nuts.
5. The connecting rod bearing clearance is 0.25-0.76 mm (0.001-0.003"). Preferred bearing clearance is 0.044-0.050 mm (0.0015-0.0020").
6. The connecting rod bolt head should be seated against the flat, machined surface in the connecting rod.
7. For a race engine, the big end of the connecting rod should be sized to the minimum diameter to get the maximum crush from the bearing.
8. Shot-peening the rods is recommended if they haven't been already.
9. Some race engines use floating piston pins. On these engines, the pin-to-connecting rod clearance should be checked. On standard production engines that use a pressed pin, the amount of interference should be checked. (Refer to *4.0L Engine Specifications*, in this section.)
10. Connecting rods with full floating pins to be used in racing applications should have the small end of the connecting rod drilled with a small hole (approximately 3/32") for increased piston pin oiling. The best location for this oiling hole is the top of the connecting rod above the pin (Figure 4-11). Pin oiling holes in the sides (5 o'clock or 7 o'clock, for example) weaken the connecting rod itself and therefore are NOT recommended. One hole in the top does the best job of oiling the pin and maintaining the connecting rod's strength.

Pistons and Rings

1. Check ring grooves for burrs, then for proper side clearance.
2. Check ring end gap against specification. DO NOT in any case exceed specifications as this will allow too much blow-by, causing power loss and/or allowing too much oil to reach the combustion chamber which can cause detonation. The ring gap ends must be square and parallel.
3. Use a fine stone to deburr rings and to just barely break edges on end gaps. Break the edges using #600 paper, but DO NOT chamfer.
4. ***Pistons and Piston Rings – General Selection*** (refer to ‘Pistons and Rings’ section of this chapter for selection information).
5. Production pistons will perform well with standard production clearance. Solid skirt, racing-type pistons will need more clearance (check with the manufacturer of the pistons you are using). This clearance is measured just below the oil ring and perpendicular to the pin centerline.
6. Production pistons are designed with an offset pin to keep piston slap to a minimum. Internal friction can be reduced by reversing this offset. On flat top pistons it is only necessary to reverse the piston on the connecting rod to accomplish this. The location notch or groove on the top of the pistons should be pointing toward the rear of the engine when you finish.
7. Pistons should be clearance checked in the bores that they will be run in. Also, piston ring end gaps should be checked in the cylinders that they will be in.
8. With either flat or domed pistons there will most likely be valve notches or reliefs cut to provide sufficient valve clearance. The edges of these notches as well as other edges on the tops of the pistons should be sanded lightly with #400 paper so they are not sharp.
9. High lift camshafts will require the pistons to be notched or the existing notches to be deepened.
10. High compression pistons have a large dome that sticks into the combustion chamber. In some cases this dome will strike the spark plug and close it up. Therefore, the end of the plug should be given 1/4" clearance in the shape of a spherical cup. This will also aid in flame propagation because the plug will be less shrouded.

Seal and Cover

With the engine parts preparation completed, parts should be sealed in paper and then covered with a plastic bag. The carburetor/throttle body flange, exhaust ports, etc., should be taped over until the engine is installed and these components are actually bolted on.

SUB-ASSEMBLY OF BASIC GROUPS

With the individual pieces of the engine prepared, we can now proceed to put together larger assemblies, such as the short block and cylinder head assemblies. Also, before starting work in this area, certain basic engine decisions should be made such as engine compression ratio and camshaft design and specifications. With these decisions made, there are some specific procedures that you should be familiar with when you are assembling the individual pieces. These procedures will be discussed separately in the following sections before going on to the final engine assembly.

The most important areas in the performance and horsepower output of any engine are as follows. Straight and round cylinder bores are the most important with their related area of sealing the ring to the cylinder wall and the piston. The valve work (valve job) is also very important to all engines. Cylinder head ports are important to high output engines. Lightweight rotating engine pieces will help the performance of all engines as long as their use is not at the expense of durability. Having a good valve assembly that works well together to do the required job is often overlooked, but is very important in engine performance. (For more information on valve train geometry, refer to ‘Camshaft and Valve Gear’ section of this chapter.)

Preliminary Assembly

It is recommended at this point that a preliminary assembly of the short block be made and various measurements taken. This preliminary assembly should consist of installing the main bearings, crankshaft, and piston and connecting rod assemblies (no rings required).

After this preliminary assembly has been made, measure the actual deck height, dome height (if a domed piston is used) or depth of the ‘dish’ (if a dished piston is used), and gasket thickness. With this information, you can then determine your initial compression ratio.

Cylinder Head and Intake Manifold

With the short block ready to be assembled, the cylinder head and intake manifold can be checked in the preliminary stages of assembly.

The intake manifold should be checked for port alignment. The intake manifold's angle should be the same as the cylinder head and it should fit such that with the gasket installed the intake manifold bolt holes line up.

For more intake manifold information, refer to 'Induction System' section of this chapter.

Camshaft and Valve Gear

Choosing the camshaft is the last of the three major engine building decisions (the three being *carburetion*, *compression ratio*, and *camshaft*), and it is easier to make once the other two decisions have been finalized. The camshaft directly affects the pistons, block, head, and complete valve gear, so it should not be taken lightly. Camshaft choice is often difficult because of the vast number of options available. However, once carburetion and compression ratio decisions are made (along with what the engine is going to be used for), the total number of choices will be narrowed down to a handful or less, which is a lot easier to select from than hundreds.

With head, valves, and springs initially assembled, the head assembly can be bolted to the block and preliminary checks on camshaft and valve gear can be made.

1. General Camshaft Selection

There are literally thousands of camshaft designs to choose from. Picking the correct one for you and your engine without spending too much money is a very tough job. Selecting the type of camshaft (hydraulic, mechanical, roller) is usually the hardest job. Mopar Performance Parts has specific recommendations for various engines. However, you must still decide on the type that best suits your application. Once you have decided to go hydraulic, solid, or roller, Mopar Performance Parts can make recommends that will work best in your application. The easiest way to identify the type of camshaft is by lift. Each category has a lift range in which it works best. For complete information and performance application recommendations, refer to 'Camshaft and Valve Gear' section of this chapter.

2. Valves and Valve Springs

a. Valves should be measured (to be sure they are the proper size) and inspected for flaws or other damage. Measure the actual outside diameter of the valves to be used and record the measurement.

b. Valve springs should be load checked. Weak springs will have to be replaced. Record loads and height checked at. The biggest advantage of load checking is to see if the springs have "gone away" or to see if a second set of the same spring is as "strong" as the first which worked well.

Note: Not all spring testers are the same. Many are not maintained and calibrated on a frequent basis. This makes the absolute value of spring loads quite unreliable. However it is a very good comparative tool; that is, measuring all springs on the same tester or measuring the same spring new and used.

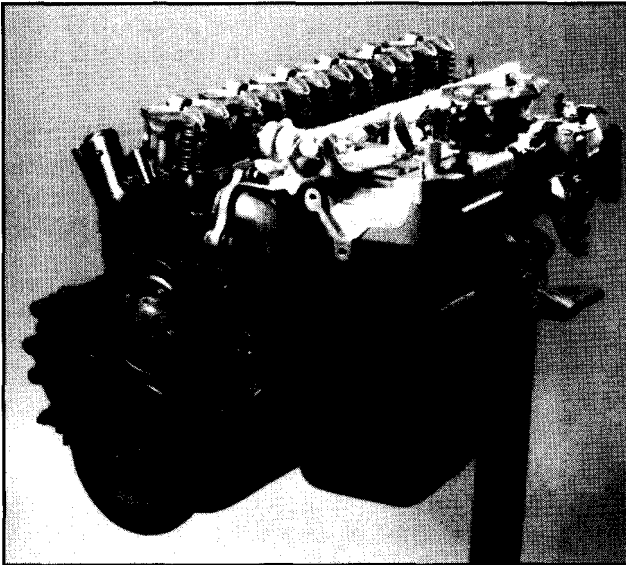
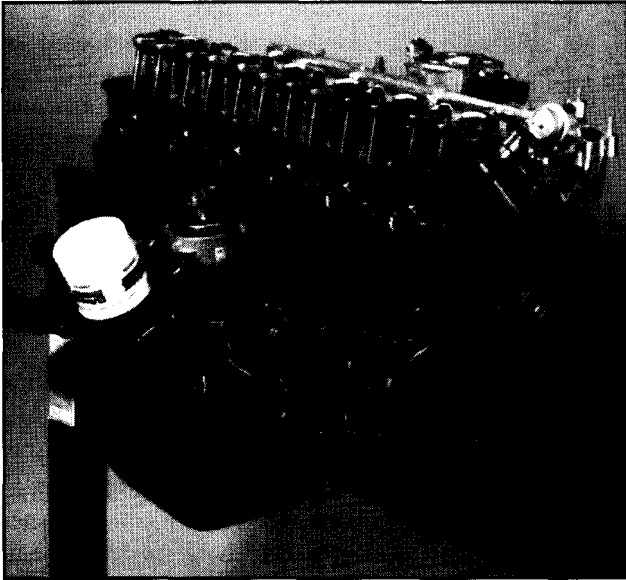
c. With the valves, keepers, and retainers installed, check the valve spring height. This should be compared to the spring load information (#2b) and the correct thickness shim chosen to get the same installed spring load on each valve. Valve spring installed height must be carefully controlled to avoid "coil bind" by providing at least .100" more height at maximum valve lift than the solid height of the spring.

Caution: DO NOT check solid height with a spring that you intend to use in the engine. Compressing a valve spring to solid height will overstress it and cause premature load loss or spring breakage.

d. With the same spring height setup as #2c, measure the outer valve spring height, the inner valve spring height, and the keeper-to-valve guide clearance. The camshaft lift (lift of the camshaft measured at the lobe or lifter) multiplied by the rocker *arm* ratio plus .050" should be less than the keeper-to-guide clearance in the valve closed position or the guide will have to be shortened. Measure the "solid height" of both the inner and outer springs. This solid height plus .100" plus the valve lift (camshaft lift multiplied by the rocker arm ratio) should be equal to or less than the installed height for each spring.

e. The valve spring installed height can be increased without installing longer valves. Usually, special retainers are used to do this. The increased installed height stresses the spring less so that it lasts longer. It also allows for higher lift camshafts with the same basic parts.

Note: DO NOT sink the valve or machine the outer spring seat down into the head to increase the installed height. This would result in decreased performance.



3. Rocker Arms and Pushrods

- a. Check rocker arm-to-valve tip relationship for alignment. Improper alignment can place undue side loads on valves, causing rapid valve guide wear. Rocker shaft spacers or grinding the rocker can be used to move the rocker arm up or down the shaft to align it on the valve tip.
- b. Check valve tips for scuffing or high wear.
- c. Check pushrods for straightness and length. If they are too short, they can't be adjusted to work properly. If they are too long, they will over-angle the rocker arm and, with high lift camshafts, hit the bottom of the rocker.

- d. Check the pushrod-to-block clearance with high lift camshafts or large diameter pushrods.

Additional clearance can be obtained by using a small electric or air grinder, a drill motor with a rotary file, or a rat-tail file. Grind to your individual need.

4. Pushrod Length

To optimize rocker arm geometry, a cut-to-length pushrod kit is recommended, but only to the very serious racer or for engines with large amounts of head milling and block decking. Custom length pushrods are used to obtain ideal rocker arm geometry which allows the best performance from a given camshaft.

For additional information, refer to *Pushrods*, 'Camshaft and Valve Gear' section of this chapter.

5. Additional Camshaft Installation Performance Tips

When installing a new camshaft, there are several items besides the camshaft that should be replaced. First, you're probably going to replace the valve springs to get the most out of the new camshaft. It's always a good idea at this point to install new valve seals.

While the camshaft is out, it's recommended that the standard silent chain be replaced with a roller timing chain and sprocket set. Refer to 'Crankshaft' section of this chapter for more information.

The 4.0L engine needs offset bushings to centerline camshafts (P3690936).

When centerlining the camshaft, we recommend using a degree wheel. Once the engine is put back together, you should use damper degree timing tape (P4529070). Refer to 'Camshaft and Valve Gear' section of this chapter for complete camshaft centerlining information.

Notes Before Final Assembly

1. Make sure all parts have been cleaned, and are kept as clean as possible.
2. Observe factory torque specifications for all fasteners, and also factory specified tightening sequences for cylinder head and intake manifold bolts to reduce the possibility of cylinder head or intake manifold warpage.
3. The engine should be assembled using oil, gasket sealer, white grease, etc., on the appropriate points.

FINAL ASSEMBLY

Now that we've gathered all our parts, the next step is to clean everything, especially the used parts that are going to be reused. Clean them before they go to the machine shop, unless you're going to pay extra to "tank" them. A machine shop will do a better job with clean parts than with greasy parts. You don't have to polish them—just degrease them.

Earlier we said we were going to rebuild our engine. This is actually a common misnomer. It would be more correct to say that we are going to assemble the engine or, in our specific case, reassemble. There are certain operations that we can't do. For these special operations, we have to select a machine shop. Typically these operations are:

1. Bore block
2. Hone block with honing plate
3. Valve job:
 - Grind valves
 - Grind seats in head
 - Install valve seats, if required
4. Deck cylinder head and/or block
5. Install bronzewall guides, if required
6. Rebuild connecting rods
7. Balancing

Once all these parts come back from the machine shop, we get to do our thing—assemble the engine—slowly, very slowly! The first step is to clean everything AGAIN—new parts, old parts, and machined parts. When completed, dry thoroughly and wipe or spray light oil onto the parts to keep them from rusting, then cover or wrap in newspaper until actual assembly time. All the measurements, clearances and fine tuning prep have to be done prior to final assembly. This usually requires parts of the engine to be sub-assembled two, three, or four times before final assembly. At this point, we'll assume all this preparation has been done.

To put the complete engine together we should consider three sub-assemblies that should be put together separately. Because of this, they may also be assembled at different times. They are:

1. Connecting rod and piston assembly
2. Cylinder head assembly
3. Rocker shaft assembly

Our final assembly steps are:

1. Block on to engine stand
2. Main bearings added to block
3. Crankshaft installed and mains torqued
4. Connecting rods attached to pistons:
 - Pressed pin (machine shop)
 - Floating pin (add snap rings)
5. Rings added to piston and connecting rod assemblies
6. Connecting rod bearings added to connecting rods
7. Connecting rod and piston assemblies inserted into block
8. Camshaft installed

9. Timing chain and sprockets added
10. Tappets inserted
11. Cylinder head assembly:
 - Valves inserted
 - Valve seals added
 - Springs installed
 - Retainers added
 - Keepers installed
12. Head gasket added
13. Cylinder head installed
14. Head bolts torqued (in proper sequence)
15. Rocker shaft assemblies:
 - Rocker arms added in order
 - Rocker bolts inserted
 - Oiling holes checked for alignment
16. Rocker shaft assemblies installed
17. Pushrods installed
18. Rocker shafts torqued down
19. Camshaft centerline checked
20. Intake and exhaust manifolds installed
21. Intake and exhaust manifold bolts torqued (in proper sequence)
22. Distributor installed
23. Valve covers, oil pan, timing covers added, as required
24. All open holes, such as carburetor/throttle body pad and exhaust ports, taped in preparation for paint or installation
25. Old spark plugs installed
26. Engine stored, painted, or installed
27. After installation, old plugs swapped for new plugs and sealing tape removed
28. Engine dress-up completed—plug wires, hoses, headers, etc.
29. Before actual engine start-up, refer to *Engine Start-up*, later in this section

And you thought this was going to be easy! Take your time and it's not so bad. If you can work on the engine full-time, allow one month. If you do the work part-time, allow two months or more. This doesn't include machine shop or parts gathering time. Be careful and don't hurry. You'll be successful. There's a lot of pride in the successful completion of an engine building project.

Camshaft into Block

1. Before installation, the camshaft and tappets should be liberally coated with Mopar Engine Oil Supplement. This lubricant will stick to the surfaces without draining off and will prevent scuffing when the engine is fired up for the first time. It has been determined that this is when the most camshaft damage takes place.
2. When installing the camshaft sprocket, use at least Grade 8 bolts, along with Loctite and safety wire. It is possible for high speed engine harmonics to cause these bolts to loosen if precautions aren't taken.
3. Because of production tolerances, it is possible for the crankshaft-to-camshaft relation to be several degrees off, either advanced or retarded. It is important that this timing be correct to produce maximum performance.
4. While the engine is still without the head, the timing marks on the crankshaft damper and the timing chain cover should be checked for accuracy of the "0" TDC mark.
5. Advancing or retarding a camshaft should only be done to install the camshaft at its designed centerline. It is very important to have the centerline correct. Most camshafts will have the design centerline stated as part of the specifications along with duration and lift. If it isn't given, it can be calculated (refer to 'Camshaft and Valve Gear' section of this chapter). Advancing or retarding a camshaft from its designed centerline is not recommended because it will reduce the overall efficiency of the engine.

Cylinder Head onto Block

When the block was honed using a honing plate, a certain cylinder head bolt thread engagement depth was used for each bolt. It is important that the cylinder head be attached using the same thread engagement depth as the honing plate did.

With the block ready to be assembled, the cylinder head and intake and exhaust manifolds can be checked in the preliminary stages of assembly.

Use the correct torque sequence when installing head bolts (refer to *Installation*, 'Cylinder Head' section of this chapter for complete procedure). Be sure to torque the bolts a second time after you've run the engine.

Valve Gear onto Engine

With the camshaft in the block and the head installed, the actual valve lift measured at the valve retainer can be checked. The camshaft lift multiplied by the design rocker arm ratio should yield the valve lift. However, this is not the case in an actual engine. The actual rocker arm ratio will be less than the design rocker ratio which is typically 1.5 for wedge engines. This will cause the valve lift to be less than the number that is calculated. This is due to the rocker arm

ratio itself plus the effect of the geometry of the head. "Blueprinted" mechanical rocker arms (those with an exact design ratio) are available for most engines from various high performance machine shops.

Intake Manifold

The intake manifold should be checked for port alignment. The intake manifold's angle should be the same as the cylinder head and it should fit such that with the gasket installed the intake manifold bolt holes line up.

The intake manifold attaching holes in some cylinder heads are shallow. Check to be sure the manifold screws are properly torqued and that the manifold is actually compressing the gaskets. If the holes are shallow, a rather severe oil leak may result.

Carburetion System (if equipped)

The carburetion system directly affects the cylinder head, but only to a minor degree. All the same, the carburetion system is rated as the number two engine building decision because of its indirect effect on camshaft selection. In many cases, the carburetion system is determined by the rules of the governing body that runs the race track. Without that to guide us, a single 3-barrel is preferred because of its simplicity.

Oiling System

Refer to 'Oiling System' section of this chapter for detailed information and parts listing.

Accessory Drives

A typical drag race vehicle has a very limited accessory drive at the front of the engine. It may consist totally of one dry sump pulley and belt. This is very simple and has never been known to cause any problems except for those who forget to charge their batteries between runs! However, other types of race vehicles typically have a water pump drive, an alternator drive, a power steering pump drive, and/or a dry sump drive. If you take the "stack it on the front and use a longer bolt" approach, you could have some problems, especially during long, high speed races. You'd like to keep the drives as close to the front of the engine as you can. However, you can't take the drag racing approach either. If you use the water pump drive to drive the alternator, you can save one separate drive. The power steering can be driven off the water pump so that it doesn't load the crankshaft and push the bolt out further. This simple approach can take several inches off the bolt length.

Valve Clearances

Proper valve clearances are very important to prevent bent or broken valves. Valve clearances to be checked include valve-to-valve, valve-to-piston, valve tip-to-rocker arm tip, and valve-to-block. For complete information, refer to 'Camshaft and Valve Gear' section of this chapter.

Boring and Milling Specifications

For information, refer to 'Block' section of this chapter.

Engine Paint

The completed engine is now ready to be painted. Seal off the open holes and machined surfaces such as carburetor/throttle body flanges and exhaust port openings. Tape over or cover all items that you don't want painted, such as chrome valve covers. Nine colors are available from Mopar Performance Parts.

Seal and Cover

When the engine assembly is completed it should be sealed with duct tape (covering exhaust ports, etc.) and then covered with a plastic bag. The carburetor/throttle body flange, exhaust ports, etc., should be taped over until the engine is installed and these accessories are actually bolted on.

Engine Enamel Spray Paint

Black (P4120753)	All 2.2L engines since 1981, and 318 and 360 engines since 1983, have been painted black.
Race Hemi Orange (P4120751)	A bright orange color used on cars equipped with Max Wedge engines (413 and 426W cross-ram) during 1962-64. Also used on 426 Race Hemis built in 1964-65.
Street Hemi Orange (P4349216)	A red-orange color used on 426 Street Hemis built in 1966-71. Commonly referred to as "Hemi Orange." 1969-71 high performance 383 and 440 engines and 1970-71, 340 'A' engines were also painted this color.
Turquoise (P4120752)	This medium blue-green color was used on all 'B-RB' big block engines during 1962-71 (with the exception of 1969-71 high performance 383 and 440 engines—they were painted Street Hemi Orange).
Red (P4349218)	This bright red color was used on all 273 'A' engines from 1964-69. Also, 1968-69, 340 engines and most mid-1960s 318 'A' engines were finished in this color.
Blue (P4349217)	This medium blue color was used on all production engines from 1972-83 with the exception of the 2.2L engine. Most 318 'A' engines built from the late 1960s through 1972 were painted this color.
Yellow (P4529144)	Used on many early 1960s Slant Six engines, including trucks.
Aluminum Silver (P4529148)	This color was used as far back as the 1940s and as late as the early 1960s. Most of the early 300 series Hemis and 1950s engines were painted this color.
Gold Metallic (P4529149)	The "Golden Lion" engines of the late 1950s and early 1960s as well as the "Golden Commando" and DeSoto "Adventurer" engines used the color.

Engine Building Checklist

	<u>YES</u>	<u>NO</u>
Do you own and have you studied the service manual for your engine?	_____	_____
Did you read this chapter completely?	_____	_____
Did you select your parts based on Mopar Performance Parts recommendations?	_____	_____
Did you take your time and carefully check everything?	_____	_____
Did you clean the parts after each operation?	_____	_____
Did you check all the various clearances?	_____	_____
Did you re-check all torques?	_____	_____
Do you know your exact compression ratio?	_____	_____
Did you record all measuremer.; and parts used?	_____	_____
How many "tricks" were added to the engine? (Put number in "NO" column.)	_____	_____
Did you select your camshaft for its intended use?	_____	_____
Was the octane of the gas available considered with the compression ratio?	_____	_____
Did you use oil, gasket sealer, white lithium grease, etc., during assembly?	_____	_____

	<u>YES</u>	<u>NO</u>
Do you know your exact camshaft centerline (as installed)?	_____	_____
Did your cylinder bores measure round and straight?	_____	_____
Did you use a dial-bore gauge to measure the cylinder bores?	_____	_____
Did you measure the camshaft lift at the valves (intake and exhaust)?	_____	_____
Did you check the connecting rod bolts for the head flush with the spot-face?	_____	_____
Did you check TDC on the damper after assembly?	_____	_____
Was the engine builder present at engine start-up?	_____	_____
Was the piston pin clearance or press checked?	_____	_____
Was the valve job done by a professional?	_____	_____

Engine Start-up

With the new engine built-up and installed in the race vehicle, you're ready to start the engine for the first time. This sounds simple enough but should not be taken lightly. The first step is to be sure that there's oil in the pan. Never assume that someone else did it. Check it yourself! Next is to add water. Check for leaks before starting. Double check the firing order, plug wires and basic timing.

In addition to these items, make sure that:

1. The oil pump and oiling system are supplying oil pressure. After installing a mechanical oil pressure gauge (only if your vehicle is not already equipped with an oil pressure gauge), remove all the spark plugs in order to relieve the compression in the cylinders and to prevent the engine from starting. The engine should be turned over with the starter motor until the oil pressure gauge shows a reading of over 10 psi.

Once you have determined that the engine does have oil pressure, the spark plugs may be reinstalled and the engine may be started. When the engine starts, the gauge should show a minimum reading of 89.6 kPa (13 psi) at 600 rpm (idle speed).

2. The fuel pump(s) is supplying fuel to the engine, and there are no fuel leaks at the various fittings.
3. The throttle linkage operates freely.
4. The ignition timing is set properly (conservatively for break-in).
5. The tach and engine shutoff (on manual transmissions) is functioning properly.

TRACK TESTING

"Track testing" can be critical to the maximum efficiency of the overall vehicle. These tests are grouped into three areas: garage, the race track itself, and pits. Obviously the title "track" is slightly misleading. The term "track" implies that the race vehicle is completed and ready-to-go, which is required for these tests. So in this sense, "track" is more a condition than a location.

Before Testing

Before any test is run, certain preparations have to be made or the test may fail. You should always test specific things, preferably one at a time.

Be sure that you have read this chapter completely. Take this book as well as the appropriate service manual with you to the test.

Preparation

Make sure that the engine/vehicle is fully prepped before going to the test. Engine full of oil, coolant, etc. Vehicle full of gas. Test the brakes, steering, transmission shifters, etc. Also write down exactly what you're going to test and in which order.

Pack all the spare parts (gaskets, sealers, etc.) that may be required in portable containers such as the Mopar Performance parts tote (P4529181). Mark each tote with what's inside. Always take extra bearings, pushrods, rocker arms, valve springs, retainers and keepers. Take all your extra ignition pieces (especially plugs and wires) and (if equipped) carburetor parts (especially jets).

Be sure that the "test parts" fit before going to the track. Generally on a seasoned race vehicle, the vehicle **is** taken to the track with the new parts installed. Then you can baseline the new parts and switch to the old parts without problems because they've been on the vehicle already.

Also, separate plug wires using P4007667 kit. Shield non-plug wires with convolute tubing for protection and neatness. Choose size by the size and number of wires being covered.

Parts Tote

Parts and tool storage can be a real hassle when you go racing or even at home in the garage. This handy parts tote is designed to hold your tools and parts neatly and safely. Made of durable impact resistant plastic that will stand up to a rugged treatment. Stackable so you can maximize space. Molded in blue. 21-1/8" x 15-1/4" x 12-3/4".

P4529181 Parts tote.

Self-Locking Cable Tie Package

Keep your engine compartment neat and free of loose wires with these handy, self-locking nylon cable ties. Available in ladder or solid locking design. Just loop around loose wires, tighten, and cable locks in place automatically. Ten each of the following lengths and styles are included: 8" and 5-1/2" solid design; 11" and 7" ladder design.

P4286521 Self-locking cable tie package.

Screw-On Cable Tie Package

Screw-on cable ties have a built in grommet for screw or bolt attachment to firewall, fenderwall, etc. Screws and bolts not included. Sold five per package. 12-1/2" length.

P4286522 Screw-on cable tie package.

Convolute Tubing Packages

Here's the best way to protect loose wires, cables and vacuum hoses. Convolute tubing is specially designed armor for protection against heat and corrosive substances. Made of black polyurethane that's ribbed for curving in tight areas and slit for easy installation over existing wiring harnesses. Keeps wires out of the way and makes a very neat underhood appearance. Each package includes 25 feet of material which can be cut to length. Select from four popular diameters.

- P4286576* 1/4" convolute tubing.
- P4286577 7/16" convolute tubing.
- P4286578* 5/8" convolute tubing.
- P4286579 1" convolute tubing.

* Package includes 24 retaining clips.

ENGINE SPECIFICATIONS

Before you run any engine test (track or shop), you should know and have written down the following information:

Camshaft Centerline _____
Valve Spring Installed Height: _____
Valve-to-Piston Clearance: _____
Intake _____ Exhaust _____
Total Spark Advance _____
TDC on Damper Checked _____

Optional items to this list are cylinder head cc's and deck height. This information should be based on actual measurements and written down as the actual number, not "stock."

At the Track

When taking the vehicle to the race track, the "trick" is for the driver-mechanic to get the most out of the package that he is testing. You learn nothing if something is wrong with one or several of the parts.

Once the vehicle is at the track and unloaded, warm up the engine. Check all the fluids. Check engine for leaks. Be sure all the gauges work. If it is a new engine, break it in easy—don't hurry. Fill the gas tank and check plug wires. Be sure that the vehicle goes straight—tire pressures equal, etc. Always use helmets and seatbelts during test.

BASIC TUNE-UP AND TROUBLESHOOTING

Basic Tuning

1. Test battery specific gravity; add water if necessary. Clean and tighten battery connections.
2. Test cranking amperage draw. See *Starting Motor Cranking Amperage Draw*, 'Electrical System' section of the service manual.
3. Tighten intake and exhaust manifold bolts in proper sequence to specification.
4. Perform cylinder compression test:
 - a. Warm up engine, if possible, to normal operating temperature. If not possible, perform cold.
 - b. Remove all spark plugs from engine. As spark plugs are being removed, check electrodes for abnormal firing indicators—fouled, hot, oil, etc. Record cylinder number of problem spark plug for future reference.
 - c. Disconnect coil wire from distributor and secure to good ground to prevent a spark from starting a fire.
 - d. If equipped with a carburetor, be sure choke and throttle blades are fully open during the compression check.
 - e. Insert compression gauge adapter into the No. 1 spark plug hole in cylinder head. Crank engine until maximum pressure is reached on gauge. Record this pressure as No. 1 cylinder pressure.
 - f. Repeat step e for all remaining cylinders.
 - g. Compression should not vary much from cylinder to cylinder. Refer to engine specifications.

The recommended compression pressures are to be used only as a guide when diagnosing engine problems. An engine should not be disassembled to determine the cause of low compression unless some malfunction is present.
5. Clean or replace spark plugs as necessary and adjust gap as specified. Tighten to specifications.
6. Test resistance of spark plug cables. Refer to 'Electrical System' section of your service manual for procedure.
7. Inspect the primary ignition wire and vacuum advance operation (if equipped). Test coil output voltage, primary and secondary resistance. Replace parts as necessary. Refer to 'Ignition System' section of your service manual for procedure and make necessary adjustment.

8. Reset ignition timing with vacuum advance line disconnected. Ignition timing should be set to specifications. Performance applications should set total spark advance with vacuum disconnected.
9. Set carburetor idle mixture adjustment (if equipped). Adjust throttle stop screw to specifications. Bigger camshafts require more idle fuel. Bigger jets may be required.
10. Test fuel pump for pressure and vacuum.
11. Air filter element should be replaced as specified in 'Lubrication and Maintenance' section of your service manual. Replace more often when vehicle is driven in dusty or sandy areas.
12. Inspect crankcase ventilation system as outlined in 'Lubrication and Maintenance' section of your service manual.
13. Inspect and adjust accessory drive belts.
14. Road test vehicle as a final test.

Basic Troubleshooting

The first step in troubleshooting is to define your problem. What does it do, when does it do it, etc? If it comes and goes or if it changes, then it can be very difficult to solve. Surprisingly, many of these apparently tough problems are solved by simply going back to the basics. We'll stick to the basics because of our space limitations and let the "pros" who have on-the-scene access to the vehicle work on the others.

If a loss of performance is noticed while running the engine, ignition timing should be checked. If ignition timing is retarded about 16°, camshaft and accessory shaft timing with the crankshaft should be checked. The timing chain may have "jumped" a tooth. This is a nice way of saying *check the camshaft centerline!*

We'd also suggest, at this point, to check TDC using the Mopar Performance Parts positive stop TDC indicator tool (P4349737) and compare with the marks on the damper being used.

Check fuel delivery system (electric pumps, etc.). Check the carburetor for wide open throttle and other functions along with vacuum leaks from hoses in the area. Also check plug wires and wire ends.

Next, run through the steps of the basic tune-up and compare readings to initial ones. If you have no initial readings, it is much more difficult to find a problem easily. You may want the engine leak tested to get better data.

PERFORMANCE TROUBLESHOOTING

Unlike basic troubleshooting, in performance troubleshooting there really isn't anything "wrong." The engine just isn't running as fast as it should be. Obviously, if there is something wrong, it will make the vehicle go slow. But this is performance troubleshooting. We are only going to concern ourselves in this short discussion with the problems of using the wrong parts, using the right parts in the wrong applications, or mixing the right parts for one application with the right parts from a different application and ending up with the wrong package. To illustrate this last point, assume that you install a high lift hydraulic camshaft in your standard production engine and use the stock valve springs. It isn't going to work proper!—no spring load, spring likely to go solid, break, etc. There's nothing wrong with the camshaft or the springs, they just aren't going to work together.

In performance troubleshooting, the first step in finding any problem is to read as much about it as you can so that you better know what to expect. Note that defining your problem isn't the first step.

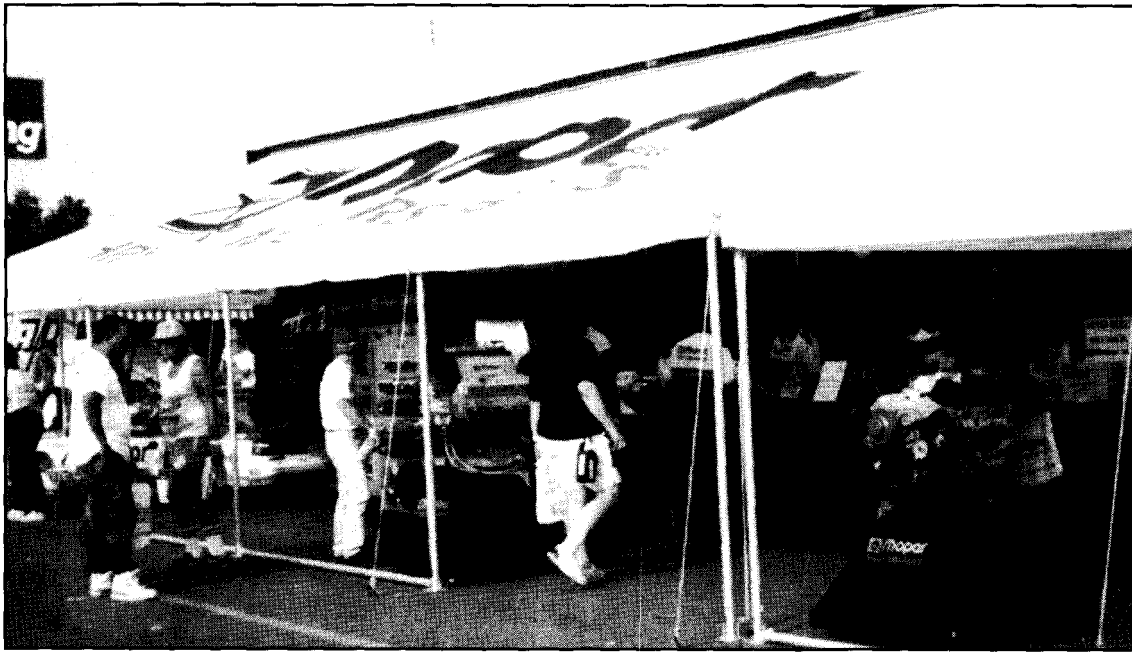
Refer to 'Camshaft and Valve Gear' section of this chapter for camshaft and valve gear performance tips. These tips are particularly good for finding which spring to use with various camshafts, and which camshaft to use for various applications. For many years Mopar Performance Parts has put together parts packages for racing at various performance levels. These packages appear in Chapter 8, *Off-Road and Racing*. All the parts needed to achieve each level are listed by part number as they apply.

Unfortunately, not all racers seem able to reach the performance level listed when they use the parts. Then, of course, the vehicle, engine, or Mopar Performance Parts is blamed. Troubleshooting race vehicles can be very difficult and, in many cases, an expert is required on the spot. Who's the "expert" going to be? Well, if you want to solve your problem without spending a lot of money and in a reasonable amount of time, you'll use this book.

YEAR-END CHECKS

At the end of the race year there are several things that you should check. Some items can change and should be checked on all engines, while other items don't really change but need to be known exactly. Any of the following items that you don't know specifically, be sure to find out before you put the race vehicle into storage.

The list is as follows: exact TDC, total timing as run (no vacuum), as-installed camshaft centerline, finish line rpm as-raced, electric fuel pump delivery rate, as-raced battery voltage, torque converter stall speed, weight distribution. Each one should be recorded on your engine/vehicle log sheet for future reference.



TDC Check

As you approach the end of the racing season, you hopefully have a completed, running engine. It may have been running for one year or carried over for the last year or two. In any case, you'll be putting it away shortly. Since the engine is probably running well, you wouldn't likely check much on the engine. However, because it is running correctly, this is the best time to check things out.

One of the things to check is the TDC mark. This is particularly critical if the damper has been off the engine or replaced. Most people don't check TDC on a race-ready engine because the cylinder head is on. Mopar Performance Parts positive stop TDC indicator tool (P4349737) is designed to check TDC with the head in place. Although using a degree wheel is best, we'll just use masking tape because it's simple and cheap.

Install masking tape (about one inch wide) on the damper with at least three inches of tape on either side of the timing mark. Remove all the spark plugs and install the positive stop TDC indicator tool in the No. 1 spark plug hole with the piston near the bottom. Rotate the engine clockwise and gently bring the piston up against the stop. On the masking tape, place a mark directly opposite the "0" on the timing tab. Then rotate the engine counterclockwise and repeat the procedure by placing a second mark on the tape. Measure the distance from the timing mark on the damper to each mark on the masking tape. The two distances should be exactly the same. If not, re-mark the damper as required and use timing tape (P4529070) to line up with the new mark.

Leak Checking

At the end of the race season, it's a good idea to check the overall condition of the engine. This is best done using a leak checking gauge. If the engine was leak tested when it was built, or last year during the racing season, then the new numbers can be compared to the old ones for added information. Always use the same leak tester. You can be fooled by switching gauges.

Leak checking is a valuable tool that can reveal a great deal about engine condition, but it doesn't provide all the answers. To leak test your engine, you'll need a source of 90-100 psi compressed air, a couple of hoses and a leak tester. **All** the spark plugs should be removed from the engine. Starting with the No. 1 cylinder, the piston is brought to TDC on the compression stroke so that both valves are closed. The spark plug fitting is screwed into the plug hole and sealed. A quick disconnect fitting is usually used to connect the plug fitting to the leak tester. Then compressed air is connected to the tester and the gauge zeroed to give an accurate reading. Then the cylinder fitting is connected and the gauge will read the percent of cylinder leakage.

With everything still connected, any severe leakage can be pinpointed by removing the radiator cap, air cleaner, and crankcase oil filler cap.

1. Air escaping through the carburetor or throttle body indicates a poorly seated or bent intake valve.
2. Air escaping through the tail pipe or headers indicates a bad, bent, or burned exhaust valve.
3. Air bubbling into the radiator indicates a leaking or blown head gasket.
4. Air escaping through the oil filler pipe indicates bad piston rings.

Where it is convenient, the exhaust and intake manifolds may be removed and the ports taped over with masking tape to give a better reading on where the air is escaping.

Blow-By

Blow-by is a loss of compression pressure and the resulting increase in oil consumption and smoking. This is very bad and should be minimized. It is a good indication that there is room for improvement in the engine's output and power. Portable blow-by meters are available.

STORAGE

In Storage

At the end of the racing season, it's time to consider putting the engine away. This usually amounts to five or six months of storage. This length of storage should not be taken lightly, relative to a precision racing engine. Since the engine is built and maintained with care, it should be stored with care.

To this end, there are several steps that we'd recommend. First, remove all the plugs and add a teaspoon of oil to each cylinder through the plug hole. Then rotate the engine with the starter and reinstall the plugs. Drain the water from the radiator and the block. Disconnect both leads from the battery (it should be charged once a month during its storage). Drain the gas out of the carburetor/throttle body (if equipped) and the fuel tank. Next, cover the carburetor/throttle body and the collector exits (options). If the engine has a .550" lift or higher camshaft, then the rocker arms or rocker arm and shaft assemblies should be removed and stored separately. This allows all the springs to sit on the valve seat (closed position) instead of several being open and possibly losing spring load. It also allows all the valves to be closed, which helps keep moisture (condensation) out of the cylinders. Finally, store the engine (vehicle) in a warm and dry area that is maintained at room temperature. Second choice would be an area that is heated and kept above 45 degrees (approx.). In colder areas you might consider storing the vehicle on top of plywood sheets instead of directly above a concrete floor. You can also place a large sheet of Styrofoam insulation on the floor (below the engine, transmission, and axle areas).

Out of Storage

When bringing your race vehicle/race engine out of storage in preparation for the racing season, it is time to consider rebuilding the engine, reworking the chassis to install bigger tires, improving weight distribution, and other performance changes. These are basically major projects. There are many minor items that are often overlooked. Even though they may be "minor" relative to rebuilding the vehicle or engine, their negative effects on performance can be very high!

We'll assume that the engine has been in storage for 4 or 5 months and is being readied for the upcoming race season without being rebuilt. It's also assumed that the engine will be raced consistently once the season starts. In this case, the major thing to check is the bearings – both rods and mains. You should also leak test the engine to make sure that one of the rings didn't "stick" during the winter. The next item is to replace the distributor cap and rotor. Chances are they ran all last year without being replaced. It's also a good idea to replace the oil filter after winter storage. It can be done before start-up or after start-up when the oil is changed, but before it's taken to the track. **Also**, check all the rubber hoses for cracks or hardness (loss of flexibility). Finally, check the spark plug wires, especially the ends. Plug wires get dirty or corroded, insulation gets cracked and the ends get torn up. If there's any question, replace the wire. It'll only cause trouble later on that you may not be able to diagnose properly in the heat of battle.

Engine Restarting

The lubrication system should be checked to ensure that it is supplying pressure to the bearings before any attempt is made to start the engine. If the engine is run, even for a few seconds, without oil pressure, there will be extensive damage done to the engine.

After installing a mechanical oil pressure gauge, all the spark plugs should be removed in order to relieve the compression in the cylinders and to prevent the engine from starting. The engine should be turned over with the starter motor until the oil pressure gauge shows a reading of at least 6 psi.

Once you have determined that the engine does have oil pressure, the spark plugs may be reinstalled and the engine may be started. When the engine starts, the gauge should show a minimum reading of 13 psi at curb idle (600 rpm), and 37-75 psi at 1,600+ rpm.

1989, 4.0L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the 1989 *Jeep Cherokee Service Manual*.

Camshaft		
Tappet Clearance	Zero Lash (Hydraulic tappets)	
End Play.	Zero (engine operating)	
Bearing Clearance	0.025-0.076 mm	0.001-0.003 in.
Bearing Journal Diameter		
No. 1	51.54-51.56 mm	2.029-2.030 in.
No. 2	51.28-51.31 mm	2.019-2.020 in.
No. 3	51.03-51.05mm	2.009-2.010 in.
No. 4	50.78-50.80 mm	1.999-2.000 in.
Base Circle Runout	0.03 mm (max)	0.001 in. (max)
Cam Lobe Lift.	6.43 mm	0.253 in.
Valve Lift.	10.76 mm	0.424 in.
Intake Valve Timing		
Opens	15° BTDC	
Closes	75° ABDC	
Exhaust Valve Timing		
Opens	59° BBDC	
Closes	31° ATDC	
Valve Overlap	46°	
Intake Duration	270°	
Exhaust Duration	270°	
Crankshaft		
End Play.	0.038-0.165 mm	0.0015-0.0065 in.
Main Bearing Journal Diameter	63.489-63.502 mm	2.4996-2.5001 in.
Main Bearing Journal Width		
No. 1	27.58-27.89 mm	1.086-1.098 in.
No. 3	32.28-32.33 mm	1.271-1.273 in.
No. 2-4-5-6-7	30.02-30.18 mm	1.182-1.188 in.
Main Bearing Clearance	0.03-0.06 mm (0.051 mm preferred)	0.001-0.0025 in. (0.002 in. preferred)
Connecting Rod Journal Diameter	53.17-53.23 mm	2.0934-2.0955 in.
Connecting Rod Journal Width	27.18-27.33 mm	1.070-1.076 in.
Maximum Out-of-Round (All Journals)	0.013 mm	0.0005 in.
Maximum Taper (All Journals)	0.013 mm	0.0005 in.

Cylinder Block		
Deck Height.	239.49-239.64 mm	9.429-9.435 in.
Deck Clearance.	0.546 mm (below block)	0.0215 in. (below block)
Cylinder Bore Diameter (standard)	98.42-98.48 mm	3.8751-3.8775 in.
Maximum Taper.	0.025 mm	0.001 in.
Maximum Out-of-Round	0.025 mm	0.001 in.
Tappet Bore Diameter.	23.000-23.025 mm	0.9055-0.9065 in.
Cylinder Block Flatness	0.03/25-0.05/152 mm (0.20 mm max)	0.001/1-0.002/6 in. (0.008 in. max)
Connecting Rods		
Total Weight (less bearings)		657-665 grams
Total Length (rener-to-center)	155.52-155.62 mm	6.123-6.127 in.
Piston Pin Bore Diameter.	23.59-23.62 mm	0.9288-0.9298 in.
Connecting Rod Bore (less bearings)	56.09-56.08 mm	2.2085-2.2080 in.
Bearing Clearance	0.03-0.08 mm (0.044-.05 mm preferred)	0.001-0.003 in. (0.0015-0.002 in. preferred)
Side Clearance	0.25-0.48 mm	0.010-0.019 in.
Maximum Twist	0.025 mm per 25.4 mm	0.001 in. per inch
Maximum Bend	0.0127 mm per 25.4 mm	0.0005 in. per inch
Cylinder Head		
Combustion Chamber Volume		64.45-67.45cc
Valve Arrangement		EI-IE-IE-EI-EI-IE
Valve Guide ID (Integral)	7.9 mm	.312 in.
Valve Stem-to-Guide Clearance	0.03-0.08 mm	0.001-0.003 in.
Intake Valve Seat Angle.		44.5'
Exhaust Valve Seat Angle.		44.5"
Valve Seat Width	1.02-1.52 mm	0.040-0.060 in.
Valve Seat Runout.	0.064 mm	0.0025 in.
Cylinder Head Flatness	0.03/25-0.05/152 mm (0.20 mm max)	0.001/1-0.002/6 in. (0.008 in. max)
Oil Pressure		
At Idle Speed (600 rpm)	13 psi	89.6 kPa
At 1600+ rpm	37-75 psi	255.1-517.1 kPa
Oil Pressure Relief.	75 psi	517.1 kPa

Oil Pump		
Gear-to-Body Clearance (Radial)	0.051-0.102 (0.051 mm preferred)	0.002-0.004 in. (0.002 in. preferred)
Gear End Clearance, Plastigage	0.051-0.152 (0.051 mm preferred)	0.002-0.006 in. (0.002 in. preferred)
Gear End Clearance Feeler Gauge.	0.1016-0.2032 mm (0.1778 preferred)	0.004-0.008 in. (0.007 in. preferred)
Pistons		
Weight (less pin)	510-514 grams	
Piston Pin Bore Centerline-to-Piston Top	41.94-42.04 mm	1.651-1.655 in.
Piston-to-Bore Clearance	0.023-0.043 mm (0.030-0.033 mm preferred)	0.0009-0.0017 in. (0.0012-0.0013 in. preferred)
Piston Ring Gap Clearance — Compression (both)	0.25-0.51 mm	0.010-0.020 in.
Piston Ring Gap Clearance — Oil Control Steel Rails	0.25-0.64 mm	0.010-0.025 in.
Piston Ring Side Clearance — No. 1 Compression.	0.043-0.081 mm (0.043 mm preferred)	0.0017-0.0032 in. (0.0017 in. preferred)
No. 2 Compression	0.043-0.081 mm (0.043 mm preferred)	0.0017-0.0032 in. (0.0017 in. preferred)
Oil Control	0.03-0.20 mm (0.08 mm preferred)	0.001-0.008 in. (0.003 in. preferred)
Piston Ring Groove Height Compression (both)	2.019-2.045 mm	0.0795-0.0805 in.
Oil Control	4.78-4.80 mm	0.188-0.1895 in.
Piston Ring Groove Diameter No. 1 and No. 2.	88.30-88.55 mm	3.476-3.486 in.
Oil Control	90.35-90.60 mm	3.557-3.566 in.
Piston Pin Bore Diameter.	23.642-23.655 mm	0.9308-0.9313 in.
Piston Pin Diameter	23.632-23.645 mm	0.9304-0.9309 in.
Piston-to-Pin Clearance	0.008-0.013 mm loose (0.013 mm preferred)	0.0003-0.0005 in. loose (0.0005 in. preferred)
Piston-to-Pin Connecting Rod	8.9kN press-fit	2000 lbf press-fit

Rocker Arms, Push Rods and Tappets		
Rocker Arm Ratio		1.6:1
Push Rod Length.	244.856-245.364mm	9.640-9.660 in.
Push Rod Diameter	7.92-8.00mm	0.312-0.315 in.
Hydraulic Tappet Diameter	22.962-22.974mm	0.904-0.9045in.
Tappet-to-Bore Clearance	0.03-0.05 mm	0.001-0.0025 in.
Valves		
Valve Length (Tip-to-Gauge Dim. Line)		
(Intake)	122.4-122.8mm	4.822-4.837in.
(Exhaust)	122.8-123.2mm	4.837-4.852in.
Valve Stem Diameter	7.9 mm	3.12 in.
Stem-to-Guide Clearance	0.03-0.08 mm	0.001-0.003 in.
Intake Valve Head Diameter.	48.5 mm	1.91 in.
Intake Valve Face Angle		45°
Exhaust Valve Head Diameter	38 mm	1.50 in.
Exhaust Valve Face Angle		45°
Maximum Allowable Removed far Tip Refinishing	0.25 mm	0.010 in.
Valve Springs		
Free Length	46.22 mm approx.	1.82 in. approx.
Spring Tension		
Valve Closed	293-329 N at 41.2	66-74 lbf at 1.625
Valve Open	911-978 N at 30.4	205-220 lbf at 1.200
Inside Diameter	24.08-24.59 mm	0.948-0.968in.

1989, 4.0L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1989 Jeep Cherokee Service Manual*.

Component	Torque	
A/C Compressor Bracket-to-Engine Bolts	34 N•m	(25ft-lbs)
A/C Low Pressure Service Valve Nut	38 N•m	(28 ft-lbs)
Alternator Adjusting Bolt	24 N•m	(18ft-lbs)
Alternator Pivot Bolt/Nut	38 N•m	(28ft-lbs)
Camshaft Sprocket Bolt	108 N•m	(80ft-lbs)
Connecting Rod Bolt Nuts	45 N•m	(33ft-lbs)
Crankshaft Main Bearing Bolts	108 N•m	(80ft-lbs)
Crankshaft Pulley-to-Damper Nut	27 N•m	(20ft-lbs)
Cylinder Head Bolts (#1-10 & #12-14)	149 N•m	(110 ft-lbs)
(#11)	135 N m	(100ft-lbs)
Cylinder Head Cover Bolts	6 N•m	(55 in-lbs)
Exhaust Manifold-to-Downpipe Nuts	27 N•m	(20ft-lbs)
Flywheel/Converter Housing Bolts	38 N•m	(28ft-lbs)
Fuel Pump Bolts	22 N•m	(16ft-lbs)
Oil Pan Bolts - 1/4-20	9 N•m	(7ft-lbs)
- 5/16-18	15 N•m	(11 ft-lbs)
Oil Pan Drain Plug	41 N•m	(30ft-lbs)
Oil Pump Attaching Bolts (Short)	14 N•m	(10ft-lbs)
Oil Pump Attaching Bolts (Long)	23 N•m	(17 ft-lbs)
Oil Pan Cover Bolts	8 N•m	(70in-lbs)
Power Steering Pump Pressure Hose Nut	52 N•m	(38ft-lbs)
Rocker Arm Assembly-to-Cylinder Head	26 N•m	(19ft-lbs)
Spark Plugs	38 N m	(28ft-lbs)
Starting Motor-to-Cylinder Block Bolts	45 N•m	(33ft-lbs)
Timing Case Cover-to-Block Bolts	7 N•m	(62 in-lbs)
Vibration Damper Bolt (Lubricated)	108 N•m	(80ft-lbs)

1999, 4.0L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the 1999 *Jeep Cherokee Service Manual*.

Engine Description		Camshaft	
Engine Type	In-line 6 Cylinder	Main Bearing Journal	
Bore and Stroke	98.4x 86.69 mm (3.88x 3.413 in.)	Width No. 1	27.58to 27.89 mm (1.086to 1.098in.)
Displacement	4.0L (242cu. in.)	Main Bearing Journal	
Compression Ratio	8.8:1	Width No. 3	32.28to 32.33 mm (1.271to 1.273 in.)
Firing Order	1-5-3-6-2-4	Main Bearing Journal	
Lubrication	Pressure Feed-Full Flow Filtration	Width No. 2-4-5-6-7.	30.02 to 30.18 mm (1.182to 1.188in.)
Cooling System	Liquid Cooled-Forced Circulation	Main Bearing Clearance	0.03to 0.06 mm (0.001to 0.0025in.)
Cylinder Block	Cast Iron	Main Bearing Clearance (Preferred)	0.051 mm (0.002in.)
Crankshaft	Cast Nodular Iron	Connecting Rod Journal	
Cylinder Head	Cast Iron	Diameter.	53.17 to 53.23 mm (2.0934to 2.0955 in.)
Camshaft	Cast Iron	Connecting Rod Journal	
Pistons	Aluminum Alloy	Width	27.18to 27.33 mm (1.070to 1.076in.)
Combustion Chamber	Dual-Quench	Out-of-Round (Max. All Journals)	0.013mm (0.0005in.)
Connecting Rods	Cast Malleable Iron	Taper (Max. -All Journals)	0.013mm (0.0005in.)
Engine Specifications		Cylinder Block	
Camshaft		Deck Height	
Hydraulic Tappet Clearance		Zero Lash	
Bearing Clearance		240.03 to 240.18 mm (9.450to 9.456in.)	
0.025 to 0.076 mm (0.001to 0.003 in.)		Deck Clearance (Below Block)	
		0.546mm (0.0215in.)	
Bearing Journal Diameter		Cylinder Bore Diameter—	
No. 1		Standard.	
51.54 to 51.56 mm (2.029to 2.030 in.)		98.45to 98.48 mm (3.8759to 3.8775 in.)	
No. 2		Cylinder Bore Diameter—	
51.28to 51.31 mm (2.019to 2.020in.)		Taper (Max.)	
No. 3		0.025mm (0.001in.)	
51.03to 51.05 mm (2.009to 2.010 in.)		Cylinder Bore Diameter—	
No. 4		Out-of-Round	
50.78to 50.80mm (1.999to 2.000 in.)		0.025 mm (0.001in.)	
Base Circle Runout		Tappet Bore Diameter	
0.03mm - max. (0.001in. - max.)		23.000 to 23.025 mm (0.9055to 0.9065 in.)	
Valve Lift		Flatness	
10.29 mm (0.405in.)		0.03mm per 25 mm (0.001in. per 1 in.)	
Intake Valve Timing		Flatness	
Opens		0.05mm per 152 mm (0.002in. per 6 in.)	
12.4° BTDC		Flatness Max.	
Closes		0.20mm max. for total length (0.008in. max. for total length)	
60.9° ABDC		Main Bearing Bore	
Exhaust Valve Timing		Diameter	
Opens		68.3514to 68.3768 mm (2.691to 2.692in.)	
49.8 BBDC		Connecting Rods	
Closes.		Total Weight (Less Bearing)	
29.2° ATDC		657 to 665 grams (23.17to 23.45oz.)	
Valve Overlap		Length (Center-to-Center)	
41.6°		155.52to 155.62mm (6.123to 6.127in.)	
Intake Duration			
253.3°			
Exhaust Duration			
259.°			
Crankshaft			
End Play			
0.038 to 0.165 mm (0.0015to 0.0065 in.)			
Main Bearing Journal			
Diameter No. 1-6			
63.489to 63.502 mm (2.4996to 2.5001 in.)			
Main Bearing Journal			
Diameter No. 7			
63.449 to 63.487mm (2.498to 2.4995in.)			

Camshaft

Piston Pin Bore Diameter 23.59to 23.62mm
 (0.9288to 0.9298in.)
 Bore (Less Bearings) 56.08to 56.09mm
 (2.2080to 2.2085in.)
 Bearing Clearance 0.025 to 0.076mm
 (0.001to 0.003in.)
 Bearing Clearance
 (Preferred) 0.044to **0.050** mm
 (0.0015to 0.0020in.)
 Side Clearance 0.25to 0.48mm
 (0.010to 0.019in.)
 Twist (Max.) 0.001mm per mm
 (0.001in. per inch)
 Bend (Max.) 0.001mm per mm
 (0.001in. per inch.)

Cylinder Compression Pressure

Ratio 8.8:1
 Pressure Range 827 to 1,034kPa
 (120to 150 psi)
 Max. Variation Between Cylinders 206 kPa
 (30psi)

Cylinder Head

Combustion Chamber 52.22to 58.22cc
 (3.37to 3.55cu. in.)
 Valve Guide I.D. (Integral) 7.95to 7.97mm
 (0.313to 0.314in.)
 Valve Stem-to-Guide
 Clearance 0.025to 0.076mm
 (0.001to **0.003** in.)
 Intake Valve Seat Angle 44.5"
 Exhaust Valve Seat Angle 44.5°
 Valve Seat Width 1.02to 1.52mm
 (0.040to 0.060in.)
 Valve Seat Runout 0.064mm (0.0025in.)
 Flatness 0.03mm per 25 mm
 (0.001in. per 1 in.)
 Flatness **0.05** mm per 152mm
 (0.002 in. per 6 in.)
 Flatness Max. 0.20mm max. for total length
 (0.008in. max. for total length)

Rocker Arms, Push Rods & Tappets

Rocker Arm Ratio 1.6:1
 Push Rod Length 244.856to 245.364mm
 (9.640to 9.660in.)
 Push Rod Diameter 7.92to 8.00mm
 (0.312to 0.315in.)
 Hydraulic Tappet Diameter 22.962to 22.974mm
 (0.904to 0.9045in.)
 Tappet-to-Bore Clearance 0.025 to **0.063** mm
 (0.001to 0.0025 in.)

Valves

Length (Tip-to-Gauge Dimension Line)
 Intake 122.479to 122.860mm
 (4.822to 4.837in.)

Length (Tip-to-Gauge Dimension Line)
 Exhaust 122.860to 123.241mm
 (4.837to 4.852in.)
 Valve Stem Diameter 7.899to 7.925mm
 (0.311to 0.312in.)
 Stem-to-Guide Clearance 0.025to 0.076mm
 (0.001to 0.003in.)
 Valve Head Diameter—
 Intake 48.387to 48.641mm
 (1.905to 1.915in.)
 Valve Head Diameter—
 Exhaust 37.973to 38.227mm
 (1.495to 1.505in.)
 Valve Face Angle—Intake 45"
 Valve Face Angle—Exhaust 45"
 Tip Refinishing (Max. Allowable) 0.25mm
 (0.010in.)

Valve Springs

Free Length (Approx.) 47.65mm (1.876in.)
 Spring Tension—
 Valve Closed 316 to 351 N @ 41.656mm
 (71to 79 lbf. @ 1.64in.)
 Spring Tension—
 Valve Open 898.6to 969.7N 30.89mm
 (202to 218 lbf @ 1.216in.)
 Inside Diameter 21.0mm to 21.51 mm
 (0.827to 0.847in.)

Pistons

Weight (Less Pin) 417 to 429 grams
 (14.7to 15.1oz.)
 Piston Pin Bore
 (Centerline to Piston Top) 40.61to 40.72mm
 (1.599to 1.603in.)
 Piston-to-Bore Clearance 0.018to 0.038mm
 (0.0008to 0.0015in.)
 Ring Gap Clearance—
 Top Compression Ring 0.229to 0.610mm
 (0.009to 0.0240in.)
 Ring Gap Clearance—
 2nd Compression Ring 0.483to 0.965mm
 (0.0190to 0.0380in.)
 Ring Gap Clearance—
 Oil Control Steel Rails 0.254to 1.500mm
 (0.010to 0.060in.)
 Ring Side Clearance—
 Compression Rings 0.042to 0.084mm
 (0.0017to 0.0033in.)
 Flng Side Clearance—
 Oil Control Rings 0.06to 0.21mm
 (0.0024 to 0.0083 in.)
 Piston Ring Groove Height—
 Compression Rings 1.530to 1.555mm
 (0.0602to 0.0612in.)

Piston Ring Groove Height
 Oil Control Ring 4.035 to 4.060 mm
 (0.1589 to 0.1598 in.)

Piston Ring Groove Diameter—
 No.1 Compression Ring 88.39 to 88.65 mm
 (3.48 to 3.49 in.)

Piston Ring Groove Diameter—
 No.2 Compression Ring. 87.63 to 87.88 mm
 (3.45 to 3.46 in.)

Piston Ring Groove Diameter—
 Oil Control Ring 89.66 to 89.92 mm
 (3.53 to 3.54 in.)

Piston Pin Bore Diameter . . . 23.650 to 23.658 mm
 (0.9312 to 0.9315 in.)

Piston Pin Diameter 23.637 to 23.640 mm
 (0.9306 to 0.9307 in.)

Piston-to-Pin Clearance 0.0102 to 0.0208 mm
 (0.0005 to 0.0009 in.)

Piston-to-Pin Connecting Rod
 (Press Fit). 8.9 kN (2000 lbf.)

Oil Pump

Gear-to-Body Clearance
 (Radial) 0.051 to 0.102 mm
 (0.002 to 0.004 in.)

Gear-to-Body Clearance
 (Radial) (Preferred) 0.051 mm (0.002 in.)

Gear End Clearance—
 Plastigage 0.051 to 0.152 mm
 (0.002 to 0.006 in.)

Gear End Clearance—
 Plastigage (Preferred) 0.051 mm (0.002 in.)

Gear End Clearance—
 Feeler Gauge 0.1016 to 0.2032 mm
 (0.004 to 0.008 in.)

Gear End Clearance—
 Feeler Gauge (Preferred) . . . 0.1778 mm (0.007 in.)

Oil Pressure
 At Idle Speed (600 rpm) 89.6 kPa (13 psi)
 At 1600 rpm & Higher 255 to 517 kPa
 (37 to 75 psi)
 Oil Pressure Relief 517 kPa (75 psi)



1999, 4.0L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1999 Jeep Cherokee Service Manual*.

TORQUE SPECIFICATIONS	
DESCRIPTION	TORQUE
A/C Compressor Bracket-to-Engine	
Bolts	34 N·m (25 ft. lbs.)
A/C Compressor	
Mounting Bolts	27 N·m (20 R. lbs.)
AIC Low Pressure Service Valve	
Nut	38 N·m (28 R. lbs.)
Block Heater	
Nut	2 N·m (16 in. lbs.)
Camshaft Sprocket	
Bolt	68 N·m (50 R. lbs.)
Camshaft Thrust Plate to Cylinder Block	
Screws	24 N·m (18 R. lbs.)
Clutch Cover to Flywheel	
Bolts	54 N·m (40 R. lbs.)
Coil Bracket to Block	
Bolts	22 N·m (192 in. lbs.)
Connecting Rod	
Nuts	45 N·m (33 R. lbs.)
Cylinder Block	
Drain Plugs	34 N·m (25 R. lbs.)
Cylinder Head	
Bolts	135 N·m (100 R. lbs.)
Cylinder Head Cover	
Bolts	10 N·m (85 in. lbs.)
Distributor Clamp	
Bolt	23 N·m (204 in. lbs.)
Engine Mounts—Front	
Support Bracket Bolts	61 N·m (45 R. lbs.)
Support Cushion Bolts/Nuts ..	41 N·m (30 R. lbs.)
Support Cushion Bracket Bolts ..	54 N·m (40 R. lbs.)
Support Cushion Bracket Stud Nuts ..	41 N·m (30 R. lbs.)
Support Cushion Thru-Bolt ...	65 N·m (48 ft. lbs.)
Engine Mounts—Rear	
Crossmember-to-Sill Bolts (Automatic) ...	41 N·m (30 R. lbs.)
Insulator Stud Assembly Nut ..	41 N·m (30 ft. lbs.)
Support Cushion/Crossmember Nuts ..	22 N·m (192 in. lbs.)
Support Cushion/Bracket Nuts (Manual) ..	75 N·m (55 R. lbs.)
Transmission Support Bracket Bolt (Manual)	46 N·m (34 R. lbs.)
Transmission Support Bracket/Cushion Bolt (4WD Auto)	75 N·m (55 R. lbs.)
Transmission Support Adaptor Bracket Bolts (2WD Auto)	75 N·m (55 R. lbs.)
Exhaust Manifold/Pipe	
Nuts	27 N·m (20 ft. lbs.)
Flywheel to Converter Housing	
Bolts	38 N·m (28 R. lbs.)
Flywheel to Crankshaft	
Bolts	143 N·m (105 R. lbs.)
Front Cover-to-Block	
Bolts 1/4–20	7 N·m (60 in. lbs.)
Bolts 5/16–18	22 N·m (192 in. lbs.)
Fuel Rail	
Bolts/Stud	12 N·m (108 in. lbs.)
Generator	
Fixed Bolt	24 N·m (18 ft. lbs.)
Thru Bolt/Nut	38 N·m (28 R. lbs.)
Main Bearing Cap	
Bolts	108 N·m (80 R. lbs.)
Main Bearing Brace	
Nuts	47 N·m (35 R. lbs.)
Oil Filter	
Filter	18 N·m (156 in. lbs.)
Connector (to adaptor)	47 N·m (35 R. lbs.)
Connector (to block)	68 N·m (50 ft. lbs.)
Adaptor Bolts	102 N·m (50 R. lbs.)
Oil Galley	
Plug	41 N·m (30 R. lbs.)
Oil Pan	
1/4–20 Bolts	9.5 N·m (84 in. lbs.)
5/16–18 Bolts	15 N·m (132 in. lbs.)
Drain Plug	34 N·m (25 ft. lbs.)
Oil Pump	
Short Attaching Bolts	23 N·m (204 in. lbs.)
Long Attaching Bolts	23 N·m (204 in. lbs.)
Cover Bolts	8 N·m (70 in. lbs.)
Power Steering Pump Pressure Hose	
Nut	52 N·m (38 R. lbs.)
Rocker Arm Assembly-to-Cylinder Head	
Capscrews	30 N·m (21 ft. lbs.)
Spark Plugs	
Plugs	37 N·m (27 R. lbs.)
Starter Motor	
Mounting Bolts	45 N·m (33 R. lbs.)
Thermostat Housing	
Bolts	18 N·m (156 in. lbs.)
Throttle Body	
Bolts	10 N·m (90 in. lbs.)
Vibration Damper	
Bolts	108 N·m (80 R. lbs.)
Water Pump/Block	
Bolts	23 N·m (17 R. lbs.)

Chapter 5

4.2L In-Line 6



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

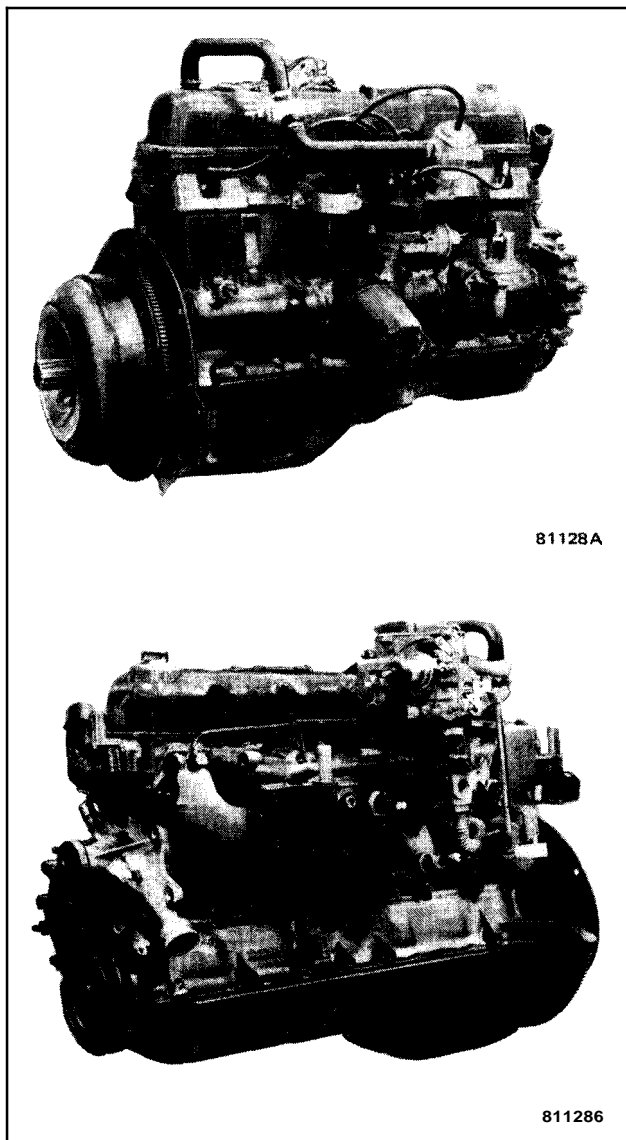
Introduction	283
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Note: Due to the similarity of 4.2L and 4.0L Jeep engines, only those procedures specific to the 4.2L engine will be covered in this chapter. All other 6-cylinder procedures, techniques and modification tips can be found in Chapter 4, *4.0L Power Tech In-line 6*. Therefore, in addition to this chapter, we highly recommend that all 4.2L engine owners read Chapter 4 in its entirety.

For additional 4.2L engine general service information, refer to the proper service manual.

Introduction

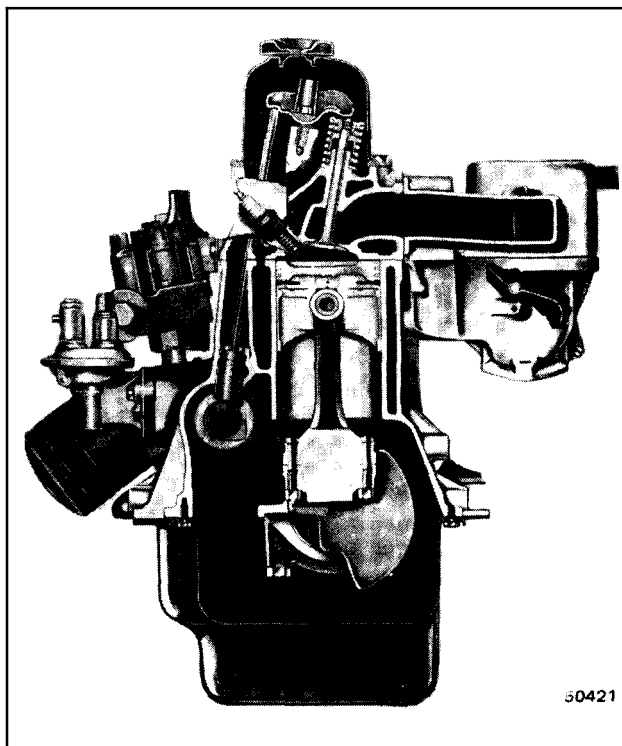
The 4.2L is an In-line 6 cylinder, carbureted engine equipped with a micro-computer controlled Fuel Feedback system. It was produced in 232 and 258 CID versions.



81128A

811286

4.2L Engine Assembly (Typical)



50421

4.2L Engine Assembly (Cut-Away View)

Block

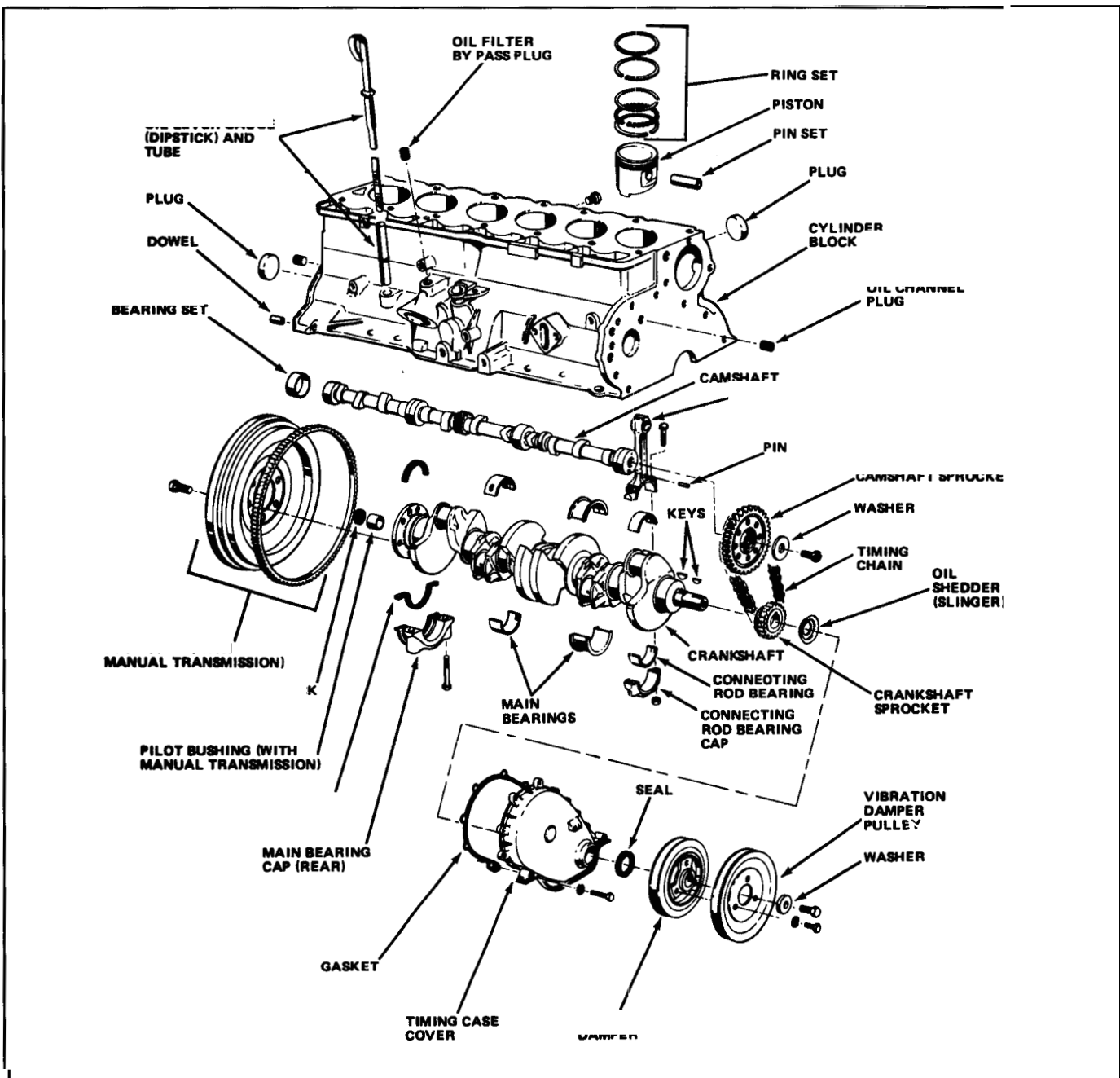
INTRODUCTION

The 4.2L is an In-line 6 cylinder, carbureted engine equipped with a micro-computer controlled Fuel Feedback system. It was produced in 232 and 258 CID versions. (Refer to the specifications that follow.)

The 4.2L engine has a bore and stroke of 95.25 x 98.93 mm (3.88 x 3.44") and incorporates an overhead valve system in

The cylinders are numbered from front to rear with a **firing** order of 1-5-3-6-2-4. The crankshaft rotates in a counterclockwise direction, viewed from the rear of the engine.

Seven two-piece main bearings are used to support the crankshaft. The camshaft is supported by four one-piece line bored bearings.



4.2L Short Block Assembly (Exploded View)

Disassembly

1. Remove the water pump and fuel pump from the cylinder block.
2. Remove the vibration damper.
3. Remove the crankshaft oil seal.
4. Remove the timing case cover.
5. Remove the oil slinger from the crankshaft.
6. Remove the camshaft retaining bolt and remove the sprockets and chain as an assembly.
7. Remove the camshaft.
8. Remove the oil pan, the gaskets, and the seals. Thoroughly clean the pan and engine block gasket surfaces.
9. Remove the oil pump.
10. Remove the connecting rods and the pistons. Remove the connecting rod and piston assemblies through the top of the cylinder bores.

Caution: Be sure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during removal.

11. Remove the crankshaft.

Cylinder Bore Measurement

1. Use a bore gauge to measure each cylinder bore diameter. If a bore gauge is not available, use an inside micrometer.
2. Measure the cylinder bore diameter crosswise to the cylinder block near the top of the bore. Repeat the measurement at the bottom of the bore.
3. Determine the taper by subtracting the smaller diameter from the larger diameter.
4. Rotate the measuring device 120° and repeat steps above. Finally, rotate the device another 120° and repeat the measurements.
5. Determine out-of-roundness by comparing the difference between each 120° measurement.
6. If the cylinder bore taper does not exceed 0.025 mm (0.001") and the out-of-roundness does not exceed 0.025 mm (0.001"), the cylinder bore can be trued by honing. If the cylinder bore taper or out-of-round condition exceeds these maximum limits, the cylinder must be bored and then honed to accept an oversize piston. A slight amount of taper always exists in the cylinder bore after the engine has been in use for a period of time.

Cylinder Bore Resurfacing

Caution: DO NOT use rigid type hones to remove cylinder wall glaze.

1. Use an expanding type hone to true the cylinder bore and to remove the glaze for faster piston ring seating. Move the hone down and up (stroke) at sufficient speed to produce a uniform 60° angle crosshatch pattern on the cylinder walls. DO NOT use more than ten strokes per cylinder (one stroke is one down-and-up movement). Refer to "Block" section of Chapter 4 for more information.
2. Scrub the cylinder bores clean with a solution of hot water and detergent.
3. Immediately apply light engine oil to the cylinder walls. Wipe with a clean, lint-free cloth.

Assembly

1. Install the crankshaft.
2. Install the connecting rods and the pistons through the top of the cylinder bores.

Caution: Be sure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during removal.
3. Install the oil pump.
4. Install the oil pan, gaskets and seals.
5. Install the camshaft.
6. Install the camshaft retaining bolt and install the sprockets and chain as an assembly.
7. Install the oil slinger on the crankshaft.
8. Install the timing case cover.
9. Install the crankshaft oil seal.
10. Install the vibration damper.
11. Install the water pump and fuel pump to the cylinder block.

ENGINE MOUNTS

Resilient rubber cushions support the engine and transmission at three points: at each side on the centerline of the engine and at the rear between the transmission extension housing and the rear support crossmember.

Replacement of a cushion may be accomplished by supporting the weight of the engine or transmission at the area of the cushion.

Crankshaft

CRANKSHAFT

The 4.2L crankshaft has twelve counterweights; the crankshaft is counterweighted and balanced independently. It has seven main bearings and six connecting rod journals.

The crankshaft has a main bearing journal diameter of 63.489-63.502 mm (2.4996-2.5001"), and main bearing journal widths of (No. 1) 27.58-27.89 mm (1.086-1.098"), (No. 2) 32.28-32.33 mm (1.271-1.273"), and (Nos. 3, 4, 5, 6 and 7) 30.02-30.18 mm (1.182-1.188").

The crankshaft has a connecting rod journal diameter of 53.17-53.23 mm (2.0934-2.0955") and a connecting rod journal width of 27.18-27.33 mm (1.070-1.076").

The component parts of the crankshaft assembly are individually balanced; then the complete assembly is balanced as a unit.

Note: On automatic transmission equipped engines, the torque converter and converter flexplate must be marked prior to removal and installed in this position upon assembly.

Service replacement dampers, crankshafts, flywheels, torque converters and clutch components are balanced individually and, therefore, may be replaced as required without rebalancing the complete assembly.

If the crankshaft is damaged to the extent that reconditioning is not feasible, it must be replaced. The engine must be removed from the vehicle for crankshaft replacement.

For more crankshaft specifications, refer to *4.2L Engine Specifications*, 'Engine Assembly' section of this chapter.

CRANKSHAFT MAIN BEARINGS

The main bearings are steel backed, sintered copper, lead alloy precision type.

Each bearing is selectively fit to its respective journal to obtain the desired operating clearance. In production, the select fit is obtained by using various-sized, color-coded bearing inserts.

When required, different sized upper and lower bearing inserts may be used as a pair; therefore, a standard size upper insert is sometimes used in combination with a .001" undersize lower insert.

Service replacement bearing inserts are available as pairs in the following undersizes: standard, .001", .002", .010", and .012". The size is stamped on the back of the inserts.

It may be necessary, in some instances, to use different sized upper and lower inserts to reduce clearance by .0005".

The bearing insert nearest to standard should always be installed in the upper location.

Caution: Never use bearing inserts with greater than .001" difference in size in pairs.

<u>Correct</u>	<u>Incorrect</u>
Upper - Std.	Upper - Std..
Lower - .001" undersize	Lower - .002" undersize

Removal

1. Disconnect the battery negative cable.
2. Remove the spark plugs.
3. Raise the vehicle.
4. Remove the oil pan and oil pump. Refer to *Oil Pump Removal* and *Oil Pan Removal*, 'Oiling System' section of this chapter, for the procedures.
5. Remove the main bearing caps and lower inserts.
6. Remove the lower insert from the bearing cap.
7. Remove the upper insert by loosening (DO NOT remove) all of the other bearing caps and inserting a small cotter pin tool in the crankshaft journal oil hole. Bend the cotter pin as illustrated to fabricate the tool (Figure 2-13). With the cotter pin tool in place, rotate the crankshaft so that the upper bearing insert will rotate in the direction of its locking tab.

Note: Because there is no hole in the No. 3 main journal, use a tongue depressor or similar soft-faced tool to remove the bearing insert. After moving the insert approximately 25 mm (1"), it can be removed by applying pressure under the tab.
8. Using the same procedure just described, remove the remaining bearing inserts (one at a time) for inspection.

Inspection

1. Wipe inserts clean and inspect for abnormal wear patterns and for metal or other foreign material imbedded in the lining. Normal main bearing insert wear patterns are shown in Figure 2-14.
2. If any of the crankshaft journals are scored, remove the engine for crankshaft repair.
3. Inspect the back of the inserts for fractures, scrapings, or irregular wear patterns.
4. Inspect the upper insert locking tabs for damage.
5. Replace all damaged or worn bearing inserts.

Fitting

The main bearing caps, numbered (front to rear) from 1 through 7 have an arrow to indicate the forward position. The upper main bearing inserts are grooved to provide oil channels while the lower inserts are smooth.

Each bearing insert pair is selectively fit to its respective journal to obtain the specified operating clearance. In production, the select fit is obtained by using various-sized color-coded bearing insert pairs. The bearing color code appears on the edge of the insert. The size is not stamped on bearing inserts used for engine production.

The main bearing journal size (diameter) is identified in production by a color-coded paint mark on the adjacent check toward the flanged (rear) end of the crankshaft, except for the rear main journal, which has the mark on the crankshaft near the flange.

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce the clearance by 0.013 mm (0.0005"). Never use a pair of bearing inserts with greater than a 0.025 mm (0.001") difference in size.

Note: When replacing inserts, the odd size inserts must be either all on the top (in cylinder block) or all on the bottom (in main bearing cap).

Main Bearing-to-Journal Clearance—Crankshaft Installed

When using Plastigauge, check only one bearing clearance at a time.

1. Install the grooved main bearings into the cylinder block and the non-grooved bearings into the bearing caps.
2. Install the crankshaft into the upper bearings dry.
3. Place a strip of Plastigauge (P4286819) across the full width of the crankshaft journal to be checked.
4. Install the bearing cap and tighten the bolts to 108N•m (80 ft-lbs) torque.

Note: DO NOT rotate the crankshaft. This will cause the Plastigauge to shift, resulting in an inaccurate reading. Plastigauge must not be permitted to crumble. If it is brittle, obtain fresh stock.

5. Remove the bearing cap. Determine the amount of clearance by measuring the width of the compressed Plastigauge with the scale on the Plastigauge envelope. The correct clearance is 0.0254 to 0.0635 mm (.0010 to .0025") for all main bearing journals, with 0.051 mm (0.002") preferred.
6. Plastigauge should indicate the same clearance across the entire width of the insert. If clearance varies, it may indicate a tapered journal or foreign material trapped behind the insert.
7. If the specified clearance is indicated and there are no abnormal wear patterns, replacement of the bearing inserts is not necessary. Remove the Plastigauge from the crankshaft journal and bearing insert. Proceed to *Crankshaft Main Bearing Installation*.
8. If the clearance exceeds specification, install a pair of 0.025 mm (0.001") undersize bearing inserts and measure the clearance as described in the previous steps.

The clearance indicated with the 0.025 mm (0.001") undersize insert pair installed will determine if this insert size or some other combination will provide the specified clearance.

Example: If the clearance was 0.0762 mm (0.003") originally, a pair of 0.0254 mm (0.001") undersize inserts would reduce the clearance by 0.0254 mm (0.001"). The clearance would then be 0.0508 mm (0.002") and within the specification. A 0.0508 mm (0.002") undersize bearing insert and a 0.0254 mm (0.001") undersize insert would reduce the original clearance an additional 0.0127 mm (0.0005") and the clearance would then be 0.0381 mm (0.0015").

Caution: Never use a pair of inserts that differ more than one bearing size as a pair. For example, DO NOT use a standard size upper insert and a 0.051 mm (0.002") undersize lower insert.

9. If the clearance exceeds the specifications using a pair of 0.051 mm (0.002") undersize bearing inserts, measure the crankshaft journal diameter with a micrometer. If the journal diameter is correct, the crankshaft bore in the cylinder block may be misaligned, which requires cylinder block replacement or machining to true bore.

If the diameter for journals 1 through 6 is less than 63.4517 mm (2.4981") or journal 7 is less than 63.4365 mm (2.4975"), replace the crankshaft or grind it down to accept the appropriate undersize bearing inserts.

Once the proper clearances have been obtained, remove the crankshaft and proceed to *Installation*.



Main Bearing Journal Diameter – Crankshaft Removed

1. Clean the main bearing journal of oil.
2. Determine the maximum diameter of the journal with a micrometer. Measure at two locations 90° apart at each end of the journal.
3. Compare the measured diameter with the journal diameter specification listed in the *Main Bearing Fitting Chart* located in your service manual, and select inserts required to obtain the specified bearing-to-journal clearance.

Installation

1. Lubricate the bearing surface of each insert with engine oil.
2. Install the main bearing upper inserts to the cylinder block.
3. Install the lower bearing inserts into the main bearing caps.
4. Carefully lower the crankshaft into the cylinder block.
5. Install the main bearing caps and lower inserts.
6. Tighten all the bolts to 54 N•m (40 ft-lbs) torque, then tighten to 95 Nom (70 ft-lbs) torque.
7. Finally, tighten the main bearing cap bolts to 108 Nom (80 ft-lbs) torque.
8. Rotate the crankshaft after tightening each main bearing cap to ensure the crankshaft rotates freely.
9. Install the oil pan with replacement gaskets and seals. Refer to the *Oil Pan Installation*, 'Oiling System' section of this chapter, for the procedure.

10. Tighten the drain plug securely.
11. Lower the vehicle.
12. Install the spark plugs. Tighten the plugs to 38 N•m (28 ft-lbs) torque.
13. Fill the oil pan with engine oil to the full mark on the dipstick level.
14. Connect the battery negative cable.

Crankshaft End Play

1. Attach a magnetic base dial indicator to the cylinder block at either the front or rear of the engine.
2. Position the dial indicator rod so that it is parallel to the centerline of the crankshaft.
3. Pry the crankshaft forward, and position the dial indicator to zero.
4. Pry the crankshaft forward and backward. Note the dial indicator readings. End play is the difference between the high and low measurements. Correct end play is 0.038 to 0.165 mm (0.0015 to 0.0065"). The desired specifications are 0.051 to 0.064 mm (0.002 to 0.0025").
5. If end play is not within specification, inspect crankshaft thrust faces for wear. If no wear is apparent, replace the thrust bearing and measure end play. If end play is still not within specification, replace the crankshaft.

REAR MAIN OIL SEAL

The crankshaft rear main bearing oil seal consists of two half pieces of neoprene with a single lip that effectively seals the rear of the crankshaft. Replace the upper and lower seal halves as a unit to ensure leak-free operation.

Removal

To replace the rear main oil seal, the transmission must be removed. Refer to the service manual for the proper procedure.

1. Remove the flywheel or torque converter drive plate.
2. Remove the oil pan. Refer to the *Oil Pan Removal*, 'Oiling System' section of this chapter, for the procedure.
3. Remove the rear main bearing cap (No. 7).
4. Push the upper seal out of the groove. Ensure that the crankshaft is not damaged.
5. Remove the lower half of the seal from the bearing cap.

Installation

1. Wipe the seal surface area of the crankshaft until it is clean.
 2. Apply a thin coat of engine oil.
 3. Coat the lip of the seal with engine oil.
 4. Position the upper seal into the groove in the cylinder block. The lip of the seal faces toward the front of the engine.
 5. Place the lower half of the seal into the bearing cap.
 6. Coat both sides of the lower seal end tabs with Mopar Gasket-in-a-Tube, or equivalent. DO NOT apply sealant to the lip of the seal.
 7. Coat the outer curved surface of the lower seal with soap and the lip of the seal with engine oil.
 8. Position the lower seal into the bearing cap recess and seat it firmly.
 9. Coat both chamfered edges of the rear main bearing cap with Mopar Gasket-in-a-Tube, or equivalent.
- Caution:** DO NOT apply sealant to the cylinder block mating surfaces of the rear main bearing cap because the bearing-to-journal clearance will be altered.
10. Install the rear main bearing cap.
 11. Tighten all main bearing bolts to 108 N•m (80 ft-lbs) torque.

VIBRATION DAMPER

The vibration damper is balanced independently and then rebalanced as part of the complete crankshaft assembly. DO NOT attempt to duplicate original damper balance holes when installing a service replacement.

The vibration damper is not repairable and is serviced only as a complete assembly.

A loose vibration damper or damage to the damper cushions may be misdiagnosed as engine bearing noise.

4.2L Vibration Damper

Replacement damper compatible with production crankshaft and piston-rod weight. For 4.2L engine with standard belt (only).

P5249535 Vibration damper.

4.2L MPI Vibration Damper

A damper kit for use with Jeep 4.2L MPI fuel injection kits.

P.5249687 1981-90 CJ and YJ with V-belt.

P.5249688 1981-90 CJ and YJ with serpentine belt.

Removal

1. Remove the drive belt(s).
2. Remove the retaining bolts and separate the vibration damper pulley (V-belt ONLY) from the vibration damper.
3. Use a vibration damper removal tool to remove the damper from the crankshaft.

Installation

1. With the key in position, align the key slot of the vibration damper hub with the crankshaft key and tap the damper onto the crankshaft.
2. Install the vibration damper retaining bolt and washer. Tighten the bolt to 108 N•m (80 ft-lbs) torque. If the crankshaft turns before the damper bolt torque valve is attained, the crankshaft can be prevented from turning by placing two 5/16 x 1-1/2" bolts into the damper front pulley holes and wedging a bar between them. Rotate the bar until it contacts the frame member to prevent the crankshaft from turning.
3. Install the damper pulley (V-belt only) and retaining bolts. Tighten the bolts to 27 N•m (20 ft-lbs) torque.
4. Install the drive belt(s) and tighten to the specified tension. Refer to the service manual for the proper specifications and procedures.

TIMING CASE COVER

The timing case cover is provided with a seal and oil slinger to prevent oil leakage at the vibration damper hub.

It is important that the timing case cover is properly aligned with the crankshaft to prevent damage to the oil seal. The oil seal may be replaced without removing the timing chain cover.

Removal

1. Remove the drive belt(s), engine fan and hub assembly, fan shroud, vibration damper, pulley and key. Refer to *Vibration Damper Removal*, in this section, for the procedure.
2. Remove the A/C compressor and alternator bracket assembly, if equipped. Refer to the service manual for additional information pertaining to the A/C system.
3. Remove the oil pan-to-timing case cover bolts and cover-to-cylinder block bolts.
4. Remove the timing case cover, front seal and gasket from the engine.
5. Cut off the oil pan side gasket end tabs flush with the front face of the cylinder block. Remove the gasket tabs.
6. Clean the timing case cover, oil pan and cylinder block gasket surfaces.
7. Remove the crankshaft oil seal from the timing case cover.
8. Remove the oil seal from the timing case cover.

Installation

1. Apply sealing compound (Mopar Gasket-In-A-Tube, or equivalent) to both sides of the replacement timing case cover gasket and position the gasket on the cylinder block.
2. Cut the end tabs off of replacement oil pan side gaskets corresponding to those cut off the original gasket. Cement the end tabs on the oil pan.
3. Coat the front cover end tab recesses generously with RTV sealant (Mopar Gasket-In-A-Tube, or equivalent) and position the seal on the timing case cover. Apply engine oil to the seal-oil pan contact surface.
4. Position the timing case cover on the cylinder block.
5. Place a timing case cover alignment and seal installation tool in the crankshaft opening of the cover.
6. Install the cover-to-cylinder block bolts and the oil pan-to-cover bolts.
7. Tighten the cover-to-cylinder block bolts to 7 N•m (62 in-lbs) torque and the oil pan-to-cover bolts to 13N•m (11 ft-lbs) torque.

8. Remove the cover alignment tool and position the replacement oil seal on the tool with the seal lip facing outward.
9. Apply a light film of Perfect Seal, or equivalent, on the outside diameter of the seal.
10. Lightly coat the crankshaft with engine oil.
11. Position the tool and seal over the end of the crankshaft and insert a screw tool into timing case cover alignment and seal installation tool. Tighten the nut against the tool until the tool contacts the cover.
12. Remove the tools and apply a light film of engine oil on the vibration damper hub contact surface of the seal.
13. With the key inserted in the keyway in the crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt to 108 N•m (80 ft-lbs) torque.
14. Install the A/C compressor and alternator bracket assembly.
15. Install the damper pulley, if removed. Tighten the bolts to 27 N•m (20 ft-lbs) torque.
16. Install the engine fan and hub assembly. Install the fan shroud.
17. Install the drive belt(s) and tighten to the specified tension. Refer to the service manual for the proper procedures.

TIMING CHAIN AND SPROCKETS

Installation of the timing chain with the timing marks of the crankshaft and camshaft sprockets properly aligned assures correct valve timing. A worn timing chain will adversely affect valve timing. If the timing chain deflects more than 1/2", it should be replaced. The correct timing chain has 48 pins. A chain with more than 48 pins will cause excessive slack.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

Removal

1. Remove the drive belt(s).
2. Remove the engine fan and hub (or Tempatrol fan) assembly.
3. Remove the vibration damper pulley (V-belt drive only).
4. Remove the vibration damper. Refer to *Vibration Damper Removal*, in this section, for the procedure.

5. Remove the timing case cover. Refer to the *Timing Case Cover Removal*, in this section, for the procedure.
6. Remove the oil seal from the timing case cover.
7. Remove the camshaft sprocket retaining bolt and washer.
8. Rotate the crankshaft until the zero timing mark on the crankshaft sprocket is closest to and on the centerline with the timing mark on the camshaft sprocket (Figure 5-1).
9. Remove the crankshaft sprocket, camshaft sprocket and timing chain as an assembly. Disassemble the chain and sprockets.

Installation

Assemble the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks aligned.

1. With the key in the keyway on the crankshaft, install the assembly on the crankshaft and camshaft.
2. Install the camshaft sprocket retaining bolt and washer and tighten to 108 N•m (80 ft-lbs) torque.
3. To verify the correct installation of the timing chain, turn the crankshaft to locate the camshaft sprocket timing mark at approximately the one o'clock position. This positions the crankshaft sprocket timing mark where the adjacent tooth meshes with the chain at the three o'clock position. Count the number of chain pins between the timing marks on both sprockets (Figure 5-2). There must be 15 pins.
4. Install the crankshaft oil slinger.
5. Install the timing case cover and replacement oil seal. Refer to *Timing Case Cover Installation*, in this section, for the procedure.
6. With the key in the keyway on the crankshaft, install the vibration damper, washer and bolt. Lubricate and tighten the bolt to 108 N•m (80 ft-lbs) torque.
7. Install the damper pulley (if removed). Tighten the bolts to 27 N•m (20 ft-lbs) torque.
8. Install the engine fan and hub (or Tempatrol fan) assembly.
9. Install the drive belt(s) and tighten to the specified tension. Refer to the service manual for the proper procedure.

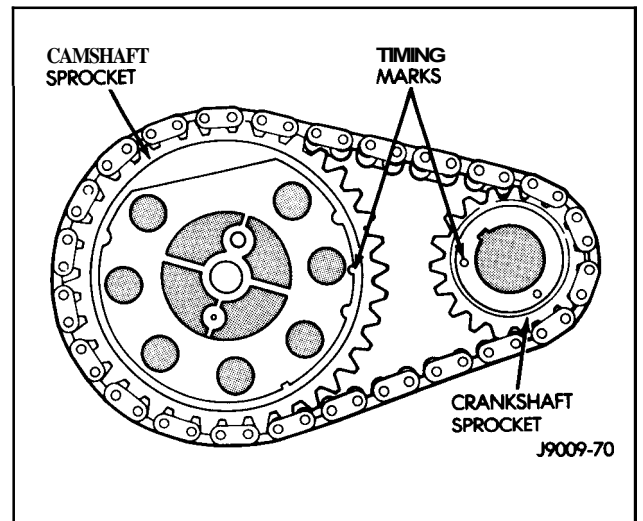


Figure 5 - 1

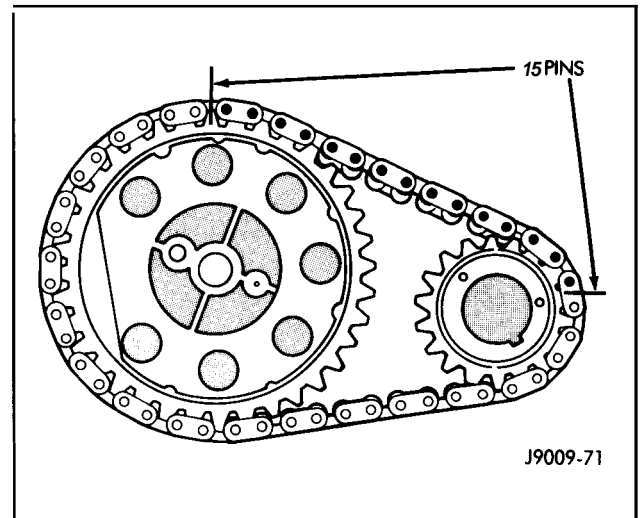


Figure 5 - 2

Piston and Connecting Rod Assembly

Cast Pistons and Rings for Jeep 4.2L Engines						
Part Number	Bore	Stroke	Rod	CR	Dome	Rings
P5249906	3.810"	3.895"	5.875"	8.2:1	Dish	P4876960

REMOVAL AND INSTALLATION PROCEDURES

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
2. Remove the capscrews, bridge and pivot assemblies, and rocker arms. Alternately loosen the capscrews, one turn at a time, to avoid damaging the bridge.
3. Remove the pushrods.
4. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter, for the procedure.
5. Position the pistons one at a time near the bottom of the stroke and use a ridge reamer to remove the ridge from the top end of the cylinder walls. Use a protective cloth to collect the cuttings.
6. Drain the engine oil.
7. Remove the oil pan, gasket and seals. Refer to *Oil Pan Removal*, 'Oiling System' section of this chapter, for the procedure.
8. Remove the connecting rod bearing caps and inserts. Retain them in the same order as removed to facilitate installation in the original location. The connecting rods and caps are stamped with the corresponding cylinder number.

Caution: Ensure that the connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose, slipped over the connecting rod bolts, will provide protection during removal.

9. Remove the connecting rod and piston assemblies through the top of the cylinder bores.

Inspection

1. Connecting Rod Bearings

Inspect the connecting rod bearings for scoring and bent alignment tabs. Check the bearings for normal wear patterns, scoring, grooving, fatigue and pitting. Replace any bearing that shows abnormal wear.

Inspect the connecting rod journals for signs of scoring, nicks and burrs.

2. Connecting Rods

Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicates the probability of a misaligned connecting rod, inspect it for correct rod alignment. Replace misaligned, bent or twisted connecting rods.

Bearing-to-Journal Clearance Measurement

1. Wipe the journal clean of oil.
2. Use short rubber hose sections over rod bolts during installation.
3. Lubricate the upper bearing insert and install in connecting rod.
4. Use piston ring compressor to install the rod and piston assemblies with the oil squirt holes in the rods facing the camshaft and the arrow on the piston crown pointing to the front of the engine. Verify that the oil squirt holes in the rods face the camshaft and that the arrows on the pistons face the front of the engine.
5. Install the lower bearing insert in the bearing cap. The lower insert must be dry. Place a strip of Plastigauge across the full width of the lower insert at the center of bearing cap. Plastigauge must not crumble in use. If brittle, obtain fresh stock.
6. Install bearing cap and connecting rod on the journal and tighten nuts to 45 N•m (33 ft-lbs) torque. DO NOT rotate crankshaft. Plastigauge will smear, resulting in inaccurate indication.
7. Remove the bearing cap and determine the amount of bearing-to-journal clearance by measuring the width of compressed Plastigauge by using the scale on the Plastigauge envelope. The correct clearance is 0.025 to 0.076 mm (0.001 to 0.003").

Note: Plastigauge should indicate the same clearance across the entire width of the insert. If the clearance varies, the variation may be caused by either a tapered journal, bent connecting rod, or foreign material trapped between the insert and cap or rod.

8. If the correct clearance is indicated, replacement of the bearing inserts is not necessary. Remove the Plastigauge from crankshaft journal and bearing insert. Proceed with installation.
9. If bearing-to-journal clearance exceeds the specification, install a pair of 0.0254 mm (0.001") undersize bearing inserts. Measure the clearance as described in the previous steps.
10. The clearance measured with a pair of 0.0254 mm (0.001") undersize bearing inserts installed will determine if two 0.0254 mm (0.001") undersize inserts or another combination is needed to provide the correct clearance.

Example: If the initial clearance was 0.0762 mm (0.003"), 0.025 mm (0.001") undersize inserts would reduce the clearance by 0.025 mm (0.001"). The clearance would be 0.002" and within specification. A 0.051 mm (0.002") undersize insert would reduce the initial clearance an additional 0.013 mm (0.0005"). The clearance would then be 0.038 mm (0.0015").
11. Repeat the Plastigauge measurement to verify your bearing selection prior to final assembly.
12. Once you have selected the proper insert, install the insert and cap. Tighten the connecting rod bolts to 45 N•m (33 ft-lbs) torque.

Side Clearance Measurement

Slide snug-fitting feeler gauge between the connecting rod and crankshaft journal flange. The correct clearance is 0.254 to .482 mm (0.010 to 0.019"). Replace the connecting rod if the side clearance is not within specification.

Installation

Each bearing insert is selectively fitted to its respective journal to obtain the specified operating clearance between the bearing and the journal. In production, the select fit is obtained by using various-sized, color-coded bearing inserts. The color code appears on the edge of the bearing insert. The size is not stamped on inserts used for production of engines.

The rod journal is identified during the engine production by a color-coded paint mark on the adjacent check or counterweight toward the flanged (rear end of the crankshaft).

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce clearance 0.013 mm (0.0005").

Caution: DO NOT intermix bearing caps. Each connecting rod and its bearing cap are stamped with the associated cylinder number on a machined surface adjacent to the oil squirt hole that faces the camshaft side of the cylinder block.

1. Clean the cylinder bores thoroughly. Apply a light film of clean engine oil to the bores with a clean lint-free cloth.
2. Install the piston rings on the pistons, if removed.
3. Lubricate the piston and rings with clean engine oil.

Caution: Ensure that connecting rod bolts DO NOT scratch the crankshaft journals or cylinder walls. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.

4. Use a piston ring compressor to install the connecting rod and piston assemblies through the top of the cylinder bores.
5. Ensure the arrow on the piston top points to the front of the engine.
6. Raise the vehicle.

Caution: Verify that the oil squirt holes in the connecting rods face the camshaft and that the arrows on the pistons face the front of the engine.

7. Install the connecting rod bearing caps and inserts in the same positions as removed.
8. Install the oil pan and gaskets. Refer to *Oil Pan Installation*, 'Oiling System' section, for the proper procedure.
9. Lower the vehicle.
10. Install the cylinder head, pushrods, rocker arms, bridges, pivots and cylinder head cover. Refer to 'Cylinder Head' section for the proper procedures.
11. Fill the crankcase with engine oil.

CONNECTING RODS

The 4.2L engine's connecting rods are made of cast iron with a total weight (less bearings) of 695-703 grams (24.5-24.9 oz.), and a total length (center-to-center) of 149.17-149.28 mm (5.873-5.877").

Connecting rod bore diameter (less bearings) is 56.08-56.09 mm (2.2080-2.2085").

For more connecting rod specifications, refer to *4.2L Engine Specifications*, 'Engine Assembly' section.

Connecting Rod Installation Tips

1. The connecting rods and caps are stamped with the cylinder numbers in which they were assembled.
2. The numbers are on the same machined surface as the squirt holes.
3. The numbered sides and the squirt holes must face the camshaft.
4. Whenever new rings are installed or piston pins are replaced, it is necessary to check the alignment of the connecting rod and piston assemblies to ensure true operation in the cylinder bore.
5. Misaligned rods will cause uneven piston and ring wear which will result in oil consumption. The connecting rod should be inspected for a twisted or bent condition.

CONNECTING ROD BEARINGS

The connecting rod bearings are steel-backed, sintered copper, lead alloy precision-type. Each bearing is selectively fit to its respective journal to obtain the desired operating clearance. In production, the select fit is obtained by using various-sized, color-coded bearing inserts.

When required, different sized upper and lower bearing inserts may be used as a pair; therefore, a standard size upper insert is sometimes used in combination with a .001" undersize lower insert.

Service replacement bearing inserts are available as pairs in the following undersizes: standard, .001", .002", .010", and .012". The size is stamped on the back of the inserts.

It may be necessary, in some instances, to use different sized upper and lower inserts to reduce clearance by .0005". The bearing insert nearest to standard should always be installed in the upper location.

Caution: Never use bearing inserts with greater than .001" difference in size in pairs.

<u>Correct</u>	<u>Incorrect</u>
Upper – Std.	Upper – Std.
Lower – .001" U.S.	Lower – .002" U.S.

Removal and Inspection

1. Drain the engine oil and remove the oil pan.
2. Rotate the crankshaft as required to position two pistons at a time at the bottom of their stroke.
3. Remove the bearing caps and upper and lower inserts. The upper insert can be readily removed by spinning it out of the connecting rod.

Note: DO NOT mix bearing caps. Each connecting rod and its matching cap is stamped with the cylinder number on a machined surface which faces the camshaft side of the engine block.

4. Inspect the bearing inserts for abnormal wear or damage. Bearing inserts exhibiting either condition should be replaced.
5. Wipe the connecting rod journals clean and use a micrometer to check for an out-of-round condition. Refer to specifications. **If** any rod journal is beyond specifications, it must be reconditioned and fit with new undersize bearing inserts.

Installation

Lubricate the bearing surface of each insert with clean engine oil. Install the bearing inserts, cap and retaining nuts. Tighten to the specified torque.

Caution: Care must be exercised when rotating the crankshaft with bearing caps removed. Be sure the connecting rod bolts DO NOT accidentally come in contact with the rod journals and scratch the finish. Bearing failure would result.

Install the oil pan using new gaskets and seal. Tighten the drain plug securely.

Use new engine oil to fill the crankcase to the specified level.

PISTONS

Aluminum alloy "Autothermic" pistons, steel reinforced for strength and controlled expansion, are used. Each piston has three piston rings, two compression and one oil control ring above the piston pin.

The piston pin boss is "offset" from the piston centerline to place it nearer the thrust side of the piston.

To ensure correct installation of the piston in the bore, a notch is cast into the top perimeter of the piston head. The notch must face forward.

Piston Fitting

Pistons are fit to their respective bores by measuring the inside diameter of the cylinder bore and the diameter of the piston.

1. Micrometer Method

- Measure the inside diameter of the cylinder bore at a point 58.725 mm (2-5/16") below the top of the bore.
- Measure outside diameter of the piston. Because pistons are cam ground, measure at right angle to piston pin at centerline of pin (Figure 5-3).

The difference between cylinder bore diameter and piston diameter is piston-to-bore clearance.

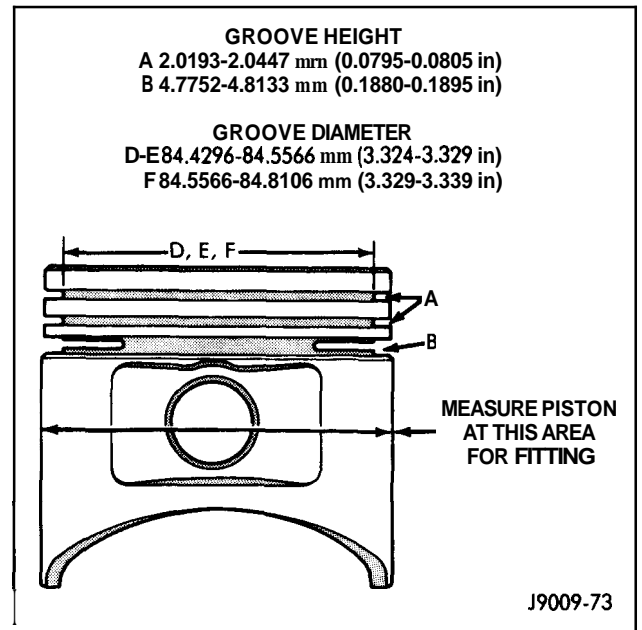


Figure 5 - 3

2. Feeler Gauge Method

(Not recommended for racing.)

- Remove the rings from the piston.
- Insert a long 0.025 mm (0.001") feeler gauge into the cylinder bore.
- Insert the piston, top first, into cylinder bore alongside the feeler gauge. With entire piston inserted into cylinder bore, the piston should not bind against feeler gauge.
- Repeat steps with a long 0.051 mm (0.002") feeler gauge. The piston should bind.
- If the piston binds on 0.025 mm (0.001") feeler gauge, the piston is too large or cylinder bore is too small. If the piston does not bind on 0.051 mm (0.002") feeler gauge, the piston is too small for cylinder bore. Pistons up to 0.102 mm (0.004") undersize may be enlarged by knurling or shot-peening. Replace pistons that are 0.102 mm (0.004") or more undersize.

PISTON RINGS

Carbon must be cleaned from all ring grooves. The oil drain openings in the oil ring grooves and pin boss must be cleared. Care must be exercised not to remove metal from either the grooves (since this will change their depth) or from the lands (since this will change the ring groove clearance and destroy ring-to-land seating).

Side clearance between land and compression rings should be as listed in 4.2L Engine Specifications, 'Engine Assembly' section.

Piston Ring Fitting

- Carefully clean the carbon from all ring grooves. Oil drain openings in the oil ring grooves and pin boss must be clear. **DO NOT** remove metal from the grooves or lands. This will change ring-to-groove clearances and will damage the ring-to-land seating.
- Measure the ring side clearance with a feeler gauge fitted snugly between the ring land and ring (Figure 5-4). Rotate the ring in the groove. It must move freely around the circumference of the groove.
- Place ring in the cylinder bore and push down with inverted piston to position near lower end of the ring travel. Measure ring gap with a feeler gauge fitting snugly between ring ends. The correct compression ring end gap is 0.25-0.51 mm (0.010-0.020"). The correct oil control ring end gap is 0.381-1.397 mm (0.015-0.055").
- Refer to Figure 2-44 for position of the ring gaps when installing piston rings.
- Install the oil control rings according to instructions in the package. It is not necessary to use a tool to install the upper and lower rails. Insert expander ring first, then side rails.
- The two compression rings are different and cannot be interchanged. The top ring is a moly ring (the scraping edge is gray in color). The second ring is a black cast iron ring (the scraping edge is black in color when new).
- The compression rings can be identified by a chamfer of either the top or bottom inside edge. The rings may also be identified by one or two dots on the top surface of the ring.
- The second compression ring (black cast iron) has a chamfer on the **BOTTOM** of the inside edge. This ring may also have two dots located on the top surface.
- Using a ring installer, install the ring with the chamfer facing down. If the ring has dots, the dots will be facing up.
- The top compression ring (the scraping edge is gray in color) has a chamfer on the **TOP** of the inside edge. This ring may also have one dot located on the top surface.
- Using a ring installer, install the top ring with the chamfer facing up. If the ring has a dot, the dot will be facing up.
- Position the ring end gaps on the piston as shown (Figure 2-44).

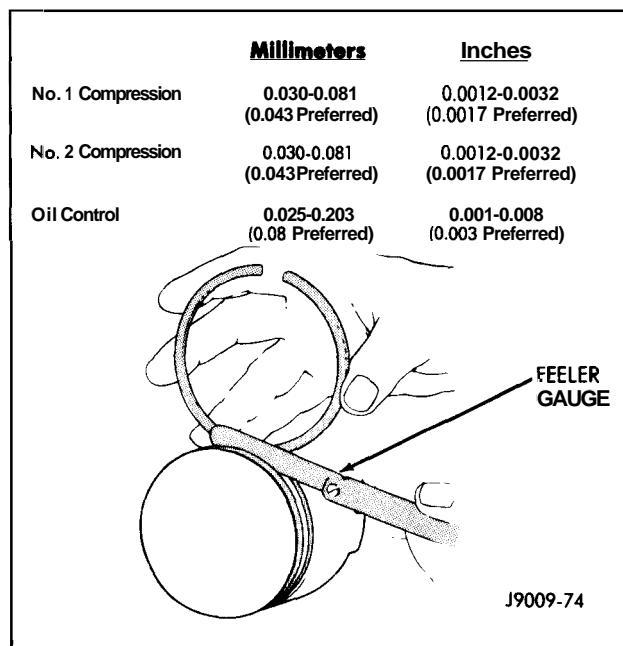


Figure 5 - 4

PISTON PIN

Removal

Piston pins are press-fit into the connecting rods and require no locking device.

- Position the piston and connecting rod assembly on an arbor press.
- Apply force to a piloted driver and press the pin completely out of the connecting rod and piston assembly. Note position of the pin through the gauge window of removal support tool.

Inspection

- Inspect the new piston pin and the connecting rod pin bore for nicks and burrs. Remove as necessary. Never reuse a piston pin.
- With the pin removed from the piston and connecting rod, clean and dry piston pin bore and the replacement piston pin.
- Position the piston so that the pin bore is in a vertical position. Insert the pin in the bore. **At** room temperature, the replacement pin should slide completely through the pin bore in the piston by force of gravity.
- Replace piston if pin jams in the pin bore.

Installation

1. Insert the piston pin pilot through the piston and connecting rod pin bores. Ensure that the arrow on the piston crown is pointing up (Figure 2-50).
2. Position the pin pilot, piston and connecting rod on a support with the squirt hole of the connecting rod to the left-hand side.
3. Insert piston pin through the upper piston pin bore and into the connecting rod pin bore.
4. Position the piloted driver inside the piston pin (Figure 2-49).
5. Using an arbor press, press the piston pin through the connecting rod and piston bores until pin pilot indexes with mark on the support. The piston pin requires an 8900 N (2,000 pounds) press-fit. If little effort is required to install the piston pin in a connecting rod or if the rod moves laterally on the pin, the connecting rod must be replaced.
6. Remove the piston and connecting rod assembly from the press. The pin should be centered in the connecting rod (+0.792 mm or +0.0312").



Cylinder Head

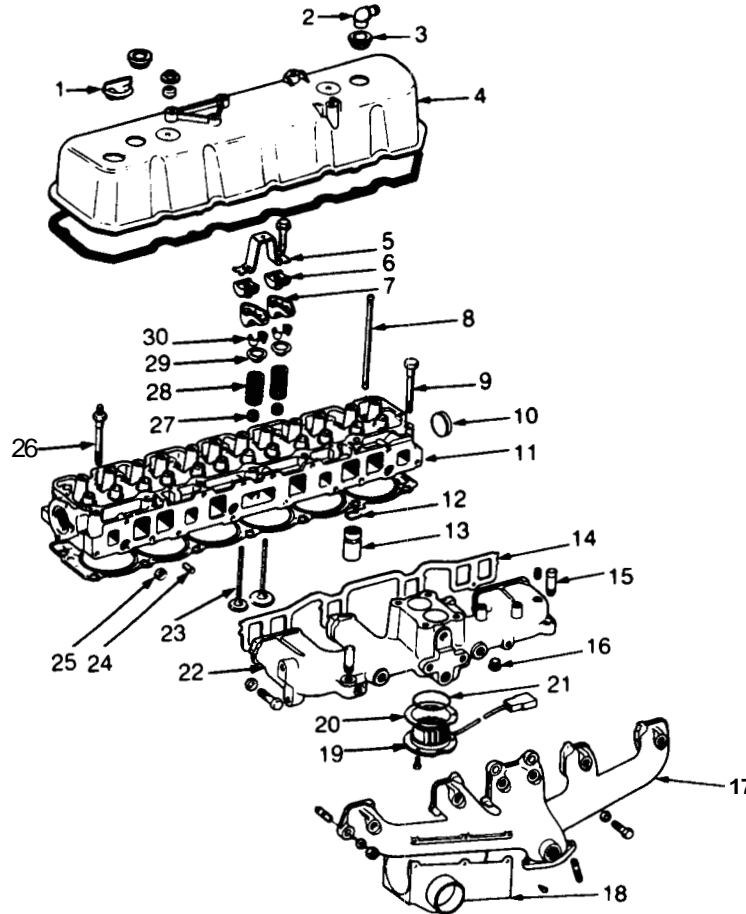
CYLINDER HEAD

The 4.2L engine uses a cast iron cylinder head with a combustion chamber volume of 64.45-67.45 cc.

The cylinder head has a quench-type combustion chamber that creates turbulence and faster burning of the air/fuel mixture, resulting in good fuel economy.

Intake and exhaust valve lengths are 121.653-122.034 mm (4.7895-4.8045").

For more cylinder head specifications, refer to *4.2L Engine Specifications*, 'Engine Assembly' section of this chapter.



- | | |
|----------------------------------|-----------------------------|
| 1 - Oil Filler Cap | 16 - Plug |
| 2 - Ventilation Valve | 17 - Exhaust Manifold |
| 3 - Grommet | 18 - Heat Stove |
| 4 - Cylinder Head (Rocker) Cover | 19 - Intake Manifold Heater |
| 5 - Bridge | 20 - Gasket |
| 6 - Pivot | 21 - O-Ring |
| 7 - Rocker Arm | 22 - Intake Manifold |
| 8 - Push Rod | 23 - Valve |
| 9 - Cylinder Head Bolt | 24 - Dowel Pin |
| 10 - Cylinder Head Core Plug | 25 - Plug |
| 11 - Cylinder Head | 26 - Cylinder Head Stud |
| 12 - Snap Ring | 27 - Oil Deflector |
| 13 - Tappet | 28 - Valve Spring |
| 14 - Intake Manifold Gasket | 29 - Retainer |
| 15 - Hose Fitting | 30 - Valve Locks |

86157

4.2L Engine Cylinder Head (Exploded View)

Removal

Warning! DO NOT remove the cylinder block drain plugs or loosen the radiator draincock with the system hot and pressurized because serious burns from the coolant can occur.

1. Drain the coolant. Disconnect the hoses at the thermostat housing.

Note: DO NOT waste reusable coolant. If the solution is clean and is being drained only to service the engine or cooling system, drain the coolant into a clean container for reuse.
2. Remove the air cleaner.
3. Remove the fuel pipe and vacuum advance hose.
4. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, in this section, for the procedure.
5. Remove the capscrews, bridge and pivot assemblies and rocker arms. Alternately loosen each capscrew, one turn at a time, to avoid damaging the bridge.
6. Remove the pushrods. Retain the pushrod, bridges, pivots and rocker arms in the same order as removed to facilitate installation in the original locations.
7. Disconnect the power steering pump bracket. Set the pump and bracket aside. DO NOT disconnect the hoses.
8. Remove the intake and exhaust manifolds from the cylinder head. Refer to the service manual for the proper procedures.
9. If equipped with air conditioning, perform the following:
 - a. Remove the air conditioner compressor drive belt idler pulley bracket from the cylinder head.
 - b. Loosen the alternator drive belt and remove the alternator bracket-to-cylinder head mounting bolt. The serpentine drive belt tension is released by loosening the alternator.
 - c. Remove the bolts from the A/C compressor mounting bracket and set the compressor aside.
10. Disconnect the ignition wires and remove the spark plugs.
11. Disconnect the temperature sending unit wire connector and battery negative cable.
12. Remove the ignition coil and bracket assembly.
13. Remove the cylinder head bolts, cylinder head and gasket.

Cleaning and Inspection

Thoroughly clean the machined surfaces of the cylinder head and block. Remove all gasket material and cement.

Remove any carbon deposits from the combustion chambers and top of the pistons.

Use a straightedge and feeler gauge to check the flatness of the cylinderhead and block mating surfaces. Refer to *4.2L Engine Specifications*, 'Engine Assembly' section of this chapter.

Installation

If the cylinder head is to be replaced and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems. Remove all carbon buildup and reface the valves. Refer to *Valve Refacing*, 'Camshaft and Valve Gear' section of this chapter, for the proper procedure.

1. Install the valves in the cylinder head using replacement valve stem oil deflectors (Figure 5-5). Refer to *Installation-Cylinder Head Removed*, 'Camshaft and Valve Gear' section of this chapter, for the proper procedure.
2. Use all of the components from the original cylinder head that are not included with the replacement head. DO NOT install the temperature sending unit until coolant is installed. This permits trapped air to escape from the cylinder block and head. Refer to the service manual for the proper procedure.

Caution: DO NOT apply sealing compound on the cylinder head and block gasket surfaces. DO NOT allow sealing compound to enter the cylinder bore.

3. Position the composition gasket on the cylinder block with the word TOP facing up.
4. Install the cylinder head. Tighten the bolts in the sequence shown to 115 N•m (85 ft-lbs) torque (Figure 4-18).

Note: The head gasket is made of aluminum-coated embossed steel and does not require the head bolts to be re-tightened.

5. Connect the battery negative cable.
6. Install the ignition coil and bracket assembly.
7. Install the spark plugs and connect the ignition wires. Tighten the spark plugs to 38 N•m (28 ft-lbs) torque.
8. Attach the air conditioner compressor mounting bracket to the cylinder head, if removed.
9. Install the intake and exhaust manifolds. Use the correct tightening sequence. Refer to the service manual for the proper procedures.

10. Install the alternator bracket bolt on the head. Install the alternator belt and adjust the tension.
 11. Install the power steering bracket and pump. Adjust the belt tension. Refer to the service manual for drive belt (including serpentine) adjustment procedures.
 12. Install the pushrods in the same order they were removed.
 13. Install the rocker arms and the bridge and pivot assemblies in the order removed. Loosely install the capscrews for each bridge and tighten alternately, one turn at a time, to avoid damaging the bridge. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
 14. Install the cylinder head cover.
 15. Connect the hoses to the thermostat housing and fill the cooling system to the specified level. Refer to the service manual for the proper procedure.
 16. The automatic transmission throttle linkage and cable must be adjusted after completing the cylinder head installation. Refer to the service manual for the proper procedures.
 17. Install the temperature sending unit and connect the wire connector.
 18. Connect the fuel pipe and vacuum advance hose.
- Warning!** Use extreme caution when the engine is operating. DO NOT stand in direct line with the fan. DO NOT put hands near the pulleys, belts or fan. DO NOT wear loose clothing.
19. Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.
 20. Install the air cleaner.

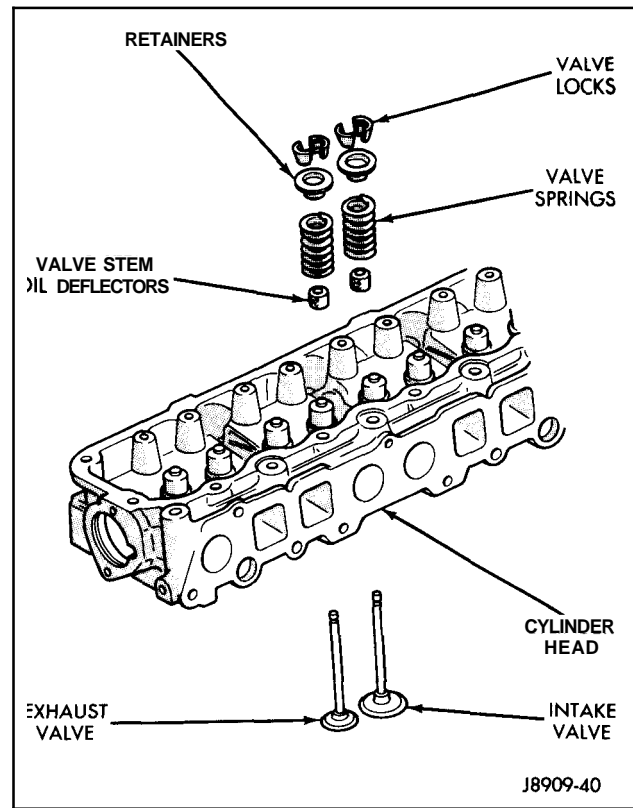


Figure 5 - 5

CYLINDER HEAD COVER

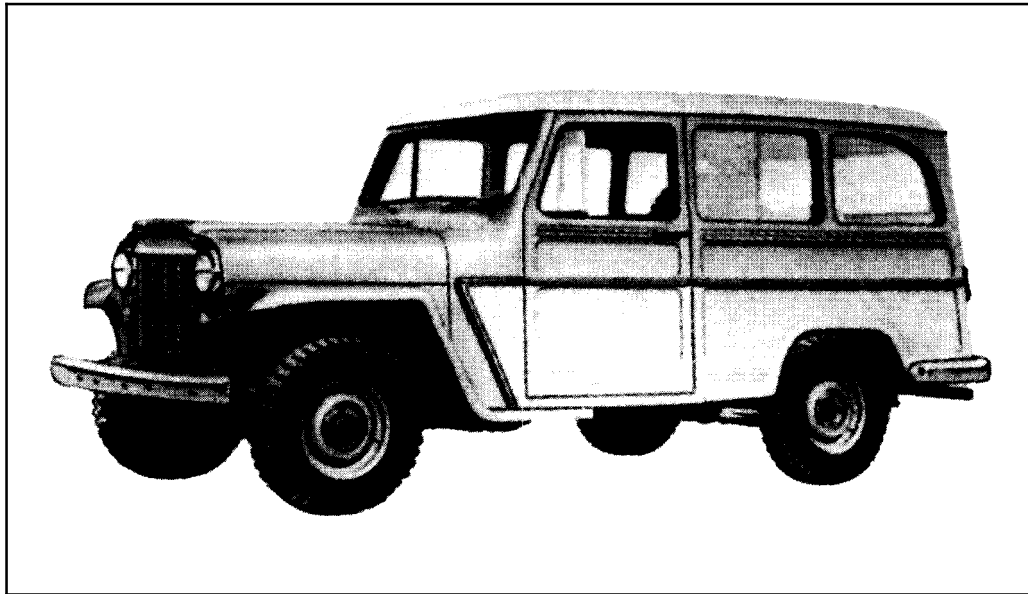
Crankcase Breather

A universal high performance re-usable crankcase breather (must have stand pipe on valve cover). Washes clean with P4529392 cleaning fluid for extra miles of service.

P4529394 Crankcase breather.

Removal

1. Disconnect the battery negative cable.
2. Remove the air cleaner and the PCV molded hose.
3. Disconnect the distributor vacuum advance hose at the distributor.
4. Disconnect the fuel pipe at the fuel pump. Rotate the pipe as necessary to provide clearance for the cylinder head cover removal/installation.
5. Remove the PCV valve from the cylinder head cover grommet and disconnect the PCV shutoff valve vacuum hose (Figure 5-6).
6. Remove the vacuum switch and bracket assembly from the cylinder head cover.



7. Remove all the necessary vacuum and air hoses to provide clearance for the cylinder head cover removal/installation. Identify and tag the hoses for installation reference.
8. Remove the cylinder head cover retaining bolts.
9. Detach the cover from the cylinder head by breaking the silicone rubber seal with a putty knife or razor blade. DO NOT attempt to pry the cover up until the seal has been completely broken.
10. Rotate the cylinder head cover toward the passenger side and remove the cover.

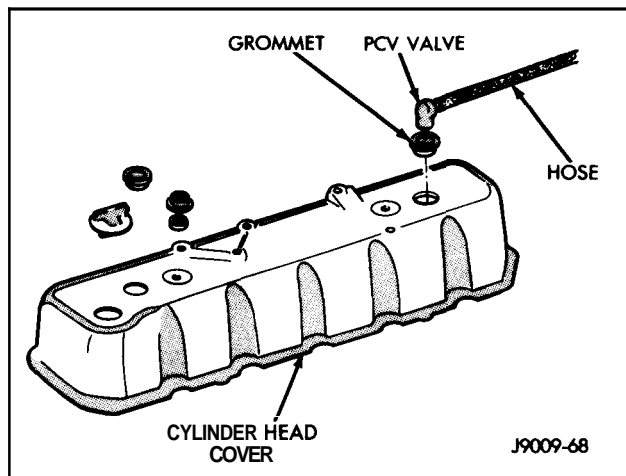


Figure 5 - 6

Inspection and Cleaning

Replace the cover if it is cracked or damaged in any way. If the pre-cured RTV seal is damaged, replace the cover.

If a replacement cover is installed, transfer the PCV valve grommet and oil filler cap from the original cover to the replacement cover.

Remove any original sealer from the cover sealing surface of the cylinder head and clean the surface using a fabric cleaner. Remove all residue from the sealing surface using a clean, dry cloth.

Installation

1. Install and tighten the cylinder head cover bolts to 8 N•m (70 in-lbs) torque.
2. Connect the fuel pipe and the distributor vacuum advance hose.
3. Reposition and/or connect all the air and vacuum hoses that were moved for cover removal clearance.
4. Connect the PCV valve and the PCV shutoff valve hose.
5. Install the air cleaner hoses.
6. Connect the battery negative cable.
7. Check the engine oil and add oil, if necessary.

Camshaft and Valve Gear

CAMSHAFT

The 4.2L engine uses a cast iron camshaft with intake and exhaust valve lifts of 10.29 mm (0.405"), intake and exhaust cam lobe lifts of 6.43 mm (0.253"), and intake and exhaust durations of 262°.

The camshaft is supported by four steel-shelled, Babbitt-lined bearings which have been pressed into the block and line reamed. The camshaft bearings are step bored, being larger at the front bearing than at the rear, to permit easy removal and installation of the camshaft. All camshaft bearings are lubricated under pressure.

Note: It is not advisable to replace camshaft bearings unless you are equipped with special removing, installing and reaming tools.

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear.

The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face. Therefore, camshaft end play is zero during engine operation.

Jeep Gear Drives

Replace conventional Jeep timing chain and gear sets and eliminate chain induced cam timing fluctuations with this Mopar Performance Parts dual idler gear drive camshaft centerlining drive system. Rugged and durable for off-road applications. Fits all 4.0L, 4.2L, and 2.5L Jeep engines.

P5249009 Jeep gear drives.

Removal

Warning! The coolant in a recently operated engine is hot and pressurized. Release the pressure before removing the draincock, cap and drain plugs.

1. Disconnect the battery negative cable.
2. Drain the cooling system.

Note: DO NOT waste reusable coolant. If the solution is clean, drain it into a clean container for reuse.
3. Remove the radiator. Refer to the service manual for the proper procedure.
4. Remove the air conditioner condenser and receiver/driver assembly as a charged unit, if equipped. Refer to the proper service manual for additional information pertaining to the A/C system.
5. Remove the distributor and ignition wires.
6. Remove the fuel pump. Refer to the proper service manual for the procedure.

7. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section, for the procedure.
8. Remove the capscrews, bridge and pivot assemblies, and rocker arms.
9. Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
10. Remove the pushrods. Position all components on a workbench in the same order as removed to facilitate installation at the original locations.
11. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter, for the procedure.
12. Remove the hydraulic valve tappets. Refer to *Hydraulic Valve Tappet Removal*, in this section, for the procedure.
13. Remove the vibration damper. Refer to *Vibration Damper Removal*, 'Crankshaft' section of this chapter, for the procedure.
14. Remove the timing case cover. Refer to *Timing Case Cover Removal*, 'Crankshaft' section of this chapter, for the procedure.
15. Remove the timing chain and sprockets. Refer to *Timing Chain and Sprockets Removal*, 'Crankshaft' section of this chapter, for the procedure.
16. Remove the grille. Refer to the proper service manual for the procedure.
17. Remove the camshaft.

Inspection

1. Inspect the cam lobes for wear.
2. Inspect the bearing journals for uneven wear pattern or finish.
3. Inspect the bearings for wear.
4. Inspect the distributor drive gear for wear.
5. If the camshaft appears to have been rubbing against the timing case cover, examine the oil pressure relief holes in the rear cam journal to ensure that they are free of debris.

Installation

1. Lubricate the camshaft with Mopar Super Oil Conditioner, or equivalent.
2. Carefully install the camshaft to prevent damage to the camshaft bearings.

3. Install the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks aligned. Refer to *Timing Chain and Sprockets Installation*, 'Crankshaft' section of this chapter, for the procedure.
4. Install the camshaft sprocket retaining bolt and tighten to 108 N•m (80 ft-lbs) torque.
5. Install the crankshaft oil slinger.
6. Install the timing case cover with a replacement oil seal. Refer to *Timing Case Cover Installation*, 'Crankshaft' section of this chapter, for the procedure.
7. Install the vibration damper. Refer to *Vibration Damper Installation*, 'Crankshaft' section of this chapter, for the procedure.
8. Install the damper pulley, if removed.
9. Install the fan assembly and shroud.
10. Install the drive belt(s) and tighten to the specified tension. Refer to the proper service manual for the procedure.
11. Install the fuel pump.
12. Rotate the crankshaft until the No. 1 piston is at the TDC position on the compression stroke.
13. Install the distributor, cap and ignition wires. Install the distributor so that the rotor is aligned with the No. 1 cylinder spark plug terminal on the cap when the distributor housing is fully seated on the cylinder block.

Lubricate the hydraulic valve tappets and all valve actuating components with Mopar Super Oil Conditioner, or equivalent, during installation. The Mopar Super Oil Conditioner must remain with the engine oil for at least 1,609km (1,000 miles); however, it does not have to be drained until the next scheduled oil change.
14. Install the hydraulic valve tappets.
15. Install the cylinder head. Refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter, for the procedure.
16. Install the pushrods.
17. Install the rocker arms and pivot and bridge assemblies. Tighten each of the two capscrews for each bridge alternately, one turn at a time, to avoid damaging the bridge.
18. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.
19. Install the fuel pump. Refer to the service manual for the proper procedure.

20. Install the A/C condenser and receiver/drier assembly, if equipped. Refer to the proper service manual for additional information pertaining to the A/C system.

Caution: Both service valves must be opened before the air conditioning system is operated.

21. Install the radiator, connect the hoses and fill the cooling system to the specified level. Refer to the service manual for the proper procedure.
22. Check the ignition timing and adjust as necessary.
23. Install the grille. Refer to the service manual for the proper procedure.
24. Connect the battery negative cable.

Measuring Cam Lobe Lift

Cam lift is a function of camshaft lobe dimensions and may be checked with a dial indicator.

To check cam lift, remove the cylinder head cover and gasket, rocker arm assembly and spark plugs. Install a dial indicator on the end of the pushrod. A piece of rubber tubing may be used to secure the dial indicator plunger to the pushrod.

Rotate the crankshaft until the cam lobe base circle (pushrod down) is under the valve tappet. Set the dial indicator to zero and rotate the crankshaft to a point where maximum upward movement of the pushrod occurs.

Read the travel at the dial indicator. An excess of minus .006" from the specified dimensions indicates a defective cam.

VALVES AND VALVE SPRINGS

Removal—Cylinder Head Removed

1. Use a valve spring compressor tool to compress each valve spring.
2. Remove the valve locks, retainers, valve springs and valve stem oil deflectors. Discard the oil deflectors.
3. Remove the valves and place them in a rack in the order in which they were removed.

Cleaning

- Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and head.
- Clean all grime and gasket cement from the cylinder head machined gasket surface.

Inspection

- Inspect for cracks in combustion chambers and valve ports.
- Inspect for cracks on the exhaust seats.
- Inspect for cracks in the gasket surface at each coolant passage.
- Inspect the valves for burned, cracked or warped heads.
- Inspect for scuffed or bent valve stems.
- Replace valves displaying any damage.

Valve Refacing

1. Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.
2. After refacing, a margin of at least 0.787 mm (0.031") must remain. If the margin is less than 0.787 mm (0.031"), the valve must be replaced.

Valve Seat Refacing

1. Install a pilot of the correct size in the valve guide bore and reface the valve seat to the specified angle with a good dressing stone.
2. Remove only enough metal to provide a smooth finish.
3. Use tapered stones to obtain the specified seat width when required.
4. Control seat runout to a maximum of 0.0635 mm (0.0025"), using a dial indicator.

Valve Spring Tension Test

(Refer to *Valve Spring Tension Test*, 'Camshaft and Valve Gear' section of the 4.0L engine chapter, for the proper procedure.)

Installation – Cylinder Head Removed

1. Thoroughly clean the valve stems and the valve guide bores.
2. Lubricate the stem lightly.
3. Install the valve in the original valve guide bore from where it was removed.
4. Install the replacement valve stem oil deflector on the valve stem. If the oversize valve stems are used, oversize oil deflectors are required.
5. Position the valve spring and retainer on the cylinder head and compress the valve spring with a valve spring compressor.
6. Install the valve locks and release the tool.
7. Tap the valve spring from side to side with a hammer to ensure that the spring is properly seated on the cylinder head.

VALVE STEM OIL DEFLECTOR

Rubber valve stem oil deflectors are installed on each valve stem to prevent the oil used for rocker arm lubrication from entering the combustion chamber through the valve guides. The oil deflectors should be replaced whenever valve service is performed or if the rubber has become hard and brittle.

The valve spring is held in place on the valve stem by a retainer and a set of valve locks. The locks can be removed only by compressing the valve spring. Whenever valve springs are removed, they should be tested for correct tension and replaced if not within specifications.

Replacement

Nylon valve stem oil deflectors are installed on each valve stem to prevent lubricating oil from entering the combustion chamber through the valve guide bores.

Caution: Ensure that the valve stem is free of burrs or sharp edges before replacing the oil deflectors.

Replace the oil deflectors whenever valve service is performed or if the oil deflectors have deteriorated.

Oil deflector replacement requires removal of the valve springs. Refer to *Valve and Valve Spring Removal – Cylinder Head Removed*, in this section, for the removal procedure.

VALVE GUIDES

The valve guides are an integral part of the cylinder head and are not replaceable. When the stem-to-guide clearance is excessive, the valve guide bores must be reamed to accommodate the next larger oversize valve stem. Ream valve guide bores in steps, starting with a 0.0762 mm (0.003") oversize reamer and progress to the size required.

Valve Stem-to-Guide Clearance Measurement

Valve stem-to-guide clearance may be measured by either of the following two methods.

1. Preferred Method

- a. Remove the valve from the head. Refer to *Valve and Valve Spring Removal – Cylinder Head Removed*, in this section, for the procedure.
- b. Clean the valve stem guide bore with solvent and a bristle brush.
- c. Insert the telescoping gauge into the bore of the valve stem guide approximately 9.525 mm (.375") from the valve spring side of the head with contacts crosswise to the cylinder head.
- d. Remove and measure the telescoping gauge with a micrometer.
- e. Repeat the measurement with contacts lengthwise to the cylinder head.
- f. Compare the crosswise to lengthwise measurements to determine out-of-roundness. If the measurements differ by more than 0.0635 mm (0.0025"), ream the guide bore to accommodate the oversize valve stem.
- g. Compare the measured valve guide bore diameter with the diameter listed in *4.2L Engine Specifications*, 'Engine Assembly' section of this chapter. If the measurement differs from the specification by more than 0.0762 mm (0.003"), ream the guide bore to accommodate the oversize valve stem.

2. Alternate Method

- a. Use a dial indicator to measure the lateral movement of the valve stem (stem-to-guide clearance) with the valve installed in its guide and just off the valve seat. The correct clearance is 0.0025-0.0762 mm (0.001-0.003").
- b. If the indicated movement exceeds the specification, ream the guide bore to accommodate an oversize valve stem.

VALVE TIMING

1. Disconnect the spark plug wires and remove the spark plugs.
2. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
3. Remove the capscrews, bridge and pivot assembly, and rocker arms from above the No. 1 cylinder.
4. Alternately loosen each capscrew, one turn at a time, to avoid damaging the bridge.
5. Rotate the crankshaft until the No. 6 piston is at top dead center (TDC) on the compression stroke.
6. Rotate the crankshaft counterclockwise (viewed from the front of the engine) 90°.
7. Install a dial indicator on the end of the No. 1 cylinder intake valve pushrod. Use rubber tubing to secure the indicator stem on the pushrod.
8. Set the dial indicator pointer at zero.
9. Rotate the crankshaft clockwise (viewed from the front of the engine) until the dial indicator pointer indicates 0.305 mm (0.012") travel distance (lift).
10. The timing notch index on the vibration damper should be aligned with the TDC mark on the timing degree scale.
11. If the timing notch is more than 13 mm (1/2") away from the TDC mark in either direction, the valve timing is incorrect.
12. If the valve timing is incorrect, the cause may be a broken camshaft pin. It is not necessary to replace the camshaft because of pin failure. A spring pin is available for service replacement.

ROCKER ARMS

Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
2. Remove the two capscrews at each bridge and pivot assembly. Alternately loosen the capscrews one turn at a time to avoid damaging the bridges.
3. Remove the bridges, pivots and corresponding pairs of rocker arms and place them on a bench in the same order as removed.
4. Remove the pushrods and place them on a bench in the same order as removed.

Cleaning and Inspection

- Clean all components with cleaning solvent and use compressed air to blow out oil passages in rocker arms and pushrods.
- Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted or excessively worn.
- Inspect the valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted.
- Inspect each pushrod end for excessive wear and replace as required. If any pushrod is excessively worn because of lack of oil, replace the pushrod and inspect the corresponding hydraulic tappet.
- A wear pattern along the length of the pushrod is not normal. Inspect the cylinder head for obstruction if this condition exists.

Installation

1. Install the pushrods in their original locations. Ensure that the bottom end of each pushrod is centered in the tappet plunger cap seat.
2. Install the rocker arms, pivots and bridge above each cylinder from which they were originally removed.
3. Loosely install the capscrews through each bridge.
4. At each bridge, tighten the capscrews alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 25 N•m (19 ft-lbs) torque.
5. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.

HYDRAULIC TAPPETS (LIFTERS)

The hydraulic valve tappet consists of a body, plunger, plunger return spring, cap and lock ring.

The tappet operates in a guide bore which has an oil passage drilled into the adjoining main oil gallery.

When the tappet is on the heel of the cam lobe, the plunger return spring indexes with an oil hole undercut in the plunger and allows the oil supply to be admitted through the tappet body. Oil under pressure flows into the body through the check valve assembly, maintaining the tappet fully charged. This cycle of operation occurs when the tappet leaks some oil during the normal valve opening events. Contact with the cam lobe causes tappet body movement, closing the check valve and transmitting "zero-lash" movement of the pushrod to open the intake or exhaust valve.

Noise Diagnosis

A loud clicking noise is usually the result of the plunger stuck below its operating position or a check valve held open. A light clicking noise at idle is usually the result of excessive "leak-down" caused by wear or slight leakage at the check valve and its seat.

An intermittent noise is the result of dirt or chips stopping the check valve action or a lack of oil flow into the body. A general tappet noise is, in most cases, due to a lack of oil volume, pressure or aeration.

A clicking noise heard upon starting the engine, reducing in level and disappearing after a short period of time, is normal. This noise is due to a slight oil leak-down condition caused by valve spring pressure exerted on the tappets.

An individual noisy tappet can readily be located by placing one end of a length of heater hose at the pushrod end of the rocker arm and the other end to the ear.

The valve tappets should be cleaned and serviced at time of engine overhaul or whenever excessive noise exists.

Removal

Retain all the components in the same order as removed to facilitate installation at the original positions.

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter, for the procedure.
2. Remove the bridge and pivot assemblies and rocker arms by removing the two capscrews at each bridge. Alternately loosen each capscrew one turn at a time to avoid damaging the bridges.
3. Remove the pushrods.
4. Remove the intake and exhaust manifolds. Refer to the service manual for the proper procedure.

5. Remove the cylinder head and gasket. Refer to *Cylinder Head Removal*, 'Cylinder Head' section of this chapter, for the procedure.
6. Remove the tappets through the pushrod openings in the cylinder block.

Disassembly, Cleaning and Inspection

Place the components of each tappet in a separate location. This will greatly assist in the installation operation.

1. Release the snap ring.
2. Remove the following from the tappet body:
 - a. plunger cap
 - b. metering valve
 - c. plunger
 - d. check valve assembly
 - e. plunger return spring
3. Clean the components of each tappet assembly in cleaning solvent to remove all varnish, gum and sludge deposits.
4. Inspect for indications of scuffing on the side and base of each tappet body.
5. Inspect each tappet base for concave wear with a straightedge positioned across the base.
6. If the base is concave, the corresponding lobe on the camshaft is also worn. Replace the camshaft and tappets.

Assembly

1. Install the following in the tappet body:
 - a. plunger return spring
 - b. check valve assembly
 - c. plunger
 - d. metering valve
 - e. plunger cap
2. Compress the plunger assembly by exerting force on the plunger cap with the pushrod and install the snap ring.

Installation

It is not necessary to charge the tappets with engine oil. They will charge themselves within a very short period of engine operation.

1. Coat each tappet in Mopar Super Oil Conditioner, or equivalent.
2. Install each tappet in the same bore from where it was originally removed.
3. Install the exhaust and intake manifolds. Refer to the service manual for the proper procedure.
4. Install the cylinder head and gasket. Refer to *Cylinder Head Installation*, 'Cylinder Head' section of this chapter, for the procedure.
5. Install each pushrod in the same location from where removed.
6. Install the rocker arms and bridge and pivot assemblies at their original locations.
7. Loosely install the capscrews through each bridge. Tighten the capscrews alternately, one turn at a time, to avoid damaging the bridges.
8. Pour the remaining Mopar Super Oil Conditioner over the entire valve actuating assembly. The Mopar Super Oil Conditioner must remain with the engine oil for at least 1,609 km (1,000 miles); however, it does not have to be drained until the next scheduled oil change.
9. Install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter, for the procedure.

Oiling System

SYSTEM OVERVIEW

A full pressure-type lubrication system is used, except for the piston pins, which are lubricated through the connecting rod squirt holes and oil throw-off.

Pressure is applied by a gear-type, positive pressure pump mounted on a boss adjacent to the No. 4 main bearing location.

Oil, drawn through the inlet screen and tube to the inlet side of the oil pump, is driven between the gears and pump body to the pressure outlet portion of the oil pump where it is routed through an oil galley to the inlet side of the full flow oil filter, and on into the main oil galley.

Each main bearing and camshaft bearing is lubricated by oil from the main oil galley.

Holes drilled in each connecting rod journal direct lubrication to the connecting rod bearings. Oil throw-off from each connecting rod bearing lubricates the cylinder walls and piston pins.

A small channel (squirt hole) located on the numbered side of the connecting rods and caps allows oil to lubricate the camshaft lobes, tappets, piston pins and distributor drive gear.

The hydraulic valve tappets are fed directly from the main oil galley.

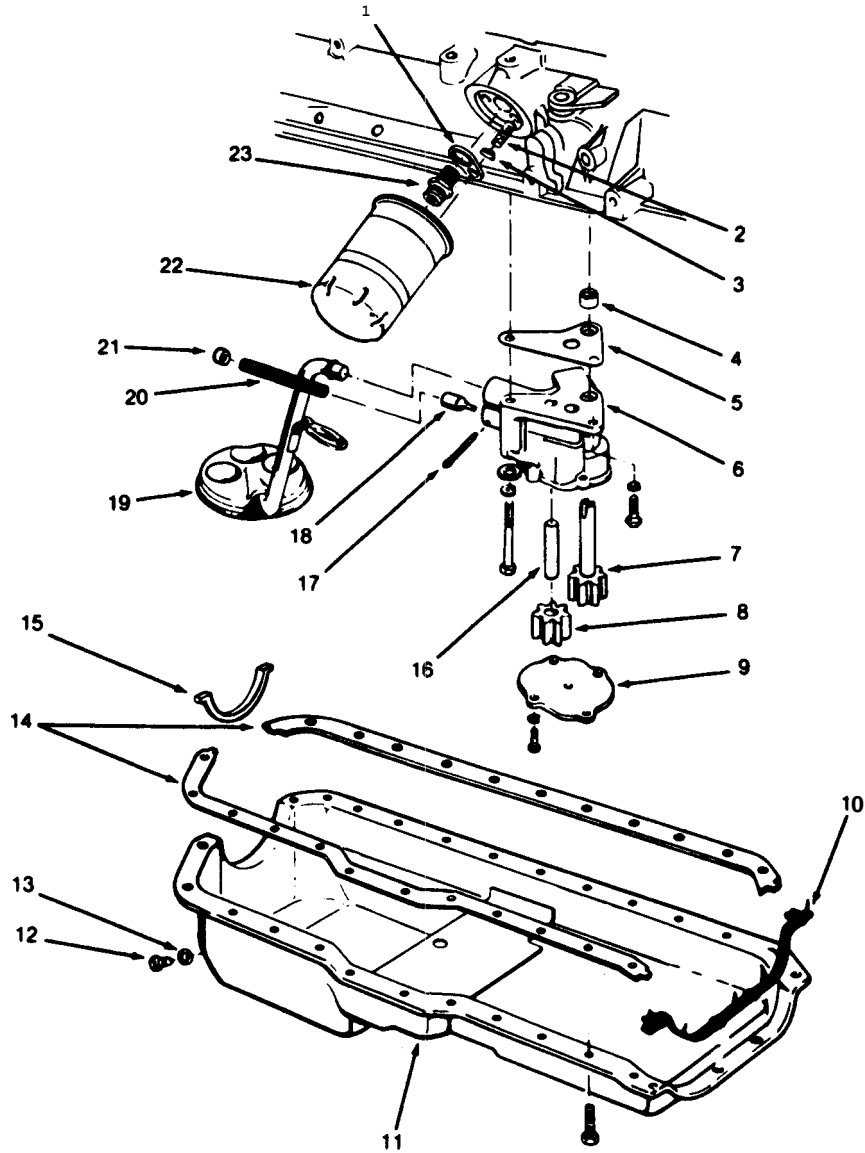
Lubrication is supplied to the timing chain and gears from the front camshaft bearing and returned to the crankcase through a cavity under the front main bearing cap.

The oil supply for rocker arms and pushrods is obtained from the No. 3 cam bearing location, where oil from the main lubrication galley is metered through a groove in the camshaft bearing surface to a galley extending upwards to the cylinder head gasket surface. At this point, the cylinder head gasket forms a seal joining the cylinder block galley with the adjoining galley in the cylinder head. Commencing at the No. 5 rocker arm support, oil then flows into the rocker arm shaft supplying lubrication to rocker arms and pushrods.

Holes cast in the cylinder head return the oil to the crankcase through the valve tappet area, which in turn lubricates the tappets.



SIX CYLINDER ENGINE ASSEMBLY — OIL PAN AND PUMP



- | | |
|---------------------------------------|--|
| 1 • Oil Filter By-Pass Valve Retainer | 13 • Oil Pan Drain Plug Gasket |
| 2 • Oil Filter By-Pass Valve Spring | 14 • Oil Pan Gasket Set |
| 3 • Oil Filter By-Pass Valve | 15 • Oil Pan-to-Bearing Cap Seal |
| 4 • Dowel Pin | 16 • Oil Pump Idler Gear Shaft |
| 5 • Oil Pump-to-Cylinder Block Gasket | 17 • Colter Pin |
| 6 • Oil Pump Body | 18 • Release Valve Plunger |
| 7 • Oil Pump Drive Shaft and Gear | 19 • Oil Pump Strainer and Inlet Tube Assembly |
| 8 • Oil Pump Idler Gear | 20 • Oil Pump Release Valve Spring |
| 9 • Oil Pump Cover | 21 • Valve Spring Release Cap |
| 10 • Oil Pan Timing Case Cover Seal | 22 • Oil Filter Element |
| 11 • Oil Pan | 23 • Oil Filter By-Pass Connector |
| 12 • Oil Pan Drain Plug | |

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OIL PAN

Removal

1. Disconnect the battery negative cable.
2. Raise and support the vehicle at the side sills.
3. Drain the engine oil.
4. Remove the starter motor.
5. Remove the flywheel/torque converter housing access cover.
6. It may be necessary to raise the engine in order to remove the oil pan.
7. Remove the oil pan bolts.
8. Remove the oil pan by sliding it to the rear.

Cleaning

- Clean the gasket and seal surfaces.
- Remove all sludge and residue from the oil pan sump.

Installation

(Refer to Figure 5-7.)

1. Install a replacement oil pan front seal on the timing case cover and apply a generous amount of Mopar Gasket-in-a-Tube (or equivalent) to the recesses in the tab ends.
2. Cement the replacement oil pan side gaskets into position on the cylinder block.
3. Apply a generous amount of Mopar Gasket-in-a-Tube (or equivalent) to the end tabs of the gaskets.
4. Coat the inside curved surface of the replacement oil pan rear seal with soap.
5. Apply a generous amount of sealant such as Mopar Gasket-in-a-Tube (or equivalent) to the gasket contacting surface of the seal end tabs.
6. Install the seal in the recess of the rear main bearing cap. Ensure that it is fully seated. Either one of two sealing methods may be used.
 - a. A sealant such as Mopar Gasket-in-a-Tube (or equivalent) may be used instead of a gasket.
 - b. If a gasket is used, coat both sides with a quick drying adhesive such as Mopar Gasket Compound (or equivalent).
7. **Apply** engine oil to the oil pan contacting surface of the front and rear oil pan seals.
8. Install the oil pan. Tighten the 1/4-20 oil pan bolts to 9 N•m (80 in-lbs) torque and tighten the 5/16-18 oil pan bolts to 15 N•m (11 ft-lbs) torque. Tighten the drain plug securely.

9. Lower and secure the engine if it was raised.
10. Install the flywheel/torque converter housing access cover.
11. Install the starter motor.
12. Raise the vehicle to remove the jackstands. Lower the vehicle.
13. Connect the battery negative cable.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or fan. DO NOT wear loose clothing.

14. Fill the oil pan with clean engine oil to the specified level. Start the engine and inspect for leaks.

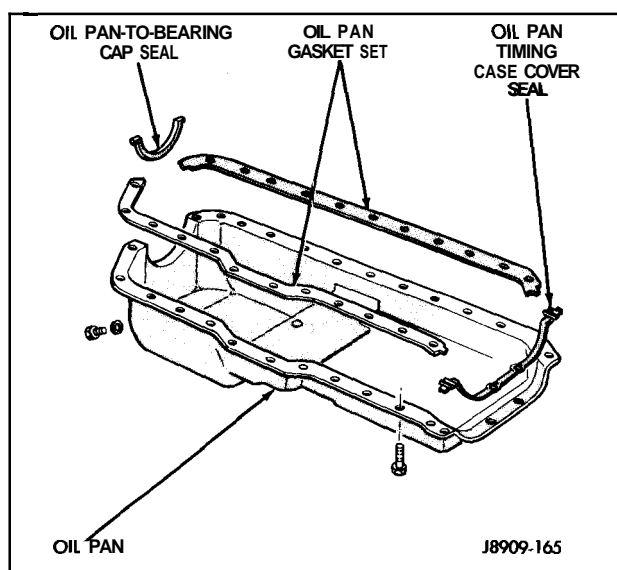


Figure 5-7

OIL PUMP

A positive displacement, gear-type oil pump is used and is driven by the distributor shaft, which in turn is driven by a gear on the camshaft. The pump incorporates a pressure relief valve to regulate maximum pressure. Crankcase oil enters the pump through a pick up tube and screen assembly which is press fit into the pump body.

Oil pump removal or replacement will not affect distributor timing as the distributor drive gear remains in mesh with the camshaft gear.

Removal

1. Drain the engine oil.
2. Remove the oil pan. Refer to *Oil Pan Removal*, in this section, for the procedure.

Caution: DO NOT disturb the position of the oil inlet tube and strainer assembly in the pump body. If the tube is moved within the pump body, a replacement tube and strainer assembly must be installed to ensure an airtight seal.

3. Remove the oil pump retaining bolts, oil pump and gasket (Figure 2-78).

Gear End Clearance Measurement

Remove the cover retaining bolts and cover from the pump body.

1. Preferred Method

- a. Place a strip of Plastigauge across the full width of each gear (Figure 2-79).
- b. Install the pump cover and tighten the bolts to 8 N•m (70 in-lbs) torque.
- c. Remove the pump cover and determine the amount of clearance by measuring the width of compressed Plastigauge with the scale on the Plastigauge envelope.

The correct clearance by this method is 0.051-0.152 mm (0.002-0.006"). The preferred measurement is 0.051 mm (0.002"). If the gear end clearance is excessive, replace the oil pump assembly.

2. Alternate Method

- a. Place a straightedge across the ends of the gears and the pump body (Figure 2-80).
- b. Select a feeler gauge that fits snugly but freely between the straightedge and the pump gears (Figure 2-80).

Using this method the correct clearance is 0.051-0.152 mm (0.002-0.006"), with the preferred measurement being 0.051 mm (0.002"). If the gear end clearance is excessive, replace the oil pump assembly.

Gear-to-Body Clearance Measurement

With both gears in place, measure the gear-to-body clearance by inserting a feeler gauge between the gear tooth and the pump body inner wall, directly opposite the point of gear mesh (Figure 2-81). Select a feeler gauge which fits snugly but freely. Rotate gears to measure each tooth-to-body clearance in this manner.

Correct clearance is 0.051-0.102 mm with 0.051 mm preferred (0.002-0.004" with 0.002" preferred). If the gear-to-body clearance is more than specified, replace the oil pump.

Disassembly

Remove the cotter pin and slide the spring retainer, spring and oil pressure relief valve plunger out of the pump body. Inspect for binding condition during disassembly. Clean or replace as necessary.

Note: The oil inlet tube and strainer assembly must be moved to allow removal of the relief valve. Install a replacement inlet tube and strainer assembly.

Assembly

Note: Two relief valve plunger sizes (standard and oversize) are available. When replacing the valve, ensure that the correct replacement valve, standard size or 0.254 mm (0.010") oversize plunger diameter, is obtained and installed.

1. Install oil pressure relief valve plunger, spring, retainer, and cotter pin.
2. If the position of the inlet tube in the pump body has been disturbed, install a replacement inlet tube and strainer assembly. Apply a light film of Permatex No. 2 sealant, or equivalent, around the end of the inlet tube.
3. Use an oil pump inlet tube installer tool to drive the tube into the body (Figure 2-82). Ensure the support bracket is properly aligned.
4. Install the idler gear and the drive gear assembly. Inspect the gears to ensure that a binding condition does not exist before installing the oil pump.
5. To ensure self-priming of the oil pump, fill the pump with petroleum jelly before installing the oil pump cover. DO NOT use grease.
6. Apply a bead of Loctite 515, or equivalent, and install the pump cover.
7. Tighten the cover bolts to 8 N•m (70 in-lbs) torque.

Installation

1. Install the oil pump with a replacement gasket. Tighten the short bolts to 14 N•m (10 ft-lbs) torque and the long bolts to 23 N•m (17 ft-lbs) torque (Figure 2-78).
2. Install the oil pan with replacement gaskets and seals. Refer to *Oil Pan Installation*, in this section, for the procedure.
3. Fill the oil pan with replacement engine oil to the specified level.

Oil Pressure Relief Valve

The oil pressure relief valve is not adjustable. A setting of 75 pounds maximum pressure is built into the tension of the spring.

In the relief position, the valve permits oil to by-pass through a passage in the pump body to the inlet side of the pump.

The oil pump pick-up tube and screen assembly is a press fit in the oil pump body.

Caution: DO NOT disturb the position of the tube assembly in the pump body unless absolutely necessary.

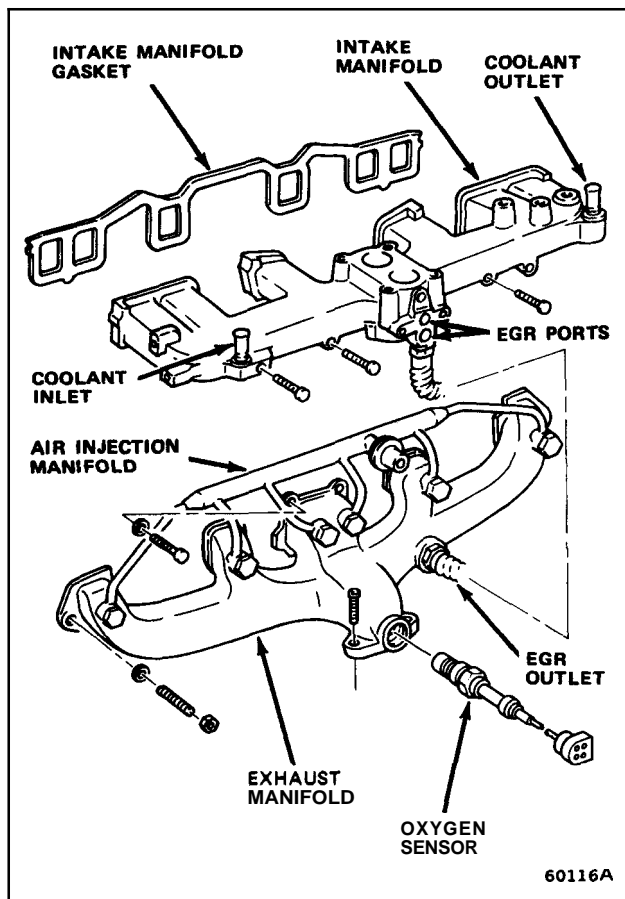
In the event the tube is disturbed, it must be replaced with a new tube assembly.

Induction System

INDUCTION SYSTEM

Vehicles with the 4.2L (258 CID) six cylinder engine were originally equipped with a model BBD two venturi, feedback-type carburetor (stock).

The stepper motor included with this carburetor has two tapered metering pins. Each metering pin is moved in and out of the carburetor air cavity to achieve the proper air/fuel ratio.



4.2L Intake and Exhaust Manifolds

Fuel Pump

The 4.2L engine uses a single action, mechanical fuel pump. The fuel pump is comprised of an actuating lever, a diaphragm and spring, an inlet valve, and an outlet valve. An eccentric lobe on the engine camshaft operates the fuel pump lever, which is linked to the pump diaphragm. The lever pulls the diaphragm to its extended position to pump fuel into the inlet valve. When the carburetor float needle valve closes, fuel pump output is limited to the amount that returns to the fuel tank through the fuel return tube. The fuel accumulated in the fuel pump chamber prevents the diaphragm from relaxing. The actuating lever continues to move up and down, but it is prevented from operating the

diaphragm, which is held in its extended position by fuel pressure. Fuel flow from the pump remains halted until excess pressure is released through the fuel return tube or until the carburetor float needle moves off its seat. This procedure continues as long as the engine is running.

Mechanical fuel pumps cannot be overhauled. Replace any mechanical fuel pump that fails either a pressure, capacity (volume) or vacuum test.

Chrome Fuel Pump Block-Off Plate

This good looking chrome plate covers the hole left when removing the mechanical fuel pump for replacement with an electric pump. Gasket included.

P4.529404 Chrome fuel pump block-off plate.

Computerized Emission Control (CEC) Fuel Feedback System

The CEC Fuel Feedback System on 4.2L six cylinder engines controls undesirable emission in to the atmosphere and maintains the ideal air/fuel ratio to provide an optimum balance between emission control and engine performance. This is accomplished by use of a Micro-Computer Unit (MCU), several MCU input components and several MCU output components.

The MCU monitors various engine operating conditions. Based on these conditions, the MCU may, depending on the mode of operation, generate output signals to provide the proper air/fuel mixture, proper ignition timing and engine idle speed. Each system operates in two modes of operation: CLOSED LOOP and OPEN LOOP.

Closed loop operation occurs when the air/fuel ratio is varied according to the oxygen content in the exhaust gas.

During open loop operation, the air/fuel ratio is predetermined by the MCU for several engine operating conditions, such as:

- Start-up
- Cold engine operation
- Wide open throttle (W.O.T.) engine operation

When the engine is started, the MCU determines which mode of operation (closed loop or open loop) is correct. It can determine this by monitoring the input signals from the various input components. Air and coolant temperature information, engine rpm information and vacuum levels are all provided to the MCU for this determination.

The MCU operates the system in the open loop mode based on a priority rating for the various predetermined engine operating conditions. It continues to operate the system and output components in the open loop mode until such time

as the engine operating conditions indicate that the closed loop mode of operation is appropriate. At this time, the MCU shifts the operation to closed loop. Based upon the oxygen content in the exhaust gas and other inputs, it continues to operate the system in the closed loop mode and constantly varies the air/fuel ratio to maintain an optimum 14.7:1 ratio.

As the engine operating conditions are constantly monitored by the MCU, any change in condition such as the engine being placed in wide open throttle, is quickly detected by the MCU. The MCU then places the system back into the appropriate open loop mode of operation.

JEEP 4.2L MULTIPOINT FUEL INJECTION CONVERSION KIT INSTALLATION INSTRUCTIONS

Jeep 4.2L MPI Conversion Kit

The Mopar Performance Parts 4.2L electronic fuel injection kit is designed to make your 1981-90 Jeep more efficient and powerful. The kit replaces the stock carburetor, intake manifold, and other major components with multi-point fuel injection (MPI). Each cylinder has its own injector that is activated sequentially with the firing order to precisely control individual fuel requirements. The MPI kit is self-compensating and runs equally well from sea level to terrain above 12,000 feet. Mechanical components are based from production 1995 Jeep parts. Emissions exempt in CA under CARB E.O. D265-14.

Note: Use of these MPI packages requires either damper kit P5249687 or P5249688.

P5249610 1981-90 manual transmission, CJ and YJ models.

P5249610 1981-90 automatic transmission, CJ and YJ models.

Note 1: This product is intended for use on stock, unmodified, well maintained 1981-90 4.2L (258 CID) engines. Installation on engines with modified camshafts, increased compression ratio, or engines that are in poor mechanical condition (such as low cranking compression or excessive oil consumption) is NOT recommended.

Note 2: This kit is emissions exempt in the State of California under C.A.R.B. Executive Order D265-7. The tune-up procedures and engine service are the same as a 1994-95 4.0L Jeep Wrangler.

Note 3: Please read these instructions thoroughly prior to installation of this kit. Check your parts against the bill of material included in the kit.

Note 4: If spark knock (detonation) occurs, it is recommended that 92 octane or better premium fuel be used. The use of Mopar combustion chamber cleaner will reduce carbon deposits and help reduce spark knock.

Note 5: This is a universal kit. Some part(s) in this kit may not be used in every installation.

Note 6: Keep all parts removed from the engine until installation is complete. You may need them later.

Disassembly

1. Disconnect the ground cable from the battery and drain the coolant from the radiator.
2. Loosen the power steering pump and the alternator and remove the drive belts. Remove the two bolts that hold the power steering pump to the water pump. Remove the two nuts from the rear power steering pump bracket (DO NOT throw this bracket away—you will need to modify and re-install later), then slide the pump forward to disengage it from the rear bracket. Remove the rear bracket from the intake manifold.
3. Remove the air cleaner assembly as a unit and discard it.
4. Remove all of the production emissions controls from the engine, including the three (3) solenoids located on top of the valve cover, the vacuum switch assembly and any lines and delay valves connected to the carburetor. All the wiring that goes to all the emission controls including the wires connected to the old carburetor can be completely removed. You can also remove the small computer that controls the carburetor.

Note 1: CJ models have the carburetor computer mounted behind the glove box. If you want to remove the computer by taking it out the glove box, you can. If you do not remove the computer, it will not hurt anything. Just be sure to cut the wires going through the firewall, push the wires in toward the computer and seal up the hole (silicone/RTV works great).

Note 2: Refer to the Production Emissions Schematic or the proper service manual for your particular year vehicle.

5. Remove the pulse air valves, which inject fresh air upstream and downstream of the catalytic converter, and all associated fittings.
6. Disconnect the heater hose from the fitting on the intake manifold. Remove the throttle linkage and throttle cable. Remove the carburetor/intake manifold assembly. This will require removing the tube that connects the exhaust manifold to the EGR valve mounted on the intake manifold. DO NOT throw this EGR tube away—you will need later at installation.

Note: It is not necessary to remove the exhaust manifold.

7. Remove the stock mechanical fuel pump and fuel lines from the engine. Make sure to mark the lines PRESSURE and RETURN where you disconnect them at the fender well. Double check your marking—the PRESSURE line is the larger of the two lines!

Caution: GASOLINE IS HAZARDOUS! WEAR eye protection and never work on a HOT engine or around FIRE OR FLAME!

8. Disconnect the upper and lower radiator hoses and remove the radiator, fan shroud, engine fan, thermostat housing and crankshaft pulley. On engines with a serpentine belt drive, do not remove the crank pulley (dampener) at this time. Only V-belt engines get the front pulley removed at this time, but not the dampener.
9. Before you start removing any parts in this step, clearly mark on the distributor cap where the number one (#1) spark plug wire connects to the distributor. The #1 spark plug is the plug at the front of the engine—the one closest to the radiator. Remove the plug wires and distributor cap. Remove the #1 spark plug and rotate the engine in its normal direction until the #1 piston is on the compression stroke. Make doubly sure that you are on the compression stroke when finding TDC. THIS IS VERY IMPORTANT. Note—we recommend removing all 6 plugs because it makes the engine much easier to turn over. The timing mark on the dampener should line up with the “0” mark on the timing tab. Note—the engine does this twice per cycle! Looking through the stock fuel pump mounting boss, rotate the engine backwards until the camshaft moves and note the amount of slack in the timing chain as degrees on the timing tab. If the slack is more than 10degrees, replace the timing chain. Rotate the engine in the direction of rotation to the “0” of the timing tab. Note the clocked position of the distributor rotor (before removal). Loosen the hold down clamp and remove the

distributor. Remove the ignition coil and bracket and discard them. After removing the old distributor refer to Figure 5-11. Looking down the distributor hole, you will see the oil pump slot. Position the oil pump slot to the 11 o'clock position. This is very important and will make the new distributor easier to install in the correct position. Note the yellow indexing lock pin on the bottom of the distributor. DO NOT remove this pin until the distributor is installed. At this time, we recommend installing the new distributor. Be sure distributor gasket is located properly. This gasket is located in the small parts box. After you have installed the distributor correctly (Figure 5-12), make sure that the old dampener (still on the engine) is at “0” on the timing tab. Now remove the indexing lock pin from the bottom of the distributor. It is very important that you remove this pin *before* you try to remove the old dampener from the engine.

10. Using a suitable puller, remove the crankshaft dampener. You will need a new dampener: P5249688 for serpentine belt, or P5249687 for V-belt driven pulleys. See Figure 5-8 and Figure 5-9.
11. Remove the brake booster fitting from the old manifold and install it in the new manifold.
12. Remove the windshield washer bottle and the charcoal fuel canister. Be sure to mark the vacuum lines that go from the fuel canister to the intake manifold and the fuel tank.
13. Remove the front three (3) driver's side oil pan bolts.
14. Remove the oxygen sensor from the exhaust manifold.
15. If the vehicle has a catalytic converter, it will be necessary to seal the air injection tubes at the CAT and header pipe. Seal by bending the end of the tube and crimping.

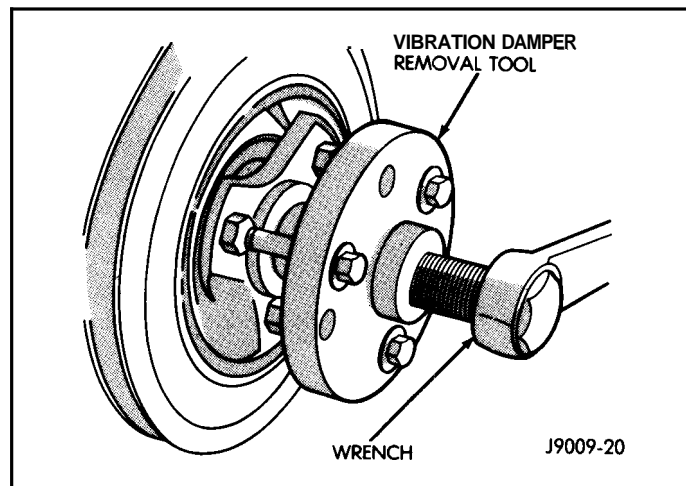


Figure 5 - 8

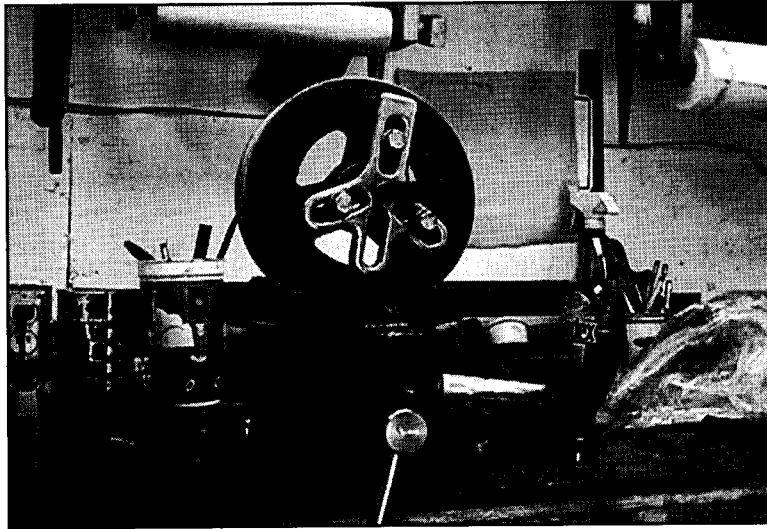


Figure 5 - 9

Assembly

1. Install the new oxygen sensor in the exhaust manifold.
2. Cut off one end of the tube that went from the exhaust manifold to the EGR valve and remove the tube nut from it. Install the saucer-shaped freeze plug into the hole in the exhaust manifold where you removed the EGR tube. Secure the freeze plug by tightening the now free tube nut down against the freeze plug.

3. Install the new distributor. (The distributor is shipped with an indexing lock pin and will not rotate. **DO NOT REMOVE THE PIN UNTIL THE DISTRIBUTOR IS INSTALLED.**)

Note: If you think the engine may have moved from TDC, make sure the engine is at TDC on the crankshaft balancer (Figure 5-10). The oil pump should be in the position shown in Figure 5-11. Install the hold down clamp and remove the white locking pin (Figure 5-12).

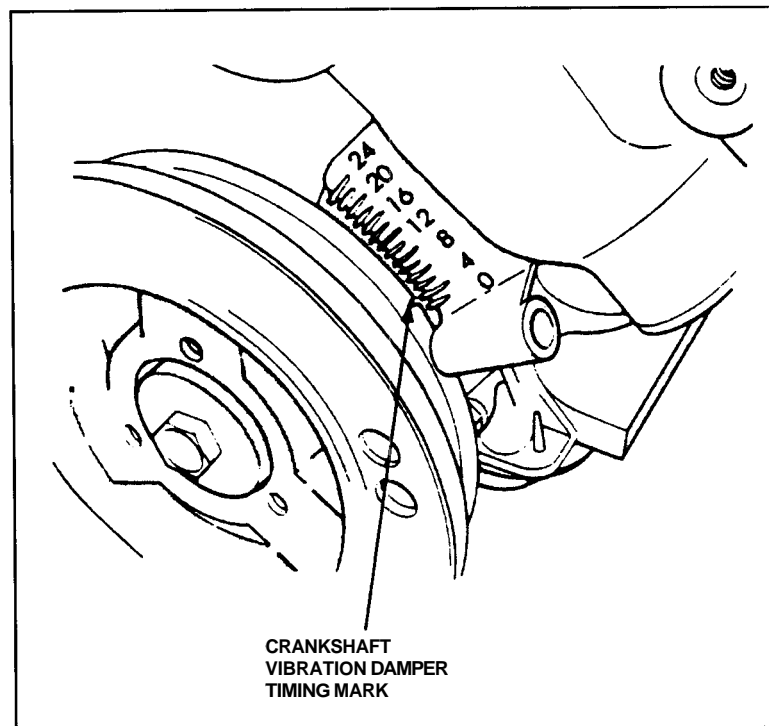


Figure 5 - 10

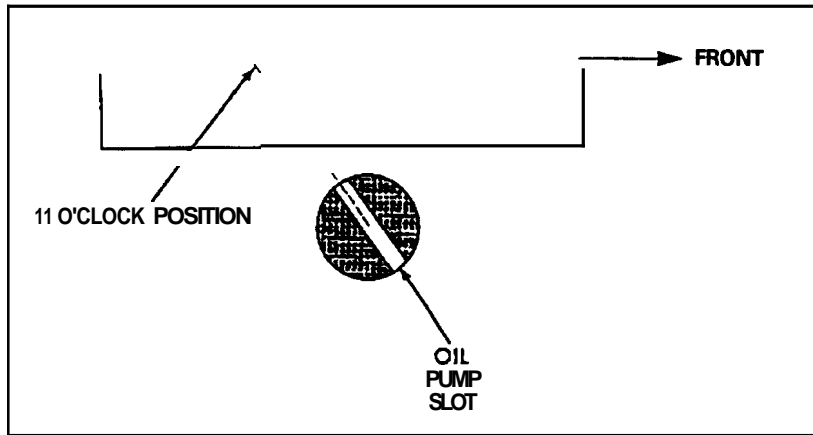


Figure 5 - 11

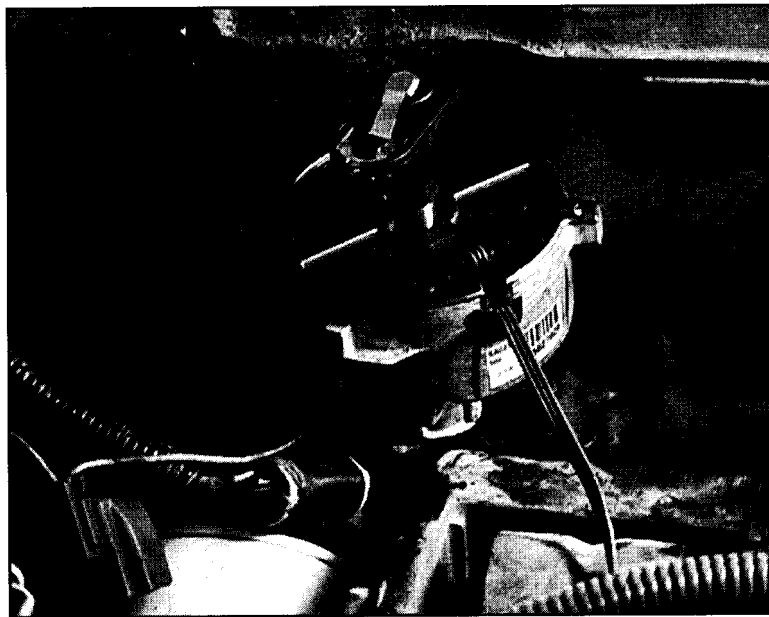


Figure 5 - 12

4. Install the combination fuel pump block-off plate/ignition coil bracket where you removed the original fuel pump. Make sure that the block-off plate has a gasket. Install the coil with the plug wire terminal toward the distributor (Figure 5-13).
5. Install the new crankshaft dampener. Torque the bolt to 120 ft-lb.
6. Install the pickup sensor bracket. The bracket bolts to the oil pan where you removed the three (3) bolts in step #13 of the disassembly instructions. Install the pickup sensor on the bracket with the bolt provided (Figure 5-26).

Note: There should be between .020" and .060" clearance between the sensor and the crankshaft dampener. This clearance is the thickness of the paper button on the end of the sensor. You push the sensor up against the dampener, then tighten the mounting screw. This will set the initial clearance (Figure 5-14 and Figure 5-26).

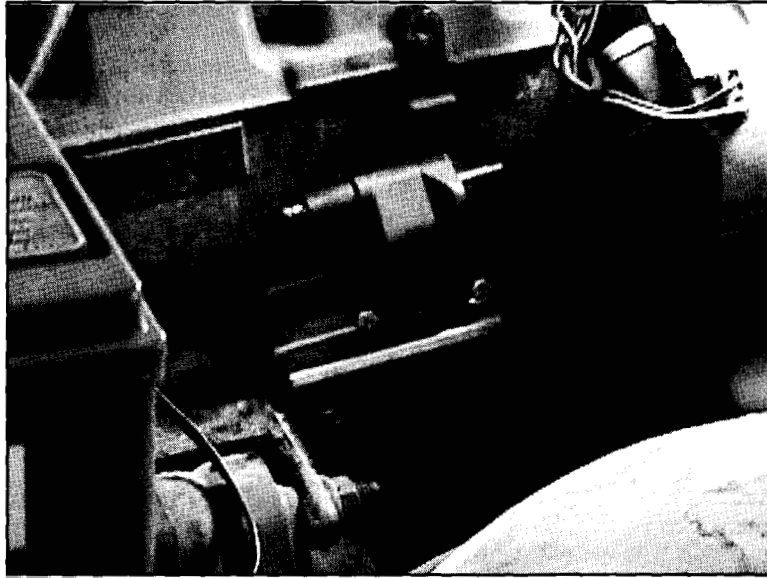


Figure 5- 13

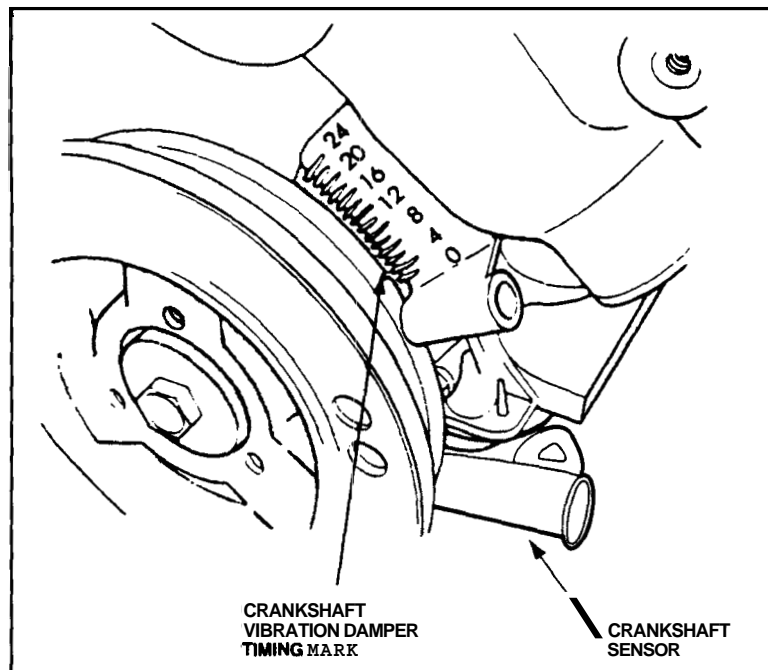


Figure 5- 14

7. Install the crankshaft pulley, the fan, and the radiator. Install the new 195 degree thermostat. This is critical. Temperature level of 195 degrees is critical for fuel system operation. Double check the thermostat and make sure that it is installed in the housing correctly. Make sure that the thermostat itself does not drop down when installing the housing onto the engine. If that happens, the housing will leak. Just a small amount of heavy grease will hold the thermostat in place while you install the housing. Install the coolant sensor supplied into the new thermostat housing in the 3/8" pipe hole, then reinstall this new assembly on the engine. When installing radiator and heater hoses, reroute the new heater hose supplied, as it no longer goes through the intake manifold.

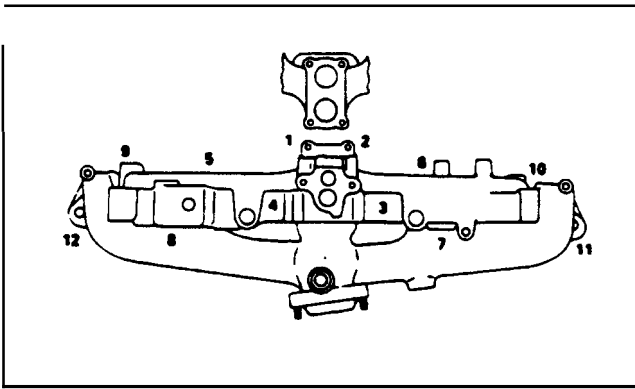


Figure 5- 15

Note: On some serpentine belt engines, the Coolant Temperature Sensor will not fit in the thermostat housing. The idler pulley bracket is too close. If you have this problem, you can install a 3/8" pipe plug in the thermostat housing and relocate the temp sensor into the heater hose. You will need to splice an adapter into the heater hose. The adapter is a "4 Seasons" part number 84540, should be available at your local hardware store or air conditioning supplier, or perhaps at your local auto parts store.

8. Install the new intake manifold. You will only be able to reinstall one of the power steering pump bracket bolts and you may have to trim the top lip off of the power steering pump bracket to make it fit the new manifold. With the new intake manifold, this bracket does not actually bolt to the manifold itself. The bracket does not need to be bolted to the manifold and will not cause any power steering pump mounting problems. For a cleaner look to the engine, you might want to modify the bracket a little more before installing it to the back of the power steering pump. Just cut the bracket horizontally above the power steering pump top bolt hole. This will eliminate the portion of the bracket that bolts to the intake manifold. DO NOT over tighten the intake manifold bolts! Bolt torque is 23 ft-lb (Figure 5-15). Take your time installing these bolts. Make sure that all the intake manifold cup washers are seated properly.
9. Install the throttle cable and bracket (Figure 5- 16 and Figure 5-17).

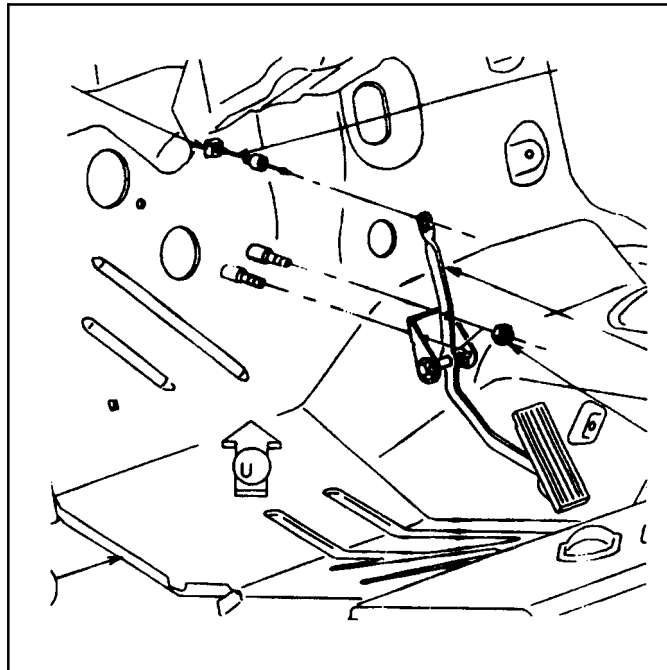


Figure 5- 16

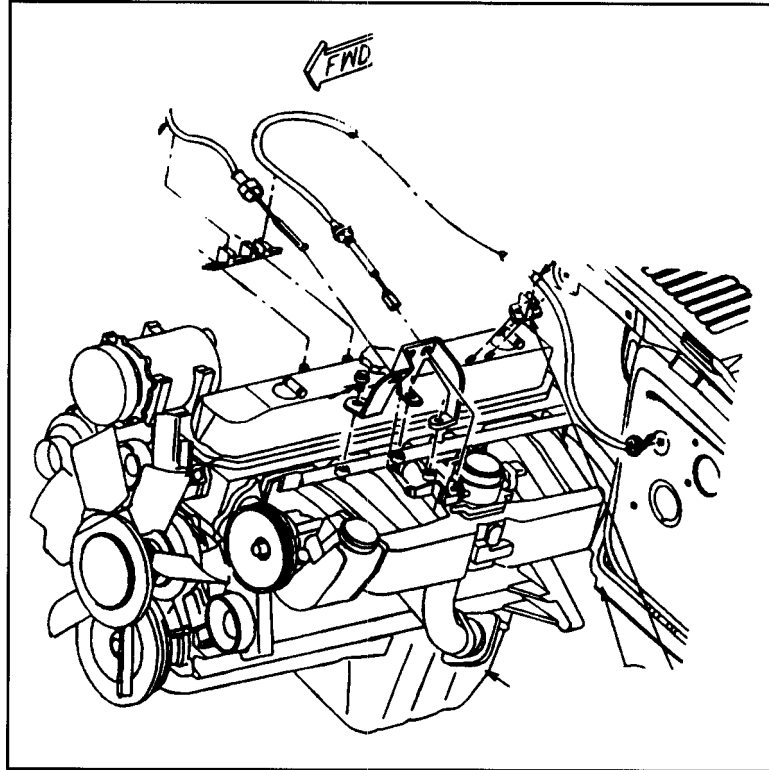


Figure 5 - 17

10. On automatic transmission vehicles, the kickdown linkage must be installed (Figure 5-18, Figure 5-19 and Figure 5-20). Once these parts are assembled, you should set the adjustment. Rotate the throttle body to wide open throttle. This will cause the cable to ratchet to the proper zero clearance (Figure 5-19). At this time, verify that the throttle linkage works smoothly and returns to IDLE (closed throttle).
11. Reinstall power steering pump bracket and belts. Tension the belts. The hole in the bracket may need to be enlarged slightly.
12. Connect the new fuel lines to the fuel rails and attach to the mounting bracket on the new intake manifold. Find the fuel inlet line where it was connected to the stock mechanical fuel pump (Note: Some CJ models have the fuel supply line routed down the right passenger side of the vehicle.) Trace this line back across the engine bay to the driver's side frame rail. Cut this line and the fuel return line a few inches behind the front leaf spring eye. Bend them up slightly to align with the new fuel lines that come from the MPI fuel rail. Connect the lines with the 5/16" fuel hose and clamps provided. Note: The new fuel lines look almost identical. You will note that one has an orange dust cap over the quick connect. This is the return line, or fuel out, and has the smaller O-rings inside. It connects to the new fuel rail on the forward end of the line coming out of the fuel pressure regulator. The pressure line has a yellow dust cap over the quick

connect which has the larger O-rings inside and connects to the second connection on the fuel rail. IT IS IMPERATIVE THAT THESE LINES ARE CONNECTED PROPERLY. Improper connection can cause damage to the fuel pump. THE **RETURN FUEL LINE** GOES FROM THE FUEL REGULATOR (on the fuel rail) BACK TO THE FUEL TANK.

Note: On models with the fuel supply line on the right side, carefully route the line around to the fuel rail similar to the O.E. setup.

Note: (CJ Models Only): If you have a CJ model that has the pressure line running down the passenger side of the vehicle, the best way to route this line is to use a 5/16" fuel injection hose. 1.) Look to see how much 5/16" fuel injection hose you are going to need. 2.) Attach one end of the fuel injection hose to the hard line that runs down the passenger side of the vehicle from the fuel tank. 3.) Route this line forward toward the radiator. 4.) Then route the line under the radiator toward the driver's side, and then back down the driver's side frame rail. When you have reached the end of the pressure line coming off the fuel rail, attach the 5/16" fuel injection hose to the hard line (again using two small hose clamps). Be very careful with the routing of this fuel line. Make sure that your bends are not restricting any fuel flow and fuel lines are not routed near the exhaust.

Caution: If you buy any fuel line to hook up the fuel pump, make sure it is rated to handle EFI pressures!

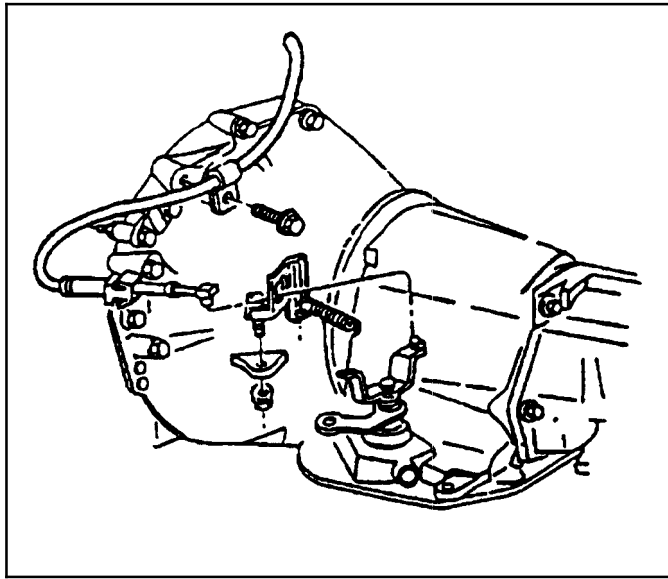


Figure 5 - 18

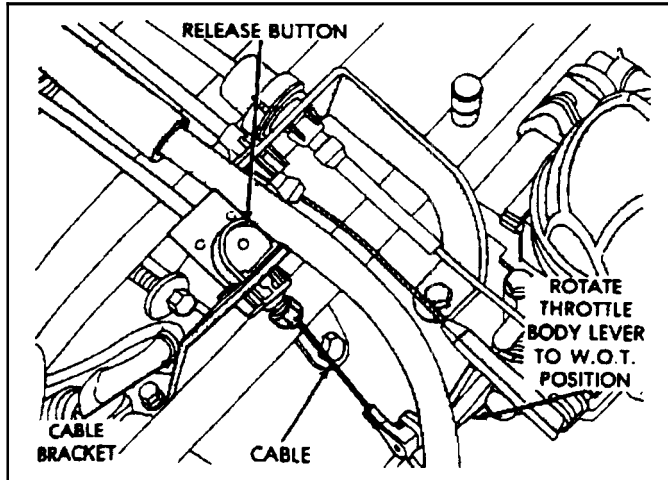


Figure 5 - 19

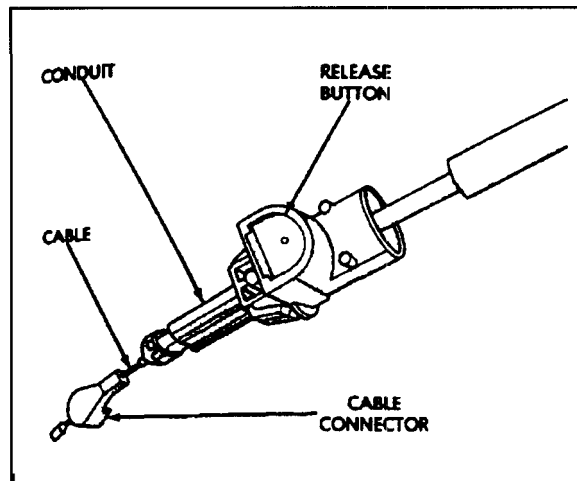


Figure 5 - 20

13. Install the fuel pump as follows:

- a. Jack up the rear of the vehicle and place on jack stands. From under the vehicle looking to the rear you will notice a crossmember in the frame above and behind the axle housing. On the driver's side of this crossmember you will notice a rubber block with three (3) flexible fuel lines emerging from it. The lines turn 90 degrees toward the frame and are connected to hard lines with clamps. On the flange of the crossmember are three (3) bolts that attach the fuel tank skid pan to the crossmember.

Note: (CJ Models Only): If you have a CJ with the fuel line running down the passenger side of the vehicle, jack up the rear of the vehicle and place on jack stands. From under the vehicle looking toward the rear, you will notice a crossmember in the frame where the skid plate for the gas tank is attached. On the driver's side of this crossmember you will notice the hard fuel lines coming through. The best way to mount the fuel filter and pump is as follows—with the fuel pump and filter in hand, use about 4 or 5 inches of the fuel hose supplied in the kit and connect the outlet side of the fuel filter to the inlet side of the fuel pump (use hose clamps on both connections). Now look at the existing hard fuel line on the vehicle. You will need to take off the small clamps holding the fuel line to the crossmember and to the passenger side frame rail. Once you have the fuel line free, use a small pipe cutter to cut the hard line close to the bend on the rear of the passenger frame rail. This is where the outlet side of the fuel pump will be attached with some of the supplied fuel hose. Now use the small pipe cutter to cut the fuel line at the rear crossmember before the hard line goes through the crossmember to the fuel tank. This is where the inlet side of the fuel filter is attached with the rest of the supplied fuel hose. Take the bolt in the center of the crossmember and the bolt closest to the passenger side frame rail out. Now mount the fuel pump and fuel filter assembly. Make sure that the fuel pump bracket nut is facing the front of the Jeep. Put the bolts you removed back in facing toward the ground. This will make them easier to tighten. The fuel pump is mounted on the passenger side bolt hole and the fuel filter is mounted in the center bolt hole.

Note: Look at the terminals on the fuel pump (before installing). There is a positive and negative terminal. Mark them so you can find the proper terminal when you wire them. They are hard to see after the pump is installed.

- b. Remove the center bolt.
 - c. Disconnect the center fuel line from its hard line at the clamp. Reconnect this flexible line to the outlet side of the new fuel pump.
 - d. Mount the fuel pump assembly to the crossmember flange using the nut and lock washer provided.
 - e. Connect the 5/16" flexible fuel line from the new fuel pump inlet to the outlet of the new fuel filter. Connect the inlet side of the fuel filter to the fuel tank outlet, in the same manner. This location of the fuel filter is important to keep debris from the tank out of the fuel pump. The fuel filter is not to be located downstream from the pump.
14. Install the new charcoal canister in the stock location and hook up the new vacuum lines. (Figure 5-21, Figure 5-22 and Figure 5-23.) Some engines will not use the plastic valve cover fittings. The many different valve covers have different PCV and fresh air fittings. Make sure to use the stock 258 PCV valve or orifice at one end of the valve cover and provide fresh air at the other end of the cover. It is important that the engine is ventilated properly to meet emissions and reduce oil leaks caused by crankcase pressure.

Note: This kit supplies a new mounting bracket for the charcoal canister. Do not get frustrated trying to make this bracket fit your vehicle. If the charcoal canister works better where the old canister mounted, just use the old canister mount. Try to get the new canister as far down as possible so there is room to mount the PCM (Powertrain Control Module).

15. Install the new Powertrain Control Module (PCM) right above the charcoal canister on the bulkhead with the supplied hardware. Figure 5-24 shows the computer being mounted vertically. If the computer will not fit vertically, you can mount the computer horizontally (Figure 5-25). If you mount the PCM horizontally, make sure that the connector plugs in toward the bottom of the PCM.

Note: Some models may vary in the space to mount the PCM, however, it should fit in this approximate location. **DO NOT OVER TIGHTEN SCREWS.**

16. Plug in the wiring harness to the PCM using the 60-pin connector. **DO NOT OVER TIGHTEN THE CONNECTOR!** Drape the harness over the top of the master cylinder, then around the back side of the engine.

Caution: THE HARNESS MUST NOT BE CLOSE TO THE EXHAUST; USE TIE WRAPS TO SECURE IT OVER THE MASTER CYLINDER (Figure 5-24).

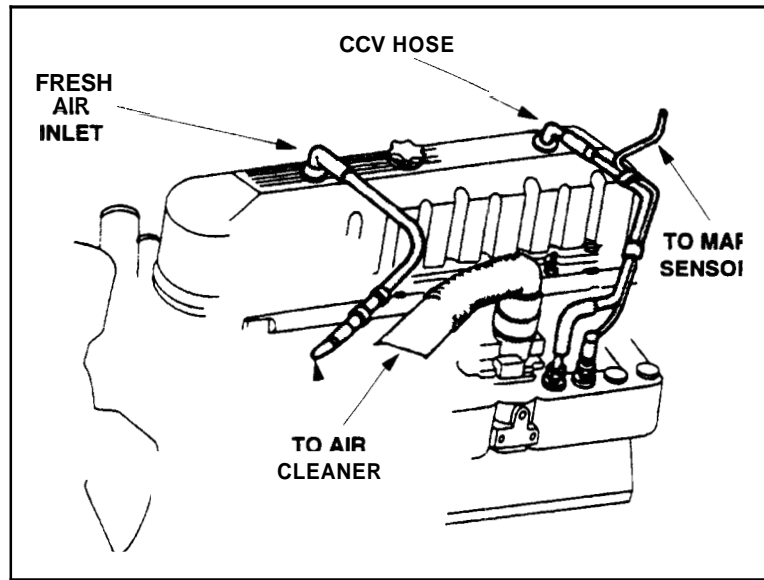


Figure 5 - 21

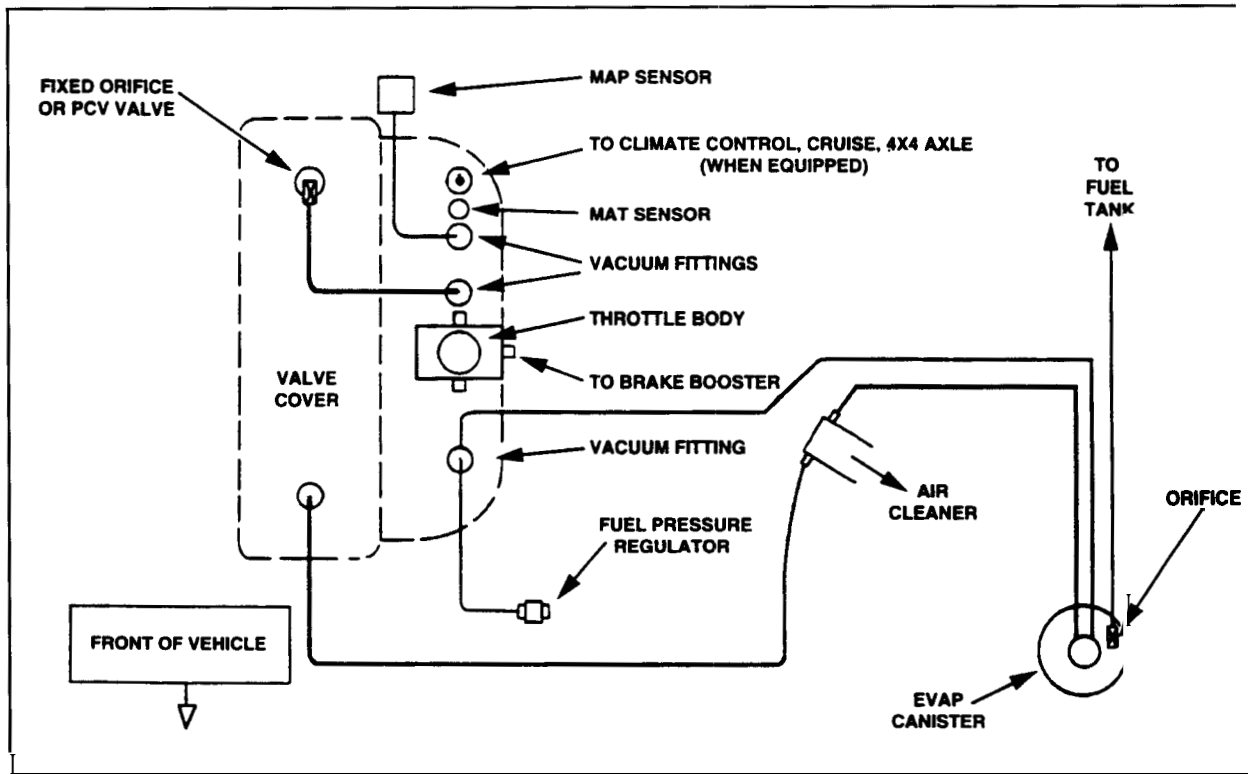


Figure 5 - 22

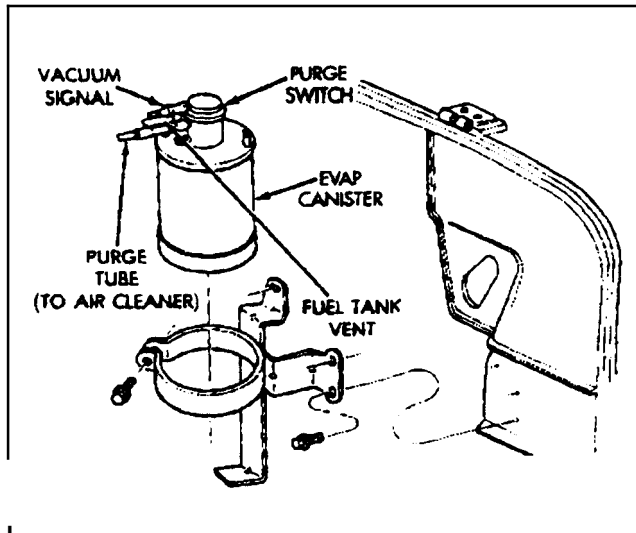


Figure 5 - 23

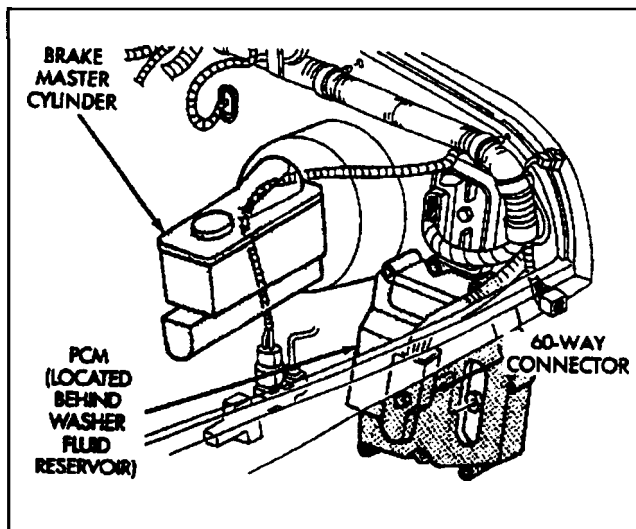


Figure 5 - 24

17. Find the two relays on the harness a short distance from the PCM. Mount them to the bulkhead with the screws provided. Note: Mount the relays with the wires pointed down. This is to prevent water build-up within the relays. The PCM may be mounted at any angle, however, do NOT mount it with the wire connector facing up. This would allow water to pool in the connector! The PCM is waterproof. The 60-pin connector is splash proof, but will not work when immersed in water.
18. Mount the MAP sensor to the bulkhead right behind the engine with the screws provided. Plug the green three (3) prong plug from the harness into the MAP sensor.

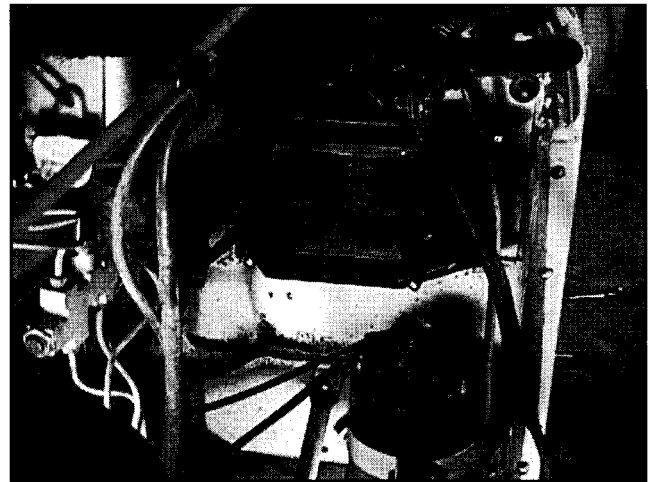


Figure 5 - 25

19. Route the harness down along the valve cover toward the front of the engine. Connect the fuel injectors. Each one is marked where it goes.
20. In the center of the harness between injector plugs #3 and #4 is a group of four plugs. Connect three (3) of these to the throttle body in their respective receptacles, and the fourth one to the Manifold Air Temperature (MAT) sensor (Figure 5-22).
21. In the harness at the front of the engine is another group of three (3) plugs. One of them is very long; this is the Oxygen Sensor plug. The three (3) prong plug in this group is the pickup sensor plug. The other (two prong) plug is the coolant sensor plug. These will only plug in to the correct sensors. Secure the cables with tie wraps provided. Make sure the pick up sensor connector is tied away from the exhaust manifold.
22. Bend the harness toward the passenger side of the Jeep® and down along the spark plug side of the head. The next plug is the ignition coil connection. Then comes the harness ground with the distributor plug. Connect the harness ground under the bolt that holds the dipstick tube to the engine block. (It has other ground wires on it. Do not remove any.) Connect the distributor.
23. Route the rest of the harness along the top of the transmission. The next plug will be the vehicle speed sensor. Route the remaining harness along the frame rail to the rear of the Jeep® to connect the fuel pump power (+) to the green wire with the black stripe. The ground wire is black with an orange stripe. Secure the harness all along its length in strategic locations with the tie wraps provided. Make sure that there is clearance between any moving parts or areas of high temperature, such as the vehicle exhaust. You may want to use dielectric grease on the connections to prevent corrosion (Mopar part number J8 126688).

24. To supply a switched 12 volt power supply to the two bulkhead mounted relays, locate the old positive (+) side coil wire (usually a yellow color). Connect this wire to the relay wire. Now connect the red relay wire to the starter relay, battery plus (+). The starter relay (also known as the starter solenoid) is usually located under the battery box or mounted on the fender panel. Mount the system fuse.

Note: Make sure that the switched 12 volt wire is not routed through a ballast resistor or resistance wire. Also make sure that 12 volts are present on this wire during cranking!

25. Install the 7.5 amp diode (supplied) in the field wire of the alternator. This is the smaller of the two wires, usually brown in color, that plugs into the alternator. Note—the field wire is a solid wire not a stranded wire. Cut the wire and install the diode with the pink crimp-on connector facing toward the alternator. It is imperative that this diode be in the field circuit to protect the new electronics.

26. You may wish to install a new windshield washer bottle and bracket. These can be obtained through your local Jeep/Eagle dealer. Washer bottle part number is 55 154744; bracket is 55026288. This washer bottle and bracket are supplied with this kit. You can mount this anywhere you would like, but the correct place to mount it is on the back side of the driver's side fender well. The fit is very tight but it does fit.

27. Install the new air filter and bracket. It attaches to the driver's side body support rod. Connect the two 1/2" hoses, from the aluminum connectors, to the valve cover vent and the fuel canister vent line. Note—the large flexible intake hose can be cut off to the length you need. In some vehicles, this flexible (CAT) hose is too long.

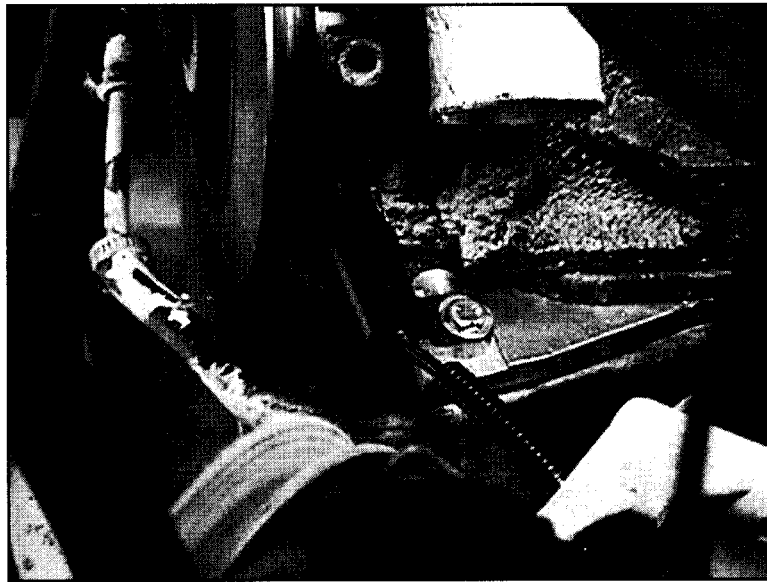


Figure 5 - 26

28. **OPTIONAL:** If you wish to install a tachometer or an engine light, the wires for these are already in the harness, located close to the relays. They will be hanging out of the harness. The tachometer wire is light gray with a yellow stripe. This is the tachometer trigger wire. The O.E. 1981-90 Jeep tachometer WILL NOT work with this system.

Note 1: In most cases the tach on the 1988-90 Wranglers will work with this MPI kit by connecting the tach wire to the negative side of the coil. The negative coil wire is gray or gray with a black tracer. The tach wire switches a 5V signal two times per engine revolution. Set your aftermarket tach on the 4-cylinder scale to achieve a true rpm reading. Some tachs will not work with this 5V signal, or they may have needle flutter at low rpm. If this is the case, you will have to splice into the coil negative side to operate your tach. If you hook up to the coil, use the 6-cylinder setting on your tach. The coil negative side wire is gray. (Hook up the tach last, after the engine is running, because some tachs have a low impedance and will short the coil to ground. This will not harm anything, but will prevent the engine from running.)

Note 2: Earlier year models will have to purchase an aftermarket tach like P4529160—a 4-6-8 tach. Follow the tach instructions for installation. If the check engine light comes on, please call the Mopar Performance Technical Assistance Hotline at 1-248-969-1690.

29. The “check engine light” wire runs directly to the PCM. The PCM grounds this wire to turn on a light to display fault codes (Figure 5-27).

The light bulb holders are available at any local electronics supply.

30. On automatic transmission Jeeps, the brown wire that is coiled near the PCM connector must be connected to the neutral safety switch. This wire can be connected to the bottom of the starter relay, or to the center terminal on the neutral safety switch. On Chrysler automatics, this is the center terminal. If you choose to connect it to the starter relay, make sure that the terminal is for the neutral start switch. It should be grounded in park and neutral. This wire is for improved idle quality when in “Drive.”



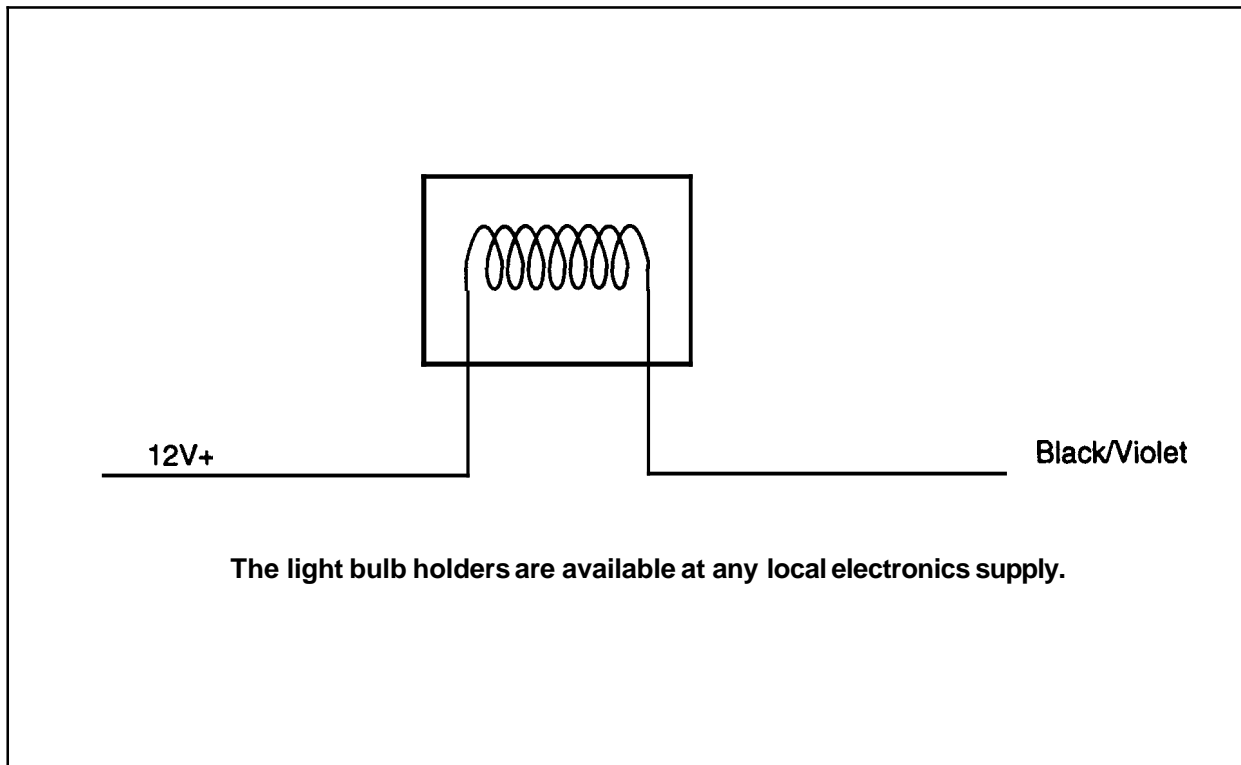


Figure 5 - 27

31. Reconnect the battery and turn on the ignition key. You should hear the electric fuel pump run for a few seconds and then shut off. Start the engine and **IMMEDIATELY CHECK FOR FUEL LEAKS**. Depending on the ambient temperature, the idle rpm may be high initially, and decrease as the engine warms up. This is normal! **DO NOT** try to adjust the rpm by changing the opening of the throttle blade. Test Drive! Recheck all connectors and fuel lines!
32. Be sure to apply the CARB E.O. decal supplied in the kit in a visible location under the hood.

Troubleshooting Notes

The following hints we have found to be useful:

1. This system is the same as used on the 1994 4.0L Wrangler. If you need service parts or are checking fault codes, refer to the *1994 Jeep® Wrangler Service Manual*. The wiring is also the same as a 1994 Wrangler in function and color. You may call 1-800-626-1523 to order a service manual.
2. The crankshaft sensor is very sensitive. Make sure it is solidly mounted. Make sure that your engine does not have too much crankshaft end play. The paper button on the sensor will wear off with use of the engine.
3. The distributor should not be turned to change timing. It will not. The distributor is set to have the rotor tip .020" past #1 spark plug terminal with the engine at TDC.

4. The fuel return line to the tank must be unrestricted. Check this carefully before you hook up the return hose.
5. You may see fault codes for charging system too high or too low. This is normal and should be ignored.
6. The PCM does take some time (15-30 minutes) after first use to "learn" the best settings for your engine. You will notice better idle quality and acceleration after this learning period. For this reason, the battery should be left connected if this vehicle is to be driven daily. If you use a kill switch, do not interrupt the B+ circuit or the PCM will need to "re-learn" every time you start the engine.

Special Note: If your engine has been rebuilt and the compression has been raised too far above stock, then you are probably going to experience some detonation. Installing headers, too large a camshaft, bigger valves, excessive porting or a combination of the above will also create a detonation problem that cannot be adjusted out through the computer.

If you have questions or experience problems, call the Mopar Performance Technical Assistance Hotline for assistance at 1-248-969-1690.

Ignition System

SOLID STATE IGNITION SYSTEM

A Solid State Ignition (SSI) system is used on the 4.2L six-cylinder engine. The SSI system is controlled by the engine Micro-Computer Unit. The SSI system consists of the following components:

- Ignition module
- Ignition coil
- Resistance wire
- Distributor
- Knock sensor
- Distributor cap and rotor
- Spark plugs and wires

System Operation

The ignition module is activated by the MCU when the ignition switch is in the START or ON position. The primary circuit is closed and current flows through the coil primary winding. When the engine begins turning the distributor, the trigger wheel teeth rotate past the pickup, coil assembly. As each tooth aligns with the pickup coil, the resulting pulse triggers the MCU which in turn signals the ignition module which closes the primary circuit. A high voltage is then induced in the coil secondary winding and current flows to the distributor cap and rotor. The rotor connects the high voltage to the proper spark plug. The timing of the ignition is constantly changed by the MCU, and vacuum and centrifugal advance mechanisms according to engine operation.

Ignition Advance

Centrifugal (mechanical) advance is controlled by engine speed. Flyweights connected to the distributor shaft are thrown outward by centrifugal force. Higher engine rpm throws the weights further out. Calibrated rate springs are used to control this movement. The outward motion of the flyweights causes the rotor and trigger wheel to be advanced on the distributor shaft several degrees in the direction of normal rotation. This is referred to as centrifugal ignition advance.

When the engine is operating under light load, the carburetor throttle plates restrict airflow, causing a relatively lean mixture to enter the combustion chambers. Ignition must occur earlier because the lean mixture requires a longer time to burn. The vacuum ignition advance mechanism is used for this purpose. When carburetor ported or manifold vacuum is high, the vacuum advance mechanism moves the pickup coil assembly several degrees opposite to the direction the distributor is

rotating. This causes the pickup coil to react to the presence of the trigger wheel teeth earlier. This process is referred to as vacuum ignition advance. With low vacuum operating conditions, such as wide open throttle acceleration, a spring in the vacuum advance mechanism pushes the pickup coil back to a position of zero advance.

IGNITION SYSTEM COMPONENTS

Micro-Computer Unit (MCU)

The 4.2L engine's ignition system is controlled by the Micro-Computer Unit (MCU). The MCU monitors various engine sensors that indicate engine operating conditions. One of these inputs originates from the distributor and represents engine speed which is used to determine ignition timing. The MCU processes ignition signals and then sends them to the ignition module. By modifying the signal it sends to the ignition module, the MCU can retard ignition timing in response to the various inputs it receives. The MCU also controls air-fuel ratio and the pulse air system.

The MCU is a completely sealed module which is located behind the glove box next to the radio. It is not repairable and must be replaced as a unit if service is required.

Inputs:

- Coolant temperature switch
- Thermal electric switch
- Four and ten inch Hg vacuum switches
- Oxygen (O₂) sensor
- Wide open throttle (W.O.T.) switch
- Knock sensor
- Distributor

Outputs:

- Stepper motor
- Idle relay
- Sole-vac throttle positioner
- Upstream and downstream solenoids
- PCV solenoid

Ignition Module

The electronic ignition module is located in the engine compartment behind the bottom of the radiator overflow bottle. It is a permanently sealed, solid state module that is not repairable and must be replaced as a unit if service is required.

The Micro-Computer Unit (MCU) controls ignition coil operation through the ignition module. The MCU processes the ignition signals it receives and then sends a signal to the ignition module. The ignition module then interrupts the primary circuit to the ignition coil causing spark to occur. Dwell is adjusted automatically.

Note: When disconnecting SSI system connectors, pull them apart with a firm, straight pull. DO NOT attempt to pry them apart with a screwdriver. When connecting them, press together firmly to overcome hydraulic pressure caused by the silicone dielectric compound. If the connector locking tabs weaken or break off, DO NOT replace the associated component. Bind the connectors together with tape or a harness tie strap to assure good electrical connection.

Ignition Coil

The ignition coil is mounted to the engine block next to the distributor. Coil operation is dictated by the ignition module which is controlled by the MCU maintaining the terminals and connectors.

When an ignition coil is suspected of malfunctioning, test it on the vehicle. A coil may “break down” after the engine has heated it to a high temperature. It is important that the coil be at operating temperature when tested. Perform the test according to the test equipment manufacturer’s instructions.

Ignition Coil Connector

The ignition coil terminals and connector are of unique design. The connector is removed from the coil by grasping both sides and pulling away from the coil.

When a tachometer is required for engine testing or tune-up, connect it using an alligator jaw type connector.

Resistance Wire

A wire with 1.35 ohms resistance is provided in the ignition wiring to supply less than full battery voltage to the ignition coil after the starter motor solenoid is de-energized. During engine starting, the resistance wire is bypassed and full battery voltage is applied to the ignition coil. The bypass is accomplished at the I-terminal on the starter motor solenoid.

Distributor

The distributor used with the 4.2L engine is equipped with centrifugal and vacuum assisted advances. Ignition timing is controlled through the engine Micro-Computer Unit (MCU).

The distributor consists of three groups of components: pickup coil and trigger wheel, ignition advance mechanisms, cap and rotor. The distributor drive gear is installed in the distributor shaft and meshes with a spiral cut gear on the camshaft. The end of the distributor shaft is flattened and fits into a slot in the top of the oil pump and provides the force to drive the oil pump.

Pickup Coil and Trigger Wheel

The ignition coil primary circuit is opened and closed electronically by the ignition module. The distributor pickup coil and trigger wheel provide the input signal for the MCU.

The trigger wheel, which is installed on the distributor shaft, has one tooth for each engine cylinder. The wheel is mounted so that the teeth rotate past the pickup coil one at a time.

The pickup coil has a magnetic field that is intensified by the presence of ferrous metal (contains iron—can be picked up with an ordinary magnet). The pickup coil reacts to the trigger wheel teeth as they pass. As a trigger wheel tooth approaches and passes the pole piece of the pickup coil, it reduces the reluctance (compared to air) to the magnetic field and increases field strength. Field strength decreases as the tooth moves away from the pole piece. This increase and decrease of field strength induces an alternating current (pulse) into the pickup coil, which triggers the MCU, which in turn signals the ignition module. The control unit opens and closes the coil primary circuit according to the position of the trigger wheel teeth.

There aren’t any contacting surfaces between the trigger wheel and pickup coil assembly. The dwell angle is determined electronically by the control unit and is not adjustable. When the ignition coil primary circuit is switched open, the MCU sends a signal to the ignition module that starts an electronic timer in the ignition module which keeps the coil primary only long enough for the electromagnetic field within the coil to collapse and the voltage to discharge. The ignition module then automatically closes the coil primary circuit. The period of time the circuit is closed is referred to as dwell.

Cap and Rotor

The central tower on the distributor cap is connected directly to the high voltage at the coil. The current flows through the spring-loaded contact on the rotor to the carbon button in the cap. The rotor tip aligns with a contact in the cap that corresponds to the cylinder to be ignited just as the ignition coil output high voltage is applied to the rotor. In this way, each spark plug is “fired” in turn.

A unique feature of the SSI is the silicone applied to the rotor blade during the manufacture. Radio interference is greatly reduced by the presence of a small quantity of silicone dielectric compound on the rotor blade. After a few thousand miles, this compound becomes charred by the high voltage current flowing through the rotor. This condition is normal. DO NOT scrape residue from the rotor blade.

When installing a replacement rotor, apply a thin coat 0.75-3.0 mm (0.03-0.12”) of silicone dielectric compound to the tip of the rotor blade.

IGNITION SYSTEM TIMING

A graduated timing degree scale located on the timing case cover is used for reference when timing the ignition system.

A milled index notch on the vibration damper is used to align the No. 1 cylinder ignition position of the crankshaft with the correct timing degree mark on the graduated scale.

Magnetic Timing Probe

A magnetic timing probe socket is provided and is integral with the timing degree scale for use with a special magnetic timing probe. This special probe detects the milled notch on the vibration damper. The probe is inserted through the probe socket until it contacts the vibration damper.

Ignition timing can then be obtained from a meter or computer printout, depending on the type of equipment being used.

The probe socket is located at 9.5° ATDC, and the equipment is calibrated to compensate for this location.

DO NOT use the timing probe socket as a reference to check the ignition timing when using a conventional timing light.

Ignition Timing Procedure

The ignition timing can be adjusted according to the following primary timing procedure.

1. Set the parking brake. Shift automatic transmissions to PARK and manual transmissions to the NEUTRAL position.
2. Start the engine and allow it to attain normal operating temperature. Ensure that the A/C is turned OFF, if equipped.
3. With the ignition switch OFF, connect an ignition timing light and a tachometer. (If the timing light has an adjustable advance control feature, turn the control to the OFF position.)
4. Disconnect the 4" and 10" Hg (CEC System) vacuum switch assembly wire connectors (located at the top of the cylinder head cover).
5. Disconnect and plug the distributor vacuum advance hose.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or the fan. DO NOT wear loose clothing.

6. Start the engine.
7. Increase the engine speed to 1,600 rpm and check ignition timing. If necessary, adjust the timing to the specifications listed on the Emission Control Information label. Also, refer to the ignition advance curve illustrations found in your vehicle's service manual.
8. Tighten the distributor hold-down clamp and verify that the ignition timing is correct.

9. Turn the engine OFF and remove the timing light and tachometer.
10. Connect the No. 1 spark plug wire, if disconnected. Connect the hose to the distributor vacuum advance mechanism. Connect the wire connector to the vacuum switch assembly.

Note: Ignition timing can also be adjusted according to the following alternate procedure.

Alternate Timing Procedure

This alternate timing procedure does not require engine speed be increased to 1,600rpm.

1. Set the parking brake.
2. Shift automatic transmissions to PARK and manual transmissions to the NEUTRAL position.
3. Start the engine and allow it to attain normal operating temperature. Ensure that the A/C is turned OFF, if equipped.
4. With the ignition switch OFF, connect an ignition timing light and a tachometer. (If the timing light has an adjustable advance control feature, turn the control to the OFF position.)
5. Disconnect the 4" Hg vacuum switch hose (located at the top of the cylinder head cover) and plug the hose opening. (The 4" Hg vacuum switch has black and red wires connected to it.)
6. Disconnect the distributor vacuum advance hose and connect the hose to the 4" Hg vacuum switch.
7. Disconnect the knock sensor wire connector and connect the wire connector to the cylinder block (GROUND) with a jumper wire.

Grounding the knock sensor wire connector prevents electromagnetic interference (EMI) from causing erroneous reactions by the fuel feedback system micro-computer unit (MCU).

8. Start the engine.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan., DO NOT put your hands near the pulleys, belts or the fan. DO NOT wear loose clothing.

9. With the engine at idle speed, check the timing. If necessary, adjust the timing one degree higher than the specifications listed on the Emission Control Information label. Also, refer to the ignition advance curve illustrations.

Note: With the alternate timing procedure, the basic timing must be one degree higher than the specification listed on the Emission Control Information label. For example, if the timing specification is listed as 6" ($\pm 2^\circ$) at 1,600rpm, the alternate procedure requires 7" ($\pm 2^\circ$) at idle speed.

SPARK PLUG SPECIFICATIONS

<u>ENGINE</u>	<u>SPARK PLUG TYPE</u>	<u>ELECTRODE GAP</u>	<u>TIGHTENING TORQUE</u>
4.2L	RFN-14LY	(0.035 in.)	37 N•m (27 ft-lbs)

Mopar Performance Parts Spark Plugs		
NEW! These spark plugs are specifically designed for the optimum performance of your Mopar engine. Each package contains 4 spark plugs.		
Race & Tuning Application Plugs (J-Strap Type)		
Pack P/N	Cross Reference	Application
P4876939	C 63C	All except 'B-RB' engines
P4876940	C 61C to C 59C	All except 'B-RB' engines
P4876941	C 57c to C 55C	All except 'B-RB' engines
P4876942	C 53c to C 51C	All except 'B-RB' engines
P4876943	C 51C	All except 'B-RB' engines
P4876944	C 61C to C 59C	All except 'B-RB' engines
P4876945	C 57c to C 55C	All except 'B-RB' engines
Pack P/N	Cross Reference	Application
P4876928	C 61C to C 59C	All Race Applications
P4876929	C 57c to C 55C	All Race Applications
P4876930	C 53C to C 51C	All Race Applications
P4876931	C 51C	All Race Applications
P4876932	S 61C to S 59C	All Race Applications
P4876933	S 57c to S 57c	All Race Applications
P4876934	S 53C to S 51C	All Race Applications
P4876935	S 51C	All Race Applications
Note: C type plugs have 3/4 inch reach with flat seat and crush gasket. S type plugs have 3/4 inch reach with tapered seat.		

SSI DISTRIBUTOR AND IGNITION COIL SPECIFICATIONS

DISTRIBUTOR PICKUP COIL	
RESISTANCE	400 to 800 OHMS @ 24°C (75°F)
IGNITION COIL	
PRIMARY RESISTANCE	1.13 to 1.23 OHMS @ 24°C (75°F) 1.5 OHMS @ 93°C (200°F)
SECONDARY RESISTANCE	7700 to 9300 OHMS @ 24°C (75°F) 12,000 OHMS @ 93°C (200°F)
MINIMUM OPEN CIRCUIT OUTPUT	
AT 1,000 RPM.....	24KV
SPARK PLUGS	
REQUIRED VOLTAGE AT 100 RPM	5 TO 16KV
MAXIMUM VARIATION BETWEEN CYLINDERS	3 TO 5KV





MOPAR PERFORMANCE PARTS ELECTRONIC IGNITION COMPONENTS

High Performance Electronic Control Units

For a hotter spark and more rpm capability, use one of Mopar Performance Parts' high performance ECUs. For general high performance and usage up through 6,000 rpm, use the Orange **Box** ECU. For higher rpm output requirements up through 8,000, select the Chrome Box ECU.

P4120505 Orange **Box** ECU.

P4120534 Chrome **Box** ECU.

Super Gold Electronic Control Unit

The Super Gold Electronic Control Unit is the culmination of eight years of high performance ignition systems development. Designed to out perform any ignition unit previously offered to Mopar racers, it will handle the high current demand by the P3690560 (Accel) high performance coil, while keeping dwell variation to less than 1" from 1,000 to 10,000 rpm. Dwell is set for maximum spark output at low and high engine speeds. The Super Gold ECU provides outstanding performance from idle to 12,000 rpm.

P4120600 Super Gold ECU—race only.

Ballast Resistor—Electronic Distributor

P2444641 Use with mechanical advance distributor using P3690560 coil. 1/4 Ohm.

P5206436 Use with electronic ignition systems using P4120505 Orange Box ECU and production coil, or with P4120889 coil. 1 Ohm.

Ignition Coils

P4120889 Accel Super Coil for all 12-volt applications. Not recommended for engine speeds over 6,500 rpm. (Use with ballast resistor P5206436.)

P.3690560 Accel Race Coil specifically designed to be used with race electronic ignition kits. Designed for racing applications only. Not recommended for continued operation at speeds below 3,000 rpm for more than 30 minute periods. (Use with ballast resistor P2444641.)

Control Wiring Harness Kit for Electronic Ignitions

Kit used to convert to a new electronic ignition system.

P3690152 Control wiring harness kit for electronic ignitions.

Chrome Ignition Coil Bracket

Another underhood piece to dress-up your engine compartment. Includes special clamp screw.

P4286728 Chrome ignition coil bracket.

Tach Adapter

Designed for applications when high capacitive discharge coils interfere with tachometer or fuel injection signals. This device provides a clear 12 volt square wave signal output with a 30% duty cycle.

P4876738 Tach adapter.

Engine Assembly

Note: For engine assembly information, performance modifications and tips, refer to 'Engine Assembly' section of Chapter 4, *4.0L Power Tech In-Line 6*.

1981, 4.2L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the *1981 Jeep Service Manual*.

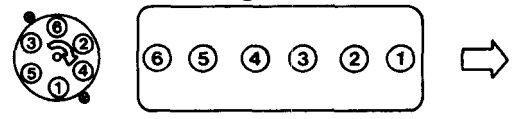
	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Type	In Line, OHV, Six-Cylinder			
Bore	3.75	95.25		
Stroke				
258	3.895	98.93		
Displacement	258 cubic inches 4.2 liters			
Compression Ratio	8.0: 1			
Compression Pressure				
258	120-150 psi	827-1034 kPa		
Maximum Variation Between Cylinders	30 psi	206 kPa		
Firing Order	1-5-3-6-2-4			
Taxable Horsepower	33.75 Bhp	25.2 kW		
Fuel	unleaded			
Camshaft				
Fuel Pump Eccentric Diameter	1.615-1.625	41.0241-28		
Tappet Clearance	Zero Lash (Hydraulic tappets)			
End Play	Zero (engine operating)			
Bearing Clearance	0.001-0.003	0.025-0.076		
Bearing Journal Diameter				
No. 1	2.029-2.030	51.54-51.56		
No. 2	2.019-2.020	51.28-51.31		
No. 3	2.009-2.010	51.03-51.05		
No. 4	1.999-2.000	50.78-50.80		
Base Circle Runout	0.001 (max)	0.03 (max)		
Cam Lobe Lift	0.253	8.43		
Intake Valve Timing				
Opens	9° BTDC			
Closes	73° ABDC			
Exhaust Valve Timing				
Opens	57° BBDC			
Closes	25° ATDC			
Valve Overlap	34°			
Intake Duration	262°			
Exhaust Duration	262°			
Connecting Rods				
Total Weight (less bearings)	258 695-703 grams			
Total Length (center-to-center)				
258	5.873-5.877	149.17-140.28		
Connecting Rod Bore (less bearings)	2.2085-2.2080	56.09-56.08		
Bearing Clearance	0.001-0.0025	0.03-0.06		
	(0.0015-0.002 preferred)	(0.044 preferred)		
Side Clearance	.010-.019			
Maximum Twist	0.001 per inch			
Maximum Bend	0.0005	0.0127	per inch	25.4 mm
Crankshaft				
End Play	0.0015-0.0065			
Main Bearing Journal Diameter	2.4986-2.5001	63.464-63.502		
Main Bearing Journal Width				
No. 1	1.086-1.098	27.58-27.89		
No. 3	1.271-1.273	32.28-32.33		
No. 2-4-5-6-7	1.182-1.188	30.02-30.18		
Main Bearing Clearance				
No. 1 Main	.0005 to .0026 (.0015 preferred)	.013 to .066 (.04 preferred)		
No. 2, 3, 4, 5, & 6 Mains	.0005 to .003 (.0017 preferred)	.013 to .076 (.045 preferred)		
No. 7 Main	.0011 to .0035 (.0023 preferred)	.028 to .089 (.058 preferred)		
Connecting Rod Journal Diameter	2.0934-2.0955			
Connecting Rod Journal Width	1.070-1.076			

60263A

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified		(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Maximum Out-of-Round (All Journals)	0.0005	0.013	Piston Ring Gap Clearance — Oil Control Steel Rails	0.010-0.025	0.25-0.64
Maximum Taper (All Journals)	0.0005	0.013	Piston Ring Side Clearance No. 1 Compression	0.0017-0.0032 (0.0017 preferred)	0.043-0.081 (0.043 preferred)
Cylinder Block			No. 2 Compression	0.0017-0.0032 (0.0017 preferred)	0.043-0.081 (0.043 preferred)
Deck Height	9.487-9.493	240.97-241.12	Oil Control	0.001-0.008 (0.003 preferred)	0.03-0.20 (0.08 preferred)
Deck Clearance	0.0148 (below block)	0.376 (below block)	Piston Ring Groove Height Compression (both)	0.0795-0.0805	2.019-2.045
Cylinder Bore (standard)	3.7501-3.7533	95.253-95.334	Oil Control	0.188-0.1895	4.78-4.80
Maximum Cylinder Taper	0.005	0.13	Piston Ring Groove Diameter No. 1 and No. 2	3.324-3.329	84.43-84.56
Maximum Cylinder (Out-of-Round)	0.003	0.08	Oil Control	3.329-3.339	84.56-84.81
Tappet Bore Diameter	0.9055-0.9065	23.0-23.025	Piston Pin Bore Diameter	0.9308-0.9313	23.642-23.655
Cylinder Block Flatness	0.001/1-0.002/6 (max)	0.03/25-0.05/152 (max)	Piston Pin Diameter	0.9304-0.9309	23.632-23.645
Cylinder Head			Piston Pin-to-Clearance	0.0003-0.0005 loose	0.008-0.013 loose
Combustion Chamber Volume	67.84-70.84cc		loose	(0.0005 preferred)	(0.013 preferred)
Valve Arrangement	E-I-E-I-E-E-I-E-I-E		Piston Pin-to-Connecting Rod	2000 lbf press-fit	8.900 kN press-fit
Valve Guide ID (Integral)	0.3735-0.3745	9.487-9.512	Rocker Arms, Push Rods and Tappets		
Valve Stem-to-Guide Clearance	0.001-0.003	0.03-0.08	Rocker Arm Ratio	1.6:1	
Intake Valve Seat Angle	30°		Push Rod Length	9.640-9.660	244.856-245.364
Exhaust Valve Seat Angle	44.50		Push Rod Diameter . . . . .	.312-.315	7.92-8.00
Valve Seat Width	0.040-0.060	1.02-1.52	Hydraulic Tappet Diameter	0.904-0.9045	22.96-22.97
Valve Seat Runout	0.0025	0.064	Tappet-to-Bore Clearance	0.001-0.0025	0.03-0.05
Cylinder Head Flatness	0.001/1-0.002/6 0.008(max)	0.03/25-0.05/152 0.20(max)	Valves		
Lubrication System			Valve Length (Tipto-Gauge Dim. Line)	4.78954-8.045	121.653-122.034
Engine Oil Capacity	4 quarts (Add 1 quart with filter change)	3.8 liters (Add 0.9 liter with filter change)	Valve Stem Diameter	0.3715-0.3725	9.436-9.462
Normal Operating Pressure	13psi at 600 rpm; 37-75 psi (max) at 1600+ rpm	89.6 kPa at 600 rpm; 255.1-517.1 kPa (max) at 1600+ rpm	Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
Oil Pressure Relief	75 psi (max)	517.1 kPa (max)	Intake Valve Head Diameter	1.782-1.792	45.26-45.52
Gear-to-Body Clearance Radial . . . . .	.002-.004 (.002 preferred)	.051-.102 (.051 preferred)	Intake Valve Face Angle	29°	
Gear End Clearance, Plastigage	0.002-0.006 (0.002 preferred)	0.0510-.152 (0.0508 preferred)	Exhaust Valve Head Diameter	1.401-1.411	35.59-35.84
Gear End Clearance, Feeler Gauge	0.004-0.008 (0.007 preferred)	0.10160-.2032 (0.1778 preferred)	Exhaust Valve Face Angle	44°	
Pistons			Maximum Allowable Removed for Tip Refinishing	0.010	0.25
Weight (less pin)	498-502grams		Valve Springs, Exhaust		
Piston Pin Bore Centerline-to-Piston TOP	1.651-1.655	41.94-42.04	Valve Open	80-88 at 1.625	
Piston-to-Bore Clearance	0.0009-0.0017 (0.0012-0.0013 preferred)	0.023-0.043 (0.030-0.033 preferred)	Valve Closed	210-226 at 1.188	
Piston Ring Gap Clearance — Compression (both)	0.010-0.020	0.25-0.51	I.D.	1.000-1.020 in.	
			Valve Springs, Intake		
			Free Length	1.99 approx.	50.55 approx.
			Spring Tension		
			Valve Closed	64-72 lbf at 1.786	285-320 N at 46.24
			Valve Open	188-202 lbf at 1.411	836-898 N at 35.84
			Inside Diameter	0.948-0.968	24.08-24.59

602638

Six-Cylinder Engine Firing Order



1981, 4.2L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the 1981 *Jeep Service Manual*.

Torque Specifications

Service Set-To Torques should be used when assembling components. **Service In-Use Recheck Torques** should be used for checking a pre-torqued item.

	USA (ft-lbs)		Metric (N·m)	
	service Set-To Torque	Service In-Use Recheck Torque	service Set-To Torque	Service In-Use Recheck Torque
Air Injection Tube-to-Manifold	20	15-20	27	20-27
Air Pump Adjusting Strap-to-Pump	20	15-22	27	20-30
Air Pump Brackets-to-Engine (A/C Compressor or Pedestals)	25	18-28	34	24-38
Air Pump-to-Bracket	20	15-22	27	20-30
Alternator Adjusting Bolt	18	15-20	24	20-27
Alternator Mounting Bracket-to-Engine	28	23-30	38	31-41
Alternator Pivot Bolt or Nut	28	20-35	38	27-47
Alternator Pivot Mounting Bolt-to-Head	33	30-35	45	41-47
Block Heater Nut	20 in-lbs	17-25 in-lbs	2	2-3
Camshaft Sprocket Screw	50	45-55	68	61-75
Carburetor Hold-Down Nuts	14	12-20	19	16-27
Clutch Housing Spacer to Block Screws	12	9-15	16	12-20
Clutch Housing-to-Block Screws (bottom)	43	37-47	58	50-64
Clutch Housing-to-Block Screws (top)	27	22-30	37	30-41
Coil Bracket-to-cylinder Head	14	10-18	19	14-24
Connecting Rod Bolt Nuts	33	30-35	45	41-47
Crankshaft Pulley-to-Damper Bolts	20	15-25	27	20-34
Cylinder Head Capscrews	85	80-90	115	108-122
Cylinder Head Cover Nuts	28 in-lbs	25-31 in-lbs	32	2.8-3.5
Distributor Clamp Bracket Screw	13	10-18	18	14-24
EGR Valve	13	9-18	18	12-24
Exhaust Manifold Bolts	23	18-28	31	24-38
Exhaust Pipe-to-Manifold	20	15-25	27	20-34
Fan and Hub Assembly Bolts	18	12-25	24	16-34
Drive Plate-to-converter Screw	22	20-25	30	27-34
EGR Tube Nuts	30	25-35	41	34-47
Flywheel or Drive Plate-to-crankshaft	105	95-115	142	129-156
Front Support Bracket-to-Block Screw	35	25-40	47	34-54
Front Support Cushion-to-Bracket	33	27-38	45	36-52
Front Support Cushion-to-Bracket-to-Frame	37	30-45	50	41-61
Fuel Pump Screws	16	13-19	22	18-26
Idler Arm Bracket-to-Sill	50	35-60	68	47-81
Idler Pulley Bracket-to-Front Cover Nut	7	4-9	9	5-12
Idler Pulley Bearing Shaft-to-Brecker Nut	33	26-38	45	38-52
Intake Manifold Coolant Fittings	20	15-25	27	20-34
Intake Manifold Heater Screws	7	5-9	9	7-12
Intake Manifold Screws	23	18-28	31	24-38
Main Bearing Capscrews	80	75-85	108	101-115
Oil Filter Adapter	48	42-55	65	57-75
Oil Pan Drain Plug	30	25-35	41	34-47
Oil Pan Screws—1/4 inch—20	7	5-9	9	7-12
Oil Pan Screws—5/16 inch—16	11	9-13	15	12-18
Oil Pump Attaching Screws (Long)	17	12-20	23	16-27
Oil Pump Attaching Screws (Short)	10	8-13	14	11-18
Oil Pump Cover Screws	70 in-lbs	60-80 in-lbs	8	7-9
Oxygen Sensor	35	32-38	48	43-52
Power Steering Pump Adapter Screw	23	18-28	31	24-38
Power Steering Pump Bracket Screw	43	37-47	58	50-64
Power Steering Pump Mounting Screw	28	25-35	38	34-47
Power Steering Pump Pressure Line Nut	38	30-45	52	41-61
Power Steering Pump Pulley Nut	58	40-65	79	54-88
Rear Crossmember-to-aidle Sill Nut	30	20-35	41	27-47
Rear Support Bracket-to-Transmission	33	27-38	45	37-52
Rear Support Cushion-to-Bracket	48	40-55	65	54-75
Rear Support Cushion-to-Crossmember	18	12-25	24	16-34
Rocker Arm Assembly-to-Cylinder Head	19	16-26	26	22-35
Sparkplug	11	7-15	15	10-20
Starter to Converter Housing Bolt	18	13-25	24	18-34
Thermostat Housing Screw	13	10-18	18	14-24
Timing Case Cover-to-Block Screws	5	4-8	7	5-11
Timing Case Cover-to-Block Studs	16	13-19	22	18-26
Vibration Damper Screw. Lubricated.	80	70-90	108	95-122
Water Pump Screws	13	9-18	18	12-24

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.

Refer to the Standard Torque Specifications and Capscrew Markings Chart in Chapter A of this manual for any torque specifications not listed above.

1990, 4.2L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the *1990 Jeep Wrangler Service Manual*.

<u>Camshaft</u>		
Tappet Clearance	zero lash (hyd.) tappets	
End Play	zero (engine operation)	
Bearing Clearance	0.025-0.076 mm	0.001-0.003 in.
Bearing Journal Diameter		
No. 1	51.54-51.56 mm	2.029-2.030 in.
No. 2	51.28-51.31 mm	2.019-2.020 in.
No. 3	51.03-51.05 mm	2.009-2.010 in.
No. 4	50.78-50.80 mm	1.999-2.000 in.
Base Circle Runout	0.03 mm max.	0.001 in. max.
Cam Lobe Lift	6.43 mm	0.253 in.
Valve Life	10.29 mm	0.405 in.
Intake Valve Timing		
Opens	9° BTDC	
Closes	73° ABDC	
Exhaust Valve Timing		
Opens	57° BBDC	
Closes	25° ATDC	
Valve Overlap	34°	
Intake Duration	262°	
Exhaust Duration	262°	
<u>Connecting Rods</u>		
Total Weight (less bearings)	695-703 grams	24.5-24.9 oz.
Total length (center-to-center)	149.17-149.28 mm	5.873-5.877 in.
Piston Pin Bore Diameter	23.59-23.62 mm	0.9288-0.9298 in.
Connecting Rod Bore (less bearings)	56.08-56.09 mm	2.2080-2.2085 in.
Bearing Clearance	0.03-0.08 mm	0.001-0.0025 in.
Preferred	0.044-.050 mm	0.0015-0.0020 in.
Side Clearance	0.25-0.48 mm	0.010-0.019 in.
Maximum Twist	0.025 per 25.4 mm	0.001 per in.
Maximum Bend	0.0127 per 25.4 mm	0.005 per in.
<u>Crankshafts</u>		
End Play	0.038-0.165 mm	0.0015-0.0065 in.
Main Bearing Journal Diameter	63.489-63.502 mm	2.4996-2.5001 in.
Main Bearing Journal Width		
No. 1	27.58-27.89 mm	1.086-1.098 in.
No. 2	32.28-32.33 mm	1.271-1.273 in.
No. 3-4-5-6-7	30.02-30.18 mm	1.182-1.188 in.
Main Bearing Clearance	0.03-0.06 mm	0.001-0.0025 in.
Preferred	0.051 mm	0.002 in.
Connecting Rod Journal Diameter	53.17-53.23 mm	2.0934-2.0955 in.
Connecting Rod Journal Width	27.18-27.33 mm	1.070-1.076 in.
Maximum Out-of-Round (All Journals)	0.013 mm	0.0005 in.
Maximum Taper (All Journals)	0.013 mm	0.0005 in.

<u>Cylinder Block</u>		
Deck Height	240.97-241.12 mm	9.487-9.493 in.
Deck Clearance (below deck)	0.376 mmi	0.0148 in.
Cylinder Bore Diameter (standard)	95.253-95.334 mm	3.7501-3.7533 in.
Maximum Taper	0.025 mm	0.001 in.
Maximum Out-of-Round	0.025 mm	0.001 in.
Tappet Bore Diameter	23.000-23.025 mm	0.9055-0.9065 in.
Cylinder Block Flatness	.03 per 25 mm	.001 per 1 in.
	.05 per 152 mm	.002 per 6 in.
Main Bearing Bore Diameter	68.35-68.38 mm	2.691-2.692 in.
<u>Cylinder Head</u>		
Combustion Chamber Volume	64.45-67.45 cc	
Valve Arrangement	EI-IE-IE-EI-EI-IE	
Valve Guide ID (Integral)	9.487-9.512 mm	0.3735-0.3745 in.
Valve Stem-to-Guide Clearance	0.03-0.08 mm	.001-.003 in.
Intake Valve Seat Angle	30°	
Exhaust Valve Seat Angle	44°30'	
Valve Seat Width	1.02-1.52 mm	.040-.060 in.
Valve Seat Runout	0.064 mm	.0025 in.
Cylinder Head Flatness	.03 per 25 mm	.001 per 1 in.
	.05 per 152 mm	.002 per 6 in.
<u>Oil Pressure</u>		
At Idle Speed (600 rpm) .....	.90 kPa	13 psi
At 1600 + rpm	255-517 kPa	37-75 psi
Oil Pressure Relief .....	.517 kPa	75 psi
<u>Oil Pump</u>		
Gear-to-Body Clearance (radial)	0.051-0.102 mm	0.002-0.004 in.
Preferred .....	.0051 mm	0.002 in.
Gear End Clearance — Plastigauge	0.051-0.152 mm	0.002-0.006 in.
Preferred .....	.0051 mm	0.002 in.
Gear End Clearance — Feeler Gauge	0.1016-0.2032 mm	0.004-0.008 in.
Preferred .....	.01778 mmi	0.007 in.
<u>Rocker Arms, Push Rods and Tappets</u>		
Rocker Arm Ratio	1.6:1	
Push Rod length	244.856-245.364 mm	9.640-9.660 in.
Push Rod Diameter	7.92-8.00 mm	0.312-0.315 in.
Hydraulic Tappet Diameter	22.962-22.974 mm	0.904-0.9045 in.
Tappet-to-Bare Clearance	0.03-0.05 mm	0.001-0.0025 in.

<u>Pistons</u>		
Weight (less pin)	510-514 grams	18-18.1 oz.
Piston Pin Bore		
Centerline-to-Piston Top	41.94-42.04 mm	1.651-1.655 in.
Piston-to-Bore Clearance	0.023-0.043 mm	0.0009-0.0017 in.
Preferred	0.030-0.033 mm	0.0012-0.0013 in.
Piston Ring Gap Clearance —		
Compression (both)	0.25-0.51 mm	0.010-0.020 in.
Piston Ring Gap Clearance —		
Oil Control Steel Rails	0.25-0.64 mm	0.010-0.025 in.
Piston Ring Side Clearance		
No. 1 and No. 2 Compression	0.030-0.081 mm	0.0012-0.0032 in.
Preferred	0.043 mm	0.0017 in.
Oil Control		
Preferred	0.03-0.20 mm	0.0080 in.
Piston Ring Groove Height	0.08 mm	0.003 in.
Compression (both)	2.019-2.045 mm	0.0795-0.0805 in.
Oil Control	4.78-4.80 mm	0.188-0.1895 in.
Piston Ring Groove Diameter		
No. 1 and No. 2	84.43-84.56 mm	3.324-3.329 in.
Oil Control	84.56-84.81 mm	3.329-3.339 in.
Piston Pin Bore Diameter	23.624-23.655 mm	0.9308-0.9313 in.
Piston Pin Diameter	23.632-23.645 mm	0.9304-0.9309 in.
Piston-to-Pin Clearance	0.010-0.015 mm	0.0004-0.0006 in.
Preferred	Loose 0.015 mm	Loose 0.0006 in.
Piston Pin-to-Connecting Rod	8.9 kN Press-fit	2000 lbs.-f Press-fit
<u>Valves</u>		
Valve Length		
(Tip-to-Gauge Dim. Line) Intake	121.653-122.034 mm	4.7895-4.8045 in.
Valve Stem Diameter	9.436-9.462 mm	0.3715-0.3725 in.
Stem-to-Guide Clearance	0.03-0.08 mm	.001-.003 in.
Intake Valve Head Diameter	45.26-45.52 mm	1.782-1.792 in.
Intake Valve Face Angle	29°	
Exhaust Valve Head Diameter	35.59-35.84 mm	1.401-1.411 in.
Exhaust Valve Face Angle	44°	
Maximum Allowable Removed for		
Tip Refinishing	0.25 mm	0.010 in.
Valve Springs Free Length	50.55 mm	1.99 in.
Valve Spring Tension Closed	285-320 N @ 45.4 mm	64.72 lbs @ 1.786 in.
Valve Spring Tension Open	836-898 N @ 35.84 mm	188-202 lbs @ 1.411 in.



Chapter 6

4.7L Power Tech V-8



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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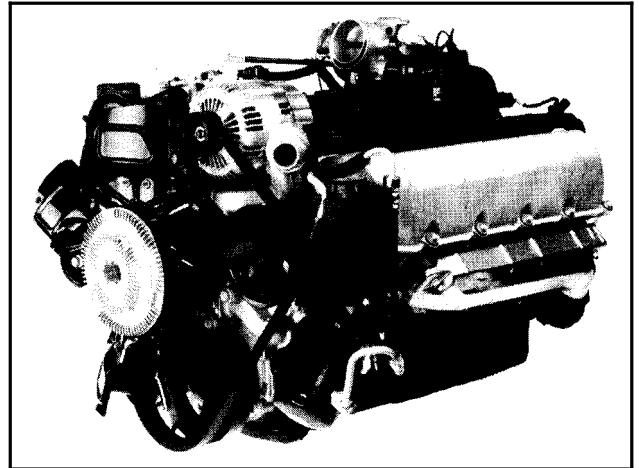
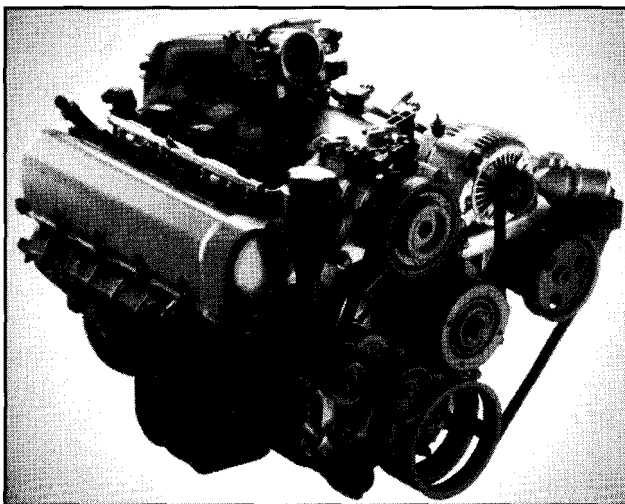
Note: Due to the limited number of performance parts currently available for 4.7L Power Tech V-8 engine, only a brief discussion and general specifications will be covered in this chapter. **All** other procedures, techniques, and modification tips which are generic to all Jeep performance engines can be found in Chapter 4, *4.0L Power Tech In-Line 6*. It is highly recommended that 4.7L Power Tech V-8 engine owners read both this chapter and Chapter 4 in their entirety.

For additional information, refer to the proper service manual.

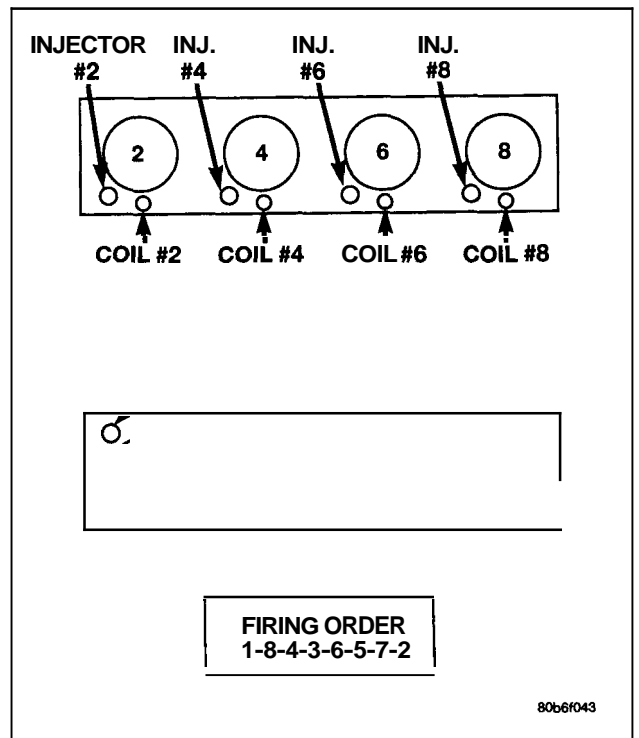
INTRODUCTION

General Specifications

- Type. 90° SOHC V-8
- Displacement 4.7L (287 CID)
- Bore. 93.0 mm (3.66")
- Stroke. 86.5 mm (3.40")
- Compression Ratio . . 9.0:1
- Horsepower 230 bhp @ 4,600 rpm
- Torque 300 lb-ft @ 3,200 rpm
- Lead Cylinder. #1 Left Bank
- Cylinder Block. Cast Iron
- Cylinder Head Aluminum
- Connecting Rod Powdered Metal with Cracked Cap
- Piston Aluminum (Press-Fit Wrist Pin)
- Lubrication. Pressure Feed-Full Flow Filtration
(Direct Crankshaft Driven Pump)
- Cooling System Liquid Cooled-Forced Circulation



Engine Firing Order



Engine Identification

The 4.7L engine is stamped with the vehicle's identification number (VIN). This area is located at the right front side of the engine block. The engine build date code is included in the yellow bar code sticker on the oil fill housing. (Figure 6-1).

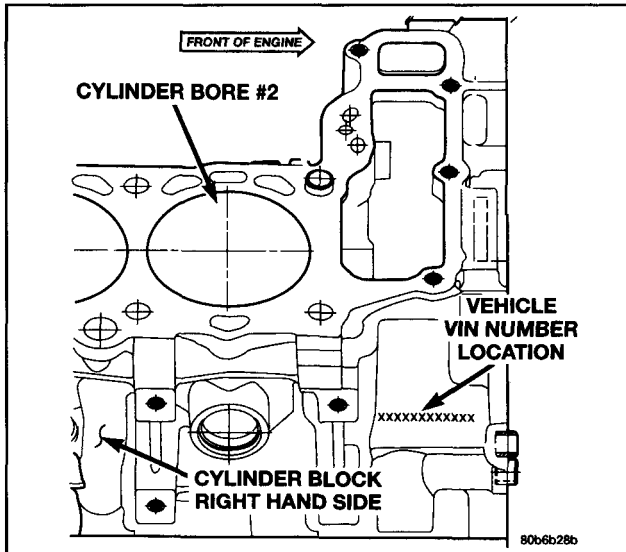


Figure 6 - 1

Fuel Requirements

The 4.7L engine is designed to meet all emissions regulations and provide excellent fuel economy and performance when using high quality unleaded gasoline having an octane rating of 87. The use of premium gasoline is not recommended. The use of premium gasoline will provide no benefit over high quality regular gasoline, and in some circumstances may result in poorer performance.

Light spark knock at low engine speeds is not harmful to your engine. However, continued heavy spark knock at high speeds can cause damage and immediate service is required. Engine damage resulting from operation with a heavy spark knock may not be covered by the new vehicle warranty.

Poor quality gasoline can cause problems such as hard starting, stalling and hesitations. If you experience these symptoms, try another brand of gasoline before considering service for the vehicle.

The American Automobile Manufacturers Association (AAMA) has issued gasoline specifications to define the minimum fuel properties necessary to deliver enhanced performance and durability for your vehicle. DaimlerChrysler recommends the use of gasoline that meet the AAMA specifications if they are available.

BLOCK

The cylinder block is made of cast iron. The block is a closed deck design with the left bank forward. To provide high rigidity and improved NVH, an enhanced compacted graphite bedplate is bolted to the block. The block design allows coolant flow between the cylinder bores, and an internal coolant bypass to a dual poppet inlet thermostat is included in the cast aluminum front cover.

Structural Dust Cover

The structural dust cover is made of die cast aluminum and joins the lower half of the transmission bellhousing to the engine bedplate. The structural cover provides additional powertrain stiffness and reduces noise and vibration.

CRANKSHAFT

The crankshaft is constructed of nodular cast iron. The crankshaft is a cross-shaped four throw design with eight counterweights for balancing purposes. The crankshaft is supported by five select main bearings with the No. 3 serving as the thrust washer location. The main journals of the crankshaft are cross drilled to improve rod bearing lubrication. The No. 8 counterweight has provisions for crankshaft position sensor target wheel mounting.

The select fit main bearing markings are located on the rear side of the target wheel. The crankshaft oil seals are one piece design. The front oil seal is retained in the timing chain cover, and the rear seal is pressed in to a bore formed by the cylinder block and the bedplate assembly.

TIMING DRIVE SYSTEM

The timing drive system (Figure 6-2) has been designed to provide quiet performance and reliability to support a non-free wheeling engine. Specifically, the intake valves are non-free wheeling and can be easily damaged with forceful engine rotation if camshaft-to-crankshaft timing is incorrect. The timing drive system consists of a primary chain and two secondary timing chain drives.

The primary timing chain is a single inverted tooth type. The primary chain drives the large 50 tooth idler sprocket directly from a 25 tooth crankshaft sprocket. Primary chain motion is controlled by a pivoting leaf spring tensioner arm and a fixed guide. The arm and the guide both use nylon plastic wear faces for low friction and long wear. The primary chain receives oil splash lubrication from the secondary chain drive and oil pump leakage. The idler sprocket assembly connects the primary and secondary chain drives. The idler sprocket assembly consists of two integral 30 tooth sprockets and a 50 tooth sprocket that is splined to the assembly. The spline joint is a press-fit, anti-rattle type. A spiral ring is installed on the outboard side of the 50 tooth sprocket to prevent spline disengagement. The idler sprocket assembly spins on a stationary idler shaft.

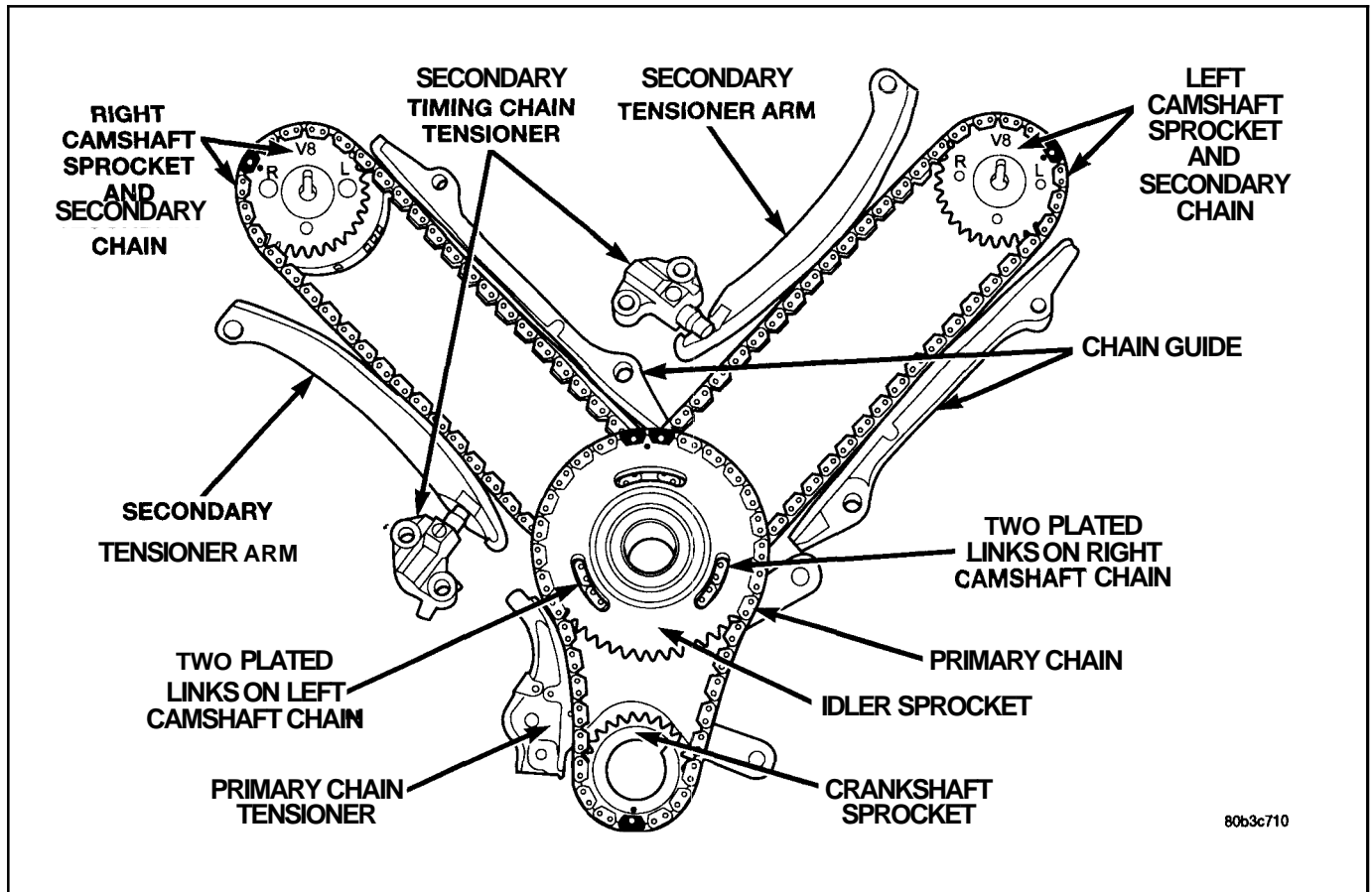


Figure 6 - 2

The idler shaft is press fit into the cylinder block. A large washer on the idler shaft bolt and the rear flange of the idler shaft are used to control sprocket thrust movement. Pressurized oil is routed through the center of the idler shaft to provide lubrication for the two bushings used in the idler sprocket assembly.

There are two secondary drive chains, both are inverted tooth-type, one to drive the camshaft in each SOHC cylinder head. There are no shaft speed changes in the secondary chain drive system. Each secondary chain drives a 30 tooth cam sprocket directly from the a 30 tooth sprocket on the idler sprocket assembly. A fixed chain guide and a hydraulic oil damped tensioner are used to maintain tightness in each secondary chain system. The hydraulic tensioners for the secondary chain systems are fed pressurized oil from oil reservoir pockets in the block. Each tensioner also has a mechanical ratchet system that limits chain slack if the tensioner piston bleeds down after engine shut down. The tensioner arms and guides also utilize nylon wear faces for low friction and long wear. The secondary timing chains receive lubrication from a small orifice in the tensioners. This orifice is protected from clogging by a fine mesh screen which is located on the back of the hydraulic tensioners.

PISTON AND CONNECTING ROD ASSEMBLY

(Refer to Figure 6-3.)

The pistons are made of a high strength aluminum alloy with an anodized top ring groove and crown. Piston skirts are coated with a solid lubricant (Molykote) to reduce friction and provide scuff resistance. The connecting rods are made of powdered metal, with a “fractured cap” design. A press-fit piston pin is used to attach the piston and connecting rod.

Note: DO NOT use a metal stamp to mark connecting rods as damage may result; instead, use ink or a scratch awl.

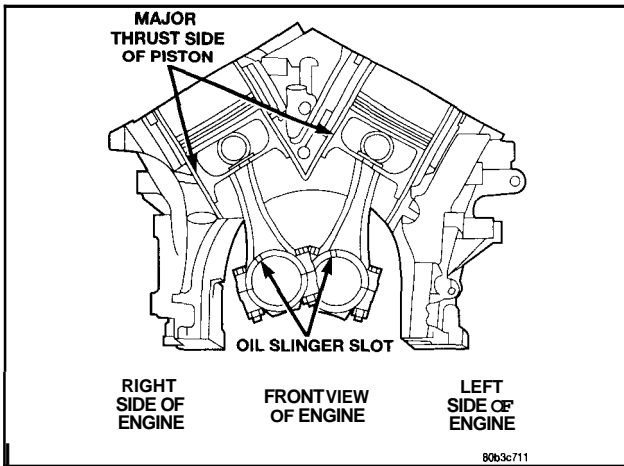


Figure 6 - 3

PISTON DIAMETER	PISTON PIN BORE DIAMETER
92.975mm (3.665 in.)	24.026 - 24.032mm (0.946 - 0.9462 in.)
RING GROOVE WIDTH	RING GROOVE DIAMETER
Upper Ring 1.541 - 1.566mm (0.0607 - 0.0617 in.)	Upper Ring 83.73 - 83.97mm (3.2965 - 3.3059 in.)
Middle Ring 1.53 - 1.55 mm (0.0603 - 0.0611 in.)	Middle Ring 82.833 - 83.033 mm (3.2612 - 3.2691 in.)
Oil Rails 3.031 - 3.055 mm (0.1194 - 0.1203 in.)	Oil Rails 83.88 - 84.08 mm (3.3024 - 3.3103 in.)

CYLINDER HEADS

Cylinder heads are made of an aluminum alloy and feature two valves per cylinder with pressed-in, powdered metal valve guides. The cylinder heads also provide enclosures for the timing chain drain, necessitating unique left and right cylinder heads.

Valve Guides

Valve guides are made of powdered metal and are pressed into the cylinder head. The guides are not replaceable or serviceable. Valve guide reaming is NOT recommended. If the guides are worn beyond acceptable limits, replace the cylinder heads.

Cylinder Head Covers

Cylinder head covers are made of die cast magnesium and are not interchangeable from side-to-side. It is imperative that nothing rest on the cylinder head covers. Prolonged contact with other items may wear a hole in the cylinder head cover.

Engine Gasket Surface Preparation

To ensure engine gasket sealing, proper surface preparation must be performed, especially with the use of aluminum engine components and multi-layer steel cylinder head gaskets.

NEVER use the following to clean gasket surfaces:

- a metal scraper
- an abrasive pad or paper to clean cylinder block and head
- a high speed power tool or wire brush on any gasket sealing surface

Note: Multi-Layer Steel (MLS) head gaskets require a scratch free sealing surface.

Only use the following for cleaning gasket surfaces:

- Mopar Brake and Parts Cleaner
- a plastic or wood scraper

CAMSHAFT AND VALVE GEAR

Camshafts consist of powdered metal steel lobes which are sinter-bonded to a steel tube. A steel post or nose piece is friction welded to the camshaft steel tube. Five bearing journals are machined into the camshaft, four on the steel tube and one on the steel nose piece. Camshaft end play is controlled by two thrust walls that border the nose piece journal. Engine oil enters the hollow camshafts at the third journal and lubricates every intake lobe rocker through a drilled passage in the intake lobe.

Rocker Arms

Rocker arms are steel stampings with an integral roller bearing. Rocker arms incorporate a 2.8 mm (0.11") oil hole in the lash adjuster socket for roller and camshaft lubrication.

Valves

Valves are made of heat resistant steel and have chrome plated stems to prevent scuffing. Each valve is actuated by a roller rocker arm which pivots on a stationary lash adjuster. All valves use three bead lock keepers to retain the springs and promote valve rotation (Figure 6-4).

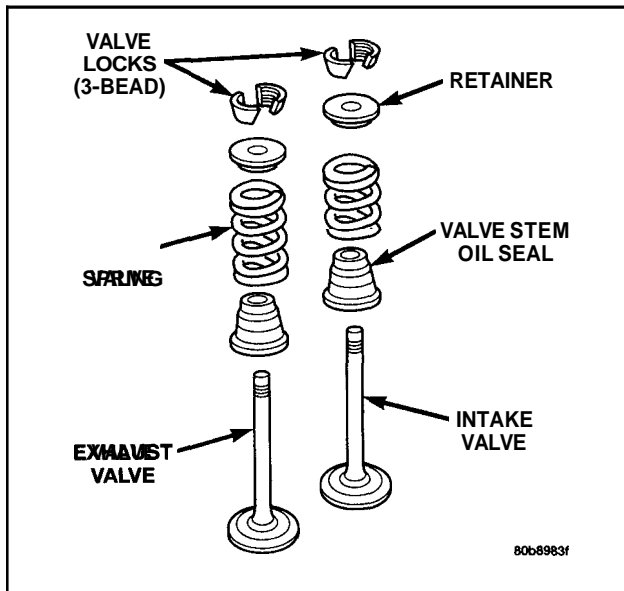


Figure 6-4

Valve Springs

Valve springs (Figure 6-4) are made from high strength chrome silicon steel. The springs are common for intake and exhaust applications. The valve spring seat is integral with the valve stem seal, which is a positive type seal to control lubrication.

Hydraulic Lash Adjusters

Valve lash is controlled by hydraulic lash adjusters that are stationary mounted in the cylinder heads. The lash adjusters have a hole in the ball plunger that feeds oil through the rocker arm squirt holes for rocker arm roller and camshaft lobe lubrication.

Valve Stem Seals

Valve stem seals (Figure 6-4) are made of rubber and incorporate an integral steel valve spring seat. The integral garter spring maintains consistent lubrication control to the valve stems.

Engine Timing Verification

Caution: The 4.7L is a non free-wheeling design engine. Therefore, correct engine timing is critical.

Note 1: Components referred to as left hand or right hand are as viewed from the driver's position inside the vehicle.

Note 2: The blue link plates on the chains and the dots on the camshaft drive sprockets may not line up during the timing verification procedure. The blue link plates are lined up with the sprocket dots only when re-timing the complete timing drive. Once the timing drive is rotated, blue link-to-dot alignment is no longer valid.

Engine base timing can be verified by the following procedure:

1. Remove the cylinder head covers. Refer to the proper service manual for the procedure.
2. Using a mirror, locate the TDC arrow on the front cover (Figure 6-5). Rotate the crankshaft until the mark on the crankshaft damper is aligned with the TDC arrow on the front cover. The engine is now at TDC.
3. Note the location of the V-8 mark stamped into the camshaft drive gears (Figure 6-6). If the V-8 mark on each camshaft drive gear is at the twelve o'clock position, the engine is at TDC on the exhaust stroke. If the V-8 mark on each gear is at the six o'clock position, the engine is at TDC on the compression stroke.
4. If both of the camshaft drive gears are off in the same or opposite directions, the primary chain or both secondary chains are at fault. Refer to Timing Chain and Sprockets procedure in the appropriate service manual.
5. If only one camshaft drive gear is off and the other is correct, the problem is confined to one secondary chain. Refer to Single Camshaft Timing in the appropriate service manual.
6. If both camshaft drive gear V-8 marks are at the twelve o'clock or the six o'clock position, the engine base timing is correct. Reinstall the cylinder head covers.

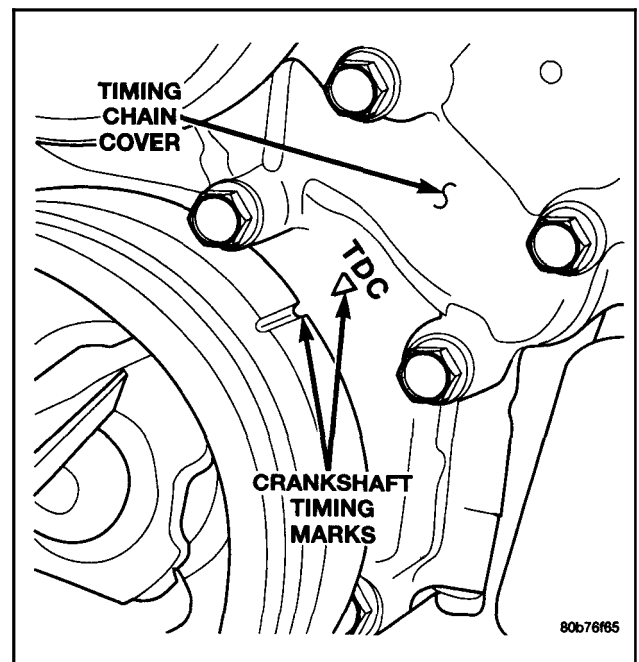


Figure 6-5

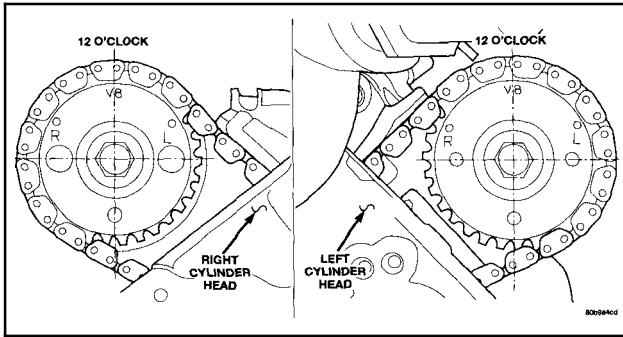
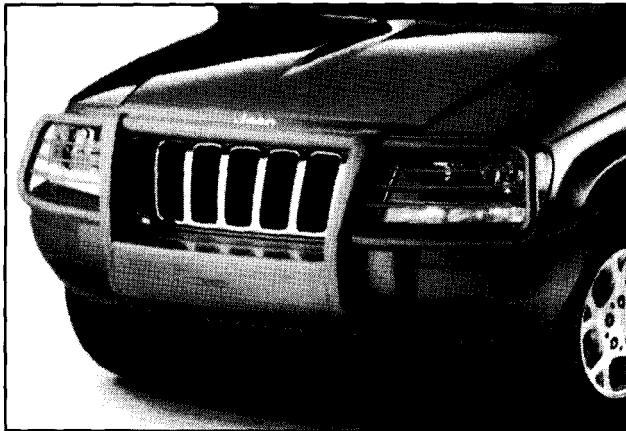


Figure 6 - 6



OILING SYSTEM

The lubrication system (Figure 6-7) is a full flow filtration, pressure feed-type. Oil from the oil pan is pumped by a gerotor-type oil pump directly mounted to the crankshaft nose. Oil pressure is controlled by a relief valve mounted inside the oil pump housing. For lubrication flow refer to *Engine Lubrication Flow Chart-Block: Table 1*, and *Engine Lubrication Flow Chart-Cylinder Heads: Table 2*.

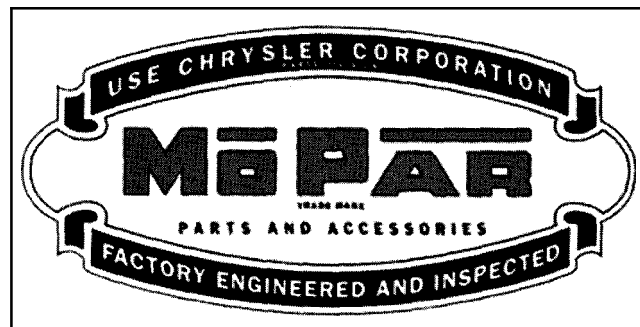
The camshaft exhaust valve lobes and rocker arms are lubed through a small hole in the rocker arm. Oil flows through the lash adjuster then through the rocker arm and onto the camshaft lobe. Due to the design of the rocker arm configuration, the camshaft intake lobes are not lubed in the same manner as the exhaust lobes. Intake lobes are lubed through internal passages in the camshaft. Oil flows through a bore in the No. 3 camshaft bearing bore. As the camshaft turns, a hole in the camshaft aligns with the hole in the camshaft bore allowing engine oil to enter the camshaft tube. Oil then exits through 1.6mm (0.063") holes drilled into the intake lobes, lubing the lobes and the rocker arms.

**ENGINE LUBRICATION FLOW CHART—
BLOCK: TABLE 1**

FROM	TO
Oil Pickup Tube	Oil Pump
Oil Pump	Oil Filter
Oil Filter	Block Main Oil Gallery
Block Main Oil Gallery	1. Crankshaft Main Journal 2. Left Cylinder Head* 3. Right Cylinder Head*
Crankshaft Main Journals	Crankshaft Rod Journals
Crankshaft Number One Main Journal	1. Front Timing Chain Idler Shaft 2. Both Secondary Chain Tensioners
Left Cylinder Head	See Table 2
Right Cylinder Head	See Table 2

**ENGINE LUBRICATION FLOW CHART—
CYLINDER HEADS: TABLE 2**

Cylinder Head Oil Port (in bolt hole)	Diagonal Cross Drilling to Main Oil Gallery
Main Oil Gallery (drilled through head from rear to front)	1. Base of Camshaft Towers 2. Lash Adjuster Towers
Base of Camshaft Towers	Vertical Drilling Through Tower to Camshaft Bearings*
Lash Adjuster Towers	Diagonal Drillings to Hydraulic Lash Adjuster Pockets
** The number three camshaft bearing journal feeds oil into the hollow camshaft tubes. Oil is routed to the intake lobes, which have oil passages drilled into them to lubricate the rocker arms.	



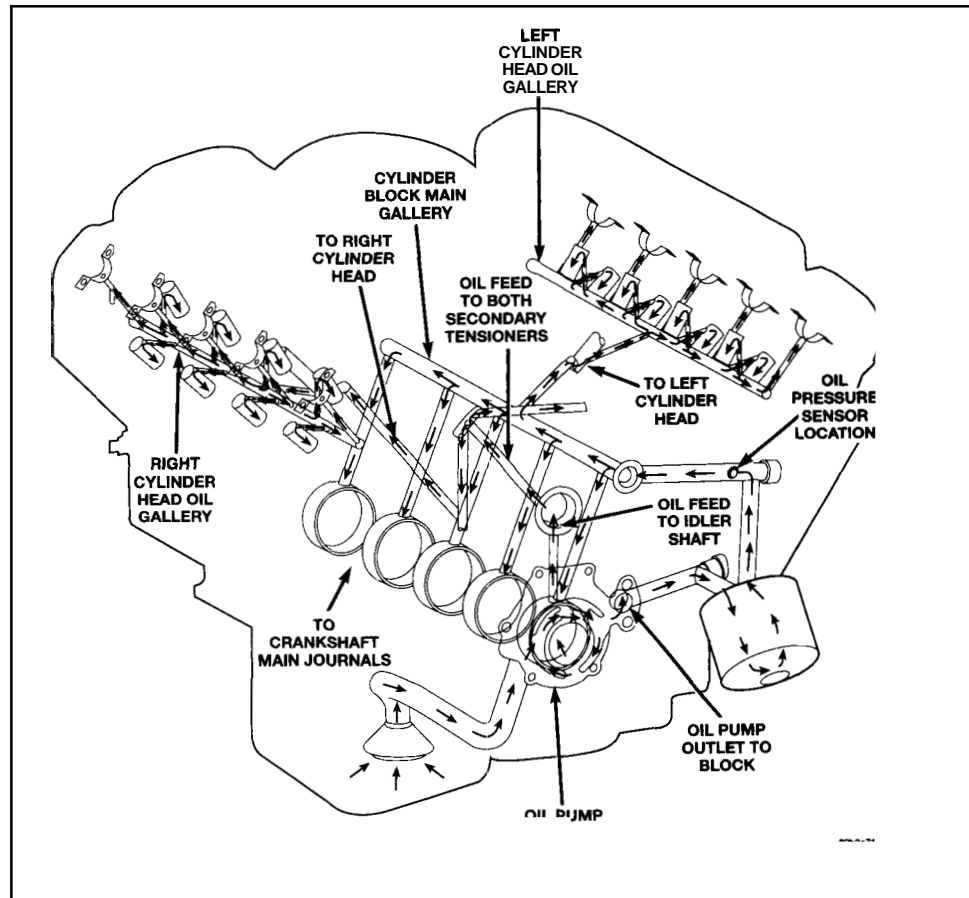


Figure 6- 7

Engine Oil

An SAE viscosity grade is used to specify the viscosity of engine oil. Use only engine oils with multiple viscosity such as SW-30 or 10W-30. These are specified with a dual SAE viscosity grade which indicates the cold-to-hot temperature viscosity range. Select an engine oil that is best suited to your particular temperature range and variation (Figure 6-8). The 4.7L engine oil capacity (with filter change) is 5.7L (6.0 quarts).

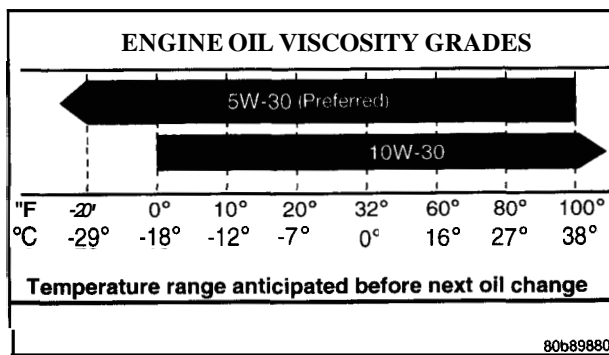


Figure 6- 8

Engine Oil Level Inspection

Caution: DO NOT overfill crankcase with engine oil; pressure loss or oil foaming can result.

Inspect engine oil level approximately every 800 kilometers (500 miles). Unless the engine has exhibited a loss of oil pressure, run the engine for about five minutes before checking oil level. Checking engine oil level on a cold engine is not accurate.

To ensure proper lubrication of an engine, engine oil must be maintained at an acceptable level. The acceptable levels are indicated between the ADD and SAFE marks on the engine oil dipstick.

1. Position vehicle on level surface.
2. With engine OFF, allow approximately ten minutes for oil to settle to bottom of crankcase, remove engine oil dipstick.
3. Wipe dipstick clean.
4. Install dipstick and verify it is seated in the tube.
5. Remove dipstick, with handle held above the tip, take oil level reading.
6. Add oil only if level is below the ADD mark on dipstick.

Engine Oil Change

Change engine oil at mileage and time intervals described in Maintenance Schedules.

Run engine until achieving normal operating temperature.

1. Position the vehicle on a level surface and turn engine off.
2. Hoist and support vehicle on safety stands.
3. Remove oil fill cap.
4. Place a suitable drain pan under crankcase drain.
5. Remove drain plug from crankcase and allow oil to drain into pan. Inspect drain plug threads for stretching or other damage. Replace drain plug if damaged.
6. Install drain plug in crankcase.
7. Lower vehicle and fill crankcase with specified type and amount of engine oil described in this section.
8. Install oil fill cap.
9. Start engine and inspect for leaks.
10. Stop engine and inspect oil level.

Engine Oil Filter Change

All engines are equipped with a high quality, full-flow, disposable-type oil filter. DaimlerChrysler Corporation recommends a Mopar or equivalent oil filter be used.

1. *Oil Filter Removal*
 - a. Position a drain pan under the oil filter.
 - b. Using a suitable oil filter wrench, loosen filter.
 - c. Rotate the oil filter (Figure 6-9) counterclockwise to remove it from the cylinder block oil filter boss.
 - d. When filter separates from adapter nipple, tip gasket end upward to minimize oil spill. Remove filter from vehicle.
 - e. With a wiping cloth, clean the gasket sealing surface (Figure 4-39) of oil and grime.
2. *Oil Filter Installation*
 - a. Lightly lubricate oil filter gasket with engine oil.
 - b. Thread filter onto adapter nipple. When gasket makes contact with sealing surface (Figure 4-39), hand tighten filter one full turn. **DO NOT** over tighten.
 - c. Add oil, verify crankcase oil level and start engine. Inspect for oil leaks.

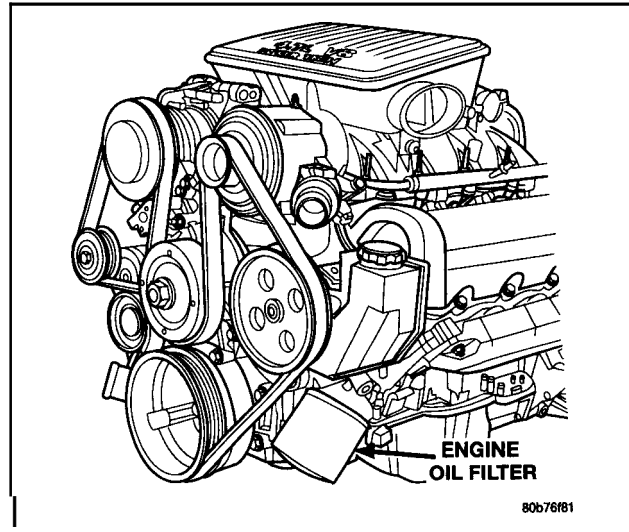


Figure 6 - 9

Oil Pan

The engine oil pan is made of laminated steel and has a single plane sealing surface. The sandwich style oil pan gasket has an integrated windage tray and steel carrier. The sealing area of the gasket is molded with rubber and is designed to be reused as long as the gasket is not cut, torn or ripped.

COOLING SYSTEM

(Refer to Figure 6-10 and Figure 6-11.)

Caution: Vehicle may be equipped with long life coolant. Extended life coolant is identified by an orange color. Normal coolant is identified by a greenish color. It is recommended that the two types of coolant not be mixed.

The cooling system regulates engine operating temperature. It allows the engine to reach normal operating temperature as quickly as possible. It also maintains normal operating temperature and prevents overheating.

The cooling system also provides a means of heating the passenger compartment and cooling the automatic transmission fluid (if equipped). The cooling system is pressurized and uses a centrifugal water pump to circulate coolant throughout the system.

Vehicles equipped with the 4.7L engine receive a “max” cooling package which consists of a heavy duty radiator, a low disengaged fan viscous fan drive and an mechanical cooling fan. This package will provide additional cooling capacity for vehicles used under extreme conditions such as trailer towing in high ambient temperatures.

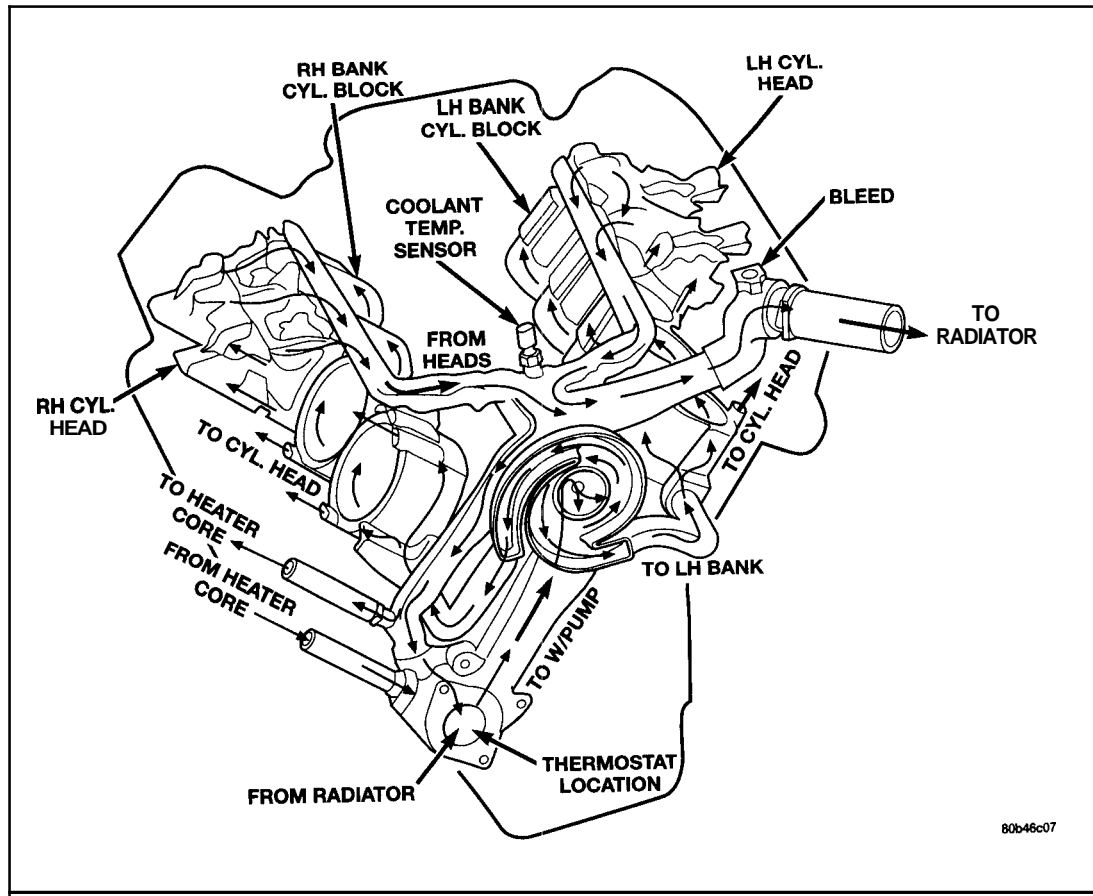


Figure 6 - 10

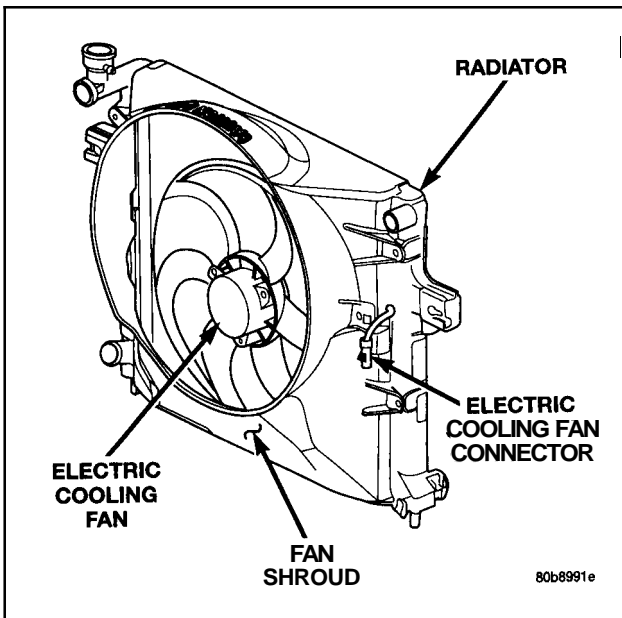


Figure 6 - 11

Cooling System Capacity

4.7L 12.3 liters (13.0 quarts)*

* Includes 2.2 liters (2.3 quarts) for coolant recovery bottle.

Cooling System Components

The cooling system consists of:

- o Radiator
- o Mechanical cooling fan
- Thermal viscous fan drive-Low disengaged
- o Fan shroud
- o Radiator pressure cap
- o Thermostat
- o Coolant reserve/overflow system
- Transmission oil cooler (if auto. trans. equipped)
- o Coolant
- o Water pump
- o Hoses and hose clamps
- o Accessory drive belt

Water Pump Bypass

(Refer to Figure 6-12.)

The 4.7L engine uses an internal water/coolant bypass system. The design uses galleries in the timing chain cover to circulate coolant during engine warm-up, preventing coolant from flowing through the radiator. The thermostat uses a stub shaft located at the rear of the thermostat to control flow through the bypass galley. When the thermostat is in the closed position, the bypass galley is not obstructed allowing 100% flow. When the thermostat is in the open position, the stub shaft enters the bypass galley obstructing bypass coolant flow by 50%. This design allows the coolant to reach operating temperature quickly when cold, while adding extra cooling during normal temperature operation.

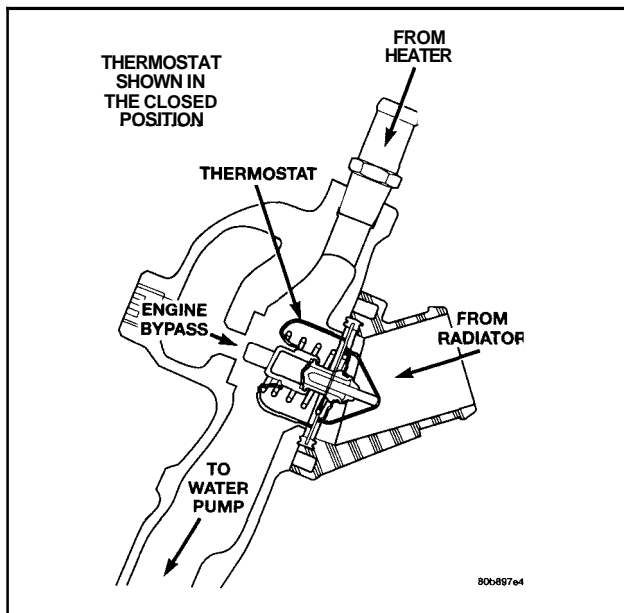


Figure 6 - 12

Coolant Reservoir/Overflow System

This system works along with the radiator pressure cap. This is done by using thermal expansion and contraction of the coolant to keep the coolant free of trapped air. It provides:

- A volume for coolant expansion and contraction.
- A convenient and safe method for checking/adjusting coolant level at atmospheric pressure. This is done without removing the radiator pressure cap.
- Some reserve coolant to the radiator to cover minor leaks and evaporation or boiling losses.

As the engine cools, a vacuum is formed in the cooling system of both the radiator and engine. Coolant will then be drawn from the coolant tank and returned to a proper level in the radiator.

The coolant reservoir/overflow system has a radiator mounted pressurized cap, an overflow tube and a plastic coolant reservoir/overflow tank.

Accessory Drive Belt Tension

Correct drive belt tension is required to ensure optimum performance of the belt driven engine accessories. If specified tension is not maintained, belt slippage may cause engine overheating, lack of power steering assist, loss of air conditioning capacity, reduced generator output rate, and/or greatly reduced belt life.

It is not necessary to adjust belt tension on 4.7L engines. These engines are equipped with an automatic belt tensioner. The tensioner maintains correct belt tension at all times. Due to use of this belt tensioner, DO NOT attempt to use a belt tension gauge on 4.7L engines.

Thermostat

(Refer to Figure 6-13.)

A pellet-type thermostat controls the operating temperature of the engine by controlling the amount of coolant flow to the radiator (Figure 6-12). The thermostat is closed below 195°F (90°C). Above this temperature, coolant is allowed to flow to the radiator. This provides quick engine warm up and overall temperature control. The thermostat is designed to block the flow of the coolant bypass journal by 50% instead of completely blocking the flow. This design controls coolant temperature more accurately.

An arrow, plus the word UP is stamped on the front flange next to the air bleed. The words TO RAD are stamped on one arm of the thermostat. They indicate the proper installed position.

The same thermostat is used for winter and summer seasons. An engine should not be operated without a thermostat, except for servicing or testing. Operating without a thermostat causes other problems. These include longer engine warm-up time, unreliable warm-up performance, increased exhaust emissions, and crankcase condensation. Crankcase condensation can result in sludge formation.

The most common type of thermostat failure, usually found on high mileage vehicles, is a thermostat failed in the shut position. The temperature gauge (if equipped) will give an indication of this condition. Depending upon length of time that vehicle is operated, the pressure cap may vent. This will expel steam and coolant to coolant reserve/overflow tank and surface (ground) below vehicle.

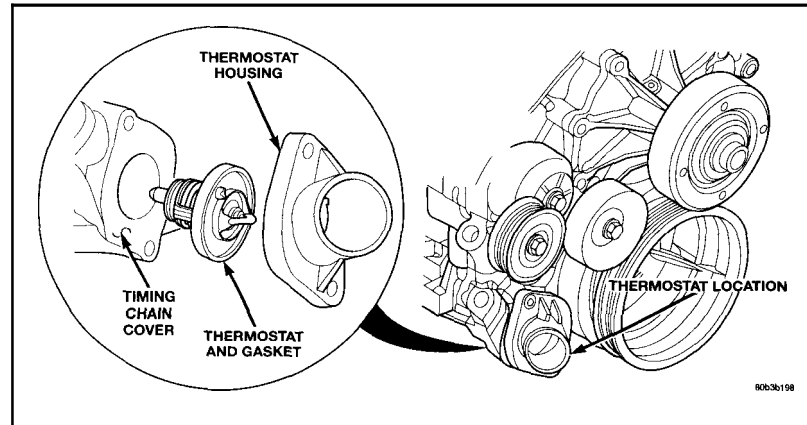


Figure 6 - 13

Coolant

1. Routine Check

Note: DO NOT remove the radiator cap for routine coolant level inspections. The coolant level can be checked at the coolant reserve/overflow tank.

The coolant reserve/overflow system provides a quick visual method for determining coolant level without removing radiator pressure cap. With engine idling and at normal operating temperature, observe coolant level in reserve/overflow tank. The coolant level should be between ADD and FULL marks.

2. Adding Additional

DO NOT remove the radiator cap to add coolant to system. When adding coolant to maintain correct level, do so at coolant reserve/overflow tank. Remove radiator cap only for testing or when refilling system after service. Removing cap unnecessarily can cause loss of coolant and allow air to enter system, which produces corrosion. Refer to the owner's manual for recommended coolant type to use.

Radiator Pressure Cap

All radiators are equipped with a pressure cap. This cap releases pressure at some point within a range of 124-145 kPa (18-21 psi). The pressure relief point (in pounds) is engraved on top of the cap.

The cooling system will operate at pressures slightly above atmospheric pressure. This results in a higher coolant boiling point allowing increased radiator cooling capacity. The cap contains a spring-loaded pressure relief valve. This valve opens when system pressure reaches the release range of 124-145 kPa (18-21 psi).

A vent valve in the center of the cap allows a small coolant flow through the cap when coolant is below boiling temperature. The valve is completely close when boiling point is reached. As the coolant cools, it contracts and creates a vacuum in cooling system. This causes the vacuum valve to

open and coolant in reserve/overflow tank to be drawn through connecting hose into radiator. If the vacuum valve is stuck shut, radiator hoses will collapse on cool-down.

A rubber gasket seals the radiator filler neck. This is done to maintain vacuum during coolant cool-down and to prevent leakage when system is under pressure.

Water Pump

(Refer to Figure 6-14.)

A centrifugal water pump circulates coolant through the water jackets, passages, intake manifold radiator core, cooling system hoses and heater core. The pump is driven from the engine crankshaft by a single serpentine drive belt.

The water pump impeller is pressed onto the rear of a shaft that rotates in bearings pressed into the housing. The housing has two small holes to allow seepage to escape. The water pump seals are lubricated by the antifreeze in the coolant mixture. No additional lubrication is necessary.

A quick test to determine if the pump is working is to check if the heater warms properly. A defective water pump will not be able to circulate heated coolant through the long heater hose to the heater core.

Both heater hoses are connected to fittings on the timing chain front cover. The water pump is also mounted directly to the timing chain cover and is equipped with a non serviceable integral pulley.

Replace water pump assembly if it has any of the following conditions:

- The body is cracked or damaged
- Water leaks from shaft seal (evident by traces of coolant below vent hole)
- Loose or rough turning bearing (also inspect viscous fan drive)
- Impeller rubs either the pump body or timing chain case/cover

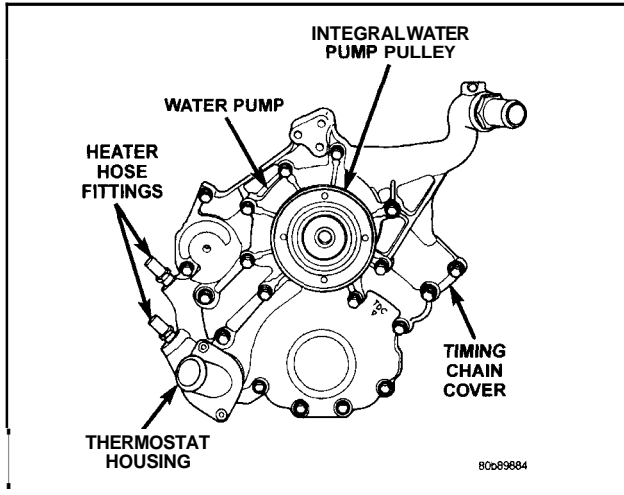


Figure 6 - 14

Cooling System Hoses

Warning! Constant tension hose clamps are used on most cooling system hoses when removing or installing, use only tools designed for servicing this type of clamp. Snap-On clamp tool (number hpc-20) may be used for larger clamps. Always wear safety glasses when servicing constant tension clamps.

Caution: A number or letter is stamped into the tongue of constant tension clamps. If replacement is necessary, use only an original equipment clamp with matching number or letter.

Rubber hoses route coolant to and from the radiator, intake manifold and heater core. The lower radiator hose is spring-reinforced to prevent collapse from water pump suction at moderate and high engine speeds.

Inspect hoses at regular intervals. Replace hoses that are cracked, feel brittle when squeezed, or swell excessively when the system is pressurized.

In areas where specific routing clamps are not provided, be sure that hoses are positioned with sufficient clearance. Check clearance from exhaust manifolds and pipe, fan blades, drive belts and sway bars. Improperly positioned hoses can be damaged, resulting in coolant loss and engine overheating.

When performing a hose inspection, inspect the radiator lower hose for proper position and condition of the internal spring.

Viscous Fan Drive

The thermal viscous fan drive (Figure 4-46) is a silicone-fluid-filled coupling used to connect the fan blades to the water pump shaft. The coupling allows the fan to be driven in a normal manner. This is done at low engine speeds while limiting the top speed of the fan to a predetermined maximum level at higher engine speeds.

An electrical cooling fan located in the fan shroud aids in low speed cooling. It is designed to augment the viscous fan; however, it does not replace the viscous fan.

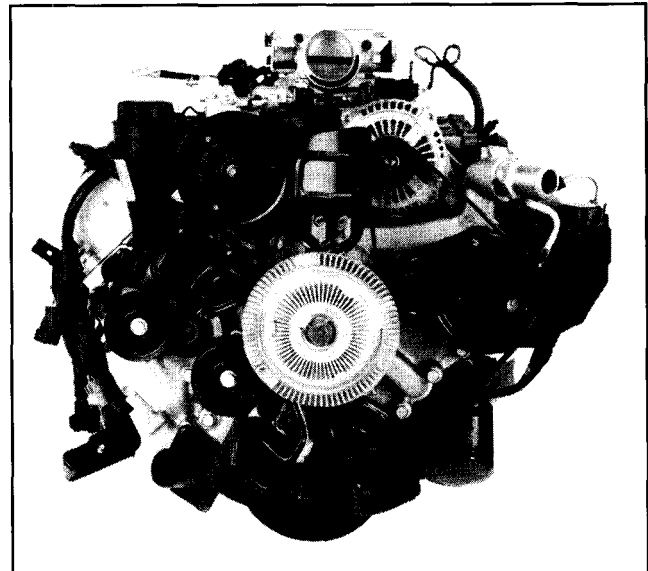
A thermostatic bimetallic spring coil is located on the front face of the viscous fan drive unit (Figure 4-46). This spring coil reacts to the temperature of the radiator discharge air. It engages the viscous fan drive for higher fan speed if the air temperature from the radiator rises above a certain point. Until additional engine cooling is necessary, the fan will remain at a reduced rpm regardless of engine speed.

Only when sufficient heat is present, will the viscous fan drive engage. This is when the air flowing through the radiator core causes a reaction to the bimetallic coil. It then increases fan speed to provide the necessary additional engine cooling.

Once the engine has cooled, the radiator discharge temperature will drop. The bimetallic coil again reacts and the fan speed is reduced to the previous disengaged speed.

Caution: Engines equipped with serpentine drive belts have reverse rotating fans and viscous fan drives. They are marked with the word REVERSE to designate their usage. Installation of the wrong fan or viscous fan drive can result in engine overheating.

If the viscous fan drive is replaced because of mechanical damage, the cooling fan blades should also be inspected. Inspect for fatigue cracks, loose blades, or loose rivets that could have resulted from excessive vibration. Replace fan blade assembly if any of these conditions are found. Also inspect water pump bearing and shaft assembly for any related damage due to a viscous fan drive malfunction.



1. Noise

Note: It is normal for fan noise to be louder (roaring) when:

- The under hood temperature is above the engagement point for the viscous drive coupling. This may occur when ambient (outside air temperature) is very high.
- Engine loads and temperatures are high such as when towing a trailer.
- Cool silicone fluid within the fan drive unit is being redistributed back to its normal disengaged (warm) position. This can occur during the first 15 seconds to one minute after engine start-up on a cold engine.

2. Leaks

Viscous fan drive operation is not affected by small oil stains near the drive bearing. If leakage appears excessive, replace the fan drive unit.

Serpentine Drive Belt Diagnosis

When diagnosing serpentine drive belts, small cracks that run across ribbed surface of belt from rib to rib (Figure 4-42), are considered normal. These are not a reason to replace belt. However, cracks running along a rib (not across) are not normal. Any belt with cracks running along a rib must be replaced (Figure 4-42). **Also** replace belt if it has excessive wear, frayed cords or severe glazing.

Refer to the *Serpentine Drive Belt Diagnosis Chart*, 'Cooling System' section of Chapter 4, for further belt diagnosis. For serpentine belt routing, refer to Figure 6-15.

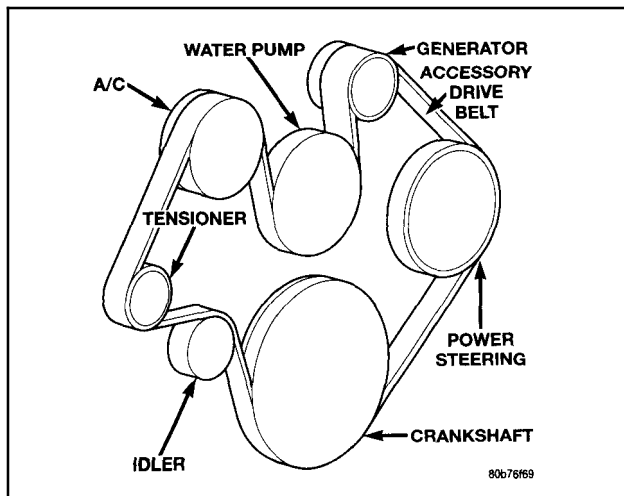


Figure 6-15

STARTING SYSTEM

The starting system consists of the following components:

- Battery
- Starter relay
- Starter motor (including an integral starter solenoid)
- Ignition switch
- Park/neutral position switch
- Wire harnesses and connections (including the battery cables).

The starting system components form two separate circuits. A high-amperage feed circuit that feeds the starter motor between 150 and 350 amperes, and a low-amperage control circuit that operates on less than 20 amperes. The high-amperage feed circuit components include the battery, the battery cables, the contact disc portion of the starter solenoid, and the starter motor. The low-amperage control circuit components include the ignition switch, the park/neutral position switch, the starter relay, the electromagnetic windings of the starter solenoid, and the connecting wire harness components.

Battery voltage is supplied through the low-amperage control circuit to the coil battery terminal of the starter relay when the ignition switch is turned to the momentary Start position. The park/neutral position switch is installed in series between the starter relay coil ground terminal and ground. This normally open switch prevents the starter relay from being energized and the starter motor from operating unless the automatic transmission gear selector is in the Neutral or Park positions.

When the starter relay coil is energized, the normally open relay contacts close. The relay contacts connect the relay common feed terminal to the relay normally open terminal. The closed relay contacts energize the starter solenoid coil windings.

The energized solenoid pull-in coil pulls in the solenoid plunger. The solenoid plunger pulls the shift lever in the starter motor. This engages the starter overrunning clutch and pinion gear with the starter ring gear on the automatic transmission torque converter drive plate.

As the solenoid plunger reaches the end of its travel, the solenoid contact disc completes the high-amperage starter feed circuit and energizes the solenoid plunger hold-in coil. Current now flows between the solenoid battery terminal and the starter motor, energizing the starter.

Once the engine starts, the overrunning clutch protects the starter motor from damage by allowing the starter pinion gear to spin faster than the pinion shaft. When the driver releases the ignition switch to the On position, the starter relay coil is de-energized. This causes the relay contacts to open. When the relay contacts open, the starter solenoid plunger hold-in coil is de-energized.

When the solenoid plunger hold-in coil is de-energized, the solenoid plunger return spring returns the plunger to its relaxed position. This causes the contact disc to open the starter feed circuit, and the shift lever to disengage the overrunning clutch and pinion gear from the starter ring gear.

Starter Motor

The starter motor is mounted with two screws to the automatic transmission torque converter housing and is located on the right side of the engine.

The starter motor incorporates several features to create a reliable, efficient, compact, lightweight and powerful unit. The electric motor of the starter features four electromagnetic field coils wound around four pole shoes, and four brushes contact the motor commutator. The starter motor is rated at 1.4 kilowatts (about 1.9 horsepower) output at 12 volts.

The starter motor is equipped with a planetary gear reduction (intermediate transmission) system. The planetary gear reduction system consists of a gear that is integral to the output end of the electric motor armature shaft that is in continual engagement with a larger gear that is splined to the input end of the starter pinion gear shaft. This feature makes it possible to reduce the dimensions of the starter. At the same time, it allows higher armature rotational speed and delivers increased torque through the starter pinion gear to the starter ring gear.

The starter motor is activated by an integral heavy duty starter solenoid switch mounted to the overrunning clutch housing. This electromechanical switch connects and disconnects the feed of battery voltage to the starter motor and actuates a shift fork that engages and disengages the starter pinion gear with the starter ring gear.

The starter motor uses an overrunning clutch and starter pinion gear unit to engage and drive a starter ring gear that is integral to the torque converter drive plate mounted on the rear crankshaft flange.

The starter motor is serviced only as a unit with its starter solenoid and cannot be repaired. If either component is faulty or damaged, the entire starter motor and starter solenoid unit must be replaced.



Manufacturer	Mitsubishi
Engine Application	4.0L, 4.7L
Power Rating	1.4 Kilowatt (1.9 Horsepower)
Voltage	12 Volts
Number of Fields	4
Number of Poles	4
Number of Brushes	4
Drive Type	Planetary Gear Reduction
Free Running Test Voltage	11.2 Volts
Free Running Test Maximum Amperage Draw	90 Amperes
Free Running Test Minimum Speed	2400 rpm
Solenoid Closing Maximum Voltage Required	7.8 Volts
*Cranking Amperage Draw Test	160 Amperes
*Test at operating temperature. Cold engine, tight (new) engine, or heavy oil will increase starter amperage draw.	

Starter Relay

The starter relay is an electromechanical device that switches battery current to the pull-in coil of the starter solenoid when the ignition switch is turned to the Start position. The starter relay is located in the Power Distribution Center (PDC), in the engine compartment. See the fuse and relay layout label affixed to the inside surface of the PDC cover for starter relay identification and location.

The starter relay consists of an electromagnetic coil, a resistor or diode, and three (two fixed and one movable) electrical contacts. The movable (common feed) relay contact is held against one of the fixed contacts normally closed) by spring pressure. When the electromagnetic coil is energized, it draws the movable contact away from the normally closed fixed contact, and holds it against the other (normally open) fixed contact.

When the electromagnetic coil is de-energized, spring pressure returns the movable contact to the formally closed position. The resistor or diode is connected in parallel with the electromagnetic coil in the relay, and helps to dissipate voltage spikes that are produced when the coil is de-energized.

The starter relay cannot be repaired or adjusted and, if faulty or damaged, it must be replaced.

CHARGING SYSTEM

The charging system consists of

- Generator
- Electronic Voltage Regulator (EVR) circuitry within the Powertrain Control Module (PCM)
- Ignition Switch
- Battery
- Battery Temperature Sensor
- Generator Lamp (if equipped)
- Check Gauges Lamp (if equipped)
- Voltmeter
- Wiring Harness and Connections

The charging system is turned on and off with the ignition switch. The system is on when the engine is running and the auto shutdown (ASD) relay is energized. When the ASD relay is on, voltage is supplied to the ASD relay sense circuit at the Powertrain Control Module (PCM). This voltage is connected through the PCM and supplied to one of the generator field terminals (Gen. Source +) at the back of the generator.

The amount of direct current (DC) produced by the generator is controlled by the Electronic Voltage Regulator (EVR) (field control) circuitry contained within the PCM. This circuitry is connected in series with the second rotor field terminal and ground.

A battery temperature sensor, located in the battery tray housing, is used to sense battery temperature. This temperature data, along with data from monitored line voltage, is used by the PCM to vary the battery charging rate. This is done by cycling the ground path to control the strength of the rotor magnetic field. The PCM then compensates and regulates generator current output accordingly.

All vehicles are equipped with On-Board Diagnostics (OBD). All OBD-sensed systems, including EVR (field control) circuitry, are monitored by the PCM. Each monitored circuit is assigned a Diagnostic Trouble Code (DTC). The PCM will store a DTC in electronic memory for certain failures it detects. Refer to the proper service manual for more DTC information.

The Check Gauges Lamp (if equipped) monitors charging system voltage, engine coolant temperature, and engine oil pressure. If an extreme condition is indicated, the lamp will be illuminated. This is done as reminder to check the three gauges. Refer to the proper service manual for additional information.

Generator

The generator is belt-driven by the engine using a serpentine-type drive belt. It is serviced only as a complete assembly. If the generator fails for any reason, the entire assembly must be replaced.

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil. Once the generator begins producing sufficient current, it also provides the current needed to energize the rotor.

The Y type stator winding connections deliver the induced AC current to 3 positive and 3 negative diodes for rectification. From the diodes, rectified DC current is delivered to the vehicle electrical system through the generator battery terminal.

Although the generators appear the same externally, different generators with different output ratings are used on the Jeep Grand Cherokee. Be certain that the replacement generator has the same output rating and part number as the original unit. Refer to the proper service manual for amperage ratings and part numbers.

Noise emitting from the generator may be caused by: worn, loose or defective bearings; a loose or defective drive pulley; incorrect, worn, damaged or misadjusted fan drive belt; loose mounting bolts; a misaligned drive pulley or a defective stator or diode.

Battery Temperature Sensor

The battery temperature sensor is attached to the battery tray located under the battery. It is used to determine the battery temperature and control battery charging rate. This temperature data, along with data from monitored line voltage, is used by the PCM to vary the battery charging rate. System voltage will be higher at colder temperatures and is gradually reduced at warmer temperatures.

Electronic Voltage Regulator

The Electronic Voltage Regulator (EVR) is not a separate component. It is actually a voltage regulating circuit located within the Powertrain Control Module (PCM). The EVR is not serviced separately. If replacement is necessary, the PCM must be replaced.

The amount of DC current produced by the generator is controlled by EVR circuitry contained within the PCM. This circuitry is connected in series with the generator's second rotor field terminal and its ground.

Voltage is regulated by cycling the ground path to control the strength of the rotor magnetic field. The EVR circuitry monitors system line voltage and battery temperature. It then compensates and regulates generator current output accordingly. Refer to the proper service manual for additional information.

INTAKE MANIFOLD

The intake manifold is made of a composite material and features long runners which maximize low end torque. The intake manifold uses single plane sealing which consists of eight individual press-in-place port gaskets to prevent leaks. Eight studs and two bolts are used to fasten the intake to the head.



FUEL DELIVERY SYSTEM

The fuel delivery system consists of

- The fuel pump module containing the electric fuel pump, fuel gauge sending unit (fuel level sense and a separate fuel filter located at bottom of pump module)
- A separate combination fuel filter/fuel pressure regulator
- Fuel tubes/lines/hoses
- Quick-connect fittings
- Fuel injector rail
- Fuel injectors
- Fuel tank
- Fuel tank filler/vent tube assembly
- Fuel tank filler tube cap
- Accelerator pedal
- Throttle cable

The fuel tank assembly consists of the fuel tank, fuel tank shield, fuel tank straps, fuel pump module assembly, fuel pump module locknut/gasket, and roll over valve.

A fuel filler/vent tube assembly using a pressure/vacuum fuel filler cap is used. The fuel filler tube contains a spring-loaded flap (door) located below the fuel fill cap. The **flap** is used as a secondary way of sealing the fuel tank if the fuel fill cap has not been properly tightened.

Also to be considered part of the fuel system is the Evaporative Control System. This is designed to reduce the emission of fuel vapors into the atmosphere. The description and function of the Evaporative Control System can be found in the appropriate service manual.

Both fuel filters (at bottom of fuel pump module and within fuel pressure regulator) are designed for extended service. They **DO NOT** require normal scheduled maintenance. Filters should only be replaced if a diagnostic procedure indicates to do so.

Fuel Pump Module

The fuel pump module is installed in the top of the fuel tank. The fuel pump module (Figure 6-16) contains the following components:

- A separate fuel pick-up filter (strainer)
- An electric fuel pump
- A threaded locknut to retain module to tank
- A gasket between tank flange and module
- Fuel gauge sending unit (fuel level sensor)
- Fuel supply tube (line) connection

- Fuel return tube (line) connection

The fuel gauge sending unit and pick-up filter may be serviced separately. If the electrical fuel pump requires service, the entire fuel pump module must be replaced.

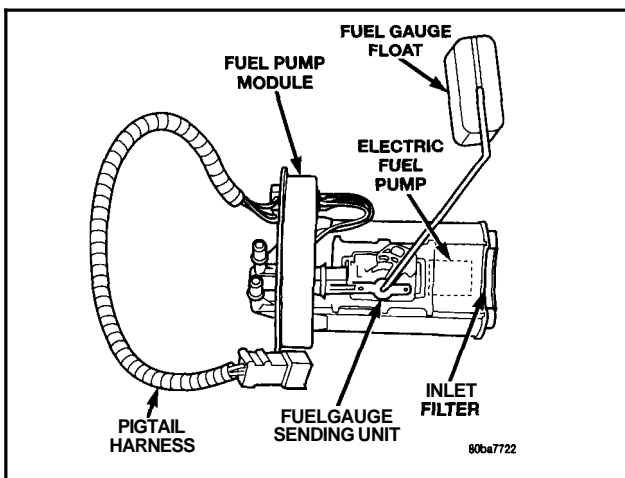


Figure 6 - 16

Fuel Pump

The electric fuel pump is located inside of the fuel pump module.

The fuel pump used in this system has a permanent magnet electric motor. Fuel is drawn in through a filter at the bottom of the module and pushed through the electric motor gear set to the pump outlet.

The pump outlet contains a one-way check valve to prevent fuel flow back into the tank and to maintain fuel supply line pressure (engine warm) when pump is not operational. It is also used to keep the fuel supply line full of gasoline when pump is not operational. After the vehicle has cooled down, fuel pressure may drop to 0 psi (cold fluid contracts), but liquid gasoline will remain in fuel supply line between the check valve and fuel injectors. Fuel pressure that has dropped to 0 psi on a cooled down vehicle (engine off) is a normal condition.

Voltage to operate the electric pump is supplied through the fuel pump relay.

Fuel Gauge Sending Unit

The fuel gauge sending unit (fuel level sensor) is attached to the side of the fuel pump module. The sending unit consists of a float, and arm and a variable resistor (track).

Fuel Filter/Fuel Pressure Regulator

A combination fuel filter and fuel pressure regulator is used on 4.7L engines. It is remotely mounted the body near the front of the fuel tank (Figure 6-17). A separate frame mounted fuel filter is not used with this engine.

The filter/regulator is equipped with three different fuel line connections (Figure 6-17). They are used for: fuel pressure (from the fuel pump module to the filter/regulator), fuel return (from the filter/regulator back to the fuel pump module), and fuel supply (to the fuel rail and fuel injectors).

The pressure regulator is a mechanical device that is not controlled by engine vacuum or the Powertrain Control Module (PCM). The regulator is calibrated to maintain fuel system operating pressure of approximately 339 kPa \pm 34 kPa (49.2 psi \pm 5 psi) at the fuel injectors. It contains a diaphragm, calibrated springs and a fuel return valve. The internal fuel filter is also part of the assembly.

Fuel is supplied to the filter/regulator by the electric fuel pump. The regulator acts as a check valve to maintain some fuel pressure when the engine is not operating. This will help to start the engine. A second check valve is located at the outlet end of the electric fuel pump.

If fuel pressure at the pressure regulator exceeds approximately 49 psi, an internal diaphragm closes. Excess fuel is then routed into a separate fuel return line and returned to the fuel tank through the top of the fuel pump module.

Both fuel filters (at bottom of fuel pump module and within fuel pressure regulator) are designed for extended service. They DO NOT require normal scheduled maintenance. Filters should only be replaced if a diagnostic procedure indicates to do so.

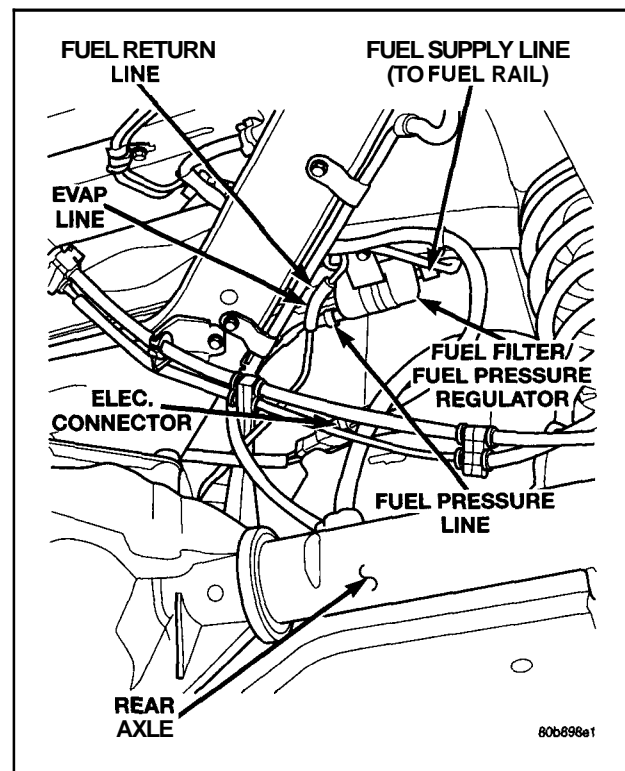


Figure 6 - 17

Fuel Tank

The fuel tank is constructed of a plastic material. Its main functions are for fuel storage and for placement of the fuel pump module.

All models pass a full 360 degree rollover test without fuel leakage. To accomplish this, fuel and vapor flow controls are required for all fuel tank connections.

A rollover valve(s) is mounted into the top of the fuel tank (or pump module). Refer to the proper service manual for rollover valve information.

An evaporation control system is connected to the rollover valve(s) to reduce emission of fuel vapors to the atmosphere. When fuel evaporates from the fuel tank, vapors pass through vent hoses or tubes to a charcoal canister where they are temporarily held. When the engine is running, the vapors are drawn into the intake manifold.

Fuel Injectors

(Refer to Figure 6-18.)

The fuel injectors are electrical solenoids. The injector contains a pintle that closes off an orifice at the nozzle end. When electric current is supplied to the injector, the armature and needle move a short distance against a spring, allowing fuel to flow out the orifice. Because the fuel is under high pressure, a fine spray is developed in the shape of a pencil stream. The spraying action atomizes the fuel, adding it to the air entering the combustion chamber. A separate fuel injector is used for each individual cylinder.

The top (fuel entry) end of the injector is attached into an opening on the fuel rail. The nozzle (outlet) end of the injector is positioned into an opening in the intake manifold just above the intake valve port of the cylinder head. The engine wiring harness connector for each fuel injector is equipped with an attached numerical tag (INJ 1, INJ 2 etc.). This is used to identify each fuel injector.

The injectors are electrically energized, individually and in a sequential order by the Powertrain Control Module (PCM). The PCM will adjust injector pulse width by switching the ground path to each individual injector on and off. Injector pulse width is the period of time that the injector is energized. The PCM will adjust injector pulse width based on various inputs it receives.

During start up, battery voltage is supplied to the injectors through the ASD relay. When the engine is operating, voltage is supplied by the charging system. The PCM determines injector pulse width based on various inputs.

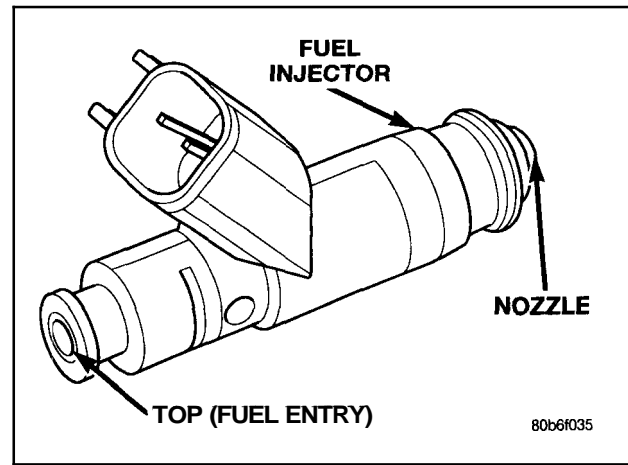


Figure 6 - 18

Fuel Injector Rail

The metal fuel injector rail is used to mount the fuel injectors to the engine. It is mounted to the intake manifold (Figure 6-19). The fuel rail is not repairable.

High pressure fuel from the fuel pump is routed to the fuel rail. The fuel rail then supplies the necessary fuel to each individual fuel injector.

A fuel pressure test port is located on the fuel rail (Figure 6-19). A quick-connect fitting with a safety latch is used to attach the fuel line to the fuel rail.

Caution: The left and right sections of the fuel rail are joined with a connector tube (Figure 6-19). DO NOT attempt to separate the rail halves at this tube. Due to the design of this connecting tube, it does not use any clamps. Never attempt to install a clamping device of any kind to the tube. When removing the fuel rail assembly for any reason, be careful not to bend or kink the connector tube.

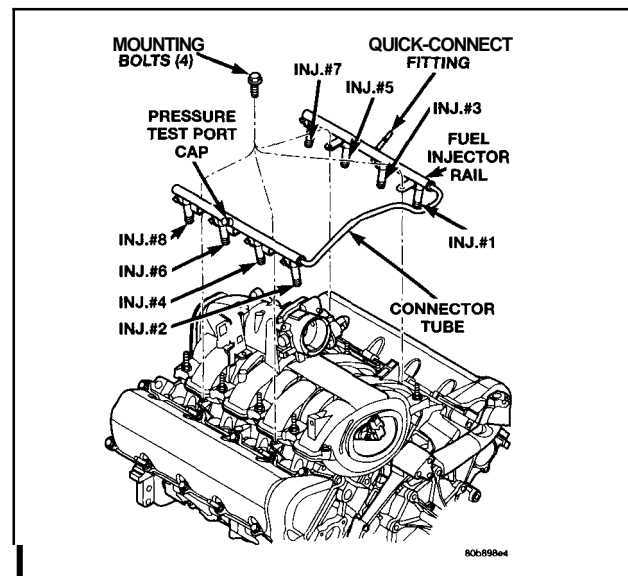


Figure 6 - 19

Fuel Tank Filler Tube Cap

The plastic fuel fill cap is threaded onto the end of the fuel fill tube.

The loss of any fuel or vapor out of fuel filler tube is prevented by the use of a pressure-vacuum fuel fill cap. Relief valves inside the cap will release fuel tank pressure at predetermined pressures. Fuel tank vacuum will also be released at predetermined values. This cap must be replaced by a similar unit if replacement is necessary. This is in order for the system to remain effective.

Caution: Remove fill cap before servicing any fuel system component. This is done to help relieve tank pressure. If equipped with a California emissions package and a Leak Detection Pump (LDP), the secondary seal below the fill cap must be pressed (opened) to relieve fuel tank pressure.

POWERTRAIN CONTROL MODULE (PCM)

The Powertrain Control Module (PCM), formerly referred to as the **SBEC** or engine controller, is a pre-programmed, triple microprocessor digital computer. It regulates ignition timing, air-fuel ratio, emission control devices, charging system, certain transmission features, speed control, air conditioning compressor clutch engagement and idle speed. The PCM can adapt its programming to meet changing operating conditions.

The PCM receives input signals from various switches and sensors. Based on these inputs, the PCM regulates various engine and vehicle operations through different system components. These components are referred to as PCM Outputs. The sensors and switches that provide inputs to the PCM are considered PCM Inputs.

The PCM adjusts ignition timing based upon inputs it receives from sensors that react to engine rpm, manifold absolute pressure, engine coolant temperature, throttle position, transmission gear selection (automatic transmission), vehicle speed, and the brake switch.

The PCM adjusts idle speed based on inputs it receives from sensors that react to throttle position, vehicle speed, transmission gear selection, engine coolant temperature, air conditioning clutch switch, and brake switch.

Based on inputs that it receives, the PCM adjusts ignition coil dwell. The PCM also adjusts the generator charge rate through control of the generator field and provides speed control operation.

Modes of Operation

As input signals to the PCM change, the PCM adjusts its response to the output devices. For example, the PCM must calculate different injector pulse width and ignition timing for idle than it does for wide open throttle.

The PCM operates in two different modes: Open Loop and Closed Loop.

During Open Loop modes, the PCM receives input signals and responds only according to preset PCM programming. Input from the oxygen (O₂) sensors is not monitored during Open Loop modes.

During Closed Loop modes, the PCM will monitor the oxygen (O₂) sensors input. This input indicates to the PCM whether or not the calculated injector pulse width results in the ideal air-fuel ratio. This ratio is 14.7 parts air-to-1 part fuel. By monitoring the exhaust oxygen content through the O₂ sensor, the PCM can fine tune the injector pulse width. This is done to achieve optimum fuel economy combined with low emission engine performance.

The fuel injection system has the following modes of operation:

- Ignition switch ON
- Engine start-up (crank)
- Engine warm-up
- Idle
- Cruise
- Acceleration
- Deceleration
- Wide open throttle
- Ignition switch OFF

The ignition switch On, engine start-up (crank), engine warm-up, acceleration, deceleration, and wide open throttle modes are Open Loop modes. The idle and cruise modes (with the engine at operating temperature) are Closed Loop modes.

Ignition Switch (Key-On) Mode

This is an Open Loop mode. When the fuel system is activated by the ignition switch, the following actions occur:

- The PCM pre-positions the idle air control (IAC) motor.
- The PCM determines atmospheric air pressure from the MAP sensor input to determine basic fuel strategy.
- The PCM monitors the engine coolant temperature sensor input. The PCM modifies fuel strategy based on this input.
- Intake manifold air temperature sensor input is monitored.
- Throttle position sensor (TPS) is monitored.
- The auto shutdown (ASD) relay is energized by the PCM for approximately three seconds.
- The fuel pump is energized through the fuel pump relay by the PCM. The fuel pump will operate for approximately three seconds unless the engine is operating or the starter motor is engaged.
- The O₂ sensor heater element is energized via the O₂ relays. The O₂ sensor input is not used by the PCM to calibrate air-fuel ratio during this mode of operation.

Engine Start-up Mode

This is an Open Loop mode. The following actions occur when the starter motor is engaged.

The PCM receives inputs from:

- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Starter motor relay
- Camshaft position sensor signal

The PCM monitors the crankshaft position sensor. If the PCM does not receive a crankshaft position sensor signal within approximately 3 seconds of cranking the engine, it will shut down the fuel injection system.

The fuel pump is activated by the PCM through the fuel pump relay.

Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.

The PCM determines the proper ignition timing according to input received from the crankshaft position sensor.

Engine Warm-up Mode

This is an Open Loop mode. During engine warm-up, the PCM receives inputs from:

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal - automatic transmission only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)

Based on these inputs the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM adjusts engine idle speed through the idle air control (IAC) motor and adjusts ignition timing.
- The PCM operates the A/C compressor clutch through the clutch relay. This is done if A/C has been selected by the vehicle operator and requested by the A/C thermostat.
- When engine has reached operating temperature, the PCM will begin monitoring O₂ sensor input. The system will then leave the warm-up mode and go into closed loop operation.

Idle Mode

When the engine is at operating temperature, this is a Closed Loop mode. At idle speed, the PCM receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)

- Camshaft position sensor signal
- Battery voltage
- Park/neutral switch (gear indicator signal – automatic transmission only)
- Oxygen (O₂) sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control injection sequence and injector pulse width by turning the ground circuit to each individual injector and off and on.
- The PCM monitors the O₂ sensor input and adjusts air-fuel ratio by varying injector pulse width. It also adjusts engine idle speed through the idle air control (IAC) motor.
- The PCM adjusts ignition timing by increasing or decreasing spark advance.
- The PCM operates the A/C compressor clutch through the clutch relay. This happens if A/C has been selected by the vehicle operator and requested by the A/C thermostat.

Cruise Mode

When the engine is at operating temperature, this is a Closed Loop mode. At cruising speed, the PCM receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal – automatic transmission only)
- Oxygen (O₂) sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then adjust the injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM monitors the O₂ sensor input and adjusts air-fuel ratio. It also adjusts engine idle speed through the idle air control (IAC) motor.

- The PCM adjusts ignition timing by turning the ground path to the coil on and off.
- The PCM operates the A/C compressor clutch through the clutch relay. This happens if A/C has been selected by the vehicle operator and requested by the A/C thermostat.

Acceleration Mode

This is an Open Loop mode. The PCM recognizes an abrupt increase in throttle position or MAP pressure as a demand for increased engine output and vehicle acceleration. The PCM increases injector pulse width in response to increased throttle opening

Deceleration Mode

When the engine is at operating temperature, this is an Open Loop mode. During hard deceleration, the PCM receives the following inputs.

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal
- Park/neutral switch (gear indicator signal – automatic transmission only)
- Vehicle speed

If the vehicle is under hard deceleration with the proper rpm and closed throttle conditions, the PCM will ignore the oxygen sensor input signal. The PCM will enter a fuel cut-off strategy in which it will not supply a ground to the injectors. If a hard deceleration does not exist, the PCM will determine the proper injector pulse width and continue injection.

Based on the above inputs, the PCM will adjust engine idle speed through the idle air control (IAC) motor.

The PCM adjusts ignition timing by turning the ground path to the coil on and off.

Wide Open Throttle Mode

This is an Open Loop mode. During wide open throttle operation, the PCM receives the following inputs.

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor

- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal

During wide open throttle conditions, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off. The PCM ignores the oxygen sensor input signal and provides a predetermined amount of additional fuel. This is done by adjusting injector pulse width.
- The PCM adjusts ignition timing by turning the ground path to the coil on and off.

Ignition Switch Off Mode

When the ignition switch is turned to the OFF position, the PCM stops operating the injectors, ignition coil, ASD relay and fuel pump relay.

POSITIVE CRANKCASE VENTILATION (PCV) SYSTEM

The 4.7L V-8 engine is equipped with a closed crankcase ventilation system and a Positive Crankcase Ventilation (PCV) valve.

This system consists of

- a PCV valve mounted to the oil filler housing (Figure 6-20). The PCV valve is sealed to the oil filler housing with an o-ring.
- the air cleaner housing.
- two interconnected breathers threaded into the rear of each cylinder head (Figure 6-21).
- tubes and hose to connect the system components.

The PCV system operates by engine intake manifold vacuum. Filtered air is routed into the crankcase through the air cleaner hose and crankcase breathers. The metered air, along with crankcase vapors, are drawn through the PCV valve and into a passage in the intake manifold. The PCV system manages crankcase pressure and meters blow-by gases to the intake system, reducing engine sludge formation.

The PCV valve contains a spring loaded plunger. This plunger meters the amount of crankcase vapors routed into the combustion chamber based on intake manifold vacuum.

When the engine is not operating, or during an engine pop-back, the spring forces the plunger back against the seat. This will prevent vapors from flowing through the valve.

During periods of high manifold vacuum, such as idle or cruising speeds, vacuum is sufficient to completely compress the spring. It will then pull the plunger to the top of the valve. In this position there is minimal vapor flow through the valve.

During periods of moderate manifold vacuum, the plunger is only pulled part way back from inlet. This results in maximum vapor flow through the valve.

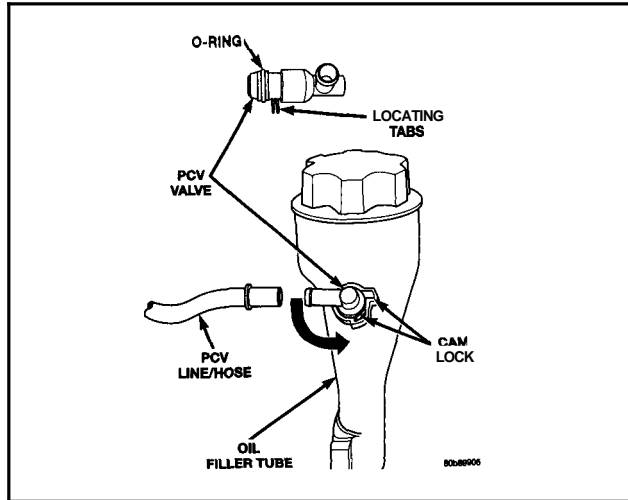


Figure 6 - 20

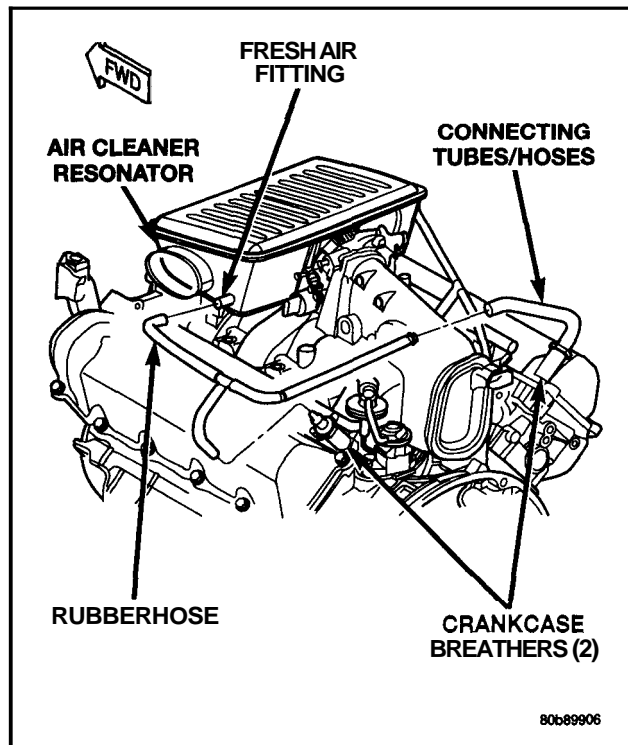


Figure 6 - 21

EXHAUST SYSTEM

Exhaust Manifolds

Exhaust manifolds are log style with a patented flow enhancing design to maximize performance. The exhaust manifolds are made of high silicon molybdenum cast iron. A perforated core graphite exhaust manifold gasket is used to improve sealing to the cylinder head. Exhaust manifolds are covered by a three layer laminated heat shield for thermal protection and noise reduction. Heat shields are fastened with a torque prevailing nut that is backed off slightly to allow for the thermal expansion of exhaust manifolds.

Oxygen Sensors

The exhaust system uses oxygen sensors to detect exhaust gasses. These gasses are sampled to determine whether the system is rich (too much fuel) or lean (not enough fuel). The Powertrain Control Module (PCM) then makes the appropriate adjustment to the fuel system.

Muffler and Tailpipe

The 4.7L engine uses a galvanized steel muffler to control exhaust noise levels and exhaust backpressure.

The tail pipe is also made of galvanized steel and channels the exhaust out of the muffler and out from under the vehicle to control noise and prevent exhaust gas fumes from entering the passenger compartment.

IGNITION SYSTEM

The 4.7L V-8 engine uses a dedicated and individually fired coil for each spark plug (8 total). Each coil is mounted directly to the top of each spark plug. A separate electrical connector is used for each coil.

Because of coil design, spark plug cables (secondary cables) are not used. A distributor is also not used.

The ignition system is controlled by the Powertrain Control Module (PCM), and consists of:

- Spark Plugs
- Ignition Coils
- Powertrain Control Module (PCM)
- Crankshaft Position Sensor
- Camshaft Position Sensor
- The MAP, TPS, IAC and ECT also have an effect on the control of the ignition system.

Spark Plugs

The 4.7L V-8 engine is equipped with “fired-in suppressor seal,” resistor-type spark plugs using a copper core ground electrode. To prevent possible pre-ignition and/or mechanical engine damage, the correct type/heat range/number spark plug must be used.

4.7L V-8 engine spark plugs have resistance values ranging from 6,000 to 20,000 ohms (when checked with at least a 1,000 volt spark plug tester). DO NOT use an ohmmeter to check the resistance values of the spark plugs. Inaccurate readings will result. Remove the spark plugs and examine them for burned electrodes and fouled, cracked or broken porcelain insulators. Keep plugs arranged in the order in which they were removed from the engine. A single plug displaying an abnormal condition indicates that a problem exists in the corresponding cylinder. Replace spark plugs at the intervals recommended in your owner’s manual.

Spark plugs that have low mileage may be cleaned and reused if not otherwise defective, carbon or oil fouled.

Caution: Never use a motorized wire wheel brush to clean the spark plugs. Metallic deposits will remain on the spark plug insulator and will cause plug misfire.

Because of the use of aluminum cylinder heads on the 4.7L engine, spark plug torque is very critical. Refer to the proper service manual for procedure and specifications.

Ignition Coils

The 4.7L V-8 engine uses a dedicated and individually fired coil (Figure 6-22) for each spark plug (8 total). Each coil is mounted directly to the top of each spark plug.

Battery voltage is supplied to the 8 ignition coils from the ASD relay. The Powertrain Control Module (PCM) opens and closes each ignition coil ground circuit at a determined time for ignition coil operation.

Base ignition timing is not adjustable. By controlling the coil ground circuit, the PCM is able to set the base timing and adjust the ignition timing advance. This is done to meet changing engine operating conditions.

The ignition coil is not oil filled. The windings are embedded in an epoxy compound. This provides heat and vibration resistance that allows the ignition coil to be mounted on the engine.

Because of coil design, spark plug cables (secondary cables) are not used.

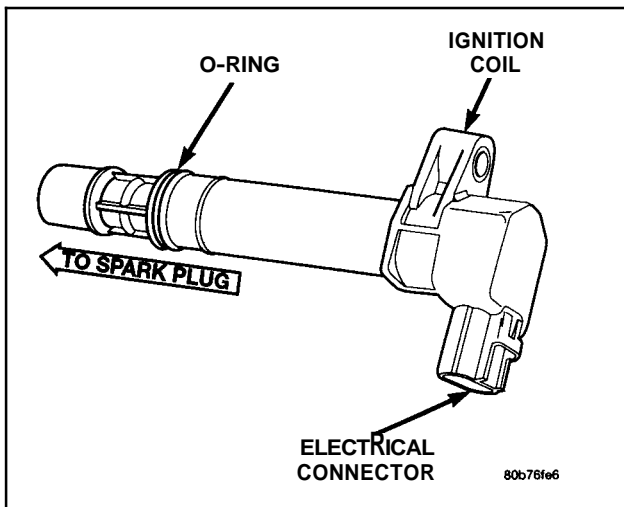
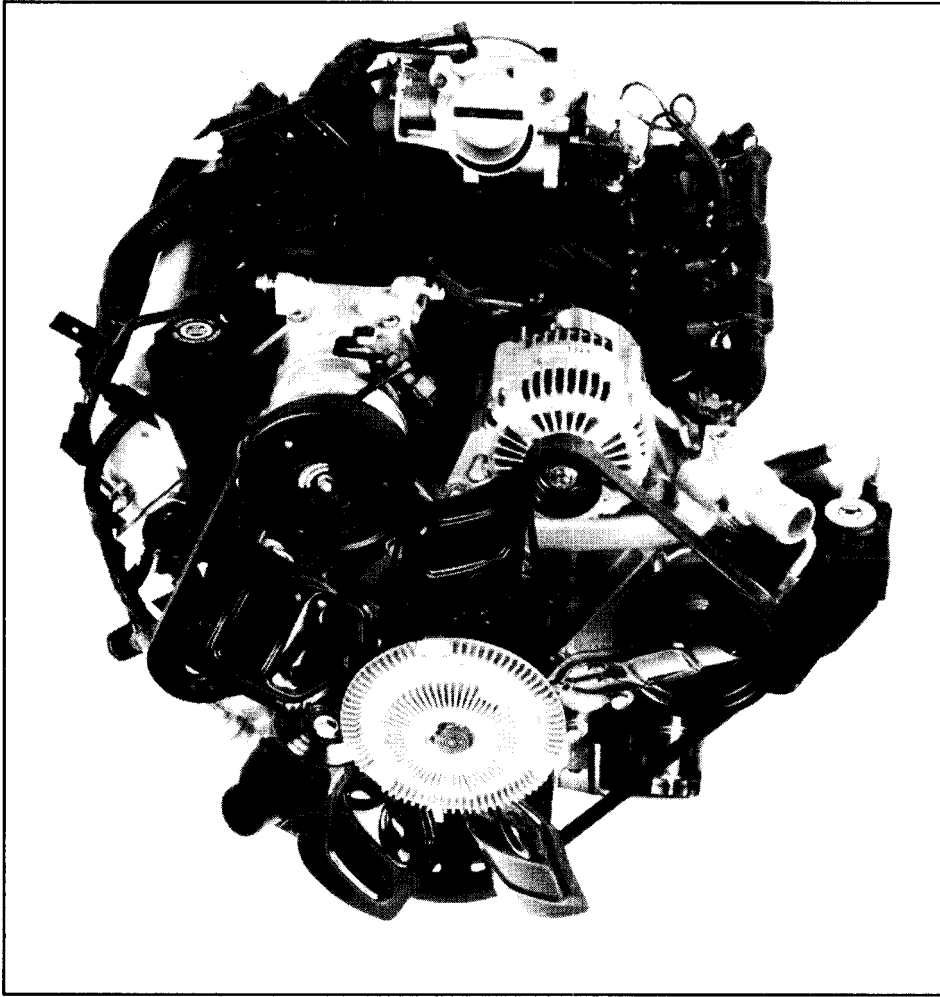
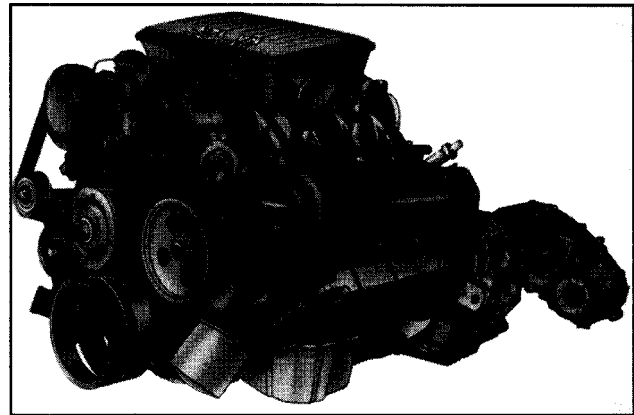


Figure 6 - 22



TROUBLESHOOTING

Cylinder Compression Pressure Test

The results of a cylinder compression pressure test can be utilized to diagnose several engine malfunctions.

Ensure the battery is completely charged and the engine starter motor is in good operating condition. Otherwise, the indicated compression pressures may not be valid for diagnosis purposes.

CYLINDER COMBUSTION PRESSURE LEAKAGE DIAGNOSIS CHART

CONDITION	POSSIBLE CAUSE	CORRECTION
AIR ESCAPES THROUGH THROTTLE BODY	Intake valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary
AIR ESCAPES THROUGH TAILPIPE	Exhaust valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary
AIR ESCAPES THROUGH RADIATOR	Head gasket leaking or cracked cylinder head or block	Remove cylinder head and inspect. Replace defective part
MORE THAN 50% LEAKAGE FROM ADJACENT CYLINDERS	Head gasket leaking or crack in cylinder head or block between adjacent cylinders	Remove cylinder head and inspect. Replace gasket, head, or block as necessary
MORE THAN 25% LEAKAGE AND AIR ESCAPES THROUGH OIL FILLER CAP OPENING ONLY	Stuck or broken piston rings; cracked piston; worn rings and/or cylinder wall	Inspect for broken rings or piston. Measure ring gap and cylinder diameter, taper and out-of-round. Replace defective part as necessary

1. Disconnect the ignition coil tower electrical connectors and remove ignition coil towers.
2. Remove the spark plugs.
3. Clean the spark plug recesses with compressed air.
4. Secure the throttle in the wide-open position
5. Disable the fuel system. (Refer to the proper service manual for the correct procedure)
6. Insert a compression pressure gauge and rotate the engine with the engine starter motor for three revolutions.
7. Record the compression pressure on the 3rd revolution. Continue the test for the remaining cylinders.

Refer to *4.7L Engine Specifications*, in this chapter, for the correct engine compression pressures.

Engine Cylinder Head Gasket Failure Diagnosis

A leaking engine cylinder head gasket usually results in loss of power, and/or coolant and engine misfiring. An engine cylinder head gasket leak can be located between adjacent cylinders or between a cylinder and the adjacent water jacket.

- An engine cylinder head gasket leaking between adjacent cylinders is indicated by a loss of power and/or engine misfire.
- An engine cylinder head gasket leaking between a cylinder and an adjacent water jacket is indicated by coolant foaming or overheating and loss of coolant.

Cylinder-to-Cylinder Leakage Test

To determine if an engine cylinder head gasket is leaking between adjacent cylinders, follow the procedures outlined in *Cylinder Compression Pressure Test*. An engine cylinder head gasket leaking between adjacent cylinders will result in approximately a 50-70% reduction in compression pressure.

Cylinder-to-Water Jacket Leakage Test

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or the fan. DO NOT wear loose clothing.

Remove the radiator cap.

Start the engine and allow it to warm up until the engine thermostat opens.

If a large combustion/compression pressure leak exists, bubbles will be visible in the coolant.

If bubbles are not visible, install a radiator pressure tester and pressurize the coolant system.

If a cylinder is leaking combustion pressure into the water jacket, the tester pointer will pulsate with every combustion stroke of the cylinder.

Cylinder Combustion Pressure Leakage Test

The combustion pressure leakage test provides an accurate means for determining engine condition.

Combustion pressure leakage testing will detect:

- Exhaust and intake valve leaks (improper seating).
- Leaks between adjacent cylinders or into water jacket.
- Any causes for combustion/compression pressure loss.

The procedure is as follows:

1. Check the coolant level and fill as required. DO NOT install the radiator cap.
2. Start and operate the engine until it attains normal operating temperature, then turn the engine OFF.
3. Disconnect ignition coil tower electrical connectors.
4. Remove ignition coil towers.
5. Remove the spark plugs.
6. Remove the oil filler cap.
7. Remove the air cleaner.
8. Calibrate the tester according to the manufacturer's instructions. The shop air source for testing should maintain 483 kPa (70 psi) minimum, 1,379 kPa (200 psi) maximum, and 552 kPa (80 psi) recommended.
9. Perform the test procedures on each cylinder according to the tester manufacturer's instructions. While testing, listen for pressurized air escaping through the throttle body, tailpipe and oil filler cap opening. Check for bubbles in the radiator coolant.

All gauge pressure indications should be equal, with no more than 25% leakage.

Example: At 552 kPa (80 psi) input pressure, a minimum of 414 kPa (60 psi) should be maintained in the cylinder.

Refer to the *Cylinder Combustion Pressure Leakage Diagnosis Chart*.

Engine Oil Leak Inspection

Begin with a thorough visual inspection of the engine, particularly at the area of the suspected leak. If an oil leak source is not readily identifiable, the following steps should be followed:

1. DO NOT clean or degrease the engine at this time because some solvents may cause rubber to swell, temporarily stopping the leak.
2. Add an oil soluble dye (use as recommended by manufacturer). Start the engine and let idle for approximately 15 minutes. Check the oil dipstick to make sure the dye is thoroughly mixed as indicated with a bright yellow color under a black light.

3. Using a black light, inspect the entire engine for fluorescent dye, particularly at the suspected area of oil leak. If the oil leak is found and identified, repair per service manual instructions.
4. If dye is not observed, drive the vehicle at various speeds for approximately 24 km (15 miles), and repeat inspection.
5. If the oil leak source is not positively identified at this time, proceed with the *Air Leak Detection Test Method*.

Air Leak Detection Test Method

1. Disconnect the breather cap to air cleaner hose at the breather cap end. Cap or plug breather cap nipple.
2. Remove the PCV valve from the cylinder head cover. Cap or plug the PCV valve grommet.
3. Attach an air hose with pressure gauge and regulator to the dipstick tube.

Caution: DO NOT subject the engine assembly to more than 20.6 kPa (3 psi) of test pressure.

4. Gradually apply air pressure from 1 psi to 2.5 psi maximum while applying soapy water at the suspected source. Adjust the regulator to the suitable test pressure that provide the best bubbles which will pinpoint the leak source. If the oil leak is detected and identified, repair per service manual procedures.
5. If the leakage occurs at the rear oil seal area, refer to *Inspection for Rear Seal Area Leaks*.
6. If no leaks are detected, turn off the air supply and remove the air hose and all plugs and caps. Install the PCV valve and breather cap hose.
7. Clean the oil off the suspect oil leak area using a suitable solvent. Drive the vehicle at various speeds approximately 24 km (15 miles). Inspect the engine for signs of an oil leak by using a black light.

Inspection for Rear Seal Area Leaks

Since it is sometimes difficult to determine the source of an oil leak in the rear seal area of the engine, a more involved inspection is necessary. The following steps should be followed to help pinpoint the source of the leak.

If the leakage occurs at the crankshaft rear oil seal area:

1. Disconnect the battery.
2. Raise the vehicle.
3. Remove torque converter or clutch housing cover and inspect rear of block for evidence of oil. Use a black light to check for the oil leak:
 - a. Circular spray pattern generally indicates seal leakage or crankshaft damage.
 - b. Where leakage tends to run straight down, possible causes are a porous block, camshaft bore cup plugs, oil galley pipe plugs, oil filter runoff, and main bearing cap-to-cylinder block mating surfaces.

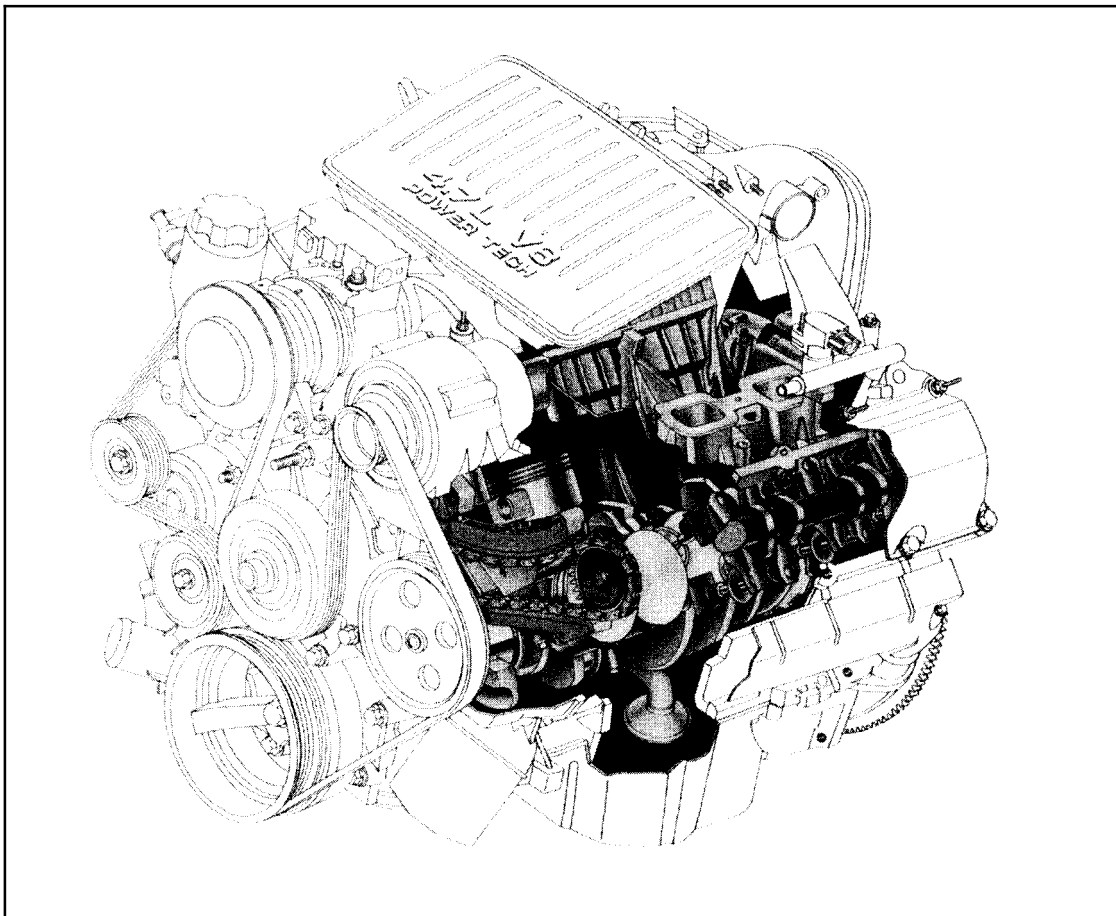
4. If no leaks are detected, pressurize the crankcase as outlined in the *Air Leak Detection Test Method*.

Caution: DO NOT exceed 20.6 kPa (3 psi) of test pressure.

5. If the leak is not detected, very slowly turn the crankshaft and watch for leakage. If a leak is detected between the crankshaft and seal while slowly turning the crankshaft, it is possible the crankshaft seal surface is damaged. The seal area on the crankshaft could have minor nicks or scratches that can be polished out with emery cloth.

Caution: Use extreme caution when crankshaft polishing is necessary to remove minor nicks and scratches. The crankshaft seal flange is specially machined to complement the function of the rear oil seal.

6. For bubbles that remain steady with shaft rotation, no further inspection can be done until the engine is disassembled.



1999, 4.7L ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the 1999 Jeep Grand Cherokee Service Manual.

DESCRIPTION	SPECIFICATION		
General Specification		Ring Width	
Type	90° SOHC V-8 16-Valve	Top Compression Ring	1.472 – 1.490 mm (0.057– 0.058in.)
Displacement	4.7Liters 4701 cc (287Cubic Inches)	2nd Compression Ring	1.472 – 1.490 mm (0.057– 0.058in.)
Bore & Stroke	93.0 mm x 86.5 mm (3.66in. x 3.40 in.)	Oil Ring (Steel Rails)	0.445 – 0.470 mm (0.017– 0.018in.)
Compression Ratio	9.0:1	Connecting Rods	
Lead Cylinder	#1 Left Bank:	Bearing Clearance	0.010 – 0.048 mm (0.0004– 0.0019 in.)
Firing Order	1,8,4,3,6,5,7,2	Side Clearance	0.10 – 0.35 mm (0.004– 0.0138in.)
Cylinder Block	Cast Iron	Piston Pin Bore	
Cylinder Head	Aluminum	Diameter	Interference fit .022 – .045 mm (0.0009– 0.0018in.)
Cylinder Block		Bearing Bore Out of Round (Max. Allowable)	0.004 mm (in.)
Cylinder Bore Diameter	93.010 ± .0075 mm (3.6619± 0.0003in.)	Total Weight (Less Bearing)	578 grams (20.388ounces)
DESCRIPTION SPECIFICATION		Crankshaft Main Bearing Journals	
Out of Round (Max)	0.076 mm (0.003in.)	Diameter	63.488 – 63.512 mm (2.4996– 2.5005 in.)
Taper (Max)	0.051 mm (0.002in.)	Bearing Clearance	0.004 – 0.032 mm (0.0002– 0.0013in.)
Pistons		Out of Round (Max.)	0.005 mm (0.0002 in.)
Type Material	Aluminum alloy	Taper (Max.)	0.008 mm (0.0004in.)
Piston diameter	92.975 mm (3.6605in.)	End Play	0.052 – 0.282 mm (0.0021– 0.0112in.)
Clearance at Size Location ..	0.0198– 0.0501 mm (0.0008– 0.0020 in.)	End Play (Max. Allowable)	0.282 mm (0.0112in.)
Piston Weight		Connecting Rod Journals	
.....	367.5grams (12.96 oz.)	Diameter	50.992 – 51.008 mm (2.0076– 2.0082 in.)
Piston Ring Groove Diameter		Bearing Clearance	0.010 – 0.048 mm (0.0004– 0.0019 in.)
No. 1	83.73– 83.97 mm (3.296– 3.269 in.)	Out Of Round (Max.)	0.005 mm (0.0002in.)
No. 2	82.833 – 83.033 mm (3.261 – 3.310 in.)	Taper (Max.)	0.008 mm (0.0004in.)
No. 3	83.88 – 84.08 mm (3.302– 3.310 in.)	Camshaft	
Piston Pins		Bore Diameter	26.02 – 26.04 mm (1.0245– 1.0252in.)
Type	Pressed Fit	Bearing Journal Diameter ..	25.975 – 25.995 mm (1.0227– 1.0235in.)
Clearance In Piston	0.018 – 0.019 mm (0.0008in.)	Bearing Clearance	0.025 – 0.065 mm (0.001– 0.0026in.)
Diameter,	24.008 – 24.013 mm (0.9452– 0.9454in.)	Bearing Clearance (Max. Allowable) ..	0.065 mm (0.0026in.)
Piston Rings		End Play	mm (in.)
Ring Gap Top Compression		Valve Timing Intake Valve	
Ring	0.37 – 0.63 mm (0.0146– 0.0249 in.)	Opens (ATDC)	3.5°
Ring Gap 2nd Compression		Closes (ATDC)	247"
Ring	0.37 – 0.63 mm (0.0146– 0.0249 in.)	Duration	243.5"
Ring Gap Oil Control (Steel Rails) ..	0.25 – 1.27 mm (0.0099– 0.05 in.)		
Ring Side Clearance			
Top Compression Ring .....	.051 – .104 mm (0.0020– 0.0041 in.)		
Second Compression Ring.	0.040– 0.080 mm (0.0016– 0.0032 in.)		
Oil Ring (Steel Rails) .....	.019 – .229 mm (.0007 – .0091 in.)		

DESCRIPTION SPECIFICATION**Valve Timing Exhaust Valve**

Opens (BBDC)	232.5°
Closes (ATDC)	21.25°
Duration	253.75°
Valve Overlap	17.75°

Cylinder Head

Gasket Thickness (Compressed) ..	.7 mm (0.0276 in.)
Valve Seat Angle	44.5° - 45.0°
Valve Seat Runout (Max) ...	0.051 mm (0.002 in.)
Intake Valve Seat Width	1.75 - 2.36 mm (0.0698 - 0.0928 in.)
Exhaust Valve Seat Width	1.71 - 2.32 mm (0.0673 - 0.0911 in.)
Guide Bore Diameter (Std.) ...	6.975 - 7.00 mm (0.2747 - 0.2756 in.)
Cylinder Head Warp (Flatness) ...	0.0508 mm (0.002 in.)

Valves

Face Angle	45.0° - 45.5°
Head Diameter Intake	47.87 - 48.13 mm (1.8846 - 1.8949 in.) (1.0227 - 1.0235 in.)
Bearing Clearance	0.025 - 0.065 mm (0.001 - 0.0026 in.)
Bearing Clearance (Max. Allowable) ...	0.065 mm (0.0026 in.)
End Play	mm (in.)
Head Diameter Exhaust	36.87 - 37.13 mm (1.4516 - 1.4618 in.)
Length—Intake (Overall) ...	113.13 - 113.89 mm (4.4539 - 4.4839 in.)
Length—Exhaust (Overall) ..	114.92 - 115.68 mm (4.5244 - 4.5543 in.)
Stem Diameter—Intake	6.931 - 6.957 mm (0.2729 - 0.2739 in.)
Stem Diameter—Exhaust	6.902 - 6.928 mm (0.2717 - 0.2728 in.)
Stem-to-Guide Clearance Intake (New) .....	.026 - .043 mm (0.0011 - 0.0017 in.)
Stem-to-Guide Clearance—Exhaust (New) .....	.072 - .073 mm (0.0029 in.)
Max. Allowable (Rocking Method)— Intake	0.069 mm (0.0028 in.)
Max. Allowable (Rocking Method)— Exhaust	0.098 mm (0.0039 in.)
Valve Lift (Zero Lash)—Intake	11.25 mm (0.443 in.)
Valve Lift (Zero Lash)—Exhaust	10.90 mm (0.4292 in.)

DESCRIPTION SPECIFICATION**Valve Spring**

Free Length (Approx.) Intake & Exhaust.	47.5 mm (1.870 in.)
Spring Force (Valve Closed) Intake & Exhaust ...	285.2-320.8 N @ 40.69 mm (64.0-72.0 lbs. @ 1.6020 in.)
Spring Force (Valve Open) Intake	775.3-846.7 N @ 29.29 mm (176.2-192.4 lbs. @ 1.1532 in.)
Spring Force (Valve Open) Exhaust	775.3-846.7 N @ 29.29 mm (176.2-192.4 lbs. @ 1.1532 in.)
Number of Coils—Intake & Exhaust	6.6
Wire Diameter Intake & Exhaust.	4.2799 - 4.3561 mm (0.1685 - 0.1715 in.)
Installed Height—Intake (Spring Seat to Bottom of Retainer) ...	40.97 mm (1.613 in.)
Installed Height—Exhaust (Spring Seat to Bottom of Retainer) ...	40.81 mm (1.606 in.)

Oil Pump

Clearance Over Rotors (Max.) ...	.035 - .095 mm (0.0014 - 0.0038 in.)
Cover Out-of-Flat (Max.) .....	.025 mm (0.001 in.)
Inner and Outer Rotor Thickness	12.08 mm (0.4756 in.)
Outer Rotor Clearance (Max.)	85.96 mm (3.3843 in.)
Outer Rotor Diameter (Min.)	85.925 mm (0.400 in.)
Tip Clearance Between Rotors (Max.) ...	150 mm (0.006 in.)

Oil Pressure

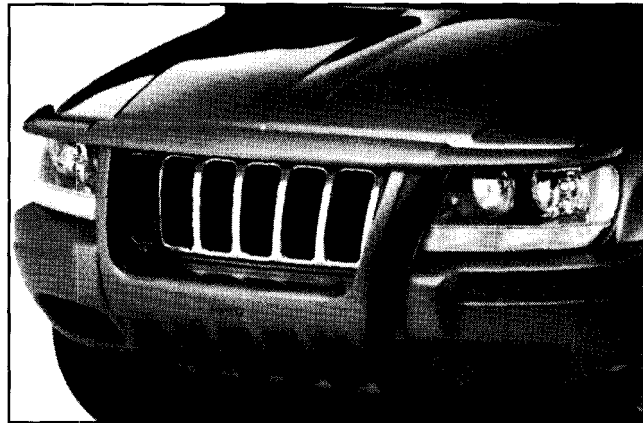
At Curb Idle Speed *	... 25 kPa (4 psi) minimum
At 3000 rpm	170 - 550 kPa (25 - 80 psi)

*CAUTION: If pressure is zero at curb idle, DO NOT run engine at 3000 rpm.

1999, 4.7L ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the 1999 *Jeep Grand Cherokee Service Manual*.

DESCRIPTION	TORQUE	DESCRIPTION	TORQUE
Camshaft Sprocket		Oil Pump	
Bolt	122 N·m (90 ft. lbs.)	Bolts	28 N·m (250 in. lbs.)
Camshaft Bearing Caps		Oil Pump Cover	
Bolt	11 N·m (100 in. lbs.)	Bolts	12 N·m (105 in. lbs.)
Timing Chain Cover		Oil Pickup Tube	
Bolt	54 N·m (40 ft. lbs.)	Bolts	28 N·m (250 in. lbs.)
Connecting Rod Cap		Oil Dipstick Tube	
Bolt	20 N·m (15 ft. lbs.), Plus 110"	Bolt	28 N·m (250 in. lbs.)
Crankshaft Main Bearing Cap/Bedplate		Oil Fill Tube	
Bolt	Refer to Procedure	Bolts	12 N·m (105 in. lbs.)
Crankshaft Damper		Spark Plugs	
Bolt	175 N·m (130 R. lbs.)	Plugs	37 N·m (27 ft. lbs.)
Cylinder Head Bolts		Starter Mounting	
M11 Bolt	81 N·m (60 ft. lbs.)	Bolts	45 N·m (33 ft. lbs.)
M8 Bolt	28 N·m (250 in. lbs.)	Timing Chain Guide	
Cylinder Head Cover		Bolts	28 N·m (250 in. lbs.)
Bolt	12 N·m (105 in. lbs.)	Timing Chain Tensioner Arm	
Exhaust Manifold		Special Pin Bolt	17 N·m (150 in. lbs.)
Bolt	25 N·m (18 ft. lbs.)	Secondary Timing Chain Hydraulic Tensioner	
Exhaust Manifold Heat Shield		Bolts	28 N·m (250 in. lbs.)
Nut	8 N·m (72 in. lbs.), then loosen 45°	Timing Chain Primary Tensioner	
Flexplate		Bolts	28 N·m (250 in. lbs.)
Bolts	60 N·m (45 ft. lbs.)	Timing Drive Idler Sprocket	
Engine Mount Bracket to Block—Front		Bolt	34 N·m (25 ft. lbs.)
Bolts	61 N·m (45 ft. lbs.)	Thermostat Housing	
Engine Mount—Rear-to-Transmission		Bolts	12 N·m (105 in. lbs.)
Bolts	46 N·m (34 ft. lbs.)	Torque Converter to Flexplate	
Generator Mounting		Bolts	38 N·m (28 ft. lbs.)
M10 Bolts	54 N·m (40 ft. lbs.)	Water Pump	
M8 Bolts	28 N·m (250 in. lbs.)	Bolts	54 N·m (40 ft. lbs.)
Intake Manifold			
Bolts	12 N·m (105 in. lbs.)—Refer to procedure for tightening sequence.		
Oil Pan			
Bolts	15 N·m (130 in. lbs.)		
Oil Pan Drain Plug			
Plug	34 N·m (25 R. lbs.)		



Chapter 7

360 AMC V-8

 **Mopar**
PERFORMANCE PARTS



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

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Note: The following procedures for the 360 AMC V-8 engine are intended to be performed in-vehicle, on a dynamometer, or as an individual change/modification.

In addition to the information contained in this chapter, much of the information contained in Chapter 4, *4.0L Power Tech In-Line 6*, is generic to all Jeep engines (including the 360 AMC V-8). Therefore, in addition to this chapter, we highly recommend that all 360 AMC V-8 engine owners read Chapter 4 in its entirety.

For additional 360 AMC V-8 engine general service information, refer to the proper service manual.

Introduction

Note: The AMC-built 360 V-8 engine is NOT related to either the DaimlerChrysler small block 360 'A' engine or 5.2L Magnum engine. For complete information on the DaimlerChrysler 'A' engine family, refer to *Small Block 'A' Engines* (P4876826). For complete information on the DaimlerChrysler Magnum engine family, refer to *Magnum Engines* (P4876668).

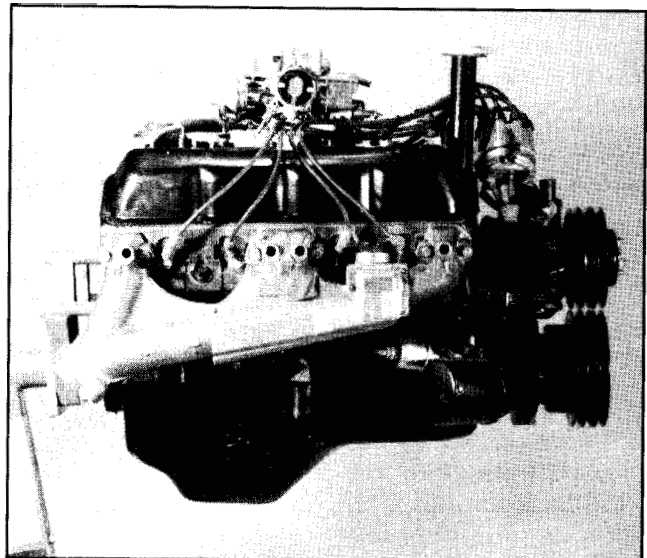
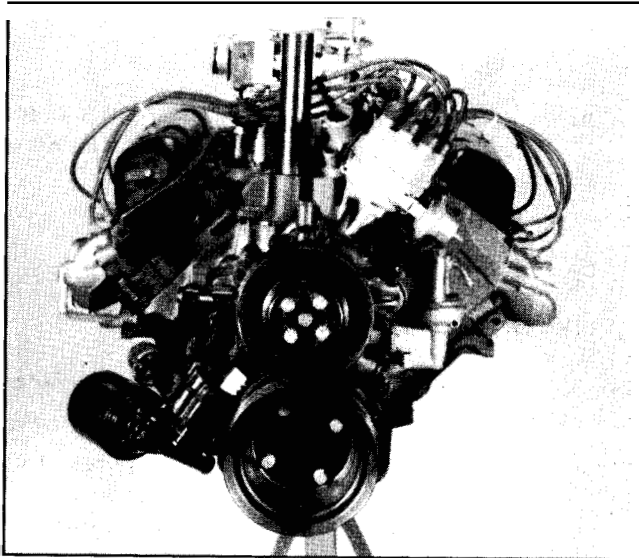
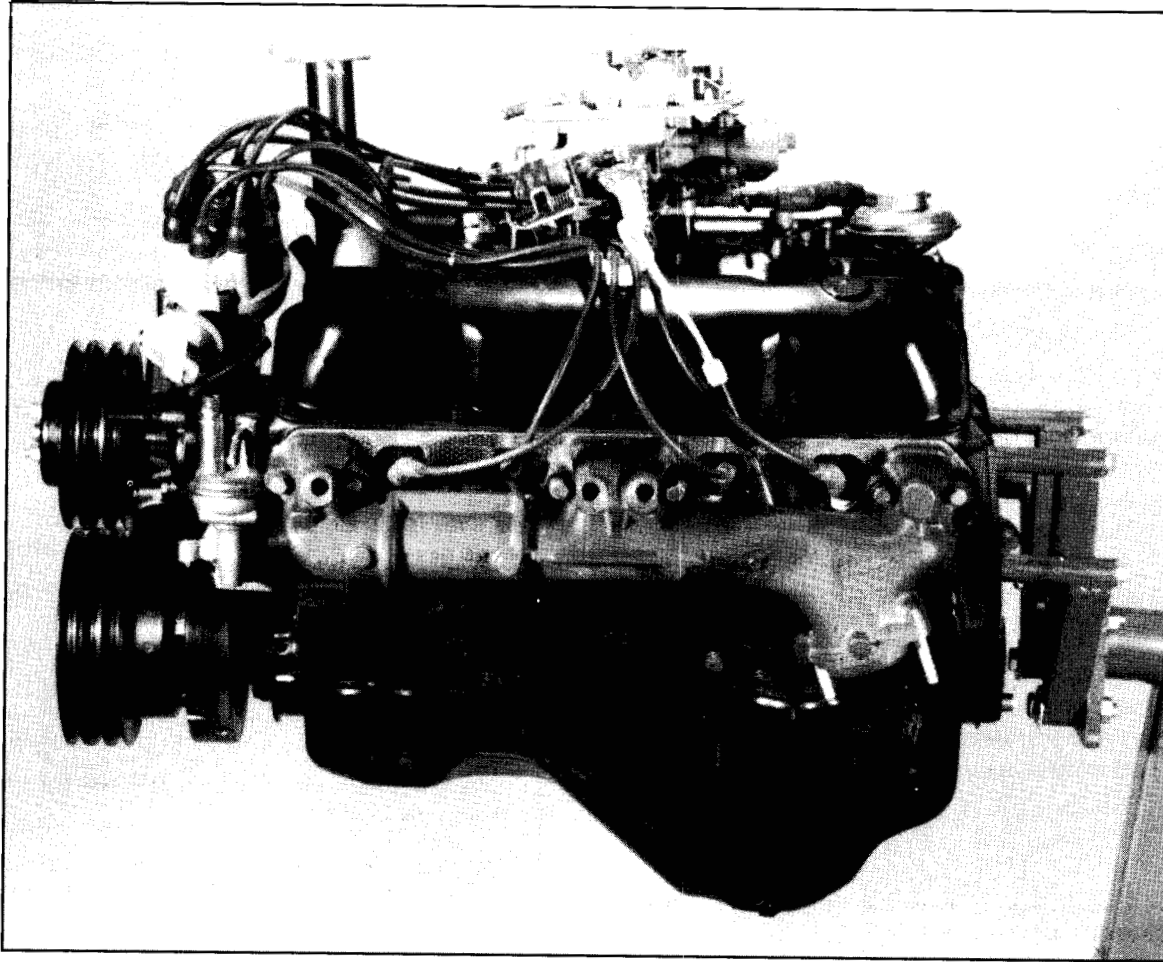
The AMC-built 360 CID engine is a cast iron, 8 cylinder, 90° V-block design that was in production from 1970-91. It has a standard bore and stroke of 103.63 x 87.38 mm (4.08 x 3.44"), and an 8.25:1 compression ratio.

AMC-built V-8 engines also came in the following CID versions:

<u>Enaine CID [Year]</u>	<u>Bore x Stroke</u>
290 (1966-69)	3.75 x 3.28"
304 (1972-80)	3.75 x 3.44"
343 (1967-69)	4.08 x 3.28"
360 (1970-91)	4.08 x 3.44"
390 (1968-70)	4.165 x 3.514"
401 (1973-79)	4.17 x 3.68"

Engine Description

Type	8 cylinder 90° V-Block
Bore and Stroke	103.63 x 87.38 mm (4.08 x 3.44 in)
Displacement	5.9L (360 cu. inch)
Compression Ratio	8.25:1
Torque	379 N·m (280 ft-lbs) @ 1500 rpm
Firing Order	1-8-4-3-6-5-7-2
lubrication	Pressure Feed-Full Flow Filtration
Engine Oil Capacity	4.7L (5 Quarts)
Cooling System	Liquid Cooled-Forced Circulation
Cooling System Capacity	13.2L (14 Quarts)
Cylinder Block	Cast Iron
Crankshaft	Cast Nodular Iron
Cylinder Head	Cast Iron
Camshaft	Cast Iron
Pistons	Aluminum Alloy (with Struts)
Pistons Combustion Cavity	Open Chamber
Connecting Rods	Cast Iron



Block

INTRODUCTION

The 360 AMC V-8 engine block cylinders are numbered 1-8 from front to rear. Cylinders 1, 3, 5 and 7 are on the left bank and cylinders 2, 4, 6 and 8 are on the right bank. The firing order is 1-8-4-3-6-5-7-2.

For more information, refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

Cylinder Block Hardware Package

This cylinder block hardware package comes complete with cam bearings, various freeze/core plugs and locating pins. For use when block is tanked/stress relieved and machined. For 360 AMC V-8 only.

P4529639 Cylinder block hardware package.

Engine Teardown Gasket Set

Designed for bearing check, bore check, or cylinder head modifications/teardown only. Gaskets include: cylinder heads, oil pan, intake manifold, exhaust manifolds and front cover gaskets. For 360 AMC V-8 only.

P4529634 Engine teardown gasket set.

Flywheel Attaching Package

This Mopar Performance Parts flywheel attaching package comes complete with all the bolts required to attach the flywheel and clutch to your engine assembly. Includes six (6) flywheel bolts, six (6) clutch bolts, and pilot bearing. For 360 AMC V-8 only.

P4529636 Flywheel attaching package.

Short Block Disassembly

1. Drain the engine oil.
2. Remove the engine assembly from the vehicle. Refer to the proper service manual for the procedure.
3. Use an engine stand to support the engine assembly.
4. Remove the distributor.
5. Remove the cylinder head covers and gaskets.
6. Remove the bridge and pivot assemblies and rocker arms. Alternately loosen the capscrews one turn at a time to avoid damaging the bridge.
7. Remove the pushrods. Retain the bridges, pivots, rocker arms, pushrods and tappets in the same order to facilitate installation in their original locations.
8. Remove the intake manifold assembly.

9. Remove the valve tappets.
10. Remove the cylinder heads and gaskets.
11. Position the pistons, one at a time, near the bottom of the stroke. Use a ridge reamer to remove the ridge, if any, from the top end of the cylinder walls.
12. Loosen all drive belts. Remove the power steering pump, air pump and air conditioner compressor, if equipped.
13. Scribe a mark on the torque converter and drive plate prior to crankshaft removal. Install in the same position during assembly.
14. Remove the damper pulley and vibration damper.
15. Remove the timing case cover.
16. Remove the oil pan.
17. Remove the camshaft.
18. Remove the connecting rod bearing caps and inserts. Retain in the same order as removed. The connecting rods and caps are stamped with the number of the associated cylinder.
19. Remove the connecting rod and piston assemblies through the top of the cylinder bores. Ensure that the connecting rod bolts DO NOT scratch the connecting rod journals or cylinder walls. Short pieces of rubber hose slipped over the rod bolts will provide protection during removal.
20. Remove the oil pickup tube and screen assembly.
21. Scribe a mark on the torque converter and drive plate prior to crankshaft removal. Install in the same position during assembly.
22. Remove the main bearing caps and inserts.
23. Remove the crankshaft.

Cylinder Bore Measurement

Use a bore gauge to measure the cylinder bores. If a bore gauge is not available, use an inside micrometer.

Measure the cylinder bore crosswise to the block near the top of the bore. Repeat the measurement at the bottom of the bore. Determine cylinder bore taper by subtracting the smaller dimension from the larger dimension.

Turn the measuring device 120° and repeat the procedure. Then turn another 120° and repeat the measurements. Determine out-of-roundness by comparing the difference between the measurements taken 120° apart.

If cylinder bore taper does not exceed 0.127 mm (0.005") and out-of-roundness does not exceed 0.076 mm (0.003"), true the cylinder bore by honing. If cylinder bore taper or out-of-round condition exceeds these limits, bore and then hone the cylinder for an oversize piston.

Cylinder Bore Reconditioning

Caution: DO NOT use rigid type hones to remove cylinder glaze. A slight amount of taper always exists in cylinder walls after the engine has been in service for a period of time.

Use an expanding hone to true the cylinder bore and to remove glaze for faster ring seating. Move the hone up and down at sufficient speed to produce a uniform 60° angle crosshatch pattern on the cylinder walls. DO NOT use more than ten (10) strokes per cylinder. A stroke is one down-and-up motion.

Caution: Protect the engine bearings and lubrication system from abrasives.

Scrub the cylinder bores clean with a solution of hot water and detergent. Wipe with a clean, lint-free cloth.

Note: If the crankshaft is not removed from the block, cover the connecting rod journals with a clean cloth during the cleaning operation.

Short Block Assembly

1. Install and lubricate the upper main bearing inserts and rear main upper seal half. Lubricate the seal lip.
2. Install the crankshaft.
3. Install the main bearing caps and inserts. If replacement bearings are installed, measure each bearing clearance with Plastigauge (P4286819).
4. Install a replacement oil pickup tube and screen assembly. DO NOT attempt to install the original pickup tube. Ensure the plastic button is inserted in the bottom of the replacement screen.
5. Install the camshaft.
6. Position the piston rings on the pistons. Refer to *Piston Ring Fitting*, 'Piston and Connecting Rod Assembly' section for the procedure.
7. Lubricate the piston and ring surfaces with clean engine oil.
8. Use a piston ring compressor tool to install the connecting rod and piston assemblies through the top of the cylinder bores. Ensure that the connecting rod bolts DO NOT scratch the connecting rod journals or cylinder walls. Short lengths of rubber hose slipped over the connecting rod bolts will provide protection during installation.
9. Install the connecting rod bearing caps and inserts in the same location as removed. Tighten the nuts to 45 N•m (33 ft-lbs) torque.
10. Install the camshaft and crankshaft sprockets and timing chain as an assembly.
11. Install the timing case cover and gaskets. Refer to *Timing Case Cover Installation*, 'Crankshaft' section for the procedure.
12. Install the engine oil pan using replacement gaskets and seals. Tighten the drain plug securely.
13. Install the vibration damper and pulley.
14. Install the cylinder heads with replacement gaskets.
15. Install the valve tappets.
16. Install the intake manifold with a replacement gasket.
17. Install the pushrods.
18. Install the rocker arms and bridge and pivot assemblies. Loosely install the capscrews through each bridge and then alternately tighten the capscrews, one turn at a time, to avoid damaging the bridge. Tighten the capscrews 26 N•m (19 ft-lbs) torque.
19. Turn the crankshaft to position the No. 1 piston at TDC on the compression stroke.
20. Reseal and install the cylinder head covers.
21. Install the power steering pump, air pump and air conditioner compressor.
22. Install the distributor.
23. Point the rotor at the No. 1 spark plug firing position.
24. Turn the oil pump drive shaft with a long screwdriver to engage it with the distributor shaft.
25. With the rotor pointing at the No. 1 spark plug firing position, rotate the distributor housing counterclockwise until the leading edge of the trigger wheel segment is aligned with the center of the sensor. Tighten the distributor hold down clamp. When the engine is installed and operating, check the ignition timing.
26. Remove the engine from the stand.
27. Install the engine assembly. Refer to the proper service manual for the procedure.

Plastigauge

When reassembling your engine you'll need a variety of Plastigauge to measure bearing clearances. This popular assortment includes one blue strip for .004" - .009" tolerances, two red strips for .002" - .006" tolerances, and two green strips for .001" - .003" tolerances. Each strip is 12" long.

P42868 19 Plastigauge assortment.

ENGINE MOUNTS

Resilient rubber mounting cushions support the engine and transmission at three points. A cushion is located at each side on the centerline of the engine (Figure 7-1). The rear is supported by a cushion between the transmission extension housing and the rear support crossmember.

Removal or replacement of any cushion may be accomplished by supporting the weight of the engine or transmission in the area of the cushion.

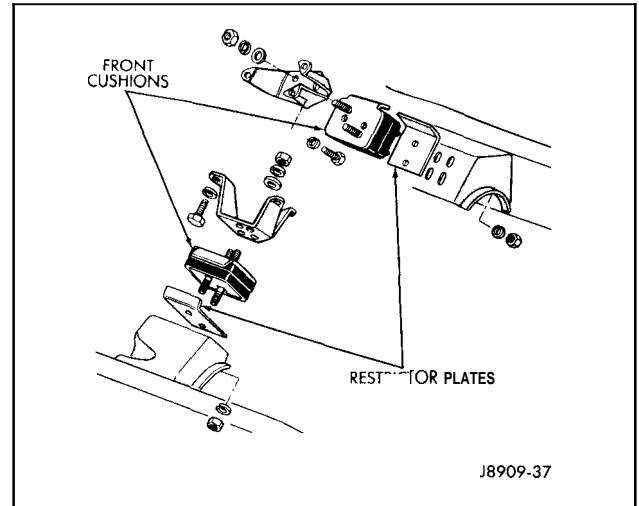


Figure 7-1



Crankshaft

CRANKSHAFT

The 360 AMC V-8 engine uses a cast nodular iron crankshaft that rotates within five (5) main bearings and has a standard bore and stroke of 103.63 x 87.38 mm (4.08 x 3.44"). Crankshaft rotation is clockwise, when viewed from the front of the engine.

The crankshaft has main bearing journal diameters of (Nos. 1, 2, 3 and 4) 69.784-69.822 mm (2.7474-2.7489"), a rear main bearing journal diameter of 69.759-69.797 mm (2.7464-2.7479"), and main bearing journal widths of (No. 1) 32.093-32.250 mm (1.2635-1.2695"), (No. 2) 31.650-31.700 mm (1.2460-1.2480"), (No. 3) 32.330-32.390 mm (1.2730-1.2750"), (No. 4) 31.650-31.700 mm (1.2460-1.2480"), and (No. 5) 30.860-30.910 mm (1.2150-1.2170").

The crankshaft has a connecting rod journal diameter of 53.172-53.266 mm (2.0934-2.0955"), and a connecting rod journal width of 50.750-50.900 mm (1.998-2.004").

Other Jeep V-8 bore and stroke measurements are:

<u>Enaine CID (Year)</u>	<u>Bore x Stroke</u>
290 (1966-69)	3.75 x 3.28"
304 (1972-80)	3.75 x 3.44"
343 (1967-69)	4.08 x 3.28"
390 (1968-70)	4.165 x 3.574"
401 (1973-79)	4.17 x 3.68"

For more crankshaft specifications, refer to *360AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

CRANKSHAFT MAIN BEARINGS

Replace crankshafts that are damaged or worn beyond feasible reconditioning. Use the procedures outlined in *Short Block Disassembly*, 'Block' section of this chapter, to remove and install a crankshaft.

Removal

The following procedure can be used when the engine is installed in the vehicle.

1. Drain the engine oil and remove the oil pan.
2. Remove the main bearing cap and lower insert.
3. Remove the lower insert from the bearing cap.

4. Remove the upper insert by loosening all the other bearing caps and inserting a tool fabricated from a cotter pin approximately 14 mm (1/2") into the crankshaft oil hole. Fabricate a cotter pin as in Figure 7-2.
5. With the cotter pin in place, rotate the crankshaft so that the upper bearing insert is rotated in the direction of its locking tab.
6. Remove the remaining bearings in the same manner.

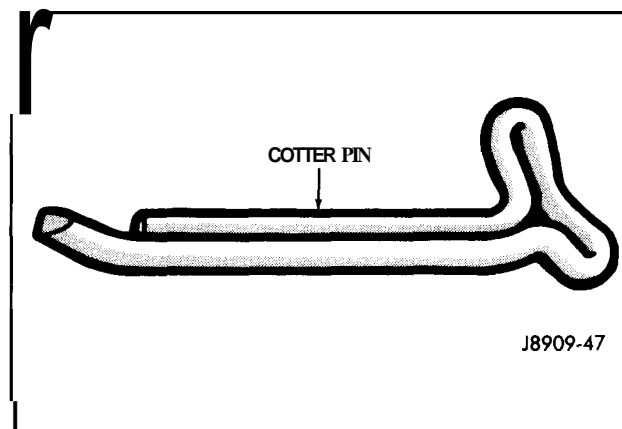


Figure 7 - 2

Inspection

1. Wipe the inserts clean and inspect for abnormal wear patterns and for metal or other foreign material imbedded in the lining.
2. If any of the crankshaft journals are scored, remove the engine for crankshaft repair.
3. Inspect the back of the inserts for fractures, scrapings or irregular wear patterns.
4. Inspect the upper insert locking tabs for damage.
5. Replace all damaged or worn bearing inserts.

Fitting

The main bearing caps are numbered 1 through 5, front to rear, with an arrow to indicate the forward position. The upper main bearing insert surfaces are grooved. The lower insert surfaces are smooth.

Each bearing insert pair is selectively fit to its respective journal to obtain the desired operating oil clearance. In production, the select fit is obtained by using various-sized color-coded main bearing inserts as listed in the *Main Bearing Fitting Chart* (Figure 7-3). The bearing color code appears on the edge of the insert. The bearing size is not stamped on production inserts.

Crankshaft Main Bearing Journal Color Code and Diameter	Bearing Color Code	
	Upper Inert Size	Lower Insert Size
Yellow – 69.8220-69.8093 mm (2.7489-2.7484 in.) (Standard)	Yellow – Standard	Yellow – Standard
Orange – 69.8093-69.7966 mm (2.7484-2.7479 in.) (0.0005 Undersize)	Yellow – Standard	Black – 0.025 mm Undersize (0.001 in.)
Black – 69.7966-69.7839 mm (2.7479-2.7474 in.) (0.001 Undersize)	Black – 0.025 mm Undersize (0.001 in.)	Black – 0.025 mm Undersize (0.001 in.)
Green – 69.7839-69.7712 mm (2.7474-2.7469 in.) (0.0015 Undersize)	Black – 0.025 mm Undersize (0.001 in.)	Green – 0.051 mm Undersize (0.002 in.)
Red – 69.5680-69.5553 mm (2.7389-2.7384 in.) (0.010 Undersize)	Red – 0.254 mm Undersize (0.010 in.)	Red – 0.254 mm Undersize (0.010 in.)

J8909-34

Figure 7 - 3

The main bearing journal diameter is identified in production by a color-coded paint mark on the adjacent cheek toward the flanged (rear) end of the crankshaft, except for the rear main journal. The paint mark that identifies the rear main journal diameter is on the crankshaft rear flange.

Refer to *Main Bearing Fitting Chart* (Figure 7-3) to select the proper bearing inserts to obtain the specified bearing clearance. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct main bearing clearances.

When required, use different size upper and lower bearing inserts as a pair. Use a standard size upper insert in combination with a 0.025 mm (0.001") undersize lower insert to reduce the clearance by 0.013 mm (0.0005"). Never use bearing inserts in combination with greater than 0.025 mm (0.001") difference in size.

Example: When installing upper and lower inserts of different sizes, install the undersize inserts either all on the top (upper) or all on the bottom (lower).

Main Bearing-to-Journal Clearance—Crankshaft Installed

1. Support the weight of the crankshaft with a jack placed under the counterweight adjacent to the journal being measured.

Note: Measure the clearance of one bearing at a time. **ALL** other bearing caps must remain tightened.

2. Remove the main bearing cap and lower insert.
3. Wipe the insert and the exposed portion of the crankshaft journal clean.
4. Place a stripe of Plastigauge across the full width of the bearing insert. The Plastigauge must not crumble. If it is brittle, obtain fresh stock.

Caution: DO NOT rotate the crankshaft. The Plastigauge will shift, resulting in an inaccurate indication.

5. Install the bearing cap and tighten the retaining bolts to 136N•m (100 ft-lbs) torque.
6. Remove the bearing cap and determine the amount of clearance by measuring the width of the compressed Plastigauge with the scale on the Plastigauge envelope. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct clearance.

The compressed Plastigauge should maintain the same size across the entire width of the insert. If the size varies, this may indicate either a tapered journal or foreign material trapped behind the insert.

If the correct clearance is indicated, bearing replacement is not necessary. Remove the Plastigauge from the crankshaft and insert. Proceed to crankshaft *Installation*. Small pieces of Plastigauge may remain on the insert or journal surfaces. It will dissolve in the hot engine oil when the engine is operated.

If the oil clearance exceeds the specification, install a pair of 0.025 mm (0.001") undersize bearing inserts and measure the clearance as described earlier.

The clearance measured with 0.025 mm (0.001") undersize inserts installed will determine if a pair of 0.025 mm (0.001") undersize inserts or some other size combination will provide the correct clearance.

Example: If the clearance was 0.089 mm (0.0035") originally, a pair of 0.025 mm (0.001") undersize inserts will reduce the clearance by 0.025 mm (0.001"). The oil clearance will be 0.064 mm (0.0025") and within the specification. The combination of a 0.051 mm (0.002") undersize insert and 0.025 mm (0.001") undersize insert will reduce this clearance by an additional 0.013 mm (0.0005") and the oil clearance will be 0.051 mm (0.002").

Caution: Never use a combination of inserts that have a difference of more than one bearing size. For example, DO NOT use a standard upper and 0.051 mm (0.002") undersize lower insert.

If the oil clearance exceeds the specification with a pair of 0.051 mm (0.002") undersize inserts, measure the crankshaft journal diameter with a micrometer. If the journal diameter is correct, the crankshaft bore in the cylinder block may be misaligned, which requires cylinder block replacement. If the journal diameter is incorrect, replace or grind the crankshaft to the standard undersize.

Main Bearing Journal Diameter – Crankshaft Removed

Wipe the main bearing journals clean.

Measure each journal diameter with a micrometer. Note the difference between the maximum and minimum diameters of each journal. (Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the maximum allowable taper and out-of-roundness.)

Compare the largest journal diameter you measured with the journal diameter listed in the *Main Bearing Fitting Chart* (Figure 7-3).

Select the insert pairs that will provide the specified bearing clearance. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct clearance.

Installation

1. Lubricate the journal contact surface of each insert with clean engine oil.
2. Loosen all main bearing caps.
3. Install the main bearing upper insert(s).
4. Install the main bearing cap(s) and lower insert(s). Tighten the retaining bolts evenly to 136 N•m (100 ft-lbs) torque in steps of 41, 81, 122 and 136 N•m (30, 60, 90 and 100 ft-lbs) torque. Rotate the crankshaft after each tightening step to determine if it rotates freely. If it does not rotate freely, examine the inserts for proper installation and size.
5. Install the oil pan using replacement gaskets and seals. Tighten the drain plug securely.
6. Fill the crankcase to the specified level with clean engine oil.

Crankshaft End Play

Crankshaft end play is controlled by the No. 3 main bearing, which is flanged for this purpose.

1. Attach a dial indicator to the crankcase adjacent to the No. 3 main bearing.
2. Set the dial indicator stem on the face of the adjacent counterweight (Figure 7-4).
3. Pry the crankshaft fore and aft (Figure 7-4).
4. Note the dial indicator readings. End play is the difference between the high and low measurements. The proper crankshaft end play is 0.08-0.20 mm (0.003-0.008").
5. If the end play is not within the specification, inspect the crankshaft thrust faces for wear. If no wear is apparent, replace the No. 3 (thrust) main bearing inserts and measure the end play. If the end play is not within specification, replace the crankshaft.

Note: When installing the No. 3 (thrust) main bearing inserts, pry the crankshaft fore and aft to align the thrust faces of the bearing inserts before final tightening.

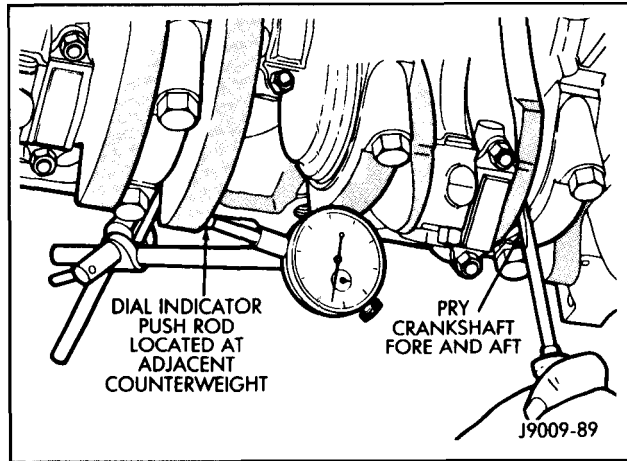


Figure 7- 4

VIBRATION DAMPER

The vibration damper is balanced independently and then rebalanced as part of the complete crankshaft assembly.

DO NOT attempt to duplicate the original vibration damper balance holes when installing a service replacement damper.

The vibration damper is not repairable and is serviced only as a complete assembly.

Vibration Damper

Production replacement vibration damper compatible with production crank and piston rod weight. For 360 AMC V-8 without serpentine belt drive (only).

P5249536 Vibration damper.

Vibration Damper Attaching Package

Attaching bolt package necessary to attach damper to crankshaft. For 360 AMC V-8 only.

P4529678 Vibration damper attaching package.

Removal

1. Loosen the damper retaining screw.
2. Loosen the alternator drive belt.
3. Loosen the air conditioner compressor drive belt and move it aside.
4. Loosen the power steering pump drive belt and move it aside.
5. Remove the damper pulley retaining bolts. Remove the damper pulley from the damper.

6. Remove the damper retaining bolt and washer and loosely install the bolt to prevent damage to the bolt threads when the removal tool is used.
7. Use a vibration damper removal tool to remove the damper from the crankshaft (Figure 7-5).

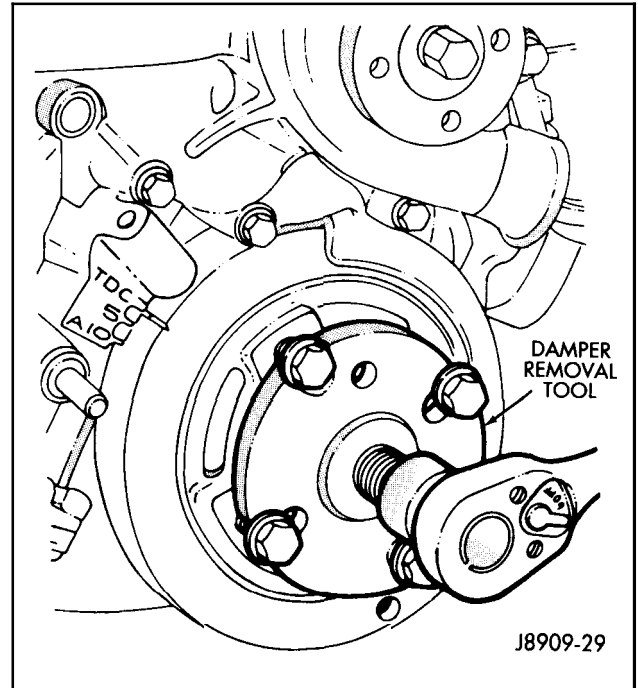


Figure 7- 5

Installation

1. Polish the damper hub with crocus cloth to prevent seal damage.
2. Apply a light film of engine oil to the seal contact surface area of the damper.
3. Align the key slot in the damper hub with the crankshaft keyway.
4. Position the damper on the end of the crankshaft.
5. Lubricate the bolt threads and washer with engine oil.
6. Install the damper retaining bolt and washer and tighten to 122 N•m (90 ft-lbs) torque. If the crankshaft turns before the specified torque is attained, proceed with the drive belt installation (refer to the proper service manual for the procedure). With the belts installed, tighten the damper retaining bolt to 122 N•m (90 ft-lbs) torque.
7. Install the damper pulley retaining bolts. Tighten the bolts to 41 N•m (30 ft-lbs) torque.
8. Install the drive belts and adjust to the specified tension. Refer to the proper service manual for the procedure.

TIMING CASE COVER

The timing case cover is die-cast aluminum (Figure 7-6). A crankshaft oil seal is used to prevent oil leakage at the vibration damper hub. The oil seal may be installed from either side of the timing case cover. It is not necessary to remove the cover whenever oil seal replacement is required.

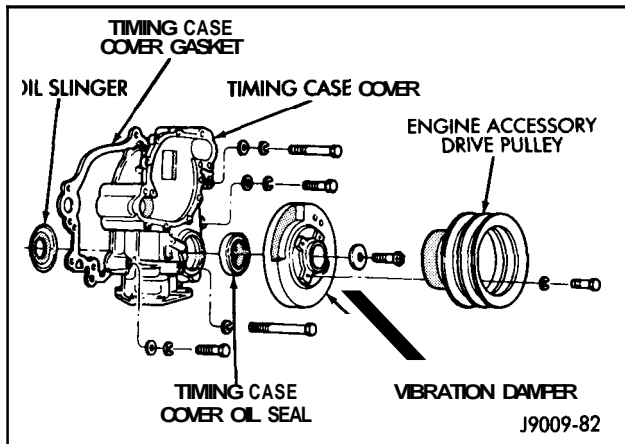


Figure 7-6

Removal

Warning! If the engine has been recently operated, use care to prevent scalding by hot coolant. The system is pressurized.

1. Drain the radiator and cylinder block. If the coolant is reusable, drain it into a clean container.
2. Disconnect the radiator hoses and bypass hose.
3. Remove all drive belts.
4. Remove the fan and hub assembly.
5. Remove the A/C compressor and bracket assembly from the engine and move aside. **DO NOT** disconnect the air conditioner hoses.
6. Remove the alternator, alternator mounting bracket and back idler pulley.
7. Disconnect the heater hose at the water pump.
8. Remove the power steering pump and bracket assembly. Remove the air pump and mounting bracket as an assembly. **DO NOT** disconnect the power steering pump hoses.
9. Remove the distributor cap. Note the rotor and housing position.
10. Remove the distributor.
11. Remove the fuel pump.
12. Remove the vibration damper pulley.
13. Remove the vibration damper.
14. Remove the two front oil pan bolts.

15. Remove the bolts that secure the timing case cover to the engine block. The cover retaining bolts are various lengths and must be installed in the same location as removed.
16. Remove the cover by pulling it forward until it is clear of the locating dowel pins.
17. Clean the gasket contact surface of the cover.
18. Remove the oil seal. Always replace the oil seal whenever the timing case cover is removed. Refer to *Oil Seal Replacement*, in this section, for the procedure.

Oil Seal Replacement

1. Loosen all the drive belts.
2. Remove the vibration damper pulley.
3. Remove the vibration damper bolt and washer.
4. Install the damper bolt in the crankshaft to prevent the damper puller from damaging the bolt threads in the crankshaft.
5. Remove the vibration damper. Remove the damper bolt.
6. Remove the oil seal (Figure 7-7).
7. Wipe the crankshaft sealing area clean.
8. Apply Permatex No. 2, or equivalent, to the outer metal surface of the replacement seal.
9. Install the seal using installer tool (Figure 7-8).
10. Apply a light coating of engine oil to the seal contact surface of the damper.
11. Install the damper, flat washer and bolt. Tighten the damper bolt to 122 N•m (90 ft-lbs) torque.
12. Install the pulley and belts. Adjust belts to specification. Refer to the proper service manual for the procedure.

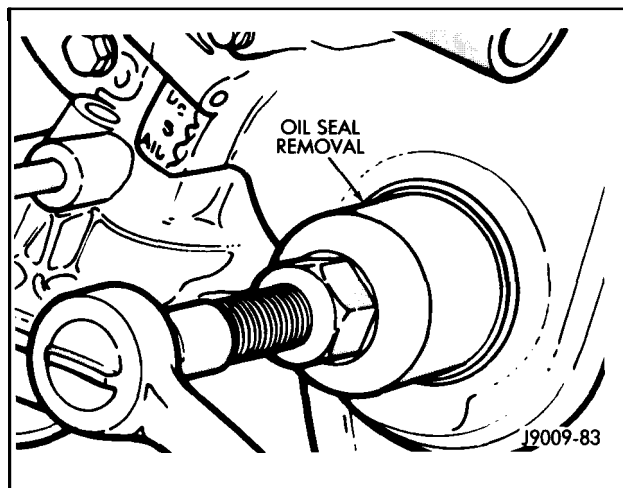


Figure 7-7

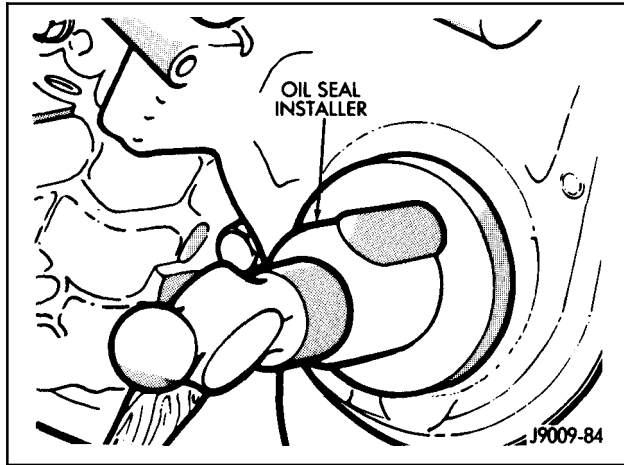


Figure 7- 8

Installation

1. Remove the lower locating dowel pin from the engine block. The dowel pin is required for correct cover alignment. The dowel must be installed after the cover is in position.
 2. Use a sharp knife or razor blade to cut both sides of the oil pan gasket flush with the engine block.
 3. Apply Permatex No. 2, or equivalent, to both sides of the replacement timing case cover gasket. Install the gasket on the timing case cover.
 4. Install a replacement front oil pan seal to the bottom of the timing case cover. There are two methods of sealing the timing case cover to the oil pan where the oil pan gaskets were cut off. If replacement oil pan gaskets are used, perform step a. If room temperature vulcanizing (RTV) silicone is used, perform step b.
 - a. Using Oil Pan Gaskets
 - i. Using original gasket pieces as a guide, trim the replacement gaskets to correspond to the amount cut off in the procedure above.
 - ii. Align the tongues of the replacement oil pan gasket pieces with the oil pan seal and cement them into place on the cover.
 - iii. Apply Permatex No. 2, or equivalent, to the cut off edges of the original oil pan gaskets.
 - iv. Place the timing case cover in position and install the front oil pan bolts.
 - v. Tighten the bolts slowly and evenly until the cover aligns with the upper locating dowel.
 - vi. Insert the lower dowel through the cover and drive it into the corresponding hole in the engine block.
 - vii. Install the remaining cover retaining bolts in the same location as removed. Tighten all bolts to 34 N•m (25 ft-lbs) torque.
 - b. Using RTV
 - i. Apply a coating of RTV silicone 3.175 mm (1/8") thick on the timing case cover flanges. Use Mopar Gasket-In-A-Tube, or equivalent. The flanges must be clean and dry.
 - ii. Place the cover in position. Align it with the top dowel.
 - iii. Loosely install the front cover retaining bolts in the same location as removed.
 - iv. Insert the lower dowel through the cover and drive it into the corresponding hole in the engine block.
 - v. Install the remaining cover retaining bolts and tighten all bolts to 34 N•m (25 ft-lbs) torque.
 - vi. Apply a small bead of RTV to the joint between the pan and the cover and force it into place with a finger.
 - vii. Apply a drop of Loctite, or equivalent, to the oil pan bolts and tighten until snug. **DO NOT** over-tighten because the oil pan will distort.
 5. Once the timing case cover is sealed to the oil pan, install the vibration damper. Tighten the retaining bolt to 122 N•m (90 ft-lbs) torque.
 6. Install the damper pulley. Tighten the retaining bolts to 41 N•m (30 ft-lbs) torque.
 7. Install the fuel pump.
 8. Install the distributor with the rotor and housing in the same position as removed.
 9. Install the distributor cap and connect the heater hose.
 10. Install the power steering pump, air pump and mounting bracket, if removed.
 11. Install the alternator, alternator mounting bracket and back idler pulley assembly.
 12. Install the air conditioner compressor and bracket assembly, if removed.
 13. Install the fan and hub assembly.
 14. Install all drive belts and adjust to the specified tension.
 15. Connect the radiator hoses and bypass hose.
 16. Fill the cooling system to the specified level.
- Warning!** Use extreme caution when the engine is operating. **DO NOT** stand in a direct line with the fan. **DO NOT** put hands near pulleys, belts or the fan. **DO NOT** wear loose clothing.
17. Start the engine and inspect for oil and coolant leaks.
 18. Adjust the initial ignition timing.

TIMING CHAIN AND SPROCKETS

Timing Chain and Sprockets Set

This kit is the ideal service replacement package for 360 AMC V-8 engines. The package includes single roller timing chain and sprockets.

P4529820 Timing chain and sprockets set.

Timing Chain Wear Measurement

1. Remove the timing case cover.
2. Rotate the camshaft or crankshaft sprocket until all slack is removed from the right side of the chain.
3. Determine a reference point for the deflection measurement (Figure 7-9). Measure up from the dowel on the right side of the engine 19 mm (3/4") and mark the location.
4. Position a straightedge across the timing chain from the point at the lowest tooth (X) on the camshaft sprocket to the point marked (Z) previously (Figure 7-9).
5. Grasp the chain where the straightedge dissects the chain and use it as a reference.
6. Move the chain in toward the centerline of the engine and mark the engine block at the point of maximum inward chain deflection (D - Figure 7-9).
7. Move the chain out from the centerline of the engine and mark the engine block at the point of maximum outward chain deflection (E - Figure 7-9).
8. Measure the distance between the two marks to determine the total deflection (F - Figure 7-9).
9. Replace the chain assembly if the deflection (wear) exceeds 22 mm (7/8").
10. Install the timing case cover.

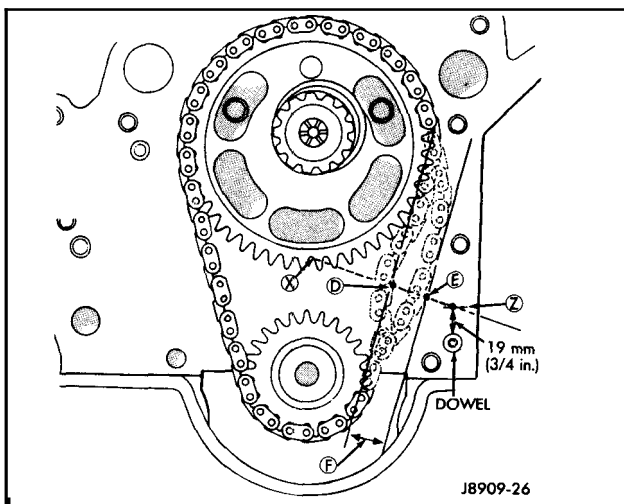


Figure 7 - 9

Removal

1. Remove the vibration damper pulley, damper, timing case cover and gasket.
2. Remove the crankshaft oil slinger.
3. Remove the camshaft sprocket retaining bolt and washer.
4. Remove the distributor drive gear and fuel pump eccentric.
5. Rotate the crankshaft until the zero timing mark on the crankshaft sprocket is closest to and on centerline with the zero timing mark on the camshaft sprocket (Figure 7-10).
6. Remove the crankshaft sprocket, camshaft sprocket and timing chain as an assembly.

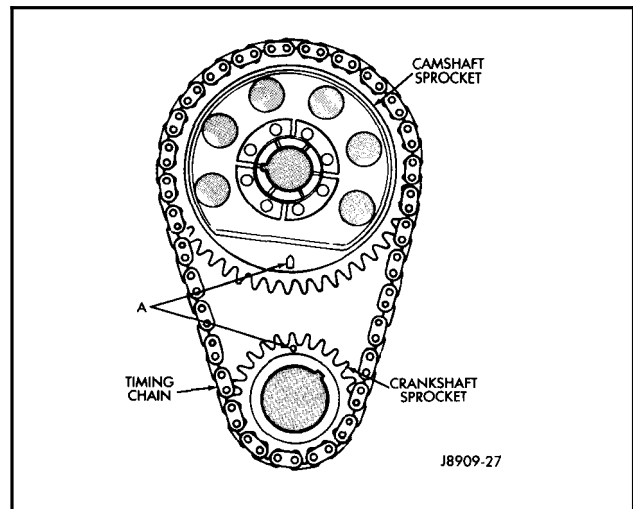


Figure 7 - 10

Installation

Assemble the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks positioned on the same centerline.

1. Install the chain and sprocket assembly on the crankshaft and camshaft.
2. Install the fuel pump eccentric and the distributor drive gear. Install the fuel pump eccentric with the stamped word REAR facing the camshaft sprocket.
3. Install the camshaft washer and retaining bolt. Tighten the bolt to 41 N•m (30 ft-lbs) torque.
4. To verify the correct installation of the timing chain:
 - a. Rotate the crankshaft until the timing mark on the camshaft sprocket is on a horizontal line at the 3 o'clock position.

- b. Beginning with the pin directly adjacent to the camshaft sprocket timing mark, count the number of pins down to the timing mark on the crankshaft sprocket.
 - c. There must be 20 pins between these two points; the crankshaft sprocket timing mark must be between pins 20 and 21 (Figure 7-11).
5. Install the crankshaft oil slinger.
 6. Remove the original oil seal from the timing case cover.
 7. Install a replacement oil seal in the timing case cover.
 8. Install the timing case cover using a replacement gasket. Tighten the retaining bolts to 34 N•m (25 ft-lbs) torque.
 9. Install the vibration damper and pulley.

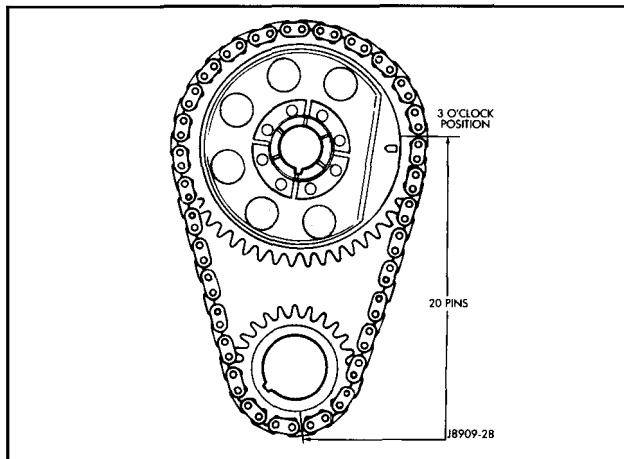


figure 7 - 11

REAR MAIN OIL SEAL

The rear main bearing oil seal consists of a two-piece neoprene single lip seal. Correct installation of the seal is required for leak-free engine operation.

Removal

1. Drain the engine oil.
2. Remove the starter motor.
3. Remove the oil pan.
4. Remove the oil pan front and rear neoprene oil seals.
5. Remove the oil pan side gaskets.
6. Thoroughly clean the gasket mating surfaces of the oil pan and engine block. Remove all sludge and residue from the oil pan sump.
7. Remove the rear main bearing cap.
8. Remove and discard the lower seal.

Note: To ensure leak-free operation, always replace the upper and lower seal halves as a pair.

9. Clean the main bearing cap thoroughly to remove all sealer.
10. Loosen all remaining main bearing capscrews.
11. Use a brass drift and hammer to tap the upper seal half until a sufficient portion of the seal is protruding to permit pulling the seal out completely.

Installation

1. Wipe the crankshaft seal surface area clean and apply a light film of oil.
2. Coat the block contact surface area of the replacement upper seal half with soap and the lip of the seal with clean engine oil.
3. Insert the upper seal half into the engine block. The lip of the seal must face the front of the engine.
4. Coat both sides of the replacement lower seal half end tabs with Mopar Gasket-In-A-Tube, or equivalent. DO NOT apply sealer to the lip of the seal.
5. Coat the outer curved surface of the lower seal half with soap and the lip of the seal with clean engine oil.
6. Insert the seal into the cap recess and seat firmly (Figure 7-12).
7. Apply Mopar Gasket-In-A-Tube, or equivalent, to both chamfered edges of the rear main bearing cap.

Caution: DO NOT apply sealer to the cylinder block mating surface of the rear main cap because bearing clearance could be affected.

8. Tighten all main bearing bolts to 136N•m (100 ft-lbs) torque.
9. Install the oil pan using replacement gaskets and seals. Tighten the drain plug securely.
10. Install the starter motor.
11. Fill the crankcase to the specified level with clean engine lubrication oil.

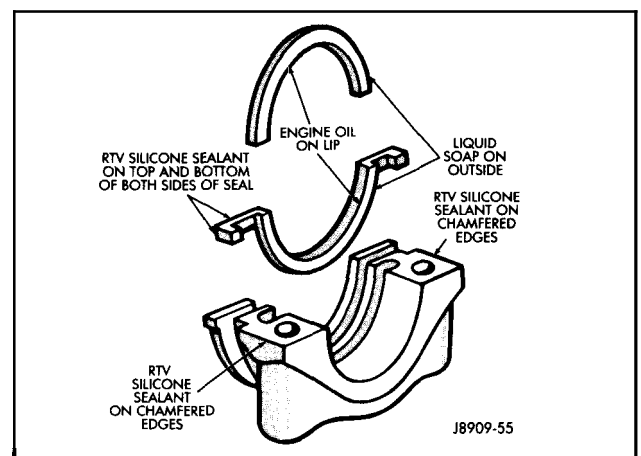
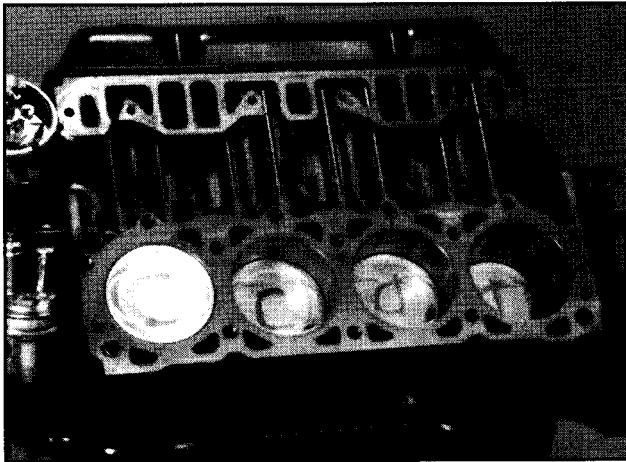


Figure 7 - 72

Piston and Connecting Rod Assembly

Part Number	Bore	Stroke	Rod	CR	Dome	Rings
P.5249907	4.110"	3.44"	5.875"	9.0:1	Flat	P4876959



PISTONS

The 360 AMC V-8 uses aluminum alloy pistons (with struts) that weigh 601-605 grams (21.20-21.34 oz.) each. The piston combustion cavity is an open chamber design.

For more piston (and piston ring) specifications, refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

CONNECTING RODS AND BEARINGS

The 360 AMC V-8's connecting rods are made of cast iron with a total weight (less the bearings) of 681-689 grams (24.0-24.3 oz.), and a total length (center-to-center) of 149.17-149.28 mm (5.873-5.877").

Connecting rod journal diameter is 53.172-53.266 mm (2.0934-2.0955"). Connecting rod journal width is 50.750-50.900 mm (1.998-2.004").

For more connecting rod specifications, refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

Connecting Rod

This heavy duty forging is shot-peened and Magna-fluxed. Includes high strength bolts. Can be used as heavy duty stock replacement. Center-to-center distance of 5.875". For 360 AMC V-8 only. (Sold individually.)

P4529611 Connecting rod.

Standard Size Connecting Rod Bearing

This Mopar Performance Parts connecting rod bearing is the same as production bearing. For 360 AMC V-8 only. (Sold individually.)

P4529607 Standard size connecting rod bearing.

Undersize Connecting Rod Bearings

These Mopar Performance Parts undersize connecting rod bearings are of same high quality as standard production bearings. For 360 AMC V-8 only. (Sold individually.)

P4529608 Connecting rod bearing, .001" undersize.

P4529609 Connecting rod bearing, .002" undersize.

Rod Ratio

For all-out modified race engines, it is recommended that a rod ratio (length of the rod divided by the stroke) of 1.75 to 1.85 be maintained (if possible) for best performance. (The stock 360 AMC V-8 has a rod ratio of 1.71 – this is considered short.) Side clearance should be 0.25-0.48 mm (0.010-0.019").

Basic Preparation

1. Rods should be checked for alignment; bores should be parallel. Check big and small ends for size. Use only a Sunnen rod reconitioner for this purpose.
2. Using a small file, deburr rods, paying particular attention to the mating surfaces and the tab groove. You need the clamping effect of a 60 micro bore. The sides should be polished by hand on a flat plate using #600 paper.
3. In an engine that is to be used in a high rpm situation, the rods and rod bolts should be Magna-Glo checked for cracks or forging flaws.
4. A race engine should always use heavy duty rod bolts and nuts.
5. The rod bearing clearances should be 0.03-0.06 mm (0.001-0.0025").

6. The rod bolt head should be seated against the flat, machined surface in the rod.
7. For a race engine, the big end rod should be sized to the minimum diameter to get the maximum crush from the bearing.
8. Shot-peening the rods is recommended if they haven't been already.
9. Clean all parts before proceeding.

Inspection

a. *Connecting Rod Bearings*

Clean the inserts.

Inspect the linings and backs of the inserts for an irregular wear pattern. Note any scraping, stress cracks or distortion. If the bearing has spun in the rod, replace the bearing and connecting rod and inspect the crankshaft journal for scoring.

The wear pattern is always greater on the upper bearing insert. Grooves can be caused by the rod bolts scratching the journal during installation.

Inspect for material imbedded in the linings that may indicate abnormal piston, timing gear, distributor gear or oil pump gear wear (Figure 7-13).

Inspect the fit of the insert locking tab in the rod cap. If the inspection indicates that the insert tab may have been pinched between the rod and rod cap, replace the upper and lower bearing inserts.

Inspect the contact area of the locking tab. Abnormal wear indicates bent tabs or improper installation of the inserts.

Replace bearing inserts that are damaged or worn.

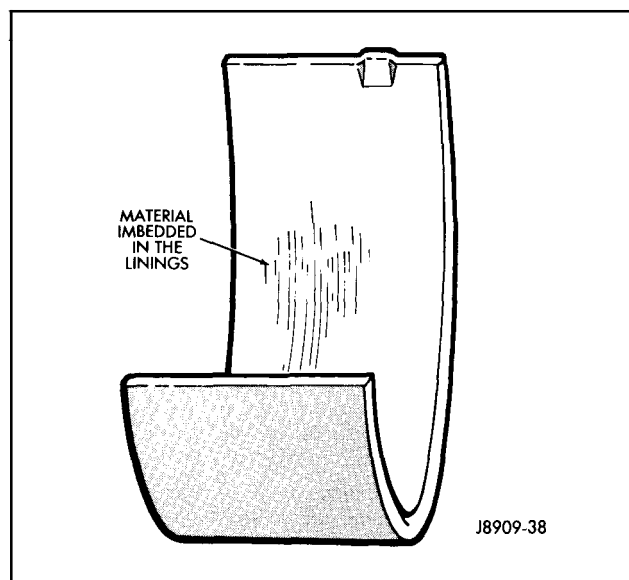


Figure 7- 13

b. *Connecting Rods*

Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicates the probability of a misaligned connecting rod, inspect it for correct rod alignment. Replace misaligned, bent or twisted connecting rods.

Connecting Rod Bearing Fitting

Connecting rod bearing inserts are selectively fit to their respective journals to obtain the desired operating clearance. In production, the select fit is obtained by using various sized, color coded bearing inserts. The bearing color code appears on the edge of the insert.

Note: Bearing size is not stamped on production inserts.

The rod journal size is identified in production by a color coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. Refer to the color codes listed on the *Connecting Rod Bearing Fitting Chart* (in your service manual) to identify the journal size and select the correct bearing inserts to obtain the correct clearances.

Caution: Never use a pair of bearing inserts that are greater than 0.025 mm (0.001") difference in size.

When required, different sized upper and lower bearing inserts may be used as a pair. A standard size insert is sometimes used in combination with a 0.025 mm (0.001") undersize insert to reduce clearance by 0.013 mm (0.0005").

Service replacement bearing inserts are available in pairs in the following sizes:

- Standard
- 0.025 mm (0.001") undersize
- 0.051 mm (0.002") undersize
- 0.254 mm (0.010")undersize

The size is stamped on the back of the service replacement inserts. The 0.051 mm (0.002") undersize inserts were not used for production engine assembly.

Measuring Bearing-to-Journal Clearance

1. *Plastigauge Method*

- a. Wipe the bearing inserts and rod journal clean.
- b. Lubricate the upper insert and install it in the rod.
- c. Place a strip of Plastigauge across the full width of the lower insert at the center of the bearing cap. The lower insert must be dry.

- d. Install the bearing cap on the connecting rod and tighten the retaining nuts to 45 N•m (33 ft-lbs) torque. DO NOT rotate the crankshaft. The Plastigauge will shift, resulting in an inaccurate indication. The Plastigauge must not crumble. If brittle, obtain fresh stock.
- e. Remove the bearing cap and determine the amount of clearance by measuring the width of the compressed Plastigauge with the scale on the Plastigauge envelope.

If the correct clearance is indicated, bearing fitting is not necessary. Remove the Plastigauge. Traces of Plastigauge left on the bearing surfaces will dissolve in hot engine oil after the engine is operating.

If the oil clearance exceeds the specification, install 0.025 mm (0.001") undersize bearing inserts and measure the clearance as described earlier.

The measured clearance with 0.025 mm (0.001") undersize bearing inserts installed will determine if a pair of 0.025 mm (0.001") undersize inserts or some other combination is needed to provide the correct clearance.

Example: If the initial clearance was 0.076 mm (0.003"), 0.025 mm (0.001") undersize inserts will reduce the clearance by 0.025 mm (0.001"). The oil clearance will be 0.051 mm (0.002") and within specification. A combination of a 0.051 mm (0.002") undersize insert and a 0.025 mm (0.001") undersize insert will reduce the clearance an additional 0.013 mm (0.0005"). The oil clearance will then be 0.038 mm (0.0015").

Caution: Never use a combination of inserts that differ more than one bearing size as a pair. For example, DO NOT use a standard upper and a 0.051 mm (0.002") undersize lower insert.

If the oil clearance exceeds the specification when 0.051 mm (0.002") undersize inserts are installed, measure the diameter of the connecting rod journal with a micrometer. If the journal diameter is correct, the inside diameter of the connecting rod is incorrect and the rod must be replaced.

2. Micrometer Method

If the journal diameter does not conform to the specification, it may have been ground 0.254 mm (0.010") or more undersize.

If the journal diameter is incorrect, replace the crankshaft or grind the journal to accept the appropriate undersized bearing insert pair.

Wipe the connecting rod journal clean

Use a micrometer to measure the journal diameter at two locations 90° apart at each end of the journal.

Note the difference between the maximum and minimum diameters.

Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the maximum allowable taper and out-of-roundness. If any rod journal dimension is not within the specifications, replace the crankshaft or recondition the crankshaft journals and fit with the appropriate undersize bearing inserts.

Compare the largest diameter measurement with the journal diameters listed on the *Connecting Rod Bearing Fitting Chart* found in your service manual.

Select the bearing insert pair required to provide the specified bearing clearance.

Always measure clearances with Plastigauge after installing replacement bearing inserts. Also, measure the clearance of each journal after installing a crankshaft kit (crankshaft supplied with bearings).

Measuring Side Clearance

1. Rotate the crankshaft to the position where the connecting rod journal is at the bottom of the stroke.
2. Insert a snug fitting feeler gauge between the connecting rods (Figure 7-14).
3. Compare the feeler gauge measurement to the specified clearance. Replace rods that are not within the specifications.

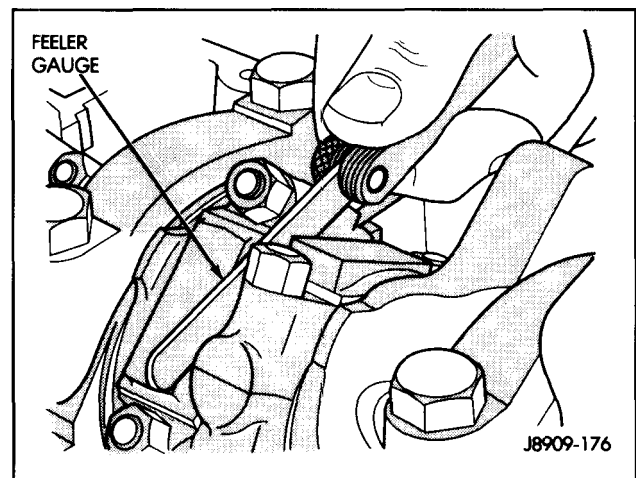


Figure 7- 14

PISTON PIN

Removal

Piston pins are press-fit into the connecting rods and DO NOT require a locking device.

1. Position the piston and connecting rod assembly on an arbor press.
2. Apply force to a piloted driver and press the pin completely out of the connecting rod and piston assembly. Note position of the pin through the gauge window of removal support tool.

Inspection

Inspect the piston and connecting rod bores for nicks and burrs. Replace the rod and piston, if necessary.

Caution: Never reuse a piston pin after it has been pressed in and out of a connecting rod.

With the pin removed from the piston and connecting rod, clean and dry the piston pin bores.

Position the piston so that the pin bore is in a vertical position. Insert a replacement pin in the bore. At room temperature, the replacement pin should slide completely through the piston bore without force.

Replace the piston if the pin jams in the bore.

Installation

1. Position the piston and connecting rod so that the piston notches will face forward and the rod squirt hole will face in when the assembly is installed in the engine.
2. Place a pilot tool through the piston and connecting rod pin bores.
3. Place the pin pilot, piston and connecting rod on a support tool.
4. Insert the piston pin into the piston pin bore and into the connecting rod pin bore.
5. Insert a driver tool into the piston pin.
6. Use an arbor press to press the piston pin through the connecting rod and piston bores until the pin pilot indexes with the mark on the support. The piston pin requires 8900 N (2,000 lbs) force for installation. If insufficient force is required to press the piston pin into the connecting rod, or if the rod slides along the pin, replace the connecting rod.
7. Remove the piston and connecting rod assembly from the press. The pin should be centered in the rod ± 0.787 mm ($\pm 1/32$ ").

PISTON AND CONNECTING ROD ASSEMBLY

Removal

Use the following procedures to service connecting rods and pistons with the engine installed in the vehicle.

1. Remove the cylinder head cover(s).
2. Alternately loosen the bridge and pivot assembly capscrews one turn at a time to avoid damaging the bridges. Remove the bridges, pivots and rocker arms.
3. Remove the pushrods. Retain the bridges, pivots, rocker arms and pushrods in the same order as removed to facilitate installation in their original locations.
4. Remove the intake manifold assembly.
5. Remove the exhaust manifold(s). It is not necessary to disconnect the exhaust pipe from the manifold.
6. Remove the cylinder head(s) and gasket(s).
7. Position the pistons, one at a time, near the bottom of the stroke. Use a ridge reamer to remove any ridge from the top end of the cylinder walls.
8. Drain the engine oil.
9. Remove the oil pan.
10. At any journal, loosen all four (4) connecting rod nuts at the same time. Remove the connecting rod bearing caps and inserts. Retain in the same order as removed to facilitate installation in their original locations. The number stamped onto the removable bearing cap and onto the adjacent machined surface of the rod corresponds to the associated cylinder.
11. Remove the connecting rod and piston assemblies through the top of the cylinder bores. Ensure that the connecting rod bolts DO NOT scratch the connecting rod journals or the cylinder walls. Short pieces of rubber hose slipped onto the rod bolts will provide protection during removal.

Piston Fitting

1. *Micrometer Method*
 - a. Use an inside micrometer to measure the cylinder bore inside diameter at a location 59 mm (2-5/16") below the top of the bore and crosswise to the block.
 - b. Measure outside diameter of piston. Pistons are cam ground and must be measured at a right angle (90°) to the piston pin at the centerline of the pin (Figure 7-15).
 - c. The difference between the cylinder bore diameter and the piston diameter is the piston-to-bore clearance. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

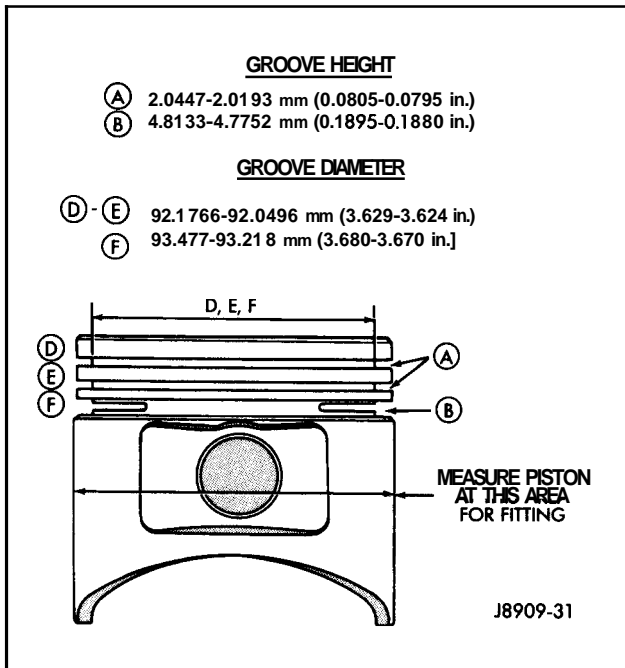


Figure 7- 15

2. Feeler Gauge Method

(Not recommended for racing.)

- Remove the rings from the piston.
- Insert a long 0.013 mm (0.0005") feeler gauge into the cylinder bore.
- Insert the piston (top first) into the cylinder bore along side the feeler gauge. With the entire piston inserted in the cylinder bore, the piston should not bind against the feeler gauge.
- Repeat the above procedure with a long 0.051 mm (0.002") feeler gauge. The piston should bind.
- If the piston binds on the 0.013 mm (0.0005") feeler gauge, either the piston is too large or the cylinder bore is too small. If the piston does not bind on the 0.051 mm (0.002") feeler gauge, the piston may be enlarged by hurling or shot-penning. Replace any piston that is 0.102 mm (0.004") or more undersize.

Piston Ring Fitting

Caution: DO NOT remove metal from the grooves or lands. Doing so will change the ring groove clearances and will destroy the ring-to-land seating.

- Carefully clean carbon deposits from all the ring grooves. Ensure the oil drain openings in the oil ring grooves and pin boss are open.

- Measure the ring side clearance with the correct size feeler gauge that fits snugly between the ring land and ring (Figure 7-16). Slide the ring around the groove. It must slide freely around the circumference of the groove. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct ring side clearance.
- Place the ring in the cylinder bore. Use an inverted piston to push the ring down near the lower end of the ring travel area. Measure the ring gap (clearance) with a feeler gauge fitting snugly in the ring opening. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the correct ring gap (clearance).
- Install the oil control rings according to the instructions in the package. Roll the upper and lower rails into place without the use of a tool (Figure 7-17).
- Install the bottom compression ring using the ring installer to expand the ring around the piston. Install the top compression ring using the ring installer to expand the ring around the piston.
- Ensure the top and bottom compression rings are installed properly. Ideally, the ring gaps should be spaced 180° from each other.
- Ensure the top and bottom compression rings are installed with the top side up.

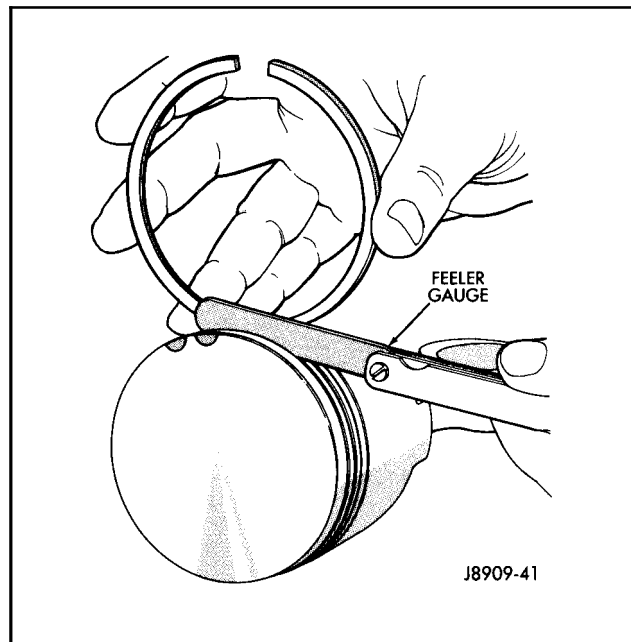


Figure 7- 16

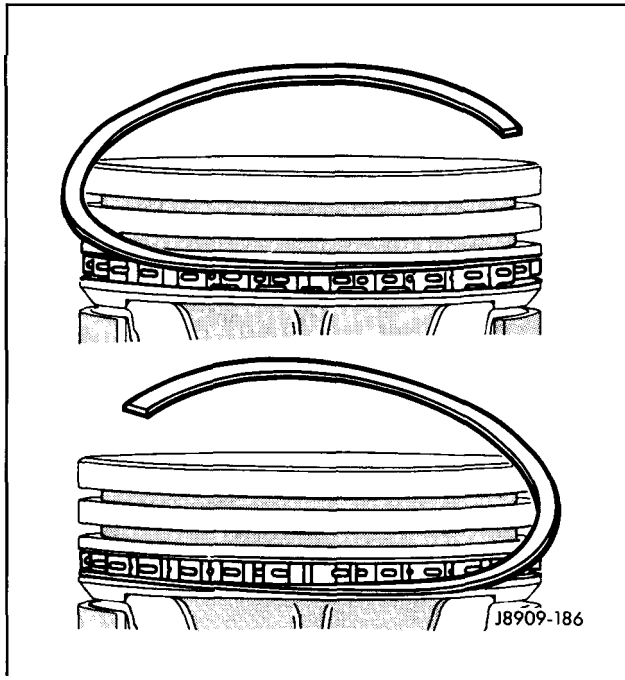


Figure 7- 17

Installation

1. Thoroughly clean the cylinder bores. Apply a light film of clean engine oil to the bores with a clean, lint-free cloth.
2. Arrange the spacing of the piston ring gaps. Refer to *Piston Ring Fitting*, in this section, for the procedure.
3. Lubricate the piston and ring surfaces with clean engine oil.

Caution: Ensure that the connecting rod bolts DO NOT scratch the connecting rod journals or cylinder walls. Short lengths of rubber hose slipped over the connecting rod bolts will provide protection during installation.

4. Use a piston ring compressor tool to install the connecting rod and piston assemblies through the top of the cylinder bores. To ensure correct installation of the pistons in the bore, two notches are cast in the top perimeter of the pistons.

Note: The notches must face forward when installed (Figure 7-18). The squirt holes in the connecting rods must face inward. The rod and cylinder numbers face outward.

5. Install the connecting rod bearing caps and inserts in their original positions. Tighten the retaining nuts to 45 N•m (33 ft-lbs) torque.
6. Install the engine oil pan using replacement gaskets and seals.
7. Install the cylinder head(s) and replacement gasket(s).
8. Install the pushrods.

9. Install the rocker arms and bridge and pivot assemblies. Loosely install the capscrews through each bridge and alternately tighten, one turn at a time, to avoid damaging the bridge.
 10. Install the intake manifold gasket and manifold assembly.
 11. Install the exhaust manifold(s).
 12. Reseal and install the cylinder head cover(s).
 13. Fill the crankcase with clean oil to the specified level.
- Warning!** Use extreme caution when operating engine. DO NOT stand in direct line with the fan. DO NOT put hands near pulleys, belts or fan. DO NOT wear loose clothing.
14. Start the engine and inspect for leaks.

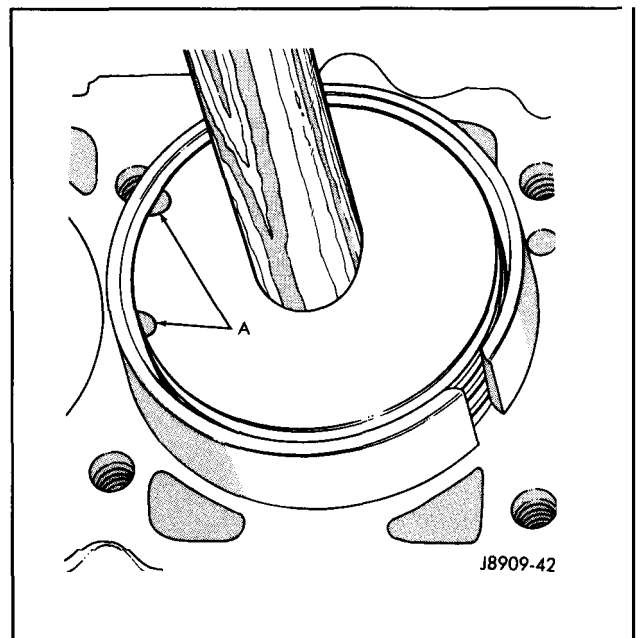


Figure 7- 18

Cylinder Heads

Introduction

The 360 AMC V-8 uses two cast iron cylinder heads (right and left banks) with combustion chamber volumes of 58.62-61.62 cc (3.58-3.76 cu. in.) each. Intake and exhaust valve lengths are 121.653-122.034 mm (4.7895-4.8045").

For more cylinder head specifications, refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

Cylinder Head Gasket Set

This heavy duty head gasket set can be used as replacement. Factory approved and engineered for performance applications. For 360 AMC V-8 only

P4529630 Cylinder head gasket set.

Removal

The following procedure can be performed with the engine in or out of the vehicle.

1. Disconnect the battery negative cable.
2. Drain the cooling system and cylinder block. If the coolant is reusable, drain it into a clean container.
3. Remove the ignition wires and spark plugs.
4. Remove the cylinder head cover and gasket.
5. Remove the capscrews, bridge and pivot assemblies and rocker arms. Alternately loosen the capscrews, one turn at a time, to avoid damaging the bridge.
6. Remove the pushrods. Retain the rocker arms, bridges, pivots and pushrods in the same order as removed to facilitate installation in the original locations.
7. Remove the intake manifold.
8. Disconnect the exhaust manifold from the head. It is not necessary to remove the exhaust down pipe from the manifold.
9. Loosen all drive belts.
10. On the right side, remove the A/C compressor mounting bracket and battery negative cable from the cylinder head.
11. On the right side, disconnect the alternator support brace from the cylinder head.
12. On the left side, disconnect the air pump and power steering mount bracket from the cylinder head.
13. Remove the cylinder head retaining bolts.
14. Remove the cylinder head and gasket.

Cleaning and Inspection

Thoroughly clean the gasket surfaces of the cylinder head and block to remove all foreign material and gasket cement. Remove carbon deposits from the combustion chambers and the top of each piston.

Use a straightedge and feeler gauge to determine the flatness of the cylinder head and block mating surfaces. Refer to *360 AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter, for the proper tolerances.

If the cylinder head is to be replaced and the original valves reused, remove the valves and measure the stem diameters.

Service replacement heads have standard-size valve guide bores. If valves with oversize stems from the original head are to be installed in a replacement head, ream the valve guide bores to the appropriate oversize diameter.

If the original valves are used, remove all carbon deposits and reface the valves. Install the valves in the cylinder head using replacement valve stem oil deflectors. If valves with oversize stems are used, oversize deflectors are also required. Transfer all the components from the original head that are not included with the replacement head.

Wire brush the threads of the cylinder head bolts prior to installation. Unclean threads will affect the tightening torque. Blow coolant from the bolt holes to prevent trapping coolant.

Installation

1. Apply an even coat of non-hardening sealing compound to both sides of the replacement head gasket.

Caution: DO NOT apply sealing compound to the head and block surfaces. DO NOT allow sealer to enter the cylinder bores.

2. Position the gasket flush on the block with the stamped word TOP facing up.
3. Install the cylinder head over the gasket.
4. Tighten the cylinder head bolts evenly with 108 N•m (80 ft-lbs) torque following the tightening sequence (Figure 7-19). Then repeat the sequence and tighten the bolts to 149 N•m (110 ft-lbs) torque.

Note: The 360 AMC V-8 engine uses an aluminum coated, laminated steel and asbestos gasket. Re-tightening head bolts after the engine has been run is not necessary.

5. On the left side, connect the air pump mounting bracket and power steering pump (if removed) to the cylinder head.

6. On the right side, connect the alternator support bracket to the cylinder head.
7. On the right side, install the air conditioner compressor mounting bracket and the battery negative cable on the cylinder head.
8. Adjust all drive belts to the specified tension. Refer to the service manual for the proper tension and procedure.
9. Install the exhaust manifold and tighten the two center retaining bolts to 34 N•m (25 ft-lbs) torque. Tighten the four outer bolts to 20 N•m (15 ft-lbs) torque. Install the other exhaust manifold.
10. Install the intake manifold. Tighten the retaining bolts to 58 N•m (43 ft-lbs) torque.
11. Install all the disconnected pipes, hoses, linkage and wires.
12. Install the pushrods, rocker arms and bridge and pivot assemblies in their original positions. Loosely install the capscrews through the bridges. Tighten the capscrews alternately, one turn at a time, to avoid damaging the bridges. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
13. Install the cylinder head cover.
14. Install the spark plugs and connect the ignition wires. Tighten the plugs to 38 N•m (28 ft-lbs) torque.
15. Fill the cooling system to the specified level.
16. Connect the battery negative cable.

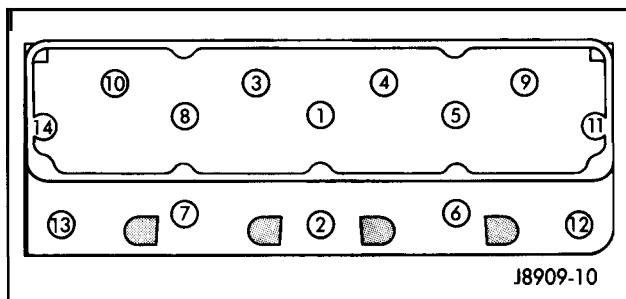


Figure 7 - 19

CYLINDER HEAD SHIMS

The primary purpose of cylinder head shims is to lower compression ratio, a primary concern of pre-1972 production engines. A shim that is .060" thick will drop an engine's actual compression ratio about one full point. Shims allow you to lower your compression ratio without rebuilding your engine. The other method of dropping the compression ratio is replacing the pistons. This is more expensive and obviously requires the engine to be rebuilt, which is much more work. We look at the head shim as a temporary fix. It's a repair that allows you to go until you can schedule (or afford) a complete engine rebuild.

Why would you want to do this? Gasoline! The 100+ octane fuel (leaded premium) that was readily available 20 years ago is no longer available. High compression ratios (10.0:1 and higher) require good gas. The best gas available today from the pump is unleaded premium which has (at best) 94 octane. This gas works best with 9 or 9.5:1 compression ratios. There is racing gas available in 55 gallon drums, but this isn't a good solution for non-racers. You could back the spark down, but the performance drops drastically. Therefore, the solution is to lower the compression ratio.

The head shim looks like a head gasket except that it's flat—no beads. The shim should be installed next to the block, and the gasket should be installed on top of the shim. We recommend that gasket sealer be used on the shim. Don't forget that with the shim installed, the head has now moved up .060" which means that multiple gaskets have to be used on the intake manifold.

The extra intake gasket thickness can be calculated the same way you would calculate head milling specifications—just in reverse. Be sure to allow some extra thickness for gasket compression.

CYLINDER HEAD COVERS

The cylinder head covers are installed with a formed-in-place RTV (room temperature vulcanizing) silicone gasket.

Crankcase Breather

A universal high performance re-usable crankcase breather (must have stand pipe on valve cover). Washes clean with P4529392 cleaning fluid for extra miles of service.

P4529394 Crankcase breather.

Air Filter Cleaning Fluid

Mopar Performance Parts long-life high performance air filters are reusable. This cleaning fluid is designed to remove dirt to extend the life of the filter.

P4529392 Air filter cleaning fluid.

Removal

1. Remove the air cleaner assembly.
2. Disconnect the air hose from the air injection manifold.
3. On the left side, disconnect the power brake vacuum hose at the intake manifold.
4. Disconnect the throttle stop solenoid wire on the left side.
5. Remove the thermostatically controlled air cleaner (TAC) hot air hose on the right side.

6. Disconnect the ignition wires and remove the plastic wire separator from the cylinder head cover bracket.
7. Remove the retaining bolts and washers. Strike the cover with a rubber mallet to break it loose from the cylinder head. Remove the cover and gasket.

Cleaning and Inspection

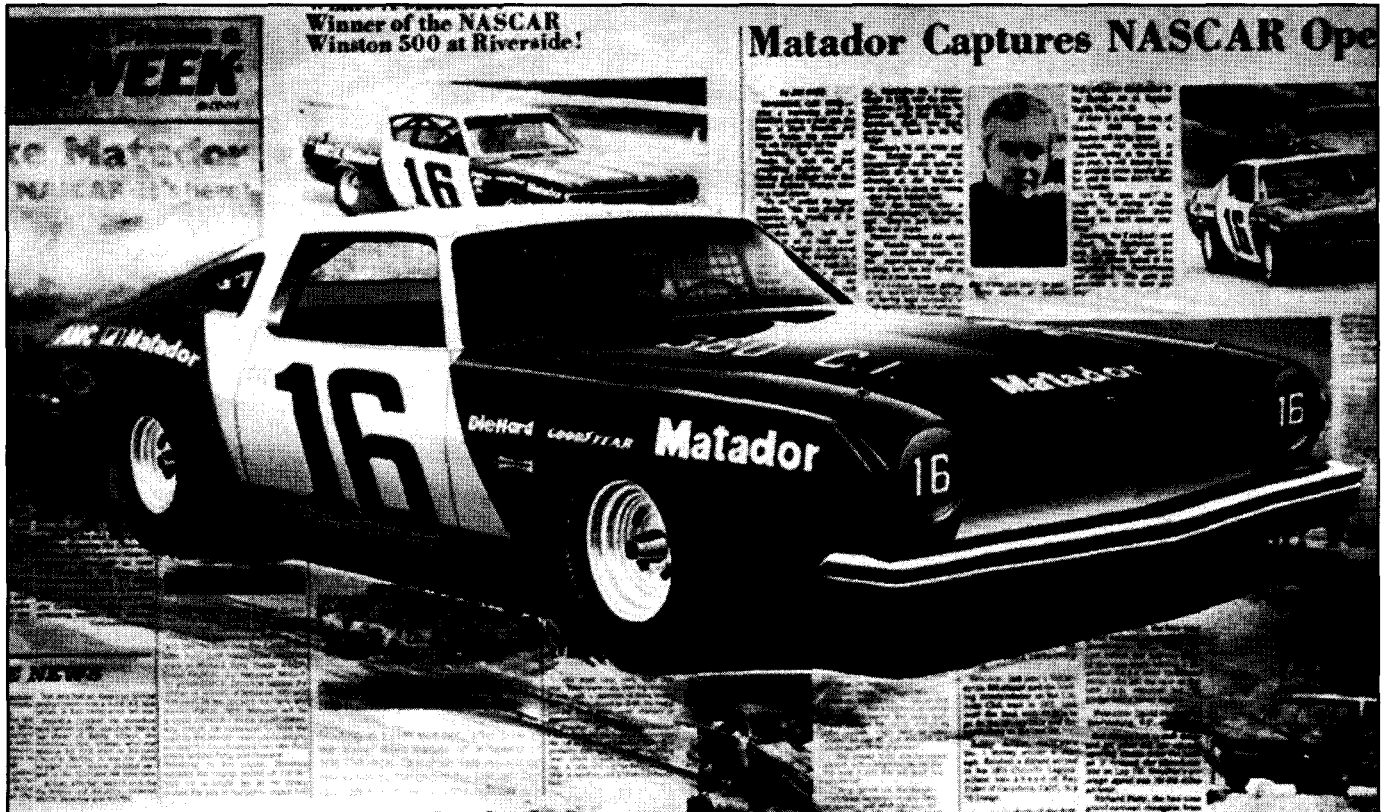
Inspect the cover for bends or cracks and repair or replace as required.

Thoroughly clean the cylinder head cover and cylinder head gasket surface area.

Installation

1. Apply a bead of Mopar Gasket-In-A-Tube, or equivalent, to the cylinder head cover gasket surface area. Ensure the sealant is fresh (i.e., not stored for longer than one year and storage area temperature is less than 27°C (80°F).

2. Position the cylinder head cover on the engine.
3. Install the retaining bolts and tighten to 6 N•m (50 in-lbs) torque.
4. Connect the ignition wires and install the plastic wire separator on the cylinder head cover bracket.
5. Install the TAC hot air hose.
6. On the left side, connect the power brake vacuum hose at the intake manifold.
7. Connect the throttle stop solenoid wire on the left side.
8. Connect the air hose to the air injection manifold.
9. Install the air cleaner assembly.



Camshaft and Valve Gear

CAMSHAFT

The 360 AMC V-8 uses a cast iron camshaft with intake and exhaust cam lobe lifts of 6.604-6.858 mm (0.260-0.270"), and intake and exhaust durations of 263.5°.

To advance or retard camshaft centerline, the 360 AMC V-8 uses offset keys. For more information on centerlining, refer to the 'Camshaft and Valve Gear' section of Chapter 4, *4.0L Power Tech In-Line 6*.

For more camshaft specifications, refer to 360 *AMC V-8 Engine Specifications*, 'Engine Assembly' section of this chapter.

Degree Wheel

Durable Mopar Performance Parts aluminum plate, 0°-90-180°-90-0° degree wheel for centerlining camshafts. Features step-by-step installation instructions printed on back side.

P4452990 Degree wheel.

Cam Lobe Lift Measurement

1. Remove the cylinder head cover and gasket.
2. Remove the bridge and pivot assemblies and rocker arms. Alternately loosen the capscrews one turn at a time to avoid damaging the bridge.
3. Remove the spark plugs.
4. Use a piece of rubber tubing to secure the dial indicator on the end of the pushrod (Figure 7-20).
5. Rotate the crankshaft until the cam lobe base circle (pushrod down) is under the valve tappet.
6. Set the dial indicator to zero.
7. Rotate the crankshaft until the point of maximum pushrod upward movement occurs.
8. Note the travel on the dial indicator. Correct lift is 6.604-6.858 mm (0.260-0.270"). The rocker arm ratio is 1.6:1. Multiply the cam lift by 1.6 to determine the valve lift.

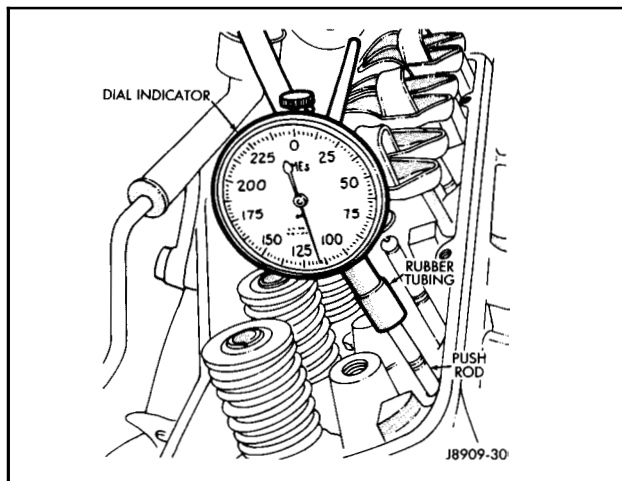
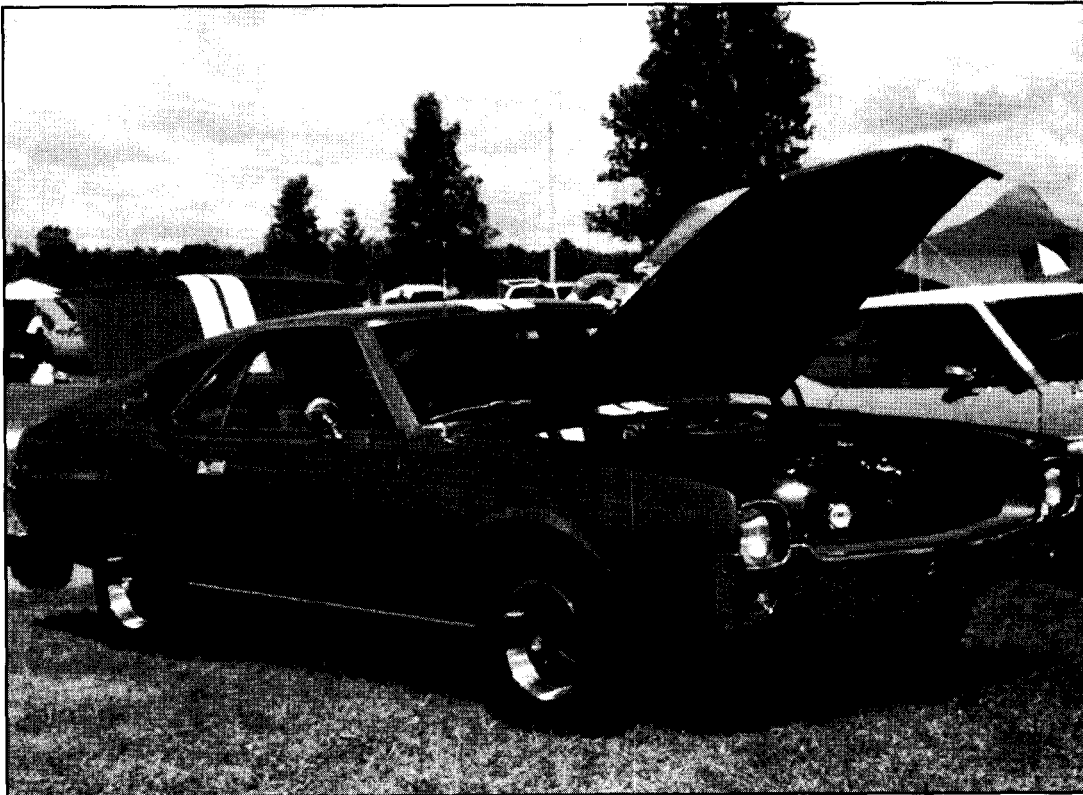


Figure 7-20

Removal

Warning! If the engine has been recently operated, use care to prevent scalding by hot coolant. The system is pressurized.

1. Drain the radiator and cylinder block. If the coolant is reusable, drain it into a clean container.
2. Remove the radiator assembly.
3. Remove the air conditioning condenser and receiver assembly as a charged unit.
4. Remove the cylinder head covers and gaskets.
5. Remove the bridge and pivot assemblies and rocker arms. Alternately loosen the capscrews one turn at a time to avoid damaging the bridge.
6. Remove the pushrods. Retain the pushrods, rocker arms, bridge and pivot assemblies and tappets in the same order as removed.
7. Remove the intake manifold assembly.
8. Remove the tappets.
9. Remove the drive belts.
10. Remove the fan and hub assembly.
11. Remove the distributor,
12. Remove the damper pulley and vibration damper.
13. Remove the timing case cover.
14. Install the vibration damper bolt with two or more flat washers to provide means of rotating the crankshaft.
15. Rotate the crankshaft until the timing mark on the crankshaft sprocket is closest to and on the centerline with the timing mark on the camshaft sprocket.



16. Remove the retaining bolt from the camshaft (Figure 7-21). Remove the retaining bolt from the crankshaft.
17. Remove the distributor drive gear and fuel pump eccentric from the camshaft (Figure 7-21).
18. Remove the crankshaft sprocket, camshaft sprocket and timing chain as an assembly.
19. Remove the hood latch support bracket, front bumper or grille as required and remove the camshaft

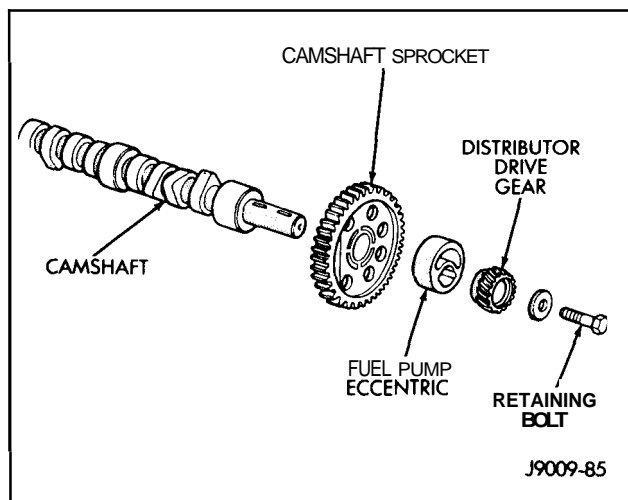


Figure 7-21

Inspection

1. Inspect the camshaft bearing journals for an uneven wear pattern or rough finish. Replace the camshaft if either condition exists.
2. Inspect the distributor drive gear for damage or excessive wear.
3. Inspect the fuel pump eccentric for excessive wear.
4. Inspect each cam lobe and the associated hydraulic valve tappet for wear. If the face of the tappet(s) is worn concave and the corresponding camshaft lobe(s) is also worn, replace both the camshaft and tappet(s).

Installation

1. Lubricate the entire camshaft generously with Mopar Super Oil Conditioner, or equivalent.
2. Carefully install the camshaft into the engine block.
3. Assemble the timing chain, crankshaft sprocket and camshaft sprocket with the timing marks aligned. Refer to *Timing Chain and Sprockets*, 'Crankshaft' section of this chapter, for the procedure.
4. Install the oil slinger on the crankshaft.

5. Install the fuel pump eccentric and distributor drive gear on the camshaft. The fuel pump eccentric has the word REAR stamped on it to indicate the proper installed position. The camshaft washer fits into the recess in the distributor drive gear. Tighten the retaining bolt to 41 N•m (30 ft-lbs) torque.
6. Install a replacement timing case cover gasket.
7. Install the timing case cover.
8. Install a replacement oil seal. Apply a light film of engine oil to the lips of the seal.
9. Install the vibration damper.
10. Install the damper pulley with the retaining bolts. Tighten the bolts to 41 N•m (30 ft-lbs) torque.
11. Install the hydraulic valve tappets lubricated with Mopar Super Oil Conditioner, or equivalent. DO NOT drain the Mopar Super Oil Conditioner from the engine for at least 1,609 km (1,000 miles); However, it does not have to be drained until the next scheduled oil change.
12. Install the intake manifold assembly with a replacement gasket.
13. Install the pushrods.
14. Install the rocker arms and bridge and pivot assemblies. Tighten the capscrews alternately, one turn at a time, to avoid damaging the bridge. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
15. Reseal and install the cylinder head covers.
16. Install the fuel pump.
17. Rotate the crankshaft until the No. 1 piston is at the TDC position on the compression stroke. After the No. 1 intake valve has closed, TDC can be attained by rotating the crankshaft clockwise as viewed from the front until the timing mark on the vibration damper aligns with the TDC index on the timing degree scale.
18. Install the distributor so that the rotor is aligned with the No. 1 terminal of the cap when fully seated on the block.
19. Install the distributor cap.
20. Install the ignition wires.
21. If removed, install the air conditioner condenser and receiver assembly.

Caution: Both service valves must be open before the air conditioning system is operated.
22. Install the hood latch support bracket and the front bumper grille, if removed.
23. Install the radiator.
24. Install the fan and hub assembly.
25. Fill the cooling system to the specified level.
26. Install and adjust the drive belts to the proper tension.

BREAKING CAMSHAFTS

Usually, the only reason you break a camshaft is because it gets hit by a connecting rod. You can fail a camshaft by wearing off a lobe, but typically they are still in one piece.

However, there is another problem that can cause the camshaft to break in two and it is not caused by the connecting rods. One problem is related to valve springs. We have valve springs today that have almost 1,000lb. open load! This goes along with the camshaft (or lobes) higher lift which makes the base circle smaller. This can cause two potential problems. The 360 AMC V-8 engine has five camshaft journals. There are four lobes between each journal. With 16 tappets each with a 1,000 lb. spring, the torsional load is extremely high. With the small diameter base circle, the high torsional load will cause the camshaft to break after the first journal where the load is the highest.

Another potential problem is related to the second or fourth journal. These journals have four lobes on either side which could be 4,000 lbs. bending the camshaft across the journal. This causes a bending failure around the second or fourth journal where the stress is the highest. You could also have a failure caused by a combination of these two situations.

The real problem in these cases is the camshaft itself. High load springs are used to keep down valve float. Valve float is a problem because the camshafts are too aggressive and have poor dynamics. On a naturally aspirated engine like Pro Stock, these aggressive camshafts can be accepted if you can accept the basic parts failures and maintenance. In a supercharged engine or an engine with nitrous, the false-motion or camshaft failure will cause a much greater mess with the engine. In these cases, a smoother camshaft profile (one that is less aggressive) is the better solution so the blower/nitrous can be used to its full advantage. This will actually make more power and be more reliable.

CAMSHAFT BEARINGS

The camshaft is supported by five steel-shelled, Babbitt-lined bearings that are pressed in the cylinder block and then line reamed. The stepped bored camshaft journals are larger at the front bearing than at the rear to permit easy removal and installation of the camshaft. The camshaft bearings are pressure lubricated.

It is not advisable to attempt to replace camshaft bearings unless special removal and installation tools are available.

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear. The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face. Camshaft end play is zero during engine operation. The rear camshaft bearing journal has two holes drilled through it to relieve pressure that could develop between the journal and camshaft plug and force the camshaft forward.

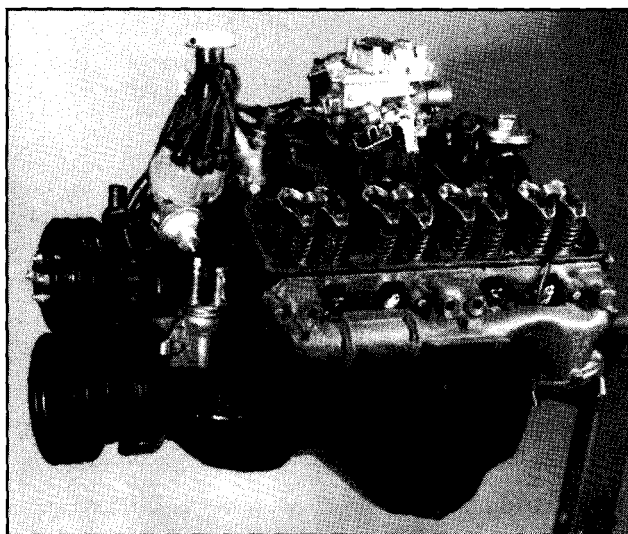
VALVES AND VALVE SPRINGS

Part Number	Location	Diameter	Length	Material	Modification
P4529613	Intake	Std.	Std.	Std.	Back-cut 3/8" stem
P4529614	Exhaust	Std.	Std.	Std.	Back-cut 3/8" stem

All AMC V-8 Engine Valve Spring Specifications Chart						
Part Number	Installed Ht.	Description	O.D.	Wire Diameter	Lift Range	Material
P4876063	1.78"	Single w/damper	1.36"	.200"	.350/.560"	Chrome-sil

360 AMC V-8 Engine Keepers (Locks) Specifications Chart						
Part Number	Valve Stem Size	Angle	Hardened	Groove	Use With Retainers	Sets
P4529653	8 mm	8°	Std.	Single	P4529616	16 Pieces

360 AMC V-8 Engine Valve Spring Retainer Specifications Chart				
Retainer	Material	Locks	Valve Stem Size	Valve Spring
P4529616	Steel	8°	3/8"	Single



Removal—Cylinder Head Removed

1. Compress each valve spring with a C-clamp type spring compressor tool (Figure 7-22). Remove the valve locks and retainers. Release the compression tool.
2. Remove the valve springs and retainers.

3. Remove the valve stem oil deflectors.
4. Remove the valves individually and place them in a rack in the same order as installed in the cylinder head.

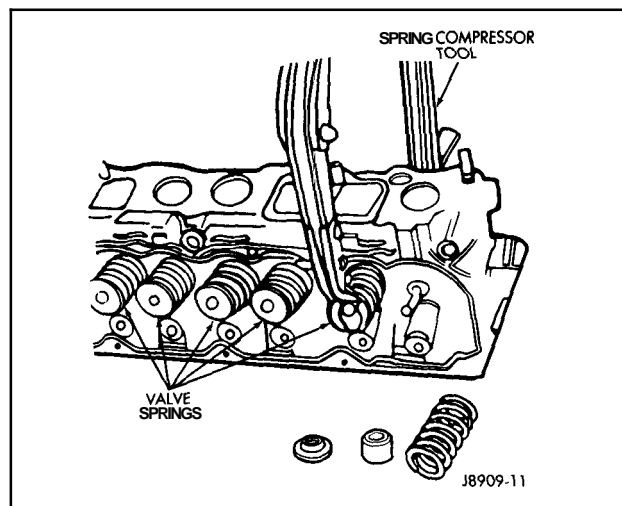


Figure 7 - 22

Cleaning

Remove all carbon deposits from the combustion chambers, valve ports, valve stems and heads.

Remove all foreign material and gasket cement from the cylinder head gasket mating surface.

Inspection

Inspect for cracks in the combustion chambers and valve ports and in the gasket surface area at each coolant passage.

Inspect for cracks on the exhaust seats.

Inspect for burned or cracked valve heads and scuffed valve stems. Replace any valve that is bent, warped or scuffed.

Installation—Cylinder Head Removed

1. Thoroughly clean the valve stems and valve guide bores.
2. Lightly lubricate the stem and install the valve in the same valve guide bore from where it was originally removed.
3. Install the replacement valve stem oil deflector on the valve stem.
4. Position the valve spring and retainer on the cylinder head and compress the valve spring with the compressor tool. Install the valve locks and release the tool.
5. Tap the valve spring from side to side with a light hammer to seat the spring properly on the cylinder head.

VALVE STEM OIL DEFLECTOR

Nylon valve stem oil deflectors are installed on each valve stem to prevent lubricating oil from entering the combustion chamber through the valve guide bores.

Caution: Ensure that the valve stem is free of burrs or sharp edges before replacing the oil deflectors.

Replace the oil deflectors whenever valve service is performed or if the oil deflectors have deteriorated.

Oil deflector replacement requires removal of the valve springs.

Viton Valve Stem Oil Seal Set

Viton heavy duty umbrella seals are specially designed to withstand high temperatures. Helps prevent oil seepage down valve guides. Good for dual purpose high performance engines. Includes 8 intake and 8 exhaust seals. Not recommended for dual valve springs. Fits 360 AMC V-8 engine valves with 3/8" stems only.

P4529629 Viton valve stem oil seal set.

Race Valve Stem Oil Seal Sets

Perfect Circle valve stem oil seals for use with dual valve springs in race applications. Set of 16 seals. Includes installation tool.

P3690963	Race valve stem oil seal set, 3/8" inside diameter.
P4876099	Race valve stem oil seal set, 11/32" inside diameter.
P4876100	Race valve stem oil seal set, 5/16" inside diameter.

Removal—Cylinder Head NOT Removed

Valve springs and oil deflectors can be removed without removing the cylinder head.

Each valve spring is held in place on the valve stem by a retainer and a set of valve locks. The locks can be removed only by compressing the valve spring.

1. Remove the cylinder head cover.
2. Remove the bridge and pivot assemblies and the rocker arms from the valves requiring valve spring or oil deflector removal.
3. Remove the two capscrews at each bridge. Alternately loosen the capscrews one turn at a time to avoid damaging the bridge.
4. Remove the bridge, pivot and rocker arms.
5. Remove the pushrods. Retain the rocker arms, bridge and pivot assemblies and pushrods in the same order as removed to facilitate installation at their original locations.
6. Remove the spark plug from the cylinder that requires valve spring or oil deflector removal.
7. Install a 14 mm (thread size) air adapter in the spark plug hole. An adapter can be constructed by welding an air hose connection to the body of a spark plug that has the porcelain removed.
8. Connect the air hose to the adapter and maintain at least 620 kPa (90 psi) pressure in the cylinder to hold the valves against their seats.
9. Use a valve spring removal/installation tool to compress the valve spring (Figure 7-22).
10. Remove the valve locks (Figure 7-23).
11. Remove the valve spring and retainer from the cylinder head (Figure 7-23).
12. Remove the oil deflector (Figure 7-23).

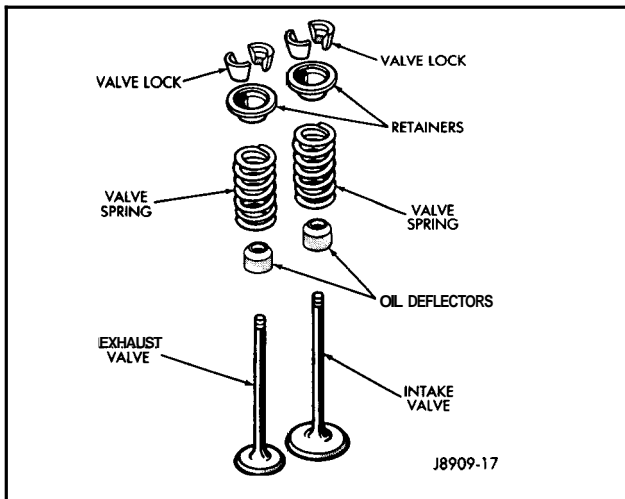


Figure 7-23

Installation – Cylinder Head NOT Removed

1. Use an 11 mm (7/16") deep socket and a hammer to gently tap the oil deflector onto the valve stem.
2. Install the valve spring and retainer. A close-coil valve spring is used with all valves. The close-coiled end must face the cylinder head when installed.
3. Compress the valve spring with a valve spring removal/installation tool (Figure 7-22).
4. insert the valve locks.
5. Release the spring compression and remove the tool.
6. Tap the valve spring from side to side with a hammer to ensure the spring is seated properly on the cylinder head.
7. Disconnect the air hose, remove the air adapter from the spark plug hole and install the spark plug. Tighten the spark plug to **38 N•m** (28 ft-lbs) torque.
8. install the pushrods. Ensure that the bottom end of each rod is centered in the plunger cap of the hydraulic valve tappet.
9. install the rocker arms and bridge and pivot assembly.
- 10 At each bridge, tighten the capscrews alternately, one turn at a time, to avoid damaging the bridge. Tighten the capscrews to **26 N•m** (19 ft-lbs) torque.
11. Install the cylinder head cover.

VALVE GUIDES

The valve guides are an integral part of the cylinder head and are not replaceable. When the stem-to-guide clearance is excessive, ream the valve guide bores to the next higher valve stem size. Ream the valve guide bores in steps. Start with the 0.076 mm (0.003") reamer and progress to the next size until the proper size is achieved.

Valve Stem-to-Guide Clearance Measurement

Valve stem-to-guide clearance can be measured by either one of two methods.

1. Preferred Method

- a. Remove the valve from the head and clean the valve guide bore with solvent and a bristle brush.
- b. Insert a telescoping gauge into the valve stem guide bore approximately 9.525 mm (0.375") from the valve spring side of the head with the contacts crosswise to the head.
- c. Use a micrometer to measure the telescoping gauge contact width.
- d. Repeat the measurement with the contacts lengthwise to the cylinder head.
- e. Compare the lengthwise and crosswise measurements to determine the out-of-round condition.
- f. If the measurements differ by more than 0.0635 mm (0.0025"), ream the guide bore to accommodate an oversize valve stem.
- g. Compare the valve guide bore diameter measurement with the diameter listed in **360 AMC V-8 Engine Specifications**, 'Engine Assembly' section of this chapter. If the measurement is larger by more than 0.076 mm (0.003"), ream the guide bore to accommodate an oversize valve stem.

2. Alternate Method

- a. Use a dial indicator to measure the lateral movement of the valve stem with the valve installed in its guide and barely off the valve seat (Figure 7-24).
- b. The correct clearance is 0.025-0.076 mm (0.001-0.003").

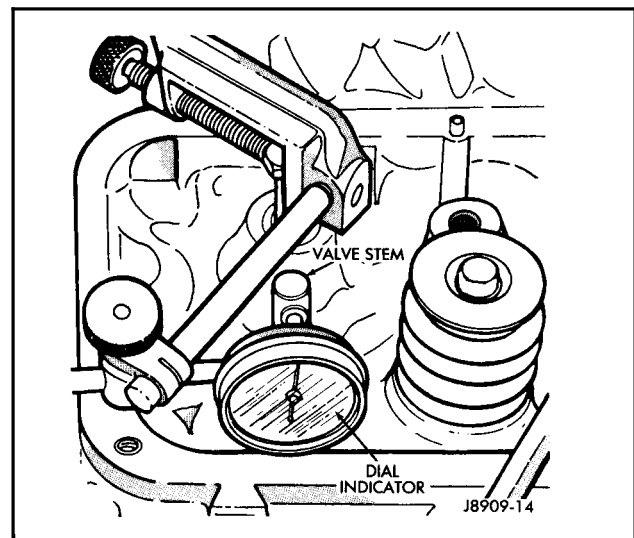


Figure 7-24

VALVE SEATS

With cast iron cylinder heads, all the valve seats are machined into the head material. (Aluminum heads use valve seat inserts.) One of the most important items in a high output engine is the valve job.

Valve Seat Refacing

Install a pilot of the correct size in the valve guide and reface the valve seat to the specified angle with a dressing stone in good condition (Figure 7-25).

Remove only enough metal to provide a smooth finish. This is especially important on exhaust valve seats. The seat hardness varies in depth.

Use tapered stones to obtain the specified seat widths when required. Measure the seat runout with a dial indicator (Figure 7-26). Maximum seat runout is 0.064 mm (0.0025").

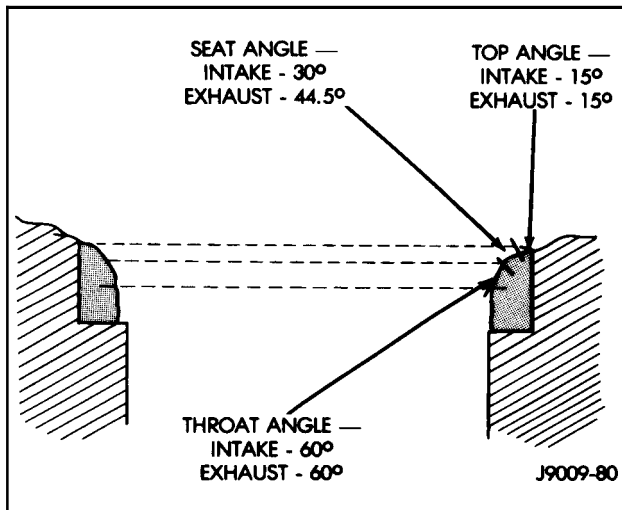


Figure 7- 25

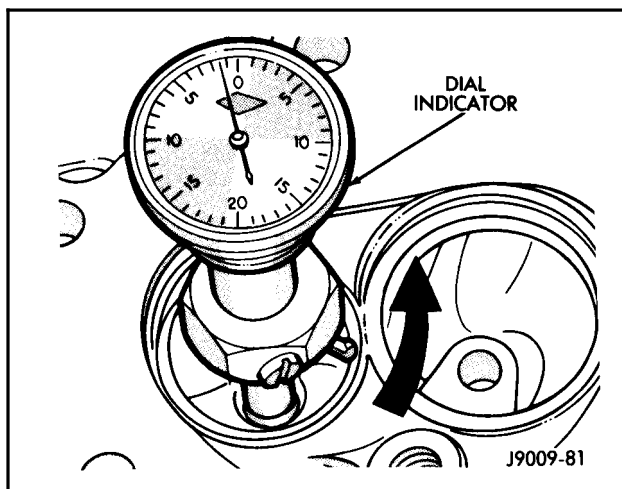


Figure 7- 26

VALVE TIMING

1. Remove the spark plugs.
2. Remove the cylinder head covers and gaskets.
3. Remove the bridge and pivot assemblies and rocker arms from the No. 1 cylinder.
4. Rotate the crankshaft until the No. 6 piston is at top dead center (TDC) on the compression stroke. This positions the No. 1 piston at TDC on the exhaust stroke in the valve overlap position.
5. Rotate the crankshaft counterclockwise 90° as viewed from the front.
6. Install a dial indicator on the No. 1 intake valve pushrod end. Use rubber tubing to secure the stem on the pushrod.
7. Set the dial indicator at zero.
8. Rotate the crankshaft slowly in the direction of normal rotation (clockwise, viewed from the front) until the dial indicator indicates 0.508 mm (0.020").
9. This should align the milled timing mark on the vibration damper with the TDC mark on the timing degree scale. If a variation of more than 13 mm (1/2") exists in either direction from the TDC mark, remove the timing case cover and inspect the timing chain installation.
10. Inspect for an incorrect camshaft sprocket location. The sprocket keyway should align with the centerline of the first lobe of the camshaft.

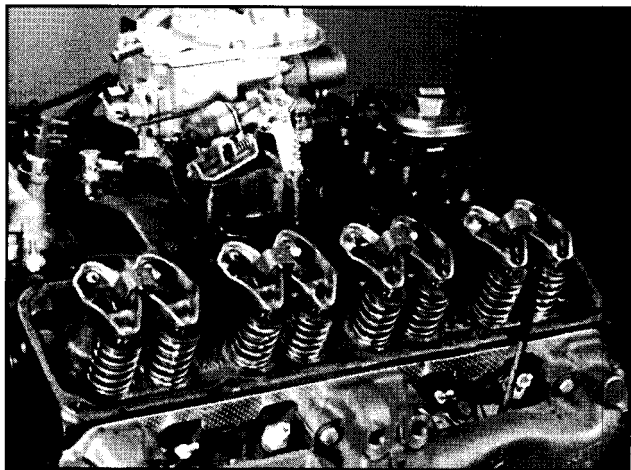
ROCKER ARMS

The most important considerations in rocker arms are strength and durability. Strength is required to minimize deflections and transfer the cam motion to the valve accurately. One important item in high performance hydraulic cams is that the higher valve spring loads required by these cams put more load on the rocker arms, which causes the pushrods to have a tendency to pierce the rocker arm. Thicker material in the pushrod ball or cup area is the only solution to this problem.

Heavy Duty Rocker Arm

Heavy duty stamped rocker arms for use with hydraulic cams (only). Right and left rockers are the same. Can be used to service stock engines. For 360 AMC V-8 engine only. (Sold individually.)

P4529619 Heavy duty rocker arm,



Removal

1. Remove the cylinder head cover. Refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter for the procedure.
2. Remove the two capscrews at each bridge. Alternately loosen the capscrews one turn at a time to avoid damaging the bridge.
3. Remove the bridge and pivot assemblies and place them on the bench in the same order as removed.
4. Remove the rocker arms and place them on the bench in the same order as removed.
5. Remove the pushrods and place them on the bench in the same order as removed.

Cleaning and Inspection

Clean all the parts with cleaning solvent. Use compressed air to clean out the oil passages in the rocker arms and pushrods.

Inspect the pivot contact surface of each rocker arm and pushrod. Replace any parts that are scuffed, pitted or excessively worn. Inspect the valve stem contact surface of each rocker arm and replace the rocker arm if deeply pitted. Inspect each pushrod end for scuffing or excessive wear. If any pushrod is excessively worn from lack of oil, replace the pushrod as well as the corresponding hydraulic valve tappet and rocker arm.

It is not normal for a wear pattern to exist along the length of the pushrod. Inspect the cylinder head for obstruction if this condition exists.

Installation

1. Install the pushrods. Ensure that the bottom end of each rod is centered in the plunger cap of the hydraulic valve tappet.
2. Install the bridge and pivot assembly and pair of rocker arms adjacent to the cylinder from where they were originally removed.

3. Loosely install two capscrews through each bridge. Tighten the rocker arm capscrews alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
4. Seal and install the cylinder head cover.

PUSHRODS

Length, strength and weight are the most critical items for pushrods, especially the first two. Length affects the geometry and the valve gear oiling. Strength keeps the deflections minimized and weight helps the engine speed, but a weight loss that causes a strength loss will result in a performance loss.

The valve train of the 360 AMC V-8 is oiled through the pushrods. Jeep engine pushrods (all Jeep engines) are hollow so that oil can pass through them to oil the valve train.

Caution: Because the 360 AMC V-8 valve train is oiled through hollow pushrods, SOLID SHAFT PUSHRODS CANNOT BE USED.

Pushrod Set

This Mopar Performance Parts pushrod set is of the same high quality as production pushrods. They are hollow to provide valve train oiling (same as production pushrods). Comes complete with sixteen (16) pushrods. For 360 AMC V-8 engine only.

P4529676 Pushrod set.

HYDRAULIC LIFTERS (TAPPETS)

Hydraulic Tappet

For use with general purpose, high performance hydraulic camshafts. Can be used as a production replacement. (Sold individually.)

P4529220 Hydraulic tappet.

Roller Tappet Set

Sold as a matched pair with guide bar. For 360 AMC V-8 engine only.

P4529856 Roller tappet set.

Removal—Cylinder Head NOT Removed

1. Remove the cylinder head cover (refer to *Cylinder Head Cover Removal*, 'Cylinder Head' section of this chapter).
2. Remove the bridge and pivot assemblies and the rocker arms. Alternately loosen the capscrews, one turn at a time, to avoid damaging the bridge.
3. Remove the pushrods. Retain the bridge and pivot assemblies, rocker arms and pushrods in the same order as removed.
4. Remove the intake manifold. Refer to the service manual for the proper procedure.
5. Remove the tappet from the guide bore in the engine block.

Disassembly, Cleaning and Inspection

1. Release the lock ring.
2. Remove the plunger cap, metering disc, plunger assembly and plunger return spring from the tappet body. Retain the tappets and all components in the same order as removed. DO NOT interchange components.
3. Clean all tappet components in cleaning solvent to remove all varnish and gum deposits.
4. Visually inspect each tappet assembly for evidence of scuffing on the side and face of the tappet body. Inspect the tappet face for wear using a straightedge across the face. If the tappet face is concave and the corresponding lobe on the camshaft is worn, replace the camshaft and tappets.
5. Replace the entire assembly if any component is worn or damaged.

Assembly

1. Install the plunger return spring, check valve assembly, plunger, metering valve and plunger cap in the tappet body.
2. Use a pushrod on the plunger cap to compress the plunger assembly and install the lock ring.

Installation—Cylinder Head NOT Removed

1. Coat each tappet assembly in Mopar Super Oil Conditioner, or equivalent.
Note: DO NOT fill the tappets with oil as this may make the engine difficult to start. The tappets will charge themselves within three to eight minutes once the engine has been started.
2. Install the tappet in the same bore from where it was originally removed.
3. Install the pushrods in the same position as removed.
4. Install the rocker arm and bridge and pivot assemblies in the same position as removed. Tighten the capscrews alternately one turn at a time to avoid damaging the bridge. Tighten the capscrews to 26 N•m (19 ft-lbs) torque.
5. Pour the remaining Mopar Super Oil Conditioner over the entire valve train mechanism. DO NOT drain the Mopar Super Oil Conditioner from the engine for at least 1,609 km (1,000 miles); however, it does not have to be drained until the next scheduled oil change.
6. Reseal and install the cylinder head cover. Refer to *Cylinder Head Cover Installation*, 'Cylinder Head' section of this chapter.
7. Install the intake manifold using a replacement gasket and end seals. Refer to the proper service manual for the procedure.
8. Install all pipes, hoses, linkage and wires disconnected from the intake manifold.

Oiling System

INTRODUCTION

The 360 AMC V-8 uses a pressure feed, full flow filtration oiling system utilizing a positive displacement, gear-type oil pump driven by the distributor shaft. The oiling system has a capacity of 4.7L (5 quarts). (For more oiling system specifications, refer to 360AMC V-8 **Engine Specifications**, 'Engine Assembly' section of this chapter.)

OIL PAN

Removal

1. Disconnect the battery negative cable
2. Raise and support the vehicle.
3. Drain the engine oil.
4. Remove the starter motor.
5. Remove the oil pan attaching bolts. Remove the oil pan.
Note: It may be necessary to raise the engine in order to remove the oil pan.
6. Remove the oil pan front and rear neoprene oil seals. Remove the oil pan bolts.

Cleaning

Thoroughly clean the gasket surfaces of the oil pan and engine block.

Remove all sludge and residue from the oil pan sump.

Installation

1. Install a replacement oil pan front seal for the timing case cover. Apply a generous amount of Mopar Gasket-In-A-Tube, or equivalent, to the end tabs.
2. Coat the inside curved surface of the replacement oil pan rear seal with soap or Mopar Gasket-In-A-Tube, or equivalent. Apply a generous amount of Mopar Gasket-In-A-Tube, or equivalent, to the gasket contacting surface of the seal end tabs.
3. Install the seal in the recess of the rear main bearing cap, ensuring it is fully seated.
4. Apply Mopar Gasket-In-A-Tube, or equivalent, to the oil pan contacting surface of the front and rear oil pan seals.
5. Cement replacement oil pan side gaskets into position on the engine block. Apply a generous amount of Mopar Gasket-In-A-Tube, or equivalent, to the gasket ends.
6. Install the oil pan. Tighten the 1/4-20 oil pan bolts to 9 N•m (80 in-lbs) torque and the 5/16-18 oil pan bolts to 15 N•m (11 ft-lbs) torque.

7. Lower and secure the engine, if it was raised.
8. Tighten the drain plug securely.
9. Install the starter motor and connect the cable.
10. Lower the vehicle.
11. Connect the battery negative cable.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or fan. DO NOT wear loose clothing.

12. Fill the oil pan with engine oil to the specified level. Start the engine and inspect for leaks.

Oil Pan Gasket Set

This Mopar Performance Parts oil pan gasket set comes complete with front, rear and side gaskets. For 360 AMC V-8 engine only.

P4529633 Oil pan gasket set.

Stock (Production) Oil Pan Modifications

The standard pan can be helped by reworking the sump so it is 2" deeper. (See Figure 7-27.) A longer oil pick-up must also be installed at the same time. A deepened pan can also be used. With this pan the pick-up must also be lengthened, or a strainer and pipe assembly, which is designed for use with the deepened pan, should be purchased. With any oil pan capacity or shape change, the dipstick should be carefully recalibrated. Be sure to fill the oil filter before calibrating!

With either of these pans installed in the vehicle, the ground clearance will be reduced and the pan will no longer be protected by the vehicle's frame. For added pan protection, a skid plate should be added and the vehicle should be driven with increased care.

In the stock pan, especially the deepened pan, the rear acceleration baffle is very important. It keeps the oil from running up into the #7 and #8 cylinders and slowing down the last rod journal with increased drag. The baffle must be sealed to the three walls (back and two sides) of the sump or it becomes useless.

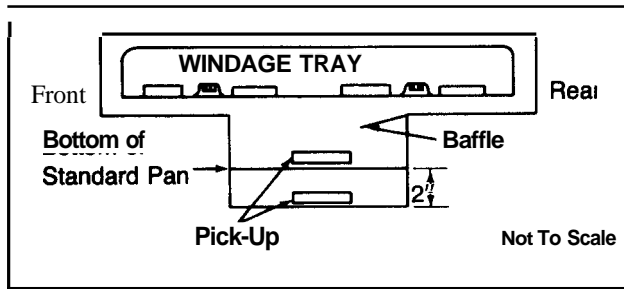


Figure 7-27

CUSTOM DRAG RACING OIL PAN FABRICATION

A Super Stock/high performance bracket race oil pan should be designed similar to Figure 7-28. The first item to check before building a race pan is to determine the lowest point of the connecting rod travel and the relationship of this point to the pan rail. The dimensions given in Figure 7-28 are measured from the lowest point in the connecting rod travel, not from the pan rail. This means that the pan must be made deeper than the number shown in Figure 7-28 by the amount that the lowest point in the connecting rod travel is below the pan rail or bottom of the block.

In-vehicle clearances should always be checked carefully before making the pan. Important items to watch for are header clearance, steering linkage clearance, frame rail clearance, and ground clearance.

The steering centerlink will usually pass through the center of the pan (Figure 7-28). This can be done by welding in a tube through the pan. This tube should only be large enough to allow the installation of the centerlink and to provide clearance during the lock-to-lock travel of the steering linkage. If the rules allow it, the engine can be removed and the centerlink dropped or reshaped so that the tube through the pan is not required. Any reshaping or changing of the centerlink should be done carefully so that the relationship of the end holes is not changed at all. If one of these points is moved, it will change the toe pattern of the front suspension which could be very dangerous in a drag race vehicle.

The two baffles shown in Figure 7-28 should be sealed on the three sides next to the actual pan sides. No oil should be able to pass between the baffle and the side of the pan, or the baffle loses its effectiveness.

If you use a swinging pick-up, the oil sump should be designed such that the pick-up can swing from the rear of the sump on acceleration to the front of the sump on deceleration. The pick-up should stop within 1/4" of the back and front walls of the sump. See Figure 7-28.

The sump should be filled with six to ten quarts of oil, with eight quarts an absolute minimum for a modified production type, high speed engine.

Many newer drag race pans have a side-bucket. The oil pan's sump is extended on the right side (passenger side as installed in the vehicle). See Figure 7-29 and Figure 7-30. Just the sump is extended externally and the swinging pick-up is extended internally. The major reason for this side-bucket design is to get more capacity from a shallow or limited-depth pan. It puts some of the oil reservoir off to the side (i.e., not directly under the crankshaft), and the oil inlet is to the side and has a longer swing travel. Refer to *Pro Stock Pan*, in this section, for more information.

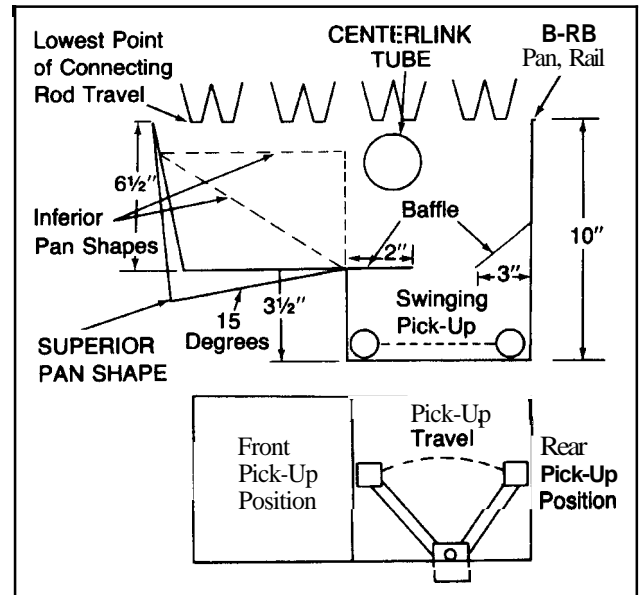


Figure 7-28

Pro Stock Pan

There are two acceptable modifications to the aforementioned Super Stock/high performance bracket race oil pan design. One is to add a side-bucket (right-side first, double side-bucket also acceptable). This is done for added capacity. It makes the bottom of the pan actually wider than the bottom of the block. Header clearance should be carefully considered before this modification is performed. Another acceptable design is a low profile side-bucket intended primarily for Pro Stock. This design is discussed in *Dry Sump Oiling System*, later in this section, and can be used on a Super Stock vehicle if the centerlink tube is added.

Pro Stock cars and similar race vehicles such as Gassers are built very low to the ground. This means there usually isn't enough room for a full 10" deep Super Stock pan, so some compromise must be made. This means a shorter oil pan; but to keep the capacity up so that the pick-up stays covered, the basic Super Stock pan design has to be changed. A design similar to the following should be used.

In Pro Stock cars having space for only a 7" deep oil pan, usually a rear half windage tray must be used. However, in cases where a 9" to 9-1/2" deep pan can be used, space permitting, a pan can be constructed requiring no windage tray as shown in Figure 7-29 and Figure 7-30. Oil can be kept at least six inches below the pan rail for the front six cylinders rather easily.

When using a pan like this one, two areas of caution must be observed:

1. Be sure to trap at least two quarts on deceleration.
2. The huge "bucket" requires use of ten quarts drainable to keep the pick-up covered at 8,000 rpm with the clutch disengaged.

Oil Pan Capacity and Swinging Pick-Up Check-out

It is a good idea to install a rubber lip seal on your wet sump swinging pick-up. In cases where a rubber oil seal has been installed on the swinging pick-up, a simple check must be made to determine whether or not the pick-up swings freely enough. Simply incline the pan rail to a 20 degree angle (nose-down) with no oil fill and move the pick-up to the rear-most position (acceleration); then release it (Figure 7-31). If it doesn't swing forward and stop with a resounding thump, the seal is too tight.

In addition, the deceleration baffle should trap at least four quarts when the pan is in the 20° position (Figure 7-31).

The acceleration baffle can be similarly checked by inclining the pan to a 45 degree angle (nose-up). The acceleration baffle in this position should trap at least five quarts of oil.

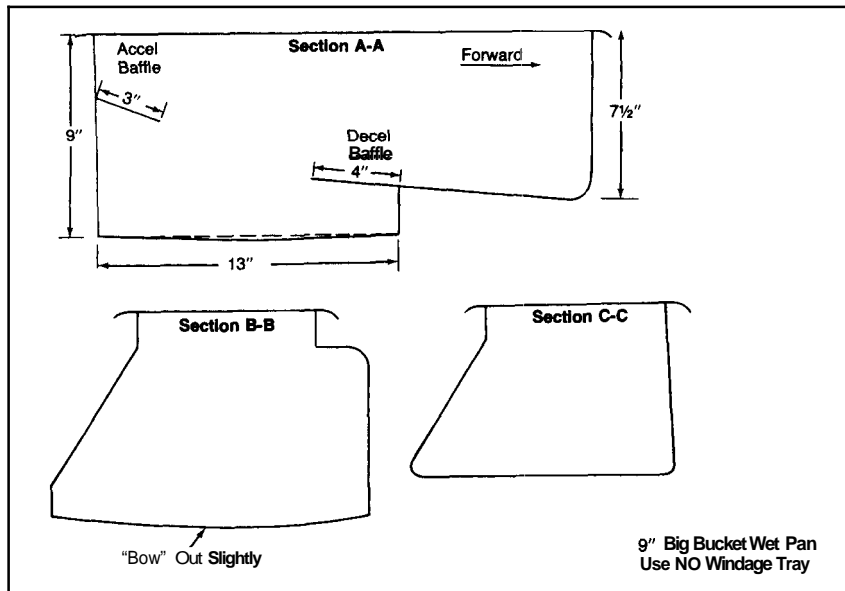


Figure 7-29

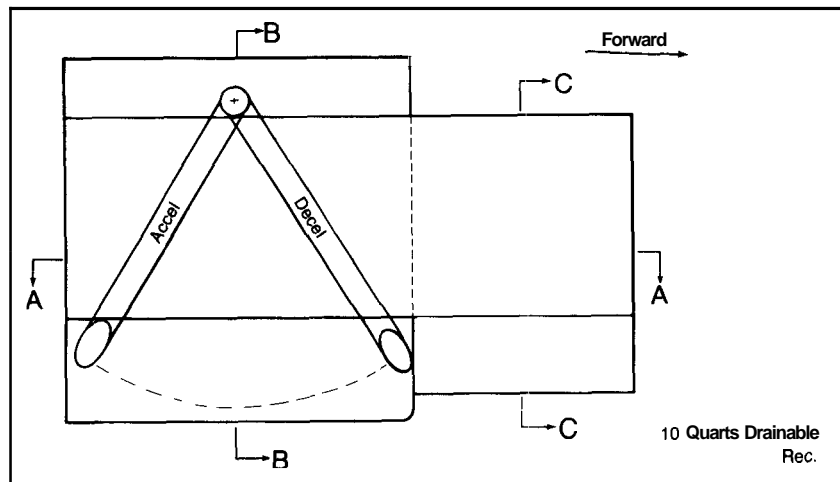


Figure 7-30

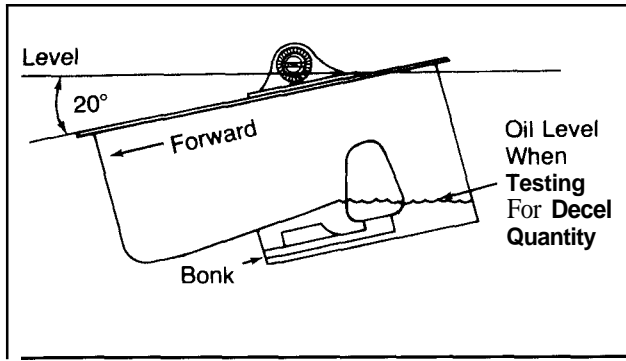


Figure 7-31

DRY SUMP OILING SYSTEM

For drag racing, a dry sump system should only be considered for vehicles that have almost no ground clearance. Dry sump oiling systems can be very advantageous in an oval track vehicle. Dry sumps provide more ground clearance so the vehicle can sit lower. This is because dry sump pans are very shallow. This allows the centerline of the crankshaft to get closer to the ground while maintaining the same actual ground clearance. (Ground clearance is usually specified and enforced by the sanctioning body.)

All production (stock) oil pans are wet sump designs. With a dry sump, the oil that is being stored in preparation for being pumped back into the engine is stored outside the engine (or remotely), usually in a separate tank (with baffles, etc.) located ahead of the engine. A race wet sump pan would have a large capacity rear sump located directly under the crankshaft.

Production wet sumps are small and may be located in the center, front or rear. A race wet sump ideally designed would be 9 to 10 inches deep. But many professionally-built race vehicles are built so low to the ground that there is no room for this style pan. Enter the dry sump. However, a properly designed dry sump system is expensive. Therefore, a racer who doesn't have his crankshaft dragging on the ground doesn't need a dry sump because it's money spent for no gain. Here, look closely at a race wet sump. There is performance in a good wet sump system race pan.

A dry sump oil system should be used whenever a deep oil pan cannot be used. There is approximately 40 hp lost to a shallow, wet sump pan.

The dry sump system consists of an oil tank, scavenge pump, and a pressure pump. The oil pump used is a multi-stage, external assembly with 2 or 3 stages for scavenge and a pressure stage. Drag race engines require 2 scavenge stages, oval track engines require 3. The pump should be run at .5 to .6 engine speed. The drag racing pump has two 1.45" wide scavenge stages and a 1.2" or 1.45" pressure stage; the oval track pump uses three 1.45" scavenge stages and a 1.45" pressure stage.



Figure 7-32, Figure 7-33, and Figure 7-34 show three views of a dry sump oil pan. Figure 7-32 shows that the sump is offset to the right side. Figure 7-33 shows the locations of the dual pick-ups. Figure 7-34 shows the windage tray (baffle) inside the pan and how it had to be slightly modified (dented) for installation of the dual pick-ups.

Note: After removing the stock oil pump, remember to block off the oil passage.

The oil pans for drag racing and oval track racing are different, mainly in pick-up location and baffles. (See Figure 7-35.) The tank for drag racing use can be as small as 5 qts., while an oval track racing tank should be 3 gallons.

Now that we know all the parts, let's see how it works. The pressure stage picks oil up from the tank, then sends it to an external oil filter, and then to the engine. The engine then gets oiled and dumps the oil back in the pan where the scavenge stages pick up the oil and return it to the tank. The tank is vented to the valve cover to equalize pressures. Contact Weaver Brothers for further details and dry sump hardware.

Weaver Brothers

1980 Boeing Way

Carson City, NV 89706

If you're doing a lot of development on the engine, then a cast pan is more durable than a stamped pan, unless a stock pan is being used; that is, an unmodified one-piece stamping. But that's not likely with a dry sump.

In developing our cast pan we found there are some very simple basics that you can't violate. Once the pan, tank and pump (we used a 4-stage Weaver Bros. - 3 scavenge and 1 pressure) are selected, everyone feels everything is handled. This can easily be a 20 to 30 horsepower error. If you check the drawing for the oil lines in Figure 7-35, it shows #1 2 line

from the pick-ups all the way to the tank. Having three long oil lines running to the dry sump tank adds weight. So, if the drawing is modified, we can have some problems. If you only run one line from the pump to the tank then you must use a #16 line. In an arrangement such as this, each scavenge section of the pump feeds into a manifold that has three #12 size inlets, and one #16 size outlet. For reference, a #12 line has a diameter of approximately 3/4" while a #16 line is 1 inch. This allows our new lightweight system to make as much power as our earlier system.

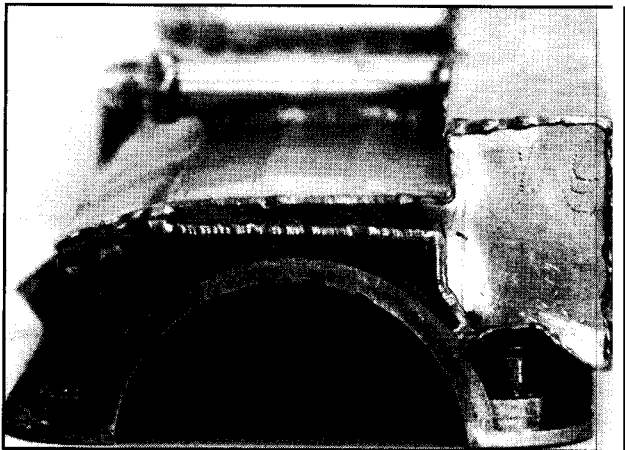


Figure 7- 32

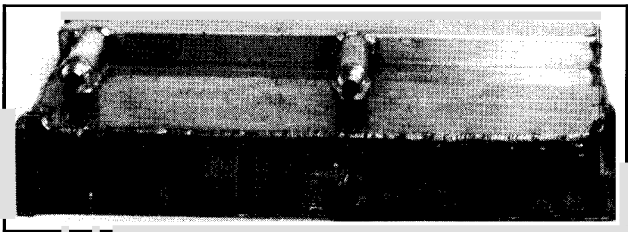


Figure 7- 33

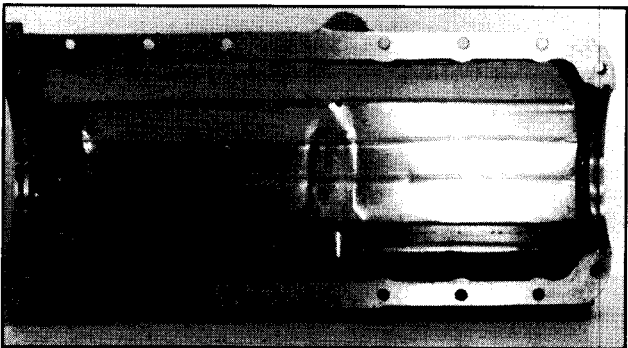


Figure 7- 34

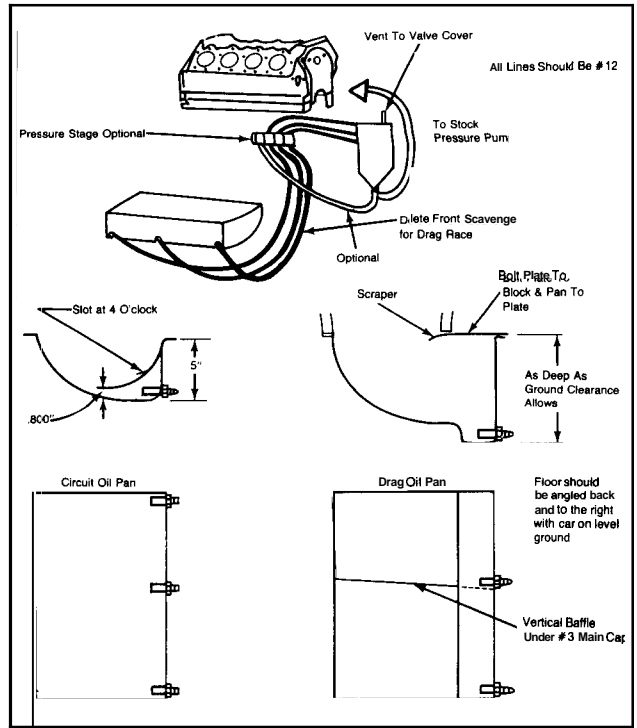


Figure 7- 35

OIL PUMP

The positive-displacement, gear-type oil pump is driven by the distributor shaft, which is driven by a gear on the camshaft. The pump is integral with the timing case cover. A cavity in the cover forms the body of the pump. A pressure relief valve regulates the maximum oil pressure.

Oil pump removal or replacement will not affect the distributor timing because the distributor drive gear will remain in mesh with the camshaft drive gear.

Oil Pressure Relief Valve

The: oil pressure relief valve is not adjustable. The spring tension is calibrated for 517kPa (75 psi) maximum pressure.

In the relief position, the valve permits oil to bypass through a passage in the pump cover to the inlet side of the pump (Figure 7-36).

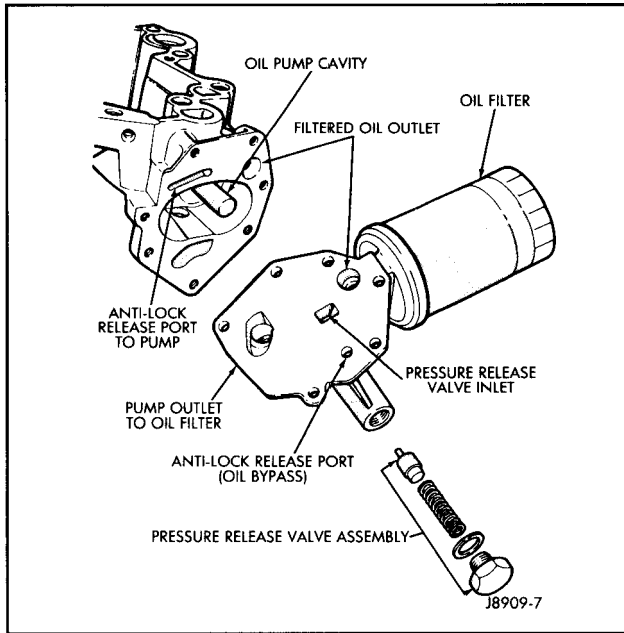


Figure 7- 36

Removal

1. Remove the retaining bolts and separate the oil pump cover, gasket and oil filter as an assembly from the pump body (timing case cover) (Figure 7-37).
2. Remove the drive gear assembly and idler gear by sliding them out of the body.
3. Remove the oil pressure relief valve from the pump cover for cleaning by removing the retaining cap and spring.

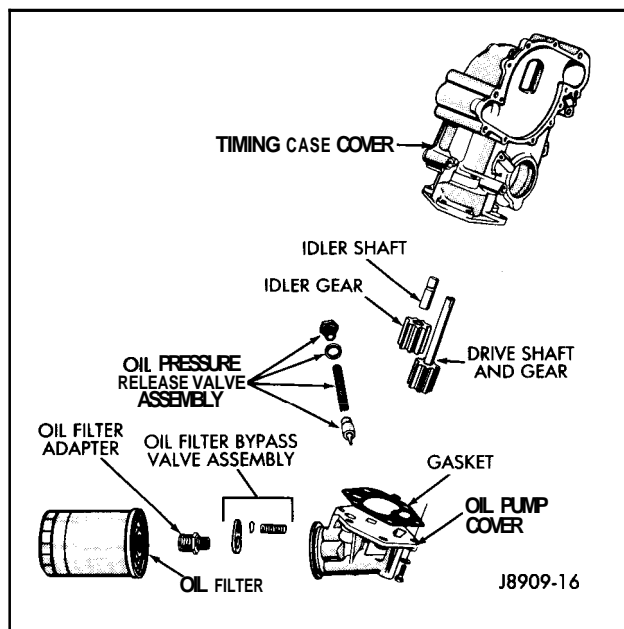


Figure 7- 37

Cleaning and Inspection

Clean the cover thoroughly. Test the operation of the relief valve by inserting the poppet valve and determining if it slides back and forth freely. If not, replace the pump cover and poppet valve.

Gear End Clearance Measurement

This measurement determines the distance between the end of the pump gear and the pump cover. The ideal clearance is as close as possible without binding the gears. The pump cover gasket is 0.229-0.279 mm (0.009-0.011") thick. Symptoms of excessive pump clearance are fair to good pressure when the oil is cold, and low or no pressure when the oil is hot.

1. Preferred Method

- a. Place a strip of Plastigauge across the full width of each gear (Figure 7-38).
- b. Install the pump cover and gasket. Tighten the bolts to 6 N•m (55 in-lbs) torque.
- c. Remove the pump cover and determine the amount of clearance by measuring the width of the compressed Plastigauge with a scale on the Plastigauge envelope. The correct clearance by this method is 0.051-0.203 mm (0.002-0.008"), with 0.051 mm (0.002") preferred.

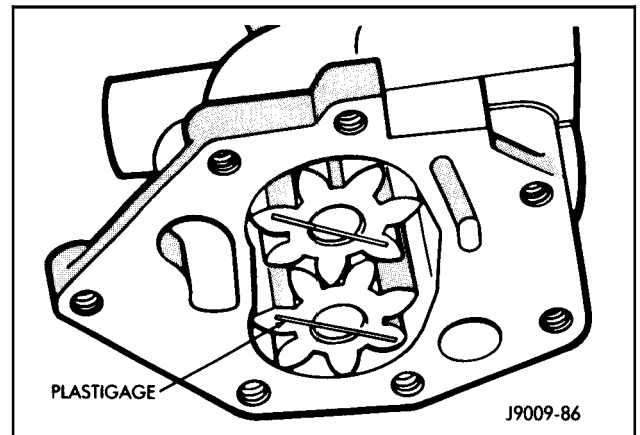


Figure 7- 38

2. Alternate Method

- a. Place a straightedge across the gears and pump body.
- b. Select a feeler gauge that will fit snugly but freely between the straightedge and the top of the gear (Figure 7-39). The correct clearance by this method is 0.102-0.203 mm (0.004-0.008") with 0.203 mm (0.008") preferred.

Note: Ensure the gears are up into the body as far as possible before the measurement is made.

If the gear end clearance is excessive, install a thinner gasket. If the gear end clearance is still excessive, replace the gears and idler shaft.

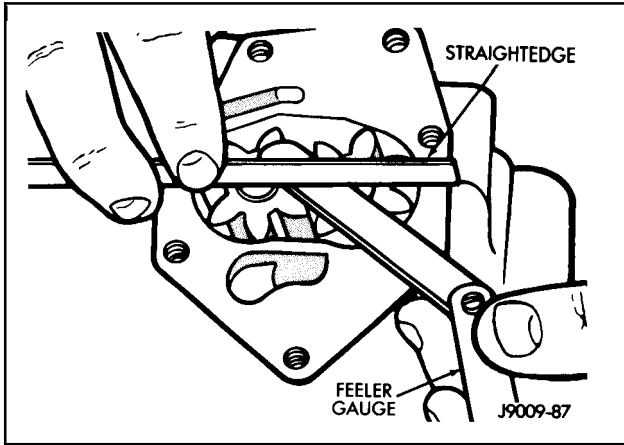


Figure 7- 39

Gear-to-Body Clearance Measurement

Insert a feeler gauge between the gear tooth and the pump body inner wall directly opposite the point of the gear mesh (Figure 7-40). Select a feeler gauge that fits snugly but can be inserted freely.

Rotate the gears and measure the clearance of each tooth and body in this manner. The correct clearance is 0.013-0.064 mm (0.0005-0.0025"), with 0.013 mm (0.0005") preferred.

If the gear-to-body clearance is more than specified, measure the gear diameter with a micrometer. If the gear diameter is correct and the gear end clearance is correct and the relief valve is functioning properly, replace the timing case cover. If the gear diameter is incorrect, replace the gears and idler shaft.

Note: If the oil pump shaft or distributor drive shaft is broken, inspect for a loose oil pump gear-to-shaft fit or worn front cover. Oversize pump shafts are not available.

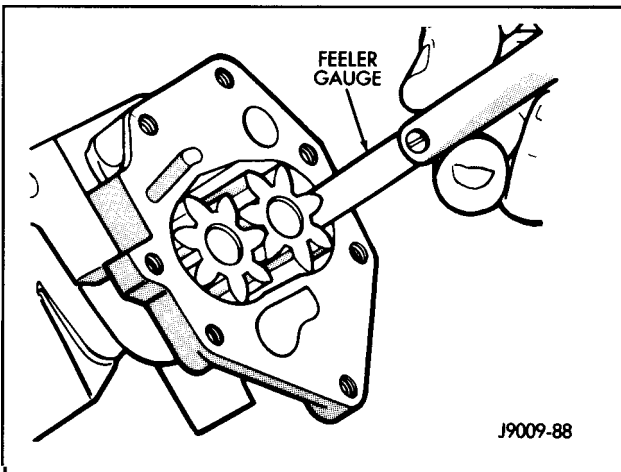


Figure 7- 40

Installation

1. Install the oil pressure relief valve in the pump cover with the spring and retaining cap (Figure 7-36).
2. Install the idler shaft, idler gear and drive gear assembly (Figure 7-37).

Note: To ensure self-priming of the oil pump, fill the pump with petroleum jelly prior to the installation of the oil pump cover. DO NOT use grease of any type.

3. Install the pump cover and oil filter assembly with a replacement gasket. Tighten the retaining bolts to **6 N•m (55 in-lbs)** torque.

Oil Pressure Requirements

Oil pressure requirements for the 360 AMC V-8 are as follows:

- At Idle Speed (600 rpm). 13 psi 90 kPa
- At 1,600+ rpm 37-75 psi. 255-517 kPa
- Oil Pressure Relief. 75 psi 517 kPa

Oil Pump Priming

The lubrication system should be checked to ensure that it is supplying pressure to the bearings before any attempt is made to start the engine. If the engine is run without oil pressure for even for a few seconds, there will be extensive damage done to the engine.

After installing a mechanical oil pressure gauge (only if your vehicle is not already equipped with an oil pressure gauge), remove all the spark plugs in order to relieve the compression in the cylinders and to prevent the engine from starting. The engine should be turned over with the starter motor until the oil pressure gauge shows a reading of over 10 psi.

The pump can be manually primed instead of turning the whole engine to get oil pressure and supply the bearings with oil before the engine is started. This method is preferred but requires a special adapter (usually a modified intermediate shaft) to be made in order to drive the oil pump only.

Once you have determined that the engine does have oil pressure, the spark plugs may be reinstalled and the engine may be started. When the engine starts, the gauge should show a minimum reading of 90 kPa (13 psi) at 600 rpm (idle speed).

Cooling System

INTRODUCTION

The AMC 360 V-8 has a liquid cooled, forced circulation cooling system with a capacity of 13.2L (14 quarts).

Not surprisingly, race engine cooling problems arise during the summer and tend to disappear in the fall. There are various causes: flex-fans, water pumps, radiator size and functioning shrouds, grille openings, and fan blade diameter and number. The not so obvious areas are improper spark advance and too lean fuel mixture.

Now, what happens if a racer has fixed all of these problems and he still overheats or runs too hot? What could this problem be? Some people feel this means there is some mysterious design problem with the engine. This is a witch hunt! Generally, engines don't have an overheating problem. Big engines make more heat than small ones, but this just requires a bigger radiator. Put simply, engines make heat; cooling systems get rid of heat. Nothing fancy! If your engine overheats, that means the balance between these two functions has been lost somewhere.

The best cooling systems to copy are late 1960s to early 1970s Chrysler-Plymouth-Dodge muscle cars. Remember the size and shape (vertical) of the grille and the size of the radiator on those muscle cars? They were very good cooling systems. If you've checked the fan, radiator, water pump, shroud, grille opening, etc., and found no problems, you obviously shouldn't overheat. However, if you still have an overheating condition, what could possibly be wrong?

Problems usually occur after an engine rebuild or parts swap that increased the engine's output. This is not easy to solve. Without scratching for "design" flaws or water pump impeller cracks, the best guess is gasoline. Although gasoline quality may be the cause, the real problem is too much compression ratio inside the engine. Having too much compression ratio is not easy to solve. You can't get rid of compression ratio without rebuilding the engine. That seems like an extreme solution. The quickest solution is to lower the total spark advance. In a race vehicle, this may make it go somewhat slower, but it also may solve the overheating problem.

A better solution is to use higher quality gas. It's usually called "race gas," and it comes in various octane/price levels. Most race vehicles use race gas that's somewhat middle of the road (cost \$2-3 per gallon). Most race gas companies have a premium brand with high octane that sells for a higher price (\$5-7 per gallon). Upgrading the gas will answer the question—is your overheating caused by too much compression ratio?

If you've been using regular race gas, be sure to drain it completely from your tank before you fill up with premium ultra high octane fuel. At the added gas price, this test may cost \$50, but there is no other test that can be run for less, short of rebuilding the engine, and you certainly can't do that for \$50. If the premium ultra high octane fuel solves your overheating problems, your best long term strategy is to rebuild the engine to lower the compression ratio. However, until you have time (and money) to attack that major project, you will have solved the overheating problem and can continue to race without performance loss by simply continuing to use ultra high octane gas.



Induction System

INTRODUCTION

The 360 AMC V-8 engine uses Model 2150, two venturi carburetor (Figure 7-41). The carburetor is identified by a code number and build date code stamped on the identification tag (Figure 7-42). Each carburetor build month is coded alphabetically beginning with the letter A for January and ending with the letter M for December (the letter I is not used). The tag is attached to the carburetor and must remain with it for proper identification.

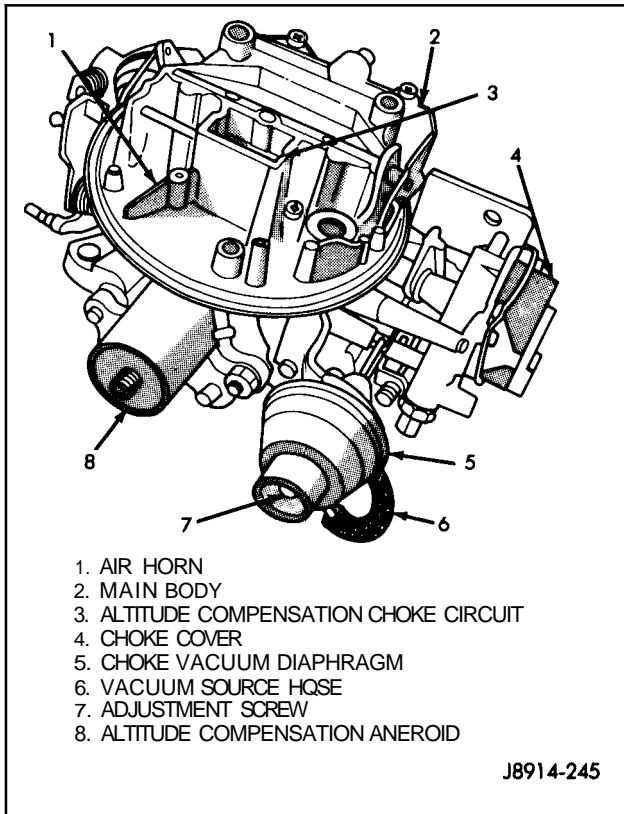


Figure 7- 41

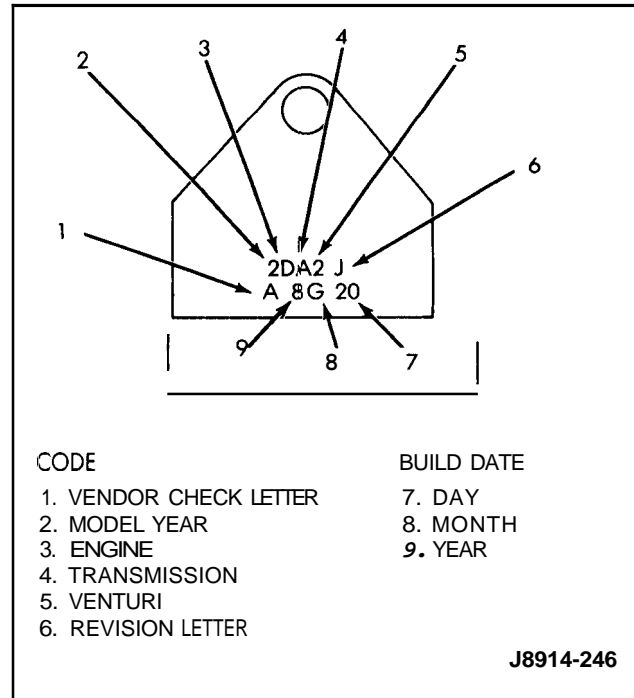


Figure 7- 42

CARBURETION SYSTEM

A carbureted engine's induction system consists of the intake manifold and the carburetor(s). It is very important that this induction system be matched to the compression ratio and camshaft set-up used in your racing engine. These three components make up the "3 C's" of engine building (compression, carburetion, and camshaft), and all three must be matched to work in perfect harmony before the engine can run at peak levels at all times. These decisions must be made before the engine building process is begun, so that none of your time will be wasted and none of your money will be spent on the wrong parts. Without these considerations, the addition of a large cfm carburetor (for example) could actually result in no increase in performance at all, or in some cases, a large decrease.

For drag and oval track racing vehicles it is recommended that the heat (exhaust) cross-over in the intake manifold be blocked by either putting shims in the gasket, or by brazing a metal plate into both sides of the cross-over in the intake manifold. (The best shim material is thin stainless steel.) With the heat crossover blocked, the choke will no longer function. The carburetor will usually have to be rejetted for racing. Blocking the heat crossover usually causes the vehicle to run poorly when dead cold, which is why it is recommended for racing vehicles only. It also should not be considered for cold weather use. (Not required on cylinder heads that have no heat cross-over.)

For any racing application, the carburetor must be specially jetted for proper fuel distribution. Standard production intake manifolds might be used with non-standard production carburetors, aftermarket manifolds installed, or intake manifold heat blocked, all of which require the carburetor to be jetted differently for each application.

Holley Universal Performance Carburetors

Holley P4781 - 850 cfm 4-Bbl.

P4348232 Mechanical secondaries, double accelerator pumps.

Holley R1850 - 600 cfm 4-Bbl.

P4349227 Vacuum secondary.

Holley R3310 - 750 cfm 4-Bbl.

P4349228 Vacuum secondary.

Holley R3418 - 855 cfm 4-Bbl.

P5249808 Vacuum secondary.

Holley Service Gasket Sets

These handy carburetor service gasket sets include the required parts to service and performance tune your Holley. Since every model is different, package contents will include only the necessary parts for proper servicing of the following: primary bowl, primary metering block, secondary bowl, secondary metering block/plate gaskets, required bowl screw O-rings and fuel transfer tube O-rings, as required.

P4349302 For Holley R1850 and R3310 4-Bbbls.

P4349304 For Holley R4412 and R7448 2-Bbbls.

P4349305 For Holley R4777, R4779 and R4781 4-Bbbls.

Holley Needle and Seat Sets

Consists of two needle and seat assemblies.

P4349329 All Holley carburetors except spread bore, .110" orifice.

P4349331 Holley spread bore only, .097" orifice.

P4349332 Holley spread bore only, .110" orifice.

Miscellaneous Plastic Plugs and Caps Package

Assorted pieces for blocking vacuum taps. For 2-Bbl. and 4-Bbl. racing applications.

P4007901 Miscellaneous plastic plugs and caps package.

Accelerator Pump Diaphragm Sets

Consists of two diaphragms.

P4349314 For Holley carburetors with 30 cc accelerator pumps.

P4349315 For Holley carburetors with 50 cc accelerator pumps.

Carter Strip Package

This package contains an assortment of primary and secondary main jets, metering rods, needles and seats for fine tuning Carter carburetors. Fits all AFB models.

P4120238 Carter strip package.

Carburetor Adapters

P4007522 Adapter to install spread bore carburetor (Thermo-Quad or Quadra-Jet) on square bore manifold.

P4876512 Adapts large 1-1/16" Holley 2-Bbl. to standard 2-Bbl. bore intake manifold.

P4876513 Adapts 4-Bbl. carburetor to 2-Bbl. intake, or 2-Bbl. carburetor to 4-Bbl. intake.

Carburetor Jets

To get the most out of your performance engine, you have to fine-tune the metering system. This translates into changing the jets in your carburetor. For racing purposes, the Holley is the most common performance carburetor. Whether it's a big two barrel, small four barrel or giant four barrel, all Holley performance carburetors use the same basic jets. Obviously the hole sizes change, but the jets are interchangeable except for their effect upon the fuel-air ratio in the engine. In the heat of the summer the jets typically need to be changed, and racing in the cool fall air requires them to be changed again. These jet changes are done to enrich or "lean-out" the engine for better horsepower and performance. To accomplish all these changes you need a spread of jet sizes. Holley jet packages come with jet sizes from #64 to #99 (usually two of each). This should cover just about any application. However, if you race two vehicles or have two carburetors on your engine, you may to get two packages.

SPECIAL CARBURETOR CONSIDERATIONS

Headers vs. Carburetors

Headers are one of the most common performance modifications. Thirty years ago, the installation of headers netted an instant performance gain. Today, the installation of headers doesn't always result in a gain except at the racetrack itself. The headers haven't really changed—the carburetors have.

Pre-1970 carburetors were richer in fuel-air ratio. Headers always lean out the fuel-air ratio of an engine. With the extra fuel available in richer, older engines, the headers leaned out the mixture level to the point that the engine was still running well, and the lower backpressure available with headers resulted in an increase in horsepower.

The emissions laws since 1970 forced production carburetors and inlet packages to have almost perfect fuel distribution, but with much leaner fuel mixtures. The better fuel distribution is a plus, but the leaner mixtures leave no room for modification. The installation of headers on to these "emissions" engines leans them out too far. This means that the gain the engine got for the decrease in back pressure was canceled because of the engine output loss due to the too lean fuel mixture.

The solution is quite simple: enrich the carburetor. This usually requires richer jets to be installed. This allows the fuel-air ratio to be corrected. The headers with the richer carburetor will then result in better output (horsepower).

Carburetor cfm

There always seems to be a lot of questions relating to carburetion, especially questions such as which carburetor to use or how much cfm the engine should have. The problem with answering these questions is that the answers vary with engine size and tuning rpm. A related problem is that all carburetor manufacturers don't use the same rating system for their carburetors, and some don't rate their carburetors' "cfm" at all. Cfm stands for *cubic feet per minute*, which is used for rating the air flow of a carburetor. OE manufacturers (such as DaimlerChrysler) don't test carburetors for air flow. Since the advent of emissions laws, OE engineers test carburetors for fuel flow because it relates to the richness level in the engine which relates to emissions.

Air flow relates better to horsepower, high rpm performance, and inversely, driveability. To use it, first you have to obtain air flow data. The only good source is Holley, but don't try to compare 2-Bbl. to 4-Bbl. data.

Check and record the accelerator pump shooter size. Also check the accelerator pump and adjust it for maximum travel. Rod adjustment to the hole closest to the pivot is recommended as the initial starting point. Be sure the metering rods move up and down smoothly by pressing lightly in the center of the metering rod bar.

The point at which the throttle opening opens the air door is determined by the number of turns on the spring. To adjust the spring, two screwdrivers (or a special tool) are required. The adjustment is typically on the driver's side. The outer slotted ring is the locking screw and must be loosened before the spring can be adjusted. Once loosened, the air door will hang vertically. Adjust the inner screws (which tensions the spring) until it just closes the air door. Then turn the screw and tension the spring an additional 1-1/2 to 2 turns. Once set, always use the same technique for future adjustments. The fewer turns, the quicker the air door open—typically used on faster vehicles. The more turns, the slower the door opens—typically used with automatics and street tires.

The amount that the air door opens can be adjusted at the track without disassembling the carburetor. This adjustment can change the amount of air flow that goes through the carburetor and also change the fuel-air ratio (richness level) of the mixture delivered to the engine. Before you make any adjustments you must know how to accurately measure the amount of opening. (Refer to the proper service manual for details.)

Remember, the first thing to do is to measure your specific carburetor and record its reading. Once the vehicle has been baselined at the track at this setting, adjustments can be made.

Always measure the air door opening using exactly the same technique. Adjust as follows: open up to increase power and lean out the mixture; close down to enrich. If it develops a miss in high gear at high speed, you have opened it up too far and it's too lean. Close it back down for best performance.

If all else fails, keep in mind the golden rule of carburetor selection—don't over carburete!

Lean Carburetor

On any given performance engine, the odds are the engine is lean. Since every engine performance increase requires more fuel, the carburetor should be rejetted for every performance modification that we make. However, this does not happen most of the time. Therefore, the engine tends to be lean (or close to it).

One of the most common modifications to a performance engine is to install a performance ignition system. These systems typically include a performance distributor. These distributors have a fast advance curve for better performance. (For more information, refer to 'Ignition Systems' section of this chapter.)

After installation, some people say that their engine runs better with the vacuum disconnected. This is most often caused by the engine being too lean to begin with. Then the engine rpm will “hunt” and “wander.” The idle engine speed will surge up and down. The engine may stall when you put it in gear. If it’s an automatic transmission, the idle may drop hundreds of rpm when you put it in gear. All of these are signs that the engine is too lean. It needs more idle fuel. This idle enrichment cannot be done by simply opening the throttle screw adjustment. This approach will make it worse. To solve, richen the idle adjusting screws or install larger primary jets. On Carter carburetors you can also swap in smaller metering rods.

Lean Idle Fuel Mixture

In high performance cars and trucks, it is a very common problem to have a lean idle fuel mixture in the carburetor that you are using. This can be more common in Carter carburetors than in Holley carburetors.

Why would a lean mixture problem be more common in a Carter carburetor than a Holley? Good question! Carter carburetors were commonly used on production engines and were not as popular in the aftermarket. Holley was very strong in the aftermarket. So if you have a Carter carburetor chances are it was used on a production vehicle while a Holley carburetor was probably obtained in the aftermarket. The typical aftermarket carburetor was built with a richer idle circuit. The production carburetor was built with a lean idle circuit.

Within the Carter carburetor family, the AFB will have the least problems, and the AVS and Thermo-Quads will have the most problems. The reason is similar to the Holley carburetor. The AFB was built up through 1967 before engine emissions became a bigger concern than engine performance. Therefore, the AFB tends to be richer at idle. Fuel economy in the early 1960s was not a big concern which also lead to using more fuel. The AVS and Thermo-Quad carburetors are both emissions carburetors that were built to tough standards. (Emissions engines actually had much better fuel distribution than older engines. From a technology standpoint, AVS and Thermo-Quad were better carburetors.)

Today, only the AFB carburetor is still made. Since it is primarily made for the aftermarket, it tends to have a richer idle. There were many more AVS and Thermo-Quad carburetors built from 1968-78 than there were AFBs from 1962-67. It’s all percentages, the law of averages! There are many exceptions. Holley makes replacement carburetors for emissions engines. There are also Carter AFB versions for emissions engines.

What’s the big deal? So production carburetors are lean. The lean fuel problem is trouble to racers because it is usually not diagnosed properly. A bigger camshaft is installed and the engine idles poorly. Blame the camshaft! Or the heads! Or the intake! The actual solution is usually a carburetor adjustment. More idle fuel! On older

carburetors and aftermarket carburetors you might actually be able to adjust the idle by turning the idle screw adjustment—usually two, a left and a right. Typically this idle adjustment is not adequate—it was adjusted and it didn’t solve the problem. Some people will then assume that idle fuel level is not the problem. In most cases, you have to change the primary jets to larger ones. Usually one or two steps will solve the problem.

Primary jets for Holley and Carter AFB carburetors are readily available. Jets for Carter AVS and Thermo-Quad carburetors are not as easily found. If you only have one set of jets, then we DO NOT recommend you make any changes. With no spare pieces or jet kits, it may be a better choice to swap carburetors to a Holley. If you can find a set of jets, even if they are the same size as the ones you already have, you can drill them out (very carefully). First you need a numbered drill set. (Most machine shops have complete sets.) Then you measure the jet size with the numbered drills. You can also find this information in the service manual for your engine. Measure it to be sure! If you have a slight problem, go **up** one step. If you have a bad problem, go **up** two steps. A step is one number drill size. Be careful to drill the hole straight through the jet. Remove any burrs from the drill surface by hand. Save the stock jets that are in the carburetor so that you can go back to them at a future date. (You may not always want to race.)

Carter carburetors have metering rods that are used for the idle mixture. To put a jet in you have to take the carburetor apart. You can change metering rods very easily without taking the carburetor apart. The problem is that it is not easy to find richer metering rods and it is not easy to make them if you don’t have a jet kit. For the Carter AFB carburetor these jet kits should be readily available. If you can find it, this is a very quick and easy way to change the idle mixture.

STANDARD PRODUCTION 2150 CARBURETOR ADJUSTMENTS/OVERHAUL

A complete disassembly is not necessary when performing routine service adjustments. In most instances, service adjustments of individual circuits may be accomplished without removing the carburetor from the engine.

A complete carburetor overhaul includes disassembly, thorough cleaning, inspection and replacement of all gaskets and any damaged or worn parts. When using an overhaul kit, use all the parts included with the kit.

Flooding, hesitation on acceleration, and other performance problems are in many instances caused by the presence of debris, water, or other foreign matter in the carburetor. To aid in diagnosing the cause of the problem, carefully remove the carburetor from the engine without removing the fuel from the bowl. Examine the contents of the bowl for contamination as the carburetor is disassembled.

Refer to the proper service manual for detailed adjustment and overhaul procedures.

Troubleshooting

A thorough road test and check of minor carburetor adjustments should always precede major carburetor service. Specifications for some adjustments are listed on the Vehicle Emission Control Information label found in each engine compartment.

Many performance complaints are directed at the carburetor. Some of these are a result of loose, misadjusted or malfunctioning engine or electrical components. Others develop when vacuum hoses become disconnected or are improperly routed. The proper approach to analyzing carburetor complaints should include a routine check of such areas.

1. Inspect all vacuum hoses and actuators for leaks.
2. Tighten intake manifold bolts, carburetor mounting nuts, and isolator mounting bolts to specifications.
3. Perform cylinder compression test.
4. Clean or replace spark plugs as necessary.
5. Test resistance of spark plug cables. Refer to *Ignition System Secondary Circuit Inspection*, 'Electrical Section' of the service manual for complete procedure.
6. Inspect ignition primary wire. Test coil output voltage, primary and secondary resistance. Replace parts as necessary. Refer to 'Ignition System' section of the service manual for complete procedure, and make necessary adjustment.
7. Reset ignition timing.
8. Check carburetor idle mixture and speed adjustment.
9. Test fuel pump.
10. Remove air cleaner filter element and blow out dirt gently with an air hose. Install a new air filter element if necessary.
11. Inspect crankcase ventilation system.
12. Road test vehicle as a final test.

Cleaning

There are many commercial carburetor cleaning solvents available which can be used with good results.

The choke diaphragm, choke housing assembly, and some plastic parts of the carburetor can be damaged by solvents. Avoid placing these parts in any liquid. Clean the external surfaces of these parts with a clean cloth or a soft brush. Shake dirt or other foreign material from the stem (plunger) side of the diaphragm. Compressed air can be used to remove loose dirt but should not be connected to the vacuum diaphragm fitting.

If the commercial solvent or cleaner recommends the use of water as a rinse, "HOT" water will produce better results. After rinsing, all traces of water must be blown from the passages with air pressure. Never clean jets with a wire, drill, or other mechanical means, because the orifices may become enlarged, making the mixture too rich for proper performance.

When checking parts removed from the carburetor, it is at times difficult to be sure they are satisfactory for further service. It is therefore recommended that in such cases, new parts be installed.

Caution: The practice of priming an engine by pouring gasoline into the carburetor air horn for starting after servicing the fuel system should be strictly avoided. Cranking the engine, and then priming by depressing the accelerator pedal several times should be adequate.

Diagnosing carburetor complaints may require that the engine be started and run with the air cleaner removed.

Warning! While running the engine with the air cleaner it is possible that the engine could backfire. A backfiring situation is likely to occur if the carburetor is malfunctioning. DO NOT place your hands or face on, over, or near the carburetor while the engine is being started or running. Severe personal injury may occur.

INTAKE MANIFOLD

Once carburetion and engine applications are known, the best intake manifold can be selected. For drag and oval track racing vehicles it is recommended that the heat (exhaust) cross-over in the intake manifold be blocked by either putting shims in the gasket, or by brazing a metal plate into both sides of the cross-over in the intake manifold. (The best shim material is thin stainless steel.) With the heat cross-over blocked, the choke will no longer function. The carburetor will usually have to be rejetted for racing. Blocking the heat cross-over usually causes the vehicle to run poorly when dead cold, which is why it is recommended for racing vehicles only. It also should not be considered for cold weather use. Not required on cylinder heads that have no heat cross-over.

Intake Manifold Gasket

This intake manifold gasket can be used with production cast iron or aftermarket aluminum intake manifolds. DaimlerChrysler engineered and approved. For 360 AMC V-8 engine only.

P4529631 Intake manifold gasket.

Intake and Exhaust Manifold Attaching Package

Package of factory original nuts and bolts to attach intake manifold and exhaust manifolds. Includes 24 bolts, 24 washers, 4 studs and 6 plugs. For 360 AMC V-8 engine only.

P452968 1 Intake and exhaust manifold attaching package.

Vacuum Leaks

All engines need an intake manifold of some kind, and usually they are made of cast iron or aluminum. Although common on standard production vehicles, using a cast iron intake manifold in racing is fairly rare. Aluminum manifolds are typically used in both drag and oval track racing. Despite these different applications, cast iron and aluminum intake manifolds do share one common problem – vacuum leaks.

Vacuum leaks are perhaps the most common type of intake manifold problem. Once solved, vacuum leaks aren't likely to return, but when you first install that new intake manifold, they can be very troublesome.

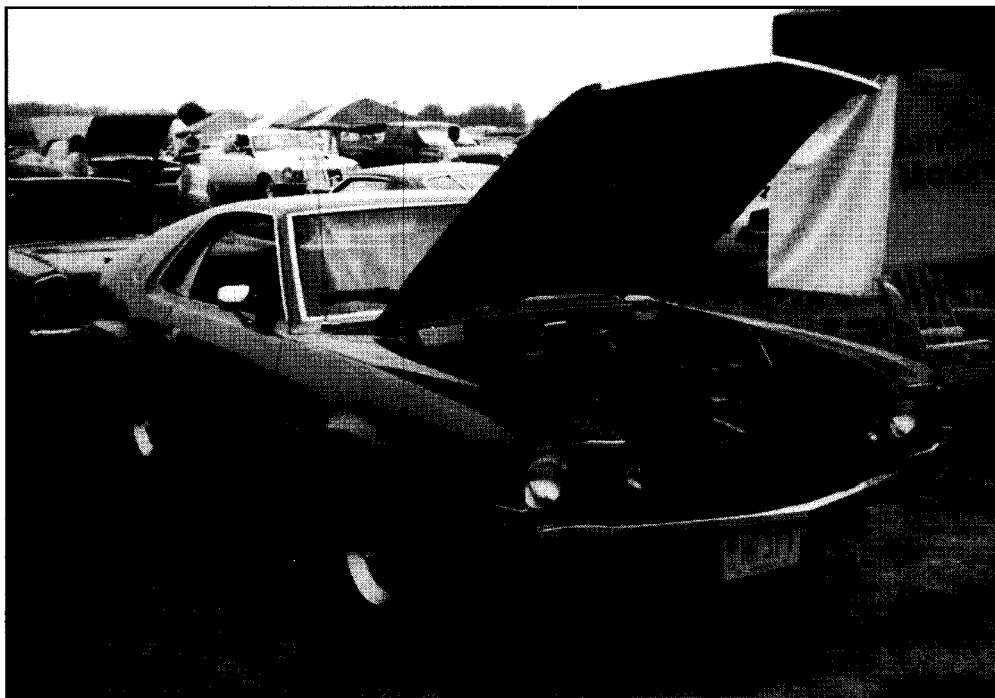
The most common locations for vacuum leaks are the intake flanges next to the heads. The second most common are the various "taps" that are screwed into the intake (one or more). On a race manifold these taps may not exist. In this case, the holes are typically plugged. However, a leak may exist around the plug.

Typically, an aluminum intake manifold is an aftermarket piece. This means it is not a production intake manifold. There are a couple exceptions to this, but we'll assume that you're using an aftermarket intake. These manifolds generally have a "dual" mounting pad for the 4-Bbl. carburetor. This allows all the popular carburetors to be bolted to the same intake manifold. This is easily observed by looking at the carburetor mounting flange with the carburetor removed and counting the holes machined and tapped. A dual mounting pad will have eight holes.

The trick here is related to the way single plane intake manifolds are made—one of the carburetor mounting holes may be machined into (or "leak" into) the top of the "runner" or "plenum." This is possible even in production manifolds. However, the production manifold typically only has four holes and any potential vacuum leak would be plugged once the carburetor is installed. This can be further ensured by using sealer on the carburetor attaching bolt threads.

With the eight hole flange and the carburetor installed normally, four holes are left unfilled. To ensure against vacuum leaks, you should plug the threaded bolt holes that are not going to be used. Why mention anything this simple? It is easy to overlook, and once you've assembled the carburetor on to the manifold, it can be almost impossible to find and can cause you a great deal of trouble.





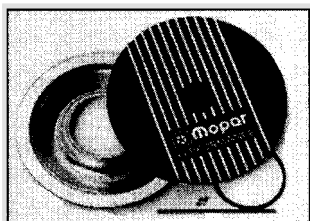
Vacuum Leak Diagnosis

An intake manifold leak is characterized by lower than normal manifold vacuum. Also, one or more cylinders may not be functioning.

1. Start the engine and allow it to warm up.
2. Inspect for disconnected vacuum hoses or hardened or cracked vacuum lines.
3. With a spray bottle, spray a small stream of water on the suspect area. **If** there is a change in rpm's, the suspected leak has been found.
4. Repair as required.

AIR CLEANERS

Cast Air Cleaner Package



This complete air cleaner package features a cast aluminum lid with Mopar Performance logo to match the style of the cast aluminum Mopar Performance valve covers. 14-inch element. Universal for all 5-1/8" inside diameter carburetor mounts. (If needed, K & N makes an adapter for small 2-Bbl. carburetor mount.)

P5249807 Cast air cleaner package.

Lowered Air Cleaner Bases

For use with typical 14" outside diameter elements. Lowers air cleaner over carburetor for added hood clearance.

- P4876755 Lowered air cleaner base, 13/16" drop.
- P4876756 Lowered air cleaner base, 1-1/4" drop.

AIR FILTERS

High Performance Air Filter Element

Special reusable filter element for high performance. Increases air flow versus stock filters which increases engine output. Fits all 1971-84 Jeep V-8 engines.

P5249606 High performance air filter element.

Air Filter Cleaning Fluid

Mopar Performance Parts long-life high performance air filters are reusable. This cleaning fluid is designed to remove dirt to extend the life of the filter.

P4529392 Air filter cleaning fluid.

Air Filter Oil

Long life, high performance air filters trap dirt with a special oil on the filter. After cleaning air filters, re-oil them with this special fluid.

P4529393 Air filter oil.

Fuel Delivery System

FUEL PUMPS

The fuel pumps of carbureted and fuel injected vehicles are different. Carbureted vehicles have a mechanical fuel pump driven by an eccentric lobe of the engine camshaft. Fuel injected engines have a gear/rotor type pump driven by a permanent, magnetic electric motor. The mechanical pump is mounted to the engine block while electric fuel pumps are suspended in the fuel tank and immersed in fuel. The electric fuel pumps used with Throttle Body Injection and Multi-Point Injection systems are different and cannot be interchanged.

Carter Electric Fuel Pump

In Stock Eliminator, one pump is sufficient. In faster categories, two pumps can be used in parallel. Provides 72 gph @ 7.0 psi.

P4007038 Carter electric fuel pump.

Holley Electric Fuel Pump

High capacity, high pressure. Can be used in parallel without mechanical pump for multiple carburetor applications. Regulator included. Provides 70 gph at 9.0 psi.

P4120227 Holley electric fuel pump.

Holley Fuel Pressure Regulator

To service Holley fuel pump P4120227.

P4120228 Holley fuel pressure regulator.

High Capacity Electric Fuel Pumps

High capacity, high pressure electric fuel pump can be used singularly or in parallel with mechanical pump. Designed for drag race applications.

P5249781 110 gph.

P5249782 140 gph.

P5249783 250 gph.

Chrome Fuel Pump Block-Off Plate

This good looking chrome plate covers the hole left when removing the mechanical fuel pump for replacement with an electric pump. Gasket included.

P4529404 Chrome fuel pump block-off plate.



360 AMC V-8 Mechanical Fuel Pump

All 360 AMC V-8s have a single action, mechanical fuel pump. The fuel pump is comprised of an actuating lever, a diaphragm and spring, an inlet valve, and an outlet valve. An eccentric lobe on the engine camshaft operates the fuel pump lever, which is linked to the pump diaphragm. The lever pulls the diaphragm to its extended position to pump fuel into the inlet valve. When the carburetor float needle valve closes, fuel pump output is limited to the amount that returns to the fuel tank through the fuel return tube. The fuel accumulated in the fuel pump chamber prevents the diaphragm from relaxing. The actuating lever continues to move up and down, but is prevented from operating the diaphragm, which is held in its extended position by fuel pressure. Fuel flow from the pump remains halted until excess pressure is released through the fuel return tube or until the carburetor float needle moves off its seat. This procedure continues as long as the engine is running.

Mechanical fuel pumps cannot be overhauled. Replace any mechanical fuel pump that fails either a pressure, capacity (volume) or vacuum test.

Mechanical Fuel Pump

Stock replacement mechanical fuel pump for use with carbureted systems. Factory original equipment comes with pump and gasket. For 360 AMC V-8 engine only.

P4529641 Mechanical fuel pump.

High Capacity Mechanical Fuel Pump

Special high capacity mechanical fuel pump. Provides high flow rate. Ideal for race applications. For 360 AMC V-8 engine only.

P4.529594 High capacity mechanical fuel pump.

FUEL FILTER

The carburetor is protected from dirt and other foreign matter by a replaceable, 15 micron, pleated paper filter. The fuel filter is located in the fuel supply tube between the fuel pump and carburetor and is secured in place with hoses and clamps. The filter has an extra nipple for the fuel return tube. The filter must be installed with the return nipple pointing upward to ensure correct operation of the Fuel Return System. Replace the fuel filter at the intervals outlined in the Maintenance Schedule in the service manual.

FUEL HOSES AND CLAMPS

Inspect all hose/clamp connections for completeness and ensure that no leaks are present. Hoses that are cracked, scuffed, swollen, have rubbed against other vehicle components or show any other signs of wear that could lead to failure must be replaced.

When installing hoses, ensure that they are routed away from contact with other vehicle components that could rub against them and cause failure.

FUEL

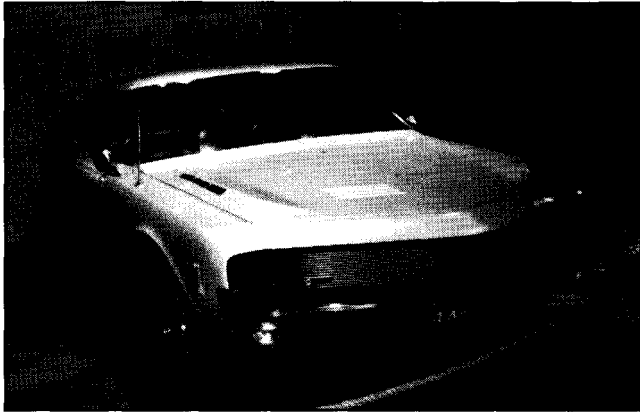
Gasoline

Twenty to thirty years ago, pump gasoline could be obtained that would support a high output, high performance engine with a moderately high compression ratio. All high performance engines had at least 10 or 10.5:1 compression ratios up to 1972. Then, everything dropped to 8 or 8.5:1. Today, these early engines will not perform adequately on pump gasoline. Using the inferior pump gasoline that's available today in these high performance engines can cause failure, especially in pistons and rings. Therefore, to race high compression engines, special high octane gasoline must be obtained. This is easier said than done.

Today, the best pump gas (highest octane) is unleaded premium. To use this fuel in older high compression engines, the racer has to back down on his ignition's spark advance. This cuts performance but at least the engine lives. The best solution, time and money allowing, is to lower the compression ratio to 9.0:1 or less. A compression ratio of 9.5:1 could be used with "blends" (octane booster, etc.), but would only be recommended for engines that are raced exclusively. Blending is troublesome and offers many opportunities for error. The 9.5:1 engine will also "carbon-up" to an actual 10.0:1 or 10.5:1 in a few thousand miles. Now you're in trouble and there isn't a good solution, except less spark advance, and that's not good for performance.

These comments are directed at the engine builder. Obviously, once the engine is built, it's too late. The compression ratio can't be adjusted at this point. Worse yet, it gets higher as deposits build up. Also keep in mind that the solution isn't to use high compression and just add more power parts (i.e., potential). Now you've got an engine with 400 hp potential (for example) that makes maybe 260-270 hp (and cost thousands more). Another problem of high compression engines running on bad gas is that they don't respond. The camshaft that normally might make 20 horsepower may gain 5 hp, no gain, or even a loss in some cases. All of this caused by detonation problems resulting from the use of inferior gas.

In summary, high compression ratio engines on race gas make more horsepower than low compression ratio engines, but without the racing gas the lower compression ratio engine wins.



Gasoline Additives

Warning! Gasoline additives are poisonous! Use with caution!

Gasoline additives do help current pump gas for racing applications. The two most common substances used are Toluene and Aniline oil. Aniline is the more effective. Gasoline additives work better on regular gasoline than they do on premium. The gasoline additive added to an 89 octane regular would result in a 4-5 point increase in octane rating. However, the same additive and a 94 octane premium fuel only results in a .5 to 1 point increase in octane rating. Therefore, engines with an 11.0:1 or greater compression ratio must have some percentage of special premium ("race") gasoline to perform at their maximum outputs.

Octane Booster Effectiveness

In this day of lower octane ratings and unleaded fuel, octane boosters/gasoline additives are more common than ever before. Simply stated, octane boosters are gasoline additives that are supposed to increase the octane of the fuel to which they are added. Because most of us don't really know what our octane requirement is, these octane boosters look like a great idea. Unfortunately, for most of us, they aren't!

First of all, octane is key to engine performance. We can only make as much power as the octane allows us to. However, octane itself doesn't make performance. Putting expensive race gas in a 360 2-Bbl. isn't going to make more power. On the other hand, running unleaded regular in a 426 Hemi 4-Bbl. isn't going to allow the engine to perform up to its rated output.

This is extremely important in older, pre-1972 engines. These engines tend to have higher compression ratios. Higher compression ratios require (demand) higher octane from the gas to perform properly. Therein lies the problem—less octane, or at least a fixed octane level (around 92-94), for the last few years. This means that if we can't get more octane we can't have higher compression ratios. Octane boosters to the rescue!

Now, let's look at the octane boosters themselves. Basically, there are three kinds – alcohol, aromatic hydrocarbon, and metallic. Examples of each are as follows:

- Alcohol: Methanol
- Aromatic Hydrocarbon: Toluene
- Metallic: Lead or Manganese

The metallics are usually found within a complex compound; for example, tetraethyl lead. But you can find the "metal" part in the name that gives you the clue. The problem is that most manufacturers don't publish this data. In general, we've always lumped all the octane boosters together and stated that they increase premium unleaded gas (best pump gas available) about one octane number. This isn't quite fair. The metallics are slightly better while the other two types are slightly below this average number.

Specifically, aromatic hydrocarbons increase the octane approximately .75 octane point. Alcohol "blends" vary a lot in effectiveness, depending on the brand, but still range from .3 to .75. On the top of the chart are the metallics, which range from 1.5 to 2.0, or slightly over twice as effective as the others. On the flip side is cost! The metallics cost around \$7.00 (or more) per can.

Before you jump at this stuff, keep in mind that even two octane numbers translate into only a 1/2 point of compression ratio—max! So don't start building high ratio engines. The big advantage of octane boosters is on engines that have already been built. The high ratio was built into it years ago and now you've got it and somehow have to live with it. If an engine rebuild costs \$1,000 (bearings, rings, pistons, machine work, head work, etc.), then you'd have to drive 20,000 to 40,000 miles before the rebuild would balance off the cost of the octane booster. At this point, the octane booster is a quick and dirty fix for having too much compression ratio. It looks even better when you realize that you really can't rebuild your engine for \$1,000. It might pay for the parts, but not the labor.

The biggest problem with knowing all this about octane boosters is that you tend to think that they solve all octane problems. For a used 9.5:1 high performance engine originally built in the late 1960s or early 1970s, they may be just what you need to solve your problem, but the 11.0:1 or 12.0:1 engine is in trouble. Even the octane booster won't help.

A related problem is that most of us may not find this out until it's too late! Detonation ruins the engine. How do you solve this problem? If you are building the engine, measure its exact compression ratio as assembled. If you've bought an engine built by someone else, do your best to measure its exact compression ratio before you do anything serious with your new project. It's not worth the gamble.

Exhaust System

The basic exhaust system on all vehicles consists of an exhaust manifold(s), front exhaust pipe, catalytic converter, heat shield(s), muffler and tailpipe.

Vehicles with the 360 AMC V-8 use a single muffler exhaust system with a single, monolithic-type catalytic converter.

The exhaust system must be properly aligned to prevent stress, leakage, and body contact. If the system contacts any body panel, it may amplify objectionable noises originating from the engine or body.

When inspecting an exhaust system, critical items to inspect for are cracked or loose joints, stripped screw or bolt threads, corrosion damage, and worn, cracked or broken hangers. Replace all components that are badly corroded or damaged. **DO NOT** attempt to repair. When replacement is required, use original equipment parts (or their equivalent). This will assure proper alignment and provide acceptable exhaust noise levels.

All exhaust systems should be checked for leaks. A leak in the exhaust system is unsafe and will cost you power.

Caution: Avoid application of rust prevention compounds or undercoating materials to exhaust system floor pan heat shields. Light overspray near the edges is permitted. Application of coating will result in excessive floor pan temperatures and objectionable fumes.

Intake and Exhaust Manifold Attaching Package

Package of factory original nuts and bolts to attach intake manifold and exhaust manifolds. Includes 24 bolts, 24 washers, 4 studs and 6 plugs. For 360 AMC V-8 engine only.

P4529681 Intake and exhaust manifold attaching package.

Exhaust Manifold Gasket Set

This exhaust manifold gasket set can be used with cast iron manifolds or headers. For 360 AMC V-8 engine only.

P4529632 Exhaust manifold gasket set.



Ignition System

INTRODUCTION

Ignition systems and components have been changing rapidly in the last few years. Further development is expected in the future to provide the DaimlerChrysler customer with the best high performance ignition systems available for his race vehicle. Older ignition systems, such as the breaker point-type, will not be covered in any detail because we no longer produce or recommend these pieces for high performance race vehicles.

Spark Advance

Spark advance is vital to an engine's overall performance. This is true whether it's a drag, oval track, or dual purpose vehicle. It even affects the engine's fuel economy, if the vehicle is used in the dual purpose mode.

Something that affects performance this extensively must be set very carefully. Unfortunately, we tend to do this very casually and our understanding of the "how-it-works" aspect is somewhat limited. We'll try to improve both of these "problems."

Spark advance is also referred to as "timing" or "ignition timing." In standard electronic ignitions (as well as breaker point-type systems), the spark advance is determined by the distributor. However, spark advance is not related directly to the type of triggering mechanism; that is, points or pick-up and reluctor. Spark advance is something that's common to both styles of ignitions/distributors.

There are 3 phases to spark advance: initial advance, primary advance, and secondary advance (see Figure 7-43). *Vacuum advance* is an add-on or supplemental function which we'll discuss later. (For the time being we'll assume that it's zero.)

Initial advance is what we set with a timing light while the engine is idling. The sum of the *primary advance* and the *secondary advance* is commonly called the *centrifugal advance*. The sum of the initial advance and the centrifugal advance is called the *total advance*. Total advance is what is used in racing to "set the timing" rather than initial advance, because of accuracy. If the spark advance is "plotted" against engine rpm, the result is called the *spark advance curve* (see Figure 7-44 for a typical advance curve). This all sounds pretty easy.

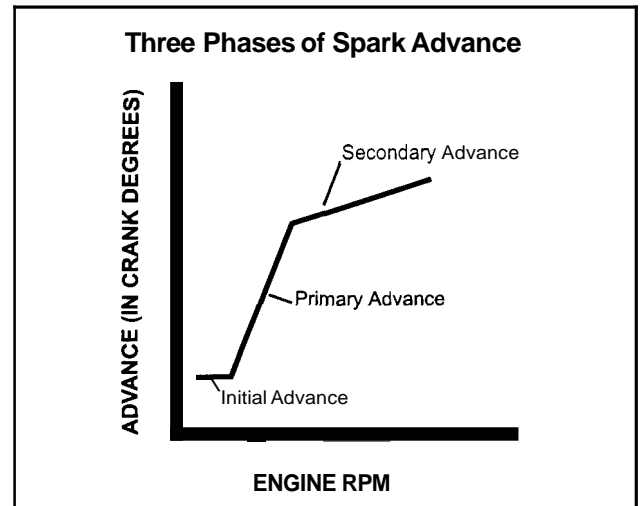


Figure 7-43

Now, let's do some performance modifications. Let's assume that our distributor has 18 degrees of centrifugal advance built into it. If we set 12 degrees initial advance with this distributor, then our total advance is 30 degrees ($12 + 18$). If we increase the initial advance to 17 degrees, then the total advance is increased to 35 degrees ($17 + 18 = 35$). This is not considered recurving the distributor. To do that we have to disassemble the distributor itself. Changing the initial setting just moves the whole curve up (or down).

Let's assume that we have a production distributor and we want to have it recurved for improved performance. To do this we have to disassemble the distributor. We can do it ourselves or take it to a distributor shop. The trick is what to do!

The first step in recurving a distributor is to run it on a distributor machine and find out what it actually has. The first question is how many degrees does the distributor have "built-in"? If we used the distributor from our example, the answer would be 18 degrees. The second question is what does the advance curve look like? A typical production distributor's advance curve is shown in Figure 7-44. If we recurve this distributor, the desired "performance curve" is also shown in Figure 7-44. It is important to look closely at this performance curve for a moment and analyze some of its characteristics. First, the centrifugal advance is the same—18 degrees. The recurving of the distributor hasn't changed this overall number. It can be changed by machining, but this is expensive and generally not recommended. Second, note that the secondary advance is zero with the performance curve. Next, with the performance curve, it is fully advanced by 2,000 rpm. This is a very desirable characteristic for maximum performance and lowest E.T. at the drag strip. Note that at 2,000 rpm the production curve has approximately 11 degrees where the performance curve has 18. That's a 65% increase in spark advance at this specific point. The engine obviously should respond!

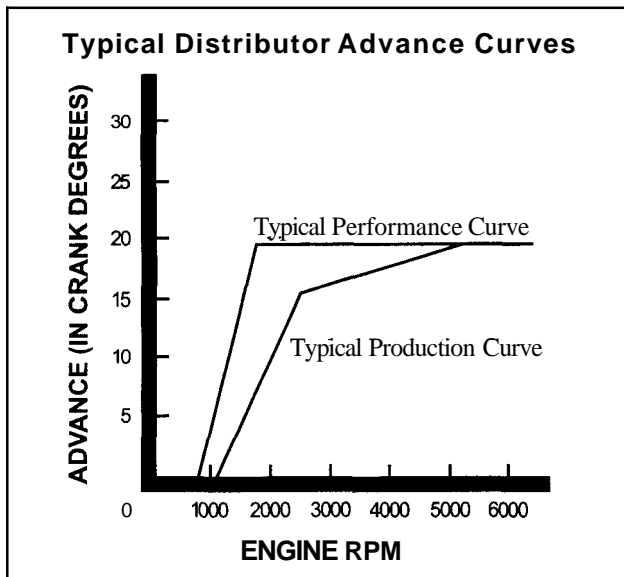


Figure 7-44

It is important to understand that the difference between advance curves (production vs. performance) within the same distributor is accomplished by changing one or two advance springs inside the distributor. A distributor must have one spring. There are positions in the advance mechanism for two springs. The second spring is somewhat optional, depending upon the desired advance curve. Changing these springs (first, second, or both) is what actually changes the curve.

In Figure 7-44, note that the “zero” point for the two curves is not the same. In truth, this point floats a lot. In a performance distributor we want it to start advancing before 1,200 rpm. Actually, the range is 750 to 1,200. A production distributor typically starts advancing before 900 rpm and has a range of 500-900. The “zero” point is controlled by tolerances in the parts, friction in the bushing, clearances, viscosity of the grease, etc. For performance applications, the “zero” point is not important. However, it does have a tremendous effect, especially if we aren’t careful!

To better explain “zero” point we need to look at the low speed part of the curve in greater detail. To do this we’ve created Figure 7-45. We’ve used 750 rpm as the typical initial (“zero”) point. We used only one point for our starting location since we’ve assumed that we have only one distributor that we’re working with.

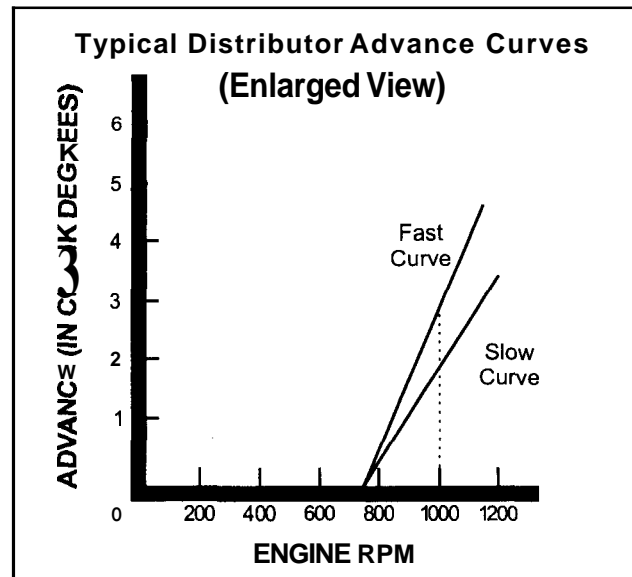


Figure 7-45

We’ve shown two spark advance curves for reference only. The slow curve is typical of a production advance curve while the fast curve is typical of a performance curve (or after recurring). Now let’s analyze Figure 7-45 and see what it tells us.

We’ll assume that we have a performance/race vehicle which has a high performance engine in it. These engines typically idle at 1,000 to 1,200 rpm. We’ll assume that our example idles at 1,000 rpm. On Figure 7-45 we’ve drawn a dashed line at 1,000 rpm. Notice that the distributor has “advanced” 2-3 degrees (depending on curve) at this point. Does this have any effect on the engine’s performance? The answer is absolutely YES!

Let’s assume that we want to set 12 degrees initial advance and we have an 18 degree centrifugal advance distributor. Using the example in Figure 7-45, we’ll set 12 degrees initial advance on the damper at idle (1,000 rpm). Question: Have we set 30 degrees advance for our desired performance number? Those of you who said “yes” are wrong! We’ve only set 27 or 28 degrees. Now let’s explain why this happened and how to solve it.

When we set 12 degrees at 1,000 rpm, the advance curve shown in Figure 7-45 says that the distributor has already advanced 2 or 3 degrees. This means there are only 15 or 16 degrees left in the distributor. So, when going from 1,000 to 5,000+ rpm we gain an additional 15 or 16 degrees. Therefore, the total advance is 27 or 28 degrees (12 + 15 or 16). Obviously, the engine isn’t going to make as much power at 27 degrees as it would at 30. Notice that if the idle was 1,200 rpm we could lose as much as 5 degrees. The faster the curve, the worse this condition becomes. How do we solve this problem?

The solution is quite simple. The problem occurs in varying degrees in all performance applications. The way to get around this problem is you set *total advance*. This means you set the "30 degree" number for total advance instead of the 12 degree initial number. Initial advance is set at idle (1,000 rpm or so); however, total advance is set at the point where the centrifugal advance reaches its maximum (the advance curve goes horizontal). With a performance curve (see Figure 7-44) this means around 2,000 rpm. With a production curve, this rpm would be around 5,000. So with a production curve in the distributor, stay with the initial setting method. (The maximum power, total advance number varies from engine to engine.)

For our performance and racing applications, we now know how to set our timing correctly and why. The next question that comes up pertains to the vacuum advance system. In our initial discussion we assumed that the vacuum advance was zero. Now we'll add it into our analysis.

The first item and most important thing to realize is that vacuum advance does not affect the previous discussion. Vacuum advance is an add-on device designed primarily to increase fuel economy. Race distributors don't even use vacuum advance. However, most people have a distributor with vacuum advance, so we'll cover this to remove the mystery.

The basic operation of the vacuum advance is quite simple. Vacuum advance increases the amount of spark advance in high vacuum conditions. Realize that we race at W.O.T. (wide open throttle) which means zero vacuum. So vacuum advance doesn't affect our performance at W.O.T. Figure 7-46 shows a typical vacuum advance curve. Note that in a high vacuum (12 inches of Mercury) the advance is approximately 16 degrees. This means that in a high vacuum condition (cruising, coasting, etc.) we can have 46 degrees of advance (30 + 16). As we open the throttle the 16 number drops until at low vacuum (approaching W.O.T.) it goes to zero.

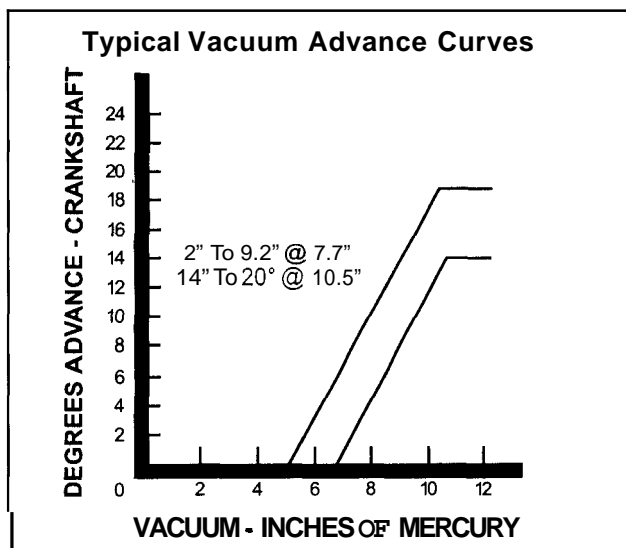


Figure 7- 46

Vacuum advance units vary greatly from year to year and engine to engine. On some electronic distributors, the amount of vacuum can be adjusted. By inserting a small Allen wrench into the vacuum tube and rotating it, the amount of vacuum can be dialed-out. In other words, the 16 degrees built into the vacuum unit can't be increased, but you can adjust it to any lower number desired. You can adjust it to be zero which would mean it didn't work. Generally, we wouldn't recommend this approach. If you don't want it to work, just disconnect the vacuum hose. When setting your timing, if you have a vacuum unit on your distributor always pull the vacuum hose off and plug it (usually with a handy bolt). At this point it doesn't work (zero add-in advance) and won't affect the total advance setting.

Now you should completely understand spark advance. However, recuring distributors usually requires a distributor machine. Spending time assembling and disassembling distributors and running them on a distributor machine gets expensive. The easiest, and in most cases, least expensive way to get the same result is to get a distributor which is already recured. It will have a performance curve similar to the one shown in Figure 7-44. This gives you the performance curve, adjustable advance, and electronic triggering all built-in.

Race (only) distributors have an even faster advance curve (see Figure 7-47). These distributors have 20 degrees built-in (typically) and are fully advanced by 1,000-1,400 rpm. This is much too quick for a dual purpose vehicle. However, the idle of a race engine is typically above 1,200-1,400. This means these race distributors give race engines a flat advance curve which is desired for racing. Pick the distributor specifically for your race application, but always remember to *set total advance!*

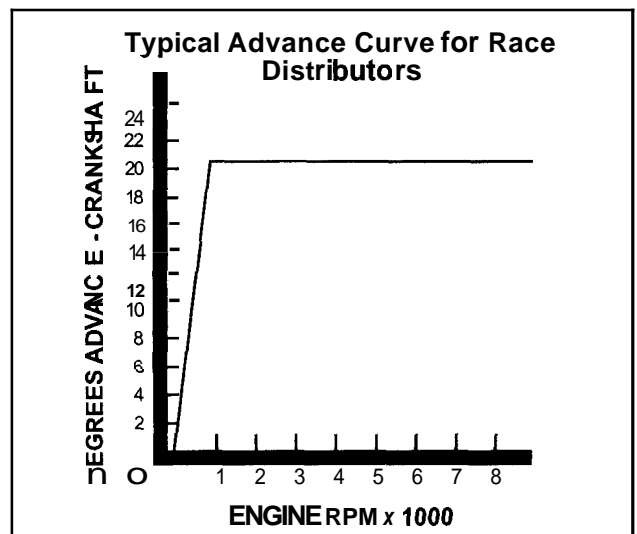


Figure 7- 47

Lean-Burn Ignition

The lean-burn ignition system was introduced in the mid-1970s on production cars. It was a specialized version of the breaker point-type ignition system.

For high performance applications, this ignition system is too complicated and worrisome, and it can't be utilized with a high output electronic ignition system, which is the system Mopar Performance Parts recommends.

Magnetos

A magneto is a completely different ignition system from any other detailed in this section. A properly set up and tuned magneto will fire a very high output race engine. However, magnetos have more spark scatter than race electronic distributors and have a large amount of spark retard with speed. The spark retard can be as high as 1 degree per thousand rpm. Another problem with magnetos is that they will "go away" in a short period of time and slow the vehicle down. And because they don't "miss" like other ignition systems, racers can't easily tell if the ignition is not doing its job, a problem that can be almost impossible to find.

SOLID STATE IGNITION (SSI) IGNITION SYSTEM

A Solid State Ignition (SSI) system is used on the 360 AMC V-8 engine. The SSI system consists of the following components:

- Ignition module
- Ignition coil
- Resistance wire
- Distributor
- Knock sensor
- Cap and rotor
- **Spark** plugs and wires

The central tower on the distributor cap is connected directly to the high voltage at the coil. The current flows through the spring-loaded contact on the rotor to the carbon button in the cap. The rotor tip aligns with a contact in the cap that corresponds to the cylinder to be ignited just as the ignition coil output high voltage is applied to the rotor. In this way, each spark plug is "fired" in turn.

SSI IGNITION COMPONENTS

Ignition Module

The electronic Ignition Module is located in the engine compartment on the left wheel well. It is a permanently sealed, solid state module that is not repairable and must be replaced as a unit if service is required.

The ignition module processes the ignition signals it receives from the distributor and then interrupts the primary circuit to the ignition coil causing spark to occur. Dwell is adjusted automatically.

When disconnecting SSI system connectors, pull them apart with a firm, straight pull. DO NOT attempt to pry them apart with a screwdriver. When connecting them, press together firmly to overcome hydraulic pressure caused by the silicone dielectric compound.

If the connector locking tabs weaken or break off, DO NOT replace the associated component. Bind the connectors together with tape or a harness tie strap to assure good electrical connection.

Distributor

360 AMC V-8 distributors are equipped with centrifugal and vacuum assisted advance to advance the engine timing the correct number of degrees during engine operation.

The distributor consists of three groups of components: pickup coil and trigger wheel, ignition advance mechanisms, cap and rotor. The distributor driver gear is installed on the distributor shaft and meshes with a spiral cut gear that is installed on the nose (front) of the camshaft. The end of the distributor shaft is flattened and fits into a slot in the top of the oil pump and provides the force to drive the oil pump.

Electronic Ignition Distributor

This Mopar Performance Parts electronic ignition distributor is the same as the production distributor and can be used as a replacement. Comes complete with cap and rotor. For 360 AMC V-8 engine only.

P4529684 Electronic ignition distributor.

Distributor Cap and Rotor Set

Replacement cap and rotor set. For 360 AMC V-8 engine only.

P4529687 Distributor cap and rotor set.

1. Ignition Advance

Centrifugal (mechanical) advance is controlled by engine speed. Flyweights connected to the distributor shaft are thrown outward by centrifugal force. Higher engine rpm throws the weights further out. Calibrated rate springs are used to control this movement. The outward motion of the flyweights causes the rotor and trigger wheel to be advanced on the distributor shaft several degrees in the direction of normal rotation. This is referred to as centrifugal ignition advance.

When the engine is operating under light load, the carburetor throttle plates restrict airflow, causing a relatively lean mixture to enter the combustion chambers. Ignition must occur earlier because the lean mixture requires a longer time to burn. The vacuum ignition advance mechanism is used for this purpose. When carburetor ported or manifold vacuum is high, the vacuum advance mechanism moves the pickup coil assembly several degrees opposite to the direction the distributor is rotating. This causes the pickup coil to react to the presence of the trigger wheel teeth earlier. This is referred to as vacuum ignition advance. With low vacuum operating conditions, such as wide open throttle acceleration, a spring in the vacuum advances mechanism pushes the pickup coil back to a position of zero advance.

2. *Pickup Coil and Trigger Wheel*

The ignition coil primary circuit is opened and closed electronically by the ignition module. The distributor pickup coil and trigger wheel provide the input signal for the ignition module.

The trigger wheel, which is installed on the distributor shaft, has one tooth for each engine cylinder. The wheel is mounted so that the teeth rotate past the pickup coil one at a time.

The pickup coil has a magnetic field that is intensified by the presence of ferrous metal (contains iron – can be picked up with an ordinary magnet). The pickup coil reacts to the trigger wheel teeth as they pass. As a trigger wheel tooth approaches and passes the pole piece of the pickup coil, it reduces the reluctance (compared to air) to the magnetic field and increases field strength. Field strength decreases as the tooth moves away from the pole piece. This increase and decrease of field strength induces an alternating current (pulse) into the pickup coil, which triggers the ignition module. The ignition module opens and closes the coil primary circuit according to the position of the trigger wheel teeth.

There is no contact between the trigger wheel and pickup coil assembly. Because there is no wear, the dwell angle does not require adjustment. The dwell angle is determined electronically by the control unit and is not adjustable. When the ignition coil primary circuit is switched open, the internal electronic timer in the ignition module keeps the coil primary only long enough for the electromagnetic field within the coil to collapse and the voltage to discharge. The ignition module then automatically closes the coil primary circuit. The period of time the circuit is closed is referred to as dwell.

3. *Distributor Cup*

The central tower on the distributor cap is connected directly to the high voltage at the coil. The current flows through the spring-loaded contact on the rotor to the carbon button in the cap. The rotor tip aligns with a contact in the cap that corresponds to the cylinder to be ignited just as the ignition coil output high voltage is applied to the rotor. In this way, each spark plug is “fired” in turn.

Remove the distributor cap and wipe it clean with a dry, lint free cloth. Visually inspect the cap for cracks, carbon paths, broken towers, white deposits on the inside (caused by condensation entering the vehicle through cracks), and damaged rotor button. Replace any cap that displays charred or eroded terminals. The machined surface of a terminal end (faces toward rotor) will indicate some evidence of erosion from normal operation. Examine the terminal ends for evidence of mechanical interference with the rotor tip.

If replacement of the distributor cap is necessary, transfer spark plug wires from the original cap to the new cap one at a time. Ensure that each wire is installed into the tower of the new cap that corresponds to its tower position in the original cap. Fully seat the wires into the towers.

4. *Distributor Rotor*

A unique feature of the SSI is the silicone applied to the distributor rotor blade. Radio interference is greatly reduced by the presence of a small quantity of silicone dielectric compound on the rotor blade. After a few thousand miles, this compound becomes charred by the high voltage current flowing through the rotor. This condition is normal. DO NOT scrape residue from the rotor blade.

When installing a replacement rotor, apply a thin coat 0.75-3.0 mm (0.03-0.12”) of silicone dielectric compound to the tip of the rotor blade.

Visually inspect the rotor for cracks, evidence of corrosion and the effects of arcing on the metal tip, and evidence of mechanical interference with the cap. Some charring is normal on the end of the metal tip. The silicone dielectric compound applied to the rotor tip for radio interference noise suppression (six- and eight-cylinder engines) will appear charred. This is normal.

DO NOT remove the charred compound. Test the spring for insufficient tension. Replace a rotor that displays any of the adverse conditions. Coat the tip of a replacement rotor with Mopar Silicone Dielectric Compound or equivalent.

Ignition Switch

The ignition switch is mounted on the lower section of the steering column and is connected to the key lock assembly by a remote lock rod.

In race vehicles, the production ignition switch is sometimes replaced by a toggle switch. This can cause problems if a high-amp rated switch (18-20 amp) isn't used. Most readily available switches are 14-16 amp rated. The lower rating causes more resistance in the ignition circuit, which cuts down on the voltage available to the ignition's control unit. The lower voltage can cause the ignition system to perform poorly or develop a miss which can be very difficult to analyze.

There are 2 special switches that are helpful in wiring a race vehicle: "On-Off" Micro Switch Assembly (P3690282); and, Push Button Starter Switch Assembly (P3690823). The "On-Off" Micro Switch Assembly is the most important. Other "econo" switches aren't rated as high on amperage and therefore put resistance between the battery and the ignition and can cause misfiring.

Ignition Switches

P3690282	"On-Off" micro switch assembly (20 amp).
P3690823	Push button starter switch assembly.

Ignition Wires

If you don't have top quality ignition wires you aren't conducting maximum spark.

Production spark plug wire is 7 mm. For racing purposes we recommend an 8 mm, 19-strand, copper, silicone-jacketed wire. The added insulation of the larger diameter wire helps control today's high energy ignition systems. Nine millimeter plug wires are not recommended because of the mismatch of the terminals in coils and caps. If more insulation is required, neoprene hose of the proper inside diameter is recommended.

Usually, once the wire is installed, pulling on the wire to remove the boot from the plug is the most common cause of failure. This is especially true of stock or cheap wires. Using the Mopar Performance Parts Plug Wire Boot Puller (P5249718) will help plug wire removal without damaging the connector. The boot puller will probably double plug wire life, making it one of the best deals in the ignition area.

The Mopar Performance Parts plug wires have straight ends at the spark plug, which is the most common style. Having been in racing for many years, we know that the straight end is not best for all applications, especially with headers. In an effort to solve this problem, we have introduced Vari Angle Plug Adapters (P4286742), which adjust easily from straight to right angles.

Our Ignition Wire Separator Package (P4007667) keeps the wires separated from the cap to the plug. This helps performance by preventing cross firing and makes the engine compartment look much more organized.

Spark Plug Wire Boot Puller

Here's the tool you need for easy removal of spark plug wires without pulling the wire out of the terminal end and boot. Saves on knuckles, too.

P5249718 Spark plug wire boot puller.

Vari-Angle Plug Adapters

Here's a convenient way to steer spark plug wires around headers, brackets, and other tight areas, in any direction you want. Vari-angle plug adapters have a built-in swivel device which maintains the position you bend them in. A handy set-up for any racer. Sold two per set.

P4286742 Vari-angle plug adapters.

Ignition Wire Separator Set

Ignition wire separators. 8 pieces per set.

P4.007667 Ignition wire separator set.

Ignition Coil Connector

The ignition coil terminals and connector are of unique design. The connector is removed from the coil by grasping both sides and pulling away from the coil.

When a tachometer is required for engine testing or tune-up, connect it using an alligator jaw type connector.

Resistance Wire

A wire with 1.35 ohms resistance is provided in the ignition wiring to supply less than full battery voltage to the ignition coil after the starter motor solenoid is de energized. During engine starting, the resistance wire is bypassed and full battery voltage is applied to the ignition coil. The bypass is accomplished at the I-terminal on the starter motor solenoid.

Vacuum Advance Control System

Manifold vacuum and carburetor ported vacuum are both used for the ignition vacuum spark advance mechanism on the 360 AMC V-8. A coolant temperature override (CTO) valve determines the appropriate vacuum source, depending upon coolant temperature. The CTO valve is screwed into the thermostat housing. A thermal sensor at the CTO valve tip is in contact with engine coolant. Depending on the coolant temperature, the CTO valve permits either manifold vacuum or carburetor ported vacuum to control the distributor vacuum advance. When coolant temperature is below 104°C (220°F), carburetor ported vacuum is supplied to the distributor vacuum advance mechanism. Above 104°C (220°F), manifold vacuum is supplied.

Spark Plugs

1. Removal

Remove the ignition wire by grasping it at the spark plug boot, and then turn (1/2 turn) and pull it straight back in one steady motion.

- a. Prior to removing the spark plug, spray compressed air around the spark plug hole and the area around the spark plug.
- b. Remove the spark plug using a quality socket with a rubber or foam insert.
- c. Inspect the spark plug. Refer to step 2 - *Inspection*.

2. Inspection

Faulty and fouled plugs may perform well at idle speed, but at higher engine speeds they frequently fail. Faulty plugs can be identified in a number of ways: poor fuel economy, power loss, decrease in engine speed, hard starting and, in general, poor engine performance. Spark plugs also malfunction because of carbon fouling, excessive air gap, or a broken insulator. Examine the spark plugs for burned electrodes and fouled, cracked or broken porcelain insulators. Keep plugs arranged in the order in which they were removed from the engine. An isolated plug displaying an abnormal condition indicates that a problem exists in the corresponding cylinder. Replace spark plugs at the intervals recommended on the Maintenance Chart in the service manual.

Spark plugs that have low mileage may be cleaned and reused if not otherwise defective. After cleaning, file the center electrode flat with a small point file or jewelers file. Adjust the gap between the electrodes to specification.

3. Specifications

<u>Engine</u>	<u>Spark Plug</u>	<u>Electrode Gap</u>	<u>Tightening Torque</u>
360 AMC V-8	RN 12YC	0.825 mm (0.033")	37 N•m (27 ft-lbs)

4. Gap Adjustment

Check the spark plug with a gap (feeler) gauge. If the gap is not correct, adjust it by bending the ground electrode. The gap for 360 AMC V-8s is 0.825 mm (0.033").

5. Installation

- a. Start the spark plug into the cylinder head by hand to avoid cross threading.
- b. Tighten the spark plug to 35 N•m (27 ft-lbs) torque.
- c. Install ignition wires over spark plugs.

Always torque spark plugs to specification. Over tightening can cause distortion resulting in a change in the spark plug gap.

When replacing ignition wires, route the wires correctly and secure them in the proper retainers. Failure to route the wires properly can cause ignition noise radio reproduction, cross ignition of the **spark** plugs or short-circuit the wires to ground.

Battery

It is very important that the battery be fully charged in racing applications with electronic ignitions. A voltmeter should be used to check the battery voltage before the vehicle is raced. The voltage should not be allowed to drop below 12.0 volts. Lower voltage will cause poor ignition performance such as misfires and result in slowing the vehicle down. It may also cut down on the electric fuel pump's efficiency.

Mopar Performance Parts Spark Plugs		
NEW! These spark plugs are specifically designed for the optimum performance of your Mopar engine. Each package contains 4 spark plugs.		
Race & Tuning Application Plugs (J-Strap Type)		
Pack PIN	Cross Reference	Application
P4876939	C 63C	All except 'B-RB' engines
P4876940	C 61C to C 59C	All except 'B-RB' engines
P4876941	C 57c to C 55c	All except 'B-RB' engines
P4876942	C 53C to C 51C	All except 'B-RB' engines
P4876943	C 51C	All except 'B-RB' engines
P4876944	C 61C to C 59C	All except 'B-RB' engines
P4876945	C 57c to C 55c	All except 'B-RB' engines
Professional Race Plugs		
P4876928	C 61C to C 59C	All Race Applications
P4876929	C 57c to C 55c	All Race Applications
P4876930	C 53c to C 51C	All Race Applications
P4876931	C 51C	All Race Applications
P4876932	S 61C to S 59C	All Race Applications
P4876933	S 57c to S 57c	All Race Applications
P4876934	S 53C to S 51C	All Race Applications
P4876935		All Race Applications
Note: C type plugs have 3/4 inch reach with flat seat and crush gasket. S type plugs have 3/4 inch reach with tapered seat.		

VOLTAGE REGULATORS

For standard or dual purpose use, the original voltage regulator should work fine. However, if your engine is a race-only piece, a constant output voltage regulator should be used.

Caution: Using a constant output voltage regulator on a vehicle intended for standard or dual purpose application can overcharge the battery and cause an electrical failure.

IGNITION SYSTEM TIMING

A graduated timing degree scale located on the timing case cover is used for reference when timing the ignition system.

A milled index notch in the vibration damper is used to align the No. 1 cylinder ignition position of the crankshaft with the correct timing degree mark on the graduated scale.

Magnetic Timing Probe

With both engines, a magnetic timing probe socket is provided integral with the timing degree scale for use with a special magnetic timing probe.

This special probe detects the milled notch on the vibration damper. The probe is inserted through the probe socket until it contacts the vibration damper. Ignition timing can then be obtained from a meter or computer printout, depending on the type of equipment being used.

The probe socket is located at 9.5° after TDC, and the equipment is calibrated to compensate for this location.

DO NOT use the timing probe socket as a reference to check the ignition timing when using a conventional timing light.

Ignition Timing Procedure

The ignition timing can be adjusted according to the following primary timing procedure.

1. Set parking brake. Shift transmission to PARK.
2. Run engine until it reaches normal operating temperature.
3. Ensure that A/C is turned OFF, if equipped.
4. With the ignition switch OFF, connect an ignition timing light and a calibrated, expanded scale tachometer.
5. Disconnect and plug the distributor vacuum advance hose.
6. Loosen distributor hold down bolt to allow adjustment.

Warning! Use extreme caution when the engine is operating. DO NOT stand in a direct line with the fan. DO NOT put your hands near the pulleys, belts or fan. DO NOT wear loose clothing.

7. Start the engine.

8. With the engine at idle speed, check and adjust (if necessary) the timing according to the specification listed on the Emission Control Information label located in the engine compartment.
9. Tighten the distributor hold-down clamp and verify that the ignition timing is correct.
10. Turn the engine OFF and remove the timing light and tachometer.
11. Connect the hose to the distributor vacuum advance mechanism.

MOPAR PERFORMANCE PARTS ELECTRONIC IGNITION COMPONENTS

High Performance Electronic Control Units

For a hotter spark and more rpm capability, use one of Mopar Performance Parts' high performance ECUs. For general high performance and usage up through 6,000 rpm, use the Orange Box ECU. For higher rpm output requirements up through 8,000, select the Chrome Box ECU.

P4120505 Orange Box ECU.

P4120534 Chrome Box ECU.

Super Gold Electronic Control Unit

The Super Gold Electronic Control Unit is the culmination of eight years of high performance ignition systems development. Designed to out perform any ignition unit previously offered to Mopar racers, it will handle the high current demand by the P3690560 (Accel) high performance coil, while keeping dwell variation to less than 1° from 1,000 to 10,000 rpm. Dwell is set for maximum spark output at low and high engine speeds. The Super Gold ECU provides outstanding performance from idle to 12,000 rpm.

P4120600 Super Gold ECU – race only.

Ballast Resistor – Electronic Distributor

P2444641 Use with mechanical advance distributor using P3690560 coil. 1/4 Ohm.

P5206436 Use with electronic ignition systems using P4120505 Orange Box ECU and production coil, or with P4120889 coil. 1 Ohm.

Ignition Coils

- P4120889 Accel Super Coil for all 12-volt applications. Not recommended for engine speeds over 6,500 rpm. (Use with ballast resistor P5206436.)
- P3690560 Accel Race Coil specifically designed to be used with race electronic ignition kits. Designed for racing applications only. Not recommended for continued operation at speeds below 3,000 rpm for more than 30 minute periods. (Use with ballast resistor P2444641.)

Control Wiring Harness Kit for Electronic Ignitions

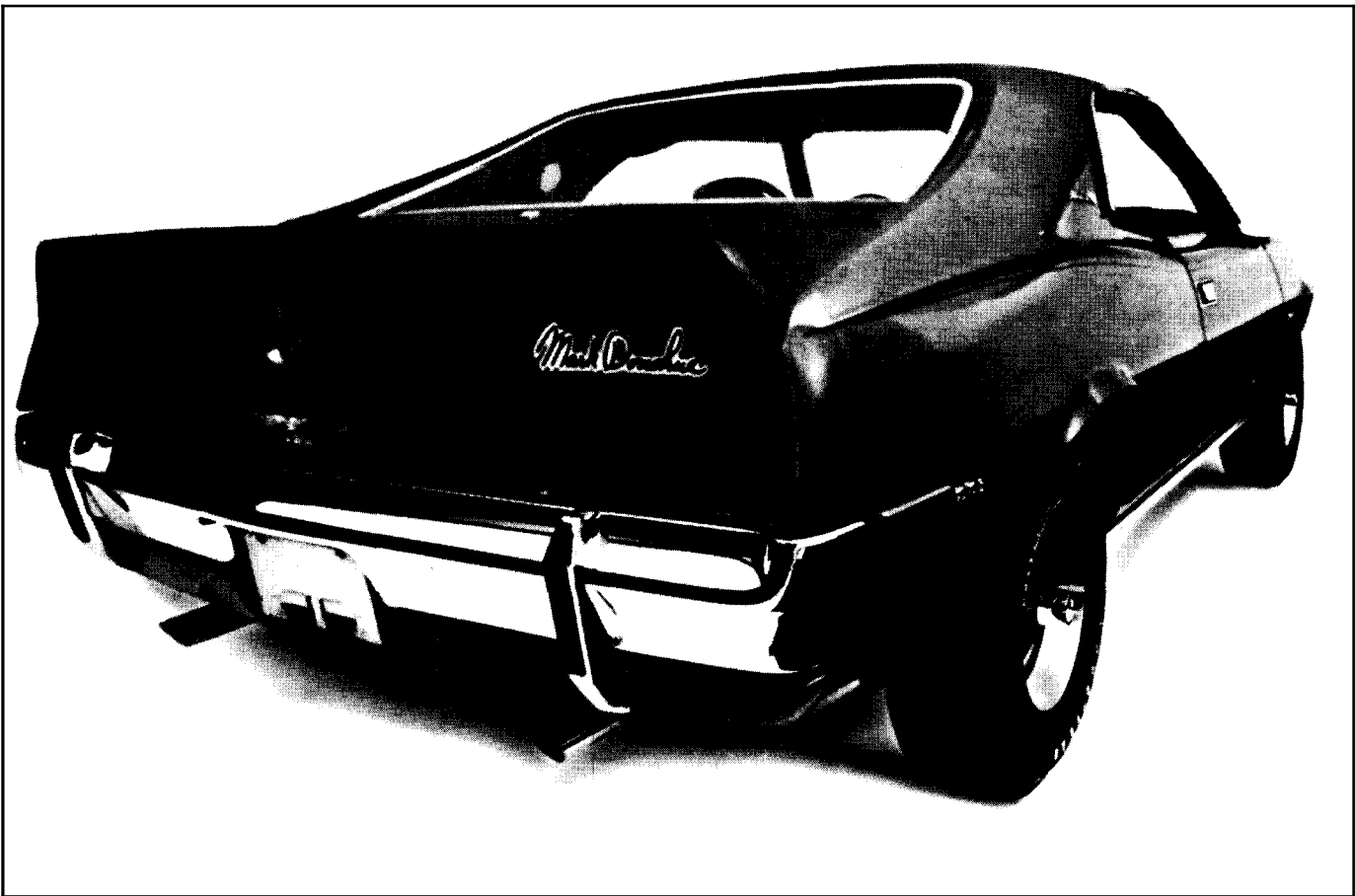
- Kit used to convert to a new electronic ignition system.
- P3690152 Control wiring harness kit for electronic ignitions.
-

Chrome Ignition Coil Bracket

- Another underhood piece to dress-up your engine compartment. Includes special clamp screw.
- P4286728 Chrome ignition coil bracket.

Tach Adapter

- Designed for applications when high capacitive discharge coils interfere with tachometer or fuel injection signals. This device provides a clear 12 volt square wave signal output with a 30% duty cycle.
- P4876738 Tach adapter.
-



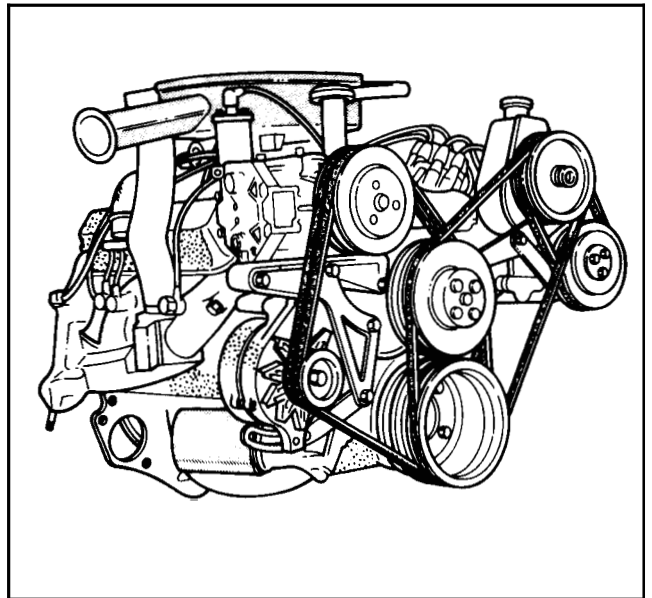
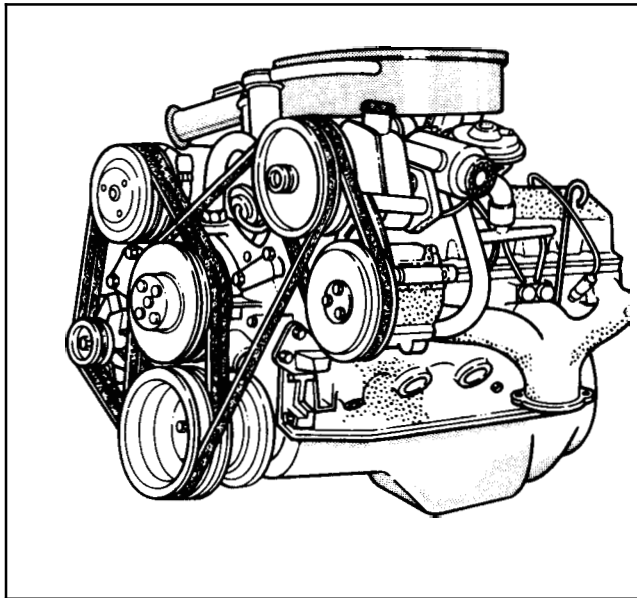
ENGINE ASSEMBLY

Note: For engine assembly information, performance modifications and tips, refer to 'Engine Assembly' section of Chapter 4, *4.0L Power Tech In-Line 6*.

1971, 304-360 AMC V-8 ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the 1971 *Jeep Service Manual*.

V-8 ENGINE SPECIFICATIONS		
	304 CID	360 CID
Type	90° V-8 OHV	90° V-8 OHV
Bore	3.7502"-3.7534"	4.0799"-4.0831"
Stroke	3.44"	3.44"
Firing Order	1-8-4-3-6-5-7-2	1-8-4-3-6-5-7-2
Displacement	304	360
Compression Ratio	8.4:1	8.5:1
Net Brake Horsepower	150 @ 4200 RPM	175 @ 4000 RPM
Net Torque	245 @ 2500 RPM	285 @ 2400 RPM
Taxable Horsepower	45.00	53.27
Fuel	Regular	Regular
Cylinder Head and Block Flatness	← .008" Max. Full Length, .002" in 6", .001" in 1" →	



V-8 ENGINE
304-360 Cubic Inch Displacement

304 CID

360 CID

VALVESValve Arrangement
(Front to Rear = 1 Bank)

Valve Stem Diameter

Valve Length

Valve Guide I.D. (Integral)

Stem to Guide Clearance

Intake Valve Face Angle

Intake Valve Seat Angle

Intake Valve Seat Width

Exhaust Valve Face Angle

Exhaust Valve Seat Angle

Exhaust Valve Seat Width

Valve Seat Run-Out

	E-I-E-E-I-E-I-E	
	←————— .3715"-.3725" —————→	
	←————— 4.7895"-.48045" —————→	
	←————— .3735"-.3745" —————→	
	←————— .001"-.003" —————→	
	←————— 29° —————→	
	←————— ∞ —————→	
	←————— .040"-.060" —————→	
	←————— 44½° —————→	
	←————— .040"-.060" —————→	
	←————— .0025" Max. —————→	

VALVE SPRING TENSION (LBS)

Closed

Open

	←————— -80 Lb.-88 Lb. @ 1 ¹⁸ / ₁₆ " —————→	
	←————— 210 Lb.-226 Lb. @ 1 ²³ / ₆₄ " —————→	

INTAKE VALVE TIMING

Opens

Closes

	←————— 14.75° BTDC —————→	
	←————— 68.75° ABDC —————→	

EXHAUST VALVE TIMING

Opens (California)

Opens (Nationwide)

Closes (California)

Closes (Nationwide)

Valve Opening Overlap

(California)

Valve Opening Overlap

(Nationwide)

	←————— 56.77° BBDC —————→	
	←————— 56.75° BBDC —————→	
	←————— 56.75° ATDC —————→	
	←————— 26.75° ATDC —————→	
	←————— 71.49° —————→	
	←————— 41.5° —————→	

CAMSHAFT

Cam Lobe Lift

End Play

Bearing Clearance

Intake Duration

Exhaust Duration (California)

Exhaust Duration (Nationwide)

Base Circle Run-Out

Tappet Clearance

	←————— .266" —————→	
	←————— .000" Engine Operating —————→	
	←————— .001"-.003" —————→	
	←————— 263.5° —————→	
	←————— 293.52° —————→	
	←————— 263.5° —————→	
	←————— .001" Max. —————→	
	←————— Zero Lash (Hydraulic lifters) —————→	

PISTONS AND RINGS

Piston to Bore Clearance @

Center Line of Piston Pin

Piston Ring Gap

Top and Center

Bottom (Steel Rail)

Piston Ring Side Clearance

#1 Compression

#2 Compression

Oil Control

Piston Pin to Connecting Rod

Piston to Pin Clearance

.001"-.0018"

.0012"-.002"

.010"-.025"

.010"-.020"

.015"-.045"

.0015"-.0035"

.0015"-.003"

.0015"-.003"

.0015"-.0035"

.0011"-.008"

.000"-.007"

Press Fit 2000 Lbs.

.0003"-.0005"

CRANKSHAFT AND BEARINGS

Main Bearing Journal Diameter

(Rear Main Only)

	←————— 2.7489"-.27474" —————→	
	←————— 2.7479"-.27464" —————→	

V-8 ENGINE		
304-360 Cubic Inch Displacement		
	304 CID	360 CID
CRANKSHAFT AND BEARINGS		
Main Bearing Journal Width	# 1 - 1.2665" # 2 - 2.247" # 3 - 1.274" # 4 - 1.247" # 5 - 1.216"	# 1 - 1.2665" # 2 - 1.247" # 3 - 1.274" # 4 - 1.247" # 5 - 1.216"
Main Bearing Clearance	← .001"-.002" →	
(Rear Main Only)	← .002"-.003" →	
Crankshaft End Play	← .003"-.008" →	
Connecting Rod Journal Diameter	2.0955"-2.0934"	2.0955"-2.0934"
Connecting Rod Journal Width	2.001"	2.001"
Connecting Rod Bearing Clearance	← .001"-.002" →	
Connecting Rod Side Clearance	← .006"-.018" →	
OIL PUMP AND LUBRICATING SYSTEM		
Oil Pump Type	← Gear →	
Normal Operating Pressure	← 13 PSI →	
@ 600 RPM	← 37 PSI Min.-75 PSI Max. →	
@ 1600 RPM or Higher	← 75 PSI →	
Oil Pressure Relief Maximum	← 75 PSI →	
Gear to Body Clearance	← .0005"-.0025" (Each Tooth) →	
Gear End Clearance (Cover and Gasket Removed)	← .002"-.006" →	
Filter	← Full Flow →	
Engine Oil Capacity	← 4 Quarts →	
	(One (1) Additional Quart With Filter Change)	

1971,304-360 AMC V-8 ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the 1971 *Jeep Service Manual*.

V-8 ENGINE			
304-360 Cubic Inch Displacement			
TORQUE SPECIFICATIONS	304 CID	Foot Pounds	360 CID
Alternator to Mounting Bracket Nuts	←	30-35	→
Alternator Bracket to Lower Support Nuts	←	18-25	→
Alternator Support Bracket to Cylinder Head Bolts	←	25-30	→
Alternator Adjusting Strap to Alternator Bolts	←	18-25	→
Camshaft Front Lock Bolt	←	25-35	→
Carburetor Adapter to Manifold Screws — 2V	←	18-25	→
Carburetor Hold-Down Nuts	←	12-15	→
Coil Mounting Bracket Bolts	←	30-35	→
Connecting Rod Nuts	←	26-30	→
Cylinder Head Bolts	←	105-115	→
Crankshaft Pulley Attachment Bolts	←	18-25	→
Clutch Housing Spacer to Block Screws	←	10-13	→
Clutch or Converter Housing to Block	←	25-28	→
Distributor Clamp Screws	←	10-15	→
Drive Plate to Converter	←	21-23	→
Fan Spacer to Water Pump Bolt	←	18-25	→
Flywheel or Drive Plate to Crankshaft Bolts	←	100-110	→
Front Engine Cover to Block Bolts	←	20-30	→
Fuel Pump Screws	←	30-35	→
Main Bearing Cap Screws	←	95-105	→
Manifold:			
Air Injection Tube to Manifold	←	35-40	→
Air Pump Bracket to Cylinder Head	←	40-45	→
Air Pump to Mounting Bracket Nut	←	20-25	→
Air Pump Pulley Bolt	←	5-8	→
Air Pump Reinforcement Nut	←	18-25	→
Air Pump Reinforcement Bolt to Water Pump Nut	←	25-35	→
By-Pass Valve Bracket to Stud Nut	←	18-25	→
Choke Heater Tube Bolt	←	10-12	→
Diverter Bracket to Valve Bolt	←	5-8	→

V-8 ENGINE
304-360 Cubic Inch Displacement

TORQUE SPECIFICATIONS	304 CID	Foot Pounds	360 CID
Exhaust Manifold to Cylinder Head Bolt	←	30-35	→
Exhaust Pipe to Manifold Nut	←	20-25	→
Intake Manifold to Cylinder Head Bolt	←	40-45	→
Mounting and Connecting Parts			
Engine Mounting Bracket to Engine Bolt	←	25-30	→
Engine Mounting Bracket to Frame Bolt	←	30-35	→
Cushion to Support & to Frame Bracket Nut	←	30-35	→
Insulator Assembly to Crossmember Locknut	←	25-30	→
Mounting to Adapter Bolt	←	25-30	→
Adapter to Transmission Bolt	←	15-20	→
Insulator and Bracket to Transmission Bolt	←	25-30	→
Insulator to Crossmember Locknut	←	25-30	→
Insulator to Transfer Case Locknut	←	15-20	→
Insulator to Transfer Case Screw	←	20-30	→
Torque Reaction Bracket to Transfer Case Bolt	←	25-30	→
Oil Pump Cover Bolts	←	48-60 In. Lbs.	→
Oil Pan Screws			
$\frac{1}{4}$ "-20	←	5-8	→
$\frac{5}{16}$ "-18	←	10-12	→
Rocker Arm Screws	←	20-30 In. Lbs.	→
Rocker Arm Cover Screws	←	20-30 In. Lbs.	→
Rocker Arm Retainer Studs	←	65-70	→
Rocker Arm Retainer Stud Nuts	←	20-25	→
Spark Plugs	←	25-30	→
Starter to Engine Bolts	←	30-35	→
Thermostat Housing Bolts	←	18-25	→
Vibration Damper Retainer Bolt	←	50-60	→
Water Pump to Block Bolts	←	40-45	→
Water Pump to Front Cover Bolts	←	45-50 In. Lbs.	→

1981,304-360 AMC V-8 ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the 1981 *Jeep Service Manual*.

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified		(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Bore			Connecting Rods		
304	3.75	95.25	Total Weight (Leu Bearings)		
360	4.08	103.63	304/360	681-689	grams
Stroke			Total Length (Center-to-Center)		
304	3.44	87.38	304/360	5.873-5.877	149.17-149.28
360	3.44	87.38	Bearing Clearance	0.001-0.003	0.03-0.08
Displacement				(0.0020-0.0025 preferred)	(0.051-0.064 preferred)
304	304 cu.in.	5 liter	Side Clearance	0.006-0.018	0.15-0.46
360	360 cu.in.	6 liter	Maximum Twist	0.0005	0.013
Compression Ratio				per inch	per 25.4 mm
304		8.40:1	Maximum Bend	0.001	0.03
360		8.25:1		per inch	par 25.4 mm
Compression Pressure			Crankshaft		
304	120-140psi (min)	827-1034 kPa	End Play	0.003-0.008	0.08-0.20
360	120-140psi (min)	827-1034 kPa	Main Bearing Journal Diameter		
Maximum Variation Between Cylinders	30psi	206 kPa	No. 1, 2, 3, 4	2.7474-2.7489	69.784-69.822
			Rear Main	2.7464-2.7479	69.759-69.797
Taxable Horsepower			Main Bearing Journal Width		
304	45.00	33.56 kW	304/360		
360	53.27	39.72 kW	No. 1	1.2635-1.2695	32.093-32.25
Fuel	unleaded		No. 2	1.246-1.248	31.65-31.70
Camshaft			No. 3	1.273-1.275	32.33-32.39
Fuel Pump Eccentric Diameter	2.182-2.192	55.423-55.677	No. 4	1.246-1.248	31.65-31.70
Tappet Clearance	Zero lash (hydraulic tappets)		No. 5	1.215-1.217	30.86-30.91
End Play	Zero (engine operating)		Main Bearing Clearance		
Bearing Clearance	0.001-0.003	0.0254-0.0762	No. 1, 2, 3, 4	0.001-0.003	0.03-0.08
	(0.0017-0.0020 preferred)	(0.0432-0.0508 preferred)		(0.0017-0.0020 preferred)	(0.04-0.05 preferred)
Bearing Journal Diameter			Rear Main		
No. 1	2.1195-2.1205	53.835-53.861	No. 5	0.002-0.004	0.05-0.10
No. 2	2.0895-2.0905	53.073-53.099		(0.0025-0.003 preferred)	(0.06-0.08 preferred)
No. 3	2.0595-2.0605	52.311-52.337	Connecting Rod Journal Diameter		
No. 4	2.0295-2.0305	51.549-51.575	304/360	2.0934-2.0955	53.172-53.266
No. 5	1.9995-2.0005	50.787-50.813	Connecting Rod Journal Width		
Maximum Base Circle Runout	0.001	0.0254	304/360	1.998-2.004	50.75-50.90
Cam Lobe Lift			Connecting Rod Bearing		
304/360	0.266	6.7564	Clearance	0.001-0.003	0.03-0.08
Intake Valve Timing				(0.0020-0.0025 preferred)	(0.051-0.064 preferred)
Opens 304/360	14.750 BTDC		Maximum Taper (All Journals)	0.0005	0.013
Closes 304/360	68.75° BTDC		Maximum Out-of-Round (All Journals)	0.0005	0.013
Exhaust Valve Timing			Cylinder Block		
Opens 304/360	56.75° BBDC		Deck Height	9.205-9.211	233.81-233.96
Closes 304/360	26.750 ATDC		Deck Clearance		
Valve Overlap			304/360	0.0145	0.368
304/360	41.50°			(below block)	(below block)
Intake Duration					
304/360	263.50°				
Exhaust Duration					
304/360	263.50°				

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified		(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Maximum Cylinder Taper	0.005	0.13	No. 2	0.0015-0.003 (0.0015 preferred)	0.038-0.076 (0.038 preferred)
Maximum Cylinder Out-of-Round. . .	0.003	0.08	Oil Control	0.0011-0.008	0.028-0.203
Tappet Bore Diameter	0.9055-0.9065	22.999-23.025	360		
Cylinder Block Flatness	0.001/1- 0.00216 0.008 (max)	0.03/25- 0.051152 0.20 (max)	No. 1	0.0015-0.003 (0.0015 preferred)	0.038-0.076 (0.038 preferred)
Cylinder Head			No. 2	0.0015-0.0035 (0.0015 preferred)	0.038-0.089 (0.038 preferred)
Combustion Chamber Volume			Oil Control	0.000-0.007	0.000-0.18
304	57.42-60.42 cc		Piston Ring Groove Height		
360	58.62-61.62 cc		No. 1 and No. 2	0.0795-0.0805	2.019-2.045
Valve Arrangement	E1-E-E1-E		Oil Control	0.1880-0.1895	4.775-4.813
Valve Guide ID (Integral)	0.3735-0.3745	9.487-9.512	Piston Ring Groove Diameter		
Valve Stem-to-Guide Clearance	0.001-0.003	0.03-0.08	304		
Intake Valve Seat Angle	30°		No. 1 and No. 2	3.328-3.333	84.53-84.66
Exhaust Valve Seat Angle	44.50		Oil Control	3.329-3.339	84.56-84.81
Valve Seat Width	0.040-0.060	1.02-1.52	360		
Valve Seat Runout	0.0025 (max)	0.064 (max)	No. 1 and No. 2	3.624-3.629	92.05-92.18
Cylinder Head Flatness	0.001/1- 0.002/6 0.008 (max)	0.03/25- 0.051152 0.20 (max)	Oil Control	3.624-3.635	92.05-92.33
Lubrication System			Piston Pin Diameter		
Engine Oil Capacity	4 quarts (add 1 quart with filter change)	3.8 liters (add 0.9 liters with filter change)	304/360	0.9308-0.9313	23.649-23.655
Normal Operating Pressure.	13 psi at 600 rpm 37-75 psi at 1600+ rpm	90 kPa at 600 rpm 255-517 kPa at 1600+ rpm	Piston Pin Bore Diameter		
Oil Pressure Relief	75 psi (max)	517 kPa (max)	304/360	0.9288-0.9298	23.592-23.617
Gear-to-Body Clearance.	0.0005-0.0025 (0.0005 preferred)	0.013-0.064 (0.013 preferred)	Piston-to-Pin Clearance	0.0003-0.0005 (0.005 preferred) loose	0.008-0.013 (0.013 preferred) loose
Gear End Clearance, Feeler Gauge . .	0.004-0.008 (0.008 preferred)	0.010-0.2 (0.10 preferred)	Piston Pin-to-Connecting Rod Fit. . .	2000 lbf Press-Fit	8900 N Press-Fit
Gear End Clearance, Plastigage	0.002-0.008 (0.002 preferred)		Rocker Arms, Push Rods, and Tappets		
Pistons			Rocker Arm Ratio	1.6:1	
Weight (Less Pin)			Push Rod Length	7.790-7.810	197.87-198.37
304	1.1-1.12 lbs	506-510 grams	Push Rod Diameter	0.312-0.315	7.93-8.00
360	1.32-1.33 lbs	601-605 grams	Hydraulic Tappet Diameter	0.9040-0.9045	22.962-22.974
Piston Pin Bore CL-to Piston Top			Tappet-to-Bore Clearance	0.001-0.0025	0.025-0.064
304/360	1.599-1.603	40.62-40.72	Valves		
Piston-to-Bore Clearance			Valve Length		
304	0.0010-0.0018 (0.0014 preferred)	0.025-0.46 10.035 preferred)	(Tip-to-Gauge Dim. Line)	4.78954-8.045	121.653-122.034
360	0.0012-0.0020 (0.0016 preferred)	0.030-0.051 (0.041 preferred)	Valve Stem Diameter	0.3715-0.3725	9.436-9.462
Piston Ring Gap Clearance			Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
No. 1 and No. 2	0.010-0.020 (0.010-0.012 preferred)	0.25-0.51 (0.25-0.305 preferred)	Intake Valve Head Diameter		
Oil Control Steel Rail			304	1.782-1.792	46.26-45.52
304	0.010-0.025	0.25-0.64	360	2.020-2.030	51.31-51.56
360	0.015-0.045 (0.010-0.020 preferred)	0.38-1.14 (0.25-0.51 preferred)	Intake Valve Face Angle		29°
Piston Ring Side Clearance			Exhaust Valve Head Diameter		
340			304	1.401-1.411	35.59-35.84
No. 1	0.0015-0.0035 (0.0015 preferred)	0.038-0.089 (0.038 preferred)	360	1.675-1.685	42.55-42.80
			Exhaust Valve Face Angle		44°
			Valve Springs		
			Free Length	1.99	50.55
			Spring Tension		
			Valve Closed	64-72 lbf at 1.786	282-317 N at 45.36
			Valve Open	202-220 lbf at 1.356	889-968 N at 34.44
			Inside Diameter (All)	0.948-0.968	24.08-24.69
					602718

1981. 304-360 AMC V-8 ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1981 Jeep Service Manual*.

Torque Specifications

Service Set-To Torques should be used when **assembling components**. **Service In-Use Recheck Torques** should be used for **checking a pre-torqued item**.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	service set-To Torque	Service In-Use Recheck Torque
Air Injection Tube-to-Manifold	38	30-45	52	41-61
Air Pump-to-Bracket Pivot Screw	20	15-22	27	20-30
Air Pump Brackets-to-Engine—AC Compressor or Pedestals	25	18-28	34	24-38
Air Pump Adjusting Strap-to-Pump	20	15-22	27	20-30
Alternator Pivot Bolt or Nut	28	20-35	38	2747
Alternator Adjusting Bolt	18	15-20	24	20-27
Alternator Mounting Bracket Bolt-to-Engine	28	23-30	38	3141
Alternator Pivot Mounting Bolt-to-Head	33	30-35	45	4147
Block Heater Nut, T-Screw Type	20 in-lbs	17-25 in-lbs	2	2-3
Camshaft Gear Retainer Screw	30	25-35	41	3447
Carburetor Adapter-to-Manifold Screws—2V	14	12-15	19	16-20
Carburetor Holddown Nuts	14	12-15	19	16-20
Connecting Rod Bolt Nuts	33	30-35	45	4147
Crankshaft Pulley-to-Damper	23	18-28	31	24-38
Cylinder Head Capscrews	110	100-120	149	136-163
Cylinder Head Cover Screws	50 in-lbs	42-58 in-lbs	6	5-7
Distributor Clamp Screw	20	18-24	18	14-24
Drive Plate-to-Converter Screw	22	20-25	30	27-34
EGR Valve-to-Manifold	13	9-18	18	12-24
Exhaust Manifold Screws				
Center (2)	25	20-30	34	2741
Outer (4)	15	12-16	20	16-24
Exhaust Pipe-to-Manifold Nuts	20	15-25	27	20-34
Fan and Hub Assembly Bolts	18	12-25	24	16-34
Flywheel or Drive Plate-to-Crankshaft	105	95-115	142	129-156
Front Support Cushion Bracket-to-Block Screw	35	2540	47	34-54
Front Support Cushion-to-Bracket-to-Frame	37	3045	50	4161
Fuel Pump Screws	16	13-19	22	18-26
Idler Pulley Bearing Shaft-to-Bracket Nut	33	28-38	45	38-52
Idler Pulley Bracket-to-Front Cover Nut	7	4-9	9	5-12
Intake Manifold Screws	43	3747	58	50-64
Main Bearing Capscrews	100	90-105	136	122-142
Oil Pump Cover Screws	55 in-lbs	45-65 in-lbs	6	5-7
Oil Pan Screws				
1/4 inch - 20	7	5-9	9	7-12
5/16 inch - 18	11	9-13	15	12-18
Oil Relief Valve Cap	28	22-35	38	3047
Power Steering Pump Adapter Screw	23	18-28	31	24-38
Power Steering Pump Bracket Screw	43	3747	58	50-64
Power Steering Pump Mounting Screw	28	25-35	38	3447
Rear Crossmember-to-Side Sill Nut	30	20-35	41	2747
Rear Insulator Bracket-to-Trans. Screw	33	27-38	45	37-52
Rear Support Insulator-to-Bracket Nut	48	40-55	65	54-75
Rear Support Cushion-to-Crossmember Screw Nut	18	12-25	24	16-34
Rocker Arm Capscrew	19	16-26	26	22-35
Spark Plugs	28	22-33	38	3045
Starter Motor to Converter Housing Screws	18	13-25	24	18-34
Thermostat Housing Screw	13	10-18	18	14-24
Throttle Valve Rod Adjusting Screw	40 in-lbs	30-50 in-lbs	5	3-6
Timing Case Cover-to-Block	25	18-33	34	2445
Vibration Damper Screw (Lubricated)	90	80-100	122	108-136
Water Pump Screws	48 in-lbs	40-55 in-lbs	5	5-6

All Torque values given in foot-pounds and newton-meters with **dry fits** unless **otherwise** specified. Refer to the Standard Torque Specifications and **Capscrew Markings Chart** in Chapter A of this manual for any torque Specifications not listed above.



1990,360 AMC V-8 ENGINE SPECIFICATIONS

Note: The following information has been reprinted from the *1990 Jeep Service Manual*.

Type	90" V-Block	
No. of Cylinders	B	
Bore	103.63 mm	4.08 in.
Stroke	87.38 mm	3.44 in.
Displacement	5.9 liter	360 cu. in.
Compression Ratio	8.25:1	
Compression Pressure (Minimum).....	827-1 034 kPa	120-140 psi
Maximum Variation Between Cylinders.....	206 kPa	30 psi
Camshaft		
Fuel Pump Eccentric Diameter.....	55.423-55.677 mm	2.182-2.192 in.
Tappet Clearance	Zero lash (hydraulic tappets)	
End Play.....	Zero (engine operating)	
Bearing Clearance	0.0254-0.0762 mm	0.001-0.003 in.
Preferred.....	0.01432-0.0508 mm	0.0017-0.002 in.
Crankshaft Bearing Journal Diameter		
No. 1	53.835-53.861 mm	2.1195-2.1205 in.
No. 2.....	53.073-53.099 mm	2.0895-2.0905 in.
No. 3.....	52.311-52.337 mm	2.0595-2.0605 in.
No. 4.....	51.549-51.575 mm	2.0295-2.0305 in.
No. 5.....	50.787-50.813 mm	1.9995-2.0005 in.
Maximum Base Circle Runout.....	0.0254 mm	0.001 in.
Cam Lobe Lift.....	6.7564 mm	0.266 in.
Intake Valve Timing		
Opens	14.75" BTDC	
Closes	68.75" BTDC	
Exhaust Valve Timing		
Opens	56.75" BBDC	
Closes	26.75° ATDC	
Valve Overlap.....	41.5"	
Intake Duration	263.5"	
Exhaust Duration.....	263.5"	
Connecting Rods		
Total Weight (Less Bearings).....	681-689 grams	24.0-24.3 oz.
Total Length (Center-to-Center).....	149.17-149.28 mm	5.873-5.877 in.
Bearing Clearance	0.03-0.08 mm	0.001-0.003 in.
Preferred.....	0.051-0.064 mm	0.002-0.0025 in.
Side Clearance	0.15-0.46 mm	0.006-0.018 in.
Maximum Twist (per in.).....	0.013 mm	0.0005 in.
Maximum Bend (per in.).....	0.03 mm	0.001 in.

Crankshaft		
End Play.....	0.08-0.20 mm	0.003-0.008 in.
Main Bearing Journal Diameter		
Nos. 1, 2, 3, and 4.....	69.784-69.822 mm	2.7474-2.7489 in.
Rear Main.....	69.759-69.797 mm	2.7464-2.7479 in.
Main Bearing Journal Width		
No. 1.....	32.093-32.250 mm	1.2635-1.2695 in.
No. 2.....	31.650-31.700 mm	1.2460-1.2480 in.
No. 3.....	32.330-32.390 mm	1.2730-1.2750 in.
No. 4.....	31.650-31.700 mm	1.2460-1.2480 in.
No. 5.....	30.860-30.910 mm	1.2150-1.2170 in.
Main Bearing Clearance		
Nos. 1, 2, 3, and 4.....	0.03-0.08 mm	0.001-0.003 in.
Preferred.....	0.04-0.05 mm	0.0017-0.002 in.
No. 5 (Rear Main).....	0.05-0.10 mm	0.002-0.004 in.
Preferred.....	0.06-0.08 mm	0.0025-0.003 in.
Connecting Rod Journal		
Diameter.....	53.172-53.266 mm	2.0934-2.0955 in.
Width.....	50.750-50.900 mm	1.998-2.004 in.
Connecting Rod Bearing		
Clearance.....	0.03-0.08 mm	0.001-0.003 in.
Preferred.....	0.051-0.064 mm	0.002-0.0025 in.
Maximum Taper (All Journals).....	0.013 mm	0.0005 in.
Maximum Out-of-Round (All Journals).....	0.013 mm	0.0005 in.
Cylinder Block		
Deck Height.....	233.81-233.96 mm	9.205-9.211 in.
Deck Clearance (Below Block).....	0.368 mm	0.0145 in.
Maximum Cylinder Taper.....	0.13 mm	0.005 in.
Maximum Cylinder Out-of-Round.....	0.08 mm	0.003 in.
Taper Bore Diameter.....	22.999-23.025 mm	0.9055-0.9065 in.
Flatness (per 25 mm/in.).....	0.03 mm	0.001 in.
(per 152 mm/6 in.).....	0.05 mm	0.002 in.
(Maximum).....	0.20 mm	0.008 in.
Cylinder Head		
Combustion Chamber Volume.....	58.62-61.62 cc	3.58-3.76 cu. in.
Valve Arrangement.....	EI-IE-EI-IE	
Valve Guide ID (Integral).....	9.487-9.512 mm	0.3735-0.3745 in.
Valve Stem-to-Guide Clearance.....	0.03-0.08 mm	0.001-0.003 in.
Intake Valve Seat Angle.....	30°	
Exhaust Valve Seat Angle	44.5°	
Valve Seat Width.....	1.02-1.52 mm	0.040-0.060 in.
Valve Seat Runout (Maximum).....	0.064 mm	0.0025 in.
Flatness (per 25 mm/in.)	0.030 mm	0.0010 in.
(per 152 mm/6 in.).....	0.050 mm	0.0020 in.
(Maximum).....	0.200 mm	0.0080 in.

Lubrication System		
Oil Capacity (with Oil Filter)	4.7 liters	5.0 quarts
Normal Operating Pressure		
@ 600 rpm	90 kPa	13 psi
@ 1600 + rpm	255-517 kPa	37-75 psi
Oil Pressure Relief	517 kPa	75 psi
Gear-to-Body Clearance		
Preferred	0.013-0.064 mm	0.0005-0.0025 in.
	0.013 mm	0.0005 in.
Oil Pump Gear End Clearance		
Feeler Gauge Method	0.102-0.203 mm	0.004-0.008 in.
Preferred	0.203 mm	0.008 in.
Plastigage Method	0.051-0.203 mm	0.002-0.008 in.
Preferred	0.051 mm	0.002 in.
Pistons weight)	601-605 grams	21.20-21.34 oz.
Piston Pin Bore CL-to-Piston Top	40.62-40.72 mm	1.599-1.603 in.
Piston-to-Bore Clearance		
Preferred	0.030-0.051 mm	0.0012-0.002 in.
	0.041 mm	0.0016 in.
Piston Ring Gap Clearance		
Nos. 1 and 2	0.25-0.51 mm	0.010-0.020 in.
Preferred	0.25-0.305 mm	0.010-0.012 in.
Oil Control Steel Rail	0.38-1.14 mm	0.015-0.045 in.
Preferred	0.25-0.51 mm	0.010-0.020 in.
Piston Ring Side Clearance		
No. 1	0.038-0.076 mm	0.0015-0.0035 in.
Preferred	0.038 mm	0.0015 in.
No. 2	0.038-0.089 mm	0.0015-0.0035 in.
Preferred	0.038 mm	0.0015 in.
Oil Control	0.000-0.180 mm	0.0000-0.0070 in.
Piston Ring Groove		
Height		
Nos. 1 and 2	2.019-2.045 mm	0.0795-0.0805 in.
Oil Control	4.775-4.813 mm	0.1880-0.1895 in.
Diameter		
Nos. 1 and 2	92.05-92.18 mm	3.624-3.629 in.
Oil Control	92.05-92.33 mm	3.624-3.635 in.
Piston Pin Diameter	23.649-23.655 mm	0.9308-0.9313 in.
Piston Pin Bore		
Diameter	23.592-23.617 mm	0.9288-0.9298 in.
Clearance	0.008-0.013 mm	0.0003-0.0005 in.
Preferred (Loose)	0.013 mm	0.0005 in.
Piston Pin-to-Connecting Rod Fit	8900 N	2000 lbf
(Press Fit)		

Rocker Arms, Push Rods and Tappets		
Rocker Arm Ratio	1.6:1	
Push Rod Length..	197.87-198.37 mm	7.790-7.810 in.
Push Rod Diameter..	7.93-8.00 mm	0.312-0.315 in.
Hydraulic Tappet Diameter..	22.962-22.974 mm	0.9040-0.9045 in.
Tappet-to-Bore Clearance	0.025-0.064 mm	0.001-0.0025 in.
Valves		
Length (Tip-to-Gauge Dim. Line).....	121.653-122.034 mm	4.7895-4.8045 in.
Stem Diameter..	9.436-9.462 mm	0.3715-0.3725 in.
Stem-to-Guide Clearance	0.03-0.08 mm	0.001-0.003 in.
Intake Valve		
Head Diameter	51.31-51.56 mm	2.020-2.030 in.
Face Angle..	29"	
Exhaust Valve		
Head Diameter	42.55-42.80 mm	1.675-1.685 in.
Face Angle..	44"	
Valve Springs		
Free Length	50.55 mm	1.99 in.
Spring Tension – Valve Closed.....	282-317 N	64-72 lbf
(@45.36 mm/1.786 in.)		
Spring Tension – Valve Open.....	889-968 N	202-220 lbf
(@34.44 mm/1.356 in.)		
Inside Diameter (All Springs).....	24.08-24.59 mm	0.948-0.968 in.

J8909-51

1990, 360 AMC V-8 ENGINE TORQUE SPECIFICATIONS

Note: The following information has been reprinted from the *1990 Jeep Service Manual*.

Component	Torque	
A/C Compressor Bracket-to-Engine Bolts	34 N•m	(25 ft-lbs)
Alternator Adjusting Bolt	24 N•m	(18 ft-lbs)
Alternator Pivot Bolt/Nut	38 N•m	(28 ft-lbs)
Camshaft Gear Retaining Bolt	41 N•m	(30 ft-lbs)
Connecting Rod Bolt Nuts	45 N•m	(33 ft-lbs)
Crankshaft Main Bearing Bolts	136 N•m	(100 ft-lbs)
Cylinder Head Bolts	149 N•m	(110 ft-lbs)
Cylinder Head Cover Retaining Bolts	6 N•m	(55 in-lbs)
Drive Plate-to-Converter Bolts	30 N•m	(22 ft-lbs)
Exhaust Manifold Bolts - Center (2)	34 N•m	(25 ft-lbs)
Exhaust Manifold Bolts - Outer (4)	20 N•m	(15 ft-lbs)
Exhaust Manifold-to-Downpipe Nuts	27 N•m	(20 ft-lbs)
Fan and Hub Assembly Bolts	24 N•m	(18 ft-lbs)
Front Support Cushion Retaining Nuts	45 N•m	(33 ft-lbs)
Fuel Pump Bolts	22 N•m	(16 ft-lbs)
Intake Manifold Bolts	58 N•m	(43 ft-lbs)
Oil Pan Bolts - 1/4-20	9 N•m	(7 ft-lbs)
- 5/16-18	15 N•m	(11 ft-lbs)
Oil Pump Cover Bolts	6 N•m	(55 in-lbs)
Rocker Arm Assembly-to-Cylinder Head	26 N•m	(19 ft-lbs)
Spark Plugs	37 N•m	(27 ft-lbs)
Starting Motor-to-Converter Housing	24 N•m	(18 ft-lbs)
Timing Case Cover-to-Block Bolts	34 N•m	(25 ft-lbs)
Vibration Damper Bolt (Lubricated)	122 N•m	(90 ft-lbs)
Vibration Damper Retaining Bolts	41 N•m	(30 ft-lbs)

Chapter 8

Off-Roading and Racing



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Off-Roading and Racing

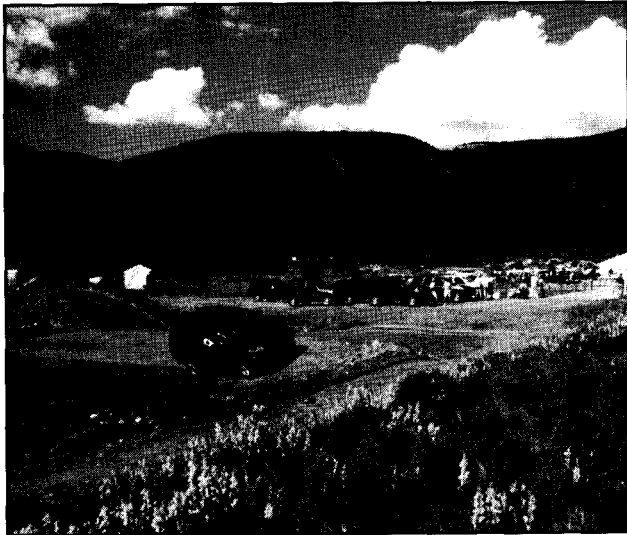
OFF-ROAD DRIVING

We pride ourselves on the off-road capability of our Jeeps. The explosion of the Sport Utility Vehicle market (and of trucks in general) has afforded us many opportunities that didn't exist in the past. It has also presented us with many challenges we have never had to face before. These vehicles are no longer strictly "workhorses."

Our biggest challenge is satisfying both the on-road and off-road needs of our customers without sacrificing performance in either area. The fact that only 20% of Jeep owners (estimated) actually take their vehicles off-road does not mean that we can abandon them. The off-road capability of Jeeps is critical to brand identity, and is what the customer is buying. That is why we continue to make all of our Jeep products Rubicon Trail-capable.

The Rubicon Trail is considered the benchmark that all production Jeeps must negotiate. It is located in the Sierra-Nevada mountains of east central California, southwest of Reno, Nevada. It is a rugged, rocky terrain that most of our competitors cannot negotiate. There is a short Rubicon-like trail at Chrysler's Chelsea (Michigan) Proving Grounds.

Jeep products are more suitable than trucks to off-road driving due in part to their shorter wheelbase, shorter body overhangs, greater ground clearance and suspension travel.



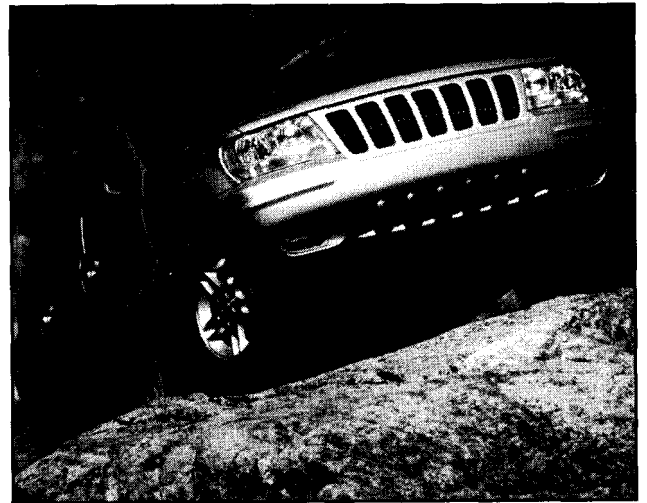
Preparation

Before you go off-road, there is some preparation that you must do. The following items should be adhered to every time you plan on going off-road.

- Oil and other fluid levels must be checked and topped off, if necessary. The battery must be inspected, making sure that it is good and is secured.

- You may need to lower the tire pressure, depending on the terrain you are negotiating. This will soften the tires and expand the footprint for greater flotation, which results in more traction when driving over rocks or in sand. It will also cushion your ride. In loose sand, you may want to lower the pressure down to 20 lbs. If you get stuck in sand, snow, or ice, you may want to lower it even further, down to 10 lbs. On trails like the Rubicon, you will want pressures of 22 to 25 lbs. Too little pressure can result in the tire being pushed off the rim, causing it to go flat.

Note: Don't forget to restore your tire pressure to manufacturer's recommendations once you return to surfaced roads. It is critical to the life of your tires!



- Be careful of sharp rocks or limbs that could puncture a sidewall, and *always* carry a full-sized spare tire.
- Make sure that tow hooks are installed on your vehicle and bring tow straps and/or a vehicle with a winch. If it is not possible to install tow hooks, know where you can attach a strap safely. Be certain that there are at least two vehicles that can assist each other.
- Take a cellular phone or CB radio in case of emergencies. Bring boots and shovels.
- Dress appropriately. Assume *all* of your clothing will get dirty!

General Advice

Be sure to memorize the trail in front of you! Get out of your vehicle and look in all directions on the trail ahead. This is critical since you cannot always see what is directly in front of you (especially when going over the top of a hill). There may be turns you need to make or obstacles you need to avoid. Visualize the route you will take, where you want to be, where to make turns, etc.

The slower the better. The commercials you see of off-road vehicles racing over rocky terrain are not every day reality. More often than not, those vehicles end up in the scrap heap. Let the vehicle idle over more difficult areas, using the accelerator pedal only as needed. Conversely, it is important to maintain an adequate speed, or you may not have enough power to make it over an obstacle. Keep moving once you are committed, but not too fast! You don't want to be going too fast as you reach the other side. And remember, if the going gets too tough, don't be afraid to stop and back up.

Drive with your thumbs up and out of the steering wheel. If your tire hits a large rock, it will cause the steering wheel to spin out of your hands. If your thumbs are in the steering wheel, the spokes can injure or even break them.

You should always drive with a partner (if possible). Most importantly, *always wear your seat belt!*

1. *Manual Transmission—Low Range*

Keep your foot off of the clutch! With the transfer case shifted into Low range, start the vehicle in gear without depressing the clutch (unless it has clutch interlock), using the throttle a little as needed. Start and stop with your key. Don't spin your wheels. Give a little throttle as needed when going uphill or over obstacles.

Warning! A vehicle should only be started in gear if the transfer case is shifted into the Low range. NEVER start a vehicle in gear shifted into High range, or the vehicle may get away from you.

2. *Automatic Transmission*

Use Low range and your lowest driving gear when navigating very rough terrain. A helpful hint is to use a two-footed driving method: left foot on the brake and right foot on the throttle. Operate both with a light foot. Speed and power are not necessary. Go slow!

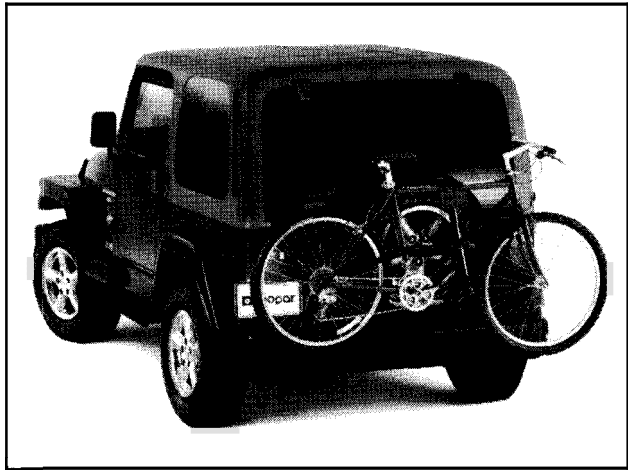
3. *Transfer Case*

In rugged terrain or in deep mud, sand, or snow, select Low range 4WD with the 4WD transfer case selector.



Off-Road Techniques

Note: Always remember to respect nature and private property. Stay on established trails and obey any ordinances. Tread Lightly!



1. *Rocks (Rock Picking)*

Do not straddle rocks! Know your clearance. You cannot make it over a twelve inch rock with an eight inch clearance. Put your tire on top of the rock and crawl over it slowly at 1-3 miles per hour. Use the throttle only to maintain "crawling" momentum.

2. *Hills (Break-Over Angle)*

Never approach a hill on an angle—go straight up. Keep your wheels on the ground, and know what is on the other side of the hill *before* you go over the top. Do not try to turn on a hill. Know your vehicle's limitations and center of gravity. Do not go over the high center of a hill or mound of dirt. You may need a jack to get your vehicle off if it is in a position where it is balanced on its underbody and none of the wheels have a firm grip on the terrain.

When going downhill, use your brakes to keep your speed low. If you start to slip or slide, turn in the direction of the slide, as on snow or ice.

When going down a steep hill in a vehicle with a manual transmission, use your lowest gear. NEVER ride (disengage) your clutch, or it will begin to spin at an extremely high rate (15,000 rpm) and disintegrate. With an automatic transmission, use your lowest drive setting.

3. *Ditches*

Know your approach angle and departure angle. Vehicle size will affect angles of entry and departure.

4. *Traction*

If you lose traction or get stuck, one way of regaining traction is to turn your steering wheel back and forth rapidly. Often this will transfer power to the wheels where it is needed. You can also place your floor mats in front of the tires, or dig out your wheels and place small logs or rocks underneath for traction.

If you get stuck in sand, you can wet the sand in front of the wheels to provide a firmer base, and rock back and forth. Lowering the tire pressure to eight or ten pounds can also help.

5. *Crossing a Log or a Tree*

Know your clearance! If the log is too big, place smaller logs on either side to create a ramp. Crossing at an angle is often easier than crossing head-on.

6. *Sand*

In addition to the tips already discussed, always have a flag on your antenna, or a mast when driving on sand dunes, to make yourself as visible as possible. Remember that sand can vary from firmly packed to loose, affecting the way you drive and the preparations you have to make.

7. *Mud Holes*

Mud holes can be deceiving. They may be a lot deeper than they appear, and they may have hidden obstacles. Use a stick to check depth and probe for obstacles. Analyze carefully before entering. If there are no tire tracks exiting out the other side, think carefully before going into the hole.

Keep moving even if you are only crawling. Turning the wheels rapidly back and forth can often give them a new grip. If you get stuck and can't go forward, try backing up and going forward again. If you still can't get across, back up and out and try to find a route around the mud hole.

If you get stuck, don't spin your tires, they will just dig you deeper. Dig out under the wheels and place small rocks or logs underneath for traction.

8. *Ruts*

If you are in deep ruts in mud or snow and can't get out, dig two small trenches at a 45 degree angle and place the materials removed into the ruts. If you drive ahead slowly, the vehicle should drive out of the ruts.

If you must enter a large rut, drive slowly and straddle where possible. If the rut gets too wide, ease into the rut while keeping the vehicle level and ride on the tire edge, or even the sidewall. Remember to keep centered in the rut and keep the vehicle as level as possible.

9. *Dust*

When driving through a dusty area, close your windows and turn on the air conditioner or fan, making sure the vent is closed. This will pressurize the cab and keep the dust out. In an open Jeep, lower the windshield. Dust will circulate behind the windshield, but with the windshield down, it will blow by.

Additional Information

For more information on off-roading techniques, refer to Mark A. Smith's *Guide to Safe, Common Sense Off-Road Driving*.



TREAD LIGHTLY!

Tread Lightly! originated in 1985 when a task force was created by the U.S. Forest Service to look into the increase of visitors to public lands for recreational purposes. The group concluded that a long-term informative program was needed to increase public awareness and that special care of the land must be exercised by recreationists if opportunities were to continue. Accordingly, the Tread Lightly! program was developed. It's based on the same premise as the Smokey Bear and Woodsy Owl programs, where Smokey Bear and Woodsy Owl focus on fire and litter, respectively. Tread Lightly! emphasizes low-impact principles, applicable to all forms of recreational activities.

Soon after the development of Tread Lightly! by the Forest Service, the Bureau of Land Management adopted the program. Corporate America joined forces with the federal government's efforts by promoting Tread Lightly! like they had championed the "Don't Drink and Drive" and "Buckle Up" safety programs.

Given the popularity of the program, the federal government determined, in order to optimize the program's operational and promotional potential, it was logical to transfer the management of Tread Lightly! from the government to the private sector. In October 1990, approximately 50 companies and organizations founded the nonprofit organization, Tread Lightly!, Inc.

Jeep is a founding member of Tread Lightly!, Inc., and was the first brand of 4x4 to win a Tread Lightly! award for its adherence to the Tread Lightly! mission in its marketing communications. Our message is simple: Use common sense and stay off unmarked trails.

Mission

Tread Lightly! is dedicated to increasing awareness on how to properly enjoy public and private lands. Tread Lightly! emphasizes responsible use of sport-utility vehicles (SUVs) and low-impact principles that apply to all outdoor recreational activities. Tread Lightly! unites federal and state land management agencies with manufacturers, publishers, environmental and user groups, and individuals who share a basic commitment to care for our valuable natural resources. We achieve our goals in three ways: developing and distributing educational materials to teachers, youngsters, and outdoor recreationists; coordinating media coverage that helps get the Tread Lightly! message out to the public; and working with both industry and public service agencies to help promote advertising that demonstrates responsible use of SUVs and other forms of backcountry travel. But Tread Lightly! can only accomplish this with your help!

The main points of the Tread Lightly! program can be easily summarized and remembered.

- T** Travel only where motorized vehicles are permitted. Never blaze your own trail.
- R** Respect the rights of hikers, skiers, campers, and others to enjoy their activities undisturbed.
- E** Educate yourself by obtaining travel maps and regulations from public agencies, complying with signs and barriers, and asking owner's permission to cross private property.
- A** Avoid streams, meadows, wildlife, etc. Stay off soft, wet roads. Stay out of wilderness areas. Cross streams only at designated crossings.
- D** Drive responsibly to protect the environment and preserve opportunities to enjoy your vehicle in our wild lands.



Off-Highway Vehicle (OHV) Trip Preparation

Consider the following as you prepare for an enjoyable, safe trip:

1. Prepare your provisions checklist: food, first aid, water, fuel, etc.
2. Plan well in advance. 30 days prior to a trip is not too early.
3. Where are you going? Get a travel map and determine which areas are open for OHV use. Check to see if there are any special rules or regulations for OHV use. Find a destination point and mark it on the map. Determine how you will get there.
4. How will the weather affect your destination during the season you travel? If roads are often wet and muddy or still snow covered, should you consider another area to visit?
5. How difficult are the roads and trails in the area you have chosen? What are the skill levels of each of your drivers?
6. Are wildlife species in the area especially sensitive to OHVs? How can you avoid disturbing them? Should you choose another area?
7. Know state laws for operating an OHV. Do you need any special equipment or a license for the driver or vehicle? Do you need to be safety certified?
8. Keep your vehicle well maintained and tuned. Excessive emissions, leaking fuel, and dripping oil are expensive problems. They also pollute the environment.

Things to Remember

1. Do not chase or intentionally disturb wildlife.
2. Don't gun the engine—save money, fuel, **and** your vehicle.
3. Be courteous to others! Remember many people are not fond of OHVs. Don't be a nuisance by creating excessive noise and dust. (Wildlife doesn't enjoy it either.)
4. Many other people may also enjoy your special place. Don't ruin their experience. **STAY ON THE ROADS AND TRAILS.**
5. Visual scarring can destroy scenery and habitat while starting an erosion problem. Don't shortcut switchbacks or create unnecessary trails.
6. Pack it in. Pack it out. Don't leave any litter, including human waste.
7. Respect private property and closed areas. Don't make a new trail to get around locked gates.
8. Be courteous on the trail. Yield to horses, slow down for hikers, maintain a cheerful attitude.
9. Today's degraded trail or road is tomorrow's "closed" area. Stay off wet roads and trails, wetlands, and meadows.

10. Wilderness areas are closed to all types of motorized and mechanized equipment.
11. Don't run over young trees and shrubs.
12. Be prepared for vehicle breakdowns. Travel with someone, pack emergency kits, let others know your travel routes in and out of all areas. Stick with your plan.
13. Be safe, protect the environment, and have fun the Tread Lightly! way.



Reading Travel Maps

Travel maps are available from land managers to explain which roads, areas and trails are open, closed or restricted seasonally or year-round. The following is a brief overview of the designations and the reasons for them.

- *Open most of the time*
Main roads, unless wet and soft. Most of the damage done on backcountry roads and trails occur during the wet fall and spring seasons.
- *Unused logging and other high-clearance roads when dry*
These roads, when designated open, offer challenges sought by off-highway vehicles (OHVs).
- *Trails outside wilderness*
Some are open only to foot or horse traffic. Others are open to OHVs.
- *Closed part-time*
Wildlife rearing areas. Specific areas may be closed in spring when disturbances can drive animals from important habitat.

- *Wet, soft trails or roads*

Sometimes fall snowstorms and spring thaws will be the reason to close some routes to vehicles to prevent damage and costly repair. When roads and trails dry, they will be reopened.

- *Wildlife winter habitat*

Late in the season, food is scarce. OHVs may disturb weakened animals, forcing them to use limited energy to escape the intruders. To protect a healthy herd of game, stay away from wildlife winter habitats. Winter habitats are usually found in foothills and lowlands below snow level where game seek easier travel and food.

- *Resource roads*

Logging, mining and oil drilling roads are often closed to the public where collisions could occur with heavy trucks. Some primitive roads, requiring high-clearance vehicles, may be open to OHVs. Refer to your travel map and current road status.

- *Closed year-round*

Wilderness. Law forbids motorized or mechanized vehicles from entering wilderness. Foot or horseback travel affords a frontier experience.

- *Meadows, new forest, steep hillsides, stream banks and lakeshores*

Sensitive land areas may be closed to protect delicate, fragile meadow plants and young trees, grasses and shrubs and to prevent soil erosion, scars and water pollution. These areas may be opened when snow is deep enough to allow for oversnow use.

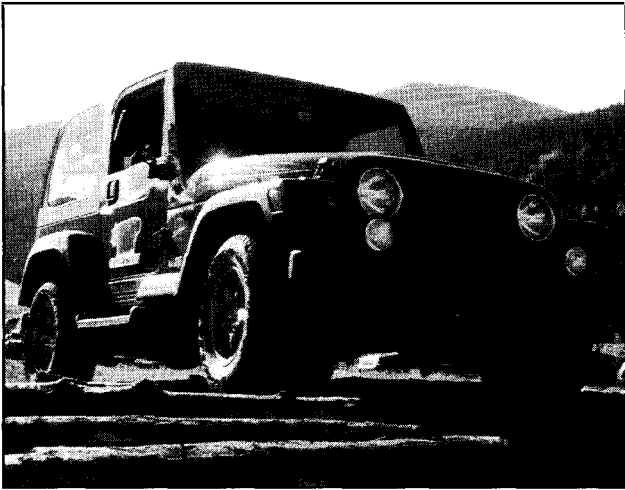
- *Roads and trails no longer open for use*

An area may be closed to the public to prevent disturbance and help endangered or threatened species. Vehicles may disturb these unique creatures and hinder their survival.

JEEP JAMBOREES

Performance vehicles are great—as long as you keep them on the streets, highways, or otherwise paved areas. But every once in a while, it's nice to have a change. To try something new. Not any less exciting, but different. Every summer, Jeep Jamborees offer a great chance to do just that.

Away from the fast and furious action at the strip or cruising the town, Jeep Jamborees offer a different kind of excitement. Instead of the heat and hassle of summer in the city, you can snake your way **up** the side of a rugged mountain, through narrow passes and along sheer cliffs. Or you can tackle the most challenging off-road courses for both driver and vehicle around. All with the expertise of some of the nation's best off-roaders.



Since 1953, when Mark Smith began the first Jeep Jamboree through the legendary Rubicon trail in California, the Jamborees have been gaining in popularity. And number.

Jamborees are now scattered all across the U.S. from coast to coast. Weekend excursions offer Jeep owners a chance to check out the capabilities of their vehicles, polish up their off-roading skills, and enjoy the wildlife. Basic off-road driving tips are offered for both first-timers and experienced off-road drivers. Jeep Jamborees are great because they offer people a chance to enjoy the outdoors and learn a little about their vehicles without having to stick to a rigid schedule. You can pretty much go at your own pace.

Each trail is different. Some of them are fairly straightforward, more for a relaxing vacation than for hair-raising experiences. Others are extremely difficult and some can even be dangerous. In order to help you pick the right trail for you, they are rated by difficulty. A trail with a difficulty level of 10 would be a real test of skill, whereas a trail rated 1 would be purely for fun.

But Jeep Jamborees are not just driving fun. Meals, permits, evening activities and accommodations are also provided. Some people enjoy the outdoors so much they bring their camping gear along instead. For a great view of America at its finest, Jeep Jamborees are definitely the ticket. You can even learn a little history along the way.

All Jeep Jamborees participate in the Tread Lightly! program, which is sponsored by the Jeep and the U.S. Forestry Service and Bureau of Land Management. Jeep Jamboree tour guides are committed to preserving our nation's wildlife for future enjoyment and responsible off-roading.

A Typical Jeep Jamboree Weekend

Jeep Jamborees are family-oriented, four-wheel-drive adventures that feature the best trails and scenic beauty in America. Jamborees are designed for all skill levels and are not competitive events.

For two full days (Friday and Saturday), you, your family and your Jeep will venture into America's backcountry – to places you would never see from the highway. To get there, you'll follow unpaved trails and learn how to properly use your Jeep in challenging off-highway situations. And best of all, you'll make lots of new friends who will help you along the way. The following is a sample itinerary.

Note: Actual itineraries vary from trip to trip. More comprehensive information will be sent to you upon registration.

- Thursday Evening Registration (5-8 p.m.)

Upon arrival at the Jamboree's headquarters, attendees have the opportunity to register at the Jamboree desk, select trails, and informally meet with other attendees.

- Friday Morning Breakfast (6:30-8 a.m.)

A country breakfast will be served for all Jamboree participants. It's just one more chance to get acquainted with fellow adventurers before hitting the trail.

- Drivers' Meeting (8:30 a.m.)

A brief orientation meeting for all Jamboree drivers covers the various dos and don'ts of four-wheeling, Jeep Jamboree guidelines, and details of the day's activities.

- Depart for Trails (9 a.m.)

After getting final instructions, all drivers assemble their vehicles for an orderly departure into the backcountry. It's time to hit the off-highway trails.

- Friday Noon Lunch Along the Trail

A few hours into the wilderness and it's time to regroup for lunch. The site chosen is usually one with a spectacular vista or breathtaking views of surrounding countryside.

- Friday Afternoon Trail Ride Continues

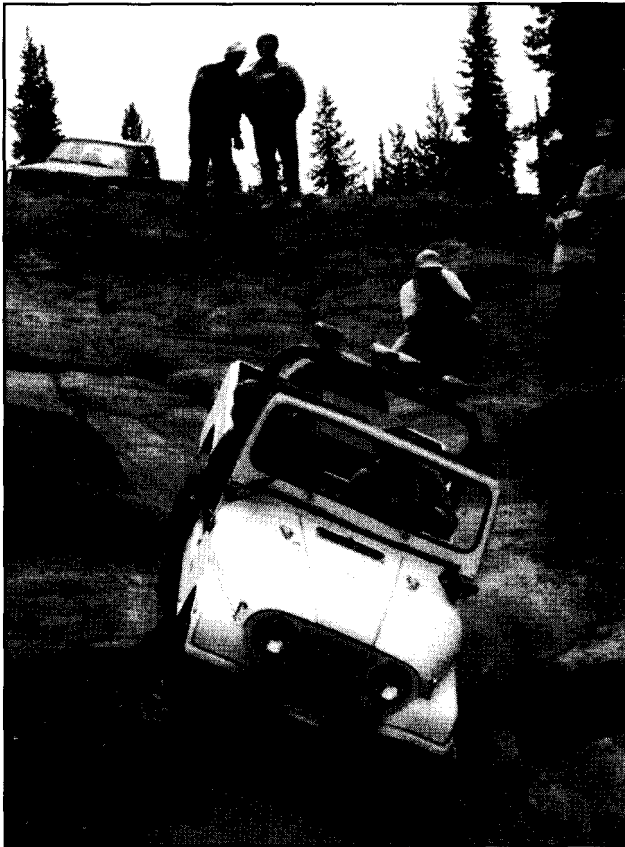
Participants press on throughout the afternoon, pushing farther into the wilderness, crossing streams, traversing boulders, conquering grades – all under the watchful eyes of veteran Jamboree guides.

- Friday Evening Dinner (6-7:30 p.m.)

As the afternoon draws to a close, all vehicles will return to a predetermined site where dinner will be served and participants will be able to discuss the day's adventures.

- Saturday Mornings Breakfast (6:30-8 a.m.)

The day starts with breakfast. Conversation about yesterday's events continues while participants begin to speculate about the day's adventures.



- **Drivers' Meeting (8:30 a.m.)**
Jamboree officials confer with all drivers to review yesterday's happenings and to present a brief preview of the day's itinerary. Four-wheeling tips and guidelines are reviewed once more.
- **Depart for Trails (9 a.m.)**
It's time to once again hit the trail.
- **Saturday Noon Lunch Along the Trails**
As on Friday, the Jamboree entourage stops for a well-deserved lunch break in the midst of nature's splendor.
- **Saturday Afternoon Trail Ride Continues**
One last drive through the backcountry, one last chance to appreciate both the area's natural beauty and each Jeep vehicle's remarkable off-highway capabilities, and it's time to return to "civilization."
- **Saturday Evening Dinner, Prize Drawing (6-7:30 p.m.)**
In the evening, everyone gathers for dinner. It's time for recounting the weekend's adventures. A special drawing is held after dinner with several Jeep related items given away to attendees.

- **Sunday Morning Breakfast (7-9 a.m.)**

Participants enjoy a relaxed continental breakfast. After final farewells, all participants have the rest of the day to take in local sights and activities before heading for home.

Frequently Asked Questions

1. *Who can I bring? How do I make a reservation?*

You can bring whomever you want—even the entire family, but you can only have as many people as there are functional seat belts in the vehicle (for example, Wrangler maximum is 4 [with rear seat], Cherokee and Grand Cherokee maximum is 5). Bringing pets, however, is strongly discouraged. If, for some reason, your pet must attend, be sure to contact the Jeep Jamboree USA office for specific requirements.

It's best to register early since most Jamborees have a 100 vehicle limit. The official host is Jeep Jamboree USA, a division of Mark A. Smith Off-Roading, Inc. To make reservations, contact:

Jeep Jamboree USA

P.O. Box 1601

2776 Sourdough Flat

Georgetown, California 9.5634

1-530-333-4777

If you have a credit card, you can send your registration by fax 1-530-333-2844 or via the Internet at <http://JeepJamboreeUSA.com>.

Upon receipt of your completed registration form, drivers will receive a confirmation packet, a schedule of events and meeting times and places, accommodations, and any other necessary information. Office hours are between 9 a.m. and 5 p.m. (Pacific Standard Time), Monday-Friday.

2. **How much does it cost?**

Individual trip fees vary. Please refer to the Jeep Jamboree website for registration fees. There is no charge for children under 3. VISA, MasterCard, personal checks, and money orders are welcome. Credit cards accepted by phone, mail, fax, or on-line. Please be aware that phone and on-line registrations need to be backed up by a mailed or faxed copy of the registration/waiver form. All fees must be paid in advance. Refund checks will be made payable to the driver only. There will be a \$35 charge for returned checks.

3. *What does the fee cover?*

Included in your fee are: experienced guides for the entire trip; all necessary permits; three meals on Friday, three on Saturday, and a continental breakfast on Sunday; and access to some of the finest trails in America, several of which are only available through Jeep Jamborees. A Jeep Jamboree event tee-shirt will also be included in the registration fee. Each Jamboree also features a giveaway, where you'll have a chance to win some great prizes.

Note: Meals vary. Unfortunately, no accommodations can be made for special diets.)



4. *Where do we sleep?*

Although lodging is not covered in your fee, you will be sent a list of motels and campgrounds in the general area of the Jamboree you select. This list will be mailed to you as soon as we receive your registration form. Please remember that rates may be subject to tax and may change without notice. Be sure to mention that you are attending a Jeep Jamboree when you make your reservation.

5. *Will I be the only rookie?*

No. There will be both first-timers and veterans who might be on their 5th or 10th Jamboree. No matter what your experience level, you'll find plenty of people happy to help you along.

6. *Can I bring my Grand Cherokee?*

Of course you can! All Jeep vehicles are tested on demanding 4x4 trails before earning the Jeep name, so every Wrangler, Cherokee, and Grand Cherokee is ready to tackle any Jamboree (However, Cherokees and Grand Cherokees are not recommended for the Rubicon Trail Jeep Jamboree.) All we require is that your vehicle be a four-wheel-drive Jeep vehicle and in good condition, with good tires, seat belts, and brakes.

We do, however, require prior approval for larger Jeep models, such as older Grand Wagoneers and J-Series Pickups. Jeep Jamboree USA reserves the right to refuse participation to any applicant whose vehicle exceeds size restrictions.

7. *Could my vehicle be damaged?*

Every effort is made by Jeep Jamboree USA to make the trails as safe as possible and to provide the proper training for four-wheeling off-highway. Participants are advised to closely follow the instructions given by trail guides, spotters, and Jeep Jamboree USA. However, there is the possibility of damage to your vehicle when traveling over rough terrain. Any damage is the owner's responsibility.

8. *Is there more than one trail at a given destination?*

This varies by destination, but there is usually more than one trail. Most Jamborees feature multiple trails.

9. *What do the Jeep Jamboree Trail Numbers mean?*

Every Jamboree trail is rated from 1 (the easiest) to 10 (the most difficult). These ratings are based on the trail overall, not just on one or two tough spots. Rain can increase ratings by one or two points. Also remember that these numerical ratings may vary from Jamboree to Jamboree due to terrain, weather conditions, and other factors. Please remember, all vehicles are subject to inspection prior to trail departure. Trails rated 1 to 2 are quite mild and may not even require the use of four-wheel-drive (4WD), 3 to 4 are moderate trails in which 4WD is required, 5 to 6 mean that you could encounter mud holes, climb over rocks, and generally experience more difficult four-wheeling conditions. Trails rated 7 to 9 present the possibility of getting stuck. Mud holes here will be deep and extreme, and the rock climbing will be arduous. 10 is reserved for only one trail—the Rubicon. Past participants know that this rating is justly deserved. You'll do things on this trail that you never thought possible in your Jeep. The Rubicon is not recommended for Cherokee or Grand Cherokee models.

Regardless of the rating and the experience level, you'll get plenty of help to meet the challenge of participating in a Jeep Jamboree. First, when you register, you'll receive a copy of Mark Smith's *Guide to Safe, Common Sense Off-Road Driving*. This comprehensive booklet, filled with off-highway driving tips, will arrive in the mail with your trip information. When you reach your Jamboree destination, you'll get on-site instruction beforehand, detailing how best to handle the terrain and local conditions you'll encounter on the trail. Although trails with higher ratings are obviously more difficult, you will get help and expert advice from your guides all along the way.

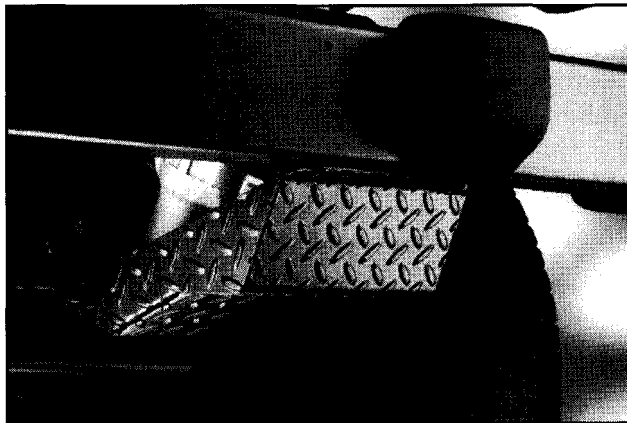
10. *Can my friend who owns a Ford or Chevy participate?*

Only if he rides in your Jeep vehicle. Jeep Jamborees are strictly for Jeep vehicles. There are no exceptions.

11. *Does my Jeep need special equipment to take part.?*

Although four-wheel-drive Jeep vehicles come from the factory ready for strenuous off-highway driving, the following equipment is **STRONGLY RECOMMENDED** for Jamboree vehicles:

- Front and rear tow-hooks should be properly mounted with high-test bolts. Draw bars or receiver hitches are acceptable as an alternative to rear tow-hooks. On some trails, tow-hooks are mandatory. If you do not have tow-hooks, you will be limited in trail selections. Please see individual trip descriptions for details.
- A full-size spare tire. In case of puncture, a space-saver (or "donut") spare just doesn't cut it on the trail.
- Skid plates covering the gas tank and transfer case.
- Rock rails for Jeep Cherokee and Grand Cherokee vehicles. (Please contact the Jamboree office for additional information.)
- Heavy-duty, 20 foot long nylon tow straps (20,000 pound minimum) with looped ends (no hooks).
- No body lifts or suspension lifts over three inches combined are allowed. Running boards and snowplow frames are also not allowed.



12. *Can I add passengers at the last minute?*

Passengers may be added until three weeks prior to the trip date. Be sure to have any new passengers sign the waiver and note "adding passengers only" on the registration form.

13. *What if the weather forecast calls for snow or heavy rain? Should I still come.?*

Absolutely! We're talking about Jeep vehicles here. And, like the postman, neither rain, nor sleet, nor snow will halt a Jeep Jamboree.

14. *What should I bring with me besides my Jeep?*

Here's what we recommend you pack for your Jamboree adventure:

- A CB radio. Although not required, it's highly recommended as a great way to communicate with newfound friends on the trail.
- An ice chest filled with your favorite NON-ALCOHOLIC beverage. A frozen jug or two of iced tea or lemonade makes a great refresher, but alcohol and off-highway driving don't mix.
- **NO ALCOHOLIC BEVERAGES ARE ALLOWED ON ANY TRAIL RIDE** for consumption by Jeep Jamboree participants. Violation of this rule will result in the removal of vehicle and occupants from the Jamboree. Their money will not be refunded, and they will be banned from future Jamborees.
- Snacks
- A tent, if camping outdoors.
- Warm clothes. It may be warm when you arrive, but temperatures can plummet overnight.
- Insect repellent. Sometimes the mosquitoes are as tough as the trails.
- A camera and lots of film or videotape so that you can capture the great time you had for family and friends.
- One or two flashlights and fresh batteries.

15. *Where can I get more information?*

Jeep Jamboree USA

1-530-333-4777

Monday-Friday, 9 a.m.-5 p.m. PST

PO Box 1601

2776 Sourdough Flat

Georgetown, CA 95634

E-mail: jeepjam@jeepjam.com

Web site (including on-line registration):
<http://JeepJamboreeUSA.com>

For a copy of the 1998 *Jeep Jamboree USA Guidebook*, please call 1-800-925-JEEP.

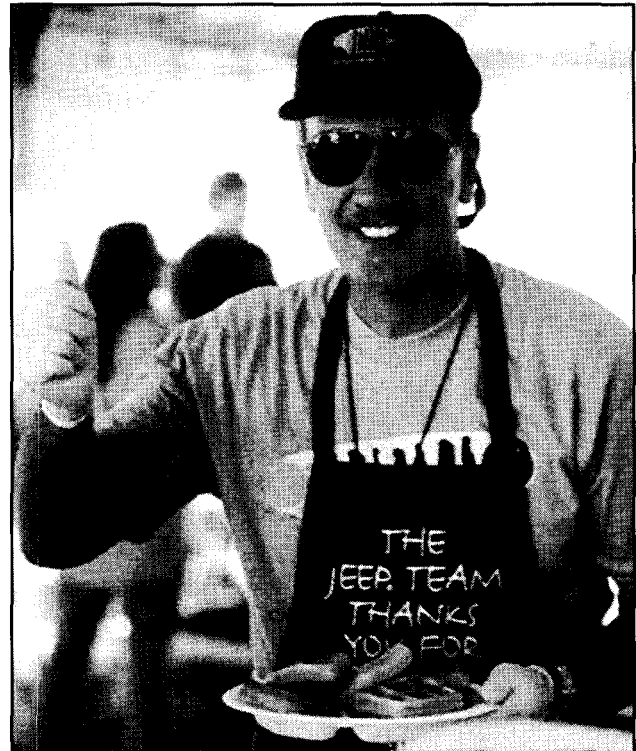
Note: Due to unforeseen circumstances, **trips** and events are subject to change and possible cancellation.

CAMP JEEP

Jeep owners, like Mopar fans, are a breed unto themselves. They love the outdoors and demand optimum performance from their vehicles under the variety of circumstances they may encounter while traversing the uncharted territories of the off-road experience. At the fifth annual Camp Jeep at historic Oak Ridge Estate in Virginia's Blue Ridge Mountains (Aug. 6-7, 1999), over 7,500 Jeep aficionados converged on the spectacular 4,800 acre site for a weekend of education, entertainment and environmental awareness.

The itinerary included outdoor adventures as well as learning to respect and protect the environment. Jeep owners could choose family-friendly activities such as outdoor concerts, fly fishing and Frisbee golf, or test their courage with white-water rafting and all-terrain mountain boarding. And of course, what would Camp Jeep be without driving and discussing the famous four-wheelers, checking out the Mopar Performance parts available to maximize the off-road experience, and looking over the newest ways to dress the icon of off-road jaunts? Plenty of Mopar staffers were on hand to give and receive input about how to create the ultimate Jeep to fit every individual's style.

On top of the valuable training and exciting "extracurricular" activities, Jeep owners were able to receive information on the latest Jeep product engineering and accessories. Owners also had the opportunity to learn more about their vehicles' potential through Jeep 101 training courses. Jeep 101 was designed to teach Jeep owners the basics of off-road driving and the four-wheel-drive capabilities of their vehicles. Training began with owners working with experienced guides on training courses, and allowed drivers to "graduate" to solo runs on surrounding trails which were rated according to difficulty. There was also an opportunity for the youngest of the Jeep contingent to get involved, with a mini-Jeep 101 training course designed exclusively for kids.



Campers were educated on maintaining the natural beauty of the roads and trails they travel through Tread Lightly!, a non-profit organization funded by major outdoor recreation companies and vehicle manufacturers, including Jeep, that promotes off-road ethics and responsibility.

Camp Jeep participants were also able to visit the on-site Jeep Store, an awesome collection of displays where one could get fully decked out with all kinds of Jeep accessories and sportswear. The large tent housed the latest and greatest in Jeep parts and clothing, and everything could be ordered or purchased on the spot. The Mopar presence was appreciated by the thousands in attendance who were able to dress up their Jeeps, and themselves, with the many accessory and sportswear products offered.

Judging from the record numbers who gathered to educate and entertain themselves at Camp Jeep 1999, it seems many Jeep owners would be quick to second that emotion.

Events and Activities

The following information highlights activities that took place at the 1999 Camp Jeep event in Virginia. For information on future Camp Jeep events (and their itineraries), refer to the Camp Jeep website (http://www.jeepunpaved.com/camp_jeep/frameset_camp_jeep.html), or call the Camp Jeep hotline at 1-800-798-JEEP.

1. *Off-Road Activities*

a. Jeep 101 Driving Courses

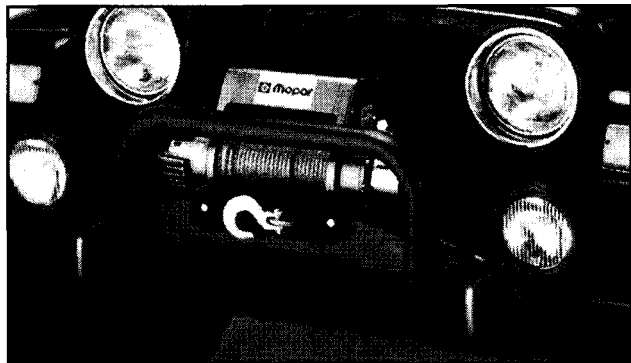
Participants learned off-road driving basics on one of two safe courses. Courses featured a series of challenging off-road obstacles, and were ideal for both new and veteran Jeep owners to hone their skills before heading out on the trails. We provided the vehicles; participants selected the one they wanted to drive. An experienced guide accompanied each driver and provided driving tips.

b. 4x4 Trail Rides

Participants tested the capabilities of their Jeep vehicle and explored some stunning terrain along the way, traveling in a group led by guides who were familiar with the trail. Participants could select a half-day ride (about four hours) or a full-day ride (about six hours).

c. Winching Demonstrations

These 15 minute demonstrations taught participants how to use a winch properly. Winch manufacturers were present to provide demonstrations.



d. Jeep Agility Challenge

The Jeep Agility Challenge included the following three driving exercises:

- Wrangler balance platform: Participants drove a Wrangler onto a special platform to try and balance it. This was a timed activity.
- Cherokee reverse steering course: A pylon course was setup to reverse steer a Cherokee through. This was a timed activity and time was added for every pylon hit and every time the driver had to back up.
- Grand Cherokee blind backup: All windows were darkened with the exception of the windshield and driver and passenger side windows. Participants had to back up through a pylon course using only the mirrors and parallel park at the end. This was a timed activity and time was added for every pylon hit and every time the driver had to drive forward.



2. *Exhibits*

a. Vehicle Displays

Camp Jeep offered participants the opportunity to check out legendary Jeep vehicles from World War II to the present along with Jeep memorabilia, samples of advertising, licensed product information, and a documentary on Jeep vehicles. Also present were concept vehicles that will continue to make the Jeep brand a leader in four-wheel-drive technology.

b. Tech Center and Arena

Many of the Components that make Jeep vehicles unique from their competitors were on display along with experts to help answer questions and demonstrate how components work. Participants had plenty of time to wander through the exhibits and plenty of opportunities to talk with product experts, handle parts, and ask questions.

Participants also saw Jeep vehicles perform against their competitors in challenging off-road situations and experienced why Jeep continues to be the leader in four-wheel-drive technology.

c. Engineering Roundtables

This was an opportunity to talk with Jeep engineers about how you use your vehicle in these very popular and friendly 1-1/2 hour roundtables. Separate sessions were conducted for Jeep Wrangler, Cherokee, and Grand Cherokee owners.

d. Engineering Technology Tent

Participants visited automotive supplier exhibits and examined the components that go into Jeep vehicles. They also sat in on “Tech Talks” given by Jeep engineers who discussed specific vehicle systems (for example, braking, powertrain, suspension) and addressed specific questions.

e. Jeep Stores

There were two stores on-site: one for Mopar products and accessories for Jeep vehicles and one for selling officially licensed Jeep products. Both Jeep and Camp Jeep wearables and products were available at both stores.

3. Trail Activities

a. Guided Hikes

Participants explored area trails on their own or joined others on a guided hike. A variety of theme hikes was offered, including:

- Backpacking Hike

A moderate hike designed to teach the principles of backpacking.

- Wilderness Survival Skills Hike

A hike designed to demonstrate the following survival skills: fire starting, emergency shelter, food and hydration management.

b. Mountain Biking and BMX

Participants were given the opportunity to join a group or set out on their own. All sizes of Jeep mountain bikes were available, or folks could bring their own.

Also available was a BMX track. Bikes, helmets and equipment were provided.

c. Nature Explorations and Presentations

Participants learned about the natural history of the region and got some exercise at the same time.

- How the Blue Ridge Mountains were formed and how it came to be what we see today on a ridgeline hike with spectacular views.
- Walk deep into the local mountain wilderness and learn about the evolution of our forests and the importance of good stewardship
- Learn about the region’s native inhabitants and discover how to locate an Indian campsite.
- Attend nature workshops. Camp Jeep 1999 included workshops on Woodland Mammals: Their Habits and Habitats; Epicurean Delight: Mushroom Cooking; and, Wildflowers of the Virginia Blue Ridge.



d. Global Positioning System (GPS) Land Navigation Learning Center and Hikes

Participants got hands-on training on the latest navigational equipment, then took it to the trails and participated in moderate hikes designed to provide field training on the principles of land navigation and the use of GPS.

e. National Geographic Photo Talks

A National Geographic photographer conducted seminars on endangered species and “how to take good photographs.” The seminar overviewed some of the different species and looked at the future of endangered species preservation.

f. Outdoor Survival Clinic

This was a class for adults on the essential skills needed for outdoor adventures. Participants learned one of the oldest friction techniques to start a fire and the edible, constructive, medicinal uses of various plant families.

Former Green Beret and educator Mitch Utterback conducted classes that entire families participated in. They learned to plan and pack for a trip in the outdoors; experienced outdoor gear from the Stone Age to the Space Age, and were taught how to think rationally and act as a team in an outdoor crisis. Utterback also conducted presentations on adventure racing such as the Eco-Challenge.

4. Water Activitiesa. Fly-Casting

Proper casting techniques were taught by instructors from Sage®—a leading fly-fishing manufacturer. Fly tying instructions were also provided by premier fly-fishing magazines *American Angler* and *Fly Tyer*.

b. Tubine Down the James River

Participants floated leisurely down the beautiful James River on inner tubes that we supplied. Time on the river lasted from 2-4 hours. Transportation was provided to and from the river.

c. Kayaking

Participants headed to a nearby lake and learn the basics of this growing sport. All equipment was provided.

5. Additional Family Activitiesa. Archery

Participants received a thorough introduction to this challenging sport from Hoyt USA, a leading archery manufacturer. Proper archery techniques were learned and practiced at a target range. All equipment was provided, and qualified instructors were available.

b. Rock Climbing

Participants learned the techniques of this fast-growing sport in a safe, controlled environment. Two rock-climbing walls were available, and all equipment was provided.

c. Golf Driving Range

Our golf driving range provided an excellent place to practice before playing one of the world-class courses at Wintergreen Resort. Nets were set up on-site so participants could work on their swing.

d. Climbing Tower and Zipline

Participants reached for the sky while ascending a 50-foot climbing tower (age limit was 10 years old and up).

6. Children's Activitiesa. Mini Jeep 101 Course

Youngsters drove in their own mini Jeep vehicles!

b. Jeep Factory

Young builders used pre-cut wooden pieces to build play Jeep vehicles “just like mom and dad’s.” Following simple instructions, they assemble their vehicle, added wheels that really turned, headlights, a bumper, and more. Then they took their Jeeps to the Customizing Center to paint and add details that made each Jeep one of a kind. Afterward, they test drove their Jeeps by racing them down a ramp at “full speed.”

c. Fresh Produce 500

Teams/families competed to build the fastest, most *edible* Jeep this side of the Mississippi! Jeeps were made of fruits and vegetables and competed in a race on Sunday.

d. Computer Workshops

e. Crafts

- Children made Jeep hats, friendship beads, bearclaw necklaces and foam puzzle picture frames
- Tattoo Time and Nametag Button Make 'n Take
- Face Painting
- Paint a Shirt
- Puppet Making
- Zome Systems
Mathematically elegant ball and stick design toy.

f. Obstacle Course

g. Marvelous Marble Games

h. Remote Control Jeeps

i. Birds of Prey Presentation

Children observed a hawk and an owl at close range.

j. Juggling Workshops

k. Cats Cradle Workshop

l. Watercolors Workshop

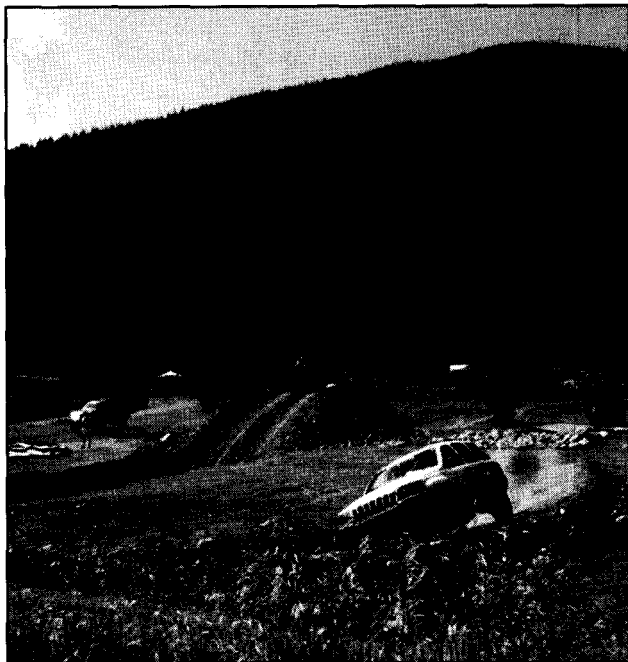
m. Yo-Yo Workshop

n. Music and Movement Workshor.

Children played instruments and danced in this fun workshop.

o. Tom Chapin

Popular children's entertainer Tom Chapin & Friends was present and gave two very special performances.

7. *Activities for Teens*a. Big Cats Presentation

This program focused on preservation and conservation and included a cougar, bobcat and Canadian lynx. The bobcat actually painted and the paintings were on display at Camp Jeep.

b. Health and Fitness Expo

Interactive games and activities like a Velcro Wall, baseball fast pitch, and Bungee run.

c. Soccer Clinic

Teens got a kick out of this soccer clinic taught by U.S. Olympic Gold Medallist Julie Foudy.

d. Paint Ball

Participants took aim at stationary targets as they moved through various stations. Markers and paint balls were provided.

e. Explored rustic trails on Jeep Mountain Bikes.

f. Discovered historic Oak Ridge Estate on foot.

g. Raced through an obstacle course.

8. *Activities for Adults*a. Sunset Magazine Craft Center

Sunset Magazine offered hands-on craft projects throughout the event. Participants made a unique keepsake of their visit to Camp Jeep

b. Southern Living

Participants were able to whet their appetites and learn to make delicious southern dishes.

c. Civil War Camp

Participants witnessed an authentic Civil War camp at the Virginia Village, which included period artisans and craftspeople.

GETTING STARTED IN RACING

Racing is not all engineering and cold, hard facts. There are many aspects of racing that are not quite so cut-and-dry. There isn't just one answer or approach *to* follow, only suggestions for the racer to consider. In this section we'll cover various aspects of racing and provide suggestions which should help the amateur racer be more successful.

Racing today is at an all-time economic high, and it doesn't look like that will be changing anytime soon. Sponsors today are spending more money on racing than ever before and come from every type of business imaginable. Soap companies! Cereal companies! Television networks! Twenty-five to thirty years ago, the only sponsors other than auto companies and parts suppliers were successful business people who used their own money to sponsor themselves. But today, with the record number of sponsors available, not only the rich can get sponsors, but just about anyone.

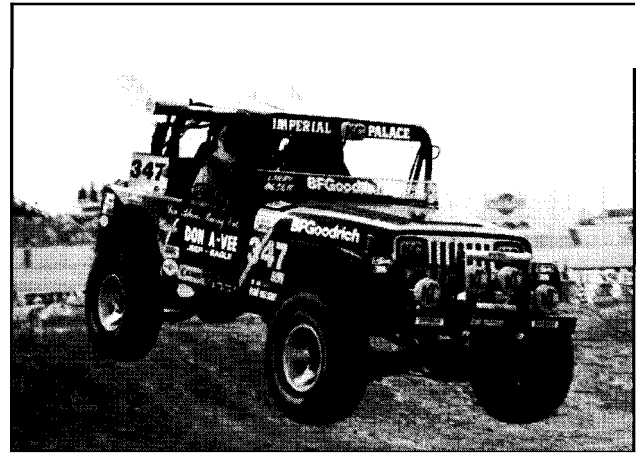
As far as where to spend your money, think of it in terms of *performance per dollars spent*. That means putting the best parts together for the least amount of money to go the fastest. These days, this approach seems a little dated because many racers have a lot of money and are willing to spend “whatever it takes” to go fast. The days of doing everything yourself are disappearing in this age of “pure drivers”; that is, drivers that do nothing with (and possibly know nothing about) their engines or chassis. Drivers that don’t get their hands dirty. “Pure drivers” don’t talk about torque or horsepower, they talk about shift points, the perfect line through a turn, where to brake, where to go flat-out, etc. So the first decision you must make is, do you want to race cars or be a race car builder? Driver or crew chief? Or both?

Recognize Your Limitations

The typical racer doesn’t have a complete understanding of automotive engineering; that is, engine, transmission, chassis, suspension, etc. He or she will usually have expertise in only one or two specific areas, such as engine and/or drivetrain (or possibly suspension). However, most racers can’t construct a decent, safe, and reliable tube frame chassis or roll cage. For example, a chassis builder is an expert in *front end geometry*, something that most racers have never heard of. And chassis builders talk to dozens of racers every weekend about what’s working, what isn’t working, and why. Racers usually don’t talk to anybody other than their own team members (they’re afraid to give any secrets away).

Also, the average racer has passenger car knowledge, which is completely different from race car theory. A lot of race cars may look like passenger cars, but they aren’t even close. For example, an oval track car can’t drive through a two inch puddle of water without stalling out, and a Super Stock drag race car can’t sit still and idle for long periods of time, both things a passenger car must be able to do.

Recognizing up front what you can do and what you must rely on a professional to do for you will go a long way in making your race program a success.



Where Do I Start?

Everyone has to start somewhere. Racing is no different. As mentioned earlier, the first choice you must make is what role you’re going to play. In racing, there are several different challenging and exciting roles to choose from. Consider the following:

1. Driver

This is the glory function—the “quarterback” of racing. To get started in racing as a driver, you need to have someone first explain the rule book. Second, attend a lot of races as a spectator and ask a lot of questions. Third, decide whether or not you’re willing to spend a lot of your hard earned money to get started (this is usually the step most people stop at).

2. Mechanic

The mechanic makes the vehicle go fast (hopefully) and fixes it when it doesn’t. The first step to being a great mechanic is to get good basic training.

3. Crew Chief

A racing crew chief must be an experienced mechanic first before he or she can be effective as a crew chief. Experience is the main ingredient. A crew chief must be an expert mechanic with engines, transmissions, axles, roll cages, suspensions, etc. This is arguably the most demanding position in racing.

4. Racing Engineer

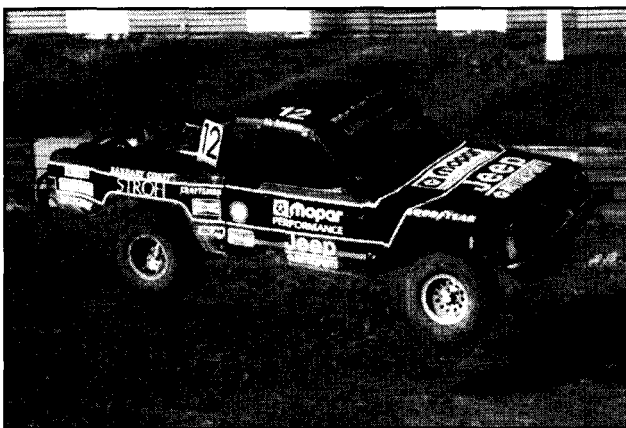
This is the most difficult racing position to obtain because there are very few jobs available. Many racers are very good engineers, but they don’t have the right college degree. A racing engineer must have a lot of racing experience (especially as a mechanic), and a college degree (usually in mechanical or electrical engineering). Usually, working for an auto company such as DaimlerChrysler is good experience and a logical intermediate step. A racing engineer can never know too much about an automobile.

5. Apprenticeship

A common (and excellent) way of getting involved in racing is volunteering to work as an apprentice or helper for someone who is already racing. The most important characteristic of a good apprentice is reliability. The racer must know that if the apprentice was told to do something, he or she did it exactly as expected. Improperly torqued wheels could cause a crash! The wrong amount of oil in the engine could cause it to fail! Simple things can cause expensive failures in highly stressed racing vehicles.

A good driver and a good mechanic are required to win at racing. Once the driver-mechanic team is formed, selecting the class in which to compete becomes important. Initially, Super Stock racing (for example) might look good to you. However, this type of racing requires a lot of money and a very good driver and mechanic to consistently win (or even be competitive). Until you have your team formed, sponsorship secured, and have raced steadily for one or two seasons, it would probably be best to race in a less competitive (and less expensive) bracket racing class. Bracket racing classes still require a very good mechanic, but the pressure on the driver isn't as high. However, every class isn't for everyone, so the choice is up to you.

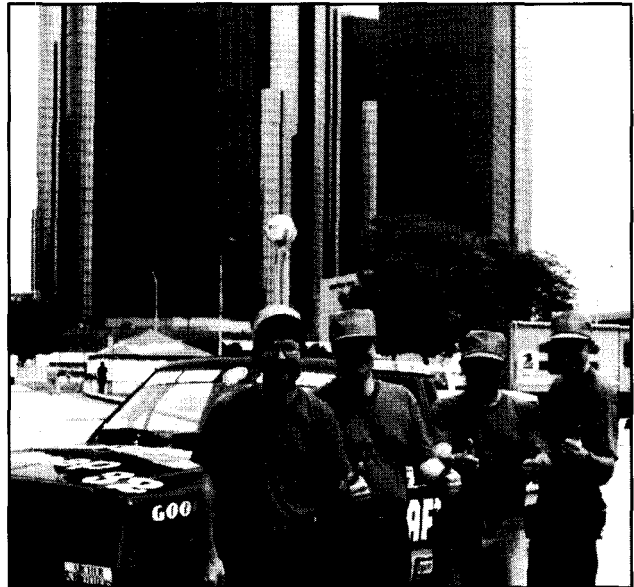
Regardless of which racing class you start in, you must understand that *it will take time* before you'll become competitive on a regular basis. You must get out to the track several times a season, qualify, race, and finish well to get yourself known and recognized. Once you are recognized, it will become easier to get sponsors. When you win it will get even easier, and you'll also start to receive contingency payouts in addition to prize money. With this extra money (and maybe even some factory support), you can do more testing and make the vehicle faster, which will make you more likely to win. Winning also gives you publicity, helping to get newspaper and magazine articles written about you and your vehicle. Mention your sponsors! Make sure their decals are easy to see and read on your vehicle! This is their "payout" for sponsoring you, and your obligation to them for being your sponsor. There's no doubt about it—successful racers are also successful business people.



Obtaining Publicity

Obtaining publicity for you and your race vehicle can be an elusive goal. Being fast, winning, or having a show-stopper is not always enough by itself. A nice vehicle, clean inside and out, is a good beginning. One common mistake is making the paint job and lettering too complicated or cluttered.

It is always easier to obtain publicity if the driver and/or crew are unique. For example, a family race team, a teacher and his students, or a crew made up of neighborhood or underprivileged kids are more "publicity worthy" than average.



A unique vehicle and/or engine package is also helpful in gaining publicity. Jeeps and AMCs have a definite advantage here. There are fewer Jeeps and AMCs competing, which makes them more unique by definition.

For newspapers and magazines, black and white photos are best. It's also helpful to have good photos of your vehicle and crew available for distribution to interested writers. One of the aspects of using black and white film is that a "blue" vehicle looks the same as a "red" vehicle. This emphasizes the need for an uncluttered, uncomplicated paint job with easy-to-read lettering.



1. *Magazines*

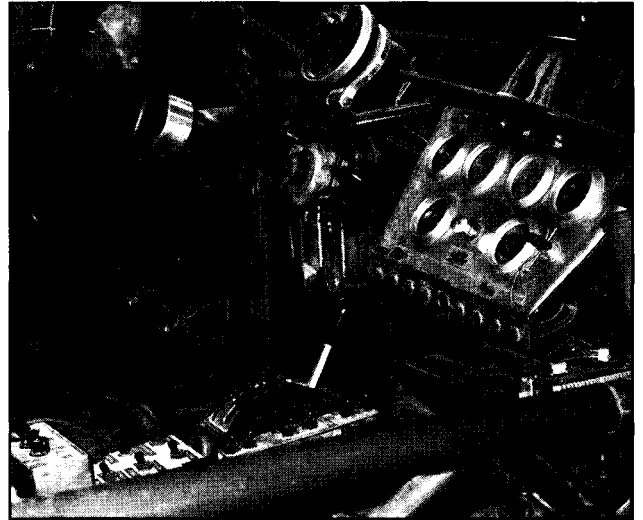
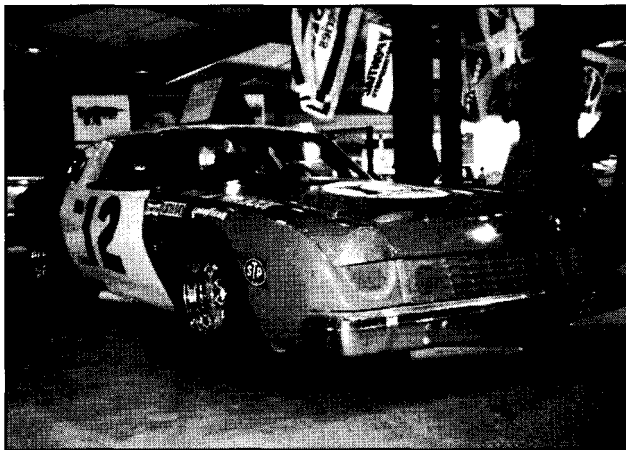
Articles in magazines are one of the best ways to get publicity. Keep in mind that drag racing magazines aren't interested in off-road vehicles, and off-road magazines don't want articles on drag racers. Being something special (unique) is important to magazines because they have the whole country from which to pick their featured vehicles.

2. *Hometown Newspapers and Racing Newspapers*

Racing newspapers usually concentrate on reporting race results – who won and how fast they went. They are difficult to get coverage in until you start to win.

Hometown newspapers, on the other hand, are much more interested in the “local angle.” However, their sportswriters usually understand football or baseball (for example), but not racing. This means you have to help educate them. Explain your sport and your vehicle. Perhaps take the writer to an event. Get them excited about racing, and in particular, your race program. Keep them up-to-date on your accomplishments (especially your victories) throughout the season.

The responsibility for getting publicity always lies with you, the racer. If you don't do something to promote your vehicle, then someone else will get the publicity, even if their vehicle isn't as nice or as fast as yours. Magazines have a lot of vehicles to pick from, so you must bring your vehicle to their attention. Newspapers have many different sports to pick from; you not only have to convince them that you have something special (newsworthy) to offer, but you must help them with background material on the sport itself.



Governing Body Problems

If you've ever raced in any organized (sanctioned) competition, most likely you had complaints and/or problems with the governing body. In most cases this is due to a lack of communication and/or failure to read the rule book. Safety violations are the most common, yet they are the easiest to avoid. You should always pay close attention to governing body rules concerning safety; after all, they're trying to *save your life*.

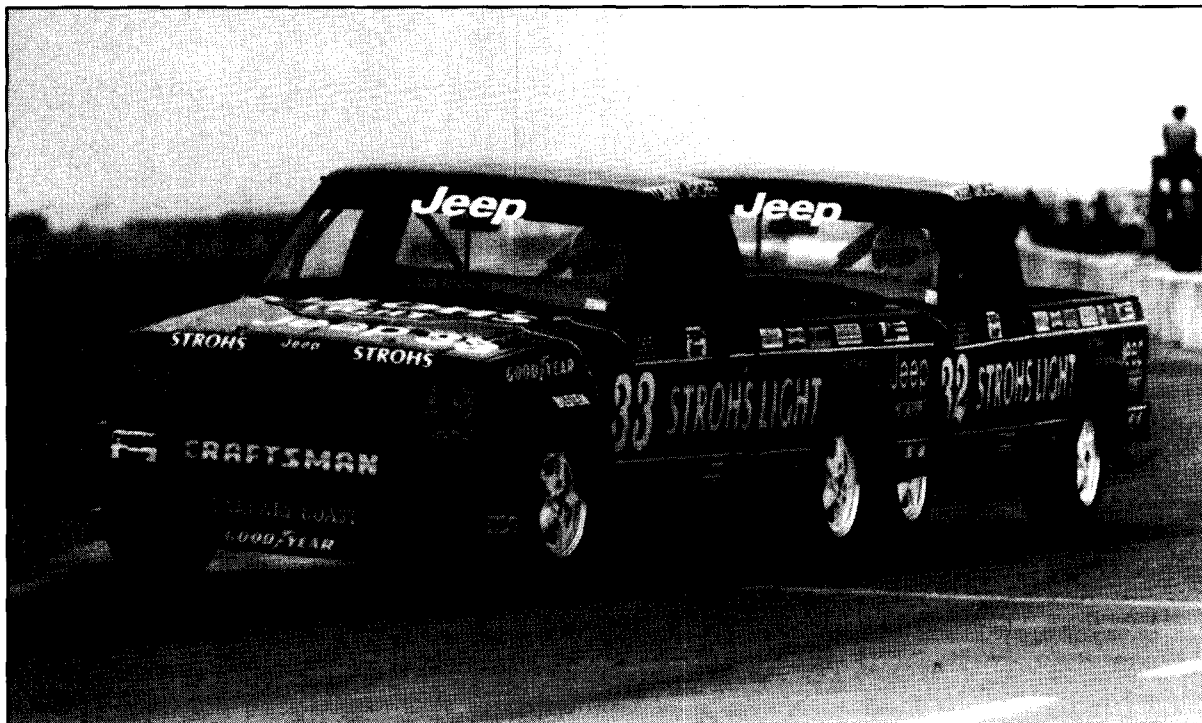
Other than safety issues, most problems with governing bodies fall into two categories: classification and legalities.

1. *Classification*

A majority of complaints concern classification. The governing body tries to put various vehicles, engines, etc., into appropriate classes to make everyone competitive. Problems arise concerning horsepower factors, weight, engine restrictions, etc. Your ideas, suggestions, and opinions should be directed to the local and/or national representatives of the governing body.

2. *Legalities*

Most legal problems concern the engine. The rule books allow certain changes. These rules must be followed to be legal and competitive. Cutting a rule too close is a gamble which is usually not worth it. For example, if the minimum allowable cylinder head volume is 71.0 cc and you mill your head to 71.0 cc, you're gambling that the tech inspector in the tech area, under less than ideal conditions and with different equipment than your own, won't measure it at 70.5. 1/2 cc is not worth the gamble.



Most engine inspections are based on numbers; for example, bore, stroke, head casting number, or carburetor part number. Be sure that the parts you are using agree with what the governing body says they should be. If you get a specific concession from a governing body official, try to get it in writing to avoid future problems, questions, or rejections from other officials. For best results, have your paperwork up-to-date before the race and be sure to always have it with you.

CONTINGENCY

There is a difference between professional racing and amateur racing. Many amateur racers are not sponsored. They may or may not use contingency money. Most professionals are sponsored, but they still use contingency money! Not all manufacturers post contingency money.

What is contingency money? Very simply, it's money paid by a manufacturer to a racer for winning and running the manufacturer's decal. At an NHRA national event such as the Mopar Mile-High Nationals, there may be as many as 100 contingency postings. Postings can range from "oil" to "vehicle body." At a local NHRA or IHRA event, these postings tend to drop to 50 or less (approximately). Compare this to a local circle track which may have only five or 10 contingency postings. (This also varies by category – faster classes tend to have more postings.)

How do you find out what is posted? At the local level, the track will usually print a sheet with all the contingency postings on it. At a bigger race, the sanctioning body would publish the posting. For the NHRA, these are published

before each national event in *National DRAGSTER*. For the IHRA, refer to *DRAG Review*. Almost all types of motorsports have contingency sponsors, but the NHRA and IHRA programs are probably the largest and most well-organized for the amateur!

Now that you know what contingency is and how to find where it is posted, how do you get the money? First, you must put the sponsor's decal on your race vehicle. Most contingency programs are left to the racer to apply. At a larger event, the sanctioning body will handle some of this, but you have to fill out an information sheet and they will check for decals *and* product. (Many manufacturers ask the sanctioning bodies to check the race vehicle to verify it has the product claimed by the decal.)

Contingency programs tend to be very specific. A posting can be for only one event or for only one product. For example, Edelbrock may post for intake manifolds, but not all of the other products that they make. Goodyear may post for the championship, but not all the local events that lead up to it.

At the local level, contingency postings are more likely to be product, not money. For example, you can win a case of oil. This is helpful because you are going to need it to race! Another form of sponsorship is sometimes called a "parts deal." This usually means you get free parts to maintain your vehicle.

The hard part of contingency programs is the OEM aspect. The vehicle and/or engine must be a certain brand. There are basically three OEMs – DaimlerChrysler, Ford, and GM. (Even a dragster or sprint car has some brand of engine.)

Mopar has the biggest and best amateur contingency program available. We post for ignition, intake manifolds, rocker arms, valve covers, etc. Our fellow OEMs tend to post only for the body (if they post at all). We also post for the body when they do. So why is there an engine assembly posting? Because it is the highest payout in the contingency program. In addition to Chrysler-Plymouth-Dodge, we also pay for AMCs, Jeeps, and DeSotos! The reason we do this is to reward our racers for racing a DaimlerChrysler/Mopar product. Other racers with different brands can't get it. Another reason—let's assume there are five Jeep Comanches in the same class. We can't sponsor all of them because there isn't enough money. If we sponsor one, the other four get mad! Contingency solves this problem. That is how DaimlerChrysler/Mopar got into the contingency program in the first place. We used it to replace sponsorships in the mid-1970s. It has worked very well in helping reward our racers over the past twenty-five years.

Mopar Performance Parts Contingency Program

Contingency programs are offered by automotive manufacturers for the use of their products. These automotive manufacturers may produce assembled vehicles, such as DaimlerChrysler, or aftermarket parts, such as Holley and Crane. Most aftermarket parts manufacturers are members of SEMA (Specialty Equipment Marketing Association), as Mopar Performance Parts is. In 1999, Mopar posted over \$1 million dollars in contingency money to drag racers alone!

How does it work? Easy! Run one or more of the eligible Mopar Performance parts in your race vehicle and have the appropriate Mopar Performance Parts decal on your vehicle. If you're a winner or runner-up in your class, the



sanctioning body will inspect your vehicle and forward the appropriate information to the Mopar Performance Parts Contingency Payout Center. A check will be in your hands less than 30 days after the event. Parts eligible for contingency payout are available through the Mopar Performance Parts Racer Store (on site at every national event), participating Chrysler-Plymouth-Dodge-Jeep dealerships, your local speed shop, as well as the *Mopar Performance Parts Catalog*.

Note: For the latest DaimlerChrysler contingency program information, check the latest issues of *Mopar Performance News*, or write to:

Mopar Performance Parts Contingency Program
20770 Westwood Road
Strongsville, Ohio 44136

SAFETY AND THE PERFORMANCE ADVANTAGE

Racing at an entry level usually involves taking a retired production vehicle, putting a seat belt in it, some sort of roll bar, making some modifications (very minimal), and going out to a track. And for those who race these old vehicles, depending on the vehicle's history, everything probably isn't in the best shape (things such as wheel bearings, brakes, etc.). So ask yourself before you buy a vehicle, "Has it been maintained well enough to go racing?" Maybe it was originally, but how about now? And most importantly, *will it be safe?*



You need to ask yourself these questions because no one else will. There are some entry level safety precautions, but these are usually only the bare minimum and in no way do they make your vehicle as safe as it should be. The theory that track owners, promoters, etc., use when asked why racers aren't required to use proper safety equipment is that "they don't go very fast." This is simply not true. They forget that these racers are driving at 60, 80, or even 100+ miles per hour. Can you imagine driving your vehicle down the highway and hitting a bridge abutment? Well, that's the same as hitting a wall at the track, and you can get just as seriously injured.

Most racers put a lot of emphasis on their engines and not their chassis. This completely ignores safety. It doesn't matter if you're ahead in the point standings or not, if you crash you're just as injured. What good does all that work to the engine do if you are unable to survive a crash?

Also, too many racers have the attitude, "I'm a good driver and therefore I won't have a crash." But the fact is there will be a point when the other guy will crash or your vehicle will break, and *you* will *be* involved whether *you* wanted to be or not. You won't have a choice. You could be the best driver in the world and it wouldn't matter. At one time or another, you will be involved in a crash.

There are several things you can do to make your race vehicle as safe as possible, and many of them don't cost a dime. Also, many of them have a hidden performance *advantage*, allowing you to perform better at the track as well as making you as safe as possible. These items will be covered individually following this introduction, but first, it is important to recognize several critical areas involving safety.

One of the most important is driver compartment roll over protection; in other words, you'd like to have, in the case of a bad crash, pieces of the race vehicle everywhere on the track, but the driver completely untouched in a little "cocoon." It takes a lot of time and energy to make that driver's compartment safe. Some people will tell you to simply put the driver in what would amount to as a cast iron "survival cell," and then build the vehicle around that. This theory just isn't true. If the driver was sitting in a little cast iron pod, he would get injured, and more than likely severely. What you need to do is use controlled *crush* to absorb or "manage" the energy; that is, let the vehicle expend all its kinetic energy bending itself up to the point where it just reaches the driver and then stops. Other areas of concern include keeping the driver in the driver's compartment, and the danger of flying debris within the driver's compartment. This takes a lot of engineering and a lot of expertise, and is one of the reasons we suggest that you have your roll cage constructed by a reputable, professional chassis builder.

On top of all this, the most critical area (and the biggest danger) is fuel. You've got to manage *the fuel*—contain it and manage it. For this there are fuel cells, which are steel enclosed

rubber bladders that can deform in case of a crash and hopefully offer some puncture resistance. Even if the bladders do puncture, the fuel will drip out at a very slow, controllable rate, as opposed to engulfing the vehicle in raw fuel.

Another safety area that is not immediately apparent to most racers is to build a vehicle that handles properly so you can *avoid* an accident. Superior handling, that is, steering, suspension, and brakes, means that the vehicle will do what you tell it to do—such as drive around an accident. How many times has someone said, "Well, I hit the brakes but nothing happened," or "The steering got loose on me"? If the vehicle is working correctly, that is, it slows down, goes fast, goes straight, goes left and goes right, you will avoid most accidents.

The key to being safe is that you have to be single-purpose minded. You'll see people at the race track who will have a fancy trailer and a big expensive motor home—and **six** month old tires on their race vehicle. But if they were serious, really serious, they would get rid of that motorhome, get themselves an open trailer and a pickup truck or van, and have *new* tires on their race vehicle every week. Most racers don't understand this: they get their priorities confused. They'll say, "Well, everyone else has a motorhome, and we don't want to look like a second rate operation." But what do you think they'll look like on the track? If they're out there losing races because their tires are old and worn, there's only one way they will look—foolish.



The only person that can make you safe is you. *You* have to make the decision to race as safely as you can so that in case of an accident, *and you* will have *an accident*, you will be able to race again.

Is it worth being competitive "at any cost" when that cost may be your own life? Only you can decide that—no amount of rules or preaching can ever get you to "do something." You alone have to make the choice.

Always remember, safety is the key to having fun while you race, and every professional driver will tell you safety should come first when you plan your race vehicle. And isn't having fun what racing is really all about?

PERSONAL SAFETY

Clothing

Your clothing should be loose fitting treated cotton—NEVER anything synthetic (such as a nylon/plastic “racing” jacket). Synthetics are the worst possible thing you can wear because in a fire they will melt and stick to your skin, whereas cotton won't—it burns and falls off. At least with treated cotton all you have to treat is the burn, as opposed to having to separate the melted synthetic from the skin and then treating what's left. This may sound a bit gory, but it's also very realistic and very true. And unfortunately, very rarely considered.

Also, the recovery time from a first or second degree burn that you may suffer when wearing treated cotton is significantly shorter than a third degree burn sustained if you were wearing a synthetic that melted. Synthetics will also cause you to scar, and in many cases, quite severely.

The next step up from treated cotton is a fire retardant suit, underwear, and gloves, but until you can get to that point, treated cotton gives you a good, reasonably safe place to start.

Helmets

Racers are required to wear helmets, but should you buy a \$50 helmet or a \$300-\$500 helmet? Well, in racing there's a saying that states “the helmet is worth the price of the head.” For this reason, we recommend that you buy the very best helmet you can afford. But remember, even with an expensive helmet *you can still get injuries*. An expensive helmet doesn't guarantee that you won't get injured, so don't start taking unnecessary chances on the track thinking that you “can't get hurt.” However, when you are involved in a wreck, *and you will be in one sootier or later*; the more expensive helmet will lessen your chances of severe injury and improve your chances of survivability.

BODY AND CHASSIS SAFETY

Fire

Fire is the single biggest danger in racing. Fires will happen, and all you can do about it is protect yourself as best you can.

To start with, make sure that you remove all plastic caps in the firewall (bulkhead) and fill in all the holes, because the firewall is the only thing that separates your body from a potential engine fire.

Also make sure that the driver's compartment is isolated from the fuel system or fuel storage system, be it a stock gas tank, a fuel cell, etc. Fuel lines should NEVER pass through the driver's compartment at any point. Also, electric fuel pumps should never be used in oval track racing because if the fuel line breaks, raw fuel will keep pumping from the line, creating a major fire hazard. Mechanical pumps should always be used in an oval track race car.

Another problem area, and one that is rarely even thought of (unless learned the hard way) is where the shifter goes through the floor. In case of a fire, when you're going down the track, that fire has to go somewhere, and that somewhere is the “path of least resistance.” If you DO NOT have the hole in the transmission tunnel plugged and the fire is being forced under the vehicle (because of the hood and the firewall), the transmission tunnel and, consequently, the hole where the shifter is mounted, becomes the path of least resistance. What happens next is that you will be sitting next to a virtual blowtorch... then what?

A way to prevent this is using a fire retardant asbestos boot (available in the aftermarket) that you can tie around the shifter—then any fire that does come into the driver's compartment is only that which can leak around the edges of the asbestos boot. What you are looking for here is time. If you can gain 20 seconds before that boot gives way, it's done its job.

Fire retardant means time. And time allows you to avoid more serious injury.

1. Fire Extinguishers

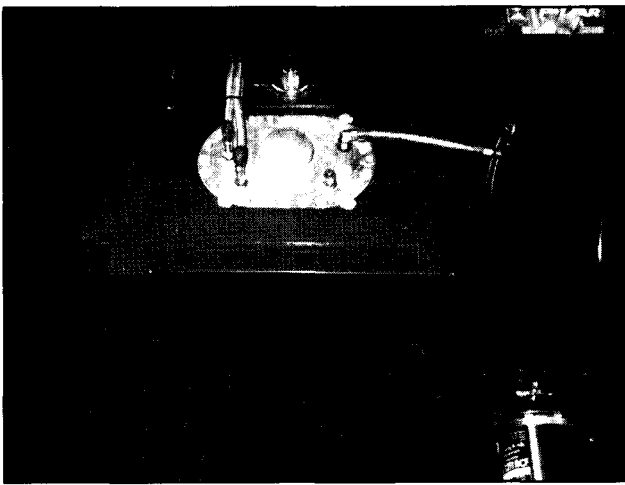
Mopar Performance Parts recommends that a fire extinguisher be carried in all race vehicles. It should be located close to the driver, mounted vertically, and available to be used quickly. There should be an additional fire extinguisher located in your pit area. The extinguishers must contain dry chemicals to help smother electrical, oil, and gasoline fires quickly and safely. Many aftermarket companies such as OMP have complete fire extinguishing systems for virtually any race vehicle. These aftermarket companies should be contacted for more information and specific recommendations.

2. Gas Tanks and Fuel Cells

The biggest danger in racing is a fuel fire. You've got to contain and manage the fuel. For this there are fuel cells, which are steel enclosed rubber bladders which can deform in case of a crash and hopefully offer some puncture resistance. Even if the bladders do puncture, the fuel will drip out at a very slow, controllable rate, as opposed to engulfing the vehicle in raw fuel, which will eventually touch something hot and cause a severe fire.

If you are using a stock gas tank, make sure that is in good condition (no rust) and is shielded as much as possible from possible punctures (for example, make sure you have a good, strong rear bumper). Also, the solid steel gas tank inlet pipe should be replaced with longer, flexible hosing or pipe. What happens is that if you hit the back end in a crash, the gas tank may be pushed either forward or sideways, and without any extra length or "give" the solid inlet pipe will pull out of the tank causing a major fuel spill. Flexible hosing or pipe will allow a lot of movement of the gas tank before being pulled out.

Another option (and a good one for drag racers) is to use a smaller tank, such as a 6 gallon marine/boat tank. With any fuel tank, you should build a firewall between the tank and the driver's compartment for added fire safety.



Roll Cage

Why do you have a roll cage? One of the primary functions of the roll cage, and certainly the most important to the driver, is safety. As the vehicle body goes through contortions, the cage keeps it all in its proper location. This means during a crash the roll cage can bend, but it should not collapse or break.

A lot of people think that the roll cage is only for when the vehicle rolls over, and that's not really true. Most crashes involve hitting the side or the front of the vehicle. But it's the hidden *performance* aspects of the roll cage that most novice drivers don't realize or understand. The roll cage keeps the vehicle stiff, which allows it to work better, last longer, and makes the vehicle go faster. But the performance aspect comes second to the primary function – safety. If the roll cage doesn't make you safe, then why would you have it at all?

It is recommended that a weld-in roll cage be used, as opposed to a bolt-in. A bolt-in roll cage can easily tear away from the body by virtue of the fact that since it is bolted in, it is a separate entity from the body and chassis. A welded-in roll cage actually becomes a structural member of the body and chassis, giving the driver ultimate protection, and there is no risk of the cage separating from the body or chassis.

A word of caution, however. In the United States, chassis builders, roll cage constructors, etc., DO NOT have to be licensed or certified. This can create a very dangerous situation when inferior workmanship is discovered, usually only after a serious crash. It is highly recommended that you shop carefully for a reputable chassis shop, one that is well known for its quality or one that has been recommended to you by a reliable and knowledgeable source. A poorly built roll cage can actually be more dangerous than no roll cage at all.



1. Roll Cage Padding

Even if a padded head restraint is used, it is mandatory that any tube in the area of the driver's head also be padded with rubber air conditioning insulation (Armstrong-Armaflex). It is also highly recommended that all roll cage tubes in the area of the driver's arms and legs be similarly padded. This padding is available in 6-foot lengths from Mopar Performance Parts (P4529065).

Roll Cage Padding

Here's a handy way to neatly pad roll cages. Black foam rubber tubing that measures 1-5/8" inside diameter and 1/2" wall thickness, 6' length.

P4.529065 Roll cage padding.

2. *Head Restraint*

A head restraint is required in vehicles that have installed a roll cage. The head restraint should be well padded and located not more than 4" behind the driver's helmet. A padded roll bar or cage by itself is not acceptable as a padded head restraint by most race sanctioning bodies.

3. *Six Point Harness*

If the roll cage performs its task, then it becomes mandatory to keep the driver securely located within the roll cage. This requires both a high quality seat belt and shoulder harness, and they should be securely attached to the roll cage, not to the seat or floor.

Interesting to note, seat belts and shoulder harnesses only offer so much deceleration time before they give way and break. They have to or even more serious injury could occur to the driver (crushed ribs, etc.). But by the time they do break, they have absorbed so much of the impact that the driver can usually walk away uninjured. Most people don't realize that seat belts, shoulder harnesses, etc., are designed to break. Therefore, they must be replaced periodically. Check with your local track for safety regulations.

4. *Seat Mounting*

With padded bars, head restraints, seat belts and shoulder harnesses all located in the area of the driver's seat, it is absolutely mandatory that the driver's seat stay in its position. It should be bolted to the frame, preferably passing below the seat. High quality bolts should be used, and the bottom bolts should be vertical.

Warning! Quick pins should NEVER be used to attach the seat to the frame.

The seat should be attached in three places: one on the floor and two on the back. The floor attachment should be to the main frame rails or roll cage structure, not to the sheet metal floor. (Attaching the seat to the floor will allow the seat to easily tear out in case of a crash.) The back support should be a vertical bar running from the main hoop to the frame rail with the seat attached to it in two places: as high as possible and midway between the floor and the upper attaching point.

The seat should be set into the tube frame and attached to the previously mentioned three locations. If an aftermarket fiberglass seat is used, the attaching bolts should run through the seat with metal reinforcement plates on the inside so that the bolt does not pull through the fiberglass. Use carriage-type bolts (rounded heads), or weld a stud to the reinforcement plate so that the head of the bolt doesn't stick into the driver when he straps himself into the seat.

5. *WindowNet*

A window net is highly recommended and is required by most sanctioning bodies. Its primary function is to keep the driver's arms contained within the roll cage in case of an accident. It also keeps flying debris from entering the driver's compartment.

Attach the net to the inside of the roll cage above the door opening. One method is to run a steel rod through the net and attach the steel rod through brackets welded to the roll cage or with hose clamps. The bottom of the safety net can be held in place with a steel rod that fits into a bracket in the rear behind the driver's left arm and has a seat belt end on the front. The net should be as far inboard as possible.

6. *Parachute*

In drag racing classes that allow the use of a parachute, it should be anchored securely to the roll cage. It is not recommended that the parachute be attached to the rear axle or rear suspension members since the rear suspension attachments may fail and pull out. It should not be attached ahead of the axle. The best choice for an anchor spot is a section of the roll cage at the rear shock crossmember. The rear crossmember, which is used primarily to support the batteries, ballast, etc., if it is very strong, can also be used as an anchor point. On a stock-bodied vehicle, it may be best to pass the parachute lines through the rear panel to the anchor. If this is done, the hole in the panel should have no sharp edges which might cut the lines anywhere from the anchor to the chute itself.

The height of the chute anchor relative to the axle centerline is extremely important. If the anchor is too high, the front wheels will be picked up. If it is too low, the oil pan will scrape. For the correct size and type of parachute, contact the manufacturer.

7. *Ballast*

Any material that is added to the vehicle for the purpose of ballast must be permanently attached to the vehicle's structure or roll cage. Consult your rule book's safety regulations for how much ballast is allowed, its location, and other details.

Steering Lock

For any race vehicle, be sure to remove all production steering locks. This is extremely important because in case of engine failure or other reason for engine shut down, if you have not removed the steering lock, you will literally be locked into the steering angle you are in, and more than likely will go off the track into a wall (or worse, another vehicle).

Wheel Loss

It sounds incredibly simple, but check those lug nuts every time before going out onto the track! You wouldn't think of it unless you were a seasoned racer, but *wheel loss is one of the most common causes of accidents in racing*, not to mention one of the most serious things that could go wrong with your vehicle. If you haven't checked them yourself and you plan on getting behind the wheel, grab a lug wrench and make sure they're tight! After all, it's *your* life that's on the line.

Brakes and Brake Lines

Brake lines must be routed outside the frame longitudinals in the bellhousing area, and any holes left in the firewall should be sealed, not left open. Brake lines should always be shielded whenever possible.

ENGINE AND DRIVETRAIN SAFETY

Fuel Filters

Warning! Only metal fuel filters should be used on any race vehicle. Glass or plastic filters should NEVER be used.

In an accident, glass can break, causing a major fuel leak. And in the case of an engine fire, plastic can melt, causing the same problem. This is very important to remember because any fuel leak under the hood leaks directly onto the engine, almost always causing a severe engine fire.

Electric Fuel Pumps

In oval track racing, electric fuel pumps are not legal due to their extreme danger. If there is a break in the fuel line or a ruptured/broken fuel filter, the electric pump will cause the

fuel to keep pumping out and when the fuel touches something hot – FIRE! Therefore, even if legal, electric fuel pumps ARE NOT recommended for oval track cars. Instead, consider a high volume mechanical fuel pump.

Mopar Performance Parts does recommend electric fuel pumps for drag racing. For more information and specific recommendations, refer to the 'Fuel Delivery' section of Chapter 4, *4.0L Power Tech In-line 6*.

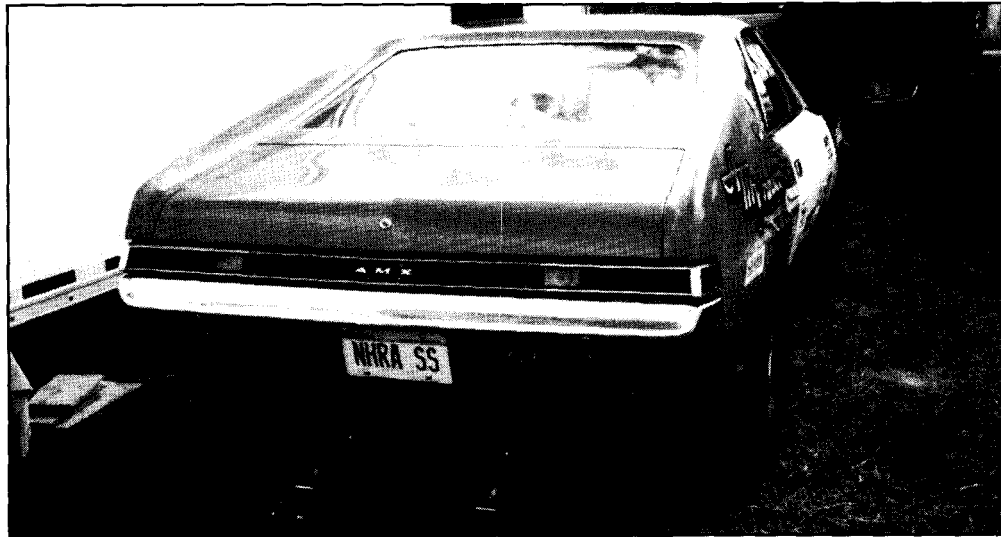
Stuck Throttles

Racers don't necessarily think of the engine as a safety item. Safety is thought of being seat belts, helmets, roll cages, maybe even fuel systems and brakes, but nobody ever thinks of the engine as a safety item. But if your throttle sticks, you are in deep trouble. So you need to check the throttle for easy action, worn cables, etc., so this doesn't happen.

You also need to use two throttle springs. If you only have one spring and it breaks or falls off, your throttle is going to stick. If you have two springs, you have twice the chance of avoiding this. Most newer vehicles have a dual throttle spring—a large thick one with a smaller one inside. This is not done for spring load, but so that in case one breaks you will have a back-up.

Note: The most common stuck throttle problem is through interference, typically with the air cleaner (most of which are usually homemade). Most racers make the mistake of checking interference with the hood up, then when they test drive the vehicle, they drive off the end of the track. So remember—*check for throttle cable interference with the hood down as well as with the hood up.*





Driveshaft Loop

A driveshaft loop is used primarily as a safety device. It is mandatory in some classes and governing bodies. It is reasonably common in class competition in drag racing. Driveshaft loops are occasionally put on other bracket vehicles and circle track/road racing vehicles, but their use is somewhat spotty. If you are building a race vehicle, you should have a driveshaft loop. Before we get to the "why," let's describe the loop itself.

A driveshaft loop is a steel circle or loop that goes completely around the driveshaft. It should be made of 1/4" thick (minimum) steel and should be 2" wide. Approximately 3" of clearance should exist between the loop and the outside of the driveshaft tube. This results in an 8" to 9" inside diameter loop. It does not have to be a perfect circle, but a round loop is recommended because it is considered stronger. It should be located anywhere from 1" to 6" to the rear of the front universal joint. The loop should be securely mounted to the vehicle. This means it should be welded to the frame, not the floor pan. Usually you run two straps horizontally from the loop over to the frame rail. One strap goes to each side/rail.

This is a very simple device to make and install. It does require welding, but the cost should be minimal. If you've paid attention you noted that we located our driveshaft loop next to the FRONT universal joint. Racers know that the rear universal joint is more likely to fail. So the obvious question is why did we locate it by the front universal? The rear universal joint moves around a lot on a vehicle so the loop would have to be much larger and heavier. To get below the rear joint with a 360° loop, the loop itself would be down too low, taking up ground clearance. Additionally, when the rear fails, it tends to fall on the ground and bang around. At the worst, if the driveshaft catches on the ground while the vehicle is moving forward, it just **pulls** the whole driveshaft out onto the ground—or the driveshaft itself may get bent.

The story is completely different at the front. If the front u-joint fails and there is no driveshaft loop, then the driveshaft falls to the ground. It is still attached at the rear, which gives the driveshaft a downward angle. Assuming that the vehicle is still moving forward, the downward sloping shaft will be driven into the ground by the forward motion of the vehicle. When it sticks into the ground, it stops. At this point the best that can happen is that you tear out the rear end and rear suspension. The worst is that you'll pole-vault the whole vehicle and destroy it. If the front universal joint fails and you have a loop, then the driveshaft tube drops down the two to three inches that the loop allows and it stops. The vehicle can now roll to a stop without further damage.

Automatic Transmission Safety

There is one very important item to keep in mind when racing an automatic transmission. If the rear axle ring and pinion, axle shaft, or driveshaft fails under wide open throttle acceleration, the automatic transmission's overrunning clutch should be inspected. In many cases, a rear axle or driveshaft failure will also fail the overrunning clutch. However, it will not appear failed externally. If the driveshaft or rear axle that failed is fixed without inspecting the overrunning clutch, during the next race the transmission may explode! By definition, a failed or damaged overrunning clutch is a failed transmission (even though it may not look broken externally), and should be repaired before it is used again.

Any time that a driveshaft is broken, be sure to check the transmission tailhousing for cracks. Also check for a bent output shaft.

Most race sanctioning bodies require a shield or blanket around an automatic transmission. Be sure to check the rule book.

For more information on automatic transmissions, refer to the appropriate service manual.

SAFETY CHECKLIST

	<u>YES</u>	<u>NO</u>
Have you contacted the necessary race sanctioning bodies and obtained their current listings of approved safety items/requirements?	_____	_____
Do you have the proper clothing (either loose fitting, treated cotton or fire retardant?)	_____	_____
Do you have an approved motorsports safety helmet?	_____	_____
Is the driver's compartment isolated from the fuel system?	_____	_____
Is there a dry chemical fire extinguisher mounted upright and located close to the driver?	_____	_____
Is there an extra fire extinguisher in the pits?	_____	_____
If a fuel cell is not being used, has your gas tank been made as safe as possible?	_____	_____
Do you have a roll cage? Is it padded?	_____	_____
Can the ignition switch be reached when the driver is strapped in tight?	_____	_____
Have you installed the proper head restraint?	_____	_____
Is your six point safety harness in good condition and attached to the roll cage and not the seat or floor?	_____	_____
Has the driver's seat been properly mounted?	_____	_____

	<u>YES</u>	<u>NO</u>
Have you installed a window net? Is it easy to release for both driver and safety personnel?	_____	_____
Have you removed the steering lock?	_____	_____
Have you checked all wheel lug nuts for proper tightness?	_____	_____
Are your brakes in good working condition?	_____	_____
Are you using a metal fuel filter? Have you replaced all rubber fuel lines?	_____	_____
Do all holes in front and rear firewalls have metal covers?	_____	_____
Has a firewall been built between the fuel tank/fuel cell and the driver's compartment?	_____	_____
Have you installed a driveshaft loop (RWD only)?	_____	_____
Have you checked throttle linkage for clearance with the hood down as well as up?	_____	_____
Are you using two throttle return springs and a toe return strap on the throttle pedal?	_____	_____

You should have answered "NO" to only one (or *maybe* two) of the items on this list. If you have answered "NO" to three or more items, chances are you're compromising safety. Ideally, all of these items should be answered "YES," especially those concerning personal safety.

It is recommended that you copy this list and go through it while building your race vehicle, as well as before every race.

DRAG RACING

All drag racing, including brackets, is made up of drivers that leave on time, drivers that generate good times, mechanics that build fast engines and fast cars, planners and developers. The purpose of this section is to give you the basic information necessary to be competitive when racing your DaimlerChrysler product.



Bracket Racing

Bracket (or E.T. Handicap) racing is the fastest growing segment in drag racing, especially Pro Gas-Super Gas. Several years ago it was a virtually unknown aspect of the sport. Today, bracket racing is really big-time with people building special bracket cars, dragsters, trucks, motorcycles, and even snowmobiles (believe it or not). Automotive categories include the following (time shown is for quarter mile):

1. Sportsman (14.00 seconds or slower)
2. Pro (12.00-13.99 seconds)
3. Super Pro (7.50-11.99 seconds)
4. Advanced E.T. (6.30-7.49 seconds)

The popularity of bracket racing is easy to understand. There are virtually no rules—you can build the vehicle and engine any way you want. It can be relatively cheap to race (it's up to you), and a good driver can make a decent amount of money. A bracket racer doesn't need the exotic cylinder heads or trick transmissions that are required to be competitive in Competition-Modified Eliminators. It also doesn't require some oddball car such as a 1952 Studebaker Wagon or a 1958 Commander three-door delivery coupe. These specialty types are what are required to win or be competitive in Stock and Super Stock Eliminators the majority of the time. Bracket racing has no factors, and any "par" that is used is dialed-in by the individual driver. This sounds like fun and you don't get outlawed if you win!

The majority of bracket racers are doorslammers; that is, race cars similar to Stock and Super Stock class cars. The most popular cars in this category are big-block intermediates and small block compacts. In most cases, these cars are not very competitive in Class racing. However, they are very common in bracket racing, and quite competitive. This all seems too good to be true—there must be some drawbacks for the racer. In truth, there are!

There are two basic drawbacks to bracket racing. One is that because the rules are so open, the racer may spend too much money on exotic items that he really doesn't need. The second is that the demand for mechanical excellence is removed. For a Super Stocker, the performance standards are very clearly spelled out and demand mechanical excellence, not only using the best parts available such as intake manifolds and torque converters. This isn't true in brackets. (For example, if you run 10.50 in a 10.20 class, you're three tenths off and must do a better job to be competitive in Class racing, while in brackets you'd dial-in a 10.50 and instantly be competitive—there'd be no reason to go 10.20.)

Bracket Racing Build-Up Strategy

Trying to organize the various approaches to Mopar bracket racing is close to an impossible task. The rules are so open that there are many ways to do the same thing, and many shades of gray. In most cases what separates these different approaches is cost. There are also many aspects to the cost question. You can calculate the amount of horsepower required to reach your goal based on horsepower-to-weight ratios, but all this amounts to is a number, say 500 hp. This can be either an expensive six cylinder or an econo big block V-8. For now we will lay down some general guidelines for the various aspects of bracket racing, but the final decision will be up to the racer.

One of the first things to do is decide upon your allowable budget both in money and time. Budgetary considerations should be given to both immediate needs and your long-term goals. In many cases, a larger investment now can save money in the long-term. Your immediate and long-term plans and budgets should be laid out now. We will show you how to modify this plan as we go along.



Another item to note in your plan is what you expect the vehicle to do; that is, how much highway mileage, how much mileage around town, how many trips to the track, and other requirements. Unlike many brands, Mopars do make excellent dual purpose vehicles. The answers to these questions will affect the parts that we use, eliminate some and demand others. A general characteristic of bracket racers is that they want to race and race often. This is obviously a strong reason for choosing a Mopar race vehicle. Bracket racers are not particularly interested in maintaining, rebuilding, or testing the vehicle on a frequent basis. Class racing demands maintaining, rebuilding, and testing, which means the amateur racer doesn't race as often because he or she needs time to do all this. How often you want to race should be noted on your plan. You should also list what you already have available as far as Mopar engines and bodies. Using one or both of these, if available, may result in the lowest cost approach.

One of the most important considerations in laying out your bracket racing plan is to be realistic concerning how fast you want to go. Overstated, this means that you shouldn't expect a 150 horsepower engine in a 4,000 pound vehicle to go 150 mph. You also shouldn't expect to convert a 150 hp engine to 800 hp. An error in basic choice such as this can be extremely expensive, and in most cases, disappointing.

As we progress through this section, we will try to provide guidelines for various performance characteristics. Later in this chapter we will put all the various Mopar engine parts into groups that will work well together. It's important that all the parts on the vehicle work together as a team. This will increase overall performance, keep costs down, and make the owner happy with his or her package.

The final item in our preliminary plan is to determine how good your current package is running. Since the rules are not restrictive, you should be sure that your current Mopar race vehicle is capable of reaching the goal you set before you invest more money in it. If you don't have a current race vehicle, this step is somewhat academic. To keep from falling into the poor execution category and spending more money than is required, it is necessary to set performance guidelines and determine if you are getting the most from the package that you've put together within your guidelines. This a complex matter and not an easy one to solve. Basically, with a given horsepower output and a given vehicle weight, the vehicle should go a certain speed.

Stock Eliminator Trucks

1991 was the first year for the new NHRA Stock Truck classes that allow 1980 and newer pickup trucks to compete in Stock Eliminator. Trucks in general are red-hot these days, so allowing them to compete in drag racing was a natural. And there's a lot of interest among drag racing enthusiasts because the trucks are rear wheel drive. This makes them naturals for drag racing events.

In 1998 there were 20 classes for trucks in Stock Eliminator: ten manual and ten automatic classes. The top class (AT/S, AT/SA) has a class weight break (based on pounds per NHRA factored horsepower) of 12.00 to 12.99.

With several different classes, there is room for everyone to be competitive. Complete NHRA factors and classifications are published in *National DRAGSTER*. The IHRA publishes their numbers in *DRAG Review*.

Note: Always be sure to check the rules with your local track and sanctioning body before you begin building your drag racing truck.



How to Build a Stock Eliminator Truck

The first step is to get the Tech Sheet and the Weight Classification Sheet for the vehicle that you have picked. The second thing that you need is the service manual for your truck. Then, you'll need a copy of the most recent NHRA or IHRA rule book.

The Tech Sheet allows you to check your engine and have the specifications by which to build it. These are legal specifications—the sanctioning body's minimums/maximums for head cc's, deck height and cam lift, and much more. The Tech Sheet also has the casting numbers for intake manifolds and cylinder heads. These must be checked against the parts that you're going to put on the engine.

Now that you have gathered all the necessary written information, you can start gathering your parts. We assume that you already had a truck or that you just bought one. For this discussion, we'll assume that you have the right engine. If you bought a separate/spare engine assembly, then you have to make doubly sure that the numbers match before you start putting it together!

As you start to gather parts, it's a good idea to keep a notebook full of all the information on your particular engine. The first thing to put in the notebook is a name for the project/engine, or a number, or other description. The second thing is to list all the casting numbers as you take the engine apart.

At this point, you start getting specific as far as parts are concerned. Each engine is unique. The specific substitutions are listed in the engine chapters of this book. The service manual for the vehicle will tell you how to take the engine and vehicle apart. It also tells you how to put it all back together. This book tells you how to modify it to make it go faster/quicker at the drag strip.

We'll assume there is nothing wrong with the truck that you have. This allows you to put together a basic list of parts required. Obviously, you need gasket sets and bearings. You will also need headers, new pistons and rings (probably oversize), a race ignition (electronic), and a low restriction air cleaner for the base plate to use as an ideal entrance. You also need a fresh set of valve springs and a "stocker" cam.

As far as the basic engine building goes, refer to the 'Engine Assembly' section of Chapter 4, *4.0L Power Tech In-Line 6*. Be sure to hone the block with a honing plate. One of the keys to making good power in a stocker is the valve job. It must be good, but also legal. It's usually best to send this out to a professional. If you have a carburetor, you're also going to need some carburetor jets. Stockers make more power and, therefore, need more fuel from the "stock" carburetor.

Now you need to switch your attention to the chassis. The first thing is to weigh the whole vehicle. This lets you know how much weight to take out to get down to the classification weight. While you are weighing the vehicle, push the front wheels off the scale and weigh just the back. This allows you to calculate the weight distribution. Trucks have basically poor weight distribution if no ballast is added.

For chassis parts you'll want a race torque converter and a race manual shift valve body (assuming automatic transmission). You need to get a Sure-Grip rear axle and a lower gear ratio. You'll need racing tires and lightweight wheels. A balance weight set will be needed for the torque converter. At this point you can start building up your new race truck. As you can see, any race project is really two projects. One is the engine and the other is the body/chassis/drivetrain. Each one is important to making the race vehicle successful.

Super Street

Super Street is an entry level category (similar to Super Gas) with a 10.90 second standard (quarter mile). It is for full-bodied cars only (full fenders, hood, grille, roof, windshield, and functional doors). Any automotive engine is permitted.

Basically, a 10.90 bracket is quite simple to define in general terms. With a 10.90 second elapsed time in the quarter mile, we can calculate the weight-to-power (W/P) ratio that will allow this performance level. The actual W/P ratio factor is a function of the type of transmission – manual or automatic. The W/P ratio for the automatic is .146; manual is .140.

To simplify this discussion, we'll assume that everyone has an automatic. This allows us to calculate how much horsepower our engine has to make to obtain our goal of 10.90 seconds. As long as we stay in this category, our required power level is .146 multiplied by the total vehicle weight.

For example, if a vehicle weighs 3,200 pounds, then the horsepower required would be 467. Total weight refers to the car's weight added to the driver's weight. The NHRA uses 170 lbs. for the average driver's weight. For best accuracy, you should use your driver's actual weight. So, if our car weighs 3,030 pounds and our driver's weight is 170 pounds, then our total race weight (vehicle weight) is 3,200 pounds.

We can also figure that if we had a 2,330 pound car and the same driver, we'd have a total weight of 2,500 pounds and would need 365 hp to go 10.90. Are you getting the picture? We saved 100 hp in engine output by taking 700 pounds off the car. On the other hand, if our car weighed 3,530 pounds, our total weight would be 3,700 pounds and the power required would be 540 hp. It is obviously easier (and less expensive) to build a 365 hp engine than a 540 hp engine. In many cases, it is cheaper to reduce the weight of the car than it is to build-in extra horsepower. Plan your project for best performance-per-dollars spent.

Consistency

Consistency. Ask any bracket racer what it takes to win and that's the answer you'll get. Consistency. Everybody knows it, every racer says it. But for the beginning bracket racer, how do you become consistent? How do you get consistent to the point of cutting a Five-0 light (.500 second) and running the same E.T. every time? Welcome to Bracket Racing 101. Class is in session. Let's dissect "consistency."

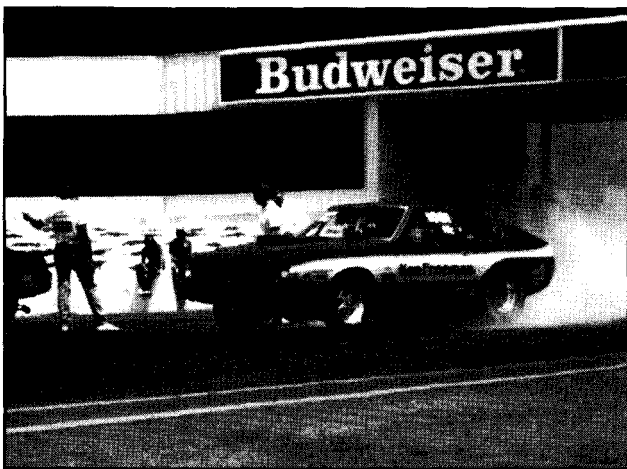
We'll assume that your vehicle is in good mechanical shape and you can find your way to the race track. The problem is, the vehicle won't run consistently. Your reaction times vary from .501 second to calendar years, and you always go out in the first round because you're off your dial-in. What do you do now?

First, let's look at reaction time. Why is cutting a Five-0 light important? Simple. In bracket racing, anything you give up at the starting line you can't get back. You "break out" if you do. Look at it this way—a vehicle traveling at 100 mph is moving 146.7 feet per second, or 1.467 feet per 100th of a second. If you cut a .560 light against your opponent's .510, and you both run right on your dial-ins, you will be 7.3 feet behind him at the finish line (approximately). To close this gap, you must break out. Five hundredths at the starting line means you lost by half a car length.

What does it take to cut a good light? A big powerful engine? No way. **As** long as the engine runs reasonably well, a stock 4.0L In-Line 6 will cut as good a light as a 426 Race Hemi. Remember, the vehicle only has to move a few inches to start the E.T. clock. A good chassis is the way to lower reaction times. When you release the brake (or line lock) and mash the pedal, the vehicle must move forward instantly. No wheel spin. Hook-up every time, the same way every time. Consistently.

Keys to a good chassis are listed in *Mopar Chassis-8th Edition* (P5249441). What it takes to hook-up varies with engine and vehicle weight, but the basic rules are: a) race the vehicle as light as you can, b) make the rear suspension work to plant the tires, c) run as much tire as you can.

Lighter vehicles react quicker, accelerate faster, allow slicks to last longer, and wear out parts slower. Put your vehicle on a diet. Instead of buying the latest trick engine part, spend your money on fiberglass parts. Convert your vehicle to manual brakes and lose the power booster. Remove the power steering pump and cast iron box and put in an aluminum manual steering unit. Or, better yet, remove any parts that aren't required. Although a street vehicle needs a heater and windshield wipers, a race vehicle doesn't. Back seats are dead weight. If you can't remove something, can you move it to the rear? The battery is a good example. Weight moved to the rear will help improve traction. Lighten up. Not only will your reaction times improve, but so will your time slips. Remember, 100lbs. = .100; that is, every 100 pounds you remove will lower your E.T. by roughly a tenth of a second (and be easier on your drivetrain as well).



Before we look at the rear suspension, let's see what's happening when you launch your vehicle. First, the body wants to move in three directions. It wants to rise in the front and squat in the rear from weight transfer, and it wants to roll over to the right (passenger side) from engine torque. The rear axle torques in the opposite direction. It wants to pick up the right rear tire. This is because the engine and driveline run in a counterclockwise direction (as viewed

from the rear). This means the left rear gets planted but the right tire gets "unloaded." In this condition, the left tire must provide most of the traction while the right tire provides very little. Something else happens, too. The differential wants to flip over backwards! The tires move in a forward rotation and the rear end wants to react in the opposite direction. The pinion wants to "climb" the ring gear, so to speak. These are basic laws of physics and are going to happen no matter what. You can't stop these reactions, but you can put them to work for you, and biased leaf springs do it best.

Biased leaf springs mean that the right spring has more leaves and thus more forward stiffness than the left. The extra stiffness causes the body's roll to the right to force that right tire back on to the track, allowing both tires to carry an equal dynamic load and provide equal dynamic traction, making both of your rear tires work equally. **An** added benefit is that, with both tires biting, the vehicle launches straight and your E.T. gets better.

As for tires, more tire means more stick, but there's no need to go overboard. A 12 second vehicle doesn't need 17 inches of Top Fuel rubber, but a little extra is better than not enough. Most 1968 and newer vehicles have pretty generous wheelwells. Remember that wider is not the only way to go. Instead of tubbing your racer out and moving the suspension inboard, try a bigger diameter tire. Larger diameter tires have a bigger "footprint" than smaller diameter tires of the same width. Be sure to keep the relationship of tire diameter to rear axle ratio. Larger diameter tires give the effect of a numerically lower gearset, but new gears can be less costly and certainly faster to install than wheel tubs and an all new rear subframe and suspension.

Now that we have you off the line and cutting consistently low reaction times, how do you get the vehicle to run consistent elapsed times? Generally, you'll find that once you have the starting line down, your vehicle should be running much more consistently already. With the rear suspension working and the tires big enough to hold the track during gear changes, your E.T.s shouldn't vary by much. But how do you get them to settle down even more? The answer: attention to detail.

The vehicle must be able to make every pass under full throttle for the entire length of the track before you can even consider getting consistent. This is just good mechanics. If the vehicle won't, why not? Let's look at some possibilities.

Does the ignition system provide enough spark? Need new spark. plug wires, higher voltage ignition coil, better ECU, or new distributor cap? **As** a rule, ignition systems will act up as engine load increases—high rpm in high gear. However, if the vehicle misses in first but then clears up, the trouble is probably not the ignition.

Does the fuel delivery system provide a constant supply of pure liquid fuel (not foam) to the carburetor? Low pressure will allow carburetors to run lean (dry); too much pressure will force the needle off the seat and they'll run rich (flood). Foamed fuel is only slightly better than no fuel at all. A fuel pressure gauge is mandatory if you are troubleshooting a possible fuel system problem. Tee it in right where the fuel line attaches to the carburetor. However, a word of caution. Fuel pressure gauges must NEVER be mounted inside the vehicle unless they are specifically designed to do so. This is an extremely dangerous fire hazard. Mount the gauge on the hood so you can read it with only a glance. If you have too much pressure, install a regulator or adjust/replace the one already on the vehicle. Too little pressure, check your pump for output, both pressure and volume, and check your fuel lines for kinks and adequate size. Fuel lines for serious six cylinder race vehicles should be 3/8". Dual purpose vehicles should use 5/16".

Mechanical problems, such as weak valve springs, will usually show up at a given rpm, without concern to engine load or how you got there. If you have a problem at 4,800 rpm, regardless of being in 1st or 4th gear or whether you rolled the throttle on or mashed it, it is generally mechanical, not fuel or electrical. Get out your manuals and start checking clearances, pressures, and preloads.

Last, but certainly not least, practice, practice, practice. Did we say it enough? OK, one more time: PRACTICE. Now that you have the vehicle in condition to cut a Five-0 light and run right on the dial-in, what good is it if the driver

doesn't react to the tree the same every time? The vehicle can only run as consistently as it is driven. Drive a good race vehicle badly and you have a bad race. When your vehicle is right, it is all up to you. You might notice that we never mentioned roller camshafts, clutchless transmissions, expensive cylinder heads, or Pro Stock-style tube frame chassis. To become a good bracket racer you don't need them. Become consistent first, then get fast. Develop control first, then blinding speed. There are plenty of racers who come to the track every weekend with the "trick-of-the-week." The vehicle changes every week and they can't string two runs together within a tenth of each other. They get beat the 1st or 2nd round every time, only to return the following weekend with a new trick to "guarantee" success. Consistency means not only the vehicle's performance capabilities and your driving ability, but also the vehicle itself. If you run what amounts to a different vehicle every weekend, it will be very difficult to learn just what you and the vehicle are really capable of.

That's it, the basics of bracket racing consistency condensed into one short course. One last word of advice: read all of your Mopar Performance Parts books (as well as your service manual) completely. They can save you from making poor choices or decisions, especially when you're just starting out. No more lecture. Make us proud (beat the Fords and Chevys). Class dismissed.



BUILDING YOUR PERFORMANCE VEHICLE IN STAGES

The large number of racing classes, sanctioning groups, and types of performance vehicles makes it impossible to describe the “perfect” way to modify regular production vehicles into competitive machines. There’s simply no *one* best method. It all depends on what kind of vehicle you start with, what kind of vehicle you want, how much mechanical expertise you have, and perhaps most importantly, how much money you have to spend.

Of course, if you have the money and know exactly what it is you want to do, then you’ll probably want to perform all the modifications at one time. On the other hand, if you have to stretch your money and like to tinker and learn as you go along, then you’ll no doubt prefer building your vehicle in steps. Racers have been doing it this way for years.

The following is a general four-step method to progressively dial-in more performance. It’s based on the “modular” concept, whereby goals are achieved by increments (phases). Each “phase” involves greater performance capability, cost and complexity. Afterward, we’ll list specific Mopar Performance engine package recommendations for your Jeep.

Stage 1: Induction, Exhaust and Timing

Stock induction and exhaust systems generally are not designed for performance use. They tend to restrict engine breathing. And since engines are basically air pumps, this in turn limits performance characteristics. The first step in getting started on the road to improved performance is to install “bolt-on” items such as carburetors, intake manifolds, exhaust headers and high performance computers. There’s no need to get inside the engine to install these parts, and they allow you to rev freely to 5,000 rpm or more. These pieces add a significant, but limited, horsepower increase (unless further engine modifications are made).

Stage 2: Cams, Valve Train and Chassis

This second phase allows the full potential to be realized from the Stage 1 modifications. The idea is to install a hydraulic cam with a good mid-range power curve that has all-around applications. By eliminating travel from the lifter, it’s possible to rev up to 6,500 rpm. Of course, as with any cam installation, it’s important to also install compatible lifters and associated valve train components. At this point, perhaps as much as 50 horsepower has been added over the stock engine. Therefore, a number of chassis improvement items such as shocks, springs and traction bars should be added.

Stage 3: Advanced Engine and Chassis Modifications

We now begin adding some very sophisticated racing equipment. This becomes somewhat expensive. It takes a lot of money to rev out to the 7,500 rpm range, which is what things such as mechanical cams, heavy duty valve trains, forged high compression pistons, and deep sump oil pans allow. In the chassis area, one-piece axle shafts, reinforced axle housings and heavy duty transmissions and clutches should be considered. (Obviously, chassis items will vary depending on the type of racing you want to be involved in.)

Stage 4: All-out Competition Modifications

This step is for the “big shooters” who run the whole thing. Engines that operate above 7,500 rpm and chassis which are subjected to tremendous loads require the very best pieces and optimum know-how. Money is not an object here if you want to be competitive. Success requires you to go all the way, especially in paying attention to details and blueprinting specifications.

MOPAR PERFORMANCE PARTS ENGINE PACKAGE RECOMMENDATIONS

Jeep enthusiasts will find these tips helpful in selecting the most advantageous parts from a cost and performance standpoint. They were developed by DaimlerChrysler and Mopar Performance Parts and represent combinations of compatible parts best suited for given performance levels. Refer to the latest *Mopar Performance Parts Catalog* for more details.

2.5L Jeep 4-Cylinder Engine Package Recommendations

Stage I

Engine Package A

Set Timing for Maximum Horsepower
 High Performance Hydraulic Camshaft – 240° (P4529656)
 or 248° (P4529657)
 Valve Seal Package (P4529661)
 Valve Spring – Conical (P4529215)
 Conical Retainer (P4529217)
 Low Restriction Exhaust
 (Estimated 10 to 20 hp gain over Stock configuration)

Stage II**Engine Package B**

Same as Engine Package A except for the following items:

High Performance Hydraulic Camshaft – 256° (P4529658) or 260°
 Centerline Cam with Bushing Kit (P3690936)
 Backcut Valves (P4529212-213)
 Richen Carburetor
 Engine Oil Cooler (P4529690)
 Exhaust Headers
 (Estimated 20 to 30 hp gain over Stage I configuration)

Stage III**Engine Package C**

Same as Engine Packages A & B except for the following items:

Increase Compression Ratio
 High Performance Hydraulic Camshaft (268")
 Ported Cylinder Head
 Intake Manifold Attaching Package (P4529679)
 Good Gas
 Heavy Duty Rod Bolt and Nuts
 (Estimated 20 to 30 hp gain over Stage II configuration)

4.0L Jeep In-line 6 Engine Package Recommendations**Stage I****Engine Package A**

Set Timing for Maximum Horsepower
 High Performance Hydraulic Camshaft (P4529228-229)
 Valve Seal Package (P4529240)
 Valve Spring – Conical (P4529215)
 Conical Retainer (P4529217)
 Computer (P4529334)
 Exhaust Headers
 Low Restriction Exhaust
 (Estimated 10 to 20 hp gain over Stock)

Stage II**Engine Package B**

Same as Engine Package A except for the following items:

High Performance Hydraulic Camshaft (P4529230)
 Centerline Cam with Bushing Kit (P3690936)
 Backcut Valves (P4529212-213)
 High Performance Computer (P4529334)
 Engine Oil Cooler (P4529690)
 (Estimated 15 to 25 hp gain over Stage I)

Stage III**Engine Package C**

Same as Engine Packages A & B except for the following items:

Increase Compression Ratio
 Heavy Duty Rod Bolt and Nuts
 High Performance Hydraulic Camshaft
 Ported Cylinder Head
 Intake Manifold Attaching Package (P4529680)
 Good Gas
 (Estimated 20 to 30 hp gain over Stage II)

360 AMC V-8 Engine Package Recommendations**Stage I****Engine Package A**

Set Timing for Maximum Horsepower
 High Performance Hydraulic Camshaft (240° or 248°)
 Valve Seal Package (P4529629)
 Valve Spring (P4876063)
 Retainer (P4529616)
 4-Bbl. Dual Plane Intake Manifold
 4-Bbl. Carburetor – 600 cfm with Vacuum Secondary (P4349227)
 Low Restriction Exhaust
 (Estimated 50 to 60 hp gain over Stock)

Stage II**Engine Package B**

Same as Engine Package A except for the following items:

High Performance Hydraulic Camshaft (256°)
 Centerline Camshaft
 Backcut Valves (P4.529613-614)
 Exhaust Headers
 4-Bbl. Carburetor – 750 cfm with Vacuum Secondary (P4349228)
 (Estimated 30 to 40 hp gain over Stage I)

Stage III**Engine Package C**

Same as Engine Packages A & B except for the following items:

Single Plane Intake Manifold
 Increase Compression Ratio
 High Performance Hydraulic Camshaft (260" or 268°)
 Ported Cylinder Heads
 Intake Manifold Attaching Package (P4529681)
 High Performance Mechanical Fuel Pump (P4529594)
 Good Gas
 (Estimated 45 to 55 hp gain over Stage II)

Optional:

More Compression Ratio
 Bigger Valves
 Bigger Camshafts

SUSPENSION UPGRADES

Shock Absorbers

Shock absorbers are probably one of the most misunderstood components of an automobile. Although it is not a complicated part, most people just don't understand what the shock absorber does or how it does the job it's supposed to do.

Actually, the name "shock absorber" is somewhat of a misnomer. The shock absorber really doesn't absorb shock at all. The spring system, or as it's more commonly called, the suspension, does the shock absorbing. What is commonly referred to as a shock absorber is really a device to dampen spring movement. In fact, in England and throughout Europe it's referred to as a "damper." However, the name "shock absorber" has been around a long time, so let's stick with it and discuss what shock absorbers do and how they do it.

Probably the most common misunderstanding is that if a shock absorber is worn out, damaged, or has lost its fluid, the vehicle will sag closer to the ground. However, the fact is that the shock absorber does not support the weight of the vehicle body in any way, shape or form. The vehicle body is supported completely by the rear springs and front springs or torsion bars. While the vehicle is standing still, the shock absorber is static. It doesn't go into action until the vehicle is moving.

The suspension does the main job of absorbing road shock as the wheels roll over bumps or go into holes, but some minor road shock is absorbed by the tires before it is transmitted to the suspension. The larger the tires, the more road shock they will absorb, but handling and safety considerations limit how large a tire you can use.

Basically, there are two spring movements that occur when the wheels hit any road surface irregularities. If the wheel hits a bump, the wheel moves upwards towards the body. This action is called *jounce*. When the wheel moves away from the body, as when going into a rut or pothole, it is referred to as *rebound*.

Jounce and rebound happen whenever there is enough force encountered to flex the spring. The spring will then continue to flex in opposite directions until the force is completely dissipated. If the load that is applied to the spring is great enough, the spring reaction is transmitted to the body. Body movement is, in most cases, opposite of wheel and spring movement.

When a vehicle travels over a sizable bump, you know that the wheels will cause the spring to flex toward the body. The upward flexing happens at the axle, or near the middle of the spring. The weight of the body causes the forces and movement at the ends of the spring to be in the opposite direction. The exact opposite happens when the wheels travel down or away from the body as in a rebound condition. When this happens, the weight of the body adds to the spring action and makes bouncing even more difficult to control.

Installation Tips

There are only a couple tips to follow when installing shock absorbers, but they are important. One is to make sure the shock is not aerated and the other concerns the bushings.

When installing new shock absorbers, always purge the operating cylinder, or pressure tube, so that the shock is not installed on the vehicle in an aerated condition. Air in the pressure tube can make shock operation soft, spongy, or spotty. It's also likely to be noisy.

To purge, hold the shock absorber right side up, or in the normal operating position, and extend it all the way. Turn the shock over and compress it until it is completely collapsed. Extend and compress the unit at least a half a dozen times. What little, if any, air that remains in the fluid will be purged after a short period of operation. Remember – make sure the shock is vertical, and always extend the shock right-side-up and compress it upside-down.

When you're ready to install the shock, always extend it in the upright position, never in a horizontal or inverted position. If you do, you'll aerate the shock all over again. If you remove a shock and plan on reinstalling it, the first thing to do is to invert it and compress it.

Be extra careful not to ever throw any shock around or get careless and drop it on the floor. The pressure tube could be damaged or the piston rod bent. A bent piston rod will put abnormal pressure on the rod guide and seal and will ruin the shock in a very short time. The bushings which are used inside the mounting eyes of the shock must be installed properly. There are also a variety of bushings that are used for different applications. Make sure you use the correct bushing and tighten the mounting nut to the correct torque.

Another important factor about the bushings is that they must be centered radially in their normal load position before they are tightened. The rubber bushing in the shock absorber mounting ring twists to allow movement between the shock and the part it's connected to. The bushing must be able to twist equally in either direction from the normal load position as the suspension moves up and down. This twisting action is known as "wind-up."

RS5000 Cellular Gas Shocks				
Year	Vehicle	Raised Height	Front	Rear
1984-92	Jeep Cherokee	Stock-3"	P5249310	P52493 11
1986-92	Jeep Comanche	Stock-3"	P52493 10	P52493 14"
1986-92	Jeep Wrangler	Stock- 1.5"	P52493 12	P52493 13

If the bushing mounting nut is tightened when the vehicle is raised off the wheels, the bushing will wind **up** in one direction when the wheels and suspension return to the normal load position. The resultant wind-up puts a constant strain on the bushing as well as the piston rod and seal, which can shorten the service life of the shock considerably.

Note: Never use any kind of lubricant other than water or soapy water on rubber bushings before or after they are installed. A lubricated bushing may slip and wear out instead of flexing normally.

RS5000 Cellular Gas Shocks

Our RS5000 shocks bridge the gap between a comfortable street ride and high performance off-road control. This is accomplished through a combination of our high-temp "cellular gas design" and our unique nine-stage velocity-sensitive valving. (Sold Individually.) Features include:

- Massive 1-3/8" steel piston head
- 14 mm chrome hardened rod
- Expanded oil reservoir
- Includes shock boot

Heavy Duty Urethane Suspension Bushings

All Mopar Performance Parts bushings are manufactured of tough and durable polyurethane which gives the bushings higher durometers than the production rubber units. The added stiffness can make the part stronger but the real advantage is that the increased stiffness increases the control of the part which can improve vehicle handling in race situations.

Steering Stabilizers

Our single stabilizers are high performance stabilizers that will exceed standard or so-called heavy duty stabilizers. They are engineered to work on standard vehicles during highway driving and will withstand the punishment of hard off-road use.

TIRES

The front and rear suspension are the link between the vehicle's body and the vehicle's wheels. The suspension and steering systems *control* wheel movement and direction. However, it is the tires which actually *determine* direction.

Don't forget that the only contact the vehicle has with the road is through the relatively small patch areas of the four tires. All directional as well as starting and stopping control is concentrated at these four tire contact areas.

Choosing Tires for On or Off-Road

They're all round and black and they help propel your car, van or light truck, but the similarity in tires ends there. An array of choices await today's tire buyer. Here are some simple rules to follow when shopping for tires:

First, analyze your tire needs—which aspects of tire performance are most important to you? What weather, road conditions and passenger/cargo loads characterize most of your daily driving? What type of vehicle do you drive, and how far do you generally go? The large assortment of tires on the market today virtually assures there will be several suited to your needs. But choosing the correct tire size and type is easier than you might think.

If you're happy with the tires that came on your vehicle when it was new, that's a good place to start. You may want to consider replacement with the same type and size the vehicle manufacturer selected as original equipment. If your vehicle was made sometime in the last two decades or so, chances are that you have radial tires.

Radial tires, known for durability and fuel efficiency that exceeds their bias and bias-belted predecessors, are original equipment on all vehicles today. Radial tires may be conventional, all-season, snow, or performance tires, each designed to fit different driver needs and expectations. This is where an honest evaluation of your driving habits can pay off.

Year	Vehicle	Single
1984-92	Jeep Cherokee with 0" to 3" lift	P5249291
1986-92	Jeep Comanche with 0" to 2" lift	P5249291
1986-92	Jeep Wrangler with 0" to 2" lift	P5249292

Heavy-Duty Urethane Suspension Bushings (Jeep)	
P4876222	Leaf Spring Bushing Set - Front & Rear - CJ5, CJ7, CJ8 and 1987-94 Wrangler
P4876223	Leaf Springs Bushing Set - Front - CJ5, CJ7, CJ8 and 1987-94 Wrangler
P4876224	Leaf Spring Bushing Set - Front & Rear - CJ5, CJ7, CJ8, and 1974-75 Wrangler
P4877225	Leaf Spring Bushing Set - Rear - CJ5, CJ7, CJ8 and 1981-86 Wrangler
P4876226	Body (Cab) Mount Kit - 1987-94 CJ5, CJ7, CJ8 and Wrangler
P4876227	Body (Cab) Mount Kit - 1981-86
P4876228	Body (Cab) Mount Kit - 1981-86 CJ5 and CJ7
P4876229	Body (Cab) Mount Kit - 1976-79 CJS, CJ7, and CJ8
P4876230	Body (Cab) Mount Kit - 1974-75 CJ5, CJ7, and CJ8
P4876231	Body (Cab) Mount Kit - 1955-73 CJ5, CJ7, and CJ8
P4876232	Sway Bar Bushing Kit - 15/16" - 1987-94 CJ5, CJ7, CJ8 and Wrangler
P4876233	Sway Bar Bushing Kit - 11/8" - 1987-94 CJ5, CJ7, CJ8 and Wrangler

Heavy-Duty Urethane Suspension Bushings (Jeep)	
P4876234	Sway Bar Bushing Kit - 15/16" - 1981-86 CJ5, CJ7, and CJ8
P4876236	Frame Shackle Bushing Kit - Front Front & Rear - 1987-92 CJS, CJ7, CJ8, and Wrangler (4 Bushings)
1'4876237	Frame Shackle Bushing Kit - Front - 1976-86 CJS, CJ7, CJ8 and Wrangler
P4876238	Frame Shackle Bushing Kit - Rear - 1976-86 CJ5, CJ7, CJ8 and Wrangler
1'4876239	Transmission Torque Arm Grommets - 1973-86 Jeep CJ (2 per package)
1'4876240	Track Arm Bushing Kit - Front or Rear 1987-94 Wrangler
1'487624 1	Control Arm Bushing Kit - Front - 1993-94 Grand Cherokee
1'4876242	Control Arm Bushing Kit - Rear - 1993-94 Grand Cherokee
1'4876243	Sway Bar Bushing Kit - Front - 1993-94 Grand Cherokee
# 876244	Sway Bar Bushing Kit - Rear - 1993-94 Grand Cherokee
P4876245	Track Bar Bushing Kit - Front - 1993-94 Grand Cherokee
P4876246	Track Bar Bushing Kit - Rear - 1993-94 Grand Cherokee



Check your vehicle's door pillars or glove compartment for a tire information placard that lists the size, type and inflation pressure of tire recommended for your vehicle by its manufacturer. It may list other tire size options, but check with a tire dealer before making any modifications.

The tire sidewall can also be a good source of information for the consumer. Molded into each sidewall by the tire manufacturer is an alpha-numeric code such as P195/75R14. While this may seem like alphabet soup to tire buyers, the codes are fairly simple: **P** is for passenger tire; 195 is the width from sidewall to sidewall, measured at the widest point in millimeters; 75 is the ratio of tire height to width; **R** means radial; and 14 is the rim diameter in inches.

Another tool for shopping comparison is the Uniform Tire Quality Grading System (UTQGS). Under UTQGS guidelines, tire manufacturers test their passenger tires for three performance factors: tread wear, traction, and temperature resistance. The grades, which are reported to the National Highway Traffic Safety Administration (NHTSA), are molded in the sidewall and appear on paper labels affixed to the tire tread. All tires must also conform to federal safety standards.

However, the UTQGS ratings are relative only within a given manufacturer's tire line. They may not be useful for performance comparison among manufacturers due to widely varying driver habits and tire maintenance. Tread wear ratings cannot be translated into specific tire mileage guarantees, according to the NHTSA and the Federal Trade Commission.

General Performance Strategies

Since lateral stability is very closely related to tires and wheels, it is easy to understand why the largest recommended tires, maximum duty ply rating and maximum wheel rim width all contribute to directional stability. This is particularly important on fully or heavily loaded vehicles.

Some of the following points were made earlier but they are worth repeating because of their effect on handling. Don't put an oversize tire on an undersize rim. If the rim is too narrow for the tire, the sidewalls will bulge excessively and you won't gain anything in load-carrying capacity or stability. For every stability problem, be sure to check tire size and type as well as tire pressure first.

If you are in doubt about the brand, size, or type of tire on a vehicle with handling problems, install a set of tires and wheels from another vehicle (ask a friend). Make sure these substitute wheels and tires are of the recommended size and inflated to recommended pressures. Road test to see if the condition has improved.

MOPAR PERFORMANCE PARTS INFORMATION AND SOURCES

Mopar Performance Parts Race Team

In March of 1983, Mopar Performance Parts began its Race Team in an effort to keep in touch with more Mopar enthusiasts and to get our latest engineering information dispersed faster. At this writing there are over ten thousand members and we're continuing to grow.

Eighteen dollars is all it costs to get a full year's subscription to *Mopar Performance News*. MPN has all the latest on new products, performance tips, race results, and more. And we'll toss in all the following items (including a current *Mopar Performance Parts Catalog*, a \$5.00 value!) at no extra cost. And with your own personal ID card number, you'll be entitled to special incentives during the year. Join now!

- One year subscription to *Mopar Performance News* (10 issues)
- *Mopar Performance Parts Catalog*
- *Mopar Sportswear Catalog*
- Race Team Membership Card
- Race Team Member Decal
- Discounts on Mopar Sportswear and Collectibles
- Race Event Ticket Discounts

To enroll, call our toll free number (1-800-348-4696), or send your \$18.00 check or money order (made payable to DaimlerChrysler) to the following address:

Mopar Performance Parts Catalog Center, Dept.
 NCTS
 P.O. Box 360445
 Stongsville, Ohio 44136

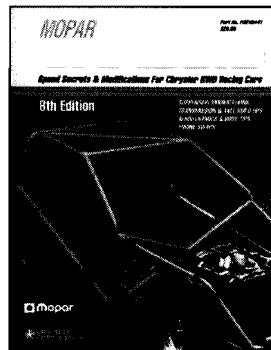
Note: The items listed in the Race Team package are current as of August, 1999. Future packages may change somewhat. Refer to the latest *Mopar Performance Parts Catalog*, *Mopar Performance News*, or call the Mopar Performance Parts Technical Assistance Hotline (1-248-969-1690) for the most up-to-date information.

Mopar Performance Parts Racing Books

These speed secret performance books are the bibles of Mopar racing. They are filled with technical information, schematics, and other data you'll need to build a winning race vehicle. Let our factory engineers and Mopar Performance Parts race teams put their knowledge and experience to work for you.

Mopar Chassis - 8th Edition

This book is a compilation of engineering information for the full range of chassis modifications of rear wheel drive cars. This 8th Edition has been revised, rewritten and updated to keep you competitive. DaimlerChrysler engineers have removed dated information and added 125 new pages to produce a book full of helpful hints for

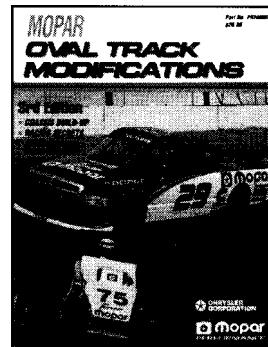


DaimlerChrysler enthusiasts, including some tips for race trucks. Racers will find this book invaluable for suspension, body components, axle, transmission, and drivetrain build-up, plus much more. (370 pages)

P5249441 *Mopar Chassis-8th Edition*

Mopar Oval Track Modifications- 3rd Edition

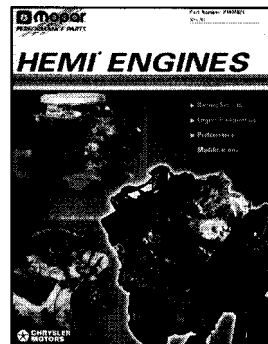
This is the book every Mopar oval track racer must have. It includes complete engine and chassis build-up information. Speed secrets and racing tips are directed primarily toward Chrysler-Plymouth-Dodge V-8 engines (273-318, 340-360 'A' engines; 361-383-400 'B' engines; 413-426W-440 'RB' engines; 5.2L and 5.9L Magnum engines). Additional chapters include information on automatic and manual transmissions, driveshafts and rear axles, front and rear suspension, steering and handling, brakes, shocks, wheels and tires, body and chassis. Late Model, Sprint Car, and NASCAR Truck racing specifications and performance recommendations are also included. Summarizes more than four decades of Chrysler-Plymouth-Dodge involvement in oval track engineering and on-track testing. (500 pages)



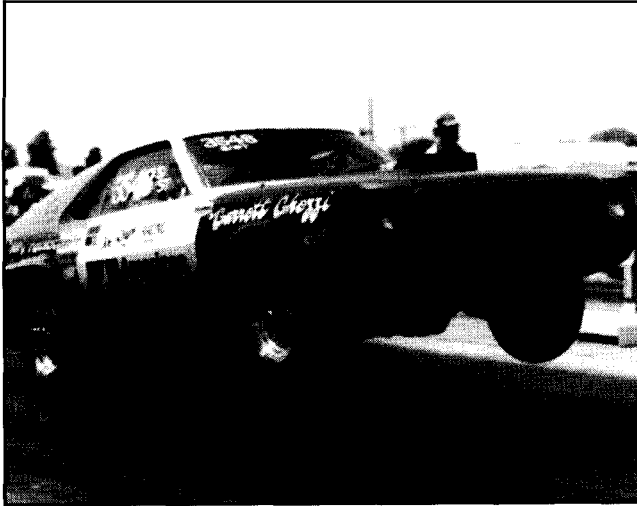
P5249959 *Mopar Oval Track Modifications-3rd Edition*

Hemi® Engines

If you currently own or have ever dreamed of owning a Hemi-powered vehicle, you want to get this new book from Mopar Performance Parts. It includes an extensive chapter on Hemi development and racing history, as well as detailed information on 331-354-392 Hemis, 426 Street and Race Hemis, Hemi Crate engines, carburetion, ignition systems, racing secrets, engine blueprinting, performance modifications, and more! Contains hundreds of photos, illustrations, tables, and charts. The most comprehensive book ever published on the Hemi engine from the company that built it! (456 pages)

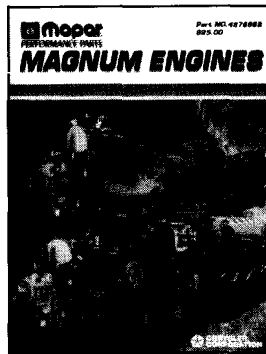


P4876824 *Hemi® Engines*



Magnum Engines

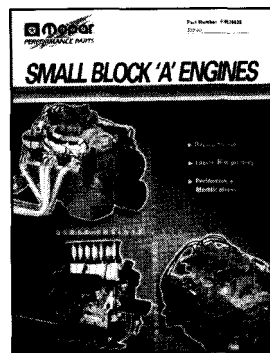
This book from Mopar Performance Parts contains Magnum engine build-up information, speed secrets, and racing tips. Includes performance information on 5.2L and 5.9L V-8, 8.0L V-10, 3.9L V-6, and 2.5L 4-cylinder Magnum engines, including our 300 and 380 horsepower Magnum Crate engines. This book is a must for every Magnum engine owner/racer. (400 pages)



P4876668 *Magnum Engines*

Small Block 'A' Engines

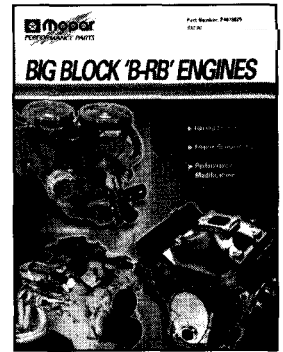
This new book from Mopar Performance Parts contains small block engine speed secrets and performance modifications, highlighted by hundreds of photos, illustrations, tables, and charts. Covers 273-318 and 340-360 'A' engines, and Old Style 277-301-318 'A' engines. Also includes information on blueprinting, carburetion, ignition systems, oval track and drag racing package recommendations, and more! The most comprehensive book ever published on DaimlerChrysler 'A' engines. A must for every small block owner/racer. (400 pages)



P4876826 *Small Block 'A' Engines*

Big Block 'B-RB' Engines

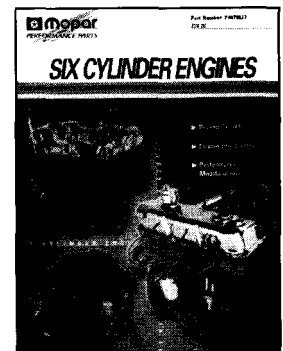
This new book from Mopar Performance Parts contains big block engine speed secrets and performance modifications, highlighted by hundreds of photos, illustrations, tables, and charts. Covers 361-383-400 'B' and 413-426W-440 'RB' engines. Also includes information on blueprinting, carburetion, ignition systems, oval track and drag racing package recommendations, and more! The most comprehensive book ever published on DaimlerChrysler 'B-RB' engines. A must for every big block owner/racer. (424 pages)



P4876825 *Big Block 'B-RB' Engines*

Six Cylinder Engines

If you own a 1986-91, 3.9L V-6 engine or any 170-198-225 Slant Six engine, you'll want to get this new speed secrets and racing modifications book from Mopar Performance Parts. It also includes chapters on 3.0L and 3.3/3.8L V-6 engines, as well as our new family of 2.7L, 3.2L, and 3.5L aluminum V-6 engines. This book is packed full of six cylinder-only information, highlighted by hundreds of photos and illustrations. Includes horsepower tips, engine blueprinting procedures, performance modifications, and racing secrets from our factory engineers and racers. (344 pages)



P4876827 *Six Cylinder Engines*



Neon Performance Modifications

This book from Mopar Performance Parts is a must for every Neon owner and racer. Contains technical help and engineering information covering every aspect of vehicle preparation, including 2.0L engines (SOHC and DOHC), transmissions (manual and automatic), body, chassis, and suspension build-up. Covers all types of Neon racing. (350 pages)

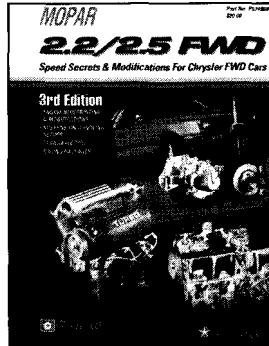
P4876667 *Neon Performance Modifications*



2.2/2.5 FWD - 3rd Edition

This is the book for those of you who want to modify your Chrysler-Plymouth-Dodge 2.2L or 2.5L FWD car. Includes technical help and engineering information covering every aspect of vehicle preparation from engine and transmission to body, chassis, and suspension build-up. Indispensable for serious 2.2L and 2.5L FWD racers. Covers all types of racing. (380 pages)

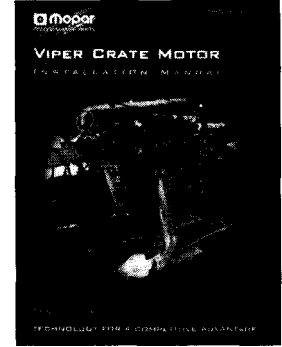
P5249585 *2.2/2.5 FWD-3rd Edition*



Viper Crate Motor Installation Manual

This brand-new manual from Mopar Performance Parts is must reading for anyone who wants to custom-install our 450 horsepower, Viper V-10 Aluminum Crate motor into a Street Rod chassis, or is simply replacing an engine in an existing Viper coupe or roadster. It contains all the information needed to do the project right, highlighted by over one hundred detailed photographs and illustrations. In addition to step-by-step installation procedures, the manual includes detailed package drawings showing engine and transmission mounting points, overall dimensions, critical clearances, etc., as well as important information on the following systems: fuel delivery, fuel injection, electrical, intake, exhaust, cooling, and oiling. Additional information includes long and short term storage procedures, general specifications charts, troubleshooting tips, and available performance upgrades. Straight from the engineers who designed and developed the now-legendary Viper! (94 pages)

P5007220 *Viper Crate Motor Installation Manual*



Mopar Performance Parts Catalogs

2000 Mopar Performance Parts Catalog

The Mopar Performance Parts Catalog is updated yearly, and includes hundreds of pages of parts for any Chrysler-Plymouth-Dodge-Jeep engine that you may have. This catalog is a must for every Chrysler-Plymouth-Dodge-Jeep owner and racer.

Note: The part number for this catalog changes each year. The number listed below is for the 2000 catalog. Refer to the latest copy of Mopar Performance News or contact your local Chrysler-Plymouth-Dodge-Jeep dealer for the latest information.

P5007400 *2000 Mopar Performance Parts Catalog*

Sportswear Collection from Mopar

For the DaimlerChrysler enthusiast in you. For complete information on the *Sportswear Collection from Mopar*, contact Collection Headquarters at P.O. Box 185, Southfield, Michigan 48037-0185. To order with a major credit card, call 1-888-267-2187, or fax your order by calling 1-888-452-9197.

Mopar Performance Parts Technical Assistance

If you find that you need further assistance, or have any performance and/or modification questions you would like to ask, you can contact Mopar Performance Parts Technical Assistance.

Write to:

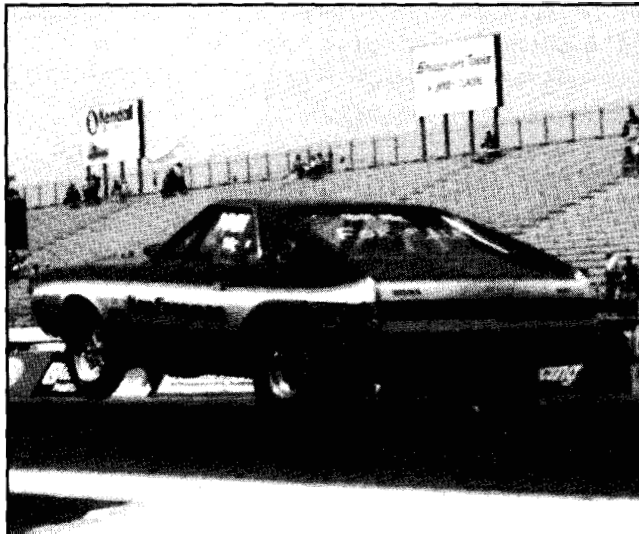
Mopar Performance Parts Technical Assistance
P. O. Box 597
Oxford, Michigan 48371-0597

Or call:

1-248-969-1690
Monday through Friday
8:00 a.m. - 12:00 p.m.
1:00 p.m. - 5:00 p.m. (EST)

Or fax:

1-248-969-3342



Mopar Performance Parts Website

Be sure to check out our new website. You'll find all the latest Mopar Race Team results, our on-line parts catalog, and a forum to ask our tech experts any questions you may have regarding your DaimlerChrysler product. The address is: <http://Nwww.performanceparts.mopar.com>.

Mopar Car Club Directory

For the latest and most up-to-date listing of Mopar car clubs throughout the world, refer to recent issues of *Mopar Performance News*. The entire club listing is updated on a regular basis.

Mopar National Events

Perhaps the best way of all to find those rare vehicles and parts you've been looking for is to attend a major Mopar national event during the race season. The granddaddy of them all – the Mopar Nationals – keeps setting new records each and every year it's run.

You say you like Street Rods? Pro Mods? Trucks? Convertibles? Street Machines? Muscle Cars? Top Fuelers? Pro Stockers? Whatever your fancy, Mopar-sponsored national events have them all! Keep up on all the events (times and places) by checking the latest issues of *Mopar Performance News*.

ADDITIONAL SOURCES

DaimlerChrysler Sources

1. *DaimlerChrysler Service Publications*

Owner's and service manuals for various Chrysler-Plymouth-Dodge-Jeep models are available from 1975 through the current year with only a few exceptions. For more information, write to:

Service Publications
DaimlerChrysler Corporation
20770 Westwood Road
Strongsville, Ohio 44136

2. *Walter P. Chrysler Museum*

To obtain additional Chrysler-Plymouth-Dodge-Jeep historical production information, write to:

Walter P. Chrysler Museum
800 Chrysler Drive
Auburn Hills, Michigan 48236



Newspapers and Magazines

For information on racing or where to buy vehicles and parts, some of the best sources are:

1. *Hemmings Motor News*
P.O. Box 100-S19698
Bennington, Vermont 05201
www.hmn.com
2. *Cars & Parts Magazine*
P.O. Box 482
Sidney, Ohio 45367
www.carsandparts.com
3. *Old Cars Weekly*
c/o Krause Publications, Inc.
700 East State Street
Iola, Wisconsin 54990
www.krause.com
4. *National DRAGSTER*
2035 Financial Way
Glendora, California 91741
www.nhraonline.com
5. *DRAG Review*
P.O. Box 3029
Bristol, Tennessee 37625-3029
www.goracing.com/ihra
6. *Drag Racing Monthly*
P.O. Box 420234
Palm Coast, Florida 32142-0234
7. *Mopar Muscle Magazine*
Subscription Fulfillment Center
P.O. Box 334
Mt. Morris, Illinois 61054-7937
www.moparmusclemagazine.com
8. *Short Track Racing*
71 Wansley Drive, Suite A
Cartersville, Georgia 30120

Drag Racing Organizations

1. *NHRA*
(National Hot Rod Association)
2035 Financial Way
Glendora, California 91741
www.nhraonline.com
2. *IHRA*
(International Hot Rod Association)
P.O. Box 3029
Bristol, Tennessee 37625
www.goracing.com/ihra

Oval Track Racing Organizations

1. *NASCAR*
(National Association for Stock Car Auto Racing)
P.O. Box Bin K
Daytona Beach, Florida 32015
www.nascar.com
2. *ARCA*
(Automobile Racing Club of America)
8117 Lewis Avenue
Temperance, Michigan 48182
3. *CASCAR, Inc.*
(Canadian Association for Stock Car Auto Racing, Inc.)
117 Superior
Komoka, Ontario
N0L 1R0
4. *USAC*
(United States Auto Club)
4910 West 16th Street
Speedway, Indiana 46224
5. *ASA*
(American Speed Association, Znc.)
P. O. Box 2500
Anderson, Indiana 46011

Sports Car Racing Organizations

SCCA
(Sports Car Club of America)
National Office
9033 E. Easter Place
Englewood, Colorado 80112
www.scca.org

Chapter 9

Additional Information



TECHNOLOGY FOR A COMPETITIVE ADVANTAGE

RACING FORMULAS

There are many mathematical formulas used by racers for various performance calculations. For your reference, we have reprinted several of the most often used formulas.

For reference:

$$\pi = 3.1415927$$

$$\frac{\pi}{4} = 0.7853982$$

Cylinder Volume

$$\frac{\pi}{4} \times \text{bore}^2 \times \text{stroke}$$

Cylinder Displacement

$$\frac{\pi}{4} \times \text{bore}^2 \times \text{stroke} \times \text{number of cylinders}$$

Stroke

$$\frac{\text{displacement}}{\frac{\pi}{4} \times \text{bore}^2 \times \text{number of cylinders}}$$

Bore

$$\sqrt{\frac{\text{displacement}}{\frac{\pi}{4} \times \text{stroke} \times \text{number of cylinders}}}$$

Compression Ratio

$$\frac{\text{cylinder} + \text{chamber volume}}{\text{chamber volume}}$$

Chamber Volume

$$\frac{\text{cylinder volume}}{\text{compression ratio} - 1.0}$$

Displacement Ratio

$$\frac{\text{cylinder volume}}{\text{chamber volume}}$$

Horsepower

$$\frac{\text{rpm} \times \text{torque}}{5252}$$

Torque

$$\frac{5252 \times \text{horsepower}}{\text{rpm}}$$

Bhp Loss

$$\frac{\text{elevation in feet}}{1000} \times 0.03 \times \text{bhp at sea level}$$

Determining Optimum Overall Quarter Mile Gear Ratio

$$\text{Manual transmission} = \frac{\text{tire diameter}}{340 \text{ mph}} \times \frac{\text{rpm}}{\text{mph}}$$

$$\text{Automatic transmission} = \frac{\text{tire diameter}}{335 \text{ mph}} \times \frac{\text{rpm}}{\text{mph}}$$

Quarter Mile E.T. Estimate

$$\text{E.T.} = \sqrt[3]{\frac{\text{weight}}{\text{hp}}} \times 5.825$$

where:

$$\text{hp} = \frac{\text{weight}}{(\text{E.T.} \div 5.825)^3}$$

$$\text{weight} = \left(\frac{\text{E.T.}}{5.825}\right)^3 \times \text{hp}$$

Quarter Mile mph Estimate

$$\text{mph} = \sqrt[3]{\frac{\text{hp}}{\text{weight}}} \times 234$$

where.

$$\text{hp} = \left(\frac{\text{mph}}{234}\right)^3 \times \text{weight}$$

$$\text{weight} = \left(\frac{234}{\text{mph}}\right)^3 \times \text{hp}$$

CHRYSLER-PLYMOUTH-DODGE-JEEP BODY AND ENGINE TYPES

Rear Wheel Drive and Four Wheel Drive Terminology Cross Reference	
Body Type	
A-Body	1964-76 Valiant 1964-69 Barracuda 1964-76 Dart All Duster Demon sport Scamp Swinger
B-Body	Coronet Satellite Road Runner Charger GTX R/T Belvedere Super Bee Cordoba 1976-78 Fury 1977-78 Monaco 1978-79 Magnum
E-Body	1970-74 Barracuda Challenger
F-Body	1976-80 Volare and Aspen Road Runner and R/T
J-Body	1980-83 Mirada and Cordoba
M-Body	1977-88 Diplomat LeBaron Gran Fury Fifth Avenue
AN-Body	1987-99 Dakota
DN-Body	1998-99 Durango
R-Body	1979-81 New Yorker St. Regis
XJ-Body	1984-99 Cherokee
YJ-Body	1987-96 Wrangler
TJ-Body	1997-99 Wrangler
ZJ-Body	1992-98 Grand Cherokee
WJ-Body	1999 Grand Cherokee
T300-Body	1994-99 Ram
VIPER-Body	1992-99 Viper RT/10 1997-99 Viper GTS

Rear Wheel Drive and Four Wheel Drive Terminology Cross Reference	
Engine Type	
Four Cylinder	2.5L
Six Cylinder	170 (Slant Six) 198 (Slant Six) 225 (Slant Six) 4.0L
V-6	3.9L (through 1991)
Magnum V-6	3.9L (1992-present)
'A' Engine	273 318 (1967-91 only) 340 360 (through 1992)
Magnum V-8	5.2L (1992-present) 5.9L (1993-present)
'B' Engine	361 383 400
'RB' Engine	413 426 Wedge 440
Hemi	426
Magnum V-10	8.0L
Terminology usage example: A 1973 Challenger equipped with a 340 engine is considered an 'A' engine, E-Body.	

METRIC TO ENGLISH CONVERSION TABLE

Multiply		By	=	To Get	Multiply		By	=	To Get
in-lbs	x	0.11298	=	Newton-Meters (N•m)	(N•m)	x	8.851	=	in-lbs
ft-lbs	x	1.3558	=	Newton-Meters (Nom)	(Nom)	x	0.7376	=	ft-lbs
Inches Hg (60°F)	x	3.377	=	Kilopascals (kPa)	(kPa)	x	0.2961	=	Inches Hg
Pounds/Sq-in	x	6.895	=	Kilopascals (kPa)	(kPa)	x	0.145	=	Pounds/Sq-in
Inches	x	25.4	=	Millimeters (mm)	(mm)	x	0.03937	=	Inches
Feet	x	0.3048	=	Meters (M)	(M)	x	3.281	=	Feet
Yards	x	0.9144	=	Meters (M)	(M)	x	1.0936	=	Yards
Miles	x	1.6093	=	Kilometers	(Km)	x	0.6214	=	Miles
Miles/Hour	x	1.6093	=	Kilometers/Hour (Km/h)	(Km/h)	x	0.6214	=	Miles/Hour
FeeVSecond	x	0.3048	=	Meters/Second (M/S)	(MS)	x	3.281	=	FeeVSecond
Kilometers/Hour	x	0.27778	=	Meters/Second (M/S)	(MS)	x	3.600	=	Kilometers/Hour
Miles/Hour	x	0.4470	=	Meters/Second (M/S)	(MS)	x	2.237	=	Miles/Hour
Common Metric Equivalents									
1 Inch	=	25 Millimeters			1 Cubic Inch	=	16 Cubic Centimeters		
1 Foot	=	0.3 Meter			1 Cubic Foot	=	0.03 Cubic Meter		
1 Yard	=	0.9 Meter			1 Cubic Yard	=	0.8 Cubic Meter		
1 Mile	=	1.6 Kilometers							

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