

480 LOADER

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Product: Case 480 Backhoe Loader Service Repair Manual 9-72572
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Sample of manual. Download All 535 pages at:
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diesel engine

C-2

188 ENGINE SPECIFICATIONS

Type ----- CASE Full Diesel, 4 Cylinder 4 Stroke Cycle Valve-in-Head Engine.

No. of Cylinder Heads ----- 1

Firing Order ----- 1-3-4-2

Bore ----- 3-13/16 Inches

Stroke ----- 4-1/8 Inches

Piston Displacement ----- 188 Cubic Inches

Compression Ratio ----- 17.5 to 1

Oil Filter, Crankcase ----- Replaceable Full Flow Element Type.

Method of Starting Diesel Engine ----- Electric Starting Motor.

Maximum Compression Pressures ENGINE WARMED UP TO OPERATING TEMPERATURE CRANKING AT APPROXIMATELY 200RPM

Altitude Sea Level 1000 ft. 2000 ft. 3000 ft. 4000 ft. 5000 ft.
Compression 400 PSI 389 PSI 373 PSI 359 PSI 346 PSI 332 PSI

Allowable Variance Between Cylinders ----- 20 Pounds

CYLINDER SLEEVES

Type ----- Replaceable Wet Type; Two Rubber "O" Ring Seals Carried on Each Sleeve.

Inside Diameter of Sleeve Bore ----- 3.8110 to 3.8120 Inches. Replace Sleeve When Inside Diameter Below Top Ring Ridge Exceeds 3.819 Inches.

Piston Clearance in Sleeve (At Skirt) ----- .002 to .005 Inch

Cylinder Sleeve Protrusion Above Block ----- .002 to .005 Inch

PISTON AND PISTON PINS

Piston Material ----- Aluminum

Piston Weight (Less Pin) ----- 2.224 to 2.233 Pounds

Diameter of Piston at Top of Skirt (Below Oil Ring Perpendicular to Pin) ----- 3.805 to 3.806 Pounds

Diameter of Piston at Bottom of Skirt (Perpendicular to Pin) ----- 3.807 to 3.808 Inches

Piston Pins ----- Full Floating Type; Held in Position With Snap Rings in Piston. Replaceable Bronze Bushing in Connecting Rod.

Piston Pin Length ----- 3.147 to 3.167 Inches

Piston Pin Diameter ----- 1.2497 to 1.2498 Inches

Piston Pin Fit in Piston ----- .0001 to .0004 Inch

Piston Pin Fit in Connecting Rod Bushing ----- .0002 to .0005 Inch

PISTON RINGS

Rings Per Piston ----- 3 (2 Compression and 1 Oil)

Compression Rings

Width of Ring-Top (Keystone) ----- .1225 to .124 Inch

2nd ----- .0930 to .0935 Inch

Ring End Gap When Compressed in 3.8125 Inch Cylinder ----- .015 to .025 Inch

Side Clearance in Groove of 2nd Ring ----- .0035 to .005 Inch

Oil Ring ----- To Install Replacement Ring, Follow Instructions Packed With Rings.

Width of Ring ----- .1825 to .1885 Inch

Side Clearance in Groove ----- .0000 to .007 Inch

CONNECTING RODS

Connecting Rod Bushing ----- Replaceable Bronze Bushing. Replacement Bushing Must Be Reamed. Use 1.2500 to 1.2502 Reamer.

Piston Pin Hole Diameter in Rod(Without Bushing)-1.312 to 1.313 Inches

Inside Diameter of Piston Pin Bushing in Rod ----- 1.2500 to 1.2502 Inches; Install New Bushing If Inside Diameter Exceeds 1.2507 Inches.

Connecting Rod Bearing ----- Replaceable Precision, Steel Backed Aluminum Liners

Connecting Rod Capscrews ----- Self Locking Type, No Lock Wires Required; May Be Used More Than Once.

Connecting Rod Length (Center to Center Between Pin Hole and Bearing Journal Hole) --- 7.0029 to 7.0039 Inches

Bearing Liner Width ----- 1.125 Inches

Diameter of Crankshaft Journal Hole in Rod (Without Liner) ----- 2.1870 to 2.1875 Inches

Inside Diameter of Bearing Liner (Standard Liner in Place in Rod and Capscrews Tight) ----2.0625 to 2.0640 Inches

Diameter of Crankshaft Rod Journal -----2.0605 to 2.0615 Inches

Clearance Between Rod Bearing and Crankshaft Journal ----- .001 to .0035 Inch; Install New Bearing Liners When Clearance Exceeds .006 Inch.

Undersize Bearing Liners Available for Service ----- .002, .010, .020, .030 Inch

Allowable Connecting Rod Bearing End Play ----- .005 to .011 Inch

CRANKSHAFT AND MAIN BEARINGS

Crankshaft ----- Balanced; Drilled to Provide Pressure Lubrication to Main and Connecting Rod Bearings.

Type Main Bearings ----- Replaceable, Precision, Steel Backed Aluminum Liners.

Bearing Capscrews ----- Self Locking Type; No Lock Wires Required. May Be Used More Than Once

Bearing Taking End Thrust ----- Center

Crankshaft End Play (Measured at Center Main Bearing) ----- .001 to .006 Inch; Install New Bearing If End Play Exceeds .012 Inch.

Main Bearing Journal Diameter ----- 2.873 to 2.874 Inches

Crankshaft Main and Connecting Rod Journal Bearings out of Round ----- Maximum .002 Inch

Inside Diameter of Main Bearing Liners (In Place and Capscrews Tight)----- 3.8748 to 3.8768 Inches

Clearance Between Main Bearing Liner and Journal ----- .0008 to .0038 Inch; Install New Bearing Liner When Clearance Exceeds .006 Inch.

Width of 1st Main Bearing Liner (Front) ----- 1.276 to 1.286 Inches

Width of 2nd and 4th Main Bearing Liners ----- .980 to 1.000 Inches

Width of 3rd (Center) Main Bearing Liner ----- 1.371 to 1.373 Inches

Width of 5th (Rear) Main Bearing Liner ----- 1.5575 to 1.5675 Inches

Width Between Crankshaft Main Bearing Cheeks

5th ----- 1.745 to 1.755 Inches

2nd, 4th ----- 1.185 to 1.189 Inches

3rd (Center)----- 1.374 to 1.377 Inches

Width Between Crankshaft Rod Bearing Journal Cheeks ----- 1.3105 to 1.3145 Inches

Undersize Main Bearing Liners Available for Service ----- .002, .010, .020, .030 Inch

**Crankshaft Main Bearing Journals
Should Be Ground to**

2.863 to 2.864 Inches for .010 Inch Undersize Bearing
2.853 to 2.854 Inches for .020 Inch Undersize Bearing
2.843 to 2.844 Inches for .030 Inch Undersize Bearing

Undersize Connecting Rod Bearing

Shells Available for Service ----- .002, .010, .020, .030 Inch

**Connecting Rod Crankshaft Journals Should
Be Ground to**

2.0505-2.0515 Inches for .010 Inch Undersize Bearing
2.0405-2.0415 Inches for .020 Inch Undersize Bearing
2.0305-2.0315 Inches for .030 Inch Undersize Bearing

CAMSHAFT AND BUSHINGS

Number of Bearing Surfaces on Camshaft -----5

Type Bushing ----- Replaceable, Precision, Steel Backed Babbitt

Diameter of Camshaft at Each Bearing Surface --- 1.749 to 1.750 Inches

Inside Diameter of Each Bushing
(Measured When in Place in Block) -----1.752 to 1.753 Inches

No. 1 (Front) Bushing Length ----- 1.213 to 1.223 Inches

No. 2 and 4 Bushing Length ----- .490 to .500 Inch

No. 3 Bushing Length ----- .713 to .723 Inch

No. 5 Bushing Length ----- 1.213 to 1.223 Inches

Camshaft End Play ----- Taken Up By Thrust Plate

Camshaft Thrust Plate Thickness ----- .147 to .149 Inch

Camshaft End Clearance ----- .003 to .007 Inch

TIMING GEARS

Total Gear Train Backlash (From Crankshaft to Injection Pump
Drive Gear)-Measured at Injection Pump Drive Gear --- Max. .030 Inch

Backlash Between Oil Pump Drive Gear
and Crankshaft Gear ----- .003 to .007 Inch

VALVE PUSH ROD LIFTERS

Type ----- Mushroom Type

Outside Diameter of End That Projects into Block --- .561 to .562 Inch

Diameter of Bore in Block for Lifter ----- .5625 to .5635 Inch

VALVES

Valve Tappet Clearance

Intake and Exhaust ----- .014 Inch, Engine Cold
Intake and Exhaust ----- .014 Inch, Engine Hot
Hot Settings Are Made At Low Idle After The Engine Has Operated At
Thermostat Control Temperature For At Least Fifteen Minutes.

Exhaust Valves

Angle of Valve Face ----- 44 Degrees

Valve Length ----- 6.339 to 6.364 Inches

Maximum Valve Face Runout ----- .002 Inch as Determined with a Dial
Indicator

Diameter of Valve Stem --.3399 to .3409 Inch Install New Valve If There
is More Than .002 Inch Difference in Diameter
At Any Point on Stem

Diameter of Valve Head -----1.403 Inches

Exhaust Valve Seat Insert

Seat Angle ----- 45 Degrees

Seat Width ----- .072 to .085 Inch

Insert Height ----- .2475 to .2525 Inch

Outside Diameter of Insert ----- 1.445 to 1.4505 Inches

Inside Diameter of Insert ----- 1.245 to 1.255 Inches

Maximum Allowable Seat Runout ----- .002 Inch as Determined
with a Dial Indicator

Exhaust Valve Guides

Length ----- 3.125 Inches

Outside Diameter ----- .6565 to .6575 Inch

Inside Diameter ----- .3429 to .3439 (After Assembly)

Valve Stem Clearance in Guide ----- .002 to .004 Inch

Distance Above Head Guide Must Protrude ----- .875 Inch, Press Fit

Intake Valves

Angle of Valve Face ----- 44 Degrees

Valve Length ----- 6.334 to 6.369 Inches

Maximum Valve Face Runout ----- .002 Inch as Determined
with a Dial Indicator

Diameter of Valve Stem ----- .3409 to .3419 Inch. Install New Valve
if there is More Than .002 Inch Difference in
Diameter at any Point on Stem.

Diameter of Valve Head ----- 1.604 Inches

Intake Valve Seat

Seat Angle ----- 45 Degrees

Seat Width ----- .082 to .094 Inch

Maximum Allowable Seat Runout ----- .002 Inch
As Determined With a Dial Indicator.

Intake Valve Guides

Length ----- 3.250 Inches

Outside Diameter ----- .6565 to .6575 Inch

Inside Diameter ----- .3429 to .3439 Inch (After Assembly)

Valve Stem Clearance in Guide ----- .001 to .003 Inch

Distance Above Head Guide Must Protrude ----- .875 Inch, Press Fit

VALVE SPRINGS

Free Length ----- Approximately 2.375 Inches

Spring Pressure at Compressed Height of
1.516 Inches (Valve Open) ----- 110-118 Pounds

Spring Pressure at Compressed Height of
1.875 Inches (Valve Closed) ----- 53-59 Pounds

ROCKER ARM ASSEMBLY

Rocker Arm Bushing ----- Replaceable Precision Bronze Bushing

Number of Bushings ----- 8

Lubrication ----- Engine Lubricated

Outside Diameter of Rocker Arm Shaft ----- .622 to .623 Inch

Inside Diameter of Rocker Arm Bushing (Installed) --- .624 to .625 Inch

Rocker Arm Shaft Spring Pressure at Compressed Height of
1.750 Inches ----- 8 Pounds; Install New Spring
If Pressure is Less Than 7.500 Pounds.

OIL PUMP

Type ----- Positive Displacement, Gear Type Pump;
Driven Off Crankshaft

Pressure Relief Valve ----- Maintains 50 to 75 Pounds Full
Pressure (Oil Warm, Engine Operating at Full
Governed Speed).

Relief Valve Spring Pressure At Compressed Height of
1.438 Inches ----- 18.4 Pounds

Radial Clearance of Gears
(Clearance Between Gears and Housing) ----- .002 to .005 Inch

Gear End Clearance
(Clearance Between Gears and Cover) ----- .0015 to .0055 Inch

WATER PUMP AND THERMOSTAT

Type of System ----- Pressurized Thermostat Controlled
Forced Circulation (Pump).

Type Pump ----- Impeller Vane Type

Temperature Control ----- Butterfly Type Thermostat

FUEL SYSTEM

Injection Pump ----- Roosa Master, Model DB. Single
Cylinder, Opposed Plunger, Inlet Metering. Dis-
tributor Type.

Direction of Pump Rotation ----- Counter-Clockwise (as
Viewed from Drive End).

Pump Mounting ----- Left Side of Engine

Pump Drive ----- Gear Driven from Pump Drive Idler Gear

Injection Pump Idler Gear End Clearance ----- .003 Inch

Injection Pump Drive Lubrication ----- Crankcase Oil Through
Timing Gear Train.

Injection Pump Drive

Shaft End Play ----- Automatically Taken Up By a Spring
Loaded Thrust Button in Front End of Pump
Drive Shaft.

Timing Marks on Engine Flywheel ----- 40° BTDC to 10° ATDC
in One Degree Increments

Fuel Injection ----- C. A. V. Long Stem Multi-Hole Type
Opening Pressure 2250 PSI.

Fuel Transfer Pump ----- Vane Type; Integral Part of Injection Pump

Governor ----- Mechanical, Fly-Weight
Integral Part of Injection Pump

Fuel Filters

Fuel Tank Air Breather ----- Vented Tank Filler Cap

Fuel Tank Water Trap ----- Located in Base of Fuel Tank

1st Stage Fuel Filter ----- Replaceable Element Type

2nd Stage Fuel Filter ----- Replaceable Sealed "Can" Type

148 ENGINE SPECIFICATIONS

Type ----- CASE 4 Cylinder, 4 Stroke Cycle, Valve in Head Engine.
 No. of Cylinder Heads ----- 1
 Firing Order ----- 1-3-4-2
 Bore ----- 3-3/8 Inches
 Stroke ----- 4 Inches
 Piston Displacement ----- 148 Cubic Inches
 Compression Ratio ----- 7.1 to 1
 Maximum Compression at Cranking Speed 200 RPM
 Engine Warmed Up to Operating Temperature ---- 115 PSI at Sea Level
 Allowable Variance Between Cylinders ----- 20 Pounds Pressure
 Oil Filter, Crankcase ----- Replaceable Cartridge Type
 Exhaust Valve Rotators ----- Positive Type
 Ignition ----- Distributor

CYLINDER SLEEVES

Type ----- Replaceable Wet Type; Two Rubber "O" Ring
 Seals Carried on Each Sleeve.
 Inside Diameter of Sleeve Bore ----- 3.3750 to 3.3765 Inches. Replace
 Sleeve When Inside Diameter Below Top Ring
 Ridge Exceeds 3.384 Inches.
 Piston Clearance in Sleeve (At Skirt) ----- .001 to .002 Inch
 Cylinder Sleeve Protrusion Above Block ----- .002 to .005 Inch

PISTON AND PISTON PINS

Piston Material ----- Aluminum
 Diameter of Piston at Top of Skirt
 (Below Oil Ring Perpendicular to Pin) ----- 3.3715 to 3.373 Inches
 Piston Pins ----- Full Floating Type; Held in Position with Snap
 Rings in Piston; Replaceable Bronze Bushing
 in Connecting Rod.
 Piston Pin Length ----- 2.750 to 2.740 Inches
 Piston Pin Diameter ----- .8592 to .8593 Inch
 Piston Pin Fit in Piston ----- .0000 to .0003 Inch
 Piston Pin Fit in Connecting Rod Bushing ----- .0002 to .0006 Inch

PISTON RINGS

Rings Per Piston ----- 4-(3 Compression and 1 Oil)
 Compression Rings (Top 3)
 Width of Rings (All 3) ----- .0930 to .0935 Inch
 Ring End Gap (All 3) When Compressed
 in 3.375 Inch Cylinder ----- .010 to .020 Inch
 Side Clearance in Groove of 1st (Top) Ring ----- .003 to .0045 Inch
 Side Clearance in Groove of 2nd and 3rd Rings ---.0025 to .004 Inch
 Oil Ring -----To install Replacement Ring, Follow
 Instructions Packed with Rings.
 Width of Ring ----- .2485 to .2490 Inch
 Ring End Gap When Compressed in
 3.375 Inch Cylinder ----- .010 to .020 Inch
 Side Clearance in Groove ----- .001 to .0025 Inch

CONNECTING RODS

Piston Pin Bushing ----- Replaceable Bronze Bushing
 Ream in Place. Use .8596 to .8598 Reamer
 Piston Pin Hole Diameter in
 Rod (Without Bushing) ----- .9045 to .9055 Inch

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Inside Diameter of Piston
 Pin Bushing in Rod ----- .8596 to .8598 Inch; Install New
 Bushing if Inside Diameter Exceeds .863 Inch
 Connecting Rod Bearing ----- Replaceable, Precision Steel Backed,
 Aluminum Liners.
 Connecting Rod Capscrews ----- Self Locking Type, No Lock Wire
 Required - May Be Used More Than Once
 Connecting Rod Length (Center to Center Between
 Pin Hole and Bearing Journal Hole) ----- 6.998 to 7.002 Inches
 Bearing Liner Width ----- 1.120 to 1.130 Inches
 Diameter of Crankshaft Journal Hole
 in Rod (Without Liner) ----- 2.1870 to 2.1875 Inches
 Inside Diameter of Bearing Liner (Standard
 Liner in Place in Rod and Capscrews Tight) ---- 2.0620 to 2.0630 Inches
 Diameter of Crankshaft Rod Journal ----- 2.0605 to 2.0615 Inches
 Clearance Between Rod Bearing
 and Crankshaft Journal ----- .0005 to .0025 Inch; Install New Bearing
 Liners When Clearance Exceeds .006 Inch

Undersize Bearing Liners
 Available for Service ----- .002, .010, .020, .030 Inch
 Allowable Connecting Rod Bearing End Play ----- .005 to .011 Inch

CRANKSHAFT AND MAIN BEARINGS

Crankshaft ----- Balanced; Drilled to Provide Pressure
 Lubrication to Main and Connecting Rod Bearings
 Type Main Bearings ----- Replaceable, Precision, Steel Backed,
 Copper Lead Liners.
 Bearing Capscrews ----- Self Locking Type, No Lock Wires
 Required - May Be Used More Than Once
 Bearing Taking End Thrust ----- Center
 Crankshaft End Play (Measured
 at Center Main Bearing) ----- .001 to .006 Inch; Install New
 Center Main If End Play Exceeds .010 Inch
 Connecting Rod Journal Diameter ----- 2.0605 to 2.0615 Inches
 Main Bearing Journal Diameter ----- 2.623 to 2.624 Inches
 Crankshaft Main and Connecting
 Rod Journal Bearing Out-of-Round ----- .002 Inch
 Inside Diameter of Main Bearing Liners
 (In Place and Capscrews Tight) ----- 2.6245 to 2.626 Inches

Clearance Between Main Bearing
 Liner and Journal ----- .005 to .003 Inch; Install New Bearing
 Liners When Clearance Exceeds .003 Inch
 Width of 1st Main Bearing Liner ----- 1.437 Inches
 Width of 2nd Main Bearing Liner ----- 1.500 Inches
 Width of 3rd Main Bearing Liner ----- 1.562 Inches
 Width Between Crankshaft Center
 Main Bearing Cheeks ----- 1.499 to 1.502 Inches
 Width Between Crankshaft Rod
 Bearing Journal Cheeks ----- 1.3105 to 1.3145 Inches
 Undersize Main Bearing Liners
 Available for Service ----- .002, .020, .040 Inch

Crankshaft Main Bearing Journals Should
 be ground to ---- 2.603 to 2.604 Inches for .020 Inch Undersize Bearing
 2.583 to 2.584 Inches for .040 Inch Undersize Bearing

Undersize Connecting Rod Bearing
 Shells Available for Service ----- .002, .010, .020, .030 Inch

Connecting Rod Crankshaft Journals Should
 be ground to --- 2.0505 to 2.0515 Inches for .010 Inch Undersize Bearing
 2.0405 to 2.0415 Inches for .020 Inch Undersize Bearing
 2.0305 to 2.0315 Inches for .030 Inch Undersize Bearing

CAMSHAFT AND BUSHINGS

Number of Bearing Surfaces on Camshaft -----3
 Type Bushing ----- Replaceable, Precision, Steel Backed Babbitt
 Diameter of Camshaft at Each Bearing Surface --- 1.749 to 1.750 Inches
 Inside Diameter of Each Bushing
 (Measured When in Place in Block) -----1.752 to 1.753 Inches
 No. 1 (Front) Bushing Length ----- 1.307 to 1.317 Inches
 No. 2 (Center) Bushing Length ----- .713 to .723 Inch
 No. 3 (Rear) Bushing Length -----1.177 to 1.197 Inches
 Camshaft End Play ----- .003 to .007 Inch
 Camshaft Thrust Plate Thickness ----- .147 to .149 Inch

TIMING GEARS

Backlash Between Oil Pump Drive Gear
 and Crankshaft Gear ----- .005 to .010 Inch
 Backlash Between Crankshaft and Camshaft Gear ---- .003 to .007 Inch

VALVE PUSH ROD LIFTERS

Type ----- Mushroom Type
 Outside Diameter of End That
 Projects into Block ----- .5615 to .5620 Inch
 Diameter of Bore in Block for Lifter ----- .5625 to .5635 Inch

VALVES**Valve Tappet Clearance**

Intake ----- .014 Inch, Engine Cold
 Exhaust ----- .020 Inch, Engine Cold
 Intake and Exhaust ----- .014 Inch, Engine Hot
 Hot Settings Are Made At Low Idle After The Engine Has Operated At
 Thermostat Control Temperatures For At Least Fifteen Minutes.

Exhaust Valves

Angle of Valve Face -----44 Degrees
 Valve Length ----- 5.166 to 5.191 Inches
 Maximum Valve Face Runout ----- .002 Inch as Determined
 with a Dial Indicator
 Diameter of Valve Stem ----- .3382 to .3390 Inch; Install New
 Valve if There is More Than .002 Inch Difference
 in Diameter at any Point on Stem.
 Diameter of Valve Head -----1.198 to 1.1208 Inches
 Valve Rotators ----- Positive Type

Exhaust Valve Seat

Seat Angle ----- 45 Degrees
 Seat Width ----- .090 to .100 Inch
 Maximum Allowable Seat Runout ----- .002 Inch as
 Determined With a Dial Indicator

Intake Valves

Angle of Valve Face -----29 Degrees
 Valve Length ----- 5.166 to 5.191 Inches
 Maximum Valve Face Runout ----- .002 Inch as Determined
 with a Dial Indicator.
 Diameter of Valve Stem ----- .3406 to .3414 Inch. Install a New Valve
 If There is More Than .002 Inch Difference in
 Diameter at any Point or Stem.
 Diameter of Valve Head -----1.323 to 1.333 Inches

Intake Valve Seat

Seat Angle -----60 Degrees
 Seat Width ----- .045 to .060 Inch

Exhaust Valve Guides

Length -----2.688 Inches
 Outside Diameter ----- .6565 to .6575 Inch
 Inside Diameter ----- .3422 to .3432 Inch
 Replace Guide When Inside Diameter Exceeds .3452 Inch
 Valve Stem Clearance in Guide ----- .0032 to .005 Inch
 Distance Above Head Guide Must Protrude ----- .968 Inch, Press Fit

Intake Valve Guides

Length -----2.688 Inches
 Outside Diameter ----- .6565 to .6575 Inch
 Inside Diameter ----- .3422 to .3432 Inch
 Replace Guide When Inside Diameter Exceeds .3452 Inch
 Valve Stem Clearance in Guide ----- .0008 to .0026 Inch
 Distance Above Head Guide Must Protrude -----1.031 Inch, Press Fit

VALVE SPRINGS**Intake**

Free Length ----- Approx. 2.375 Inches
 Spring Pressure at Compressed Height of
 1.521 (Valve Open) -----110 to 118 Pounds; Install New Spring if
 Pressure is Less Than 102 Pounds.
 Spring Pressure at Compressed Height of
 1.875 Inches (Valve Closed) ----- 53 to 59 Pounds; Install New Spring if
 Pressure is Less Than 50 Pounds.

Exhaust

Free Length ----- Approx. 2.188 Inches
 Spring Pressure at Compressed Height of
 1.332 Inches (Valve Open) ----- 110 to 118 Pounds; Install New Spring if
 Pressure is Less Than 102 Pounds.
 Spring Pressure at Compressed Height of
 1.688 Inches (Valve Closed) -----53 to 59 Pounds; Install New Spring if
 Pressure is Less Than 50 Pounds.

ROCKER ARM ASSEMBLY

Rocker Arm Bushings -----Replaceable Precision Bronze Bushing
 Number of Bushings -----8
 Lubrication ----- Pressure Lubricated; Crankcase
 Oil To Rocker Arms Full Pressure
 Oil Holes in Rocker Arm Shaft -----Oil Holes Must Face
 Downward. Shaft Cannot Be Rotated
 Positioning of Exhaust Valve
 Rocker Arms -----Spacer Washers Position Exhaust
 Valve Rocker Arm and Eliminates End Play
 Without Binding.
 Outside Diameter of Rocker Arm Shaft ----- .622 to .623 Inch
 Inside Diameter of Rocker Arm Bushing ----- .624 to .625 Inch
 Rocker Arm Shaft Spring Pressure at Compressed Height of
 .687 Inch ----- 8 Pounds; Install New Spring if
 Pressure is less than 7.500 Pounds.

OIL PUMP

Type ----- Positive Displacement, Gear Type Pump
 Driven Off Crankshaft.
 Pressure Relief Valve ----- Maintains 28 to 32 Pounds
 Oil Pressure (Oil Warm, Engine Operating at
 Full Governed Speed).
 Relief Valve Spring Pressure at Compressed Height of
 1.438 Inches ----- 18.4 Pounds
 Radial Clearance of Gears
 (Clearance Between Gears and Housing) ----- .002 to .005 Inch
 Gear End Clearance
 (Clearance Between Gears and Cover) ----- .0015 to .0055 Inch

WATER PUMP AND THERMOSTAT

Type of System ----- Thermostat Controlled, Forced Circulation (Pump).
 Type Pump ----- Impeller Vane Type
 Radiator ----- Heavy Duty Fin and Tube Type
 Temperature Control ----- By-Pass Type Thermostat

FUEL SYSTEM

Type of System ----- Gravity Flow
 Carburetor ----- Marvel Schebler TSX635
 Float Level ----- 1/4 Inch from Gasket to Nearest Surface of Float.
 Load Jet ----- Adjustable
 Venturi Size ----- .776 to .786 Inch Dia. Throat
 Flange ----- SAE 1 Inch

SPECIAL TORQUE SPECIFICATIONS

**For Torques Not Listed Below
 Use Torque Chart on Following Page**

Camshaft Nut ----- 80-90 Ft. Lbs.
 Connecting Rod Nut ----- 45-50 Ft. Lbs.
 Connector Bolts (High Pressure Line to Injection Pump)- 33-36 Ft. Lbs.
 Crankshaft Nut ----- 125-135 Ft. Lbs.
 Cylinder Head Capscrew(In Water Pump Housing)-Maximum 30 Ft. Lbs.
 Cylinder Head Nuts (Gasoline) ----- 95-105 Ft. Lbs.
 Cylinder Head Nuts (Diesel) ----- 110-120 Ft. Lbs.
 Engine to Torque Tube ----- 150-160 Ft. Lbs.
 Engine to Front Support ----- 120-135 Ft. Lbs.
 Flywheel Capscrews ----- 65-70 Ft. Lbs.
 Governor Control Rod to Engine Block ----- 15 Ft. Lbs.
 Heat Plug ----- 25-30 Ft. Lbs.
 High Pressure Fuel Line Nuts to Injector ----- 15 to 20 Ft. Lbs.
 Injection Nozzle Cap Nut ----- 50 Ft. Lbs.
 Injector Stud Nuts (To Cylinder Head) ----- 12-15 Ft. Lbs.
 (To Avoid Distorting Nozzle Holder the Two Nuts must Be Tightened Simultaneously)
 Injector Spring Cap Nut ----- 75 Ft. Lbs.
 Injector Pump Drive Shaft ----- 35-40 Ft. Lbs.
 Main Bearing Place Bolts ----- 90-100 Ft. Lbs.
 Manifold Stud Nuts ----- 25-30 Ft. Lbs.
 Oil Pan Capscrews ----- 10-12 Ft. Lbs.
 Oil Seal Retainer Capscrews ----- 6-8 Ft. Lbs.
 Oil Pump Cover Capscrews ----- 6-8 Ft. Lbs.
 Push Rod Adjustable Screw ----- Minimum 30 In. Lbs.
 Screen Assembly at Injection Pump Inlet ----- 12 Ft. Lbs.
 Spark Plugs ----- 32-35 Ft. Lbs.
 Timing Window Cover Screw on Injection Pump ----- 1-2 Ft. Lbs.
 Valve Cover Stud Nuts ----- 5-6 Ft. Lbs.
 Water Pump Stud Nuts ----- 20-25 Ft. Lbs.

GENERAL TORQUE SPECIFICATION TABLE (Revised 5-64)

USE THE FOLLOWING TORQUES WHEN SPECIAL TORQUES ARE NOT GIVEN

NOTE: These values apply to fasteners as received from supplier, dry, or when lubricated with normal engine oil. They do not apply if special graphited or moly-disulphide greases or other extreme pressure lubricants are used. This applies to both UNF and UNC threads.

SAE Grade No.	5		8 *	
Bolt head identification marks as per grade Note: Manufacturing Marks Will Vary				
	Torque Foot Pounds		Torque Foot Pounds	
Bolt Size	Min.	Max.	Min.	Max.
1/4"	9	11	12	15
5/16	15	18	24	28
3/8	35	40	45	50
7/16	54	60	70	80
1/2	80	90	110	125
9/16	110	120	160	180
5/8	150	165	220	240
3/4	260	280	380	420
7/8	360	400	600	660
1"	540	600	900	1000
1-1/8	720	800	1280	1440
1-1/4	1000	1100	1800	2000
1-3/8	1460	1680	2380	2720
1-1/2	1940	2200	3160	3560

* Thick nuts must be used with Grade 8 bolts

TIMING CHART

ENGINE	FULL LOAD GOVERNED ENGINE SPEED	NUMBER OF DEGREES
188D (480)	1750	8° BTDC
148G (480)	1750	4° BTDC (Static) 25° BTDC (Running at Full Load RPM)

VALVE TIMING

With valve clearances set correctly, dial indicator mounted above valve stem reading taken with valve .040" off its seat.

188D Inlet Valve (No. 1 Cyl.) ----- 3° 30' ATC

148G Exhaust Closing (No.1 Cyl. ----- 10° BTC

NOTE "Inlet opening" and "Exhaust closing" are the only positions on these engines that can be checked by the flywheel timing marks. Use the degree marks already on the flywheel for measurement. If this position is correct, it can be assumed that the timing gears are correctly marked and properly assembled.

Section 22

CYLINDER HEAD AND VALVES 188 DIESEL ENGINES

SPECIFICATIONS

	Maximum Limit Including Wear
CYLINDER HEAD	
Warpage .....	.006"
EXHAUST VALVES	
Tappet Clearance (Hot and Cold) .....	.014"
Face Angle	44°
Face Run-Out .....	.002"
O.D. of Head	1.398" to 1.408"
O.D. of Stem .....	.3399" to .3409" .002"
Length	6.339" to 6.364"
Insert Seat Angle	45°
Seat Face Width .....	.0415"
Seat Run-Out .....	.002"
Insert Height .....	.2475" to .2525"
O.D. of Insert	1.4450" to 1.4505"
I.D. of Insert	1.245" to 1.255"
INTAKE VALVES	
Tappet Clearance (Hot and Cold) .....	.014"
Face Angle	44°
Face Run-Out .....	.002"
O.D. of Head	1.599" to 1.609"
O.D. of Stem .....	.3409" to .3419" .002"
Length	6.339" to 6.364"
Seat Angle	45°
Seat Run-Out .....	.002"
Seat Width .....	.082" to .094"

SPECIFICATIONS (Continued)

	Maximum Limit Including Wear
EXHAUST VALVE GUIDES	
Length	3.125"
O.D. ....	.6565" to .6575"
I.D. (Installed and Reamed) .....	.3429" to .3439" ..... .001"
Valve Stem Clearance in Guide .....	.002" to .004"
Protrusion Above Cylinder Head .....	.875"
INTAKE VALVE GUIDES	
Length	3.250"
O.D. ....	.6565" to .6575"
I.D. (Installed and Reamed) .....	.3429" to .3439" ..... .001"
Valve Stem Clearance in Guide .....	.001" to .003"
Protrusion Above Cylinder Head .....	.875"
VALVE SPRING	
Free Length	2.375"
Total Coils	8.25
Wire Diameter .....	.162"
I.D. ....	.958" to .978"
Compressed to 1.521" (Valve Open)	110 to 118 lbs.
Compressed to 1.875" (Valve Closed)	53 to 59 lbs.
ROCKER ARM ASSEMBLY	
O.D. of Shaft .....	.622" to .623"
I.D. of Arm Bore .....	.624" to .625"
Shaft Spring	
Free Length	2.5"
Wire Diameter .....	.072"
Compressed to 1.75"	7.5 to 8.5 lbs.
Lubrication	Engine oil, camshaft metering
Shaft Oil Holes	Toward valve side of engine, shaft cannot be rotated.

SPECIAL TORQUES

Cylinder Head Studs w/Flange Nuts	90 to 100 ft. lbs.
Intake and Exhaust Manifold Stud Nuts	25 to 30 ft. lbs.
Cylinder Head Valve Cover Stud Nuts	5 to 8 ft. lbs.
Rocker Arm Bracket Bolts	25 to 30 ft. lbs.

CHECKING COMPRESSION PRESSURE

1. Clean the engine thoroughly, preferably by steam cleaning.
2. Before cranking the engine make sure all operating controls are in neutral, brakes are set and the wheels are securely blocked.
3. There are two methods of checking compression pressure - the cranking method

and the engine running method. **NOTE:** The engine must be at operating temperature for either method used.

A. CRANKING METHOD - Close the needle valve at the fuel tank. Disconnect all high pressure fuel lines and leak-off lines between injectors. Remove all of the injectors. Refer to the chart on Page 3.

CHECKING COMPRESSION PRESSURE (Continued)

B.RUNNING METHOD - Disconnect the high pressure fuel line and leak-off line from number one injector. Using an appropriate length of tubing or hose, route the fuel from these lines back to the fuel tank or a clean container. Refer to chart below.

- Clean the injector bores of loose carbon and residue. Replace the compression seal in the injector bore of the cylinder to be checked and install a Bacharach 70-314 (D-558). Compression Gauge Adapter, Figure 1. Secure with an original injector clamp assembly and spacer, Figure 1, Inset A. Tighten bolt to 20 ft. lbs. Connect Case No. CD-504 Compression Gauge to the adapter, Figure 2.

IMPORTANT: It is very important that all cylinder pressure be approximately alike. For the allowable compression pressure variation refer to chart below.

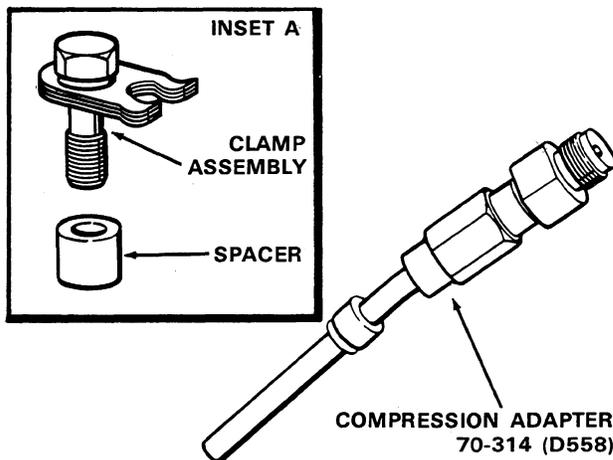


Figure 1

- If the compression is greater than the figure mentioned, carbon deposits are indicated. If the reading is below these figures, leaking valves or excessive ring clearance is indicated. **NOTE:** To make a simple check when a compression leak is indicated, squirt

a small amount (a teaspoon) of oil into the cylinder and recheck the compression. If the pressure rises to near normal, compression loss is past the rings. Very little change in compression indicates leakage past the valves. A low pressure reading will cause difficulty in starting particularly at low temperatures.

NOTE: Take several compression reading on each cylinder. This is done by pressing the vent valve button, Figure 2, to relieve gauge pressure. When the button is released the gauge will again indicate compression pressure.

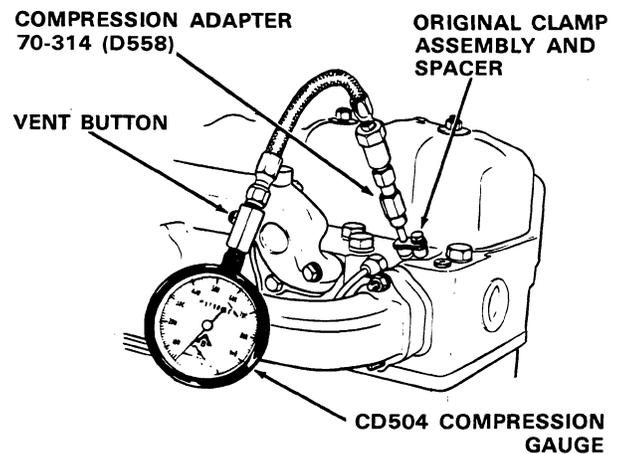


Figure 2

IMPORTANT: Replace the compression seal on all injectors at the time of installation, Figure 3.

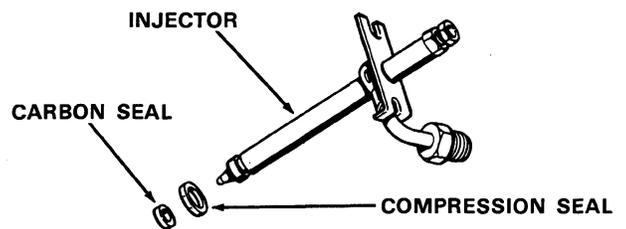


Figure 3

	ENGINE SPEED	NORMAL COMPRESSION PRESSURE	ALLOWABLE VARIATION BETWEEN CYLINDERS
CRANKING	Approximately 200 RPM	400 PSI*	25 PSI
RUNNING	800 RPM	480 PSI*	20 PSI

NOTE: *A 4% reduction in PSI must be allowed for every 1000 ft. above sea level.

CYLINDER HEAD AND COMPONENTS

(Refer to Figure 4)

Disassembly

Remove the muffler and hood from vehicle. Disconnect the exhaust system and air cleaner from the manifolds. Loosen the alternator adjusting bolt and remove the fan belt. Remove the water pump and all stud nuts securing water manifold to cylinder head. Steam clean the entire area where service work is to be performed.

1. Drain the cooling system. **CAUTION:** If the engine is hot, do not remove the radiator cap until the coolant has had sufficient time to cool. Loosen the cap to the first stop carefully to relieve any excess pressure before removing it completely. Remove the upper radiator and water pump hoses.
 2. Disconnect the high pressure fuel lines from the injectors and the leak-off tubes. Cap them to prevent any foreign particles from entering. Remove the injectors as described in Section 33 of the Service Manual.
 3. Remove the breather tube (1).
 4. Remove the intake elbow (2) and gasket (3), and discard the gasket.
 5. Remove the intake manifold (4) and discard the gaskets (5).
 6. Remove the exhaust stack (6) and gasket (7).
 7. Remove the exhaust manifold (8) and discard the gaskets (9).
 8. Remove the valve cover (10) and cover gasket (11). Discard gasket.
 9. Remove the bolts and washers (12), and the rocker arm assembly (13). Remove the push rods (14) and tag them for proper re-assembly.
 10. Remove the flanged nuts (15). Remove the cylinder head assembly (16), fire rings (17) and head gasket (18). Discard the fire rings and head gasket.
- NOTE:** Refer to Inspection and Servicing on Page 6 and 7 prior to assembly.

Assembly

1. Place new cylinder head gasket (18) on the engine block. **NOTE:** Be sure the two dowel rings are installed in their proper location, Inset A.
2. Install the new fire rings (17) with either side up. **NOTE:** The fire rings must be installed dry.
3. Install new gasket (19) between timing cover and cylinder head, coating it with a sealer.
4. Install the cylinder head (16) and flanged nuts (15). Lubricate threads with clean engine oil prior to torquing. Torque the flange nuts to 60 ft. lbs. and then to 90-100 ft. lbs. using the torquing sequence shown in Inset B.
5. Install the water pump and a new gasket, coating the gasket with a sealer. Torque the water pump stud nuts 20-25 ft. lbs. Install the fan belt and adjust.
6. Coat the push rods (14) with clean engine oil and install them in their original location.
7. Install the rocker arm assembly (13). **NOTE:** The rear mounting bolt is drilled for oil passage to the rocker arm shafts. Torque the bolts (12) to 25-30 ft. lbs. Adjust the valve tappet clearance, refer to Page 16.
8. Install the intake (4) and exhaust (8) manifolds using new gaskets (5 & 9). Torque the stud nuts and bolts 25-30 ft. lbs.
9. Install the intake elbow (2) using new gasket (2). Install the exhaust stack (6) using new gasket (7).
10. Reinstall the air cleaner system and exhaust system. Refill the cooling system. Reconnect the high pressure fuel lines to the injectors and the leak-off tubes.
11. Apply clean engine oil to the rocker arm assembly and start the engine. Check that the rocker arms are receiving lubricating oil. Operate the engine for approximately one hour, (under load if possible) to thoroughly warm up the engine seat the head gaskets.
12. Shut the engine off. Back off each cylinder head flanged nut individually 1/4 and re-torque to 100 ft. lbs. **NOTE: DO NOT BACK OFF ALL THE FLANGED NUTS AT THE SAME TIME.**
13. Install new valve cover gasket (11) and valve cover (10). Torque the valve cover stud nuts 5-8 ft. lbs. Install breather tube (1).

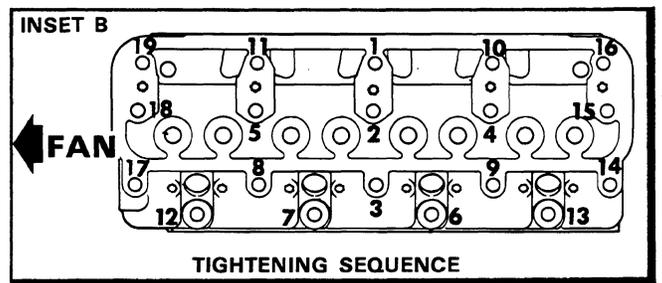
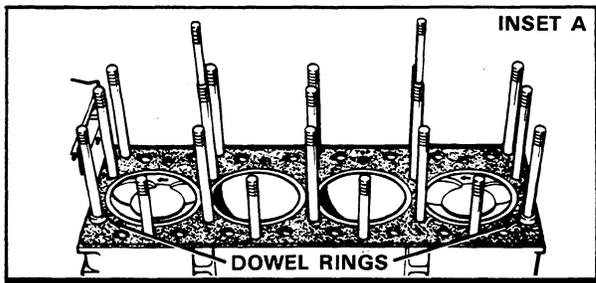
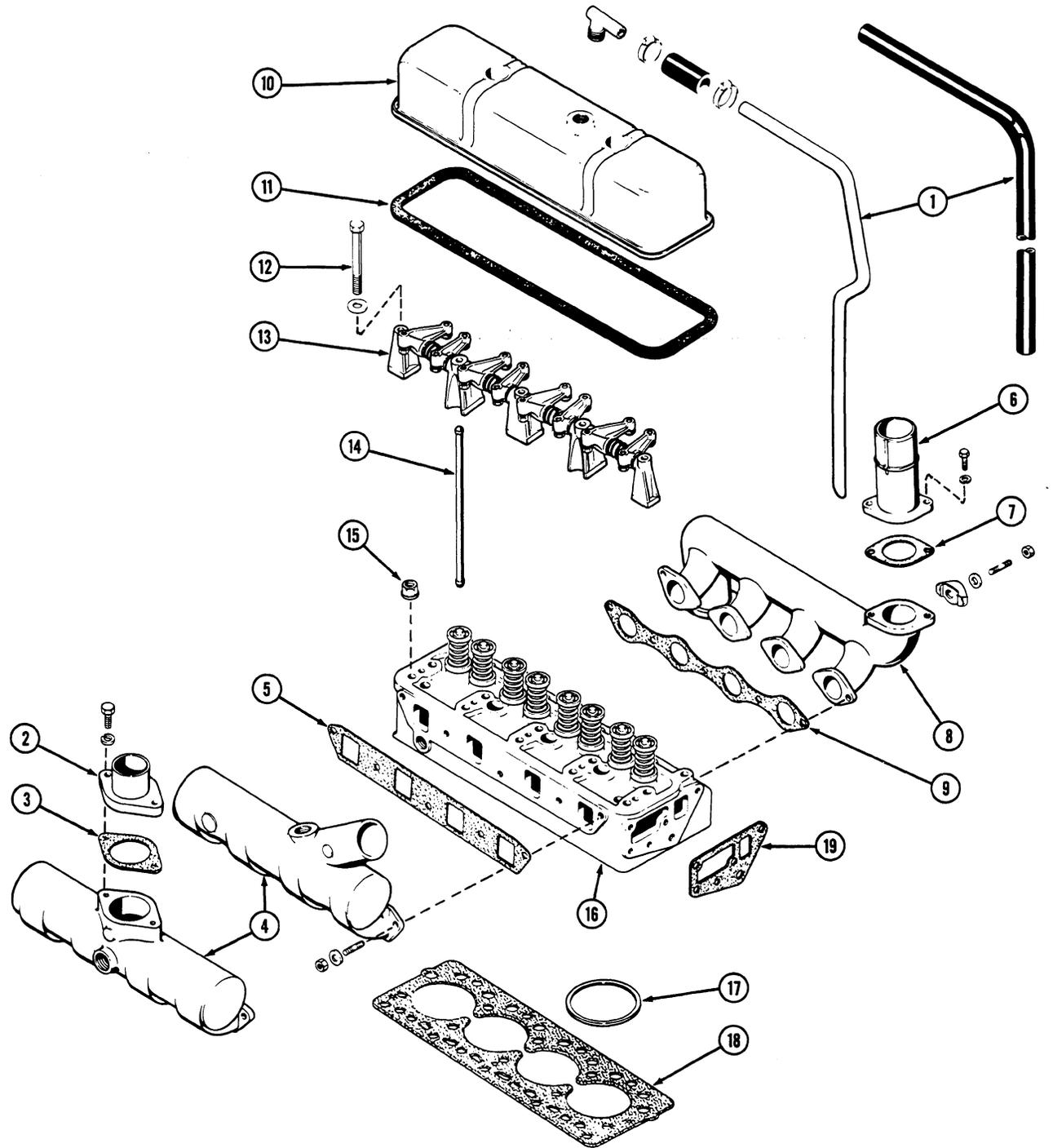


Figure 4

CYLINDER HEAD AND COMPONENTS (Continued)

Inspection

Replace all gaskets, seals and worn or defective parts.

- Clean the top surface of the block and sleeve flange carefully. All traces of carbon and other deposits must be removed. During cleaning, the use of a rag dampened in solvent is recommended.
- Using extreme care not to scratch surfaces. Remove any small burrs in the areas to be measured so accurate readings can be obtained.
- Sleeve protrusion must be checked to determine which fire ring is used, Figure 5. Make sure the correct fire ring is used. **NOTE:** Only the standard size fire ring is included in the valve grind gasket kit. However, a thicker fire ring is available if the protrusion chart indicates a need for it. The thicker fire ring can be identified by a black marking stripe. Either a magnetic base dial indicator or a depth micrometer can be used to determine the cylinder sleeve protrusion as indicated in Figure 6. Measure cylinder sleeve protrusion at points A,B,C and D. Using ball (A28312), clamping bar (A40682) and plate (OTC 970-7), clamp the cylinder sleeve in place, Figure 7. **NOTE:** The plate OTC 970-7 is available through local Owatonna Tool dealers or the Owatonna Tool Co., Owatonna, Minnesota. Torque the hold down capscrews to 50 ft. lbs.
- Clean and inspect the cylinder head thoroughly. If evidence of fretting or erosion exists in the area of fire-ring contact or if the head is warped more than .006", the head must be resurfaced or replaced.
- Inspect push rods for straightness, cracked or worn ends. Replace if necessary.
- Clean all bolt and stud threads.
- Clean the rocker arm cover and discard the old gasket.
- Replace all hoses if cracks and deterioration is found. Replace hose clamps to assure a tight connection.

CYLINDER SLEEVE PROTRUSION	USE STANDARD FIRE RINGS	USE OVERSIZE (THICKNESS) FIRE RINGS
MORE THAN .003"	X	
.001" - .003"	X	
LESS THAN .001"		X

Figure 5

*If sleeve protrusion varies more than .003" around circumference, change that sleeve and check again. If sleeve shows severe erosion, replace the sleeve. **NOTE:** Cylinder head warpage should not exceed .006" (maximum) measuring from end to end.

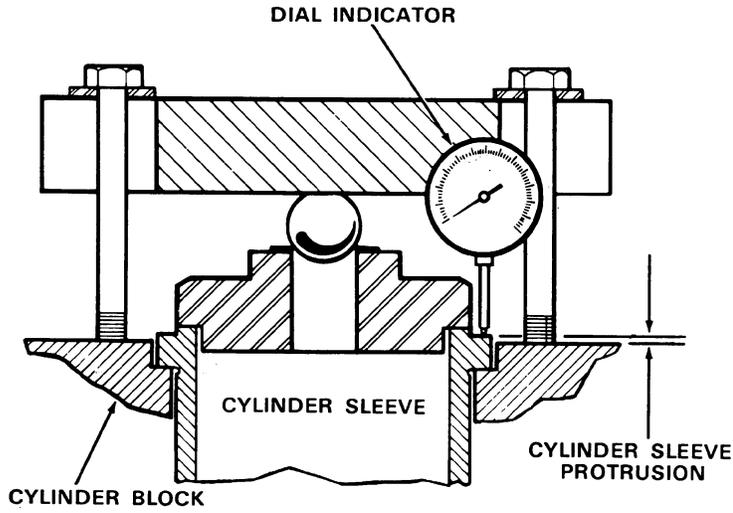


Figure 6

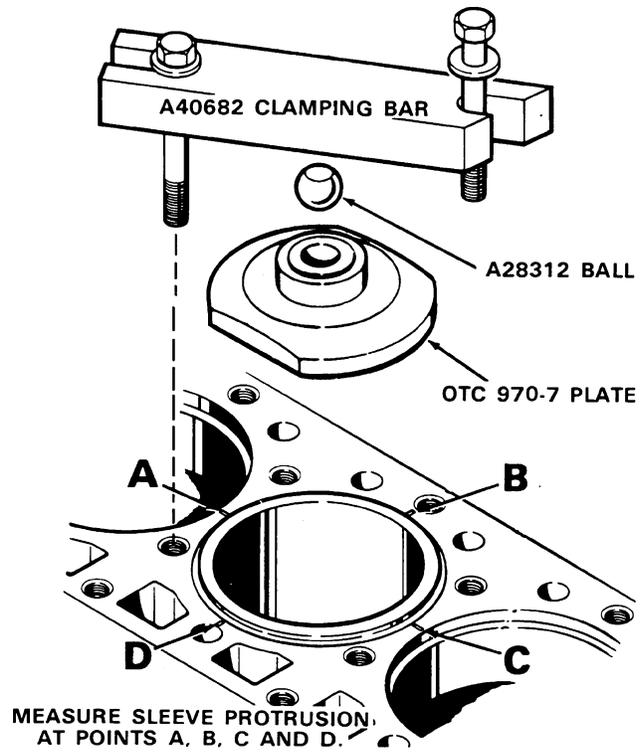


Figure 7

ROCKER ARM ASSEMBLY

(Refer to Figure 8)

Disassembly

1. Remove the rocker arm shaft bracket bolts (1 & 9). **NOTE:** The rear bracket bolt is drilled for oil passage to the rocker arm shafts.
2. Remove and tag each rocker arm (4 & 7) and bracket (3, 10, 11 & 12) for proper location when assembling.
3. Remove the shaft springs (6) and tag the front and rear shafts (8).
4. Remove each tappet adjusting screw (5) from each rocker arm, refer to Inset A.

Inspection

Check the shaft springs for damage and proper tension.

SPRING SPECIFICATIONS

Free Length	2.5"
Wire Diameter .....	.072"
Compressed to 1.75"	7.5 to 8.5 lbs.

Flush the shafts to remove any residual material. Inspect the shafts for excessive wear or worn spots on the bottom side of the shafts.

Inspect the rocker arm shaft passages for wear. The maximum clearance between the

shaft and rocker arm is .010". Replace the shaft and rocker arms when wear is beyond this point.

Clean the oil passage in the rocker arms to insure free oil flow. Inspect the valve stem contact area on the rocker arm for wear. Replace if worn.

Clean and check the oil passages in the tappet adjusting screws and the rear bracket bolt.

Inspect the push rods for straightness, cracked or worn ends, replace if these conditions exist.

Assembly

With all component parts cleaned thoroughly and worn parts replaced, coat them with clean engine oil.

1. Install the intermediate brackets (10) on the shafts (8), starting with the front shaft. The front shaft is installed with the short end of the shaft (from the cut-out) toward the front of the engine, see Inset B. The rear shaft is installed with the short end of the shaft (from the cut-out) toward the rear of the engine.
2. Insert the bracket bolt (9) into the intermediate bracket (10) - it must line up with the cut-out in the shaft.
3. Install the tappet adjusting screws (5) into the rocker arms (4 & 7), make sure the screws are turned into the rocker arms as far as possible.
4. Install the rocker arms (4 & 7) and springs (6) on the rocker arm shafts (8).
5. Install the center bracket (11) to the long end (from the cut-out) of the shafts (8). Install the front (12) and rear (3) brackets to the shafts (8).
6. Before installing the rocker arm assembly on the cylinder head, crank the engine (fuel injectors removed) with the starting motor (approximately 1 to 3 minutes) until oil appears at the rear oil passage in the head, see Inset C. Install the rocker arm assembly to the cylinder with bracket bolts (1 & 9), making sure the rear bracket drilled bolt (1) is installed the cylinder head oil passage hole.
7. Adjust the tappets, refer to Page 16.

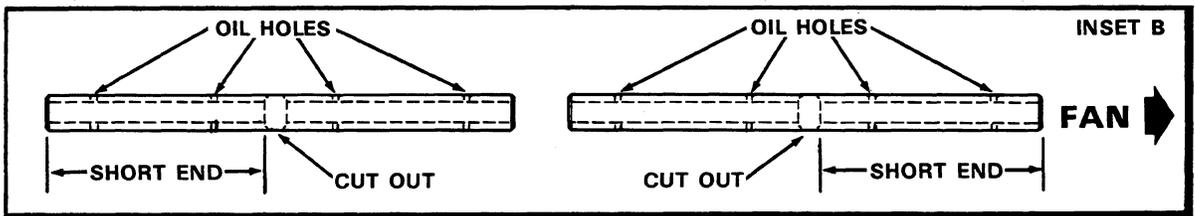
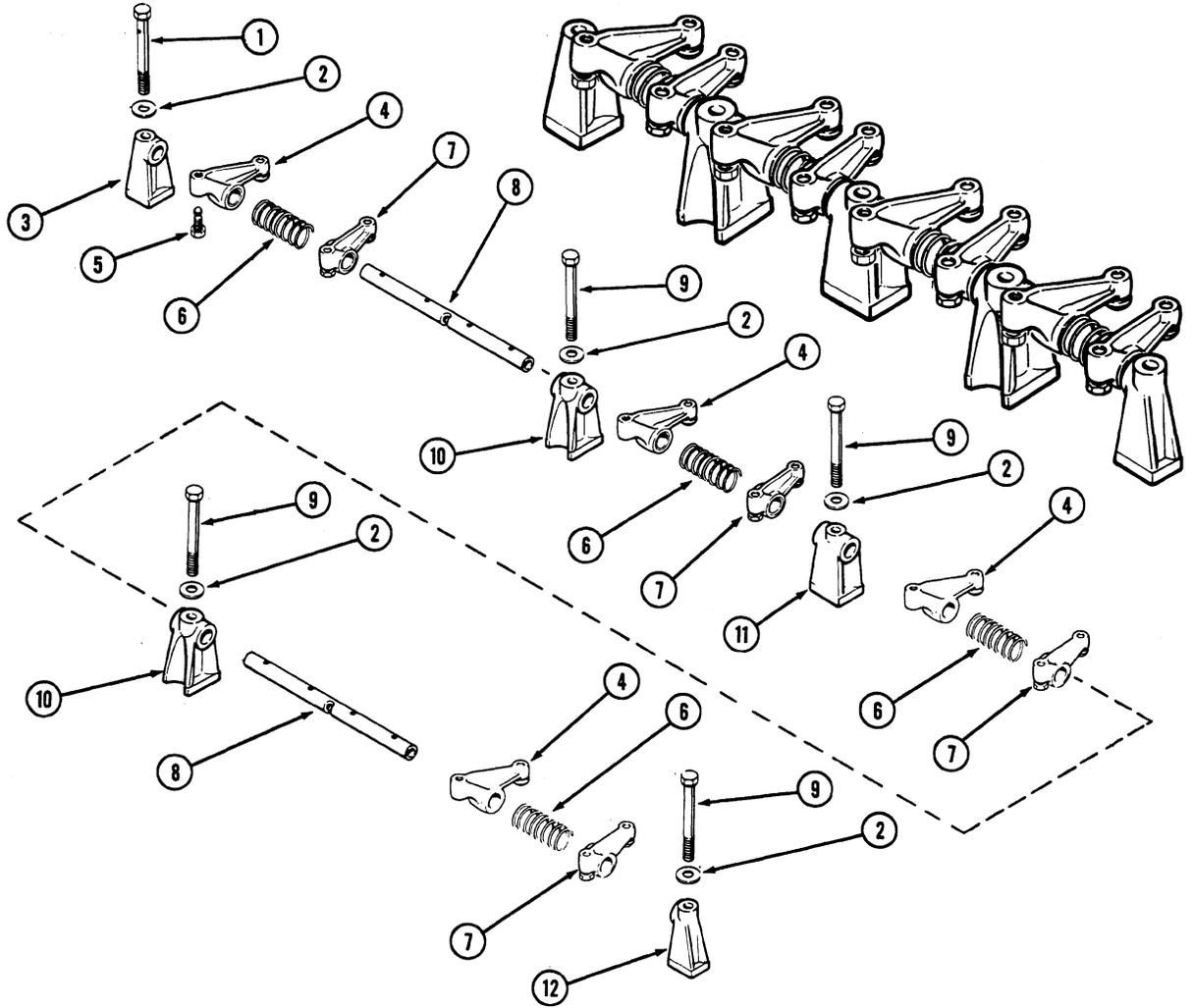
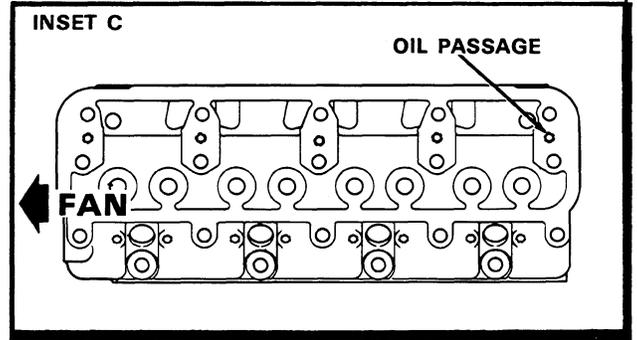
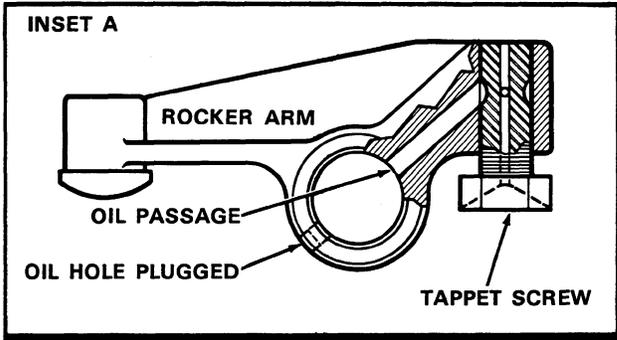


Figure 8

CYLINDER HEAD ASSEMBLY

(Refer to Figure 9)

Disassembly

1. Using a valve spring compressor, compress the spring (1) enough to remove the valve retainer locks (2). Release the spring compressor and remove the valve spring retainer (3). Remove the valve spring (1), valve stem oil seals (4) and valve spring seats (5). Remove any carbon from the valve stems before they are removed from the cylinder head.
2. Remove the intake valves (6) and the exhaust valves (7) from the cylinder head (13) and set them in a rack or holder. **NOTE:** Mark them on removal so they may be installed in their original location.
3. Drive the intake valve guide (8) and exhaust valve guide (9) down through the head using an arbor.
4. The exhaust valve seats (10) can be removed with a special seat removing tool, Inset B. **NOTE:** Never attempt to remove a valve seat with a center punch, cold chisel or pry bar.
5. To remove the cup plugs (11) or expansion plug (12) they must be drilled and pryed out.

NOTE: Refer to Inspection and Servicing on Pages 12,13,14 and 15 prior to assembly.

Assembly

1. If the valve guides have been replaced, install the new guides (8 & 9) using an arbor. Press the guides into the head from the top of the cylinder head. The guides must protrude above the cylinder head (intake and exhaust) .875", Inset A.
2. To install new exhaust valve seats (10) clean the recess in the cylinder head. Place the valve seats in dry ice to shrink them. Insert the valve seats in the head and press them in place, using a suitable press.
3. Lubricate the intake valves (6) and exhaust valves (7) with clean engine oil and install them in their original locations.
4. Install the valve spring seats (5), valve springs (1), the valve retainers (3). Compress the valve springs so the valve stem seals (4) can be installed in the lower grooves of the valve stems. Install the valve retainer locks (2). Remove the spring compressor carefully.
5. Install new plugs (11 & 12) if they were removed. **NOTE:** The cup plug (11) lip must be flush with the top of the cylinder head. The expansion plug (12) must be firmly seated against the ridge in the cylinder head.

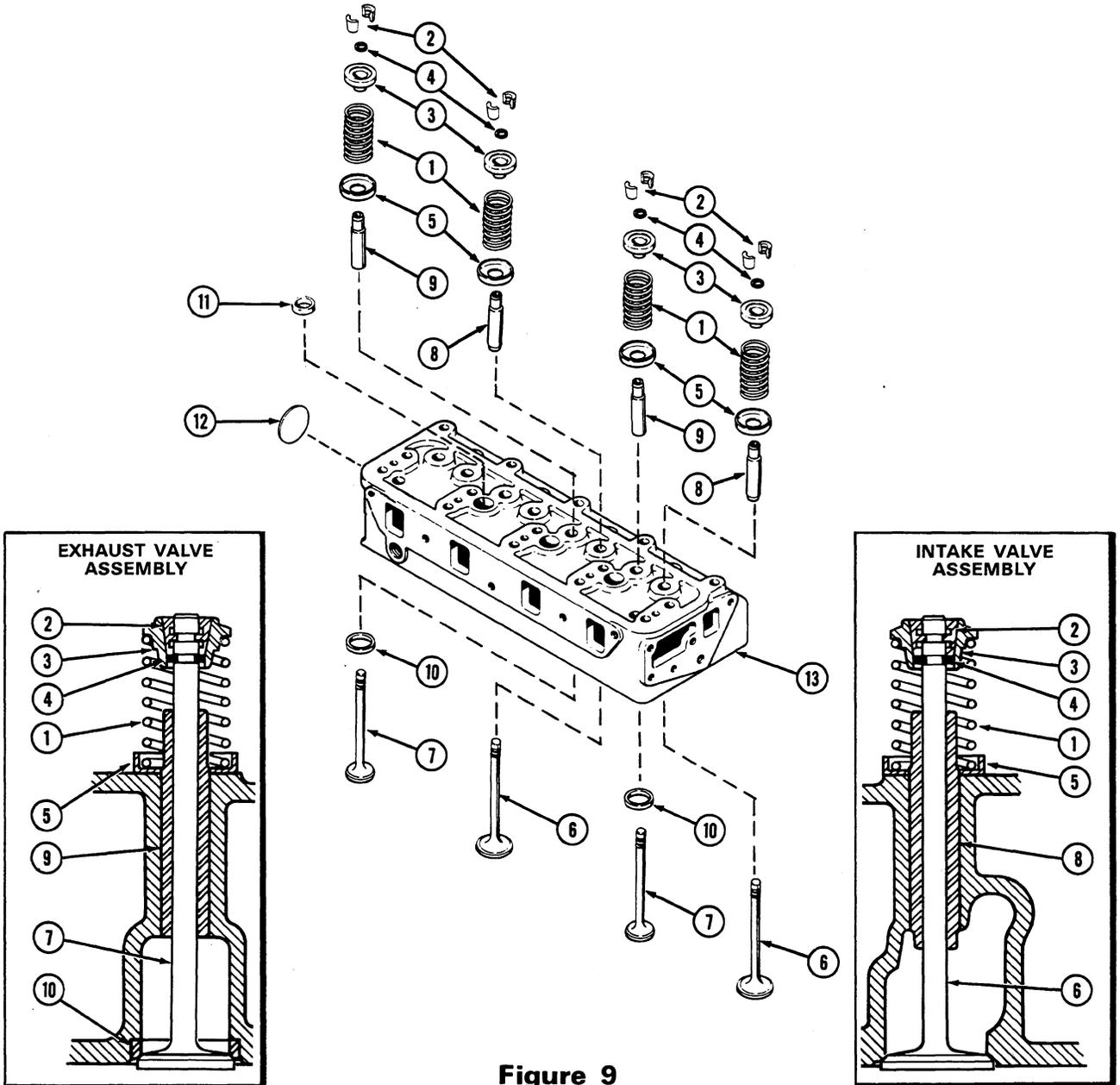
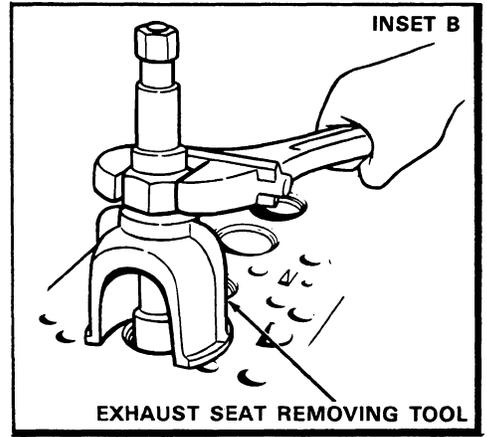
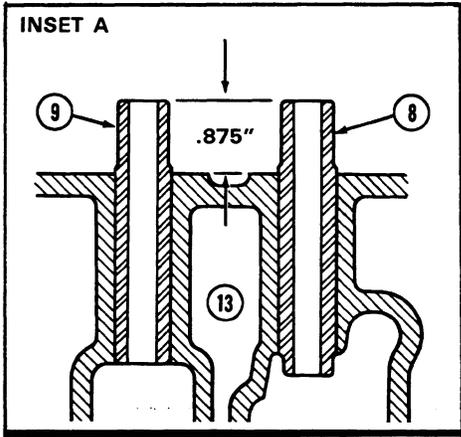


Figure 9

INSPECTION OF VALVES, GUIDES, HEAD AND SPRINGS

Clean the cylinder head completely. Remove all traces of carbon and other deposits. Check for cracks and any evidence of fretting or erosion existing in the area of fire ring contact. Check the head for evidence of warpage. If warpage exists and is more than .006", the cylinder head must be resurfaced or replaced.

Valve springs should be checked for flat squared ends, broken coils and correct spring pressure. Use a Valve Spring Tester referring to the spring specifications below:

Free Length ----- 2.375"
 Total Coils ----- 8.25"
 Wire Diameter ----- .162"

Valve Position	Compressed Height	Spring Pressure	Replace if Less than
Valve Open	1.521"	114 lbs.	110 lbs.
Valve Closed	1.875"	56 lbs.	53 lbs.

Remove all carbon from the bore of the valve guides with a fine wire brush and blow clean with compressed air. Valve guides can be checked for wear by using a bore gauge and micrometer, refer to Figure 10, Inset A. The valve guides should be checked at the top, middle and bottom of the guide bore for wear, Figure 10. If the diameter is greater than .3440" at any point along the bore, the guide must be replaced. Use an arbor equal to the inside diameter of the valve guide to keep the guide from collapsing when pressed into place. Press in from the top of the head until the guide (Intake and Exhaust) protrudes a distance of .875" above the head, refer to Figure 9, Inset A, Page 11. Replacement guides must be reamed after installation. Ream the guide .3429" to .3439" diameter.

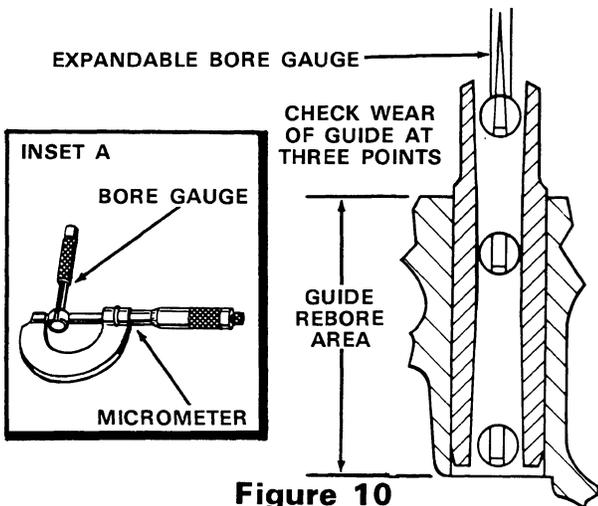


Figure 10

Clean the valves with a power driven fine wire brush, being very careful not to scratch the valve stems. Refer to Figure 11 for valve nomenclature.

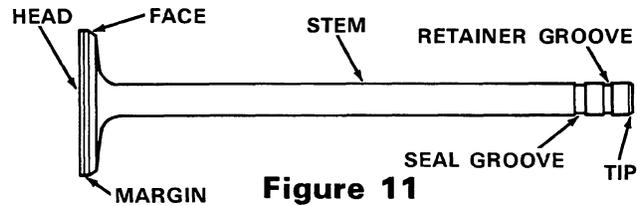


Figure 11

Inspect the valves for excessive wear or necked stems, Figure 12. This can be caused by lack of lubrication, plugged water passages or operating the engine under continuous overload at excessive engine RPM. Replace valves if this condition exists.

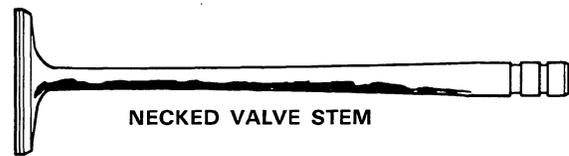


Figure 12

Inspect the valves for deep grooves in the face, Figure 13. This can be caused by abrasives entering the engine through the intake system or not servicing the air cleaner regularly. If grinding the valve face will not correct this condition, replace the valve.

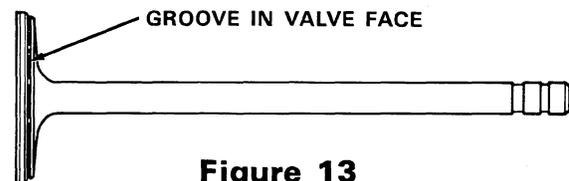


Figure 13

Inspect the valve face and stem for rust or pitting, Figure 14. Rust or pitting can usually be removed by grinding the valve face. If rust or pitting on the valve stem exists, replace the valve. These conditions can be caused by using poor quality engine oil or fuel that does not meet the specification given in Section 11 and by improper storing of the engine.

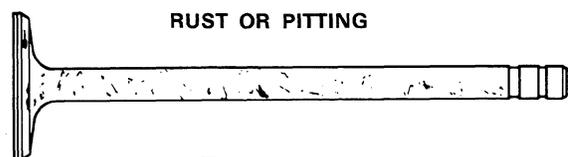


Figure 14

INSPECTION OF VALVES, GUIDES, HEAD AND SPRINGS (Cont'd)

Heavy carbon or varnish deposits on the valves, Figure 15, should be removed before valves are ground. This condition is usually caused by worn piston rings and sleeves which allow too much oil to reach the combustion chamber. This conditions could also be caused by worn valve guides or bad seals on the valves. Low operating temperature is still another cause.

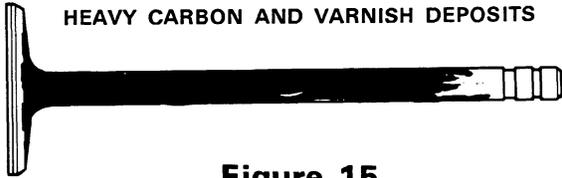


Figure 15

Inspect the valve head for dishing and the valve face for deep burned spots, Figure 16. These conditions cannot be corrected by grinding the valves. The valves must be replaced. These conditions are usually caused by running the engine under excessive loads at high engine temperatures.

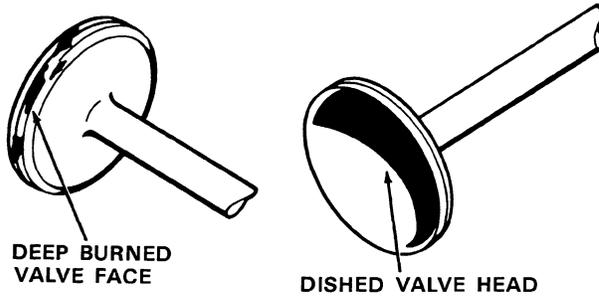


Figure 16

Valves with worn keeper grooves or if the stem tip is worn or dished beyond the chamfer, replace the valves, Figure 17.

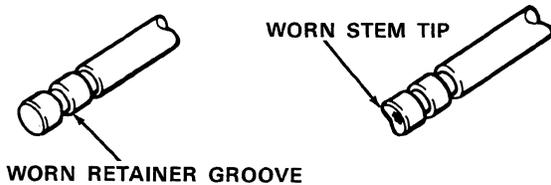


Figure 17

The checking of the valve stem diameter can be best be done with a good, accurate micrometer, Figure 18. The valve stem being straight, should be measured at three points along the stem, Figure 18. Wear limit must not exceed .002" at all points of measurement. If the wear is greater, replace the valve.

CHECK DIAMETER OF STEM AT THREE POINTS

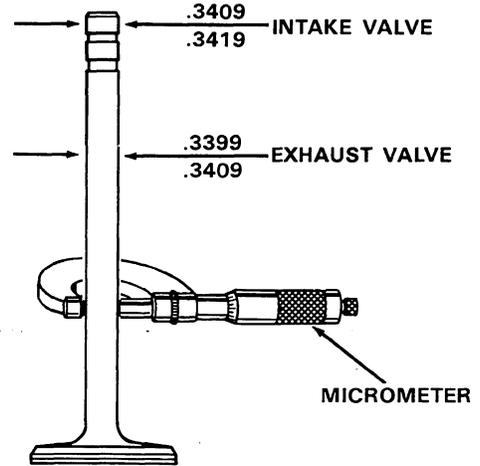


Figure 18

The checking of the valve face runout should be done after the valves have been ground. A Vee block type holder with a dial indicator, Figure 19 can be used to check the valve face and stem runout. The valve face runout should not exceed more than .002". The valve stem runout should not exceed .002". If the valve face and/or valve stem runout is greater, the valve must be replaced.

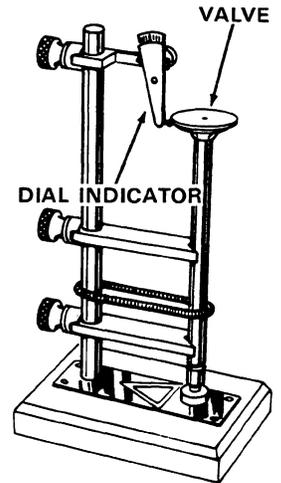


Figure 19

NOTE: Small amounts of very fine pitting, Figure 20, may be found on the surfaces of the valves faces and seats after the valves are cleaned. These are normal and will not affect engine performance. This fine pitting is caused by a normal oxidation process and can happen on any engine during the run-in period. It is not necessary to grind valves or seats if this fine pitting is found as the pitting will generally reoccur after the engine is run for a few hours.

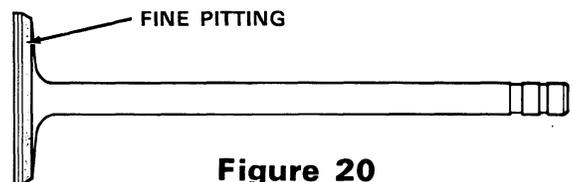


Figure 20

REFACING INTAKE AND EXHAUST VALVES

Before refacing the valves, they should be wire brushed, cleaned and inspected. A 44° angle is the correct valve face grinding angle. Set the refacing machine protractor at this angle. Be sure the chuck of the machine is clean before installing the valve. Dress the grinding wheel before starting to reface the valves. Take only light cuts as the valve is refaced. The last cut must be very fine so the valve face will have a polished finish.

IMPORTANT: Replace any valve that has a thin edge or margin, Figure 21. If the margin on the ground valve is less than half the margin on a new valve, replace the valve.

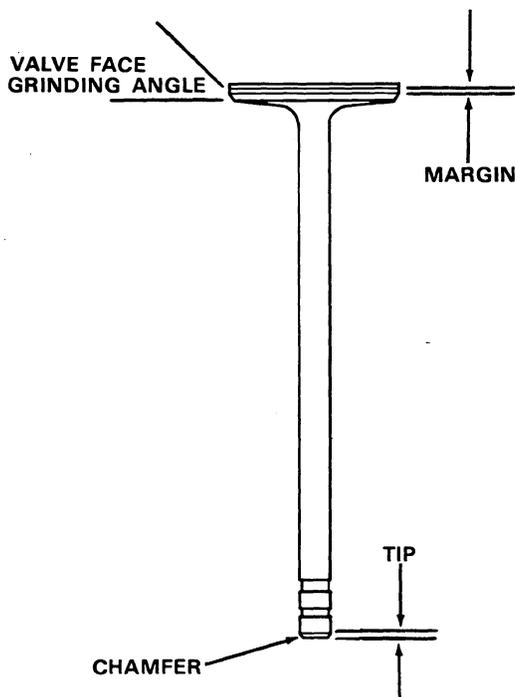


Figure 21

The tip end of the valve should be checked for roughness or wear. Usually this can be removed with some very light cuts against the side of the grinding wheel and will square up the end. Never grind off the valve stem end beyond the chamfer.

Correct refacing of intake and exhaust valves and valve seats will provide a 1° interference angle. This angle is important since it aids in cutting carbon and helps seat the valves.

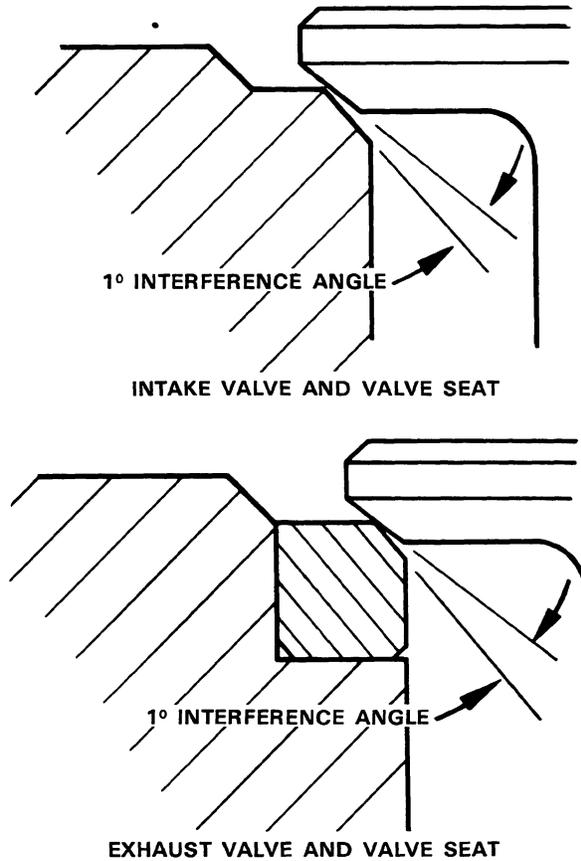


Figure 22

When the top edge of the contact area is too high or low on the valve face, the seat contact area must be moved. This is done by using the narrowing stones. Refer to Page 15. The contact area width should never exceed the specified dimension of .0608" to .0962" (exhaust valve) and .704" to .1057" (intake valve).

GRINDING INTAKE AND EXHAUST VALVE SEATS

Always use a precision seat grinder. Take very light cuts with the grinding stones so just enough metal is removed to end up with a good smooth seat finish.

The proper angle of grind is 45° for exhaust valve and intake valve seats, Figure 23. The seat grinding angle of the stone should be dressed frequently on a stone dresser to maintain a clean accurate surface.

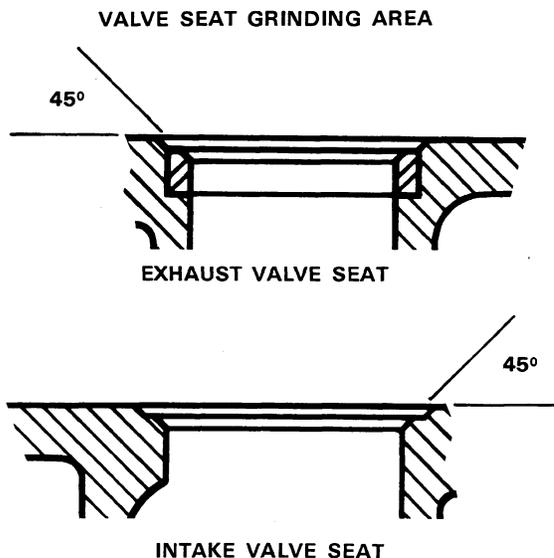


Figure 23

IMPORTANT: The valve seat runout should be checked after finish grinding with a dial indicator and seat grinding pilot, Figure 24. The runout of the valve seat must not exceed .002" .

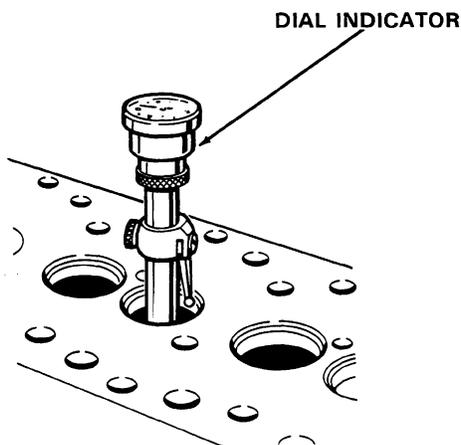


Figure 24

The valve seat contact area width and location can be changed by using the 30° and 60° narrowing stones, Figure 25.

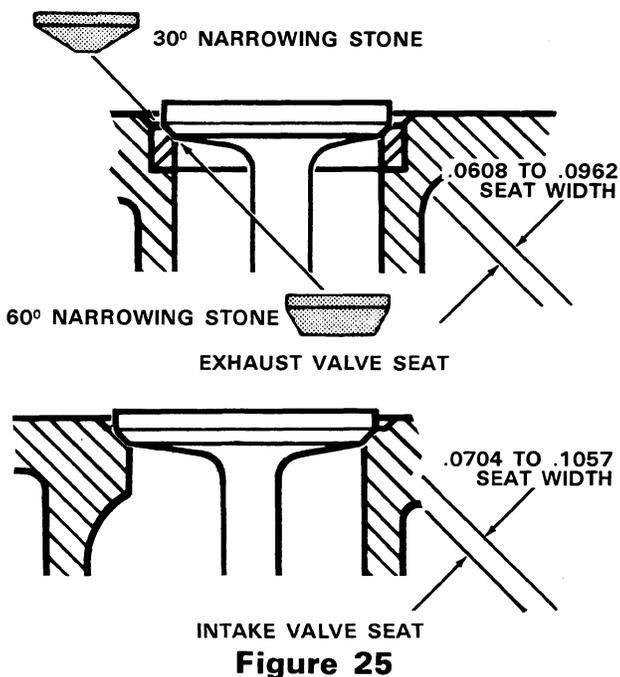


Figure 25

NOTE: If the valve head has receded more than .010" (exhaust valve and intake valve) below the cylinder head surface, Figure 26, the valve or valve insert or both should be replaced to keep the compression ratio equal between cylinders for an efficient running engine.

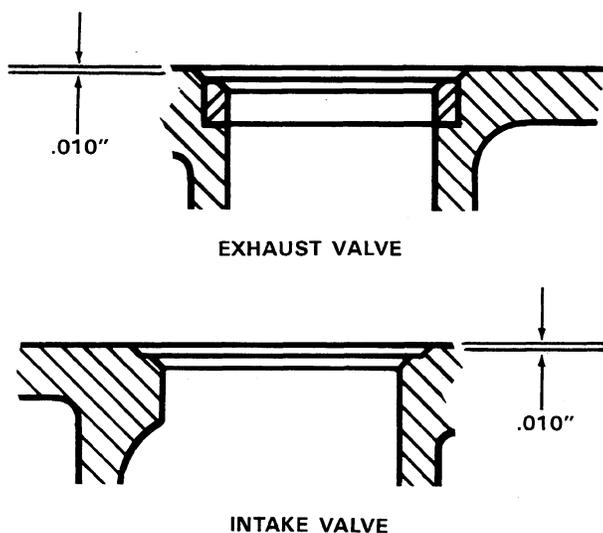


Figure 26

LOCATING TOP DEAD CENTER AND TAPPET ADJUSTMENTS

FIRING ORDER 1-3-4-2

The Top Dead Center position of number 1 and 4 cylinders is indicated by the TDC mark on the flywheel. Refer to Figure 27

The tappet adjustments can be done in two steps as described in the following manner.

COLD SETTING

STEP 1 - Remove the valve cover. Crank the engine until the timing pointer is aligned with the TDC timing mark on the flywheel, Figure 27. Check the push rods on No. 1 cylinder for looseness. If the push rods are loose, No. 1 cylinder is at TDC on the compression stroke. If the push rods are tight, crank the engine one complete revolution and align the pointer and the TDC mark on the flywheel, Figure 27.

Check and adjust the following valve clearances; intake valve at .014" clearance on cylinders 1 and 2, and the exhaust valves on cylinders 1 and 3 at .014" clearance, Figure 28.

STEP 2 - Crank the engine one complete revolution and align the timing pointer and the TDC mark on the flywheel, Figure 27. Cyl-

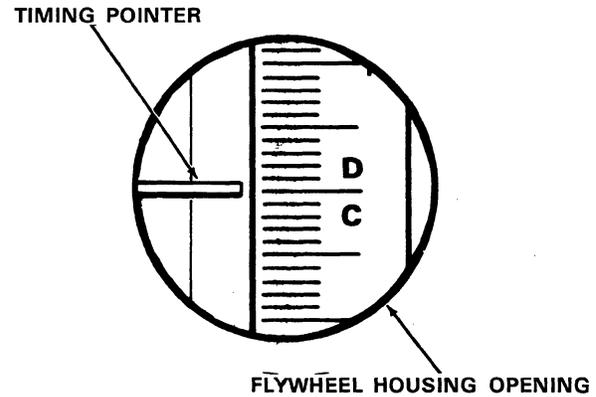


Figure 27

inder No. 4 should be at TDC on the compression stroke. Check the push rods on No. 4 cylinder for looseness.

Check and adjust the following valve clearances; intake valves at .014" clearance on cylinders 3 and 4, and the exhaust valves on cylinders 2 and 4 at .014" clearance, Figure 28.

HOT SETTING

Follow steps 1 and 2 while the engine is hot. The tappet clearances for hot settings are .014" for the intake valves and .014" for the exhaust valves.

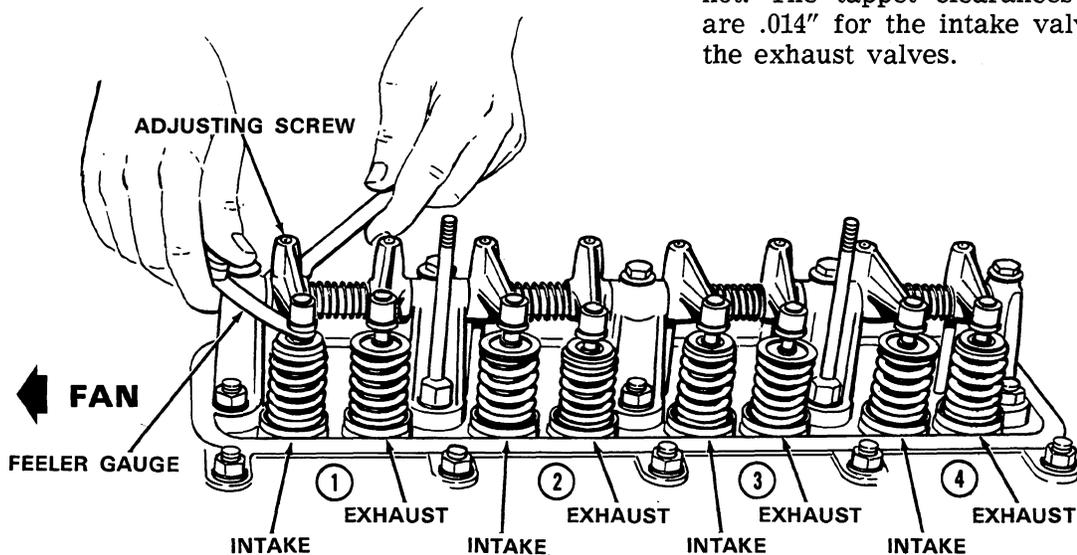


Figure 28

IMPORTANT: The valve tappet clearance is a critical adjustment.

The entire combustion system of the engine will be seriously affected by adjusting the valve tappet clearance to any other setting.

Excessive clearance will change the valve timing and could result in overheating, power loss and possible valve breakage.

Insufficient clearance would allow the valves to remain open and be burned by the hot exhaust gases.

Section

23

ENGINE BLOCK ASSEMBLIES

188D DIESEL AND 188G, 159G, 148G SPARK IGNITION ENGINES

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SPECIFICATIONS

NOTE: All dimensions are given in inches. Specifications apply to all engines unless noted.

Maximum Limit
Including Wear

CYLINDER SLEEVES

I.D. of sleeve (159G)	3.5013 to 3.5028	.....	.005
(188D)	3.8115 to 3.8125	.....	.005
(188G)	3.8130 to 3.8145	.....	.005
(148G)	3.3745 to 3.3765	.....	.005
Sleeve out-of-round .....			.004
Clearance to bottom of piston skirt (188D) .....	.0035 to .0055		
(188G) .....	.0025 to .0035		
(159G) .....	.0015 to .0045		
(148G) .....	.0030 to .0035		
Taper .....			.001

PISTON

Type	Cam Ground		
Material	Aluminum Alloy		
O.D. at bottom of skirt: 90° to piston pin (188G)	3.8090 to 3.8105		
(188D)	3.8070 to 3.8080		
(159G)	3.4983 to 3.4998		
(148G)	3.3735 to 3.3750		
I.D. of piston pin bore (188D)	1.2500 to 1.2503	.....	.001
(188G, 159G) .....	.9992 to .9994	.....	.001
(148G) .....	.8592 to .8594	.....	.001

Width of 1st ring groove (188D)	Keystone Type		
(188G, 159G, 148G) .....	.0965 to .0975		
Width of 2nd ring groove (188D) .....	.097 to .098		
(148G, 159G, 188G) .....	.0955 to .0965		
Width of 3rd ring groove (188D) .....	.1895 to .1885		
(188G, 159G, 148G) .....	.0955 to .0965		
Width of 4th ring groove (188G, 159G, 148B) .....	.250 to .251		

PISTON RINGS

No. 1 Compression (188D)	Chrome Grooved Keystone		
(188G, 159, 148G)	Tapered Face		
Width (188D)	Not measurable		
(188G, 159G, 148G) .....	.0930 to .0935		

SPECIFICATIONS (Cont'd)

PISTON RINGS (Continued)	Maximum Limit Including Wear
End gap in 3.812 I.D. sleeve (188D) .....	.015 to .025
3.375 I.D. sleeve (148G) .....	.010 to .020
3.500 I.D. sleeve (159G) .....	.010 to .020
3.812 I.D. sleeve (188G) .....	.010 to .020
Side clearance (188D)	Not measureable
(188G, 159G, 148G) .....	.0030 to .0045
No. 2 Compression (188G, 159G, 148G)	Tapered Face
(188D)	Grooved
Width (188G, 159G, 148G) .....	.0930 to .0935
(188D) .....	.0925 to .0935
End Gap in 3.812 sleeve (188D) .....	.015 to .025
3.375 sleeve (148G) .....	.010 to .020
3.500 sleeve (159G) .....	.010 to .020
3.812 sleeve (188G) .....	.010 to .020
No. 2 Compression	
Side clearance (188D) .....	.0035 to .0055
(188G,159G,148G) .....	.0020 to .0035
No. 3 Compression (188G,159G,148G)	Tapered Face
Width .....	.0930 to .0935
End gap in 3.812 sleeve (188G) .....	.010 to .020
3.375 sleeve (148G) .....	.010 to .020
3.500 sleeve (159G) .....	.010 to .020
Side clearance .....	.0020 to .0035
OIL RINGS	
Width (188D) .....	.1825 to .1888
(188G,159G,148G) .....	.2485 to .2490
Side clearance (188D) .....	.000 to .007
(188G,159G,148G) .....	.0010 to .0015
End gap in 3.812 I.D. sleeve (188G) .....	.010 to .018
3.375 I.D. sleeve (148G) .....	.010 to .018
3.500 I.D. sleeve (159G) .....	.010 to .018
Rail end gap in 3.812 I.D. sleeve (188D) .....	.015 to .055

SPECIFICATIONS (Cont'd)

Maximum Limit
Including Wear

PISTON PIN

Type	Full Floating
O.D. of pin (188D)	1.2497 to 1.2498
(188G, 159G) .....	.9991 to .9992
(148G) .....	.8592 to .8593
Fit in piston (188D) .....	.0002 to .0006
(188G, 159G) .....	.0000 to .0003
(148G) .....	.0000 to .0002
Fit in rod bushing (188D) .....	.0002 to .0006
(188G,159G,148G) .....	.0003 to .0006

CONNECTING ROD

Bushing	Replaceable Bronze		
Bushing I.D. installed (reamed to size)			
(188G,159G)9995 to .9997001
(188D)	1.2502 to 1.2504001
(148G)8596 to .8598001
Bushing out-of-round0015
Bearing Liners	Replaceable		
Bearing liner width	1.120 to 1.130		
Rod width at crank end	1.3035 to 1.3055		
Journal I.D. without bearing liners	2.1870 to 2.1875		
Bearing oil clearance0010 to .0035006
Undersize bearings for service .....	.002,.010,.020,.030	
Side clearance .....	.005 to .011	
Cap bolts	Self locking type		

CRANKSHAFT

Type	Balanced		
Main bearing liners	Replaceable		
End play, center main bearing cap .....	.001 to .006	
Thrust spacer std. thickness .....	.092 to .098	
Connecting rod journal std. O.D.	2.0605 to 2.0615		
Grind to .010" O.D. undersize	2.0505 to 2.0515		
.020" O.D. undersize	2.0405 to 2.0415		
.030" O.D. undersize	2.0305 to 2.0315		
Connecting rod journal maximum taper002