

SMCS - 1124

SEHS95640001

Introduction

This Special Instruction contains the necessary procedures and information for the repair of 3400 engines after a cylinder head gasket failure. Proper repair procedures will increase the longevity of a head to block joint repair. The omission of any of the steps from the procedure could reduce the useful service life of the new cylinder head gasket.

In addition to the steps outlined in this special instruction, correct calibration and operation of other components/systems should be verified. These can include:

- * Ether Starting Aids
- * Timing Advance
- * Governor Rack/Torque Settings
- * Water Pump Output/Thermostat Operation
- * Radiator/Oil Cooler Flow - Winter Fronts
- * Intake/Exhaust System Restriction Levels

These components affect the cylinder pressure and thermal stress to which the head gasket is subjected. Improper calibration and operation will adversely affect the life of the head to block joint repair.

NOTE: Refer to the service manual for operations not covered in this special instruction. Two videos are available to provide additional information on testing and repair procedures. Refer to LEVR2245, "Detection of Air Combustion Gases in the Cooling System" and LEVR2361, "Head to Block Joint Repair". Refer to the guidelines for reusable parts for other criteria on component reuse not covered in this publication.

Reference: Engine Data Sheet, LEKQ7235. Guideline For Reusable Parts, SEBF8131, "Spacer Plates", SEBF8068, "Cylinder Liners", and SEBF8198, "Procedure to Install Top Deck Insert in 3406 Remanufactured Engines or Short Blocks". Special Instructions, SMHS8222, "Installation of 2W-3815 or 5N-0093 Inserts". Video, LEVR2245, "Detection of Air and Combustion Gases in the Cooling System" and LEVR2361, "Head to Block Joint Repair".

Required Tooling

TOOLS	
Part No.	Description
1P-3036	Tap
1U-6318	Puller
6V-7059	Micrometer
8T-0455	Liner Projection Tool Group
9U-7990	Counterbore Tool Group
9U-7993	Depth Gauge Assembly
PT-2000-101	Plug (Kent Moore part No.)
MATERIALS	
5P-3321	Adhesive
5P-3413	Thread Sealant
6V-4876	Molykote Paste Lubricant
7M-7456 or 6V-6640	Bearing Mount Liquid Gasket
8T-9011	Component Cleaner

Combustion Gas Leakage Tests

Refer to video LEVR2245, "Detection of Air Combustion Gases in the Cooling System". Coolant loss and aeration can be caused by reasons other than combustion gas leakage past the head gasket fire ring seal.

Air can enter the system by:

- * Filling the system improperly.
- * Allowing the coolant level to drop too low.
- * Improper cooling system maintenance.
- * Venting the system improperly.
- * Through a cracked air compressor head.

Combustion gases can enter the cooling system at:

- * The head to block joint.
- * An injector adapter/seal.
- * A cracked cylinder head.
- * A cracked cylinder liner flange.
- * Through a pitted cylinder liner.

One way to detect air or combustion gas entry into the cooling system is to visually inspect the system's components.

The simplest is to check the coolant level. Significant coolant aeration is unlikely if the system is full and no coolant has recently been added. If it is low, there may have been an overflow discharge, a result of air or gas in the cooling system.

A more thorough procedure is to pressurize the system [75 to 103 kPa (11 to 15 psi)] and check for external leaks:

- * Hoses and lines.
- * Clamps and connections.
- * Water pump seal.
- * Radiator, heat exchanger/expansion tank cap.
- * Radiator core, header and tanks.
- * Gaskets and drain plugs.

All of these could be sources of leaks and should be repaired immediately.

A properly functioning radiator cap is crucial to sealing and maintaining the cooling system pressure. If the cap is not seated tightly in the filler neck or the pressure relief valve opens at a pressure that is too low, the system pressure and the boiling point of the coolant will be reduced. This can allow coolant to escape through the overflow hose.

It is very important to make sure the cooling system is filled to the proper level. **BE CAREFUL NOT TO OVERFILL THE SYSTEM.** It will purge itself to reach equilibrium and coolant will be discharged through the overflow.

When the radiator is filled initially or when the coolant is changed, premixed coolant should be added no faster than 20 liters (5 gallons) per minute. This fill rate reduces the chance of trapping air bubbles in the system and causing the coolant level to be too low.

Inspect the coolant level in the top tank. Bring the coolant to the proper level before testing.

An easy method to test for air or combustion gas in the cooling system is the Pressure Test using a 9S8140 Pressurizing Pump and Gauge Kit. Disengage the fan so that it will not come on and decrease the coolant temperature.

Remove the pressure cap or radiator cap and run the engine until the thermostat opens and the engine coolant reaches operating temperature of 91 to 100°C (195 to 210°F). This will vent the normal coolant expansion.

After the temperature stabilizes, install the 9S-8140 Pressurizing Pump and Gauge Kit.

Use the pump to pressurize the system to nominal pressure of 35 to 50 kPa (5 to 7 psi). Continue to run the engine at a constant rpm (at rated or < 1800 rpm) and monitor the gauge.

NOTICE

Because the pressurizing kit does not have an automatic pressure relief valve, do not exceed 103 kPa (15 psi) or cooling system components may be damaged.

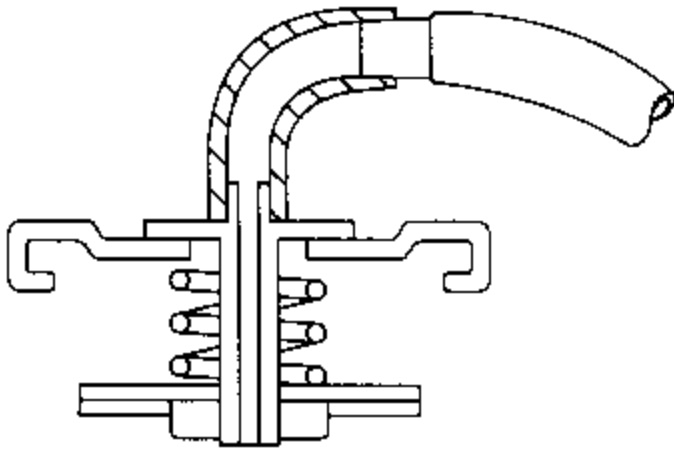
If the pressure reaches 75 kPa (11 psi) or greater within five to ten minutes, release it back to 35 to 50 kPa (5 to 7 psi). If the pressure rises again to 75 kPa (11 psi) or greater, there probably is an internal leak that will require removal and inspection of the cylinder head, gasket, injector adapters or cylinder liners.

If there is no combustion gas leakage, the gauge will remain at 35 to 50 kPa (5 to 7 psi).

Air and gas in the system can also be checked with the Bottle Test.

The equipment needed for this test is a bucket of water, a calibrated half liter or pint bottle, and a length of hose attached to a modified radiator cap.

The modified cap should allow air and gases to be vented through the center top of the cap and out the hose. Most vehicle and commercial engines have a separate pressure relief valve. An identical cap should be obtained and modified to perform this test. (Refer to Engine Data Sheet LEKQ7235 Cooling System Field Test.)



Typical example of radiator cap modified to allow air and gases to be vented.

After the pressure test, the engine should already be at operating temperature and the expansion air and gases vented. Install the modified radiator cap and hose. Submerge the bottle in the bucket, filling the bottle completely with water. Invert the bottle, keeping the mouth under water. Place the loose end of the hose into the water-filled bottle.

Continue to run the engine at constant rpm (at rated or < 1800 rpm). If there is a combustion gas leak, the gas will make its way to the radiator, through the hose and into the inverted bottle.

COOLING SYSTEM WATER DISPLACEMENT			
Engine	Displacement	Water/Minute Displacement	
		No Load (A)	Load (B) (5% of displacement)
3406	14.6 L	0.5 L 2 cup 17 oz	0.75 L 3 cup 25 oz
3408	18 L	0.6 L 2.5 cup 20 oz	0.9 L 4 cup 30 oz
3412	27 L	0.9 L 4 cup 30 oz	1.35 L 5.5 cup 45 oz

If more water per minute than specified for No Load value (A) is displaced, air or gas entering the cooling system is excessive. Under a load condition on a dyno, displacement value (B) per minute would be excessive. There is probably an internal leak that will require removal and inspection of the cylinder head, gasket, injector adapters or cylinder liners.

Repair Procedure

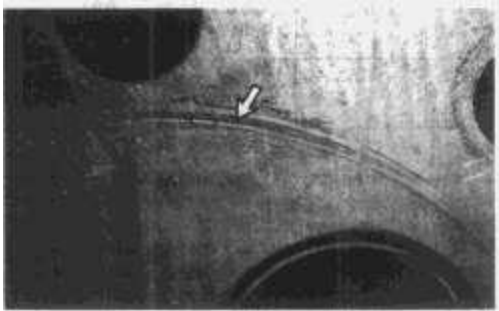
Cylinder Head - Bottom Deck

Refer to video LEVR2361, "Head to Block Joint Repair" for additional information. Remove the cylinder head from the engine to expose the bottom deck sealing surface. Before cleaning or machining of the cylinder head bottom deck, remove fuel injection nozzles/adapters from the head. Use a putty knife to scrape off any excess gasket material. With the valves still in place, thoroughly clean the bottom deck with a wire wheel or "Scotchbrite" pad. Use 8T-9011 Component Cleaner to remove any oil, grease or loose carbon from the combustion surface and wipe clean.

NOTICE

If a metal reconditioning disk is used to remove gasket material, caution should be used to not remove any metal. If used too long in a small area, metal may be removed which may affect sealing surfaces.

Visually inspect the bottom deck of the cylinder head for damage. Determine if the combustion surface flatness is within specification. Occasionally, the head gasket fire ring sealing surface can suffer erosion or "Beat-In" following a gasket failure. If a depression can be felt in this area with the fingertip or fingernail, measure the depth with a 8T-0455 Liner Projection Tool Group. Be sure the tool dial indicator is correctly calibrated before use.



If erosion or fire ring "Beat-In" exceeds 0.025 mm (.0010 in), the cylinder head combustion surface must be repaired by machining or the head replaced.

Erosion around the water hole is not critical if there is enough material left to support the water ferrule. Erosion in this area can sometimes be corrected with a room temperature vulcanizing (RTV) compound, 5P-3321 Adhesive (epoxy), a compound of liquid metal fillers or Belzona® Ceramic R Metal.

Cylinder Heads - Critical Factors for Reconditioning

There are several factors which affect the amount of material that can be removed from the surface of a cylinder head. These include valve projections, surface flatness and finish. Measure these areas as well as the cylinder head minimum thickness dimensions whenever you recondition the head to block mating surface.

Before cleaning or machining of the cylinder head bottom deck, remove fuel injection nozzles/adapters from the head. On occasion, intake and exhaust valves may also require removal. Machining this surface can be accomplished with a mill, surface broach machine or surface grinder.

NOTE: Remove the minimum amount of material necessary to make the repair. The minimum head thickness following machining is 111.51 mm (4.390 in) on all 3400 Engines (except the 3406E). The minimum head thickness for 3406E Engines is 119.50 mm (4.705 in).

Surface Finish/Flatness

Machined surfaces must be smooth to form a good seal. The surface finish of the cylinder head faces must be as smooth as a new head. Cylinder head flatness must not vary more than 0.13 mm (.005 in) overall, or 0.025 mm (.0010 in) for any 76 mm (3.0 in) span.

Cylinder head flatness can be measured by using a 610 mm (24.0 in) straight edge for measuring the total length flatness and a 152 mm (6.0 in) straight edge for measuring across the sealing surface.

* Place the straight edge on the sealing surface.

* Use the feeler gauge and very carefully slide it under the straight edge.

NOTE: Clean machining debris from internal head passages prior to reassembly.

Valve Projection

After the cylinder head has been reconditioned, you must measure the valve projection. The maximum and minimum projection specifications for intake and exhaust valves are listed in the Service Manual for the engine. Excessive projection can cause the valve head to contact the piston during engine operation. For additional information, refer to the articles in August 1995 Truck Engine News, September 1995 Engine News, and August 28, 1995 Service Magazine.

Cylinder Head Coolant Passages

To improve coolant flow near the #6 cylinder of the existing cylinder head on 3406 and near the #1 and #12 cylinders on 3412 Engines, drill two new coolant flow passages through the top and intermediate decks. On the 3408 heads, two coolant flow passages should be drilled near the #1 and #8 cylinders. The coolant flow passages must be drilled before proceeding with the head gasket repair. If using a parts stock cylinder head, the coolant passages should already exist and no further drilling is required.

New cylinder heads have the additional coolant passages cast in the rear part of the head. The additional coolant passages provide improved coolant circulation in that area. This will result in reduced thermal stresses in the head to block joint at the rear of the engine. The reduced stress will result in increased cylinder head gasket life.

Initially, the cylinder heads were drilled to add two coolant passages. This change is identified by the pipe plug at the rear center of the 3406 and 3412 cylinder heads, between the head bolts. The 3408, as well as 3406 and 3412, heads can be identified by the enlarged 5.0 mm (.20 in) to 15.0 mm (.59 in) diameter hole in the intermediate deck below the pipe plug. This is located in the corner near #1 and #8 cylinders.

New cylinder heads are cast with the additional coolant passages. This change is identified by the casting part number. The part number and its location is identified in the chart below.

HEADS WITH ADDITIONAL COOLANT PASSAGES	
Casting Part Number	Location
3406 Cylinder Head	
9Y-3777	Left rear side
3408 Cylinder Head	
105-3787	Inside near #4 cylinder (right side)
	Inside near #5 cylinder (left side)
3412 Cylinder Head	
105-3797	Inside near #3 cylinder (left side)
	Inside near #10 cylinder (right side)

The following charts show effective serial numbers for drilled and cast cylinder heads on 3406, 3408, and 3412 Engines.

**CHART A. 3406 ENGINE ADDITIONAL DRILLED AND CAST
COOLANT PASSAGES EFFECTIVE WITH**

Model	Engine Serial Number	
	Drilled	Cast
Machine	11N3735	11N3780
Industrial	6TB9834 90U19927 —	6TB9857 90U19927 4FD325
Marine	4TB3476	4TB3482
Generator Set	2WB11470 4RG1501 —	2WB11476 4RG1502 4JK99
Remanufactured Industrial	9HB404	—
Truck	3ZJ22852 5KJ7877 4CK2575	3ZJ23244 5KJ7879 4CK2892
Remanufactured Truck	8SB2753 7XC3353	— —

CHART B. 3408 ENGINE ADDITIONAL DRILLED AND CAST COOLANT PASSAGES EFFECTIVE WITH		
Model	Engine Serial Number	
	Drilled	Cast
Machine	48W35135	48W35358
Industrial	67U15990 6NB1015 —	67U16071 6NB1041 9TD617
Marine	1LG653 8RG102 99U7556	1LG658 8RG108 99U7599
Generator Set	78Z4804 —	78Z4867 2BG648
Truck	28V4907	28V4911

CHART C. 3412 ENGINE ADDITIONAL DRILLED AND CAST COOLANT PASSAGES EFFECTIVE WITH		
Model	Engine Serial Number	
	Drilled	Cast
Machine	73W14563	73W14714
Industrial	38S16434 9XF68 — —	38S16484 9XF77 3NK94 7DB839
Marine	60M5076 3JK129 —	60M5161 3JK146 7HG88
Generator Set	81Z14247	81Z14500

Cylinder Head-Drill Coolant Passages (3406 Engines Only)

Remove the 38.35 mm (1.509 in) cup (core) plug from the rear face of the cylinder head. This plug is often hidden from view by the rear engine lifting eye. The rear head coolant passage and exhaust port

wall will be visible. Measure the distance from the rear face of the head to the wall of the exhaust port. This dimension will vary on every cylinder head due to casting variations. Locate the centerline of the new drilled hole so that the drill bit does not contact the exhaust port wall. Do this by subtracting a minimum of 8.1 mm (.32 in) from the measured dimension. Locate and mark the cylinder head center line. This centerline extends through the nozzle adapter holes. The first step is to use a 15.00 mm (19/32 in) drill bit and drill a hole 85.0 mm (3.35 in) deep. (Approximately 25.4 mm (1.00 in) from the bottom surface of the head.) Do not exceed this depth, as damage to the bottom deck may occur. Use the existing hole as a pilot and a 18 mm (23/32 in) drill bit and enlarge the hole in the top deck to a depth of 20.0 mm (.79 in). Tap the hole to accept a 1/2-14 NPTF threaded pipe plug.

Remove the existing pipe plug from the right rear corner of the cylinder head top deck. Visible inside is a 5 mm (.2 in) diameter bleed hole. Use a 15.00 mm (19/32 in) drill bit and enlarge the 5 mm (.2 in) diameter hole, drilling 85.0 mm (3.35 in) deep. Use care not to damage the existing pipe threads. Clean up threads if necessary.

NOTE: Some older version heads have 3/8 inch pipe plug in this location. The 3/8 inch pipe plug can be retained or it can be enlarged to a 1/2 inch pipe plug using drill diameters given above.

Clean the chips from both holes using a magnet. Scrape out any existing sludge from the newly exposed cavities to improve heat rejection. Install the new and previously removed pipe plugs with 5P-3413 Thread Sealant. Install new 2M-6471 Plug (core) with 7M-7456 Bearing Mount or 6V-6640 Liquid Gasket on the outside diameter to prevent leakage.

Cylinder Head-Drill Coolant Passages (3408 Engines Only)

The end of the cylinder head that is to be machined is the #1 cylinder end on the left bank and #8 cylinder end on the right bank. The "3408 Cylinder Head - Drill Coolant Passage" illustration shows the location of the existing pipe plug on the right rear corner. (Same as the 3406 Engine.)

Remove the existing pipe plug from the right rear corner of the cylinder head top deck. Visible inside is a 5 mm (.2 in) diameter bleed hole. Use a 15 mm (19/32 in) drill bit and enlarge the 5 mm (.2 in) hole, drilling 85.0 mm (3.35 in) deep. Use care not to damage the existing pipe threads. Clean up the threads, if necessary.

NOTE: Some earlier versions of the cylinder head have a 3/8 inch pipe plug in this location. The 3/8inch pipe plug can be retained, or it can be enlarged to a 1/2 inch pipe plug using the drill diameters given below.

Due to the location of the threaded hole for a valve cover retaining bolt, the machining for the 3408 cylinder heads is different than that required for the cylinder heads used on the 3406 Engines. Remove the 44.80 mm (1.764 in) cup (core) plug from the end of the cylinder heads near the #8 and #1

cylinders. Locate the vertical center line of the core plug hole. This will be in-line with the nozzle adapter holes. Use a 19.0 mm (.75 in) end mill at a 45° angle. See Illustration, "3408 Cylinder Head - Drill Coolant Passages".

NOTE: Align the end mill to miss the lower corner of the core plug hole.

Machine a flat surface to start the drill bit. It is not necessary to clean up the entire 19.0 mm (.75 in) diameter. Finish drilling a 15.00 mm (19/32 in) diameter hole through the intermediate deck [approximately 25.4 mm (1.00 in) from the bottom surface of the head].

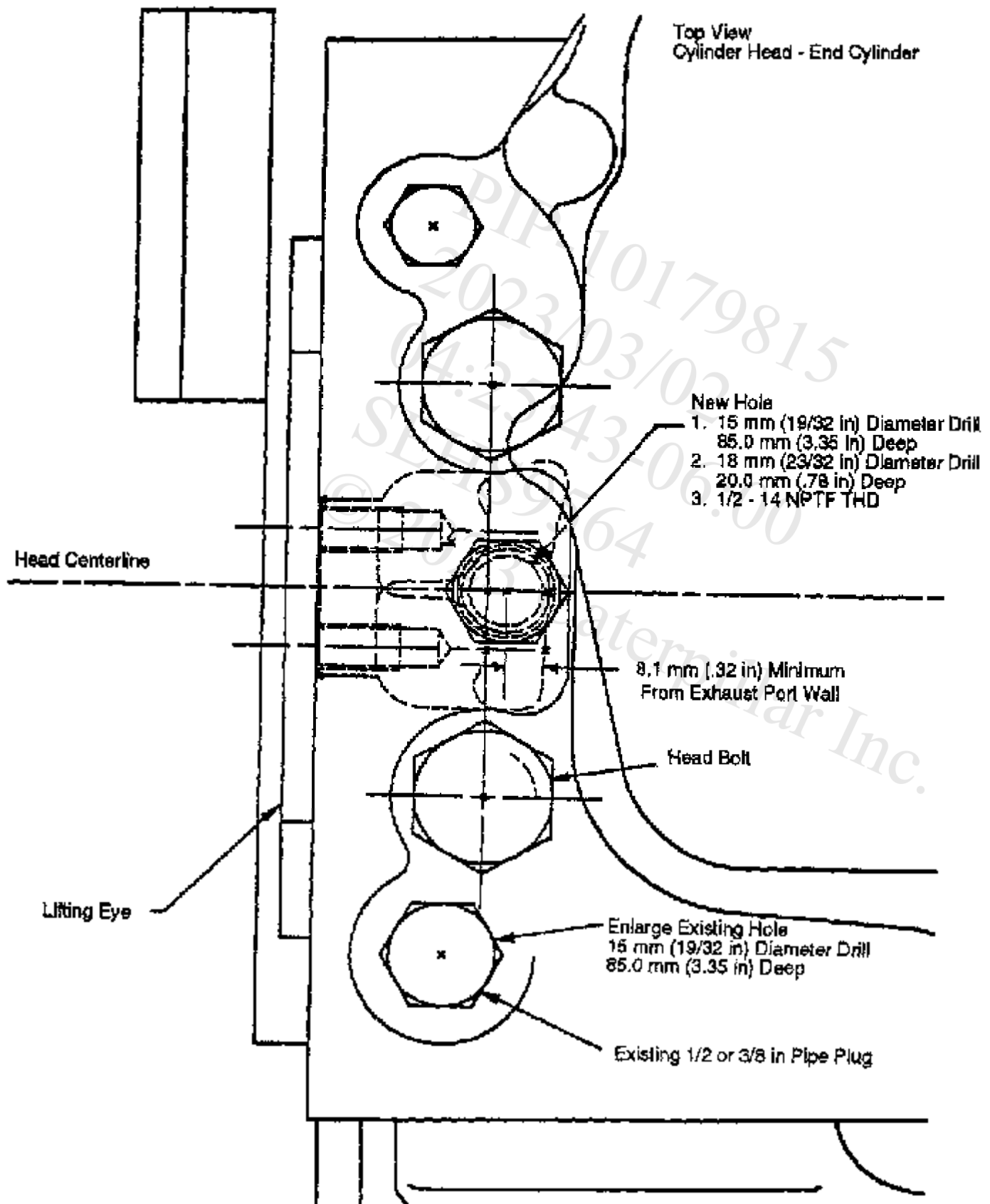
Clean metal chips from both holes using a magnet. Scrape out any existing sludge from the newly exposed cavities to improve heat rejection. Install the new and previously removed pipe plugs with 5P-3413 Thread Sealant. Install a new 2M-6471 Plug with 7M-7456 Bearing Mount or 6V-6640 Liquid Gasket on the outside diameter to prevent leakage.

Cylinder Head-Drill Coolant Passages (3412 Engines Only)

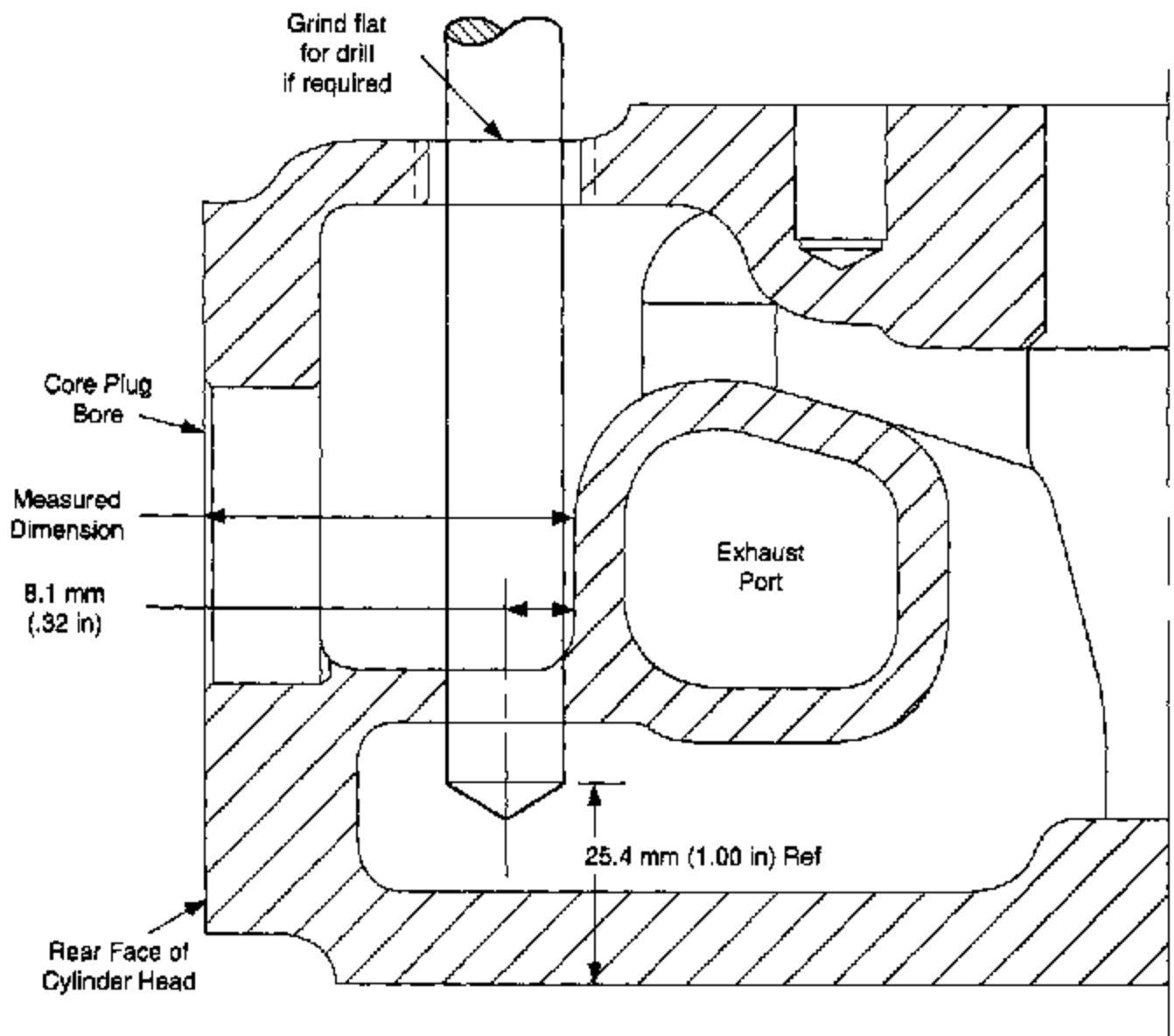
The end of the cylinder head that is to be machined is the #1 cylinder end on the left bank and #12 cylinder end on the right bank. The cylinder heads for 3412 Engines are to be machined similar to those for the 3406 Engines. To machine the head, remove 44.80 mm (1.764 in) cup (core) plug from the end of the head.

NOTE: Older 3412 heads with 55.0 mm (2.17 in) diameter injector adapters, instead of the current 40.0 mm (1.57 in) adapters, should be drilled at an angle like the 3408 heads.

3406 and 3412 Cylinder Head - Drill Coolant Passages



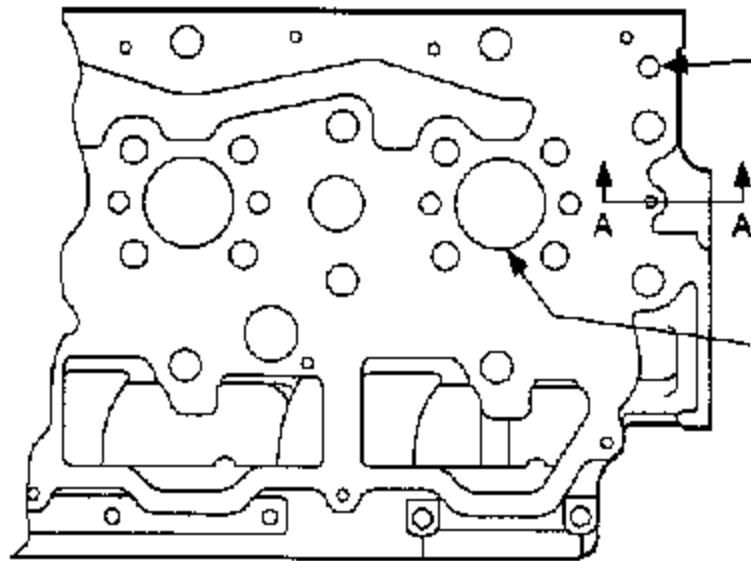
3406 and 3412 Cylinder Head-Drill Coolant Passages Cross-Section



3408 Cylinder Head - Drill Coolant Passages

Existing 1/2 or 3/8 inch Pipe Plug

Enlarge existing hole
15 mm (19/32 in) Diameter Drill
85.0 mm (3.35 in) Deep



#1 or #8
Cylinder

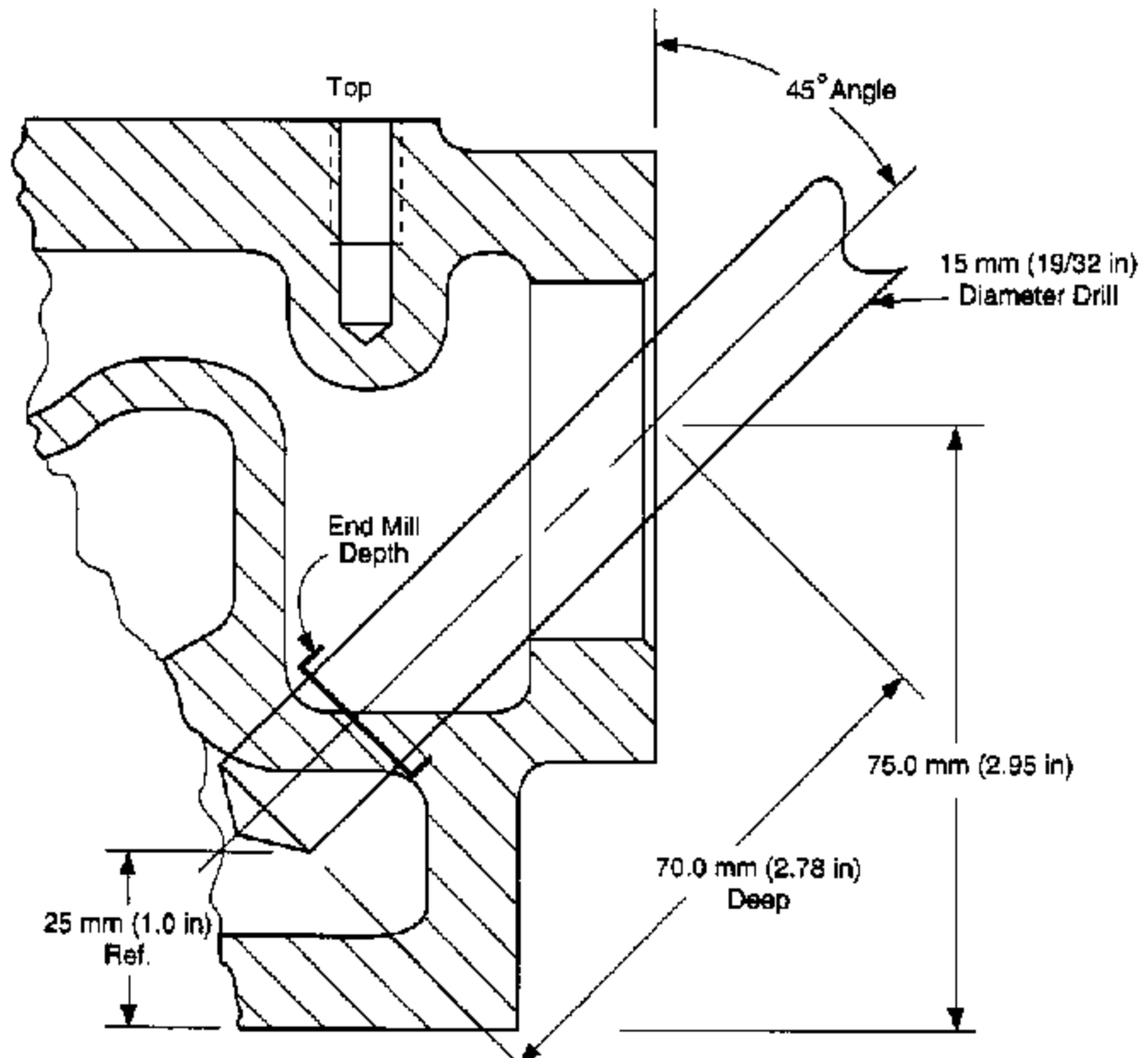


CHART D. SERVICE PART NUMBERS																		
3406 CYLINDER HEADS - SERVICE PART NUMBERS																		
Application									Remanufactured				Reference Part Numbers					
Adapter Bore Dia.	Engine	Valve						New Head Assem.	New Head Group	Head Assembly		Head Group		Description	Head Assem.	Head Group		
		Seat Type	Seat Angle Intake	Seat Angle Exhaust	Gudge Material	Exhaust Port Shape w/inlet	New			Upgrade to New	New	Upgrade to New						
40mm	Diesel	Std	30	45	Cast Iron	Rect. Rect.				DR-3571		OR-3574		3406B Truck		4W-245B		
												OR-3575		3406B Non Truck		1W-145B		
												OR-4175		3406B Trs AT&AC-450hp				
42mm	Diesel	Std	30	45	Cast Iron	Round	11D-5590			DR-3716				3406B Machine	61D-500B	7E-087D, 7W-220B		
														OR-4000		3406B Machine	11D-500B	11D-600B
														OR-4919		3406B Wheel Tractor	11D-600B	7W-240C, 11D-500B
														OR-4982		3406B Excavator	11D-600B	7E-065D
														OR-3716		3406B Truck		4W-240B
														OR-3730		3406B Non Truck		1W-140B
														OR-3943		3406B Trs AT&AC-450hp		
														40mm	Diesel	Swirl	30	45
OR-4886		3406C Trs JohnDee 8H	115-235B	115-046D														
OR-4885		3406C Trs Blue Ox B&L	115-335B															
EUI	Diesel	Std	30	45	Cast Iron	Rnd w/inlet	122-0942	122-702A		DR-3870				3406E	4F-095D			
														OR-3870		3406E		
														OR-3873		3406E		4N-527D
35mm	Diesel	Std	30	45	Cast Iron	Rect. Rect.				DR-3571		OR-3574		3406E 300hp and below		4N-527D		
												OR-3575		3406E Prechamber		4N-528D, 4W-530D		
												OR-3576		3406E		4N-527D		
35mm	SI	Std	20	30	Powdered	Round	123-7334	123-7333					Stackomatic		6U-556B			
													OR-4587	OR-4588	Stackomatic			
3408 CYLINDER HEADS - SERVICE PART NUMBERS																		
Application									Remanufactured				Reference Part Numbers					
Adapter Bore Dia.	Engine	Valve						New Head Assem.	New Head Group	Head Assembly		Head Group		Description	Head Assem.	Head Group		
		Seat Type	Seat Angle Intake	Seat Angle Exhaust	Gudge Material	Exhaust Port Shape w/inlet	New			Upgrade to New	New	Upgrade to New						
40mm	Diesel	Std	30	45	Cast Iron	Rectangular	7W-2025		545-8121	CR-4145	DR-4150	OR-4129	OR-4130	DI (Old Head)	105-378B	7W-2024, 7D-048B, 1D-732D		
														PC	105-3791	6W-744B, 6W-744B		
35mm	Diesel	Std	30	45	Cast Iron	Rectangular	7W-065B			CR-4150	DR-4150	OR-4127	OR-4130	DI	105-3791			
														DI	105-3791			
														DI (Old Head)	105-3791			
40mm	SI	Std	20	30	Cast Iron	Rectangular						OR-4480	OR-4481	Stackomatic	105-335B			
														Stackomatic	105-379B			
35mm	SI	Std	20	30	Cast Iron	Rectangular							OR-4480	OR-4481	Stackomatic	105-379B		

CHART D. SERVICE PART NUMBERS (CONTINUED)																	
3412 CYLINDER HEADS - SERVICE PART NUMBERS																	
Application									Remanufactured				Reference Part Number				
Adapter Bore Dia.	Engine	Valve						New Head Assem.	New Head Group	Head Assembly		Head Group		Description	Head As.	Head Group	
		Seat Type	Seat Angle Intake	Seat Angle Exhaust	Gudge Material	Exhaust Port Shape w/Inlet	New			Upgrade to New	New	Upgrade to New					
40mm	Diesel	Std	30	45	Cast Iron	Rectangular	7W-2243			OR-4147	DR-4135	OR-4148	DR-4148	DI (Old Head)	105-380D	7W-2242, 10D-1087	
35mm	Diesel	Std	30	45	Cast Iron	Rectangular	7W-065B			OR-4126	DR-4134	OR-4144	OR-4140	PC	105-379B	1W-556B	
						Rectangular						OR-4145	OR-4141		DI	105-379B	
						Rectangular						OR-4131			DI (Old Head)	105-379B	
												OR-4487	OR-4488		Stackomatic		
35mm	SI	Std	20	30	Cast Iron	Rectangular	123-7336	123-7335					OR-4488	OR-4488	Stackomatic	105-379B	
35mm	SI	Std	30	30	Cast Iron	Rectangular	4W-047B							OR-4488	OR-4488	Stackomatic	105-379B

Spacer Plate (3406, 3408, and 3412 Engines)

Use care when removing and handling aluminum spacer plates to retain maximum reusability. Before cleaning the spacer plate, perform a quick visual inspection for bending (warping), deep scratches or cuts, wide cracks, heat or impact damage. Hairline cracks do not necessarily prevent the reuse of the spacer plate. The Guideline For Reusable Parts, SEBF8131, clarifies the reuse guidelines for 3400 Engine spacer plates. Do not reuse a spacer plate that has cracks with spalling of material or scorch paths from prolonged combustion gas leakage.

Cracks without measurable width (hairline) are permitted between the large head bolt holes and the large cylinder liner clearance holes or valve train pockets. Hairline cracks are also permitted between adjacent large cylinder liner clearance holes as these cracks do not affect the function of the spacer

plate. Cracks or connecting surface depressions across the outside perimeter of the plate on either side are not permitted. These characteristics may create paths for external fluid leakage.

Steel spacer plates can be cleaned with traditional methods. However, for aluminum plates, glass beading is the preferred cleaning method. Do not scrape the aluminum plate with a steel putty knife or sand the surface with sandpaper, wire brush or wheel. Refer to the following chart for standard spacer plate thickness.

CHART E. SPACER PLATE SPECIFICATIONS				
Engine	Serviceable Part No.(1)	Material	Thickness(2)	
3406 (early)	4N-2104	Steel	8.585 ± 0.025 (.3380 ± .0010)	
	7N-0624			
3406 3406B 3406C	2W-8601	Aluminum		
	7N-1199	Steel		
	6I-2981			
3406E	6I-4421 (Standard)	Steel	8.509 ± .025 (.3350 ± .0010 inch)	
	138-9381 (Undersized)			
3408 3408B 3408C	4N-4178	Aluminum (4C-8531)	8.585 ± 0.025 (.3350 ± .0010)	
		Steel (7C-8616)		
	6I-4613	Steel		
3412 3412C	4N-4501	Aluminum (7C-8532)		
		Steel (4C-8617)		
	6I-4611	Steel		
3406 3406B 3406C	6I-3189	Aluminum	8.509 ± 0.025 (.3350 ± .0010) Parts Service 0.078 (.0030) thinner than Standard	
	6I-4303	Steel		
3408 3408B 3408C	6I-0860	Aluminum		
	102-5943	Steel		
3412 3412C	6I-0861	Aluminum		
	102-5942	Steel		
All dimensions are mm (in).				

(1) The last number in the column (by engine) is the most current.

(2) Thickness may vary no more than 0.025 mm (.0010 in) on a given plate

Optional Thinner Spacer Plate

The thinner spacer plates are 0.076 mm (.0030 in) thinner than the production spacer plates. They can compensate for repairs that produce liner projection less than 0.076 mm (.0030 in). They can be used when liner projection across all six cylinders is consistent, but near the minimum specification of 0.03

mm (.001 in). If inspection of the block top deck reveals no measurable damage directly under the liner flanges, but the average liner projection is less than 0.076 mm (.0030 in), these thinner spacer plates can be installed.

NOTE: Use of the thinner spacer plate in situations that result in excessive liner projection greater than 0.152 mm (.0060 in) is not an acceptable repair.

Visual Inspection (Cracks and/or Depressions That Are Not Allowed)

Check for cracks and connecting surface depressions due to corrosion, erosion and handling damage in the following zones (both sides of the plate).

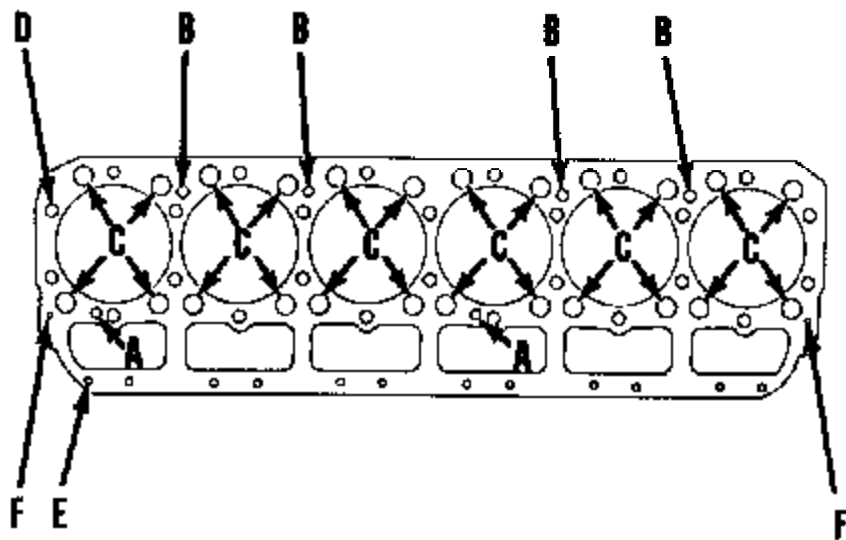


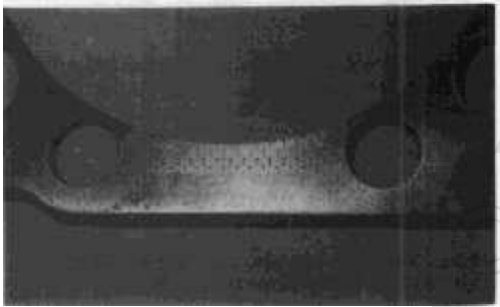
CHART F. 3400 ENGINE SPACER PLATE	
Hole	Description
A	Oil supply holes
B	Oil drain back holes
C	Water ferrules
D	Bolt holes (large)
E	Bolts holes (small)
F	Holes for locating dowels (for assembly)

1. Within 6.0 mm (.24 in) along the edge of the plate and valve mechanism opening.

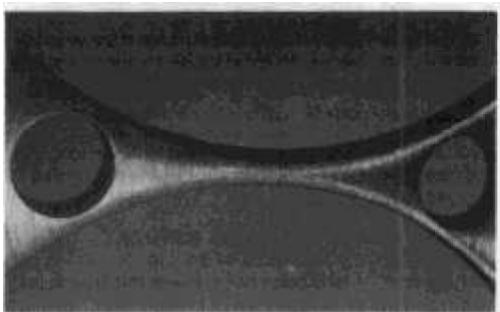
2. Within 6.5 mm (.26 in) along the edge of the gasket (or where gasket goes on plate).
3. Inside and 6.0 mm (.24 in) around oil supply holes (A).
4. Within 6.0 mm (.24 in) around the oil drain back holes (B).
5. Within 6.0 mm (.24 in) around the water ferrules (C).

Areas outside of these boundaries may have surface depressions up to 1.0 mm (.04 in) deep and 6.0 mm (.24 in) in diameter. This applies to both sides of the plate.

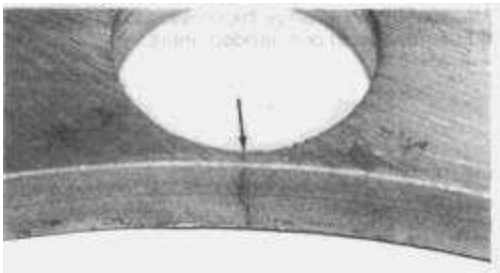
The 0.030 mm (.0012 in) maximum thickness variation does not apply to the depressed areas.



Perforated gasket core imprint - Use Again



Damage caused by unacceptable cleaning methods (Scotchbrite wheel) - Do Not Use Again



Crack without measurable width (hairline) - Use Again

Cylinder Liner - Inspect Flanges

Extended operation after a head gasket failure or filler band leakage can allow erosion or corrosion on the liner flange to cylinder block joint(s). Excessive amounts of erosion/corrosion damage can affect the

sealing capability of the head to block joint if not corrected. In order to thoroughly inspect this joint, the cylinder packs must be removed.

NOTE: Remove the cooling jets before cylinder pack removal to avoid damage to the jets.

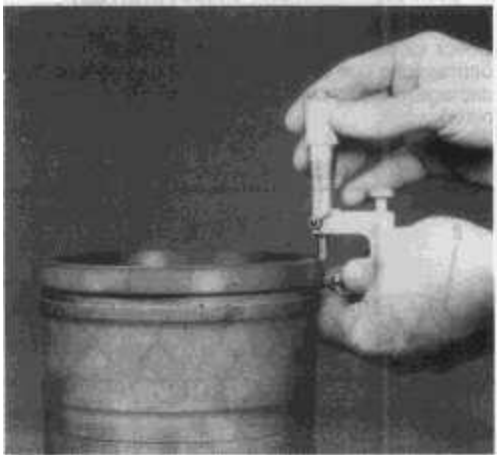
Do not measure liner projection before cylinder pack removal, unless necessary to verify the workmanship of a previous repair.

Remove all cylinder packs from the engine using the 1U-6318 Puller or equivalent. Use care when removing the packs from the block to guard against inadvertent damage to the liner seat by the connecting rod/bolts. Remove the filler bands, and clean the liner flange/seat area with a hand or rotary wire brush to allow for careful visual inspection. Do not use glass beads, as this process will disguise any erosion or flange cracks.

Evidence of minor fretting/dark stains or discoloration is acceptable when it is circumferential and does not prevent the liner from sealing. Groups or patches or pits/erosion occurring in random patterns under the liner flange are not acceptable; do not reuse the liner. This type of extensive damage normally occurs adjacent to similar erosion on the cylinder block.

Measure the liner flange thickness in four places, 90 degrees apart or in eroded areas.

Cylinder Liner - Flange Thickness



Use a 6V-7059 Micrometer to measure the thickness of the flange.

Measure the thickness of the flange with a 6V-7059 Micrometer. Use the liner again only if it is acceptable according to the specifications in the chart below.

CAHRT G. THICKNESS SPECIFICATIONS	
New Flange Thickness	"Use Again" Minimum Thickness
8.890 ± 0.020 mm (.3500 ± .0008 in)	8.870 mm (.3492 in)



Liner with significant erosion/corrosion in filler band area, under liner flange, and in fillet radius (crack could be hidden by glass beading or by improper cleaning) - Do Not Use Again



Liner with significant erosion/corrosion in filler band area, under liner flange, and in fillet radius (crack could be hidden by glass beading or by improper cleaning) - Do Not Use Again



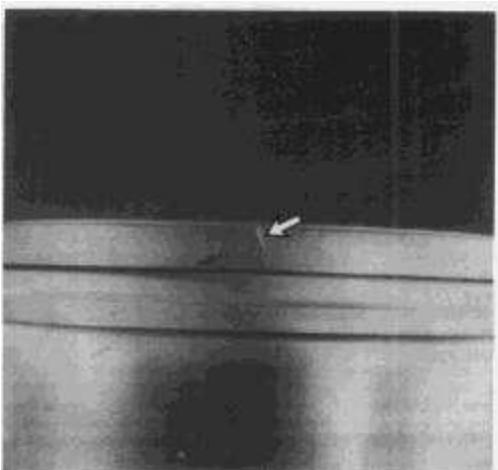
Liner with nick on the bottom of flange - Do Not Use Again



Damage to the fire dam. Use Again only if the damage is not extended completely across the fire dam and any burrs or sharp edges are removed.



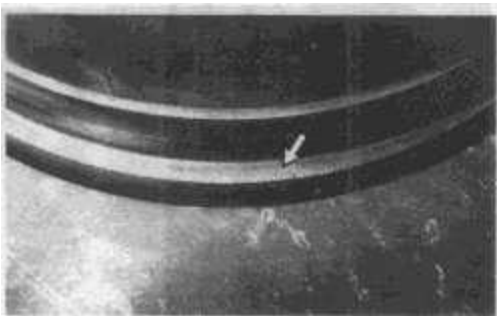
Damage in the gasket surface area. Do Not Use Again.



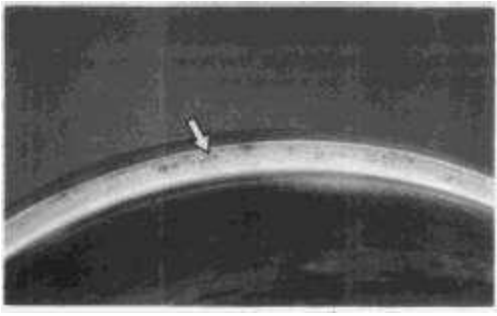
Nick in the vertical flange edge. Use Again after any sharp edges or high areas are removed with a file.



Chip in the seal edge of the flange. Do Not Use Again.



Rough, pebbly surface extending in a random pattern. Do Not Use Again.



Pits and fretting under the liner flange. Large pits or groups of pits are not acceptable, especially in the radius. Do Not Use Again.

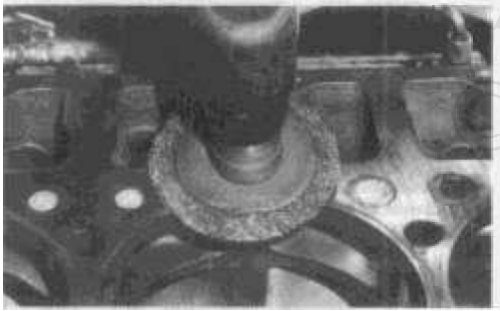


Fretting is acceptable when it is circumferential and does not prevent the liner from sealing. Measure flange thickness. Use

Again.

Refer to Guideline For Reusable Parts SEBF8068 "Cylinder Liners".

Cylinder Block - Top Deck



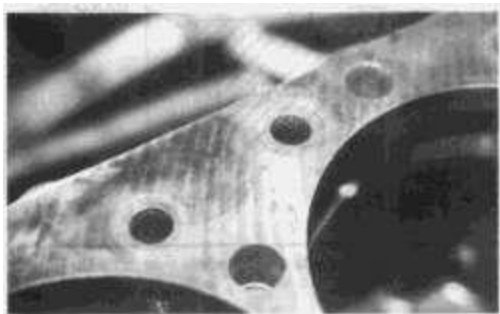
Cylinder block top deck cleaning.

Clean the cylinder block top deck completely with wire brush or "Scotchbrite" pad. Use caution when cleaning around the liner bores with rotary abrasive pads. The liner seat can be damaged if pad is not held parallel with the block surface. This damage and its reduced seating area may cause a head joint failure shortly after engine operation has begun.



Removing burrs from top deck.

After cleaning, use a flat file to dress the top deck to remove burrs and highlight the original factory milling marks.



Milling pattern marks.

Carefully inspect each liner seat area for signs of measurable erosion. Determine measurable erosion with an 8T-0455 Liner Projection Tool Group. Measurable erosion generally will destroy the milling mark

pattern and exhibit a rough, pebbly surface. If erosion directly under the liner flange measures .025 mm (.0010 in) deep or more with the depth gauge, record these measurements in the Service Report.

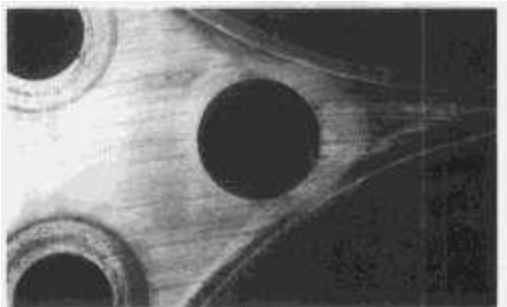
Measurable erosion under the liner flange is permissible when the eroded area is not more than .025 mm (.0010 in) deep. Multiple areas of erosion are also permissible if depth does not exceed .025 mm (.0010 in) deep. These small areas of erosion under the liner flange are acceptable. Erosion is slowed when water seals and filler band are replaced. The liner flange is designed with sufficient rigidity to span those areas without affecting sealability of the head gasket. This erosion or fretting damage is acceptable if it does not affect liner projection.



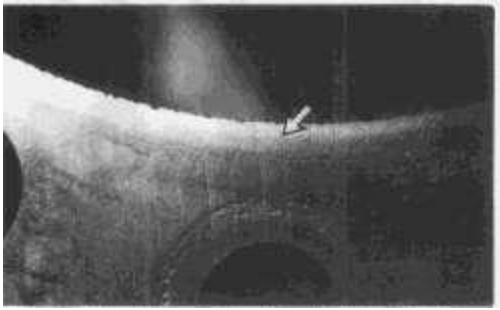
Milling marks evident, no visible or measurable erosion, liner seat areas with dark stains. Do Not Counterbore.



Milling marks evident, no visible or measurable erosion, liner seat areas with dark stains. Do Not Counterbore.



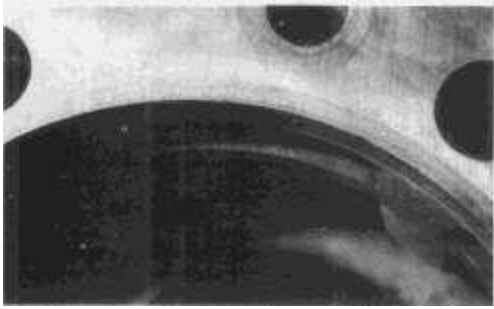
Milling marks evident, no visible or measurable erosion, liner seat areas with dark stains. Do Not Counterbore.



Milling marks evident, no visible or measurable erosion, liner seat areas. Do Not Counterbore.



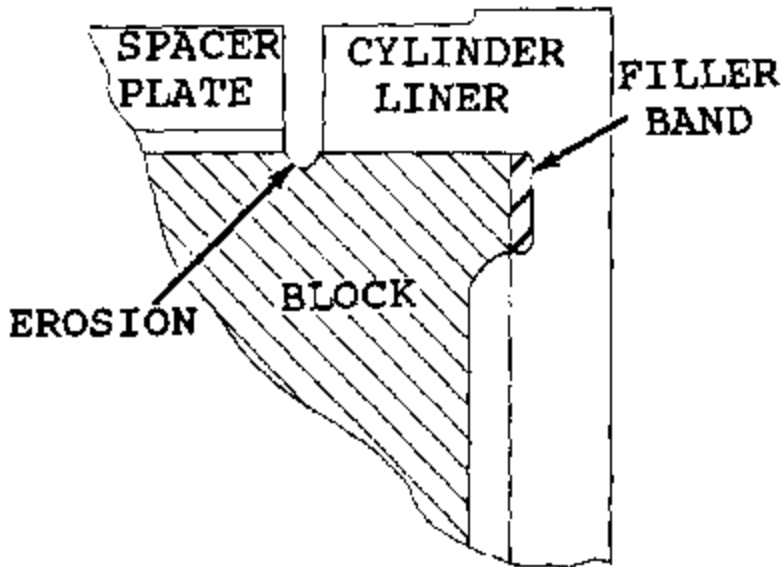
Casting damage extends more than half way across width of liner seat. Counterbore to restore liner seat flatness.



Erosion and milling mark pattern measures less than 0.025 mm (.0010 in) deep. Do Not Counterbore.

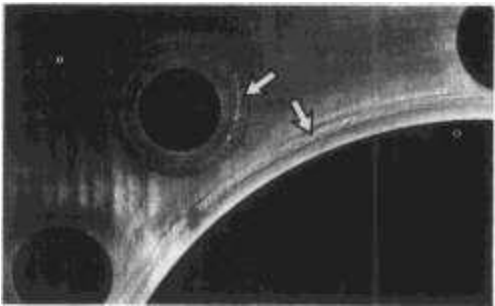


Erosion and milling mark pattern measures less than 0.025 mm (.0010 in) deep. Do Not Counterbore.



Measurable erosion outside the immediate liner seat. Do Not Counterbore.

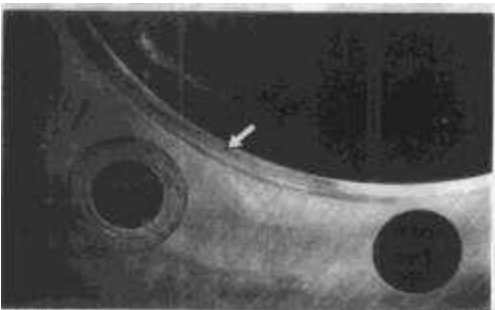
Measurable erosion occurring outside the immediate liner seat area is permissible. This erosion does not affect the stability of the liner nor the sealing ability of the head gasket. This erosion will not clean up by counterboring.



Erosion under the water ferrules and outside the liner seat area.

Erosion under the water ferrules is permissible. This erosion can be filled with a room temperature vulcanizing (RTV) compound, 5P-3321 Adhesive (epoxy), a compound of liquid metal fillers or Belzona® Ceramic R Metal.

NOTE: Machining the top deck of the block for this type of erosion around the water ferrule is NOT required.



Pebbly block surface in liner seat.



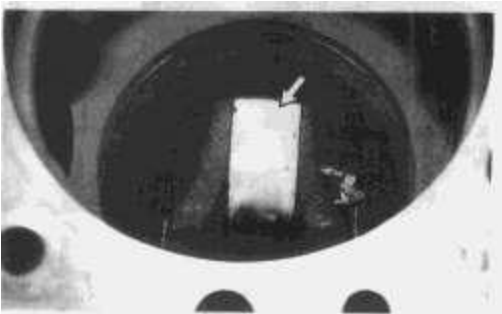
Measurable erosion of 0.089 mm (.0035 in) deep.

Rough pebbly block surface in liner seat area must be measured. Erosion measuring more than .025 mm (.0010 in) deep must be removed by counterboring. Repair this damage by counterboring the block deck and installing the thinnest possible stainless steel insert.

Cylinder Block - Counterbore for Liner Seat Inserts

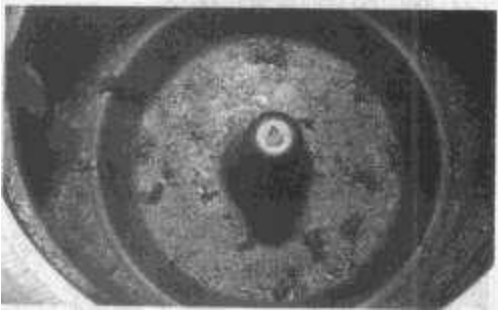
Counterbore only the block liner seats that exhibit measurable erosion of 0.025 mm (.0010 in) or greater. Generally, liner seat erosion resulting from a head gasket failure require counterboring only one or two cylinder liner seats.

NOTE: Refer to Chart K, Projection Specifications, in the Cylinder Liner Projection section for the recommended liner projection when counterboring a cylinder block.



Protected crankshaft journal.

When machining work is done on a cylinder block, special precautions are required to protect other engine components from contamination. Protect the crankshaft rod journals adjacent to the repair by covering with paper towels and taping. Cover the lifter bore area with paper towels or foam inserts.



Plastic bore plug.

Install plastic cylinder bore plugs into the lower bore to keep chips off the crankshaft (use Kent Moore USE part number PT-2000-101 or equivalent). Tape, plug or coat with heavy grease the two oil supply dowels/holes to prevent chip entry.

NOTE: Refer to Special Instruction, SMHS8222, Installation of 2W-3815 or 5N-0093 Inserts.



Attach 9U-7990 Counterbore Tool Group.

Install 9U-7990 Counterbore Tool Group and tighten the hold down bolts to a torque of 68 N·m (50 lb ft). A counterboring tool, equipped with a dealer fabricated handle for continuous rotation of the tool, provides a smoother cut than a tool equipped with a "Tee" style handle. Continuous rotation of the tool reduces tool chatter caused by start-stop rotation. Machine a maximum of 0.10 mm (.004 in) for any one dial setting.

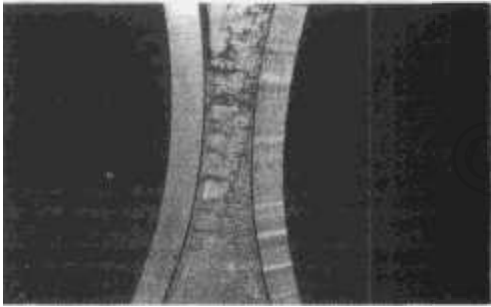
NOTE: Additional information on operating the 9U-7990 Counterbore Tool Group can be found in Tool Operating Manual NEHS0612.



Depth gauge or use a 9U-7993 Depth Gauge Assembly.

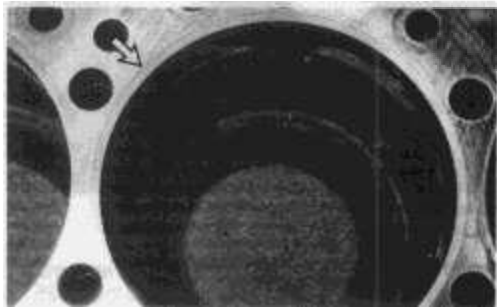
Use a depth gauge, as shown, or use a 9U-7993 Depth Gauge Assembly to measure progress when

nearing the depth needed to install the thinnest insert. Reduce machine depth to .025 mm (.0010 in) per cut until reaching the final depth. Measure to verify actual insert thickness and install insert so that it is flush with the top of the block within 0.013 mm (.0005 in).



Left: A good counterbore. Right: Chatter marks must be cleaned up before assembly.

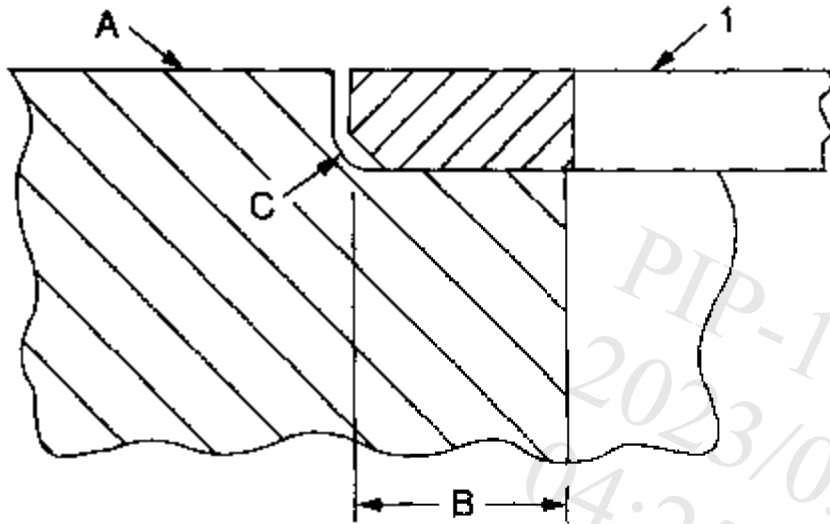
Measure the machined counterbore in four places to ensure that it is level. Check to see that it is also free of tool chatter marks.



Counterbore machining.

If counterboring to the depth of the thinnest insert does not clean up 100 percent of the erosion/crack damage, machine to the depth of the next insert.

NOTE: At the time of installation, the Stainless Steel Inserts are installed dry (WITHOUT the use of sealants).



1. The design of insert (1) and the size of the counterbore give the insert a slip (loose) fit in the cylinder block. The outer diameter of the counterbore is 166.051 ± 0.025 mm ($6.5374 \pm .001$ in). If the counterbore has been cut correctly, the top of the insert will be even or within 0.0127 mm ($.00050$ in) of the top surface (A) of the cylinder block to give the necessary projection for the cylinder liner. Location (B) shows the liner seat area that must clean up 100 percent before it is permissible to install an insert in the counterbore. The radius (C), 0.25 ± 0.13 mm ($.010 \pm .005$ in), is determined by the cutting tool.
2. There is a plus or minus tolerance for the thickness of the insert. The insert thickness should be measured prior to installation to determine the plus or minus tolerance.

CHART H. STAINLESS STEEL INSERTS	
Part No.	Nominal Thickness mm (In)
6I-4361	0.772 (.0304)
9Y-3368	0.822 (.0324)
6I-4362	0.872 (.0343)
6I-4363	1.555 (.0612)
2W-3815	1.605 (.0632)
6I-4364	1.656 (.0652)
6I-4365	2.660 (.1047)
5N-0093	2.710 (.1067)
6I-4366	2.760 (.1087)
101-0524	5.160 (.2031)
101-0523	5.210 (.2051)
101-0525	5.260 (.2071)

Caterpillar does not recommend counterboring the cylinder block deeper than 5.260 mm (.2071 in). Contact your Caterpillar dealer or service representative if damage extends deeper. Remanufactured short blocks are available for 3400 Engines if the block cannot be reconditioned by counterboring per the above specification.



Counterbore deburring.

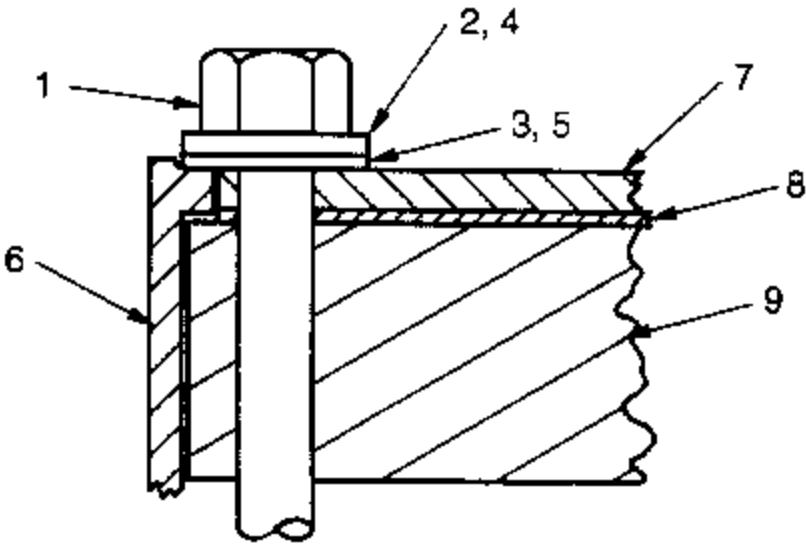
When machining is complete, deburr both edges of the counterbore with emery paper or #400 wet-dry sandpaper. Use a wet-dry vacuum to remove cuttings from cylinder bores, water jacket and head bolt holes. Remove plastic bore plugs, foam inserts, paper towels, tape and all other protective covers. If necessary, run threaded tap down head bolt holes to remove burrs and thoroughly clean out head bolt holes. Wash down cylinder block with solvent and use pressure air to ensure block/crankshaft/lifter bore cleanliness. Install inserts dry (no sealant) with chamfer facing down.

Cylinder Liner Projection

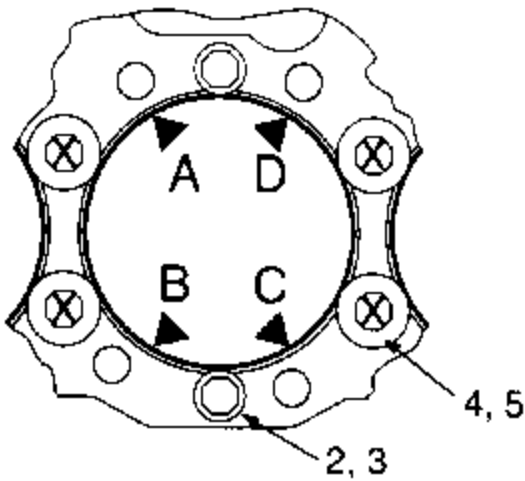
NOTE: Use this procedure for both aluminum and steel spacer plates.

NOTE: This procedure alleviates the need for the "H" bar to hold down liners during projection measurements.

CHART 1. TOOLS NEEDED		
Part No.	Description	Qty
8T-0455	Liner Projection Tool Group	1



Typical 3406 Installation of Bolts and Washers



Install larger diameter washers (4) and (5) under bolts marked "X" on 3408 and 3412 Engines. Install smaller diameter washers (2) and (3) under remaining two bolts on 3408 and 3412 Engines. Install smaller diameter washers (2) and (3) under all bolts on 3406 Engines.

CHART J. COMPONENTS NEEDED					
Item	Part No.	Description	3406	3408	3412
1	7H-3598	Bolt	26	18	26
2	8F-1484	Washer (steel)	26	8	12
3	7K-1977	Washer (fiber)	26	8	12
4	7X-0564 ¹	Washer (steel)	—	10	14
5	126-1454 ¹	Washer (fiber)	—	10	14
6	—	Liner			
7	—	Spacer Plate			
8	—	Spacer Plate Gasket			
9	—	Block			

Quantity of six each required for one cylinder on any engine, except where noted.

¹ Use these washers for 3408 and 3412 on the four corners of each cylinder.

NOTE: 3408 and 3412 Engines show quantities for one bank only.

Install clean liners or cylinder packs (without the filler band or the rubber seals), spacer plate gasket and clean spacer plate.

Install bolts and washers as shown in the previous illustrations. Install all bolts or the six bolts around the liner. Tighten bolts evenly in four steps to a torque of 95 N·m (70 lb ft).

Use the 8T-0455 Liner Projection Tool Group to measure liner projection at positions indicated with A, B, C and D (refer to illustration on following page).

Use the worksheets on the following pages for recording liner projection measurements and calculating averages and variances.

3406 Liner Projection Measurements

Date

Miles, Km

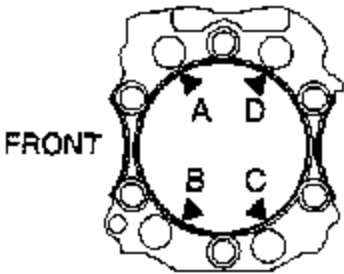
Hours

Engine

Serial Number

Vehicle

Serial Number



1	2	3	4	5	6
---	---	---	---	---	---

Liner Projection

Max. 0.15 mm (.006 in)
Min. 0.03 mm (.001 in)

1A	
1B	
1C	
1D	
SUM 1	
AVG 1	
2A	
2B	
2C	
2D	
SUM 2	
AVG 2	
3A	
3B	
3C	
3D	
SUM 3	
AVG 3	
4A	
4B	
4C	
4D	
SUM 4	
AVG 4	
5A	
5B	
5C	
5D	
SUM 5	
AVG 5	
6A	
6B	
6C	
6D	
SUM 6	
AVG 6	

Max Variation Each Cylinder

Max. 0.051 mm (.0020 in)

Max 1A-1D	
Min 1A-1D	
Variation	
Max 2A-2D	
Min 2A-2D	
Variation	
Max 3A-3D	
Min 3A-3D	
Variation	
Max 4A-4D	
Min 4A-4D	
Variation	
Max 5A-5D	
Min 5A-5D	
Variation	
Max 6A-6D	
Min 6A-6D	
Variation	

Max Variation of AVG Between Adjacent Liners

Max. 0.051 mm (.0020 in)

AVG 1	
AVG 2	
Variation	
AVG 2	
AVG 3	
Variation	
AVG 3	
AVG 4	
Variation	
AVG 4	
AVG 5	
Variation	
AVG 5	
AVG 6	
Variation	

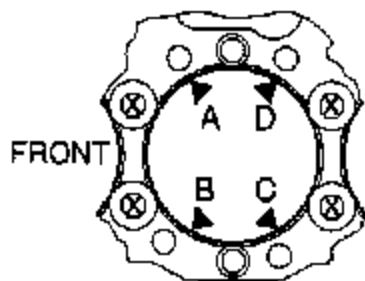
Max Variation of AVG Under One Cylinder Head

Max. 0.102 mm (.0040 in)

Max AVG 1 - 6	
Min AVG 1 - 6	
Variation	

3408 Liner Projection Measurements

Date _____ Miles, Km _____ Engine _____ Vehicle _____
 Hours _____ Serial Number _____ Serial Number _____



FRONT	2	4	6	8
-------	---	---	---	---

FRONT	1	3	5	7
-------	---	---	---	---

Liner Projection

Max. 0.15 mm (.006 in)
 Min. 0.03 mm (.001 in)

1A		2A	
1B		2B	
1C		2C	
1D		2D	
SUM 1		SUM 2	
AVG 1		AVG 2	
3A		4A	
3B		4B	
3C		4C	
3D		4D	
SUM 3		SUM 4	
AVG 3		AVG 4	
5A		6A	
5B		6B	
5C		6C	
5D		6D	
SUM 5		SUM 6	
AVG 5		AVG 6	
7A		8A	
7B		8B	
7C		8C	
7D		8D	
SUM 7		SUM 8	
AVG 7		AVG 8	

Max Variation Each Cylinder

Max. 0.051 mm (.0020 in)

Max 1A-1D		Max 2A-2D	
Min 1A-1D		Min 2A-2D	
Variation		Variation	
Max 3A-3D		Max 4A-4D	
Min 3A-3D		Min 4A-4D	
Variation		Variation	
Max 5A-5D		Max 6A-6D	
Min 5A-5D		Min 6A-6D	
Variation		Variation	
Max 7A-7D		Max 8A-8D	
Min 7A-7D		Min 8A-8D	
Variation		Variation	

Max Variation of AVG Between Adjacent Liners

Max. 0.051 mm (.0020 in)

AVG 1		AVG 2	
AVG 3		AVG 4	
Variation		Variation	
AVG 3		AVG 4	
AVG 5		AVG 6	
Variation		Variation	
AVG 5		AVG 6	
AVG 7		AVG 8	
Variation		Variation	

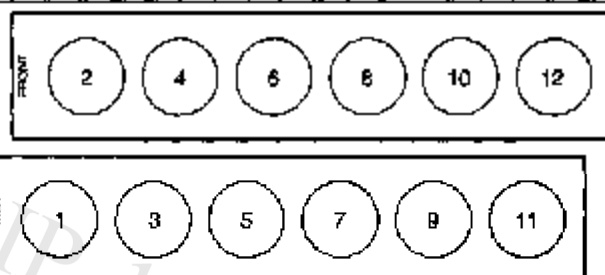
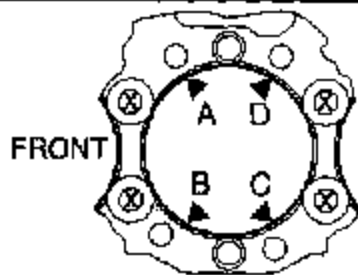
Max Variation of AVG Under One Cylinder Head

Max. 0.102 mm (.0040 in)

Max AVG 1 - 7		Max AVG 2 - 8	
Min AVG 1 - 7		Min AVG 2 - 8	
Variation		Variation	

3412 Liner Projection Measurements

Date _____ Miles, Km _____ Engine _____ Vehicle _____
 Hours _____ Serial Number _____ Serial Number _____



Liner Projection Max. 0.15 mm (.006 in) Min. 0.03 mm (.001 in)

1A		2A	
1B		2B	
1C		2C	
1D		2D	
SUM 1		SUM 2	
AVG 1		AVG 2	
3A		4A	
3B		4B	
3C		4C	
3D		4D	
SUM 3		SUM 4	
AVG 3		AVG 4	
5A		6A	
5B		6B	
5C		6C	
5D		6D	
SUM 5		SUM 6	
AVG 5		AVG 6	
7A		8A	
7B		8B	
7C		8C	
7D		8D	
SUM 7		SUM 8	
AVG 7		AVG 8	
9A		10A	
9B		10B	
9C		10C	
9D		10D	
SUM 9		SUM 10	
AVG 9		AVG 10	
11A		12A	
11B		12B	
11C		12C	
11D		12D	
SUM 11		SUM 12	
AVG 11		AVG 12	

Max Variation Each Cylinder Max. 0.051 mm (.0020 in)

Max 1A-1D		Max 2A-2D	
Min 1A-1D		Min 2A-2D	
Variation		Variation	
Max 3A-3D		Max 4A-4D	
Min 3A-3D		Min 4A-4D	
Variation		Variation	
Max 5A-5D		Max 6A-6D	
Min 5A-5D		Min 6A-6D	
Variation		Variation	
Max 7A-7D		Max 8A-8D	
Min 7A-7D		Min 8A-8D	
Variation		Variation	
Max 9A-9D		Max 10A-10D	
Min 9A-9D		Min 10A-10D	
Variation		Variation	
Max 11A-11D		Max 12A-12D	
Min 11A-11D		Min 12A-12D	
Variation		Variation	

Max Variation of AVG Between Adjacent Liners Max. 0.051 mm (.0020 in)

AVG 1		AVG 2	
AVG 3		AVG 4	
Variation		Variation	
AVG 3		AVG 4	
AVG 5		AVG 6	
Variation		Variation	
AVG 5		AVG 6	
AVG 7		AVG 8	
Variation		Variation	
AVG 7		AVG 8	
AVG 9		AVG 10	
Variation		Variation	
AVG 9		AVG 10	
AVG 11		AVG 12	
Variation		Variation	

Max Variation of AVG Under One Cylinder Head Max. 0.102 mm (.0040 in)

Max AVG 1 - 11		Max AVG 2 - 12	
Min AVG 1 - 11		Min AVG 2 - 12	
Variation		Variation	

CHART K. PROJECTION SPECIFICATIONS	
Liner projection for each cylinder ¹	0.025 to 0.152 mm (.0010 to .0060 in)
Maximum variation in each cylinder	0.051 mm (.0020 in)
Maximum variation between averages of adjacent cylinders	0.051 mm (.0020 in)
Minimum variation between averages of all cylinders (under one head)	0.102 mm (.0040 in)

¹ The recommended liner projection for counterbored blocks is 0.089 mm (.0035 in).

If the liner projections are out of specification, try rotating the liner or install the liner in another bore to see if the measurements improve.

If the liner projections are all below the specifications or low in the range, 0.025 mm (.0010 in) or 0.051 mm (.0020 in), try using a thinner spacer plate. For spacer plate part numbers, see chart in the "Spacer Plate" section. These plates are 0.076 mm (.0030 in) thinner than the standard plate and will increase the liner projection, thus increasing the fire ring crush. Use these spacer plates to compensate for low liner projections that are less than 0.076 mm (.0030 in) or if the inspection of the top deck reveals no measurable damage directly under the liner flanges, but the average liner projection is less than 0.076 mm (.0030 in).

Do not exceed the maximum liner projection of 0.152 mm (.0060 in). Excessive liner projection will contribute to liner flange cracking.

With the proper liner projection, mark the liners in the proper position and set them aside.

When the engine is ready for final assembly, the O-ring seals, cylinder block and upper filler band must be lubricated before installation.

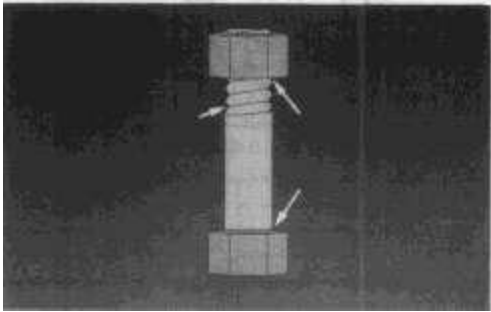
NOTE: Apply liquid soap and/or clean engine oil immediately before assembly. If applied too early, the O-rings and the filler bands may swell and be pinched under the liners during installation.

If the lower O-rings are black in color, apply liquid soap on the lower O-ring seals and the cylinder block. Use clean engine oil on the upper filler band.

If the lower O-rings are brown, brown with blue coating or black with orange coating, apply engine oil on the lower O-ring seals, the cylinder block and the upper filler band.

Head Bolts

Inspect head bolts for reusability. Replace the head bolts that have surface damage (pitting or erosion) on the shank that cannot be polished smooth.



The high stress areas on a bolt are:

- * The first exposed thread root on the joint side of the nut or tapped hole.
- * The first thread root after the shank.
- * The underhead fillet.

Damage in these areas can lead to bolt failure.



Corrosion on bolt shank. Do Not Reuse.



Corrosion on bolt shank. Do Not Reuse.

Combustion gas leakage can lead to corrosion on the bolt shank. If this corrosion damage cannot be removed with emery paper or wet-dry sand paper, replace the bolt. Any remaining irregular surfaces would create unnecessary stress raisers and ultimately weaken the bolt.

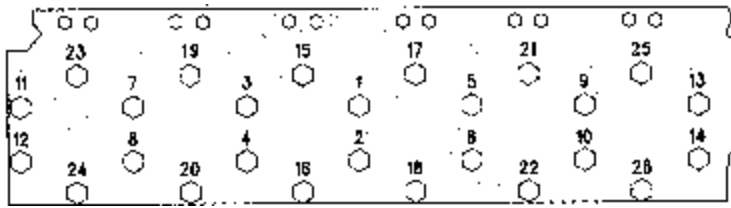
Final Engine Assembly

Use a 1P-3036 Tap to remove burrs from each head bolt hole. Thoroughly clean each hole to remove excess fluid and debris which would affect final torque values.

Lightly coat the head bolt threads, washers and bottom of bolt heads with 6V-4876 Molykote Paste Lubricant. Use of this friction reducing paste will significantly improve the load on the head gasket. Do not use oil.

Install the head gasket dry. Remove excess oil/grease from the top of the liner flanges, spacer plate and bottom of the cylinder head with 8T-9011 Component Cleaner.

3406 and 3406E Head Bolt Tightening Sequence



Torque Specification for 3406 Engines

Put 6V-4876 Molykote Paste Lubricant on bolt threads and between the washer and the underside of the bolt head.

1. Tighten bolts 1 through 14 in the numerical sequence to a torque of 270 ± 25 N·m (200 ± 20 lb ft).
2. Tighten bolts 1 through 14 in the numerical sequence to a torque of 470 ± 20 N·m (340 ± 15 lb ft).
3. Tighten bolts 1 through 14 again to a torque of 470 ± 20 N·m (340 ± 15 lb ft).
4. Install the rocker arm shafts for the engine valves and the remaining (3/4 in) bolts and/or compression brake studs.
5. Tighten bolts 15 through 26 in the numerical sequence to a torque of 270 ± 25 N·m (200 ± 20 lb ft).
6. Tighten bolts 15 through 26 in the numerical sequence to a torque of 450 ± 20 N·m (330 ± 15 lb ft).
7. Tighten bolts 15 through 26 again to a torque of 450 ± 20 N·m (330 ± 15 lb ft).
8. Tighten the thirteen bolts to a torque of 45 ± 7 N·m (33 ± 5 lb ft).

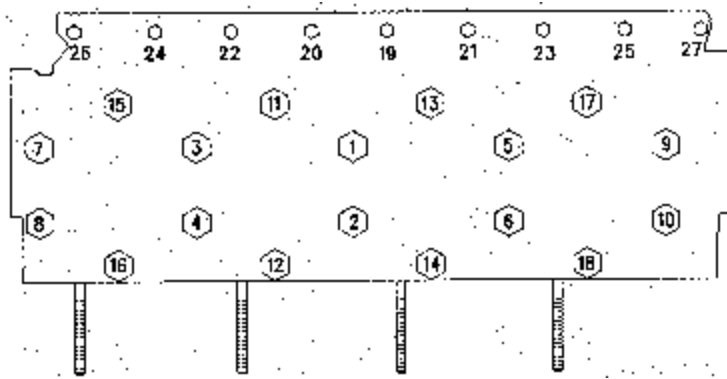
Torque Specification for 3406E Engines

Put 6V-4876 Molykote Paste Lubricant on bolt threads and between the washer and the underside of the bolt head.

1. Tighten bolts 1 through 26 in the numerical sequence to a torque of 270 ± 15 N·m (200 ± 11 lb ft).

2. Tighten bolts 1 through 26 in the numerical sequence to a torque of 450 ± 20 N·m (330 ± 15 lb ft).
3. Tighten bolts 1 through 26 in the numerical sequence to a torque of 450 ± 20 N·m (330 ± 15 lb ft).

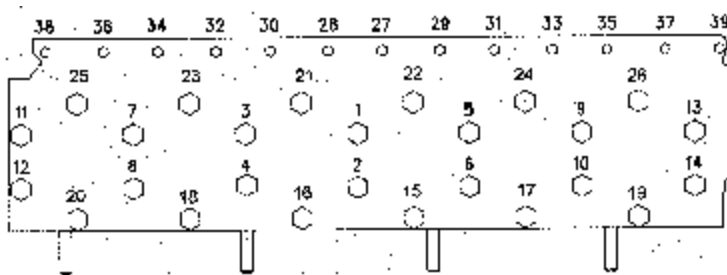
3408 Head Bolt Tightening Sequence



Put 6V-4876 Molykote Paste Lubricant on the bolt threads and between the washer and the underside of the bolt head.

1. Tighten bolts 1 through 14 in a numerical sequence to 280 ± 27 N·m (220 ± 20 lb ft).
2. Tighten bolts 1 through 14 in a numerical sequence to 440 ± 20 N·m (320 ± 15 lb ft).
3. Tighten bolts 1 through 14 in a numerical sequence again to 440 ± 20 N·m (320 ± 15 lb ft).
4. Install rocker arm shafts for the engine valves and the remaining (3/4 in) bolts.
5. Tighten bolts 15 through 18 in a numerical sequence to 280 ± 27 N·m (210 ± 20 lb ft).
6. Tighten bolts 15 through 18 in a numerical sequence to 440 ± 20 N·m (320 ± 15 lb ft).
7. Tighten bolts 15 through 18 in a numerical sequence again to 440 ± 20 N·m (320 ± 15 lb ft).
8. Tighten bolts 19 through 27 in a numerical sequence to 44 ± 7 N·m (32 ± 5 lb ft).

3412 Head Bolt Tightening Sequence

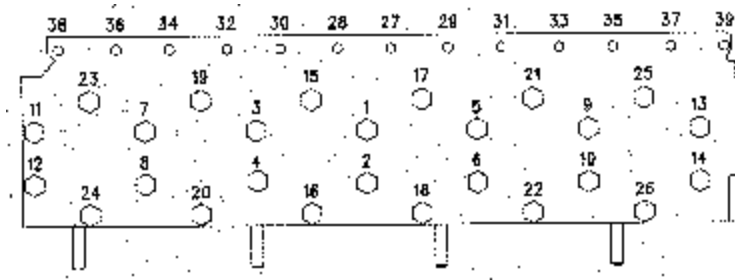


Torque Specification for 3412 Engines

Put 6V-4876 Molykote Paste Lubricant on bolt threads and between the washer and the underside of the bolt head.

1. Tighten bolts 1 through 20 in a numerical sequence to 280 ± 27 N·m (210 ± 20 lb ft).
2. Tighten bolts 1 through 20 in a numerical sequence to 440 ± 20 N·m (320 ± 15 lb ft).
3. Tighten bolts 1 through 20 in a numerical sequence again to 440 ± 20 N·m (320 ± 15 lb ft).
4. Install rocker arm shafts for the engine valves and the remaining (3/4 in) bolts.
5. Tighten bolts 21 through 26 in a numerical sequence to 280 ± 27 N·m (210 ± 20 lb ft).
6. Tighten bolts 21 through 26 in a numerical sequence to 440 ± 20 N·m (320 ± 15 lb ft).
7. Tighten bolts 21 through 26 in a numerical sequence again to 440 ± 20 N·m (320 ± 15 lb ft).
8. Tighten bolts 27 through 39 in a numerical sequence to 47 ± 9 N·m (35 ± 7 lb ft).

3412E Head Bolt Tightening Sequence



Torque Specification for 3412E Engines

Put 6V-4876 Molykote Paste Lubricant on bolt threads and between the washer and the underside of the bolt head.

1. Tighten bolts 1 through 26 in a numerical sequence to 270 ± 15 N·m (200 ± 1 lb ft).
2. Tighten bolts 1 through 26 in a numerical sequence to 450 ± 15 N·m (320 ± 11 lb ft).
3. Tighten bolts 1 through 26 in a numerical sequence again to 450 ± 15 N·m (330 ± 11 lb ft).
4. Tighten bolts 27 through 39 in a numerical sequence again to 45 ± 7 N·m (33 ± 5 lb ft).

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