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MANUAL PREVIEW

Caterpillar

Service Manual

D379, D398D, D399,

G379, G398 & G399

Engines

Service Manual

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CT-S-ENG D379+

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MANUAL PREVIEW

SERVICE MANUAL for
CATERPILLAR

D399 G399

D398 G398

D379 G379

ENGINES

SERIAL NUMBERS

35B1-UP

49C1-UP

91B1-UP

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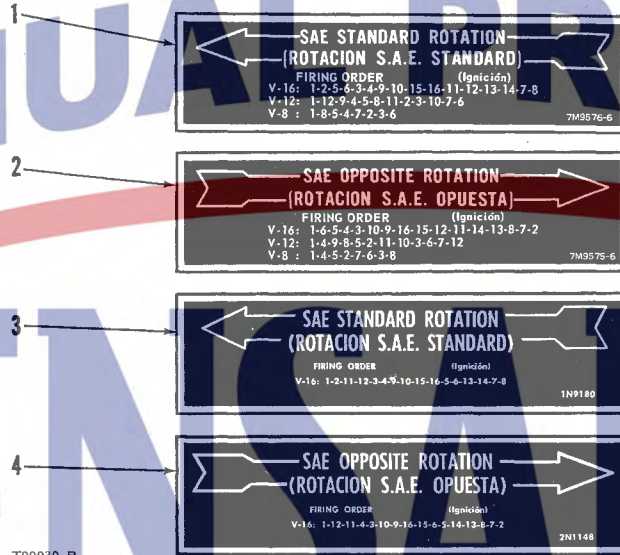
72B264-UP

69B824-UP

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ENGINE ROTATION

SAE Standard Rotation engine (counterclockwise as viewed from the flywheel end) is marked with a transfer on the flywheel housing. SAE Opposite Rotation engine (clockwise as viewed from the flywheel end) is also marked with a transfer on the flywheel housing.



ENGINE ROTATION TRANSFERS

1-Transfer used on SAE Standard Rotation Natural Gas and Diesel (8 and 12 cylinder) engines and Diesel 16 cylinder engines. 2-Transfer used on SAE opposite Rotation Natural Gas and Diesel (8 and 12 cylinder) engines and Diesel 16 cylinder engines. 3-Transfer used on SAE Standard Rotation Natural Gas 16 Cylinder engines. 4-Transfer used on SAE Opposite Rotation Natural Gas 16 cylinder engines.

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These instructions will be helpful in following the instructions in the Service Manual. In analyzing a system malfunction, use this systematic procedure to locate and correct the problem.

1. Determine problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in logical order to determine cause.
5. Consider remaining service life against cost of parts and labor.
6. Make necessary repair.
7. Recheck.

SYMBOLS

Throughout this Service Manual, symbols are used on the illustrations to point out parts which are to be removed or disconnected. These removals or disconnections are indicated by the following code:

☐ Remove  Disconnect

The part to be removed or disconnected is pointed out by a number in the symbol and this number corresponds to the part description listed in the caption copy beneath the picture. The disconnect arrow points as close as possible to point of disconnection.

SAFETY AND WORKMANSHIP SUGGESTIONS

Your safety and that of others is always the number one consideration when working around machines. Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of "do's" and "don'ts".

Always show proper respect for weight. Do not attempt to lift heavy parts when a hoist should be used. Never leave heavy parts in an unstable position. When raising a portion of a machine, be sure the machine is blocked securely at front and rear. The weight should be supported by blocks rather than lifting equipment.

When using a hoist, follow the recommendations outlined in the manual. Fabricate and use the illustrated lifting devices in conjunction with the hoist to achieve the proper balance of the assemblies being lifted and to assure safe handling.

CLEANLINESS

The most important single item in preserving the long life of the machine is to keep dirt out of vital working parts. Precautions have been taken to safeguard against this. Enclosed compartments, seals and filters have been provided to keep the supply

of air, fuel and lubricants clean. It is important that these safeguards be maintained.

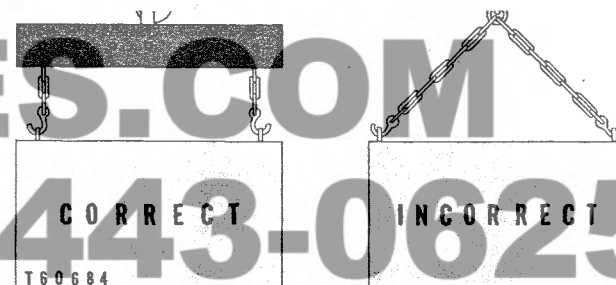
Whenever hydraulic, fuel, lubricating oil or air lines are disconnected, clean the point of disconnection as well as the adjacent area. As soon as the disconnection is made, cap, plug or tape the line or opening to prevent entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

SPECIFICATIONS

The manual SPECIFICATIONS sections contain dimensions for new parts and a suggested guide for amount of wear that might normally be considered a reasonable figure to use in determining when to replace parts. These wear dimensions are shown after the description, "permissible clearance". The specifications are provided to help determine when new parts should be installed. This information should not be regarded as the only factor in determining when to replace parts. Past performance should be the governing factor for part replacement. Even though parts are worn they still may be satisfactory. The remaining service life of these parts must be considered when deciding if parts should be replaced. If a machine is disassembled for reconditioning, it is well to replace parts not completely worn out if the remaining service life is deemed short.

REMOVAL AND INSTALLATION



Correct and incorrect method of lifting component.

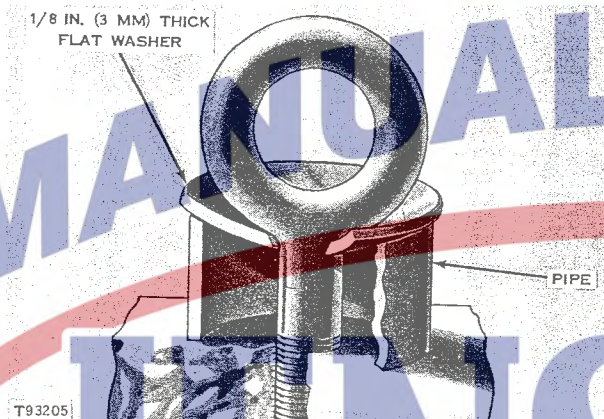
Unless otherwise specified, all removals should be accomplished using an adjustable lifting beam. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

When it is necessary to remove a component on an angle, remember that the capacity of an eyebolt

SERVICE MANUAL

GENERAL INSTRUCTIONS

diminishes as the angle between the supporting members and the object becomes less than 90°. Eyebolts and brackets should never be bent and should only have stress in tension. A length of pipe and a washer can be used, as shown, to help relieve these stresses on eyebolts.



Forged eyebolt support.

Some removals require the use of lifting fixtures to obtain proper balance and provide safe handling.

Use a hoist to remove heavy parts. The weights of some components are given in their respective sections of the manual.

If a part resists removal, check to be certain all nuts and bolts have been removed and that an adjacent part is not interfering.

DISASSEMBLY AND ASSEMBLY

When assembling a machine, complete each step in turn. Do not partially assemble one part and start assembling some other part. Make all adjustments as recommended. Always check the job after it is completed to see nothing has been overlooked.

Recheck the various adjustments by operating the machine before returning it to the job.

PRESSING PARTS

When pressing one part into another, use 9M3710 Anti-Seize Compound or a molybdenum disulfide base compound to lubricate the mating surfaces.

Assemble tapered parts dry. Before assembling parts with tapered splines, be sure the splines are clean, dry and free from burrs. Position the parts together by hand to mesh the splines before applying pressure.

Parts which are fitted together with tapered splines are always very tight. If they are not tight, inspect the tapered splines and discard the part if the splines are worn.

BOLTS AND BOLT TORQUE

Use bolts of the correct length. A bolt which is too long may "bottom" before the head is tight against the part it is to hold. The threads can be damaged when a "long" bolt is removed.

If a bolt is too short, there may not be enough threads engaged to hold the part securely.

Unless reference is made in the copy to the topic, SPECIFICATIONS, the standard torque values listed in the chart should be used for standard heat-treated bolts and studs and steel nuts when assembling Caterpillar Equipment.

GENERAL TIGHTENING TORQUE

inches	mm	lb. ft.	mkg
Bolts and Nuts			
1/4	6,35	9±3	1,24±0,4
5/16	7,94	18±5	2,5±0,7
3/8	9,53	32±5	4,4±0,7
7/16	11,11	50±10	6,9±1,4
1/2	12,70	75±10	10,4±1,4
9/16	14,29	110±15	15,2±2,0
5/8	15,88	150±20	20,7±2,8
3/4	19,05	265±35	36,6±4,8
7/8	22,23	420±60	58,1±8,3
1	25,40	640±80	88,5±11,1
1 1/8	28,58	800±100	110,6±13,8
1 1/4	31,75	1000±120	138±16,6
1 3/8	34,93	1200±150	166±20,7
1 1/2	38,10	1500±200	207±27,7
Taperlock Studs			
1/4	6,35	5±2	0,69±0,3
5/16	7,94	10±3	1,4±0,4
3/8	9,53	20±3	2,8±0,4
7/16	11,11	30±5	4,1±0,7
1/2	12,70	40±5	5,5±0,7
9/16	14,29	60±10	8,3±1,4
5/8	15,88	75±10	10,4±1,4
3/4	19,05	110±15	15,2±2,0
7/8	22,23	170±20	23,5±2,8
1	25,40	260±30	35,9±4,1
1 1/8	28,58	320±30	44,2±4,1
1 1/4	31,75	400±40	55±5,5
1 3/8	34,93	480±40	66±5,5
1 1/2	38,10	550±50	76±7
Hydraulic Valve Body Bolts and Nuts			
5/16	7,94	13±2	1,8±0,3
3/8	9,53	24±2	3,3±0,3
7/16	11,11	39±2	5,4±0,3
1/2	12,70	60±3	8,3±0,4
5/8	15,88	118±4	16,3±0,5

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LOCKS

Lockwashers, flat metal locks or cotter pins are used to lock nuts and bolts.

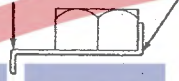
Flat metal locks must be installed properly to be effective. Bend one end of the lock around the edge of the part. Bend the other end against one flat surface of the nut or bolt head.

Always install new locks in compartments which house moving parts.

When installing lockwashers on housings made of aluminum, use a flat washer between the lockwasher and the housing.



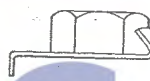
SHARP BENDS



T60687 CORRECT

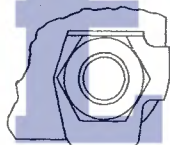


CORRECT

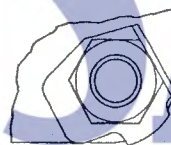


INCORRECT

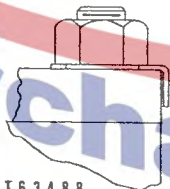
Correct and incorrect methods of installing flat metal locks.



CORRECT



INCORRECT



T63488

Correct and incorrect method for lock positioning and bending.

LINES AND WIRES

When removing or disconnecting a group of lines or wires, tag each one to assure proper assembly.

LUBRICATION

Where applicable, fill the compartments of the components serviced with the amount, type and grade of lubricant recommended in the Operation and Maintenance Instructions.

RUST PREVENTIVE COMPOUND

Clean the rust preventive compound from all machined surfaces of new parts before installing them.

SHIMS

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

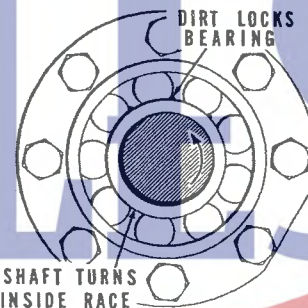
BEARINGS

Anti-Friction Bearings

When an anti-friction bearing is removed, cover it to keep out dirt and abrasives. Wash bearings in nonflammable cleaning solution and allow them to drain dry. The bearing may be dried with compressed air but **do not spin the bearing**.

Discard the bearings if the races and balls or rollers are pitted, scored or burned. If the bearing is serviceable, coat it with oil and wrap it in clean paper. Do not unwrap new bearings until time of installation.

The life of an anti-friction bearing will be shortened if not properly lubricated. Dirt in an anti-friction bearing can cause the bearing to lock resulting in the shaft turning in the inner race or the outer race turning within the cage.



T59296

Effect of dirt in bearing.

Double Row, Tapered Roller

Double row, tapered roller bearings are precision fit during manufacture and the components are not interchangeable. The cups, cones and spacers are usually etched with the same serial number and letter designator. If no letter designators are found, wire the components together to assure correct installation. Reusable bearing components should be installed in their original positions.

Heating Bearings

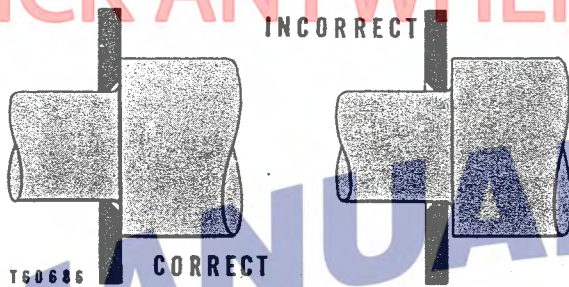
Bearings which require expansion for installation should be heated in oil not to exceed 250° F. (121° C.). When more than one part is heated to aid in assembly, they must be allowed to cool and then pressed together again. Parts often separate as they cool and shrink.

Installation

Lubricate new or used bearings before installation. Bearings that are to be preloaded must have a film of oil over the entire assembly to obtain accurate preloading. When installing a bearing, spacer

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or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder.



Correct and incorrect installation of spacer.

When pressing bearings into a retainer or bore, apply pressure to the outer race. If the bearing is pressed on the shaft, apply pressure on the inner race.

Preload

Preload is an initial load placed on the bearing at the time of assembly. Whether a taper roller bearing should have preload could depend on any of several conditions: rigidity of the housings and shaft, bearing spread, speed of operation, etc.

The only certain way to determine what a bearing requires, preload or end clearance, is to consult the disassembly and assembly topic pertaining to that bearing.

Care should be exercised in applying preload. Misapplication of preload to bearings requiring end clearance can result in bearing failure.

Sleeve Bearings

Do not install sleeve bearings with a hammer. Use a press if possible and be sure to apply the pressure directly in line with the bore. If it is necessary to drive on a bearing use a bearing driver or a bar with a smooth flat end. If a sleeve bearing has an oil hole, align it with the oil hole in the mating part.

GASKETS

Be sure the holes in the gaskets correspond with the lubricant passages in the mating parts. If it is necessary to make gaskets, select stock of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage.

When removed, always install new cylinder head and manifold gaskets using recommended gasket compound on head gaskets to allow uniform sealing.

BRAKE LININGS

Replace brake linings before they have worn enough to permit the rivet heads to contact and score the brake drums.

BATTERIES

Clean batteries by scrubbing with a solution of baking soda and water. Rinse with clear water. After cleaning, dry thoroughly and coat terminals and connections with an anti-corrosion compound or grease.

If a machine is to be stored or not used for a long period of time, the batteries should be removed. Store them in a warm, dry place, preferably on wooden shelves. Never store on concrete. A small charge should be introduced periodically to keep the specific gravity rating at recommended level.

SEALS

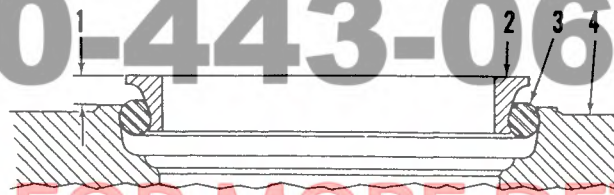
Duo-Cone Floating Seals

Floating ring seals have highly finished surfaces and are held together by toric sealing rings. The flexibility of the toric sealing rings makes the floating ring seals self aligning and compensates for wear on the metal faces.

During disassembly, tape the metal floating ring seals together so they will be kept in matched sets. Always install the metal floating ring seals in pairs; that is, two new seals together or two seals that have previously run together. Never reinstall a used toric sealing ring.

Handle all parts with care to avoid nicks. File smooth any parts, other than the sealing faces, that have nicks that may make assembly difficult or questionable. Wash off all dirt accumulation from used parts. Use a wire brush to clean dirt or rust from the bore of the seal retainers to assure they are clean and smooth. Remove all oil or the protective coating from floating ring seals and retainers with a nonflammable cleaning solvent. Be sure the ramp on the retainers and on the floating ring seals are dry.

Check the ramps for tool marks and nicks. On used parts, remove dirt or rust deposits from the ramps. Smooth the surface with emery cloth.



An example of a correct installation of a metal floating ring seal and toric sealing ring. The illustration shows the dimension (1) to be checked, the metal floating ring seal (2), the rubber toric sealing ring (3) and the toric sealing ring retainer (4). The dimension must be uniform around the entire circumference of the floating ring seal. Check the dimension at 90° intervals.

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Install new toric sealing rings or floating ring seals. Seat the toric sealing rings uniformly in the relief of the ring seal. Be sure the toric sealing ring is not twisted. It must set straight against the lip which keeps it from falling off the floating ring seal.

Duo-Cone floating seal installation tools are available for various size seals.

SEAL INSTALLING TOOL SELECTION CHART			
DUO-CONE SEAL GROUP	METAL RING SEAL	TORIC SEALING RING	SEAL INSTALLER
4K6049	4K174	4K173	1S8966
7M481	7M480	7M475	9M5143
5M1176	4M2621	2M344	8M7911
5M8647	1M9012	1M9011	8M9395 (1S576)
5M1177	4M659	4M660	8M7912
5M7294	4M735	4M736	8M7913
4D4510	4D4471	4D4472	1S4320
2M2858	1M3098	1M3097	5M2196
1M8747	8H2229	8H2262	5M2158
1M8746	8H2230	8H2265	5M2160
1M8748	8H2231	6H1309	5M2162
4S5001 & 7S1527	4S5002 & 7S1528	3S4672	5S4275
5K5288	5K5126	5K5129	5S4276
5K1078	5K1069	5K1075	2S8027
4D8960	4D8959	4D3472	7S3128

T93960

If an installer tool is not used, install the toric sealing ring and floating ring seal as an assembly by pressing on the toric sealing ring. Use finger pressure only. Be sure the toric sealing ring is seated uniformly in the recess of both the floating ring seal and the retainer. Make sure it sets in the bore straight and against the lip that keeps it from falling out of the retainer. **Do not use a screwdriver or stick to assemble the toric sealing ring in the retainer. Use finger pressure only.**

Before assembling floating ring seals together, wipe faces of seals with lint-free tissue to remove any foreign material and fingerprints. Place one drop of oil on the cleaning tissue and coat the sealing surfaces of the seals. Be careful to prevent any oil from contacting the toric sealing ring or its mating surfaces.



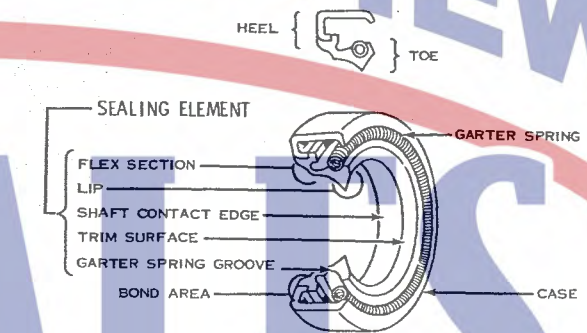
Duo-Cone floating seals installed with metal floating ring seal (2) and toric sealing ring (3) properly positioned.

Lip-Type Rubber Seals

Lubricate the lips of lip-type rubber seals before installation. Use the same type lubricant in which

the seal will be operating. Do not use grease on any seal except a grease seal.

The main parts of a lip-type seal are the case, sealing element, and garter spring. The picture below illustrates the construction of a simple lip-type seal. The cross section at the top shows the terms "heel" and "toe" used to identify the sides of a single element seal. With few exceptions, the toe of an oil seal with one lip is next to the lubricant that is sealed. Some seals have a second auxiliary lip, which does not carry a garter spring. Use the spring-loaded lip to orient the installation of such seals.



T87198

Lip-type seal construction.

If, during installation, the seal lip must pass over a shaft that has splines, a keyway, rough surface or a sharp edge, the lip can easily be damaged. Shim stock or other such material can be formed around the area to provide a smooth surface over which to slide the seal.

HYDRAULIC SYSTEMS

Cleanliness

Dirt and like contaminants in a hydraulic system affect operation and will result in serious damage to the system components. Dirty hydraulic systems are a major cause of machine failures.

Keep the system clean:

- ... When removing components of a hydraulic system cover all openings in both the component and the machine.
- ... If evidence of metal or rubber particles are found in the hydraulic system, flush the entire system.
- ... Disassemble and assemble hydraulic components on a clean surface. Clean all metal parts in a nonflammable cleaning fluid. Then lubricate all components to aid in assembly.

Safety

Before servicing any hydraulic system, NEUTRALIZE THE HYDRAULIC PRESSURE.

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PROCEDURE:

1. Place all implements (bucket, ripper, dozer, etc.) on the ground. (In some instances a removal procedure may require the implement to be blocked in a certain position. Consult the removal and installation topics pertaining to that implement).
2. With the engine shut-off, move all the control levers to all positions to insure there is no pressure in the system.
3. Place all control levers in HOLD position.

When attached hydraulic equipment is removed from a machine which will continue to be used, the hydraulic system lines must be securely blocked. High pressure protective covers are available. The following chart lists the protective covers for various size hydraulic hoses. One O-ring seal is required with each protective cover.

APPROXIMATE HOSE SIZE				PRO - TECTIVE COVER	O - RING SEAL	TWO BOLT FLANGE	SPLIT FLANGE
INCHES		MILLIMETERS					
O.D.	I.D.	O.D.	I.D.				
1.00	.50	25.4	12.7	5H4017	5F7054	5F6804	1H5278
1.06	.62	26.9	15.7	8S7668	4J8996	—	6K3253
1.25	.75	31.7	19.0	5H4013	5F1678	5F2046	2K190
1.50	1.00	38.1	25.4	5H4019	4F7391	5F2442	1H3305
2.00	1.25	50.8	31.7	5H4020	4F7952	—	3H3667
2.25	1.50	57.1	38.1	2J2668	7F8267	—	3H4330

Do not use the thin sheet metal covers designed for shipping and storage. These covers can rupture when high pressure is applied.

Sealing Elements

Inspect all sealing elements (O-rings, gaskets, etc.) when disassembling and assembling the hydraulic system components. Install new elements if necessary.

Hydraulic Lines

When installing metal tubes, tighten all bolts finger-tight. Then, in this order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After the tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger-tight. Position the hose so it does not rub the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

Due to manufacturing methods there is a natural curvature to a hydraulic hose. The hose should be installed so any bend is with this curvature. In case of replacement hoses with angled-stem, reusable fittings, the hose curvature must be taken into con-

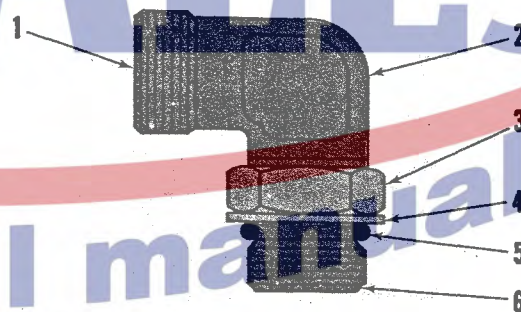
sideration when assembling and positioning the angled stems.

After the hoses are installed, follow this procedure: With the diesel engine running, move the appropriate control levers to move the implement to every possible position. Observe the hoses during the cycle. Then lower the implement to the ground. Shut off the diesel engine and eliminate any twisting, rubbing and/or excessive drooping of hoses by rotating the stem of the hoses.

Hydraulic Fittings

Fitting Bodies with Straight Threads and O-ring Seals

This type of fitting is used in several applications. The tube end of the body will vary in design depending upon the application. However, the installation procedure of the fitting body into its mating boss will be the same. If the tube end of the fitting body is as illustrated (either elbow or straight body) a presetting procedure is necessary to assemble the sleeve onto the tube before connecting the tube to end. See the topic ASSEMBLY OF SLEEVES ONTO TUBES, TYPE A.



T88381

Typical example of an elbow body assembly. Parts are: 1-End of fitting body (connects to tube). 2-Fitting body. 3-Locknut. 4-Backup washer. 5-O-ring seal. 6-End of fitting (screws into mating boss).

1. Place the nut, washer and seal as far back on the fitting body as possible. Hold the components in this position and screw the fitting into its boss until the washer just contacts the face of the boss.
2. Place the fitting assembly in its correct angular position by turning the body out (counterclockwise), a maximum of 359°. Tighten the nut finger-tight.

NOTE

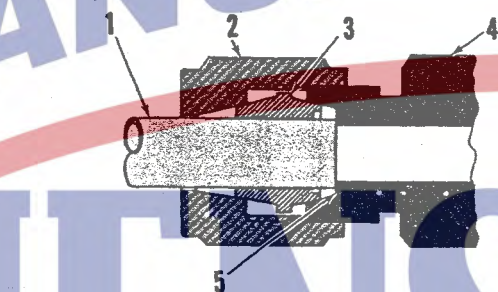
If the fitting is a connector (straight fitting), the hex on the body takes the place of the nut. Install this type fitting by tightening the hex against the face of the boss.

3. Install the assembled tube onto the tube end of the body, finger-tight. Tighten the nut positioning the body. Then tighten the nut on the tube assembly.

Assembly of Sleeves onto Tubes

Type A

It is necessary to preset this type of sleeve onto the tube before the tube assembly is installed on the fitting body.



Typical example of a sleeve-type fitting. Parts are: 1-Tube. 2-Nut. 3-Sleeve. 4-Presetting tool. 5-Shoulder of tool (4).

1. Lubricate the sleeve and the threads on presetting tool and nut.

NOTE

Presetting tools are commercially available; however, the fitting body can be used in place of a presetting tool. If the fitting body is used, the body should be removed from the machine to permit satisfactory presetting.

2. Place the nut on the tube with the threaded end of the nut toward the end of the tube.
3. Place the sleeve onto the tube so the short-tapered heavy end faces the presetting tool as illustrated.
4. Bottom tube end against shoulder of tool.
5. Assemble the nut to the tool finger-tight. Then tighten the nut until the threads on the tool are no longer visible.
6. Remove the tube from the presetting tool. Check to be certain sleeve does not move longitudinally. (The sleeve can rotate on the tube.)
7. When the tube assembly is assembled onto the fitting body, tighten the nut until the threads on the body are no longer visible. Refer to the topic FITTING BODIES WITH STRAIGHT THREADS AND O-RING SEALS for the installation of the fitting bodies.

Type B

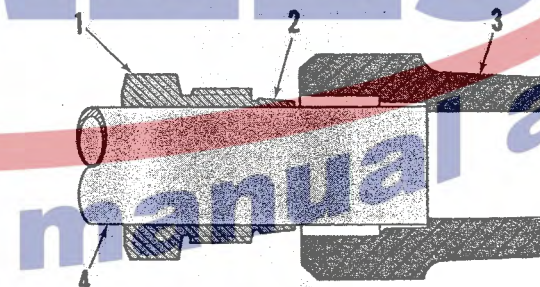
1. Place the nut and sleeve onto the tube. Install the sleeve so the thick end faces away from the body.
2. Install the insert into the tube.



Typical example of sleeve and insert-type fitting. Parts are: 1-Nut. 2-Tube. 3-Sleeve. 4-Insert. 5-Fitting body.

3. Bottom the tube and insert in the body as illustrated.
4. Tighten the nut $1\frac{1}{2}$ turns past finger-tight.

Type C



Typical example of a shear-type fitting. Parts are: 1-Nut. 2-Sleeve. 3-Fitting body. 4-Tube.

With the nut and sleeve installed loosely in the body, install the tube through the nut and sleeve until the end of the tube is seated against the shoulder in the fitting body.

Grip the tube firmly to prevent twisting or turning and tighten nut until a slight "give" or decreased resistance is felt. The "give" indicates that the sleeve has been sheared from the nut. Tighten the nut an additional $1\frac{1}{2}$ turns. It is not necessary to tighten the nut all the way down.

Hydraulic Valves

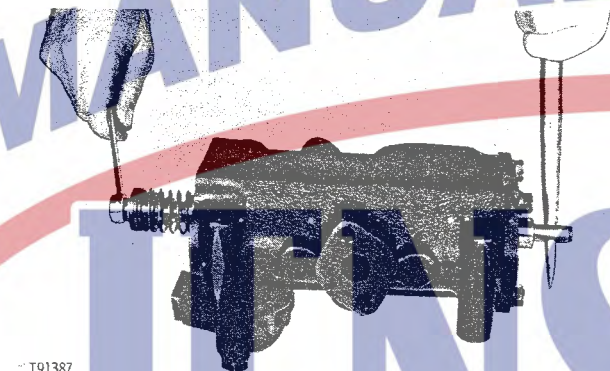
Examine all valves, valve bores and valve seats for nicks, burrs and/or scratches. (Rough spots may be removed with a crocus cloth or fine emery

SERVICE MANUAL GENERAL INSTRUCTIONS

cloth.) All valves which operate in bores must slide freely in their bores. Be certain all passages are clean and open.

Check all springs to be certain they meet the values listed in the SPECIFICATIONS.

On control valve spools having bolt-retained centering or return springs, the bolt should be removed while the valve spool is in the valve body. This procedure will prevent spool distortion and possible damage to the spool lands.



Typical example of removing bolt.

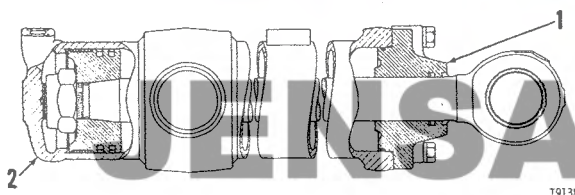
Cylinders

Rod End or Head End

The "rod end" of a cylinder is that end that has the rod extending.

The "head end" is the other end of the cylinder — the blind end.

The rod end line directs oil to the rod end of the cylinder to retract the rod. The head end line directs oil to the head end of the cylinder to extend the rod.



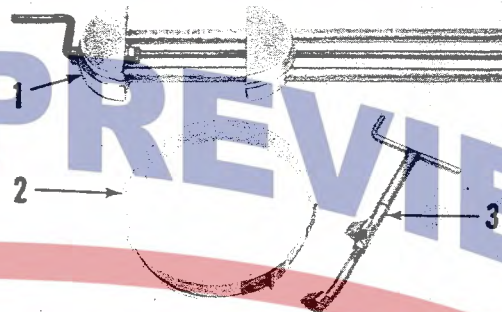
This is a cross section of a hydraulic cylinder. Identified are: 1-Rod end. 2-Head end.

Installation of Solid Seal Assemblies on Pistons

Each solid seal assembly consists of a solid, rubber, inner expansion ring and a solid, plastic, outer seal. Since these seals are continuous rings (no split joint), special tools and procedures are required for installation.

The tools needed to install the outer seals of the piston seal assemblies are: one 4S9181 Expander assembly, one 4S9446 Clamp Assembly (two clamp assemblies are required on the larger diameter pis-

tons), and one seal compressor. Measure the diameter of the piston to select the correct seal compressor. See the COMPRESSOR SELECTION CHART for the seal compressor to be used.



T81980

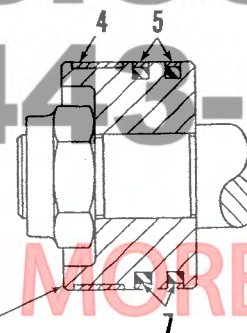
Solid seal installation tools. Parts identified are: 1-4S9181 Expander Assembly. 2-Seal compressor. 3-4S9446 Clamp Assembly.

COMPRESSOR SELECTION CHART		
PISTON DIAMETER		SEAL COMPRESSOR PART (NO.)
(IN INCHES)	(IN MILLIMETERS)	
1.50 - 3.00	38,1 - 76,2	9S289
3.00 - 3.25	76,2 - 82,5	4S9447
3.50 - 3.75	88,9 - 95,2	4S9448
4.00 - 4.25	101,6 - 107,9	4S9449
4.50 - 4.75	114,3 - 120,6	4S9450
5.00 - 5.25	127,0 - 133,3	4S9451
5.50 - 5.75	139,7 - 146,0	4S9452
6.00 - 6.25	152,4 - 158,3	4S9453
6.50 - 6.75	165,0 - 171,4	4S9454
7.00 - 7.25	177,8 - 184,1	4S9455*
8.00 - 8.25	203,2 - 209,5	4S9456*
9.25 - 9.50	234,9 - 241,3	4S9457*
10.25 - 10.50	260,3 - 266,7	9S2419*

*TWO 4S9446 CLAMP ASSEMBLIES REQUIRED.

T93676-A

Compressors are marked for nominal ranges shown in the chart. The actual usable range can be calculated by reducing the low figure 1/16 in. (1,5 mm) and increasing the high figure 3/16 in. (4,7 mm).



T81981

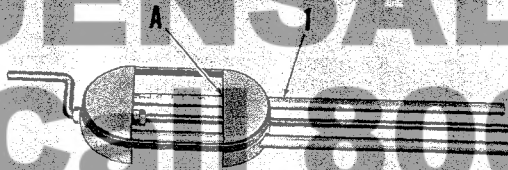
Solid seal assemblies installed on piston. Parts identified are: 4-Wear ring. 5-Solid, plastic outer seals. 6-Piston. 7-Solid, rubber, inner expansion rings.

1. For ease of seal installation, remove the wear ring.
2. Install the inner expansion rings on the piston.
3. Measure the diameter of the piston to determine the diameter to which the seal must be expanded. The outer seals of the seal assemblies must be expanded to a diameter slightly larger than the diameter of piston to allow the seal to be placed over the piston. Be careful not to over-expand the seals or they can be ruined.

NOTE

The bars of the expander are graduated, representing piston diameters. If the seal can be slipped off the expander when the inside face of the movable block is at point (A) (indicated piston diameter) the seal is expanded sufficiently.

4. Place a seal on the expander. Turn the crank on the expander until the inside face of the movable block is slightly past point (A). Then return to point (A). Rotate the seal 90° on the expander and expand again. Check to see if the seal will slip off the expander. If not, repeat the procedure, expanding the seal farther each time, until seal will slip off the expander when block is returned to point (A).
5. Lubricate the outer seals and place them on the piston. Install and lubricate the wear ring.
6. Select the applicable compressor from the COMPRESSOR SELECTION CHART. Install the clamp on the compressor. Place the compressor loosely over the outer seals. Place the compressor on the piston so the rolled side of the compressor will be facing the cylinder when the piston is installed in the cylinder.



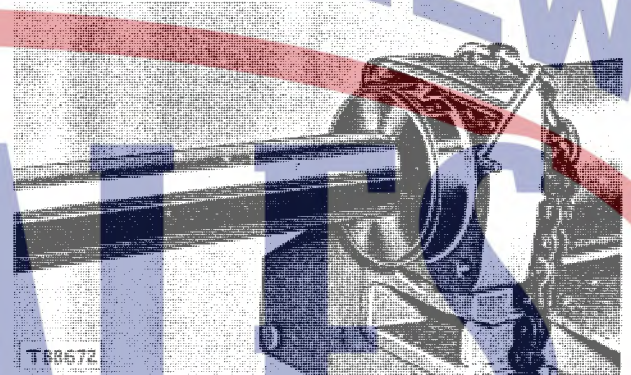
T81982

This shows the seal on the expander. Illustrated are: 1-4S9181 Expander Assembly. A-Indicated piston diameter.

7. Slowly turn the handle on the clamp and force the seals into their grooves. Be certain the seals are being seated in their grooves as they are being compressed.



The tools illustrated compressing seals are: 2-Seal compressor. 3-4S9446 Clamp Assembly.



This shows the installation of the piston into the cylinder.

8. Place the piston assembly into the cylinder bore as illustrated; be certain the piston is square in the bore.
9. Drive on the piston rod until the entire piston assembly is in the cylinder bore. Remove the clamp and the compressor.
10. Install the bolts securing the cylinder head to the cylinder with the piston rod fully extended. Tighten the bolts to the torque value in the SPECIFICATIONS.

Pumps

The direction of pump rotation, clockwise (CW) or counterclockwise (CCW), is the direction the pump turns when viewed from the drive shaft end. Refer to the SPECIFICATIONS for the rotation of a particular pump.

After assembling any pump, lubricate it thoroughly. After assembly, the pump must rotate freely by hand.

Assembly of Insert Vane-type Pumps

The insert vane-type pump capacity and direction of rotation will vary with different applications. The assembly procedure however will be the same.

Before disassembling a pump, mark the pump body and cover to insure correct assembly with respect to port relationship.

D399 ENGINE

(35B1-UP, 91B1-UP)

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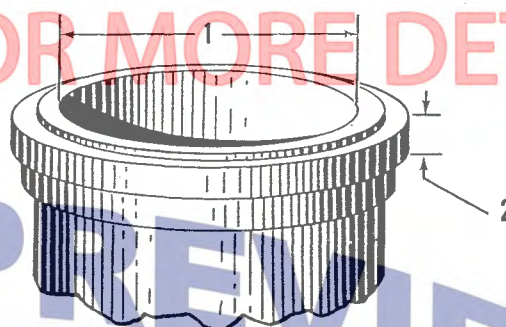
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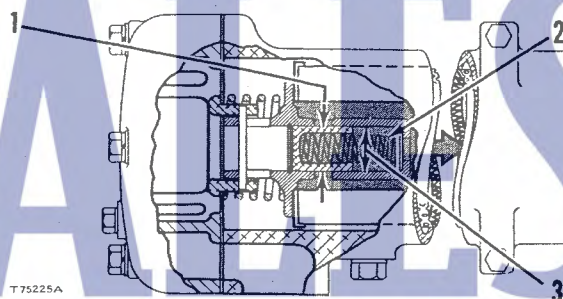
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CYLINDER LINER



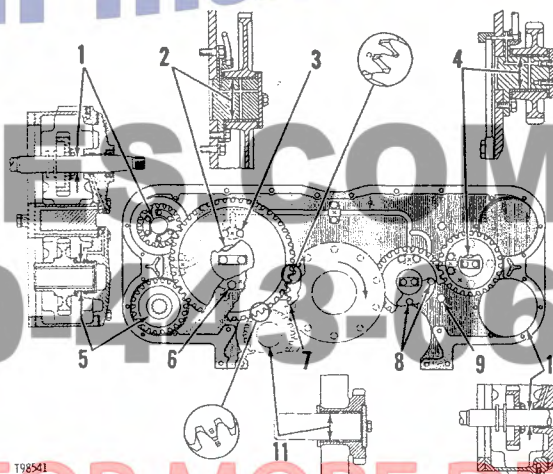
- (1) Bore in liner 6.250–6.252 in. (158,75–158,80 mm)
Maximum bore (worn) measured near top of
ring travel 6.260 in. (159,004 mm)
- (2) Thickness of flange504–.506 in. (12,80–12,85 mm)
Counterbore depth in block498–.500 in. (12,65–12,70 mm)
Maximum permissible counterbore depth545 in. (13,84 mm)

OIL FILTER



- (1) Diameter of valve 1.4965–1.4975 in. (38,011–38,036 mm)
- (2) 3H2757 Spring for bypass valve:
Length under test force 2 in. (50,8 mm)
Test force 32–37.5 lbs. (14,51–17,01 kg)
Free length after test 4 in. (101,6 mm)
Outside diameter 1.148 in. (29,16 mm)
- (3) Bore in housing 1.4995–1.5005 in. (38,087–38,113 mm)

FRONT ACCESSORY DRIVE



Auxiliary Drive upper left turns counterclockwise (view from front) at 1.92 times engine speed.

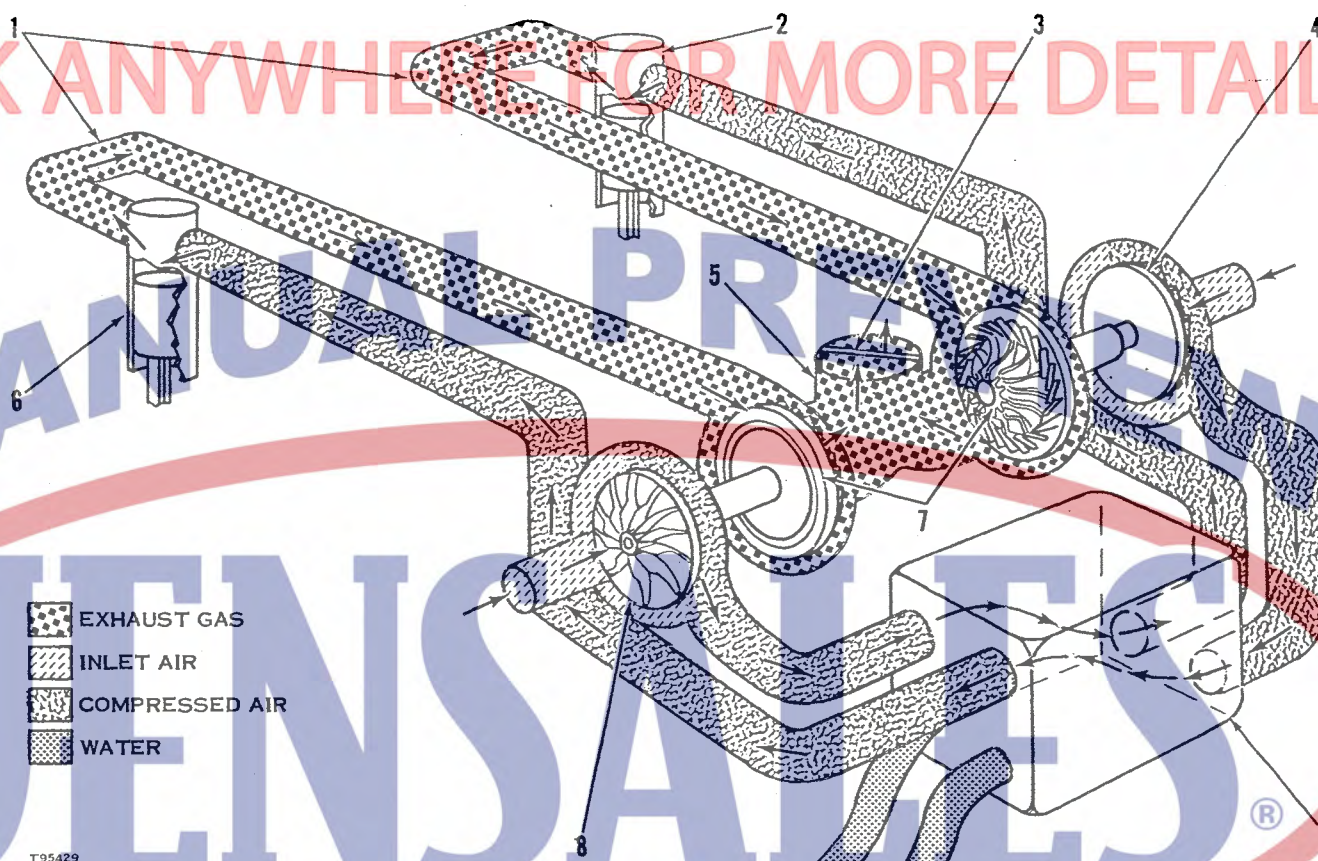
- (1) Water pump drive:
Turns clockwise (view from front) at 1.92 times engine speed
- Diameter of shaft bearing
journal 1.245–1.246 in. (31,52–31,65 mm)
- Bore in water pump shaft
bearing 1.248–1.249 in. (31,62–31,65 mm)
- Maximum permissible clearance between shaft
and bearing008 in. (0,203 mm)

SAE Standard Rotation
Engine Illustrated

NOTE—FOR TORQUE VALUES NOT INDICATED, REFER TO FIRST
PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

ENGINE

AIR INDUCTION AND EXHAUST SYSTEM



AIR INDUCTION AND EXHAUST SYSTEM

1-Exhaust manifolds. 2-Right cylinder bank. 3-Diffuser plate. 4-Right turbocharger impeller. 5-Exhaust elbow. 6-Left cylinder bank. 7-Turbocharger turbine wheels. 8-Left turbocharger impeller. 9-Aftercooler.

OPERATION

This engine incorporates two turbochargers. The engine is cross-blown, that is, the right turbocharger furnishes air to the left cylinder bank (6) and the left turbocharger furnishes air to right cylinder bank (2).

Variation in engine load and fuel injected results in changes in speed that the turbine wheels and impellers rotate.

When the turbocharger compresses the inlet air for the engine cylinders, the temperature of the air increases. A water cooled aftercooler (9), installed between the turbochargers and the air inlet manifolds to cylinder banks (2) and (6) will cool and condense the compressed air from the turbochargers. Cooler compressed air has more oxygen, thus more fuel can be injected. When more oxygen is present, more fuel is burned and engine power is increased.

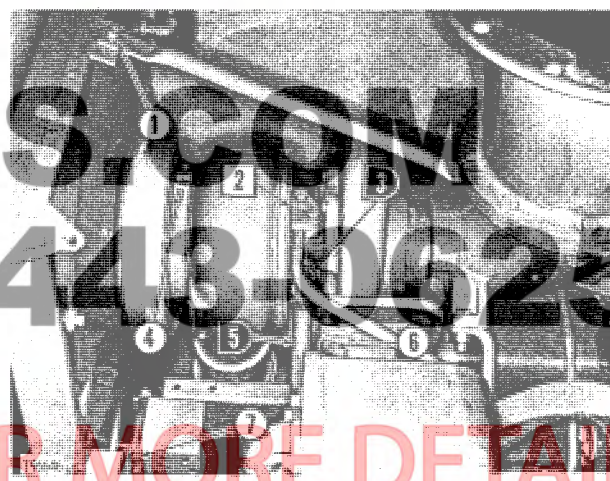
A cast in diffuser plate (3) in the center of exhaust elbow (5) keeps the exhaust from each turbocharger separated to reduce exhaust back pressure.

TURBOCHARGER REMOVAL

Remove bolts (1) and (7) and loosen clamp screw (4) then move the air cleaner away from the turbocharger.

NOTE

At assembly coat mating surfaces of housing and hose with 5H2471 Adhesive before tightening clamp screw (4).



PREPARING TO REMOVE TURBOCHARGER

1-Bolt. 2-Oil inlet line. 3-Oil line. 4-Clamp screw. 5-Oil return line. 6-Bolts (four). 7-Bolts (four).

Remove bolts (6) and loosen clamp screw (11) and remove the turbocharger. At the time of installation