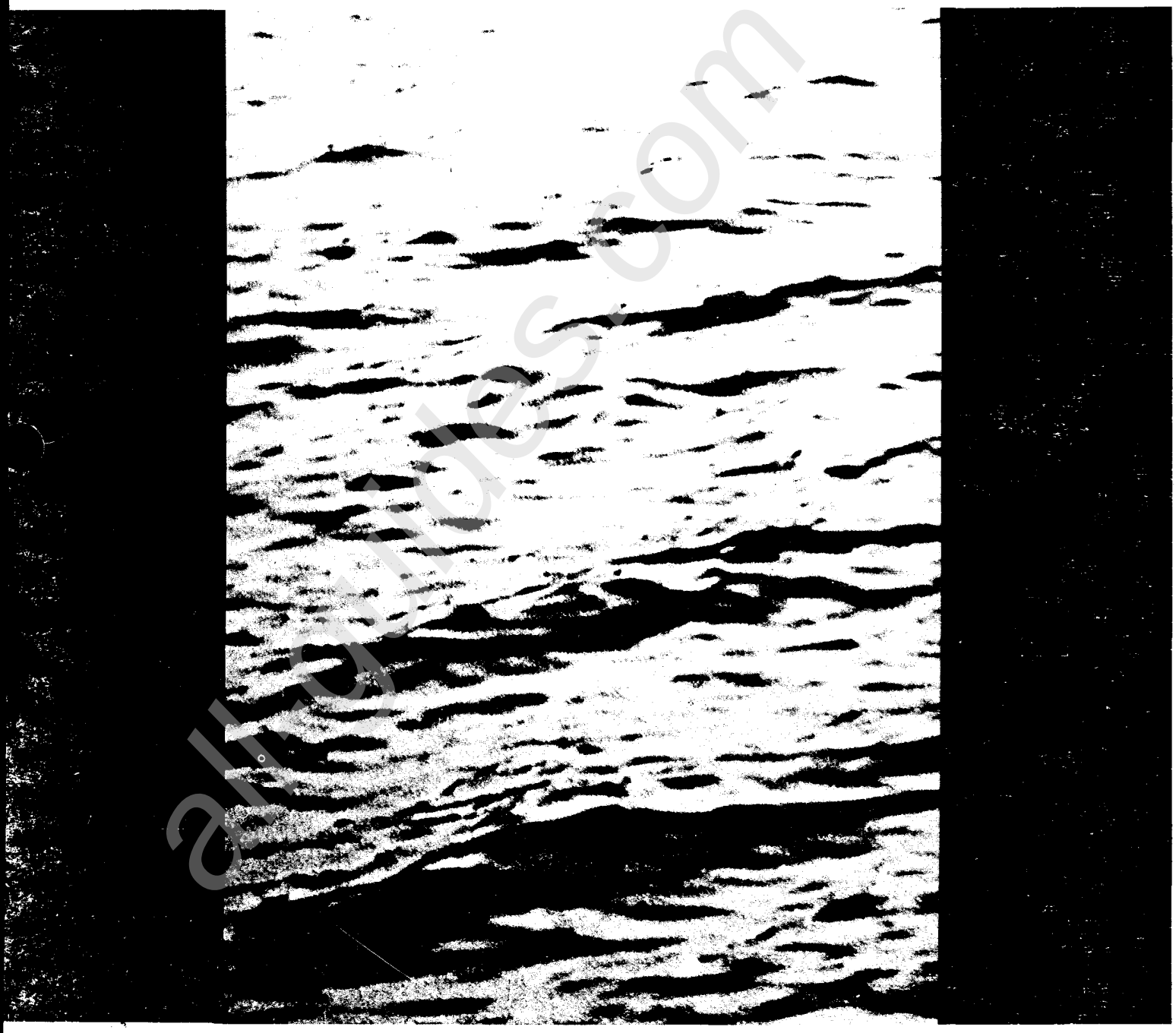
Cummins Marine Diesel Engines



Operation and Maintenance Manual

Bulletin 983709-OE, Printed 11-1971
Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Operation and Maintenance Manual

Cummins Marine Diesel Engines

IMPORTANT REFERENCE NUMBERS

SHIP/BOAT NO. _____

ENGINE MODEL _____

ENGINE SERIAL NO. _____

FUEL FILTER NO. _____

FULL FLOW LUBRICATING FILTER ELEMENT NO. _____

BY-PASS FILTER ELEMENT NO. _____

WATER FILTER ELEMENT NO. _____

AIR CLEANER ELEMENT NO. _____

WATER PUMP BELT NO. _____

ALTERNATOR BELT NO. _____

RAW (SEA) WATER PUMP BELT NO. _____

Foreword

The information contained in this publication pertains to Cummins Inline and V Diesel Engines currently being produced by Cummins Engine Company, Inc., and subsidiaries for marine applications. Operation and maintenance procedures are detailed so a new or experienced engine owner, operator or serviceman can use the information to obtain the best service from the engine.

For model identification of an engine, check the Data or Serial No. Plate. The letter and number code indicates breathing (naturally aspirated except when letter "T" for turbocharged is present), cubic inch displacement, application and maximum rated horsepower.

Examples:

NT-380-M
N = 4 valve head
T = Turbocharged
380 = Maximum rated horsepower
M = Marine Application

V-903-M
V = Type engine
903 = Cubic Inch Displacement
M = Marine Application

Disassembly and assembly of components peculiar to the marine version are contained in this manual. For complete disassembly, rebuild and assembly of the engine, refer to Engine Shop Manual.

This is an operation and maintenance manual; repair operations should be performed by specially trained personnel. Trained personnel are available at all Cummins Distributor and Dealer locations to perform full repair.

Cummins Engine Company, Inc.
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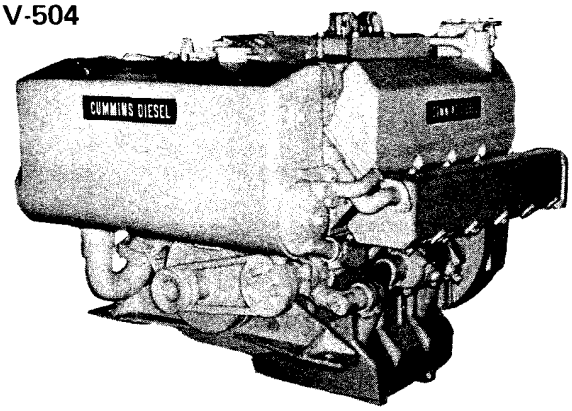
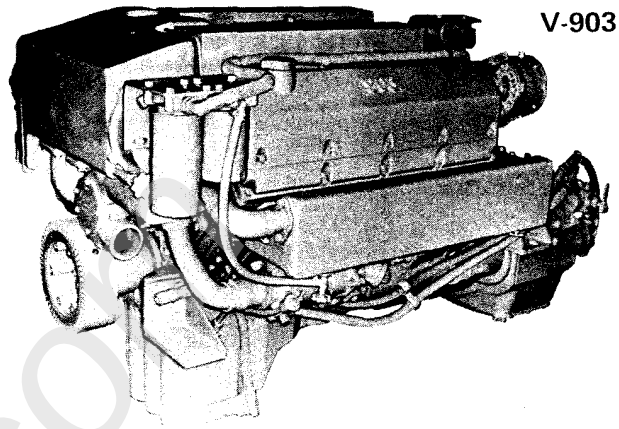
Table 1: Cummins Marine Diesel Engine Ratings

Engine Model	Bore and Stroke Inch [mm]	Displacement Cubic Inch [cc]	No. Cyl.	Boat/Ship Rating	Engine BHP @ RPM	Shaft HP @ RPM
V-504	4-5/8 x 3-3/4 [117 x 95]	504 [8260]	8	Pleasure Boat	202 @ 3300	189 @ 3300
				Light Duty	197 @ 3000	184 @ 3000
				Heavy Duty	158 @ 2500	148 @ 2500
V-555	4-5/8 x 4-1/8 [117 x 105]	555 [9096]	8	Pleasure Boat	230 @ 3300	216 @ 3300
				Light Duty	218 @ 3000	204 @ 3000
				Heavy Duty	175 @ 2800	164 @ 2800
V8-300	5-1/2 x 4-1/8 [140 x 105]	785 [12,866]	8	Pleasure Boat	300 @ 3000	280 @ 3000
				Light Duty	260 @ 2800	245 @ 2800
				Heavy Duty	220 @ 2600	206 @ 2600
VT8-370	5-1/2 x 4-1/8 [140 x 105]	785 [12,866]	8	Pleasure Boat	370 @ 3000	350 @ 3000
				Light Duty	320 @ 2800	300 @ 2800
				Heavy Duty	270 @ 2600	252 @ 2600
V-903	5-1/2 x 4-3/4 [140 x 121]	903 [14,800]	8	Pleasure Boat	320 @ 2600	286 @ 2600
				Light Duty	302 @ 2500	282 @ 2500
				Heavy Duty	250 @ 2300	233 @ 2300
NH-250	5-1/2 x 6 [140 x 152]	855 [14,013]	6	Pleasure Boat	250 @ 2100	225 @ 2100
				Light Duty	210 @ 2100	197 @ 2100
				Medium Duty	200 @ 1800	188 @ 1800
				Heavy Duty	190 @ 1800	179 @ 1800
NT-335	5-1/2 x 6 [140 x 152]	855 [14,013]	6	Pleasure Boat	335 @ 2100	315 @ 2100
				Light Duty	285 @ 2100	268 @ 2100
				Medium Duty	265 @ 1800	249 @ 1800
				Heavy Duty	235 @ 1800	221 @ 1800
NT-380	5-1/2 x 6 [140 x 152]	855 [14,013]	6	Pleasure Boat	380 @ 2300	357 @ 2300
				Light Duty	320 @ 2300	301 @ 2300
				Medium Duty	300 @ 2000	282 @ 2000
				Heavy Duty	253 @ 2000	236 @ 2000
V12-500	5-1/2 x 6 [140 x 152]	1710 [28,027]	12	Pleasure Boat	500 @ 2100	450 @ 2100
				Light Duty	425 @ 2100	398 @ 2100
				Medium Duty	400 @ 1800	373 @ 1800
				Heavy Duty	370 @ 1800	345 @ 1800
VT12-635	5-1/2 x 6 [140 x 152]	1710 [28,027]	12	Pleasure Boat	635 @ 2100	594 @ 2100
				Light Duty	540 @ 2100	505 @ 2100
				Medium Duty	490 @ 1800	458 @ 1800
				Heavy Duty	435 @ 1800	407 @ 1800
VT12-700	5-1/2 x 6 [140 x 152]	1710 [28,027]	12	Pleasure Boat	700 @ 2100	654 @ 2100
				Light Duty	595 @ 2100	556 @ 2100
				Medium Duty	545 @ 1800	509 @ 1800
				Heavy Duty	480 @ 1800	449 @ 1800
VT12-800	5-1/2 x 6 [140 x 152]	1710 [28,027]	12	Pleasure Boat	800 @ 2100	749 @ 2100
				Light Duty	680 @ 2100	636 @ 2100
				Medium Duty	620 @ 1800	580 @ 1800
				Heavy Duty	550 @ 1800	514 @ 1800

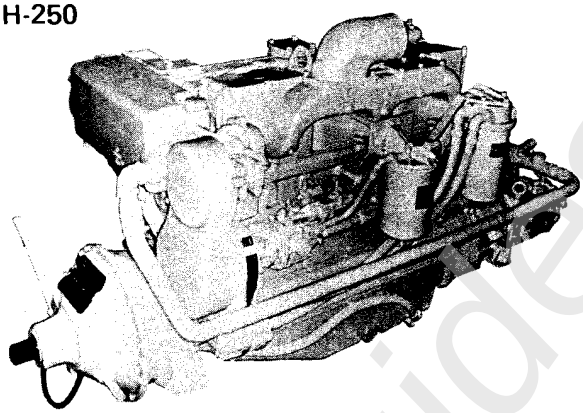
V-504



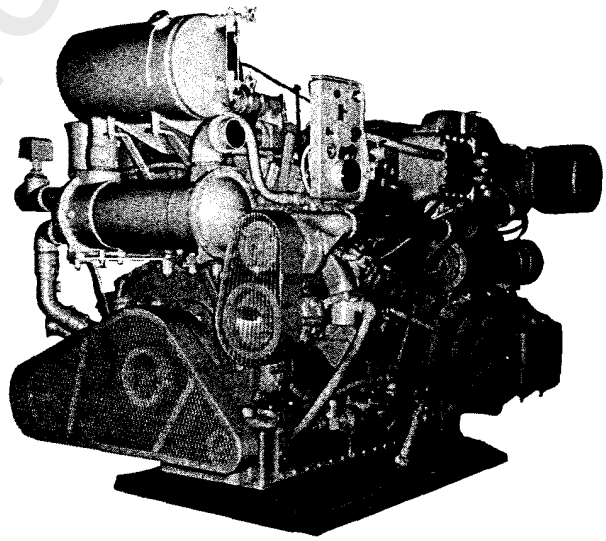
V-903



NH-250



VT-12



Boat And Ship Engine Ratings (Ref. Table 1)

Pleasure Boat Rating

This is the maximum rating and is intended for use in variable load applications where the average load factor does not exceed the continuous rating and where full throttle operation does not exceed 15 minutes duration in any one hour. These are SAE standard ratings.

Light Duty Commercial Rating

This rating is intended for use in applications where the average load factor does not exceed the continuous rating and where full throttle does not exceed eight hours total in any 24-hour period.

Medium Duty Commercial Rating

This rating is intended for use in applications where the average load factor does not exceed the continuous rating and where full throttle does not exceed fifteen hours total in any 24-hour period.

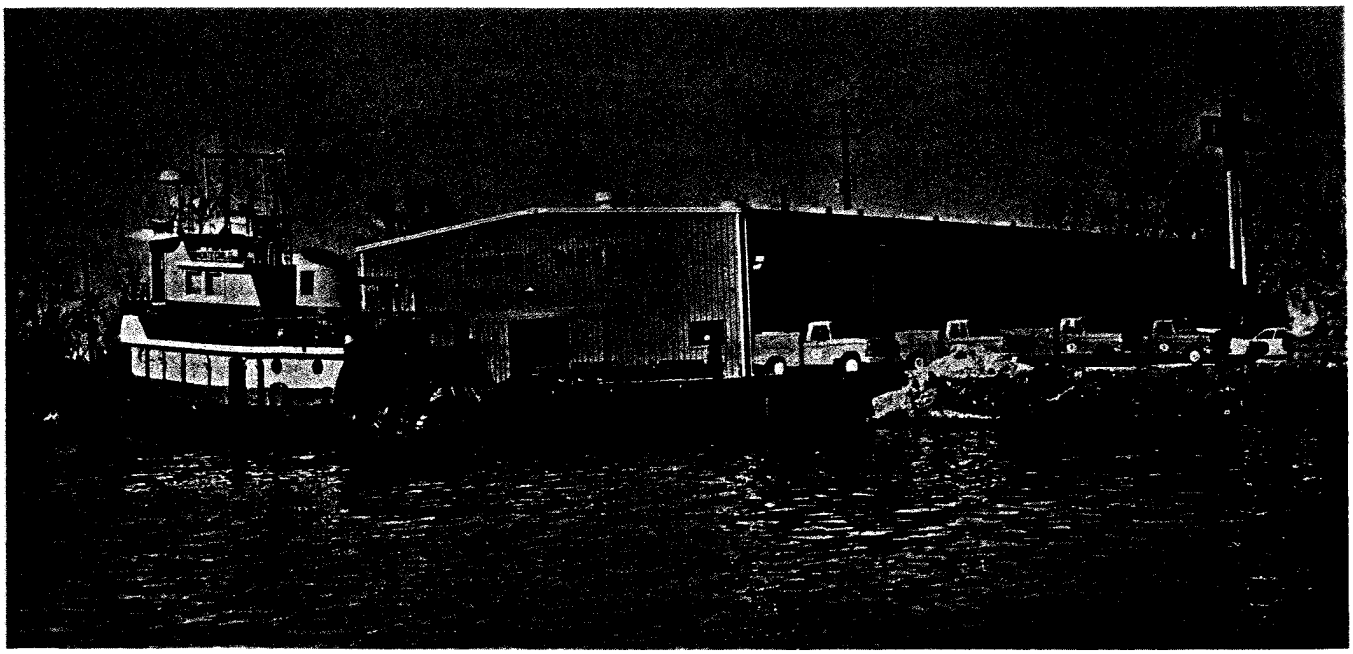
Continuous Duty Rating

This is a 24-hour continuous rating and is intended for use in applications requiring uninterrupted service at full throttle operation.

TO THE ENGINE OWNER

All new Cummins Engines should be made available to a Cummins Distributor or Dealer within the first 500 hours of operation or 120 days from delivery, whichever occurs first, who are authorized to perform new engine inspection to assure proper engine performance.

When a Cummins engine is shipped from the factory, a detachable engine inspection tag is a part of the engine data plate. This tag is 1-1/4 inch long and has the engine model and serial number stamped on it. This tag is not to be removed from the nameplate until the new engine inspection is performed as Cummins Engine Company, Inc. may not honor an inspection claim unless this tag accompanies the report of new engine inspection when submitted by the inspection Dealer or Distributor. If this inspection tag is missing prior to the new engine inspection, please notify the Dealer/Distributor from which the engine was purchased.



New engine inspection check list consists of the following:

1. CHECK BEFORE STARTING ENGINE
Engine and Accessory Mountings for Fuel, Lubricating Oil, and Coolant Leakage
Fuel System Installation
Lubricating Oil System Installation, Lubricating Oil Level, and Oil Pan Drain Plug Torque
Cooling System Installation and Coolant Level
Air Cleaner
Engine Breather
All Belt Tension

2. CHECK WHILE OPERATING ENGINE
For Unusual Noises
Throttle Operation
Fuel, Lubricating Oil, Coolant Leakage
Operation of Gauges and Controls
Lubricating Oil Pressure
Engine Performance
Air Induction System
Exhaust System

3. ADJUSTMENTS
Injectors
Crossheads
Valves

4. INSTRUCT OWNER IN
Changing Fuel and Lubricating Oil Filters
Changing Lubricating Oil
Use of Proper Fuel Oil
Operating Temperature
Starting and Stopping Procedure
Damages Caused by Over-Speeding
Use of Corrosion Inhibitor and Antifreeze
Use of Cold Starting Device
Air Cleaner Maintenance
Belt Maintenance

Operating Instructions

The operator of the engine assumes the responsibility of unit care during operation. This is important and will determine to a large degree the life of the unit. There are comparatively few rules which the operator must observe to get the best service from the Cummins Diesel. However, if any of these rules are broken, a penalty is certain to follow. The penalty may be lower engine efficiency or it may be in down time and costly repair bills resulting from premature engine failure.

Marine Engines

New And Rebuilt Engine Break-In

The way a new engine is operated during the first 100 hours' service will have an important effect on the life of the engine and its parts. Its moving parts are closely fitted for long service, and even though all Cummins engines are run on a dynamometer for several hours before they leave the factory, an additional period may be required before uniform oil films are established between all mating parts.

During the first 100 hours' service:

1. Operate as much as possible in half to three-quarter throttle or load range.

2. Avoid operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of five minutes.

3. Develop the habit of watching engine instruments closely during operation and letting up on throttle if oil temperature reaches 250 deg. F [121 deg. C] or coolant temperature exceeds 190 deg. F [88 deg. C].

4. Operate with a power requirement low enough to allow acceleration to governed speed under any condition. Propeller should allow engine to reach rated rpm.

5. Check oil level each 10 hours until rings are seated (oil consumption levels off) during break-in period.

Pre-Starting Instructions – First Time Or Seasonal

Priming The Fuel System

1. Fill fuel filter with clean No. 2 diesel fuel oil meeting the specifications outlined in Section 3.

a. With PT (type G) fuel pump, fill pump through plug next to tachometer with clean fuel.

b. With PT (type R) fuel pump, remove suction line and wet gear pump gears with clean fuel.

2. Check fuel tanks. There must be an adequate supply of a good grade, clean No. 2 diesel fuel in the tanks. See "Fuel Oil Specifications," Page 3-4.

Caution: Do not service or fill fuel tanks near an open flame. Clean area of any spilled fuel.

3. If injector and valve or other adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting the engine.

Priming The Lubricating System

Note: On turbocharged engines, remove oil inlet line from the turbocharger and fill bearing housing with clean lubricating oil. Reconnect oil supply line.

1. Fill crankcase to "L" (low) mark on dipstick. See Lubricating Oil Specifications, Section 3.

2. Remove plug from head of lubricating oil filter housing

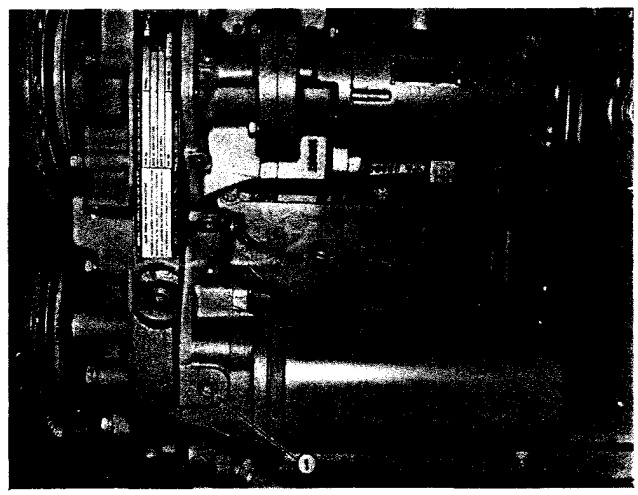


Fig. 1-1, (N11963). NH, NT Lubricating oil priming point

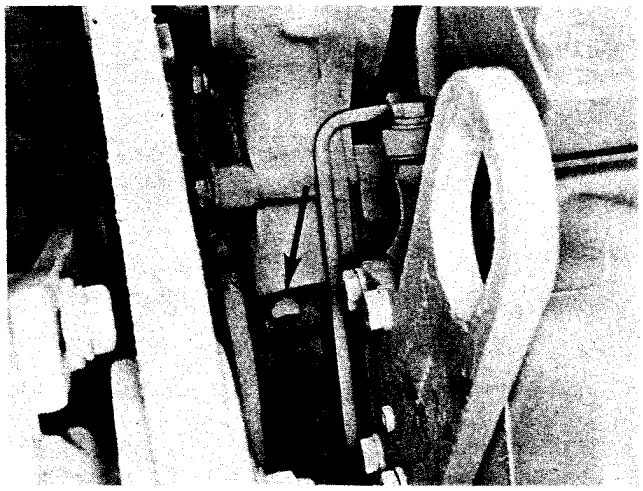


Fig. 1-2, (V21964). V Lubricating oil priming point

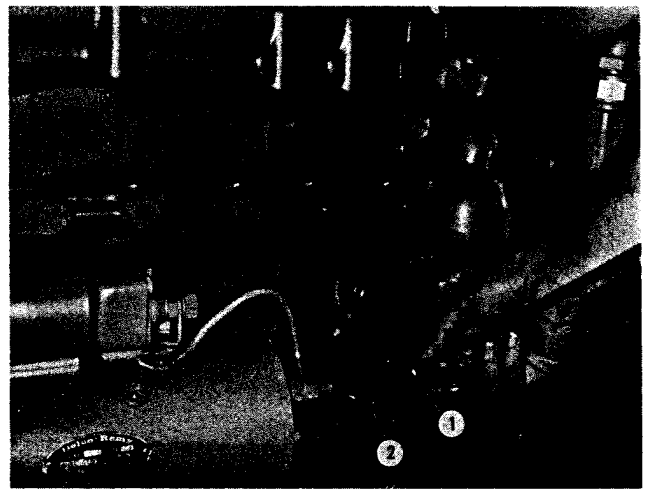


Fig. 1-3, (N12012). Checking engine oil level

(Fig's. 1-1 and 1-2) or filter can to prime NH, NT or V12 series engines. Remove plug from boss on gear housing on V-504, V8-300, VT8-370 and V-903 series engines.

Caution: Do not prime engine lubricating system from by-pass filter.

3. Connect a hand or motor-driven priming pump line from source of clean lubricating oil (see Section 3) to priming point.

4. Prime until a 30 psi [2.1 kg/sq cm] minimum pressure is obtained.

5. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [1.05 kg/sq cm].

6. Remove external oil supply line and replace plug, torque 15 to 20 ft-lbs [2.07 to 2.77 kg m].

Caution: Clean area of any lubricating oil spilled while priming or filling crankcase.

7. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications, listed in Section 3. No change in oil viscosity or type is needed for new or newly rebuilt engines.

A dipstick oil gauge is located on the side of the engine. Fig. 1-3. The dipstick has an "H" (high) (1) and "L" (low) (2) level mark to indicate lubricating oil supply. The dipstick must be kept with the oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan part numbers.

Lubricating Oil Dipstick Gauge Marking

Many marine engines require shipment with unmarked (high and low level) lubricating oil dipstick gauges. The reason for this is the engine mounting angle is determined at installation; and even though a given amount of oil is required, the dipstick must be marked so the oil level is correct at the engine mounting angle.

Where the preceding conditions exist, dipstick is lost or not originally furnished, use the following procedures in marking the dipstick oil gauge.

1. With engine in installed position, remove the oil pan drain plug or use suction pump to be sure all oil is drained before beginning the marking procedure. Replace plug.

Caution: Any oil left in oil pan will cause error in marking; the oil sometimes accumulates as the oil drains from upper portions and oil passages within the engine.

2. On new engines a tag is attached to the engine indicating high and low lubricating oil capacities of engine. If there is doubt about proper capacities, consult oil pan capacity tabulations in Engine Shop Manuals, Group 7. Other methods are to report oil pan, dipstick tube and dipstick gauge part numbers to your nearest Cummins Distributor.

3. Fill engine with amount of oil listed as low-level capacity.

4. Allow five (5) minutes or more for oil to drain to the oil pan. If engine and/or oil temperature is below 40 deg. F [4.4 deg. C], a longer period may be required for full drain.

5. Insert dipstick into gauge tube until fully seated; hold for five (5) to ten (10) seconds, then withdraw slowly.

6. Mark oil level indicated on dipstick with two (2) center punch marks or by electric etch. Depth of marks must not exceed 0.010 inch [0.2540 mm]. Stamp "L" above mark.

7. Add enough additional oil to fill engine to listed high-level capacity.

8. Repeat Steps 4, 5 and 6. Stamp letter "H" directly above the second or "high" level mark.

The above procedures determine dipstick gauge marking for oil pan capacity only. Do not confuse with complete oil system capacity which also includes drilled passages, lines and filters.

Depending upon oil viscosity, oil temperature and ambient temperatures, oil drain-back time can be from as little as two (2) minutes @ 200 deg. F [93.3 deg. C] oil temperature to thirty (30) minutes @ 25 deg. F [−3.8 deg. C] oil temperature. Even after these periods there could still be as much as 2.5 quarts of oil in oil passages; full drain-back may require as long as two (2) to three (3) hours.

Fill Marine Gear To Oil Level — A-Check

The marine gear is a separate unit and carries its own lubrication. Fill housing through filler tube, Fig. 1-4, to high-level mark on dipstick gauge with correct viscosity of oil. Table 2-3.

Caution: Never operate marine gear with oil level below "L" mark or above "H" mark on dipstick.

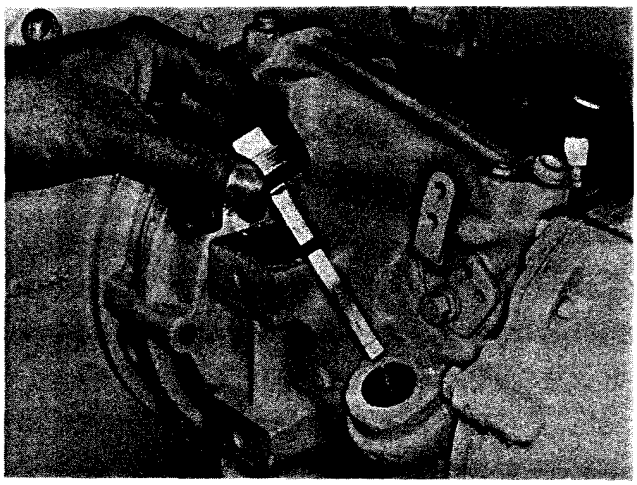


Fig. 1-4, (V11932). Marine gear fill location

Capitol Gear

Fill marine gear with Lubriplate APG90 or equivalent oils meeting MIL-L-2105 or MIL-L-2105-A specifications. Keep oil level as near "Full" mark as possible.

Twin Disc Gear

Fill the SAE 30 heavy-duty type engine oil when cooling water is above 55 deg. F [12.8 deg. C]. Use SAE 20 when cooling water is less than 55 deg. F [12.8 deg. C].

Borg Warner Gear

Automatic Transmission Fluid Type "A" for normal operation.

Note: If necessary to mark dipstick, the high level is 1/4 inch [6.350 mm] above bend in dipstick; stamp letter "H" (electric etch on spring steel) immediately above mark. The low mark is 1/2 inch [12.700 mm] below bend; stamp letter "L" immediately above mark.

Paragon Gear

Automatic Transmission Fluid Type "A" for normal operation. If this is not possible, use good non-detergent, anti-foaming oil of same SAE rating as used in engine.

Check Raw Water Pump Oil Level (V-12)

Check oil level in raw water pump if pump has an oil sump.

1. Remove pipe plug from side of pump.

2. Fill housing with hypoid SAE 90 oil, replace plug.

Check Oil Bath Cleaner Oil Level — A-Check

NH, NT, V12 and VT-12 Engines

Daily, check oil level, Fig. 1-5, in oil bath air cleaner to be sure oil level in oil cup is at indicated mark. To remove oil cup, loosen wing nuts. During wet weather and in winter

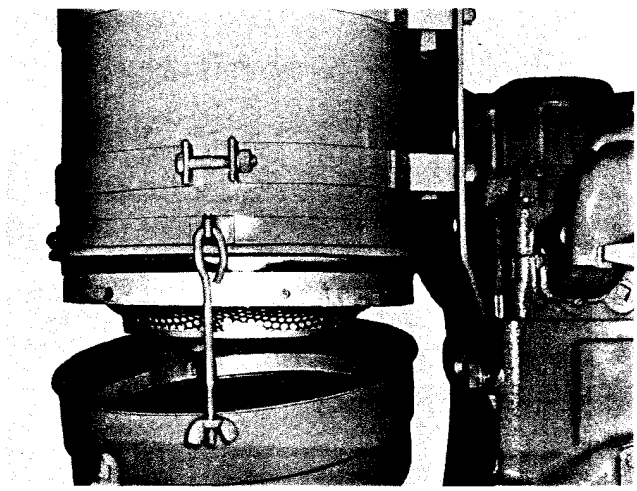


Fig. 1-5, (N11001). Checking air cleaner oil level

months, excessive moisture in air cleaner oil sometimes causes cleaner to become flooded and results in oil pull-over or plugging of the bottom air cleaner screen. Add or change oil as necessary. This is especially important if oil bath cleaner is the only cleaner on the engine.

Some oil bath air cleaners have a rubber seal at the junction of the cleaner body and oil pan. This seal must not leak, since the entrance of dirt at this point can wear an engine out in a short time.

Inspect the seal ring carefully at each service period and replace seal as necessary.

Check Air Silencers

Check air silencers to see that they are clean and free from obstructions.

Check Marine Gear Alignment With Propeller Shaft

The Marine Gear, the crankshaft and the propeller shaft should have been correctly aligned during initial installation; but, if the gear becomes overheated or if "hot spots" are detected under full-load condition, it is an indication of gear misalignment or of incorrect bearing or gear clearances. Improper alignment will result in vibration, bent propeller shaft and undue wear because of excessive stressing of parts in both the clutch and the reverse gear mechanism.

Experience has shown that hulls often change shape after the boat is launched, recheck and correct alignment, if necessary, with boat in the water. This can be accomplished by removing the bolts in the propeller shaft coupling and checking the spacing of the two flanges on the circumference. For satisfactory alignment, variation should not exceed 0.004 inch [0.1016 mm]. See Fig. 1-6.

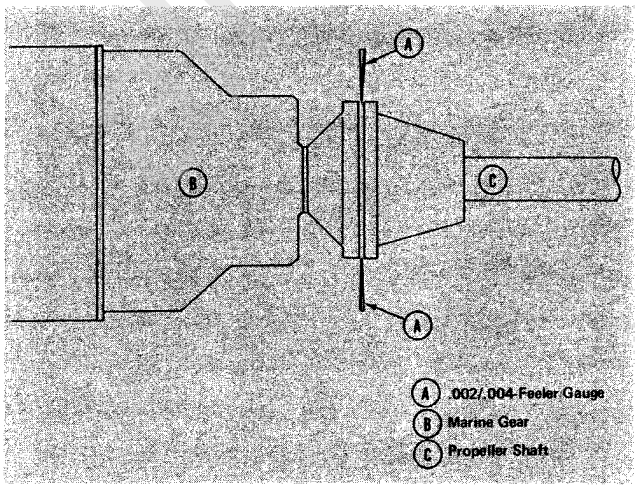


Fig. 1-6, (V21967). Checking alignment between marine gear and propeller shaft

Check Air Connections — A-Check

Check air connections to compressor and air equipment, as used, and to air cleaners and air crossovers.

Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsing hose, or other damage. Tighten clamps or replace parts as necessary to insure an airtight air intake system (Fig. 1-7). Make sure that all air goes through air cleaner (if used).

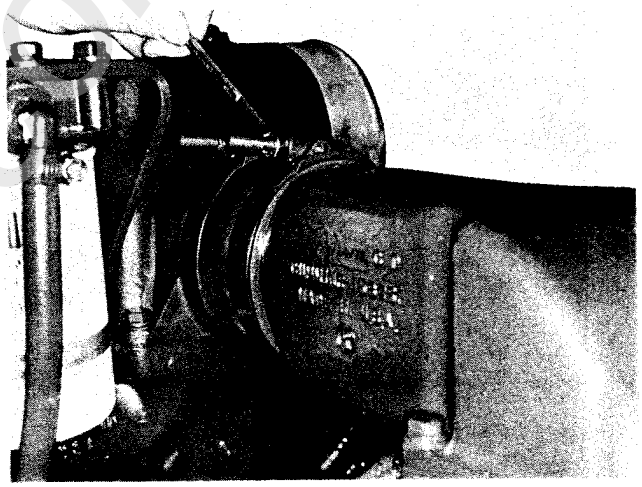


Fig. 1-7, (V51925). Tightening air intake piping clamp

Check Zinc Plugs

Remove and check zinc plug in heat exchanger or marine gear cooler. Fig. 1-8. If zinc anode has deteriorated to less than 1/2 original size, replace with new.

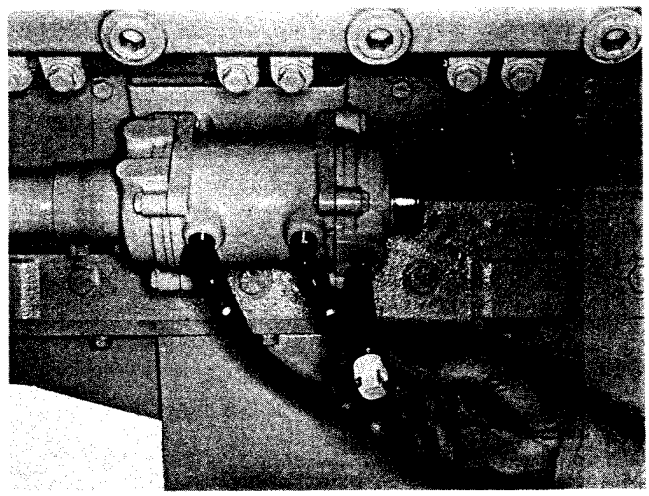


Fig. 1-8, (V11933). Checking zinc plugs

Check Engine Coolant — A-Check

1. Remove heat exchanger cap and check engine coolant supply. Add coolant and check corrosion resistor, Section 2. See Section 3 for coolant specifications.

2. Check for evidence of coolant leakage around tubing, hose connections, etc.; correct as necessary, Fig. 1-9. Inspect water pump bleed hole for leakage. Leakage indicates worn or damaged seal.

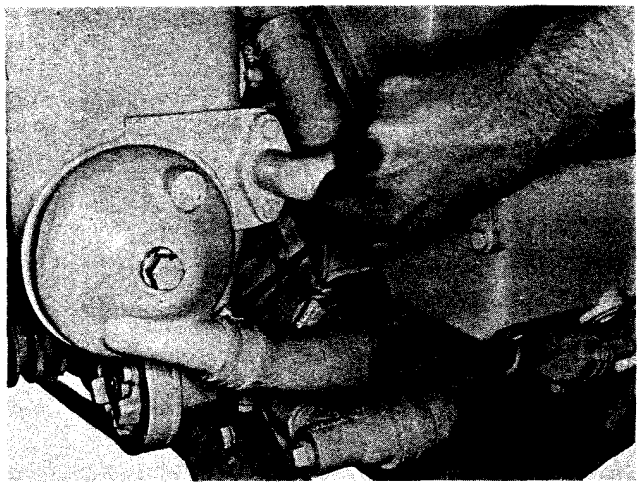


Fig. 1-9, (V11940). Tightening coolant hose clamps

Check Fuel Supply And Connections — A-Check

Caution: Fuel leaks may create a fire hazard if not corrected.

1. Visually check for evidence of external fuel leakage at fuel connections.

2. Tighten fuel fittings and connections as necessary.

3. Check for air leaks in fuel system after engine has started by placing ST-998 Sight Gauge in the line between fuel filter(s) and pump. Bubbles over 1/2 inch long or of a "milky" appearance indicate an air leak; find and correct. Fig. 1-10.

Starting The Engine

Starting requires only that clean air and fuel be supplied to the combustion chamber in proper quantities at the correct time.

Caution: Protect the turbocharger during the start-up by not opening throttle or accelerating above 1000 RPM until normal engine idle speed oil pressure registers on gauge.

Normal Starting Procedure

1. Open raw water inlet and outlet valves to permit raw water flow through heat exchanger and marine gear oil cooler.

2. If fuel system is equipped with overspeed stop, push "Re-set" button before attempting to start engine.

3. Set throttle for idle speed.

4. Place marine gear in neutral.

5. Open manual fuel shut-down valve, if engine is so equipped. Electric shut-down valves operate automatically.

Note: A manual over-ride knob, Fig. 1-11, provided on the forward end of the electric shut-down valve allows the valve

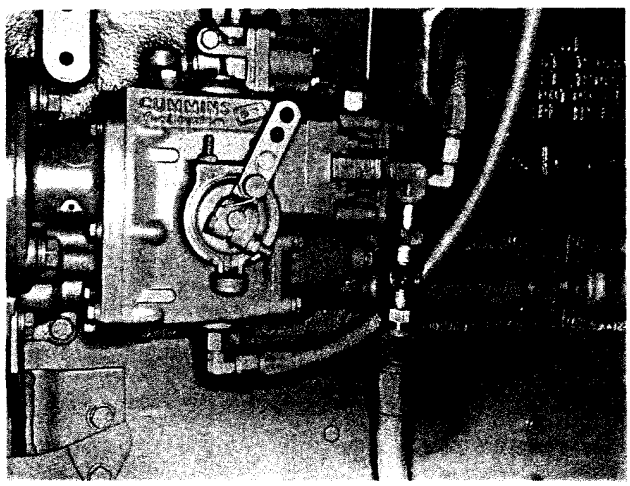


Fig. 1-10, (N11964). Checking for air in fuel lines

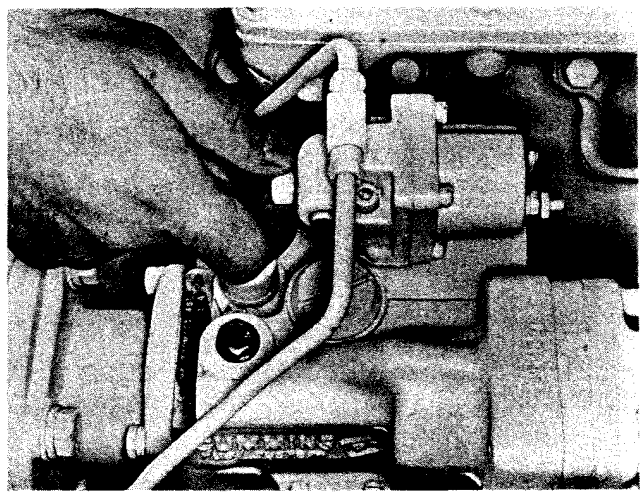


Fig. 1-11, (V21970). Fuel pump manual override knob

to be opened in case of electric power failure. To use, open by turning full clockwise.

6. If engine is equipped with compression release, pull lever.

7. Press starter button or turn switch-key to "start" position.

Caution: To prevent permanent cranking motor damage, do not crank engine for more than 30 seconds continuously. If engine does not fire within first 30 seconds, wait one to two minutes before recranking.

8. After three or four seconds of cranking, close the compression release (if so equipped) and continue to crank until the engine fires.

Caution: After engine has run for a few minutes, shut it down and wait 15 minutes for oil to drain back into pan. Check engine oil level again; add oil as necessary to bring oil level to "H" mark on dipstick. The drop in oil level is due to absorption by the oil filter and filling of the oil cooler. Never operate the engine with oil level below the low level mark (2), or above the high level mark (1).

Lubricating Oil Leaks — A-Check

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections, or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps; see that they are tightened securely.

Cold-Weather Starting

To aid in starting engine when temperature is 50 deg. F [10.0 deg. C] or below, an intake air preheater is available. Preheater equipment consists of a hand-priming pump to pump fuel into intake manifold, a glow plug which is electrically heated by battery and a switch to turn on glow plug. Fuel burns in the intake manifold and heats intake air. See Fig's. 1-12 and 1-13.

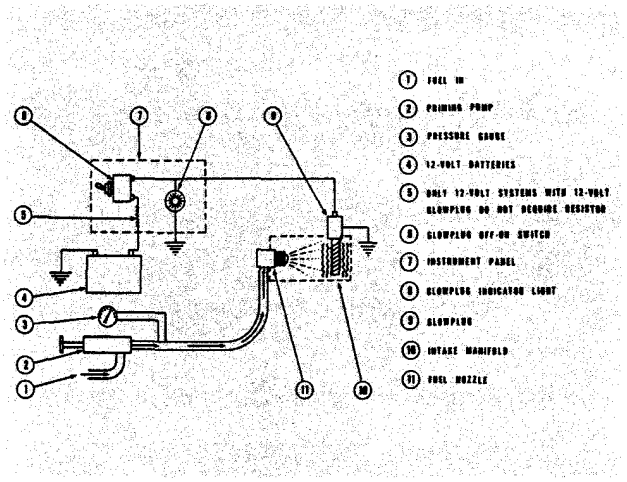


Fig. 1-12, (N11804). Preheater wiring diagram

Caution: Do not use ether in conjunction with the preheater. To do so could result in a fire.

To use the preheater for cold starting:

1. Set throttle in idle position. Do not accelerate engine during the starting procedure.

2. Turn glow plug toggle switch to "ON" position. Red indicator light must be on.

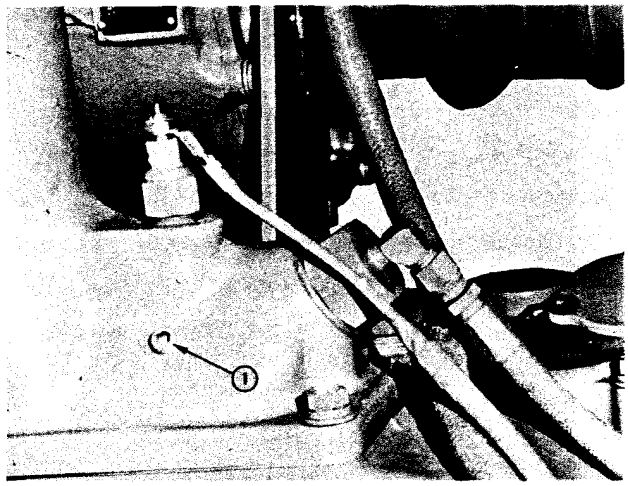


Fig. 1-13, (N11949). Glow plug inspection hole

3. After red light has been on for 20 seconds, start cranking the engine. As soon as engine begins rotating, operate the preheater priming pump to maintain 80 to 100 psi [5.6245 to 7.0307 kg/sq cm] fuel pressure. Use of primer before the 20-second interval will wet glow plug and prevent heating.

Note: On engines equipped with an oil pressure safety switch, the fuel by-pass switch must be in "start" position before operating priming pump. Hold the fuel by-pass switch in "start" position until engine oil pressure reaches 7 to 10 psi [0.4920 to 0.7031 kg/sq cm]; then, move to "run" position.

4. If engine does not start within 30 seconds, stop cranking. Wait one to two minutes and repeat cranking operation.

5. After engine starts, pump primer slowly to keep engine idling smoothly. In cold weather this may require 4 to 5 minutes or longer. Do not accelerate engine.

6. When the engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch. (Red indicator light will go out.)

Failure To Start

1. If the engine gives no indication of starting during the first three full strokes of the preheater pump, touch-check the intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove 1/8 inch pipe plug (1, Fig. 1-13) from manifold near glow plug and carefully check for flame while a helper performs the preceding Steps 2, 3 and 4.

2. If no flame is observed, close glow plug manual switch for 15 seconds and observe glow plug through 1/8 inch pipe plug hole. The glow plug should be white hot; if not, connect wiring to a 6- or 12-volt (as used) source and check amperage; it should be 30 to 32 (minimum). If glow plug is all right, check manual switch and resistor (if used) and replace if necessary.

Ether-Compound Metering Equipment

This consists of a metering chamber for ether compound capsules and controls to release the starting compound during cranking.

The metering chamber is installed to release the starting fluid between the air cleaner and the turbocharger on engines so equipped. On naturally aspirated engines, the metering chamber releases the ether fluid into air intake manifold. To start engines equipped with this cold-starting aid:

1. Close shut-off cock (1, Fig. 1-14). If properly installed, the spring will hold it closed.

2. Remove cap (2) and insert capsule of starting fluid.

3. Push cap down sharply to puncture capsule and tighten one-fourth turn.

4. Wait 30 seconds before engaging starter.

5. Engage starter and, while engine is being cranked, open the shut-off valve.

Caution: Do not open valve before cranking or there will be one excessively heavy charge instead of the metered amounts which starting requires.

6. After engine has started and all fluid has drained out of chamber, close the valve to prevent entry of dusty air into the engine.

7. Remove and discard empty capsule, and reassemble empty primer.

Spray Nozzle Application Of Starting Fluid

Spray nozzle application is an effective aid in starting engine when temperatures drop below 50 deg. F [10.0 deg. C]. This cold-starting fluid should never be used with any type preheater system. Serious damage could result.

Spray nozzle assembly consists of a control knob operated from pilot house, a flexible cable and cable housing attached to container, bracket mounted on bulkhead (1, Fig. 1-15). Pulling knob, in pilot house, releases spray through a small plastic hose (2) into spray nozzle (3) located in intake crossover connection or air intake manifold. Small orifice holes in spray nozzle must be positioned to allow fluid to spray into both left bank and right bank intake manifolds of V type engines.

Caution: When pulling knob, do not hold knob any longer than 2 seconds at any one time. Serious damage could result from releasing excessive fluid into intake chambers.

If engine does not start after first 2 seconds of spray application, wait 1 or 2 minutes and repeat starting procedure. In extreme cold weather conditions, such as −25 deg. F [−31.5 deg. C], if unit will not start with above instructions, remove starting fluid can and warm to room

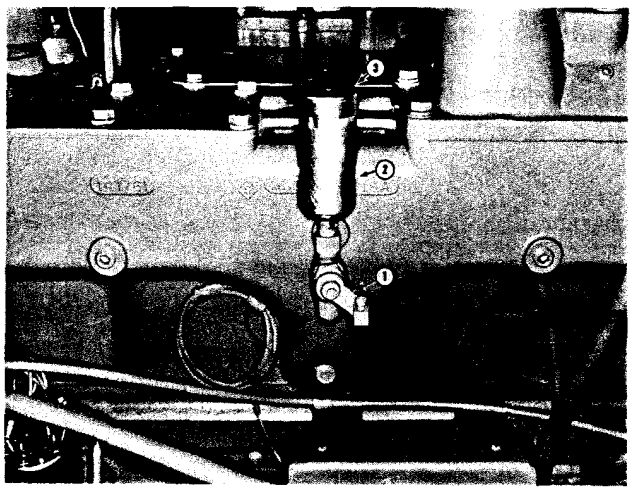


Fig. 1-14, (N11841). Ether compound metering equipment

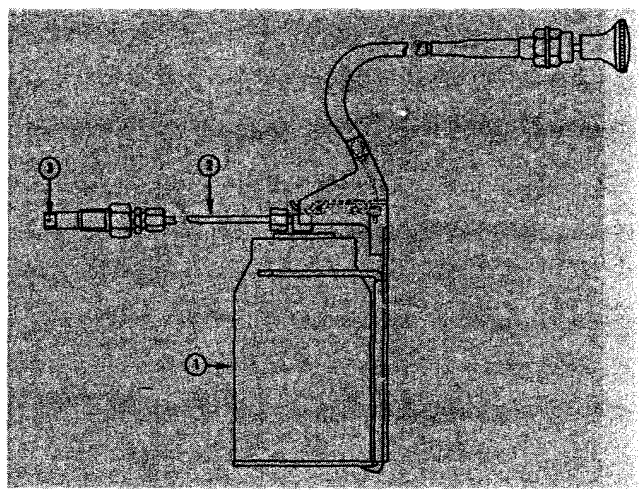


Fig. 1-15, (V11469). Starting fluid spray applicator

temperature; check spray nozzle in intake connection to be sure orifice holes are free of foreign material. Install can in bracket and connect spray nozzle and repeat normal starting procedure with use of spray nozzle.

Use Of Ether Without Metering Equipment

If the engine is not equipped with a preheater arrangement or ether compound metering equipment, two men can use the following method to start the engine.

1. Spray ether into air intake, Fig. 1-16, while second man cranks the engine.

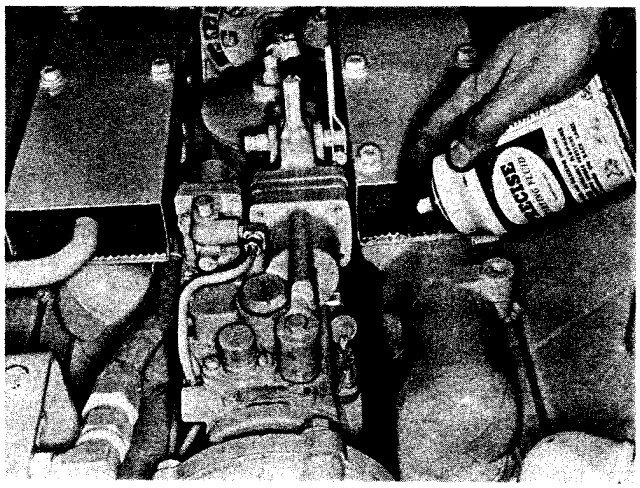


Fig. 1-16, (V11936). Ether spray application

Caution: Never handle ether near an open flame. Never use it with preheater or flame thrower equipment. Do not breathe the fumes. Use of too much ether will cause excessively high pressures and detonation.

2. Ether fumes will be drawn into the intake air manifold and the cold engine should start without difficulty.

Engine Warm-Up

When the engine is started, it takes a while to get the lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature.

Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up. Allow the engine to run at 800 to 1000 rpm for 4 to 5 minutes or preferably until water temperature reaches 140 deg. F [60 deg. C] before engaging the load. During the next 10 to 15 minutes, or until water temperature reaches 160 to 165 deg. F [71.10 to 73.9 deg. C], operate at partial load at approximately 75% of governed rpm.

Record Engine Temperatures And Oil Pressure — A-Check

Some work boat engineers are required to record engine temperatures and oil pressure daily. After engine has warmed up, reduce engine speed to idle and record oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change. Record all engine temperatures.

Engine Speeds

Idle Speeds

In most applications engine idle speeds are 550 to 650 rpm; however, the parasitic load may require a slightly higher value to smooth out operation.

Caution: Cummins Engine Company, Inc., recommends idling turbocharged engines three (3) minutes minimum before applying load to obtain adequate oil flow through turbocharger.

Governed Speeds

All Cummins engines are equipped with governors to prevent speeds in excess of maximum or predetermined lower speed rating.

The governor has two functions: First, it provides the exact amount of fuel needed for idling when the throttle is in idling position. Second, it overrides the throttle and shuts off fuel if engine rpm exceeds the maximum rated speed.

Speeds listed in Table 1-1 are for engines rated at maximum rpm and fuel rate; many engines are set at other values due to equipment being powered or loads applied to equipment and engine.

Table 1-1: Engine Speeds

Engine Model	Governed RPM (Pleasure Boat Rating)	Recommended Cruising RPM
V-504	3300	2800
V8-300, VT8-370	3000	2600
V-903	2600	2200
NH-250, NT-335	2100	1800
NT-380	2300	2000
All V-12's	2100	1800

Don't Overwheel

Engines should be matched with a propeller that will allow the engine to turn its rated rpm under full load. Installation of too large a propeller will reduce maximum obtainable engine speed, prevent use of maximum available horsepower and reduce operating period between overhauls.

Operate At Reduced RPM For Continuous-Duty Or Cruising

When operating the engine on a continuous-duty (or work boat cycle) and engine is rated at maximum horsepower and rpm, maintain engine rpm at approximately 85 percent of rated rpm. See Table 1-1. This will give adequate power as well as economical fuel consumption.

Engine governors are normally set for reduced rpm or the fuel pump at reduced fuel rate for continuous-duty operation.

Marine Gear

Movement of a single lever on the control valve to neutral, forward or reverse controls the marine gear operation. If so desired, the control lever may be interlocked with the throttle; therefore, the marine gear should be shifted to forward or reverse before the throttle is moved from idle position and returned to neutral when the throttle is closed.

Caution: Never shift the control lever to any position with the engine running faster than 1000 RPM.

The use of an interlock system is mandatory when the pilot house control is used and no engineer is present in the engine room.

Record Marine Gear Oil Pressure — A-Check

If unit is being operated for the first time, remove pipe plug and attach an oil pressure gauge to pressure point. Fig. 1-17 and Fig. 1-18.

Refer to gear manufacturer's manual for procedures, temperatures and recommended oil pressures.

Start the engine and bring up speed and temperatures slowly and record the oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of bearings, shafts, clutch disc, gears, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Check Marine Gear For Oil Leaks

Check all hose connections, fittings, hose, gaskets and oil seals for leaks. If the oil seal at the rear of the gear housing is leaking, tighten the bearing retainer cap.

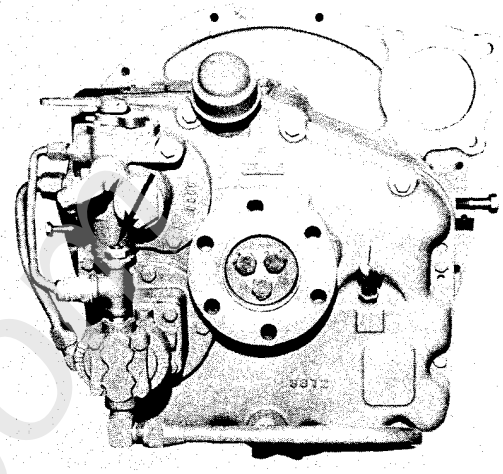


Fig. 1-17, (V11939). Twin Disc marine gear pressure check point

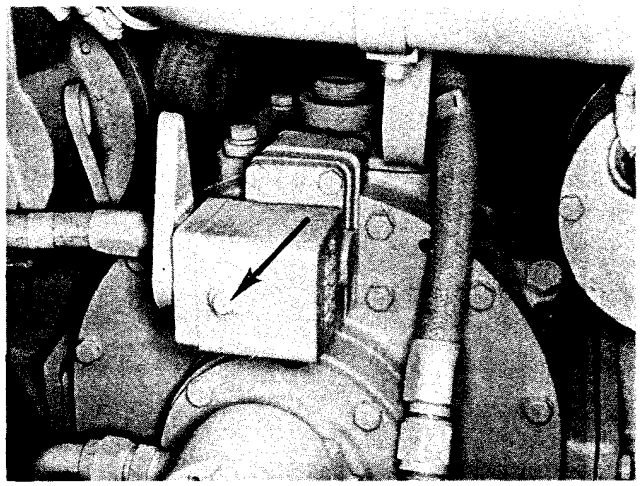


Fig. 1-18, (V21808). Capitol marine gear pressure check point

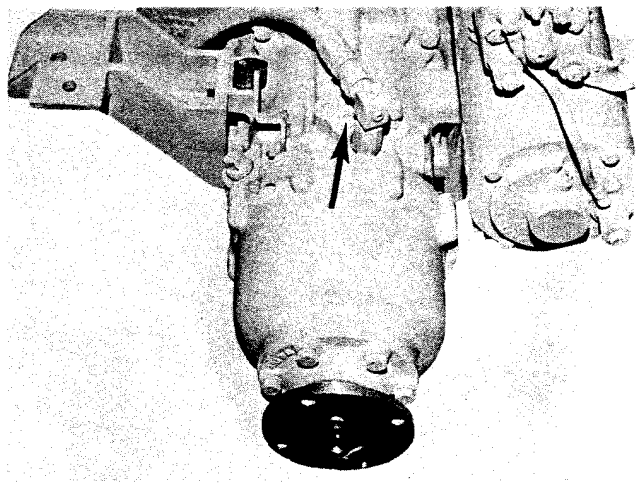


Fig. 1-18A, (V11937). Borg Warner marine gear pressure check point

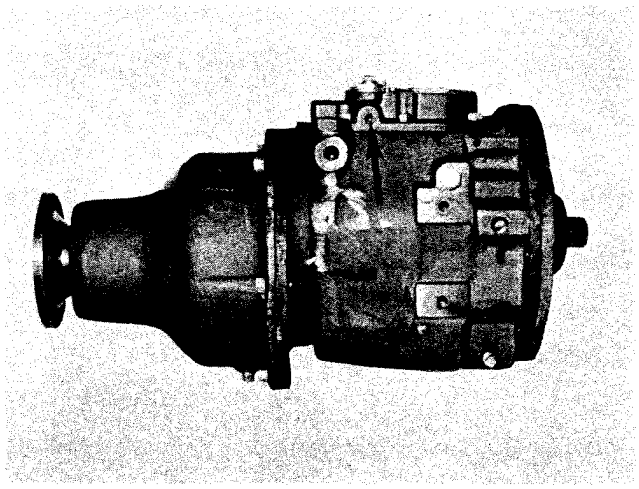


Fig. 1-18B, (V11938). Paragon marine gear pressure check point

Instrument Panels

Operate By The Instruments

It makes no difference whether an engine is in a boat or on some other type of operation; the operator should use the panel board instruments. The instruments show at all times the operating characteristics of the engine. Fig. 1-19.

Use The Tachometer

Governed engine speed is the maximum rpm which a properly adjusted governor will allow the engine to turn under full load. At high idle (no-load) conditions, engine rpm will exceed governed speed by a small percentage.

Operate at partial throttle in continuous-duty situations to give required torque with the tachometer showing rpm approximately 15 percent below governed speed.

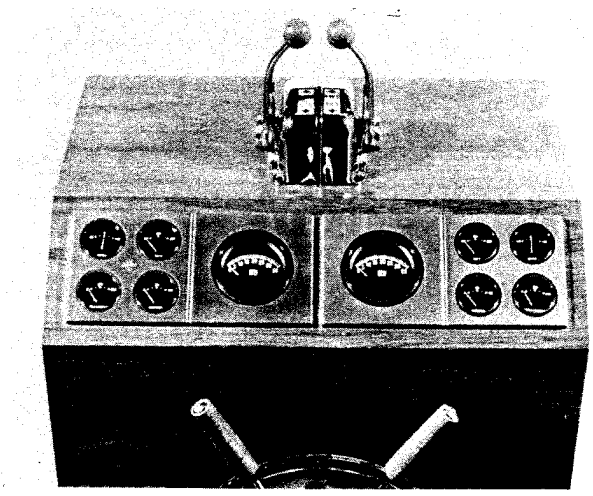


Fig. 1-19, (V21806). Marine instrument panel

Oil Temperature Gauge Indicates Best Operating Range

The oil temperature gauge normally should read between 180 deg. F [82.2 deg. C] and 225 deg. F [115.6 deg. C] for best lubrication. Under full load conditions, a temperature of 265 deg. F [129.4 deg. C] for a short period is not to be considered cause for alarm.

Caution: Any sudden increase in oil temperature which is not caused by load increase is a warning of possible mechanical failure and should be investigated at once.

During warm-up period, apply load gradually until oil temperature reaches 140 deg. F [60 deg. C]. While oil is cold it does not do a good job of lubricating. Continuous operation with oil temperatures much below 140 deg. F [60 deg. C] increases likelihood of crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

Water Temperature

A water temperature of 165 to 195 deg. F [73.9 to 90.6 deg. C] is the best assurance that cylinder liners are heated to the proper temperature to support good combustion and that working parts of the engine have expanded evenly to the most favorable oil clearances. See "Engine Warm-up."

When water temperature is too low, the cylinder walls retard heating of air during compression and delay ignition. This causes incomplete combustion, detonation, excessive exhaust smoke and high fuel consumption.

Overheating problems require mechanical correction. It may be caused by loose or worn water pump belts, a clogged cooling system or heat exchanger, or clogged sea water pump inlet. Maximum engine coolant temperature of 200 deg. F [93.3 deg. C] should not be exceeded.

Keep thermostats in the engine summer and winter, avoid long periods of idling, and take necessary steps to keep water temperatures up to a minimum of 165 deg. F [73.9 deg. C]. (Refer to "Cold-Weather Operation.")

Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil pressure or mechanical malfunction in the lubricating oil system. The operator should note loss of oil pressure immediately and shut down the engine before the bearings are ruined. Table 1-2.

Normal Operating Pressures at 225 deg. F [107 deg. C] are shown in Table 1-2.

Table 1-2: Engine Oil Pressures

Engine Model	Idle RPM	PSI [kg/sq cm]	Rated RPM	PSI [kg/sq cm]
V-504	600	10/25 [0.7/1.8]	3300	45/75 [3.2/5.3]
V8-300, VT8-370, V-903	650	10/30 [0.7/2.1]	3000	40/65 [2.8/4.6]
NH, NT	600	5/20 [0.4/1.7]	2100	30/70 [2.1/4.9]
All V-12	550	15 (Min.) [1.2]	2100	40 (Min.) [2.8]

Note: Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition. (High oil pressure during start-up is not cause for alarm.)

Engine Exhaust

The engine exhaust is a good indicator of engine operation and performance. A smoky exhaust may be due to a poor grade of fuel, dirty air cleaner, overfueling, or poor mechanical conditions.

If engine exhaust is smoky, corrective action should be taken.

Maximum Horsepower Requirements

Maximum horsepower is attained only at rated engine rpm. Whenever engine rpm is pulled down by overload, horsepower is lost and continues to be lost as long as the engine continues to lose rpm. When full horsepower is needed, operate engine as near rated rpm as possible.

One rule sums up all rules for proper operation to give the power needed and best performance from the equipment:

Always operate so power requirement will allow the engine to accelerate to, or maintain, governed rpm when advancing to full throttle.

When more power is required, bring engine speed near the governor. This will produce the additional horsepower needed.

Power Take-Off Applications With SVS Governor PT (type G) Fuel Pump

1. The SVS governor lever is used to change governed speed of engine from rated speed to an intermediate power take-off speed.

2. Engine will not idle if SVS lever is in power take-off speed position and standard throttle is in idle position. Operate as follows:

a. For PTO operation, bring engine to idle speed.

b. Set standard throttle 600 to 800 rpm above idle.

c. Hold standard throttle in above position and shift SVS governor lever to low speed or power take-off position.

d. Slowly close standard throttle until speed of power take-off engagement is reached; engage power take-off.

e. Open standard throttle to full open and control unit with SVS governor lever.

3. To return to standard throttle control:

a. Use standard throttle and decrease engine speed until power take-off may be disengaged.

b. Disengage power take-off and shift SVS governor lever to high-speed position.

c. Return standard throttle to idle position and resume operation of unit.

Caution: Never return standard throttle to idle position while SVS governor lever is in low speed or power take-off position or engine will fail to idle properly.

4. SVS governor should not be used with power take-off speeds lower than 1100 rpm; for these applications use MVS governor, described in "Operating Principles."

Engine Shut-Down

Idle Engine A Few Minutes Before Shut-Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, the turbocharger temperature may rise as much as 100 deg. F [46.6 deg. C]. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine For Excessively Long Periods

Long periods of idling are not good for an engine because operating temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings.

If engine coolant temperature becomes too low, raw fuel

will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If the engine is not being used, shut it down.

To Shut Down The Engine Turn Switch Key To "Off" Position

The engine can be shut down completely by turning off the switch key on installations equipped with an electric shut-down valve, or by turning the manual shut-down valve lever. Turning off the switch key which controls the electric shut-down valves always stops the engine unless override button on shut-down valve has been locked in open position. If manual override on electric shut-down valve is being used, turn button full counterclockwise to stop engine. Refer to "Normal Starting Procedure," Page 1-10. Valve cannot be reopened by switch key until after engine comes to complete stop.

Caution: Never leave switch key or override button in valve open or run position when engine is not running. With overhead tanks this would allow fuel to drain into cylinders, causing hydraulic lock.

Do Not Use The Compression Release Lever To Stop The Engine

Some engines are equipped with a compression release lever. Pulling this lever lifts the intake or exhaust (depending on engine model) valve push tubes and opens the valves. The push tubes are lifted off their sockets and extensive wear on the balls and sockets will result from using the compression release to stop the engine.

The compression release lever can be used as an aid in cranking, before starting, or while making injector and valve adjustment, but not to stop the engine.

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine. A delay of ten seconds after a bearing failure causes a knock; may result in a ruined crankshaft or allow a block to be ruined by a broken connecting rod.

Never try to make another trip after the engine indicates that something is wrong. It does not pay!

Cold-Weather Protection

1. For cold-weather operation, use of permanent-type ethylene glycol-base antifreeze with rust inhibitor additives is recommended. See Section 3.

2. To completely drain cylinder block and heads, open petcock or remove drain plugs on engine block, lubricating oil cooler, heat exchanger, water pump inlet connections, sea water pump, marine gear oil cooler and exhaust manifolds. Failure to drain any of these units may cause serious damage in freezing weather.

Ship's Log Or Engineers Report — A-Check

The engine must be maintained in top mechanical condition if the operator is to get the most satisfactory service. Engine adjustments, etc., are the work of a Cummins Distributor. However, the Cummins Distributor needs running reports from the operator in order to make provisions for more extensive maintenance work.

Comparison and intelligent interpretation of the daily or trip report will make it possible to eliminate most failures and emergency repairs.

Always write in the report any of the following conditions:

1. Low lubricating oil pressure.
2. Low fuel pressure.
3. Abnormal water temperature.
4. Unusual engine noise.
5. Excessive smoke.
6. Difficulty in starting.
7. Excessive fuel consumption.
8. Excessive lubricating oil consumption.
9. Overheating of marine gear.

Maintenance Operations

Although it may vary in different applications, marine unit wear is, for the most part, proportional to work or output of the unit.

Marine unit application, working conditions, adverse weather and excessive engine loads must also be considered when determining desirable maintenance schedule.

Maintenance Schedule

Scheduled Maintenance Operations

This section is arranged so a maintenance program can be set up immediately. Instructions are complete for each operation and necessary forms are shown which may be reproduced for your own use.

Effective maintenance objectives can be accomplished by performing "system" maintenance as outlined on the chart on Page 2-2 and detailed in the following pages. Study this section carefully to become familiar with the procedure. Later, the chart will be needed only as a check-off sheet.

Maintenance intervals given on the chart are based on average engine operation. To effectively adapt the chart to a specific application, calculate exact hourly fuel consumption for an engine and integrate these figures into the chart.

Major Inspection

At the "E" Check, the engine must have a major inspection. This is not routine maintenance and therefore is described separately.

Maintenance — Standby Service Engines

For units aboard yachts, in standby service, or when hours of operation fall below those listed, adjust the maintenance schedule accordingly as follows and with due consideration.

A. Weekly.

B. Monthly.

C. Every 3 months.

D. Every 6 months.

E. Yearly.

Lubricating oil standing in engines that are used infrequently or are in storage between seasons may tend to oxidize and require changing even though it is not dirty.

Laboratory testing is the best way to determine whether oil or fuel is oxidizing under these conditions and we suggest that oil be checked regularly. After several tests, it will be possible to schedule oil changes where the oil is not actually being contaminated due to dirt.

On work boats, the oil change periods suggested in the regular maintenance schedules can be followed safely; however, here, too, laboratory analysis may indicate possible lengthening of time between changes for greater economy.

Marine units aboard yachts or in standby service should be started once each month. Start engine and bring unit up to normal operating temperature and run for approximately thirty minutes. Check electrical equipment for corrosion on all relays and switch terminals. Check controls for leaks and proper operation.

The above procedures are only recommendations; therefore, the operator must take into consideration the environment of his particular unit installation.

Extending The Maintenance Schedule

Any change in the established maintenance schedule should be preceded by a complete re-analysis of the operation. A lubricating oil analysis should be the major factor used in establishing the original maintenance schedule; it should be studied before making any change in or extending the schedule periods. In extremely dirty and under severe operating conditions, the scheduled maintenance period may even need reducing. Again, the operation should be re-analyzed and a lubricating oil analysis should be made.

Extending or reducing the schedule period should be done only after a complete study; basically, it should be the same as used in establishing the original maintenance schedule period. Lubricating oil analysis is described on Page 2-7.

Maintenance Schedule

Cummins Marine Engines

SHIP/BOAT _____ ENGINE SERIAL NO. _____
MECHANIC _____ HOURS, GALLONS _____
TIME SPENT _____ CHECK PERFORMED _____
PARTS ORDER NO. _____ DATE _____

Check each operation as performed.

A—Daily

- ☐ Check Operator Report
- ☐ Check Ship's Log
- ☐ Check Engine Oil Level
- ☐ Record Engine Oil Pressure
- ☐ Check Marine Gear Oil Level
- ☐ Record Marine Gear Data
- ☐ Record All Running Temperature
- ☐ Check Leaks and Correct
- ☐ Check Cooling System Level
- ☐ Check Raw Water Pump Oil Level
- ☐ Check Air Intake Connections
- ☐ Check Air Cleaner Oil Level
- ☐ Fill Fuel Tanks
- ☐ Drain Fuel Filter
- ☐ Drain Fuel Tank Sump
- ☐ Check Air Compressor Connections

B—Check

- ☐ Repeat "A" Check
- ☐ Change Engine Oil
- ☐ Change Oil Filter
- ☐ Record Oil Pressure
- ☐ Clean Crankcase Breather
- ☐ Change Corrosion Resistor
- ☐ Check Zinc Plugs
- ☐ Check Raw Water Pump
- ☐ Check All Hose for Corrosion
- ☐ Check and Adjust Belt Tension
- ☐ Clean Air Cleaner Element
- ☐ Clean Air Silencer
- ☐ Change Oil Bath Cleaner Oil
- ☐ Check Air Intake System for Corrosion
- ☐ Check Exhaust System for Leaks and Deterioration
- ☐ Change Marine Gear Oil
- ☐ Change Gear Oil Filter/Strainer

C—Check

- ☐ Repeat "A" and "B" Check
- ☐ Change By-Pass Filter Element
- ☐ Change Oil in Raw Water Pump
- ☐ Check Turbocharger Oil Leaks
- ☐ Change Fuel Filter
- ☐ Clean Heat Exchanger and Cooling System
- ☐ Clean Marine Gear Oil Cooler
- ☐ Check Thermostat
- ☐ Tighten Mounting Bolts; Check Alignment
- ☐ Check Vibration Damper
- ☐ Check Alternator/Cranking Motor
- ☐ Clean Electrical Connections
- ☐ Check Control Panel Operation
- ☐ Check Exhaust Back Pressure

D—Check

- ☐ Repeat "A", "B" and "C" Check
- ☐ Clean Engine
- ☐ Clean Fuel Pump Screen
- ☐ Clean Injectors
- ☐ Check Fuel Manifold Pressure
- ☐ Adjust Injectors and Valves
- ☐ Lubricate Engine Water Pump
- ☐ Tighten Manifold Nuts or Capscrews
- ☐ Tighten Turbocharger Mounting Nuts
- ☐ Clean Turbocharger, Check Clearances
- ☐ Check Engine Blow-By
- ☐ Check Crankshaft End Clearance
- ☐ Check Accessory Drive Pulley
- ☐ Check Safety Controls

E—Check

- ☐ Repeat "A", "B", "C" and "D" Checks
- ☐ This Maintenance Check is often referred to as "In-Chassis Inspection" where some key parts, such as bearings, are checked for wear to determine if the engine may be operated for another service period. Likewise, oil consumption oil pressure and other signs of wear should be analyzed during the check. Wear limits and other information is available from Cummins Distributors and Dealers.

Table 2-1: Suggested Base Maintenance Intervals

Engine Series	Interval Basis	B	C	D	E
V-504	U. S. Gal. [Liter] Hours	960 [3730] 120	1900 [7290] 240	4000 [15,140] 1,200	20,000 [75,700] 6,000
V8-300	U. S. Gal. [Liter] Hours	2000 [7570] 200	4000 [15,140] 400	8000 [30,280] 1,200	64,000 [242,200] 6,400
VT8-370	U. S. Gal. [Liter] Hours	2500 [9460] 200	5000 [18,920] 400	10,000 [37,850] 1,200	80,000 [302,800] 6,400
V-903	U. S. Gal. [Liter] Hours	2200 [8330] 200	4400 [16,660] 400	8800 [33,300] 1,600	70,400 [266,500] 8,000
NH-250	U. S. Gal. [Liter] Hours	2000 [7570] 200	4000 [15,140] 400	8000 [30,280] 1,600	64,000 [242,200] 8,000
NT-335	U. S. Gal. [Liter] Hours	2200 [8330] 200	4400 [16,660] 400	8800 [33,300] 1,600	70,400 [266,500] 8,000
NT-380	U. S. Gal. [Liter] Hours	2400 [9080] 200	4800 [18,170] 400	9600 [36,340] 1,600	76,800 [290,700] 8,000
V12-500	U. S. Gal. [Liter] Hours	3750 [14,190] 250	7500 [28,390] 500	15,000 [56,770] 2,000	90,000 [350,600] 8,000
VT12-635, 700, 800	U. S. Gal. [Liter] Hours	5000 [18,925] 250	10,000 [37,850] 500	20,000 [75,700] 2,000	120,000 [454,200] 8,000
All	Calendar	3 months	6 months	1 year	5 years

Notes:

1. Perform checks on interval basis that occurs first. Normally, calendar period is used only when fuel used is less than 1/3 that suggested during the three (3) month period.

2. At first oil change or initial inspection, adjust injectors and valves; thereafter, at "D" Check.

Using The Suggested Schedule Check Sheet

The maintenance schedule check sheet is designed as a guide until you have adequate experience to establish a schedule to meet your specific operation.

A detailed list of component checks is provided through several check periods; also, a suggested schedule basis is given for gallons of fuel used, hours of operation and time interval. See Table 2-1.

Your maintenance schedule should be established using the check sheet as a guide; the result will be an excellent maintenance program to fit your specific operation.

The check sheet shown can be reproduced by any printer so you can have forms made up for your use. The person making each check can then indicate directly on the sheet that he has completed the operation. When a complete column (under A, B, C, etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Maintenance Operations Summary Sheet

The maintenance operations summary sheet (at the end of this section) is designed to be used to summarize scheduled maintenance checks for a specific engine, by unit or engine serial number. The summary sheet records operation or check performed, fuel used, mechanic, labor costs, parts used, etc. A complete record of this type is essential to perform a thoroughly efficient cost record of the operation.

The above Maintenance Schedule has been established on

average fuel consumption per hour for series so specified. If the fuel consumption ratio to hours of operation for the engine being operated does not adhere to the above schedule, adjust Maintenance Schedule fuel-hour ratio accordingly.

Storage For Engines Out Of Service

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Contact the nearest Cummins Distributor for information concerning engine storage procedures.

A–Maintenance Check

Perform the following checks at intervals suggested on Pages 2-1 and/or 2-3.

The following are described in "Operating Instructions" and should be performed daily.

1. Check ship's log.
2. Check for fuel, oil and coolant leaks.
3. Check engine oil level.
4. Check marine gear oil level.
5. Check engine coolant level.
6. Record engine oil pressure.
7. Record marine gear oil pressure.
8. Record all running temperatures.
9. Check air cleaner oil level.
10. Check air intake connections.

Guard Against Corrosion

This "eating away of metal" or corrosion, as it is commonly called, is likely to occur in any heating or cooling system. Corrosion may or may not be associated with iron rust and, as a result, may not show up in the coolant.

Research has shown there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained corrosion resistor as described under "C" Maintenance Check.

Aeration refers to air bubbles which may be drawn into heat exchanger core tubes, then into water pump and engine. The worst effect of aeration is loss of water pump prime due to an accumulation of air resulting in complete flow stoppage. Entrained air promotes accelerated internal corrosion. Entrained air in coolant will increase the temperature differential between combustion gases and water due to reduction in heat transfer.

An open expansion tank is often the cause of air entering the system. Due to the high velocity of coolant entering the heat exchanger, the surface becomes very agitated and tends to draw air into core tubes along with coolant. It is very difficult on many units to completely fill the cooling system at initial fill; this is due to trapping of air in pockets in the engine or other parts of the system. The system should be bled of air or refilled after a short period of operation to purge air from the coolant.

Fill Fuel Tanks

Modern refining methods now make it possible to process more and more by-products from fuel oil distillate, leaving less and less straight-run neutral distillates available on the market. Therefore, today, we find more cracked stock being mixed with straight-run distillate.

Some cracked stock can be burned efficiently in a diesel engine if used shortly after it is refined. However, if it is held in storage for an extended time, it tends to oxidize and form gum, and sludges when it is burned. This is caused in part by excessive sulphur content.

Two other handicaps of "mixed" diesel fuel are that it ignites with explosive force, yet has considerable "after burning" with a tendency to smoke and foul piston rings.

Distilled fuels range in color from water clear to a medium-yellow tone. If the color is more of a dark-brown hue, then chances are it is a low-grade cracked fuel; find out what the boiling range is to be sure it meets manufacturer's specifications.

Every precaution is taken to keep fuel clean from the time it is refined until it is sold to the customer. It is necessary to continue to protect fuel from dirt and water after it is purchased.

Fuel should always be strained or filtered before being put into the supply tank of an engine. This will lengthen life of the engine fuel filter and reduce chances of dirt getting into the fuel pump.

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged will be more of a handicap than help to an engine. It will allow damaging sediment and dirt to circulate through the fuel system and will restrict flow of fuel, thus reducing horsepower output.

Excessive amounts of water in fuel will cause rusting and corrosion of injectors as well as fuel pump shafts, bearings and other parts. In some sections of the country it is difficult to purchase fuel which does not contain some water. Normal condensation, either in storage tank or in the fuel tank, increases water content. This water must be filtered out or drained off before it gets into the fuel pump.

The life of a fuel pump and injectors can be considerably extended if the operator takes the precaution of draining about a cup of fuel from the lowest point in the fuel system before starting the engine at each run.

Drain plugs are located in bottom of some fuel filter cases and in sump of fuel supply tank. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm returning fuel from injectors heats fuel in the supply tank. If fuel level is low in cold weather, the fact that the upper portion of the tank is not being heated by returning fuel tends to increase condensation. In warm weather both supply tank and fuel are warm. In the night, however, cool air lowers temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

In cold weather, water that accumulates in the fuel system will sometimes freeze and block supply of fuel. This condition can be prevented by adding one quart of denatured alcohol to each 50 gal. [189.2501 lit] of fuel oil. This not only keeps water from freezing but allows it to go into solution with alcohol and fuel oil so it can pass through the fuel system and be "burned" without doing any damage.

Drain Sediment From Fuel Filter And Tanks (Weekly)

1. Loosen drain cock, if used, at bottom of fuel filter case and drain out any accumulated water and sediment. Tighten drain cock and refill filter case with clean fuel.

2. Unscrew throw-away units, dump water and sediment. Fill element with clean fuel and replace.

3. Loosen fuel tank drain cock or plug and drain approximately 1 cup of fuel. Close drain cock or plug.

Fuel/Water Filter Separator

If more moisture than usual is present when checking fuel tanks, it may be advisable to install a water separator.

Contact your nearest Cummins Dealer for the separator that meets your requirements.

Check Air Compressor Connections (Weekly)

Check all air and vapor lines and connections from compressor, for leaks, breaks, stripped threads, etc., correct as needed.

In cold weather, condensed moisture in air tanks and lines may freeze and make controls useless.

Drain air tanks to keep all water out of the compressed air system.

B—Maintenance Check

At each "B" Maintenance Check, perform all "A" Checks in addition to the following.

Perform the following checks at intervals suggested on Pages 2-1 and/or 2-3.

Change Engine Oil

Kind of oil used, efficiency of filtering system and condition of engine must be considered in determining when to change oil.

Recent tests, using Cummins full-flow paper element filter in combination with a Cummins by-pass filter, oil recommended in Section 3, and using oil analysis with filter restriction measurement, indicate that a naturally aspirated engine may have the oil change period extended as much as 50% under closely controlled conditions. This indicates the economy that can be obtained through a good maintenance program.

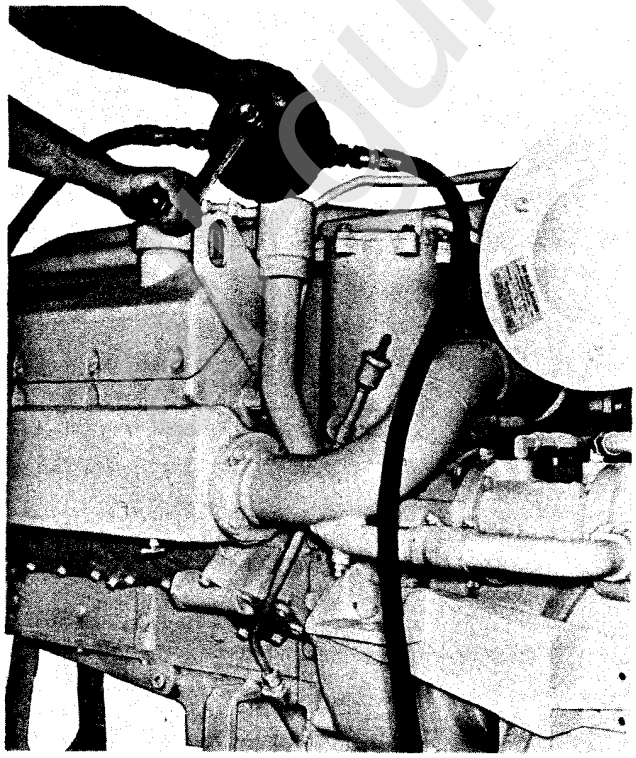


Fig. 2-1, (V21987). Pumping oil from oil pan

It is suggested that oil change periods be set up on schedule indicated in Maintenance Schedule, and then extended, or in unusual cases reduced, based upon the type of oil used and other items as described in the above paragraph.

Factors to be checked and limits for oil analysis are listed below. Oil change at "B" Check, as shown in maintenance chart on Page 2-2, is for average conditions.

If oil pan drain plug is too close to keel to drain the oil, it is most advantageous to attach a hose or tube to aid in pumping oil from pan. Use a motorized or hand pump to remove oil from pan. Fig. 2-1.

1. Bring engine to operating temperature, shut down engine, attach draining pump or remove drain plug from bottom of oil pan, and drain oil in suitable container.

2. Install drain plug in oil pan of NH, NT, V-12 and V-903 engines, and torque to 60 to 70 ft-lbs [8.0 to 9.7 kg m]. Install drain plug in oil pan of V-504 engine and torque to 35 to 40 ft-lbs [4.8 to 5.5 kg m].

3. Fill crankcase to "H" (high level) mark on dipstick.

4. Start engine and visually check for oil leaks.

5. Shut down engine; allow 15 minutes for oil to drain back into pan; recheck oil level with dipstick. Add oil, as required, to bring oil level to "H" mark on dipstick.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. After several test periods, a time interval (gallons of fuel consumed, hours, weeks, etc.) for oil change can be established; however, a new series of tests should be run if filters, oil brands or grades are changed.

In the beginning, tests should be made at each 100 gal. [378.5 lit or 83.3 U.K. gal.] of fuel consumed (after the first 400 gal. [1514.0 lit or 333.0 U.K. gal.]), or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary. Repeat analysis cycle until a definite pattern is established.

Wide variations in different brands of lubricating oil make it profitable to contact the oil supplier to assist in the development of the oil change period because he knows best the factors peculiar to his brand(s) of oil.

Analysis Test For Lubricating Oil

Following is a suggested list of lubricating oil properties which should be checked during laboratory analysis. The suggested methods are fully described in the American Society for Testing Materials Handbook.

Oil Property	Test Number
Viscosity at 100 deg. F. and 200 deg. F. [38 deg. and 93 deg. C]	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

General Limits For Oil Change

1. Minimum Viscosity (dilution limit): Minus one SAE grade from oil being tested or point equal to a minimum containing five percent by volume of fuel oil.

2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210 deg. F [99 deg. C] or 25 percent increase at 100 deg. F [38 deg. C].

3. Sediment Content: Normal pentane insoluble 1.0 to 1.5 percent. Benzine insoluble 0.75 to 1.0 percent.

4. Acid Number: Check with your oil supplier as this value differs with each oil brand and grade.

5. Water Content: 0.2 percent maximum.

6. Additive Reduction: 25 percent maximum.

Caution: If the above tests indicate presence of any bearing metal particles, or if found in filter, the source should be determined before a failure results.

The efficiency of any maintenance program can only be judged on the basis of the failures prevented or intercepted before the engine or unit is damaged.

Change Oil Filter Element (Case Type)

1. Remove capscrews, lockwashers and flatwashers securing cover to filter case; lift off cover and discard gasket.

2. Lift filter element from case.

3. Remove lubricating oil from filter case with a suction pump (or remove drain plug if used) and wipe out with clean rags.

4. Assemble a new filter element. Fill case with engine oil.

5. Install cover and secure with flatwashers, lockwashers and capscrews.

Change Oil Filter Element (Center Bolt)

1. Remove drain plug from filter can and allow oil to drain. Replace drain plug.

2. Loosen center bolt and remove filter can. Fig. 2-2.

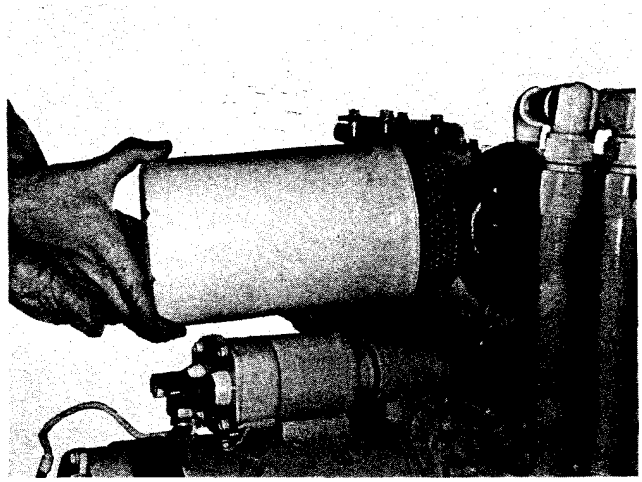


Fig. 2-2, (V11943). Full-flow oil filter element

3. Withdraw filter element; inspect for the following then discard.

a. Inspect for metal particles.

Caution: If the inspection indicates presence of any bearing metal particles, the source should be determined before a failure results.

b. Inspect outside wrapper of element for wrinkles and pleats for waviness or bunching. Presence of these conditions indicates that oil contains moisture.

c. If element is relatively clean, it may be possible to lengthen change periods.

d. If element is clogged, the change period should be shortened. Oil pressure drop reading across filter is the best way to determine change periods. Pressure drop from inlet (1, Fig. 2-3) to outlet side (2) of filter should not exceed 10 psi [0.70 kg/sq cm] with 140 deg. F [60 deg. C] oil and engine at high-idle speed.

4. Remove seal ring from filter head and discard.

Caution: Two or more seal rings attached to filter head will cause leakage, permitting unfiltered oil to enter by-pass element.

5. Clean filter can thoroughly. Handle can and/or store in manner to prevent out-of-round.

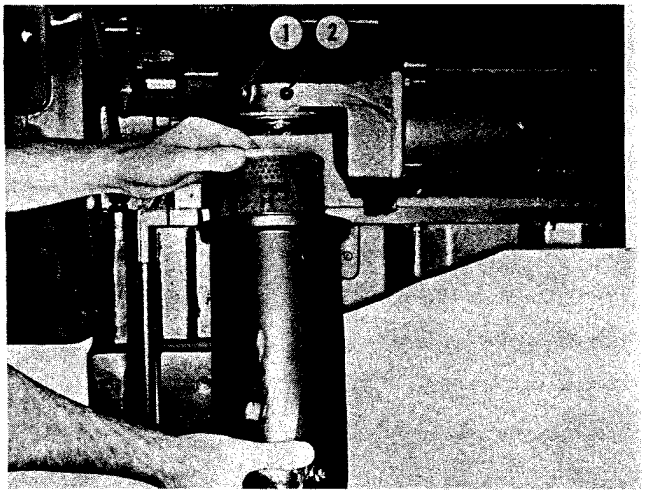


Fig. 2-3, (V51908). Location of oil filter check points

Note: It is recommended that every second oil change to change the small seal rings (4 and 17, Fig. 2-4) at bottom of oil filter can to prevent oil leakage due to hardening of rubber seals. Inspect seals each oil change for deterioration.

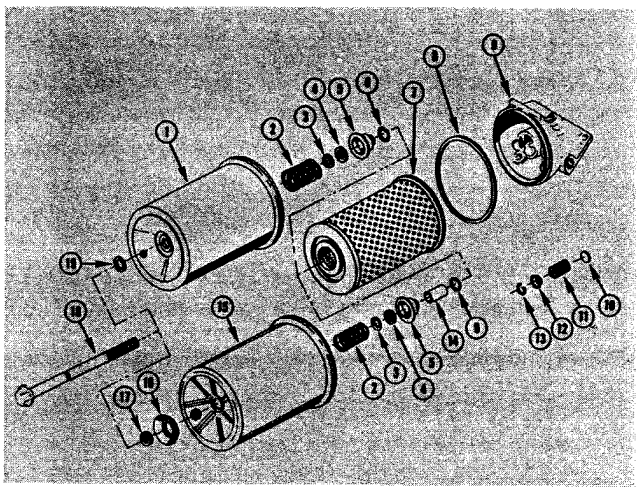


Fig. 2-4, (V10702). Full flow oil filter assembly

6. Insert new element in filter can and fill with oil, if possible.

7. With new seal ring in position on filter head, position filter can to filter head and tighten center bolt to 25 to 35 ft-lbs [3.4575 to 4.8405 kg m].

8. Check engine oil level. Run engine and check for leaks.

9. Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

Record Engine Lubricating Oil Pressure

Start engine and operate at 800 to 1000 rpm until oil temperature gauge reads 140 deg. F [60 deg. C]. Reduce engine speed to idle and record oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Check Raw (Sea) Water Pump

Maintenance and service periods for raw water pump must be adjusted to agree with the type of application to which it is subjected. Fig. 2-5.

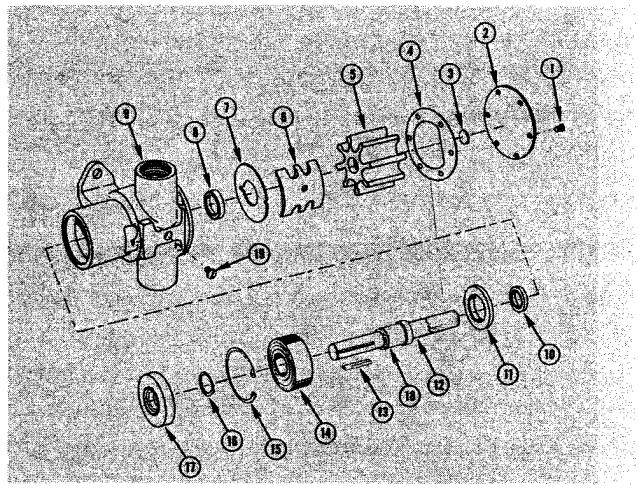


Fig. 2-5, (V10815). Raw water pump — exploded view

If coolant being pumped through the raw water pump is relatively free of sediment, corrosive chemicals, foreign material and abrasives such as sand or mud; normal maintenance periods are sufficient.

Accelerated maintenance periods are necessary to compensate for undesirable operating conditions.

1. Check all pipes and fittings for leaks. Tighten as necessary.

2. Remove cover plate to drain pump.

3. Lift out rubber impeller and check for cracks, breaks or damage. Install impeller if necessary.

Note: If impeller is subjected to extreme temperatures, either hot or cold, impeller life is shortened and inspection periods must be adjusted accordingly.

4. Clean out all sediment.

5. Install new cover plate gasket and install cover on pump.

Note: A 0.015 inch [0.38 mm] gasket should be used to maintain proper impeller-to-cover clearance.

6. The raw water pump is self-priming.

7. No lubrication is necessary when sealed bearings are used.

Check Zinc Plugs

Check zinc plug in marine gear cooler, Fig. 2-6, or heat exchanger head and change if badly eroded. (Frequency of change depends upon chemical reaction of raw water circulated through marine gear cooler.) If zinc anode has deteriorated to less than 1/2 original size, replace with new one.

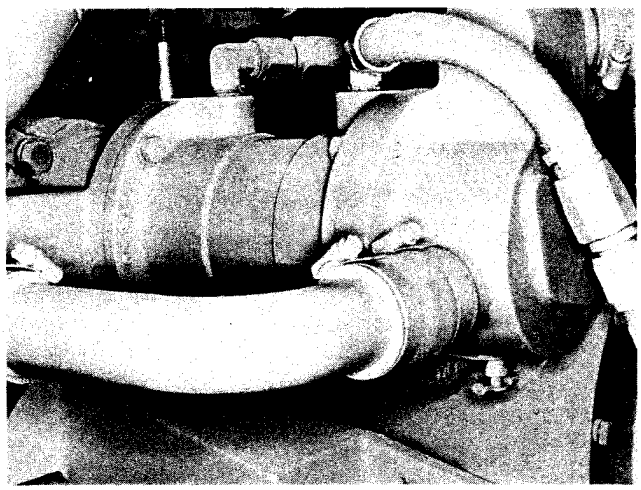


Fig. 2-6, (V21976). Checking zinc plug

Clean Crankcase Breather

Screen Element

1. Remove vent tube if not previously removed.

2. Remove capscrews, washers, cover screens and baffle from the breather body.

3. Clean vent tube, screens and baffle in an approved cleaning solvent. Dry with compressed air. Wipe out breather housing.

4. Assemble baffle, screens and new gasket in body.

5. Replace cover with cover boss resting securely on point of screen; secure with washers and capscrews.

6. Replace vent tube.

Paper Element

Dry-type breathers containing a chemically-treated paper element are used on some naturally-aspirated engines.

Note: Do not attempt to clean paper elements.

1. Remove wing nut, washer and seal securing cover to body; lift off cover.

2. Remove and discard element and gasket.

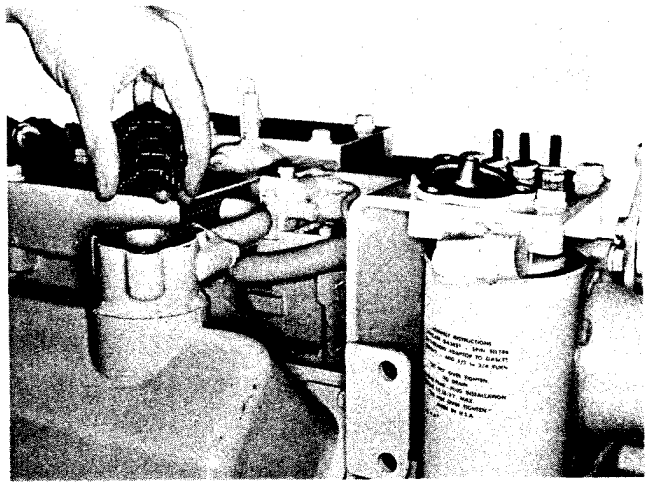


Fig. 2-7, (V11944). Changing crankcase breather

3. Wipe out cover and body with a clean cloth.

Caution: Do not attempt to clean paper elements. Service life of such elements are very short, use a new element.

4. Position new element in body.

5. Position new gasket in cover and position cover on body secure with seal, washer and wing nut.

Check And Adjust Belt Tension

The service life of belts can be greatly extended by proper installation, adjustment and maintenance practices. Neglect or improper procedures often lead to problems of cooling or bearing failures, as well as short belt life. Following are the most important rules to be observed to extend belt life:

Belt tension adjustments are often neglected because of difficult accessibility. One general rule is applicable to all such operations: **All driven assemblies must be secured in operating position before reading or judging belt tension.**

Installation

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.

2. Always replace pairs of belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth should not vary over 1/16 inch [1.59 mm] on matched belt sets.

3. Pulley misalignment must not exceed 1/16 inch [1.59 mm] for each ft. [30.48 cm] of distance between pulley centers.

4. Belts should not bottom on the pulley grooves; nor should they protrude over 3/32 inch [2.38 mm] above top edge of groove.

5. Do not allow belts to rub any adjacent parts.

Belt Tension

1. Tighten belts up to 1/2 inch [12.7 mm] wide, until a reading of 90 to 110 lbs. is indicated on ST-968 Belt Tension Gauge, (Fig. 2-8). For belts over 1/2 inch [12.7 mm] wide, use ST-1138 Belt Gauge.

2. If belt tension gauge is not available, tighten belts so pressure of index finger will depress belt amount of deflection in Table 2-2. The index finger should be extended straight down from hand; in this manner, force will be approximately 13 lbs. [5.90 kg] deflection (1, Fig. 2-9) per foot [0.30 m] of span (2).

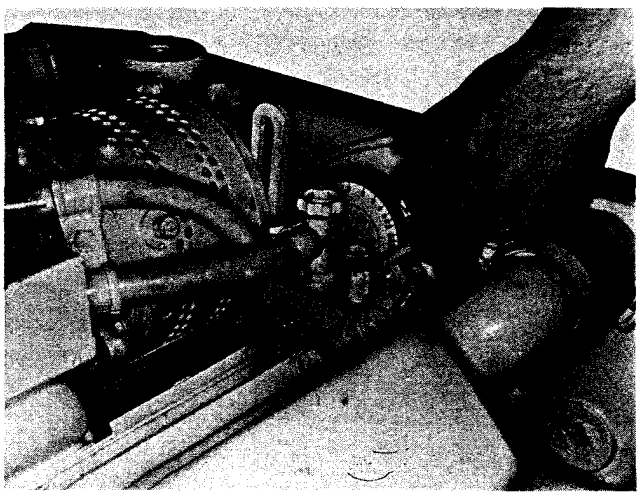


Fig. 2-8, (V11954). Checking belt tension with ST-968

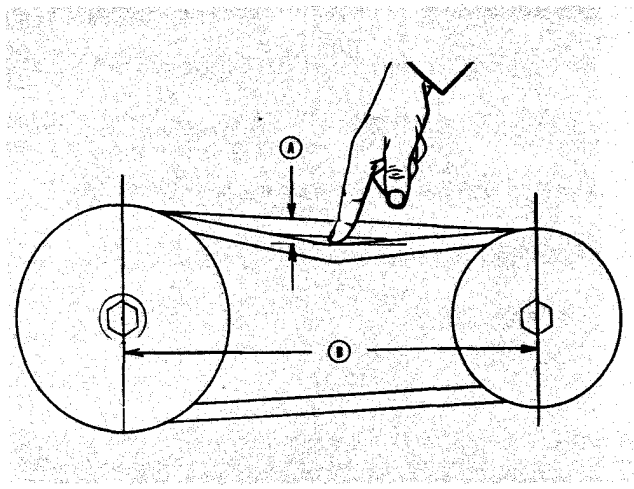


Fig. 2-9, (N11471). Manually checking belt tension

Table 2-2: Belt Tension — Inch [mm]

Belt Width		Deflection Per Ft. [0.305 m] of Span	
1/2	[12.70]	13/32	[10.32]
11/16	[17.46]	13/32	[10.32]
3/4	[19.05]	7/16	[11.11]
7/8	[22.22]	1/2	[12.70]
1	[25.40]	9/16	[14.29]

Note: Adjust V-504 raw water pump drive belt tension to 40 to 45 lbs. as indicated on ST-968 Belt Tension Gauge.

3. Deflection (1, Fig. 2-9) should equal amount indicated in Table 2-2 for each foot of belt span (2).

Readjusting New Belts

All new belts will loosen after running for an hour or more and must be readjusted. Readjust as described under "Belt Tension."

Belt Care And Maintenance

Do not tighten belt beyond figures given to eliminate belt squeak. Squeak does not necessarily mean belt slippage. Tightening to excess may damage bearings as well as belts.

Change Marine Gear Oil

Capitol Gear

Note: Change oil and flush sump after 100 hours operation, thereafter at each "B" check.

Table 2-3: Marine Gear Oil Information

Manufacture Model	Operating Pressure psi [kg/sq cm]	Minimum Pressure psi [kg/sq cm]	Capacity U.S. Quarts [Lit]	Type of Viscosity	Operating Temperature deg. F [deg. C]	Maximum Temperature deg. F [deg. C]
Borg Warner 72C and 73C	140/170 [9.84/11.95]	145 [10.19]	1.6 [1.5]	Automatic Transmission Type A	140/190 [60/88]	225 [107]
All Capitol	220/230 [15.4/16]	210 [14]	See Below	APG 80 Gear Oil or SAE 30 Engine Oil	160/180 [71/82]	200 [93]
Paragon P 400	100/130 [7.03/9.14]	60 [4.22]	2.5 [2.4]	Automatic Transmission Type A	140/170 [60/77]	190 [88]
Twin Disc MG-506	300/320 [21.09/22.50]	270 [19]	4.5 [4.3]	SAE 30 Engine Oil	140/180 [60/82]	225 [107]
Twin Disc MG-509 MG-514	200/220 [14/15.4]	193 [13.5]	See Below	SAE 30 Engine Oil	140/180 [60/82]	225 [107]
Twin Disc MG-521, MG-527	185/220 [13/15.4]	180 [12.6]	See Below	SAE 30 Engine Oil	140/180 [60/82]	225 [107]

Notes:

The oil capacity of the gears not in the table is as follows:

Capitol 10200, 10250 8 [7.57]; 10700, 10750 9 [8.5]; 6900, 6950 (10100) 16 [15]; 7700, 7750 (10300) 24 [22.7]; 10800, 10850 32 [30.3]; 9400, 9450 (9428) 30 [28.4]; 10500, 10550 40 [37.8].

Twin Disc MG-509 10/15 [9.5/14.2]; MG-514 25/35 [23.7/33.2]; MG-521 48 [45.6]; MG-527 58 [55].

Fill oil sump to full or to mark on dipstick. See gear manufacturer's booklet for procedure. (Some gears check oil level with engine idling and gear in neutral.)

Use SAE 20 Oil in Twin Disc gears with raw water cooled marine gear heat exchanger.

1. Remove drain plug from bottom of gear housing and drain oil in a suitable container or pump oil from housing.

2. Reinstall drain plug and fill gear to "H" oil level on dipstick. Fig. 2-10.

Note: Some gears require the inspection plate to be removed to fill gear; others have an oil filler spout.

3. Fill marine gear to full mark on dipstick with oil specified in Table 2-3. Operate engine and gear at idle speed for a short time to fill all circuits and accessories. Oil level should be checked immediately after engine is shut down. Add oil (if necessary) to bring oil level to full mark on dipstick.

Twin Disc Gear

Change oil every 1000 hours or each season.

When a complete oil change is required, it is necessary to drain oil from gear oil cooler and hose as well as marine gear sump. In addition, if an oil filter assembly is installed, the filter and connecting hose must be drained and filter element replaced. Alternate methods of draining marine gear sump are as follows:

1. Gravity Drain — Remove suction line from bottom of gear housing. Drain all oil into a suitable container. Install suction line. Fig. 2-11.

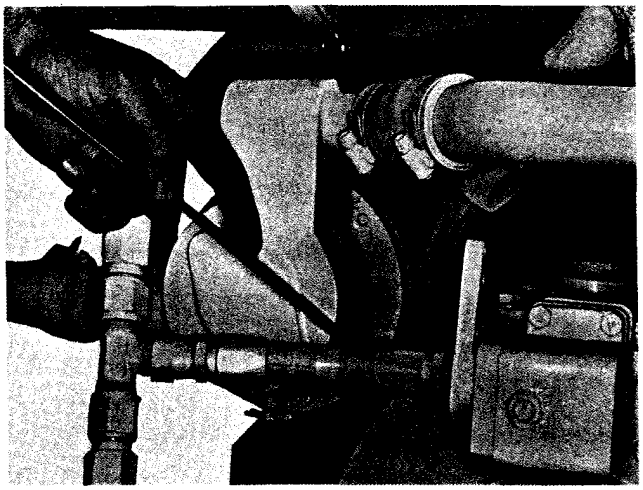


Fig. 2-10, (V21972). Checking Capitol marine gear oil level

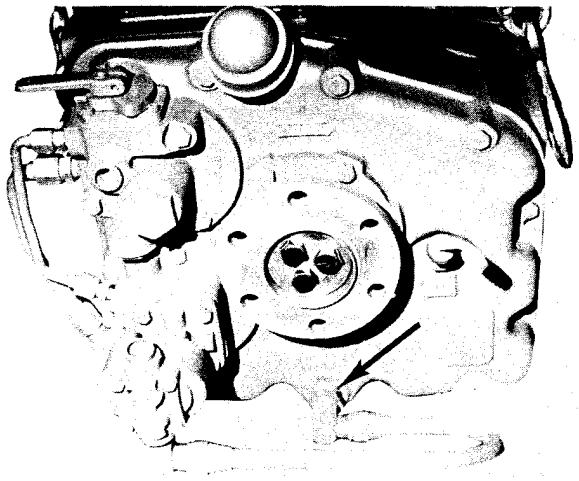


Fig. 2-11, (V11959). Twin Disc marine gear drain point

2. Suction Drain — A suction pump can be used to drain marine gear sump. The oil level gauge tube is serrated to accommodate a suction hose. Remove oil gauge and install suction hose in oil gauge tube. Operate suction pump until all oil has been removed from sump. Remove pump and hose and install oil gauge in oil gauge tube.

3. Filling — Make certain drain plug is tight. Remove breather cap nipple assembly. Fill marine gear to full mark on dipstick with oil specified in Table 2-3. Pour oil slowly into breather cap nipple as nipple is baffled. Fill to full mark on dipstick. Start engine and, at idle speed, allow oil to obtain proper temperature. Shift marine gear to forward and reverse positions. Recheck oil level with engine at idle speed and marine gear in neutral position; oil level must be at the full mark on dipstick. Add oil as necessary to bring oil level to full mark. Install breather cap assembly.

4. Clean filter screen at same time oil is changed.

a. To remove filter screen, disconnect adapter union fitting in suction hose line between oil pump assembly and sump. Remove filter screen from rear cover.

b. Clean screen in clean diesel fuel or an approved solvent. Remove all foreign material from filter screen.

c. Use liquid lead sealer or Teflon sealing tape on threads of filter screen; install filter screen in rear cover. Use same sealing compound as stated above on all fittings and connect adapter union fitting to pipe elbow in suction line.

5. Remove breather cap from cap nipple. Flush breather cap in clean diesel fuel or approved solvent. Dry with compressed air. Install cap on nipple.

Borg Warner Gear

Change oil each season.

1. Turn oil filler cap, which is located below shift lever on rear left side of transmission, counterclockwise and remove.

2. If space permits, place a container of approximately 2 quarts capacity under drain cap. Unscrew drain cap, Fig. 2-12, reach into opening with suitable tool and remove strainer assembly. Allow all oil to drain into container.

3. Clean oil strainer assembly in an approved solvent.

4. Install oil strainer large end first, small end out; position gasket on drain cap and install drain cap into gear housing. Torque cap to 28 to 30 ft-lbs [3.81 to 4.15 kg m].

5. Reinstall cooler line fitting and line; tighten securely.

6. Remove breather assembly from reverse gear and wash in an approved cleaning solvent; dry thoroughly and reinstall.

7. Fill marine gear to full mark on dipstick with oil

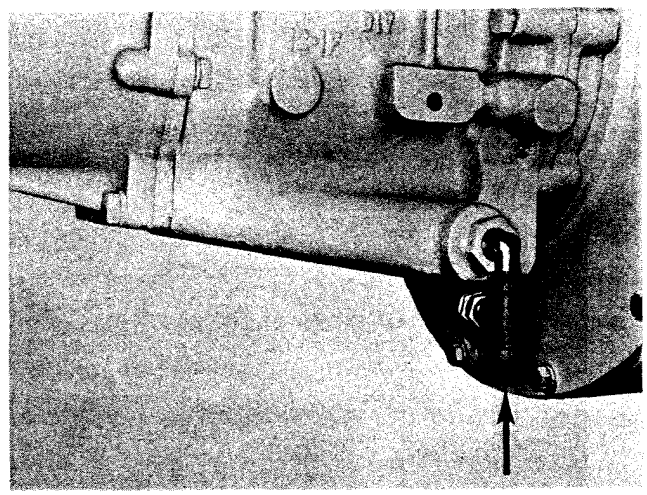


Fig. 2-12, (V11957). Borg Warner marine gear drain point

specified in Table 2-3. Operate engine and gear at idle speed for a short time to fill all circuits and accessories. Oil level should be checked immediately after engine is shut down. Add oil (if necessary) to bring oil level to full mark on dipstick.

Paragon Gear

Change oil every 100 hours or each season.

1. Remove drain plugs located at bottom of reverse gear and reduction gear. Fig. 2-13. Drain oil into suitable container.

2. If impossible to drain oil from sumps, insert suction pump tube through oil filler spout and pump oil out of sump.

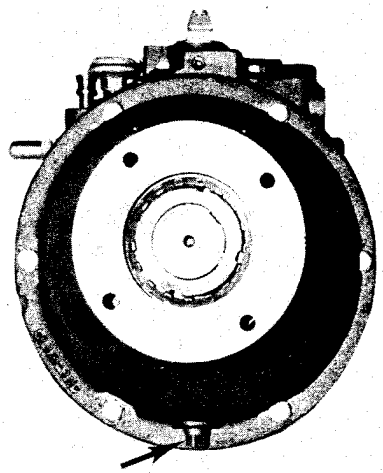


Fig. 2-13, (V11958). Paragon marine gear drain point

3. Remove breather assembly from reverse gear and wash in an approved cleaning solvent; dry thoroughly and reinstall.

4. Fill marine gear to full mark on dipstick with oil specified in Table 2-3. Operate engine and gear at idle speed for a short time to fill all circuits and accessories. Oil level should be checked immediately after engine is shut down. Add oil (if necessary) to bring oil level to full mark on dipstick.

Clean Marine Gear Oil Strainer (When Used)

1. Disconnect oil hose and remove capscrews securing cover to housing; slide out strainer assembly and discard gasket.

2. Wash strainer in an approved solvent and dry thoroughly.

3. Assemble strainer to cover and position assembly in housing with new gasket; secure with capscrews and connect all hose.

Change Marine Gear Oil Filter (When Used)

1. Use a suitable container, remove drain plug from bottom of filter housing.

2. Disconnect the flexible hose from filter cover.

3. Remove capscrews securing filter cover to filter body; lift cover and filter assembly from filter body.

4. Unscrew filter tube spring and seat assembly from cover plate; discard filter element and gasket.

5. Clean inside of filter body, cap, seat, tube and spring with a lint free cloth.

6. Position a new element to filter head; secure with filter seat, spring and tube.

7. Install a new gasket on filter head and insert filter cover assembly in filter body; secure cover to body with capscrews, tighten to 85 ft-lbs [11.75 kg m] torque.

8. Connect flexible hose to filter cover and replace drain plug.

Check Engine Coolant

Periodic tests of engine coolant should be made to insure the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for specific condition of operation. In cases where "make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary.

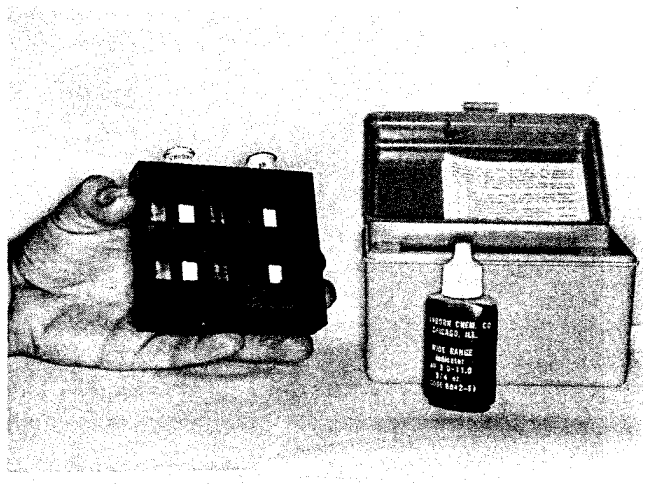


Fig. 2-14, (N11946). ST-993 Coolant Checking Kit

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating with chromate compounds, the concentration of effective inhibitor dissolved in coolant can be measured by color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check. Fig. 2-14.

Most commercially available antifreezes contain a coloring dye that renders the color comparison method ineffective. When colored antifreezes are present in the coolant, effective control of corrosion can be determined by inspecting coolant for accumulation of reddish-brown or black, finely granulated dirt. A small amount of corrosion produces significant quantities of these corrosion products; therefore, if corrosion resistor servicing is adjusted at the first indication of increased accumulation of these products, actual corrosion will be limited to a negligible amount.

Examine sump of corrosion resistor for these "dirt" materials at time of servicing or check them in a small sample of coolant drained from cylinder block after allowing coolant to settle.

Certain antifreeze compounds are chemically incompatible with the chromate corrosion resistor element. This is evidenced by the formation of a green scum in the coolant filler opening. See nearest Distributor for a list of antifreeze known to be compatible with chromate elements.

pH Value Test

1. Separate tubes marked "pH" are furnished in ST-993 Test Kit. Select a tube and fill to mark with coolant to be checked.

2. Add eight drops of pH Reagent to tube and mix thoroughly.

3. Insert tube in comparator hole marked "pH."

4. Compare color of test sample with color standards on either side. Preferred range is 8.0 to 9.5.

5. Wash out test tubes after each test and keep reagent container caps in place.

Chromate Concentration Test

1. Draw sample of coolant and pour into tube marked "chromate."

2. Dilute coolant 50% with clear water.

3. Insert sample into comparator hole marked "chromate."

4. Compare color of test sample with color standards on either side. Preferred range as indicated by the color standards is 100 to 150 grains per gal. [3.785 lit or 0.833 U.K. gal.] or 1700 to 2500 parts per million (ppm). The dilution (Step 2) is done to match the standards, but actual results are 3400 to 5000 ppm range of engine coolant.

5. Wash out test tubes after each test.

Adjusting Coolant To Specifications

If above tests indicate coolant is outside specifications, make an adjustment immediately to prevent corrosion.

If Cummins Corrosion Resistor is used, change element, and run engine four to six hours; then, check coolant again; in extreme cases it may be necessary to change element a second time. However, the latter condition may be due to larger coolant system than corrosion resistor was designed to treat; note reference on resistor label.

If chromate compounds are used, follow manufacturers instructions to bring concentration to 3500 PPM. Amount of compound required depends upon cooling system capacity.

Make-Up Coolant Specifications

Where possible, it is recommended that a supply of make-up coolant be prepared to the following specifications, using soft water where possible and a compatible antifreeze. Chromate treatment of coolant assures constant level of concentration where coolant is added and requires no change in schedule of element replacement.

Chromate Concentration – NA_2CRO_4 – 3500 ppm

pH Value – 8 to 9.5

Alkalinity – 1500 ppm $CaCo_3$
(Methyl Orange Indicator)

Chromate compounds for use in preparation of treated make-up coolants are available from the sources listed below or other chemical distribution points. Make sure the preparation used will provide protection to the values indicated above.

1. Formula 2389 from Bird-Archer Co.,
4337 North American Street
Philadelphia, Pennsylvania, 19104

2. Dearborn Compound No. 530 from:
Dearborn Chemical Company
14230 Ridge Road
Plymouth, Michigan, 48170

3. NALCO No. 38 (pellet) or 37 (powder) from:
NALCO Chemical Company
180 N. Michigan Avenue
Chicago, Illinois, 60601

Note: Corrosion resistor element must continue to be used with pre-treated water.

Keel Cooling And/Or Heat Exchanger Systems

Start-Up Treatment Of Coolant

1. Determine capacity of complete cooling system: all connections, piping, cooling units and the engine itself.

2. Add 1/2 oz. [14.7869 cc] of NALCO 38 or Dearborn Formula 530 or equivalent chromate treatment for each U.S. gal. [3.785 lit or 0.8327 U.K. gal] of water.

3. Start unit and check pH value of coolant after solution is thoroughly mixed.

4. The corrosion resistor will maintain the proper concentration for normal engine cooling capacity; however, where the total capacity exceeds 16 to 20 U.S. gal. [60.56 lit or 13.32 U.K. gal. to 75.7 lit or 16.65 U.K. gal.] it is recommended that treated "make-up" coolant be added to the system.

Note: pH value must be in a range of 8.0 to 9.5 and chromate value of 100 to 150 grains per gallon.

Check Hose

Inspect lubricating oil and cooling system hose and hose connections for corrosion, leaks and/or deterioration. Particles of deteriorated hose can be carried through cooling system or lubricating system and restrict or clog small passages, especially heat exchanger core, and lubricating oil cooler, and slow down or partially stop circulation. Replace as necessary.

Check Air Intake System For Corrosion

1. Check air intake manifold for corrosion.

2. Check all hose clamps to be certain they are not corroded or rusted tight.

3. Check air silencers or air cleaner for corrosion.

4. Check air intake piping from air cleaner to intake manifold. Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsing hose or other damage.

5. Tighten clamps or replace parts as necessary to insure an air-tight air intake system. Make sure all air goes through the air cleaner.

Clean Air Cleaner Elements

The paper element in a dry-type air cleaner may be cleaned several times by using an air jet to blow off dirt or by washing with nonsudsing household detergent and warm water, preferably 120 to 140 deg. C [48.9 to 60.0 deg. C], then drying with compressed air, approximately 40 psi [2.8124 kg/sq cm]. Do not hold air jet too close to paper element or damage to element may result.

Elements that have been cleaned several times will finally clog and air flow to engine will be restricted. After cleaning, check restriction and replace element if necessary.

Holes, loose end seals, dented sealing surfaces and other forms of damage require immediate element replacement.

Clean Air Silencer

1. Remove air silencers. Fig. 2-15.

2. Steam clean air silencer. Direct the steam jet from air outlet side of silencers to wash dirt out in opposite direction of air flow.

3. Position air silencers with new gaskets to intake manifolds; secure with flatwashers, lockwashers and capscrews.

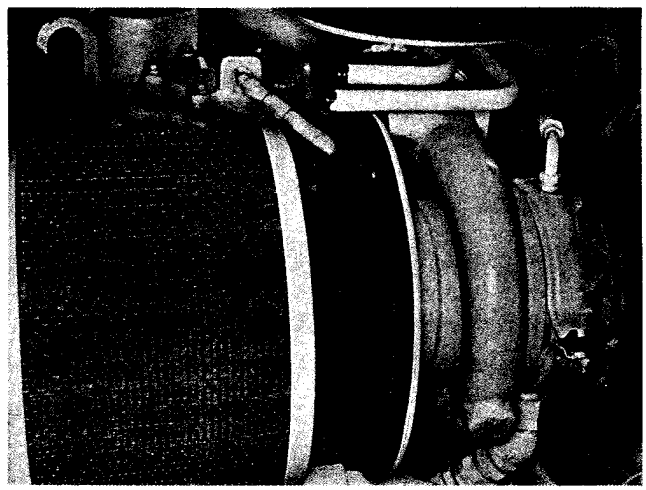


Fig. 2-15, (V21989). Removing air silencer from VT8-370 engine

Change Oil Bath Air Cleaner Oil And Clean Tray Screen NH, NT, V-12 and VT-12 Engines

Air Cleaner Oil

Before dirt build-up reaches 1/2 inch [12.7 mm], remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Note: During wet weather and in winter months, many oil bath air cleaners are neglected because visible dust and dirt laden air is not encountered. However, changing of oil is

equally as important as during dusty weather since the air cleaner inlet may be located in an air stream which carries excessive moisture into the cleaner.

Fill oil cup to level indicated by bead on its side with clean, fresh oil and assemble to cleaner. Oil of the same grade as that in crankcase should be used in cleaner; however, in extremely cold weather a lighter grade may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in oil bath air cleaners.

Caution: Never use crankcase drainings, this oil would already be "dirt laden."

Clean Tray Screen

Immerse tray screen (Fig. 2-16) in kerosene or cleaning solvent.

Slosh screen up and down several times. Dry thoroughly with compressed air, and reassembly to air cleaner.

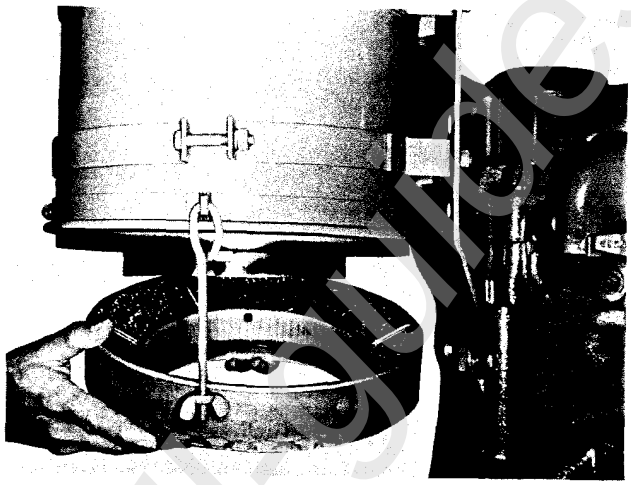


Fig. 2-16, (N11967). Removing oil bath air cleaner tray screen

Note: If tray screen is extremely dirty or coated with varnish, it may be necessary to singe the screen with a flame. Be careful not to melt tin plate on screen.

Check Exhaust System For Leaks And Deterioration

1. Check exhaust manifold connections for exhaust leaks.

2. Check all exhaust piping connections to be certain they are air tight.

3. If water is used in exhaust piping, check all connections and tubing for leaks and corrosion.

Change Corrosion Resistor

The initial service life of a corrosion resistor element on a new or newly rebuilt engine or after complete change of coolant supply is 100 hours; maintenance periods thereafter are as follows:

Change corrosion resistor or element at each "C" Check unless facilities are available for testing. See "Check Engine Coolant."

Selection of element to be used should be based upon "Coolant Specifications," Section 3.

Note: Whenever coolant supply is changed (spring and fall), the system must be drained and flushed.

Caution: Make sure corrosion resistor, bracket and mounting point on engine are free from paint to form a good ground. If located off engine, run ground wire from resistor mounting capscrew to engine.

Package Type Element

1. Close shut-off valves on inlet and drain lines. Unscrew drain plug at bottom of housing.

2. Remove cover capscrews and lift off cover; discard gasket.

3. Remove concave plate securing element; lift element from housing and discard. Remove flat plate below element.

4. Lift spring from housing.

5. Replace spring and install new lower flat plate.

6. Remove new element from transparent package; install element in housing. Fig. 2-17.

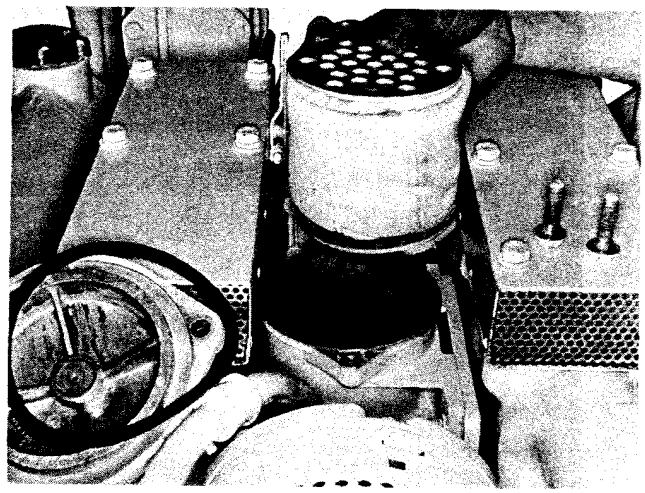


Fig. 2-17, (V11955). Installing package type corrosion resistor

Caution: Make sure antifreeze being used in cooling system is compatible with chromate element. Check with a Cummins Distributor, they are furnished with a list of compatible antifreezes each year.

7. Install new upper concave plate, gasket and cover.

8. Replace drain plug and open shut-off valves in inlet and drain lines.

Spin-On Element

1. Close shut-off valves on inlet and drain lines.

2. Unscrew element and discard. Fig. 2-18.

Caution: Mechanical tightening will distort or crack filter head.

3. Install new element (see Caution above), tighten until seal touches filter head. Tighten an additional one-half to three-fourths turn.

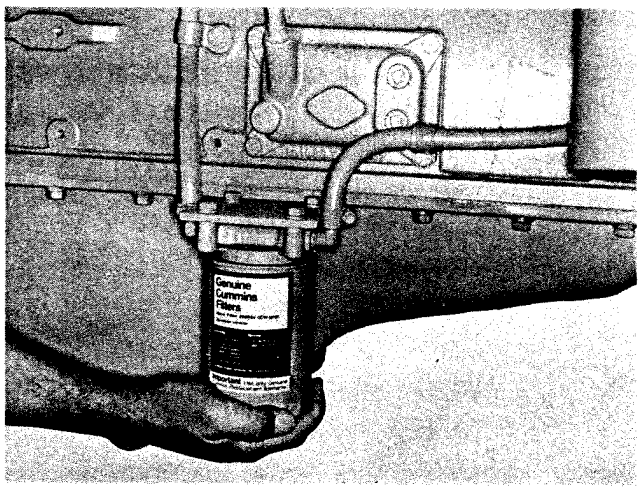


Fig. 2-18, (N11976). Spin-on type corrosion resistor

C—Maintenance Check

At each "C" Maintenance Check, first perform all "A," and "B" Checks in addition to those following.

Perform the following checks at intervals suggested on Pages 2-1 and/or 2-3.

Check Fuel Filter Restriction And Air Entrainment

To check restriction, connect ST-434 Vacuum Gauge to the fuel pump as shown in Fig. 2-19, using the special adapter furnished. If restriction reads 8 inches, vacuum while the engine is running at full speed and load, change element or check other sources of restriction and correct. When restriction becomes as great as 10 or 11 inches vacuum, the engine will lose power.

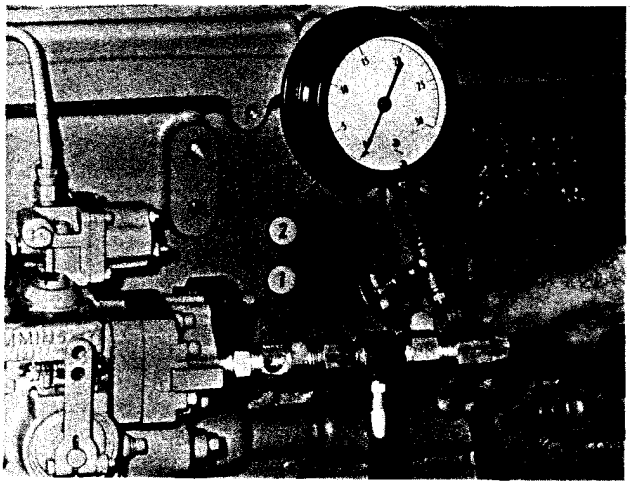


Fig. 2-19, (V21984). Checking fuel filter restriction

Check sight gauge ST-998 for air bubbles which indicate air entrainment and possible gasket or other leaks on suction side of pump.

Change Throw-Away Type Fuel Filter

1. Unscrew combination case and element, discard. Fig. 2-20.

2. Fill new filter with clean fuel.

3. Install filter; tighten by hand until seal touches filter head. Tighten an additional one-half to three-fourths turn.

Fig. 2-20, (V21981). Changing fuel filter

Caution: Mechanical tightening will distort or crack filter head.

Change Replaceable Element Fuel Filter

1. Remove drain plug from bottom of filter case and drain contents.

2. Loosen bolt at top of fuel filter. Take out dirty element, clean filter case and install a new element.

3. Fill filter case with clean fuel to aid in faster pick-up of fuel. Install a new gasket in filter head and assemble case and element. Tighten center bolt to 20 to 25 ft-lbs [2.8 to 3.5 kg m] with a torque wrench.

Change Lubricating Oil By-Pass Filter Element

To change Cummins by-pass filter elements:

Note: By-pass filters may be mounted either vertically, horizontally or inverted; all are serviced in like manner.

1. Remove drain plug (5, Fig. 2-21) from bottom of housing and drain oil.

2. Remove clamping ring capscrew (1) and lift off cover.

3. Unscrew upper support hold-down assembly (3); lift out element (4) and hold-down assembly. Discard element.

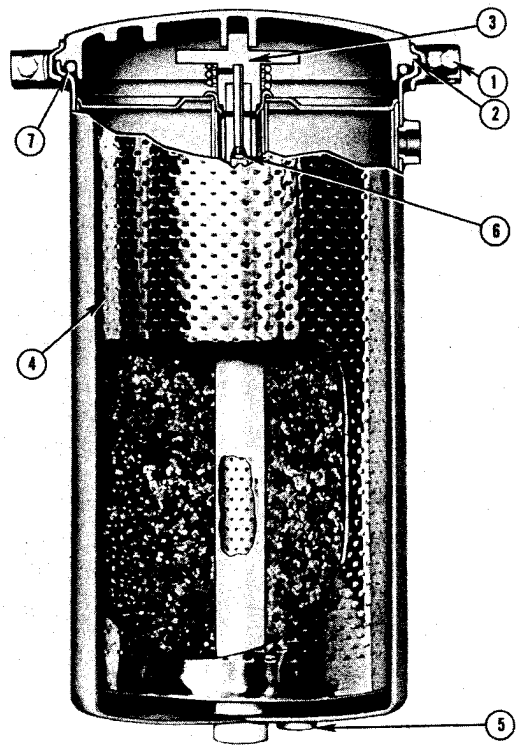


Fig. 2-21, (V41908). Lubricating oil by-pass filter

4. Clean housing and hold-down assembly in solvent.

5. Inspect hold-down assembly spring and seal. Replace if damaged.

6. Inspect drain plug and connections. Replace if damaged.

7. On the Cummins by-pass filter, check orifice plug (6) inside oil outlet connection or standpipe; blow out with air jet to make sure sorifice is open and clean.

8. Check filter cover "O" ring (7). Replace if damaged or deteriorated.

9. Install new element in housing.

10. Replace upper support hold-down assembly in filter and tighten down to stop.

11. Position "O" ring seal on housing flange.

12. Install cover and clamping ring; tighten capscrews until clamping lugs are indexed.

13. Add enough extra oil to crankcase to fill case and element.

Caution: Never use a by-pass filter in place of a full-flow filter.

Check Thermostat

Cummins Engines are normally equipped with either 160 to 175 deg. F [71 to 79 deg. C] or 170 to 185 deg. F [77 to 85 deg. C] range thermostats, depending on engine application requirement. Thermostats start to open at the lower figure and are fully opened at the higher figure. Check stamping on thermostat; install same range thermostat as that removed.

The opening and closing of thermostats can be checked against a thermometer while immersed in water as the water is brought up to thermostat operation temperature by heating. Fig. 2-22.

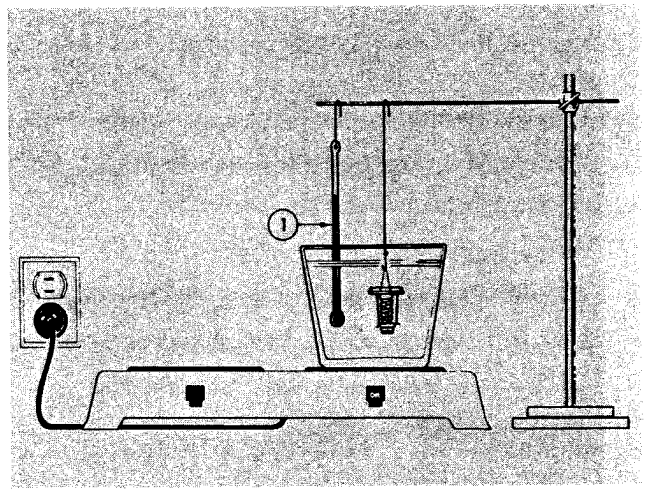


Fig. 2-22, (V10808). Testing thermostat

Clean Electrical Connections

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork alternator and regulator and shorten their lives.

1. Add water (distilled) to battery cells as required. Check solution level every 15 days during hot weather, every 30 days during cold weather; keep solution filled to 3/8 inch above separator plates.

2. Remove corrosion from around terminals; then coat with petroleum jelly or a non-corrosive inhibitor.

3. Keep connections clean and tight. Prevent wires and lugs from touching each other or any metal except screw terminals to which they are attached.

4. Replace broken or worn wires and their terminals.

5. Have battery tested periodically. Follow battery manufacturer's instructions for maintenance.

Lubricate (Raw) Water Pump (Sump Type)

Remove drain plugs on top, one side and bottom of raw water pump oil sump; drain oil into a suitable container. Replace bottom drain plug and fill sump to side opening with SAE 90 HYPOID. Replace top and side pipe plugs.

Check Vibration Damper Alignment

Damper hub (1, Fig. 2-23) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

There should be no indication of relative rotation between hub and inertia member. Check for extrusion of rubber particles between hub and inertia member.

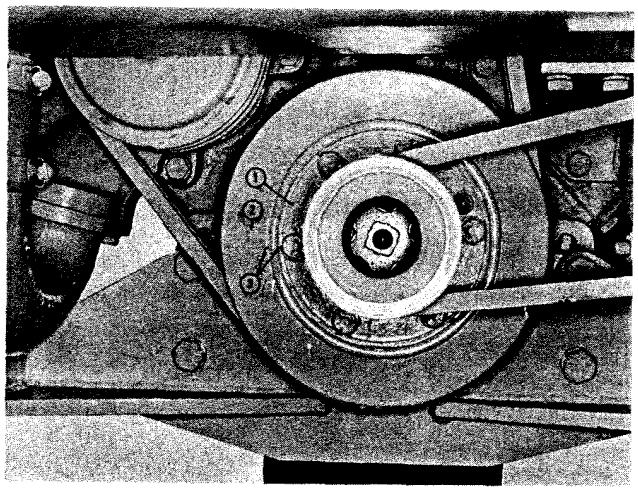


Fig. 2-23, (V11963). Vibration damper alignment marks

Clean Cooling System

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection through the exchanger. Use clean water which will not clog any of the hundreds of small passages in the heat exchanger or water passages in the block.

Clean out heat exchanger, oil cooler, marine oil cooler, and block passages which have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

The best way to insure an efficient cooling system is to prevent formation of rust and scale by using a Cummins Corrosion Resistor, but if they have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by neutralizer and flushing.

Pressure Flushing

Flush the unit to be cleaned when antifreeze is added or removed, or before installing a Corrosion Resistor on a used engine.

When pressure flushing the heat exchanger, open the upper and lower hose connections. Remove thermostats from housing and flush block with water. Use hose connections on both upper and lower connections to make the operation easier. Attach the flushing gun nozzle to the lower hose connection and let water run until the heat exchanger is full. When full, apply air pressure gradually to avoid damage to the core. Shut off air and allow heat exchanger to refill, then apply air pressure. Repeat until water coming from heat exchanger is clean.

Sediment and dirt settles into pockets in the block as well as the core. Partially restrict the lower opening until the block fills up. Apply air pressure and force water from the lower opening. Repeat the pressure until stream of water coming from block is clean.

Clean And Inspect Alternator

The frequency of inspection is determined largely by the type of operating conditions. High-speed operation, high temperatures, and dust and dirt all increase the wear of brushes, slip rings and bearings.

At regular intervals, inspect the terminals for corrosion and loose connections, and the wiring for frayed insulation. Check the mounting bolts for tightness, and the belt for alignment, proper tension and wear. Belt tension should be adjusted in accordance with recommendations. When tightening belt tension, apply pressure against the stator

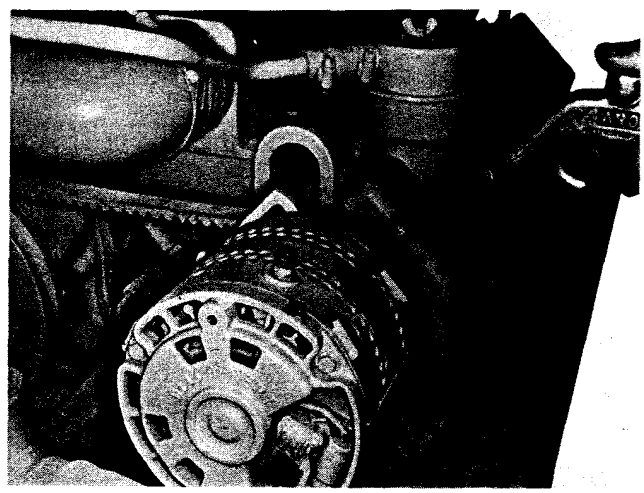


Fig. 2-24, (V21977). Blowing dust from alternator

laminations between the end frames (not against either end frame).

1. Blow out dust and dirt with compressed air. Fig. 2-24.

2. Slip rings and brushes can be inspected through alternator end frame assembly. If slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth.

Note: Never use emery cloth to clean slip rings. Hold polishing cloth against slip rings with alternator in operation. Blow away all dust after cleaning operation.

3. Check alternator bearings for wear. Shaft will be excessively loose if bearings are worn.

4. If brushes are worn close to the holder, the alternator must be removed and sent to manufacturer's rebuild station.

Tighten Engine Mounting Bolts And Nuts

Engine mounting bolts will occasionally work loose and cause supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews. If necessary, recheck alignment of marine unit to propeller shaft. Shim and tighten all mounting bolts.

Check Exhaust Back Pressure

1. When engine pistons must act against a back pressure in exhaust system to expel exhaust gas, usable output of engine is lowered; since air-fuel ratio will be reduced because of incomplete scavenging of cylinder, fuel economy is reduced and exhaust temperatures will increase. Although turbocharged engines are affected to a lesser degree than naturally aspirated engines due to positive pressure in intake manifold, it is essential exhaust system for all engines be designed to offer least possible restriction to exhaust flow.

2. High pressure indicates restriction caused by foreign objects, excessive bends or small size of piping. The lowest pressure obtainable is desired.

3. If exhaust back pressure exceeds those values listed, early engine failure and poor performance may be expected.

Cummins Distributors are equipped with special tools to check exhaust back pressure. If back pressure is too high, check entire exhaust system for restriction.

Check Turbocharger Oil Leaks

Check both intake and exhaust sides of turbocharger for

Exhaust Back Pressure Table

Engine Model	Pleasure Boat		Light Duty		Medium Duty		Heavy Duty	
	In. Hg. [mm]	In. Water [cm]	In. Hg. [mm]	In. Water [cm]	In. Hg. [mm]	In. Water [cm]	In. Hg. [mm]	In. Water [cm]
V-504	3 [76.2]	41 [104]	3 [76.2]	41 [104]			1-1/2 [38.1]	20 [50.8]
V8-300	3 [76.2]	41 [104]	1-1/2 [38.1]	20 [50.8]			1-1/2 [38.1]	20 [50.8]
VT8-370	3 [76.2]	41 [104]	2 [50.8]	28 [71.1]			2 [50.8]	28 [71.1]
V-903	3 [76.2]	41 [104]	3 [76.2]	41 [104]			1-1/2 [38.1]	20 [50.8]
NH-250	3 [76.2]	41 [104]	3 [76.2]	41 [104]	1-1/2 [38.1]	20 [50.8]	1-1/2 [38.1]	20 [50.8]
NT-335, NT-380	3 [76.2]	41 [104]	3 [76.2]	41 [104]	2 [50.8]	28 [71.1]	2 [50.8]	28 [71.1]
V12-500	3 [76.2]	41 [104]	3 [76.2]	41 [104]	1-1/2 [38.1]	20 [50.8]	1-1/2 [38.1]	20 [50.8]
VT12-635, 700, 800	3 [76.2]	41 [104]	3 [76.2]	41 [104]	2 [50.8]	28 [71.1]	2 [50.8]	28 [71.1]

wet oil. If oil is present, be sure that it is not caused by worn piston rings or oil seal leakage in turbocharger. Check hose, tubing and connections for leaks, and tighten or replace as necessary.

Check Control Panel Operations

1. Check throttle levers for ease of operation.

2. Check connections and pivot points for rust and corrosion.

3. Check throttle travel to make sure linkage operates throttle from stop to full throttle and that degree of travel is within specifications for application.

Clean Air Compressor Breather

On some ships the air compressor air inlet is connected to air intake piping. Others use a paper element breather; clean or change breather per manufacturers recommendations.

D–Maintenance Check

At each "D" Maintenance Check, perform all "A," "B" and "C" Checks in addition to those following. Most of these checks should be performed by a Cummins Distributor or Dealer and where Cummins Shop Manuals are available for complete instructions.

Perform the following checks at intervals suggested on Pages 2-1 and/or 2-3.

Clean Engine

There are many reasons why the exterior of the engine should be kept clean. Dirt from the outside will find its way into fuel and lubricating oil filter cases and into the cylinder heads when removed, unless dirt is removed first.

Steam is the most satisfactory method of cleaning a dirty engine exterior. A portable fuel oil or electric heated steam cleaner is satisfactory for use on Cummins engines. If steam is not available, use mineral spirits or some other solvent to wash down the engine.

Prior to steam cleaning cover all generator, cranking motor openings and other electrical equipment to protect from the force of the steam jet or solvent.

Cleaning the engine exterior will prevent damage that might occur from dirt entering the engine during operation or during unit replacement.

Clean Fuel Passages And Injectors

Clean the fuel drillings that carry fuel in the cylinder heads, when required, to injector inlet passages. Injectors have fine mesh screens to provide the last protection against dirt entering injectors.

Clean and calibrate injectors regularly to prevent restriction of fuel delivery to combustion chambers. Refer to Bulletin No. 983536. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

Clean Fuel Pump Screen And Magnet

PT Fuel Pump

1. Loosen and remove cap, "O" ring and spring. Lift out filter screen assembly. Fig. 2-25.

2. Clean screen and magnet in cleaning solvent and dry with compressed air.

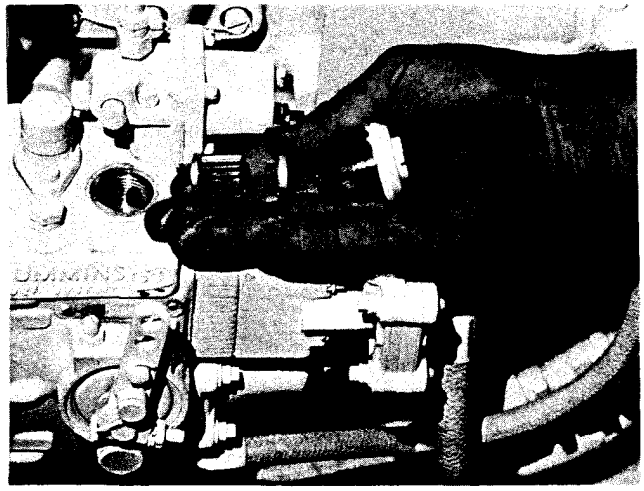


Fig. 2-25, (V41911). Fuel screen in fuel pump

3. Replace screen retainer and install filter screen assembly in fuel pump with hole down. Replace spring on top of filter screen assembly.

4. Replace can and "O" ring; tighten to 20 to 25 ft-lbs [2.76 to 3.46 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap and dynaseal from governor housing. Remove fuel supply tube, if necessary.

2. Remove "O" ring retainer, "O" ring, screen and spring from filter cap. Fig. 2-26.

3. Using a screwdriver or wire hook, remove bottom screen and magnet assembly from fuel pump housing. Remove screen retainer.

4. Clean parts as described above.

5. Install screen retainer and place bottom screen assembly in fuel pump housing with removable end up.

6. Install spring, large end first, in filter cap; install upper screen, closed end first, in cap and snug against spring.

7. Install new "O" ring on "O" ring retainer; insert in filter cap, "O" ring first.

8. Install filter cap and dynaseal in governor housing;

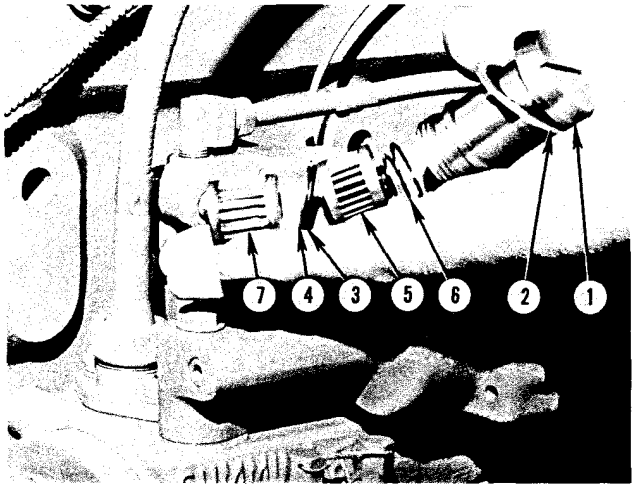


Fig. 2-26, (N11940). Fuel screen in fuel pump with MVS governor

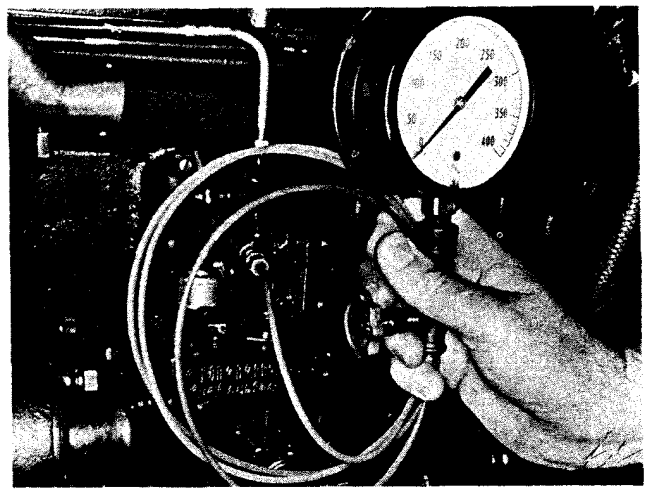


Fig. 2-27, (N11966). Checking fuel manifold pressure with ST-435

tighten cap to 20 to 25 ft-lbs [2.77 to 3.46 kg m] with torque wrench and screwdriver adapter. Install fuel supply tube, if removed.

Check Fuel Manifold Pressure

Assurance of correct governed speed is necessary before any other fuel pump checks are attempted. Use an accurate tachometer or revolution counter. Use of a dynamometer makes determining rated speed easy. If no dynamometer is used, take a reading of the no-load maximum speed. Allow 10% above the rated speed as a maximum governed speed. Example: 2100 rpm rated, 2310 rpm maximum.

There may be some variation in maximum governed speed from various causes:

1. Air compressor pumping.

2. Generator/alternator carrying high charging rate.

3. Any auxiliary load such as power assisting pump, air-conditioning compressor, etc.

4. Variations in governor characteristics make small difference in maximum governed speed between different engines. Such variations are of small importance in most applications.

Note: Injectors must be adjusted to proper specifications before taking fuel manifold pressure readings.

5. Check maximum fuel manifold pressure with ST-435. Fig. 2-27. Remove 1/8 inch pipe plug from side of fuel shut-off valve on top of fuel pump. Connect the gauge line in pipe plug hole.

6. Remove linkage from the throttle lever. This will allow throttle to be operated by hand.

Caution: On turbocharged engines with aneroids, temporarily disconnect aneroid inlet line and plug hole, to reach maximum fuel pressure during the short acceleration period.

7. Start the engine. Run long enough to purge air from the pump. Loosen the gauge end of pressure line and bleed air from line.

8. Watch gauge closely and snap throttle fully open. The gauge hand will hit a maximum value, then immediately drop back as the governor takes control.

9. Compare the maximum value with previous readings taken to determine if fuel readings are satisfactory. Normally this check is only taken if there is a suspected loss of power.

10. Remove plug and reconnect aneroid to fuel pump, remove air line from intake manifold to aneroid and check "no air" pressure.

Note: "No air" pressures are given in Fuel Pump Calibration, Bulletin No. 983725 or check with your Cummins Dealer.

11. Always make above checks on a hot engine.

Adjust Injectors And Valves

It is essential injectors and valves be in correct adjustment at all times for engine to breathe and deliver fuel to the cylinders. Final operating adjustments must be made using correct values for the actual temperature of the engine.

Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to the next VS mark

corresponding to firing order of engine, and that cylinder will be ready for adjustment.

Valve Set Mark Alignment (V-903 Series)

To bar engine, remove key, insert hex drive and press inward until barring gear engages drive gear; then advance. Fig. 2-28. After completion of adjustment, be sure drive retracts and install key into safety lock groove.

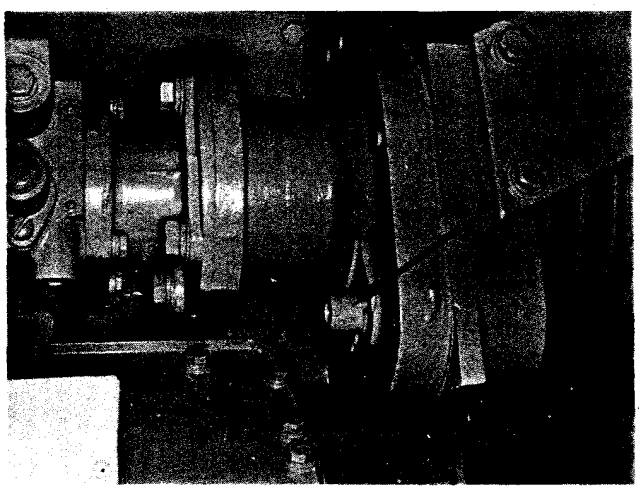


Fig. 2-28, (V51486). Engine barring arrangement

Bar crankshaft in direction of rotation until No. 1 "VS" mark appears on the vibration damper crankshaft pulley or accessory drive pulley as used. See Fig. 2-29 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1; if not, advance crankshaft one revolution. See Fig. 2-30, Fig. 2-31 and Table 2-4.

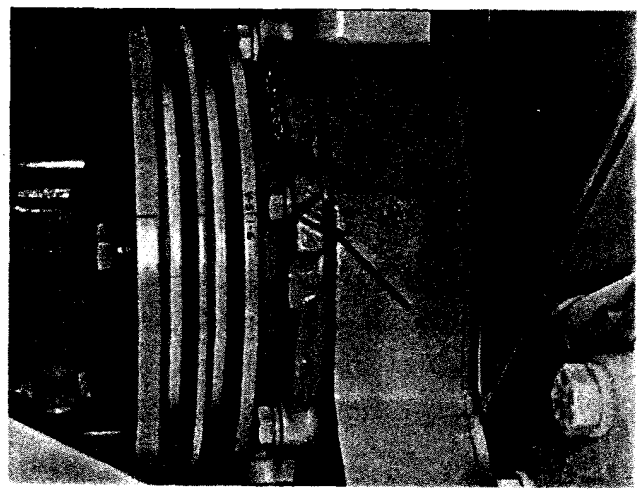


Fig. 2-29, (V514125). Valve set marks – V-903 Marine Engine

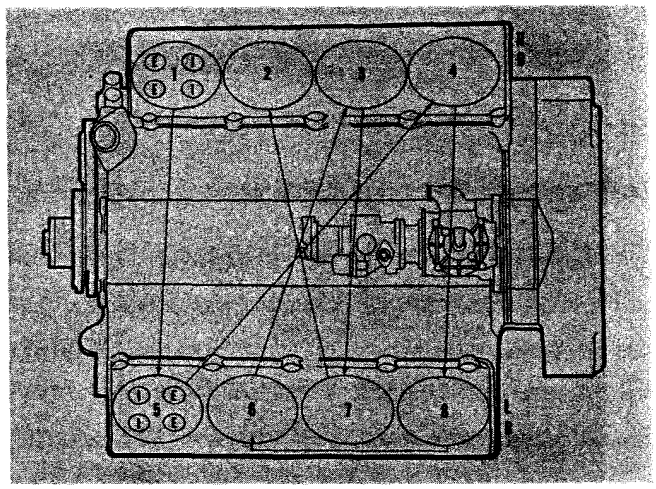


Fig. 2-30, (V11462). V8 Firing order diagram – Right hand rotation

Table 2-4: V8 Engine Firing Order

Right-Hand	1-5-4-8-6-3-7-2
Left-Hand	1-2-7-3-6-8-4-5

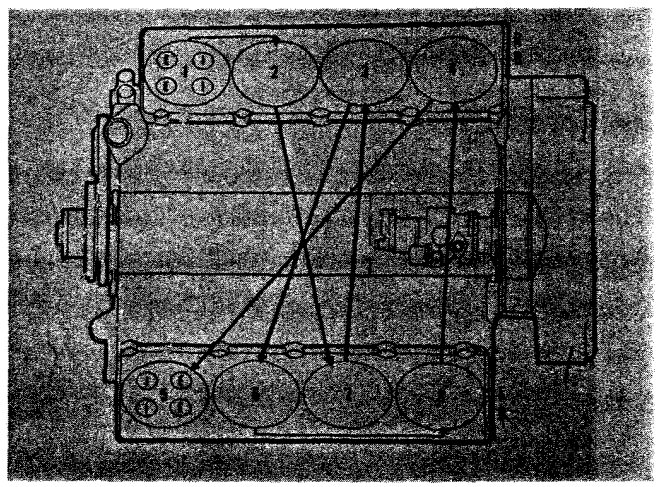


Fig. 2-31, (V11947). V8 Firing order diagram – Left hand rotation

Note: Once familiar with injector and valve adjustment, start at any cylinder and follow firing order to make adjustments.

Before adjustments, tighten injector hold-down capscrew to 30 to 35 ft-lbs [4.15 to 4.84 kg m] torque.

V-903, V8-300 And VT8-370 Injector Adjustment, Using ST-1170 Dial Indicator Method

This method involves adjusting injector plunger travel with an accurate dial indicator rather than tightening the adjusting screw to a specified torque.

The "indicator method" eliminates errors in adjustment caused by friction in the screw threads and distortion from overtightening the adjusting screw locknut. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-5 for specifications.

Table 2-5: Adjustment Limits Using Indicator Method Of Adjustment, Cold Set – Inch [mm]

Injector Plunger Travel Adjustment Value	Reset Limit	Valve Clearance Intake	Exhaust
0.180 to 0.181 [4.57 to 4.60]	0.179 to 0.182 [4.55 to 4.62]	0.012 [0.30]	0.025 [0.63]

Caution: Do not use these specifications when setting valves by the torque method. See Page 2-31 for definition of "Cold Setting."

The timing mark location (Fig's. 2-32 and 2-33) used with the dial indicator method of setting injectors and valves is not the same as used with injector settings made with a torque wrench.

The "VS" (valve set) marks on the vibration damper or rear accessory drive pulley are used when setting the injectors by the indicator method, but a new indicator mark location is used on the front cover or on the accessory drive support. See Fig. 2-32 and 2-33.

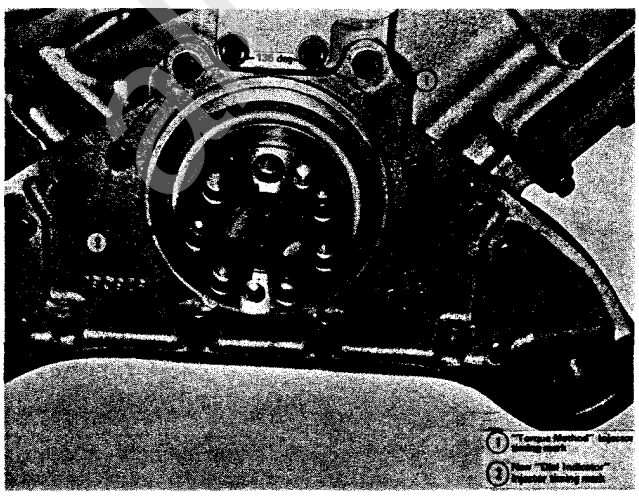


Fig. 2-32, (V51922). Relative location of timing marks on front cover

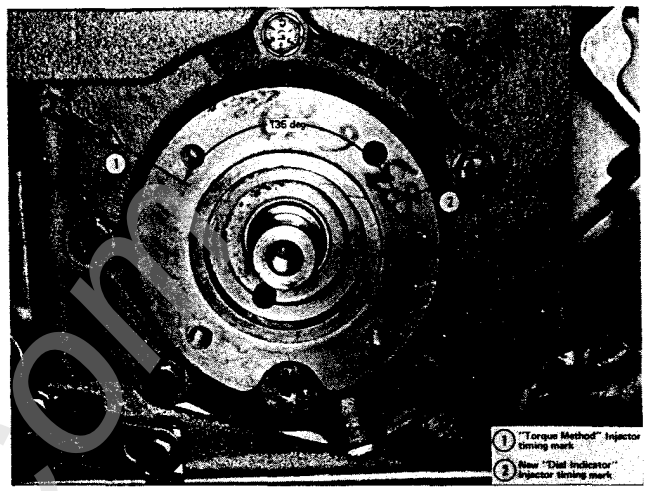


Fig. 2-33, (V514103). Relative location of timing marks on accessory drive support

When using the indicator method, the "VS" (valve set) mark on the damper is aligned with the front cover capscrew 135 deg. counterclockwise from the timing mark, newer engines are equipped with a pointer under the capscrew. See Fig. 2-32. The valve set mark on the accessory drive pulley is aligned with the accessory drive support capscrew 135 deg. clockwise from the current timing mark. See Fig. 2-33. Alignment, in both cases, should be held to one-half inch [12.7 mm] of the capscrew.

Using regular engine barring device (Fig. 2-28), rotate engine in direction of rotation until "VS" mark for cylinder 2-8 is aligned with appropriate capscrew or pointer. In this position both the intake and exhaust valve rocker levers for Number 2 cylinder should be free and can be moved up and down. If not, bar engine another 360 deg. in direction of rotation and realign the 2-8 "VS" mark with the capscrew.

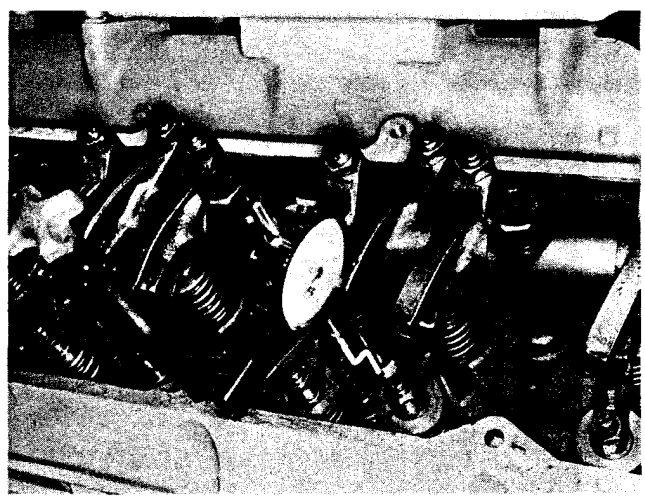


Fig. 2-34, (V514114). Dial indicator in place with extension in contact with injector plunger

Note: No. 2 cylinder is selected for purposes of illustration only. Any other cylinder could be used, if so desired.

1. Set up the ST-1170 Indicator Support with the indicator extension plunger top at No. 2 cylinder. Fig. 2-34.

2. Make sure that the indicator extension is not against the rocker lever.

3. Using ST-1147 Pliers, Fig. 2-35, bar the lever forward until injector plunger is bottomed in cup to squeeze oil film from between plunger and cup.

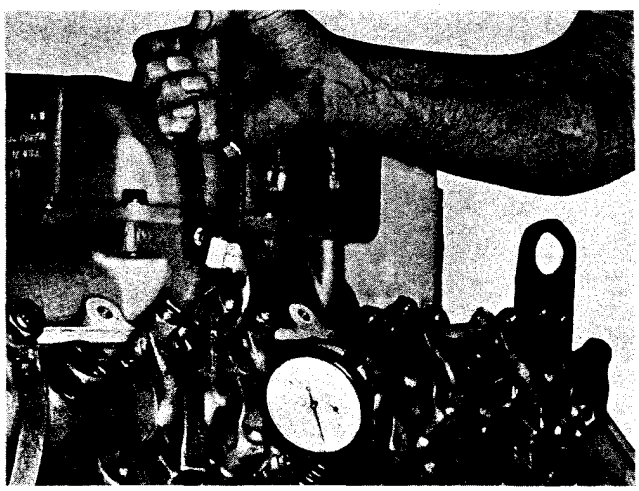


Fig. 2-35, (V514105). Bottoming injector plunger in cup

4. Allow the injector plunger to rise and then bottom again and set indicator at zero (0). We recommend lever be released and plunger bottomed again to check setting.

5. Release the lever completely, indicator should show a total reading as indicated in Table 2-5. (Use proper value depending if new adjustment or reset check.) Adjust to correct tolerance as necessary.

6. Tighten the adjusting screw locknut to 30 to 40 ft-lbs [4.15 to 5.53 kg m] and actuate the injector plunger several times as a check of the adjustment. Tighten to 25 to 35 ft-lbs [3.46 to 4.84 kg m] when using ST-669 Adapter on torque wrench.

7. Adjust intake and exhaust valve overhead to valve clearances given in Table 2-5. Torque adjusting screw locknuts to 30 to 40 ft-lbs [4.15 to 5.53 kg m] or 25 to 35 ft-lbs [3.46 to 4.84 kg m] when using a ST-669 Adpater.

8. Bar engine in direction of engine rotation until 1-6 "VS" mark aligns with tne new set mark and adjust cylinder 1. Continue through the firing order until all cylinders are adjusted. For engine firing order see Table 2-4.

Injector Plunger Adjustment Using Torque Method, All Small V Series

Where possible, always use the dial indicator method of adjustment for V-903 Series Engines, if impossible use following instructions.

To bar V-504 engine, place 3/4 inch drive extension through sea water pump drive pulley and into vibration damper inside square. Use 3/4 inch drive breaking bar for barring engine. Fig. 2-36.

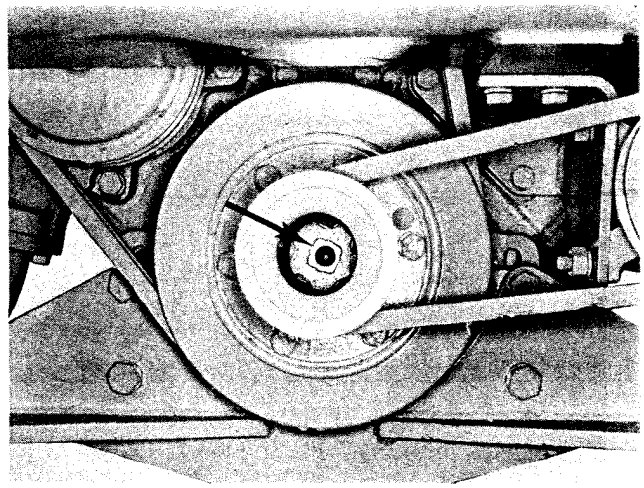


Fig. 2-36, (V11946). V-504 Engine barring location

To bar V8-300 and VT8-370 engines, barring lugs are located on rear accessory drive pulley.

Valve Set Mark Alignment

Turn crankshaft in direction of rotation until No. 1 "VS" mark appears on the vibration damper, crankshaft pulley or accessory drive pulley. See Fig. 2-37 (also see Fig's. 2-32 and 2-33, Item 1) for location of valve set marks. In this position both intake and exhaust valves must be closed for cylinder No. 1; if not, advance crankshaft one revolution. See Fig. 2-30, Fig. 2-31 and Table 2-4 for firing order.

Note: Two complete revolutions of the crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.

Before adjusting injector, tighten injector hold-down capscrew to 30 to 35 ft-lbs [4.15 to 4.84 kg m] torque.

The injector plungers of all engines must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap on Model TE-12 or equivalent torque wrench and a

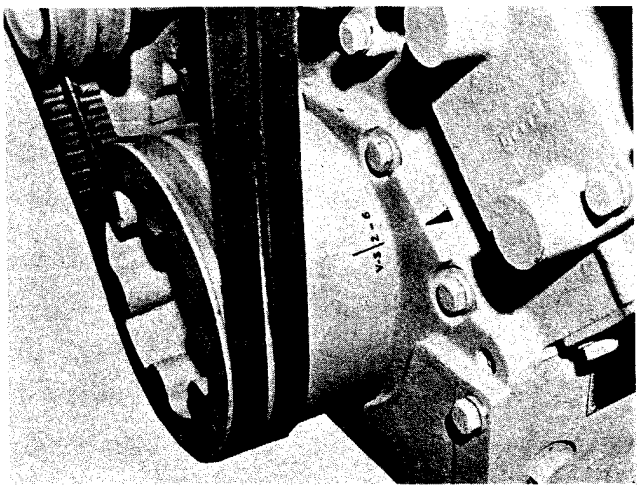


Fig. 2-37, (V11913). Valve set marks

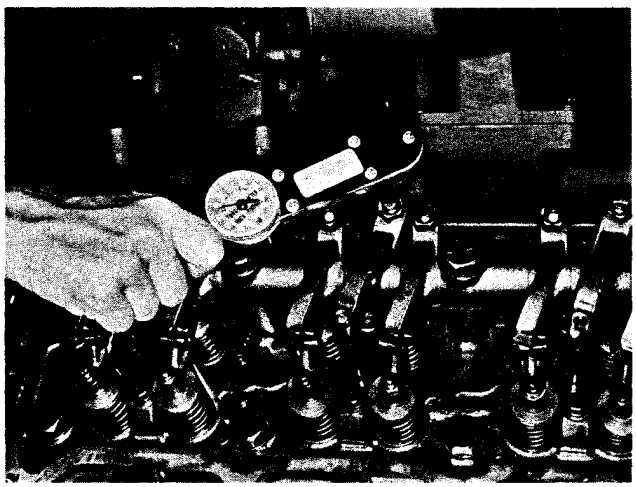


Fig. 2-38, (V51488). Adjusting injector plunger

screwdriver adapter can be used for this adjustment. Fig. 2-38.

Table 2-6: Injector Plunger Adjustment Torque

Engine Model	Cold Setting
V-504	60 inch-lb [0.69 kg m]
V8-300, VT8-370	50 inch-lb [0.57 kg m]
V-903	40 inch-lb [0.46 kg m]

Note: When making final injector plunger adjustments, see Page 2-31 for definition of "Cold Setting." The most accurate settings are made when engine is at a stabilized temperature.

Table 2-7: Injector And Valve Locknut Torque (All Models)

With ST-669	Without ST-669
25 to 35 ft-lbs [3.46 to 4.84 kg m]	30 to 40 ft-lbs [4.15 to 5.53 kg m]

1. Turn adjusting screw down until plunger contacts cup. Advance an additional 15 degrees to squeeze oil from cup.

2. Loosen adjusting screw one turn, then, using a torque wrench calibrated in inch-pound and a screwdriver adapter, tighten the adjusting screw to values shown in Table 2-6 for cold setting and tighten the locknut.

3. Hold injector adjusting screw and tighten injector locknut to values indicated in Table 2-7. When ST-669 Adapter is used, nut torque is reduced to compensate for additional torque arm length. Fig. 2-39.

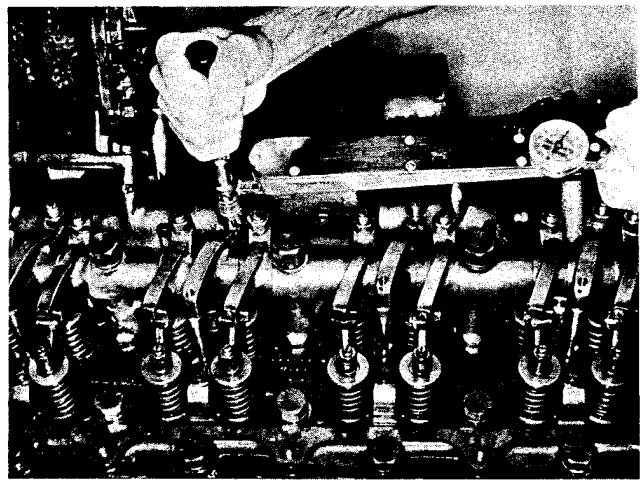


Fig. 2-39, (V51489). Torquing injector adjusting screw locknut

Crosshead Adjustment

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.

2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).

3. Turn down crosshead adjusting screw until it touches valve stem. Fig. 2-40.

4. With new crossheads and guides, advance screw an additional one-third of one hex (20 deg.) to straighten stem

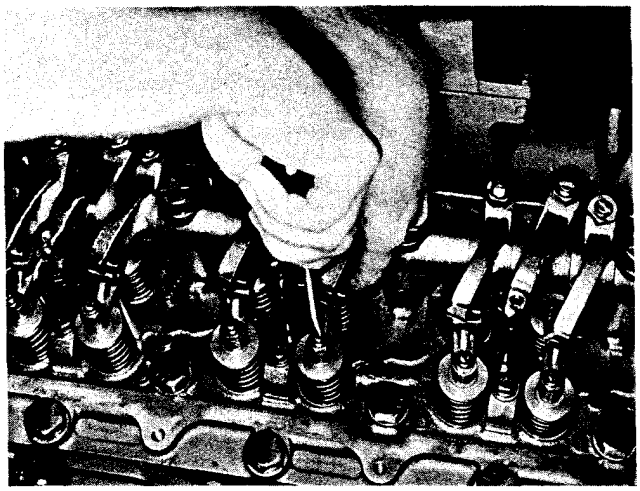


Fig. 2-40, (V51490). Adjusting crossheads

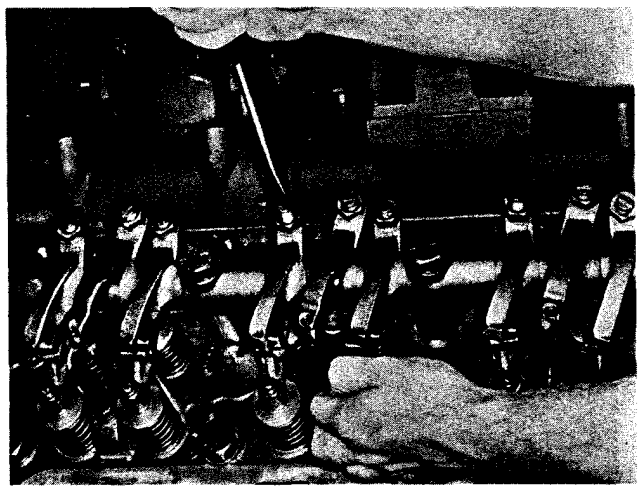


Fig. 2-41, (V51492). Adjusting valves

with guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg. to straighten stem with guide.

5. Hold adjusting screw in this position and torque locknut to 25 to 30 ft-lbs [3.46 to 4.15 kg m]. When ST-669 Torque Wrench Adapter is used, torque to 22 to 26 ft-lbs [3.04 to 3.59 kg m].

Note: Insure that crosshead retainers, when used, on exhaust valves (if used) are positioned equally on both sides of spring over crossheads and valve springs properly.

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.63 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

Table 2-8: Valve Clearance – Inch [mm]

Engine Model	Intake Valves Cold Setting	Exhaust Valves Cold Setting
V-504 V8-300, VT8-370, V-903	0.012 [0.30] 0.014 [0.35]	0.022 [0.56] 0.027 [0.68]

Note: When making final valve adjustment, see Page 2-31 for definition of "Cold Setting." The most accurate settings are made when engine is at a stabilized temperature.

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Valve clearances are shown in Table 2-8. Turn screw down until lever just touches gauge and lock adjusting screw in this position with locknut. Fig. 2-41. Torque locknut to values indicated in Table 2-7, note Step 3 under "Injector Plunger Adjustment."

2. Always make final valve adjustment after injectors are adjusted.

Adjust Injectors And Valves NH And NT Series

It is essential that injectors and valves be in correct adjustment at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Final operating adjustments must be made using correct values for the actual temperature of the engine.

Before adjusting injectors, torque hold-down capscrews in alternate steps to 10 to 12 ft-lbs [1.38 to 1.65 kg m].

NH and NT Injector Adjustment Using ST-1170 Dial Indicator Method

This method involves adjusting injector plunger travel with an accurate dial indicator rather than tightening the adjusting screw to a specified torque. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method.

Temperature conditions described as "Hot Set" or Cold Set" must be observed when recheck is being performed. If travel exceeds recheck values, adjust to proper value shown in "Adjustment Value" column. Check and/or adjust valves as necessary.

Maintenance Adjustment

The appropriate recheck values in Table 2-9A are applicable on engines which have operated long enough to warrant checking of injector setting and valve clearance.

Temperature Settings

The following temperature conditions provide the necessary stabilization of engine components to assure accurate settings.

Definition Of "Cold Set"

Engine must have reached a stabilized temperature without operation (4 hours minimum) in ambient temperature where adjustments are to be made. "Cold Set" is preferred.

Definition Of "Hot Set"

Engine With Non-Slotted Thread Injector Adjusting Screws

1. Adjust injectors and valves immediately after the engine has been operated at 210 deg. F [99 deg. C] oil sump temperature or until normal oil operating temperature has been obtained, for a period of 10 minutes minimum.

2. If oil temperature gauge is unavailable, set injectors and valves immediately after engine has operated at rated speed and load or at high idle for a period of 40 minutes minimum.

Engines With Slotted Thread Injector Adjusting Screws

1. Set injectors and valves immediately after the engine oil sump temperature has reached 210 deg. F [99 deg. C] or until normal oil operating temperature has been obtained.

2. If oil temperature gauge is unavailable, set injectors and valves immediately after engine has operated at rated speed and load or at high idle for a period of 20 minutes.

Check Plunger Free Travel

Do not check on engines with injector indicator adjustment decal on valve cover. In order to prevent excessive loading of injector actuating train and possible failure, "Plunger Free Travel" MUST be checked as follows:

1. Back injector adjusting screw out 2 to 3 full turns from normal operating position, tighten locknut.

2. With ST-1170 Dial Indicator extension on injector plunger top, bar engine and record total amount of each plunger travel. This is called "Plunger Free Travel" and MUST NOT exceed 0.206 inch [5.232 mm] on any one (1) cylinder of engine on which dial indicator method of adjustment is to be used.

Table 2-9: Injector and Valve Set Position

Bar In Direction	Pulley Position	Set Cylinder Injector	Set Cylinder Valve
Start	A or 1-6VS	3	5
Advance To	B or 2-5VS	6	3
Advance To	C or 3-4VS	2	6
Advance To	A or 1-6VS	4	2
Advance To	B or 2-5VS	1	4
Advance To	C or 3-4VS	5	1

Note: On engines with Plunger Free Travel exceeding 0.206 inch [5.232 mm] the Torque Method of adjustment must be used unless component changes (rocker levers and/or cam followers) are made which will allow 0.206 inch [5.232 mm] limit of Free Travel to be obtained.

Adjustments After Replacing Head Gasket And/Or Rocker Housing Gasket

Adjust injectors and valves using appropriate values in the "Cold Set" column. See Table 2-9A. The engine must operate for approximately 1 hour at rated speed to allow stability of structural components as affected by the gasket replacement. Recheck injectors and valves.

Note: Readjustment after 1 hour operation is necessary to assure lowest smoke potential and avoid excessive injector train loads.

Injector And Valve Adjustment

Note: Jacobs Brakes must be removed from engines, so equipped, for adjustment of injectors and valves to appropriate values as stated under "Hot" or "Cold" set.

1. Bar engine in direction of rotation until point "A" or 1-6 "VS" mark on accessory drive pulley is aligned with point on gear case cover. In this position, both intake and exhaust valve rocker levers for cylinder No. 5 must be free (valves closed). Injector plunger for cylinder No. 3 must be at top of travel; if not, bar engine 360 deg. in direction of rotation and realign point "A" or 1-6 "VS" mark on accessory drive pulley with pointer on gear case cover.

Note: Any cylinder combination may be used as a starting point. See Table 2-9.

2. Install ST-1170 Indicator Support at No. 3 cylinder with indicator extension on injector plunger top. Make sure indicator extension is not against rocker lever.

Note: Before adjusting injectors and valves be sure to determine if rocker housings are Cast Iron or Aluminum and use appropriate setting.

Table 2-9A: Adjustment Limits Using Dial Indicator Method

	Injector Plunger Travel Inch [mm]		Valve Clearance Inch [mm]	
Lubricating Oil Temperature	**Adjustment Value**	**Recheck Limit**	**Intake**	**Exhaust**
Aluminum Housings				
Cold Set	0.170 [4.318]	0.169 to 0.171 [4.293 to 4.343]	0.011 [0.279]	0.023 [0.584]
Hot Set	0.170 [4.318]	0.169 to 0.171 [4.293 to 4.343]	0.008 [0.203]	0.023 [0.584]
Cast Iron Housings				
Cold Set	0.175 [4.445]	0.174 to 0.176 [4.420 to 4.470]	0.011 [0.279]	0.023 [0.584]
Hot Set	0.175 [4.445]	0.174 to 0.176 [4.420 to 4.470]	0.008 [0.203]	0.023 [0.584]

Note: Make recheck at same stabilized temperature as adjustments. All travel and clearance values are with locknuts properly torqued.

3. Using ST-1193 Rocker Lever Actuator, bar lever toward injector until plunger is bottomed in cup to squeeze oil film from between plunger and cup. Allow injector plunger to rise and then bottom again and set indicator at zero (0). Lever should be released and plunger bottomed again to check setting. Fig. 2-42.

4. Release lever completely, indicator should show a total reading as indicated in Table 2-9A (use proper value depending if new adjustment or reset check). Adjust to correct tolerance as necessary.

5. If loosened, tighten locknut to 30 to 40 ft-lbs [4.15 to 5.53 kg m] and actuate injector plunger several times as a check of adjustment. Tighten to 25 to 35 ft-lbs [3.46 to 4.84 kg m] when using ST-669 Adapter on torque wrench.

Caution: Before checking valve set, be sure crossheads are properly adjusted.

6. Adjust valves on cylinder No. 5 to values in Table 2-9A. Torque locknuts 30 to 40 ft-lbs [4.15 to 5.53 kg m] or 25 to 35 ft-lbs [3.46 to 4.84 kg m] when using a ST-669 Adapter.

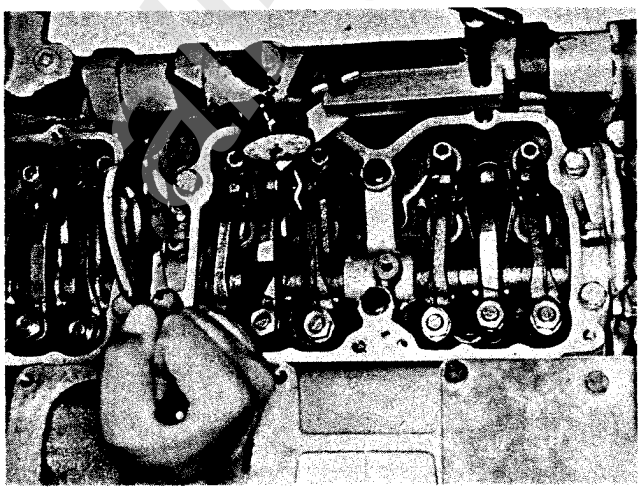


Fig. 2-42, (N114232). Checking injector plunger travel with ST-1170

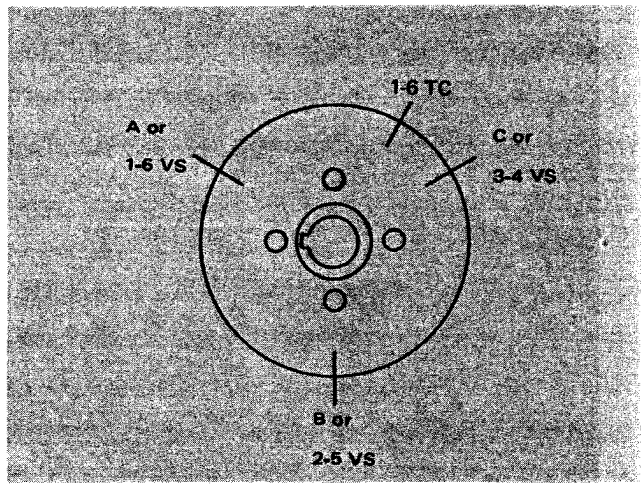


Fig. 2-43, (N114230). Accessory drive pulley markings

Note: Move ST-1170 Indicator Support to next cylinder, following firing order as indicated in Fig. 2-43, and repeat Steps 2 through 6 for adjustment.

Timing Mark Alignment — Torque Method

1. If used, pull compression release lever back and block in open position when barring engine, this allows the crankshaft to be rotated without working against compression.

2. Loosen the injector rocker lever adjusting nut on all cylinders. This will aid in distinguishing between cylinders adjusted and not adjusted.

3. Bar engine in direction of rotation until a valve set mark (1, Fig. 2-44) aligns with the boss (2) on the gear case cover. Example: A or 1-6 "VS." This location is marked with a notch in the drive pulley.

4. Check the valve rocker levers on the two cylinders aligned indicated on pulley (example: 1 and 6 cylinders for A or 1-6 "VS"). On one cylinder of the pair, both rocker levers will be free and valves closed, this is cylinder to be adjusted.

5. Adjust injector plunger first, then crossheads and valves to clearances indicated in the following paragraphs.

6. For firing order see Table 2-10.

7. Continue to bar engine to next "VS" marks and adjust each cylinder in firing order.

Note: Only one cylinder is aligned at each mark. Two complete revolutions of the crankshaft are required to adjust all cylinders.

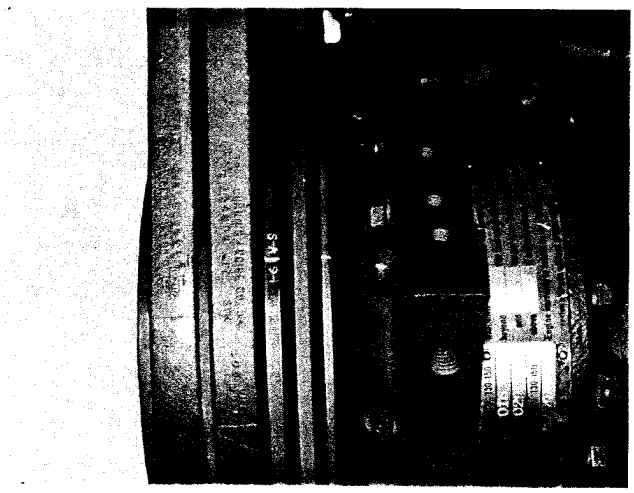


Fig. 2-44, (N114220). Valve set timing marks on NH engine

Table 2-10: Engine Firing Order — NH and NT Engines

Right Hand Rotation	Left Hand Rotation
1-5-3-6-2-4	1-4-2-6-3-5

Injector Plunger Adjustment — Torque Method NH and NT Engines

The injector plungers of all engines must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. See Fig. 2-45.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

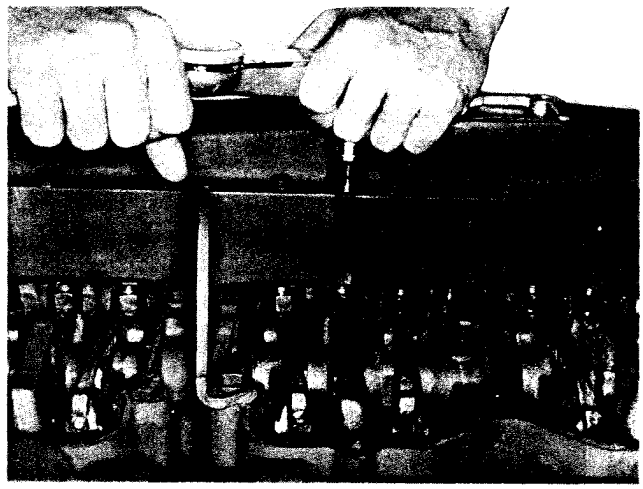


Fig. 2-45, (N11466). Adjusting injector plunger

2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter, tighten the adjusting screw to values shown in Table 2-11

Table 2-11: Injector Plunger Adjustment — Inch-lbs. [kg m]

Cold Setting	Hot Setting
Cast Iron Housing	
48 [0.55]	72 [0.83]
Aluminum Housing	
72 [0.83]	72 [0.83]

and tighten the locknut to 30 to 40 ft-lbs [4.15 to 5.53 kg m] torque.

If ST-669 torque wrench adapter is used, torque to 25 to 35 ft-lbs [3.46 to 4.84 kg m].

Crosshead Adjustment – NH, NT Engines

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

The crosshead adjustment changes as a result of valve seat wear during engine operation. Therefore, always adjust crossheads when rocker lever clearance is found tight. Make sure crossheads are adjusted before adjusting rocker levers.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-46) one turn.

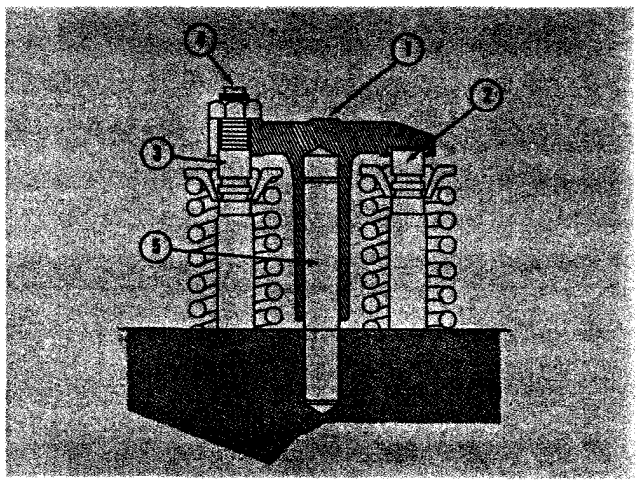


Fig. 2-46, (N21461). Adjusting valve crosshead

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2) (without adjusting screw).

3. Turn down crosshead adjusting screw until it touches valve stem (3).

4. With new crossheads and guides, advance setscrew an additional one-third of one hex (20 deg.) to straighten stem on its guide (5) and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg. to straighten stem on its guide.

5. Using ST-669 Torque Wrench Adapter, tighten locknuts to 22 to 26 ft-lbs [3.04 to 3.60 kg m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [3.46 to 4.15 kg m].

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance at this point.

Valve Adjustment – NH, NT Engines

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in running position.

2. Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Fig. 2-47. Tighten locknut to 30 to 40 ft-lbs [4.15 to 5.53 kg m] torque. When using ST-669 torque to 25 to 35 ft-lbs [3.46 to 4.84 kg m].

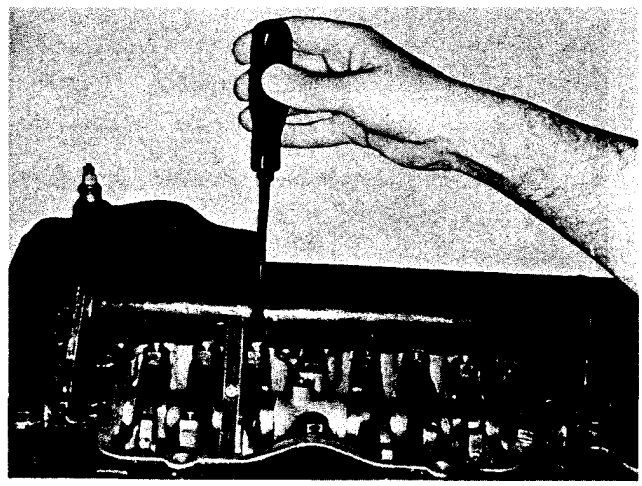


Fig. 2-47, (N114215). Adjusting valves

3. Always make final valve adjustment to correct value at 210 deg. F [99 deg. C] engine lubricating oil temperature. See Table 2-12.

Table 2-12: Valve Clearance – Inch [mm] NH, NT Series

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]
Cast Iron Rocker Housing			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]

Adjust Injectors And Valves – V12 Engines

It is essential that injectors and valves be in correct adjustment at all times for engine to operate properly. This controls engine breathing and fuel delivery to the cylinders. Final adjustment must be made when engine is at operating temperature. Injectors must always be adjusted before valves.

Timing Mark Alignment - V12 Engines

1. If so equipped, pull compression release lever back and block in open position to lift all intake valves. This allows crankshaft to be rotated without working against compression.

2. Bar engine in direction of rotation until No. 1L-6L VS mark appears. See Fig. 2-48 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1, on engine left bank. (Remove block from compression release before setting valves.)

3. Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to next VS mark corresponding to firing order of engine and corresponding cylinder will be ready for adjustment.

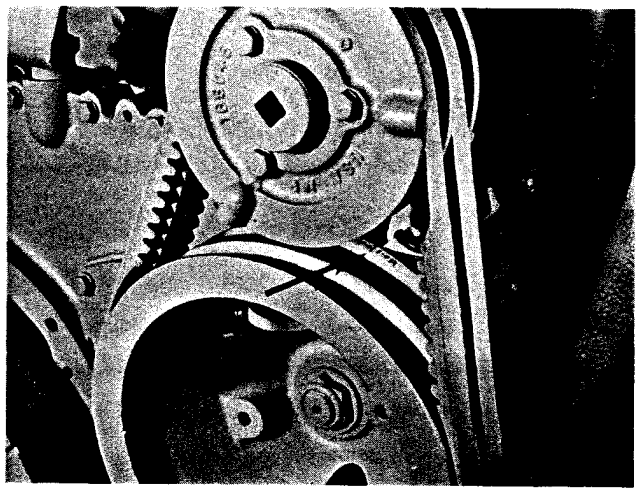


Fig. 2-48, (V41484). Valve set marks

Engine Firing Order – V12 Engines

Right Hand –
1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Left Hand –
1L-4R-3L-2R-5L-1R-6L-3R-4L-5R-2L-6R

Note: Number one L and one R cylinders on V-1710 engines are at gear case end of engine. When facing gear case end of engine the right bank is on your right side.

4. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

Note: Two complete revolutions of crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.

Injector Plunger Adjustment – V12 Engines

The injector plungers of all engines must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 2-49.Torque hold-down capscrews before adjusting plungers.

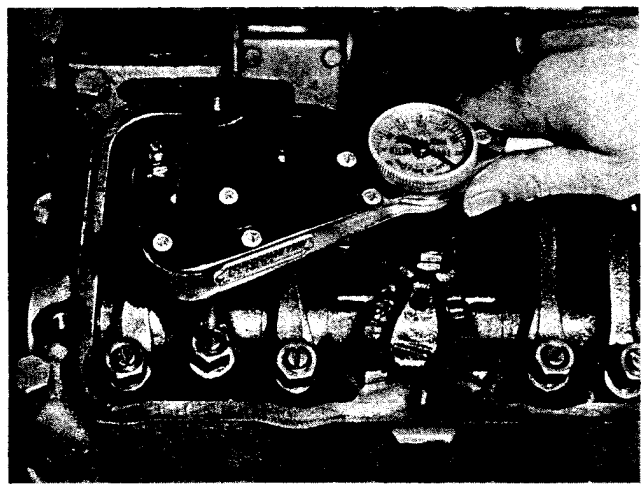


Fig. 2-49, (V414190). Adjusting injector plunger

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter, tighten the adjusting screw to values shown in Table 2-13 and tighten the locknut. Table 2-14.

3. Hold injector adjusting screw and tighten injector locknuts to values indicated in Table 2-13. Where ST-669 is used, nut torque is reduced to compensate for additional torque arm length. Fig. 2-50.

Table 2-13: Injector Plunger Adjustment Torque

Cold Setting	
50 inch-lbs	[0.57 kg m]

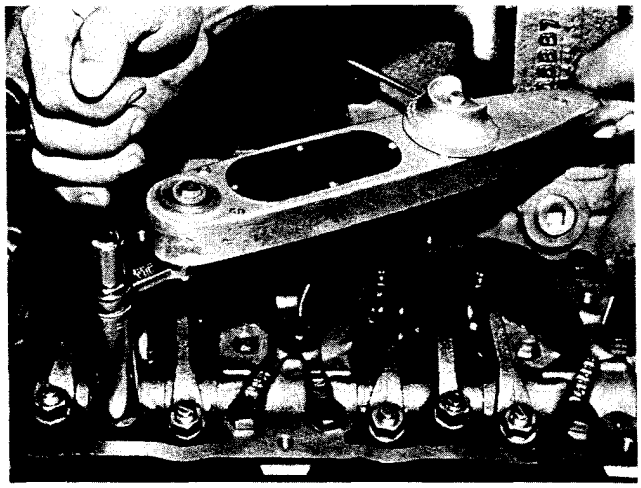


Fig. 2-50, (V414201). Torquing injector adjusting screw locknut with ST-669

Table 2-14: Injector And Valve Locknut Torque	
With ST-669	**Without ST-669**
25/35 ft-lb [3.46/4.84 kg m]	30/40 ft-lb [4.15/5.32 kg m]

Crosshead Adjustments — V12 Engines

V-1710 Series engines have four-valve heads; it is necessary to adjust the crossheads before making valve adjustments, Fig. 2-51.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.

2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).

3. Turn down crosshead adjusting screw until it touches valve stem.

4. With new crossheads and guides, advance screw an additional one-third of one hex (20 deg.) to straighten stem in guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw 30 deg. to straighten stem in guide.

5. Hold adjusting screw in this position and torque locknut to 25 to 30 ft-lbs [3.46 to 4.15 kg m]. With ST-669, torque locknut 22 to 26 ft-lbs [3.04 to 3.59 kg m].

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance at this point.

Valve Adjustment — V12 Engines

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves, make sure compression release is in running position.

2. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Turn screw down until lever just touches gauge and lock adjusting screw in this position with the locknut. Fig. 2-52. Torque locknut to values indicated in Table 2-14; note Step 3 under "Injector Plunger Adjustment."

3. Always make final valve adjustment after injectors are adjusted. Valve clearances are shown in Table 2-15.

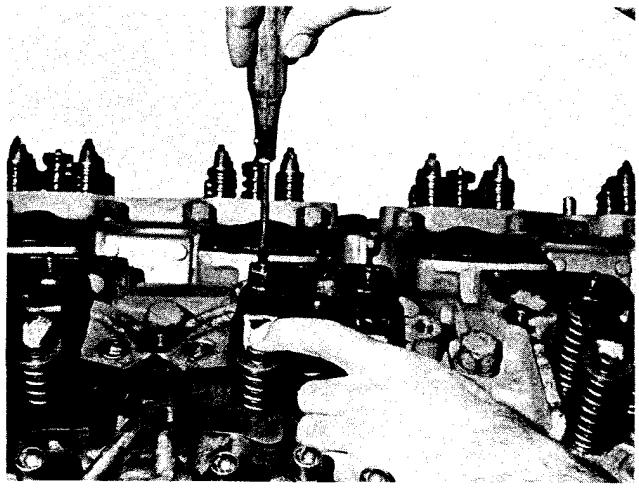


Fig. 2-51, (V414163). Adjusting crosshead

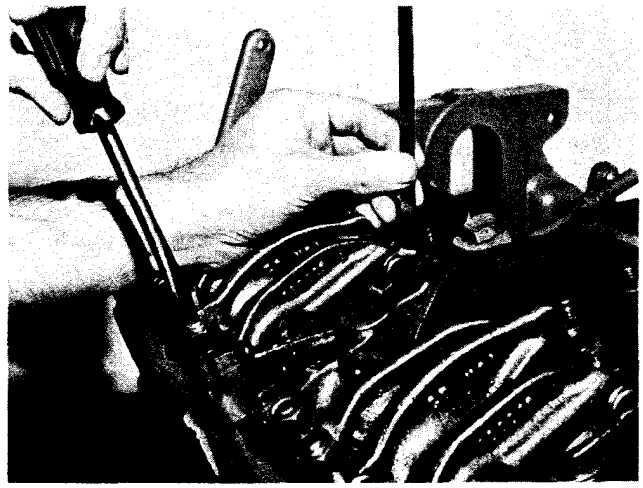


Fig. 2-52, (V414193). Adjusting valves

Table 2-15: Valve Clearance, Cold Setting - Inch [mm]

Intake Valves	Exhaust Valves
0.016 [0.41]	0.029 [0.74]

Tighten Manifold And Turbocharger Mountings

Check exhaust, intake and water manifolds mounting hardware for tightness; correct deficiencies as required.

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so that vibration will be at a minimum.

Clean Turbocharger Compressor Wheel And Compressor Housing

Compressor wheel and compressor housing must be kept clean for best turbocharger performance. Any build-up of dirt or oil sludge on compressor wheel will substantially reduce compressor efficiency, increase rotor imbalance and reduce intake manifold air pressure. This may ultimately lead to a failure. Possibility of mechanical failure and loss of performance demands periodic inspections.

Under normal operating conditions, turbocharger is subject to very little wear since rotor is only moving part. Rotor must be accurately balanced due to its high rotative speed and extremely close-running clearances. It is very important that this balance not be disturbed and that running clearances be maintained.

1. Remove air intake-to-turbocharger connection, air inlet piping to turbocharger and compressor casing to expose compressor wheel. Use Bendix cleaner, or a similar-type solvent, and a bristle brush to clean carbon from compressor wheel and compressor casing.

Caution: Never use a caustic solution that may attack aluminum. Such solution may either weaken parts or destroy their balance. Also, never use a wire brush or scraper to clean compressor wheel.

2. Dry unit carefully and reassemble compressor casing to bearing housing.

3. Reconnect air piping and secure with clamps.

4. Check compressor wheel for oil sludge build-up. Determine cause and correct.

Check Turbocharger Bearing Clearances T-50, VT-50, ST-50

Bearing clearances can be checked without removing turbocharger from engine. Use a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance. Fig. 2-53.

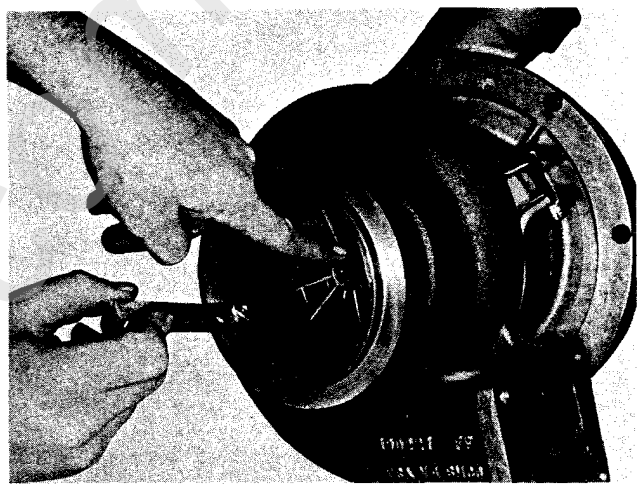


Fig. 2-53, (T-544). Checking side clearance

Checking Procedure

1. Remove exhaust and intake piping from the turbocharger to expose ends of rotor assembly.

2. Remove one capscrew from the front plate (compressor wheel end) and replace with a long capscrew. Attach an indicator to the long capscrew and register indicator point on the end of rotor shaft. Push the shaft from end-to-end, making note of total indicator reading. Move indicator point to the end of the shaft and check end-play of rotor assembly. See Table 2-16 for limits.

3. Check radial clearance on compressor wheel only. Note that limits in Table 2-16 are minimum figures.

Table 2-16: Turbocharger Bearing Clearances — Inch [mm]

Turbocharger Model	Radial Clearance	End Clearance
T-50, VT-50, ST-50	0.005/0.033 [0.13/0.84]	0.006/0.017 [0.15/0.43]
T-18A	0.003/0.007 [0.08/0.18]	0.004/0.009 [0.10/0.23]

4. If end clearance exceeds limits shown in Table 2-16, remove turbocharger from engine and replace with a new or rebuilt unit.

T-18A Checking Procedure

1. Fasten a dial indicator (plunger type with one inch travel) using a mounting plate and two inch indicator extension rod to the turbocharger oil drain mounting pad (Fig. 2-55). The mounting plate and indicator can be secured with the bolts which were removed to gain access to the oil drain hole. Fig. 2-54 gives the dimensions for fabricating the mounting plate to properly align indicator.

2. After securing the dial indicator properly, move the rotating shaft up and down to check bearing radial clearance. Use care to move shaft in the same direction as the dial indicator travels. Equal pressures should be applied to the shaft at both ends simultaneously. The total dial indicator displacement should be within 0.003 to 0.007 inch [0.08 to 0.18 mm]; if the measured movement is 0.007 inch [0.18 mm] or more, the rotating assembly must be repaired or replaced.

3. Fasten a dial indicator to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side (Fig. 2-56). Move the shaft axially back and forth by hand; the total indicator reading should be 0.004 to 0.009 inch [0.10 to 0.23 mm]. If the total indicator reading exceeds 0.009 inch [0.23 mm], the rotating assembly must be repaired or replaced.

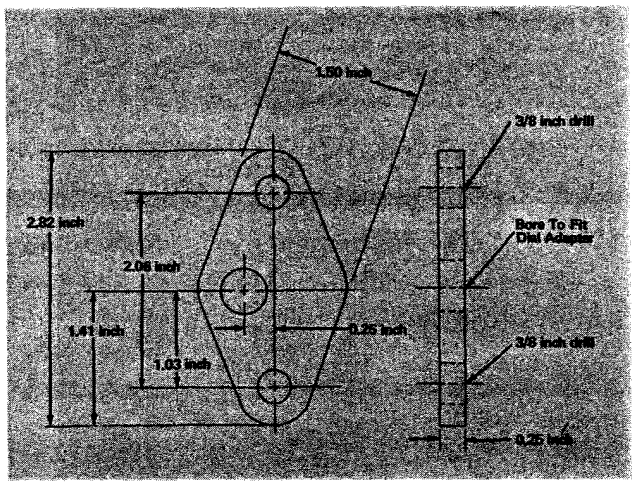


Fig. 2-54, (TA-45). Dial indicator adaptor for T-18A turbocharger

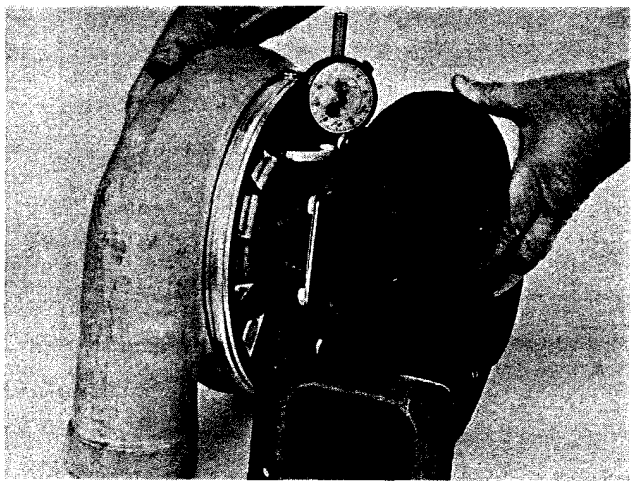


Fig. 2-55, (TA-46). Checking bearing radial clearance of T-18A

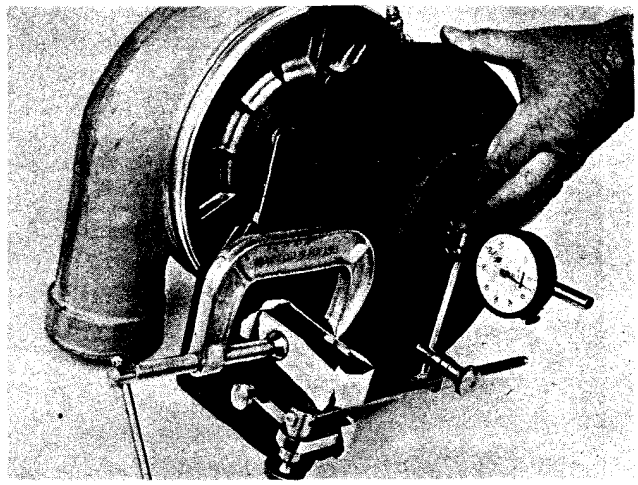


Fig. 2-56, (TA-47). Checking turbocharger end clearance

Check Safety Controls

Engine safety controls may be wired into the fuel pump shut down valve or may be hooked up to a horn or other noise maker.

Checking High Water Temperature Control

1. Remove sensing unit from water passage.

2. The opening of the circuit can be checked against a thermometer, while immersed in water, as the water is heated to activate temperature control.

3. Horn should sound at about 200 deg. F and engine should shut down at about 205 to 210 deg. F.

Checking Low Lubricating Oil Pressure Protective Device

1. With engine shut down, remove protective device from engine block and reconnect. Fig. 2-57.

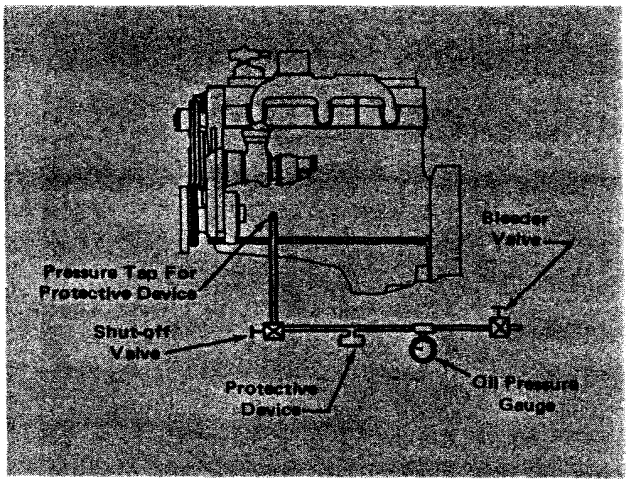


Fig. 2-57, (N11701). Checking low oil pressure protective device

2. With shutoff valve in oil pressure line open and bleed valve closed, operate engine at rated speed and no load.

3. Open bleed valve and purge air from system.

4. Close bleed valve and read and record oil pressure. Close shutoff valve.

5. Observe oil pressure gauge and slowly open bleed valve until protective device shuts down engine.

6. Sensing unit should activate when pressure is lowered below operating level.

7. If above procedure is not applicable, this method may be adjusted to meet the particular circumstances.

Check Engine Blow-By

Engine blow-by or escape of combustion gases past piston rings, is a good indicator of engine condition when used on a comparison basis. However, caution must be observed in its use, and it must be remembered that some gas will always escape from a breather. Distinct puffs and oil consumption are the marks of true blow-by. Cummins Distributors have available special tools to check for blow-by on an engine at full load and can tell if blow-by is excessive.

Check Crankshaft End Clearance

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 2-17. An engine must not be operated with more than the worn limit end clearance shown in Table 2-17.

If engine is disassembled for repair, and thrust ring wear permits end clearance in excess of 0.020 inch [0.51 mm], install new thrust rings.

Table 2-17: Crankshaft End Clearance – Inch [mm]

Engine Model	New Minimum	New Maximum	Operating Worn Limit
V-300, V-370, V-903	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]
V-504	0.004 [0.10]	0.014 [0.36]	0.022 [0.56]
NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
V-12	0.006 [0.15]	0.013 [0.33]	0.026 [0.66]

Caution: Do not pry against outer damper ring.

The check can be made by attaching an indicator to rest against the damper or pulley, Fig. 2-58, while prying against the front cover and back side of damper hub. End clearance must be present (as stated in Table 2-17) with engine mounted in the craft and assembled to marine gear.

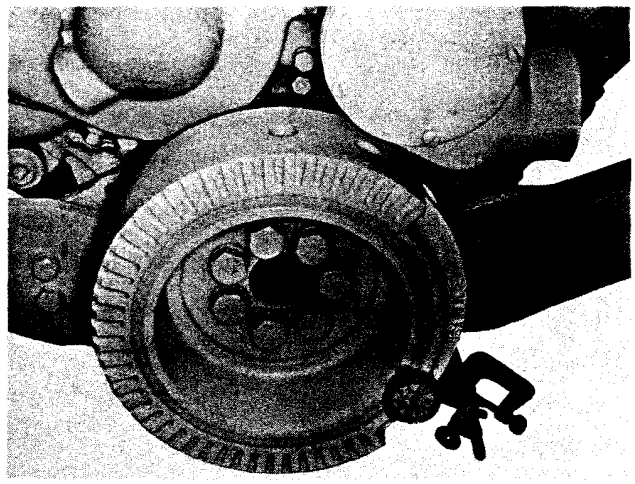


Fig. 2-58, (V22035). Checking crankshaft end clearance

Check Accessory Drive Hub And Pulley

Check hub and drive pulley to be sure that they are securely mounted.

Tighten capscrews each check. Check drive pulley for looseness or wobble, and, if necessary, remove hub and tighten the shaft nut. Tighten the bracket capscrews.

Lubricate Engine Water Pump — V-504, V-903, V-12

When water pumps contain a grease fitting or plug, through which grease may be inserted, give one "shot" (approximately 1 tablespoonful) each check. Units without grease fittings or pipe plugs should be disassembled, cleaned and repacked with grease at each "D" check. Fig. 2-59.

V8-300 and VT8-370 engine water pumps are lubricated by internal drillings and engine oil.

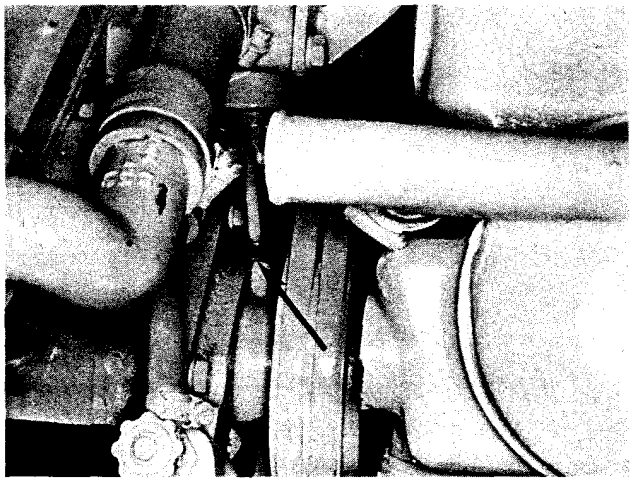


Fig. 2-59, (V11960). Water pump lubrication point of V-504

Lubricate Engine Water Pump — NH, NT

Check water pump for type and weight of lubricant used before adding SAE 90 gear lubricant or SAE 30 engine lubricating oil. Do not mix grades or brands of lubricant as damage to bearings and seals may result.

Assemblies Lubricated With Grease

1. Lubricate eccentric body (no idler pulley for belt adjustment) type water pump by applying grease gun to fitting, give one "shot" from grease gun. Fig. 2-60.

2. Overheating and bearing failure will result if overfilled. If disassembled, pack bearings and fill 1/2 to 2/3 capacity, see Page 5-3.

Assemblies Lubricated With SAE 90 Gear Lubricant Or SAE 30 Engine Lubricating Oil

1. Check level of lubricant in water pump (pump with idler pulley for belt adjustment) by removing pipe plug from side of pump (90 deg. from vertical) and checking for lubricant flow. Fig. 2-61 and 2-62.

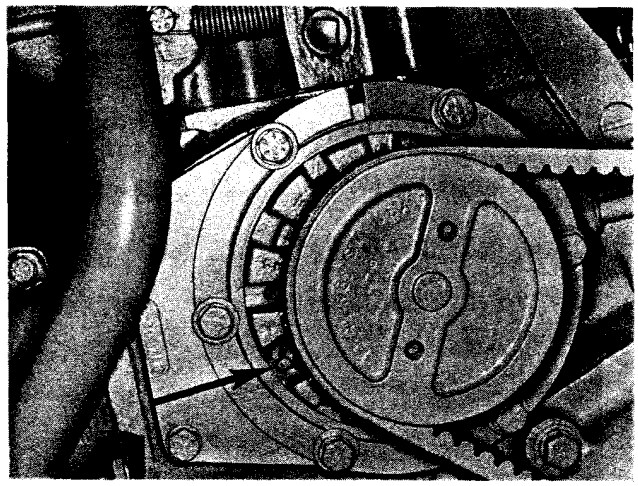


Fig. 2-60, (N11973). Eccentric body type water pump

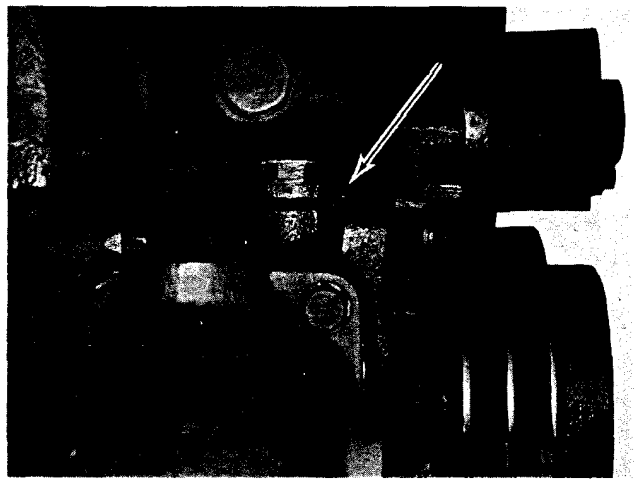


Fig. 2-61, (N11970). NTA-380 Remote type water pump

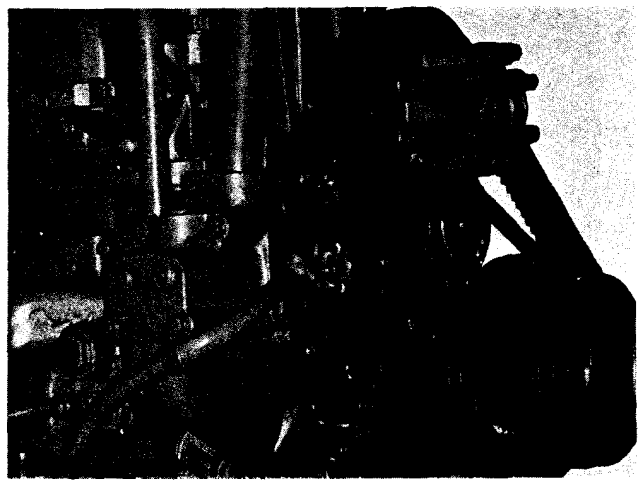


Fig. 2-62, (N11974). NH Water pump with idler pulley

2. To lubricate water pump, remove pipe plug from horizontal hole and fill cavity from upper (top) plug hole with lubricant until oil flows from plug hole on side of pump body. See Section 5 for lubricant specifications.

3. After lubrication is complete, replace both pipe plugs.

Note: When rebuilding all water pumps, except those lubricated by internal drillings with engine oil; clean thoroughly, prepack bearings and fill cavity 1/2 to 2/3 full with grease listed in specifications, Section 3.

E–Maintenance Check

At each "E" Maintenance Check, perform all "A," "B," "C" and "D" Checks in addition to those following.

The "E" Maintenance Check is often referred to as an engine overhaul, where engine is not removed from the boat, but some assemblies are rebuilt. In addition, a major inspection should be performed to determine whether engine may be operated for another service period, or whether it should be completely overhauled. Oil consumption, no oil pressure at idling, dilution and other signs of wear should be analyzed as part of the inspection.

Since major inspection requires partial disassembly of the engine, it should be done only in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

At this period, perform all previous checks and:

Inspect Bearings
Rebuild Cylinder Head
Replace Cylinder Liner Seals
Replace Piston Rings
Replace Front And Rear Crankshaft Seals
Replace Vibration Damper
Inspect Cylinder Liners
Inspect Pistons
Inspect Crankshaft Journals
Inspect Camshaft Lobes
Clean Engine Oil Cooler
Clean Marine Gear Oil Cooler
Calibrate Fuel Pump
Clean and Calibrate Injectors
Inspect Turbocharger Bearings
Rebuild Air Compressor or Vacuum Pump
Inspect Alternator/Generator and Cranking Motor
Inspect Intake and Exhaust System
Rebuild Engine Water Pump
Rebuild Raw Water Pump

Parts which are worn beyond replacement limits at this inspection should be replaced with new or rebuilt parts or units.

MAINTENANCE OPERATIONS SUMMARY

NOTE: INCLUDE SUMMARY OF DAILY "A" REPORTS PERFORMED BETWEEN "B" OPERATIONS IN NEXT "B" REPORT.

ENGINE SERIAL NO.____________

CHECKS	DUE	PERFORMED	DATE	MECHANIC	LABOR	PARTS		FUEL	LUBE OIL	TIME LOST	EMERGENCY REPAIRS			REMARKS
ENTER CHECKS B, C, D, E AS PERFORMED	U.S. GALLONS or HOURS	U.S. GALLONS or HOURS			HOURS	REQ. NO.	COST	U.S. GALLONS	U.S. QUARTS	HRS. OUT OF SERIVICE	LABOR	PARTS	TIME LOST—HOURS	ACCIDENTS—CAUSE OF FAILURE—MAJOR ITEMS REPLACED, ETC.
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCDE														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCD														
A B														
ABC														
A B														
ABCDE														
TOTALS														

Specifications and Torque

Providing and maintaining an adequate supply of clean, high-quality fuel, lubricating oil, grease and coolant in an engine is one way of insuring long life and satisfactory performance.

Lubricant , Fuel and Coolant

Lubricating Oil

Lubricating oil is used in Cummins engines to lubricate moving parts, provide internal cooling and keep the engine clean by suspending contaminants until removed by the oil filters. Lubricating oil also acts as a combustion seal and protects internal parts from rust and corrosion.

The use of quality lubricating oil, combined with appropriate lubricating oil drain and filter change intervals, is an important factor in extending engine life. Cummins Engine Company, Inc. does not recommend any specific brand of lubricating oil. The responsibility for meeting the specifications, quality and performance of lubricating oils must necessarily rest with the oil supplier.

Oil Performance Specifications

The majority of lubricating oils marketed in North America (and many oils marketed world-wide) are designed to meet oil performance specifications which have been established by the U.S. Department of Defence and the Automobile Manufacturers Association. A booklet entitled "Lubricating Oils for Heavy Duty Automotive and Industrial Engines" listing commercially available brand name lubricants and the performance classification for which they are designed, is available from Engine Manufacturing Association, 111 East Wacker Drive, Chicago, Illinois, 60601.

Following are brief descriptions of the specifications most commonly used for commercial lubricating oils.

Table 3-1: Oil Recommendations

Light Service Only (Stop-and-Go) All Diesel Models	Naturally Aspirated Diesel Models	Turbocharged Diesel Models	All Natural Gas Models All Service
API Class CC/SC [2/5] 1.85% Maximum Sulfated Ash Content [3]	API Class CC [1] 1.85% Maximum Sulfated Ash Content [3]	API Class CC/CD [2] 1.85% Maximum Sulfated Ash Content [3]	API Class CC .03 to .85% Sulfated Ash Content [4]

[1] API classification CC and CD quality oils as used in turbocharged engines and API classification CC/SC quality oils as used for stop-and go-service are satisfactory for use in naturally aspirated engines.

[2] API classification CC/SC and CC/CD indicate that the oil must be blended to the quality level required by both specifications. The range of oil quality permitted by the CC classification is so broad that some oils that meet the classification will not provide adequate protection (varnish and ring sticking) for engines operated in certain applications. For example, turbocharged engines require the additional protection provided by the CD classification. Engines operated in stop and go service require the additional protection provided by the SC classification.

[3] A sulfated ash limit has been placed on all lubricating oils for Cummins engines because past experience has shown that high ash oils may produce harmful deposits on valves that can progress to guttering and valve burning.

[4] Completely ashless oils or high ash content oils, are not recommended for use in gas engines; a range of ash content is specified.

[5] SD or SE may be substituted for SC.

API classification CC is the current American Petroleum Institute classification for lubricating oils for heavy duty gasoline and diesel service. Lubricating oils meeting this specification and designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

API classification CD is the current American Petroleum Institute classification for severe duty lubricating oils to be used in highly rated diesel engines operating with high loads. Lubricating oils which meet this specification have a high detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation.

API classification SC, SD and SE were established for the Automobile Manufacturers Association. They require a sequence of tests for approval. The primary advantage of lubricating oils in these categories is low temperature operation protection against sludge, rust, combustion chamber deposits and bearing corrosion. The test procedure for these specifications are published by the American Society for Testing and Materials as STP-315.

Break-In Oils

Special "Break-In" lubricating oils are not recommended for new or rebuilt Cummins Engines. Use the same lubricating oil as will be used for the normal engine operation.

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 3-1. Multigraded oils are generally produced by adding viscosity index improver additives to a low viscosity base stock to retard thinning effects at operating temperatures. Poor quality multigraded oils use a viscosity index improver additive which has a tendency to lose its effectiveness after a short period of use in a high speed engine. These oils should be avoided.

2. Oils which meet the low temperature SAE viscosity standard (0 deg. F [−18 deg. C]) carry a suffix "W." Oils that meet the high temperature viscosity SAE standard (210 deg. F [99 deg. C]) as well as the low temperature carry both viscosity ratings − example 20-20W. See Table 3-2.

Table 3-2: Operating Temperatures Vs Viscosity

Ambient Temperatures	Viscosity
−10 deg. F. [−23 deg. C] and below	See Table 3-3.
−10 to 30 deg. F. [−23 to −1 deg. C]	10W
20 to 60 deg. F. [−7 to 16 deg. C]	20 - 20W
40 deg. F. [4 deg. C] and above	30

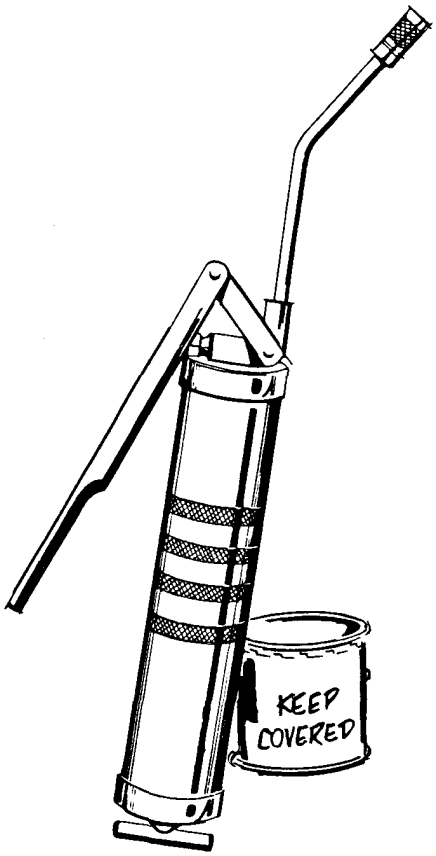
Arctic Operations

For operation in areas where the ambient temperature is consistently below −10 deg. F [−23 deg. C] and there is no provision for keeping engines warm during shutdowns, the lubricating oil should meet the requirements in Table 3-3.

Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is void, and SAE 5W oils should not be used.

Table 3-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC API class CC/CD
SAE Viscosity Grade	10W-20, 10W-30, 10W-40
Viscosity @−30 deg. F. (ASTM D-445)	10,000 Centistokes Maximum
Pour Point (ASTM D-97)	At least 10 deg. F. [6 deg. C] below lowest expected ambient temperature.
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum



Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact lubricant supplier for grease meeting these specifications.

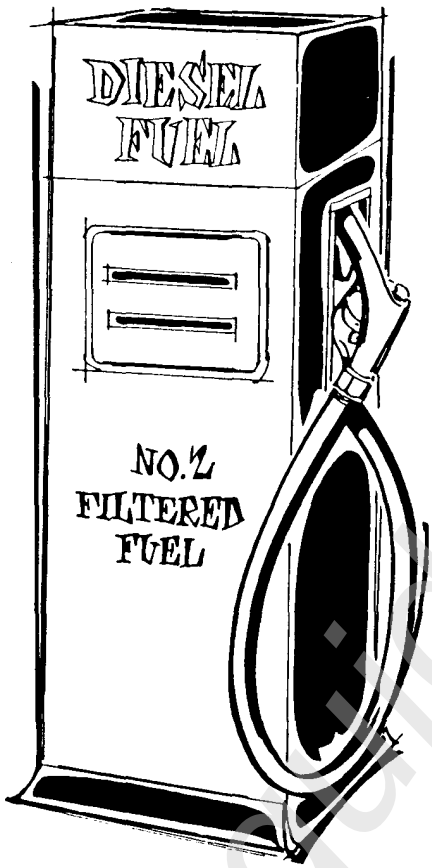
Test	Test Procedure	
High-Temperature Performance		
Dropping point, deg. F.	ASTM D 2265	350 min.
Bearing life, hours at 300 deg. F. 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0 deg. F.		15,000 max.
Run at 0 deg. F.		5,000 max.
Rust Protection and Water Resistance		
Rust test	ASTM D 1743	Pass
Water resistance, %	ASTM D 1264	20 max.
Stability		
Oil separation, % 30 Hours @ 212 deg. F	*FTM 321	5 max.
Penetration		
Worked	ASTM D 217	250-300
Bomb Test, PSI Drop	ASTM D 942	
100 Hours		10 max.
500 Hours		25 max.
Copper, Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

*Federal Test Method Standard No. 791a.

Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow grease to be thrown out, due to rotative speed.

Fuel Oil

Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.



Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	Centistokes 1.4 to 5.8 @ 100 deg. F. (30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125 deg. for legal temperature if higher than 125 deg. F.
Gravity (ASTM D-287)	30 to 42 deg. A.P.I. at 60 deg. F. (0.815 to 0.875 sp. gr.)
Pour Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122 deg. F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 675 deg. F. All of the fuel should evaporate at less than 725 deg. F.

Coolant

Water should be clean and free of any corrosive chemicals such as chloride, sulphates and acids. It should be kept slightly alkaline with pH value in range of 8.0 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Cummins Corrosion Resistor on the engine. The resistor by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

Table 3-4: Selection of Corrosion Resistor

Cooling System Capacity U.S. Gal.	Resistor Part No.	Element Part No.
To 15	209606	209604 (1)
To 30	209607	209605 (1)
Over 30	210107	209605 (2)

In Summer (No Antifreeze)

1. Fill system with water.

2. Install or replace corrosion resistor element (See Table 3-4.) as recommended in Section 2.

In Winter (Using Antifreeze)

1. Select an antifreeze known to be satisfactory for use with chromate element of the corrosion resistor and continue to use the resistor element or;

2. If you are not sure the antifreeze is compatible with the chromate resistor element:

a. Check with nearest Cummins Distributor for list of compatible antifreezes or ask antifreeze supplier to certify his antifreeze meets tests described in following paragraphs.

b. Use only antifreeze, with compounded inhibitors, in proper percentage and follow antifreeze supplier's recommendation to prevent corrosion.

c. In case "b," check corrosion control by draining a sample of coolant from the system as described under "Check Engine Coolant," Section 2.

Caution: Never use soluble oil in the cooling system when a Corrosion Resistor is being used.

Checking Antifreeze For Compatibility With Cummins Corrosion Resistor Chromate Elements

There have been several requests for information on the test to determine antifreeze-to-chromate compatibility, especially from foreign locations. The following test may be used; however, only a slight difference in antifreeze formulation can change the compatibility. The responsibility for meeting the compatibility tests, specifications, quality and performance of the antifreeze must necessarily rest with the antifreeze supplier.

The test for compatibility is made as follows:

1. Establish base solutions by:

a. Sodium Chromate – 35,000 ppm – Add 35 grams of anhydrous sodium chromate ($Na_2 CrO_4$) to a one liter volumetric flask and dilute to the one liter mark with distilled water.

b. Calcium Acetate – 125 ppm as $CaCO_3$ – Add 0.220 grams of calcium acetate monohydrate [$Ca(CH_3 COO)_2 H_2 O$] to a one liter volumetric flask and dilute to the one liter mark with distilled water.

2. Add 10 ml. (milli-liter) of the 25,000 ppm chromate solution (Step 1-a) to a centrifuge tube. (ASTM long form graduated tube. The first ml. should be divided into 1/20 ml. increments.)

3. Add 40 ml. (milli-liter) of standard calcium acetate solution (Step 1-b) to the centrifuge tube.

4. Add 50 ml. (milli-liter) of the antifreeze to be tested to this centrifuge tube.

5. Stopper, with a cork, and place in the oven at 160-165 deg. F for 96 hours.

6. At end of 96 hours, remove and insert in the centrifuge. Centrifuge at 10,000 relative centrifugal force for 15 minutes.

Note: Relative centrifugal force (rcf) is used as a standard for specifying the centrifuge specifications.

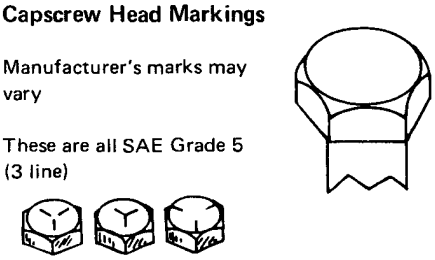
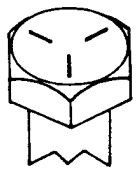
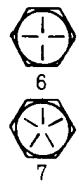
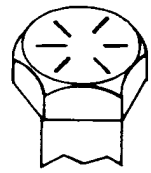
$$rcf = \left(\frac{rpm}{265}\right)^2 \times \text{dia. of swing}$$

7. A solids level of 0.5 ml. (milli-liter) or less is required for the antifreeze to be compatible with chromate elements.

Make-Up Coolant Specifications

Where possible, it is recommended that a supply of make-up coolant be prepared to specifications, using soft water where possible and a compatible antifreeze. Chromate treatment of coolant assures constant level of concentration when coolant is added and requires no change in schedule of element replacement. See Section 2.

Standard Capscrew Markings And Torque

Current Useage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI [Kg/Sq Cm]	To 1/2–69,000 [4850.70] To 3/4–64,000 [4499.20] To 1–55,000 [3866.50]	To 3/4–120,000 [8436.00] To 1–115,000 [8084.50]	To 5/8–140,000 [9842.00] To 3/4–133,000 [9349.90]	150,000 [10545.00]
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6 or 7	8
Capscrew Head Markings Manufacturer's marks may vary These are all SAE Grade 5 (3 line)				

Capscrew Body Size (Inches) – (Thread)		Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]
1/4	–20	5	[0.69]	8	[1.11]	10	[1.38]	12	[1.66]
	–28	6	[0.83]	10	[1.38]			14	[1.94]
5/16	–18	11	[1.52]	17	[2.35]	19	[2.63]	24	[3.32]
	–24	13	[1.80]	19	[2.63]			27	[3.73]
3/8	–16	18	[2.49]	31	[4.29]	34	[4.70]	44	[6.09]
	–24	20	[2.77]	35	[4.84]			49	[6.78]
7/16	–14	28	[3.81]	49	[6.78]	55	[7.61]	70	[9.68]
	–20	30	[4.15]	55	[7.61]			78	[10.79]
1/2	–13	39	[5.39]	75	[10.37]	85	[11.76]	105	[14.52]
	–20	41	[5.67]	85	[11.76]			120	[16.60]
9/16	–12	51	[7.05]	110	[15.21]	120	[16.60]	155	[21.44]
	–18	55	[7.61]	120	[16.60]			170	[23.51]
5/8	–11	83	[11.48]	150	[20.74]	167	[23.10]	210	[29.04]
	–18	95	[13.14]	170	[23.51]			240	[33.19]
3/4	–10	105	[14.52]	270	[37.34]	280	[38.72]	375	[51.86]
	–16	115	[15.90]	295	[40.80]			420	[58.09]
7/8	–9	160	[22.13]	395	[54.63]	440	[60.85]	605	[83.67]
	–14	175	[24.20]	435	[60.16]			675	[93.35]
1	–8	235	[32.50]	590	[81.60]	660	[91.28]	910	[125.85]
	–14	250	[34.58]	660	[91.28]			990	[136.92]

1. Always use the torque values listed above when definite specifications are not available.

   Note: Do not use standard values in place of those specified in the above engine groups; special attention should be observed in case of SAE Grade 6, 7 and 8 capscrews.

2. The above is based on use of clean and dry threads.

3. Reduce torque by 10% when engine oil is used as a lubricant.

4. Reduce torque to 20% if new plated capscrews are used.

Caution: Capscrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

Trouble Shooting

Trouble shooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart on the next page does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column until you come to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?

2. What previous repair and maintenance work has been done?

3. Has similar trouble occurred before?

4. If the engine still runs, is it safe to continue running it to make further checks?

The answers to these questions can usually be obtained by:

1. Questioning the operator.

2. Reading the Daily Operators Report.

3. Consulting the Maintenance Check Sheet.

4. Taking time to think the problem through.

5. Looking for additional symptoms.

6. Consulting the Trouble Shooting Chart.

7. Checking the simplest things first.

8. Double checking all conclusions before "disassembly of the engine or units."

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lubricating oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

Trouble Shooting

CAUSES	Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubricating Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearing and Journals	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM																										
Restricted Air Intake	●		●		●		●	●																		
High Exhaust Back Pressure	●		●		●		●	●										●								
Thin Air In Hot Weather or High Alt.			●		●		●																			
Air Leaks Between Cleaner and Engine							●													●	●	●				
Dirty Turbocharger Compressor			●		●		●	●																		
Improper Use of Starter Aid/Air Temp.	●																						●			
FUEL SYSTEM																										
Out of Fuel or Fuel Shut-Off Closed	●											●														
Poor Quality Fuel	●	●		●		●			●			●											●			
Air Leaks in Suction Lines	●	●				●			●	●		●														
Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●		●	●		●	●		●														
External or Internal Fuel Leaks						●			●			●			●	●										
Plugged Injector Spray Holes	●	●	●	●		●			●			●														
Broken Fuel Pump Drive Shaft	●											●														
Scored Gear Pump or Worn Gears	●					●																				
Loose Injector Inlet or Drain Connection	●														●											
Wrong Injector Cups			●	●		●			●						●											
Cracked Injector Body or Cup			●	●					●						●											
Mutilated Injector Cup "O" Ring									●						●											
Throttle Linkage or Adjustment					●	●				●	●	●														
Incorrectly Assembled Idle Springs										●	●	●														
Governor Weights Assembled Incorrectly												●														
High-Speed Governor Set Too Low					●	●																				
Water in Fuel	●	●				●						●														
LUBRICATING SYSTEM																										
External and Internal Oil Leaks													●		●											
Dirty Oil Filter														●	●	●					●	●				
Faulty Cylinder Oil Control			●	●									●		●					●	●	●				
Clogged Oil Drillings																●				●	●	●				
Oil Suction Line Restriction																●				●	●	●				
Faulty Oil Pressure Regulator																●										
Crankcase Low or Out of Oil																●		●	●	●	●	●				
Wrong Grade Oil for Weather Conditions													●			●										
Oil Level Too High						●		●					●						●							
COOLING SYSTEM																										
Insufficient Coolant																●		●	●				●	●		
Worn Water Pump																●		●	●							
Faulty Thermostats														●		●	●	●	●							
Damaged Water Hose																●		●	●							
Clogged Water Passages																●		●	●							
Internal Water Leaks															●	●										
Clogged Oil Cooler																●										
Heat Exchanger Core Dirty																●		●	●							
Air in Cooling System																●		●	●							
Exterior Water Leaks																●		●	●							
Insufficient Coolant Capacity																●							●			
Coolant Temperature Low														●	●								●			
OPERATION AND MAINTENANCE PRACTICES																										
Dirty Filters and Screens					●									●						●	●	●				
Long Idle Periods	●	●	●	●	●									●												
Engine Overloaded				●				●								●		●	●	●	●	●	●	●		
Oil Needs Changing														●						●	●	●				
Engine Exterior Caked with Dirt																●			●							
MECHANICAL ADJUSTMENTS OR REPAIR																										
Gasket Blow-by or Leakage			●	●	●																			●		
Faulty Vibration Damper																								●		
Unbalanced or Loose Flywheel																								●		
Valve Leakage	●	●			●																	●				
Broken or Worn Piston Rings	●	●	●	●	●								●							●				●		
Incorrect Bearing Clearances					●			●								●					●			●		
Excessive Crankshaft End Clearance																					●			●		
Main Bearing Bore Out of Alignment																					●			●		
Engine Due for Overhaul	●		●		●			●					●			●				●	●	●		●		●
Damaged Main or Rod Bearings																●					●			●		
Broken Tooth in Gear Train																								●		
Excessive Gear Back Lash																								●		
Misalignment Engine to Marine Gear								●																●		●
Loose Mounting Bolts																								●		●
Incorrect Valve and Injection Timing	●		●	●	●																	●				
Worn or Scored Liners or Pistons			●	●	●								●							●				●		
Injectors Need Adjustment			●	●	●			●															●			
Bent Shaft					●																					●
Bent Wheel					●																					●
Over Wheeled					●																					