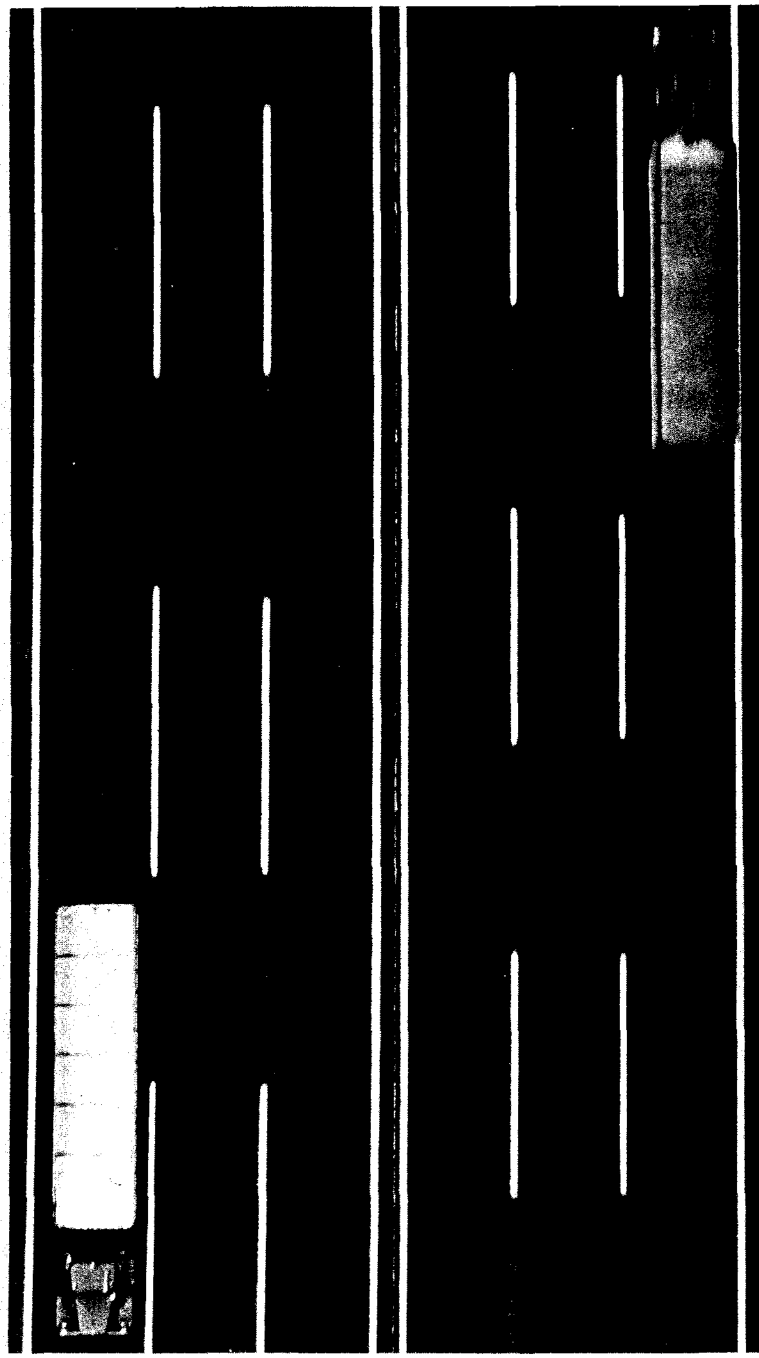
Cummins Automotive Diesel Engines



Operation and Maintenance Manual

Bulletin 983700-CE Printed 8-1972
Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A., 47201

Operation and Maintenance Manual

Cummins Automotive Diesel Engines

IMPORTANT REFERENCE NUMBERS

CHASSIS SERIAL 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. ____________________

FAN BELT NO. ____________________

ALTERNATOR BELT NO. ____________________

POWER STEERING PUMP BELT NO. ____________________

Foreword

The information contained in this publication pertains to Cummins Inline and V6-V8 Diesel Engines used in automotive 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:

NTA - 370	V903 - 320
N = 4 valve head	V = Type engine
T = Turbocharged	903 = Cubic Inch Displacement
A = Aftercooled	320 = Maximum rated horsepower
370 = Maximum rated horsepower	

Table: Other Application Designations

*	Automotive (On-highway)
B	Off - Highway (Usually less compressor)
C	Construction (Construction Industry)
G	Generator Set
P	Power Units (Various Components used.)
M	Marine
D	Dump or Mixer Application

*Refer to Table on Page 4 for Automotive Engines Horsepower Specifications.

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.

Your Cummins Diesel Engine has been built by Cummins to comply with the requirements of the Federal (U.S.) Clean Air Act. Proper Maintenance of the Engine, which is your responsibility, is essential to keep emission levels low. Section 2, Maintenance Operations, of this manual sets forth the maintenance schedule which you should follow.

To prove that you have properly maintained the Engine you should retain records, such as work orders and receipts, showing that scheduled maintenance has been performed.

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A.

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Table 1: Automotive Model Specifications

Engine Model	HP @ RPM * Sea Level/60 deg F	HP @ RPM 500'/85 deg F	Aspiration	No. Cyl.	Bore and Stroke	Displacement Cu. In.
Heavy Duty						
NH-230	230 @ 2100	220 @ 2100	Natural	6	5-1/2 x 6	855
NHC-250	250 @ 2100	240 @ 2100	Natural	6	5-1/2 x 6	855
Super-250	250 @ 2100	240 @ 2100	Natural	6	5-1/2 x 6-1/2	927
NTC-290	290 @ 2100	290 @ 2100	Turbocharged	6	5-1/2 x 6	855
NTC-335	335 @ 2100	335 @ 2100	Turbocharged	6	5-1/2 x 6	855
NTC-350	350 @ 2100	350 @ 2100	Turbocharged, Aftercooled	6	5-1/2 x 6	855
NTA-370	370 @ 2100	370 @ 2100	Turbocharged, Aftercooled	6	5-1/2 x 6	855
V-903	320 @ 2600	307 @ 2600	Natural	8	5-1/2 x 4-3/4	903
VT-903	320 @ 2600	320 @ 2600	Turbocharged	8	5-1/2 x 4-3/4	903
Medium Duty						
V6-155	155 @ 3300	149 @ 3300	Natural	6	4-5/8 x 3-3/4	378
V8-210	210 @ 3300	202 @ 3300	Natural	8	4-5/8 x 3-3/4	504
V-555E	210 @ 3300	202 @ 3300	Natural	8	4-5/8 x 4-1/8	555
V-555	225 @ 3300	216 @ 3300	Natural	8	4-5/8 x 4-1/8	555
V-555	240 @ 3300	230 @ 3300	Natural	8	4-5/8 x 4-1/8	555
Special Duty						
C-180	180 @ 2500	173 @ 2500	Supercharged	6	4-7/16 x 5	464
C-190**	190 @ 2500	190 @ 2500	Turbocharged	6	4-7/16 x 5	464
NHD-230**	230 @ 2100	220 @ 2100	Natural	6	5-1/2 x 6	855
Power Torque 270	270 @ 2100	270 @ 2100	Turbocharged	6	5-1/2 x 6	855
NHF-240**	240 @ 2300	230 @ 2300	Natural	6	5-1/2 x 6	855
NHF-265**	265 @ 2300	255 @ 2300	Natural	6	5-1/2 x 6	855
NTF-295**	295 @ 2300	295 @ 2300	Turbocharged	6	5-1/2 x 6	855
NTF-365**	365 @ 2300	365 @ 2300	Turbocharged	6	5-1/2 x 6	855
NTA-400**	400 @ 2100	400 @ 2100	Turbocharged, Aftercooled	6	5-1/2 x 6	855
NTA-420**	420 @ 2300	420 @ 2300	Turbocharged,	6	5-1/2 x 6	855
NHH-250 80° Tilt**	250 @ 2100	240 @ 2100	Natural	6	5-1/2 x 6	855
Shotts						
NHK-205 †		197 @ 2100	Natural	6	5-1/8 x 6	743
NHK-220 †		212 @ 2100	Natural	6	5-1/8 x 6	743

Note: K designates right hand drive models to be sold only in the United Kingdom.

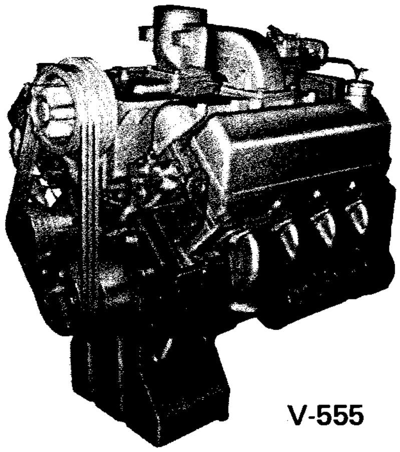
* Horsepower stated is derived by adjusting SAE standard J816A rating of naturally aspirated engines by 4 percent to indicate approximate performance at sea level and 60 deg. F [16 deg. C] intake air temperature, assuming an adjustment to fuel rate to maintain same fuel: air ratio as SAE rating.

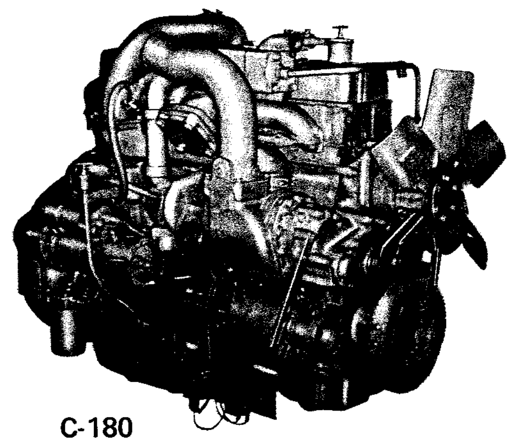
** C-190 is designed for transit-mix and dump trucks. NHD-230 is designed for transit-mix, dump trucks, and drill rigs. "F" engines are designed for fire trucks and crane carriers. NTA-400 is designed for on-highway logging applications. NTA-420 is designed for off-highway logging applications and crane carriers. NHH-250 80 deg. tilt engine is designed for use in buses.

† NHK-205 and NHK-220 are smoke certified only for the U.K. to BS AU141a 1971 British Standard. Other engines built at the Shotts, Scotland plant to U.S. design standards carry the U.S.A. smoke certification.

Naturally aspirated engines, permanently stationed at altitude, should be derated 3% by fuel rate adjustment for each 1000 feet [304.8 m] above 500 feet [152.4 m] and 1% for each 10 deg. F [6 deg. C] above 85 deg. F [29 deg. C] temperature.

Turbocharged engines may be operated to altitudes specified on engine performance curves without changing fuel rate.


V-555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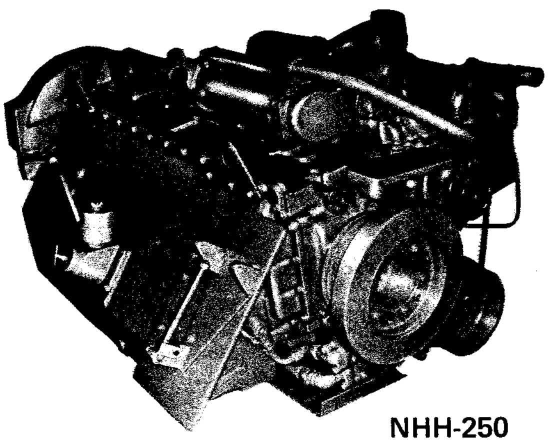
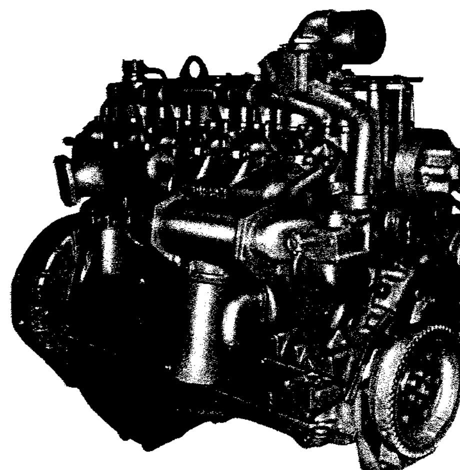
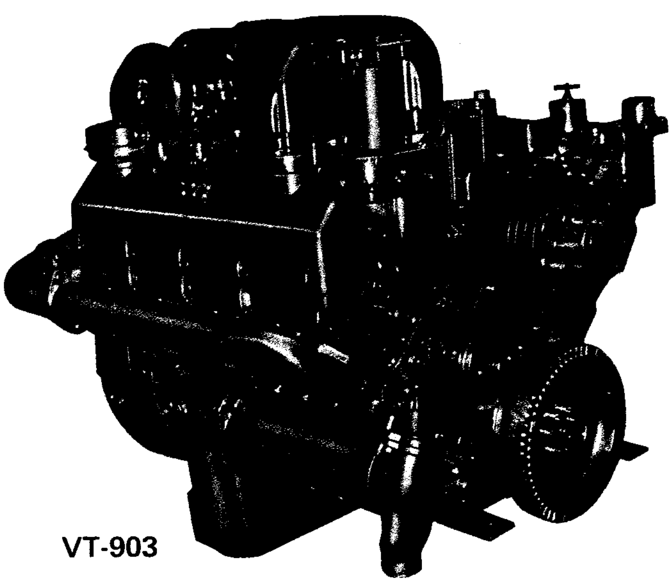
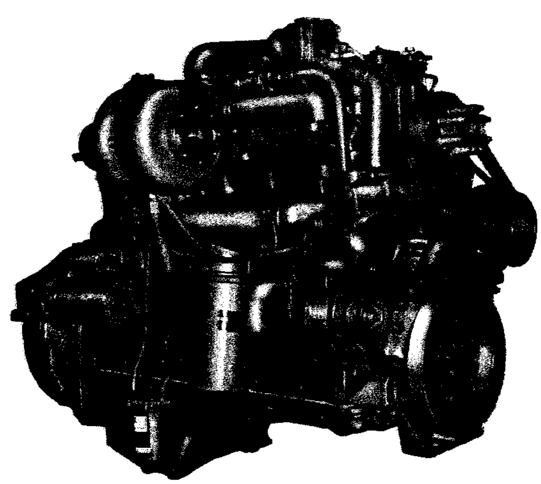

NHH-250


Super-250

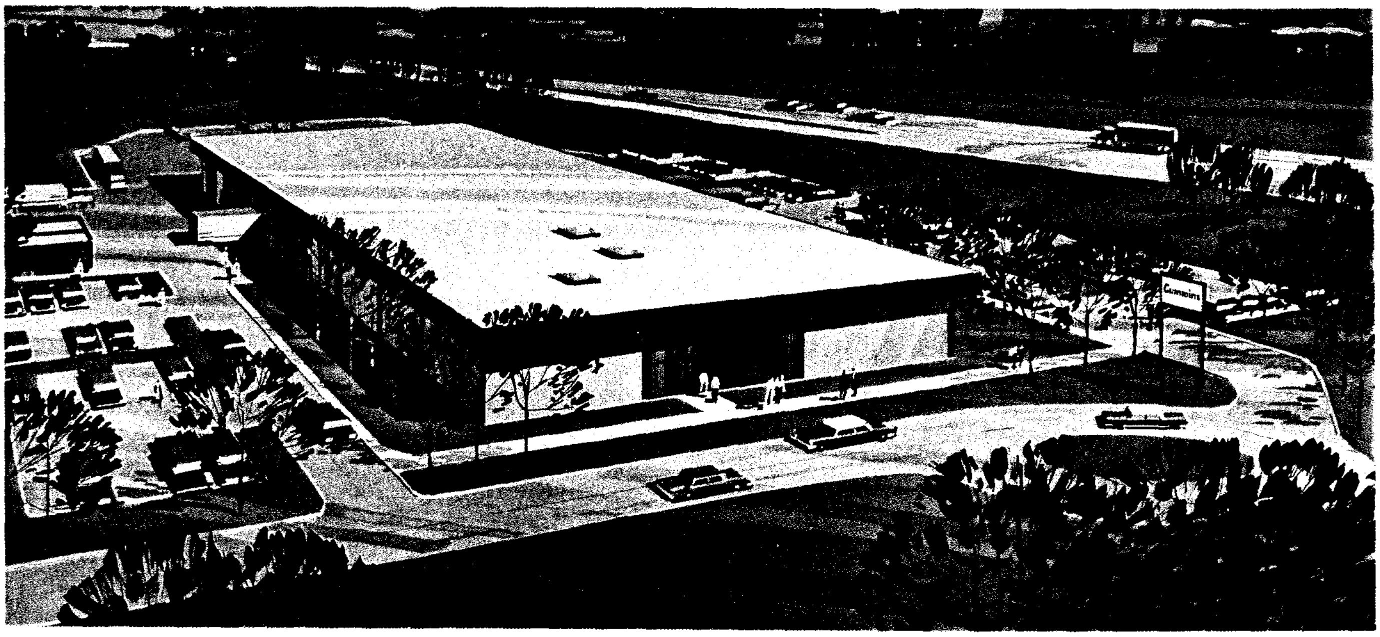

VT-903


NTC-335

TO THE ENGINE OWNER

All new Cummins Engines should be made available to a Cummins Distributor or Dealer at the first "B" interval as specified in the Maintenance Schedule, Page 2-2 or 90 days of operation, 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 inspecting 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 engine operator must assume responsibility of engine care while engine is being operated. This is an important job and one that will determine to a large degree the extent of profit from operation. There are comparatively few rules which operator must observe to get 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.

Automotive Engines

New And Rebuilt Engine Break-In

Cummins engines are run-in on dynamometers before being shipped from the factory and are ready to be put to work in applications such as emergency fire trucks.

In other applications, the engine can be put to work, but the operator has an opportunity to establish conditions for optimum service life during initial 100 hours or 3000 mi. [4827 km] of service by:

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

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

3. Developing 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. Operating with a power requirement that allows acceleration to governed speed when conditions require more power.

5. Checking oil level at each 300 mi. [483 km] or 10 hours during the break-in period.

Pre-Starting Instructions — First Time

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 and fill fuel tanks.

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's. 1-1 and 1-2) or gear case cover to prime system.

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 plug boss in housing.

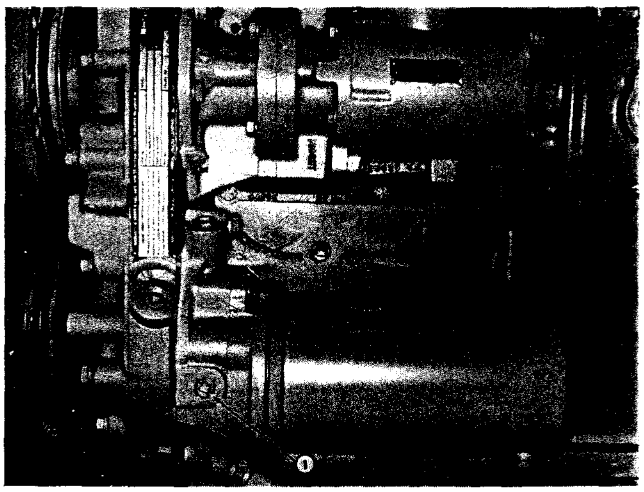


Fig. 1-1, (N11963). Lubricating system priming point - inline engine

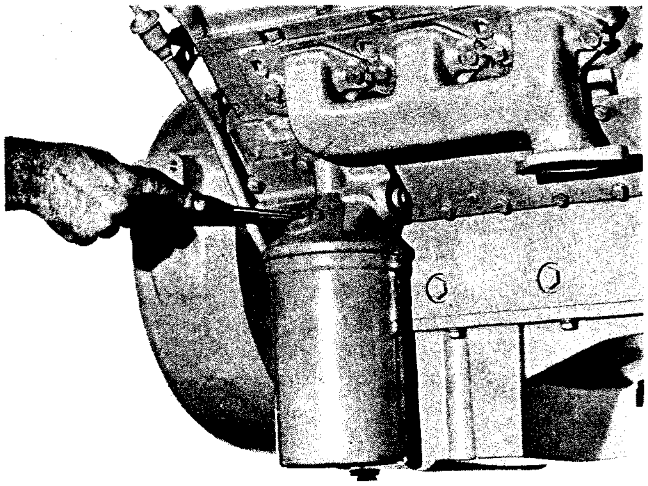


Fig. 1-2, (V11466). Lubricating system priming point - small V-engine

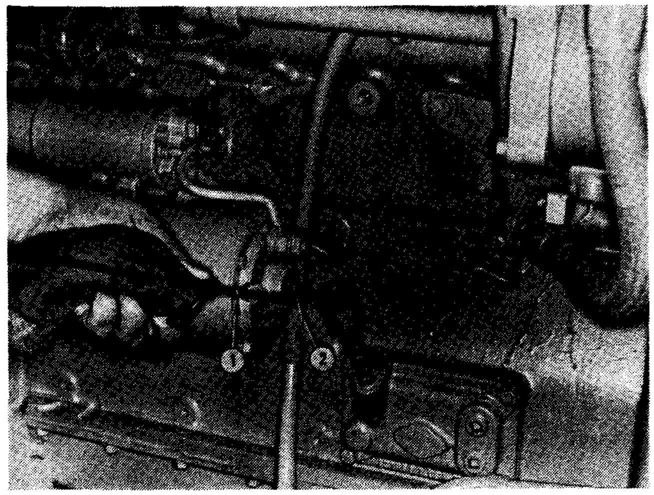


Fig. 1-3, (N12004). Checking engine oil level

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 [1.1 kg/sq cm].

6. Remove external oil supply line and replace plug in lubricating oil filter housing, torque 15 to 20 ft-lbs [2.1 to 2.8 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.

Check Air Connections

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

Check Engine Coolant Supply

1. Remove radiator cap and check engine coolant supply. Add coolant as needed to completely fill system. See Section 3 for coolant specifications.

2. Make visual check for leaks and open corrosion resistor shut-off valves.

Check Fuel Supply And Connections

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

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

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

If fuel system is equipped with overspeed stop, push "Reset" button before attempting to start engine.

Caution: Before starting, check to make sure everyone is clear of engine and equipment, to prevent accidents.

1. Set throttle for idle speed.

2. Disengage driven unit or make sure gears are in neutral.

3. Open manual fuel shut-down valve, if engine is so equipped. Electric shut-down valves operate as switch is turned on.

4. Pull the compression release (if so equipped).

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

position.

Note: A manual override knob provided on the forward end of the electric shut-down valve allows the valve to be opened in case of electric power failure. To use, open by turning fully clockwise; return to run position after electric repair.

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.

6. 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).

Cold-Weather Starting

To aid in starting engine when temperature is 50 deg. F [10 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. 1-4 and 1-5.

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:

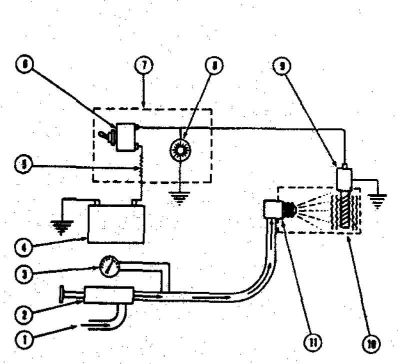


Fig. 1-4, (N11804). Preheater wiring diagram

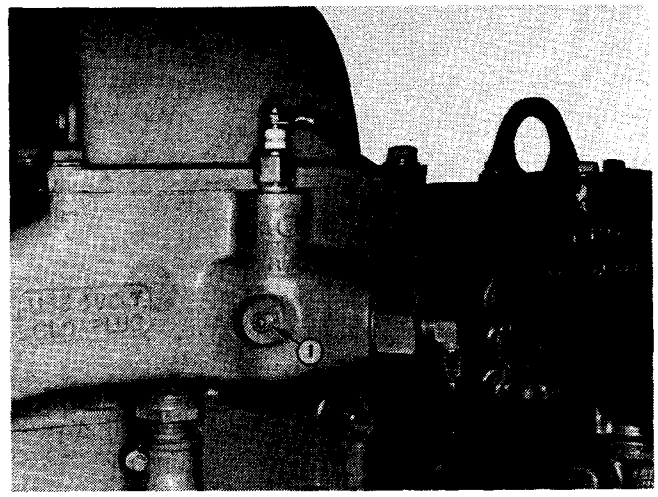


Fig. 1-5, (N11949). Glow plug inspection hole plug - NT engine

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.

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 [5.6 to 7 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 [0.5 to 0.7 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. 1-5) 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. 1-6). If properly installed, the spring will hold it closed.

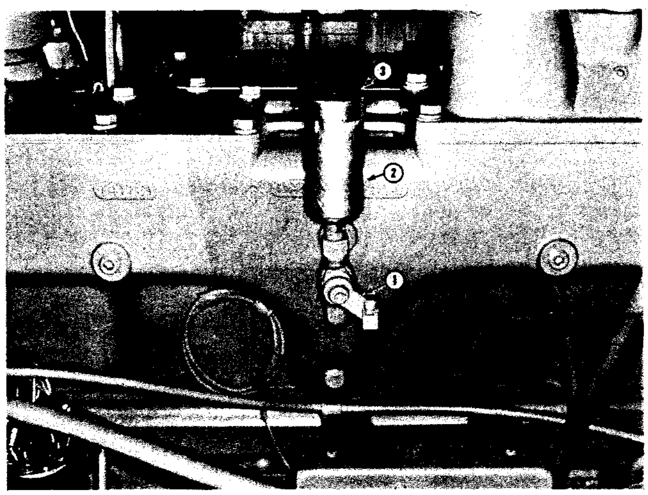


Fig. 1-6, (N11841). Ether compound metering equipment

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 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 cab, a flexible cable and cable housing attached to container, bracket mounted on fire wall (1, Fig. 1-7). Pulling knob, in cab, 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.

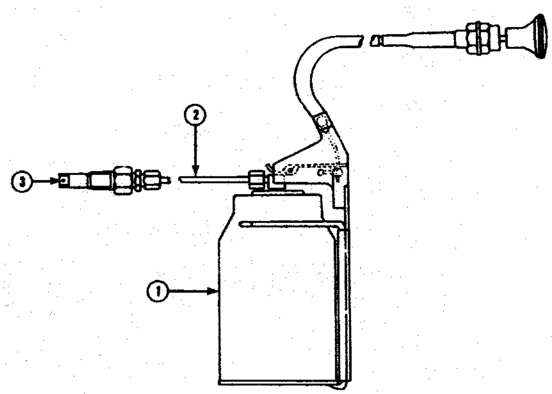


Fig. 1-7, (V11469). Starting fluid spray applicator

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 [−32 deg. C], if unit will not start with above instructions, remove starting fluid can and warm to room 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 cleaner intake, Fig. 1-8, while second man cranks the engine.

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.

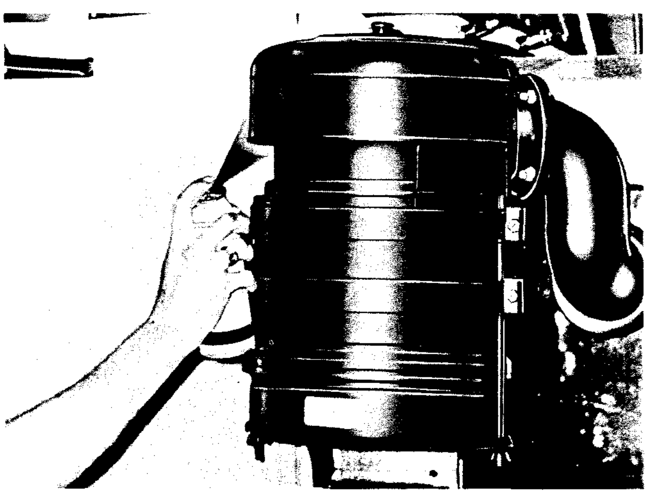


Fig. 1-8, (N11807). Ether spray application

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 to 74 deg. C], operate at partial load at approximately 75% of governed rpm.

On some emergency equipment (such as fire engines) warm-up may not be necessary due to equipment being housed inside a heated building.

Engine Speeds

Idle Speeds

In most applications engine idle speeds are 580 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, except when pushed by load downhill, etc.

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: Automotive Engine Speeds

Engine Model	Rated RPM	Cruising RPM
All NH-NT	1950	1800-1900
All NH-NT (except CT)	2100	1900-2000
Power Torque 270	2100	1600-2000
Super-250	2100	1900-2000
All NH-NT	2300	1950-2100
V-903, VT-903	2600	2200-2300
V-378, V-504, V-555	3000	2500-2550
V-378, V-504, V-555	3300	2800-2850
C	2500	2150-2250

Operate At Reduced RPM For Efficiency

When operating a truck on a level highway, hold engine rpm at approximately 90 percent (80 percent for Custom-Torque Engines) of governed rpm. See Table 1-1. This will give adequate power and economical fuel mileage.

Most automotive operations will fall in this speed range. The engine will be operating in the easy shift range and will not be working hard.

Many trucks are geared for higher maximum road speeds than schedules require, so drivers can operate in high gear and at reduced engine rpm. This is good practice as long as the engine pulls its load at partial throttle.

Instrument Panels

The instruments show at all times how to get the most satisfactory service from any engine.

Use The Tachometer

Rated engine speed is the rpm attained at full load. Governed engine speed is the highest rpm a properly adjusted governor will allow the engine to turn, no load. Governed engine speed must never be exceeded on downgrades or any other condition in which the load drives the engine.

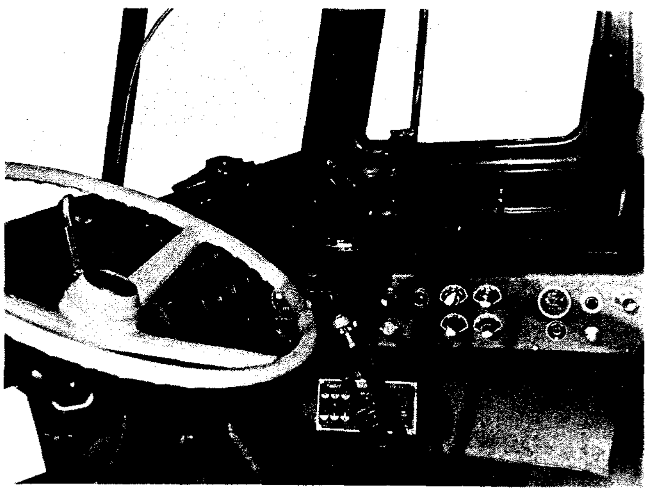


Fig. 1-9, (V51930). Typical automotive instrument panel

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

Oil Temperature Gauge Indicates Best Operating Range

The oil temperature gauge normally should read between 180 deg. F [82 deg C] and 225 deg F [116 deg C] for best lubrication. Under full load conditions, a temperature of 265 deg F [129 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 [74 to 91 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 water pump belts, a clogged cooling system, or insufficient radiator capacity. Report cases of overheating to the Maintenance Department for correction; 200 deg. F [93 deg. C] maximum engine coolant temperature 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 [74 deg. C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling. (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.

Normal Operating Pressures at 225 deg. F [107 deg. C] are:

Table 1-2: Oil Pressure PSI [kg/sq cm]

Engine Series	Idle Speed	Rated Speed
NH-NT, Super-250	5/20 [0.4/1.7]	40/75 [2.8/5.3]
C	10/30 [0.7/2.1]	40/75 [2.8/5.3]
V-903, VT-903	5/25 [0.4/1.8]	40/65 [2.3/4.6]
V-378, V-504, V-555	10/25 [0.7/1.8]	45/75 [3.2/5.3]

For record purposes these readings are more accurate and reliable when taken immediately after an oil change.

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.

Attention Operator

Your Cummins Diesel Engine has been built by Cummins to comply with the requirements of the Federal (U.S.) Clean Air Act. Proper Maintenance of the Engine, which is your responsibility, is essential to keep emission levels low.

Once the engine is placed in service the responsibility for meeting state and local regulations must necessarily be with the owner/operator.

Observation of good operating practices, regular maintenance and proper adjustments are factors which will help stay within the regulations.

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. This rule applies to all applications (except High-Torque Engines).

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.

Shift To A Lower Gear When The Load Pulls Down Engine RPM

The practice of shifting gears – next to safety observance – is a most important phase of good engine operation.

The shift point differs from unit to unit depending upon engine rated speed, torque peak point, and transmission or gear splits available; therefore, it is not always possible to state exactly at which speed to shift unless all the variable facts are known. A good rule is "shift down at the same engine speed the tachometer indicated immediately after shifting up."

As one example, run to the governor (engine rated speed) in fourth gear, then shift to fifth gear. The engine speed falls to 1700 rpm, which indicates the ratio difference between these two gears. Likewise, when pulling up a hill in fifth gear, shift to fourth when the engine speed pulls down to 1700 rpm. The engine will increase to governed speed in fourth, and the increased horsepower acting through the lower ratio of fourth gear will allow the engine to pull the grade.

On a steep grade, start down-shift before the engine actually pulls down to shifting speed, because the truck will lose speed while shifting gears.

Failure to shift down at the right time, or a delayed down-shift, will result in the engine failing to reach full power, and make another down-shift necessary.

When approaching a hill, open throttle smoothly to start the up-grade at full power, then shift down as soon as the engine has dropped to shifting speed. Do not wait until the engine is below shifting speed. Less gear shifts will be required and average road speed will be higher if this is done smoothly. Custom Torque Engines will require fewer gear shifts, due to higher torque at lower rpm. Through driving experience, one will learn when down-shifting is required.

Downhill Operation

The Cummins Diesel is effective as a brake on downhill grades, but care must be exercised not to overspeed the engine going downhill. The governor has no control over engine speed when it is being pushed by the loaded vehicle.

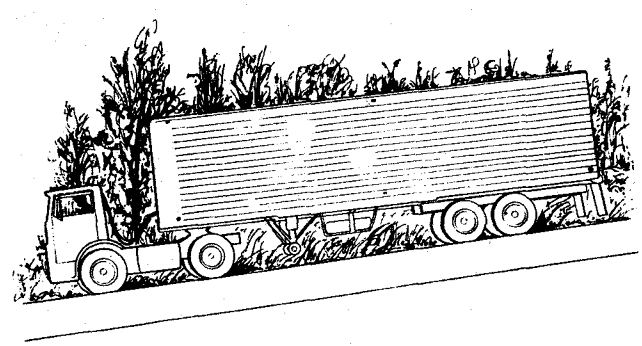


Fig. 1-10, (V21817). Downhill operation

Never turn off the switch key while going downhill. With the engine still in gear, fuel pressure will build up against the shut-down valve and may prevent it from opening when the switch key is turned on.

Use Brake As Needed To Prevent Excessive Engine Speeds

Use a combination of brakes and gears to keep vehicle under control at all times, and to **keep engine speed below rated governed rpm.**

Auxiliary Braking Systems

Some trucks are equipped with auxiliary braking equipment which utilize the engine as a braking device to reduce wear on the normal truck brake system. Operation of the units is relatively simple; however, correct adjustment is very important to prevent damage to the engine; check with a Cummins Distributor for any necessary adjustments before using auxiliary braking system.

Cummins Engine Company, Inc. warranty does not cover engine damage resulting from use of auxiliary braking systems since such damage can be caused by improper application, lack of maintenance, incorrect use or malfunction of such brakes.

Exhaust Brake

So called because closing of a valve in the exhaust system retains compression pressures within the exhaust manifolding and engine cylinders to utilize these pressures to reduce speed. Compression braking is most efficient when engine is permitted to turn at same speeds as for efficient power and may be used as much and as often as possible.

Jacobs Engine Brake

This braking system converts the engine into a power absorbing air compressor using a master slave piston arrangement to open engine exhaust valves near top of engine compression stroke releasing pressures to exhaust. The effect being a net energy loss since work done during compression is not returned during the expansion process.

The operator selects a gear which will provide a balance between engine speed and road speed. If engine exceeds maximum rated rpm for a designed road speed, a lower gear can be selected, or intermittent use can be made of vehicle service brakes. Selection of a lower gear will generally allow complete control of vehicle by the brake leaving the service brakes in reserve for emergency stops.

High Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft. [304.8 m] altitude above sea level for a naturally aspirated engine. Most turbocharged engines are rated at higher altitudes than naturally aspirated engines. (See Engine Specification Tables at front of this manual.) An engine will have a smoky exhaust at high altitude unless a lower gear is used so the engine will not demand full-fuel from the fuel system unless the engine is altitude compensated by the use of a turbocharger. Smoke wastes fuel, burns valves and exhaust manifolds, and "carbons up" piston rings and injector spray holes. Shift gears as needed to avoid exhaust smoke.

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 automotive 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 automotive throttle is in idle position. Operate as follows:

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

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

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

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

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

3. To return to automotive throttle control:

a. Use automotive 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 automotive throttle to idle position and resume operation of unit as an automotive vehicle.

Caution: Never return automotive 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 Section 5, "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 [47 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.

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

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 1-2. 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 the next trip or another load 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 drain cylinder block and head on an Inline 855 Series Engine, open petcock in thermostat housing and remove drain plug in rear of oil cooler cover or at rear of block, Fig. 1-11. To drain a 927 Series Engine, open petcock in thermostat housing and remove two drain plugs, one in front of cooler and the other at rear of block, Fig. 1-12

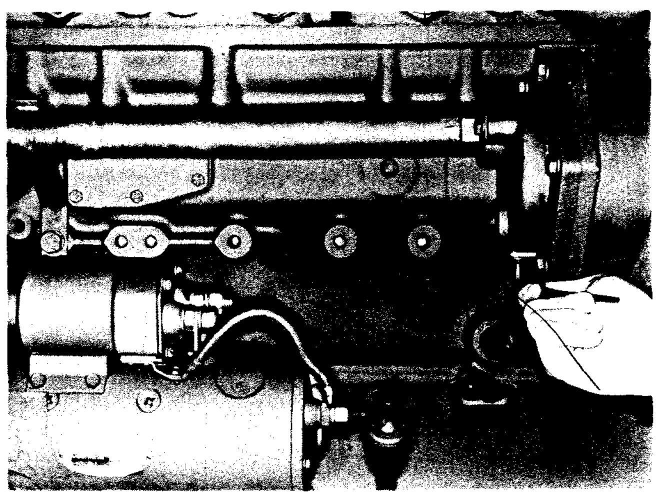


Fig. 1-11, (N100124). NH or NT-855 Cylinder block drain point

3. To completely drain V-378, V-504, V-555 and V-903 cylinder blocks and cylinder heads, open petcock or remove drain plug on water header plate and on lubricating oil cooler (1, Fig's. 1-13 and 1-14) when used. If an air compressor, heat exchanger or other "water-cooled" accessory is used, open petcock and drain. Fig. 1-15. Failure to drain any of these units may cause serious damage in freezing weather.

4. To drain cylinder block and head on C Series, open drain cock or remove drain plug on side of cylinder block,

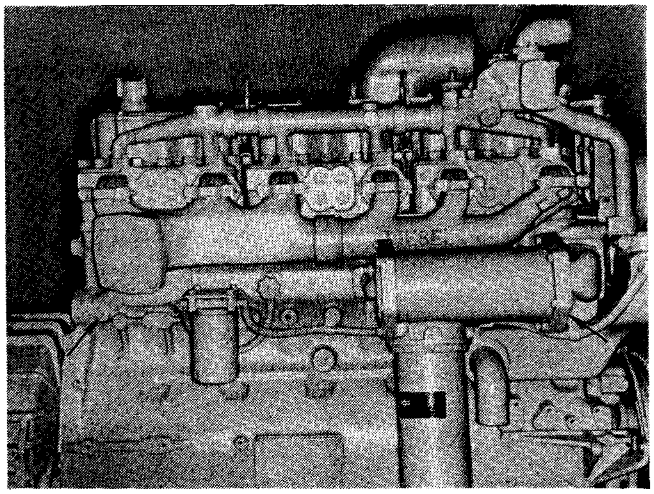


Fig. 1-12, (N100126). Super-250 Coolant drain points

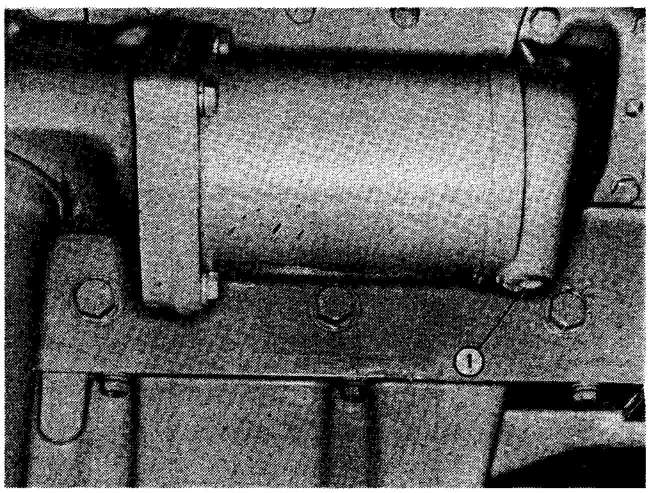


Fig. 1-13, (V10819). Coolant drain point (oil cooler side) V Series

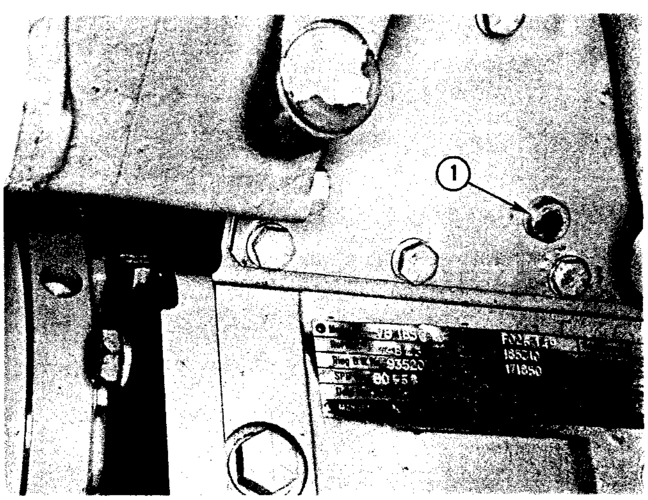


Fig. 1-14, (V10820). Coolant drain point (left bank side) V Series

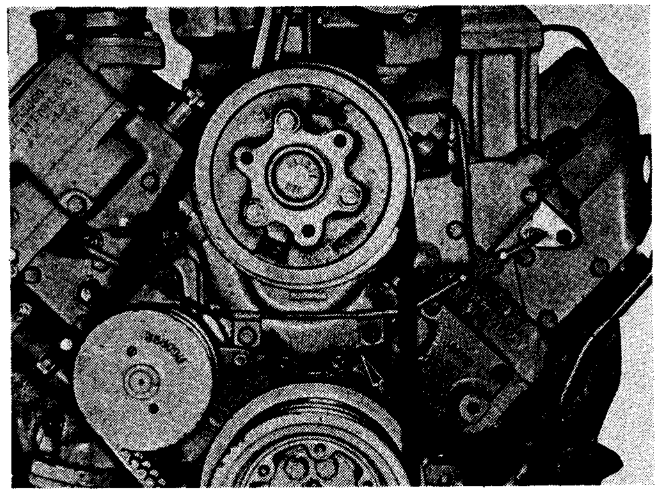


Fig. 1-15, (V10821). Coolant drain point (front water crossover) V Series

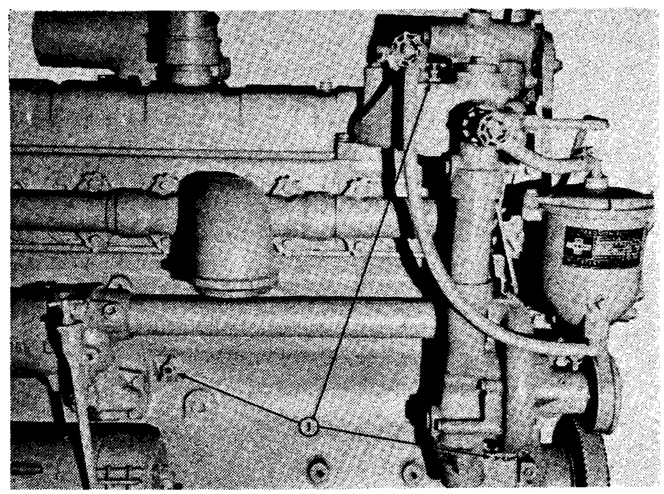


Fig. 1-16, (N20001). Coolant drain point C Series

bottom of water pump and open vent cock on thermostat housing, Fig. 1-16.

Operator's Daily Report

Make A Daily Report Of Engine Operation To The Maintenance Department

The engine must be maintained in top mechanical condition if the operator is to get optimum satisfaction from its use.

Engine adjustments, etc., are the work of the Maintenance Department. However, the Maintenance Department needs daily running reports from the operator to make necessary adjustments in the time allotted between runs and to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate practically all road failures and emergency repairs.

Report to the Maintenance Department any of the following conditions:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noise.
5. Excessive smoke.
6. Excessive use of coolant, fuel or lubricating oil.
7. Any fuel or lubricating oil leaks.

Maintenance Operations

Maintenance is the key to lower operating costs. A diesel engine — like any other engine — requires regularly scheduled maintenance to keep it running efficiently. Most diesel engines are purchased and used for the sake of revenue. Any failure or loss of efficiency reduces revenue, it also requires additional funds or repair.

Maintenance Schedule

Preventive maintenance performed on schedule is the easiest, as well as the least expensive type of maintenance. It permits the Maintenance Department to work on schedule, rather than at inconvenient hours.

Accessories must have a place in the maintenance schedule the same as the basic engine, for an accessory failure may put the entire engine out of operation.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of the engine must govern establishment of the maintenance schedule. Some engines operate under rather clean conditions, some under moderately dusty conditions and others under severely dusty or dirty conditions; each type of operation must be analyzed as the maintenance schedule is established.

Hours of operation, miles [kilometers], or calendar period as shown on Page 2-2 are convenient units of measurement, and should be used to set up the maintenance schedule interval basis. These periods, as stated, are based on average operating conditions.

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 2-6.

Using The Suggested Schedule Check Sheet

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

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, calendar of time or miles [kilometers] driven.

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

The check sheet shown can be reproduced by any printer so the forms may be available for use. The person making each check can then indicate directly on the sheet that the operation has been completed. 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 Schedule

Cummins Automotive Engines

EQUIPMENT NO. ____________________ ENGINE SERIAL NO. ____________________
MECHANIC ____________________ MILEAGE, HOURS ____________________
TIME SPENT ____________________ CHECK PERFORMED ____________________
PARTS ORDER NO. ____________________ DATE ____________________

Check each operation as performed.

A–Daily	B–Check	C–Check	D–Check	E–Check	Seasonal
☐ Check Operator Report	☐ Repeat "A"	☐ Repeat "A" and "B"	☐ Repeat "A, B and C"	☐ Repeat "A, B, C and D"	☐ Spring and Fall
☐ Check Leaks, Correct ☐ Check Engine Oil Level ☐ Lubricate P.T.O. Bearing ☐ Check Coolant Level ☐ Clean Fuel Tank Breather/ Drain Sediment from Tanks ☐ Fill Fuel Tank ☐ Check Oil Bath Cleaner Oil Level ☐ Drain Air Tank ☐ Drain Fuel Filter ☐ Check Fuel System for Tampering ☐ Check All Systems for Damage	☐ Change Engine Oil [2] ☐ Change Oil Filters ☐ Record Oil Pressure ☐ Lubricate Electric Equipment ☐ Change Fuel Filter Element ☐ Check Air Piping ☐ Check Air Cleaner Restriction ☐ Clean Air Cleaner Element ☐ Change Oil Bath Cleaner Oil ☐ Clean Breather Element ☐ Clean Radiator – External ☐ Check Throttle Linkage ☐ Check Fuel Pump Seals ☐ Change Corrosion Resistor ☐ Check Engine Coolant ☐ Check and Adjust Belt Tension ☐ Adjust Injectors and Valves[3]	☐ Steam Clean Engine ☐ Clean Fuel Pump Screen and Magnet ☐ Check Engine Fuel Pressure ☐ Check Vibration Damper ☐ Lubricate Water Pump ☐ Clean Oil Bath Air Cleaner ☐ Check Alternator/Generator Cranking Motor ☐ Lubricate Fan Hub ☐ Adjust Injectors and Valves ☐ Change Aneroid Oil ☐ Check Aneroid Setting ☐ Replace Aneroid Breather ☐ Check Exhaust Back Pressure ☐ Check Supercharger	☐ Clean and Calibrate Injectors ☐ Check Fuel Pump Calibration ☐ Clean Turbocharger, Check Clearances, as Necessary ☐ Replace Aneroid Bellows and calibrate ☐ Inspect Units, Install Rebuilt as Necessary	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.	☐ Check Fan Mounting ☐ Clean Cooling System ☐ Replace Hose as Required ☐ Clean Electric Connections ☐ Check Cold Start Aid ☐ Check Thermal Controls ☐ Tighten Mountings ☐ Check P.T.O. Adjust Clutch ☐ Check Crankshaft Clearance

Engine Series	Interval Basis [1]	B	C	D	E	Type Service
C, V6, V8 (470,504,555)	Mileage	6000/8000[2]	36,000	100,000	200,000	Stop and Go or Short Haul
	[Kilometers]	[9,650/12,870]	[57,960]	[160,900]	[321,800]	
	Hours	300	1,600	3,200	6,400	
	Calendar	3 Months	1 Year	2 Years	4 Years	
Super-250,NH, NT,V-903, VT-903	Mileage	10,000	50,000	150,000	300,000	Line Haul
	[Kilometers]	[16,090]	[80,500]	[241,500]	[483,000]	
	Hours	250	1,600	2,500	6,400	
	Calendar	3 Months	1 Year	2 Years	4 Years	

Note:
1. Perform checks on operating basis of interval that occurs first. Normally, calendar period is used only when mileage is less than 1/3 that suggested during the three (3) month period.
2. All engines in short haul (pick-up and delivery) applications change engine oil at 6,000 miles [9,650 Kilometers] or each two (2) months, also V6 without oil cooler.
3. At first oil change or initial inspection, adjust injectors and valves; thereafter, at "C" Check.

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.

Attention Owner

Your Cummins Diesel Engine has been built by Cummins to comply with the requirements of the Federal (U.S.) Clean Air Act. Proper Maintenance of the Engine, which is your responsibility, is essential to keep emission levels low. This Section sets forth the maintenance schedule which you should follow.

To prove that you have properly maintained the Engine you should retain records, such as work orders and receipts, showing that scheduled maintenance has been performed.

The maintenance record form on this page is for your convenience.

Maintenance Performance Record

Engine Serial No. ______________________ *Engine Model* ______________________

Owner Name ______________________ *Equipment Name/Number* ______________________

Interval Basis Mileage			Other	Check	Date	Actual Mileage	Distributor/Dealer Location/Shop	Authorized Signature
6,000	8,000	10,000		A, B				
12,000	16,000	20,000		A, B				
18,000	24,000	30,000		A, B				
24,000	32,000	40,000		A, B				
30,000				A, B				
36,000	36,000	50,000		A, B, C				
42,000	40,000	60,000		A, B				
48,000	48,000	70,000		A, B				
54,000	56,000	80,000		A, B				
60,000		90,000		A, B				
66,000	64,000	100,000		A, B, C				
72,000	72,000	110,000		A, B				
78,000	80,000	120,000		A, B				
84,000	88,000	130,000		A, B				
90,000				A, B				
96,000	96,000	140,000		A, B				
102,000	104,000	150,000		A, B, C, D				

'A' Maintenance Checks

Check Operator's Report

Check operator's daily or trip reports, and investigate and correct reported cases of:

1. Low, high or change in lubricating oil pressure.

2. Low power.

3. Abnormal water or oil temperature.

4. Unusual engine noises.

5. Excessive smoke.

6. Excessive use of coolant, fuel or oil.

7. Observe all instruments and gauges (with coolant temperatures in operating range) with engine running at most applicable speed; take any corrective action required.

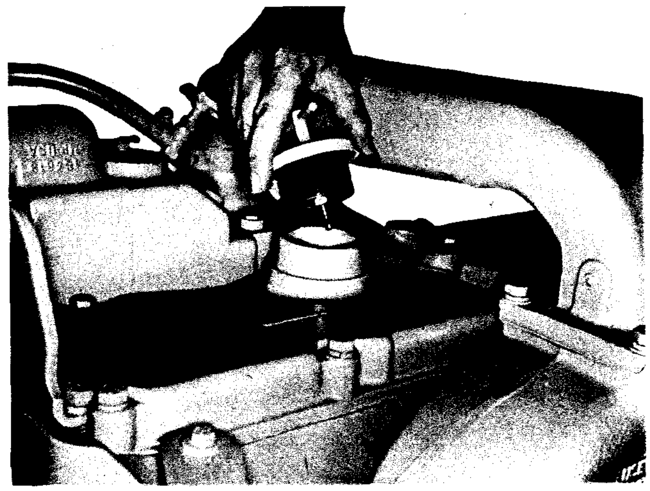


Fig. 2-1, (N12011). Checking lubricating oil filler tube cap

Check Leaks And Correct

Check for evidence of external air, coolant or oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. Fig. 2-1. See that they are tightened securely.

Fuel Oil

1. Check for evidence of external fuel leakage.

2. If there are indications of air leaks on suction side of fuel pump, check for air leaks by placing ST-998 Sight Gauge (1, Fig. 2-2) in the line between fuel filter(s) and pump. Bubbles or "milky" appearance indicates an air leak. Find and correct.

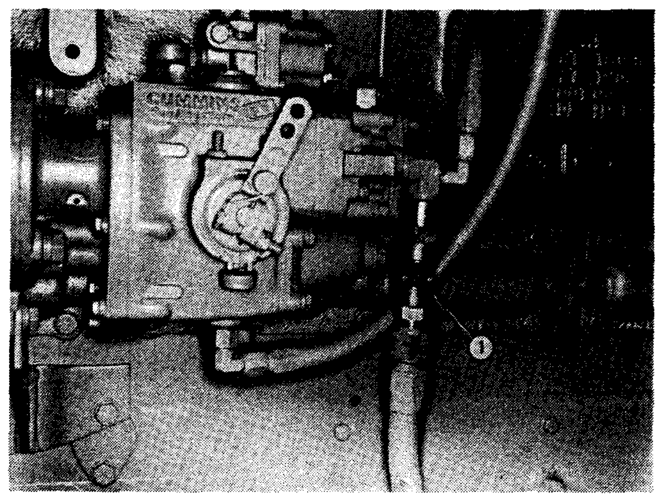


Fig. 2-2, (N11964). Checking air leaks with ST-998 Sight Gauge

Engine Oil Level

1. Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked for approximately 15 minutes after engine shut-down. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" (high) mark as possible.

Caution: Never operate the engine with oil level below the "L" (low) mark or above the "H" (high) mark.

2. Add oil as necessary of the same quality and brand as already in the engine. See Section 3.

Lubricate Power Take-Off

Apply a small amount of any high-grade, soda base, short fiber, heat-resistant, gun-lubricant grease once a day through fitting on tapered part of housing to throw-out collar.

Check Coolant Level

Keep cooling system filled to operating level. Check coolant level daily or at each fuel fill point. Investigate for causes of coolant loss. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets. Requirements of a good coolant are described in Section 3. Check coolant level only when system is cool.

Clean Fuel Tank Breather(s) And Drain Sediment From Tanks

1. Clean tank breather(s) in cleaning solvent and dry with compressed air.

2. Open fuel tank drain cock(s) or remove plug(s) and drain approximately 1 pint of fuel from each tank. Close drain cock(s) or replace plug(s).

Fill Fuel Tanks

Always filter or strain fuel while putting it in tank. See "Fuel Oil Specifications," Section 3.

In cold weather, water which accumulated in the fuel system will sometimes freeze and block the supply of fuel. This condition can be prevented by adding one quart of denatured alcohol to each 50 gal. [189 lit or 42 U.K. gal] of fuel oil.

This not only keeps the water from freezing, but allows it to go into solution with the alcohol and fuel oil so it can pass through the fuel system and be "burned" without doing any damage.

Drain plugs are located in the bottom of some fuel filter cases, and in the sump of the 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 by filling at the end of the work day. Warm returning fuel from injectors heats the fuel in the supply tank. If the fuel level is low in cold weather, the upper portion of the tank (which is not heated by returning fuel) tends to increase condensation. In warm weather both the supply tank and fuel are warm. In the night, however, the cool air lowers the temperature of the tank more rapidly than the temperature of the fuel. Again this tends to increase condensation.

Check Oil Bath Cleaner Oil Level

Daily check oil level, Fig. 2-3, 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 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.

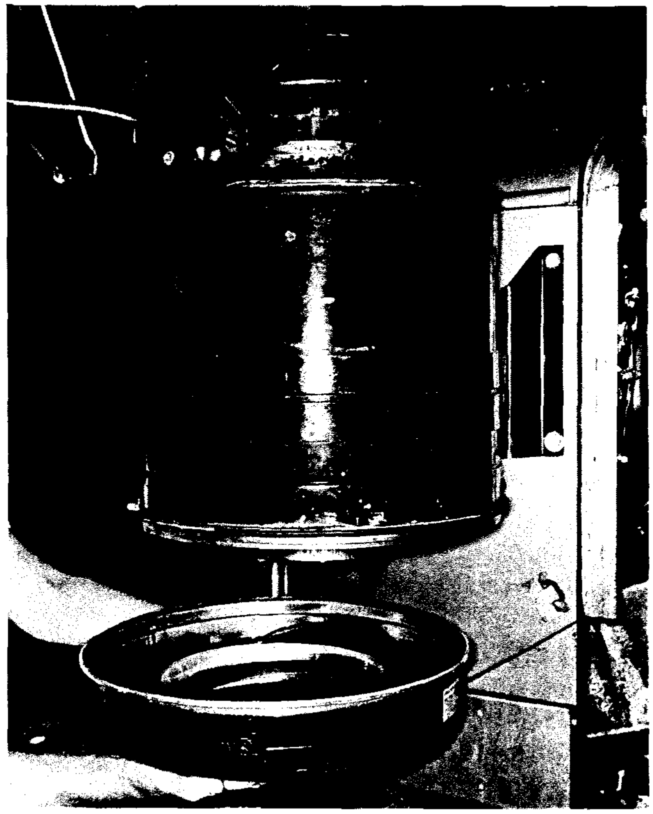


Fig. 2-3, (N11971). Checking oil level in air cleaner

Drain Air Tank(s)

Open drain cock(s) and drain all moisture and sediment from air tank(s). Quantity of condensation will be dependent on local humidity.

Drain Sediment From Fuel Filter

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

2. Unscrew throw-away type element without drain cock; dump water and sediment. Fill element with clean fuel and replace.

Check Fuel System Adjustment

Visually check fuel system, aneroid (if used) etc. for misadjustment or tampering.

Check Completely For Damage

Visually check all systems and connections for leaks or damage.

'B' Maintenance Checks

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

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 Fleetguard full-flow paper element filter in combination with a Fleetguard by-pass filter, oil recommended in Section 3, and using oil analysis with filter restriction measurement, indicate that a naturally aspirated on-highway truck may have the oil change period extended under closely controlled conditions. This indicates the economy. that can be obtained through a good maintenance program.

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.

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

2. Install drain plug in oil pan of inline engine and V-903 engine, and torque to 60 to 70 ft-lbs [8 to 9.7 kg m]. Install drain plug in oil pan of V-378, V-504, V-555 engines 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. Fig. 2-4. After several test periods a time interval for the oil change can be established; however, a new series of tests should be run if filters, oil brands or grades are changed.

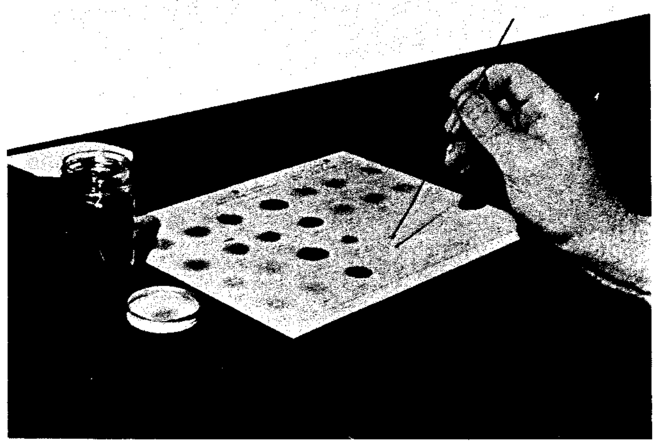


Fig. 2-4, (N11945). Lubricating oil analysis test

In the beginning, tests should be made each 100 gal. of fuel consumed (after the first 400 gal.), or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary.

Analysis Test For Lubricating Oil

Check oil properties in the following list during analysis. These methods are fully described in the American Society for Testing Materials Handbook.

Oil Property	Test Number
Viscosity at 100 deg. F and 210 deg. F	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: Total number 3.5 maximum.

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 filters, 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 Engine Full-Flow Filter Element (Can Type With Center Bolt)

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

2. Loosen center bolt and remove filter can and filter element. See Fig's. 2-5, 2-6 and 2-7.

3. Inspect filter element 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. 2-6) 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.

e. Discard element after inspection.

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 case thoroughly. Handle case and/or store in manner to prevent out-of-round.

Note: It is recommended that every second oil change to change the small seal rings (4 and 17, Fig. 2-7) at bottom of oil filter can to prevent oil leakage due to hardening of rubber seals. Inspect seals each oil change for deterioration.

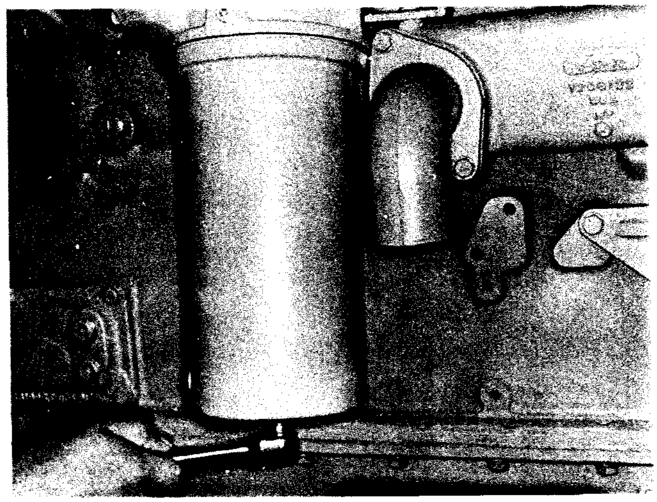


Fig. 2-5, (N10098). Lubricating oil filter (center bolt)

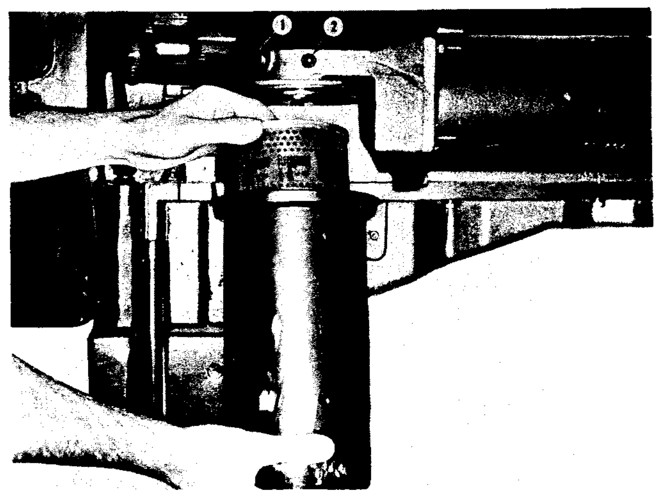


Fig. 2-6, (V51908). Removing full flow lubricating oil filter element — V-903

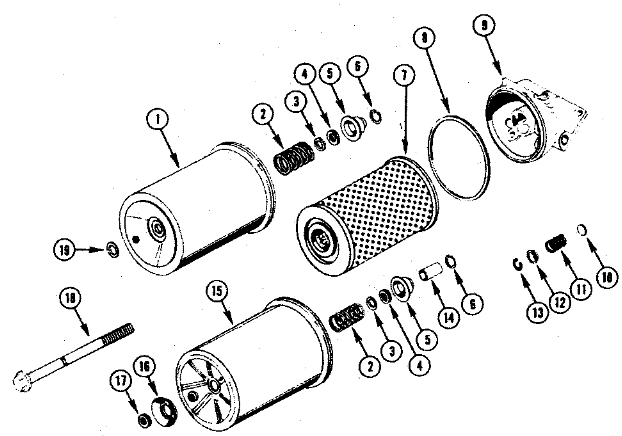


Fig. 2-7, (V10702). Full-flow filter assembly — V-378, V-504 and V-555 engines

6. Check to make sure element end seals are in place and install new element over spring support assembly.

7. Position new seal ring on filter head or can; install new element in filter case. Position to filter head and tighten center capscrew to 25 to 35 ft-lbs [3.5 to 4.8 kg m]. Tighten clamp-type filter capscrews securely.

Caution: Make sure to fit new seal ring to filter can or head as design requires or seal may become distorted or damaged.

8. Fill engine to "H" (high level) mark on dipstick with lubricating oil meeting specifications listed in Section 3. Run engine and check for leakage.

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

Note: Always allow oil to drain back to oil pan before checking level. This will require 15 minutes.

Change Engine Full-Flow Filter Element (NTA Series And Filter Mounted Atop Cooler)

1. Remove drain plug from filter housing and allow oil to drain.

2. Remove capscrews and washers securing cover to housing; lift off cover and discard gasket.

3. Lift out filter element; inspect element then discard.

4. Wipe housing clean with lint free cloth; install drain plug.

5. Insert new element in filter housing seating securely on end seal.

6. Position cover with new gasket over element to housing; secure with capscrews and lockwashers.

Change Lubricating Oil By-Pass Filter Element

To change Cummins Fleetguard 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. 2-8) 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.

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

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

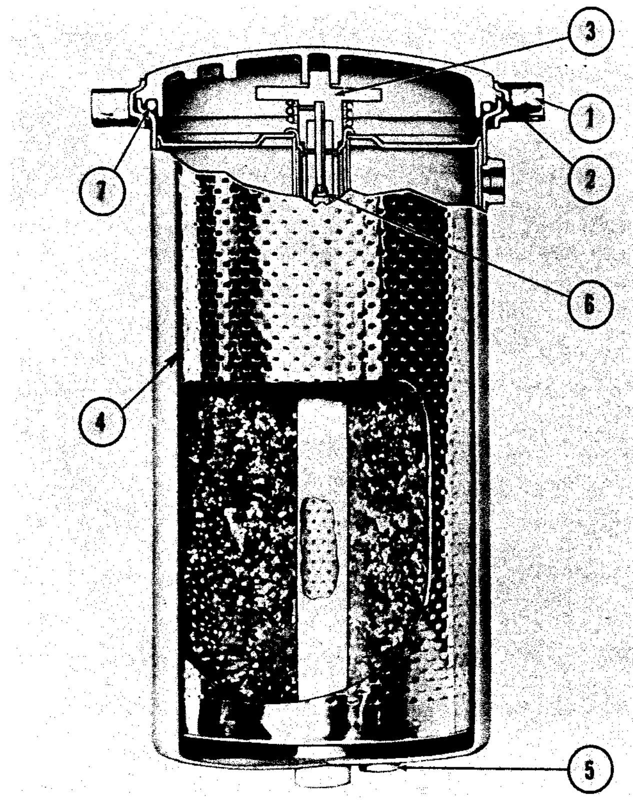


Fig. 2-8, (V41908). By-pass filter cross section

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

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

Record Oil Pressure

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140 deg. F [60 deg. C]. Reduce engine speed to idle and record the 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.

Lubricate Alternator Or Generator

Lubricate alternator (if required) or generator by adding five or six drops of SAE 20 lubricating oil to oil cup or by turning down grease cup a maximum of one turn.

Caution: Avoid over-lubrication which is harmful to insulation.

If no cups are present, unit contains sealed bearings and requires no lubrication.

When a generator or alternator filter is used, clean filter screen at each lubrication period. Remove filter screen and wash in an approved cleaning solvent; blow dry with compressed air and reassemble.

Lubricate Cranking Motor

Electric

Add five or six drops of clean SAE 30 weight lubricating oil to cranking motor bearings. Fig. 2-9

Air

Air cranking motor may be equipped with grease fittings, felt wicks with outer grease cups or air line lubricators. Follow manufacturer's recommendation for procedure interval and lubricant specifications.

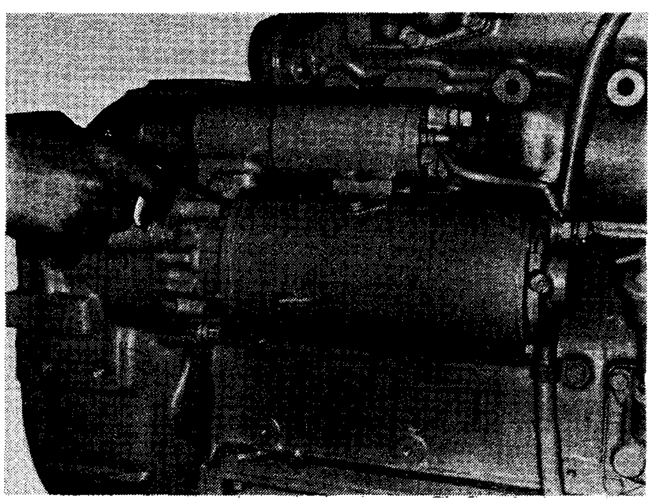


Fig. 2-9, (N11972). Lubricating cranking motor

Change Fuel Filter Element

When double elements of the standard or extended life (throw-away) fuel filters are used, the capacity is approximately doubled.

The most accurate method of determining element change period is by measurement of fuel restriction as follows:

Check Fuel Restriction

To check restriction, connect a ST-434 Vacuum Gauge to the fuel pump as shown in (2, Fig. 2-10) using the special adapter furnished. If restriction reads 8 to 8.5 inches vacuum while the engine is running at full speed and load, change element or remedy other sources of restriction. When restriction becomes as great as 10 or 11 inches vacuum, the engine will lose power.

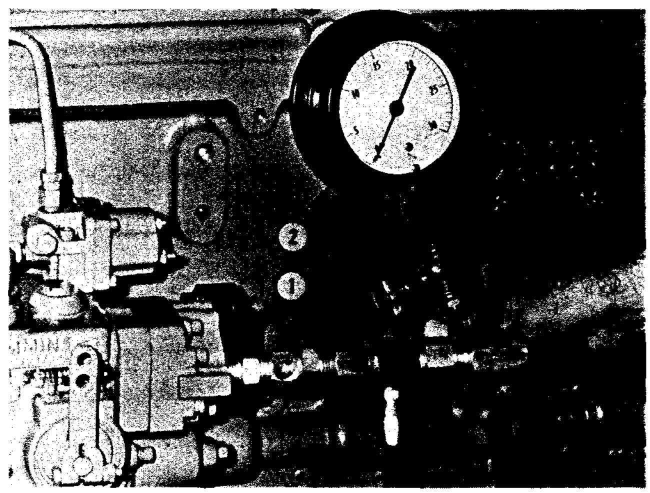


Fig. 2-10, (N11917). Checking fuel filter restriction with ST-434 Vacuum Gauge

Throw-Away Type Filter

1. Unscrew combination case and element, discard.

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.

Caution: Mechanical tightening will distort or crack filter head.

Replaceable Element

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

2. Loosen bolt at top of fuel filter. Take out dirty element,

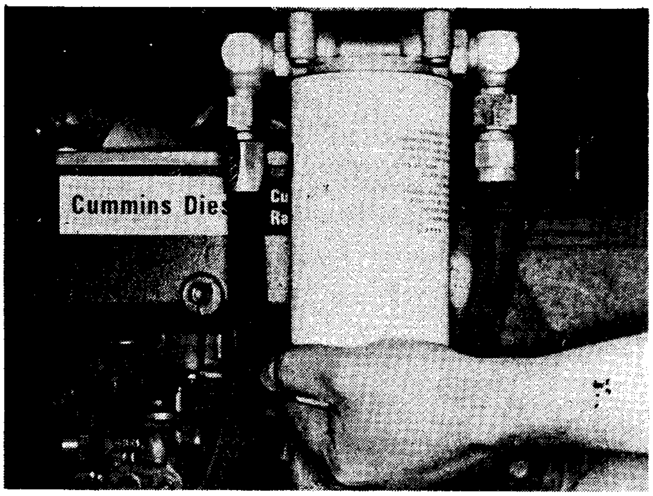


Fig. 2-11, (V11909). Changing throw-away type fuel filter

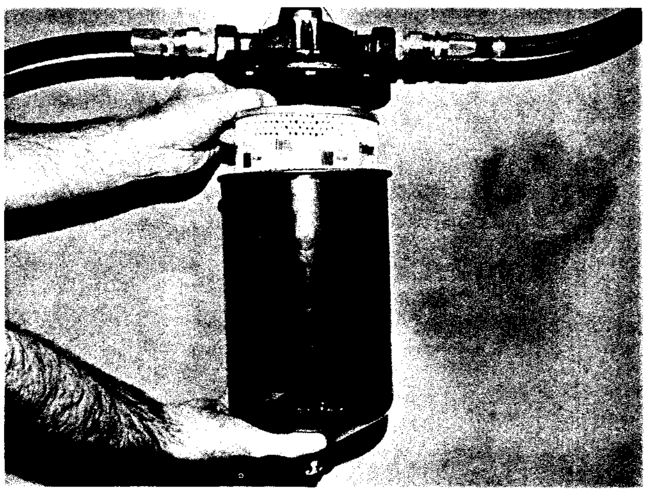


Fig. 2-12, (V11910). Installing replaceable fuel filter element

clean filter case and install a new element. Fig. 2-12.

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.

Check Air Piping, Turbocharger Connections And Manifolds

Check air intake piping from air cleaner to turbocharger or intake manifold. Check for loose clamps, connections, cracks, punctures or tears in hose or tubing. Tighten clamps, Fig. 2-13, manifold capscrews and turbocharger mounting nuts. Replace parts as necessary to insure an air-tight intake system.

Check Inlet Air Restriction Gauge

The best method for determining dry-type air cleaner

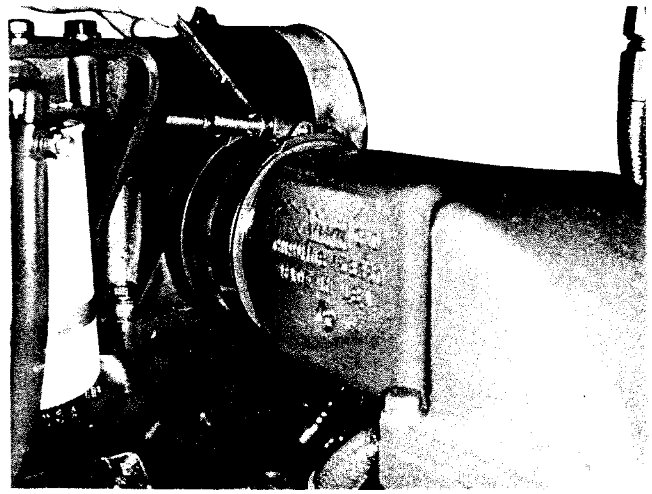


Fig. 2-13, (V51925). Tightening air intake piping clamp

maintenance periods is through air restriction checks.

A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The restriction indicator signals when to change cartridges. The red flag (1, Fig. 2-14) in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge, reset indicator by pushing reset button (2). Push button all the way in firmly; then release. If button sticks, repeat pushing slowly.

Note: Never remove felt washer from gauge, it is necessary to absorb moisture.

Vacuum switches are available which actuate a warning light on the instrument panel when air restriction becomes

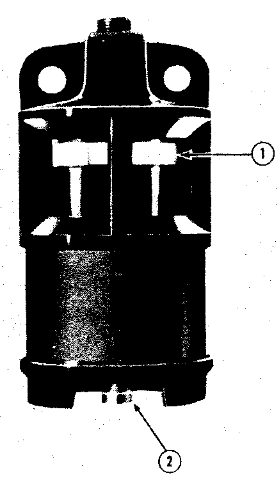


Fig. 2-14, (CGS-20). Air inlet restriction gauge excessive. Items required for installation are:

1. Electric source (1, Fig. 2-15).

2. Air piping with fitting for switch (2).

3. Vacuum switch (3).

4. Red indicator light (4).

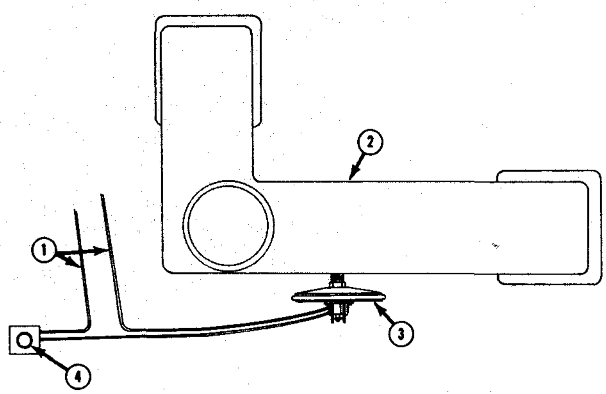


Fig. 2-15, (V11010). Vacuum switch to check air inlet restriction

Note: Air restriction checks should not be used to determine maintenance periods for oil bath air cleaners. Before dirt build-up reaches 1/2 inch [12.700 mm] maximum height, perform maintenance as described under "Change Air Cleaner Oil."

Check Air Inlet Restriction – Vacuum Gauge

When a restriction gauge is not part of the system, check as follows:

1. On naturally aspirated engines, attach vacuum gauge or water manometer in middle of intake manifold or on air intake piping. When located in air intake piping, adapter must be perpendicular to air flow and not more than 6 inches [152.4 mm] from air intake manifold connection.

2. On turbocharged engines, the vacuum manometer should be connected to air intake pipe, one to two pipe diameters upstream from turbocharger inlet, in a straight section of pipe. The engine should be at normal operating temperature and at governed speed. Turbocharged engines should be under full load with time provided to allow the turbocharger to reach maximum speed when restriction is measured. (High idle, no load readings on turbocharged engines are not satisfactory.)

3. Air restriction readings may be taken at air cleaner outlet pipe. The adapter must be mounted perpendicular to air flow, and restriction must not exceed 20 inches [508 mm] of water or 1.5 inches [38 mm] of mercury when checked at this location.

4. When checking at the engine intake manifold, idle engine until normal operating temperature is reached.

5. Operate engine at rated speed and take reading from vacuum gauge or manometer. Air restriction must not exceed 25 inches [635 mm] of water or 1.8 inches [45.72 mm] of mercury at intake manifold.

6. If air restriction exceeds limits in Step 3 or 5 above:

a. Clean or replace dry-type cleaner element.

b. Replace damaged air piping, rain shield or housing.

c. Remove excessive bends or other source of restriction in air piping.

Clean Air Cleaner Elements

The paper element in a dry-type air cleaner, Fig's 2-16, 2-17 and 2-18 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. F [49 to 60 deg. C], then drying with compressed air, approximately 40 psi [2.8 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 as previously described and replace element if necessary.

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

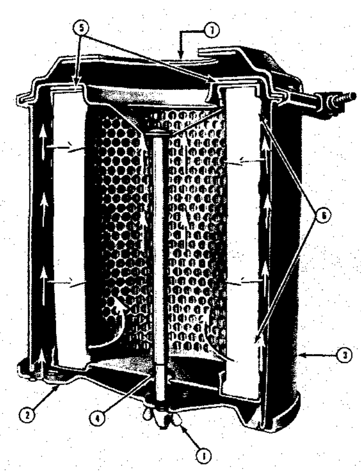


Fig. 2-16, (N11003). Air cleaner dry type

Caution: Holes in the element of a dry-type air cleaner render cleaner inoperative. Do not use damaged cleaner element.

Replace paper element in all dry-type air cleaners when breaks appear or if air restriction is still excessive after element has been cleaned. To change element·

1. Loosen wing nut (1, Fig. 2-16) securing bottom cover (2) to cleaner housing (3). Remove cover.

2. Pull element (6) down from center bolt (4).

3. Remove gasket (5) from outlet end (7) of housing.

When installing the element, make sure it seats on the gasket at the air cleaner outlet end.

Heavy Duty Dry-Type Air Cleaners

Heavy duty air cleaners (single and dual types) combine centrifugal cleaning with element filtering, Fig's. 2-17 and 2-18 before air enters engine.

Dirty air enters through an opening in the side of the single or dual type, cyclopac cleaner body. On single element type air immediately travels through a ring of vanes around the outside and through a primary element and on into the engine. Fig. 2-17. Whereas, on a dual element type air travels through a ring of vanes around the outside and through a primary element (6), Fig. 2-18) and then through a safety element (9) and on into the engine.

Before disassembly, wipe dirt from cover and upper portion of air cleaner. To clean single or dual types:

1. Loosen wing bolt, remove band securing dust pan (1, Fig. 2-17), (2, Fig. 2-18).

2. Loosen wing nut (2, Fig. 2-17 and 3, Fig. 2-18), remove dust shield (3, Fig. 2-17), (4, Fig. 2-18) from dust pan (1, Fig. 2-17), (2, Fig. 2-18), clean dust pan and shield.

3. Remove wing nut (2, Fig. 2-17), (5, Fig. 2-18) securing air cleaner primary element (6, Fig. 2-18) in air cleaner housing, inspect rubber sealing washer on wing nut (4, Fig. 2-17), (5, Fig. 2-18).

4. Blow out element from clean air side with compressed air.

Caution: Air pressure should not be more than 100 psi [7 kg/sq cm] to avoid rupturing element. Do not concentrate air pressure in one spot.

5. Wash element with non-sudsing household detergent and warm water 120 to 140 deg. F [49 to 60 deg. C]. Dry with compressed air 40 psi [2.8 kg/sq cm].

6. Inspect element after cleaning to be sure no holes are present.

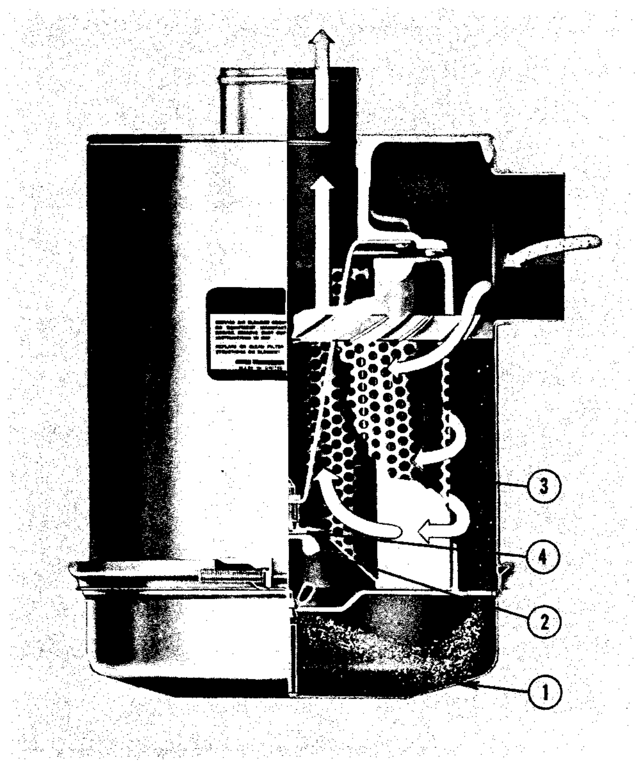


Fig. 2-17, (V11005). Air cleaner - heavy duty

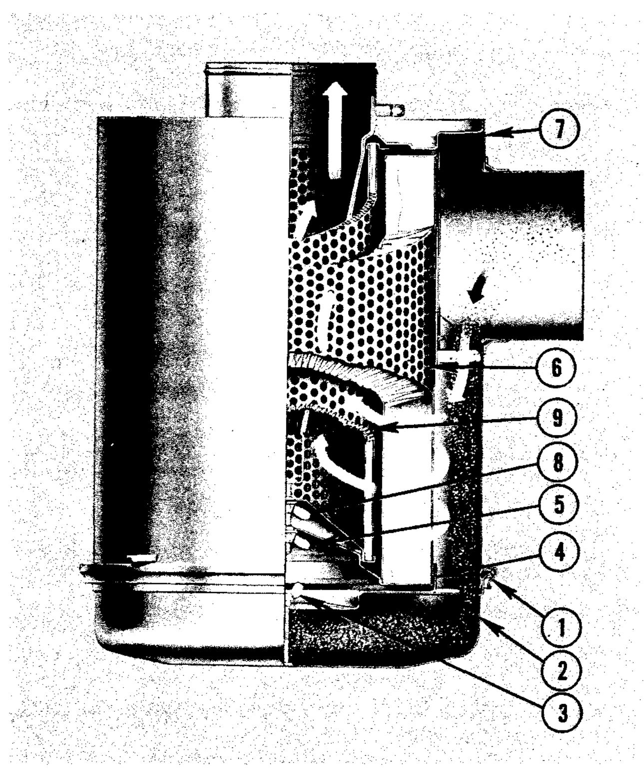


Fig. 2-18, (N11030). Air cleaner - heavy duty dual element

7. Install new or cleaned primary element.

8. Be sure gasket washer (4, Fig. 2-17), (5, Fig. 2-18) is in place under wing nut before tightening.

9. Reassemble dust shield (3, Fig. 2-17), (4, Fig. 2-18) and dust pan (1, Fig. 2-17), (2, Fig. 2-18) position to air cleaner housing and secure with band (1, Fig. 2-18).

10. On dual element type cyclopac cleaner:

a. Check air restriction indicator, if air restriction is excessive, disassemble air cleaner, remove wing nut (8, Fig. 2-18), and replace safety element (9).

b. Reassemble air cleaner as described in Steps 8 and 9 above.

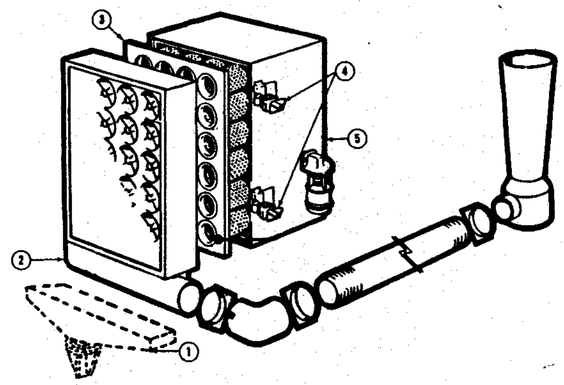


Fig. 2-19, (N21026). Air cleaner - cartridge type (two stage)

Cartridge Type Air Cleaner Element

1. Loosen wing nuts (4, Fig. 2-19 or 2-20) on air cleaner housing (5) to remove pre-cleaner panel with dust bin (1). To remove pre-cleaner panel (2) equipped with exhaust aspirator loosen "U" bolt clamp securing pre-cleaner to aspirator tubing.

2. To remove dirty Pamic cartridge (3), insert fingers in cartridge opening using a "bowling-ball grip." Loosen all four corners of cartridge, one at a time, by pulling straight out.

With larger cartridge, it may be necessary to break seal along edges of cartridge. After seal has been broken, pull the cartridge straight out and slightly up so cartridge will clear sealing frame and edges of air cleaner housing.

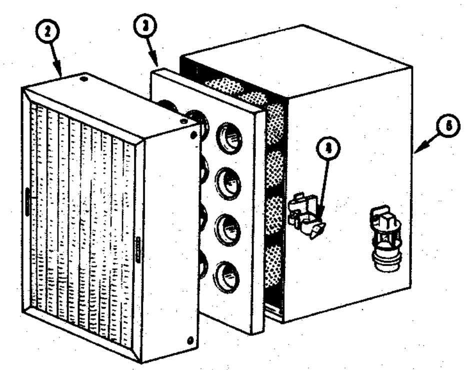


Fig. 2-20, (V11009). Air cleaner - cartridge type (single stage)

Cleaning And Inspection

1. Clean pre-cleaner openings (2) of all soot, oil film and any other objects that may have become lodged in openings.

a. Remove any dust or dirt that may be in lower portion of pre-cleaner and aspirator tubing. Inspect inside of air cleaner housing to be sure it is free of all foreign material.

b. Pre-cleaners with dump valve in dust bin automatically expell dust and water while engine is running. During engine operation the dust bin is under a slight vacuum utilizing the engines pulsing action to open and close the dump valve. The dump valve also expells dirt and water whenever engine is shut down.

2. Inspect dirty cartridge for soot or oil. If there is soot inside Pamic tubes, check for leaks in engine exhaust system, exhaust "blow-back" into air intake and exhaust from other equipment. If cartridge appears "oily," check for fumes escaping from crankcase breather. Excessive oil mist shortens life of any dry-type cartridge. Trouble-shooting before new cartridge is placed in the air cleaner can appreciably lengthen cartridge life.

3. It is not recommended to clean and reuse cartridge. Considerable laboratory testing shows that shaking, washing, rapping or blowing out with compressed air can cause cracks or ruptures in paper filter cartridges, which would permit wear-causing dirt particles to enter engine. If a failure occurs, there is no way of discovering it until cartridge is changed again.

4. Repeated tests have also shown that fine particles that penetrate deep into pores of filter paper cannot be removed by any method of cleaning. When returned to service, life expectancy (even if no failure occurs) of a paper cartridge will be only a fraction of original service life.

5. Inspect clamps and flexible hose or tubing to be sure all fittings are air tight on cleaners with exhaust aspirators.

6. The pre-cleaner dust bin is self-cleaning.

Assembly

1. Inspect new filter cartridge for shipping damage before installing.

2. To install a new cartridge, hold cartridge (3, Fig. 2-19 and 2-20) in same manner as when removing from housing (5). Always inspect inside of air cleaner housing keeping it free of all foreign material. Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.

3. The cleaner requires no separate gaskets for seals; therefore, care must be taken when inserting cartridge to insure a proper seat within air cleaner housing. Firmly press all edges and corners of cartridge with fingers to effect a positive air seal against sealing flange of housing. Under no circumstances should cartridge be pounded or pressed in center to effect a seal.

4. Replace pre-cleaner panel (2) and tighten wing nuts (4) by hand, for final tightness turn 1-1/2 to 2 turns with a small adjustable wrench. On pre-cleaner with exhaust aspirator, assemble aspirator tube to pre-cleaner panel and tighten "U" bolt.

5. Care should be taken to keep leaves, rags or side curtains from obstructing cleaner face. Obstructing air intake can result in reverse exhaust flow through bleed line and damage to cartridge.

Caution: Cartridge elements or tube damage may result from overtightening wing nuts or using a hammer when inserting the cartridge.

Change Oil Bath Air Cleaner Oil And Clean Tray Screen

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 a wheel or 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."

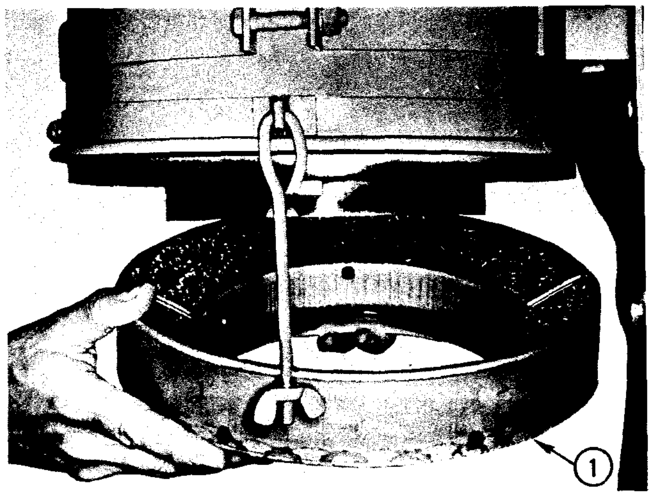


Fig. 2-21, (V51933). Removing air cleaner tray screen

Clean Tray Screen

Immerse tray screen (1, Fig. 2-21) in kerosene or cleaning solvent.

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

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.

Clean Crankcase Breather

Several different types of crankcase breathers are used on Cummins Engines; some are pressed into the valve cover, others are a combination breather and oil filler tube cap.

Mesh Element Breather

1. Remove wing nut (6, Fig. 2-22), flatwasher and rubber washer securing cover (1), to breather body (5).

2. Lift off cover and lift out breather element (2), vapor element (3) and gasket (4).

Cleaning And Inspection

1. Clean all metal and rubber parts in approved cleaning solvent.

2. Dry thoroughly with compressed air.

3. Inspect rubber gasket; replace if necessary.

4. Inspect body and cover for cracks, dents or breaks; discard all unserviceable parts.

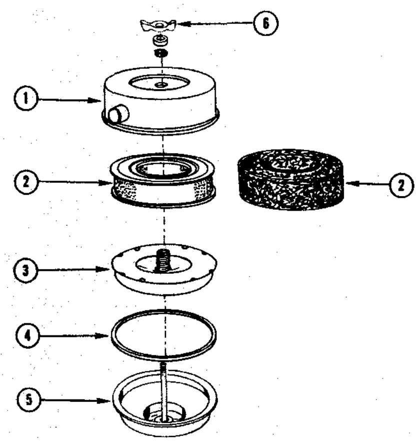


Fig. 2-22, (V51909). Crankcase breather - mesh element with vapor barrier

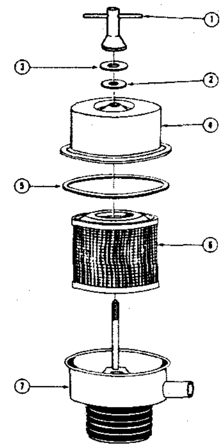


Fig. 2-23, (N20311). Crankcase breather - combination type

Assembly

1. Install cleaned or new breather element (2, Fig. 2-22) and cleaned vapor element (3) to breather body (5).

2. Install rubber gasket (4) in cover (1), position cover assembly to body (5).

3. Install rubber washer, flatwasher and wing nut (6); tighten securely.

Paper Element Breather

1. Remove wing nut (6, Fig. 2-22) flatwasher and rubber washer securing cover (1) and element assembly to breather.

2. Lift off cover and lift out element (2) and gasket (4).

3. Separate cover from element. Discard element.

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

4. Clean and inspect parts as described under "Mesh Element Breather."

5. Assemble parts using new paper element, see assembly under "Mesh Element Breather."

Screen Element Breather — Cleaning And Inspection

1. Remove vent tube if not previously removed.

2. Remove capscrews, washers, cover (1, Fig. 2-24) screens (3) and baffle (4) from the breather body (5).

3. Clean vent tube, screens and baffle in an approved

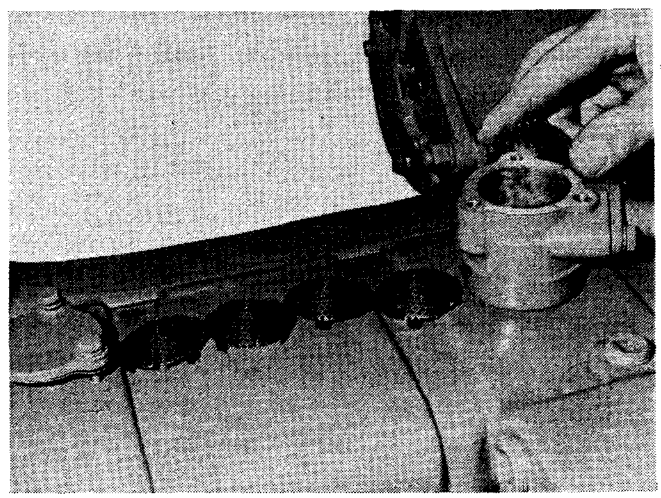


Fig. 2-24, (N21928). Changing crankcase breather element - screen type

cleaning solvent. Dry with compressed air. Wipe out breather housing.

4. Assemble baffle (4), screens (3) and new gasket (2) in body (5).

5. Replace cover (1) with cover boss resting securely on point of screen; secure with washers and capscrews.

6. Replace vent tube.

Clean (Externally) Radiator Core

Blow out all insects, dust, dirt and debris (leaves, bits of paper, etc.) that may be on front of radiator or lodged between radiator core fins and tubes.

Check Throttle Linkage

Check throttle linkage and make sure it is in good operating condition. Check throttle travel to make sure linkage operates throttle from stop to full throttle and that degree of travel is within specifications for application.

Check Fuel Pump Seals

Throttle stop screws and governor idle screw plug are "sealed" after final pump setting. Seals should be regularly checked to prevent, or catch immediately, unauthorized fuel pump settings.

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 3000 miles or 100 hours; maintenance periods thereafter are as follows:

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

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. 2-25.

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.

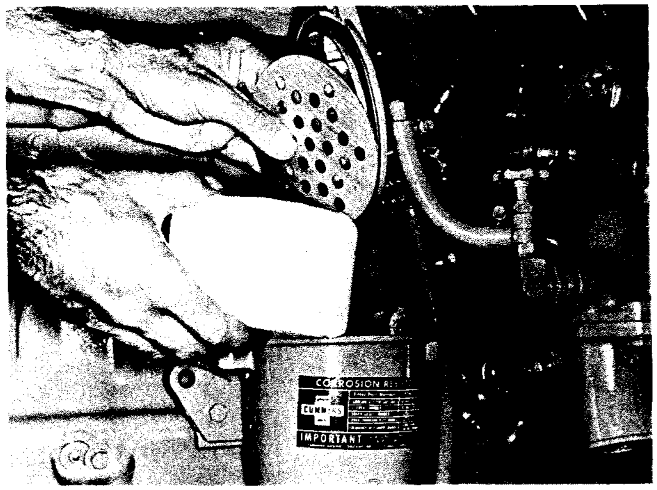


Fig. 2-25, (N11901). Changing corrosion resistor element - package type

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.

3. Install new element (see caution above), tighten until seal touches filter head. Tighten an additional one-half to three-fourths turn. Fig. 2-26, open shut-off valves.

Caution: Mechanical tightening will distort or crack filter head.

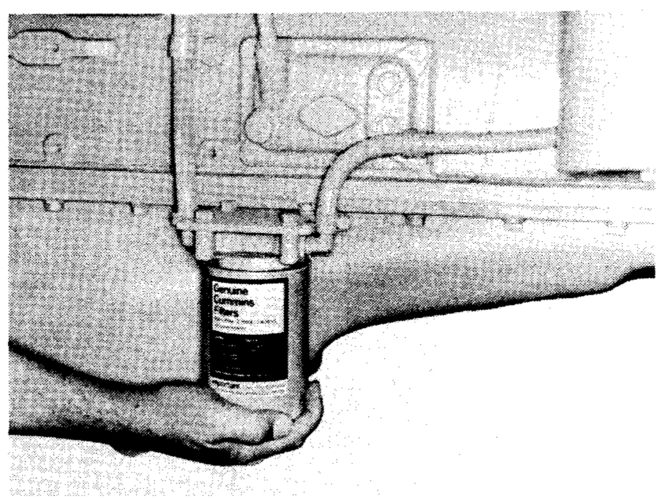


Fig. 2-26, (N11976). Installing spin-on corrosion resistor

Check Engine Coolant

Periodic tests of engine coolant should be made to insure that 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.

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 the color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check. Fig. 2-27.

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 bottom of radiator 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 radiator filler opening. See nearest distributor for a list of antifreeze known to be compatible with chromate elements.

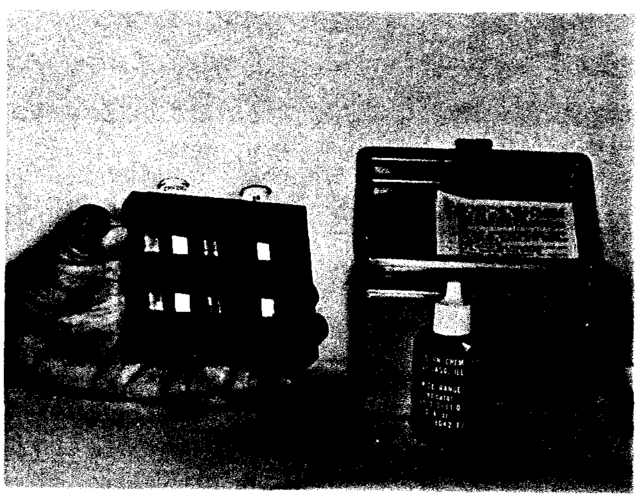


Fig. 2-27. (N11946). ST-993 Coolant Checking Kit

pH Value Test

1. Separate tubes marked "pH" are furnished in the 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 to 9.5.

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

Chromate Concentration Test

Chromate concentration should be maintained at or above 3500 PPM.

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 is 100 to 150 grains per gal. [3.8 lit or 0.8 U.K. gal] or 1700 to 2500 parts per million (ppm) as the standard indicates. The dilution (Step 2) is done to match the standard, but actual results are 3400 to 5000 (ppm) range of chromate concentration.

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 when coolant is added and requires no change in schedule of element replacement.

Chromate Concentration – NA_2CRO_4–3500 PPM (Min.)
NA_2CRO_4–7000 PPM (Max.)

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 from NALCO Chemical Company
180 N. Michigan Avenue
Chicago, Illinois, 60601

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

Check And Adjust Belt Tension

The service life of belts used to drive fans, water pumps and generators/alternators 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.**

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll belt over the pulley and never pry it on with a tool such as a screwdriver. Either 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 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 foot [0.3 m] of distance between pulley centers.

4. Belts should not bottom on 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. 2-28). For belts over 1/2 inch [12.7 mm] wide, use ST-1138 Belt Gauge, (Fig. 2-29).

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. [5.9 kg] deflection (1, Fig. 2-30) per foot [0.3 m] of span (2).

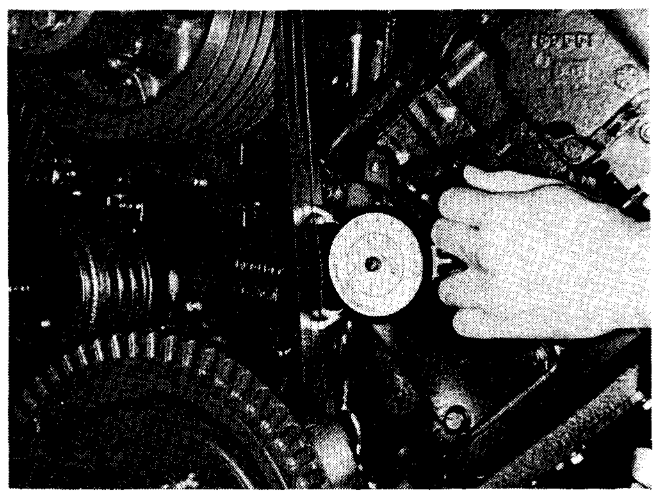


Fig. 2-28, (V51475). Checking belt tension with ST-968

Table 2-2: Belt Tension – Inch [mm]

Belt Width		Deflection Per Ft. [0.30 m] of Span	
1/2	[12.7]	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]

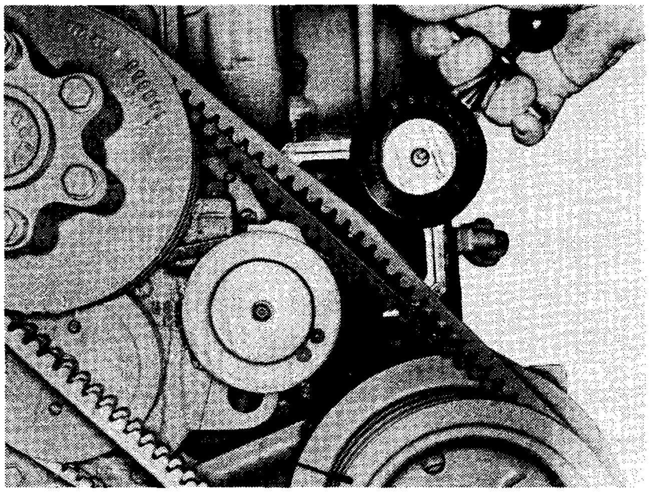


Fig. 2-29, (N11977). Checking belt tension with ST-1138

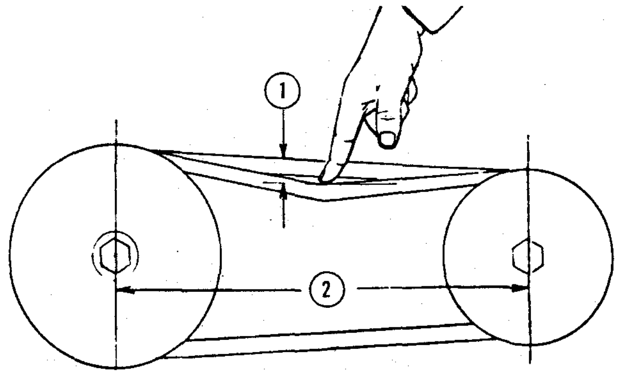


Fig. 2-30, (N11471). Checking belt tension manually

Inline Engine Water Pump Belts (No Idler)

1. Eccentric water pump adjustment.

a. Loosen water pump clamp ring to allow pump body to turn.

b. Loosen pump body by pulling up on belts. A sharp jerk may be required. Some coolant will be lost.

c. Insert bar in water pump body slots and rotate pump body counterclockwise to tighten belts.

Note: Do not adjust to final tension at this time.

d. Snug clamp ring capscrew farthest from belts, on exhaust side to 5 ft-lbs [0.7 kg m].

e. Snug two capscrews above and below the first one to 5 ft-lbs [0.7 kg m].

f. Snug clamp ring capscrew on belt side, then two remaining capscrews to 5 ft-lbs [0.7 kg m].

g. Finish tightening by alternating from side to side in 5 ft-lbs [0.7 kg m] increments to a final torque to 12 to 15 ft-lbs [1.7 to 2.1 kg m].

h. Check the belt tension with applicable Belt Tension Gauge.

Notice that final belt tension was not obtained by the adjustment alone. The water pump body was pulled straight by snugging the capscrews in the order described, thus increasing belt tension to final value.

2. Adjustable (split) pulley water pumps.

a. Remove the capscrews which join the two halves of the pulley.

b. The outer half of the pulley is screwed onto the hub extension of the inner half. Some pulleys are provided with flats, and some with lugs for barring.

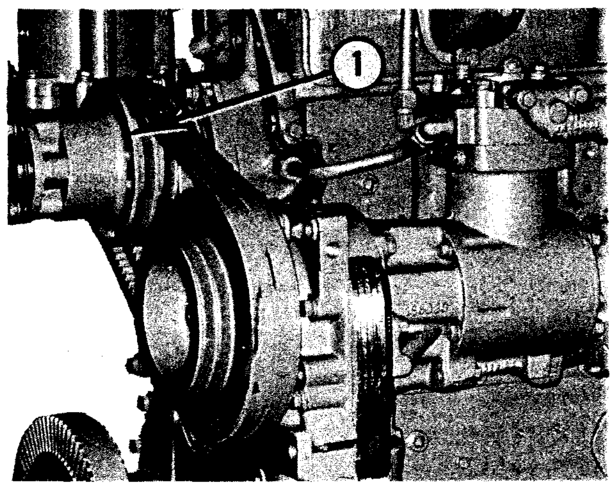


Fig. 2-31, (N11973). Water pump - no idler

c. Bar the engine over to roll the belt outward on the pulley as the outer half is turned in.

d. Adjust until the ST-968 Belt Tension Gauge reads 90 to 110 pounds, or until the belt will deflect 3/4 to 1 inch when pressure of index finger is applied.

e. Turn the outer half in enough to align the capscrew holes.

f. Start the capscrews and tighten alternately and evenly. Final tension is:

5/16 — 18 capscrew to 10 to 12 ft-lbs [1.4 to 1.7 kg m]
3/8 — 16 capscrew to 17 to 19 ft-lbs [2.4 to 2.6 kg m]

g. Bar the engine over one or two revolutions to seat the belt.

h. Recheck the belt tension.

Inline Engine Water Pump Belts (With Idler)

1. Loosen capscrews and lockwashers or locknut securing idler pulley to bracket or water pump.

2. Using pry bar (NTA) or adjusting screw (Super-250) adjust idler pulley until belt tension shows 60 to 80 pounds as measured with ST-968 Belt Tension Gauge.

3. Secure idler pulley or bracket in position by tightening locknut or capscrews and lockwashers.

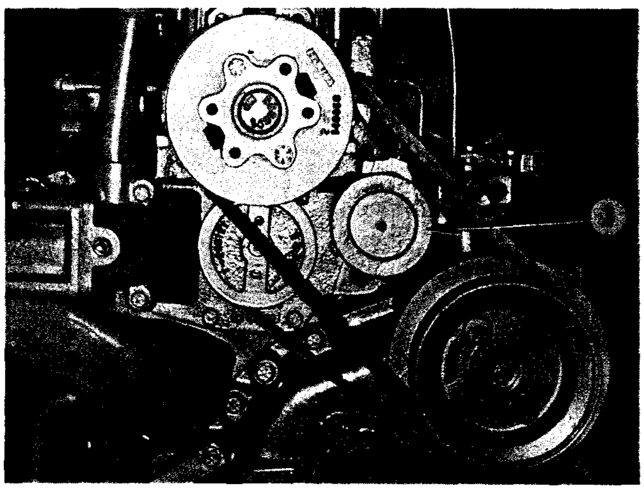


Fig. 2-32, (N11974). Water pump - with idler

Fan Drive Belts

Most fans are mounted on hub assemblies, supported in a bracket; an adjusting screw is provided which raises or lowers the hub shaft to adjust the belt tension. On V-type this adjusts both fan and water pump belts.

1. Loosen large locking nut on fan hub shaft or capscrews securing fan hub shaft to mounting bracket. The fan hub will fall out of line when this is done.

2. Turn the adjusting screw to increase belt tension.

3. Tighten the locknut or capscrews until the fan hub is straight. As this is done, belt tension will increase. Snug the nut to maintain hub in proper alignment with the fan hub bracket.

Caution: Do not adjust to full tension with the adjusting screw, this would result in overtightening.

4. Check belt tension with applicable gauge. The gauge should read 90 to 100 pounds. If a gauge is not available, the belt should be checked with pressure of index finger at the center of the longest span. Deflection should be one thickness per foot of pulley center distance.

5. Tighten inline engine locknut to 400 to 450 ft-lbs [55.3 to 62.2 kg m]; then back off 1/2 turn. Tighten capscrews 75 to 85 ft-lbs [10.4 to 11.8 kg m].

a. On V-903 engines tighten capscrews to 75 ft-lbs [10.4 kg m] or single nut to 450 ft-lbs [62.2 kg m].

b. On V-378, V-504 and V-555 engines, tighten fan hub capscrews to 78 to 85 ft-lbs [10.8 to 11.8 kg m] or large nut to 300 ft-lbs [41.5 kg m].

6. Recheck belt tension.

7. Back out adjusting screw one-half turn to prevent breakage.

Generator/Alternator Belts

These belts are much easier to adjust since the generator/alternator is mounted on a swinging bracket.

Belt tension should be 90 to 110 pounds as measured with the applicable gauge. When no gauge is available, index finger pressure should not deflect belt more than indicated in Table 2-2.

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."

C' Maintenance Checks

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

Steam Clean Engine

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

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use mineral spirits or some other solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the steam jet.

Clean Fuel Pump Screen And Magnet

PT Fuel Pump

Remove and clean fuel pump filter screen at each "C" Check. To clean filter screen:

1. Loosen and remove cap (1, Fig. 2-33) and "O" ring (2), spring (3). Lift out filter screen assembly (4).

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

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 cap and "O" ring; tighten to 20 to 25 ft-lbs [2.8 to 3.5 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap (1, Fig. 2-34) and dynaseal (2) from governor housing.

2. Remove "O" ring retainer (3), "O" ring (4), screen (5) and spring (6) from filter cap.

3. Using a screwdriver or wire hook, remove bottom screen and magnet assembly (7) from fuel pump housing. Remove screen retainer.

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

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

6. Install spring, large oil 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; tighten cap to 20 to 25 ft-lb [2.8 to 3.5 kg m] with torque wrench and screwdriver adapter.

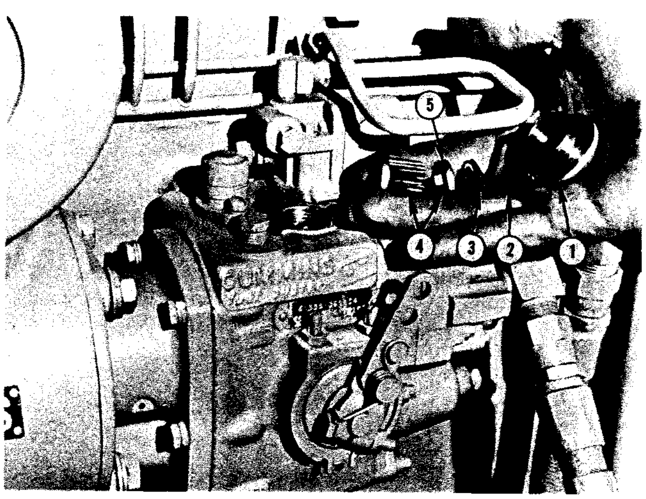


Fig. 2-33, (N11950). Fuel pump screen - PT fuel pump

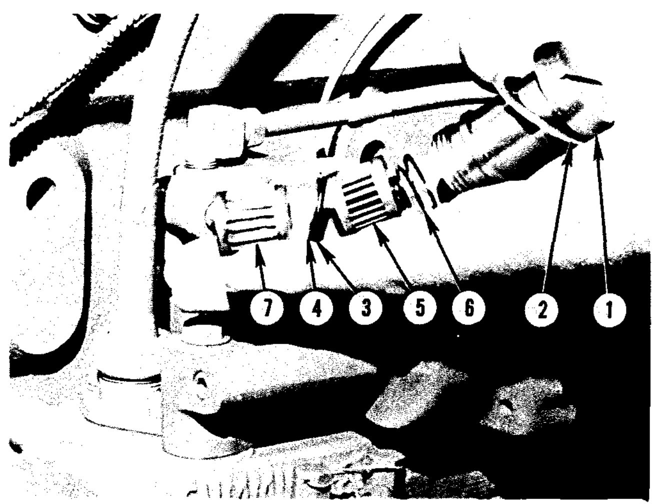


Fig. 2-34, (N11940). Fuel pump screen for MVS governor

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-steering 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. 2-35. 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.

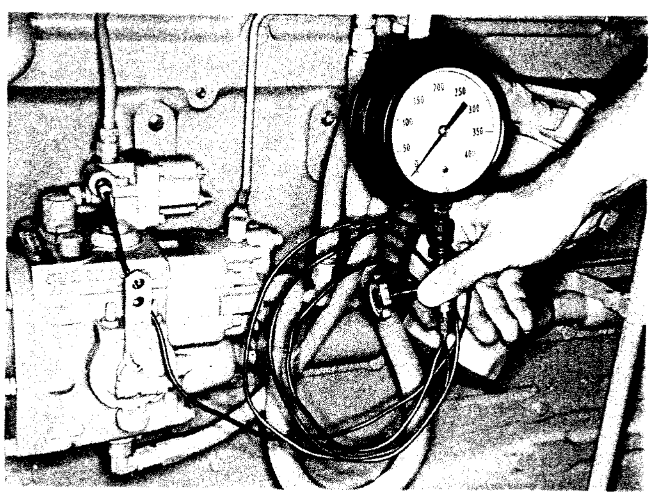


Fig. 2-35, (N11966). Checking fuel manifold pressure with ST-435

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. Check with a Cummins Distributor.

11. Always make above checks on a hot engine.

Check Vibration Damper Alignment

Damper hub (1, Fig. 2-36) 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.

Lubricate Water Pump and Idler Pulley

Caution: Prior to adding lubricant to water pump and idler pulley, remove pipe plugs (if used) and check type of lubricant used. Do not mix lubricants.

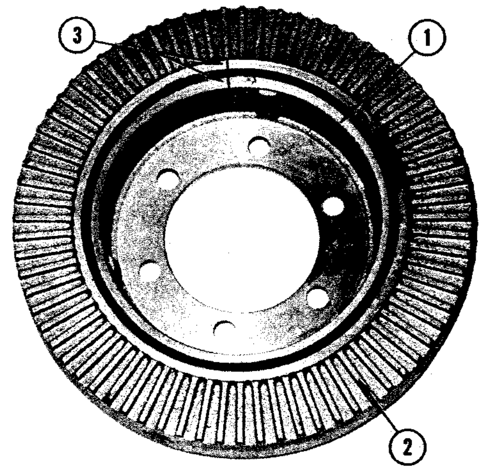


Fig. 2-36, (N10146). Vibration damper alignment marks

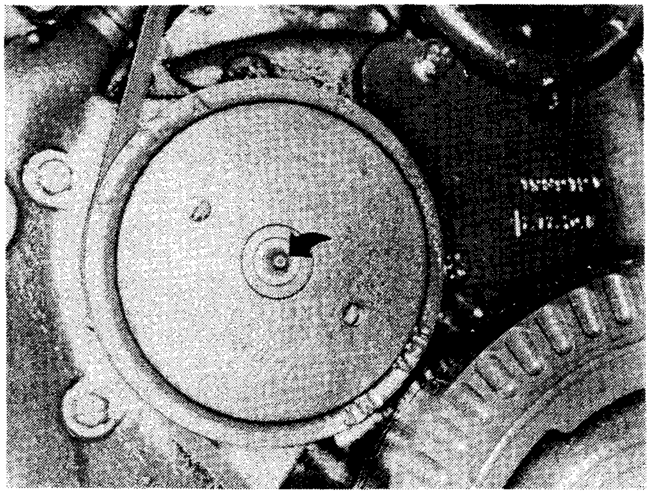


Fig. 2-37, (V51914). Water pump lubricating point – V-903

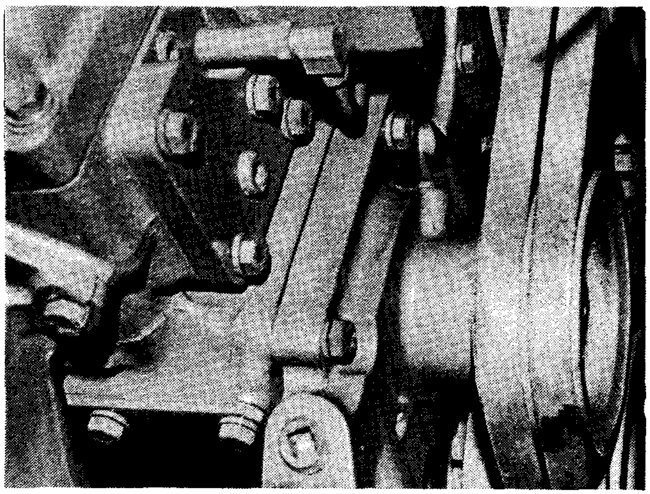


Fig. 2-38, (V11907). Water pump lubrication point – V-378, V-504 and V-555

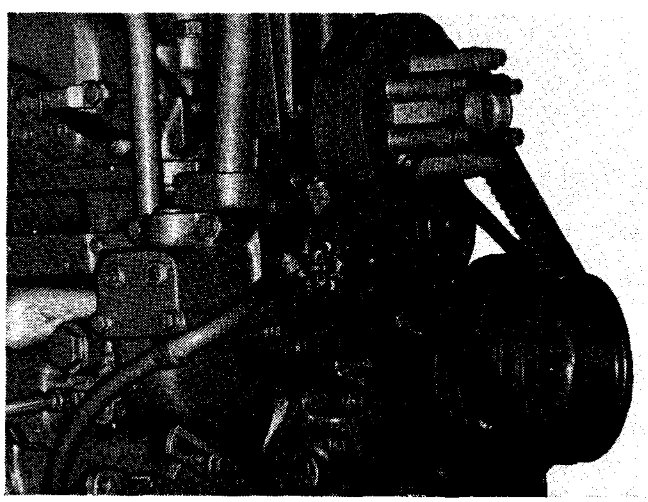


Fig. 2-39, (N11975). Water pump lubrication point – FFC Series

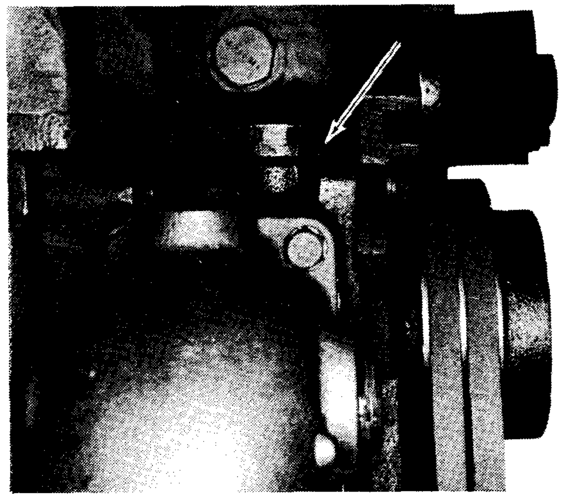


Fig. 2-40, (N11970). Water pump lubrication point – NTA Series

Assemblies Lubricated With Grease (Every 2nd C Check)

1. Install grease fitting (if removed), apply grease gun, give one "shot" of grease or until grease appears at relief fitting (if used).

2. Do not overfill; overheating and bearing failure will result. If disassembled, pack bearings and fill 1/2 to 2/3 capacity, see Section 3 for Grease Specifications.

Assemblies Lubricated With SAE 90 Lubricant

1. If it is determined lubricant should be added to water pump or idler pulley, add SAE 90 Lubricant to level of drain hole. Replace pipe plugs.

2. At rebuild period, water pumps and idlers using SAE 90 Lubricant should be cleaned thoroughly. Prepack bearings and fill cavity 1/2 to 2/3 full with grease listed in Specifications, Section 3.

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

Clean Complete Oil Bath Air Cleaner

Steam

Steam clean the oil bath air cleaner main body screens. Direct the steam jet from the air outlet side of the cleaner to wash dirt out in the opposite direction of air flow.

Solvent-Air Cleaning

Solvent-bath cleaning requires a 55-gallon drum and a source of air pressure. Any good commercial solvent may be used.

1. Steam clean exterior of cleaner.

2. Remove air cleaner oil cup.

3. Clamp hose with air line adapter to air cleaner outlet.

4. Submerge air cleaner in solvent.

5. Introduce air into unit at 3 to 5 psi [0.2 to 0.4 kg/sq cm] and leave in washer 10 to 20 minutes.

6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent.

7. Dry thoroughly with compressed air.

Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from cleaner.

8. If air cleaner is to be stored, dip in lubricating oil to prevent rusting of screens.

Note: If screens cannot be thoroughly cleaned by either method, or if body is pierced or otherwise damaged, replace with new air cleaner.

Check Alternator/Generator And Cranking Motor Brushes And Commutators

Failure of an alternator/generator or cranking motor may cause unit downtime and nearly always result in expensive replacement.

1. Inspect terminals for corrosion and loose connections, Fig. 2-41, and wiring for frayed insulation. Check mounting bolts for tightness and check belt for alignment, proper tension and wear.

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 and 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.

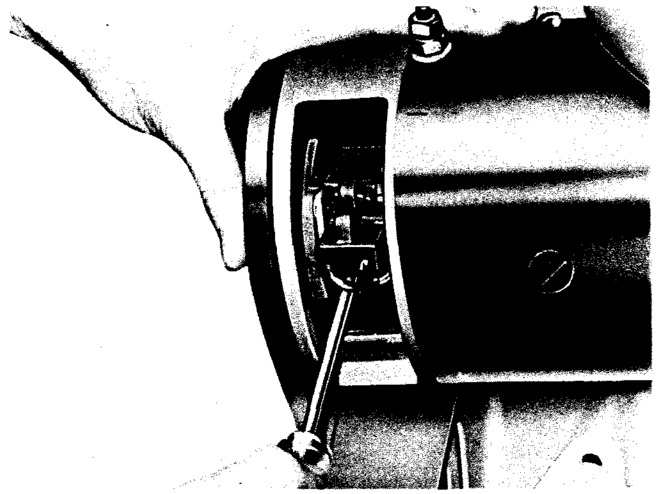


Fig. 2-41, (N11308). Checking generator brushes

Lubricate Fan Hub

Caution: Prior to adding lubricant to fan hub, remove pipe plug and check type of lubricant used.

Assemblies Lubricated With Grease

1. Remove pipe plugs, install grease fitting (1, Fig. 2-42) in fan hub. Give one "shot" (approx. 1 tablespoon) each second "C" Check.

Note: After greasing fan hub, remove grease fittings and install pipe plugs.

2. Completely disassemble, clean and inspect at each "D" Check.

3. If fan hub has no provisions for greasing, disassemble, clean and inspect each second "C" Check.

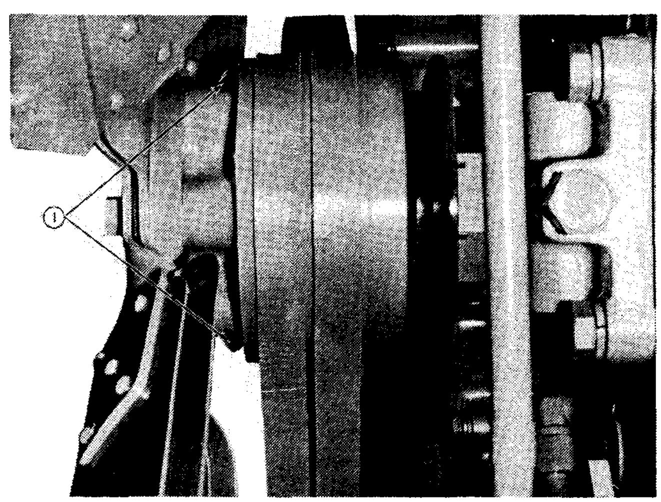


Fig. 2-42, (N21935). Fan hub lubricating point

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

1. Check level of lubricant by turning hub pulley until one filler hole is in horizontal (90 deg. from vertical) position. Allow lubricant to "settle-out" and remove pipe plugs; if lubricant flows from open hole, reinstall pipe plug.

2. If lubricant level is low, drain and refill 1/2 full or until oil comes from drain hole with SAE 30 lubricating oil; do not overfill. Replace pipe plugs.

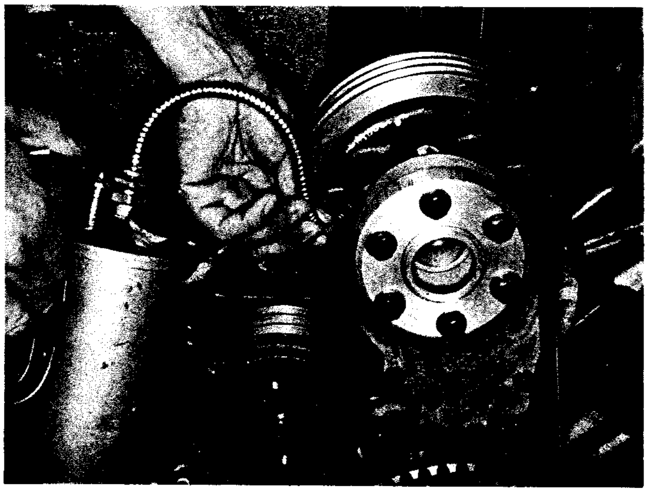


Fig. 2-43, (V51926). Lubricating fan hub

Caution: After filling, wait for lubricant to "settle-out" then recheck. This will insure fan hub is filled to proper level.

3. At rebuild period fan hubs using SAE 90 Lubricant should be cleaned thoroughly. Fill 1/2 full with SAE 30 lubricating oil if not previously changed.

Adjust Injectors And Valves

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 as stated.

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 (oil temperature to be within 10 deg. F of ambient air temperature). Up to 4 hours may be required to reach this condition on engines which have operated at a high load immediately prior to shut down.

Definition Of "Hot Set"

1. Set injectors and valves immediately after the engine has reached normal stabilized operating oil temperature.

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.

Valve Set Mark Alignment (V-903 Series)

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. 2-44 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. 2-45 and Table 2-3.

Table 2-3: Engine "V" Series Firing Order

Right Hand	V8	1-5-4-8-6-3-7-2
Right Hand	V6	1-4-2-5-3-6

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

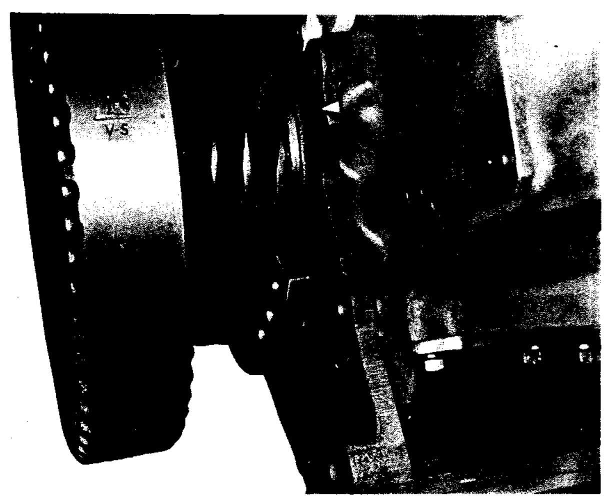


Fig. 2-44, (V514115). Valve set marks

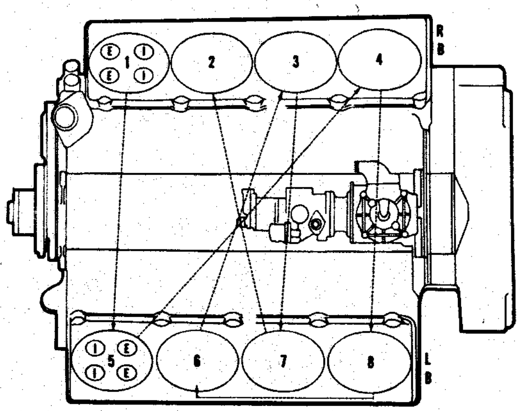


Fig. 2-45, (V11462). V8 Firing order diagram

Before adjustments tighten injector, hold down capscrew to 30 to 35 ft-lbs [4.1 to 4.8 kg m] torque.

Note: Do not use fan to rotate engine. Remove key, insert hex drive and press inward until barring gear engages drive gear; then advance. Fig. 2-46. After completion of adjustment, be sure drive retracts and install key into safety lock groove.

V-903 And VT-903 Injector Adjustment, Using 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.

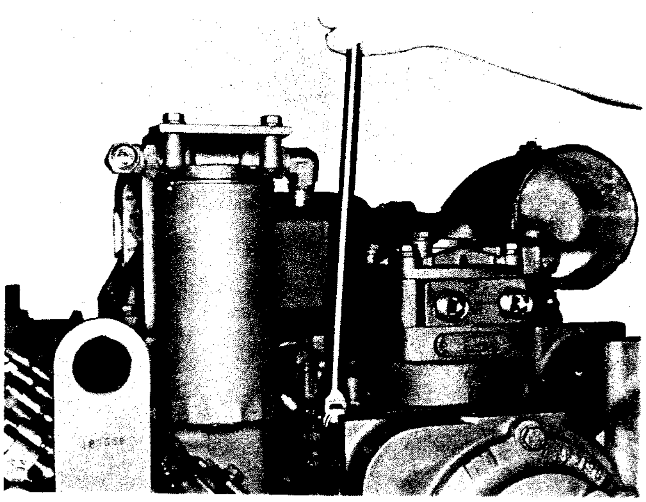


Fig. 2-46, (V51486). Engine barring arrangement

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 2-4 for specifications.

Note: Values listed in Table 2-4 are to be used for either "Cold Set" or "Hot Set".

Table 2-4: Adjustment Limits Using Indicator Method Of Adjustment — Inch [mm]

Injector Plunger Travel		Valve Clearance	
Adjustment Value	**Reset Limit**	**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 [0.64]

The timing mark location (Fig's. 2-47 and 2-48) 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. 2-47 and 2-48.

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. Fig. 2-47. 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. Newer engines have a pointer cast on accessory drive support. See Fig. 2-48. Alignment, in both cases, should be held to one-half inch [12.70 mm] of the capscrew.

Using regular engine barring device (Fig. 2-46), 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.

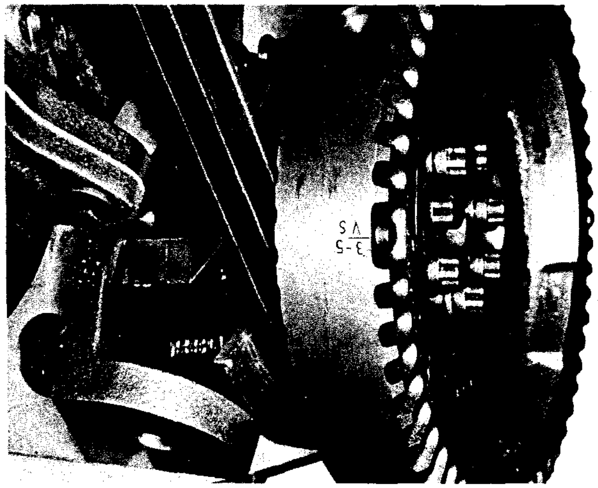


Fig. 2-47 (V514126). Location of timing marks on front cover and vibration damper

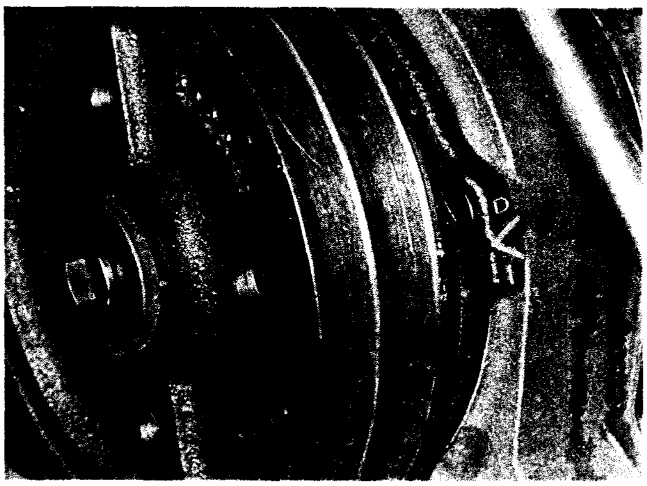


Fig. 2-48 (V514127). Location of timing marks on accessory drive support

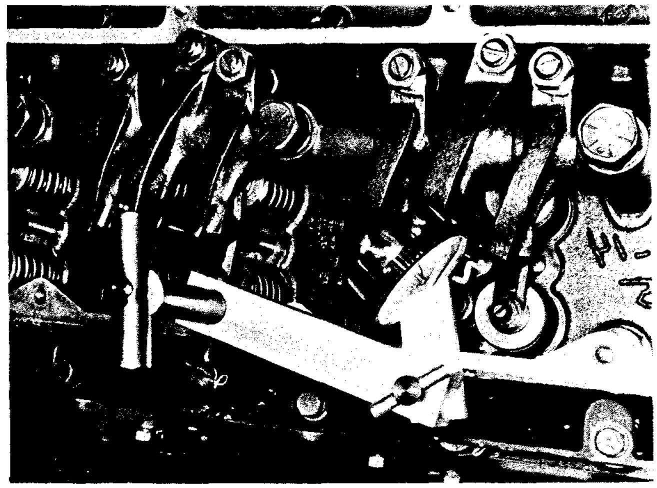


Fig. 2-49, (V514114). Dial indicator in place - extension in contact with plunger

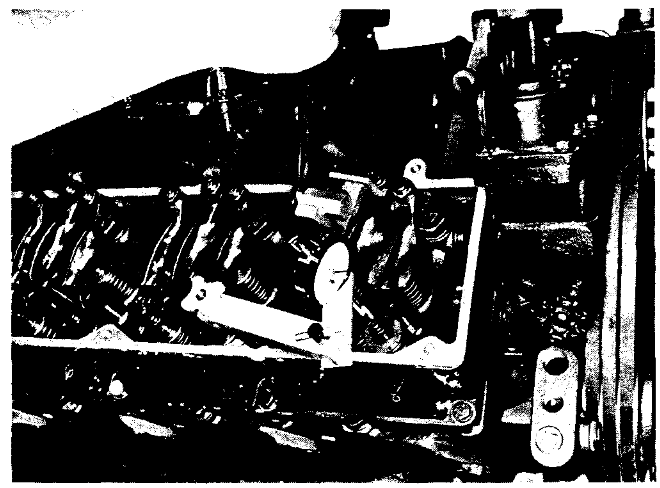


Fig. 2-50, (V514128). Bottoming injector plunger in cup

Do not use fan to rotate engine.

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

1. Set up the ST-1170 Indicator Support with the indicator extension atop the injector plunger flange at No. 2 cylinder. Fig. 2-49.

2. Make sure that the indicator extension is secure in indicator stem and not against the rocker lever.

3. Using ST-1251 Actuator, Fig. 2-50, bar the lever forward until injector plunger is bottomed in cup to squeeze oil film from between plunger and 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 2-4. (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 [4.1 to 5.5 kg m] and actuate the injector plunger several times as a check of the adjustment. Tighten to 25 to 35 ft-lbs [3.5 to 4.8 kg m] when using ST-669 Adapter on torque wrench.

7. Adjust intake and exhaust valve overhead to valve clearances given in Table 2-4. Torque adjusting screw locknuts to 30 to 40 ft-lbs [4.1 to 5.5 kg m] or 25 to 35 ft-lbs [3.5 to 4.8 kg m] when using a ST-669 Adapter.

8. Bar engine in direction of engine rotation until 1-6 "VS" mark aligns with the new set mark and adjust cylinder 1. Continue through the firing order until all cylinders are adjusted. For engine firing order see Table 2-3.

Injector Plunger Adjustment Using Torque Method, V-378, V-504, V-555 C.I.D. Series Engines

Valve Set Mark Alignment

Turn crankshaft in direction of rotation until a "VS" mark appears on the vibration damper, crankshaft pulley or accessory drive pulley. See Fig. 2-51 for location of valve set marks. In this position, both intake and exhaust valves must be closed for that cylinder; if not, advance crankshaft one revolution. See Fig. 2-52, Fig. 2-45 and Table 2-3 for firing order.

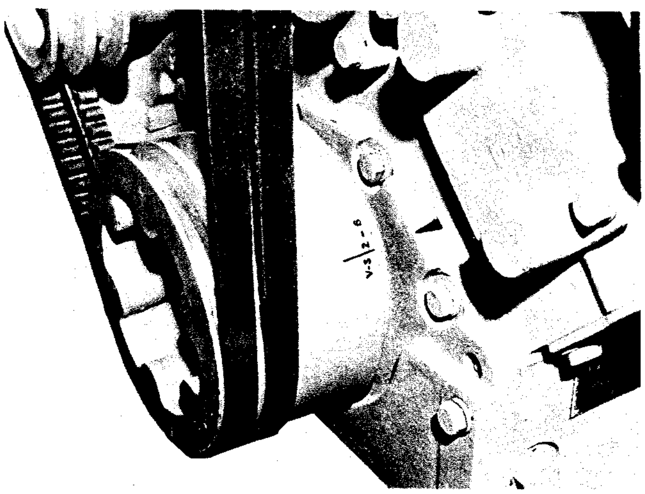


Fig. 2-51, (V11913). Valve set marks

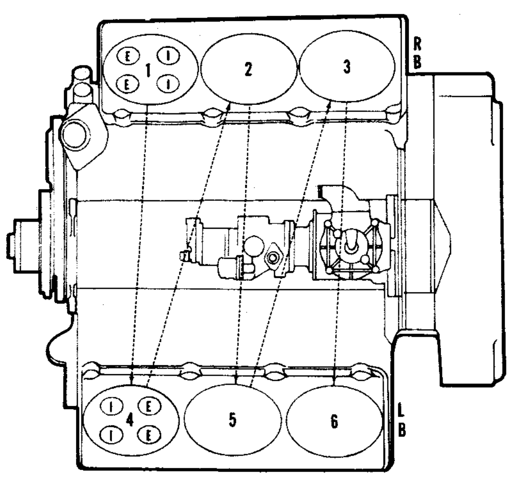


Fig. 2-52, (V11461). V6 Firing order

Before adjusting injector, tighten injector hold-down capscrew to 30 to 35 ft-lbs [4.1 to 4.8 kg m] torque.

The injector plungers of all engines must be adjusted with an inch-pound torque wrench to a definite torque setting. A Snap on Model TE-12 or equivalent torque wrench and a screwdrive adapter can be used for this adjustment. Fig. 2-53.

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 screwdrive adapter, tighten the adjusting screw to values shown in Table 2-5 for cold setting and tighten the locknut.

Note: Values listed in Tables 2-5 and 2-7 are to be used for either "Cold Set" or "Hot Set".

Table 2-5: Injector Plunger Adjustment Torque

Engine Model	Set
V-378, 504, 555	60 inch-lb [0.7 kg m]

3. Hold injector adjusting screw and tighten injector locknut to values indicated in Table 2-6. When ST-669 Adapter is used, nut torque is reduced to compensate for additional torque arm length. Fig. 2-54.

Note: If cylinder head gasket or any components of actuating train have been replaced, engine must be started and brought to operating temperature, then allowed to cool thoroughly. Cylinder head capscrews must be retorqued. See Shop Manual. Injector plungers should then be reset to values listed above.

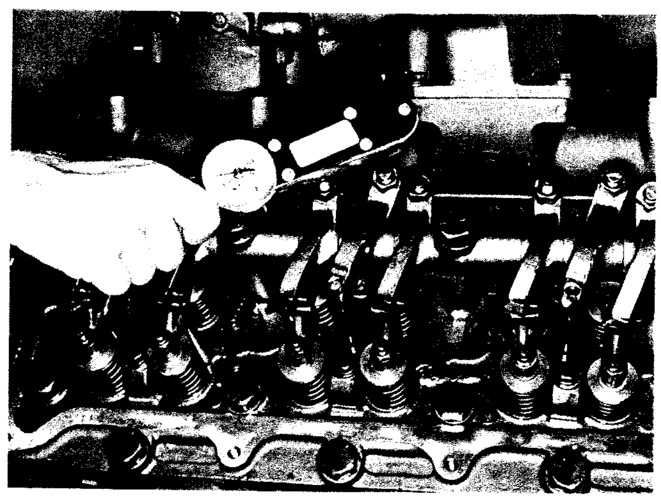


Fig. 2-53, (V51488). Adjusting injector plungers

Table 2-6: Injector And Valve Locknut Torque (All Models)

With ST-669	Without ST-669
25 to 35 ft-lbs [3.5 to 4.8 kg m]	30 to 40 ft-lbs [4.1 to 5.5 kg m]

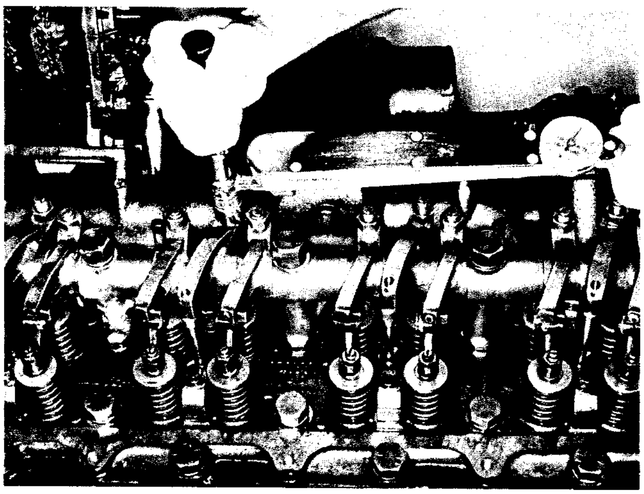


Fig. 2-54, (V51489). Tightening injector adjusting screw locknut

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. 2-55.

4. Hold adjusting screw in this position and torque locknut to 25 to 30 ft-lbs [3.5 to 4.1 kg m].

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

5. Check clearance between crosshead and valve spring retainer with wire gauge. there must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

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

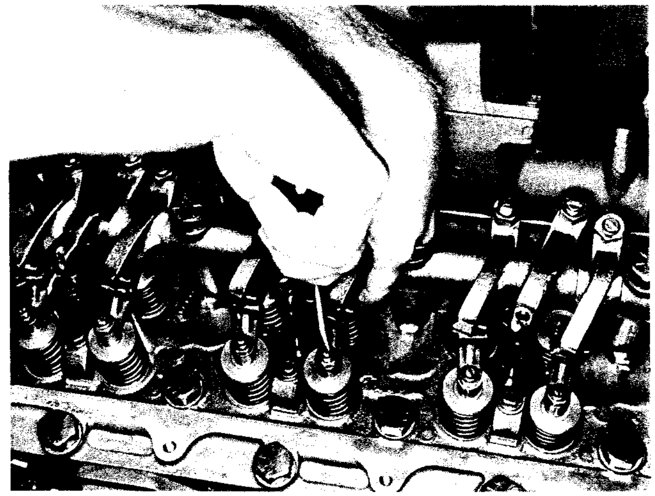


Fig. 2-55, (V51490). Adjusting crossheads

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Valve clearances are shown in Table 2-7. Turn screw down until lever just touches gauge and lock adjusting screw in this position with locknut. Fig. 2-56. Torque locknut to values indicated in Table 2-6, note Step 3 under "Injector Plunger Adjustment."

Table 2-7: Valve Clearance — Inch [mm]

Intake Valves Set	Exhaust Valves Set
V-378, 504, 555 Engines	
0.012 [0.30]	0.022 [0.56]

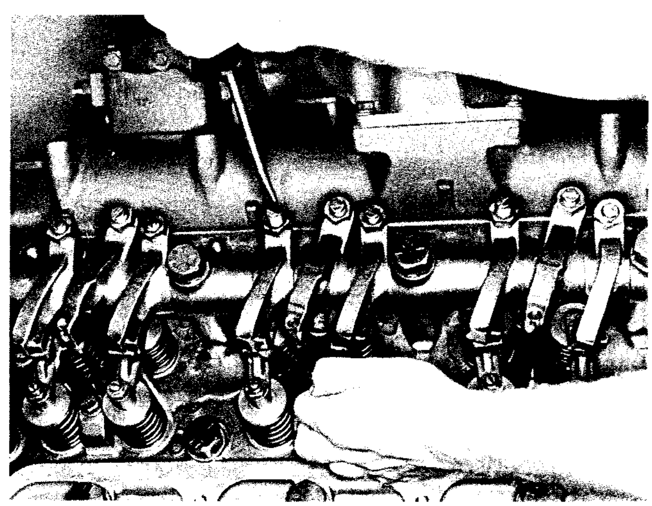


Fig. 2-56, (V51492). Adjusting valves

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

Injector And Valve Adjustment Using ST-1170 Dial Indicator Method NH-NT Series

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. See Table 2-8.

Temperature conditions described as "Cold Set" or "Hot Set" (Page 2-25) 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.

Before adjusting injectors, torque cylindrical injector, hold-down capscrews in alternate steps to 10 to 12 ft-lbs [1.4 to 1.7 kg m]. With flange injectors torque hold-down capscrews in alternate steps to 12 to 14 ft-lbs [1.7 to 1.9 kg m]. Tighten fuel inlet and drain connections to 20 to 25 ft-lbs [2.8 to 3.5 kg m] in flange injectors.

Check Plunger Free Travel (Engines Without Injector Adjustment Procedure Decal)

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 1-1/2 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 [5.23 mm] on any one (1) cylinder of engine on which dial indicator method of adjustment is to be used.

Note: On engines with Plunger Free Travel exceeding 0.206 inch [5.23 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 [5.23 mm] limit of Free Travel to be obtained.

Maintenance Adjustment

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

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.

Table 2-8: Injector and Valve Set Position

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

1. Bar engine until "A" or 1-6 "VS" mark on pulley, Fig. 2-57, is aligned with pointer on gear case cover. In this position, both 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., realign marks with pointer.

2. Set up ST-1170 Indicator Support with indicator extension on injector plunger top at No. 3 cylinder, Fig. 2-58. Make sure indicator extension is secure in indicator stem and not against rocker lever.

Note: Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only. Any cylinder combination may be used as a starting point, see Table 2-8.

Table 2-9: Uniform Plunger Travel Adjustment Limits

Oil Temp.	Injector Plunger Travel Inch [mm] Adj. Value	Injector Plunger Travel Inch [mm] Recheck Limit	Valve Clearance Inch [mm] Intake	Valve Clearance Inch [mm] Exhaust
Aluminum Rocker Housing				
Cold	0.170 [4.32]	0.169 to 0.171 [4.29 to 4.34]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 [4.32]	0.169 to 0.171 [4.29 to 4.34]	0.008 [0.20]	0.023 [0.58]
Cast Iron Rocker Housing				
Cold	0.175 [4.45]	0.174 to 0.176 [4.42 to 4.47]	0.011 [0.28]	0.023 [0.58]
Hot	0.175 [4.45]	0.174 to 0.176 [4.42 to 4.47]	0.008 [0.20]	0.023 [0.58]

3. Using ST-1193 Rocker Lever Actuator, Fig. 2-59, or equivalent, bar lever toward injector until plunger is bottomed to squeeze oil film from cup. Allow injector plunger to rise, bottom again, set indicator at zero (0). Check extension contact with plunger top.

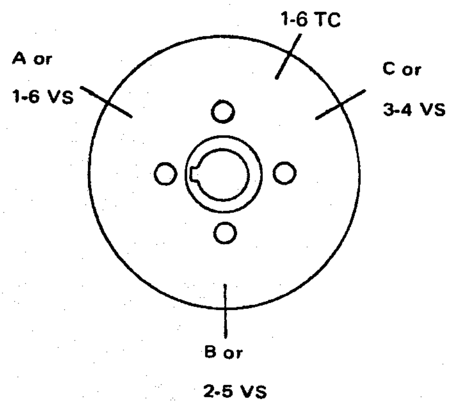


Fig. 2-57, (N114230). Accessory Drive Pulley Markings

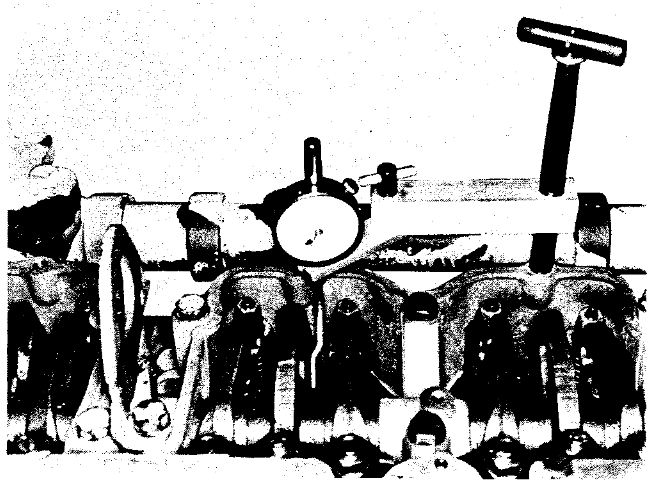


Fig. 2-58, (N114231). Dial indicator in place - extension in contact with plunger

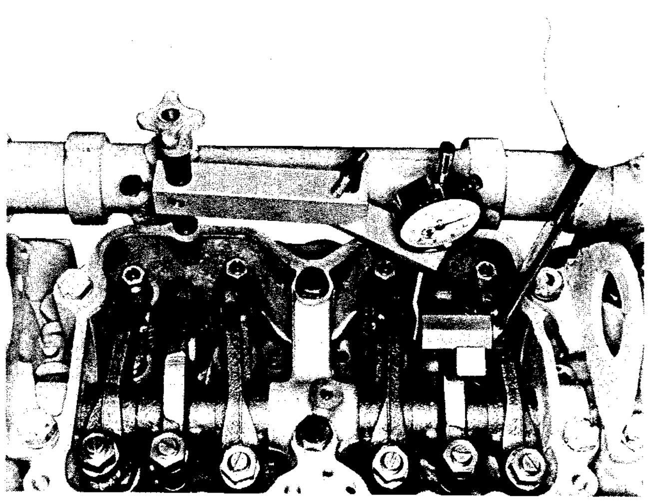


Fig. 2-59, (N114237). Bottoming injector plunger in cup

4. Bottom plunger again, release lever; indicator must show travel as indicated in Table 2-9 (use proper value depending if adjustment or recheck). Adjust as necessary.

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

5. If loosened, tighten locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] and actuate injector plunger several times as a check of adjustment. Tighten to 25 to 35 ft-lbs [3.5 to 4.8 kg m] when using ST-669 Adapter.

Caution: Before checking or setting valves, be sure crossheads are adjusted.

6. Adjust valves on cylinder No. 5 to values in Table 2-9. Torque locknuts to same value as injectors. Move to next cylinder as indicated in Table 2-8 and repeat adjustment.

7. Apply Injector Adjustment Decal to frontmost plain rocker housing cover if not previously installed.

Adjustment Of Engine on which Head Gasket and/or Rocker Housing Gasket has been replaced.

Adjust injectors and valves using appropriate values in the "Cold Set" column. See Table 2-9. The engine must operate for approximately 1 hour at rated speed and load 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.

Adjust Injectors And Valves NH,NT And C Series (Torque Method)

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 cylindrical injector, hold-down capscrews in alternate steps to 10 to 12 ft-lbs [1.4 to 1.7 kg m]. With flange injectors torque hold-down capscrews in alternate steps to 12 to 14 ft-lbs [1.7 to 1.9 kg m]. Tighten fuel inlet and drain connections to 20 to 25 ft-lbs [2.8 to 3.5 kg m] in flange injectors.

Timing Mark Alignment

1. If used, pull compression release lever back and block in open position while 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. 2-60 and 2-61) 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 as 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.

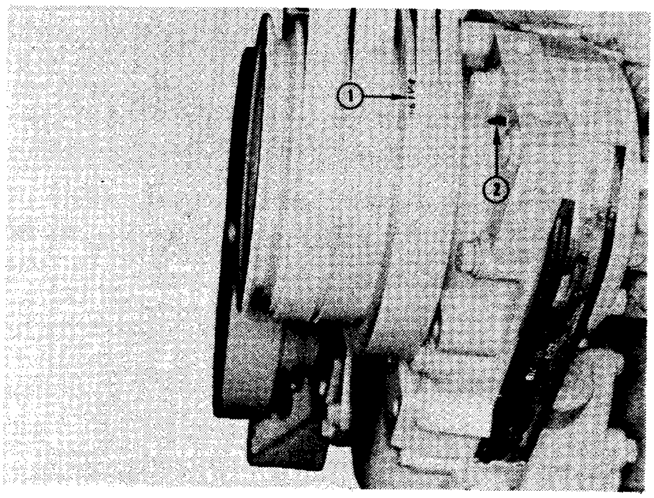


Fig. 2-60, (N114220). Valve set timing marks — H-NH Series

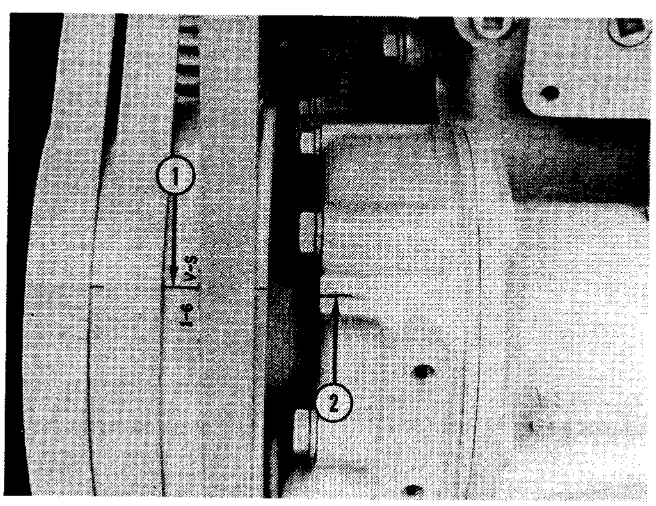


Fig. 2-61, (N21459). Valve set timing marks — C Series

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.

Table 2-10: Engine Firing Order — Inline

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

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

Injector Plunger Adjustment — Torque Method

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. 2-62.

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 2-11 and tighten the locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] torque. If ST-669 torque wrench adapter is used, torque to 25 to 35 ft-lbs [3.5 to 4.8 kg m].

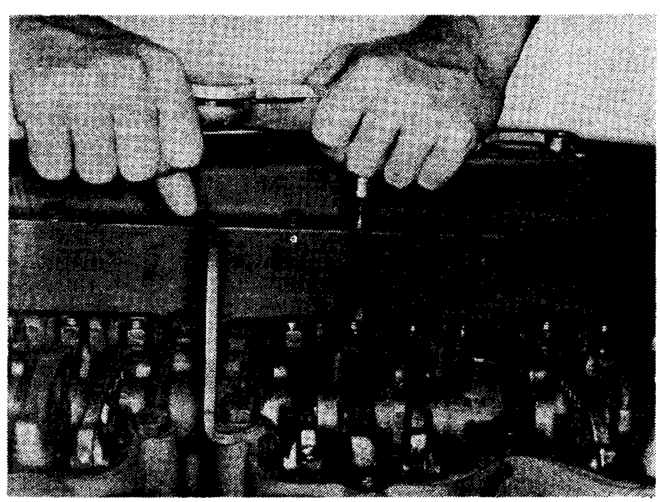


Fig. 2-62, (N11466). Adjusting injector plungers

Table 2-11: Injector Adjustment (Oil Temperature)

Cold Set	Hot Set
NH and NT Series	
Cast Iron Rocker Housing	
48 inch-lb [0.6 kg m]	72 inch-lb [0.8 kg m]
Aluminum Rocker Housing	
72 inch-lb [0.8 kg m]	72 inch-lb [0.8 kg m]
C Series	
48 inch-lb [0.6 kg m]	60 inch-lb [0.7 kg m]

Crosshead Adjustment

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. Make sure crossheads are adjusted before adjusting valve rocker levers.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-63) one turn.

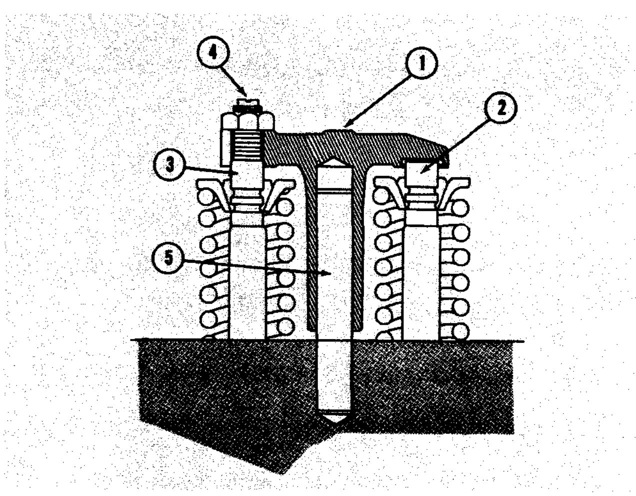


Fig. 2-63, (N21461). Valve crosshead

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 to 3.6 kg m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [3.5 to 4.1 kg m].

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment — Torque Method

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. 2-64. Tighten locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] torque. When using ST-669 torque to 25 to 35 ft-lbs [3.5 to 4.8 kg m].

3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-12 for appropriate valve clearances.

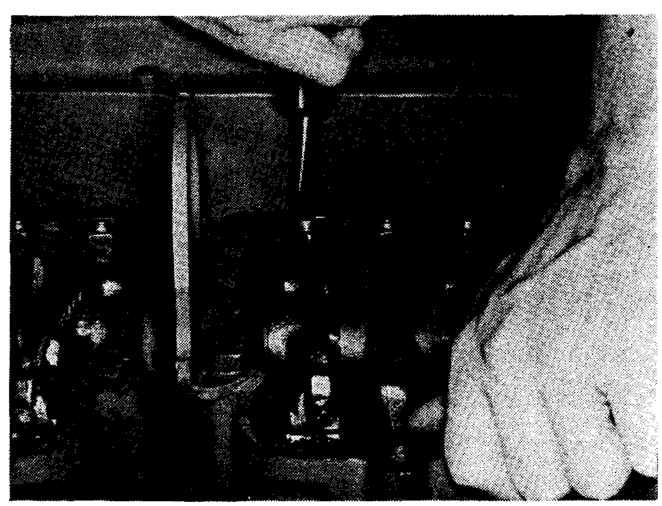


Fig. 2-64, (N114215). Adjusting valves

Table 2-12: Valve Clearance — Inch [mm]

Intake Valves		Exhaust Valves	
Cold Set	Hot Set	Cold Set	Hot Set
NH and NT Series			
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]
C Series			
0.017 [0.43]	0.015 [0.38]	0.027 [0.69]	0.025 [0.64]

Change Aneroid Oil And Replace Breather

At each "C" Check, remove fill plug (1, Fig. 2-65) and drain plug (2), allow aneroid to drain. Replace drain plug (2), fill aneroid with clean engine lubricating oil. Replace fill plug (1). Remove and replace aneroid breather (3).

Check Aneroid Adjustment And Check Bellows

Adjustment

Normally, no adjustment of the aneroid is required; however, if smoke is evident and all other engine adjustments have been checked, back out adjusting screw (4, Fig. 2-65). If screw must be backed out until acceleration is slow, have unit checked by a Cummins Distributor.

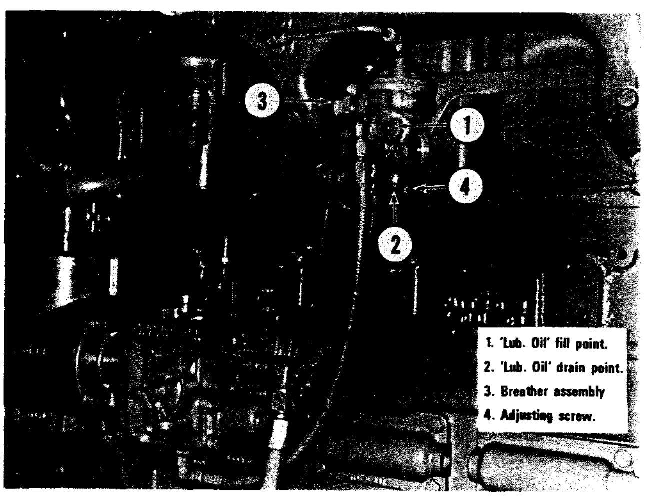


Fig. 2-65, (N10503). Aneroid

Note: If smoke is excessive after 15 seconds of full throttle operation, aneroid is not at fault, have fuel system and turbocharger checked.

If during Fuel Manifold Pressure Check, Steps 5 through 11, Page 2-22, it is determined that aneroid bellows should be replaced, refer to Bulletin No. 983725 for complete rebuild instructions. Rebuild and Calibration must be performed by a Cummins Distributor.

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 that 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 below, early engine failure and poor performance may be expected.

4. Maximum permissible back pressure for V-378, V-504 and V-555 Series is 3 inches [76.2 mm] Hg or 40.8 inches [103.6 cm] of water for all naturally aspirated engines.

All Other Models

a. Naturally Aspirated: 2.0 inches [50.9 mm] Hg. or 27 inches [68.6 cm] water.

b. Turbocharged: 2.5 inches [63.5 mm] Hg. or 34 inches [86.4 cm] water.

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

Check For Oil Leaks At Supercharger

Remove supercharger outlet connection and visually check ends of the rotor and case for evidence of oil leakage from supercharger seals. Rotor will always show some oil from the vapor tube that is connected to the cylinder head cover.

Only the appearance of "wet" oil at ends of the rotors and excessive oil consumption should be cause for changing supercharger seals. Check supercharger connections for leaks and correct if necessary.

'D' Maintenance Checks

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.

Clean And Calibrate Injectors

Clean and calibrate injectors regularly to prevent restriction of fuel delivery to combustion chambers. 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.

To clean and calibrate injectors, refer to Bulletin No. 983536 and revisions thereto.

Check Fuel Pump Calibration

Check fuel pump calibration on engine if required. See the nearest Cummins Distributor or Dealer for values.

Clean Turbocharger Compressor Wheel And Diffuser

Keep the compressor wheel and diffuser clean for best turbocharger performance. Any buildup of dirt on the compressor wheel will choke off air flow and cause rotor imbalance.

At every "D" Check, clean the compressor wheel and diffuser. Refer to pertinent Turbocharger Manual for specific instructions.

Check Turbocharger Bearing Clearance

Check bearing clearances every "D" Check. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance. Fig. 2-66.

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. Refer to Turbocharger Manual.

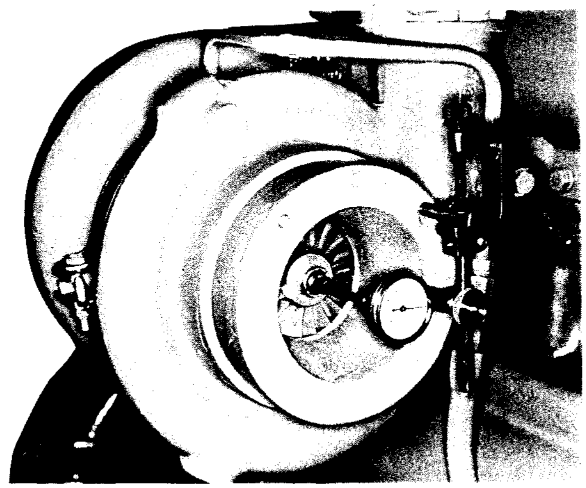


Fig. 2-66, (N11956). Checking turbocharger bearing end clearance

3. Check radial clearance on compressor wheel only.

4. If end clearance exceeds limits shown in Specific Bulletin, remove turbocharger from engine and replace with a new or rebuilt unit.

Inspect/Install Rebuilt Unit As Necessary

At this time the following assemblies should be inspected and rebuilt as necessary in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and disassembly and assembly procedures:

Water Pump
Fan Hub
Lubricating Oil Pump
Air Compressor
Injectors
Fuel Pump

Inspect each rebuilt unit before installing it on the engine. Be sure all units are clean and that all capscrews, nuts and bolts are tight. Install units on engine in convenient sequence; refer to Cummins Shop Manuals for correct assembly procedures.

Replace Bellows And Calibrate Aneroid

At each "D" Check replace aneroid bellows. This can be accomplished without changing aneroid settings if precautions are taken to assure that same spring and shims are reinstalled.

1. Remove flexible hose or tube from aneroid cover to intake manifold.

2. Remove lead seal or file away end of rivet type seal (if used).

3. Remove screws and aneroid cover.

4. Remove self-locking nut and retaining washer securing bellows (7, Fig. 5-9) to shaft (6) and piston (8).

5. Clean bellows sealing area on body and cover.

6. Install new bellows, align holes in bellows with corresponding holes in aneroid body. Position retaining washer over bellows and secure with self-locking nut.

7. Position cover to body; secure with flatwashers, lockwashers and fillister head screws.

8. Install new seal. Refer to Bulletin No. 983725 for sealing instructions and calibration procedure. Calibration must be performed by a Cummins Distributor on a fuel pump test stand.

9. Reinstall flexible hose or tube from aneroid cover to intake manifold.

'E' Maintenance Checks

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 a chassis overhaul, where engine is not removed from the unit 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, oil dilution and other signs of wear such as "blow-by" 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
Inspect Cylinder Liners
Replace Cylinder Liner Seals
Inspect Pistons
Inspect Connecting Rods
Replace Piston Rings
Inspect Crankshaft Journals
Inspect Camshaft
Inspect Cam Followers
Replace Front And Rear Crankshaft Seals
Replace Vibration Damper
Clean Oil Cooler

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

If, during major inspection, it is determined that crankshaft journals or any other engine parts are worn beyond worn replacement limits, engine should be removed and completely rebuilt.

Check Engine Blow-By

Engine blow-by or escape of combustion gases past pistons and liners, is usually caused by worn or stuck piston rings, worn cylinder liners or worn pistons.

Blow-by can be detected by running the engine and observing the gas escape from the lubricating oil filler hole with cap or breather open or removed. There is always some vapor or gas escape at this point due to heated oil and piston movement, but distinct puffs indicate blow-by.

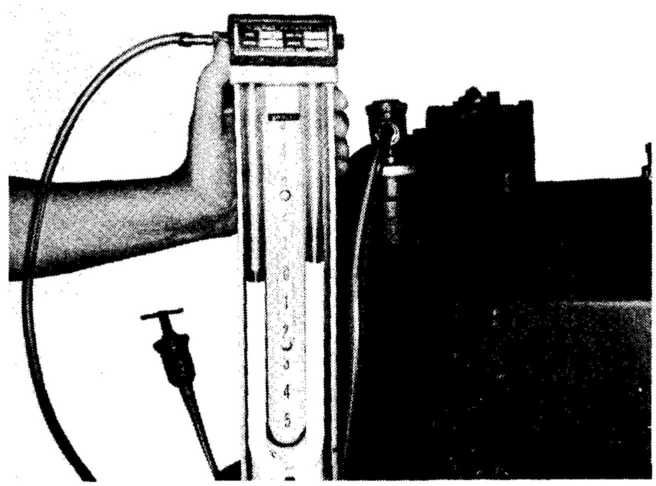


Fig. 2-67. (V51497). Checking blow-by

Experience and comparison with other units operating at the same speed are needed to make a conclusion as to the extent of blow-by. Normally, excessive blow-by is accompanied by oil consumption.

Cummins Distributors are equipped to check engines for blow-by under loaded conditions with special tools to determine if blow-by is excessive. Fig. 2-67.

Other Maintenance Checks

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Check Fan And Drive Pulley Mounting (Spring And Fall)

Check fan to be sure it is securely mounted; tighten capscrews as necessary. Check fan for wobble or bent blades.

Check fan hub and crankshaft drive pulley to be sure they are securely mounted. Check fan hub pulley for looseness or wobble; if necessary, remove fan hub and tighten the shaft nut. Tighten the fan bracket capscrews.

Clean Cooling System (Spring And Fall)

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 from radiator. Use clean water that will not clog any of the hundreds of small passages in radiator or water passages in block. Clean radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

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

Pressure Flushing

Flush radiator and block when antifreeze is added or removed, or before installing a Corrosion Resistor on a used engine.

When pressure flushing radiator, open upper and lower hose connections and screw radiator cap on tight. Use hose connection on both upper and lower connections to make the operation easier. Attach flushing gun nozzle to lower hose connection and let water run until radiator is full. When full, apply air pressure gradually to avoid damage to core. Shut off air and allow radiator to refill; then apply air pressure. Repeat until water coming from radiator is clean.

Sediment and dirt settle into pockets in block as well as radiator core. Remove thermostats from housing and flush block with water. Partially restrict lower opening until block fills. Apply air pressure and force water from lower opening. Repeat process until stream of water coming from block is clean.

Check Hose (Spring And Fall)

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

Clean Electric Connections (Spring And Fall)

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 [9.53 mm] 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.

Check Preheater Cold-Starting Aid (Fall)

Remove 1/8 inch pipe plug from manifold, near glow plug, and check operation of preheater as described in Section 1.

Check Shutterstats And Thermatic Fans (Fall)

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 2-13 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195 deg. F [82 to 91 deg. C] thermostats are used only with shutterstats that are set to close at 187 deg. F [86 deg. C] and open at 195 deg. F [91 deg. C].

Check Thermostats And Seals (Fall)

Remove thermostats from thermostat housings and check for proper opening and closing temperature.

Most Cummins Engines are equipped with either medium 170 to 185 deg. F [77 to 85 deg. C] or low 160 to 175 deg. F [71 to 79 deg. C] and in a few cases high-range 180 to 195 deg. F [82 to 91 deg. C] thermostats, depending on engine application.

Tighten Mounting Bolts And Nuts (As Required)

Mounting bolts will occasionally work loose and cause the supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Check Power Take-Off Clutch Adjustment (As Required)

If clutch does not pull, heats or operating lever jumps out, clutch must be adjusted. To adjust clutch, remove hand hole plate in housing and turn clutch until adjusting lockpin can be reached. Due to variations in clutch arrangements, check manufacturer manual for procedure.

Disengage adjusting lockpin and turn adjusting yoke or ring to right, or clockwise, until operating lever requires a distinct pressure to engage. A new clutch generally requires several adjustments until friction surfaces are worn in.

Tighten Turbocharger Mounting Nuts (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. Fig. 2-68.

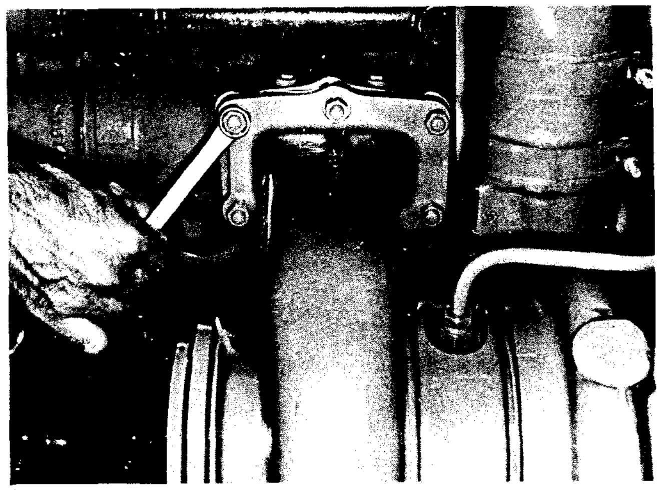


Fig. 2-68, (N11953). Tightening turbocharger mounting nuts

Check Crankshaft End Clearance (At Clutch Adjustment)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 2-14. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is disassembled for repair; install new thrust rings if wear results in end clearance in excess of value under "Worn Limit."

Table 2-13: Thermal Control Settings

Control Used	Setting With 160 deg. to 175 deg. F [71 deg. to 79 deg. C] Thermostat		Setting With 170 deg. to 185 deg. F [77 deg. to 85 deg. C] Thermostat		Setting With 180 deg. to 195 deg. F [82 deg. to 91 deg. C] Thermostat	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185 deg. F [85 deg. C]	170 deg. F [77 deg. C]	190 deg. F [88 deg. C]	182 deg. F [83 deg. C]	Not Used	
Shutterstat	180 deg. F [82 deg. C]	172 deg. F [78 deg. C]	185 deg. F [85 deg. C]	177 deg. F [81 deg. C]	195 deg. F [91 deg. C]	187 deg. F [86 deg. C]
Modulating Shutters Open	175 deg. F [79 deg. C]		185 deg. F [85 deg. C]		195 deg. F [91 deg. C]	

Table 2-14: Crankshaft End Clearance – Inch [mm]

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
V-903, VT-903	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]
V-378, V-504, V-555	0.004 [0.10]	0.014 [0.36]	0.022 [0.56]
C	0.004 [0.10]	0.015 [0.38]	0.022 [0.56]

The check can be made by attaching an indicator to rest against the damper or pulley, Fig. 2-69, while prying against the front cover and inner part of pulley or damper. End clearance must be present with engine mounted in the unit and assembled to transmission or converter.

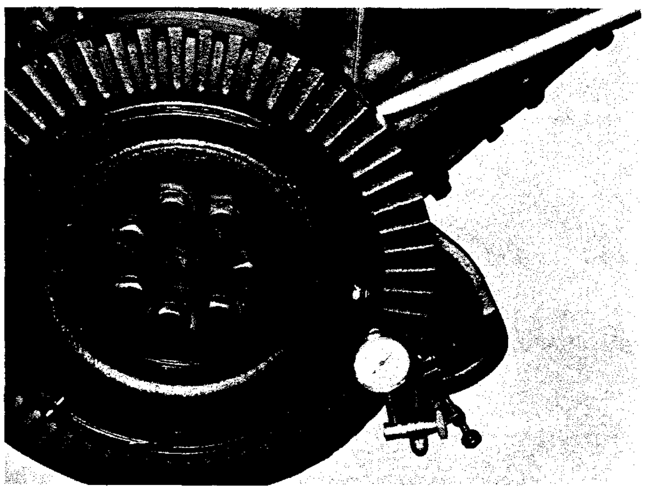


Fig. 2-69, (V51918). Checking crankshaft end clearance

Caution: Do not pry against outer damper ring.

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 Defense 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.

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.

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 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 viscocity 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.

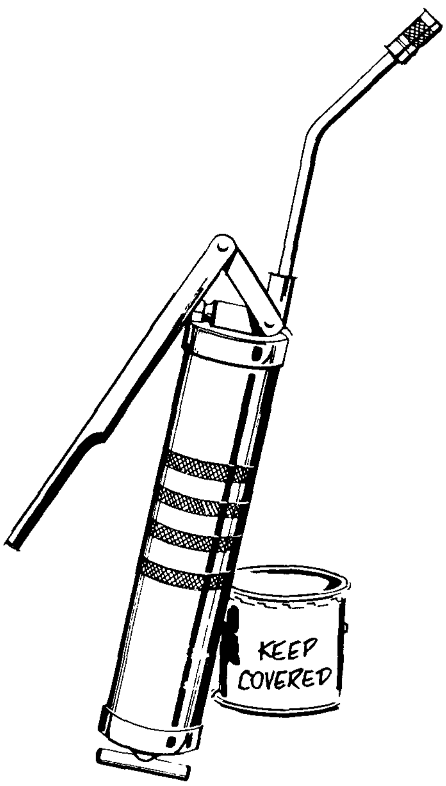
Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is void, and SAE 5W oils should not be used.

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.



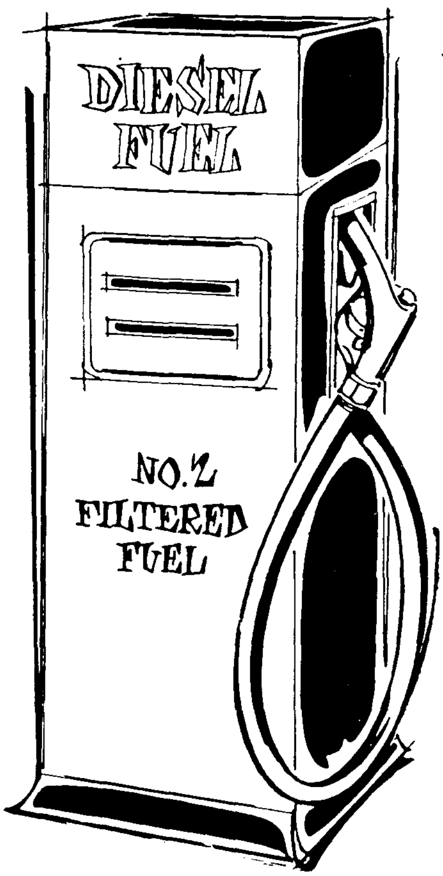
Test	Test Procedure	
High-Temperature Performance		
Dropping point, deg. F	ASTM D 2265	350 min.
Bearing life, hours at 300 deg. F. 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0 deg. F		15,000 max.
Run at 0 deg. F.		5,000 max.
Rust Protection and Water Resistance		
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 grease and lubricating oil 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 lubricant 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 and 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_2CrO_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 [$Ca(CH_3COO)_2H_2O$] to a one liter volumetric flask and dilute to the one liter mark with distilled water.

2. Add 10 ml. (milli-liter) of the 35,000 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 to 165 deg. F [71 to 74 deg. C] 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.

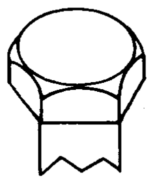
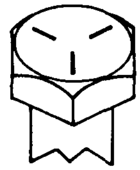
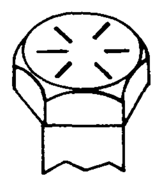
$$rcf = \left(\frac{rpm}{265}\right)^2 \times \text{dia. of swing}$$

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 the following 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.

Capscrew Markings and Torque Values

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). 			 6  7	

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 [7.60]	120 [16.60]		170 [23.51]
5/8 – 11	83 [11.48]	150 [20.75]	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]

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. 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 precedure for investigation and correction of the difficulty. The chart of 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 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?

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 lube 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 realtionship 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 Bearings 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	●	●				●					●															
	Aneroid Check Valve Stuck Open				●	●																					
	Aneroid Set Improperly	●																									
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																●		●	●							
	Loose Fan Belts																●		●	●							
	Radiator Shutters Stuck Open														●			●									
	Clogged Water Passages																●		●	●							
	Internal Water Leaks															●											
	Clogged Oil Cooler																●			●							
	Radiator Core Openings 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 Driven Unit								●													●				●	●
	Loose Mounting Bolts																								●		●
	Incorrect Valve and Injection Timing	●		●	●	●																	●	●			
	Worn or Scored Liners or Pistons			●	●	●								●							●				●		
	Injectors Need Adjustment		●	●	●	●			●															●			

Operating Principles

Dependable service can be expected from a Cummins Diesel Engine when the operating procedures are based upon a clear understanding of the engine working principles. Each part of the engine affects the operation of every other working part and of the engine as a whole. Cummins Diesel Engines treated in this manual are four-stroke-cycle, high-speed, full-diesel engines. Horsepower ratings and other engine specifications for each model are tabulated on preceding pages.

The Cummins Diesel Engine

Cummins Diesel Cycle

Cummins Diesel Engines differ from spark-ignited engines in a number of ways. Compression ratios are higher, the charge taken into combustion chamber during the intake stroke consists of air only – with no fuel mixture. Cummins injectors receive low-pressure fuel from the fuel pump and deliver it into individual combustion chambers at the proper time, in equal quantity and atomized condition for burning. Ignition of fuel is caused by heat of compressed air in the combustion chamber.

It is easier to understand the function of engine parts if it is known what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly, valves and injectors must act in direct relation to each of the four strokes of the piston. The intake valves, exhaust valves and injectors are camshaft actuated, linked by tappets or cam followers, push rods, rocker levers and valve crossheads. The camshaft is gear driven by the crankshaft gear, thus rotation of the crankshaft directs the action of the camshaft which in turn controls the opening and closing sequence of the valves and the injection timing (fuel delivery).

Intake Stroke

During intake stroke, the piston travels downward; intake valves are open, and exhaust valves are closed. The downward travel of the piston allows air from the atmosphere to enter the cylinder. On turbocharged engines the intake manifold is pressurized as the turbocharger forces more air into the cylinder through the intake manifold. The intake charge consists of air only with no fuel mixture.

Compression Stroke

At the end of the intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed.

At end of compression stroke, air in combustion chamber has been forced by piston to occupy a smaller space (depending upon engine model about one-fourteenth to one-sixteenth as great in volume) than it occupied at beginning of stroke. Thus, compression ratio is the direct proportion in the amount of air in the combustion chamber before and after being compressed.

Compressing air into a small space causes temperature of that air to rise to a point high enough for ignition of fuel.

During last part of compression stroke and early part of power stroke, a small metered charge of fuel is injected into combustion chamber.

Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by the existing hot compressed air.

Power Stroke

During the beginning of the power stroke, the piston is pushed downward by the burning and expanding gases; both intake and exhaust valves are closed. As more fuel is added and burns, gases get hotter and expand more to further force piston downward and thus adds driving force to crankshaft rotation.

Exhaust Stroke

During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on upstroke.

Upward travel of piston forces burned gases out of combustion chamber through open exhaust valve ports and into the exhaust manifold.

Proper engine operation depends upon two things – first, compression for ignition; and second, that fuel be measured and injected into cylinders in proper quantity at proper time.

Fuel System

The PT fuel system is used exclusively on Cummins Diesels. The identifying letters, "PT," are an abbreviation for "pressure-time."

The operation of the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the passage size through which the liquid flows. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors for each cylinder.

2. A means of controlling pressure of the fuel being delivered by the fuel pump to the injectors so individual cylinders will receive the right amount of fuel for the power required of the engine.

3. Fuel passages of the proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.

4. Injectors to receive low-pressure from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantities and proper condition to burn.

The PT fuel system consists of the fuel pump, supply lines, drain lines, fuel passages and injectors. Fig's. 5-1 and 5-2. There are two types of PT fuel pumps. The first type, commonly called PT (type G), is shown in Fig. 5-3. The second type, called PT (type R), is shown in Fig. 5-4.

The designations PT (type G) and PT (type R) stand for "Governor-Controlled" and the "Pressure-Regulated" respectively. Hereafter, these designations will be used to describe both the fuel system and the fuel pump.

Fuel Pump

The fuel pump is coupled to the compressor, vacuum pump or fuel pump drive which is driven from the engine gear

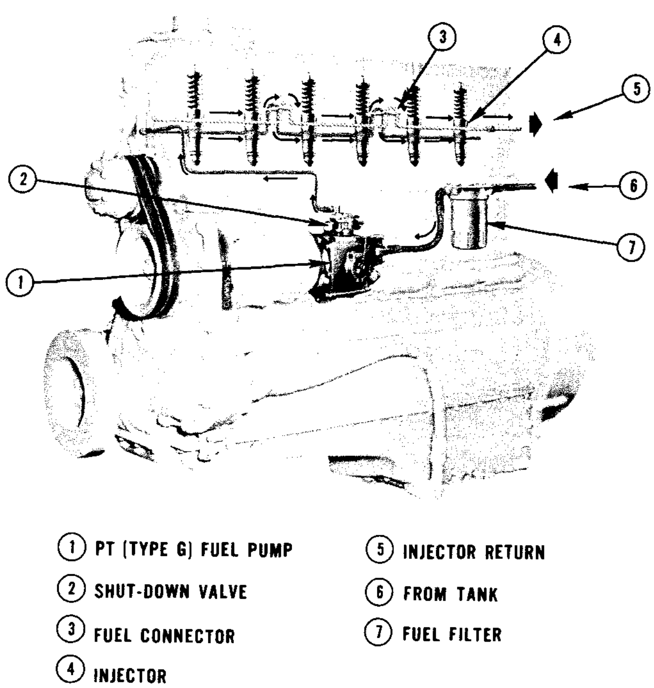


Fig. 5-1, (FWC-13). Fuel flow diagram — PT (type G) pump and cylindrical injectors — Inline Engine

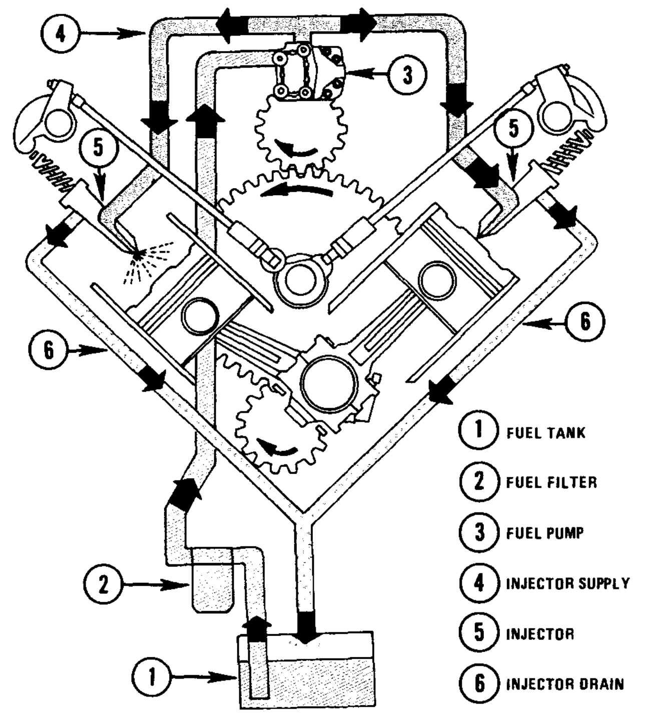
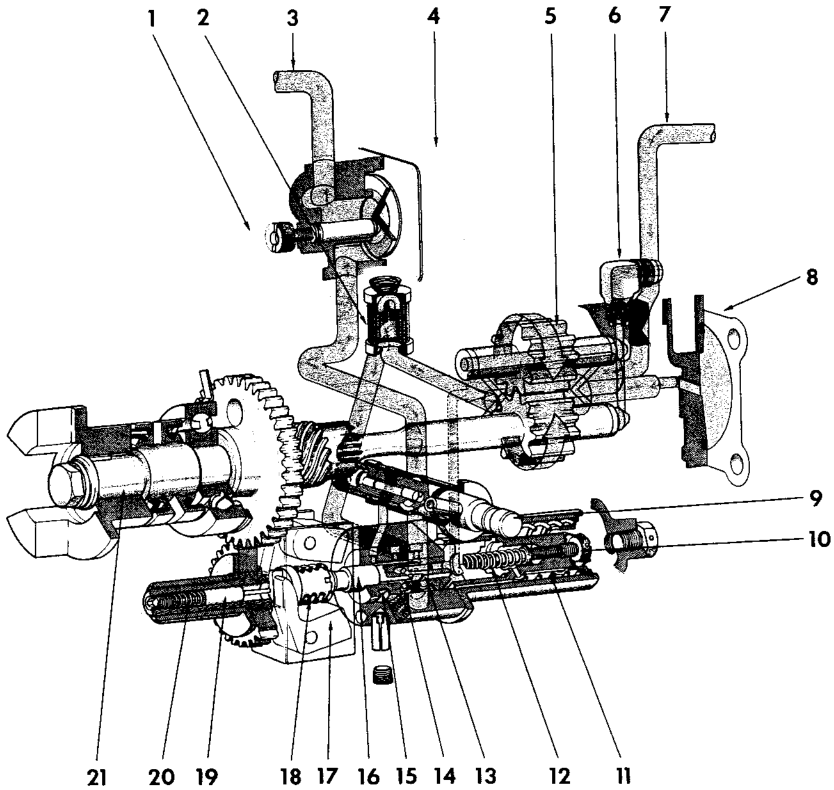


Fig. 5-2, (FWC-30). PT fuel system flow schematic — V Engine



1 TACHOMETER SHAFT
2 FILTER SCREEN
3 FUEL TO INJECTORS
4 SHUT-DOWN VALVE
5 GEAR PUMP
6 CHECK VALVE ELBOW
7 FUEL FROM TANK
8 PULSATION DAMPER
9 THROTTLE SHAFT
10 IDLE ADJUSTING SCREW
11 HIGH SPEED SPRING
12 IDLE SPRING
13 GEAR PUMP PRESSURE
14 FUEL MANIFOLD PRESSURE
15 IDLE PRESSURE
16 GOVERNOR PLUNGER
17 GOVERNOR WEIGHTS
18 TORQUE SPRING
19 GOVERNOR ASSIST PLUNGER
20 GOVERNOR ASSIST SPRING
21 MAIN SHAFT

Fig. 5-3, (FWC-31). PT (type G) fuel pump and fuel flow

train. Fuel pump main shaft in turn drives the gear pump, governor and tachometer shaft assemblies.

The location of fuel pump components is indicated in Fig's. 5-3 and 5-4.

PT (type G) Fuel Pump

The PT (type G) fuel pump can be identified by the absence of the return line at the top of the fuel pump. The pump assembly is made up of three main units:

1. The gear pump, which draws fuel from the supply tank and forces it through the pump filter screen to the governor.

2. The governor, which controls the flow of fuel from the gear pump, as well as maximum and idle engine speeds.

3. The throttle, which provides a manual control of fuel flow to the injectors under all conditions in the operating range.

PT (type R) Fuel Pump

The PT (type R) fuel pump can be identified easily by the presence of a fuel return line from the top of the fuel pump housing to the supply tank. The pump assembly is made up of four main units:

1. The gear pump, which draws fuel from the supply tank, forcing it through the pump filter screen into the pressure regulator valve.

2. A pressure regulator, which limits the pressure of the fuel to the injectors.

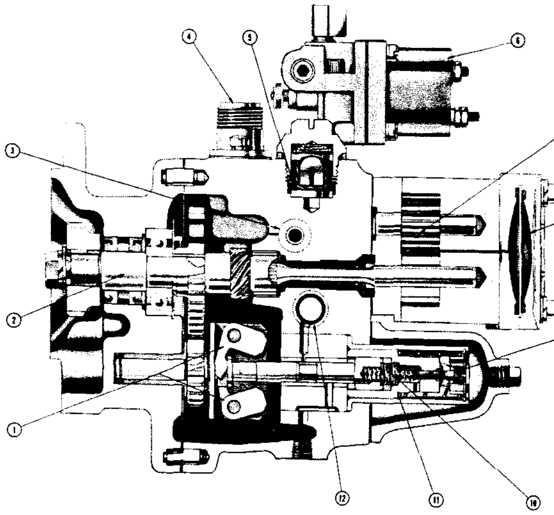
3. The throttle, which provides a manual control of fuel flow to the injectors under all conditions in the operating range.

4. The governor assembly, which controls the flow of fuel at idle and to maximum governed speed.

Gear Pump And Pulsation Damper

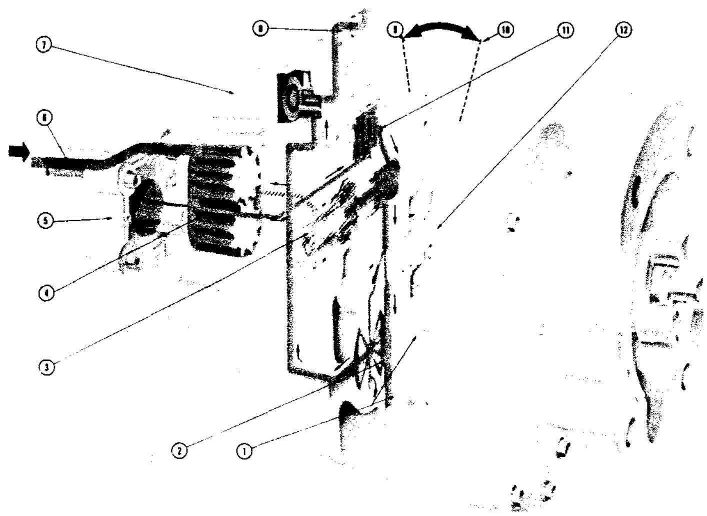
The gear pump and pulsation damper located at the rear of the fuel pump perform the same function on both PT (type G) and PT (type R) fuel pumps.

The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. Inlet to the gear pump on small V-type engines may be through the fuel pump main housing. On other engines it's at the rear of the gear pump.



1 GOVERNOR WEIGHTS	7 GEAR PUMP
2 MAIN SHAFT	8 PULSATION DAMPER
3 PRESSURE REGULATOR	9 IDLE SPEED SCREW
4 TACHOMETER CONNECTION	10 IDLE SPRINGS
5 FILTER SCREEN	11 MAXIMUM SPEED SPRING
6 SHUT-DOWN VALVE	12 THROTTLE SHAFT

Fig. 5-4, (FWC-4). PT (type R) fuel pump and fuel flow



1 GOVERNOR WEIGHTS	7 SHUT-DOWN VALVE
2 GOVERNOR PLUNGER	8 TO INJECTORS
3 PRESSURE REGULATOR	9 IDLE
4 GEAR PUMP	10 FULL
5 PULSATION DAMPER	11 FILTER SCREEN
6 FROM TANK	12 THROTTLE SHAFT

A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smoothes fuel flow through the fuel system. From the gear pump, fuel flows through the filter screen and:

1. In the PT (type G) fuel pump to the governor assembly as shown in Fig. 5-3.

2. In the PT (type R) fuel pump to the pressure regulator assembly as shown in Fig. 5-4.

Pressure Regulator

Used in the PT (type R) and in the torque modification device of PT (type G) "High-torque engine" fuel pump, Fig. 5-5, functions as a by-pass valve to regulate fuel pressure to the injectors. By-passed fuel flows back to the suction side of the gear pump. See Fig. 5-4.

Throttle

In both fuel pumps, the throttle provides a means for the operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In the PT (type G) fuel pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the shaft.

In the PT (type R) fuel pump, fuel flows past the pressure regulator to the throttle shaft. Under idling conditions, fuel

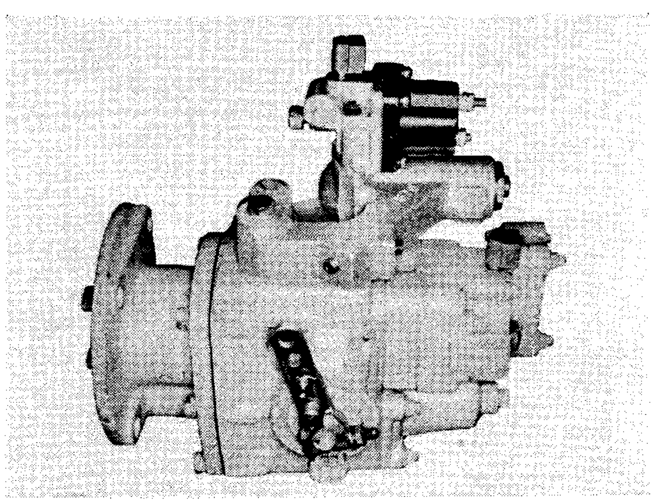


Fig. 5-5, (F-5212). High torque engine fuel pump passes around the shaft to the idle port in the governor barrel. For operation above idle speed, fuel passes through the throttling hole in the shaft and enters the governor barrel through the main fuel port.

Governors

Idling and High-Speed Mechanical Governor: The mechanical governor, sometimes called "automotive governor," on both PT (type G) and PT (type R) fuel pumps, is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle springs in the governor spring pack position the governor plunger so the idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors. This fuel is controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT (type G) fuel pumps and pressure regulator of PT (type R) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner, engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shut-down valve, inlet supply lines and on into the injectors.

PT (type G) Variable-Speed Governors

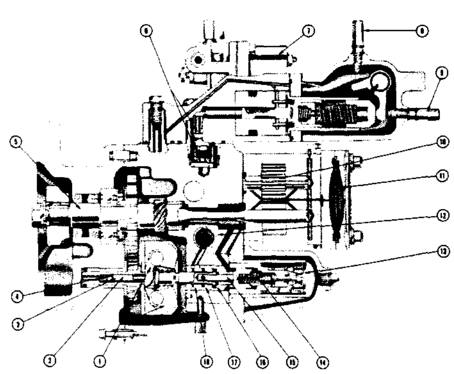
There are two mechanical variable-speed governors used with the PT (type G) fuel pump. The "Mechanical Variable-Speed (MVS)" governor which is mounted directly on top of the fuel pump or remotely near the fuel pump; and the "Special Variable-Speed (SVS)" governor which is a special spring pack assembly at the lower rear of the fuel pump. See Fig's. 5-5 and 5-7.

Mechanical Variable-Speed (MVS) Governor

This governor supplements the standard automotive governor to meet the requirements of applications when the engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Fig. 5-6.

As a variable-speed governor, this unit is suited to the varying speed requirements of power take-off, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.



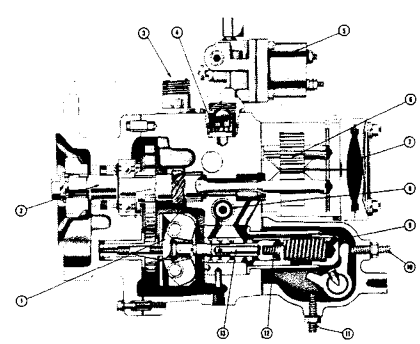
1 GOVERNOR WEIGHTS
2 GOVERNOR ASSIST PLUNGER
3 SHIMS
4 GOVERNOR ASSIST SPRING
5 MAIN SHAFT
6 FILTER SCREENS
7 SHUT-DOWN VALVE
8 MAXIMUM SPEED SCREW
9 IDLE SPEED SCREW
10 GEAR PUMP
11 PULSATION DAMPER
12 THROTTLE SHAFT
13 IDLE ADJUSTING SCREW
14 IDLE SPRING
15 GOVERNOR PLUNGER
16 GEAR PUMP PRESSURE
17 FUEL MANIFOLD PRESSURE
18 IDLE PRESSURE

Fig. 5-6, (FWC-9). PT (type G) fuel pump with MVS governor

The MVS governor assembly mounts atop the fuel pump, and the fuel solenoid is mounted to the governor housing. The governor may also be remote mounted.

Fuel from the fuel pump body enters the variable-speed governor housing and flows to the governor barrel and plunger. Fuel flows past plunger to the shut-down valve and on into the injector according to governor lever position, as determined by the operator.

The variable-speed governor cannot produce engine speeds in excess of the automotive governor setting. The governor can produce idle speeds below the automotive pump idle speed setting, but should not be adjusted below the automotive fuel pump speed setting when operating as a combination automotive and variable-speed governor.



1 GOVERNOR WEIGHTS
2 MAIN SHAFT
3 TACHOMETER CONNECTION
4 FILTER SCREEN
5 SHUT-DOWN VALVE
6 GEAR PUMP
7 PULSATION DAMPER
8 THROTTLE SHAFT
9 GOVERNOR SPRING
10 IDLE SPEED ADJUSTING SCREW
11 MAXIMUM SPEED ADJUSTING SCREW
12 IDLE SPRING
13 GOVERNOR PLUNGER

Fig. 5-7, (FWC-10). PT (type G) fuel pump with SVS governor

Special Variable-Speed (SVS) Governor

The SVS governor provides much of the same operational features of the MVS governor but is limited in application. An overspeed stop should be used with SVS governors in unattended applications and in attended installations, a positive shut-down throttle arrangement should be used if no other overspeed stop is used. Fig. 5-7.

Power take-off applications use the SVS governor lever to change governed speed of the engine from full rated speed to an intermediate power take-off speed. During operation as an automotive unit, the SVS governor is in high-speed position. See operation instructions for further information.

PT (type R) Mechanical Variable-Speed Governor

On some applications this governor replaces the standard "automotive" governor to meet the requirements of applications on which the engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed this governor has a speed droop between full-load and no-load of approximately eight percent. A cross section of this governor is shown in Fig. 5-8.

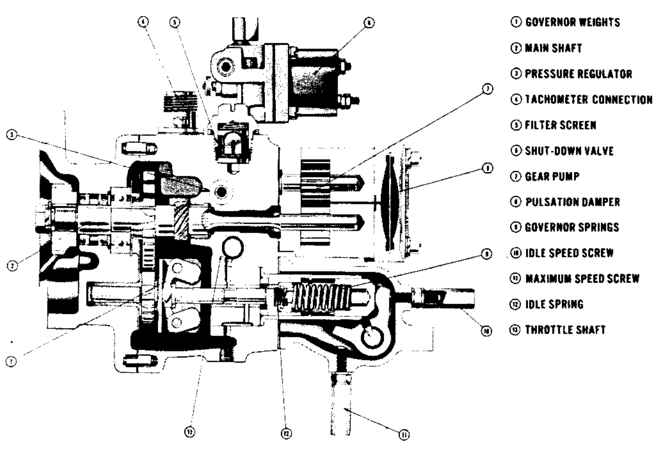


Fig. 5-8, (FWC-7). PT (type R) fuel pump with MVS governor

As a variable-speed governor, this unit is suited to the varying speed requirements of power take-off, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.

Aneroid

The aneroid control, Fig. 5-9, provides a fuel by-pass system that responds to air manifold pressure and is used on turbocharged engines for close control of exhaust smoke.

The aneroid limits fuel pressure to the injectors when accelerating the engine from speeds below normal operating range, and while air intake manifold air pressure is not sufficient for complete combustion. Air intake manifold pressure rises with turbocharger speed which is powered by exhaust gas energy and is therefore low at low engine speed and exhaust gas output.

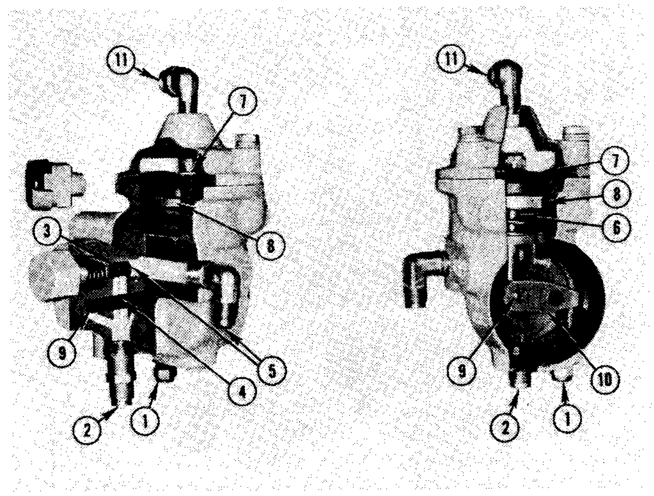


Fig. 5-9, (F-5244). Aneroid cutaway

During acceleration or rapid engine load changes, turbocharger speed (intake manifold pressure) change inherently lags behind the power or fuel demand exercised by opening of the throttle. This lag does not exist in the fuel system; therefore, an overrich or high fuel to air ratio, usually accompanied by smoke, occurs until the turbocharger "catches up."

The function of the aneroid is to create a lag in fuel system so response is equivalent to the turbocharger, thus controlling engine smoke level.

Caution: Aneroids must not be removed, disconnected or otherwise rendered ineffective, nor should settings be altered to exceed specifications as set at the factory, see "Maintenance Schedule."

Fuel Flow

1. Fuel from the fuel pump enters aneroid and is directed to starting check valve area (5, Fig. 5-9).

2. The starting check valve (3) prevents aneroid from by-passing fuel at engine cranking speeds. For speeds above cranking, fuel pressure forces the check valve open, allowing fuel to flow to valve port (4) of shaft (9).

3. Shaft (9) and its bore form, a fuel by-pass valve. This shaft and bore allows passage or restricts fuel flow in a similar manner as throttle shaft and sleeve in PT fuel pump.

4. The shaft and sleeve are by-passing fuel when arm (10) of lever is resting against adjusting screw (1). The amount of fuel by-passed is adjusted by this screw, which protrudes from bottom of aneroid.

5. The lever arm connected to piston (8) by actuating shaft (6), rotates shaft; closing valve port. The lever is rotated by action of air intake manifold pressure (11) against piston and diaphragm (7), moving actuating shaft downward against resisting spring force. Fig. 5-9.

6. Anytime engine intake manifold air pressure is above preset "air actuation pressure," aneroid is "out of system."

7. The aneroid begins dumping when intake manifold pressure drops below preset value as happens after deceleration in traffic, deceleration during gear shifts, down grade motoring with closed throttle or down grade operation on light load portion of governor droop curve.

8. The aneroid does not by-pass fuel under full throttle lug down conditions until speed is low enough to reduce intake manifold air pressure to aneroid operating range (usually below engine stall-out speed).

9. Fuel allowed to pass through by-pass valve is returned (2) to suction side (inlet fitting) of PT gear pump. The by-passed fuel reduces fuel pump out-put to engine and reduces fuel manifold pressure in proportion to the by-pass rate.

PT (type D) Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are the same for inline and V-engines but injector size and internal design differs slightly. Fig's. 5-10 and 5-11.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Fig's. 5-1 and 5-2. A radial groove around each injector mates with the drilled passages in the cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in the injector body. A fine mesh screen at each inlet groove provides final fuel filtration.

The fuel grooves around the injectors are separated by "O" rings which seal against the cylinder head injector bore. This forms a leak-proof passage between the injectors and the cylinder head injector bore surface.

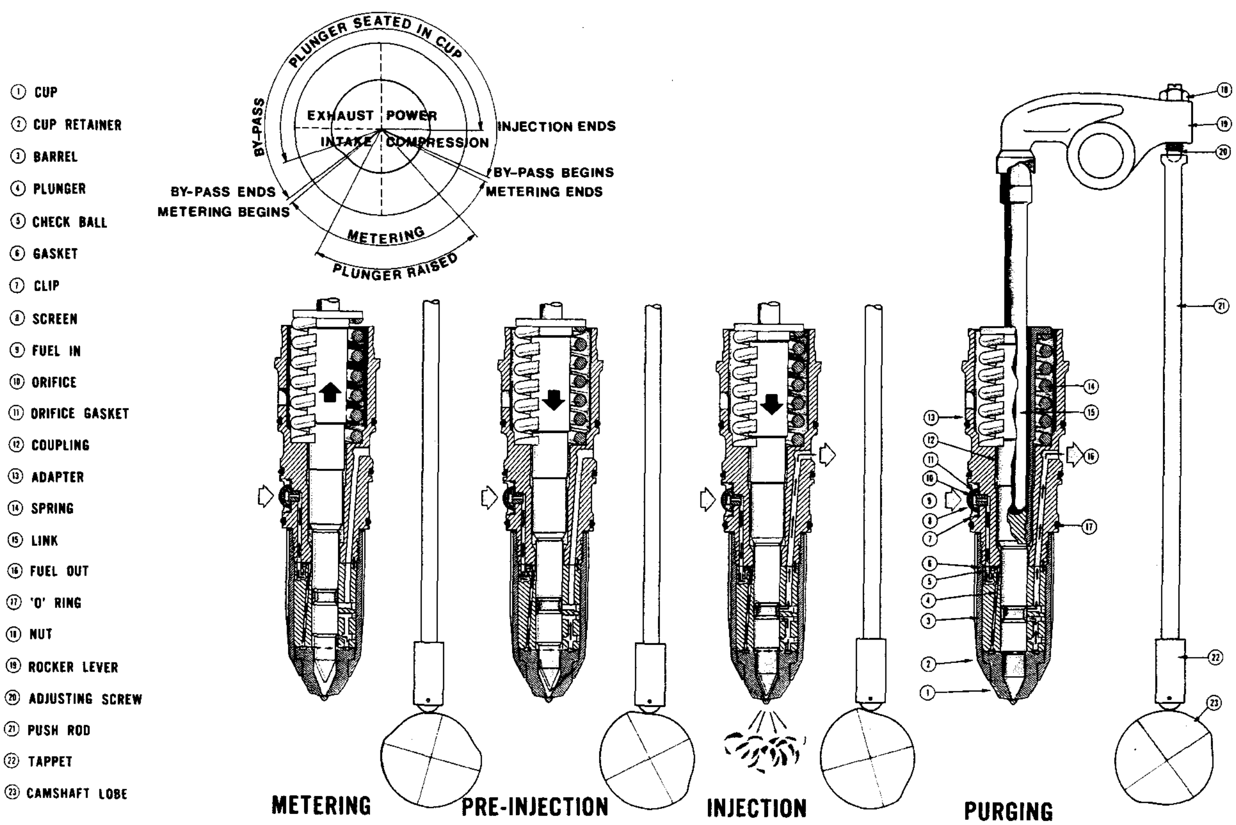


Fig. 5-10, (FWC-28). Fuel injection cycle, PT (type D) injector 3/8 inch diameter plunger

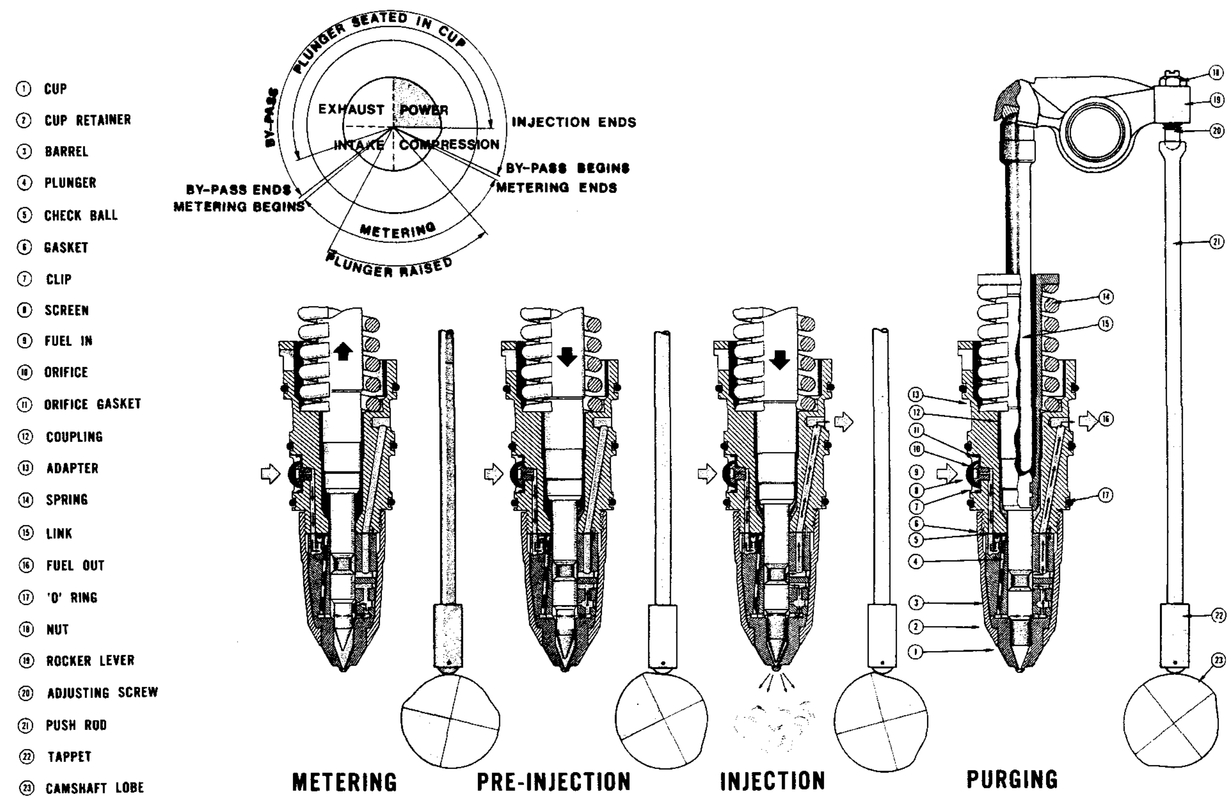


Fig. 5-11, (FWC-29). Fuel injector cycle. PT (type D) injector 5/16 inch diameter plunger

Fuel flows from a connection atop the fuel pump shut-down valve through a supply line into the lower drilled passage in the cylinder head. A second drilling in the head is aligned with the upper injector radial groove to drain away excess fuel. A fuel drain allows return of the unused fuel to the fuel tank.

The injector contains a ball check valve. As the injector plunger moves downward to cover the feed opening, an impulse pressure wave seats the ball and at the same time traps a positive amount of fuel in the injector cup for injection. As the continuing downward plunger movement injects fuel into the combustion chamber, it also uncovers the drain opening and the ball rises from its seat. This allows free flow through the injector and out the drain for cooling purposes and purging gases from the cup.

Flanged Injector

Fuel is supplied to and drained from flanged injectors through external fuel lines and connections. From the inlet connection, fuel flows down the inlet passage of the injector, around the injector plunger between the body and cup, up the drain passage to the drain connections and lines where it returns to the supply tank.

As the plunger rises, the metering orifice is uncovered and part of the fuel is metered into the cup. At the same time,

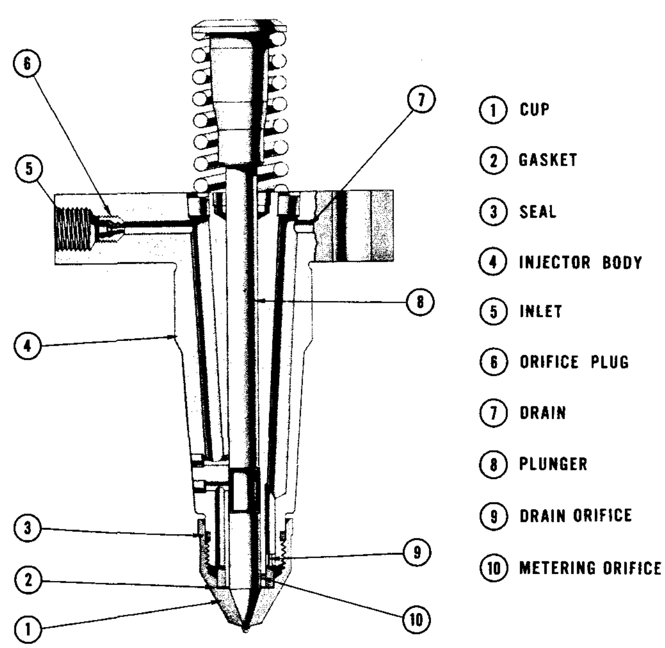


Fig. 5-11A, (FWC-11A). Flanged PT injector the rest of the fuel flows out of the drain orifice. The amount of fuel passing through the metering orifice and into the cup is controlled by fuel pressure and timing. Fig. 5-11A.

During injection, the plunger is forced downward until the metering orifice is closed and the fuel in the cup is injected into the cylinder. While the plunger is seated, all fuel flow through the injector stops.

Injectors contain an adjustable orifice or selected inside diameter orifice plug in the inlet passage which regulates fuel flow into the injector.

Fuel Lines, Connections And Valves

Supply And Drain Lines

Fuel is supplied through lines to cylinder heads. A common drain line returns fuel not injected, to supply tank.

On engines using flanged injectors, fuel is supplied through a single tube to the fuel supply manifold. The drain manifold returns fuel not injected to the supply tank through a drain line located at the rear of the engine.

Automotive-applied engines are equipped with an external by-pass fuel line from pump damper or gear pump to injector return line or to tank. This reduces internal pump temperatures by returning fuel to tank rather than circulating inside pump when vehicle is going downhill and throttle is in idle position. The check valve in the line is marked and must be installed so arrow points in direction of flow, away from pump.

The PT (type R) fuel pump has a drain line returning from the top of the pump to the supply tank. This line is not necessary with the PT (type G) pump. Fig's. 5-1 and 5-2.

Connections

Fuel connectors are used between the inline engine cylinder heads to bridge the gap between each supply and drain passage (3, Fig. 5-1).

Flanged injectors are connected to the supply and drain manifolds through connections. The inlet connection contains a fine mesh screen which acts as the final filter before fuel enters the combustion chamber.

Shut-Down Valve

Either a manual or an electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, the control lever must be fully clockwise or open to permit fuel flow through the valve.

With the electric valve, the manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through the valve.

Lubricating System

Cummins engines are pressure lubricated, pressure is supplied by a gear-type lubricating oil pump located in oil pan or on side of the engine.

A pressure regulator is mounted in the lubricating oil pump to control lubricating oil pressure.

Filters and screens are provided in lubricating oil system to remove foreign material from circulation and prevent damage to bearings or mating surfaces. A by-pass valve is provided in full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

Maximum cleansing and filtration is achieved through use of both by-pass and full-flow lubricating oil filters. Full-flow filters are standard on all engines; by-pass filters are used on all turbocharged models and optionally on all other engines.

Some engines are equipped with special oil pans and filters for some applications, and others with auxiliary oil coolers to maintain closer oil temperature regulation.

Air compressors and turbochargers are lubricated from engine oil system. Turbocharger is also cooled by same lubricating oil used for lubrication.

Fuel pumps and injectors are lubricated by fuel oil.

Inline Engines

NH And NT Series

Oil is drawn into the pump through an external oil line connected to the oil pan sump. A screen in the sump filters the oil. On NH and NT engines (Fig. 5-12) oil is drawn from

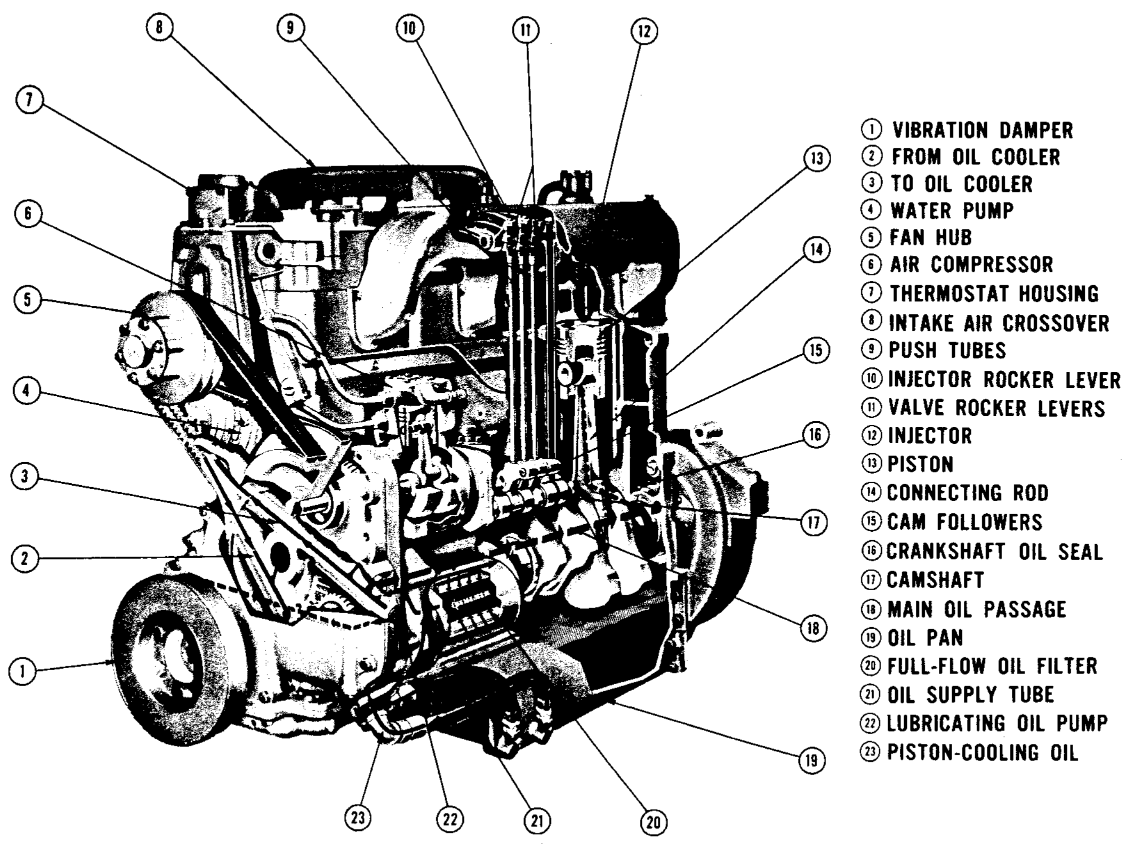


Fig. 5-12, (LWC-18). Lubricating oil and coolant flow – Inline Engine the pan by the pump out through a full-flow filter and circulates back into the block. The filter may be mounted directly to the rear of pump, vertically mounted on exhaust side of engine or remote mounted. External lines are used for remote mounting arrangements.

On remote and pump mounted filters oil flows from the pump to the oil cooler then flows to oil header through internal drillings in the gear case. On NTA engines oil flow is from pan to pump, to filter, to oil cooler, to block.

An oil header drilled full length of block, fuel pump side, delivers oil to moving parts within the engine. Oil pipes carry oil from the camshaft to upper rocker housings and drillings through the block, crankshaft, connecting rods, and rocker levers complete the oil circulating passages.

On engines equipped with oil cooled pistons, an oil header drilled the length of the block, exhaust manifold side, supplies oil to six spray nozzles used for piston cooling.

A piston cooling oil pump, as a second section of engine lubricating oil pump or a larger capacity oil pump, pumps this oil to the oil header.

NTC Series (Full Flow Oil Cooling)

The NTC (FFC) engine is pressure lubricated by a gear-type lubricating oil pump located on the intake manifold side of the engine. Oil pressure to the main rifle is controlled by a regulator located in the cooler support on the exhaust side of the engine.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig's. 5-13 and 5-14, then transferred from the suction cavity by the pump gears into the pressure cavity.

FFC OIL FLOW CIRCUIT

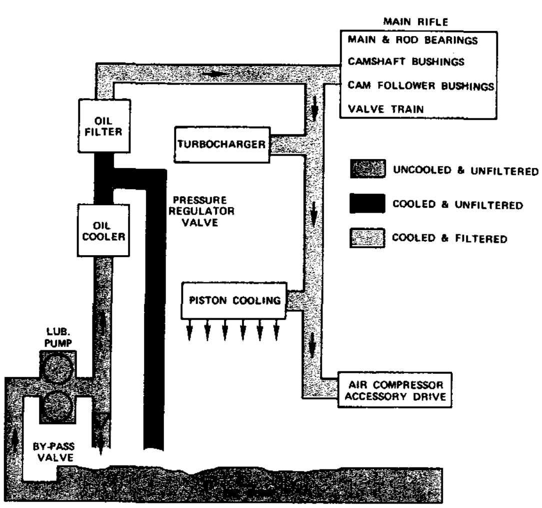


Fig. 5-13, (N10740). Full flow oil cooling (NTC Series)

Lubricating oil passes from the pump into the block, then across the front of the block by means of an internal oil passage and enters the cooler support. Oil is routed out of the cooler support and into the cooler housing, passing through the cooler housing. (The oil cooler is a counterflow tube-and-shell type heat exchanger, with oil passing from front to rear through the shell and coolant water passing from rear to front through the tubes.) Oil exits the cooler housing and passes into the cooler cover, then enters the "rifle drilling" at the bottom rear of the cooler housing and flows forward into the filter head.

Lubricating oil flowing into the filter shell from the filter head enters outside the filter element and passes through the element from outside to inside. Filtered lubricating oil then re-enters the filter head and flows through rifle drilling in the bottom of the cooler housing, then flows forward out of the cooler housing and into the cooler support where the flow divides.

Filtered and cooled lubricating oil from the cooler support is routed to the turbocharger through the supply hose. Turbocharger return oil is then routed by the drain hose back to the crankcase.

Filtered and cooled lubricating oil re-enters the block from the cooler support and is transferred internally back across the front of the block through a drilled oil transfer passage to the head of the main rifle drilling. Accessory drive lubrication is supplied from the transfer passage leading to the head of the main rifle drilling. An intersecting drilling routes lubricating oil from the transfer passage out the front of the block and into the gear cover on the exhaust side of the engine, then across the front of the engine through a tube in the gear cover. The flow path then splits, part being routed to the accessory drive bushing in the gear cover and the rest being routed to the air compressor.

Piston-cooling is supplied from the transfer passage leading to the head of the main rifle drilling. An intersecting drilling allows flow to the piston-cooling rifle from the oil transfer passage. The piston-cooling rifle extends from the front to the rear of the block on the exhaust side of the engine. Six piston-cooling nozzles inserted from the outside of the block direct a spray of lubricating oil from the piston-cooling rifle to the bottom of each piston.

Lubricating oil entering the main rifle is routed by means of drilled passages and pipes to the main bearings, rod bearings, piston pin bushings, camshaft bushings, cam follower shafts and levers, rocker box shafts and rocker arms, etc., then returns to the oil pan.

C Series

The C Series engines are pressure lubricated by a gear-type lubricating oil pump. Lubricating oil pump is mounted on bottom of block, enclosed in oil pan and driven by an idler gear off the crankshaft gear.

Lubricating oil, drawn from the pan sump through a slotted suction line or a screen, is delivered to the engine working

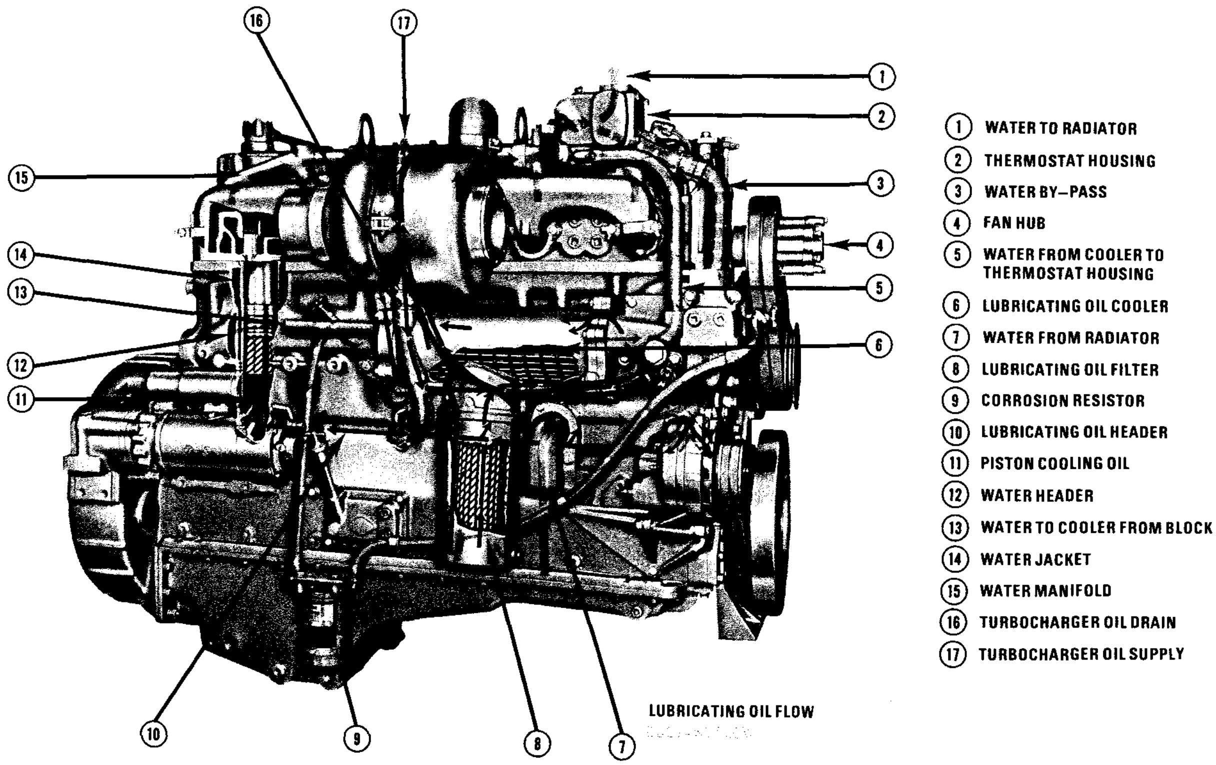


Fig. 5-14, (LWC-25). Lubricating oil and coolant flow – FFC (NTC Series)

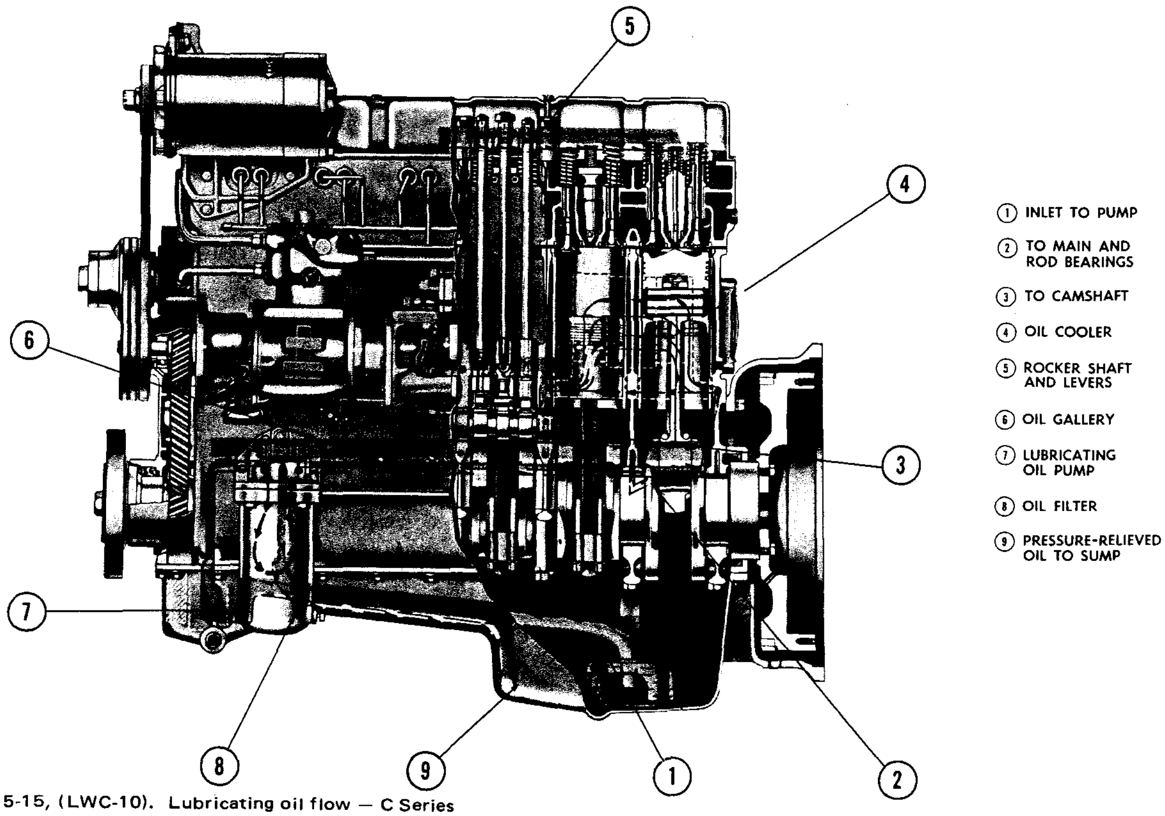


Fig. 5-15, (LWC-10). Lubricating oil flow – C Series

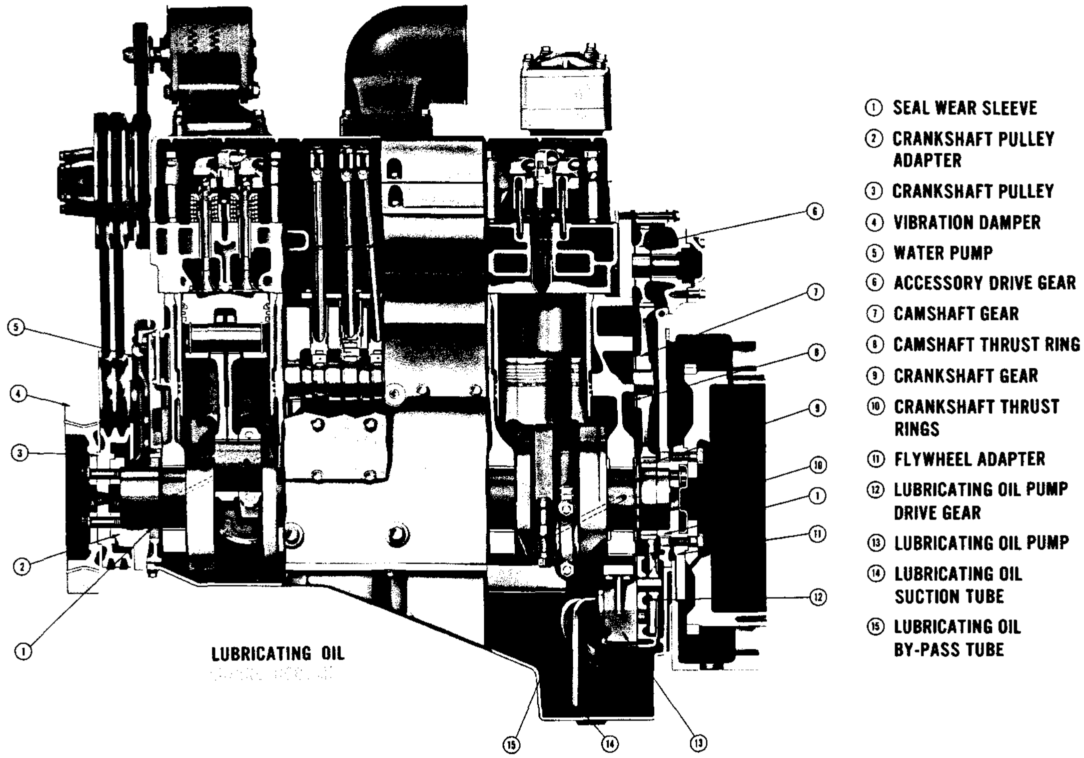


Fig. 5-16, (LWC-16). Lubricating oil and coolant flow – V-903

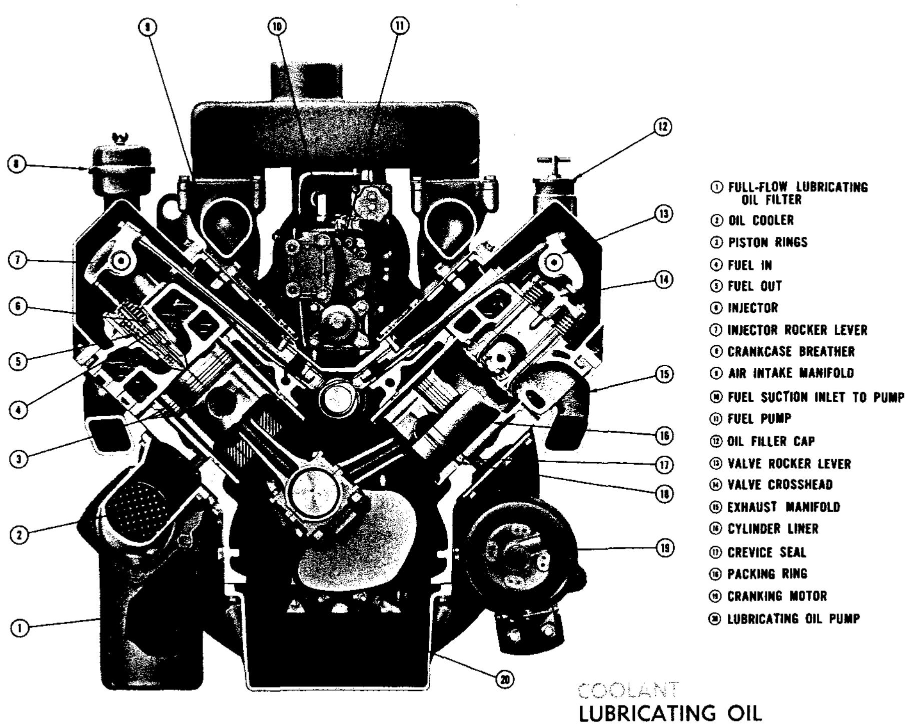


Fig. 5-17, (LWC-4). Lubricating oil and coolant flow – V-378, V-504 and V-555 components through a pressure regulator, full-flow filter, transfer connection, lubricating oil cooler, into an oil header which is drilled the length of the block. Drillings in the block, cylinder head, crankshaft, connecting rods and rocker levers complete the oil circulating passages. Fig. 5-15.

Connecting rod and main bearings are lubricated by oil drillings through the crankshaft.

Lubricating oil pressure is controlled by a pressure regulator located in lubricating oil filter head or on side of block.

Filters and screens are provided throughout the lubricating oil system to keep foreign material from entering engine and damaging bearings or mating surfaces.

Maximum cleansing and filtration is achieved through the use of both by-pass and full-flow lubricating oil filters. Full-flow filters are standard on all engines; by-pass filters are used on all turbocharged models.

Some engines are equipped with special oil pans and filters for some applications and others with auxiliary oil coolers to maintain closer oil temperature regulation.

V Series Engines

V6 and V8 Series engines are pressure lubricated by a gear type lubricating oil pump mounted on bottom of block, enclosed in oil pan, and gear driven from crankshaft gear.

Oil drawn from pan sump through a screen is delivered to engine working components through oil lines and oil headers which are drilled the length of block. Drillings in block, cylinder head, crankshaft and rocker lever shafts complete oil circulation passages. Fig. 5-16 and 5-17.

Oil flows through a suction tube to the lubricating oil pump up a passage in rear of block to the cooler (if used) and filter.

V-903 Series Engines

1. Oil flows from cooler and filter to right bank of oil drilling at front of engine to front center of block. Oil flows through crossover at front of block to left bank and right bank main drillings (drilled length of block). Fig. 5-16.

2. Oil flows through left bank drilling toward rear of engine to left bank tappets, accessory drive, to numbers 2, 3, 4 and 5 cam bushings, main bearings and connecting rods.

3. At the same time oil flows to a right bank drilling toward rear of engine to oil right bank tappets.

4. Right bank rocker levers are oiled intermittently from rear cam bushing location. Left bank rocker levers are oiled intermittently from front cam bushing.

V-378, V-504 And V-555 Series Engines

1. Oil flows from filter to right bank oil drilling at rear of engine to accessory drive gear, rear cam bushing and rear main bearing which in turn supplies the two rear connecting rods. Fig. 5-17.

2. Right bank rocker levers are oiled intermittently from rear cam bushing location.

3. Oil flows through the right bank drilling toward front of engine to right bank injector tappets, to center cam bushings, main bearings and connecting rods.

4. Oil flows through a crossover at front of block to left bank.

5. Left bank rocker levers are oiled intermittently through front cam bushing.

6. Oil then flows to a left bank drilling toward rear of engine to oil left bank injector tappets.

Cooling System

Water is circulated by a centrifugal water pump mounted either in or on the front of the engine, belt driven from the accessory drive or crankshaft, except C-180 water pump is mounted on side of block and is coupling driven by supercharger.

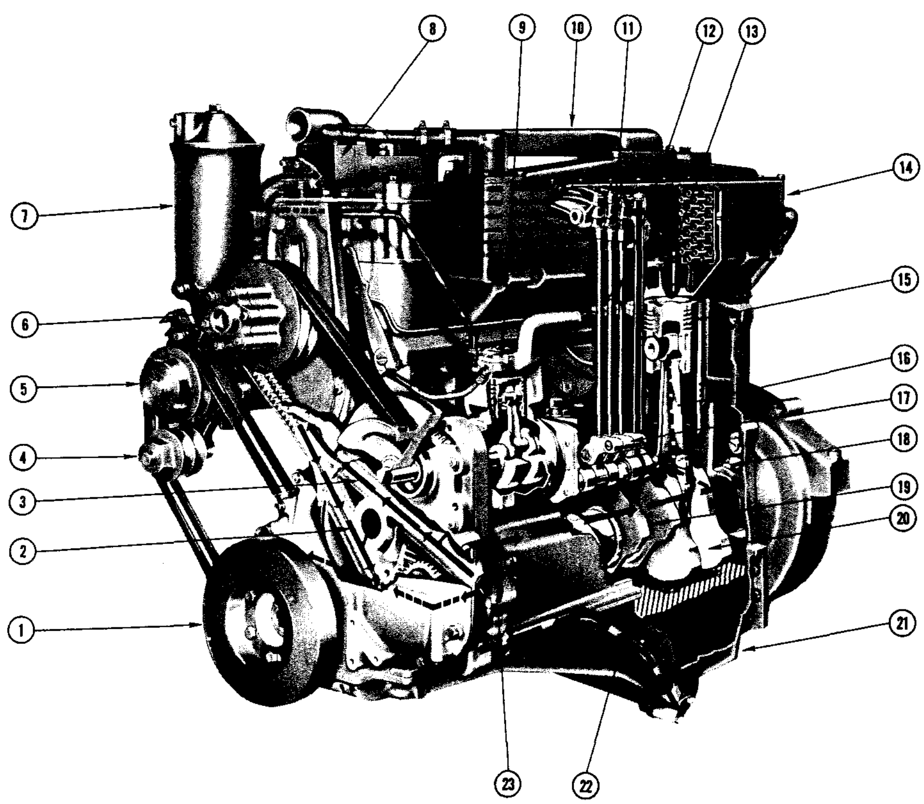
Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Fig. 5-12, 5-16, 5-17 and 5-18. Injector sleeves, in which injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat or thermostat(s) to control engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.

The Cummins Corrosion Resistor is standard on Cummins Engines. The resistor by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

Refer to coolant specifications for corrosion resistor capacity and treatment of make-up water.

NTA Aftercooled Engine

Water flows from radiator into cavity of water pump, where water flow splits. One portion circulates to the cylinder block water header around wet type cylinder liners, through the cylinder head and around the injector sleeves, upwards to the water manifold, to the thermostat housing. At the rear of the block water header, water is directed to the aftercooler, Fig. 5-18. Water flows forward through the aftercooler to the water crossover to the thermostat housing. The second portion of water flows from the cavity of the water pump housing through the oil cooler and tubing to the rear of the water manifold forward to the thermostat housing, to control engine temperature.



1 VIBRATION DAMPER
2 OIL FROM COOLER
3 OIL TO COOLER
4 IDLER PULLEY
5 WATER PUMP
6 FAN HUB
7 OIL FILTER
8 THERMOSTAT
9 AIR COMPRESSOR
10 INTAKE AIR CROSSOVER
11 ROCKER LEVERS
12 PUSH TUBES
13 INJECTOR
14 AFTERCOOLER
15 PISTON
16 CONNECTING ROD
17 CAM FOLLOWERS
18 CRANKSHAFT OIL SEAL
19 MAIN OIL PASSAGE
20 CRANKSHAFT
21 OIL PAN
22 OIL SUPPLY TUBE
23 LUBRICATING OIL PUMP

Fig. 5-18, (LWC-22). Coolant and lubricating oil flow – NTA Inline Engine

Air System

The diesel engine requires hundreds of gallons of air for every gallon of fuel that burns. For the engine to operate efficiently, it must breathe freely, intake and exhaust systems must not be restricted.

The intake air should always be routed through an air cleaner (or air silencers). The cleaner may be mounted on engine or equipment and may be either oil bath, paper element or composite type depending upon engine application. Air is routed from air cleaner directly to intake air manifold, turbocharger or supercharger.

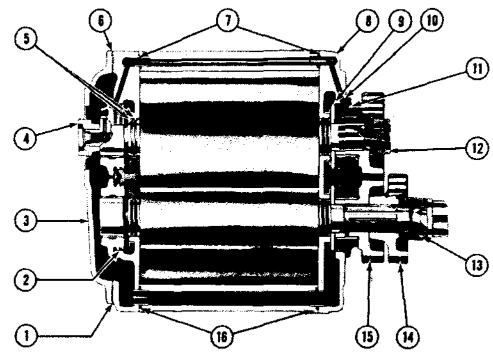
NTA Aftercooler

An aftercooler (or intercooler as it is sometimes called) is a device in the engine intake system designed to reduce intake air temperature and/or preheat intake air temperature.

The aftercooler consists of a housing, used as a portion of the engine intake air manifold, with an internal core. The core is made of tubes through which engine coolant circulates. Air is cooled or heated by passing over the core prior to going into the engine combustion chambers. Therefore, improved combustion results from better control of intake air temperature cooling or warming as applied by the aftercooler.

Supercharger

A supercharger is a gear-driven air pump which employs rotors to force air into engine cylinders. The supercharger is driven from the engine crankshaft through a gear train turning at about 1.8 times engine speed. Fig. 5-19.



1 COVER GASKET
2 BEARING CAGE SEAL RING
3 END COVER
4 WATER PUMP COUPLING
5 PISTON RING OIL SEALS
6 END PLATE--PUMP END
7 OIL PRESSURE LINE SEAL RINGS
8 END PLATE--GEAR END
9 THRUST WASHER
10 SHIMS
11 BEARING CAGE
12 LOCKNUTS
13 BEARING JOURNAL
14 DRIVE GEAR
15 ROTOR TIMING GEAR
16 OIL DRAIN LINE SEAL RING

Fig. 5-19, (N21004). Supercharger (cross section)

Turbocharger

The turbocharger forces additional air into combustion chambers so engine can burn more fuel and develop more horsepower than if it were naturally aspirated. In some cases the turbocharger is used for the engine to retain efficiency (balanced fuel to air ratio) at altitudes above sea level.

The turbocharger consists of a turbine wheel and a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft.

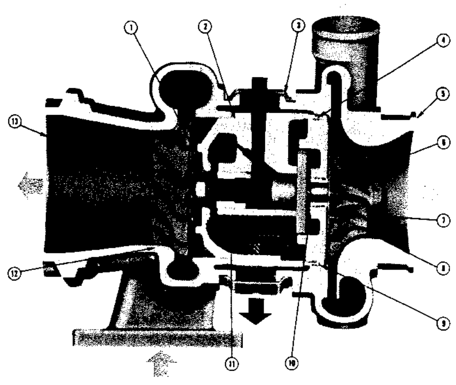
The power to drive turbine wheel – which in turn drives the compressor – is obtained from energy of engine exhaust gases. Rotating speed of the turbine changes as energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig. 5-20, 5-21, 5-22 and 5-23. The turbocharger is lubricated and cooled by engine lubricating oil.

Air Compressor

The Cummins air compressor may be either a single or two cylinder unit coupling or gear driven from the engine gear train accessory drive. Lubrication is received from the engine lubrication system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

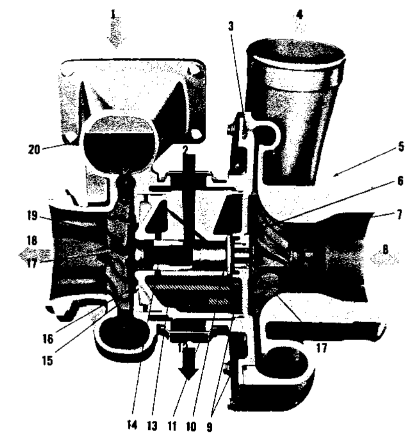
Air Intake

Air is drawn into the compressor through the engine intake air manifold or compressor mounted breather. As the piston moves down, a partial vacuum occurs above it.



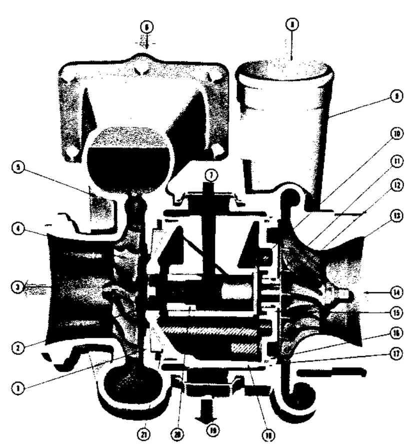
1 PISTON RING SEAL
2 BEARING HOUSING
3 'V' CLAMP
4 'O' RING SEAL
5 COMPRESSOR CASING
6 OIL SEAL ASSEMBLY
7 COMPRESSOR WHEEL
8 PISTON RING SEAL
9 'O' RING SEAL
10 THRUST WASHER
11 BEARING
12 TURBINE WHEEL
13 TURBINE CASING

Fig. 5-20, (T-380-A). T-35 turbocharger (cross section)



1 EXHAUST IN
2 OIL IN
3 DIFFUSER PLATE
4 AIR TO ENGINE
5 COLLECTOR HOUSING
6 OIL SEAL ASSEMBLY
7 IMPELLER
8 AIR IN
9 O-RING SEALS
10 BEARING INSERT
11 V-BAND CLAMP
12 OIL OUT
13 BEARING HOUSING
14 BEARING
15 INSULATION PAD
16 HEAT SHIELD
17 PISTON RING SEAL
18 EXHAUST OUT
19 TURBINE WHEEL AND SHAFT
20 TURBINE CASING

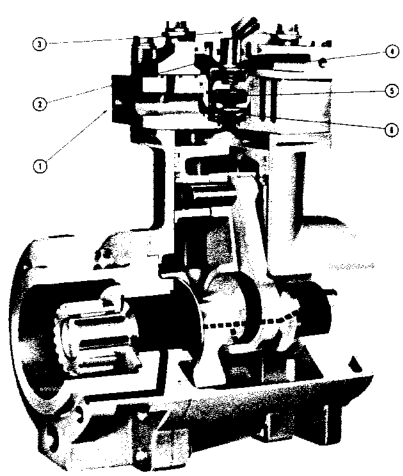
Fig. 5-23, (AWC-12). ST-50 turbocharger (cross section)



1 HEAT SHIELD
2 PISTON RING SEAL
3 EXHAUST OUT
4 TURBINE WHEEL
5 TURBINE CASING
6 EXHAUST IN
7 OIL IN
8 AIR TO ENGINE
9 COMPRESSOR CASING
10 BEARING INSERT
11 PISTON RING SEAL
12 OIL SEAL ASSEMBLY
13 COMPRESSOR WHEEL
14 AIR IN
15 SEAL PLATE
16 O-RING SEAL
17 O-RING SEAL
18 BEARING HOUSING
19 OIL OUT
20 BEARING
21 INSULATION PAD

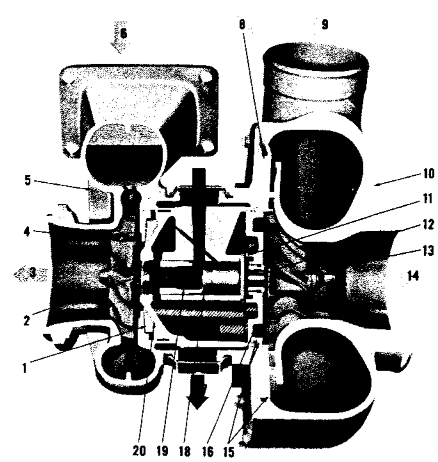
Fig. 5-21, (AWC-8). T-50 turbocharger (cross section)

The difference in cylinder pressure and atmospheric pressure forces the inlet valve down from its seat, allowing the air to flow through the intake port and into the cylinder. When the piston has reached the bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces the valve against its seat. Fig. 5-24 and Fig. 5-25.



1 COOLANT
2 UNLOADER VALVE
3 AIR GOVERNOR CONNECTION
4 AIR INLET
5 INTAKE VALVE
6 EXHAUST VALVE

Fig. 5-24, (AWC-10). Cummins air compressor (single cylinder)

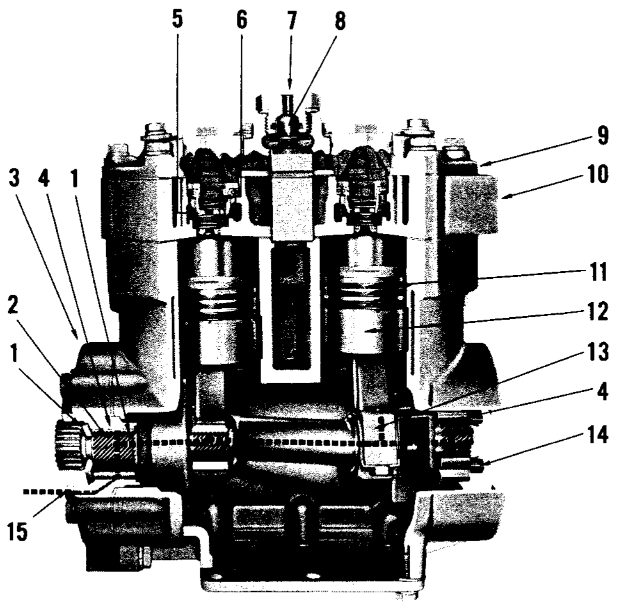


1 HEAT SHIELD
2 PISTON RING SEAL
3 EXHAUST OUT
4 TURBINE WHEEL AND SHAFT
5 TURBINE CASING
6 EXHAUST IN
7 OIL IN
8 BACKPLATE
9 AIR TO ENGINE
10 COMPRESSOR CASING
11 BEARING INSERT
12 OIL SEAL ASSEMBLY
13 COMPRESSOR WHEEL
14 AIR IN
15 O-RING SEALS
16 SEAL PLATE
17 OIL OUT
18 BEARING HOUSING
19 BEARING
20 INSULATION PAD

Fig. 5-22, (AWC-9). VT-50 turbocharger (cross section)

Compression

When the piston starts its upward stroke, the increased pressure of air in the cylinder and head forces the outlet valve away from its seat. The compressed air then flows through outlet ports and into the air tank as the piston continues its upward stroke. On piston downstroke, the exhaust valve closes and the intake valve opens except during unloading period.



1	THRUST WASHERS	9	CYLINDER HEAD COVER
2	CRANKSHAFT	10	CYLINDER HEAD
3	SUPPORT	11	PISTON RINGS
4	BUSHINGS	12	PISTON
5	EXHAUST VALVE	13	CONNECTING ROD
6	INTAKE VALVE	14	FUEL PUMP DRIVE
7	AIR GOVERNOR INLET	15	LUBRICATING OIL INLET
8	UNLOADER VALVE ASSEMBLY		

Fig. 5-25, (AWC-11). Cummins air compressor (two cylinder)

Unloading

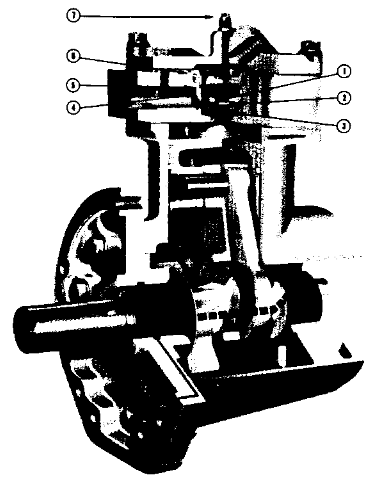
When pressure in the air tank is at a predetermined level, air pressure is applied to top of unloader cap by a compressor governor. This pressure forces the unloader cap down and holds the intake valve open during non-pumping cycle. When pressure in air tank drops, the unloader cap returns to its upper position and intake and compression sequences begin once again.

Vacuum Pump

The Cummins Vacuum Pump, shown in Fig. 5-26, is an adaptation of Cummins Air Compressor; it is a single-cylinder unit driven from engine by integral crankshaft and accessory drive. Lubrication is received from engine lubricating system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

As piston moves downward on intake stroke a vacuum occurs above piston. The difference in cylinder pressure and atmospheric pressure forces inlet valve from its seat



1. EXHAUST VALVE SEAT
2. EXHAUST VALVE
3. EXHAUST VALVE SPRING
4. INTAKE VALVE SPRING
5. INTAKE VALVE
6. INTAKE VALVE SEAT
7. VALVE SET SCREW

Fig. 5-26, (V11205). Cummins vacuum pump

allowing air to flow through intake port into cylinder from vacuum tank thus creating vacuum in vacuum tank. When piston has reached bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat.

Compression

When piston starts upward stroke, increased pressure of air in cylinder and head forces outlet valve away from seat. Air then flows through outlet port and is discharged into vacuum pump crankcase or engine crankcase, as piston continues upward stroke. When piston reaches end of stroke, air pressure in head drops to a point where spring forces exhaust valve against seat and closes outlet passage.

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