NH, NT-855

Cummins Diesels **N-927** series

Operation and

Maintenance Manual

Bulletin 983698-AE, Printed 3-1971
Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Operation and Maintenance Manual

Cummins Diesel Engines
NH,NT–855 series
N–927 series

Foreword

The information contained in this publication pertains to Cummins NH and NT (855 and/or 927 cubic inch displacement) engines. 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.

Example: NTA-855 C 370

N= 4 valve head

T = Turbocharged

A = Aftercooled

855= Cubic-inch displacement

C = Off-highway application (See Table below.)

370= Maximum rated horsepower

Note: The letter "G" preceding the letter "N" indicates Gas Engines; all other models are diesel.

Table:	Application Designations (Combinations of Letters May Be Used)
—	Automotive (On-highway) See Table 1.
B	Off-highway (Usually less compressor)
C	Construction (Construction Industry)
G	Generator Set (GS - Standby, GC - Continuous Duty)
P	Power Unit (Various components used)
M	Marine
D	Dump or Mixer application
IF	Fire Engine (Pump)
L	Locomotive
I	Industrial
F	Fire Fighting Equipment
C	Used before horsepower - custom rated.
D	Used after horsepower - dual diesel/compressor.

Refer to Tables 1 through 5 for all NH and NT Series Engine Specifications. All 855 and 927 engine models are included in this manual because the operations performed are the same or very similar and because these engines are very often used in the same fleet or operation.

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.

Full repair Shop Manuals may be purchased from a Cummins Distributor at a nominal cost.

Federal Smoke Emission Certification

Beginning January 1, 1970, all new Cummins Engines for use in automotive applications, are in all material respects, substantially the same as test engines certified by the U.S. *Department of Health, Education and Welfare* as conforming to Federal Regulations pertaining to exhaust smoke emission. 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 you to stay within the regulations.

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

Table of Contents

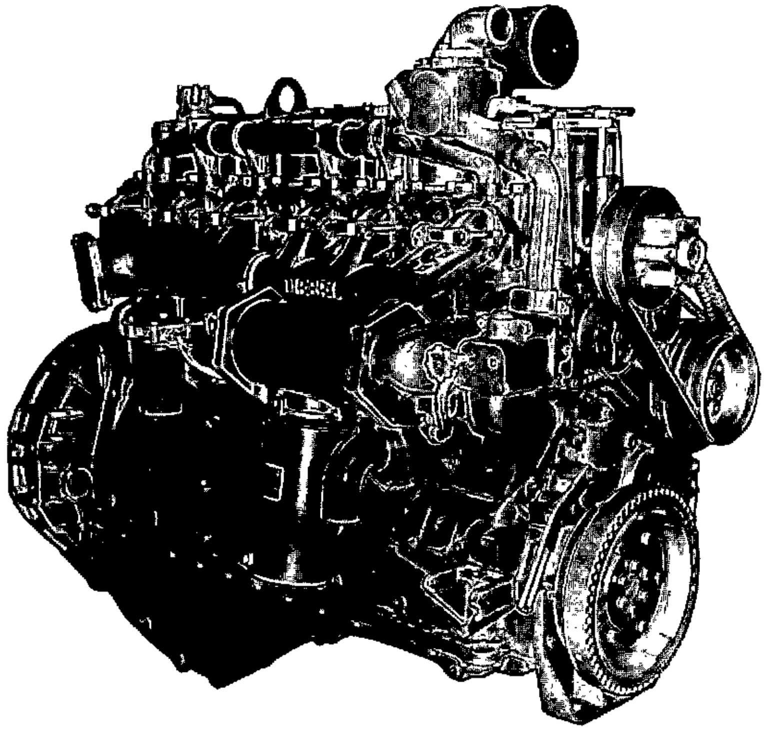


Table 1: Automotive Model Specification

Engine Model	At Sea Level Max. HP@RPM	At 500 Ft Altitude Max. HP@RPM	Begin Deration @ Altitude	Engine Breathing
Automotive Models				
NH-230	230@2100	220@2100	Sea Level	N/A
NHD-230	230@2100	220@2100	Sea Level	N/A
NHC-250	250@2100	240@2100	Sea Level	N/A
	225@2100	216@2100	Sea Level	N/A
	225@2100	216@1950	Sea Level	N/A
N-927	270@2100	260@2100	Sea Level	N/A
NHCT-CT*	240@2100	240@2100	8000	T
NHCT-270	270@2100	270@2100	12000	T
	255@2100	255@2100	12000	T
	240@2100	240@2100	12000	T
NTC-335	335@2100	335@2100	12000	T
	325@2100	320@2100	12000	T
	300@2100	300@2100	12000	T
	280@2100	280@2100	12000	T
	260@2100	260@2100	12000	T
NTC-350	350@2100	350@2100	12000	T
	335@2100	335@2100	12000	T
	320@2100	320@2100	12000	T
	300@2100	300@2100	12000	T
NTA-370	370@2100	370@2100	12000**	T
NTA-420	420@2300	420@2300	6000	T

* Custom Torque
** If permanently operated at high altitude the limit is 10,000 feet. **Table 1 continued on next page.**

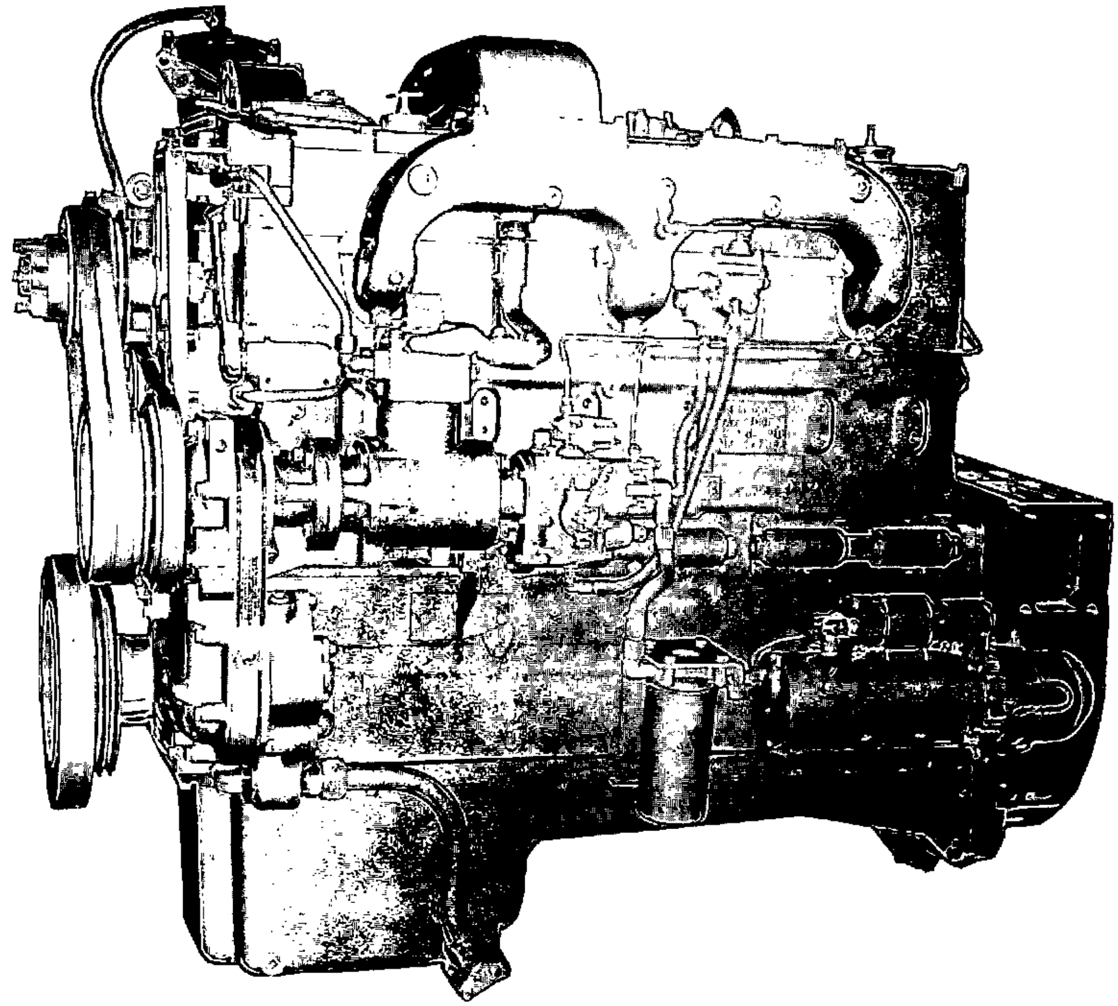


Table 1: Automotive Model Specification (Continued)

Engine Model	At Sea Level Max. HP@RPM	At 500 Ft Altitude Max. HP@RPM	Begin Deration @ Altitude	Engine Breathing
<u>Fire Truck Models</u>				
NHF-240	240@2300	230@2300	Sea Level	N/A
NHF-265	265@2300	255@2300	Sea Level	N/A
NHTF-295	295@2300	295@2300	5000	T
NTF-365	365@2300	365@2300	5000	T

1. Naturally aspirated engines are derated 3% for each 1000 ft [304.800 m] above sea level and 1% for each 10 deg. F [5.56 deg. C] rise in air temperature.
2. Turbocharged engines are derated 4% for each 1000 ft [304.800 m] altitude above 12000 ft[5657.600 m].

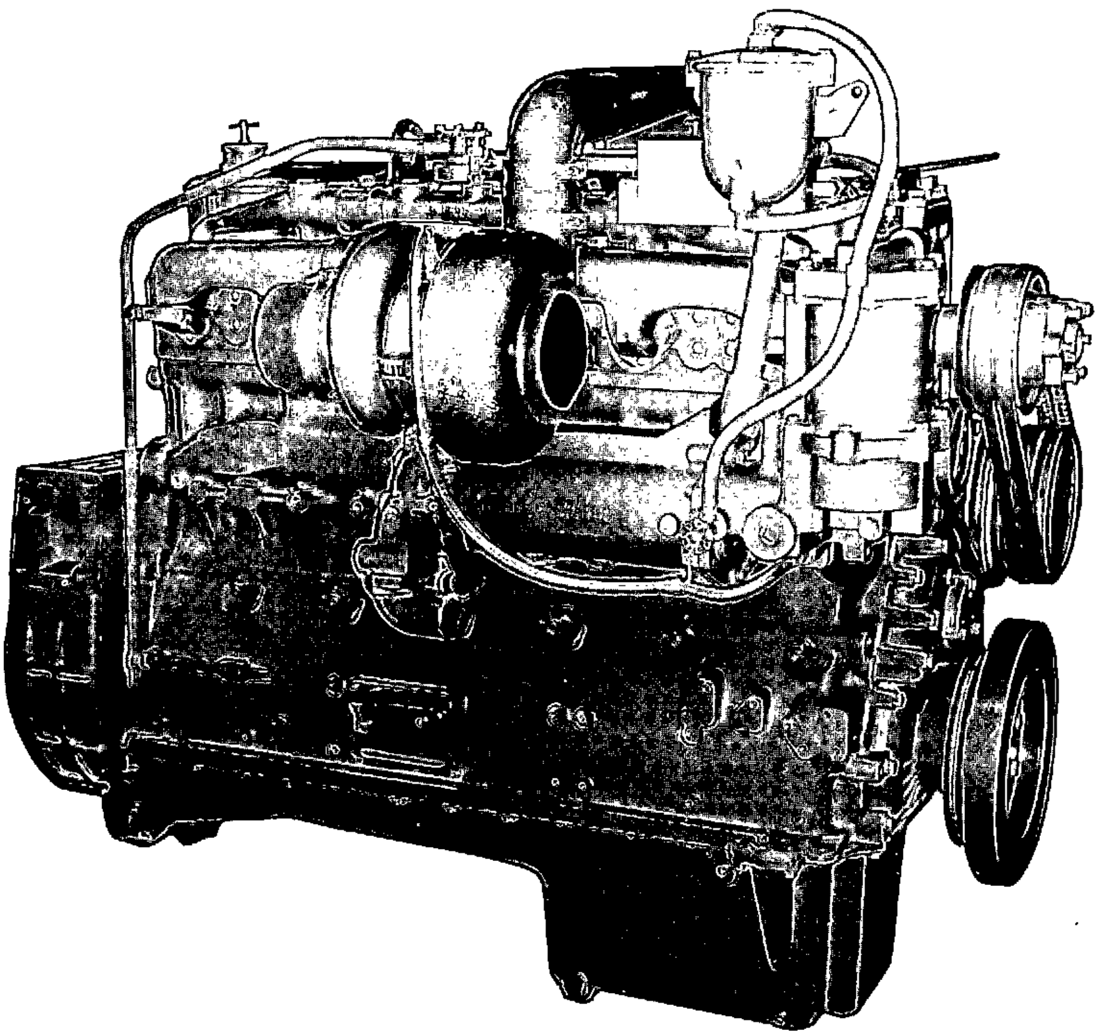


Table 2: Construction Model Specifications

Engine Models	At 500 ft. Max. HP@RPM	At Sea Level Max. HP@RPM	Begin Derate Altitude	Engine Breathing
N-855-C250	240@2100	250@2100	500	N/A
NT-855-C280	280@2100	280@2100	9000	T
NT-855-C310	310@2100	310@2100	12000	T
NT-855-320	320@2300	320@2300	12000	T
NT-855-335	335@2100	335@2100	12000	T
NTA-855-380	380@2300	380@2300	8000*	T
NTA-855-C420	420@2300	420@2300	6000	T

* With old style intercooler. Altitude limit 5000 feet without intercooler.

1. Naturally aspirated engines are derated 3% for each 1000 ft [304.800 m] above sea level and 1% for each 10 deg. F [5.56 deg. C].
2. Turbocharged engines are derated 4% for each 1000 ft [304.800 m] altitude above 12000 ft [3657.000m].

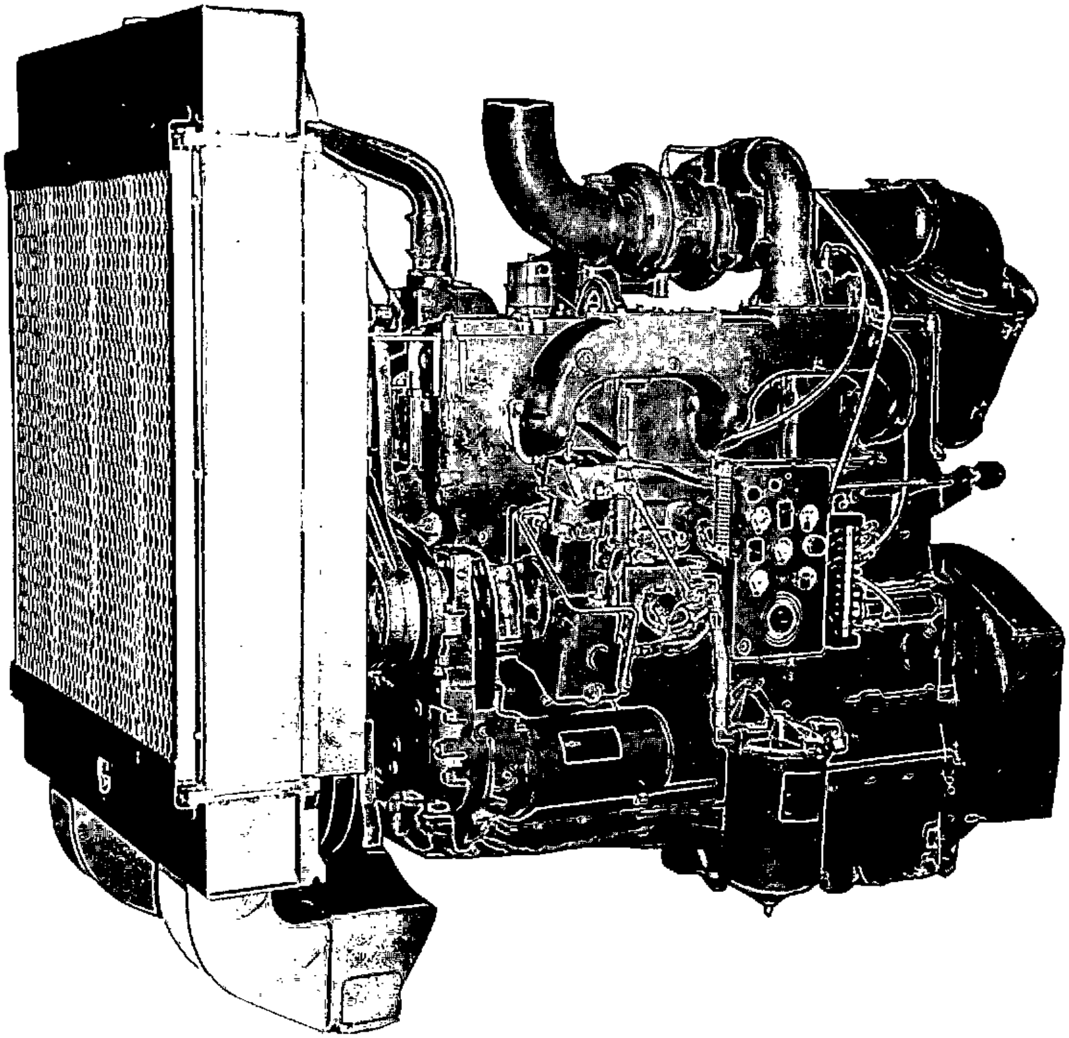
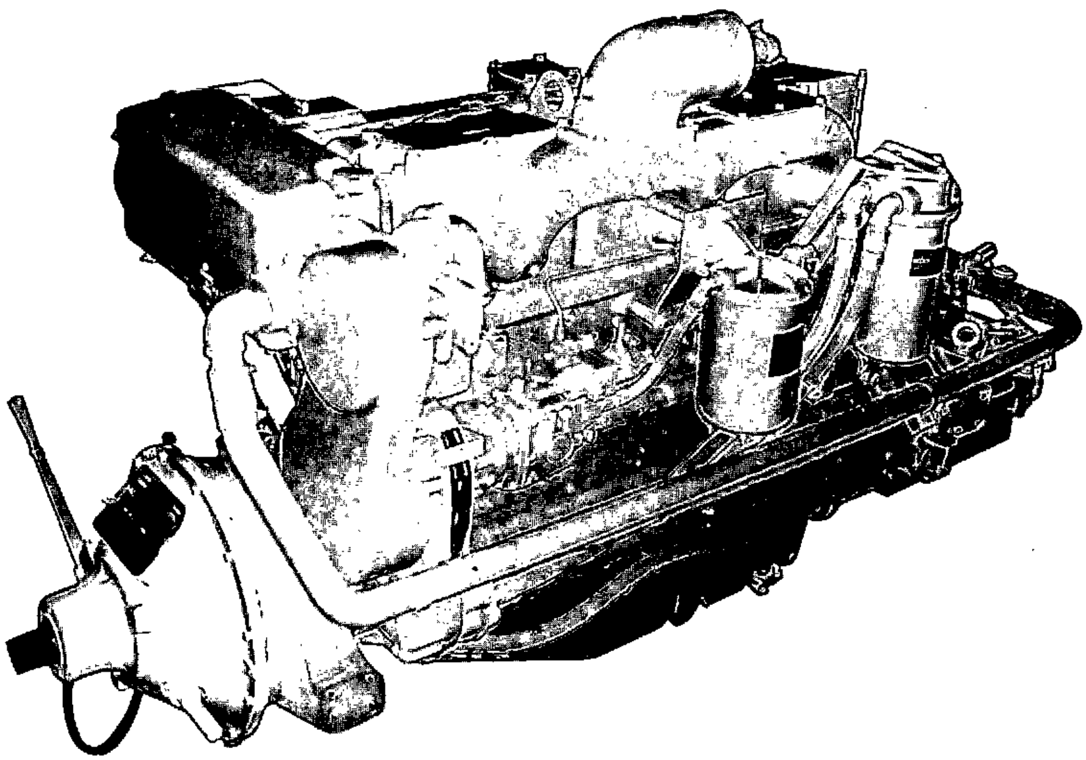


Table 3: Industrial Model Specifications | **Locomotive**

Model	500 Ft. Max. HP@RPM	Sea Level Max. HP@RPM	Begin Derate Altitude	Engine Breathing	Model	500 Ft. HP@RPM	Begin Derate Altitude	Engine Breathing
N-855P250	240@2100	250@2100	500	N/A	N-855-L	238@2100	500	N/A
NT-855P310	310@2100	310@2100	8,500*	T	NT-855-L1	285@2100	500	T
NT-855P335	335@2100	335@2100	5,000*	T	NT-855-L2	325@2100	500	T
NT-855P380	380@2300	380@2300	2,500**	T	NTA-855-L	370@2100	500	T

* With standard T-50. Use of optional VT-50 raises limit to 12,000 ft. [3657.000M].
** With standard T-50. Use of optional VT-50 raises limit to 5,000 ft. [1524.000M].

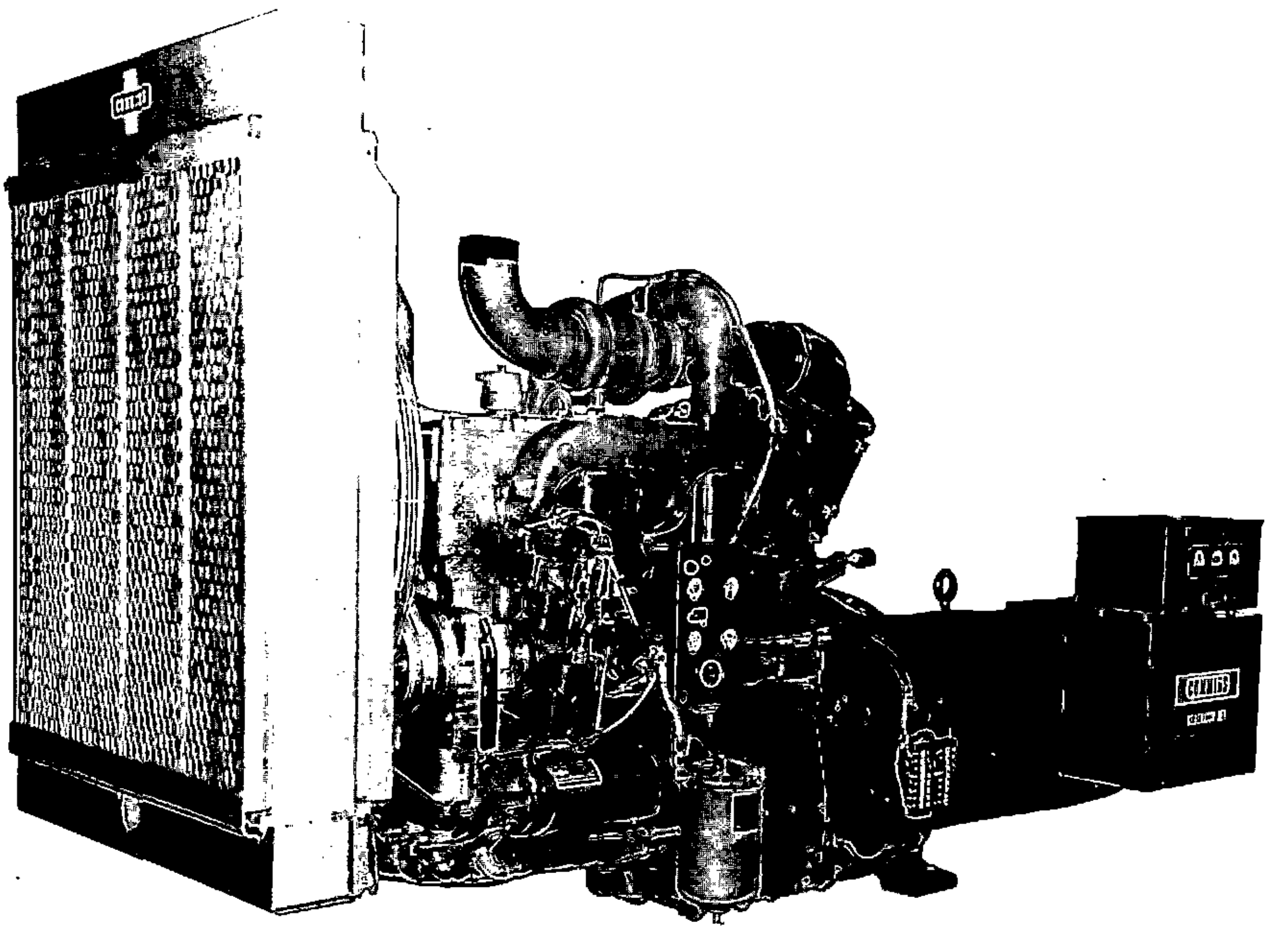
1 Naturally aspirated engines are derated 3% for each 1000 ft. [304.800M] above sea level and 170 for each 10 deg. F [5.56 deg. C] rise in air temperature.
2 Turbocharged engines are derated 4% for each 1000 ft. [304.800M] altitude above 12,000 ft. [3657.000M].



For general operating instructions of Marine units refer to Bulletin No. 983624

Table 4: Cummins Marine Diesels

Engine Model	Pleasure Boat Max. HP@RPM	Light Duty Commercial Max. HP@RPM	Medium Duty Max. H. P. @RPM	Heavy Duty Max. H.P. @RPM	Engine Breathing
NH-250-M	240 @ 2100	210 @ 2100	200 @ 1800	190 @ 1800	N/A
NT-335-M	335 @ 2100	285 @ 2100	265 @ 1800	235 @ 1800	T
NT-380-M	380 @ 2300	320 @ 2300	300 @ 2000	253 @ 2000	T



For general operating instructions of Generator Sets refer to Bulletin No. 983600.

Table 5: Standard Generator Set Application Specification

Engine Model	1800 RPM Stand-by	60 Hertz Prime Power	1500 RPM Stand-by	50 Hertz Prime Power	Gen: Frame Size	Number of Leads
NT-270 GS-GC	GS-150 KW	GC-125 KW	GS-125 KW	GC-100 KW	500	12
NT-310 GS-GC	GS-175 KW	GC-150 KW	GS-150 KW	GC-125 KW	500	12
NT-335 GS-GC	GS-200 KW	GC-175 KW	GS-165 KW	GC-150 KW	500	12
NT-400 GS-GC	GS-230 KW	GC-200 KW	GS-190 KW	GC-170 KW	500	12

Operating Principles

Dependable service can be expected from a Cummins Diesel Engine when the operation 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

Diesel engines differ from spark ignition internal combustion engines in a number of ways. Compression ratios are higher than in spark-ignited engines. The charge taken into the combustion chamber through the intake consists of air only—with no fuel mixture. Injectors receive low pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time in equal quantities and proper condition to burn. Ignition of fuel is caused by the heat of the 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 the order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly the valves and injectors must act at the proper time. Action of the valves and injectors is controlled by properly adjusted linkage (consisting of cam followers, push rods, levers, valve crosshead and injector link) connecting them with the camshaft. Lobes on the camshaft provide mechanical action; the camshaft is driven from the crankshaft.

Intake Stroke

During the intake stroke, the piston travels downward, the intake valves are open, and the exhaust valves are closed. The downstroke of the piston permits air from outside to enter cylinder through the open intake port. Where used, the turbocharger increases air pressure in the engine intake manifold and forces it into the cylinder.

The intake charge consists of air only with no fuel mixture.

Compression Stroke

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

At the end of the compression stroke, the air in the combustion chamber has been forced by the piston to occupy a space about one-fifteenth as great in volume as it occupied at the beginning of the stroke. Thus, we say the compression ratio is 15:1 etc.

Compressing the air into a small space causes the temperature of that air to rise. Near the end of the compression stroke, the pressure of the air above the piston is approximately 500 to 600 psi [35.1500 to 42.1800 kg/sq cm] and the temperature of that air is approximately 1000 deg F [537.7 deg C].

During the last part of the compression stroke and the early part of the power stroke, a small metered charge of fuel is injected into the combustion chamber. Almost immediately the fuel is ignited by the hot compressed air and starts to burn.

Power Stroke

During the power stroke, the piston travels downward and both intake and exhaust valves are closed.

By the time the piston reaches the end of the compression stroke, the burning fuel causes a further increase in the pressure above the piston. As more fuel is added and burns, the gases get hotter and expand more to push the piston downward and add impetus to crankshaft rotation.

Exhaust Stroke

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

Burned gases are forced out of the combustion chamber through the open exhaust valve ports by the upward travel of the piston.

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

Fuel System

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

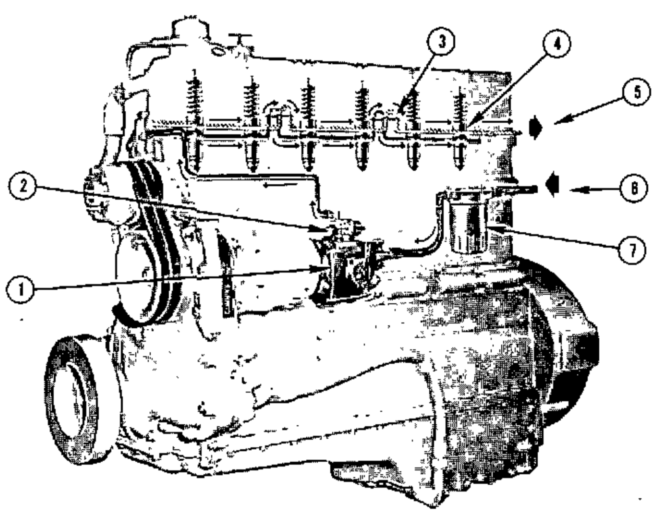
The operation of the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the passage size through which the liquid flows. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

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.



1. PT (TYPE G) FUEL PUMP
2. SHUT-DOWN VALVE
3. FUEL CONNECTOR
4. INJECTOR
5. INJECTOR RETURN
6. FROM TANK
7. FUEL FILTER

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

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

The designations PT (type G) and PT (type R) stand for "Governor-Controlled" and "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 or fuel pump drive which is driven from the engine gear train. The fuel pump main shaft turns at engine crankshaft speed, and drives the gear pump, governor and tachometer shaft. The location of fuel pump components is indicated in Figs. 1-2 and 1-3.

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:

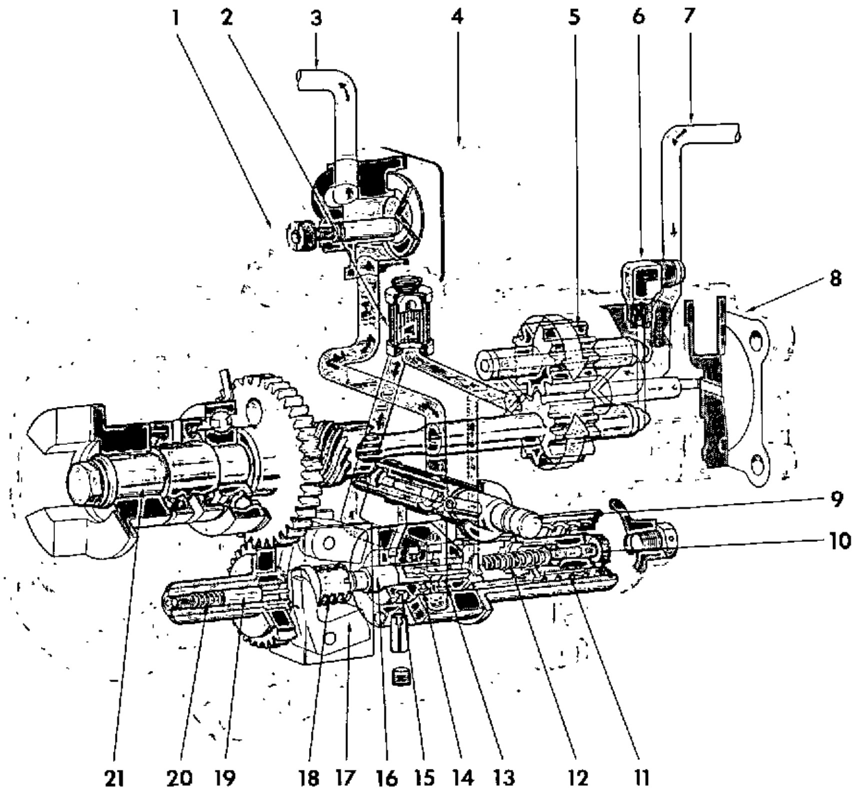
1. The gear pump, which draws fuel from the supply tank and forces it through the pump filter screen to the governor.

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.

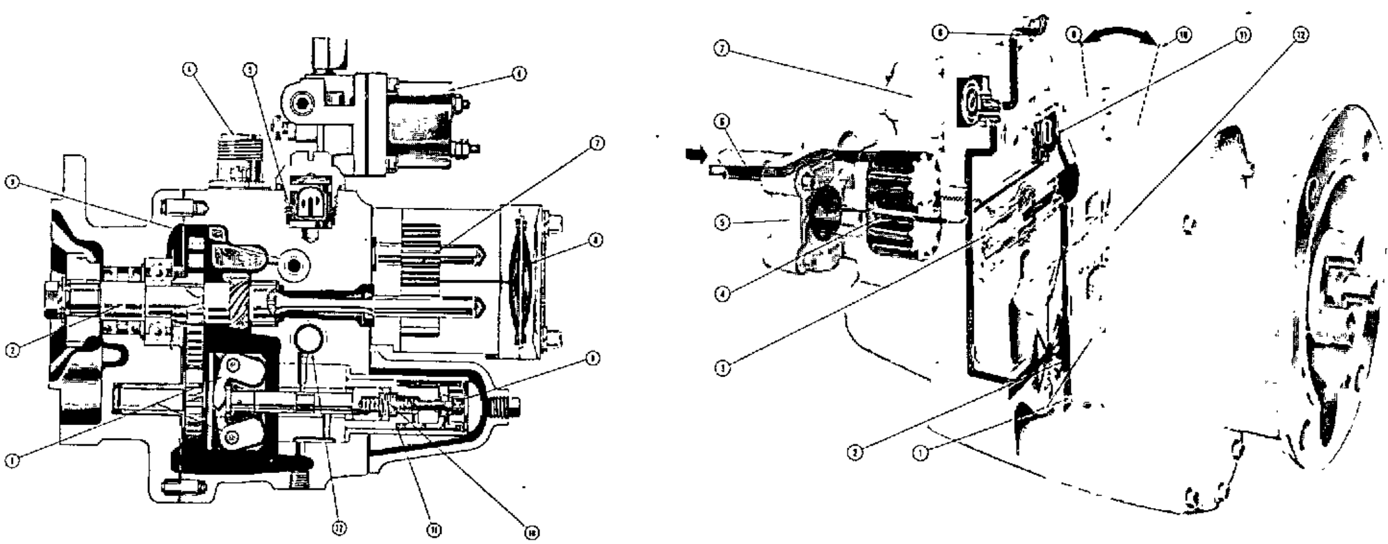
PT (type R) Fuel Pump

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 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. 1-2, FWC-31. PT (type G) fuel pump and fuel flow



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

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

Fig. 1-3, FWC-4. PT (type R) fuel pump and fuel flow

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. 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. 1-2.

2. In the PT (type R) fuel pump, to the pressure regulator assembly as shown in Fig. 1-3.

Pressure Regulator

Used in the PT (type R) and in the torque modification device of PT (type G) "High-torque engine" fuel pump; 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. 1-3.

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 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 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, 1-4 and 1-5.

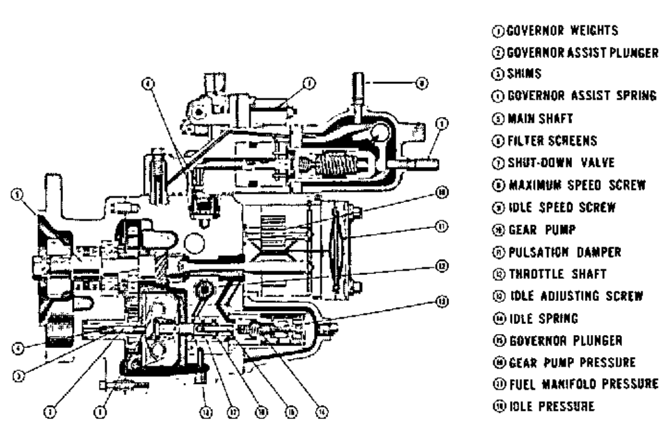


Fig. 1-4, FWC-9. PT (type G) fuel pump with MVS governor

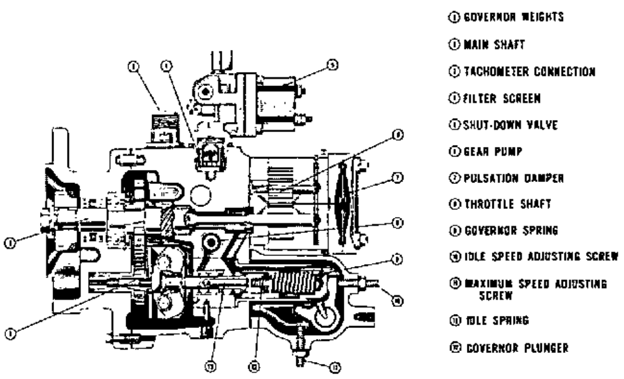


Fig. 1-5, FWC-10. PT (type G) fuel pump with SVS governor

Mechanical Variable-Speed (MVS) Governor

This governor supplements the standard automotive governor to meet the requirements of machinery 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. 1-4.

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

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

The MVS governor assembly mounts atop the fuel pump, and the fuel solenoid is mounted to the governor housing. See Fig. 1-4. 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.

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.

Marine applications require the automotive throttle of the fuel pump to be locked open during operation and engine speed control is maintained through the SVS governor lever. Also, only PT (type B, C or D) injectors should be used in marine engines equipped with SVS governed fuel pump.

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.

Hydraulic governor applications not having variable speed setting provisions use the SVS governor to bring engine speed down from rated speed for warm-up at or slightly above 1000 RPM.

PT (type R) Mechanical Variable-Speed Governor

On some applications this governor replaces the standard "automotive" governor to meet the requirements of machinery 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. 1-6.

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

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

PT (type R) Torque Converter Governor

A PT (type R) fuel pump is usually supplied when a torque converter is used to connect the engine with its driven unit. An auxiliary governor may be driven off the torque converter output shaft to exercise control over the engine governor and to limit converter output shaft speed. The engine governor and the converter governor must be adjusted to work together.

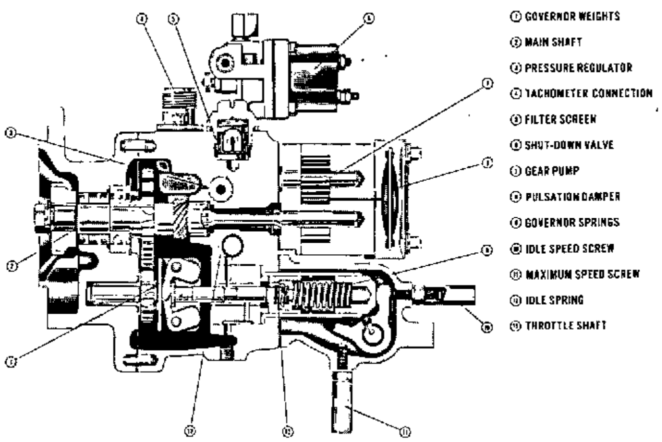


Fig. 1-6, FWC-7. PT (type R) fuel pump with MVS governor

The PT torque-converter governor consists of two mechanical variable-speed governors in series — one driven by the engine and the other by the converter. Fig. 1-7.

The engine governor, in addition to giving a variable engine speed, acts as an overspeed and idle speed governor while the converter-driven governor is controlling the engine. Each governor has its own control lever and speed adjusting screws.

The converter-driven governor works on the same principle as the standard engine governor except it cannot cut off fuel to the idle jet in the engine-driven governor. This insures that if the converter tailshaft overspeeds it will not stop the engine.

Hydraulic Governor

Hydraulic governors are used on stationary power applications where it is desirable to maintain a constant speed with varying loads.

The Woodward SG hydraulic governor uses lubricating oil, under pressure, as an energy medium. It is supplied from a sump on the governor drive housing or from the engine oil gallery. For oil viscosity, see Page 3-2.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in the governor control linkage acts to decrease fuel delivery. See Fig's. 1-8 and 1-9.

In order that its operation may be stable, speed droop is introduced into the governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of approximately one-half of one percent to seven percent.

Assume that a certain amount of load is applied to the

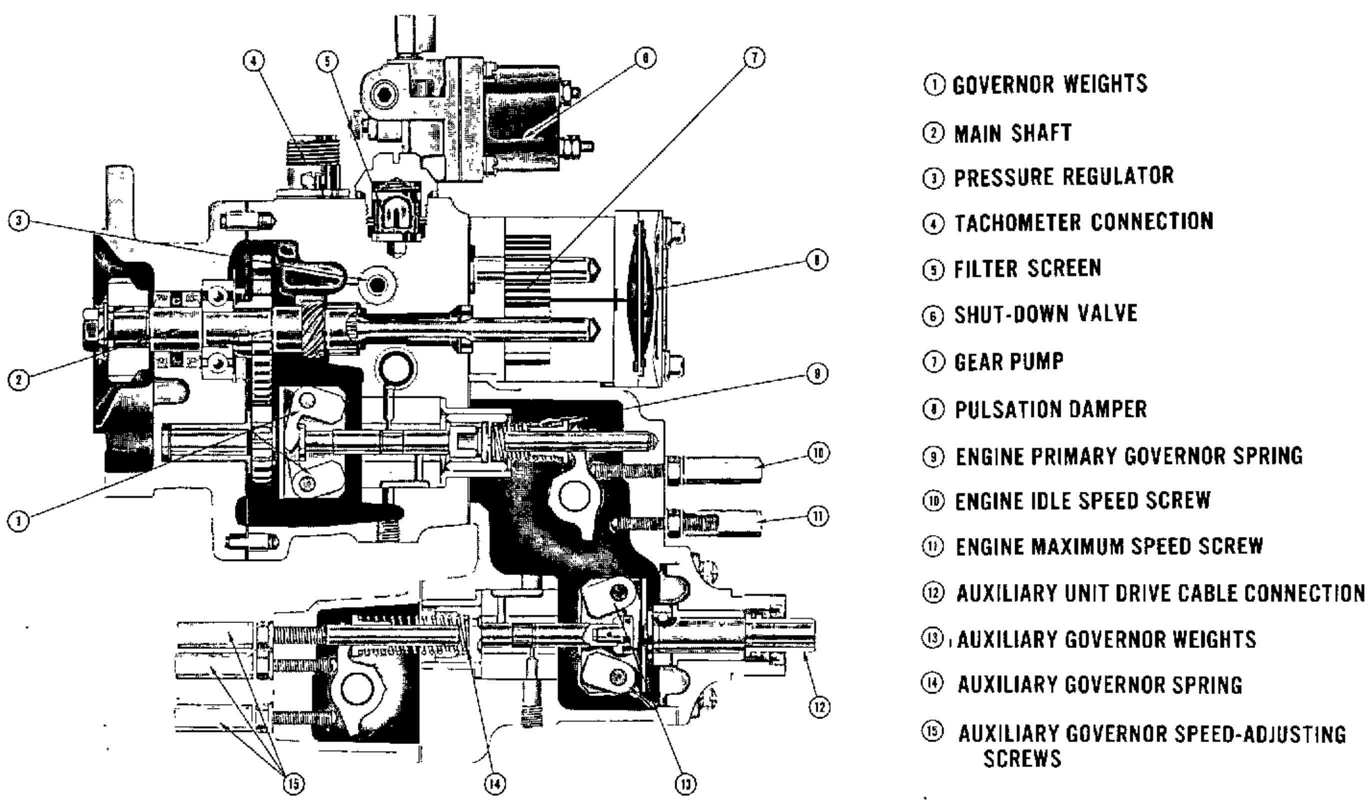
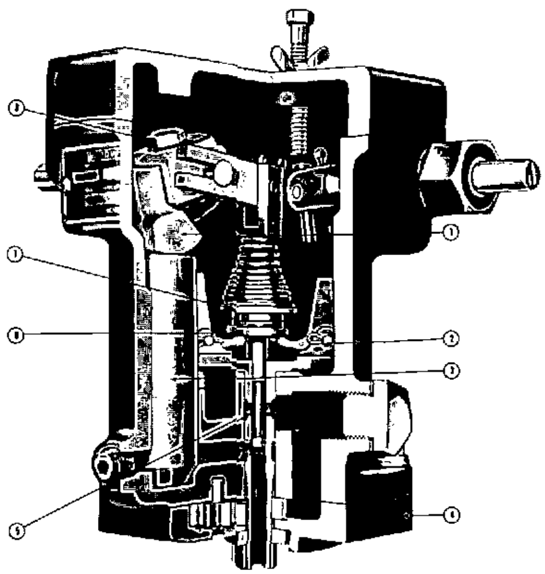
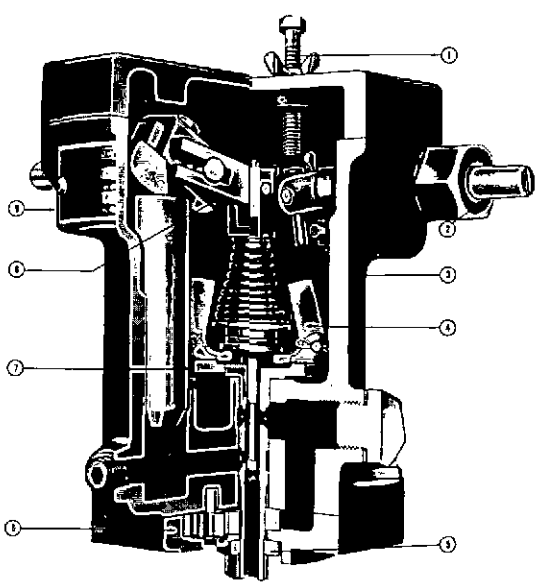


Fig. 1-7, FWC-8. PT (type R) fuel pump with torque converter governor



1. TERMINAL LEVER
2. BALLARM PIN
3. SERVO MOTOR PISTON
4. GOVERNOR BASE
5. PILOT VALVE PLUNGER
6. THRUST BEARING
7. SPRING SEAT
8. SPEED DROP ADJUSTING SCREW

Fig. 1-8, FWC-1A. Hydraulic governor with load off, speed increased position



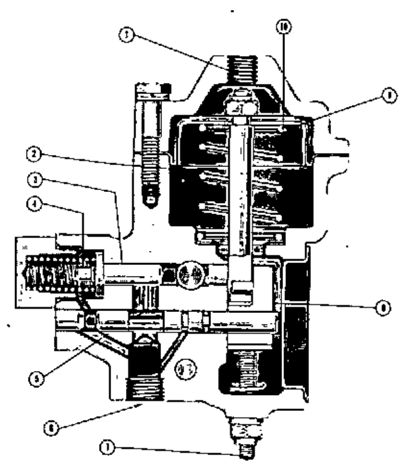
1. LOW LIMIT ADJUSTING SCREW
2. SPEED ADJUSTING SHAFT
3. GOVERNOR CASE
4. BALL ARM
5. DRIVE SHAFT COLLAR
6. PUMP GEAR
7. BALLHEAD
8. FLOATING LEVER
9. NAME PLATE

Fig. 1-9, FWC-1B. Hydraulic governor with load on, speed decreased position

engine. The speed will drop, the flyballs will be forced inward and will lower the pilot valve plunger. This will admit oil pressure underneath the power piston, which will rise. The movement of the power piston is transmitted to the terminal shaft by the terminal lever. Rotation of the terminal shaft causes the fuel setting on the engine to be increased.

Aneroid

The aneroid control, Fig. 1-10, provides a fuel by-pass



1. AIR INLET
2. DIAPHRAGM
3. BY-PASS VALVE
4. VALVE SPRING
5. *THROTTLING SHAFT*
6. FUEL RETURN OUTLET
7. ADJUSTING SCREW
8. SHAFT LEVER
9. PISTON
10. PISTON SPRING

Fig. 1-10, AWC-2. Aneroid control

system that responds to air manifold pressure and is used on turbocharged engines whenever close control of exhaust smoke is desirable.

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.

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.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Figs. 1-1 and 1-11. 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.

Fuel flows from a connection atop the fuel pump shut-down valve through a supply line into the lower drilled passage in cylinder head at the front of the engine. A second drilling in the head is aligned with the upper injector radial groove to drain away excess fuel. A fuel drain at the flywheel end of the engine 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 openings, 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.

Fuel Lines, Connections and Valves

Supply And Drain Lines

The drain returns fuel not injected to the supply tank through a drain line located at the rear of the engine.

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. 1-1.

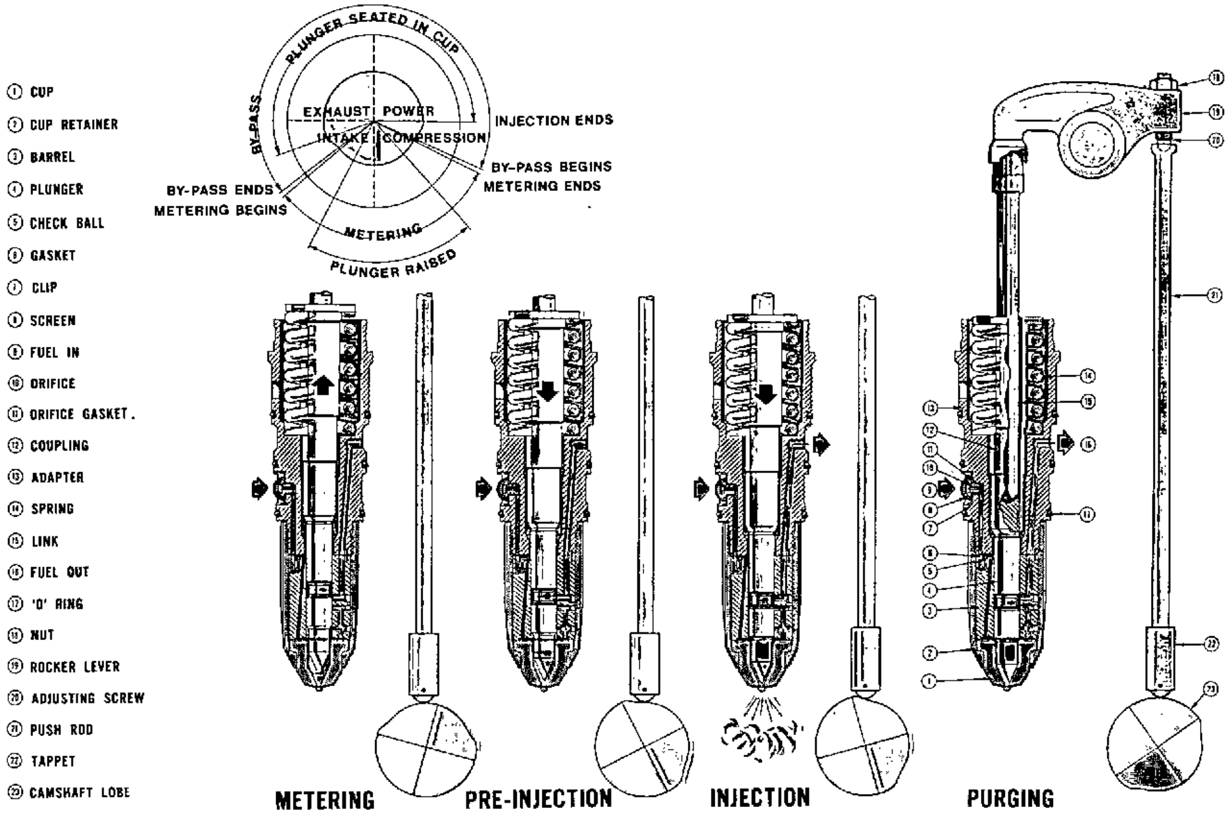


Fig. 1-11, FWC-28. Fuel injection cycle - PT (type D) injector

Connections

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

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. The pressure is supplied by a gear type lubricating oil pump located on the side of the engine.

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. 1-12) oil is drawn from the pan to the pump 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 (Fig. 1-13 and 1-15) 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 oil distribution.

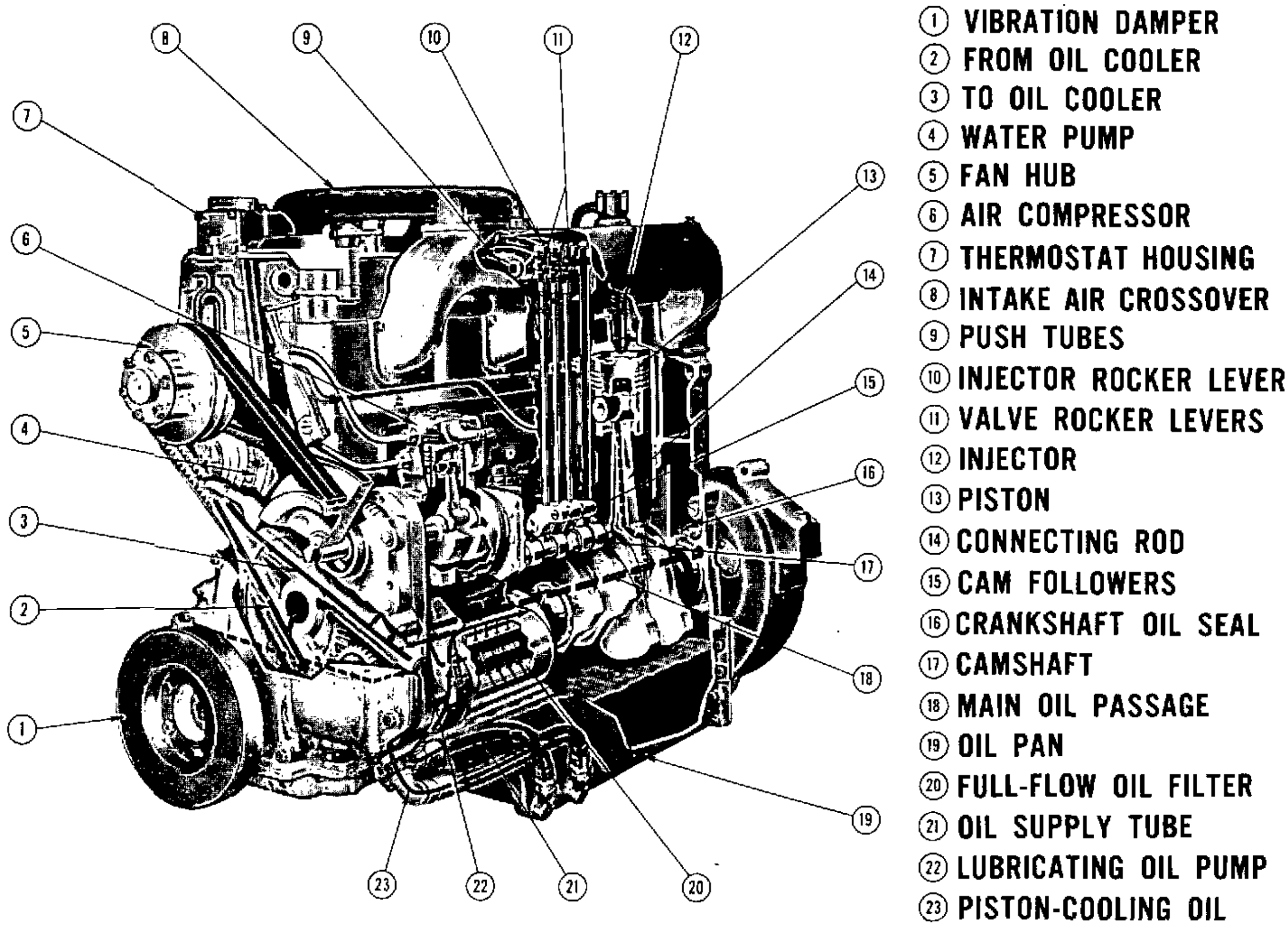


Fig. 1-12, LWC-18. Lubrication oil flow - NT engine (fuel pump side)

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

Lubricating oil pressure is controlled by a regulator in the oil pump or filter. Normal operating pressure is maintained at 30 to 70 psi [2.1093 to 4.9210 kg/sq cm]. Refer To Fig. 1-14 for lubricating oil flow.

Filters and screens are provided in lubricating oil system to remove foreign material from circulation and prevent damaging bearings or mating surfaces. 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 compressor and turbocharger 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, and most hydraulic governors, when used, use engine lubricating oil from a separate combination drive and oil sump.

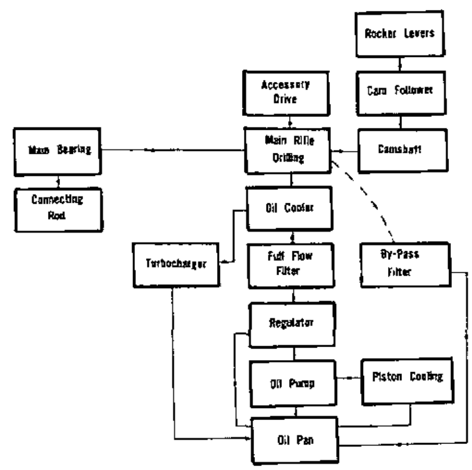


Fig. 1-14, N10727. Lubricating oil flow schematic

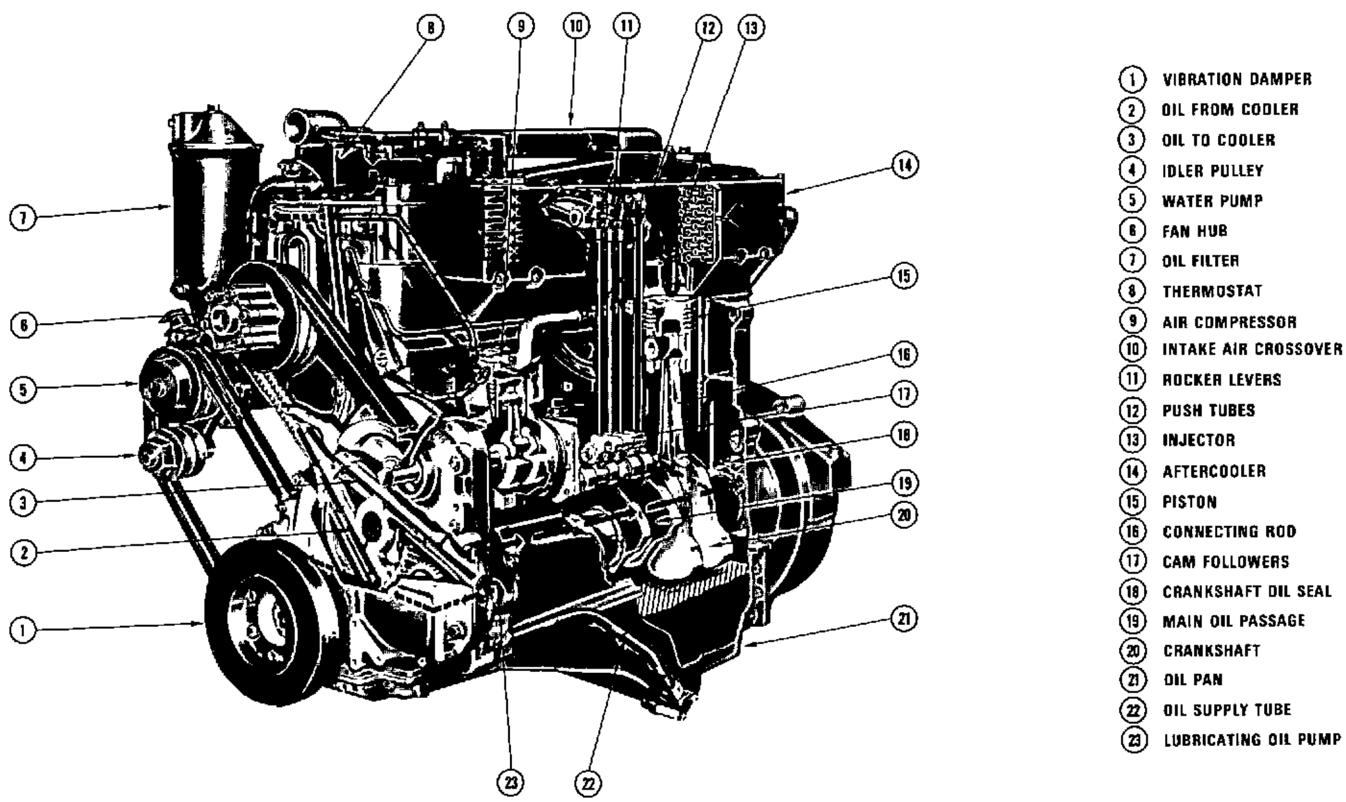


Fig. 1-13, LWC-22. Lubricating oil flow - NTA engine

Cooling System

Water Pump

Accessory Driven

Water is circulated by a centrifugal water pump mounted on the gear cover end of the engine installed in block cavity and driven by belts from the accessory drive. (1, Fig. 1-16).

The water circulates around the wet-type cylinder liners, through the cylinder head and around the injector sleeves. Discharge connections between the heads are provided by a water manifold. The water manifold houses a single thermostat to control engine operation temperature.

The engine coolant is cooled by a radiator or by heat exchangers, depending on the type of installation. In some cases, the heat exchanger and oil cooler are built as one unit.

Where heat exchangers are used, a raw or sea water pump is mounted on the engine.

Crankshaft Driven

Water is circulated by a centrifugal type water pump mounted on the exhaust side of the engine and driven by the belts from the crankshaft. (2, Fig. 1-16).

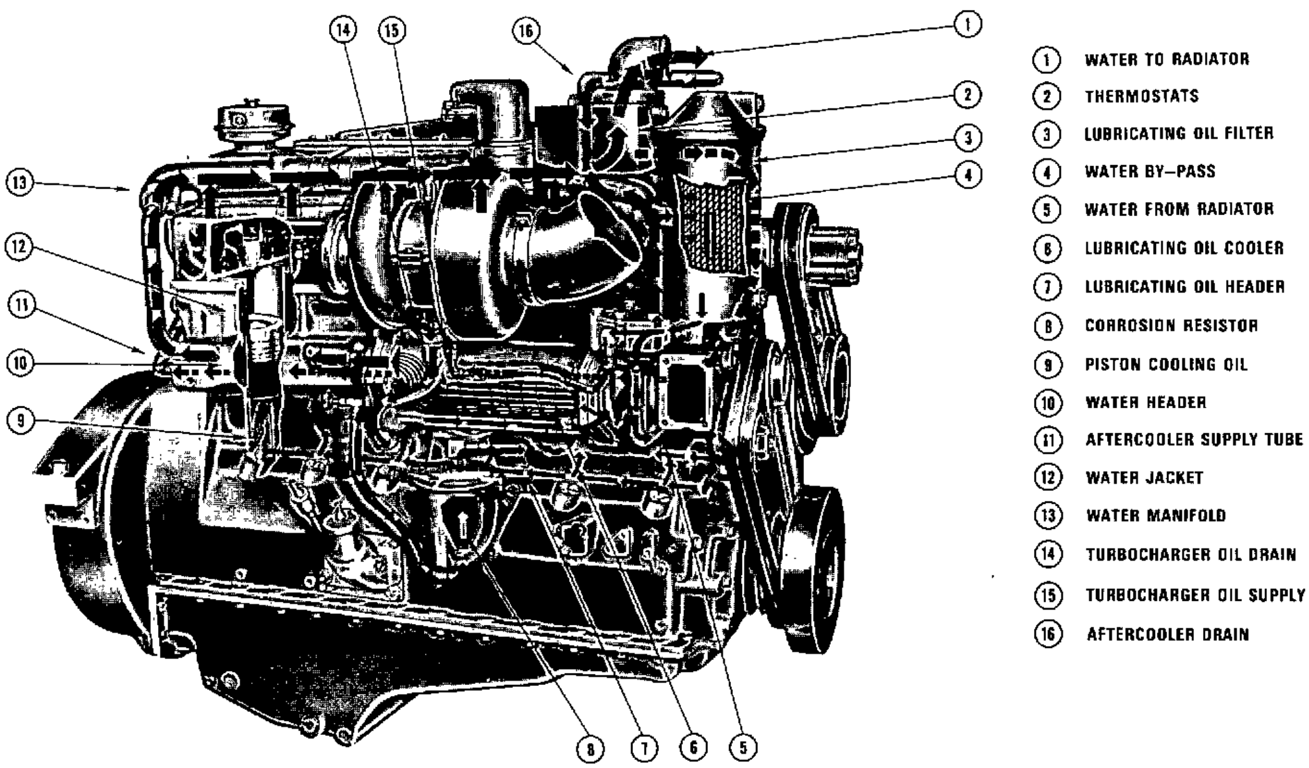


Fig. 1-15, LWC-21. Coolant and lubricating oil flow - NTA engine (exhaust manifold side)

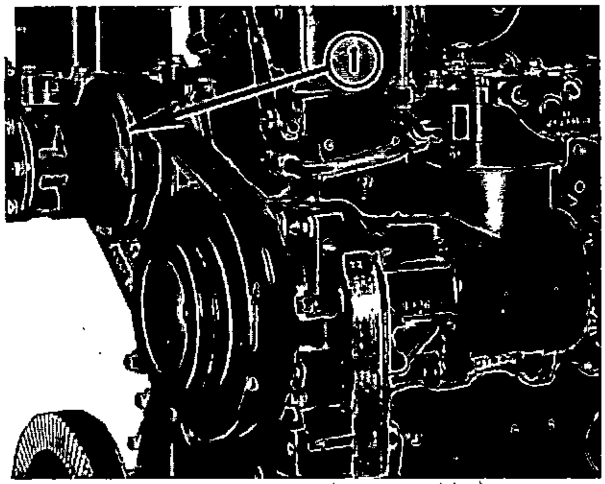


Fig. (1) 1-16, LWC20. Water pump (accessory drive)

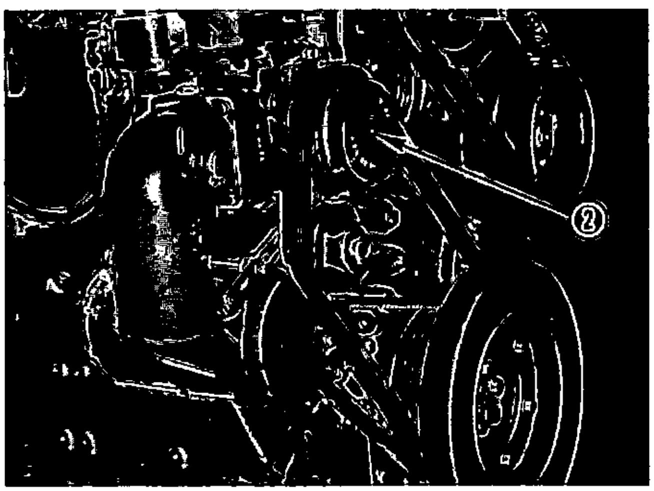


Fig. (2) 1-16, LWC23. Water pump (crankshaft drive)

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. 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.

927 Water Pump Arrangements

Water is circulated by a centrifugal type water pump, belt driven from accessory drive. Belt adjustment is obtained by raising or lowering the idler adjusting pulley. (Fig. 3, 1-16).

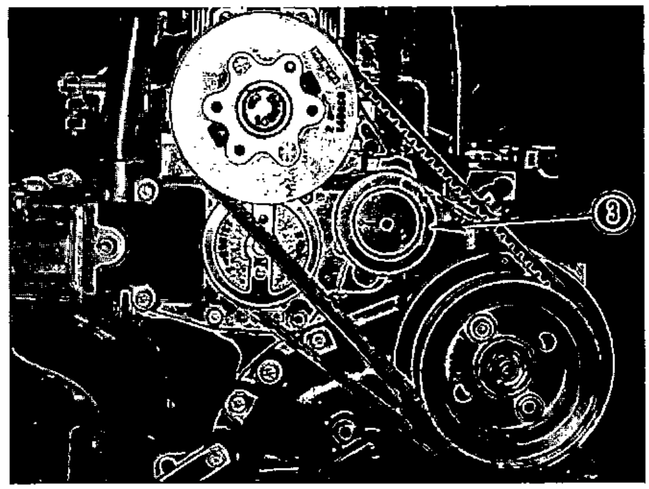


Fig. (3) 1-16, LWC24. Water pump (927)

Air System

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, or turbocharger if engine is a turbocharged model.

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.

The turbocharger forces additional air into combustion chambers so engine can burn more fuel and develop more horsepower than if it were naturally aspirated.

Turbocharger

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.

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

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 the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig. 1-17 and Fig. 1-18. The turbocharger is lubricated and coated by engine lubricating oil.

Air Compressor

The air compressor may be either a single or two cylinder unit 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:

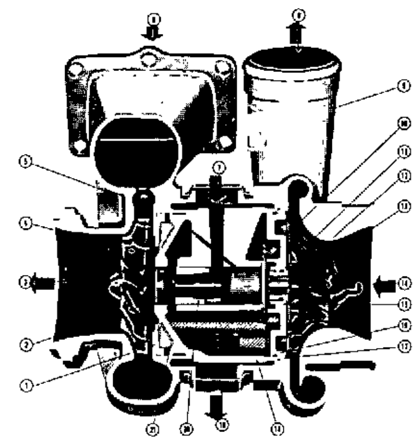


Fig. 1-17, AWC8. T-50 turbocharger (cross-section)

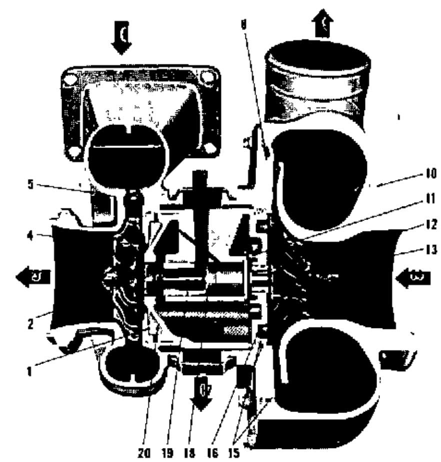
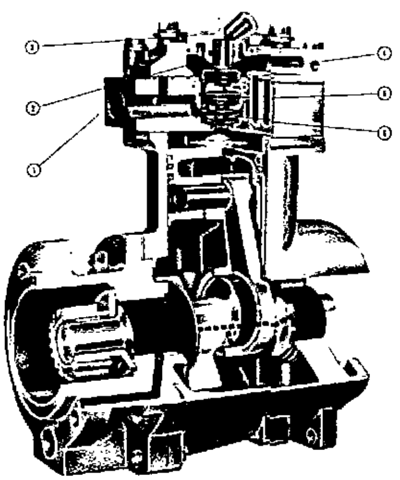


Fig. 1-18, AWC9. VT-50 turbocharger (cross-section)

Air Intake

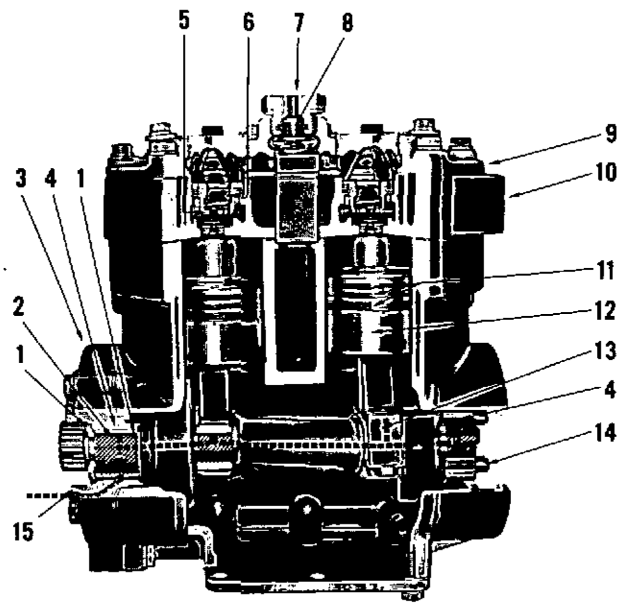
Air is drawn into the compressor through the engine intake air manifold. As the piston moves down, a partial vacuum occurs above it.

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. 1-19 and Fig. 1-20.



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

Fig. 1-19, AWC 10. Cummins air compressor



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. 1-20, AWC 11. Two cylinder air compressor

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.

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.

Dual Diesel

Cummins Dual Diesel Cycle Operating As Air Compressor

The following paragraphs describe the operation of the NH-250 engine as a Dual Diesel, i.e., on the road as a motive power and at the site as a self-powered compressor to unload a tank trailer unit.

This concept was developed primarily for the bulk transportation of certain dry and liquid cargo to its destination and unloading the product by the use of compressed air. Operation as a self-powered air compressor is accomplished by running the engine on two cylinders, while pumping air with the other four. Fuel is shut off to the rear four pumping cylinders and the air being "pumped" is directed through the exhaust system and connected piping to the location desired.

The front two cylinders continue to operate as normal engine power as described on Page 1-1. During the four piston strokes of the pumping cylinders, the following action takes place.

Intake Stroke

During the intake stroke, the piston travels downward, the intake valves are open, and the exhaust valves are closed. If the unit is to operate above a 15 psi pressure head, the exhaust valves must have springs with a heavier than normal spring load rate to prevent valve flutter thus obtaining more positive seating.

Note: Factory built engines to be operated as Dual Diesels have the correct exhaust valve springs.

The downstroke of the piston permits air from outside to enter the cylinder around the open intake valves.

Compression Stroke

At the end of the intake stroke, the intake valves close and the piston starts upward on the compression stroke. The compression pressure formed in the cylinder helps equalize pressure on the crankshaft.

Expansion Stroke

During the expansion stroke, (the normal power stroke of the engine) the piston travels downward and both intake and exhaust valves are closed. This stroke is so called because the air compressed during the compression stroke expands. As expansion occurs, a downward force is applied to the piston, providing a normal balance of pressure on all connecting rod journals of the crankshaft.

Exhaust Stroke

During the exhaust stroke, intake valves are closed, the exhaust valves are open, and the piston is on its upstroke. The compressed air is forced out of the cylinder around the open exhaust valve(s) by the upward travel of the piston. The compressed air is routed to a connection point by a butterfly-type valve in the exhaust piping, so the air can be utilized at the desired location rather than escaping through the exhaust system.

The Fuel System

The MVS (Mechanical Variable-Speed) governor is mounted directly on top of the fuel pump (or remotely near the fuel pump) to supplement the standard automotive governor to meet the pumping requirements where the engine must operate at near constant speed, but extremely close regulation is not necessary. Fig's. 1-4 and 1-21.

Adjustment for engine rpm for pumping can be made by means of a lever control or adjusting screw. The lever control may be automatically positioned by an air cylinder.

Fuel Lines And Valves

Fuel is supplied through lines and drillings to the injectors.

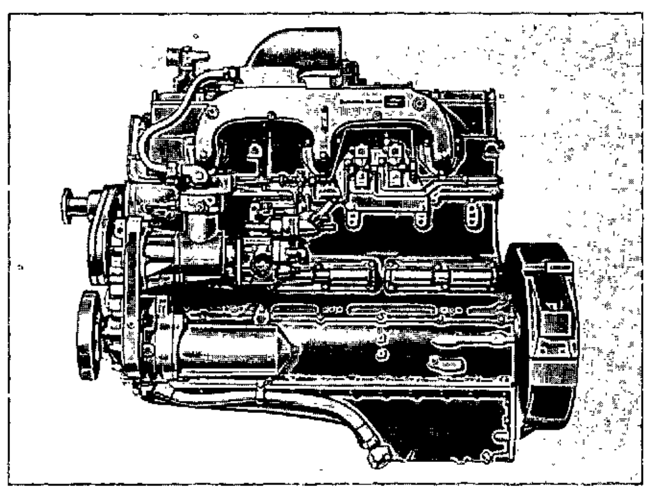


Fig. 1-21, N11952. Fuel line arrangement - NH-250 Dual Diesel

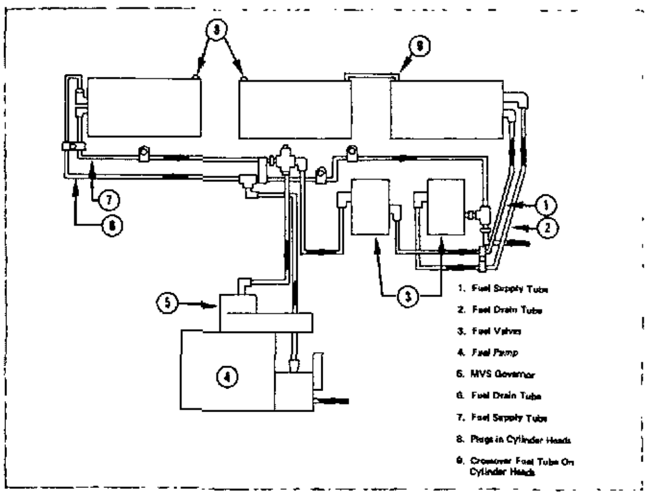


Fig. 1-22, N-11830. Dual Diesel fuel line and valve plumbing

A drain line returns fuel, which is not injected, to the supply tank. The supply and drain lines to the pumping cylinders have fuel shut-off valves which close, during engine operation as an air compressor, to trap fuel in the lines for injector lubrication. Fig. 1-22.

Intake System

The Cummins Dual Diesel Engines are naturally aspirated; therefore, the engine air system consists of an air cleaner, piping and intake air manifold. The air cleaner may be mounted directly to the engine or located remotely, depending on design of the equipment in which the engine is used.

Exhaust System

The exhaust system uses separate exhaust piping (or possibly connected by a tee joint) for the pumping and driving cylinders.

Exhaust piping from the pumping cylinders is directed to a "wye" with one outlet mounted to the vehicle's normal exhaust outlet and the other to the desired location for the compressed air take-off. During operation as engine power, the compressed air take-off is capped. A normally open air-operated exhaust control valve is installed in the exhaust piping between the "wye" and the vehicle exhaust outlet on the four pumping cylinders; this valve is closed during the air pumping operation so compressed air cannot escape through the normal exhaust piping and is discharged through the product line. Fig. 1-23.

Exhaust Control Valve

An exhaust control valve to shut off the exhaust outlet during the air pumping cycle, to prevent compressed air escaping into the exhaust system, is mounted in the pumping cylinders exhaust piping. During operation as an engine, the valve is open and the compressed air line capped off to prevent escape of exhaust gas (except the gas which goes through the muffler). Fig. 1-23.

Four-Way Air Control Valve

A four-way valve is used to direct air pressure to the air cylinder controlling the MVS governor lever position (if used), the valves in the fuel inlet and outlet lines of the air pumping cylinders, exhaust piping valve and any safety device which may be used. When desired, the valve may be used to automatically set the parking brake when the hand lever is placed in pumping position.

Check Valve

The check valve is used to prevent return of the product to the engine in case of an engine stoppage or slow-down. The valve is closed only by gravity or reverse flow; therefore, it must be mounted vertically. The valve is held open during pumping by velocity of air flow. To prevent bouncing of the valve during road operation, and corresponding seat and bearing wear, it should be mounted at the end of the discharge pipe as shown in Fig. 1-23. The valve is held in place by a stem inserted in center of the cap; this stem is adjusted to touch-check valve shaft when cap is in place. The stem is normally made from a threaded rod with jam nuts on each side of cap top.

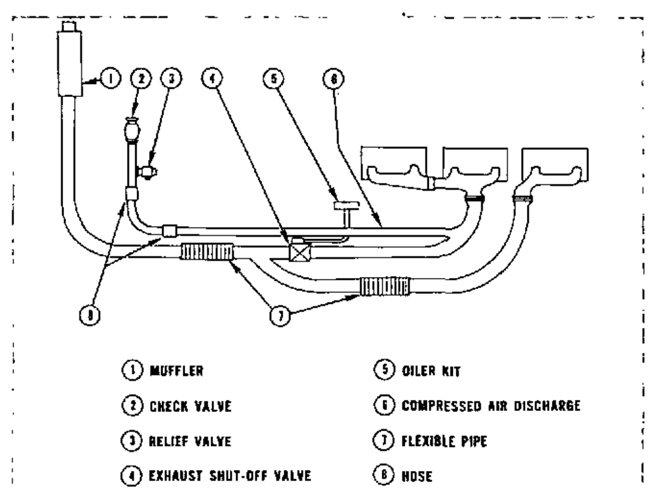


Fig. 1-23, N11831. Dual Diesel schematic

Operating Instructions

An operator is responsible for the care of an engine while it is operating. This is an important job and one that will determine to a large degree the extent of profit from the operation. There are comparatively few rules which an operator must observe to receive dependable service from a Cummins Engine. Neglect of these rules result in a penalty. The penalty may be lowered engine efficiency or down time and costly repair bills resulting from premature engine failure.

General-All Applications

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 generator sets. (For marine engine operation and maintenance, consult Cummins Bulletin No. 983624.) 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. [4827.900 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 [121.1 deg C] or coolant temperature exceeds 190 deg F [87.8 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. [482.790 km] or 10 hours during the break-in period.

Pre-Starting Instructions — First Time

Priming The Fuel System

1. Fill fuel filter with clean fuel oil meeting the specifications outlined on Page 3-1.

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

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

2. Check fuel tanks. There must be an adequate supply of a good grade, clean, No. 2 diesel fuel in the tanks. See "Fuel Oil Specifications", Page 3-1.

3. If injector and valve 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

1. Fill crankcase to "L" (low) mark on dipstick. See Page 3-2.

2. Remove drain plug from base of lubricating oil filter housing (Fig. 2-1) or filter can 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 Page 3-2) to drain plug boss.

4. Prime until a 30 psi [2.1090 kg/sq cm] minimum pressure is obtained.

5. Crank engine at least 15 seconds (with fuel shut-off valve

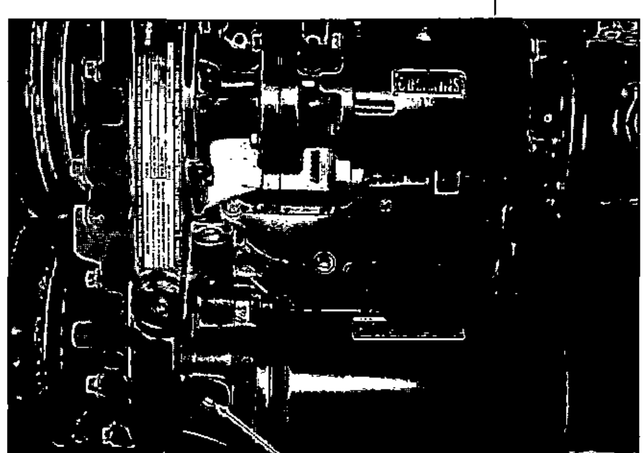


Fig. 2-1, N11963. Lubricating system priming point

closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [1.0545 kg/sq cm].

6. Remove external oil supply and replace drain plug in base of lubricating oil filter housing or filter cap, torque 15 to 20 ft. lbs. [2.0745 to 2.7660 kg m].

Caution: Clean area of any lubricating oil spilled while priming or filling crankcase to prevent injury to personnel

7. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications shown on Page 3-2. No change in oil viscosity or type is needed for new or newly rebuilt engines.

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.

Check Oil Level

1. A dipstick oil gauge is located on the side of the engine. The dipstick supplied with the engine has an "H" (high) and "L" (low) 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.

2. Keep oil level as near the high mark as possible (1, Fig. 2-2).

Caution: Never operate the engine with oil level below the low-level mark (2), or above the high-level mark (1).

Check Air Connections

Check the air connections to the compressor and air equipment, if used, and to the air cleaners.

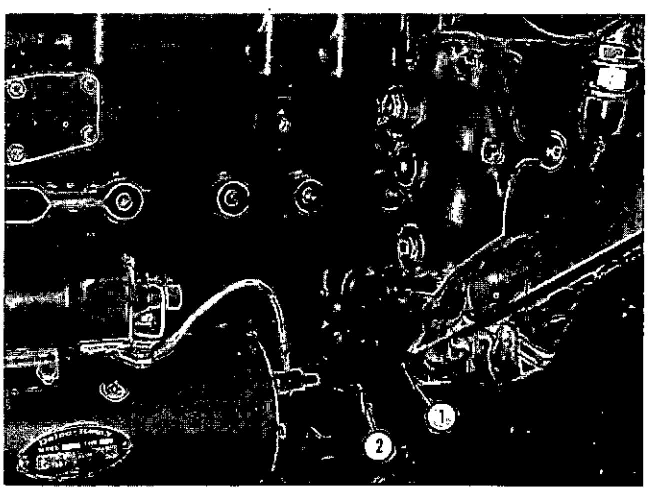


Fig. 2-2, N12012. Checking engine oil level

Check Engine Coolant Supply

1. Remove radiator cap and check engine coolant supply. Add coolant as needed to completely fill system.

2. Make visual check for leaks.

3. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 3-4.

Check Fuel Supply And Connections

1. Fill fuel tanks with fuel meeting specifications on Page 3-1.

2. 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 while cranking engine.

Caution: Protect the turbocharger during 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 main disconnect switch is open.

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 over-ride 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 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.

Cold Starting Aids

Use The Preheater For Cold-Weather Starting

To aid in starting the engine when the temperature is 50 deg F [10.0 deg C] or below, an intake air preheater is available. The preheater equipment consists of a hand-priming pump to pump fuel into the intake manifold, a glow plug which is electrically heated by the battery and a switch to turn on the glow plug. The fuel burns in the intake manifold and heats the intake air. See Fig. 2-3.

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

To use the preheater for cold starting:

1. Leave 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 [5.6245 to 7.0307 kg/sq cm] fuel pressure. Use of primer before the 20-second interval will wet glow plug and prevent heating.

Note: On engine 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 [0.492 to 0.7031 kg/sq cm]; then, move to "run" position.

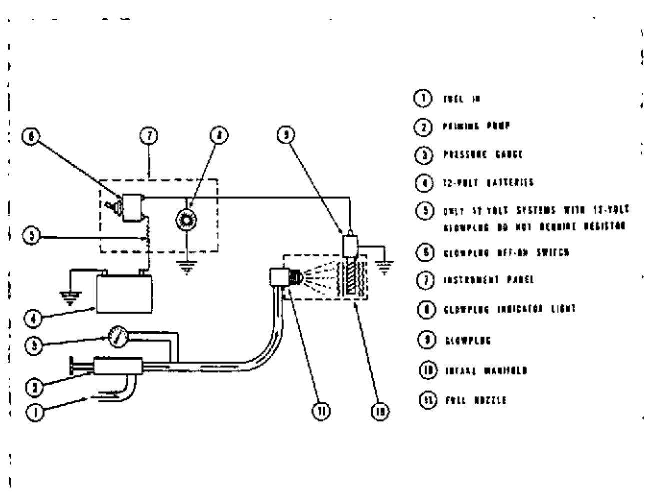


Fig. 2-3, N11804. Preheater wiring diagram

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 from manifold near glow plug and carefully check for flame while a helper performs the preceding Steps 2, 3 and 4. See Fig. 2-4.

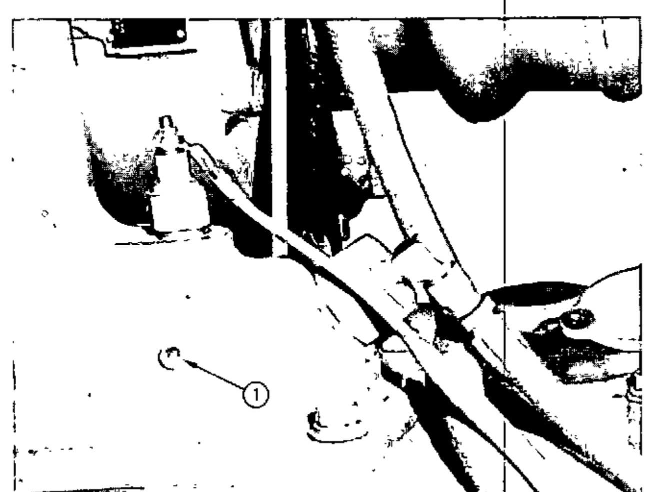


Fig. 2-4, N11949. Glow plug inspection hole plug

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 it 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.

Other Cold-Starting Aids

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. 2-5). If properly installed, the spring will hold it closed.

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

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

4. Wait 30 seconds before engaging starter.

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

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

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

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

Note: Other cold starting aids have been approved for use on Cummins Engines, where used, refer to manufacturers instructions.

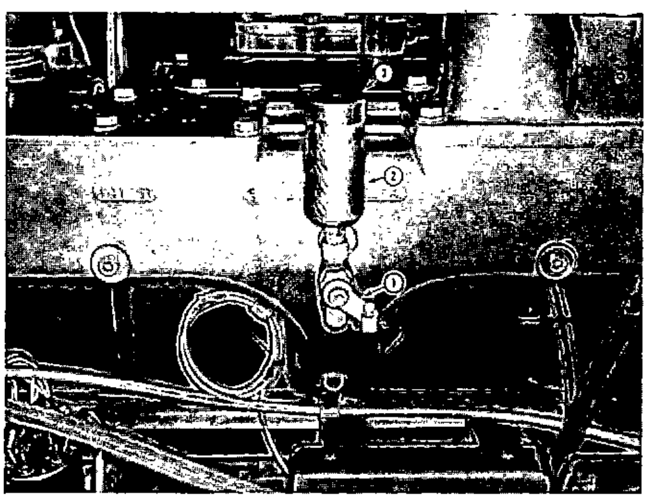


Fig. 2-5, N11841. Ether compound metering equipment

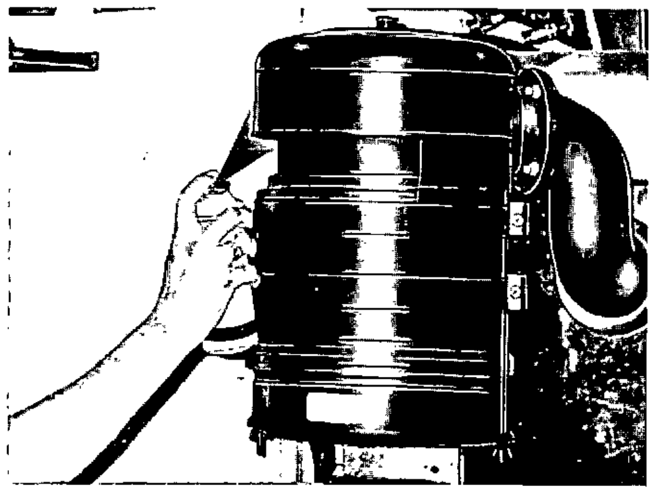


Fig. 2-6, N11807. Ether spray application

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.

Spray ether into air cleaner intake while second man cranks the engine. Fig. 2-6.

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.

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

Engine Warm-Up

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

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

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 or motored by power generator, 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 Tables 1, 2, 3 and 4 are for engines rated at maximum rpm and fuel rate; many engines, such as generator sets, see Table 5, are set at other values due to equipment being powered or loads applied to equipment and engine.

Operate At Reduced RPM For Continuous-Duty Or Cruising

When operating the engine in a continuous-duty situation and engine is rated at maximum horsepower and rpm such as cruising on a level highway or powering a boat, etc., maintain engine rpm at approximately 85 percent of rated rpm. See Table 2-1. This will give adequate power as well as economical fuel consumption.

Engine governors are normally set for reduced rpm, or the fuel pump at reduced fuel rate, for continuous-duty operation. If engine is applied under these conditions constantly, see later paragraphs.

Idle Speeds

In most applications engine idle speeds are 580 to 620 rpm; however, the parasitic load may require a slightly higher value to smooth out operation.

Note: Turbocharged engines should idle three (3) minutes minimum before load is applied to make sure turbocharger is getting lubrication.

Instrument Panels

Operate By The Instruments

It makes no difference whether an engine is in a truck, in a boat or on some other type of operation; the operator must use the panel board instruments. Fig. 2-7. 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 down-grades or any other condition in which the load drives the engine.

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 [82.2 deg. C] and 225 deg. F [115.6 deg. C] for best lubrication. Under full-load conditions, a temperature of 265 deg. F [129.4 deg. C] for a short period is not to be considered cause for alarm.

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

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

Water Temperature

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

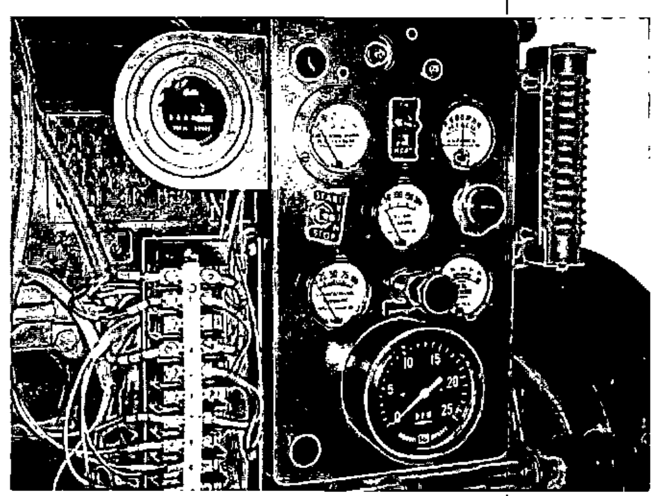


Fig. 2-7. N11843. Instrument panel

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 heat exchanger, or insufficient radiator capacity. Report cases of overheating to the maintenance department for correction; 200 deg F [93.3 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 [73.9 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 are:

At Idle . . . . . 5 To 20 psi [0.352 To 1.7575 kg/sq cm]
At Rated Speed . 30 To 70 psi [2.1092 To 4.921 kg/sq cm]

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 to comply with Federal Regulations pertaining to smoke emission.

Federal Smoke Emission Certification

Beginning January 1, 1970 all new Cummins Engines for use in automotive applications are, in all material respects, substantially the same as test engines certified by the U.S. Department of Health, Education and Welfare as conforming to Federal Regulations pertaining to exhaust smoke emission. 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 you to 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 the engine as near the 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.

High-Altitude Operation

Engines lose horsepower when operated at high altitude because the air is to thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.800 m] altitude above sea level for a naturally aspirated engine. (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 smokey exhaust at high altitude unless a lower gear is used so the engine will not demand full-fuel from the fuel system. Smoke wastes fuel, burns valves and exhaust manifolds, and "carbons up" piston rings and injector spray holes. Shift gears as needed to avoid smoking.

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 mush as 100 deg F

[46.6 deg C]. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine For Excessively Long Periods

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

If engine coolant temperature becomes too low, raw fuel will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

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

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 over-ride button on shut-down valve has been locked in open position. If manual over-ride on electric shut-down valve is being used, turn button full counterclockwise to stop engine. Refer to "Normal Starting Procedure", Page 2-2. Valve cannot be reopened by switch key until after engine comes to complete stop.

Caution: Never leave switch key or over-ride 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 Page 3-4.

2. To drain cylinder block and head on an 855 Series engine, open petcock in thermostat housing and remove drain plug in rear of oil cooler cover or at rear of block, Fig. 2-8. 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. 2-9.

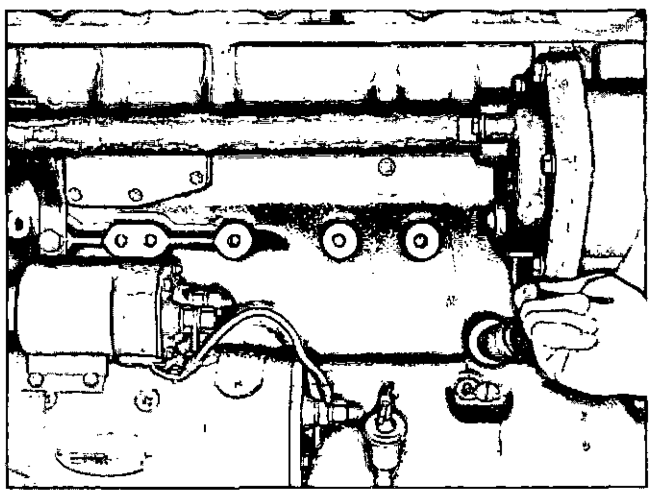


Fig. 2-8. N100124. 855 Cylinder Block Drain Point

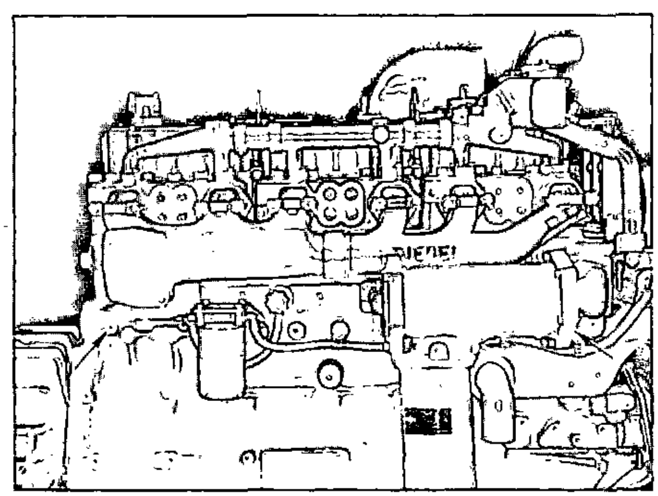


Fig. 2-9. N100126. 927 Engine drain points

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 alotted 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.

Automotive Applications

Engine break-in, before starting and general operational procedures for automotive applications follow that previously described. Additional items, applying to automotive applications only, follow.

Apply Load Gradually

Always engage the load in a gear low enough to prevent slipping the clutch and racing engine above 800 rpm. Shift up as the engine reaches rated speed. Do not skip gears. Shock loads take their toll of tires and transmission as well as being hard on the engines. Apply load gradually.

Operate At Reduced RPM For Cruising

When operating a truck on a level highway, or cruising, hold engine rpm at approximately 90 percent (80 percent for Custom- Torque Engines) of governed rpm. See Table 2-2. This will give adequate power for cruising and economical fuel mileage.

Most 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 cruise in high gear and at reduced engine rpm. This is good practice as long as the engine pulls its load at partial throttle.

Table 2-2: Automotive Engine Speeds

Engine Model	Rated RPM	Cruising RPM
All	1950	1800-1900
All (except CT)	2100	1900-2000
NHCT-270-CT	2100	1600-2000
All	2300	1950-2100

Use The Tachometer

Governed engine speed is the maximum rpm which a properly adjusted governor will allow the engine to turn under full-load.

Never over-ride the governor or allow engine to exceed the governed rating while out of gear, operating at partial load, or driving downhill.

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 you shifted 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.

If you are on a steep grade, you would need to start your down-shift before the engine actually pulls down to shifting speed, because the truck will lose speed while you are shifting.

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 the 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.

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

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

2. The engine will not idle if the SVS lever is in power take-off speed position and the 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; then 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 can 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. The SVS governor should not be used with power take-off speeds lower than 1100 rmp. These applications require use of the MVS governor described in Section 1.

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.

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.

Operating A Vehicle With Jacobs Compression Brake

In order to retard a vehicle on a downgrade using the Jacobs Compression Brake, and if the engine speed exceeds maximum rated R.P.M. for a desired road speed, a lower gear should be selected. The selection of a lower gear will generally allow complete control of the vehicle by the Jacobs Compression Brake, leaving the vehicle service brakes in reserve to be used for emergency stops.

Energizing the Engine Brake effectively converts a power producing diesel engine into a power absorbing air compressor. This is accomplished when desired by motion transfer through a master-slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke releasing the compressed cylinder charge to exhaust.

The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the power stroke, the effect being a net energy loss since the work done in compressing the cylinder charge is not returned during the expansion process.

Exhaust Brakes

The only exception to recommended maximum back pressure is the high back pressure that it is permissible to impose on an engine to cause it to absorb the kinetic energy generated by the movement of the vehicle for which it supplies motive power; with this arrangement, the engine can be used as a substitute for service brakes to avoid wear created by long or frequent brake operation. Impedance to flow of exhaust gas is controlled by a valve located downstream from the manifold on naturally aspirated engines and on the downstream side of turbocharger on turbocharged engines, which creates a back pressure against which piston must operate during exhaust stroke. The work thus expended by piston is used to retard rotation of crankshaft, and hence results in retarding the vehicle.

Caution: Maximum exhaust back pressure under any operating condition is 45 psi (with exhaust brakes).

Use Brake As Needed To Prevent Excessive Engine Speeds

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

Dual Diesel Operation

Engine Operation On The Road

1. The four-way valve must be positioned in "UP", or in full engine run position. Some valves may be mounted so "UP" is not run position.

2. When parking brake is in run position, air pressure is allowed to pass through the valve, thereby releasing parking brake and activating governor air cylinder. This action locates MVS governor lever in a position which gives the automotive governor complete control of engine rpm.

3. On derated engines, operation as an air compressor may require a higher rpm than engine high idle. In this application the MVS governor will control both engine high idle and compressor operating speed.

Engine Operating As Air Compressor

The unit should first be operated as full-rated diesel engine until water and oil are at operating temperatures.

1. With unit on delivery site, apply the parking brake.

2. Floor-board accelerator, pull hand throttle out and lock at high-idle.

3. Connect product hose to customer's pipe and trailer outlet.

4. Close product valves. Fully open assist and blow-down valves.

5. Remove dust cap and connect air supply hose. Fig. 2-10.

Note: Handle cap carefully to prevent damage to stem (if so equipped) which seats valve during on the road operation.

6. Place cab dash control in "DOWN" (Compressor) position; engine is now operating as compressor. Fig. 2-11. If air from blow-down valve contains smoke after one minute of operation, check fuel line valves to compressor cylinders to make sure they are operating correctly.

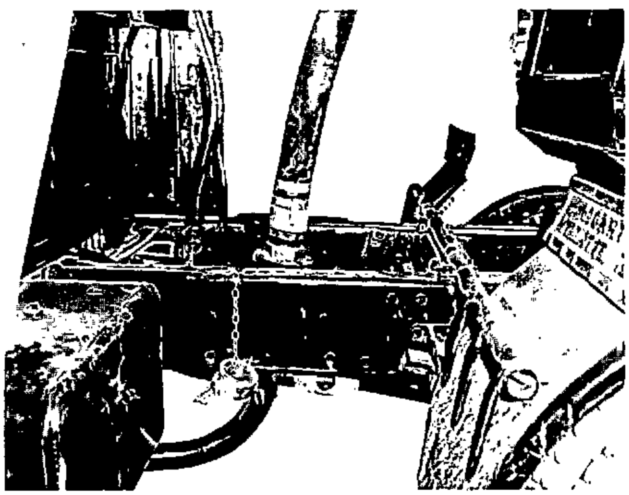


Fig. 2-10, N11832. Compressed - air line connected to trailer

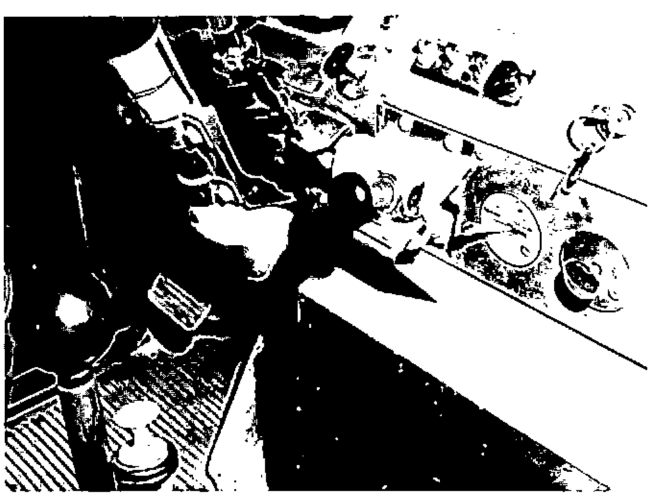


Fig. 2-11, N11833. Dash control in down position

7. Close blow-down valve. If air pressure is lower than normal, check the exhaust control valve in the exhaust piping; it may not be closed completely. Also, check for leaks on the trailer air system.

8. Proceed with normal unloading procedure according to the type of trailer.

9. IMPORTANT – After 60 minutes of operation as compressor, return to full diesel engine operation by:

a. Closing product valve.

b. Placing cab dash control in "UP" (Engine) position.

10. Operate at high idle as a full diesel for 3 minutes, then return to compressor operation to complete unloading.

Cautions:

1. Never attempt to install air outlet dust cap when engine is operating as compressor; if done, engine would be pumping against a "dead head."

2. Be sure dust cap is removed and trailer hose is connected before operating engine as a compressor.

3. Never move dash control to down position while in transit; this automatically applies all brakes.

4. Prolonged pumping of air against a dead head can cause engine coolant temperatures to rise above recommended maximum of 200 deg F [93.3 deg C].

11. When converting back to full engine operation, it is normal for engine to "hesitate" for a few seconds before regaining power on all cylinders.

Adjustment Of Pumping Pressure And Temperature Check

Air flow (CFM) is primarily a function of engine speed (RPM) although the volume is affected by the pressure head. The pressure head or pumping pressure is regulated by hand control valves on product-carrying vessel. Since maximum pressure allowable at any particular engine speed is determined by maximum fuel rate of two engine driving cylinders, it is very important that the MVS governor be set so no overfueling can result. To accomplish this, the following procedures are required:

1. Determine maximum pressure required; in most cases this must be obtained from the customer. An allowance of 2 psi [0.1406 kg/sq cm], to provide for line losses, must be made between customer's gauge on vessel and pressure at pumping cylinders discharge. For example, customer requires 15 psi [1.0545 kg/sq cm] at tank, engine must actually work against a 17 psi [1.1951 kg/sq cm] head.

2. Once pressure is determined, refer to Fig. 2-12 (NH-250) for maximum engine speed required. For example, the NH-250, a maximum pumping speed of 2050 RPM can be used to obtain about 268 CFM. If less flow is desired than maximum obtainable at any particular pressure as determined by maximum fuel rate, engine speed may be adjusted to obtain this flow. Greater pressures are allowed with reduced engine speeds up to a maximum of 30 psi [2.1090 kg/sq cm].

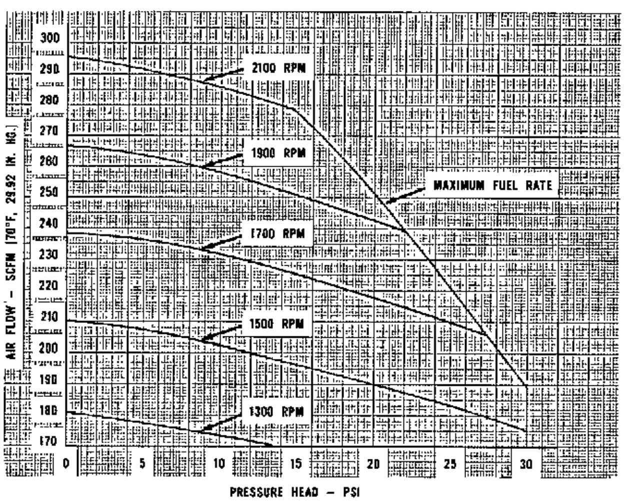


Fig. 2-12, N11838. Air flow - NH-250 engine

3. To set MVS governor:

a. Place ST-1167 Pressure Adapter Tool (1, Fig. 2-13) on discharge pipe and connect a pressure gauge (3), pyrometer (4) and temperature thermocouple.

b. Start engine and operate as if pumping.

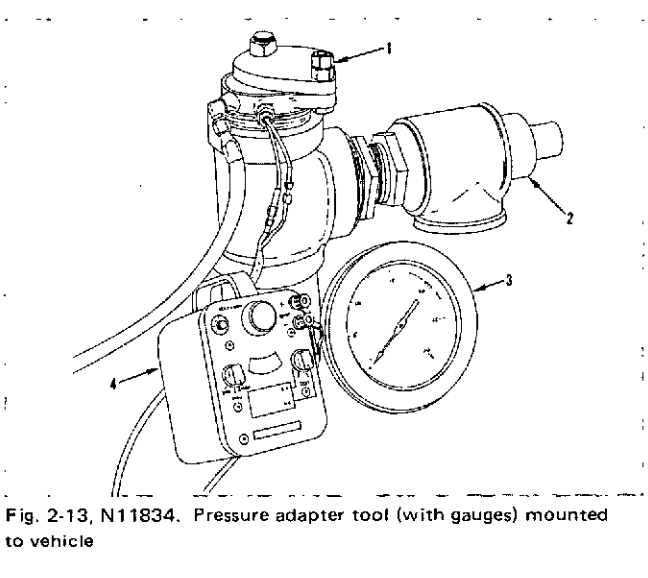


Fig. 2-13, N11834. Pressure adapter tool (with gauges) mounted to vehicle

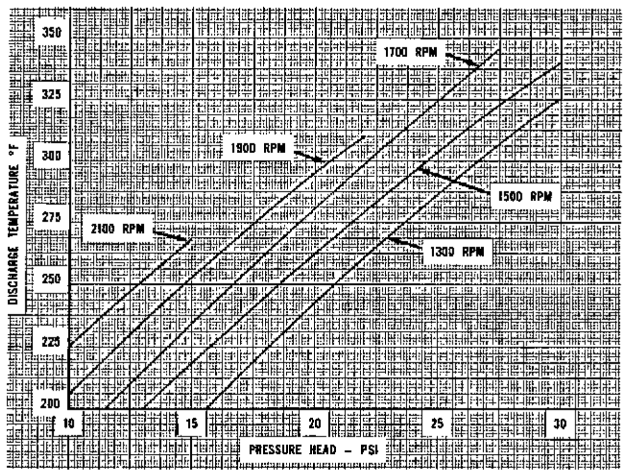


Fig. 2-14, N11840. Air discharge temperature — NH-250 Engine

c. Adjust MVS governor for engine speed and adapter tool for pressure head. It may take several adjustments of each to balance system to desired values.

d. Check discharge temperature to be certain it is within an acceptable range. Fig. 2-14 (NH-250) shows temperature values for various pressures and engine speeds. If values obtained are excessive, fuel inlet valve is not properly seated and is allowing some fuel to be burned.

e. Stop engine, remove adapter tool and replace cap on air discharge line after settings are accomplished.

Trouble Shooting

The following trouble shooting checks pertain only to Dual Diesel Engines. For other engine trouble shooting checks, refer to Page 4-1.

Engine Fails To Return To Full Engine Operation

1. Check fuel inlet valve-to-compressor cylinders if low on power.

2. Check fuel outlet valve if exhaust is smoky or engine speed fails to stabilize at idle.

3. Check exhaust control valve, it may be stuck in closed position.

Compressor Pump-Up Time Exceeds 4 Minutes

Note: This limit will vary due to trailer design, type of load, etc. Therefore, past experience with same equipment should be used as a guide line.

1. Exhaust control valve not adjusted to close completely.

2. Exhaust control valve held open by carbon deposits.

3. Bracket holding exhaust control valve air cylinder flexing, causing valve to stay partially open.

4. Pressure relief valve incorrectly adjusted. This valve must be set while engine is pumping compressed air, not statically because the pressure fluctuations can cause some popping-off during compressor operations.

5. Exhaust system leaks.

6. Trailer leaks.

7. Engine RPM slow.

Check-Valve Burned Or Excessive Temperature In Pumping Lines

1. Inlet fuel valve leakage causing some combustion in pumping cylinders.

Note: During initial installation and at other times as necessary use the pressure adapter tool to measure pumping temperature and pressure.

2. During operation as a diesel; check-valve cap may not be installed.

Check-Valve Worn Excessively

Due to flutter or bouncing during non-pumping operations. The hold-down spring or stem screw may require replacing.

Product Contaminated

Fuel, oil or water leaking into the pumping cylinders.

Injector Plungers Scored Or Sticking

Injectors not receiving proper lubrication. If fuel drain valve leaks, it will bleed off the lubricating fuel.

Caution: Do not exceed one hour pumping time before lubricating injectors for three minutes under full diesel engine operation or injectors may be damaged or scored from running dry.

Engine Decelerates Slowly Under Full Diesel Operation

Fuel drain valve may be stuck shut or not fully open.

Product Difficult To Pump Off With All Adjustments Correct

1. Light granular products are more difficult to move than powdery items.

2. Long horizontal distances make pumping operations more difficult.

Generator Set Applications

For complete installation, operation and maintenance instructions covering generator sets, refer to Cummins Static Generator Sets, Bulletin No. 983600, or Cummins Brushless Generator Sets, Bulletin No. 983679.

Marine Applications

For complete operation and maintenance instructions covering Cummins 855 Series Marine Diesel Engines refer to Bulletin No. 983624.

Industrial Engine Applications

Engine break-in, prestarting checks and operation follow "General Operating Instructions" and include the additional specific instructions listed below.

Prestarting Checks

1. Check torque converter (if used) oil level; maintain oil level as near as possible to "H" (high-level) mark on dipstick. Fill converter with grade and weight of oil listed on torque converter specification plate.

2. On stationary units check for proper alignment of engine to driven unit.

Operation

1. Observe torque converter temperature gauge (operating range is 180 to 230 deg F [82.2 to 107.1 deg C]). Temperature should not be allowed to exceed 250 deg F [121.1 deg C].

2. Observe torque converter oil pressure gauge. Operate with pressure as specified by converter manufacturer listed on converter specification plate.

Hydraulic Governor Applications With SVS Governor PT (Type G) Fuel Pump

1. The SVS governor is used in combination with hydraulic governors in industrial installations to bring engine speed down from rated rpm, where it is normally maintained by the hydraulic governor, for engine warm-up.

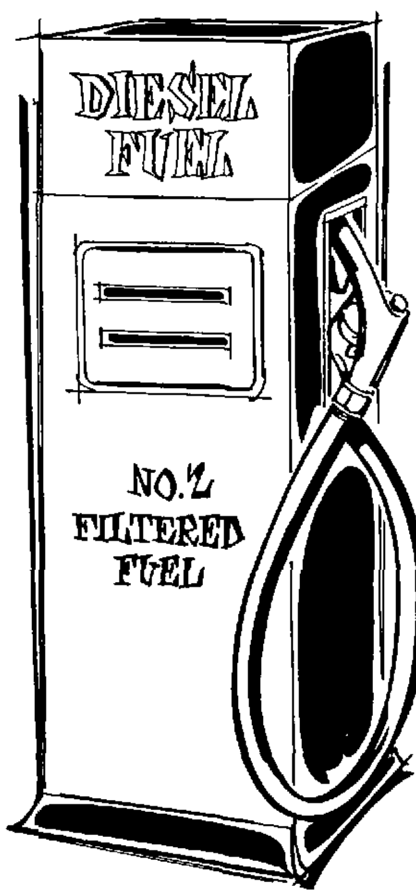
2. Idle speed or warm-up should be set at 1000 rpm or above with the SVS governor.

Specifications

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.

Fuel Oil Specifications

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. F. or 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.)
Cloud 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.

Lubricating Oil 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 Industrial Engines" listing commercially available brand name lubricants in accordance with their ability to meet these performance specifications is available at a price of $1.25 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.

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.

Table 1: Cummins Minimum Oil Recommendations

Light Service Stop-and-go	**General-Medium and High Load Factor Service**	
All Models	**Naturally Aspirated**	**Turbocharged**
API class CC/SC*	API Class CC	API Class CC/CD
Ash Content 1.85% Max.	Ash Content 1.85% Max.	Ash Content 1.85% Max.

***Note:** SD or SE may be substituted for SC.

1. API classification CC/SC and API classification CC/CD indicate that the oil must be blended to the quality level required by both specifications.

2. API classification CC/CD quality oils used in turbocharged engines are satisfactory for use in naturally aspirated engines.

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.

Table 2: Operating Temperatures Vs Viscosity

Ambient Temperatures	**Viscosity**
−10 deg F. [−23 deg C] and below	See Table 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

Multigraded lubricating oils can be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limit shown in Table 1.

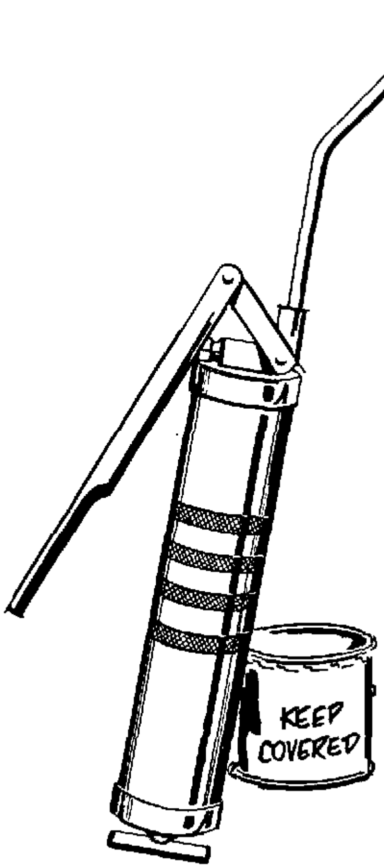
Arctic Operations

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. 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-20295-A, which is void, and SAE 5W oils should not be used.

Table 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-445)	At least 10 deg F. [6 deg C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum

Grease Specifications



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 your 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.

Oil Lubricated

Fan hubs utilizing tapered roller bearings can be lubricated with SAE 30 engine lubricating oil.

Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow grease to be thrown out, due to rotative speed.

Coolant Specifications

Water should be clean and free of any corrosive chemicals such as chlorides, 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.

Install and/or 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. In addition, a sacrificial metal plate arrests pitting of metals in the system by electro-chemical action. The resistor is available from any Cummins Distributor or Dealer. See Table 3-4.

Table 3-4: Corrosion Resistor Elements

Part No. Cummins	Fleetguard	Type	No. of Elements	Cooling System Capacity
171645	WF1004	Package	1	10 US gallon
132732	WF1001	Package	1	15 US gallon
132732	WF1001	Package	2	30 US gallon
132732	WF1001	Package	4	30 US gallon and over
209604	WF1010	Spin-On	1	15 US gallon
209605	WF1012	Spin-On	1	30 US gallon
209605	WF1012	Spin-On	2	30 US gallon and over

In Summer (No Antifreeze)

1. Use only corrosion resistor with chromate or chromate element.

2. Replace corrosion resistor element(s) as recommended in Section 5.

In Winter (Using Antifreeze)

1. Select an antifreeze known to be satisfactory for use with chromate element of the corrosion resistor, as stated under "In Summer (No Antifreeze) 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.

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." If there has been a loss of corrosion control, change antifreeze.

Caution: Never use soluble oil in the cooling system when a Corrosion Resistor is being used.

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.

Coolant must be maintained at the following minimum:

Chromate Concentration – $Na_2 CRO_4$ – 3500 PPM

pH Value – 8 to 9.5

Alkalinity – 1500 PPM $CaCO_3$
(Methyl Orange Indicator)

Note: Materials to perform the methyl orange test may be procured from pretreatment compound supplier or a chemical supply house. Consult compound supplier or chemical supply house regarding use and interpretation of results. The coolant color will influence the reliability of this test.

Chemicals for pretreating coolant may be purchased from the following sources or any other sources which provides the preceding treatment values:

Formula 2389 from:
Bird-Archer Co.
4337 North American St.
Philadelphia, Pennsylvania 19104

Dearborn Compound No. 530 (granular) or 517 (powder) from:

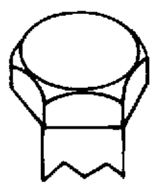
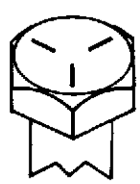
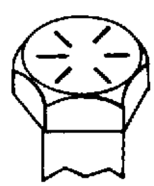
Dearborn Chemical Company
14230 Ridge Road
Plymouth, Michigan 48170

NALCO No. 38 (pellet) or 37 (powder) from:

National Aluminate Corp.
6216 West 66th Place
Chicago, Illinois 60607

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

Standard Capscrew Markings And Torque Specifications

Usage	**Much Used**	**Much Used**	**Used at Times**	**Used at Times**
Capscrew Diameter and Minimum Tensile Strength psi	**To 1/2 – 69,000** **To 3/4 – 64,000** **To 1 – 55,000**	**To 3/4 – 120,000** **To 1 – 115,000**	**To 5/8 – 140,000** **To 3/4 – 133,000**	**150,000**
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 [0.6915]	8 [1.1064]	10 [1.3830]	12 [1.6596]
– 28	6 [0.8298]	10 [1.3830]		14 [1.9362]
5/16 – 18	11 [1.5213]	17 [2.3511]	19 [2.6277]	24 [3.3192]
– 24	13 [1.7979]	19 [2.6277]		27 [3.7341]
3/8 – 16	18 [2.4894]	31 [4.2873]	34 [4.7022]	44 [6.0852]
– 24	20 [2.7660]	35 [4.8405]		49 [6.7767]
7/16 – 14	28 [3.8132]	49 [6.7767]	55 [7.6065]	70 [9.6810]
– 20	30 [4.1490]	55 [7.6065]		78 [10.7874]
1/2 – 13	39 [5.3937]	75 [10.3725]	85 [11.7555]	105 [14.5215]
– 20	41 [5.6703]	85 [11.7555]		120 [16.5960]
9/16 – 12	51 [7.0533]	110 [15.2130]	120 [16.5960]	155 [21.4365]
– 18	55 [7.6065]	120 [16.5960]		170 [23.5110]
5/8 – 11	83 [11.4789]	150 [20.7450]	167 [23.0961]	210 [29.0430]
– 18	95 [13.1385]	170 [23.5110]		240 [33.1920]
3/4 – 10	105 [14.5215]	270 [37.3410]	280 [38.7240]	375 [51.8625]
– 16	115 [15.9045]	295 [40.7985]		420 [58.0860]
7/8 – 9	160 [22.1280]	395 [54.6285]	440 [60.8520]	605 [83.6715]
– 14	175 [24.2025]	435 [60.1605]		675 [93.3525]
1 – 8	235 [32.5005]	590 [81.5970]	660 [91.2780]	910 [125.8530]
– 14	250 [34.5750]	660 [91.2780]		990 [136.9170]

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 or procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart 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 relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

Trouble Shooting

System	CAUSES / COMPLAINTS	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		●	●	●	●			●															●			

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 for repair.

Investigate any successful operation where engines are used and you will find a good, regularly scheduled, maintenance program in effect.

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 do work in the shop on schedule, rather than on the job under poor working conditions and 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 enviornment of the engine must govern the 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. A look at the suggested check sheet, on the following page, indicates some checks may have to be performed more often under heavy dust or other special conditions. The schedule is also dependent upon the amount of work being done which can best be determined by the amount of fuel being burned. A record of gallons of fuel used is the best yardstick to be used in establishing an accurate regular maintenance schedule.

Hours of operation may be used for the same purpose; in so doing you should determine the amount of fuel used per hour during normal operation. For example, if the average fuel consumption of an engine is five to six gal [22.710 lit or 4.996 U.K. gal] per hour, the "B" Check would be made every 1600 to 1850 gal [6056.000 lit or 1332.272 U.K. gal to 7002.250 lit or 1539.4495 U.K. gal] of fuel or *approximately every 250 hours of operation.*

Miles traveled also should be set up on the basis of miles per gallon of fuel used; after this is established, miles traveled record can be used in setting up the maintenance schedule. For example, if the average fuel consumption of an engine is 6 mi [9.654 km] per gallon, the "B" Check would be made every 8000 mi. [12,872.000 km]. The figure 8000 would then be inserted for the "B" Check, 48,000 for the "C" Check, etc. See Table 5-1.

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 5-8.

Using The Suggested Schedule Check Sheet

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

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for gallons of fuel used, hours of operation and miles driven.

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

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

Maintenance Schedule

Check Sheet

EQUIPMENT NO. ______
MECHANIC ______
TIME SPENT ______
PARTS ORDER NO. ______

ENGINE SERIAL NO. ______
MILEAGE, HOURS, GALLONS ______
CHECK PERFORMED ______
DATE ______

Notes:

1. The AC Check indicates those maintenance checks which should be performed at a more frequent interval when the engine operates under adverse conditions.
2. This schedule is based on the use of a full-flow oil filter only. If a by-pass filter is used, extend oil change period by 50% (8,000 to 12,000, etc.).

See Table 5-1, Page 5-3, For Suggested Maintenance Intervals

Check (✓) In Blank Space, Under Appropriate Interval, Each Operation As Performed	A	AC	B	C	D	E
Full Instructions Begin On Page	5-4	5-7	5-8	5-24	5-30	5-32
Check Operator's Report						
Check Leaks And Correct						
Check Engine Oil Level						
Check Converter Oil Level						
Lubricate PTO Bearing						
Check/Refill Coolant Level						
Drain Fuel Tanks; Clean Breather						
Fill Fuel Tanks						
Drain Sediment						
Drain Air Tanks						
Check Oil Bath Air Cleaner Oil Level						
Clean Pre-Cleaner And Dust Pan						
Change Engine Oil						
Change Hydraulic Governor Oil						
Change Engine Oil Filter (Full-Flow)						
Change By-Pass Oil Filter						
Record Oil Pressure						
Lubricate Electrical Equipment						
Change Fuel Filter; Check Fuel Restriction						
Check Air Piping						
Check Air Cleaner Restriction Gauge						
Clean/Change Dry-Type/Composite Cleaner Element						
Replace Cartridge-Type Cleaner Element						
Change Oil Bath Cleaner Oil; Clean Tray Screen						
Clean/Change Crankcase Breather Element						
Clean Radiator Core (Externally)						
Check Throttle Linkage						
Check Fuel Pump Seals						
Check Engine Coolant/Change Resistor Element						
Check/Adjust Drive Belt Tension						
Steam Clean Engine						
Adjust Injectors And Valves						
Clean Complete Oil Bath Air Cleaner						
Check Turbocharger For Leaks						
Check Alternator/Generator/Cranking Motor						
Check Vibration Damper Alignment						
(Every 2nd "C" Check) Lubricate Water Pump And Fan Hub						
Clean Fuel Pump Screen And Magnet						
Check Fuel Manifold Pressure						
Clean And Calibrate Injectors						
Check Fuel Pump Calibration						
Clean And Check Turbocharger						
Tighten Manifold/Turbo. Mtg. Capscrews						
Inspect/Install Rebuilt Units As Necessary						
Inspect Bearings						
Rebuild Cylinder Heads						
Replace Cylinder Liner Seals						
Replace Piston Rings						
Replace Vibration Damper						
Replace Front And Rear Crankshaft Seals						
Inspect Cylinder Liners						
Inspect Pistons						
Inspect Crankshaft Journals						
Clean Oil Cooler						

Full Instructions For The Following Begin On Page 5-33.

Operation	Interval		
Change Converter Oil And Filter	See Manufacturer's Recommendations		
Check Fan And Drive Pulley Mounting	Spring And Fall		
Clean Cooling System	Spring And Fall		
Check Hose; Replace As Necessary	Spring And Fall		
Clean Electrical Connections	Spring And Fall		
Check Thermal Controls	Fall		
Check Cold-Starting Aid	Fall		
Check Engine Blow-By	As Required		
Tighten Mtg. Bolts And Nuts	As Required		
Check And Adjust Clutch	As Required		
Check Crankshaft End Clearance	At Clutch Adjustment		

Maintenance Operations Summary Sheet

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

Maintenance — Standby Service Engines

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

1. Monthly, perform "A" Checks.
2. Every 3 months, perform "B" Checks.
3. Every 6 months, perform "C" Checks.
4. Yearly, perform "D" Checks.

Lubricating oil standing in engines that are used infrequently or are in storage between seasons may tend to oxidize and require changing even though it is not dirty. Laboratory testing is the best way to determine whether oil or fuel is oxidizing under these conditions; we suggest that oil be checked regularly. After several tests it will be possible to schedule oil changes where the oil is not actually being contaminated due to dirt.

Units in standby service should be started once each week in locations where ambient temperature remains below 70 deg F [21.1 deg C] and contains a high percentage of humidity. Start engine, bring unit up to normal operating temperature and run for approximately thirty minutes. Check electrical equipment for corrosion on all relays and switch terminals. Check controls for leaks and proper operation.

On units in locations where ambient temperature is normally above 70 deg F [21.1 deg C], perform starting procedures as above once every two weeks.

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

Table 5-1: Suggested Base Maintenance Intervals

INTERVAL	A	AC	B	C	D	E
HOURS OPERATION	Daily	See	250	1,600	4,800	8,000
MILES OPERATION	Daily	Note 1	8,000	48,000	144,000	240,000
U.S. GALLONS FUEL USED						
Naturally Aspirated	Daily	See	1,600	9,600	28,800	48,000
Turbocharged	Daily	Note 1	1,850	11,200	33,600	56,000
CALENDAR	Daily		3 Months	1 Year	3 Years	5 Years

Notes:
1. "AC" intervals apply to engines operating under adverse conditions only.
2. *If a Cummins Fleetguard by-pass filter is used, the oil change and filter change periods may be extended by* 50% (8,000 to 12,000 miles, etc.).
3. Maintenance periods should be established on the operating basis fitting operating conditions, or whichever interval occurs first (500 hours if it occurs before 3 months, etc.). Under normal conditions the calendar interval basis only used when operation is less than 3000 miles or 100 hours per month.
4. The safest and most economical method for determining the oil change period is by lubricating oil analysis. See Page 5-8.

'A' Maintenance Checks

Check Operator's Report (A Check)

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.

Check Leaks And Correct (A Check)

Lubricating Oil

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. See that they are tightened securely. Fig. 5-1.

Fuel Oil

1. Check for evidence of fuel leakage.

a. Check fuel pump and filter.

b. Check fuel suction line and connections at fuel tank, fuel filter and fuel pump.

c. Check fuel inlet line and connections at fuel pump shut-down valve.

d. Check all fuel supply and drain lines, connections and fittings on cylinder heads.

e. Check fuel lines between engine and fuel tank(s).

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. 5-2) in the line between fuel filter(s) and pump. Bubbles over 1/2 inch [12.70 mm] long or "milky" appearance indicates an air leak. Find and correct.

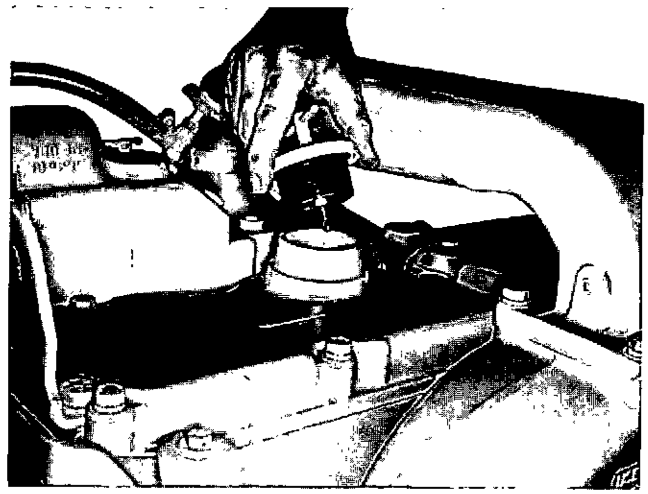


Fig. 5-1, N12011. Lubricating oil filler tube

Coolant

Check for evidence of external coolant leakage. Tighten capscrews, hose clamps, fittings and connections, or replace gaskets or hose as necessary to correct.

Air Connections

Visually check air system connections for leaks or damage while making other visual checks.

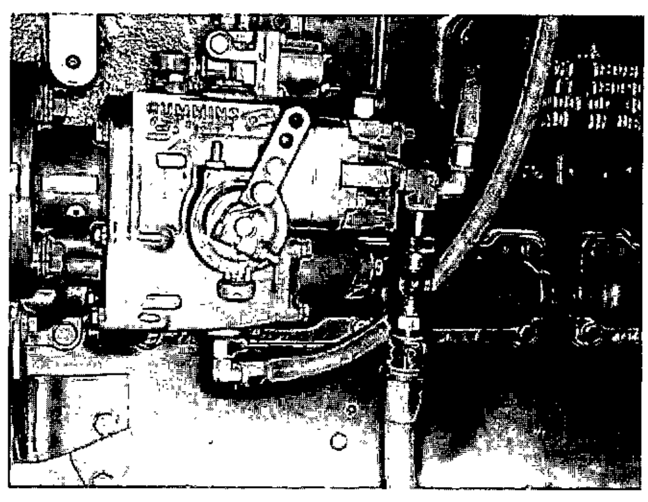


Fig. 5-2. N11964. Checking air leaks with ST-998 Sight Gauge

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

Valves and piston rings must seal properly against *compression and combustion pressures.*

The amount of fuel that can be burned and power developed is as dependent upon air as fuel. If there is too little air to burn all the fuel, the excess fuel causes a smoky exhaust — high exhaust temperatures and a loss of horsepower. Wasted fuel is not the only loss caused by incomplete combustion. The excess fuel washes lubricating oil off cylinder walls, resulting in seized pistons and bearing failures. Carboned injector cup spray holes and stuck piston rings are other troubles which result from insufficient air. Dirty air cleaner elements, leaky valves, worn rings, damaged silencers and air piping that is too small or with sharp bends are common causes of air restriction.

When engines operate under extremely dusty conditions, adjust the maintenance intervals to those in the "AC" column of check sheet on Page 5-2.

Engine Oil Level (A Check)

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 Page 3-2.

Lubricating Oil Performs Four Functions In An Engine:

1. *Reduces friction (heat and wear) by providing a film* between bearing surfaces.

2. Scavenges by picking up carbon and other small particles, carrying them to the oil filter where they are taken out of circulation.

3. Cools pistons, liners and bearings and absorbs heat from the engine. This heat is then dissipated by radiation from the pan and by an oil cooler. It is important that air be free to flow around the oil pan.

4. Completes the seal of rings to pistons and cylinder walls.

There Are Two Broad Classes Of Lubrication Failures:

1. Those caused by running an engine without or low on oil, resulting in seizures of pistons or bearings within minutes.

2. Failures due to poor or marginal lubricating, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

Check Hydraulic Governor Oil Level (A Check)

If the engine has a hydraulic governor, use clean lubricating oil of the same grade as used in the engine in the governor sump.

Keep level half-way up on the inspection glass or to high level mark on dipstick oil gauge.

Check Converter Oil Level (A Check)

Different models of vehicles may vary in the manner in which oil level check is made — it may be made with a dipstick, a level plug or a petcock. Oil level should be maintained at full. If needed, add oil according to oil specifications on nameplate.

1. Cold Check

The cold check (engine not running) insures that there is sufficient oil in the system to start the engine — especially if equipment has been standing idle for a long period of time. Be sure oil is at high level.

2. Hot Check

The hot check should be made at operating temperature, with the engine running from 600 to 1000 rpm and with the transmission in neutral range.

3. If the converter is operating in combination with a Torqmatic transmission, the oil level check is made at the transmission.

Lubricate Power Take-Off And Clutch Throw-Out Bearing (A Check)

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.

Manual Spring-Loaded Input Disconnect Clutch

Approximately once a week, lubricate the release bearings with two "shots" from a grease gun using grease described above. Two grease fittings are usually provided atop the clutch housing.

Check Coolant Level (A Check)

Keep cooling system filled to operating level. Check coolant level daily or at each fuel fill point. Invertigate for causes of coolant loss. Recheck the level after engine reaches normal operation temperature. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets. Recommended coolant requirements are described on Page 3-4.

Many operators have been shocked to find water in crankcase and to learn it got there through "pin holes" or pitted areas that started on water side of cylinder liners.

Corrosion may not be associated with iron rust, and as a result may not show up in the coolant. Research has shown there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained corrosion resistor.

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

An open (non-baffled) radiator top tank is often the cause of air entering the system. Due to high velocity of coolant entering top tank, the surface becomes very agitated and tends to draw air into core tubes along with coolant. It is every difficult on many units to completely fill cooling system at initial fill; this is due to trapping of air in pockets in engine or other parts of the system. The system should be bled of air or refilled after a short period of operation to purge air from the coolant. The system should be purged of air by opening vent valve atop thermostat housing. Continue to add coolant until no air is expelled from vent.

Fill Cooling System (A Check)

Keep cooling system completely filled. Check coolant level daily before starting engine. Recheck after engine cools. Do not check coolant on a hot engine unless no pressure valve is in the system, except in an emergency.

Check pressure valve at each "E" Check to prevent coolant loss through overflow. Investigate an excessive loss of coolant.

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

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

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

Fill Fuel Tanks (A Check)

Always filter or strain fuel before or while putting it in tank. See "Fuel Oil Specifications," Section 3. This will lengthen the life of the engine fuel filter and reduce the chance of dirt getting into the fuel pump.

In cold weather, water which accumulates 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. [189.250 lit or 41.6335 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.

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

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

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

Drain Sediment From Fuel Filter (A Check)

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.

Drain Air Tank(s) (A Check)

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

'AC' Maintenance Checks

The maintenance checks listed under the "AC" column of the check sheet are those which must be performed at more frequent intervals than the regular "B" Maintenance Checks, when the engine is operating under adverse conditions. The frequency of the intervals is dependent upon actual operating conditions and will vary with the intensity of dust, dirt or adverse weather conditions. Applications normally considered to be dusty are dry cement haulers, construction, mining, etc.

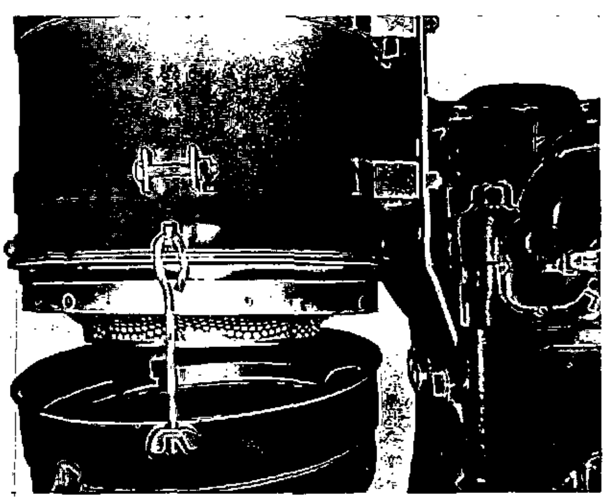
If the above conditions apply to engines being maintained, we suggest that a local Cummins Distributor be contacted in establishing a maintenance schedule for a particular operation. The "AC" Check may have to be performed at each shift or sooner.

Detailed instructions for performing the remaining "AC" Checks are described as a part of the "B" Maintenance Checks, since this is the interval at which these checks are performed under normal working conditions.

Check Oil Bath Cleaner Oil Level (AC Check)

Perform at A Check under adverse conditions

Daily, check oil level, Fig. 5-3, 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. This is especially important if oil bath cleaner is the only cleaner on the engine.



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

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

Clean Pre-Cleaner And Dust Pan (Less Ejection Valve) (AC Check)

Perform at A Check or sooner under adverse conditions

On engines working under extremely dirty conditions an air pre-cleaner may be used. Clean pre-cleaner jar and dry-type air cleaner dust pans daily or more often as necessary depending on operating conditions.

'B' Maintenance Checks

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

Change Engine Oil (B Check)

Perform at AC Check under extremely dusty conditions

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 on Page 3-2, and using oil analysis with filter restriction measurement, indicate that a naturally aspirated on-highway truck may have the oil change period extended as much as 50% under closely controlled conditions. This indicates the economy that can be obtained through a good maintenance program.

It is suggested that oil change periods be set up on schedule indicated in Table 5-2, 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 5-2, is for average conditions and closely follows that indicated as "Full-Flow Paper Element Only" in Table 5-2.

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

2. Install drain plug in oil pan and torque to 60 to 70 ft-lb [8.2980 to 9.6810 kg m].

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

4. Start engine and visually check for oil leaks.

Note: It is important to visually check for oil leaks after every oil and/or filter change.

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. 5-4. 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.

Table 5-2: Suggested Initial Oil And Filter Change Periods

Filtering Arrangement	Gallons Fuel Consumed	Mileage Driven	Hours Operated
Full-Flow Paper Element Only	1600	8,000	250
Full-Flow Paper & By-Pass	2400	12,000	375

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.

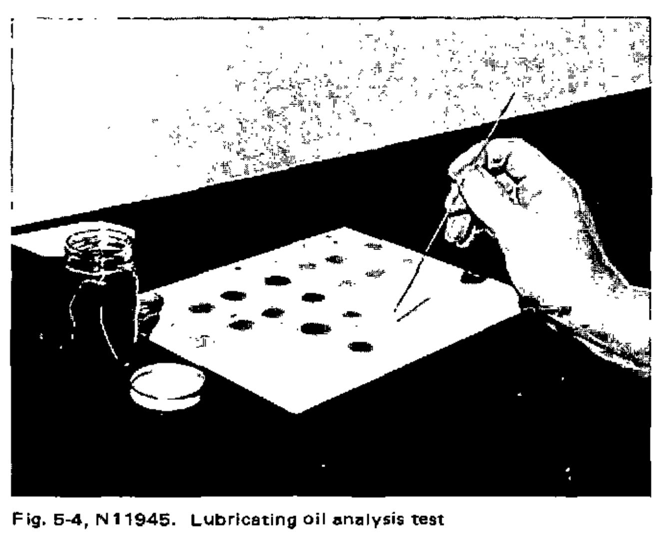


Fig. 5-4, N11945. Lubricating oil analysis test

Oil Property	**Test Number**
Viscosity at 100 deg F and 200 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 per cent by volume of fuel oil.

2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210 deg F [98.9 deg C] or 25 percent increase at 100 deg F [37.8 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 Hydraulic Governor Oil (B Check)

Change oil in the hydraulic governor sump at each "B" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications", Page 3-2.

Note: When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to insure free flow for satisfactory governor action.

Change Engine Full-Flow Filter Element (B Check)

Perform at AC Check under extremely dusty conditions

Filters Only

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

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

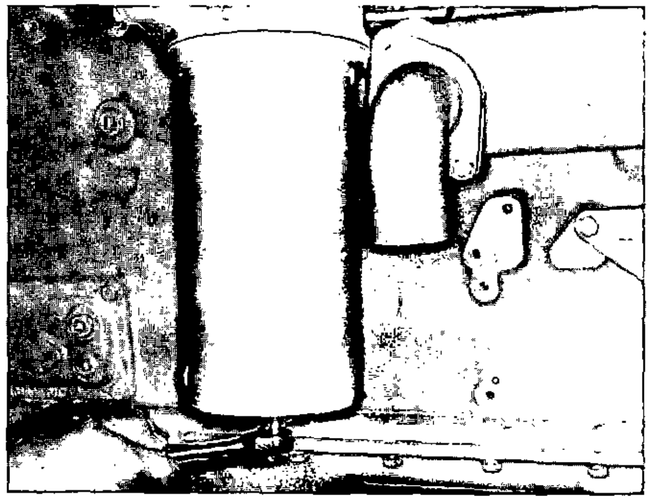


Fig. 5-5, N10098. Lubricating oil filter on 927 (center bolt)

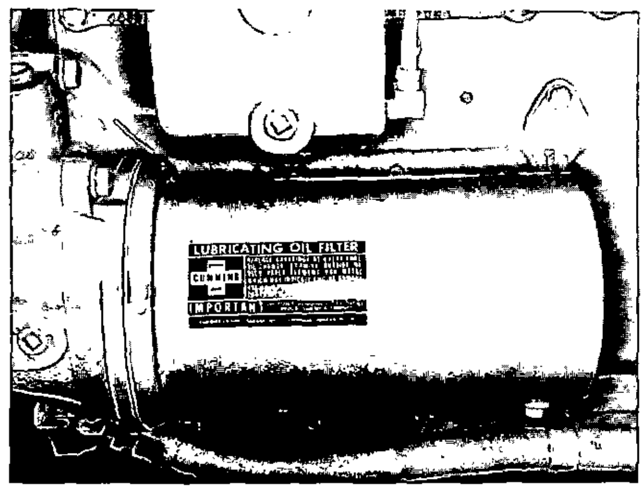


Fig. 5-6, N11960. Horizontal lubricating oil filter (center bolt)

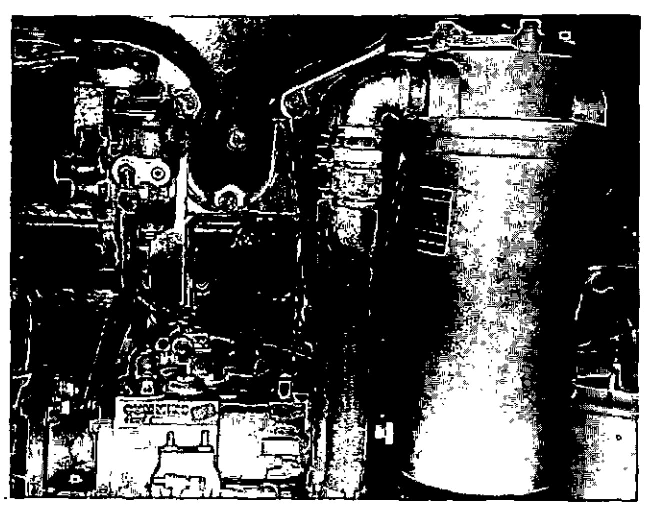


Fig. 5-7, N11961. Typical remote mounted lubricating oil filter (center bolt)

3. Inspect filter element then discard.

a. Inspect for metal particles.

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 to outlet side of filter should not exceed 10 psi [0.7030 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 filer head and discard.

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

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; install new element in filter case and fill with clean lubricating oil. Position to filter head and tighten center capscrew to 25 to 35 ft-lb [3.4575 to 4.8405 kg m]. Tighten clamp-type filter capscrew securely.

Caution: Never attempt to fit new seal ring to filter can, or seal may become distorted or damaged.

8. Fill engine to "H" high level mark on dipstick with lubricating oil meeting specifications on Page 3-2. 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.

Filter Cooler Combination

1. Remove drain plug (Fig. 5-7, 1 and 2) and allow oil to drain.

2. Remove capscrews, lockwashers and flatwashers from filter housing; lift off cover plate and gasket.

3. Replace drain plug.

4. Remove filter element and inspect.

a. Inspect for metal particles.

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 to outlet side of filter should not exceed 10 psi [0.7030 kg/sq cm] with 140 deg. F [60 deg. C] oil and engine at high-idle speed.

e. Discard element after inspection.

5. Install new element in filter case and fill with clean lubricating oil. Position a new gasket over filter case.

6. Position a new gasket over filter case, then place cover plate on top of gasket, replace capscrews, lockwashers and flatwashers and tighten to standard torque, see Page 3-5.

7. Fill engine to "H" high level mark on dipstick with lubricating oil meeting specifications on Page 3-2. Run engine and check for leakage.

8. Recheck engine oil level; add oil as necessary to bring oil level to "H" marking on dipstick.

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

Change Lubricating Oil By-Pass Filter Element (B Check)

Perform at AC Check under extremely dusty conditions

To change Cummins Fleetguard by-pass filter elements:

1. Remove drain plug (5, Fig. 5-8) from bottom of housing and drain oil.

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

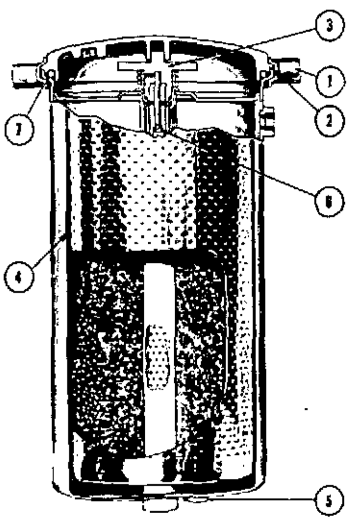


Fig. 5-8, V41908. Lubricating oil by-pass filter

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.

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 come together.

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 (B Check)

Perform at AC Check under adverse conditions

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 (B Check)

Perform at AC Check under adverse conditions

Lubricate alternator or generator by adding five or six drops of SAE 20 lubricating oil to oil cup (Fig. 5-9) 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 (B Check)

Perform at AC Check under adverse conditions

Electric

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

Air

Air cranking motor may be equipped with grease fittings,

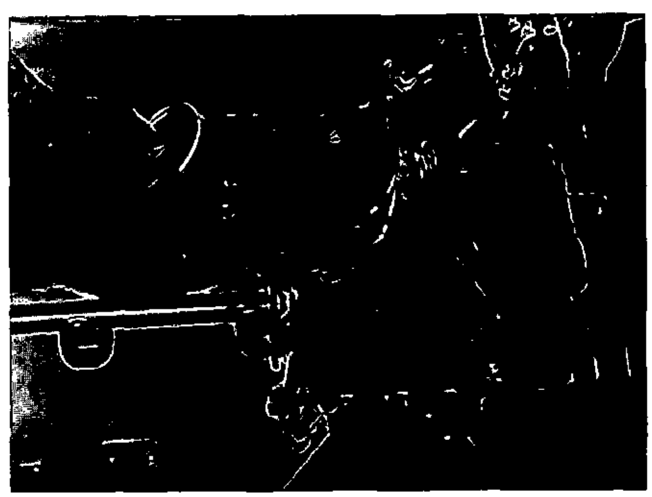


Fig. 5-9, N11951. Lubricating points of the generator felt wicks with outer grease cups or air line lubricators. Follow manufacturer's recommendation for procedure, interval and lubricant specification.

Change Fuel Filter Element (B Check)

Perform at AC Check under adverse conditions

Change the single 5-3/4 inch long (throw-away) fuel filter after 2000 gal [7570.000 lit or 1665.340 U.K. gal] of fuel consumption. Change the single 7-1/2 inch long (throw-away fuel filter) after 3000 gal [11,355.000 lit or 2498.010 U.K. gal] of fuel consumption and the stack disc (replacement element) after 4000 gal [15,140.000 lit or 3330.068 U.K. gal] fuel consumption.

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

Note: Capacities listed above are under normal working conditions and with proper storage of fuel.

The most accurate method of determining element change period is by measurement of fuel restriction as outlined below.

Check Fuel Restriction

To check restriction, connect ST-434 Vacuum Gauge to the fuel pump as shown in (2, Fig. 5-10) 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.

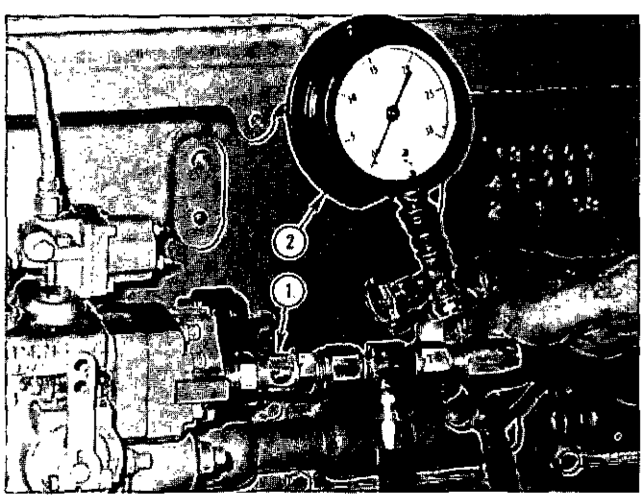


Fig. 5-10, N11917. Checking fuel filter restriction with ST-434 Vacuum Gauge

Throw-Away Type Filter

1. Unscrew combination case and element, discard.

2. Fill 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, clean filter case and install a new element. Fig. 5-11.

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-lb [2.7660 to 3.4575 kg m] with a torque wrench.

4. Check fittings in filter head for leaks. Fittings should be tightened to 30 to 40 ft-lb [4.1490 to 5.5320 kg m].

Check Air Piping (B Check)

Perform at AC Check under adverse conditions

Check air intake piping from air cleaner to intake manifold. Check for loose clamps or connections, cracks, punctures,

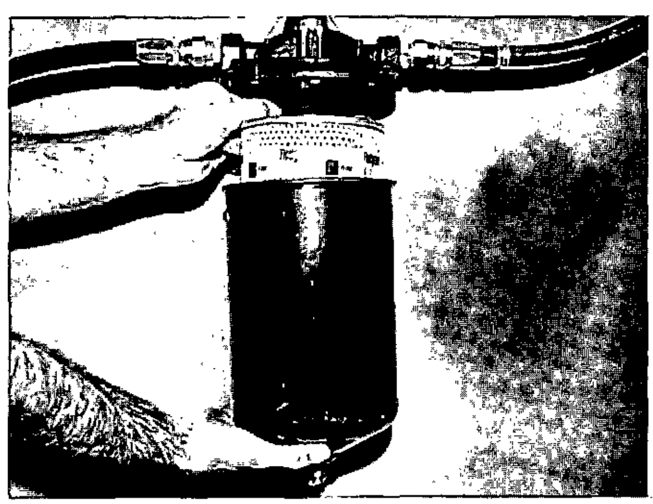


Fig. 5-11, V11910. Installing replaceable fuel filter element

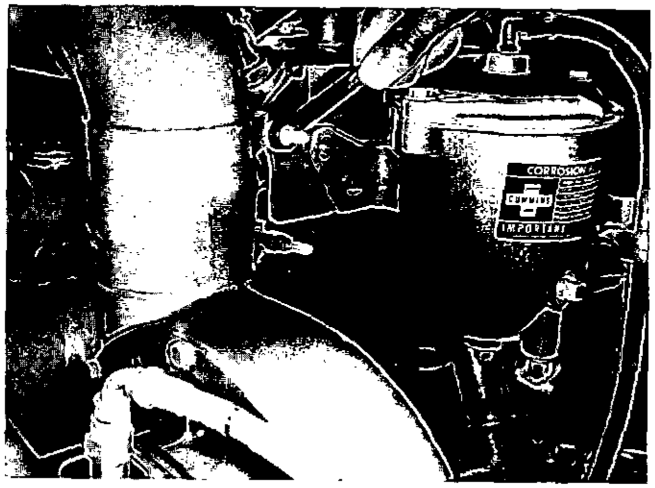


Fig. 5-12, N11968. Tightening air intake piping clamp

or tears in hose or tubing, collapsing hose, or other damage. Tighten clamps, Fig. 5-12, or replace parts as necessary to insure an air-tight air intake system. Make sure all air goes through the air cleaner.

Check Inlet air Restriction Gauge (B Check)

Perform at AC Check under adverse conditions

The best method for determining dry-type air cleaner maintenance periods is through air restriction checks.

Check Air Inlet Restriction At Engine

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 tthan six (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 [508.0 mm] of water or 1.5 inch [38.100 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 inch [635.0 mm] of water or 1.8 inch [45.720 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.

Check Air Inlet Restriction At Air Cleaner

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. 5-13) 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 re-set 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 excessive. Items required for installation are:

1. Electric source (1, Fig. 5-14).

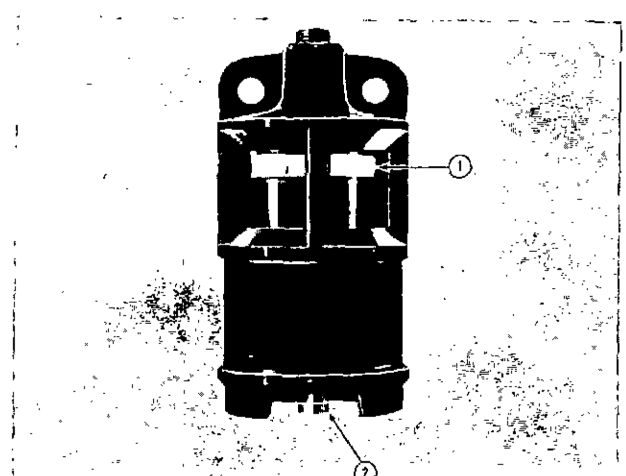


Fig. 5-13, CGS20. Air inlet restriction gauge

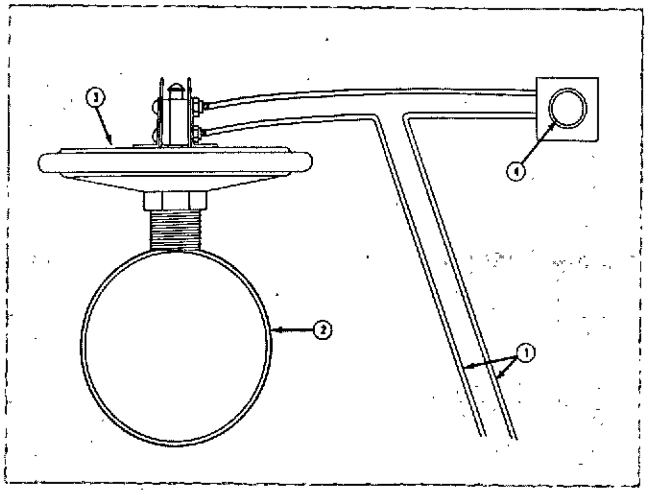


Fig. 5-14, N21905. Vacuum switch for air inlet restriction check

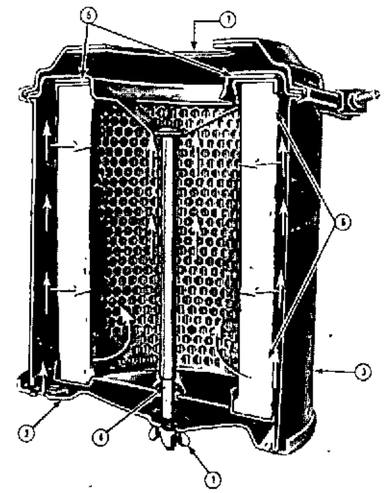


Fig. 5-15, N11003. Air cleaner - dry type

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

3. Vacuum switch (3).

4. Red indicator light (4).

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".

Clean Air Cleaner Elements (B Check)

Perform at AC Check under adverse conditions

Dry Type

The paper element in a dry-type air cleaner, Fig. 5-15, may be cleaned several times by using an air jet to blow off dirt or by washing with non-sudsing houshold detergent and warm water, perferably 120 to 140 deg F [48.9 to 60.0 deg C], then drying with compressed air, approximately 40 psi [2.8124 kg/sq cm]. Do not hold air jet too close to paper element or damage to element may result.

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

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

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. 5-15) 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.

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

Heavy Duty Air Cleaners

Heavy duty air cleaners (single and dual types) combine centrifugal cleaning with element filtering, Fig's. 5-16 and 5-17, 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 of a primary element and on into the engine. Fig. 5-16. Whereas, on a dual element type air travels through a ring of vanes around the outside of a primary element (6, Fig. 5-16) and then through a safety element (9, Fig. 5-16) and on into the engine.

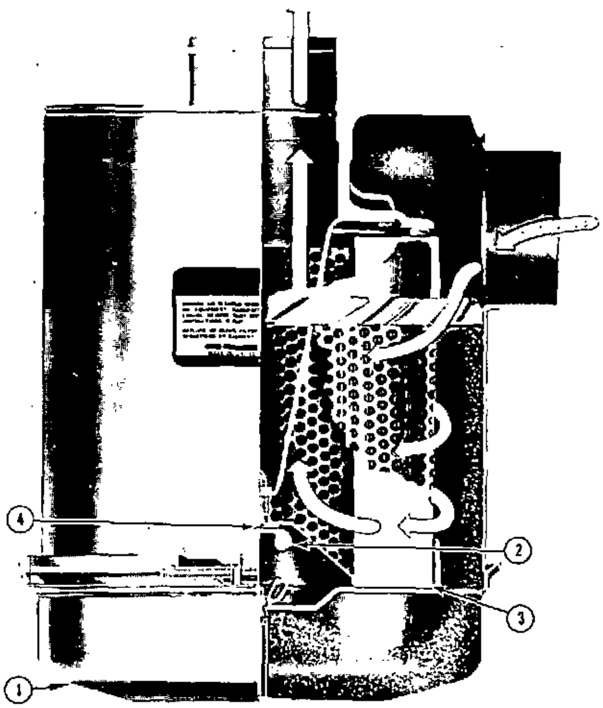


Fig. 5-16, V11005. Air cleaner - single element

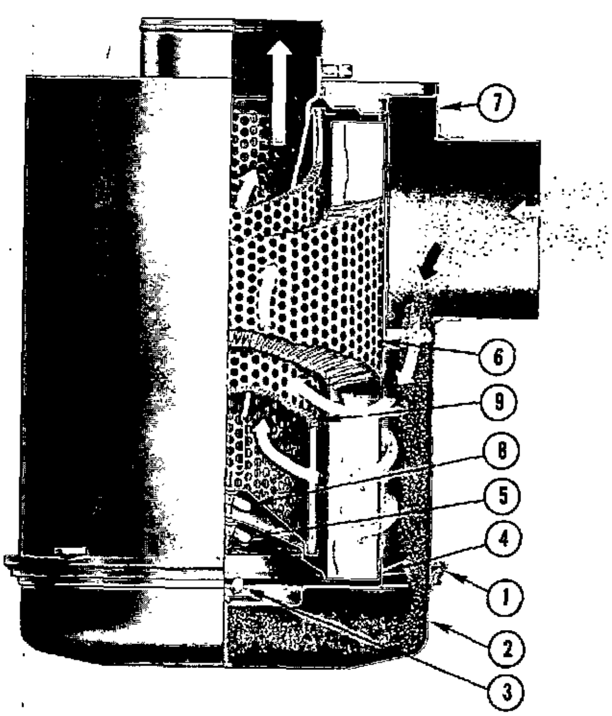


Fig. 5-17, N11030. Air cleaner - dual element

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. 5-16), (2, Fig. 5-17).

2. Loosen wing nut (3, Fig. 5-17), remove dust shield (3, Fig. 5-16), (4, Fig. 5-17) from dust pan (1, Fig. 5-16), (2, Fig. 5-17), clean dust pan and shield.

3. Remove wing nut (2, Fig. 5-16), (5, Fig. 5-17) securing air cleaner primary element (6, Fig. 5-17) in air cleaner housing, inspect rubber sealing washer on wing nut (4, Fig. 5-16), (5, Fig. 5-17).

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

Caution: Air pressure should not be more than 100 psi [*7.0310* 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 [48.8 to 60 deg. C]. Dry* with compressed air 40 PSI [2.8120 kg/sq cm].

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

7. Install new or cleaned primary element.

8. Be sure gasket washer (4, Fig. 5-16), (5, Fig. 5-17) is in place under wing nut before tightening.

9. Reassemble dust shield (3, Fig. 5-16), (4, Fig. 5-17) and *dust pan (1, Fig. 5-16), (2, Fig. 5-17) position to air cleaner* housing and secure with band (1, Fig. 5-17).

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. 5-17), *replace safety element* (9, *Fig.* 5-17).

b. Reassemble air cleaner as described in Steps 6 and 7 above.

Replace Cartridge-Type Air Cleaner Element (B Check)

Perform at AC Check under adverse conditions

Two Stage — Disassembly

1. Loosen wing nuts (4, Fig. 5-18) on air cleaner housing

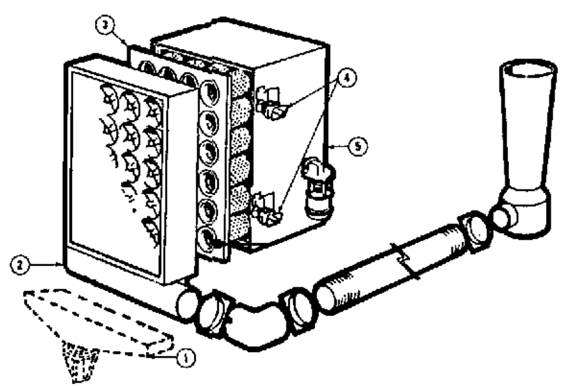


Fig. 5-18, N21026. Air cleaner — cartridge type (two stage) with exhaust aspirator or dust bin (dotted lines)

(5) to remove pre-cleaner panel with dust bin (1). To remove pre- cleaner panel equipped with exhaust aspirator (2) 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.

Cleaning And Inspection

1. Clean pre-cleaner openings 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. 5-18) 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, assembly 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.

Single Stage — Disassembly

1. Loosen wingnuts (3, Fig. 5-19) on air cleaner housing and remove moisture eliminator (1) and rain guard, if used.

2. To remove dirty Pamic cartridge (2), insert fingers in cartridge opening using a "bowling-ball grip" and pull

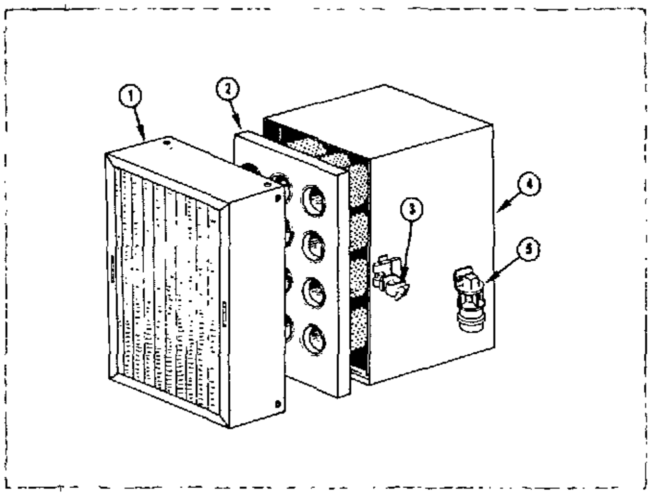


Fig. 5-19, V11009. Cartridge – type air cleaner – single stage

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.

Cleaning And Inspection

1. Wash moisture eliminator in an approved solvent and dry thoroughly.

2. Wipe out air cleaner housing with a clean cloth.

3. Inspect housing and moisture eliminator for dents, split seams and holes; repair or replace as necessary.

4. Inspect hose, tubing and clamps for damage; replace if defective.

Assembly

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

2. To install a new cartridge, hold cartridge (2, Fig. 5-19) in same manner as when removing from housing (4). 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. Position moisture eliminator (1) to air cleaner housing (4) and secure wingnuts (3).

Change Oil Bath Air Cleaner Oil And Clean Tray Screen (B Check)

Perform at AC Check under adverse conditions

Air Cleaner Oil

Before dirt build-up reaches 1/2 inch [12.700 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".

Clean Tray Screen

Immerse tray screen (1, Fig. 5-20) 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.

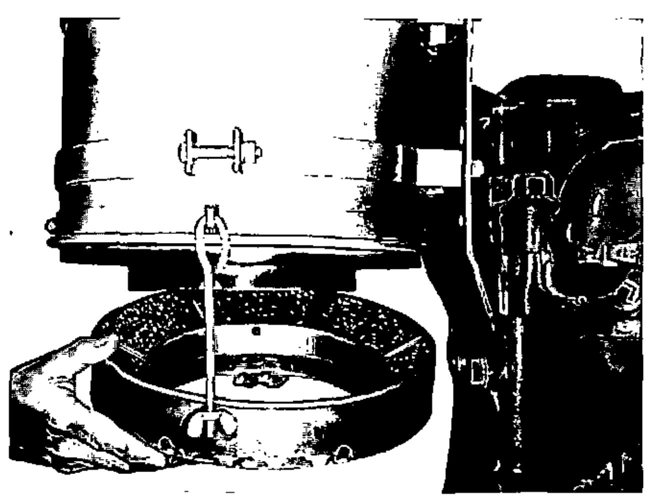


Fig. 5-20, N11967. Removing air cleaner tray screen

Clean Crankcase Breather (B Check)

Perform at AC Check under adverse conditions

Four different types of crankcase breathers are installed in Cummins Engines. Fig's. 5-21, 5-22, 5-23 and 5-24.

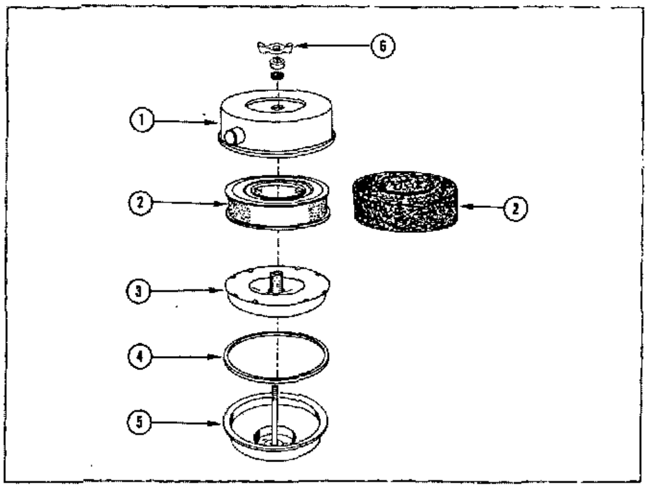


Fig. 5-21, V51909. Crankcase breather — mesh element with vapor barrier

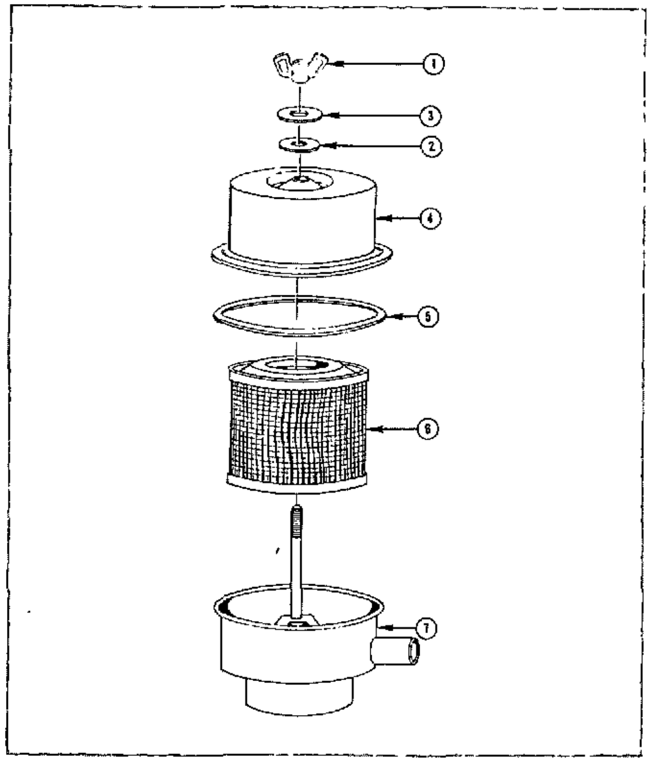


Fig. 5-23, N10310. Crankcase breather — pressed in paper element type

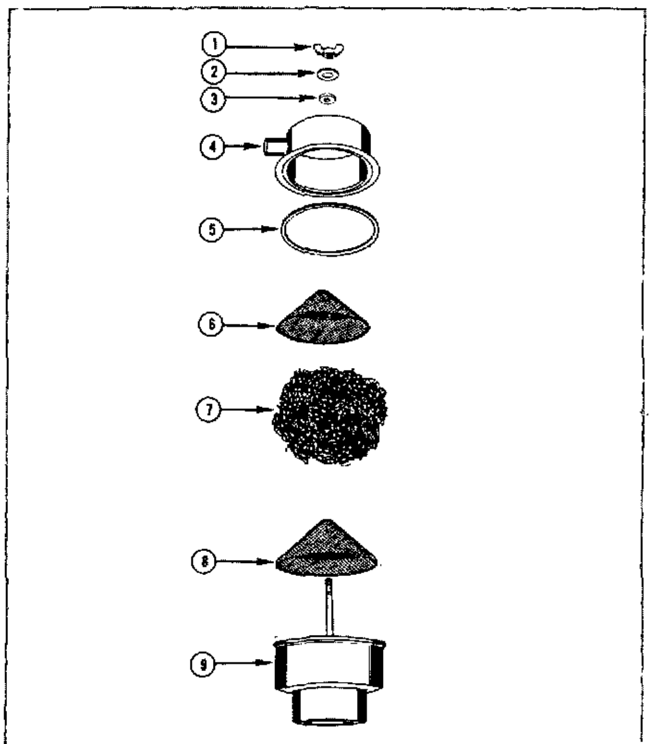


Fig. 5-22, V40310. Crankcase breather — Mesh Type

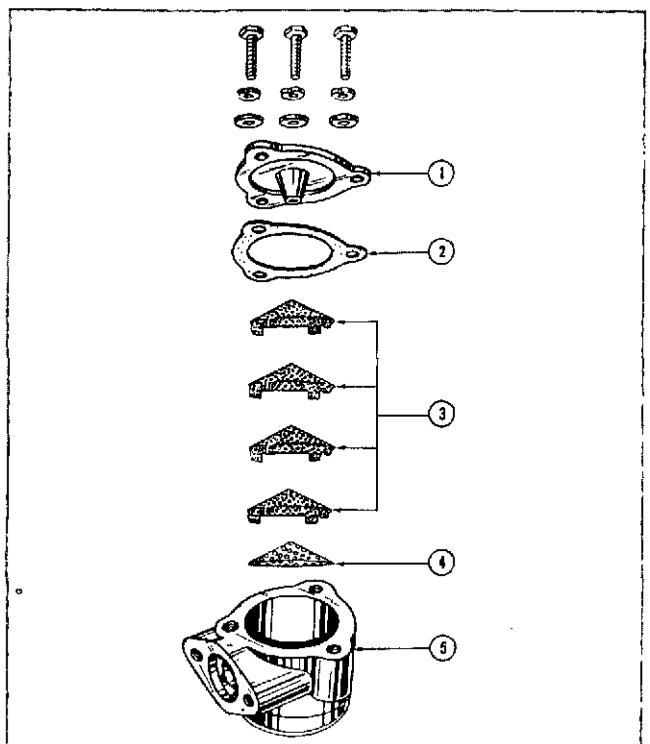


Fig. 5-24, N20312. Crankcase breather — screen type element

Mesh Element Breather with Vapor Barrier—Disassembly

1. Remove wing nut (6, Fig. 5-21.) flatwasher and rubber washer securing cover (1), breather element (2) and vapor element (3) to breather body (5).

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

3. Discard breather element.

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 elements; make sure screens are not ruptured.

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

Assembly

1. Install cleaned or new breather element (2, Fig. 5-21.) 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.

Mesh Element Breather — Disassembly

1. Remove wing nut (1, Fig. 5-22), flatwasher (2) and rubber washer (3) securing cover (4) and element assembly to breather.

2. Lift off cover, gasket (5), upper screen (6), mesh element (7) and lower screen (8) from body (9).

Cleaning And Inspection

1. Clean all parts in solvent. Use solvent that is not harmful to rubber. Clean mesh element and screens thoroughly.

2. Dry thoroughly with moisture-free compressed air.

3. Inpsect rubber washers and gaskets; replace as necessary.

4. Inspect body for cracks, dents or breaks. Discard all unserviceable parts.

Assembly

1. Position lower screen (8, Fig. 5-22) into breather body (9).

2. Position new or cleaned element (7) and upper screen (6) over center screw in breather body.

3. Place cover (4) on body with gasket (5) in position.

4. Install rubber washer (3), flatwasher (2) and wing nut (1). Tighten securely.

Paper Element Breather — Disassembly

1. Remove wing nut (1, Fig. 5-23) flatwasher (3) and rubber washer (2) securing cover (4) and element assembly to breather.

2. Lift off cover and lift out element (6) and gasket (5).

3. Separate cover from element. Discard element.

Cleaning And Inspection

1. Clean all parts in solvent. Use solvent that is not harmful to rubber.

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

2. Dry thoroughly with moisture-free compressed air.

3. Use clean cloth to wipe body clean.

4. Inspect rubber washers and gaskets; replace as necessary.

5. Inpsect body for cracks, dents or breaks. Discard all unserviceable parts.

Assembly

1. Install new element (6, Fig. 5-23) over center screw in breather body (7).

2. Place cover (4) on body with gasket (5) in position.

3. Install rubber washer (2), flatwasher (3) and wing nut (1); tighten securely.

Screen Element Breather — Cleaning And Inspection

1. Remove vent tube if not previously removed.

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

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

4. Assembly 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 (B Check)

Perform at AC Check under adverse conditions

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 (B Check)

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 (B Check)

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 (B Check)

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 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.

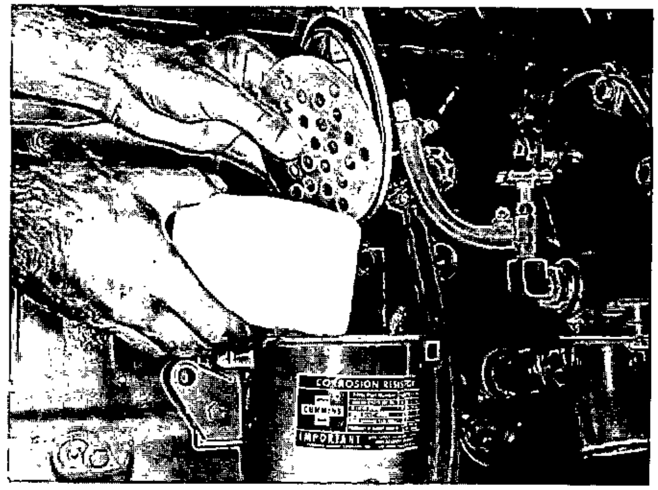


Fig. 5-25, N11901. Changing corrosion resistor element

To Change Bag-Type Element

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

2. Remove cover capscrews and cover. Fig. 5-25.

3. Remove plate securing element; lift element(s) from housing and discard. Remove plate below element.

4. Lift spring from housing.

5. Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.

6. Replace spring and lower plate.

7. Remove new element from transparent bag; install element in housing.

Caution: Make sure antifreeze is compatible with chromate-type elements. Refer to Table 3-4.

8. Replace upper plate, gasket and cover; secure with capscrews and washers.

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

To Change Spin-On Element

1. Close shut-off valves on inlet and drain lines. Fig. 5-26.

2. Unscrew element and discard.

Fig. 5-26, N11962. Spin on corrosion resistor

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

Caution: Mechanical tightening will distort or crack filter head.

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. 5-27.

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.

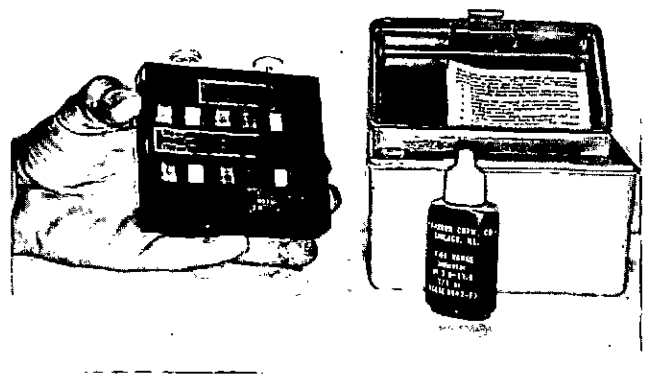


Fig. 5-27, N11946. ST-993 Coolant Checking Kit

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 anti-freeze 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 anti-freeze known to be compatible with chromate elements.

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 8.0 to 9.5.

5. Wash out test tubes after each test and keep reagent container caps 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 [3.785 lit or 0.83267 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. Refer to Coolant Specifications, Section 3.

If Cummins Corrosion Resistor is used, change element, Fig. 5-25, 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.

Check And Adjust Belt Tension (B Check)

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.**

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-lb [0.6915 kg m].

e. Snug two capscrews above and below the first one to 5 ft-lb [0.6915 kg m].

f. Snug clamp ring capscrew on belt side, then two remaining capscrews, to 5 ft-lb [0.6915 kg m].

g. Finish tightening by alternating from side to side in 5 ft-lb [0.6915 kg m] increments to a final torque of 12 to 15 ft-lb [1.6596 to 2.0745 kg m].

h. Check the belt tension with applicable Belt Tension Gauge. Fig. 5-28. Correct tension is 90 to 110 pounds as indicated on this gauge. If gauge is not available, apply pressure of the index finger at center of the longest span of belt. Deflection should be one belt thickness per foot of pulley center distance. Fig. 5-29. See Table 5-3.

Note: Use ST-968 Gauge for belts which are 3/8 to 1/2 inch in width. Use ST-1138 Gauge for belts which are 11/16 to 1 inch in width.

Table 5-3: Belt Tension—Inch [mm]

Belt Width		Deflection Per Ft [0.3048 m] of Span	
1/2	[12.700]	13/32	[10.318]
11/16	[17.462]	13/32	[10.318]
3/4	[19.050]	7/16	[11.112]
7/8	[22.225]	1/2	[12.700]
1	[25.400]	9/16	[14.287]

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.

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.

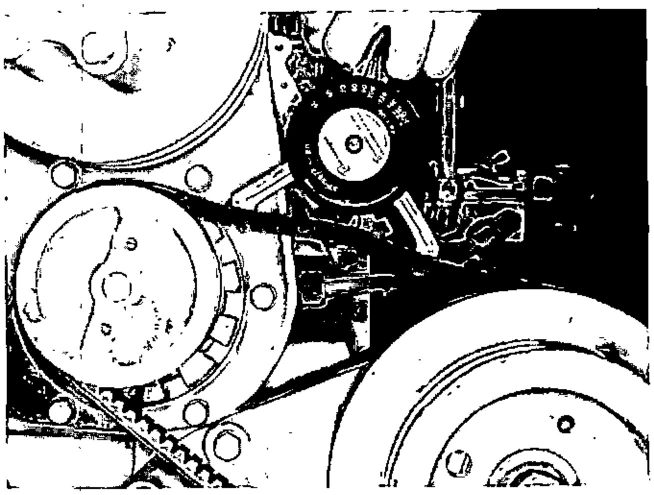


Fig. 5-28, N11969. Checking belt tension with ST-1138 Gauge

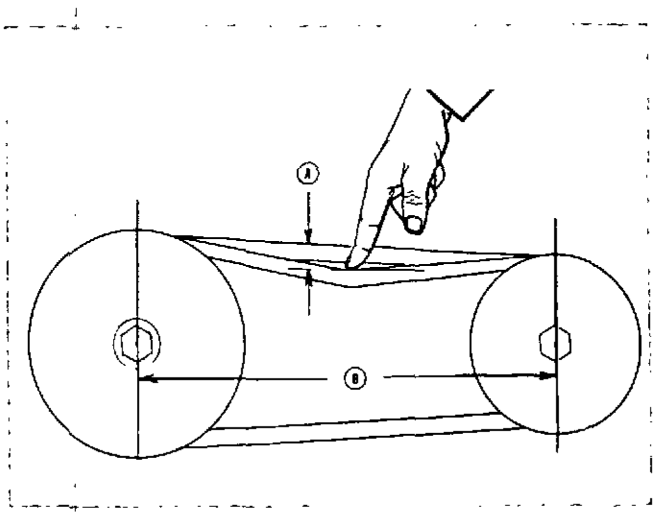


Fig. 5-29, N11471, Checking belt tension manually

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

5/16-18 10 to 12 ft-lb [1.3830 to 1.6596 kg m]
3/8-16 17 to 19 ft-lb [2.3511 to 2.6277 kg m]

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

h. Check the belt tension. It should be 90 to 110 pounds on the ST-968 or ST-1138 Gauge, or should deflect to values listed in Table 5-3.

Water Pump Belts (With Idler)

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

2. Lift idler pulley until belt tension shows 90 to 110 pounds as measured with applicable gauge.

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

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.

1. Loosen large locking nut on fan hub shaft on 855 series and loosen capscrews securing fan hub shaft to mounting bracket on the 927 series. 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 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 110 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 as listed in Table 5-3.

5. Secure the locknut on 855 series and capscrews on 927 series. Tighten locknut to 400 to 500 ft.-lb. [55.3200 to 69.1500 kg/sq cm]; then, back off 1/2 turn. Tighten capscrews 75 to 85 ft-lbs. [10.3725 to 11.7555 kg m].

6. 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 5-3.

Water Pump Belt Installation (No Idler)

The eccentric body water pump does not provide enough range of adjustment to allow the drive belts to be installed without rolling them on.

However, they can be installed without damage if a few simple rules are followed:

1. Be sure the water pump body is turned to its closest point to the drive pulley.

2. Place the new belt over the water pump pulley and engage the belt in the top of the drive pulley sheave.

3. Place a shop rag under the belt, and pull it into the sheave while barring the engine.

4. Transfer the belt to the inner pulley sheave, using the shop rag to guide it. Always replace multiple belts in complete sets.

5. Rotate the water pump body counterclockwise to adjust belt tension. Adjust tension with applicable gauge; correct tension is 90 to 110 pounds as indicated on this gauge. If gauge is not available, apply pressure of the index finger at center of the longest span of belt. See Table 5-3 and Fig. 5-29.

6. All new belts require re-adjustment after a short period of operation. Operate the engine twenty minutes to one-half hour, then re-adjust.

Note: Belt tension should be checked visually each time the unit is serviced, or at oil change periods on industrial and construction units. Attention given to these important belt drives will be repaid in reduced repair costs and extended engine life.

'C' Maintenance Checks

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

Steam Clean Engine (C Check)

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 (C Check)

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. 5-30) 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-lb [2.7660 to 3.4575 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap (1, Fig. 5-31) 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 parts as described above.

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

6. Install spring, large coil 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.

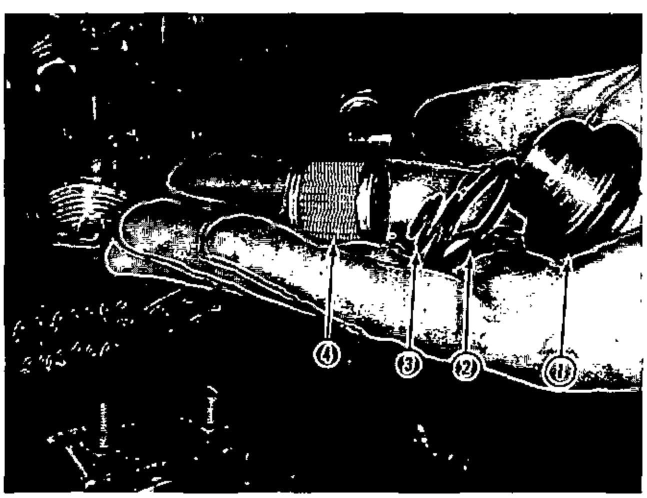


Fig. 5-30, N11950. Fuel pump filter assembly — PT (type G) fuel pump

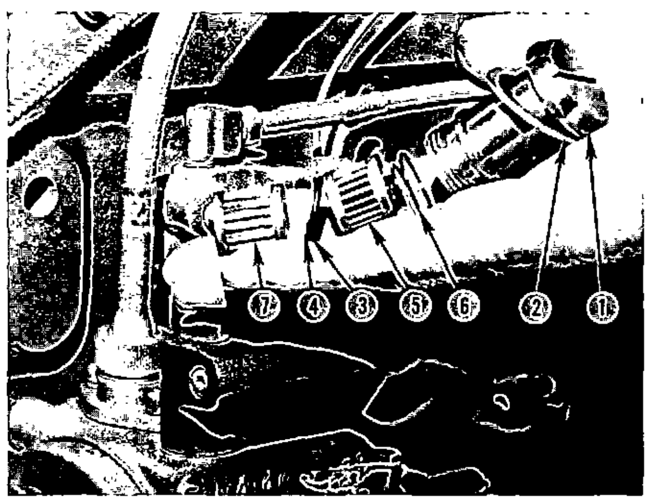


Fig. 5-31, N11940. Fuel pump filter assembly — PT (type G) fuel pump with MVS governor

8. Install filter cap and dynaseal in governor housing; tighten cap to 20 to 25 ft-lb [2.7660 to 3.4575 kg m] with torque wrench and screwdriver adapter.

Adjust Injectors And Valves (C Check)

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 injector hold-down capscrew in alternate steps to 11 to 12 ft-lb [1.5213 to 1.6596 kg m].

Timing Mark Alignment

1. If used, pull compression release lever back and block in open position; 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. 5-32) aligns with the boss (2) on the gear case cover. Example: 1-6 VS. This location is marked with a notch in the drive pulley.

Note: ST-747 Barring Tool can be used to bar engine in direction of rotation.

4. Check the valve rocker levers on the two cylinders aligned indicated on pulley (example: 1 and 6 cylinders for 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. 5-32, N114220. Valve set timing marks

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

6. For firing order see Table 5-4.

Table 5-4: Engine Firing Order

Righthand Rotation	Lefthand Rotation
1-5-3-6-2-4	1-4-2-6-3-5

Note: ST-747 Barring Tool can be used to bar engine in direction of rotation.

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

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

Injector Plunger Adjustment

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. 5-33.

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 5-5 and tighten the locknut.

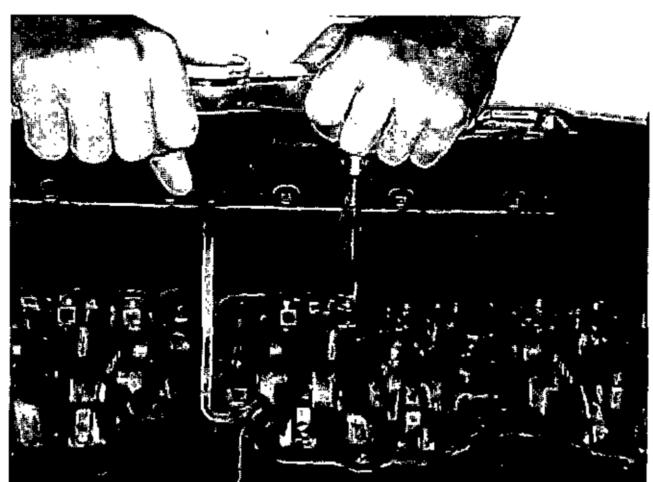


Fig. 5-33, N11466. Adjusting injector plungers

Table 5-5: *Injector Plunger Adjustment—Inch Lbs. [kg m] Oil Temperature—deg. F. [deg. C]*

70	**[21.1]**	**140**	**[60]**	**210**	**[98.9]**
48	[0.5520]	60	[0.6900]	72	[0.8280]

Note: Tighten injector plunger in aluminum housing to 72 inch lbs. torque. Reset injector plunger in cast iron and aluminum housing to 72 inch lbs. torque at 210 deg. F. [98.9 deg. C].

Crosshead Adjustments

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

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

1. Loosen valve crosshead adjusting screw locknut and back off screw 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. 5-34.

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

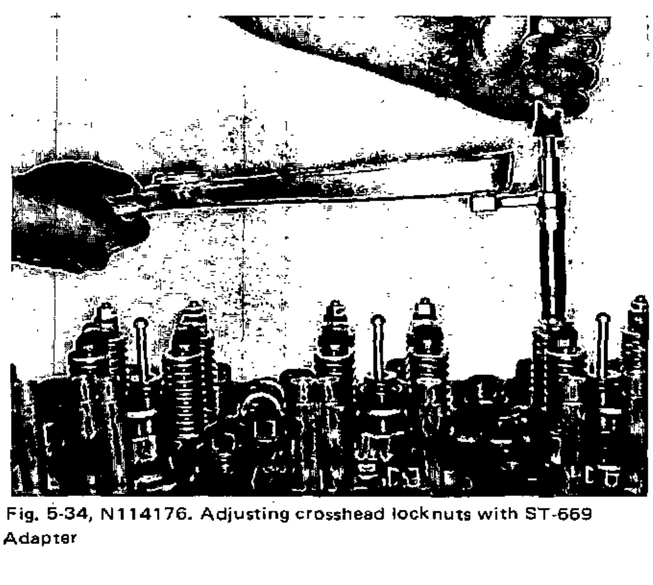


Fig. 5-34, N114176. Adjusting crosshead locknuts with ST-669 Adapter

5. Hold adjusting screw in this position and tighten locknut to 25 to 30 ft-lb [3.4575 to 4.1490 kg m] torque.

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of *0.020 inch [0.5080 mm] clearance at this point.*

Valve Adjustment

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. 5-35. Tighten locknut to 30 to 40 ft-lb [4.1490 to 5.5320 kg m] torque. When using ST-669 torque to 25 to 35 ft-lb [3.4575 to 4.8405 kg m].

Table 5-6: Valve Clearance — Inch [mm]

Intake Valves Oil Temp. deg. F. [deg. C]			**Exhaust Valves Oil Temp. deg. F. [deg. C]**		
70 [21.1]	**140 [60.0]**	**210 [98.9]**	**70 [21.1]**	**140 [60.0]**	**210 [98.9]**
0.016 [0.4064]	*0.014* [0.3556]	*0.014* [0.3556]	*0.029* [0.7366]	*0.027* [0.6858]	*0.027* [0.6858]

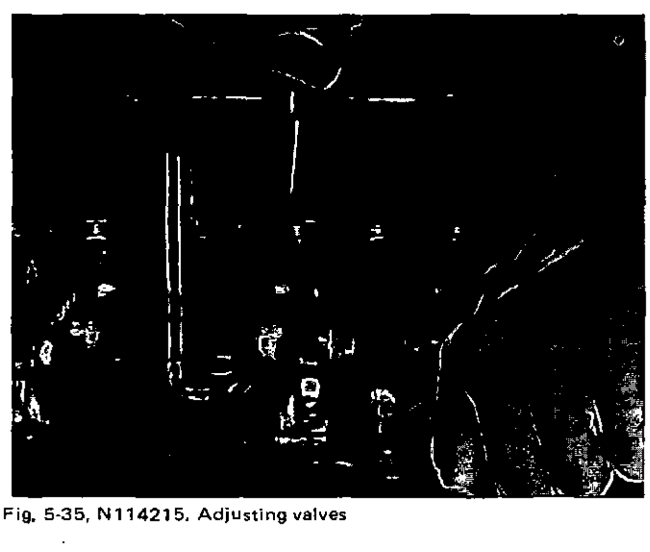


Fig. 5-35, N114215. Adjusting valves

3. Always make final valve adjustment to correct value at 210 deg. F [98.9 deg. C] engine lubricating oil temperature. See Table 5-6.

Governed Engine Speed

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.

Compression Release Adjustment

A properly adjusted compression release provides a clearance between the compression release shaft and valve push tube flanges when the compression release lever is in the stop (engine running) position. Adjustment of the compression release as applied to exhaust valve is the same as the adjustments formerly used with intake valves. However, adjustment is more critical on the exhaust valves because the valves operate at higher temperatures.

Adjustment Procedure

1. Loosen the compression release lever on the compression release shaft.

2. Set compression release lever with stop pin midway between the lever stops.

3. Turn the compression release shaft clockwise with a screwdriver (slot in shaft) until it contacts the valve push tube flange (may be either intake or exhaust valve).

4. Tighten the compression release lever to the compression shaft with the clamping capscrew. The stop pin and lever stops remain in position described in Step 2.

5. Move lever to running position stop against pin (lever toward the exhaust side of the engine).

6. Move lever in opposite direction to compression released position stop against pin.

7. Repeat Steps 5 and 6 while cranking the engine. During Step 5 there should be no contact between shaft and push tubes.

Note: Some equipment manufacturers supply their own compression release levers. The adjustment procedure remains the same. In some cases, air or hydraulic actuating mechanisms are also supplied. These should be checked for proper operation; be especially sure that they allow return to full running position.

Clean Complete Oil Bath Air Cleaner (C Check)

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 [0.2109 to 0.3516 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 For Oil Leaks At Turbocharger (C Check)

Check both intake and exhaust sides of turbocharger for "wet" oil. If oil is present, be sure that it is not caused by worn rings or an oil-over condition from an oil bath air cleaner. Check hose, tubing and connections for leaks and tighten or replace as necessary.

Check Alternator/Generator And Cranking Motor Brushes And Commutators (C Check)

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. 5-36, and wiring for frayed insulation. Check mounting bolts for tightness and check belt for alignment, proper tension and wear.

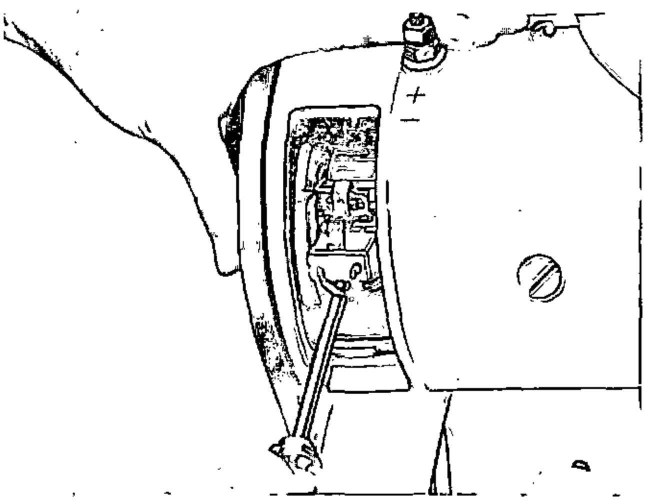


Fig. 5-36, N11308. Checking generator brushes

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. 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.

Check Vibration Damper Alignment (C Check)

Damper hub (1, Fig. 5-37) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

Inspect damper every "C" Check. There should be no relative rotation between hub and inertia member resulting from engine operation.

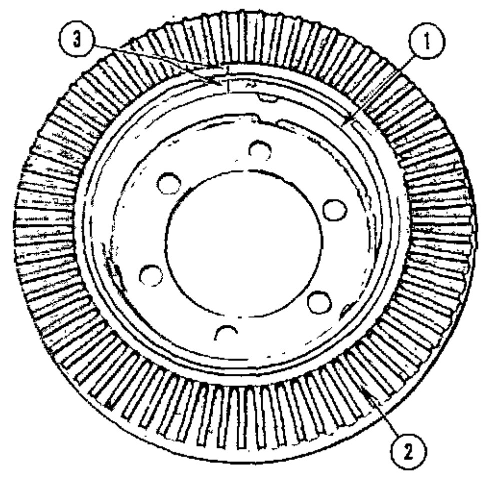


Fig. 5-37, N10146. Vibration damper alignment marks

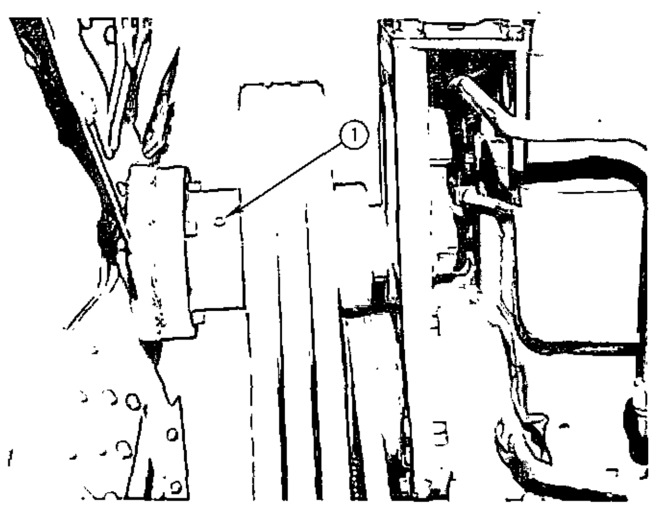


Fig. 5-38, N11932. Fan hub lubricating point

Lubricate Fan Hub (C Check)

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. 5-38) 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.*

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

1. Check level of lubricant by turning hub pulley until one filler hole is in horizontal (90 deg. from vertical) position and other is in vertical position. Allow lubricant to "settle-out," remove horizontal plug and check for lubricant flow from open hole.

Caution: If fan hub lubricant is low and more lubricant is required, rotate until a small amount of oil runs from horizontal hole. Check for type and weight of lubricant used before adding SAE 90 gear lubricant or SAE 30 engine lubricating oil. Do not mix grades or brands of lubricant, as damage to bearings and seals may result.

2. Fill fan hub (see Section 3 for lubricant specifications) 1/2 full or until oil comes from vertical hole, do not overfill. If oil is cold, warm so it will flow freely to all portions of hub.

Caution: After filling, wait for 5 minutes for lubricant to "settle-out" then recheck. This will insure fan hub is filled to proper level.

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

Water Pump

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

Assemblies Lubricated With Grease

1. Lubricate eccentric body (no idler pulley for belt adjustment) type water pump by applying grease gun to fitting, give one "shot" from grease gun. (Refer to 1, Fig. 1-16).

2. Do not overfill; overheating and bearing failure will result, if disassembled pack bearings and fill 1/2 to 2/3 capacity, see Page 3-3.

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

1. Check level of lubricant in water pump (pump with idler pulley for belt adjustment) by removing pipe plug from side of pump (90 deg. from vertical) and checking for lubricant flow. (See views 2 and 3 in Fig. 1-16.)

2. To lubricate water pump, remove pipe plug from horizontal hole and fill cavity from upper (top) plug hole with lubricant until oil flows from plug hole on side of pump body. See Section 3 for lubricant specifications.

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

Check Fuel Manifold Pressure (C Check)

1. Check maximum fuel manifold pressure with ST-435. Fig. 5-39. 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.

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

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

4. 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.

5. 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.

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

6. Always make the above checks on a hot engine.

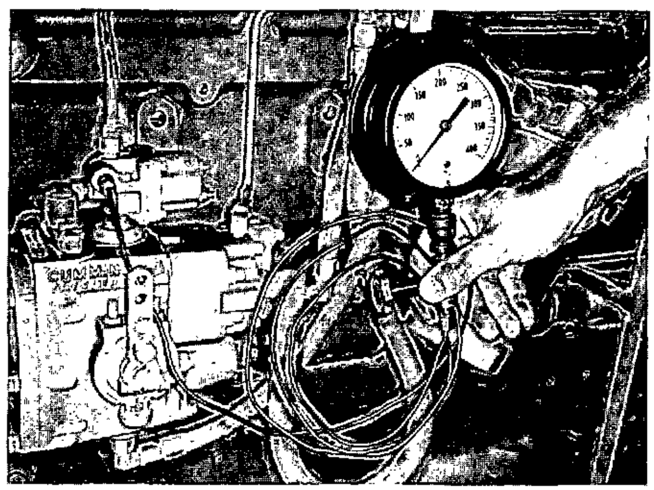


Fig. 5-39, N11966. Checking fuel manifold pressure ST-435

'D' Maintenance Checks

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

Clean And Calibrate Injectors (D Check)

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 (D Check)

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

Clean Turbocharger Compressor Wheel And Diffuser (D Check)

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 as follows:

1. Remove intake piping, air cleaner piping and support bracket (if used) from turbocharger.

2. Use a good carbon-removing solvent and a brush with nylon or hog bristles to clean the compressor wheel and diffuser. Never use a solvent that may attach aluminum and result in an imbalanced compressor wheel.

3. *If the unit is very dirty, remove the turbocharger from* the engine and send to Cummins Distributor.

4. Immerse compressor wheel end of turbocharger in cleaning fluid to the bearing housing; allow to soak. Do not rest weight of turbocharger on compressor wheel or on end of shaft.

5. Dry the unit thoroughly with compressed air. Reassemble intake piping, air cleaner piping and support (if used.)

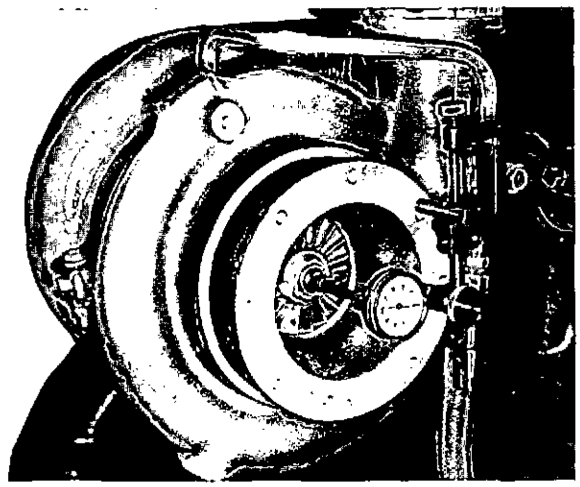


Fig. 5-40, N11956. Checking T-50 turbocharger bearing end clearance

Check Turbocharger Bearing Clearance (D Check) T-50, VT-50

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. 5-40.

Checking Procedure

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

2. *Remove one capscrew from the front plate (compressor* wheel end) and replace with a long capscrew. Attach an indicator to the long capscrew and register indicator point on the end of rotor shaft. Push the shaft from end-to-end, making note of total indicator reading. Move indicator point to the end of the shaft and check end-play of rotor assembly. See Table 5-7 for limits.

3. Check radial clearance on compressor wheel only. Note that limits in Table 5-7 are minimum figures.

4. If end clearance exceeds limits shown in Table 5-7, remove turbocharger from engine and replace with a new or rebuilt unit.

Table 5-7: Turbocharger Bearing Clearances — Inch [mm]

Turbocharger Model	Radial Clearance Min.	Radial Clearance Max.	End Clearance Min.	End Clearance Max.
T-50	0.005 [0.1270]	0.033 [0.8382]	0.006 [0.1524]	0.019 [0.4826]
VT-50	0.005 [0.1270]	0.033 [0.8382]	0.006 [0.1524]	0.017 [0.4318]

Inspect/Install Rebuilt Units as Necessary (D Check)

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 any convenient sequence; refer to Cummins Shop Manual, Bulletin No. 983696 for correct assembly procedures.

'E' Maintenance Checks

At each "E" Maintenance Check, perform all "A", "AC", "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, dilution and other signs of wear should be analyzed as part of the inspection.

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

At this period, perform all previous checks and:

Inspect Bearings
Rebuild Cylinder Head
Replace Cylinder Liner Seal
Replace Piston Rings
Replace Front And Rear Crankshaft Seals
Replace Vibration Damper
Inspect Cylinder Liners
Inspect Pistons
Inspect Crankshaft Journals
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.

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.

Change Converter Oil, Filter, And Clean Screens (See Manufacturer's Instructions)

Oil should be changed every spring and fall in the hydraulic system, or more ofter, depending on operating conditions. Also, the oil must be changed whenever it shows traces of dirt or the effects of high operating temperature evidenced by discoloration or strong odor.

Where possible follow converter manufacturer recommendations.

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

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

Pressure Flushing

Flush radiator and block when anti-freeze 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 connections 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 the 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 [9.5250 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 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 5-8 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195 deg. F [82.2 to 90.6 deg. C] thermostats are used only with shutterstats that are set to close at 187 deg. F [86.1 deg. C] and open at 195 deg. F [90.6 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 [76.7 to 85.0 deg C] or low 160 to 175 deg F [71.1 to 79.4 deg C] and in a few cases high-range 180 to 195 deg F [82.2 to 90.6 deg C] thermostats, depending on engine application.

Check Preheater Cold-Starting Aid (Fall)

Remove 1/8 inch pipe plug from manifold, near glow plug, and check operation of preheater as described on Page 2-3.

Check Engine Blow-By (As Required)

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. 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. 5-41.

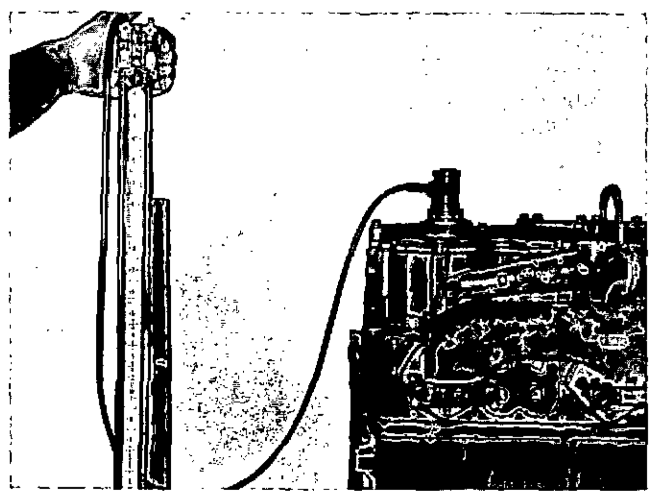


Fig. 5-41, N11489. Checking blow-by under load

Table 5-8: Thermal Control Settings

Control Used	Setting With 160 deg/175 deg F [71.1 deg/79.4 deg C] Thermostat	Thermostat	Setting With 170 deg/185 deg F [76.7 deg/85.0 deg C] Thermostat		Setting With 180 deg/195 deg F [82.2 deg/90.6 deg C] Thermostat	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185 deg F [85.0 deg C]	170 deg F [76.7 deg C]	190 deg F [87.8 deg C]	182 deg F [83.3 deg C]	Not Used	
Shutterstat	180 deg F [82.2 deg C]	172 deg F [77.8 deg C]	185 deg F [85.0 deg C]	177 deg F [80.6 deg C]	195 deg F [90.6 deg C]	187 deg F [86.1 deg C]
Modulating Fan Lockup	185 deg F [85.0 deg C]		190 deg F [87.8 deg C]		Not Used	
Modulating Shutters Open	175 deg F [79.4 deg C]	190 deg F	190 deg F [87.8 deg C]		195 deg F [90.6 deg C]	

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.

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. 5-42.

Check Crankshaft End Clearance (At Clutch Adjustment)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 5-9. 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 0.022 inch [0.5588 mm].

The check can be made by attaching an indicator to rest against the flywheel/crankshaft while prying against a crankshaft throw through an inspection plate (Fig. 5-43), if the oil pan is not removed. End Clearance must be present with engine mounted in the unit and assembled to transmission, converted or other driven equipment.

Table 5-9: Crankshaft End Clearance — Inch [mm]

New Minimum	New Maximum	Operating Worn Limit
0.007 [0.1778]	0.017 [0.4318]	0.022 [0.5588]

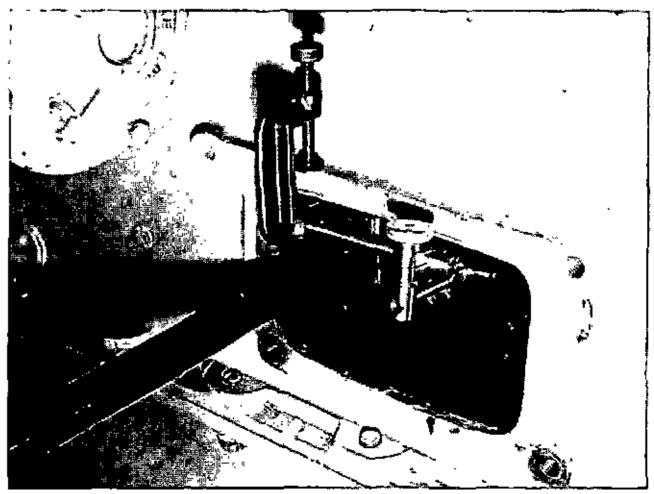


Fig. 5-43, N11957. Checking crankshaft end clearance

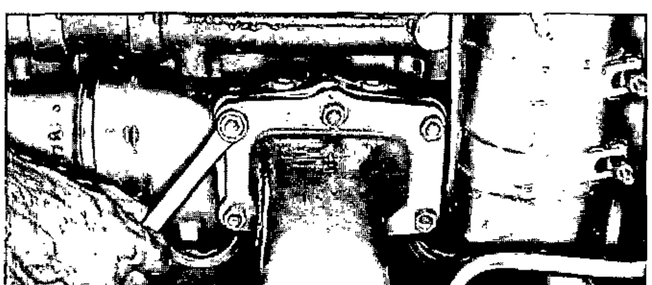


Fig. 5-42, N11953. Tightening T-50 turbocharger mounting nuts

MAINTENANCE OPERATIONS SUMMARY

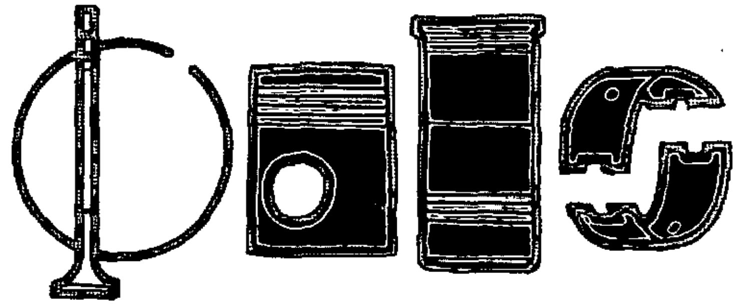
NOTE: INCLUDE SUMMARY OF DAILY "A" REPORTS PERFORMED BETWEEN "B" OPERATIONS IN NEXT "B" REPORT.

ENGINE SERIAL NO.__________

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

Index

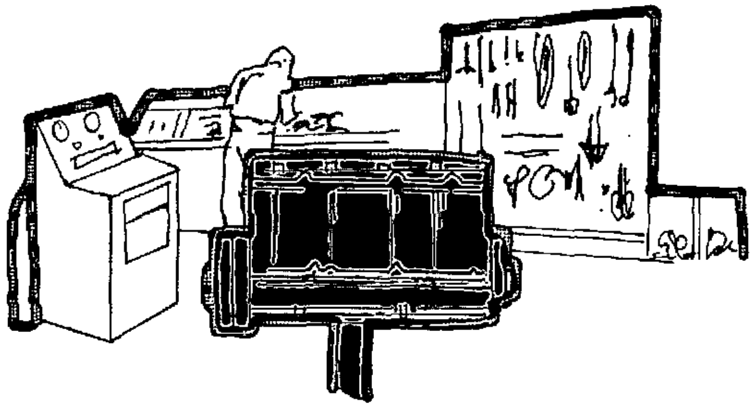
Index



Parts

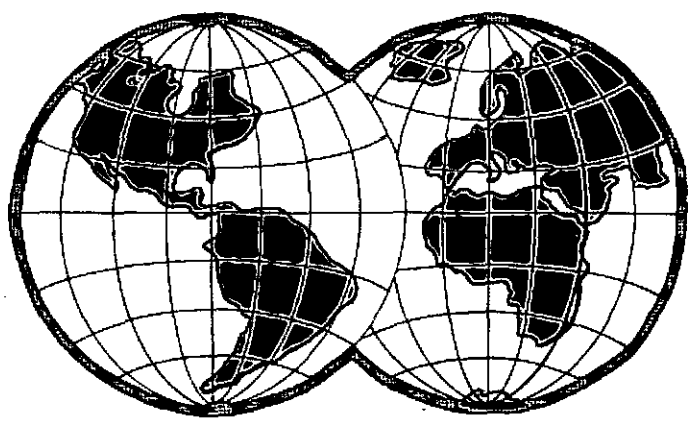
Genuine Cummins service parts are of the same high quality as those used on the original engine so your engine will continue to give good service after any repair or maintenance.

These parts are available only from authorized Cummins Distributors and Dealers, and we urge you to make full use of their parts stocking facilities.



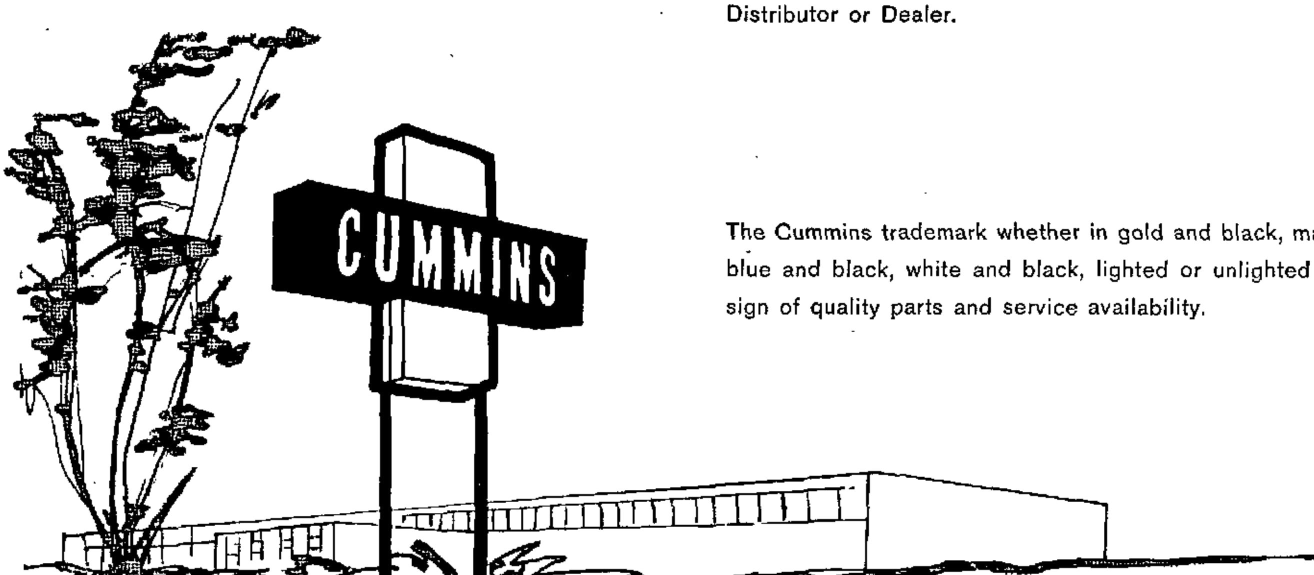
Service

Trained servicemen, special tools and equipment (where required) and an active interest in each customer will make you immediately aware that service is the by-word of the Cummins Distributor and Dealer Organization.



Location

The Cummins Distributor and Dealer Organization reaches to the "far corners" of the world and points in between. Each Distributor or Dealer is a respected businessman from the Locality which he serves; this is an important reason why Cummins Service has gained such an outstanding reputation. For assistance in selecting new engine power, parts and service; see your nearest Cummins Distributor or Dealer.



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Bulletin No. 983698-AE 3-71 Printed in U.S.A.