H, NH
NT series

Cummins Diesels

Operation and Maintenance Manual

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Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Operation and Maintenance Manual

Cummins Diesel H, NH, NT series

Foreword

This manual is applicable to all 4- and 6-cylinder H and NH Series Cummins Diesels currently being produced by Cummins Engine Company, Inc., and subsidiaries. It contains instructions for operators that will enable them to get the best service from their engines. Before operating the engine, become familiar with the procedures described.

The engine models covered can be identified as to design, breathing (if no letter "T" or "S", engine is naturally aspirated), cubic-inch displacement, application and maximum rated horsepower by the following code:

Example: NT-855C335

N = 4-valve head

T = Turbocharged

855 = Cubic-inch displacement

C = Off-Highway Application

335 = Maximum Rated Horsepower

Refer to Tables 1, 2, 3, 4, 5 and 6 for all H and NH Series Engine Specifications.

The maintenance section is for men who are responsible for the upkeep and availability of the engine on the job. The maintenance program is simple, realistic, easy to control and a profitable one to practice.

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.

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

Table of Contents

Principles Of Operation

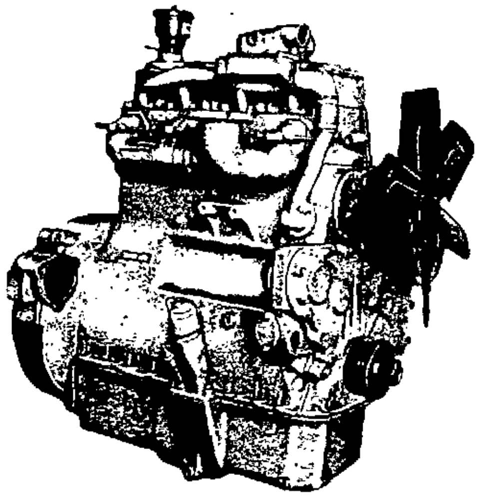
Operating Instructions

Specifications

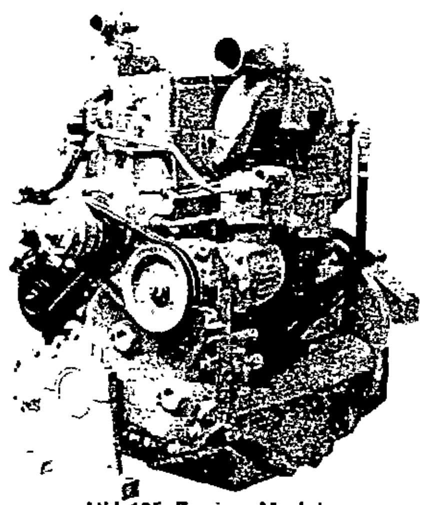
Trouble Shooting

Maintenance Operations

Index



NHC-4 Engine Model



NH-135 Engine Model

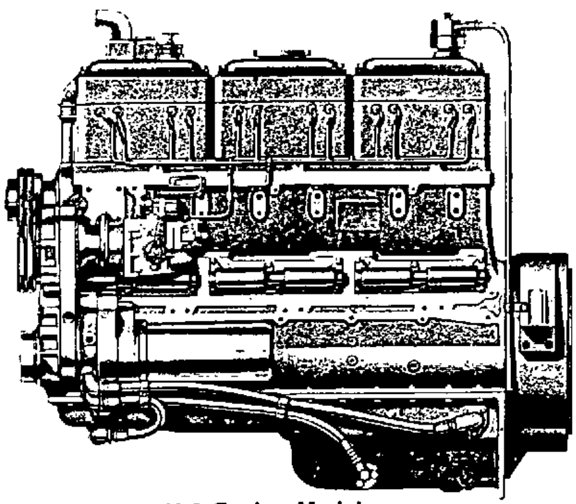
Table 1: Cummins Four-Cylinder Naturally Aspirated and Turbocharged H and NH Series Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Valves Cylinder	Max. HP @ RPM	Engine Breathing
HRC-4	5 1/8x6 [130.175x152.400]	495 [8111.64]	2	115 @ 1800	Naturally Aspirated
NHC-4, N495P130	5 1/8x6 [130.175x152.400]	495 [8111.64]	4	130 @ 2000	Naturally Aspirated
*NH-135	5 1/2x6 [139.700x152.400]	570 [9340.68]	4	135 @ 2100	Naturally Aspirated
*NH-160	5 1/2x6 [139.700x152.400]	570 [9340.68]	4	160 @ 2100	Naturally Aspirated
NT-165	5 1/8x6 [130.175x152.400]	495 [8111.64]	4	165 @ 2000	Turbocharged

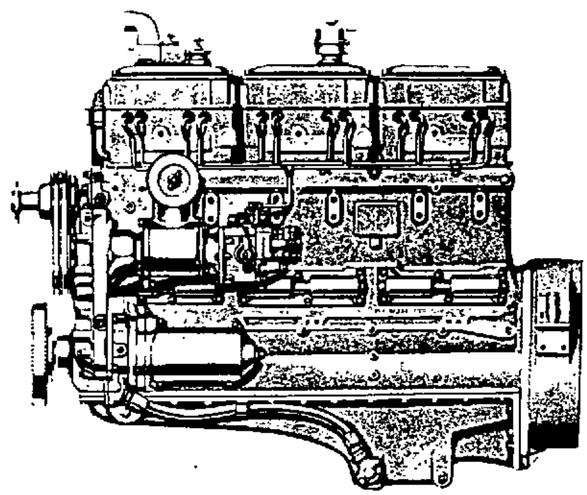
1. Horsepower ratings (stated in U. S. values) established at 29.92 In./Hg [759.968 mm/Hg] barometric pressure (sea level), 60 deg F [15.5 deg C] air intake temperature, dry air. Derate naturally aspirated engines 3% for each 1000 ft [304.800 m] above sea level and 1% for each 10 deg F [5.56 deg C] rise in air temperature.

2. Turbocharged engines are derated 4% for each 1,000 ft [304.800 m] altitude above 12,000 ft [3657.600 m].

* Availa. .e from Shotts, Scotland Factory Only.



H-6 Engine Model



HRF-6 Engine Model

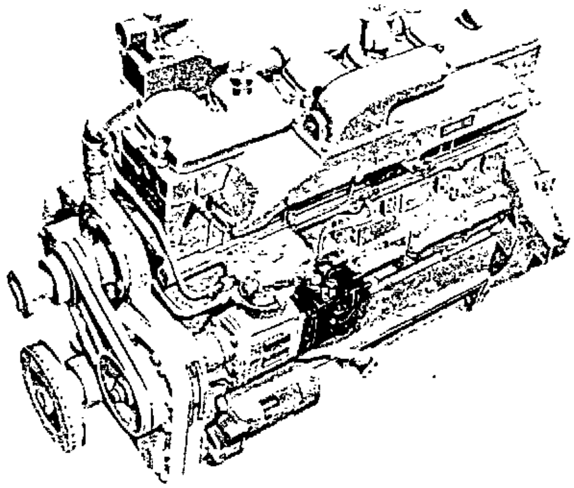
Table 2: Cummins Six-Cylinder Naturally Aspirated and Supercharged H Series Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Valves Cylinder	Max. HP @ RPM	Engine Breathing
H-135, H672C135	4 7/8x6 [123.825x152.400]	672 [11014.08]	2	135 @ 1800	Naturally Aspirated
H-6, H672B160	4 7/8x6 [123.825x152.400]	672 [11014.08]	2	160 @ 1800	Naturally Aspirated
•HU-170	4 7/8x6 [123.825x152.400]	672 [11014.08]	4	170 @ 1800	Naturally Aspirated
HR-6, H743P175	5 1/8x6 [130.175x152.400]	743 [12177.77]	2	175 @ 1800	Naturally Aspirated
HRF-6, H743B190	5 1/8x6 [130.175x152.400]	743 [12177.77]	2	190 @ 2000	Naturally Aspirated
HS-6,H672B210	4 7/8x6 [123.825x152.400]	672 [11014.08]	2	210 @ 1800	Supercharged
HRS-6, H743B240	5 1/8x6 [130.175x152.400]	743 [12177.77]	2	240 @ 1800	Supercharged

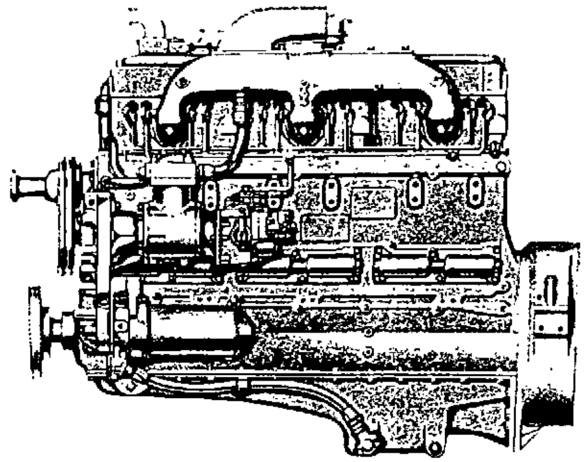
1. Ratings established at 29.92 In./Hg [759.968 mm/Hg] barometric pressure (sea level), 60 deg F [15.5 deg C] air intake temperature, dry air.

2. Derate naturally aspirated and supercharged engines 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.

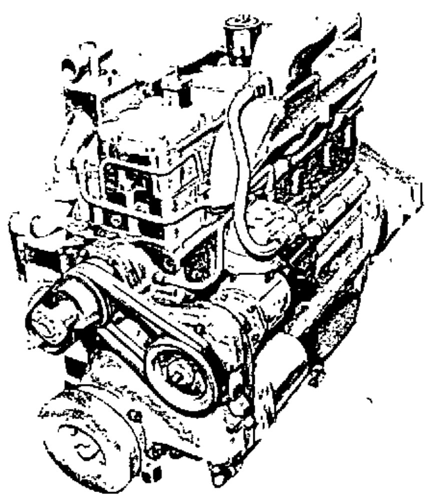
• Available from Shotts, Scotland Factory Only.



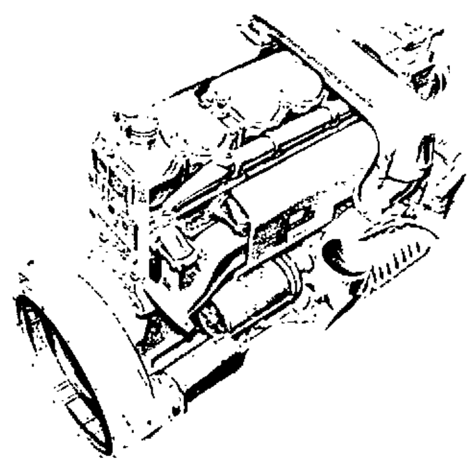
NH-180 Engine Model



NH-220 Engine Model



NH-250 Engine Model



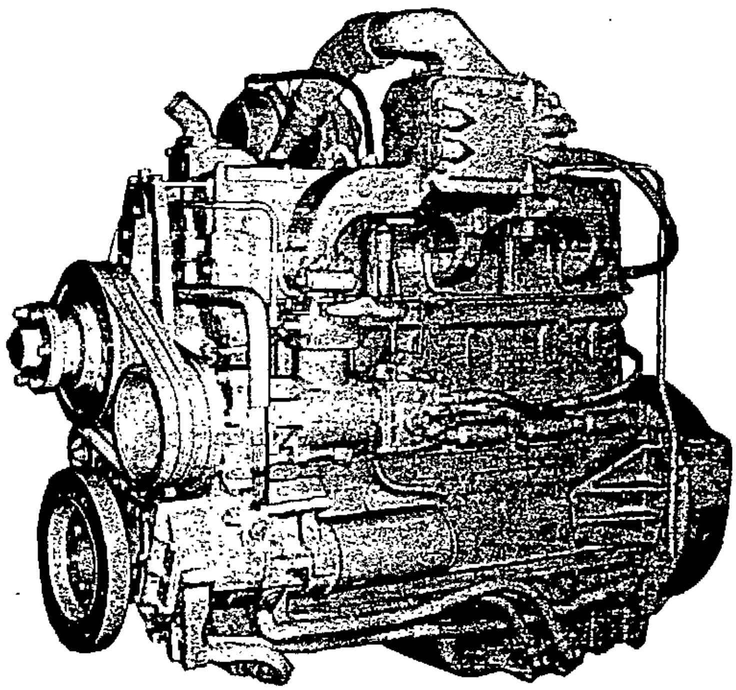
NHRS-6 Engine Model

Table 3: Cummins Six-Cylinder Naturally Aspirated and Supercharged NH Series Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Valves Cylinder	Max. Hp @ RPM	Engine Breathing
NH-180	4 7/8x6 [123.825x152.400]	672 [11014.08]	4	180 @ 2100	Naturally Aspirated
NHE-180	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	180 @ 1950	Naturally Aspirated
NHE-195	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	195 @ 1950	Naturally Aspirated
NH-220, N743B220	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	220 @ 2100	Naturally Aspirated
NHE-225, N855B225	5 1/2x6 [139.700x152.400]	855 [14012.45]	4	225 @ 1950	Naturally Aspirated
NH-230, N855B230 NH230-D	5 1/2x6 [139.700x152.400]	855 [14012.45]	4	230 @ 2100	Naturally Aspirated
NH-250, N855B250	5 1/2x6 [139.700x152.400]	855 [14012.45]	4	250 @ 2100	Naturally Aspirated
NHS-6, N743B290	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	290 @ 2100	Supercharged
NHRS-6, N743B320	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	320 @ 2100	Supercharged

1. Ratings established at 29.92 In./Hg [759.968 mm/Hg] barometric pressure (sea level), 60 deg F [15.5 deg C] air intake temperature, dry air.

2. Derate 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.



NT-380 Engine Model

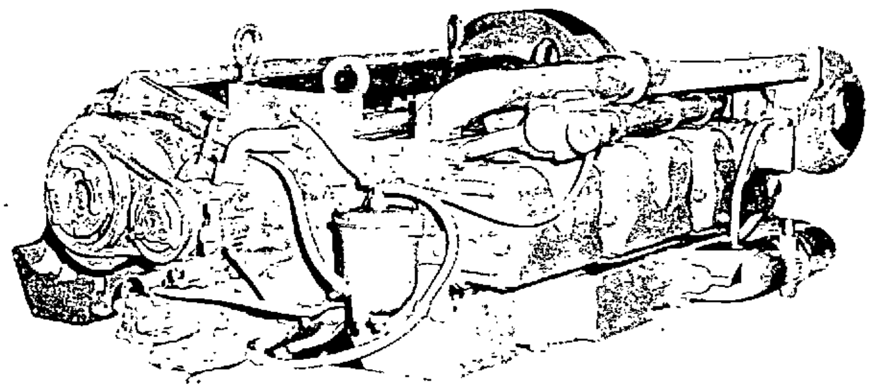
Table 4: Cummins Six-Cylinder Turbocharged NH Series Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Max. HP @ RPM	Begin Derate @ Altitude
NTE-235, NT743B235	5 1/8x6 [130.175x152.400]	743 [12177.77]	235 @ 2100	14,500
NT-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	250 @ 2100	12,000
NTO-6, NT743B262	5 1/8x6 [130.175x152.400]	743 [12177.77]	262 @ 2100	12,000
NT-270	5 1/2x6 [139.700x152.400]	855 [14012.45]	270 @ 2100	12,000
NT-280, NT855B280	5 1/2x6 [139.700x152.400]	855 [14012.45]	280 @ 2100	12,000
NT-300	5 1/2x6 [139.700x152.400]	855 [14012.45]	300 @ 2100	12,000
NRT-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	300 @ 2100	12,000
NT-310	5 1/2x6 [139.700x152.400]	855 [14012.45]	310 @ 2100	12,000
NRTO-6, NT743B335	5 1/8x6 [130.175x152.400]	743 [12177.77]	335 @ 2100	5,000
NT-335, NT855B335	5 1/2x6 [139.700x152.400]	855 [14012.45]	335 @ 2100	7,500 (T-590), 12,000 (T-50)
NT-380, NT855B380	5 1/2x6 [139.700x152.400]	855 [14012.45]	380 @ 2300	8,000
* NT-400	5 1/2x6 [139.700x152.400]	855 [14012.45]	400 @ 2300	2,000

Turbocharged engines are derated 4% for each 1,000 ft [304.800 m] altitude above listing in table.

* Available from Shotts, Scotland Factory Only.

NHH-220 Engine Model

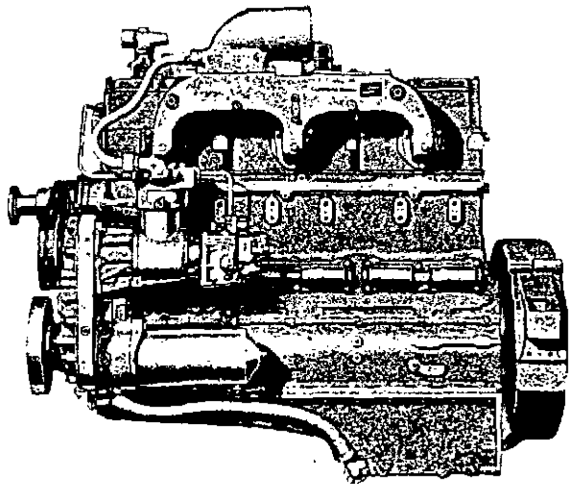


NHHRTO-6 Engine Model

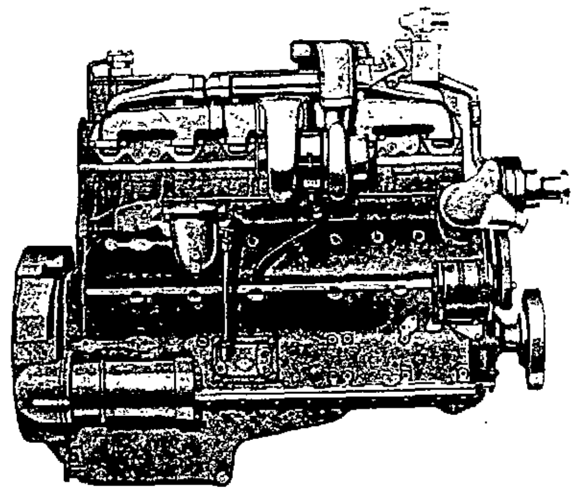
Table 5: Cummins H and NH Horizontal Engines

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Valves Cylinder	Max. HP @ RPM	Engine Breathing
HHR-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	2	175 @ 1800	Naturally Aspirated
HHRF-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	2	190 @ 2000	Naturally Aspirated
NHH-180	4 7/8x6 [123.825x152.400]	672 [11014.08]	4	180 @ 2100	Naturally Aspirated
NHHE-180	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	180 @ 1950	Naturally Aspirated
NHHE-195	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	195 @ 1950	Naturally Aspirated
NHH-220	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	220 @ 2100	Naturally Aspirated
NHHRS-6.	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	320 @ 2100	Supercharged
NHHT-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	250 @ 2100	Turbocharged
NHHTO-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	262 @ 2100	Turbocharged
NHHRT-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	300 @ 2100	Turbocharged
NHHRTO-6	5 1/8x6 [130.175x152.400]	743 [12177.77]	4	335 @ 2100	Turbocharged

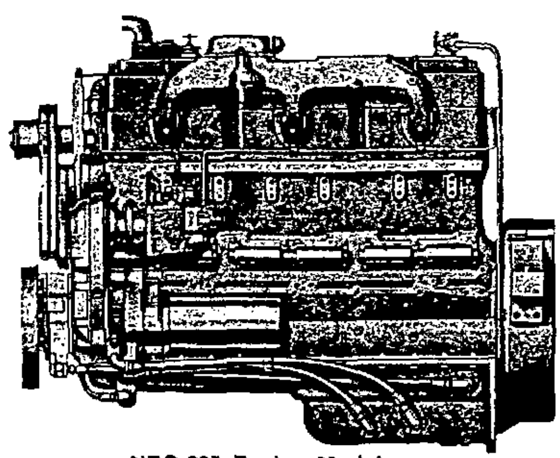
See previous Tables 2, 3 and 4 for engine derating specifications, which are the same as corresponding "vertical" engine models.



NHC-250 Engine Model



NHCT-270 Engine Model



NTC-335 Engine Model

Table 6: Cummins Custom-Rated Diesels

Engine Model	Bore & Stroke In. [mm]	Displ. Cu. In. [cc]	Max. HP @ RPM	Engine Breathing	Begin Derate @ Altitude *
NHC-250	5 1/2x6 [139.700x152.400]	855 [14012.45]	225 @ 2100	Naturally Aspirated	Sea Level
NHC-250	5 1/2x6 [139.700x152.400]	855 [14012.45]	250 @ 2100	Naturally Aspirated	Sea Level
NHCT-270	5 1/2x6 [139.700x152.400]	855 [14012.45]	240 @ 2100	Turbocharged	12,000
NHCT-270	5 1/2x6 [139.700x152.400]	855 [14012.45]	255 @ 2100	Turbocharged	12,000
NHCT-270	5 1/2x6 [139.700x152.400]	855 [14012.45]	270 @ 2100	Turbocharged	12,000
**NHCT-270-CT	5 1/2x6 [139.700x152.400]	855 [14012.45]	240 @ 2100	Turbocharged	12,000
NTC-335	5 1/2x6 [139.700x152.400]	855 [14012.45]	260 @ 2100	Turbocharged	12,000
NTC-335	5 1/2x6 [139.700x152.400]	855 [14012.45]	280 @ 2100	Turbocharged	11,000 (T-590), 12,000 (T-50)
NTC-335	5 1/2x6 [139.700x152.400]	855 [14012.45]	300 @ 2100	Turbocharged	10,000 (T-590), 12,000 (T-50)
NTC-335	5 1/2x6 [139.700x152.400]	855 [14012.45]	320 @ 2100	Turbocharged	8,500 (T-590), 12,000 (T-50)
NTC-335	5 1/2x6 [139.700x152.400]	855 [14012.45]	335 @ 2100	Turbocharged	7,500 (T-590), 12,000 (T-50)
NT-350	5 1/2x6 [139.700x152.400]	855 [14012.45]	350 @ 2100	Turbocharged	10,000 (T-50)

*With T-50 Turbo except as noted.
**Custom torque.

Operating Principles

The most satisfactory 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 other 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.

Intake Stroke

During the intake stroke, the piston travels downward, the intake valve is open, and the exhaust valve is closed. Some engines have dual intake and exhaust valves as indicated on preceding pages.

The downstroke of the piston permits air from outside to enter the cylinder through the open intake valve port. On engines where used, the supercharger or 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 valve closes and the piston starts upward on the compression stroke. The exhaust valve remains 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 after the fuel charge is injected into the combustion chamber, 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.

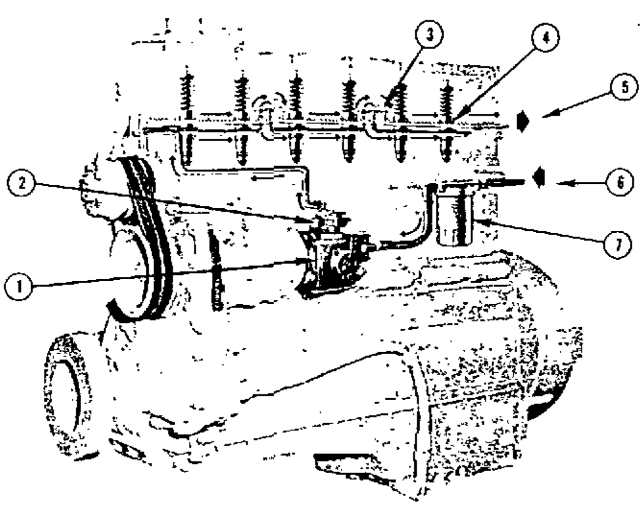
Proper engine operation depends upon two things—first, compression for ignition; and second, that fuel be measured and injected into the cylinder in the proper quantities and at the proper time.

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 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.



(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 and drain lines and 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.

PT (type G) Fuel Pump

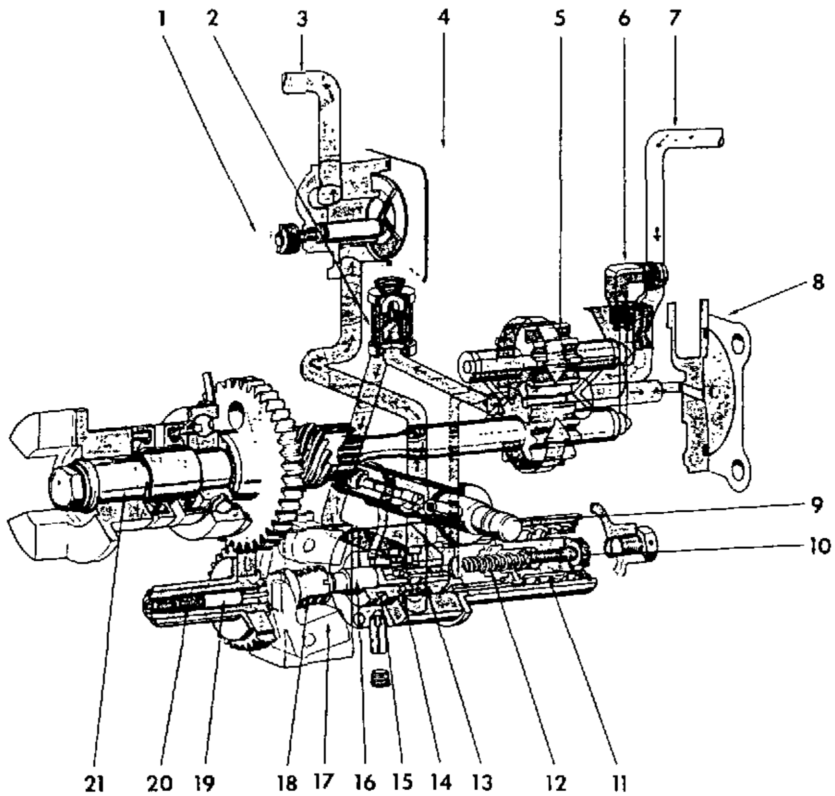
The PT (type G) fuel pump can be identified by the absence of the return line at the top of the fuel pump. The pump assembly is made up of three main units:

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. The location of fuel pump components is indicated in Figs. 1-2 and 1-3.

PT (type R) Fuel Pump

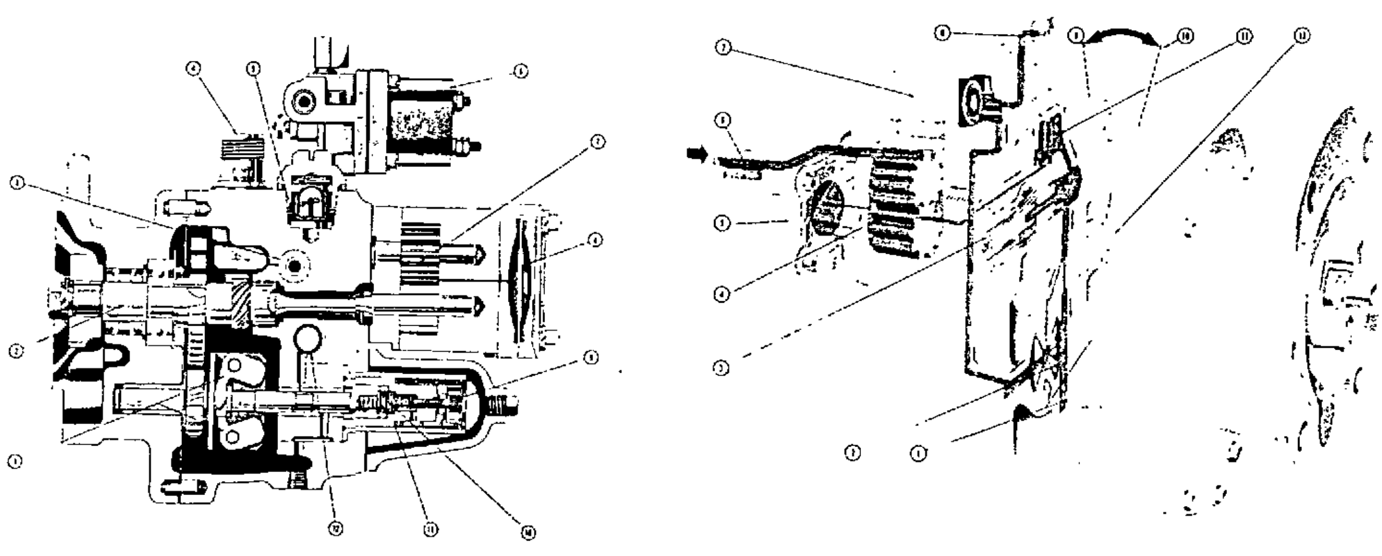
The PT (type R) fuel pump can be identified easily by the presence of a fuel return line from the top of the fuel pump housing to the supply tank. The pump assembly is made up of four main units:

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



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 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.

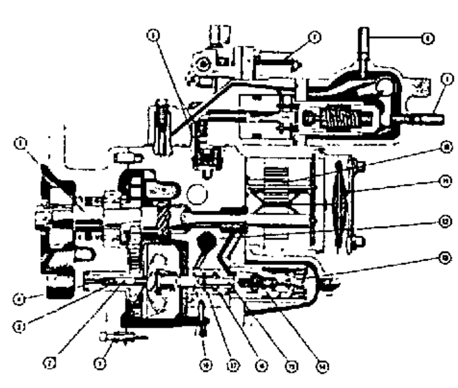
Governors

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.



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

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

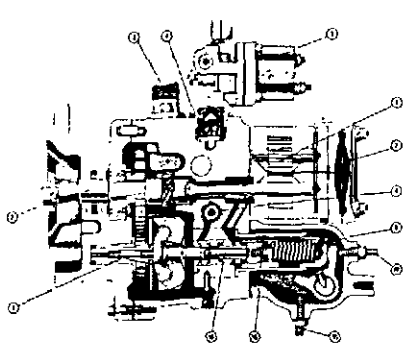


Fig. 1-5, FWC 10. PT (type G) fuel pump with SVS governor

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 replaced 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.

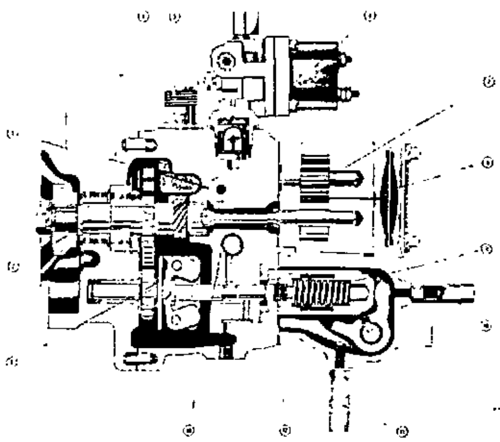


Fig. 1-6, FWC 7. PT (type R) fuel pump with MVS governor

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 over-speed 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

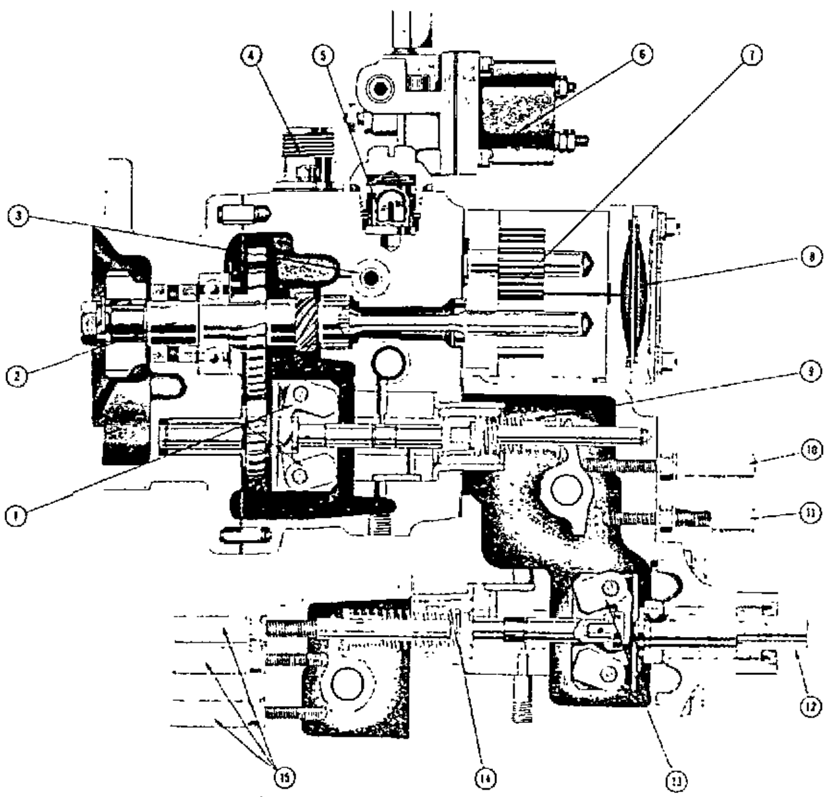
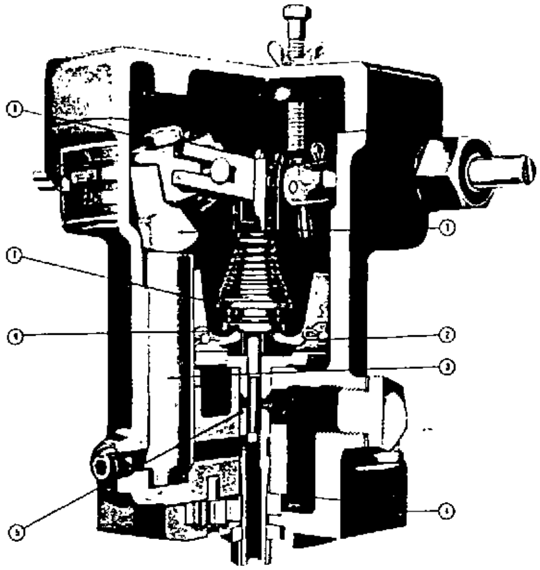
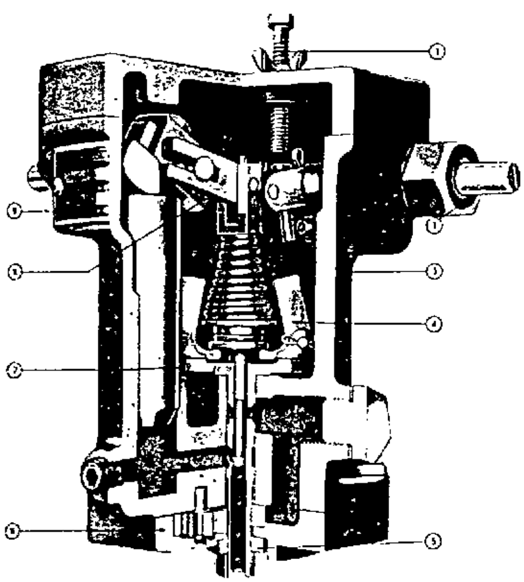


Fig. 1-7, FWC 8. PT (type R) fuel pump with torque converter governor



(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.

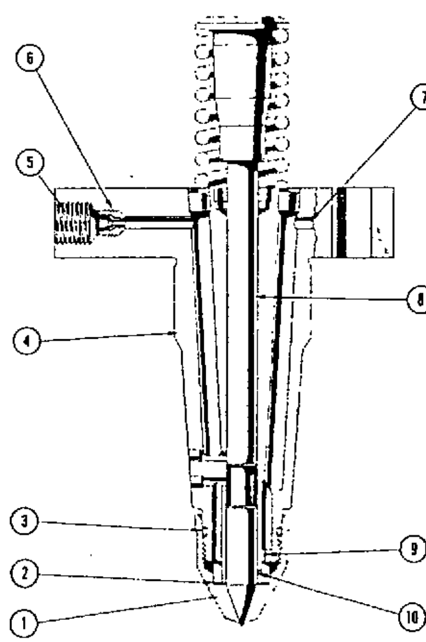
Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Two types of injectors—flanged and cylindrical—are found in H-NH Series Engines.

Flanged Injector

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

As the plunger rises, the metering orifice is uncovered and part of the fuel is metered into the cup. At the same time, the rest of the fuel flows out of the drain orifice. The amount of fuel passing through the metering orifice and into the cup is controlled by fuel pressure and timing. Fig. 1-10.



(1) CUP
(2) GASKET
(3) SEAL
(4) INJECTOR BODY
(5) INLET
(6) ORIFICE PLUG
(7) DRAIN
(8) PLUNGER
(9) DRAIN ORIFICE
(10) METERING ORIFICE

Fig. 1-10, FWC 11A. Flanged PT injector

During injection, the plunger is forced downward until the metering orifice is closed and the fuel in the cup is injected into the cylinder. While the plunger is seated, all fuel flow through the injector stops. Fig. 1-11.

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

Cylindrical Injector

When cylindrical injectors are used, fuel supply and drain are accomplished through internal drilled passages in the cylinder head. Fig. 1-1. 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.

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 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.

Functions of the PT (type B) and PT (type D) shown in Fig's. 1-12 and 1-13 are identical; however, PT (type D) design change provides greater parts interchangeability and those areas subject to wear are localized in small parts for

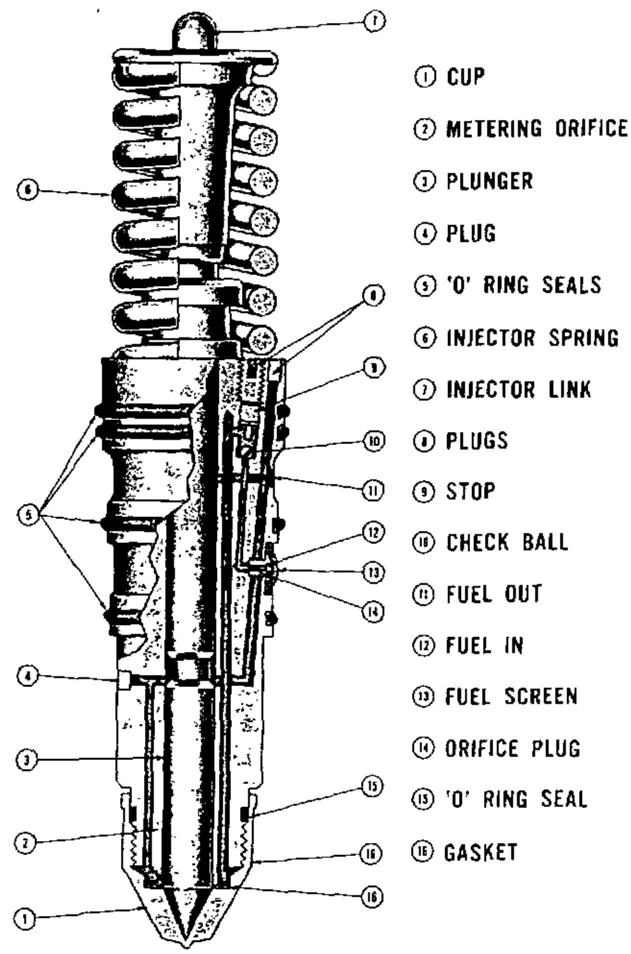


Fig. 1-12, FWC 14. Cylindrical PT (type B) injector

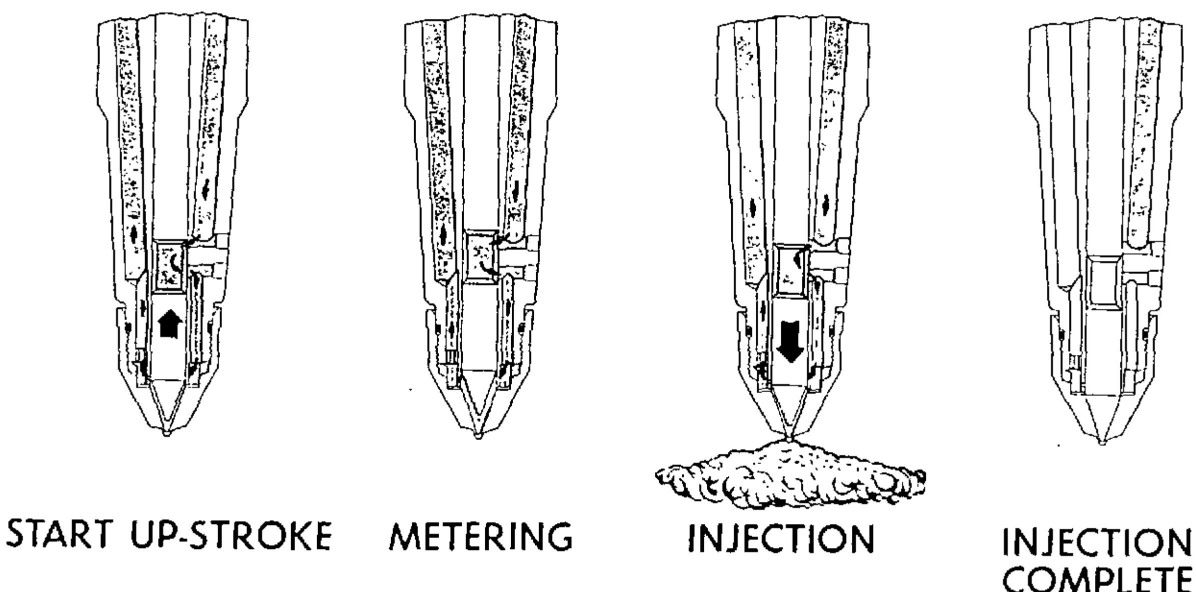


Fig. 1-11, FWC 11B. Fuel injection cycle — flanged PT injector

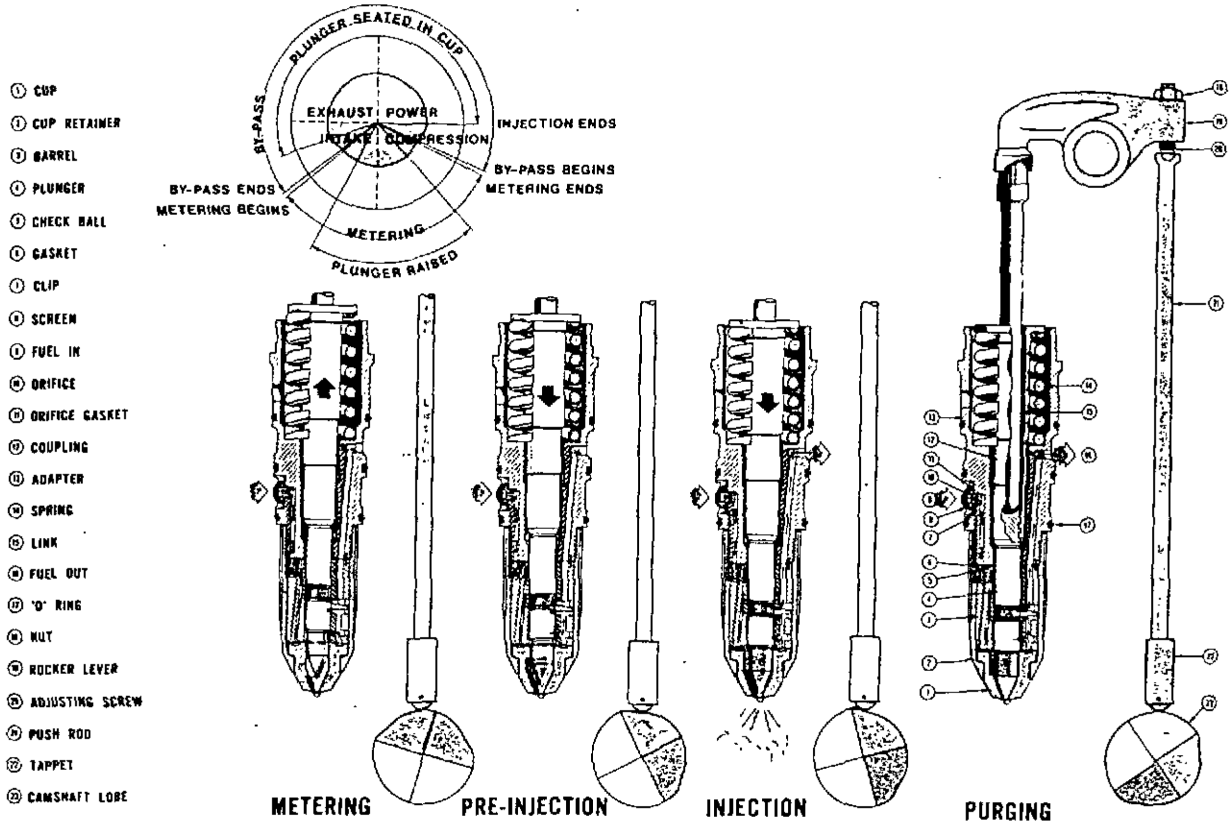


Fig. 1-13. FWC 28. Fuel injection cycle — PT (type D) cylindrical injector

easier servicing. Engines with PT (type B) can be changed to PT (type D) injectors by replacing the complete engine set.

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

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

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.

Connections

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

NH engines using cylindrical injectors have fuel connectors between the heads to bridge the gap between each cylinder head supply and drain passage. Fig. 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.

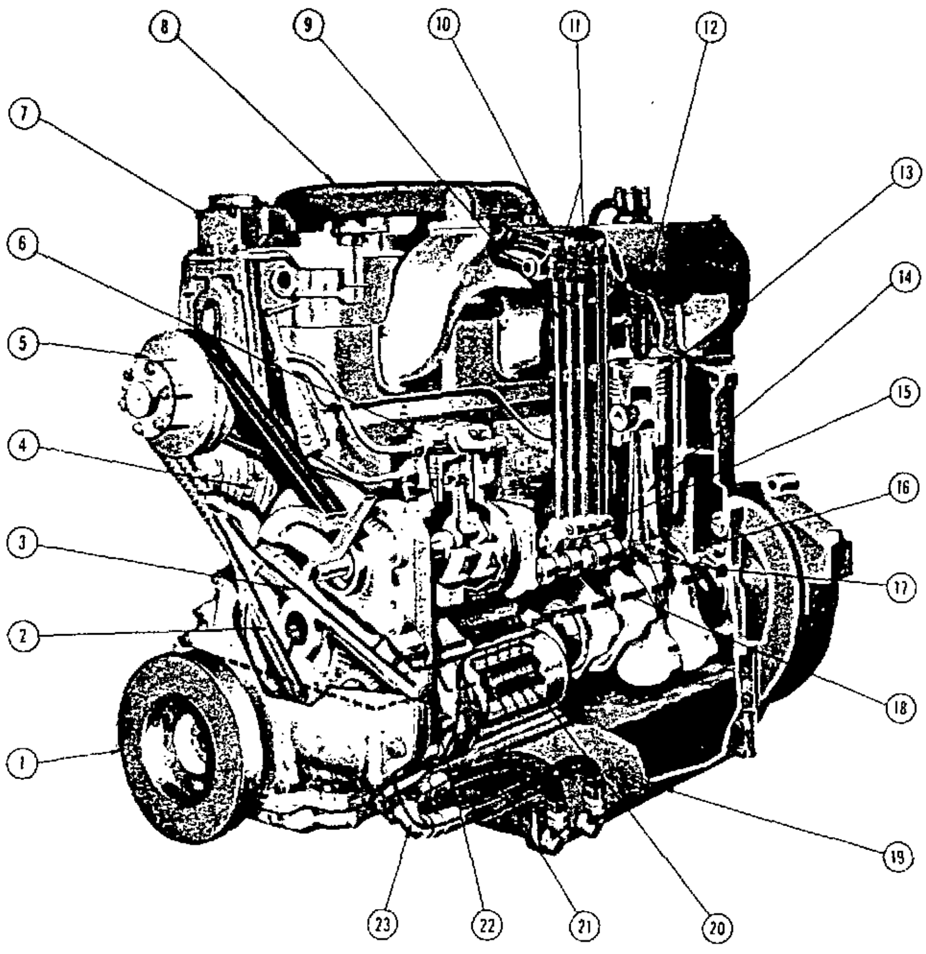
With the electric valve, the manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through the valve.

Lubricating System

Cummins H and NH Series Engines are pressure lubricated. The pressure is supplied by a gear-type lubricating oil pump located on the fuel pump side of the engine.

A by-pass valve is provided in the full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

1. 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.
2. Oil flows from the pump through a full-flow filter and back into a pump-to-block connection. The filter may be either bracket-mounted to the block or mounted directly to the rear of the pump. External lines are used in the bracket-mounted arrangement.
3. On IOL engines the filtered oil then flows from the pump connection to the oil cooler and from the cooler back to the oil header through internal drillings in the gear case. On EOL engines, oil flow from pump-to-cooler-to-oil header is accomplished by external lines. Fig. 1-14.



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

Fig. 1-14, LWC18. Lubricating oil flow - NT-380 Engine (fuel pump side)

Note: The identifying letters "IOL" and "EOL" are abbreviations for "Internal Oil Line" and "External Oil Line".

4. An oil header, drilled the full length of the block on the fuel pump side, delivers oil to moving parts within the engine.

5. Oil pipes—or a combination of pipes and passages—carry oil from the camshaft to upper rocker housings, and various drillings through the block, crankshaft, connecting rods and rocker levers complete the oil circulating passages.

6. On engines equipped with piston oil cooling, an oil header drilled the length of the block, on the manifold side, supplies oil to spray nozzles used for cooling pistons. A piston-cooling oil pump, located on the gear case cover, or as an additional section on the standard pump, pumps this oil to the cooler and from the cooler to the header.

7. Lubricating oil pressure is controlled by a regulator located in the lubricating oil pump.

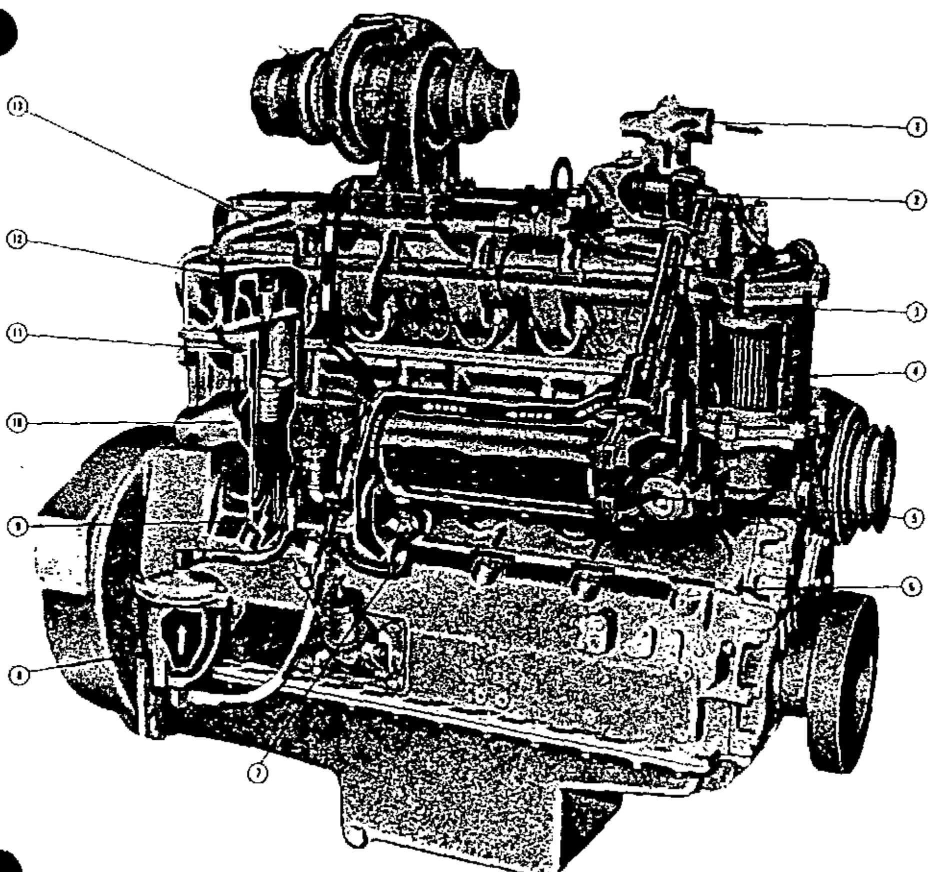
Cooling System

Water is circulated by a centrifugal-type water pump mounted on the gear cover end of the engine and driven by belts from the accessory drive. Fig. 1-15.

The water circulates around the wet-type cylinder liners, through the cylinder head and around the injector sleeves. The injector sleeves in which the injectors are mounted are copper for fast dissipation of heat. Discharge connections between the heads are provided by a water manifold. The water manifold houses a single thermostat to control engine operating 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 sea water pump is mounted on the engine.



1. WATER TO RADIATOR
2. THERMOSTAT
3. WATER BY-PASS
4. LUBRICATING OIL FILTER
5. LUBRICATING OIL COOLER
6. LUBRICATING OIL HEADER
7. WATER FROM RADIATOR
8. CORROSION RESISTOR
9. PISTON COOLING OIL
10. WATER HEADER
11. WATER JACKET
12. HEAD WATER PASSAGE
13. WATER MANIFOLD

Fig. 1-15, LWC19. Coolant and lubricating oil flow - NT-380 Engine (exhaust manifold side)

Air System

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

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

The HRS, NHS and NHRS engines have superchargers; the NT, NTO, NRT, NTC, NHCT and NRTO engines are equipped with turbochargers.

Supercharger

A supercharger is a gear-driven air pump which employs rotors to force air into the engine cylinders. The supercharger is driven from the engine crankshaft through a gear train turning at about 1.8 times engine speed. Fig. 1-16.

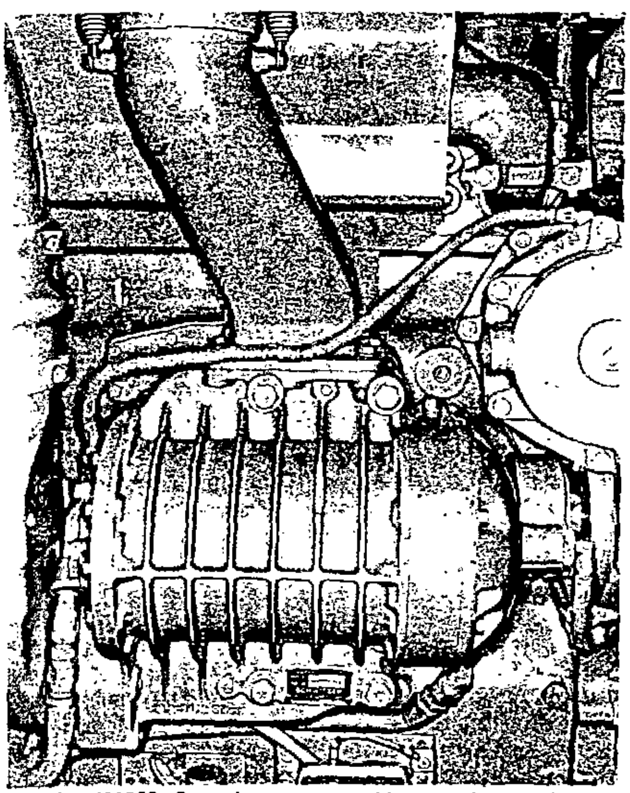


Fig. 1-16, N11028. Supercharger mounted in operating position

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.

The power to drive the turbine wheel—which in turn drives the compressor—is obtained from the energy of the engine exhaust gases. The rotating speed of the turbine changes as the energy level of the gas changes so the engine is supplied with enough air to burn the fuel for its load requirement. Fig. 1-17.

The turbocharger is lubricated and cooled by engine oil which is filtered by a separate oil filter.

Note: On turbocharged engines equipped with water-cooled exhaust manifolds, never operate the engine with the manifold "dry". This will result in overspeeding and eventual turbocharger failure.

Air Compressor

The Cummins Air Compressor is driven from the engine by integral crankshaft and accessory drive or by belt. Lubrication is received from the engine lubrication system, with the oil carried by internal drillings or external lines. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

Air is drawn into the compressor from a separate filter or

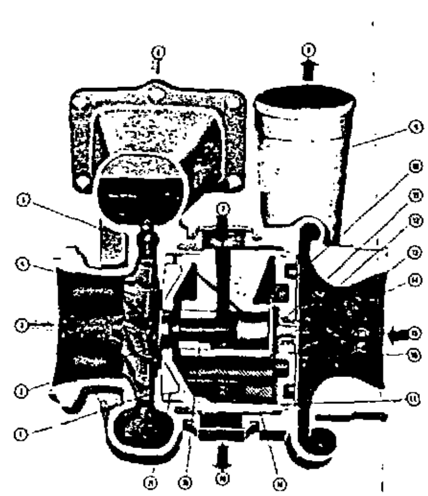


Fig. 1-17, AWC 6. Turbocharger exhaust gas and air flow from the engine air system after the air cleaner. As the piston moves down, a partial vacuum occurs above the piston. The difference in cylinder pressure and atmospheric pressure forces the inlet valve down from its seat, allowing air to flow through the intake port and into the cylinder. When the piston has reached the bottom of its stroke, the spring pressure is sufficient to overcome the lesser pressure differential and forces the valve against its seat. Fig. 1-18.

Compression

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

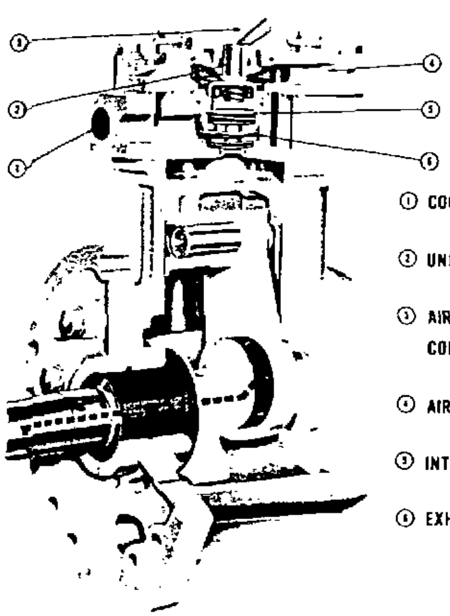


Fig. 1-18, AWC 1. Cummins air compressor

NH Series Dual Diesel

The following paragraphs cover the description, and Page 2-10 the differences in operation, of the NH-220 and NH-250 engines when either is applied as a Dual Diesel, i.e., on road as 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.

Cummins Dual Diesel Cycle Operating As Air Compressor

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 1-19.

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.

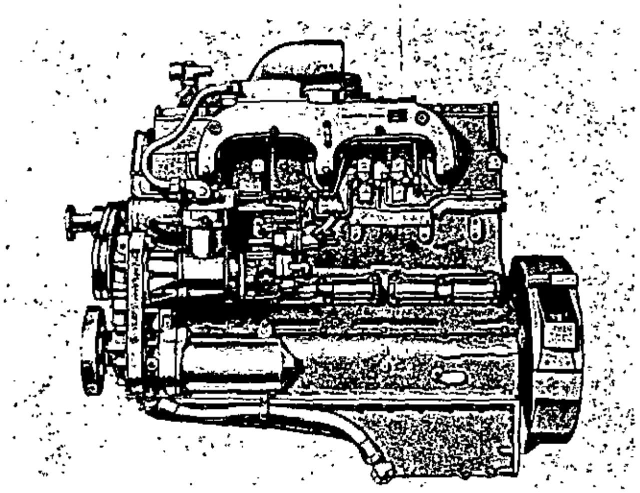


Fig. 1-19, N11952. Fuel line arrangement — NH-250 Dual Diesel Engine

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. 1-20.

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. 1-21.

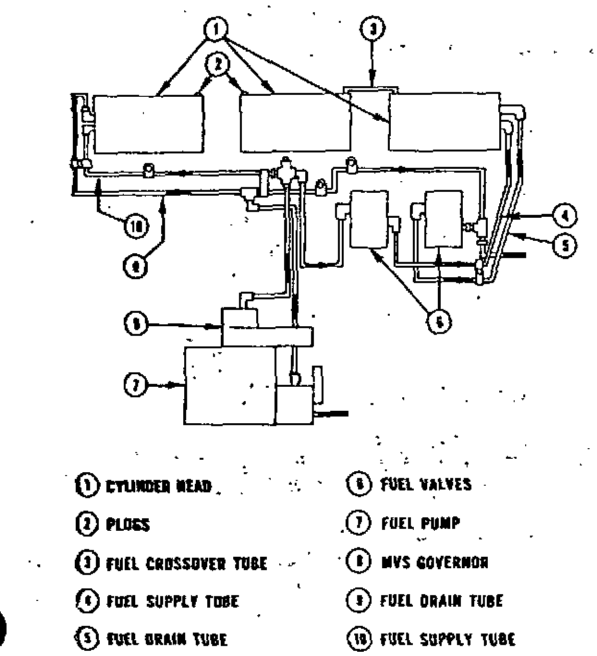


Fig. 1-20, N11830. Fuel line and valve plumbing

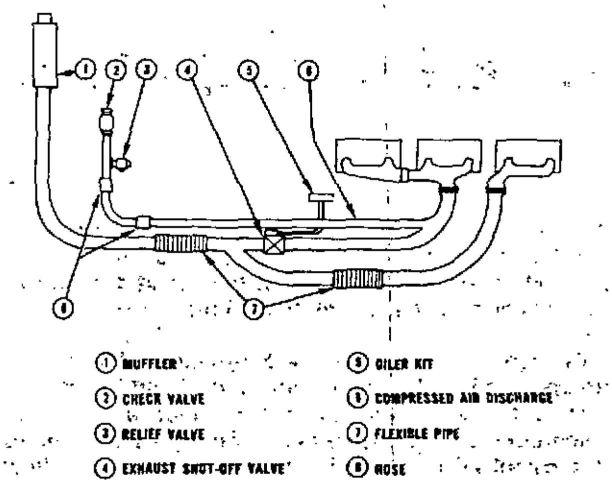


Fig. 1-21, N11831. Dual Diesel schematic

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. 1-21.

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. 1-21. 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.

Operating Instructions

The operator of the engine assumes the responsibility of engine care while it is being worked. 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 the operator must observe to get the best service from the Cummins Diesel. However, if any of these rules are broken, a penalty is certain to follow. The penalty may be in lack of work accomplished because of lowered engine efficiency or it may be in down time and costly repair bills resulting from premature engine failure.

General-All Applications

New 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 3-1.
2. Remove pipe plug from side of cylinder block if bag-type filter element is used; if paper element is used, remove plug on side of lubricating oil pump, Fig. 2-1.
3. Connect a hand- or motor-driven priming pump line from source of clean lubricating oil (see Page 3-1) to oil 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 closed or disconnected to prevent starting), while

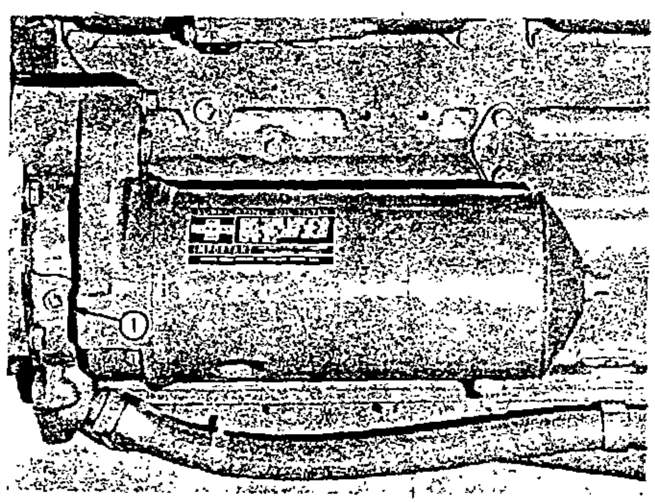


Fig. 2-1, N11927. Lubricating system priming point maintaining external oil pressure at a minimum of 15 psi [1.0545 kg/sq cm].

6. Remove external oil supply and replace plug in cylinder block.

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

7. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications 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, N12004. 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 3-3.

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

3. Tighten fuel manifold fittings; tighten fuel connections to 20/25 in-lb [2.7660/3.4575 kg m].

4. On engines with internal fuel passages in the head, check fuel supply line at front of No. 1 head.

5. Tighten fuel connector mounting screws to 34/38 in-lb [0.3910/0.4370 kg m].

Starting The Engine

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

Normal Starting Procedure

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

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.

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 use the preheater for cold starting:

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

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

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.

4. If engine does not start within 30 seconds, stop cranking.

2-4

Wait one to two minutes and repeat crar

5. After engine starts, pump primer slowl., 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.

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 30/32 (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 supercharger or

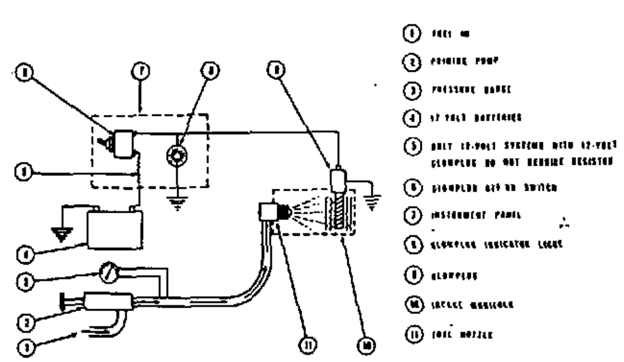


Fig. 2-3, N11804. Preheater wiring diagram

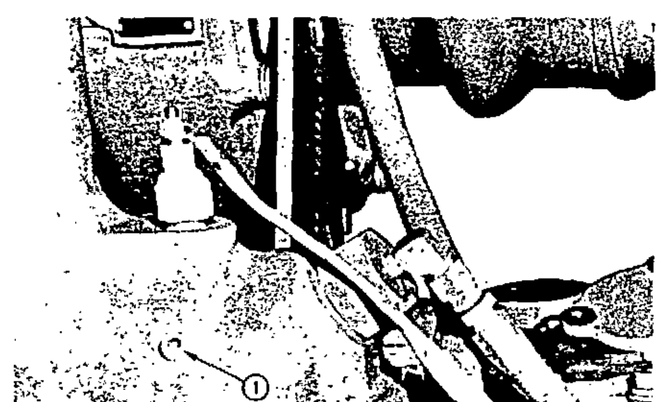


Fig. 2-4, N11949. Glow plug inspection hole plug turbocharger on engines so equipped. On naturally aspirated engines, the metering chamber releases the ether fluid into air intake manifold. To start engines equipped with this cold-starting aid:

1. Close shut-off cock (1, Fig. 2-5). If properly installed, the spring will hold it closed.
2. Remove cap and insert capsule (2) of starting fluid.
3. Push cap (3) 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.

Use Of Ether Without Metering Equipment

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

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

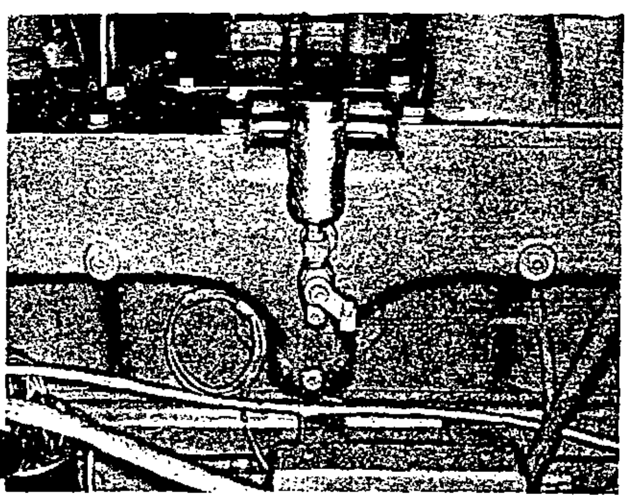


Fig. 2-5, N11841. Ether compound metering equipment

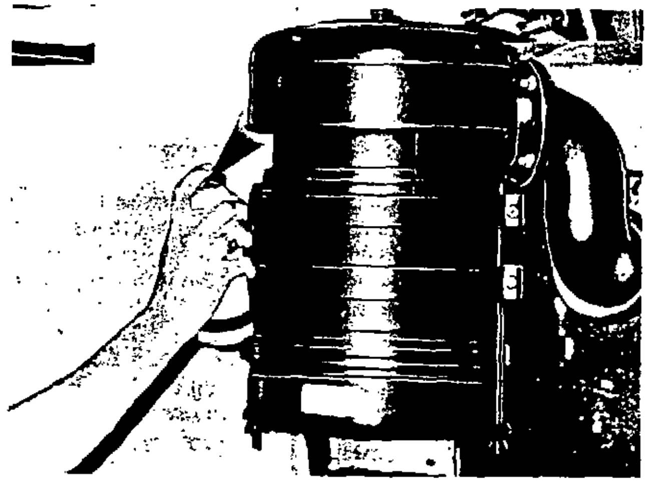


Fig. 2-6, N11807. Ether spray application

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

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

Engine Warm-Up

Warm Up Engine Before Applying Load

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/165 deg F [71.10/73.9 deg C], operate at partial load at approximately 75% of governed rpm.

Engine Speeds

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.

Table 2-1: Engine Speeds

Model Std. Ratings	Rated RPM Full Load
H-6, HU-170	1800
HS-6	1800
HR(C)-4	1800
HR-6,HRS-6	1800
HRF-6, NHC-4	2000
NHE-180, 195	1950
NH-180, NH-135	2100
NH-160	2100
NHR-195	2100
NH-220	2100
NHE-225	1950
NH-250, NHC-250	2100
NT-165	2000
NHRS-6, NHS-6	2100
NH-200, NH-180	2100
NH-230	2100
NTO-6, NT-6	2100
NT-280, NTC-280	2100
NT-310, NHCT-270	2100
NRTO-6, NRT-6	2100
NT-335, NTC-335	2100
NT-380, NT-400	2300
NHCT-270HT	2100

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 Table 2-1 are for engines rated at maximum rpm and fuel rate; many engines, such as generator sets, are set at other values due to equipment being powered or loads applied to equipment and engine.

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 sstisfactory 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

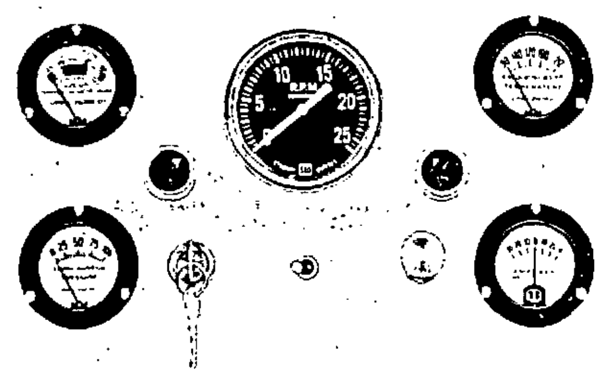


Fig. 2-7, N11808. Instrument panel

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".

Engines should be warmed up slowly before applying full load so that pistons will not expand too fast for the cylinder liners. Many cases of piston and liner scoring start with throwing full load on a cold engine.

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.

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".)

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.

Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil supply 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 . . . . 5/20 psi [0.352/1.7575 kg/sq cm]
At Rated Speed . . . . 30/70 psi [2.1092/4.921 kg/sq cm]

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

Engine Exhaust

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

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

Maximum Horsepower Requirements

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

Let The Engine Idle A Few Minutes Before Shutting It Down

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

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

Do Not Idle Engine For Excessively Long Periods

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

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

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

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 pulling out the manual shut-down lever. Turning off the switch key which controls the electric shut-down valve 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 H-NH Series 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 pulled from 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 adjustments, 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 completely drain cylinder block and head, open petcock or remove drain plug on manifold side of cylinder block at rear of engine, Fig. 2-8. If an air compressor or other "water-cooled" accessory is used, open petcock on unit. Fig 2-9.

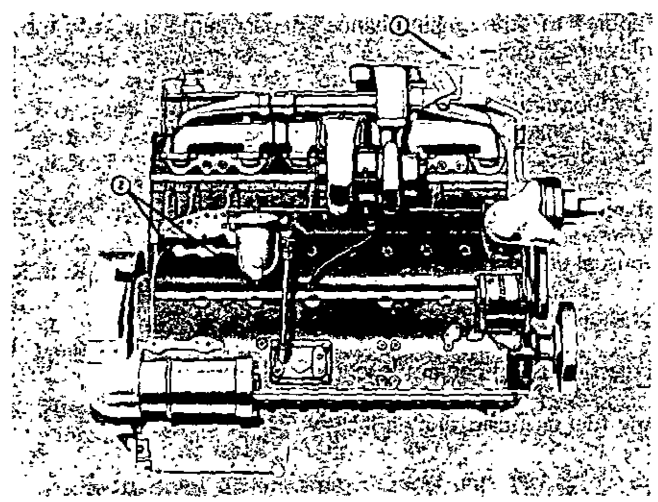


Fig. 2-8, N10001. Engine drain points

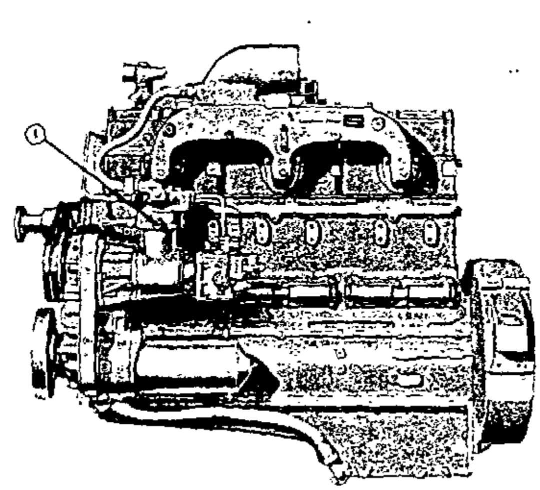


Fig. 2-9, N11827. Air compressor drain point

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 the most satisfaction from its use.

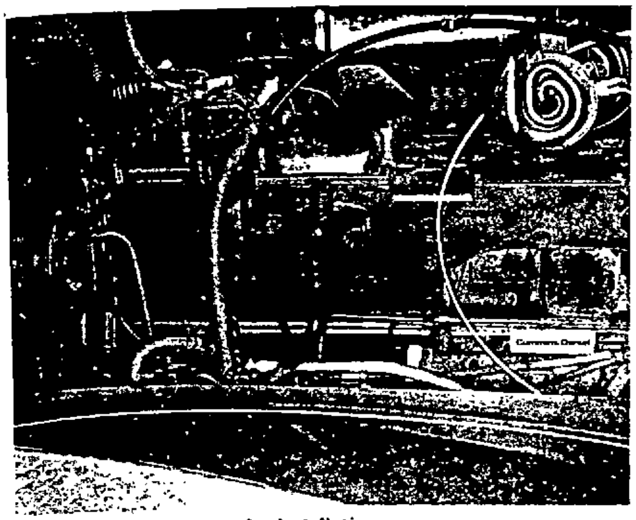
Engine adjustments, etc., are the work of the maintenance department. However, the maintenance department needs daily running reports from the operator to make necessary adjustments in the time alotted between runs and to make provisions for more extensive maintenance work as the reports indicate the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



N1[illegible] Typical automotive installations

Engine break-in, before starting and general operational procedure follows 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 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 transmissions as well as being hard on the engine. 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	2000	1850-1950
All (except CT)	2100	1900-2000
NHCT-270-CT	2100	1600-2000
NT-380	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 up 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 rpm, because these applications use 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.

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 engine speed below rated governed rpm.

Refer to Tables 1 through 5 for most Automotive Engine Specifications.

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 a 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.

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

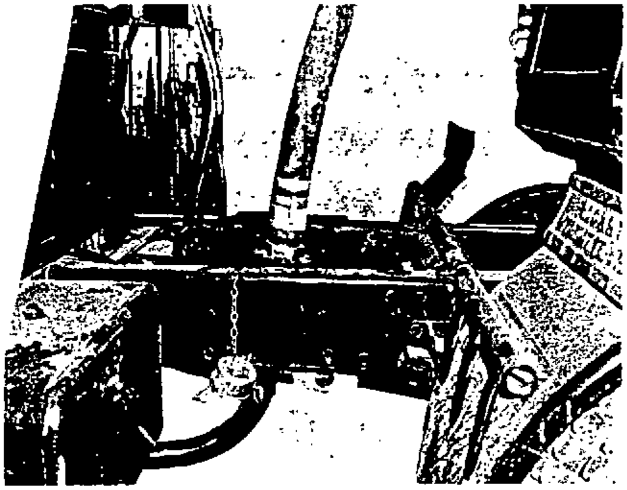


Fig. 2-10, N11832. Compressed-air line connected to trailer

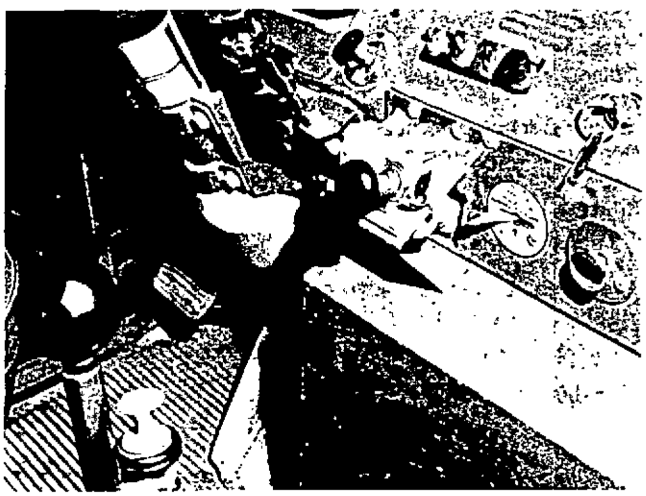


Fig. 2-11, N11833. Dash control in down position

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.**

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-220) and Fig. 2-13 (NH-250) for maximum engine speed required. For example, to obtain a 17 psi [1.1951 kg/sq cm] pressure head, NH-220 can be set at 2100 RPM, which gives a flow of 234 CFM. For the NH-250, a maximum

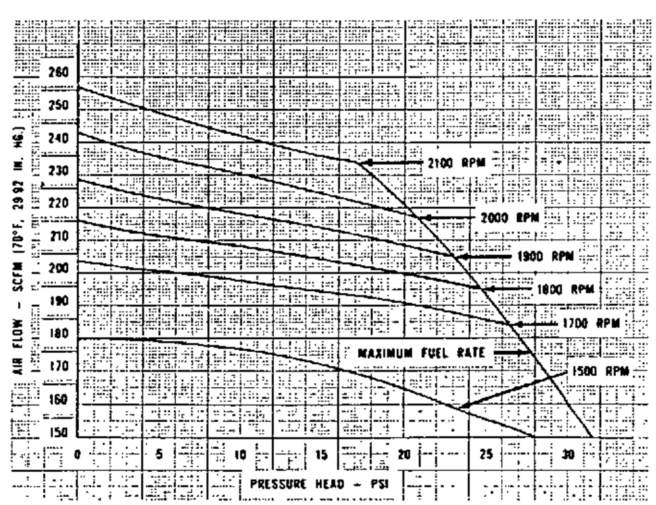


Fig. 2-12, N11837. Air flow — NH-220 Engine

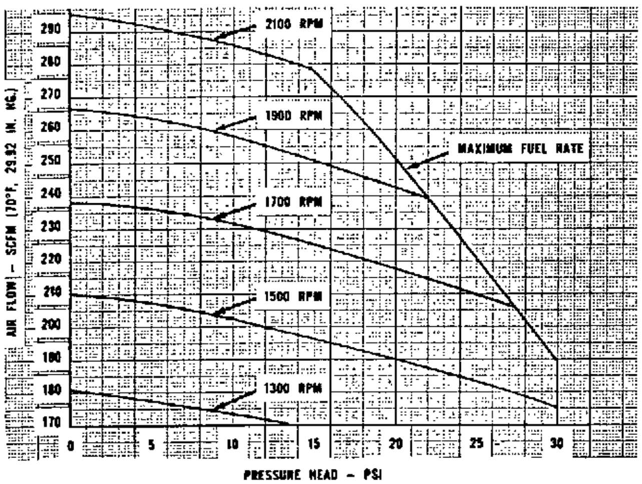


Fig. 2-13, N11838. Air flow – NH-250 Engine

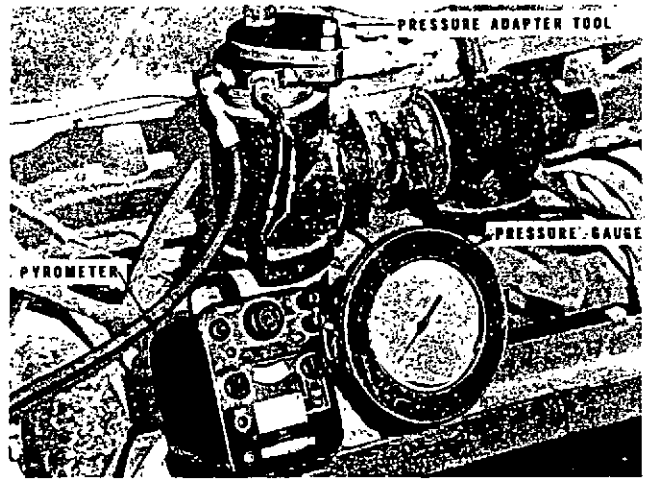


Fig. 2-15, N11834. Pressure adapter tool (with gauges) mounted to vehicle

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].

3. To set MVS governor:

a. Place Pressure Adapter Tool shown in Fig. 2-14 on discharge pipe and connect a pressure gauge and temperature thermocouple as shown in Fig. 2-15.

Note: The Pressure Adapter Tool is not available from Cummins at this time. It can be made from a three-inch pipe, two 1/8-inch pipe couplings and a flat, sliding adjustable cap. Fig. 2-14.

b. Start engine and operate as if pumping.

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's. 2-16 (NH-220) and 2-17 (NH-250) show 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.

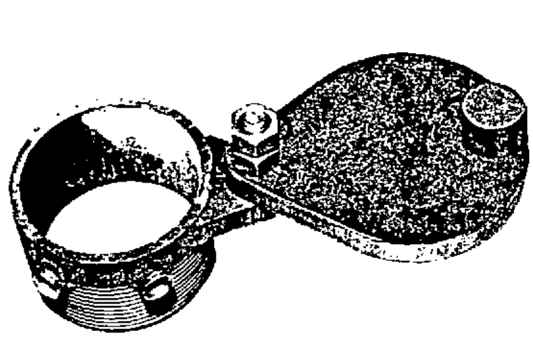


Fig. 2-14, N11835. Pressure adapter tool

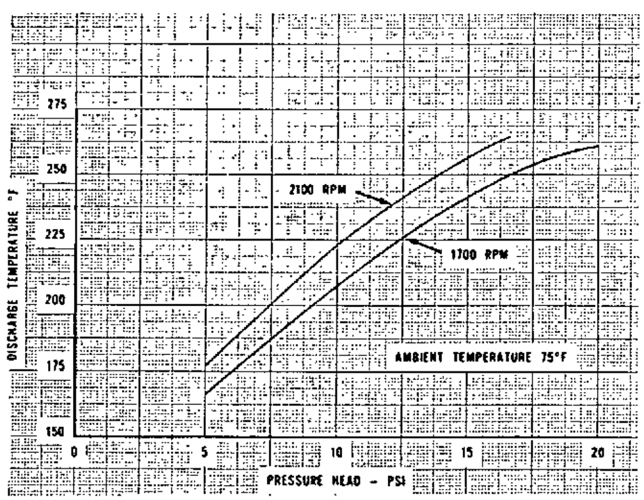


Fig. 2-16, N11839. Air discharge temperature – NH-220 Engine

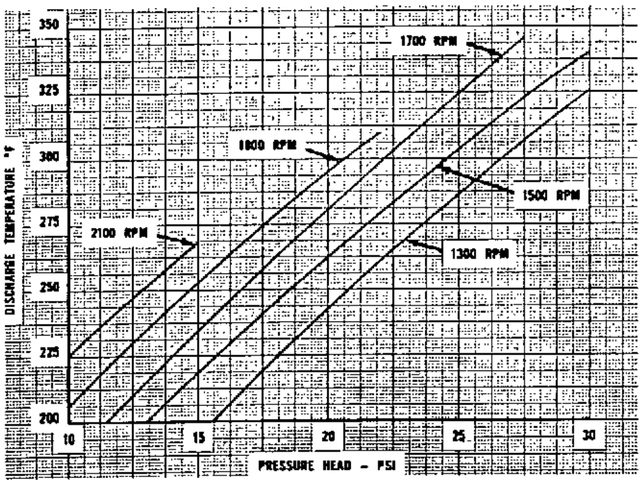


Fig. 2-17, N11840. Air discharge temperature — NH-250 Engine

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.

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

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

Product Contaminated

1. Fuel, oil or water leaking into the pumping cylinders.

Injector Plungers Scored Or Sticking

1. 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.

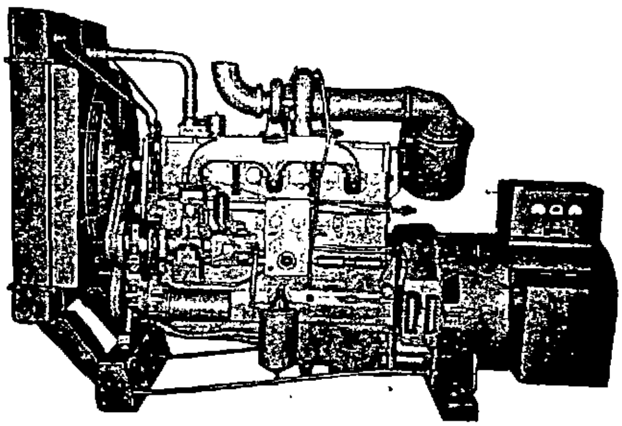
Engine Decelerates Slowly Under Full Diesel Operation

1. 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



N11529. Typical generator set

In addition to the general operating instructions, perform the following.

Before starting: Refer to the applicable Generator Set Manual, Cummins GS/GC Generator Sets, Bulletin No. 983600-B.

1. Open main power disconnect switch from load line.
2. Check electrical connections.
3. Lubricate generator end bearing as stated on generator.

Check Hydraulic Governor

Refer to applicable Governor Manual, Cummins GS/GC Generator Sets, Woodward-SG, PSG, EG-B2C, EG-3C and 2301 manuals.

1. Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps. This governor uses lubricating oil as an energy medium. For governor oil viscosity, see Page 3-2.
2. Oil level in governor sump must be at full mark on dipstick. Fig. 2-18.

Starting Procedure

Refer to "Starting The Engine" in Section 2.

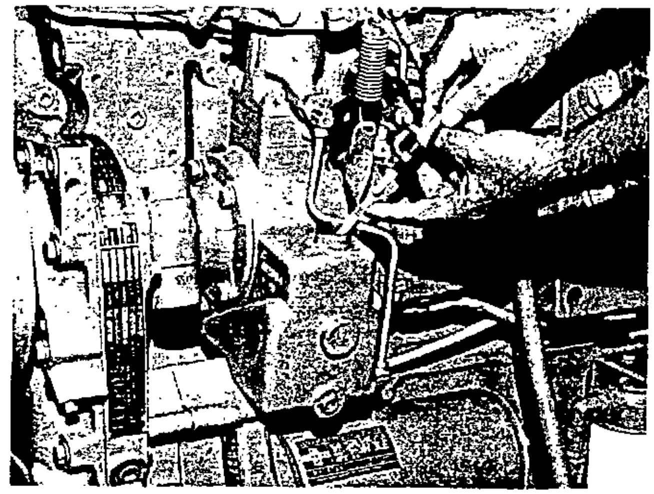


Fig. 2-18, N11826. Checking hydraulic governor oil level

Operation

1. Bring engine to rated operating rpm as circumstances dictate. On standby power units, this may be done immediately. However, greater engine life will be obtained, particularly for prime power units, if engine speed is kept below 1000 RPM until engine temperature reaches 140 deg F [60 deg C].

Caution: Make sure all power lines and control stations are clear of personnel.

2. Engage disconnect switch and adjust load bank.

Generator Set – Parallel Operation

In many cases where electric power is required, it may be advantageous to install two or more smaller generator sets instead of one single set of higher rating. Table 2-3. This condition also exists when it becomes necessary to increase the capacity of the existing plant by adding generator sets. When two or more generators are connected and operated together in such a way that they deliver electric energy to the system, they are said to be operating in parallel. Parallel operation is considered successful when the generators deliver energy to the external system without delivering energy to each other.

To be suitable for parallel operation, the generating equipment selected must meet the following requirements:

1. The generator voltage and frequency ratings must be the

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Table 2-3: Standard Generator Set Application Specifications

Engine Model	1800 RPM Standby	60-Cycle Prime Power	1500 RPM Standby	
NHC-4	GS-60KW	GC-50KW	GS-50KW	
NHC-4	GS-75KW	GC-60KW	GS-60KW	
HR-6	GS-100KW	GC-75KW	GS-85KW	
NH-220	GS-125KW	GC-100KW	GS-100KW	
NT-270	GS-150KW	GC-125KW	GS-125KW	
NT-310	GS-175KW	GC-150KW	GS-150KW	...KW
NT-335	GS-200KW	GC-175KW	GS-165KW	GC-150KW
NT-400	GS-230KW	GC-200KW	GS-190KW	GC-170KW

same for all sets.

2. These generators should have approximately the same waveform. Similar waveshapes are readily obtainable if machines are of similar types.

3. The generators should have similar voltage regulation characteristics.

4. The driving engines should have the same speed regulation characteristics. The governors should be adjusted to give the same speed droop when applying or removing the load.

Connections

1. When two or more power units are to be operated in parallel, they must be tied together electrically and connected to the load system. This interconnection is referred to as "the bus".

2. The connecting cables, or bus, must be installed between the corresponding line terminals of each power unit. Thus L-1 on one unit will be connected to L-1 on the second unit, L-2 to L-2 and L-3 to L-3, etc. On 3-phase, 4-wire units, the L-0 terminals will also be connected together.

   Caution: Both sets must be connected to a common ground. This is most readily achieved by running a No. 12 or larger wire from the grounding terminal on the housing of one set to the grounding terminal on the other set. This wire should be protected from mechanical damage. It need not be insulated.

3. The generator must be connected so the output voltage of both sets will be the same.

4. Power units which are suitable for parallel operation will be equipped with necessary cross-current compensation equipment to assure proper parallel operation.

Initial Operation

Generator Test

Before operating power units in parallel, each generator and regulator should be checked by starting and operating each unit individually.

1. Check engine, battery, generator and connecting cables in accordance with the operating procedure for single-unit *operation outlined in the technical manual for the set in* use.

   Caution: When conducting these preliminary tests, never close the main switches (or contactors) of both sets at the same time.

2. Check operation of the voltage regulators of each of the sets as described in the technical manual and adjust as described therein, if necessary.

Speed Droop Check

Since it is important that both engines have the same speed droop characteristics, each set should be checked individually for speed droop and the governors adjusted, if necessary. This may be accomplished by using any load which does not exceed the rating of a single set. When a dummy load is not available, the use of the end item as a load is permissable. Loads which vary, such as tracking antennas, should be avoided, but acquisition antennas running at constant speed are acceptable loads.

1. Start one machine and adjust to standard no-load speed (62 cycles for 60-cycle machines and 415 cycles for 400-cycle machines).

2. Adjust set to rated voltage operating under automatic voltage regulator control. Load the set with as much steady state load as is available, up to the rated capacity of the machine.

3. Determine the frequency at which the set is operating under load.

4. Shut down first machine and repeat steps 1 and 2 above on second machine.

5. In accordance with the applicable governor manual, adjust the governor droop characteristic of the second machine so *the set will be operating at the same frequency as the first*

machine when loaded with the same load.

Preliminary Tests

Before operating two sets in parallel for the first time, two preliminary electrical tests should be made.

Phase Rotation Test

Only generators connected together with the proper phase rotation (phase sequence) can be operated in parallel.

1. Connect units to the bus as directed in "Connections", preceding.
2. Start both units, leaving main switch or contactor on both sets open. See Fig. 2-19.
3. Adjust voltage on both sets to rated value by means of the automatic voltage regulator rheostat.
4. Adjust both sets to the same frequency (no-load).
5. Close main switch on one set and turn on synchronizing lamp switch on the other machine.
6. If the phase sequence on both generators is the same, both synchronizing lights will light and go dark simultaneously. If the machines do not have the same phase sequence, at no time will both lamps be dark simultaneously; instead, the lamps in the different legs will darken successively. In the latter case, the phase rotation of the machines can be matched by interchanging any two cables at the one-load terminal panel.

Caution: Never work on load or bus lines unless both sets are shut down.

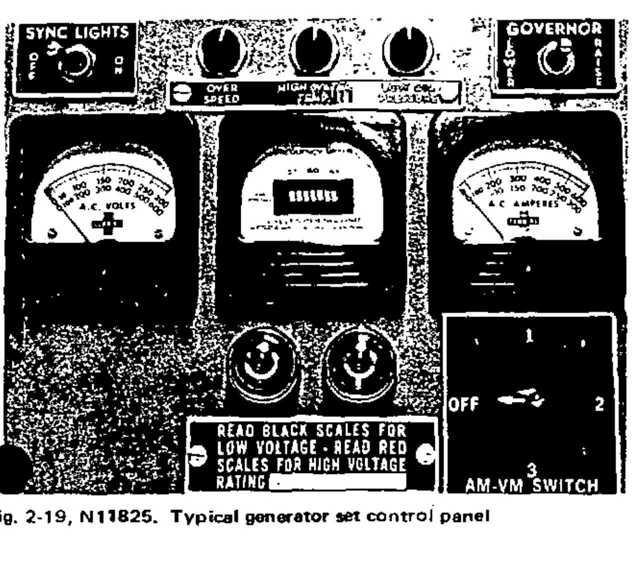


Fig. 2-19, N11825. Typical generator set control panel

Cross-Current Compensation

When two generators are operated in parallel, supplying a load whose power factor is other than unity, each generator must supply its proper share of reactive (wattless) KVA. If one generator carries more than its share of wattless current, overheating of the generator may take place. The voltage regulator functions to hold the voltage constant. In addition, when sets are operated in parallel, the voltage regulators function to provide proper division of wattless KVA load between generators. They also serve to prevent useless circulating current from flowing between the two machines. For these purposes, cross-current compensation equipment is provided with the regulators.

Polarity Test

Proper functioning of the cross-current compensating equipment depends on the connections to the current transformers being made correctly. If the polarity of the transformer secondaries is incorrect, the compensation will aggravate current unbalance instead of restoring the proper division.

To determine if the connections are correct:

1. Start both machines as directed in "Preliminary Tests" above. Close the parallel operation (cross-current compensator) switches on both sets and adjust voltage and frequency.
2. Adjust speed of either set so synchronizing lights blink slower and slower (about once every two seconds). When both lights are dark, close the circuit breaker.
3. Some circulating current will flow between the two machines as indicated on the ammeters. If it does not or if it is very great, turn the voltage regulator rheostat on either set to cause about 10 percent of rated current to flow between the sets.
4. Turn off the parallel operation (cross-current compensating switch) on one set. If the current rises, the circuit is connected correctly. If the current falls, the leads to the current transformer secondaries must be reversed on that set.
5. Repeat operation on second machine.

Adjustment

1. After the proper polarity of the compensation circuit has been established, the amount of compensation should be adjusted. For single, non-parallel operation, the voltage regulator can be adjusted for a negligible voltage drop. As soon as compensation is connected in the regulator circuit, a drop in the AC voltage, held by the voltage regulator, is introduced when a lagging power factor load is applied or increased during operation. Depending upon how much resistance is used across the current transformers, the AC

voltage will drop from 2 to 5 percent when the load varies from zero to rated load. It should be noted that voltage drop due to compensation will only occur when the load has a lagging power factor; on unity power factor (pure resistance) loads, this compensation drop is negligible.

2. Increasing the compensating resistance will increase the compensating effect toward equalizing the division of current between generators; but at the same time the voltage drop will increase, which is an undesirable effect. Therefore, it is advisable to use just enough compensation to obtain satisfactory parallel operation. Generally, parallel operation is considered successful if the differences between the currents of the two generators (as indicated by the load ammeter) is less than 10 percent of the rated current of one machine when the load is anything from 20 percent to 100 percent of rated load.

3. The compensating resistor (or resistors) is set at the factory for load and power factor conditions normally encountered in the field. This setting will usually provide satisfactory parallel operation and will eliminate cross currents. The voltage drop during parallel operation will be negligible. It is recommended that the setting of the compensating resistor not be changed unless the load conditions are so abnormal that the compensation is inadequate. Once set and found satisfactory, the resistor setting should be left unchanged.

Synchronizing

Once the preliminary tests have been performed and adjustments made, the settings will remain correct as long as the respective wire and cable connections remain unchanged. It is not necessary to make these tests every time the alternators are to be paralleled. It is, however, necessary to synchronize each time the generators are to be paralleled.

1. Make sure both main switches (breakers or contactors) are open.

2. Start both sets and adjust to frequency, without load, by adjusting governor controls. (Normally this setting will be about 62 cycles for 60-cycle sets and 415 cycles for 400-cycle sets.)

3. Operate both sets on their automatic voltage regulators. Adjust both sets to the same voltage.

4. Throw both cross-current compensation (parallel operation) switches to the "ON" position.

5. Close the breaker on one of the sets.

6. Turn on the synchronizing lamp switch on the other set. The synchronizing lamps will flash on and off rapidly at a frequency depending on the difference in speeds of the two units.

7. Adjust the speed of the unit whose breaker is open until the lamps flash on and off slowly (about once every two seconds). After making a speed adjustment it may be necessary to wait a few seconds until lamp fluctuations slow down.

8. When the lamps are dark, close the main breaker of the set.

9. Open the synchronizing lamp switch.

Note: The above procedure can be followed if one of the sets is already on the line. Follow the above directions with the loaded set taken to be the one with the closed main switch.

Load Division

After units are operating in parallel, load should be divided proportionately to generator ratings. In case of addition of a set to one already carrying a load, it is necessary to shift part of the load to the second generator. In case of two units of the same size, each should carry half of the load. On AC generators, load can be shifted from one generator to another only by speed control, not by manipulating the voltage regulator rheostat. Such manipulation will only change the power factor of the generator and hence current output of the machines, causing undesirable cross current.

1. Increase the load on the machine with the lesser amount of total load by increasing governor throttle control. This increase will be indicated on the wattmeter.

2. When two loads are correct as indicated by the wattmeters, check frequency as indicated on either sets' frequency meter. If frequency is too high, it will be necessary to re-adjust both the governor controls to feed less fuel to the machines. Conversely, if the combined speed is too low, opening the governor controls on both machines will increase the frequency. When raising or lowering the frequency, care must be taken to re-adjust load division so wattmeter readings are equal (or proportional to set size if sets are not the same size).

Eliminating Wattless Current

After the KW load has been proportionally divided, the reactive (wattless) load should also be divided proportionally. Assuming that both generators have the same rating, both generators should show same load amperes. This indicates cross currents and should be eliminated by adjustment of voltage regulator rheostats on the sets.

1. Slowly turn the voltage adjusting knob on one of the units first clockwise, then counterclockwise. One movement or the other should result in decreasing ammeter readings. Adjust until both ammeters are at the lowest point at which they both read the same value on similar sets. On different-sized sets, the proportional load division described previously will have to be considered.

2. After adjustment, it may be found that the output voltage is too high or too low. If too low, turn the voltage regulator rheostat on one of the sets up slightly and repeat the operation of the preceding paragraph, using the rheostat on the other set for balancing. Conversely, if the voltage is too high, turn down one of the rheostats and balance with the other.

Adjustments

Once the proper load distribution between the units is established, little or no adjustment of the load distribution should be required when the load is increased or decreased. Such adjustments as may be necessary should be carried out as indicated in the preceding paragraphs. Proportional division of the KW load is assured by the speed regulation characteristics of the units. The proportional division of the wattless load will be maintained by the cross-current compensation feature of the voltage regulators.

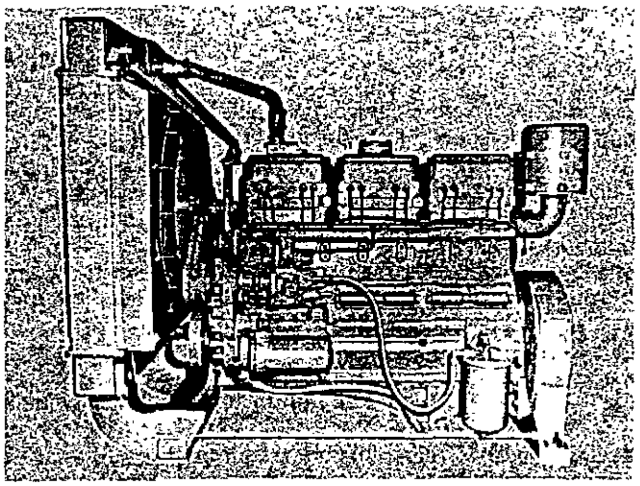
Removing A Generator From The Line

To remove a generator operating in parallel, reduce the load carried by that machine by manipulating the speed control until the KW indication on the wattmeter is very small, then open the main switch or contactors on that machine. Turning the speed control in the decrease speed direction will decrease the load carried by that generator.

Marine Applications

For complete operation and maintenance instructions covering Cummins H-NH Series Marine Diesel Engines, refer to Bulletin No. 983624.

Industrial Engine Applications


N11818. Typical industrial unit

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, 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.

Table 2-4: Converter and Industrial Power Units

Engine Model	Max. HP @ RPM (Sea Level, 60 deg F [15.69])	Converter Unit Max. HP	Cont. HP	Power Unit Cont. HP
NHC-4	130 @ 2000	96	84	93 @ 1800
HRF-6	190 @ 2000	140	123	142 @ 2000
NH-220	220 @ 2100	162	143	152 @ 1800
NH-250	250 @ 2100	184	164	174 @ 1800
NT-280	280 @ 2100	214	183	193 @ 1800
NHRS-6	320 @ 2100	236	206	217 @ 1800
NT-335	335 @ 2100	256	218	234 @ 1800
NT-380	380 @ 2300	290	245	262 @ 2000

1. Converter output horsepower is based on 10% correction for accessories and 85% converter efficiency at 500 ft [152.4 m] and 85 deg F [29.4 deg C].

Table 2-5: Construction Application

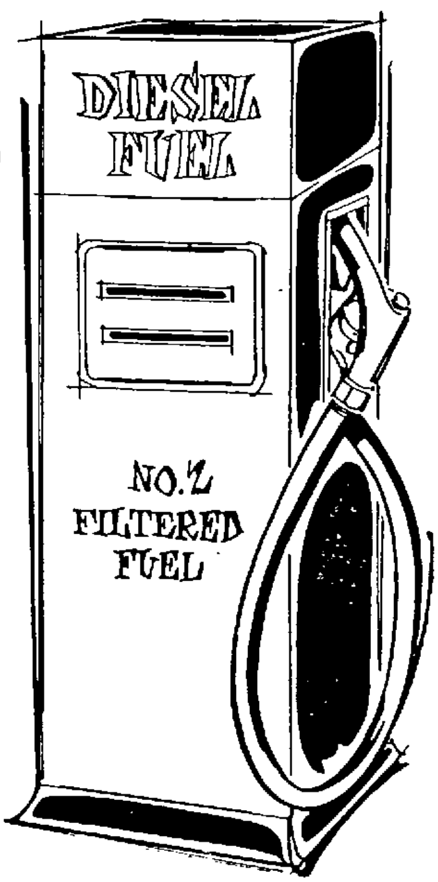
Engine Models	60 deg. F [15.6 deg. C] Sea Level HP @ RPM	Off-Highway Trucks	Dozers, Scrapers, Compactors	Road Graders	Excavators, Tractors, Shovels	Air Compressor
NHC-4	130 @ 2000		120 @ 2000	120 @ 2000	120 @ 2000	120 @ 2000
H-6 & H-135	160 @ 1800		148 @ 1800	148 @ 1800	148 @ 1800	148 @ 1800
HR-6	175 @ 1800		162 @ 1800	162 @ 1800	162 @ 1800	162 @ 1800
HRF-6	190 @ 2000		176 @ 2000	176 @ 2000	176 @ 2000	
HS-6	210 @ 1800		178 @ 1800		194 @ 1800	
HRS-6	240 @ 1800				222 @ 2100	
NH-220	220 @ 2100	204 @ 2100	204 @ 2100	204 @ 2100	204 @ 2100	204 @ 2100
NHS-6	290 @ 2100	268 @ 2100	246 @ 2100		268 @ 2100	
NHRS-6	320 @ 2100	296 @ 2100	272 @ 2100		296 @ 2100	
NH-250	250 @ 2100	231 @ 2100	231 @ 2100	231 @ 2100	231 @ 2100	231 @ 2100
NT-310	310 @ 2100		310 @ 2100			310 @ 2100
NT-335	335 @ 2100	335 @ 2100			335 @ 2100	
NT-380	380 @ 2300	380 @ 2300				

1. All ratings shown in equipment columns are for ratings of 1500 ft [457.2 m] altitude and 90 deg F [32.2 deg C].

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

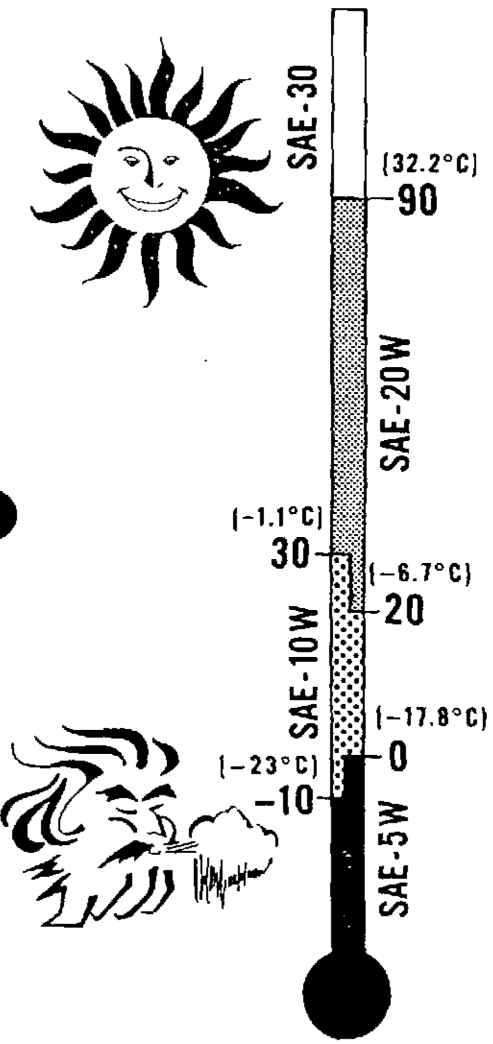


Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	Centistrokes 1.4 to 5.8, or Saybolt Universal: 34 to 42.
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125 deg. for legal temperature if higher than 125 deg. F.
Gravity (ASTM D-287)	30 to 42 degrees A.P.I. at 60 deg. F (0.815 to 0.875 Sp. Gr.).
Pour Point (ASTM D-97)	10 deg. F 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



Cummins Engine Company, Inc., recommends that owners of Cummins Diesels give special consideration to use of heavy-duty oils developed for use in diesel engines. Under normal conditions, the oil used should meet or exceed the requirements of U.S. Military Specifications Mil-L-2104-A. Under adverse conditions such as continuous high-power applications, the use of high-sulfur fuels, or light-load operation during cold weather, consideration should be given to the use of Supplement 1 or Mil-L-2104-B oils. The responsibility for meeting these specifications, the quality of the product and its performance must necessarily rest with oil supplier. Cummins Engine Company, Inc., does not recommend any specific brand of lubricating oil. Many brands which meet specifications following are listed in the "Lubricating Oils for Industrial Engines" booklet published by The Internal Combustion Engine Institute (Room 1516; 210 North Wells Street; Chicago, Illinois 60606.

Mil-L-2104-A and/or British Defense Spec. DEF-2101-B

Recommended oils for Cummins Engines operating under normal highway service and where the sulfur content of the fuel is less than 0.5%. MIL-L-2104-A has been dropped as a Military Specification, but oils that meet its requirements are available for commercial service.

Supplement 1 (S1)

These oils have been developed for use with high-sulfur fuels and are recommended where the sulfur content of the diesel fuel normally exceeds 0.5%.

Mil-L-2104-B

This is the current Military Specification for lubricating oils. These oils meet or exceed the Supplement 1 requirements for high-temperature operation and also provide protection against rust and sludge from low temperature operation. They may be used in Cummins Engines.

Series 3 (Mil-L-45199)

These are oils developed to overcome high-temperature ring sticking and piston carbon and lacquer. They are not required in Cummins Engines except in very unusual high-load operating conditions. These oils should not be used in applications where exhaust valve deposits have been encountered.

Viscosity Recommendations

Except in extreme climates most engine operation will be in the range of -10 deg. F (-23 deg. C) to 120 deg. F (49 deg. C), oil viscosity should be as follows:

SAE 10-W—temperatures consistently between — 10 deg. F (-23 deg. C) and 30 deg. F (-1.1 deg. C).

SAE 20—temperatures consistently between 20 deg. F (-6.7 deg. C) and 90 deg. F (32.2 deg. C).

SAE 30—temperatures above 90 deg. F (32.2 deg. C).

Where temperatures are not above 0 deg. F (-17.8 deg. C), SAE 5W oils meeting the requirements of Mil-L-10295 may be used. However, in heavily loaded applications it may be necessary to use one grade heavier oil to maintain minimum recommended oil pressures of engine being operated.

Oil which is best for general operation is also best for the "break-in" period. No change in oil viscosity or type is needed for new or newly rebuilt engines. Do not mix brands or grades of oil in the engine. Choose carefully the best oil available and continue to use that brand consistent with above conditions and engine wear.

Grease Specifications

Longer service, less maintenance and more effective lubrication are possible when a high-quality engine accessory grease is used. Cummins Engine Company, Inc., recommends use of grease meeting the specifications of Mil-G-3545, excluding those of sodium or soda soap-type thickeners. Contact your lubricant supplier for grease meeting these specifications.

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		
100 hours		10 max.
500 hours		25 max.
Copper Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

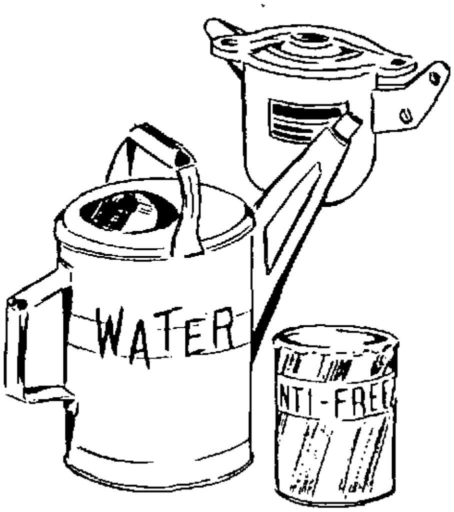
*Federal Test Method Standard No. 791a.

Caution: Do not mix grades or brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication.

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 8.3 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.



In Summer (No Anti-freeze)

1. Use the corrosion resistor with chromate element(s), Part No. 132732. Do not use element 168481 (PAF) with plain water.

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

3. If no corrosion resistor is used, add 1/2 oz. [14.1747 g] chromate compound in the system for every U.S. gal [3.785 lit] of water or until the coolant mixture meets requirements indicated in Section 5 under "Check Engine Coolant".

In Winter (Using Anti-freeze)

1. Select an anti-freeze known to be satisfactory for use with the chromate element of the corrosion resistor and continue to use the 132732 resistor element or;

2. If you are not sure the anti-freeze is compatible with the chromate resistor element 132732:

a. Use anti-freeze, in percentage to prevent freezing, with a PAF (168481) element in the corrosion resistor.

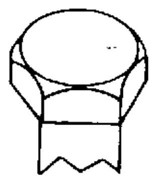
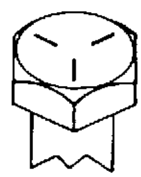
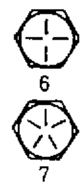
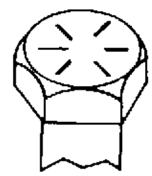
b. Use only anti-freeze, with compounded inhibitors, in proper percentage and follow anti-freeze supplier's recommendation to prevent corrosion.

c. Check corrosion control by draining a sample of coolant from the system as described under "Check Engine Coolant".

d. If there has been a loss of corrosion control, change anti-freeze.

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

Capscrew Markings And Torque

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). 				

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

Cummins Diesel Engines

The chart 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 searach 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

CUMMINS ENGINES

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 & Engine																				●	●	●				
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					●	●																				
	Incorrectly Assembled Idle Springs									●	●																
	Governor Weights Assembled Incorrectly											●															
	High-Speed Governor Set Too Low					●	●																				
	Water in Fuel	●	●				●					●															
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●											
	Dirty Lube Oil Strainer														●							●	●				
	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																●		●	●							
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●						●	●	●				
	Long Idle Periods	●	●	●	●	●									●	●											
	Engine Overloaded				●				●								●		●	●	●	●	●	●	●		
	Lube 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 environment 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 opposite 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 NH 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 NH Engine is six 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.

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 3-2.

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

Maintenance Schedule

CHECK SHEET

EQUIPMENT NO. ______ ENGINE SERIAL NO. ______

MECHANIC ______ MILEAGE, HOURS, GALLONS ______

TIME SPENT ______ CHECK PERFORMED ______

PARTS ORDER NO. ______ 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 Air Tanks						
Check Oil Bath Air Cleaner Oil Level						
Clean Pre-Cleaner And Dust Pan						
Change Engine Oil						
Check/Change Hydraulic Governor Oil						
Change Engine And Turbo. Oil Filters (Full-Flow)						
Change By-Pass Oil Filter						
Record Oil Pressure						
Lubricate Electrical Equipment						
Change Fuel Filter; Check Fuel Restriction						
Drain Sediment (Replaceable-Element Filter)						
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 Air Compressor Breather Element						
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						
Clean Fuel Pump Screen And Magnet						
Adjust Injectors And Valves						
Check Fuel Manifold Pressure						
Clean Complete Oil Bath Air Cleaner						
Lubricate Water Pump And Fan Hub						
Check Supercharger/Turbocharger For Leaks						
Check Alternator/Generator/Cranking Motor						
Check Vibration Damper Alignment						
Clean And Calibrate Injectors						
Clean Injector Inlet Screens						
Inspect/Install Rebuilt Units As Necessary						
Check Fuel Pump Calibration						
Clean And Check Turbocharger						
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.

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 Manifold/Turbo. Mtg. Capscrews	As Required		
Tighten Mtg. Bolts And Nuts	As Required		
Check And Adjust Clutch	As Required		
Check Crankshaft End Clearance	At Clutch Adjustment		

check is due.

Maintenance Operations Summary Sheet

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

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.

...ATION

Lubricating oil stand
infrequently or are in st
oxidize and require cha
Laboratory testing is the
or fuel is oxidizing unde
oil be checked regular
possible to schedule oil c
being contaminated due to un...

5-4

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 procedure 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	Notes	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
Supercharged & Turbocharged	Daily	Notes	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 is 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 in. [12.70 mm] long or "milky" appearance indicates an air leak. Find and correct.

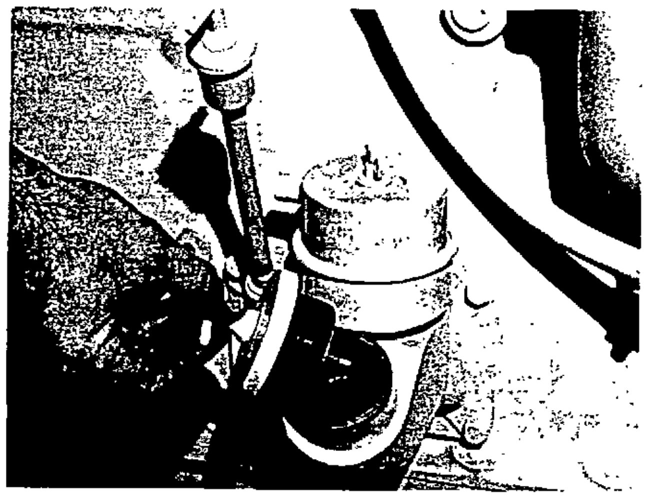


Fig. 5-1, N12005. Lubricating oil filler tube

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.

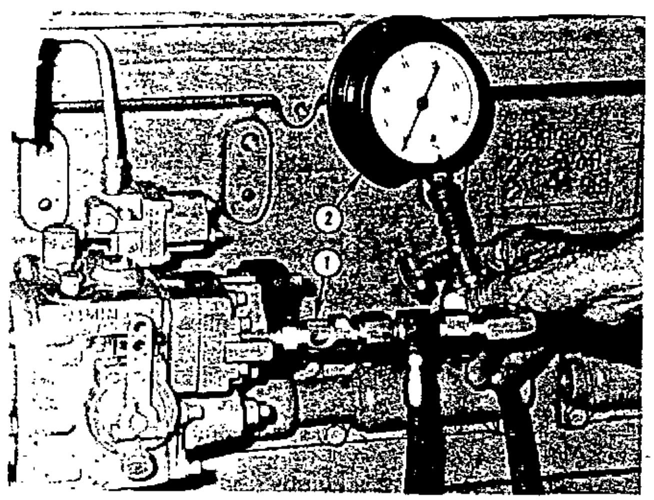


Fig. 5-2, N11917. Checking air leaks with ST-998 Sight Gauge

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 lubrication, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

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. Investigate for causes of coolant loss. Recheck the level after engine reaches normal operating 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. Requirements of a good coolant 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.

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

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

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 in 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 very 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 any 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", Page 3-1.

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

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged 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.

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

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

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 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 you work with your local Cummins Distributor in establishing a maintenance schedule for your particular operation. The two items listed on this page 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.

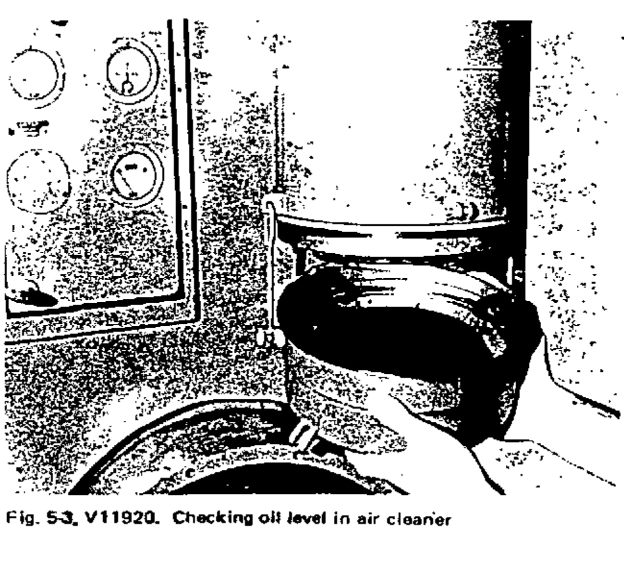


Fig. 5-3, V11920. Checking oil level in air cleaner

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 (Mil-L-2104A, Supplement 1, Mil-L-2104B, etc.), 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, Supplement 1 oils, 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 60/70 ft-lb [8.2980/9.6810 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.

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

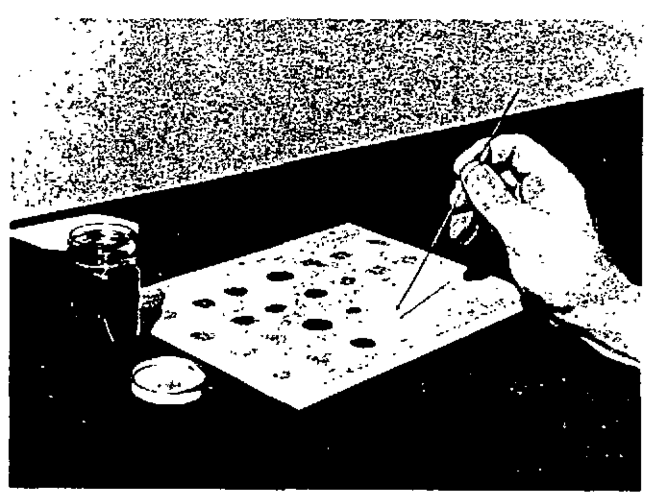


Fig. 5-4, N11945. Lubricating oil analysis test

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.

Check Hydraulic Governor Oil Level (B 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.

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

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

Loosen and completely unscrew center capscrew; remove filter case assembly (with element) from filter head. See Fig's. 5-5, 5-6 and 5-7.

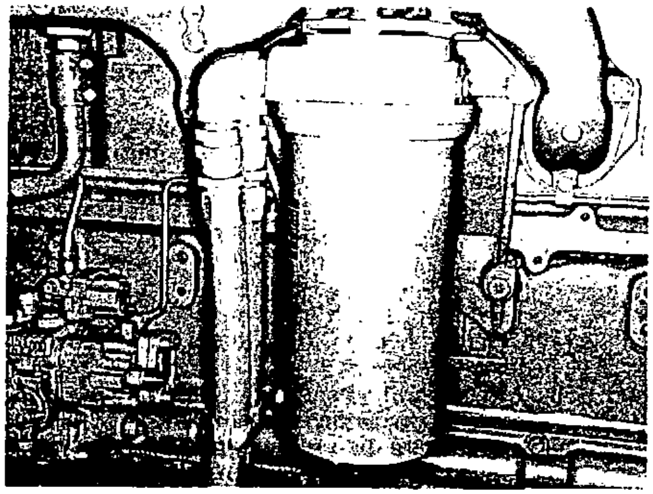


Fig. 5-5, N11958. Typical remote-mounted lubricating oil filter (center bolt)

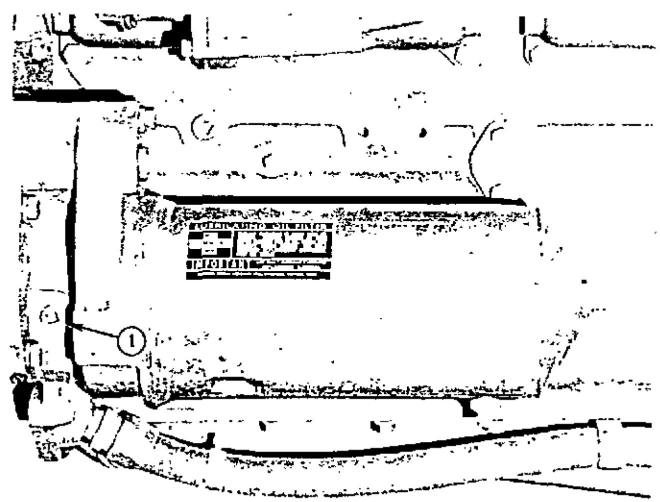


Fig. 5-6, N11927. Horizontal lubricating oil filter (center bolt)

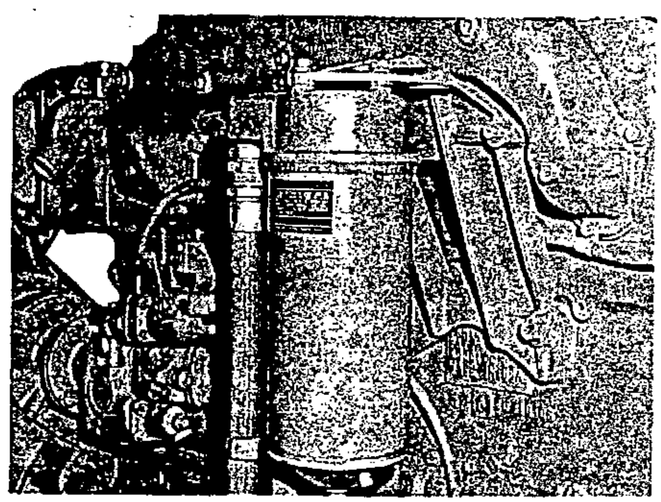


Fig. 5-7, N11926. Typical remote-mounted lubricating oil filter (center bolt)

3. Withdraw filter element and inspect.

a. Inspect for metal particles.

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.

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 filter head and discard.

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

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 25/35 ft-lb [3.4575/4.8405 kg m]. Tighten clamp-type filter capscrews securely.

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

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

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

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

Change Turbocharger Oil Filter (B Check)

The throw-away type turbocharger oil filter is used in conjunction with all turbochargers except the T-50 model.

Change filter at each oil change or install a pressure gauge in the filter outlet line; change filter element when gauge indicates a 15 psi [1.0545 kg/sq cm] lower pressure than oil pressure on inlet side.

To change element:

1. Unscrew element and discard. Fig. 5-8.

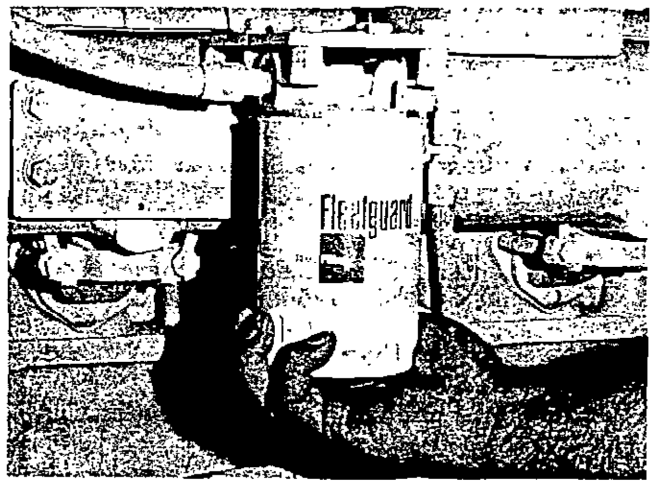


Fig. 5-8, N11928. Removing turbocharger oil filter

2. Clean filter head with solvent that is not harmful to aluminum.

3. Inspect head for cracks and distorted threads; discard if damaged.

4. Coat gasket and fill new element with clean engine lubricating oil.

5. Install element to head; tighten until gasket contacts head.

6. Rotate element an additional one-half to three-fourths turn to seal gasket. Do not overtighten.

Caution: Do not attempt to use substitute elements. Element threads and filter paper are of special design.

7. Reconnect oil supply and discharge lines, if previously removed.

Caution: Make sure oil supply line to filter is connected at opening marked "in". Reversing connections will lead to turbocharger failure.

Change 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. 5-9) from bottom of housing and drain oil.

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

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

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

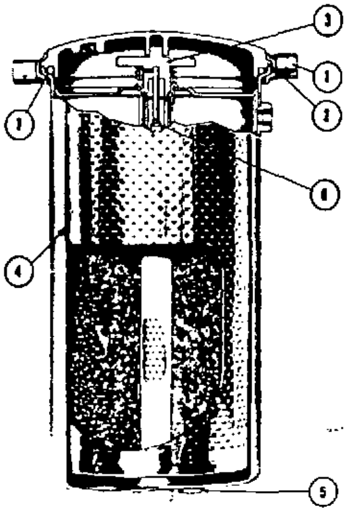


Fig. 5-9, V41908, Lubricating oil by-pass filter

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

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

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. 5-10) 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, 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

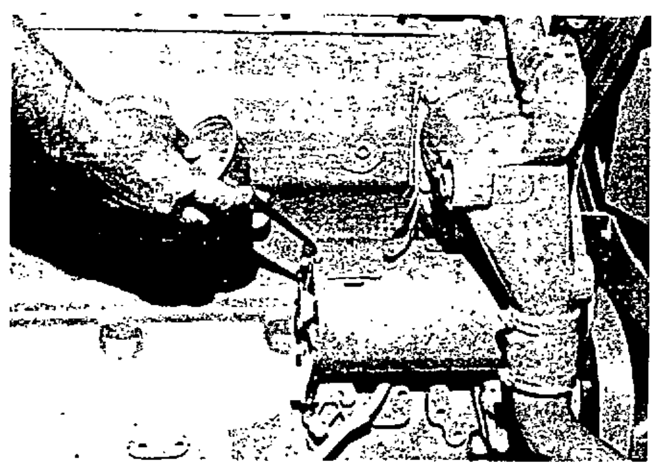


Fig. 5-10, N11951, Lubricating the generator after 2000 gal [7570.000 lit or 1665.340 U.K. gal] of fuel consumption. Change the single 7 1/2-inch long (throw-away fuel filter) after 3000 gal [11,355.000 lit or 2498.010 U.K. gal] of fuel consumption and the stack disc (replacement element) after 4000 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. 5-11) using the special adaptor 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.

Throw-Away Type Filter

1. Unscrew combination case and element; discard. Fig. 5-12.

   Note: On elements that do not have an integral "O" ring seal, install new "O" ring before installing element.

2. Fill element with clean fuel.
3. Install new case and element; tighten by hand until seal

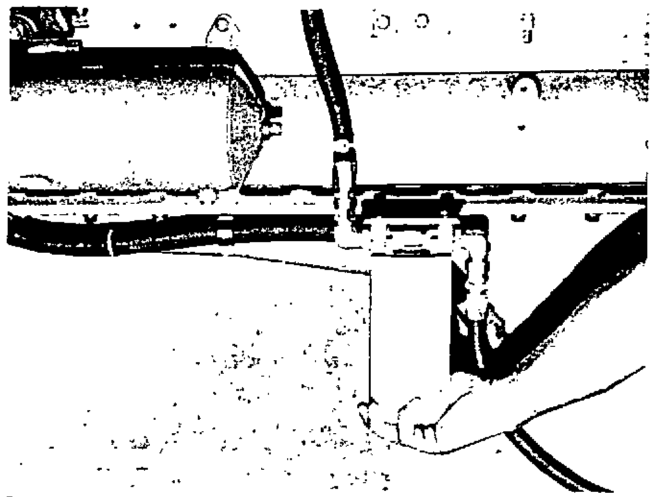


Fig. 5-12, N11929. Removing throw-away type fuel filter

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 nut at top of fuel filter. Take out dirty element, clean filter case and install a new element. Fig. 5-13.
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

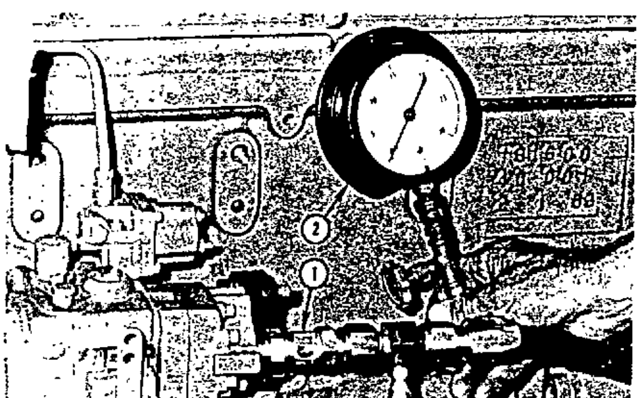


Fig. 5-11, N11917. Checking fuel filter restriction with ST-434 Vacuum Gauge

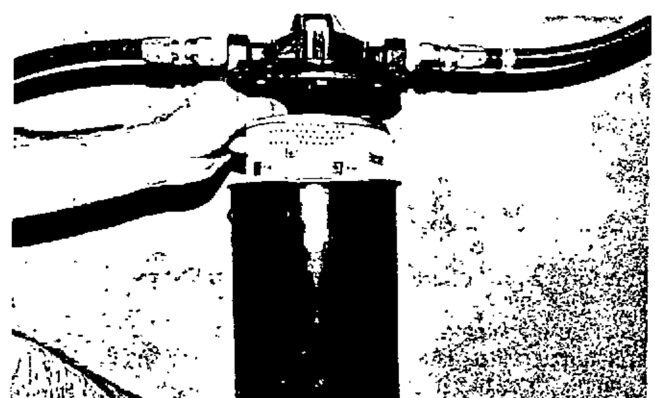


Fig. 5-13, V11910. Installing replaceable fuel filter element and element. Tighten center bolt to 20/25 ft-lb [2.7660/3.4575 kg m] with a torque wrench.

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

Drain Sediment From Fuel Filter (B Check)

Perform at AC Check under adverse conditions

1. Loosen drain cock, if used, at bottom of fuel filter case and drain out any accumulated water and sediment. Tighten drain cock.
2. Unscrew throw-away type element without drain cock; dump water and sediment. Fill element with clean fuel and replace.

Check 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, or tears in hose or tubing, collapsing hose, or other damage. Tighten clamps, Fig. 5-14, 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.

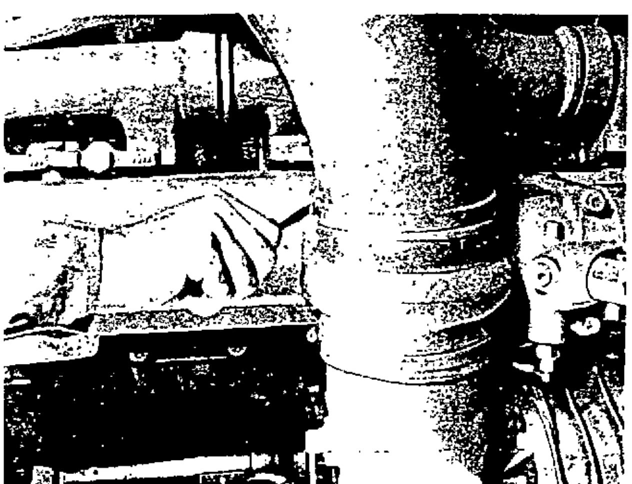


Fig. 5-14, N11908. Tightening air intake piping clamp

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 than 6 in. [152.4 mm] from air intake manifold connection.
2. 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 in. [508.0 mm] of water or 1.5 in. [38.100 mm] of mercury when checked at this location.
3. Idle engine until normal operating temperature is reached.
4. Operate engine at rated speed and take reading from vacuum gauge or manometer. Air restriction must not exceed 25 in. [635.0 mm] of water or 1.8 in. [45.720 mm] of mercury at intake manifold.

If air restriction exceeds limits above (step 2 or 4):

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. 5-15) in window gradually rises as cartridge

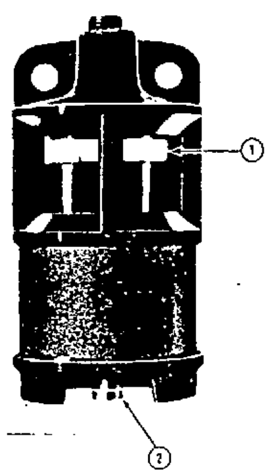


Fig. 5-15, CGS20. Air inlet restriction gauge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge, reset indicator by pushing re-set button (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. 5-16).
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 in. [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. 5-17, may be cleaned several times by using an air jet to blow off dirt or by washing with non-sudsing household detergent and warm water, preferably 120/140 deg F [48.9/60.0 deg C], then drying with compressed air, approximately 40 psi

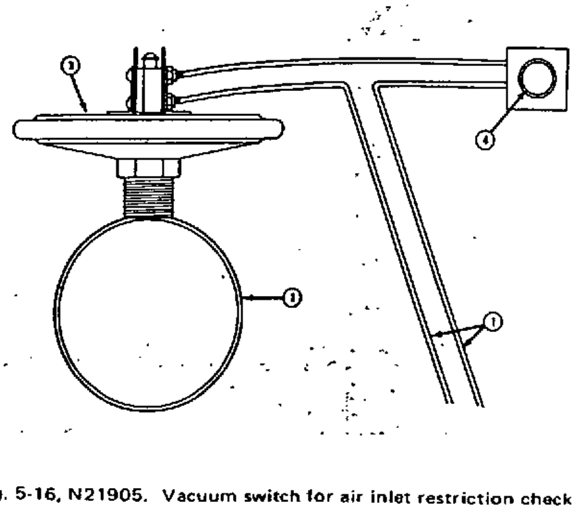


Fig. 5-16, N21905. Vacuum switch for air inlet restriction check

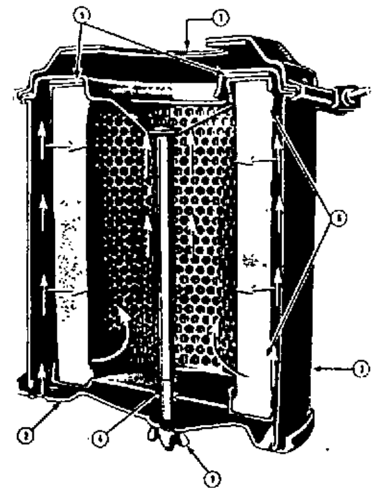


Fig. 5-17, N11003. Air cleaner — dry type

[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. 5-17) 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.

Cyclopac And Donaclone Types

The Cyclopac and Donaclone air cleaners combine a centrifugal cleaning stage with a paper filter element. Fig's. 5-18 and 5-19.

On the Cyclopac model, dirty air enters through an opening in the side of the cleaner body, where it immediately travels through a ring of vanes around the outside of the element.

These vanes impart a cyclonic twist to the air, thereby throwing dust and dirt particles outward and down into the dust cup. The air then passes through the element (from the outside) and on into the engine.

On the Donaclone model, dirty air enters through an opening in the top or side of the cleaner body, where it enters plastic tubes. These tubes contain vanes which impart a cyclonic twist to the air, thereby throwing dust and dirt particles outward and down into the dust cup. The air then travels up through the aluminum tubes inside the plastic tubes, through the filter element (from the inside) and on into the engine.

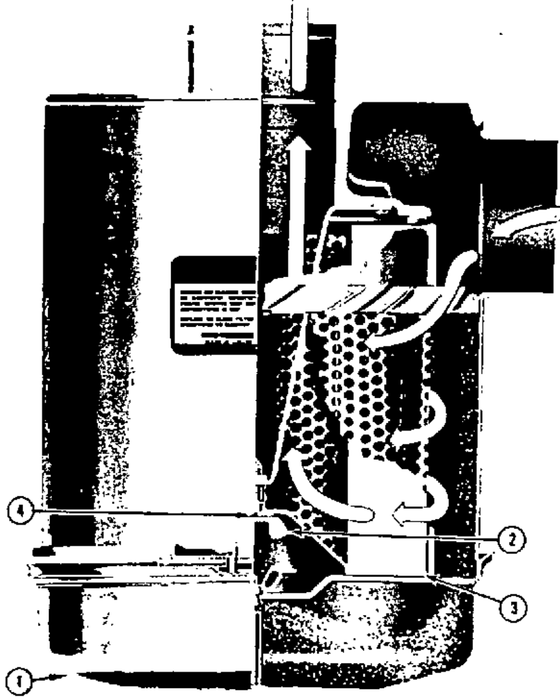


Fig. 5-18, V11005. Air cleaner — Cyclopac type

Before disassembly, wipe dirt from cover and upper portion of air cleaner. To clean composite-type:

1. Loosen clamps and remove cover (1, Fig. 5-19).
2. Unscrew wing bolt holding inner cover and element (3, Fig. 5-18) (4, Fig. 5-19) in position; remove element carefully so loose dirt will not fall into chamber (2, Fig. 5-18) (3, Fig. 5-19).
3. Remove dust cup (1, Fig. 5-18) (2, Fig. 5-19) and clean.
4. Tap side or bottom ring of element with palm of the hand or soft hammer.
5. 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.

6. Wash element with non-sudsing household detergent and warm water (120/140 deg F [48.8/60.0 deg C]). Dry with compressed air (40 psi [2.8120 kg/sq cm]).
7. Remove retainer clamp. Separate upper and lower bodies; remove "O" ring.
8. Hold element up to light and inspect tubes (Donaclone type) for dust deposits. Remove dust with stiff fiber brush.
9. Inspect gaskets and "O" rings; discard if worn or mutilated.
10. Inspect element after cleaning to be sure no holes are present.
11. Position upper body with gasket on lower body; secure with retainer clamp.
12. Install element and inner cover in position.
13. Be sure gasket washer (4, Fig. 5-18) is in place under wingnut before tightening.
14. Install cover.
15. Install dust cup.

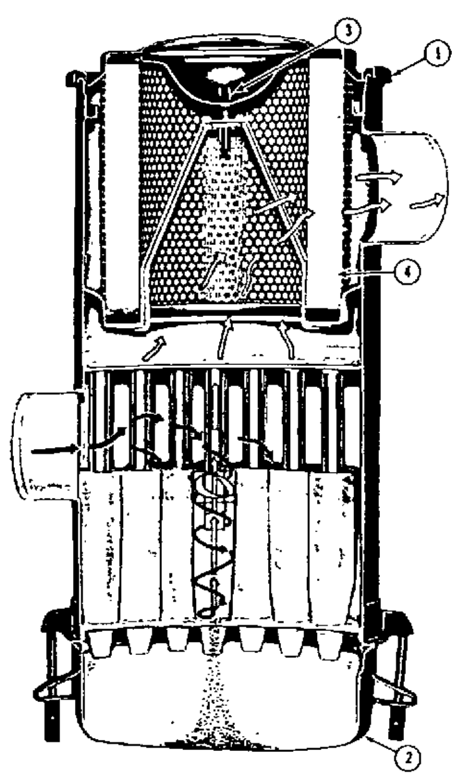


Fig. 5-19, V11004. Air cleaner — Donaclone type

Replace Cartridge-Type Air Cleaner Element (B Check)

Perform at AC Check under adverse conditions

Two-Stage

Disassembly

1. Loosen wingnuts (4, Fig. 5-20) on air cleaner housing (3). Loosen "U" bolt clamp securing pre-cleaner to aspirator tubing. Remove pre-cleaner panel(1).

2. To remove dirty Pamic cartridge (2), 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. 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.

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.

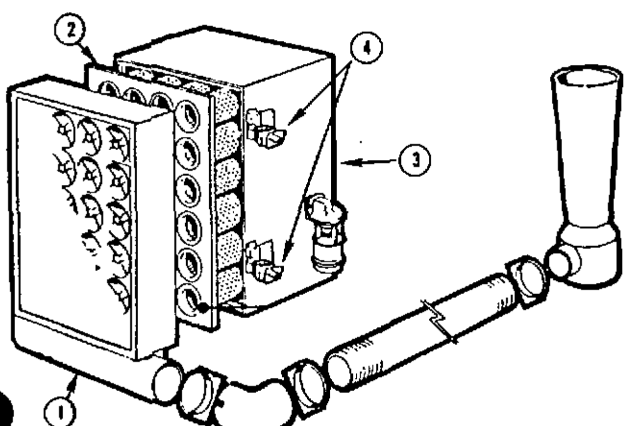


Fig. 5-20, N21017. Cartridge-type air cleaner — two stage

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 flexible hose or tubing and clamps to be sure all fittings are air tight.

Assembly

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

2. To install a new cartridge, hold cartridge (2, Fig. 5-20) in same manner as when removing from housing (3). 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 (1) and tighten wingnuts (4). Assemble aspirator tube to pre-cleaner panel and tighten "U" bolt.

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

Single Stage

Disassembly

1. Loosen wingnuts (3, Fig. 5-21) 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". Loosen all four corners of cartridge, one at a time, by pulling straight out. With larger cartridge, it may be necessary to break seal along edges of cartridge. After seal has been broken, pull the cartridge straight out and slightly up so cartridge will clear sealing frame and edges of air cleaner housing.

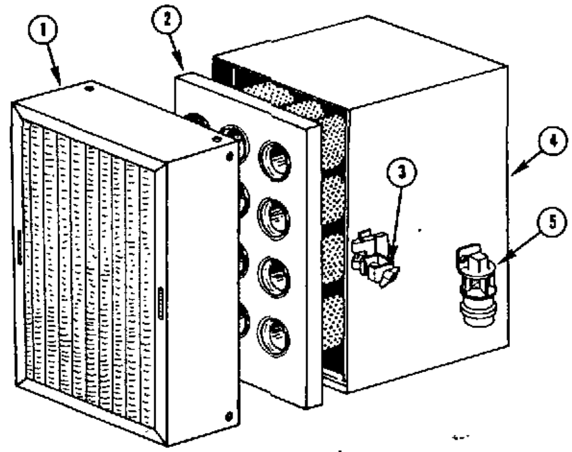


Fig. 5-21, V11009. Cartridge-type air cleaner — single stage

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. 5-21) 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 in. [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 bath air cleaner oil is equally as important as during dusty weather since the air cleaner inlet may not be equipped with an adequate rain shield or 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.

Clean Tray Screen

Immerse tray screen (1, Fig. 5-22) 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.

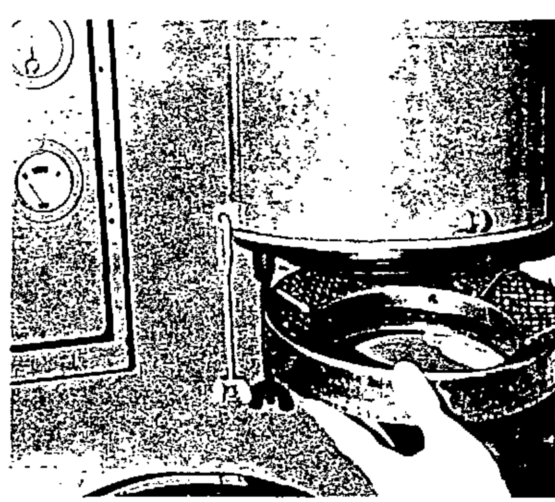


Fig. 5-22, N11002. Removing air cleaner tray screen

Clean Or Change Air Compressor Breather Element (B Check)

Perform at AC Check under adverse conditions

Three types of breathers are available to provide filtered air for the air compressor when the intake line is not connected to the engine air intake system.

When used, service breathers regularly as follows.

Bendix-Westinghouse Mesh

Remove the breather and disassemble completely; wash all parts in solvent. Dry with compressed air, reassemble and install on compressor. Oil the mesh element very lightly with SAE 20 oil to aid in capturing dirt particles.

Bendix-Westinghouse Sponge

Remove the breather from the air compressor. Fig. 5-23. Disassemble the breather, wash all metal parts in solvent and blow dry with compressed air. Wash the element in solvent using a squeezing action; remove all solvent from element. Dip in clean engine oil and squeeze excess oil from element.

Bendix-Westinghouse Oil Bath

Unsnap the spring clips and remove the oil cup. Wash in solvent, dry, replenish cup with oil to level mark and reassemble. Use clean oil, the same grade as used in the crankcase.

Every other service period, unscrew the wingnut on top and remove the filter element. Wash in solvent, dry and reassemble to cover.

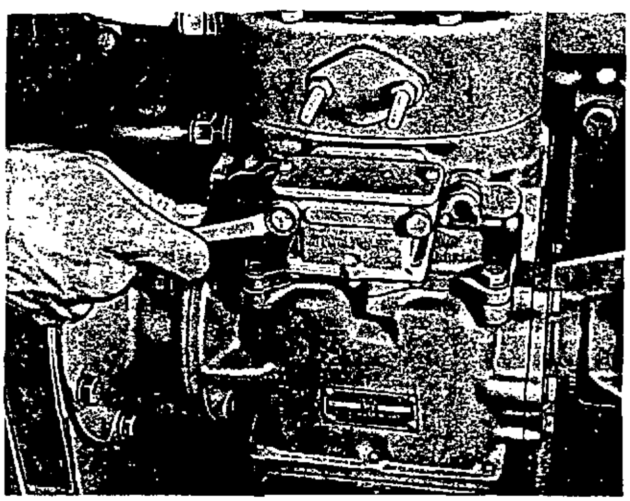


Fig. 5-23, N11904. Bendix-Westinghouse air compressor breather – sponge element

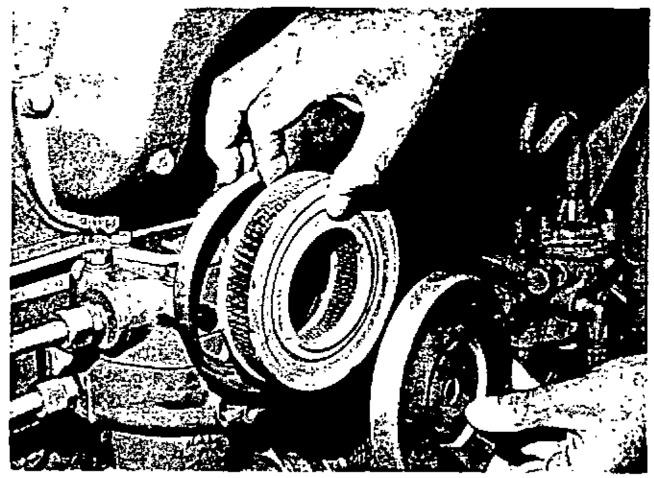


Fig. 5-24, N11937. Cummins air compressor breather – paper element

Cummins Compressor Paper

A light-weight, self-contained air cleaner with "paper element" was formerly optional on Cummins air compressor. Clean the element at each "B" Maintenance Check. Remove wingnut securing front cover to body. Lift off front cover and element. Inspect paper element before cleaning by reverse flow of compressed air; discard if damaged or unsuitable for cleaning. Fig. 5-24.

Caution: Do not rupture filter element.

Clean the body and front cover with a clean cloth. With rubber gasket on center bolt, place element in front cover and assemble over center bolt; secure with wingnut.

Note: At any time the three-prong unloader hat is used, it will set up air pulsations across the compressor intake which can destroy the paper element. Pipe intake air for Cummins compressors from engine air manifold when the three-prong unloader hat is applied; current factory-installed compressors are so equipped. This same procedure may be used for any Cummins Compressor in the field. See your nearest distributor.

Clean Crankcase Breather (B Check)

Perform at AC Check under adverse conditions

Oil Bath

Immerse breather in kerosene or cleaning solvent. Wash thoroughly and dry with compressed air. Fill breather oil cup to level indicated with oil of the same grade used in the engine. Fig. 2-25.

Screen Element

Clean element by washing in clean solvent and drying with compressed air. Clean breather housing with dry cloth. Fig. 5-26.

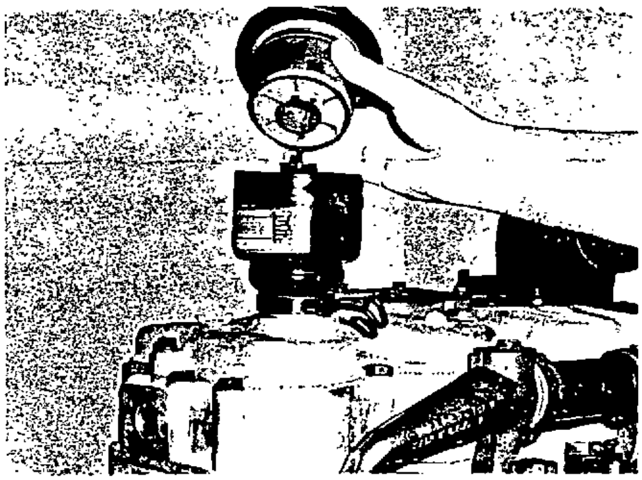


Fig. 5-25, N11935. Crankcase breather — oil bath type

Wire Mesh Element

Clean breather element in cleaning solvent and dry with compressed air. Wipe out breather housing. Soak element in oil; drain out excess.

Change Crankcase Breather Paper Element (B Check)

Perform at AC Check under adverse conditions

Dry-type crankcase breathers containing a chemically treated paper element are used on naturally aspirated engines. Install new element—**Do Not Attempt To Clean. Do Not Use On Engines With Pressurized Systems.** Fig. 5-27.

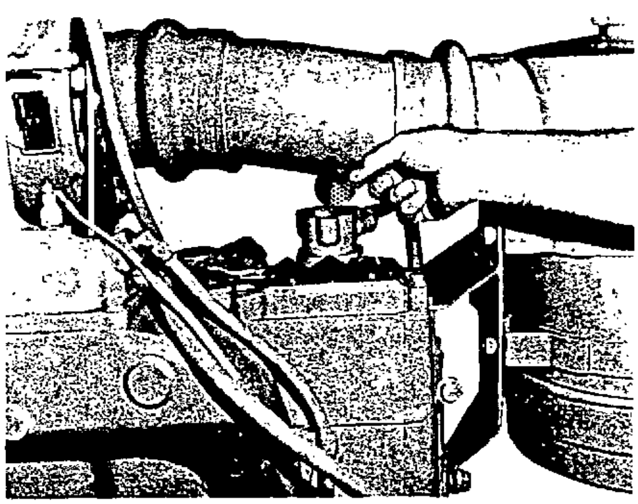


Fig. 5-26, N11948. Crankcase breather — screen element type

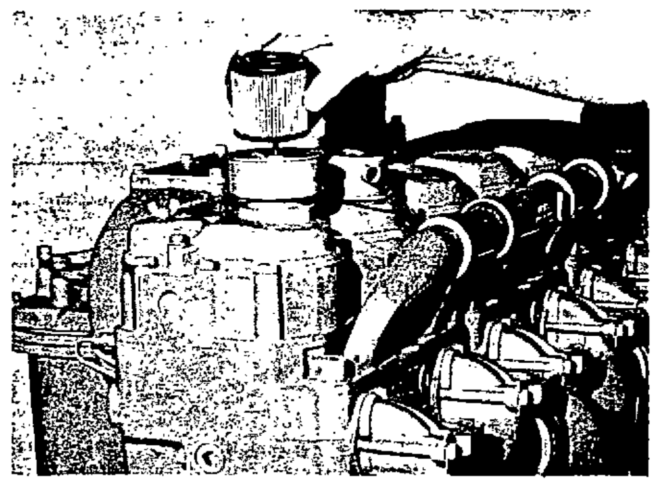


Fig. 5-27, N11933. Crankcase breather — paper element type

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.

Check Engine Coolant And Corrosion Resistor Element (B Check)

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. 5-28.

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

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

Certain anti-freeze compounds are chemically incompatible with the regular corrosion resistor element containing chromate. This is evidenced by the formation of a green scum in the radiator filler opening.

In such cases, use the PAF corrosion resistor element, which contains no chromate. The anti-freeze contains its own inhibiting compound.

Caution: Do not use PAF element with plain water coolant, unless you are able to add chromate compound.

Note: We do not recommend the addition of chromate compound to anti-freeze coolant. Recommended anti-freeze compounds contain adequate inhibitors when used as recommended.

pH Value Test

1. Separate tubes marked "pH" are furnished in the test kit.

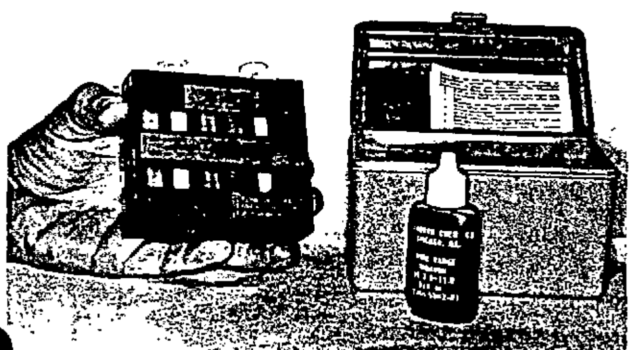


Fig. 5-28, N11946. ST-993 Coolant Checking Kit

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 8.3 to 9.5.

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

Chromate Concentration Test

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

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

3. 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).

4. Wash out test tubes after each test.

Adjusting Coolant To Specifications

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

If Cummins Corrosion Resistor is used, change element, Fig. 5-29, 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, add enough compound to bring concentration to proper level. Normal usage is 1/2 oz. [218.75 grains] chromate for each 1 gal [3.785 lit or 0.83267 U.K. gal] of coolant.

Table 5-3: Comparison Units—Chromate Concentration

Ounces Per Gallon	Parts Per Million	Grains Per Gallon
0.16	850	50
0.32	1700	100
0.50	2550	150

Check/Change Corrosion Resistor (B Check)

Change corrosion resistor element, Fig. 5-29, at each "B" Check unless facilities are available for testing. See "Check Engine Coolant". Change element when concentration

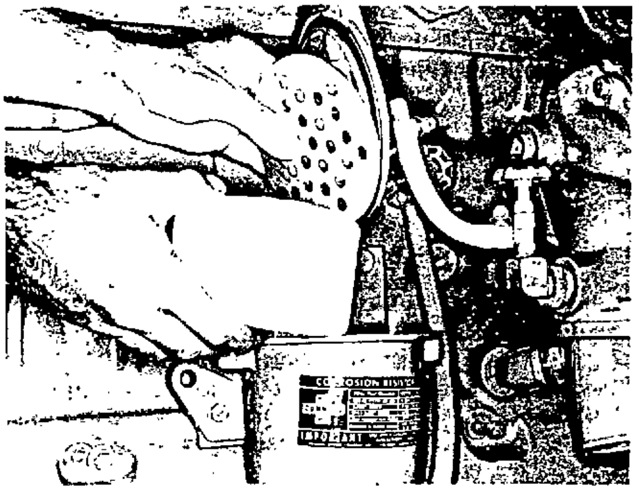


Fig. 5-29, N11901. Changing corrosion resistor element

drops below 100 grains per gal [3.785 lit or 0.83267 U.K. gal].

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.

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

Note: Whenever a cooling system is changed from one element formula to the other, the system must be drained and flushed.

Change 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. 5-29.
3. Remove plate securing element(s); lift element(s) from housing and discard. Remove plate below element(s).
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(s) from transparent bag; install element(s) in housing.
8. Replace upper plate, gasket and cover.
9. Replace drain plug and open shut-off valves in inlet and drain lines.

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

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.

Caution: Do not adjust to final tension.

d. Snug clamp ring capscrew farthest from belts, on exhaust side, to five ft-lb [0.6915 kg m].

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

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

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

h. Check the belt tension with applicable Belt Tension Gauge. Fig. 5-30. Correct tension is 90-110 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. 5-31. See Table 5-4.

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.

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.

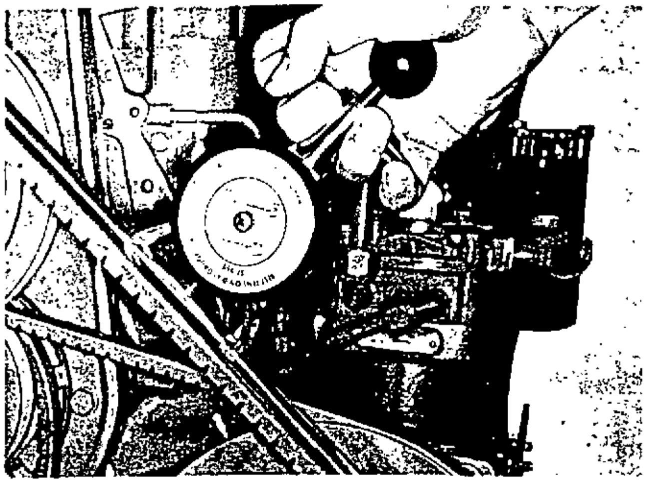


Fig. 5-30, N11955. Checking belt tension with ST-968 Gauge

Table 5-4: Belt Tension – In. [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]

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.

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

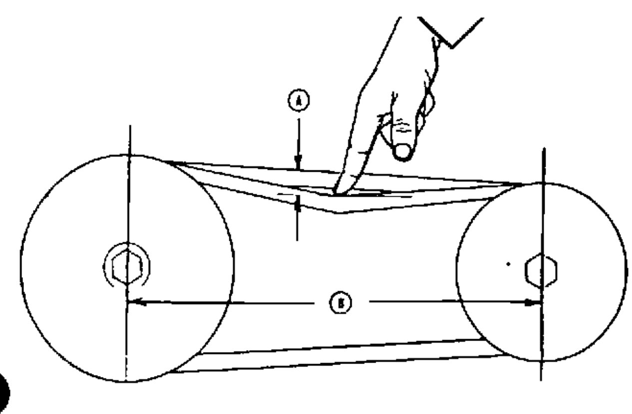


Fig. 5-31, N11471. Checking belt tension manually

e. Adjust until the ST-968 Belt Tension Gauge reads 90-95 pounds, or until the belt will deflect 3/4 to 1 in. when pressure of index finger is applied.

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

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

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

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

i. Check the belt tension. It should be 90-110 pounds on the ST-968 or ST-1138 Gauge, or should deflect to index finger pressure one belt thickness per ft. [0.3048 m] of span, pulley center to center.

Fan Drive Belts

Most current fans are mounted on adjustable hub assemblies, supported in suitable brackets. An adjusting screw is provided which raises or lowers the shaft to adjust the belt tension.

1. Loosen the large locking nut on the fan hub shaft. The fan hub will fall out of line when this is done.
2. Turn the adjusting screw down to increase belt tension.

   Caution: Do not adjust to full tension with the adjusting screw.

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 a square attitude.
4. Check belt tension with applicable gauge. The gauge should read 90-110 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 one thickness per foot of pulley center distance.
5. Secure the locknut. Tighten to 400/500 ft-lb [55.3200/69.1500 kg/sq cm]; then back nut off 1/2 turn.
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 80-100 pounds as measured with the applicable gauge. When no gauge is available, index finger pressure should not deflect belt more than 3/4 in.

Water Pump Belt Installation

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. Roll the water pump body counterclockwise to adjust belt tension. Adjust tension with applicable gauge; correct tension is 90-110 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.
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.

Summary

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. 5-32) and "O" ring (2) spring (3). Lift out filter screen assembly (4).
2. Remove top screen retainer (5) from filter screen assembly.

   Note: Some filter screens do not contain a magnet. If not, magnet can be obtained from any Cummins distributor. Magnetic action will remove any ferrous metal particles that may enter fuel system.

3. Clean screen and magnet in cleaning solvent and dry with compressed air.
4. Replace screen retainer and install filter screen assembly in fuel pump with hole down. Replace spring on top of filter screen assembly.
5. Replace cap and "O" ring; tighten to 20/25 ft-lb [2.7660/3.4575 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap (1, Fig. 5-33) 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

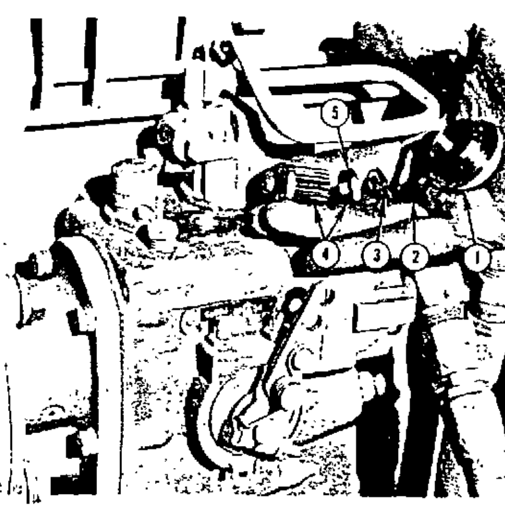


Fig. 5-32, N11950. Fuel pump filter assembly — PT (type G) fuel pump

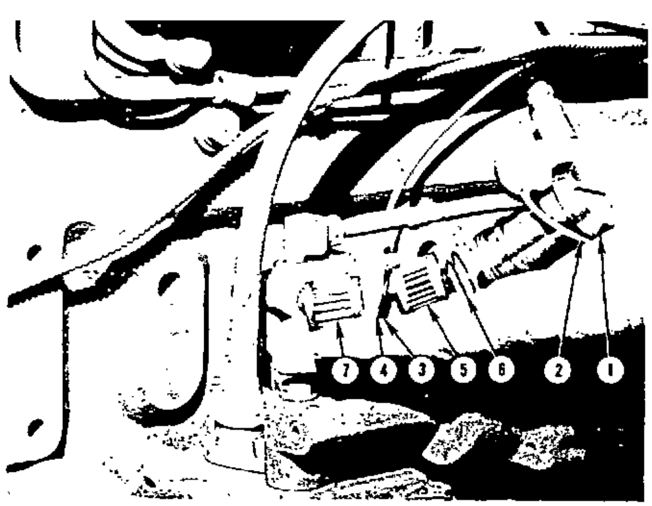


Fig. 5-33, N11940. Fuel pump filter assembly — PT (type G) fuel pump with MVS governor cap, "O" ring first.

8. Install filter cap and dynaseal in governor housing; tighten cap to 20/25 ft-lb [2.7660/3.4575 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.

Adjust valves and injectors at "C" Checks or sooner. Final operating adjustments must be made using correct values for the actual temperature of the engine. Check engine nameplate for hot and cold setting.

Torque injector hold-down capscrew in alternate steps before adjusting injectors.

4 7/8 in. and 5 1/8 in. Bore Engines: Torque standard hold-down capscrews to 10/12 ft-lb [1.3830/1.6596 kg m] and Nylock capscrews to 12/14 ft-lb [1.6596/1.9362 kg m]. Start tightening on capscrew opposite inlet and drain connection.

5 1/2 in. Bore Engine: Torque standard hold-down capscrews with lockwasher to 10/12 ft-lb [1.3830/1.6596 kg m] and Nylock capscrew to 7/8 ft-lb [0.9681/1.1064 kg m].

Note: If injector plunger is stamped letter "A" or "B" after class mark or if PT (type D) injector is used, torque Nylock capscrews to 11/12 ft-lb [1.5213/1.6596 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.

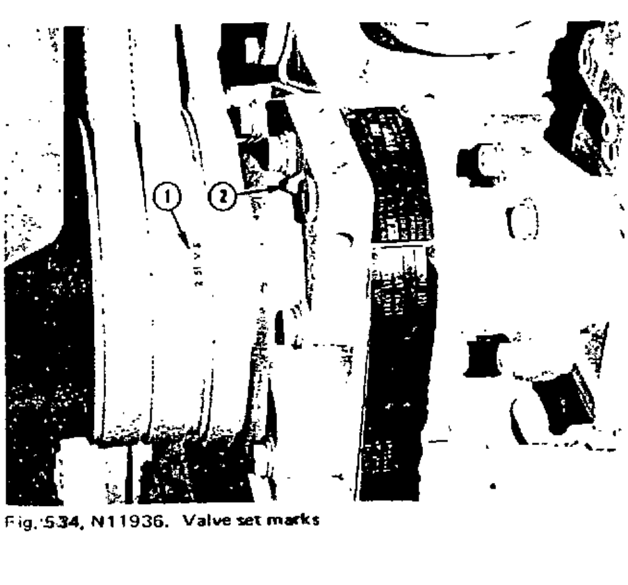


Fig. 5-34, N11936. Valve set marks

2. Bar engine in direction of rotation until a valve set mark (1, Fig. 5-34) 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. (On horizontal engines, the valve set marks are on the vibration damper flange.)

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

3. Check the valve rocker lever position on the two cylinders aligned. On one cylinder of the pair, both rocker levers will be free and valves closed.

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

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

6. For firing order see Table 5-5.

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 TQ12B or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. See Fig. 5-35.

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

Table 5-5: Engine Firing Order

No. of Cylinders	Righthand Rotation	Lefthand Rotation
4	1-2-4-3	1-3-4-2
6	1-5-3-6-2-4	1-4-2-6-3-5

Note: Number one cylinder on H/NH engines is at the gear case end of the engine.

Table 5-6: Injector Plunger Adjustment

Torque — Inch Pounds

Oil Temperature (70 deg. F [21.1 deg. C])	Oil Temperature (140 deg. F [60 deg. C])
48	60

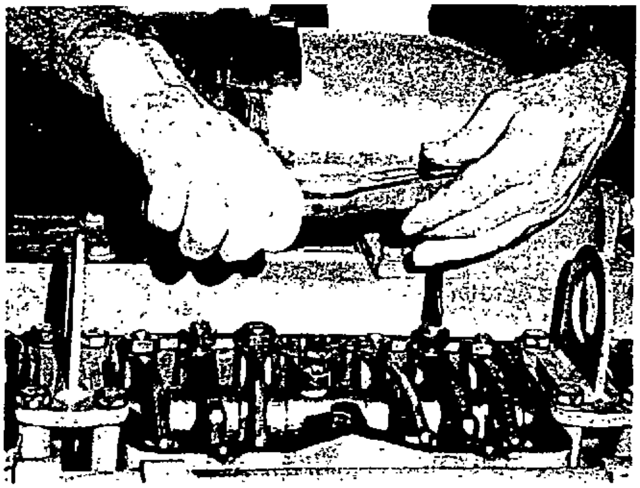


Fig. 5-35, N11941. Adjusting injector plungers

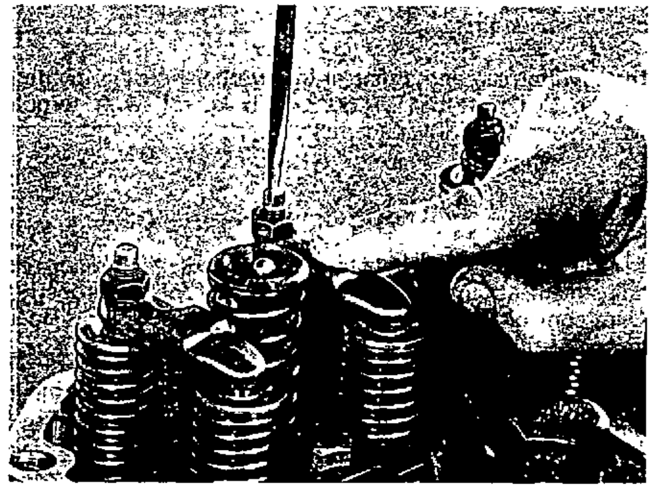


Fig. 5-36, N11462. Adjusting crossheads

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 5-6 for cold setting and tighten the locknut.

Crosshead Adjustments

NH Series Engines have four-valve heads. 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 in operation. This is evidenced by reduced rocker lever-to-crosshead clearance. 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. See Fig. 5-36.
4. With new crossheads and guides, advance screw an additional one-third of one hex (20 deg) to straighten stem in guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg to straighten stem in guide.
5. Hold adjusting screw in this position and tighten locknut to 25/30 ft-lb [3.4575/4.1490 kg m] torque.
6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of .020 in. [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 top of the valve stem or crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut, Fig. 5-37. Tighten locknut to 30/40 ft lb [4.1490/5.5320 kg m] torque. When using ST-669 torque to 25/35 ft lb [3.4575/4.8405 kg m].
3. Always make final valve adjustment to correct value for actual engine temperature after injectors are adjusted. See Table 5-7.

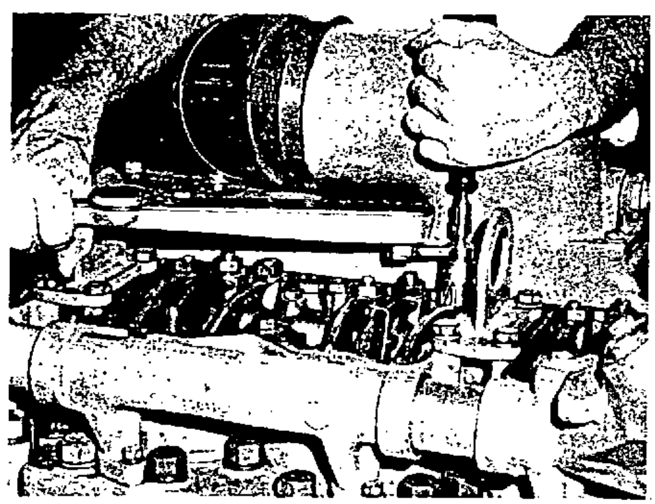


Fig. 5-37, N11942. Adjusting valves

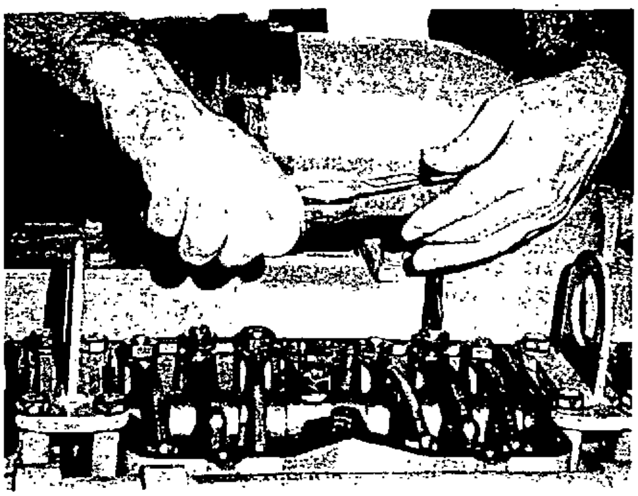


Fig. 5-35, N11941. Adjusting injector plungers

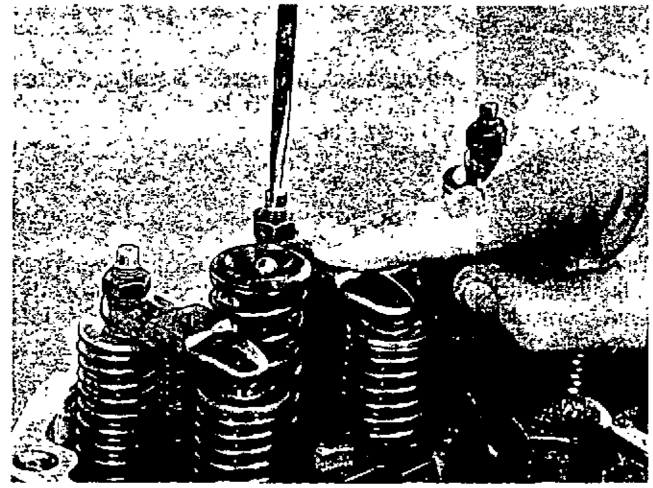


Fig. 5-36, N11462. Adjusting crossheads

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 5-6 for cold setting and tighten the locknut.

Crosshead Adjustments

NH Series Engines have four-valve heads. 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 in operation. This is evidenced by reduced rocker lever-to-crosshead clearance. 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. See Fig. 5-36.
4. With new crossheads and guides, advance screw an additional one-third of one hex (20 deg) to straighten stem in guide and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg to straighten stem in guide.
5. Hold adjusting screw in this position and tighten locknut to 25/30 ft-lb [3.4575/4.1490 kg m] torque.
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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 top of the valve stem or crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Fig. 5-37. Tighten locknut to 30/40 ft lb [4.1490/5.5320 kg m] torque. When using ST-669 torque to 25/35 ft lb [3.4575/4.8405 kg m].
3. Always make final valve adjustment to correct value for actual engine temperature after injectors are adjusted. See Table 5-7.

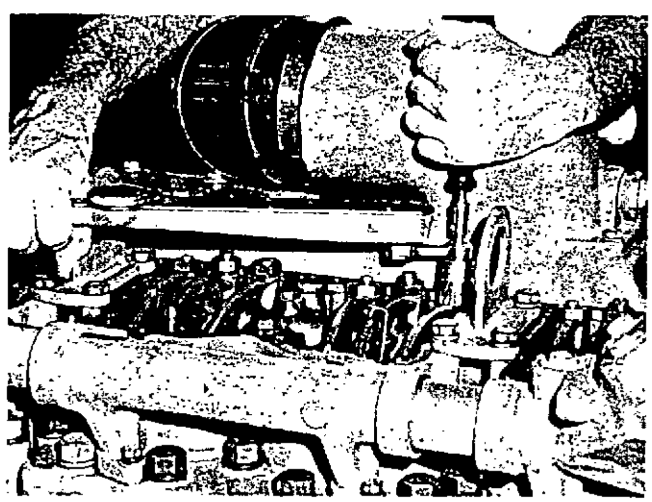


Fig. 5-37, N11942. Adjusting valves

Table 5-7: Valve Clearance — In. [mm]

Intake Valves Oil Temperature 70 deg F [21.1 deg C]	140 deg F [60.0 deg C]	Exhaust Valves Oil Temperature 70 deg F [21.1 deg C]	140 deg F [60.0 deg C]
0.016 [0.4064]	0.014 [0.3556]	0.029 [0.7366]	0.027 [0.6858]

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 can be used, take a reading of the no-load maximum. 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 differences in maximum governed speed between different engines. Such variations are of small importance in most applications.

Check Fuel Manifold Pressure (C Check)

1. Check maximum fuel manifold pressure with ST-435. Fig. 5-38. Remove 1/8 in. 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, aneroids (if used) must be disconnected to reach maximum fuel pressure during the short acceleration period.

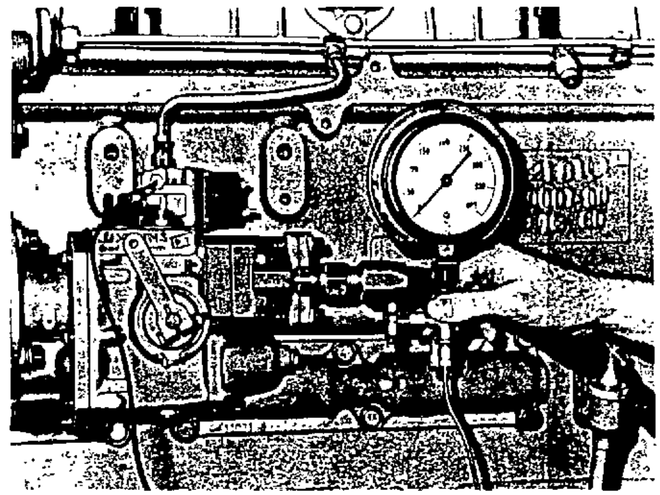


Fig. 5-38, N11491. Checking fuel manifold pressure with ST-435

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

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 valves 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 screw driver (slot in shaft) until it contacts the exhaust valve push tube flange.
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 3/5 psi [0.2109/0.3516 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.

Lubricate Water Pump And Fan Hub (C Check)

1. If water pump and fan hub contain grease fittings or plugs (1, Fig. 5-39) through which grease may be applied, give one "shot" (approx. 1 tablespoon) each "C" Check.
2. Completely disassemble, clean and inspect at each third "C" Check.
3. If water pump or fan hub has no provisions for greasing, disassemble, clean and inspect each second "C" Check.
4. Pack bearings and fill water pump and fan hub bearing cavities 1/2 to 2/3 full of grease meeting specifications shown on Page 3-3.

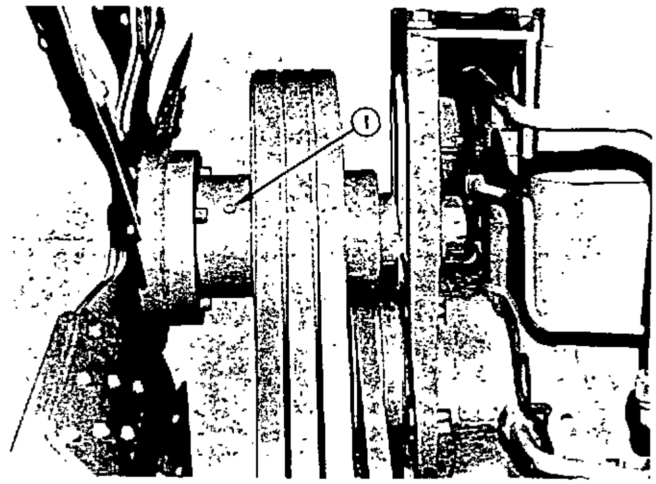


Fig. 5-39, N11932. Fan hub lubricating point

Check For Oil Leaks At Supercharger Or Turbocharger (C Check)

Supercharger

Remove supercharger outlet connection and visually check ends of the rotors and case for evidence of oil leakage from supercharger seals. Rotors will always show some oil from the vapor tube which is connected to a rocker housing cover.

Only the appearance of "wet" oil at the ends of the rotors and excessive oil consumption should be cause for changing supercharger seals.

Check supercharger lubricating oil lines and connections for leaks and correct as needed.

Turbocharger

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 the 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 results in expensive replacement.

1. Inspect terminals for corrosion and loose connections, Fig. 5-40, and wiring for frayed insulation. Check mounting

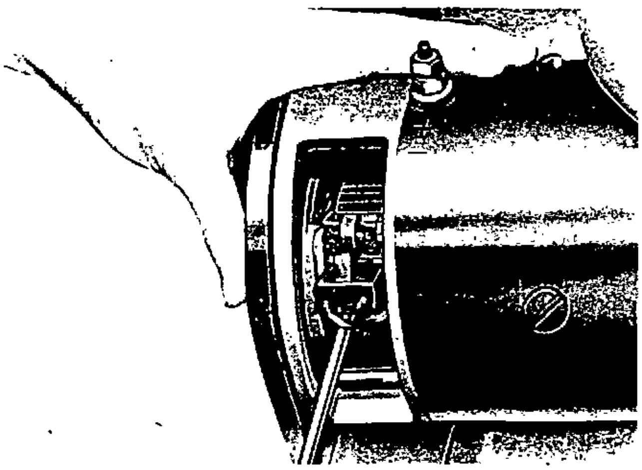


Fig. 5-40, N11308. Checking generator brushes

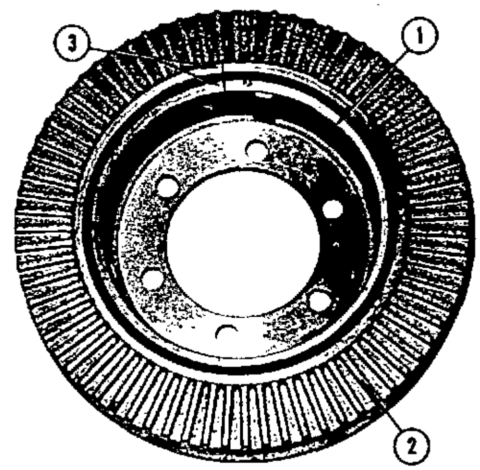


Fig. 5-41, N10146. Vibration damper alignment marks

bolts for tightness and check belt for alignment, proper *tension and wear.*

2. Slip rings and brushes can be inspected through alternator end frame assembly. If slip rings are dirty, they should be cleaned with 400-grain or finer polishing cloth. 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. 5-41) 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.

'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 or 983532.

Clean Injector Inlet Screens (D Check)

On external-fuel line engines, each fuel inlet connection has a fine mesh screen at the large end. This screen is the last protection against dirt entering the injector.

To clean: Remove the strainer screen; wash in solvent and dry with compressed air. Reassemble as removed. Fig. 5-42.

On internal-fuel line (drilled passages in cylinder heads) engines, the inlet passage has a fine mesh screen in the injector. This screen is the last protection against dirt entering the injector. To clean: remove injector, remove screen, wash in solvent and dry with compressed air. Reassemble as removed.

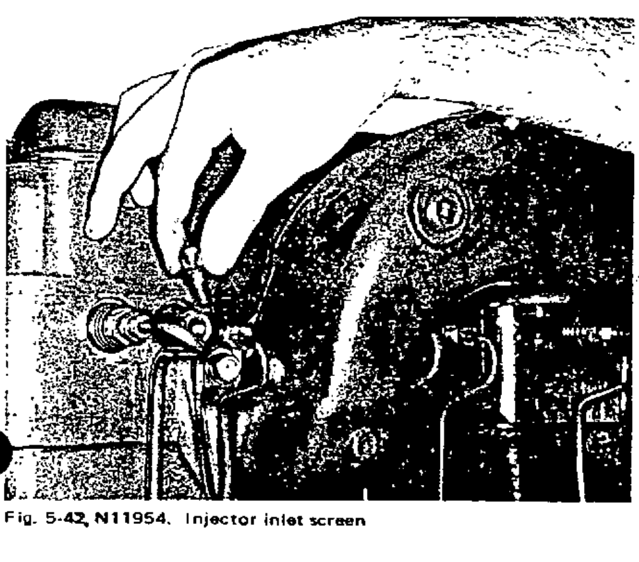


Fig. 5-42, N11954. Injector inlet screen

Inspect/Install Rebuilt Units As Necessary (D Check)

At this time the following assemblies should be rebuilt 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. 983646, for correct assembly procedures.

Check Fuel Pump Calibration (D Check)

Check fuel pump calibration on engine as required. See your 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. Loosen and remove capscrews, lockwashers and plain washers from the plate. Remove the front plate to expose compressor wheel and diffuser.

   Note: On T-50 turbocharger loosen and remove V-clamp between housings. Pull T-50 compressor housing.

3. 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 attack aluminum and result in an imbalanced compressor wheel.
4. If the unit is very dirty when the front plate or compressor housing is removed, remove the turbocharger from the

engine.

5. Immerse compressor wheel end of turbocharger in cleaning fluid to the diffuser plate face; allow to soak. Do not rest weight of turbocharger on compressor wheel or on end of shaft.

6. Dry the unit thoroughly with compressed air. Reassemble front plate to turbocharger.

Note: *On the T-50 turbocharger install compressor housing* and V-clamp. Tighten V-clamp capscrew to 32/36 in-lb [0.3680/0.4140 kg m]; do not overtighten.

Check Turbocharger Bearing Clearance (D Check)

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. 5-43.

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 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 5-8 for limits.

3. Check radial clearance on compressor wheel only. Note that limits in Table 5-8 are minimum figures.

4. If end clearance exceeds limits shown in Table 5-8, remove turbocharger from engine and replace with a new or rebuilt unit.

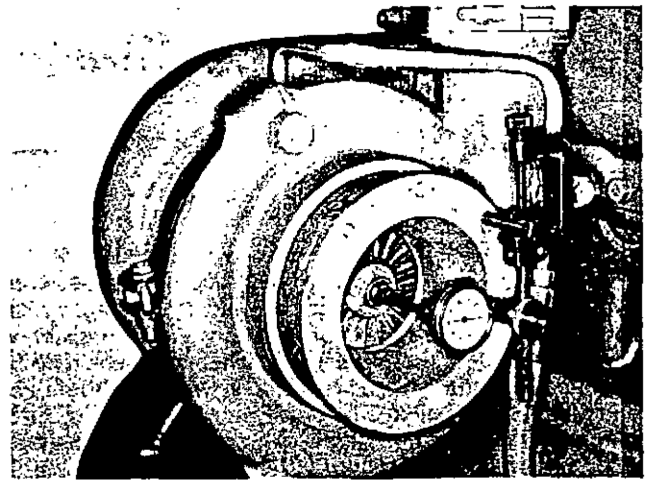


Fig. 5-43, N11956. Checking T-50 Turbocharger bearing clearance

Table 5-8: Turbocharger Bearing Clearances — In. [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]
T-350	0.009 [0.2286]		0.003 [0.0762]	0.008 [0.2032]
T-506	0.008 [0.2032]		0.003 [0.0762]	0.010 [0.2540]
T-590	0.008 [0.2032]		0.003 [0.0762]	0.011 [0.2794]

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

At this period, perform all previous checks and:

Inspect Bearings
Rebuild Cylinder Head
Replace Cylinder Liner Seals
Replace Piston Rings
Replace Front And Rear Crankshaft Seals
Replace Vibration Damper
Inspect Cylinder Liners
Inspect Pistons
Inspect Crankshaft Journals
Clean Oil Cooler

Parts which are worn beyond worn 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)

Change Converter Oil

Oil should be changed every spring and fall in the hydraulic system, or more often, 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 and 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 by-pass 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 in. [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 5-9 gives settings for shutterstats and thermatic fans as normally used. The 180/195 deg F [82.2/90.6 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 170/185 deg F [76.7/85.0 deg C] or low 160/175 deg F [71.1/79.4 deg C] and in a few cases high-range 180/195 deg F [82.2/90.6 deg C] thermostats, depending on engine application.

Check 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. 5-44.

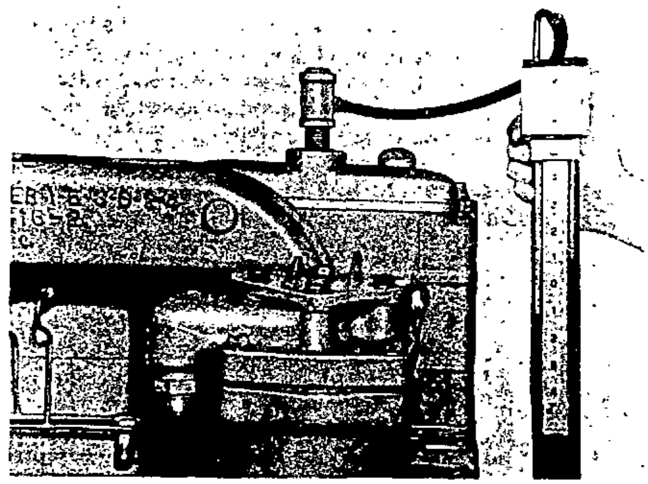


Fig. 5-44, N11489. Checking blow-by under load

Table 5-9: Thermal Control Settings

Control Used	Setting With 160 deg/175 deg F [71.1 deg/79.4 deg C] 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]	177 deg F [80.6 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]		185 deg F [85.0 deg C]		195 deg F [90.6 deg C]	

Tighten Manifold Nuts Or Capscrews (As Required)

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

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. 5-45.

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.

Check Crankshaft End Clearance (At Clutch Adjustment)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed for that model in Table 5-10. 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 in. [0.5588 mm].

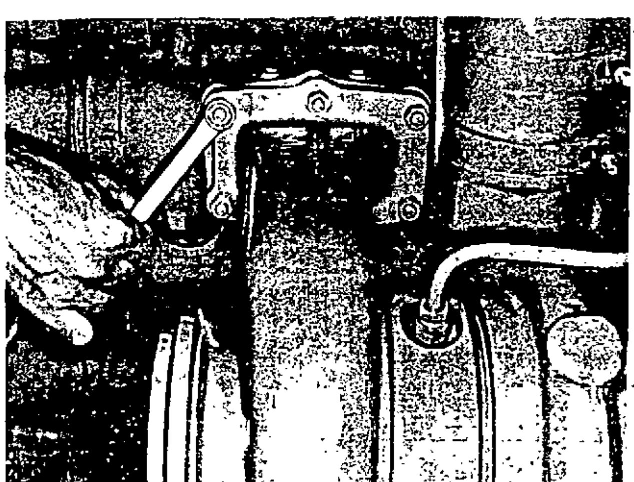


Fig. 5-45, N11953. Tightening T-50 Turbocharger mounting nuts

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. 5-46) if the oil pan is not removed. End clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Table 5-10: Crankshaft End Clearance – In.[mm]

New Minimum	New Maximum	Operating Worn Limit
0.007 [0.1778]	0.017 [0.4318]	0.035 [0.8890]

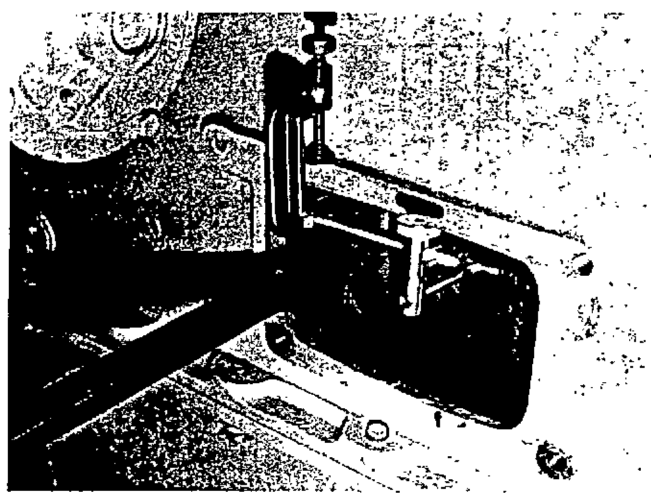
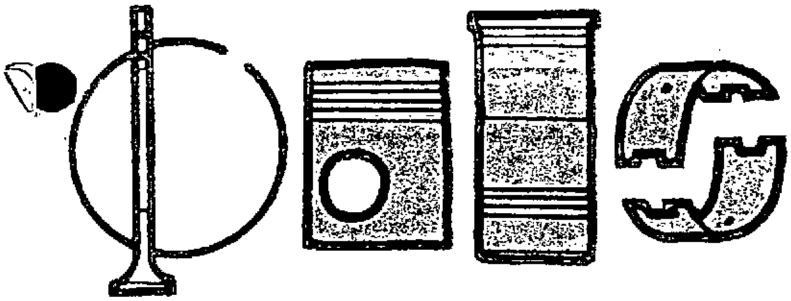


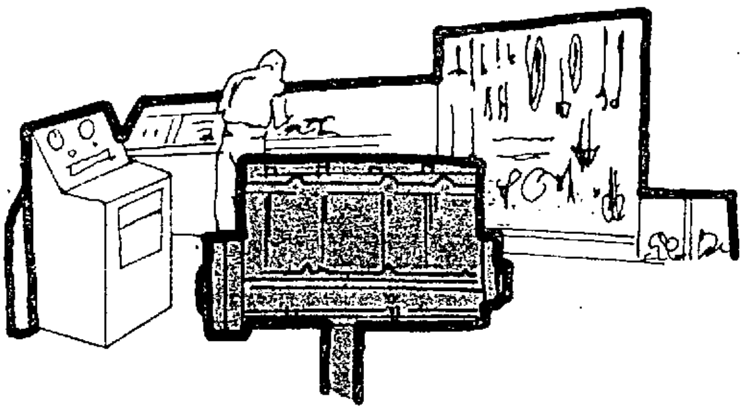
Fig. 5-46, N11957. Checking crankshaft end clearance



Parts

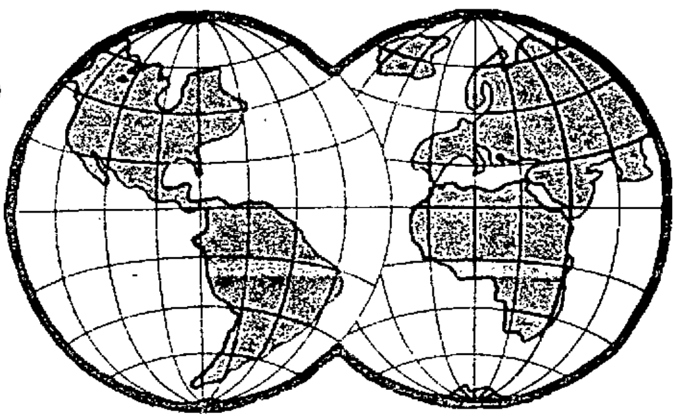
Genuine Cummins service parts are of the same high quality as those used on the original engine so your engine will continue to give good service after any repair or maintenance.

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



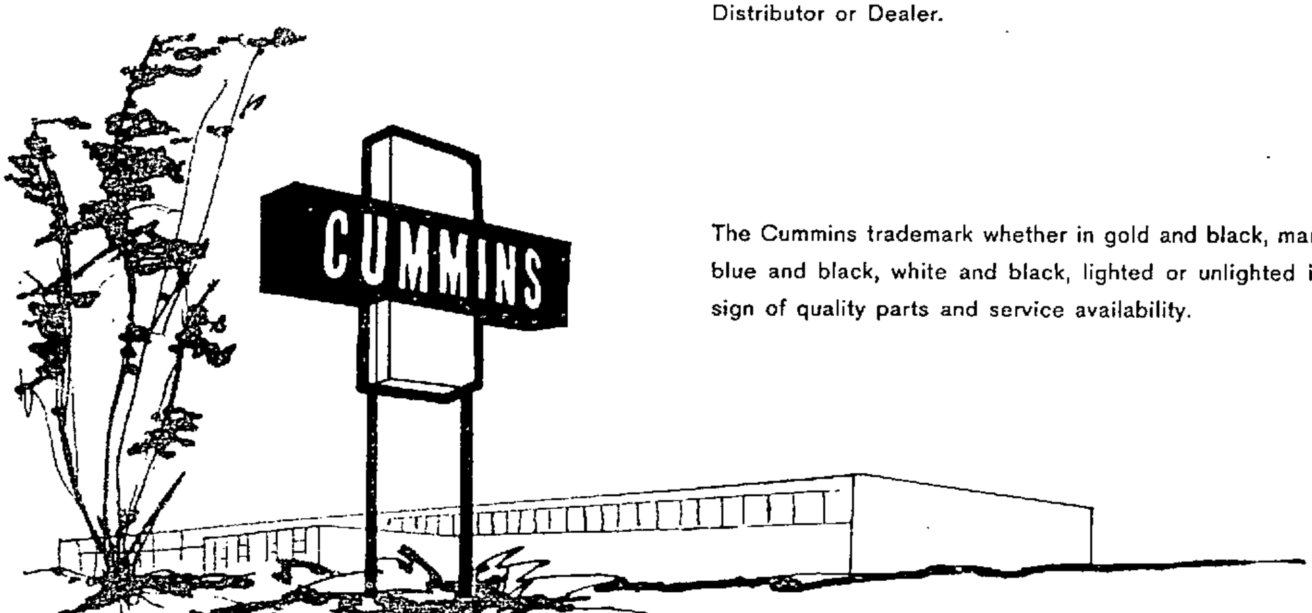
Service

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.



The Cummins trademark whether in gold and black, marine blue and black, white and black, lighted or unlighted is a sign of quality parts and service availability.

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															

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Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Cummins Engine Company, Ltd.
Coombe House, St. George's Square
New Malden, England
Cable: INTCUMLON MALDEN

Overseas Factories:
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