Cummins Diesels

H and NH series

Operation and Maintenance Manual

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

Operation and Maintenance Manual

Cummins Diesel H and NH 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 maintenance section is for the men who are responsible for the upkeep and availability of 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 if you are equipped to do your own repair work.

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

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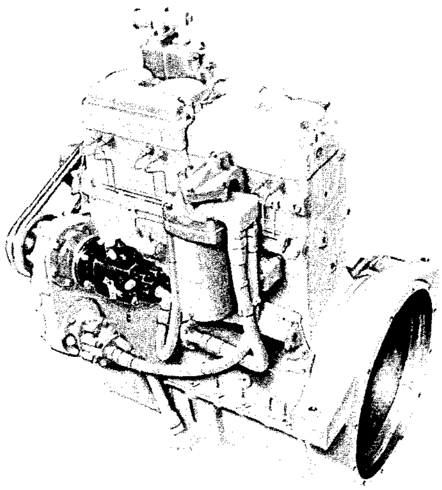
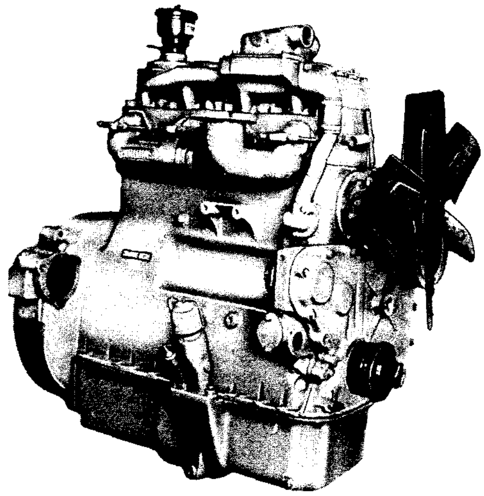
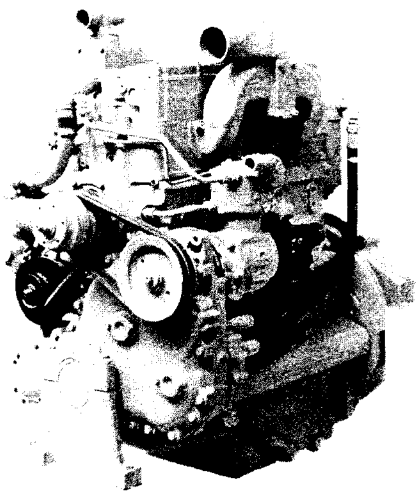


HRC-4 Engine Model



NHC-4 Engine Model



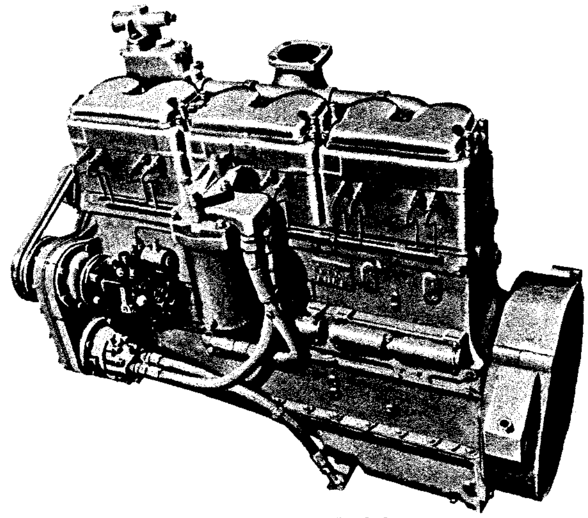
NH-135 Engine Model

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

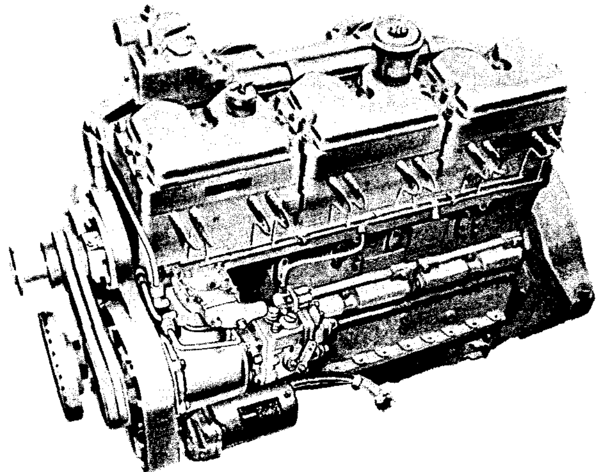
Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Engine Breathing
HRC-4	$5^1/_8$ x 6	495	2	115 @ 1800	Natural Aspirated
NHC-4	$5^1/_8$ x 6	495	4	130 @ 2000	Natural Aspirated
*NH-135	$5^1/_2$ x 6	570	4	135 @ 2100	Natural Aspirated
*NH-160	$5^1/_2$ x 6	570	4	160 @ 2100	Natural Aspirated
NT-165	$5^1/_8$ x 6	495	4	165 @ 2000	Turbocharged

* Available from Shotts, Scotland Factory Only.

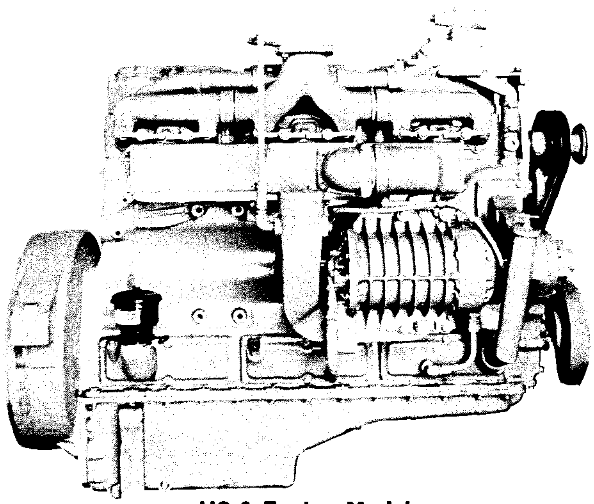
1. Ratings established at 29.92 In./Hg. barometric pressure (sea level), 60°F. air intake temperature, dry air. Derate natural aspirated engines 3% for each 1000 feet above sea level and 1% for each 10°F. rise in air temperature.
2. Turbocharged engines are derated 3% for each 1,000 feet altitude above 12,000 feet and 1% for each 10° F. air temperature rise above 125° F.



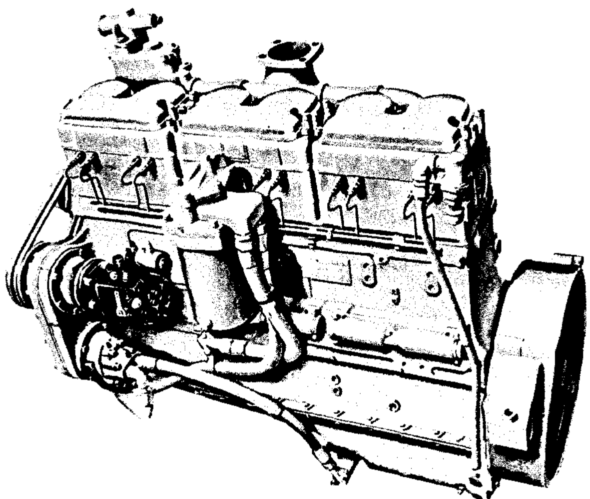
H-6 Engine Model



HRF-6 Engine Model



HS-6 Engine Model



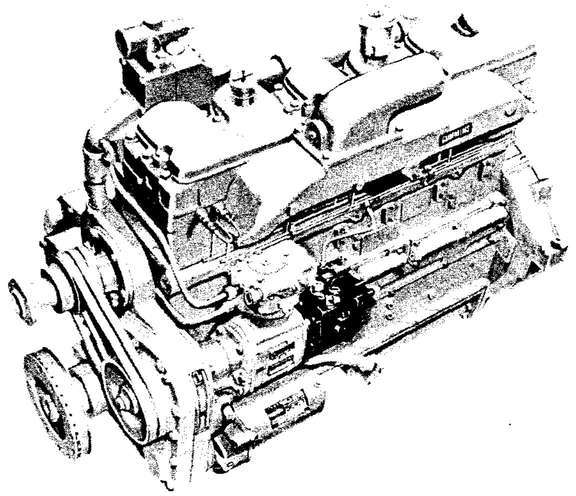
HRS-6 Engine Model

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

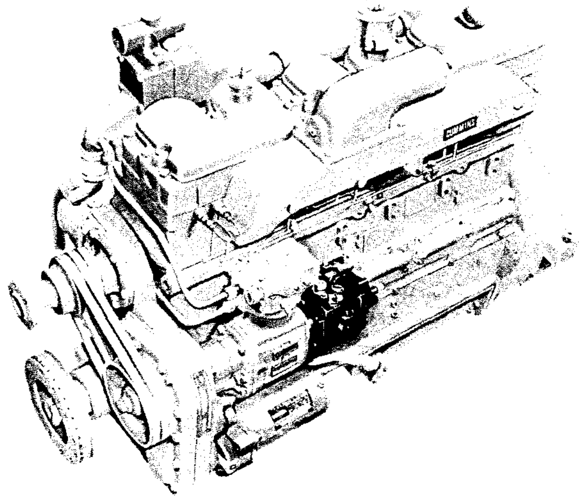
Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Engine Breathing
H-135	4⅞ x 6	672	2	135 @ 1800	Natural Aspirated
H-6	4⅞ x 6	672	2	160 @ 1800	Natural Aspirated
*HU-170	4⅞ x 6	672	4	170 @ 1800	Natural Aspirated
HR-6	5⅛ x 6	743	2	175 @ 1800	Natural Aspirated
HRF-6	5⅛ x 6	743	2	190 @ 2000	Natural Aspirated
HS-6	4⅞ x 6	672	2	210 @ 1800	Supercharged
HRS-6	5⅛ x 6	743	2	240 @ 1800	Supercharged

* Available from Shotts, Scotland Factory Only.

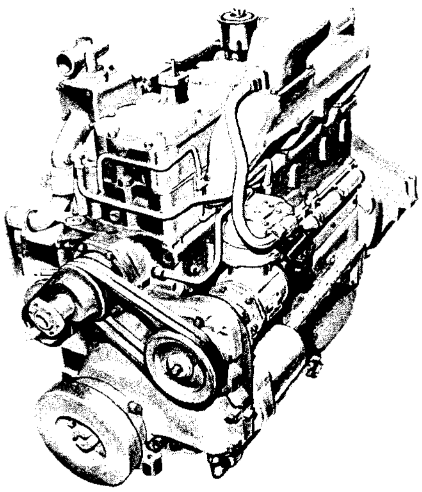
1. Ratings established at 29.92 In./Hg. barometric pressure (sea level), 60°F. air intake temperature, dry air.
2. Derate natural aspirated and supercharged engines 3% for each 1000 feet above sea level and 1% for each 10°F. rise in air temperature.



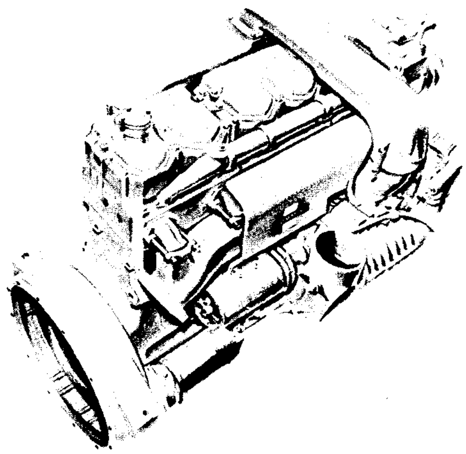
NH-180 Engine Model



NH-220 Engine Model



NH-250 Engine Model



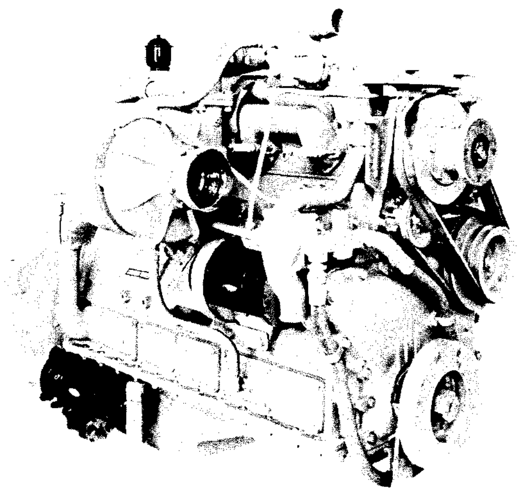
NHRS-6 Engine Model

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

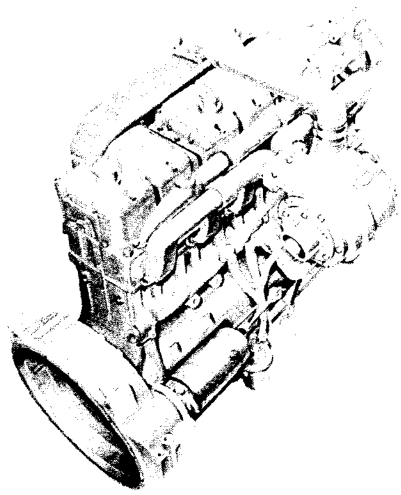
Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Engine Breathing
NH-180	4 7/8 x 6	672	4	180 @ 2100	Natural Aspirated
NHE-180	5 1/8 x 6	743	4	180 @ 1950	Natural Aspirated
NHE-195	5 1/8 x 6	743	4	195 @ 1950	Natural Aspirated
NH-220	5 1/8 x 6	743	4	220 @ 2100	Natural Aspirated
NHE-225	5 1/2 x 6	855	4	225 @ 1950	Natural Aspirated
NH-250	5 1/2 x 6	855	4	250 @ 2100	Natural Aspirated
NHS-6	5 1/8 x 6	743	4	290 @ 2100	Supercharged
NHRS-6	5 1/8 x 6	743	4	320 @ 2100	Supercharged

1. Ratings established at 29.92 In./Hg. barometric pressure (sea level), 60°F. air intake temperature, dry air.

2. Derate 3% for each 1000 feet above sea level and 1% for each 10°F. rise in air temperature.



NRTO-6 Engine Model



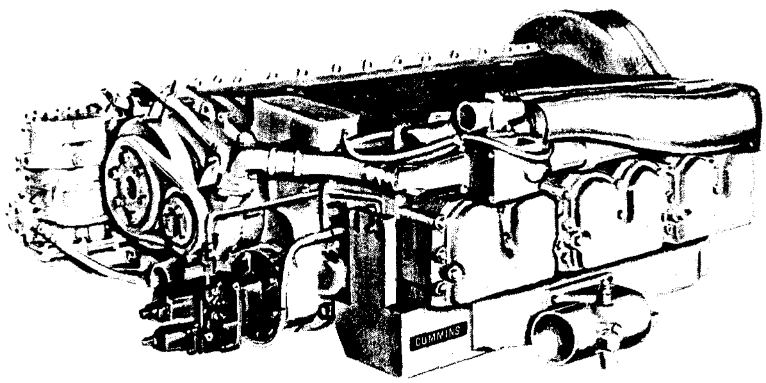
NT-380 Engine Model

Table 4: Cummins Six Cylinder Turbocharged NH Series Engines

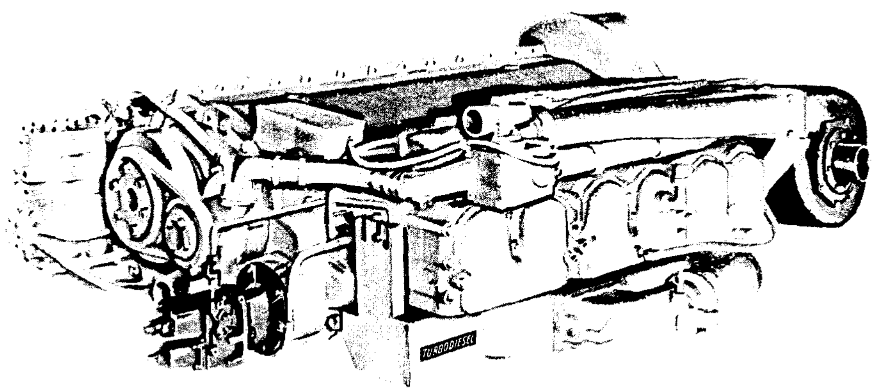
Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Begin Derate @ Altitude
NTE-235	5 1/8 x 6	743	4	235 @ 2100	15,000
NT-6	5 1/8 x 6	743	4	250 @ 2100	12,000
NTO-6	5 1/8 x 6	743	4	262 @ 2100	12,000
NT-280	5 1/2 x 6	855	4	280 @ 2100	12,000
NT-300	5 1/2 x 6	855	4	300 @ 2100	12,000
NRT-6	5 1/8 x 6	743	4	300 @ 2100	12,000
NT-310	5 1/2 x 6	855	4	310 @ 2100	12,000
NRTO-6	5 1/8 x 6	743	4	335 @ 2100	5,000
NT-335	5 1/2 x 6	855	4	335 @ 2100	10,000
NT-380	5 1/2 x 6	855	4	380 @ 2300	8,000
*NT-400	5 1/2 x 6	855	4	400 @ 2300	2,000

1. Turbocharged engines are derated 3% for each 1,000 feet altitude above listing in table and 1% for each 10° F. air temperature rise above 125° F.

* Available from Shotts, Scotland Factory Only.



NHH-220 Engine Model

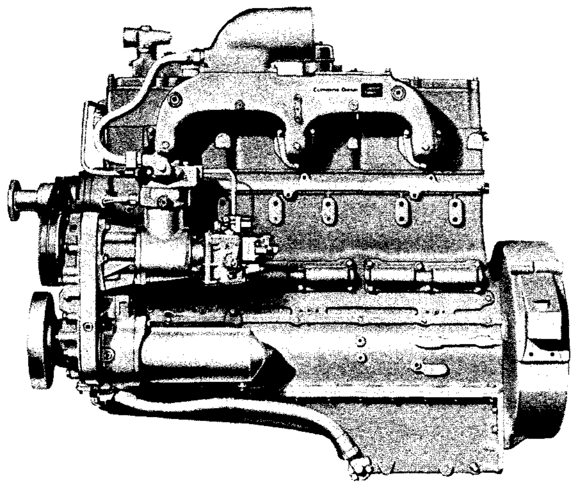


NHHRTO-6 Engine Model

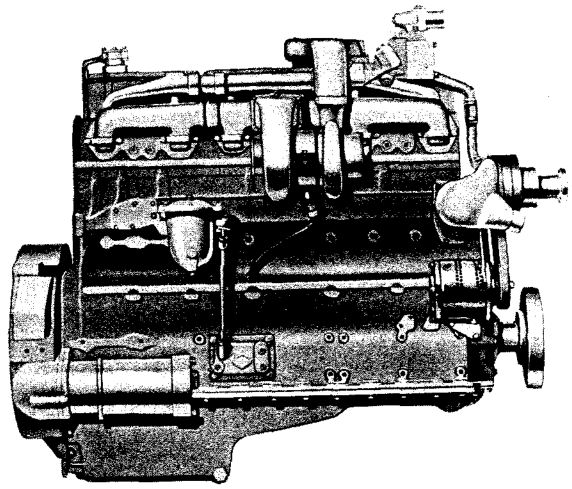
Table 5: Cummins H and NH Horizontal Engines

Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Engine Breathing
HHR-6	5⅛ x 6	743	2	175 @ 1800	Natural Aspirated
HHRF-6	5⅛ x 6	743	2	190 @ 2000	Natural Aspirated
NHH-180	4⅞ x 6	672	4	180 @ 2100	Natural Aspirated
NHHE-180	5⅛ x 6	743	4	180 @ 1950	Natural Aspirated
NHHE-195	5⅛ x 6	743	4	195 @ 1950	Natural Aspirated
NHH-220	5⅛ x 6	743	4	220 @ 2100	Natural Aspirated
NHHRS-6	5⅛ x 6	743	4	320 @ 2100	Supercharged
NHHT-6	5⅛ x 6	743	4	250 @ 2100	Turbocharged
NHHTO-6	5⅛ x 6	743	4	262 @ 2100	Turbocharged
NHHRT-6	5⅛ x 6	743	4	300 @ 2100	Turbocharged
NHHRTO-6	5⅛ x 6	743	4	335 @ 2100	Turbocharged

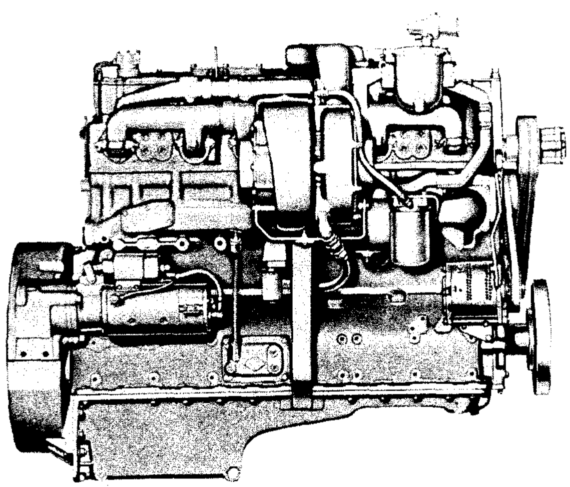
1. See previous table 2, 3 and 4 for engine derating specifications which are the same as corresponding "vertical" engine model.



NHC-250 Engine Model



NHCT-270 Engine Model



NTC-335 Engine Model

Table 6: Cummins Custom Rated Diesels

Engine Model	Bore & Stroke	Cu. In. Displ.	Valves Cylinder	Max. HP @ RPM	Engine Breathing	Begin Derate @ Altitude
NHC-250	5½ x 6	855	4	225 @ 2100	Natural Aspirated	Sea Level
NHC-250	5½ x 6	855	4	250 @ 2100	Natural Aspirated	Sea Level
NHCT-270	5½ x 6	855	4	240 @ 2100	Turbocharged	12,000
NHCT-270	5½ x 6	855	4	255 @ 2100	Turbocharged	12,000
NHCT-270	5½ x 6	855	4	270 @ 2100	Turbocharged	12,000
NTC-335	5½ x 6	855	4	260 @ 2100	Turbocharged	9,000
NTC-335	5½ x 6	855	4	280 @ 2100	Turbocharged	9,000
NTC-335	5½ x 6	855	4	300 @ 2100	Turbocharged	5,000
NTC-335	5½ x 6	855	4	320 @ 2100	Turbocharged	5,000
NTC-335	5½ x 6	855	4	335 @ 2100	Turbocharged	5,000

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 effects 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 quantity 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 pounds per square inch and the temperature of that air is approximately 1000° F.

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 quantity 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 size of passage the liquid flows through. 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 the pressure of the fuel being delivered by the fuel pump to the injectors so the 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 that the 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 quantity and proper condition to burn.

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

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.

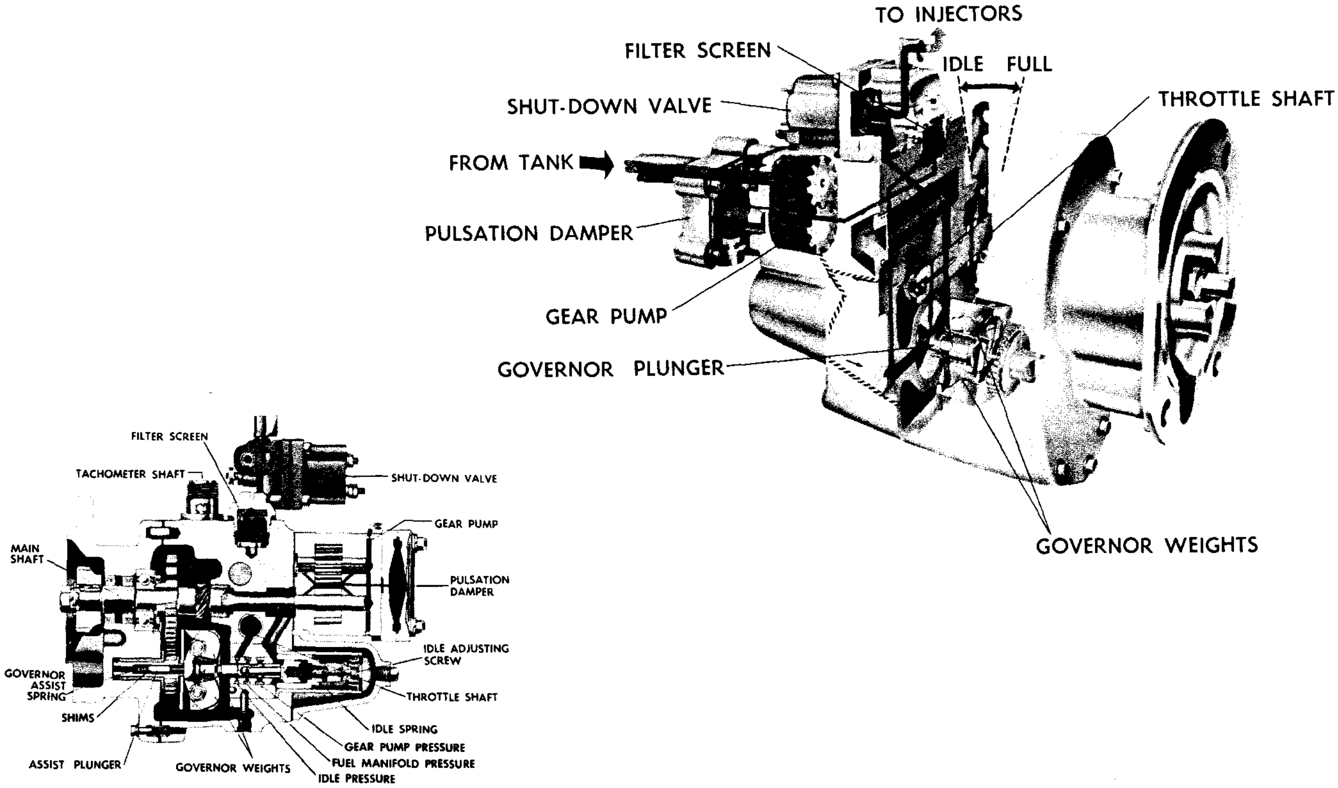


Fig. 1-1. PT (type G) fuel pump cross-section and fuel flow

FWC-5 FWC-6

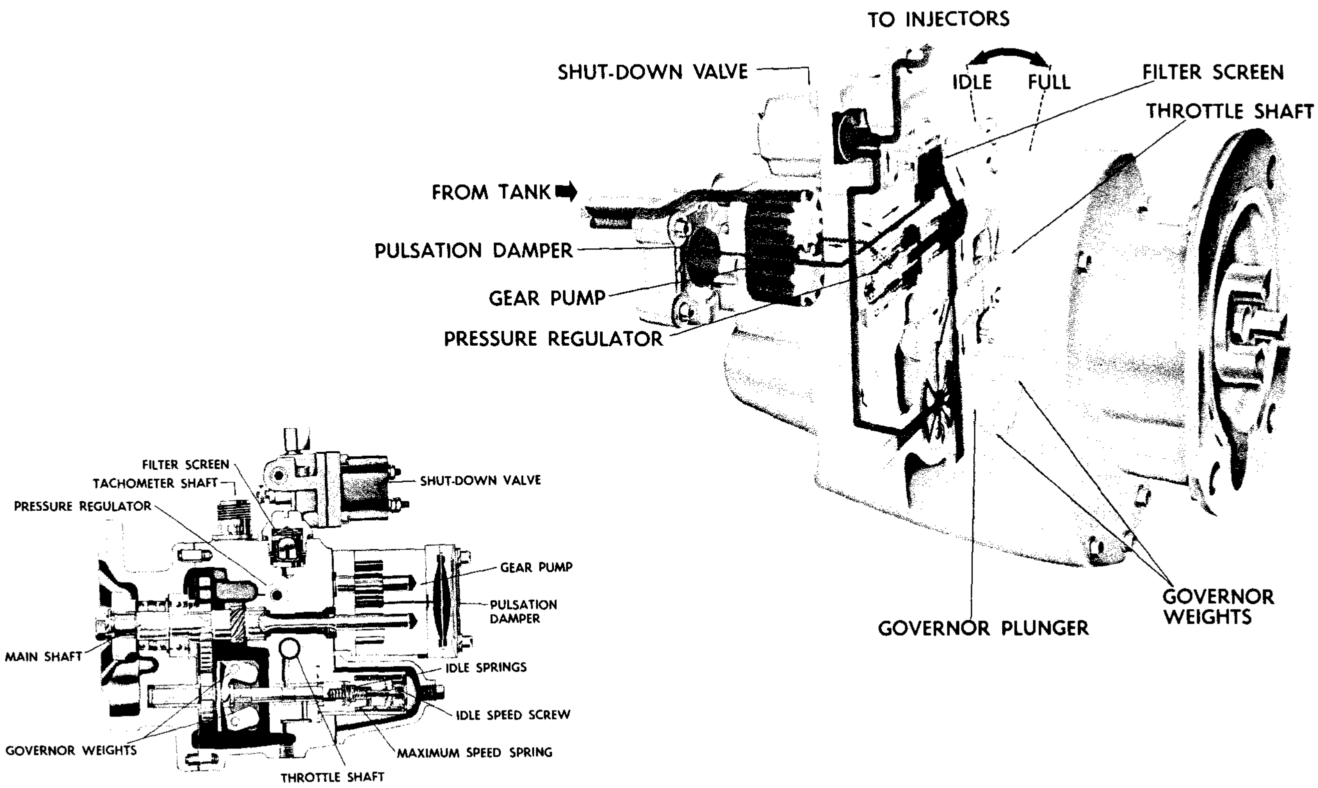


Fig. 1-2. PT (type R) fuel pump cross-section and fuel flow FWC-4

PT-(type G) Fuel Pump

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

1. The gear pump which draws fuel from the supply tank and forces it through the pump filter screen to the governor.
2. The governor which controls the flow of the fuel from the gear pump, as well as the 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. 1-1 and 1-2.

PT-(type R) Fuel Pump

The PT-(type R) fuel pump can be identified easily by the presence of a fuel return line from the top of the fuel pump housing to the supply tank.

The pump assembly is made up of four main units.

1. The gear pump which draws fuel from the supply tank forcing it through the pump filter screen into the pressure regulator valve.
2. A pressure regulator which limits the pressure of the fuel to the injectors.
3. The throttle which provides a manual control of fuel flow to the injectors under all conditions in the operating range.
4. The governor assembly which controls the flow of fuel from idle 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. 1-1.

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

Pressure Regulator

The pressure regulator, used only in the PT-(type R) fuel pump, functions as a bypass valve to regulate the fuel pressure to the injectors. By-passed fuel flows back to the suction side of the gear pump. See Fig. 1-2.

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", identical 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 positions 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 in accord with the engine requirements as 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.

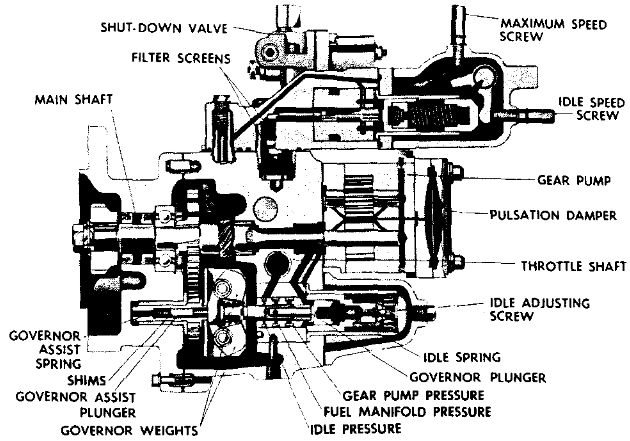


Fig. 1-3. PT (type G) fuel pump with MVS governor FWC-9

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 Figs. 1-3 and 1-4.

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.

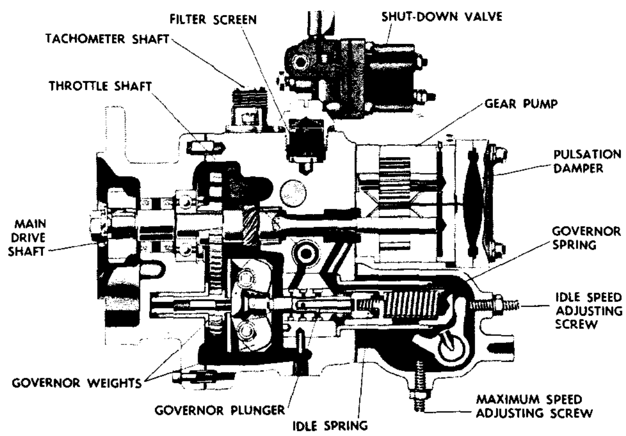


Fig. 1-4. PT (type G) fuel pump with SVS governor FWC-10

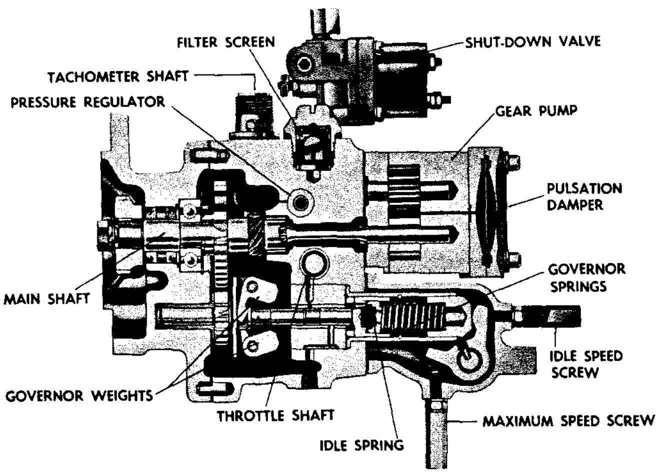


Fig. 1-5. PT (type R) fuel pump with MVS governor FWC-7

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. 1-3.

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. 1-3. The governor also may 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.

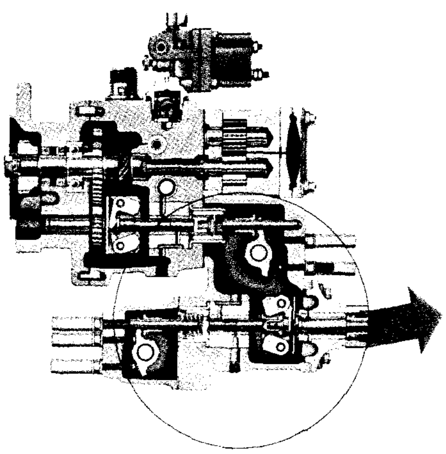
Special Variable Speed (SVS) Governor

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 shutdown 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) injectors should be used in marine engines equipped with the 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.



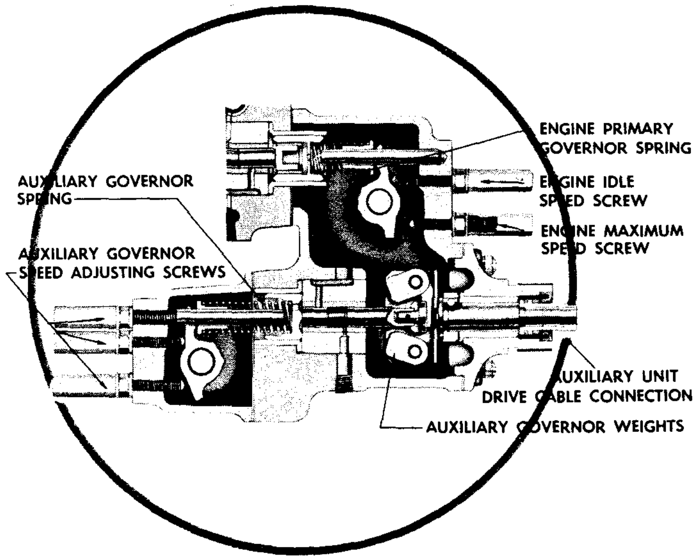


Fig. 1-6. Cross-section torque converter governor and PT (type R) fuel pump FWC-8

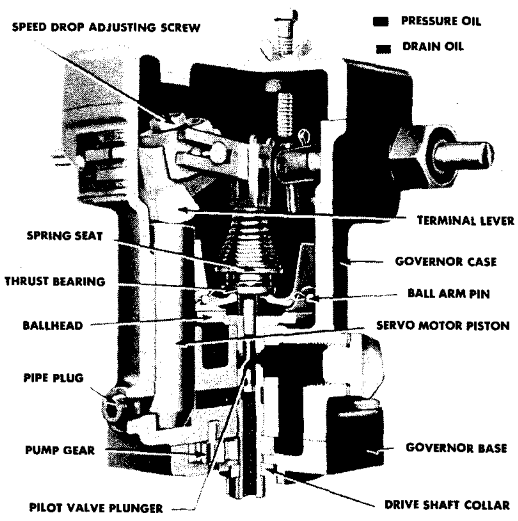


Fig. 1-7. Load off, speed increased position FWC-1

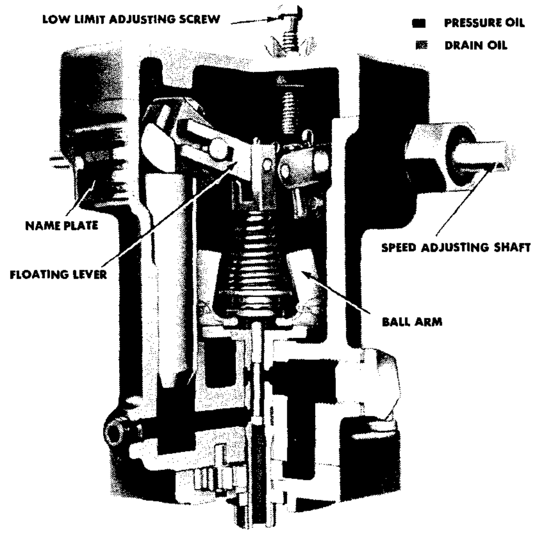


Fig. 1-8. Load on, speed decreased position FWC-1

PT-(type R) Mechanical Variable-Speed Governor

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

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross-section of this governor is shown in Fig. 1-5.

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.

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. 1-6.

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 engine oil gallery. For oil viscosity, see Page 3-1.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in the governor control linkage acts to decrease fuel delivery.

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 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 as shown in Fig. 1-9. 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. Fig. 1-10.

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 is accomplished through internal drilled passages in the cylinder head. Fig. 1-13. 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 a 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

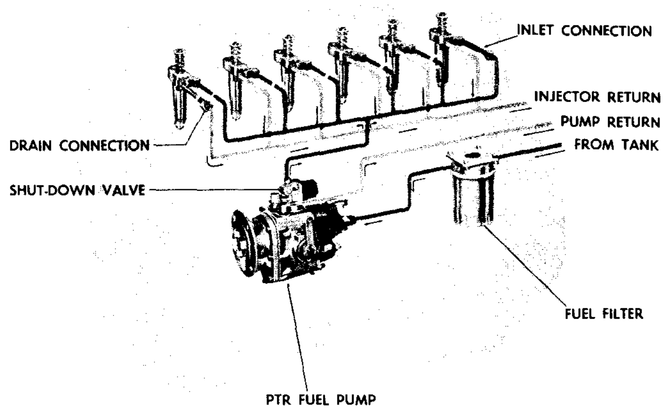


Fig. 1-9. Fuel flow diagram, PT (type R) pump and flange injector FWC-16

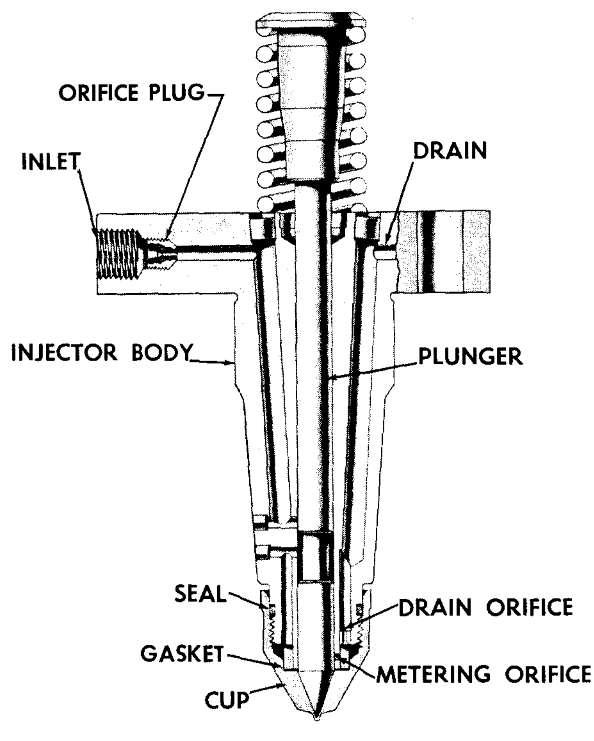


Fig. 1-10. Cross-section, flanged PT injector FWC-11

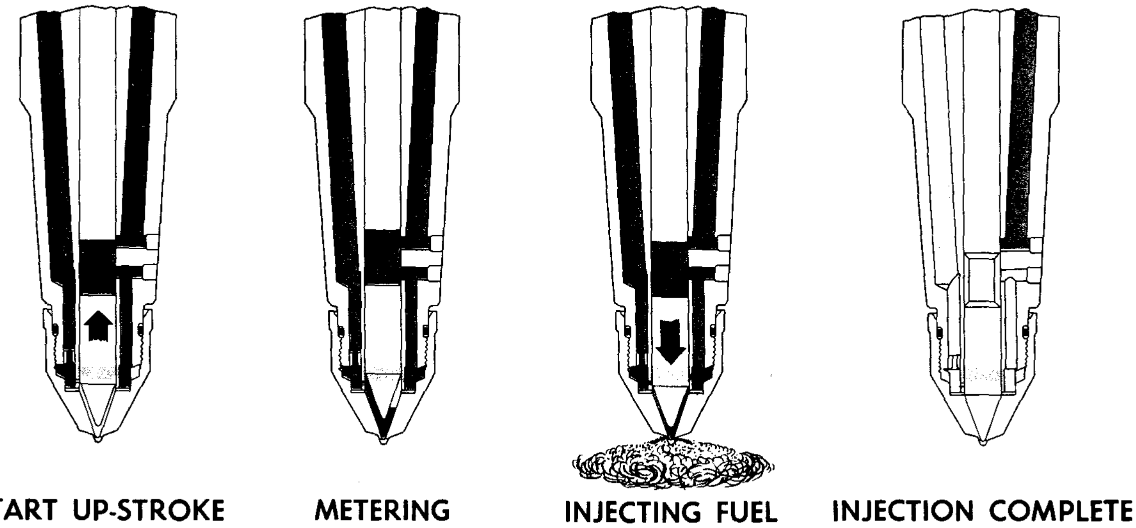


Fig. 1-11. Fuel injection cycle, flanged PT injector FWC-11

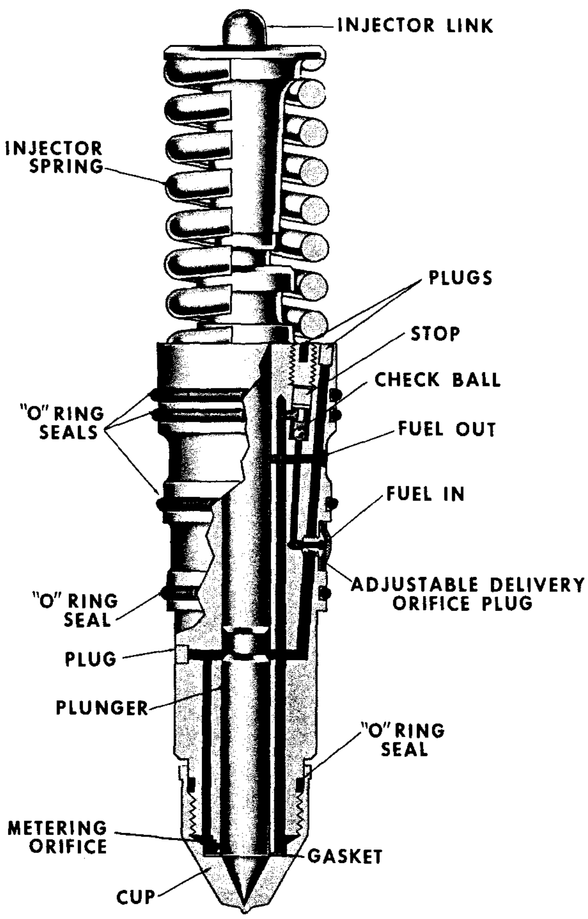


Fig. 1-12. Cross section, cylindrical PT (type B) injector FWC-14

bore. Fig. 1-12. This forms a leak-proof passage between the injectors and the cylinder head injector bore surface.

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.

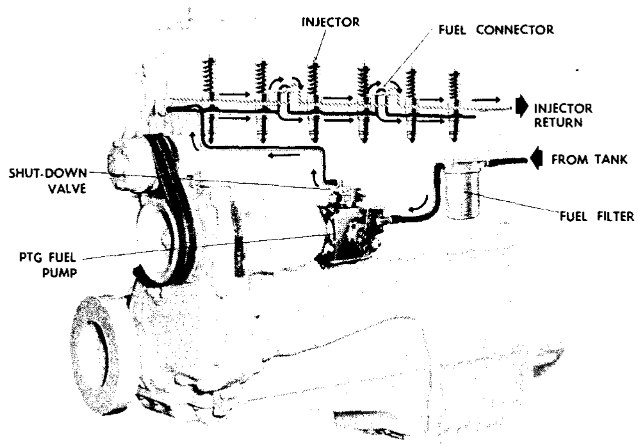


Fig. 1-13. Fuel flow diagram, PT (type G) pump and cylindrical injectors FWC-13

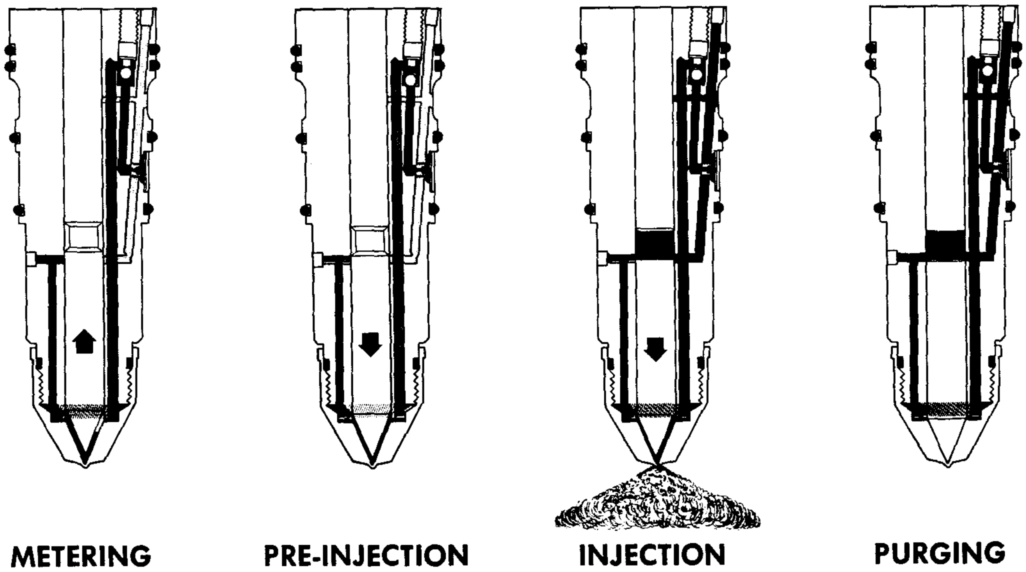


Fig. 1-14. Fuel injection cycle, PT (type B) cylindrical injector FWC-14

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 as shown in Fig. 1-9. 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. Fig. 1-9. This line is not necessary with the PT (type G) pump. Fig. 1-13.

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. 1-13.

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 counter-clockwise 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.

Aneroid

The aneroid control (Fig. 1-15.) provides a fuel by-pass system that responds to air manifold pressure and is used on some turbocharged engines whenever close control of exhaust smoke is desirable.

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

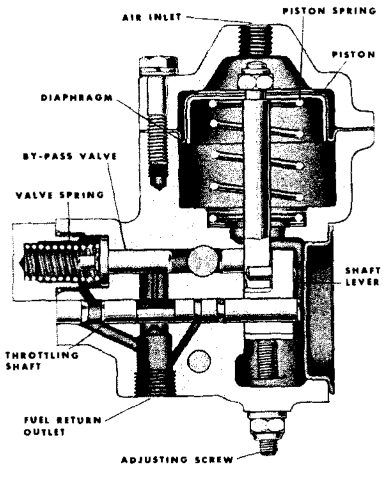


Fig. 1-15. Aneroid control cross-section AWC-2

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 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 again 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, Fig. 1-16, 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.

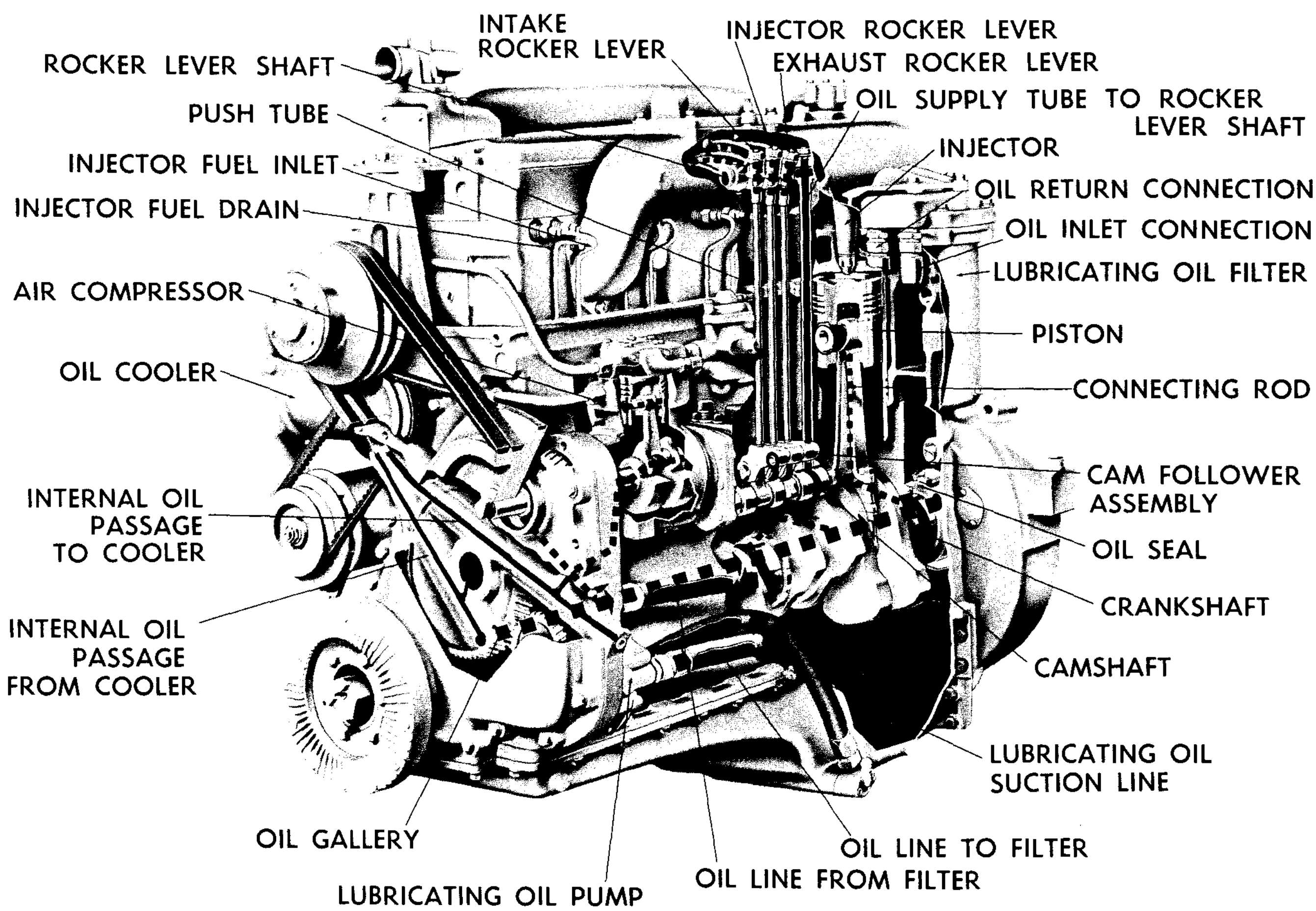


Fig. 1-16. Lubricating oil flow

LWC-9 & LWC-12

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. 1-17.

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.

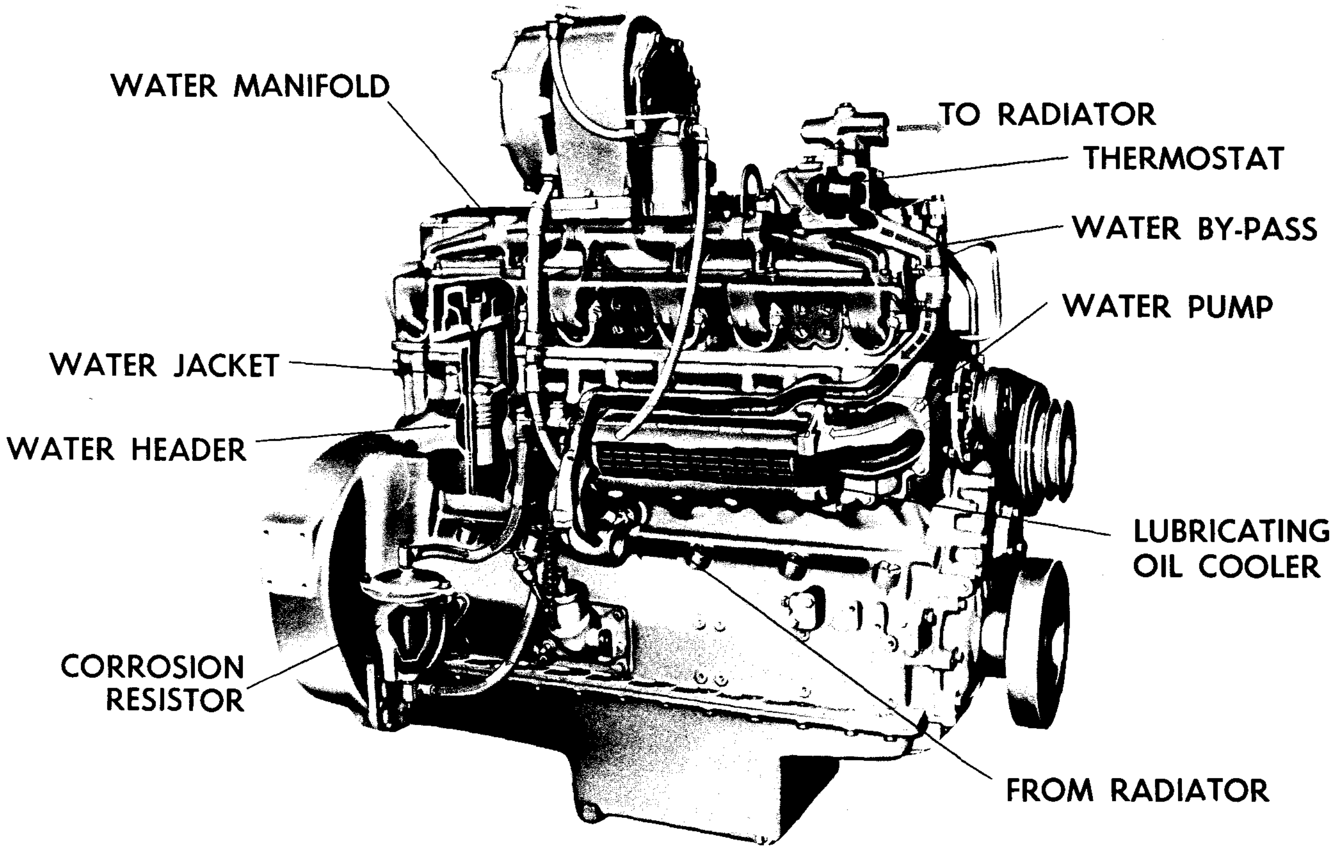


Fig. 1-17. Coolant flow NT-380 engine

CWC-7

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 either oil bath, paper element or composite type depending upon the 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 HR, 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.

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. 1-18.

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 a single cylinder unit 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:

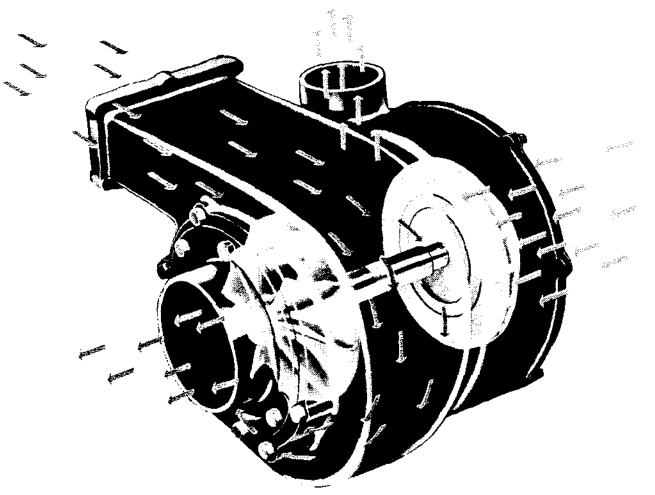


Fig. 1-18. Turbocharger exhaust gas and air flow N11022

Air Intake

Air is drawn into the compressor from a separate filter or 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. 1-19.

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 the top of the unloader cap by a compressor governor. This pressure forces the cap down and seals off the intake passage. When pressure in the air tank drops, the cap returns to its upper position and the intake and compression sequences begin again.

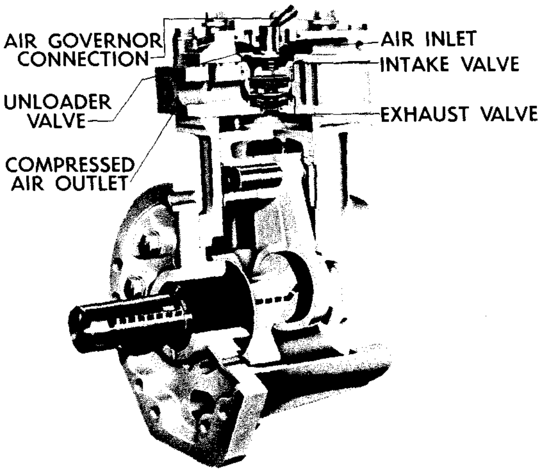


Fig. 1-19. Cummins air compressor cross-section AWC-1

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

The way a new engine is operated during the first 3000 miles or 100 hours' service will have an important effect on the life of the engine and its parts. Its moving parts are closely fitted for long service, and even though all Cummins engines are run on a dynamometer for several hours before they leave the factory, an additional period may be required before uniform oil films are established between all mating parts.

During the first 100 hours' service:

1. Operate at one-half to three-quarters throttle. Do not operate at maximum horsepower for more than five minutes at a time.
2. Do not idle the engine for long periods as this will cause cylinder walls to glaze before the piston rings seat properly and result in excessive lubricating oil consumption.
3. Watch the instruments closely. Decrease engine rpm if oil temperature reaches 250°F. or if coolant temperature exceeds 190°F.
4. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

Pre-Starting Instructions — First Time

Fuel System

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

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

B. With PT (type R) 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 3-3.
3. If injector and valve adjustments have been disturbed by any maintenance work, check to be sure that they have been properly adjusted before starting the engine.

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, plug on side of lubricating oil pump. Fig. 2-1.
3. Connect a hand or motor driven priming pump line from source of clean (see Page 3-1) lubricating oil to oil plug boss.
4. Prime until a 30 psi minimum pressure is obtained.
5. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi.
6. Remove external oil supply and replace plug in cylinder block.

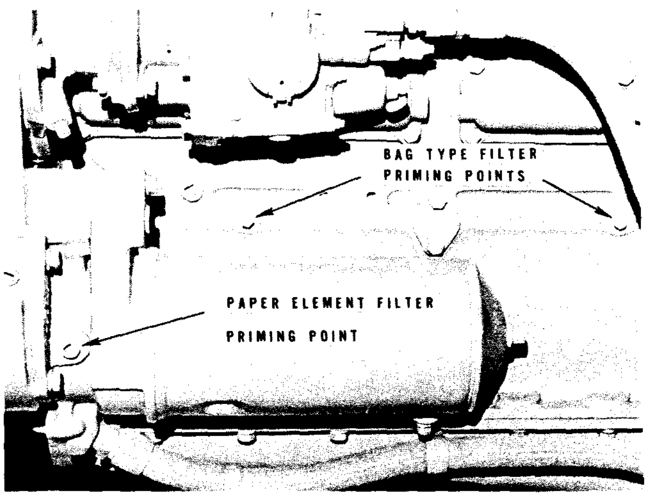


Fig. 2-1. Lubricating system priming points N11938

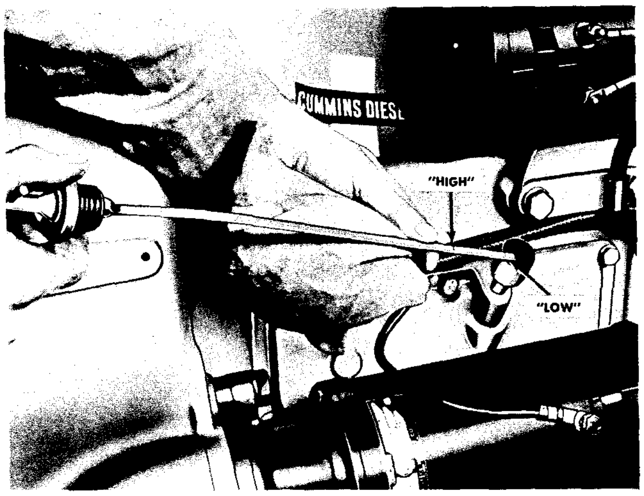


Fig. 2-2. Checking engine oil level N11801

7. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications shown on Page 3-1. No change in oil viscosity or type is needed for new or newly rebuilt engines.

Caution: After engine has run a few minutes it will be necessary to add lubricating oil to compensate for that absorbed by filter element(s) and oil cooler.

Cooling System

1. Fill cooling system with coolant or anti-freeze solution, as required.
2. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described on Page 3-4.

Normal-Daily Checks

Check Oil Level

1. A dip stick oil gauge is located on the side of the engine. The dip stick supplied with the engine has a high "H" and low "L" level mark to indicate lubricating oil supply. The dip stick 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 parts numbers.
2. Keep oil level as near the high mark as possible. Fig. 2-2.

Caution: Never operate the engine with oil level below the low level mark, or above the high level mark.

Check Air Connections

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

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check the engine coolant supply. Add coolant as needed to completely fill the system.
2. Make visual check for leaks.

Check Fuel Supply

1. Fill fuel tanks with fuel meeting specifications on Page 3-3.
2. Visually check for evidence of external fuel leakage at the fuel connections.
3. Tighten fuel manifold fittings; tighten fuel connections to 20/25 in. lbs.
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. lbs.

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.

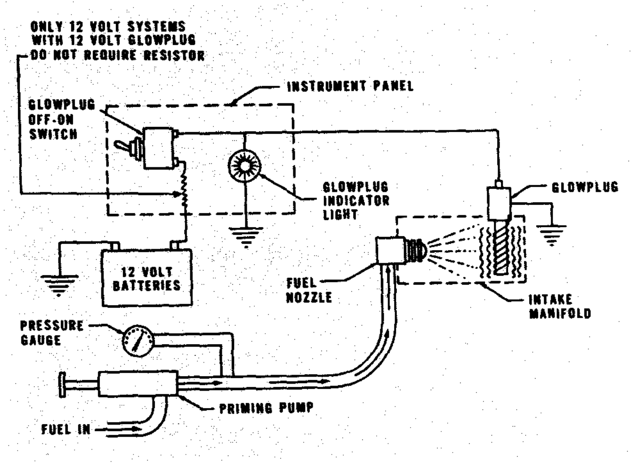


Fig. 2-3. Preheater wiring diagram N11804

Use the Preheater for Cold Weather Starting

To aid in starting the engine when the temperature is 50°F. 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.

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 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; then, move to "run" position.
4. If engine does not start within 20 seconds, stop cranking. Wait 30 seconds and repeat cranking operation.
5. After engine starts, pump primer slowly to keep engine idling smoothly. In cold weather this may require 4 to 5 minutes, or longer. Do not accelerate engine.
6. When the engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch. (Red indicator light will go out).

Failure To Start

1. If the engine gives no indication of starting during the first three full strokes of the preheater pump, touch-check the intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove 1/8" pipe plug from manifold near glow plug and carefully check for flame while a helper performs the preceding Steps 2, 3 and 4.
2. If no flame is observed, close glow plug manual switch 15 seconds and observe plug plug through 1/8" pipe plug hole. The glow plug should be white hot; if not, connect glow plug to a 6 or 12 volt (as used) source and check amperage which should be 30/32 (minimum). If glow plug is all right, check manual switch and resistor, if used, and replace if necessary.

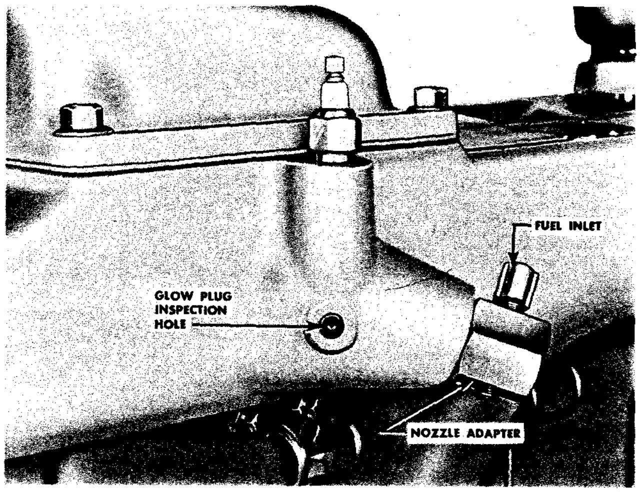


Fig. 2-4. Glow plug inspection hole N11805

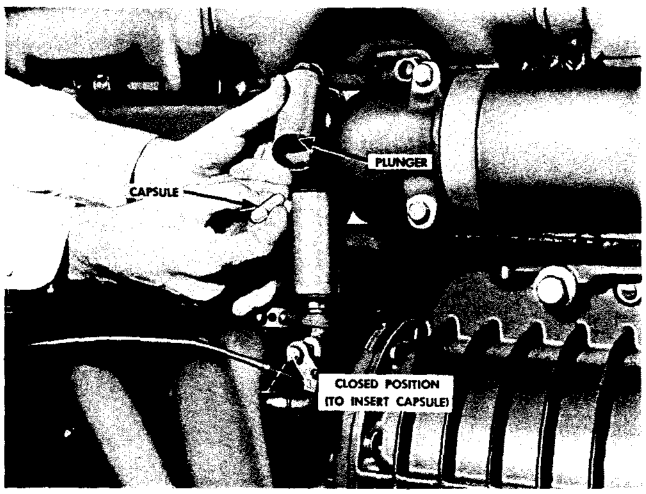


Fig. 2-5. Ether compound metering equipment N11806

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 turbo-charger 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. If properly installed, the spring will hold it closed.
2. Remove cap and insert capsule of starting fluid. Fig. 2-5.
3. Push cap down sharply to puncture capsult 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.

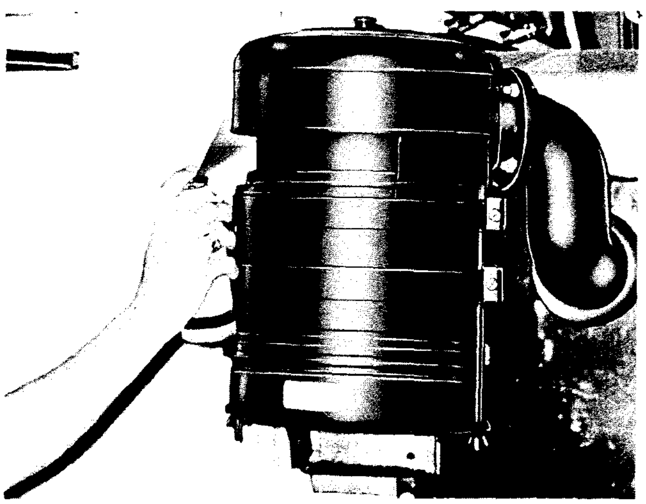


Fig. 2-6. Ether spray application N11807

Use of Ether Without Metering Equipment

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

Caution: Never handle ether near an open flame. Never use it with preheater or flame thrower equipment. Do not breathe the fumes.

1. Pour three tablespoonfuls of ether on a cloth; hold cloth close to air cleaner intake while second man cranks the engine.

   Caution: Be sure cloth is outside the air cleaner and cannot be drawn into the engine.

2. As an alternate method, spray ether into air cleaner intake while second man cranks the engine. Fig. 2-6.

   Caution: Use of too much ether will cause excessively high pressures and detonation.

3. 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 some 4 to 5 minutes or preferably until water temperature reaches 140° F. before engaging the load. During the next 10 to 15 minutes, or until water temperature reaches 160°/165° F. 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	Governed RPM Full Load	Cruising RPM
H-6, HU-170	1800	1500 to 1550
HS-6	1800	1500 to 1550
HR(C)-4	1800	1500 to 1550
HR-6, HRS-6	1800	1500 to 1550
HRF-6, NHC-4	2000	1700
NHE-180, 195	1950	1650 to 1700
NH-180, NH-135	2100	1750 to 1800
NH-160	2100	1750 to 1800
NHR-195	2100	1750 to 1800
NH-220	2100	1750 to 1800
NHE-225	1950	1650 to 1700
NH-250, NHC-250	2100	1750 to 1800
NT-165	2000	1700
NHRS-6, NHS-6	2100	1750 to 1800
NH-200, NH-180	2100	1750 to 1800
NTO-6, NT-6	2100	1750 to 1800
NT-280, NTC-280	2100	1750 to 1800
NT-310, NHCT-270	2100	1750 to 1800
NRTO-6, NRT-6	2100	1750 to 1800
NT-335, NTC-335	2100	1750 to 1800
NT-380, NT-400	2300	1950 to 2000

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 the 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 operation; the operator must use the panel board instruments. The instruments show at all times how to get the most satisfactory service from any engine.

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 override the governor, or allow the engine to exceed governed rating during operation.

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

The Oil Temperature Gauge Indicates Best Operating Range

The oil temperature gauge normally should read between 180°F. and 225°F. for best lubrication. Under full-load conditions, a temperature of 250/265°F. 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° F. While oil is cold it does not do a good job of lubricating. Continuous operation with oil temperatures much below 140° F. increases likelihood of crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

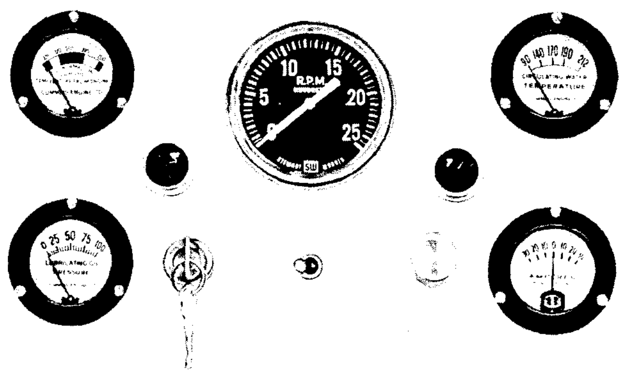


Fig. 2-7. Instrument panel N11808

Keep Water Temperature Between 165° F. And 195° F.

A water temperature of 165° F. to 195° F. 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. Most 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, excessive exhaust smoke and high fuel consumption.

Keep thermostats in the engine summer and winter, avoid long periods of idling, and do whatever else is required to keep water temperatures up to a minimum of 165° F. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

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° F. maximum engine coolant temperature should not be exceeded.

Keep An Eye On The 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

At Rated Speed .... 30/70 psi

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.

Observe 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 maximum, or governed, 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 near the governor. This rule applies to any kind of application.

When More Power Is Needed Increase Engine RPM

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 torque or 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 feet of altitude above sea level for a naturally-aspirated engine. An engine will have a smoky exhaust at high altitude unless a lower gear is used so that 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° F. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle The 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 shutdown valve, or by pulling out the manual shut-down lever. Turning off the switch key which controls the electric shutdown 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 valve push rods and opens the valves. The push rods 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 The 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 the rear of engine. If an air compressor or other "water cooled" accessory is used, open petcock on unit.

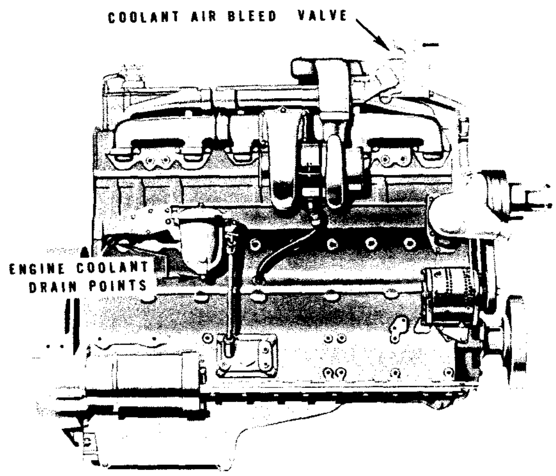


Fig. 2-8. Drain points- engine N10001

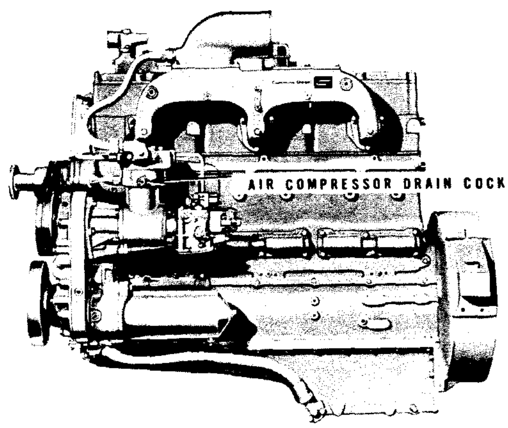


Fig. 2-9. Drain point-air compressor N11827

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.

Automotive Applications

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

Apply Load Gradually

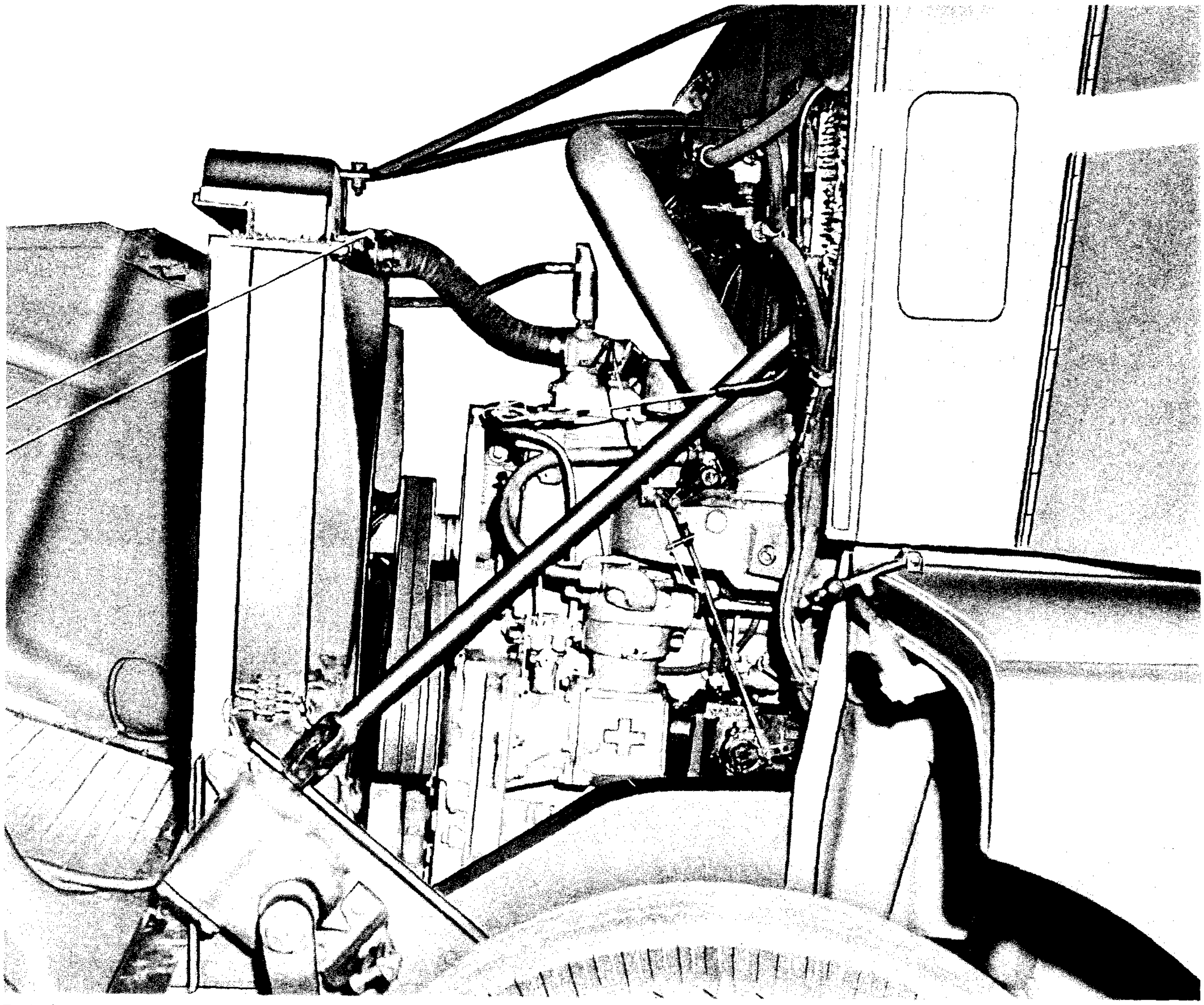
Always engage the load in a gear low enough to allow acceleration to governed rpm, then catch the next gear as the engine decelerates. Do not skip gears.
Shock loads take their toll of tires and transmissions as well as being hard on the engine. Apply load gradually.

Operate At Reduced RPM For Cruising

When operating a truck on a level highway, or cruising, hold engine rpm at approximately 85 percent of governed rpm. See Table 2-1. 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



Typical automotive installation

N11810

and at reduced engine rpm. This is good practice as long as the engine pulls its load at partial throttle.

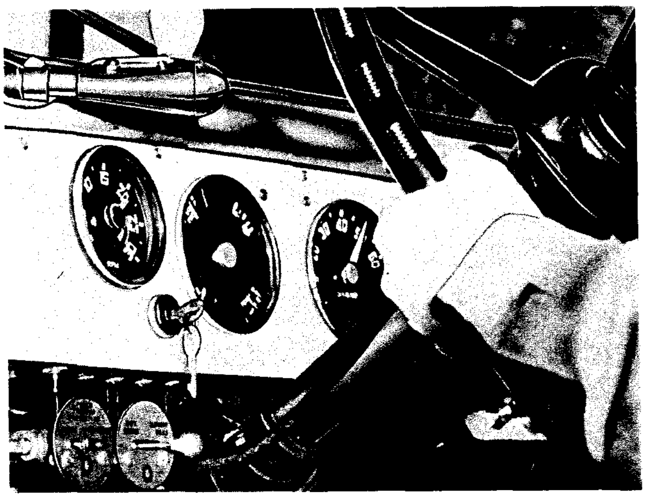


Fig. 2-10. Cruise at 85% of governed rpm N11811

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 override the governor, or allow engine to exceed the governed rating while out of gear, operating at partial load, or driving down hill.

Shift To A Lower Gear When The Load Pulls Down Engine RPM As Much As 10%

If the grade gets steeper and load starts to pull down engine rpm, treat that part of the grade like another hill and shift to a still lower gear.

Never allow engine rpm to drop more than 10 percent below the governor at full-throttle before shifting. If the next gear cannot be "caught" at the 10 percent drop, let up on the throttle until reaching the right rpm for the shift, but at full-throttle do not pull down engine rpm more than 10 percent. The practice of shifting gears — next to safety observance — is the most important phase of good engine operation.

When approaching a hill more torque at the wheels is required. Shift to a lower gear, and rev up the engine near the governor. This will give the additional horsepower needed without loss of road speed.

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

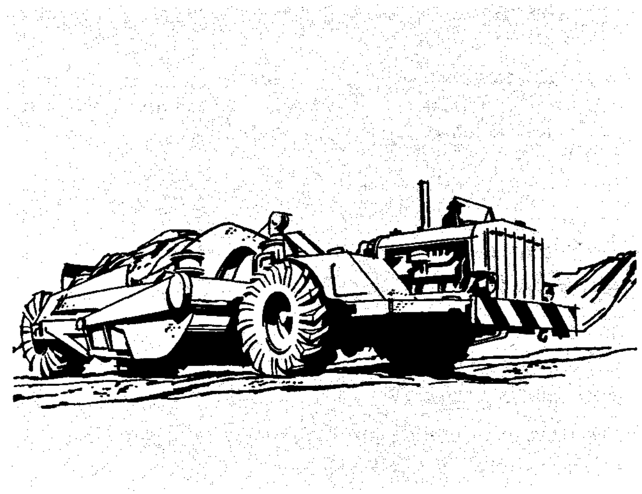


Fig. 2-11. Change gears for more power N11812

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 takeoff 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 takeoff position.

d. Slowly close automotive throttle until speed of power takeoff engagement is reached, engage power takeoff.

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 takeoff may be disengaged.

b. Disengage power takeoff 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 takeoff position or engine will fail to idle properly.

4. The SVS governor should not be used with power takeoff speeds lower than 1100 rpm, for these applications use the MVS governor, described in Section 1.

Down-Hill 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 down hill. With the engine still in gear, fuel pressure will build up against the shut-down valve and may prevent it from opening when the switch key is turned on.

Use Brake As Needed To Prevent Excessive Engine Speeds

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

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

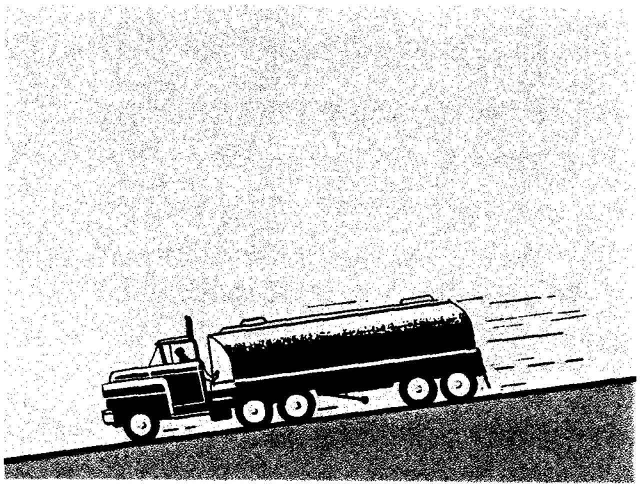


Fig. 2-12. Down-hill operation N11813

Generator Set Applications

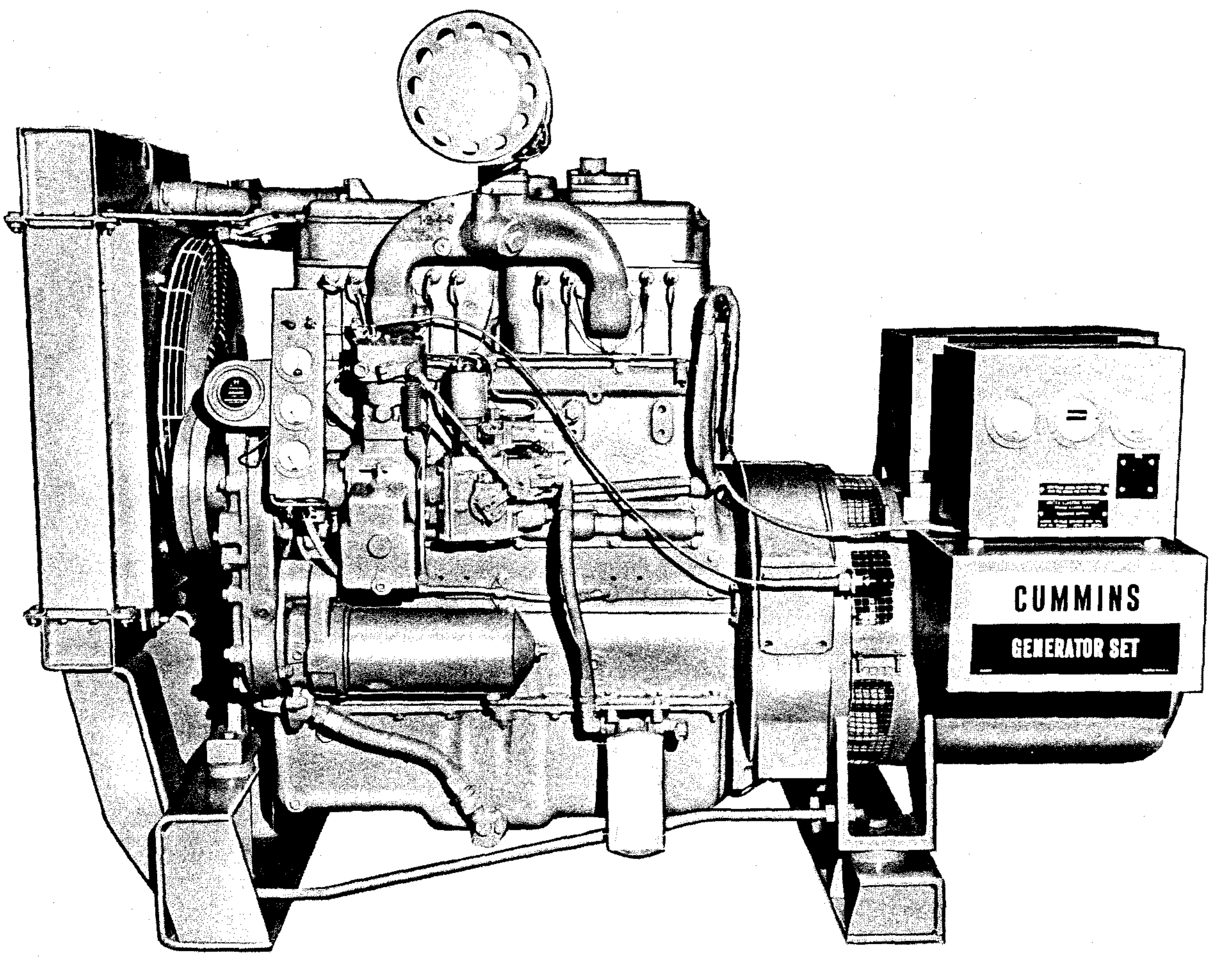
In addition to the general operating instructions, perform the following.

Before starting:

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

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 viscoscity, see Page 3-1.
2. Oil level in governor sump must be at full mark on dipstick. Fig. 2-13.



Typical generator set

CGS-47

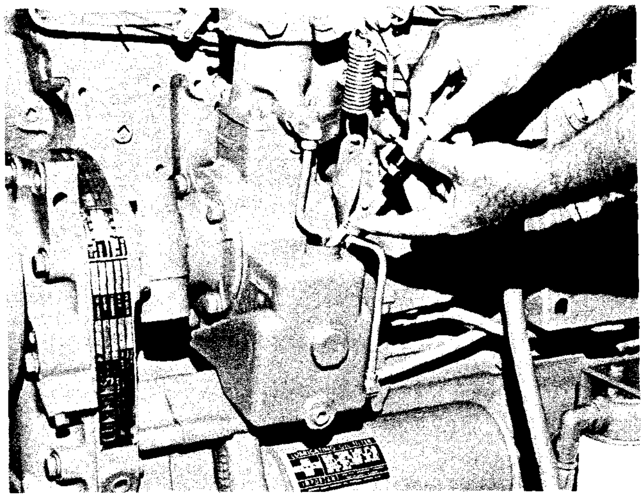


Fig. 2-13. Checking hydraulic governor oil level N11826

Starting Procedure

On some generator sets where main generator current is used to actuate the pump shut-off valve, start the engine by using the manual override button, and then disengage the button to allow the engine safety circuit to take over pump and engine control. This arrangement is usually used with air starting systems.

Operation:

1. Bring engine to desired operating rpm.

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 2-2. 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 same for all sets.
2. The generators should have approximately the same waveform. Similar waveshapes are readily obtainable if machines are of similar type.
3. The generators should have similar voltage regulation characteristics.
4. The driving engines should have the same speed regulation characterictics. 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. Bar positions on the set's reconnection panels must be connected in the same way so that 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 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 instructions contained in the technical manual, adjust the governor droop characteristic of the second machine so that 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 bus as directed in paragraph "connections" above.
2. Start both units leaving main switch or contactor on both sets open.
3. Adjust voltage on both sets to rated value by means of automatic voltage regulator rheostat.
4. Adjust both sets to 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 two (any two) cables at the one-load terminal panel.

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

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 that 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.

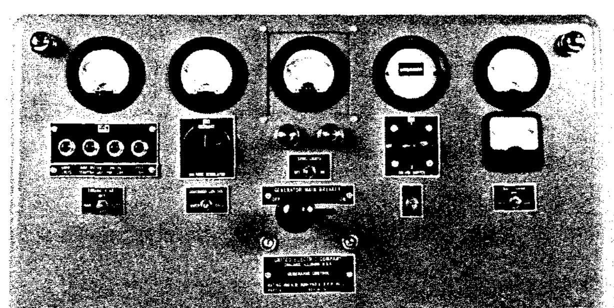


Fig. 2-14. Typical switch gear control panel V41811

Adjustment:

a. 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 load with a power factor other than unity 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 power factor other than unity; on unity power factor (pure resistance) loads, this compensation drop is negligible.

b. 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.

c. The compensating resistor (or resistors) are 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 and every 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. (Nominally 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 up.
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, this involves shifting of 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 generator and hence current output of the machines, causing undesirable cross current.

1. Increase the load on 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 readjust 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 readjust load division so that 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

Table 2-2: Standard Generator Set Application Specifications

Engine Model	1800 RPM Stand-by	60 Cycle Prime Power	1500 RPM Stand-by	50 Cycle Prime Power
NHC-4	GS-60KW	GC-50KW	GS-50KW	GC-42KW
NHC-4	GS-75KW	GC-60KW	GS-62.5KW	GC-50KW
HR-6	GS-100KW	GC-75KW	GS-83.3KW	GC-62KW
NH-220	GS-125KW	GC-100KW	GS-104KW	GC-83KW
NTO-6	GS-150KW	GC-125KW	GS-125KW	GC-104KW
NRTO-6	GS-175KW	GC-150KW	GS-146KW	GC-125KW
NT-335	GS-200KW	GC-175KW	GS-167KW	GC-137KW
NT-400	GS-225KW	GC-200KW	GS-187KW	GC-167KW

Engine Model	1200 RPM Stand-by	60 Cycle Prime Power
NT-400	GS-125KW	GC-100KW

they both read the same value on similar sets. On different size 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

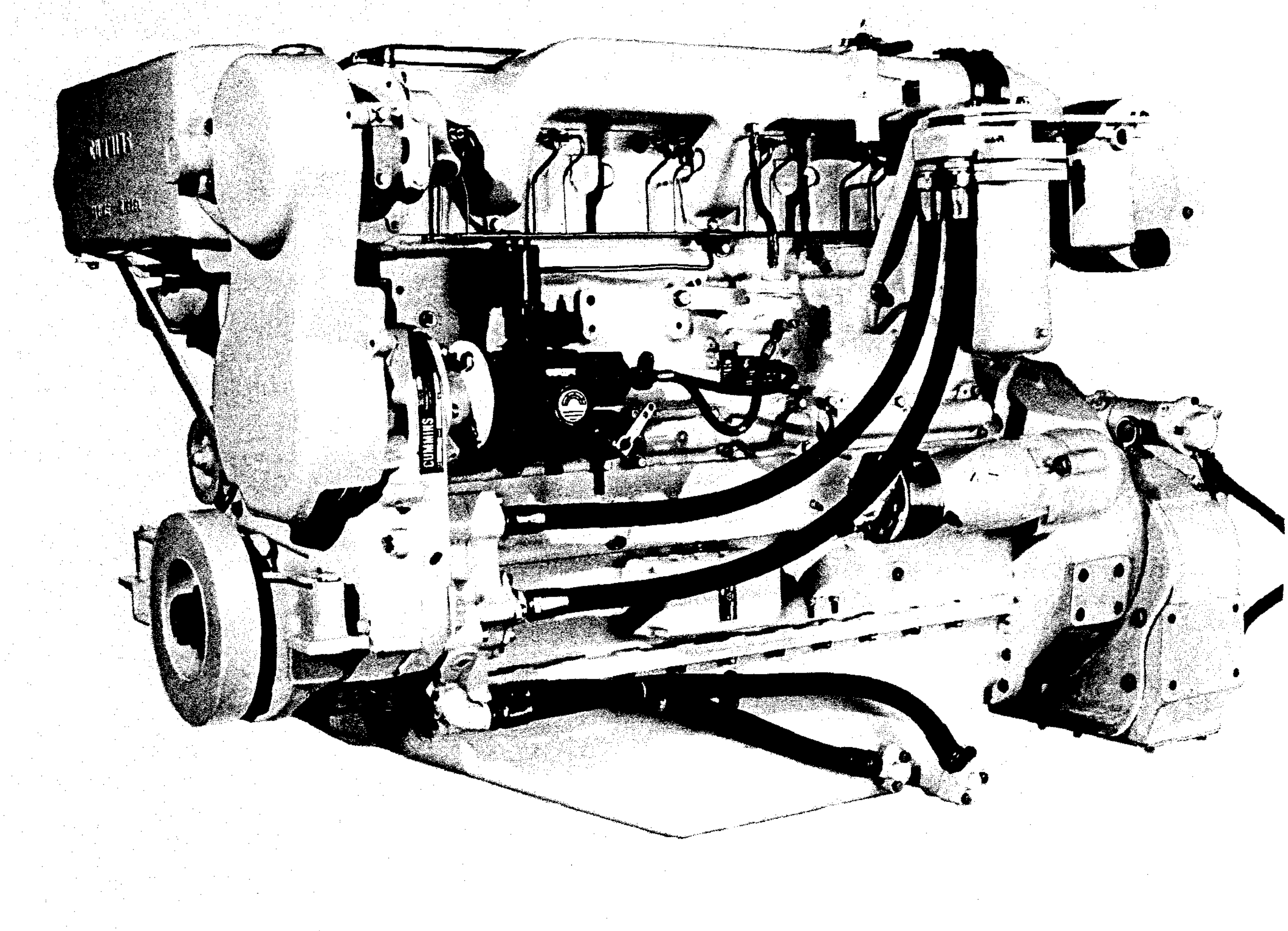
Pleasure boat and work boat engines are rated at a different horsepower output and speed (rpm) for the same model engine, due to the continuous duty requirements of the work boat. Refer to Table 2-3. Engine break-in, pre-starting checks and operation follow "General Operating Instructions" and include the specific instructions listed below.

Prestarting Checks

Check marine gear oil level. The marine gear is a separate unit and carries its own lubrication. Fill housing through filler tube to high level mark on dipstick gauge with correct viscosity of oil according to specification plate on gear housing.

Check Fresh Water System

Fill fresh water expansion tank of heat exchanger with coolant or antifreeze to about one inch from top of tank. This will allow room for expansion when coolant gets warm and eliminates overflow. See Page **5-18** for coolant treatment.



Typical marine unit **N11816**

Table 2-3: Cummins Marine Diesels

Model	Pleasure boat intermittent duty Bhp-rpm	Work boat continuous duty Bhp-rpm
NHC-4-M	130 @ 2000	90 @ 1800
*NH-135-M	135 @ 2100	94 @ 1800
*HU-170-M	164 @ 1800	128 @ 1800
HR-6-M	175 @ 1800	126 @ 1800
NH-220-M	220 @ 2100	142 @ 1800
NH-250-M	250 @ 2100	162 @ 1800
HRS-6-M	240 @ 1800	173 @ 1800
NHRS-6-M	320 @ 2100	205 @ 1800
NT-335-M	335 @ 2100	217 @ 1800
NT-380-M	380 @ 2300	253 @ 2000
*NT-400-M	400 @ 2300	270 @ 2000

*Available from Shotts only

Open Seacocks

1. Check for obstructions and clear as required.
2. Open seawater inlet and outlet valves to permit seawater flow through heat exchanger.

Starting Procedure

Place marine gear in neutral position and follow general starting procedure and other instructions as follows:

Check Marine Gear Oil Level

Check oil level of marine gear daily. Keep oil level as near "H" mark as possible.

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

Operate By The Instruments

1. Tachometer. Do not operate the engine above governed rpm. Excessive engine speeds are dangerous and may lead to engine failure.
2. Oil temperature gauge. The oil temperature gauge may read as high as 240° F. with the engine at sustained load operation. Under heavy load conditions, lubricating oil temperature may reach 250°/265° for a short period. However, a 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.
3. Coolant temperature gauge. A minimum temperature of 165° F. indicates that cylinder liners are heated to the proper temperature to support good combustion. Engines should be warmed up slowly before applying full-load so pistons will not expand faster than the cylinder liners. Piston and liner scoring is often caused by operating at full-load while the engine is cold. When coolant temperature is too low, the cylinder walls retard heating of air during compression, thereby delaying ignition. This causes delayed combustion, excessive smoke and high fuel consumption. Properly operating thermostats are necessary during both summer and winter. Avoid long periods of idling and do whatever else is required to keep water temperatures up to a minimum of 165° F. Over-heating problems usually require mechanical corrections. They may be caused by a worn water pump, a clogged cooling system, worn sea water pump, clogged sea water inlet or outlet.

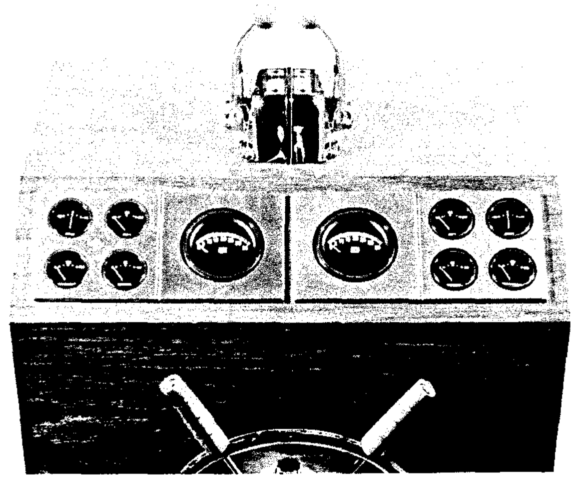


Fig. 2-15. Marine unit instrument panel V21806

4. Oil pressure gauge. The oil pressure gauge indicates the lubricating oil pressure. Shut down the engine immediately at loss of oil pressure. Under full load conditions, oil pressure may drop to 30 psi and oil temperature may reach 265° F. for a short period. This is not 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.

Marine Gear

Movement of a single lever on the control valve to neutral, forward or reverse controls the marine gear operation. If so desired, the control lever may be interlocked with the throttle therefore the marine gear may be shifted to forward or reverse before the throttle is moved from idle position and returned to neutral when the throttle is closed. The use of an interlock system is mandatory when the pilot house control is used and no engineer is present in the engine room.

Check Marine Gear Oil Pressure

If unit is being operated for the first time, remove pipe plug and attach an oil pressure gauge to the control valve. Oil pressure should be 80/85 psi at 600 rpm.

Clutch slippage can be corrected by adjusting the oil pump pressure regulator by adding or removing washer atop the pressure regulator spring.

Check Marine Gear For Oil Leaks

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

Check For Misalignment Or Binding

The Marine Gear, the crankshaft and the propeller shaft should have been correctly aligned during initial installation, but if the gear becomes overheated or if "hot spots" are detected under full-load condition, it is an indication of gear misalignment or of incorrect bearing or gear clearances. Correct as necessary.

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

Operating Procedure

1. Operate pleasure craft at 85% of governed rpm for cruising.
2. Operate with a power requirement that will permit marine unit to reach governed rpm under loaded condition. See Table 2-3.

PT (Type G) Fuel Pumps With SVS Governor

1. The engine is operated by means of the SVS governor lever and the automotive throttle is set in wide open position during operation.
2. The engine must contain a fuel pump with special limited by-pass governor plunger to prevent "under-shoot" during deceleration, and the fuel pump does not require a torque spring.
3. An overspeed stop must be used in unattended applications, and in attended installations the automotive throttle should be set so it will act as a positive shut-down, if no other overspeed stop is used.

Caution: When the automotive throttle is used as a positive shutdown, it must not be used except in an emergency to shut down the engine; at all other times the throttle should remain in wide open position.

Industrial Engine Applications

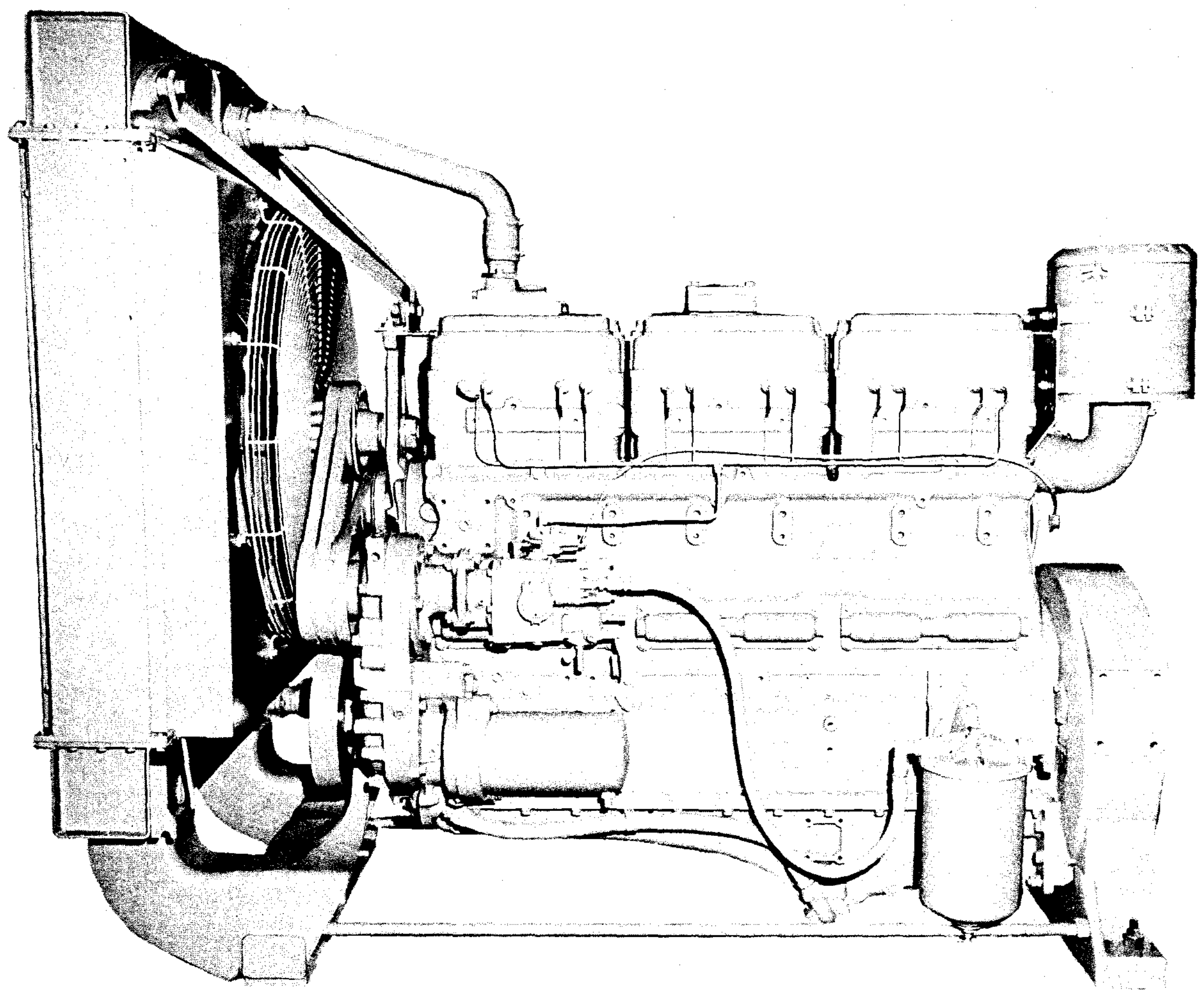
Engine break-in, prestarting checks and operation follow "General Operating Instructions" and include the additional specific instructions listed below.

Prestarting Checks

1. Check torque converter oil level, when used; 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° F. to 230° F.). Temperature should not be allowed to exceed 250° F.
2. Observe torque oil pressure gauge. Operate with pressure as specified by converter manufacturer listed on converter specification plate.



Typical industrial unit

N11818

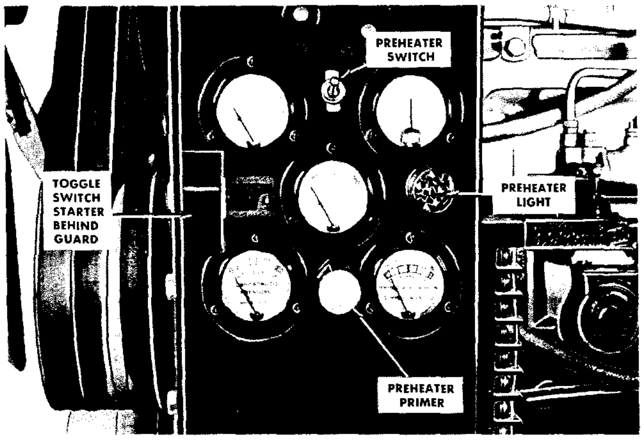


Fig. 2-16. Instrument panel, power unit N11803

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° F.)	Converter Unit Max. HP	Converter Unit 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. and 85° F.

Table 2-5: Construction Application

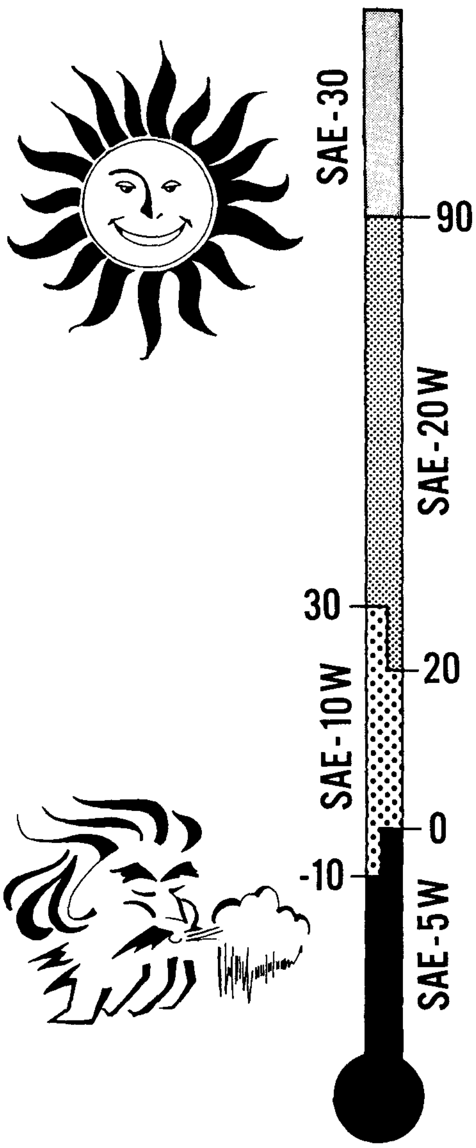
Engine Models	60°F. Sea Level HP & RPM	Off Highway Trucks	Dozers, Scrapers, Compactors	Road Graders	Excavators, Tractors, Shovels	Air Compressor
NHC-4	130 @ 2000	—	120 @ 2000	120 @ 2000	120 @ 2000	120 @ 2000
H-6 & H-135	160 @ 1800	—	148 @ 1800	148 @ 1800	148 @ 1800	148 @ 1800
HR-6	175 @ 1800	—	162 @ 1800	162 @ 1800	162 @ 1800	—
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 feet altitude and 90° F.

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, Lubricants And Coolant



Lubricating Oil

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 the requirements of U. S. Military Specifications Mil-L-2104-A. The responsibility for meeting these specifications, the quality of the product and its performance must necessarily rest with the 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, (Chicago 6, Illinois).

Mil-L-2104-A and/or British Defense Spec. DEF-2101B
Recommended for engines operating under normal conditions and where sulphur content of the diesel fuel is from 0.5% to 1% content by weight.

Supplement 1 (SI)
Recommended where a fuel with a corrosive sulphur content in excess of 1% is used. These oils have a higher additive level than Mil-L-2104-A.

Mil-L-2104-B
These oils meet or exceed the levels of Supplement 1 oils, and may be used in Cummins Engines, to provide additional sludge and rust protection.

Series 3 (Mil-L-45199)
These are premium oils and are not required for Cummins Engines except under very unusual operating conditions. Do not use in applications where exhaust valve deposits are encountered.

Viscosity Recommendations
Except in extreme climates most engine operation will be in the range of —10° F. to 90° F., oil viscosity should be as follows:

SAE 10W — temperatures consistently between —10° F. and 30° F.

SAE 20 — temperatures consistently between 20° F. and 90° F.

SAE 30 — temperatures above 90° F.

Where temperatures are not above 0° F., 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 listed in Section 2.

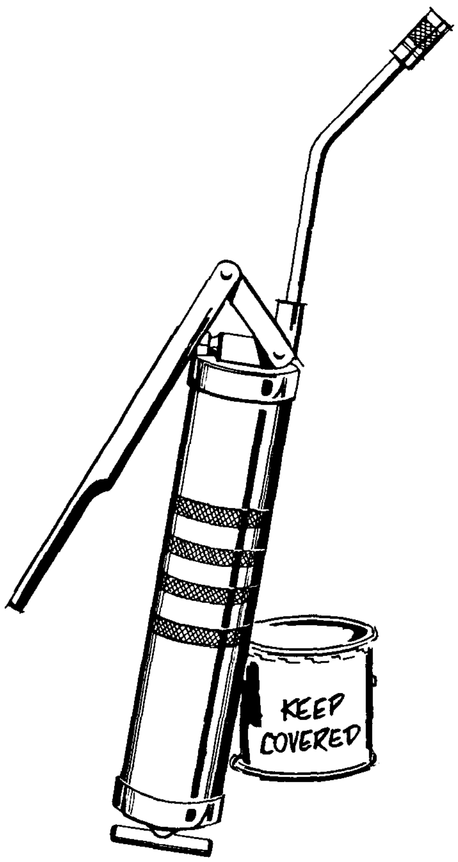
Lubricating Oil (Con't.)

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

Longer service, less maintenance and more effective lubrication is possible when a multi-purpose industrial lubricant is used. Cummins Engine Co. recommends use of lubricants meeting specifications given below or Mil-G-3545. Contact your lubricant supplier for this type lubricant.



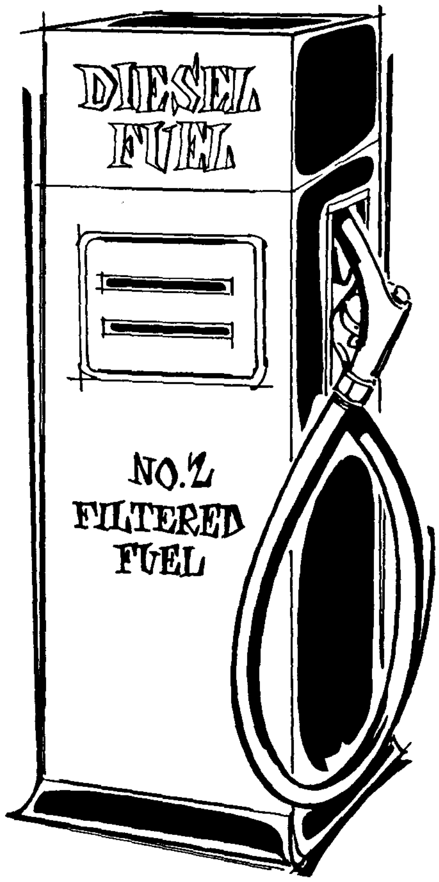
ASTM Penetration, Normal Worked	285 to 320.
Oxidations	10 lb. drop in 100 hrs.
Water Resistance	20% maximum loss.
Dropping Point	325°F.
Consistency Stability, Maximum ASTM	
Penetration After 100,000 Strokes	Penetration shall not increase more than 50 points and in no case be more than 350.
Water	1% Maximum.
Wheel Bearing Test	a. 1% leakage (220°F., 6 hrs.) b. No adherent deposits of varnish, gum or lacquer-life material acceptable after removal of the grease from the bearing.
Rust Preventive Properties	One (1) rating — Pass.
Mineral Oil Properties	
Viscosity @ 100°F.	750 Saybolt Universal Sec., maximum
Viscosity @ 210°F.	70 Saybolt Universal Sec., minimum
Flash	340°F. minimum
Fire	380°F. minimum

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

Fuel Oil

Fuel oil serves two purposes in a Cummins Diesel. It supplies the energy for the work done by the engine and it lubricates many of the fuel system parts. Fuel oil should be a neutral distillate petroleum oil, free from suspended matter, and not a mixture of light oil and heavy residue.
Physical and chemical properties should meet the following requirements.

Viscosity @ 100° F.	Centistokes: 2.4 to 5.0, or Saybolt Universal: 34 to 42.
Gravity	30 to 42 degrees A.P.I. at 60° F.
Cetane Number	40 minimum except that in warm weather and where no starting difficulties are encountered, the cetane number may be lower.
Pour Point	10° F. below lowest temperature expected.
Bottom Sediment and Water	Not to exceed .05% of weight.
Distillation	At least 10% should distill below 460°F. At least 90% should distill below 675°F. End point should not exceed 725°F. Minimum recovery 98%.
Conradson Carbon Residue	Not to exceed .25% on 10% bottoms.
Ash	Not to exceed .02% of weight.
Sulphur	Not to exceed 1% of weight.
Copper Strip Corrosion	Must pass test 3 hours @ 122°F.



Coolant

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.

Recommended

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 a chromate element(s), Part No. 132732. Do not use element 168481 (PAF) with plain water.
2. Replace corrosion resistor element(s) as recommended in the "Maintenance Operations" section of this manual.
3. If no corrosion resistor is used, then add one-half ounce chromate compound in the system for every gallon 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 suppliers recommendations to prevent corrosion.

C. Check corrosion control by draining a sample of coolant from the system as described in Section 5 under "Check Engine Coolant".

D. If there has been a loss of corrosion control, renew anti-freeze.

Caution: Never use soluble oil in the cooling system when a Corrosion Resistor is being 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 following chart 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 to the source of the trouble.

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 most obvious things first; this will save time and trouble.

Report All Troubles

The operator should report any troubles or emergency repairs to the Maintenance Department for checking and recording.

Trouble Shooting Chart

CAUSES / COMPLAINTS	Hard Starting	Engine Misses	Smoke at Idle	Smoke Under Load	Low Power	Can't Reach Gov. Speed	Excess Fuel Consumption	Poor Deceleration	Engine Dies	Surge At Governed Speed	Excessive Oil Consumption	Dilution	Low Oil Pressure	Coolant Temperature Low	Coolant Temperature High	Oil Too Hot	Fuel Knocks	Mechanical Knocks	Excess Vibration
Restricted Air Intake	●			●	●		●												
Thin Air In Hot Weather or High Altitude				●	●		●												
Oil Level Too High					●		●									●			
Out of Fuel or Fuel Shut-Off Closed	●								●										
Poor Quality Fuel	●			●	●		●		●								●		
Restricted Fuel Lines	●	●	●	●	●	●	●	●											
External or Internal Fuel Leaks							●			●		●							
Loose Injector Inlet or Drain Connection	●											●							
Throttle Linkage					●	●	●												
External and Internal Oil Leaks											●	●							
Crankcase Out of Oil or Low													●		●				
Wrong Grade Oil for Weather Conditions											●		●						
Insufficient Coolant															●	●	●	●	
Worn Water Pump															●	●			
Damaged Water Hose															●	●			
Loose Fan Belts															●	●			
Radiator Shutters Stuck Open														●					
Radiator Core Openings Plugged with Dirt															●	●			
Exterior Water Leaks															●				
Long Idle Periods	●	●	●	●	●							●							
Engine Overloaded				●			●								●	●	●		
Lube Oil Needs Changing																			
Engine Exterior Caked with Dirt															●	●			
Loose Mounting Bolts or Worn Mounts																		●	●

Maintenance Schedule

CHECK SHEET FOR ALL MODELS

CUMMINS

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

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

Notes: *Under extremely dusty conditions, perform at more frequent interval. **All other than Cummins element.

Suggested Basis At Bottom — Insert Your Actual Interval Basis	Engine Application	See Notes	DAILY A	B	C	D	E	F
LUBRICATING SYSTEM								
Check Engine Oil Level	(ALL)		✓	✓	✓	✓	✓	Major Inspection — Perform Using Engine Shop Manual Wear Limits
Check Marine Gear Oil Level	(MARINE)		✓	✓	✓	✓	✓	
Check Converter Oil Level	(INDUST.)		✓	✓	✓	✓	✓	
Lubricate P.T.O. Clutch Throwout Bearing	(INDUST. MAR.)		✓	✓	✓	✓	✓	
Check Leaks and Correct	(ALL)		✓	✓	✓	✓	✓	
Change Engine and Aneroid Control Oil	(ALL)			✓	✓	✓	✓	
Change Engine and Turbocharger Filter (Full-Flow)	(ALL)			✓	✓	✓	✓	
Record Oil Pressure	(ALL)			✓	✓	✓	✓	
Lubricate Electrical Equipment	(ALL)			✓	✓	✓	✓	
Change Marine Gear Oil, Clean Strainer	(MARINE)			✓	✓	✓	✓	
Change Bypass Filter Element (Engine)	(ALL)	**B		**	✓	✓	✓	
Change Converter Oil, Filter and Clean Strainer	(INDUST.)	*C			*	✓	✓	
Lubricate Water Pump and Fan Hub	(ALL)						✓	
FUEL SYSTEM								
Fill Fuel Tanks; Check Leaks and Correct	(ALL)		✓	✓	✓	✓	✓	
Drain Sediment From Filters	(ALL)	*A	*	✓	✓	✓	✓	
Check Hydraulic Governor Oil Level/Change Filter	(INDUST.)			✓	✓	✓	✓	
Clean Tank Breather and Drain Sediment	(INDUST. MAR.)	*B		*	✓	✓	✓	
Change Filter Element(s) and Check Restriction	(ALL)				✓	✓	✓	
Clean Fuel Pump Screen and Magnet	(ALL)						✓	
Change Hydraulic Governor Oil	(INDUST.)						✓	
Clean Injectors and Screens	(ALL)						✓	
Adjust Injectors and Valves	(ALL)						✓	
Check Fuel Manifold Pressure	(ALL)						✓	
COOLING SYSTEM								
Fill Cooling System; Check Leaks and Correct	(ALL)		✓	✓	✓	✓	✓	
Check Heat Exchanger Zinc Plugs	(MARINE)				✓	✓	✓	
Check and Adjust Belt Tension	(ALL)				✓	✓	✓	
Change Corrosion Resistor Element/Check Coolant	(ALL)				✓	✓	✓	
Check Thermal Controls	(ALL)					✓	✓	
Check Fan Hub and Drive Pulley	(ALL)					✓	✓	
Check Sea Water Pump	(MARINE)					✓	✓	
Clean Cooling System	(ALL)		SPRING AND FALL					
AIR SYSTEM								
Check Air Cleaner Oil Level, Oil Bath	(ALL)		✓	✓	✓	✓	✓	
Clean Pre-Cleaner/Dust Pan	(INDUST.)		✓	✓	✓	✓	✓	
Clean Dry Type/Composite Cleaner Element	(ALL)	*A	*	✓	✓	✓	✓	
Change Air Cleaner Oil — Oil Bath	(ALL)	*A	*	✓	✓	✓	✓	
Check Air Piping and Vent Tube Connections	(ALL)	*B		*	✓	✓	✓	
Check Inlet Air Restriction	(ALL)	*C			*	✓	✓	
Replace Dry-Type/Composite Cleaner Element	(ALL)	*C			*	✓	✓	
Clean Tray Screen	(ALL)	*C			*	✓	✓	
Clean Crankcase Breather/Change Element	(ALL)	*C			*	✓	✓	
Check Supercharger/Turbocharger For Oil Leaks	(ALL)					✓	✓	
Tighten Manifold and Turbocharger Mountings	(ALL)					✓	✓	
Clean Air Compressor Breather	(ALL)	*C			*	✓	✓	
Clean Aneroid Air Filter	(ALL)	*D				*	✓	
Clean Oil-Bath Air Cleaner	(ALL)	*D				*	✓	
Clean Turbocharger Compressor Wheel and Diffuser	(ALL)						✓	
Check Turbocharger Bearing Clearances	(ALL)						✓	
Check Preheater	(ALL)		SPRING AND FALL					
OTHER								
Check Operator's Report	(ALL)		✓	✓	✓	✓	✓	
Check Clutch Adjustment	(ALL)		AS REQUIRED					
Clean Electric Units and Tighten Connections	(ALL)					✓	✓	
Check Alternator/Generator Brushes and Commutator	(ALL)						✓	
Steam Clean Engine	(ALL)						✓	
Tighten Mounting Bolts and Nuts	(ALL)						✓	
Check Engine Blow-By	(ALL)						✓	
Check Crankshaft End Clearance	(ALL)						✓	
Check Vibration Damper	(ALL)						✓	

Engine	Basis	A	B	C	D	E	F
Naturally Aspirated Engine	Gallons Fuel Used	Daily	1000	2000	4000	8000	32000
Supercharged/Turbocharged Engines	Gallons Fuel Used	Daily	1200	2400	4800	9600	36400
Naturally Aspirated Engine	Hours Operation	Daily	200	400	800	1600	6400
Supercharged/Turbocharged Engines	Hours Operation	Daily	200	400	800	1600	6400
Naturally Aspirated Engine	Miles Driven	Daily	6000	12000	24000	48000	192000
Supercharged/Turbocharged Engines	Miles Driven	Daily	6000	12000	24000	48000	192000

AS APPLICABLE TO YOUR UNIT — CHECK EACH OPERATION OVER ✓ MARK AS PERFORMED.

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 as well as requiring 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 and each type operation must be analyzed as the maintenance schedule is established. A look at the suggested check sheet, on the opposite page, indicates some checks (shown by shaded areas) 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 gallons per hour the "B" check would be made every 1000 to 1200 gallons of fuel or approximately every 200 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 miles per gallon the "B" check would be made every 6000 miles. The figure 6000 would then be inserted for the "B" check, 12000 for the "C" check, etc.

Extending The Maintenance Schedule

Any change of 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 and 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, the same as used in establishing the original maintenance schedule period. Lubricating oil analysis is described on Page 5-4.

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 (over the shaded check mark), that he has completed the operation. When a complete column (under A, B, C etc.) of checks are indicated the engine will be ready for additional service until the next check is due.

Maintenance Operations Summary Sheet

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

Maintenance — Standby Service Engines

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

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

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

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

Units in locations where ambient temperature is normally above 70°F. 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.

Lubricating System Maintenance

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.

Perform each of the following operations that applies to your particular engine application.

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 30 minutes after engine shutdown. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" mark as possible. Fig. 2-1.

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

2. Add oil as necessary of the same quality and brand as already in engine. See Page 3-1.

Check Marine Gear Oil Level (A Check)

Check oil level of marine gear daily. Keep oil level as near "H" mark as possible.

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

Check Converter Oil Level (A Check)

Different models of vehicles may vary in the manner in which oil level check is made — either 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 there is sufficient oil in system to start 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 Torqumatic 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 throwout collar.

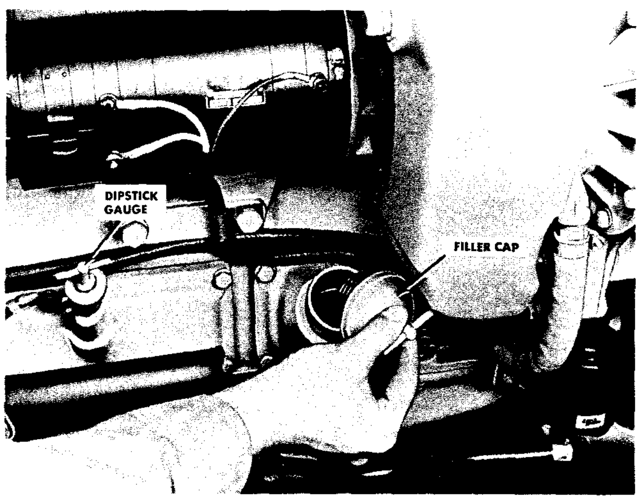


Fig. 5-0. Lubricating Oil Filler Tube

Manual Spring-Loaded Input Disconnect Clutch

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

Check Leaks And Correct (A Check)

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. See that they are tightened securely. Fig. 5-0.

Engine Oil Change (B Check)

The kind of oil used (Mil-L-2104A, Supplement 1, Mil-L-2104B, etc.) the efficiency of the filtering system and condition of the engine must be considered in determining when to change oil. Over the years four levels of filtering efficiency have been used, depending upon engine users requests; therefore, these must be taken into consideration.

Recent tests using Cummins Fleetguard full-flow paper element filtering in combination with a Fleetguard by-pass filter, Supplement 1 oils, and using oil analysis with filter restriction measurement indicate a naturally-aspirated on-highway truck may have the oil change period extended as much as 50% under closely controlled conditions. This indicates the enonomy that can be obtained through a good maintenance program.

It is suggested that oil change periods be set up on the schedule indicated in Table 5-1 and then extended, or in unusual cases reduced, based upon type oil used and other items as described in the above paragraph.

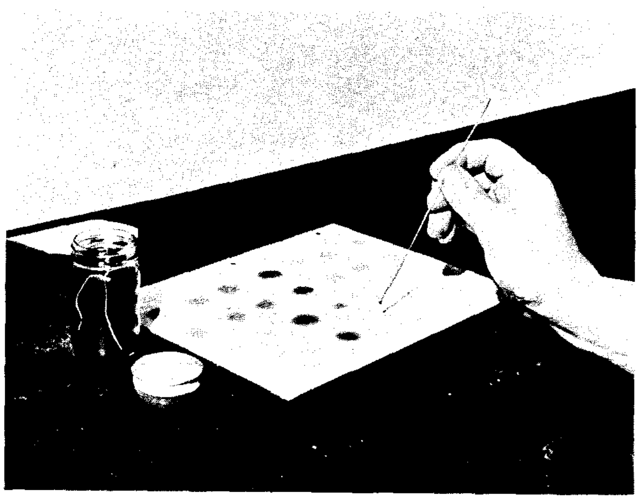


Fig. 5-1. Lubricating Oil Analysis N11945

Table 5-1: Suggested Initial Oil and Filter Change Periods

Filtering Arrangement	Gallons Fuel Consumed	Mileage Driven	Hours Operated
Full-Flow Bag Only	675	4,000	135
Full-Flow Bag & By-Pass	1000	6,000	200
Full-Flow Paper Element Only	1300	8,000	265
Full-Flow Paper & By-Pass	2000	12,000	400

Factors to be checked and the limits for oil analysis are listed below. The oil change at the "B check" as shown in the maintenance check chart on Page 4-2 is for average conditions which closely follows that indicated as "Full-Flow Bag and By-Pass" above.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. After several test periods a time (gallons fuel consumed, hours, weeks, etc.) 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.

In the beginning, tests should be made each 100 gallons fuel consumed (after the first 400 gallons), or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary. Repeat analysis cycle until a definite pattern is established.

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

Analysis Test For Lubricating Oil

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

Oil Property	Test Number
Viscosity at 100°F. and 200°F.	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

General Limits For Oil Change

1. Minimum Viscosity (dilution limit): Minus one SAE grade

from oil being tested or point equal to a minimum containing five per cent by volume of fuel oil.

2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten per cent increase at 210°F. or 25 per cent increase at 100°F.
3. Sediment Content: Normal pentane insoluble 1.0 to 1.5 per cent. Benzine insoluble 0.75 to 1.0 per cent.
4. Acid Number: Total number 3.5 maximum.
5. Water Content: 0.2 per cent maximum.
6. Additive Reduction: 25 per cent 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.

Fig. 5-2. Examining Oil Filter bag N10718

Change Engine Full Flow Filter Element (B Check)

Bag Type

1. Drain full-flow lubricating oil filter by removing drain plug.
2. Remove strainer element from case. With clean cloths — NOT WASTE — wipe case clean.
3. Turn used bag inside out and inspect for bearing metal, grit, etc. (Fig. 5-2). If metal is found in the bag, an inspection of all connecting rod and main bearings should be made at once. Inspect spool gasket, bag clamp and spacer mat. If they are not in good condition, replace with new parts.

Caution: Do not attempt to wash and re-use filter bag.

4. Clean all parts thoroughly except bag, gaskets and "O" rings.
5. Install a new filter bag as shown in Fig. 5-3.
6. Insert element, spring end down, in filter case; position case to cover with new "O" ring(s) and tighten capscrews to secure.

Caution: Make certain cover capscrews are drawn down evenly to assure a good seal between cover and case.

7. Add approximately one gallon clean lubricating oil to fill filter case.
8. Check engine oil level after operating engine long enough to bring to operating temperature; bring level to "H" mark to replace oil absorbed by new element.

Paper Element Type

1. Remove drain plug from filter case and allow oil to drain. Fig. 5-5 and Fig. 5-6.
2. Loosen center bolt and remove filter case from filter head. Some filters use the same case as the bag-type element and should be disassembled in a like manner.
3. Withdraw filter element, inspect, then discard.

Note: Inspect for metal particles. If metal is found, a check of connecting rods and main bearings should be made at once.

4. Remove seal ring from filter head and discard.
5. Clean filter case thoroughly.
6. Check to make sure element end seals are in place and install new element over pilot valve assembly.
7. Position new seal ring in place; assemble filter case to head and tighten center bolt (if used) to 25/35 foot-pounds.
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.

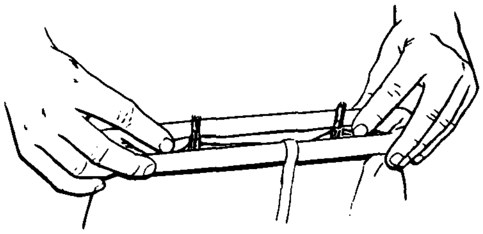
Note: Always allow oil to drain back to oil pan before checking level.

Change Turbocharger Oil Filter (B Check)

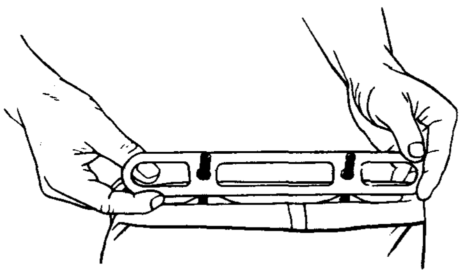
The throw-away type turbocharger oil filter prevents clogging of the turbocharger oil supply orifice.

Change filter at each oil change or install a pressure gauge in the filter outlet line and change filter when gauge indicates a 15 psi lower pressure than oil pressure on inlet side.

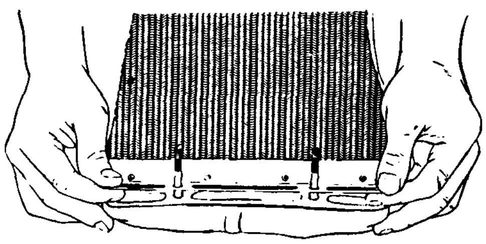
1. Install ring in filter bag with studs protruding. Fold top of bag inward over ring about 1/2 inch; tuck bag snugly around ring stud bases to assure good seat.



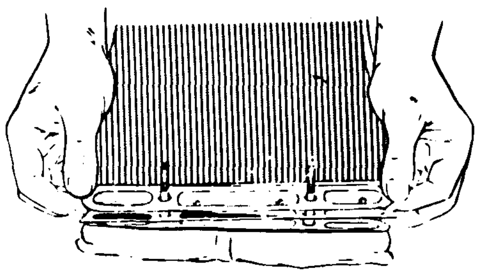
2. Install gasket over studs and against bag.



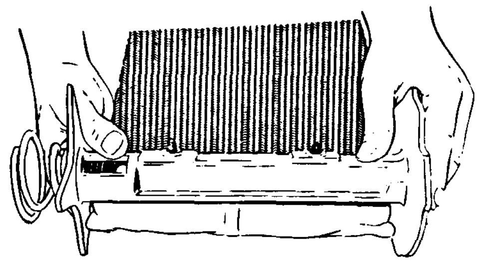
3. Install retainer attached to wire mesh spacer over studs.



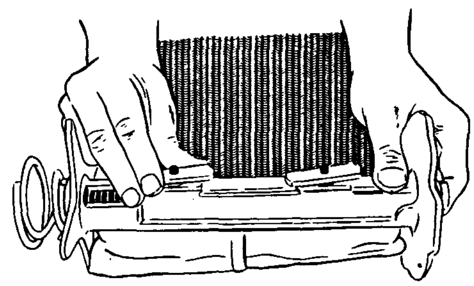
4. Install second gasket over studs and down against spacer retainer.



5. Insert ring studs in spool through oil channel.



6. Install wing nuts over studs and tighten until nuts are parallel with spool.



7. Place filter assembly on clean flat surface with wire mesh spacer on top and filter bag on bottom. Roll bag and spacer around spool so that spacer is between bag and studs.

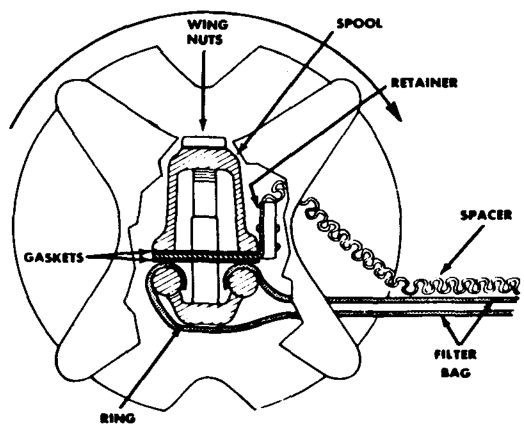


Fig. 5-3. Assembling full flow filter bag and spacer mat

N10703

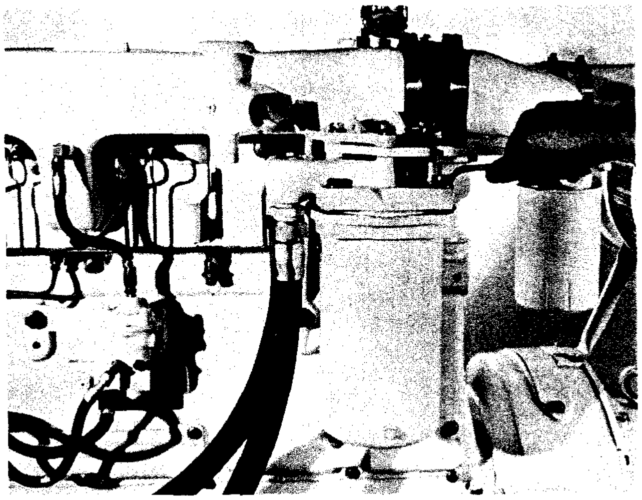


Fig. 5-4. Removing lubricating oil filter N11919

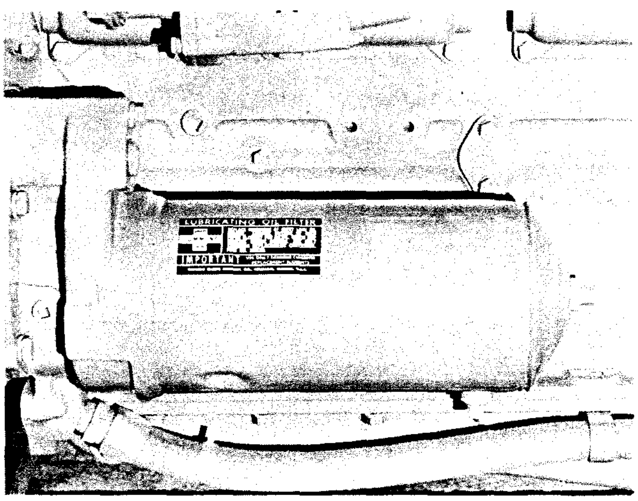


Fig. 5-5. Horizontal lubricating oil filter N11927

To change element:

1. Unscrew element and discard. Fig. 5-7.
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 a special design.

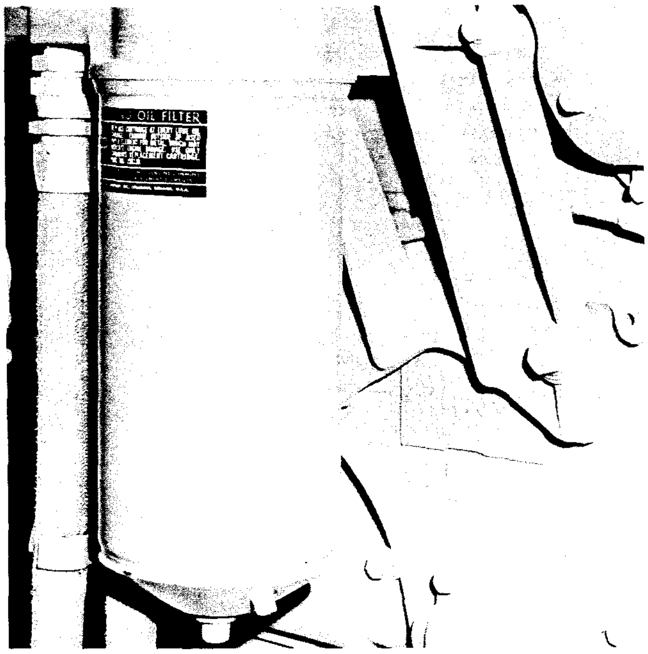


Fig. 5-6. Vertical paper element filter N11926

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.

Record Oil Pressure (B Check)

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140°F. Reduce engine speed

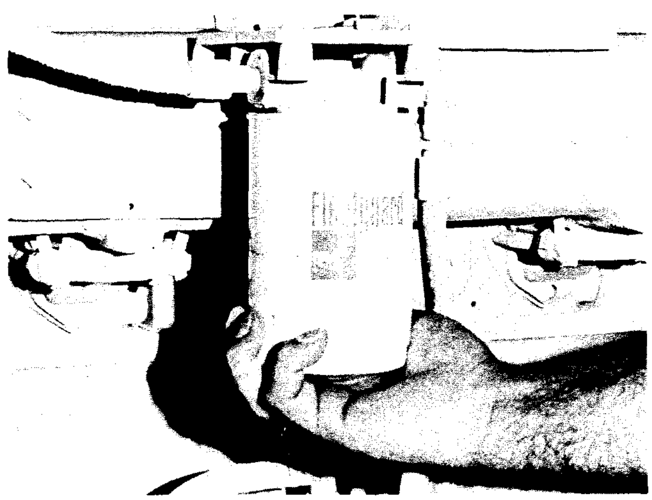


Fig. 5-7. Removing turbocharger oil filter N11928

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)

Lubricate alternator or generator by adding five or six drops of SAE 20 lubricating oil to oil cup (Fig. 5-8) 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 librication.

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)

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.

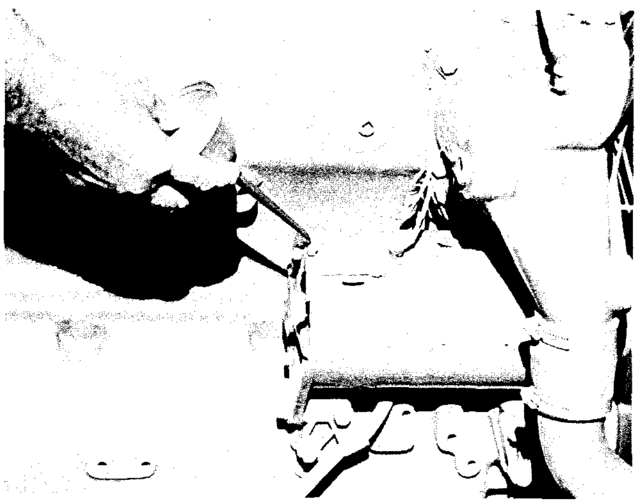


Fig. 5-8. Lubricate generator N11939

Change Marine Gear Oil (B Check)

1. Remove drain plug from bottom of gear housing and drain oil or pump from sump at each "B" check or follow manufacturer's recommendations.
2. Reinstall drain plug and fill marine gear to "H" level on dipstick with same lubricating oil as used in engine, or as specified on gear name plate.

Note: On some gears the inspection plate must be removed to fill gear while others have an oil filler spout.

Clean Marine Gear Oil Strainer (B Check)

1. Clean oil strainer at each "B" check.
2. Disconnect oil hose and remove capscrews securing cover to housing; slide out strainer assembly and discard gasket.
3. Wash strainer in an approved solvent and dry thoroughly.
4. Assemble strainer to cover and position assembly in housing with new gasket; secure with capscrew and connect all hose.

Change Oil In Aneroid Control (B Check)

1. Remove the plug from the bottom of aneroid control and drain oil.
2. Replace drain plug and remove filter or pipe plug at hole marked "Lub Oil".
3. Fill aneroid with clean engine lubricating oil through the hole until oil fills to hole level. Fig. 5-9. Reinstall filter or pipe plug.

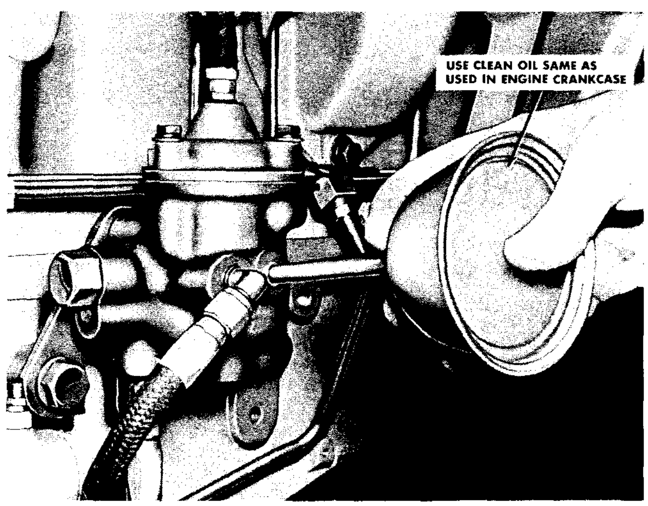


Fig. 5-9. Fill aneroid with oil N11913

Change By-Pass Filter Element (B Check)

Change by-pass filter elements on engine so equipped as follows:

1. Remove drain plug from bottom of housing and drain oil.
2. Remove clamping ring capscrew and lift off cover.
3. Unscrew pack hold-down assembly; lift out element and hold-down assembly (Fig. 5-10). Discard element.
4. Clean housing and hold-down assembly in solvent.
5. Inspect hold-down assembly spring and seal. Replace if damaged.
6. Inspect drain plug and connections. Replace plug.
7. On the Cummins Fleetguard by-pass filter, check orifice plug 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. Replace if damaged or deteriorated.
9. Install new element in housing.
10. Replace hold-down assembly in filter and tighten down to stop.
11. Position cover "O" ring seal.
12. Install cover and clamping ring; tighten capscrew until clamping lugs come together.
13. Add enough extra oil to crankcase to fill case and element.

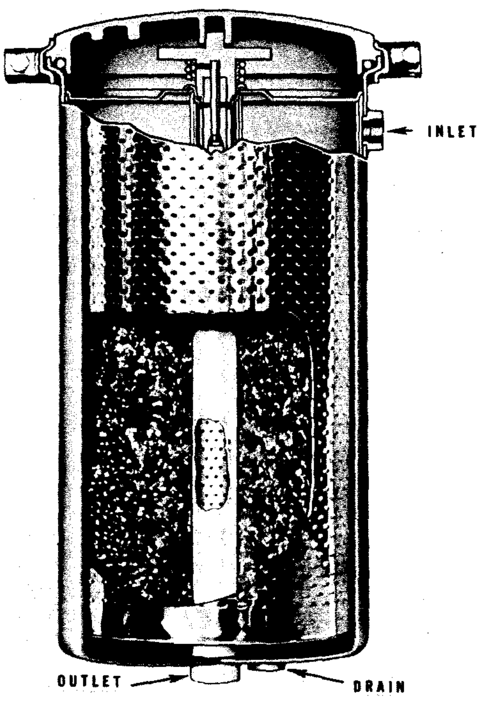


Fig. 5-10. By-pass filter cross-section V41908

14. Loosen vent plug in cover and start engine. Close vent plug when oil reaches vent.

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

Change Converter Oil Filter And Screens (C Check)

Change Converter Oil

Oil should be changed every "C" check in the hydraulic system or oftener, depending on operating conditions. Also the oil must be changed whenever the oil shows traces of dirt or the effects of high operating temperature evidenced by discoloration or strong odor.

Change Converter Filter and Screen

The hydraulic system filter should be changed every oil change and the strainer thoroughly cleaned.

Lubricate Water Pump And Fan Hub (E Check)

1. If water pump and fan hub contains grease fittings or plugs through which grease may be applied, give one "shot" (approx. 1 tablespoon) each "E" check. Fig. 5-11.
2. Completely disassemble, clean and inspect at each third "E" check.
3. If water pump or fan hub has no provisions for greasing, disassemble, clean and inspect each second "E" check.
4. Pack bearings and fill water pump and fan hub bearing cavities 1/2 to 2/3 full of multi-purpose industrial grease meeting specifications shown on Page 3-2.

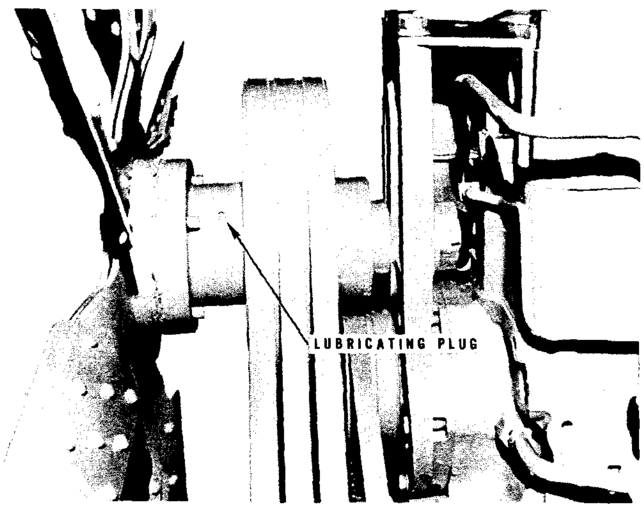


Fig. 5-11. Fan hub lubricating point N11932

Fuel System Maintenance

Fuel should always be strained or filtered before being put into the supply tank of an engine. 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 overuse will be more of a handicap than help in an engine. It will allow damaging sediment and dirt to circulate through the fuel system and 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 in 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. 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 not being 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.

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

Fill Fuel Tanks (A Check)

Always filter or strain the fuel before or while putting it in the tank. See "Fuel Oil Specifications", Page 3-3.

Check Leaks And Correct (A Check)

1. Check for evidence of fuel leakage.
   a. Check fuel pump and filter.
   b. Check fuel supply line and connections at fuel tank, fuel filter and fuel pump.
   c. Check fuel inlet tube 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 and tubing 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 a sight gauge in the line between fuel filter(s) and pump. Bubbles over 1/2 inch long or "milky" appearance indicates an air leak. Find and correct.

Drain Sediment From Filter (A Check)

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

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. Fig. 2-13.

Change Hydraulic Governor Oil Filter (B Check)

Some engines have hydraulic governors which are lubricated from the engine oil supply and utilize a filter. Change filter every 200 hours or install a pressure gauge in the filter outlet line and change filter when gauge indicates a pressure drop of 7 psi or more across filter head at engine governed speed.

To change element:

1. Unscrew element and discard.
2. Clean filter head in solvent that is not harmful to aluminum.
3. Inspect head for cracks and distorted threads; discard if damaged.
4. Coat gasket atop new element with clean lubricating oil and fill element.
5. Install element to head; tighten until gasket contacts head.
6. Rotate element an additional one-half turn to seal gasket. Do not overtighten.

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

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

1. Clean tank breather(s) in cleaning solvent and dry with compressed air.
2. Loosen fuel tank drain cock or plug and drain approximately 1 pint of fuel. Close drain cock or plug.

Change Filter Element (C Check)

Change the single 5¾ inch long (throw-away) fuel filter after 2000 gallons of fuel consumption. Change the single 7½ inch long (throw-away fuel filter) after 3000 gallons of fuel consumption and the stack disc (replacement element) after 4000 gallons 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 Fig. 5-12 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.

Change element as described below.

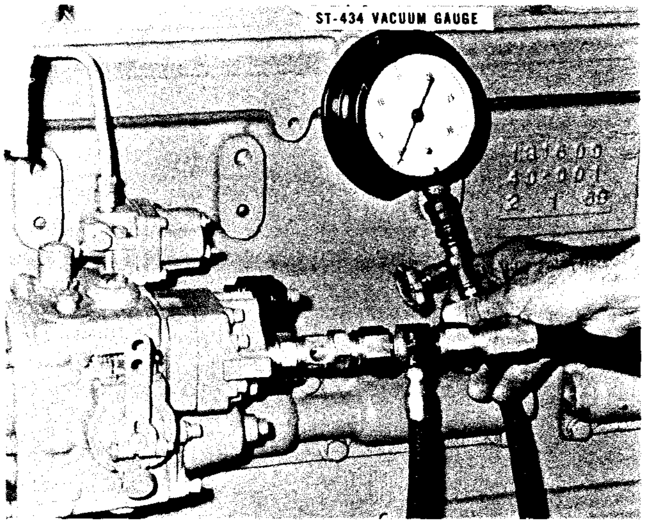


Fig. 5-12. Checking fuel filter restriction N11917

Throw-Away Type Filter

1. Unscrew combination case and element; discard. Fig. 5-13.

   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 touches filter head. Tighten an additional one-half to three-fourths turn.

   Caution: Mechanical tightening will distort or crack filter head.

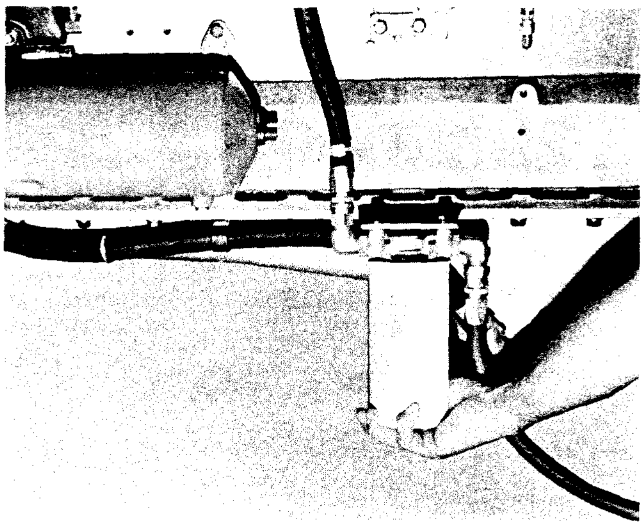


Fig. 5-13. Removing throw-away type fuel filter N11929

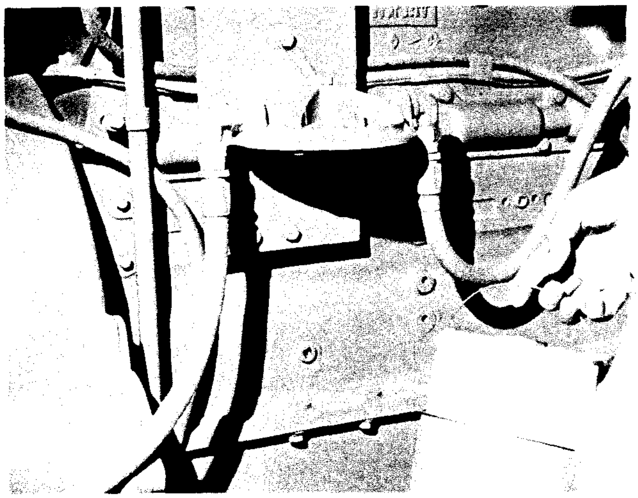


Fig. 5-14. Replaceable element fuel filter N11930

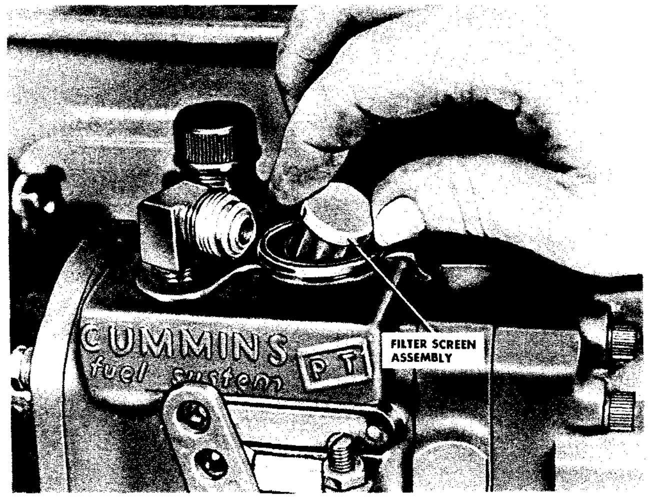


Fig. 5-15. Removing fuel pump filter screen N21901

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. 5-14.
3. Install a new gasket in filter head and assemble case and element. Tighten center bolt to 20/25 foot-pounds with a torque wrench. Fill filter case with clean fuel to aid in faster pick-up of fuel.
4. Check fittings in filter head for leaks. Fittings should be tightened to 30/40 foot-pounds.

Clean Fuel Pump Screen And Magnet (E Check)

PT Fuel Pump

Remove and clean fuel pump filter screen at each "E" check. To clean filter screen:

1. Loosen and remove cap at top of fuel pump. Remove spring. Lift out filter screen assembly. Fig. 5-15.
2. Remove top screen retainer 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, tighten to 20/25 foot-pounds.

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap and dynaseal from governor housing. See Fig. 5-16.
2. Remove "O" ring retainer, "O" ring, screen and spring from filter cap.
3. Using a screwdriver or wire hook, remove bottom screen and magnet assembly from fuel pump housing. Remove screen retainer.
4. Clean parts as described above.
5. Install screen retainer and place bottom screen assembly in fuel pump housing with removable end up.
6. Install spring, large coil first, in filter cap; install upper screen, closed end first, in cap and snug against spring.
7. Install new "O" ring on "O" ring retainer; insert in filter cap, "O" ring first.
8. Install filter cap and dynaseal in governor housing; tighten cap to 20/25 foot-pounds with torque wrench and screw-driver adapter.

Change Hydraulic Governor Oil (E Check)

Change oil in the hydraulic governor sump at each "E" check.

Use the same grade oil as used in the engine. See "Lubricating Oil Specifications." Page 3-1.

Note: When temperatures are 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.

Fig. 5-16. Fuel pump screens — PT (type G) fuel pump with MVS governor N11940

Fig. 5-17. Clean injector inlet screens N21902

Clean And Calibrate Injectors (E 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.

Clean Injector Inlet Screens (E 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. 5-17.

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.

Adjust Injectors And Valves (E 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 "E" checks. Final adjustment must be made when the engine is at operating temperature. Injectors must always be adjusted before valves. The procedure is as follows:

Time Mark Alignment

1. If used, pull compression release lever back and block in open position to lift all intake valves. This allows the crankshaft to be rotated without working against compression.
2. Bar engine in direction of rotation until No. 1 VS mark appears. See Fig. 5-18 for location of valve set marks. (On horizontal engines, the valve set marks are on the vibration damper flange.) In this position, both intake and exhaust valves must be closed for cylinder No. 1, if not, advance crankshaft one revolution.
3. Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to the next VS mark corresponding to firing order of the engine and the corresponding cylinder will be ready for adjustment.
4. Firing order is as follows:

Table 5-2: 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.

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

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

6. On engines without a compression release, turn each intake valve adjusting screw down one-half turn from adjusted position before turning the engine. Then, adjust injectors and valves on each cylinder in manner described.

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. 5-19.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.
2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter, tighten the adjusting screw to values shown in Table 5-3 for cold setting and tighten the locknut. After all injectors and valves are adjusted and engine has been started and warmed up to 140°F. oil temperature; reset the injectors to the warm setting.

Table 5-3: Injector Plunger Adjustment

Torque — Inch Pounds	
Oil Temperature (70°)	Oil Temperature (140°)
48	60

Crosshead Adjustments

On NH Series engines having four-valve heads, it is necessary to adjust the crossheads before making valve adjustments. See Fig. 5-20.

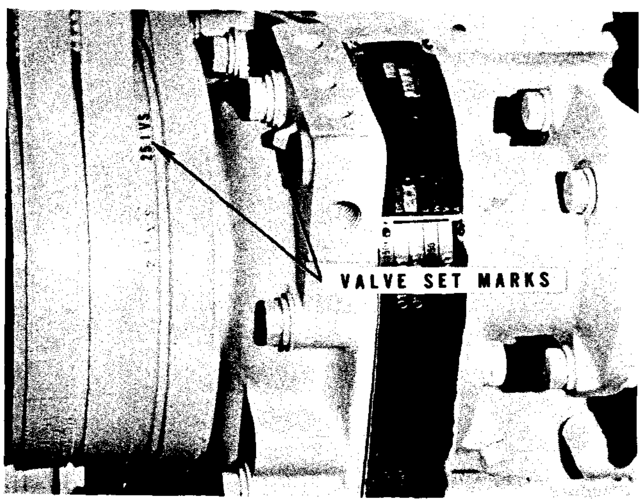


Fig. 5-18. Valve set marks N11936

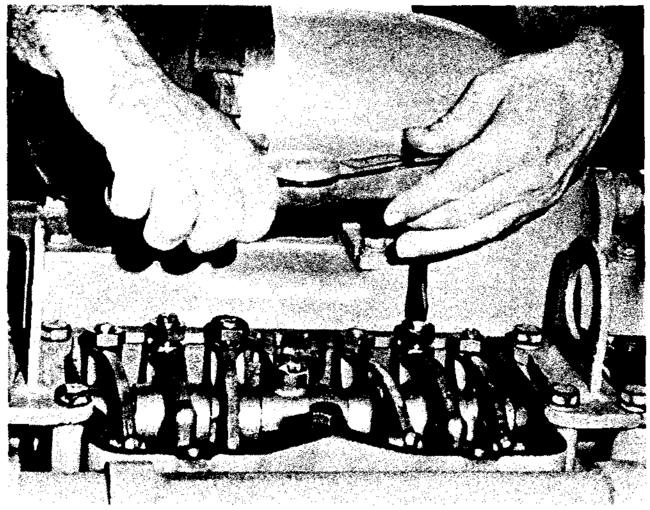


Fig. 5-19. Adjusting injector plungers N11941

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.
2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).
3. Turn down crosshead adjusting screw until it touches valve stem.
4. With new crossheads and guides, advance screw an additional one-third of one hex (20°) 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° to straighten stem in guide.
5. Hold adjusting screw in this position and tighten locknut to 25/30 foot-pounds torque.

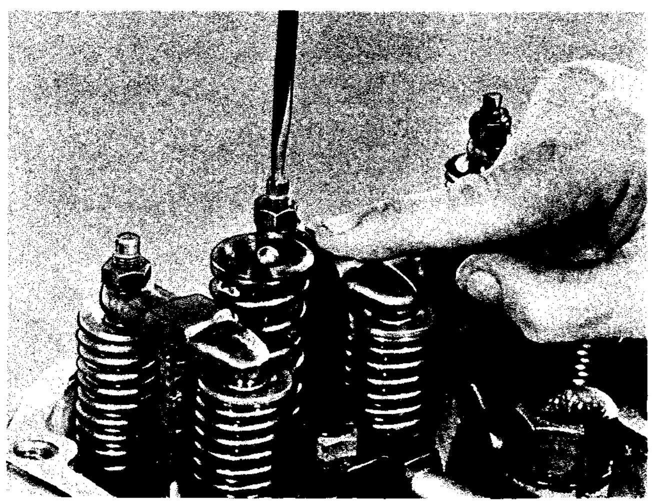


Fig. 5-20. Adjusting crossheads N11462

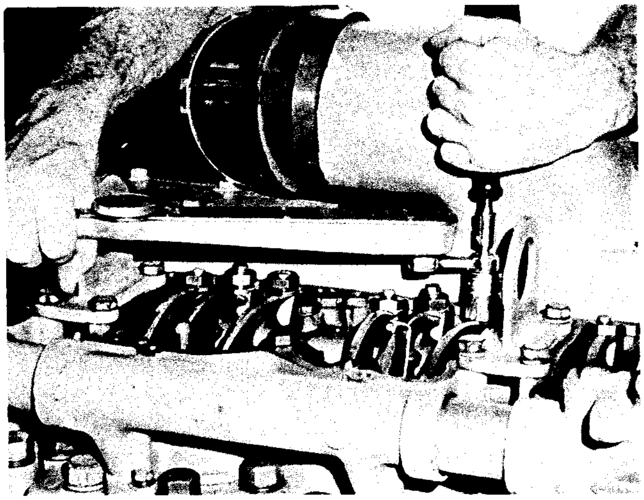


Fig. 5-21. Adjust valves N11942

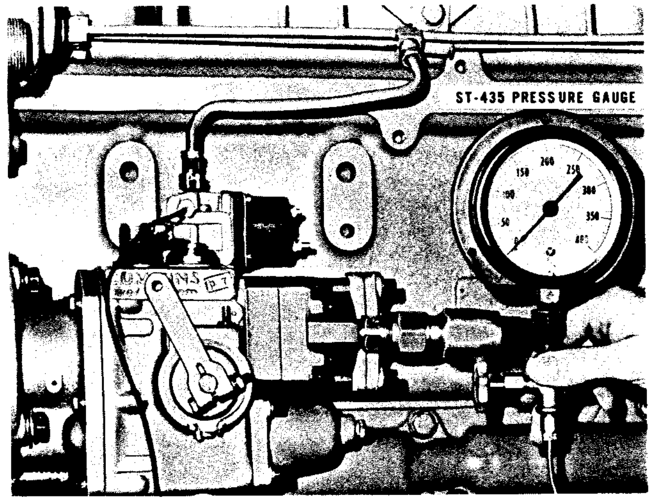


Fig. 5-22. Checking fuel manifold pressure N11491

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of .020 inch 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. 5-21.
3. Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature. Valve clearances are shown in Table 5-4.

Table 5-4: Valve Clearance

Intake Valves Oil Temperature		Exhaust Valves Oil Temperature	
70°	140°	70°	140°
.016	.014	.029	.027

Check Fuel Manifold Pressure (E Check)

1. Check maximum fuel manifold pressure with ST-435. Remove plug from shut-down valve and connect gauge line. Run engine up until governor "cuts in" and check maximum pressure reached. Compare with previous readings to determine if fuel pressure output is satisfactory. Normally this check only required if loss of power is suspected.

Caution: On turbocharged engines aneroids must be disconnected to reach maximum fuel pressure during the short acceleration period.

2. Always make the above checks on a hot engine and operate engine for a minimum of five minutes between checks to clear system of air.

Cooling System Maintenance

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

Aeration refers to the air bubbles which may be drawn into the radiator core tubes, then into the water pump and engine. The worst effect of aeration is the 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 the coolant will increase the temperature differential from the combustion gases to the water due to the reduction in heat transfer.

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

Fill Cooling System (A Check)

Keep cooling system completely filled. Check the coolant level daily or at each fuel fill point. Investigate for cause 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.

Check Leaks And Correct (A Check)

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

Check Heat Exchanger Zinc Plugs (C Check)

Check zinc plugs in heat exchanger and change if badly eroded. Frequency of change depends upon chemical reaction of raw water circulated through heat exchanger.

Check And Adjust Belt Tension (C 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:

Installation

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Both of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.
2. Always replace pairs of belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth should not vary over 1/16 inch on matched belt sets.
3. Pulley misalignment must not exceed 1/16 inch for each foot of distance between pulley centers.
4. Belts should not bottom on the pulley grooves nor should they protrude over 3/32 inch above top edge of groove.
5. Do not allow belts to rub any adjacent parts.

Belt Tension

1. Tighten belts until a reading of 90 to 110 pounds is indicated on ST-968 Belt Tension Gauge. Fig. 5-23.
2. If belt tension gauge is not available, tighten belts so that the pressure of the index finger will depress belt as shown in Table 5-5. The index finger should be extended straight down from the hand; in this manner, force will be approximately 13 pounds. Fig. 5-24.

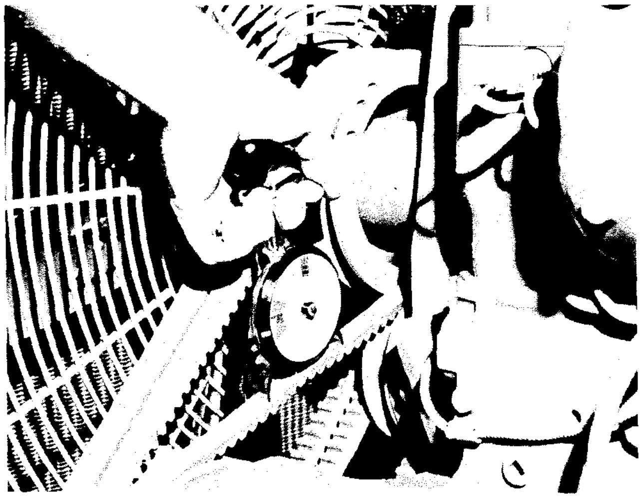


Fig. 5-23. Checking belt tension with ST-968 gauge N11944

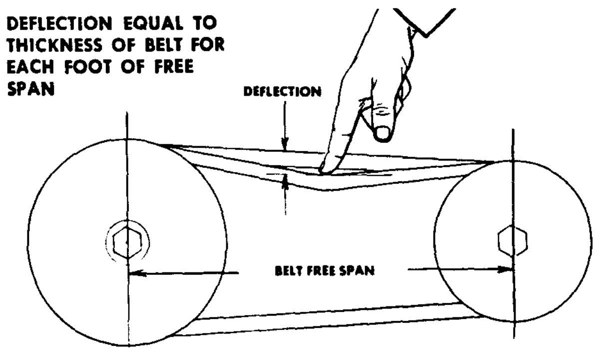


Fig. 5-24. Checking belt tension manually N11471

Re-Tensioning New Belts

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

Table 5-5: Belt Tension

Belt Width	Deflection Per Ft. of Span
1/2"	13/32"
11/16"	13/32"
3/4"	7/16"
7/8"	1/2"
1"	9/16"

Belt Care or Maintenance

Belts often slip or squeak because of the glaze which forms due to dirt or steam cleaning.

To clean a belt, wipe it off with approved belt lubricant or hydraulic brake fluid. Cleaning in this manner will eliminate most cases of squeaking.

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

Check Engine Coolant (C Check)

Periodic tests of engine coolant should be made to insure the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for the specific condition of operation.

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 disolved in the coolant can be measured by the color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check. Fig. 5-25.

Most commercially available antifreezes contain a coloring dye which renders the color comparison method ineffective. When colored antifreezes are present in the coolant effective control of corrosion can be determined by inspecting the coolant for accumulation of redish 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 the sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from the bottom of the radiator after allowing coolant to settle.

Note: Use of chromate compound, added to the coolant without a corrosion resistor, with antifreeze is not recommended.

pH Value Test:

1. Separate tubes marked "pH" are furnished in the test kit. Select a tube and fill to mark with coolant to be checked.
2. Add eight (8) drops of the pH Reagent to tube and mix thoroughly.
3. Insert the tube in the 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.

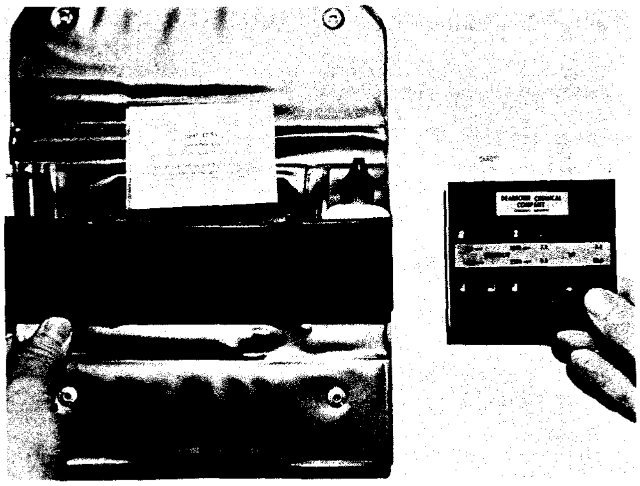


Fig. 5-25. Checking coolant — ST-993 N11946

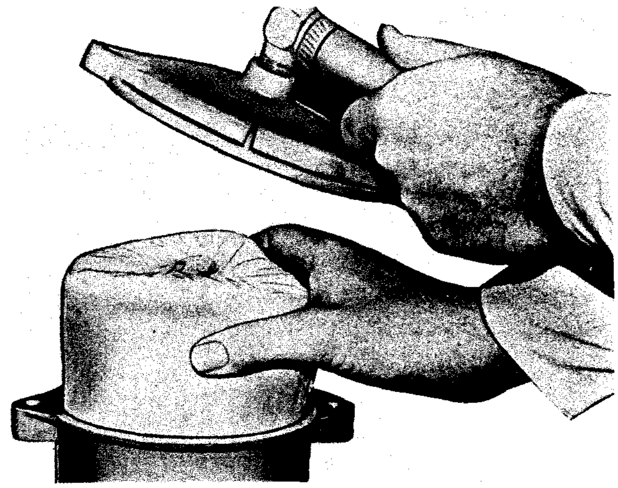


Fig. 5-26. Cummins corrosion resistor N11901

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 gallon or 1700 to 2500 parts per million (ppm).
4. Wash out test tubes after each test.

Adjusting Coolant To Specifications

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

If the Cummins Corrosion Resistor is used change the element or elements 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.

Table 5-6: Comparison Units Chromate Concentration

Ounces Per Gallon (Oz./Gal.)	Parts Per Million (PPM)	Grains/Gallon (Gr./Gal.)
0.16	850	50
0.32	1700	100
0.50	2550	150

If chromate compounds are used, add enough compound to bring concentration to proper level. Normal usage is one-half (1/2) ounce chromate for each one gallon coolant.

Change Corrosion Resistor (C Check)

Change corrosion resistor element at each "C" check unless facilities are available for testing. See "Check Engine Coolant", preceding. Change element when concentration drops below 100 grains per gallon.

To 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.
3. Remove plate securing element(s); lift element(s) from housing and discard. Remove plate below element.
4. Lift spring from housing.
5. Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.
6. Replace spring and lower plate.
7. Remove transparent bag from new element(s); install element(s) in housing. Fig. 5-26.
8. Replace upper plate, gasket and cover.
9. Replace drain plug and open shut-off valves in inlet and drain lines.

Keel Cooling or Heat Exchanger Systems

1. Determine complete capacity of cooling system over and above that of engine itself.
2. Add one-half ounce of Nalco 38, Dearborn Formula 517 or equivalent chromate treatment for each gallon of water over that stated in Step 1.

3. Start unit and check pH value and chromate concentration after solution is thoroughly mixed.
4. The single element corrosion resistor will maintain the proper chromate concentration for systems up to 16 gallons coolant capacity. If above this capacity it is recommended that treated "make-up" coolant be added to the system. See "Check Engine Coolant" preceding.

Check Thermal Controls (D Check)

Thermostat

Most Cummins Engines are equipped with either medium (170/185°F.) or low (160/175°F.) and in a few cases high range (180/195°F.) thermostats, depending on engine application.

The lower value indicates where thermostat starts to open and the higher value where it is fully open. Check stamping on thermostat; install same range new thermostat as that removed.

The opening and closing of thermostats can be checked against a thermometer while immersed in water as the water is brought up to temperature by heating. Fig. 5-27.

Other Thermal Controls

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 5-7 gives settings for shutterstats and thermatic fans as normally used. The 180/195°F. thermostats are used with shutterstats only that are set to close at 187°F. and open at 195°F.

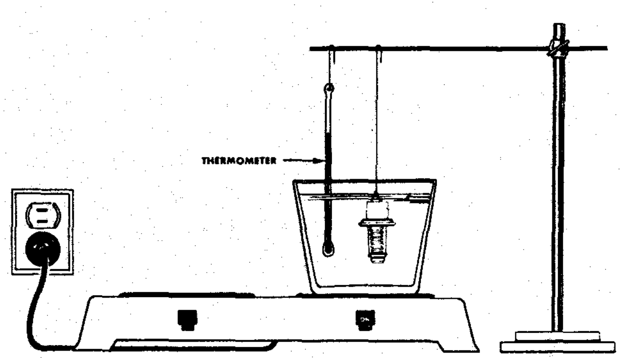


Fig. 5-27. Testing thermostat N10809

Table 5-7: Thermal Control Settings

Unit	Settings with 170/185°F. Thermostats		Settings with 160/175°F. Thermostats	
	Start-Open	Stop-Close	Start-Open	Stop-Close
Thermatic Fan	195°F.	180°F.	185°F.	170°F.
Shutterstat	190°F.	182°F.	180°F.	172°F.
Shutterstat with Thermatic Fan	180°F.	172°F.	170°F.	162°F.

Check Fan Hub And Drive Pulley (D Check)

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

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

Check Sea Water Pump (D Check)

Maintenance and service periods for sea water pump must necessarily be adjusted to agree with the type of application to which it is subjected.

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

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

1. Check all pipes and fittings for leaks. Tighten as necessary.
2. Remove cover plate to drain pump.
3. Lift out rubber impeller and check for cracks, breaks, or damage. Install new impeller if necessary.

   Note: If impeller is subjected to extreme temperatures, either hot or cold, impeller life is shortened and inspection periods must be adjusted accordingly.
4. Clean out all sediment.
5. Install new cover plate gasket and install cover on pump. .015 inch gasket should be used to maintain proper impeller-to-cover clearance.
6. The sea water pump is self-priming.
7. No lubrication is necessary when sealed bearings are used.

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 the radiator. Use clean water which will not clog any of the hundreds of small passages in the radiator or water passages in the block.

Clean out radiator cores, heater cores, oil cooler and block passages which have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

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

Pressure Flushing

Flush the radiator and block when anti-freeze is added or removed, or before installing a Corrosion Resistor on a used engine.

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

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

Air System Maintenance

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

Valves, pistons and rings must seal properly against compression and combustion pressures.

The amount of fuel which can be burned and the 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. Therefore, it is necessary to perform air system maintenance regularly as follows.

When engines operate under extremely dusty conditions, adjust the maintenance intervals to those indicated by shaded blocks in the check sheet on Page 4-2.

Check Air Cleaner Oil Level (A Check)

Daily or at each trip, check oil level in oil bath air cleaner to be sure oil level is at indicated mark. During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes the cleaner to become flooded and results in oil pullover 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. 5-28.

Clean Pre-Cleaner And Dust Pan (A Check)

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 oftener as necessary depending on operating conditions.

Clean Dry-Type Cleaner Element (B Check)

Perform at A Check under extreme dusty conditions.

The paper element in a dry-type air cleaner may be cleaned several times by using a compressed air jet to blow off the dirt. Do not hold air jet too close to paper element or damage to element will result.

Fig. 5-28. Oil level in air cleaner N11001

When installing the element, make sure it seats on the gasket at the air cleaner outlet end. Fig. 5-29.

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

Clean Composite-Type Cleaner Element (B Check)

Perform at A Check under extreme dusty conditions.

Composite cleaners combine a centrifugal cleaning stage with a paper filter element. Figs. 5-30 and 5-31.

Air enters the cleaner through a hooded inlet on the side of the cleaner and passes into a tube. Vanes on the tube impart a cyclonic twist to the air which throw dust particles to the outside.

The separated dust collects in a pan at the bottom of the cleaner while the clean air passes up through the center of the tube to a paper filter. The paper filter then removes any small dust particles remaining in the air.

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

1. Loosen clamps and remove cover.

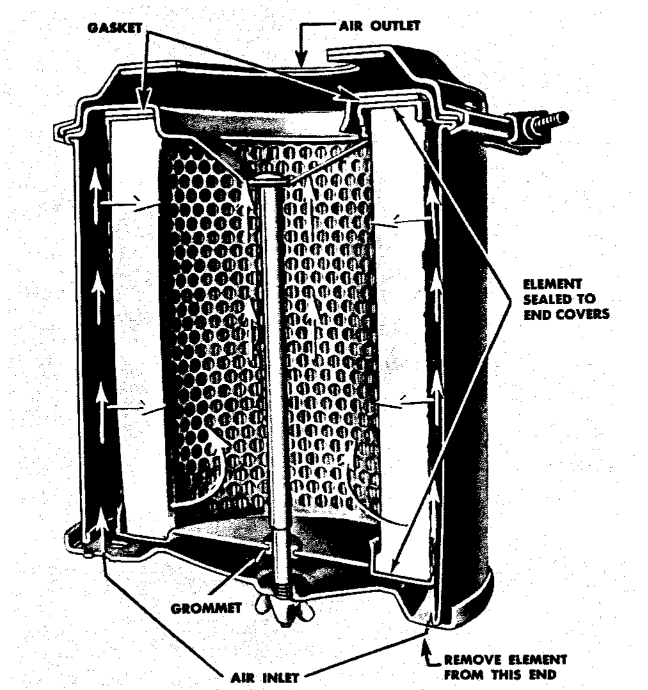


Fig. 5-29. Air cleaner—dry type N11003

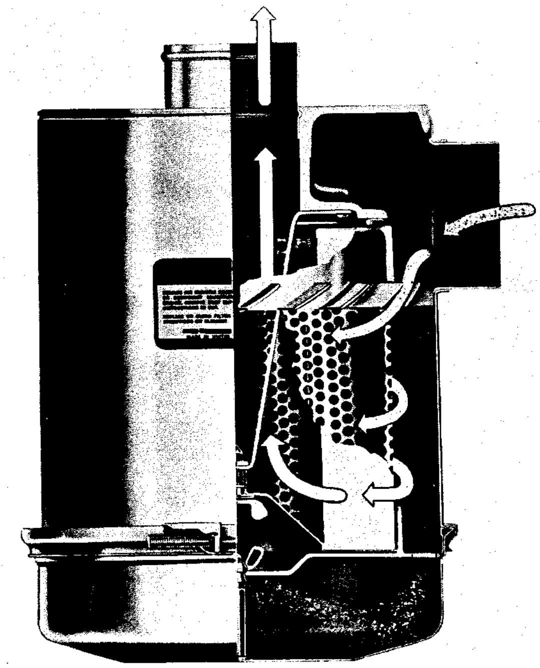


Fig. 5-30. Air cleaner—centrifugal type V11005

2. Unscrew wing bolt holding inner cover and element in position; remove element carefully so loose dirt will not fall into chamber.
3. Remove dust cup 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 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°F.). Dry with compressed air. (40 psi).
7. Remove retainer clamp. Separate upper and lower bodies; remove "O" ring.
8. Hold element up to light and inspect tubes 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 there are no holes in filter.
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 is in place under wingnut before tightening.

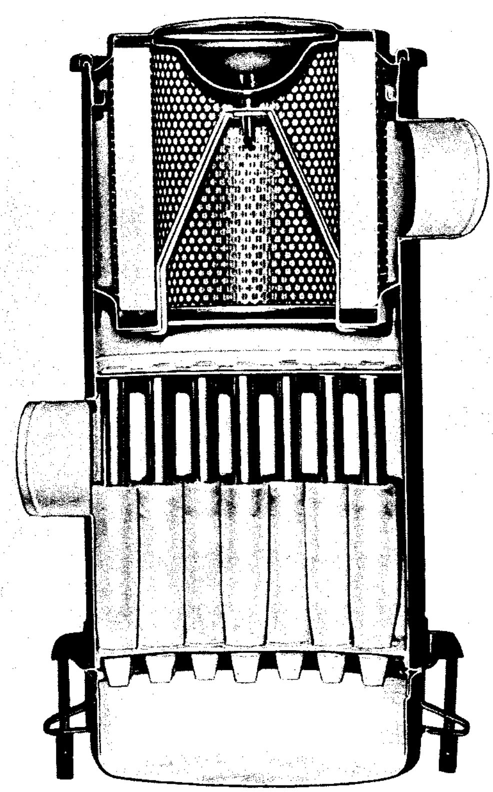


Fig. 5-31. Air cleaner—composite type V11004

14. Install cover.
15. Install dust cup.

Change Oil Bath Air Cleaner Oil (B Check)

Perform at A Check under extreme dusty conditions.

Before dirt build-up reaches ½ inch, remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Fill oil cup to level indicated by bead on its side with clean, fresh oil and assemble to cleaner. An oil of the same grade as that in the crankcase should be used in the 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.

Cartridge Type Air Cleaner (C Check)

1. The best method to tell when to change any dry-type air cleaner is by use of a filter restriction indicator which clearly indicates when the element is loaded. Fig. 5-35. Other indications are a loss of engine power or excessive smoke in the exhaust gases.
2. Cartridge changes can be scheduled, but due to wide variations in dust and weather conditions, even in the same location, changing "as required" is usually more economical.
3. The filter restriction indicator, Fig. 5-35, signals when to change cartridges. The flag in the window gradually rises as the cartridge loads with dirt. Do not change cartridge until the flag reaches the top and locks in that position. When locked, the flag will remain up after the engine is shut down. Change the cartridge when the flag locks at the top. After changing the cartridge reset the indicator by pushing the re-set button. Push button all the way in firmly, then release. If button sticks, repeat pushing slowly.
4. Loosen wing nuts on air cleaner housing. Loosen "U" bolt clamp securing pre-cleaner to aspirator tubing. Remove pre-cleaner panel.
5. To remove dirty Pamic cartridge insert fingers in cartridge opening using a "bowling ball grip". Loosen all four corners of the cartridge, one at a time, by pulling straight out. With larger cartridges it may be necessary to break the seal along edges of the cartridge. After seal has been broken pull the cartridge straight out and slightly up so that the cartridge will clear the sealing frame and edges of the air cleaner housing.
6. Clean the pre-cleaner openings of all soot, oil film and any other objects that may have become lodged in the openings. Remove any dust or dirt that may be in the lower portion and the aspirator tubing. Inspect the inside of the air cleaner housing to be sure it is free of all foreign material.

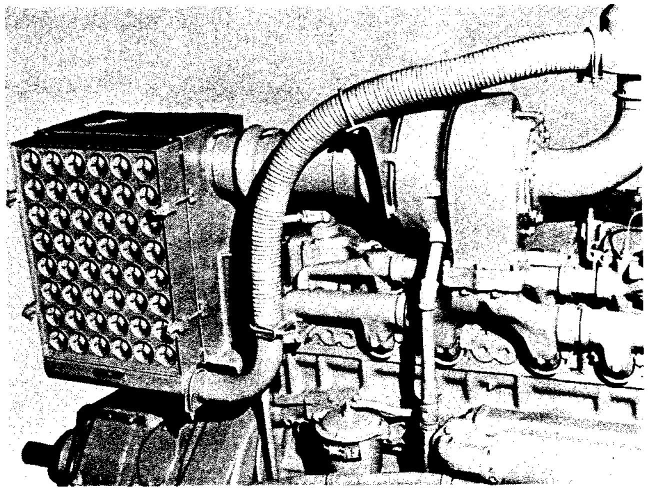


Fig. 5-32. Air cleaner—cartridge type N11947

7. Inspect the dirty cartridge for soot or oil. If there is soot inside the Pamic tubes check for leaks in engine exhaust system, exhaust "blow back" into air intake and exhaust from other equipment. If the 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.
8. It is not recommended to clean and reuse the cartridge. Considerable laboratory testing shows that shaking, washing, rapping or blowing out with compressed air can cause cracks or ruptures in paper filter cartridges, which would permit wear-causing dirt particles to enter the engine. If a failure occurs, there is no way of discovering it until the cartridge is changed again.
9. Inspect flexible hose or tubing and clamps to be sure all fittings are air tight.
10. Inspect each new filter cartridge for shipping damage before installing.
11. To install a new cartridge, hold cartridge in the same manner as when removing it from the housing. Insert the clean cartridge into housing, avoid hitting the cartridge tubes against the sealing flange on the edges of air cleaner housing.
12. Because the cleaner requires no separate gaskets or seals, care must be taken when inserting cartridge to insure a proper seat within the air cleaner housing. Firmly press all edges and corners of the cartridge with fingers to effect a positive air seal against the sealing flange of the housing. Under no circumstances should the cartridge be pounded or punched in the center with the fist to effect a seal.
13. Replace pre-cleaner panel and tighten wing nuts. Assemble aspirator tube to pre-cleaner panel and tighten "U" bolt.

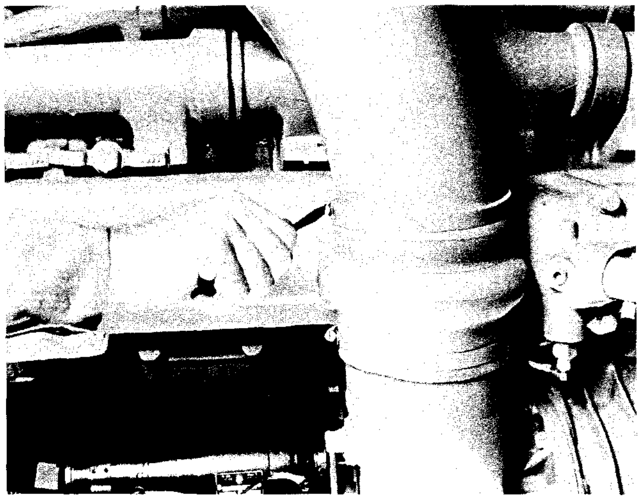


Fig. 5-33. Check air intake piping N11908

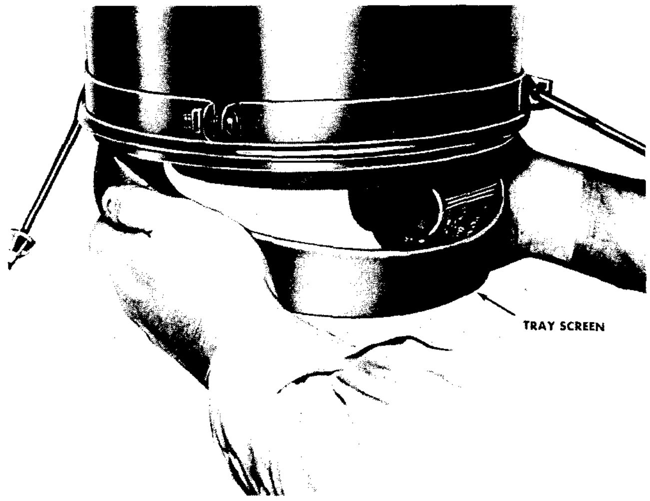


Fig. 5-34. Removing tray screen N11002

14. Care should be taken to keep leaves, rags or side curtains from obstructing the cleaner face. Obstructing air intake can result in reverse exhaust flow through the bleed line and damage to cartridge.
15. Be sure Service Indicator is re-set before starting engine, if this accessory is used.

Check Air And Vapor Line Connections (C Check)

Perform at B Check under extreme dusty conditions.

Check all air and vapor lines and connections from compressor, supercharger, rocker housing cover and cylinder head for leaks, breaks, stripped threads, etc.; correct as needed.
In cold weather, condensed moisture in air tanks and lines may freeze and make brakes useless.

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

Check Air Piping (C Check)

Perform at B Check under extreme dusty 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 or replace parts as necessary to insure an airtight air intake system. Make sure that all air goes through the air cleaner. Fig. 5-33.

Clean Tray Screen (D Check)

Perform at C Check under extreme dusty conditions.

Immerse the tray screen in kerosene or cleaning solvent. Slosh the screen up and down several times. Dry thoroughly with compressed air, and reassemble to air cleaner. Fig. 5-34.

Note: If the 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 screens.

Check Inlet Air Restriction (D Check)

Perform at C Check under extreme dusty conditions.

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

Check Air Inlet Restriction At Engine

1. On naturally aspirated engines attach vacuum gauge or water manometer in the middle of the intake manifold or on the air intake piping. When located in the air intake piping, the adaptor must be perpendicular to the air flow and not more than 6 inches from the air intake manifold connection.
2. On turbocharged or supercharged engines, attach the checking fixture one pipe diameter upstream from the supercharger or turbocharger in a straight section of tubing.
3. Idle the engine until normal operating temperature is reached.
4. Operate engine at rated speed, full-load and intake reading from vacuum gauge or manometer. Air restriction must not exceed 25 inches of water or 1.8 inches of mercury.
5. If air restriction exceeds 25 inches of water or 1.8 inches of mercury:

a. Clean or replace dry-type cleaner element.

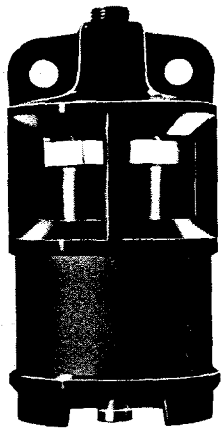


Fig. 5-35. Air inlet restriction gauge CGS-20

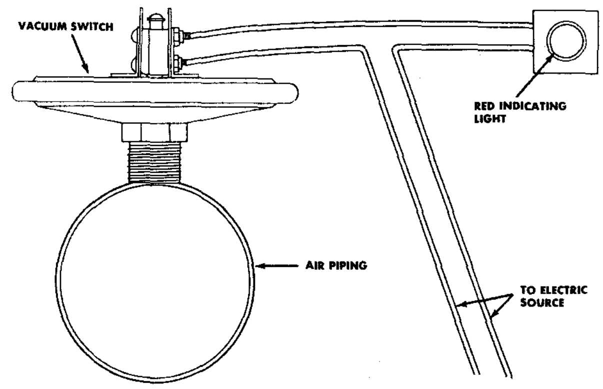


Fig. 5-36. Vacuum switch to check inlet air restriction N21905

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 Cleaner

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

A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in the air cleaner outlet or on the vehicle instrument panel. The gauge shows completely red in the indicator window when restriction reaches 20 inches of water. Fig. 5-35.

Vacuum switches are available which actuate a warning light on the instrument panel when air restriction becomes excessive. Fig. 5-36.

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

Replace Dry-Type Cleaner Element (D Check)

Perform at C Check under extreme dusty conditions.

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

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

Replace Composite-Type Cleaner Element (D Check)

Perform at C Check under extreme dusty conditions.

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

1. Remove cover; lift out element. Do not allow dust from element to fall back into air cleaner. Discard element.
2. Inspect "O" rings or gaskets. Replace as needed.
3. Insert new element and tighten cover securely.

Clean Crankcase Breather (D Check)

Perform at C Check under extreme dusty 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. 5-37.

Screen Element

Clean element by washing in clean solvent and drying with

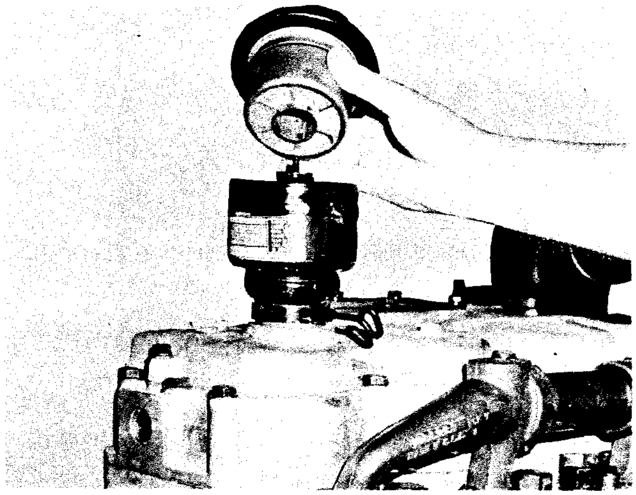


Fig. 5-37. Clean crankcase breather oil bath N11935

compressed air. Clean breather housing with dry cloth. Fig. 5-38.

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

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. 5-39.

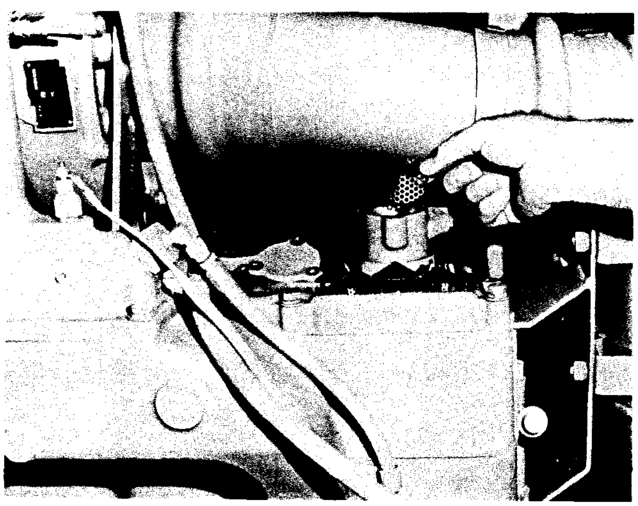


Fig. 5-38. Clean crankcase breather — screen element N11934

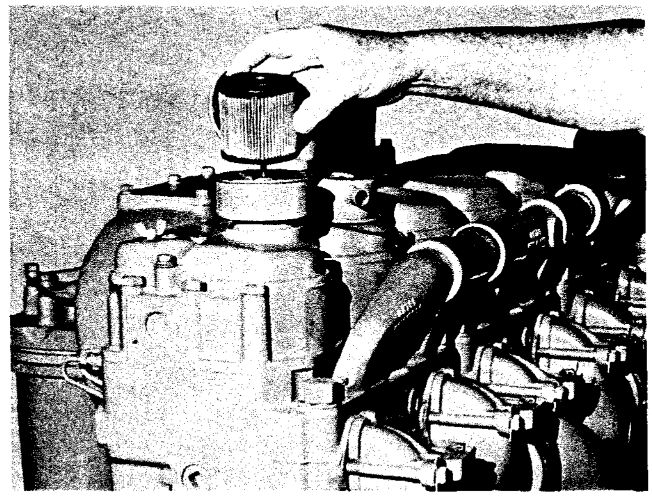


Fig. 5-39. Change crankcase breather — paper element N11933

Clean Air Compressor Breather (D Check)

Perform at C Check under extreme dusty 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.

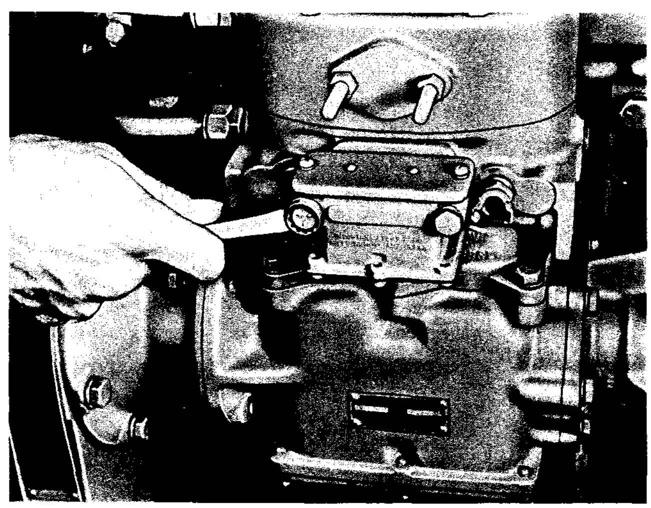


Fig. 5-40. Bendix-Westinghouse air compressor breather N11904

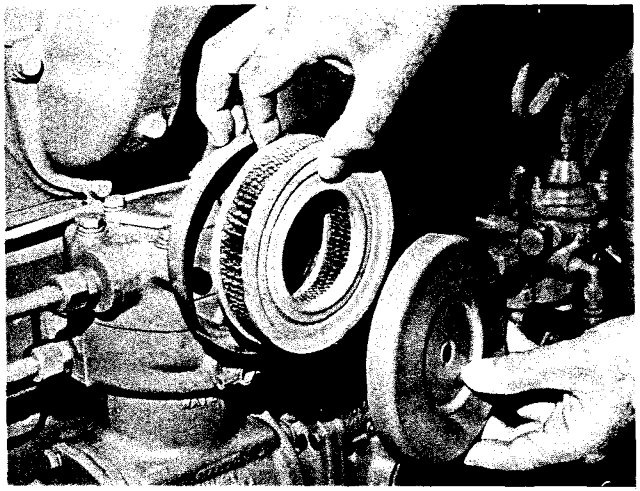


Fig. 5-41. Cummins air compressor breather — paper element N11937

Bendix-Westinghouse Sponge

Remove the breather from the air compressor. 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 with oil to level mark and reassemble. Use clean oil, the same grade as used in the crankcase.

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

Cummins Compressor Paper

A light weight self-contained air cleaner with "paper element" is optional on Cummins air compressor. Clean the element at each "D" maintenance check. Remove wing nut 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. 5-41.

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 wing nut.

Check For Oil Leaks At Supercharger Or Turbocharger (D 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.

Tighten Manifold Nuts Or Capscrews (D Check)

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

Tighten Turbocharger Mounting Nuts (D Check)

Tighten all turbocharger mounting capscrews and nuts to

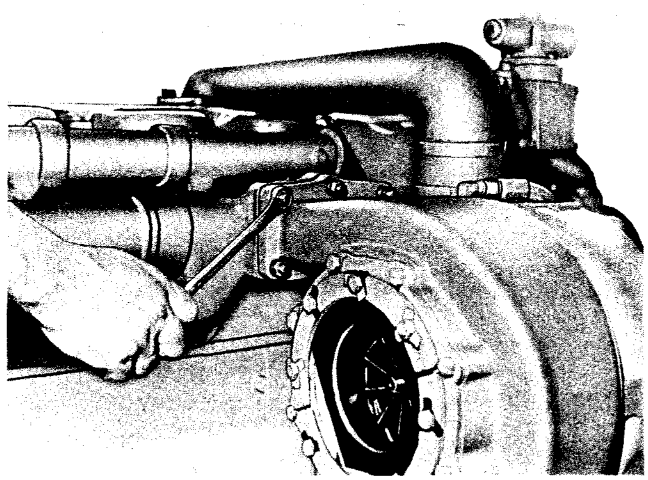


Fig. 5-42. Tighten turbocharger mounting nuts N11906

be sure that they are holding securely. Tighten mounting bolts and supports so that vibration will be at a minimum. Fig. 5-42.

Clean Aneroid Air Filter (E Check)

Perform at D Check under extreme dusty conditions.

At each "E" check, remove filter and reverse flush with compressed air; it is not necessary to disassemble filter.

Clean Oil Bath Air Cleaner (E Check)

Perform at D Check under extreme dusty conditions.

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

This method of 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 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.

   If the screens cannot be thoroughly cleaned by either of the above methods, or if body is pierced or otherwise damaged, replace with new air cleaner.

Clean Turbocharger Compressor Wheel And Diffuser (E 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 "E" check, clean the compressor wheel and diffuser as follows:

1. Remove intake piping, air cleaner piping and support bracket from turbocharger, if used.
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 to 36 inch pounds; do not overtighten.

Check Turbocharger Bearing Clearance (E Check)

Check bearing clearances every "E" check. This can be done, without removing the turbocharger from the engine,

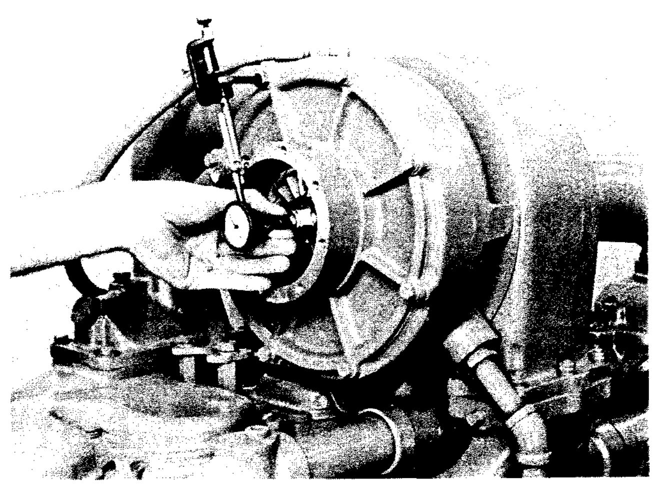


Fig. 5-43. Checking turbocharger bearing clearance N11019

by using a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance.

Checking Procedure

1. Remove exhaust and intake piping from the turbocharger to expose ends of rotor assembly. Fig. 5-43.
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 for limits.
3. Check radial clearance on compressor wheel only. Note that limits in Table 5-8 are minimum figures.

Table 5-8: Turbocharger Bearing Clearances

Turbocharger Model	Radial Clearance Minimum	Radial Clearance Maximum	End Clearance Minimum	End Clearance Maximum
T-50	0.0115	0.024	0.006	0.018
T-350	0.009	——	0.003	0.008
T-506	0.008	——	0.003	0.010
T-590	0.008	——	0.003	0.011

4. If end clearance exceed limits shown above, remove turbocharger from engine and replace with a new or rebuilt unit.

Check Preheater (Spring And Fall)

1. Inspect wiring; remove 1/8" pipe plug from manifold near glow plug and check flame while a helper performs preheating operation. See Page 2-3.
2. If no flame is observed, remove and replace with new or tested parts.

Other Maintenance

Check Operator's Report (A Check)

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

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noises.
5. Excessive smoke.

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 lock-pin 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.

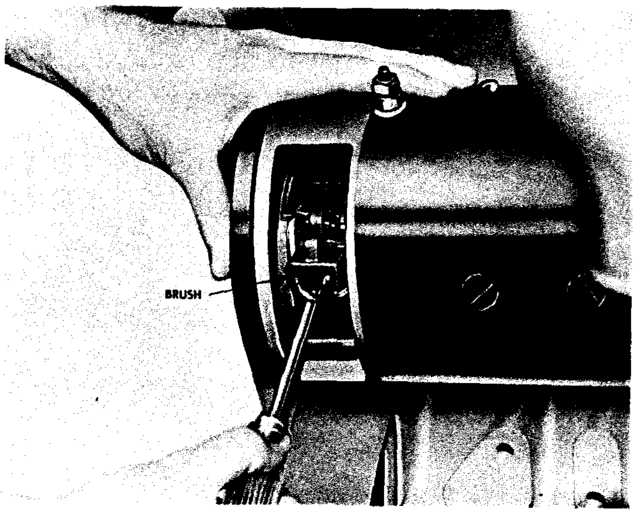


Fig. 5-44. Checking generator brushes N11308

Clean Dust From Alternator/Generator And Cranking Motor (D Check)

Dust and dirt, if allowed to accumulate in the generator/alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.
Remove the cover band and blow out the dust and dirt with compressed air.

Clean And Tighten Electric Connection (D Check)

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

1. Add water to battery cells to keep tops of plates covered.
2. Remove corrosion from around terminals, then coat with petroleum jelly.
3. Keep connections clean and tight. Prevent wire 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 Alternator/Generator Brushes And Commutator (E Check)

The failure of an alternator/generator may cause unit downtime and nearly always results in expensive replacement.

1. Clean dirty commutators with No. 00 sandpaper; never with emery cloth.
2. Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension or high mica on the commutator. Check out-put and action of an ammeter indicator after brush replacement. Fig. 5-44.
3. Shorts and incorrect polarization can be detected at the ammeter. Incorrect polarization is indicated by minus reading when generator is turned. Take unit to an electric service station for immediate correction.

Steam Clean Engine (E Check)

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

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

Tighten Mounting Bolts And Nuts (E Check)

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 Engine Blow-By (E Check)

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 beather open or remove. 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. 5-45.

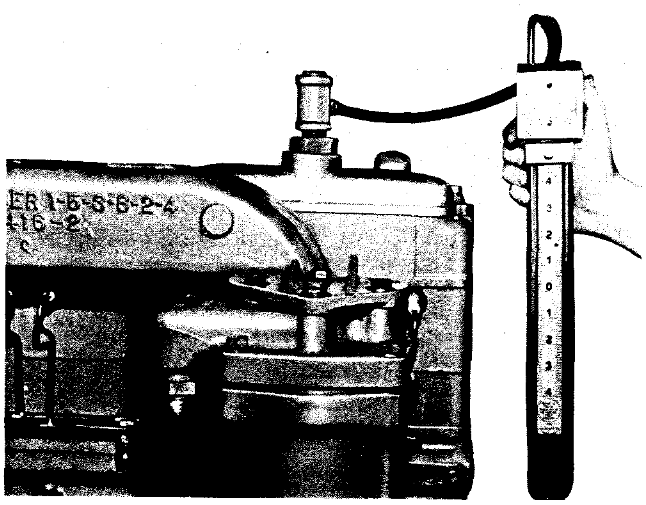


Fig. 5-45. Checking blow-by under load N11489

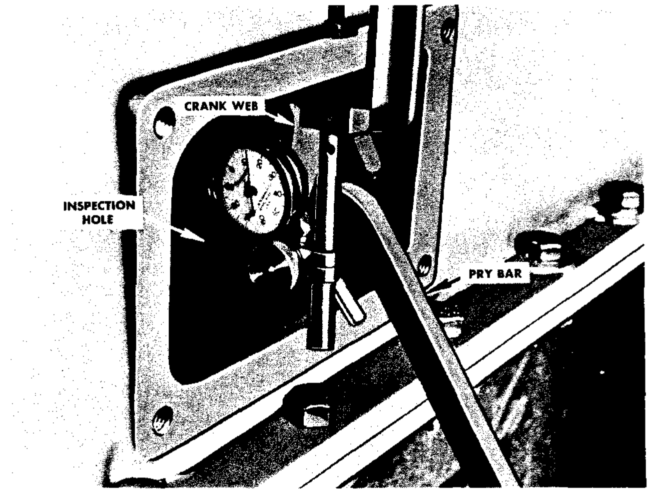


Fig. 5-46. Checking cranksnaft end clearance N11905

Check Crankshaft End Clearance (E Check)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed for that model in Table 5-9. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is disassembled for repair, install new thrust rings if wear results in end clearance in excess of .022 inch.

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 5-9: Crankshaft End Clearance

New Minimum	New Maximum	Operating Worn Limit
.007	.017	.035

Check Vibration Damper Alignment (E Check)

Damper hub and inertia member are stamped with an index mark to permit detection of movement between the two components. Fig. 5-47.

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

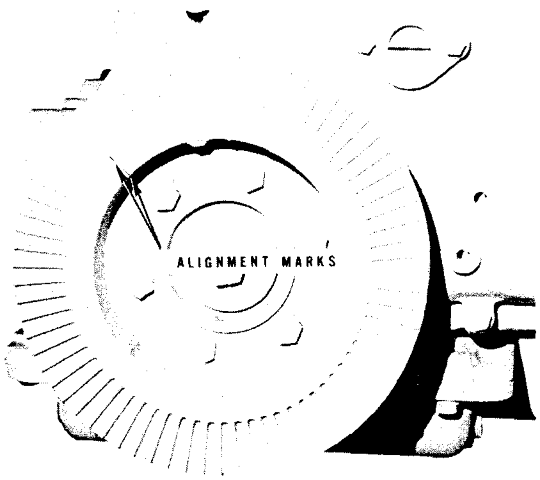


Fig. 5-47. Vibration damper alignment marks N11931

Major Inspection

After the engine has had four "E" checks, it should have a major inspection to determine whether it may be operated for another service period, or whether it should be overhauled. Oil consumption, oil pressure at idling, dilution and other signs of wear should be analyzed as part of the inspection.

Since the 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 with disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

Inspect the following items at this period:

Main and Connecting Rod Bearing Shells
Crankshaft Journals
Camshaft Lobes
Cylinder Heads (Grind Valves)
Cylinder Liners
Pistons and Rings
Fuel Pump (Calibrate)
Injectors (Clean and Calibrate)
Supercharger Seals and Bearings
Oil Cooler (Clean)
Turbocharger Bearing Clearances
Air Compressor or Vacuum Pump
Alternator/Generator and Cranking Motor
Intake and Exhaust System (Clean and Correct Leaks)

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

Engine Rebuild

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

After an engine has been rebuilt it is essentially a new engine and should be treated as such. By treating the rebuilt engine like a new engine and by following the preventive maintenance schedule, the same dependable service can be expected from the engine that it gave during its first service period.

Maintenance Operations Summary Sheet

Information should be collected from each maintenance check sheet and consolidated on a single summary sheet such as shown on the next page. Each engine thus has an established history and cost records can be computed quickly. A review of the summary sheet will then tell you which operations can be reduced or increased to make the maintenance program more effective, resulting in more efficiency from the engine at lower cost. A potential failure caught before it happens provides savings to the engine owner and a ready for service unit for the operator.

NOTE: INCLUDE SUMMARY OF [illegible] PERFORMED BETWEEN [illegible]

	OPERATIONS		DUE	PERFORMED	DATE	MECHANIC	LABOR	PARTS		FUEL	LUBE OIL	TIME LOST	EMERGENCY REPAIRS			REMARKS
	CHECKS	FUEL GALLONS	GALLONS or HOURS	GALLONS or HOURS			HOURS	REQ. NO.	COST	GALLONS	QUARTS	HRS. OUT OF SERVICE	LABOR	PARTS	TIME LOST — HOURS	ACCIDENTS — CAUSE OF FAILURE — MAJOR ITEMS REPLACED, ETC.
	C															
	B															
	G															
	TOTALS															

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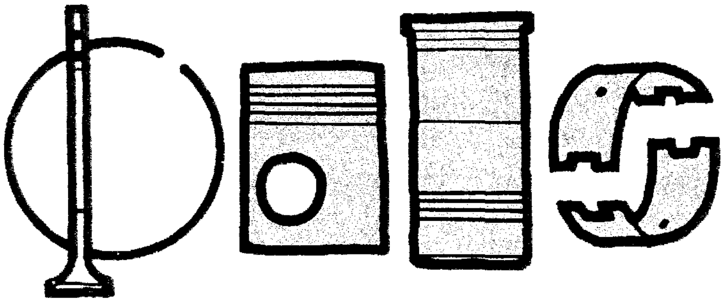
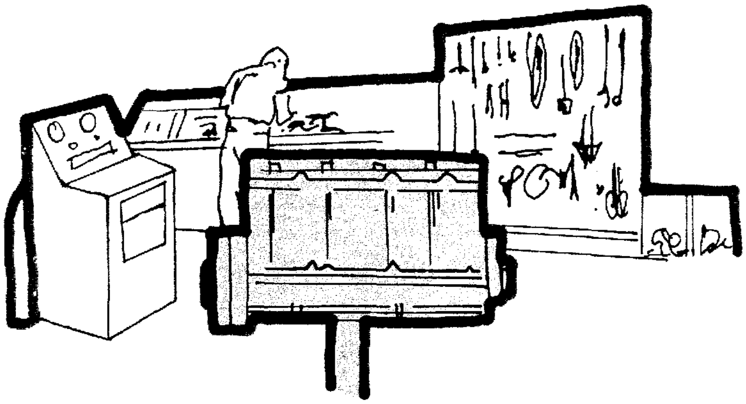


Parts

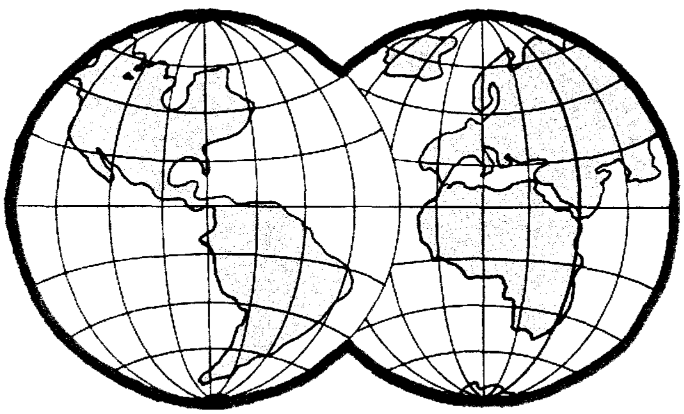
Genuine Cummins service parts are of the same high quality as those used on the original engine so your engine will continue to give good service after any repair or maintenance.

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



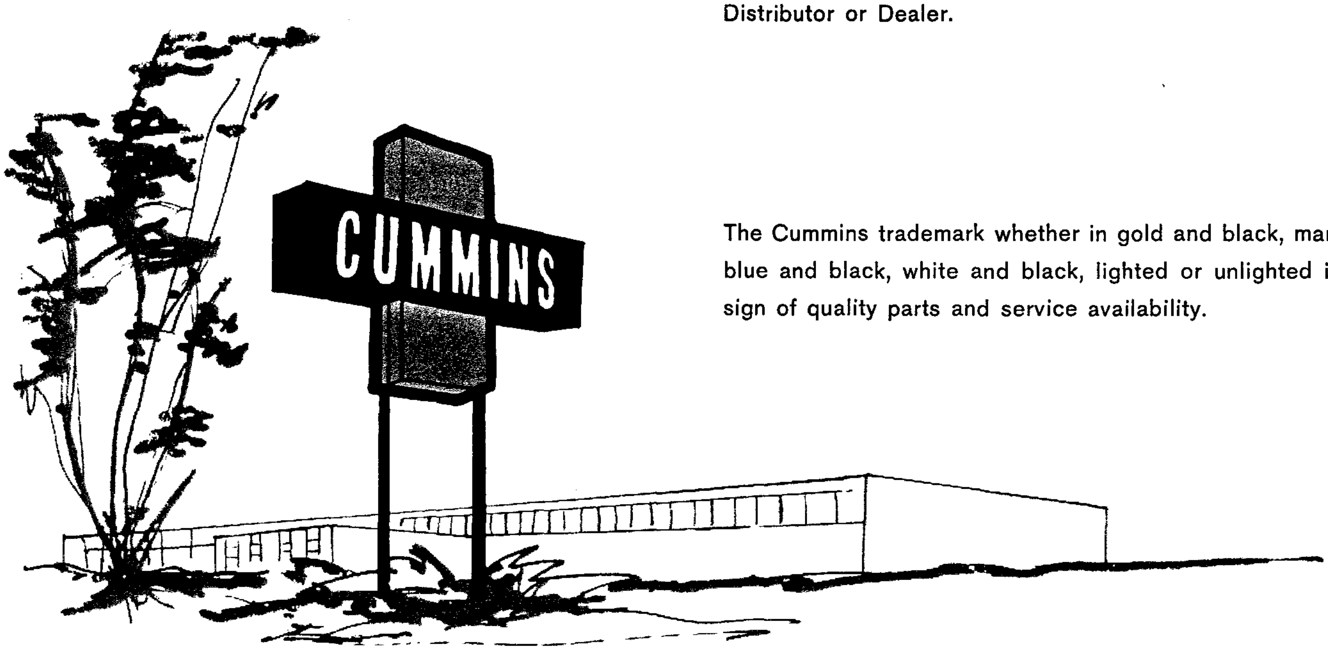
Service

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.