ummins Diesels

V-1710 series

Operation and Maintenance Manual

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

Operation and Maintenance Manual

Cummins Diesel V-1710 Series

Foreword

This manual is applicable to all V1710 Series Cummins Diesels currently being produced by Cummins Engine Company, Inc. It contains instructions for operators that will enable them to get the best service from their engines. Before operating engine become familiar with procedures described.

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

Federal Smoke Emission Certification

Beginning January 1, 1970 all new Cummins Engines for use in automotive applications, are in all material respects, substantially the same as test engines certified by the U.S. Department of Health, Education and Welfare as conforming to Federal Regulations pertaining to exhaust smoke emission. Once the engine is placed in service the responsibility for meeting state and local regulations must necessarily be with the owner/operator. Observation of good operating practices, regular maintenance and proper adjustments are factors which will help stay within the regulations.

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

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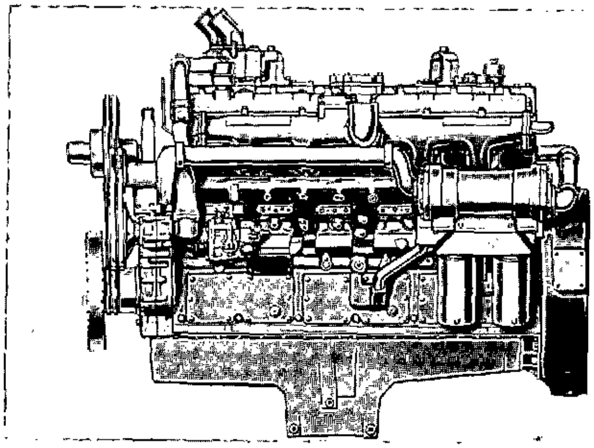


Specifications

Horsepower	500
Governed RPM	2100
Number of Cylinders	12
Bore and Stroke	5-1/2" x 6"
Piston Displacement – cu. in.	1710
Operating Cycles	4
Crankcase Oil Capacity – gals.	18
Engine Coolant Capacity – gals.	21
Net Weight with Standard Accessories (lbs.)	5280

Design Features

1. Internal Fuel Lines: Drilled passages in cylinder heads eliminate threaded fuel line connectors and external lines.

2. Large Intake and Exhaust Passages: Minimize restriction of air and exhaust flow. Allows maximum air charge for clean burning, top economy.

3. Overhead Valves: Precision machined from high strength alloy steel. Intake valves are of silichrome steel. Exhaust valves of big displacement models are nitrogen steel for high temperature strength and faced with corrosion resistant material.

4. Open Type Combustion Chamber: Gives most efficient *combustion . . . most power from each gallon of fuel.*

5. Replaceable Wet-type Cylinder Liners: Dissipate heat faster. Liners are easily replaced without reboring block.

6. *Conventional Push Rod and Rocker Lever Arrangement:* Activates valves and injectors from dual camshafts. Roller type camshaft followers are used for long life.

7. Cam-ground Pistons: Assure perfect fit at operating temperatures.

8. Alloy Cast Iron Cylinder Block: Follows proven design and material specification to achieve maximum durability.

9. Large Volume Water Passages: Give even flow of coolant around cylinder liners, valves, and injectors to draw excess heat from combustion chamber. Centrifugal pump circulates large volumes of water.

10. Connecting Rods: Forged from high tensile strength alloy steel. I-beam section gives maximum strength. Large diameter piston pins are full-floating. Tapered piston pin end used for superior load distribution and maximum crown material on thee piston.

11. Counterweighted Crankshaft: Precision machined from high tensile strength steel forgings. Bearing journals are induction hardened for long life.

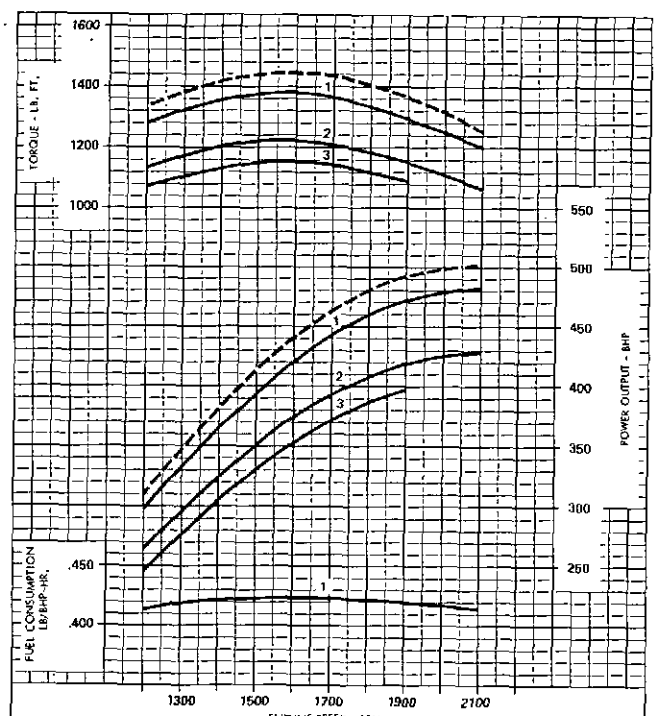
Performance

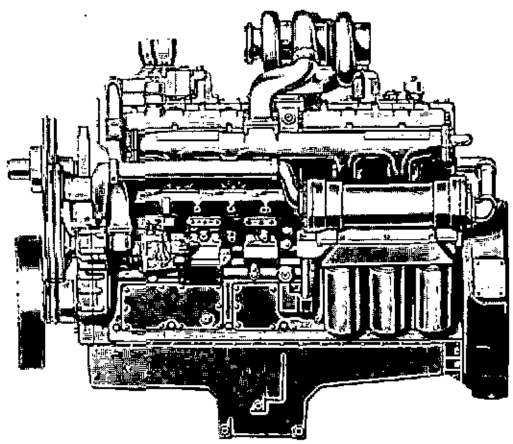
Horsepower, torque and fuel consumption shown on solid lines represents performance at 500 feet altitude and 85 deg. F intake air temperature. Dotted lines indicate performance corrected to conditions of sea level altitude (29.92 inches mercury) and 60 deg. F intake air temperature. Curves represent performance of the engine with fuel system, water pump, lubricating oil pump, and air cleaner. Battery charging generator, compressor, fan, and optional equipment are not included in these ratings.

Curves represent performance on No. 2 diesel or furnace oil. *Equivalent results can be obtained with fuels ranging from heavy* furnace oils to light jet and military type fuels without recalibration. Engines permanently stationed at high altitudes should be derated 3% for each 1000 feet increase in altitude above 500 feet and 1% for each 10 deg. F increase in temperature above 85 deg. F to maintain rated air to fuel ratios.

Curve No. 2 is a suggested rating for intermittent application in which periods of operation at full load are followed by equal periods at partial load, idle, or shut down. *For altitude performance,* curve No. 2 should be derated 3% for each 1000 feet above 5000 feet.

Curve No. 3 is a suggested rating for continuous duty service in which full power is required for long periods of time without equal intervals of operation at reduced loads or shut down. For altitude performance, curve No. 3 should be derated 3% for each 1000 feet above 7000 feet.





Specifications

Horsepower	635
Governed RPM	2100
Number of Cylinders	12
Bore and Stroke	5½" x 6"
Piston Displacement—cu. in.	1710
Operating Cycles	4
Crankcase Oil Capacity—gals.	18
Engine Coolant Capacity—gals.	21
Net Weight with Standard Accessories (lbs.)	5780

Design Features

1. Internal Fuel Lines: Drilled passages in cylinder heads eliminate threaded fuel line connectors and external lines.

2. Large Intake and Exhaust Passages: Minimize restriction of air and exhaust flow. Allows maximum air charge for clean burning, top economy.

3. Overhead Valves: Precision machined from high strength alloy steel. Intake valves are of silichrome steel. Exhaust valves of big displacement models are nitrigen steel for high temperature strength and faced with corrosion resistant material.

4. Open Type Combustion Chamber: Gives most efficient combustion . . . most power from each gallon of fuel.

5. Replaceable Wet-type Cylinder Liners: Dissipate heat faster. Liners are easily replaced without reboring block.

6. Conventional Push Rod and Rocker Lever Arrangement: Activates valves and injectors from dual camshafts. Roller type camshaft followers are used for long life.

7. Cam-ground Pistons: Assure perfect fit at operating temperatures.

8. Alloy Cast Iron Cylinder Block: Follows proven design and material specification to achieve maximum durability.

9. Large Volume Water Passages: Give even flow of coolant around cylinder liners, valves, and injectors to draw excess heat from combustion chamber. Centrifugal pump circulates large volumes of water.

10. Connecting Rods: Forged from high tensile strength alloy steel. I-beam section gives maximum strength. Large diameter piston pins are full-floating. Tapered piston pin end used for superior load distribution and maximum crown material on thee piston.

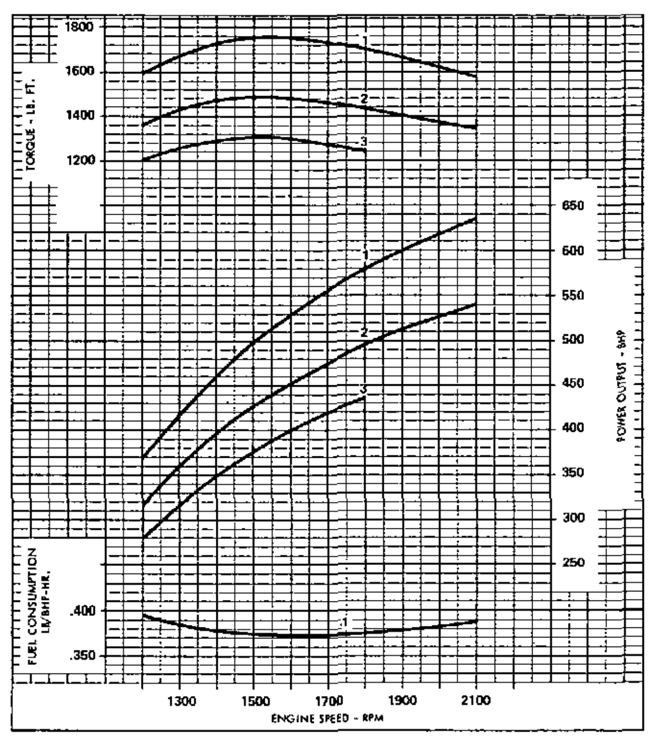
11. Counterweighted Crankshaft: Precision machined from high tensile strength steel forgings. Bearing journals are induction hardened for long life.

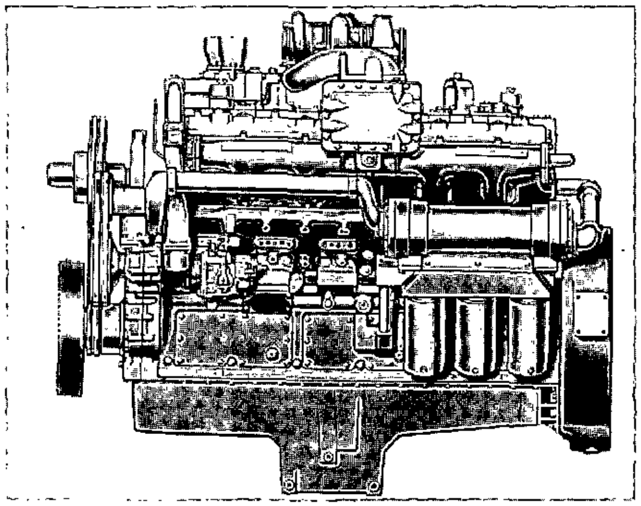
Performance

Horsepower, torque, and fuel consumption shown on Curve No. 1 represent performance obtained from sea level to 11,000 feet altitude. Curves represent performance of the engine with fuel system, water pump, lubricating oil pump, and air cleaner. Battery charging generator, compressor, fan, and optional equipment are not included in these ratings. Equivalent results can be obtained with fuels ranging from heavy furnace oils to light jet and military type fuels without recalibration.

Curve No. 2 is a suggested rating for intermittent applications in which periods of operation at full load are followed by equal periods of operation at partial load or shut-down.

Curve No. 3 is a suggested rating for continuous duty service in which full power is required for long periods of time without equal intervals of operation at reduced loads or shut down.





Specifications

Horsepower	700
Governed RPM	2100
Number of Cylinders	12
Bore and Stroke	5½" x 6"
Piston Displacement—cu. in.	1710
Operating Cycles	4
Crankcase Oil Capacity—gals.	18
Engine Coolant Capacity—gals.	21
New Weight with Standard Accessories (lbs.)	5780

Design Features

1. Internal Fuel Lines: Drilled passages in cylinder heads eliminate threaded fuel line connectors and external lines.

2. Large Intake and Exhaust Passages: Minimize restriction of air and exhaust flow. Allows maximum air charge for clean burning, top economy.

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4. Open Type Combustion Chamber: Gives most efficient combustion . . . most power from each gallon of fuel.

5. Replaceable Wet-type Cylinder Liners: Dissipate heat faster. Liners are easily replaced without reboring block.

6. Conventional Push Rod and Rocker Lever Arrangement: Activates valves and injectors from a dual camshaft. Roller type camshaft followers are used for long life.

7. Cam-ground Pistons: Assure perfect fit at operating temperatures.

8. Alloy Cast Iron Cylinder Block: Follows proven design and material specification to achieve maximum durability.

9. Large Volume Water Passages: Give even flow of coolant around cylinder liners, valves, and injectors to draw excess heat from *combustion chamber. Centrifugal pump circulates large volumes of* water.

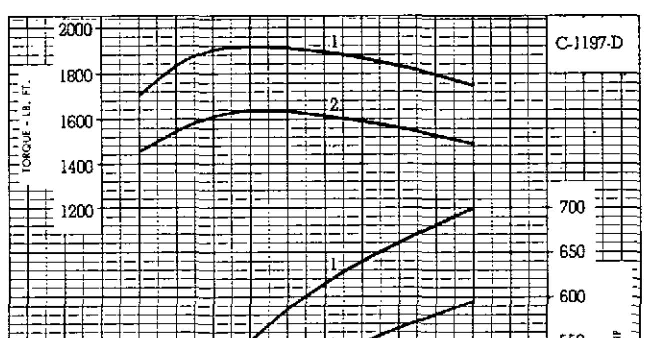
10. Connecting Rods: Forged from high tensile strength alloy steel. I-beam section gives maximum strength. Large diameter piston pins are full-floating. Tapered piston pin end used for superior load distribution and maximum piston crown material.

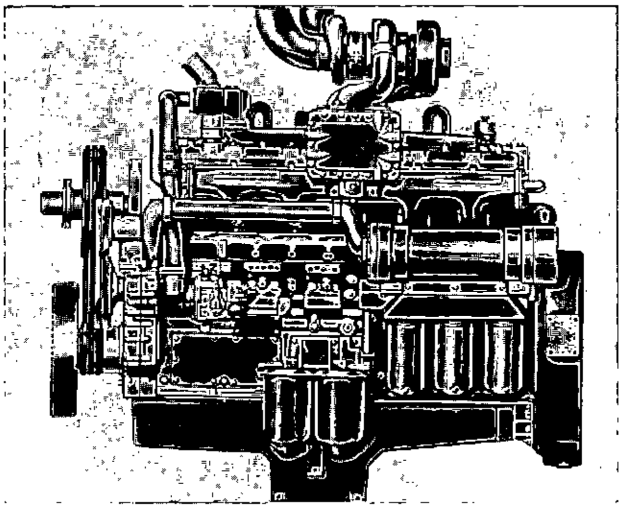
11. Counterweighted Crankshafts: Precision machined from high tensile strength steel forgings. Bearing journals are induction hardened for long life.

Performance

Horsepower, torque, and fuel consumption shown on Curve No. 1 represent performance obtained from seal level to 8,500 feet altitude. Curves represent performance of the engine with fuel system, water pump, lubricating oil pump, and air cleaner. Battery charging generator, compressor, fan, and optional equipment are not included in these ratings. Equivalent results can be obtained with fuels ranging from heavy furnace oils to light jet and military type fuels without recalibration.

Curve No. 2 is a suggested rating for intermittent applications in which periods of operation at full load are followed by equal periods of operation at partial load or shut-down.





Specifications

Horsepower	800
Governed RPM	2100
Number of Cylinders	12
Bore and Stroke	5½" x 6"
Piston Displacement—cu. in.	1710
Operating Cycles	4
Crankcase Oil Capacity—gals.	18
Engine Coolant Capacity—gals.	21
Net Weight with Standard Accessories (lbs.)	5800

Design Features

1. Internal Fuel Lines: Drilled passages in cylinder heads eliminate threaded fuel line connectors and external lines.

2. Large Intake and Exhaust Passages: Minimize restriction of air and exhaust flow. Allows maximum air charge for clean burning, top economy.

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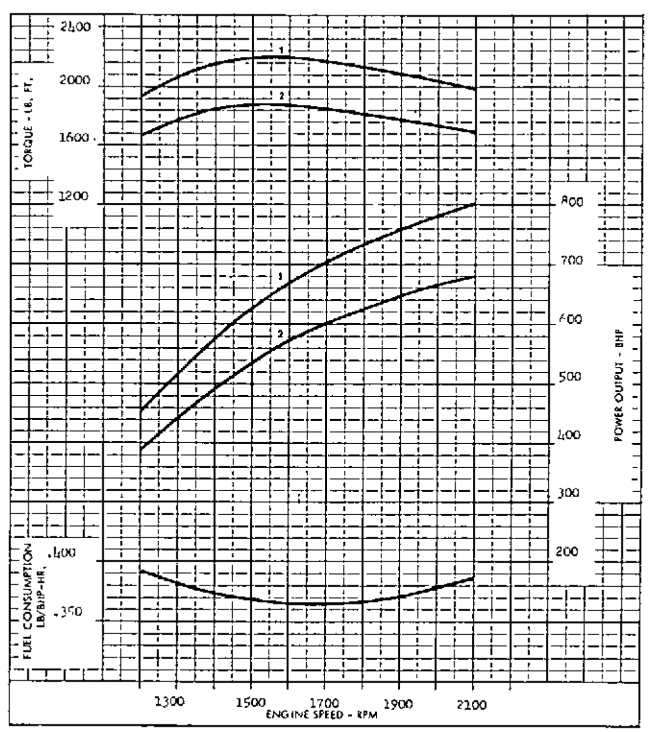
11. Counterweighted Crankshaft: Precision machined from high tensile strength steel forgings. Bearing journals are induction hardened for long life.

Performance

Horsepower, torque, and fuel consumption shown on Curve No. 1 represent performance obtained from sea level to 7,500 feet altitude. Curves represent performance of the engine with fuel system, water pump, lubricating oil pump, and air cleaner. Battery charging generator, compressor, fan, and optional equipment are not included in these ratings. Equivalent results can be obtained with fuels ranging from heavy furnace oils to light jet and military type fuels without recalibration.

Curve No. 2 is a suggested rating for intermittent applications in which periods of operation at full load are followed by equal periods of operation at partial load or shut-down.



Operating Principles

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

Cummins Diesel Engine

Cummins Diesel Cycle

Diesel engines differ from other internal combustion engines in a number of ways. Compression ratios are higher than in spark-ignited engines. The charge taken into the combustion chamber through the intake consists of air only – with no fuel mixture. Injectors receive low pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time in equal quantities and proper condition to burn. Ignition of fuel is caused by the heat of the compressed air in the combustion chamber.

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

Intake Stroke

During the intake stroke, the piston travels downward, the intake valve is open, and the exhaust valve is closed. 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 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 to a point high enough for ignition of fuel.

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

Almost immediately after the fuel charge is injected into the combustion chamber, the fuel is ignited by the hot compressed air and starts to burn.

Power Stroke

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

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

Exhaust Stroke

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

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

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

Fuel System

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

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

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

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

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

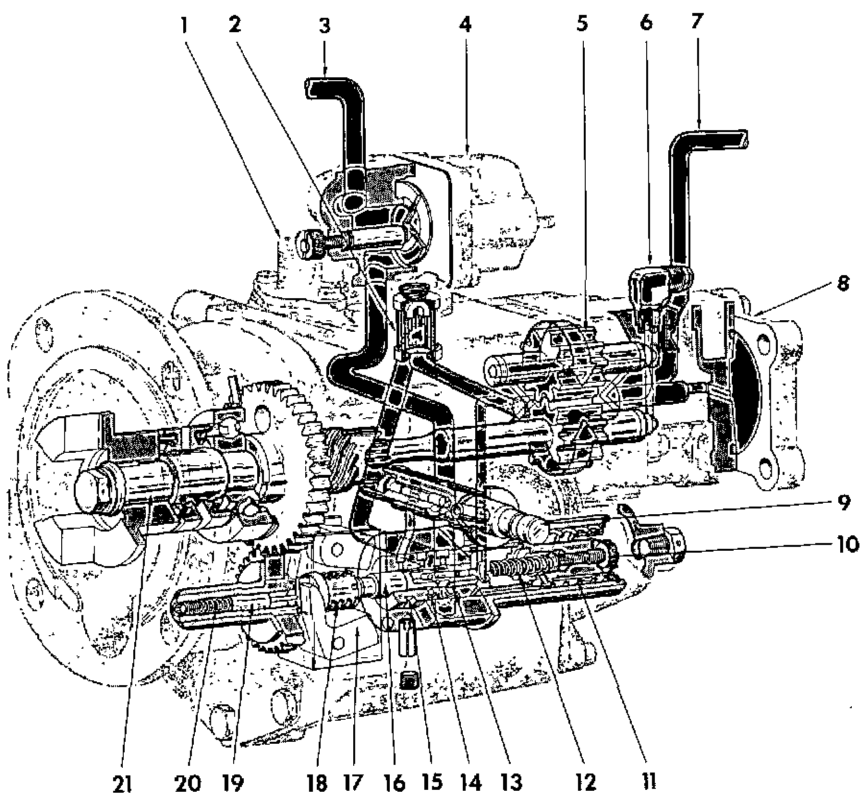
4. Injectors to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantities and proper condition to burn.

The PT fuel system consists of the fuel pump, supply and drain lines and passages, and 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.

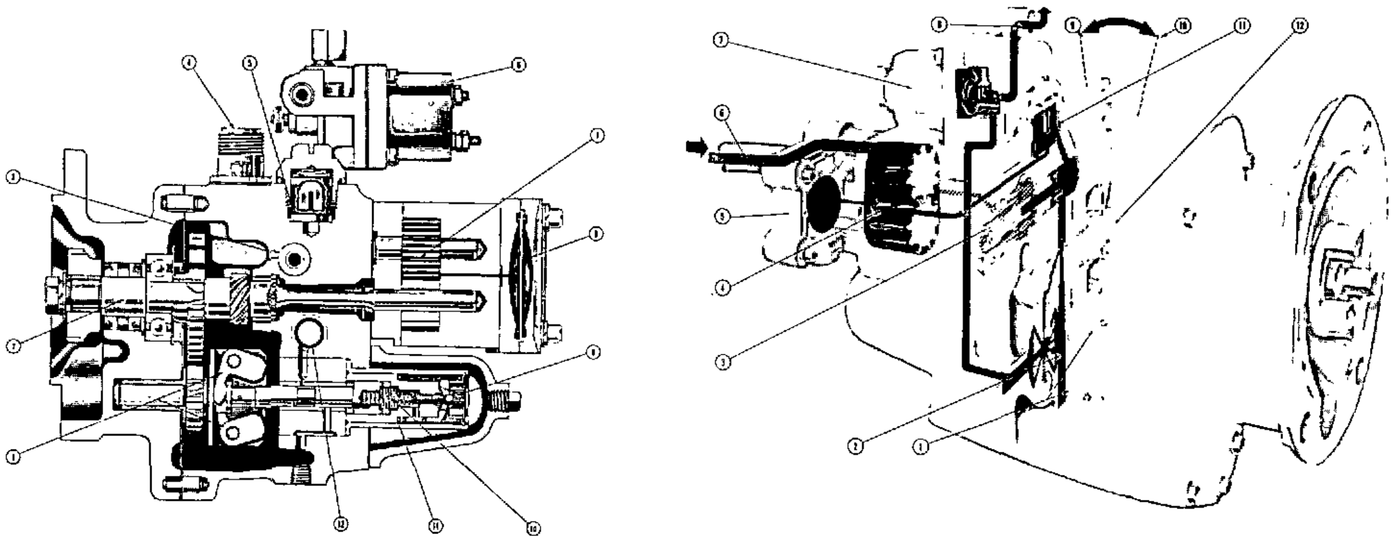
Fuel Pump

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



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

Fig. 1-1, FWC31. PT (type G) fuel pump and fuel flow



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

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

Fig. 1-2, FWC4. PT (type R) fuel pump and fuel flow

drives the gear pump, governor and tachometer shaft.

PT (type G) Fuel Pump

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

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

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

3. The throttle, which provides a manual control of fuel flow to the injectors under all conditions in the operating range. The location of fuel pump components is indicated Figs. 1-2 and 1-3.

PT (type R) Fuel Pump

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

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

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

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

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

Gear Pump And Pulsation Damper

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

The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smoothes fuel flow through the fuel system. From the gear pump, fuel flows through the filter screen and:

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

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

Pressure Regulator

Used in the PT (type R) fuel pump; functions as a by-pass valve to regulate fuel pressure to the injectors. By-passed fuel flows back to the suction side of the gear pump. See Fig. 1-2.

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.

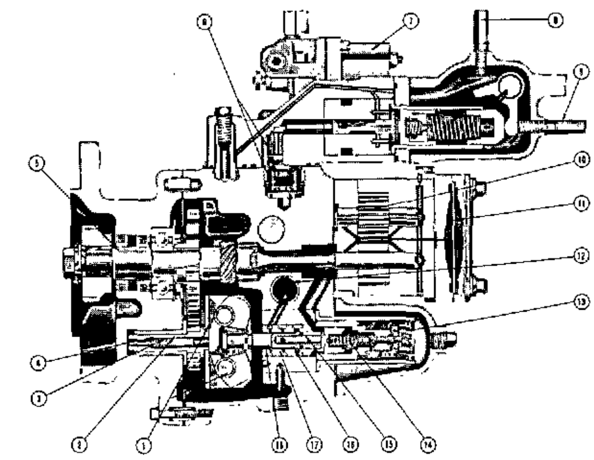
In the PT (type G) fuel pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the shaft.

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

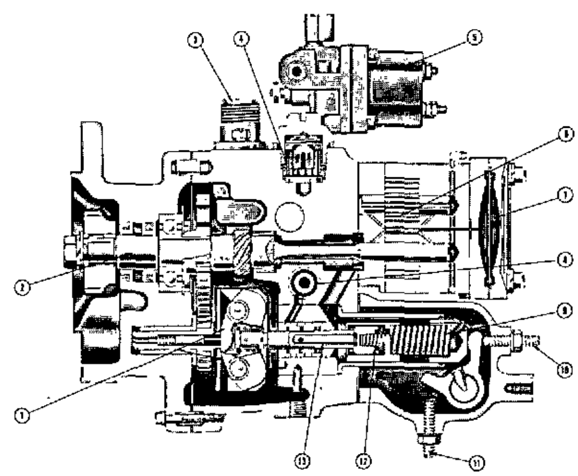
Idling and High-Speed Mechanical Governor: The mechanical governor, sometimes called "automotive governor", on both PT (type G) and PT (type R) fuel pumps, is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle 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. This fuel is controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT (type G) fuel pumps and pressure regulator of PT (type R) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shut-down valve, inlet supply lines and on into the injectors.



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

Fig. 1-3, FWC9. PT (type G) fuel pump with MVS governor



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

Fig. 1-4, FWC10. PT (type G) fuel pump with SVS governor

PT (type G) Variable-Speed Governors

There are two mechanical variable-speed governors used with the PT (type G) fuel pump. The "Mechanical Variable-Speed (MVS)" governor which is mounted directly on top the fuel pump or remotely near the fuel pump; and the "Special Variable-Speed (SVS)" governor which is a special spring pack assembly at the lower rear of the fuel pump. See Fig's. 1-3 and 1-4.

Mechanical Variable Speed (MVS) Governor

This governor supplements standard automotive governor to meet the requirements of machinery on which 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. 1-3.

As a variable-speed governor, this unit is suited to varying speed requirements of cranes, shovels, etc., in which same engine is used for propelling 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 fuel pump, and fuel solenoid is mounted to governor housing. See Fig. 1-3. The governor also may be remote mounted.

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

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

Special-Variable Speed (SVS) Governor

The SVS governor provides many of the same operational features of MVS governor, but is limited in application. An overspeed stop should be used with SVS governors in unattended applications; in attended installations, a positive shutdown throttle arrangement should be used if no other overspeed stop is used.

Marine applications require automotive throttle of fuel pump to be locked open during operation and engine speed control is maintained through 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 SVS governor lever to change governed speed of engine from full-rated speed to an intermediate power take-off speed. During operation as an automotive unit, SVS governor is in high-speed position. See operation instructions for further information.

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

PT (type R) Mechanical Variable-Speed Governor

On some applications this governor replaces standard automotive governor to meet requirements of machinery on which 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 varying speed requirements of cranes, shovels, etc., in which same engine is used for propelling 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.

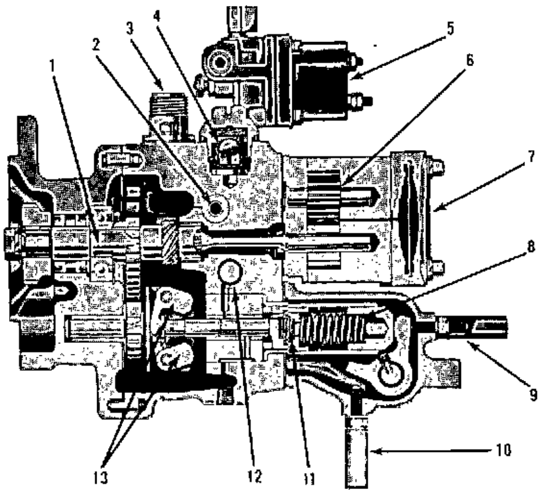
PT (type R) Torque Converter Governor

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 by torque converter output shaft to exercise control over engine governor and to limit converter output shaft speed. The engine governor and 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 engine and the other by converter. Fig. 1-6.

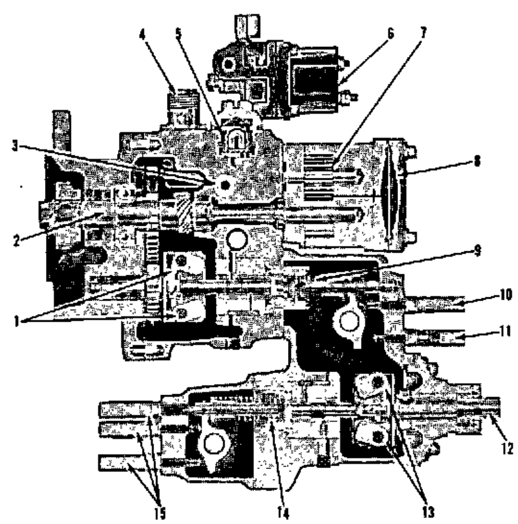
The engine governor, in addition to giving a variable engine speed, acts as an over-speed and idle-speed governor while the converter driven governor is controlling the engine. Each governor has its own control lever and speed adjusting screws.

The converter-driven governor works on same principle as standard engine governor except it cannot cut off fuel to



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

Fig. 1-5, FWC7. PT (type R) fuel pump with MVS governor



1 GOVERNOR WEIGHTS
2 MAIN SHAFT
3 PRESSURE REGULATOR
4 TACHOMETER CONNECTION
5 FILTER SCREEN
6 SHUT-DOWN VALVE
7 GEAR PUMP
8 PULSATION DAMPER
9 ENGINE PRIMARY GOVERNOR SPRING
10 ENGINE IDLE SPEED SCREW
11 ENGINE MAXIMUM SPEED SCREW
12 AUXILIARY UNIT DRIVE CABLE CONNECTION
13 AUXILIARY GOVERNOR WEIGHTS
14 AUXILIARY GOVERNOR SPRING
15 AUXILIARY GOVERNOR SPEED-ADJUSTING SCREWS

Fig. 1-6, FWC8. PT (type R) fuel pump with torque converter governor

idle jet in engine-driven governor. This insures that if converter tailshaft overspeeds, it will not stop 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 governor drive housing. For oil viscosity, see Page 3-2.

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

In order that its operation may be stable, speed droop is introduced into 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 a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower pilot valve plunger. This will admit oil pressure underneath power piston, which will rise. The movement of power piston is transmitted to terminal shaft by terminal lever. Rotation of terminal shaft causes fuel setting of engine to be increased. Fig's. 1-7 and 1-8.

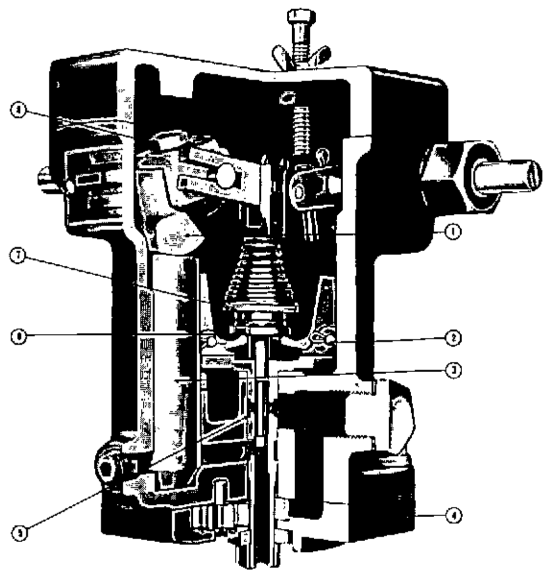
Injectors

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, PT (type B) or PT (type D), may be used in V1710 Series engines.

With cylindrical injectors, the fuel supply and drain is accomplished through internal drilled passages in the cylinder heads. Fig. 1-9. A radial groove around each injector mates with drilled passages in cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in injector body. A fine mesh screen at fuel inlet orifice of each injector provides final fuel filtration.

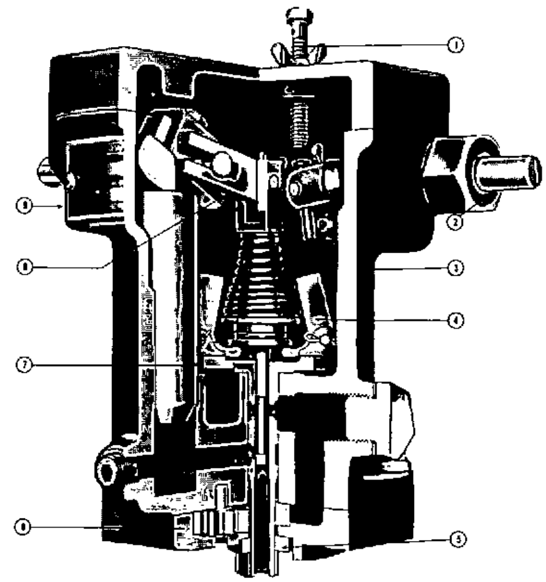
Fuel flows from a connection atop fuel pump shut-down valve through a supply line into lower drilled passage in cylinder head. A second drilling in head is aligned with upper injector radial groove to drain away excess fuel. A fuel drain at flywheel end of engine allows return of unused fuel to fuel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

Fuel grooves around injectors are separated by "O" rings which seal against cylinder head injector bore. Fig. 1-11. This forms a leak-proof passage between injectors and cylinder head injector bore surface.



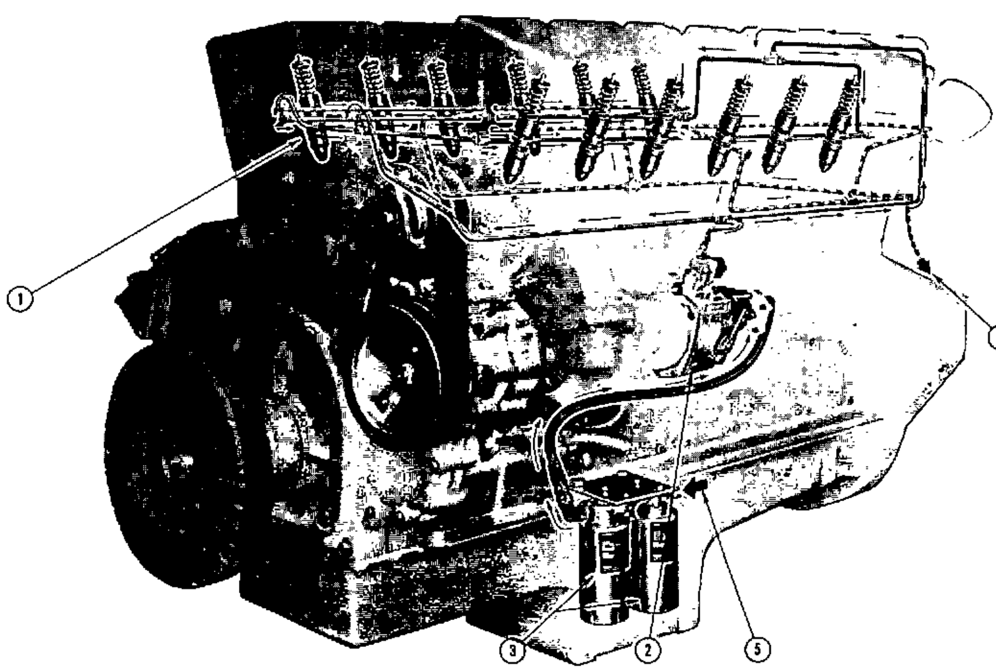
1. TERMINAL LEVER
2. BALLARM PIN
3. SERVO MOTOR PISTON
4. GOVERNOR BASE
5. PILOT VALVE PLUNGER
6. THRUST BEARING
7. SPRING SEAT
8. SPEED DROP ADJUSTING SCREW

Fig. 1-7, FWC1. Load off increased speed, hydraulic governor



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

Fig. 1-8, FWC1. Load on, decreased speed, hydraulic governor



1. INJECTOR
2. FUEL PUMP
3. FUEL FILTERS
4. TO SUPPLY TANK
5. FROM SUPPLY TANK

Fig. 1-9, FWC15A. Fuel flow schematic

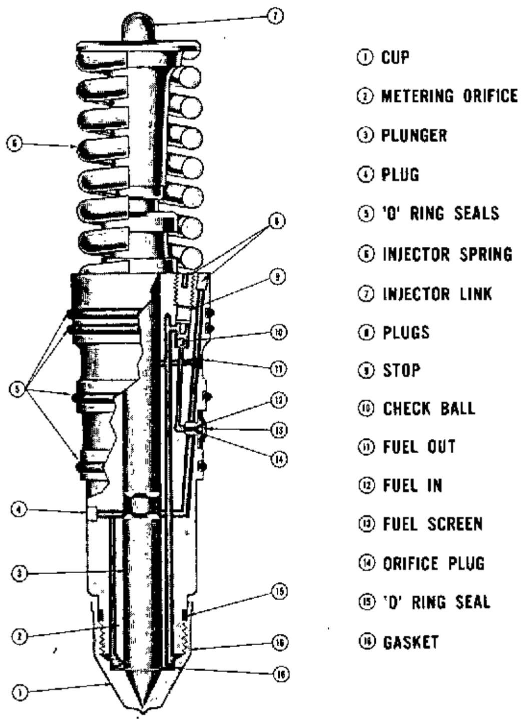


Fig. 1-10, FWC14. Cylindrical PT (type B) injector

Functions of the PT (type B) and PT (type D) injectors are identical; however, the PT (type D) design provides greater parts interchangeability and those areas subject to wear are localized in small parts for easier servicing. Engines with PT (type B) injectors can be changed to PT (type D) injectors by replacing the complete set.

The injector contains a ball check valve. As injector plunger moves downward to cover feed openings, an impulse pressure wave seats ball and at the same time traps a positive amount of fuel in injector cup for injection. As the injectors continuing downward plunger movement injects fuel into combustion chamber, it also uncovers drain opening and ball rises from its seat. This allows fuel flow through injector and drain for cooling purposes. Fig. 1-10.

Fuel Lines, Connections And Valves

Supply And Drain Lines

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

The PT (type R) fuel pump has a drain line returning from top of pump to supply tank. This line is not necessary with the PT (type G) pump. Fig. 1-9.

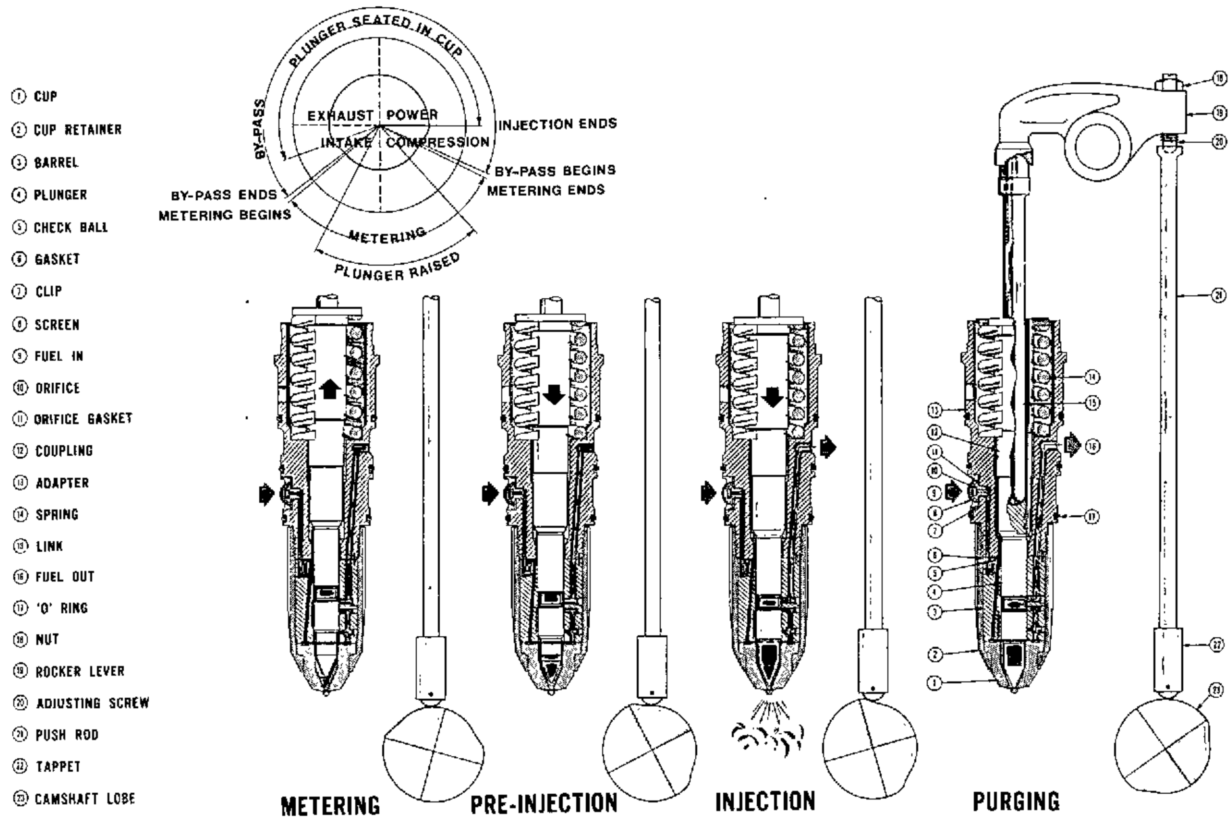


Fig. 1-11, FWC28. Fuel injection cycle – PT (type D) cylindrical injector

Shut-Down Valve

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

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

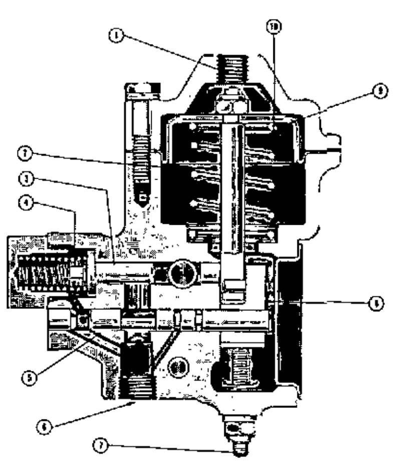
With electric valve, manual control knob must be fully counterclockwise to permit solenoid to open valve when "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through valve.

Aneroid

The aneroid control, Fig. 1-12 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 injectors when accelerating 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 powered by exhaust gas energy and is resultingly low at low engine speed and exhaust gas output.

When turbocharger speed rises to the point where air and fuel ratio support proper combustion, the aneorid becomes inactive allowing full flow of fuel as required by the engine operators throttle control.



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

Fig. 1-12, AWC-2. Aneroid Control

Lubricating System

Cummins V1710 Series engines are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump.

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

1. Oil is drawn into pump through an oil line to oil pan sump. A screen in sump strains the oil.

2. Internal lubricating oil flows from pump to cooler to full-flow filters mounted on side of engine, then to oil headers in block.

3. Oil headers, drilled full length of block on each side, deliver oil to moving parts within engine.

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

5. On engines equipped with oil-cooled pistons, oil headers are drilled the length of block on each side; headers supply oil to spray nozzles, which direct oil to piston skirts.

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

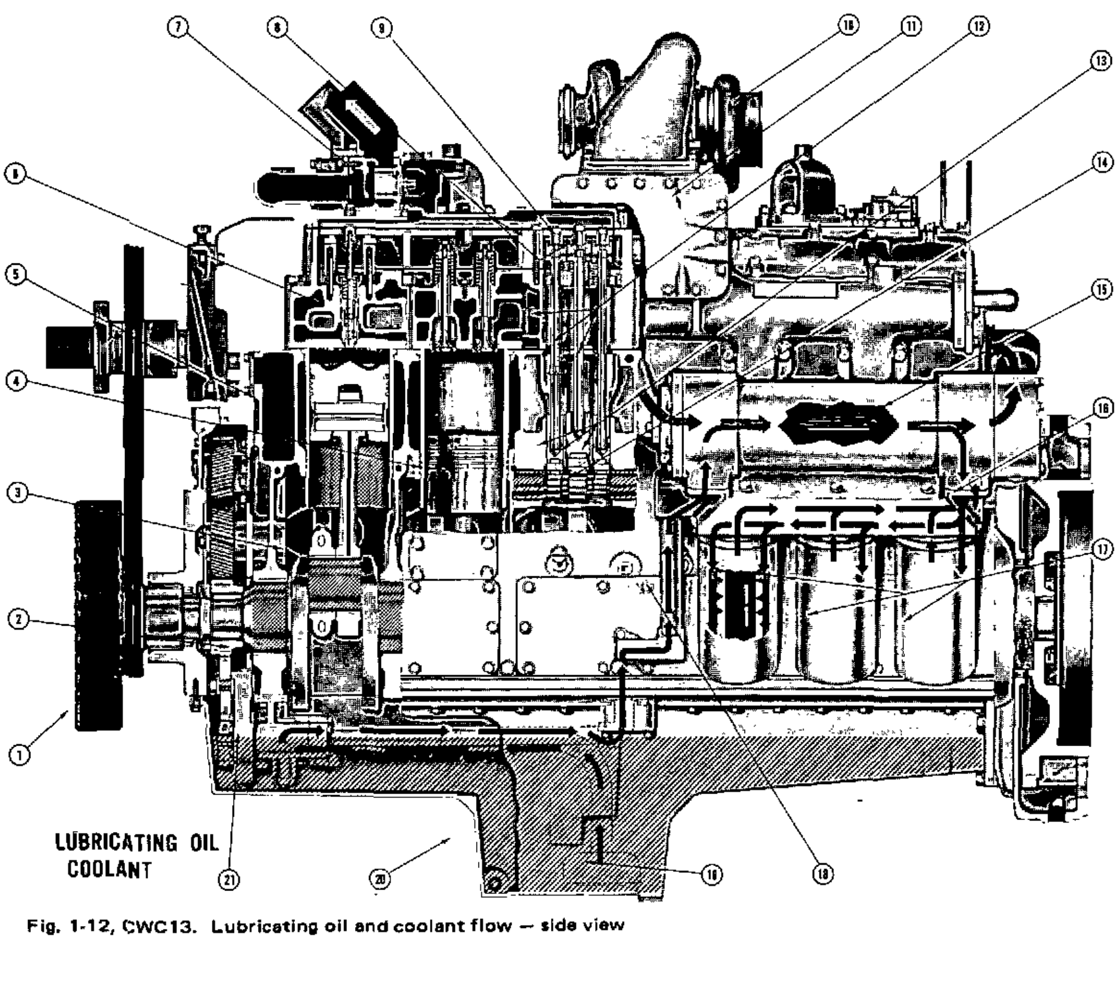


Fig. 1-12, CWC13. Lubricating oil and coolant flow – side view

Cooling System

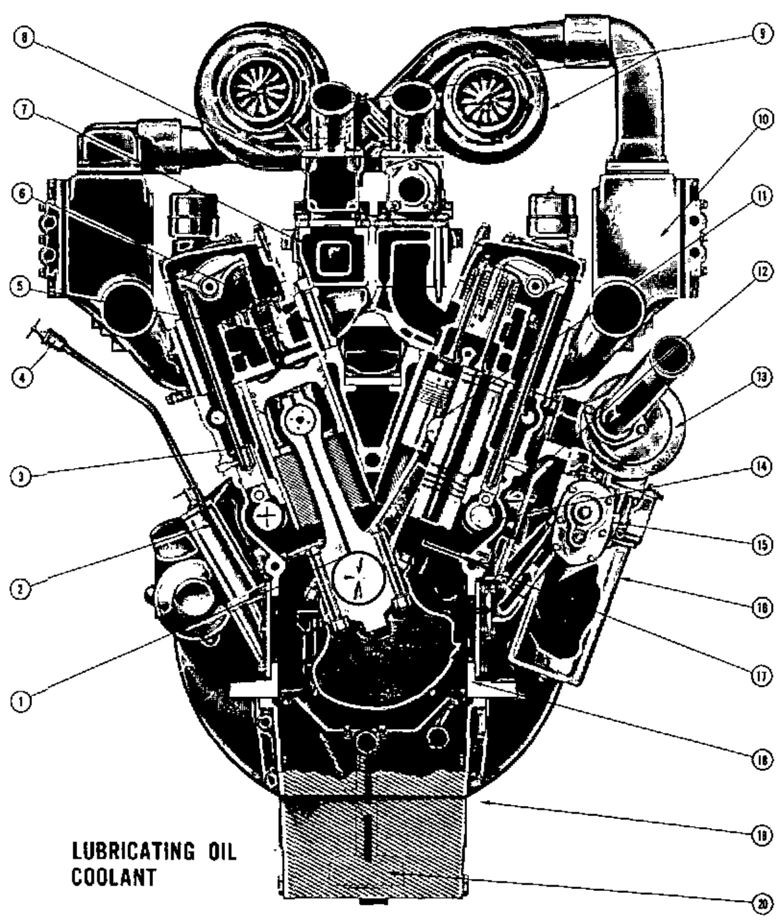
Coolant is circulated by a centrifugal-type water pump mounted at the front of the engine and driven by belts from the accessory drive.

Coolant is drawn from the radiator or heat exchanger by the water pump and circulated as follows:

Coolant flows from water pump to oil cooler to water header, through block and cylinder heads and exhaust manifolds or water manifold. From return header (exhaust or water manifold) coolant goes to thermostat housing where it is directed to radiator for cooling, or, if it has not been heated sufficiently to actuate thermostats, it is directed through a by-pass tube to the water pump for recirculation.

Note: Heat exchangers, marine type (oil coolers and coolant section in one unit), coolant flow in both sections is cooled by sea water circulated by the sea water pump.

The engine coolant is cooled by a radiator or by heat exchangers, depending on type of installation. An oil cooler is always used on V1710 engines.



1. CONNECTING ROD
2. OIL FILLER
3. PUSH TUBE
4. OIL DIPSTICK
5. INJECTOR
6. COOLANT PASSAGE
7. EXHAUST MANIFOLD
8. THERMOSTAT HOUSING
9. T-50 TURBOCHARGER
10. INTER-COOLER/AIR INTAKE MANIFOLD
11. PISTON
12. TAPPET
13. OIL COOLER
14. CAMSHAFT
15. FUEL PUMP
16. FULL-FLOW OIL FILTER
17. PISTON-COOLING NOZZLE
18. OIL TO COOLER AND ENGINE
19. LUBRICATING OIL PAN
20. OIL SUCTION

Fig. 1-13, CWC12. Lubricating oil and coolant flow — end view

Air System

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

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

Turbocharger

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

The power to drive turbine wheel – which in turn drives the compressor – is obtained from energy of engine exhaust gases. Rotating speed of the turbine changes as the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig. 1-14, Fig. 1-15 and Fig. 1-16.

Air Compressor

The air compressor may be a Cummins Single-Cylinder Unit or a Cummins Two Cylinder Unit driven from the engine by integral crankshaft and accessory drive. Lubrication is

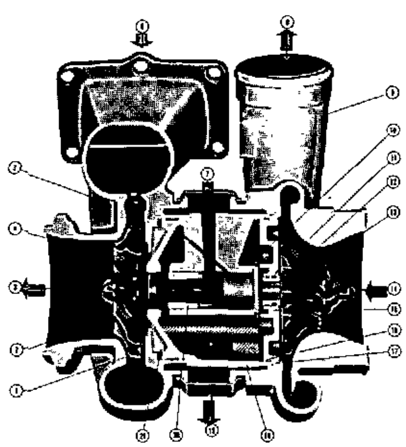


Fig. 1-14, AWC8. T-50 turbocharger cross-section

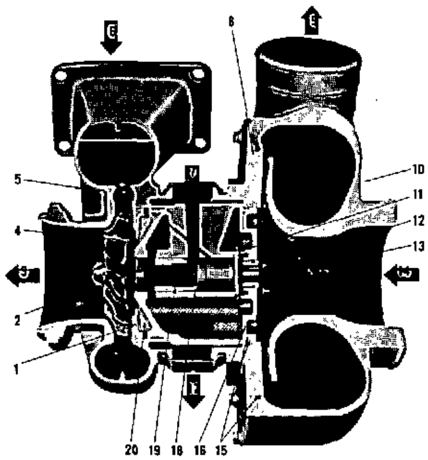


Fig. 1-15, AWC9. VT-50 turbocharger cross-section

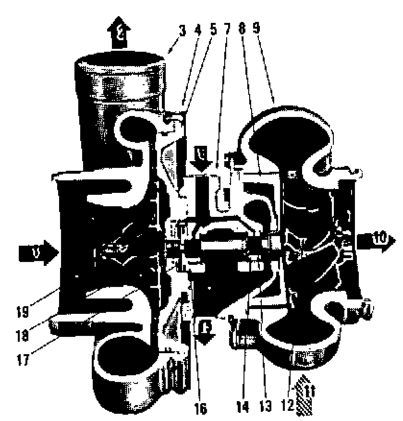


Fig. 1-16, TA1. T-18-A turbocharger cross-section

received from the engine lubrication system, with oil carried by internal drillings or external lines. The cylinder head is cooled by engine coolant. Operating functions are as follows:

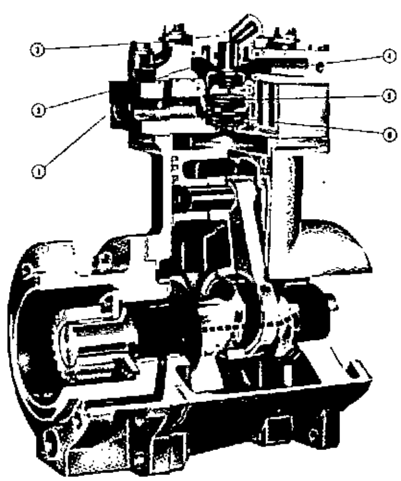
Air Intake

Air is drawn into the compressor from a separate filter or from the engine air system after air cleaner or silencers. As the piston moves down, a partial vacuum occurs above it.

The difference in cylinder pressure and atmospheric pressure forces the inlet valve down from its seat, allowing the air to flow through the intake port and into the cylinder. When the piston has reached the bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces the valve against its seat. Fig. 1-17 and Fig. 1-18.

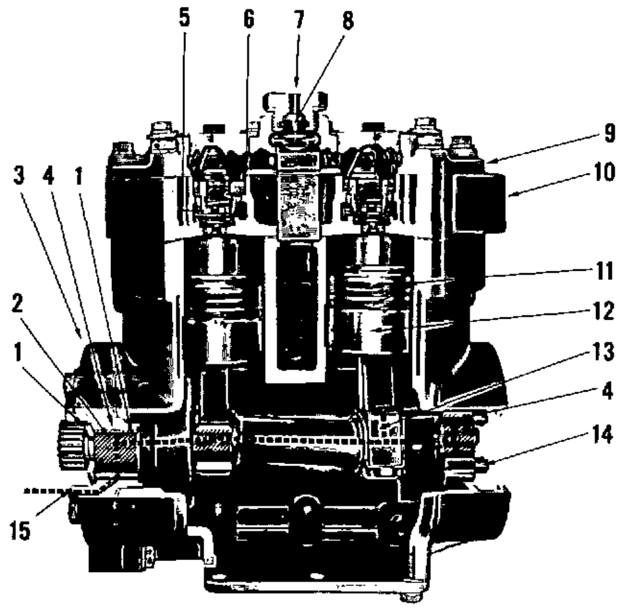
Compression

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



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

Fig. 1-17, AWC 10. Cummins air compressor



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

Fig. 1-18, AWC 11. Two cylinder air compressor

Unloading

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

Operating Instructions

The engine operator assumes responsibilty 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 the down time and costly repair bills resulting from premature engine failure.

General—All Applications

New Engine Break-In

Cummins engines are run-in on dynamometers before being shipped from factory and are ready to be put to work in applications such as emergency generator sets, fire pump engines and turbine-starting engines. In other applications, engine can be put to work, but the operator has an opportunity to establish conditions for optimum service life during the initial 100 hours of service by:

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

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

3. Developing the habit of watching the engine instruments closely during operation and letting up on the throttle if the oil temperature reaches 250 deg F [121.1 deg C] or the coolant temperature exceeds 190 deg F [87.8 deg C].

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

Pre-Starting Instructions — First Time

Priming Fuel System

1. Prime the fuel pump before starting the engine for the first time. Remove the plug next to the tachometer drive — PT (type G) pump — and fill with clean fuel oil meeting the specifications outlined in Section 3. On all PT fuel pumps, fill the gear pump through suction fitting with clean lubricating oil to aid in faster pick-up of the fuel. If the fuel filter is "dry", fill with clean fuel oil before starting the engine.

Caution: Clean areas of any fuel oil spilled while priming fuel pump to reduce fire hazard.

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

Caution: Do not service or fuel vehicle near an open flame or with electrical pre-heater devices in operation.

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

Priming Lubricating System

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

1. Fill the crankcase to "L" (low) mark on the dipstick.

Note: Most dipsticks have dual marking(s), with high- and low-level marks; static oil marks on one side, engine running at low idle speed marks on opposite side. Be sure to use proper scale. Fig. 2-1.

2. Remove the pipe plug from the lubricating oil filter head for paper element filters.

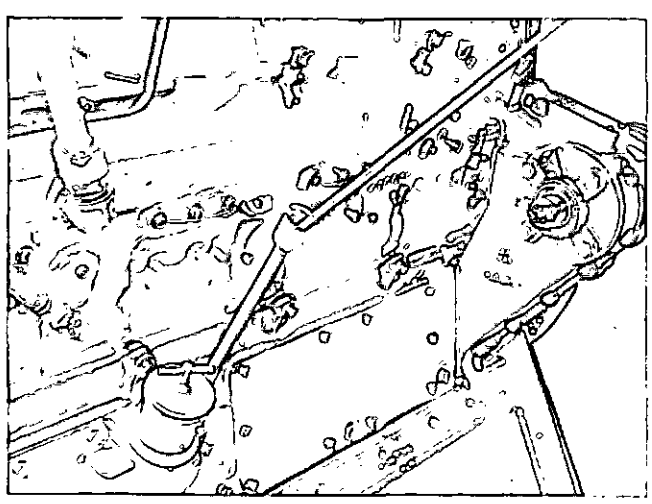


Fig. 2-1, V41928. Checking engine oil level

Caution: Pressurize at this plug only to prevent rupturing element.

3. Connect a hand- or motor-driven priming pump line from source of clean lubricating oil (See Page 3-2.) to oil plug boss.

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

5. Crank the engine for at least 15 seconds while maintaining external oil pressure at minimum of 15 psi [1.0545 kg/sq cm].

6. Remove external oil supply and replace the plug in oil filter head.

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

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

Caution: After the engine has run a few minutes, it will be necessary to add lubricating oil to compensate for that absorbed by the filter element(s) and the oil cooler. Never operate the engine with oil level below low-level mark, or above high-level mark.

Check Hydraulic Governor

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

Normal-Daily Checks

Check Oil Level

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

Note: Most dipsticks have dual markings, with high- and low-level marks; static marks on one side, engine running at low idle speed marks on opposite side. Be sure to use proper scale.

2. Keep oil level as near high mark as possible.

Check Air Connections

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

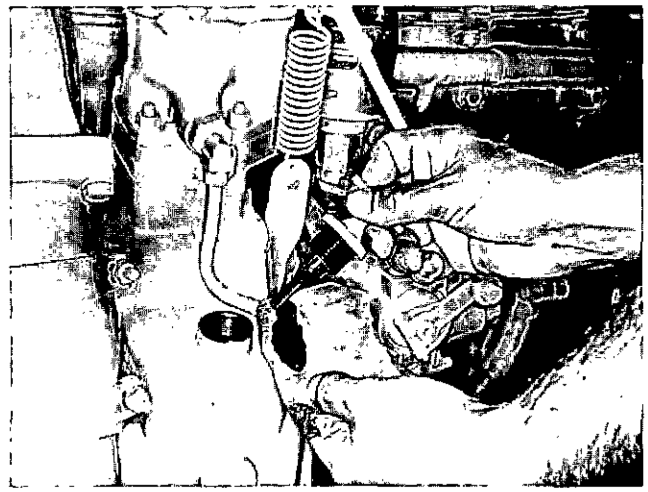


Fig. 2-2, V41802. Checking hydraulic governor oil level

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 system.

Note: If cooling capacity is over 36 gal. [136.260 lit] add treated make-up water described in Section 3.

2. Make visual check for leaks.

3. There are several recognized methods of protecting the engine cooling systems from rust and corrosion. These methods are described in Section 3.

Check Fuel Supply And Connnections

1. Fill fuel tanks with fuel meeting specifications in Section 3.

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

3. On engines with internal fuel passages in head, check fuel supply line at front and rear of engine.

Starting The Engine

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

Normal Starting Procedure

Prelube Engine

If the fuel sytem is equipped with overspeed stop, push

"Reset" button before attempting to start engine.

1. On units equipped with air activated prelube device, open the air valve for 10 to 12 seconds to activate the piston in prelube device which will lubricate all moving parts in the engine prior to engaging starter.

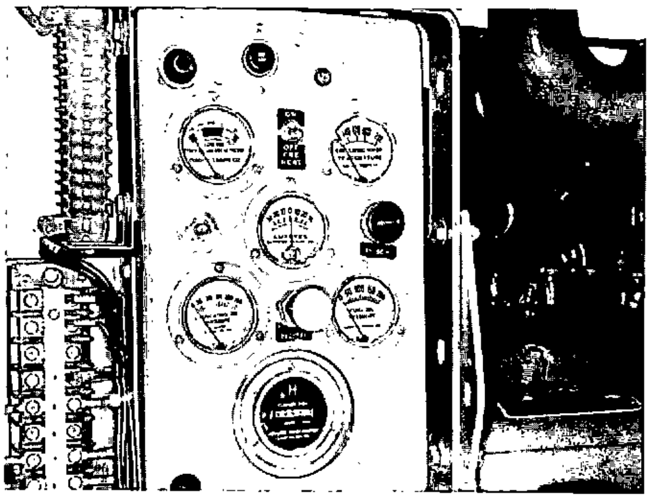


Fig. 2-3, V41929. Typical instrument panel

2. Set the throttle for idle speed.

3. Disengage driven unit or make sure the main disconnect switch is open.

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

5. Pull the compression release.

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

Note: A manual over-ride knob provided on 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.

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

7. After three or four seconds of cranking, close the compression release and continue to crank until the engine fires.

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

9. Release the lever quickly at instant engine starts. Make certain the lever returns to "off" position.

Use Preheater For Cold-Weather Starting

To aid in starting engine when temperature is 50 deg F [10 deg C] or below, an intake air preheater is availalbe. The preheater equipment consists of a hand-priming pump (1, Fig. 2-4) to pump fuel into the intake manifold (9), a glow plug (7) which is electrically heated by battery (3), and a switch (5) to turn on the glow plug. Fuel burns in the intake manifold and heats the intake air.

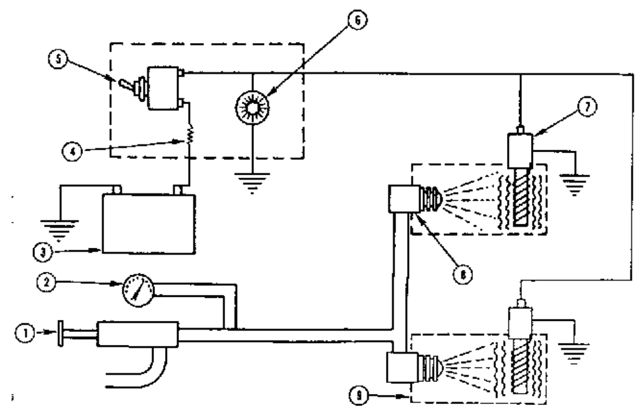


Fig. 2-4, V41803. Preheater wiring diagram

Caution: Do not use ether in conjunction with preheater.

To use preheater for cold starting:

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

2. Turn glow plug toggle switch to "ON" position. Red indicator light (6) must be on.

3. After red light has been on for 20 seconds, start cranking engine. As soon as engine begins rotating, operate preheater priming pump to maintain 80 to 100 psi [5.6240 to 7.0300 kg/sq cm] fuel pressure. Use of the primer before the 20-second interval will wet the glow plug and prevent heating.

Note: On engine equipped with an oil pressure safety switch, fuel by-pass switch must be in "start" position before operating priming pump. Hold the fuel by-pass switch in "start" position until the engine oil pressure reaches 7 to 10 psi [0.4921 to 0.7030 kg/sq cm]; then, move to "run" position.

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

Failure To Start

1. If engine gives no indication of starting during first three full strokes of preheater pump, touch-check the intake manifold for heat. If there is no heat, check the electric wiring. If the wiring is all right, remove 1/8" pipe plug (1) from manifold near glow plug and check the flame while a helper performs the preceding Steps 2, 3 and 4. Fig. 2-5.

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

Other Cold-Starting Aids

Use of Ether Without Metering Equipment

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

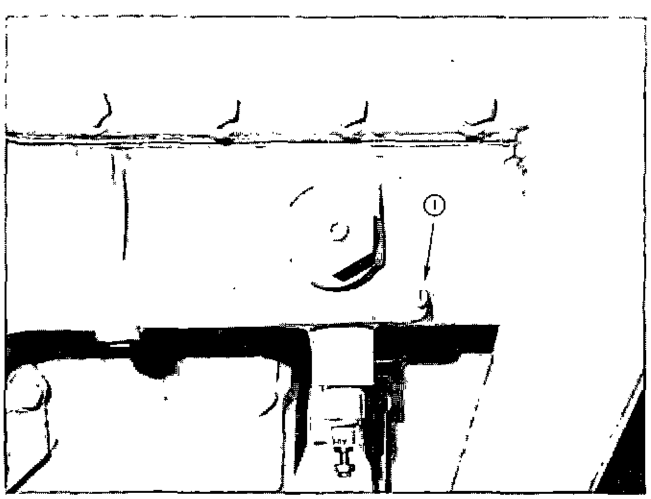


Fig. 2-5, V41818. Glow plug inspection hole

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 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.

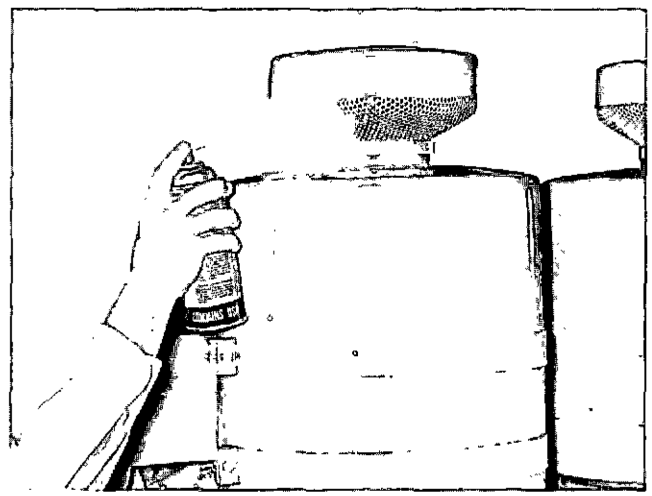


Fig. 2-6, V41805. Ether spray application

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

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

Caution: Do not store ether in vehicle cab or engine compartment.

Warm Up Engine Before Applying Load

When engine is started, it takes a while to get 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 the engine parts reach normal operating temperature.

Avoiding seizing the 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 perferably until water temperature reaches 140 deg F [60 deg C] before engaging the load. During the next 10 to 15 minutes, or until the water temperature reaches 160 to 165 deg F [71.1 to 73.9

deg C], operate at partial load at approximately 75% of govered rpm.

Note: Engines on emergency or stand-by service (generator sets, etc.) normally are located indoors and/or are equipped with some type oil or water heating device to maintain oil and coolant temperatures at a level high enough to permit full load to be applied immediately after start up.

Engine Speeds

It is necessary in some applications to reduce the engine horsepower and rpm due to load or climatic conditions under which the engine operates.

Operation of an engine at its maximum rating for prolonged periods will reduce engine life.

Operate At Reduced RPM For Continuous-Duty Or Cruising

When operating engine in continuous-duty situation and engine is rated at maximum horsepower and rpm such as powering a boat, or running continuous-operation generators, etc., maintain engine rpm at approximately 85 percent of rated rpm (approximately 1750 to 1800 rpm). This will give adequate power as well as economical fuel consumption.

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

Governed Speeds

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

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

Many engines, such as generator sets, are set at other values due to equipment being powered or loads applied to equipment and the engine.

Idle Speed

In most applications engine idle speed is adjusted at 520 to 570 rpm; however, parasitic loads may require a slightly higher value to eliminate rough idle.

Instrument Panels

Operate By The Instruments

It makes no difference whether an engine is 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 Tachometer

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

Never override governor, or allow engine to exceed governed rating during operation.

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

Oil Temperature Gauge Indicates Best Operating Range

The oil temperature gauge normally should read between 180 deg F [82.2 deg C] and 200 deg F [93.3 deg C] for best lubrication. Under the full-load conditions, a temperature of 225 deg F [107.2 deg C] for a short period is not to be considered cause for alarm.

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

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

Keep Water Temperature Between 165 Deg. [73.9 deg C] And 195 Deg. F [90.6 deg C]

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

Engine should be warmed up slowly before applying full load so pistons will not expand too fast for 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 the water temperatures to a minimum of 165 deg F [73.9 deg C]. If necessary, in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

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 maintenence department for correction; 200 deg F [93.3 deg C] 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 engine before the bearings are ruined.

Normal Operating Pressures are:

Idle (525 to 575 rpm) PSI [kg/sq cm]	Rated Speed (2100 rpm) PSI [kg/sq cm]

Note: Individual engines may vary from above normal pressures. Observe and record pressures when the engine is new to serve as a guide for indication of progressive engine condition.

Observe Engine Exhaust

Engine exhaust is a good indicator of the 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.

Increase Engine RPM When More Power Is Needed

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

Caution: Always operate so power requirements will allow engine to accelerate to, or maintain, governed rpm when operating under loaded condition.

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

High Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.8000 m] of altitude above sea level for a naturally aspirated engine. An engine will have a smoky exhaust at high altitude unless a lower power requirement is used so 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. See "Engine Ratings" for altitude ratings for V1710 engines.

Engine Shut-Down

Let 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 combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to high heat of combustion exhaust gases. While engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, turbocharger temperature may rise as much as 100 deg F [37.8 deg C]. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine For Excessively Long Periods

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

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

If engine is not being used, shut it down.

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

The engine can be shut down completely by turning off switch key on installations equipped with an electric shut-down valve, or by pulling the manual shut-down lever.

Turning off switch key which controls electric shut-down valve always stops 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 fully counterclockwise to stop engine. Refer to "Normal Starting Procedure," Page 2-2. Valve cannot be re-opened 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 could allow fuel to drain into cylinders causing hydraulic lock.

Do Not Use Compression Release Lever To Stop Engine

V1710 Series engines are equipped with a compression release lever. Pulling this lever lifts the intake valve push tubes and opens the valves. The push tubes are pulled from their sockets and extensive wear on balls and sockets will result from using compression release to stop engine.

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

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to operator before parts fail and ruin engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down engine. A delay of ten seconds after a bearing failure causes a knock and 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 engine indicates that something is wrong. It does not pay.

Cold-Weather Protection

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

2. To completely drain cylinder block and head, open petcock (1, Fig. 2-7) or remove drain plug on water pump, and both banks of cylinder block at the front and rear of engine. If an air compressor, oil cooler, heat exchanger or other "water-cooled" accessory is used, open petcock on unit. Failure to drain any of these units may cause serious damage in freezing weather.

3. Immersion-type water and oil heaters are available for engines used in cold-weather operations.

Operator's Daily Report

Make A Daily Report Of Engine Operation To Maintenance Department

The engine must be maintained in top mechanical condition if operator is to get most satisfaction from its use. Engine adjustments, etc., are the work of maintenance department. However, the maintenance department needs daily running reports from operator to make necessary adjustments in time allotted and to make provisions for more extensive maintenance work as reports indicate necessity.

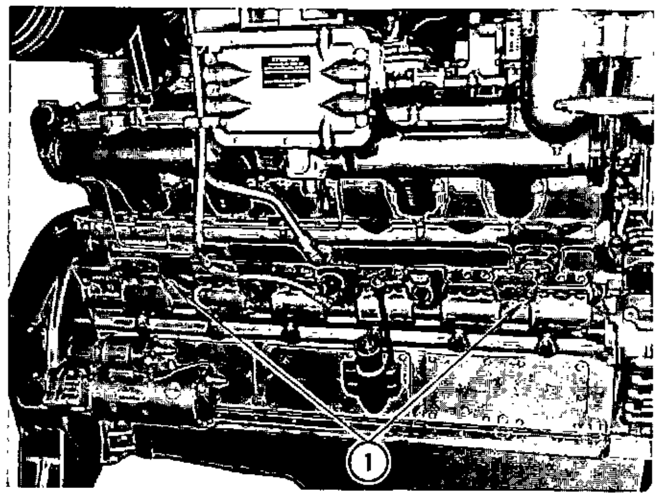


Fig. 2-7, V41930. Engine drain points

Comparison and intellignet interpretation of daily report along with a practical follow-up action will eliminate practically all operating failures and emergency repairs. Report to maintenance department any of following conditions:

1. Low lubricating oil pressure.

2. Low power.

3. Abnormal water or oil temperature.

4. Unusual engine noises.

5. Excessive smoke.

Vehicular Applications

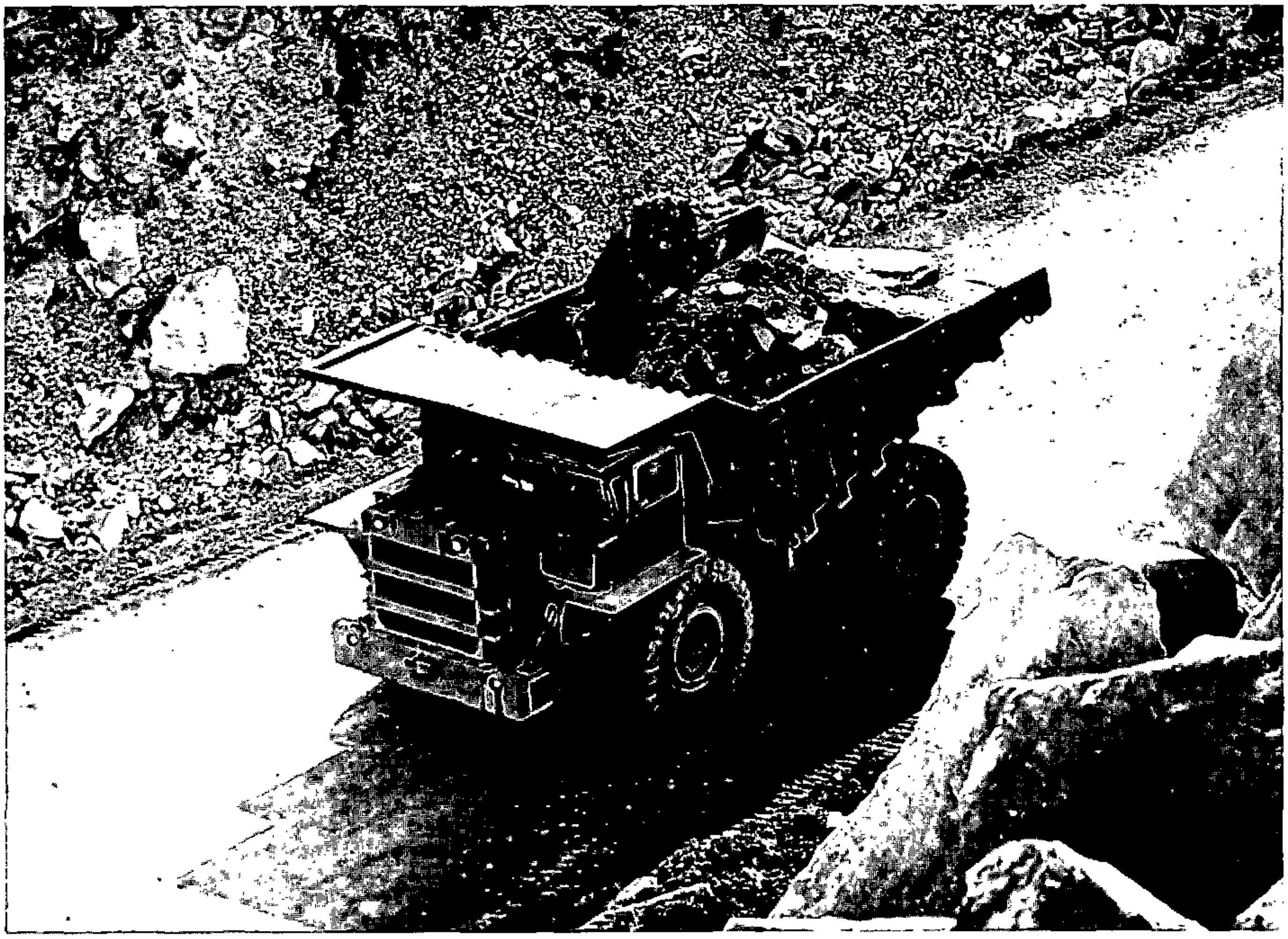


Fig. 2-8, V41807. Typical vehicular installation

Engine break-in, before starting and general operational procedures are as previously described. Additional information, as applied to vehicular applications only, is as follows:

Apply Load Gradually

Always engage load in a gear low enough to allow acceleration to governed rpm. The operator should become familiar with transmission and gear train used in vehicle *before placing unit into operation.* Many power train options are available due to variety of applications in which V1710 Series engines are used. Several of these power trains requires full throttle at all times, some require vehicle to come to a complete stop before shifting gears, and on some a gear split may be obtained while engine is decelerating. A power-shifted or mechanical-shifted transmission may be used with or without a single stage or three-stage torque converter, with or without a variable rear axle ratio, with or without a lockup feature in torque converter; or may have an electric power train which could have an electric motor in each driving wheel.

As noted, the operation of any one of the above combinations would differ greatly from any other combination, and should be driven accordingly. Do not skip gears.

Shock loads take their toll of tires and transmissions as well as being hard on engine. Apply load gradually.

Operate At Reduced RPM For Cruising

When operating a vehicle on level ground hold engine rpm at approximately 85 percent of governed rpm. This will give adequate power for cruising and economical fuel mileage. The engine will be operating in proper range and will not be working hard.

Use Tachometer

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

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

Shift To Lower Gear When Load Pulls Down Engine RPM

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

Do not pull down engine rpm more than 10 to 20 percent.

The practice of shifting gears, when used, - next to safety observance — is the most important phase of good engine operation.

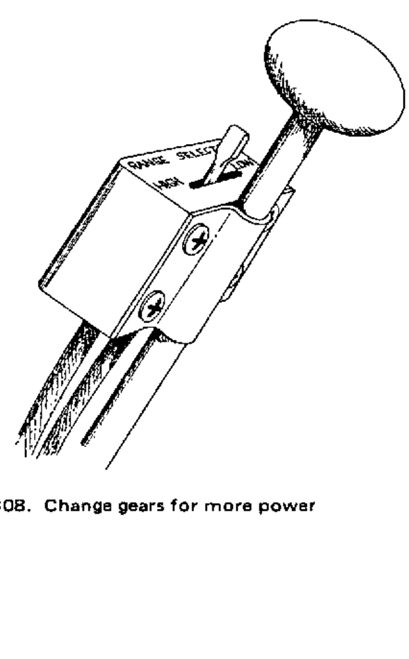


Fig. 2-9, V41808. Change gears for more power

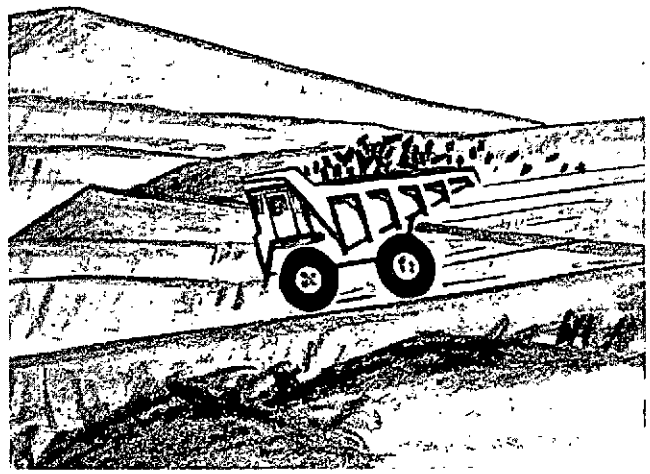


Fig. 2-10, V41809. Down-hill operation

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

Downhill Operation

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

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

Use Brake As Needed To Prevent Excessive Engine Speeds

Use a combination of brakes, gears and any other mechanism available on vehicle to keep it under control at all times, and to keep engine speed below rated governed rpm.

Generator Applications

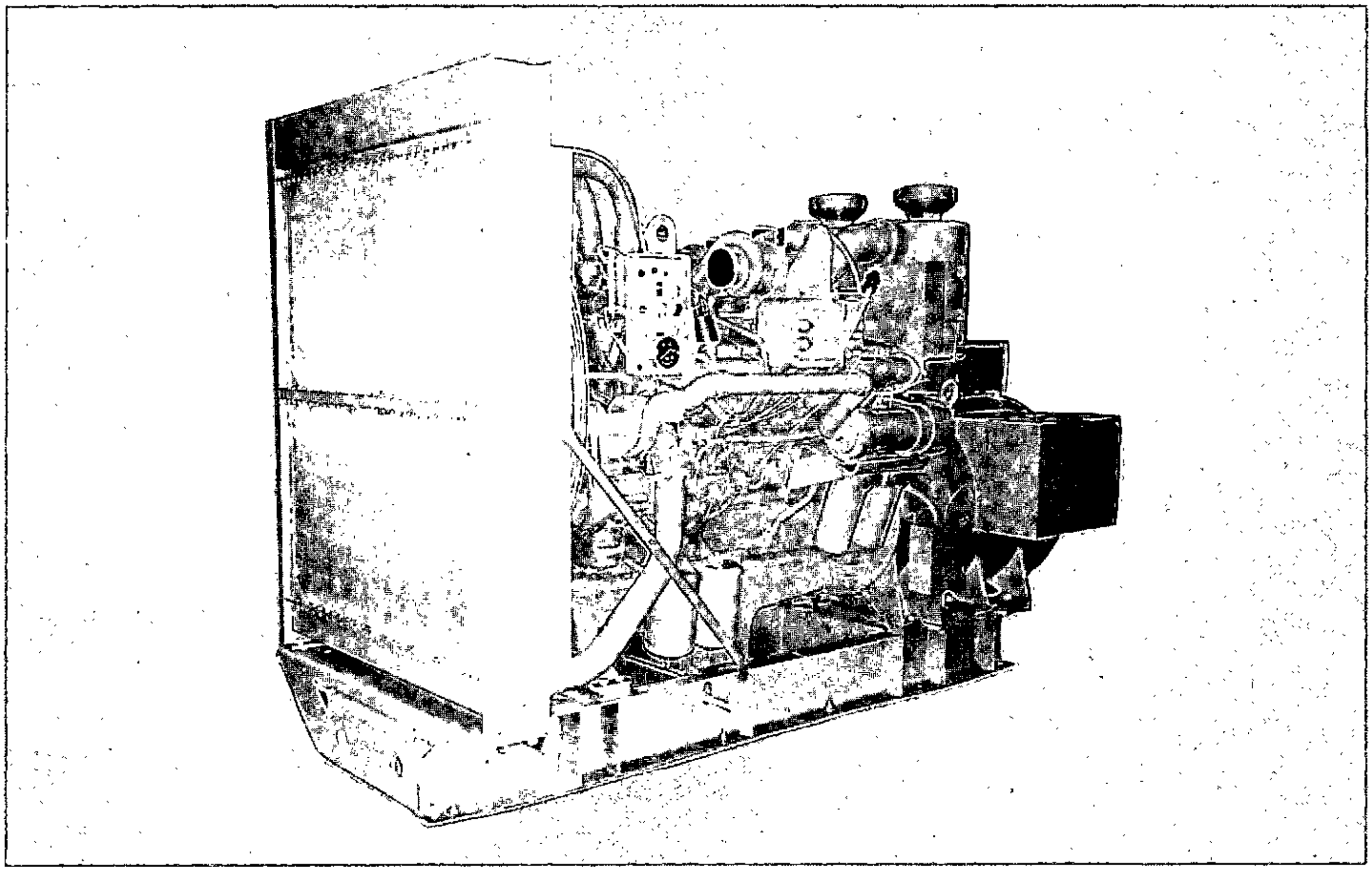


Fig. 2-11, Typical generator set

For general operating instructions of Generator Sets refer to Bulletin 983600-B or reprints there of.

Table 2-1: Standard Generator Set Application Specifications

Engine Model	50 Cycle				60 Cycle			
	Stand By		Prime Power		Stand By		Prime Power	
	KW	RPM	KW	RPM	KW	RPM	KW	RPM
V12-500	250	1500	210	1500	300	1800	250	1800
VT12R-600	300	1500	250	1500	350	1800	300	1800
VT12-700	335	1500	300	1500	400	1800	350	1800
VTA12-800	370	1500	330	1500	450	1800	400	1800

Marine Applications

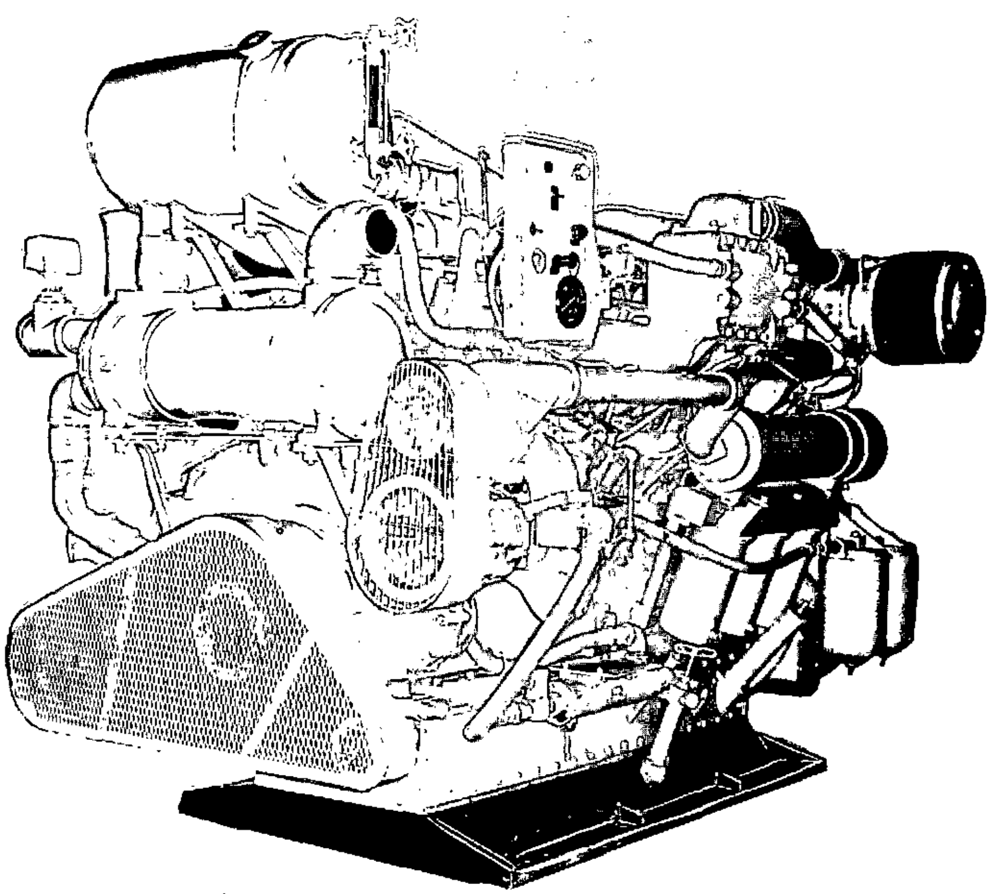


Fig. 2-12. Typical marine unit

For general operating instructions of Marine Units refer to Bulletin 983624-B or reprints there of.

Table 2-2: Cummins Marine Diesels

Engine	Pleasure Boat	Light Duty Commercial	Medium Duty Commercial	Heavy Duty Commercial
V12-500-M	500 @ 2100	425 @ 2100	400 @ 1800	370 @ 1800
VT12-635-M	635 @ 2100	540 @ 2100	490 @ 1800	435 @ 1800
VT12-700-M	700 @ 2100	595 @ 2100	545 @ 1800	480 @ 1800
VT12-800-M	800 @ 2100	680 @ 2100	620 @ 1800	550 @ 1800

Industrial Applications

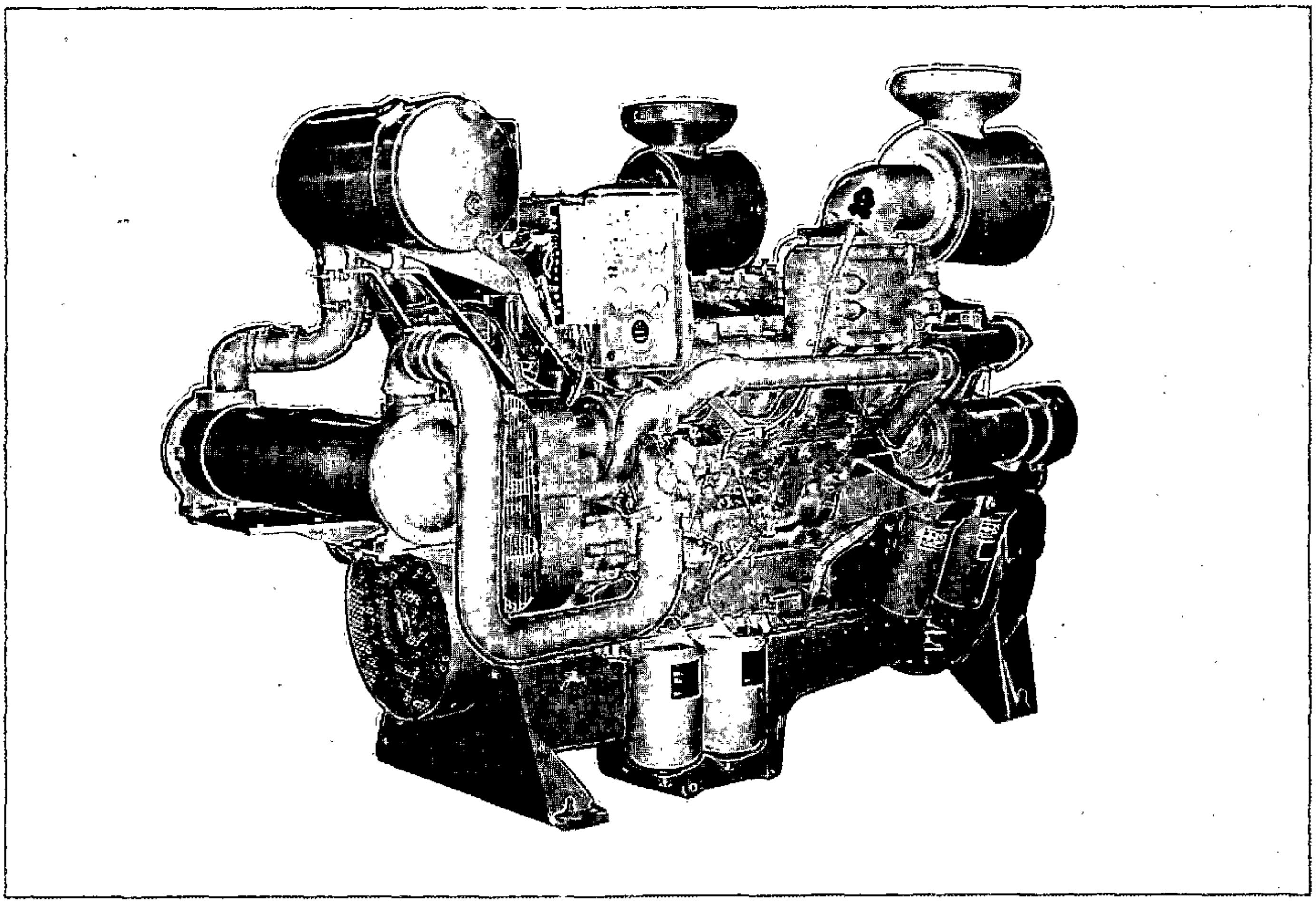


Fig. 2-13. Typical industrial unit

Engine break-in, prestarting checks and operation follow "General Operating Instructions" and include 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 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 deg F to 230 deg F [82.2 deg C to 110 C]. Temperature should not be allowed to exceed 250 deg F [121.1 deg C].

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

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

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

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

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.

Table 2-3: Industrial Power Unit Specifications

Model	Max. HP @ RPM	Cont. HP @ RPM
V1710-500	500 @ 2100	370 @ 1800
VT1710-635	635 @ 2100	435 @ 1800
VTA1710-800	800 @ 2100	550 @ 1800

Specifications and Torque

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

Lubricant,Fuel and Coolant

Lubricating Oil

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

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

Oil Performance Specifications

The majority of lubricating oils marketed in North America (and many oils marketed world-wide) are designed to meet oil performance specifications which have been established by the U.S. Department of Defense and the Automobile Manufacturers Association. A booklet entitled "Lubricating Oils for Heavy Duty Automotive and Industrial Engines" listing commercially available brand name lubricants and the performance classification for which they are designed, is available from Engine Manufacturing Association, 111 East Wacker Drive, Chicago, Illinois 60601.

Following are brief descriptions of the specifications most commonly used for commercial lubricating oils.

API classification CC is the current American Petroleum Institute classification for lubricating oils for heavy duty gasoline and diesel service. Lubricating oils meeting this specification and designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

Table 3-1: Oil Recommendations

Light Service Only (Stop-and-Go) All Diesel Models	Naturally Aspirated Diesel Models	Turbocharged Diesel Models	All Natural Gas Models All Service
API Class CC/SC [2/5] 1.85% Maximum Sulfated Ash Content[3]	API Class CC [1] 1.85% Maximum Sulfated Ash Content[3]	API Class CC/CD [2] 1.85% Maximum Sulfated Ash Content[3]	API Class CC .03 to .85% Sulfated Ash Content[4]

1 API classification CC and CD quality oils as used in turbocharged engines and API classification CC/SC quality oils as used for stop-and-go service are satisfactory for use in naturally aspirated engines.

2 API classification CC/SC and CC/CD indicate that the oil must be blended to the quality level required by both specifications. The range of oil quality permitted by the CC classification is so broad that some oils that meet the classification will not provide adequate protection (varnish and ring sticking) for engines operated in certain applications. For example, turbocharged engines require the additional protection provided by the CD classification. Engines operated in stop and go service require the additional protection provided by the SC classification.

3 A sulfated ash limit has been placed on all lubricating oils for Cummins engines because past experience has shown that high ash oils may produce harmful deposits on valves that can progress to guttering and valve burning.

4 Completely ashless oils or high ash content oils, are not recommended for use in gas engines; a range of ash content is specified.

5 SD or SE may be substituted for SC.

API classification CD is the current American Petroleum Institute classification for severe duty lubricating oils to be used in highly rated diesel engines operating with high loads. Lubricating oils which meet this specification have a high detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation.

API classification SC, SD and SE were established for the Automobile Manufacturers Association. They require a sequence of tests for approval. The primary advantage of lubricating oils in these categories is low temperature operation protection against sludge, rust, combustion chamber deposits and bearing corrosion. The test procedure for these specifications are published by the American Society for Testing and Materials as STP-315.

Break In Oils

Special "Break-In" lubricating oils are not recommended for new or rebuilt Cummins Engines. Use the same lubricating oil as will be used for the normal engine operation.

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 3-1. Multigraded oils are generally produced by adding viscosity index improver additives to a low viscosity base stock to retard thinning effects at operating temperatures. Poor quality multigraded oils use a viscosity index improver additive which has a tendency to lose its effectiveness after a short period of use in a high speed engine. These oils should be avoided.

2. Oils which meet the low temperature SAE viscocity standard (0 deg F [−18 deg C] carry a suffix "W". Oils that meet the high temperature viscosity SAE standard (210 deg F [99 deg C]) as well as the low temperature carry both viscosity ratings — example 20-20W. See Table 3-2.

Table 3-2: Operating Temperatures Vs Viscosity

Ambient Temperatures	Viscosity
−10 deg F. [−23 deg. C] and below	See Table 3-3.
−10 to 30 deg. F. [−23 to −1 deg. C]	10W
20 to 60 deg. F. [−7 to 16 deg. C]	20 - 20W
40 deg. F. [4 deg. C] and above	30

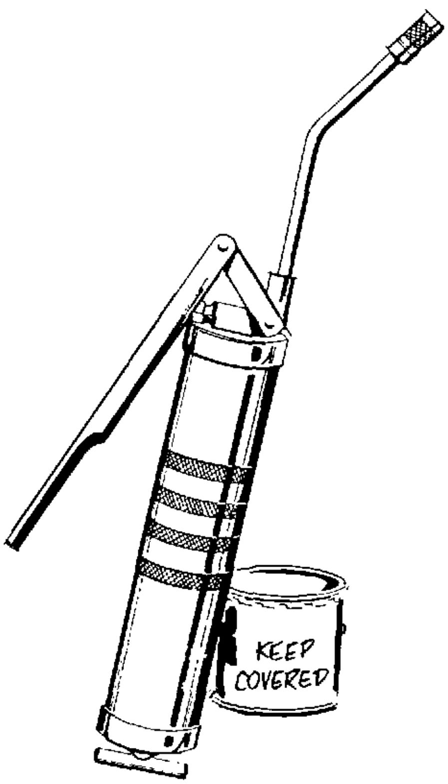
Arctic Operations

For operation in areas where the ambient temperature is consistently below −10 deg F [−23 deg C] and there is no provision for keeping engines warm during shutdowns, the lubricating oil should meet the requirements in Table 3-3.

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

Table 3-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC API class CC/CD
SAE Viscosity Grade	10W-20, 10W-30, 10W-40
Viscosity @—30 deg. F. (ASTM D-445)	10,000 Centistokes Maximum
Pour Point (ASTM D-97)	At least 10 deg. F. [6 deg. C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum



Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact lubricant supplier for grease meeting these specifications.

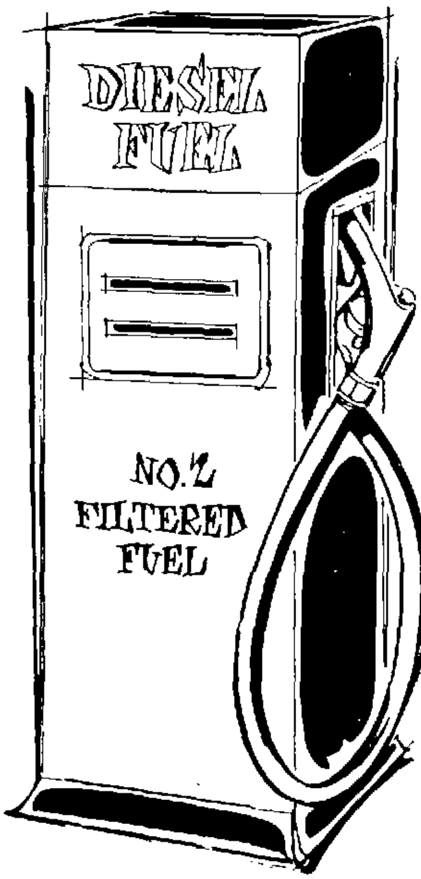
Test	Test Procedure	
High-Temperature Performance		
Dropping point, deg. F	ASTM D 2265	350 min.
Bearing life, hours at 300 deg. F. 10,000 rpm	*FTM 331	600 min.
Low-Temperature Properties		
Torque, GCM	ASTM D 1478	
Start at 0 deg. F		15,000 max.
Run at 0 deg. F.		5,000 max.
Rust Protection and Water Resistance		
Rust test	ASTM D 1743	Pass
Water resistance, %	ASTM D 1264	20 max.
Stability		
Oil separation, %		
30 Hours @ 212 deg. F.	*FTM 321	5 max.
Penetration		
Worked	ASTM D 217	250-300
Bomb Test, PSI Drop	ASTM D 942	
100 Hours		10 max.
500 Hours		25 max.
Copper, Corrosion	*FTM 5309	Pass
Dirt Count, Particles/cc	*FTM 3005	
25 Micron +		5,000 max.
75 Micron +		1,000 max.
125 Micron +		None
Rubber Swell	*FTM 3603	10 max.

*Federal Test Method Standard No. 791a.

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

Fuel Oil

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



Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	Centistokes 1.4 to 5.8 @ 100 deg. F. (30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125 deg. for legal temperature if higher than 125 deg. F.
Gravity (ASTM D-287)	30 to 42 deg. A.P.I. at 60 deg. F. (0.815 to 0.875 sp. gr.)
Pour Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122 deg. F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 675 deg. F. All of the fuel should evaporate at less than 725 deg. F.

Coolant

Water should be clean and free of any corrosive chemicals such as chloride, sulphates and acids. It should be kept slightly-alkaline with pH value in range of 8.0 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

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.

The engine must have chromate protection at all times. Use only the standard chromate element with clear water or compatible antifreezes.

Caution: Do not use the "PAF" or Borate element.

In Summer (No Antifreeze)

1. Use only corrosion resistor with chromate or chromate element. See Table 3-4.

Table 3-4: Corrosion Resistor Elements

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

2. Replace corrosion resistor or element as recommended in Section 5.

In Winter (Using Antifreeze)

1. Select an antifreeze known to be satisfactory for use with chromate corrosion resistor or element or:

2. If it is not known if the antifreeze is compatible with the chromate resistor or element:

a. Use only antifreeze, with compounded inhibitors, in proper percentage and follow antifreeze suppliers's recommendation to prevent corrosion. Check with nearest Cummins Distributor for list of compatible antifreezes.

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

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

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

Make-Up Coolant Specifications

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

Coolant must be maintained at the following minimum:

Chromate Concentration — NA_2CRO_4 — 3500 PPM

pH Value — 8 to 9.5

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

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

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

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

Dearborn Compound No. '530 (granular) or 517 (powder) from:
Dearborn Chemical Company
14230 Ridge Road
Plymouth, Michigan 48170

NALCO No. 38 (pellet) or 37 (powder) from:
National Aluminate Corp.
6216 West 66th Place
Chicago, Illinois 60607

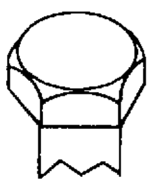
Note: Spin on or replaceable element type corrosion resistor must continue to be used with pre-treated water.

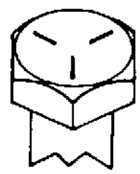
Capscrew Markings and Torque Values

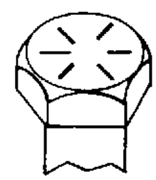
Usage	Much Used	Much Used	Used at Times	Used at Times
Capscrew Diameter and Minimum Tensile Strength psi	To 1/2 – 69,000 To 3/4 – 64,000 To 1 – 55,000	To 3/4 – 120,000 To 1 – 115,000	To 5/8 – 140,000 To 3/4 – 133,000	150,000
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6 or 7	8

Capscrew Head Markings

Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).







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

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

Trouble Shooting

Trouble shooting is an organized study of the problem and a planned method of precedure for investigation and correction of the difficulty. The chart of the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

Cummins Diesel Engines

The chart does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column until you come to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?

2. What previous repair and maintenance work has been done?

3. Has similar trouble occurred before?

4. If the engine still runs, is it safe to continue running it to make further checks?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first; following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

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

Find And Correct Basic Cause Of Trouble

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

Trouble Shooting

System	CAUSES / COMPLAINTS	Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubricating Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM	Restricted Air Intake	●			●	●			●																		
	High Exhaust Back Pressure				●	●			●										●								
	Thin Air in Hot Weather or High Alt.				●	●																					
	Air Leaks Between Cleaner and Engine																				●	●	●				
	Dirty Turbocharger Compressor				●	●			●																		
	Improper Use of Starter Aid/Air Temp.	●																						●			
FUEL SYSTEM	Out of Fuel or Fuel Shut-Off Closed	●										●															
	Poor Quality Fuel	●	●		●	●			●			●												●			
	Air Leaks in Suction Lines	●	●			●				●	●	●	●											●			
	Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●	●	●		●	●																	
	External or Internal Fuel Leaks					●			●			●				●	●										
	Plugged Injector Spray Holes	●	●	●	●	●			●																		
	Broken Fuel Pump Drive Shaft	●										●															
	Scored Gear Pump or Worn Gears	●				●																					
	Loose Injector Inlet or Drain Connection	●														●											
	Wrong Injector Cups			●	●	●			●							●											
	Cracked Injector Body or Cup			●	●				●							●											
	Mutilated Injector Cup "O" Ring								●							●											
	Throttle Linkage or Adjustment					●	●			●	●	●	●														
	Incorrectly Assembled Idle Springs									●	●	●															
	Governor Weights Assembled Incorrectly										●	●															
	High-Speed Governor Set Too Low					●	●																				
	Water in Fuel	●	●				●					●															
	Aneroid Check Valve Stuck Open				●	●																					
	Aneroid Set Improperly	●																									
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●											
	Dirty Oil Filter														●		●					●	●				
	Faulty Cylinder Oil Control			●	●									●		●											
	Clogged Oil Drillings																				●	●	●				
	Oil Suction Line Restriction																●				●	●	●				
	Faulty Oil Pressure Regulator																●										
	Crankcase Low or Out of Oil																●		●	●	●	●	●				
	Wrong Grade Oil for Weather Conditions													●			●										
	Oil Level Too High					●			●					●						●							
COOLING SYSTEM	Insufficient Coolant																●		●	●							
	Worn Water Pump																●		●	●							
	Faulty Thermostats														●		●	●	●	●							
	Damaged Water Hose																●		●	●							
	Loose Fan Belts																●		●	●							
	Radiator Shutters Stuck Open														●			●									
	Clogged Water Passages																●		●	●							
	Internal Water Leaks															●											
	Clogged Oil Cooler																●			●							
	Radiator Core Openings Dirty																●		●	●							
	Air in Cooling System																●		●	●							
	Exterior Water Leaks																●		●	●							
	Insufficient Coolant Capacity																●		●	●							
	Coolant Temperature Low														●	●								●			
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●						●	●	●				
	Long Idle Periods	●	●	●	●	●									●	●											
	Engine Overloaded				●				●								●		●	●	●	●	●	●	●		
	Oil Needs Changing														●						●	●	●				
	Engine Exterior Caked with Dirt																●		●	●							
MECHANICAL ADJUSTMENTS OR REPAIR	Gasket Blow-by or Leakage			●	●	●										●											
	Faulty Vibration Damper																								●		●
	Unbalanced or Loose Flywheel																								●		●
	Valve Leakage	●	●			●																	●				
	Broken or Worn Piston Rings	●	●	●	●	●								●							●				●		
	Incorrect Bearing Clearances					●			●								●					●			●	●	
	Excessive Crankshaft End Clearance																					●			●	●	
	Main Bearing Bore Out of Alignment																					●			●		●
	Engine Due for Overhaul	●		●	●	●			●					●			●				●	●	●		●	●	●
	Damaged Main or Rod Bearings																●					●			●		
	Broken Tooth in Gear Train																								●	●	
	Excessive Gear Back Lash																								●	●	
	Misalignment Engine to Driven Unit								●													●				●	●
	Loose Mounting Bolts																								●		●
	Incorrect Valve and Injection Timing	●		●	●	●																	●	●			
	Worn or Scored Liners or Pistons			●	●	●								●							●				●		
	Injectors Need Adjustment		●	●	●	●			●															●			

Maintenance Operations

Maintenance is the key to lower operating costs. Cummins Diesel Engines — like any other engine — requires regularly scheduled maintenance to keep them running efficiently. Most diesel engines are purchased and used for the sake of revenue. Any failure or loss of efficiency reduces revenues as well as requiring additional funds for repair. Investigate any successful operation where engines are used and there will be 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 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 maintenance schedule the same as basic engine, for an accessory failure may put entire engine out of operation.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of engine must govern establishment of 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 maintenance schedule is established. A look at suggested check sheet, on the opposite page, indicates some checks may have to be performed more often under heavy dust of other conditions. The schedule is also dependent upon amount of work being done which can best be determined by 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 amount of fuel used per hour during normal operation. For example, if the average fuel consumption of a V1710 engine is 15 to 20 gallons [56.8 to 75.7 liters] per hour, the "B" check would be made every 3750 to 5000 gal. [14193.0000 to 18925.0000 liters] of fuel or approximately every 250 hours of operation.

Extending 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 original maintenance schedule and it should be studied before making any change in or extending schedule periods. In extremely dirty and under severe operating conditions, scheduled maintenance period may even need reducing. Again, operation should be re-analyzed and a lubricating oil analysis should be made. Extending or reducing schedule period should be done only after a complete study, basically, the same as used in establishing original maintenance schedule period. Lubricating oil analysis is described on Page 5-11.

Using Suggested Schedule Check Sheet

Maintenance schedule check sheet (next page) is designed as a guide until adequate experience has been acquired to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for gallons of fuel used, hours of operation or under some conditions a calendar period for stand-by service. See Table 5-1.

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

The check sheet shown can be reproduced by any printer to provide forms for use. The person making each check can then indicate directly on the sheet (in the blank box following the operation) that the operation has been completed. When a complete column (under A, B, C etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Maintenance 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 Schedule

CHECK SHEET

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

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

As Applicable To Your Unit — Check Each Operation As Done			A	B	C	D	E	F
Suggested Engine Maintenance Interval	Naturally Aspirated	Hours Operation	Daily	250	500	1000	2000	6000
	Turbocharged	Hours Operation	Daily	250	500	1000	2000	6000
	Naturally Aspirated	Gal's Fuel Used	Daily	3750	7500	15,000	30,000	90,000
	Turbocharged	Gal's Fuel Used	Daily	5000	10,000	20,000	40,000	120,000
If Different From Suggested — Insert Your Actual Interval								

Check or Operation	A	B	C	D	E	F
Check Operators Report						Major Inspection — Perform Using Engine Shop Manual Wear Limits As Guide
Check Leaks and Correct						
Check Engine Oil Level						
Check Coolant Level						
Fill Fuel Tanks						
Check Oil Bath Air Cleaner Oil						
Clean Pre-Cleaner Dust Pan						
Check Marine Gear Oil Level						
Check Raw Water Pump Oil Level						
Check Converter Oil Level						
Lubricate P.T.O. Bearing						
Drain Sediment From Fuel Filter						
Clean Dry-Type Air Cleaner Element						
Change Oil Bath Air Cleaner Oil						
Change Engine and Aneroid Oil						
Change Engine (Full Flow) Filter						
Record Oil Pressure						
Lubricate Electrical Equipment						
Change Marine Gear Oil, Clean Strainer						
Check Hydraulic Governor Oil Level, Change Filter						
Change Engine By-Pass Oil Filter Element						
Clean Fuel Tank Breather, Drain Sediment						
Change Corrosion Resistor Element/Check Coolant						
Check Air and Vent Piping Connections						
Change Fuel Filter and Check Restriction						
Check and Adjust Belt Tension						
Check Heat Exchanger Zinc Plugs						
Change Converter Oil Filter, Clean Strainer						
Check Inlet Air Restriction						
Replace Dry-Type Air Cleaner Element						
Clean Oil Bath Air Cleaner Tray Screen						
Clean/Change Crankcase Breather Element						
Clean Air Compressor Breather						
Check Cooling System Thermal Controls						
Check Fan Hub and Drive Pulley						
Clean Electrical Units/Tighten Connections						
Tighten Manifold Capscrews and Nuts						
Check Turbocharger For Oil Leaks						
Tighten Turbocharger Manifold Mountings						
Check and Lubricate Raw Water Pump						
Clean Aneroid Air Filter						
Clean Oil Bath Air Cleaner						
Lubricate Water Pump and Fan Hub						
Clean Fuel Pump Screen						
Adjust Valves and Injectors						
Check Fuel Manifold Pressure						
Clean Turbocharger Compressor Side						
Check Turbocharger Bearing						
Check Alternator/Generator Brushes/Commutator						
Check Starting Motor Brushes/Commutator						
Steam Clean Engine						
Tighten Engine Mountings						
Check Engine Blow-By						
Check Crankshaft End Clearance						
Check Vibration Damper						
Change Hydraulic Governor Oil						

Clean Cooling System	Spring and Fall		
Check Engine Preheater	Spring and Fall		
Check Hose	Spring and Fall		
Check Clutch Adjustment	As Required		
Clean Injectors and Inlet Screens	As Required		

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:

Table 5-1: Standby Service

Perform Checks	A	B	C	D
1. Monthly	X			
2. 3-Months	X	X		
3. 6-Months	X	X	X	
4. Yearly	X	X	X	X

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

Units in standby service should be started once each week in locations where ambient temperature remains below 70 deg F [21.1 deg C] and contains a high percentage of humidity. Start engine 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.

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

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

'A' Maintenance Checks

Check Operator's Report (A Check)

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

1. Low lubricating oil pressure.

2. Low power.

3. Abnormal water or oil temperature.

4. Unusual engine noises.

5. Excessive smoke.

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

Check Leaks And Correct (A Check)

Lubricating Oil

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick (1, Fig. 5-1) and filler tube caps (2). See that they are tightened securely.

Fuel Oil

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 shutdown 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 ST-998 Sight Gauge (1, Fig. 5-2) in the line between fuel filter(s) and pump. Bubbles over ½ in. [1.270 cm] long or "milky" appearance indicates an air leak. Find and correct.

Fig. 5-1, V40736. Lubricating oil filler tube

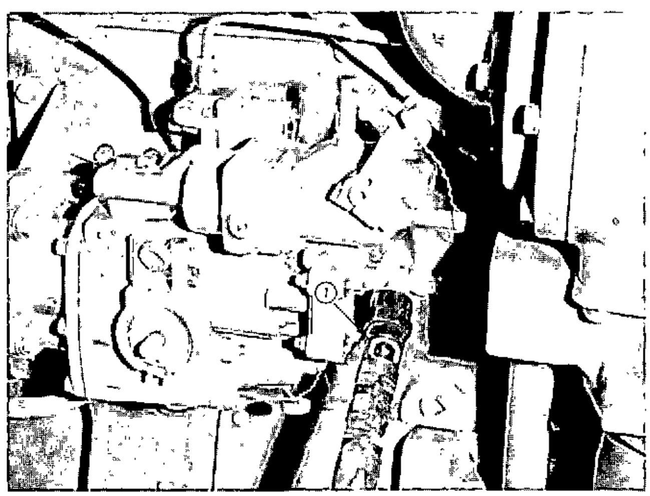


Fig. 5-2, V41923. Sight gauge in fuel suction line

Coolant

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

Air Connections

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

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

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

The amount of fuel that can be burned and power developed is as dependent upon air as fuel. If there is too little air to burn all the fuel, the excess fuel causes a smoky exhaust – high exhaust temperatures and a loss of horsepower.

Wasted fuel is not the only loss caused by incomplete combustion. The excess fuel washes lubricating oil off cylinder walls resulting in seized pistons and bearing failures. Carboned injector cup spray holes and stuck piston rings are other troubles which result from insufficient air. Dirty air cleaner elements, leaky valves, worn rings, damaged silencers and air piping that is too small or with sharp bends are common causes of air restriction. Therefore, it is necessary to perform air system maintenance regularly as follows:

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. 5-1.

Note: Some dipsticks have dual markings, with high- and low-level marks: static oil marks on one side, engine running at low idle speed marks on opposite side. Be sure to use proper scale.

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 Section 3.

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.

Fill Cooling System (A Check)

Keep cooling system completely filled. Check 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 in Section 3.

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 entitled "Check Engine Coolant (C Check)".

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

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

Fill Fuel Tanks (A Check)

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

In cold weather, water which accumulates in the fuel system will sometimes freeze and block the supply of fuel.

This condition can be prevented by adding one quart of denatured alcohol to each 50 gal. [189.250 lit.] 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 it can pass through the fuel system and be "burned" without doing any damage.

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

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged from over use will be more of a handicap than help to an engine. It will 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 to fuel pump shafts, bearings and other parts. In some sections it is difficult to purchase fuel which does not contain some water. Normal condensation, either in the storage tank or in the fuel tank, increases water content. This water, of course, must be filtered out or drained off before it gets into the fuel pump. The life of a fuel pump and injectors can be considerably extended if the operator takes the precaution of draining about a cup of fuel from the lowest point in the fuel system before starting the engine each day.

Drain plugs are located in the bottom of some fuel filter cases, and in the sump of the fuel supply tank. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. 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.

Check Air Cleaner Oil Level (A Check)

Daily, check oil level (4, Fig. 5-3) in oil bath air cleaner (3) to be sure oil level in oil cup (2) is at indicated mark. To remove oil cup, loosen wing nuts (1). During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes 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.

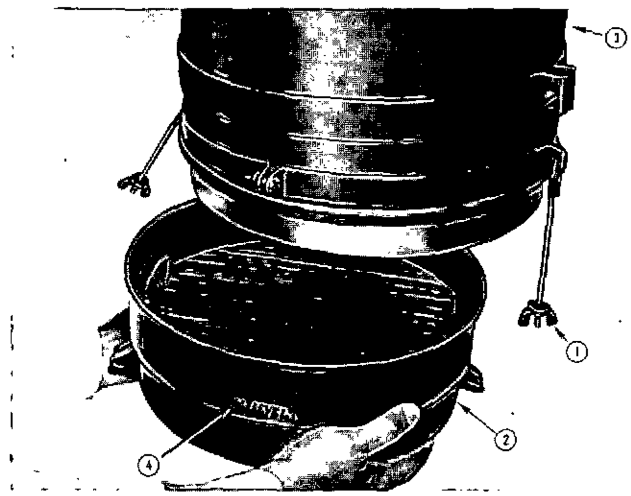


Fig. 5-3, N11001. Oil level in air cleaner

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.

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 Raw Water Pump Oil Level (A Check)

Check oil level by removing plug (1, Fig. 5-4). Fill with hypoid SAE 90 oil when pump with oil sump is used.

Check Converter Oil Level (A Check)

Different models of equipment 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:

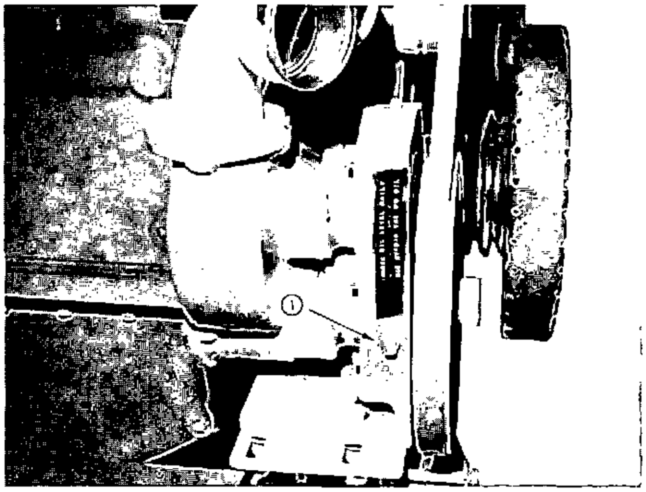


Fig. 5-4, V41819. Sea water pump oil level check point

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 throw-out collar.

Manual Spring-Loaded Input Disconnect Clutch

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

'B' Maintenance Checks

Drain Sediment From Filter (B Check)

Perform at A Check under extremely dusty conditions.

1. Open drain cocks (1, Fig. 5-5), if used, at bottom of fuel filter case and drain out any accumulated water and sediment. Tighten the drain cock. If drain plug is used, tighten to 5 to 10 ft lb [0.6915/1.3830 kg m].

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

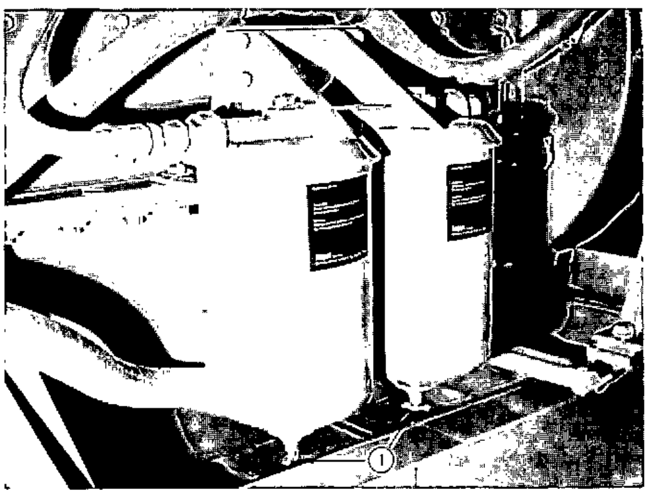


Fig. 5-5, V41927. Fuel filter drain cocks

Clean Dry-Type Cleaner Element (B Check)

Perform at A Check under extremely dusty conditions.

The paper element in a dry-type air cleaner, Fig. 5-6, may be cleaned several times by using an air jet to blow off dirt by washing with non-sudsing household detergent and warm water, preferably 120 to 140 deg. F [48.9 to 60.0 deg. C], then drying with compressed air, approximately 40 psi [2.8124 kg/sq cm]. Do not hold air jet too close to paper element or damage to element may result.

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

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

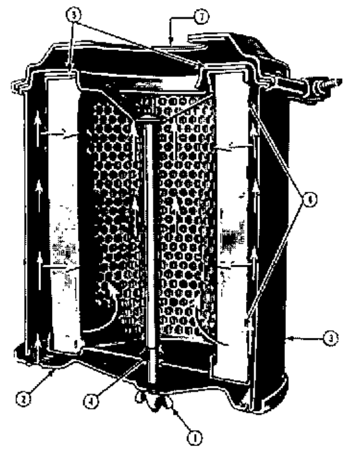


Fig. 5-6, N11003. Air cleaner - dry type

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

1. Loosen wing nut (1, Fig. 5-6) securing bottom cover (2) to cleaner housing (3). Remove cover.

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

3. Remove gasket (5) if damaged from housing.

4. Insert new or cleaned element (6) over center bolt (4) seating squarely on gasket (5), be sure grommet over center bolt is in position.

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

5. Position bottom cover (2) to cleaner housing (3), secure with wing nut (1).

Heavy Duty Single And Dual Types

Heavy duty air cleaners (single and dual element) combine centrifugal cleaning with paper element filtering, Fig's. 5-7 and 5-8, before air enters engine.

Dirty air enters through an opening in the side of the single or dual type, heavy duty cleaner body. On the single element type, air immediately travels through a ring of vanes around and thru the element and on into the engine. Fig. 5-7. Whereas, on a dual element type, air travels

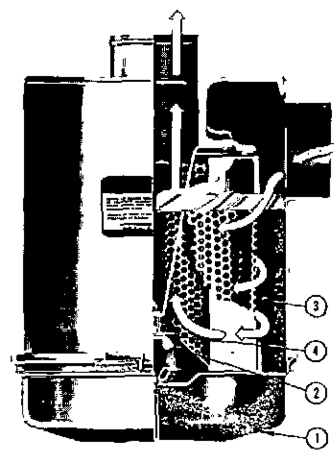


Fig. 5-7, V11005. Air cleaner - heavy duty

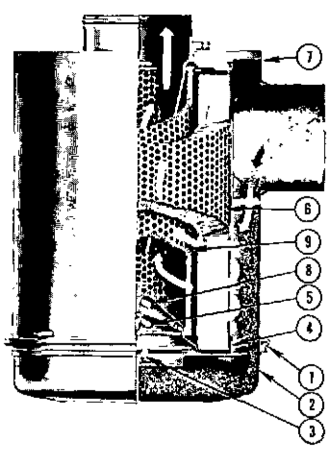


Fig. 5-8, N11030. Air cleaner - heavy duty dual element

through a ring of vanes around and thru a primary element (6, Fig. 5-8) and then through a safety element (9, Fig. 5-8) and on into the engine.

Before disassembly, wipe dirt from cover and upper portion of air cleaner.

Single Element

1. Loosen wing bolt and clamp, remove dust cup (1, Fig. 5-7).

2. Unscrew wing nut (2) holding element (3) in position, remove element.

3. Remove dust cover from dust cup and clean.

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

Caution: Air pressure should not be more than 100 psi [7.0310 kg/sq cm] to avoid rupturing element. Do not concentrate air pressure in one spot.

5. Wash element with non-sudsing household detergent and warm water (120 to 140 deg F [48.8 to 60.0 deg C]). Dry with compressed air (40 psi [2.8120 kg/sq cm]).

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

7. Install new or cleaned element, secure with wing nut.

Note: Be sure gasket washer (4, Fig. 5-7) is in place under wing nut before tightening.

8. Install cover into dust cup secure with wing nut.

9. Install dust cup to air cleaner housing; position band over housing and dust cup, secure with wing bolt.

Dual Element

1. Loosen wing bolt, remove band (1, Fig. 5-8), securing dust pan (2).

2. Loosen wing nut (3), remove dust shield (4) from dust pan (2), clean dust pan and shield.

3. Remove wing nut (5) securing air cleaner primary element (6) in air cleaner housing (7) inspect rubber sealing washer on wing nut (5).

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

Caution: Air pressure should not be more than 100 psi [7.0310 kg/sq cm] to avoid rupturing element. Do not concentrate air pressure in one spot.

5. Wash element with non-sudsing household detergent and warm water (120 to 140 deg. F [48.8 to 60.0 deg C]). Dry with compressed air (40 psi [2.8120 kg/sq cm]).

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

6. Install new or cleaned primary element (6) secure with wing nut (5).

7. Reassemble dust shield (4) and dust pan (2), position to air cleaner housing and secure with band (1).

8. Check air restriction indicator, if air restriction is excessive, disassemble air cleaner, remove wing nut (8), replace safety element (9).

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

Cartridge-Type Air Cleaner (B 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. 5-23. Other indications are a loss of engine power or excessive smoke in 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. 5-23 signals when to change cartridges. The flag in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge, reset indicator by pushing Re-Set Button. Push button all the way in firmly, then release. If button sticks, repeat pushing slowly.

4. Loosen wing nuts (4, Fig. 5-9) on air cleaner housing (5) to remove pre-cleaner panel with dust bin (1). To remove pre-cleaner panel equipped with exhaust aspirator (2), loosen "U" bolt clamp securing pre-cleaner to aspirator tubing.

5. To remove dirty Pamic cartridge (3), insert fingers in cartridge opening using a "bowling-ball grip." Loosen all four corners of cartridge, one at a time, by pulling straight out. With larger cartridge, it may be necessary to break seal along edges of cartridge. After seal has been broken, pull the cartridge straight out and slightly up so cartridge will clear sealing frame and edges of air cleaner housing.

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

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

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

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

8. It is not recommended to clean and reuse cartridge. Considerable laboratory testing shows that shaking, washing, rapping or blowing out with compressed air can cause cracks or ruptures in paper filter cartridges, which

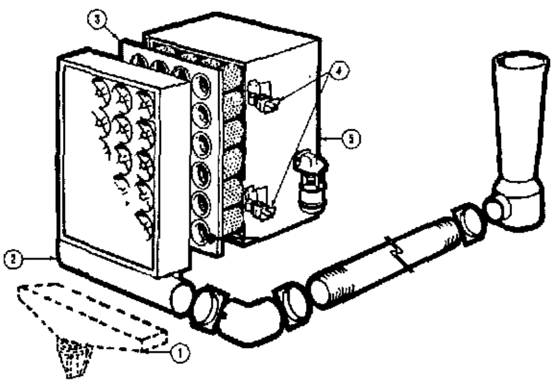


Fig. 5-9, N21026. Air cleaner - cartridge type (two stage)

would permit wear-causing dirt particles to enter engine. If a failure occurs, there is no way of discovering it until cartridge is changed again.

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

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

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

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

13. To install a new cartridge, hold cartridge (3, Fig. 5-9) in same manner as when removing from housing (5) always inspect inside of air cleaner housing keeping it free of all foreign material. Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.

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

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

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

Engine Oil Change (B Check)

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

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 5-2 is for average conditions.

The maintenance schedule can be lengthened or may even, in rare cases, be reduced, based on oil analysis and other closely controlled tests, such as filter restriction measurement.

Lubricating Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. Fig. 5-10. After several test periods, a time interval (gallons fuel consumed, hours, weeks, etc.) 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 200 gal. [757 lit.] fuel consumed (after the first 800 gal. [3028 lit], 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 deg F and 200 deg F	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

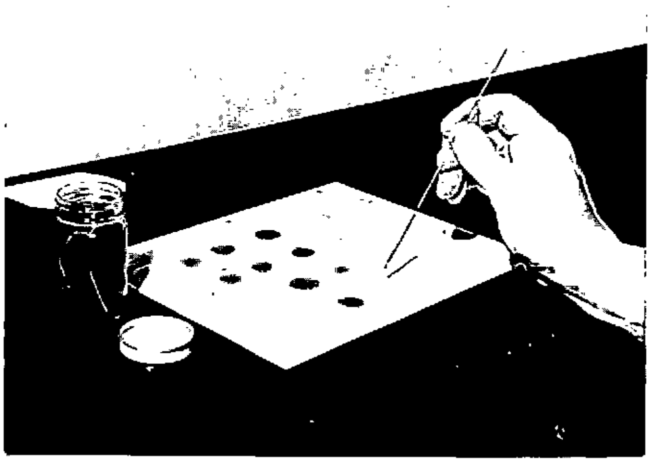


Fig. 5-10, N11945. Typical lubricating oil analysis test

General Limits For Oil Change

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

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

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

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

5. Water Content: 0.2 percent maximum.

6. Additive Reduction: 25 percent maximum.

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

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

Change Oil In Aneroid Control (B Check)

1. Remove plug from 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 hole until oil fills to hole level. Fig. 5-11. Reinstall filter or pipe plug.

Change Engine Full-Flow Filter Element (B Check)

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

2. Loosen center capscrew(s) and remove filter case(s) from filter head.

3. Withdraw filter element, inspect, then discard. Fig. 5-12.

Fig. 5-11, V41022. Fill aneroid with oil

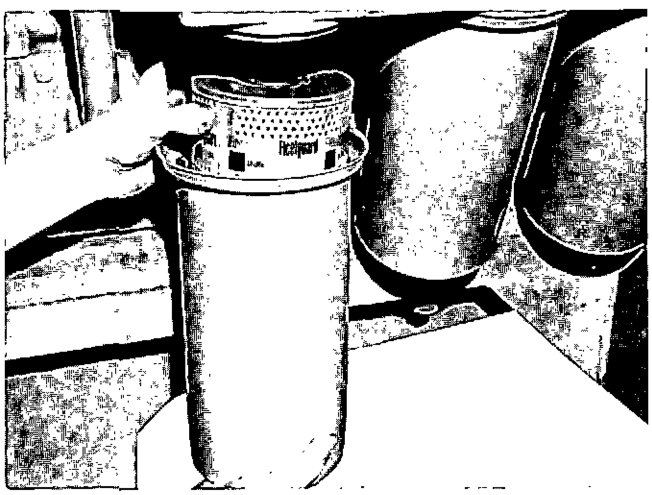


Fig. 5-12, V40737. Removing paper element lubricating oil filter(s)

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

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

c. If element is clogged the change period should be shortened. Oil pressure drop reading across filters is the best way to determine change periods. Pressure drop from inlet to outlet side of filter should not exceed 10 psi [0.7030 kg/sq cm] with 140 deg F [60 deg C] oil and engine at high-idle speed.

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 spring support assembly.

7. Position new seal ring in place; assemble filter case to head and tighten center capscrew to 25 to 35 ft-lb [6.915 to 9.681 kg m].

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.

Record Oil Pressure (B Check)

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140 deg F [60 deg C]. Reduce engine speed to idle and record 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. 5-13) or by turning down grease cup a maximum of one turn.

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

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

When a generator or alternator filter is used, clean filter screen at each lubrication period. Remove filter screen and

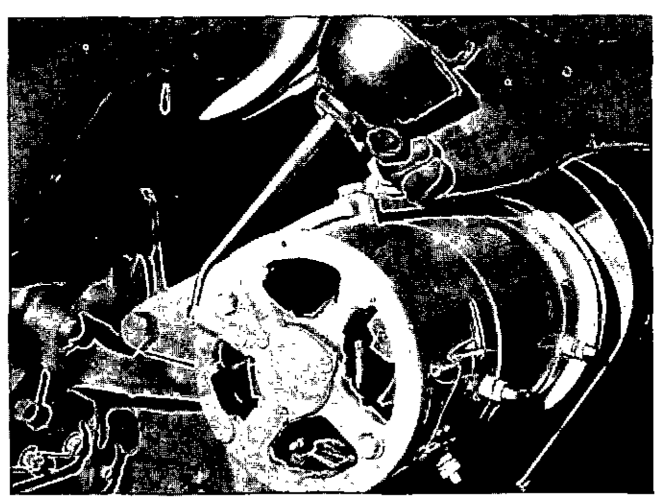


Fig. 5-13, V41304. Lubricating generator wash in an approved cleaning solvent; blow dry with compressed air and reassemble.

Lubricate Cranking Motor (B Check)

Electric

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

Air

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

Change Marine Gear Oil (B Check)

1. Remove drain plug from bottom of gear housing and drain oil, or pump from sump, or follow manufacturer's recommendations.

2. Reinstall drain plug and fill marine gear to "H" level on dipstick with lubricant as specified by the gear manufacturer.

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

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

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

Check Hydraulic Governor Oil Level (B Check)

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

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

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 [0.49217 kg/sq cm] 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.

Change By-Pass Filter Element (B Check)

Change Cummins Fleetguard (LF-750) by-pass filter elements on engine so equipped as follows:

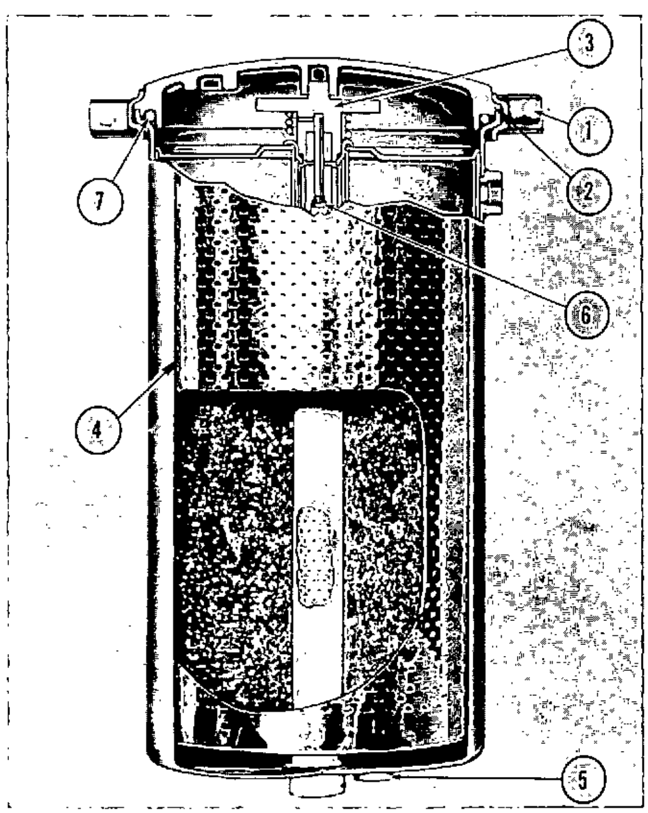


Fig. 5-14, V41908. By-pass filter cross-section

1. Remove drain plug (5, Fig. 5-14) from bottom of housing and drain oil.

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

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

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

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

6. Inspect drain plug and connections. Replace plug.

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

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

9. Install new element in housing.

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

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

12. Install cover and clamping ring; tighten capscrew until clamping lugs come together.

13. Add enough extra oil to crankcase to fill case and element. (Approximately 2.9 gal [10.9775 lit] per filter.)

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

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

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

2. Loosen fuel tank drain cock(s) or plug(s) and drain approximately 1 cup of fuel. Close darin cock(s) or plug(s).

Change Corrosion Resistor (B Check)

The initial service life of a corrosion resistor or element on a new or newly rebuilt engine or after complete change of coolant supply is 3000 miles or 100 hours; maintenance periods thereafter are as follows:

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

Selection of resistor(s) or element(s) to be used should be based upon "Coolant Specifications," Section 3.

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

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

To Change Package-Type Element(s)

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

2. Remove cover capscrews and cover(s). Fig. 5-15.

Fig. 5-15, V40820. Changing corrosion resistor elements

3. Remove alumiunum plate(s) securing element(s), lift element(s) from housing and discard, Remove magnesium plate(s) below element(s).

4. Lift spring(s) from housing(s).

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

6. Replace spring(s) and lower magnesium plate(s).

7. Remove new element(s) from transparent package(s), install element(s) in housing(s).

Caution: Make sure antifreeze is compatible with chromate-type elements.

8. Replace upper aluminum plate(s), gasket(s) and cover(s), secure with capscrews and washers.

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

To Change Spin-On Corrosion Resistor

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

2. Unscrew resistor(s) and discard. Fig. 5-15A.

Caution: Make sure antifreeze being used in cooling system is compatible with chromate, resistor. All Cummins Distributors are furnished with a new listing of compatible antifreezes each year.

3. Install new resistor(s), tighten until seal touches filter head. Tighten an additional one-half to three-fourths turn. Fig. 5-15A.

Caution: Mechanical tightening will distort or crack filter head.

Fig. 5-15A, V41933. Changing spin-on corrosion resistors

Keel Cooling Or Heat Exchanger Systems

1. Determine complete capacity of cooling system over and above that of engine itself.

2. Add pre-treated coolant, see "Make-up Coolant Specifications" Section 3.

3. Start unit and check pH value and chromate concentration after solution is thoroughly mixed.

4. The corrosion resistor will maintain proper chromate concentration for systems up to 30 to 36 gal [115.550 to 136.260 lit] of coolant capacity. If above this capacity, it is recommended that treated "make-up" coolant be added to the system. See "Check Engine Coolant."

Check Engine Coolant (B 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 specific condition of operation. In cases where "Make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary. (See "Keel Coolant" preceding.)

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating with chromate compounds, the concentration of effective inhibitor dissolved in coolant can be measured by the color comparison method. Cummins Coolant Checking Kit ST-993 is available from Cummins Distributors for this check. Fig. 5-16.

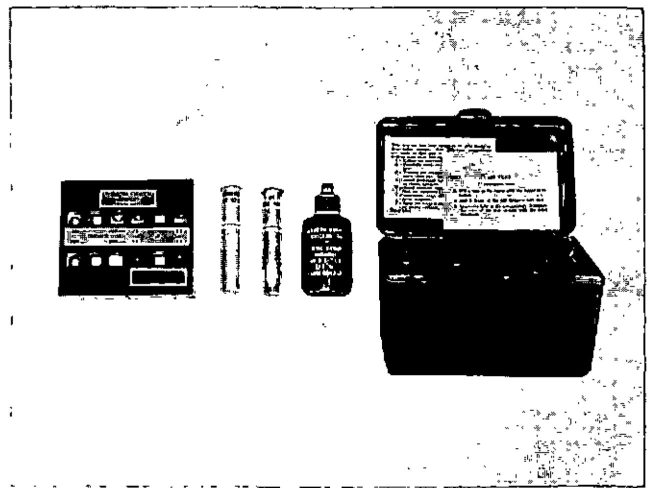


Fig. 5-16, N11946. ST-993 Coolant Test Kit

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

Examine sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from bottom of 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 ST-993 Test Kit, Fig. 5-16.

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

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

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

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

Chromate Concentration Test

1. Draw a sample of coolant and pour into tube marked "Chromate." Dilute sample by 50% with clean water.

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 gr per U.S. gal or 1700 to 2500 parts per million (ppm).

Note: This test is equivalent to 3500 to 5000 parts per million (ppm) of undiluted coolant.

4. Wash 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 element(s), and run four to six hours; then check coolant again; in extreme cases it may be necessary to change element(s) the second time. However, the latter condition may be due to larger coolant system than corrosion resistor was designed to treat. See "Coolant Specifications" Section 3.

If chromate compounds are used, add enough compound to bring concentration to proper level. Normal usage is 1/2 oz. [218.75 grains] chromate for each 1 gal [3.785 lit] coolant.

Table 5-2: Comparison Units Chromate Concentration

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

V-1710 Coolant Specifications

The V-1710 engine must have chromate protection at all times. Effective immediately, use only the standard chromate element with clear water or compatible antifreezes. Do not use the "PAF" or Borate element.

'C' Maintenance Checks

Check Air And Vapor Line Connections (C Check)

Perform at B Check under extremely dusty conditions.

Check all air and vapor lines and connections from compressor, 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 or cranking motors useless.

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

Check Air Piping (C Check)

Perform at B Check under extremely dusty conditions.

Check air intake piping from air cleaner to intake manifolds. Check for loose clamps or connections, cracks, punctures, or tears in hose 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 air cleaner. Fig. 5-17.

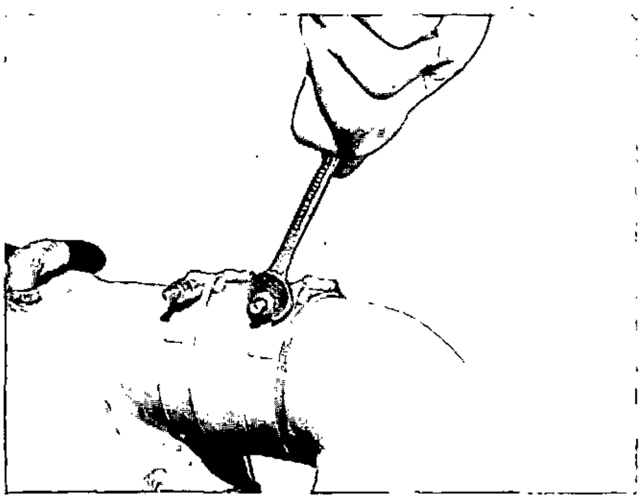


Fig. 5-17, V41023. Checking air intake piping

Change Fuel Filter Element (C Check)

Double element (throw-away) fuel filters are used. Under normal working conditions and with proper storage of fuel, filter should be changed every 7500 gal [28,387.500 lit] of fuel used.

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 fuel pump as shown in Fig. 5-18 using special adapter furnished. If restriction reads 8 to 8.5 inch [20.320 to 21.590 cm] vacuum while 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 inch [25.400 or 27.940 cm] vacuum, engine will lose power.

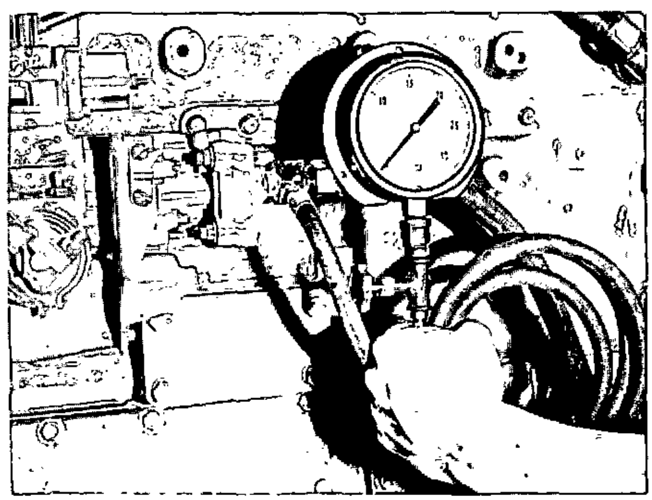


Fig. 5-18, V414211. Checking fuel filter restriction

Change element as described below.

Replaceable Element

1. Open drain cock(s) in bottom of filter case(s) and drain contents.

2. Loosen nut(s) at top of fuel filter(s). Take out dirty elements, clean filter case(s) and install new element(s). Fig. 5-19.

3. Install new gasket(s) in filter head(s) and assemble case(s)

and element(s). Tighten center bolt(s) to 20 to 25 ft-lb [2.766 to 3.4575 kg m] with a torque wrench. Fill filter case(s) with clean fuel to aid in faster pick-up of fuel.

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

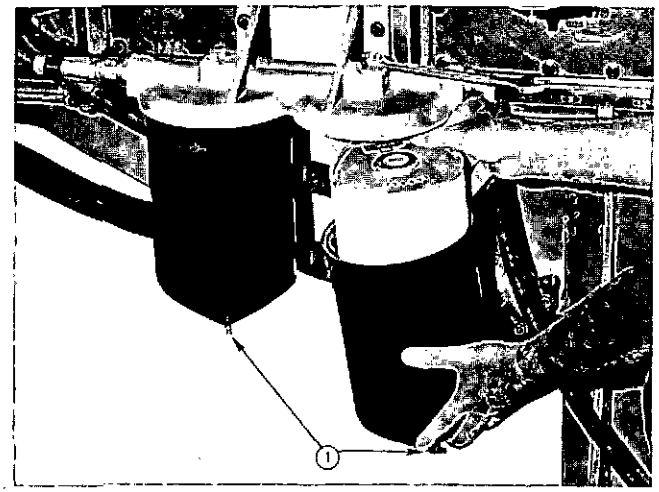


Fig. 5-19, V40040. Replaceable element fuel filter

Throw-Away Type Filter

1. Unscrew combination case(s) and element(s) (1); discard. Fig. 5-20.

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

2. Fill element(s) with clean fuel.

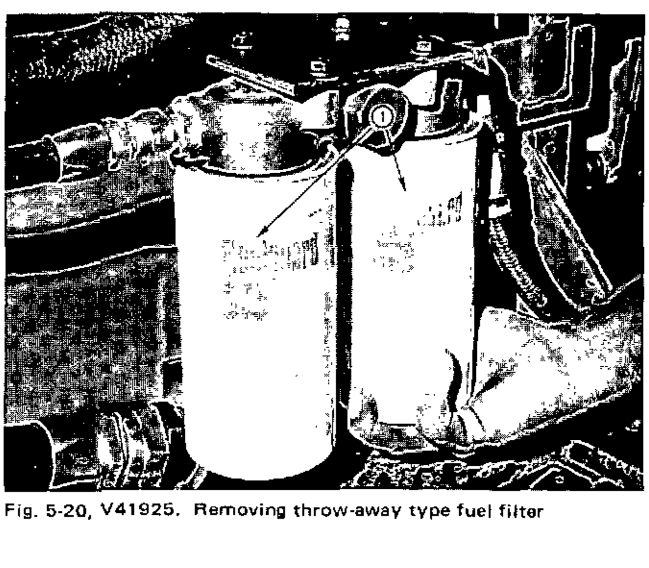


Fig. 5-20, V41925. Removing throw-away type fuel filter

3. Install new element(s); 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(s).

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 precedures 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. Either of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.

2. Always replace belts in complete sets to prevent early failure and to provide efficient operation,belt riding depth should not vary over 1/16 inch [1.587 mm] on matched belt sets.

3. Pulley misalignment must not exceed 1/16 inch [1.587 mm] for each ft. [0.3048 m] of distance between pulley centers.

4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 inch [2.381 mm] above top edge of groove.

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

Belt Tension

Check the belt tension with applicable Belt Tension Gauge. Fig. 5-21. Correct tension is 90-110 pounds as indicated on this gauge. If gauge is not available, apply pressure of index finger at center of the longest span of belt. Deflection should be one belt thickness per foot of pulley center distance. Fig. 5-22. See Table 5-3.

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

Belt adjustment (split) pulley

1. Remove the capscrews and lockwashers which secure the sheaves to pulley hub.

Note: Bar engine over to roll belt outward on pulley as pulley sheaves are turned in to obtain desired belt tension.

2. Turn front and rear adjusting sheave while securing hub in stationary position to obtain desired belt tension.

3. Lock sheaves in position with lockwashers and capscrews.

Readjusting New Belts

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

Belt Care Or Maintenance

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

To clean a belt, wipe it 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.

Table 5-3: Belt Tension — In. [mm]

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

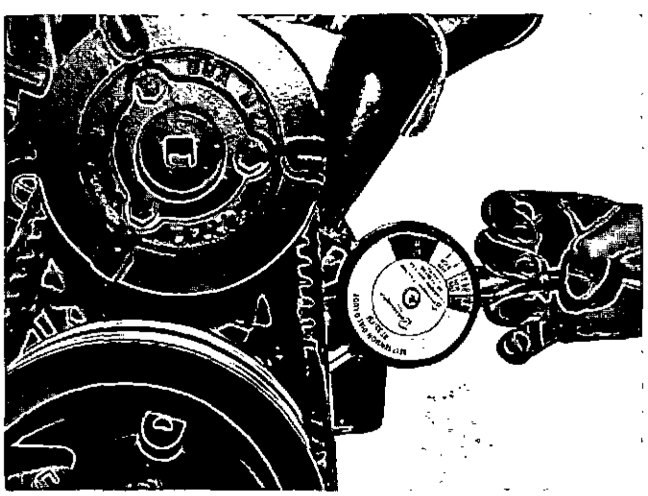


Fig. 5-21, V41922. Checking belt tension with ST-968 Belt Gauge

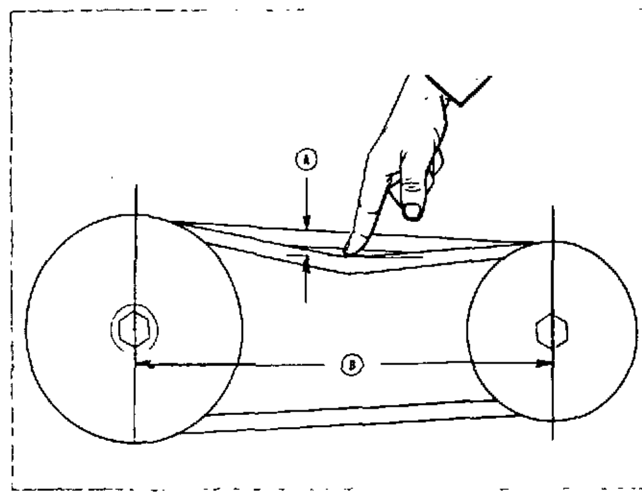


Fig. 5-22, N11471. Checking belt tension manually

Check Heat Exchanger Zinc Plugs (C Check)

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

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 it 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.

'D' Maintenance Checks

Check Inlet Air Restriction (D Check)

Perform at C Check under extremely 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 air intake piping. When located in air intake piping, adapter must be prependicular to air flow and not more than 6 inch [152.4 mm] from air intake manifold connection.

2. On turbocharged engines, attach checking fixture one pipe diameter upstream from turbocharger in a straight section of tubing.

3. Idle engine until normal operating temperature is reached.

4. Operate engine at rated speed, full-load and observe reading from vacuum gauge or manometer. Air restriction must not exceed 25 inch [635.0 mm] of water or 1.8 inch [45.720 mm] of mercury:

5. If air restriction exceeds 25 inch [635.0 mm] of water or 1.8 inch [45.720 mm] of mercury:

a. Clean or replace dry-type cleaner element.

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

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

Check Air Inlet Restriction At Cleaner

Air restriction readings may be taken at air cleaner outlet pipe. The adapter must be mounted perpendicular to air flow, and restriction must not exceed 20 inch [508.0 mm] of water or 1.5 inch [38.100 mm] of mercury when checked at this location.

A mechanical restriction gauge is available to indicate excessive air restriction. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The gauge shows completely red in indicator window (1, Fig. 5-23), (plunger 2) when restriction reaches 20 inch [508.0 mm] of water.

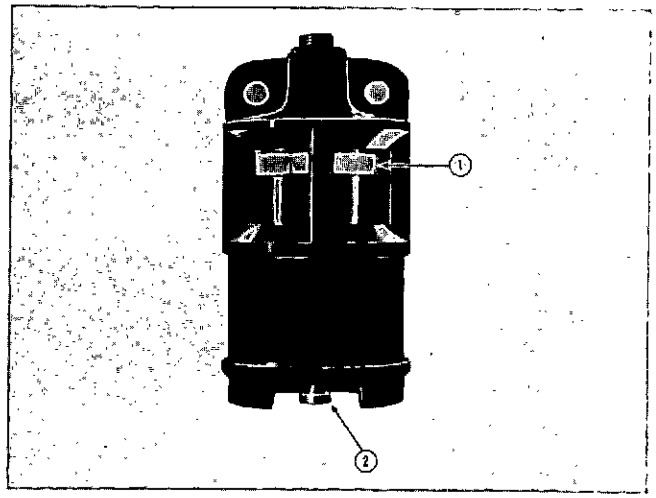


Fig. 5-23, CGS20. Air inlet restriction gauge

Replace Dry-Type Cleaner Element (D Check)

Perform at C Check under extremely dusty conditions.

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

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

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

1. 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 Tray Screen (D Check)

Perform at C Check under extremely dusty conditions.

Immerse tray screen (1, Fig. 5-24) in kerosene or cleaning solvent.

Slosh screen up and down several times. Dry thoroughly

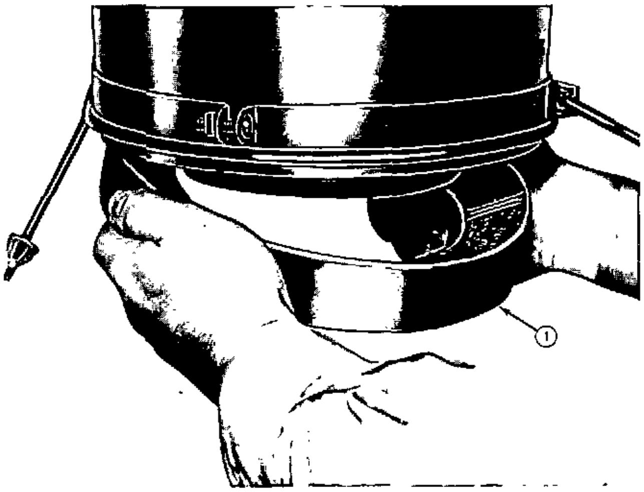


Fig. 5-24, N11002. Removing tray screen

with compressed air, and reassemble to air cleaner.

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

Clean Crankcase Breather (D Check)

Perform at C Check under extremely dusty conditions.

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. Check gasket; replace if damaged. Fig. 5-25.

Fig. 5-25, N40313. Crankcase breather — mesh element

Clean Air Compressor Breather (D Check)

Perform at C Check under extremely dusty conditions.

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

When used, service breathers regularly as follows.

Bendix-Westinghouse Paper Element

Remove the breather cover and element. Fig. 5-26. Clean by reverse flushing with compressed air; reassemble on compressor. Discard element if damaged or unsuitable for cleaning.

Bendix-Westinghouse Sponge

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

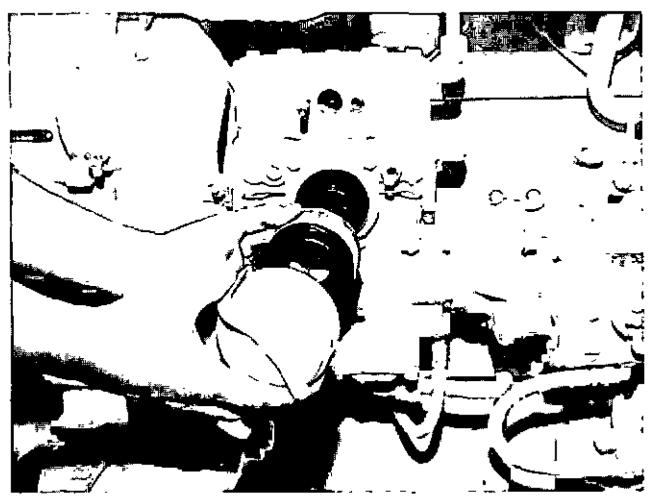


Fig. 5-26, V414210. Bendix-Westinghouse air compressor breather

Bendix-Westinghouse Oil Bath

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

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

Cummins Paper

A light-weight, self-contained air cleaner with "paper element" is optional on Cummins air compressor. Clean 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. 5-27.

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.

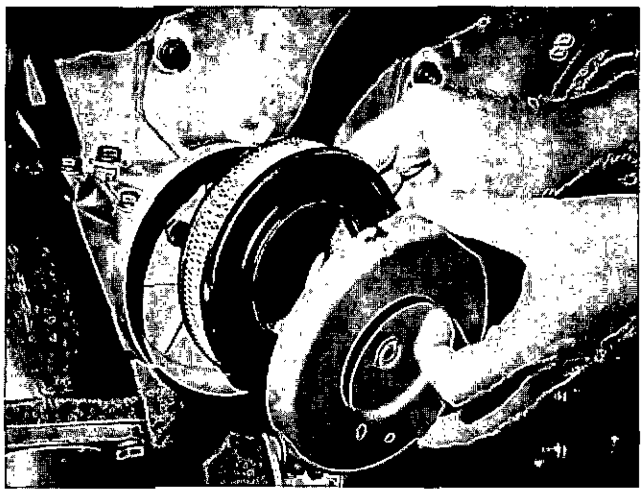


Fig. 5-27, V414209. Cummins air compressor breather — paper element

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

Check Thermal Controls (D Check)

Thermostat

Most Cummins Engines are equipped with either medium 170 to 185 deg F [76.7 to 85.0 deg C] or low 160 to 175 deg F [71.1 to 79.4 deg C] and, in a few cases, high-range 180 to 195 deg F [82.2 to 90.6 deg C] thermostat, 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 thermostat can be checked against a thermometer reading (1, Fig. 5-28) while immersed in water as the water is brought up to temperature by heating.

Table 5-4: Thermal Control Settings

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

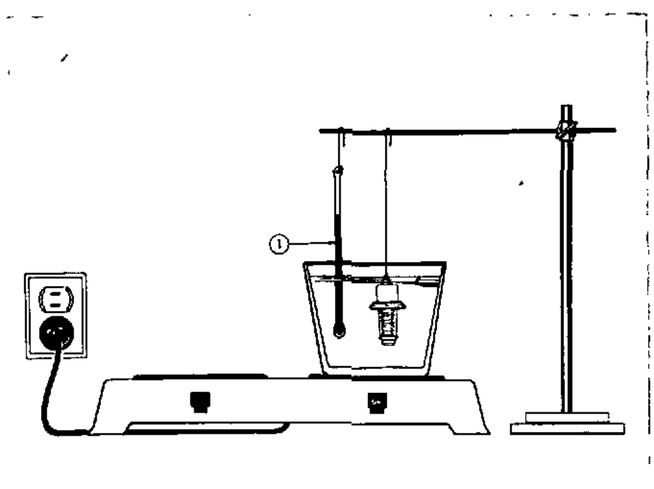


Fig. 5-28, N10809. Testing thermostat

Other Thermal Controls

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 5-4 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195 deg F [82.2 to 90.6 deg C] thermostats are used with shutterstats only that are set to close at 187 deg F [86.1 deg C] and open at 195 deg F [90.6 deg C].

Check Fan Hub And Drive Pulley (D Check)

Check fan hub and drive pulley to be sure 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 shaft nut as follows:

1. Tighten bracket capscrews.

2. Torque fan hub locknut to 50 ft lbs [6.9150 kg m].

3. Adjust belt tension as described on Page 5-16.

4. Using ST-845 Fan Hub Wrench advance locknut 60 deg (1 hex). This provides a final torque of approximately 450 ft. lb. [62.2350 kg m].

5. Recheck belt tension to be sure a reading of 90 to 110 lb is indicated on ST-1138 Gauge.

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

Dust and dirt, if allowed to accumulate in generator/alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.

Remove cover band and blow out dust and dirt with compressed air.

Clean And Tighten Electric Connections (D Check)

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

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

2. Remove corrosion from around terminals, then coat with petroleum jelly.

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

4. Replace broken or worn wires and their terminals.

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

Check For Oil Leaks At Turbochargers (D Check)

Check both intake and exhaust sides of turbochargers 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 and intake manifolds mounting hardware for tightness; correct deficiencies as required.

Tighten Turbocharger Mounting Nuts (D Check)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so vibration will be at a minimum. Fig. 5-29.

Check Raw Water Pump (D Check)

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

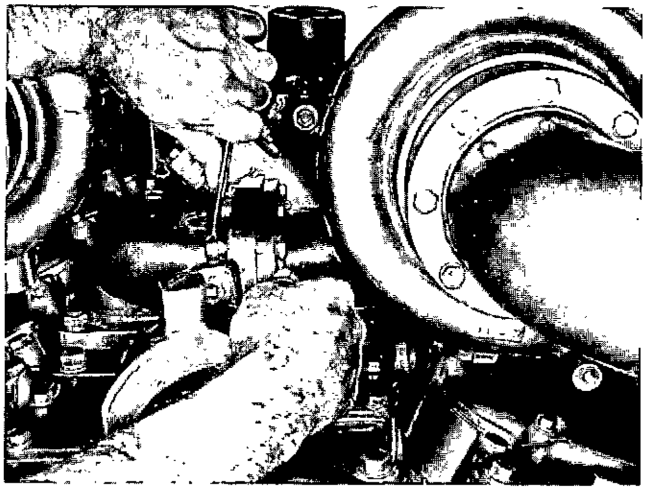


Fig. 5-29, V41931. Tighten turbocharger mounting nuts

If coolant being pumped through raw water pump is relatively free of sediment, corrosion 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. Slide out rubber impellers and check for cracks, breaks or damage. Install new impellers 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. 0.015 inch [0.3810 mm] gasket should be used to maintain proper impeller-to-cover clearance.

6. The raw water pump is self-priming.

Lubricate Raw Water Pump (Sump Type) (D Check)

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

'E' Maintenance Checks

Clean Aneroid Air Filter (E Check)

Perform at D Check under extremely 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 extremely dusty conditions.

Steam Cleaning

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

Solvent Bath Cleaning

This method of cleaning requires a 55 gal [219.175 lit] drum and a source of air pressure. Any good commercial solvent may be used.

1. Steam clean exterior of cleaner.

2. Remove air cleaner oil cup.

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

4. Submerge air cleaner in solvent.

5. Introduce air into unit at 3 to 5 psi [0.21093 to 0.3155 kg/sq cm] and leave in washer 10 to 20 minutes.

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

7. Dry thoroughly with compressed air.

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

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

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

Lubricate Water Pump And Fan Hub (E Check)

1. The water pump and fan hub contain plugs (1 and 2, Fig. 5-30) through which grease may be applied; give one "shot" (approx. 1 tablespoon) each "E" check.

Caution: Remove grease fittings and install pipe plugs after applying grease to prevent expelling grease during operation.

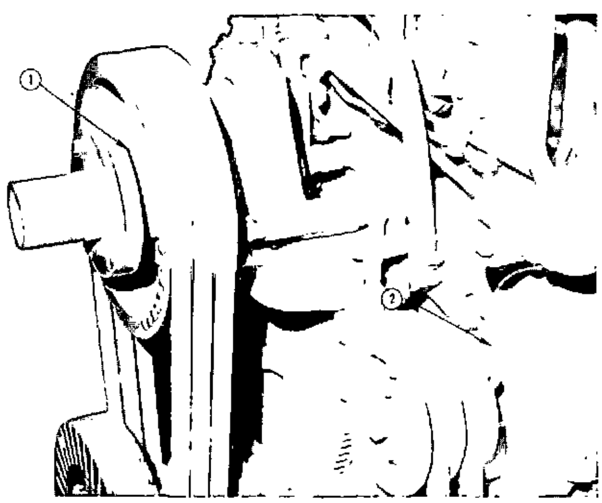


Fig. 5-30, V40821. Fan hub lubricating point

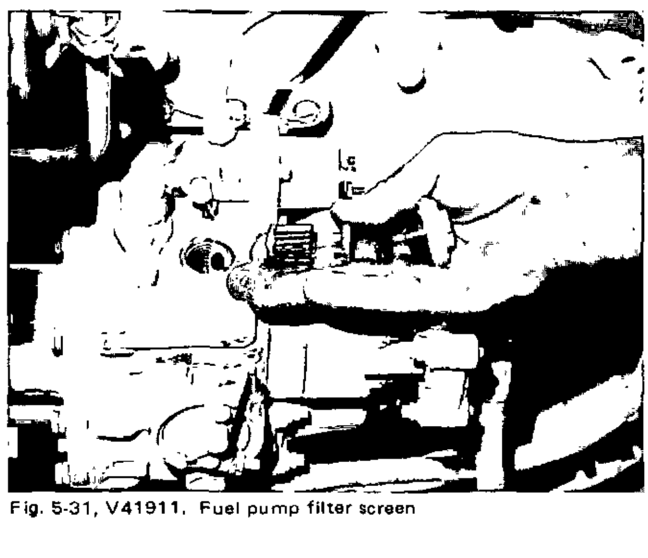


Fig. 5-31, V41911. Fuel pump filter screen

2. Completely disassemble, clean and inspect at each third "E" check. Pack bearings and fill water pump and fan hub bearing cavities 1/2 to 2/3 full of grease meeting specifications shown in Section 3.

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. 5-31.

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 to 25 ft-lb [2.7660 to 3.4575 kg m].

PT (type G) Fuel Pump With MVS Governor

1. Remove filter cap and dynaseal from governor housing. See Fig. 5-32.

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 to 25 ft-lb [2.7660 to 3.4575 kg m] with torque wrench and screwdriver adapter.

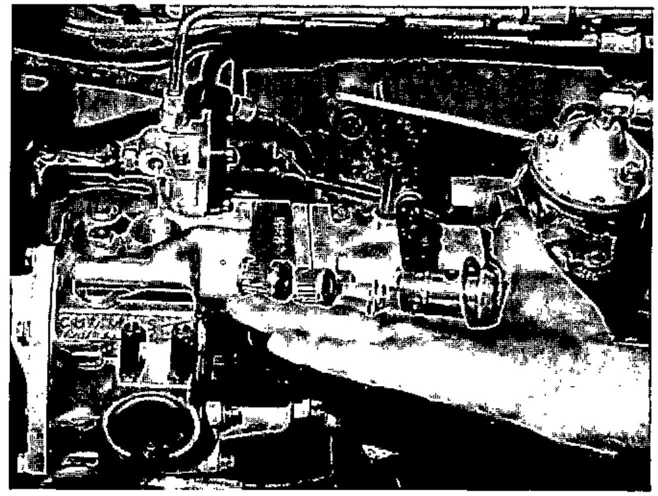


Fig. 5-32, V41912. Fuel pump screens – PT (type G) fuel pump with MVS governor

Adjust Injectors And Valves (E Check)

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

Time Mark Alignment

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

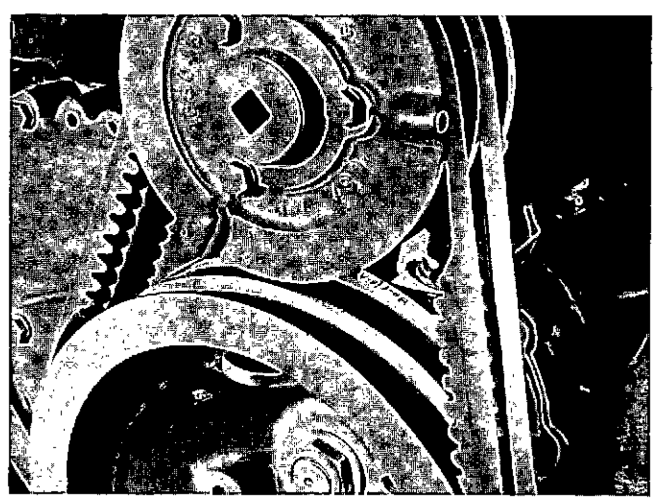


Fig. 5-33, V41484. Valve set marks

2. Bar engine in direction of rotation until No. 1-6L VS mark appears. See Fig. 5-33 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1, on engine left bank. (Remove block from compression release before setting valves.)

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

Engine Firing Order

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

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

Note: Number one L and one R cylinders on V1710 engines are at gear case end of engine.

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

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

Injector Plunger Adjustment

The injector plungers of all engines must be adjusted with an inch-lb torque wrench to a definite torque setting. Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 5-34.

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 in.-lb and a screwdriver adapter, tighten the adjusting screw to values shown in Table 5-5 and tighten the locknut. Table 5-6.

Table 5-5: Injector Plunger Adjustment Torque
Oil Temperature 70 deg. F [21.1 deg. C]
50 in.-lb [0.5750 kg m]

3. Hold injector adjusting screw and tighten injector

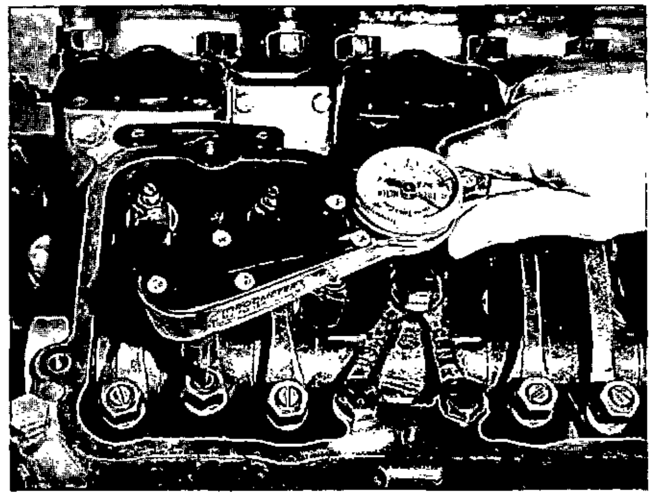


Fig. 5-34, V414190. Adjusting injector plungers

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locknuts to values indicated in Table 5-6. Where ST-669 is used, nut torque is reduced to compensate for additional torque arm length. Fig. 5-35.

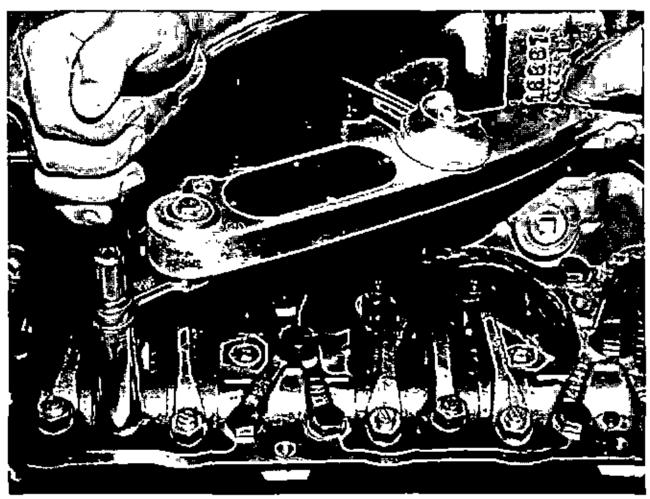

Fig. 5-35, V414201. Tightening injector adjusting screw locknut with ST-669

Table 5-6: Injector And Valve Locknut Torque

With ST-669	Without ST-669
25 to 35 ft-lbs [3.4575 to 4.8405 kg m]	30 to 40 ft-lbs [4.1490 to 5.5320 kg m]

Crosshead Adjustments

V1710 Series engines have four-valve heads; it is necessary to adjust the crossheads before making valve adjustments, Fig. 5-36.

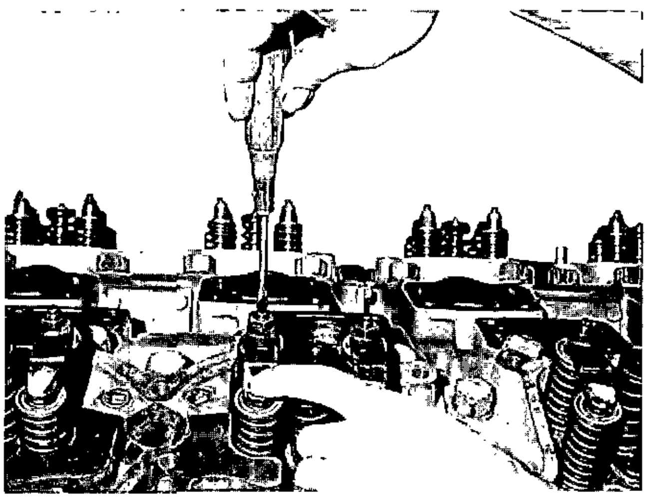

Fig. 5-36, V414163. Adjusting crossheads

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

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

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

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

5. Hold adjusting screw in this position and torque locknut to 25 to 30 ft-lb [3.4575 to 4.1490 kg m]. If ST-669 adapter is used with torque wrench tighten to 22 to 26 ft-lb [3.0426 to 3.5958 kg m] torque.

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

Valve Adjustment

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

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

2. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Turn screw down until lever just touches gauge and lock adjusting screw in this position with the locknut. Fig. 5-37. Torque locknut to values indicated in Table 5-6; note Step 3 under "Injector Plunger Adjustment".

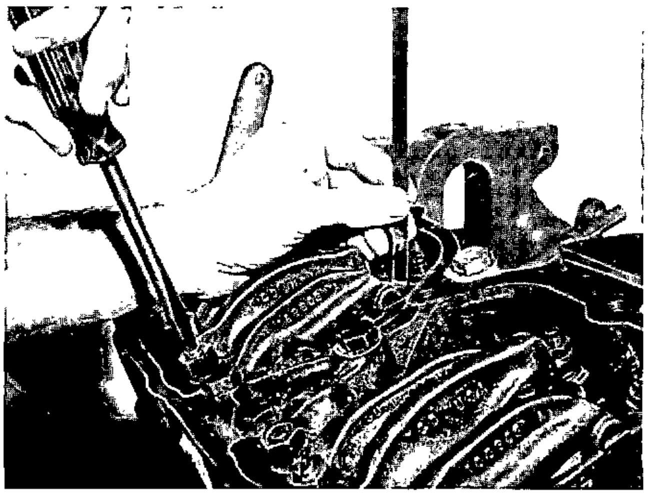

Fig. 5-37, V414193. Adjusting valves

3. Always make final valve adjustment after injectors are adjusted. Valve clearances are shown in Table 5-7.

Table 5-7: Valve Clearance — In. [mm]

Intake Valves Oil Temperature 70 deg. F [21.1 deg. C]	Exhaust Valves Oil Temperature 70 deg. F [21.1 deg. C]
0.016 [0.4064]	0.029 [0.7366]

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 is required only if loss of power is suspected. Fig. 5-38.

Caution: Aneroids (when used) on turbocharged engines must be disconnected to reach maximum fuel pressure during the short acceleration period.

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

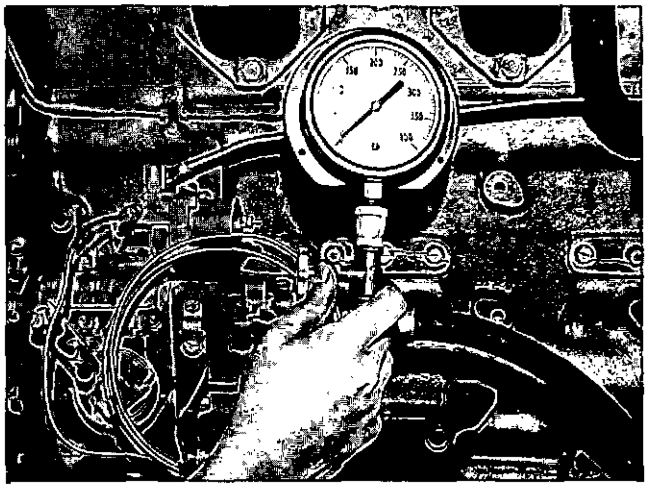

Fig. 5-38, V41021. Checking fuel manifold pressure

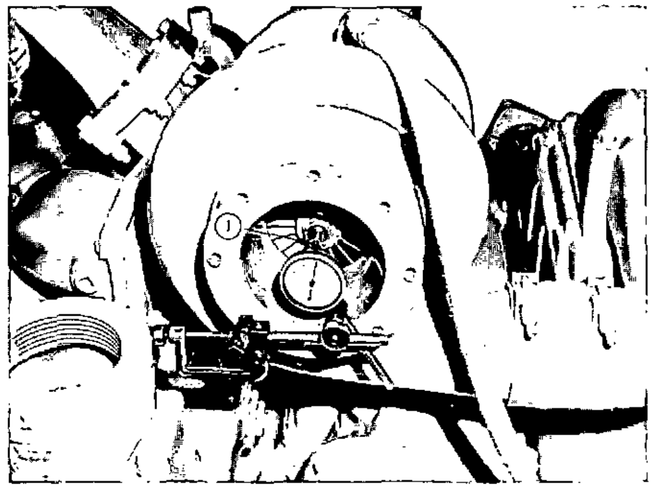

Fig. 5-39, V41024. Checking turbocharger bearing clearance

Clean Turbocharger Compressor Wheel And Diffuser (E Check)

Keep compressor wheel and diffuser clean for best turbocharger performance. Any build-up of dirt on compressor wheel will restrict air flow and cause rotor imbalance.

At every "E" check, clean compressor wheel and diffuser. Refer to pertinent Turbocharger Manual for specific instructions.

Check Turbocharger Bearing Clearance (E Check)

T-50 and VT-50

Check bearing clearances every "E" check. This can be done, without removing turbocharger from engine, by using a dial indicator (1, Fig. 5-39) to indicate end-play of rotor shaft and a feeler gauge to indicate radial clearance.

Checking Procedure

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

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

3. Check radial clearance on compressor wheel only.

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

Table 5-8: Turbocharger Bulletins

Turbocharger Model	Bulletin Number
T-50	983701
VT-50	983705
T-18-A	983678

T-18-A

Check bearing clearances every "E" check. Refer to the T-18-A Service Manual for procedures.

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

Failure of an alternator/generator or cranking motor 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 brush spring tension (1, Fig. 5-40) or high mica on the cummutator. Check generator manufacturer's specifications for spring tension data. Check out-put and action of an ammeter indicator after brush replacement.

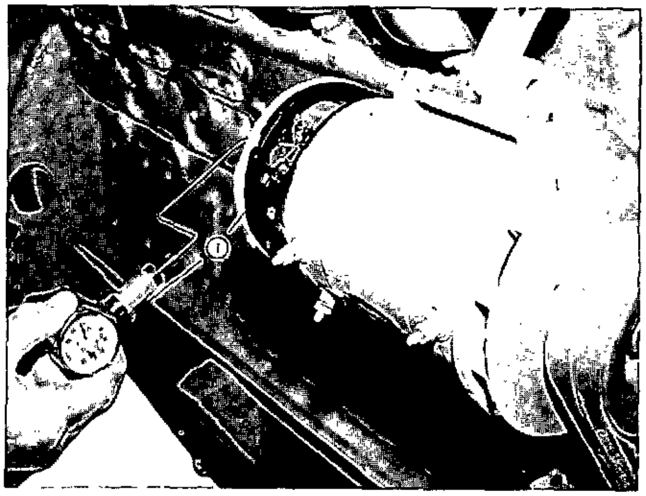

Fig. 5-40, V41926. Checking generator brush spring tension

3. Shorts and incorrect polarization (on generators) 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 exterior of engine should be kept clean. Dirt from the outside will find its way into fuel and lubricating oil filter cases and into rocker housings when covers are removed unless dirt is removed first.

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

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

Tighten Mounting Bolts And Nuts (E Check)

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

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 engine and observing gas escape from lubricating oil filler hole with cap or breather open or removed. There is always some vapor or gas escape at this point due to heated oil and piston movement, but distinct puffs indicate blow-by. Experience and comparison with other units operating at same speed are needed to make a conclusion to 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.

Check Crankshaft End Clearance (E Check)

The crankshaft of a new engine must have end clearance as listed in Table 5-9. A worn engine must not be operated with more than worn limit end clearance shown in same table. If engine is disassembled for repair, install new thrust rings if wear results in end clearance in excess of 0.022 inch [0.5588 mm].

The check can be made by attaching an indicator (1, Fig. 5-41) to rest against flywheel/crankshaft while prying (2) against a crankshaft throw through an inspection hole if the oil pan is not removed. End clearance must be present with engine mounted in unit and assembled to transmission or converter.

Table 5-9: Crankshaft End Clearance – In. [mm]

New Minimum	New Maximum	Operating Worn Limit
0.006 [0.1524 mm]	0.013 [0.3302 mm]	0.026 [0.6604 mm]

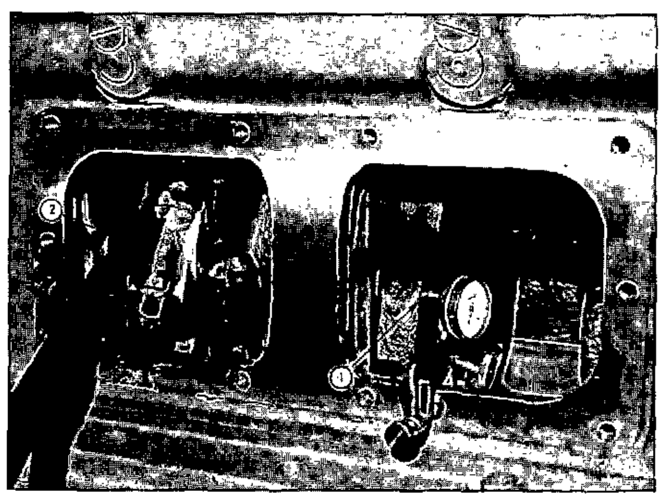

Fig. 5-41, V41924. Checking crankshaft end clearance

Check Vibration Damper Alignment (E Check)

Damper hub (1, Fig. 5-42) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

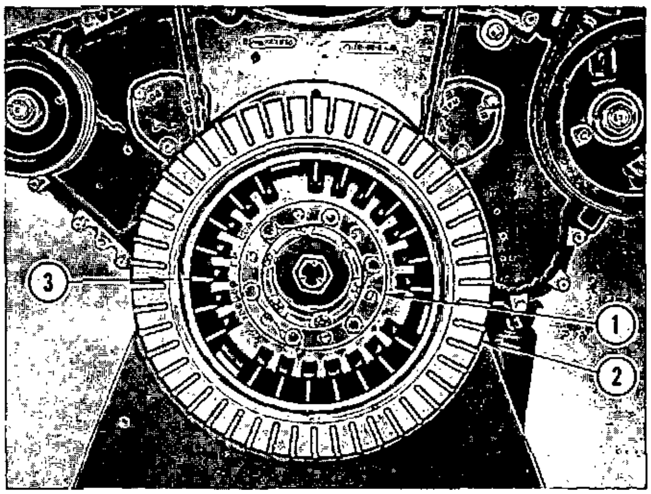

Fig. 5-42, V41932. Vibration damper alignment marks

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

Check for extrusion of rubber particles between hub and inertia member.

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 engine. See "Lubricating Oil Specifications," Section 3.

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

Clean Cooling System (Spring And Fall)

The cooling system must be clean to do its work properly.

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

Chemical Cleaning

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

Pressure Flushing

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

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

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

Check Preheater (Spring And Fall)

1. Inspect wiring; remove 1/8 inch pipe plug from manifold near glow plug and check flame while a helper performs preheating operation.

2. If no flame is observed, remove and replace with new or tested parts.

Check Hose (Spring And Fall)

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

Check Power Take-Off Clutch Adjustment (As Required)

If clutch does not pull, heats or operating lever jumps out, clutch must be adjusted. To adjust clutch, remove hand hole plate in housing and turn clutch until adjusting lockpin can be reached.

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

Clean And Calibrate Injectors (As Required)

Clean and calibrate injectors as required 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.

Normally, it is necessary to clean and calibrate injectors when there is an indication of low power, excessive smoke and when adjustment does not bring engine performance back to normal.

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

'F' Maintenance Checks

After engine has had four "E" checks, it should have an "F" check or 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 major inspection requires partial disassembly of 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 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)

Oil Cooler (Clean)

Turbocharger Bearing Clearances

Air Compressor

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 major inspection, it is determined crankshaft journals or any other engine parts are worn beyond worn replacement limits, 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 rebuilt engine like a new engine and by following preventive maintenance schedule, the same dependable service can be expected from 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 summary sheet will then tell which operations can be reduced or increased to make maintenance program more effective, resulting in more efficiency from engine at lower cost. A potential failure caught before it happens provides savings to engine owner and a ready-for-service unit.

MAINTENANCE OPERATIONS SUMMARY

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

ENGINE SERIAL NO.__________

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

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