Operation and Maintenance Manual

Cummins Diesel Engines

Construction

Industrial

Industrial Firepump

Logging

Mining

Railway

Generator

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

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Foreword

Information in this publication pertains to Cummins Diesel Engines used in construction, logging, mining, industrial, generator, railroad, and industrial fire pump applications.

This is an engine operation and maintenance manual, not a repair manual. The design of Cummins engines makes it possible to replace worn or damaged parts with new or rebuilt parts with a minimum of down time. Contact the nearest Cummins Distributor for parts replacement as they are equipped and have well informed, trained personnel to perform this service. If your shop is properly equipped to perform either maintenance, unit replacement and/or complete engine rebuild, contact the nearest Cummins Distributors to obtain available repair manuals and arrange for training of personnel.

For model identification of an engine, check the data plate, the letter and number code indicates breathing (naturally aspirated except when letter "T" for turbocharged is present), cubic inch displacement, application and maximum rated horsepower.

Examples:

NTA-855-370
N = 4 valve head
T = Turbocharged
A = Aftercooled
370 = Maximum rated horsepower

V903 - 320
V = Type engine
903 = Cubic Inch Displacement
320 = Maximum rated horsepower

Table: Other Application Designations

B	Off-Highway (Usually less compressor)
C	Construction (Construction Industry)
G	Generator Set
P	Power Units (Various Components used.)
M	Marine
D	Dump or Mixer Application
IF	Industrial Fire Pump
L	Locomotive
R	Railcar

Refer to Table on Pages 4, 5 and 6 for Engine Horsepower Specifications.

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

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IMPORTANT REFERENCE NUMBERS

CHASSIS SERIAL NO. ____________________

ENGINE MODEL ____________________

ENGINE SERIAL NO. ____________________

FUEL FILTER NO. ____________________

FULL FLOW LUBRICATING FILTER ELEMENT NO. ____________________

BY-PASS FILTER ELEMENT NO. ____________________

WATER FILTER ELEMENT NO. ____________________

AIR CLEANER ELEMENT NO. ____________________

WATER PUMP BELT NO. ____________________

FAN BELT NO. ____________________

ALTERNATOR BELT NO. ____________________

POWER STEERING PUMP BELT NO. ____________________

Table 1: Construction Mining, Logging and Industrial Engine Specifications

Engine Model	HP @ RPM 60° F [16° C] Sea Level*	HP @ RPM 85° F [29° C] 500 Ft.*	Aspiration	No Cylinders	Bore and Stroke Inch [mm]
V Series Engines					
V-378-C	155 @ 3300†	149 @ 3300	Natural	6	4-5/8 x 3-3/4 [117 x 95]
V-504-C	210 @ 3300†	202 @ 3300	Natural	8	4-5/8 x 3-3/4 [117 x 95]
V-555-C	240 @ 3300†	230 @ 3300	Natural	8	4-5/8 x 4-1/8 [117 x 105]
V-903-C	320 @ 2600†	307 @ 2600	Natural	8	5-1/2 x 4-3/4 [140 x 121]
V-378-P	155 @ 3300	149 @ 3300	Natural	6	4-5/8 x 3-3/4 [117 x 95]
V-504-P	210 @ 3300	202 @ 3300	Natural	8	4-5/8 x 3-3/4 [117 x 95]
VT-903-C	320 @ 2600	320 @ 2600	Turbocharged	8	5-1/2 x 4-3/4 [140 x 121]
Inline Engines					
CT-464-C	175 @ 2500	175 @ 2500	Turbocharged	6	4-7/16 x 5 [113 x 127]
CS-464-C	195 @ 2600†	187 @ 2600	Supercharged	6	4-7/16 x 5 [113 x 127]
N-743-C	220 @ 2100†	212 @ 2100	Natural	6	5-1/8 x 6 [130 x 152]
NT-855-C	335 @ 2100†	335 @ 2100	Turbocharged	6	5-1/2 x 6 [140 x 152]
NTA-855-C	420 @ 2300†	420 @ 2300	Turbocharged	6	5-1/2 x 6 [140 x 152]
CT-464-P	175 @ 2500	175 @ 2500	Turbocharged	6	4-7/16 x 5 [112 x 127]
CS-464-P	180 @ 2500	173 @ 2500	Supercharged	6	4-7/16 x 5 [112 x 127]
N-743-P	220 @ 2100†	212 @ 2100	Natural	6	5-1/8 x 6 [130 x 152]
N-855-P	250 @ 2100	240 @ 2100	Natural	6	5-1/2 x 6 [140 x 152]
NT-855-P	380 @ 2300†	380 @ 2300	Turbocharged	6	5-1/2 x 6 [140 x 152]
V12 Series Engines					
V-1710-C	500 @ 2100	480 @ 2100	Natural	12	5-1/2 x 6 [140 x 152]
VT-1710-C	635 @ 2100†	635 @ 2100	Turbocharged	12	5-1/2 x 6 [140 x 152]
VTA-1710-C	800 @ 2100†	800 @ 2100	Turbocharged	12	5-1/2 x 6 [140 x 152]
V-1710-P	500 @ 2100	480 @ 2100	Natural	12	5-1/2 x 6 [140 x 152]
VT-1710-P	635 @ 2100	635 @ 2100	Turbocharged	12	5-1/2 x 6 [140 x 152]
VTA-1710-P	800 @ 2100†	800 @ 2100	Turbocharged	12	5-1/2 x 6 [140 x 152]

† Optional power and RPM ratings available.

Turbocharged engines deliver the horsepower shown from sea level to altitudes specified on engine performance curves. Naturally aspirated and supercharged engines should be derated for altitude operation at the rate of 3% per 1000 feet [304 m] above 500 feet [152 m].

* Values shown for naturally aspirated engines are derived by adjusting the horsepower at 85 deg. F and 500 feet [29 deg. C] [152 m] altitude by about 4% to indicate approximate performance at sea level and 60 deg. F [16 deg. C] intake air temperature.

Table 2: Locomotive and Railcar Engine Ratings

Locomotive —

Engine Model	Bore and Stroke Inch [mm]	No. Cyl.	Aspiration	Horsepower @ RPM Rating		
				Yard Service	Road Service	
H-743-L	5-1/8 x 6 [130 x 152]	6	Natural	175 @ 1800	157 @ 1800	
N-855-L	5-1/2 x 6 [140 x 152]	6	Natural	238 @ 2100	205 @ 1900	215 @ 2100
NT-855-L2†	5-1/2 x 6 [140 x 152]	6	Turbocharged	335 @ 2100	285 @ 1900	300 @ 2100
NTA-855-L	5-1/2 x 6 [140 x 152]	6	Turbocharged	370 @ 2100	318 @ 1900	335 @ 2100
V-1710-L	5-1/2 x 6 [140 x 152]	12	Natural	475 @ 2100	410 @ 1900	430 @ 2100
VT-1710-L	5-1/2 x 6 [140 x 152]	12	Turbocharged	650 @ 2100	560 @ 1900	590 @ 2100
VTA-1710-L	5-1/2 x 6 [140 x 152]	12	Turbocharged Aftercooled	750 @ 2100	640 @ 1900	680 @ 2100

Railcar 80° Tilt Engine —

Engine Model	Bore and Stroke Inch [mm]	No. Cyl.	Aspiration	Horsepower @ RPM Rating	
				Suburban Service	Road Service
N-855-R	5-1/2 x 6 [140 x 152]	6	Natural	238 @ 2100	215 @ 2100
NT-855-R2†	5-1/2 x 6 [140 x 152]	6	Turbocharged	335 @ 2100	300 @ 2100
NTA-855-R	5-1/2 x 6 [140 x 152]	6	Turbocharged Aftercooled	370 @ 2100	335 @ 2100

†Optional power and RPM ratings available.

Table 3: Engine And Generator Specifications — 1800 and 1500 RPM Units

Engine Model	1800 RPM Stand-By	60 Hertz Prime Power	1500 RPM Stand-By	50 Hertz Prime Power
HR-6	GS-100KW	GC-75KW	GS-85KW	GC-65KW
NH-220	GS-125KW	GC-100KW	GS-100KW	GC-85KW
NT-270	GS-150KW	GC-125KW	GS-125KW	GC-100KW
NT-310	GS-175KW	GC-150KW	GS-150KW	GC-125KW
NT-335	GS-200KW	GC-175KW	GS-165KW	GC-150KW
NT-400	GS-250KW	GC-200KW	GS-190KW	GC-170KW
V12-500	GS-300KW	GC-250KW	GS-250KW	GC-210KW
VT12R600	GS-350KW	GC-300KW	GS-300KW	GC-250KW
VT12-700	GS-400KW	GC-350KW	GS-335KW	GC-300KW
VT12-800	GS-450KW	GC-400KW	GS-370KW	GC-330KW
VTA12-800	GS-500KW	GC-450KW	GS-400KW	GC-360KW

For single-phase operation the KW ratings are approximately 2/3 of the three phase ratings.

Table 4: **Fire Pump Engine Specifications**

Engine Model	HP @ RPM U.L. Rating*	HP @ RPM Factory Mutual Ratings	Aspiration	No. Cylinder	Bore and Stroke Inch [mm]
NH-220-IF	175 @ 1750	172 @ 1750	Natural	6	5-1/8 x 6 [130 x 152]
		182 @ 1900	Natural	6	5-1/8 x 6 [130 x 152]
		191 @ 2100	Natural	6	5-1/8 x 6 [130 x 152]
NT-280-IF	255 @ 1750	255 @ 1750	Turbocharged	6	5-1/2 x 6 [140 x 152]
	255 @ 1900	255 @ 1900	Turbocharged	6	5-1/2 x 6 [140 x 152]
	255 @ 2100	255 @ 2100	Turbocharged	6	5-1/2 x 6 [140 x 152]
NT-380-IF	285 @ 1750	285 @ 1750	Turbocharged	6	5-1/2 x 6 [140 x 152]
	303 @ 1900	303 @ 1900	Turbocharged	6	5-1/2 x 6 [140 x 152]
	325 @ 2100	325 @ 2100	Turbocharged	6	5-1/2 x 6 [140 x 152]
	340 @ 2300	340 @ 2300	Turbocharged	6	5-1/2 x 6 [140 x 152]
V6-125-IF	86 @ 1750	86 @ 1750	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	100 @ 2000	100 @ 2000	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	111 @ 2200	111 @ 2200	Natural	6	4-5/8 x 3-3/4 [117 x 95]
V6-155-IF	118 @ 2400	118 @ 2400	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	125 @ 2600	125 @ 2600	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	130 @ 2800	130 @ 2800	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	133 @ 3000	133 @ 3000	Natural	6	4-5/8 x 3-3/4 [117 x 95]
	136 @ 3300	136 @ 3300	Natural	6	4-5/8 x 3-3/4 [117 x 95]
V8-168-IF	121 @ 1750	121 @ 1750	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	141 @ 2000	141 @ 2000	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	145 @ 2200	145 @ 2200	Natural	8	4-5/8 x 3-3/4 [117 x 95]
V8-210-IF	157 @ 2400	157 @ 2400	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	168 @ 2600	168 @ 2600	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	174 @ 2800	174 @ 2800	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	182 @ 3000	182 @ 3000	Natural	8	4-5/8 x 3-3/4 [117 x 95]
	185 @ 3300	185 @ 3300	Natural	8	4-5/8 x 3-3/4 [117 x 95]

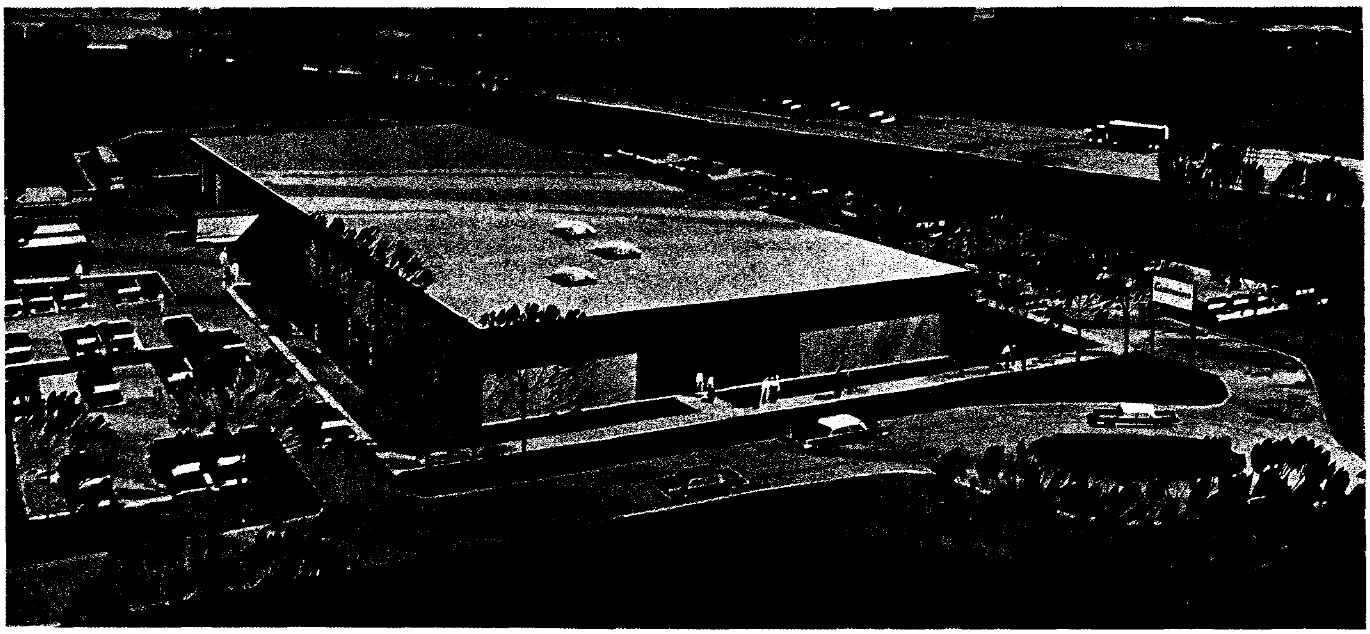
* Underwriters' Laboratories Ratings –

If permanently stationed at altitude above sea level, engines with above Underwriters' Laboratories Ratings should be derated 5% for each 1000 ft. [304.8 m] above sea level.

To The Engine Owner

All new Cummins Engines should be made available to a Cummins Distributor or Dealer within the first 200 hours or 90 days of operation, whichever occurs first, who are authorized to perform new engine inspection to assure proper engine performance.

When a Cummins Engine is shipped from the factory, a detachable engine inspection tag is a part of the engine data plate. This tag is 1-1/4 inch long and has the engine model and serial number stamped on it. This tag is not to be removed from the nameplate until the new engine inspection is performed as Cummins Engine Company, Inc. may not honor an inspection claim unless this tag accompanies the report of new engine inspection when submitted by the inspecting Dealer or Distributor. If this tag is missing prior to the new engine inspection, please notify the Dealer/Distributor from which the engine was purchased.



New engine inspection check list consists of the following:

1. CHECK BEFORE STARTING ENGINE
Engine and Accessory Mountings for Fuel, Lubricating Oil, and Coolant Leakage
Fuel System Installation
Lubricating Oil System Installation, Lubricating Oil Level, and Oil Pan Drain Plug Torque
Cooling System Installation and Coolant Level
Air Cleaner
Engine Breather
All Belt Tension

2. CHECK WHILE OPERATING ENGINE
For Unusual Noises
Throttle Operation
Fuel, Lubricating Oil, Coolant Leakage
Operation of Gauges and Controls
Lubricating Oil Pressure
Engine Performance
Air Induction System
Exhaust System

3. ADJUSTMENTS
Injectors
Crossheads
Valves

4. INSTRUCT OWNER IN
Changing Fuel and Lubricating Oil Filters
Changing Lubricating Oil
Use of Proper Fuel Oil
Operating Temperature
Starting and Stopping Procedure
Damages Caused By Over-Speeding
Use of Corrosion Inhibitor and Antifreeze
Use of Cold Starting Device
Air Cleaner Maintenance
Belt Maintenance

Operating Instructions

The engine operator must assume responsibility of engine care while engine is being operated. There are comparatively few rules which the operator must observe to get the best service. from a Cummins Diesel, such as increased engine efficiency, less down time and lower repair bills.

General—All Applications

Pre-Starting Instructions — First Time

Priming The Fuel System

1. Fill fuel tanks and filter(s) with clean No. 2 diesel fuel oil meeting the specifications in Section 3.

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

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

2. If injector and valve or other adjustments have been disturbed by maintenance work, be sure they have been properly adjusted before starting engine.

Priming The Lubricating System

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

1. Fill crankcase to "L" (low) mark on dipstick. See Lubricating Oil Specifications, Section 3.

Note: Most V-1710 Engine dipsticks have dual markings with high and low-level marks; static oil marks on one side and engine running at low idle speed marks on opposite side. Be sure to use proper scale.

2. Remove plug from head of lubricating oil filter housing (Fig's. 1-1 and 1-2) or gear case to prime system.

Caution: Do not prime engine lubricating system from by-pass filter.

3. Connect a hand or motor driven priming pump line from source of clean lubricating oil to plug boss in housing. Prime until a 30 psi [2.1 kg/sq cm] minimum pressure is obtained.

4. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [1.1 kg/sq cm].

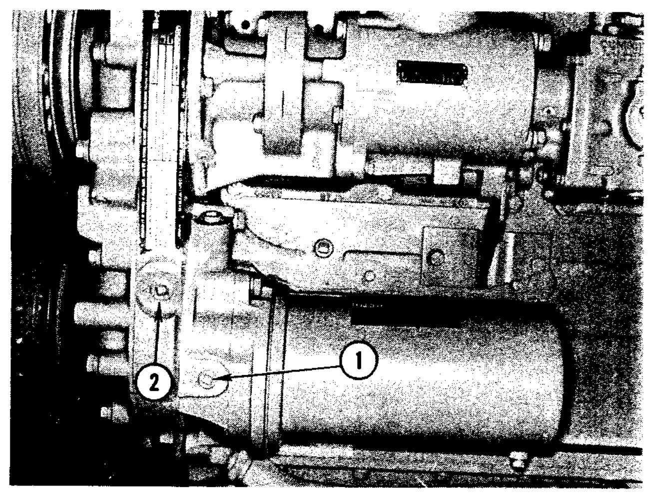


Fig. 1-1 (N11963) Lubricating system priming point - inline engine

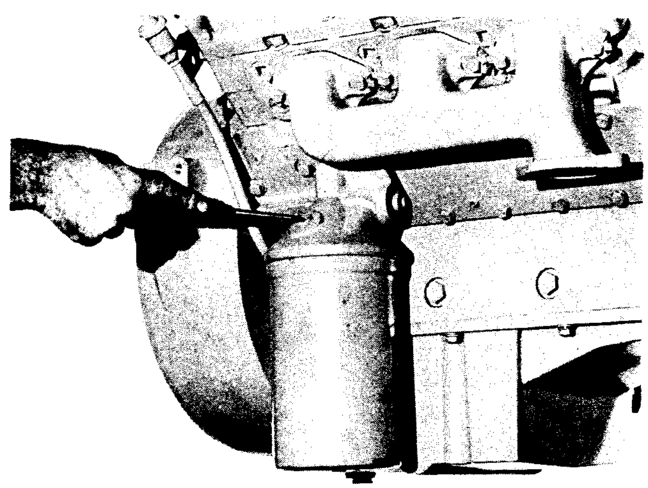


Fig. 1-2 (V11466) Lubricating system priming point - small V-engine

5. Remove external oil supply line and replace plug.

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

6. Finish filling crankcase to "H" (high) mark on dipstick.

Check Hydraulic Governor

Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps which use lubricating oil as an energy medium, same weight as used in engine. Oil level in governor sump must be at full mark on dipstick.

Check Air Connections

Check and make sure air connections to compressor and air equipment, as used, and to air cleaners and air crossover are tight.

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check engine coolant supply. Add coolant as needed.

Note: If cooling capacity is over 36 gal. [136.3 lit], add treated make-up water. See Section 3.

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

New And Rebuilt Engine Break-In

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

In other applications, the operator has an opportunity to establish conditions for optimum service life during initial 100 hours of service by:

1. Operating as much as possible in half to three-quarter throttle or load range and avoiding operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of five minutes.

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

3. Watch engine instruments closely during operation and reduce rpm if oil temperature reaches 250 deg. F [121 deg. C] or coolant temperature exceeds 190 deg. F [88 deg. C]. Check oil level every 10 hours during the break-in period.

Normal Starting Procedure

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

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

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

Note: On engines equipped with an oil pressure safety switch, hold the fuel by-pass switch in "start" position until engine oil pressure reaches 7 to 10 psi [0.5 to 0.7 kg/sq cm]; then, move to "run" position.

2. Set throttle for idle speed and disengage driven unit.

Caution: Protect the turbocharger during start-up by not opening throttle or accelerating above 1000 RPM until idle speed oil pressure registers on gauge.

3. Open manual fuel shut-down valve, if so equipped. Electric shut-down valves operate as switch is turned on. A manual override knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, turn fully clockwise; return to run position after electric repair.

4. Pull the compression release (if so equipped) and press started button or turn switch-key to "start" position. After three of four seconds of cranking, close compression release (if so equipped) and continue to crank until engine fires.

5. After engine has run for a few minutes, shut it down and wait 15 minutes for oil to drain back into pan. Check engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick. The drop in oil level is due to absorption by oil filter and filling of oil cooler.

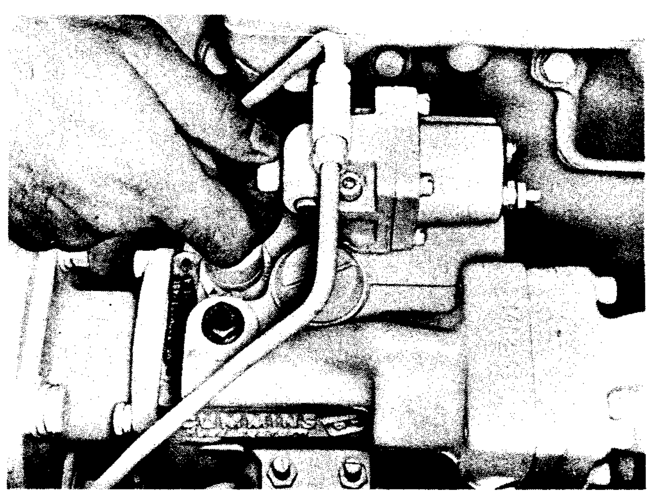


Fig. 1-3 (V21970) Using manual override knob

Cold-Weather Starting

Pre-Heater

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

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

To use preheater for cold starting:

1. Set throttle in idle position. Turn glow plug toggle switch to "ON" position. Red indicator light must be on.

2. 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 [5.6 to 7.0 kg/sq cm] fuel pressure. Use of primer before the 20-second interval will wet glow plug and prevent heating.

3. If engine does not start within 30 seconds, stop cranking. Wait one or two minutes and repeat cranking operation.

4. 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.

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

6. If engine gives no indication of starting during first three full strokes of preheater pump, touch-check intake manifold for heat. If no heat, check electrical wiring. If wiring is all right, remove 1/8 inch pipe plug (1, Fig. 1-4) from manifold near glow plug and close glow plug manual switch for 15 seconds and observe glow plug through 1/8 inch pipe plug hole. The glow plug should be white hot; if not, connect wiring to a 6- or 12-volt (as used) source and check amperage; it should be 30 to 32 (minimum). If glow plug is all right, check manual switch and resistor (if used) and replace if necessary.

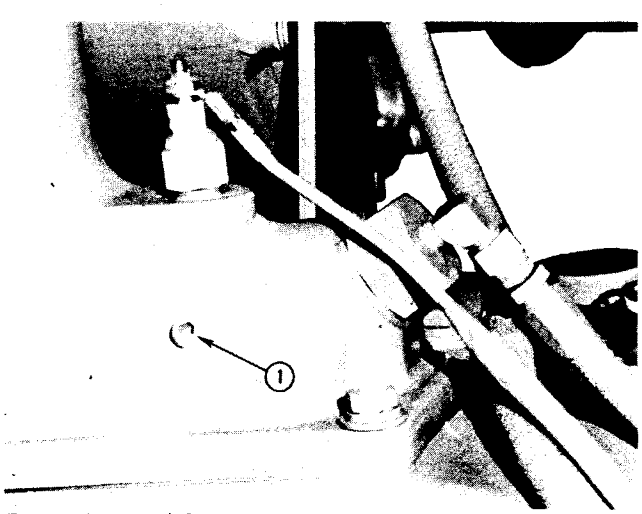


Fig. 1-4 (N11949) Glow plug inspection hole plug - NT engine

Spray Nozzle Application Of Starting Fluid

Cold-starting fluid should never be used with any type preheater system. Serious damage could result.

Spray nozzle assembly consists of a control knob operated by a flexible cable and cable housing attached to container, bracket mounted on unit (1, Fig. 1-5). Pulling knob, in cab, releases spray through a small plastic hose (2) into spray nozzle (3) located in intake crossover connection or air intake manifold. Small orifice holes in spray nozzle must be positioned to allow fluid to spray into both left bank and right bank intake manifolds of V type engines. Do not hold knob any longer than 2 seconds at any one time.

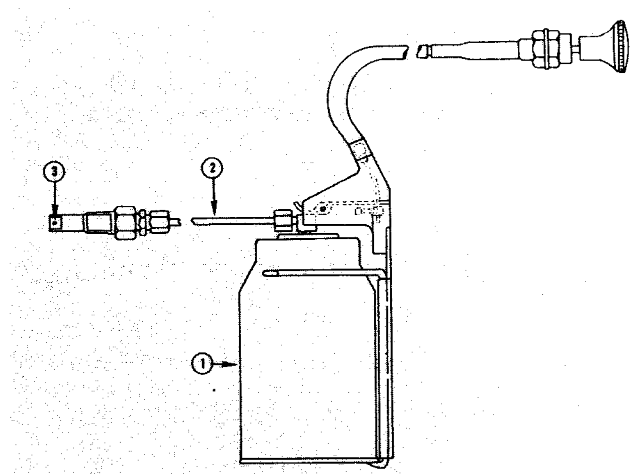


Fig. 1-5 (V11469) Starting fluid spray applicator

If engine does not start after first 2 seconds of spray application, wait 1 or 2 minutes and repeat starting procedure. In extreme cold weather conditions, if unit will not start with above instructions, remove starting fluid can and warm to room temperature; check spray nozzle in intake connection to be sure orifice holes are free of foreign material. Install can and repeat normal starting procedure.

Use Of Ether Without Metering Equipment

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

Warning: Never handle ether near an open flame. Never use

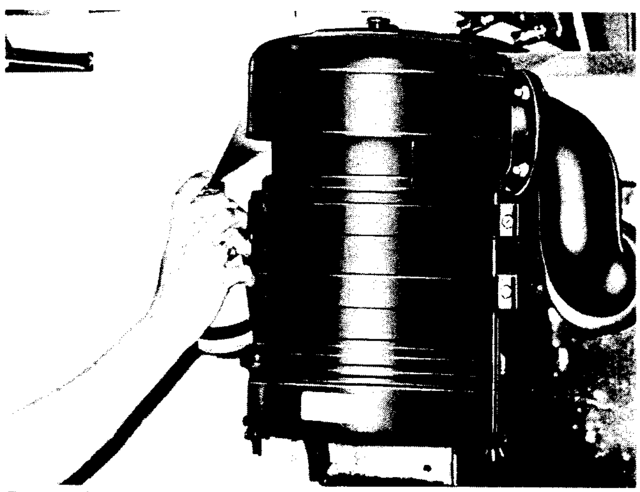


Fig. 1-6 (N11807) Ether spray application

it with preheater or flame thrower equipment. Do not breathe the fumes. Use of too much ether will cause excessively high pressures and detonation.

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

Warning: Fuel oil or volatile fuel cold starting aids are not to be used in underground mine or tunnel operations. If the engine is so equipped check with the local U.S. Bureau of Mines Inspector for use of starting aid.

Engine Warm-Up

The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature; bring the engine up to operating speed gradually as it warms up. Allow the engine to run at 800 to 1000 rpm for 4 to 5 minutes or preferably until water temperature reaches 140 deg. F [60 deg. C] before engaging load. Operate at approximately 75% of governed rpm until water temperature reaches 160 to 165 deg. F [71 to 74 deg. C].

Engines on emergency or stand-by service normally are located indoors and/or are equipped with some type oil or water heating device to maintain oil and coolant temperatures high enough to permit full load to be applied immediately after start up.

Engine Speeds .

In most applications engine idle speeds are 520 to 650 rpm; however, the parasitic load may require a slightly higher speed to smooth out operation.

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

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 the fuel needed for idling when the throttle is in idle position. Second, it overrides the throttle and shuts off fuel if engine rpm exceeds maximum rated speed.

Speeds listed in Table 1-1 are for engines rated at maximum rpm and fuel rate.

Table 1-1: Engine Speeds (RPM)

Engine Model	Maximum Rated	Normal Operating
All NH NT,855-R,855-L	2100	1900-2000
All NH-NT	2300	1950-2100
V-903, VT-903	2600	2200-2300
V-378, V-504, V-555	3000	2500-2550
V-378, V-504, V-555	3300	2800-2850
C-464	2500	2150-2250
V-1710, V-1710-L	2100	1800-1900

Note: Engines in many applications are applied at a lower than maximum rated speed, check the nameplate.

Rated engine speed is the rpm attained at full load. Governed engine speed is the highest rpm a properly adjusted governor will allow the engine to turn, no load. Governed engine speed must never be exceeded.

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

Maximum Horsepower Requirements

Maximum horsepower is attained only at rated engine rpm. Whenever engine rpm is pulled down by overload, horsepower is lost and continues to be lost as long as the engine continues to lose rpm. When full horsepower is needed, operate engine as near rated rpm as possible. This rule applies to all applications.

Always operate so power requirement will allow the engine to accelerate to governed rpm when advancing to full throttle.

Oil Temperature

The oil temperature gauge normally should read between 180 deg. F [82 deg. C] and 225 deg. F [116 deg. C]. Under full load conditions, an oil temperature of 265 deg. F [129 deg. C] for a short period is not cause for alarm.

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

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

Water Temperature

A water temperature of 165 to 195 deg. F [74 to 91 deg. C] is the best assurance that working parts of the engine have expanded evenly to the most favorable oil clearances. Maximum engine coolant temperatures should not exceed 200 deg. F [93 deg. C].

Keep thermostats in the engine summer and winter, avoid long periods of idling, and take necessary steps to keep water temperature up to a minimum of 165 deg. F [74 deg. C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

Oil Pressure

Normal engine oil pressures at 225 deg. F [107 deg. C] are:

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

Engine Series	Idle Speed	Rated Speed
NH-NT,855-R,855-L	5/20 [0.4/1.7]	30/70 [2.1/4.9]
C-464	10/30 [0.7/2.1]	40/75 [2.8/5.3]
V-903,VT-903	5/25 [0.4/1.8]	40/65 [2.3/4.6]
V-378,V-504,V-555	10/25 [0.7/1.8]	45/75 [3.2/5.3]
V-1710,V-1710-L	15 [1.0] min.	50 [3.5] min.

Note: Individual engines may vary from above normal pressures. Observe and record pressure when engine is new to serve as a guide for indication of progressive engine condition. (High oil pressure during start-up is not cause for alarm). For record purposes these readings are more accurate and reliable when taken immediately after an oil change.

Engine Exhaust

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

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

High Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.8 m] of altitude above sea level for a naturally aspirated engine. Operate using a lower power requirement at high altitude to prevent smoke and over-fueling.

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

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

2. Engine will not idle if SVS lever is in power take-off speed position and throttle is in idle position. Operate as follows:

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

b. Set throttle 600 to 800 rpm above idle.

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

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

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

3. To return to standard throttle control:

a. Use standard throttle and decrease engine speed until power take-off may be disengaged.

b. Disengage power take-off and shift SVS governor lever to high-speed position.

c. Return throttle to idle position and resume operation of unit.

Caution: Never return standard throttle to idle position while SVS governor lever is in low speed or power take-off position or engine will fail to idle properly.

4. SVS governor should not be used with power take-off speeds lower than 1100 rpm; for these applications use MVS governor.

Engine Shut-Down

Idle Engine A Few Minutes Before Shut-Down

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

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, the turbocharger temperature may rise as much as 100 deg. F [47 deg. C].

The engine can be shut down completely by turning off the switch key on installations equipped with an electric shut-down valve, or by turning the manual shut-down valve lever. Turning off the switch key which controls the electric shut-down valve always stops the engine unless override button on shut-down valve has been locked in open position. If manual override on electric shut-down valve is being used, turn button full couterclockwise to stop engine.

Caution: Never leave switch key or override button in valve open or run position when engine is not running. With overhead tanks this would allow fuel to drain into cylinders, causing hydraulic lock.

The compression release lever, Fig. 1-7, can be used as an aid in cranking, before starting, or while making injector and valve adjustment, but not to stop the engine.

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning before parts fail and ruin the engine. Many engines are saved because alert

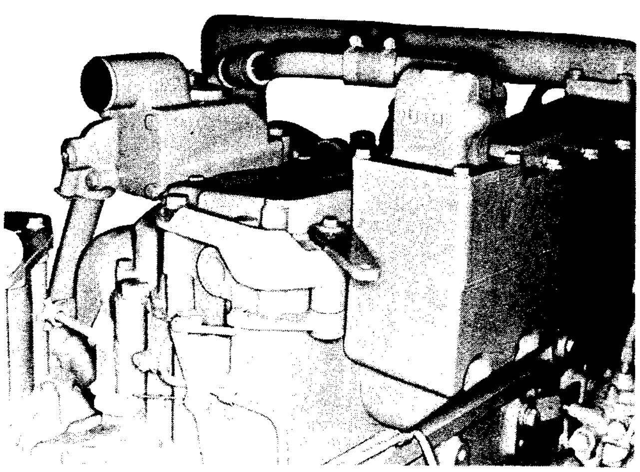


Fig. 1-7 (N114178) Compression release lever

operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine.

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. Drain cylinder block and heads on all engines by opening petcocks and removing drain plugs as shown in Fig's. 1-8 to 1-14. If an air compressor, heat exchanger or other "water cooled" accessory is used, open petcock and drain. Failure to properly drain engine and accessories may cause serious damage during freezing weather.

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

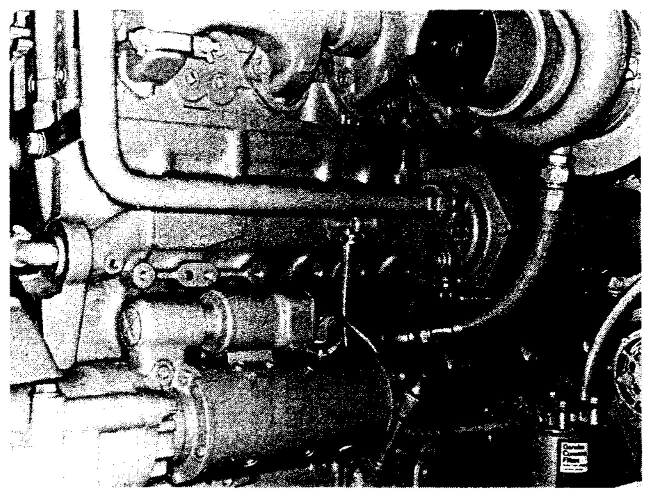


Fig. 1-8 (N100124) NH or NT-855 Cylinder block drain point

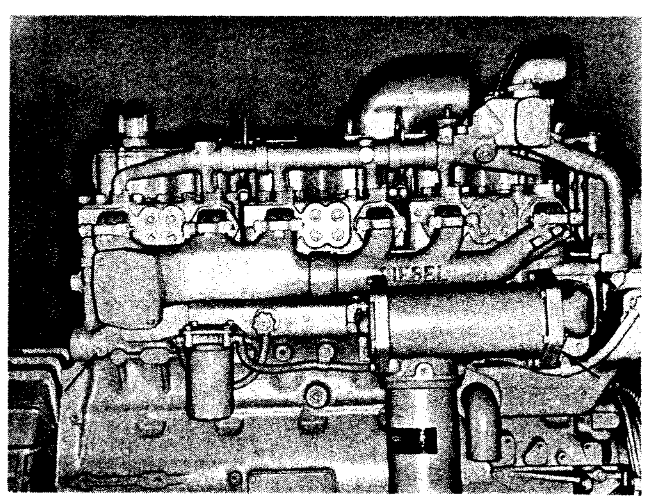


Fig. 1-9 (N100126) 927 C.I.D. engine coolant drain points

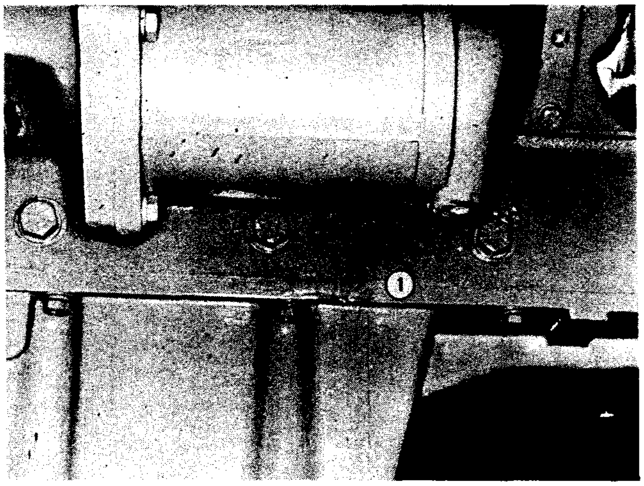


Fig. 1-10 (V10819) Coolant drain point (oil cooler side) V Series

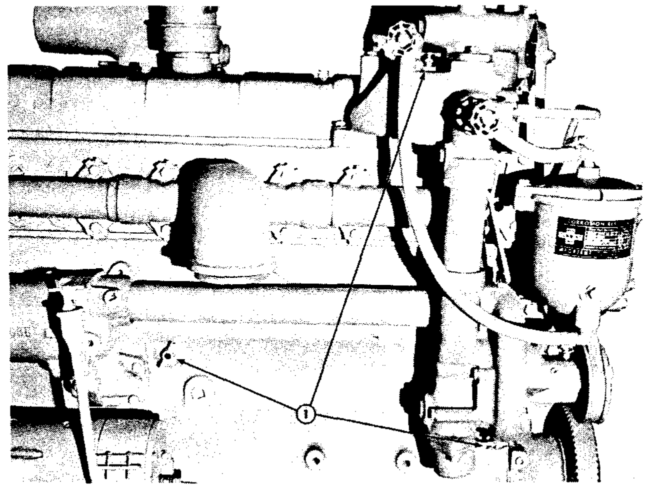


Fig. 1-13 (N20001) Coolant drain point C Series

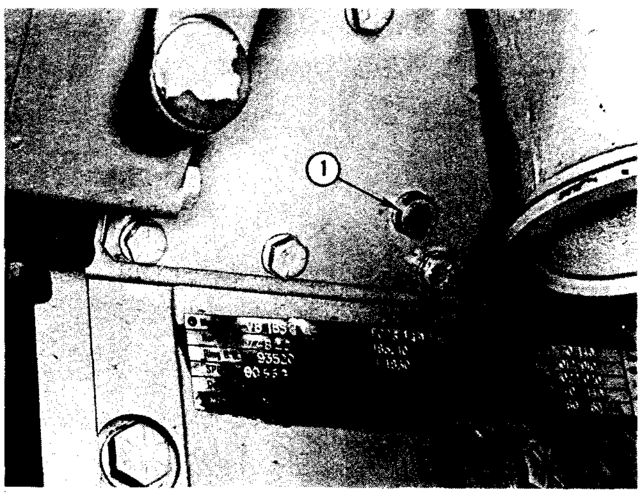


Fig. 1-11 (V10820) Coolant drain point (left bank side) V Series

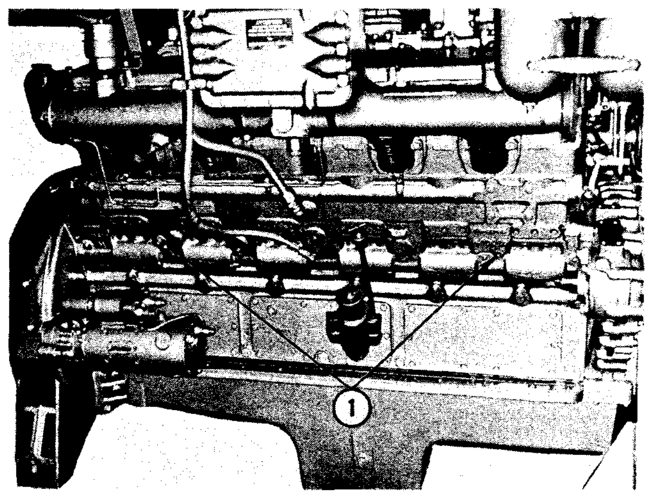


Fig. 1-14 (V41930) Coolant drain point V-1710 Series

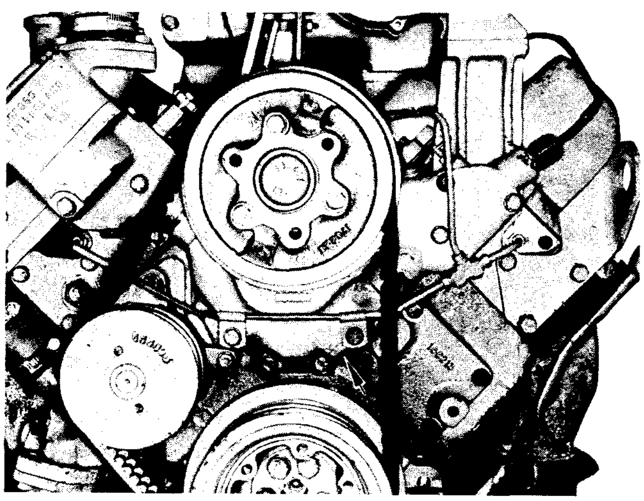


Fig. 1-12 (V10821) Coolant drain point (front water crossover) V Series

Operator's Daily Report

Make A Daily Report Of Engine Operation To The Maintenance Department

The engine must be maintained in top mechanical condition to get utmost satisfaction from its use. The maintenance department needs daily running reports from the operator to make necessary adjustments in time allotted and to make provisions for more extensive maintenance work as reports indicate necessity.

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

Report to the Maintenance Department any of the following conditions:

1. Low lubricating oil pressure.

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

Industrial Fire Pump Engines

Fire pump engines are built and applied under conditions set down by agencies such as Underwriters Laboratory; therefore, parts originally supplied must not be deviated from without qualifying agency approval. The following instructions are those special items necessary to this application, and should be used in conjunction with those previously stated.

Starting And Testing

Manual Start System (Identified by one contactor (A, Fig. 1-15) and one magnetic switch (B, Fig. 1-15).

1. Contact operating personnel responsible for fire protection system before starting to familiarize yourself with any special equipment or accessories.

2. Assure that pre-lubing has been completed and pre-heaters are in operation, because engine will immediately come to full speed and load upon starting.

3. Operate engine for sufficient period of time to reach stabilized temperature.

4. Record speed, temperatures and pressures. Check for leaks.

5. With approval from operating personnel, shut engine down and perform any repairs necessary.

Note: Fuel pump must be left in full load position per qualifying agencies.

Automatic Start System (Identified by two contactors (A, Fig. 1-15) and two magnetic switches (B, Fig. 1-15).

1. Contact operating personnel responsible for fire protection system.

2. Follow operating personnel's starting procedure.

3. Assure that prelubing has been completed and preheaters are in operation.

4. Observe operation of automatic system:

a. Disconnect fuel solenoid lead to prevent engine from starting.

b. Place Automatic/Manual Selector switch in manual position. Engine should crank predetermined amount of time on one system, pause and transfer to other system. This can be verified by observing the emergency start

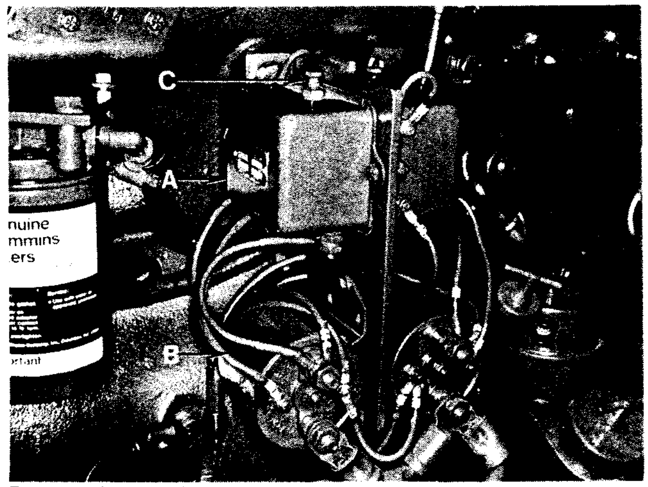


Fig. 1-15 (V12014) Magnetic switches and contactors

button (C, Fig. 1-15) on the other contactor.

c. Reconnect fuel solenoid lead.

5. Using starting procedure, start engine.

6. Operate engine for sufficient period of time to reach stabilized temperature.

7. Record speed, temperatures and pressures. Check for leaks.

8. With approval from operating personnel, shut down engine and perform any repairs necessary.

Note: Fuel pump must be left in full load position per qualifying agencies.

Overspeed Switch Adjustment

The speed switches required for overspeed protection on fire pump engines require high speed for the overspeed adjustment.

Caution: These speeds may be sufficient to damage the pump. An adapter, ST-1224 with 2:1 ratio, is available to drive the tachometer and speed switch at twice engine speed. This tool when installed in place of the existing adapter permits adjustment to be made to the speed switch at slightly over 1/2 engine and pump speed. This maintains a pump speed well within its safe speed range while adjustments are being made.

Adjustment Procedure

1. Remove present tachometer drive adapter.

2. Install service tool, ST-1224, in position of standard drive adapter. Connect tachometer and overspeed stop switch to the ST-1224 tool.

3. Start engine and warm to operating temperature.

4. Set engine speed to desired engine shut down speed as indicated by tachometer.

a. On inline engine models, this can be accomplished by adjusting vernier throttle control.

b. On small "Vee" engines the speed adjustment must be made by adjusting the governor idle and maximum speed screws. The idle screw is in the front of the MVS governor. The maximum speed screw is mounted to the MVS governor by a bracket and is on the left hand side of the fuel pump. Engine slow down is accomplished by turning the idle speed screw counterclockwise and turning the maximum speed screw in a clockwise direction. To increase engine speed, reverse the procedure.

5. Set single element speed switch.

a. Loosen three (3) set screws. Rotate cover clockwise (this decreases trip speed) until switch actuates and stops engines. Secure set screws.

b. On manual reset models, reactivate the switch by pushing the reset button on top of switch.

6. Set dual element speed switches.

a. Remove the round head dust cover screw marked 2 from top of switch.

b. Insert 1/16" Hex Allen wrench into adjusting screw located just below surface of cover.

c. Turn clockwise to lower the engine shut down speed. Counterclockwise to raise engine shut down speed.

Caution: Do not turn adjusting screw more than 3 revolutions in either direction from factory setting. Do not attempt to set dual element switch in same manner as the single element switch.

d. Replace the dust cover screw.

e. On manual reset models, reactivate the switch by pushing the reset button on top of switch.

7. Replace service tool, ST-1224, with original drive adapter and reconnect cables.

Maintenance Operations

Maintenance is the key to lower operating costs. A diesel engine requires regularly scheduled maintenance to keep it running efficiently.

Maintenance Schedule

Preventive maintenance is the easiest and least expensive type of maintenance. It permits the Maintenance Department to do the work at a convenient time.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of the engine governs the maintenance schedule. The suggested check sheet on the following page indicates some checks have to be performed more often under heavy dust or other special conditions.

Extending The Maintenance Schedule

Any change in the established maintenance schedule should be preceded by a complete re-analysis of the operation. A lubricating oil analysis should be the major factor used in establishing the original maintenance schedule; it should be studied before making any change in or extending the schedule periods.

Using The Suggested Schedule Check Sheet

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

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

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

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

Storage For Engines Out Of Service

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Contact the nearest Cummins Distributor or consult applicable Shop Manual for information concerning engine storage procedures.

Maintenance Schedule

CUMMINS DIESEL ENGINES

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

ENGINE SERIAL NO. ____________
HOURS, CALENDAR ____________
CHECK PERFORMED ____________
DATE ____________

Check each operation as performed.

A–CHECK
Pages 2-4, 2-8

- ☐ Daily

Lubrication
- ☐ Check Engine Oil Level
- ☐ Check Oil Bath Cleaner Oil Level

Fuel System
- ☐ Drain Sediment from Fuel Tanks

Air System
- ☐ Clean Pre-Cleaner Dust Pan
- ☐ Check Air Cleaner Restriction
- ☐ Clean/Change Air Cleaner Element
- ☐ Change Oil Bath Cleaner Oil

Cooling System
- ☐ Check Coolant Level

Other Maintenance
- ☐ Drain Air Tank
- ☐ Check Leaks, Correct

B–CHECK
Pages 2-9, 2-19

- ☐ Repeat "A"

Lubrication
- ☐ Change Engine Oil
- ☐ Change Engine Full-Flow Oil Filter
- ☐ Change By-Pass Filter
- ☐ Record Oil Pressure

Fuel System
- ☐ Check Aneroid Oil
- ☐ Check Hyd. Gov. Oil
- ☐ Check Throttle Linkage
- ☐ Adjust Injectors and Valves [2]
- ☐ Change Fuel Filter
- ☐ Clean Fuel Tank Breather

Air System
- ☐ Clean/Change Crankcase Breather
- ☐ Check Air Piping
- ☐ Clean Oil Bath Air Cleaner Tray Screen
- ☐ Clean/Change Air Compressor Breather Element

Cooling System
- ☐ Change Water Filter
- ☐ Check/Adjust Belts

Other Maintenance (None)

C–CHECK
Pages 2-20, 2-30

- ☐ Repeat "A" and "B"

Lubrication
(None)

Fuel System
- ☐ Adjust Injectors and Valves
- ☐ Change Hyd. Governor Oil
- ☐ Change Aneroid Oil
- ☐ Check Aneroid Adjustment
- ☐ Replace Aneroid Breather

Air System
- ☐ Check Vent Piping
- ☐ Clean Oil Bath Air Cleaner

Cooling System
- ☐ Clean Radiator – External
- ☐ Check Fan Hub Idler and Water Pump

Other Maintenance
- ☐ Inspect Units Replace as Required (Alternator/ Generator, Starter, etc.)
- ☐ Check Air Compressor
- ☐ Check Vibration Damper

D–CHECK
Pages 2-31, 2-33

- ☐ Repeat "A, B and C"

Lubrication
(None)

Fuel System
- ☐ Clean and Calibrate Injectors
- ☐ Replace Fuel Pump Filter Screen and Magnet
- ☐ Check Fuel Pump Calibration
- ☐ Replace Aneroid Bellows and Calibrate

Air System
- ☐ Clean Turbocharger Compressor Wheel and Diffuser
- ☐ Check Turbocharger Bearing Clearance
- ☐ Tighten Manifold Nuts or Capscrews

Cooling System
(None)

Other Maintenance
- ☐ Steam Clean Engine
- ☐ Tighten Mounting Bolts and Nuts (as Required)
- ☐ Check Crankshaft End Clearance
- ☐ Check Fan Hub and Drive Pulley

E–CHECK
Pages 2-34

- ☐ Repeat "A, B, C and D"
- ☐ This Maintenance Check is often referred to as "In-Frame Inspection" where some key parts, such as bearings, are checked for wear to determine if the engine may be operated for another service period. Likewise, oil consumption oil pressure and other signs of wear should be analyzed during the check. Wear limits and other information is available from Cummins Distributors and Dealers.

SEASONAL
Pages 2-35, 2-36

- ☐ Clean Cooling System
- ☐ Replace Hose as Required
- ☐ Clean Electric Connections
- ☐ Check Cold Start Aid
- ☐ Check Thermal Controls
- ☐ Check Heat Exchanger Zinc Plugs

Engine Series	Interval [1]	B	C	D	E	Seasonal
C-464	Hours	200	1000	3000	6000	
V-378, V-504	Hours	200	1000	3000	6000	
V-555						
V-903, VT-903	Hours	250	2000	4000	8000	
N-743, N-855,	Hours	250	2000	4000	8000	
N-927	Hours	250	2000	4000	8000	
V-1710	Hours	250	2000	4000	8000	
	Calendar	3 mo.	1 year	2 year	4 years	

Note: 1. Perform checks on operating basis of interval that occurs first. Normally calendar period is used only when hours are less than 1/3 that suggested during the three (3) month period.
2. At first oil change or initial inspection, adjust injectors and valves, thereafter at "C" Check.

Attention Owner

This Section sets forth the maintenance schedule which should be followed.

To prove that engine has been properly maintained retain records, such as work orders and receipts, showing that scheduled maintenance has been performed.

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

Maintenance Performance Record

Engine Serial No. ______________________ *Engine Model* ______________________

Owner Name ______________________ *Equipment Name/Number* ______________________

Interval Basis Hours	Calendar	Check	Date	Actual Hours	Distributor/Dealer Location/Shop	Authorized Signature
		AB				
		AB				
		AB				
		AB				
		AB				
		AB				
		AB				
		ABC				
		AB				
		AB				
		AB				
		AB				
		AB				
		AB				
		AB				
		ABCD				

'A' Maintenance Checks

Lubrication

Check Engine Oil Level

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.

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

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

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

Check Oil Bath Cleaner Oil Level

Daily check oil level, Fig. 2-1, in oil bath air cleaner to be sure oil level in oil cup is at indicated mark. Refill as required.

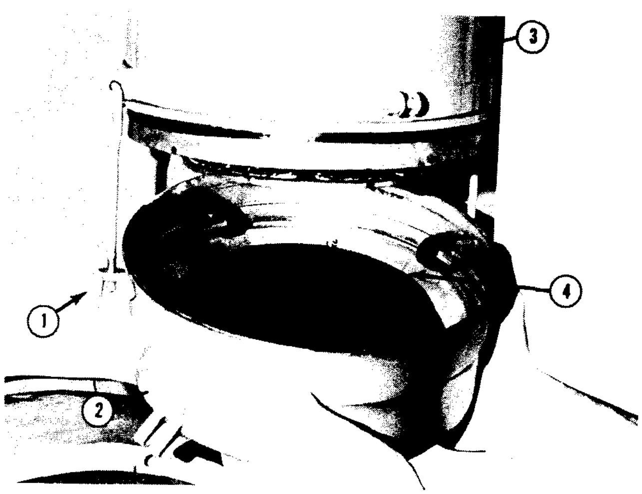


Fig. 2-1 (N11001) Checking oil level in air cleaner

Fuel System

Drain approximately 1 pint of fuel from each tank to remove water and sediment.

Air System

Clean Pre-Cleaner And Dust Pan

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 operation conditions.

Check Inlet Air Restriction Gauge

A mechanical restriction gauge is available to indicate excessive air restriction through a dry-type air cleaner. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The restriction indicator signals when to change cartridges. The red flag (1, Fig. 2-2) in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. After changing cartridge, reset indicator by pushing reset button (2).

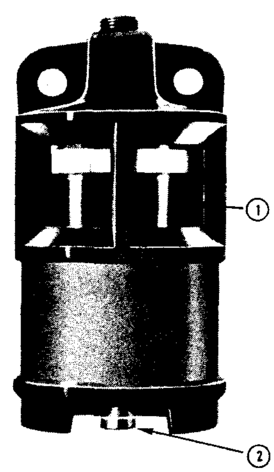


Fig. 2-2 (CGS20) Air inlet restriction gauge

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

Vacuum switches, Fig. 2-3, are available which actuate a warning light on the instrument panel when air restriction becomes excessive.

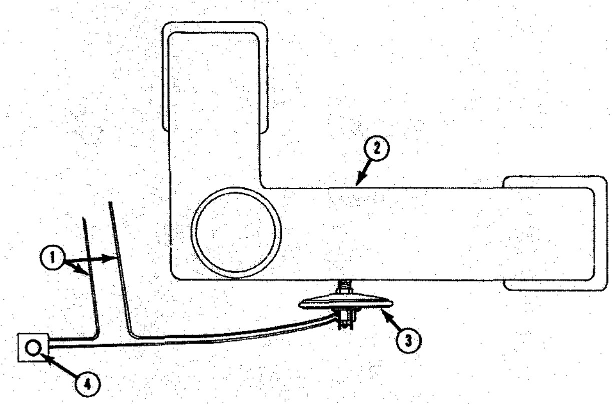


Fig. 2-3 (V11010) Vacuum switch to check air inlet restriction

Check Air Inlet Restriction Systems Without Indicator Gauge

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

1. On naturally aspirated engines, attach vacuum gauge or water manometer in middle of intake manifold or on air intake piping. When located in air intake piping, adapter must be perpendicular to air flow and not more than 6 inches [152.4 mm] from air intake manifold connection. Also, air restriction readings may be taken at air cleaner outlet pipe, the adapter must be mounted perpendicular to air flow.

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

3. When checking at the engine intake manifold or turbocharger inlet, idle engine until normal operating temperature is reached.

4. Operate engine at rated speed and take reading from vacuum gauge or manometer.

a. Air restriction must not exceed 25 inches [635.0 mm] of water or 1.8 inches [45.72 mm] of mercury at intake manifold.

b. At the air cleaner outlet, restriction must not exceed 20 inches [508 mm] of water or 1.5 inches [38.1 mm] of mercury.

5. If air restriction exceeds limits in Step 4 above:

a. Clean or replace dry-type cleaner element.

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

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

Clean Air Cleaner Elements

The paper element in a dry-type air cleaner, Fig's. 2-4, 2-5 and 2-6, may be cleaned several times by using air to blow off dirt or by washing with nonsudsing household detergent and water at 120 to 140 deg. F [49 to 60 deg. C], then drying with compressed air, approximately 40 psi [2.8 kg/sq cm]. Do not hold air jet too close to paper element.

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.

Caution: Holes, loose end seals, dented sealing surfaces and other forms of damage render cleaner inoperative and require immediate element replacement.

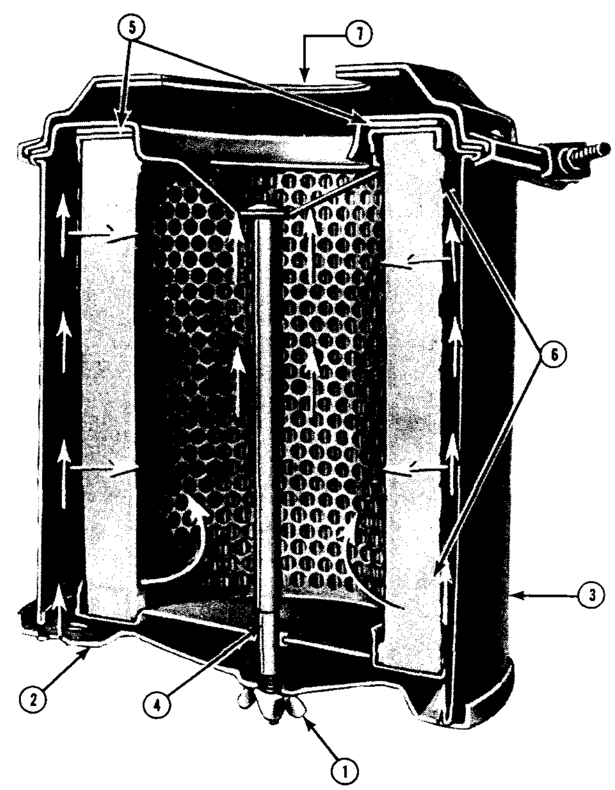


Fig. 2-4 (N11003) Air cleaner (dry-type)

To change element:

1. Loosen wing nut (1, Fig. 2-4) securing bottom cover (2) to cleaner housing (3). Remove cover.

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

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

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

Heavy Duty Dry-Type Air Cleaners

Heavy duty air cleaners (single and dual types) combine centrifugal cleaning with element filtering, Fig's. 2-5 and 2-6, before air enters engines.

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

1. Loosen wing bolt, remove band securing dust pan (1, Fig. 2-5), (2, Fig. 2-6).

2. Loosen wing nut (2, Fig. 2-5 and 3, Fig. 2-6), remove dust shield (3, Fig. 2-5), (4, Fig. 2-6), from dust pan (1, Fig. 2-5), (2, Fig 2-6), clean dust pan and shield.

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

4. Blow out element from clean air side with compressed air not exceeding 100 psi [7 kg/sq cm].

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

6. Inspect element after cleaning.

7. Install new or cleaned primary element.

8. Be sure gasket washer is in place under wing nut before tightening.

9. Reassemble dust shield and dust pan, position to air cleaner housing and secure with band.

10. On dual element type Cyclopac cleaner:

a. Check air restriction indicator, if air restriction is excessive, disassemble air cleaner, remove wing nut (8, Fig. 2-6), and replace safety element (9).

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

Cartridge Type Air Cleaner Element

1. Loosen wing nuts (4, Fig. 2-7 or 2-8) on air cleaner

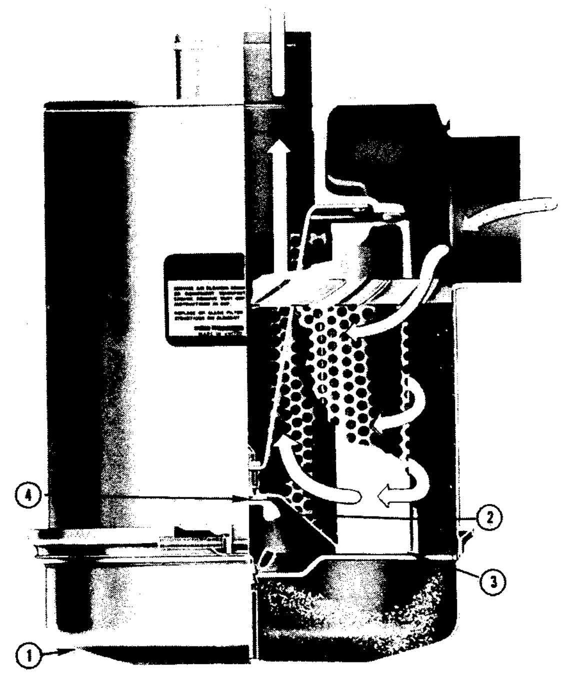


Fig. 2-5 (V10005) Air cleaner — heavy duty

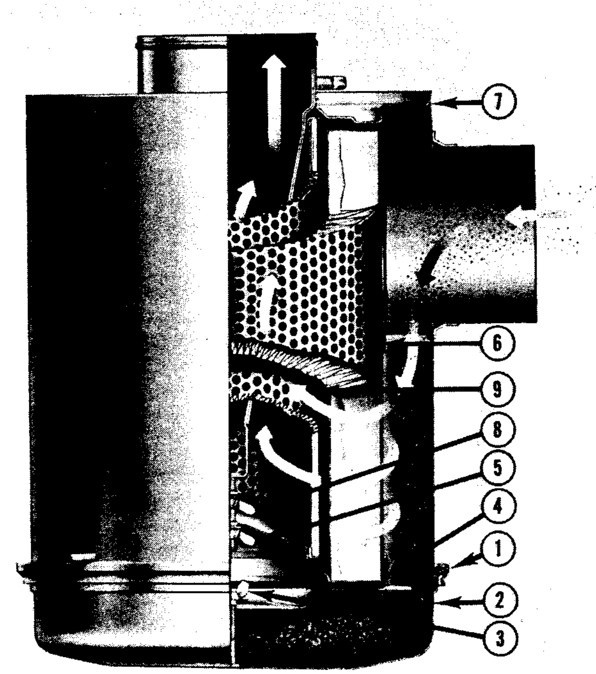


Fig. 2-6 (N11030) Air cleaner — heavy duty dual element

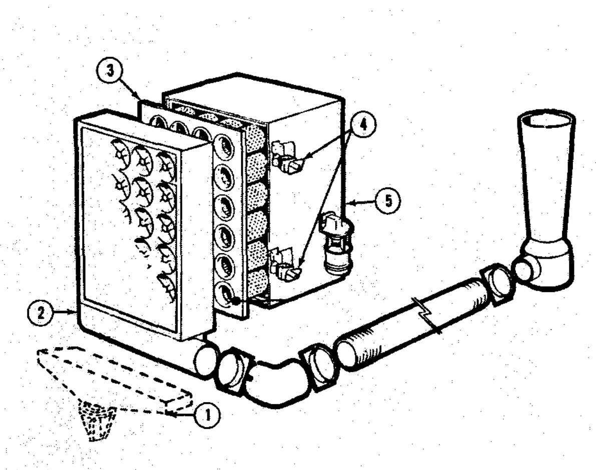


Fig. 2-7 (N21026) Air cleaner – cartridge type (two stage)

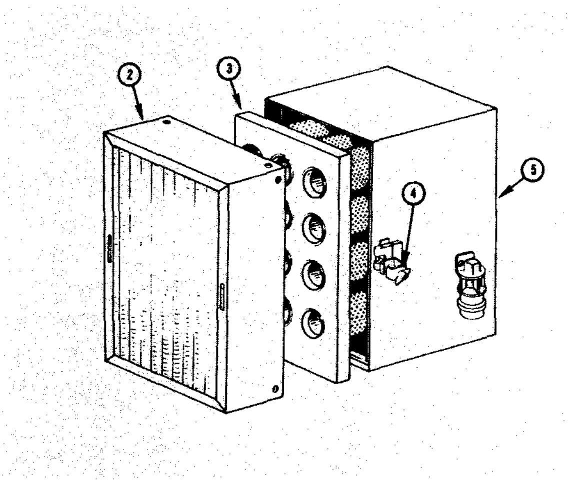


Fig. 2-8 (V11009) Air cleaner – cartridge type (single stage)

housing (5) to remove pre-cleaner panel with dust bin (1). To remove pre-cleaner panel (2) equipped with exhaust aspirator loosen "U" bolt clamp securing pre-cleaner to aspirator tubing.

2. Remove dirty Pamic cartridge (3), by inserting fingers in cartridge opening. Loosen all four corners of cartridge, one at a time, by pulling straight out.

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

Cleaning And Inspection

1. Clean pre-cleaner openings (2) of all soot, oil film and any other objects that may have become lodged in openings. Remove any dust or dirt in lower portion of pre-cleaner and aspirator tubing. Inspect inside of air cleaner housing for foreign material.

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

3. It is not recommended to clean and reuse cartridge. When returned to service, life expectancy of a paper cartridge will be only a fraction of original service life.

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

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

Assembly

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

2. To install a new cartridge, hold cartridge (3, Fig. 2-7 and 2-8) in same manner as when removing from housing. Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.

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

4. Replace pre-cleaner panel (2) and tighten wing nuts (4) by hand, for final tightness turn 1-1/2 to 2 turns with a small adjustable wrench. Do not overtighten. On pre-cleaner with exhaust aspirator, assemble aspirator tube to pre-cleaner panel and tighten "U" bolt.

5. Care should be taken to keep cleaner face unobstructed.

Change Oil Bath Air Cleaner Oil

Before dirt build-up reaches 1/2 inch [12.7 mm], remove oil cup from cleaner. Discard oil and wash cup in cleaning solvent or fuel oil.

Note: During wet weather and in winter months, changing of oil is equally as important as during dusty weather since the air cleaner inlet may be located in an air stream which carries moisture into the cleaner.

Fill oil cup to level indicated by bead on side with clean, fresh oil of the same grade as that in crankcase and assemble to cleaner. In extremely cold weather a lighter grade may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in oil bath air cleaners.

Caution: Never use dirty or used oil.

Cooling System

Keep cooling system filled to operating level. Check coolant level daily or at each fuel fill point. Investigate for causes of coolant loss. Check coolant level only when system is cool.

Other Maintenance

Drain Air Tank(s)

Open drain cock(s) and drain all moisture and sediment from air tank(s).

Check Leaks And Correct

1. Check for evidence of external air, coolant, fuel or oil leakage. Correct as necessary.

2. If there are indications of air leaks on suction side of fuel pump, check for air leaks by placing ST-998 Sight Gauge (1, Fig. 2-9) in the line between fuel filter(s) and pump. Bubbles or "milky" appearance indicate an air leak. Find and correct.

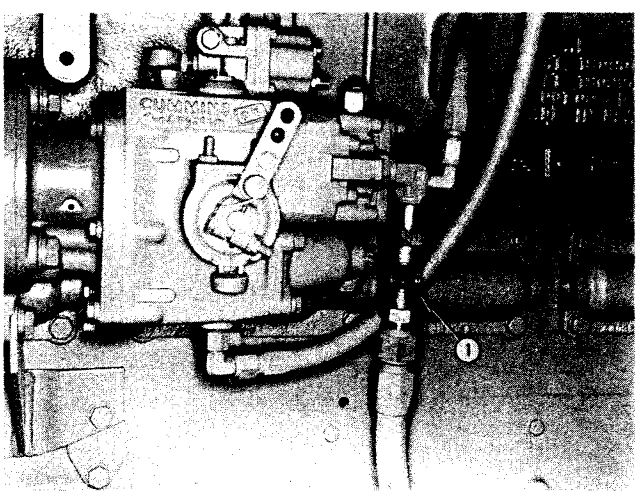


Fig. 2-9 (N11964) Checking air leaks with ST-998 Sight Gauge

'B' Maintenance Checks

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

Lubrication

Change Engine Oil

Factors to be checked and limits for oil analysis are listed below. Oil change at "B" Check, as shown in maintenance chart on Page 2-2, is for average conditions.

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

2. Install drain plug in oil pan. On Inline and V-903 Engines torque to 60 to 70 ft-lbs [8.0 to 9.7 kg m]. On V-378, V-504 and V-555 Engines torque to 35 to 40 ft-lbs [4.8 to 5.5 kg m]. On V-1710 Engines torque to 45 to 55 ft-lbs [6.2 to 7.6 kg m].

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

4. Start engine and visually check for oil leaks.

5. Shut down engine; allow 15 minutes for oil to drain back into pan; recheck oil level with dipstick. Add oil, as required.

Lubrication Oil Analysis

The most satisfactory method for determining when to change lubricating oil is by oil analysis using laboratory tests. A new series of tests should be run if filters, oil brands or grades are changed.

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

Analysis Test For Lubricating Oil

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

Oil Property	Test Number
Viscosity at 100 deg. F and 210 deg. F	ASTM-D445
Sediment	ASTM-D893
Water	ASTM-D95
Acid and Base Number	ASTM-D664

General Limits For Oil Change

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

2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210 deg. F [99 deg. C] or 25 percent increase at 100 deg. F [38 deg. C].

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

4. Acid Number: Total number 3.5 maximum.

5. Water content: 0.2 percent maximum.

6. Additive Reduction: 25 percent maximum.

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

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

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

2. Remove filter can and filter element. See Fig's. 2-10, 2-11, 2-12, and 2-13.

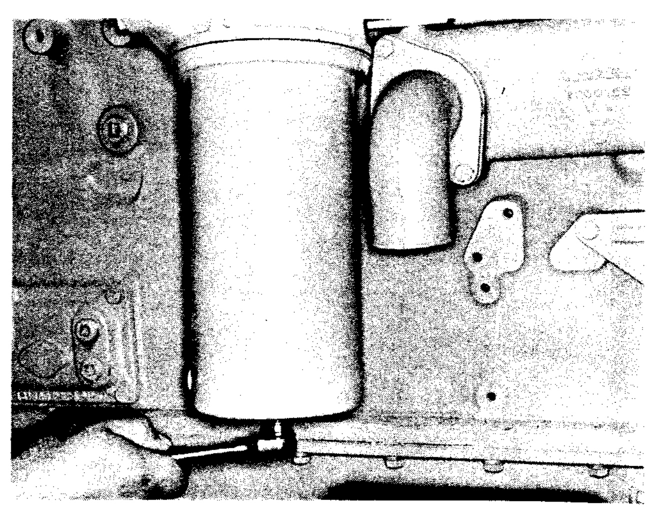


Fig. 2-10 (N10098) Removing lubricating oil filter, 927 C.I.D. Series

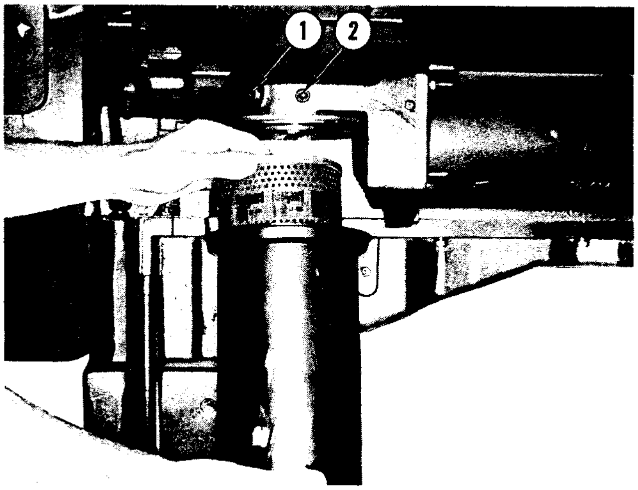


Fig. 2-11 (V51908) Removing lubricating oil filter element V-903

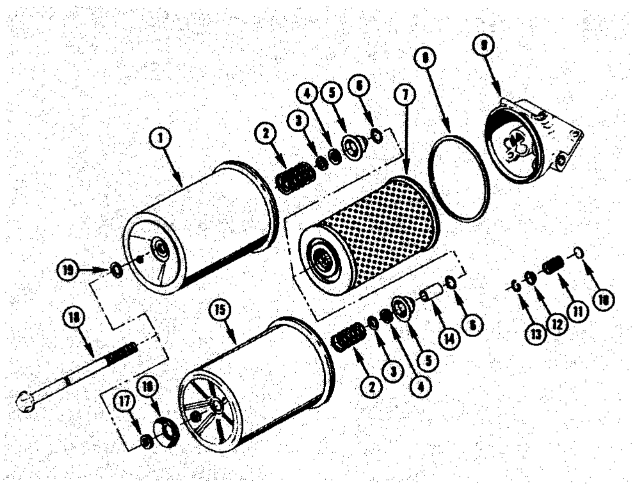


Fig. 2-12 (V10702) Full-Flow filter assembly V-378, V-504 and V-555

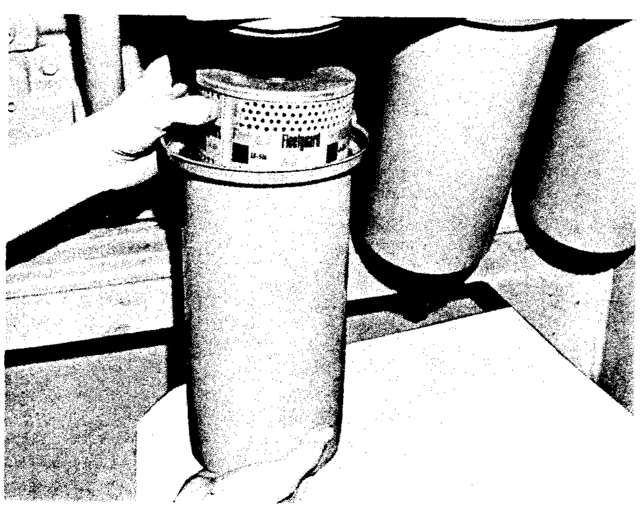


Fig. 2-13 (V40737) Removing lubricating oil filter element(s)

3. Inspect filter element.

a. Inspect for metal particles.

b. Inspect outside wrapper of element for wrinkles and pleats for waviness or bunching. Presence of these conditions indicates that oil contains moisture.

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

d. If element is clogged, the change period should be shortened. Oil pressure drop reading across filter is the best way to determine change periods. Pressure drop from inlet (1, Fig. 2-11) to outlet side (2) of filter should not exceed 10 psi [0.7 kg/sq cm] with 140 deg. F [60 deg. C] oil temperature and engine at high-idle speed.

e. Discard element after inspection.

4. Remove seal ring from filter head and discard.

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

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

Note: It is recommended that every second oil change to change the small seal rings (4 and 17, Fig. 2-12) at bottom of oil filter can to prevent oil leakage due to hardening of rubber seals. Inspect seals each oil change for deterioration.

6. Position element end seals in place and install new element over spring support assembly.

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

8. Fill engine to "H" (high level) mark on dipstick with lubricating oil. Run engine and check for leakage.

9. Recheck engine oil level; add oil as necessary.

Note: Always allow 15 minutes for oil to drain back to oil pan before checking level.

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

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

2. Remove capscrews and washers securing cover to housing; lift off cover and discard gasket. Lift out element; inspect, then discard.

3. Wipe housing clean.

4. Insert new element in filter housing seating securely on end seal and install cover and new gasket.

Change Lubricating Oil By-Pass Filter Element

Note: By-pass filters may be mounted either vertically, horizontally or inverted; all are serviced in like manner.

1. Remove drain plug (5, Fig. 2-14) and drain oil.

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

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

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

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

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

7. Check orifice plug (6) inside oil outlet connection or standpipe; blow out with air to open and clean.

8. Check filter cover "O" ring (7). Replace if necessary.

9. Install new element in housing.

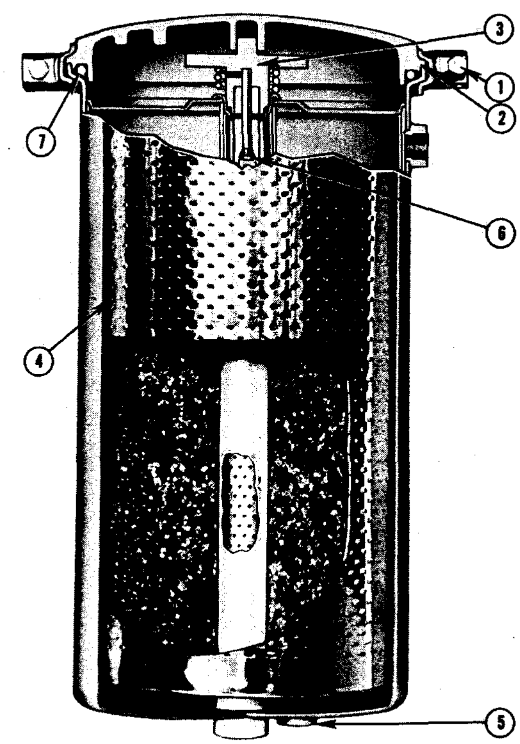


Fig. 2-14 (V41908) By-Pass filter cross section

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

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

12. Install cover and clamping ring; tighten capscrews until clamping lugs are indexed.

13. Run engine check for leaks, add enough extra oil to crankcase to fill to "H" (high) mark on dipstick.

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

Record Oil Pressure

Start the engine and operate at 800 to 1000 rpm until engine reaches normal operating temperature. Reduce to idle and record oil pressure. A comparison with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings should be taken immediately after an oil change.

Fuel System

Check Aneroid Oil

1. Remove pipe plug from hole marked "Lub Oil".

2. Fill with engine lubricating oil to level of pipe plug hole. Reinstall pipe plug.

Check Hydraulic Governor Oil Level

Keep level half-way up on inspection glass or to high-level mark on dipstick. Use same grade oil as used in engine.

Check Throttle Linkage

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

Adjust Injectors and Valves (See "C" Check)

At first "B" Check, check and/or adjust injectors, crossheads and valves. Thereafter at "C" Check.

Change Fuel Filter Element

Throw-Away Type Filter

1. Unscrew combination case and element, Fig. 2-15, discard element.

2. Fill new filter with clean fuel.

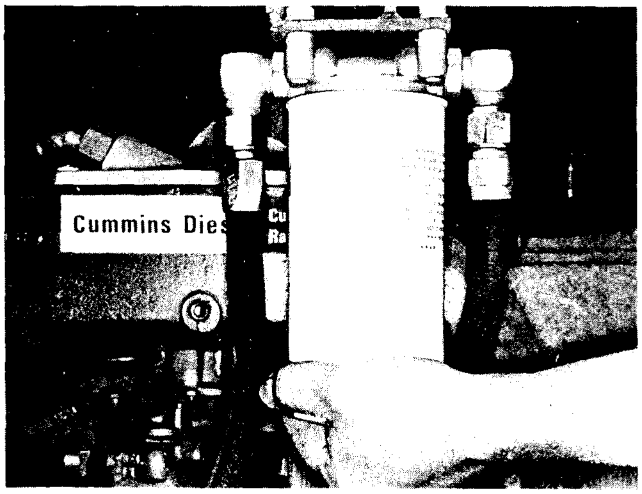


Fig. 2-15 (V11909) Changing throw-away type fuel filter

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

Caution: Mechanical tightening will distort or crack filter head.

Replaceable Element

1. Open drain cock(s) and drain contents.

2. Loosen nut(s) at top of fuel filter(s). Take out dirty element, clean filter case(s) and install new element(s). Fig. 2-16.

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-lbs [2.8 to 3.5 kg m] with a torque wrench. Fill filter case(s) with clean fuel to aid in faster pick-up of fuel.

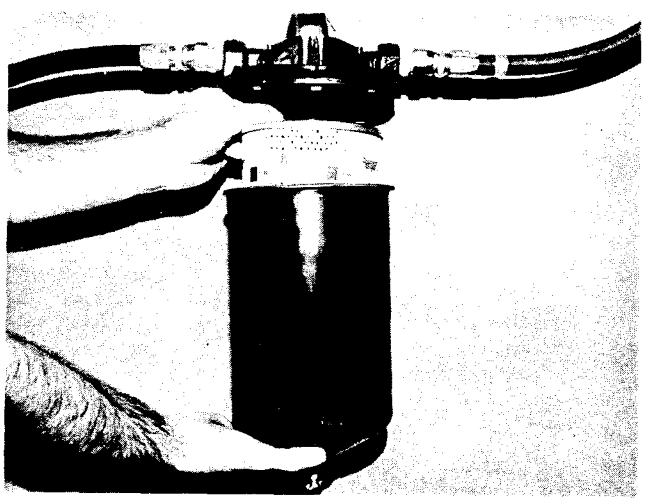


Fig. 2-16 (V11910) Installing replaceable fuel filter element

4. Check fittings in filter head(s) for leaks. Fittings should be tightened to 30 to 40 ft-lbs [4.1 to 5.5 kg m].

Clean Fuel Tank Breather

1. Remove breather, clean in solvent, and dry with compressed air.

2. Check breather(s) for freedom of air flow. Reinstall clean breather(s).

Air System

Clean/Change Crankcase Breather

Mesh Element Breather

1. Remove wing nut (6, Fig. 2-17), flatwasher and rubber washer securing cover (1), to breather body (5).

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

3. Clean all metal and rubber parts in approved cleaning solvent. Dry thoroughly with compressed air.

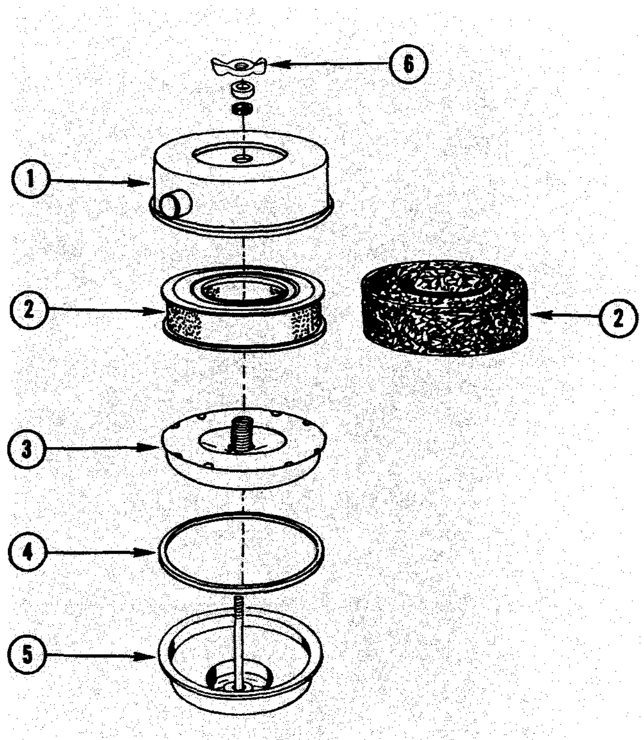


Fig. 2-17 (V51909) Crankcase breather — mesh element with vapor barrier

4. Inspect rubber gasket; replace if necessary. Inspect body and cover for cracks, dents or breaks; discard all unserviceable parts.

5. Install cleaned or new breather element (2, Fig. 2-17) and cleaned vapor element (3) to breather body (5).

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

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

Paper Element

1. Remove wing nut (6, Fig. 2-18), flatwasher and rubber washer securing cover (1) and element assembly to breather.

2. Remove cover, element (2) and gasket (4).

3. Separate cover from element. Discard element.

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

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

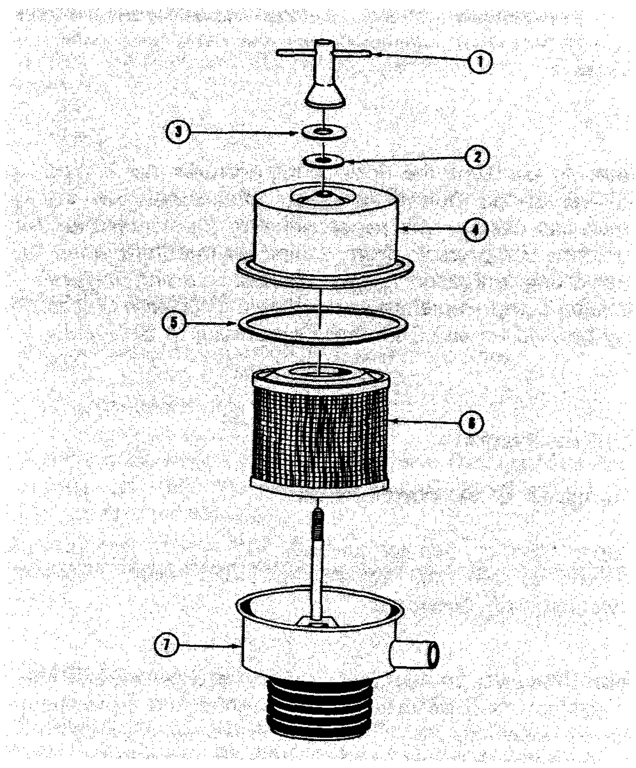


Fig. 2-18 (N20311) Crankcase breather — combination type

Screen Element Breather — Cleaning And Inspection

1. Remove vent tube if not previously removed.

2. Remove capscrews, washers, cover, screens and baffle if used, from breather body, Fig. 2-19.

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

4. Assemble baffle and screens, if used, and new gasket in body.

5. Replace cover with cover boss resting securely on point of screen, if used; secure with washers and capscrews.

6. Replace vent tube.

Fig. 2-19 (N21928) Crankcase breather — screen type

Check Air Piping, Turbocharger Connections And Manifolds

Check air intake piping from air cleaner to turbocharger or intake manifold, Fig. 2-20. Replace or tighten parts as necessary to insure an air-tight intake system.

Clean Tray Screen

Clean tray screen in kerosene or cleaning solvent. Dry with compressed air, reassemble to cleaner.

Note: If tray screen is extremely dirty, it may be necessary to singe the screen with a flame. Do not melt tin plate on screen.

in these coolants; therefore, a separate test is performed when antifreeze is used. This kit only measures one of the many chemicals present in D C A to give an indication of concentration and should not be used in place of a regular maintenance and service program.

Checking Coolant Without Antifreeze

1. Rinse the mixing bottle (Part No. 259027) several times with a part of the coolant sample to be tested, then fill to the 10 ml. mark.

2. Add one (1) dropperful of Bromothymol Blue Indicator Solution (Part No. 259026) and swirl to mix. A blue to purple color will develop.

3. Add a single drop at a time of the Sulfuric Acid Standard Solution, 0.500 N (Part No. 259028), until the color changes from blue or purple to yellow, swirling to mix after the addition of each drop.

Note: Most accurate results for drop-count can be obtained by holding the dropper vertical and dispensing drops at the rate of about one (1) drop per second. Count the number of drops required for the color change and compare to Table 2-1 for corrective maintenance requirements.

Caution: Use extreme care in handling of the Sulfuric Acid Solution, it can cause acid burn.

Table 2-1: Coolant Condition and Corrective Action

No. Drops Added	Coolant Condition	Maintenance Required
0 – 7	Dangerous	Pre-charge System
8 – 11	Border line	Replace Service Filter
12 – over	Acceptable	None

Checking Coolant With Antifreeze

1. Rinse the mixing bottle several times with a part of the sample coolant to be tested, then fill to the 10 ml. mark.

2. Add one (1) dropperful of Bromothymol Blue Indicator Solution and swirl to mix. A blue to purple color will develop.

3. Add 0.5 ml. increments of Sulfuric Acid Standard Solution, 0.500 N to the sample, using the 0.5 ml. calibrated dropper (markings on side of dropper) and swirl to mix after the addition of each 0.5 ml. Continue until the color changes.

Note: Since most antifreezes contain dyes, it may be helpful to first test a sample containing only the antifreeze used and water (without D C A inhibitors) to more clearly determine the correct endpoint color change for the coolant.

Caution: Use extreme care in handling of the Sulfuric Acid Solution, it can cause acid burn.

4. Accurate results can only be obtained by determining the contribution of the antifreeze to the reserve alkalinity reading. A solution must be made up of the antifreeze and water mixture being used plus enough D C A chemical to make the D C A concentration equal to 1.5 dry ounces (42.5 gms.) per gallon of solution. This will be checked in the same manner as coolant samples to give the value to be used for "Adequate Coolant Condition", Table 2-2.

Adjusting Coolant To Specifications

If above tests indicate coolant is outside specifications, make an adjustment immediately to prevent corrosion. Change to a pre-charge element, and run engine until next "B" Check. However, make sure the coolant system is not larger than the water filter was designed to treat; see Section 3.

Table 2-2: Coolant With Antifreeze Condition And Type Antifreeze Record

DCA Concentration Evaluation	Coolant Condition	Maintenance Required
0 – 66% "adequate ml."	Dangerous	Pre-charge
67 – 99% "adequate ml."	Border line	Replace Service Filter
100% – over "adequate ml."	Adequate	None

Antifreeze Used	Concentration – %	Adequate – ml.

Make-Up Coolant Specifications

Where possible, it is recommended that a supply of make-up coolant be prepared using one package D C A dri-charge, Part No. 299050, to each four gallons soft water (where possible) and/or antifreeze as required.

Note: Continue to use Fleetguard D C A Water Filters with pre-treated water.

Check And Adjust Belt Tension

All driven assemblies must be secured in operating position before reading or judging belt tension.

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll belt over the pulley and never pry it on with a tool such as a screwdriver. Either will damage belts and cause early failure.

2. Replace belts in complete sets. Belt riding depth should not vary over 1/16 inch [1.59 mm] on matched belt sets.

3. Pulley misalignment must not exceed 1/16 inch [1.6 mm] for each foot [0.3 m] of distance between pulley centers.

4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 inch [2.38 mm] above top edge of groove.

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

Belt Tension

1. Using appropriate gauge, Fig. 2-26, check and/or adjust belts to tension as indicated in Table 2-3.

2. If belt tension gauge is not available, tighten belts so pressure of finger will depress belt amount of defelction in Table 2-4. The finger should be extended straight down from hand; in this manner, force will be approximately 13 lbs. [5.9 kg] deflection (1, Fig. 2-27) per foot [0.3 m] of span (2).

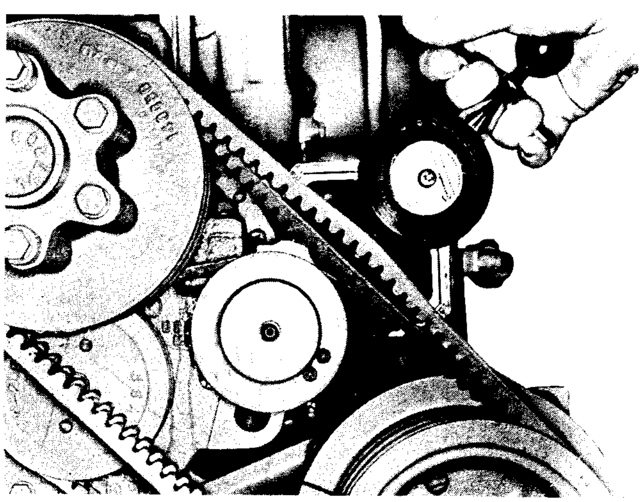


Fig. 2-26 (N11977) Checking belt tension with ST-1138

Table 2-3: Belt Tension (Pounds)

Belt Width (Inches)	New Belt Installation Tension	Running Tension	Reset Tension After Run-In	Belt Tension Gauge
3/8	110	70 to 90	70	ST-1274
3/8	110	80 to 95	80	ST-968
1/2	110	80 to 100	80	ST-1274 or ST-968
11/16	110	80 to 100	80	ST-1138
3/4	110	80 to 100	80	ST-1138
7/8	120	90 to 110	90	ST-1138
1	130	100 to 120	100	ST-1138
15/32 (FFC Idler Pulley)	120 to 140	70 to 90	70	ST-1274 or ST-968

Note: When installing or checking alternator or generator drive belts, subtract 20 pounds tension from above gauge readings.

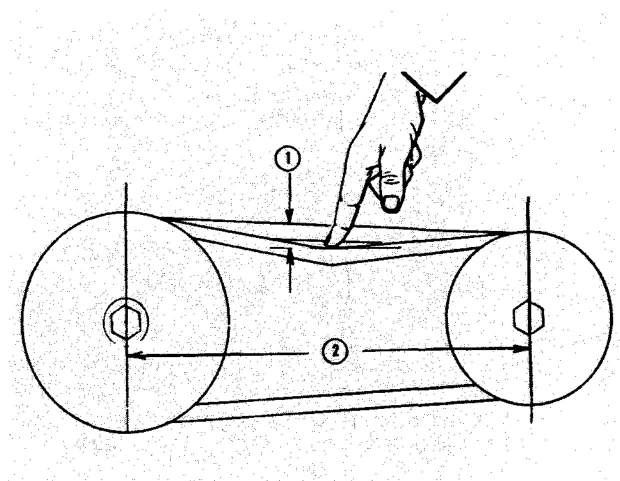


Fig. 2-27 (N11471) Checking belt tension manually

Table 2-4: Belt Tension – Inch [mm]

Belt Width		Deflection Per Ft. [0.3 m] of Span	
1/2	[12.70]	13/32	[10.32]
11/16	[17.46]	13/32	[10.32]
3/4	[19.05]	7/16	[11.11]
7/8	[22.22]	1/2	[12.70]
1	[25.40]	9/16	[14.29]

3. Deflection (1, Fig. 2-27) should equal amount indicated in Table 2-4 for each foot of belt span (2).

Inline Engine Water Pump Belts (No Idler)

1. Eccentric water pump adjustment.

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

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

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

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

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

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

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

g. Check belt tension.

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

2. Adjustable (split) pulley water pumps.

a Remove capscrews joining the sheave(s) of the pulley. V-1710 Series Engines have a sheave on each side of hub.

Note: Clean capscrew threads and holes in sheaves thoroughly to avoid capscrew breakage during reassembly.

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

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

d. Adjust belt(s) to tension indicated in Table 2-3 or 2-4.

e. Turn outer sheave(s) in enough to align the capscrew holes.

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

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

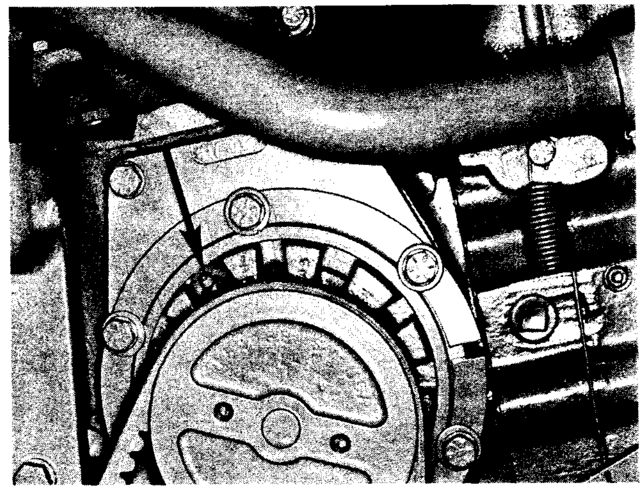


Fig. 2-28 (N11973) Water pump — no idler

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

h. Recheck belt tension.

Inline Engine Water Pump Belts (With Idler)

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

2. Using a pry bar (NTA) or adjusting screw (FFC Series) adjust idler pulley until proper belt tension is indicated on gauge. See Table 2-3.

3. Secure idler pulley or bracket in position by tightening locknut or capscrews and lockwashers to 45 to 55 ft-lbs [6.2 to 7.6 kg m] torque.

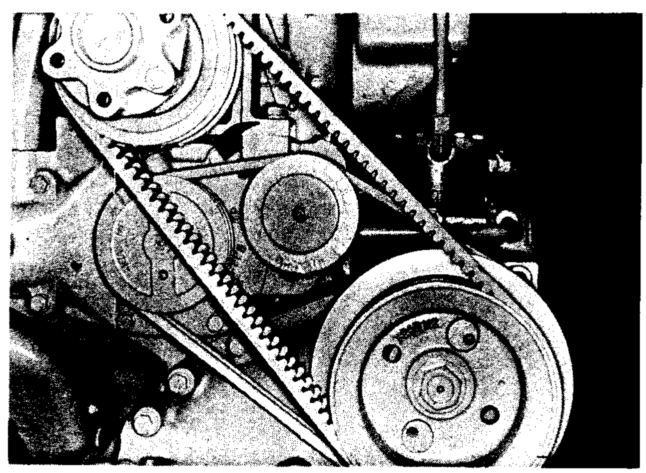


Fig. 2-29 (N11974) Water pump — with idler

Fan Drive Belts

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

2. Turn the adjusting screw to increase belt tension.

3. Tighten the locknut or capscrews until the fan hub is straight. Snug the nut to maintain hub in proper alignment with the fan hub bracket.

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

4. Belt tension should read as indicated in Table 2-3 on applicable gauge. If a gauge is not available, the belt should be checked with finger pressure at the center of the longest span. Deflection should be one thickness per foot [0.3 m] of pulley center distance.

5. Tighten N-743, 855 and V-1710 Series engines locknut to 400 to 450 ft-lbs [55.3 to 62.2 kg m]; then back off 1/2 turn. Tighten capscrews 75 to 85 ft-lbs [10.4 to 11.8 kg m].

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

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

c. On C engines, if fan hub is adjusted with adjusting screw, adjust belt tension by turning adjusting screw; then tighten shaft nut (behind bracket) to 400 to 500 ft-lbs [55.3 to 69.2 kg m] with ST-832 Fan Hub Nut Wrench. If fan hub is adjusted with an eccentric shaft, turn shaft with ST-891 Wrench until proper tension of belts is reached; using ST-892 Wrench, tighten shaft locknut to 300 ft-lbs [41.5 kg m].

6. Recheck belt tension.

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

Generator/Alternator Belts

Belt tension should be as indicated in Table 2-3 when measured with the applicable gauge. When no gauge is available, finger pressure should not deflect belt more than indicated in Table 2-4.

Readjusting New Belts

All new belts will loosen after running a short period of time and must be readjusted to installation tension. After initial installation and retensioning, belts should then be set at running tension. Ref. Table 2-3.

'C' Maintenance Checks

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

Fuel System

Adjust Injectors And Valves

It is essential that injectors and valves be in correct adjustment at all times for the engine to operate properly.

Temperature Settings

The following temperature conditions provide the necessary stabilization of engine components to assure accurate settings.

Cold Setting

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

Hot Setting

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

2. If oil temperature gauge is unavailable, set injectors and valves immediately after engine has operated at rated speed and load or at high idle for a period of 20 minutes.

Valve Set Mark Alignment (V-903 Series)

Bar crankshaft in direction of rotation until No. 1 "VS" mark appears on the vibration damper crankshaft pulley or accessory drive pulley as used. See Fig. 2-30 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1; if not, advance crankshaft one revolution. See Fig. 2-31 and Table 2-5.

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

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

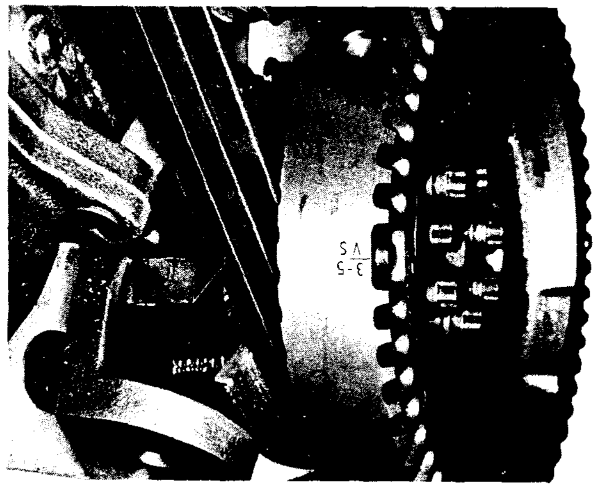


Fig. 2-30 (V514115) Valve set marks V-903

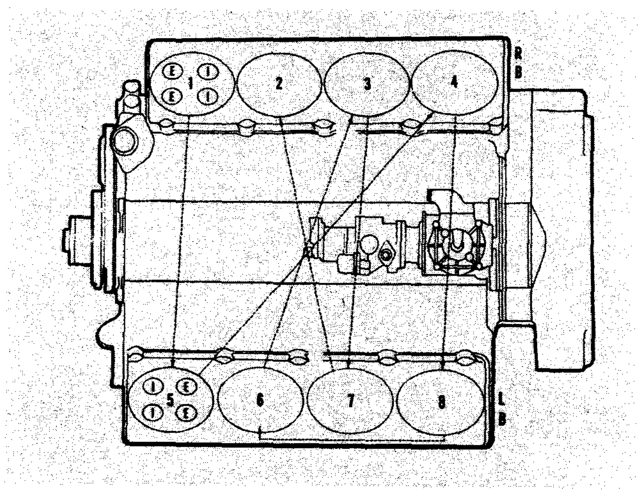


Fig. 2-31 (V11462) V8 Firing order diagram

Table 2-5: Engine "V" Series Firing Order

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

Note: Do not use fan to rotate engine, use barring arrangement. Fig. 2-32. Remove key, insert hex drive and press inward until barring gear engages drive gear; then advance. After completion of adjustment, be sure drive retracts and install key into safety lock groove.

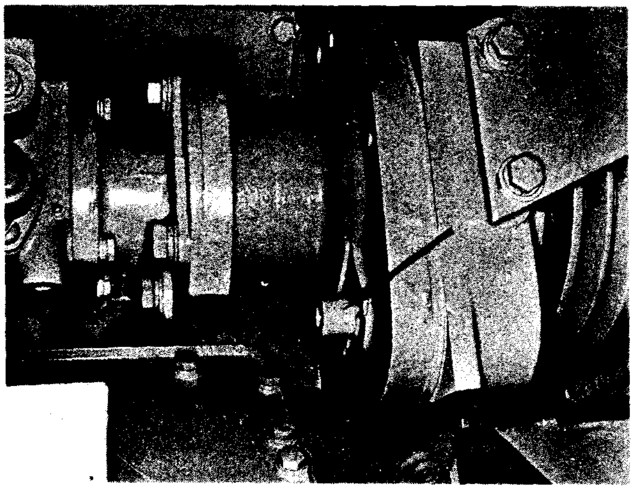


Fig. 2-32 (V51486) Engine barring arrangement (V-903)

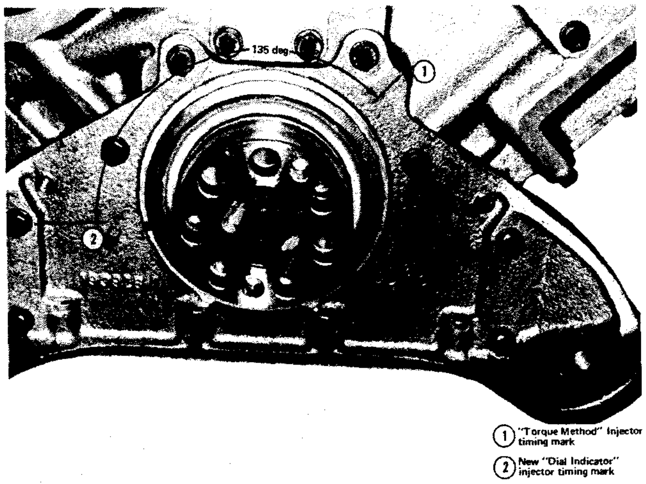


Fig. 2-33 (V51922) Relative location of timing marks on front cover

V-903 Series Injector Adjustment – Dial Indicator Method

This method involves adjusting injector plunger travel with an accurate dial indicator rather than tightening the adjusting screw to a specified torque.

Note: Values listed in Table 2-6 are to be used for either "Cold Set" or "Hot Set". "Cold Set" is the preferred temperature.

A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-6 for specifications.

Table 2-6: Adjustment Limits (V-903 Series) (Indicator Method of Adjustment) – Inch [mm]

Injector Plunger Travel		Valve Clearance	
Adjustment Value	**Reset Limit**	**Intake**	**Exhaust**
0.180 to 0.181 [4.57 to 4.60]	0.179 to 0.182 [4.55 to 4.62]	0.012 [0.30]	0.025 [0.64]

Caution: These values apply only when setting valves in conjunction with injector dial indicator method of adjustment.

The "VS" (Valve set) marks on the vibration damper or rear accessory drive pulley are used when setting injectors by the indicator method, but a new indicator mark location is used on the front cover or on the accessory drive support. See Fig's 2-33 and 2-34.

When using the indicator method, the "VS" (valve set) mark on the damper is aligned with the front cover capscrew 135 deg. counterclockwise from the timing mark, see Fig. 2-33. Newer engines are equipped with a pointer at the capscrew. The valve set mark on the accessory drive pulley is aligned with the accessory drive support capscrew 135 deg. clockwise from the current timing mark. See Fig. 2-34. Alignment in both cases, should be held to one-half inch [12.7 mm] of the capscrew.

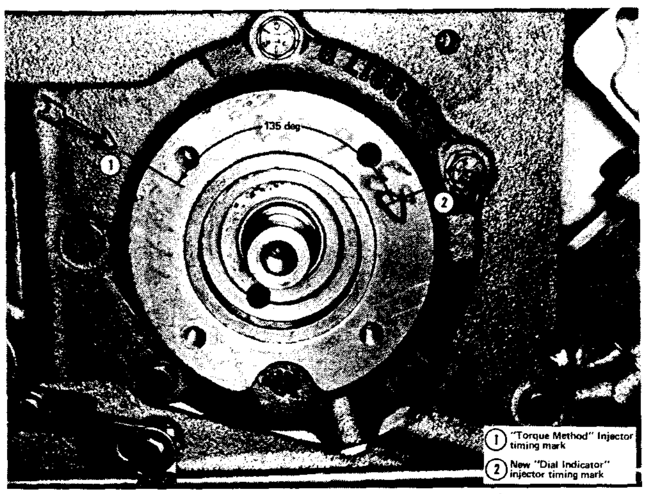


Fig. 2-34 (V514103) Relative location of timing marks on accessory drive support

Using engine barring device (Fig. 2-32), rotate engine in direction of rotation until "VS" mark for cylinder 2-8 is aligned with appropriate capscrew or pointer. In this position both the intake and exhaust valve rocker levers for No. 2 cylinder should be free and can be moved up and down. If not, bar engine another 360 deg. in direction of rotation and realign the 2-8 "VS" mark with the capscrew or pointer.

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

1. Set up ST-1170 Indicator Support with the indicator extension atop injector plunger flange at No. 2 cylinder. Fig. 2-35.

2. Make sure indicator extension is not contacting rocker lever.

3. Using ST-1251 rocker lever actuator, Fig. 2-36, bar injector rocker lever forward until plunger is bottomed in cup to squeeze all oil film from cup.

4. Allow the injector plunger to rise and then bottom again and set indicator at zero (0); release and bottom again and set indicator at zero (0); release and bottom plunger again to check setting.

5. Release the lever completely, indicator should show a total reading as indicated in Table 2-6. (Use adjustment value or reset limit.) Adjust to correct tolerance as necessary.

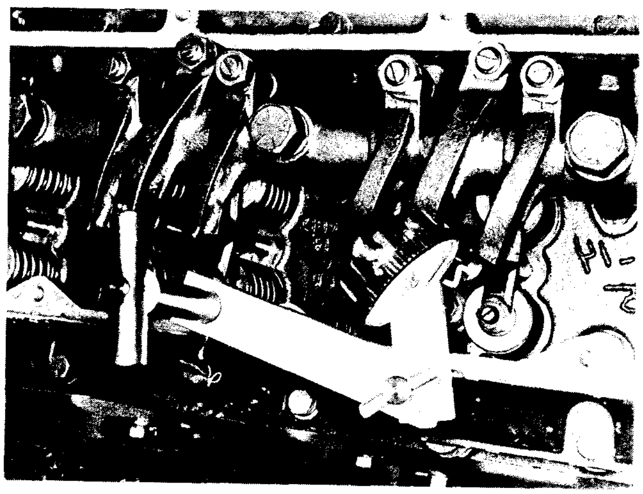


Fig. 2-35 (V514114) Dial indicator in place - extension in contact with plunger, V-903 Series

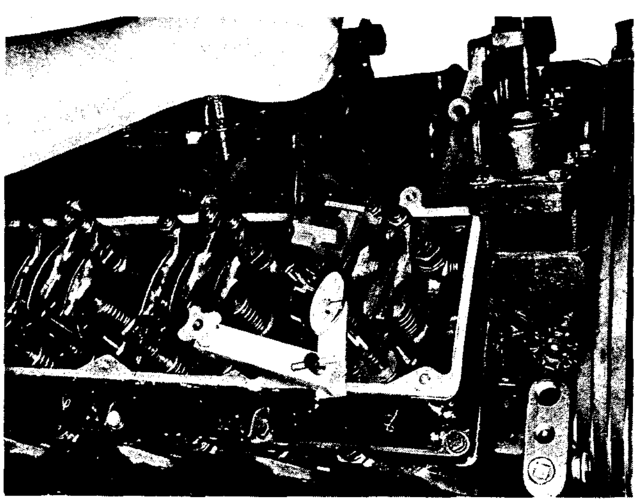


Fig. 2-36 (V514128) Bottoming injector plunger in cup, V-903 series

6. Tighten the adjusting screw locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] or 25 to 35 ft-lbs [3.5 to 4.8 kg m] when using ST-669 Adapter on torque wrench and actuate the injector plunger several times as a check of the adjustment.

7. Loosen crosshead adjusting screw, push down at rocker lever contact surface to hold crosshead in contact with valve stem; turn down adjusting screw until it touches valve stem and torque each nut to 25 to 30 ft-lbs [3.5 to 4.1 kg m]. Check clearance with a wire gauge; minimum clearance is 0.025 inch [0.64 mm].

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

Valve Set Mark Alignment

Turn crankshaft in direction of rotation until a "VS" mark appears on the vibration damper, crankshaft pulley or accessory drive pulley. See Fig. 2-37 for location of valve set marks. In this position both intake and exhaust valves must be closed for that cylinder; if not, advance crankshaft one revolution. See Fig. 2-38, Fig. 2-31 and Table 2-5 for firing order.

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

The injector plungers of all engines must be adjusted with an inch-pound torque wrench to a definite torque setting.

Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 2-39.

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

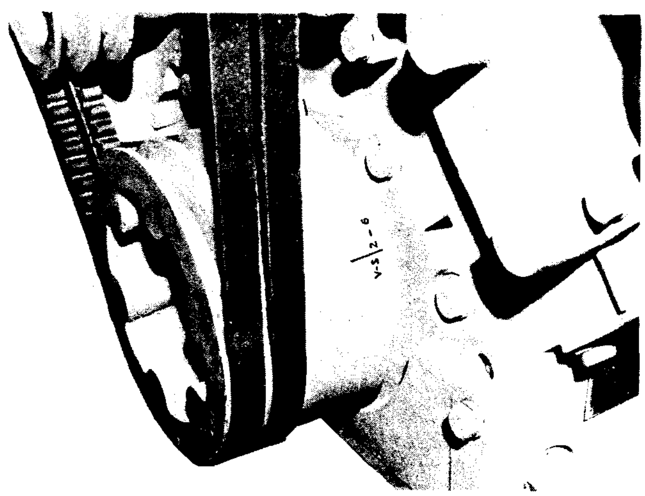


Fig. 2-37 (V11913) Valve set marks, V-378

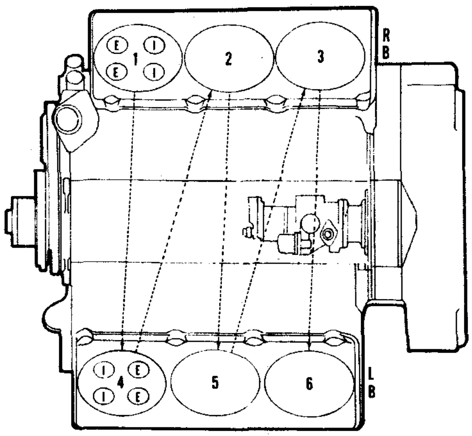


Fig. 2-38 (V11461) V6, Firing order

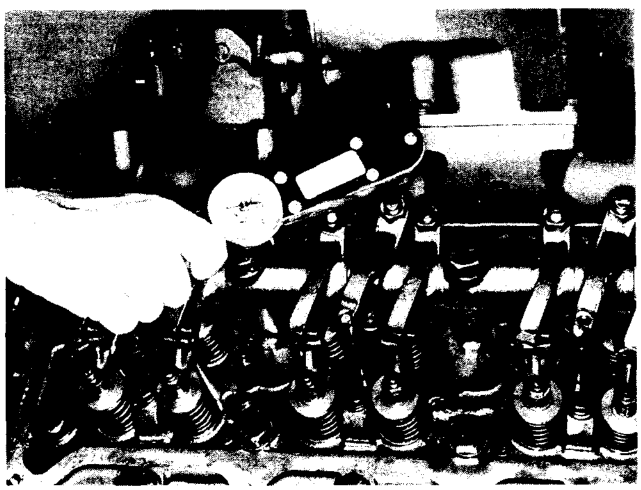


Fig. 2-39 (V51488) Adjusting injector plunger V-378

2. Loosen adjusting screw one turn, then, using a torque wrench calibrated in inch-pound and a screwdriver adapter, tighten the adjusting screw to 60 inch-lbs [0.7 kg m].

3. Hold injector adjusting screw and tighten injector locknut, Fig. 2-40, to values indicated in Table 2-7.

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

Crosshead Adjustment

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

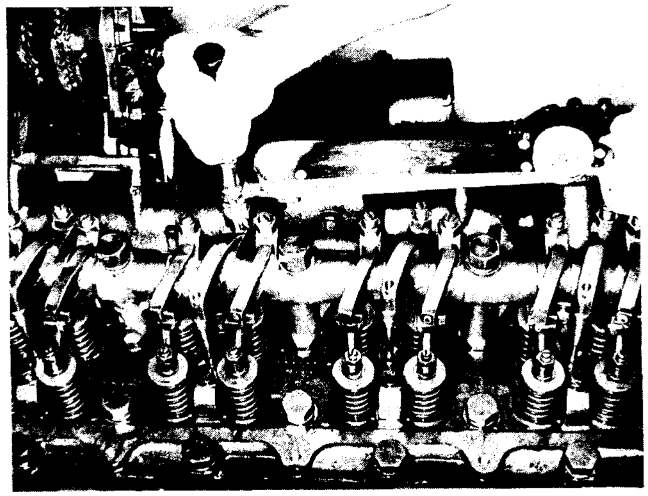


Fig. 2-40 (V51489) Tightening injector adjusting screw locknut

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

3. Turn down crosshead adjusting screw until it touches valve stem, Fig. 2-41.

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

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

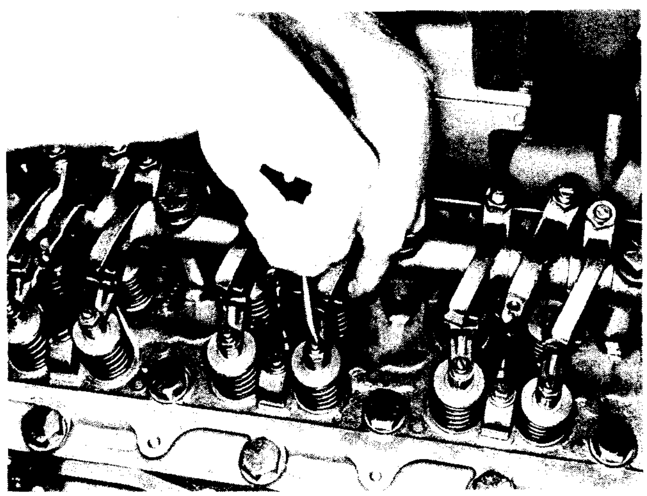


Fig. 2-41 (V51490) Adjusting crossheads

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

Table 2-7: Injector And Valve Locknut Torque (All Models)

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

Valve Adjustment

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

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Valve clearances are; Intake 0.012 inch [0.30 mm], Exhaust 0.022 inch. [0.56 mm]. Turn screw down until lever just touches gauge and lock adjusting screw in this position with locknut. Fig. 2-42. Torque locknut to values indicated in Table 2-7.

Note: If cylinder head gasket has been replaced, engine must be started and brought to operating temperature, then allowed to cool thoroughly. Cylinder head capscrews must be retorqued. See Engine Shop Manual. Valves should then be reset to values listed above.

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

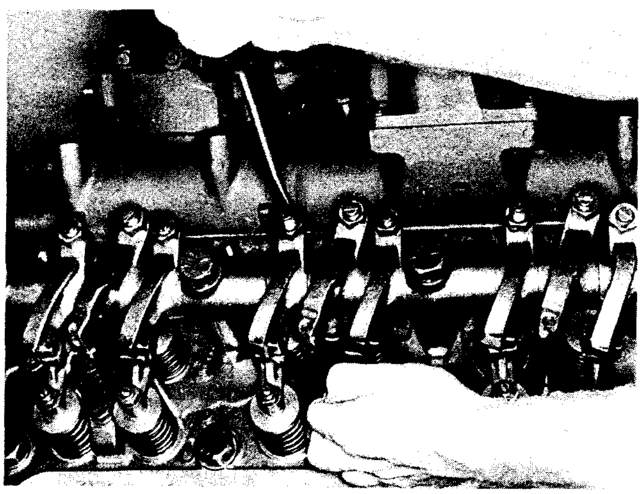


Fig. 2-42 (V51492) Adjusting valves

NH-743, N-855, N-927 C.I.D. Series Engines, Injector And Valve Adjustment (Dial Indicator Method)

Temperature conditions described as "Hot Set" or "Cold Set" must be observed when recheck is being performed. If travel exceeds recheck values, adjust to proper value shown in "Adjustment Value" column. Check and/or adjust valves as necessary.

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

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

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

1. Back injector adjusting screw out 1-1/2 full turns from normal operating position, tighten locknut.

2. With ST- 1270 Dial Indicator Extension on injector plunger top, bar engine and record total amount of travel at each plunger. This is called "Plunger Free Travel" and MUST NOT exceed 0.206 inch [5.23 mm] on any one (1) cylinder of engine on which dial indicator method of adjustment is to be used.

Note: On engines with Plunger Free Travel exceeding 0.206 inch [5.23 mm] the Torque Method of adjustment must be used unless component changes (rocker levers and/or cam followers) are made which will allow 0.206 inch [5.23 mm] limit of Free Travel to be obtained.

Maintenance Adjustment

The appropriate check values in Table 2-8 are applicable to engines which have operated long enough to warrant checking of injector setting and valve clearance.

Injector And Valve Adjustment

Note: If used, Jacobs Brakes must be removed from engines, for adjustment of injectors and valves.

1. Bar engine until "A" or 1-6 "VS" mark on pulley, Fig. 2-43, is aligned with pointer on gear case cover. In this position, both valve rocker levers for cylinder No. 5 must be free (valves closed). Injector plunger for cylinder No. 3 must be at top of travel; if not, bar engine 360 deg., realign mark with pointer.

2. Set up ST-1170 Indicator Support with indicator extension on injector plunger top at No. 3 cylinder, Fig. 2-44. Make sure indicator extension is secure in indicator stem and not against rocker lever.

Note: Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only.

Any cylinder combination may be used as a starting point, see Table 2-9.

Table 2-8: Uniform Plunger Travel Adjustment Limits

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

Table 2-9: Injector And Valve Set Position

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

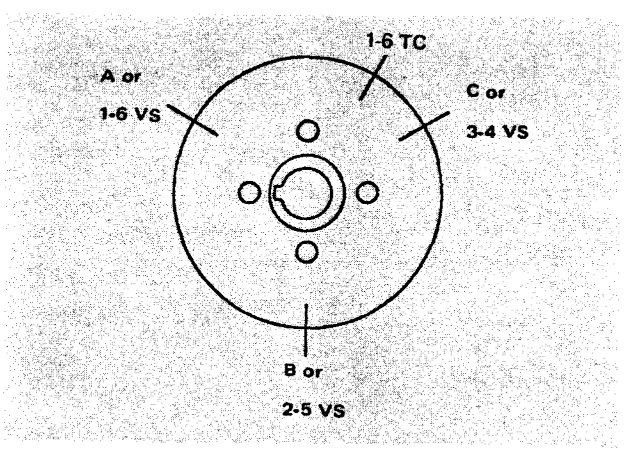


Fig. 2-43 (N114230) Accessory drive pulley marking

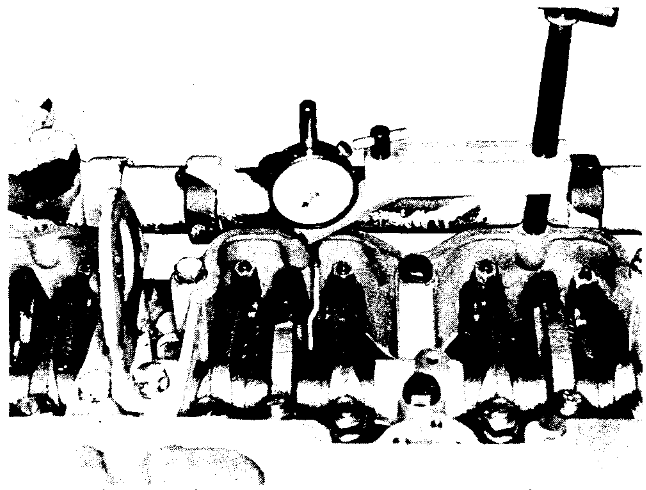


Fig. 2-44 (N114231) Dial indicator in place - extension in contact with plunger, N-Series

3. Using ST-1193 Rocker Lever Actuator, Fig. 2-45, or equivalent, bar lever toward injector until plunger is bottomed to squeeze oil film from cup. Allow injector plunger to rise, bottom again, set indicator at zero (0). Check extension contact with plunger top.

4. Bottom plunger again, release lever; indicator must show travel as indicated in Table 2-8. Adjust as necessary.

Note: Make recheck at same stabilized temperature as adjustments. All travel and clearance values are with locknuts properly torqued. "Cold Set" is the preferred stabilized temperature.

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

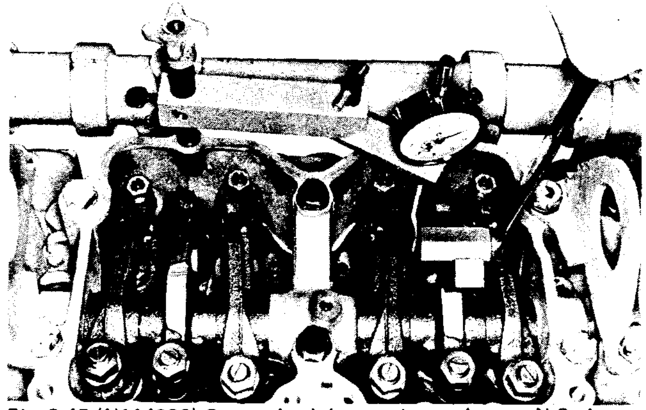


Fig. 2-45 (N114232) Bottoming injector plunger in cup, N-Series

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

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

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

Adjustment Of Engine On Which Head Gasket And/Or Rocker Housing Gasket Has Been Replaced

Adjust injectors and valves using appropriate values in the "Cold Set" column. See Table 2-8. The engine must operate for approximately 1 hour at rated speed to allow stability of structural components as affected by the gasket replacement. Recheck injectors and valves.

Note: Readjustment after 1 hour operation is necessary to assure lowest smoke potential and avoid excessive injector train loads.

Adjust Injectors And Valves (Torque Method) V-1710, NH-743, N-855, N-927 and C-464, C.I.D. Series Engines

Timing Mark Alignment

1. If used, pull compression release lever back and block in open position only while barring engine.

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

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

3. Bar engine in direction of rotation until a valve set mark (Fig's. 2-46, 2-47 and 2-48) aligns with the mark or pointer on the gear case cover. Example: A or 1-6 "VS" on inline engines or 1-6R "VS" on V-1710 engines.

4. Check the valve rocker levers on the two cylinders aligned as indicated on pulley. On one cylinder of the pair, both rocker levers will be free and valves closed, this is cylinder to be adjusted.

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

6. For firing order see Table 2-10 for inline engines and Table 2-11 and Fig. 2-49 for V-1710 Series Engines.

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

Note: Only one cylinder is aligned at each mark. Two

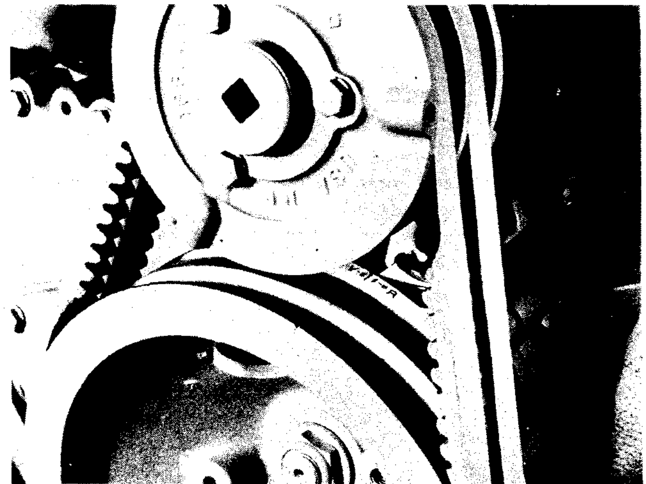


Fig. 2-46 (V41484) Valve set marks - V-1710 Series

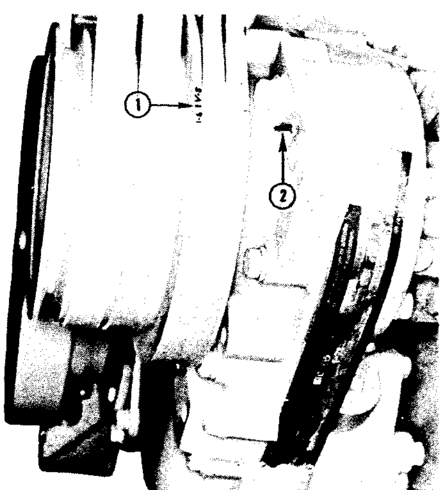


Fig. 2-47 (N114220) Valve set marks - H, NH Series

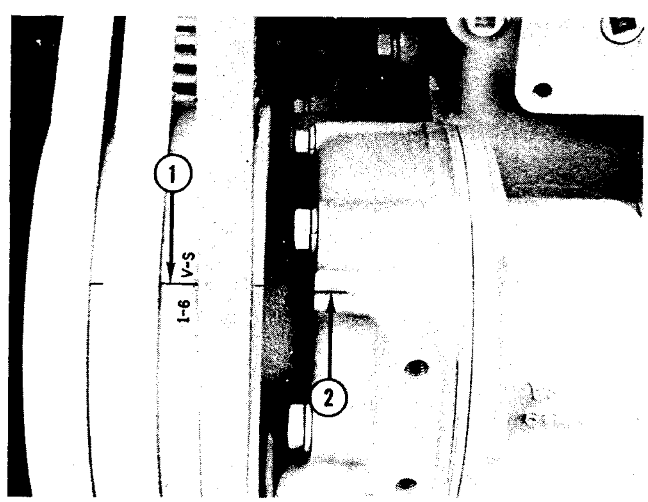


Fig. 2-48 (N21459) Valve set marks - C Series

complete revolutions of the crankshaft are required to adjust all cylinders.

Injector Plunger Adjustment

The injector plungers must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. See Fig's. 2-50 and 2-51.

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

Note: Number one L and one R cylinders on V-1710 engines are at gear case end of engine.

2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter tighten the adjusting screw to values shown in Table 2-12 and tighten locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] torque. If ST-669 Torque Wrench Adapter is used, torque to 25 to 35 ft-lbs [3.5 to 4.8 kg m].

Crosshead Adjustment

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

The crosshead adjustment changes as a result of valve seat wear during engine operation. Make sure crossheads are adjusted before adjusting valve rocker levers.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-52) one turn.

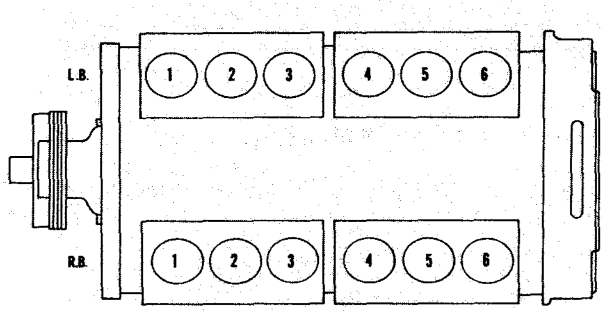


Fig. 2-49 (V414231) V-1710 firing order

Table 2-10: Engine Firing Order – Inline

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

Table 2-11: V-1710 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

Table 2-12: Injector Plunger Adjustment – Inch lbs [kg m]

Cold Set	Hot Set
V-1710 Series	
50 [0.6]	
NH-NT-743, 855, 927 C.I.D. Series Cast Iron Rocker Housing	
48 [0.6]	72 [0.8]
Aluminum Rocker Housing	
72 [0.8]	72 [0.8]
C-464 C.I.D. Series	
48 [0.6]	60 [0.7]

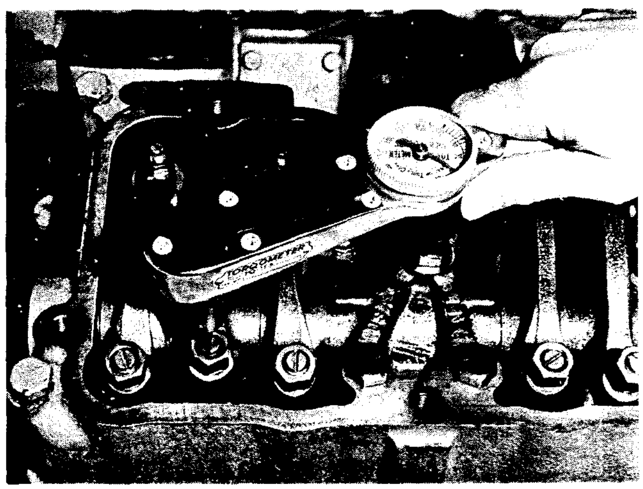


Fig. 2-50 (V414190) Adjusting injector plungers - V-1710 Series

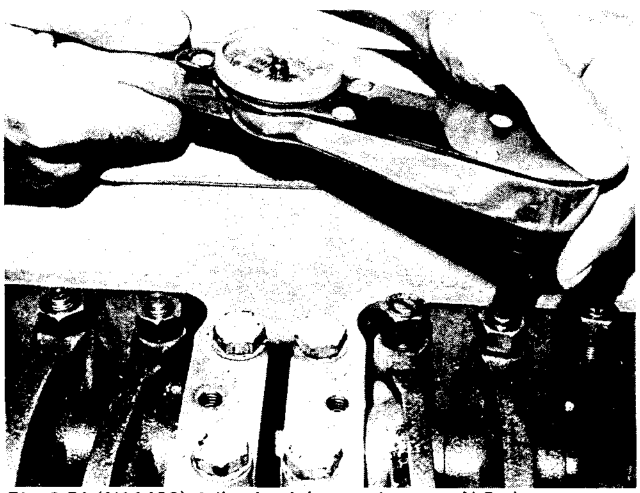


Fig. 2-51 (N11466) Adjusting injector plungers - N Series

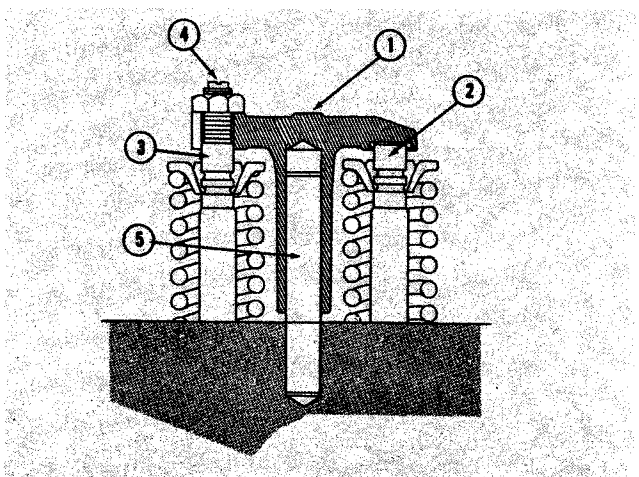


Fig. 2-52 (N21461) Adjusting valve crossheads

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2).

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

4. With new crossheads and guides, advance setscrew an additional one-third of one hex (20 deg.) to straighten stem on its guide (5) and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg. to straighten stem on its guide.

5. Using ST-669 Torque Wrench Adapter, tighten locknut to 22 to 26 ft-lbs [3.0 to 3.6 kg m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [3.5 to 4.1 kg m].

6. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance at this point.

Valve Adjustment

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

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in running position.

2. Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Fig. 2-42. Tighten locknut to 30 to 40 ft-lbs [4.1 to 5.5 kg m] torque. When using ST-669 torque to 25 to 35 ft-lbs [3.5 to 4.8 kg m].

3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-13 for appropriate valve clearances.

Table 2-13: Valve Clearance — Inch [mm]

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
V-1710 Series			
0.016 [0.41]		0.029 [0.74]	
NH-NT-743, 855, 927 C.I.D. Series **Cast Iron Rocker Housing**			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]
C-464 C.I.D. Series			
0.017 [0.43]	0.015 [0.38]	0.027 [0.69]	0.025 [0.64]

Change Hydraulic Governor Oil

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

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

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

Change Aneroid Oil

1. Remove fill plug (1, Fig. 2-53) from hole marked "Lub Oil".

2. Remove drain plug (2) from bottom of aneroid.

3. Replace pipe plug (2), fill aneroid with clean engine lubricating oil. Replace fill plug (1).

Check Aneroid Adjustment And Check Bellows

Normally, no adjustment of the aneroid is required; however, if smoke is evident and all other engine adjustments have been checked, back out adjusting screw (4, Fig. 2-53). If screw must be backed out until acceleration is slow, have unit checked by a Cummins Distributor.

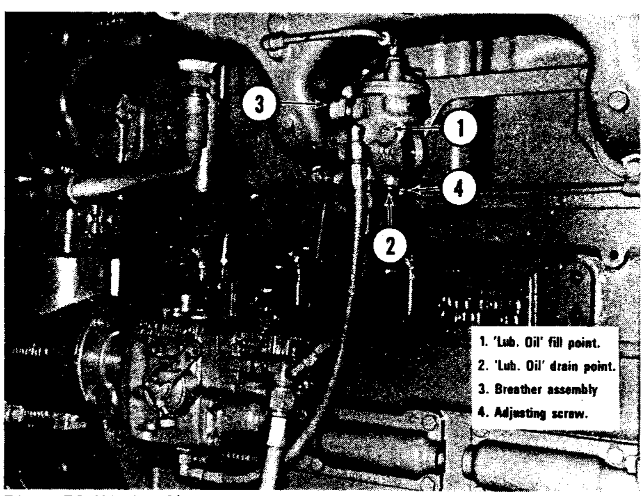


Fig. 2-53 (N10503) Aneroid

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

Replace Aneroid Breather

Remove and replace aneroid breather (3, Fig. 2-53).

Air System

Check Air And Vapor Line Connections

Check all air and vapor lines and connections for leaks, breaks, stripped threads, etc.; correct as needed.

Clean Complete Oil Bath Air Cleaner

Steam

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

Solvent-Air Cleaning

1. Steam clean exterior of cleaner.

2. Remove air cleaner oil cup.

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

4. Submerge air cleaner in solvent.

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

6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent. Dry with compressed air.

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

7. 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.

Cooling System

Clean (Externally) Radiator Core

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

Inspect Water Pump, Idler Pulley And Fan Hub

Inspect water pump, idler pulley and fan hub for wobble and evidence of grease or coolant leakage. Replace with rebuilt prelubricated units as necessary.

Other Maintenance

Check Alternator/Generator And Cranking Motor Brushes And Commutators

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

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

Note: Never use emery cloth to clean slip rings. Hold polishing cloth against slip rings with alternator in operation and blow away all dust after cleaning operation.

3. Check alternator bearings for wear. Shaft will be excessively loose if bearings are worn.

4. If brushes are worn close to the holder, the alternator must be removed and sent to manufacturer's rebuild station.

Air Compressor

Inspect air compressor, check for evidence of oil or coolant leakage. Replace with rebuilt unit as necessary.

Check Vibration Damper

Rubber Damper

Damper hub (1, Fig. 2-54) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

There should be no relative rotation between hub and inertia member resulting from engine operation.

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

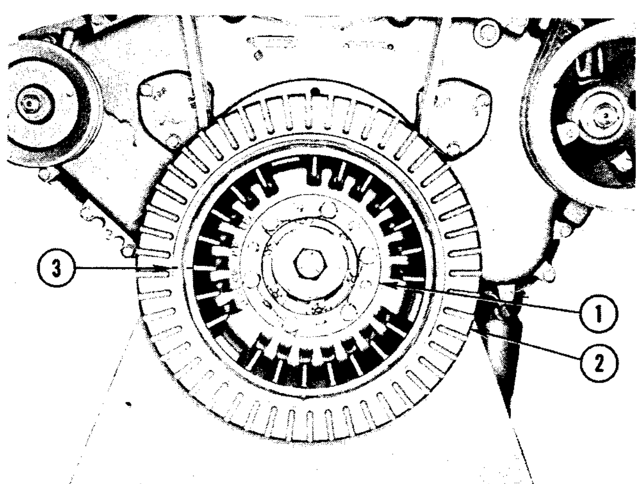


Fig. 2-54 (V41932) Vibration damper alignment marks

Viscous Dampers

Check damper for evidence of fluid loss, dents and wobble. Replace as required.

'D' Maintenance Checks

At each "D" Maintenance Check, perform all "A", "B" and "C" Checks in addition to those following. Most of these checks should be performed by a Cummins Distributor or Dealer and where Cummins Shop Manuals are available for complete instructions.

Fuel System

Clean And Calibrate Injectors

Clean and calibrate injectors regularly to prevent restriction of fuel delivery to combustion chambers. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

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

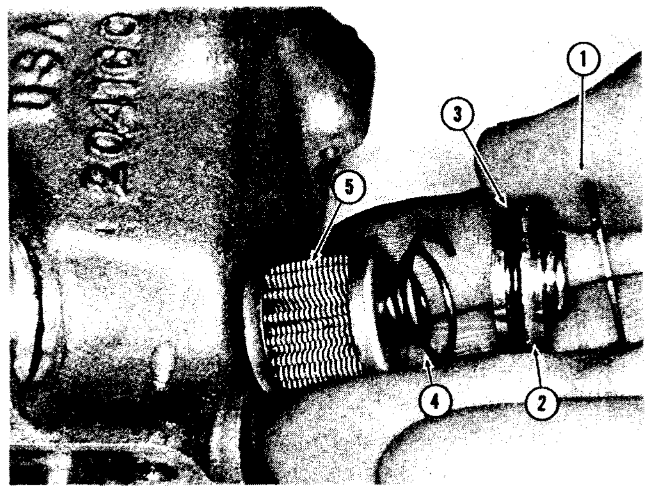


Fig. 2-55 (K11931) VS Fuel pump screen

Replace Fuel Pump Screen And Magnet

PT (type G) Fuel Pump

1. Loosen and remove cap, remove "O" ring and spring.

2. Lift out filter screen assembly. Discard screen assembly.

3. Install new filter screen assembly in fuel pump with hole down, position spring on top of filter screen assembly.

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

PT (type G) VS Fuel Pump

1. Remove snap ring (1, Fig. 2-55) securing filter cap (2) from bottom rear of fuel pump housing.

2. Using a screwdriver or small pry bar remove cap with "O" ring (3), spring (4) and filter screen assembly (5) from housing. Discard "O" ring and screen assembly.

3. Lubricate new "O" ring (3) and position in groove of filter cap (2).

4. Position new screen assembly (5) on spring (4) and cap (2) install in bore of fuel pump housing.

5. Secure with snap ring (1).

Check Fuel Pump Calibration

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

Replace Bellows And Calibrate Aneroid

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

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

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

3. Remove screws and aneroid cover.

4. Remove self-locking nut and retaining washer securing bellows (7, Fig. 5-10) to shaft (6) and piston (8).

5. Clean bellows sealing area on body and cover.

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

7. Install new seal. Refer to Bulletin No. 983725 for sealing and calibration procedure. Calibration must be performed by a Cummins Distributor.

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

Air System

Clean Turbocharger Compressor Wheel And Diffuser

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

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

Check Turbocharger Bearing Clearance

Check bearing clearances every "D" Check. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance. Fig. 2-56.

Checking Procedure

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

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

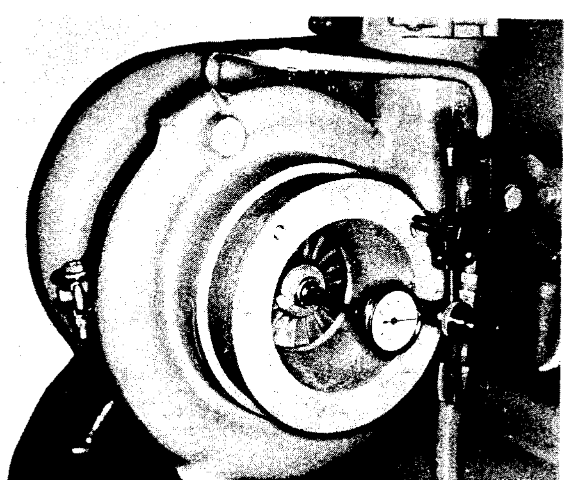


Fig. 2-56 (N11956) Checking turbocharger bearing end clearance

3. Check radial clearance on compressor wheel only.

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

Tighten Manifold Nuts Or Capscrews

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

Other Maintenance

Steam Clean Engine

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 (As Required)

Tighten all mounting bolts or nuts and replace broken or lost bolts or capscrews.

Check Crankshaft End Clearance (At Clutch Adjustment)

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

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

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH,	0.007	0.017	0.022
NT	[0.18]	[0.43]	[0.56]
V-903,	0.005	0.015	0.022
VT-903	[0.13]	[0.38]	[0.56]
V-378, V-504,	0.004	0.014	0.022
V-555	[0.10]	[0.36]	[0.56]
C-464	0.004	0.015	0.022
	[0.10]	[0.38]	[0.56]
V-1710	0.006	0.013	0.026
	[0.15]	[0.33]	[0.66]

The check can be made by attaching an indicator to rest against the damper or pulley, Fig. 2-57, while prying against the front cover and inner part of pulley or damper. End clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Caution: Do not pry against outer damper ring.

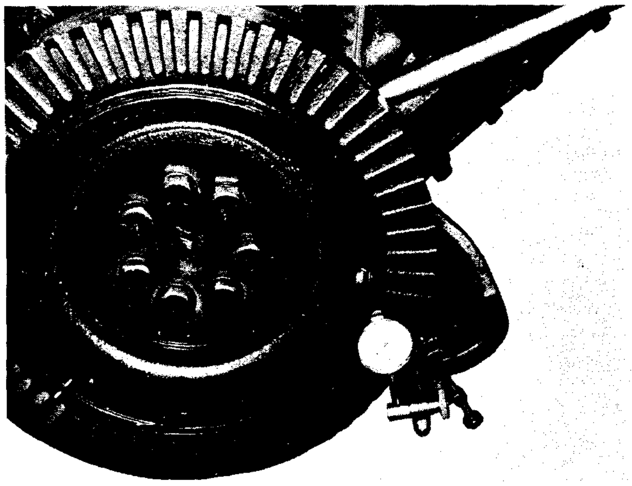


Fig. 2-57 (V51918) Checking crankshaft end clearance

Check Fan Hub And Drive Pulley

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

Tighten fan capscrews and check drive pulley for looseness or wobble. Tighten shaft nut if necessary.

'E' Maintenance Checks

The "E" Maintenance Check is often referred to as a chassis overhaul, where engine is not removed from the unit but some assemblies are rebuilt. In addition, a major inspection should be performed to determine whether engine may be operated for another service period, or whether it should be completely overhauled. Oil consumption, no oil pressure at idling, oil dilution and other signs of wear such as "blow-by" should be analyzed as part of the inspection.

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

At this period, perform all previous checks and:

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

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

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

Seasonal Maintenance Checks (Spring and Fall)

Clean Cooling System

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

If rust and scale have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium pisulphate or oxalic acid followed by neutralizer and flushing.

Pressure Flushing

Flush radiator and block before filling with antifreeze, or installing a corrosion resistor on a used or rebuilt engine when cooling system.

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

Caution: Do not use excessive air pressure while starting water flow. This could split or damage radiator core.

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.

Replace Hose (As Required)

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

Clean Electric Connections

1. Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork alternator and regulator and shorten their lives. Keep connections clean and tight. Prevent wires and lugs from touching each other or any metal except screw terminals to which they are attached.

2. Add water (distilled) to battery cells as required. Check solution level every 15 days during hot weather, every 30 days during cold weather; keep solution filled to 3/8 inch [9.52 mm] above separator plates.

3. Remove corrosion from around terminals; then coat with petroleum jelly or a non-corrosive inhibitor.

4. Replace broken or worn wires and their terminals.

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

Check Preheater Cold-Starting Aid (Fall)

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

Check Shutterstats And Thermatic Fans (Fall)

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 2-15 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195 deg. F [82 to 91 deg. C] thermostats are used only with shutterstats that are set to close at 187 deg. F [86 deg. C] and open at 195 deg. F [91 deg. C].

Check Thermostats And Seals (Fall)

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

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

Table 2-15: Thermal Control Settings

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

Check Heat Exchanger Zinc Plugs

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.

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 viscosity 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 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 lubricant to be thrown out, due to rotative speed.

Fuel Oil

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

Recommended Fuel Oil Properties:

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

Coolant

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

Maintain the Fleetguard D C A Water Filter on the engine. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

1. In summer, with no antifreeze, fill system with water.

2. In winter, select an antifreeze, all except Dowtherm 209 are compatible with D C A , use with water as required by temperature.

3. Install or replace D C A Water Filter as follows and as recommended in Section 2.

New Engines Going Into Service Equipped With D C A Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a "D C A pre-charge" element. See Table 3-4. This element is compatible with plain water or all permanent-type antifreezes except Dowtherm 209.

2. At the first "B" Check (oil change period) change the D C A Pre-charge element should be changed to D C A Service Element. See Table 3-4.

3. Replace the D C A Service Element at each "B" Check except under the following conditions.

a. If make up coolant must be added between element changes, use coolant from a pre-treated supply, see "Make-Up Coolant Specifications", Section 2.

b. Each time system is drained revert back to pre-charge element for one oil change period.

4. To insure adequate corrosion protection have the coolant checked at each third element change or oftener. See "Check Engine Coolant", Section 2.

Engines Now In Service With Spin-On Type Chromate Corrosion Resistor Element

1. Remove chromate element.

2. Flush cooling system.

3. Install pre-charge D C A element and operate engine to next oil change. See Table 3-4.

4. Install D C A service element, replacing regularly at each engine oil change thereafter except under the following conditions.

a. If make-up coolant must be added between element changes use coolant from a pre-treated supply, see "Make-Up Coolant Specifications", Section 2.

b. Each time system is drained revert back to pre-charge element for one oil change period.

Table 3-4: Spin-On Type Water Filter

Cooling System U.S. Gal.	DCA Pre-charge Element	DCA Service Element	Corresponding Obsolete Chromate Element
0 to 8	299082	299080	209604
8 to 15	299083	299080	209604
15 to 30	299084	299080	209605
30 to 60	(2) 299084	(2) 299080	(2) 209605
*	(2) 299084	(2) 299086	(2) 209605

* V-1710 Series Engines

Engines Now In Service With Package (Bag) Or Cannister Type Chromate Corrosion Resistor Elements

1. Remove chromate package or cannister, discard package element and plates or cannister, retain spring for use with D C A service element.

2. Flush cooling system.

3. Pre-charge system with coolant and dri-charge, Part No. 299050, (D C A 4), according to Table 3-5, using applicable service cannister.

4. At next "B" Check install service cannister, replacing regularly at each engine oil change thereafter, except under following conditions:

a. If make up coolant must be added between cannister changes use coolant from a pre-treated supply, see "Make-Up Coolant Specifications", Section 2.

b. Each time system is drained revert back to Step 3 instructions for one oil change period.

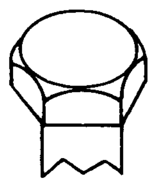
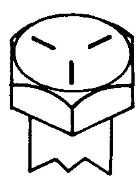
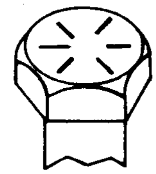
Table 3-5: Package or Cannister Type

DCA Pre-Charge Cannister		DCA Service Cannister		Corresponding Obsolete Chromate Cannister or Bag
None *		299071		132732
None *		299074		171645
None *	(2)	299091	(2)	132732

*** 299050 (DCA-4) Pre-Charge To Be Used With Service Elements**

Cooling System U.S. Gal.	Service Element 299074	Service Element 299071	Service Element 299091	Service Element (2)299091
0-5	1			
5-9	2	1		
9-13	3	2	1	
13-17	0	3	2	
17-21	0	4	3	1
21-25	0	5	4	2
25-28	0	0	5	3
28-32	0	0	6	4
32-36	0	0	7	5
36-40	0	0	8	6
40-45	0	0	0	7
45-49	0	0	0	8
49-53	0	0	0	9
53-57	0	0	0	10
57-61	0	0	0	11
61-65	0	0	0	12
65-69	0	0	0	13
69-73	0	0	0	14
73-79	0	0	0	15
79-81	0	0	0	16

Capscrew Markings and Torque Values

Usage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI [Kg/Sq Cm]	To 1/2–69,000 [4850] To 3/4–64,000 [4500] To 1–55,000 [3865]	To 3/4–120,000 [8435] To 1–115,000 [8085]	To 5/8–140,000 [9840] To 3/4–133,000 [9350]	150,000 [10545]
Quality of Material	**Indeterminate**	**Minimum Commercial**	**Medium Commercial**	**Best Commercial**
SAE Grade Number	**1 or 2**	**5**	**6 or 7**	**8**
Capscrew Head Markings Manufacturer's marks may vary. These are all SAE Grade 5 (3-line). 			 6  7	
Capscrew Body Size (Inches) – (Thread)	**Torque Ft-Lb [kg m]**	**Torque Ft-Lb [kg m]**	**Torque Ft-Lb [kg m]**	**Torque Ft-Lb [kg m]**
1/4 – 20	5 [0.69]	8 [1.11]	10 [1.38]	12 [1.66]
– 28	6 [0.83]	10 [1.38]		14 [1.94]
5/16 – 18	11 [1.52]	17 [2.35]	19 [2.63]	24 [3.32]
– 24	13 [1.80]	19 [2.63]		27 [3.73]
3/8 – 16	18 [2.49]	31 [4.29]	34 [4.70]	44 [6.09]
– 24	20 [2.77]	35 [4.84]		49 [6.78]
7/16 – 14	28 [3.81]	49 [6.78]	55 [7.61]	70 [9.68]
– 20	30 [4.15]	55 [7.61]		78 [10.79]
1/2 – 13	39 [5.39]	75 [10.37]	85 [11.76]	105 [14.52]
– 20	41 [5.67]	85 [11.76]		120 [16.60]
9/16 – 12	51 [7.05]	110 [15.21]	120 [16.60]	155 [21.44]
– 18	55 [7.60]	120 [16.60]		170 [23.51]
5/8 – 11	83 [11.48]	150 [20.75]	167 [23.10]	210 [29.04]
– 18	95 [13.14]	170 [23.51]		240 [33.19]
3/4 – 10	105 [14.52]	270 [37.34]	280 [38.72]	375 [51.86]
– 16	115 [15.90]	295 [40.80]		420 [58.09]
7/8 – 9	160 [22.13]	395 [54.63]	440 [60.85]	605 [83.67]
– 14	175 [24.20]	435 [60.16]		675 [93.35]
1 – 8	235 [32.50]	590 [81.60]	660 [91.28]	910 [125.85]
– 14	250 [34.58]	660 [91.28]		990 [136.92]

Notes:

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

Trouble Shooting

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

Cummins Diesel Engines

The chart does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column 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 lubricating oil consumption" caused by leaking gaskets or connections, etc.

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

Double-Check Before Beginning Disassembly Operations

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

Find And Correct Basic Cause Of Trouble

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

Trouble Shooting

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

Operating Principles

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

The Cummins Diesel Engine

Cummins Diesel Cycle

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

The four strokes and order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

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

Intake Stroke

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

Compression Stroke

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

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

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

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

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

Power Stroke

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

Exhaust Stroke

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

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

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

Fuel System

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

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

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

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

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

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

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

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 air compressor, vacuum pump or fuel pump drive which is driven from the engine gear train. Fuel pump main shaft in turn drives the gear pump.

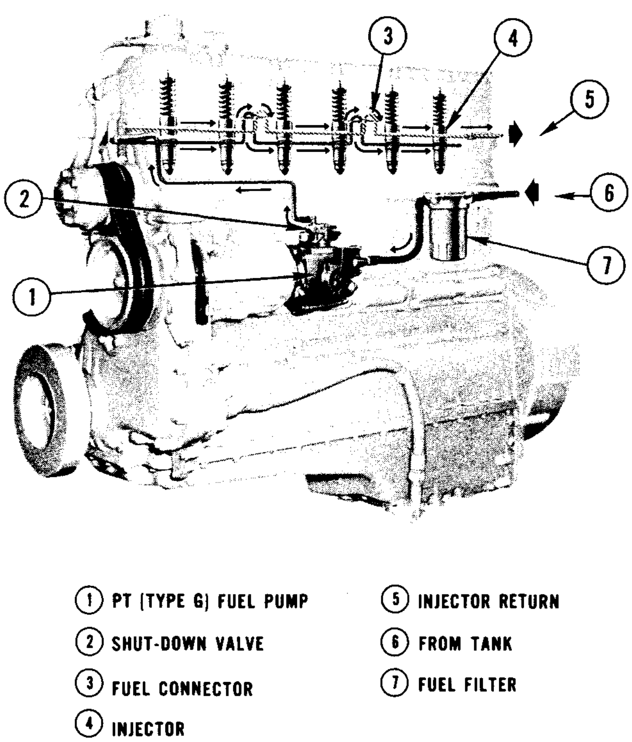


Fig. 5-1, (FWC-13). Fuel flow diagram – PT (type G) pump and Cylindrical Injectors – Inline Engine

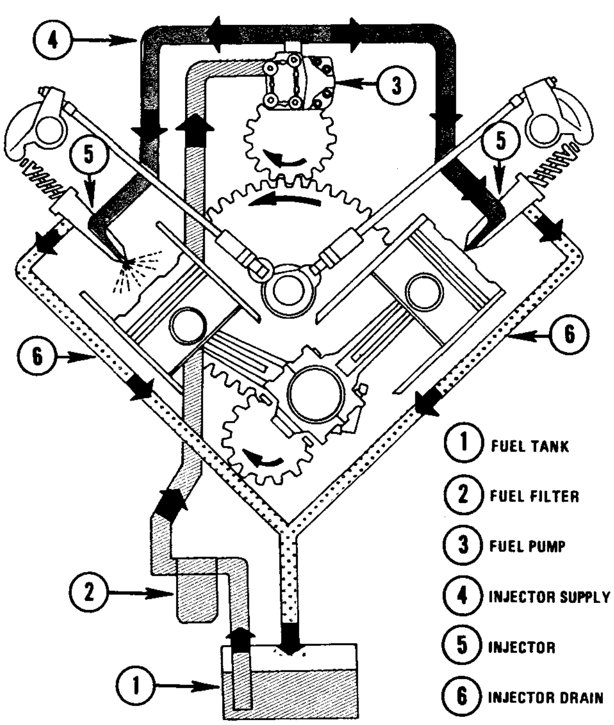


Fig. 5-2, (FWC-30). PT fuel system flow schematic – V Engine

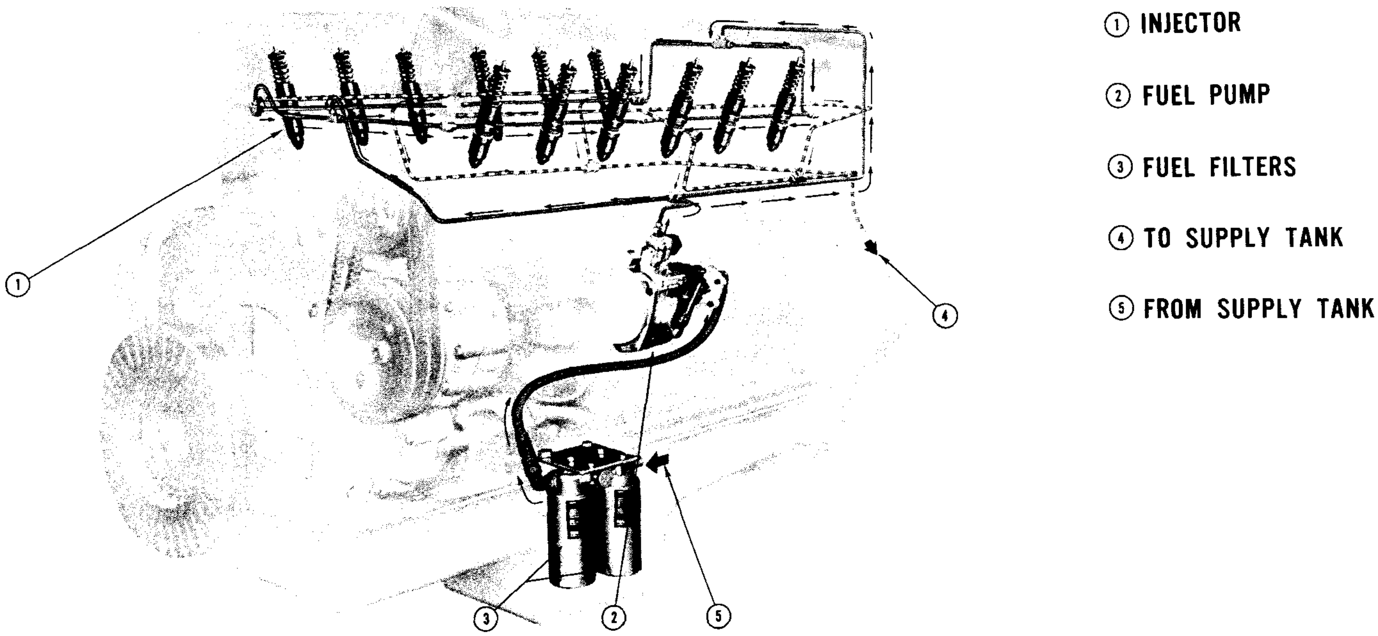


Fig. 5-3 (FWC-15A). Fuel flow schematic - V-1710 Engine

governor and tachometer shaft assemblies.

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

PT (type G) Fuel Pump

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

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

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

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

PT (type R) Fuel Pump

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

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

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

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

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

Gear Pump And Pulsation Damper

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

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

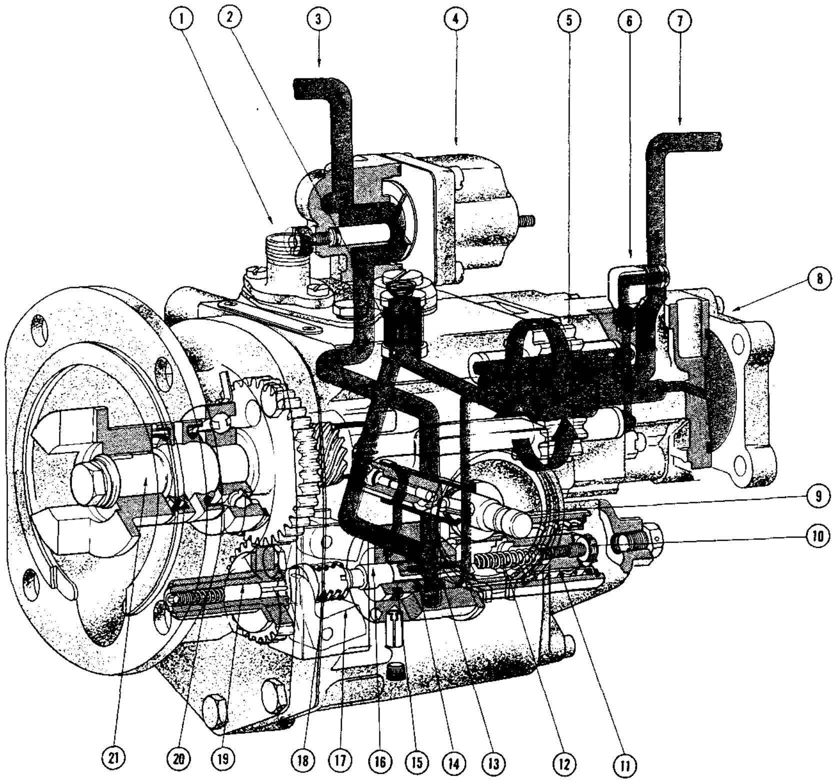


Fig. 5-4, (FWC-31). PT (type G) fuel pump and fuel flow

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

1. In the PT (type G) fuel pump to the governor assembly as shown in Fig. 5-4.

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

Pressure Regulator

Used in the PT (type R) functions as a by-pass valve to regulate fuel pressure to the injectors. By-passed fuel flows back to the suction side of the gear pump. See Fig. 5-5.

To control the manifold pressure, the pressure regulator:

1. Provides for an adjustment of manifold pressure.

2. Compensates for changes in fuel oil temperature.

3. Provides for engine torque characteristics.

4. Prevents excessive gear pump pressures.

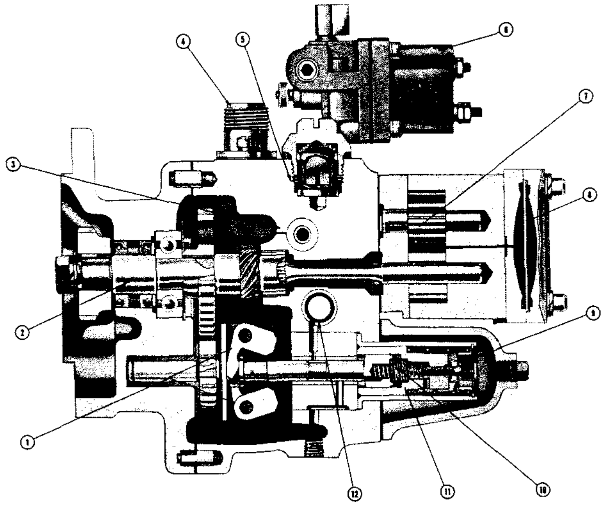
The pressure regulator controls and limits gear pump fuel pressure through a by-pass system. The fuel pressure by-pass system by-passes part of the total gear pump fuel delivery to the suction side of the gear pump and fuel pump body. This limits fuel delivery to only the required amount.

The pressure regulator assembly controls and limits gear pump fuel delivery by the valve action of the by-pass valve sleeve and by-pass valve plunger.

There are three types of by-pass holes located in most plungers: (a) fuel adjustment holes to regulate fuel manifold pressure, (b) torque holes for engine torque characteristics, (c) dump holes to prevent excessive gear pump pressures.

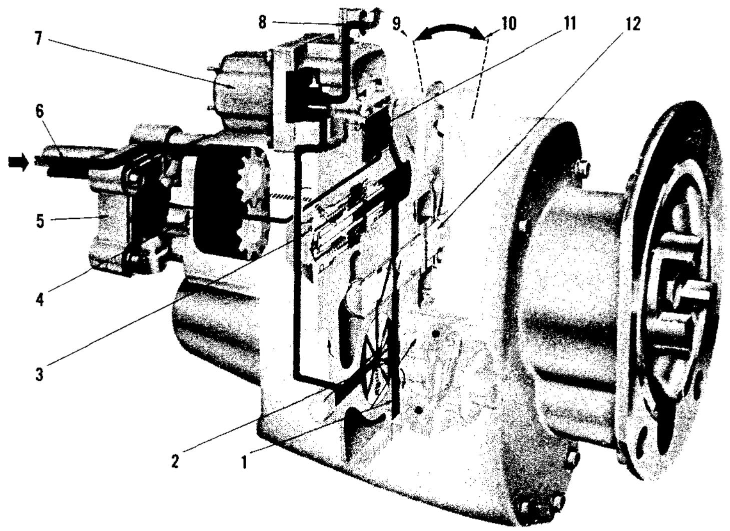
The fuel adjusting holes are first to appear and are evenly spaced around the plunger immediately next to its shoulder. The dump holes appear last and are the large holes near the end of the plunger. The torque holes depend upon the engine application and cannot be described by number, size, or location except they are located between the fuel adjustment and dump holes.

The torque holes, in the by-pass valve plunger, control the fuel manifold pressure curve. This fuel manifold pressure control gives the engine desired torque rise.



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

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



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

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.

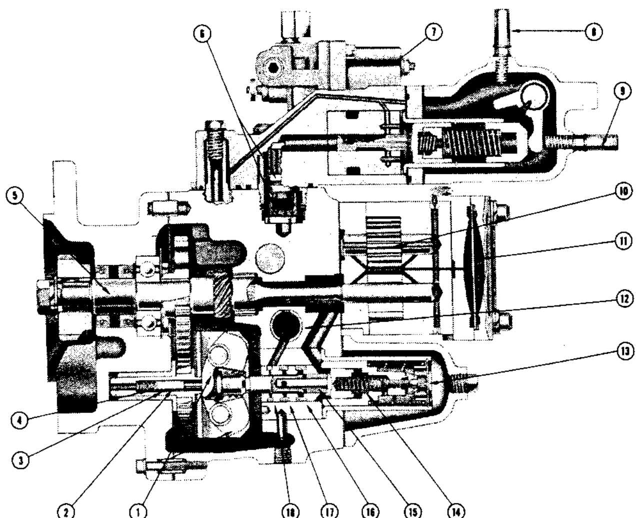
Governors

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

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

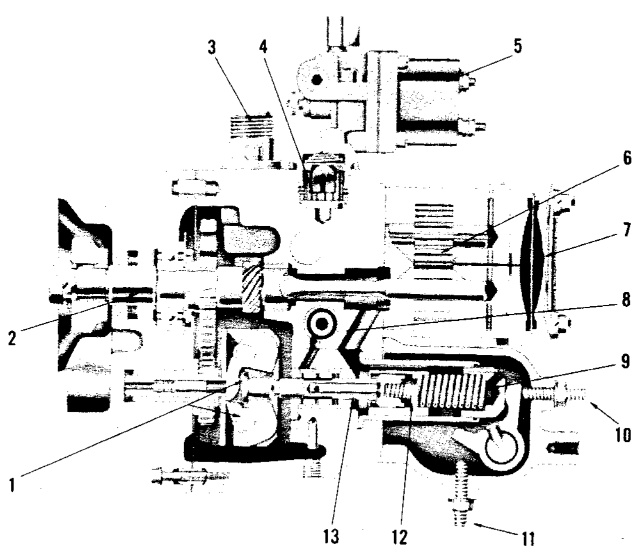
PT (type G) Variable-Speed Governors

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



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

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



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

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

Mechanical Variable-Speed (MVS) Governor

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

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

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

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

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

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

Special Variable-Speed (SVS) Governor

The SVS governor provides much of the same operational features of the MVS governor but is limited in application.

An overspeed stop should be used with SVS governors in unattended applications, and in attended installations a positive shut-down throttle arrangement should be used if no other overspeed stop is used. Fig. 5-7.

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

PT (type R) Mechanical Variable-Speed Governor

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

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

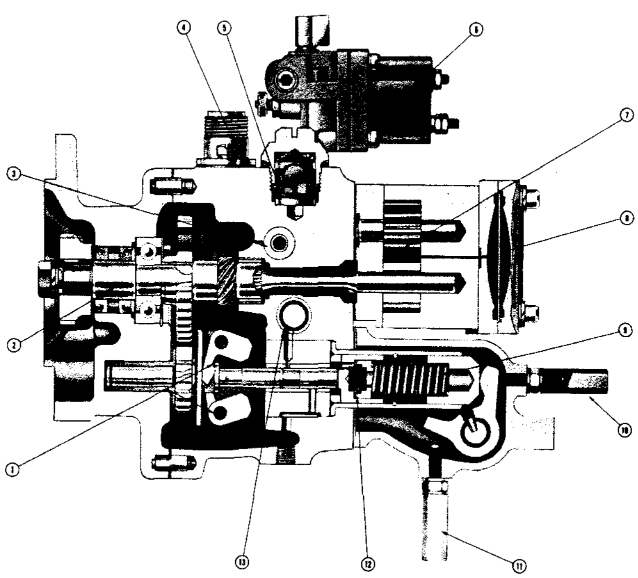
As a variable-speed governor, this unit is suited to the varying speed requirements of power take-off, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.

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.

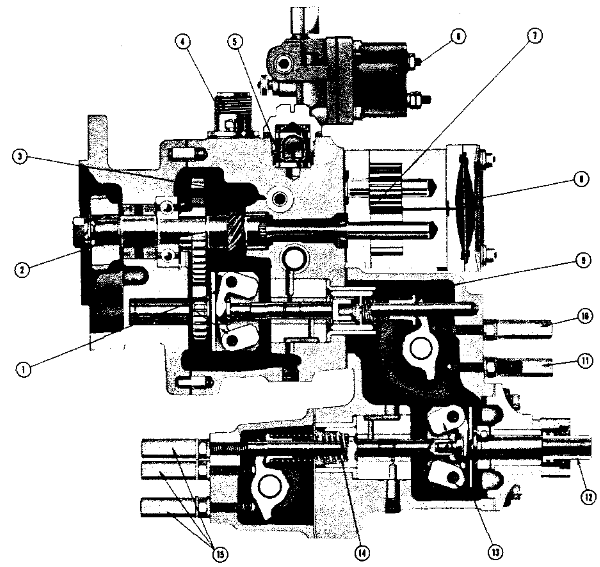
The PT torque-converter governor consists of two mechanical variable-speed governors in series – one driven by engine and the other by converter. Fig. 5-9.

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.



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. GOVERNOR SPRINGS
10. IDLE SPEED SCREW
11. MAXIMUM SPEED SCREW
12. IDLE SPRING
13. THROTTLE SHAFT

Fig. 5-8, (FWC-7). 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
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. 5-9, (FWC-8). PT (type R) fuel pump with torque converter governor

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

Aneroid

The aneroid control, Fig. 5-10, provides a fuel by-pass system that responds to air manifold pressure and is used on turbocharged engines for close control of exhaust smoke.

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

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

The function of the aneroid is to create a lag in fuel system

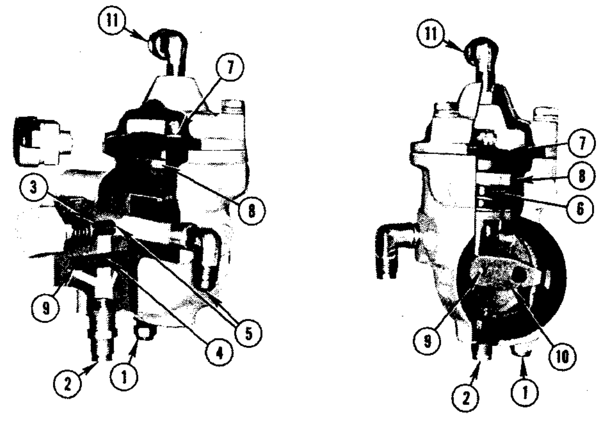


Fig. 5-10, (F-5244). Aneroid cutaway

so response is equivalent to the turbocharger, thus controlling engine smoke level.

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

Fuel Flow

1. Fuel from the fuel pump enters the aneroid and is directed to starting check valve area (5, Fig. 5-10).

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

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

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

5. The lever arm connected to piston (8) by actuating shaft (6), rotates shaft; closing valve port. The lever is rotated by action of air intake manifold pressure (11) against piston and diaphragm (7), moving actuating shaft downward against resisting spring force. Fig. 5-10.

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

7. The aneroid begins dumping when intake manifold pressure drops below preset value.

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

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

PT (type D) Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are the same for inline and V-engines but injector size and internal design differs slightly. Fig's. 5-11 and 5-12.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Fig's. 5-1, 5-2 and 5-3. A radial groove around each injector mates with the drilled passages in the cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in the injector body. A fine mesh screen at each inlet provides final fuel filtration.

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

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

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

Flanged Injector

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

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

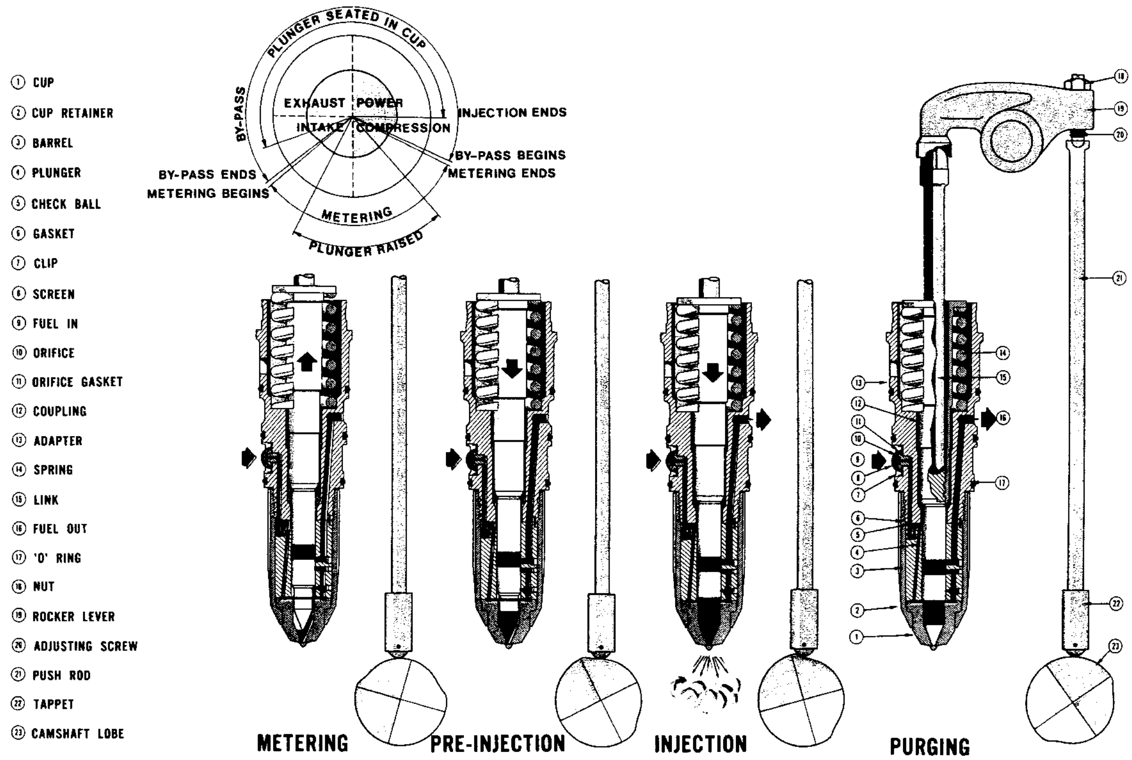


Fig. 5-11, (FWC-28). Fuel injection cycle. PT (type D) injector 3/8 inch diameter plunger

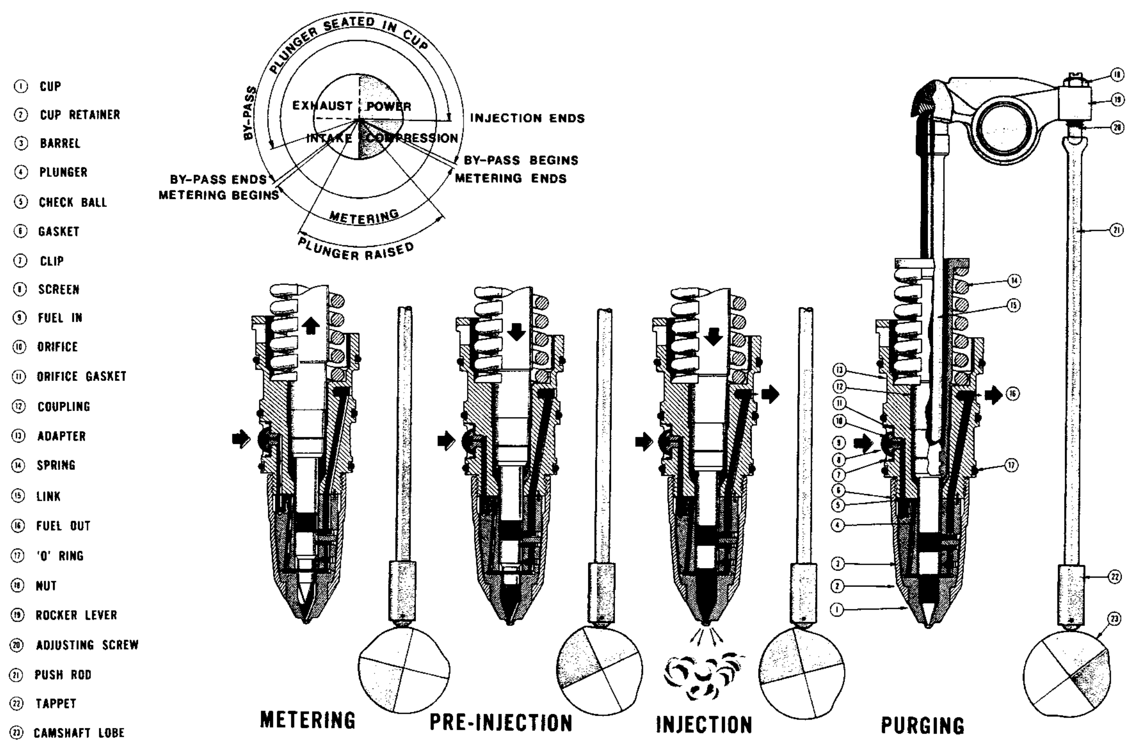


Fig. 5-12, (FWC-29). Fuel injector cycle, PT (type D) injector 5/16 inch diameter plunger amount of fuel passing through the metering orifice and into the cup is controlled by fuel pressure and timing. Fig. 5-13.

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

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

Fuel Lines, Connections And Valves

Supply And Drain Lines

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

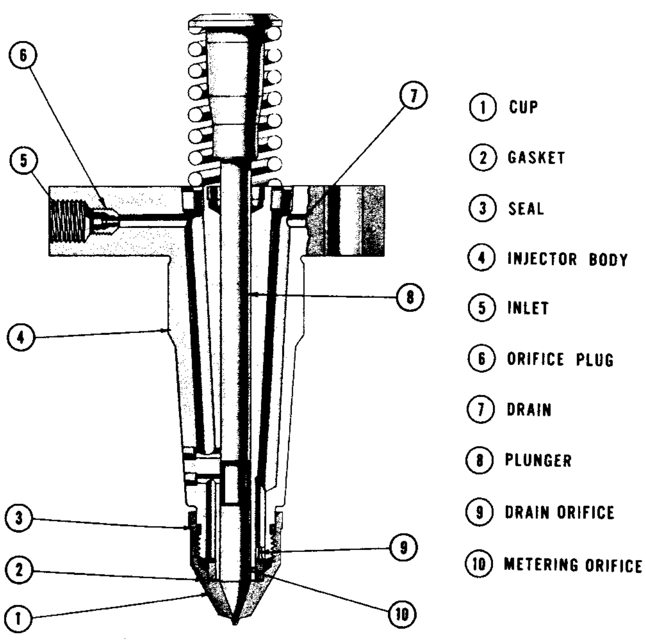


Fig. 5-13, (FWC-11A). Flanged PT injector

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

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

Connections

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

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

Shut-Down Valve

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

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

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

Lubricating System

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

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

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

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

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

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

Fuel pumps and injectors are lubricated by fuel oil.

Inline Engines

NH And NT Series

Oil is drawn into the pump through an external oil line connected to the oil pan sump. A screen in the sump filters the oil. On NH and NT engines (Fig. 5-14) oil is drawn from

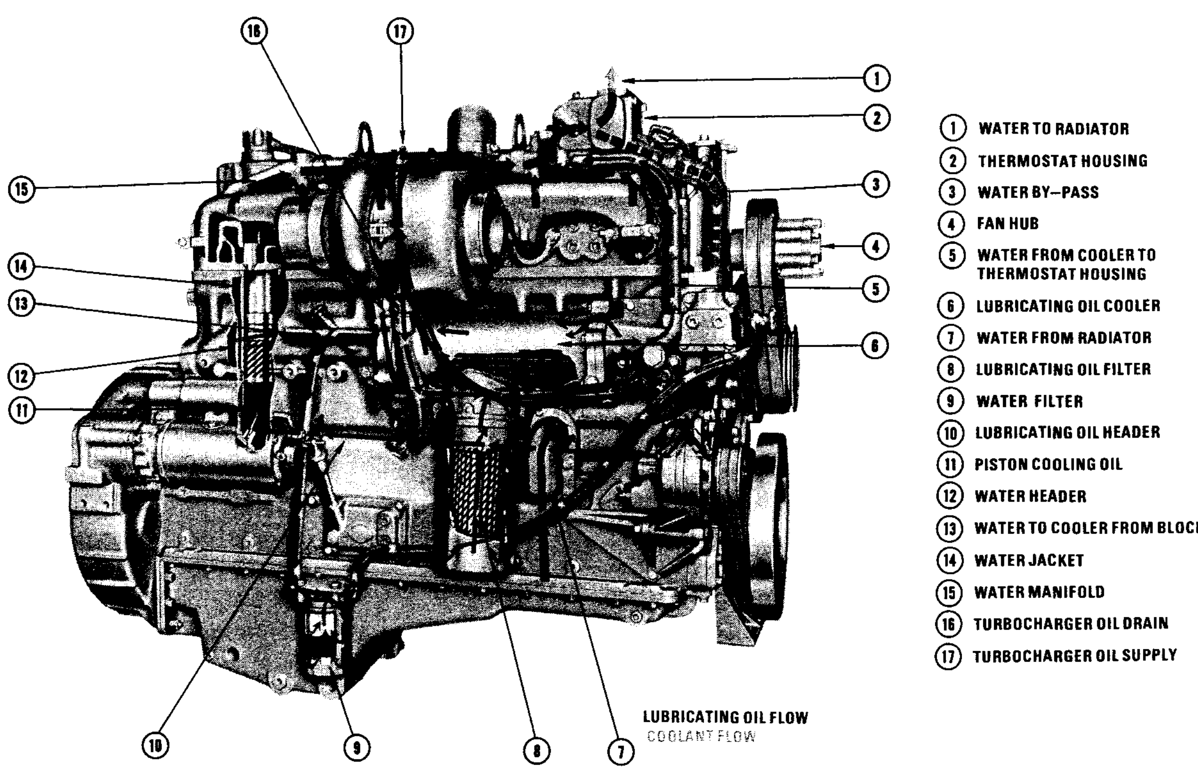


Fig. 5-14, (LWC-18). Lubricating oil and coolant flow - Inline Engine the pan by the pump out through a full-flow filter and circulates back into the block. The filter may be mounted directly to the rear of pump, vertically mounted on exhaust side of engine or remote mounted. External lines are used for remote mounting arrangements.

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

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

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

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

NTC Series (Full Flow Oil Cooling)

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

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig's. 5-15 and 5-16, then transferred from the suction cavity by the pump gears into the pressure cavity.

FFC OIL FLOW CIRCUIT

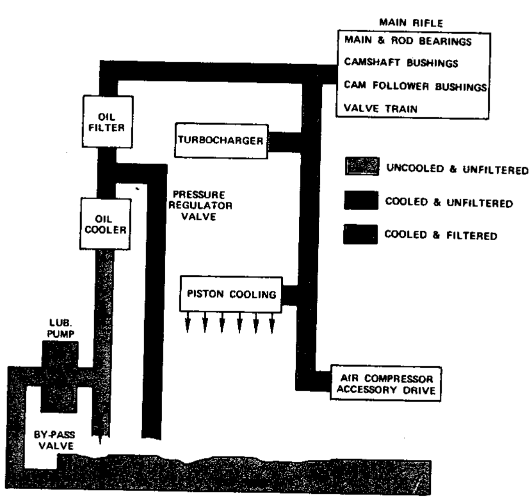


Fig. 5-15, (N10740). Full flow oil cooling (NTC Series)

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

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

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

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

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

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

C Series

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

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

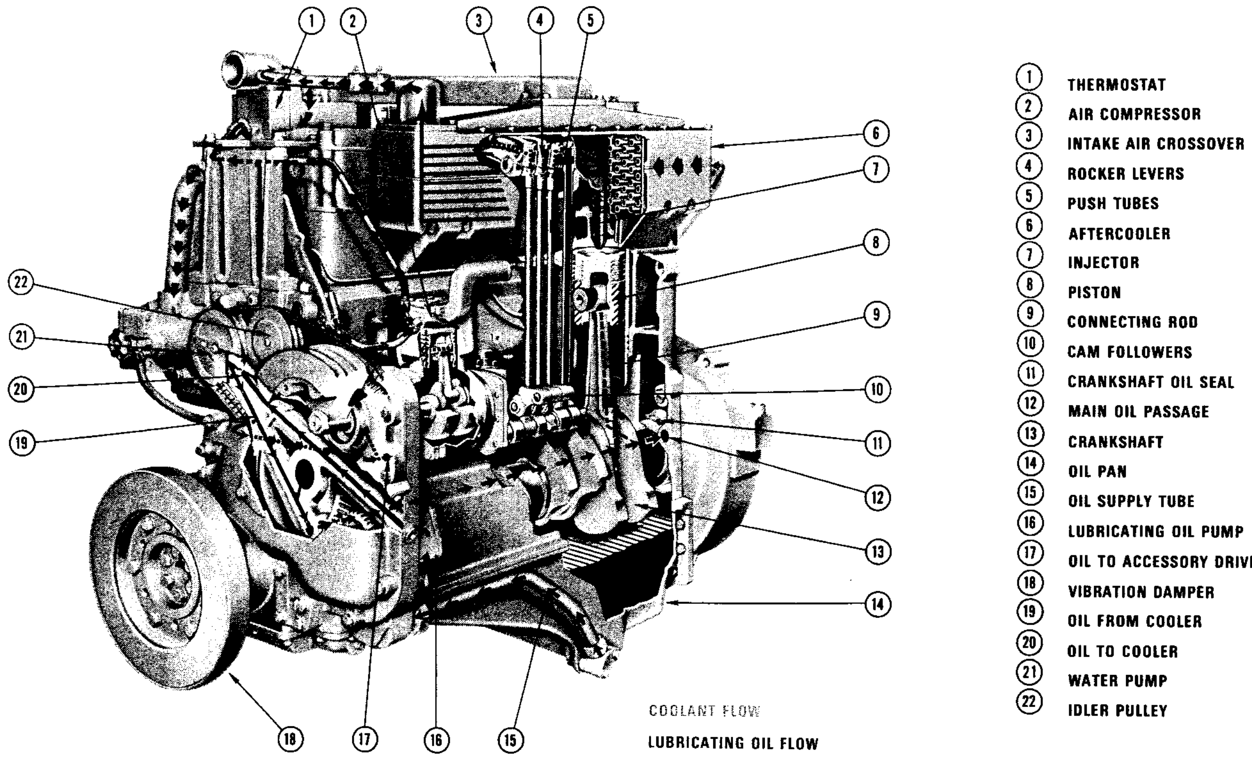


Fig. 5-16, (LWC-25). Lubricating oil and coolant flow – FFC (NTC Series)

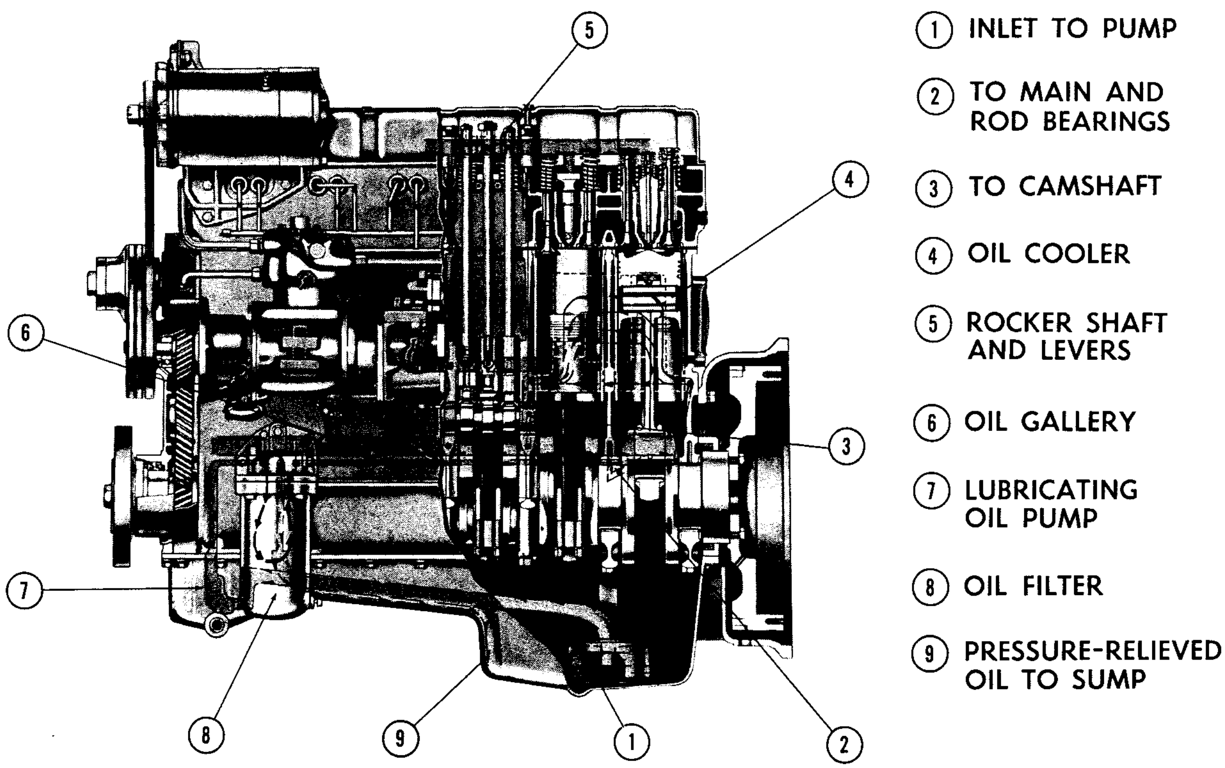
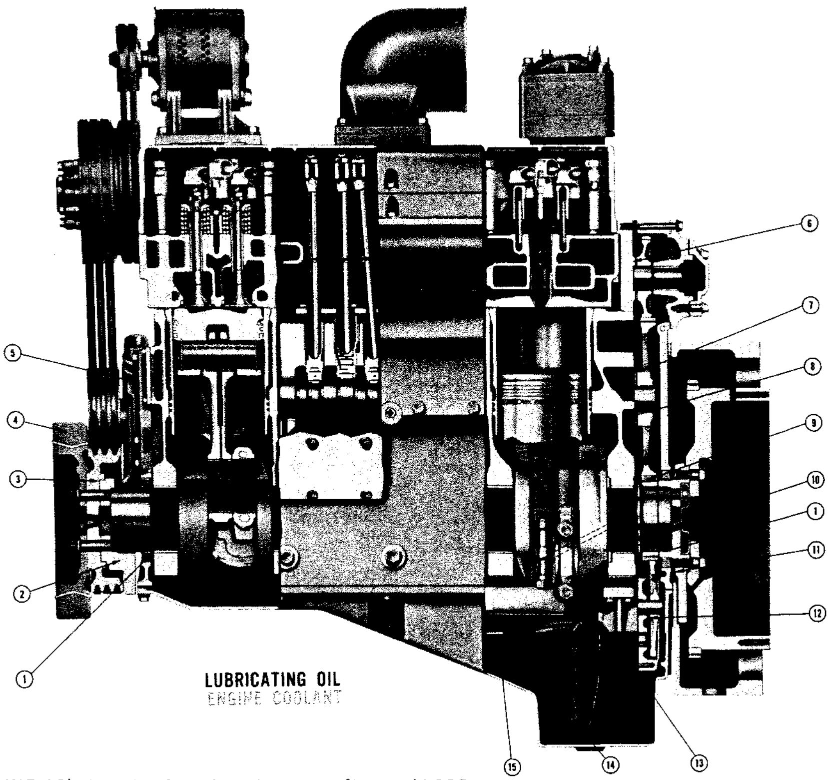
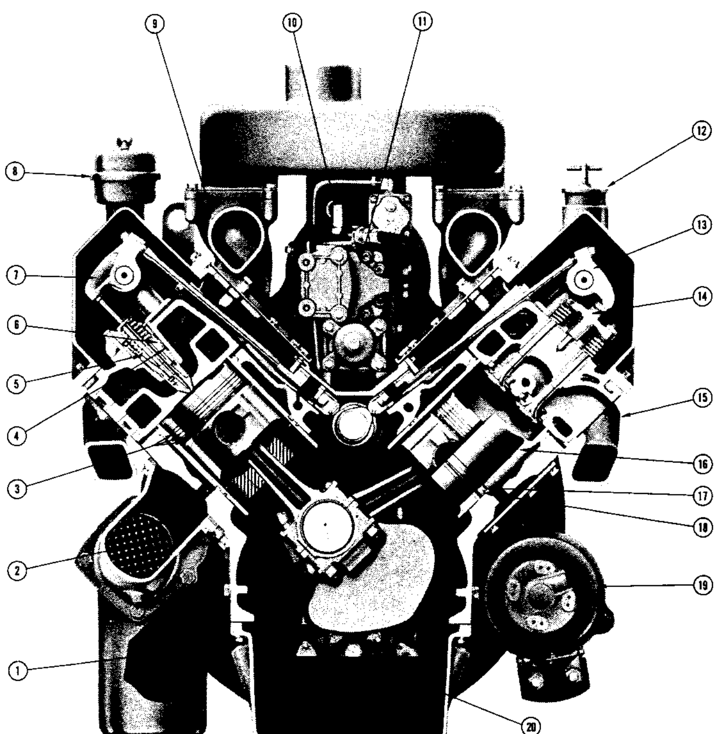


Fig. 5-17, (LWC-10) . Lubricating oil flow – C Series



① SEAL WEAR SLEEVE
② CRANKSHAFT PULLEY ADAPTER
③ CRANKSHAFT PULLEY
④ VIBRATION DAMPER
⑤ WATER PUMP
⑥ ACCESSORY DRIVE GEAR
⑦ CAMSHAFT GEAR
⑧ CAMSHAFT THRUST RING
⑨ CRANKSHAFT GEAR
⑩ CRANKSHAFT THRUST RINGS
⑪ FLYWHEEL ADAPTER
⑫ LUBRICATING OIL PUMP DRIVE GEAR
⑬ LUBRICATING OIL PUMP
⑭ LUBRICATING OIL SUCTION TUBE
⑮ LUBRICATING OIL BY-PASS TUBE

Fig. 5-18, (LWC-16). Lubricating oil and coolant flow – V-903



① FULL-FLOW LUBRICATING OIL FILTER
② OIL COOLER
③ PISTON RINGS
④ FUEL IN
⑤ FUEL OUT
⑥ INJECTOR
⑦ INJECTOR ROCKER LEVER
⑧ CRANKCASE BREATHER
⑨ AIR INTAKE MANIFOLD
⑩ FUEL SUCTION INLET TO PUMP
⑪ FUEL PUMP
⑫ OIL FILLER CAP
⑬ VALVE ROCKER LEVER
⑭ VALVE CROSSHEAD
⑮ EXHAUST MANIFOLD
⑯ CYLINDER LINER
⑰ CREVICE SEAL
⑱ PACKING RING
⑲ CRANKING MOTOR
⑳ LUBRICATING OIL PUMP

COOLANT
LUBRICATING OIL

Fig. 5-19, (LWC-4). Lubricating oil and coolant flow – V-378, V-504 and V-555 components through a pressure regulator, full-flow filter, transfer connection, lubricating oil cooler, into an oil header which is drilled the length of the block. Drillings in the block, cylinder head, crankshaft, connecting rods and rocker levers complete the oil circulating passages. Fig. 5-17.

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

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

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

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

V Series Engines

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

Oil drawn from pan sump through a screen is delivered to engine working components through oil lines and oil headers which are drilled the length of block. Drillings in block, cylinder head, crankshaft and rocker lever shafts complete oil circulation passages. Fig. 5-18 and 5-19.

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

V-903 Series Engines

1. Oil flows from cooler and filter to right bank of oil drilling at front of engine to front center of block. Oil flows through crossover at front of block to left bank and right bank main oil drillings (drilled length of block). Fig. 5-18.

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

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

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

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

1. Oil flows from filter to right bank oil drilling at rear of engine to accessory drive gear, rear cam bushing and rear main bearing which in turn supplies the two rear connecting rods. Fig. 5-19.

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

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

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

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

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

V-1710 Series Engines

Cummins V-1710 Series engines are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump, located in the oil pan and gear driven from the crankshaft gear.

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.

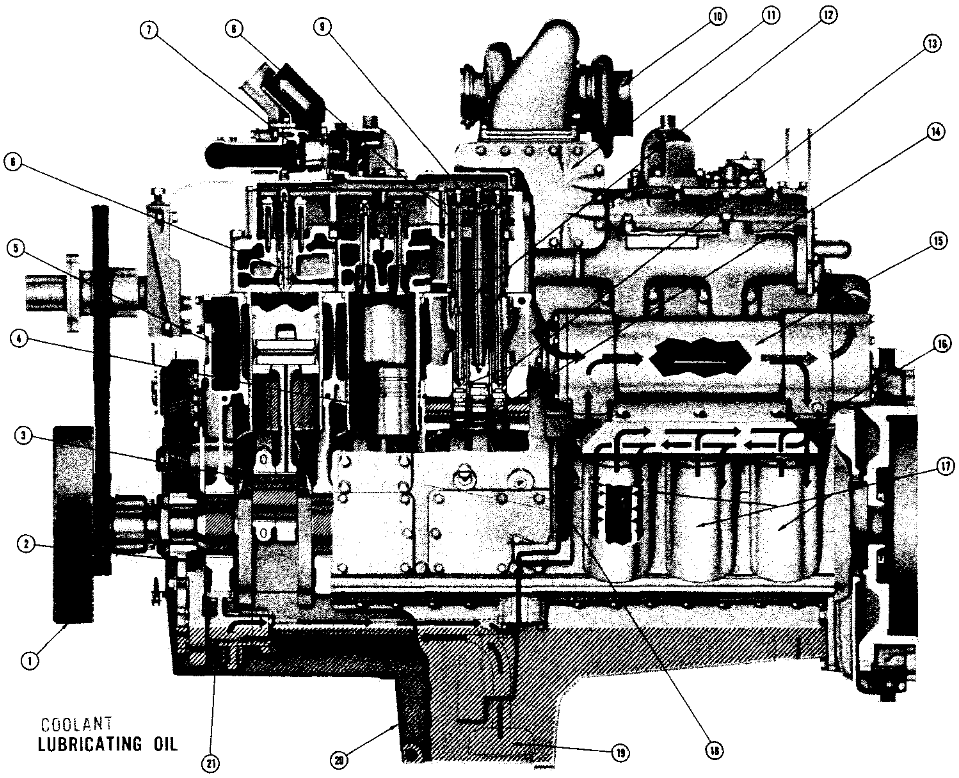
2. Internal lubricating oil flows from pump to cooler to full-flow filters mounted on side of engine, then to oil headers in block.

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 is supplied from the front of the block to oil headers which 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.



1. VIBRATION DAMPER
2. MAIN BEARING
3. CONNECTING ROD BEARING
4. PISTON
5. COOLANT PASSAGE
6. INJECTOR
7. THERMOSTAT
8. VALVE ROCKER LEVERS
9. INJECTOR ROCKER LEVER
10. T-50 TURBOCHARGER
11. INTER-COOLER/AIR INTAKE MANIFOLD
12. PUSH TUBES
13. TAPPETS
14. CAMSHAFT
15. OIL COOLER
16. OIL TO ENGINE
17. FULL-FLOW OIL FILTERS
18. OIL TO COOLER
19. OIL SUCTION
20. LUBRICATING OIL PAN
21. LUBRICATING OIL PUMP

Fig. 5-20, (CWC-13.) Lubricating oil and coolant flow - side view, V-1710

Cooling System

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

Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Fig. 5-14 through Fig. 5-21. Injector sleeves, in which injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat or thermostats to control engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.

The Fleetguard Water Filter is standard on Cummins Engines. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. Refer to Coolant Specifications for water filter capacity and treatment of make-up water.

NTA Aftercooled Engine

Water flows from radiator into cavity of water pump, where water flow splits. One portion circulates to the cylinder block water header around wet type cylinder liners, through the cylinder head and around the injector sleeves, upwards to the water manifold, to the thermostat housing. At the rear of the block water header, water is directed to the aftercooler, Fig. 5-21. Water flows forward through the aftercooler to the water crossover to the thermostat housing. The second portion of water flows from the cavity of the water pump housing through the oil cooler and tubing to the rear of the water manifold forward to the thermostat housing, to control engine temperature.

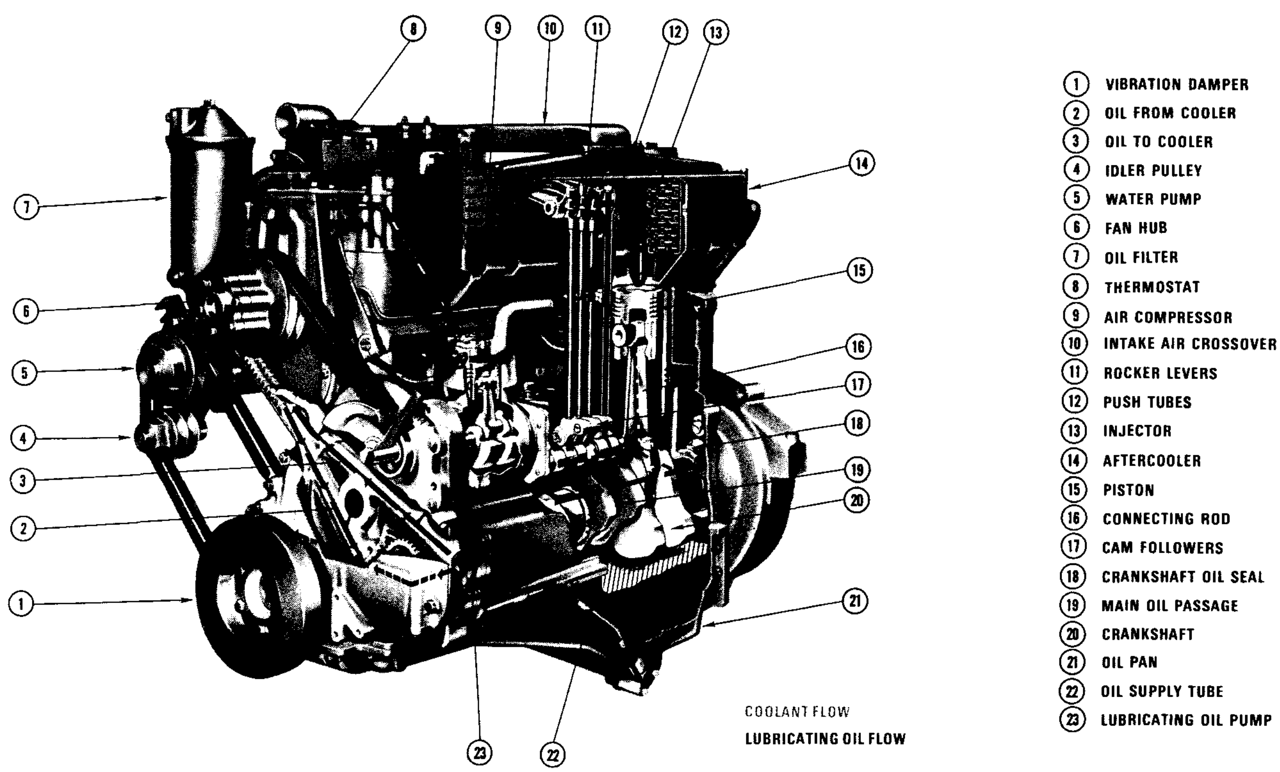


Fig. 5-21, (LWC-22). Coolant and lubricating oil flow – NTA Inline Engine

Air System

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

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

NTA Aftercooler

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

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

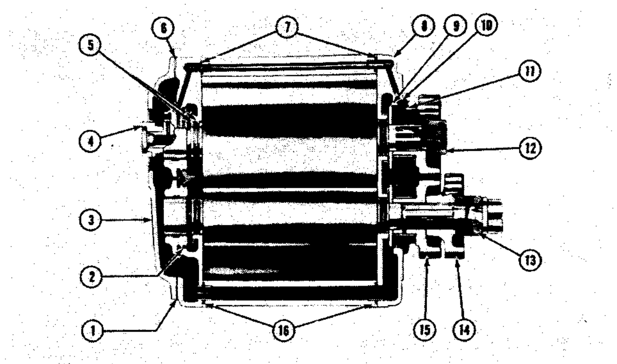


Fig. 5-22, (N21004). Supercharger (cross section)

Supercharger

A supercharger is a gear-driven mechanism which employs rotors to force air into engine cylinders. The supercharger is driven from the engine crankshaft through a gear train turning at about 1.8 times engine speed. Fig. 5-22.

Turbocharger

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

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

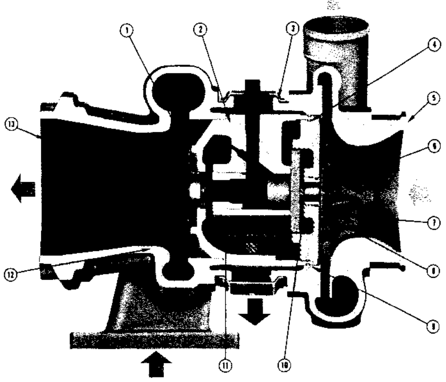
The power to drive the turbine wheel – which in turn drives the compressor – is obtained from energy of engine exhaust gases. Rotating speed of the turbine changes as the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig. 5-23, 5-24, 5-25, 5-26 and 5-27. The turbocharger is lubricated and cooled by engine lubricating oil.

Air Compressor

The Cummins air compressor may be either a single or two cylinder unit coupling or gear driven from the engine gear train accessory drive. Lubrication is received from the engine lubricating system, with oil carried by internal drillings, on 80 deg tilt engines air compressor crankcase is drained by a scavenger pump mounted on gear case cover and is driven by lubricating oil pump drive gear. The cylinder head is cooled by engine coolant. Operating functions are as follows:

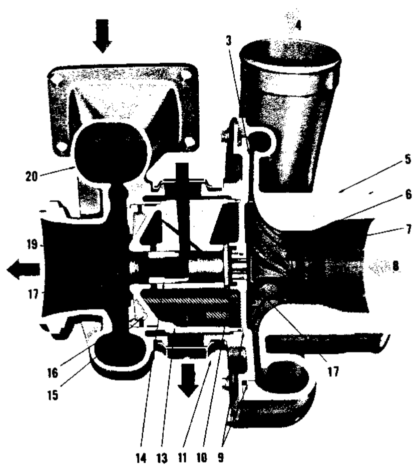
Air Intake

Air is drawn into the compressor through the engine intake



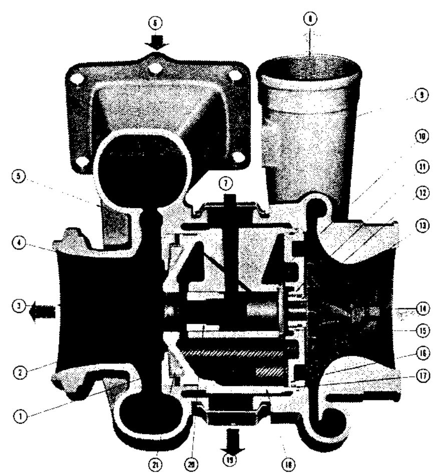
1. PISTON RING SEAL
2. BEARING HOUSING
3. 'V' CLAMP
4. 'O' RING SEAL
5. COMPRESSOR CASING
6. OIL SEAL ASSEMBLY
7. COMPRESSOR WHEEL
8. PISTON RING SEAL
9. 'O' RING SEAL
10. THRUST WASHER
11. BEARING
12. TURBINE WHEEL
13. TURBINE CASING

Fig. 5-23, (T380-A). T-35 turbocharger (cross section)



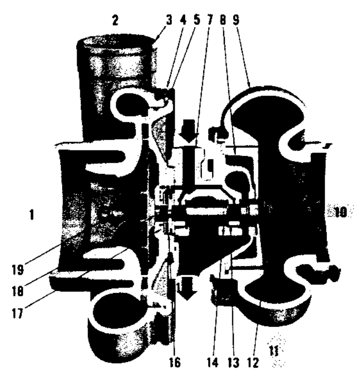
1. EXHAUST IN
2. OIL IN
3. DIFFUSER PLATE
4. AIR TO ENGINE
5. COLLECTOR HOUSING
6. OIL SEAL ASSEMBLY
7. IMPELLER
8. AIR IN
9. O-RING SEALS
10. BEARING INSERT
11. V-BAND CLAMP
12. OIL OUT
13. BEARING HOUSING
14. BEARING
15. INSULATION PAD
16. HEAT SHIELD
17. PISTON RING SEAL
18. EXHAUST OUT
19. TURBINE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

Fig. 5-26, (AWC-12). ST-50 turbocharger (cross section)



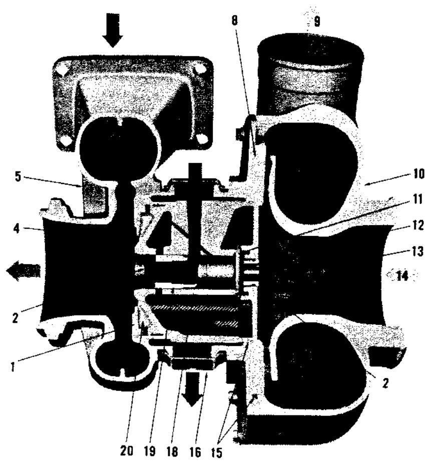
1. HEAT SHIELD
2. PISTON RING SEAL
3. EXHAUST OUT
4. TURBINE WHEEL
5. TURBINE CASING
6. EXHAUST IN
7. OIL IN
8. AIR TO ENGINE
9. COMPRESSOR CASING
10. BEARING INSERT
11. PISTON RING SEAL
12. OIL SEAL ASSEMBLY
13. COMPRESSOR WHEEL
14. AIR IN
15. SEAL PLATE
16. O-RING SEAL
17. O-RING SEAL
18. BEARING HOUSING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

Fig. 5-24, (AWC-8). T-50 turbocharger (cross section)



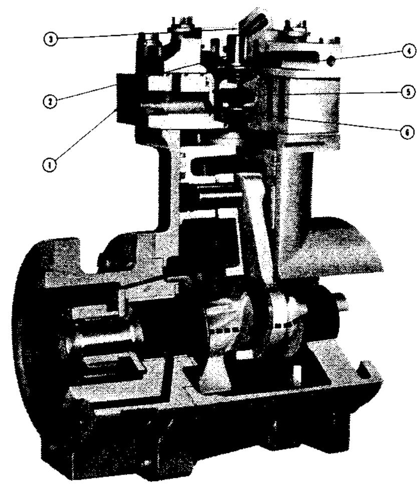
1. AIR IN
2. AIR OUT
3. COMPRESSOR HOUSING
4. V-BAND CLAMP
5. BACKPLATE
6. OIL IN
7. CENTER HOUSING
8. SHROUD
9. TURBINE HOUSING
10. EXHAUST OUT
11. EXHAUST IN
12. TURBINE WHEEL AND SHAFT
13. BEARINGS
14. SNAP RINGS
15. OIL OUT
16. THRUST WASHER
17. THRUST COLLAR
18. OIL SEAL ASSEMBLY
19. COMPRESSOR WHEEL

Fig. 5-27, (TA-1). T18-A turbocharger (cross section)



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

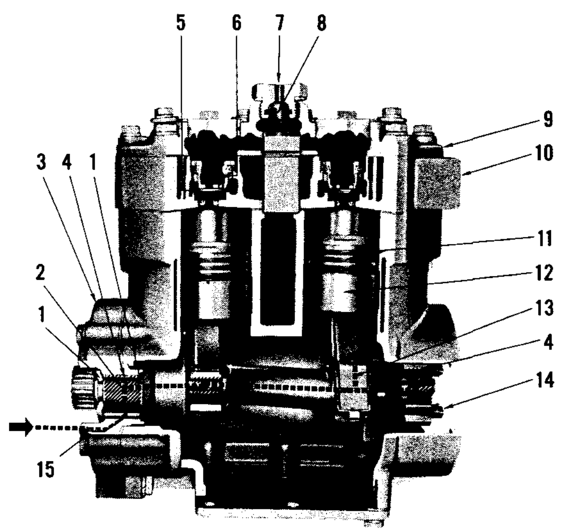
Fig. 5-25, (AWC-9). VT-50 turbocharger (cross section)



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

Fig. 5-28, (AWC-10). Cummins air compressor (single cylinder) air manifold or compressor mounted breather. 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. 5-28 and Fig. 5-29.



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. 5-29 (AWC-11) Cummins air compressor (two cylinder)

Compression

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

Unloading

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

Vacuum Pump

The Cummins Vacuum Pump, shown in Fig. 5-30, is an adaptation of Cummins Air Compressor; it is a single-cylinder unit driven from engine gear train accessory drive. Lubrication is received from engine lubricating

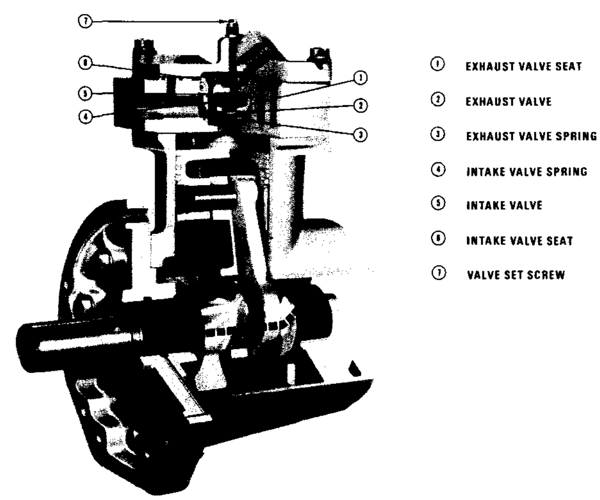


Fig. 5-30, (V11205). Cummins vacuum pump

system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

As piston moves downward on intake stroke a vacuum occurs above piston. The difference in cylinder pressure and atmospheric pressure forces inlet valve from its seat allowing air to flow through intake port into cylinder from vacuum tank thus creating vacuum in vacuum tank. When piston has reached bottom of its stroke, spring pressure is sufficient to overcome lesser pressure differential and forces valve against its seat.

Compression

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

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