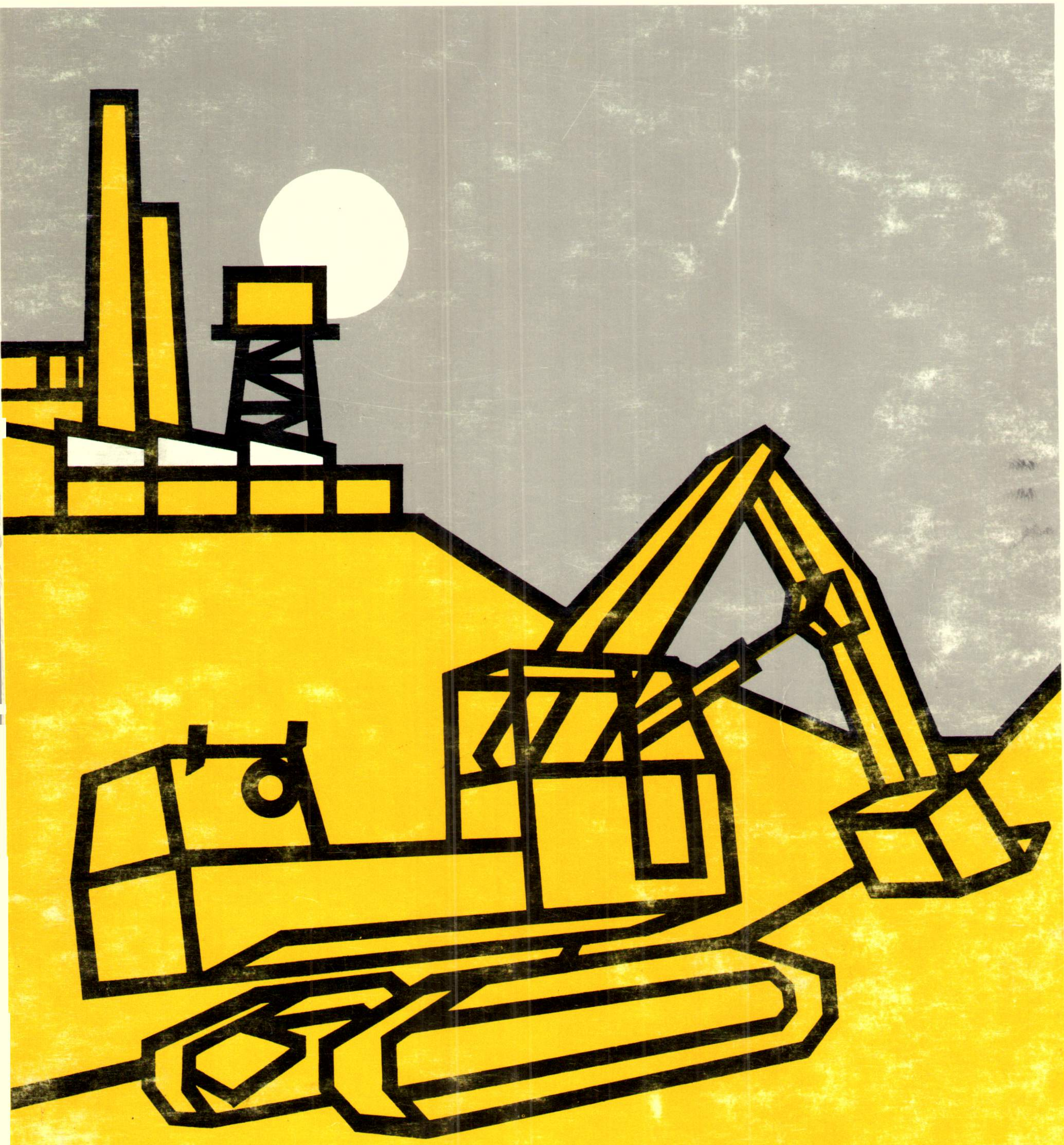
Construction/Industrial Diesel Engines
Operation and Maintenance Manual

560



Operation and Maintenance Manual

Cummins Diesel Engines

Agricultural

Construction

Industrial

Industrial Fire Pump

Logging

Mining

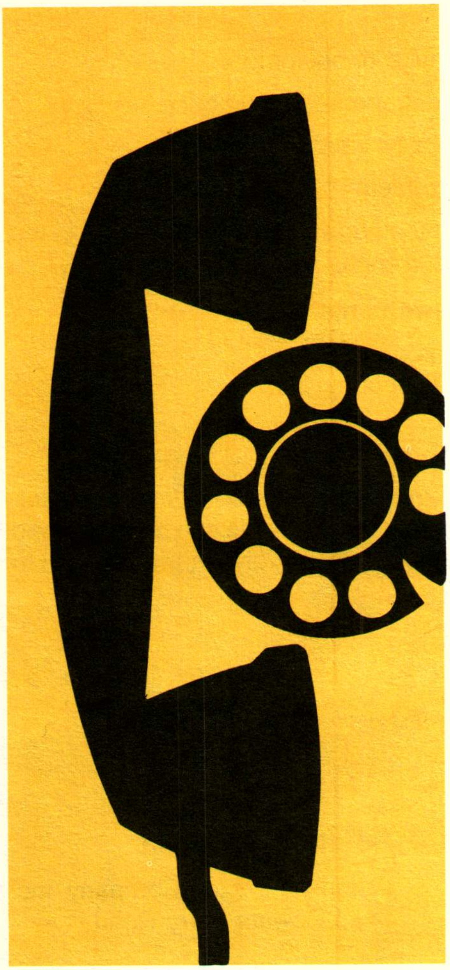
Railway

Generator

Bulletin 3379052-07, Printed 11/78

Emergency Service Assistance

If you should require emergency service assistance, check the yellow pages for the nearest Cummins distributor or authorized dealer.



Should you be unable to reach the local dealer or distributor in the above manner, Cummins Engine Company has established a 24 hours a day, toll free number for service assistance. In 47 states, you can call Cummins Customer Relations toll free by dialing 800-457-5300. In Alaska, Hawaii, Indiana and Canada, call collect 812-379-6115.

Cummins Owner Assistance

Cummins Engine Company backs its engines with expert service and complete parts support. We built a service network of more than 3,000 Cummins distributors and dealers, the largest in the world devoted exclusively to diesel engines. We trained our people to provide the Cummins owner with sound advice, expert service and professional treatment at all Cummins locations.

Any problem that you have in connection with the sale, operation or service of your engine can be handled at the nearest Cummins location. Occasionally, you may feel a problem has not been handled to your satisfaction. At those times, we urge you to pursue the problem until you are satisfied.

Many problems result from a breakdown in communications and can often be solved by bringing in a third party as a mediator. Bring your problem to the next higher authority to discuss.

We recommend:

1. If problem originates with a salesperson or service technician, talk to the sales or service manager.
2. If problem originates with a sales or service manager, talk to the owner of the service location.
3. If problem originates with a dealer, talk to the Cummins distributor with whom he has his service agreement.
4. If problem originates with a distributor, please call the nearest Cummins Divisional Office. Most problems are solved at or below the divisional office level. Their phone numbers and addresses are listed below. However, before you call, write down the following information and have it ready:
   - A. Name and location of the Cummins distributor or dealer
   - B. Type and make of equipment
   - C. Engine model and serial number
   - D. Total miles or hours of operation
   - E. Nature of problem
   - F. Summary of the current problem arranged in the order of occurrence.

If you still have problems please write:

Customer Relations
Cummins Engine Company, Inc.
1000 Fifth Street
Columbus, Indiana 47201

We do request that the above steps be followed in order. Most of the actual work on an engine can be performed at the original location, so please give them a chance to satisfy you first.

Cummins Divisional Offices

Canadian Division

Cummins Engine Company, Inc.
77 City Centre Drive
Suite 302
Mississauga, Ontario
Canada
Phone: 416-270-0240

Eastern Division

Cummins Engine Company, Inc.
Norwalk Towers
Suite 200
Bedlon Avenue & Cross Street
Norwalk, Connecticut 06850
Phone: 203-846-3241

Midwestern Division

Cummins Engine Company, Inc.
Oak Brook East Building
2000 Spring Road
Oak Brook, Illinois 60521
Phone: 312-654-0020

Plains Division

Cummins Engine Company, Inc.
Twin Towers, North
Suite 633
8585 North Stemmons Freeway
Dallas, Texas 75247
Phone: 214-638-5410

Rocky Mountain Division

Cummins Engine Company, Inc.
5660 S. Syracuse Circle
Englewood, Colorado 80110
Phone: 303-773-2866

Southern Division

Cummins Engine Company, Inc.
6425 Powers Ferry Road
Suite 120
Atlanta, Georgia 30339
Phone: 404-955-5025

Western Division

Cummins Engine Company, Inc.
Two Embarcadero Center
Suite 2050
San Francisco, California 94111
Phone: 415-981-2900

Foreword

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 dataplate. 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

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

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

Table of Contents

Operating Instructions

Maintenance Operations

Specifications and Torque

Trouble-Shooting

Operating Principles

Index

Engine Specifications

Table 1: Agricultural, Construction, Industrial, Logging and Mining Engine Specifications

			Performance Ratings 500 ft. [150 m] 85°F [29°C]			
Engine Model	**Configuration Number**	**Displacement Cu. Inch [liter]**	**HP [kW]**	**@ RPM**	**Peak Torque ft-lbs [N•m]**	**@ RPM**
N-495-C130	D08 1 001 CX01	495 [8.1]	125 [93]	@ 2000	387 [525]	@ 1100
NT-495-C180		495 [8.1]	180 [134]	@ 2100	494 [670]	@ 1500
N-743-C220	D07 1 011 CX01	743 [12.2]	212 [158]	@ 2100	580 [786]	@ 1500
NT-743-C262		743 [12.2]	262 [195]	@ 2100	720 [975]	@ 1400
NT-743-C335		743 [12.2]	335 [250]	@ 2100	900 [1220]	@ 1500
N-855-C220	D09 1 220 CX00	855 [14.0]	220 [164]	@ 2100	644 [873]	@ 1500
N-855-C235	D09 1 215 CX01	855 [14.0]	235 [175]	@ 2100	647 [877]	@ 1500
NT-855-C250	D09 2 294 CX00	855 [14.0]	250 [187]	@ 2100	750 [1017]	@ 1500
NT-855-C280	D09 2 135 CX00	855 [14.0]	280 [209]	@ 2100	805 [1092]	@ 1500
			280 [209]	@ 2100	810 [1098]	@ 1500
NT-855-C310	D09 2 136 CX00	855 [14.0]	310 [231]	@ 2100	890 [1207]	@ 1500
NT-855-C335	D09 2 137 CX00	855 [14.0]	335 [250]	@ 2100	930 [1260]	@ 1500
NTA-855-C360	D09 3 139 CX00	855 [14.0]	360 [269]	@ 2100	990 [1342]	@ 1500
NTA-855-C400	D09 3 295 CX00	855 [14.0]	400 [298]	@ 2100	1150 [1559]	@ 1500
KT-1150-C450	D19 2 005 CX02	1150 [18.9]	450 [336]	@ 2100	1350 [1831]	@ 1500
KTA-1150-C525	D19 3 011 CX02	1150 [18.9]	525 [392]	@ 2100	1575 [2136]	@ 1500
KTA-1150-C600	D19 3 006 CX02	1150 [18.9]	600 [448]	@ 2100	1650 [2237]	@ 1600
V-378-C	D20 1 025 CX00	378 [6.2]	145 [108]	@ 3000	280 [380]	@ 1900
V-504-C	D21 1 031 CX00	504 [8.3]	195 [146]	@ 3000	375 [508]	@ 1900
VT-555-C	D22 2 024 CX00	555 [9.1]	230 [172]	@ 3000	455 [616]	@ 1900
V-903-C265	D17 1 010 CX00	903 [14.8]	265 [198]	@ 2600	657 [891]	@ 1500
V-903-C295	D17 1 034 CX00	903 [14.8]	295 [220]	@ 2600	700 [949]	@ 1800
VT-903-C320	D17 2 009 CX00	903 [14.8]	320 [239]	@ 2600	775 [1051]	@ 1800
VT-903-C350	D17 2 016 CX00	903 [14.8]	350 [261]	@ 2600	848 [1150]	@ 1800
VT-903-C375	D17 2 050 CX00	903 [14.8]	375 [278]	@ 2600	848 [1150]	@ 1800
VT-903-C430	D17 2 045 CX00	903 [14.8]	430 [321]	@ 2500	1000 [1356]	@ 1800
VT-1710-C635	D15 2 014 CX00	1710 [28.0]	635 [474]	@ 2100	1747 [2369]	@ 1500
VTA-1710-C700	D15 3 025 CX00	1710 [28.0]	700 [522]	@ 2100	1925 [2610]	@ 1500
VTA-1710-C800	D16 3 035 CX00	1710 [28.0]	800 [597]	@ 2100	2200 [2983]	@ 1500
KT-2300-C900	D23 2 003 CX02	2300 [37.8]	900 [671]	@ 2100	2475 [1356]	@ 1500

Table 1: Agricultural, Construction, Industrial, Logging and Mining Engine Specifications (Cont'd.)

Engine Model	Configuration Number	Displacement Cu. Inch [liter]	Performance Ratings 500 ft. [150 m] 85°F [29°C] HP [kW] @ RPM	Peak Torque ft-lbs [N•m] @ RPM
KTA-2300-C1050	D23 3 004 CX02	2300 [37.8]	1050 [783] @ 2100	2890 [3919] @ 1500
KTA-2300-C1200	D23 3 001 CX02	2300 [37.8]	1200 [895] @ 2100	3300 [4470] @ 1500
KTA-3067-C1600	D28 3 003 CX02	3067 [50.3]	1600 [1194]@ 2100	4400 [5966] @ 1500
			Restricted Availability	
N-855-P190	D09 1 178 PX00	855 [14.0]	190 [142] @ 2100	566 [768] @ 1200
N-855-P220	D09 1 179 PX00	855 [14.0]	220 [164] @ 2100	664 [873] @ 1500
N-855-P250	D09 1 058 PX00	855 [14.0]	240 [179] @ 2100	658 [892] @ 1500
N-855-C190	D09 1 175 CX00	855 [14.0]	190 [142] @ 2100	566 [768] @ 1200
N-855-C220	D09 1 148 CX00	855 [14.0]	220 [164] @ 2100	644 [873] @ 1500
N-855-C250	D09 1 075 CX00	855 [14.0]	240 [170] @ 2100	658 [892] @ 1500
NT-855-C310	D09 2 076 CX00	855 [14.0]	310 [231] @ 2100	860 [1166] @ 1500
NT-855-C335	D09 2 056 CX00	855 [14.0]	335 [250] @ 2100	930 [1261] @ 1500
VTA-903-T	D17 3 020 TX01	903 [14.8]	450 [336] @ 2600	1000 [1356] @ 1900
V-378-C155	D20 1 007 CX00	378 [6.2]	149 [111] @ 3300	289 [392] @ 1900
V-504-C210	D21 1 008 CX00	504 [8.3]	202 [151] @ 3300	387 [525] @ 1900
V-555-C230	D22 1 003 CX00	555 [9.1]	230 [172] @ 3300	425 [576] @ 1900
VT-555-C240	D22 2 016 CX00	555 [9.1]	240 [179] @ 3300	445 [603] @ 1900
VT-555-C250	D22 2 022 CX00	555 [9.1]	250 [187] @ 3300	445 [603] @ 1900
N-495-P130	D08 1 002 PX01	495 [8.1]	125 [93] @ 2000	187 [525] @ 1100
NT-495-P180		495 [8.1]	180 [134] @ 2100	494 [670] @ 1500
N-743-P220	D07 1 016 PX01	743 [12.2]	211 [157] @ 2100	580 [786] @ 1500
NT-743-P335		743 [12.2]	335 [250] @ 2100	900 [1220] @ 1500
N-855-P235	D09 1 276 PX02	855 [14.0]	235 [175] @ 2100	647 [877] @ 1500
N-855-P250	D09 1 058 PX00	855 [14.0]	240 [179] @ 2100	658 [892] @ 1500
NT-855-P310	D09 2 110 PX00	855 [14.0]	310 [231] @ 2100	852 [1155] @ 1500
NT-855-P335	D09 2 059 PX00	855 [14.0]	335 [250] @ 2100	930 [1261] @ 1600
NT-855-P335	D09 2 278 PX02	855 [14.0]	335 [250] @ 2100	930 [1261] @ 1500
NTA-855-P360	D09 3 279 PX02	855 [14.0]	360 [269] @ 2100	990 [1342] @ 1500
NTA-855-P400	D09 3 280 PX02	855 [14.0]	400 [298] @ 2100	1150 [1559] @ 1500
KT-1150-P450	D19 2 018 PX02	1150 [18.9]	450 [336] @ 2100	1350 [1831] @ 1500
KTA-1150-P600	D19 3 019 PX02	1150 [18.9]	600 [448] @ 2100	1650 [2237] @ 1600
V-378-P	D20 1 026 PX00	378 [6.2]	145 [108] @ 3000	280 [380] @ 1900

Table 1: Agricultural, Construction, Industrial, Logging and Mining Engine Specifications (Cont'd.)

			Performance Ratings 500 ft. [150 m] 85° F [29° C]			
Engine Model	**Configuration Number**	**Displacement Cu. Inch [liter]**	**HP [kW]**	**@ RPM**	**Peak Torque ft-lbs [N•m]**	**@ RPM**
V-504-P	D21 1 032 PX00	504 [8.3]	195 [146]	@ 3000	375 [508]	@ 1900
VTA-1710-P700	D15 3 075 PX02	1710 [28.0]	700 [522]	@ 2100	1925 [2610]	@ 1500
VTA-1710-P800	D15 3 076 PX02	1710 [28.0]	800 [597]	@ 2100	2200 [2983]	@ 1500
KT-2300-P900	D23 2 013 PX02	2300 [37.8]	900 [671]	@ 2100	2475 [3356]	@ 1500
KTA-2300-P1200	D23 3 014 PX02	2300 [37.8]	1200 [895]	@ 2100	3300 [4470]	@ 1500
KTA-3067-P1600	D28 3 004 PX02	3067 [50.3]	1600 [1194]	@ 2100	4400 [5966]	@ 1500
V-378-P	D20 1 002 PX00	378 [6.2]	149 [111]	@ 3300	289 [392]	@ 1900
V-504-P	D21 1 003 PX00	504 [8.3]	202 [151]	@ 3300	387 [525]	@ 1900

Table 2: Locomotive and Railcar Engine Specifications

			Performance Ratings 500 ft. [150 m] 85° F [29° C]			
Engine Model	**Configuration Number**	**Displacement Cu. Inch [liter]**	**HP [kW]**	**@ RPM**	**Peak Torque ft-lbs [N•m]**	**@ RPM**
N-855-R2	D09 1 229 RX01	855 [14.0]	235 [175]	@ 2100	650 [881]	@ 1500
N-855-L1	D09 1 217 LX00	855 [14.0]	235 [175]	@ 2100	650 [881]	@ 1500
NT-855-L4	D09 2 199 LX00	855 [14.0]	335 [250]	@ 2100	930 [1261]	@ 1500
NT-855-R4	D09 2 223 RX01	855 [14.0]	335 [250]	@ 2100	930 [1261]	@ 1500
NTA-855-L3	D09 3 296 LX00	855 [14.0]	400 [298]	@ 2100	1150 [1559]	@ 1500
NTA-855-R	D09 3 304 RX01	855 [14.0]	400 [298]	@ 2100	1150 [1559]	@ 1500
KT-1150-L	D19 2 009 LX02	1150 [18.9]	450 [336]	@ 2100	1350 [1831]	@ 1500
KTA-1150-L	D19 3 010 LX02	1150 [18.9]	600 [448]	@ 2100	1650 [2237]	@ 1500
VTA-1710-L1	D15 3 077 LX01	1710 [28.0]	700 [522]	@ 2100	1920 [2604]	@ 1500
VTA-1710-L2	D15 3 078 LX01	1710 [28.0]	800 [597]	@ 2100	2200 [2983]	@ 1500
KT-2300-L	D23 2 006 LX02	2300 [37.8]	900 [671]	@ 2100	2475 [3356]	@ 1500
KTA-2300-L	D23 3 005 LX02	2300 [37.8]	1200 [895]	@ 2100	3300 [4474]	@ 1500
KTA-3067-L	D28 3 004 LX02	3067 [50.3]	1600 [1194] **Restricted Availability**	@ 2100	4400 [5966]	@ 1500
NHRS-6-L1		743 [12.2]	272 [203]	@ 2100	730 [989]	@ 1600
N-855-R	D09 1 011 RX01	855 [14.0]	240 [179]	@ 2100	648 [892]	@ 1500

Table 3: Fire Pump Engine Specifications

Engine Model	Configuration Number	Displacement Cu. Inch [liter]	Performance Ratings Sea Level 60° F [16° C] HP [kW]	@ RPM
N-855-F	D09 1 190 FX01	855 [14.0]	160 [119]	@ 1460
			190 [142]	@ 1750
			200 [149]	@ 1900
			215 [160]	@ 2100
NT-855-F1	D09 2 012 FX01	855 [14.0]	255 [190]	@ 1750
			255 [190]	@ 1900
			255 [190]	@ 2100
NT-855-F2	D09 2 061 FX01	855 [14.0]	285 [212]	@ 1750
			303 [226]	@ 1900
			325 [242]	@ 2100
			340 [254]	@ 2300
V-378-F1	D20 1 017 FX01	378 [6.2]	116 [87]	@ 1750
			135 [101]	@ 2000
			111 [83]	@ 2200
V-378-F2	D20 1 018 FX01	378 [6.2]	118 [88]	@ 2400
			125 [93]	@ 2600
			130 [97]	@ 2800
			133 [99]	@ 3000
			136 [101]	@ 3300
V-504-F1	D21 1 025 FX01	504 [8.3]	121 [90]	@ 1750
			141 [105]	@ 2000
			145 [108]	@ 2200
V-504-F2	D21 1 024 FX01	504 [8.3]	157 [117]	@ 2400
			168 [125]	@ 2600
			174 [130]	@ 2800
			182 [136]	@ 3000
			185 [138]	@ 3300
VT-1710-F	D15 2 053 FX01	1710 [28.0]	435 [324]	@ 1460
			525 [392]	@ 1750
			550 [410]	@ 1900
			580 [433]	@ 2100

Table 4: Engine and Generator Specifications (1800 RPM ratings are 60 HZ., 1500 RPM ratings are 50 HZ.)

			Performance Ratings 500 ft. [150 m] 85°F [29°C]	
Engine Model	Configuration Number	Displacement Cu. Inch [liter]	Stand-By Output KW @ RRM	Cont. Output KW @ RPM
N-855-GS/GC	D09 1 241 GX02	855 [14.0]	135 @ 1800	135 @ 1800
			155 @ 1500	115 @ 1500
NT-855-GS/GC	D09 2 242 GX02	855 [14.0]	230 @ 1800	205 @ 1800
			190 @ 1500	170 @ 1500
NTA-855-GS/GC	D09 3 243 GX02	855 [14.0]	260 @ 1800	235 @ 1800
			220 @ 1500	200 @ 1500
KT-1150-GS/GC	D19 2 013 GX02	1150 [18.9]	300 @ 1800	275 @ 1800
			265 @ 1500	240 @ 1500
KTA-1150-GS/GC	D19 3 015 GX02	1150 [18.9]	365 @ 1800	325 @ 1800
			310 @ 1500	280 @ 1500
VT-1710-GS/GC	D15 2 072 GX02	1710 [28.0]	450 @ 1800	375 @ 1800
			410 @ 1500	335 @ 1500
VTA-1710-GS/GC	D15 3 074 GX02	1710 [28.0]	550 @ 1800	455 @ 1800
			440 @ 1500	400 @ 1500
KT-2300-GS/GC	D23 2 009 GX02	2300 [37.8]	600 @ 1800	535 @ 1800
			500 @ 1500	450 @ 1500
KTA-2300-GS/GC	D23 3 010 GX02	2300 [37.8]	750 @ 1800	
			580 @ 1500	
KTA-3067-GS/GC	D28 3 006 GX02	3067 [50.3]	1000 @ 1800	900 @ 1800
			825 @ 1500	745 @ 1500

Engine Model	Configuration Number	Displacement Cu. Inch [liter]	1800 RPM HP*	1800 RPM [kW]	1500 RPM HP	1500 RPM [kW]
N-855-G	D09 1 241 GX02	855 [14.0]	215	[160]	180	[134]
			(195)	[145]	(160)	[119]
NT-855-G	D09 2 442 GX02	855 [14.0]	355	[265]	295	[220]
			(320)	[239]	(265)	[198]
NTA-855-G	D09 3 243 GX02	855 [14.0]	300	[298]	335	[250]
			(360)	[269]	(300)	[224]
KT-1150-G	D19 2 013 GX02	1150 [18.9]	465	[347]	405	[302]
			(420)	[313]	(365)	[272]
			(415)	[310]	(345)	[257]
KT-1150-G	D19 3 015 GX02	1150 [18.9]	560	[418]	470	[351]
			(505)	[377]	(425)	[317]
			(500)	[373]	(425)	[317]
VT-1710-G	D15 2 072 GX02	1710 [28.0]	685	[511]	620	[463]
			(555)	[414]	(465)	[347]
VTA-1710-G	D15 3 074 GX02	1710 [28.0]	760	[567]	690	[515]
			(680)	[507]	(570)	[425]

Table 4: Engine and Generator Specifications (1800 RPM Ratings are 60 HZ., 1500 RPM ratings are 50 HZ.) (Cont'd.)

			Performance Ratings 500 ft. [150 m] 85° F [29° C]			
Engine Model	Configuration Number	Displacement Cu. Inch [liter]	1800 RPM HP *	1800 RPM [kW]	1500 RPM HP	1500 RPM [kW]
KT-2300-G	D23 2 009 GX02	2300 [37.8]	915	[683]	760	[567]
			(820)	[611]	(685)	[511]
KTA-2300-G	D23 3 010 GX02	2300 [37.8]	1135	[832]	940	[701]
			(1005)	[749]	(845)	[630]
KTA-3067-G	D28 3 006 GX02	3067 [50.3]	1490	[1112]	1240	[925]
			1350	[1007]	1125	[839]

* ( ) Marine Approved Rating

Operating Instructions

The engine operator must assume responsibility of engine care while engine is being operated. There are comparatively few rules which operator must observe to get best service from a Cummins Diesel.

General—All Applications

New and Rebuilt Engines 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 trucks and rail car applications.

In other applications, the engine can be put to work, but the operator has an opportunity to establish conditions for optimum service life during initial 100 hours of service by:

1. Operating as much as possible at three-quarter throttle of load range.
2. Avoiding operation for long periods at engine idle speeds, or at maximum horsepower levels in excess of five minutes.
3. Developing the habit of watching engine instruments closely during operation and letting up on throttle if oil temperature reaches 250° F [121° C] or coolant temperature exceeds 190° F [88° C].
4. Operating with a power requirement that allows acceleration to governed speed when conditions require more power.
5. Checking oil level every 10 hours during the break-in period.

New or Rebuilt Engines Pre-Starting Instructions — First Time

Priming The Fuel System

1. Fill fuel filter with clean No. 2 diesel fuel oil meeting the specifications outlined in Section 3.
2. Remove fuel pump suction line and wet gear pump gears with clean lubricating oil.
3. Check and fill fuel tanks.
4. If injector and valve or other adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting the engine.

Priming The Lubricating System

Note: On turbocharged engines, remove oil inlet line from the turbocharger and prelubricate bearing by adding 2 to 3 oz. [50 to 60 cc] of clean lubricating oil. Reconnect oil supply line.

1. Fill crankcase to "L" (low) mark on dipstick. See Lubricating Oil Specifications, Section 3.
2. Remove plug from lubricating oil crossover passage on NH/NT-855 Engines, Fig. 1-1. Remove plug from head of lubricating oil filter housing on V Engines, Fig's. 1-2, 1-3, 1-4, 1-5 and 1-6. On KT/KTA-1150 Engines, remove plug from front of oil cooler housing, Fig. 1-7.

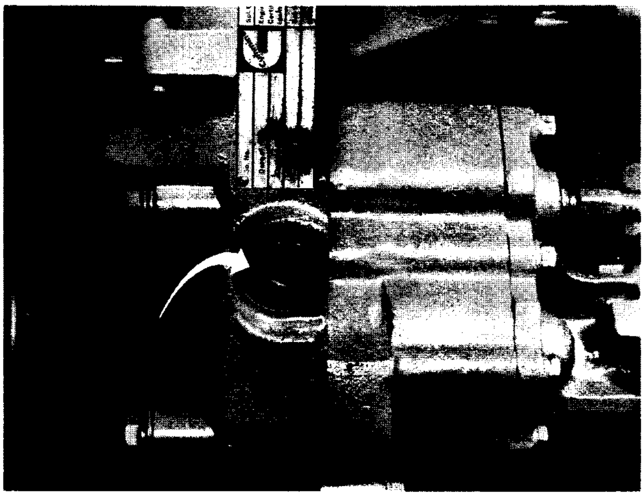


Fig. 1-1, (N11985). Lubricating system priming point — N/NT-855 Engine

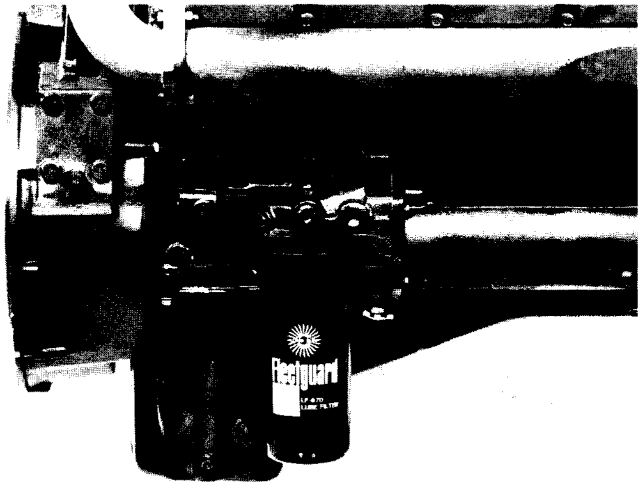


Fig. 1-2, (OM101). Lubricating system priming point — V/VT-903 Engine

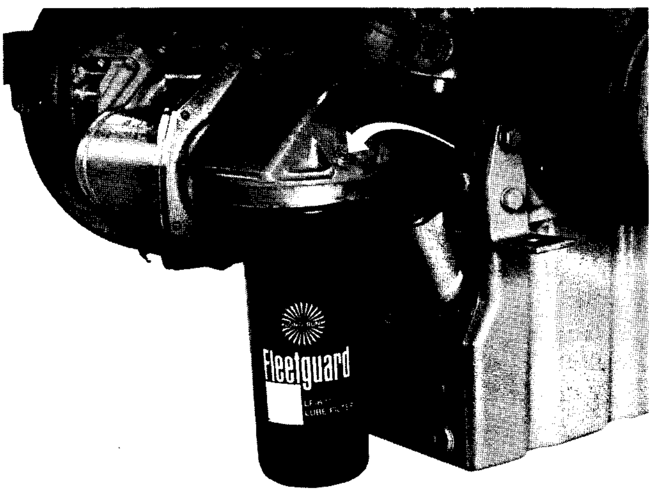


Fig. 1-3, (OM102). Lubricating system priming point — V-378, V-504, V/VT-555 Engines

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.

4. Prime until a 30 psi [207 kPa] minimum pressure is obtained.

5. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [103 kPa].

6. Remove external oil supply and replace plug.

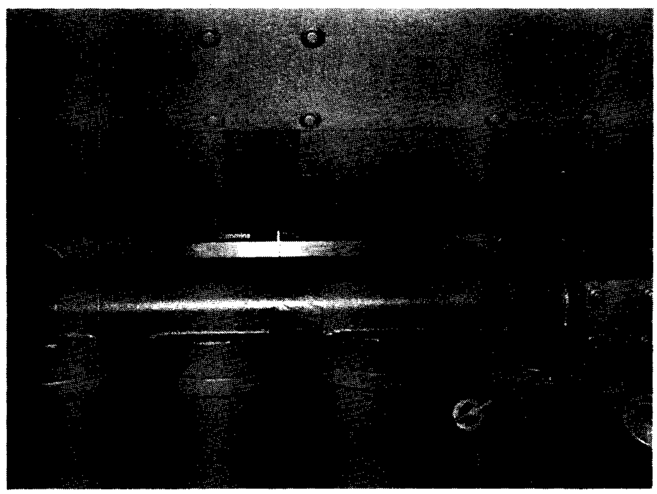


Fig. 1-4, (K21902). Lubricating system priming point — KT(A)-2300 Engine

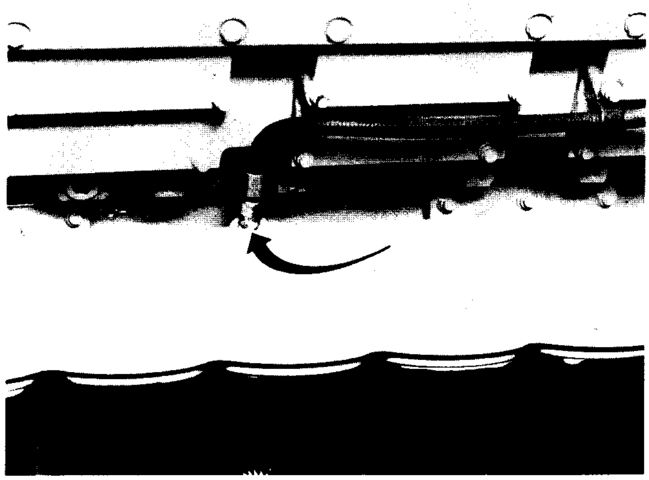


Fig. 1-5, (OM202). Lubricating system priming point — KTA-3067 Engine

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

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

A dipstick oil gauge is located on the side of the engine. Fig. 1-8. The dipstick has an "H" (high) (1) and "L" (low) (2) level mark to indicate lubricating oil supply. The dipstick must be kept with the oil pan, or engine, with which it was orginally supplied. Cummins oil pans differ in capacity with different type installations and oil pan part numbers.

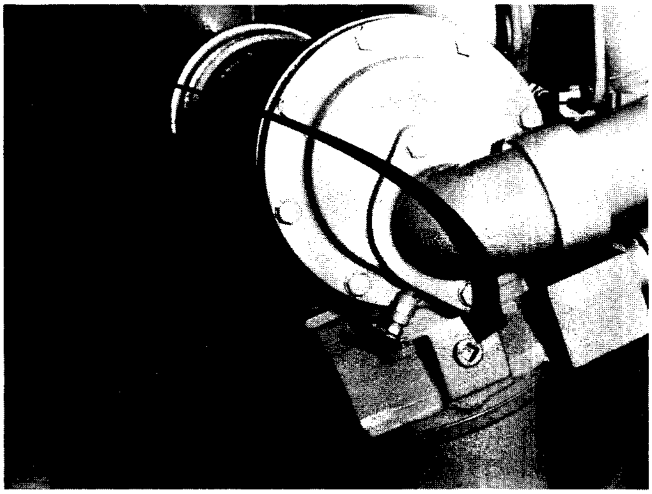


Fig. 1-6, (V41816). Lubricating system priming point — V-1710 Engine

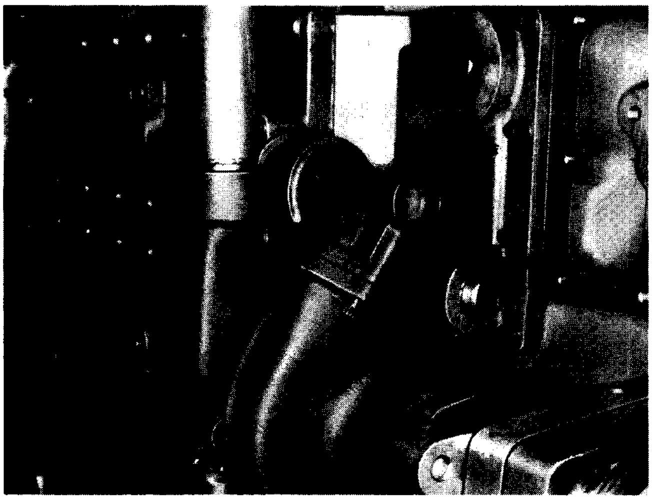


Fig. 1-7, (K11949). Lubricating system priming point — KT(A)-1150 Engine

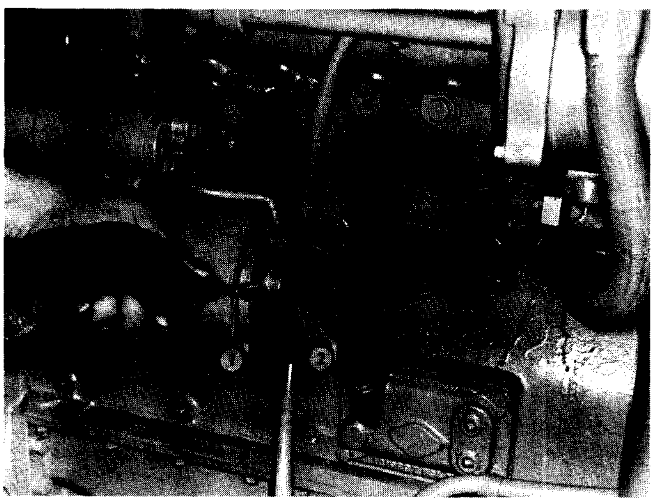


Fig. 1-8, (N12004). Checking engine oil level

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 air connections to compressor and air equipment, as used, and to air cleaners and air crossovers to assure all are secured.

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check engine coolant supply. Add coolant as needed.
2. Make visual check for leaks and open water filter shut-off valves.

Starting the Engine

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

Normal Starting Procedure

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

1. On units equipped with air activated prelube device, open air valve 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 [48 to 69 kPa]; 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. Fig. 1-9. Electric shut-down valves operate as switch is turned on. A manual override knob provided on

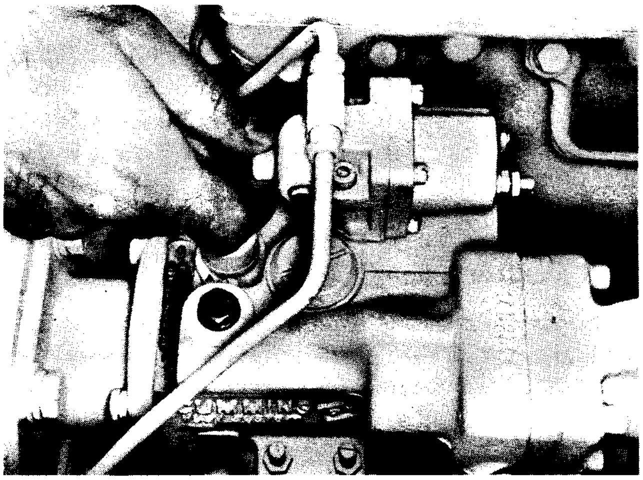


Fig. 1-9, (V21970). Using manual override knob

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.

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

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

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

5. At the initial start or after oil or filter changes and after engine has run for a few minutes, shut it down and wait 15 minutes for oil to drain back into pan. Check engine oil level again; add oil as necessary to bring oil level to "H" mark on dipstick. The drop in oil level is due to absorption by oil filters. Never operate the engine with oil level below the low level mark or above the high level mark.

Cold-Weather Starting

Preheater

The glow plug system supplies heat to the cylinders so compression temperatures are sufficient to ignite fuel.

To aid in starting engine when temperature is 50° F [10.0° 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 vapor 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 [552 to 689 kPa] 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. 1-10) from manifold near glow plug and close glow plug manual switch for 15 seconds and observe glow plug through 1/8 inch plug hole. The glow plug should be white hot; if not, connect wiring to a 6- to 12-volt (as used) source and check amerpage; it should be 30 to 32 (minimum). If glow plug is all right, check manual switch and resistor (if used) and replace if necessary.

Note: Preheater priming pump, switches and resistor are located at the instrument panel and are to be checked during engine starting.

Fluid Starting Aid

Starting fluids allow combustion with a lower cylinder temperature since it is a more volatile fuel. A pressurized spray can or a rag wet with fluid will usually provide quick starting as low as —10° F [—23° C].

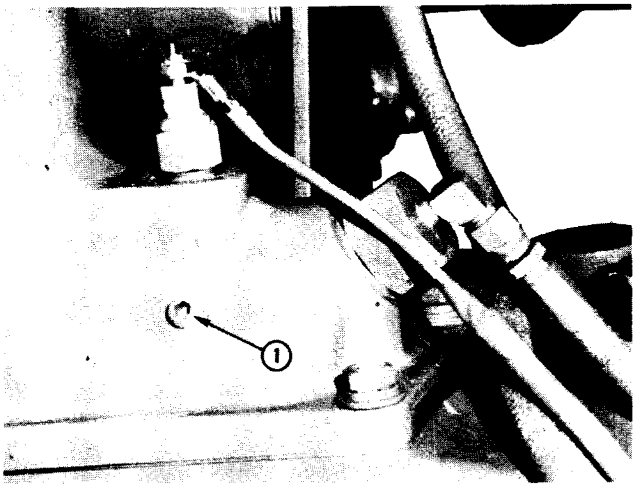


Fig. 1-10, (N11949). Glow plug inspection hole — N/NT-885 Engine

Below this temperature, some means of injecting a carbureted vapor directly into the intake manifold is necessary.

The cold starting aid, approved for use in Cummins Engines, has been based upon starting aid capabilities to —25° F [—32° C].

Caution: Do not attempt to use vapor compound type starting aids near heat, open flame or on engines equipped with glow plug system.

Manually Operated Valve

The manually operated valve, illustrated in Fig. 1-11 includes valve body assembly (6), clamp (2) and nylon tube (3). Fuel cylinder (1), atomizer fitting (5) and pull control (7) must be ordered separately.

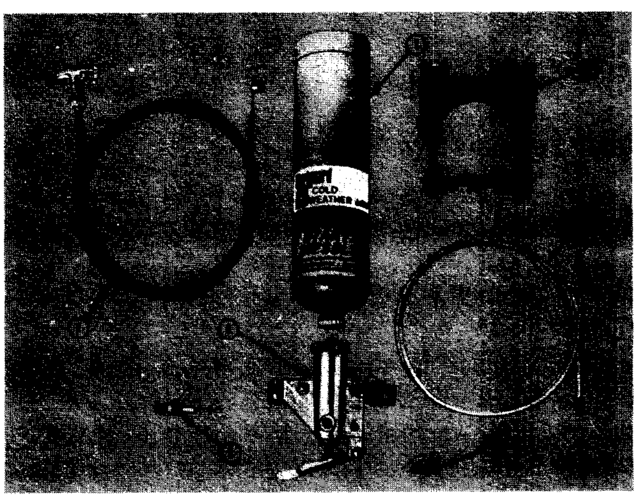


Fig. 1-11, (V11011). Manual operated valve

Standard pull or throttle control cables may be used, to actuate the manual valve, if desired.

Electrically Operated Valve

The electrically operated valve, Fig. 1-12, includes valve body (7), 90 degree elbow (5), clamp (2), push button switch (6), and nylon tube (3). The thermostat is mounted on the engine exhaust manifold and cuts out the valve by sensing manifold heat when the engine is running. See parts catalog for fuel cylinder (1) and fuel atomizer fittings (4). These fittings must be ordered separately, as required.

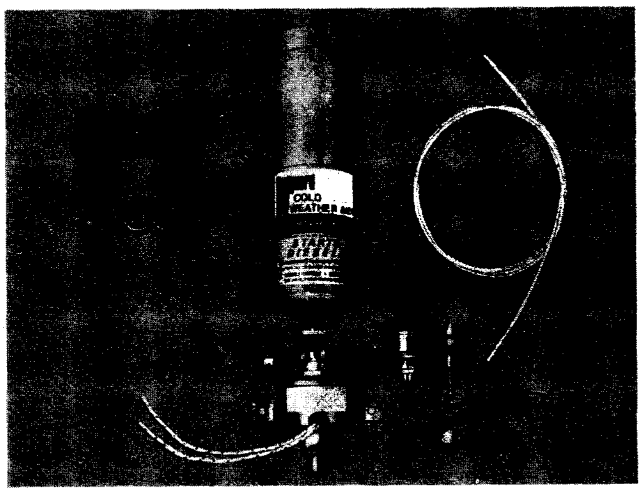


Fig. 1-12, (V11012). Electric operated valve

Installation Recommendations

The atomizer fittings must be mounted in the engine air intake manifold or inlet connection to provide an equal distribution of starting fuel to each cylinder. The atomizer holes are 180 degrees apart and must be mounted so the spray is injected the "long way" of the manifold. If incorrectly installed, the spray goes crosswise of the manifold.

Recommended Starting Technique Using Fleetguard Starting Aid

1. Set throttle for idle.
2. Disengage driven unit or make sure gears are in neutral.
3. Open manual fuel shut-down valve, or electric shut-down valve, whichever used.
4. Engage starter and while cranking, apply metered amounts of starting fluid until engine idles smoothly.

Use of Starting Fluid Without Metering Equipment

1. Spray starting fluid into air cleaner intake, while second man cranks engine.

Warning: Never handle starting fluid near an open flame. Never use it with preheater or flame thrower equipment. Do not breathe the fumes. Use of too much will cause excessively high pressures and detonation, or over speed engine.

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

Warning: Fuel oil or volatile fuel cold starting aids are not be 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

When the engine is started, it takes a while to get the lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature. Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up.

On some emergency equipment (such as fire pump engines) warm-up may not be necessary due to equipment being housed inside a heated building. For an engine starting with a parasitic load, such as a fire pump, coolant temperatures must be a minimum of 120° C [49° C].

Engine Speeds

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

The governor has two functions: First, it provides 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.

Note: Engines in many applications are applied at a lower than maximum rated speed; check the serial dataplate.

Power generator units are pre-set to operate at a specific governed rpm.

Table 1-1: Engine Speeds (RPM)

Engine Model	Maximum Rated
All NH, NT, 855-R, 855-L	2100
All NH, NT	2300
V-903	2600
VT-903	2400
V-378, V-504, V-555	3000
V-378, V-504, V-555	3300
V-1710, V-1710-L	2100
KT-1150	2100
KTA-1150	2100
KT-2300	2100
KTA-2300	2100
KTA-3067	2100

Oil Temperature

The oil temperature gauge normally should read between 180° F [82° C] and 225° F [116° C]. Under full load conditions, an oil temperature of 226° F [129° 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° F [60° 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° F [60° 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° F [74 to 91° 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° F [93° 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° F [74° C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

Oil Pressure

Normal engine oil pressure at 225° F [107° C] are listed in Table 1-2.

Table 1-2: Oil Pressure PSI [kPa]

Engine Series	Idle Speed	Rated Speed
NH, NT, 855-R, 855-L	5/20 [34/138]	40/75 [276/517]
V-903, VT-903	5/25 [34/72]	40/65 [276/448]
V-378, V-504, V-555	10/30 [69/207]	45/85 [310/586]
V-1710, V-1710-L	15 [103]	50 [345]
KTA-1150	15 [103]	45/70 [310/483]
KTA-2300	20 [138]	45/70 [310/483]
KTA-3067	20 [138]	45/70 [310/483]

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, over-fueling or poor mechanical conditions.

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

High Altitude Operation

Some engines, particularly naturally aspirated, 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 Application With PT (type G) VS Fuel Pump

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

When changing from standard speed range to power take-off speed with engine idling on standard throttle, operate as follows:

1. Place the VS speed control lever in operating position.
2. Lock the standard throttle in full-open position.
3. Engage power take-off.

To return to standard throttle:

1. Disengage power take-off.
2. Return standard throttle to idle position.
3. Lock the VS speed control lever in maximum speed position.

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° F [56° C]. The results of extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine for Excessively Long Periods

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

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

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

Turn Switch Key to "Off" Position to Shut Down the Engine

The engine can be shut down completely by turning off the switch key on installations equipped with an electric shut-down valve, or by turning the manual shut-down valve knob. 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 fully counterclockwise to stop engine. Refer to "Normal Starting Procedure". Valve cannot be reopened by switch key until after engine comes to complete stop.

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

Do Not Use the Compression Release Lever to Stop the Engine

Some engines are equipped with a compression release lever. Pulling this lever lifts the intake or exhaust (depending on engine model) valve push tubes and opens the valves. The push tubes are lifted off their sockets and extensive wear on the balls and sockets will result from using the compression release to stop the engine.

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

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine.

Cold-Weather Protection

1. For cold-weather operation, use of permanent-type 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. 1-13 to 1-19. If an air compressor (Fig. 1-20), 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 and to maintain temperatures to permit the engine to operate at full load at start-up.

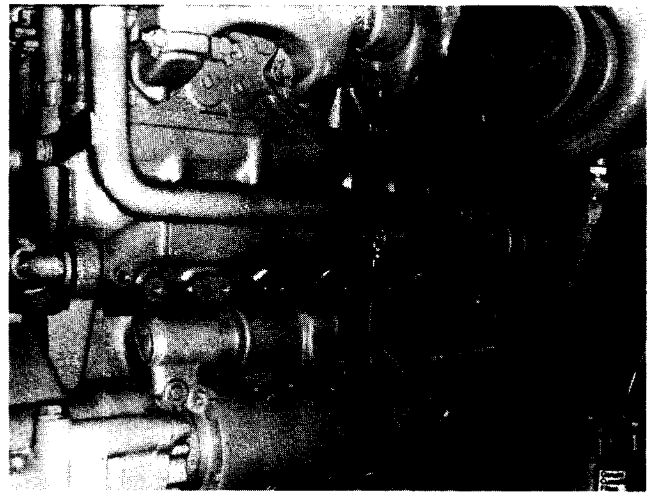


Fig. 1-13, (V100124). Coolant drain point — N/NT-855 Engine

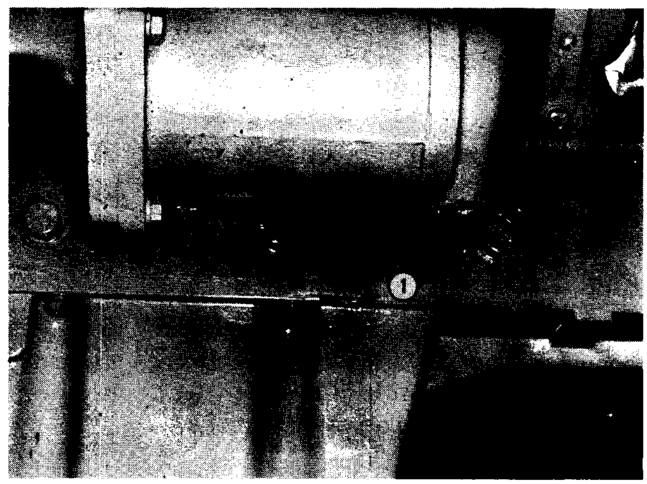


Fig. 1-14, (V50056). Coolant drain point — V/VT-903 Engine

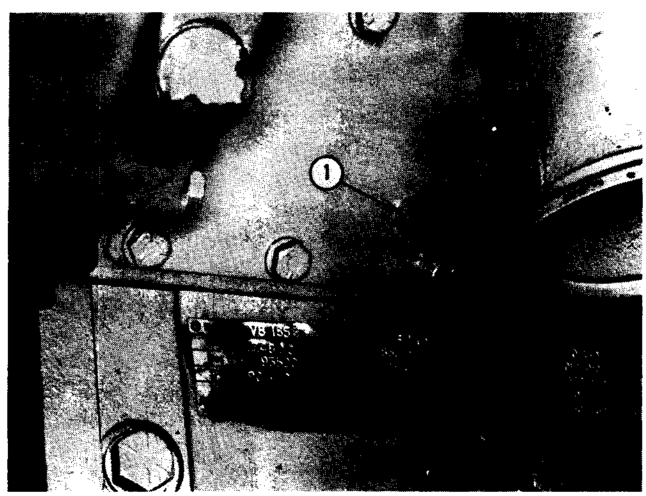


Fig. 1-15, (V10820). Coolant drain point — V-378, V-504, V/VT-555 Engines

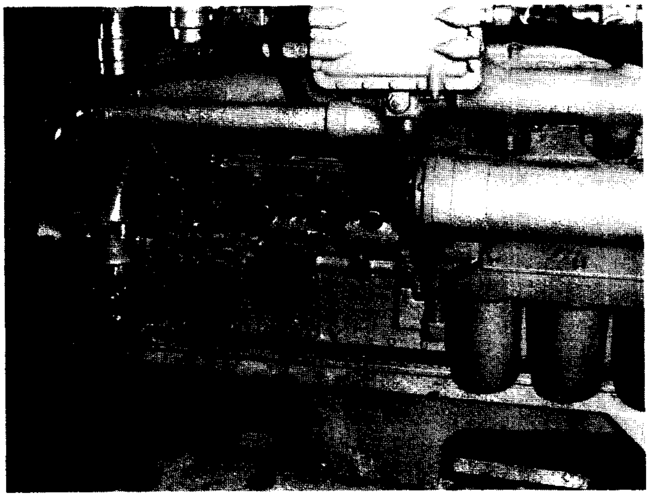


Fig. 1-16, (V40033). Coolant drain point — V/VT-1710 Engine

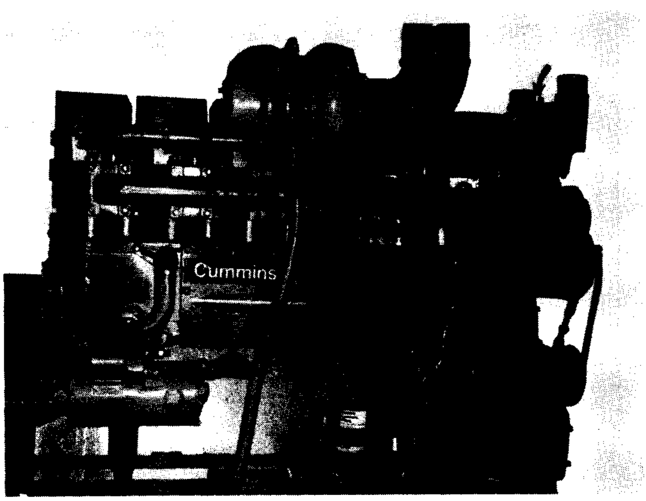


Fig. 1-17, (K11950). Coolant drain point — KT(A)-1150 Engine

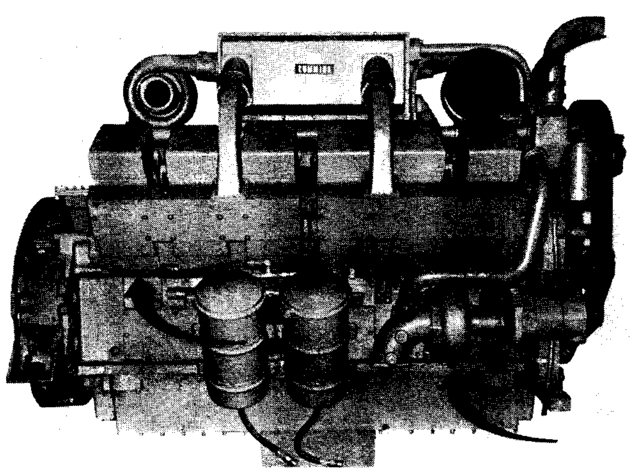


Fig. 1-18, (K21903). Coolant drain point — KT(A)-2300 Engine

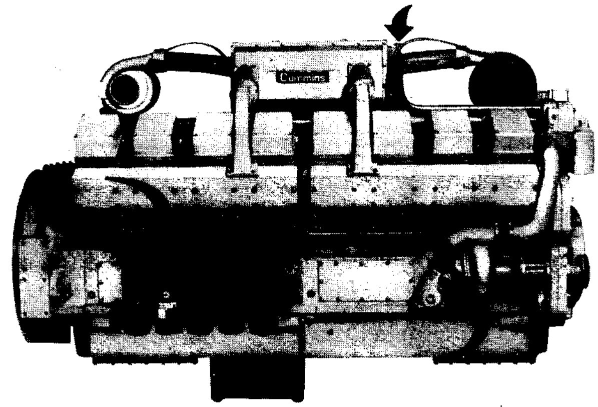


Fig. 1-19, (OM203). Coolant drain point — KTA-3067 Engine

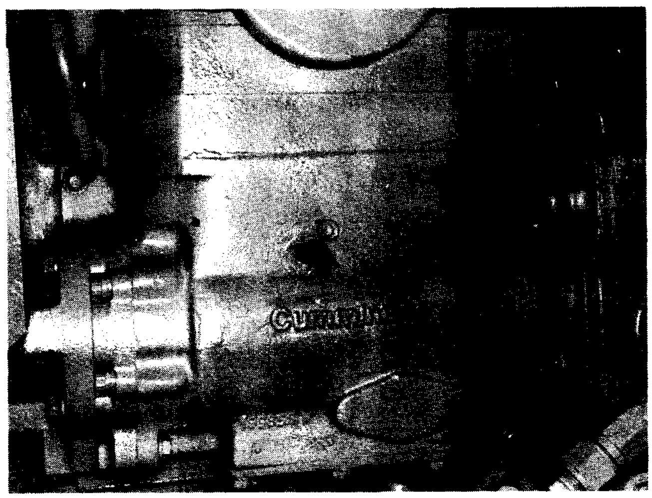


Fig. 1-20, (K21904). Two cylinder air compressor coolant drain

Engine Operation in Cold Weather

Satisfactory performance of a diesel engine operating in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures. The colder the temperatures encountered the greater the amount of modification required and yet with the modifications applied, the engines must still be capable of operation in warmer climates without extensive changes. The following information is provided to engine owners, operators and maintenance personnel on how the modifications can be applied to get satisfactory performance from their diesel engines.

There are three basic objectives to be accomplished:

1. Reasonable starting characteristics followed by

practical and dependable warm-up of engine and equipment.

2. A unit or installation which is as independent as possible from external influences.
3. Modifications which maintain satisfactory operating temperatures with a minimum increase in maintenance of the equipment and accessories.

If satisfactory engine temperature is not maintained, higher maintenance cost will result due to increased engine wear, poor performance and formation of excessive carbon, varnish and other deposits. Special provisions to overcome low temperatures are definitely necessary, whereas a change to warmer climate normally requires only a minimum of revision. Most of the accessories should be designed in such a way that they can be disconnected so there is little effect on the engine when they are not in use.

The two most commonly used terms associated with preparation of equipment for low temperature operation are "Winterization" and "Arctic Specifications".

Winterization of the engine and/or components so starting and operation are possible in the lowest temperature to be encountered requires:

1. Use of correct materials.
2. Proper lubrication, low temperature lubricating oils.
3. Protection from the low temperature air. The metal temperature does not change, but the rate of heat dissipation is affected.
4. Fuel of proper grade for lowest temperature.
5. Heating to be provided to increase engine block and component temperature to a minimum of —25° F [—32° C] for starting in lower temperatures.
6. Proper external heating source available.
7. Electrical equipment capable of operating in lowest expected temperature.

Arctic specifications refer to the design material and specifications of components necessary for satisfactory engine operation in extreme low temperatures to —65° C] [—54° C]. Contact Cummins Engine Company, Inc., or the equipment manufacturer to obtain the special items required.

Caution: "Anti-leak" antifreezes are not recommended for use in Cummins Engines. Although these antifreezes are chemically compatible with DCA water treatment, the "anti-leak" agents may clog the coolant filters and render them ineffective.

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.

Initial Start-Up

Note: Contact operating personnel responsible for fire protection system before starting. Obtain approval to service or repair. After repair obtain authorized signature of acceptance.

1. Remove heat exchanger cap, check or fill engine coolant supply; open water filter inlet and outlet valves.
2. Prelubricate engine with oil metering specification MIL-L-46152 (API-CC/SC) viscosity 10W30. This includes removal of turbocharger oil inlet line on turbocharged engines to prelubricate housing by adding 2 to 3 oz [60 cc] of clean engine lubricating oil.
3. Check crankcase oil level and fill to high mark on dipstick.
4. Remove fuel pump solenoid lead and crank engine through both cranking cycles.
5. If engine is equipped with "Vernier throttle", place in idle position; if not place MVS throttle in idle position. On turbocharged models the delay cylinder line may be disconnected at the block and the block opening plugged.
6. Reconnect fuel solenoid lead and start engine; run at idle speed.
7. Verify lubricating oil pressure has been established, normally in 6 to 8 seconds.

Note: Some automatic controllers require lubricating oil pressure higher than the normal pressure at 600 rpm idle. Increase idle to 800 to 900 rpm if this condition is encountered. All turbocharged engines should be set to 800 to 900 rpm idle.

8. Continue to operate engine 3 to 5 minutes and review all systems for leaks or unusual conditions; correct as required.
9. Stop the engine and install ST-1224 Adapter.
10. Check crankcase oil level and fill to high mark.
11. Start engine and adjust overspeed.
12. Remove ST-1224 and replace original adapter.
13. Clean raw water strainer.
14. Start engine and adjust operating speed.
15. Adjust raw water pressure regulator.
16. Engine is now ready for normal operation.

Normal Operation

1. Daily or normal operation would include checking of fuel, lubricating oil, coolant and correcting any leaks or unusual conditions as required.
2. Check coolant and oil heaters to assure at least 120°F [49°C] water temperature has been maintained.
3. Manually start engine using prescribed starting procedure.
4. Operate engine the prescribed period of time or 5 minutes after stabilization of coolant temperature.
5. Shut engine down using normal test shut-down procedures.

Note: To extend engine operating life and prevent premature component failures it is recommended the engine speed be reduced to idle for 3 to 5 minutes prior to engine shut-down. After shutting down the engine, return speed control to full open position.

Fire Pump Engines — Overspeed Switch Adjustment (IF Engine Models)

The speed switches required for overspeed protection on fire pump engines require high speed for the overspeed adjustment. All engines are now being shipped adjusted at maximum overspeed. The following overspeed adjustments are 20 percent above rated engine speed.

An adapter, ST-1224 with 2:1 ratio, in speed switch drive only, (1, Fig. 1-20) is available to drive the 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.

Table 1-3: Engine Overspeeds

Engine Model	Rated Speed	Overspeed
V-378-F1	1750-2200	2100-2640
V-378-F2	2400-3300	2880-3960
V-504-F1	1750-2200	2100-2640
V-504-F2	2400-3300	2880-3960
N-855	1460-2100	1750-2520
NT-855-F1	1750-2100	2100-2520
NT-855-F2	1750-2300	2100-2760
VT-1710-F	1750-2100	2100-2520

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.

Note: Overspeed stop switch cable must be connected to short adapter connection. (1, Fig. 1-21.)

3. Start engine and warm to operating temperature.
4. Set engine speed to one-half (1/2) the 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 Medium Duty V engines, the speed adjustment must be made by adjusting the governor idle and maximum speed screws. The idle screw is housed 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. Remove lockwire from setscrews on side of switch. Loosen three (3) setscrews.
   b. Rotate cover clockwise (this decreases trip speed) until switch actuates and stops engine.
   c. Secure setscrews and replace locking wire.
   d. On manual reset models, re-activate the switch by pushing the reset button on top of switch.
6. Set dual element speed switches.

Caution: Do not break or remove lockwire.

   a. Remove the round head dust cover screw marked 2 from top of switch. Fig. 1-22.
   b. Insert 1/16 inch Hex Allen wrench into adjusting screw located just below surface of cover.

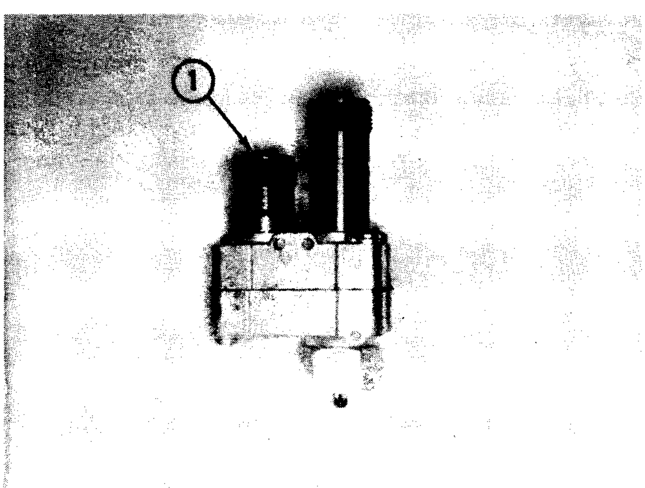


Fig. 1-21, (ST-1224). ST-1224 adapter

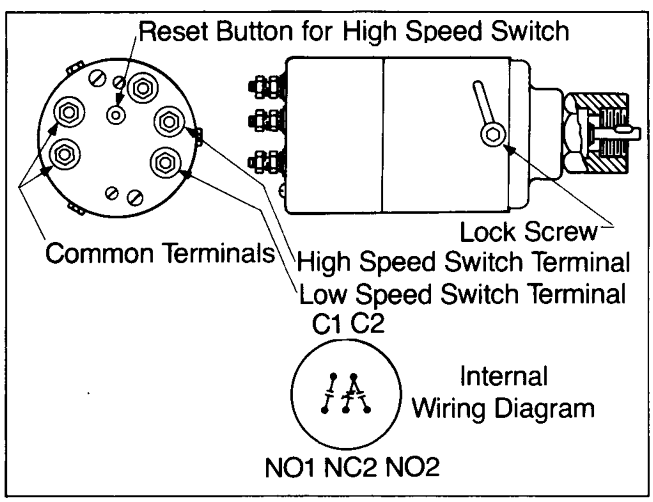


Fig. 1-22, (CGS27). Double speed switch

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

Caution: Do not turn adjusting screw more than three (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 removed in "Step a" above.

e. All overspeed switches must be manually reset, 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.

Note: If stop crank adjustment is required do not use ST-1224 Adapter. Replace with standard adapter to effect adjustment.

Fire Pump Engine Operating Speed Adjustment

All Cummins fire pump engines will be shipped adjusted at the following speeds unless prior approval has been established for a specific speed.

Final operating speed adjustment should be made at the time of the in service inspection to obtain the required fire pump operating speed.

This speed adjustment must be made with the Vernier throttle in full fuel position and the systems fire pump operating at its rated condition. All speed ranges of N-NT and V-12 models are available by adjusting the MVS high speed adjusting screw. Fig's. 1-23 and 1-24.

Table 1-4: Fire Pump Engine Operating Speed

Engine Model	Fuel Pump Code	Factory Adjusted Speed	Maximum Operating Speed
V-378 F1	C-653	1750	2200
V-378 F2	C-651	2400	3300
V-504 F1	C-652	1750	2200
V-504 F2	C-650	2400	3300
N-855	8761	1750	2100
NT-855 F1	8770	1750	2100
NT-855 F2	8771	1750	2300
VT-1710 F	8784	1750	2100

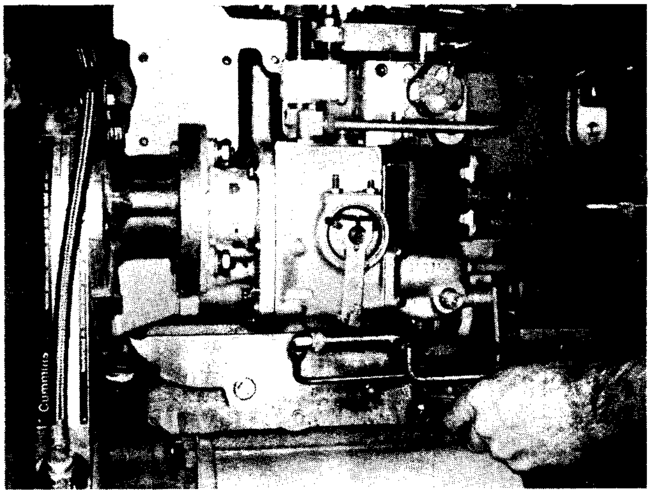


Fig. 1-23, (N11979). Adjusting engine speed

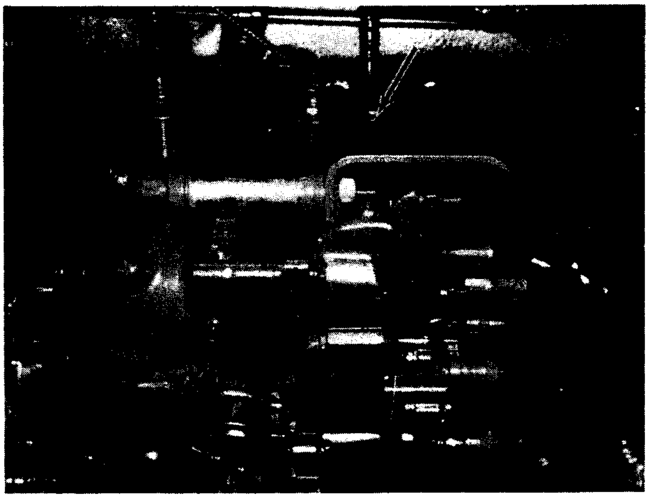


Fig. 1-24, (N11980). Governor adjusting screw

This screw requires a 1/8 inch Allen wrench and adjustment is made by loosening 7/16 inch locking nut and backing screw out to increase engine speed through the full speed range.

The V-378 and V-504 F1 and F2 models require two differently calibrated fuel pumps. One pump code provides speeds between 1750 and 2300 rpm. A different pump code is required for speeds between 2400 and 3300 rpm. The required speeds on these models are similarly obtained by MVS adjustment within the calibrated range as indicated above. It normally is prohibited by UL and FM to change engine ratings by changing fuel pumps on any models of fire pump engines. In the event of fuel pump rebuild, the pump must be calibrated to the original code and **any deviation would be a violation to the insurance agencies approval.**

Industrial Fire Pump Engine Maintenance Schedule

EQUIPMENT NO. ____________ ENGINE SERIAL NO. ____________
MECHANIC ____________ HOURS, CALENDAR ____________
TIME SPENT ____________ CHECK PERFORMED ____________
PARTS ORDER NO. ____________ DATE ____________

CUMMINS DIESEL FIRE PUMP ENGINES

Check each operation as performed.

A—CHECK	B—CHECK	C—CHECK	D—CHECK	SEASONAL	OTHER
Daily ☐ Check engine operating log ☐ Check engine: • oil level • coolant level ☐ Check engine lubricating oil and coolant heaters * • oil bath cleaner oil level ☐ Visually inspect engine for damage, leaks, loose or frayed belts **Weekly** ☐ Repeat Daily "A" Check ☐ Check air cleaner • clean precleaner dust pan • check restriction indicator • clean/change air cleaner element * • change oil bath cleaner oil ☐ Drain water/sediment from fuel tanks & fuel filters ☐ Check raw water strainer ☐ Check starter battery ☐ Start engine & check for unusual noise	**Repeat "A" (Daily/Weekly)** ☐ Change engine oil ☐ Change filters • oil full flow • fuel filter ☐ Check coolant • check engine coolant DCA concentration level. Add make-up DCA and change element if required ☐ Clean/change • crankcase breather * Clean oil bath air cleaner tray/screen	**Repeat "A" & "B"** ☐ Adjust valves & injectors * Clean oil bath air cleaner	**Repeat "A", "B" & "C"** ☐ Clean & calibrate injectors, fuel pump ☐ Check and/or rebuild and/or replace the following assemblies: • turbocharger • vibration damper ☐ Rebuild or replace the following assemblies: • water pump	**Fall** ☐ Clean & flush cooling system ☐ Replace hose as required ☐ Check cold start & thermal aids ☐ Clean electrical connections and check batteries ☐ Clean engine water heater **Spring** ☐ Steam clean engine ☐ Tighten mounting bolts ☐ Check crankshaft end clearance ☐ Check heat exchanger zinc plugs annually or as required ☐ Check overspeed switch	**Electrical Components** ☐ + Starter ☐ + Alternator ☐ + Batteries ☐ + Voltage regulator ☐ + Switches ☐ + Gauges ☐ + Tachometer ☐ + On these components follow the manufacturer's procedure
Engine Series **Interval**	**B**	**C**	**D**		
All Hours Calendar	250 6 mos.	1500 1 year	4500 2 years		

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time. In other words, use hours, or calendar time, whichever comes first.

***Cummins Engine Company, Inc., recommends the use of dry type air cleaners.**

Maintenance

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.

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 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 procedure.

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	B—CHECK	C—CHECK	D—CHECK	SEASONAL	OTHER
Daily ☐ Check operator's report ☐ Check engine: • Oil level • Coolant level * • Oil bath cleaner oil level ☐ Visually inspect engine for damage, leaks, loose or frayed belts and listen for unusual noises **Weekly** ☐ Repeat Daily "A" Check ☐ Check air cleaner • Clean precleaner dust pan • Check restriction indicator • Clean/change air cleaner element * • Change oil bath cleaner oil ☐ Drain air tanks ☐ Drain water/sediment from fuel tanks and fuel filters	**Repeat "A" (Daily/Weekly)** ☐ Change engine oil ☐ Change filters • Oil full flow • Oil by-pass • Fuel filter ☐ Check coolant • Check engine coolant DCA concentration level. Add make-up DCA and change element if required ☐ Check oil levels • Aneroid • Hydraulic governor ☐ Clean/change • Crankcase breather—All except KT/KTA-2300 and 3067 • Air compressor breather * ☐ Clean oil bath air cleaner tray/screen	**Repeat "A" & "B"** ☐ Adjust valves & injectors ☐ Change oil • Aneroid • Hydraulic governor ☐ Replace aneroid breather ☐ Inspect back side idler * ☐ Clean oil bath air cleaner	**Repeat "A", "B" & "C"** ☐ Clean & calibrate injectors, fuel pump and aneroid ☐ Check and/or rebuild and/or replace the following assemblies: • Turbocharger • Vibration damper • Air compressor ☐ Rebuild or replace the following assemblies: • Fan hub • Idler pulley assembly • Water pump • Back side idler ☐ Clean/change crankcase breather on KT/KTA-2300 and 3067	**Fall** ☐ Clean and flush cooling system ☐ Replace hose as required ☐ Check cold start & thermal aids ☐ Clean electrical connections and check batteries **Spring** ☐ Steam clean engine ☐ Tighten mounting bolts ☐ Check crankshaft end clearance ☐ Check heat exchanger zinc plugs annually or as required	☐ + Alternator ☐ + Generator ☐ + Starter ☐ + Exhaust brake ☐ + Air compressor ☐ + Electrical connections ☐ + Batteries ☐ + Freon compressor + On these components follow the manufacturer's recommended maintenance procedure
Engine Series **Interval**	**B**	**C**	**D**		
All Hours Calendar	Chart Method or 250 6 mos.	1500 1 year	4500 2 years		

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time. In other words, use hours, or calendar time, whichever comes first.

***Cummins Engine Company, Inc., recommends the use of dry type air cleaners.**

Maintenance Performance Record

Engine Serial No. ______________________ Engine Model ______________________

Owner Name ______________________ Equipment Name/Number ______________________

Interval Basis Mileage	[Kilometres]	Check	Mileage	[Kilometres]	Check	Other	Date	Actual Mileage	Distributor/Dealer Location/Shop	Authorized Signature
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B, C								
		A, B			A, B, C					
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B, C			A, B					
		A, B								
		A, B			A, B, C					
		A, B			A, B					
		A, B			A, B					
		A,B,C,D			A, B					
		A, B			A, B					
		A, B			A,B,C,D					

To prove that the 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 that purpose.

"A" Maintenance Checks—Daily

Make a Daily Report of Engine Operation to the Maintenance Department

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

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate most 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, coolant or lubricating oil leaks.

Check Engine

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. Fig. 2-1. 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.

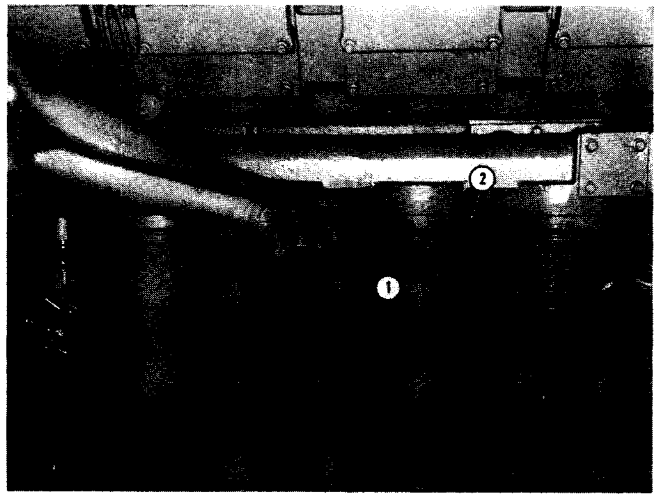


Fig. 2-1, (K21901). Checking engine oil level

Check Engine Coolant Level

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.

Check Belts

Visually check belts for looseness. If there is evidence of belt slippage adjust as follows:

Using appropriate gauge, Fig's. 2-2 and 2-3, check

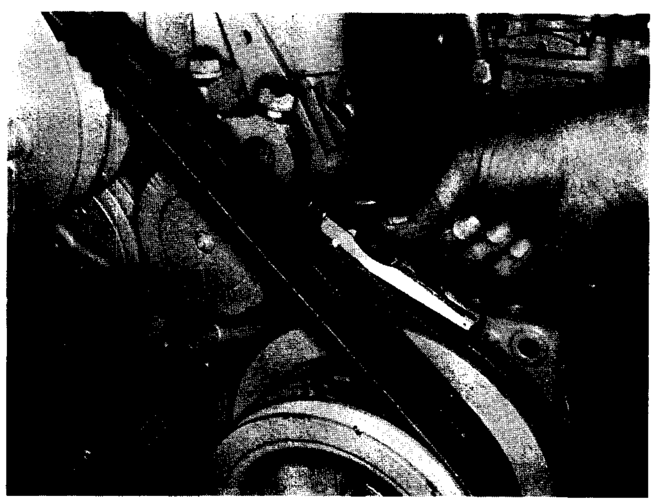


Fig. 2-2, (N11977). Checking belt tension with ST-1274

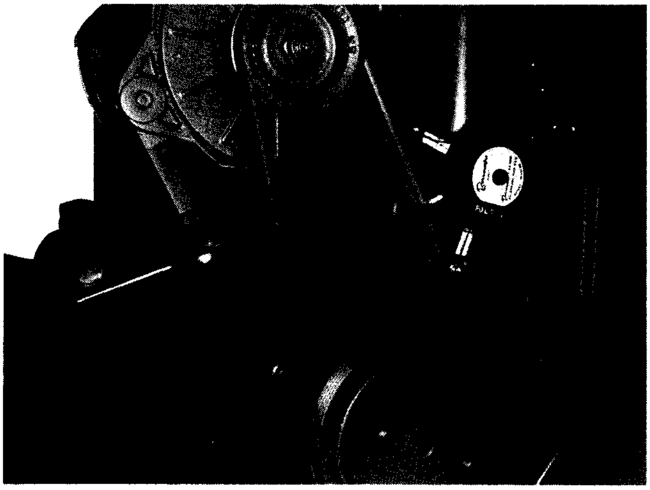


Fig. 2-3, (K114101). Checking belt tension with ST-1293

and/or adjust belts to tension as indicated in Table 2-1.

Table 2-1: Belt Tension (Pounds)

Belt Width Inches	Belt Gauge	*New Belt Tension + or —10	**Belt Tension After Run-in + or —10
Standard "V" Belt			
1/2	ST-968	140	100
	ST-1274	140	100
11/16	ST-1138	140	100
3/4	ST-1138	140	100
Poly-V			
6 Rib	ST-1293	150	130
Special Applications			
V-378, V-504, V-555			
2 Pulley (Fan-alternator drive)			
1/2	ST-968	90	50
	ST-1274	90	50
3 Pulley (crankshaft, water pump, fan drive)			
1/2	ST-968	130	90
	ST-1274	130	90
11/16	ST-1138	140	100
NT-855 (Water pump with idler)			
15/32	ST-968	130	80
	ST-1274	130	80

*New belts must be retensioned to values listed under "Belt tension after run-in".

**Used belts should be retensioned to values listed under "Belt tension after run-in".

Note: When using the "Krikit" gauge the correct belt tension reading for the belt tested must be read at the point where the **top** of the black indicator arm crosses the bottom numbered scale. Position gauge in the center of the belt between two pulleys. The flange at side of gauge should be flat against edge of belt.

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 [7 N • m].
   e. Snug two capscrews above and below the first one to 5 ft-lbs [7 N • m].
   f. Finish tightening by alternating from side to side in 5 ft-lbs [7 N • m] increments to a final torque of 12 to 15 ft-lbs [16 to 20 N • 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, V-903 Engines only.
   a. Remove capscrews joining the sheave(s) of the pulley.

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 2-1.
   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 [14 to 16 N • m]
3/8-16 capscrew, 17 to 19 ft-lbs [23 to 26 N • m]

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. Fig. 2-4.

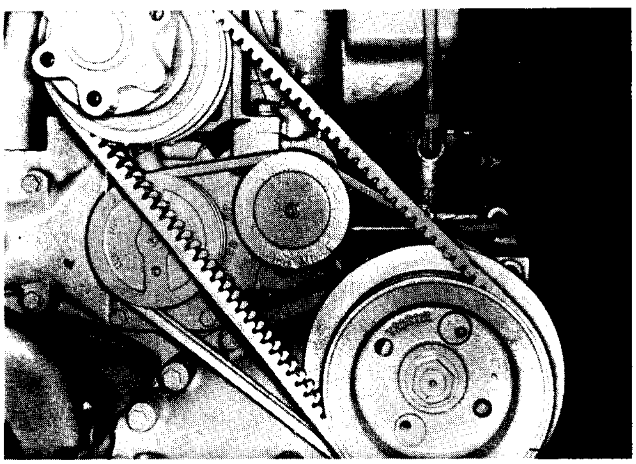


Fig. 2-4, (N11974). Water pump — with idler

2. Using a pry bar (NTA) or adjusting screw (FFC) adjust idler pulley until proper belt tension is indicated on gauge. See Table 2-1.
3. Secure idler pulley or bracket in position by tightening locknut or capscrews and lockwashers to 45 to 55 ft-lbs [61 to 75 N • m] torque.

Note: Self tensioning idler on V-1710 belt driven water pumps requires no adjustment or belt tension check.

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 2-1 on applicable gauge.
5. Tighten NH/NT Engines locknut to 400 to 450 ft-lbs [542 to 610 N • m]; then back off 1/2 turn. Tighten the four 1/2 inch capscrews, Fig. 2-5, on NTC-350 FFC Engines to 75 to 85 ft-lbs [101 to 115 N • m].

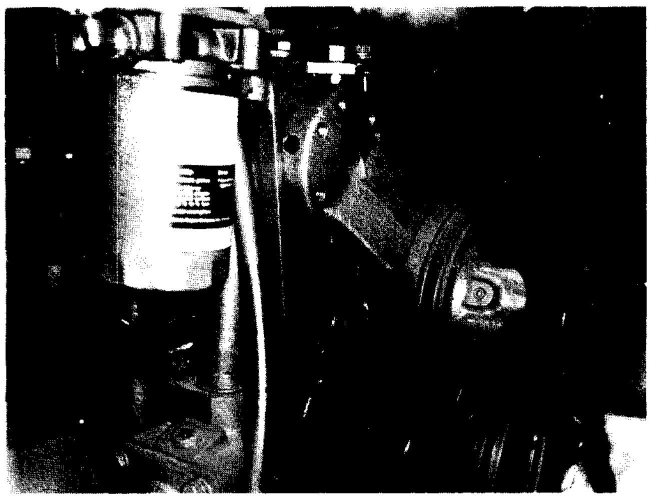


Fig. 2-5, (N12018). Fan hub installation —NTC-350 FFC

On V-903 Engines tighten capscrews to 75 ft-lbs [102 N • m] or single nut to 450 ft-lbs [610 N • m].

6. Recheck belt tension.
7. Back out adjusting screw one-half turn to prevent breakage.

Note: Self tensioning backside idler on KT/KTA-2300 and KTA-3067 belt driven fan requires no adjustment or belt tension check.

Generator/Alternator Belts

Belt tension should be as indicated in Table 2-1 when measured with the applicable gauge.

Belt Installation

If belts show wear or fraying, replace as follows:

1. Always shorten distance between pulley centers so belt can be installed without force. Never roll a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage belts and cause early failure.
2. Always replace belts in complete sets. Belts riding

depth should not vary over 1/16 in [1.6 mm] on matched belt sets.

3. Pulley misalignment must not exceed 1/16 in [1.6 mm] for each ft [0.3 m] of distance between pulley centers.
4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 in [2.4 mm] above top edge of groove.
5. Do not allow belts to rub any adjacent parts.
6. Adjust belts to proper tension.

Readjusting New Belts

All new belts will loosen after running for 5 minutes and must be readjusted to "belt tension after run-in". Ref. Table 2-1.

Check Oil Bath Cleaner Oil Level

Daily check oil level, Fig. 2-6, in oil bath air cleaner to be sure oil level in cup is at indicated mark. Refill as required.

***Cummins Engine Company, Inc. recommends the use of dry type air cleaners.**

Check for Damage

Visually check fuel system, etc., including AFC fuel pump, for misadjustment or tampering; check all connections for leaks or damage. Check engine for damage; correct as necessary.

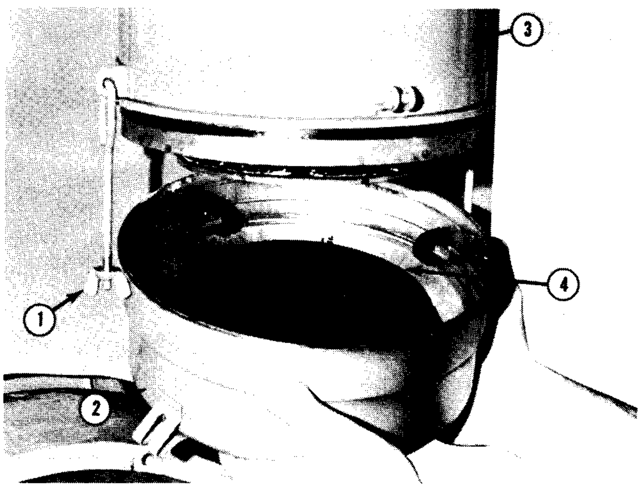


Fig. 2-6, (N11001). Checking oil level in air cleaner

"A" Maintenance Checks—Weekly

Repeat Daily Checks

Check Air Cleaner

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 more often, as necessary, depending on operating conditions.

Check Inlet Air Restriction

Mechanical Indicator

A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in air cleaner outlet or on vehicle instrument panel. The red flag (1, Fig. 2-7) in window gradually rises as cartridge loads with dirt. After changing or replacing cartridge, reset indicator by pushing reset button (2).

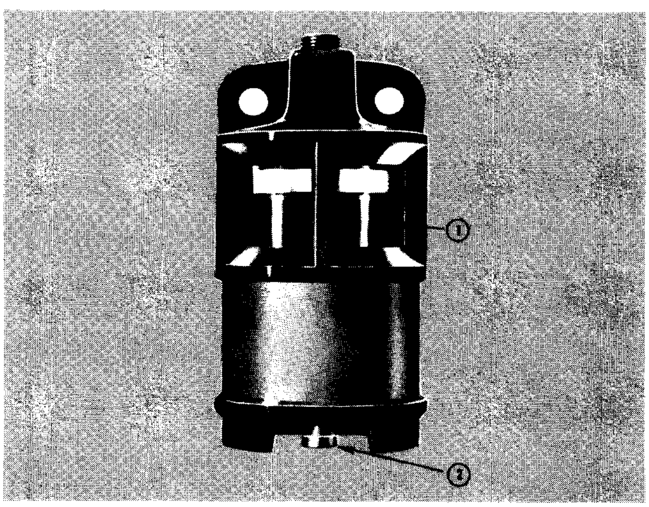
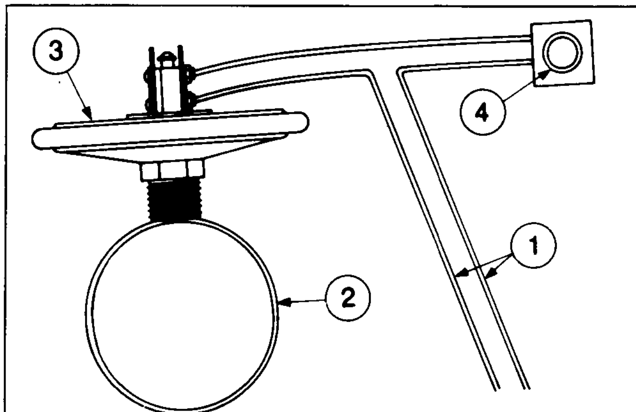


Fig. 2-7, (CGS-20). Air inlet restriction indicator

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

Vacuum Indicator

Vacuum switches, Fig. 2-8, are available which actuate a warning light on the instrument panel when air restriction becomes excessive.



1. Wiring
2. Piping
3. Vacuum Switch
4. Warning Light

Fig. 2-8, (N21905). Vacuum switch to check air inlet

1. Air restriction on turbocharged engines must not exceed 25 inches [635 mm] of water or 1.8 inches [46 mm] of mercury under full power conditions.
2. Naturally aspirated engine air restriction must not exceed 20 inches [508 mm] of water or 1.5 inches [38 mm] of mercury at air intake manifold at rated speed.

Clean or Replace Air Cleaner Elements

The paper element in a dry-type air cleaner, Fig's. 2-9, 2-10, 2-11 and 2-12, 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° F [49 to 60° C], then drying with compressed air, approximately 30 psi [306 kPa]. 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.

To change element:

1. Loosen wing nut (1, Fig. 2-9) securing bottom cover

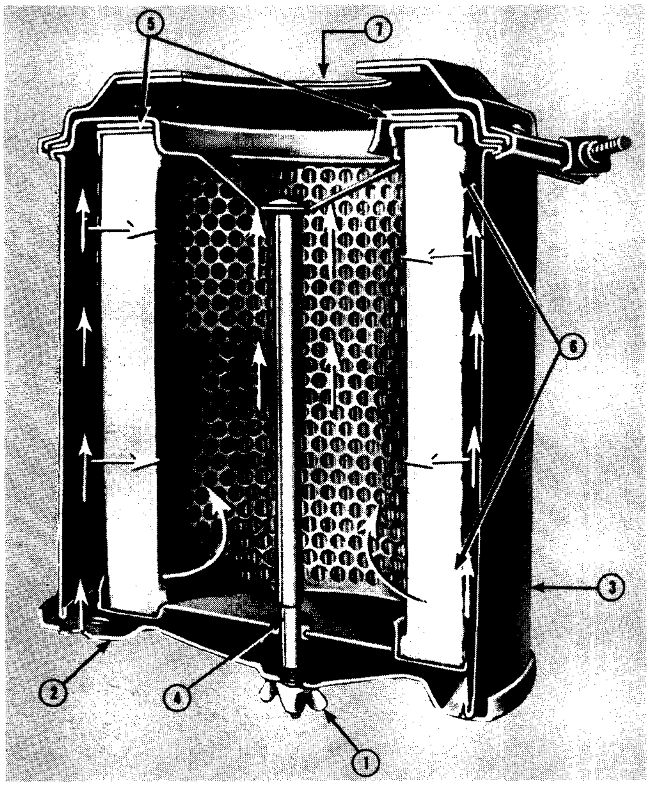


Fig. 2-9, (N11003). Air cleaner — dry type

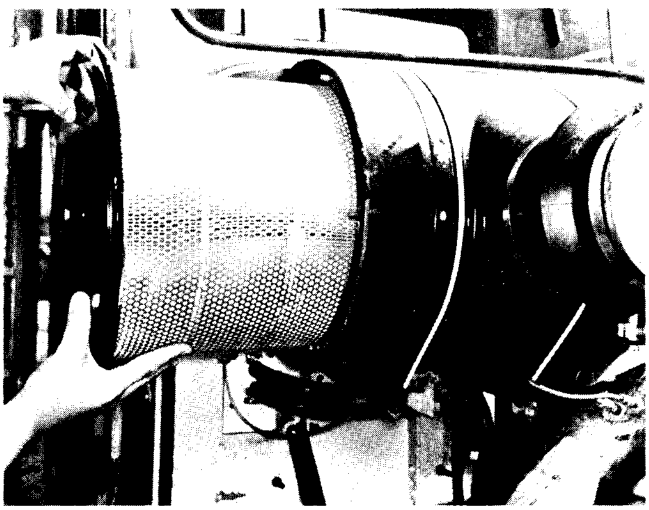


Fig. 2-10, (K11913). Changing air cleaner element

(2) to cleaner housing (3). Remove cover.

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

Caution: Pull cover and element straight out when removing from housing, Fig. 2-10, to avoid damage to element.

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

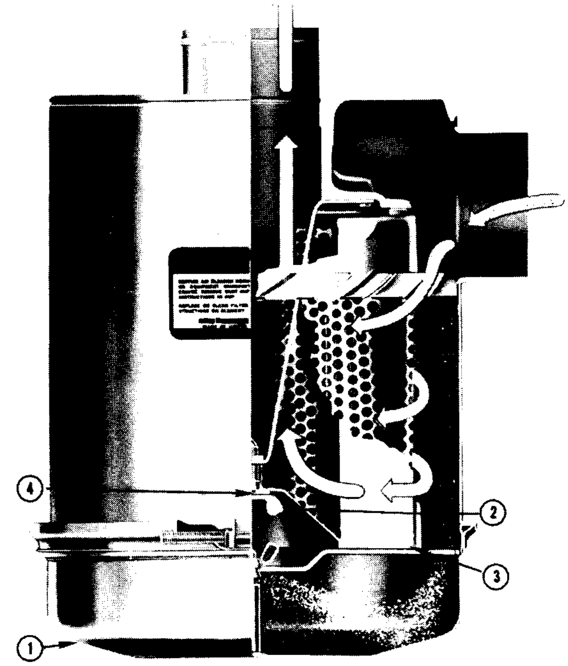


Fig. 2-11, (V10005). Air cleaner — heavy duty

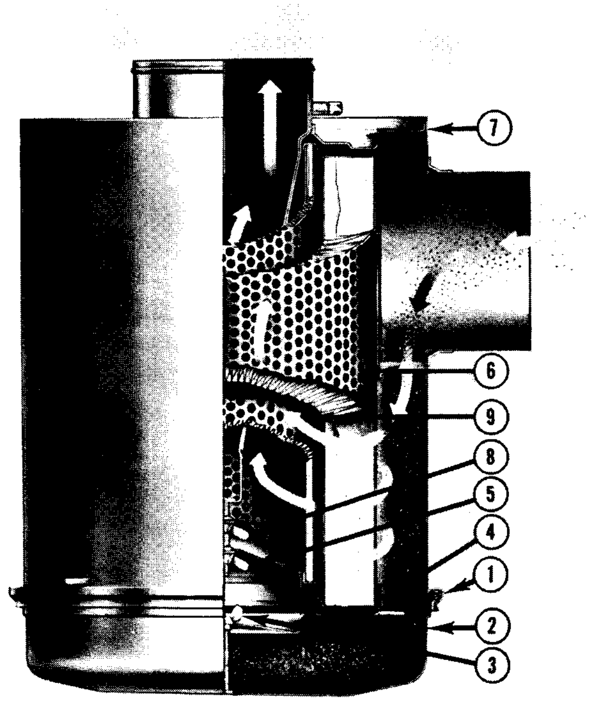


Fig. 2-12, (N11030). Air cleaner — heavy duty (dual element)

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. 2-11 and 2-12, 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. 2-11), (2, Fig. 2-12).
2. Loosen wing nut (2, Fig. 2-11 and 3, Fig. 2-12), remove dust shield (3, Fig. 2-11), (4, Fig. 2-12), from dust pan (1, Fig. 2-11), (2, Fig. 2-12), clean dust pan and shield.
3. Remove wing nut (2, Fig. 2-11), (5, Fig. 2-12) securing air cleaner primary element (6, Fig. 2-12) in air cleaner housing, inspect rubber sealing washer on wing nut (4, Fig. 2-11), (5, Fig. 2-12).
4. Blow out element from clean air side with compressed air not exceeding 30 psi [207 kPa].
5. Wash element with nonsudsing household detergent and water, 120 to 140° F [49 to 60° C]. Dry with compressed air, 30 psi [207 kPa].
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. 2-12), 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. 2-13 or 2-14) on air cleaner 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.

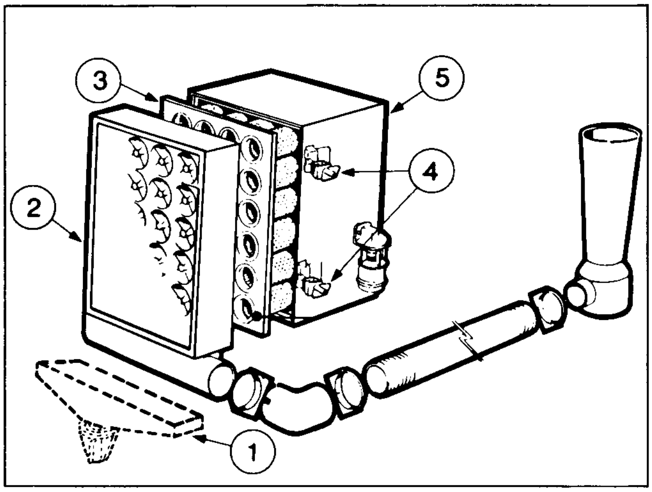


Fig. 2-13, (N21026). Air cleaner — cartridge type (two stage)

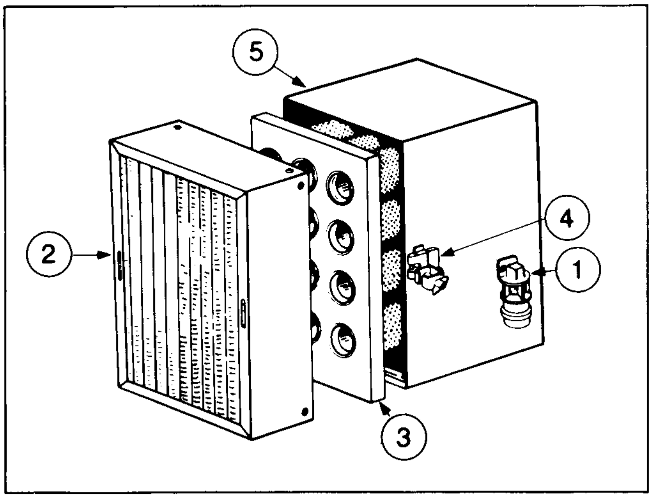


Fig. 2-14, (V11009). Air cleaner — cartridge type (single stage)

2. Remove dirty Pamic cartridge (3), by inserting fingers in cartridge opening (loosen all four corners of cartridge, one at a time) and 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. Troubleshooting 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. 2-13 and 2-14) 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.

Drain Air Tanks

In cold weather, condensed moisture in air tanks and lines may freeze and make controls useless.

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

Drain Sediment from Fuel Tanks

Loosen fuel tank drain cock or plug, if used, and drain approximately 1 cup of fuel to remove water and sediment. Close drain cock or plug.

Fuel/Water Filter Separator

If more moisture than usual is present when checking fuel tanks, it may be advisable to install a water separator.

Contact the nearest Cummins Dealer for a Fleetguard water separator that meets requirements.

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

"B" Maintenance Checks

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

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 855, V-903, KT(A)-1150, KT(A)-2300 and KTA-3067 Engines torque to 60 to 70 ft-lbs [81 to 95 N • m]. On V-378, V-504 and V-555 Engines torque to 35 to 40 ft-lbs [47 to 54 N • m]. On V-1710 Engines torque to 45 to 55 ft-lbs [61 to 75 N • 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.

Note: Use lubrication oil meeting specifications listed in Section 3, and genuine Cummins filters on equipment.

Lubricating Oil Change Intervals

1. The recommended oil change interval is determined by the "Chart Method" based on fuel oil consumed and lubricating oil added. See "Chart Method" following.
2. An alternate to the "Chart Method" is 250 hours or 6 months.
3. A second alternate method of determining oil change interval may be established through the use of oil analysis. Refer to "Lubricating Oil Analysis".

Chart Method

Advancement in lubrication technology has made it possible for users of Cummins engines to successfully extend oil change intervals, thus reducing maintenance costs.

Note: At oil change, change full-flow filter, by-pass filter (if used) and fuel oil filter.

Lubricating oil change intervals depends on the following variables:

1. Fuel consumption per hour.
2. Oil consumption per hour.
3. Filtration systems.
4. Lubricating system capacity.

The following graphs are to be used to determine the proper oil change interval for engines.

Total lubricating system capacity (in gallons) can be determined by adding the oil pan (high level), full-flow filter(s) and by-pass filter(s) capacities. Total lubricating capacities must be rounded to the nearest gallon. See example following.

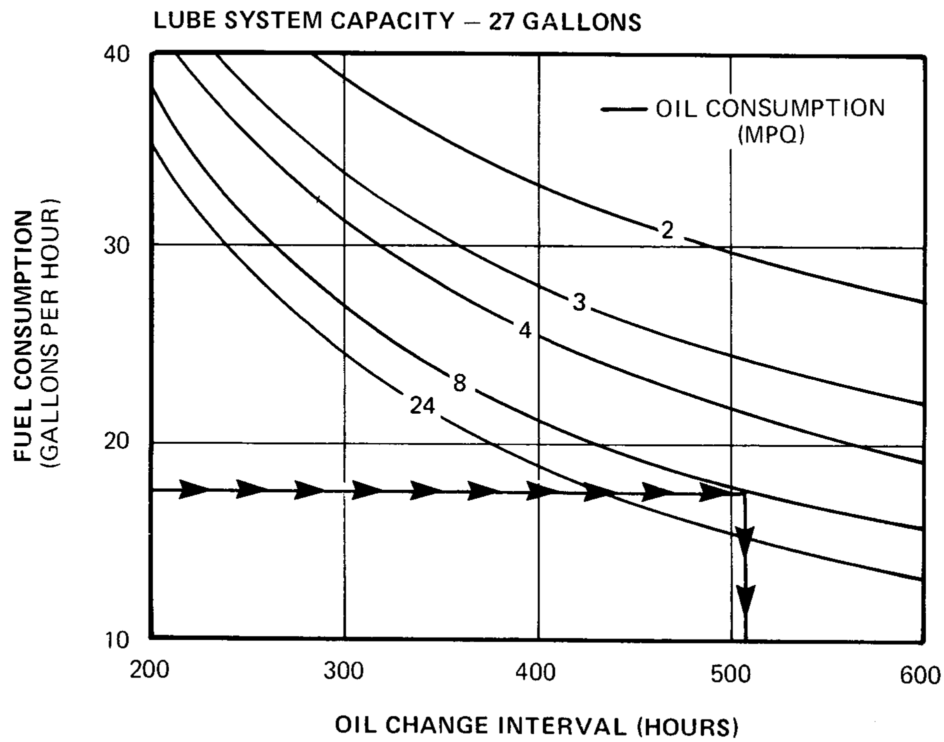
Note: Cummins Engine Company, Inc. **does not** recommend exceeding 600 hour oil change intervals. Therefore, curves are limited to 600 hours and should not be extended.

VT-1710 Off-Highway Engine

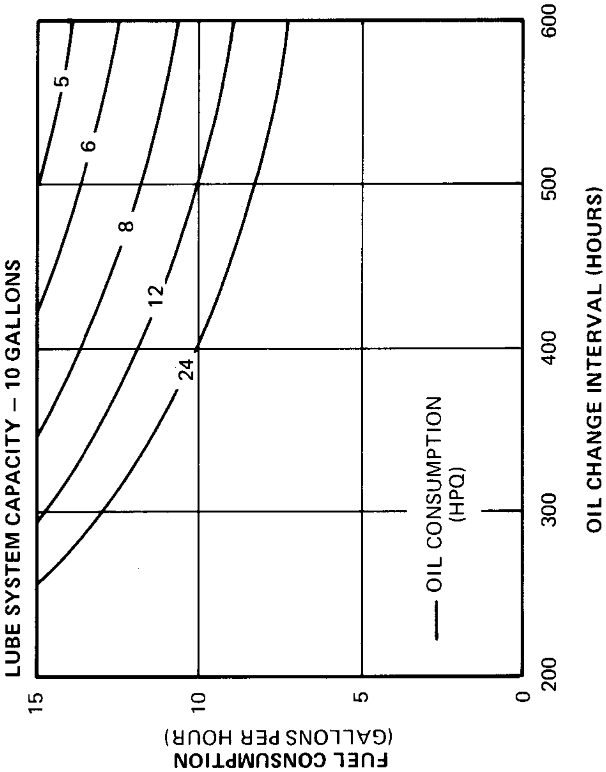
Oil pan capacity	18.00 gal.
Full-flow filter (3)	2.79 gal.
By-pass filter (2)	5.82 gal.
Total system capacity	26.61 gal. — 27 gallons

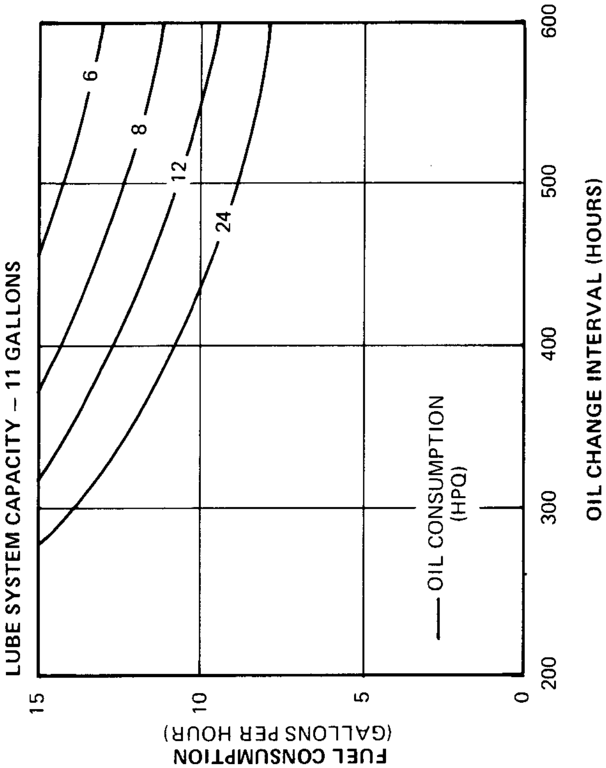
Example:

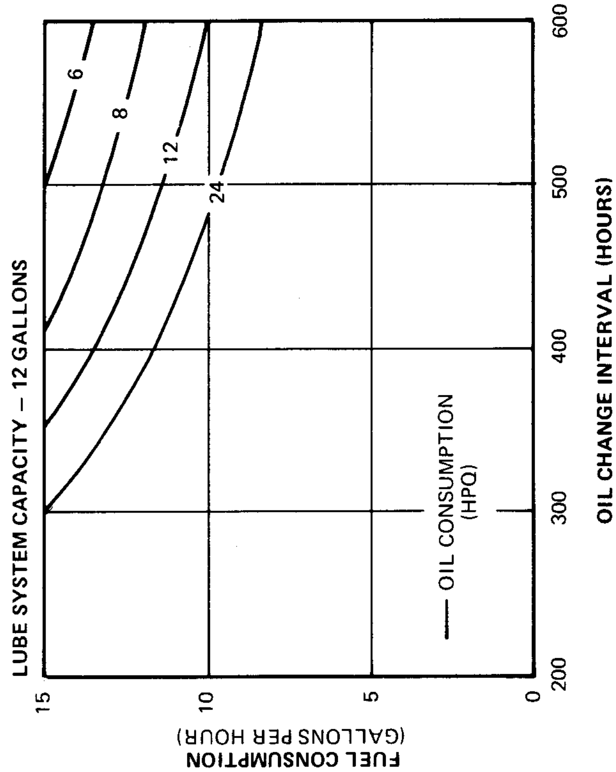
VT-1710 Off-Highway Engine With 750 By-Pass Filter
Lubricating System Capacity — 27 Gallons
Fuel Consumption: 17.5 Gallons/Hour
Oil Consumption: 8 Hours Per Quart
Recommended Oil Change Interval: 505 Hours

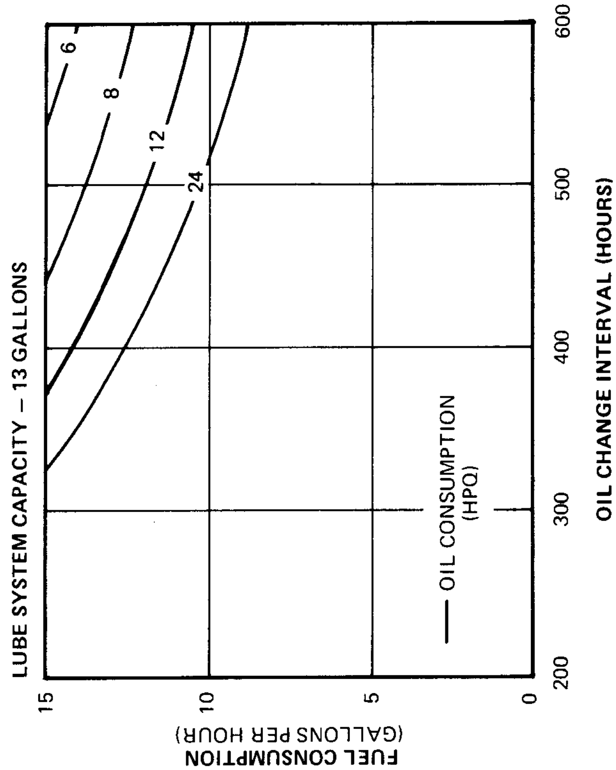


OFF HIGHWAY – NATURALLY ASPIRATED WITH BY-PASS FILTER

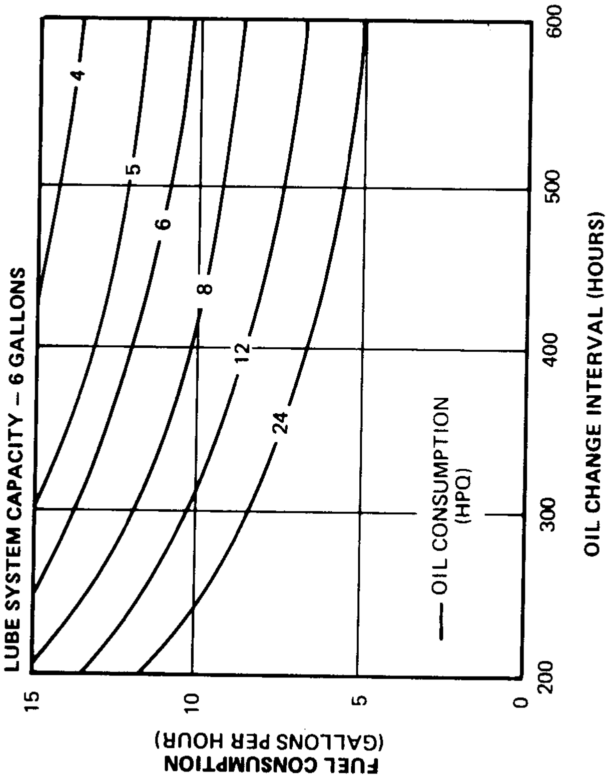


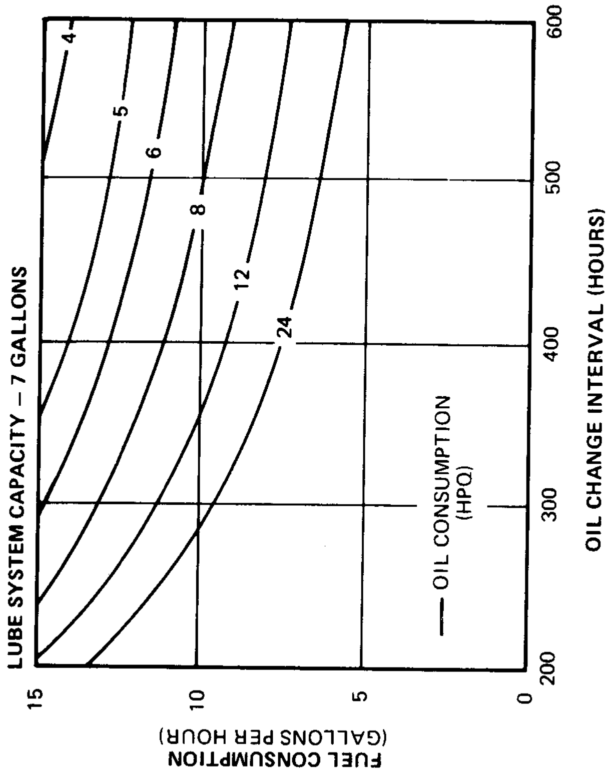


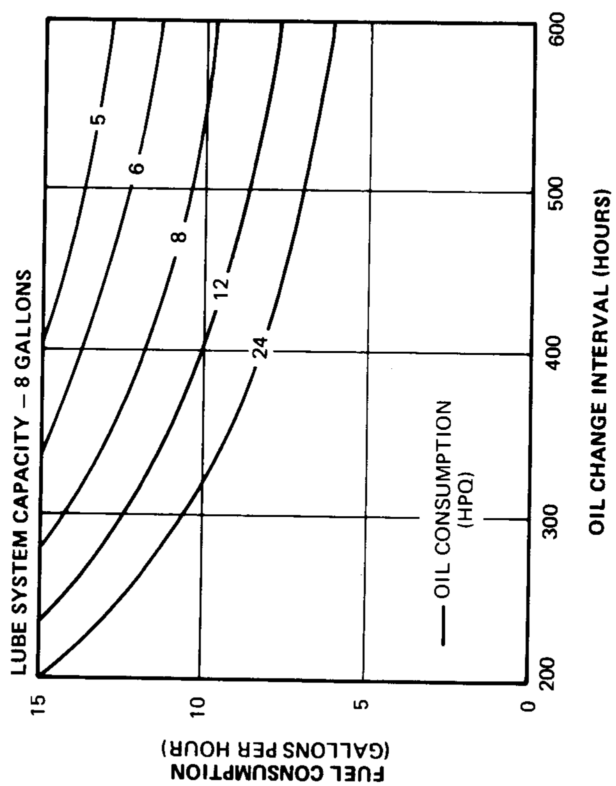


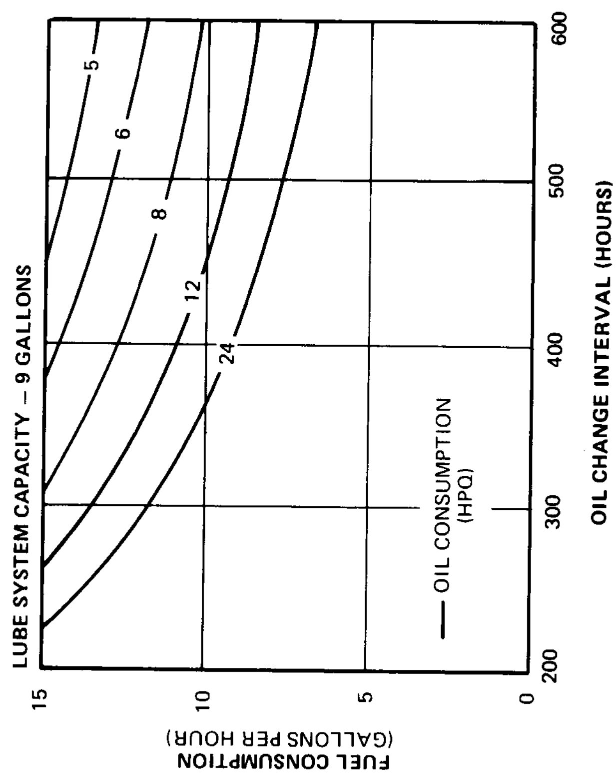


OFF HIGHWAY — NATURALLY ASPIRATED WITH BY-PASS FILTER

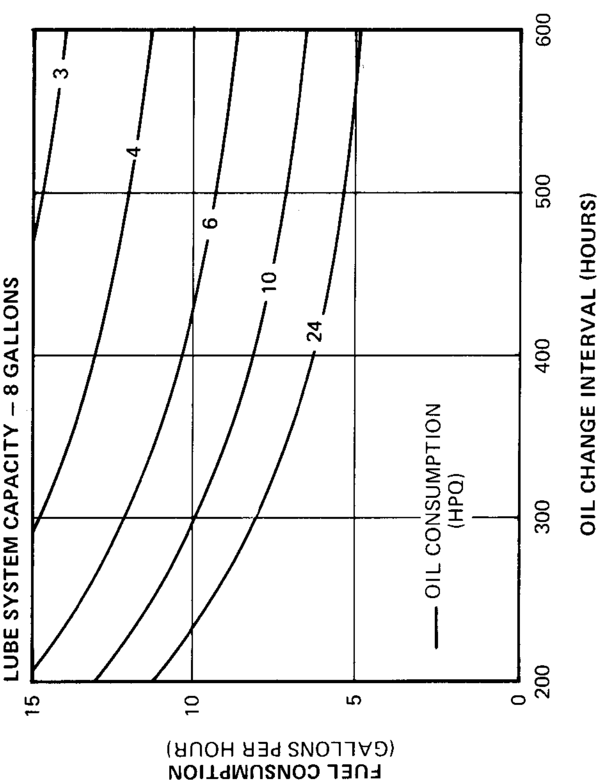


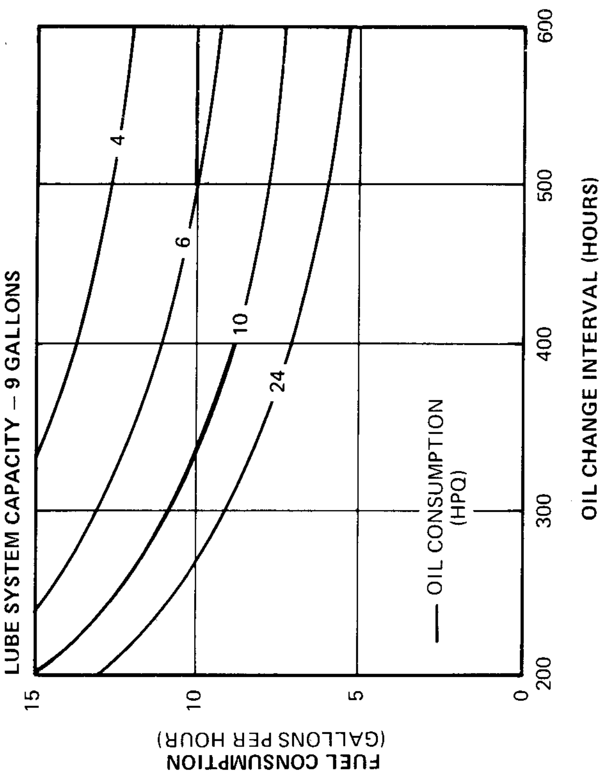


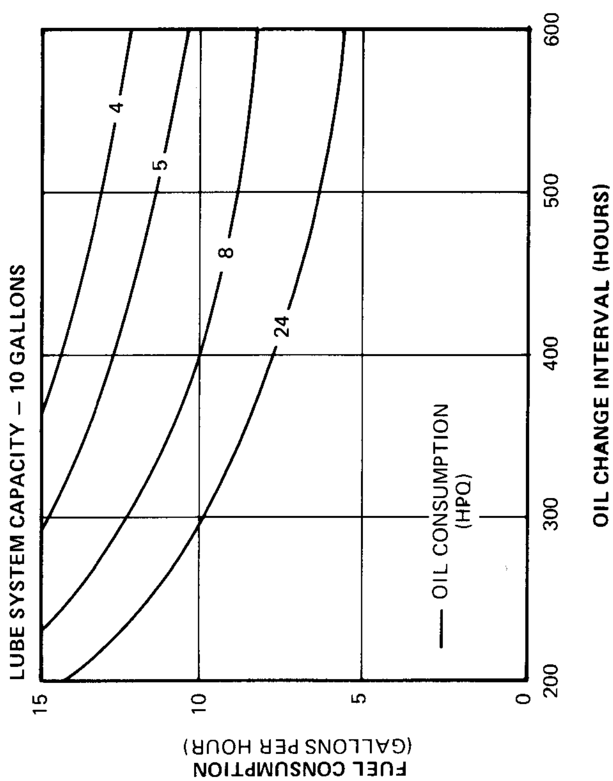


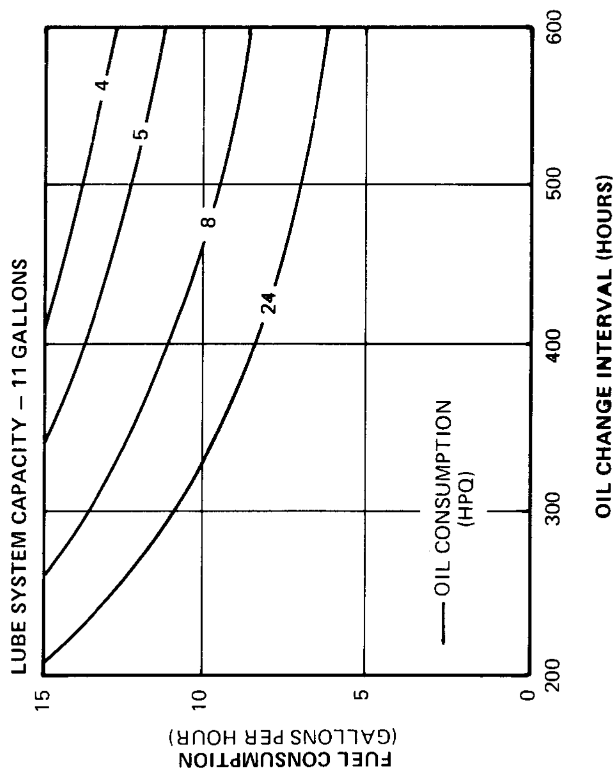


OFF HIGHWAY — TURBOCHARGED WITH BY-PASS FILTER



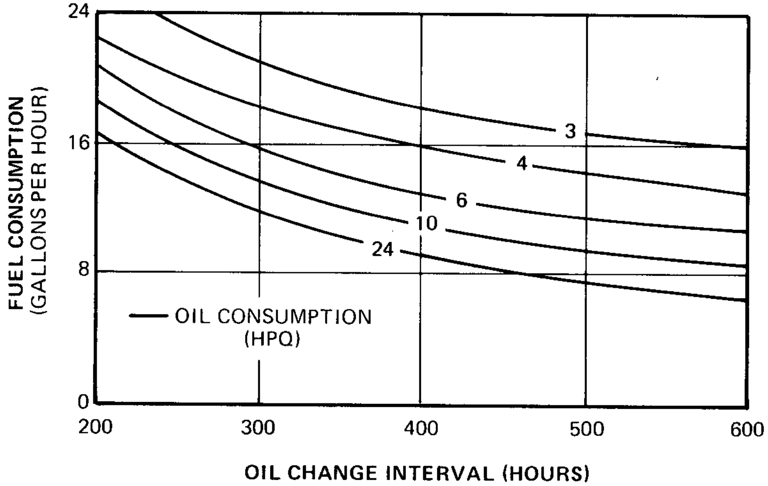




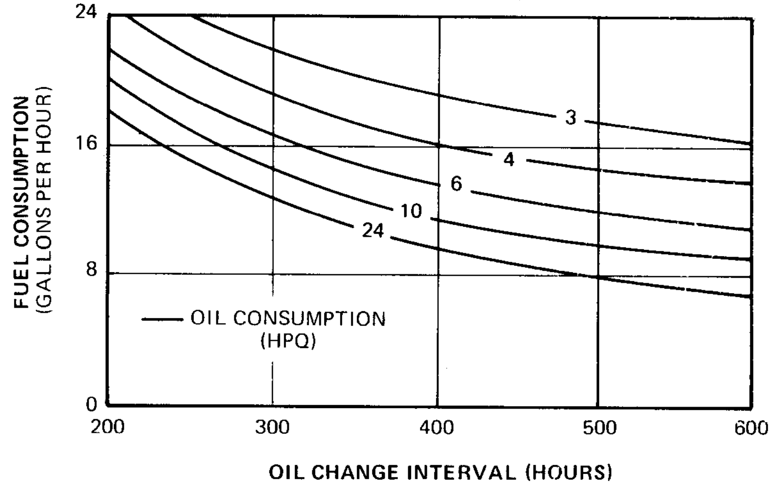


OFF HIGHWAY — TURBOCHARGED WITH BY-PASS FILTER

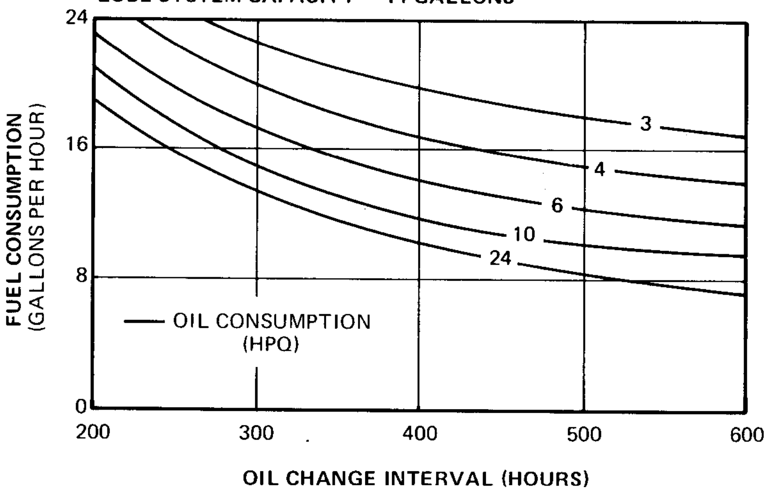
LUBE SYSTEM CAPACITY — 12 GALLONS



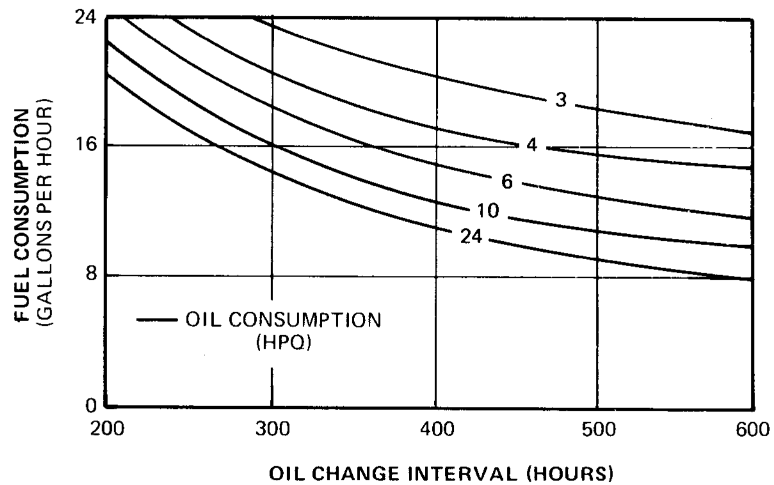
LUBE SYSTEM CAPACITY — 13 GALLONS



LUBE SYSTEM CAPACITY — 14 GALLONS

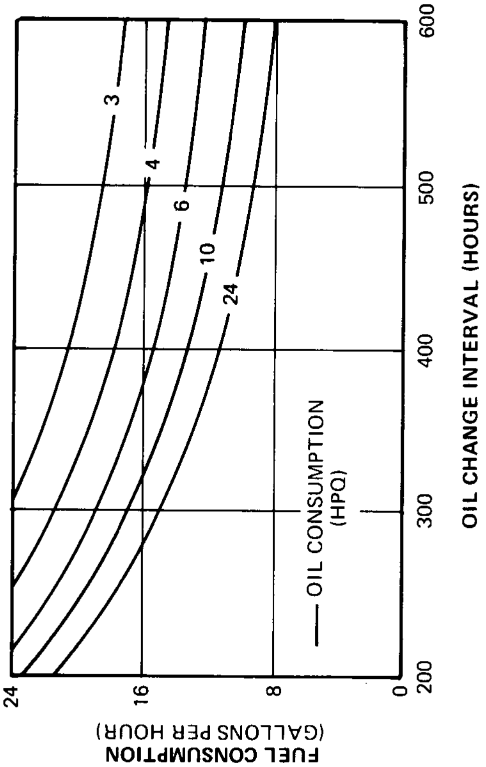


LUBE SYSTEM CAPACITY — 15 GALLONS

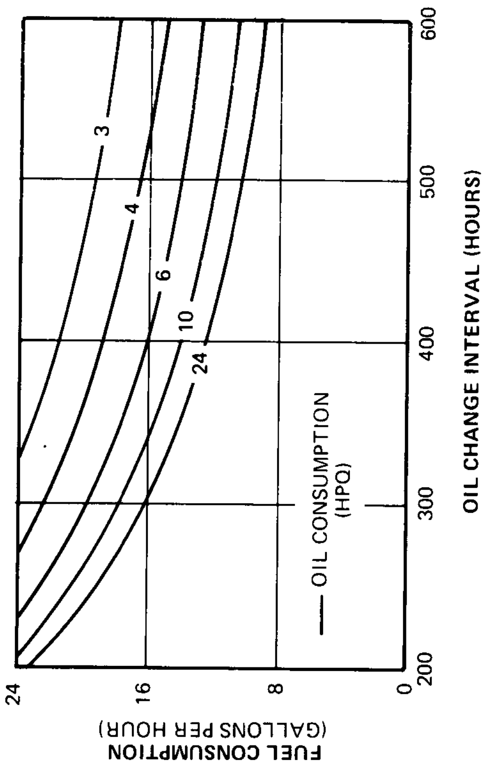


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

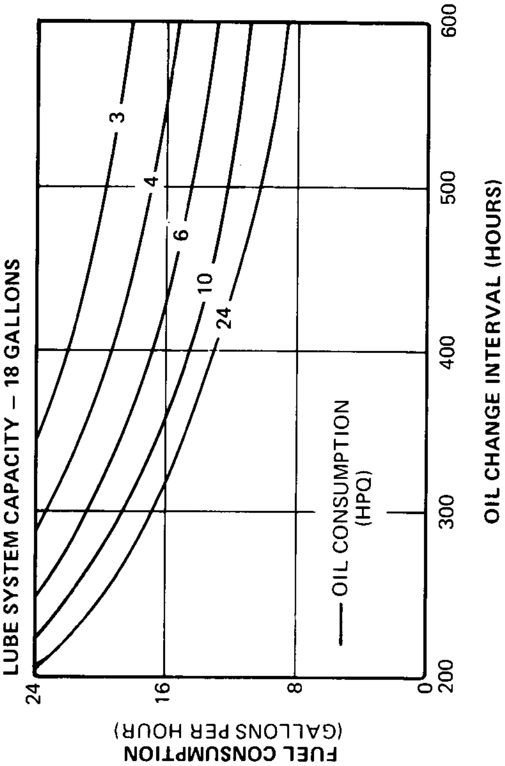
LUBE SYSTEM CAPACITY – 16 GALLONS



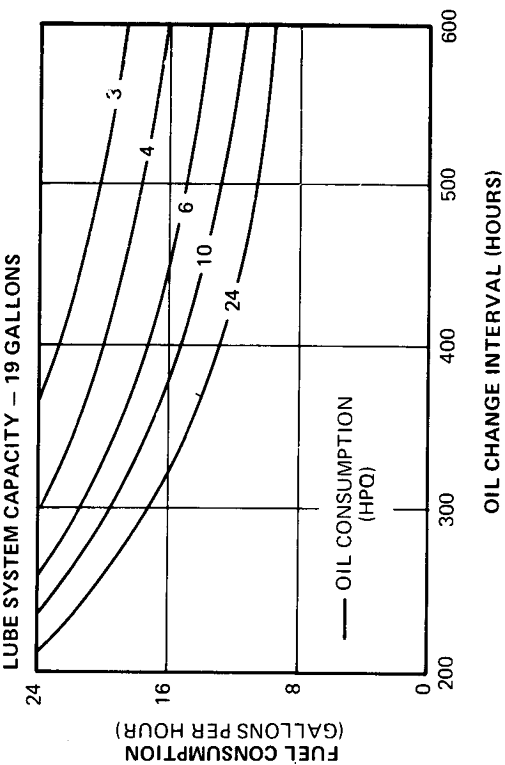
LUBE SYSTEM CAPACITY – 17 GALLONS



LUBE SYSTEM CAPACITY – 18 GALLONS

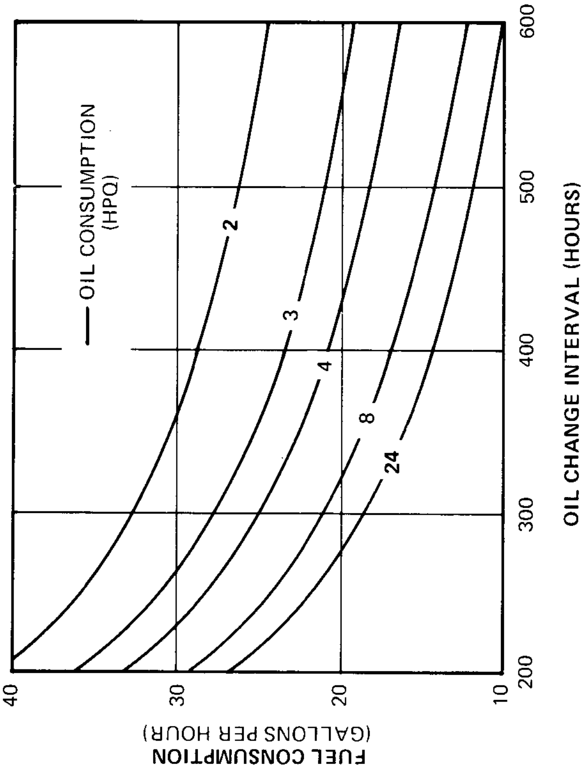


LUBE SYSTEM CAPACITY – 19 GALLONS

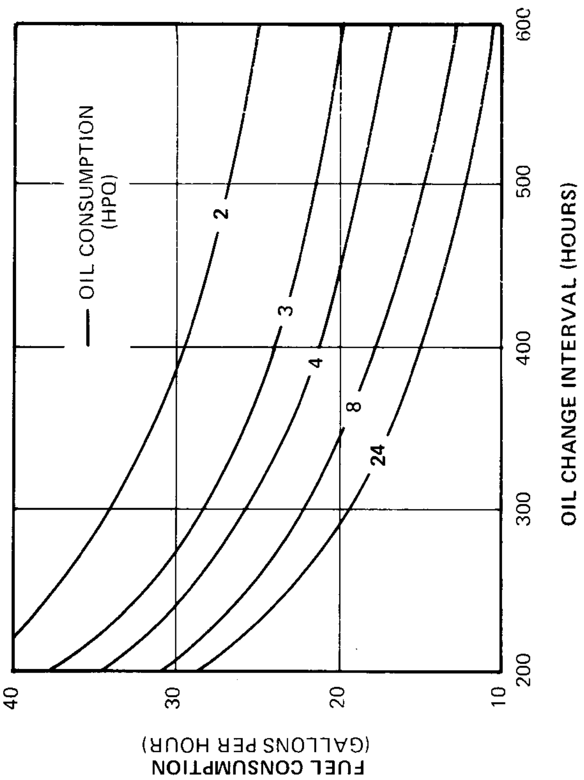


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

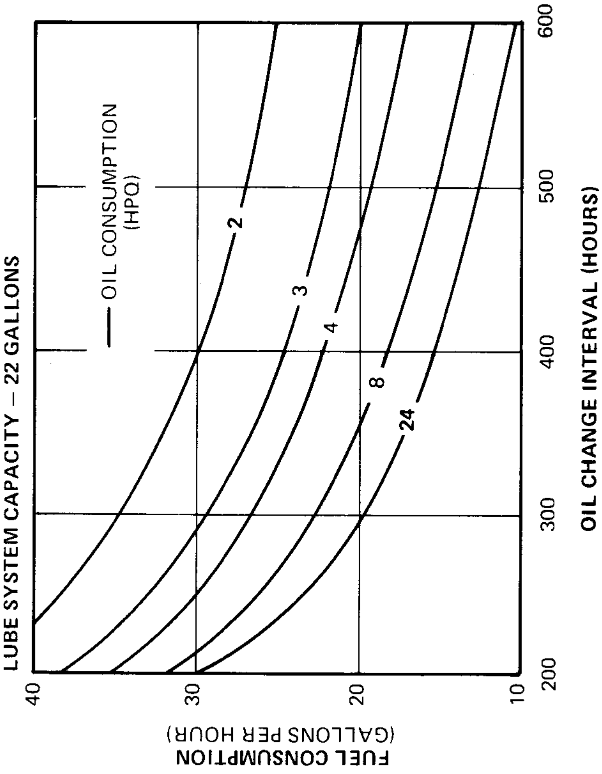
LUBE SYSTEM CAPACITY – 20 GALLONS



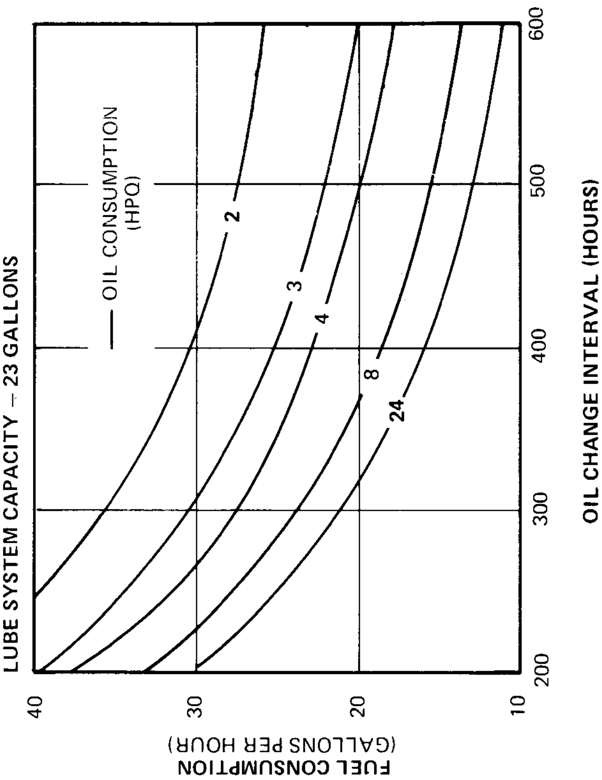
LUBE SYSTEM CAPACITY – 21 GALLONS



LUBE SYSTEM CAPACITY – 22 GALLONS

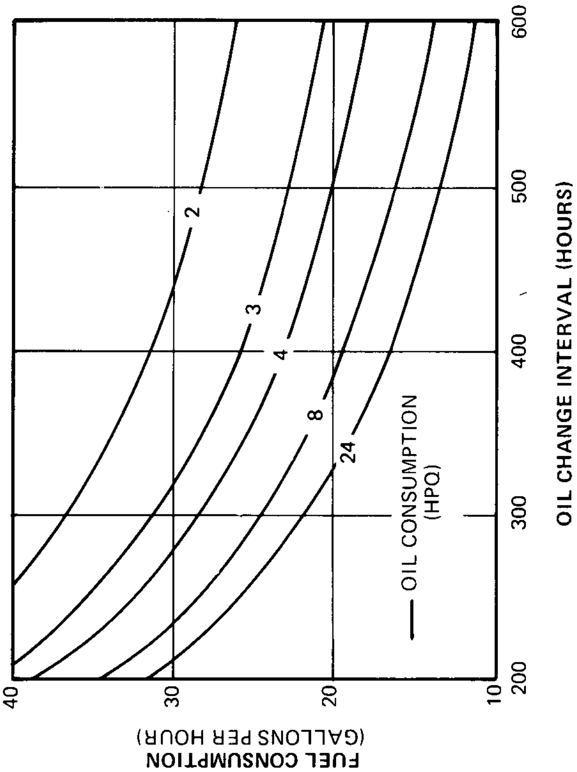


LUBE SYSTEM CAPACITY – 23 GALLONS

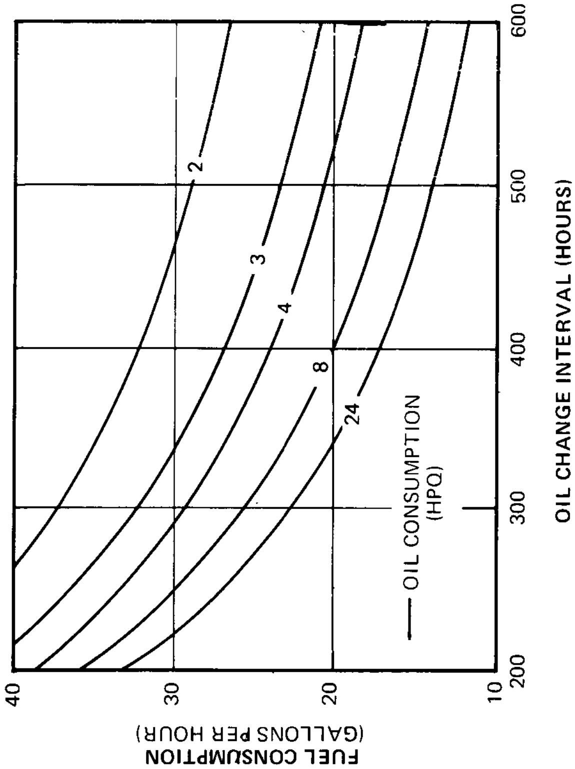


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

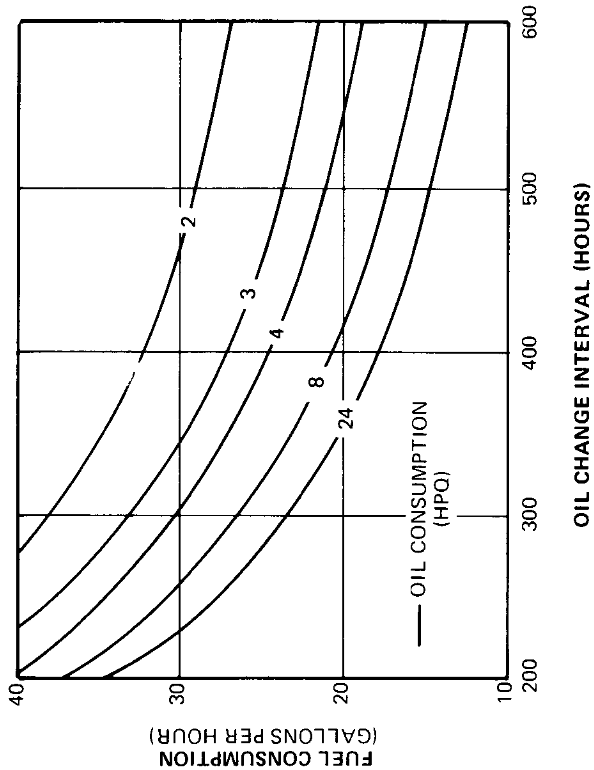
LUBE SYSTEM CAPACITY – 24 GALLONS



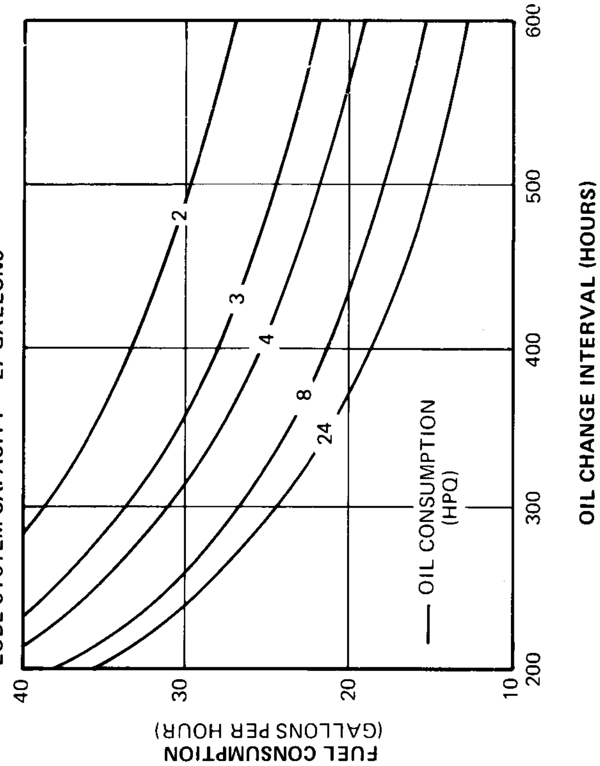
LUBE SYSTEM CAPACITY – 25 GALLONS



LUBE SYSTEM CAPACITY – 26 GALLONS

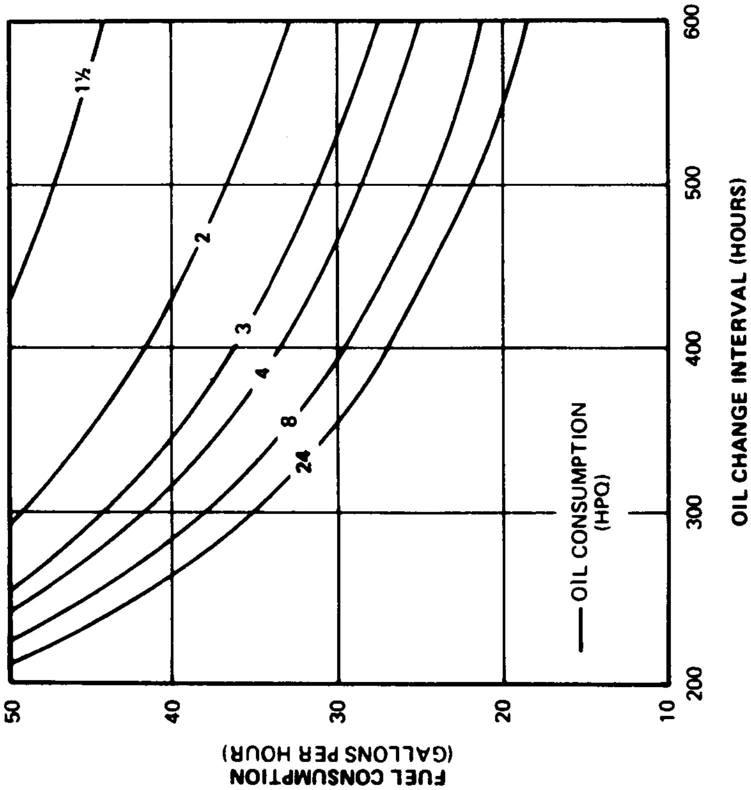


LUBE SYSTEM CAPACITY – 27 GALLONS



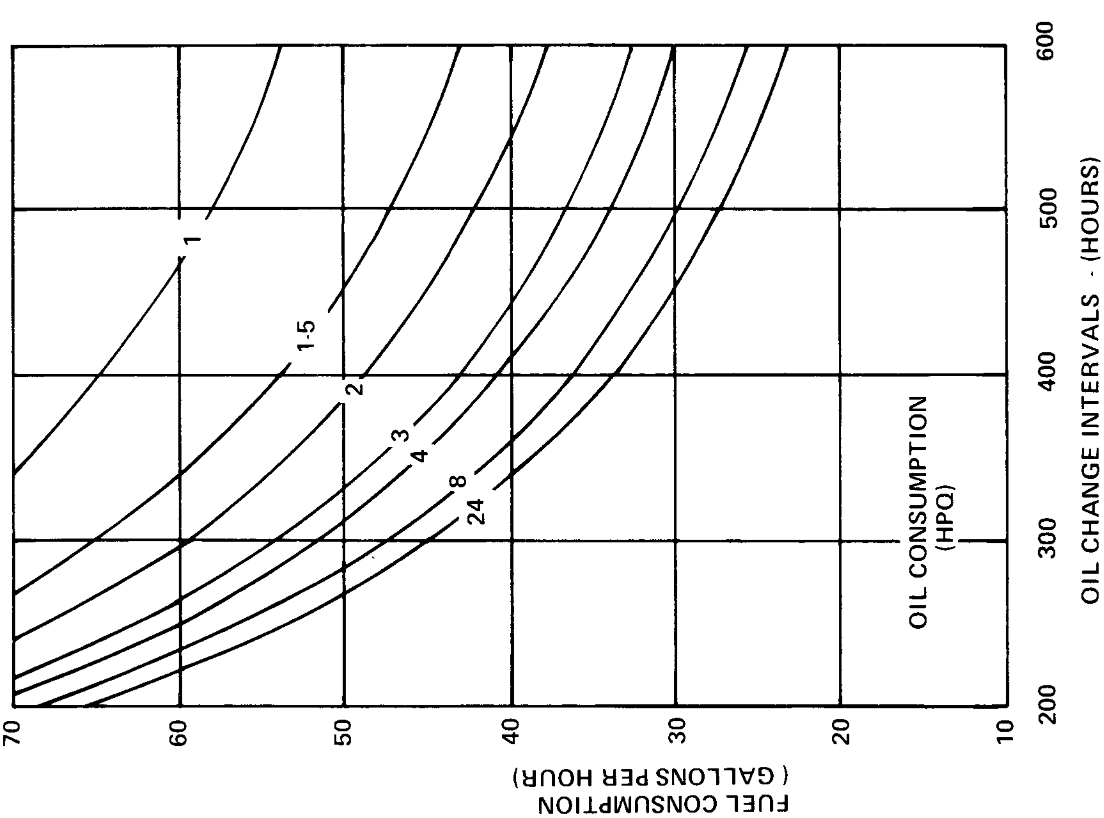
OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

LUBE SYSTEM CAPACITY – 40 GALLONS



OFF HIGHWAY - TURBOCHARGED WITH BYPASS FILTER

LUBE SYSTEM CAPACITY - 51 GALLONS



Example:

VT-1710 Off-Highway Engine With 750 By-Pass Filter
Lubricating System Capacity — 27 Gallons
Fuel Consumption: 17.5 Gallons/Hour
Oil Consumption: 8 Hours Per Quart
Recommended Oil Change Interval: 505 Hours

Lubrication Oil Analysis

An alternate 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 gallons of fuel consumed (after the first 400 gallons), or 20 hours (after the first 100 hours) until the analysis indicates the first oil change is necessary.

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° F and 210° 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 on fuel oil.
2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210° F [99° C] or 25 percent increase at 100° F [38° 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 Spin-On Lubricating Oil Filter Elements

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

Fig. 2-15, (K11951). Removing "spin-on" lubricating oil filter — KT(A)-1150 Engine

Note: At each filter change check torque of adapter mounting capscrew; it should be 25 to 35 ft-lbs [34 to 47 N • m]. If the capscrew is not within torque range, the adapter may rotate when spin-on filter is removed. Replace adapter to filter head gaskets at each "C" maintenance check.

2. Fill elements with lubricating oil.
3. Position element to filter head, Fig. 2-16. Tighten by

Fig. 2-16, (K21907). Installing "spin-on" lubricating oil filter — KT(A)-2300 Engine hand until seal touches filter head, tighten an additional one-half to three-fourths turn.

Caution: Mechanical tightening may distort threads or damage filter element seals.

4. Run engine, check for leaks, recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

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

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. 2-17) and drain oil.
2. Remove clamping ring capscrew (1) and lift off cover.

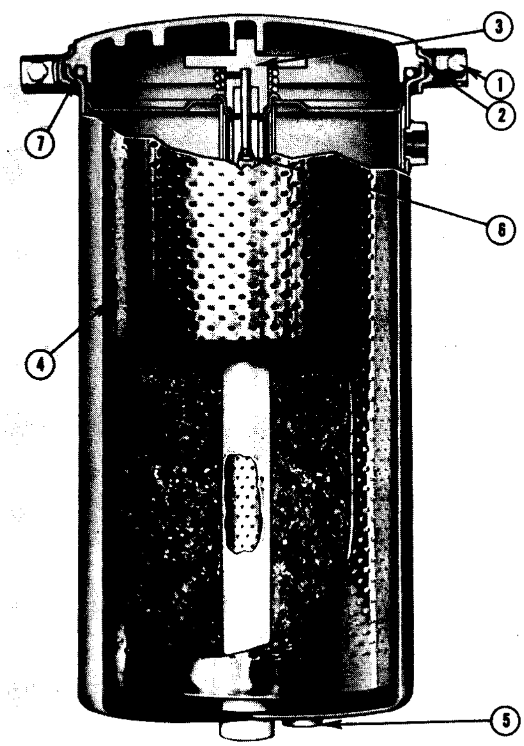


Fig. 2-17, (V41908). By-pass filter cross section

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. 2-18.

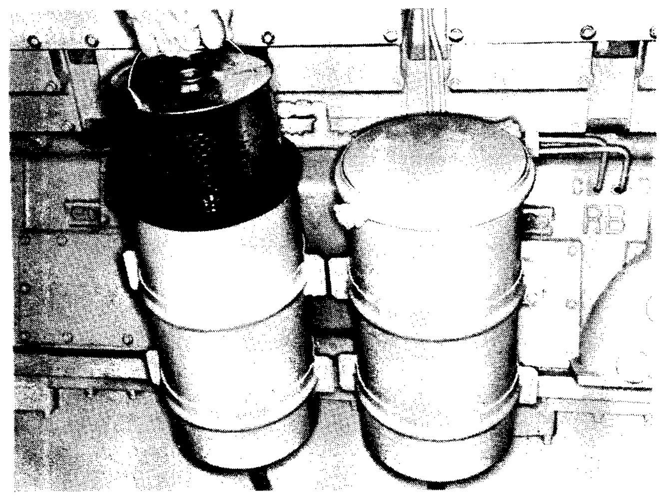


Fig. 2-18, (K21908). Installing by-pass filter element

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.

Change Fuel Filter Element

Spin-On Type Filter

1. Unscrew combination case and element, Fig. 2-19, discard element.
2. Fill new filter with clean fuel.
3. Install filter; tighten by hand until seal touches filter head. Tighten an additional one-half to three-fourths turn.

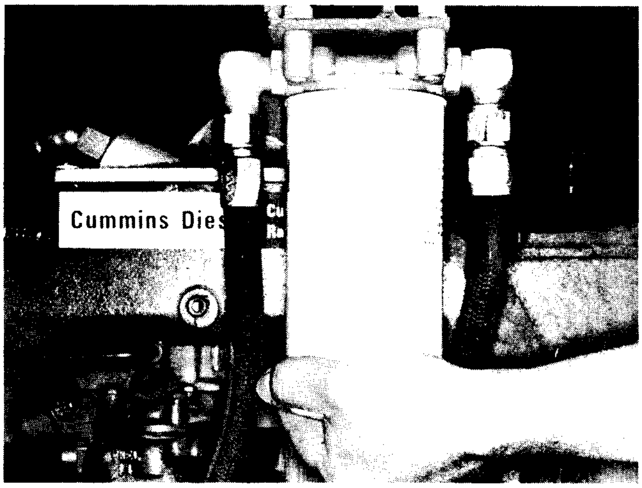


Fig. 2-19, (V11909). Changing "spin-on" type fuel filter

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. 2-20.

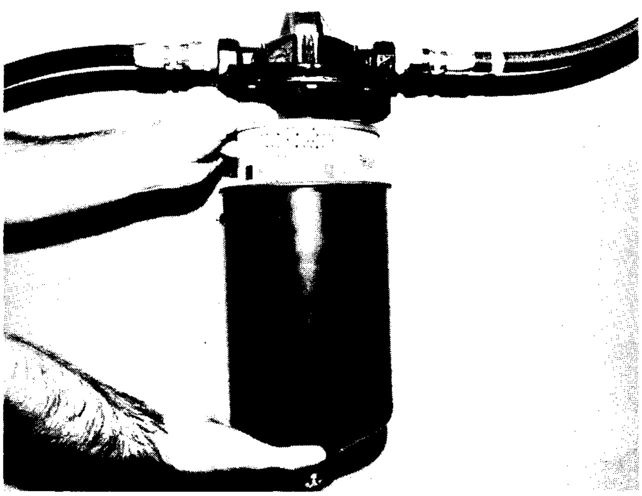


Fig. 2-20, (V11910). Installing replaceable fuel filter element

3. Install new gasket(s) in filter(s) and assemble case(s) and element(s). Tighten center bolt(s) to 20 to 25 ft-lbs [27 to 34 N • m] with a torque wrench. Fill filter case(s) with clean fuel to aid in faster pick-up of fuel.
4. Check fittings in filter head(s) for leaks. Fittings should be tightened to 30 to 40 ft-lbs [41 to 54 N • m].

Check Engine Coolant

Periodic tests of engine coolant should be made to insure that the frequency of water filter servicing or concentration of DCA inhibitor is adequate to control corrosion for any specific condition of operation. In cases where "make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary.

The concentration of effective inhibitor dissolved in coolant can be measured by Fleetguard DCA Coolant Checking Kit Part No. 3300846-S or Cummins 3375208 which is available from Cummins Distributors for this check. Fig. 2-21.

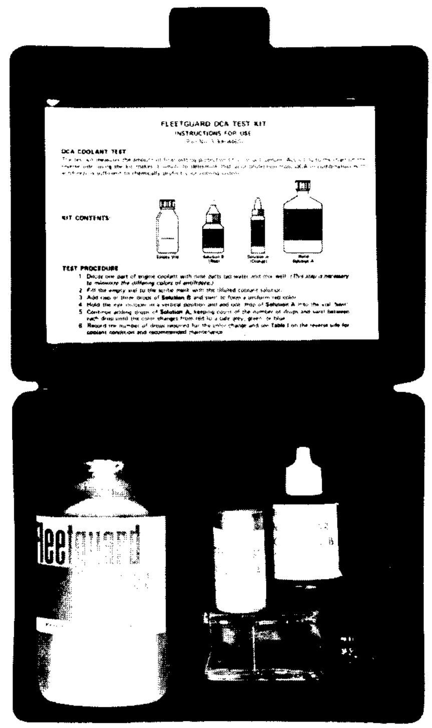


Fig. 2-21, (N12021). DCA coolant test kit

The test kit indicates DCA concentration by measuring the total nitrite of a coolant sample, which provides cylinder liner cavitation protection.

When antifreeze is present, it may contribute to the total nitrite, but most of the nitrite protection is obtained from the DCA inhibitor. In general, a good nitrite reading indicates that the combined inhibitor packages contained in the antifreeze (if used) and in DCA are sufficient to insure complete cooling system protection.

Concentration Test Procedure

1. Dilute one part of engine coolant with nine parts tap water. Mix well.
2. Fill vial to scribe mark, Fig. 2-22, with the diluted coolant solution. Add two or three drops of nitrite indicator solution and swirl to attain a uniform red color.

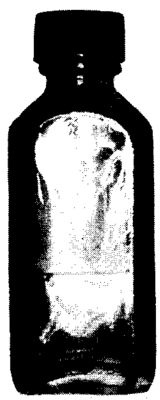


Fig. 2-22, (V12022). Mixing bottle

3. Add one drop of nitrite test solution "A" to the solution in the vial. Swirl to mix.
4. Continue to add nitrite test solution "A" one drop at a time, mixing between each drop, until a color-change from red to pale blue, gray or green is observed. Make sure that the dropper is held in a vertical position.
5. Record the number of drops required for color change, and consult Table 2-2 for coolant condition and maintenance.

Adding Make-Up Coolant and DCA to Cooling System

1. Test coolant for DCA according to nitrite test procedure "With or Without Antifreeze" depending on the presence or absence of antifreeze in the cooling system.
2. Estimate make-up DCA. For example, if a fifteen gallon cooling system contains only 0.5 oz/gal. [4 ml per l] DCA, and 1.5 oz/gal. [12 ml per l] is required, 15 ounces [426 g] of DCA should be added to the make-up coolant.

Note: A one pint bottle of DCA-4L liquid (P/N 3300858) contains six dry ounces of DCA chemical in Step 2, concentrations are in dry ounces of chemical per gallon of coolant.

Table 2-2: Number of Drops of Test Solution "A"

Coolant With Antifreeze	Coolant Without Antifreeze	Coolant Condition	Maintenance Required
0-12	0-6	Dangerous (0 to 0.6 oz. per gallon DCA)	Precharge system or add make-up DCA to top tank.
12-17	7-12	Borderline (0.7 to 1.2 oz. per gallon DCA)	Replace service filter and/or add make-up DCA to top tank.
18-25	13-20	Acceptable (1.3 to 2.0 oz. per gallon DCA)	None.
25-30	20-30	Tolerable (2.0 to 3.0 oz. per gallon DCA)	None.
Over 30	Over 30	Overrated (over 3.0 per gallon DCA)	Drain part of coolant and make-up with plain antifreeze and water.

Note: Ethylene glycol/water solutions should not contain more than 3.0 oz. per gallon DCA or Dowtherm 209/water solutions should not contain more than 2.0 oz. per gallon DCA. Concentrations in excess of the above can cause sludge to form in the water filter.

3. Estimate the total amount of make-up coolant required (gallons), and calculate the proportions of water and antifreeze, if used, required. For example, one gallon of 50-50 antifreeze/water solution will require two quarts of antifreeze and two quarts of water.
4. Add the required amount of water to a mixing container and dissolve the number of ounces of DCA obtained in Step 2 in the water. If negative or zero results were obtained in Step 2, do not add DCA. (For DCA to dissolve, water should be above 50°F [10°C].
5. Add the required amount of antifreeze, if used, to the water solution and mix thoroughly.
6. Add make-up coolant to cooling system.

Note: If the DCA concentration is low, and coolant level high, DCA may be added directly to the radiator in the amount indicated in Step 2. The engine should be running and warm enough to permit coolant circulation throughout the entire system.

Bulk Storage of Make-Up Coolant

If make-up coolant is stored in bulk, the following recommendations are provided for mixing and storing the coolant.

1. Drain and clean bulk storage tank to remove any possible contaminants.
2. Knowing the total capacity of the holding tank, calculate the proportions of water and antifreeze, if used, required. For example, a 500 gallon [1892 l] tank will hold 250 gallons [946 l] of water and 250 gallons [946 l] of antifreeze for a 50-50 mixture.
3. Multiply the desired DCA concentration by the total capacity of the holding tank in gallons. In the example above, 1.5 oz. DCA per gallon [12 ml per l] of coolant can be used in the 50-50 mixture. Multiplying 1.5 oz. DCA per gallon [12 ml per l] times 500 gallons [1892 l] yields a total DCA requirement of 750 oz. (46 lb. 14 oz.) [21.3 kg].
4. Add the water to the holding tank. Agitating continuously, add the DCA to the water in small amounts until all of the chemical has dissolved. The water should be above 50°F [10°C].
5. Add the antifreeze last, if used, maintaining agitation to bring and keep the finished coolant in solution. Both antifreeze and DCA will settle to the bottom of the tank unless constant mixing or recirculation is provided. An example of recirculation is the use of a small pump operating continuously to draw DCA and antifreeze off the bottom of the tank and discharging the solution at the top. Samples of coolant can be drawn off the top, middle and bottom of the storage tank and tested for antifreeze and/or DCA concentration if inadequate mixing is suspected.

Change DCA Water Filter

Change filter or element at each "B" Check; selection of element to be used should be based upon size of system. See "Coolant Specifications", Section 3.

Note: Whenever coolant supply is changed the system must be drained, flushed, and precharged. See "Coolant Specifications", Section 3 for DCA compatibility with different brands of antifreeze.

Spin-On Element

1. Close shut-off valves on inlet and drain lines.
2. Unscrew element and discard.
3. Install new element, tighten until seal touches filter head. Tighten an additional one-half to three-fourths turn. Fig. 2-23. Open shut-off valves.

Fig. 2-23, (V514132). Installing DCA "spin-on" water filter

Caution: Mechanical tightening will distort or crack filter head.

Check Oil Levels

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.

Clean/Change Crankcase Breather

Mesh Element Breather

1. Remove wing nut (6, Fig. 2-24), flatwasher and rubber washer securing cover (1), to breather body (5).

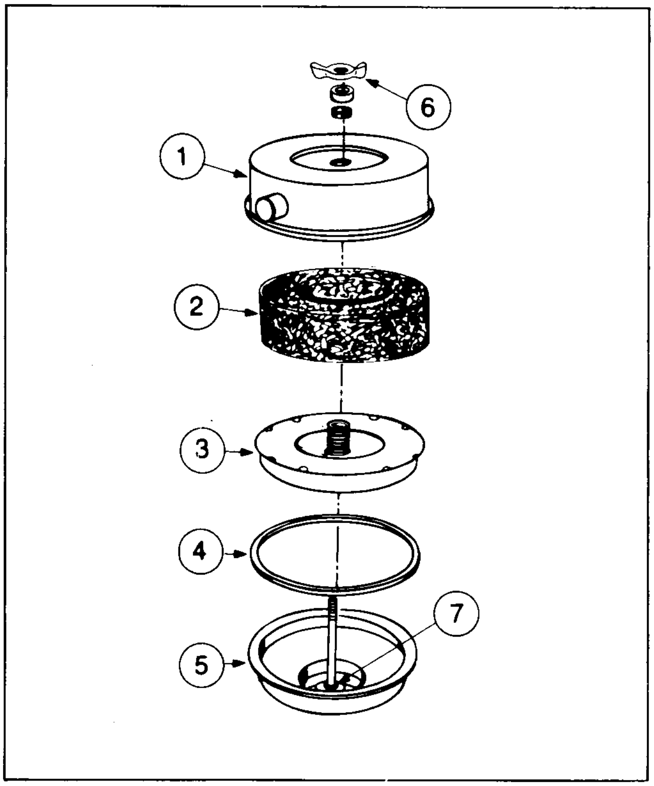


Fig. 2-24, (V51909). Crankcase breather — mesh element with vapor barrier

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.
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. 2-24) 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.

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. 2-25.

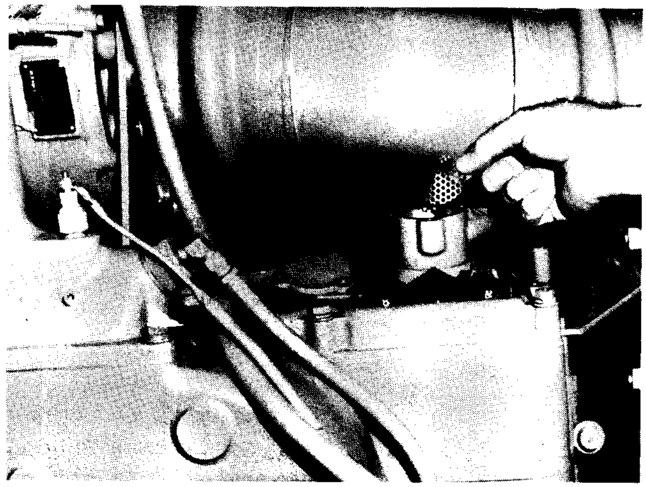


Fig. 2-25, (N11934). Crankcase breather — screen type

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.

Clean Air Compressor Breather

When used, service breathers regularly as follows:

Bendix-Westinghouse Paper Element

Remove breather cover and element. Fig. 2-26. Clean by reverse flushing with compressed air; reassemble on compressor. Discard element if damaged or unsuitable for cleaning.

Bendix-Westinghouse Sponge

Remove breather from air compressor. Disassemble

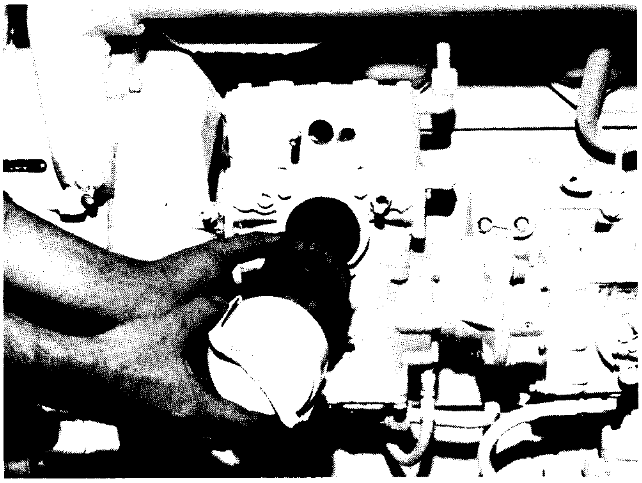


Fig. 2-26, (V41420). Bendix-Westinghouse air compressor breather

breather, wash all metal parts in solvent and blow dry with compressed air. Wash element in solvent; remove all solvent from element; dip in clean engine oil and squeeze excess oil from element.

Cummins Paper

Clean element at each "D" maintenance check. Remove wing nut securing front cover to body. Lift off front cover and element. Inspect paper element before cleaning by reverse flow of compressed air; discard if damaged or unsuitable for cleaning. Fig. 2-27.

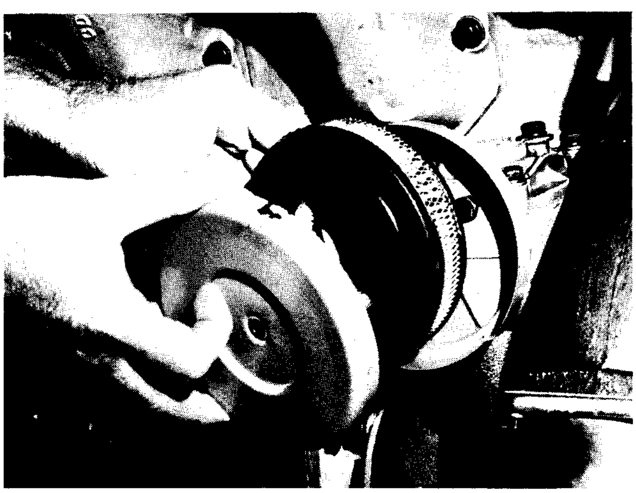


Fig. 2-27, (V414209). Cummins air compressor breather — paper element

Caution: Do not rupture filter element.

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

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

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.

"C" Maintenance Checks

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

Adjust Injectors and Valves

It is essential that injectors and valves be in correct adjustment at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Final operating adjustments must be made using correct values as stated.

Caution: Be sure injector and valve set marking, wherever located, are in proper alignment with indicator mark.

Temperature Settings

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

Definition of "Cold Set"

Engine must have reached a stabilized temperature (4 hours minimum) without operation in ambient temperature where adjustments are to be made.

Definition of "Hot Set"

1. Adjust injectors and valves immediately after the engine has been operated at 210° F [99° C] oil sump temperature for a period of 10 minutes minimum, or until normal oil operating temperature has been obtained.
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 40 minutes minimum.

Injector Plunger Adjustment Using Torque Method, V-378, V-504, V-555 Engines

Injectors and valves must be in correct adjustment at all times for engine to operate properly. This controls engine breathing and fuel delivery to cylinder. Final adjustment must be made when engine is at operating temperature. Injectors must always be adjusted before valves. The procedure is as follows:

Valve Set Mark Alignment

1. Turn crankshaft in direction of rotation until No. 1 "VS" mark appears on the vibration damper or crankshaft pulley. See Fig. 2-28 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. 2-29, Fig. 2-30 and Table 2-3 for firing order.

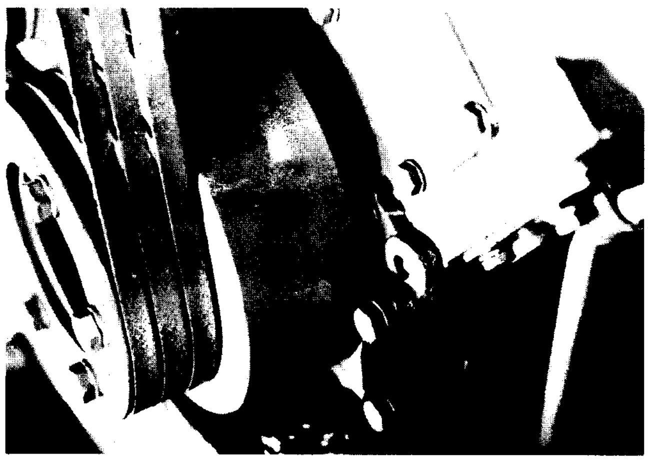


Fig. 2-28, (OM103). Valve set marks — V-378, V-504, V-555 Engines

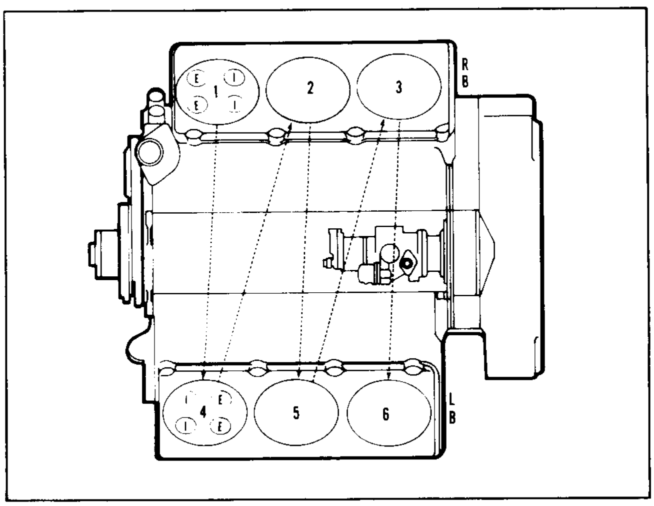


Fig. 2-29, (V11461). V6 firing order

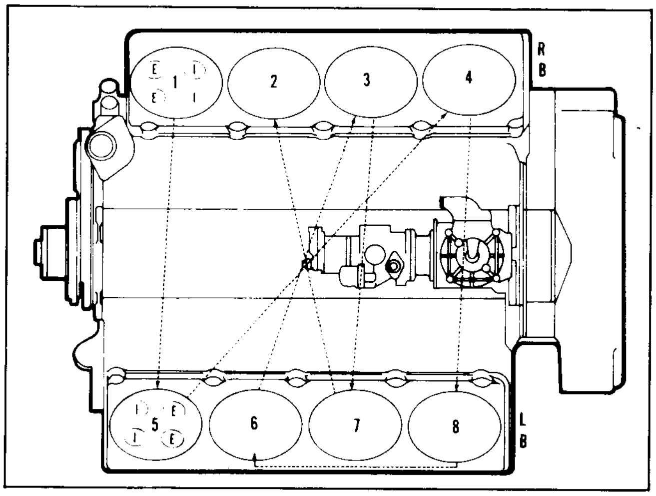


Fig. 2-30, (V11462). V8 firing order

Note: Do not use fan to rotate engine.

2. Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to next "VS" mark corresponding to firing order of engine and corresponding cylinder will be ready for adjustment. See Table 2-3.
3. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

Table 2-3: Engine Firing Order V Engines

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

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

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

Injector Plunger Adjustment

Before adjusting injector, tighten injector hold-down capscrew to 30 to 35 ft-lbs [41 to 47 N • m].

The injector plungers of all engines must be adjusted with an in-lb torque wrench to a definite torque setting. Snap-On Model TQ12B or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 2-31.

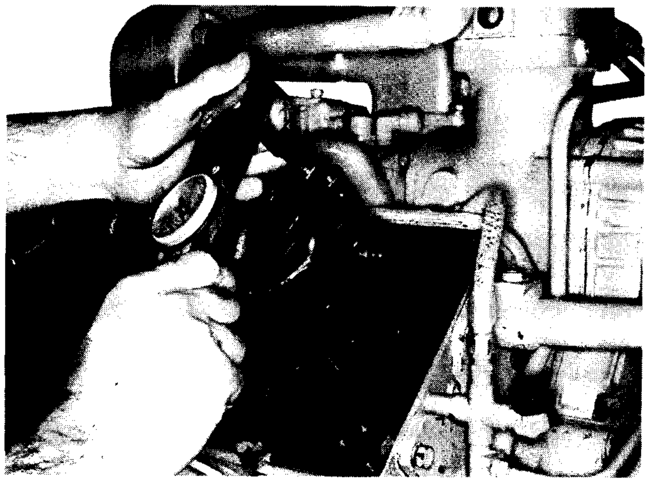


Fig. 2-31, (V11914). Adjusting injector plunger

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.
2. Loosen adjusting screw one turn; using a torque wrench calibrated in in-lbs and a screwdriver adapter, tighten the adjusting screw to values shown in Table 2-4 for cold setting and tighten the locknut.

Table 2-4: Injector Plunger Adjustment Torque V-378, V-504, V-555 Engines

Oil Temperature Cold	Oil Temperature Hot
60 in-lbs [6.8 N • m]	60 in-lbs [6.8 N • m]

Note: After all injectors and valves are adjusted and engine has been started and warmed up to 140° F [69° C] oil temperature, reset injectors to the warm setting. This is only necessary if injectors, lever assemblies, or push rods have been changed.

3. Hold injector adjusting screw and tighten injector adjusting screw locknut to values indicated in Table 2-5.

When ST-669 Adapter is used, nut torque is reduced to compensate for additional torque arm length. Fig. 2-32.

Table 2-5: Injector and Valve Locknut Torque V-378, V-504, V-555 Engines

Without ST-669	With ST-669
40 to 45 ft -lbs. [54 to 61 N • m]	30 to 35 ft-lbs [41 to 47 N • m]

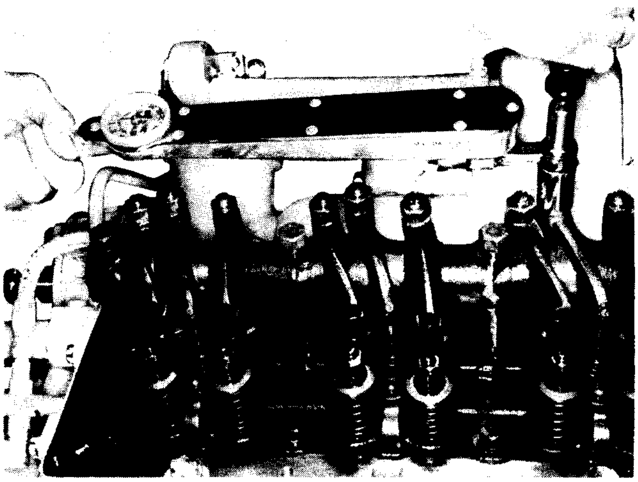


Fig. 2-32, (V114115). Tightening adjusting screws locknut

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.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.
2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw).
3. Turn down crosshead adjusting screw until it touches valve stem. Fig. 2-33.
4. Hold adjusting screw in this position and torque locknut to values listed in Table 2-6.
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.

Valve Adjustment

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

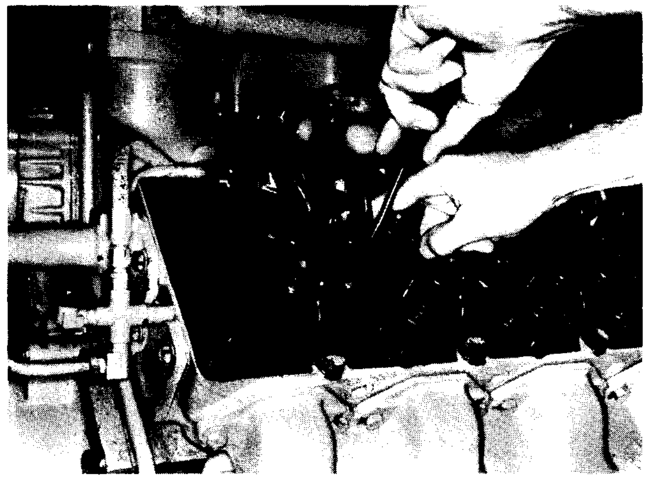


Fig. 2-33, (V11915). Adjusting crossheads

Table 2-6: Crosshead Locknut Torque

Without ST-669	With ST-669
25 to 30 ft-lbs [34 to 41 N • m]	22 to 26 ft-lbs [30 to 35 N • m]

1. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and top of crosshead. Valve clearances are shown in Table 2-7. Turn screw down until lever just touches gauge and lock adjusting screw in this position with locknut. Fig. 2-34. Torque locknut to values indicated in Table 2-5; note Step 2 under "Injector Plunger Adjustment".

Table 2-7: Valve Clearances — Inch [mm] V-378, V-504, V-555 Engines

Intake Valve Oil Temperature		Exhaust Valve Oil Temperature	
Cold	Hot	Cold	Hot
0.012 [0.30]	0.010 [0.25]	0.022 [0.56]	0.020 [0.51]

2. Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature.

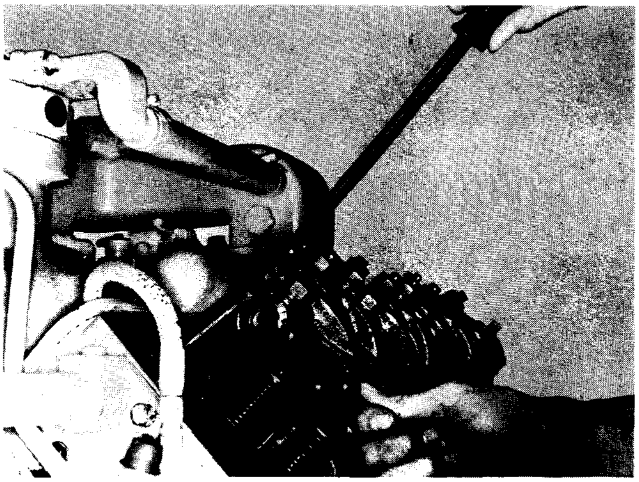


Fig. 2-34, (V11916). Adjusting valves

V-903 Engines Injector Adjustment, Using 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.

The "indicator method" eliminates errors in adjustment caused by friction in the screw threads and distortion from overtightening the adjusting screw locknut. 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 2-8 for specifications.

Table 2-8: Adjustment Limits Using Dial Indicator Method Inch [mm] V-903 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
1 to 1 Rocker Lever Ratio — Injector Lever P/N 211319		
0.187 ± 0.001 [4.75 ± 0.03]	0.012 [0.30]	0.025 [0.64]

Before adjustment, tighten injector hold-down capscrew to 30 to 35 ft-lbs [41 to 47 N • m] torque.

Note: Remove key, and using either 3/8 inch hex drive for female type barring device or 5/8 inch six-point socket for male type barring device, press inward until barring gear engages drive gear; then advance. Fig. 2-35. After completion of adjustment, be sure drive retracts and install key into safety lock groove.

Using regular engine barring device, Fig. 2-35, rotate engine in direction of rotation until "VS" mark for cylinder 2-8 is aligned with 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 degrees in direction of rotation and realign the 2-8 "VS" mark.

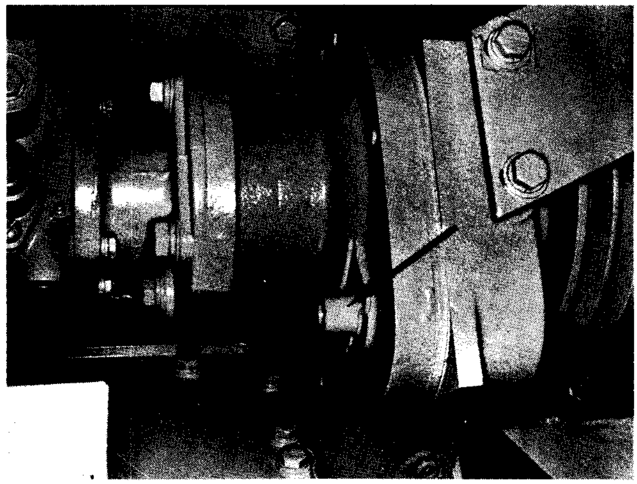


Fig. 2-35, (V51486). Engine barring arrangement — V-903

The timing mark locations (Fig's. 2-36 and 2-37) are used with the dial indicator method of setting injectors and valves. Alignment, in either location, should be held to one-half inch [12.7 mm] of pointer.

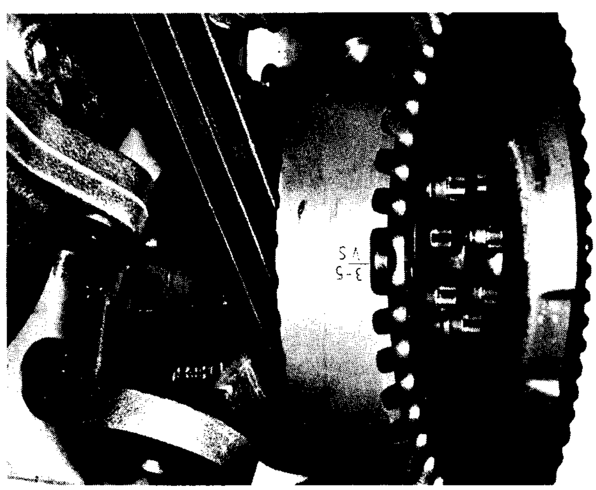


Fig. 2-36, (V514115). Valve set marks on vibration damper — V-903

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

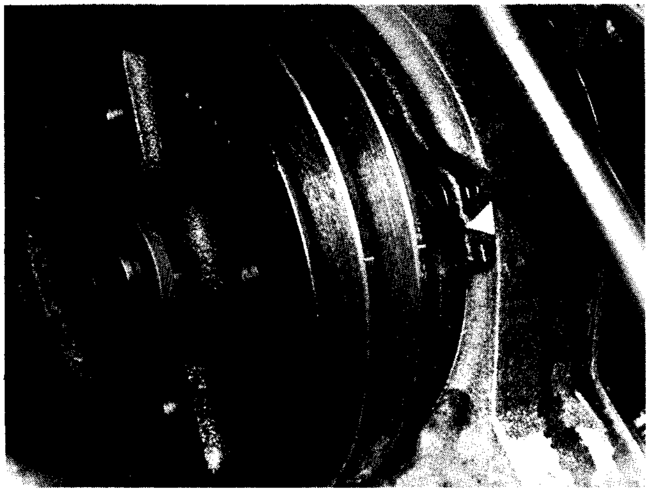


Fig. 2-37, (V514127). Valve set mark on accessory drive — V-903

1. Set up the ST-1270 Indicator Support with the indicator extension atop the injector plunger flange at No. 2 cylinder. Fig. 2-38.

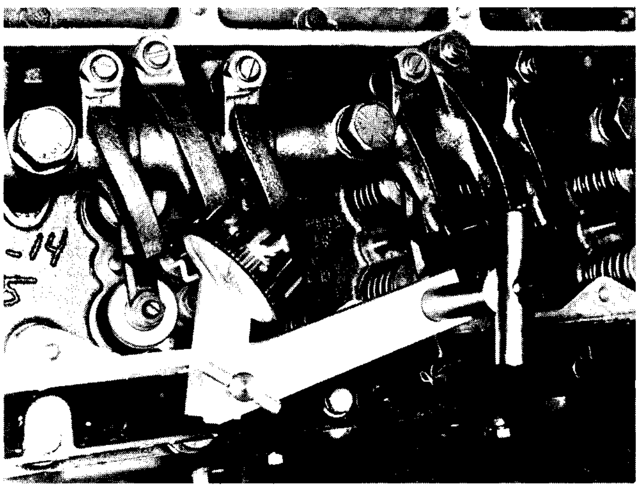


Fig. 2-38, (V514114). Dial indicator in place — V-903

2. Screw injector lever adjusting screw down until plunger is bottomed in cup, back off approximately 1/2 turn then bottom again, set dial indicator at zero (0).

Note: Care must be taken to assure injector plunger is correctly bottomed in cup, without overtightening adjusting screw, before setting dial indicator.

3. Back adjusting screw out until a reading of 0.187 inch [4.75 mm],. reference Table 2-8, is obtained on dial indicator. Snug tighten locknut.

4. Using ST-1251 Rocker Lever Actuator, bottom injector plunger, check zero (0) setting. Fig. 2-39. Allow plunger to rise slowly, indicator must show plunger travel to be within range specified in Table 2-8.

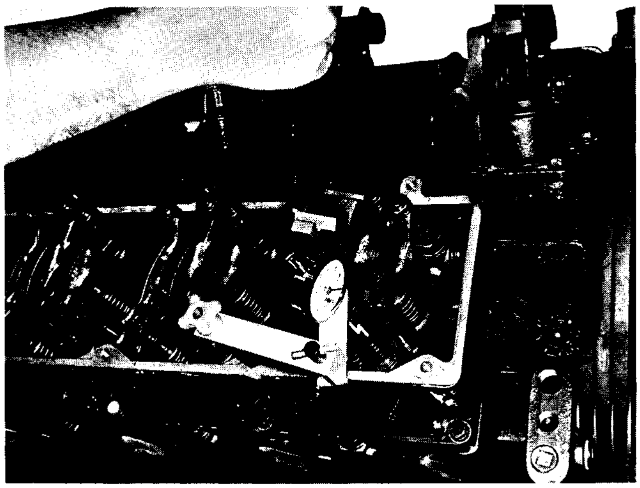


Fig. 2-39, (V514128). Bottoming injector plunger in cup — V-903

5. Using ST-669 Torque Wrench Adapter to hold adjusting screw in position, torque locknut 30 to 35 ft-lbs [41 to 47 N • m]. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, torque locknuts 40 to 45 ft-lbs [54 to 61 N • m].
6. Actuate injector plunger several times as a check of adjustment. Remove dial indicator assembly.
7. Adjust valves on appropriate cylinder as determined in Step 1 and Table 2-8. Tighten locknuts same as injector locknut.

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.

1. Loosen valve crosshead adjusting screw locknut and back off screw one turn.
2. Use light finger pressure at rocker lever contact surface to hold crosshead in contact with valve stem (without adjusting screw). Fig. 2-40.
3. Turn down crosshead adjusting screw until it touches valve stem.
4. Hold adjusting screw in position and torque locknut

Fig. 2-40, (V51490). Adjusting crossheads — V-903

to values listed in Table 2-6.

Note: Be sure that crosshead retainers on exhaust valves, if used, are positioned equally on both sides of spring over crossheads and valve springs properly.

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.

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 cross-head. Fig. 2-41. Valve clearances are shown in Table 2-8. Turn screw down until lever just touches gauge, and lock adjusting screw in position with locknut. Torque adjusting screw locknuts to 40 to 45 ft-lb [54 to 61 N • m] or 30 to 35 ft-lb [41 to 47 N • m] when using an ST-669 Adapter.

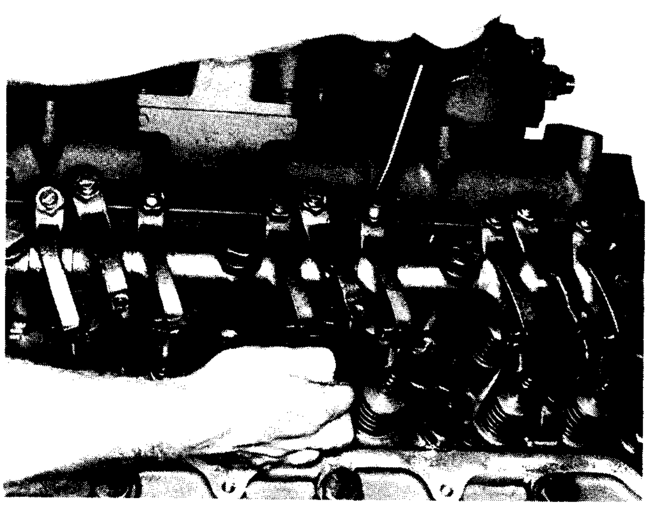


Fig. 2-41, (V51492). Adjusting valves — V-903

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

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

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 [14 to 16 N • m]. With flange injectors torque hold-down capscrews in alternate steps to 12 to 14 ft-lbs [14 6 to 18 N • m]. Tighten fuel inlet and drain connections to 20 to 25 ft-lbs [27 to 34 N • m] in flange injectors.

Maintenance Adjustment

1. Bar engine until "A" or 1-6 "VS" mark on pulley, Fig. 2-42, 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 degrees, realign mark with pointer.

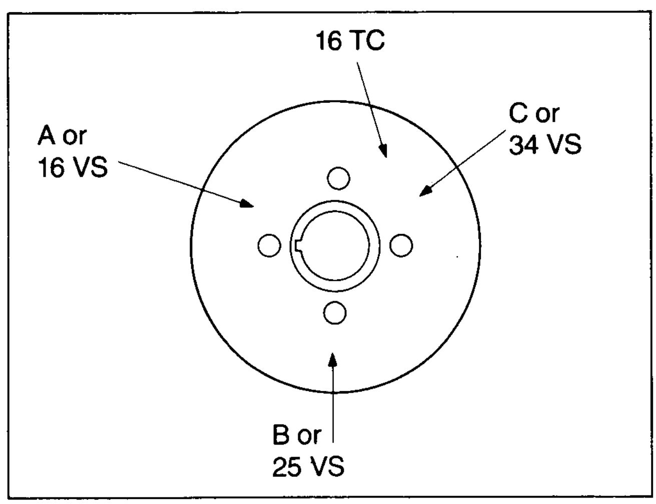


Fig. 2-42, (N114230). Accessory drive pulley marking — N-855

2. Set up ST-1170 Indicator Support with indicator extension on injector plunger top at No. 3 cylinder, Fig. 2-43. Make sure indicator extension is secure in

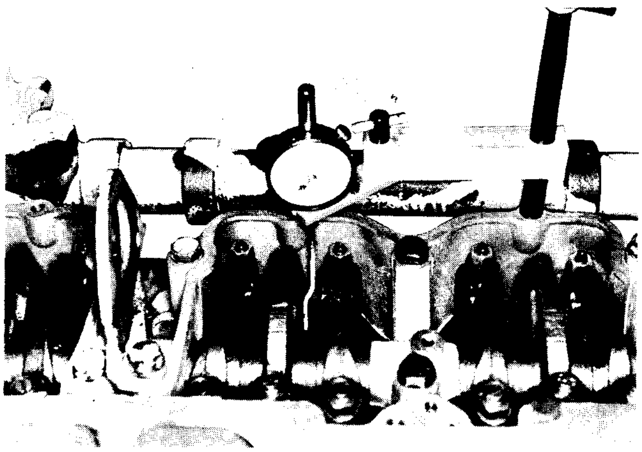


Fig. 2-43, (N114231). Dial indicator in place — extension in contact with polunger — N-855

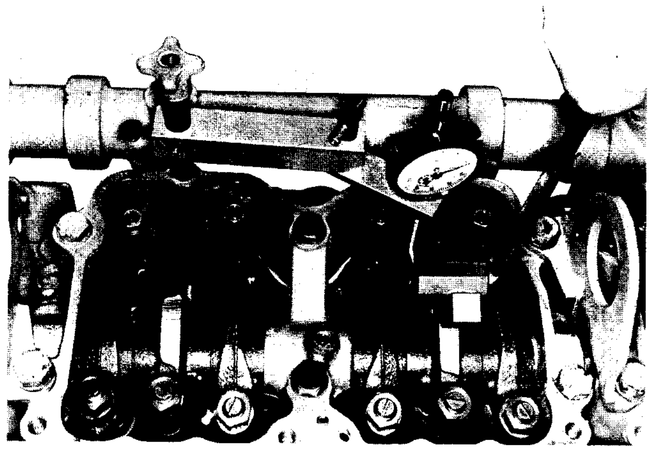


Fig. 2-44, (N114232). Bottoming injector plunger in cup — N-855

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 2-9: Injector and Valve Set Position N-855 Engines

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

3. Using ST-1193 Rocker Lever Actuator, Fig. 2-44, 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 2-10. Adjust as necessary.
5. If loosened, tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] and actuate injector plunger several times as a check of adjustment. Tighten to 30 to 35 ft-lbs [41 to 47 N • m] when using ST-669 Adapter.

Table 2-10: Adjustment Limits Using Dial Indicator Method Inch [mm] N-855 Engines

Oil Temp.	Injector Plunger Travel	Valve Clearance Intake	Exhaust
Aluminum Rocker Housing			
Cold	0.170 ± 0.001 [4.32 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 ± 0.001 [4.32 ± 0.03]	0.008 [0.20]	0.023 [0.58]
Cast Iron Rocker Housing			
Cold	0.175 ± 0.001 [4.45 ± 0.03]	0.011 [0.28]	0.023 [0.58]
Hot	0.175 ± 0.001 [4.45 ± 0.03]	0.008 [0.20]	0.023 [0.58]

Adjust Injectors and Valves (Torque Method) V-1710, NH-743, N-855 C.I.D. 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. 2-45, 2-46 and 2-47) 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.

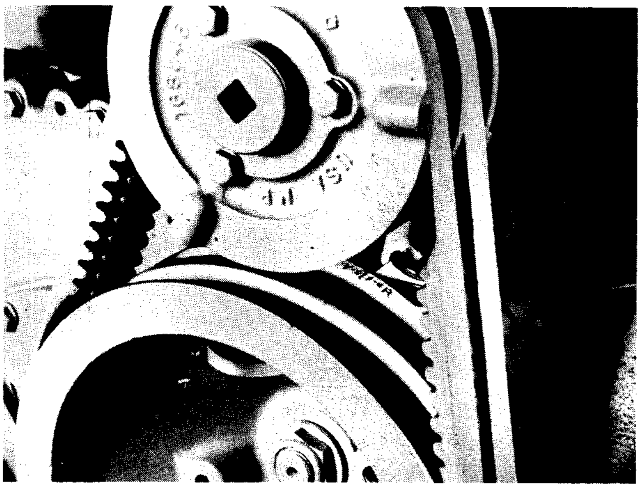


Fig. 2-45, (V41484). Valve set mark — V-1710

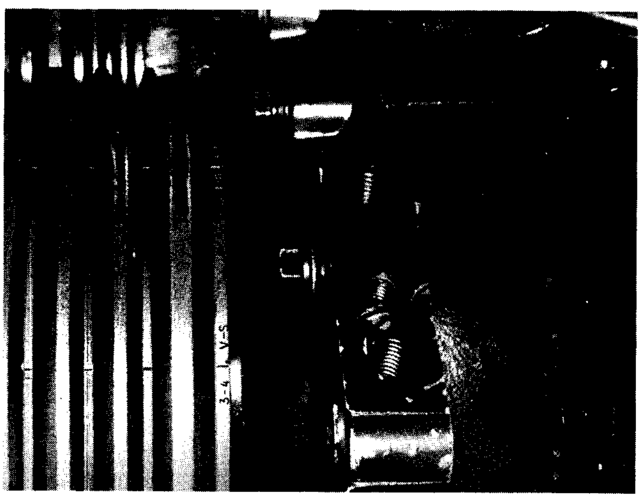


Fig. 2-46, (N114220-A). Valve set mark — N-855

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 2-11 for Inline Engines and Table 2-12 and Fig. 2-47 for V-1710 Engines.

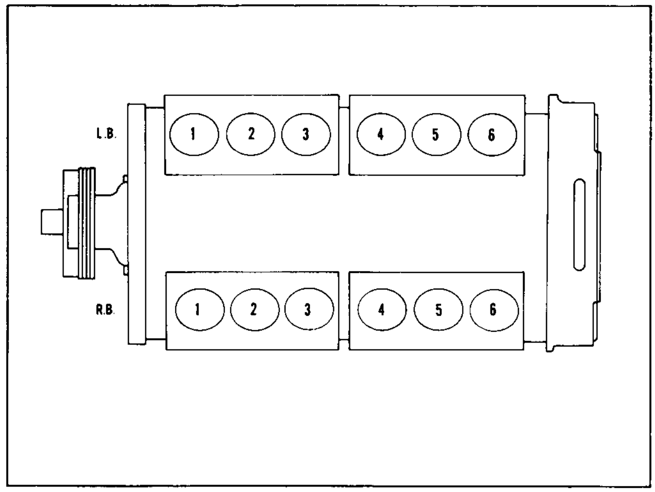


Fig. 2-47, (V414231). V-1710 piston position

Table 2-11: Engine Firing Order N-855 Engines

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

Table 2-12: Firing Order V-1710 Engine

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

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 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. 2-48 and 2-49.

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.

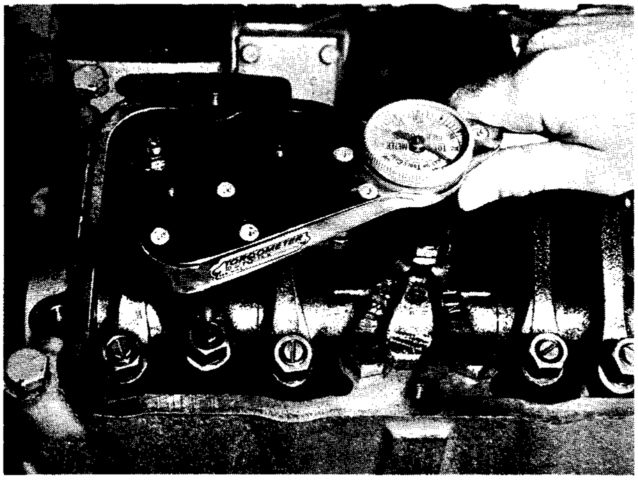


Fig. 2-48, (V414190). Adjusting injector plunger — V-1710

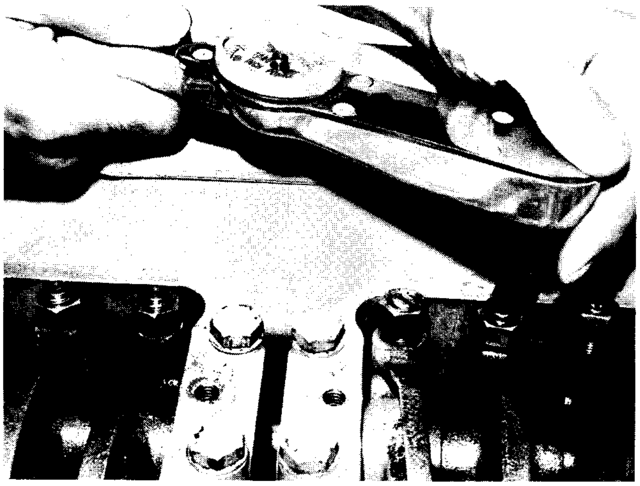


Fig. 2-49, (N11466). Adjusting injector plunger — N-855

2. Loosen adjusting screw one turn; then using a torque wrench calibrated in inch-pounds and a screwdriver adapter tighten the adjusting screw to value shown in Table 2-13 and tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] torque. If ST-669 Torque Wrench Adapter is used, torque to 30 to 35 ft-lbs [41 to 47 N • 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.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-50) one turn.

Table 2-13: Injector Plunger Adjustment — Inch-lbs [N • m]

Cold Set	Hot Set
V-1710 Engines	
50 [0.6]	
NH-NT-743 and 855 Engines Cast Iron Rocker Housing	
48 [5.4]	72 [8.1]
Aluminum Rocker Housing	
71 [8.1]	72 [8.1]

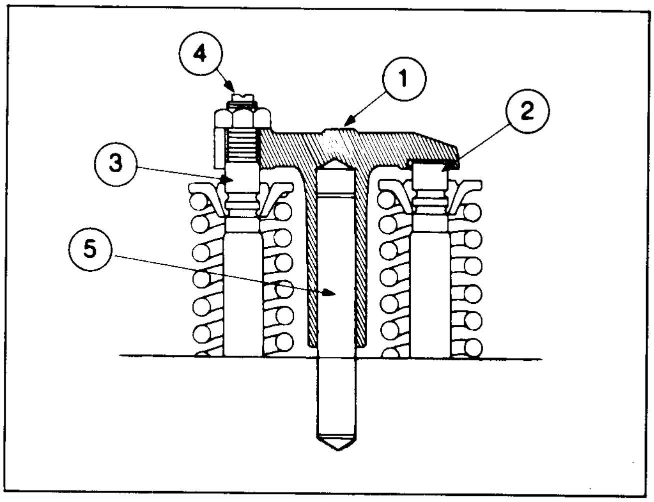


Fig. 2-50, (N21461). Valve crosshead

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. Using ST-669 Torque Wrench Adapter, tighten locknut to 22 to 26 ft-lbs [30 to 35 N • m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [34 to 41 N • m].
5. 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. Tighten locknut to 40 to 45 ft-lbs [54 to 61 N • m] torque. When using ST-669 torque to 30 to 35 ft-lbs [41 to 47 N • m].
3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-14 for appropriate valve clearances.

Table 2-14: Valve Clearance — Inch [mm]

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
V-1710 Engines			
0.014 [0.36]		0.027 [0.69]	
NH-NT-743 and 855 Engines			
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]

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit KT(A)-1150 Engines

This method involves adjusting injector plunger travel with accurate dial indicator. 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 2-15.

3375004 Injector Adjustment Kit is used to adjust the injectors with or without Jacobs Brake units installed.

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

Table 2-15: Injector and Valve Set Position KT(A)-1150

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

Firing Order 1-5-3-6-2-4

One controls engine breathing; the other controls fuel delivery to the cylinders.

Operating adjustments must be made using correct values as stated.

Injector and Valve Adjustment

Note: Do not use fan to rotate engine. Remove shaft retainer key. Fig. 2-51, and press shaft inward until barring gear engages drive gear; then advance. After adjustments are completed retract shaft and install retainer key into safety lock groove.

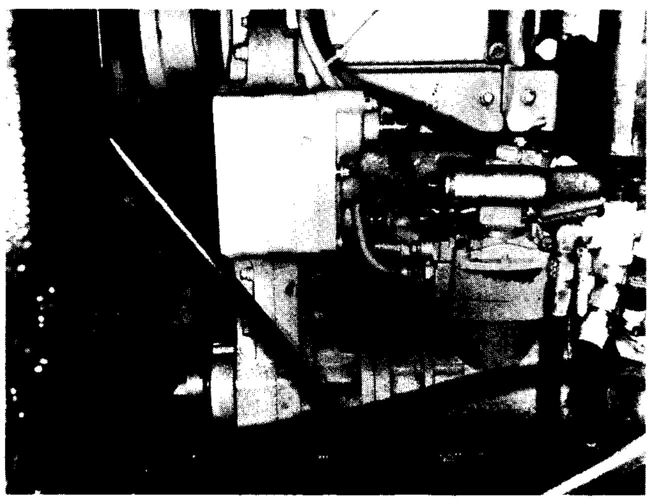


Fig. 2-51, (K11919). Engine barring arrangement — KT(A)-1150

Caution: Barring mechanism gear must be completely engaged when barring engine to avoid damage to teeth of gear.

1. Bar engine in direction of rotation until "B" mark on

pulley, Fig. 2-52, is aligned with pointer on gear case cover. In this position, both valve rocker levers for cylinder No. 3 must be free (valves closed). Injector plunger for cylinder No. 6 must be at top of travel; if not, bar engine 360 degrees, realign marks with pointer.

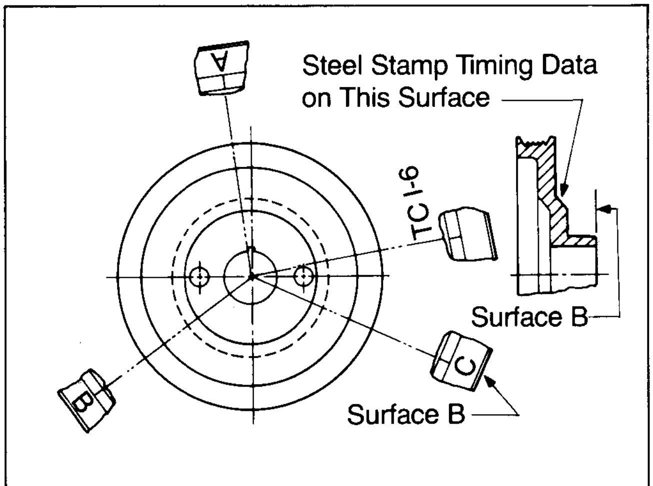


Fig. 2-52, (K11920). Accessory drive pulley marking — KT(A)-1150

Note: The injector and valves on any one (1) cylinder can not be set at the same valve set position. Example: If the rocker levers on No. 3 cylinder are free (valves closed) the injector plunger travel on No. 6 cylinder is to be adjusted. Any valve set position may be used as a starting point. See Table 2-15.

2. Install 3375004 Dial Indicator Assembly to rocker housing, extension (3375005) must go through opening in Jacobs Brake housing and contact injector plunger top. Fig. 2-53.

3. Screw injector lever adjusting screw down until plunger is bottomed in cup, back off approximately 1/2 turn then bottom again, set dial indicator at zero (0).

Note: Care must be taken to assure injector plunger is correctly bottomed in cup, without overtightening adjusting screw, before setting dial indicator.

4. Back adjusting screw out until a reading of 0.304 inch [7.72 mm], reference Table 2-16, is obtained on dial indicator. Snug tighten locknut.

5. Using 3375009 Rocker Lever Actuator Assembly and Support Plate, bottom injector plunger, check zero (0) setting. Fig. 2-54. Allow plunger to rise

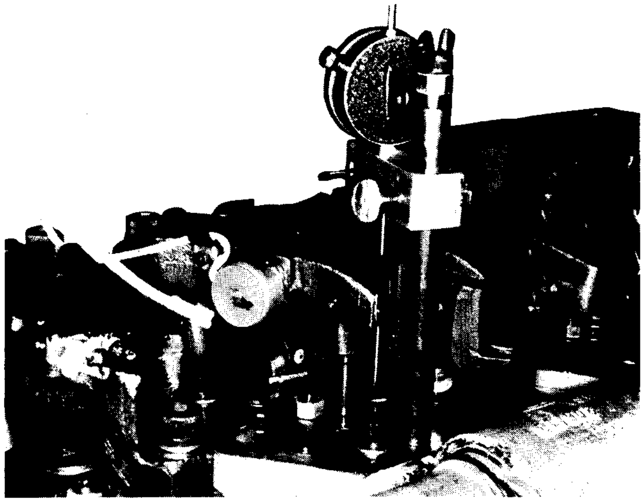


Fig. 2-53, (K114130). Dial indicator in place — extension in contact with plunger — KT(A)-1150

Table 2-16: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-1150 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.304 ± 0.001 [7.72 ± 0.03]	0.014 [0.36]	0.027 [0.69]

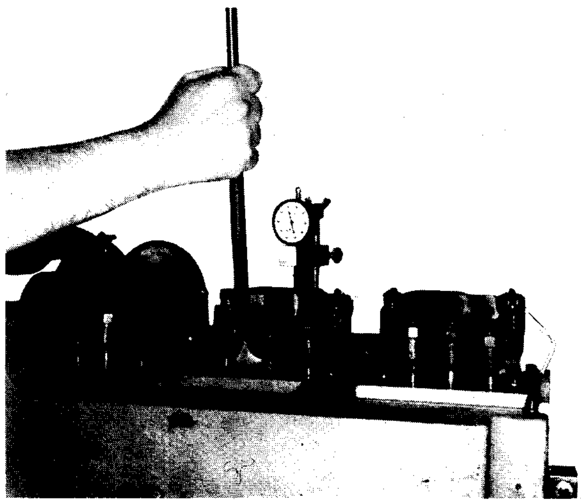


Fig. 2-54, (K114104). Actuating rocker lever

slowly; indicator must show plunger travel to be within range specified in Table 2-16.

6. Using ST-669 Torque Wrench Adapter to hold adjusting screw in position, torque locknut 30 to 35

ft-lbs [41 to 47 N • m]. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, torque locknuts to 40 to 45 ft-lbs [54 to 61 N • m].

7. Actuate injector plunger several times as a check of adjustment. Remove dial indicator assembly.

Caution: If Jacobs Brake is not used, be sure crossheads are adjusted before setting valves. See Crosshead Adjustment following.

8. Adjust valves on appropriate cylinder as determined in Step 1 and Table 2-16. Tighten locknuts same as injector locknut.
9. If Jacobs Brake is used, use 3375012 (0.018 inch [0.46 mm] thick) Feeler Gauge and 3375008 Torque Wrench Adapter, set exhaust valve crosshead to Jacobs Brake slave piston clearance. Fig. 2-55.

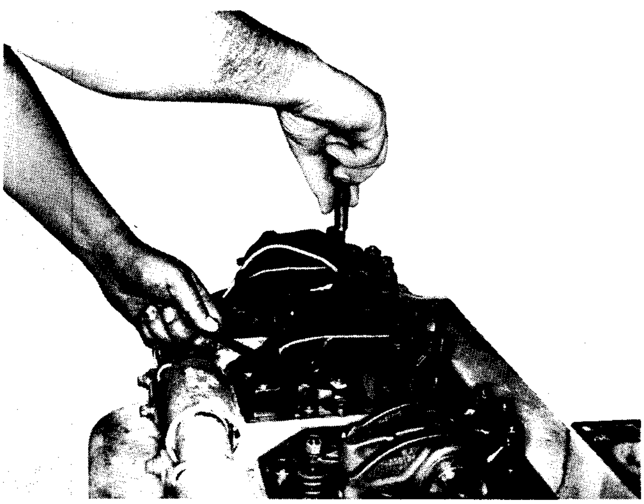


Fig. 2-55, (K114105). Adjusting crosshead to slave piston clearance

Note: Turn both adjusting screws alternately and evenly until crosshead and feeler gauge contact slave piston and adjusting screws are bottomed on valve stem. Back adjusting screws out one-fourth (1/4) to one-half (1/2) turn. Starting with outer adjusting screw (next to water manifold), then moving to screw under rocker lever, retighten gradually until crosshead and feeler gauge contact slave piston. Snug tighten locknuts.

10. Hold crosshead adjusting screws with a screwdriver, torque locknuts 22 to 26 ft-lb [20 to 35 N • m] using 3375008 Adapter and torque wrench.
11. See Table 2-16 for valve clearance values.
12. Repeat adjustment procedure for each cylinder. See Table 2-15 for firing order and injector and valve set positions.

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.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-56) one turn.

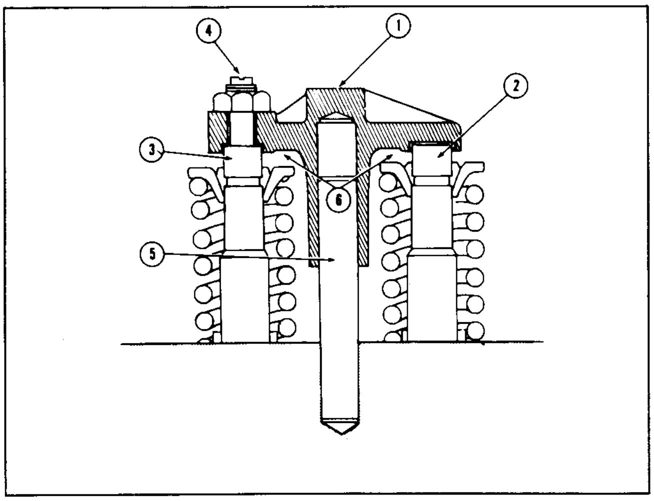


Fig. 2-56, (K21924). Valve crosshead

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2) (without adjusting screw).
3. Turn down crosshead adjusting screw until it touches valve stem (3).
4. Using ST-669 Torque Wrench Adapter, tighten locknuts to 22 to 26 ft-lbs [30 to 35 N • m]. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [34 to 41 N • m].
5. Check clearance (6) 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.

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit KT(A)-2300 and KTA-3067 Engines

Valve Set Mark Alignment

Note: KT(A)-2300 and KTA-3067 injectors, crossheads and valves are adjusted to same values. Refer to Fig's. 2-57 and 2-58 for specific cylinder arrangement and engine firing order.

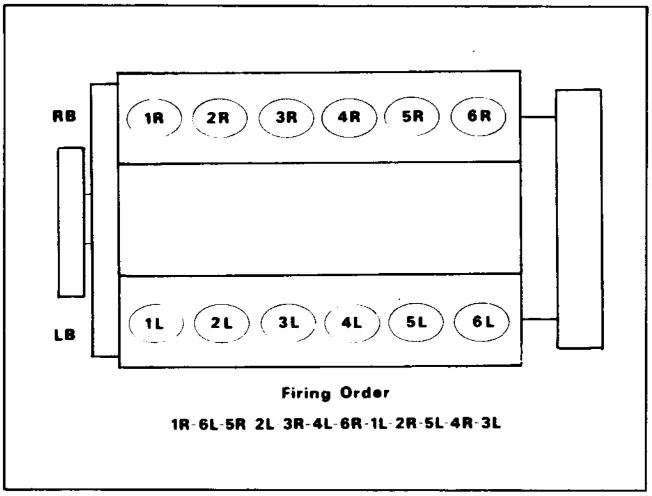


Fig. 2-57, (K21916). Cylinder arrangement and firing order — KT(A)-2300

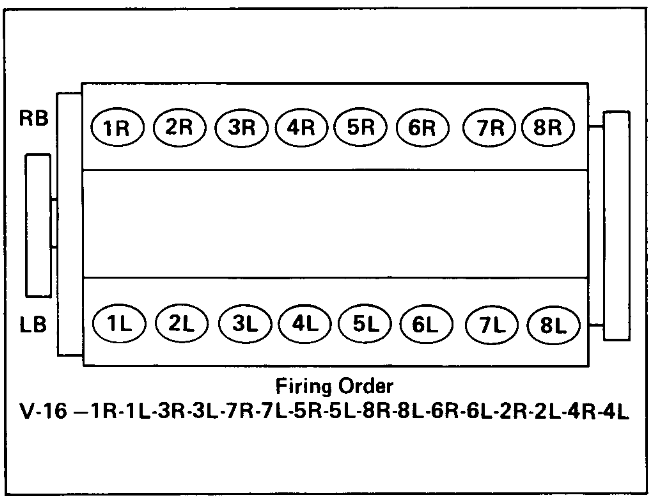


Fig. 2-58, (OM204). Cylinder arrangement and firing order — KTA-3067

Three locations are provided where valve and injector alignment marks may be viewed. Injector plunger travel and valves both may be set on one cylinder at the same valve set location. The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.

Note: Barring mechanism may be located on either left bank or right bank at the flywheel housing. Cover plate on opening "A" or "C" directly above barring mechanism must be removed when viewing timing marks at flywheel housing.

1. When viewing engine at vibration damper, Fig. 2-59, align timing marks on damper with pointer on gear case cover.

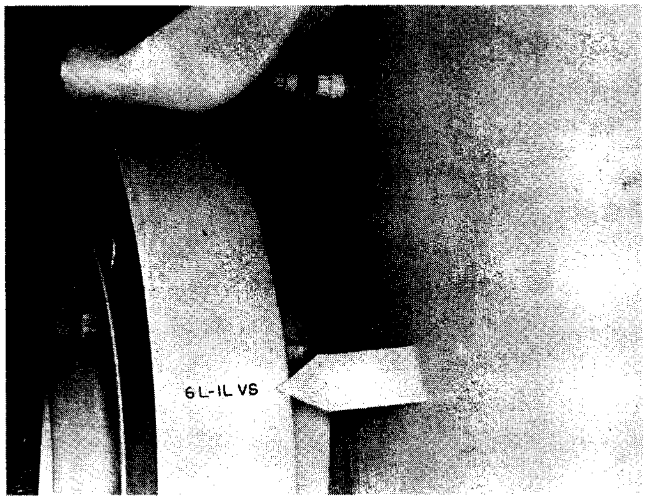


Fig. 2-59, (K21917). Valve set marks on vibration damper — KT(A)-2300

2. When barring engine from right bank at flywheel housing "A" VS timing marks on flywheel (1, Fig. 2-60) must align with scribe mark (2) when viewed through opening marked "A" on flywheel housing.

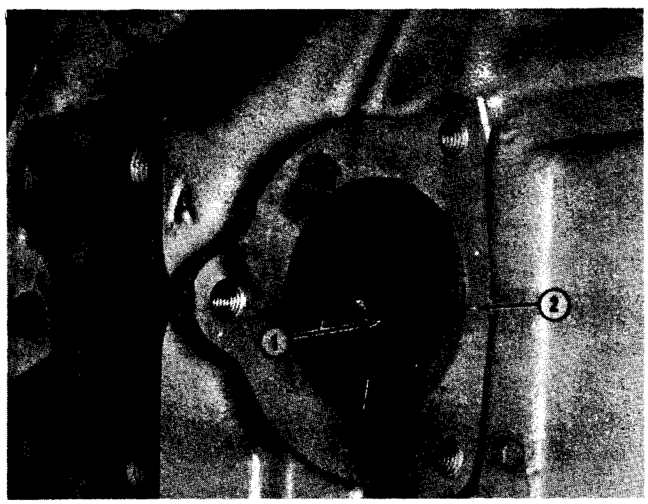


Fig. 2-60, (K21918). Valve set marks on right bank flywheel and housing — KT(A)-2300

3. When barring engine from left bank at flywheel housing "C" VS timing marks on flywheel (1, Fig.

2-61) must align with scribe mark (2) when viewed through opening marked "C" on flywheel housing.

Caution: When aligning valve set marks at either flywheel housing location, care must be taken to assure that "A" or "C" valve set marks on flywheel match "A" or "C" marks on flywheel housing opening.

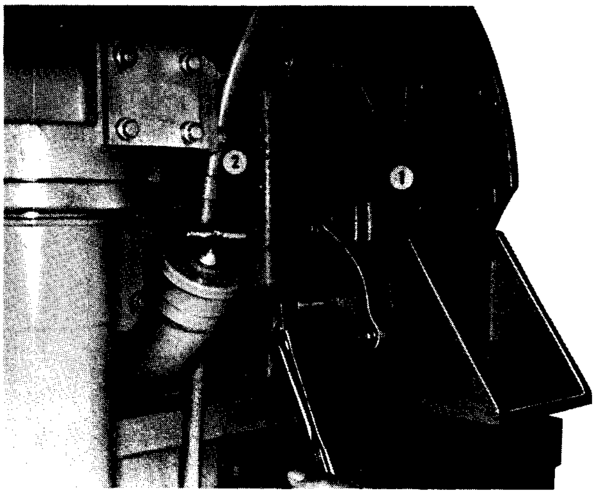


Fig. 2-61, (K21919). Engine barring device

Injector Plunger Adjustment

1. Bar engine in direction of rotation until appropriate valve set mark is aligned with scribe mark on flywheel housing or until a valve set mark on vibration damper is aligned with pointer on gear case cover.

Note: Any valve set position may be used as a starting point when adjusting injectors, crossheads and valves. Determine which of the two (2) cylinders indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

2. Set up 3375007 Indicator Support on rocker lever housing, of cylinder selected, with indicator extension 3375005 on injector plunger top. Fig. 2-62.

Note: Make sure indicator extension is secure in indicator stem and is not touching rocker lever.

3. Using rocker lever actuator, Fig. 2-63, depress lever toward injector until plunger is bottomed in cup to squeeze oil film from cup. Allow injector plunger to rise, bottom again, hold in bottom position and set indicator at zero (0). Check extension contact with plunger top.
4. Allow plunger to rise then bottom plunger again, release lever, indicator must show travel as indicated in Table 2-17. Adjust as necessary.

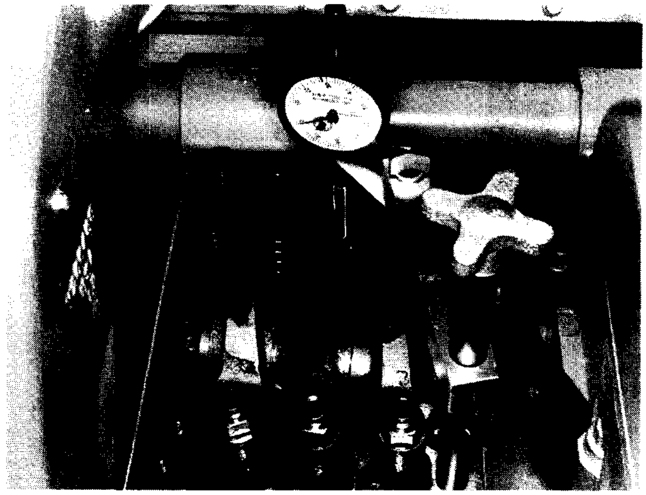


Fig. 2-62, (K21920). Dial indicator in place — extension in contact with plunger

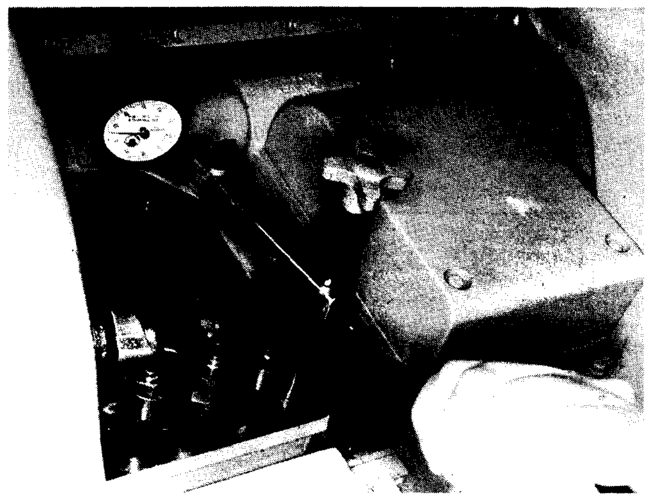


Fig. 2-63, (K21921). Bottoming injector plunger in cup

5. If adjusting screw locknuts were loosened for adjustment, tighten to 40 to 45 ft-lb [54 to 61 N•m]

Table 2-17: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-2300 and KTA-3067 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.308 ± 0.001 [7.82 ± 0.03]	0.014 [0.36]	0.027 [0.69]

6. Remove 3375004 Kit.

torque and actuate plunger several times as a check of adjustment. Tighten locknuts to 30 to 35 ft-lb [41 to 47 N • m] torque when using ST-669 Torque Wrench Adapter.

6. Remove 3375004 Kit.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever, an adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.

1. Loosen adjusting screw locknut, back off screw (4, Fig. 2-56) one turn.
2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2). Adjusting screw should not touch valve stem (3) at this point.
3. Turn down adjusting screw until it touches valve stem (3).
4. Using 3375008 Torque Wrench Adapter to hold adjusting screw in position, tighten locknut to 22 to 26 ft-lb [30 to 35 N • m] torque. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, tighten locknut to 25 to 30 ft-lb [34 to 41 N • m] torque.
5. Check clearance (6) 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.

Valve Adjustment

1. Insert correct thickness feeler gauge between rocker lever and crosshead for valves being adjusted. See Table 2-17 for valve clearances.

Note: Exhaust valves are toward front of engine in each cylinder head on LB side and are toward rear of engine in each cylinder head on RB side.

2. If adjustment is required, loosen locknut and turn adjusting screw down until rocker lever just touches feeler gauge; lock adjusting screw in this position with locknut.
3. Tighten locknut to 40 to 45 ft-lb [54 to 61 N • m] torque. When using ST-669 Torque Wrench Adapter tighten locknuts to 30 to 35 ft-lbs [41 to 47 N • m] torque.

After completing the injector plunger travel, crosshead and valve adjustment on this cylinder bar engine in direction of rotation until next valve set mark is aligned with scribe mark at flywheel housing or pointer on gear case cover; repeat procedure. See Fig's. 2-57 and 2-58 for cylinder arrangement and engine firing order.

Change Oil

Change Aneroid Oil

1. Remove fill plug (1, Fig. 2-64) from hole marked "Lub Oil".

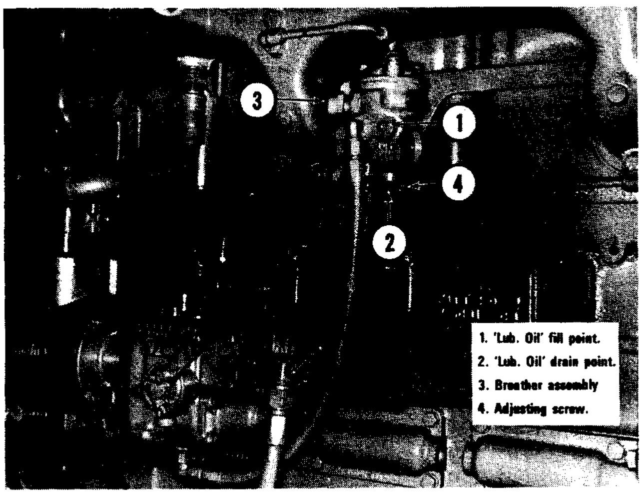


Fig. 2-64, (N10503). Aneroid

2. Remove drain plug (2) from bottom of aneroid.
3. Replace drain plug (2), fill aneroid with clean engine lubricating oil. Replace fill plug (1).

Replace Aneroid Breather

Remove and replace aneroid breather (3, Fig. 2-64).

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.

Backside Idler Fan Drive

1. Inspect idler assembly to be sure pivot arm is not

binding. Grasp pulley, pull back on idler assembly and release; pivot arm should move freely toward belt without binding.

2. If idler assembly does not move freely, remove and disassemble idler assembly. Inspect teflon bushings, replace if worn. Repack bushings with Aeroshell No. 5, Lubriplate (type 130AA), or Moly-disulfide grease, reassemble and install idler assembly.

Clean Complete Oil Bath Air Cleaner

Steam

Steam clean the oil bath cleaner main body screens. Direct the stream 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 [21 to 34 kPa] 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.

"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.

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. 3379071 and revisions thereto.

After removing injectors from KT(A)-1150, KT(A)-2300 or KTA-3067 Engines for cleaning the seal seat should be removed from the injector (1, Fig. 2-65) or injector "well" for cleaning, examination and/or replacement as necessary.

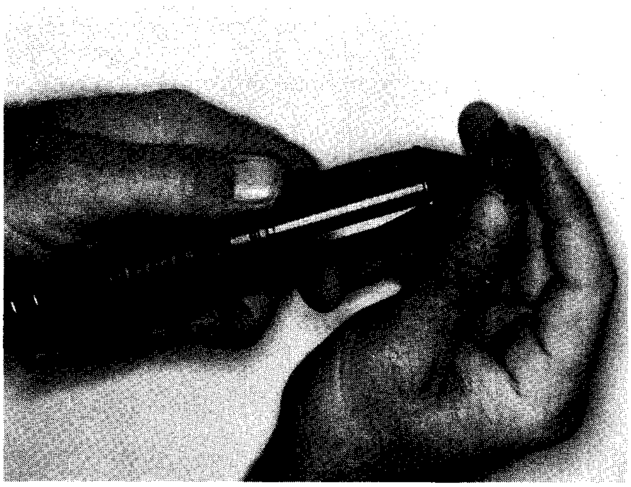


Fig. 2-65, (K11918). Injector seal seat — all KT Engines

Caution: There must be only one (1) seal seat used in each injector "well". Use of more than one seal seat per injector will change injector protrusion and cause combustion inefficiency.

Clean and Calibrate Fuel Pump

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

Clean and Calibrate Aneroid

1. Remove flexible hose or tube from aneroid cover to intake manifold.
2. Remove lead seal (if used), screws and aneroid cover.
3. Remove bellows, piston, upper portion of two piece shaft and spring from aneroid body.

Note: Count and record amount of thread turns required to remove upper shaft, piston and bellows from lower shaft.

4. Place hex portion of shaft in vise, snug tighten vise, remove self-locking nut, retaining washer and bellows.
5. Clean parts in approved cleaning solvent.
6. Position new bellows over shaft to piston, secure with retaining washer and self-locking nut. Tighten self-locking nut to 20 to 25 ft-lb [2.3 to 2.8 N • m] torque.
7. Install spring, shaft, piston and bellows assembly into aneroid body. As two piece shaft is re-assembled, turn upper portion of shaft same amount of thread turns recorded during disassembly.

Caution: Amount of thread turns during installation must correspond with turns during removal to avoid changing aneroid setting.

8. Align holes in bellows with corresponding capscrew holes in aneroid body.
9. Position cover to body; secure with flatwashers, lockwashers and fillister head screws.
10. Install new seal. Refer to Bulletin No. 3379084 for sealing instructions and calibration procedure. Calibration, if required, must be performed by a Cummins Distributor on a fuel pump test stand.
11. Reinstall flexible hose or tube from aneroid cover to intake manifold.

Inspect/Install Rebuilt Unit as Necessary

The following assemblies should be inspected at this time. The options are: inspect and reuse, rebuild per shop manual instructions, replace with new or Distributor/Dealer exchange units or Cummins Diesel ReCon Inc. units.

Inspect Water Pump and Fan Hub

Inspect water pump and fan hub for wobble and evidence of grease leakage. Replace with rebuilt pre-lubricated units as necessary.

Idler Pulley

Inspect, rebuild and repack idler pulley with correct grease. Refer to Engine Shop Manual for rebuild and lubricating procedure for idler pulley.

Inspect Turbocharger

Check Turbocharger Bearing Clearance

Check bearing clearances. 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. 2-66.

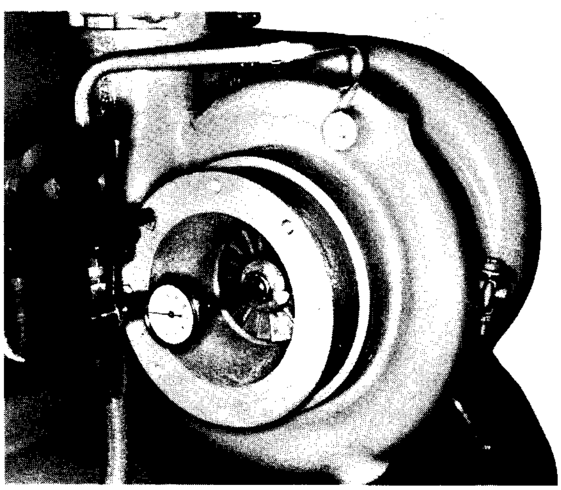


Fig. 2-66, (N11956). Checking turbocharger bearing and clearance

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 end of rotor shaft. Push shaft from end-to-end making note of total indicator reading. Fig. 2-66. On T-50, ST-50 and VT-50 end clearance should be 0.006 to 0.018 inch [0.15 to 0.46 mm].
   a. Push wheel toward side of bore.
   b. Using feeler gauge, check distance between tip of wheel vanes and bore. On T-50, ST-50 and VT-50 clearance should be 0.003 to 0.033 inch [0.08 to 0.84 mm].
3. Check radial clearance on compressor wheel only.
4. If end clearances exceeds limits, remove turbocharger from engine and replace with a new or rebuilt unit.
5. Check T-18A turbochargers as follows:
   a. For checking procedures refer to Service Manual Bulletin No. 3379055.
   b. End clearance should be 0.004 to 0.009 inch [0.10 to 0.23 mm], radial clearance should be 0.003 to 0.007 inch [0.08 to 0.18 mm]. If clearances exceed these limits, remove turbocharger(s) from engine and replace with new or rebuilt units.
6. Install exhaust and intake piping to turbocharger(s).

Inspect Vibration Damper

Rubber Damper

Damper hub (1, Fig. 2-67) and inertia member (2) are stamped with an index mark (3) to permit detection of movement between the two components.

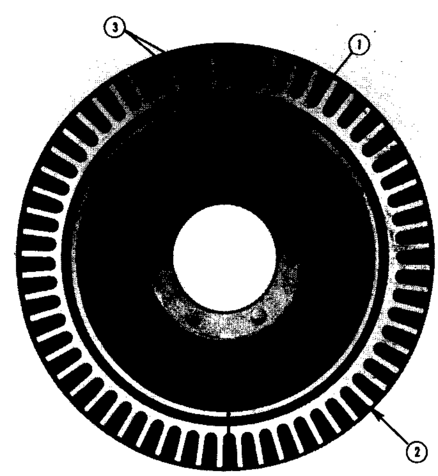


Fig. 2-67, (N10146). Vibration damper alignment marks

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.

If there is evidence of inertia member movement and rubber extrusion, replace damper.

Viscous Dampers

Check damper for evidence of fluid loss, dents and wobble. Visually inspect the vibration damper's thickness for any deformation or raising of the damper's front cover plate.

1. If lack of space around damper will not permit a visual inspection, run a finger around inside and outside of front cover plate. If any variations or deformations are detected, remove vibration damper and check as follows.
2. Remove paint, dirt and grime from front and rear surface of damper in four (4) equal spaced areas. Clean surface with paint solvent and fine emery cloth.
3. Using micrometer measure and record thickness of dampers at the four (4) areas cleaned in Step 3. Take reading approximately 0.125 inch [3.18 mm] from outside edge of front cover plate.
4. Replace damper if variation of the four (4) readings exceeds 0.010 inch [0.25 mm].

Air Compressor

Inspect air compressor, check for evidence of oil or coolant leakage. Drain air tank and check for air compressor lubricating oil carry over. Replace with rebuilt unit as necessary.

Backside Idler Fan Drive

Remove pivot arm assembly, disassemble and clean. Replace teflon bushings with new, inspect thrust washers and replace as necessary. Pack teflon bushings with Aeroshell No. 5, Lubriplate (type 130AA) or Moly-disulfide grease, reassemble and install idler assembly.

Clean Crankcase Breathers (KT(A)-2300 and KTA-3067 Engines

Remove crankcase breathers from right bank front and left bank rear of cylinder block. Clean in approved cleaning solvent, dry with compressed air, install breather.

Seasonal Maintenance Checks

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Clean Cooling System (Fall)

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

Chemical Cleaning

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

Pressure Flushing

Flush radiator and block before filling with antifreeze, or installing a water filter on a used or rebuilt engine.

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 passage especially radiator core, and lubricating oil cooler, and partially stop circulation. Replace as necessary.

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 2-18 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195° F [82 to 91° C] thermostats are used only with shutterstats that are set to close at 187° F [86° C] and open at 195° F [91° 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° F [77 to 85° C] or low 160 to 175° F [71 to 79° C] and in a few cases high-range 180 to 195° F [82 to 91° C] thermostats, depending on engine application.

Steam Clean Engine (Spring)

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

All electrical components and wiring should be protected from the full force of the cleaner spray nozzle.

Checking Mountings (Spring)

Tighten Mounting Bolts and Nuts (As Required)

Engine mounting bolts will occasionally work loose and cause the engine supports and brackets to wear

Table 2-18: Thermal Control Settings

Control	Setting With 160 to 175°F [71 to 79°C]		Setting With 170 to 185°F [77 to 85°C]		Setting With 180 to 195°F [82 to 91°C]	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185°F [85°C]	170°F [77°C]	190°F [88°C]	182°F [83°C]		
Shutterstat	180°F [82°C]	172°F [78°C]	185°F [85°C]	177°F [81°C]	195°F [91°C]	187°F [86°C]
Modulating Shutters open	175°F [79°C]		185°F [85°C]		[91°C]	

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

Tighten Turbocharger Mounting Nuts (As Required)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so that vibration will be at a minimum. Fig. 2-68.

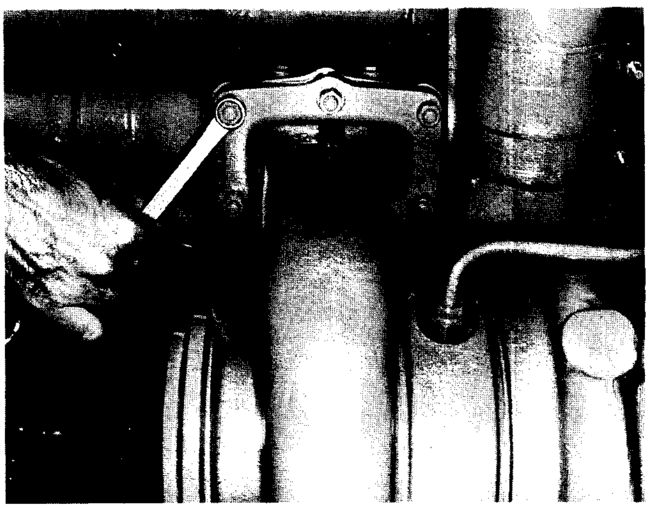


Fig. 2-68, (N11953). Tightening turbocharger mounting marks

Check Fan and Drive Pulley Mounting (Spring)

Check fan to be sure it is securely mounted; tighten capscrews as necessary. Check fan for wobble or bent blades.

Check fan hub and crankshaft drive pulley to be sure they are securely mounted. Check fan hub pulley for looseness or wobble; if necessary, remove fan pilot hub and tighten the shaft nut. Tighten the fan bracket capscrews.

Check Crankshaft End Clearance (Spring)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 2-19. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is disassembled for repair, install new thrust rings.

Caution: Do not pry against outer damper ring.

The check can be made by attaching an indicator to rest against the damper or pulley, while prying against the front cover and inner part of pulley or damper. End

Table 2-19: Crankshaft End Clearance — Inch [mm]

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
V-903, VT-903	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]
V-378, V-504 V-555	0.004 [0.10]	0.014 [0.36]	0.022 [0.56]
V-1710	0.006 [0.15]	0.013 [0.33]	0.018 [0.46]
KT(A)-1150	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
KT(A)-2300 KTA-3067	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]

clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Check Heat Exchanger Zinc Plugs (Spring)

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

In-Chassis Overhaul/Major Engine Overhaul

In-Chassis Overhaul/Major Engine Overhaul

Operating conditions of the engine, normally dictate when the engine is in need of an in-chassis overhaul or a major overhaul. Oil consumption, excessive drop of oil pressure at idling, oil dilution, excessive blow-by, unusual noise, vibrations and exhaust smoke should be analyzed in determining the next course of action.

At this time, perform all previous checks and inspect the following:

Accessory Drive
Bearings
Cylinder Head
Cylinder Liners
Front Gear Train
Rear Gear Train
Lubricating Oil Pump
Pistons
Connecting Rods
Piston Rings
Crankshaft Journals
Camshafts
Cam Followers
Accessory Drive Seal
Front and Rear Crankshaft Seals
Oil Cooler

Rebuild instructions, new parts or exchange parts are available from any Cummins Distributor or Dealer.

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 or 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 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

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 0.03 to 0.85 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 submitted for SC.

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 are designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

API classification CD is the current American Petroleum Institute classification for severe duty lubricating oil 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° F [—18° C]) carry a suffix "W". Oils that meet the high temperature viscosity SAE standard 210° F [99° 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° F [—23° C] and below	See Table 3-3.
—10 to 30° F [—23 to —1° C]	10W
20 to 60° F [—7 to 16° C]	20-20W
40° F [4° C] and above	30

Arctic Operations

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

Table 3-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC API class CC/CD
Viscosity	' 10,000 centistokes Max. @ —30° F 5.75 centistokes Min. @ 210° F
Pour Point (ASTM D-97)	At least 10° F [6° C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt. % Maximum

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 mineral oils should not be used.

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, °F.	ASTM D 2265 350 min.
Bearing life, hours at 300°F. 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0°F.	15,000 max.
Run at 0°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°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 3606 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°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°F or legal temperature if higher than 125°F.
Gravity (ASTM D-287)	30 to 42° A.P.I. at 60°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°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°F. All of the fuel should evaporate at less than 725°F.

Coolant

Water should be clear and free of any corrosive chemicals such as chloride, sulfates and acids. It should be kept slightly alkaline with pH value in range of 8.5 to 10.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleetguard DCA 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 and use with water as required by temperature.

Note: Some antifreeze also contain anti-leak additives such as inert inorganic fibers, polymer particles or ginger root; these antifreeze should not be used in conjunction with the water filter. The filter element will filter out the additives and/or become clogged and ineffective.

3. Install or replace DCA Water Filter as follows and as recommended in Section 2.

New Engines Going Into Service Equipped With DCA Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a DCA precharge element. This element is compatible with plain water or all permanent-type antifreeze except Dowtherm 209. See Table 3-4 for Dowtherm 209 precharge instructions.
2. At the first "B" Check (oil change period) the DCA precharge element should be changed to DCA Service Element. See Table 3-4.
3. Replace the DCA Service Element at each succeeding "B" Check.
   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, precharge according to Table 3-4.
4. Service element may be changed at "C" Check if 3300858 (DCA-4L) direct chemical additive is added to the cooling system at each "B" Check between service element changes. One bottle of direct additive should be used for every 10 gallon of cooling system capacity. Add one bottle for every 15 gallon capacity if methoxy propanol antifreeze (Dowtherm 209) is used in the cooling system.
5. To insure adequate corrosion protection have the

Table 3-4: Spin-On Type DCA Water Filter

Cooling System	Ethylene Glycol Base Antifreeze		Methoxy Propanol Base Antifreeze (Dowtherm 209)	
Capacity (U.S. Gallons)	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**
0-8	1	WF-2010 (P/N 299080)	1	WF-2011 (P/N 3300721)
9-15	2	WF-2010	2	WF-2011
16-30	5	WF-2010	4	WF-2011
31-60	10	WF-2010	8	WF-2011
35-90 (V-1710)	12	WF-2016 (P/N 299086)	8	WF-2017 (P/N 300724)
70-90 (KT-2300)	16	WF-2010	16	WF-2011
80-100 (KTA-3067)	16	(4)WF-2010		

coolant checked at each third element change or more often. See "Check Engine Coolant", Section 2.

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

1. Remove chromate element.
2. Clean and flush cooling system.
3. Install service DCA element and precharge according to Table 3-4. Operate engine to next "B" Check; then treat as "New Engine Going Into Service" above. See Table 3-4.

Table 3-5: Canister Type

DCA Precharge Canister	DCA Service Canister	Fleetguard P/N
None*	299071	WF-2001
None *	299074	WF-2004
None *	(2) 299091	(2) WF-2021

*** 3300858 (DCA-4L) Precharge 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

Note: Canister type elements are not available for use with methoxy propanol base antifreeze (Dowtherm 209); however, conversion kits are available to convert the pot type water filters to spin-on elements.

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

1. Remove chromate package or canister, discard package element and plates or canister, retain spring for use with DCA service element.
2. Flush cooling system.
3. Precharge system with coolant and DCA-4L, Part No. 3300858, according to Table 3-5, using applicable service canister.
4. At next "B" Check install service canister, replacing regularly at each succeeding "B" Check thereafter, except under following conditions:

   a. If make-up coolant must be added between canister 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.

Capscrew Markings and Torque Values

Current Usage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI MPa	To 1/2—69,000 [476] To 3/4—64,000 [421] To 1—55,000 [379]	To 3/4—120,000 [827] To 1—115,000[793]	To 5/8—140,000 [965] To 3/4—133,000 [917]	150,000 [1 034]
Quality of Material	**Indeterminate**	**Minimum Commercial**	**Medium Commercial**	**Best Commercial**
SAE Grade Number	**1 or 2**	**5**	**6 or 7**	**8**
Capscrew Head Markings Manufacturer's marks may vary These are all SAE Grade 5 (3 line)				

Capscrew Body Size (Inches) — (Thread)	Torque Ft-Lbs [N • m]	Torque Ft-Lbs [N • m]	Torque Ft-Lbs [N • m]	Torque Ft-Lbs [N • m]
1/4 — 20	5 [7]	8 [11]	10 [14]	12 [16]
— 28	6 [8]	10 [14]		14 [19]
5/16 — 18	11 [15]	17 [23]	19 [26]	24 [33]
— 24	13 [18]	19 [26]		27 [37]
3/8 — 16	18 [24]	31 [42]	34 [46]	44 [60]
— 24	20 [27]	35 [47]		49 [66]
7/16 — 14	28 [38]	49 [66]	55 [75]	70 [95]
— 20	30 [41]	55 [75]		78 [106]
1/2 — 13	39 [53]	75 [102]	85 [115]	105 [142]
— 20	41 [56]	85 [115]		120 [163]
9/16 — 12	51 [69]	110 [149]	120 [163]	155 [210]
— 18	55 [75]	120 [163]		170 [231]
5/8 — 11	83 [113]	150 [203]	167 [226]	210 [285]
— 18	95 [129]	170 [231]		240 [325]
3/4 — 10	105 [142]	270 [366]	280 [380]	375 [508]
— 16	115 [156]	295 [400]		420 [569]
7/8 — 9	160 [217]	395 [536]	440 [597]	605 [820]
— 14	175 [237]	435 [590]		675 [915]
1 — 8	235 [319]	590 [800]	660 [895]	910 [1234]
— 14	250 [339]	660 [895]		990 [1342]

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 of Grade 5 capscrews torque and must attain two capscrew diameters of thread engagement.

Caution: If replacement capscrews are of a higher grade than originally supplied, adhere to torque specifications for that placement.

Troubleshooting

Troubleshooting 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 troubleshooting 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

CUMMINS ENGINES

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 Lubrication Oil Pressure	Fuel Leakage AFC Vent Capscrew	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 Set Improperly				●	●																						
	Aneroid Check Valve Stuck Open	●																										
	AFC Set Improperly			●		●																						
	Damaged or Worn AFC Plunger Seal																	●										
	Fuel Pump Out of Adjustment					●																						
	Injector Flow Incorrect					●																						
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 crosshead. The camshaft is gear drive 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 engines the intake manifold is pressurized as the turbocharger 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 of each cylinder.
2. A means of controlling pressure of the fuel being delivered by the fuel pump to 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 fuel suction line, fuel filters, fuel pump, aneroid, supply lines, fuel passages, fuel manifolds, injectors, drain passages and drain lines. See Fig's. 5-1 through 5-5 for fuel flow.

There are four types of fuel pumps currently used on Cummins Engines. The PT (type G), PT (type G) VS, PT (type G) AFC and the PT (type G) AFC (without Air/Fuel control).

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, governor and tachometer shaft assemblies.

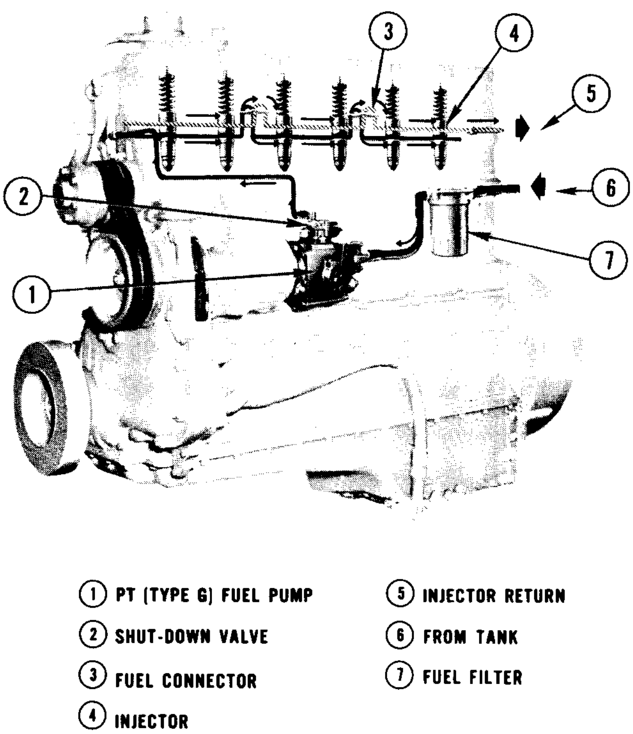


Fig. 5-1, (FWC-13). Fuel flow schematic — N/NT-855 Engine

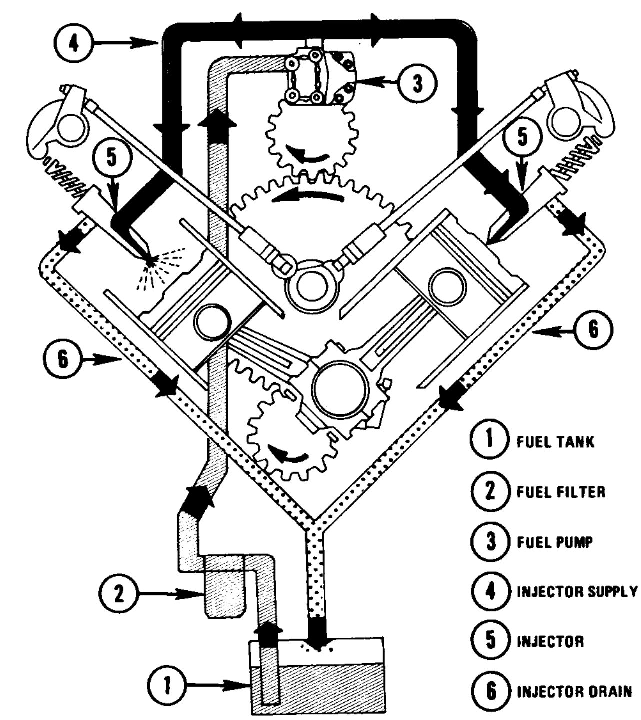


Fig. 5-2, (FWC-30). Fuel flow schematic — V Engine

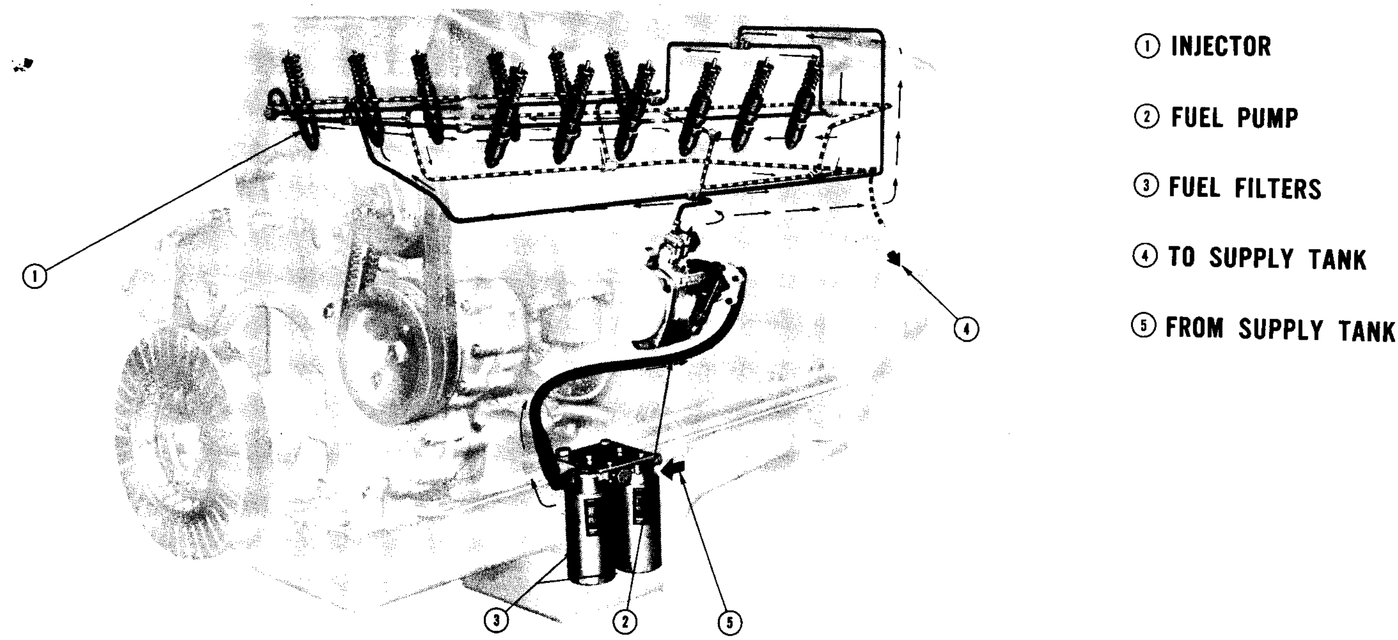


Fig. 5-3, (FWC-15A). Fuel flow schematic — V-1710 Engine

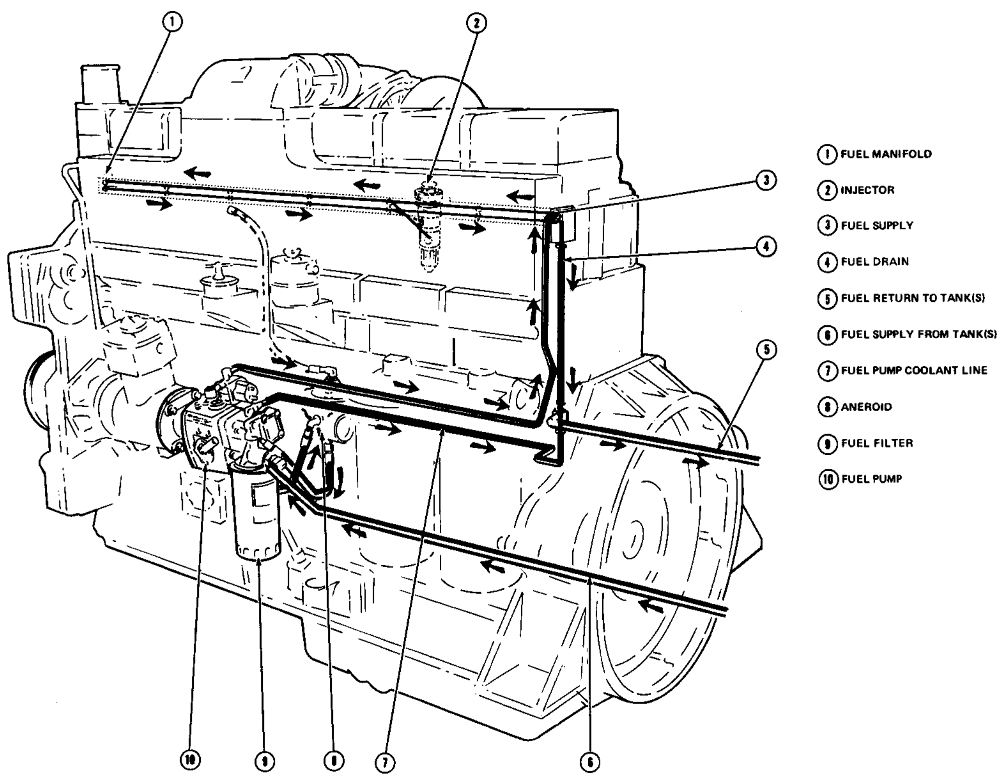


Fig. 5-4, (K11941). Fuel flow schematic — KT(A)-1150 Engine

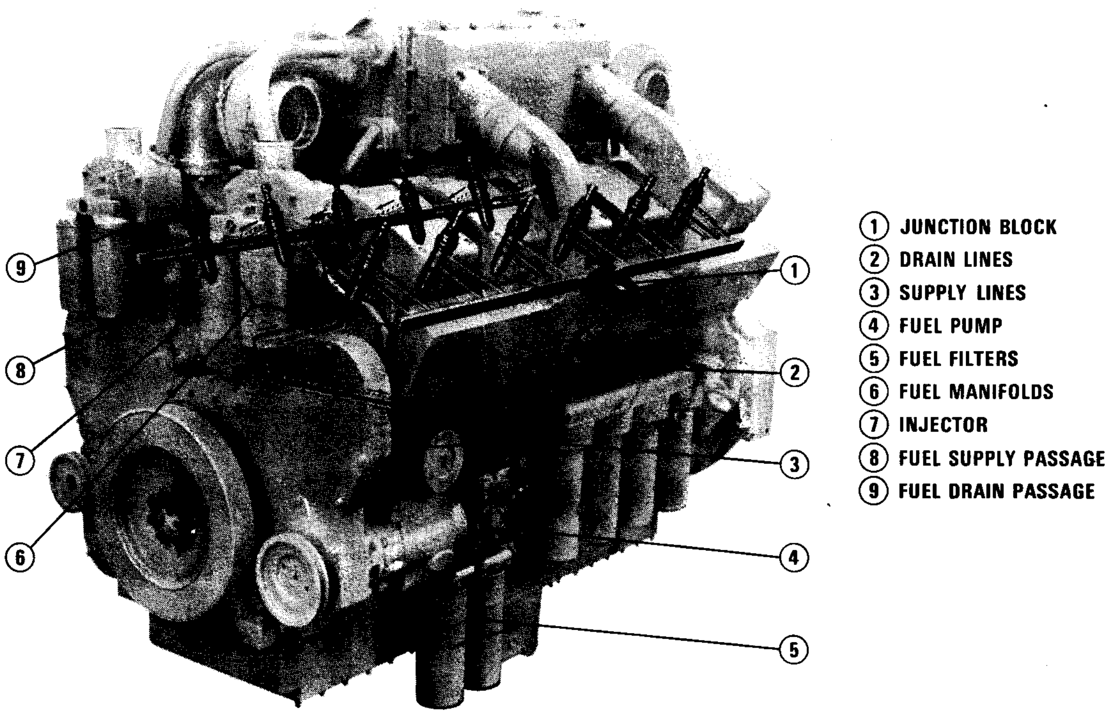


Fig. 5-5, (FWC-40). Fuel flow schematic — KT(A)-2300 Engine

PT (type G) Fuel Pump

The PT (type G) fuel pump assembly, Fig. 5-6, is made up of three main units: the gear pump, standard governor and throttle.

PT (type G) VS Fuel Pump

The PT (type G) VS fuel pump, Fig. 5-7, is made up of four main units: the gear pump, standard governor, throttle as in PT (type G) Fuel Pump and a VS (Variable Speed) governor.

Gear Pump and Pulsation Damper

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.

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:

In the PT (type G) and PT (type G) VS fuel pumps to the governor assembly as shown in Fig's. 5-6, 5-7 and 5-8.

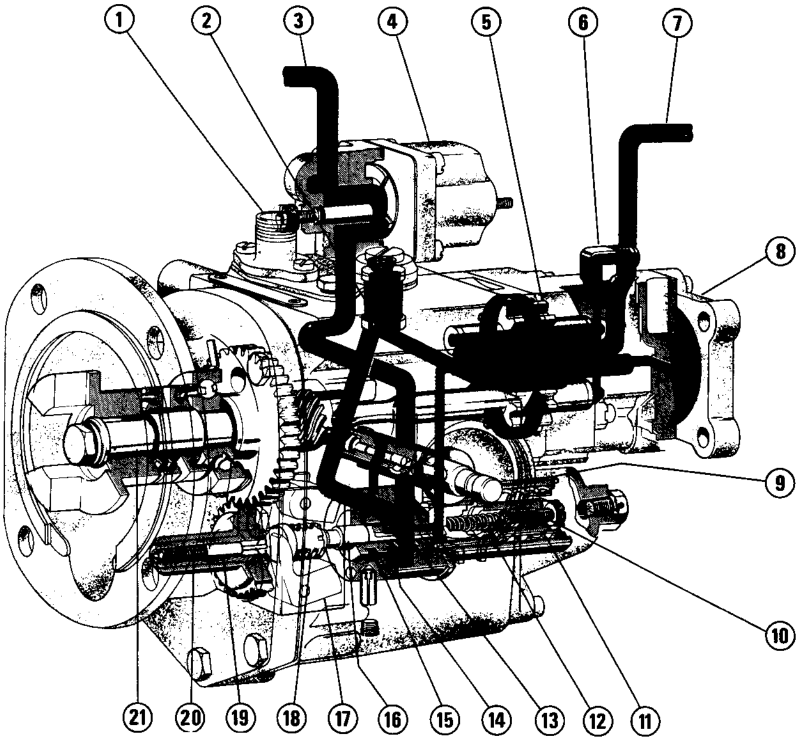
Throttle

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

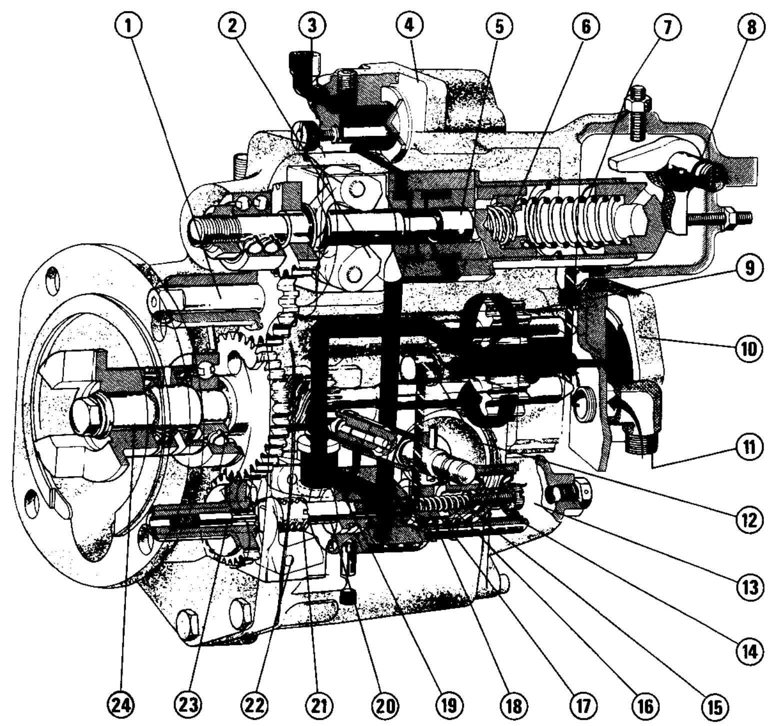
Governors

Idling and High-Speed Mechanical Governor: The mechanical governor, 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



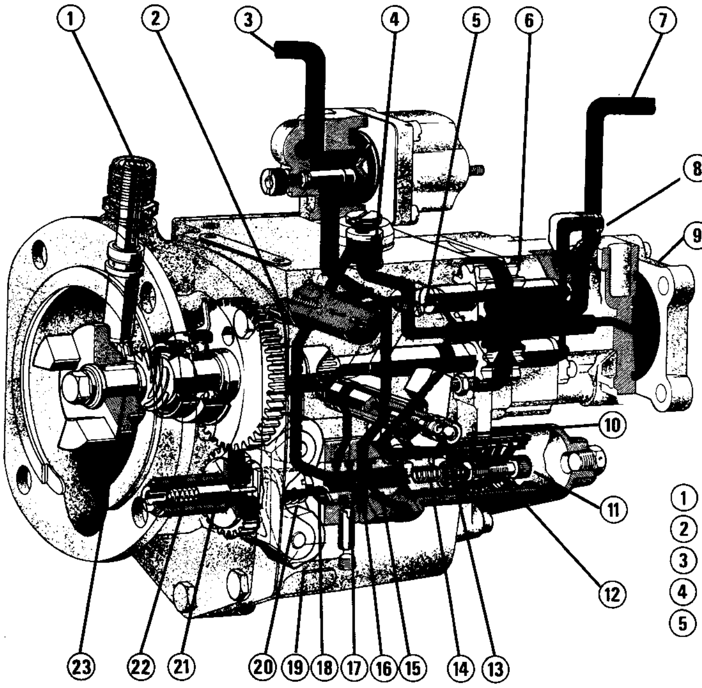
1. TACHOMETER SHAFT
2. FILTER SCREEN
3. FUEL TO INJECTORS
4. SHUT-DOWN VALVE
5. GEAR PUMP
6. CHECK VALVE ELBOW
7. FUEL FROM TANK
8. PULSATION DAMPER
9. THROTTLE SHAFT
10. IDLE ADJUSTING SCREW
11. HIGH SPEED SPRING
12. IDLE SPRING
13. GEAR PUMP PRESSURE
14. FUEL MANIFOLD PRESSURE
15. IDLE PRESSURE
16.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

Fig. 5-6, (FWC-31). PT (type G) fuel pump and fuel flow



1. IDLER GEAR AND SHAFT
2. VS GOVERNOR WEIGHTS
3. FUEL TO INJECTORS
4. SHUTDOWN VALVE
5. VS GOVERNOR PLUNGER
6. VS IDLE SPRING
7. VS HIGH SPEED SPRING
8. VS THROTTLE SHAFT
9. GEAR PUMP
10. PULSATION DAMPER
11. FUEL FROM FILTER
12. PRESSURE REGULATOR VALVE
13. IDLE ADJUSTING SCREW
14. SPRING SPACER
15. HIGH SPEED SPRING
16. IDLE SPRING
17. IDLE SPRING PLUNGER
18. THROTTLE SHAFT
19. FILTER SCREEN
20. GOVERNOR PLUNGER
21. TORQUE SPRING
22. GOVERNOR WEIGHTS
23. GOVERNOR ASSIST PLUNGER
24. MAIN SHAFT

Fig. 5-7, (FWC-35). PT (type G) VS (Variable Speed) fuel pump and fuel flow



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

Fig. 5-8, (FWC-52). PT (type G) fuel pump (Non-air fuel control)

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. 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

The VS governor, Fig. 5-7, in the upper portion of the fuel pump housing, operates in series with the standard governor to permit operation at any desired (near constant) speed setting within the range of the standard governor. Speed can be varied with the VS speed control lever, located at top of pump. This pump gives surge free governing throughout the engine speed range with a speed droop smaller than the standard governor and is suited to the varying speed requirements of power take-off etc., in which the same engine is used for propelling the unit and also driving a pump or other fixed-speed machine.

When operating the PT (type G) VS fuel pump at any desired constant speed, the VS governor lever should be placed in operating position and the throttle locked in full open position to allow a full flow of fuel through the standard governor.

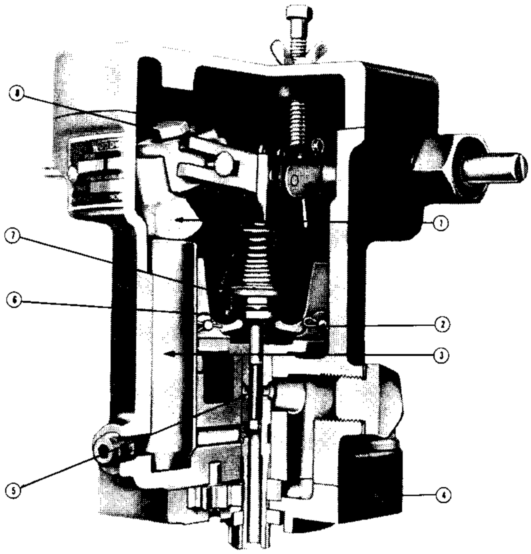
Hydraulic Governor

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

The Woodward Hydraulic Governor uses lubricating oil, under pressure, as an energy medium. It is supplied from a sump on governor drive housing. For oil viscosity, see Page 3-2.

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

In order that its operation may be stable, speed droop is



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

Fig. 5-9, (FWC-1). Woodward hydraulic governor

introduced into governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of 0 to 5 percent on the PSG to 7 percent on SG.

Assume a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower pilot valve plunger. This will admit oil pressure underneath servo piston, which will rise (as shown in Fig. 5-9). The movement of servo piston is transmitted to terminal shaft by terminal lever. Rotation of terminal shaft causes fuel setting of engine to be increased.

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

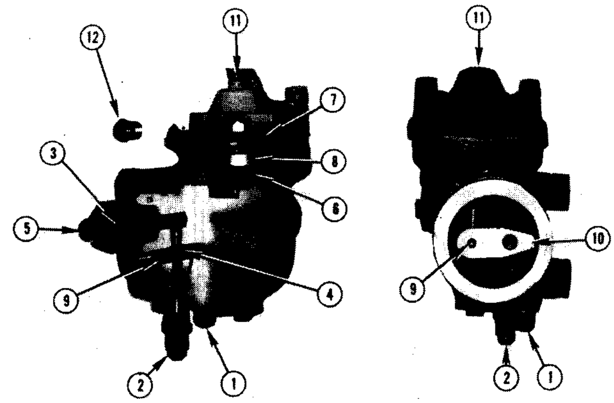


Fig. 5-10, (F-5244). Aneroid cutaway

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 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.
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.
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 output 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 injectors size and internal design differs slightly. Fig. 5-11 and 5-12.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Fig's. 5-1 through 5-5. 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.

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.

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.

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.

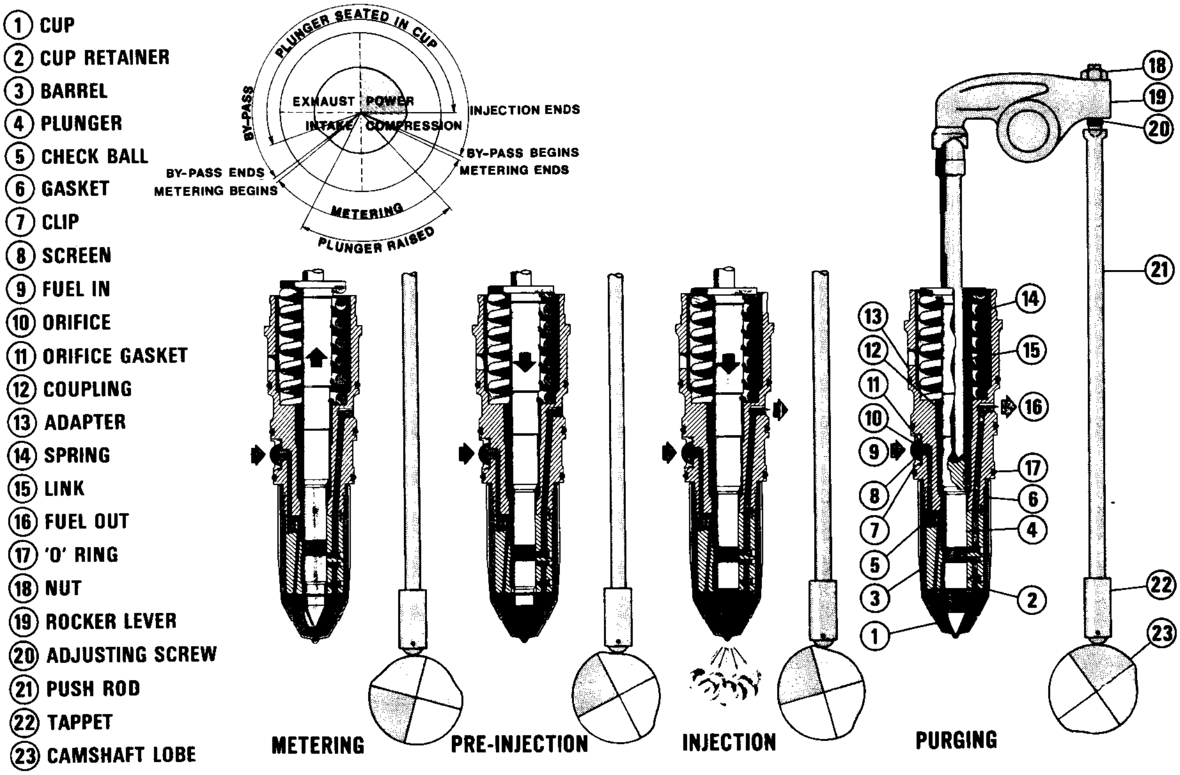


Fig. 5-11, (FWC-24). Fuel injection cycle PT (type D) injector 3/8 inch diameter plunger

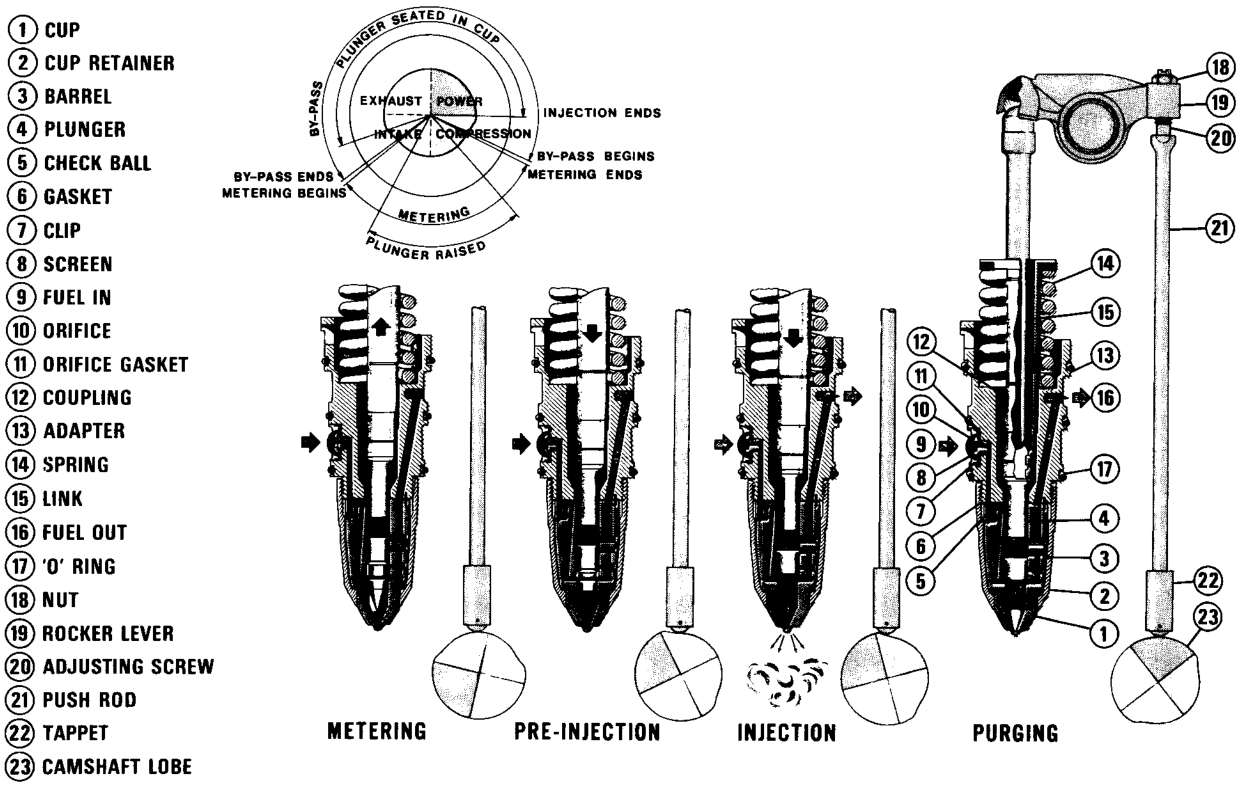


Fig. 5-12, (FWC-29). Fuel injection cycle PT (type D) injector 5/16 inch diameter plunger

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 specific 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. 5-13) oil is drawn from 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

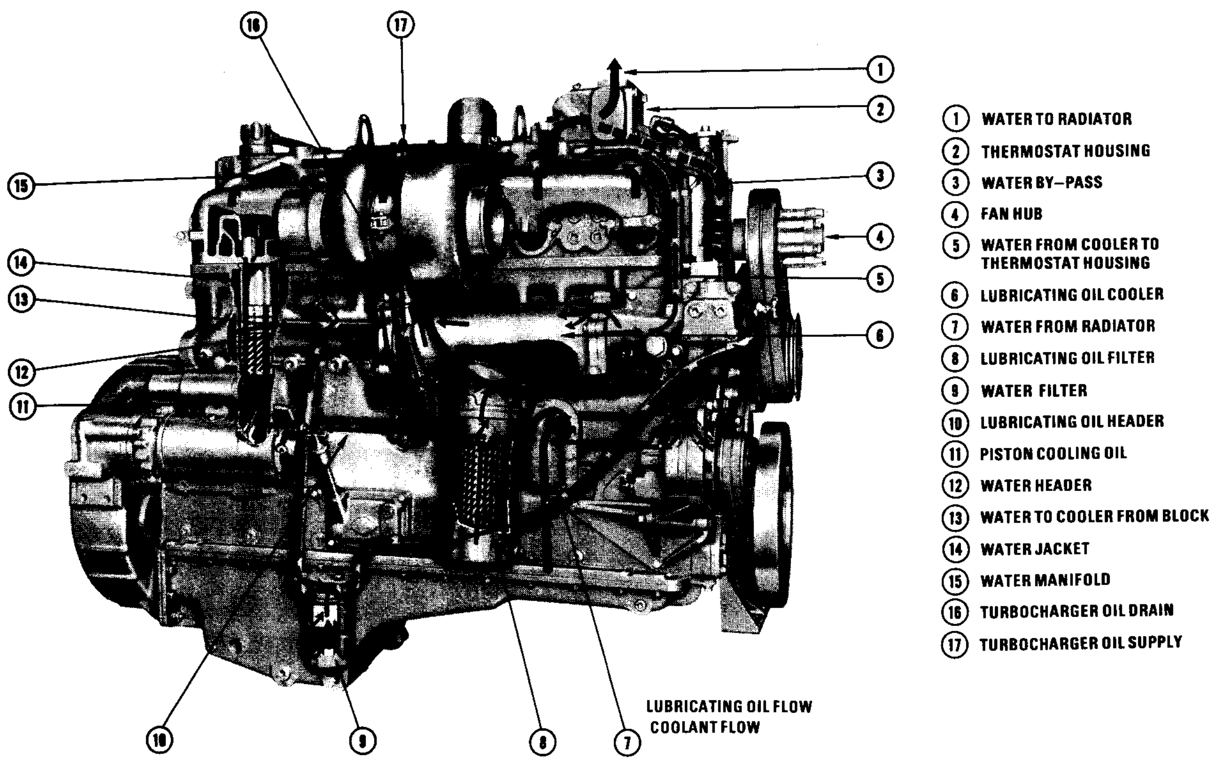


Fig. 5-13, (LWC-18). Lubricating oil and coolant flow — N/NT-855 Engine mounted. External lines are used for remote mounting arrangements.

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. Internal oil passages carry oil from the camshaft to upper rocker housings and drillings through the block, crankshaft, connecting rods, and rocker levers completes the oil circulation.

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.

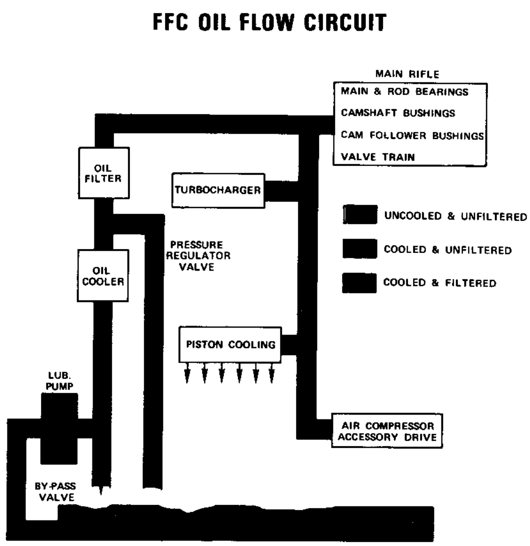


Fig. 5-14, (N10740). Full flow oil cooling schematic — NTC-855 Engine

NTC Engines (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. 5-14 and 5-15, then transferred from the suction cavity by the pump gears into the pressure cavity.

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 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

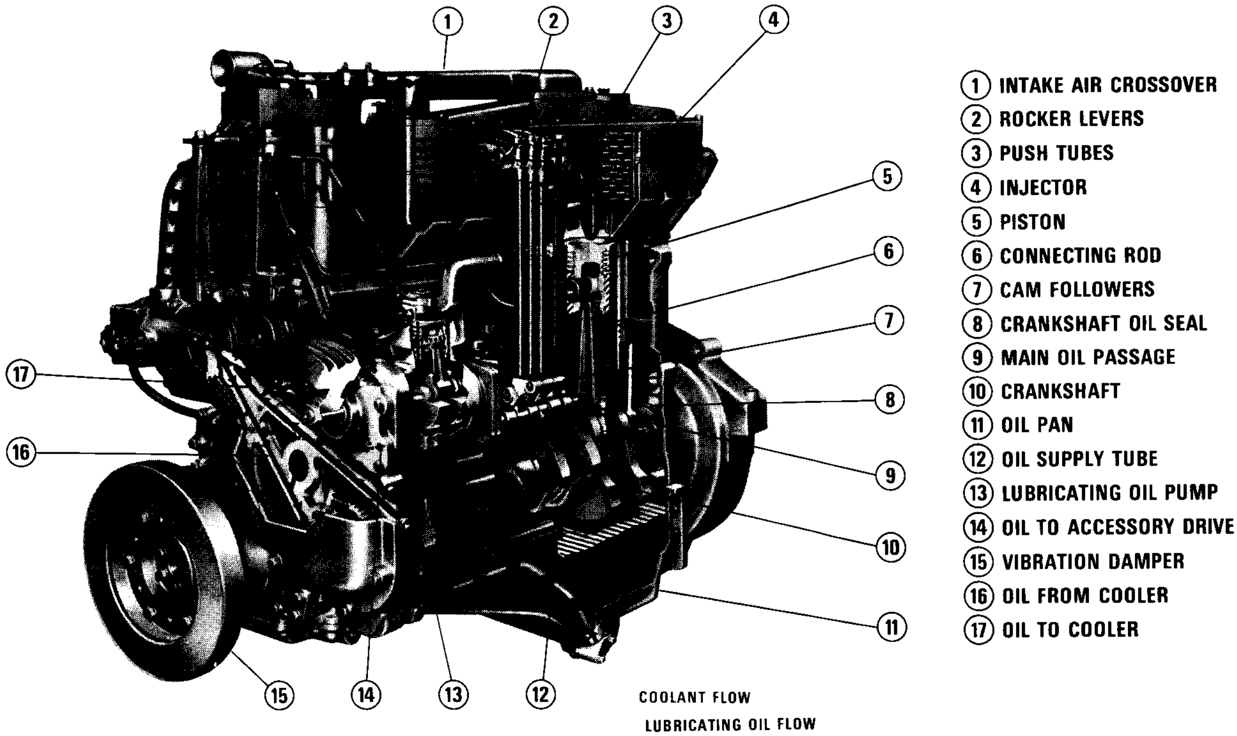


Fig. 5-15, (LWC-25). Lubricating oil and coolant flow — FFC (NTA Engine)

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 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.

V Engines

V6 and V8 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's. 5-16 and 5-17.

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 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. 5-16.
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 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. 5-17.

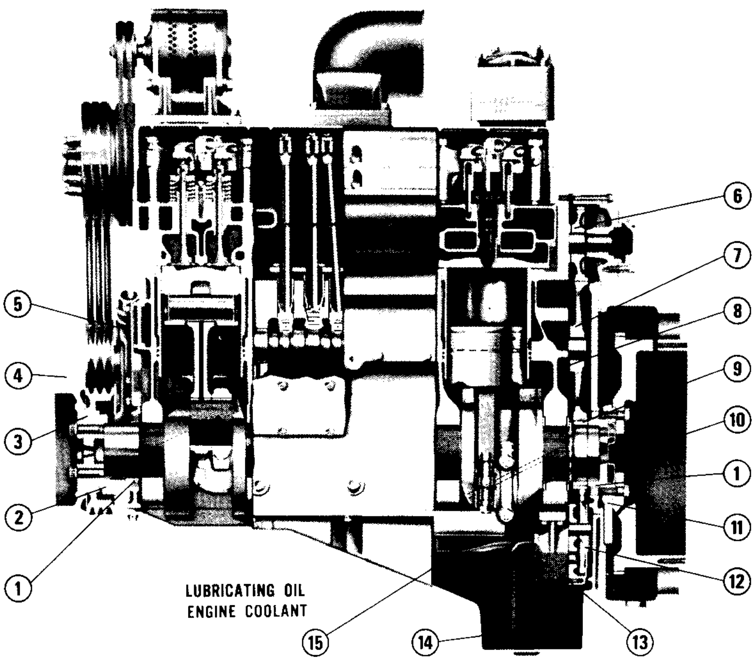


Fig. 5-16, (LWC-16). Lubricating oil and coolant flow — V-903 Engine

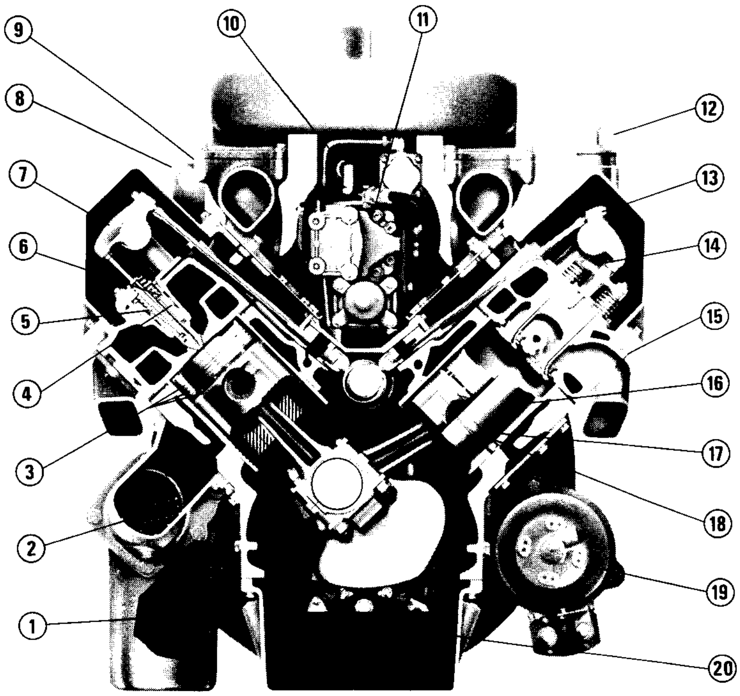


Fig. 5-17, (LWC-4). Lubricating oil and coolant flow — V-378. V-504, V-555 Engines

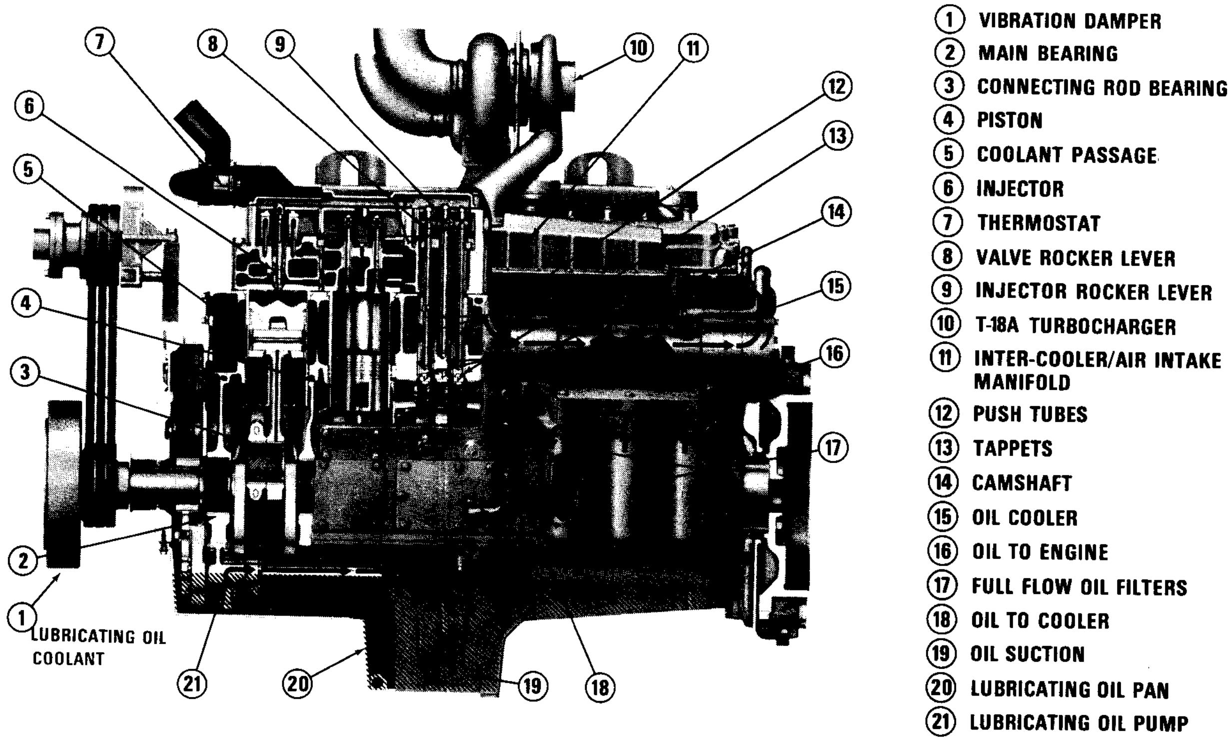


Fig. 5-18, (CWC-13). Lubricating oil and coolant flow — V-1710 Engine

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 Engines

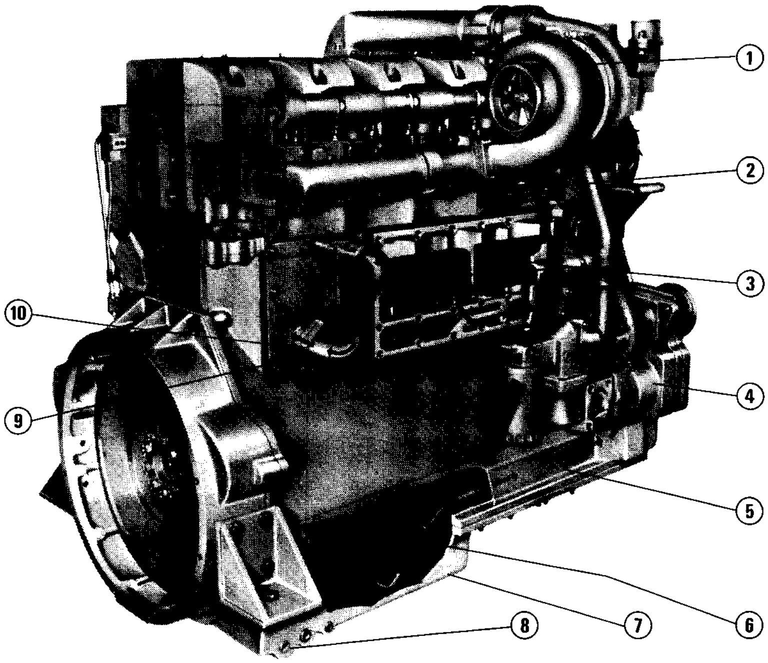
Cummins V-1710 Engines, Fig. 5-18, are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump, located in the oil pan and gear driven from the crankshaft gear.

1. Oil is drawn into pump through an oil line to oil pan sump. A screen in pump 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. Main oil header, drilled full length in center of block delivers 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.

KT(A)-1150 Engines

The KT(A)-1150 Engines are pressure lubricated by a gear-type lubricating oil pump located on the exhaust manifold side of the engine directly below the water pump inside the gear cover.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig. 5-19, then transferred from the suction cavity by the pump gears



① TURBOCHARGER SUPPLY
② TURBOCHARGER DRAIN
③ OIL COOLER ELEMENTS
④ OIL PUMP
⑤ OIL PAN ADAPTER
⑥ SUCTION TUBE
⑦ OIL PAN
⑧ OIL PAN DRAIN PLUG
⑨ TRANSFER TUBE
⑩ TO LUBRICATING OIL FILTERS

Fig. 5-19, (LWC-29). Lubricating oil flow — KT(A)-1150 Engine

into the pressure cavity. A pressure regulator valve dumps excess oil directly into the pump intake rather than back into the oil pan.

From the lubricating oil pump, oil flows to lubricating oil cooler, through the cooler, then across the block. On air intake side of block it flows to filter head. A by-pass valve is provided in the oil inlet cavity to assure against interruption of oil flow if filter elements become clogged. From the filter head oil enters the shells and passes through the elements, then up, splitting into two passages. One flows to the main engine oil passage and the other to the piston-cooling passage. A second pressure control valve, located in the base of the filter head, limits the flow of lubricating oil to nozzles depending on pump supplied pressure.

Main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from the main passage into camshaft bushings; from there, by constant flow, it goes to cam follower shafts and up through the cylinder heads. The cam followers are lubricated from their shaft; the cam followers are individually drilled to supply lubricating oil to rollers and push tube seats. The rocker lever bushings are also shaft lubricated. Adjusting screws are lubricated through drillings in levers and bushings. See Fig. 5-20.

The connecting rod bearings get lubrication from cross drillings in the crankshaft; oil then flows through angle drillings in the connecting rods to lubricate piston pins and bushings. It is then routed from the main passage through drillings in the gear housing and cover to the camshaft and water pump idler gears. It then moves across to the gear cover and is routed by drillings to the rest of the gears and bushings.

Filtered and cooled lubricating oil is routed to the turbocharger through an external drilling in the gear housing. Turbocharger drain oil is dumped directly into the crankcase. Fig. 5-19.

KT(A)-2300 and KTA-3067 Engines

The KT(A)-2300 and KTA-3067 Engines are pressure lubricated by a gear-type lubricating oil pump located in the oil pan at the rear of the engine. The pump is mounted to block directly below crankshaft and is driven from rear crankshaft gear.

Lubricating oil is drawn from the pan, through a suction tube, by the pump then transferred from suction cavity by pump gears into pressure cavity. A pressure regu-

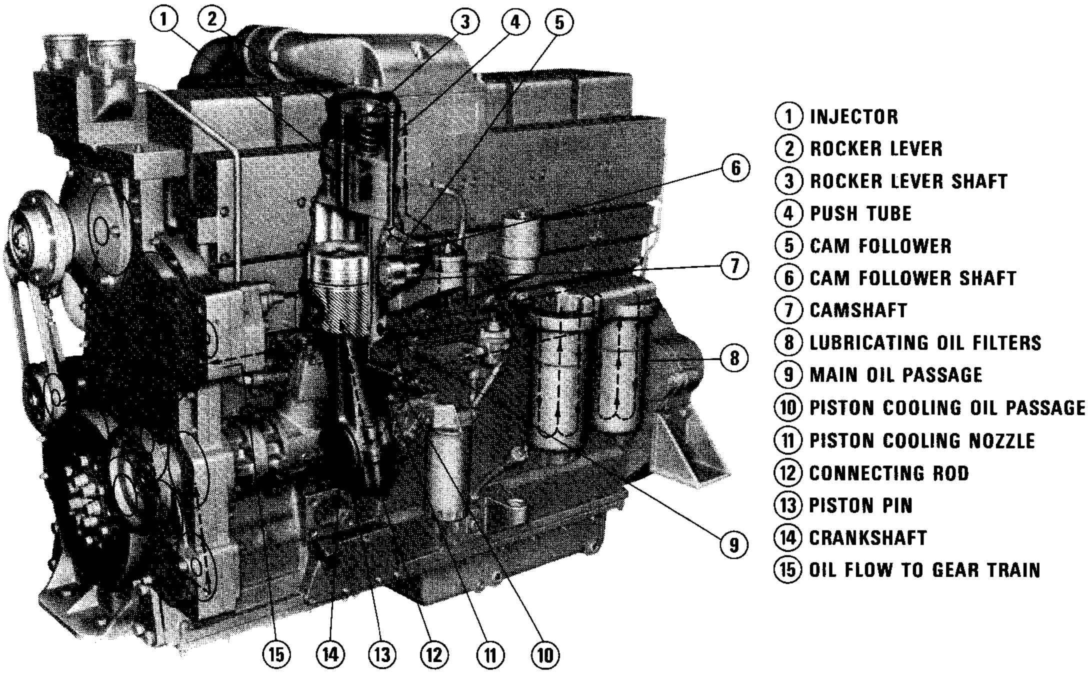


Fig. 5-20, (LWC-28). Lubricating oil flow — KT(A)-1150 Engine

lator valve dumps excess oil back into the oil pan.

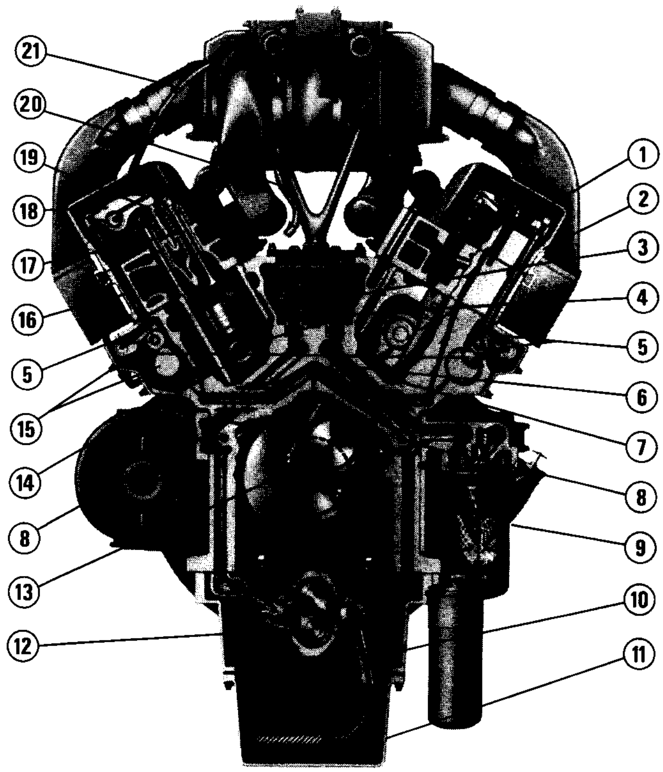
From lubrication oil pump, oil flows through block drillings to lubricating oil cooler located in block "V", through cooler, then to filters which may be mounted on either side of block. Fig's. 5-21, 5-22, 5-23 and 5-24. A by-pass valve is provided in filter head oil inlet cavity to assure against interruption of oil flow if filter elements become clogged.

From filter head, oil enters and passes through filter elements; it then flows to the main oil passage located in block "V". This passage feeds two (2) camshaft and two (2) piston cooling drillings in the block. Pressure control valves limit the flow of lubricating oil to piston cooling nozzles, depending on lubricating oil pump pressure.

Main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from cam passages into camshaft bushings; from there by constant flow, it goes to cam follower shafts and up through cylinder heads. The cam followers are lubricated from their shaft; cam followers are individually drilled to supply lubricating oil to rollers and push tube seats. Rocker lever bushings are also shaft lubricated. Adjusting screws and valve guides are lubricated through drillings in rocker levers and bushings.

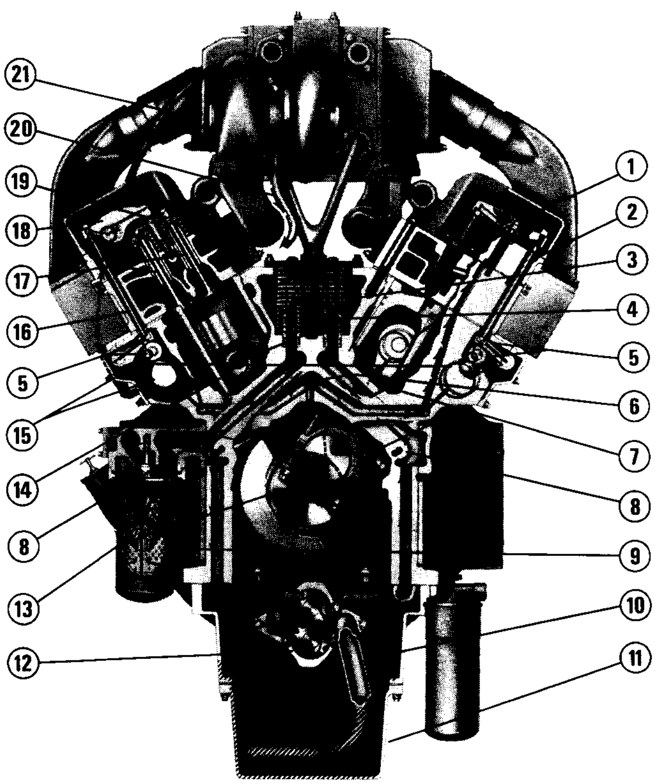
Connecting rod bearings are lubricated from cross drillings in the crankshaft; oil then flows through angle drillings in connecting rods to lubricate piston pins and bushings. Lubricating oil is routed from main oil passage through passages in gear housing and cover to lubricate front gear train gears, bushings and idler shafts. The rear gear train receives lubrication through an intersecting drilling from the right bank camshaft passage.

Filtered and cooled lubricating oil is routed from camshaft passages to each turbocharger through external lines from drillings in cylinder block. Turbocharger drain oil is dumped back into oil pan through drilling in cylinder block.



1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

Fig. 5-21, (LWC-35). Front view standard lubricating oil flow — KT(A)-2300 Engine



1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

Fig. 5-22, (LWC-34). Front view optional lubricating oil flow — KT(A)-2300 Engine

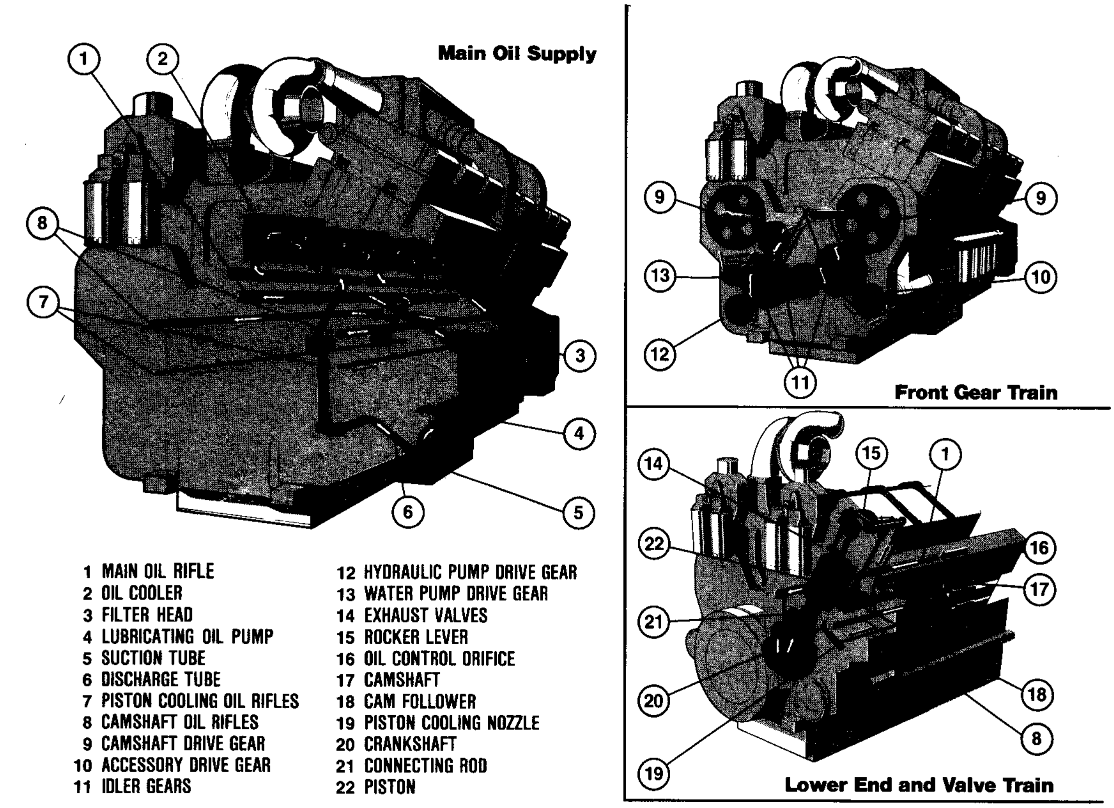


Fig. 5-23, (LWC-35). Lubricating oil flow schematic — KTA-3067 Engine

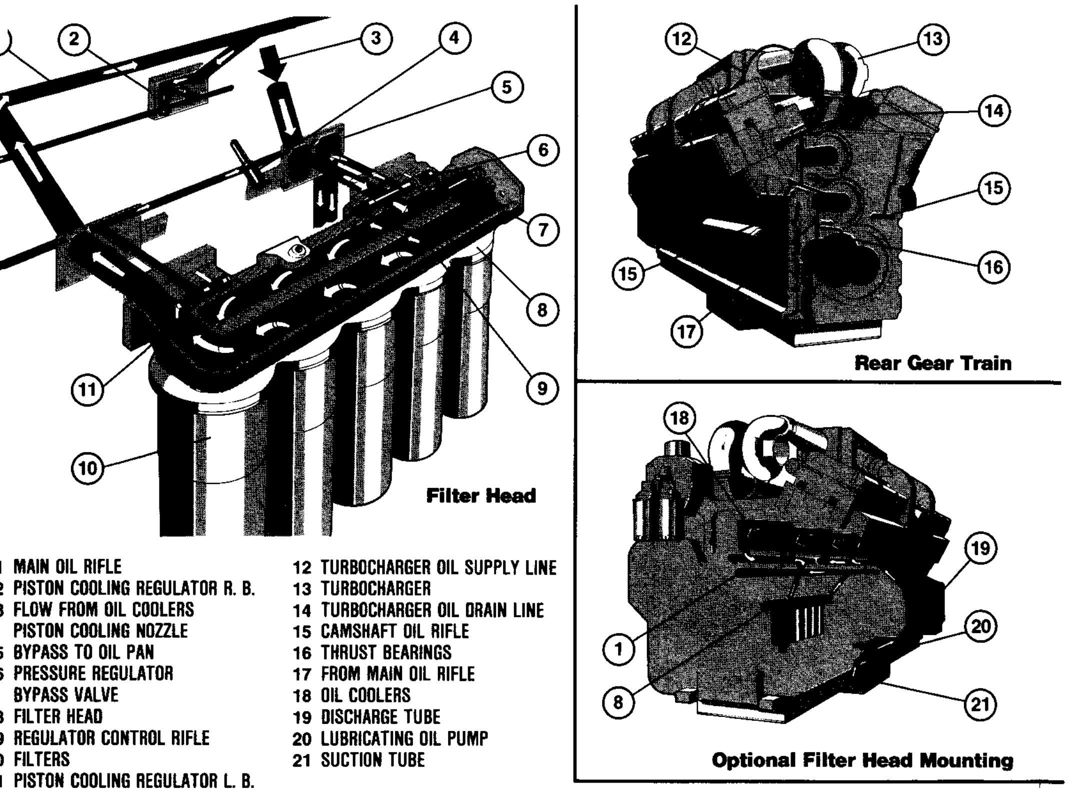


Fig. 5-24, (LWC-36). Optional lubricating oil flow schematic — KTA-3067 Engine

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.

Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Fig. 5-13 through Fig. 5-18. 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. 5-25. 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.

KT(A)-1150 Engines

Water is circulated by a centrifugal water pump, Fig.

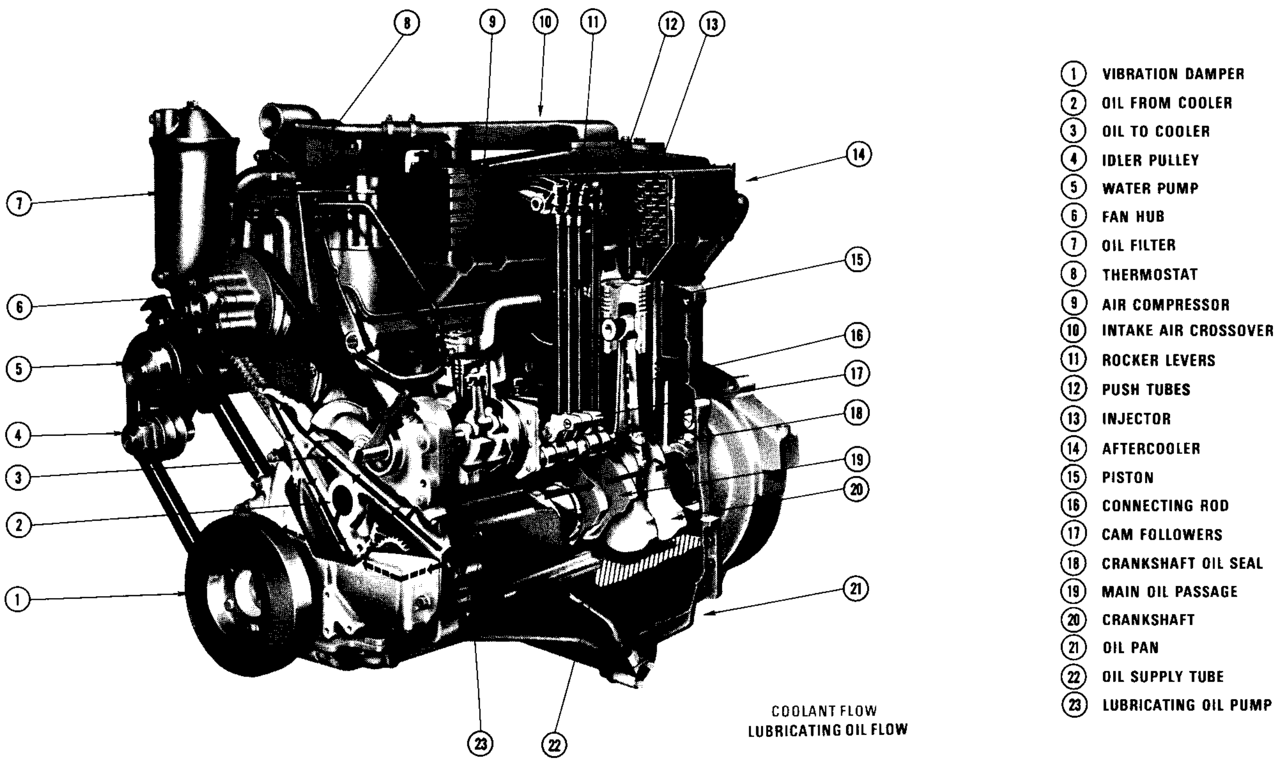


Fig. 5-25, (LWC-22). Coolant and lubricating oil flow — NTA Engine

5-26, mounted on exhaust side of block. The pump is driven by an idler gear from the crankshaft.

Coolant flows from water pump volute into the oil cooler housing, through cooler housing (serving as a water distribution manifold) into block, maintaining an equal flow around all cylinder liners. From liner area coolant flows into individual cylinder heads through holes drilled between valves and around injector "wells". From cylinder heads water flows to rocker housing (water outlet manifold) then to thermostat housing. At thermostat housing water is returned to water pump via a by-pass tube until engine coolant temperature activates dual thermostats. Coolant flow is then directed through a radiator or heat exchanger.

KT(A)-2300 and KTA-3067 Engines

Water is circulated by a centrifugal water pump mounted on right bank side of block. The pump is driven by an idler gear from the crankshaft. Fig's. 5-27 and 5-28.

Coolant flows from water pump volute into the center of "V" of cylinder block, around lubricating oil cooler elements. The center of "V" serves as a water distribution manifold to supply a flow of coolant through aftercooler elements and around cylinder liners.

From liner area coolant flows into individual cylinder heads through passages between valves and around injector "wells". From cylinder heads coolant flows to rocker housing (water outlet manifold) then to thermostat housings. At thermostat housings coolant is returned to water pump via a by-pass tube until engine coolant temperature activates thermostats. Coolant flow is then directed through a radiator or heat exchanger. Coolant circulated through the aftercooler is also returned into the thermostat housings.

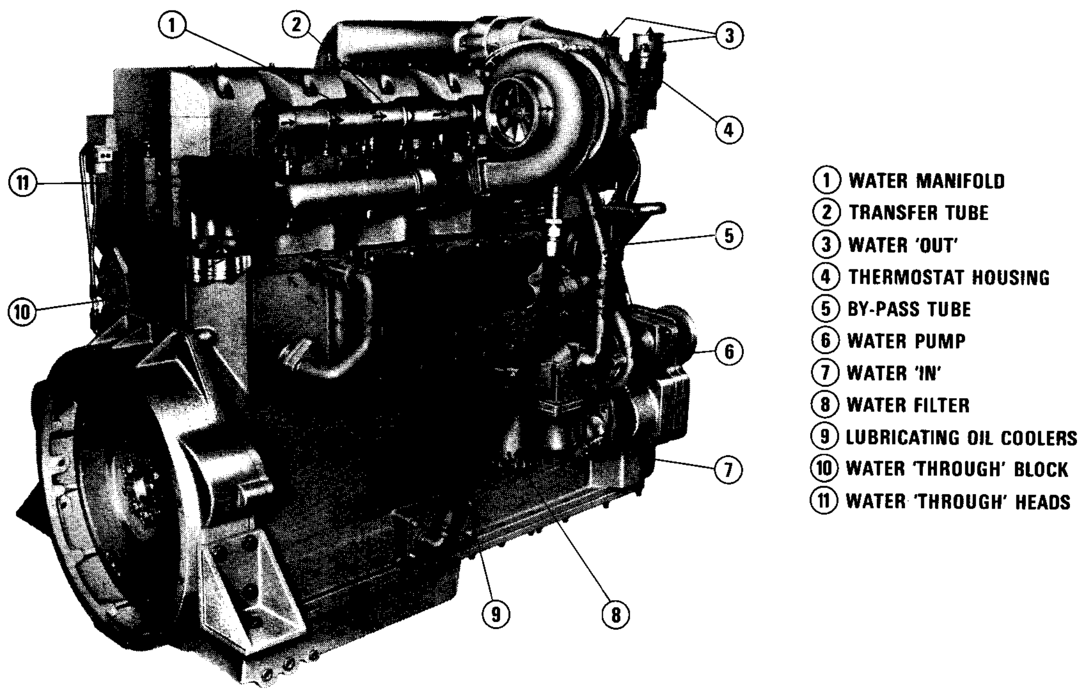


Fig. 5-26, (CWC-14). Coolant flow — KT(A)-1150 Engine

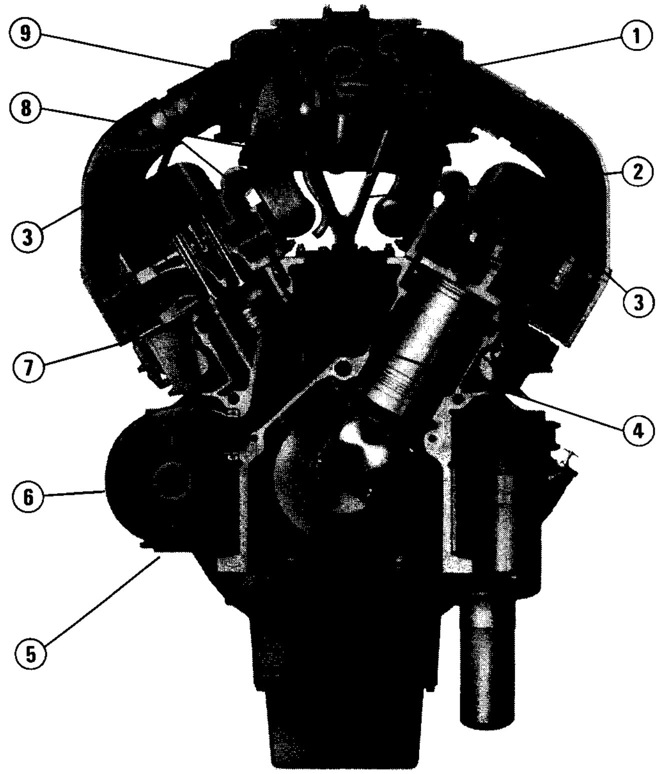


Fig. 5-27, (CWC-27). Coolant flow — KT(A)-2300 Engine

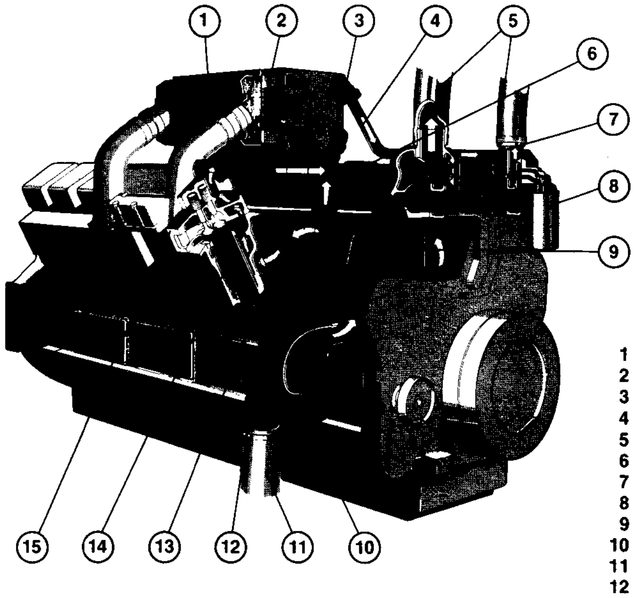


Fig. 5-28, (CWC-29). Coolant flow schematic — KTA-3067 Engine

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, or turbocharger.

NTA and KT(A)-1150 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. Fig. 5-29. Therefore, improved combustion results from better control of intake air temperature cooling or warming as applied by the aftercooler.

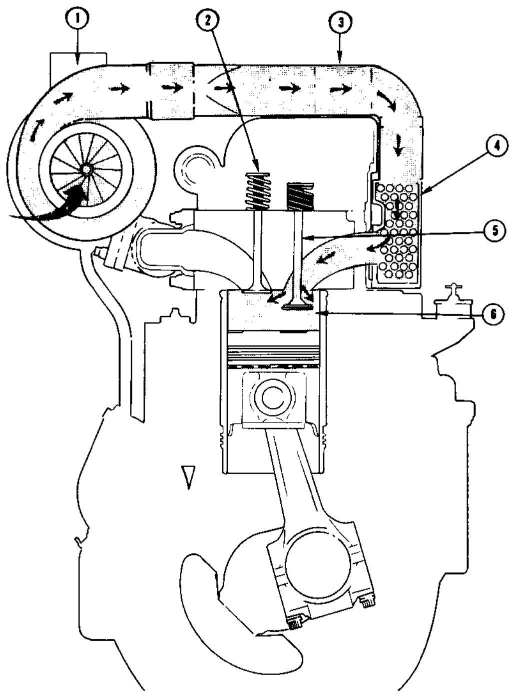


Fig. 5-29, (K11947). Intake air flow schematic — KT(A)-1150 Engine

KT(A)-2300 and KTA-3067 Aftercooler

The aftercooler consists of a housing, mounted above the cylinder block, with two (2) internal cores. The cores through which engine coolant circulates, cools or heats the air passing over the core prior to going into the engine combustion chambers. Therefore, improved combustion results.

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's. 5-32, 5-33, 5-34 and 5-35. 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 degree tilt engines air compressor crankcase is drained by a scavenger pump

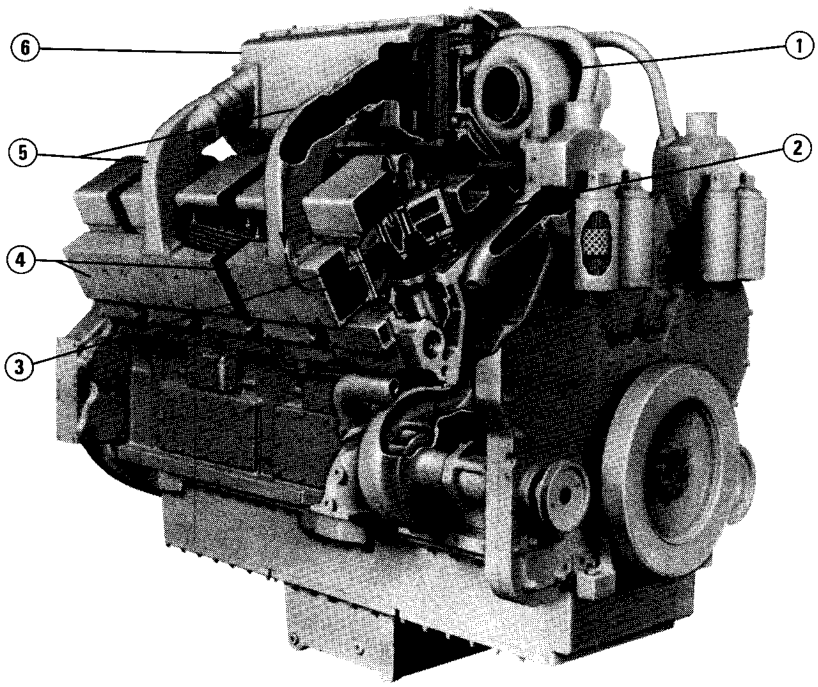


Fig. 5-30, (AWC-19). Intake air flow — KT(A)-2300 Engine

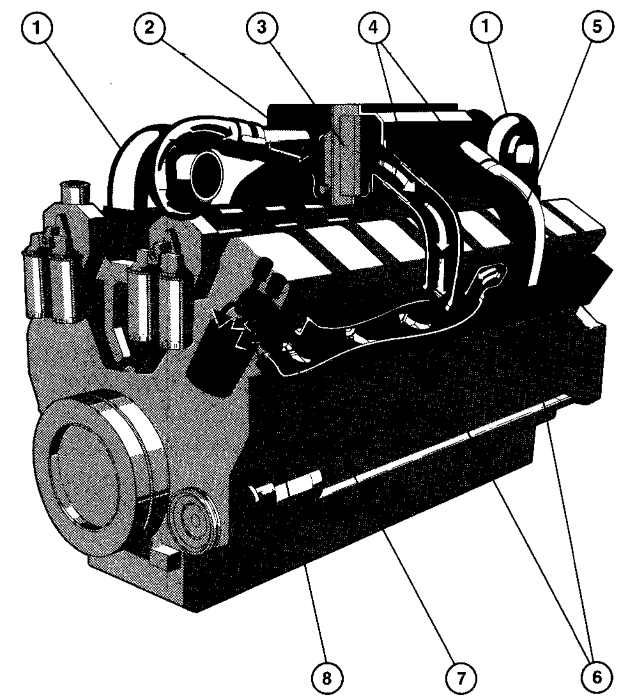
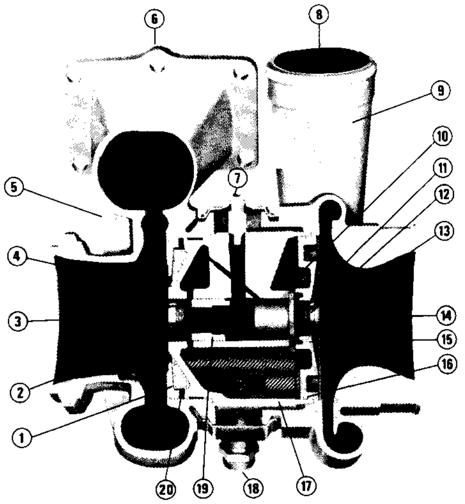
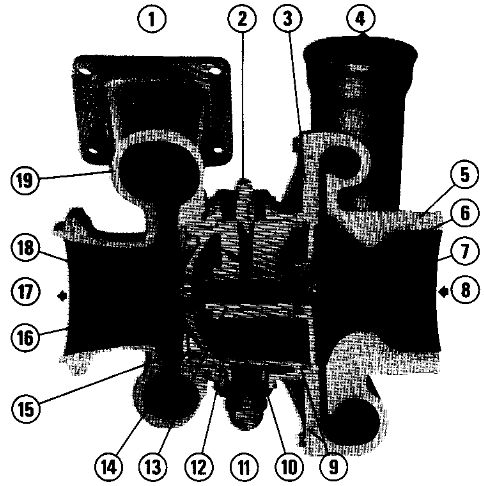


Fig. 5-31, (AWC-21). Intake air flow schematic — KTA-3067 Engine



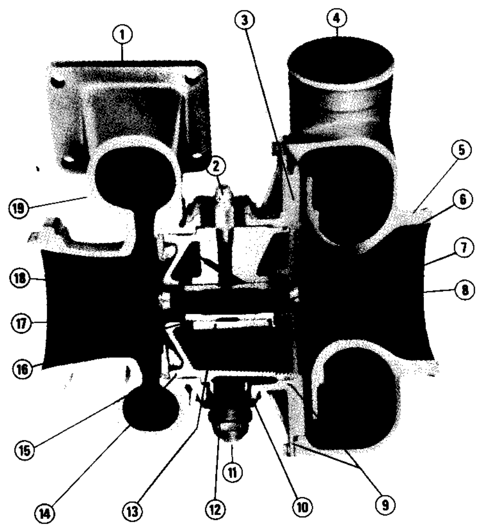
1. HEAT SHIELD
2. SEALING RING
3. EXHAUST OUT
4. TURBINE WHEEL AND SHAFT
5. TURBINE CASING
6. EXHAUST IN
7. OIL IN
8. AIR TO ENGINE
9. COMPRESSOR CASING
10. BEARING INSERT
11. OIL SEAL SLEEVE
12. SEALING RING
13. COMPRESSOR WHEEL
14. AIR IN
15. OIL SEAL PLATE
16. "O" RING SEAL
17. BEARING HOUSING
18. OIL OUT
19. FLOATING BEARING
20. INSULATION BATT

Fig. 5-32, (AWC-8). T-50 Turbocharger (cross section)



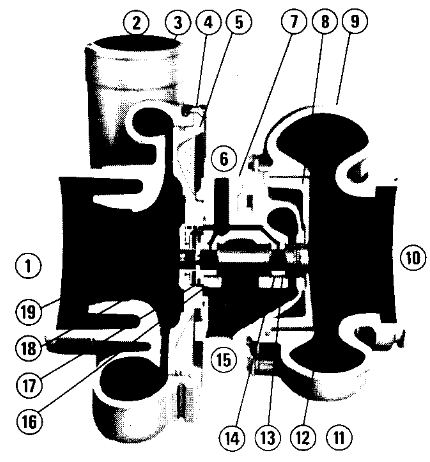
1. EXHAUST IN
2. OIL IN
3. DIFFUSER PLATE
4. AIR TO ENGINE
5. COMPRESSOR CASING
6. OIL SEAL SLEEVE
7. COMPRESSOR WHEEL
8. AIR IN
9. "O" RING SEAL
10. "V" BAND CLAMP
11. OIL OUT
12. BEARING HOUSING
13. FLOATING BEARING
14. INSULATION BATT
15. HEAT SHIELD
16. SEALING RING
17. EXHAUST OUT
18. TURBINE WHEEL AND SHAFT
19. TURBINE CASING

Fig. 5-34, (AWC-12). ST-50 turbocharger (cross section)



1. EXHAUST IN
2. OIL IN
3. DIFFUSER PLATE
4. AIR TO ENGINE
5. COMPRESSOR CASING
6. OIL SEAL SLEEVE
7. COMPRESSOR WHEEL
8. AIR IN
9. "O" RING SEAL
10. "V" BAND CLAMP
11. OIL OUT
12. BEARING HOUSING
13. FLOATING BEARING
14. INSULATION BATT
15. HEAT SHIELD
16. SEALING RING
17. EXHAUST OUT
18. TURBINE WHEEL AND SHAFT
19. TURBINE CASING

Fig. 5-33, (AWC-9). VT-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. 5-35, (TA-1). T-18 turbocharger (cross section) 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 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's. 5-36 and 5-37.

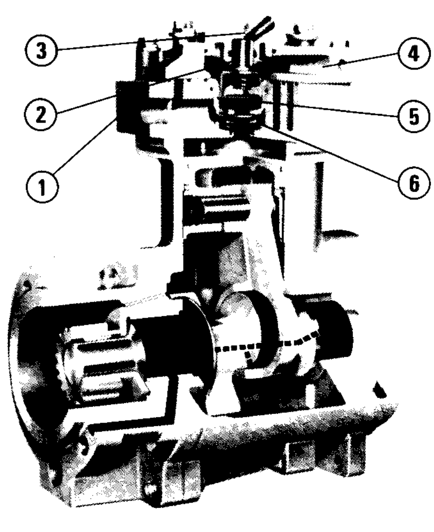


Fig. 5-36, (AWC-10). Cummins air compressor (single cylinder)

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.

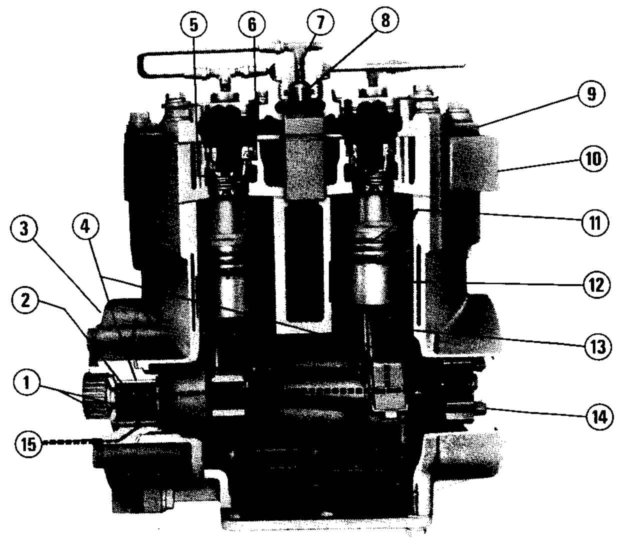


Fig. 5-37, (AWC-11). Cummins air compressor (two cylinder)

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. 5-38, 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 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

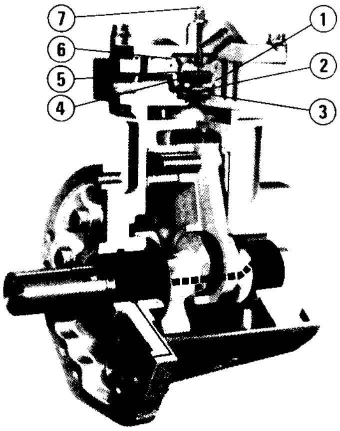


Fig. 5-38, (V11205). Cummins vacuum pump

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.

Torque Converter Governor on PT (type G) VS Fuel Pump

When a torque converter is used to connect engine with its driven unit, an auxiliary governor is driven off torque converter output shaft to exercise control over engine governor. The torque converter governor controls converter output shaft speed. The engine governor and converter governor must be adjusted to work together.

The PT-G — VS governor and the torque converter governor are two separate mechanical variable-speed governors — one drive by engine, the other by converter.

A conventional VS governor allows variable speed governing when operating at low tailshaft speeds or with the tailshaft governor disconnected. The converter governor is in series with the automotive and VS governors and controls engine speed by sensing converter tailshaft speed. Dual levers in the cab allows the operator to operate on either the tail-shaft governor or VS governor. There is no automotive throttle lever.

An adjustable converter plunger stop prevents the tail-shaft governor from shutting off the engine, when the load motors and overspeeds the tailshaft, as is the case when moving vehicles down hill.

Index

The following Cummins Service Publications concerning Cummins Engines and Units can be purchased by filling out this order form and mailing it with check or money order to Literature Control Service, P.O. Box 99085, Louisville, Ky. 40299 or Parts and Service Publications Department, Cummins Engine Company, Inc., 1000 5th Street, Columbus, Indiana, U.S.A. 47201. When desired these publications may be ordered from Cummins Daventry, Royal Oak Way South, Daventry, Northants NN 11 5NU England or from any Cummins Distributor or Cummins Dealer. Manuals ordered from Daventry, England may be available in one of the major European languages; please specify language required when ordering. If specific language requirement cannot be filled, an English Language Manual will be furnished.

Prices listed are applicable only in the U.S.A. and are subject to change without notice and without incurring obligation. Prices outside the U.S.A. vary by area. Obtain details from your nearest Cummins Distributor or Dealer. Where manuals have been updated and a new number assigned, the latest issue will be sent.

Engine Series Publication Description	Bulletin Number	Price Each U.S.A.	Qty. Req'd.	Total Cost
Mechanics Specifications Handbook 1976	3379116	6.00	______	______
Mechanics Specifications Handbook 1977	3379138	6.00	______	______
Automotive Operation and Maintenance Manual United States and Canada	3379137	4.75	______	______
Automotive Operation and Maintenance International	3379141	4.75	______	______
Construction Operation and Maintenance	3379052	4.75	______	______
Marine Diesel Engine Operation and Maintenance	3379075	4.75	______	______
V-378, 504, 555 C.I.D. Engine Shop Manual	3379069	8.50	______	______
N, NH672, 743 Engine Shop Manual	3379067	8.50	______	______
NH/NT Engine Shop Manual	3379076	8.50	______	______
V-903 C.I.D. Engine Shop Manual	3379057	8.50	______	______
V-1710 C.I.D. Engine Shop Manual	3379088	8.50	______	______
KT/KTA-1150 Engine Shop Manual	3379078	8.50	______	______
KT/KTA-2300 Engine Shop Manual	3379053	8.50	______	______
PT Fuel Pump Shop Rebuild	3379084	7.50	______	______
PT Injectors Shop Rebuild	3379071	6.50	______	______
PT (type G) Fuel Pump Calibration	3379068	8.50	______	______
T-35, T-46, T-50, ST-50 and VT-50 Turbocharger Rebuild	3379091	5.25	______	______
T-18A Turbocharger Shop Rebuild	3379055	3.75	______	______
Cummins Compressor Shop Rebuild	3379056	5.25	______	______
Generator Set Service Manual	3379143	15.00	______	______
Guide to Troubleshooting	3379090	3.75	______	______
V-378 Parts Catalog	3379577	2.75	______	______
V-504 Parts Catalog	3379549	2.75	______	______
V, VT-555 Parts Catalog	3379535	2.75	______	______
H, NH-743 Parts Catalog	967108	2.75	______	______
HS, NHS-743 Parts Catalog	967124	2.75	______	______
NH-855 Parts Catalog	3379528	2.75	______	______
NT-855 Parts Catalog (FFC)	3379511	2.75	______	______
NT-855 Parts Catalog	3379512	2.75	______	______
NTA-855 Parts Catalog	3379580	2.75	______	______
NTC-250, NTC-290, NTC-350 Big Cam	3379509	2.75	______	______
V-903 Parts Catalog	3379532	2.75	______	______
V-1710 Parts Catalog	3379540	2.75	______	______
N, NT-855 Railcar Parts Catalog	3379513	2.75	______	______
N, NH, NT Fire Pump Parts Catalog	3379508	2.75	______	______
V6, V8 Fire Pump Parts Catalog	3379534	2.75	______	______
VT-1710 Fire Pump Parts Catalog	3379543	2.75	______	______
NT-855 Generator Set Parts Catalog	3379539	2.75	______	______
NTA-370, 400, 420 FFC Auto Parts Catalog	967177	2.75	______	______
V12 Generator Set Parts Catalog	3379541	2.75	______	______
VT-1710 Generator Set (Low Profile) Parts Catalog	3379567	2.75	______	______
Super 250/270 Parts Catalog	967167	2.75	______	______
KT-450, KT-1150-C Parts Catalog	3379517	2.75	______	______
KT/KTA-1150 Generator Set Parts Catalog	3379558	2.75	______	______
KT(A) 2300 Parts Catalog	3379518	2.75	______	______
Formula 230	3379529	2.75	______	______
Formula 290	3379530	2.75	______	______
KTA-2300-GS/GC Parts Catalog	3379570	2.75	______	______
KT/KTA-1150-G Drive Parts Catalog	3379559	2.75	Total Order	______

Indiana residents — add 4% Sales Tax ______

IMPORTANT: PLEASE PRINT CLEARLY OR TYPE NAME AND ADDRESS. Total Amount Enclosed ______

Name ______

Street Address ______

City ______ State ______ Zip Code ______

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201
Cable: CUMDIEX COLUMBUS

Registered Office:
Cummins Engine Company, Ltd.
Coombe House, St. George's Square
New Malden, England
Cable: INTCUMLON MALDEN
Registration No. 573951 England

Bulletin No. 3379052-07 Printed in U.S.A. 11-78