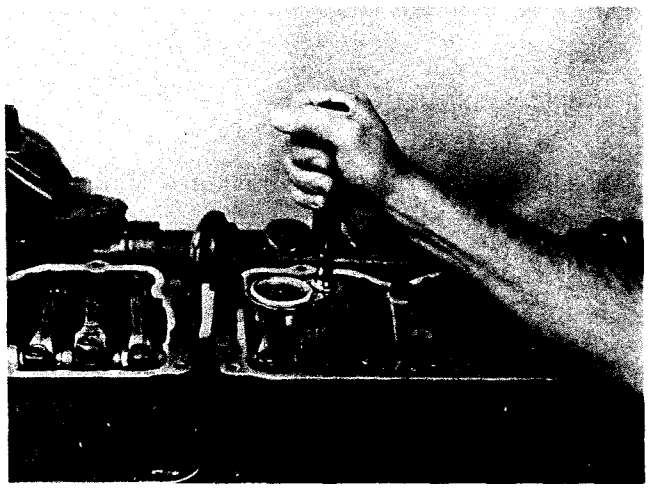


Fig. 14-59, (N114280). Adjusting injector plunger

while barring engine, this allows crankshaft to be rotated without working against compression.

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

3. Bar engine in direction of rotation until a valve set mark (Fig's. 14-54 and 14-55), aligns with the boss on the gear case cover.

Example: A or 1-6 "VS".

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.

Example: 1 and 6 cylinders for A or 1-6 "VS".

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

Injector Plunger Adjustment – Torque Method

The injector plungers are adjusted with a torque wrench and a screwdriver adapter to a definite torque setting.

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

2. Loosen adjusting screw one turn; then, tighten adjusting screw making two or three passes with torque wrench, to values shown in Table 14-9.

Note: Set ST-753-1 Torque Wrench on value required and pull to "0". Break adjusting screw loose and pull torque to value shown in each tightening pass.

3. 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

See Crosshead Adjustment (Dial Indicator Method).

Valve Adjustment – Torque Method

The same engine position used in adjusting in-

Table 14-9: Injector Adjustment (Oil Temperature)

Cold Set	Hot Set
Cast Iron Rocker Housing	
48 inch-lb [5.4 N• m]	72 inch-lb [7.1 N• m]
Aluminum Rocker Housing	
72 inch-lb [8.1 N• m]	72 inch-lb [8.1 N• m]

Table 14-10: Valve Clearance – Inch [mm] (Torque Method)

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]
Cast Iron Rocker Housing			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]

jectors 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 adjusting screw. Insert feeler gauge between rocker lever and crosshead. Valve clearances are shown in Table 14-10. Turn screw down until lever just touches gauge and lock in this position. Fig. 14-60. 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].

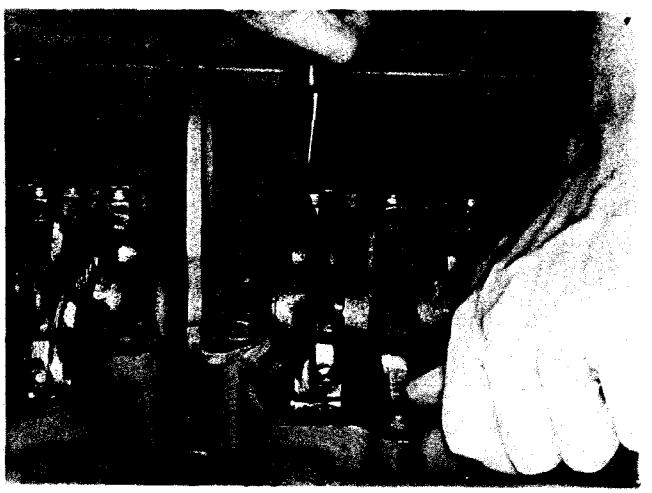


Fig. 14-60, (N114215). Adjusting valves

3. Continue to bar engine to next "VS" mark and adjust each cylinder in firing order. See Table 14-7.

After injector and valve adjustment is completed, bar or crank (in-chassis overhaul) engine several revolutions to properly seat adjusting screws, plunger links, push tubes, etc. to mating surfaces. Take break-away torque reading on injector plunger adjusting screws. Break-away torque must be the same as adjustment torque. See Table 14-9. Readjust as necessary.

Rocker Housing Covers

Position covers and gaskets on rocker housings or Jacobs Brake. Tighten capscrews of covers using cork gaskets:

Cast aluminum cover 12 to 17 ft-lbs [16 to 23 N• m].

Stamped steel cover 10 to 15 ft-lbs [14 to 21 N• m].

Cast aluminum covers using combination cork and rubber gaskets tighten to 75 to 95 in-lbs [8.5 to 10 N• m].

Note: Check current Parts Catalog for correct cover-gasket combination.

Intake Manifold or Aftercooler

1. Install new gasket, flatwasher, lockwasher and capscrew at bottom of each intake manifold port. Lift manifold into place with slots over capscrews.

Note: Extra long capscrews are used to install aftercooler.

2. Install remaining flatwashers, lockwashers and capscrews; torque all capscrews on aluminum cover to 15 to 20 ft-lbs [20 to 27 N• m]; torque capscrews on steel covers to 22 to 27 ft-lbs [30 to 37 N• m].
3. Position and secure air inlet connection with new gasket on air intake manifold.
4. Using new hose and "O" ring, position water transfer tube assembly to aftercooler connection and block adapter; secure transfer tube connection using new "O" ring into block adapter with snap ring. Install new hose to aftercooler connection and transfer tube connection. Tighten hose clamps.

Aneroid Control

1. Secure aneroid control and bracket to fuel pump side of engine, when used.
2. Install fuel pressure line from bottom of fuel pump (out-board fitting) to "IN" connection on aneroid control and fuel return line from "OUT" connection on aneroid control to fuel inlet connection.
3. Install air line and fittings, if removed, from top of aneroid to air intake manifold.

Fuel Filter

Throw-Away Element Type

The fuel filter bracket may be mounted to block with aneroid control bracket using same center capscrew or mounted separately.

Note: Engines rated above 350 horsepower and all construction engines should be equipped with dual fuel filters mounted on a one-piece dual head.

1. Position and secure filter mounting bracket in desired location.
2. Position and secure filter head to mounting bracket.
3. Coat gasket with a light coat of lubricant, install new element on head, tighten by hand until seal touches filter head. Tighten an additional one-half to three-fourths turn.
4. Connect fuel line between fuel pump and fuel filter head to fitting marked "OUT".

Replaceable Element Type

1. Position and secure mounting bracket in desired location.
2. Check fittings in filter head for leaks; torque to 30 to 40 ft-lbs [41 to 54 N• m].
3. Install filter head to mounting bracket; using a new gasket, assemble case and element. Torque center bolt to 20 to 25 ft-lbs [27 to 34 N• m].
4. Connect fuel supply line between fuel filter and fuel pump.

Remove Engine From Stand

1. Attach lifting arrangement and remove engine from stand; mount front and rear supports to engine.
2. Remove engine stand support plates from water header and replace with proper gaskets and cover plates.

Exhaust Manifold

1. Assemble sections of exhaust manifold and install new steel exhaust manifold gaskets. Side of gasket marked "OUT" must be installed outward or next to manifold.
2. Coat capscrew threads with anti-seize compound. On turbocharged engines, if heat shield is used, install special capscrews with threaded heads. These capscrews are used to mount both heat shield and manifold.
3. Torque mounting capscrews to 25 ft-lbs [34 N• m]. Bend lockplate tangs up against capscrew heads. When washers or lockplates are not used, increase torque to 40 ft-lbs [54 N• m] and install heat shield if used.

Lubricating Oil Cooler

Water Pump Mounted (NTA Series)

1. Install oil cooler support bracket to cylinder block. Position assembled oil cooler and new gasket to water inlet housing, install capscrew and lockwasher through support bracket into cooler housing, do not tighten.
2. Install capscrews, securing cooler housing to water inlet housing. Torque to 30 ft-lbs [41 N• m]. Tighten support bracket capscrew.
3. Using new "O" rings, install transfer tube from rear of oil cooler to water manifold.

Block-Mounted Oil Cooler

1. Position gasket and assembled cooler to cylinder block. Do not tighten capscrews.
2. Install water by-pass tube to connection on thermostat housing. Position clamps over hose and by-pass tube, install hose to cooler. Leave clamps loose.
3. Tighten cooler to block capscrews to 30 ft-lbs [41 N• m] torque; tighten hose clamps.

Lubricating Oil Filter

Water Pump Mounted (NTA Series)

Install new sealing "O" rings in water pump inlet housing and body. Position and secure lubricating oil filter to water inlet housing and water pump body.

Thermostat Housing By-Pass Connection

Water Pump Mounted Oil Filter

Remove by-pass connection from thermostat housing, insert transfer tube into filter housing. Position and secure by-pass connection to thermostat housing.

Compressor Water Lines

Install water supply and drain lines to compressor, cylinder block and water by-pass connections. Tighten just enough to bring brass sleeves snugly against nuts; this will compress rubber grommets and provide a positive seal.

Block Mounted Oil Cooler and Filter Assembly

1. Install cooler/filter support and support bracket to block. Torque capscrews to 30 ft-lbs [41 N• m].

2. Position assembled oil cooler to cooler/filter support, install lockwashers and capscrews through support bracket and support into cooler housing; do not tighten.

3. Install by-pass tube into thermostat housing. Position by-pass adapter onto cooler housing and over by-pass tube. Torque cooler to cooler/filter support, and adapter capscrews to 30 to 35 ft-lbs [41 to 47 N• m].

4. Install filter element support in base of filter housing support if removed, position oil filter housing to cooler/filter support. Torque capscrews to 30 to 35 ft-lbs [41 to 47 N• m]. Install new filter element into housing. Be sure filter element seats properly on support in base of housing support. Position cover to filter housing. Torque capscrews to 30 to 35 ft-lbs [41 to 47 N• m].

Lubricating Oil Cooler/Filter (FFC Series)

1. Install water pump to thermostat housing by-pass tube. Secure with hose clamps.

2. Install water inlet support bracket to cylinder block. Start capscrews with lockwasher into block; do not tighten. Position water inlet assembly to water pump and support bracket. Torque water inlet to water pump capscrews to 30 ft-lbs [41 N• m].

3. Tighten support bracket to block and bracket to inlet housing capscrews. Install water header cover plate.

4. Coat "O" rings with clean lubricating oil; position on water transfer tube. Be sure "O" rings are not twisted. Position water transfer tube in water header cover.

5. Install oil cooler to block bracket. Do not tighten capscrew. Position oil cooler assembly to block and transfer tube and install capscrews finger tight. Torque cooler support bracket to block capscrews to 30 ft-lbs [41 N• m]. Install water return to thermostat housing tube (FFC Series).

6. Using new sealing "O" ring and filter element, position oil filter can to oil cooler housing. Torque center bolt to 25 to 35 ft-lbs [34 to 47 N• m].

7. Maintain a 1/4 inch [6.4 mm] clearance between oil filter shell and pan rail while tightening support and bracket capscrews. Tighten to 30 ft-lbs [41 N• m].

Generator or Alternator

1. Secure generator or alternator mounting bracket to cylinder block. Position hardened steel washers or spacers as needed between alternator or generator and mounting bracket.

Note: Do not use lockwashers or soft steel washers when securing generator or alternator to bracket or adjusting link.

2. Check capscrew size and torque mounting capscrews to values in Table 14-11.

3. Position adjusting link to alternator or generator termination point. Install capscrew and hardened washer securing adjusting link to alternator, do not tighten. Install belt(s), pry unit away from block to tighten belt(s) to operation tension. Torque capscrews to values in Table 14-12.

Note: If generator or alternator pulley has been removed or a new pulley is installed, use hardened steel washer and locknut. Torque to values in Table 14-13.

Table 14-11: Torque Values (To Bracket)

Nominal Bolt Size Inch	Torque Ft-Lb [N•m]
3/8	29 to 31 [39 to 42]
7/16	63 to 65 [85 to 88]
1/2	77 to 80 [104 to 108]

Table 14-12: Torque Value (To Adjusting Link)

Nominal Bolt Size Inch	Torque Ft-Lb [N•m]
5/16	15 to 19 [20 to 26]
7/16	25 to 30 [34 to 41]
1/2	50 to 55 [68 to 75]

Table 14-13: Torque Values (Pulley to Alternator or Generator)

Nominal Thread Size Inch	Torque Ft-Lb [N•m]
1/2	50 to 60 [68 to 81]
5/8	55 to 65 [75 to 88]
3/4	90 to 100 [122 to 126]

Note: Exception to the above limits are:

Delco-Remy Alternators	Torque Ft-Lb [N•m]
10 DN 150	
25 SI	70 to 80 [95 to 108]

Oil Spray Nozzles

1. Lubricate new "O" rings with clean lubricating oil and position on nozzle using ST-835 "O" Ring Loader. Be sure "O" rings are not twisted in groove.

Note: Do not soak "O" rings in oil.

2. Insert nozzles in block and secure. Using a screwdriver adapter, torque slotted screw to 5 to 8 ft-lbs [7 to 11 N• m]. Torque hex head capscrews to 10 ft-lbs [14 N• m].

Note: Identification numbers stamped on the mounting flange of oil spray nozzles are: No. 6 FFC Series Engines, No. 1 all others.

Breather Tube

Install breather tube, if used, to rocker housing cover and secure to block with clamp.

Cranking Motor

1. Check cranking motor; see that it is the same type as removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear.

2. Mount cranking motor (and spacer if used) to flywheel housing.

Note: When wet type clutch is used, use "O" rings and Nylok capscrews when installing starter.

Oil Gauge Bracket

Install oil bayonet gauge bracket, using new gaskets.

Water Filter

1. Secure water filter head to engine or mounting bracket; attach shut-off valves and lines in proper position.

2. Install pre-charge element; tighten until seal touches filter head then tighten an additional 1/2 to 3/4 turn.

Turbocharger

1. Coat turbocharger mounting stud or capscrew threads with anti-seize compound. Place gasket

on exhaust manifold with convex side toward turbocharger.

2. Install turbocharger to exhaust manifold and secure with hug-lock nuts. Oil drain line must always be in a vertical or down position or within 30 degrees of that position.
3. Connect No. 6 oil inlet line or equivalent size tubing from top of turbocharger to oil cooler or transfer housing.
4. Connect No. 16 oil drain line or equivalent size tubing from turbocharger to large boss on side of cylinder block.

Note: If turbocharger "vee clamp" is loosened to align oil drain line, tighten to 30 to 32 in-lbs [3.4 to 3.6 N• m] torque.

5. Install air intake crossover between turbocharger outlet and air intake manifold or aftercooler. Install new rubber tubing connection and T-bolt type clamps. Tighten T-bolt clamps to 65 to 75 in-lbs [7.4 to 8.5 N• m].

Electric Connections

Secure electric connections to mounted equipment, using wire as specified. See Engine Wiring Diagram, Bulletin No. 3379099.

Fan Installation

Note: When installing fan to fan hub 5/16 inch [7.94 mm] capscrew must have 15/32 inch [11.91 mm] thread engagement, 3/8 inch [9.53 mm] capscrews must have 9/16 inch [14.29 mm] thread engagement, 1/2 inch [12.70 mm] capscrews must have 3/4 inch [19.05 mm] thread engagement. Check decal on fan hub or water pump pulley for proper thread length. The fan may be installed before or after engine dynamometer testing.

Engine Testing

Engine break-in and testing are accomplished simultaneously. Break-in on a new or rebuilt engine is necessary because it provides an operating period during which moving parts acquire their final finish and mating surfaces reach a full seat. Engine testing helps detect possible assembly errors, need for adjustments as engine "breaks-in" and establishes a period for final adjustments for best engine performance.

Priming the Fuel System

1. Fill fuel tanks and filter(s) with clean No. 2 diesel fuel oil meeting the specifications in Group 18.
   a. With PT (type G) fuel pump, fill pump through plug next to tachometer with clean fuel.
   b. With PT (type R) fuel pump, remove suction line and wet gear pump gears with clean fuel.
2. If injector and valve or other adjustments have been disturbed, be sure they have been properly adjusted before starting engine.

Priming the Lubricating System

Note: If engine is equipped with a turbocharger, remove oil inlet line and lubricate bearing with approximately 2 to 3 oz [60 ml] of clean engine lubricating oil. Reconnect oil inlet line.

1. Fill crankcase to "L" (low) mark on dipstick. See Lubricating Oil Specifications, Group 18.

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

2. Remove plug from head of lubricating oil filter housing or gear case to prime system. See 1 or 2, Fig. 14-61.

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

3. Connect a hand or motor driven priming pump line from source of clean lubricating oil to plug boss in housing. Prime until a 30 psi [207 kPa] maximum pressure is obtained.
4. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnect to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [103 kPa].

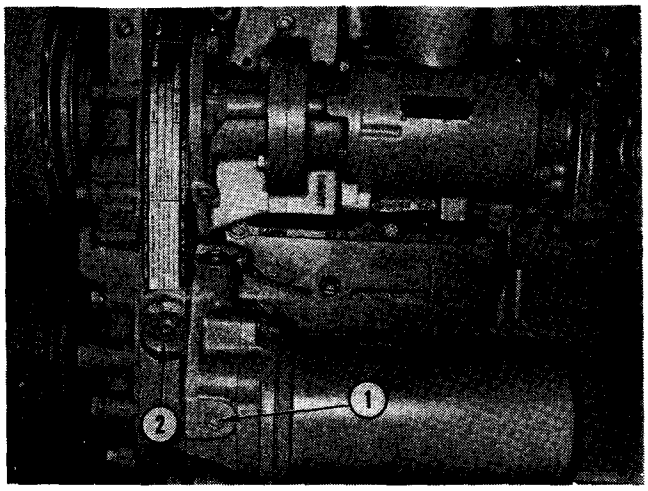


Fig. 14-61, (N11963). Lubricating system piming point

5. Remove external oil supply line and replace plug.

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

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

Lubricating Cranking Motor and Generator

Use 6 or 8 drops of clean lubricating oil to lubricate cranking motor and generator or alternator bearings (if required). Avoid excessive oiling which would cause damage to wire insulation.

Fill Hydraulic Governor

Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps. This governor uses lubricating oil (of the same weight as used in the engine) as an energy medium. Oil level in governor sump must be at full mark on dipstick, or half-way level on inspection glass.

Engine Dynamometer

Check dynamometer capacity. Make sure capacity is sufficient to allow testing at 96 to 100 percent maximum engine horsepower. If capacity is insufficient, testing procedures must be modified to prevent damage to dynamometer.

Installation of Engine

1. Place engine on dynamometer test stand; secure engine mounting pads to engine support risers.

2. Position dynamometer drive shaft flange to engine flywheel. Check for proper alignment per manufacturers instructions.

3. Connect water supply and return hose to the water cooling arrangement.

4. Attach ST-1190 Fuel Consumption Measuring Device to engine.

5. If engine is equipped with an aneroid control, disconnect fuel pressure and fuel return line and plug lines. The aneroid is reconnected just after "power check" is made.

6. Connect throttle linkage instruments, exhaust piping and air intake piping to engine.

7. On naturally aspirated engines, plug vent holes in cylinder heads before making blow-by check. After testing, remove pipe plugs.

8. Install 3375150 Blow-By Checking Tool in crankcase breather opening or special rocker cover. Use water manometer and fill to "O" mark at middle of scale. Close all openings that would allow blow-by pressure to escape.

9. Start engine, see "Starting Procedure", open coolant supply to engine water connection. Introduce water to dynamometer per manufacturer's instructions. Check all tubing, hose, lines, fittings and plugs for leaks. Correct as necessary. See "Check Turbocharger Oil Flow" following.

10. For engine run-in, see "Test Procedure".

Check Turbocharger Oil Flow

1. Disconnect turbocharger oil drain line.

2. Start engine and maintain rpm at low idle.

3. Observe oil drain. Oil should flow in 10 to 15 seconds. If no oil flows in 30 seconds, shut down engine and correct fault.

4. Reconnect oil drain line when flow is established.

Starting Procedure

Normal Without Cold-Starting Aid

1. Set throttle for idle-speed, open manual fuel shut-down valve, if used. Electric fuel shut-down valves operate automatically.

Note: The manual override knob provided on forward end of electric shut-down valve, allows valve to be opened in case of electric power failure or if power is not available during testing. To use, open by turning fully clockwise.

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

Caution: Do not crank engine continuously for more than 30 seconds. If engine does not fire, wait two to five minutes before repeating to avoid cranking motor damage.

Cold Start with Preheater

1. Set throttle in idle position, turn glow plug toggle-switch to "ON" position. (Red indicator light must be on.) 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 20 second interval will wet and cool glow plug and prevent heating.)

Note: On engines equipped with an oil pressure switch, the fuel by-pass switch must be in "START" position before use of priming pump. Hold in "START" position until engine oil pressure reaches 7 to 10 psi [48 to 69 kPa] then move to "RUN" position.

2. If engine does not start within 20 seconds, stop cranking; wait two to five minutes and repeat cranking operation.

3. After engine starts, pump primer slowly to keep engine idling smoothly. Do not accelerate engine.

4. When engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch.

Failure to Start

1. If engine gives no indication of starting during first three full strokes of preheater pump, check intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove pipe plug from manifold and observe glow plug. Glow plug should be white hot; if not, connect plug to a six or twelve-volt source and check amperage which should be 30 (minimum). If glow plug is all right, check manual switch and resistor; replace if necessary.

Test Procedure

Horsepower Ratings

1. The maximum horsepower ratings at rpm shown in Table 14-14, "Dynamometer Test Chart", are for engines operating at No. 1 Curve or intermittent-duty applications at sea level, 60°F [16°C] intake air temperature and 29.92 inch [760.0 mm] Hg (Mercury) barometric pressure.

2. Where it is necessary to derate because of high altitude operation, the derating may be done by reducing maximum governed rpm or maximum fuel rate. Refer to Cummins fuel pump manuals.

3. Naturally aspirated engines must be derated 3 percent for each 1000 ft [305 m] altitude above sea level, and 1 percent for each 10°F [6°C] ambient temperature rise above 60°F [16°C].

4. Turbocharged engines do not require fuel derating below maximum altitudes shown in the "Dynamometer Test Chart". Above maximum altitudes, derate at 4 percent for each 1000 ft [305 m] additional altitude and 1 percent for each 10°F [6°C] air temperature rise above 12°F [52°C].

5. New or newly rebuilt engine during dynamometer tests are not required to deliver more than 96 percent of maximum horsepower at power checks.

Break-In Run

Initial Starting

Start engine and idle at approximately 800 rpm no load for five to ten minutes. Check oil pressure and water circulation; look for leaks.

At Each Phase

1. Apply dynamometer load to (±10%) horsepower at (±5%) speed shown in Table 14-14 "Dynamometer Test Chart".

2. Check crankcase pressure (blow-by) with 3375150. If pressure continues to drop, reduce run-in time by half; otherwise, run engine for time period shown on dynamometer chart.

At Phase 1

1. Run engine until normal oil operating temperature has been obtained.

2. Add lubricating oil to bring level up to "H" mark on bayonet gauge; allow oil temperature to stabilize.

At Phase 2

Set engine idle, governed speed and fuel rate. Refer to Bulletin No's. 983505 or 3379068-00.

At Phase 3

If blow-by rises, reduce load to preceding phase and run for 30 minutes; then return to original phase specifications.

At Phase 4

1. Run at speed and horsepower indicated.

2. Check for leaks and tighten all exposed capscrews.

3. Recheck valves and injectors. Use "Hot Setting", refer to Tables 14-8, 14-9 and 14-10.

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

Power Check

1. Run engine at rated speed for 5 minutes. It should develop 96 percent of rated horsepower at standard fuel rate. Check crankcase pressure (blow-by). If pressure exceeds value shown in Table 14-14, reduce engine speed and load to preceding phase, run engine 30 to 45 minutes.

2. Repeat procedure described above until engine develops 96 percent rated horsepower at standard fuel rate within permissible crankcase pressure limit.

3. After power check is completed, remove pipe plugs in naturally aspirated engine cylinder heads and install vent plugs. On turbocharged engines connect aneroid, if used.

Checks During Run-In Test

During the period of engine run-in, the following checks should be made frequently.

Lubricating Oil

1. Lubricating oil pressure should remain at or near a constant figure at constant engine speed and load (see Table (14-15) after normal operating temperature has been reached. Abnormally high pressures may indicate blocked lubricating oil lines. Abnormally low pressures indicate an insufficient supply of lubricating oil from the pump or increased oil clearances which may be due to bearing failure.

2. If oil temperature rises sharply above 225°F [107°C], shut down engine and correct as necessary.

3. New lubricating oil filter elements will absorb oil; therefore, engine must be shut down after 5 or 10 minutes of operation and additional oil added to bring oil level to "H" mark on bayonet oil gauge. Check oil level every phase during run-in test.

Table 14-14: Dynamometer Test Chart

Engine Model	HP @ RPM	Rated HP @ RPM 500 Ft. Alt.	Fuel Rate Lb./Hr.	Air Manifold Pressure In./Hg.	Altitude Max. HP Alt.	Turbo.	Crankcase Pressure With 3375150	Phase 1 To Temp. Hp @ RPM	Phase 2 15 Min. HP @ RPM	Phase 3 15 Min. HP @ RPM	Phase 4 15 Min. HP @ RPM	Power Check 5 Min. HP @ RPM	Torque Ft./Lb. Sea Level	Torque Ft./Lb. 500 Ft. Altitude
NHE-225	225@1950	216@1950	85				8	113@1463	169@1950	191@1950	202@1950	216@1950	668	644
NH-250	250@2100	240@2100	97				8	125@1575	188@2100	213@2100	225@2100	240@2100	690	660
Super-250	250@2100	240@2100	94				8	125@1575	188@2100	213@2100	225@2100	240@2100	710	600
NT-6	250@2100	250@2100	98	18/26	12,000	T-50	12	125@1575	188@2100	213@2100	225@2100	240@2100	695	695
NT-280	280@2100	280@2100	109	29/35	10,000	T-50	12	140@1575	210@2100	238@2100	252@2100	268@2100	780	780
NTE-235	235@2100	235@2100	92	18/26	14,500	T-50	12	117@1575	176@2100	200@2100	212@2100	225@2100	650	650
NTC-290	290@2100	290@2100	105	16/22	12,000	VT-50	12	145@1575	218@2100	247@2100	261@2100	278@2100	825	825
NT-310	310@2100	310@2100	122	32/38	8,500	VT-50	12	155@1575	232@2100	263@2100	279@2100	298@2100	855	855
NT-320	320@2200	320@2200	127	34/42			12	160@1650	240@2200	272@2200	288@2200	307@2200		
NT-335	335@2100	335@2100	130	34/42	5,000	VT-50	12	168@1575	251@2100	285@2100	302@2100	322@2100	925	925
NTC-350	350@2100	350@2100	130	26/34	12,000	VT-50	12	175@1575	263@2100	298@2100	316@2100	336@2100	975	975
NHC-250	250@2100	240@2100	97				8	125@1575	188@2100	213@2100	225@2100	240@2100	685	685
NHCT-270	270@2100	270@2100	103	24/26	12,000	T-50	12	135@1575	203@2100	230@2100	243@2100	259@2100	740	740
NTC-335	335@2100	335@2100	128	34/42	12,000	VT-50	12	168@1575	251@2100	285@2100	302@2100	321@2100	930	930
NTA-370	370@2100	370@2100	145	29/37	12,000	VT-50	12	185@1575	278@2100	315@2100	324@2100	361@2100	1015	1015
NTA-400	400@2100	400@2100	158	31/39	12,000	VT-50	12	200@1575	300@2100	340@2100	360@2100	383@2100	1000	1000
NHH-250	250@2100	240@2100	95				8	125@1575	188@2100	213@2100	225@2100	240@2100	658	600
NHHTC-335	335@2100	335@2100	130	30/38	12,000	VT-50	12	168@1575	251@2100	285@2100	302@2100	321@2100	838	838

Notes:

1. Naturally aspirated engines must be derated 3 percent for each 1,000 ft. [304.8 m] above sea level, and 1 percent for each 10°F [6°C] ambient temperature rise above 60°F [16°C].
2. Turbocharged engines do not require fuel derating below altitude shown in column entitled "Rating @ Altitude Maximum". Above maximum altitude, derate at each 1,000 ft [304.8 m] additional altitude by 4 percent.
3. Crankcase pressure with 3375150 is given in inches of water.
4. See Bulletin No. 3379068-00 for Rated HP @ RPM and fuel rate for derated engines not listed above.
5. Percent of HP @ RPM ratings for break-in phases are established as follows: Phase 1 – 50% HP @ 75% RPM, Phase 2 – 75% HP @ 100% RPM, Phase 3 – 85% HP @ 100% RPM, Phase 4 – 90% HP @ 100% RPM, Power Check – 96% HP @ 100% RPM.

Table 14-15: Normal Lubricating Oil Pressures

Idle Speed PSI [kPa]	Rated Speed PSI [kPa]
15 [103]	50/70 [345 to 483]

Note: Individual engines may vary from above pressures.

Smoke Level

See Service Tool Instructions.

Engine Coolant

After engine is started, add coolant as necessary to completely fill cooling system and replace entrapped air. Coolant should not exceed 200°F [93°C] or drop below 160°F [71°C] during engine operation. Do not turn engine off immediately after a load run. Heat stored in the iron masses will boil coolant in the jackets if air and coolant circulation is immediately stopped while engine is hot. Allow engine to idle for a few minutes before shutting down.

Fuel Pressures

For fuel pressure reading and adjustment, refer to Bulletin No's. 3379101, 3379077 and 3379068.

Overspeed Stop

Overspeed stops, when used, are set to trip and shut off fuel supply when engine exceeds maximum rated speed by approximately 15 percent. After determining and correcting cause of overspeed stop trip, reset in running position.

Engine Fuel Rate

ST-1190 Fuel Consumption Measuring Device operates by drawing fuel from fuel tank, then through flowmeter.

Return fuel from injector drain is routed through float tank so when float tank is filled, float valve opens and allows return fuel flow to flowmeter. Make-up fuel or amount of fuel being consumed by engine will flow through flowmeter thus showing rate of fuel consumption in pounds per hour. See fuel pump calibration manuals.

Blow-By Readings

1. Manometer readings must be taken frequently during run-in test so mechanic will note any blow-by increase at a given speed and load. If there is any indication of blow-by increase, engine speed must be reduced for a few minutes and then brought back to the original setting.

2. During each power check, keep a constant check on the manometer; if pressure rises, more run-in is required. Respective pressure limits for engine running at governed speed and pulling 96 to 100 percent of rated horsepower are given in Table 14-14. If pressure is greater than values listed at end of testing period, engine should be checked as follows:

   a. Naturally aspirated engines: Operate 30 minutes extra at 96 to 100 percent rated load and rpm. If there is no rapid change in excess of 1 inch [25.4 mm] of water and maximum reading does not exceed 100 percent of representative pressure, blow-by is acceptable.

   b. Turbocharged engines: Operate 30 minutes extra at 96 to 100 percent rated load and rpm. If there is no rapid change in excess of 2 inches [50.8 mm] of water and reading does not exceed 100 percent of representative pressure, blow-by is acceptable.

Note: Manometer readings not exceeding 0.3 inch [7.62 mm] surge are desirable.

Chassis Dynamometer Tests

If the engine is installed in equipment, it may be tested on a chassis dynamometer as follows:

1. Check instruments, follow manufacturer's instructions.

2. Run power check on engine as outlined in Table 14-14 up to and including Phase I of the table.

Maintenance of Dynamometer

Follow manufacturer's maintenance instructions to service dynamometer.

Calibrating Instruments

Keep beam or spring scales properly calibrated. Follow manufacturer's recommendation when recalibrating or instrument adjustment is necessary.

In-Chassis Run-In

In-chassis repaired engines should receive run-in equivalent to that on an engine dynamometer. Follow procedure given below after an in-chassis repair or rebuild.

1. Start engine. Idle at 800 to 1000 rpm, no-load for 5 to 10 minutes. Check oil pressure and water circulation. Correct any leaks.

2. Operate at 1/4 to 1/2 throttle for first 5 to 10 hours.

3. Operate at 1/2 to 2/3 throttle for next 45 to 50 hours.

4. After 50 hours of operation, do not operate engine at full load and speed in excess of 5 minutes continuously at any time. After 5 minutes full power run, drop back to 3/4 throttle.

5. During the first 100 hours service:

   a. Do not idle engine for long periods.

   b. Watch instruments closely. Decrease engine rpm if oil temperature reaches 250°F [121°C] or if coolant temperature exceeds 190°F [88°C].

   c. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

6. Check exhaust restrictions (back-pressure) as follows:

   a. Using a mercury or water manometer, take readings when engine is developing maximum horsepower at rated engine speed.

   b. The point of measurement must be as close as possible to the manifold or turbocharger outlet flange in an area of uniform flow such as a straight section of pipe at least one pipe diameter from any changes in flow area or flow direction.

   c. Where it is impossible to locate the point of measurement in a straight section, it is permissible to measure on the side of a bend where flow is uniform and equivalent to flow along the centerline. Do not measure on inside or outside radius of bend as flow is not uniform at these points.

   d. At the point selected, weld a 1/8 inch [3.17 mm] pipe coupling to the exhaust tubing. Drill through tubing with a 1/8 inch [3.17 mm] drill. Remove all burrs. Mount 90 degree Weatherhead fitting to coupling. Then use 3 ft [0.91 m] of 1/8 inch [3.17 mm] inside diameter copper tubing plus 10 ft [3.05 m] of 3/16 inch [4.76 mm] inside diameter soft rubber hose to manometer. (See Note.) The manometer may be mercury filled or water filled.

Note: It is important that line to manometer be as specified to minimize variation in reading due to a standing wave phenomenon which occurs in manometer line. A change in length or material of this line can significantly change reading obtained.

   e. Start engine and operate until oil temperature reaches 140°F [60°C].

   f. Add reading of mercury in both columns for final figure.

Example: If mercury is 1 inch [25.4 mm] high in left column and 1 inch [25.4 mm] low in right column, you have 2 inches [50.8 mm] of pressure. If the mercury is 1 inch [25.4 mm] high in the right column and 1 inch [25.4 mm] low in the left column, you have 2 inches [50.8 mm] of vacuum.

   g. Maximum permissible back-pressure is 3.0 inches [76 mm] Hg or 40.7 inches [1.04 m] water.

7. Check smoke level.

Torque Convertor Governor (PTR Fuel Pump)

When a torque converter is used to connect engine with its driven unit, an auxiliary governor may be driven off torque converter output shaft to exercise control over engine governor and limit converter output shaft speed. The engine governor and converter governor must be adjusted to work together. See PTR Fuel Pump Manual, Bulletin No. 3379101.

Aneroid Control Adjustment

The aneroid bellows spring is preset and sealed at Cummins Engine Company, Inc. The following adjustment can be made while the engine is on a dynamometer.

1. Start engine and check idle speed. In most cases, idle will be low and must be adjusted upward with fuel pump governor idle screw.

2. Check engine rated power and speed. If smoke is not excessive during first 15 seconds of full throttle operation, but becomes excessive thereafter, aneroid is not at fault.

3. Check fuel system and turbocharger before readjusting aneroid control.

4. If hard starting is encountered, the aneroid pressure valve may be sticking in open position, closed position will result in excessive smoke. Replace if necessary. See Bulletin No. 3379068 for adjustment procedure.

Paint Engine

1. Prior to painting, clean surface for maximum paint adherence. Dry with compressed air.

2. Cover all openings, pulley grooves, instrument faces and belts. Cover all dataplates, exposed threads, wire terminals, hose fittings and pipe openings with water proof paper or tape.

3. Cover clutch contact surface on flywheel with anti-rust compound, if engine is not going into immediate service.

4. Spray outside surfaces of castings and corrodible parts with a primer coat of yellow lacquer to serve as a base for the second coat of engine enamel.

Engine Storage

On any engine not in service, the unpainted machined surfaces are subject to rust and corrosion. The rate of corrosion varies with climatic conditions. An engine stored in a climate with a high amount of moisture in the air will corrode more rapidly than an engine stored in a dry climate.

Temporary Storage

If an engine remains out of service for three or four weeks (maximum six months), special precautions should be taken to prevent rust. The operations listed below are required to minimize or prevent damage to temporarily stored engines.

1. Engine must be started and operated until thoroughly warm. Disconnect fuel lines to engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil.

2. Start engine with fuel line to filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After engine is running smoothly, switch fuel line to container with preservative oil. Operate 5 to 10 minutes on preservative oil. Stop engine and reconnect the fuel lines.

3. Drain oil sump, fuel filters and fuel tank and reinstall drain plugs. Sump may remain empty until engine is ready for use, tag engine with warning tag.

4. Disconnect electrical wiring and turn fuel pump manual shut-off valve fully counterclockwise. Spray lubricating oil into intake manifold and air compressor while cranking engine slowly.

5. Cover all openings with tape to prevent entrance of dirt and moisture.

6. Drain coolant from cooling system unless it is permanent type antifreeze with rust inhibitor added.

7. Store engine in dry and uniform temperature area.

8. Bar engine crankshaft two or three revolutions each three to four weeks.

Permanent Storage

1. When engine is to be stored six months or more, the lubricating system, cooling system, fuel system, crankcase and external parts must be protected against rust and corrosion.

2. Start engine and operate at fast idle until the engine is thoroughly warm. Stop engine and drain old oil.

3. Fill crankcase to full mark on bayonet gauge or dipstick with preservative oil, U.S. Military Specification MIL-L-21250, Type P-10, Grade 2 SAE 30. This specification may be obtained as Shell-Brand Code 66202, or equivalent.

4. Disconnect fuel lines to engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil U.S. Military Specification MIL-L-644, Type P-9. Preservative oil to this specification is Daubert Chemical Co., Nox-Rust No. 518 or equivalent. Contact Daubert Chemical, Chicago, Illinois.

5. Start engine with fuel line to filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After engine is running smoothly, switch fuel line to container with preservative oil. Operate 5 to 10 minutes on the preservative oil. Stop the engine and reconnect the fuel lines.

6. Drain oil sumps of pumps, compressors, coolers, filters and crankcase, etc. Replace all plugs after draining.

7. Remove intake and exhaust manifold. Spray all intake and exhaust ports, including air compressor intake port, with preservative oil. Replace intake and exhaust manifolds.

8. Inspect cooling system; if coolant is contaminated, drain and flush, fill with rust preventive compound.

9. If air starter is used, remove exhaust plate, spray with preservative oil and replace plate. Loosen V-belt tension.

10. Brush or spray a film of rust preventive compound on all exposed, unpainted surfaces of engine. Use a rust preventive conforming to Type P-2, Grade 1 or 2, U.S. Military Specification MIL-C–16173C. Remove cylinder head covers and spray rocker levers, valve stems, springs, guides, crossheads and push tubes. Replace cover.

11. Cover all engine openings with heavy paper and tape. Tag engine to indicate that it has been treated with preservatives and crankshaft should not be barred over. Tag should show coolant has been removed, date of treatment and indicate that engine is not ready to run.

12. Store engine in an area where air is dry and temperature uniform.

Note: Engines in storage more than 24 months should be flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventive materials. Periodically inspect engines for rust or corrosion. Take corrective action if necessary.

13. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean, the accumulated deposits should be removed after being allowed to settle.

Preparing A Stored Engine For Service

When an engine is removed from storage and put into service, the following operations should be performed.

Clean Engine

1. Clean accumulated dirt from exterior of engine. Remove covers, tape and wrappings.

2. Use suitable cleaner to remove rust preventive compound from unpainted surfaces.

3. Refill crankcase with clean lubricating oil. Flush and fill cooling system.

Inspection

1. When an engine has been stored for six months or less, it is necessary to adjust injectors, valves and belts, tighten cylinder head capscrews and connections; replace filters and check air filter and screens.

2. When an engine has been stored for six months or more, the following procedure should be followed:

   a. Flush fuel system with clean fuel oil until all preservative oil is removed.

   b. Remove plug from oil gallery and force hot, light mineral oil through the oil passages to flush away all preservative oil. Bar over engine crankshaft three or four revolutions during flushing operation.

   c. Replace all filters and clean all screens before engine is started.

   d. After inspecting engine and parts, make sure all preservative oil and gummed oil has been flushed away. Start engine as described in Engine Testing. See Page 14.

Instructions For Use of Service Tools

Smoke Level Check with ST-1294 Model 101B Celesco Opacity Meter

1. Engine must be at normal oil operating temperature.

2. Apply dynamometer load as rpm is increased; (shift to direct drive gear when chassis dynamometer is used) until rated rpm and horsepower is reached and load is stabilized.

3. Using 0-20 scale on opacity meter, zero the meter and place on exhaust stack(s); record readings. Remove meter after readings are completed.

Note: An accurate smoke reading can usually be obtained in 10 to 15 seconds.

4. Increase load until rpm is reduced to 60 percent of rated rpm.

5. Recheck zero on opacity meter, place on exhaust stack(s); record readings and remove meter.

6. Reduce load and rpm.

7. Accelerate engine to rated rpm, no load (when chassis dynamometer is used shift to a lower gear that would allow full acceleration in approximately 3 to 5 seconds). Return to idle.

8. Using 0-100 scale on opacity meter, zero the meter and place on exhaust stack(s).

9. Accelerate to rated rpm, no load; record the highest opacity reading. Remove meter.

Note: When rechecking zero during a test and the readjustment to zero is off by more than two (2) percent, clean lenses on opacity meter before rezeroing the scale.

Federal tests require averaging five (5) one-half (1/2) second smoke peak intervals for lug down tests and fifteen (15) second smoke peak intervals for acceleration, to determine smoke levels. Consult Local Air Pollution Agency for environmental regulations covering smoke opacity limits.

Group 15

Instruments and gauges show at all times how to get the most satisfactory service from an engine. Safety controls are used on Cummins Engines to shut down the engine because of high coolant temperature, low or loss of lubricating oil pressure and engine speeds above rated rpm.

Instrument and Control

Tachometer

The tachometer indicates the engine speed in revolutions per minute. Properly used, the tachometer can help save fuel and unnecessary maintenance and can detect problems in the engine speed governor.

Rated engine speed is the rpm attained at maximum power. Governed engine speed is the highest rpm a properly adjusted governor will allow the engine to turn, no load. Governed engine speed must never be exceeded on down-grades or any other condition in which the load drives the engine.

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

Oil Temperature Gauge

The oil temperature gauge normally should read between 180°F [82°C] and 225°F [116°C] for best lubrication. 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.

Water Temperature Gauge

A water temperature of 165 to 195°F [74 to 91°C] is the best assurance that cylinder liners are heated to the proper temperature to support good combustion and that working parts of the engine have expanded evenly to the most favorable oil clearances.

Overheating problems require mechanical correction. They may be caused by loose water pump or fan belts, a clogged cooling system, or insufficient radiator capacity. Report cases of overheating to the maintenance department for correction. 200°F [93°C] maximum engine coolant temperature should not be exceeded.

Oil Pressure Gauge

The oil pressure gauge indicates the pressure of oil reaching the bearings and other moving engine parts. A drop in oil pressure indicates a drop in lubricating oil level, mechanical malfunction in the lubricating oil system, or engine bearing failure. The operator should note loss of oil pressure immediately and shut down the engine before serious engine damage results. Individual engines may vary from normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition.

These gauges are not normally supplied by Cummins Engine Company, Inc.; therefore, removal and installation is not covered in this manual.

Nason Safety Controls

The Nason (formerly Hawk) Safety Control System provides protection from low lubricating oil pressure and excessively high coolant temperature of preset values. When either is exceeded, the controls disrupt the electrical circuit to the fuel solenoid shut-down valve and shuts down the engine. The oil pressure safety control is mounted directly in the main oil gallery. The temperature

safety control mounts directly into the water manifold.

During cranking of engine a permissive start switch is used to by-pass the low lubricating oil pressure safety control. Actual cranking is accomplished by use of a push button type starting switch wired into the cranking circuit.

Group 16

The mounting adaptations groups consists of the flywheel, flywheel housing and recommendations for the installation of marine gears and driven units such as transmissions, torque converters, etc.

Mounting Adaptations

Flywheel and Ring Gear

Flywheel Inspection

Flywheels should be inspected for cracks anytime they are removed from engine.

Magnetic Crack Detection

Inspect the flywheel for cracks using the ST-1166 Magnetic Crack Detector.

1. Remove keeper bar from magnet poles.
2. Place magnet on areas being inspected.
3. Spray a moderate amount of powder on area to be checked. Blow off excess powder with low pressure air. Powder will remain in cracks and will show as a white line.

Note: When dispensing powder, hold thumb partially over spray head to keep cap from blowing off.

If any cracks are discovered in the bolt circle area, the flywheel should not be reused.

Flywheels driving clutches may have heat cracks or checks in the clutch face area. These cracks or checks may be removed by machining.

1. The flywheel may not be machined to less than 5/8 inch [15.87 mm] in thickness and static balance must be maintained to 2 inch ounces [1440 gmm] or less.
2. NO machining may be done within a 4 inch [101.6 mm] radius of the center of the flywheel.

Replacement of Flywheel Ring Gears

Inspection and Removal

1. Inspect ring gear for broken or cracked teeth.
2. If replacement is necessary, drive gear from flywheel with blunt chisel.

Replacement

1. If an oven with a heat control is not available, heat gear with a heating torch – **not a cutting torch** – from inside diameter so heat travels outward to teeth.
2. Use a 600°F [316°C] Tempilstick crayon or equivalent to determine amount of heat applied. Stroke gear several times while applying heat. The crayon will leave a chalk mark until temperature is reached then a liquid smear. Overheating will soften gear.
3. Place ring gear on flywheel and quickly drive on until firmly seated.
4. No attempt should be made to remachine flywheels in a shop that is not equipped to maintain factory standards both as to dimensions and static balance. The static balance tolerance of flywheels is 2 inch ounce [1440 gmm] maximum. Never reface flywheel beyond point where clutch face is less than 5/8 inch [15.88 mm] thick.

Marine Gear

The most important precaution to insure satisfactory operation of a marine reverse gear is to make sure that the closest possible alignment is provided between engine crankshaft and marine gear.

Alignment with Crankshaft

Improper alignment will result in undue wear because of excessive stress on parts in both the clutch and the reverse gear mechanism.

1. Check the flywheel housing and see that it is the one specified for use with marine gear.
2. Make sure that flywheel housing and flywheel are assembled as directed in Group 14.

Assembly to Engine

The marine gear and clutch assembly are assembled to engine as one unit.

1. Remove small cover plate atop clutch housing.
2. Install two studs in flywheel housing to act as guides during installation of marine gear.
3. Assemble marine gear to engine. Install bolts and secure loosely. Gear clutch plate must pilot in flywheel housing before bolts are tightened.
4. Tighten bolts alternately until secure.
5. For additional details refer to the maintenance manual pertinent to gear being used and follow manufacturer's recommendations.

Assembly to Boat

1. Whenever possible, it is recommended that the new marine gear be assembled to engine before it is installed in boat.
2. After entire assembly has been set on its foundation, it must be properly aligned with propeller shaft. Make this alignment without pulling support brackets on marine gear out of position. It is recommended that clearance for shimming be provided at this point. Recheck alignment after engine foundation bolts have been tightened and then carefully shim up under marine gear support bracket.
3. Experience has shown that hulls often change shape after boat is launched; recheck and correct alignment, if necessary, with boat in water. This can be accomplished by removing the bolts in propeller shaft coupling and checking spacing of the two flanges on the circumference. For satisfactory alignment, variation should not exceed 0.004 inch [0.10 mm]. Fig. 16-1.

Crankshaft End Clearance

Due to variations in characteristics of various types of drives and engines involved, there are no established standards to be followed and each drive must be evaluated individually.

Note: Crankshaft end clearance must be maintained after assembly of driven unit to engine.

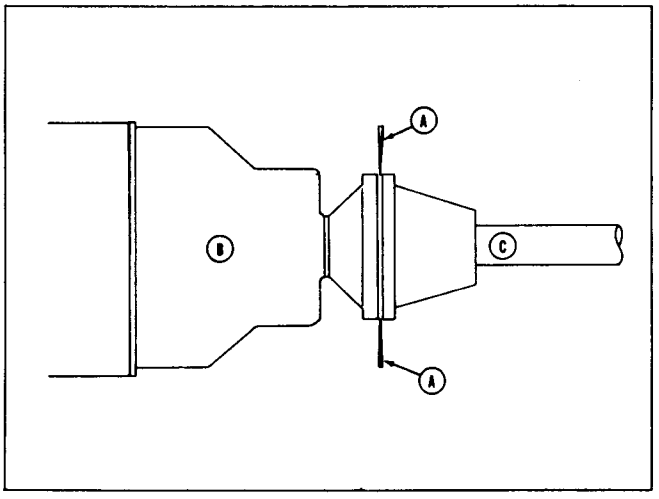


Fig. 16-1, (V11967). Checking alignment between marine gear and propeller shaft

Group 18

Worn limits as stated in this manual indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. All engine models are the same unless otherwise stated. Limits are given in U.S. and metric measurements. All metric units are enclosed in brackets [ ].

Wear Limits, Specifications and Torque

Group 1: Cylinder Block Specifications – Inch [mm]

		2 Inch Cam Engines			2-1/2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
1.	**Camshaft Bushing**						
	Inside Diameter	**2.0015 [50.838]**	1.999 [50.775]	2.0005 [50.813]	**2.5008 [63.520]**	2.4983 [64.357]	2.4998 [63.495]
	Camshaft Bushing Bore						
	Inside Diameter	**2.1305 [54.115]**	2.1285 [54.064]	2.1295 [54.089]	**2.6265 [66.721]**	2.6245 [66.662]	2.6255 [66.688]
2.	**Cylinder Liner Counterbore**						
	Inside Diameter		6.5615 [166.662]	6.5635 [166.713]			
	Depth	**0.412 [10.46]**	0.350 [8.89]	0.352 [8.94]			
	Liner to Block Clearance						
	Lower Bore		0.002 [0.05]	0.006 [0.15]			
	Lower Liner Bore						
	Inside Diameter		6.124 [155.55]	6.126 [155.60]			
3.	**Main Bearing Bore**						
	Inside Diameter	**4.7505 [120.663]**	4.7485 [120.612]	4.750 [120.650]			
4.	**Block Ref. Fig. 1-2**						
	Height from Main Bearing Centerline	**18.994 [482.45]**	19.003 [482.68]	19.007 [482.78]			
	Height from Installed Alignment Bar	**16.619 [422.12]**	[6.628] [422.35]	[6.632] [422.45]			
5.	**Cylinder Liner**						
	Inside Diameter	**5.505 [139.83]**	5.4995 [139.687]	5.501 [139.73]			

Note: New cylinder liners dimensions at 60 to 70°F [16 to 21°C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.

Group 1: Cylinder Block Specifications – Inch [mm] (Cont'd.)

		2 Inch Cam Engines			2-1/2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
	Protrusion (Installed)		0.003 [0.08]	0.006 [0.15]			
6.	**Crankshaft**						
	Connecting Rod Journal Outside Diameter	**3.122 [80.30]**	3.1235 [79.337]	3.125 [79.38]			
	Main Bearing Journal Outside Diameter	**4.4975 [114.237]**	4.4985 [114.262]	4.500 [114.30]			
	Thrust Bearing Surface to Rear Counterweight	**3.006 [76.35]**	3.001 [76.23]	3.003 [76.28]			
	Main and Rod Journals Out-of-round T.I.R.**	**0.002 [0.05]**					
	Main and Rod Journal Taper (Length of Journal)	**0.0005 [0.013]**					
	**T.I.R. – Total Indicated Runout						
7.	**Main Bearings**						
	Shell Thickness	**0.1215 [3.086]**	0.123 [3.12]	0.1238 [3.145]			
	Journal Clearance	**0.007 [0.18]**	0.0015 [0.038]	0.005 [0.13]			
8.	**Rod Bearings*** **						
	Shell Thickness	**0.071 [1.80]**	0.0724 [1.839]	0.0720 [1.852]	**0.093 [2.36]**	0.0942 [2.393]	0.0947 [2.405]
	*** Also available in 0.010, 0.020, 0.030 and 0.040 inch undersize.						
9.	**Crankshaft Thrust Ring**						
	157280 Std.						
	Thickness	*	0.245 [6.22]	0.247 [6.27]			
	157281 0.010 O.S.						
	Thickness [0.25]	*	0.255 [6.48]	0.257 [6.53]			
	157282 0.020 O.S.						
	Thickness [0.51]	*	0.265 [6.73]	0.267 [6.78]			
	*Use Crankshaft End Clearance						
10.	**Crankshaft End Clearance**						
	End Clearance (Installed)	**0.022 [0.56]**	0.007 [0.18]	0.017 [0.43]			
11.	**Connecting Rod**						
	Crankpin Bore Inside Diameter		3.2725 [83.122]	3.2730 [83.134]		3.3160 [84.226]	3.3165 [84.239

Group 1: Cylinder Block Specifications – Inch [mm] (Cont'd.)

		2 Inch Cam Engines			2-1/2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
	Center to Center Length		11.998 [304.75]	12.000 [304.80]			
	Piston Pin Bushing						
	Inside Diameter	**2.002 [50.856]**	2.001 [50.83]	2.0015 [50.838]			
	Connecting Rod						
	Bend	**0.008**		0.008			
	Without Bushing	**[0.20]**		[0.20]			
	Bend	**0.004**		0.004			
	With Bushing	**[0.010]**		[0.010]			
	Twist	**0.020**		0.020			
	Without Bushing	**[0.51]**		[0.51]			
	Twist	**0.010**		0.010			
	With Bushing	**[0.25]**		[0.25]			
	Connecting Rod Bolt						
	Minimum Outside Diameter	**0.540 [13.72]**	0.541 [13.74]	0.545 [13.84]			
	Pilot Outside Diameter	**0.6242 [15.855]**	0.6245 [15.862]	0.6250 [15.875]			
	Connecting Rod Capscrew						
	Minimum Outside Diameter	**0.583 [14.81]**	0.584 [14.83]	0.590 [14.99]			
	Cap Outside Diameter	**0.637 [16.18]**	0.638 [16.21]	0.643 [16.33]			
	Bolt Hole Pilot (2 Bolt Rods)						
	Rod	**0.6249 [15.872]**	0.6243 [15.857]	0.6248 [15.870]			
	Cap	**0.6252 [15.880]**	0.6246 [15.865]	0.6251 [15.878]			
	Dowel and Pilot (2 Capscrew Rod)						
	Dowel Diameter		0.3127 [7.943]				
	Rod Dowel Hole		0.3128 [7.945]	0.3133 [7.958]			
	Dowel Protrusion		0.220 [5.59]	0.250 [6.35]			
	Dowel Press-Fit in Cap		0.0001 [0.003]	0.0006 [0.015]			
12.	**Piston**						
	Skirt Diameter at 70°F [21°C]	**5.483 [139.27]**	5.487 [139.37]	5.488 [139.40]			
	Piston Pin Bore						
	Inside Diameter at 70°F [21°C]	**1.999 [50.775]**	1.9985 [50.762]	1.9989 [50.772]			

Group 1: Cylinder Block Specifications – Inch [mm] (Cont'd.)

		2 Inch Cam Engines			2-1/2 Inch Cam Engines		
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum	Worn Limit	New Minimum	New Maximum
13.	**Piston Pin**						
	Outside Diameter	**1.9985 [50.762]**	1.9988 [50.770]	1.9990 [50.775]			
14.	**Piston Ring**						
	Part No. 147670						
	Gap in Ring Travel Area of Liner	*	0.023 [0.58]	0.033 [0.85]			
	132880						
	Gap in Ring Travel Area of Liner	*	0.019 [0.48]	0.029 [0.74]			
	214730						
	Gap in Ring Travel Area of Liner	*	0.019 [0.48]	0.029 [0.74]			
	218732						
	Gap in Ring Travel Area of Liner	*	0.010 [0.25]	0.025 [0.64]			
	*Add 0.003 inch [0.08 mm] ring gap to new maximum limit for each 0.001 inch [0.03 mm] wear in cylinder liner wall inside diameter.						
15.	**Camshaft Journal**						
	Outside Diameter	**1.996 [50.70]**	1.997 [50.72]	1.998 [50.75]	**2.495 [63.37]**	2.496 [63.40]	2.497 [63.42]
	Thrust Bearing						
	Thickness	**0.083 [2.11]**	0.093 [2.36]	0.098 [2.49]			
	Support Bushing						
	Inside Diameter	**1.370 [34.80]**	1.3725 [34.862]	1.3755 [34.938]			
	Outboard Bearing Support						
	Inside Diameter	**1.757 [44.63]**	1.751 [44.48]	1.754 [44.55]			
16.	**Gear Case Cover**						
	Accessory Drive Bushing						
	Part No.						
	213820 Std						
	Inside Diameter	**1.571 [39.90]**	1.565 [39.75]	1.569 [39.85]			
	213821 0.010 U.S. [0.25]						
	Inside Diameter	**1.561 [39.65]**	1.555 [39.50]	1.559 [39.60]			
	213822 0.020 U.S. [0.51]						
	Inside Diameter	**1.551 [39.40]**	1.545 [39.24]	1.549 [39.34]			
	200822 Std (NTA Series)						
	Inside Diameter	**1.7585 [44.666]**	1.7525 [44.513]	1.7565 [44.615]			

Group 1: Cylinder Block Specifications – Inch [mm] (Cont'd.)

Torque Specifications ft-lbs [N•m]

		Minimum	Maximum
17.	**Pipe Plug Size**		
	1/8	15 [20]	20 [27]
	1/4	30 [41]	35 [47]
	3/8	35 [47]	45 [61]
	1/2	45 [61]	55 [75]
	3/4	60 [81]	70 [95]
	1-1/4	75 [102]	85 [115]
	1-1/2	90 [122]	100 [136]
18.	**Main Bearing Capscrews**		
	Step 1. Tighten to	140 [190]	150 [203]
	Step 2. Advance to	300 [407]	310 [420]
	Step 3. Loosen	All	All
	Step 4. Tighten to	140 [190]	150 [203
	Step 5. Advance	300 [407]	310 [420]

Torque Specifications ft-lbs [N•m]

		Minimum	Maximum
19.	**Connecting Rod Nuts or Capscrews**		
	Step 1. Tighten to	70 [95]	75 [102]
	Step 2. Advance to	140 [190]	150 [203]
	Step 3. Loosen	All	All
	Step 4. Tighten to	25 [34]	30 [41]
	Step 5. Tighten to	70 [95]	75 [102
	Step 6. Advance to	140 [190]	150 [203]

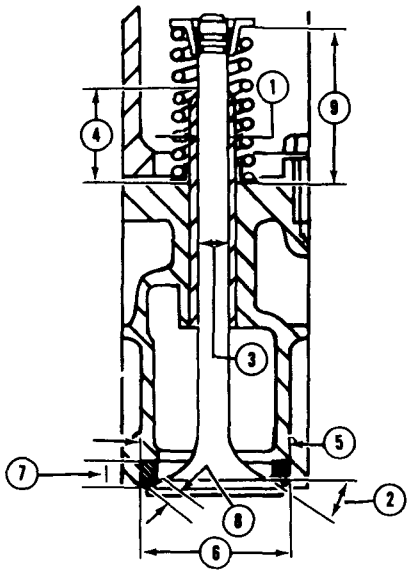
*For torquing sequence see Fig. 1-11.

Group 2: Specifications – Inch [mm]

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1.	**Cylinder Head**			
	Height	**4.340 [110.24]**	4.370 [111.00]	4.380 [111.25]
2.	**Valve, Stem**			
	Outside Diameter	**0.449 [11.41]**	0.450 [11.43]	0.451 [11.46]
	Face Angle		30 degree	30 degree
3.	**Valve Guide**			
	Inside Diameter	**0.455 [11.56]**	0.4525 [11.494]	0.4532 [11.511]

Group 2: Specifications – Inch [mm] (Cont'd.)

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
	Assembled Height		0.270 [32.36]	0.280 [32.51]			
4.	**Valve Seat Insert***						
	Outside Diameter		2.0025 [50.84]	2.0035 [50.889]			
	Cylinder Head						
	Inside Diameter		1.9995 [50.787]	2.0005 [50.813]			
	Insert Height		0.278 [7.06]	0.282 [7.16]			
	Run Out in 360 Degree	**0.002 [0.05]**					
	Refaced Seat Width		0.063 [1.59]	0.125 [3.18]			
5.	**Valve Spring****						
	Assembled Height			2.250 [57.15]			



*See Ref. No. 8 for oversize valve seat inserts.
**See Ref. No. 9 for valve spring data.

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
6.	**Crosshead Guide**						
	Outside Diameter	**0.432 [10.97]**	0.433 [11.00]	0.4335 [11.011]			
	Assembled Height		1.860 [47.24]	1.880 [47.74]			
	Crosshead Bore	**0.440 [11.18]**	0.434 [11.02]	0.436 [11.07]			
7.	**Injector Sleeve**						
	Tip Protrusion		0.060 [1.52]	0.070 [1.78]			

8. Valve Seat Insert Part No.	Oversize Diameter	Oversize Depth	Insert O.D.	Cylinder Head I.D.	Insert Thickness
127935	0.005	Std.	2.0075/2.0085 [50.991/51.016]	2.0045/2.0055 [50.914/50.940]	0.278/0.282 [7.06/7.16]
127931	0.010	Std.	2.0125/2.0135 [51.118/51.143]	2.0095/2.0105 [51.041/51.067]	0.278/0.282 [7.06/7.16]
127932	0.020 [0.50]	0.005 [0.13]	2.0225/2.0235 [51.372/51.397]	2.0195/2.0205 [51.205/51.321]	0.283/0.282 [7.19/7.29]

Group 2: Specifications – Inch [mm] (Cont'd.)

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	New Minimum	New Maximum	2-1/2 Inch Cam Engines Worn Limit	New Minimum	New Maximum
	127933	0.030 [0.76]	0.010 [0.25]	2.0325/2.0335 [51/626/51.651]	2.0295/2.0305 [51.549/51.575]		0.288/0.292 [7.32/7.42]
	127934	0.040 [1.02]	0.015 [0.38]	2.0425/2.0435 [51.880/51.905]	2.0395/2.0405 [51.803/51.829]		0.293/0.297 [7.44/7.54]

Be sure to measure insert before machining head or installing insert in head.

9. **Valve Spring Data**

Valve Spring Part No.	Approximate Free Length Inch [mm]	No. Coils	Wire Diameter Inch [mm]	Length Inch [mm]	Required Load for Length Lb [N] Worn Limit	Lb [N] New Minimum	Lb [N] New Maximum
211999	2.685 [68.20]	9	0.177 [4.50]	1.724 [43.79]	**143 [636]**	147.25 [655]	162.75 [724]
178869	2.290 [74.17]	9.5	0.177 [4.50]	1.765 [44.83]	**150 [667]**	155 [689]	189 [841]

10. **Cylinder Head Pipe Plug Torque – ft-lbs [N•m]**

Plug Size	Minimum	Maximum
1/16 inch	3 [4]	6 [8]
1/8 inch	5 [7]	10 [14]
3/8 inch	35 [47]	45 [61]
1/2 inch	60 [81]	70 [95]
3/4 inch	65 [88]	75 [102
1 inch	135 [183]	145 [197]

Group 3: Specifications – Inch [mm]

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	New Minimum	New Maximum	2-1/2 Inch Cam Engines Worn Limit	New Minimum	New Maximum
1.	**Bushing** Inside Diameter	**1.1286 [28.664]**	1.1245 [28.562]	1.1275 [28.639]			
2.	**Shaft** Outside Diameter	**1.122 [28.50]**	1.123 [28.52]	1.124 [28.55]			

Group 4: Specifications — Inch [mm]

Ref. No.	Measurement	2 Inch Cam Engines Worn Limit	2 Inch Cam Engines New Minimum	2 Inch Cam Engines New Maximum	2-1/2 Inch Cam Engines Worn Limit	2-1/2 Inch Cam Engines New Minimum	2-1/2 Inch Cam Engines New Maximum
1.	**Shaft**						
	Outside Diameter	**0.748**	0.7485	0.749	**0.748**	0.7485	0.749
		[19.00]	[19.012]	[19.02]	**[19.00]**	[19.012]	[19.02]
2.	**Bushing**						
	Inside Diameter	**0.7515**	0.7495	0.7505	**0.752**	0.7501	0.7511
		[19.088]	[19.037]	[19.063]	**[19.10]**	[19.053]	[19.078]
3.	**Injector Cam Roller**						
	Inside Diameter	**0.505**	0.503	0.504	**0.705**	0.703	0.704
		[12.83]	[12.78]	[12.80]	**[17.91]**	[17.86]	[17.88]
	Outside Diameter	**1.2485**	1.2495	1.2505	**1.2485**	1.2495	1.2505
		[31.71]	[31.73]	[31.76]	**[31.71]**	[31.73]	[31.76]
4.	**Valve Cam Rollers**						
	Inside Diameter	**0.503**	0.5005	0.5015	**0.503**	0.5005	0.5015
		[12.78]	[12.713]	[12.73]	**[12.78]**	[12.773]	[12.708]
	Outside Diameter	**1.248**	1.2495	1.2505	**1.2485**	1.2495	1.2505
		[31.71]	[31.73]	[31.76]	**[31.71]**	[31.73]	[31.76]
5.	**Cam Roller Pin Diameter**						
	Valve	**0.497**	0.4995	0.500	**0.497**	0.4995	0.500
		[12.62]	[12.687]	[12.70]	**[12.62]**	[12.687]	[12.70]
	Injector	**0.497**	0.4995	0.500	**0.697**	0.6995	0.7000
		[12.62]	[12.687]	[12.70]	**[17.70]**	[17.767]	[17.780]

Push Tube Length — Inch [mm]

	2 Inch Cam	2-1/2 Inch Cam
Injector	18.290 [464.57]	17.775 [451.49]
	18.320 [465.32]	17.805 [452.25]
Valve	18.360 [466.34]	17.880 [454.15]
	18.390 [467.11]	17.910 [454.91]

Group 7: Hose Size

Location	Minimum Hose Size
Turbo Oil Supply	No. 6
Full-Flow Filter	No. 16
Turbo Oil Drain	No. 16
By-Pass Filter	See Page 7-10

Group 7: Hose Bends — Inch [mm] (Teflon-Lined)

Hose Size	Inside Dia.		Outside Dia.		Minimum Bend Radius	
6	5/16	[7.94]	39/64	[15.48]	4	[101.60]
16	7/8	[22.23]	1-13/64	[30.56]	7-3/8	[187.33]

Group 7: Hose Bends — Inch [mm] (Rubber-Lined)

Hose Size	Inside Dia.		Outside Dia.		Minimum Radius	
4	3/16	[4.76]	31/64	[12.30]	2	[50.80]
5	1/4	[6.35]	35/64	[13.89]	2-1/4	[57.15]
6	5/16	[7.94]	39/64	[15.48]	2-3/4	[69.85]
8	13/32	[10.32]	47/64	[18.65]	4-5/8	[117.48]
10	1/2	[12.70]	53/64	[21.03]	5-1/2	[139.70]
12	5/8	[15.87]	61/64	[24.21]	6-1/2	[165.10]
16	7/8	[22.23]	1-13/64	[30.56]	7-3/8	[187.34]
20	1-1/8	[28.58]	1-31/64	[37.70]	9	[228.60]
24	1-3/8	[34.93]	1-23/32	[43.66]	11	[279.40]

Group 7: Lubricating Oil Pump Specifications – Inch [mm]

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Single Lubricating Oil Pump			
1.	**Bushings**			
	Inside Diameter	**0.6185 [15.710]**	0.6165 [15.659]	0.6175 [15.684]
2.	**Idler and Drive Shaft**			
	Outside Diameter	**0.6145 [15.608]**	0.615 [15.62]	0.6155 [15.634]
	Drive Gear to Body			
	Clearance	**0.012 [0.30]**		
	Drive Shaft			
	End Play		0.002 [0.05]	0.005 [0.13]
	Idler Shaft			
	Shaft Protrusion Inside Body		0.720 [18.29]	0.740 [18.80]
	Driven Gear/Drive Shaft			
	Shaft Prctrusion		0.855 [21.72]	0.875 [22.22]
	Single Double Capacity Lubricating Oil Pump			
1.	**Bushings**			
	Inside Diameter	**0.879 [22.33]**	0.8767 [22.268]	0.8777 [22.293]
2.	**Idler and Drive Shaft**			
	Outside Diameter	**0.874 [22.17]**	0.8745 [22.212]	0.875 [22.22]
	Drive Gear to Body			
	Clearance	**0.012 [0.30]**		
	Drive Shaft			
	End Play		0.002 [0.05]	0.008 [0.20]
	Idler Shaft			
	Shaft Protrusion Above Body to Cover Face			0.955 [24.26]
	Driven Gear/Drive Shaft			
	Shaft Protrusion		1.035 [26.29]	1.055 [26.80]
3.	**Piston Cooling Oil Tube**			
	Protrusion Above Body Mounting Face		2.970 [75.44]	3.000 [76.20]
	Double Lubricating Oil Pump			
1.	**Bushings**			
	Inside Diameter	**0.6185 [15.710]**	0.6165 [15.659]	0.6175 [15.684]
2.	**Idler and Drive Shaft**			
	Outside Diameter	**0.6145 [15.608]**	0.615 [15.02]	0.6155 [15.634]

Group 7: Lubricating Oil Pump Specification – Inch [mm] (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Drive Gear to Body			
	Clearance	**0.012**		
	Suffix Letter L	**[0.30]**		
	Drive Shaft			
	End Play		0.004	0.007
			[0.10]	[0.18]
	Idler Shaft			
	Shaft Protrusion Above Back		2.600	2.620
	Surface of Body		[66.04]	[66.55]
	Idler Shaft			
	Suffix Letter L		2.680	2.690
			[68.07]	[68.33]
	Drive Gear/Drive Shaft			
	Shaft Protrusion		0.040	0.060
			[1.02]	[1.52]
	Single Scavenger Pump			
1.	**Bushings**			
	Inside Diameter	**0.6185**	0.6165	0.6175
		[15.710]	[15.659]	[15.684]
2.	**Idler and Drive Shaft**			
	Outside Diameter	**0.6145**	0.615	0.6155
		[15.608]	[15.62]	[15.634]
	Idler Shaft			
	Protrusion	Flush with front surface of pump		
	Driven Gear/Drive Shaft			
	Protrusion		0.580	0.610
			[14.73]	[15.49]
	Coupling Dowels			
	Protrusion Above Coupling		0.990	1.010
	Face		[25.15]	[25.65]
	Coupling/Drive Shaft			
	Shaft Protrusion		0.050	0.070
			[1.27]	[1.78]
	Drive Shaft			
	End Play		0.004	0.010
			[0.10]	[0.25]
	Double Scavenger Pump			
1.	**Bushings**			
	Inside Diameter	**0.841**	0.840	0.8405
		[21.36]	[21.34]	[21.349]
2.	**Idler and Drive Shaft**			
	Outside Diameter	**0.837**	0.8375	0.838
		[21.26]	[21.272]	[21.29]

Group 7: Lubricating Oil Pump Specifications – Inch [mm] (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Idler Shaft			
	Protrusion	Flush with front surface of pump		
	Driven Gear/Drive Shaft			
	Protrusion		0.580 [14.73]	0.610 [15.49]
	Coupling Dowels			
	Protrusion Above Coupling Face		0.990 [25.15]	1.010 [25.65]
	Coupling/Drive Shaft			
	Shaft Protrusion		0.050 [1.27]	0.070 [1.78]
	Drive Shaft			
	End Play		0.004 [0.10]	0.010 [0.25]
	Filter/Cooler Pressure Regulator Spring			
	Free Length			3.410 [86.36]
	Load at 2.125 inch [53.98 mm] lb [N]		45 [200]	50 [222]
	Recommended Oil Pressure psi [kPa]		50 [345]	70 [483]

Group 8: Cooling System Specifications – Inch [mm]

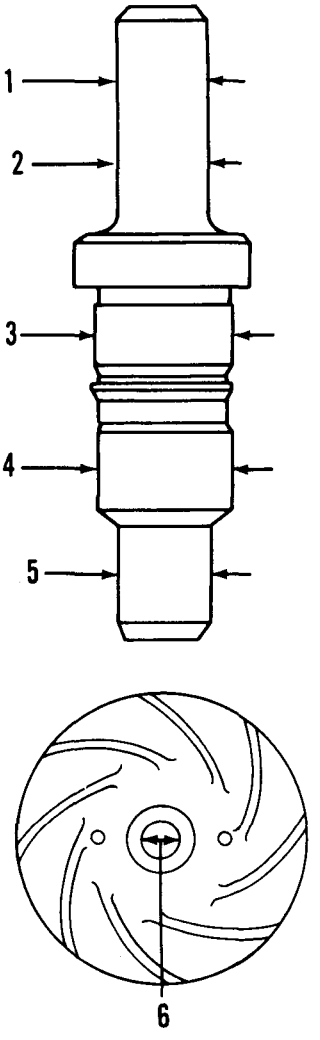
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1.	**Water Pump**			
	Impeller to Shaft Press-Fit	**0.001 [0.03]**		
	Impeller to Body Clearance		0.020 [0.51]	0.040 [1.02]
2.	**Fan Hub**			
	End Clearance		0.003 [0.08]	0.016 [0.40]
	Bearing to Shaft Press-Fit		0.000 [0.00]	0.001 [0.03]

3.	**Thermostats**	**Operating Range**		**Opening Travel**
	Ventless, By-Pass*	175°F [79°C]	195°F [91°C]	0.375 inch minimum [9.53 mm] minimum

*Other Temperature Ranges are available upon request.

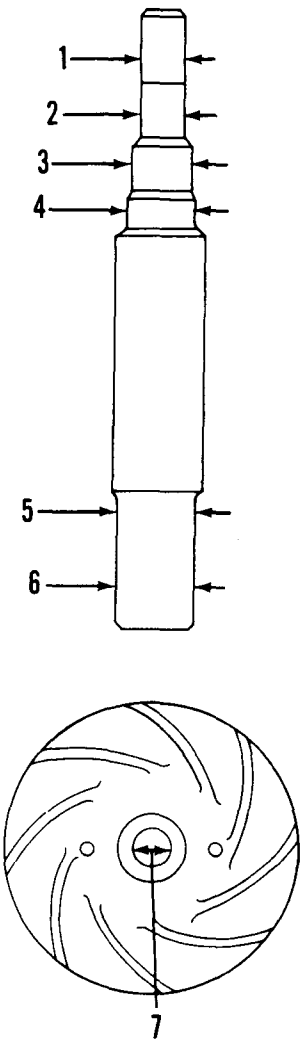
Group 8: Cooling System Specifications – Inch [mm] (Cont'd.)

Ref. No.	Dimension Locations	New Minimum	New Maximum	Worn Limit
	Housing Bearing Bores	2.4408 [61.996]	2.4414 [62.012]	**2.4494 [62.215]**
	Housing Bore Carbon Face Seal	1.5000 [38.100]	1.5200 [38.608]	
1.	**Shaft Diameter** Impeller End	0.6262 [15.905]	0.6267 [15.918]	
2.	**Shaft Diameter** Seat Location	0.6262 [15.905]	0.6267 [15.918]	
3.	**Shaft Diameter** Inner Bearing	0.9843 [25.001]	0.9847 [25.011]	
4.	**Shaft Diameter** Outer Bearing	0.9843 [25.001]	0.9847 [25.011]	
5.	**Shaft Diameter** Pulley End	0.6693 [17.000]	0.6696 [17.008]	
6.	**Impeller Bore**	0.624 [15.85]	0.625 [15.88]	
	Impeller Vane to Body Clearance			
	(Cast Iron)	0.020 [0.51]	0.040 [1.02]	
	(Phenolic)	0.030 [0.76]	0.050 [1.27]	
	Pulley Bore Diameter	0.6663 [16.924]	0.6673 [16.949]	
	Minimum Press-Fit Between			
	Shaft and Impeller	0.001 [0.03]		
	Shaft and Pulley	0.001 [0.03]		



Group 8: Cooling System Specifications – Inch [mm] (Cont'd.)

Ref. No.	Dimension Locations	New Minimum	New Maximum	Worn Limit
	Housing Bore Outer Bearing	2.8345 [71.996]	2.8351 [72.012]	**2.8431 [72.215]**
	Housing Bore Inner Bearing	2.0471 [51.996]	2.0477 [52.012]	**2.0557 [52.215]**
	Housing Bore Carbon Face Seal	1.435 [36.45]	1.436 [36.47]	
	Housing Bore Outer Seal	2.9985 [76.162]	3.0015 [76.238]	
	Housing Bore Inner Seal	1.374 [34.90]	1.376 [34.95]	
1.	**Shaft Diameter** Impeller End	0.6262 [15.905]	0.6267 [15.918]	
2.	**Shaft Diameter** Seat Location	0.6262 [15.905]	0.6267 [15.918]	
3.	**Shaft Diameter** Inner Seal	0.872 [22.15]	0.878 [22.30]	
4.	**Shaft Diameter** Inner Bearing Surface	0.9842 [24.999]	0.9846 [25.009]	
5.	**Shaft Diameter** Outer Bearing Surface	1.1810 [29.997]	1.1814 [30.008]	
6.	**Shaft Diameter** Pulley End	1.1810 [29.997]	1.1814 [30.008]	
7.	**Impeller Bore**	0.624 [15.85]	0.625 [15.88]	
	Impeller Vane to Body Clearance	0.020 [0.51]	0.040 [1.02]	
	Pulley Bore	1.1787 [29.939]	1.1798 [29.967]	
	Wear Sleeve O.D. Outer Seal Surface	2.2540 [57.252]	2.2560 [57.302]	
	Minimum Press-Fit Between Shaft and Impeller	0.001 [0.03]		
	Shaft and Pulley	0.001 [0.03]		



Group 9: Drive Unit Specifications – Inch [mm]

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Shaft			
	Outside Diameter (Bushing Location)	**1.310 [33.27]**	1.3115 [33.312]	1.312 [33.32]
	Bushing			
	Inside Diameter	**1.321 [33.55]**	1.316 [33.43]	1.319 [33.50]
	Outside Diameter		1.449 [36.80]	1.450 [36.83]
	Out-of Round	**0.002 [0.05]**		
	Press-Fit Between Housing and Bushing		0.002 [0.05]	0.0045 [0.11]
	Accessory Drive			
	End Clearance NH/NT		0.002 [0.05]	0.012 [0.26]
	End Clearance NTA		0.004 [0.10]	0.024 [0.61]
	Hydraulic Governor Drive			
	End Clearance		0.003 [0.08]	0.006 [0.15]

Group 14: Assembly Specifications – Inch [mm]

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1.	**Main Bearing**			
	Journal Clearance	**0.007 [0.18]**	0.0015 [0.038]	0.005 [0.13]
2.	**Connecting Rod Bearing**			
	Journal Clearance	**0.007 [0.18]**	0.0015 [0.038]	0.0045 [0.114]
3.	**Crankshaft**			
	End Clearance	**0.022 [0.56]**	0.007 [0.18]	0.017 [0.43]
4.	**Cylinder Liner**			
	Protrusion		0.003 [0.08]	0.006 [0.15]
	Out-of-Round Top One (1) Inch			0.003 [0.08]
	Out-of-Round Packing Ring (Lower) Area			0.002 [0.05]
5.	**Connecting Rod**			
	Side Clearance		0.0045 [0.114]	0.013 [0.33]

Group 14: Assembly Specifications – Inch [mm] (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
6.	**Gear Train (Gear to Gear) Crankshaft, Camshaft, Accessory Drive and Lubricating Oil Pump**			
	Backlash	**0.020 [0.51]**	0.0045 [0.114]	0.0105 [0.267]
7.	**Camshaft (With Thrust Plate)**			
	End Clearance		0.001 [0.03]	0.005 [0.13]
	(With Outboard Bearing Support)			
	End Clearance		0.008 [0.20]	0.013 [0.33]
8.	**Injection Timing**			
	Refer to Table 14-4			
9.	**Injector, Crosshead and Valve Adjustments**			
	Refer to Injector and Valve Adjustment			
10.	**Dynamometer Testing**			
	Refer to Test Procedure and Table 14-14			
11.	**Lubricating Oil Pressure**			
	Refer to Table 14-15			
12.	**Blow-By**			
	Refer to Test Procedure and Table 14-14			
13.	**Back Pressure**			
	Refer to In-Chassis Run-In			

Crankshaft Flange Capscrew Torque Specifications – ft.-lb [N•m]

	Engine Model	Part No.	Minimum	Maximum
14.	NT Series	196653 Capscrew 196654 Retainer	250 [339]	270 [366]
15.	NH Series	140410 Capscrew 140411 Retainer	180 [244]	200 [271]

Group 14: Torque Values (Alternator Bracket)

Nominal Bolt Size Inch	Torque Ft-Lb [N•m]
3/8	29 to 31 [39 to 42]
7/16	63 to 65 [85 to 88]
1/2	77 to 80 [104 to 108]

Adjusting Link

Nominal Bolt Size Inch	Torque Ft-Lb [N•m]
5/16	15 to 19 [20 to 26]
7/16	25 to 30 [34 to 41]
1/2	50 to 55 [68 to 75

Pulley to Alternator or Generator

Nominal Thread Size Inch	Torque Ft-Lb [N•m]
1/2	50 to 60 [68 to 81]
5/8	55 to 65 [75 to 88]
3/4	90 to 100 [122 to 136]

Note: Exception to the above limits are:

Delco-Remy Alternators	Torque Ft-Lb [N•m]
10 DN 150 25 SI	70 to 80 [95 to 108]

Injector and Valve Set Position

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

Engine Firing Order — Inline

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

Uniform Plunger Travel Adjustment Limits

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

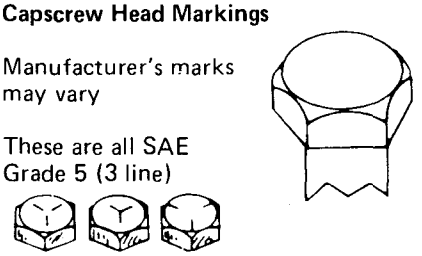
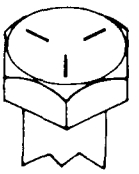
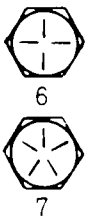
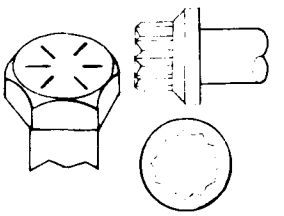
Injector Adjustment Oil Temperature

Cold Set	Hot Set
Cast Iron Rocker Housing	
48 inch-lb [5.4 N•m]	72 inch-lb [8.1 N•m]
Aluminum Rocker Housing	
72 inch-lb [8.1 N•m]	72 inch-lb [8.1 N•m]

Valve Clearance -- Inch [mm] (Torque Method)

Intake Valves		Exhaust Valves	
Cold Set	Hot Set	Cold Set	Hot Set
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69
Cast Iron Rocker Housing			
0.010 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]

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.

Lubricating Oil

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

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

Oil Performance Specifications

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

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

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

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

Break-In Oils

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

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 18-1. 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 18-2.

Table 18-1: Oil Recommendations

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

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

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

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

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

[5] SD or SE may be substituted for SC.

Table 18-2: 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

Table 18-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC or 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% by wt. Maximum

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 shut-downs, the lubricating oil should meet the requirements in Table 18-3.

Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is now 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 Start at 0°F. Run at 0°F.	ASTM D 1478 15,000 max. 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 500 Hours	10 max. 25 max.
Copper, Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc	*FTM 3005
25 Micron + 75 Micron + 125 Micron +	5,000 max. 1,000 max. None
Rubber Swell	*FTM 3603 10 max.

*Federal Test Method Standard No. 791a.

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

Fuel Oil

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

Recommended Fuel Oil Properties:	
Viscosity (ASTM D-445)	centiStokes 1.4 to 5.8 @ 100°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-83)	At least 125°F for 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.)
Cloud 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.

Recommended Fuel Oil Properties: (Cont'd.)

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

Maintain the Fleetguard 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 antifreezes also contain anti-leak additives such as inert inorganic fibers, polymer particles or ginger root, these antifreezes 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 element as follows and as recommended in Cummins Engine Operation and Maintenance Manuals.

Engines Equipped With DCA Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a "DCA pre-charge" element. See Table 18-4. This element is compatible with plain water or all permanent-type antifreezes except Dowtherm 209.

2. At the first "B" Check (oil change period) the Pre-charge element should be changed to DCA element. See Table 18-4.

3. Replace the DCA Service Element at each succeeding "B" Check except under the following conditions:

   a. If make-up coolant must be added between element changes, use coolant from a pre-treated supply, as stated in "Make-Up Coolant Specifications", in Group 2 of Operation and Maintenance Manual.

   b. Each time system is drained revert back to pre-charge element.

4. To ensure adequate protection have the coolant checked at each third element change or oftener.

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

1. Remove chromate element.

2. Flush cooling system.

3. Install pre-charge DCA element and operate engine to next "B" Check. See Table 18-4.

4. Install DCA Service Element; replace DCA Service Element at each succeeding "B" Check, except under the following conditions:

   a. If make-up coolant must be added between element changes use coolant from a pre-treated supply.

   b. Each time system is drained revert back to pre-charge element.

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,

Table 18-4: 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	(2) WF-2010	8	(2) WF-2011
35-90	12	(2) WF-2016	8	(2) WF-2017

Table 18-5: Canister Type

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

Part No. 3300858, according to Table 18-5, 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.

   b. Each time system is drained and new coolant is used, revert back to Step 3 instructions for one oil change period.

Group 20

The vehicle braking group consists of exhaust brakes, intake suppressors and compression brakes. Operation and installation of the Jacobs Brake is also covered in this group.

Vehicle Braking

Compression Brake

Exhaust Brakes

1. The only exception to recommended maximum back pressure is the high back pressure that is permissible while the engine is being used to slow the vehicle. With an exhaust brake, the engine can be used as a substitute for service brakes to avoid wear created by long or frequent brake operation. Impedance to flow at exhaust gas is controlled by a valve located downstream from the manifold on naturally aspirated engines and downstream of the turbocharger on turbocharged engines. This creates a back pressure against which the pistons must operate during their exhaust strokes. The work thus expended is used to retard the rotation of the crankshaft, and hence to retard the vehicle.

2. Exhaust brakes may promote carboning in certain applications. In these applications, electric or hydraulic retarders are generally preferred where braking is required for extended periods of time.

3. The use of exhaust brake systems on Cummins Diesel Engines is permissible under the following conditions:

   a. Maximum exhaust back pressure under any operating condition is 45 psi [310 kPa.

   b. When exhaust brake is installed, heavy-duty exhaust valve springs, Part No. 178869, and valve guides, Part No. 170296, must be installed in cylinder heads.

   c. The brake damper plate must be fully open when engine is accelerating or pulling full load.

   d. When engine is at idle speed and exhaust brake damper plate closed, the damper plate must be adjusted to permit some air flow through the engine to assure proper combustion of the small amount of fuel injected.

   e. On naturally aspirated engines, it is recommended to use an air intake suppressor (in conjunction with an exhaust brake) to prevent dirt from being passed through the air cleaner into engine. The exhaust brake can be used without a relief valve to provide maximum braking.

   f. On turbocharged engines, the brake should be located downstream from turbocharger. Braking limits are the same as for naturally aspirated engines. Turbocharged engines will also benefit from use of the air intake suppressor.

   g. Leakage of the exhaust system or other engine damage resulting from use of an exhaust brake is not warranted by Cummins Engine Company, Inc. since such damage might be caused by improper application, lack of maintenance, incorrect use or malfunction of the exhaust brake.

   h. Within the above limitations, refer to the exhaust brake manufacturer's instructions for details of application, use, adjustment and maintenance of the exhaust brake.

4. Consult Cummins Application Engineering Department for permissible exhaust restriction

before applying any new exhaust brake.

Exhaust Brake — Intake Suppressors

When using an exhaust brake, it is possible to create pulsations in the air intake system due to a combination of cylinder pressures and intake valves opening during the braking period. These pulsations can cause dirt to migrate through the cleaner element resulting in element failure, particularly with dry type cleaners.

The use of a suitable intake suppressor (Fig. 20-1) should be considered when an exhaust brake is to be installed. The suppressor should be installed between the engine and air cleaner as close to engine as possible. These suppressors will generally require tuning to the specific installation of engine and induction system. Some installations may not require suppressors, depending on the engine model and over-all induction system design; however, this would have to be determined on an individual basis. As a guide the following will apply to most installations incorporating exhaust brakes.

1. Intake suppressors are required on naturally aspirated engines using air cleaners containing dry elements.

2. Suppressors are recommended for all other combinations of engines and air cleaners unless analysis of the individual design determines that it is not necessary.

3. Oil bath cleaners should incorporate a seal between the oil sump and the cleaner body. This is necessary to prevent oil being blown through this connection.

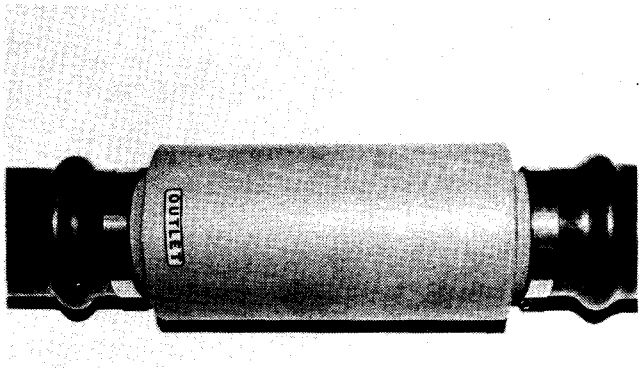


Fig. 20-1, (N21018). Air intake suppressor

Note: Part No. 147706 Wave Suppressor is used with 4-inch intake piping; Part No. 147707 Wave Suppressor is used with 5-1/2 inch intake piping.

Jacobs Brake (Compression)

Installation

1. Install new gaskets and Jacobs Brake units to rocker housings.

Note: If studs were removed from rocker housings; replace and tighten to 65 to 75 ft-lbs [88 to 102 N• m] torque in sequence as shown in Fig. 14-53.

2. Install special locking plates on two studs located in center of each housing. Tighten nuts to 55 to 60 ft-lbs [75 to 81 N• m] torque in sequence as shown in Fig. 14-53.

3. Bend long tab or each special locking plate down over housing surface, bend one short tab up against flat of each hex nut.

Slave Piston Adjustment Procedure

Loosen and back off locknut. Insert socket head wrench and back slave piston adjusting screw out of housing until slave piston seats in bore.

Slave piston adjustment must be made with the engine stopped (warm or cold) and the exhaust valves closed. Bar the engine in direction of rotation until "A" or "1-6 VS" mark on accessory drive pulley lines up with the timing mark on the gear case cover. With the engine in this position, the exhaust valves of cylinders 1-6 are closed. Insert a 0.018 inch feeler gauge between the slave piston and the crosshead, turn the adjusting screw in until a slight drag is felt on the feeler gauge. Continue turning engine in direction of rotation and set slave piston clearance on cylinders 2-5 and 3-4.

To bleed brake units for immediate operation, manually depress solenoid armature five or six times in succession with engine running to permit oil to fill passages in housing.

Attach electrical harness to terminal in Engine Brake housing.

Fuel Pump Mounting

Mount fuel pump switch and actuating arm as shown (Fig. 20-2) using capscrews on fuel pump to secure switch.

Actuating arm may be bent or relocated to contact switch when throttle lever is in idle position.

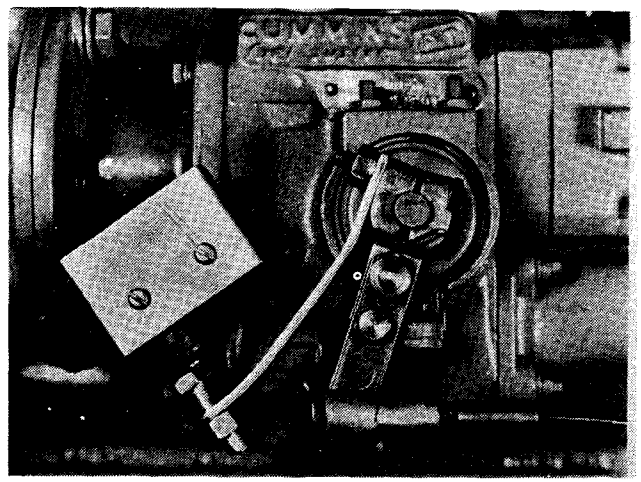


Fig. 20-2, (N12030J). Fuel pump switch mounted

Adjustment

Adjust screw in actuating arm so that audible "click" is heard when throttle arm moves to an idle fuel position.

Note: Check PT Fuel Pump throttle shaft to insure that throttle pedal will move throttle shaft to full fuel position after installing the actuating arm.

Clutch Mount

Mount enclosed switch so that adjustable rod on switch actuator is in contact with clutch pedal arm. Fig. 20-3.

Adjustment

With clutch pedal in relaxed position, loosen actuator rod clamp so that switch "clicks" with rod in contact with clutch arm. Tighten clamp in this position. This adjustment should allow switch

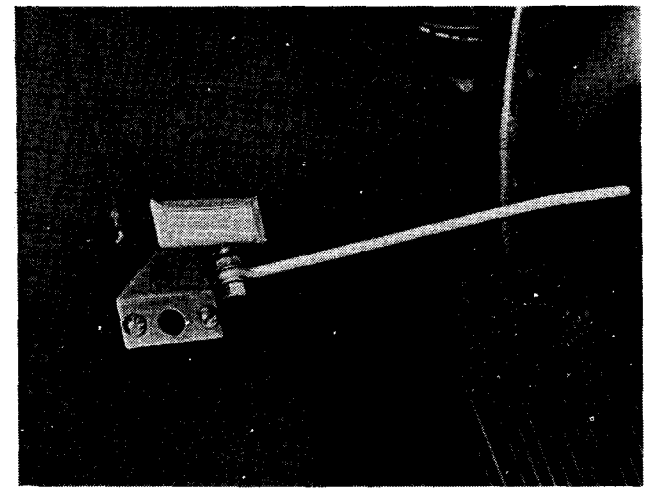


Fig. 20-3, (N12031J). Clutch pedal switch mounted

to work on the "backlash" of clutch pedal before actual clutch disengaging takes place.

Dash Switch should be located conveniently for the driver, and close to key switch. Connect fuse harness as shown in diagram. Fig. 20-4.

Operation

Energizing the Jacobs Brake effectively converts a power producing diesel engine into a power absorbing air compressor. This is accomplished when desired by motion transfer through a master-slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke releasing the compressed cylinder charge to exhaust.

The blowdown of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the power stroke, the effect being a net energy loss since the work down in compressing the cylinder charge is not returned during the expansion process.

Exhaust blowdown occurs as follows:

1. Energizing the solenoid valve permits engine lubricating oil to flow under pressure through slave piston control valve to both the master piston and slave piston.

2. Oil pressure causes the master piston to move down, coming to rest on injector rocker arm adjusting screw.

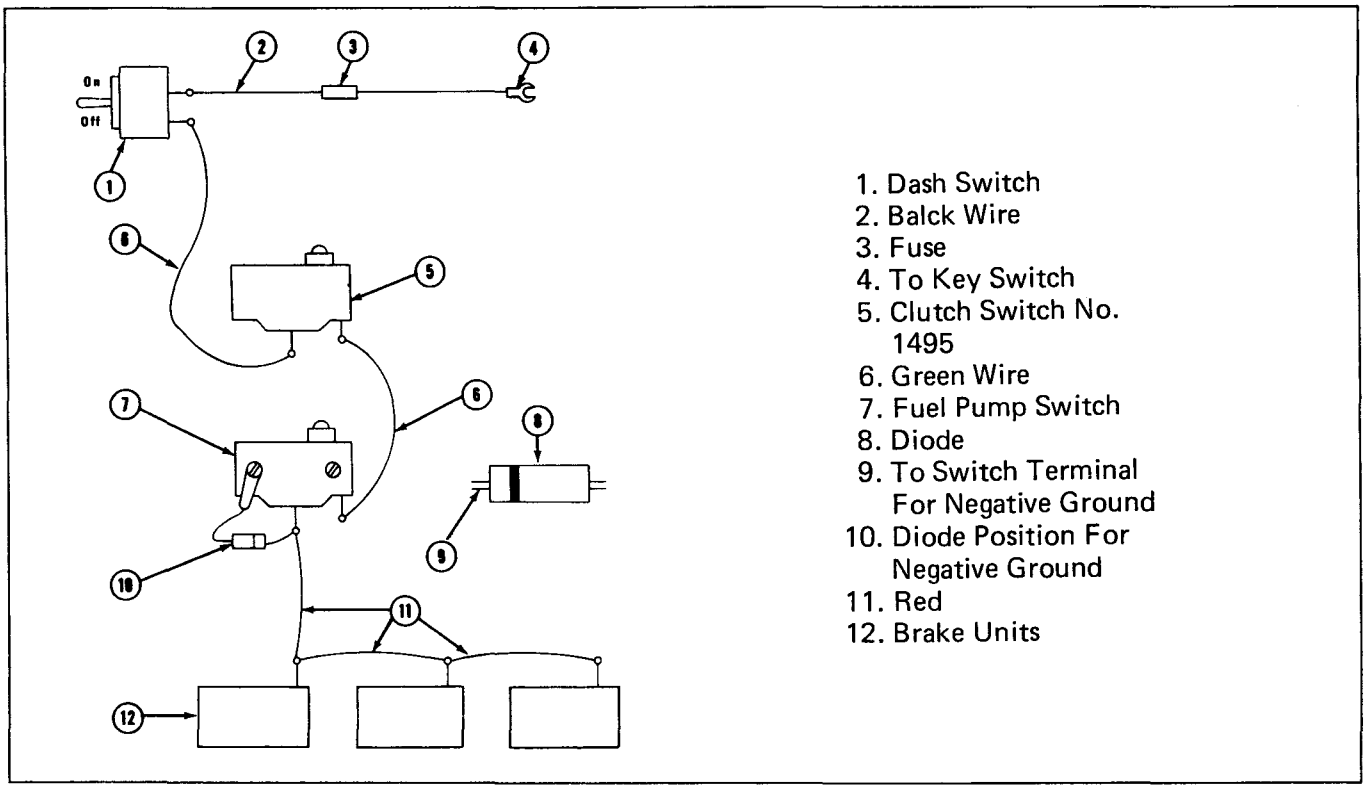


Fig. 20-4, (N12032J). Wiring diagram

3. The injector rocker arm adjusting screw begins upward travel (as in normal injection cycle) forcing the master piston upward and creating a high pressure oil flow to the slave piston. The ball check valve in the control valve imprisons high pressure oil in the master-slave piston system.

4. The slave piston under the influence of high pressure oil flow moves down, momentarily opening exhaust valve, while the engine piston is near its top dead center position, releasing compressed cylinder air to the exhaust manifold.

5. Compressed air escapes to atmosphere completing a compression braking cycle.

Operating a Vehicle with Jacobs Brake

In order to retard a vehicle on a downgrade using the Jacobs Compression Brake, and if the engine speed exceeds maximum rated rpm for a desired road speed, a lower gear should be selected. The selection of a lower gear will generally allow complete control of the vehicle by the Jacobs Compression Brake, leaving the vehicle service brakes in reserve to be used for emergency stops.

Retarders

Hydraulic Retarders

The heat generated by retarder and absorbed by heat exchanger may exceed cooling capacity of engine cooling system. That is, the heat rejected during full power operation. The cooling system should be designed around the higher heat input. Safety warning devices are required to prevent damage through overheating.

An automatic high water temperature warning light or buzzer should be provided in all retarder installations to warn the operator of excessive water temperatures and allow reduced retarding action so that boiling of coolant will not occur. The retarder manufacturer may also insist on a high oil temperature warning device to protect retarder in addition to high coolant temperature warning device.

Hydrotarders

As with hydraulic (oil) retarder, heat generated by a hydrotarder (water) may also exceed maximum heat load of the engine, and this should be provided for in the design of the cooling system.

The water storage tank should have a minimum capacity of 1 gal [3.8 lit] for each three horsepower of absorption.

It is advisable to install a water temperature gauge on outlet of hydrotarder as well as an automatic warning device on engine water outlet.

Group 21

Correct installation of generator set is a prerequisite for long life and satisfactory operation.

Main Power Generator

Power Generators

To insure satisfactory service of a power generator, make sure that the closest possible alignment is provided between engine crankshaft and power generator. Proper alignment can be accomplished as follows:

1. Using a suitable lifting device, position generator assembly to engine.

2. Secure generator frame snugly to engine flywheel housing with lockwashers and capscrews.

Note: Do not force alignment of units. Shift generator from side to side and raise or lower with lifting device as necessary.

3. Position drive disc to flywheel and secure with lockwashers and capscrews.

4. Remove block or jacks from under rear of engine and remove lifting device from generator lifting eyes.

5. Place brushes on slip rings of static excited units, install vent screen.

6. Position control panel on generator, if so located, and secure with mounting hardware.

7. Remove tags and connect all electrical leads to proper terminals of control panel and terminal board. Refer to pertinent wiring diagram for wiring connections.

Note: Crankshaft end clearance must be maintained after assembly of generator to engine.

For detailed information of generator set, refer to specific generator Bulletin as required.

Index

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