Section 50
POWER TRAIN REPAIR

CONTENTS OF THIS SECTION

Group 00
SPECIFICATIONS

SPECIFICATIONS

Item	Specification
Clutch disk thickness	
4270D; 6404D (Segmented disk)	0.432-0.442 in. (10.97-11.22 mm)
6404T, A; 6466	0.429-0.453 in. (10.90-11.51 mm)
Pilot bearing	
I.D.	1.1808-1.1811 in. (29.992-30.000 mm)
O.D.	2.8342-2.8346 in. (71.989-72.000 mm)
Clutch drive shaft	
4270D; 6404; 6466D, T; 6466A (-041994)	
O.D. at pilot bearing	1.1808-1.1811 in. (29.992-30.002 mm)
O.D. at bearing surface	
Side-load application	2.2515-2.2525 in. (57.188-57.214 mm)
In-line application	2.2330-2.2450 in. (56.718-57.023 mm)
O.D. at release collar sliding surface	2.2480-2.2490 in. (57.099-57.125 mm)
6466A (041995-)	
O.D. at pilot bearing	1.1808-1.1811 in. (29.992-30.002 mm)
O.D. at bearing surface	
Side-load application	2.6265-2.6275 in. (66.713-66.739 mm)
In-line application	2.5960-2.6080 in. (65.938-66.243 mm)
O.D. at release collar sliding surface	2.4490-2.5000 in. (62.205-63.500 mm)
Clutch separator springs	
4270D; 6404; 6466D, T; 6466A (-041994)	
Free length	1.06 in. (26.9 mm)
Compressive load	0.81 in. (20.06 mm) at 15-20 lbs. (67-89 N)
6466A (041995-)	
Free length	2.00 in. (50.8 mm)
Compressive load	1.18 in. (30.16 mm) at 15-20 lbs. (67-89 N)

SPECIFICATIONS—Continued

Item	Specification
Drive shaft end play	0.004-0.006 in. (0.10-0.15 mm)
Flywheel housing face run-out	0.008 in. (0.20 mm) Maximum variation
Flywheel face flatness	
Maximum variation	
4270D	0.006 in. (0.152 mm)
All other	0.009 in. (0.230 mm)
Maximum variation per 1.0 in. (25 mm) of area	0.0005 in. (0.013 mm)
Pilot bearing bore concentricity	0.005 in. (0.127 mm) Maximum variation
Torques	
Driving ring-to-flywheel	35 ft-lbs (47 Nm) (4.7 kgm)
Clutch housing-to-flywheel housing	
Side-load application 35 ft-lbs	35 ft-lbs (47 Nm) (4.7 kgm)
In-line application	55 ft-lbs (75 Nm) (7.5 kgm)
Drive shaft nut	170-180 ft-lbs (19.2-20.3 Nm) (1.95-2.07 kgm)
Operating lever engagement force	
4270D; 6404; 6466D, T; 6466A (-041994)	60-70 lbs. (267-311 N)
6466A (041995-)	65-75 lbs. (289-333 N)

Group 05
POWER TAKE-OFF

GENERAL INFORMATION

The direct-drive power take-off unit is designed to permit engine power to gradually be transferred to any application by use of the PTO clutch.

The power take-off assembly may be either an in-line or side-load application. The side-load application cannot be used for in-line work and the in-line application cannot be used for side-load work.

The PTO units used on all 400 Series engines are essentially the same. Throughout this section, "early" refers to the PTO used on 4270D, 6404, 6466D and T and 6466A (-041994) engines. "Late" refers to the PTO used on 6466A (041995-).

DIAGNOSING MALFUNCTIONS

Clutch Slips

Clutch out of adjustment
Worn or burned clutch
Oil or grease on driving disk(s)

Clutch Grabs or Chatters

Loose or worn drive ring
Worn teeth on driving disk(s)

Clutch Noise

Clutch loose on drive shaft
Drive ring loose

Clutch Will Not Release

Frozen pilot bearing

Clutch Drag

Broken lever springs
Rough clutch splines
Oil-soaked driving disk(s)
Broken separator springs
Clutch parts worn
Excessive clutch face runout

Clutch Engages Itself

Improper adjustment
Worn linkage
Worn release collar

Drive Shaft Bearing Runs Hot

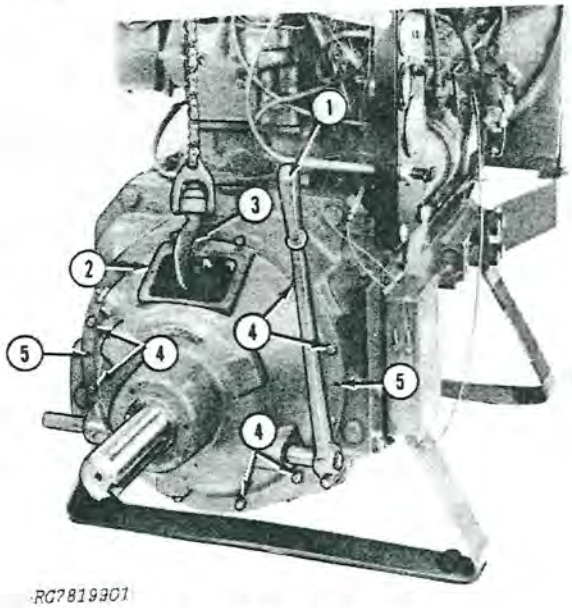
Insufficient bearing end play
Excessive bearing lubrication
Insufficient bearing lubrication

Defective Pilot Bearing

Improper removal or installation
Lack of lubrication

REMOVAL

Clutch Housing



RG7819301

Fig. 1-PTO Removal Steps

1. Engage clutch operating lever.
2. Remove name plate (not shown).
3. Insert hook from chain hoist securely in hole
4. Remove twelve cap screws.
5. Install two of the cap screws just removed i tapped holes in housing.
6. Tighten cap screws evenly to separate PTO ur from flywheel housing.

Clutch Unit

1. Remove pilot bearing (41, Fig. 2) using a puller.
2. Disconnect grease tube (18) from housing (25).
3. Bend back tab on lock washer (39).
4. Carefully pry up on pressure plate (30) to center shaft assembly in housing. Position wedges between bottom of pressure plate and clutch housing.
5. Strike pilot end of shaft with a soft-faced hammer to break clutch unit loose from tapered shaft.

NOTE: Do not strike shaft with excessive force as bearing(s) may be damaged.

6. Remove clutch assembly from drive shaft. Place on bench with clutch body (37) down.

Yoke

1. Disconnect grease tube (18) from housing.
2. Remove clutch unit (see above).
3. Loosen cap screws (23) on yoke (24).
4. Drive yoke either left or right to expose Woodruff Keys (2).
5. Remove keys.
6. Withdraw yoke shaft from yoke and housing. Remove yoke.

DISASSEMBLY

Replacing Segmented Driving Disk (4270D; 6404)

If the segmented driving disk is to be replaced, the entire clutch need not be disassembled.

Support PTO on blocks with output end of shaft down.

Disengage clutch and remove driving disk segments.

Install new driving disk segments.

Remove driving ring (34, Fig. 2) from flywheel and use to center driving disk segments in clutch assembly.

Engage clutch to hold segments in place.

Clutch Unit

Remove release lever spring (17) from release sleeve assembly.

Mark both halves of release collar (20) for reassembly.

Remove bolts (19) and nuts (12) and separate collar from release sleeve (21).

Remove pins (13) and remove release sleeve from clutch assembly.

Remove adjusting lock (29).

Remove adjusting ring (28) by unscrewing from pressure plate (30).

Lift pressure plate from clutch body.

Remove driving disk (31). On late units, remove center plate (32) and second driving disk (33).

Remove separator springs (35) from body.

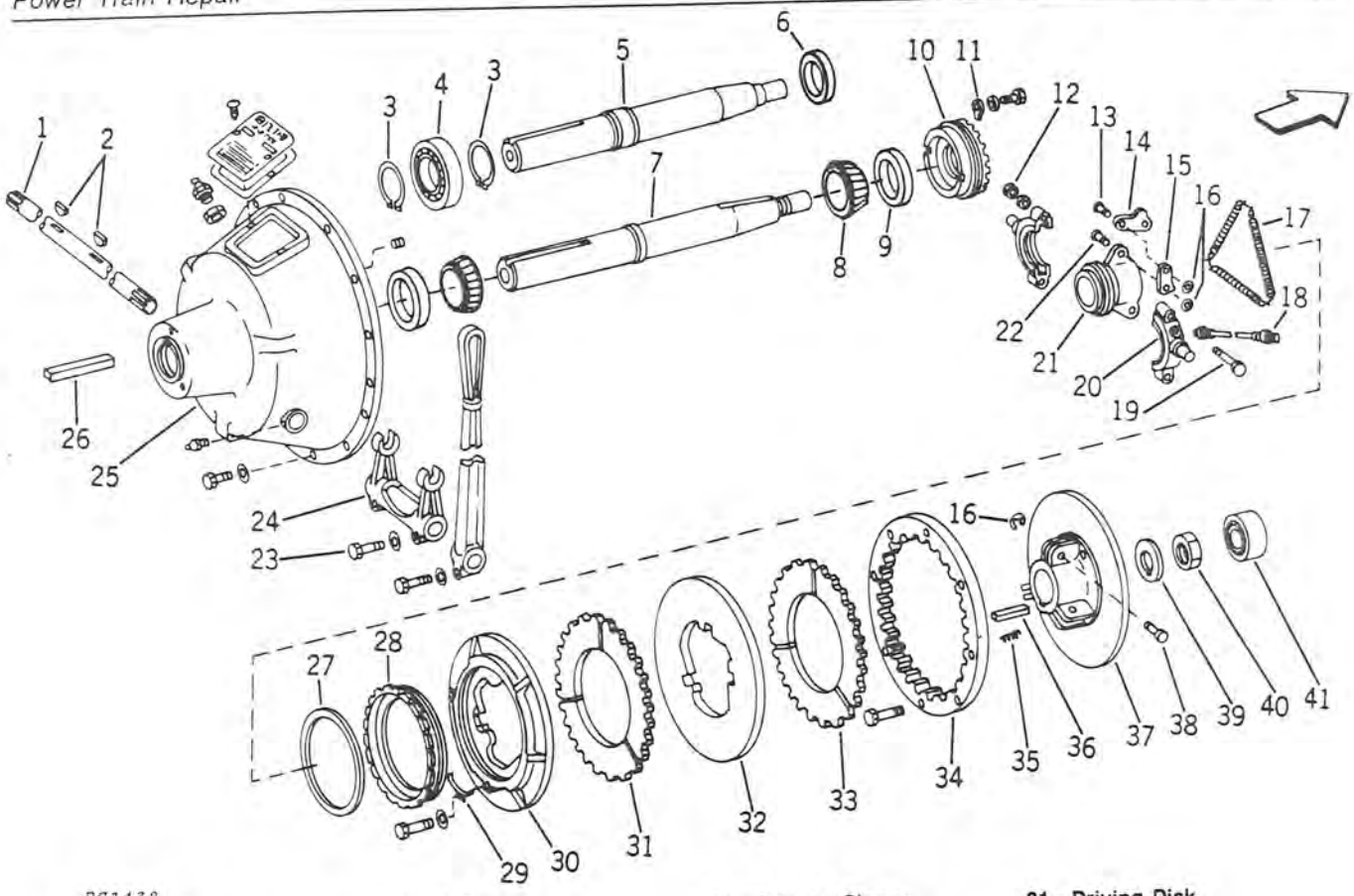
Drive Shaft and Bearings

Remove clutch assembly.

Remove lock plate (11, Fig. 2). Rotate bearing retainer (10) counterclockwise to remove from housing.

Strike output end of drive shaft with a soft-faced hammer to drive shaft with bearings from housing.

On side-load applications, rear bearing cup will remain in housing bore. To remove, alternately drive a punch in holes at rear of housing near drive shaft to drive cup from housing.



RG1432

1—Yoke Shaft
2—Woodruff Key
3—Snap Ring*
4—Bearing*
5—Drive Shaft*
6—Spacer*
7—Drive Shaft**
8—Bearing Cone**
9—Bearing Cup**
10—Bearing Retainer
11—Lock Plate
12—Nut (2 used)
13—Pin (3 used)
14—Lever (3 used)
15—Link (3 used)
16—Retaining Ring (9 used)
17—Lever Spring
18—Grease Tube
19—Bolt (2 used)
20—Release Collar
21—Release Sleeve
22—Pin (3 used)
23—Cap Screw (2 used)
24—Yoke
25—Housing
26—Key
27—Plate
28—Adjusting Ring
29—Adjusting Lock
30—Pressure Plate
31—Driving Disk
32—Center Plate***
33—Driving Disk***
34—Driving Ring
35—Spring (3 used)
36—Key
37—Clutch Body
38—Pin (3 used)
39—Lock Washer
40—Nut
41—Pilot Bearing

*-In-line application only
**-Side-load application only
***-6466A (041995-) only

Fig. 2-PTO Assembly

INSPECTION

1. Check thickness of clutch driving disk(s) (31 and 33, Fig. 2).

CLUTCH DISK SPECIFICATION

Thickness of new disk
- 4270D; 6404D (segmented disk) . . 0.432-0.442 in. (10-97-11.22 mm)
- 6404T, A; All 6466 . . . . . 0.429-0.453 in. (10.90-11.51 mm)

Also inspect driving disk for worn driving teeth and burning or scoring of the faces. Replace as necessary.

2. Inspect separator springs (35) for correct tension. Replace any spring that is rusted, bent or distorted.

SEPARATOR SPRING SPECIFICATION

Early
- Free length . . . . . 1.06 in. (26.9 mm)
- Compressive load . . . . . 0.81 in. at 15-20 lbs. (20.06 mm at 67-89 N)

Late
- Free length . . . . . 2.00 in. (50.8 mm)
- Compressive load . . . . . 1.18 in. at 15-20 lbs. (30.16 mm at 67-89 N)

3. Check all bearings for roughness or tightness and replace as necessary.

PILOT BEARING SPECIFICATION

- Bearing I.D. . . . . 1.1808-1.1811 in. (29.992-30.000 mm)
- Bearing O.D. . . . . 2.8342-2.8346 in. (71.998-72.000 mm)

4. Press drive shaft from bearing(s). On in-line applications, remove snap rings (3, Fig. 2) before pressing.

Check bearing surfaces on shaft for wear or roughness.

CLUTCH DRIVE SHAFT SPECIFICATIONS

Early
- O.D. at
  - Pilot bearing . . . . . 1.1808-1.1811 in. (29.992-30.002 mm)
  - Bearing surface
    - Side-load . . . . . 2.2515-2.2525 in. (57.188-57.214 mm)
    - In-line . . . . . 2.2330-2.2450 in. (56.718-57.023 mm)
  - Release collar sliding surface 2.2480-2.2490 in. (57.099-57.125 mm)

Late
- O.D. at
  - Pilot bearing . . . . . 1.1808-1.1811 in. (29.992-30.002 mm)
  - Bearing surface
    - Side-load . . . . . 2.6265-2.6275 in. (66.713-66.739 mm)
    - In-line . . . . . 2.5960-2.6080 in. (65.938-66.243 mm)
  - Release collar sliding surface . 2.4490-2.5000 in. (62.205-63.500 mm)

ASSEMBLY

Drive Shaft and Bearings

Side-load Application

CAUTION: Oil fumes or oil can ignite above 380°F (193°C). Use a thermometer and do not exceed 360°F (182°C). Do not allow a flame or heating element to be in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

Heat new bearing(s) in oil to no more than 300°F (149°C).

Install bearing on shaft until bearing cone is flush against shoulder of shaft.

Remove rear bearing cup as previously directed.

Start new bearing cup in housing.

Insert drive shaft with bearings against cup. Using a soft hammer, strike end of shaft while rotating shaft until bearing cup bottoms in housing.

Pack bearings with grease.

Install shaft with bearings in housing.

Position front bearing cup in housing bore.

Install bearing retainer, turning clockwise until retainer presses cup into place against bearing.

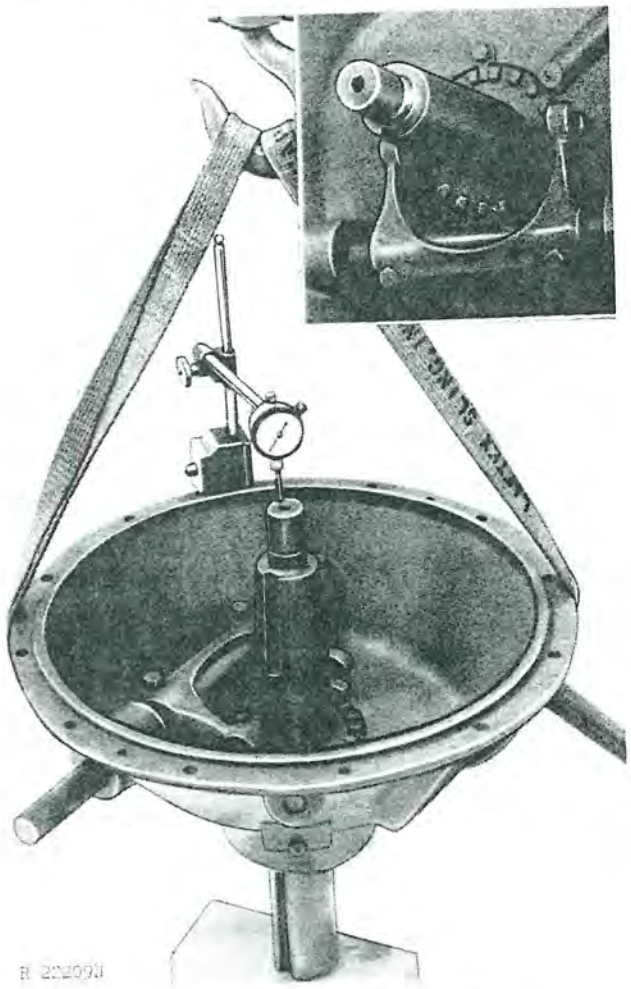


Fig. 3-Adjusting Drive Shaft End Play

Use a lifting sling or similar device to cradle housing so that drive shaft is vertical (Fig. 3).

Allow end of drive shaft to rest on wood block on floor.

Raise housing slightly and tap pilot end of drive shaft to seat parts.

Mount dial indicator on face of clutch housing and adjust pointer to rest on pilot end of drive shaft. Zero the indicator.

Lower housing so drive shaft rests on block.

Tap lightly around housing near drive shaft to seat front bearing in cup.

Read indicator.

DRIVE SHAFT END PLAY SPECIFICATION

End play..... 0.004-0.006 in. (0.10-0.15 mm)

Adjust drive shaft end play by turning bearing retainer clockwise to decrease end play (Inset, Fig. 3).

In-line Application

Install one snap ring (3, Fig. 2) on shaft. Stand shaft on end.

Heat new bearing in oil to no more than 300°F (149°C).

Install new bearing on shaft until bearing is flush against snap ring.

Install remaining snap ring.

Pack bearing with grease.

Install shaft with bearing into housing.

Install spacer.

Install bearing retainer, turning clockwise until retainer presses bearing to bottom of housing.

Install lock plate (11, Fig. 2).

Clutch Unit

Place clutch body (37, Fig. 2) on bench with hub end up.

Install separator springs (35) in holes in clutch body.

Position clutch driving disk over hub.

On late clutch units, position center plate (32) and second driving disk (33) over hub.

ASSEMBLY—Continued

Position pressure plate (30, Fig. 2) over hub. Notches in I.D. of pressure plate must align with release lever bosses on clutch body. Lower pressure plate onto separator springs.

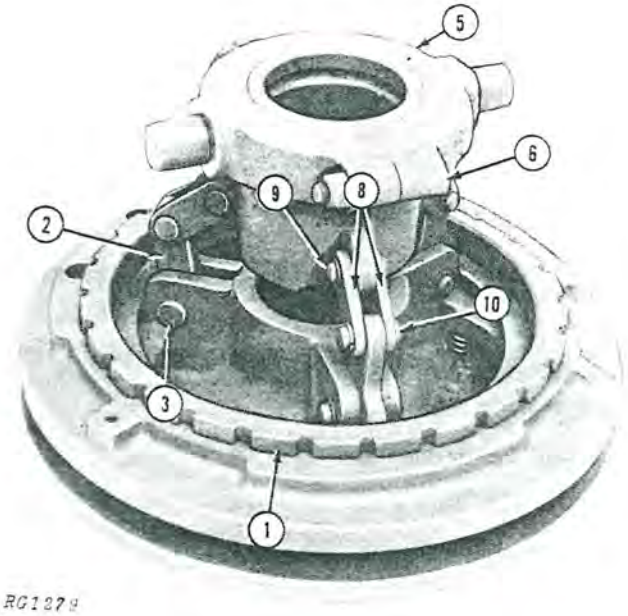


Fig. 4-Clutch Unit Assembly

Referring to Fig. 4;

1. Screw adjusting ring into pressure plate until it bottoms.

2. Install three release levers with tab on lever facing out.

3. Insert pins with heads facing direction of rotation. Secure pins with retaining rings.

4. Apply grease to I.D. of clutch release sleeve collar halves (not shown).

5. Place two halves of release collar together over shoulder of release sleeve, aligning scribe marks. Be sure machined side of collar faces up.

6. Install bolts and nuts, tightening to 20 ft-lbs (27 Nm) (2.7 kgm).

Rotate collar to check for binding. If collar binds, shim between release collar halves to obtain clearance.

7. Place release lever spring (17, Fig. 2) over release sleeve and against release collar before installing links (not shown).

8. Place one link on each side of ear on release sleeve with triangular tab on link at release sleeve and point of triangle facing center of sleeve.

9. Install pins with heads facing direction of rotation. Secure pins with retaining rings.

10. Install release sleeve assembly on clutch with each pair of links astride release lever. Install pins and retaining rings.

Slide release lever spring into place over release levers.

Center clutch driving disk(s) between clutch body and pressure plate using driving ring (34, Fig. 2).

Turn adjusting ring counterclockwise until pressure plate almost contacts driving disk.

Engage clutch by applying pressure to release sleeve. If driving disk can be moved, adjust ring counterclockwise enough to lock driving disk in place.

Install driving ring on flywheel, tightening cap screws to 35 ft-lbs (47 Nm) (4.7 kgm).

Install clutch unit on drive shaft. Make sure that pins on release collar are inserted in yoke arms and that grease tube hole on collar faces tube hole in housing.

Push clutch unit firmly onto drive shaft.

Install key (36, Fig. 2) between drive shaft and clutch unit.

Install lock washer (39) and nut (40). Tighten nut to 170-180 ft-lbs (230-244 Nm) (23.0-24.4 kgm). Bend tab on lock washer against nut.

Connect grease tube to release collar and housing.

Yoke

Install yoke through inspection opening in housing. Cap screw heads on yoke should face towards clutch.

Push yoke shaft into position through yoke and housing.

Install Woodruff keys in shaft.

Center yoke on shaft and tighten cap screws to 20 ft-lbs (27 Nm) (2.7 kgm).

FLYWHEEL INSPECTION - ALL MODELS

NOTE: When measuring flywheel face or housing face, maintain end pressure on crankshaft to hold shaft against main thrust bearing.

Flywheel Housing Face Run-Out

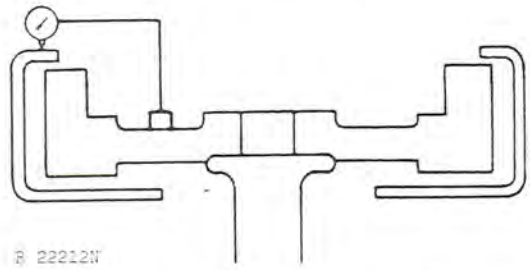


Fig. 5-Checking Flywheel Housing Face Run-out

Mount dial indicator on flywheel (Fig. 5). Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

Rotate flywheel by turning crankshaft. Read dial indicator.

HOUSING FACE RUN-OUT SPECIFICATION

Maximum variation.....0.008 in. (0.20 mm)

Flywheel Face Flatness

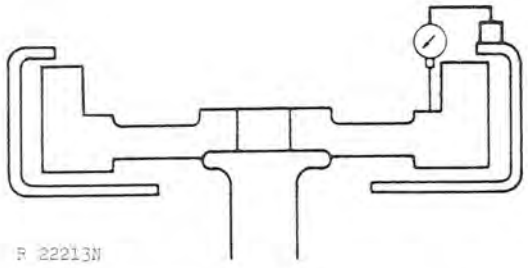


Fig. 6-Checking Flywheel Face Flatness

Mount dial indicator base on flywheel housing (Fig. 6). Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

Rotate flywheel by turning crankshaft. Read dial indicator.

FLYWHEEL FACE FLATNESS SPECIFICATION

Maximum variation		
4270D	0.006 in.	(0.152 mm)
All other	0.009 in.	(0.230 mm)
Maximum variation per 1.0 in.		
(25 mm) of area	0.0005 in.	(0.013 mm)

Pilot Bearing Bore

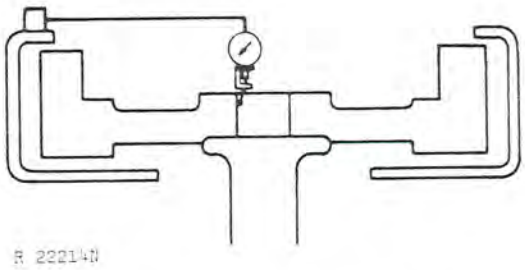


Fig. 7-Checking Pilot Bearing Bore

Mount dial indicator on flywheel housing face and position pointer to contact I.D. of pilot bearing bore in flywheel (Fig. 7).

Rotate flywheel by turning crankshaft. Read dial indicator.

BEARING BORE CONCENTRICITY SPECIFICATION

Maximum variation..... 0.005 in. (0.127 mm)

Driving Ring

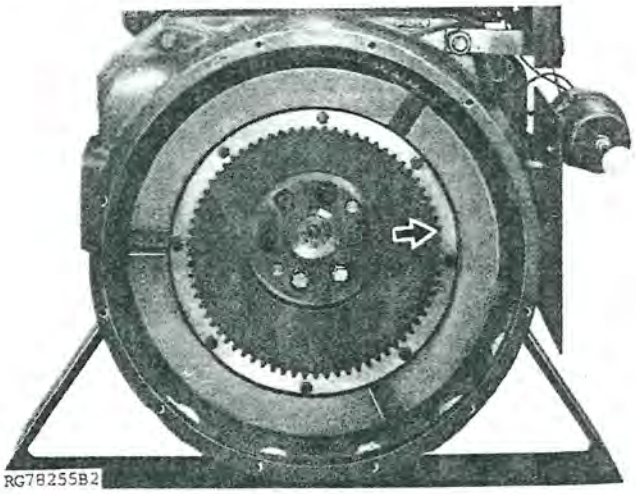


Fig. 8-Clutch Driving Ring

Inspect clutch driving ring (Fig. 8) for broken teeth, cracks or distortion. If removed, tighten cap screws to 35 ft-lbs (47 Nm) (4.7 kgm).

INSTALLATION
All Models

1. Install pilot bearing on drive shaft.

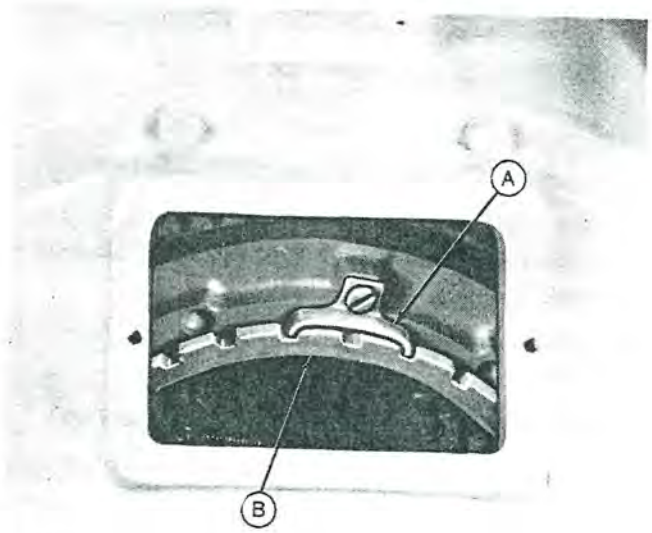
2. Insert hook from chain hoist as shown in Fig. 1.

3. Install PTO on engine, making sure pilot bearing enters flywheel bore and driving disk teeth engage driving ring.

4. Install PTO-to-flywheel housing cap screws, tightening to 55 ft-lbs (75 Nm) (7.5 kgm).

5. Adjust clutch as directed below.

ADJUSTMENT



R 27550

A—Adjusting Lock **B—Adjusting Ring**

Fig. 9-Adjusting Clutch

1. Remove name plate.

2. Remove adjusting lock (A, Fig. 9).

3. Turn adjusting ring (B) to adjust clutch engagement pressure.

Measure engagement pressure at clutch handle with a spring scale.

CLUTCH ENGAGEMENT PRESSURE SPECIFICATION

Force at lever

Early . . . . . 60-70 lbs. (267-311 N)
Late . . . . . 65-75 lbs. (289-333 N)

4. Install adjusting lock and tighten screw securely.

5. Install name plate.

6. Disengage clutch.

Section 220
ENGINE OPERATION AND TESTS

CONTENTS OF THIS SECTION

Group 00
SPECIFICATIONS AND SPECIAL TOOLS

SPECIFICATIONS

Engine oil pressure	
4270D	25 to 40 psi (1.72 to 2.75 bar) (1.76 to 2.81 kg/cm²)
6404; 6466	40 to 50 psi (2.75 to 3.45 bar) (2.81 to 3.52 kg/cm²)
Compression pressure	
4270D	400 psi (27.6 bar) (28.0 kg/cm²) at 275 rpm
6404D; 6466D	370 to 400 psi (25.5 to 27.6 bar) (24.9 to 28.0 kg/cm²) at 200 to 250 rpm
6404T, A; 6466T, A	330 to 370 psi (22.8 to 25.5 bar) (23.2 to 24.9 kg/cm²) at 200 to 250 rpm
Radiator leakage test	18 psi (1.24 bar) (1.26 kg/cm²)
Valve lift	
4270D	
Intake	0.431 to 0.461 in. (10.9 to 11.7 mm)
Exhaust	0.427 to 0.457 in. (10.8 to 11.6 mm)
6404D; 6466D	
Intake	0.424 to 0.454 in. (10.77 to 11.53 mm)
Exhaust	0.414 to 0.444 in. (10.52 to 11.28 mm)
6404T, A; 6466T, A	
Intake	0.412 to 0.442 in. (10.5 to 11.2 mm)
Exhaust	0.413 to 0.443 in. (10.5 to 11.3 mm)
Valve clearance	
4270D	0.018 in. (0.5 mm)
6404; 6466	
Intake	0.018 in. (0.5 mm)
Exhaust	0.028 in. (0.7 mm)
Crankshaft end play	
6404 (-444687)	0.0025 to 0.0085 in. (0.064 to 0.216 mm)
4270D; 6404 (444688-); 6466	0.0015 to 0.0150 in. (0.038 to 0.380 mm)
Damper radial runout (6 cylinder)	0.040 in. (1.0 mm) Maximum

SPECIFICATIONS—Continued

Dynomometer test at full-load RPM (Engine equipped with fan)

Engine	Horsepower (kilowatts) Maximum Continuous	Intermittent	RPM
4270DR (Reg. Governor)	62(46)	68(51)	2200
4270DF (3-5% Governor)			
6404D (Reg. Governor)	84(63)	99(74)	2200
6404DR-20 (Reg. Governor)	97(72)	107(80)	2200
6404DF (Reg. Governor)	97(72)	107(80)	2200
6404DF (3-5% Governor)	71(53)	86(64)	1800
6404TR-13 (Reg. Governor)	106(79)	125(93)	2200
6404TR-14 and TF (3-5% Governor)	115(86)	135(101)	2200
6404AR-09 (Reg. Governor)	141(106)	168(125)	2200
6404AR-16 and AF (3-5% Governor)	142(106)	168(125)	2200
6466DR-05 and DF (Reg. Governor)	105(78)	118(88)	2200
6466DF (3-5% Governor)	97(72)	109(82)	1800
6466TF (Reg. Governor)	121(90)	145(108)	2200
6466TR-09 and TF (3-5% Governor)	121(90)	145(108)	2200
6466AF (Reg. Governor)	174(130)	208(155)	2100
6466AR-03 and AF (3-5% Governor)	174(130)	208(155)	2100

SPECIAL TOOLS

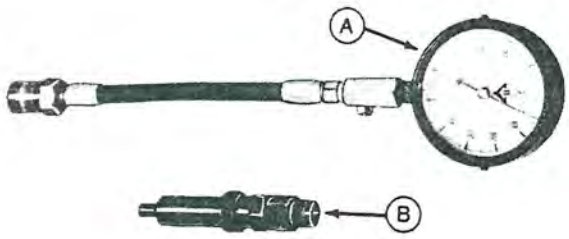
TOOL	NUMBER	USE
 R 27489N	A-D-14547BA Motorite Tester* B-D-14550BA* (9.5 mm nozzles) D-14554BA* (KDL nozzles) D-14557BA* (KDEL nozzles)	To test compression pressure.

Fig. 1-Compression Test Equipment

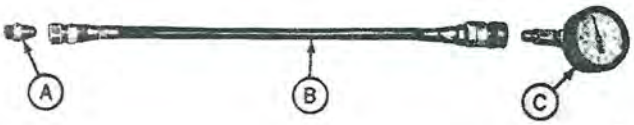
 R 27490N	A-D-1 Fitting* B-19-HP Hose and Fitting Assembly* C-D-20 Gauge*	To test oil pressure.

Fig. 2-Oil Pressure Test Equipment

 R 26133N	D-05104ST Pressure Pump*	To test radiator.

Fig. 3-Radiator Test Equipment

**Order from: Service Tools, P.O. Box 314, Owatonna, MN 55060*

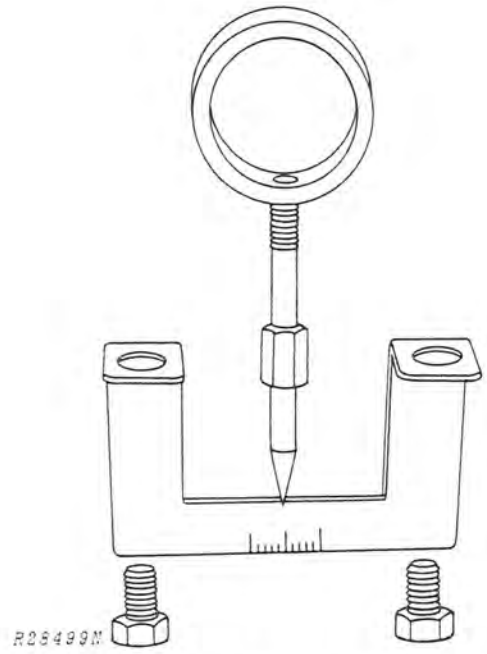
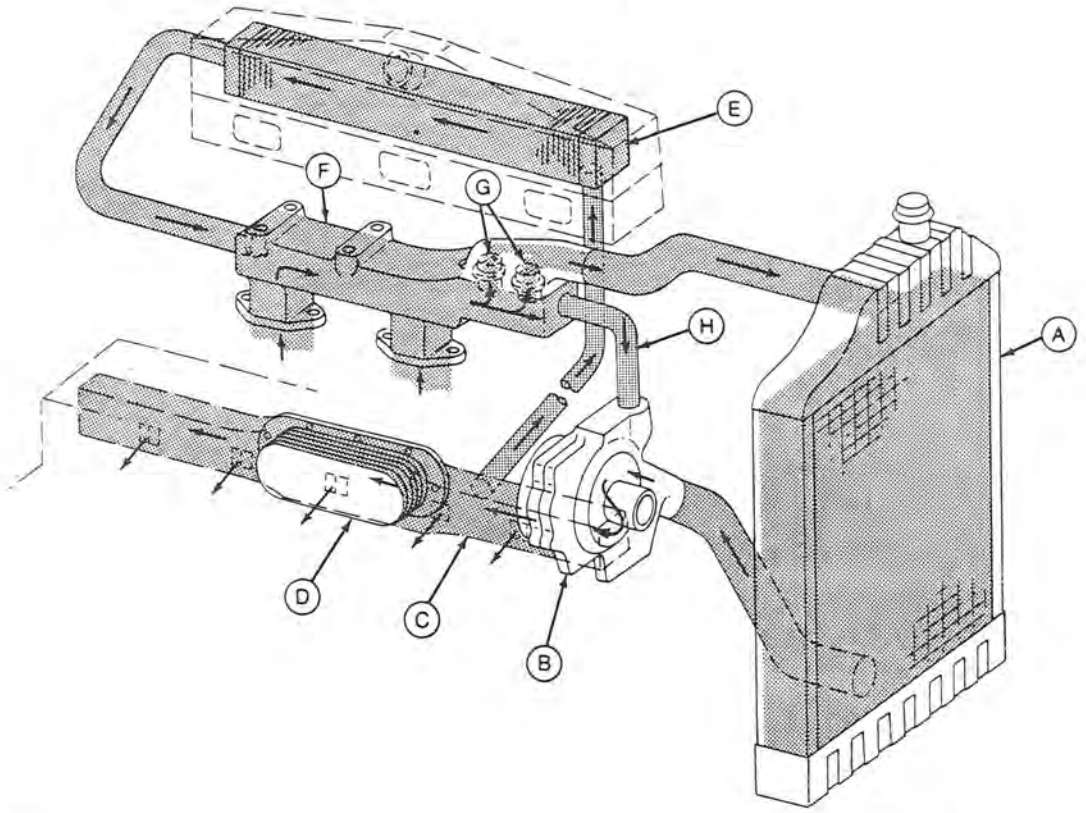


Fig. 4-Gear Backlash Indicator

JDE-109 Gear Backlash Indicator*	**To check camshaft - oil pump gear backlash.**

**Order from: Service Tools, P.O. Box 314, Owatonna, MN 55060*

Group 05
COOLING SYSTEM OPERATION
HOW THE SYSTEM WORKS



RG1281

A—Radiator
B—Water Pump
C—Cylinder Block Main Cooling Gallery
D—Engine Oil Cooler
E—Intercooler ("A" Engines)
F—Water Manifold
G—Thermostats
H—Water Bypass Pipe

Fig. 1-Engine Cooling System (6 Cylinder Shown)

The cooling system consists of a conventional type radiator (A, Fig. 1), water pump (B), two thermostats (G), and water manifold (F).

The pump draws coolant from the bottom of the radiator (A) and discharges it into the main coolant gallery (C) on the left-hand side of the engine. Coolant from the gallery circulates through the block to cool block and cylinder liners, then flows into the cylinder head. From the cylinder head, the coolant passes into the water manifold (F) and thermostat housing.

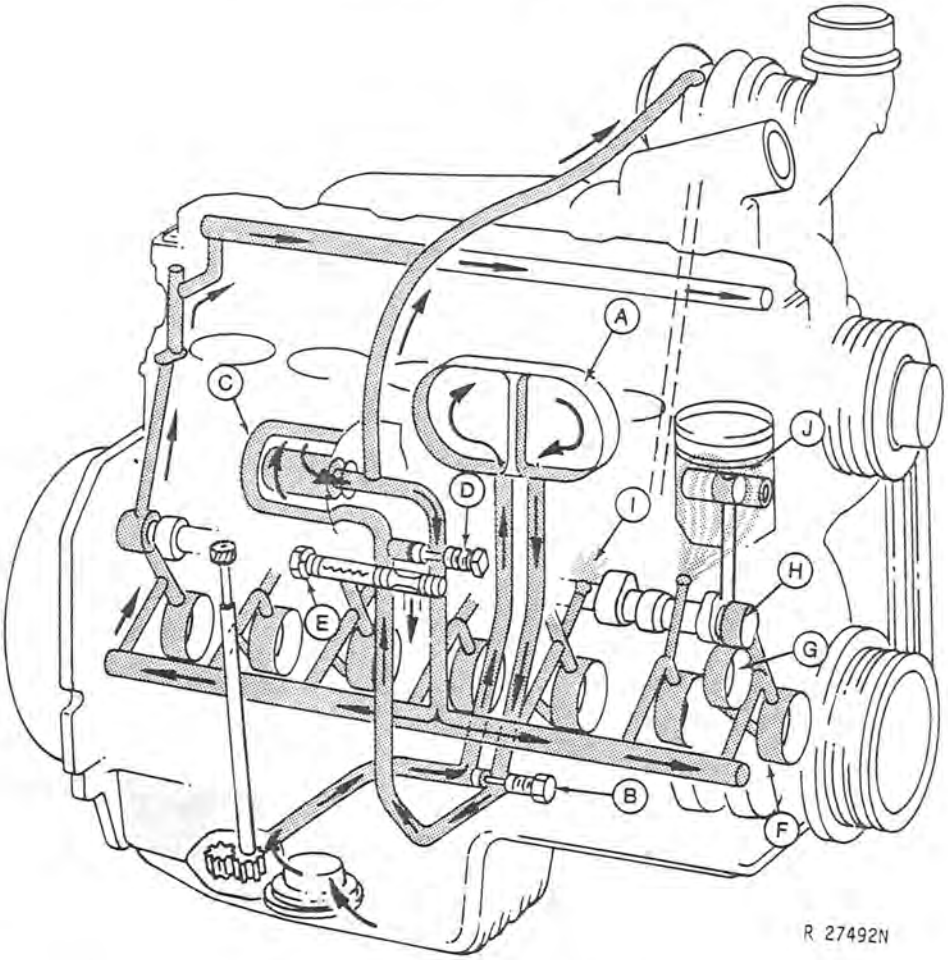
If the thermostats are closed (as during warm-up periods) coolant is directed back to the pump through the bypass pipe (H) to be recirculated. This provides a faster and more uniform warm-up.

If the thermostats are open (engine at normal operating temperature) coolant flows back through the thermostats to the top of the radiator.

On "A" engines, coolant is also taken from the main gallery into the intercooler (E) to cool intake air. It circulates through the intercooler and out to the water manifold.

The engine oil cooler (D), located in the main gallery, receives its cooling capacity from the coolant flow around it.

LUBRICATION SYSTEM



A—Engine Oil Cooler
B—Oil Cooler Bypass Valve
C—Oil Filter
D—Filter Bypass Valve
E—Oil Pressure Regulating Valve
F—Main Bearings
G—Connecting Rod Bearings
H—Camshaft Bushings
I—Piston Cooling Orifices
Engine Oil Pressure
Oil Pan Oil

Fig. 2-Engine Lubrication System (6-Cylinder)

The engine lubrication system consists of a gear-driven positive displacement pump, oil cooler, oil filter, cooler bypass valves, oil pressure regulating valve and filter bypass valve.

Oil is pumped from the oil pan by the engine oil pump through the engine oil cooler (D, Fig. 1) around the oil cooler bypass valve (B) into the engine oil filter (C). Passing through the filter, the oil continues around the filter bypass valve (D) and in front of the engine oil pressure regulating valve (E) into the engine oil gallery in the cylinder block. Oil is then distributed, under pressure, to each main bearing to lubricate main bearings (F) and piston cooling orifice.

Cross-drilled passages in the crankshaft distribute oil from the main bearing journals to the connecting rod journals to lubricate connecting rod bearings (G). Numbers 1, 3, 5, and 7 main bearings are also drilled to lubricate the four camshaft bushings (H). A drilled passage from the rear camshaft bushing through the cylinder block and cylinder head provides lubrication to the rocker arm shaft.

Group 10
SYSTEM TESTS AND DIAGNOSIS

DYNAMOMETER TEST

If possible, test the engine on a dynamometer before it is tuned. This test gives the horse power output and fuel consumption of the engine as it is. This will help determine if a tune-up can restore the engine or whether an overhaul is needed.

Good performance by the engine depends on these basic things:

1. An adequate supply of clean air and fuel.

2. Good compression.

3. Proper valve and injection pump timing for good combustion.

4. Proper air and fuel temperatures.

Make the dynamometer test as follows:

1. Connect the engine to the dynamometer using the manufacturers instructions.

2. Operate the engine at one-half load until the coolant and crankcase oil temperature are up to normal.

3. Run engine at fast idle (See Specifications below).

4. Gradually increase the load on the engine until its speed is reduced to full load (rated) rpm.

5. Read the horsepower on the dynamometer.

6. Compare the reading taken with the chart on page 220-00-2.

Engine	Engine Speeds (RPM) Slow Idle	Fast Idle	Full Load
4270DR (Reg. Governor)	800	2750	2500
4270DF (3-5% Governor)	800	1890-1900	1800
6404DR and DF (Reg. Governor)			
(357084-499999)	800	2400	2200
(500000-)	800	2400	2200
6404DR and DF (3-5% Governor)			
(357084-499999)	800	1890-1900	1800
(500000-)	800	1890-1900	1800
6404TR-13 and AR-09			
(-357083)	800	2650	2500
6466DR and DF			
Regular Governor	800	2400	2200
3-5% Governor	800	1890-1900	1800
6404TR-14 & AR-16			
(357084-445569)	800	2300	2160
(445570-)	800	2300	2160
6466TF (Reg. Governor)	800	2400	2200
6466TF & TR-09 (3-5% Governor)	800	2310	2200
6466AF (Reg. Governor)	800	2300	2100
6466AF & AR-03 (3-5% Governor)	800	2200	2100

INSTRUCTIONS FOR ENGINE BREAK-IN

Use a dynamometer to perform the following break-in procedure. If necessary, engine break-in can be performed without a dynamometer if under controlled operating conditions.

Fill engine crankcase with Torq-Gard Supreme 10W-20 oil to proper level for use during the break-in operation.

TIME	LOAD	ENGINE SPEED	REMARKS
5 Minutes	No Load	800 RPM	Check
5 Minutes	No Load	1500 to 2000 RPM *(1300 to 1600 RPM)	oil pressure,
5 Minutes	1/4 Load	1900 to 2200 RPM *(1500 to 1800 RPM)	coolant
10 Minutes	1/2 Load	1900 to 2200 RPM *(1500 to 1800 RPM)	temperature
10 Minutes	1/2 to 3/4 Load	1900 to 2200 RPM *(1500 to 1800 RPM)	and leakage.
10 Minutes	3/4 to Full Load	2200 RPM *(1800 RPM)	

**Engines equipped with 3-5% governors.*

After break-in, run engine 1 to 2 minutes at 1500 RPM, No Load before shut-down. Loosen, then retighten cylinder head cap screws per specified sequence (p. 20-10-9 and p. 20-10-10). Loosen, then retighten rocker arm shaft clamps to 65 ft-lbs. (88 Nm) (8.8 kgm). Check and reset valve clearance to specifications.

During the first 100 hours of operation, avoid over-loads, excessive idling, and no-load operations. After 100 hours, drain crankcase oil and change oil filter. Fill crankcase with oil of proper viscosity and service classifications.

DIAGNOSING ENGINE MALFUNCTIONS

Will Not Start

- Fuel System Malfunction—See Section 230
  - Empty fuel tank
  - Improper fuel
  - Plugged fuel filter
  - Fuel shut off at tank
  - Fuel shut off solenoid defective ("D" engines)
  - Rack Puller defective ("T" and "A" engines)
  - Improper starting procedure
  - Dirty or faulty injection nozzle(s)
  - Plugged air cleaner
- Electrical System Malfunction—See Section 240
  - Corroded or loose battery connections
  - Weak battery

Engine Runs Irregularly or Misses

- Basic Engine Problem—See Section 20
  - Improper valve clearance
  - Low compression
  - Engine overheating
  - Valves sticking or burned
  - Worn camshaft lobes
  - Detonation
- Fuel System Malfunction—See Section 230
  - Low fuel supply
  - Restricted fuel line or filter
  - Air in fuel
  - Incorrect injection pump timing
  - Plugged or defective injection nozzle(s)
  - Faulty injection pump
  - Faulty fuel pump
  - Speed advance not working (D engines)

Frequent Stalling

- Operator Error
  - Engine not at operating temperature
- Fuel System Malfunction—See Section 230
  - Restricted fuel lines
  - Faulty fuel pump
  - Plugged fuel filter
  - Vent on fuel tank cap obstructed
  - Plugged or defective injection nozzle(s)

Lack of Power

Basic Engine Problem—See Section 20
- Low compression
- Engine overheating
- Incorrect valve clearance
- Blown cylinder head gasket
- Worn camshaft lobes
- Burned, warped, pitted or sticking valves
- Weak valve springs

Service Problem
- Dirty or obstructed air cleaners
- Improper fuel

Fuel System Malfunction—See Section 230
- Plugged fuel filters
- Faulty injection nozzles
- Restricted exhaust system
- Plugged fuel tank vent
- Injection pump out of time

Power Train Malfunction—See Section 250
- Clutch Slipping

Engine Overheats

Basic Engine Problem—See Section 20
- Loose or broken fan belt
- Faulty thermostats
- Defective radiator pressure cap
- Faulty water pump
- Clogged radiator

Service Problem—See Section 10
- Low coolant level
- Crankcase oil level low
- Engine overloaded
- Improper fuel

Fuel System Malfunction—See Section 230
- Excessive fuel delivery
- Improper injection pump timing

Excessive Oil Consumption

Basic Engine Problem—See Section 20
- Worn valve guides or valve stems
- Oil control rings worn or broken
- Worn or scored liners or pistons
- Piston ring gaps not staggered
- Excessive main or connecting rod bearing clearance

Service Problem—See Section 10
- Engine oil too thin
- Oil level too high

Low Oil Pressure

Basic Engine Problem—See Section 20
- Stuck or improper regulating valve adjustment
- Excessive main and connecting rod bearing clearance
- Plugged oil pump intake screen
- Leakage at internal oil passages
- Faulty oil pump

Service Problem—See Section 10
- Low oil level
- Improper viscosity of oil

High Oil Pressure

Basic Engine Problem—See Section 20
- Stuck or improperly adjusted regulating valve

Excessive Fuel Consumption

Basic Engine Problem—See Section 20
- Low compression

Fuel System Malfunction—See Section 230
- Leaks in fuel system
- Restricted air cleaner
- Faulty injection pump timing
- Improper valve clearance
- Excessive fuel delivery
- Faulty injection nozzles

Service Problem—See Section 10
- Improper grade of fuel

White Exhaust Smoke

Basic Engine Problem—See Section 20
- Low compression

Fuel System Malfunction—See Section 230
- Faulty injection nozzles
- Improper fuel

Slow Acceleration

Fuel System Malfunction—See Section 230
- Faulty injection pump
- Faulty injection nozzles

Detonation

Fuel System Malfunction—See Section 230
- Oil picked up by intake air stream
- Faulty injection nozzles

Abnormal Engine Noise

Basic Engine Problem—See Section 20
- Low engine oil level
- Excessive valve clearance
- Worn cam followers
- Bent push rods
- Worn rocker arm shafts
- Worn main or connecting rod bearings
- Foreign material in combustion chamber
- Worn piston pin bushings and pins
- Scored piston
- Incorrect engine timing
- Excessive crankshaft end play
- Loose main or connecting rod bearing caps
- Camshaft oil pump drive gear worn or broken

TESTING COMPRESSION PRESSURE

NOTE: Before beginning test, insure that batteries are fully charged.

IMPORTANT: Thoroughly clean area around injection nozzles.

1. Remove fuel pressure and fuel leak-off lines from injection nozzles.

2. Remove injection nozzles.

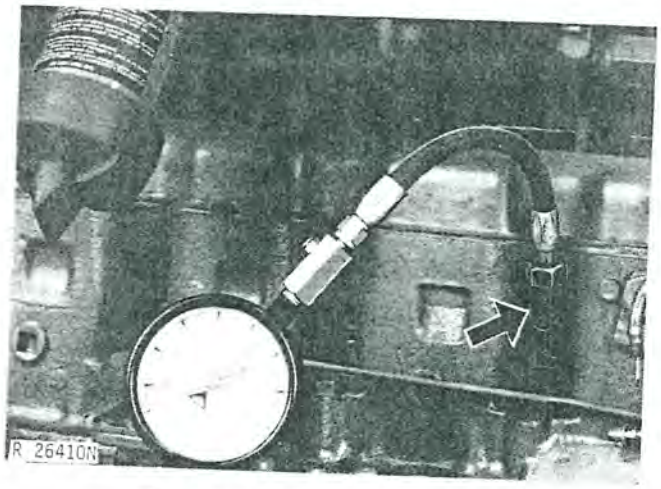


Fig. 1-Testing Compression Pressure

3. Select proper adapter (see pg. 220-00-02) and install in injection nozzle bore (Fig. 1).

4. Attach test gauge to adapter.

5. Close shut off valve at fuel supply.

6. On "D" engines, depress engine stop button while cranking engine with starter.

On "T" and "A" engines, leave rack puller reset handle in the up position while cranking engine.

7. Crank engine with starter for no more than 30 seconds to prevent starter overheating.

In a new engine, the compression should be approximately as follows:

	Cranking Speed	Compression Pressure*
4270D	275 rpm	400 psi (27.6 bar) (28.0 kg/cm²)
6404D; 6466D	200-250 rpm	370-400 psi (25.5-27.6 bar) (24.9-28.0 kg/cm²)
6404T,A; 6466T,A	200-250 rpm	330-370 psi (22.8-25.5 bar) (23.2-24.9 kg/cm²)

*Pressure given was taken at 1000 feet above sea level. A 3.6% reduction in gauge pressure will result for each additional 1000 feet of altitude.

If pressure is much lower than shown, remove gauge and apply oil to the ring area of piston through injection nozzle hole. Do not use too much oil. Do not get oil on the valves.

Test compression again. If pressure is higher, worn or stuck piston rings are indicated. If the pressure is still low, it is possible that valves are worn or sticking.

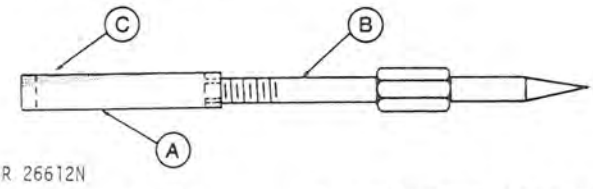
It is very important that all cylinder pressures be approximately alike. There should be less than 25 psi (1.72 bar) (1.75 kg/cm²) difference between cylinder pressures.

Checking Camshaft-Oil Pump Gear Backlash (6-Cylinder Engines)

NOTE: Before measuring backlash, the engine must be at normal operating temperature.

Installing Gauge

1. Remove speed-hour meter drive housing located on rear right-hand side of engine block.



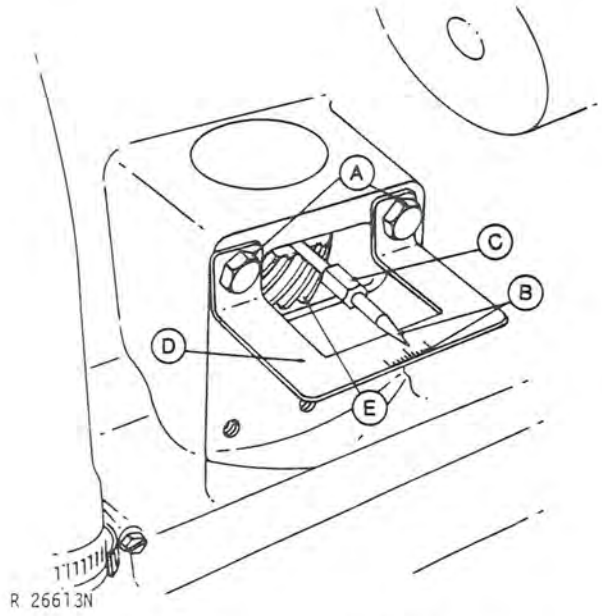
A—Ring **B—Pointer** **C—Grind Material as Required**

Fig. 2-Ring with Pointer

2. Screw together Pointer and Ring from JDE-109 Backlash Indicator Tool (Fig. 2).
3. Install ring with pointer on top flange of engine oil pump drive gear.

NOTE: If interference exists between the cylinder block and the ring, grind some material from ring (Fig. 2). Do not tighten pointer.

Checking Backlash



A—Cap Screws
B—Center Alignment
C—Hex Part of Pointer
D—Gauge
E—Engine Oil Pump Drive Gear

Fig. 3-Installing JDE-109 Gear Backlash Indicator

1. Install gauge (D) on engine block using the two cap screws provided (A, Fig. 3).

2. Align the pointer over the center mark on gauge and tighten pointer (B).

NOTE: It is extremely important that the pointer is tight before determining backlash measurement.

3. Place fingers on hex portion of the pointer (C), and move the pointer back and forth by hand.

IMPORTANT: Do not use excessive force to move the pointer.

NOTE: If the total movement of the pointer is 5 marks or more, check camshaft oil pump drive gear and gear on oil pump for a step wear pattern on teeth of gears.

Checking Valve Lift

Measuring valve lift can give an indication of wear to cam lobes, cam followers, and push rods.

1. Set valve clearance to specifications as previously indicated.

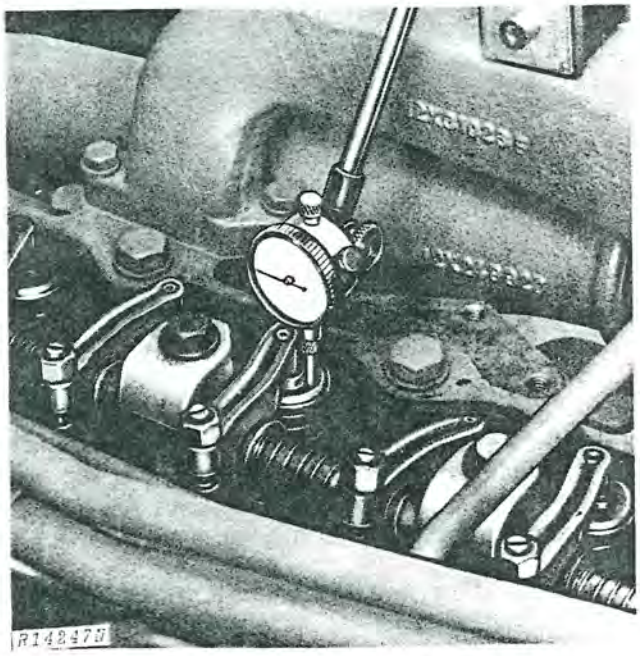


Fig. 4-Checking Valve Lift

2. Place dial indicator on rotator (Fig. 4).

3. Manually turn engine in running direction with JDE-81 Engine Rotation Tool (6-cyl) or with screwdriver (4270D).

Checking Valve Lift—(Continued)

4. After rocker arm contacts valve stem, observe dial indicator reading as valve is moved to full open.

VALVE LIFT SPECIFICATIONS

4270D	
Intake Valves	0.431 to 0.461 in. (10.9 to 11.7 mm)
Exhaust Valves	0.427 to 0.457 in. (10.8 to 11.6 mm)
6404D; 6466D	
Intake Valves	0.424 to 0.454 in. (10.77 to 11.53 mm)
Exhaust Valves	0.414 to 0.444 in. (10.52 to 11.28 mm)
6404T, A; 6466T, A	
Intake Valves	0.412 to 0.442 in. (10.5 to 11.2 mm)
Exhaust Valves	0.413 to 0.443 in. (10.5 to 11.3 mm)

Checking Valve Clearance

4270D

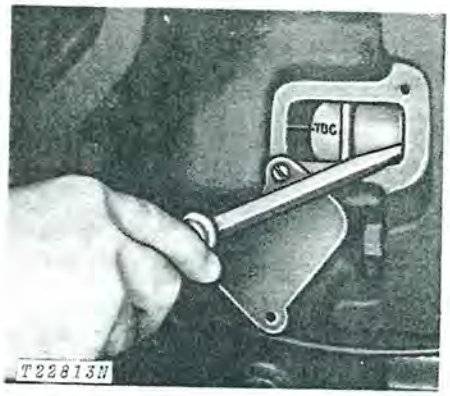


Fig. 5-Setting Engine to TDC

1. Using a screwdriver or similar tool, manually turn flywheel until timing mark on flywheel aligns with reference mark on flywheel housing (Fig. 5). Always turn flywheel MANUALLY when aligning timing marks.

VALVE CLEARANCE SPECIFICATIONS

Intake and Exhaust Valves .....0.018 in. (0.5 mm)

2. Adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves (Fig. 6).

3. Rotate flywheel 360 degrees until No. 4 piston is at TDC of its compression stroke.

4. Adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves (Fig. 6).

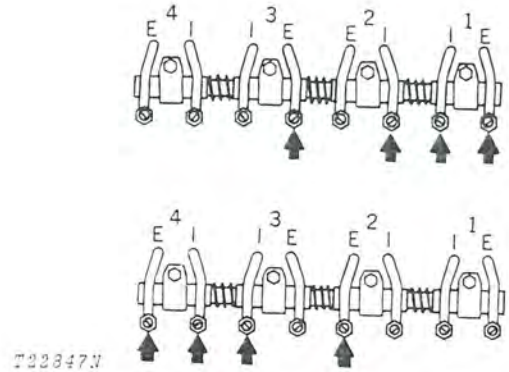
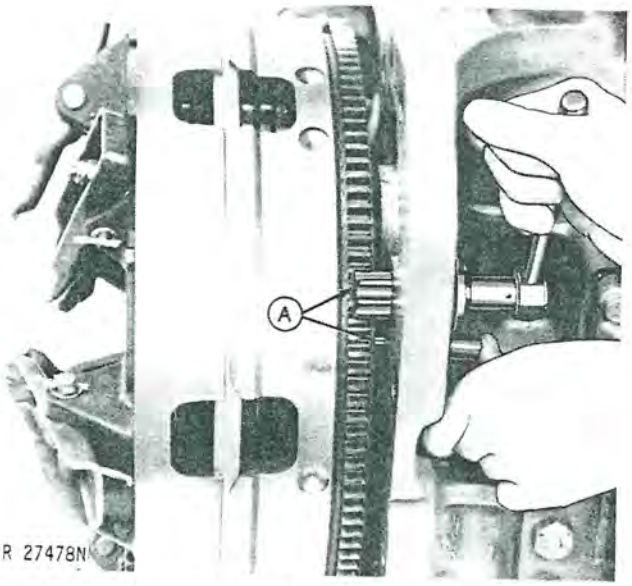


Fig. 6-Valve Clearance Adjustment

6404 and 6466



A—JDE-81 Engine Rotation Tool Set

Fig. 7-Setting Engine to TDC

1. Use JDE-81 Engine Rotation Tool Set (A, Fig. 7) to position No. 1 piston at TDC of its compression stroke.

2. Turn flywheel until rotation tool timing pin engages timing hole in flywheel and both valves on No. 1 cylinder are in the up position. (Rocker arms loose).

VALVE CLEARANCE SPECIFICATIONS

Intake Valves .....0.018 in. (0.5 mm)
Exhaust Valves.....0.028 in. (0.7 mm)

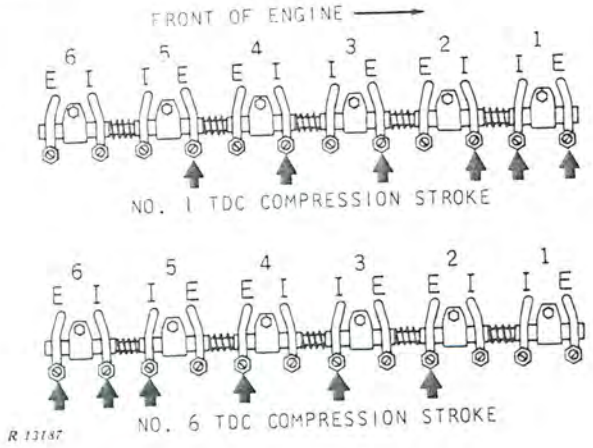


Fig. 8-Valve Clearance Adjustment

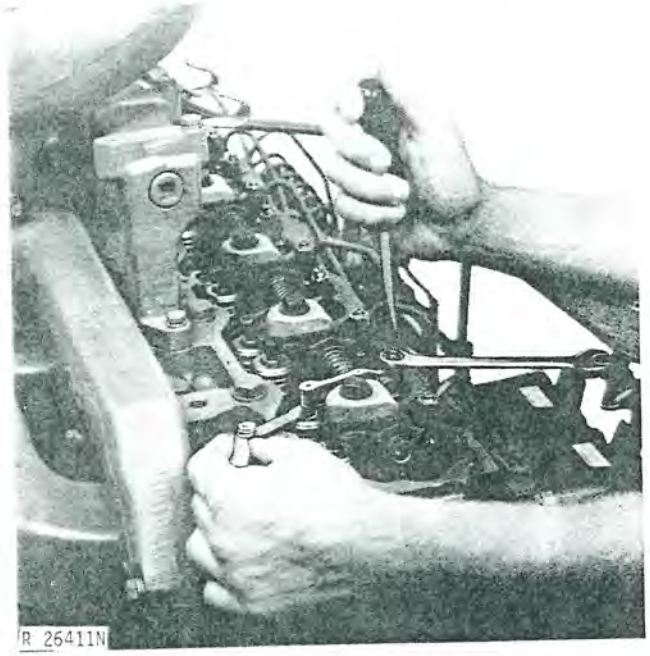


Fig. 9-Checking Valve Clearance

3. Adjust valve clearance on No. 1, 3, and 5 exhaust valves and No. 1, 2, and 4 intake valves (Figs. 8 and 9).

4. Rotate flywheel 360 degrees until No. 6 piston is at "TDC" of its compression stroke, and tool timing pin engages flywheel hole.

5. Adjust valve clearance on No. 2, 4, and 6 exhaust valves and No. 3, 5, and 6 intake valves to the specifications listed above.

Checking Crankshaft End Play

Use the following procedure to check crankshaft end play before removing crankshaft:

1. Completely engage and release the clutch.

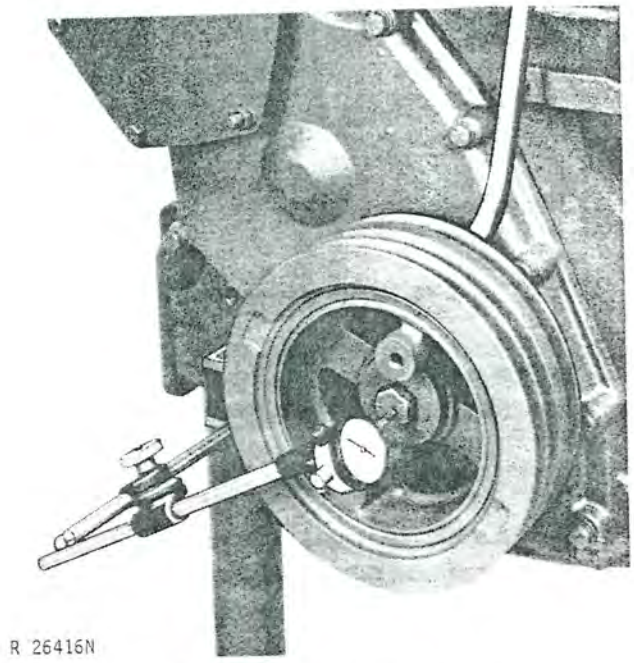


Fig. 10-Checking Crankshaft End Play

2. Place a dial indicator on crankshaft pulley or damper (Fig. 10).

IMPORTANT: Use care not to distort the timing gear cover or damage the bearing inserts when prying. Do not pry on rubber damper at rear of pulley.

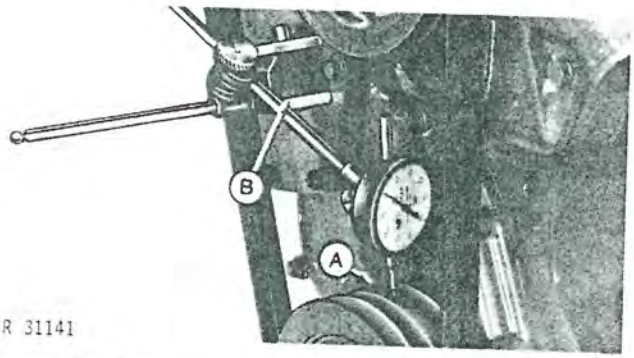
3. Pry between the pulley and timing gear cover (Fig. 10).

CRANKSHAFT END PLAY SPECIFICATIONS

New part end play (new thrust bearing)

6404 (-444687)	0.0025 to 0.0085 in (0.064 to 0.216 mm
4270D; 6404 (444688-6466	); 0.0015 to 0.0150 in (0.038 to 0.380 mm

Checking Damper Run-out (6-cylinder)



A—Damper Edge B—Indicator Base

Fig. 11-Checking Damper Run-out

NOTE: Engine should be run for approximately five minutes before checking damper run-out. The damper assembly becomes more concentric after warming up.

1. Thoroughly clean outer edge of damper pulley (A, Fig. 11) so an accurate indicator reading may be made.
2. Attach a dial indicator base (B) to side frame and position indicator contact point on damper.
3. Use JDE-81 Engine Rotation Tool Set to rotate crankshaft, while observing indicator read out. If runout of damper exceeds 0.040 in. (1 mm), replace damper.

CHECKING OIL PRESSURE

1. Remove pipe plug from main oil gallery.
2. Install pressure gauge (Fig. 12 or 13).
3. Warm up engine and run at 1900 RPM.
4. Check engine oil pressure.

ENGINE OIL PRESSURE SPECIFICATION

4270D	25 to 40 psi (1.72 to 2.75 bar) (1.76 to 2.81 kg/cm²)
6404 and 6466	40 to 50 psi (2.75 to 3.45 bar) (2.81 to 3.52 kg/cm²)

To adjust oil pressure on 4270D engines, remove cap nut from pressure regulator and loosen jam nut. Turn adjusting screw out to decrease pressure or in to increase pressure. Tighten jam nut and install cap nut (Fig. 12).

To adjust oil pressure on 6404 and 6466 engines, remove regulating valve spring at filter base. Add adjusting washers to increase pressure or remove washers to decrease pressure. Do not use more than five washers.

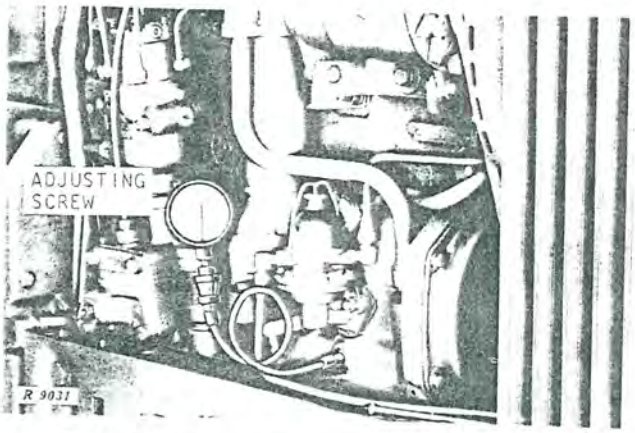


Fig. 12-Checking and Adjusting Oil Pressure (4270D)

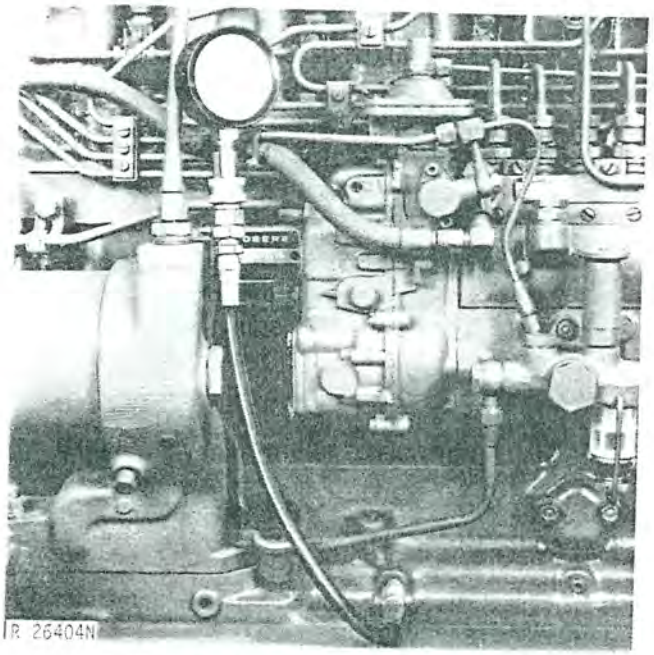


Fig. 13-Checking Oil Pressure (6404T Shown)

Testing Cooling System

1. Visually inspect radiator for leaks or damage.

2. Remove radiator cap.

3. Attach D-05104ST Pressure Pump to radiator filler neck. (Fig. 14).

4. Use pump to apply 18 psi (1.24 bar) (1.26 kg/cm²) pressure to system.

5. Check engine, radiator and hoses for coolant leaks.

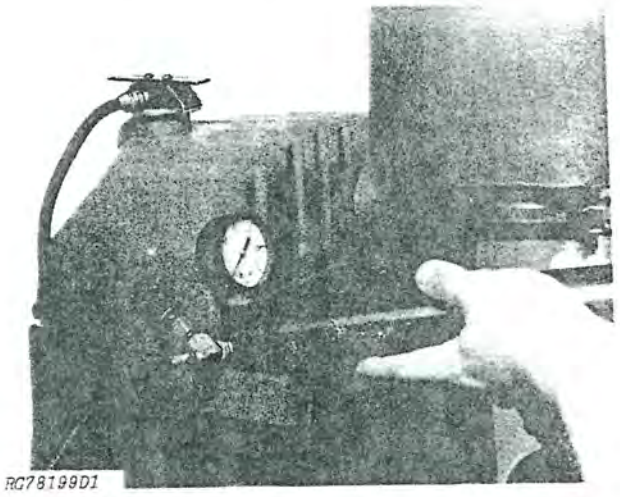


Fig. 14-Testing Cooling System