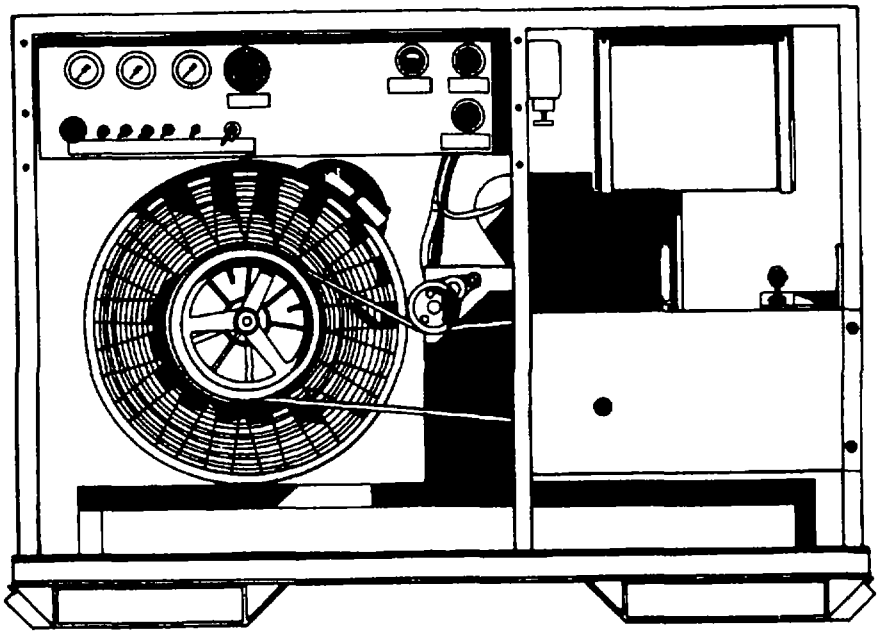
TECHNICAL MANUAL

OPERATOR, UNIT AND INTERMEDIATE (DIRECT SUPPORT / GENERAL SUPPORT) MAINTENANCE MANUAL



20 CFM COMPRESSOR DIVING AIR
MODEL K-20
NSN 4310-01-291-8028

Approved for public release; distribution is unlimited.

H E A D Q U A R T E R S , D E P A R T M E N T O F T H E A R M Y
2 3 O c t o b e r 1 9 9 0

CHANGE

NO. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 31 AUGUST 1996

Operator, Unit, and Intermediate (Direct Support/General Support)
Maintenance Manual

20 CFM COMPRESSOR DIVING AIR
MODEL K-20
(NSN 4310-01-291-8028)

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited

TM 5-4310-389-14, 23 October 1990, is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages	Insert pages
i and ii	i and ii
1-1 and 1-2	1-1 and 1-2
1-9 and 1-10	1-9 and 1-10
3-3 and 3-4	3-3 and 3-4
3-9 and 3-10	3-9 and 3-10
B-9 and B-10	B-9 and B-10
B-13 and B-14	B-13 and B-14

2. Retain this sheet in front of manual for reference purposes.

By Order of the Secretary of the Army:

DENNIS J. REIMER
General, United States Army
Chief of Staff

Official:

JOEL B. HUDSON
Administrative Assistant to the
Secretary of the Army
02127

DISTRIBUTION:
To be distributed in accordance with DA Form 12-25-E, block no. 5418, requirements for TM 5-4310-389-14.

WARNINGS

Never attempt to rectify faults or carry out repairs for which you do not have the necessary equipment and special tools.

Before starting the compressor unit, ensure that no one is standing in the vicinity of the engine or driven machine. Ensure that hearing protection is worn.

Do not inject an excessive amount of fuel. Excessive quantities of fuel injected before starting can lead to engine damage. For safety reasons, never use start pilot simultaneously with preheating systems.

When working on the battery, keep heat and open flames away; do not permit smoking. Do not allow acid to come in contact with skin or clothing. Wear protective goggles. Do not place tools on battery.

Prior to starting the engine, ensure that there is sufficient oil for the start.

Always stop the engine before refueling. Observe strict cleanliness. Do not spill any fuel. Always stop the engine before carrying out maintenance or repair work.

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

In no event use gasoline or hot liquids for cleaning air cartridges.

When working on the fuel system, keep away from heat and open flame. Do not smoke. Do not spill any fuel.

To prevent personnel injury, ensure that work clothes are closely fitting so that they cannot be caught by rotating machinery or projecting parts.

Ensure that the compressor unit is secured and that system pressure has been bled to zero when performing any maintenance procedure.

Do not attempt to remove cartridges until the gauge pressure is zero.

Eye protection/face shield must be worn when using compressed air for cleaning. Never use compressed air over 35 psi line pressure for cleaning. Clear immediate area of personnel.

Heat the oil in a container on a hot plate (not with welding torch). Do not exceed the specified temperature range. Danger of burns.

A small amount of oil runs out when screwing off the oil filter. Danger of scalding in case of hotoil! Catch old oil in suitable receptacle to prevent pollution of the environment! To prevent serious eye injury while removing/installing retaining ring(s), wear safety eye protection.

Ensure retaining ring(s) is secure in the ring groove.

Valve pieces may fall out when removing the 4th stage head.

To prevent injury to personnel, attach a suitable lifting device to the engine, as it weighs 650 lbs.

To prevent injury, ensure that rigging device of adequate capacity is installed to lift the power take-off.

When installing oil pump, oil pump should be primed by filling the pump with oil and turning the shaft until oil is pushed from the pressure side of the pump.

Fuel timing shims are matched to each pump assembly. Do not interchange shims, barrels, plungers, or metering valves. Serious damage or personnel injury may occur.

All work performed on the compressor must be accomplished only while the unit is depressurized.

TECHNICAL Manual

No 5-4310-389-14

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 23 OCTOBER 1990

Operator, Unit and Intermediate Direct Support/General Support Maintenance Manual

20 CFM COMPRESSOR DIVING AIR MODEL K-20 NSN 4310-01-291-8028

Approved for public release; distribution is unlimited.

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes, or if you know of a way to improve these procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual directly to: Commander, US Army Aviation and Troop Command, ATTN: AMSAT-I-MP, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798. You may also submit your recommended changes by E-mail directly to <mpmt%avma28@st-louis-emh7.army.mil>. A reply will be furnished directly to you. Instructions for sending an electronic 2028 may be found at the back of this manual immediately preceding the hard copy 2028.

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

CHAPTER 1
INTRODUCTION AND DESCRIPTION

Section I.
GENERAL INFORMATION

1-1. SCOPE. This technical manual contains descriptive data, operating instructions, set-up and storage procedures, and maintenance instructions for a 20 cfm Compressor. The manufacturer's part number for the 20 cfm Compressor is Model K-20.

NOTE

Where possible, all dimensional values are given in the English system and Metric system. The metric values will appear in parenthesis beside the English system value.

1-2. PURPOSE. The purpose of the compressor unit (figure 1-1) is to provide purified high-pressure compressed air breathing for charging Type I and Type II manifold servicing units.

1-3. MAINTENANCE FORMS, RECORDS, AND REPORTS. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 738-750, The Army Maintenance Management System (TAMMS).

1-4. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR). If your K-20 compressor unit needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design or performance. Put it on an SF-368 (Quality Deficiency Report). Mail it to us at: Commander, U.S. Aviation Troop Command, ATTN: AMSAT-D-WTT, 4300 Goodfellow Blvd., St. Louis, Mo. 63120-1798. A reply will be furnished to you.

1-5. LIST OF ABBREVIATIONS.

cfm	Cubic feet per minute
rpm	Revolutions per minute
psi	Pounds per square inch
hp	Horsepower
cc	Cubic centimeters
qts	Quarts
IL	In-line
in	Inch
lbs	Pounds
psig	Pounds per square inch gauge
BAR	Bars
Nm	Newton meters
lb-.ft	Pound-feet

1-5. LIST OF ABBREVIATIONS (Contd).

CO ..... Carbon monoxide
CO_2.....Carbon dioxide
cu.ft..... Cubic feet
gal .....Gallon
PMCS .....Preventive Maintenance Checks and Services
MAC ..... Maintenance Allocation Chart
PMV .....Pressure maintaining valve
ACD .....Automatic condensate drain
cm .....Centimeter
mm .....Millmeter
V ..... Volts

1-6 DESTRUCTION OF ARMY MATERIEL TO PREVENT ENEMY USE. The procedures for destroying army materiel to prevent enemy use are listed in TM 750-2443.

Section II.
EQUIPMENT DESCRIPTION AND DATA

1-7 EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES. Equipment characteristics, capabilities, and features of the model K-20 consists of a high-pressure compressor coupled to a two-cylinder diesel connected by a V-belt drive (figures 1-1 and 1-2). The unit includes an instrument panel, fuel tank, purification system, and a skid-mounted frame. The K-20 is capable of providing 20 cfm (cubic feet per minute) of free air compressed to 5000 psi (pounds per square inch). The unit can be operated in temperatures ranging from -25 to +125°F.

a. Compressor. The compressor is a four-cylinder, four-stage, reciprocating, air-cooled unit. The cylinders are arranged in the form of an X. The compressor will deliver 20 cfm free air compressed to 5000 psi. The fourth stage cylinder is lubricated by means of a force-fed lubrication system; the other cylinders are mist-lubricated. The cylinders of the compressor block, the intermediate coolers, and the after cooler are air-cooled. For this purpose, the compressor is equipped with a cooling fan which draws the cooling air through the cooling fan cover from the surroundings. The cooling fan is driven by the drive motor V-belt and is mounted on the flywheel.

b. Diesel Engine. The diesel engine is an air-cooled, four-cycle, two-cylinder, IL (in-line) engine coupled with a dry plate clutch developing 27 hp (horse power) at 2200 rpm. The engine can be battery started using a 12-volt system or may be started by use of a hand crank provided.

c. Instrument Panel. The instrument panel is located on the front side of the unit (figure 1-1) on antivibration shocks. The rear of the panel is accessible by removing five screws from the back plate.

d. Fuel Tank. The fuel tank is located above the engine, toward the front (figure 1-1). It has a 13gal (gallon) capacity with no reserve; it is sufficient for eight hours of continuous operation.

e. Purification System. The purification system consists of two purifying cylinders using replaceable cartridges.

f. Frame. The frame is constructed of steel channels unitized by welds. Integrated into the frame design are skids and slinging/tie-down attachments. The subframe is attached to the main frame by 10 antivibration mounts.

g. Clutch. The dry plate clutch is operated by a hand lever, which enables the engine to be started without the compressor.

h. Inter and After Coolers. Coolers that enable air to be cooled between the stages of the compressor.

i. Oil/Water Separator Block. The oil/water separator block used on the K180 is almost identical to the commercial version with the exception of the shatterproof condensate drain coil. The 0 rings are Buna-N rubber instead of Viton and the sinter filters have been removed (the 0-rings and sinter filter removal are due to the -25°F operating temperature).

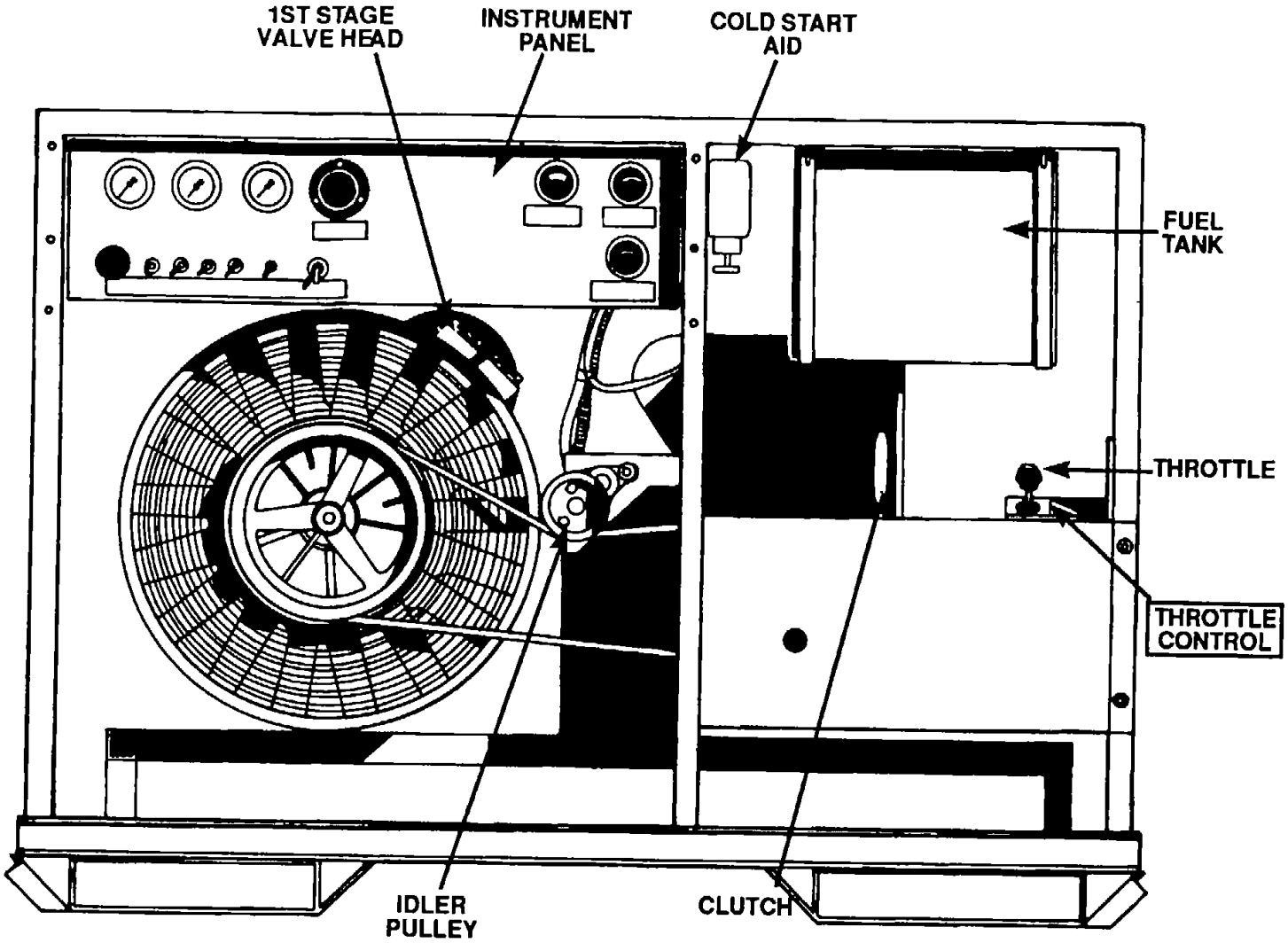


Figure 1-1. K-20, Front View

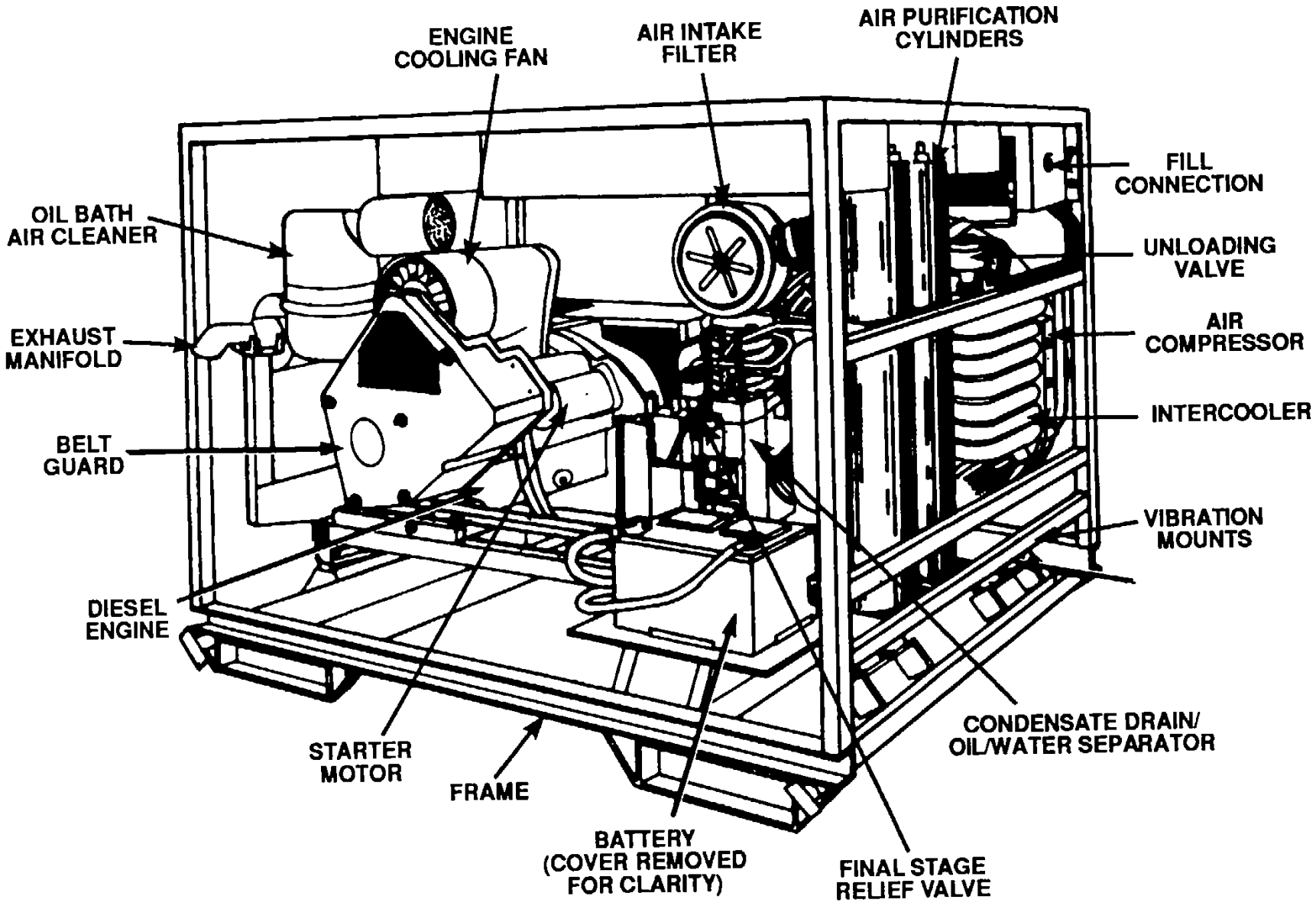


Figure 1-2. K-20, 3/4 Rear View

The air is passed through three oil/water separators from the second, third, and final stages, respectively.

The drawn-off oil/water is maintained in the separator blocks until the condensate drain is activated.

Power is momentarily interrupted by the condensate drain switch and allows the piston seal to release the second stage air pressure to the atmosphere. The pressure release allows the second, third, and final condensate valve block seats to lift and allows the oil/water condensate to vent through the condensate drain valves, past the drain valve seats and back to the drain passage in the lower condensate block, and vents directly to the atmosphere.

The condensate heater is used in cold weather operations to prevent condensate from the second, third, and final stages from freezing. The use of the condensate heater does not have to be below 32°F (0°C) due to relative humidity and the fast-moving air within the separator block. Any slow draining or visible freezing of the condensate during colder weather may warrant the use of the condensate heater. The condensate heater draws 200 watts of power so it should only be turned on after the unit is operational.

CAUTION

The diesel engine and compressor are built to metric standard measurement. The frame and mounting equipment are manufactured using English standard sizes. Do not use improper tool sizes in affecting maintenance or repairs. USE THE RIGHT TOOL FOR THE RIGHT JOB.

1-8 EQUIPMENT DATA. The equipment data for the compressor and its components is listed in Table 1-1.

Table 1-1. Equipment Data/Characteristics

Engine	
Model	F2L912
Cylinders	2 IL
Displacement	115 cu.in. (1884 cc)
Initial Oil Capacity	6-1/2 qts (6.15 ltrs)
Oil Change Refill	5 qts (4.7 ltrs)
Weight	650 lbs (295 kg)
Lubrication	Deutz injection
Engine Delivers	27 hp at 2200 rpm
Direction of Rotation Viewing at Flywheel	Counterclockwise
Compressor Block	
Model	K-180

Table 1-1. Equipment Data/Characteristics (Continued)

Compressor Block (Contd)	
Intermediate Pressures	
1st/2nd Stage	45 to 60 psi (3-4 BAR)
2nd/3rd Stage	230 to 260 psi (16-18 BAR)
3rd/4th Stage	1000 to 1100 psi (70-75 BAR)
Oil Capacity	4 qts (3.8 ltrs)
Weight	270 lbs (122.5 kg)
Purification	
Purification System	P-S
Cartridges Required	2
Power	Battery, 12 V
Compressor Unit	
Model	K-20
Operating Parameters	
Compressor Block Delivers	20 cfm at 5000 psi
Lubrication	Bosch injection
Dimensions	
Unit Dry Weight	1850 lbs (839.2 kg)
Volume	80.3 cu.ft. (2274 cc)
Length	59 in. (150 cm)
Width	48 in. (122 cm)
Height	49 in. (125 cm)
Ambient Temperature (max)	125°F (52°C)
Air Discharge Temperature	18 to 27°F (10 to 15°C) above ambient temperature
Permissible Inclination of Compressor	
*Forwards/Backwards	150
*To Right/Left Side	150

*These values are only valid if the oil level of the compressor, in level position, agrees with the upper mark of the oil dipstick and may not be exceeded.

1-9 DIFFERENCES BETWEEN MODELS. Model K-20, 4310-01-291-8028, is the only provisioned model for this 20 cfm diving compressor. It is supported by TM5-43 10-389-14 and TM5-43 10-389-24P.

1-10 SAFETY, CARE, AND HANDLING.

a. This manual is not intended to dictate safe diving operations or procedures. Diving supervisors are ultimately responsible for conducting safe diving operations in accordance with approved regulations and instructions.

b. Always shut down and depressurize the system to carry out any work on the compressor. Failure to observe this warning may result in injury or death to personnel.

c. Never resolder or reweld pressure lines.

d. Never open outlet valves when under pressure.

e. Check for leakage of the complete system from time to time by brushing all fittings and couplings with non-ionic detergent water solution. Remedy any leakage.

f. Connecting hoses must be in satisfactory condition and threads undamaged. Pay particular attention to damage on the interface from hose fitting to hose. If the rubber is scored, the hose must be discarded; otherwise, water can enter and attack wire gauze causing it to rust and thus endangering pressure tightness.

g. Leave 1-1/2 threads exposed on fitting when applying Teflon tape. This will ensure that no Teflon tape will hang down into the air or fuel system. Teflon tape should be wrapped in such a manner that when the fitting is tightened, the tape will not loosen. Incorrectly wrapped tape may result in contamination or blockage of the air or fuel system and subsequent possible injury to the diver.

h. Ensure that all air lines and components removed (or openings into the air system) are inserted into a plastic bag and sealed, and that FMEC (foreign material enclosure caps) are inserted into openings. Failure to do so can cause the air system to become contaminated and could result in injury or death to the diver.

i. Do not use trichloroethylene or methyl chloroform in cleaning operations associated with any diving system. Use of either chemical or similar contaminates can result in death when operators/ divers are exposed to these contaminates under pressure. These contaminants are not water soluble. If contamination or suspected contamination occurs, immediately discontinue all equipment diving operations and notify the Army diving safety office, AUTOVON 927-1329/ Commercial (804) 878-1329. The only acceptable cleaning agents are tribastic sodium phosphate and non-ionic soaps; liquid Joy and liquid Ivory.

j. Remove all traces of lacquer thinner with non-ionic detergent (NID) solution and rinse with fresh water. Residual lacquer thinner will contaminate breather atmosphere and may cause injury or death to personnel.

k. Repair or replace worn or damaged parts immediately with authorized parts. Failure of a component during equipment usage could result in injury or death to personnel.

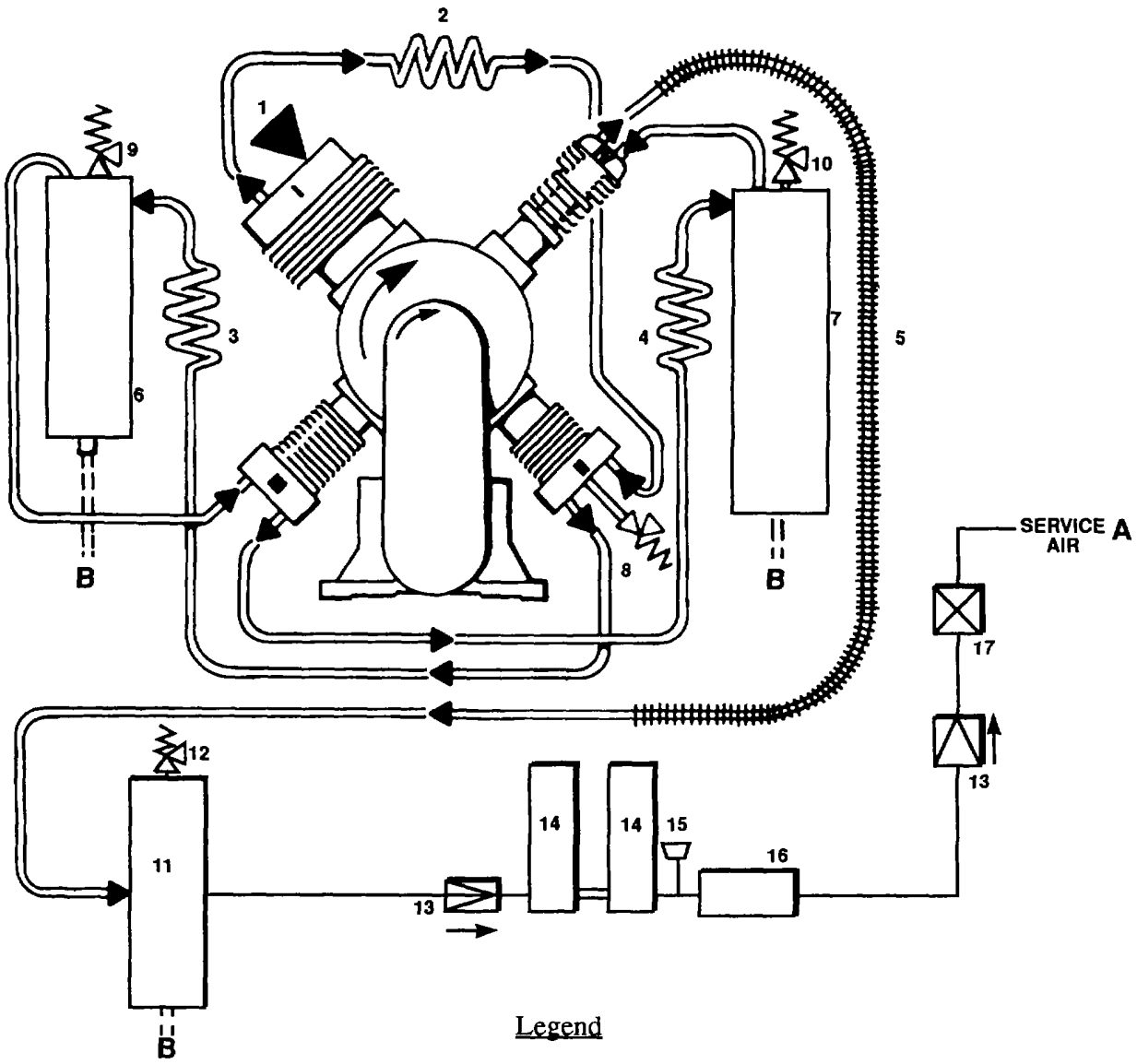
l. The engine and compressor can be cleaned with a pressurized cleaning system (steam cleaner), but care must be talon. Cap off engine and compressor intakes. Do not spray water (steam) directly into the instruments or the back of the instrument panel. Do not spray the starter or alternator directly. If possible, dry with compressed air and run unit immediately after washing to prevent rust and corrosion.

Section III
TECHNICAL PRINCIPLES OF OPERATION

1-11 COMPRESSOR. The compressor is driven at constant speed and, when the final air pressure is reached, the pressure relief valve opens to the atmosphere. When air pressure is reduced to 4600 psi, the relief valve closes. Each stage of the compressor is connected to the next higher stage by an intercooler. The fourth stage discharge is connected to an after cooler. The purpose of the coolers is to reduce the temperature of the compressed air. A separator is connected to the second, third, and fourth coolers to drain the oil and moisture accumulated during compression and cooling of the air. The accumulated water and oil vapors should be drained every 15 minutes by depressing the switch on the instrument panel so all separators drain.

1-12 AIR FLOW. Refer to figures 1-3 and 1-4. The first stage (I) of the compressor draws in atmospheric air through micronic intake filter (1). Here the air is compressed to a pressure of about 45 psi (3.0 bar). The compressed air entering the second stage (II) is recooled by the intercooler (2). In the second stage (II), the air is further compressed to about 230 psi (16 bar), then passed through the intercooler (3) and interfilter (6) to the third stage (III). In the third stage, the air is compressed 1000 to 1100 psi (70 to 75 bar). Leaving the third stage, the air passes through intercooler (4) and interfilter (7) to the fourth stage (IV). In the fourth stage, the air is finally compressed to the operating pressure of the compressor unit. On leaving the fourth stage, the air is passed through the after cooler (5) and is routed via connection A to the filter system of the compressor unit. The intermediate pressures of the individual stages are monitored by the intermediate pressure safety valves. Final pressure is monitored by the final pressure safety valve. Condensate can be manually drained by a switch on the instrument panel. Upon shutdown, the condensate automatically drains.

1-13 PURIFIERS. The compressed air that leaves the final separator is relatively free from oil vapors and condensate. At this point, the air is not up to diving air purity. As the air passes through the two purification cylinders, the finer oil and water vapors, taste, odor, and carbon monoxide are removed, thereby producing pure diving air.



Legend

1. Intake Filter
2. Intercooler (1st stage)
3. Intercooler (2nd stage)
4. Intercooler (3rd stage)
5. After Cooler
6. Condensate Block (2nd/3rd stage)
7. Interfilter (3rd/4th stage)
8. Interm. Pressure Safety Valve (1st stage)
9. Interm. Pressure Safety Valve (2nd stage)
10. Interm. Pressure Safety Valve (3rd stage)
11. Condensate Block (4th stage)
12. Final Pressure Relief
13. One-Way Valve
14. Filters
15. Bleed Off Valve
16. Pressure Maintaining Valve
17. Service Valve

A Air Outlet

B Condensate Outlet

Note: Condensate Blocks 6, 7, and 11 are actually mounted on a heated condensate drain manifold along with the final separator.

Figure 1-3. Compressor Air Flow Diagram

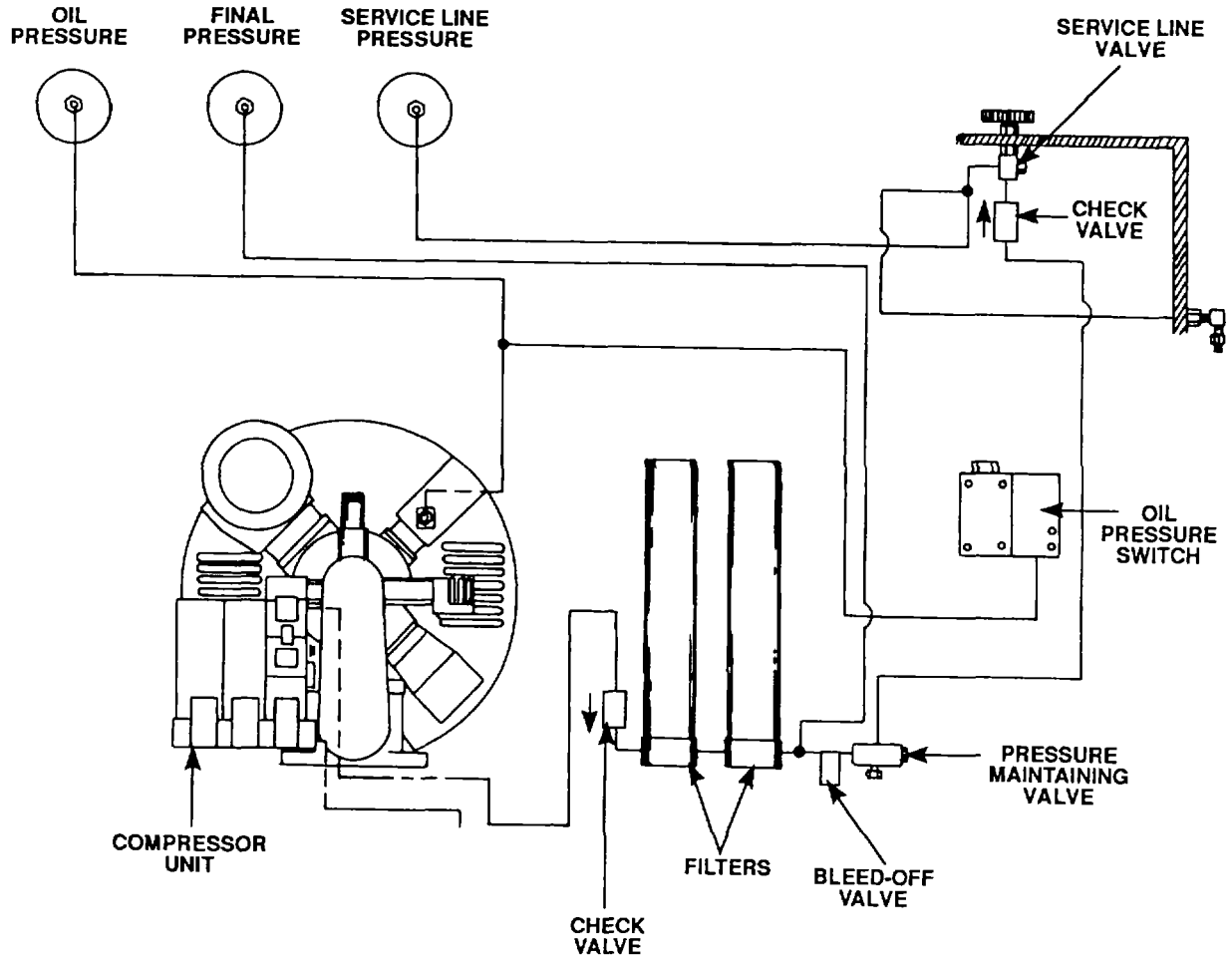


Figure 1-4. Air System Flow Diagram

CHAPTER 2
OPERATING INSTRUCTIONS

Section I.
DESCRIPTION AND USE OF THE OPERATOR'S CONTROLS AND INDICATORS

2-1 GENERAL. The instrument panel is located on the front side of the unit. It contains all the operator's gauges, switches, valves, and controls with the exception of the clutch control lever, ether injector, and engine throttle. See figure 2-1 for instrument location and paragraph 2-2 for functional description.

2-2 OPERATOR'S CONTROLS AND INDICATORS.

a. Service Line Pressure Gauge (1). This gauge indicates the air pressure delivered to the service outlet (O to 5000 psi).

b. Final Pressure Gauge (2). This gauge indicates the air pressure discharged from the final (fourth) stage (1800 to 5000 psi).

c. Compressor Oil Pressure Gauge (3). This gauge indicates the lubricating pressure in the air compressor. Pressure normally reads between 750 to 870 psi.

d. Hourmeter (4). The hourmeter is electrically operated and indicates total running hours of the compressor from 0000.0 to 9999.9.

e. Ammeter (5). The ammeter indicates the operation of the alternator; it normally reads positive.

f. Engine Head Temperature Gauge (6). This gauge indicates the temperature in the engine head; it normally reads 170OF to 2700F.

g. Engine Oil Pressure Gauge (7). This gauge indicates the oil pressure in the engine; it normally reads 30 to 90 psi, with a minimum of 15 psi.

h. Ignition Switch (8). This is a three-position switch. Moving the lever to the ON position on the right energizes the electrical system. Moving the lever to the START position runs the starter motor. After the engine starts, move the lever back to the RUN position.

i. Relay Latch (9). This button activates the automatic shutdown if the engine or compressor temperatures are excessive or if oil pressure is abnormal. The relay latch button must be pushed in before starting engine.

j. Safety Bypass Switch (10). The safety bypass switch is used for normal starting to bypass the compressor oil pressure switch. Turn to ON before starting. Turn to OFF after oil pressure is established.

k. Condensate Drain Switch (11). This switch causes all drains to open as long as the switch is held in the DRAIN position.

l. Heater Condensate Switch (12). This on/off switch controls the heater for the condensate valve assembly. It is used only when the engine is running during cold weather 32'F (00C) or below.

m. Heater On Light (13). This light indicates when the condensate heater is on.

n. Service Line Control Valve (14). This valve controls air flow to the service line outlet.

o. Low Pressure Override (15). Overrides low pressure safety switch. Used for starting.

2-3 SAFETY DEVICES.

a. Purifier Venting Bore. Located in the purifier is a vent switch which allows air to escape when the purifier cartridge is missing. When the cartridge is in place, the vent closes, allowing air pressure to build up. This safety device prevents the operator from delivering unpurified air. See figure 2-2.

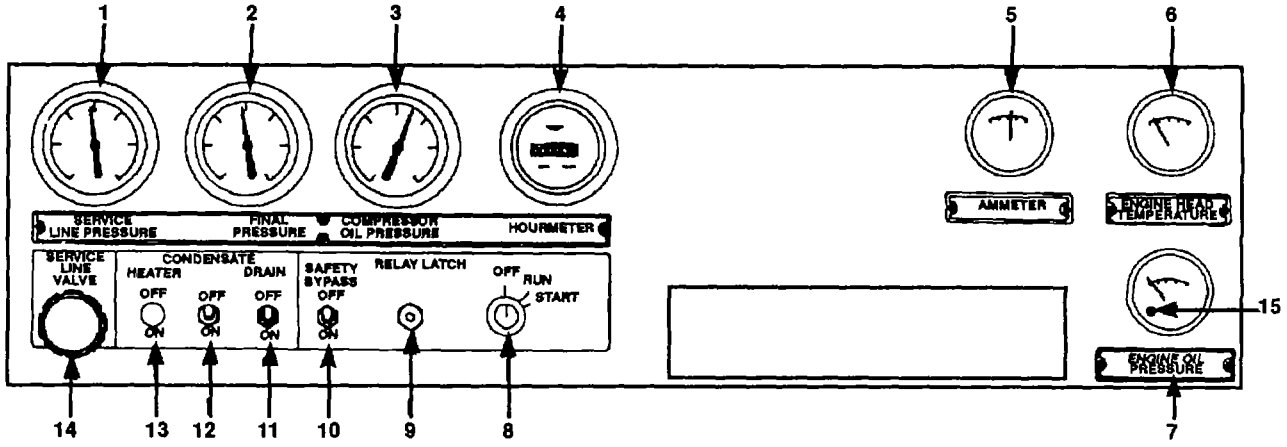
b. Bleed Valve. This valve is used to remove air pressure from the entire system whenever maintenance is performed. Turning clockwise opens the valve. See figure 2-3.

c. Pressure Maintaining Valve. This valve is located downstream of the purifiers and is factory set to open at 2000 psi. Air cannot be delivered to the service outlet until the purifiers have reached an internal pressure of 2000 psi, which is the minimum pressure for the purifiers to function properly.

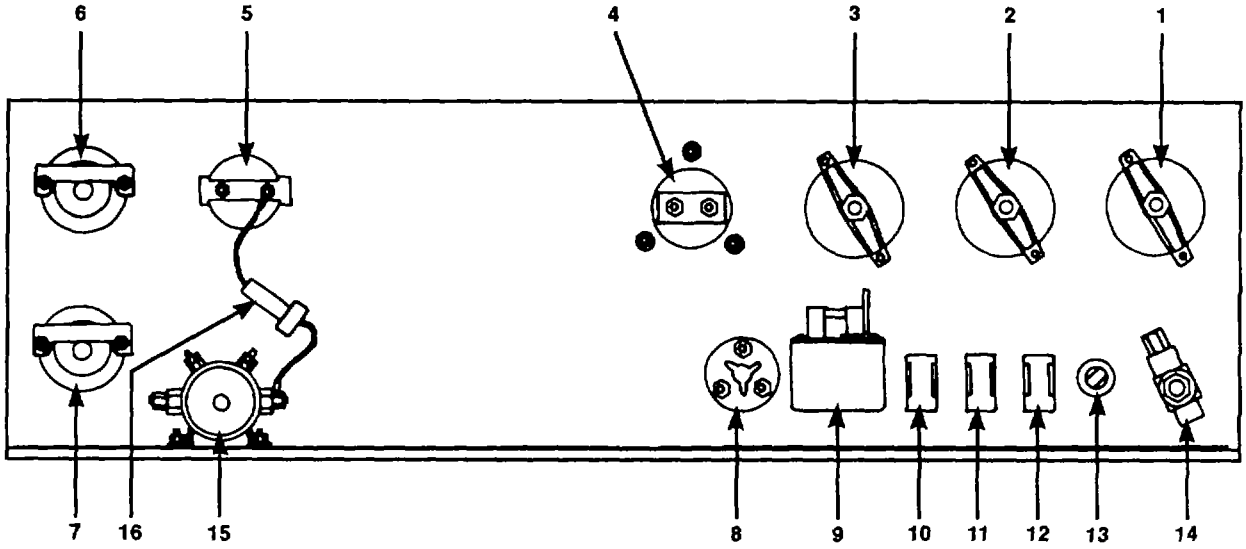
d. Pressure-Relief Valves. This unit is equipped with a pressure-relief valve on each stage.

Whenever air pressure upstream of each valve exceeds the preset relief pressure, the valve will open and dump air pressure to the atmosphere. Once the upstream pressure returns to normal, the valve will close.

e. Air Check Valve. This valve prevents air from the filled pressure vessel from backing up through the purifiers when the compressor is not delivering air. Air flowing upstream through the purifiers can cause damage to the cartridges and separators.



REAR



Legend

1. Service Line Pressure Gauge
2. Final Pressure Gauge
3. Compressor Oil Pressure Gauge
4. Hourmeter
5. Ammeter
6. Engine Head Temperature Gauge
7. Engine Oil Pressure Gauge
8. Ignition Switch
9. Relay Latch with Fuse
10. Safety Bypass Switch
11. Condensate Drain Switch
12. Heater Condensate Switch
13. Heater On Light
14. Service Line Control Valve
15. Condensate Relay
16. Condensate Heater Fuse

Figure 2-1. Instrument Panel

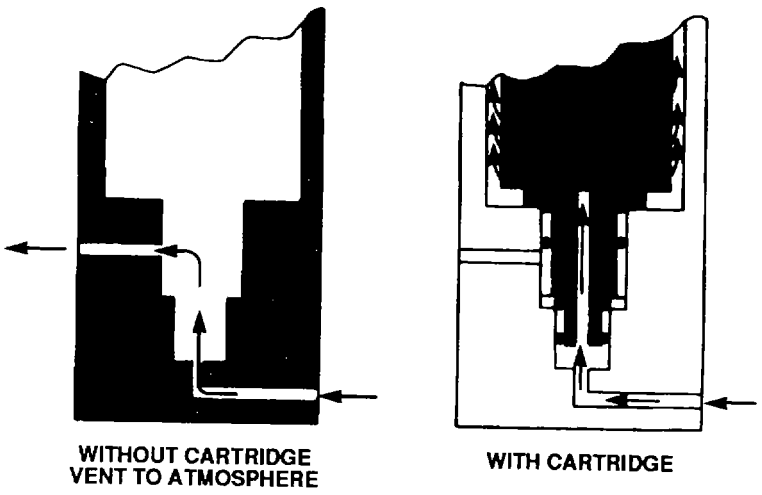


Figure 2-2. Venting Bore

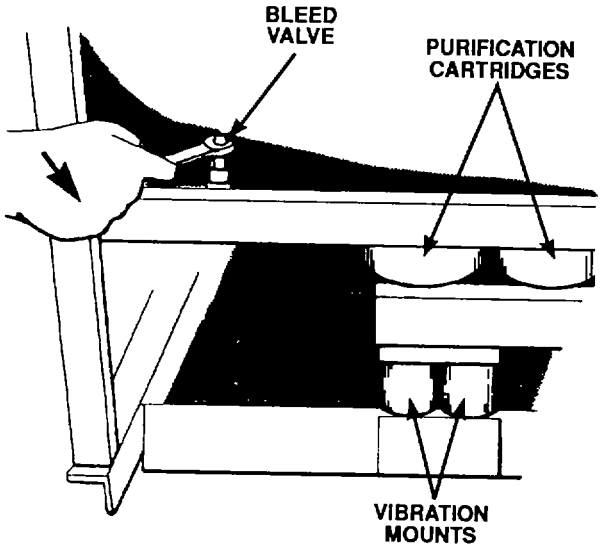


Figure 2-3. Bleed Valve

Section II
PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

2-4 GENERAL.

a. Before you operate. Always keep in mind the CAUTIONS AND WARNINGS. Perform your before (B) PMCS.

b. While you operate. Always keep in mind the CAUTIONS AND WARNINGS. Perform your during (D) PMCS.

c. After you operate. Be sure to perform your after (A) PMCS.

d. If your equipment fails to operate. Troubleshoot with proper equipment. Report any deficiencies using the proper forms. See DA PAM 738-750.

2-5 PREVENTIVE MAINTENANCE CHECKS AND SERVICES PROCEDURES. Table 2-1 lists and describes the operator PMCS required for the air compressor. Table 2-1 consists of four columns containing the following:

a. Item Number Column. Checks and services are numbered in chronological order regardless of interval performed. The items numbers will be entered in the TM number column on DA Form 2404 when recording the results of PMCS.

b. Intervals Column. Intervals are headed B for before operation, D for during operation, and A for after operation.

c. Item To Be Inspected Column. Items listed in this column are divided into functional groups and by item common name. This column also contains the information required to accomplish the checks and services.

d. Equipment Is Not Ready/Available If: Column. This column is used to tell why the equipment cannot be used.

2-6 OPERATOR'S PREVENTIVE MAINTENANCE CHECK AND SERVICES. Refer to Table 2-1 for operator preventive maintenance checks and services.

Table 2-1. Operator Preventive Maintenance Checks and Services (PMCS)

Note: B - Before Operation D - During Operation A - After Operation

Item No.	Intervals B	D	A	Item to be Inspected (Procedure)	Equipment is not Ready/Available if:
1	•			Compressor Unit. Check entire unit for cleanliness, loose bolts, nuts, and mounting hardware. Check tube and tube fittings for vibrating or rubbing high pressure lines.	Deficiencies are noted. Check for oil and fuel leakage.
2	•	•	•	Meters and Gauges. Check service line pressure, final pressure, and compressor oil pressure gauges for current comparison/calibration label. Check all gauge/meter faces, loose gauge mounting hardware. During operation, refer to paragraph 2-2 for operating parameters.	Faces, pointers and lenses are damaged.
3	•		•	Engine Fuel Tank. Check the fuel supply. Ensure that tank is full.	No fuel is available.
4	•			V-belts (Alternator). Visually inspect belt set for wear, fraying, and peeling through guard screen. Check belt tension through hand crank opening.	Belt depression is more than 1/2-inch or belts are frayed, peeled or cracked. See paragraph 3-21.
5	•		•	Engine Oil Level. Check engine oil. Fill to proper level, as required.	Oil level is at or below the add line.
6	•			Oil Bath Air Cleaner. Ensure that air cleaner bowl is filled to oil level mark before starting the engine. same grade oil as is used in engine.	Oil level is below oil level mark. Use
7	•		•	Battery. Check battery electrolyte level. Fill as needed with distilled water. Check terminal condition for tightness and corrosion.	Loose terminals or corrosion exists.

Table 2-1 Operator Preventive Maintenance Checks and Services (PMCS)(Continued)

Note: B - Before Operation D - During Operation A - After Operation

Item No.	Intervals B	D	A	Item to be Inspected (Procedure)	Equipment is not Ready/Available if:
8	•		•	Compressor Oil Level. oil level. Fill to proper level.	Check
9	•			V- belts (Compressor Drive). Inspect the belt for wear, fraying, peeling and belt tension. Visually inspect for cracking, Inspect belt tension by pressing belts midway between engine pulley and compressor flywheel.	Belt depression is more than 1/2-inch.
10	•			Clutch. Check clutch engagement. There should be a noticeable snapping action when clutch is properly adjusted. is disengaged before starting.	Clutch slips, handle dis-engages, no snapping action or clutch has no Ensure clutch adjustment left.
11		•		Pressure Maintaining Valve (PMV)	PMV does not main-tain 1800 to 2000 psi on the final pressure gauge.

Section III.
OPERATION UNDER USUAL CONDITIONS

2-7 ASSEMBLY AND PREPARATION FOR USE. Before starting an engine, ensure that the person has the necessary qualifications and training and is aware of all necessary safety precautions and regulations that must be observed.

WARNING

To prevent injury, ensure that work clothes are closely fitting so that they cannot be caught by rotating machinery or projecting parts.

a. Inspection. Inspect the unit for damage. Report all discrepancies in accordance with DA PAM 738-750.

b. Preparation. The tarpaulin furnished must be completely removed for depreservation in accordance with DA Form 2258 provided. The only assembly required is connecting the battery cables, filling with electrolyte, and inserting the cartridges into the correct chamber. Ensure that pipes, hoses, and connections are securely in place.

c. Location. The site location must be free of contaminated air and a sufficient supply of fresh air for properly cooling the unit should be available. The compressor should be placed on a level surface. Under no circumstances should the compressor be operated if tilted more than 15 degrees in any direction. The unit must be located at least 20 inches from any wall and away from other machinery. Remember, the intake hose with rain cap must be fully extended and always located upwind. When the wind changes, the compressor air intake must be relocated. This action is imperative to ensure the least contaminated air from entering the breathing inlet.

2-8 PRE-OPERATIONAL CHECKS.

a. Ensure that the engine exhaust is located downwind and the compressor air intake with rain cap is upwind and fully extended. See figure 2-4.

b. Check oil level in the compressor and engine; add as required.

c. Check fuel in tank; top off, if required. (Allow room for fuel expansion.)

d. Ensure that the air cleaner bowl (2, figure 2-5) has been filled (use same grade motor oil for engine).

e. Check ether reservoir; add, if required (cold weather).

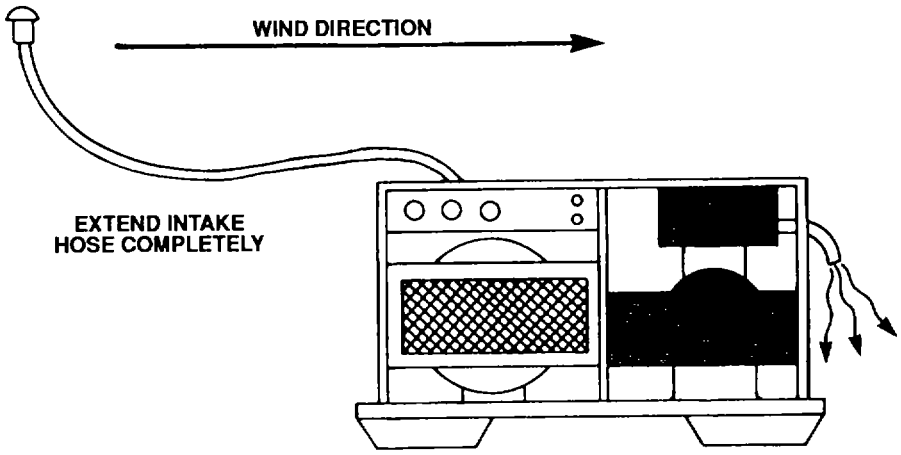


Figure 2-4. Intake Hose Extended

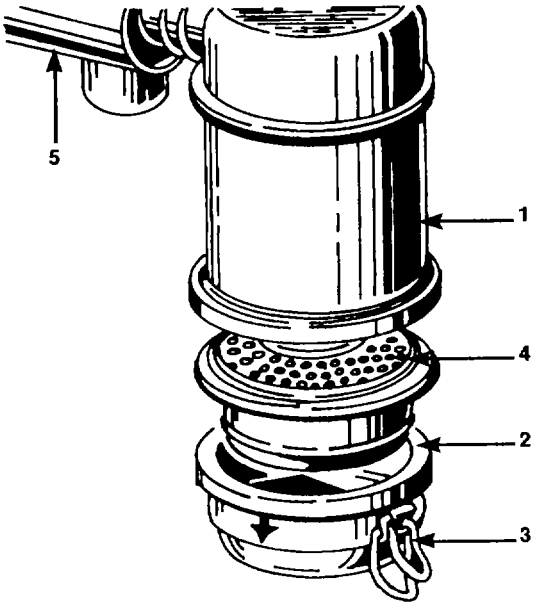


Figure 2-5. Oil Bath Air Cleaner

f. Check log book to determine if cartridge life has been exceeded. If it has, insert new cartridges. Refer to maintenance schedule for cartridge life and instructions on replacing cartridges.

g. Close service line control valve (14, figure 2-1).

2-9 START-UP PROCEDURE (ELECTRIC).

WARNING

When the compressor is engaged and operating, there are two safety shutdown circuits that will shut down the engine: fourth stage head temperature and low compressor oil pressure. Ensure, when compressor unit is operating, that the safety bypass is OFF. Severe damage to equipment or injury to personnel may result.

a. Locate ignition switch (on instrument panel).

b. Press button on top of throttle control release to put in idle position. Turn the engine throttle counterclockwise about two turns.

c. Ensure the clutch is disengaged.

d. Ensure safety bypass switch is ON.

e. Press and hold button on engine oil pressure gauge.

f. Press and hold relay latch button.

CAUTION

Do not actuate starter for more than 20 seconds at a time. Wait one minute between each starting attempt.

g. Move ignition to START. When engine starts, release the start switch to RUN position. Continue holding pressure on the relay latch and override button on the oil pressure gauge until operating oil pressure is built up by the engine.

h. Allow engine to warm up 2 to 5 minutes.

i. Bring engine to full throttle and engage clutch.

j. After compressor oil pressure reaches 750 to 870psi, turn safety bypass switch to OFF. See item 10, figure 2-1.

k. The compressor will deliver air until the final pressure gauge reads 5000 psi. The safety valve will automatically open and dump the air until the pressure reaches 4600 psi. This cycle repeats automatically.

l. Check all gauges for proper operation of engine and compressor. See paragraph 2-2.

m. Approximately every 15 minutes, the condensate drain switch must be manually depressed for 5 to 6 seconds to remove condensate from the separators. In high humidity and temperature conditions, the condensate must be drained every 10 minutes.

n. Do not operate the K-20 unit if ambient temperature exceeds 125'F (52'C).

2-10 START-UP PROCEDURE (MANUAL).

CAUTION

This procedure should be used only when the battery is extremely low or dead or when the alternator is not producing voltage. This procedure eliminates all compressor and engine safety devices and should only be used in emergency situations and with the approval of the diving supervisor and dive officer.

a. Manual Start (Battery Low or Dead and Alternator Producing Voltage).

1. Place crank bungie cord from run solenoid to muffler guard.

2. Turn throttle two turns counterclockwise from the IDLE position, then turn starter switch to RUN.

3. Turn decompressor lever (1) counterclockwise until it stops (figure 2-6).

4. Place crank in crank hole and turn counterclockwise (engine will turn freely approximately six turns before compression) (figure 2-7).

5. With engine running, check ammeter for a positive reading (if ammeter does not have a positive reading, go to step 2 in Manual Start (with Battery Dead and Alternator Not Producing Voltage).

6. Allow warm-up, bring throttle to full speed, and engage clutch.

7. Push relay latch in and ensure safety bypass is in the OFF position.

8. Release bungie cord (engine should continue to run and all safety devices are functional when the bungie cord is released; alternator should also recharge battery).

9. Shut down in accordance with paragraph 2-11.

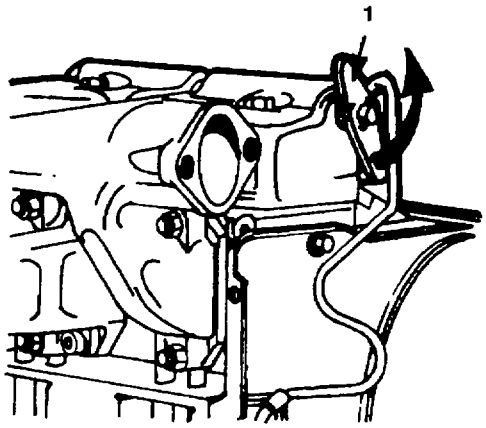


Figure 2- 6. Decompression Device

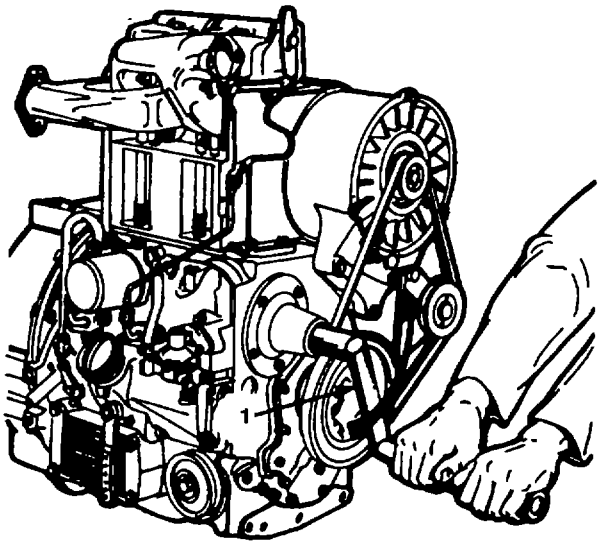


Figure 2-7. Cranking Device

b. Manual Start (Battery Dead and Alternator Not Producing Voltage).

1. Place crank bungie cord from run solenoid to muffler guard.

2. Remove condensate drain solenoid and remove the cylindrical valve from the condensate block.

3. Remove the spring from the piston and reinstall the piston into the cylindrical valve and reinstall (solenoid does not have to be reinstalled, but should be placed over the cylindrical valve to prevent damage.

4. Turn throttle two turns from the IDLE position.

5. Turn decompressor lever counterclockwise until it stops.

6. Place crank in crank hole and turn counterclockwise (engine will turn freely for approximately six turns before compression).

7. Allow warm-up, then bring to full throttle and engage clutch.

CAUTION

No safety devices will activate during this start-up procedure.

8. AR safety functions are bypassed; monitor compressor unit control panel to ensure proper operation.

9. To bleed condensate, insert a 5/32-inch maximum diameter or smaller wire in the top of the solenoid valve to release pressure.

c. Manual Shutdown.

1. Disengage clutch and allow engine to cool down.

2. Remove bungie cord from engine run solenoid.

3. Reassemble solenoid.

2-11 SHUTDOWN PROCEDURE.

CAUTION

Diesel engine should not be suddenly shut down from full-load condition.

a. Disengage clutch.

b. Set throttle to idle (push in and let idle two to three minutes).

c. If condensate heater is operating, flip switch to OFF position.

d. Turn ignition switch (8, figure 2-1) to OFF.

e. Close service line control valve (14, figure 2-1).

f. Allow unit to cool and cover with tarpaulin.

2-12 PREPARATION FOR MOVEMENT.

a. Bleed off all system air pressure via bleed valve. See figure 2-3.

b. Loosen all drive belts.

c. Close and secure all valves.

d. Disconnect and remove battery.

e. Cover air intakes for engine and compressor. Cover exhaust manifold.

f. Cover unit with foul weather tarpaulin and secure using the draw rope furnished.

2-13 DECAL/INSTRUCTION PLATES. Decals and instruction plates are provided for the safety of personnel who are employed in the operation and use of the compressor unit. The following warnings and information are provided on the label plates for this compressor unit.

a. Operating instructions (figure 2-8).

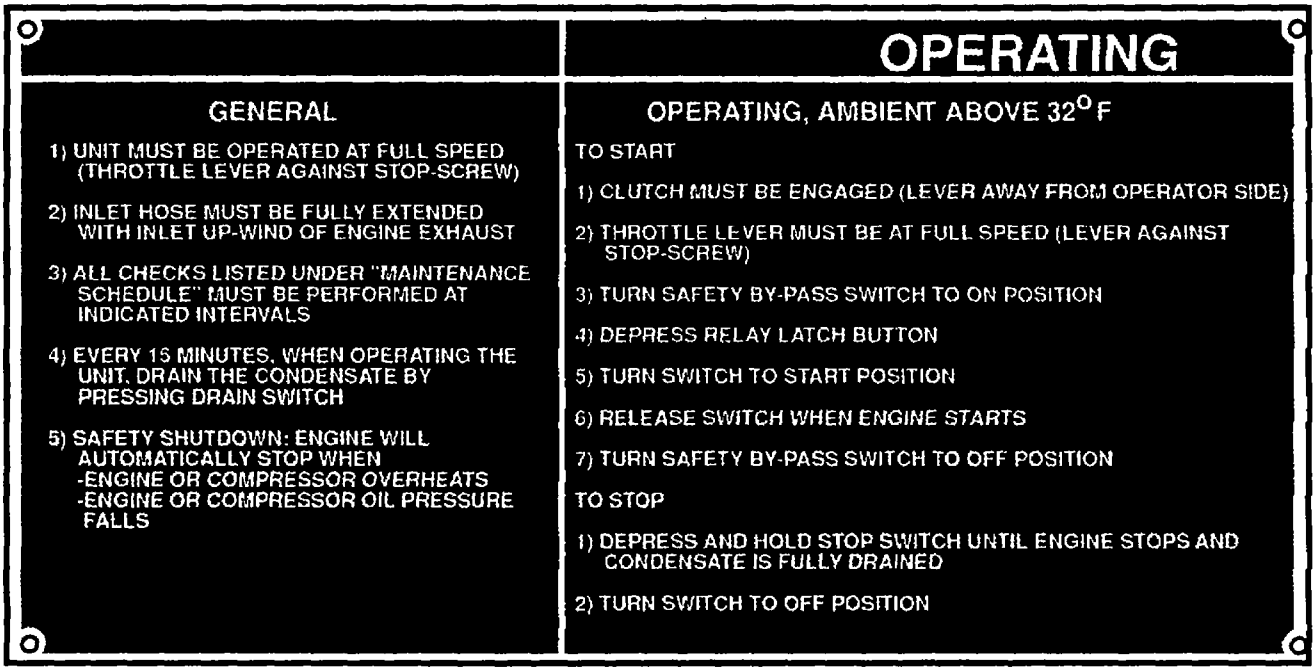
b. Maintenance schedule (figure 2-9).

c. Hearing protection required within 26 feet (figure 2-10).

d. Relieve pressure before opening cylinders (figure 2-11).
e. Cartridge in cylinder must be replaced no later than every 80 operating hours (figures 2-12 and 2-13).

f. Throttle control (figure 2-14).

g. Data plate (figure 2-15).



(NAMEPLATE IS SEPARATED FOR CLARITY)

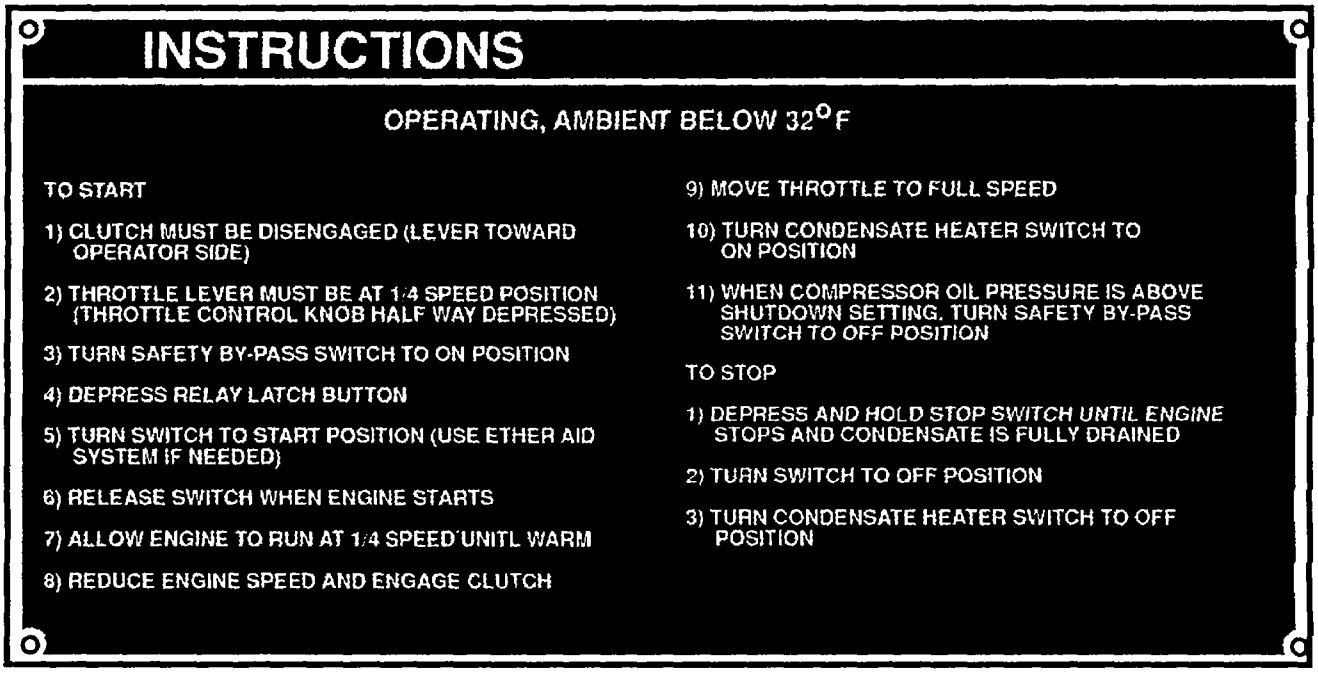


Figure 2-8. Operating Instructions

80 HRS	REPLACE PURIFICATION FILTER CARTRIDGES
100 HRS	CLEAN ENGINE (OIL COOLER AND CYLINDER HEAD) COOLING FINS CLEAN COMPRESSOR COOLING FINS INSPECT MICRONIC FILTER (COMPRESSOR INTAKE). REPLACE AS NEEDED LUBRICATE CLUTCH ANTIFRICTION BEARING
250 HRS	CHANGE ENGINE OIL AND CLEAN LUBE OIL FILTER CHANGE COMPRESSOR OIL CHECK ENGINE COOLING FAN V-BELT TENSION

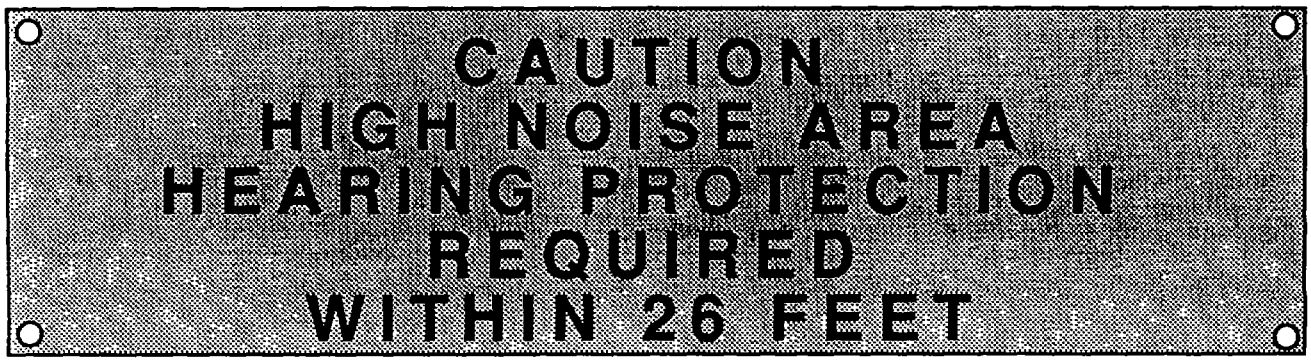


Figure 2-9. Maintenance Schedule

MAINTENANCE SCHEDULE

INTERVAL	MAINTENANCE
10 HRS	CHECK TENSION AND CONDITION OF DRIVE V-BELTS. ADJUST OR REPLACE AS NEEDED CHECK ENGINE OIL LEVEL. ADD AS NEEDED CHECK COMPRESSOR OIL LEVEL, ADD AS NEEDED LUBRICATE CLUTCH APPLY BEARING (THROW-OUT COLLAR)

Figure 2-10. Caution-High Noise Area

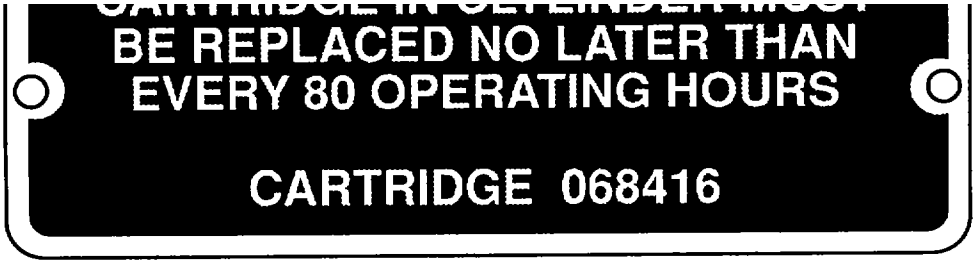


Figure 2-11. Warning - Pressure Relief

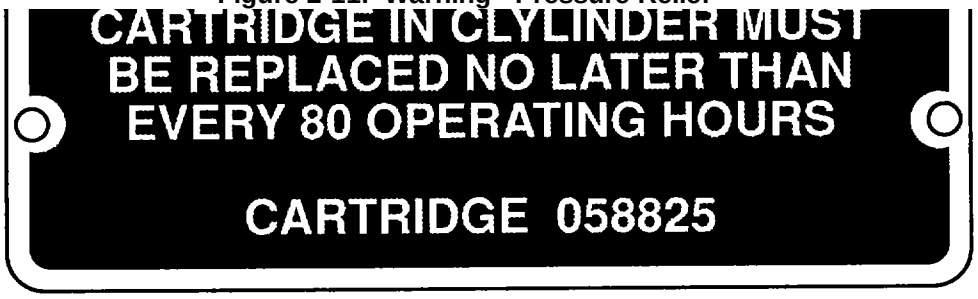


Figure 2-12. Cylinder Cartridge (058825) Replacement Schedule

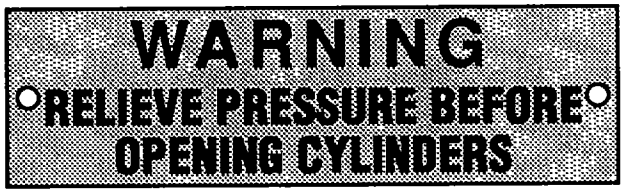


Figure 2-13. Cylinder Cartridge (068416) Replacement Schedule

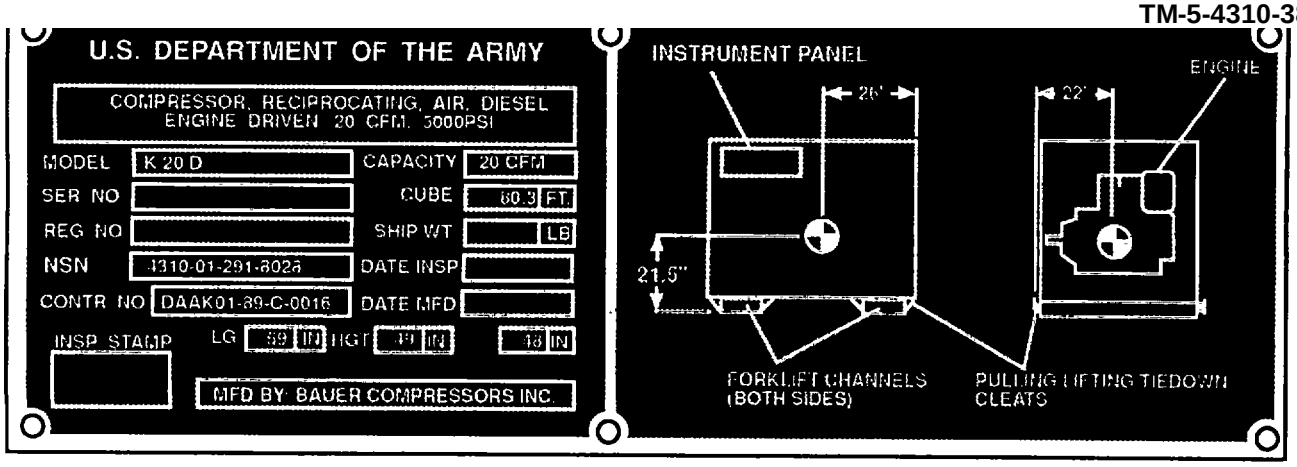


Figure 2-14. Throttle Control Knob

Figure 2-15. Nameplate Data/Lifting Points

Section IV.
OPERATING UNDER UNUSUAL CONDITIONS

2-14 OPERATION IN EXTREME COLD.

NOTE

When operating the K-20 in cold weather 320F (00C) or below, both the engine and compressor lubricating oils must be changed to cold weather oils.

To ensure satisfactory cold starting, the choice of the viscosity grade should be governed by the ambient temperature prevailing at the time of starting. As to the oil change intervals, it should be kept in mind that operation below 50'F (100C) requires shorter oil change intervals.

Use winter-grade fuel in winter because, with ordinary fuel, waxing may occur at low temperatures and clog the fuel filter. At excessively low temperatures, even winter-grade fuel may tend to wax. Therefore, if only summer-grade fuel is available, or if winter-grade fuel is used at excessively low temperatures, the following percentages are recommended (figure 2-16) for mixtures of diesel fuel and kerosene or regular-grade gasoline.

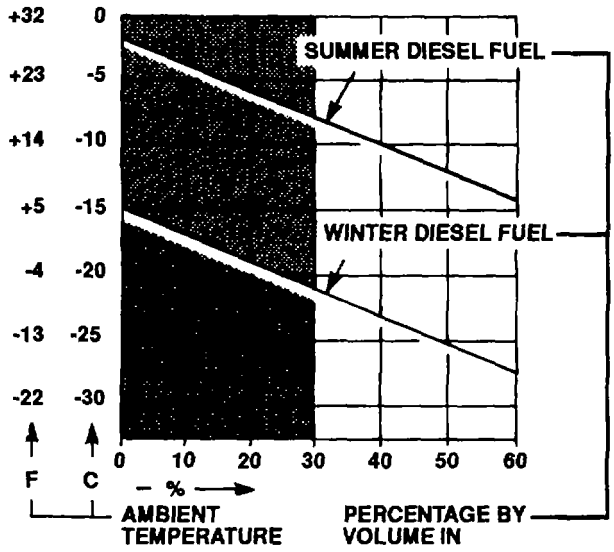


Figure 2-16. Fuel Mixture by Temperature

Prepare the blend in the tank itself: fill in the gasoline first, then add diesel fuel. The blend is as easily flammable as pure gasoline. A mixture of the latter, however, is permissible for a short period only, but never for permanent operation.

CAUTION

A maximum mixture of regular-grade gasoline is 30 percent; when mixing more than 30 percent, use kerosene only. Never use premium fuel.

CAUTION

Check hoses and ducts for cracks or other cold weather damage prior to starting compressor. Keep fuel tank full to minimize moisture condensation.

a. Locate ignition switch.

b. Pull the engine throttle OUT 1/4 to 1/2 (press button on top of throttle control to release from position).

c. Disengage clutch.

d. Turn safety bypass switch to ON.

e. Press and hold set-up button on engine oil pressure gauge.

f. Press and hold relay latch button in.

g. While engine is cranking, press ether injection knob (figure 2-17) for two seconds. (The flow will start when the knob is released.)

CAUTION

Do not actuate starter for more than 20 seconds at a time. Wait one minute between each starting attempt.

h. Let the engine run about five minutes before engaging the clutch.

NOTE

Engage clutch before turning safety bypass switch to OFF.

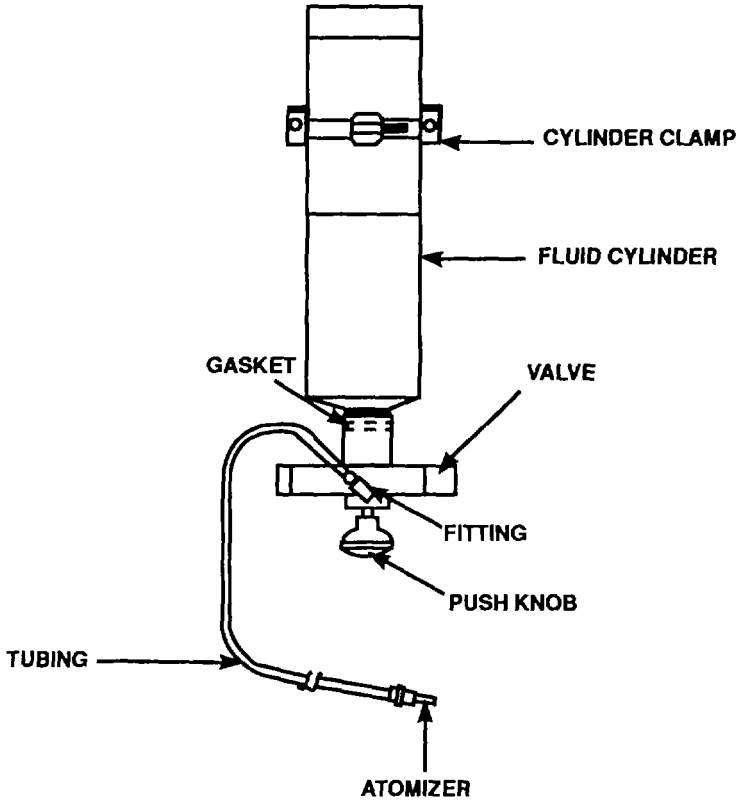


Figure 2-17. Cold Start Aid

i. Once the clutch is engaged, the bypass switch must be placed in the OFF position, activating the low pressure safety shutdown.

j. The compressor will deliver air until the final pressure gauge reads 5000 psi. The unloader valve will open automatically and dump air until the pressure drops down to 4600 psi if this amount is exceeded. This cycle will repeat itself automatically.

k. Set condensate heater switch to the ON position.

CAUTION

The condensate heater should only be operated when the engine is running, since the heating element uses energy from the electrical system. In cold weather, 32°F (0°C), the condensate heater should be left on until the unit is shut down.

2-15 OPERATION IN EXTREME HEAT.

CAUTION

Do not operate the compressor if the ambient temperature exceeds 25°F (52°C).

a. Keep all engine, compressor, and heat exchanger cooling fins clean and free of obstructions.

b. Ensure that cooling air flow is not restricted and that cooling air comes from the coldest available source. Avoid having heated air drawn into the cooling fan.

c. If possible, provide shade to protect the unit from direct sunlight.

2-16 OPERATION IN DUSTY OR SANDY AREAS.

a. Protect the unit from dust and sand. Take advantage of all natural barriers that could protect the unit from blowing dust or sand. Install a tarpaulin when the unit is not in operation.

b. Keep fuel clean. Strain the fuel before adding to the tank. Ensure the fuel storage and transfer cans are clean.

C. Check and service the engine/compressor air cleaners often.

d. Clean the engine, compressor, and heat exchanger cooling fins often. Wipe with clean cloth.

2-17 OPERATION IN RAINY OR HIGH HUMIDITY CONDITIONS.

a. Store unit in a sheltered area when not in use.

b. Keep fuel clean and free of water. To minimize condensation, keep the fuel tank full when the unit is not in use.

c. Whenever possible, protect the unit from direct rainfall when operating. Cover the unit with a tarpaulin suspended about three feet above the unit.

d. Drain the oil/moisture separators often. Press and hold the condensate drain switch for 10 to 15 seconds every 10 minutes of continuous operation.

e. Do not allow water to enter compressor air intake hose.

2-18 OPERATION IN SALT WATER AREAS.

a. Avoid direct contact with salt water to prevent corrosion. If salt water does come in contact with the unit, rinse the unit with clean, fresh water.

b. Repair any paint damage, such as cracks and chips. Apply standard issue rustproofing material to all exposed ferrous metal (steel) surfaces. If rustproofing material is not available, apply a light film of oil or grease to all exposed metal surfaces.

2-19 OPERATION AT HIGH ALTITUDES.

a. Engine power output will decrease to about 3-1/2 percent for every 1000 feet above sea level. The compressor will have a similar loss of operating efficiency.

b. Service the engine/compressor air cleaner often to minimize this loss of efficiency.

CHAPTER 3

UNIT MAINTENANCE

Section I.
LUBRICATION INSTRUCTIONS

3-1 GENERAL. The objective of this section is to present the operator with engine and compressor lubrication instructions.

3-2 OIL VISCOSITY. The viscosity of the oil is greatly influenced by the ambient temperature; therefore, the choice of the oil should be governed by the ambient temperature at engine site (figure 3-1). When temperatures temporarily fall below the limit of the oil selected, this will merely affect the starting performance but cause no engine damage.

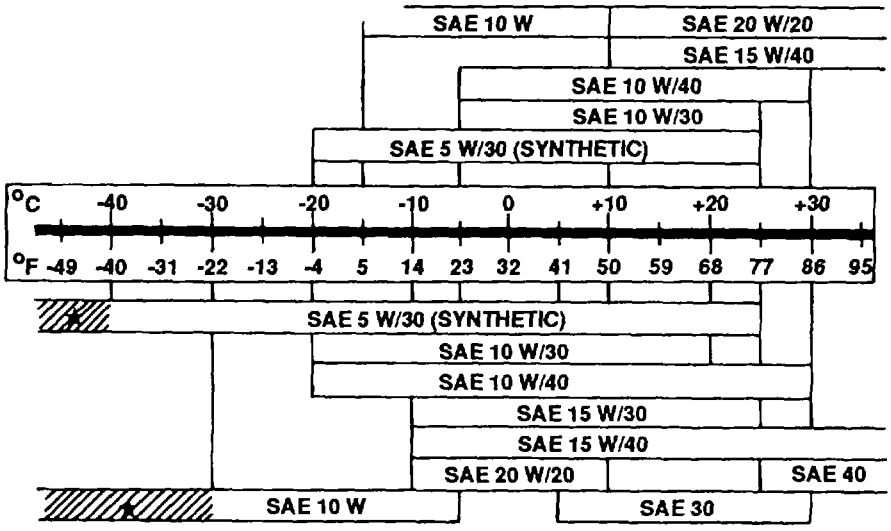


Figure 3-1. Oil Viscosity Chart

Since a too viscous oil causes starting difficulties, the choice of the viscosity grade during winter operation should be governed by the ambient temperature prevailing at the time of engine starting. Oil changes as a function of ambient temperatures can be avoided by using multigrade oils, which are again subject to the oil change intervals recommended.

3-3 LUBRICATION OF ENGINE. For proper care and maintenance of the engine, using the correct viscosity of oil and adhering to the maintenance procedures is of vital importance. It is required that the oils used in the engine conform to the chart (figure 3-1).

3-4 FILLING/CHECKING ENGINE OIL LEVEL.

CAUTION

Check the lubricating oil prior to starting to ensure sufficient engine oil for the start.

To check the oil level accurately, it is necessary to shut down the engine after about one minute of operation; the entire oil system will be filled. Therefore, an immediate oil level check will then show the oil sump filling volume actually available during operation of the engine. It is recommended to carry out this double check of the oil level before any prolonged engine operation, particularly if the check prior to the engine start discloses an oil level in the vicinity of the lower or minimum mark on the dipstick. Normally, new engines have a higher oil consumption. During the running-in period (about 200 running hours), it is therefore essential to check the oil level twice a day. After the running-in period, one check per day is sufficient.

a. Engine must be in horizontal position and shut down.

b. Pull out dipstick.

c. Wipe with a clean, non-fraying rag.

d. Reinsert as far as it will go, then withdraw again.

NOTE

Where engines are inclined, oil level should reach top mark of dipstick.

e. The oil level should be between the marks on the dipstick (figure 3-2). If the level is only up to or even below the lower mark, immediately top off with oil (fill through filler neck, figure 3-3), preferably up to the upper mark, in order to prevent serious damage to the engine.

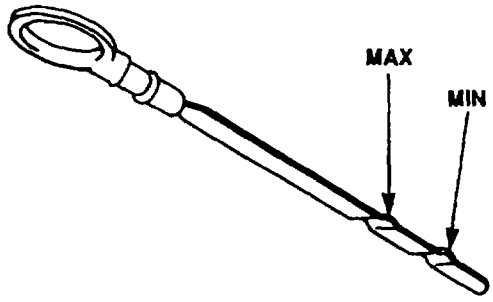


Figure 3-2. Oil Dipstick

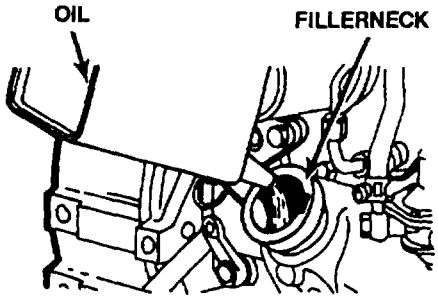


Figure 3-3. Filler Neck

3-5 LUBRICATION OF COMPRESSOR UNIT. For proper care and maintenance of the compress unit, using the correct viscosity of oil and adhering to the maintenance procedures is of vital importance. It is required that the oils used for the compressor be restricted to those that conform to MILL-17331 (Normal Temperature, 2190 TEP) and MIL-H-17672 (Arctic Temperature, 2135TH). Engine oil must conform to specification MIL-L,2104.

3-6 OIL CAPACITIES. The oil capacity of the compressor is 4.2 quarts (4.0 liters), and the engine is 4.75 quarts (4.52 liters).

3-7 MAINTENANCE ON A NEW ENGINE AND COMPRESSOR.

a Engine.

1. V-Belt Retention. At the end of 50 hours running.

2. Change Oil. At the first oil change, the following jobs are also due.

   a) Clean lube oil filter.

   b) Retighten engine mounting bolts.

   c) Check connections for air intake (1) and exhaust (3) manifolds to cylinder heads for tightness and retighten bolts (2), if necessary. See figure 3-4.

   d) Check valve clearance (paragraph 3-23); readjust, if necessary.

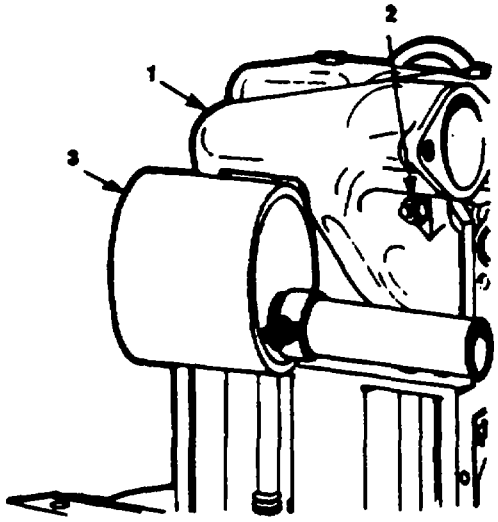


Figure 3-4. Intake and Exhaust Manifold Securing Bolts

b. Compressor.

1. 25-hour oil change.

2. Soap test all fittings.

Section II.
REPAIR PART, SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

3-8 TOOLS AND EQUIPMENT REQUIRED TO SERVICE COMPRESSOR UNIT.

a. Common Tools. For authorized common tools, refer to Modified Table of Organization and Equipment (MTOE) applicable to your unit and appendix B of this technical manual.

b. Repair Parts. Repair parts are listed and illustrated in TM-5-43 10-389-24P.

c. Special Tools. The special tools required for maintenance on the compressor unit are listed in TM-5-43 10-389-24P.

Section III.
SERVICE UPON RECEIPT OF MATERIAL

3-9 SCOPE. This chapter covers information required by organizational maintenance personnel to ensure the equipment will be adequately inspected, serviced, and operationally tested before it is subjected to normal use. These procedures include site and shelter requirements, service upon receipt of material, and preliminary servicing and adjustment.

3-10 SITE AND SHELTER REQUIREMENTS. The usage site for the compressor should be selected so as to avoid excessive dust, mud, rain, snow, heat, or cold. The compressor must be kept as level as possible. The compressor must never be operated if it is tilted at an angle in excess of 15 degrees in any direction.

Ensure all loose trash is removed from the area of the compressor, to prevent refuse from entering the cooling air inlets. Ensure compressor is not operated inside closed rooms or buildings. If such operation is mandatory, connect extension pipe to engine exhaust and pipe exhaust fumes outside. Also, ensure the compressor is protected from rain, wind, snow, dust, and tropical or desert sun. A temporary shelter should be provided by tarpaulins or other means. The maximum usage of natural shelter such as trees, hills, and rock formations is highly recommended.

3-11 UNPACKING INSTRUCTIONS. No specific unpacking instructions are required. Refer to the depreservation guide DA Form 2258 packed with each unit.

3-12 CHECKING UNPACKED EQUIPMENT.

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, report the damage on DD Form 6, Packaging Improvement Report.

b. Check the equipment against the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instructions of DA PAM 738-750.

3-13 PRELIMINARY SERVICE AND ADJUSTMENT.

a. Adjust alternator belt.

b. Adjust compressor belt.

c. Check engine crankcase oil.

d. Check compressor crankcase oil.

e. Connect battery cables.

f. Check fuel oil. Top off, if needed.

Section IV.
PREVENTIVE MAINTENANCE CHECKS AND SERVICES

3-14 UNIT PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS). Refer to table 3-1 for PMCS pertaining to unit maintenance. Perform Operator Maintenance Checks and Services (PMCS) before performing Unit PMCS.

NOTE

Check paragraph 3-7 for new unit requirements.

Table 3-1. Unit PMCS

H - Interval in Hours D- Daily W - Weekly M - Monthly Q - Quarterly

ITEM NO.	INTERVAL H	D	W	M	Q	ITEM TO BE INSPECTED	PROCEDURES
						ENGINE	
1.					•	Fuel Injector Pipe Flange	Check for leakage; tighten as required.
2.		•				Alternator V-belt	Inspect belts for wear, fraying, peeling, cracking and tension. Adjust belt tension if deflection exceeds 1/2-inch (13 mm); see paragraph 3-21.
3.			•			Cold Start Aid (Cold Weather Only)	Change if required; see paragraph 3-37.
4.	10					Clutch Throw-out Collar and Lever Shaft	Lubricate; see paragraph 3-39.
5.	50					Clutch Main Shaft Bearing and Pilot Bearing	Grease clutch.
6.	100 or mo.					Oil Bath Air Cleaner	Clean, if dirty; see paragraph 3-3.

Table 3-1. Unit PMCS (Continued)

H - Interval in Hours D- Daily W - Weekly M - Monthly Q - Quarterly

ITEM NO.	INTERVAL H	D	W	M	Q	ITEM TO BE INSPECTED	PROCEDURES
						ENGINE (Contd)	
7.	100					Clutch Lever Shaft	Grease; see paragraph 3-39.
8.	100					Oil Cooler Fins	Service, clean; see paragraph 3-25.
9.	500					Clutch	Check clearance; see paragraph 3-39.
10.	500 or. ann.					Oil NOTE Check paragraph 3-7 for new unit requirements.	Change. See paragraph 3-21.
11.	500 or ann.					Intake and Exhaust Manifold	Inspect. See paragraphs 3-32 and 3-36.
						COMPRESSOR UNIT	
12.			•			Meters and Gauges faces, pointers, lenses, liquid fill leaks and proper operation. Replace as required. Ensure gauges are in calibration.	Inspect for damaged
13.			•			Switches and Controls damage. Replace, as required.	Inspect for operation and
14.	50 or mo.					Compressor Tubing and Fittings.	Soap test.

Table 3-1. Unit PMCS (Continued)

H - Interval in Hours D- Daily W - Weekly M - Monthly Q - Quarterly

ITEM NO.	INTERVAL H	D	W	M	Q	ITEM TO BE INSPECTED	PROCEDURES
						COMPRESSOR UNIT (Contd)	
15.	80/ semi-ann.					Purification Cartridges.	Replace all cartridges Notify Direct Support.
16.	100					Cooling Fins and Fan Blades	Service and clean. See paragraph 3-19.
17.	100				•	Compressor Air Intake Filter and Hose	Inspect and clean. See paragraph 3-20.
18.	200					Tooth Belt of Oil Pump Drive	Check. See paragraph 3-18.
			•			Compressor V-belts	Inspect belts for wear, fraying, peeling, cracking, and tension. Adjust belt tension, if deflection exceeds 1/2-inch (13 mm). See paragraph 3-16.
19.	500 or ann.					Intermediate Stage Pressure	Install test gauge to condensate block.
20.	500 or ann.					Compressor Oil	Change oil. See paragraph 3-16.
21.	750 to 800					Compressor Valves	Inspect. Refer to Direct Support.
22.	2000					Oil Pump Drive Belt	Replace. Refer to Direct Support Maintenance.

Table 3-1. Unit PMCS (Continued)

H - Interval in Hours D- Daily W - Weekly M - Monthly Q - Quarterly

ITEM NO.	INTERVAL H	D	W	M	Q	ITEM TO BE INSPECTED	PROCEDURES
						COMPRESSOR UNIT (Contd)	
23.	2000					Compressor Valves	Change. Refer to Direct Support.
24.	3000					Compressor Piston Rings	Inspect. Refer to Direct Support.
25.	ann.					Compressor Safety Valves	Ensure valves are seated at final pressure and valves are in calibration. Remove for calibration at General Support Maintenance. Also ensure seizing wire is holding adjusting screw firmly.
26.	ann.					Pressure Gauges (air)	Calibrate/comparison at Direct Support Maintenance. NOTE Calibrate every 540 days or whenever inaccuracies are noted.
27.	500 or ann.					Compressor Oil Pressure Safety Switch	Adjust to 750 psi. Notify Direct Support Maintenance.
28.	500 or ann.					Oil Pressure Regulator	Adjust to 870 psi.

Section V.
UNIT TROUBLESHOOTING PROCEDURES

3-15 GENERAL. This section will contain troubleshooting information for locating and correcting most of the operating difficulties that may occur in the K-20; as authorized by the MAC (Maintenance Allocation Chart). Although this manual cannot list all the malfunctions that may occur, nor all the test, inspections, and corrective actions, table 3-2 lists the common malfunctions which you may find during the operation or maintenance of the K-20 Diving Equipment Set and its components.

NOTE

Troubleshooting procedures listed below do not necessarily have to be performed in sequence.

Table 3-2. Unit Troubleshooting Procedures

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR
1. Compressor will not load. Step 1. Check to see if pressure relief valve is leaking or not closing properly. Adjust or replace. Notify Direct Support Maintenance. Step 2. Check to see if bleed valve is open. Close. Step 3. Check to see if cartridges are not in purifiers. Notify Direct Support Maintenance.
2. Compressor output low. Step 1. Check to see if air intake filter is clogged. Clean. Step 2. Check to see if condensate drain valves are leaking. Clean, tighten, and reset. Step 3. Check to see if compressor is at rated speed. Notify Direct Support Maintenance.
3. Low compressor oil pressure (shutdown). Step 1. Check to see if oil lines are leaking. Repair/replace. Step 2. Check to see if crankcase oil level is low. Add oil as required.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

COMPRESSOR (Contd)

3. Low copressor oil pressure (shutdown) (Contd).

   Step 3. Check oil pressure regulator for proper setting. Notify Direct Support Maintenance. Clean or adjust.
   Step 4. Check to see if cooling fins are dirty. Clean.

4. Compressed air has oily taste.

   Step 1. Check to see if wrong oil is being used. Drain and replace.
   Step 2. Check to see if cartridge life has expired. Notify Direct Support Maintenance. Replace.
   Step 3. Check compressor oil pressure. Adjust.

5. Sight glass exhibits air bubbles.

   Step 1. Check to see if the oil pressure regulator is dirty. Clean and adjust oil pressure regulator. Notify Direct Support Maintenance.

   NOTE
   Small air bubbles are normal in sight glass when compressor is above 4500 psi.

6. Compressor does not attain final pressure.

   Step 1. Check to see if final stage safety valve is opening prematurely. Clean final safety valve and readjust. Notify Direct Support Maintenance.
   Step 2. Check to see if condensate drain valves or fittings are leaking. Tighten and reseal.

7. Excessive vibration of unit.

   Step 1. Check antivibration mounts for wear, looseness, or damage. Tighten.
   Step 2. Check to see if compressor or engine bolts are loose. Tighten. Notify Direct Support Maintenance.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

COMPRESSOR (Contd)

8. Condensate drain system not draining (cold weather only).

   Step 1. Check to see if condensate heater switch and light are on.
   Step 2. Check fuse. Replace. Notify Direct Support Maintenance.

9. No oil pressure.

   Step 1. Check to see if there is air trapped in the oil pump. Vent pump and line. Notify Direct Support Maintenance.

10. Compressor output insufficient.

    Step 1. Check to see if intake filter is clogged. Replace filter element.
    Step 2. Check intermediate stage pressures.
    Step 3. Check engine compressor rpm. Adjust as required. Notify Direct Support Maintenance.

11. Safety valves between individual stages releasing pressure.

    Step 1. Check intermediate stage pressure. Notify Direct Support Maintenance.
    Step 2. Check to see if valves are not closing properly. Notify Direct Support Maintenance and clean valves.

12. Compressor overheats (shutdown activates).

    Step 1. Check to see if intake or outlet valves are not closing properly. Notify Direct Support Maintenance.
    Step 2. Check to see if there is an insufficient supply of cooling air. Move to location which permits adequate air for cooling and observe ambient temperature for operation.
    Step 3. Check to see if cooling fins are dirty. Clean.

13. Automatic condensate drains do not unload.

    Step 1. Check to see if condensate drain valve piston is jammed. Dismantle drain valve; clean or replace piston. Notify Direct Support Maintenance.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

14. Automatic drain does not close.

    Step 1. Check electrical circuit on condensate solenoid. Check supply lines.

15. Automatic drain leaks and blows off.

    Step 1. Check to see if drain valves are dirty. Remove and clean valves. Notify Direct Support Maintenance.

16 Compressor speed low.

    Step 1. Check to see if drive belts have proper tension. Adjust idler pulley.
    Step 2. Check to see if engine is running at rated rpm. Increase speed to correct rpm. Notify Direct Support Maintenance.
    Step 3. Check clutch for slippage. Adjust clutch.

ENGINE

17. Engine does not turn over.

    Step 1. Improper starting procedure. Follow proper starting procedure.
    Step 2. Check to see if battery is defective or dead. Recharge or replace.
    Step 3. Check to see if cable connections of starter motor circuit are oxidized. Replace cable connections.
    Step 4. Check to see if cable connections of starter motor circuit are loose. Tighten connections.
    Step 5. Check to see if starter motor is defective or pinion does not engage. Notify Direct Support Maintenance. Replace starter motor.
    Step 6. Check to see if starting aid is defective. Notify Direct Support Maintenance. Replace starting aid or ensure ether reservoir is full.

18. Engine fails to start or difficult to start.

    Step 1. Improper starting procedure. Follow proper starting procedure.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

18. Engine fails to start or difficult to start (Contd).

Step 2. Check to see if engine shutdown lever has been placed in operating position. Place shutdown lever in operating position.
Step 3. Check to see if the speed control lever has been placed in the starting position. Set speed control lever to about one-quarter speed.
Step 4. Check to see if fuel tank is empty and/or the fuel cock is closed. Open fuel cock; fill tank as needed.
Step 5. Check to see if there is air in the fuel system. Air bleed the fuel system.
Step 6. Check to see if cable connections of starter motor circuit are loose. Tighten connections.
Step 7. Check to see if wrong grade of motor oil has been used. Change to proper viscosity oil.
Step 8. Check to see if fuel filters and/or lines are fouled. Replace fuel filter. Inspect fuel for contamination; clean tank.
Step 9. Check to see if starting aid is defective. Notify Direct Support Maintenance. Replace starting aid or ensure ether reservoir is full.

19. Temperature Shutdown Activates.

Step 1. Check to see if oil level is too low. Fill to required level.
Step 2. Check to see if oil level is too high. Drain to proper level.
Step 3. Check to see if blower V-belt is loose, cracked, or broken. Replace V-belt.
Step 4. Check to see if cooling air is heating up (heat is being recycled). Clean cooling system of contaminants. Ambient temperature above operating parameters.
Step 5. Check to see if cooling fins are soiled. Clean the cooling system.
Step 6. Check to see if air cowling plates are loose, cracked, or missing. Tighten or replace, as needed.
Step 7. Check to see if lube oil cooler is soiled. Clean oil cooler to ensure heat transfer to surroundings and/or flush core.
Step 8. Check to see if air cleaner is contaminated. Clean or replace air cleaners.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

ENGINE (Contd)

20. Engine gives poor performance.

    Step 1. Check to see if engine shutdown lever is not in the operating position. Place shutdown lever in operating position.
    Step 2. Check to see if oil level is too high. Drain to proper level.
    Step 3. Check to see if air cleaner is contaminated. Clean or replace air cleaner.
    Step 4. Check to see if speed control lever is not reaching full-load stop. Free of obstruction.
    Step 5. Check to see if fuel filter and/or lines are fouled. Notify Direct Support Maintenance. Clean or replace fuel filter, flush fuel lines.
    Step 6. Check to see if there is air in fuel system. Air bleed the fuel system.
    Step 7. Check to see if fuel feed pump is defective (diaphragm). Replace, as required. Notify Direct Support Maintenance.
    Step 8. Check to see if exhaust back pressure is excessive. Clean cooling systems of contamination. Notify Direct Support Maintenance.

21. Engine oil pressure zero or too low.

    Step 1. Check to see if engine is excessively inclined. Ensure that inclination is no greater than 15 degrees in direction.
    Step 2. Check to see if engine oil is too low. Fill to proper level.
    Step 3. Check to see if wrong grade of motor oil is being used. Change to proper viscosity oil.
    Step 4. Check to see if lube oil cooler is soiled. Clean exterior and flush core.
    Step 5. Check oil suction pipe strainer for blockage or leakage. Clean or change strainer. Notify Direct Support Maintenance.

22. Engine oil consumption excessive.

    Step 1. Check to see if the engine is excessively inclined. Ensure that engine is not inclined over 15 degrees.
    Step 2. Check to see if oil level is too high. Drain to proper level.
    Step 3. Check to see the engine is run mainly at low load. Operate engine at rated rpm.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

ENGINE (Contd)

22. Engine oil consumption excessive (Contd).

    Step 4. Check to see if oil metering screw for rocker arm lubrication is incorrectly set. Adjust oil metering screw. Notify Direct Support Maintenance.
    Step 5. Check engine oil breather. Clean or replace.

23. Engine smokes white.

    Step 1. Check to see if engine is below start limit temperature or cold start procedure has been unobserved. Observe ambient condition.
    Step 2. Check to see if cold start aid is defective. Notify Direct Support Maintenance. Repair or replace.
    Step 3. Check stop lever position when starting. Possible defective run solenoid.
    Step 4. Check air in fuel system. Bleed air from fuel system.

24. Engine smokes blue.

    Step 1. Check to see if the engine is excessively inclined. Ensure that engine is not inclined over 15 degrees.
    Step 2. Check to see if oil level is too high. Drain to proper level.
    Step 3. Check to see the engine is run mainly at low load. Operate engine at rated rpm.
    Step 4. Check to see if oil metering screw for rocker arm lubrication is incorrectly set. Adjust oil metering screw. Notify Direct Support Maintenance.

25. Engine smokes black.

    Step 1. Check to see if air cleaner is contaminated. Clean air cleaner.
    Step 2. Check to see if exhaust back pressure is excessive. Clear cooling system of contamination. Refer to Direct Support Maintenance.
    Step 3. Check fuel return lines for clogging or crimping. Clean, replace as necessary.
    Step 4. Check valve and decompressor clearance. Adjust if necessary.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION

ENGINE (Contd)

26. Engine does not run smoothly.

    Step 1. Check to see if engine suspension is defective or incorrect. Notify Direct Support Maintenance. Replace or adjust engine vibration mounts.
    Step 2. Check to see if there is air in the fuel system. Air bleed the fuel system. Refer to Direct Support Maintenance.
    Step 3. Check to see if fuel return line is clogged. Flush return line.

27. Engine overheats or backfires.

    Step 1. Check to see if crankcase oil level is too low. Fill to proper level.
    Step 2. Check to see if belts are slipping on engine cooling fan. Adjust.
    Step 3. Check to see if fuel in tank is of poor grade. Drain. Replace.
    Step 4. Check to see if cooling fins are dirty. Clean. Notify Direct Support Maintenance.

NOTE

When engine stops suddenly with compressor engaged and safety bypass off, engine can be shut down by low compressor oil pressure or compressor 4th stage head temperature.

28. Engine stops suddenly.

    Step 1. Check to see if fuel tank is empty. Add fuel as required.
    Step 2. Check crankcase oil level. Add oil, as required.
    Step 3. Check cylinder head temperature gauge. Let engine cool. Check cooling fins.
    Step 4. Restart engine and check oil pressure. If low, notify Direct Support Maintenance.

29. Battery undercharged (ammeter indicates constant discharge).

    Step 1. Inspect for defective cables, dirty or corroded battery posts and terminals. Clean or replace as necessary.

Table 3-2. Unit Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (Contd)
29. Battery undercharged (ammeter indicates constant discharge) (Contd). Step 2. Check for loose or broken V-belt. Tighten or replace V-belt. Step 3. Check for worn or broken brushes. Replace brush assembly. Contact Direct Support Maintenance. Step 4. Check for defective charging system. Perform alternator test procedures to determine extent of problem.
30. Battery overcharges. Step 1. Check for defective wire harness. Perform harness test. Step 2. Check for defective charging system. Replace voltage regulator. Contact Direct Support Maintenance. Step 3. Check for poor or inadequate ground. Ensure clean ground contact. Step 4. Check for broken ammeter lead wire. Clean, repair, or replace as necessary.
31. Battery charges at idle but discharges under load conditions. Step 1. Check for loose or slipping V-belts. Adjust belt tension or replace belts as necessary. Step 2. Check for defective alternator. Perform diode test. If defective, contact Direct Support Maintenance.
32. Ammeter shows (-) under moderate load; battery appears charged. Step 1. Test for defective diodes. Replace diodes. Contact Direct Support Maintenance.

Section VI.
UNIT MAINTENANCE PROCEDURES

3-16 COMPRESSOR.

DESCRIPTION

This task covers: Inspect, Test, Service, Adjust.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Compressor unit secured (paragraph 2-11).
2. Bleed off all air pressure (paragraph 2-3, b).

Materials/parts:
Oil, item 22 Appendix E
Brush, item 8 Appendix E
Lint-free Cloth, item 9 Appendix E
Funnel, item 16 Appendix E

INSPECT

a. General.

WARNING

Ensure that the compressor unit is secured and that system pressure has been bled to zero.

1. Inspect the air intake filter; ensure it is free from obstruction.
2. Ensure all hoses are securely in place.
3. Inspect the fins on the after cooler for dust.
4. If battery cables are frayed or oxidized, replace as required.

b. Oil Level Check.

SERVICE

NOTE

Check oil level every day prior to putting compressor into operation.

1. Pull oil dipstick out, located at the rear of the compressor (2, figure 3-5).

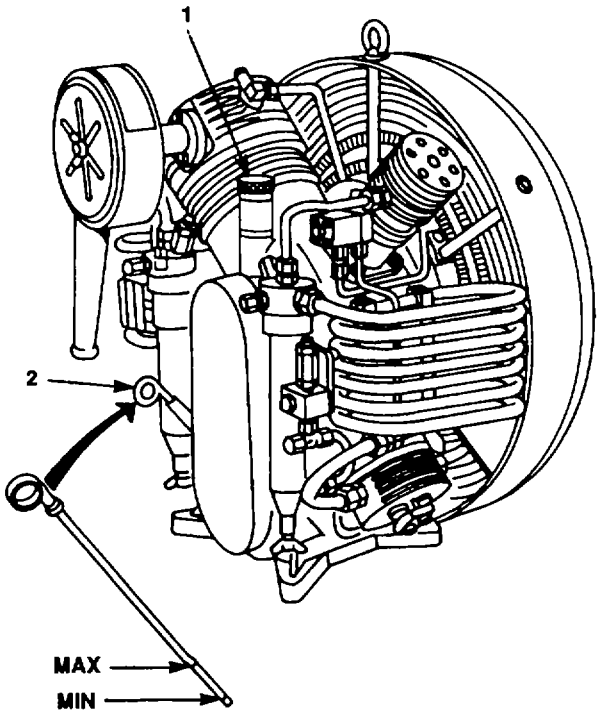


Figure 3-5. Compressor Block

2. Wipe off dipstick with a lint-free cloth; reinsert dipstick.
3. Oil level should rest between the indentation marks on the dipstick when removed.
4. If oil is required, unscrew the oil filler cap (1) located above the oil pump belt cover.
5. Add oil, as necessary, through the oil filler.

c. Change Lube Oil.

CAUTION

The Federal Water Pollution Control Act prohibits the discharge of oil or oily waste into or upon the navigable waters of the United States or the waters of the contiguous zone, if such discharge causes a film or discoloration of the surface of the water or causes a sludge or emulsion beneath the surface of the water. Ensure a container of sufficient size is used when draining the oil.

1. To drain compressor oil, remove plug (figure 3-6) from drain pipe located on the side of the compressor.

NOTE

For best results, drain oil when compressor is warm.

2. Insert plug (figure 3-6) and add new oil through oil filler (1, figure 3-5).

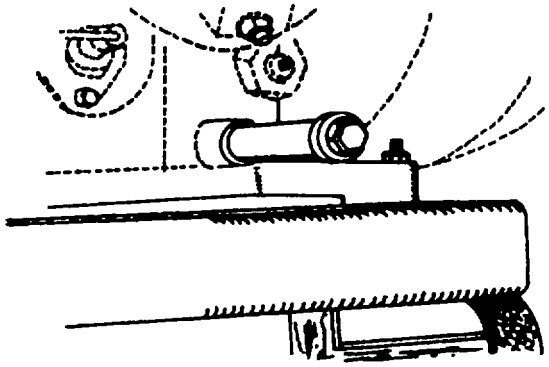


Figure 3-6. Oil Drain Plug

d. Venting the Oil Pump.

INSPECT SERVICE

NOTE

Unit must be in operation.

1 Loosen vent screw (1) by one or two turns until oil emerges free of air bubbles (figure 3-7).

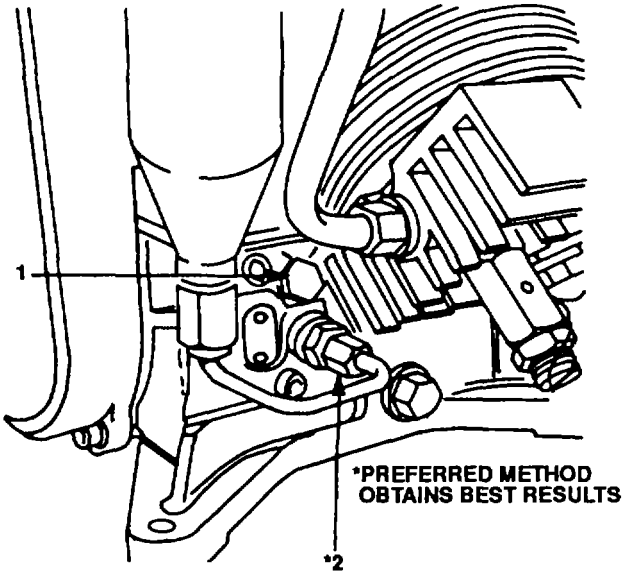


Figure 3-7. Venting the Oil Pump

2. Tighten vent screw (1).

OR

1. Loosen coupling (2) until bubble-free oil emerges.
2. Tighten coupling (2).

e. Compressor Drive V-Belt.

INSPECT

1. To check tension on compressor drive; detach belt guard by removing six 7/16-in. Hex bolts (figure 3-8).
2. Check belt for fraying, cracks or dryness.

ADJUST

1. Press V-Belts down between idler pulley and compressor fan drive (figure 3-9).
2. If slack is more than 1/2-inch, the belts require adjustment.
3. Loosen two 9/16-inch hex bolts (2, figure 3-9).
4. Push down on idler pulley until 1/2-inch depression is obtained.

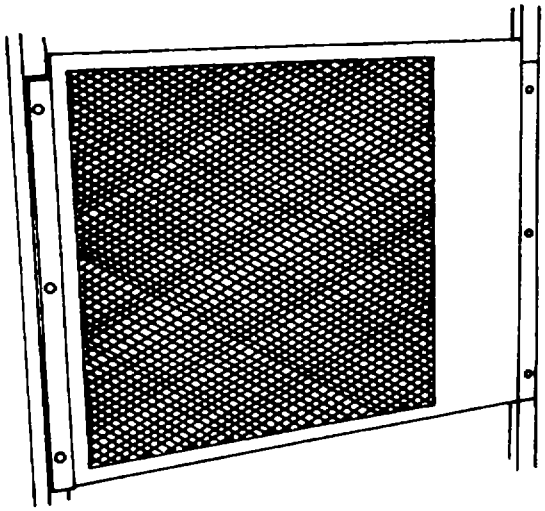


Figure 3-8. Belt Guard

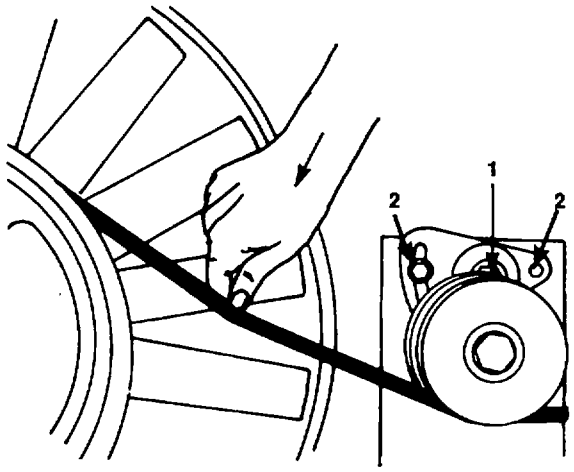


Figure 3-9. Compressor V-Belt and Idler Pulley

5. Tighten both hex bolts.
6. Replace belt guard and tighten 6 hex bolts.

SERVICE

1. Loosen (9/16-inch) hex bolts (2) on idler pulley control arm.
2. Push pulley up providing enough slack to remove belts.

NOTE

When two V-belts are provided, always renew both belts even though only one may be damaged.

3. Replace belts as a matched set.
4. Push pulley down removing all slack.
5. Retighten hex bolts (2).
6. Replace belt guard and tighten six hex bolts.

f. Oil Pressure Regulating Valve (Compressor).

NOTE

Compressor must be in operation. The oil pressure regulator is mounted on the 4th stage cylinder and adjusted to 870 psi (70 BARS). (Normal operating range is 750 psi to 870 psi.)

ADJUST

CAUTION

Before starting the compressor, ensure that the set screw (2) has not been screwed all the way in.

NOTE

Two persons required for following procedure.

NOTE

Turning adjusting screw clockwise (+) increases pressure and counterclockwise (-) reduces pressure.

1. Remove acorn nut (1) and turn adjusting screw (2) slowly on the oil pressure regulator (3, figure 3-10).

2. Read oil pressure from compressor oil pressure gauge on control panel. Observe the oil sight gauge under the regulator for flow.

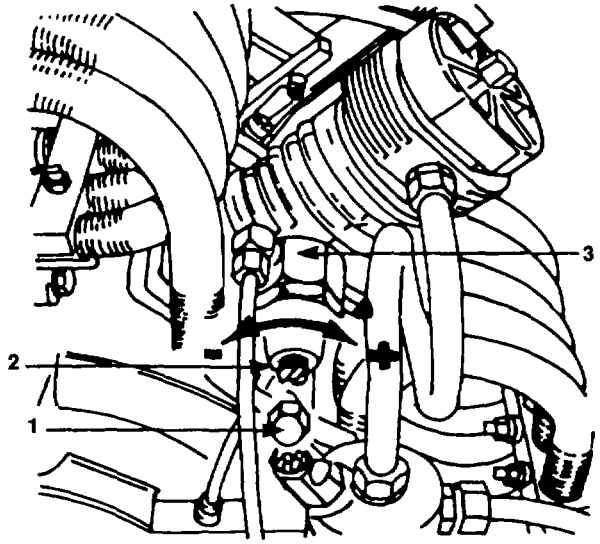


Figure 3-10. Oil Pressure Regulating Valve

TEST

g. Air Purity Standard.

1. Semi-annual air sampling is required in accordance with NAVSEA 0994-LP-O(1-9010.

2. If air is suspect at any time, sample should be drawn and compressor deadlined until sample is verified.

3-17 LOWER CRANKCASE (COVER).

DESCRIPTION

This task covers: Remove. Install.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Compressor unit secured (paragraph 2-11).

Material/Parts:
None

REMOVE INSTALL

1. Remove 4 allen head bolts (1) and washers (figure 3-11).
2. Remove cover (2) from crankcase.
3. Reinstall crankcase cover.
4. Reinstall alien bead bolts and washers and tighten securely.

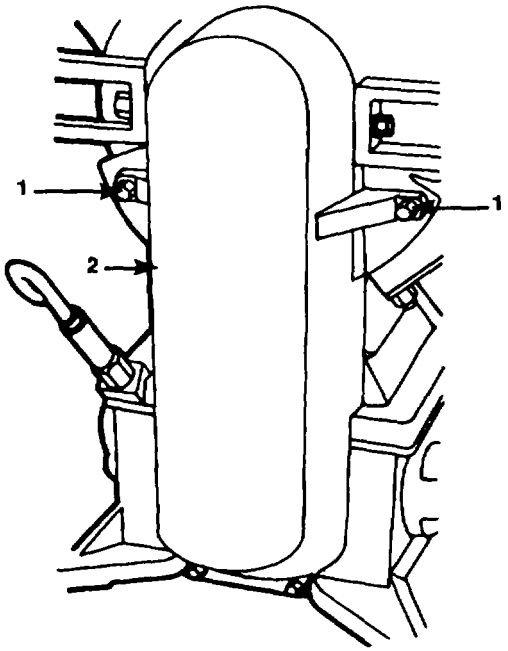


Figure 3-11. Oil Pump Drive Belt Cover

3-18 TENSION PULLEY ASSEMBLY (OIL PUMP TIMING BELT)

DESCRIPTION

This task covers: Adjust

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Compressor unit secured (paragraph 2-11).
2. Crankcase cover removed (paragraph 3-17).

Material/Parts:
None

ADJUST

CAUTION
Always remove negative terminal first to prevent shorting.

a. Remove battery terminals and battery.

b. Remove cover (paragraph 3-17).

CAUTION
Do not remove belts from pulleys. Fourth Stage damage will occur.

c. Loosen two alien head bolts (1) on belt tensioner (2, figure 3-12). Adjust tensioner until 3/8-inch deflection is obtained. Notify General Support if replacement is necessary.

d. Tighten tensioner bolts.

e. Reinstall cover (paragraph 3-17).

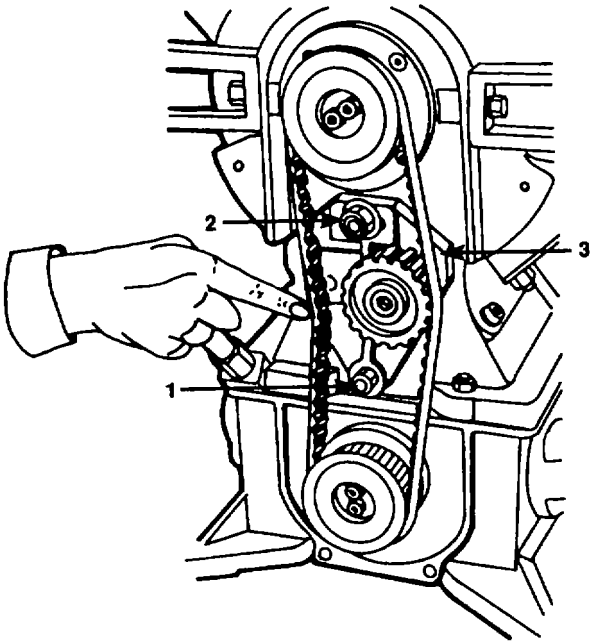


Figure 3-12. Oil Pump Drive Belt Adjustment

3-19 COOLING SYSTEM (COMPRESSOR).

DESCRIPTION

This task covers: Inspect. Service

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Secure equipment (paragraph 2-11).

Materials/parts:
Non-ionic detergent, item 13 Appendix E
Brush, item 8 Appendix E
Lint-free cloth, item 9 Appendix E
Face shield, item 26 Appendix E

INSPECT SERVICE

WARNING

Eye protection/face shield must be worn when using compressed air for cleaning. Never use compressed air over 35 psi line pressure for cleaning. Clear immediate area of personnel.

a. Detach belt guard by removing six 7/16-inch hex bolts.

b. Brush a non-ionic soap solution on compressor cylinder head fins, cooler fins, and fan (figure 3-13). Rinse well with clear water.

c. Blow dry using compressed air at 35 psi, if necessary.

d. Replace belt guard using six hex bolts.

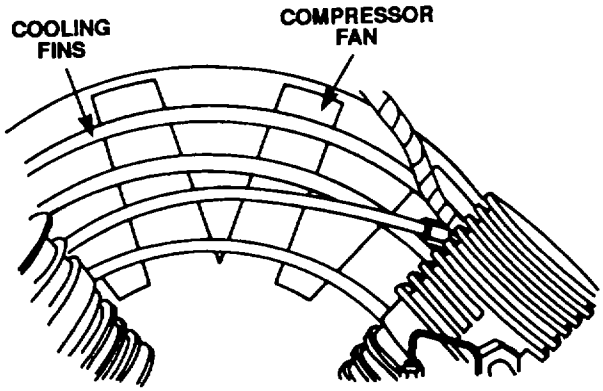


Figure 3-13. Compressor Fan and Cooling Fins

3-20 INTAKE FILTER ASSEMBLY (COMPRESSION)

DESCRIPTION

This task covers:

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Secure equipment (paragraph 2-11).
2. Bleed air pressure (paragraph 2-3, b).

Materials/parts:
Brush, item 8 Appendix E
Lint-free cloth, item 9 Appendix E
Non-ionic detergent, item 13 Appendix E

REPAIR

a. Remove wingnut (1, figure 3-14).

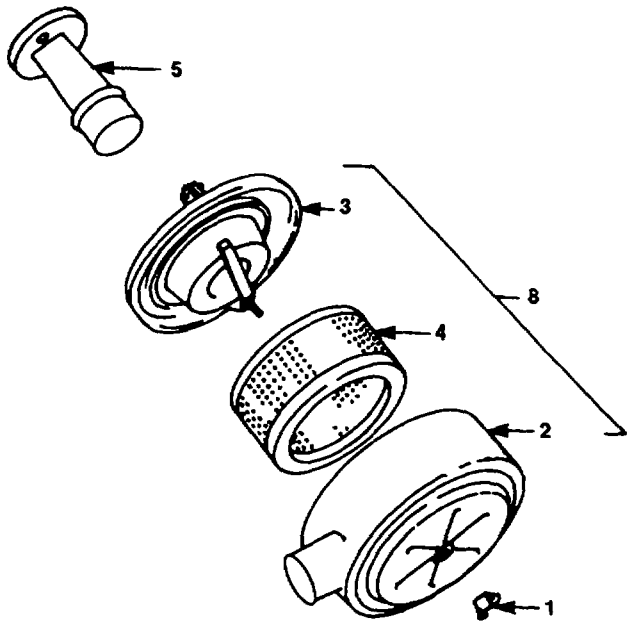


Figure 3-14. Intake Filter Assembly

b. Remove filter housing (2) from filter base (3).

c. Remove filter cartridge (4) and discard.

d. Loosen hose clamp on the filter base (3) and remove from intake pipe (5).

e. Clean filter cartridge (4) with brush.

f. Clean filter housing with damp cloth.

INSPECT

a. Ensure no obstructions were allowed to enter the intake pipe (5).

b. Ensure inlet of filter housing (2) has no obstructions.

c. Place new filter cartridge (4) onto filter base (3) and insert into the filter housing (2).

d. Secure with wingnut (1).

e. Place the intake filter assembly (8) over the intake pipe. Tighten hose clamp.

3-21 ENGINE.

DESCRIPTION

This task covers: Inspect. Service.

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Hot plate, oil

Equipment conditions:
Engine secured after running (paragraph 2-11).

Materials/parts:
Engine
Funnel, item 16 Appendix E
Oil, item 24 Appendix E

Lubricating oil level check.

INSPECT

a. To check the engine oil level, pull the dipstick located on the side of the engine.

b. Oil level must rest between tile indentation marks (figure 3-15).

SERVICE

a. If oil is required, unscrew the oil filler cap adjacent to the oil dipstick.

b. Add oil, as necessary, through the oil filler (figure 3-16).

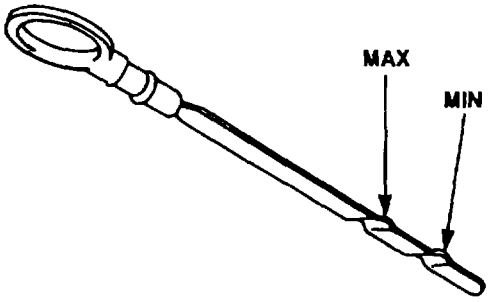


Figure 3-15. Oil Dipstick

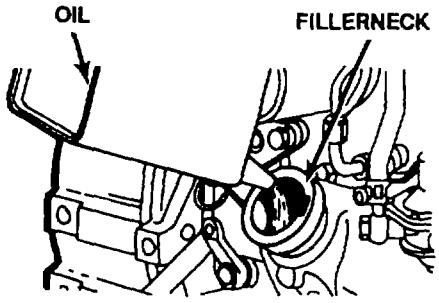


Figure 3-16. Filler Neck

Oil Change.

SERVICE

NOTE

Change oil while the engine is still hot, as the old oil will run more easily in this condition.

a. Shut down the engine.

WARNING

Danger of scalding when draining off the hot oil. Catch old oil in suitable receptacle to prevent pollution of the environment.

b. Unscrew drain plugs (1, figure 3-17) after placing suitable receptacle underneath.

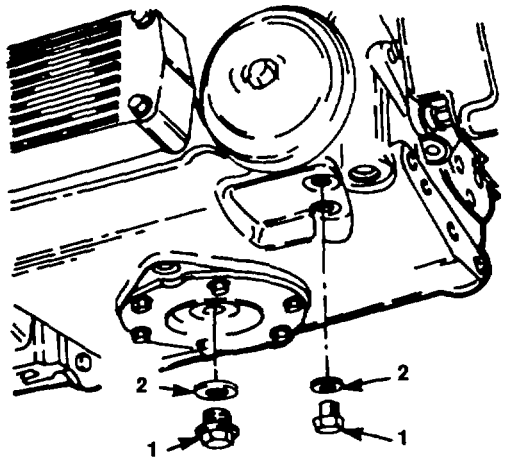


Figure 3-17. Changing Oil

c. When all old oil has run off, refit drain plugs (1) and replace sealing rings when necessary.

NOTE

Upon changing over to a higher grade of oil following a prolonged period of operation, change oil at the end of 20 hours and clean oil filter element.

d. Fill in fresh oil through filler neck up to the upper dipstick mark.

e. Following a short trial run, check oil level again; if necessary, top up to the upper mark (max).

V-Belt.

INSPECT

a. Remove belt guard.

NOTE

When V-belt replacement is necessary, replace with a matched set only (refer to unit activity). New V-belt sets require readjustment after 20 minutes running time.

b. Inspect V-belt over whole length for damage or cracks.

c. Check by pressing with thumb midway between the pulleys to see whether the V-belt deflects inward a maximum of 0.4 to 0.6 in. (10 to 15 mm)

SERVICE

a. Slacken hex bolts (1, 2, and 3; figure 3-19).

b. Pull alternator (4) in direction A until the correct belt tension is obtained.

c. Retighten hex bolts (1, 2 and 3).

d. Replace belt guard.

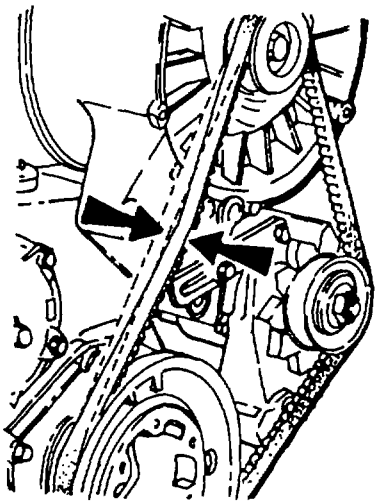


Figure 3-18. Checking V-Belt Deflection (Belt Guard Removed)

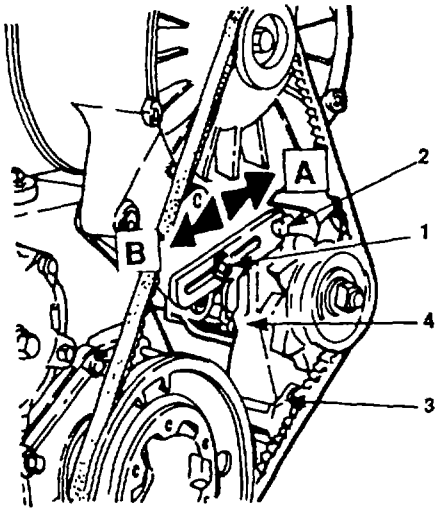


Figure 3-19. Adjusting V-Belt Tension

3-22 CYLINDER HEAD SET (VALVE COVERS)

DESCRIPTION

This task covers: Remove/Install.

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Torque wrench

Equipment Conditions:
Engine secured (paragraph 2-11)

Materials/Parts
None

REMOVE INSTALL

a. Remove bolt (1), washer (2), and seal (3) (figure 3-20).

b. Remove cover (4) and gasket (5) from head (6). Replace gasket if damaged.

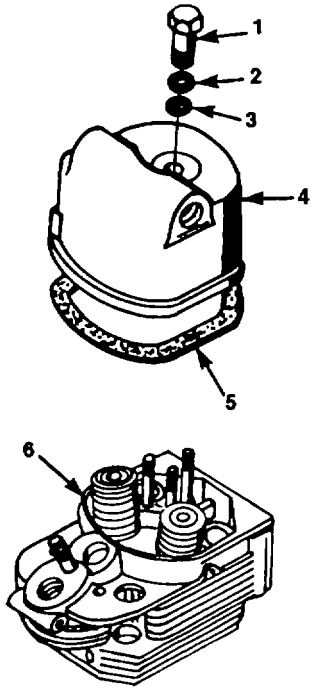


Figure 3-20. Cylinder Head

c. Clean gasket mating surface and cylinder head.

d. Reinstall valve cover (4), seal (3), washer (2), and bolt (1). Torque bolt to 7.4 lb-ft (10 Nm).

3-23 TIMING GEARS (VALVE ADJUSTMENT/DECOMPRESSION CHECK)

DESCRIPTION

This task covers: Adjust

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment Conditions:
1. Engine secured and cooled down (paragraph 2-11).
2. Valve covers removed (paragraph 3-22).

Materials/parts
Gasket

ADJUST

NOTE
Valve clearance to be checked with cold engine.

a. Turn crankshaft at front end until the valves of the cylinder in question are overlapping (exhaust valve about to close, inlet valve about to open).

b. Mark crankshaft pulley.

c. Then continue turning the crankshaft through 360 degrees.

d. Check valve clearance (figure 3-21).

1. Valve clearance (1) is correct when a 0.15 mm feeler gauge can be inserted with a slight drag between rocker arm (2) and valve (3).

2 If valve clearance must be readjusted.

e. Adjust according to the following steps.

1. Loosen locknut (4) by two to three turns.

2. Adjust setscrew (5) with screwdriver so that, when locknut is retightened, the feeler gauge can be inserted and withdrawn with slight drag.

f. Check the valve clearances of the remaining cylinder and readjust if necessary.

NOTE

Whenever checking valve clearance, be sure to also check the adjustment of thrust screw located on the rocker arm and designed for determining the clearance of the decompression device.

g. With valves closed, i.e., piston in compression TDC, press thrust pad (2) by hand against the valve stem end (figure 3-22).

h. In this position, measure the rocker arm setting dimension A; it should be 2.350 + 0.007-inch (59.7 + 0.2 mm).

i. Setting the thrust screw (1). Loosen hex nut (3) by 2 to 3 turns with a 13 mm open end wrench.

i. Adjust thrust screw with a 5 mm open end wrench so that the setting A; stated above is obtained when hex nut is tightened.

k. Reinstall rocker cover (paragraph 3-22).

l. After tightening the cover fastening bolts, check that the decompression shafts can be turned easily through 10 degrees.

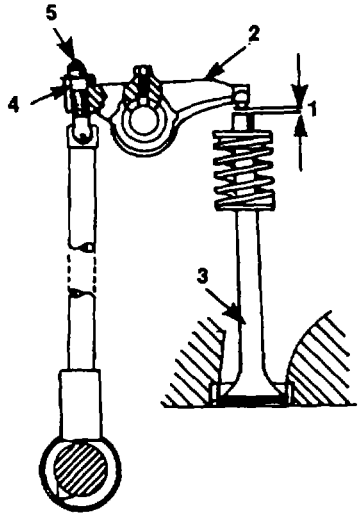


Figure 3-21. Valve Clearance

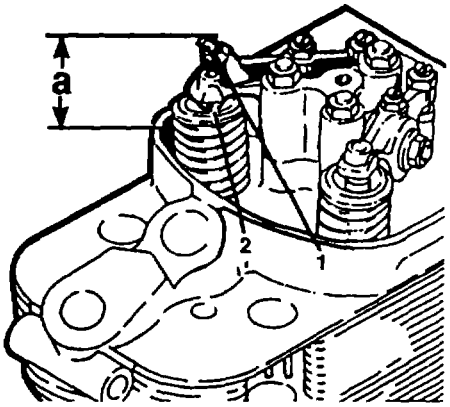


Figure 3-22. Adjusting Thrust Screw

3-24 LUBE OIL FILTER (ENGINE).

DESCRIPTION

This task covers: Replace

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment Conditions:
Equipment secured (paragraph 2-11).

Materials/Parts:
Clean diesel fuel, item 15 Appendix E
5 quart receptacle
Gaskets (3) - part number 0337-1914; (6) - part number 0223-7991
Wiping rags, item 25 Appendix E

REPLACE

WARNING

A small amount of oil runs out when screwing off the oil filter. Danger of scalding in case of hot oil. Catch old oil in suitable receptacle to prevent pollution of the environment.

a Unscrew hexbolt (1, figure 3-23).

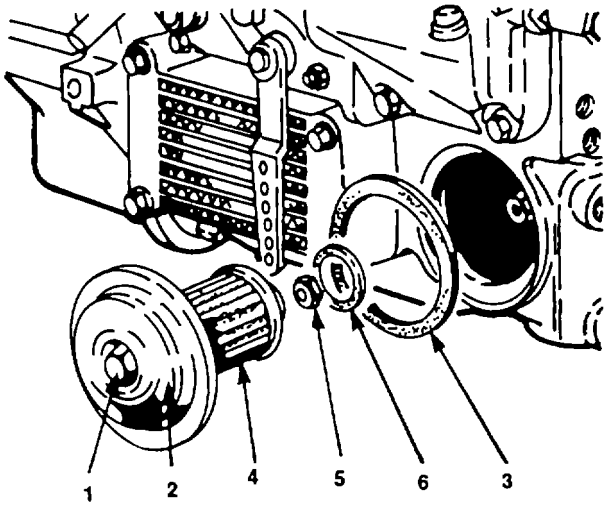


Figure 3-23. Lube Oil Filter

b Remove cover (2) with gasket (3) and filter element (4).

c Unscrew hexnut (5) of hex bolt (1) and take off element (4).

d Wash element (4) in clean diesel fuel and allow to thoroughly drip-dry.

e When reassembling, ensure correct positioning of gasket (3) for cover (2) and gasket (6) of element (4).

NOTE

During trial run following reassembly, check oil pressure and tightness of filter mountings.

3-25 LUBE OIL COOLER (ENGINE).

DESCRIPTION

This task covers: Inspect. Service. Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Engine secured (paragraph 2-11).

Materials/Parts:
Face shield, item 26 Appendix E
Detergent, item 12 Appendix E
Wiping rags, item 25 Appendix E

INSPECT SERVICE

WARNING

Eye protection/face shield must be worn when using compressed air for cleaning. Never use compressed air over 35 psi line pressure for cleaning. Clear immediate area of personnel.

a Inspect oil cooler (figure 3-24) for leaks, damage, accumulated dirt, and oil.

b To clean oil cooler, remove speed control lever (1) and remove four fastening bolts (3).

c Remove cooler (2), being careful not to let oil spilling from the cooler enter between the fins. Cap lube oil cooler so contaminants do not enter oil cooler.

NOTE

Steam jet cleaning is recommended. If a steam jet cleaner is not available, use compressed air set at 35 psi to clean fins and cylinder head.

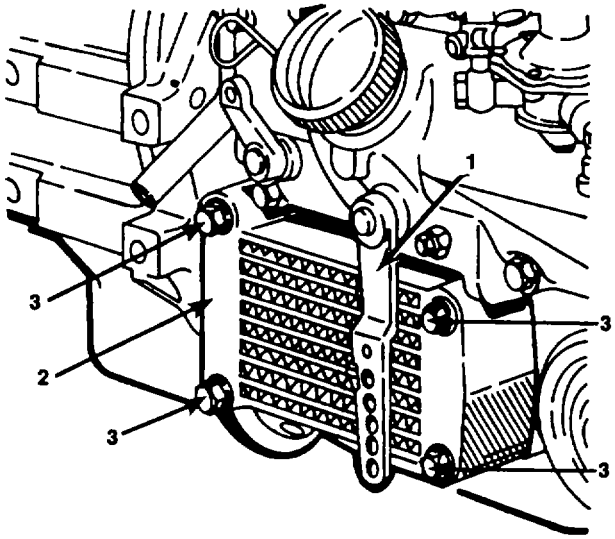


Figure 3-24. Lube Oil Cooler/Removal

REPAIR

a Replace lube oil cooler (2), ensuring that siphon is securely in place.

b Secure with four fastening bolts (3).

c Reinstall speed control lever (1).

3-26 FUEL FILTER CARTRIDGE (ENGINE).

DESCRIPTION

This task covers: Replace

INITIAL SETUP

Tools:
Strap wrench

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/Parts:
Fuel Filter (0117-4696)
Wiping rags item 25 Appendix E
Oil, item 24 Appendix E

REPLACE

NOTE
In case of high-level tank, close fuel cock.

a Place receptacle in position to catch escaping fuel.

b Screw off fuel filter cartridge (1, figure 3-25) using strap wrench, if necessary.

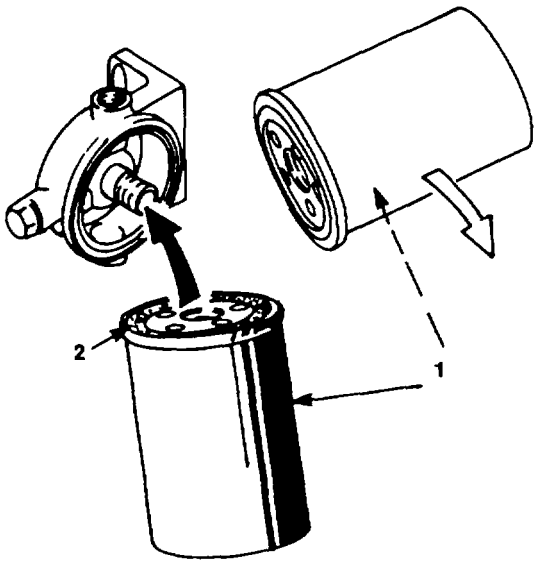


Figure 3-25. Fuel Filter Cartridge

c Clean sealing surface.

d Apply alight film of oil to rubber gasket of the new filter cartridge.

e Screw new cartridge in place by hand until gasket is evenly seated.

f Give cartridge a final half turn.

g Air bleed fuel system.

NOTE

Poor engine performance can be due to a clogged filter cartridge. If the filter cartridge clogs up too quickly, check fuel for contamination, clean tank, and check sealing of filler cap.

3-27 FUEL INJECTION PIPES (ENGINE).

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11).

Material/Parts:
Injection pipes (0415-4513)
Injection pipes (0415-4514)
Breather pipes (0347-0027)
Silicone sealant
Wiping rags, item 25 Appendix E

INSPECT

Visually inspect fuel injection pipes (4, figure 3-26) for leaks, holes, crimps or damage. Ensure compression fittings (5) and mounting brackets (2) are secure.

REPAIR

a. Loosen fittings (5).
b. Remove bolt (1) or nut (7) and brackets (2) with washers (3).
c. Remove fuel injection pipe (4) or tap out breather pipe (6) using a small rubber mallet.
d. Apply a small amount of silicone sealant to breather pipe.
e. Reinstall injection pipe (4) or breather pipe (6).
f. Reinstall bolt (1) or nut (7) with bracket (2) and washers (3).
g. Tighten fittings on injection pipes or tap breather pipe in place.
h. Tighten bracket bolts or nut securely.

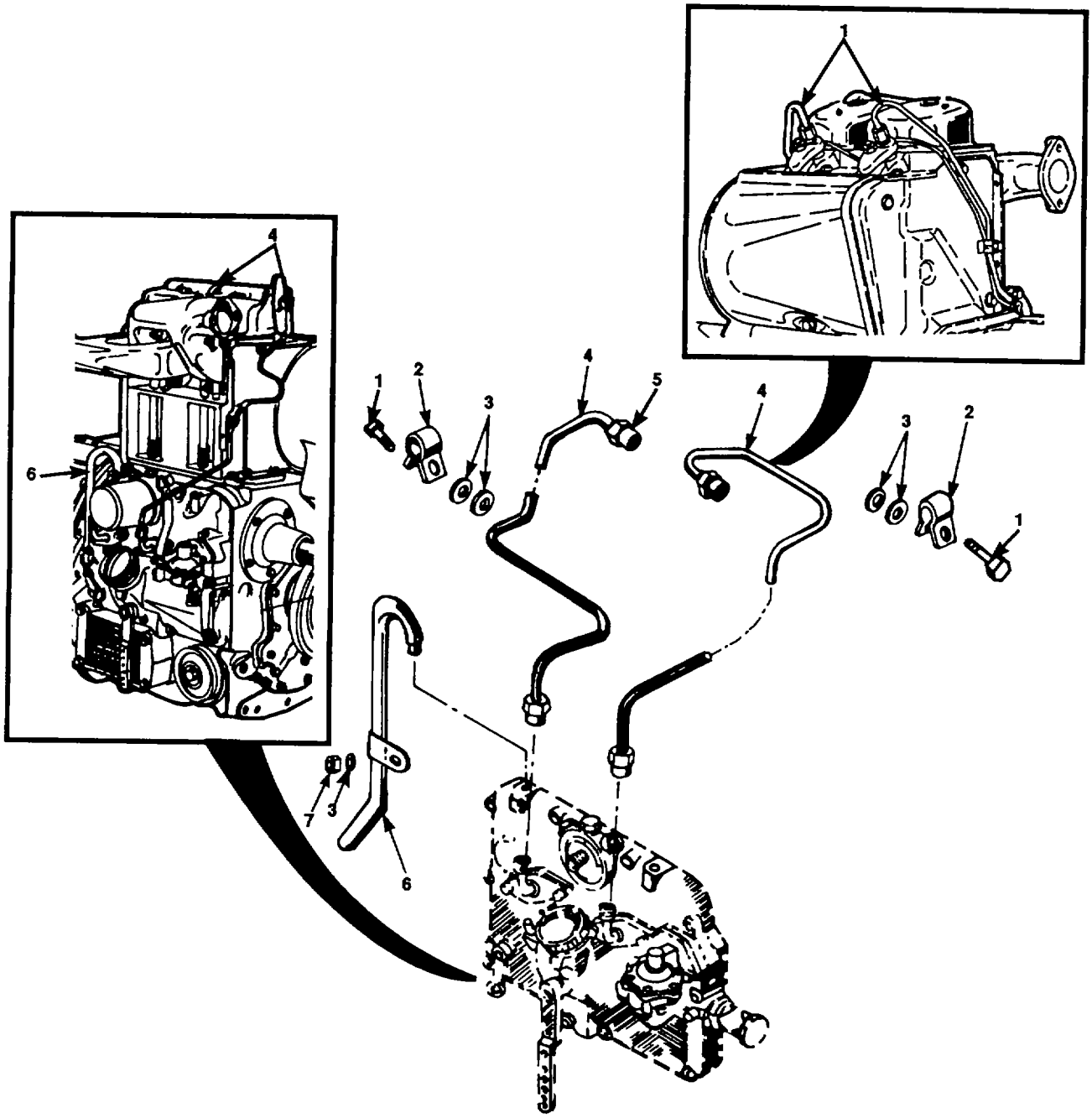


Figure 3-26. Injection Lines

3-28. FUEL FEED PUMP (ENGINE)

DESCRIPTION

This task covers: Service

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Engine secured (paragraph 2-11).

Materials/parts:
Clean diesel fuel, item 15 Appendix E

SERVICE

WARNING

When working on the fuel system, keep away from heat and open flame. Do not smoke. Do not spill any fuel.

NOTE

Palling off engine performance can be due to contamination of this strainer.

a Remove 8mm hex bolt (1, figure 3-27).

b Take off cover (2).

c Take out gasket (3) and strainer (4).

d Clean strainer in diesel fuel.

e Replace gasket (3).

f Reinstall strainer (4), gasket (3), cover (2), and hex bolt (1). Tighten bolt securely.

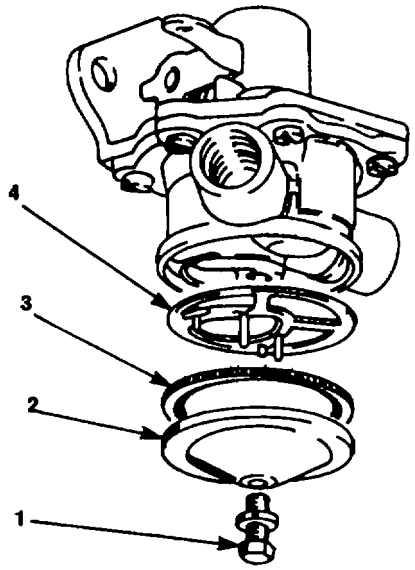


Figure 3-27. Feed Pump Strainer

3-29 FUEL HOSE (ENGINE).

DESCRIPTION

This task covers: Inspect. Repair.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11)

Materials/parts:
Wiping rags, item 25 Appendix E

INSPECT

Visually inspect fuel hose for signs of leakage from external damages. Inspect copper washers (2, figure 3-28) for deterioration. Ensure banjo bolts are tight.

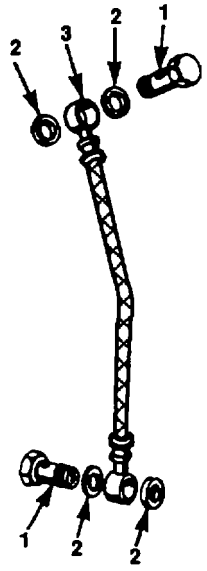


Figure 3-28. Fuel Hose

REPAIR

a Remove bolts (1) and washers (2, figure 3-28).

b Remove hose (3).

c Reinstall hose, washers, and bolts. Tighten bolts securely.

3-30 FUEL RETURN LINE (ENGINE).

DESCRIPTION

This task covers: Repairs

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Equipment secured (paragraph 2-11).

Materials/parts:
Wiping rags, item 22 Appendix E

INSPECT

Visually inspect overflow line for any sign of external damage, crimping, pit holes, or bends. Examine copper washers for deterioration. Ensure banjo bolts are tight.

REPAIR

a Tank Return Line.

1 Loosen hose clamps (11) and remove hose (12, figure 3-29).

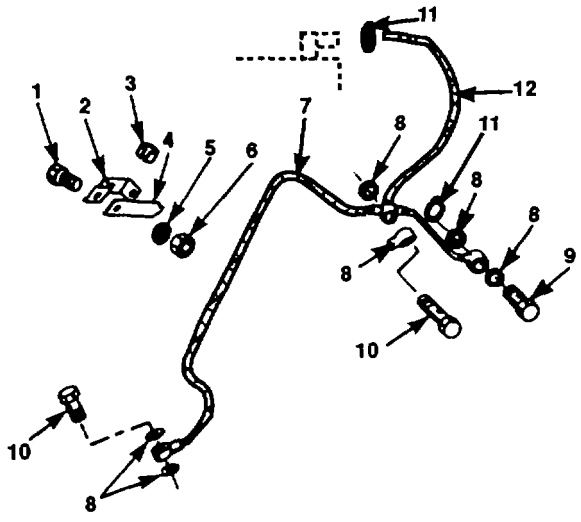


Figure 3-29. Overflow Pipe

2 Cut new hose to same length.

3 Reinstall hose with hose clamps onto fittings.

4 Tighten hose clamps securely.

b Filter Return Line.

1 Remove banjo bolts (9 and 10) and washers (8).

2 Remove bolt (1), brackets (2 and 4), washers (5), and nut (6).

3 Remove return line (7).

4 Reinstall return line (7), washers (8), and banjo bolts (9 and 10); tighten bolts securely.

5 Reinstall brackets (2 and 4), nut (6), washer (5), and bolt (1); tighten bolt securely.

3-31 OIL BATH AIR CLEANER (ENGINE).

DESCRIPTION

This task covers: Service. Replace. Repair.

INITIAL SETUP

Tools
None

Equipment conditions:
Equipment secured (paragraph 2-11).

Materials/parts:
Solvent, item 28 Appendix E
Face shield, item 26 Appendix E
Brush, item 8 Appendix E
Oil, item 24 Appendix E

SERVICE

To service the oil bath air cleaner:

a Release the two clips (3, figure 3-30) on the sides of the filter housing (1). The bowl and metal filter should drop out easily.

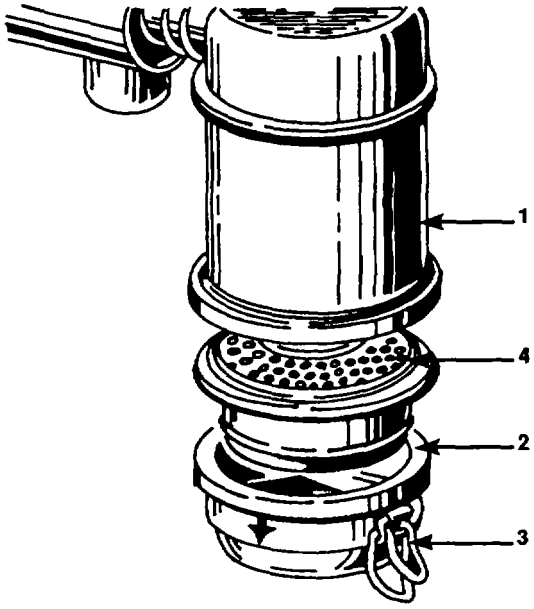


Figure 3-30. Oil Bath Air Cleaner

b Remove the metal filter from inside the bowl (2).

c Pour out the old oil. Rinse bowl with solvent and add new oil up to the bead mark. The oil should be the same as used in the engine.

WARNING

Eye protection/face shield must be worn when using compressed air for drying. Never use compressed air over 35 psi line pressure for drying. Clear immediate area of personnel.

d Clean the metal filter (4). Using solvent and a brush, blow dry with compressed air.

e Install metal filter (4) inside of bowl (2).

f Position bowl and filter assembly under filter housing (1). Secure clips (3) in place.

REPLACE REPAIR

a Remove two bolts attaching air cleaner assembly to intake manifold.

b Remove oil bath air cleaner assembly.

c Reinstall air cleaner assembly and two bolts. Tighten bolts securely.

3-32 INTAKE MANIFOLD (ENGINE).

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
2 Manifold gaskets (0223-0704)
Gasket (01 12-0870)
Grease, item 18 Appendix E

Equipment conditions:
Engine secured (paragraph 2-11).
Oil bath air cleaner removed (paragraph 3-31)

NOTE
Only remove an intake if found damaged or if suspected of leaking.

INSPECT

a Check the intake manifold for visible cracks or damage.

b Check intake manifold studs and oil bath air cleaner bolts for loose or missing nuts.

c Check for missing or broken gaskets.

REPAIR

a Remove muffler guard from frame. Remove ether injection connection.

b Remove four nuts (2) that secure intake manifold (1) to engine (figure 3-31).

c Remove manifold and discard gaskets.

d Clean sealing surfaces and apply a light coat of grease.

e Install gaskets and place manifold on the studs.

f Tighten the four nuts securely.

g Reinstall the oil bath air cleaner assembly and tighten the two bolts.

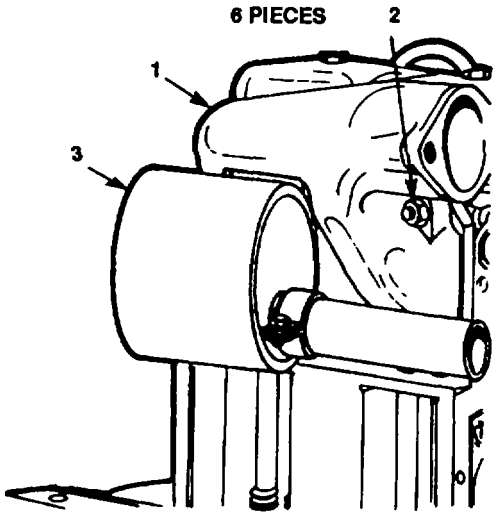


Figure 3-31. Intake Manifold

3-33 COOLING AIR DUCTING SYSTEM (ENGINE).

DESCRIPTION

This task covers: Service Inspect Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11)

Materials/parts:
Wiping rags, item 25 Appendix E
Face shield, item 26 Appendix E
Detergent, item 12 Appendix E

INSPECT SERVICE

CAUTION
Never clean the engine while it is running.

a. Cleaning the cooling system is most important since accumulation of dust on the cooling air blower blading (1), on the cooling fins of the cylinder heads (2), cylinders (3, figure 3-32), or oil cooler (see paragraph 3-25) is liable to substantially reduce cooling efficiency, especially where the dust is retained by a film of fuel or oil.

b. Regularly check the cooling system for contamination; clean, if necessary. Please note that the inspection intervals of every 500 hours can only be given as guide figures based on normal operating conditions, and that in the case of abnormally contaminated cooling air (check mounted cooling air sieve boxes for correct seating and good condition) the inspection and cleaning intervals may have to be shortened accordingly.

c. For inspecting and cleaning, proceed by removing hex bolt (1, figure 3-33) securing air cowling hood (2) on the alternator side, and removing the hood. Then on exhaust side, detach baffle by removing two hex bolts. Inspect gasket; replace, if required. If further inspection is required on the exhaust side, remove the oil bath air cleaner assembly by removing two bolts. Inspect gasket; replace, if required. Remove four bolts (1, figure 3-34), lock washers, and washers that secure the exhaust side deflection cover (2) in place. Place deflection cover and tighten bolts, lock washers, and washers. Replace the oil bath air cleaner assembly. Tighten bolts.

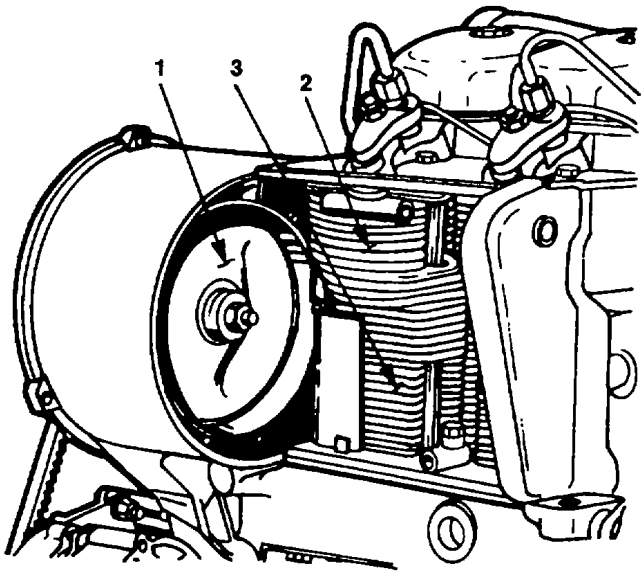


Figure 3-32. Cooling System Components

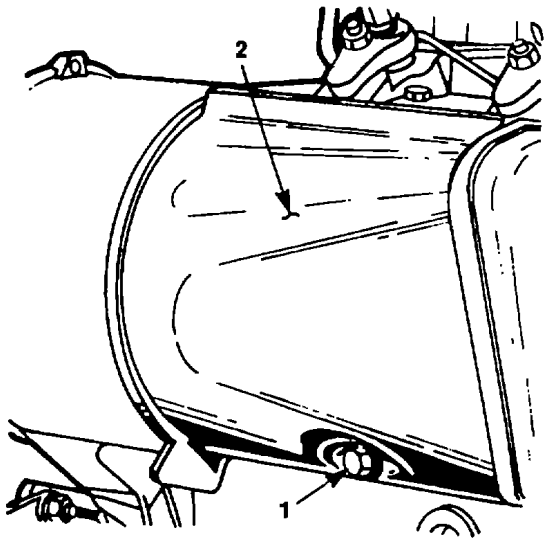


Figure 3-33. Air Cooling

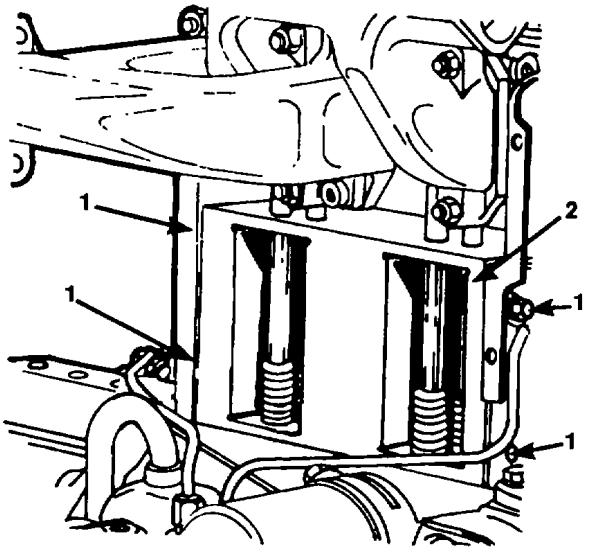


Figure 3-34. Waste Air Box

CAUTION

When cleaning the engine by means of a cold cleansing agent or steam, cover up the injection pump, alternator, voltage regulator, and starter motor as protection against direct application of the jet.

NOTE

If a high-pressure water jet is available, this method of cleaning the engine cooling system is recommended above all others.

d When using compressed air, begin cleaning the cooling system by blowing through from the exhaust side. Ensure any dirt blown into the air cooling space is removed.

e When cleaning with a cold cleaning agent, allow an adequate soak-in period, then wash the engine with a powerful water jet.

f After we-cleaning, let the engine run until warm so that any water left behind will be evaporated before rust can form.

REPAIR

Repair is by replacing any missing or damaged components.

3-34 STARTING MOTOR.

DESCRIPTION

This task covers: Replace

INITIAL SETUP

Tools:
General Mechanic Tool Box

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/parts:
None

REPLACE

CAUTION
Always remove negative battery terminal first.

NOTE
Test is at Direct Exchange.

a Disconnect negative battery terminal, then disconnect positive battery terminal.
b Disconnect starter electrical leads.
c Remove two bolts (1, figure 3-35) that secure starter motor to engine.
d Replace with identical unit
e Secure starter to engine with mounting bolts.
f Connect starter electrical leads.
g Reconnect the battery.

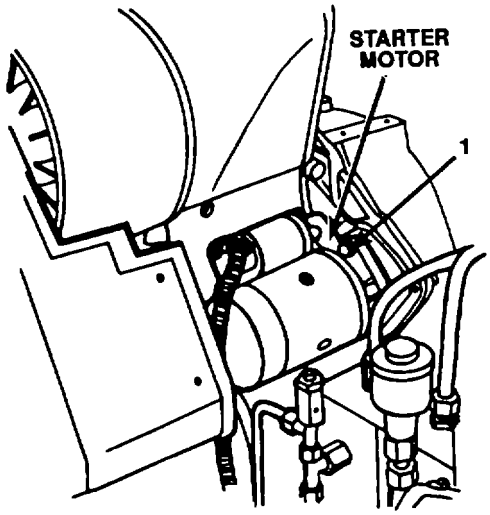


Figure 3-35. Starter Motor

3-35 V-BELT GUARD (ENGINE).

DESCRIPTION

This task covers: Inspect Replace Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/parts:
None

INSPECT

Check for visible signs of damage, missing hardware, grommets, and washers. Inspect hand crank cover (2) and spring (3, figure 3-36) for proper operation.

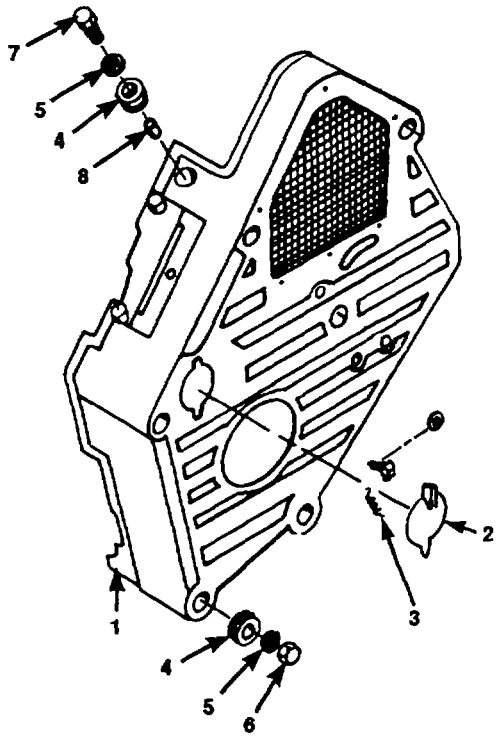


Figure 3-36. V-Belt Guard

REPLACE REPAIR

Repair is by replacing with identical components.

a. To remove guard (1, figure 3-36) from engine, remove the five cap nuts (6) and washers (5) on the front of the guard. Remove bolt (7), washer (5), and spacer (8).

NOTE
Ensure inner washers remain positioned on studs.

b Remove guar.

c Install guar. Reinstall bolt, nuts, and washers. Tighten bolt and nuts securely.

3-36 EXHAUST MANIFOLD ASSEMBLY (ENGINE).

DESCRIPTION

This task covers: Inspect Repair

INITIAL SETUP

Tools:
General Mechanics Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/parts:
Gasket (0337-1689)

INSPECT

a Check the exhaust manifold for visible cracks or damage.

b Look for black exhaust soot for indication of leakage.

REPAIR

a Remove nuts and washers that secure U-bolt (1, figure 3-37) to compressor frame. Remove U-bolts.

b Remove nuts and washers that secure U-bolt (1) to spark arrestor and muffler (3), and remove spark arrestor and tail piece.

c Remove nuts that secure muffler/exhaust manifold to engine.

d Remove exhaust manifold assembly.

e Discard gasket.

f Replace defective parts and gaskets.

g Install new gaskets and exhaust manifold assembly.

h Tighten nuts that secure exhaust manifold to engine.

i Reinstall spark arrestor and tail pipe.

j Install two U-bolts at the spark arrestor, and tighten.

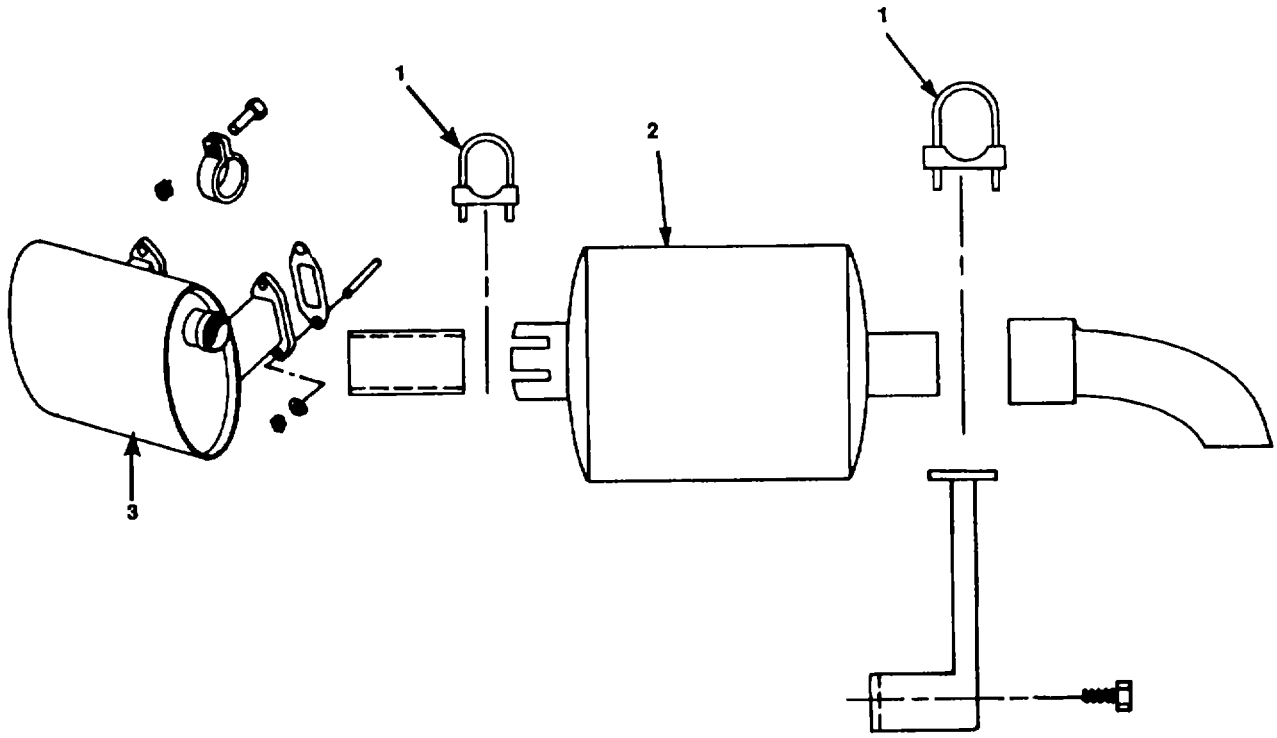


Figure 3-37. Exhaust Manifold

3-37 COLD START AID (ENGINE)

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/parts:
None

REPLACE REPAIR

a Remove nozzle (figure 3-38) from intake manifold.

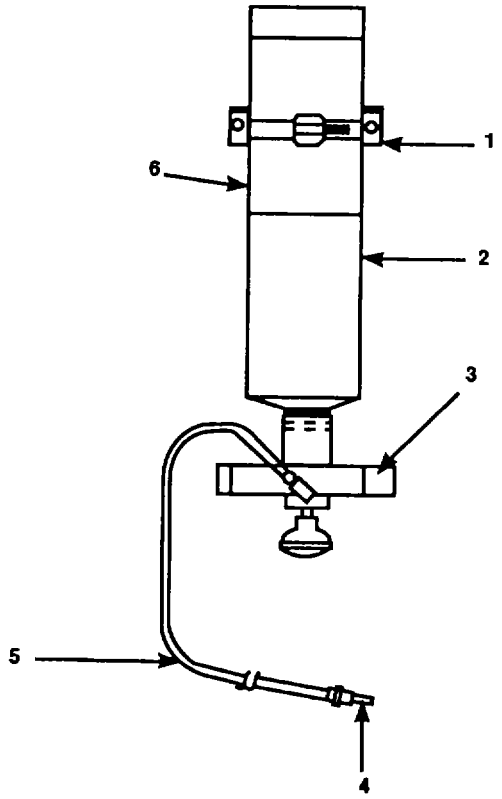


Figure 3-38. Cold Start Aid

b Remove expended ether cartridge.

c Disconnect lines from reservoir; reservoir will come free of compressor frame.

d Remove charging line from hand pump and unscrew locknut that secures hand pump to compressor frame.

e Replace any defective components.

3-38 ALTERNATOR (ENGINE)

DESCRIPTION

This task covers: Replace Test

INITIAL SETUP

Tools:
General Mechanics Tool Kit
Multimeter

Materials/parts:
None

Equipment conditions:
1. Engine secured (paragraph 2-11).
2. V-belt guard removed (paragraph 3-35).

TEST

NOTE
All tests performed with alternator installed and multimeter attached as shown in figures.

a. Open Diode Test.

1. Turn ignition on, but do not start engine. Ensure jumper (JU1) is not attached (no electrical load). Check for battery voltage at terminal A and for 1.5 to 3.0 volts at terminal B (figure 3-39).

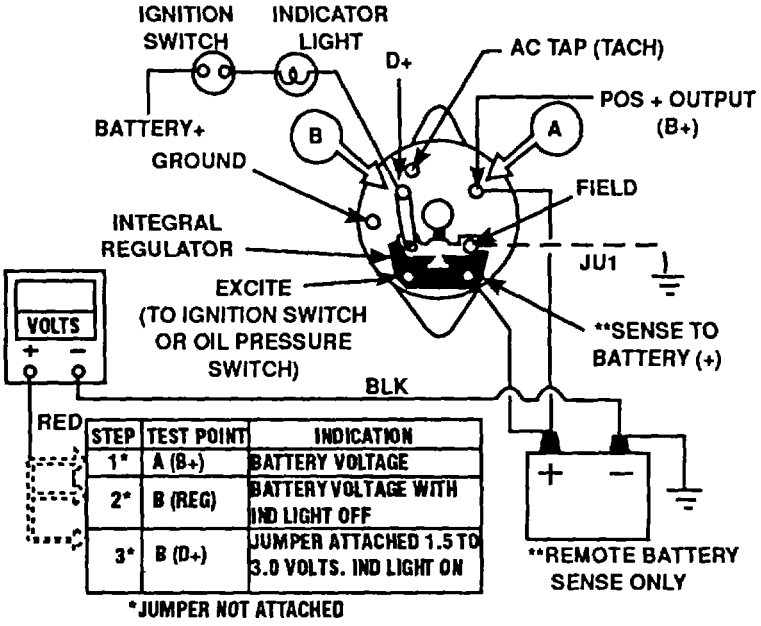


Figure 3-39. Regulator Test

2. Attach jumper (JU1) between terminals A and B; start engine and run at idle. If amp meter shows + and charging voltage is present at terminal A, one or all of the diodes are defective (open).

3. Replace or notify Direct Support for repair.

b. Open Regulator Test.

1. Disconnect wire from terminals extending through rear cover.

2. Remove rear cover screws and remove rear cover.

3. Reconnect wire removed in step 1.

4. Turn ignition switch on but do not start engine. Ensure jumper (JU1) is not attached. Check for battery voltage at terminals A and B. Test light will come on (figure 3-40).

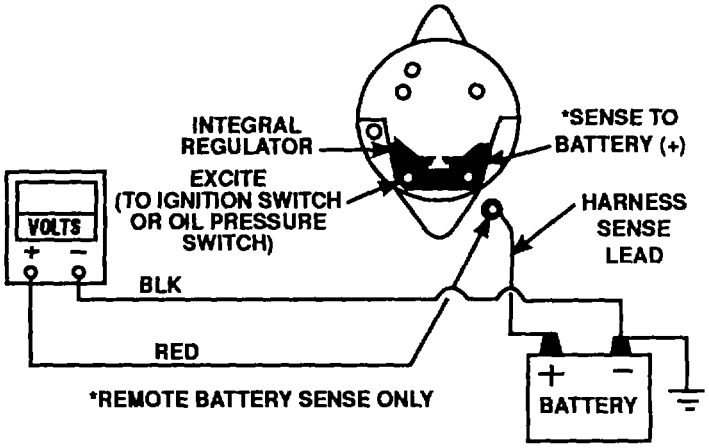


Figure 3-40. Cable Harness Voltage Test

5. Add jumper (JU1) between field and ground. If 1.5 to 3.0 volts is present at terminal B and the amp meter shows (-), the regulator is defective (open). If amp meter shows (+), an open field circuit is indicated.

6. Replace or notify Direct Support for alternator repair.

c. Harness Voltage Test.

1. Remove ammeter (+) wire from terminal and connect multimeter as shown in figure 3-40. Meter should indicate battery voltage (12.6 volts). If voltage is zero (0), the harness lead is open and should be repaired or replaced.

d. Alternator Output Test.

1. Connect multimeter as shown (figure 3-41).

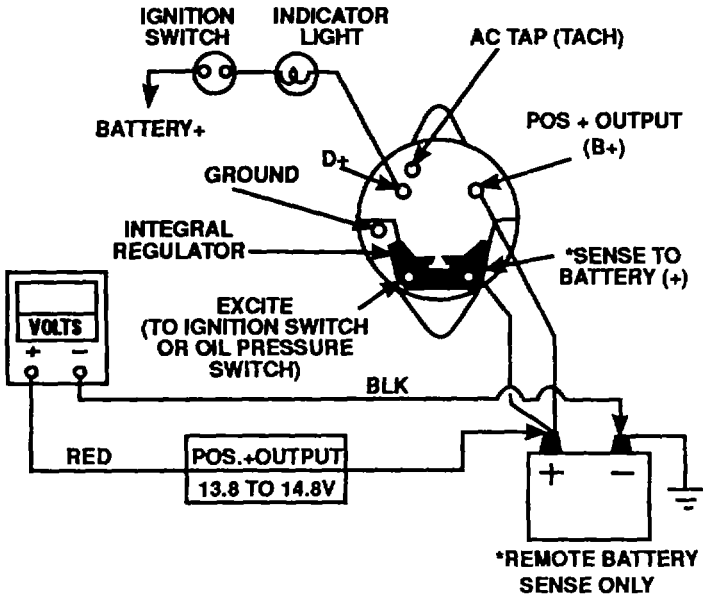


Figure 3-41. Alternator Output Test

2. Start and run engine at a fast idle (1200 to 1500 rpm).

3. Check for system output voltage of 13.8 to 14.8 volts. Voltage may vary a few tenths due to ambient temperature. If alternator voltage is not as indicated, replace or notify Direct Support for alternator repair.

REPLACE

a. Disconnect negative battery terminal and then disconnect positive battery terminal.

b. Disconnect terminals at alternator.

c. Loosen bolts that secure alternator to engine bracket.

d. Push against alternator to remove V-belt.

e. Remove bolts (1, 2 and 3, figure 3-42) and remove alternator from engine.

f. Replace alternator by installing bolts (1, 2 and 3) and install belts. Refer to paragraph 3-23 for proper tension and adjustment.

g. Check belts for alignment. Correct any misalignment by adding or deleting washers.

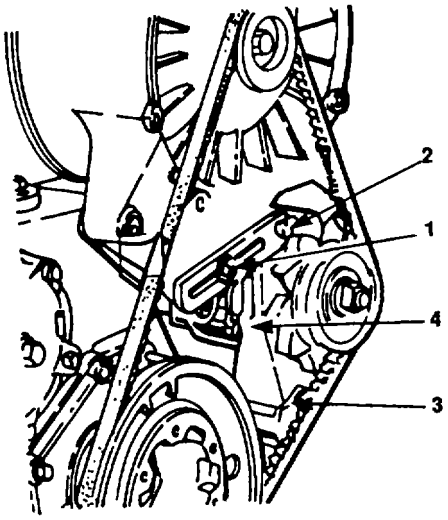


Figure 3-42. Alternator

h. Reconnect electrical connections at alternator.

i. Reconnect positive terminal and then negative terminal.

j. Replace belt guard.

3-39 CLUTCH SYSTEM.

DESCRIPTION

This task covers: Inspect Service Adjust

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Grease gun

Equipment conditions:

Materials/parts:
Grease, item 18 Appendix E

INSPECT

If clutch slips, do not pull; overheats, or the clutch lever jumps out of the engaged position, the clutch must be adjusted.

SERVICE

NOTE

Any high-grade lithium-based #2 short fiber grease, having an operating temperature of 200°F recommended for roller bearings may be used.

a. To service the clutch thrust bearing, throw out collar and lever shaft; use hand-operated grease gun on grease fittings (1, 2, and 3, figure 3-43) (one stroke only).

b. To service clutch pilot bearing (4), use hand-operated grease gun (two strokes only).

c. To service clutch main shaft bearing (3), use hand-operated grease gun (four to six strokes only).

NOTE

Unit should be operating during this inspection.

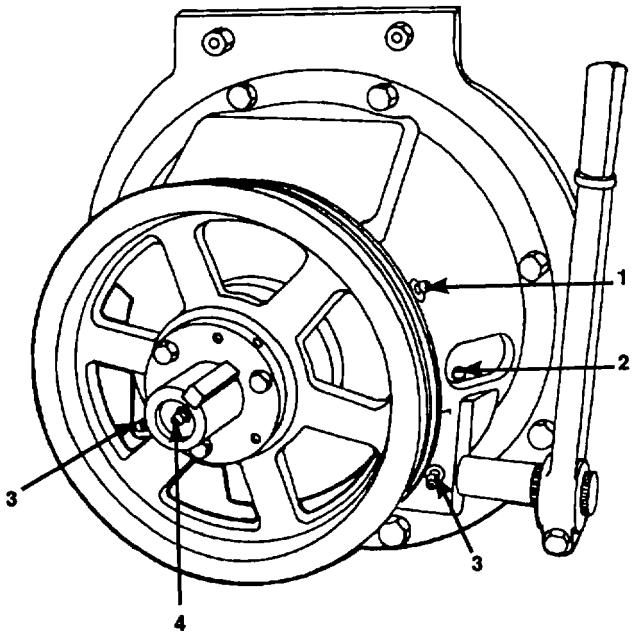


Figure 3-43. Grease Fittings

NOTE

A new clutch generally requires several adjustments until the friction surfaces are worn in. Do not let the clutch slip as this may damage friction plates.

NOTE

A common indication that the friction surface is worn out is that the adjusting ring cannot be further tightened.

ADJUST

a. To adjust the clutch, remove the inspection cover plate in the housing and rotate the clutch until the adjusting lock and lock screw can be reached. Remove the bolt and the adjusting lock. Turn the adjusting ring counterclockwise to obtain recommended operating lever pressure.

b. Reinstall the adjusting lock and bolt.

c. Reinstall the inspection cover plate.

3-40 HANDLE ASSEMBLY.

DESCRIPTION

This task covers: Replace

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment condition:
Engine secured (paragraph 2-11)

Materials/parts:
None

REPLACE

Loosen the 9/16-inch nut (1, figure 3-44) and remove handle (2) from shank.

NOTE
Test is at Direct Exchange.

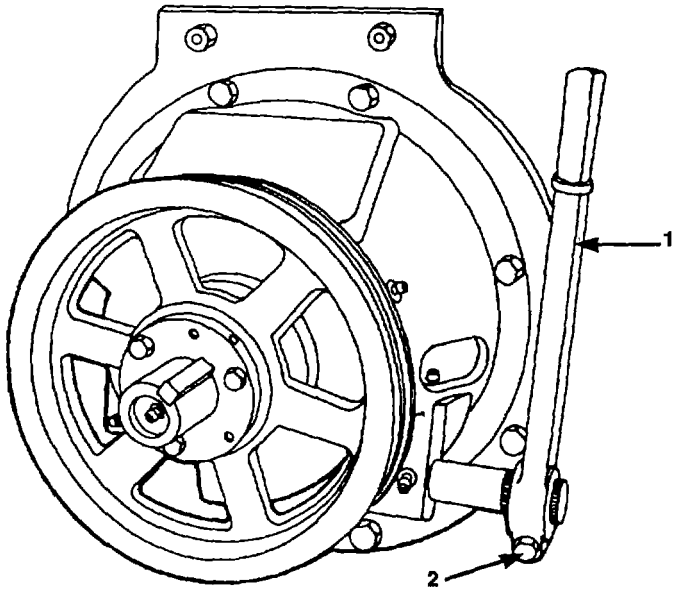


Figure 3-44. Service Points

3-41 PRESSURE MAINTAINING VALVE.

DESCRIPTION

This task covers: Adjust

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
System operating (paragraph 2-9).

Materials/parts:
None

INSPECT

Check to see that the pressure maintaining valve (PMV) maintains 1800 to 2000 psi by observing the final pressure gauge with the service line valve venting to the atmosphere. Ensure service line pressure is maintained below 500 psi.

WARNING

Due to the sensitive nature of the pressure maintaining valve, adjustment should be made by qualified personnel.

ADJUST

If final pressure is not 1800 to 2000 psi, adjust PMV using an 8 mm allen wrench (counterclockwise to decrease pressure, clockwise to increase pressure).

3-42 PURIFIER CHAMBER.

DESCRIPTION

This task covers: Inspect

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Compressor unit secured (paragraph 2-11).

Materials/parts:
None

INSPECT

a. Inspect purifier (figure 3-45) and separator block chambers for physical signs of damage. Check associated tubings and fittings.

b. Check hourmeter and log book to ascertain if service life of cartridges has expired. (Cartridge life is 80hoursor semi-annually, whichever comes first.) If cartridge life is expired, notify Direct Support Maintenance.

NOTE
Whenever cartridges are replaced, it must be noted in the log book.

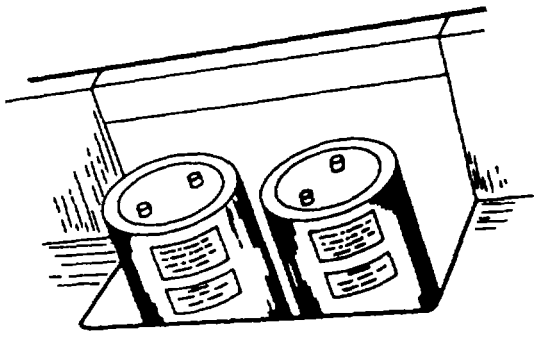


Figure 3-45. Purifier Cartridges

3-43 SEPARATOR BLOCK.

DESCRIPTION

This task covers: Inspect

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment condition:
Compressor unit operating

Materials/parts:
Detergent, item 13 Appendix E
Water, item 32 Appendix E

INSPECT

a. Inspect exterior for damage, corrosion, loose fittings, and loose mounting bolts (figure 3-46). Perform leak test using non-ionic soapy water. Rinse and allow to dry.

NOTE

If compressor unit is at 5000 psi, fourth stage relief valve will be lifted.

b. Check proper operation of the condensate drain by activating drain switch. Condensate should drain.

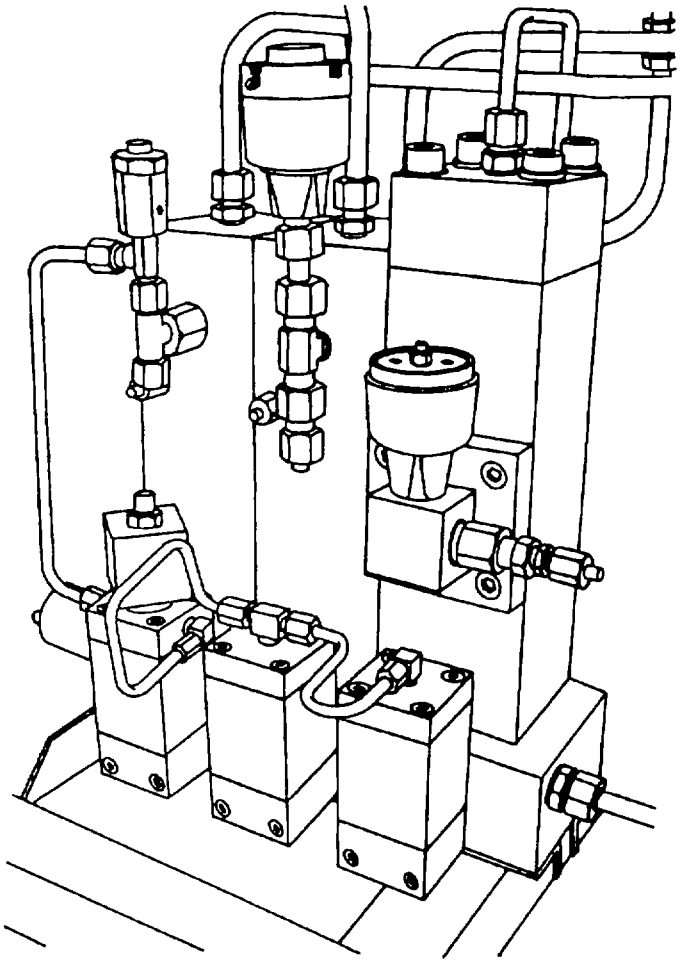


Figure 3-46. Separator Block

3-44 INSTRUMENTS AND CONTROL PANEL ASSEMBLY (GAUGES).

DESCRIPTION

This task covers: Inspect Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
1. Compressor unit secured (paragraph 2-11).
2. Bleed system of air (paragraph 2-3, b).

Materials/parts:
Lint-free cloth, item 9 Appendix E
Tape, item 30 Appendix E
Bag, item 6 Appendix E

INSPECT

a. Remove rear cover. Inspect for loose hardware gauge mounting and fittings.

CAUTION

Liquid filled gauges should be replaced with identical unit and damaged gauge should be returned to the manufacturer for repair and recalibration.

b. If gauges are cracked or physically damaged, replace as required.

REPAIR

WARNING

Due to the sensitive nature of the pressure gauges and other various compressor controls, they must be replaced as a unit and calibrated by General Support Maintenance.

a. Service Line Pressure, Final Pressure, Compressor Oil Pressure.

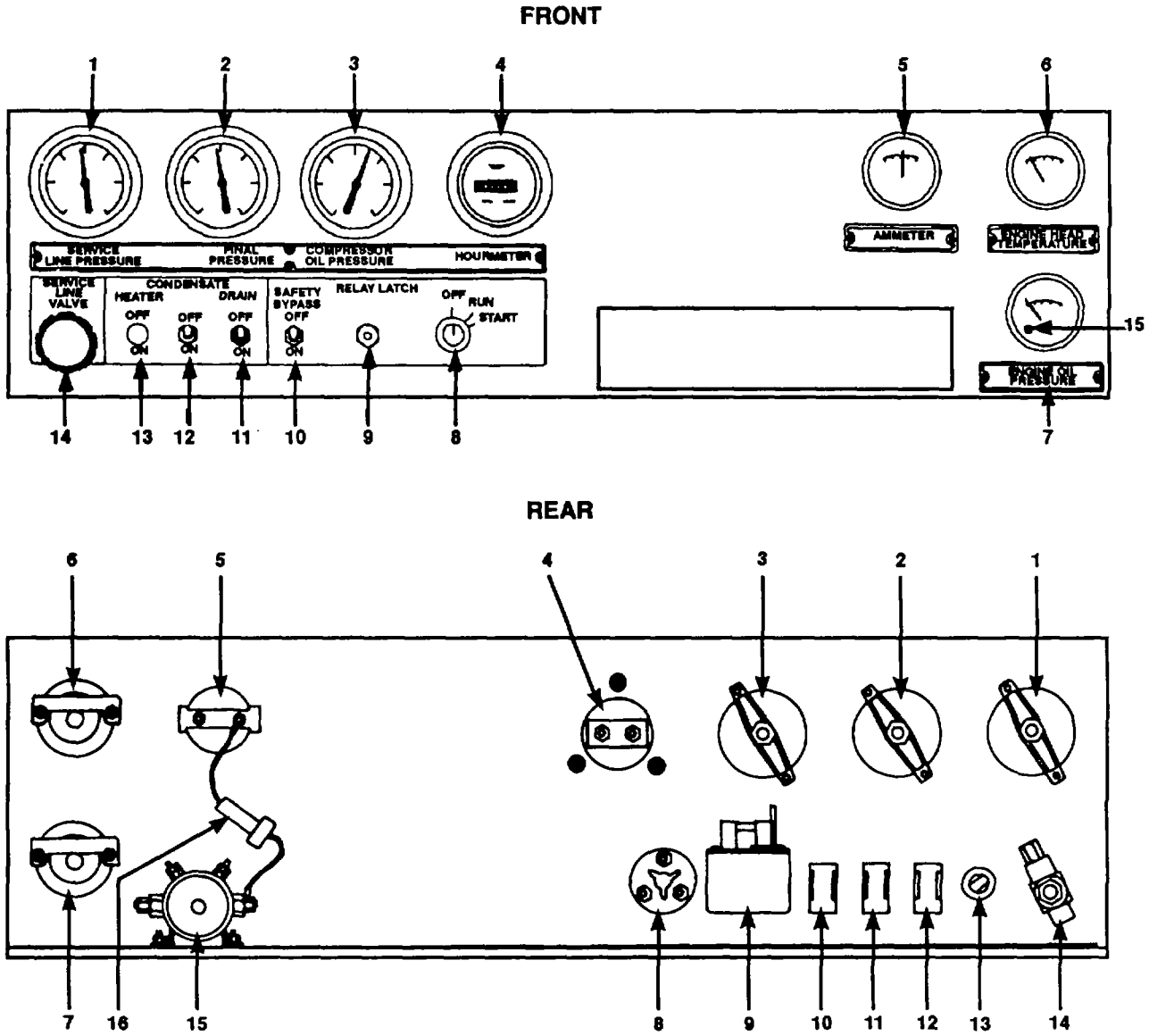
CAUTION

Always remove negative terminal first to prevent shorting.

1. Remove battery terminals and battery.
2. Remove rear cover by removing five hex head bolts.
3. Disconnect sensing line to related gauge (1, 2, 3 or 7, figure 3-47) as required.
4. Loosen and remove gauge mounting bracket. Remove gauge.
5. Install replacement gauge. Secure gauge mounting bracket. Connect sensing line to gauge.

b. Engine Head Temperature Gauge.

1. To remove engine head temperature gauge, the air cowling must be removed to remove sensor from the cylinder head. See paragraph 3-33, c.
2. Using two 13 mm open end wrenches, hold nut closest to cylinder head secure while loosening the jam nut. Loosen nut closest to the cylinder head until sensor can be removed.
3. Remove grommet from air shrouding. Pull sensor and wire through grommet hole.
4. Repeat steps a.4 and a.5, above.



Legend

1. Service Line Pressure Gauge
2. Final Pressure Gauge
3. Compressor Oil Pressure Gauge
4. Hourmeter
5. Ammeter
6. Engine Head Temperature Gauge
7. Engine Oil Pressure Gauge
8. Ignition Switch
9. Relay Latch with Fuse
10. Safety Bypass Switch
11. Condensate Drain Switch
12. Heater Condensate Switch
13. Heater On Light
14. Service Line Control Valve
15. Condensate Relay
16. Condensate Heater Fuse

Figure 3-47. Instrument Panel

3-45 ELECTRICAL SYSTEM.

DESCRIPTION

This task covers: Inspect Test Service Adjust

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Multimeter
Hydrometer

Equipment conditions:
Equipment secured (paragraph 2-11).

Materials/parts:
Distilled water, item 32 Appendix E

INSPECT SERVICE

a. Battery (checking electrolyte level).

WARNING

When working on the battery, keep away from heat or open flame. Do not smoke. Do not allow acid to come into contact with the skin or clothing. Wear protective goggles. Do not place tools on battery.

1. Remove cell caps.
2. If the electrolyte level is low, top up with distilled water only.
3. Replace cell caps.

NOTE

Before inspecting/testing an individual electrical component, inspect all wires, terminals, and connections, and test wires for continuity.

b. Start Switch.

Inspect starter switch for proper operation.

NOTE
If engine does not start, switch must be turned off before trying to restart.

c. Relay Latch.

1. With starter switch in OFF position, press latch relay (latch button should stay in).
2. Turn starter switch to RUN.
3. Relay latch button should release.

d. Safety Bypass.

Check for proper operation.

e. Condensate Drain Switch.

Check for proper operation. (Switch is spring-loaded and should return to the OFF position.)

f. Condensate Heater Switch.

1. Check for proper operation.
2. Turn starter switch to RUN position.
3. Turn condensate heater switch ON. Green light should be lit.

g. Engine Oil Pressure Gauge Switch.

1. Depress button on face of gauge.
2. Ensure needle moves between the 40 and 50 psi marks.
3. Release button.
4. Oil pressure needle should return to 30 psi.

h. Engine Head Temperature Gauge Switch.

1. Shut down arm pin should be between 285 to 305°F (140 to 150°C).

i. Compressor Oil Safety Switch.

1. While engine is running with clutch disengaged, turn safety bypass switch to OFF.
2. Engine should shut down.
3. Turn safety bypass ON.
4. Restart engine and engage clutch.
5. Ensure compressor oil pressure is above 750 psi.
6. Turn safety bypass switch to OFF. Engine should continue to run.
7. If engine shuts down, notify Direct Support Maintenance.

j. Hourmeter and Ammeter.

Check for loose mounting, connections, and corrosion. With compressor unit operating, ammeter should read to the positive side and the hourmeter should be tabulating.

k. Condensate Heater Relay. (Solenoid switch located inside instrument panel.)

1. Inspect for corrosion, loose bolts, and wires.
2. If condensate heater light does not turn on, turn on heater switch.
3. Turn on ignition switch. Hold hand on relay. Turn heater switch on.

l. Condensate Drain.

1. Inspect for proper operation while unit is running. Push drain switch. Unit should drain.
2. Release switch; unit should stop draining.

m. The 4th Stage Temperature Sensor.

1. Ensure temperature sensor is secure in 4th stage exhaust fitting.
2. Check electrical connection for corrosion or damage.
3. Check wiring for corrosion, cracks, or deterioration.

TEST

a. Battery.

Ensure specific gravity of all cells is between 1.250 to 1.300.

b. Start Switch.

1. Remove start switch by removing retaining nut.
2. Disconnect wires 1, 6 and 7 (figure 3-48, rear, item 8).
3. With switch in OFF position, using a multimeter continuity should not exist between terminals.
4. Place switch in RUN position. Battery and ignition terminal should have continuity.
5. Place switch in START position. Continuity should exist between battery and start terminal.

c. Relay Latch.

1. With starter switch in RUN position, check for 12V on the battery terminal of the relay latch (B) and on both sides of the fuse terminal. Replace fuse if required.
2. Remove relay latch. Remove and note wire position.
3. Using multimeter, test fuse for continuity. With relay latch button out, test terminal B and C. Circuit should be open. B to S, open.
4. Push latch button in 15 to 20 ohms. Continuity should be read between the S and C terminal and the S and B terminal.

d. Safety Bypass.

1. Isolate switch.
2. Check for continuity in ON position. Open circuit in OFF position.

e. Condensate Drain Switch.

1. Isolate switch.
2. Check for continuity in normal position.
3. Check for open circuit in the momentary position.

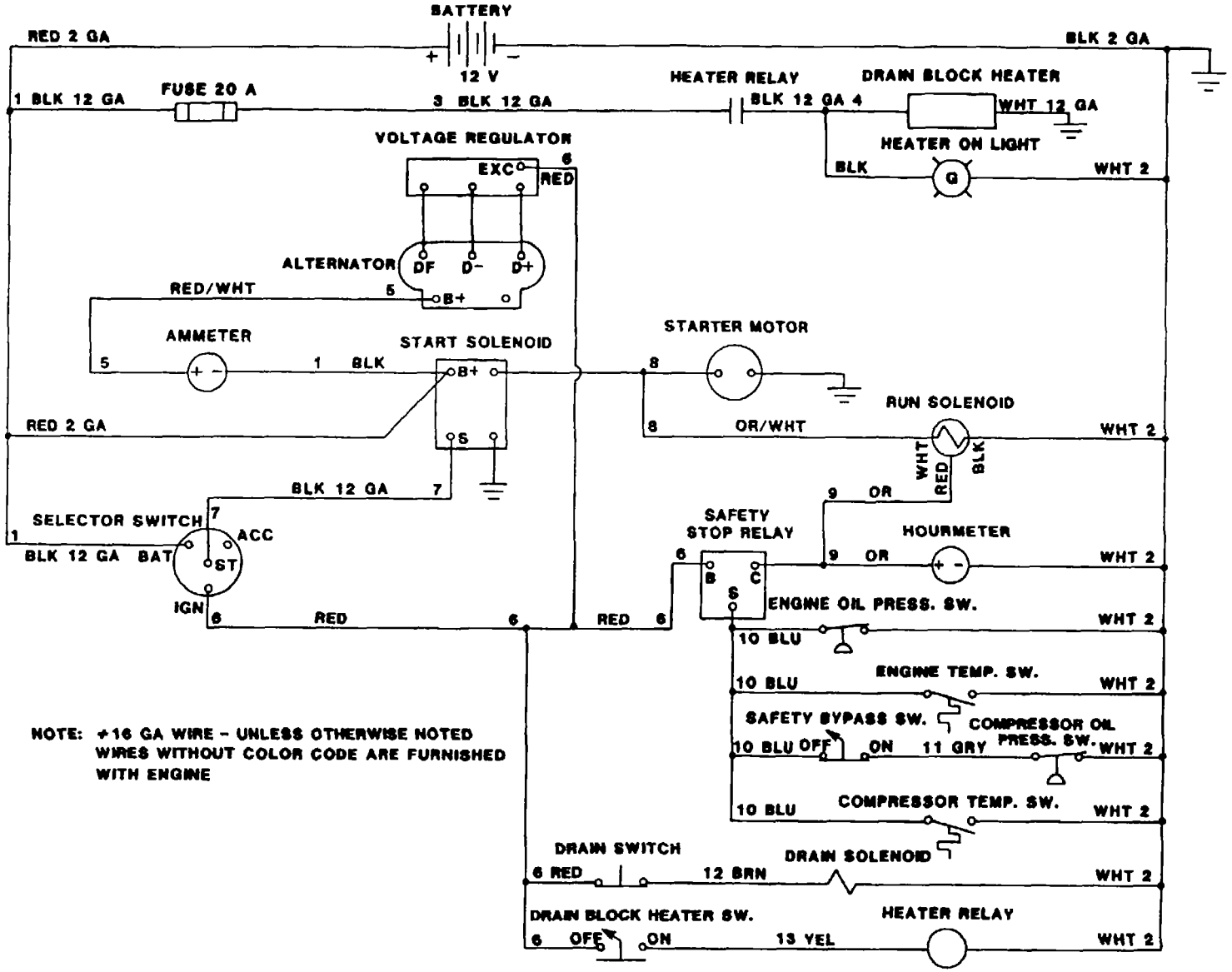


Figure 3-48. Wiring Diagram

4. Refer to paragraph 3-45 (1) for condensate drain solenoid test.

f. Condensate Heater Switch.

1. Isolate switch.
2. Check for continuity in ON position. Open circuit in OFF position.

g. Engine Oil Pressure Gauge Switch.

1. Disconnect battery.
2. Check continuity between wire 10 to engine oil pressure gauge switch and ground.
3. Multimeter should read open circuit while pressing engine oil pressure gauge switch button.

h. Engine Head Temperature Gauge Switch.

1. Disconnect battery.
2. Check continuity between engine head temperature gauge switch wire 10 and ground.
3. Multimeter should read open circuit while pressing engine oil pressure gauge switch button.

i. Compressor Oil Safety Switch.

If inspection verifies a bad compressor oil safety switch, notify Direct Support Level maintenance.

j. Hourmeter and Ammeter.

Hourmeter.

1. Compressor unit operating.
2. Check for voltage at hourmeter terminal.
3. If voltage is present, hourmeter is defective.

Ammeter.

1. Isolate ammeter.
2. Check for continuity between the two terminals.

3. Check both terminals to ground for open circuit.

k. Condensate Heater Relay.

1. Inspect light bulb.

2. Check fuse (32V, SFE20) located between ammeter and solenoid.

3. Test ON/OFF switch for proper operation.

4. Isolate and test solenoid relay directly under ammeter.

5. If steps 1 to 4 above indicate no problems, proceed with the following steps.

6. Remove two screws off heater element cover located on bottom of condensation block.

7. Pull back cover to expose wires.

8. Check two wires going into heating element. Resistance should exist.

l. Condensate Drain.

1. Connect multimeter to condensate drain wires (isolated).

2. If open circuit exists, replace solenoid normal reading (15 to 20 ohms).

m. Run Solenoid (Visual Test).

1. Perform operator PMCS up to the point of turning the switch to the START position (paragraph 2-9).

2. Watch the run solenoid when engaging the starter. As the engine turns over, the solenoid should move to the RUN position (move towards the front of the engine).

3. If solenoid moves toward the front of the engine, stop and proceed to Table 3-2. If solenoid does not move, notify Direct Support Maintenance.

n. The 4th Stage Temperature Sensor.

1. Disconnect electrical connection going to the sensor unit.

2. Using a multimeter, test for open circuit (defective sensor will read a grounded circuit).

ADJUST

Run Solenoid.

1. Remove pin and cotter key from the run solenoid until the plunger is fully seated at its internal stop.
2. Push on the back of the solenoid until the plunger is fully seated at its internal stop.
3. The stop lever hole should line up with the clevis holes. If not, adjust accordingly.
4. Install pin and cotter key. Test solenoid for proper operation. Refer to Direct Support Maintenance if solenoid is in operation.

3-46 TUBINGS AND FITTINGS.

DESCRIPTION

This task covers: Inspect

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Swedgelock tool(s)

Equipment conditions:
1. Equipment secured (paragraph 2-11).
2. System bled of pressure (paragraph 2-3).

Materials/parts:
Detergent, item 13 Appendix E
Water, item 32 Appendix E

INSPECT

a. Check tubing for crimps, bends or pit holes. If any damage is apparent, contact Direct Support Maintenance.

b. Check for leaks using a non-ionic detergent while unit is at full pressure.

c. Secure unit and bleed air (paragraph 2-3).

d. Tighten fittings as necessary; do not overtighten.

CHAPTER 4
DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

Section I.
DIRECT SUPPORT TROUBLESHOOTING

4-1 DIRECT SUPPORT TROUBLESHOOTING PROCEDURES. This section contains direct support troubleshooting procedures as authorized by the maintenance allocation chart (MAC).

Table 4-1. Direct Support Troubleshooting Procedures

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR
1 Compressor will not load. Step 1. Check stage safety valves. Check cartridges in purifiers.
2. Compressor output low. Step 1. Check compressor rpm for rated speed. Step 2. Perform intermediate stage pressure check.
3. Low compressor oil pressure. Step 1. Check oil pressure regulator for proper setting. Adjust, repair, or replace as needed.
4. Compressor air has oily taste. Step 1. Check cartridge evaporation date. Replace. Step 2. Check oil pressure regulator to high. Adjust.
5. Sight glass exhibits air bubbles. Step 1. Check oil pressure regulator. Clean and adjust regulator. Step 2. Check oil pump final pressure. Clean or replace. Step 3. Check 4th stage piston clearance. Replace as necessary.

Table 4-1. Direct Support Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
6. Compressor does not attain final pressure. Step 1. Check final stage safety valve. Replace. Step 2. Check drain valves and stage safety. Clean, repair, or replace. Step 3. Check intermediate stage pressures. Replace valves/rings as necessary.
7. Excessive vibration of unit. Step 1. Fuel delivery (timing off). Check, adjust if necessary. Step 2. Floating frame cracked. Weld, replace as necessary.
8. Condensate drain not draining (cold weather). Step 1. Condensate heater inoperative. Test circuit and element, replace if necessary.
9. No oil pressure. Step 1. Check oil pump. Test and service as required. Step 2. Check regulator. Clean and adjust as necessary. Replace if required.
10. Compressor output insufficient. Step 1. Check engine rpm. Adjust as required. Step 2. Check compressor valves. Replace as necessary. Step 3. Check compressor rings. Replace as necessary.
11. Safety valves between stages releasing pressure. Step 1. Check stage valves. Replace as necessary. Step 2. Check stage safety valves. Adjust; replace as necessary.

Table 4-1. Direct Support Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
12. Compressor overheats (shutdown activates). Step 1. Check stage valves. Replace as necessary. Step 2. Check compressor rings. Step 3. Check oil pressure. Adjust as required.
13. Automatic condensate drain does not unload. Step 1. Check condensate drain circuit and solenoid. Clean piston or replace as necessary. Step 2. Check condensate drain valves. Dismantle, clean/replace as necessary.
14. Automatic drain leaks and blows off continuously. Step 1. Check valve seats and pistons. Clean; replace as necessary.
15. Compressor speed low. Step 1. Check rpm. Adjust rpm.
16. Engine does not turn over. Step 1. Check starter motor and pinion. Repair or replace as necessary.
17. Engine gives poor performance. Step 1. Check fuel system. Clean fuel system. Step 2. Check fuel delivery (fuel timing). Adjust timing as required. Step 3. Check exhaust back pressure. Replace muffler or spark arrestor if required.
18. Engine oil pressure zero or too low. Step 1. Check oil suction strainer for blockage or leakage. Clean or change strainer. Notify General Support.

Table 4-1. Direct Support Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
19. Engine oil consumption excessive. Step 1. Check rocker arm metering screws. Adjust. Step 2. Check fuel feed pump diaphragm. Replace diaphragm if required. Step 3. Check valve guides. Notify General Support. Step 4. Check piston/cylinders. Notify General Support.
20. Engine smokes white. Step 1. Check for defective injector. Clean or replace as necessary. Step 2. Check injector sealing washer. Replace if necessary. Step 3. Check fuel pump timing. Retime if necessary. Step 4. Check injector pump pressure. Test for serviceability; replace if required. Step 5. Check compression. Test for low compression.
21. Engine smokes blue. Step 1. Check valve guides. Notify General Support. Step 2. Check compression. Replace rings and piston if required.
22. Engine smokes black. Step 1. Check engine injector. Clean or replace injector. Step 2. Check fuel delivery (fuel timing). Adjust as required. Step 3. Check fuel quantity adjustment. Adjust as required. Step 4. Check engine compression. Notify General Support.

Table 4-1. Direct Support Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
23. Engine does not run smoothly. Step 1. Engine/compressor mounts broken or loose. Tighten or replace as required.
24. Engine overheats or backfires. Step 1. Fuel delivery wrong (fuel timing). Adjust as required.
25. No alternator output. Step 1. Check for defective regulator. Repair or replace regulator. Step 2. Inspect for defective brushes. Repair or replace brushes. Step 3. Check for open field diode. Replace diode. Step 4. Check for open rotor. Replace rotor.
26. Low alternator output. Step 1. Check for defective regulator. Replace regulator. Step 2. Inspect for worn brushes. Replace brushes. Step 3. Grounded/shorted rotor windings. Replace rotor. Step 4. Grounded/shorted stator windings. Replace stator. Step 5. Shorted/open rectifier diode. Replace diode.
27. Noisy alternator. Step 1. Loose drive pulley. Tighten pulley. Step 2. Cracked or damaged housing. Replace alternator. Step 3. Worn bearings. Replace bearings.

Table 4-1. Direct Support Troubleshooting Procedures (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
27. Noisy alternator (Contd). Step 4. Shorted rectifier diode. Replace diode. Step 5. Shorted or grounded stator windings. Replace stator.

Section II.
DIRECT SUPPORT MAINTENANCE

4-2 GENERAL. This chapter will describe maintenance to be performed on the engine and compressor assemblies beyond authorized capability of lower levels. This chapter contains maintenance at the Direct Support Level as authorized by the Maintenance Allocation Chart (MAC).

4-3 OPERATING PARAMETERS AND TOLERANCES. This section will contain an itemized list of manufacturer's sizes and tolerances desired for the K-20.

Table 4-2. General Engine Data

Item	Data
Type	F2L912
Total Piston Displacement	115 cu.in. (1885 cu. cm)
Working Cycle	Four-stroke diesel
Combustion System	Direct injection
Bore	3,937 in. (100 mm)
Stroke	4,724 in. (120 mm)
Weight of Engine	517 lbs (235 Kg)
Direction of Rotation (when facing flywheel)	CCW
Rated Speed (max)	2500 rpm
Idle Speed (min.)	750 to 800 rpm
Compression Ratio	17:1
Compression Pressure	294 to 412 psi (20 to 28 bar)
Valve Clearance	
Inlet	0.006 in. (0.15 mm)
Exhaust	0.006 in. (0.15 mm)
Firing Order	2-1
Timing Data Check (intake/exhaust valve	
clearance)	0.006 in. (0.15 mm)
Inlet Opens	320 30' BTDC
Inlet Closes	600 30' ABDC
Exhaust Opens	700 30' BBDC
Exhaust Closes	32° 30' ATDC
Piston Clearance from Cylinder Head	0.039 to 0.047 in. (1.0 to 1.2 mm)

Table 4-3. Fuel Injection System

Item	Data
Pressure for Testing Tightness of Relief Valve	2200 psi (150 bar) to 2050 psi (140 bar) permissible in one minute)
Min. Pressure that must be attained with the Injection Pump Element	4400 psi (300 bar) with about 5 rotations of crankshaft
Injection Nozzle	DLLA 149 S 774
Injection/Operating Pressure	2573 psi +118 psi (175 +8 bar)
Injection Pressure in New Condition	2646 psi +118 psi (180 +8 bar)

Table 4-4. Cylinder Head

Item	Dimension		Tolerance (min/max)	
	Inch	(mm)	Inch	(mm)
Valve Guide Outside Diameter	0.5906	(15.0)	+0.0018 +0.0022	+(0.45) +(.056)
Bore - Cylinder Head	0.5906	(15.0)	+0.004	+(.01 1)
Valve Guide'(pressed in) Inside Diameter	0.3150	(8.0)	+0.0006	+(.015)
Outside Diameter - Oversizes	0.6004	(15.25)	+0.0018	+(.045)
	0.6102	(15.50)	+0.0018	+(.045)
Bore in Cylinder Head - Oversizes	0.6004	(15.25)	+0.0004	+(.01 1)
	0.6102	(15.50)	+0.0004	+(.011)
Intake Valve Stem Diameter	0.3133	(7.96)	-0.0006	-(.015)
Exhaust Valve Stem Diameter	0.3126	(7.94)	-0.0008	-(.02)
Intake Valve Stem Clearance	0.0015	(.04)	-0.0028	-(.07)
Exhaust Valve Stem Clearance (Normal)	0.0118	(.03)	0	
Intake Valve Seat Outside Diameter (Nominal)	0.0023	(.06)	-0.0037	-(.095)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Intake Valve Seat Outside Diameter - Oversize (3 increments of .1 mm)	1.7976	(45.66)	-0.0008	-(.02)
Intake Valve Bore in Cylinder Head (Nominal)	1.7913	(45.5)	+0.0010	+(.025)
Exhaust Valve Seat Outside Diameter (Nominal)	1.5811	(40.16)	-0.0008	-(.02)
Exhaust Valve Seat Outside Diameter - Oversize (3 increments of .1 mm)			-0.0008	-(.02)
Exhaust Valve Seat Bore in Cylinder Head (Nominal)	1.5748	(40.0)	+0.0010	+(.025)
Valve Seat with Intake/Exhaust	0.0591	(1.5)	+0.0197	+(.5)
Valve Seat Intake Diameter	1.6929	(43.0)	±0.0039	±(.1)
Valve Seat Exhaust Diameter	1.4567	(37.0)	±0.0039	±(.1)
Seat Angle Intake and Exhaust	45°			
Rim Thickness:				
Intake	0.0394	(1.0)	-0.0079	-(.2)
Exhaust	0.0591	(1.5)	-0.0079	-(.2)
Wear Limit:				
Intake	0.0197	(.5)	0	
Exhaust	0.0197	(.5)	0	
Valve Recess (Intake and Exhaust)	0.1999	(5.078)	0	
Valve Recess Limit (Intake and Exhaust)	0.2237	(5.681)	0	
Cylinder Head Height				
With Shim	0.2520	(6.4)		
Without Shim	0.2480	(6.3)		
Valve Spring				
Total Windings	7			
Unloaded Length (normal)	2.3228	(59.0)	±0.0748	±(1.9)
Unloaded Length (fatigue limit)	2.2047	(56.0)		
Length of Cylinder Head Studs (nominal)	8.3071	(211)	±0.0197	±(.5)
Length of Cylinder Head Studs (Maximum)	8.3661	(212.5)	±0.0197	±(.5)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Cylinder				
Bore (normal)	3.9370	(100.0)	±0.0087	±(.022)
Bore (oversizes)	3.9567	(100.5)	±0.0087	±(.022)
Bore (wear limit)	0.0118	(0.3)	±0.0087	± (.022)
Piston				
Diameter (normal)	3.9335	(99.91)	±0.0004	±(.009)
Diameter (oversizes)	3.9532	(100.41)	±0.0004	±(.009)
Bore for Piston Pin	1.3780	(35.0)	+0.0002	+(.006)
Piston Pin Diameter	1.3780	(35.0)	0.0002	(.006)
Piston Ring Grooves Based on Diameter of:	3.8199	(97.0)	-0.0039	-(.10)
Width of First Groove	0.0868	(2.205)	+0.0047	+(.120)
	0.0868	(2.205)	+0.0039	+(.100)
Width of Second and Third Grooves	0.0984	(2.5)	+0.0043	+(.110)
	0.0984	(2.5)	+0.0035	+(.090)
Width of Scraper Ring Groove	0.1969	(5.0)	+0.0020	+(.050)
			+0.0012	+(.030)
Piston Rings				
Side Clearance - First Compression Ring	0.0031	(.079)	0.0048	(.119)
Clearance Limit	0.0197	(.5)		
Second Compression Ring	0.0039	(.10)	0.0052	(.132)
Clearance Limit	0.0118	(.30)		
Third Compression Ring	0.0039	(.10)	0.0052	(.132)
Clearance Limit	0.0118	(.30)		
Fourth Slotted Oil Ring	0.0016	(.04)	0.0028	(.072)
Clearance Limit	0.0059	(.15)		
Normal Gap, Compression Rings	0.0138	(.35)	0.0217	(.55)
Gap, Limit Value	0.1575	(4.0)		
Gap, Slotted Oil Control Rings (normal)	0.0098	(2.5)	0.0059	+(.15)
Gap, Limit Value	0.0098	(2.5)		
Connecting Rod				
Hole for Piston Pin Bushing	1.4961	(38.0)	0.0006	+(.016)
Outside Diameter	1.4980	(38.05)	0.0012	+(.030)
Inside Diameter (pressed in)	1.3795	(.04)	0.0018	+(.046)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Piston Pin Clearance in:				
Pin Bushing	0.0016	(.04)	0.0036	(.091)
Clearance Limit	0.0098	(.25)		

Table 4-5. Motion Parts

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Connecting Rod				
Bearing Bore	2.597	(64.0)	0.0008	(.019)
Bearing Shell; Nominal Inside Diameter	2.3622	(60.0)	0.0015	(.039)
Number of Undersizes	6			
Each Undersize	0.0098	(.25)		
Min. Inside Diameter	2.3032	(58.5)	0.0015	+(.039)
Nominal Wall Thickness	0.0785	1.995)	0.0002	±(.005)
Oversize Wall Thickness (6 increments, tolerances as for nominal size)	0.0098	(.25)	0.0079	-(.2)
Width of Bearing	1.3228	(33.6)	0.0032	-(.080)
Width of Connecting Rod	1.3228	(33.6)	0.0056	-(.142)
Connecting Rod Bearing Clearance				
Radial Clearance (normal)	0.0394	(.04)	0.0039	(.098)
Radial Clearance Limit Value (replacement governed by oil pressure)	0.0118	(.3)		
Side Clearance (normal)	0.0189	(.48)	0.0229	(.581)
Side Clearance Limit Value	0.0315	(.8)		
Idler Gear and Journals				
Bearing Bushing Internal Diameter (pressed in)	1.5748	(40.0)	0.0004 0.0010	+(.009) +(.025)
Journal Diameter	1.5748	(40.0)	0.0010	-(.025)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Journal Clearance in Bearing Bushing	0.0007	(.018)	0.0020	(.05)
Journal Clearance Maximum Limit Value	0.0079	(.2)		
Camshaft				
Side Clearance	0.0079	(.2)	0.0118	(.3)
Radial Clearance, Bearing Bushing	0.0012	(.03)	0.0043	(.109)
Radial Clearance, Crankcase Center	0.0024	(.06)	0.0054	(.136)
Radial Clearance, Crankcase Rear	0.0020	(.05)	0.0045	(.114)
Radial Clearance, Crankcase	0.0028	(.07)	0.0047	(.120)
Limit Value (replacement governed by oil pressure)	0.0079	(.2)		
Valve Cam Lift				
Inlet	0.3150	(8.0)		
Exhaust	0.3150	(8.0)		
Bearing Bushing, Nominal Internal Diameter	2.0461	(51.97)	0.0024	+(.06)
Crankshaft				
Crankpin Diameter (normal)	2.3606	(59.96)	0.0008	-(.019)
Number of Undersizes	6			
Each Undersize	0.0098	(.25)		
Hardness Normal - HRc	58	+.3		
Hardness Limit Value	50			
Shaft Journal for Crankshaft Bearing Diameter (normal)	2.4410	(62)	0.0004	-(.01)
	2.4410	(62)	0.0011	-(.029)
Number of Undersizes	6			
Each Undersize	0.0098	(.25)		
Length of Journal	1.3386	(34.0)	0.0015	(.039)
Hardness Normal - NRc	58.0		±3	
Hardness Limit Value	50.0			
Main Bearing				
Bore	2.6378	(67.0)	0.0008	+(.019)
Inside Diameter (normal)	2.4429	(62.05)	0.0017	+(.043)
Number of Undersizes	6			
Each Undersize	0.0098	(.25)		
Minimum Inside Diameter	2.3839	(60.55)	0.0017	+(.043)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Nominal Wall Thickness	0.0974	(2.474)	0.0002	±(.006)
Number of Oversizes	6			
Each Oversize	0.0049	(.125)		
Radial Clearance (normal)	0.0024	(.06)	0.0048	(.122)
Radial Clearance Limit Value (replacement governed by oil pressure)	0.0118	(.3)		
Journals for Crankshaft Center Thrust Bearing				
Nominal Diameter	2.7559	(70.0)	0.0004	-(.010)
	2.7559	(70.0)	0.0011	-(.029)
Number of Undersizes	6			
Each Undersize	0098	(.25)		
Minimum Diameter for Undersize Bearings	2.6969	(68.5)	0.0004	-(.010)
	2.6969	(68.5)	0.0011	-(.029)
Length of Journal	1.4567	(37.0)	0.0015	+(.039)
Radius of Fillet	0.1772	(4.5)	0.0079	-(.2)
Hardness Normal - HRc	58.0		±3	
Hardness Limit Value	50			
Crankshaft Thrust Bearing				
Diameter of Bore	2.9331	(74.5)	0.008	+(.019)
Number of Undersizes	6			
Each Undersize	0.0098	(.25)		
Inside Diameter (normal)	2.7575	(70.040)	0.0017	+(.043)
Nominal Wall Thickness	0.0884	(2.244)	0.0002	±(.005)
Number of Oversizes	6			
Each Oversize	0.0049	(.125)		
Radial Clearance (normal)	0.0020	(.05)	0.043	(.11)
Radial Clearance Limit Value (replacement governed by oil pressure)	0.0012	(.03)		
Bearing Width				
Outside Distance of Stop Rings	1.4508	(36.85)	0.0055	-(.139)
Thrust Half-Rings (blower side) Nominal				
Inside Diameter	3.1102	(79.0)	0.0118	+(.3)
Outside Diameter	3.7402	(95.0)	0.0014	-(.036)
	3.7402	(95.0)	0.0152	-(.386)

Table 4-4. Cylinder Head (Continued)

Item	Dimension		Tolerance (min./max.)	
	Inch	(mm)	Inch	(mm)
Thrust Half-Rings (flywheel side)				
Nominal				
Inside Diameter	3.1102	(79.0)	0.0118	+(.3)
Outside Diameter	4.0158	(102.0)	0.0014	-(.036)
	4.0158	(102.0)	0.0152	-(.386)
Stop Ring Thickness	0.1175	(2.985)	0.0020	-(.05)
Number of Oversizes	4			
Each Oversize	0.0098	(.25)		
Side Clearance (normal)	0.0004	(.011)	0.0113	(.288)
Side Clearance Limit Value	0.0158	(.4)		
Lubrication Oil Pump				
Engine Speed (rpm)	2500			
Pump Speed (rpm)	3125			
Delivery Rate ±10% at (80 psi ±7)				
5.5 ±.5 Bar 90°C (oil SAE 20,				
cycles per hour)	1380			
Side Clearance of Delivery Gears				
(normal)	0.0015	(.038)	0.0033	(.083)
Side Clearance of Delivery Gears				
Limit Value	0.0039	(.1)		
Distance Between Centers	3.2994	(83.804)		
Crankshaft Gear Backlash	0.0006	(.015)	0.0065	(.164)

Table 4-6. Lubrication Oil

Item	Operating Parameters
At Low Idling Min	(7.4 psi) .5 Bar
Safety Valve on Lube Oil Pump	(74 to 103 psi) 5 to 7 Bar
Bypass Valve on Filter Housing	(34 to 47 psi) 2.3 to 3.2 Bar
Pressure Control Valve on Front Cover	(74 psi) 5.0 Bar
Initial Oil Fill (engine)	6.50 qts (6.2 ltrs)
Refill 4.75 qts (4.5 ltrs)	
Initial Oil Fill (compressor)	4.20 qts (4.0 ltrs)
Refill 3.50 qts (3.3 ltrs)	

Table 4-7. Compressor Valve Tolerances

Component	Intake		Exhaust		Intake	Exhaust
	Min	Max	Min	Max		
	In. (mm)	In. (mm)	In. (mm)	In. (mm)	In. (mm)	In. (mm)
1st Stage Valve Spring	0.0551 (1.4) 0.2756 (7.0)	0.0591 (1.5) 0.3150 (8.0)	0.0512 (1.3) 1.6535(42.0)	0.0551 (1.4) 1.6535 (42.0)	0.8268 (21.0)	0.78 74 (20.0)
Number of Valve Plates (Type CD 35)		1		2		
2nd Stage Valve Spring	0.0394 (1.0) 0.3543 (9.0)	0.0492 (1.25) 0.4134 (10.5	0.0394 (1.0) 0.8268 (21.0)	0.0492 (1.25) 0.9449 (24.0)	0.4921 (12.5)	0.4921 (12.5)
3rd Stage Valve Spring	0.0315 (0.8) 0.3543 (9.0)	0.0413 (1.05) 0.4134 (10.5)	0.0315 (0.8) 0.8268 (21.0)	0.0413 (1.05) 0.9449 (24.0)	0.3150 (8.0)	0.3150 (8.0)
4th Stage Valve Seat Width	0.0351 (0.8) 0.0394 (1.0)	0.0422 (1.2) 0.0394 (1.0)	0.0354 (0.9)	0.0422 (1.2)	0.1575 (4.0)	0.1575 (4.0)
Valve Disc (groove depth)		0.0079 (.2)		0.0079 (.2)		
Valve Body (no grooves at ID)	0.6693 (17.0)	0.6693 (17.1)	0.6693 (17.1)			

Table 4-8. Compressor Tolerances

Component	Min.		Max	
	In.	(mm)	In.	(mm)
Connecting Rods on Crankshaft				
Axial Play	0.0158	(0.4)	0.0315	(0.8)
Radial Play of Bearings	0.0039	(1.0)	0.0787	(2.0)

Table 4-8. Compressor Tolerances (Continued)

Component	Min.		Max	
	In.	(mm)	In.	(mm)
Mounting Order/Center Distances of Bearing				
Third Stage			4.7244	(120.)
Fourth Stage			4.7244	(120.)
First Stage			5.7087	(145.)
Second Stage			6.6929	(170.)
Crankshaft Stroke			1.9685	(50.0)
Cylinder and Piston				
Fourth Stage				
Cylinder Bore			0.5512	(14.0)
Nominal Diameter				
First Stage			5.1181	(130)
Second Stage			2.3622	(60)
Third Stage			1.2598	(32)
Fourth Stage (guide cylinder and piston)			2.3622	(60)
Piston Diameter				
First Stage			4.7209	(119.91)
Second Stage			2.3602	(59.95)
Third Stage			1.2571	(31.93)
Fourth Stage			2.3598	(59.94)
Cylinder Diameter/Wear Limits				
First Stage			4.7291	(120.12)
Second Stage			2.3665	(60.11)
Third Stage			1.2602	(32.01)
Fourth Stage			2.3658	(60.09)
Wear Limit of Cylinder Bore				
First Stage			4.7315	(120.18)
Second Stage			2.3677	(60.14)
Third Stage			1.2614	32.04)
Fourth Stage			2.3673	(60.13)
Standard Clearance of Piston Cylinder				
First Stage			0.0083±0.0004	(.21 ±.01)
Second Stage			0.0063±0.0004	(.16±.01)
Third Stage			0.0032±0.0004	(.08±.01)
Fourth Stage			0.0059±0.0004	(.15±.01)

Table 4-8. Compressor Tolerances (Continued)

Component	Min.		Max	
	In.	(mm)	In.	(mm)
Piston Ring Gap				
First Stage	0.0256	(.065)	0.0315	(.80)
Second Stage	0.0138	(.35)	0.0197	(.50)
Third Stage	0.0004	(.01)	0.0098	(.25)

Table 4-9. Clutch Tolerances

Component	Tolerance	
	In.	(mm)
Clutch Support Flange Axial Play:		
Nominal Diameter	0.9843 (25.0) to 0.0005	(.013)
Limit	0.9803	(24.9)
Clutch Lining: Nominal Thickness	0.1969	(5.0)
Limit	0.1890	(4.8)
Clutch Drum: Nominal Thickness		
Limit	11.0158	(279.8)

4-4 GENERAL NOTES ON ENGINE REPAIR.

a. The front end of the engine is understood to be the end opposite the flywheel and the other engine faces are designated accordingly. Thus, cylinder number 1 is at the rear end (at the flywheel end). The cylinder numbers are applied to the crankcase, below the cylinder seating area. The sense of rotation of the engine is counterclockwise, when facing the flywheel.

b. The parts of the crankshaft assembly, timing gear, cylinders, pistons, and cylinder heads should be numbered in sequence unless they are already marked. The numbering should commence at the flywheel end.

c. For precision workmanship and repair, procedures should be performed in clean and neat surroundings. As the parts are dismantled, place them where they will not get damaged. Components that are subject to wear should be kept apart and should be individually gauged. If the low tolerances are exceeded, the components must be replaced or rectified. In any case, fit new gaskets, packing, and 0-seals.

d. Should bearing or pistons be damaged, the crankshaft and connecting rods should be inspected for cracks, if possible, by the magnaflux testing method. It is important that the cause of the damage be established. Testing, repairs, and/or reworking can be undertaken by the manufacturers or their appointed repair shops.

e. For the repair work to be carried out on the removed engine, mounting on a swiveling assembly stand, special fixture 003-0453 is recommended.

4-5 GENERAL NOTES ON COMPRESSOR REPAIR.

a. Normally, the valves should be cleaned every 750 to 800 operating hours.

b. Should the valves exhibit excessive wear and the valve seats are impaired, the valves must be replaced.

c. Always replace the valves as a set.

d. Observe the following instructions in valve maintenance.

1. Carefully clean the dirty valves. Never use a sharp tool for this purpose. Soak the valves in an ultrasonic cleaner and clean with a soft brush.

2. Observe the correct sequence when fitting together.

3. Check individual components for excessive wear. If the valve seat and valve discs are dented, replace the valves.

CAUTION

To avoid fatigue failure, the valves must be replaced every 2000 operating hours.

4. After completing all maintenance work on the valves, manually turn the compressor using the flywheel to ensure components have been correctly installed.

5. Check the valve space in the valve head for dirt; clean, if necessary.

6. Discard old gaskets and 0-rings. Insert new gaskets and 0-rings on reassembly.

4-6 LOWER CRANKCASE (TIMING BELT).

DESCRIPTION

This task covers: Repair.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Cloth, Lint-free, item 9 Appendix E
Detergent, item 13 Appendix E
Water, item 32 Appendix E

Equipment conditions:
System bled of pressure (paragraph 2-3).
Equipment secured (paragraph 2-11).
Battery disconnected.

Oil Pump Timing Belt Replacement.

a. Disassembly.

1. Remove the crankcase cover and belt tensioner. (Refer to paragraphs 3-17 and 3-18.)

2. Remove 4th stage head (refer to paragraph 4-8).

3. Remove the top (crankshaft) belt pulley from the crankshaft and remove the pulley and belt at the same time (shaft is 0-ring sealed so there will be some resistance).

4. Bring the 4th stage piston to top dead center (TDC).

5. Turn the lower belt pulley clockwise until the greatest resistance is felt (cam at its highest point on the oil pump roller).

6. Note the position of the holes in the crankshaft and the holes in the belt pulley and place the belt over the lower pulley and on the crankshaft at the same time.

NOTE

Ensure that the 4th stage piston is at TDC and the camshaft is at its highest resistance.

b. Reassembly.

1. Replace the two crankshaft bolts and torque to specs in Appendix F.
2. Replace tensioner and refer to paragraph 3-18. Torque bolts; refer to Appendix F.
3. Replace crankshaft cover (refer to paragraph 3-17).
4. Replace 4th stage head (refer to paragraph 4-8).
5. Perform operational checks and run unit to operating temperature.
6. Check oil pressure and adjust if needed (refer to paragraph 3-16).
7. Soap test all fittings.

4-7 CYLINDER BLOCK ASSEMBLY; ALL STAGES (COMPRESSOR).

DESCRIPTION

This task covers: Inspect. Replace. Repair.

INITIAL SETUP

Tools:
- Cylinder meter
- Micrometer
- Feeler gauge
- Piston ring compressor

Equipment conditions:
- Applicable valve head removed (paragraph 4-8).

Materials/parts:
- Circlip
- Alcohol, Isopropyl, item 1 Appendix E
- Apron, Rubber, item 4 Appendix E
- Bag, Plastic, item 6 Appendix E
- Cloth, Lint-free, item 9 Appendix E
- Detergent, item 13 Appendix E
- Gloves, Rubber, item 17 Appendix E
- Grease, Halo Carbon, item 19 Appendix E
- Oil, Lubrication, item 22 Appendix E
- Shield, Face, item 27 Appendix E
- Trisodium Phosphate, item 31 Appendix E
- Water, Distilled, item 32 Appendix E

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

REPLACE REPAIR

a. Removal/Installation 1st Stage Cylinder and Piston.

1. Place piston at bottom dead center (BDC).
2. Carefully lift off cylinders taking care not to damage piston or rings. Remove and discard 0-ring.
3. Remove piston from connecting rod by first removing circlip and piston pin.
4. Install piston on connecting rod and insert piston pin with a new circlip.
5. Install new 0-ring and, using a ring compressor, install the cylinder sleeve over the piston.
6. Set piston to top center. Lubricate sufficiently with oil and check that the piston ring gaps are in correct position. Use the piston ring compressor and install the cylinder.
7. The crown of the piston at TDC must be flush with the top surface of the cylinder with cylinder head gasket removed.
8. Reinstall first stage head assembly; refer to paragraph 48.

b. Removal/Installation, 2nd and 3rd Stage Cylinder and Piston.

1. Place piston at bottom dead center.
2. Remove the four cylinder retaining nuts and washers, and pull off the cylinder. Remove and discard 0-ring.
3. Remove piston from connecting rod by first removing circlip and piston pin.
4. Install piston on connecting rod and insert piston pin with new circlips.
5. Install new 0-ring and, using a ring compressor, install the cylinder sleeve near the piston.

6. Install the four nuts and washers. Torque nuts; refer to Appendix F.

7. Reinstall head assembly (refer to paragraph 4-8).

c. Removal / Installation 4th Stage Cylinder and Piston.

1. Remove the three oil pump regulator fittings.

2. Remove the four cylinder retaining nuts and washers.

3. Remove the entire cylinder from the float piston, being careful not to drop the 4th stage piston (place thumb over the piston hole to hold in place). Remove 0-ring and discard.

NOTE

Fourth stage piston and cylinder sleeve are replaced as a matched set.

4. Remove floating piston by removing the circlips and piston pin.

5. Reinstall float piston and piston pin onto connecting rod using new circlips.

6. Install new 0-ring on the cylinder sleeve.

d. Piston Rings (1st, 2nd and 3rd Stage Pistons).

1. Remove rings from piston with a ring expander.

2. Clean rings and pistons.

3. Replace rings as required.

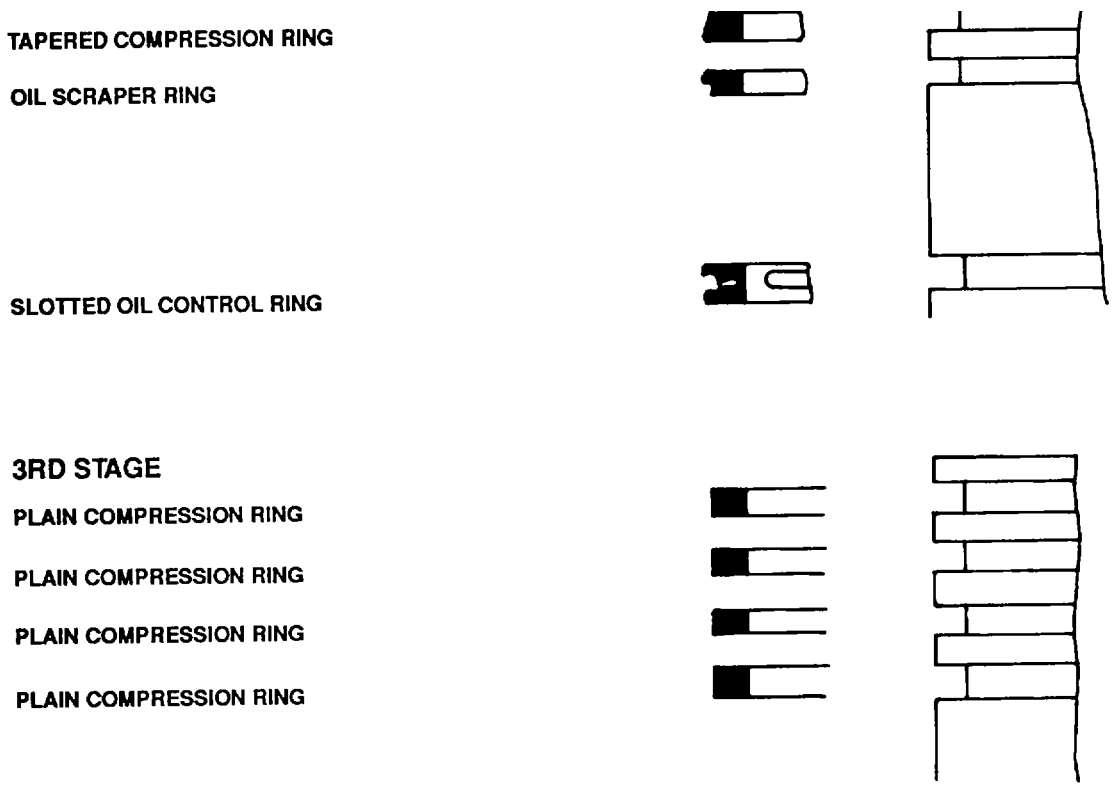
4. Install piston ring into the cylinder about 3/4-1 inch (20 mm) and square with piston head. Measure ring end gap. Refer to table 4-8.

5. Measure the piston ring groove clearance. Refer to table 4-8.

6. Install piston rings onto piston using a ring expander. Refer to figure 4-1 for correct ring location. Stagger ring gaps equally.

INSPECT

a. Measuring Cylinders.



NOTE

The cylinders of all stages cannot be rebored. After having cleaned the cylinder, check visually for wear (scoring). If the wear is too severe, replace the cylinder. Cylinders with normal wear should be measured before being refitted.

Figure 4-1. Piston Ring Sets

NOTE

The cylinders of all stages cannot be rebored. After having cleaned the cylinder, check visually for wear (scoring). If the wear is too severe, replace the cylinder. Cylinders with normal wear should be measured before being refitted.

1. Measuring procedure: a) adjust cylinder meter (figure 4-2), b) Measure cylinder, c) determine the measuring points (figure 4-3) and compare with table 4-8.

2. Cylinder measuring points: measure at four points in longitudinal direction A and four points at 90 degrees to the longitudinal direction of the crankshaft B (figure 4-3).

NOTE

The high-pressure stage can only be measured with special measuring instruments.

Figure 4-2. Installing Cylinder Meter

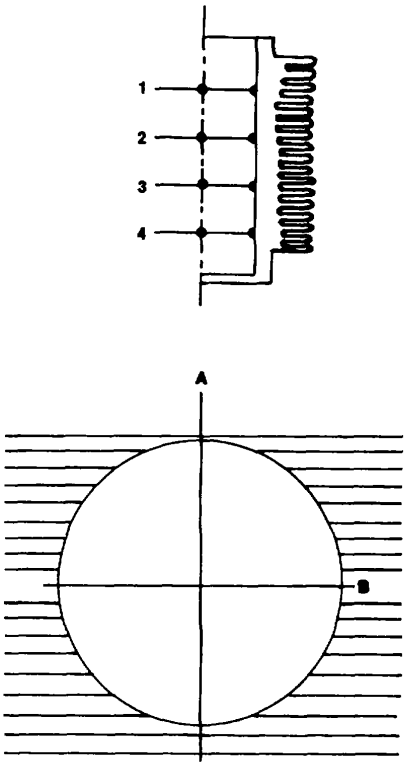


Figure 4-3. Measuring Cylinder

4-8 VALVE HEAD ASSEMBLY (1ST, 2ND, 3RD, AND 4TH STAGES) (COMPRESSOR).

DESCRIPTION

This task covers: Inspect. Replace. Repair.

INITIAL SETUP

Tools:
- General Mechanics Tool Kit
- Lapping Plate
- Torque Wrench

Materials/parts:
- Alcohol, Isopropyl, item 1 Appendix E
- Apron, Rubber, item 5 Appendix E
- Bag, Plastic, item 6 Appendix E
- Cloth, Lint-free, item 9 Appendix E
- Compound, Lapping and Grinding, item 10 Appendix E
- Detergent, Non-ionic, item 13 Appendix E
- Gloves, Rubber, item 17 Appendix E
- Grease, Halo Carbon, item 19 Appendix E
- Shield, Face, item 27 Appendix E
- Trisodium Phosphate, item 31 Appendix E
- Water, Distilled, item 32 Appendix E

Equipment conditions:
1. Equipment secured (paragraph 2-11).
2. Bleed system pressure (paragraph 2-3, b).

INSPECT

a. Changing valves of the 1st stage. Refer to figure 4-4.

1. Remove acorn nut (1).
2. Screw out stud (2) a number of turns (until loose).
3. Remove and discard gasket (3) if necessary.
4. Remove valve cover nuts (4), washers (5), and valve cover (6).
5. Remove and discard 0-ring (7).
6. Take off valve cap (8) and extract the valve (9).

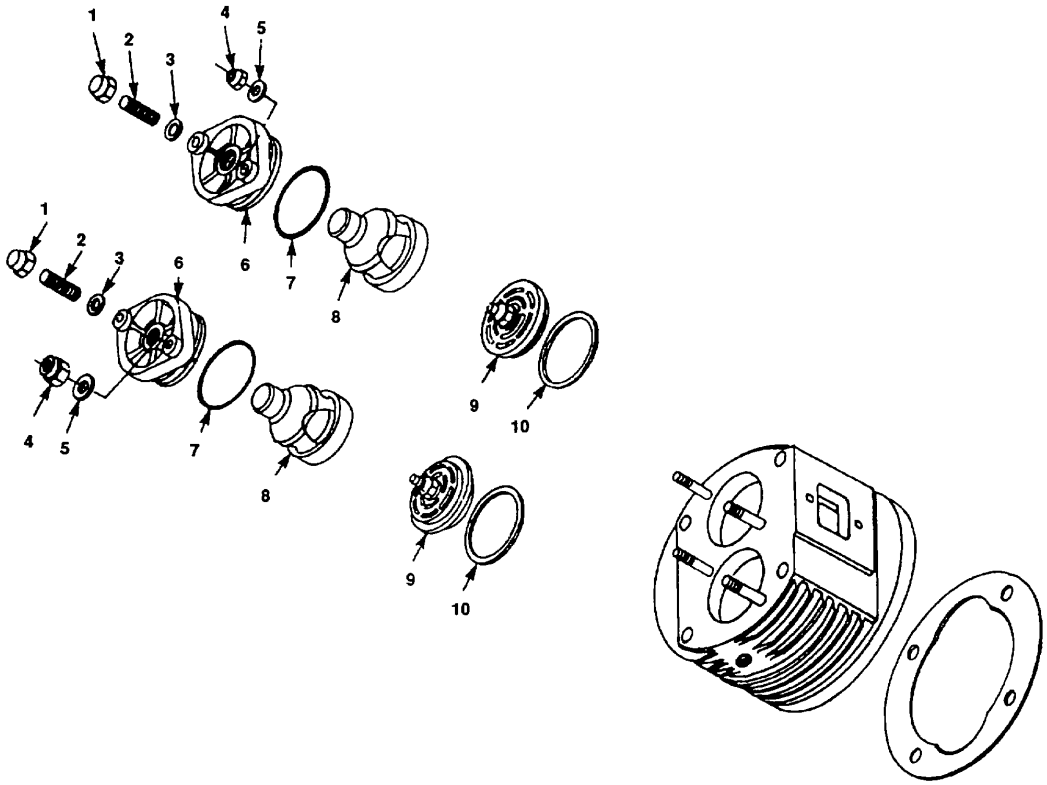


Figure 4-4. Valve Head, 1st Stage

7. Remove and discard valve gasket (10).

REPLACE REPAIR

1. Install new valve (9) with gasket (10) and locate valve cap (8).
2. Install valve cover (6) with new 0-ring (7) and fasten with self retaining nuts (4) and washers (5).
3. Tighten retaining nuts to 33 lb-ft (45 Nm) torque. Install new gasket (3) over studs.
4. Tighten stud (2) to 18 lb-ft using allen key and screw on cap nut (1).

INSPECT

b. Changing the valves of 2nd and 3rd stage. Refer to figure 4-5.

1. Loosen and remove the hex head nuts (1) and washers (2); remove cap holder (3).
2. Insert two screwdrivers into the groove of the valve cap (5) and lift off valve cap with 0-ring (4).
3. Check 0-ring (4) and replace, if required.
4. Withdraw valve (6); remove gasket (7) and discard.
5. Check valve (6) and replace, if required.

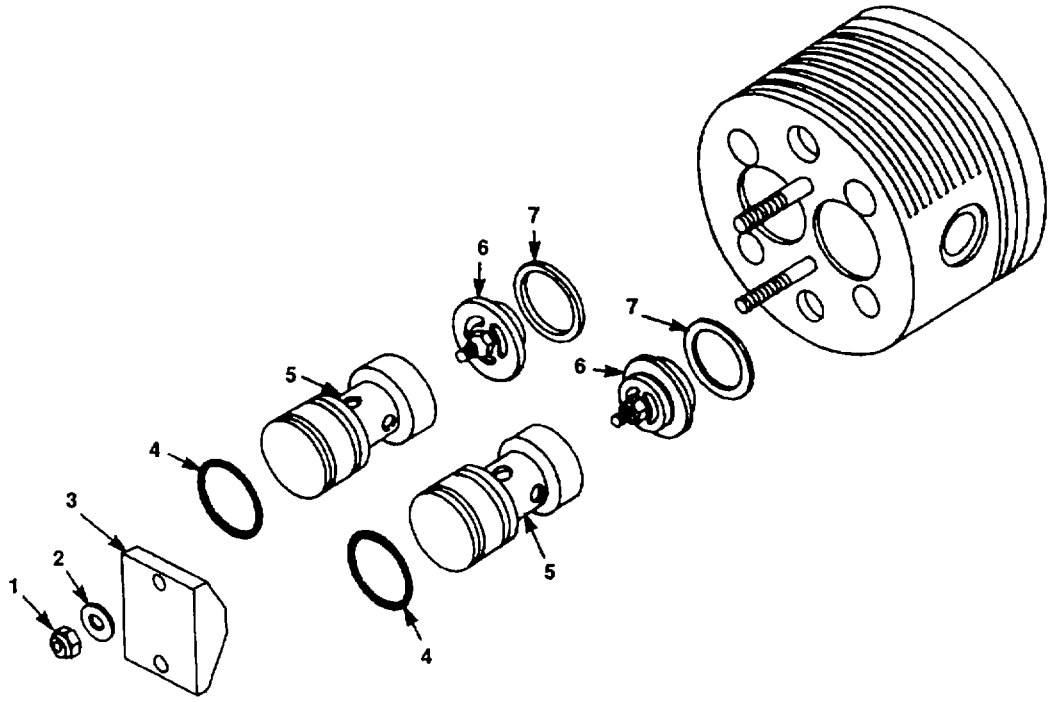


Figure 4-5. Valve Head, 2nd and 3rd Stage

REPLACE REPAIR

CAUTION

Do not interchange inlet and discharge valve caps. The valve cap of the inlet valve protrudes 2.5 mm (.098-in.) out of the valve head more than the valve cap for **the discharge valve (cap holder is designed accordingly).**

1. Install new valve (6) with gasket (7) and place valve cap (5) with 0-ring (4) into head.

2. Install the cap holder (3), washers (2), and nuts (1). Tighten nuts to 33 lb-ft (45 Nm).

INSPECT

c. Changing the valves of the 4th stage. Refer to figure 4-6.

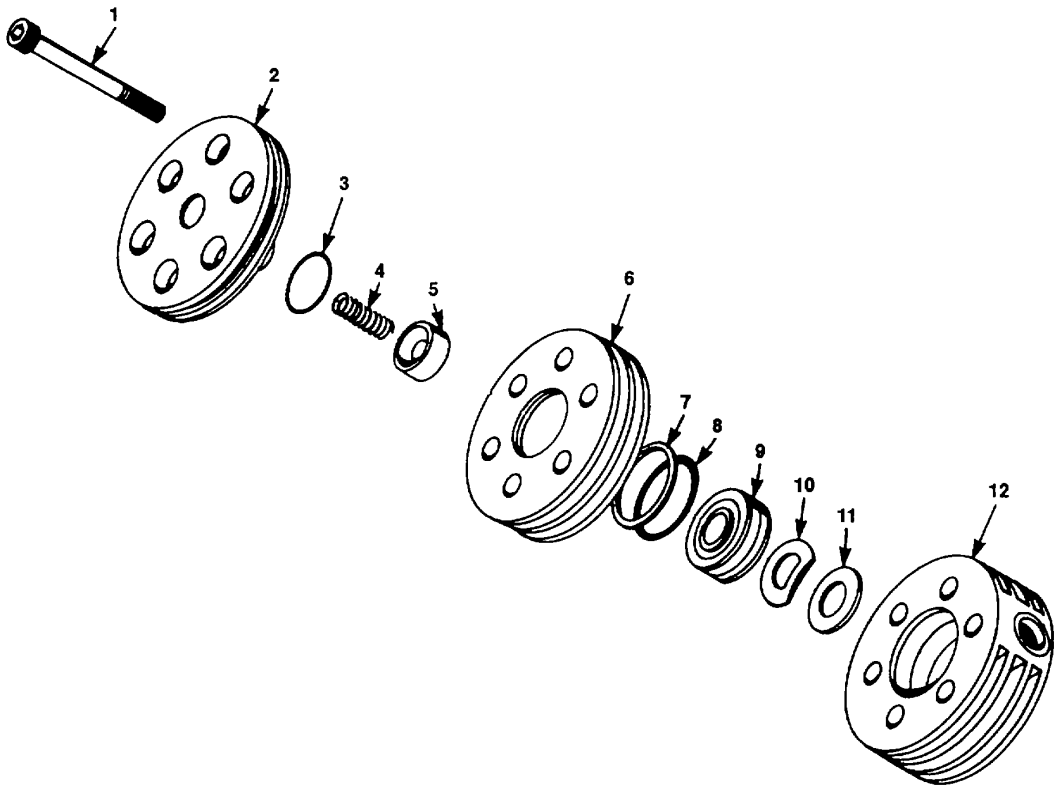


Figure 4-6. Valve Head, 4th Stage

NOTE

The valves of the 4th stage are located in the valve head of the 4th stage. The inlet valve includes a valve disc and a Wavy washer. The inlet valve seat is machined directly into the cylinder liner of the 4th stage piston. The discharge valve includes the valve seat, valve disc, valve spring, and stroke limiter.

The valve head includes the bottom section and the upper section. The valve head is secured by means of valve head screw connecting the cylinder.

d. Head Removal (1st Stage).

1. Loosen six bolts to remove fan guard.
2. Remove 1st stage head oiler and pressure line.
3. Remove cooling fan guard (see paragraph 4-9, a and b).
4. Remove the four head nuts and remove head and head gasket.

WARNING

Valve pieces may fall out when removing the 4th stage head.

e. Head Removal (2nd, 3rd, and 4th Stage).

1. Remove intake and exhaust lines.
2. Remove the six allen head bolts.
3. Remove the head.

f. Head Reassembly (1st Stage).

1. Place new gasket on cylinder and install the head.
2. Tighten the four head nuts in accordance with Appendix F and in torque sequence as listed in figure 4-7.

g. Head Reassembly (2nd, 3rd, and 4th Stages).

1. Place head on cylinder and install allen head nuts.

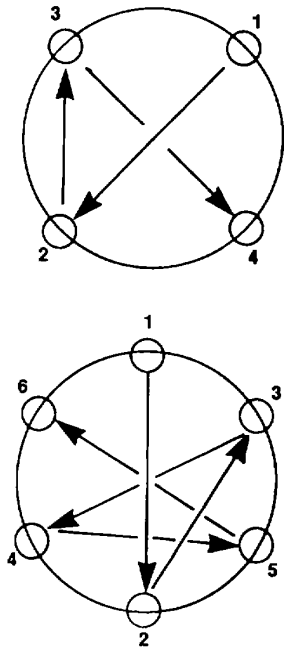


Figure 4-7. Valve Head Tightening Sequence

2. Tighten nuts in accordance with Appendix F and figure 4-7.

1st Stage Intercooler (2, figure 4-8).

a. Removal.

1. Remove intercooler tube from 1st stage head.
2. Remove intercooler tube from 2nd stage head (at U-bent pipe).
3. Remove the eight mounting brackets from the outer part of the intercooler ring.
4. Remove intercooler.

b. Install.

1. Place intercooler in place and loosely fit the mounting brackets in place.
2. Finger-tighten both the 2nd stage head fitting and the 1st stage head fitting.

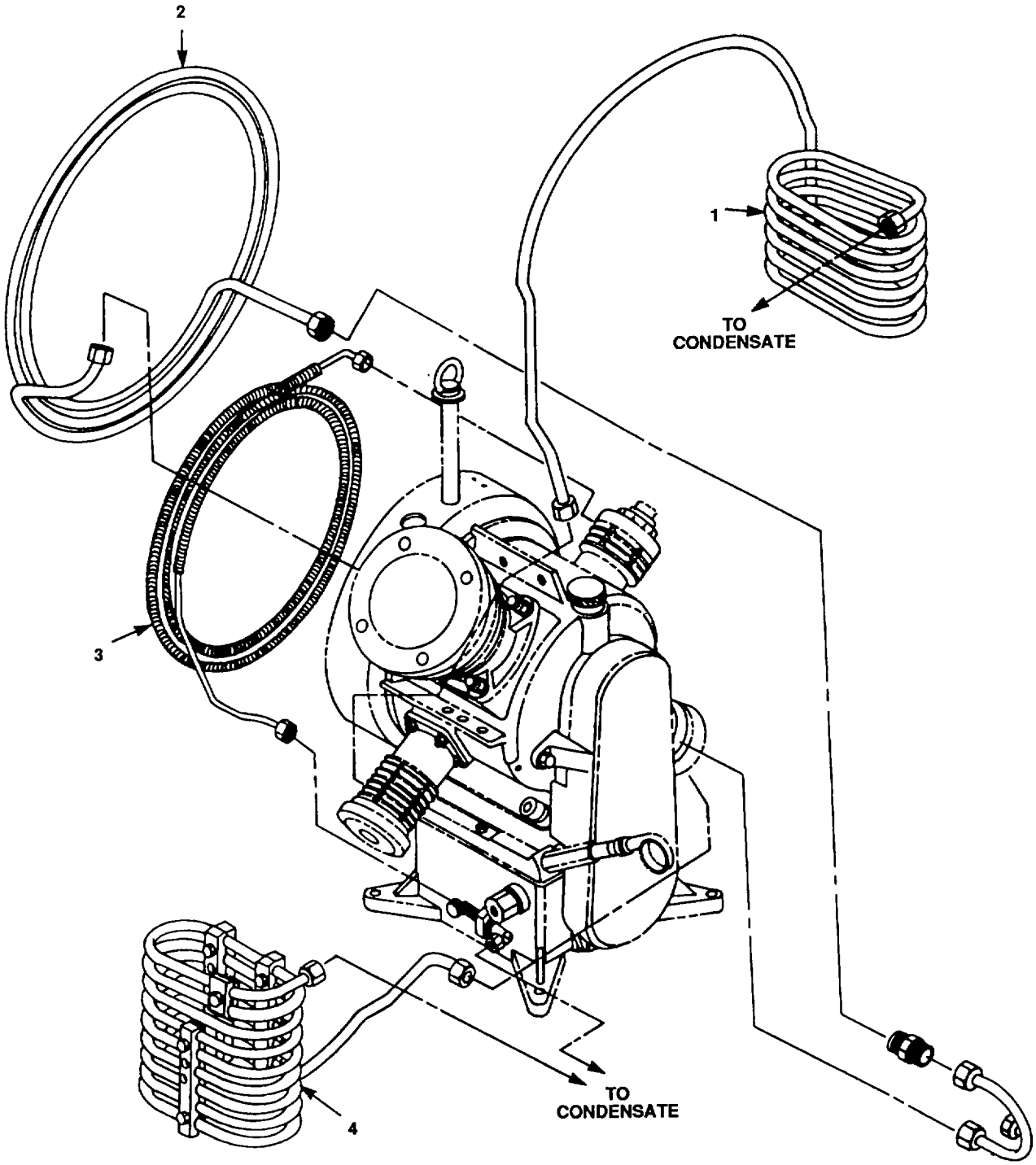


Figure 4-8. Cooling System Components

3. Tighten the mounting brackets in place ensuring that the blank spacers are in the correct position.
4. Tighten the 2nd stage head fitting and the 1 st stage head fitting securely.
5. Reinstall flywheel/cooling fan (paragraph 4-9); reinstall belt guard (paragraph 3-16).
6. Soap test.

2nd Stage Intercooler (4, figure 4-8).

a. Removal.

1. Remove intercooler tube fitting from 2nd stage head (exhaust side AUS).
2. Remove the tube that goes from the top of the 2nd condensate drain block to the third stage intake side of the head.
3. Remove the tube that goes from the back of the 2nd condensate drain block to the top of the cooling coils.
4. Remove the lower mounting bracket from each cooling ring on the front of the compressor.
5. Remove the four mounting allen head bolts and nuts from inside the cooling coil assembly.
6. Carefully remove the 2nd stage cooler.

b. Install.

1. Carefully insert the intercooler between the 1st and 2nd stage cylinders.
2. Finger-tighten the tube fitting on the 2nd stage head.
3. Tighten the four allen head bolts and nuts.
4. Reinstall the tubing that goes from the top of the 2nd stage condensate block to the 3rd stage intake and tighten.
5. Reinstall the tubing that goes from the back of the 2nd stage condensate drain block to the top of the 2nd stage cooling coils.
6. Tighten the 2nd stage exhaust side fitting.

7. Reinstall flywheel/cooling fan (paragraph 49); reinstall belt guard (paragraph 3-16).
8. Soap test.

3rd Stage Intercooler (1, figure 4-8).

a. Removal.

1. Remove the oil pressure line from the oil pump to the oil regulator.
2. Remove tube fitting from 4th stage intake side and 3rd stage exhaust side.
3. Remove the two mounting brackets at the top of the cooling coils.
4. Remove the fitting at the top of the 3rd stage cooling coil.
5. Remove the four nuts that secure the cooling coil to the compressor mounting bracket.
6. Carefully remove the cooling coil.

b. Install.

1. Install the 3rd stage cooler and hand-tighten the 3rd stage head filter.
2. Hand-tighten the fitting at the top of the cooler.
3. Tighten the four nuts to the compressor mounting bracket.
4. Reinstall the mounting bracket on the front of the compressor.
5. Reinstall the oil pump pressure line.
6. Reinstall flywheel/cooling fan (paragraph 4-9); reinstall belt guard (paragraph 3-16).

NOTE
Oil pump bleeding may be necessary.

7. Leak test.

4th Stage Intercooler (3, figure 4-8).

a. Removal.

1. Remove the fitting on the 4th stage exhaust side.
2. Remove fitting at the base of the block that connects the after cooler to the condensate drain.
3. Remove five mounting brackets that hold the after cooler in place on the cooling ring.
4. Remove 4th stage cooler carefully.

b. Install.

1. Install cooler in place and finger-tighten fittings.
2. Install mounting brackets and tighten.
3. Tighten fittings.
4. Reinstall flywheel/cooling fan (paragraph 4-9); reinstall belt guard (paragraph 3-16).
5. Leak test.

4-9 FLYWHEEL/COOLING FAN (COMPRESSOR).

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
General Mechanics Tool Kit

Materials/Parts:
None

Equipment conditions:
Equipment secured (paragraph 2-11).
Bleed system of pressure (paragraph 2-3,b).
Belt guard removed (paragraph 3-16).

Flywheel/Cooling Fan.

REPLACE REPAIR

a. Loosen idler pulley and remove V-belts.

b. Loosen screws and washers, and remove cooling fan guard (3, figure 4-9).

c. Remove hex screw (5) and washers (6 and 7). Remove pulley (8).

d. Remove and replace individual fan wings as required.

e. Replace pulley (8). Replace washers (6 and 7) and hex screws (5).

f. Replace cooling fan guard (3). Replace washers and tighten screws.

g. Replace V-belts. Tighten idler pulley.

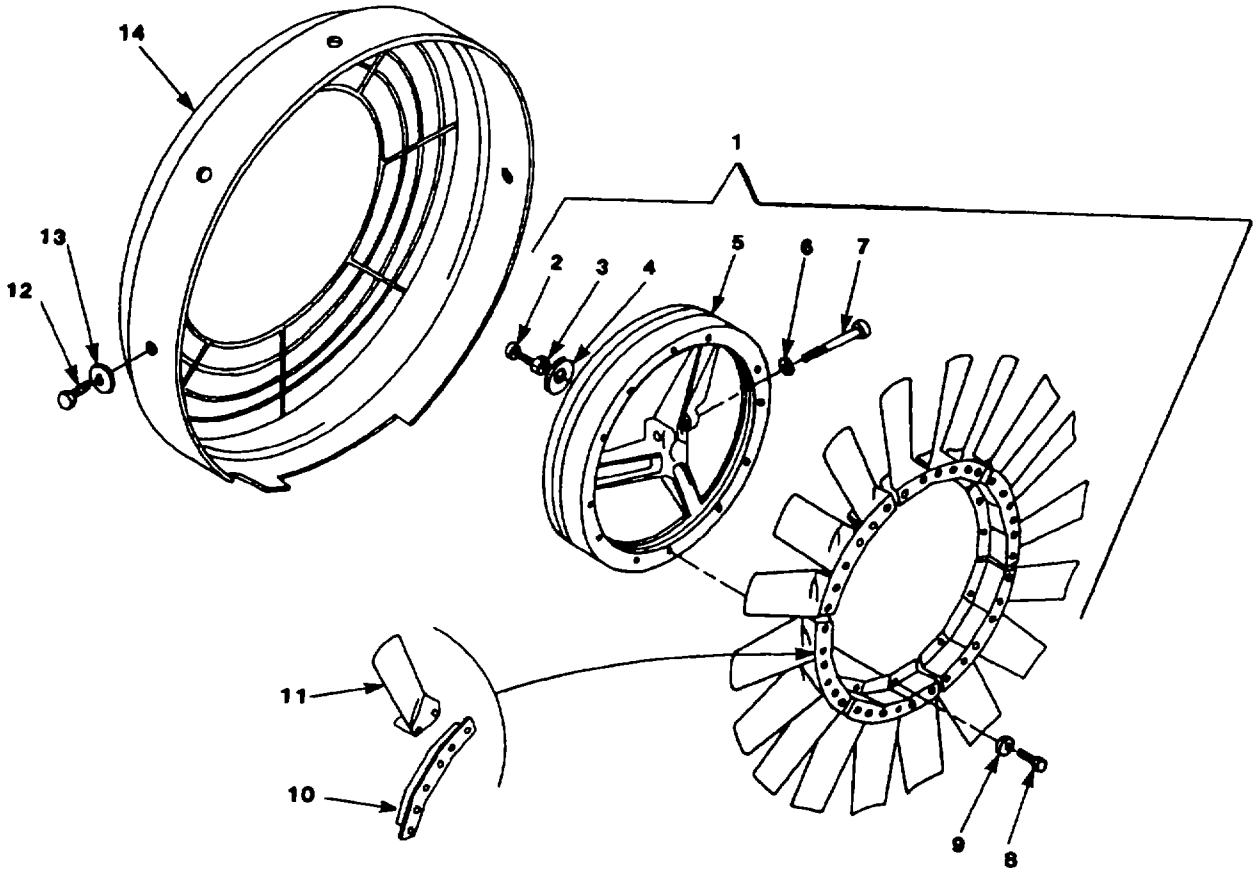


Figure 4-9. Flywheel / cooling Fan

4-10 OIL LUBRICATING SYSTEM (COMPRESSOR).

DESCRIPTION

This task covers: Replace, Repair

INITIAL SETUP

Tools:
General Mechanics Tool Kit

Materials/parts:
Oil
Oil Container
Cloth, Lint-free, item 9 Appendix E

Equipment conditions:
Equipment secured (paragraph 2-11).
Drain oil from system (paragraph 3-20, figure 3-10).

REPLACE REPAIR

WARNING

Cleanliness is imperative in maintaining and handling diving system components. An tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

a. Lube oil pump. (Figure 4-10).

1. Loosen tube connection (5) to separate oil supply tube from lube oil pump (6).
2. Place suitable oil catch container beneath oil supply tube. Remove allen screws (4) and washers (3) that secure oil pump to compressor.

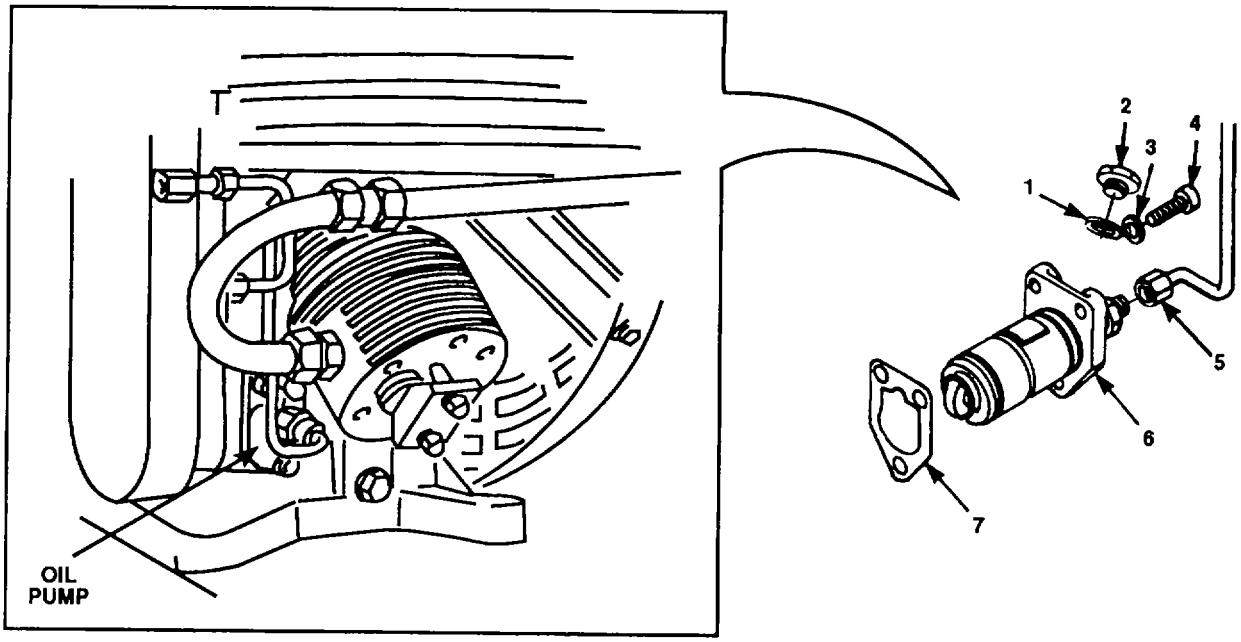


Figure 4-10. Lube Oil Pump

3. Remove oil pump and clean.
4. Replace if required.
5. Remove and discard gasket (7).
6. Ensure that a new gasket has been installed.
7. Ensure oil pump is replaced.
8. Secure oil pump to compressor. Replace washers (3) and alien screws (4).
9. Replace oil supply tube (5) to lube oil pump (6).
10. Replenish oil before starting the compressor.

b. Oil pressure regulating valve. (Refer to figure 4-11).

1. Remove pressure connections (1, 19, and 20) to oil pressure regulating valve (10).
2. Remove retaining screws (11).
3. Remove oil pressure regulating valve and replace with identical unit.

4. Reinstall screws (11)
5. Reconnect pressure lines (1, 19, and 20) to oil pressure regulating valve.
6. Tighten all pressure line connections, then tighten screws.

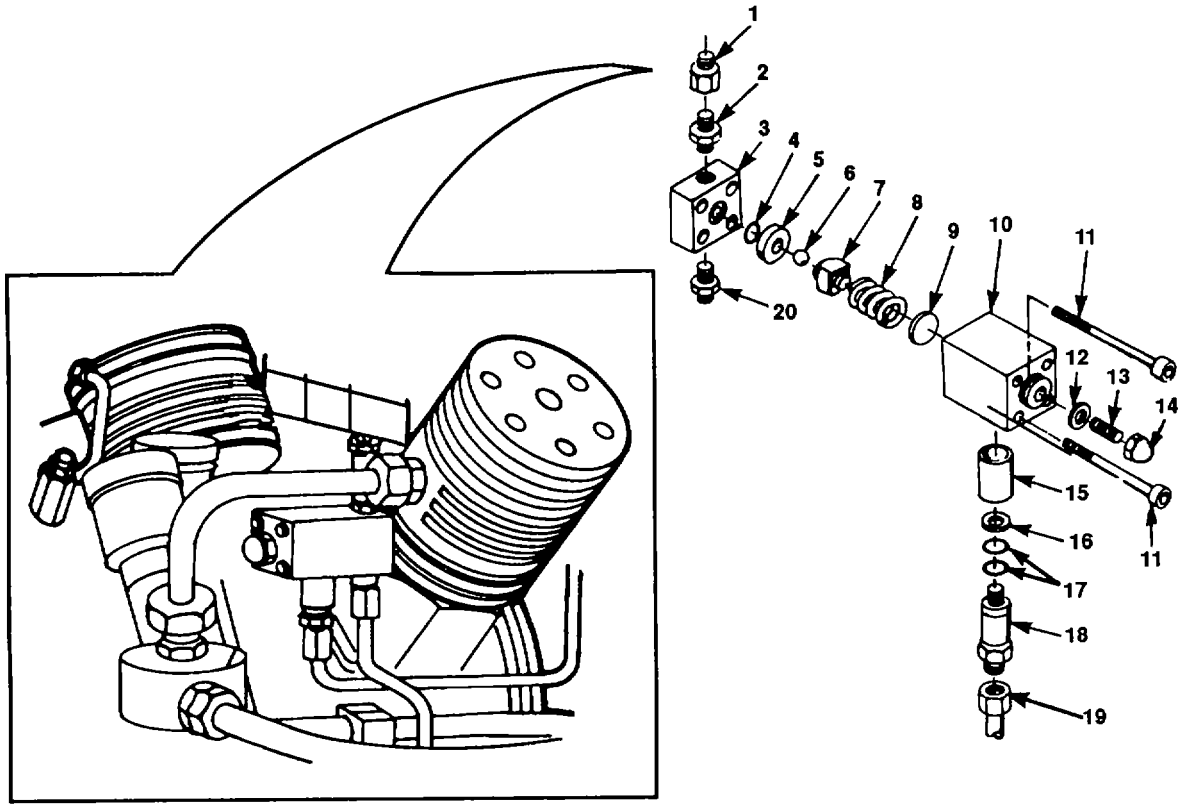


Figure 4-11. Oil Pressure Regulating Valve

4-11 ENGINE.

DESCRIPTION

This task covers: Replace.

INITIAL SETUP

Tools:
General Mechanics Tool Kit
Hand-held Tachometer

Equipment conditions:
Engine secured (paragraph 2-11).

Materials/parts:
None

REPLACE

a. Frame and Vibration Mounts.

1. The outer and inner frames are welded; therefore, no disassembly is required.
2. Vibration Mounts (figure 4-12).

a) There are three sets of two vibration mounts between the engine frame and the K-20 frame. Between the compressor(K180) and the K-20frame, there are two sets of two vibration mounts.

b) Replace if the vibration mounts show signs of cracking, drying, or wear.

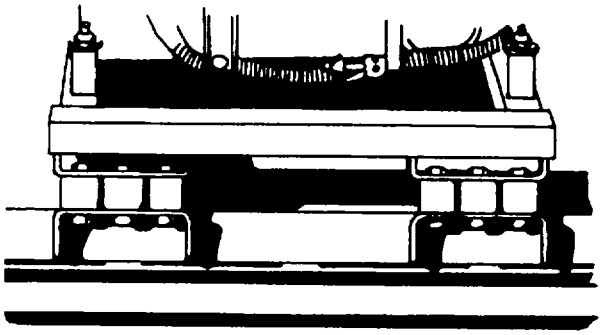


Figure 4-12. Vibration Mounts

3. Using two open end wrenches, loosen and remove the hex nuts and washers.
4. Remove bolts, washers, and vibration mounts.
5. Renew, as required.
6. Replace vibration mounts and washers. Secure with bolts. Tighten hex nuts.

b. Engine.

1. Remove electrical connections to starter motor and alternator.
2. Engage clutch from engine using toggle lever. Remove PTO clutch from engine (paragraph 4-23).
3. Remove V-belts.
4. Remove speed control/throttle cable.
5. Remove fuel supply and return line connection to fuel feed pump (paragraph 3-27).
6. Drain oil (paragraph 3-21).
7. Remove cold start aid connection from #1 cylinder (paragraph 3-37).
8. Remove oil bath air cleaner from the intake manifold (paragraph 3-31).
9. Remove muffler and spark arrestor from exhaust manifold (paragraph 3-36).
10. Remove oil pressure line from engine.

WARNING

To prevent injury to personnel, attach a suitable lifting device to the engine, as it weighs 650 lbs.

11. Attach lifting device to engine.
12. Loosen and remove bolts that secure engine to frame.
13. Attach suitable lifting device to engine, as it weighs 650 lbs.
14. Remove and replace engine.

15. Mount engine in place to inner frame.
16. Align the pulleys between the compressor and engine. Check for parallel or angular alignment.
17. Fasten the PTO clutch housing to engine (paragraph 4-23).
18. Replace V-belts.
19. Reinstall muffler and spark arrestor onto exhaust manifold (paragraph 3-36).
20. Reinstall oil bath air cleaner to intake manifold (paragraph 3-31).
21. Reattach cold start aid to the intake manifold.
22. Reinstall speed control/throttle cable.
23. Replace fuel line connection to fuel feed pump (paragraph 3-27).
24. Replace electrical connections.
25. Refill oil to proper level (paragraph 3-21).
26. Remove any slack in bolts remaining between engine and vibration mounts.

c. Speed Control/Throttle (figure 4-13).

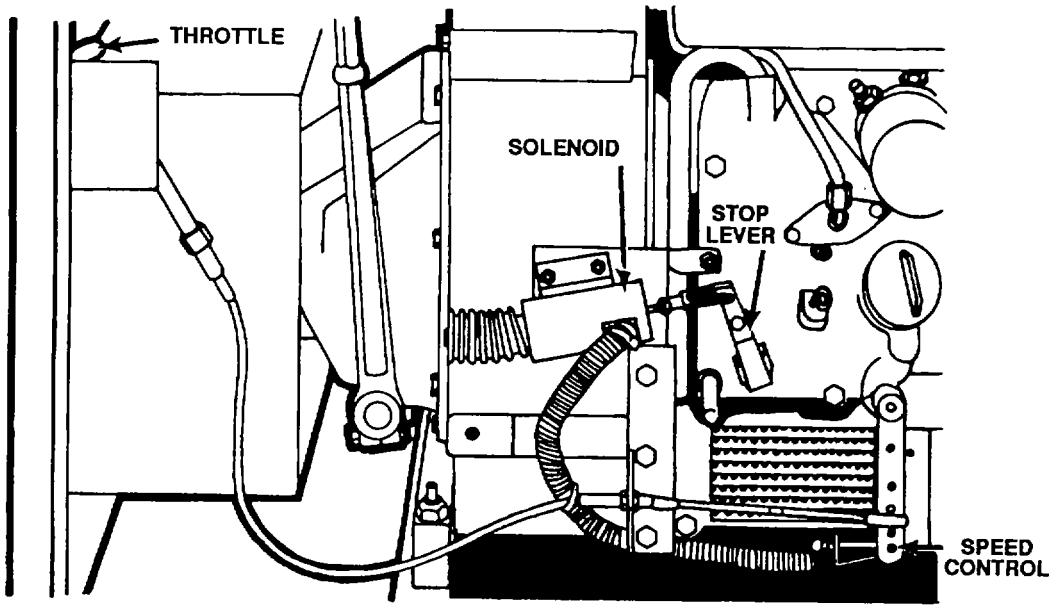


Figure 4-13. Stop Lever/Solenoid Speed Control/Throttle

1. Remove throttle linkage from speed control lever.
2. Remove throttle from frame.
3. Replace defective or worn components.
4. Reattach linkage to speed control lever.
5. Attach throttle control to frame.
6. Adjust idle speed at 900 to 1000.
7. Adjust full speed at 2100 to 2300.

4-12 CYLINDERS (ENGINE)

DESCRIPTION

This task covers: Replace, Repair

INITIAL SETUP

Tools:
General Mechanics Tool Kit
Piston ring compressor (003-0430)
Precision gauge

Equipment conditions:
Cylinder head removed (paragraph 4-15).

Materials/parts:
Wood, oil, lint-free rags
Cloth, Lint-free, item 9 Appendix E
Oil, Engine Lubrication, item 24 Appendix E

REPLACE REPAIR

a. Position the piston at Bottom Dead Center (BDC).

NOTE

Do not knock the piston against the crankcase or connecting rod. Remove the shims from the cylinder.

b. Remove the cylinder (figure 4-14), taking care not to damage piston skirt.

Figure 4-14. Removing the Cylinder

c. Check the joint surface for the cylinder on the crankcase.

d. The cylinder joint surface must be level and free from indentations. If necessary, dismantle the adjacent cylinder and baffle plate.

e. Adhere to cylinder by means of grease at least one shim of 0.008 inch (0.2 mm) thickness.

f. Place the piston on two wooden slats. Oil the working face of the cylinder and the piston. Position the rings so that their gaps are equally spaced around the piston.

g. Mount and tension the piston ring compressor No. 003-0430.

h. Install the cylinder with the cutouts facing the push rod bores (figure 4-15).

i. Bring the cylinder into alignment with the adjacent cylinders.

j. Inspect cylinder for defects. If necessary, replace complete with piston.

k. Set bore gauge (figure 4-16) to the basic standard or oversize bore (see specification data in table 4-4).

1. Measure cylinder bore at levels 1 to 4 of engine centerline as well as crossline b (figure 4-17).

m. Compare readings with the specification data in table 4-4. if the wear limits are reached, replace the parts concerned. Pistons and cylinders are available in two oversizes.

n. Check that cylinder top and bottom joint faces are flat.

Follow on maintenance: Replace cylinder heads (paragraph 4-15).

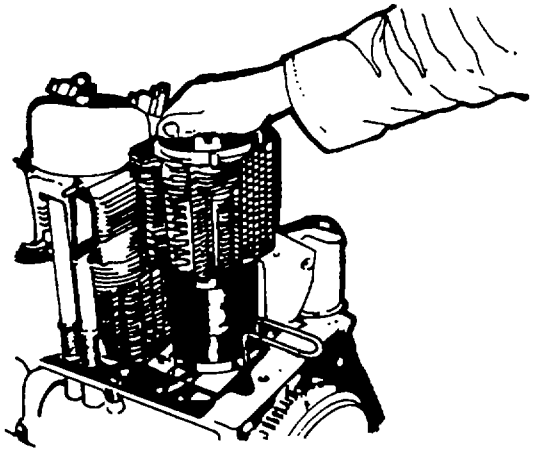


Figure 4-15. Correct Installation of Cylinder

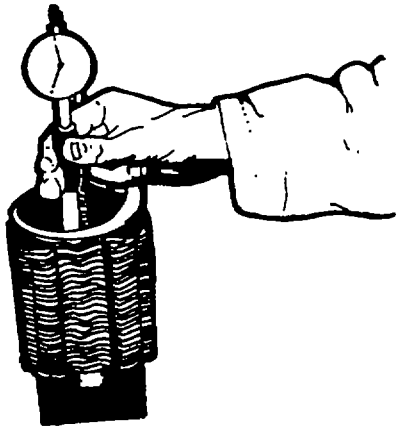


Figure 4-16. Setting the Bore Gauge

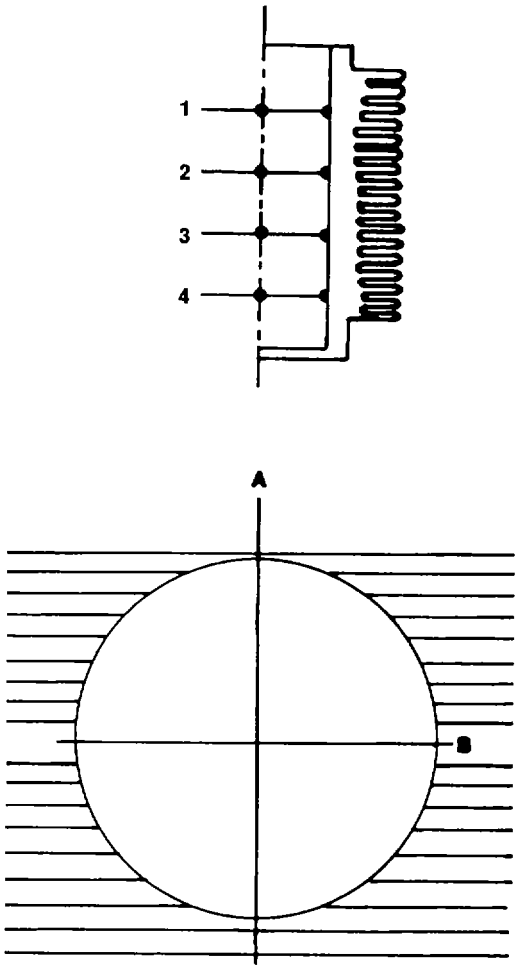


Figure 4-17. Measuring the Cylinder Bore

4-13 CONNECTING ROD (ENGINE).

DESCRIPTION

This task covers: Inspect, Replace, Repair

INITIAL SETUP

Tools:
Fixture (003-1079)
Micrometer
Torque Wrench

Equipment conditions:
Piston removed (paragraph 4-14).
Fuel injection pump removed (paragraph 4-18)

Materials/parts:
Cloth, Lint-free, item 9 Appendix E

REPLACE REPAIR

a. Disassemble the connection rod bolts.

b. Loosen and remove the rod bearing caps. Withdraw the cylinder with piston and connecting rod from the crankcase. Remove the bearing shells and mark them on the back corresponding to the connecting rods. Use an electric scriber.

c. Place bearing shells in a clean work area.

d. Pull out old piston pin bushing with fixture No. 003-1079 and pull in new piston pin bushing with the same device (figure 4-18).

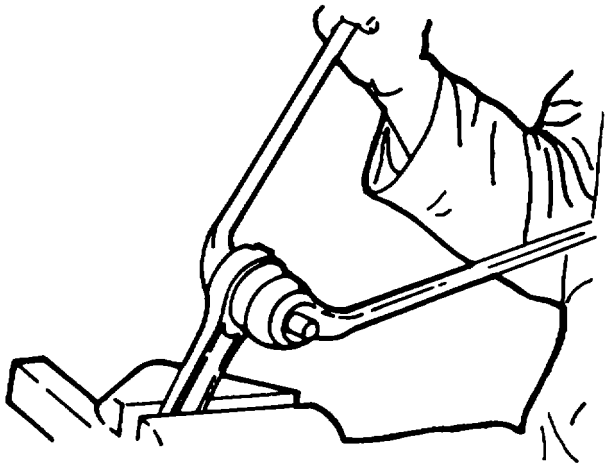


Figure 4-18. Removing/Installing Piston Pin Bushing

e. Pull in the new piston pin bushing flush; ensure the oil bores in the bushing and connecting rod coincide.

NOTE

The connecting rod bearings (6) are of the finished type. They are made of two ha]f-shells and correspond to the possible repair sizes of the crank pins and are available in six sizes. The bearings cannot be reconditioned.

f. Assemble the connecting rod bearing cap (4) to connecting rod (1); ensure that they bear the same identification number (figure 4-19)

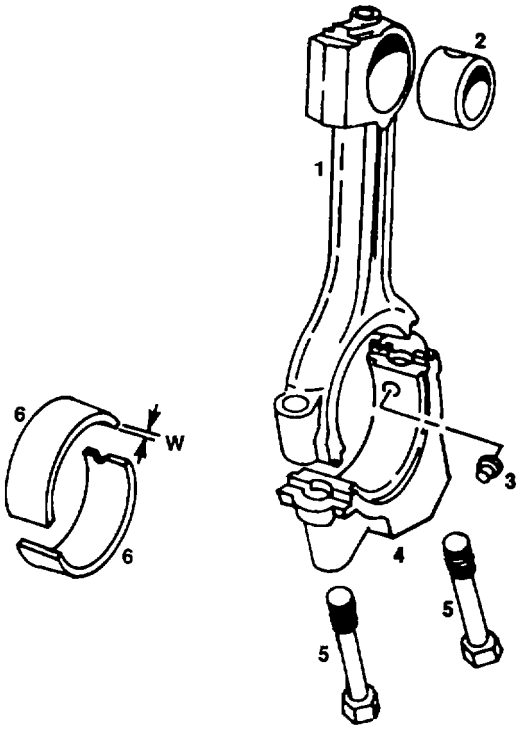


Figure 4-19. Connecting Rod Assembly

9. Mount bearing caps and tighten bolts (5) according to torque specifications listed in Appendix F.

h. Set the precision gauge to the basic inner diameter size by means of a micrometer frame. See specifications in table 4-5.

i. Measure connecting rod bearing bore at points 1 and 2 in planes a and b (figure 4-20). Note any contraction, out-of-roundness, or conicity.

j. If the readings keep within the limits of the specifications in table 4-5, the respective bearing bores are in acceptable condition and the necessary preload will be obtained after installation of new bearing shells.

k. If the recordings at the bearing bore deviate only slightly from the specified values, the measurements must be repeated when the new shells are installed.

1. Remove bearing cap and insert new bearing shells.

m. Refit bearing cap, then preload and tighten down according to torque specifications listed in Appendix F. Repeat measurement.

n. If the recordings show that the bearing tolerances remain up to a maximum of 0.020 mm above the values indicated in the specifications in table 4-5, the connecting rod is still fit for use.

Otherwise it must be replaced. It is not permissible to restore the preload by reworking the parting faces on the connecting rod bearing bore or shimming the shells.

o. Mark matching bearing shells and connecting rod.

p. Check connecting rod with mounted small end bushing (2, figure 4-19), but without connecting rod shells (6, figure 4-19), for parallelism (figure 4-21). Use a connecting rod tester.

NOTE

When measuring the parallelism with the plug gauge, the deviation should not exceed a=O.08 mm over a distance of a=100 mm.

q. Check connecting rod for squareness; A and B should be equal (figure 4-22).

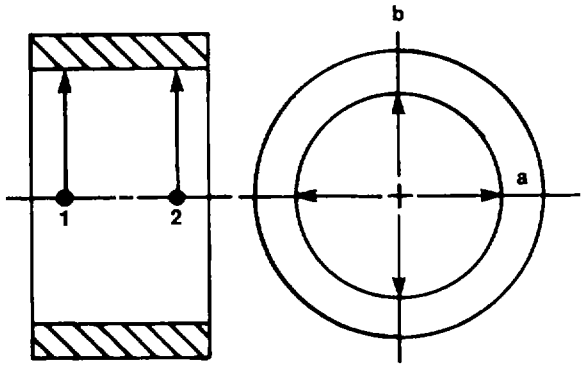


Figure 4-20. Measuring Piston Pin Bushing Connecting Rod Bearing Bore

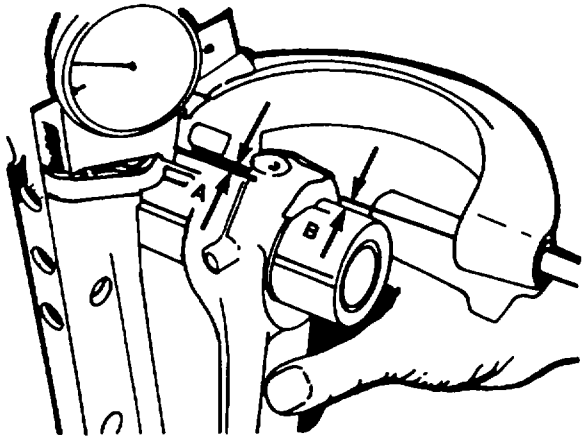


Figure 4-21. Checking Connecting Rod for Parallelism

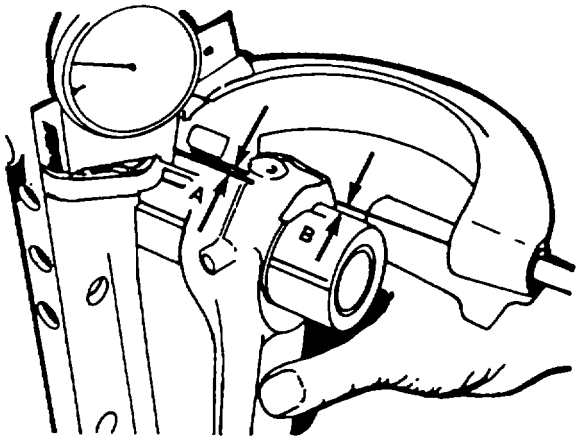


Figure 4-22. Checking Connecting Rod for Squareness

r. Weigh the connecting rods.

NOTE

The set of connecting rods for an engine should be of the same weight class. When renewing connecting rods, observe the color code on the rod cap indicating the weight tolerance within a certain weight class.

Gauging and replacing piston pin bushing.

INSPECT

a. Set inside micrometer to starting dimension using a micrometer frame.

b. Measure the piston pin bush at points one and two in planes a and b (figure 4-20).

NOTE

Compare recorded values with those specified in the specifications in table 4-5.

Follow on Maintenance.

Replace pistons; paragraph 4-14.

Replace fuel pump; paragraph 4-18.

4-14 PISTON

DESCRIPTION

This task covers: Inspect Replace, Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Piston heater (003-0414)
Piston ring expander (003-0496)
Gauge (003-0438)

Equipment conditions:
Cylinder removed (paragraph 4-12)

Materials/parts:
Grease, 2 mm lead wire

Disassembly.

a. Heat piston to about 176OF (80'C) using piston heater No. 003-0414 (figure 4-23). Remove circlip and withdraw the piston pin.

b. Remove the piston.

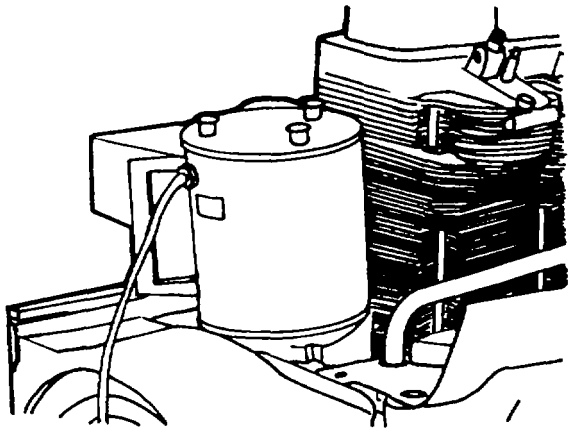


Figure 4-23. Piston Heater

INSPECT

a. If the cylinder is renewed, a new piston must be fitted. Normal sizes and oversizes are given in the specifications table.

b. Inspect the piston, including the bosses, for damage or visible wear. Inspect the area above the top ring. If the grooves cannot be felt on any part of the piston, replace the piston.

c. Remove the compression rings and oil control ring using piston ring expander No. 003-0496 (figure 4-24). Inspect the ring lands for damage or wear.

d. Open and remove the expander spring for the oil control ring.

e. Clean the piston ring grooves.

f. Measure axial piston ring clearance using commercial tools.

NOTE

If, when measuring a piston with trapezoidal ring groove, a gap is found to exist between the inserted gauge and the piston, this indicates that the axial piston ring clearance is within the tolerances stated in the specification data in table 4-4 and the piston is fit for further use.

g. Measure first piston ring groove, if trapezoidal, by means of trapezoidal groove wear gauge No. 003-0438. Note gap S (figure 4-25).

h. If the gauge contacts the side of the piston (without gap), the piston must be renewed.

i. Insert all the piston rings singly in the cylinder and press down with the piston to a distance of 30 mm from the cylinder head contacting surface. Measure the gap clearance of the piston ring.

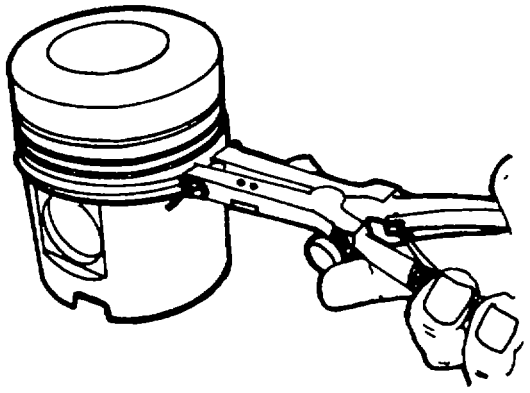


Figure 4-24. Removing Piston Rings

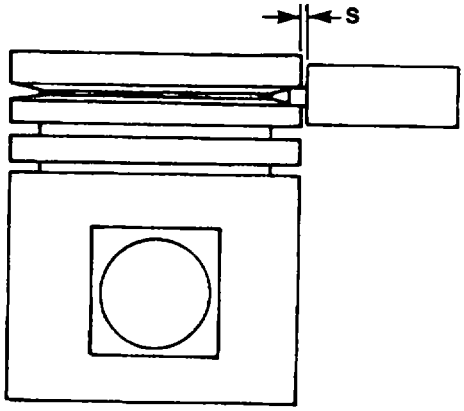


Figure 4-25. Axial Clearance for Trapezoidal Piston Ring

j. Compare the gap clearance of the piston rings with the values given in the specifications, table 4-4.

k. Renew defective pistons together with piston pin and rings.

1. When installing the piston rings, start by fitting the expander spring for the bevelled scraper ring in the bottom groove.

REPLACE REPAIR

a. Using piston ring expander No. 003-0496, assemble the piston rings in the following sequence:

NOTE

Place the rings so that the gaps are evenly spaced 120 degrees apart around the piston (figure 4-26).

1. (No. 3) Slotted, double-chamfered oil-control ring, chromium-plated.
2. (No. 2) Tapered compression ring, ferrox finished; install with face marked TOP upwards.
3. (No. 1) Top, double-trapezoidal compression ring, chromium-plated, TOP upwards.

b. Fit the circlip in the boss that will face the cylinder that has not been dismantled.

c. Heat piston with the piston heater No. 003-0414 [temperature about 176°F (80°C)]. Position the piston so that the exhaust side (marked with an arrow on the piston crown) faces the push rod bores (figure 4-27).

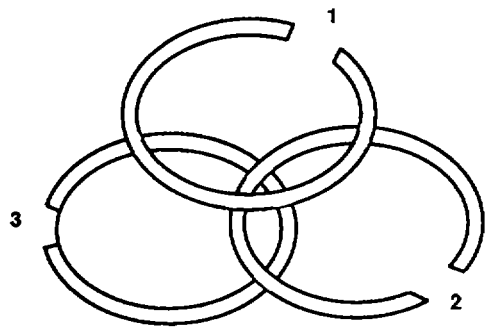


Figure 4-26. Piston Ring Gap Replacement

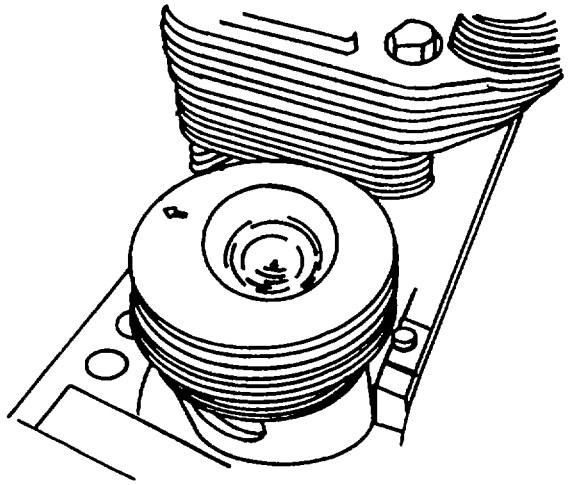


Figure 4-27. Positioning Piston

d. Press the piston pin into the piston bosses and the small end of the connecting rod.

NOTE

Secure the opposite end of the piston pin in position. Place the piston on the small end of the connecting rod so that the exhaust air side of the piston (marked on the piston crown) is in the same direction as the open side of the connecting rod bearing. Press in the piston pin.

e. Install the second circlip for installation of the piston pin.

f. Check piston pin for wear using a bevelled steel straight-edge or measuring angle.

Follow on maintenance.

Replace cylinders (paragraph 4-12).

Replace cylinder heads (paragraph 4-15).

Replace the front vertical plate and blower (paragraph 3-33).

4-15 CYLINDER HEAD SET (ENGINE)

DESCRIPTION

This task covers: Replace.

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Fixture (003-0500)
- Socket spanner (003-0512)
- Square - recess socket (003-0511)
- Spring tensioning tool (003-0501)
- Torque wrench

Equipment conditions:
Remove fuel return (para. 3-30),
air cleaner assembly (para. 3-31),
intake manifold (para. 3-32),
air cowling (para. 3-33),
and fuel supply lines.
Remove alt V-belt guard (para. 3-35).
Remove temperature probe (para. 3-44).
Remove air blower assembly
(para. 4-20).

Materials/parts:
- Cloth, Lint-free, item 9 Appendix E
- Compound, Sealing, item 11 Appendix E

REPLACE

CAUTION

As soon as the pipes are disconnected, plug the bores and fit caps over the connecting stubs of the fuel system.

a. Remove the valve cover.

b. Loosen push rod lock nuts and back off adjusting screws approximately two turns.

c. Remove rocker arm support assemblies and pushrods.

d. Remove the cover plugs and washers.

e. Slacken the cylinder head bolts in quarter turn stages and diagonal sequence.

f. Remove the cylinder head and pushrod tubes.

g. Align the cylinders.

h. Check/adjust piston crown clearance.

1. Apply grease to a piece of lead wire of 0.079-inch (2 mm) thickness and stick wire to piston crown (figure 4-28).

NOTE

Ensure piston is below TDC.

2. Mount cylinder head and insert securing bolts with washers.

3. Preload bolts by above wrench through 22 lb-ft (30 Nm) (see tightening procedure, table F-1) and tighten through one stage (45 degrees) with the aid of device No. 003-0500 (figure 4-29).

4. Rotate crankshaft by one revolution (360 degrees).

5. Unscrew bolts and remove head. Mark heads relative to cylinders.

6. Take out wire and gauge at weakened point. Tolerance should be .039 to .047 inch (1.0 to 1.2 mm).

7. Adjust clearance by using shims of 0.008 and 0.020-inch (0.2 mm and 0.5 mm).

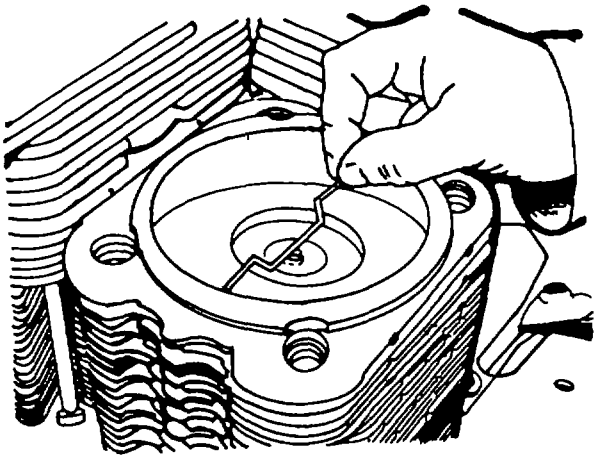


Figure 4-28. Checking Piston Crown Clearance

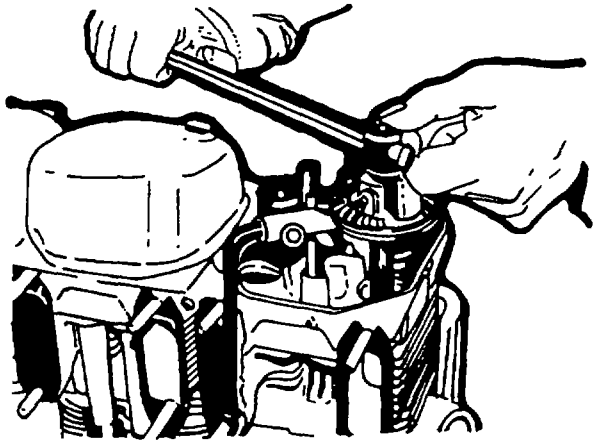


Figure 4-29. Tightening Cylinder Head Bolts with Tool 003-0500

NOTE

This is the recommended method of obtaining the correct clearance.

8 If the clearance is too small, remove cylinder and place the number of shims required below the cylinder.

NOTE

In the case of a distance of 0.024-inch (0.6 mm), instead of using several thin shims, use either one shim of 0.020-inch (0.5 mm) or one shim of 0.020-inch plus 0.008-inch (0.5 mm plus 0.2 mm), taking into consideration the piston crown clearance with appropriate tolerance.

9. If the clearance is too large, raise the cylinder and remove the surplus shims.

i. Install head gasket (reusable gasket).

j. Measure the length of head bolts. Renew those cylinder head studs that have stretched beyond the permissible maximum limits 8.307-inch +.020-inch (211 mm ±.5 mm).

k. Assemble and hand-tighten the studs fitted with washers. Align the induction and exhaust flanges of the cylinder heads without disturbing the alignment of the cylinders (figure 4-30).

1. Tighten and torque down the head bolts in accordance with Appendix F.

m. Install brass screw plugs with new gasket in the cylinder head. The tightening torque for the brass screw plugs is 60 to 65 lb-ft (80 to 90 Nm).

n. Assemble and tension the spring on the push rod tube (figure 4-31) using spring tensioning tool.

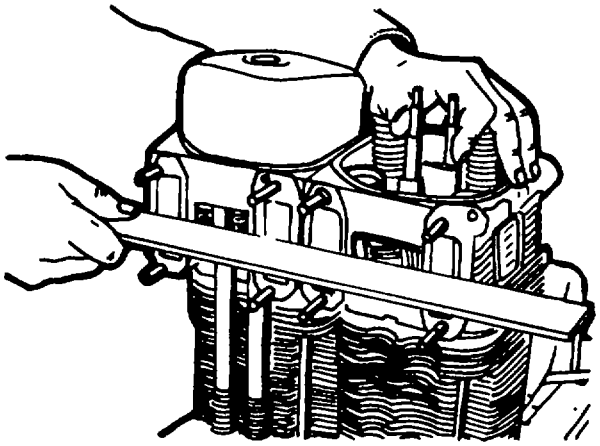


Figure 4-30. Aligning the Intake and Exhaust Flanges

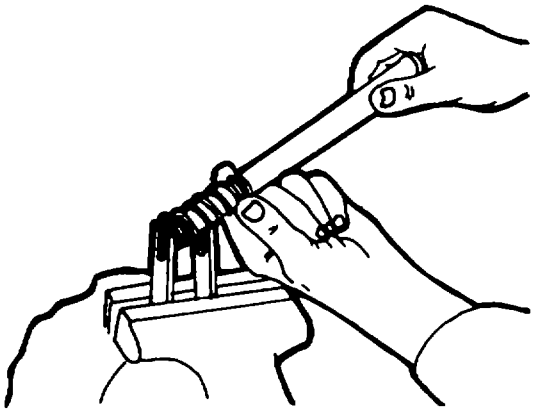


Figure 4-31. Assembling Spring onto Push Rod Tube

o. Install the back-up washer with the domed side facing towards the spring. Install a new sealing ring with the flat side facing towards the end of the push rod tube (figure 4-32, left).

p. At the opposite end of the tube, install a new sealing ring with the flat side facing towards the shoulder (figure 4-32, right).

q. Insert the spring ends of the two push rod tubes in the push rod holes in the crankcase and locate the upper ends with gaskets in the cones of the cylinder head. Remove the spring tensioner (figure 4-33).

r. Install the push rods.

s. Install the rocker arm and shaft support (figure 4-34).

t. Adjust the valve clearance (refer to 3-23).

u. Apply jointing compound to a new gasket and position on the rocker arm cover. Mount the rocker arm cover, align, and secure with a screw fitted with a new gasket. For tightening instructions, see specification data in table F-1.

v. If the cylinder head of the final cylinder was dismantled, assemble the screw in the front vertical plate.

. Install the exhaust air plate.

x. Position the upper cover plate on the cylinder heads (figure 4-35).

y. Place the rear vertical plate in position.

z. Secure upper cover plate and rear vertical plate (figure 4-36).

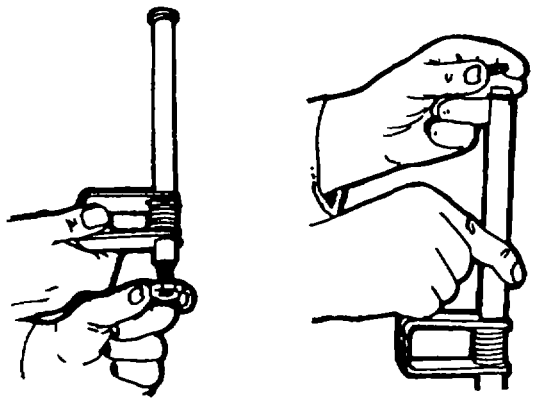


Figure 4-32. Fitting Seal Rings to Push Rod Tube

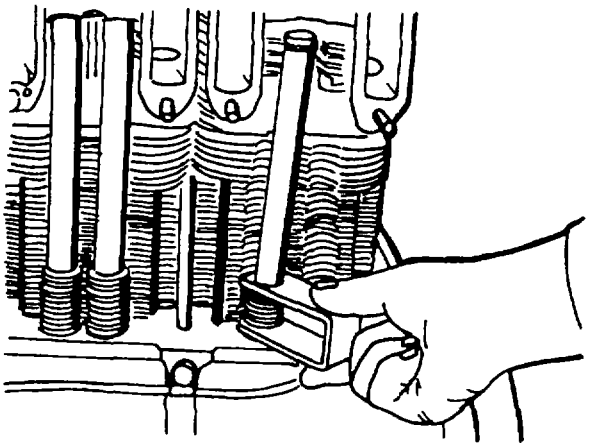


Figure 4-33. Removing Spring Tensioner

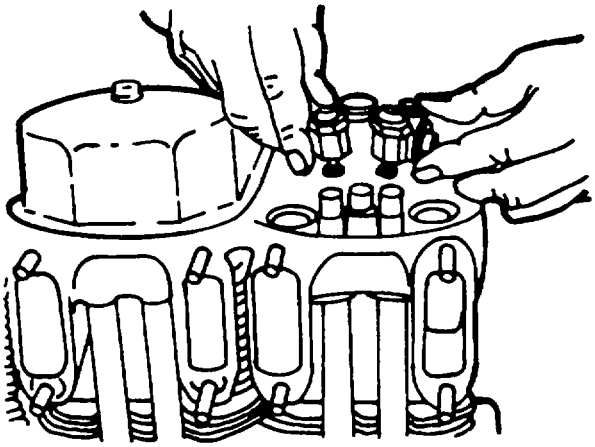


Figure 4-34. Mounting Rocker Arm Shaft Support

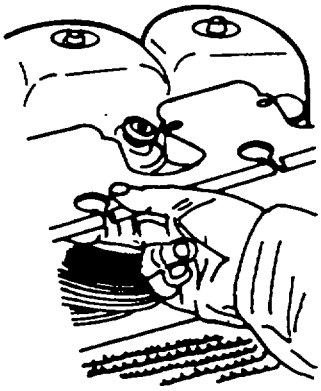


Figure 4-35. Upper Cover Plate

aa. Install the fuel delivery line, using clips to cylinder 1, to the crankcase and the line leading to cylinder 2 to the front vertical plate. Install a rubber sleeve between the clip and fuel delivery line. Tighten injection piping. Refer to table F-1.

ab. Hook the air cowling to the upper cover plate and close.

NOTE

Do not exchange gaskets for intake and exhaust manifolds.

ac. Install new gaskets, flat end upwards, for the intake and exhaust manifolds.

ad. Mount the intake manifold using washers and nuts.

ae. Place the exhaust manifold in position. Install the washers and tall brass nuts.

af. Install the air filter.

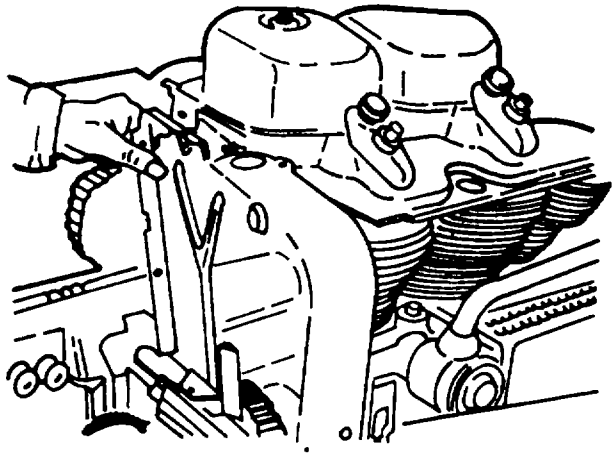


Figure 4-36. Rear Vertical Plate

4-16 TIMING GEARS (SET TIMING).

DESCRIPTION

This task covers: Adjust

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Dial indicator 100400
- Adjusting device 100640
- Pointer 101300
- Protractor 100910
- High pressure (HP) hand pump 101500
- Reservoir tank 101510
- Retainer 143400

Equipment conditions:
- Disconnect battery
- Valve covers removed (paragraph 3-22)

Materials/parts:
- Rags, Wiping, item 26 Appendix E

ADJUST

a. Determine Top Dead Center (TDC)

1. Turn engine over until valves of cylinder No. 1 overlap. (Exhaust valve almost closed, inlet valve just open.)
2. Mount the pointer to the front of the engine. Mark the pulley and use a straight edge to mark the pulley at 1800 from the pointer (figure 4-37).
3. Turn the engine 1800 so the second mark and the pointer line up.
4. Mount adjusting device on cylinder No. 1.
5. Using the pressure screw of the adjusting device, press down the rocker arm by 0.20 to 0.24-inch (5 to 6 mm) (figure 4-38).

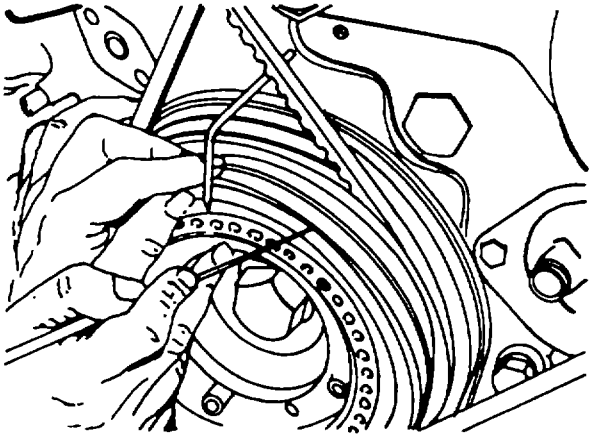


Figure 4-37. Measuring and Marking Halfway Points

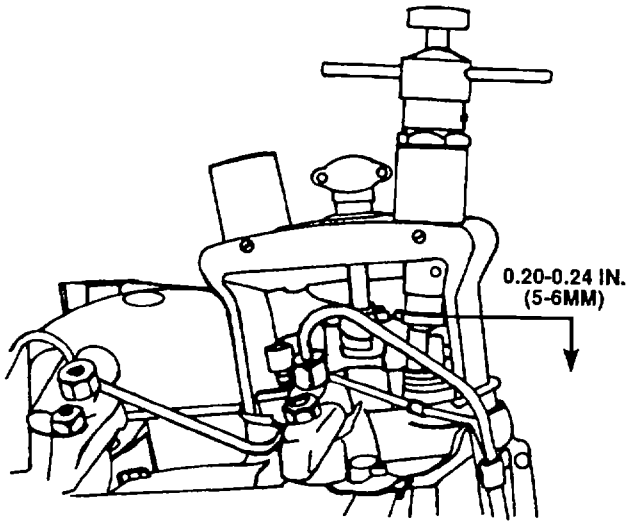


Figure 4-38. Setting the Adjusting Drive

6. Place the dial indicator and preload on the top of the adjusting device.

7. Turn crankshaft clockwise until dial indicator gauge begins to move. Turn crankshaft slowly until the dial pointer starts moving in the opposite direction. Set gauge to zero.

8. Apply mark on crankshaft pulley.

9. Turncrankshaft180 0 clockwise. Turn crankshaft counterclockwise until the dial pointer starts moving in the opposite direction. Apply second mark on the crankshaft.

10. The midway point between the two marks is TDC. (Do not remove pointer.)

NOTE

If the second mark and the first mark coincide, that is the TDC position.

b. Set timing.

1. Ensure that TDC has been determined.
2. Mount magnetic protractor so zero coincides with TDC (figure 4-39).
3. Turn crankshaft approximately 90° counterclockwise from TDC.
4. Remove fuel filter. Remove injector line No. 1 from injector and remove fuel return line.
5. Plug fuel return line with plug and connect adapter for HP hand feed pump.

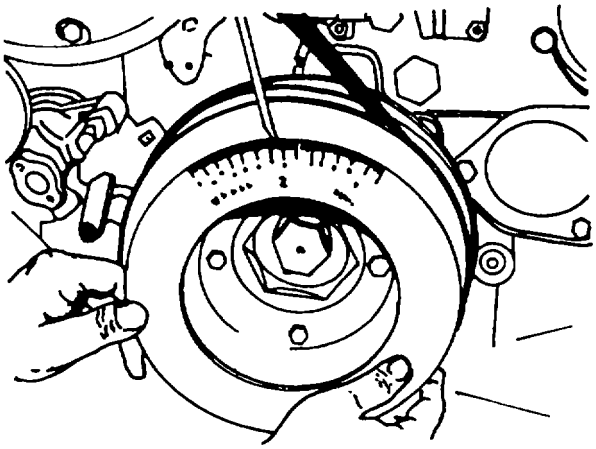


Figure 4-39. Zeroing Magnetic Protractor

6. Connect the HP hand feed pump and connect the reserve tank to the hand pump. Fill the tank with fuel (figure 4-40).

7. Pump HP hand pump until fuel is in a steady stream from the No. 1 pump (figure 4-41).

8. Turn the crankshaft slowly clockwise until the No. 1 pump stops flowing freely and drips fuel.

9. Observe pointer on the protractor disc at this time.

a) If the beginning of the fuel delivery coincides with the data plate, fuel injection timing is correct. If timing is correct, proceed to step m.

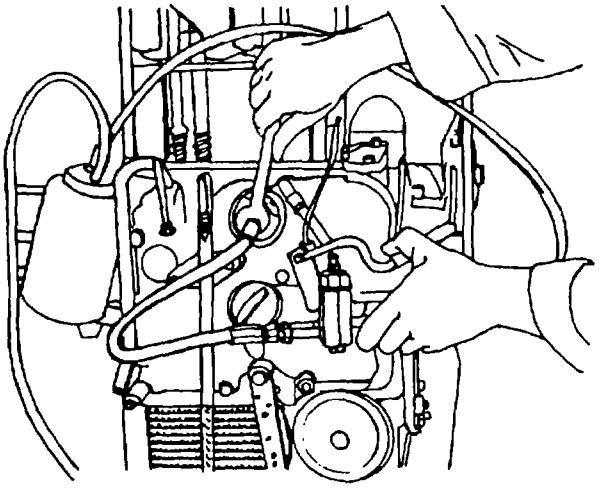


Figure 4-40. Connect HP Hand Feed Pump

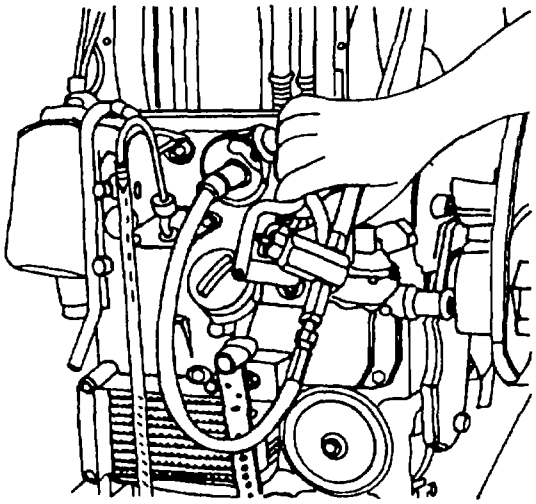


Figure 4-41. Pump HP Hand Pump

b) If the fuel delivery point does not agree with the protractor disc, turn the crankshaft until it does.

c) Remove camshaft cover.

d) Remove hand crank flange.

e) Remove hand cranking plate from camshaft.

f) Remove two opposing allen head bolts from the camshaft. Loosen the two remaining allen head bolts.

g) Screw two M8 x 80 bolts into the empty threaded holes of the camshaft (figure 4-42).

h) Pump the HP hand pump and turn the camshaft until the fuel is dripping from No. 1 injector pump.

i) Tighten the loose allen head bolts on the camshaft.

j) Check the magnetic protractor disc and ensure that the degrees on the pointer coincide with the data plate.

k) Remove the two M8 x 80 bolts. Replace the two camshaft bolts and torque according to Appendix F.

1) Turn crankshaft until fuel runs out of No. 1 injector pump. Push engine fuel stop to the OFF position. Fuel should stop at this point. If not, refer injector pump to General Support Maintenance.

m) Recheck the beginning of fuel delivery (figure 4-43).

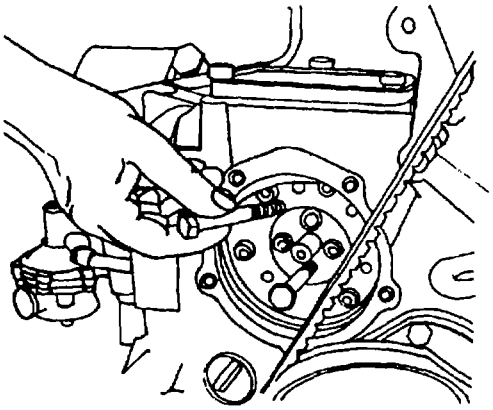


Figure 4-42. Install Camshaft Jacking Bolts

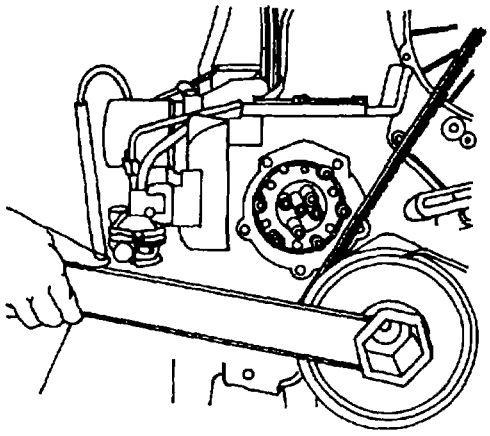


Figure 4-43. Rechecking Fuel Delivery

n) Install the hand crank plate to the camshaft, and torque.

o) Install a new gasket and torque the hand crank flange in place.

p) Install No. 1 injector, and torque.

q) Remove fuel return line plug and reinstall return line.

r) Remove quick disconnect and HP pump and reinstall fuel filter assembly.

s) Remove the degree wheel and pointer.

4-17 INJECTORS (ENGINE)

DESCRIPTION

This task covers: Replace, Repair

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Tool kit auto fuel and electric system repair
- Testing outfit
- Soft-jawed vise

Equipment conditions:
- Engine secured (paragraph 2-11)

Materials/parts:
- Cloth, Lint-free, item 9 Appendix E
- Clean diesel oil, item 15 Appendix E

REPLACE REPAIR

a. Disconnect fuel lines.
b. Remove nut (4) that secures clamping bridge (5) to cylinder (figure 4-44).
c. Remove clamping bridge.
d. Remove injector (2) with bushing (1). Replace, as required. Ensure sealing washer (3) is removed.
e. Check thrust piece (7). Replace, as required.
f. Install thrust piece (7).
g. Install sealing washer (3) on injector (2). Replace injector.
h. Reinstall bushing (1) that secures fuel injector (2) to cylinder.
i. Replace clamping bridge (5) and secure with nut (4).
j. Connect fuel lines.

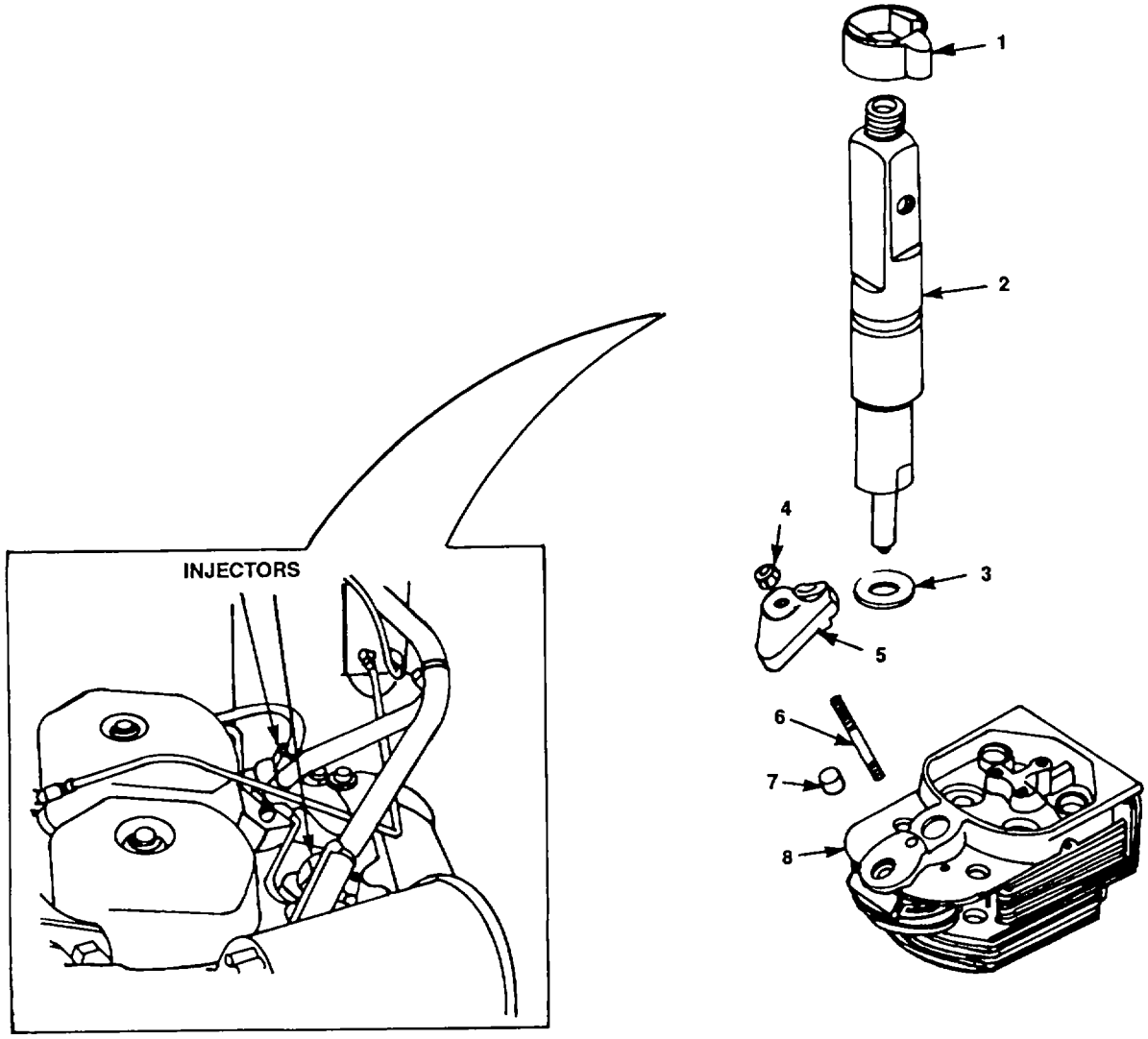


Figure 4-44. Injector Components

4-18. FUEL INJECTION PUMP (ENGINE).

DESCRIPTION

This task covers: Test. Adjust. Replace. Repair.

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Graduation magnet (003-1189)
- Dial segment for V-belt pulleys (003-0677)
- Setting device (003-0498)
- Dial gauge (003-0543)
- Graduated scale (003-0677)
- Pointer (003-0678)

Materials/parts:
- Lint-free Cloth, item 9 Appendix E
- Sealing Compound, item 11 Appendix E
- Automotive and Artillery Grease, item 18 Appendix E

Equipment conditions:
- Equipment secured (paragraph 2-11).
- Fuel injection lines removed (paragraph 3-27).
- Oil dipstick removed (paragraph 3-23).
- Fuel oil filter removed (paragraph 3-26).
- Stop/start solenoid and throttle label removed (paragraph 4-11).
- The fuel feed pump intake is connected to the fuel tank or a receptacle containing filtered fuel. Proper fuel delivery is a prerequisite (for testing only).

TEST

a. Connect the pressure line of the high-pressure tester.
b. Disassemble the fuel filter. Disassemble the fuel line of cylinder 1 connecting with the pumping element and the leak-off line connecting with the fuel injection pump cover. Plug the leak-off hole and connect the pressure line of the instrument to the threaded sleeve for the fuel filter (figure 4-45).

NOTE

Number 1 cylinder is the closest cylinder to the flywheel. The hand pump can also be used if a blanking cover with hollow screw is provided.

c. Connect the overflow pipe with funnel and the return line to the stub for the fuel line to cylinder 1.

d. Pump the HP unit until fuel comes out of the overflow pipe. Slowly turn crankshaft in normal direction until only a few droplets come out at intervals of 5 to 8 seconds.

e. Ensure the Beginning of Delivery (FB) mark on the belt pulley agrees with pointer, so the fuel delivery timing is correct.

f. Turn off the high-pressure tester.

When setting beginning of delivery, turn the crankshaft in the direction opposite that of engine rotation through 90 degrees from the FB mark, and then in the direction of engine rotation until the FB mark on the V-belt pulley registers with the retainer sleeve or setting indicator.

ADJUST

a. Determining TDC with Setting Device.

1. Remove no. I rocker chamber cover. (Cylinder closest to the flywheel.)

2. Turn crankshaft until valves overlap, then give crankshaft another half turn.

3. Mount setting device (003-0498). Using pressure screw of device, press down one rocker arm approximately 0.20 to 0.24-inch (5 to 6 mm) (figure 4-46).

4. Fit dial gauge (003-0543) with preload.

5. Secure graduated scale (003-0677) to V-belt pulley and fix pointer to dowel sleeve (figure 4-47).

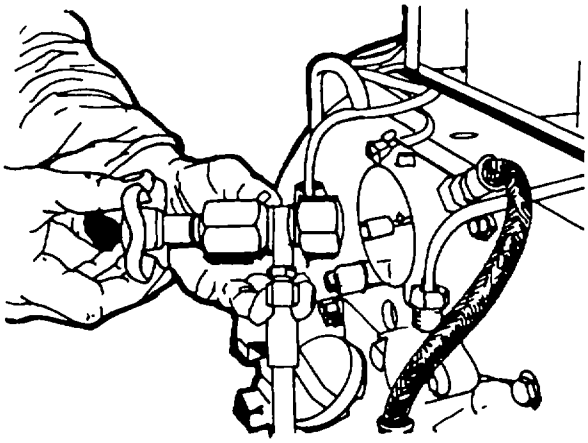


Figure 4-45. Connecting High-Pressure Tester

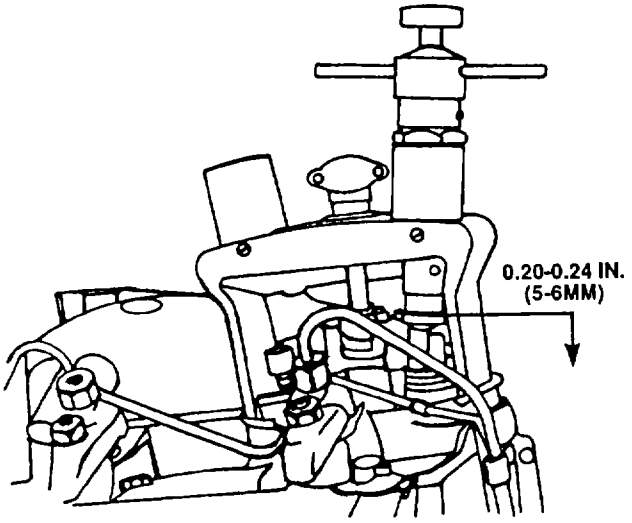


Figure 4-46. Setting the Adjusting Device

6. Set pointer to 0 on scale (figure 4-48).

7. Turn crankshaft carefully in nominal direction until piston pushes up the valve. Slowly turn farther until gauge pointer changes the direction. Set gauge at 0.

8. Turn back crankshaft through about one revolution of gauge pointer, then again in original direction up to 0.004-inch (0.1 mm) (10 graduations) from 0 position. Read crankshaft position from scale and record.

9. Turn crankshaft in running direction beyond 0 through about one revolution of the gauge and turn back up to 0.004-inch (0.1 mm) (10 graduations) before 0.

10. Read crankshaft position again from scale and record. The middle of the two crankshaft positions is the TDC (=OT) mark.

11. Turn crankshaft so that the mark found agrees with the pointer (003-0678). The piston is now in TDC position.

12. Set pointer to 0 position of scale.

b. Determining TDC without graduated scale.

NOTE

Mounted are tuning unit no. 003-0498 and dial gauge no. 003-0543. The dial gauge is pretensioned.

1. Extend dowel sleeve by a piece of wire.

2. Turn crankshaft carefully in normal direction until piston pushes up the valve. Slowly turn farther until gauge pointer changes the direction. Set gauge at 0.

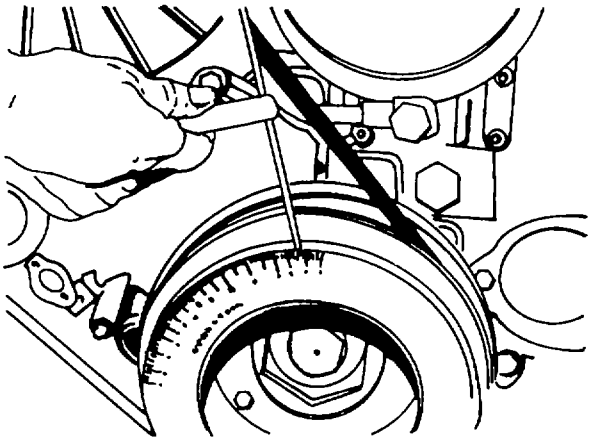


Figure 4-47. Securing Graduated Scale to V-Belt Pulley

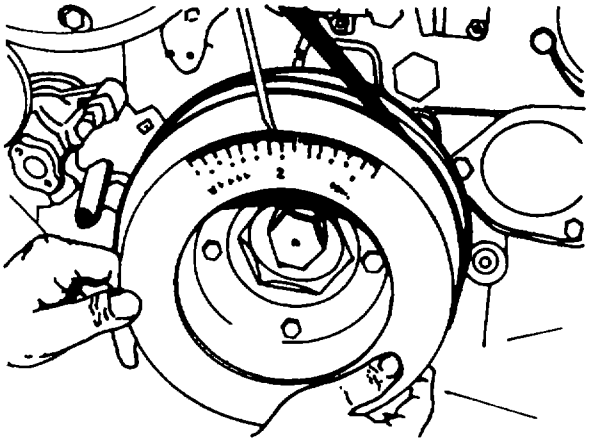


Figure 4-48. Zeroing Magnetic Protractor

3. Turn back crankshaft through about one revolution of gauge pointer, then again in original direction up to 0.1 mm (10 graduations) from 0 position. Provide a mark on the V-belt pulley agreeing with dowel sleeve (figure 4-49).

4. Turn crankshaft in running direction beyond 0 through about one revolution of the gauge and turn back up to 0.1 mm (10 graduations) before 0. Provide second mark on belt pulley.

5. Measure and mark the half-way position between the two marks (figure 4-50).

NOTE

The midway mark will be the dead center mark. When it is opposite the retainer sleeve, cylinder 1 will be in the top dead center position.

6. Remove the two oil cooler bolts that secure the engine throttle stop to the cooler.

7. Remove ten bolts and nuts.

8. Remove pump.

9. Remove bolts of starting crank bearing and remove bearing (figure 4-51).

10. Unscrew hex head socket screws from the starting crank and remove.

11. Remove two diagonally located screws securing the gear wheel on the camshaft.

12. In place of these two screws, assemble two, 8 mm diameter x 80 mm jacking screws and slacken the other two screws.

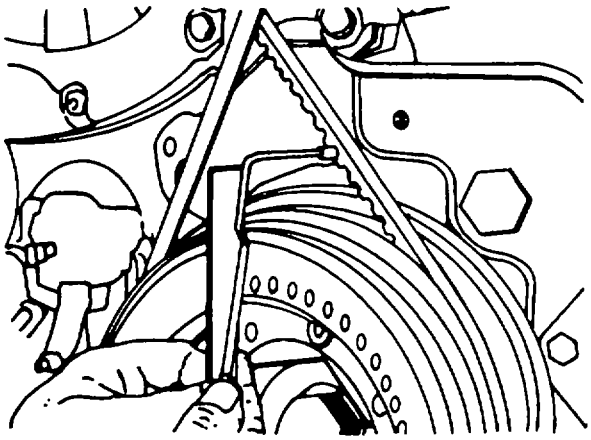


Figure 4-49. Setting Gauge Pointer Halfway Points

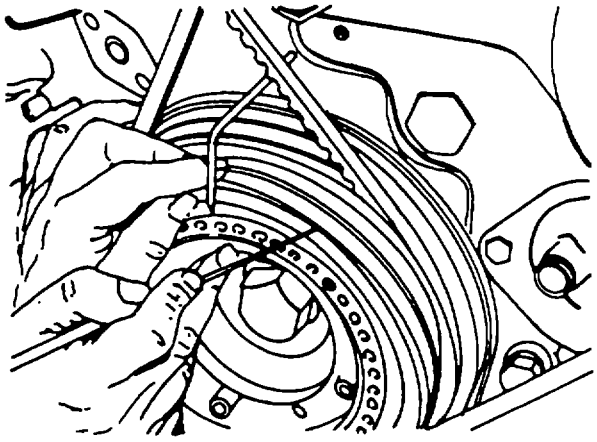


Figure 4-50. Measuring and Making

13. By means of the two long jacking screws, turn the camshaft in the direction of engine rotation until the injection pump starts to deliver fuel (figure 4-52).

14. Ensure that fuel comes out from overflow pipe (when operating test unit or pump) only in droplets at intervals of 5 to 8 seconds.

15. Tighten the two screws securing the camshaft gear wheel. Check again the point of fuel delivery and, if necessary, correct. Turn off the high-pressure tester.

16. Unscrew both long bolts and refit original fastening bolts.

CAUTION

When reassembling, ensure that the radial seal in the crank handle bearing is not damaged.

17. Reinstall the gear wheel cover and affix a new gasket.

18. Dismantle the adjusting device. Make the injection pump ready for operation. Connect the fuel line, free from tension, to cylinder 1.

REPLACE **REPAIR**

NOTE

Uniformly slacken screws in diagonal sequence.

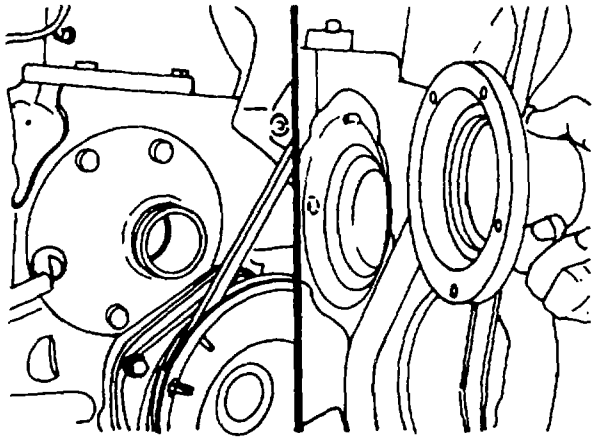


Figure 4-51. Removing Starting Crank Bearing

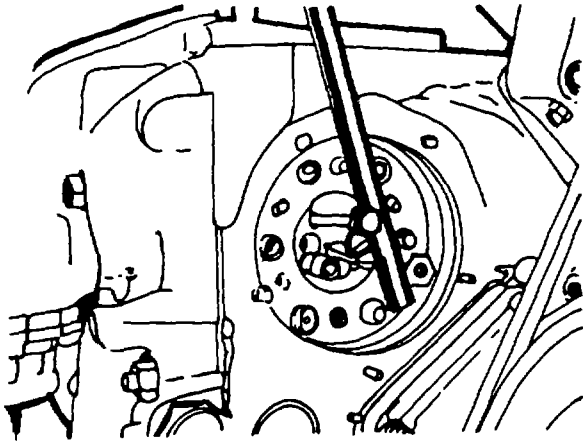


Figure 4-52. Turning Camshaft Using Jacking Bolts

a. Remove the screws securing injection pump (3) to the engine.

b. Separate the injection pump from the gasket and discard gasket (4, figure 4-53).

c. Apply grease to a new gasket and place in position on the injection pump cover. Reinstall clamping bushings (5). Turn the crankshaft so that the fuel cams face in the direction of the crankcase. Mount the fuel injection pump cover so that the gears are in mesh.

d. Uniformly tighten in diagonal sequence the screws that secure the injection pump cover.

e. Connect breather pipe (1) and bracket (2) and install with jointing compound in the injection pump cover. Install the oil dipstick fitted with a new rubber 0-seal.

f. Connect the fuel injection lines.

NOTE

Install and secure with clips the fuel injection line to cylinder 1 to the crankcase and that to cylinder 2 to the front vertical plate. Insert rubber sleeve between each clip and the fuel delivery line.

TEST

a. Disconnect injection line(s) on the fuel injection pump. Evacuate the air from the fuel injection pump. Connect the tester to the pump element to be checked (figure 4-54).

b. Open the second connection of the tester and evacuate the air. When the escaping fuel is free from bubbles, close the second connection.

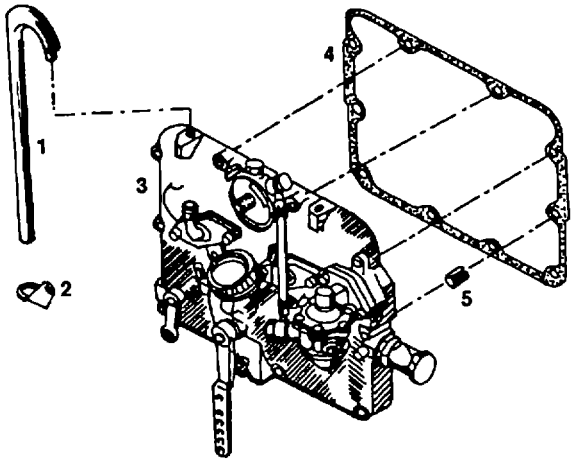


Figure 4-53. Deutz Fuel Injection Pump

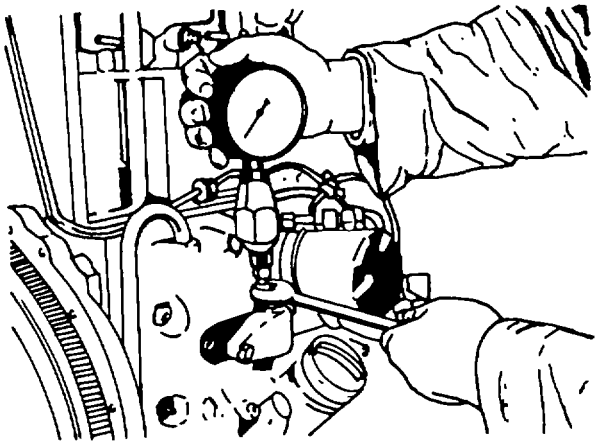


Figure 4-54. Injection Pump Tester Hookup

NOTE

The manual operation of the fuel injection pump elements differs from one type of engine to another.

c. Rotate the crankshaft until the air is evacuated or until the pressure has built up.

d. To check a pressure relief valve, generate a pressure of 2205 psi (150 bar). The indicator of the pressure gauge may not drop back more than 147 psi (10 bar) during a minute.

e. Generate a pressure peak of 5145 psi (350 bar). This must be clearly indicated by the pressure gauge.

f. A faulty injection pump should be replaced or repaired by specialists.

CAUTION

Any time the fuel injection pump has been removed, the following operational check must be performed.

g. Operational Check.

1. With HP hand pump still attached, turn the engine over until the injector has a free flow of fuel.

2. Push the stop lever to the OFF position (without run solenoid in place, it will be in the RUN position).

3. Fuel should stop flowing. If not, do not start unit. Locate problem.

4. Remove oil bath air cleaner assembly.

5. Locate a board or tool box tray that will fit securely over the intake. Place it close to the unit in the event of a runaway engine (uncontrollable engine speed) to seal off the air intake to the engine.

6. Perform operator's PMCS and start the unit.

7. Set engine idle speed and full throttle speed with the two adjusting screws under the throttle arm. Set to engine manufacturer's specifications.

8. Adjust fuel amount so when the engine is throttled from idle to full speed, there should be a light amount of black smoke and then clear up upon reaching full throttle.

9. Fuel balancing should only be attempted with an exhaust temperature indicator to measure the temperature difference. Fuel balance adjusting screw is located behind the fuel filter.

4-19. FUEL FEED PUMP (ENGINE).

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Lint-free Cloth, item 9 Appendix E

Equipment conditions:
Equipment secured
(paragraph 2-11)

REPAIR

a. Remove fuel feed pump from the fuel injection pump.

b. Discard the gasket (3, figure 4-55).

c. Remove screws that fasten pump top (2) to pump bottom (1).

d. Using repair kits (4 and 5), replace gaskets and/or rings in fuel feed pump.

e. Assemble pump top (2) to pump bottom (1).

f. Insert new gasket (3) and secure feed pump to fuel injection pump.

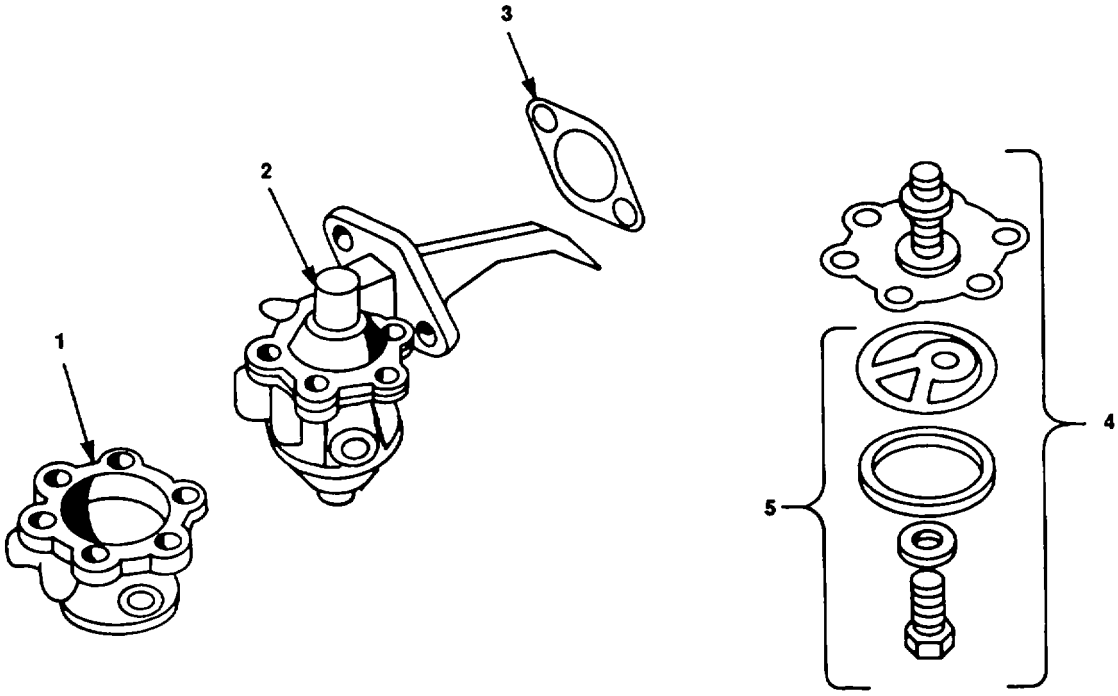


Figure 4-55. Fuel Feed Pump

4-20. COOLING AIR BLOWER (ENGINE).

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
Fixture 003-1189
Retaining ring set pliers
Vice

Materials/parts:
None

Equipment conditions:
Engine secured (paragraph 2-11).

Slacken the fasteners securing the alternator, remove the V-belt, and remove the cooling air blower (figure 4-56).

REPLACE

a. Unscrew securing bolt (10) and remove nut (1).

b. Remove V-belt pulley (9), blower impeller (2), and bearing shaft (4).

c. Remove circlip (8) and press out the two grooved ball bearings (5 and 7) and spacer sleeve (6).

REPAIR

a. Renew the two grooved ball bearings and fill them with special high-melting-point bearing grease. Install the first grooved ball bearing (7) to the rear with the enclosed side to the back.

b. Insert the bearing shaft (4) in the grooved ball bearing and slide the space sleeve (6) on the bearing shaft.

c. Half-fill the space between the distance sleeve and casing wall with special high-melting-point bearing grease.

d. Press in the second ball bearing (5) so that the enclosed side faces the front. Install the circlip in the groove (8).

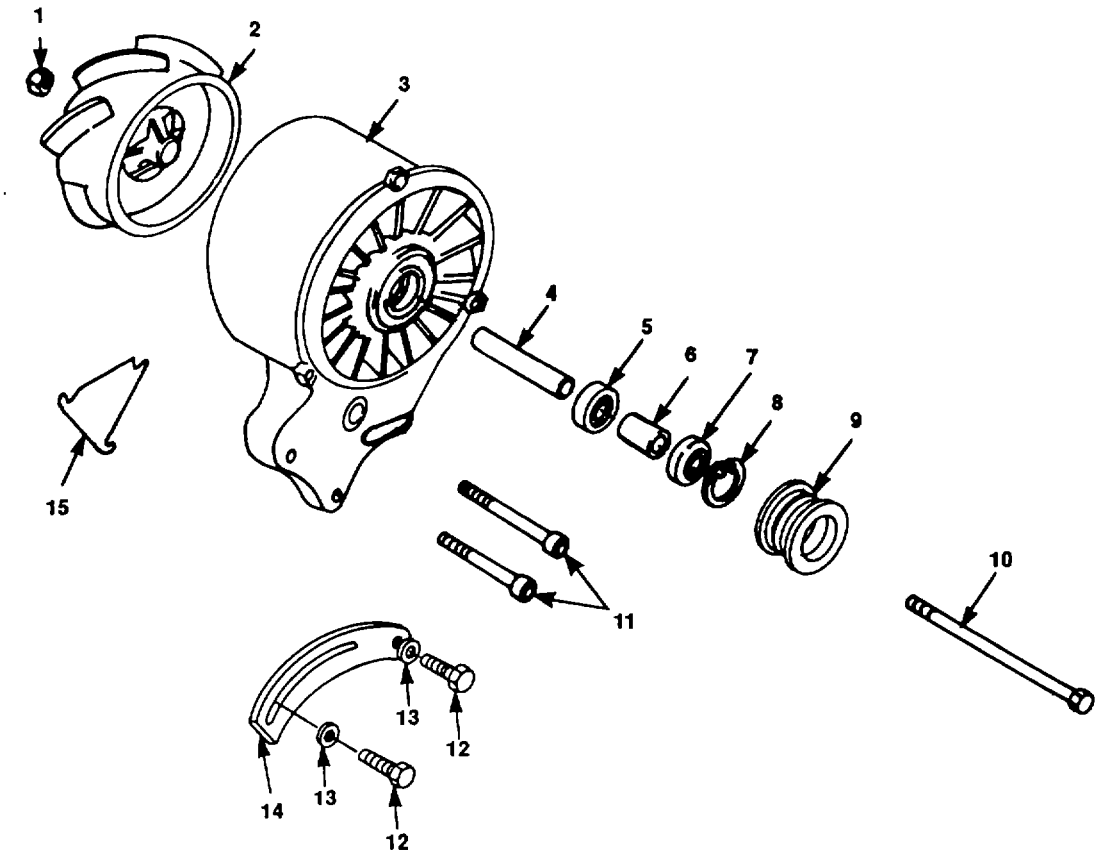


Figure 4-56. Cooling Air Blower

e. Install impeller on the bearing shaft and install the pulley (9), bolt (10), and nut (1).

f. Hold the nut in a vice and torque the bolt in accordance with Appendix F.

REPLACE

a. Mount the cooling air blower and check whether its belt pulley is in alignment with the crankshaft belt pulley (figure 4-57).

b. If the pulleys are out of alignment, correct by varying the number of shims under the cooling air blower.

c. Hook the top of the air cowling to the upper cover plate and fix it at the bottom.

d. Install washers to adjust the clearance between the front end shield and the cooling air blower.

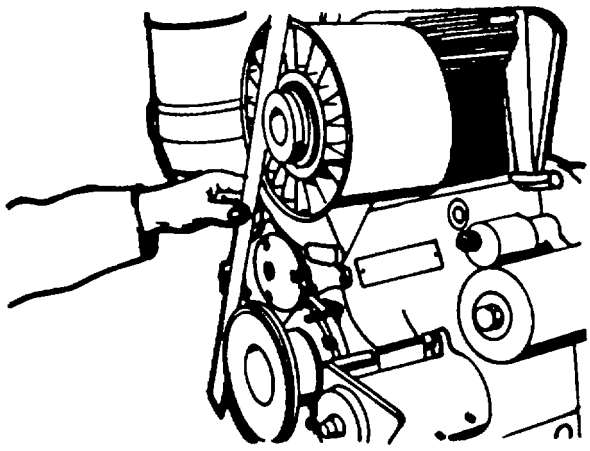


Figure 4-57. Checking V-Belt Pulley Alignment

4-21. STARTING MOTOR.

DESCRIPTION

This task covers: Repair. Test.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Grease MIL-G-21164, item 20 Appendix E

Equipment condition:
Engine secured (paragraph 2-11)
Starter removed from engine (paragraph 3-34)

REPAIR

NOTE

Two tests should be performed on the starter motor before repairs are made. These tests will help determine what repairs will be necessary during starter motor over haul. The two tests are a no-load test and a locked rotor test.

TEST

a. No-Load Test.

1. Remove starter motor with solenoid from engine.

2. Check armature for freedom of operation by turning pinion.

   a) Tight, dirty, or worn bearings, bent armature shaft, or loose pole shoe screws will cause armature to drag. If armature does not turn freely, do not perform no-load test. Disassemble motor and repair.

   b) If armature does operate freely, proceed with no-load test.

CAUTION

Never operate starter motor for more than 5 seconds at a time. Allow motor to cool for at least 2 minutes between operations. Overheating can cause sever damage to motor.

3. Perform no-load test as follows:

   a) Connect starter motor as in figure 4-58 in series with fully charged 12-voltbattery, ammeter (200 amp capacity), and variable resistance.

   b) Connect voltmeter from motor battery terminal to motor frame.

   c) Install rpm indicator on motor shaft to measure armature speed.

   d) Install jumper between motor battery terminal and starter solenoid terminals.

   e) Obtain specified voltage by varying resistance.

   f) Read current draw and armature speed and compare with the following specifications.

4. Interpret no-load test results as follows:

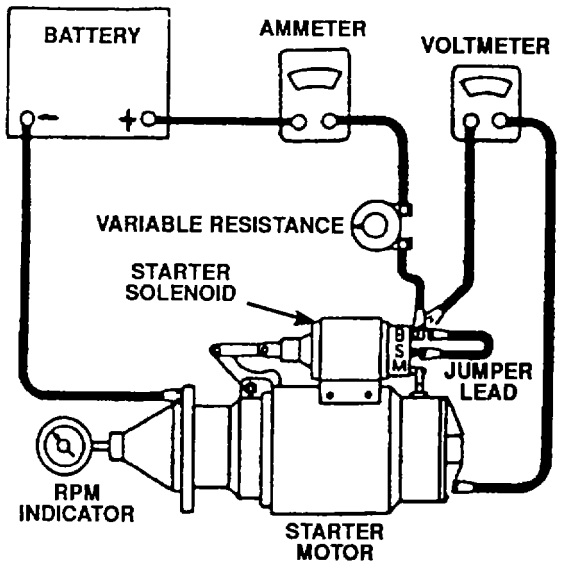


Figure 4-58. No-Load Test Connections

a) Rated current draw and rpm indicate that starter motor is in normal condition.
Volts 11.3
Amps (min) 70
Amps (max) 130
RPM (min) 5,000
RPM (max) 10,000

b) Low speed and high current draw indicate the following:

1) Too much friction - tight, dirty, or worn bearings, bent armature shaft, or loose pole shoes.

2) Shorted armature. Check armature on megger after disassembly.

3) Grounded armature.

c) Failure to operate and high current draw indicate the following:

1) Direct ground in terminal.

2) Frozen bearings.

d) Failure to operate and no current draw indicate the following:

1) Open armature windings. Inspect armature for badly burned commutator bars after disassembly.

2) Broken brush springs, worn brushes, high insulation between commutator bars, or other causes preventing good contact between brushes and commutator.

e) Low speed and low current draw indicate high internal resistance due to poor connections, defective leads, and dirty commutator.

5. When test is complete, and if no further disassembly is required, proceed as follows:

a) Remove test equipment.

b) Reinstall motor.

c) Reconnect battery cables.

d) Remove OUT-OF-SERVICE tag from control panel.

b. Locked Rotor Test.

1. Perform locked rotor test as follows (figure 4-59).

a) Lock clutch so that it cannot rotate.

b) Connect starter motor in series with fully charged 12-volt battery, ammeter (1200 amp capacity), and high current capacity variable resistance.

c) Connect voltmeter from motor starter solenoid terminal to motor frame.

d) Install jumper between motor battery and starter solenoid terminals.

e) When 5 volts are applied, current should fall between 1050 (minimum) and 1100 (maximum) amps.

2. When test is complete, and if no further disassembly is required, proceed as follows:

a) Remove test equipment.

b) Reinstall starter motor.

c) Reconnect battery cables.

d) Remove OUT-OF-SERVICE tag from control panel.

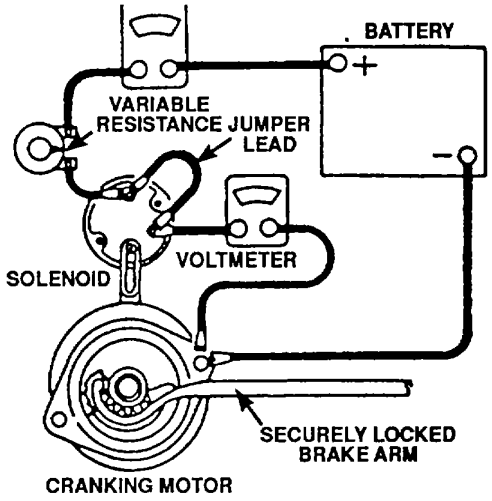


Figure 4-59. Locked Rotor Test Connections

c. Starter Motor Repair.

1. Remove starter motor and solenoid from engine.
2. Remove screws from the protective cap.
3. Pry off the protective cap, taking care not to damage 0-ring seal.
4. Remove shims and positioning disc.
5. Loosen excitation windings.
6. Disconnect the solenoid terminal from the motor field lead.
7. Remove the solenoid retaining screws located at the drive end housing, and slide solenoid out of the housing while disengaging the control lever.
8. Remove the commutator shield.
9. Hold the brush return springs.
10. Remove the brushes from the brush plate.
11. Remove the brush plate from the armature shaft.
12. Remove stator housing from drive end (DE) bearing housing. Ensure the rubber strip and metal plate are not lost.
13. Remove the thin studs from the DE housing.
14. Remove the control lever and armature from DE housing.
15. Remove the starter drive pinion overrunning clutch from the armature by:

    a) Remove pinion stop collar covering snap ring using a metal sleeve the same diameter as the collar.

    b) Drive the collar toward the pinion and off the snap ring (figure 4-60).

    c) Remove the snap ring from the armature shaft and slide the collar off.

    d) Smooth any burrs on the armature shaft near the snap ring groove.

    e) Remove the starter drive from the armature shaft.

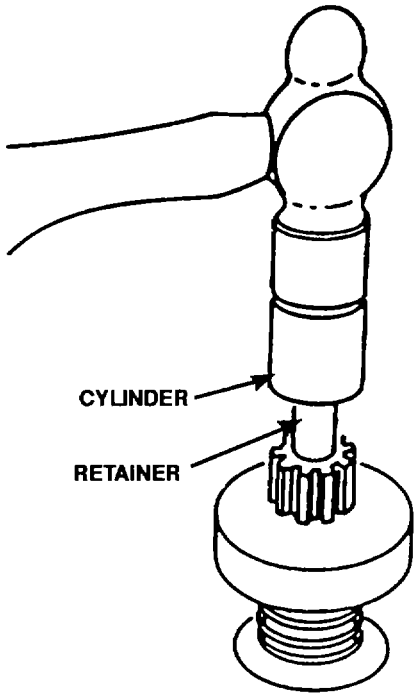


Figure 4-60. Starter Drive Retainer Removal

CAUTION

Do not attempt to disassemble the starter drive, as it is a sealed unit. Do not clean the starter drive in solvent, as internal lubricant would be dissolved.

16. Remove the intermediate bearing plate from the armature.

17. Clean, inspect, and repair components.

18. Replace brushes if worn down to 0.610-inch in length (15.5 mm).

19. Ensure that brushes do not bind in holders.

20. Ensure that full brush surface rides on commutator with proper spring tension of 72 ounces (minimum) to 88 ounces (maximum).

21. Locate short circuits in armature by rotating armature in growler with steel strip (such as a hacksaw blade) held on armature. Steel strip will vibrate on area of short circuit.

22. Check for brush dust or copper between commutator bars. Undercut insulation to eliminate shorts.

23. If commutator bars are not completely burned, resolder leads in riser bars and turn commutator in lathe. Undercut insulation between bars to 1/32-inch (0.5 mm).

24. Use test lamp and prods to check for grounds in armature. If lamp lights when one test prod is placed on the armature core or shaft, then armature is grounded.

25. Use test lamp to check field coils for grounds and opens, as follows:

    a) To check for grounds, disconnect field coil ground connections. Connect one test prod to field frame and the other prod to the field connector. If lamp lights, then field coils are grounded.

    b) To check for opens, connect test prods to ends of field coil leads. If lamp does not light, then field coils are open.

26. If field coils need to be removed, be careful to avoid grounding or shorting coils when replacing. Refer to reassembly procedures.

27. Coat the armature shaft pinion drive splines with a thin coat of grease (MIL-G-21164).

28. Place collar on armature shaft with cupped surface facing snap ring groove.

29. Place snap ring on end of shaft. With piece of wood on top of it, force snap ring over shaft with a light hammer blow. Then slide snap ring down into groove (figure 4-61).

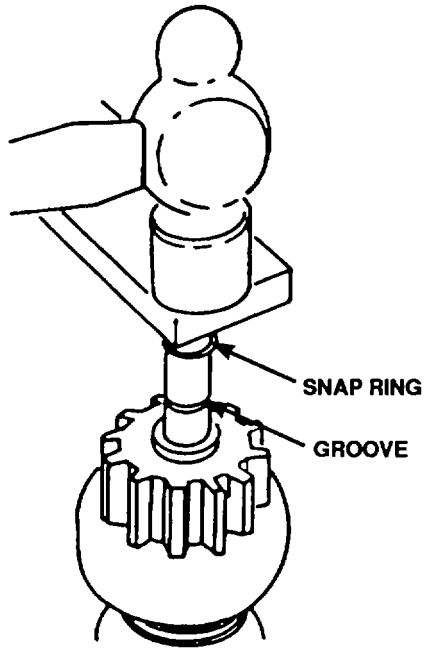


Figure 4-61. Starter Drive Snap Ring Installation

30. To force collar over snap ring, place suitable inside diameter washer over shaft.

31. Squeeze retainer and washer together with pliers. Remove washer (figure 4-62).

32. Install the armature with the control lever into the DE housing.

33. Insert the rubber seal between the DE housing and stator frame. Tighten control lever bearing pin in DE housing.

34. Install stator frame over armature.

35. Install brush plate on armature shaft and insert brushes into holders. Check brush pressure. Brush pressure should be 8.5 to 9.6 lb-ft (11 to 13 Nm).

36. Install commutator end plate.

37. Install washers and insulating washer on commutator end shaft. Install end cap and tighten retaining screws.

38. Reinstall solenoid in DE housing with three retaining screws. Install field lead to the solenoid terminal.

39. Check the spacing between the pinion (in the normally off position) and the stop ring (figure 4-63). The spacing should be 0.70 to +0.060-inch (18 ±1.5 mm).

40. Conduct starter motor performance test.

41. Reinstall starter motor.

42. Reconnect battery cables.

43. Remove OUT-OF-SERVICE tag from control panel.

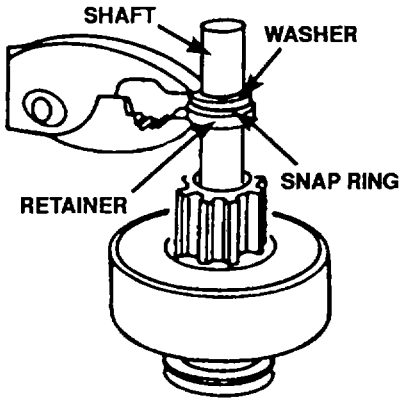


Figure 4-62. Securing Drive Retainer

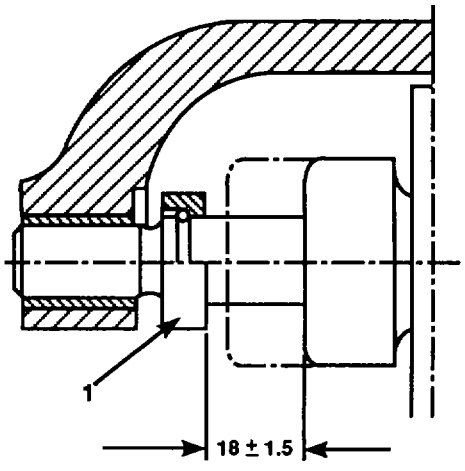


Figure 4-63. Pinion Depth

4-22. ALTERNATOR (ENGINE).

DESCRIPTION

This task covers: Repair. Test.

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Diagonal pliers
- Ohmmeter
- Bearing puller

Materials/parts:
- Inhibited Methyl Chloroform (O-T620)

Equipment conditions:
1. Alternator removed from engine (paragraph 3-38)
2. Electrical connections secured (paragraph 3-38)

REPAIR TEST

a. Clamp pulley (3) in a vise using an old oversize V-belt to prevent damage to the metal edges.

b. Remove pulley mounting nut (1) from shaft and split lock washer (2). Remove pulley and spacer (4) from alternator (figure 4-64).

c. Using diagonal pliers, remove Woodruff key (11), then remove fan baffle (5), fan (6), and fan spacer (7).

d. Inspect fan for bent, cracked or broken fins noting condition of the mounting hole. If it is worn, replace the fan.

e. Inspect pulley for worn drive surfaces. Note condition of key groove; check bore for wear. Replace, if required.

f. Disassemble stator. Using a wooden wedge and a screwdriver, remove four thru-bolts (18). Pry the front and rear housings apart so that stator (15) and rear housing (17) remain as an assembly and the rotor (12) and front housing (8) are another assembly.

g. Separate stator and rear housing.

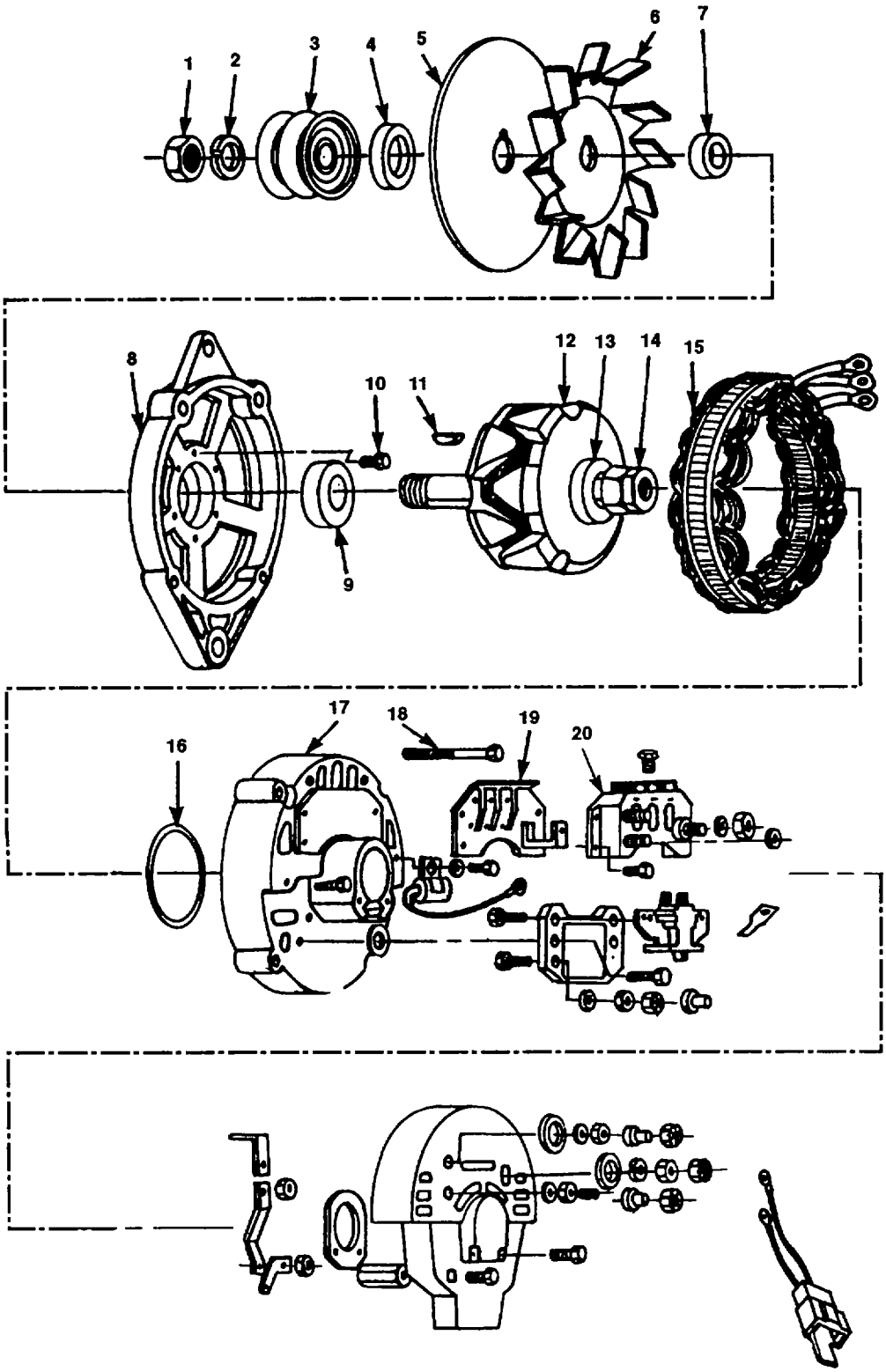


Figure 4-64. Alternator

1. Remove nuts and washers from A terminals. Lift stator leads off studs and separate rear housing (17) from stator assembly (15).

2. Place stator on a clean work surface. Clean off any accumulated chips or debris that would potentially damage the stator windings.

3. Separate rear housing from rectifier diode terminals (19).

h. Stator testing.

1. Inspect stator for physical damage. Look for evidence of the rotor striking lamination, broken insulation, or foreign material that may impede the flow of cooling air.

2. Check for discoloration of the winding insulating enamel. Discoloration of winding insulation enamel is a sign of an overheated stator that may result in shorted or grounded wires. Replace stator if discoloration is evident.

3. The stator assembly consists of three individual windings terminated in the delta type connections. Using an ohmmeter or a test lamp, check for winding continuity between terminals A to B, B to C, and C to A (figure 4-65). There should be no continuity from any terminal to point D (laminations).

i. Separate diode from rear housing. Remove hex nuts, lock washers, and insulators from alternator terminal studs. Remove negative brush lead from the negative rectifier heat sink. Carefully remove diode from the rear housing. Check rear housing for possible damage, paying particular attention to the bearing contacting surface. Replace housing if this surface is damaged or worn. Replace, if defective.

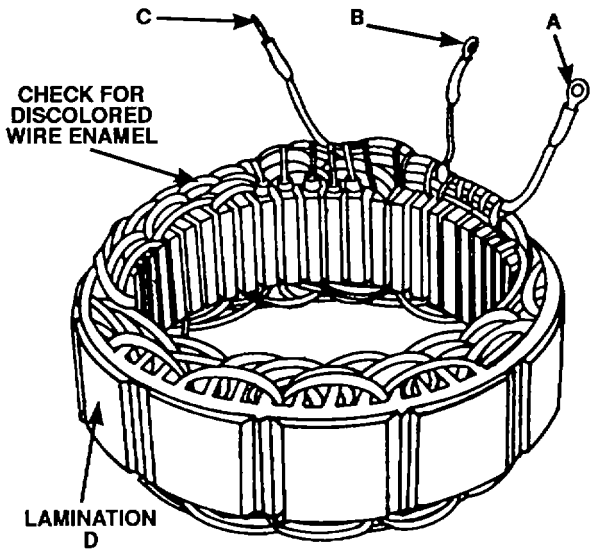


Figure 4-65. Stator Winding Test

j. Separate rotor from front housing.

1. Remove retaining screws (10).

2. Place the rotor/front housing assembly on a press, pushing rotor and front bearing (9) out of the front housing (8). Use a bearing puller to remove front bearing from the rotor shaft. Lift bearing off the shaft.

3. Check the rotor assembly for current draw or resistance.

CAUTION

Turn off dc power source before removing test leads to avoid arc damage to slip ring surfaces.

NOTE

Place test leads on edges of slip rings to avoid arcing on brush contact surfaces.

a) Current draw in amperes at 700 to 80'F should be 3.2 to 3.7 amps.

b) Resistance of windings in ohms at 700 to 80'F should be 4.0 to 4.7 ohm.

4. Grounded slip ring or winding.

Using a 12-Vdc test lamp, multimeter, or 1 10-Vac test lamp, place one test lead on the rotor body and the other on either slip ring. An open circuit should exist.

k. Test rotor winding.

1. Continuity. Use ohmmeter to check continuity, insulation, and resistance of the rotor winding.

2. Rotor shaft and body. Inspect for a) stripped threads on shaft, b) worn key slot, c) worn bearing surface, d) scuffed pole fingers, and e) worn or dry rear bearing. Replace rotor if any of the deficiencies are noted.

l. Slip ring removal. This is only necessary if the slip rings are worn beyond reuse or if the rear bearing must be replaced. Unsolder ends of rotor leads from slip ring terminals. Carefully unwind the ends of the rotor coil leads from the slip ring terminals. Straighten rotor leads. Insert a No. 10 x 1-inch cap screw into the opening at the center of the slip ring assembly. Position bearing puller (figure 4-66) and remove slip rings from rotor shaft. Slip ring assembly will usually slide off shaft. Use care not to damage leads. Slip ring may be cleaned with a fine crocus cloth.

m. Rear bearing removal. Move rotor leads away from the bearing puller contact area. Carefully remove bearing. Do not damage the threads at the end of the shaft with the puller. This completes the disassembly of the alternator. Clean all parts being reused with solvent (O-T-62).

n. Replace bearing.

o. Slide slip ring onto shaft.

1. Guide the rotor leads through one of the oval passages in the slip ring assembly. Ensure the oval passage is in line with groove in rotor shaft.

2. Place the rotor on a press (figure 4-67) and, using an installation sleeve with a diameter that clears the leads, press the slip ring assembly onto the rotor shaft.

3. Solder the rotor leads to the leads on the slip ring. Trim all excess lead extending above the soldered connections.

p. Solder end of rotor leads to slip ring terminals.

q. Placing the rotor/front housing assembly on a press, press front bearing (9) onto the rotor shaft and into the front housing (8).

r. Place diode (20) into rear housing.

s. Insert insulators into alternator terminal studs; replace lock washers and hex nuts.

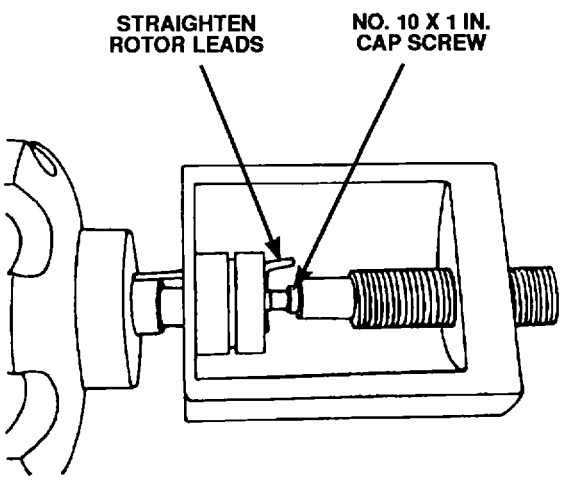


Figure 4-66. Removing Slip Ring Assembly

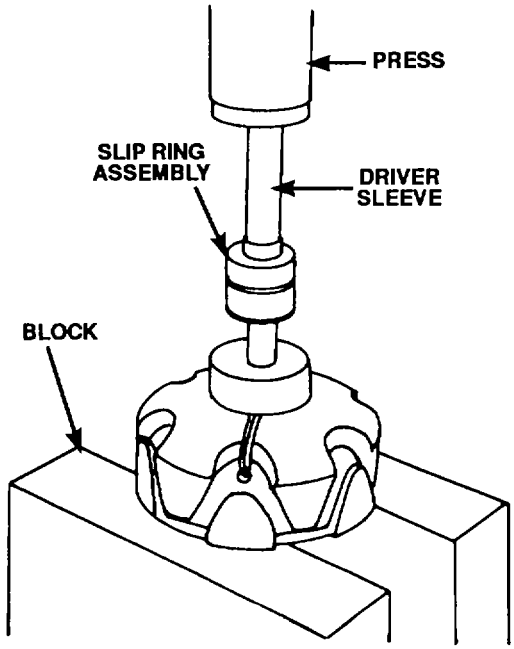


Figure 4-67. Installing Slip Ring Assembly

t. Attach rear housing (17) to rectifier diode terminals (19).

u. Place stator leads on studs and attach rear housing (17) to stator assembly (15). Replace washers and nuts onto A terminals.

v. Reattach rear housing assembly (with stator, 15) to front housing assembly (8) (with rotor, 12) with four thru-bolts (18).

w. Reinstall four spacer (7), fan (6), and fan baffle (5), and secure with Woodruff key (11).

x. Replace pulley (3) and spacer (4) onto shaft and secure with split lock washer (2) and pulley mounting nut (1).

y. Mount the alternator in a fixture cable of producing 5000 alternator rpm.

1. Connect leads, meters and instruments as shown (figure 4-68).

NOTE

The carbon pile or resistor load bank and ammeter must be capable of handling the alternator rated output at rated rpm.

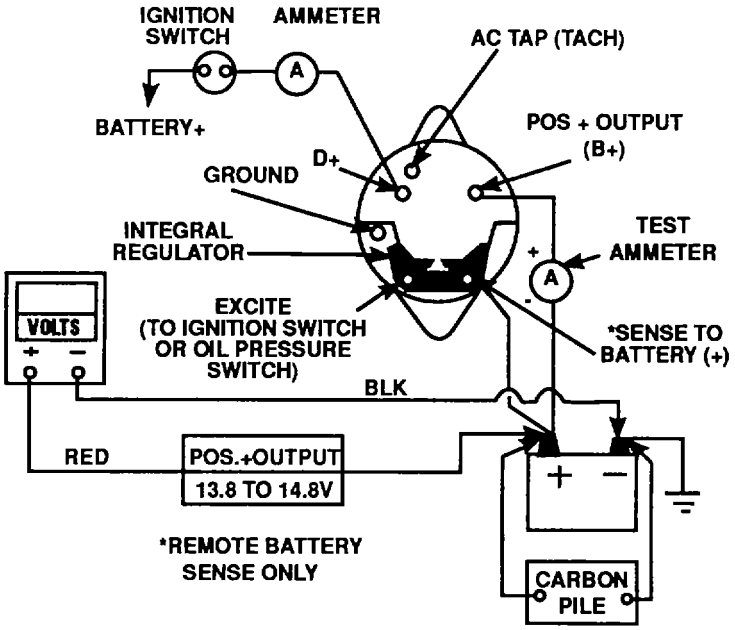


Figure 4-68. Alternator Performance Test

CAUTION

Ensure connections are secured and tightened to avoid possible damage to instruments, alternator, or wiring due to short circuits.

2. With the carbon pile off, turn the drive motor on and obtain 5000 alternator rpm. Slowly increase the load while observing the test ammeter and maintaining 5000 rpm.

3. Increase load until a minimum output voltage of approximately 13.7 volts is achieved. Record the output current at this point. The minimum acceptance output is 46 amps.

Follow on maintenance. Reinstall alternator onto engine (paragraph 3-39).

4-23. CLUTCH.

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Dial indicator
- Hammer

Materials/parts:
- Rigging device
- Wood blocks

Equipment conditions:
- Equipment secured (paragraph 2-11).

REMOVAL

a. Removal of PTO from the engine.

NOTE
Unless otherwise noted, callouts refer to figure 4-69.

1. Remove all attached parts such as guards, PTO front cover, belts, and drive components. Remove the drive key and grease fitting from the output end of the shaft.

NOTE
Not all power take-offs will have a grease fitting in the output end of the shaft. (Engage clutch operating handle to hold clutch facings in place, when removing PTO from engine.)

WARNING
To prevent injury, ensure that rigging device of adequate capacity is installed to lift the power take-off.

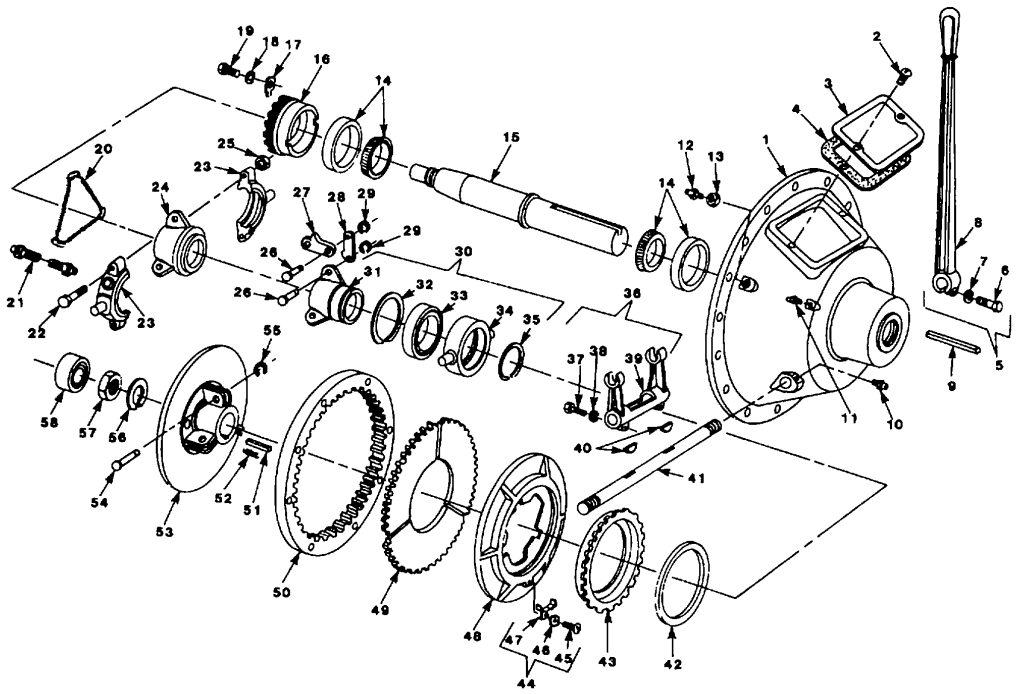


Figure 4-69. Clutch

2. Attach a suitable lifting device to the power take-off.

3. Remove the hex head cap screws that secure the power take-off housing to the flywheel housing.

CAUTION

Caution should be exercised when removing the power take-off from the engine so that the facings and pilot bearing are not damaged.

4. Support the power take-off on blocks with output end of the shaft down.

5. Remove two screws (1), nameplate (2), and gasket (3) from the power take-off housing (13).

6. Use 3/8-16 x 1/4-inch bolts in the PTO mounting flange threaded holes if necessary to separate the PTO from the flywheel housing.

NOTE

A common indication that the friction surface is worn out is that the adjusting ring cannot be turned any tighter.

b. Removal of clutch from shaft.

1. Bend lock tab on lock (56) away from nut (57).

2. Remove nut (57) and lock (56).

3. Remove clutch from shaft as follows: Place pry bars at opposite end of the clutch housing and behind pressure plate. Exert pressure outward (away from the roller bearings), rap pilot end of the shaft sharply with soft hammer to jar clutch assembly off the taper of the drive shaft.

c. Disassembly of HE clutch.

1. Remove clutch release lever (holdback) spring (20) from clutch release sleeve.

2. Match mark each half of release sleeve collar (23) to ensure that they will be assembled in their same relative position.

3. Remove the two nuts and bolts holding collar (23) together, then remove collar from release sleeve (24).

WARNING

To prevent serious eye injury while removing/installing retaining ring(s), wear safety eye protection. Ensure retaining ring(s) is secure in the ring groove.

4. Remove retaining rings (29) from pins (26). Remove pins (26) from links (28) and levers (27).

5. Remove retaining rings (55) from pins (54) that connect release levers (27) to the bosses on the clutch body (53). Remove pins and levers from clutch body. Note the direction the heads of the link to release sleeve and release lever to pressure plate pins are facing before removing so they may be installed in the same direction as they were removed.

6. Remove the adjusting ring lock retaining bolt (45), lock washer (46), and lock (47) from pressure plate (48).

7. Remove clutch adjusting ring (43) by turning counterclockwise out of the clutch pressure plate.

8. Lift clutch pressure plate (48) straight up off bosses of clutch body (53).

9. Remove the three clutch pressure plate separator springs (52) from holes in clutch body.

REPLACE **REPAIR**

a. Power Take-off. Wash all parts of the power take-off, except the clutch facings, in clean fuel oil or a good solvent, then blow dry before inspection.

NOTE

Tough or sticking spots of the bearings are cause to reject the bearings from further use.

1. Bearings. Examine cups, races, balls, and rollers for indications of corrosion or pitting. Apply light engine oil to the bearings; then, while holding the inner race, slowly revolve the bearing and outer race to check for free rolling of the balls or rollers on the races and cups. Power take-off with ball-type shaft bearings do not require bearing adjustment. The approved method for field adjustment of tapered roller bearings in the power takeoff unit is by use of a dial indicator to measure actual shaft end play. Adjust tapered roller bearings as follows:

   a) Remove the housing hand hole plate and the retainer lock.

   b) Tighten retainer to firmly seat both bearings. Mark notch for reference.

   c) Back off bearing retainer three of four notches.

   d) Tap output end of shaft with soft hammer to seat bearing cup against bearing retainer. This should be the approximate end play required.

   e) Measure actual end play with a dial indicator.

   f) Indicator readings should be taken with the indicator anchored to the housing and the indicator tip resting on the end of the shaft. Firmly hold housing and pry shaft axially in and out to get indicator reading.

   g) Adjust bearing retainer until measured end play is within limits.

   h) Lock bearing retainer.

2. Clutch Facings. Examine the clutch facings for being scored, burned or cracked; inspect driving teeth for wear or damage and measure thickness of the facings. Replace any clutch facing that is badly scarred, burned, or has driving teeth that are worn and/or damaged, or if the facing thickness is worn to under 5/16-inch.

3. Pressure Plates. Inspect the friction surfaces on the clutch body and pressure plate for being flat, smooth, and free from cracks and head checks. The drive bosses and keyway of the clutch body and the adjusting ring threads and boss notches of the pressure plate should be examined for wear, and if worn excessively, should be replaced.

4. Inspect the inner face and threads of the adjusting ring for wear or damage. If worn excessively, replace adjusting ring.

5. Pins and Pin Holes. Examine all lever and link pins and pin holes in links, release levers, release sleeve, and pressure plate for wear. If pins and pin holes in parts are worn excessively, the parts must be replaced.

6. Lock. Inspect the fingers of the adjusting ring lock for wear. Replace lock if fingers are worn excessively or have been damaged. Lock must have sufficient tension to hold adjusting ring from turning when clutch is operating.

7. Clutch Release Sleeve and Collar. Examine the wearing surface of the release sleeve collar and the mating surface on the release sleeve. If parts show excessive wear, they must be replaced.

8. Clutch Release Yoke. Inspect the surface of the clutch release yoke fingers and mating trunnions on the release sleeve collar for wear. If parts are worn excessively, they must be replaced.

9. Clutch Drive Shaft. Examine threads, keyways, and pilot bearing surface of the drive shaft.

10. Separator Springs. Check the pressure plate separator springs for being broken or weak. Approximate spring pressure is 15 to 20 lbs with the spring compressed to 13/16 of an inch.

b. Clutch Reassembly. With all the clutch parts cleaned and inspected and the necessary parts on hand, the power take-off may be reassembled as outlined in the following: Clutch Assembly having cleaned, inspected, and replaced all worn parts, assemble clutch as follows:

1. Place clutch body (53) on a workbench with hub end (release lever bosses) of pressure plate up.

2. Place clutch pressure plate separator springs (52) in holes provided in plate next to release lever bosses.

NOTE

If whole ring facing is to be used, it must be installed at this time.

3. Place pressure plate (48) on top of the clutch body (smooth face down) with notches in pressure plate in line with the release lever bosses of the clutch body, then lower pressure plate down on the three pressure plate separator springs (52).

4. Lubricate threads on clutch adjusting ring (43) and turn it clockwise into pressure plate (48) until it bottoms.

5 Install clutch release levers (27) in opening of bosses or clutch body (53) with notch end of lever up and out.

WARNING

To prevent serious eye injury while removing/installing retaining ring(s), wear safety eye protection. Ensure retaining ring(s) is secure in ring groove.

CAUTION

Ensure retaining rings are securely locked on pins.

CAUTION

Determine the direction the clutch will rotate when attached to the engine, then install lever pins with the heads of the pins leading the rotation of the clutch.

6. Align holes in levers (27) with holes in bosses of outer plate, then insert pins (54) through pin holes and secure with retaining rings (55).

7. Heeding the match marks previously placed on the two halves, lubricate inside diameter of clutch release sleeve collar (23). Place two halves together over the shoulder on release sleeve (24) with machined side of collar down and secure them together with two bolts and nuts. Rotate collar on sleeve to check for free turning. If collar binds on sleeve, it may be necessary to shim between the collar halves to allow running clearance.

CAUTION

Ensure the tapped hole in the release sleeve is facing the grease tube when assembled in the power take-off.

8 Place clutch release lever (holdback) spring (20) over end of release sleeve (24) and up against release collar before installing links (28) to release sleeve (24).

9. Place one release lever link (28) on each side of each hole on clutch release sleeve (24) with triangular end of release lever link at release sleeve and point of triangle facing toward center of release sleeve.

10. Attach lines to release sleeve with link pins (26) and retaining rings (29).

11. Place the clutch release sleeve (24) with other parts assembled, down on clutch with each pair of release links (28) astride release lever (27).

CAUTION

When installing pins, all pins must be installed with head leading rotation.

12. Connect links to levers with pins (26) and retaining rings.

NOTE

Be sure retaining rings (29) are securely locked on pins (26).

13. With the clutch release links (28) and release levers (27) connected, slide clutch release lever (holdback) spring (20) over ends of release lever lines and into place on release levers (27).

14. Insert the clutch facings (27 and 29) (three segments) in between the clutch body (53) and pressure plate (49), and center.

15. Lock clutch facings between the pressure plates as follows:

    a) With the clutch assembly resting on workbench, turn the clutch adjusting ring (43) counterclockwise until pressure plate (48) almost contacts clutch facing (49).

    b) Place clutch driving ring over clutch facings with teeth in driving ring in mesh with teeth of clutch facings, and locate the driving ring centrally relative to the pressure plate and clutch body.

NOTE

If driving ring is not properly located relative to pressure plate and clutch body, the clutch cannot be assembled on the flywheel as the teeth of clutch facings will not enter the teeth of driving ring even though the clutch drive shaft enters the pilot bearing.

c) Engage the clutch by applying pressure on top of release sleeve and collar assembly and lock clutch facings between the pressure plate and clutch body. If clutch facings are still free to move, disengage the clutch and turn adjusting ring counterclockwise just enough to lock the clutch facings in place when the clutch is engaged.

NOTE

The clutch must now be kept engaged until the power take-off assembly is attached to the engine.

16. Remove clutch driving ring (50) from the clutch facings and attach it to the flywheel with the specified bolts and lock washers.

c. Disassembly of Ball Bearing.

1. With the power take-off housing supported on blocks, use a standard bearing puller and remove the pilot bearing from the clutch shaft.

2. Straighten the tang on lock washer (34). Hold clutch and shaft, remove clutch shaft nut (33).

3. Remove the clutch from clutch shaft (15) as follows: Place pry bars at opposite sides over the housing and back of the clutch pressure plate. Hold pressure on both bars and rap the pilot bearing end of the shaft sharply with a babbitt hammer to free clutch from shaft.

4. Remove clutch and drive key (51) from drive shaft (15).

5. Loosen clamp bolt (6) and remove operating handle (7) from cross shaft (41).

6. Loosen the two bolts (37) in yoke (39).

7. Slide yoke left or right on the cross shaft to expose Woodruff keys (40).

8. Remove Woodruff keys (40) from cross shaft (41).

9. Withdraw shaft (41) from yoke (39) and housing (13).

10. Remove bearing retainer lock bolt (19) and lock (17).

11. Remove bearing retainer (16) bearing assembly (14) (bearing and spacer).

12. Remove the clutch shaft from the front of the power take-off housing by lightly tapping on the output end of the shaft with a soft hammer.

13. Thoroughly wash the bearing with clean fuel oil or solvent. Blow dry with compressed air and examine for wear, corrosion, or rough spots. If it is determined that the bearing is unsatisfactory for use, it must be removed from the shaft as follows:

    a) Remove retaining ring from bearing assembly (14, not shown).

    b) Place the clutch shaft on a press and press the bearing off the shaft.

d. Reassembly Procedure. Follow disassembly procedure in the reverse order to reassemble the power take-off, except for bearing installation.

1. Place one snap ring on the shaft, then stand shaft on end.

2. Heat bearing in oil until bearing expands enough to slide on shaft.

3. Lightly tap bearing to seat bearing against retaining ring.

4. Install remaining retaining ring against bearing.

e. Clutch Drive Shaft End Play.

1. Support the power take-off housing with a sling or chain hoist, drive (pulley) end of shaft down.

2. Lower power take-off until end of drive shaft rests on wood block on floor.

3. Take up space between bearing retainer and drive shaft by inserting four pieces of suitable shim stock equally spaced around shaft. The four pieces of shim stock must be of same thickness.

4. Mount a dial indicator to pilot bearing end of drive shaft. Position indicator to contact face of power take-off housing next to bearing retainer. Set dial indicator at zero.

5. Lift power take-off housing and drive shaft assembly from wood block.

CAUTION

Do not hit the shaft hard enough to disturb the dial indicator.

6. Lightly tap pilot bearing end of shaft to set shaft and outer bearing assembly against the outer roller bearing cup.

7. Note reading of dial indicator. Indicator will show amount of end play between drive shaft and housing.

8. Lower power take-off until end of drive shaft again rests on wood block and weight of power take-off is no longer supported by hoist.

9. Lightly tap on inner side of power take-off housing alternately around bearing retainer to ensure that inner roller bearing is set against bearing cup. The dial indicator should again be at zero.

10. Readjust end play, if necessary, by turning bearing retainer clockwise to decrease or counterclockwise to increase drive shaft end play.

11. Repeat steps 5 through 9 to ensure shaft end play readings are correct.

12. Reinstall bearing retainer lock and bolt.

13. Remove shim stock and dial indicator.

14. Support power take-off on wood blocks in horizontal position.

NOTE

Rotate the clutch drive shaft when filling bearing cavity to ensure that bearings and housing are full of grease.

15. Fill bearing cavity with lithium-based #2 grease, until grease starts to seep out around the clutch shaft at each end of power take-off housing.

f. Install Clutch.

1. Reinstall drive plate with clutch gear ring installed on the drive plate.

2. Torque to 18 lb-ft.

3. Reinstall clutch assembly with clutch lever engaged. Torque bolts to 32 lb-ft.

4. Check belt alignment.

5. Adjust belt tension (paragraph 3-16).

6. Adjust clutch lever tension (paragraph 3-39).

4-24. PRESSURE MAINTAINING VALVE (PMV)

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Alcohol, Isopropyl, item 1 Appendix E
Apron, Rubber, item 5 Appendix E
Bag, Plastic, item 6 Appendix E
Cloth, Lint-free, item 9 Appendix E
Detergent, non-ionic, item 13 Appendix E
Gloves, Rubber, item 17 Appendix E
Grease, Halo Carbon, item 19 Appendix E
Shield, Face, item 26 Appendix E
Teflon Tape, item 30 Appendix E
Trisodium Phosphate, item 31 Appendix E
Water, Distilled, item 32 Appendix E

Equipment conditions:
1. Equipment secured (paragraph 2-11)
2. Bleed system of pressure (paragraph 2-3)

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

REPLACE **REPAIR**

a. Removal.

1. Remove service line from PMV.

2. Remove PMV.

b. Disassemble (figure 4-70).

1. Loose jam nut (11) on PMV.

2. Remove adjusting screw (10).

3. Remove spring (9) and pad assembly (8).

4. Remove screw seat (3) from inlet side.

5. Remove ball (4) and plunger assembly (6). Remove and discard 0-ring (7).

6. Inspect the screw seat and ball for nicks, scratches, pitting, and unusual wear.

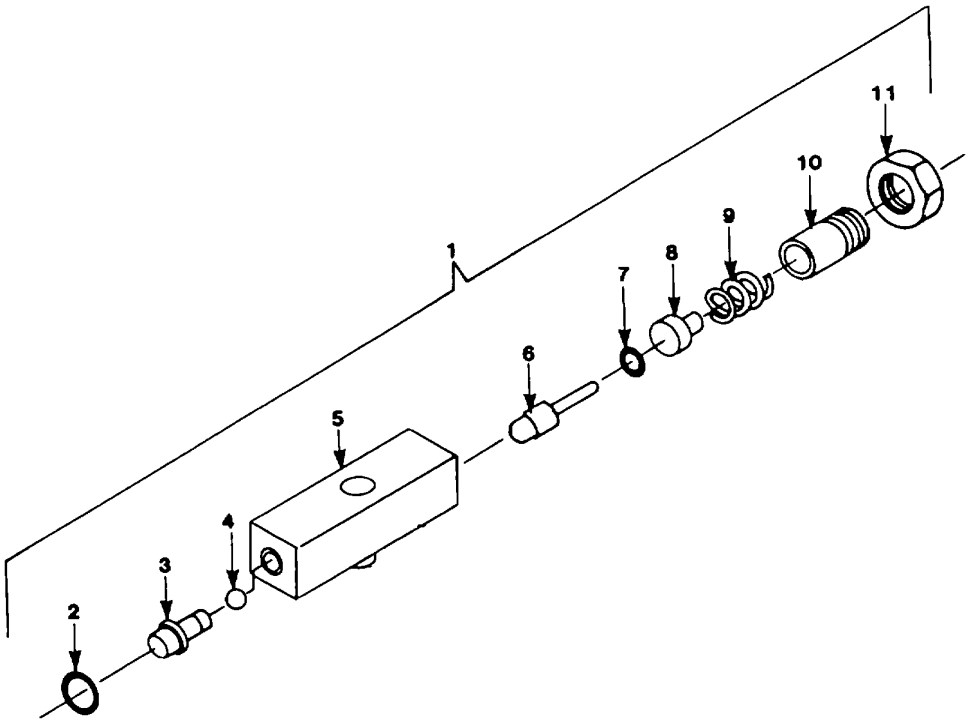


Figure 4-70. Pressure Maintaining Valve (PMV)

7. Remove 0-ring (2) from screw seat and inspect. Replace as necessary.

8. Clean all parts in accordance with Army diving cleaning procedures.

c. Reassemble.

1. Install 0-ring (2) on seat screw.

2. Install 0-ring (2) on plunger (6) approximately 1/4-inch onto shaft and lightly lubricate 0-ring and shaft.

3. Insert plunger (6) assembly into inlet side of PMV.

4. Lightly lubricate seat screw 0-ring, and install seat screw (3) through the inlet side of PMV. Tighten screw until the seat bottoms out.

5. Install spring (9) and spring pad (8) into PMV adjustment side.

6. Install adjusting screw (10) over spring and hand-tighten.

d. Installation.

1. Reinstall PMV onto filter chamber outlet.

2. Reinstall service line connection.

4-25. PURIFIER CHAMBER.

DESCRIPTION

This task covers: Replace Repair

INITIAL SETUP

Tools:
- General Mechanic Tool Kit
- Securus wrench

Materials/parts:
- Alcohol, Isopropyl, item 1 Appendix E
- Apron, Rubber, item 5 Appendix E
- Bag, Plastic item 6 Appendix E
- Book, Record, item 7 Appendix E
- Cloth, Lint-free, item 9 Appendix E
- Detergent, Non-ionic item 13 Appendix E
- Gloves, Rubber item 17 Appendix E
- Grease, Halo Carbon, item 19 Appendix E
- Shield, Face, item 26 Appendix E
- Trisodium Phosphate, item 31 Appendix E
- Water, Distilled, item 32 Appendix E

Equipment condition:
1. Equipment secured (paragraph 2-11)
2. Bleed system of pressure (paragraph 2-3)

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

SERVICE

a. Removal (figure 4-71).

1. Using Securus wrench, unscrew chamber caps (9).
2. Remove and discard filter (7).

b. Installation.

CAUTION

While replacing filters, do not allow hands to come in contact with filters. Follow installation instructions explicitly.

1. Remove both ends of filter packaging.
2. Remove protection caps at either end.
3. Grasp filter in mid-section with filter packaging in place.
4. Position filter over housing and carefully allow filter to slide fiom packaging into housing. Press down on filter to seat 0-rings.
5. Reinstall cap and, using Securus wrench, tighten cap securely.

REPLACE **REPAIR**

a. Removal.

1. Remove inlet tubing from the pressure maintaining valve (PMV).
2. Remove the final gauge line from the bleed down tee fitting.
3. Remove the PMV.
4. Remove the outlet tubing.

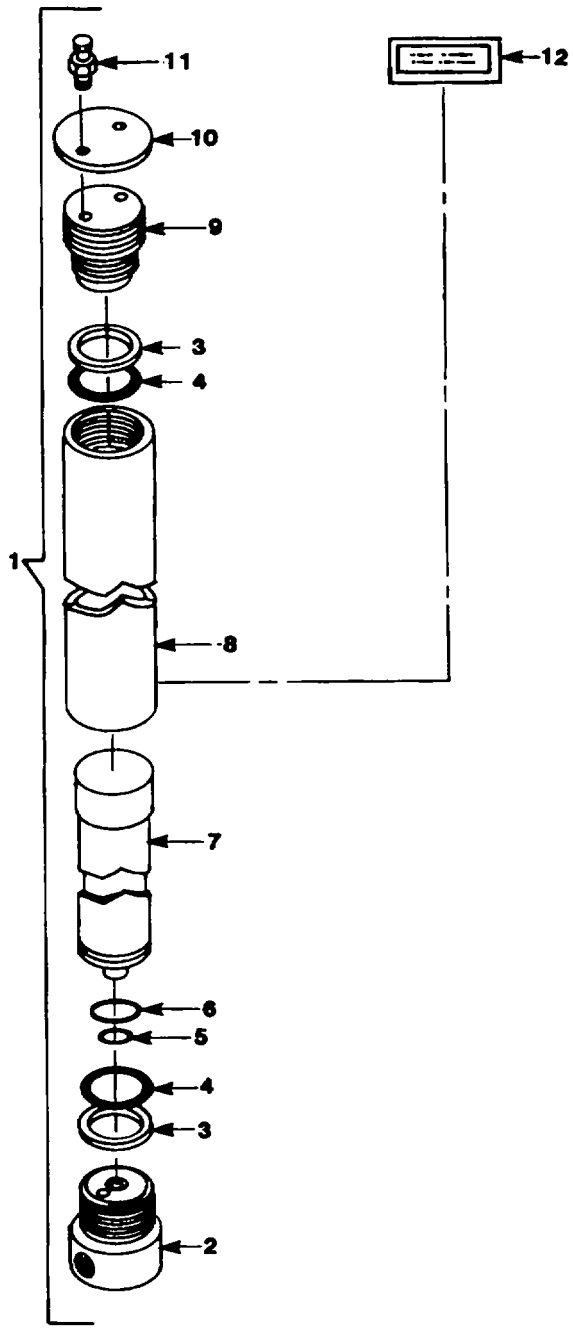


Figure 4-71. Purifier Chamber

CAUTION

Care should be taken when loosening the chamber brackets. The chambers should drop down approximately one to two inches and could possibly break off the bleed off and check valve fittings.

5. Remove chambers from frame.

6. Disassemble chambers and replace seals, if necessary.

REPLACE REPAIR

Purification Check Valve.

a. The purification check valve serves a dual purpose in the air system.

   1. Maintains 1800 to 2000 psi on the purification chambers when not in use (air escaping through compressor).

   2. Prevents sudden loading of the 4th stage in case the service line check valve fails.

b. The purification check valve is suspect when the unit has been secured for 24 hours and when opening the bleed valve no air is heard to escape (a leak check should be performed with unit at full pressure to ensure air did not leak out).

c. Removal (air bled off system).

   1. Remove service line.

   2. Remove fitting from check valve.

   3. Remove check valve.

NOTE

Repair is by replacement only. Do not attempt repair.

d. Install.

   1. Install check valve.

   2. Install fitting.

3. Install service line.
4. Perform operators maintenance and start compressor.
5. Perform leak test and repeat step b.

4-26. SEPARATOR BLOCK

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Equipment conditions:
Battery removed

Materials/parts:
Cloth, Lint-free, item 9 Appendix E
Detergent, Non-ionic, item 13 Appendix E
Grease, Halo Carbon, item 19 Appendix E
Rags, Wiping, item 26 Appendix E
Teflon Tape, item 30 Appendix E

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

a. Remove (figure 4-72).

1. Remove the six tubes that are attached to the top of the condensate blocks.

2. Remove the condensate drain line (located on the bottom right hand side of the block.)

3. Remove the four bolts securing the condensate block to the frame.

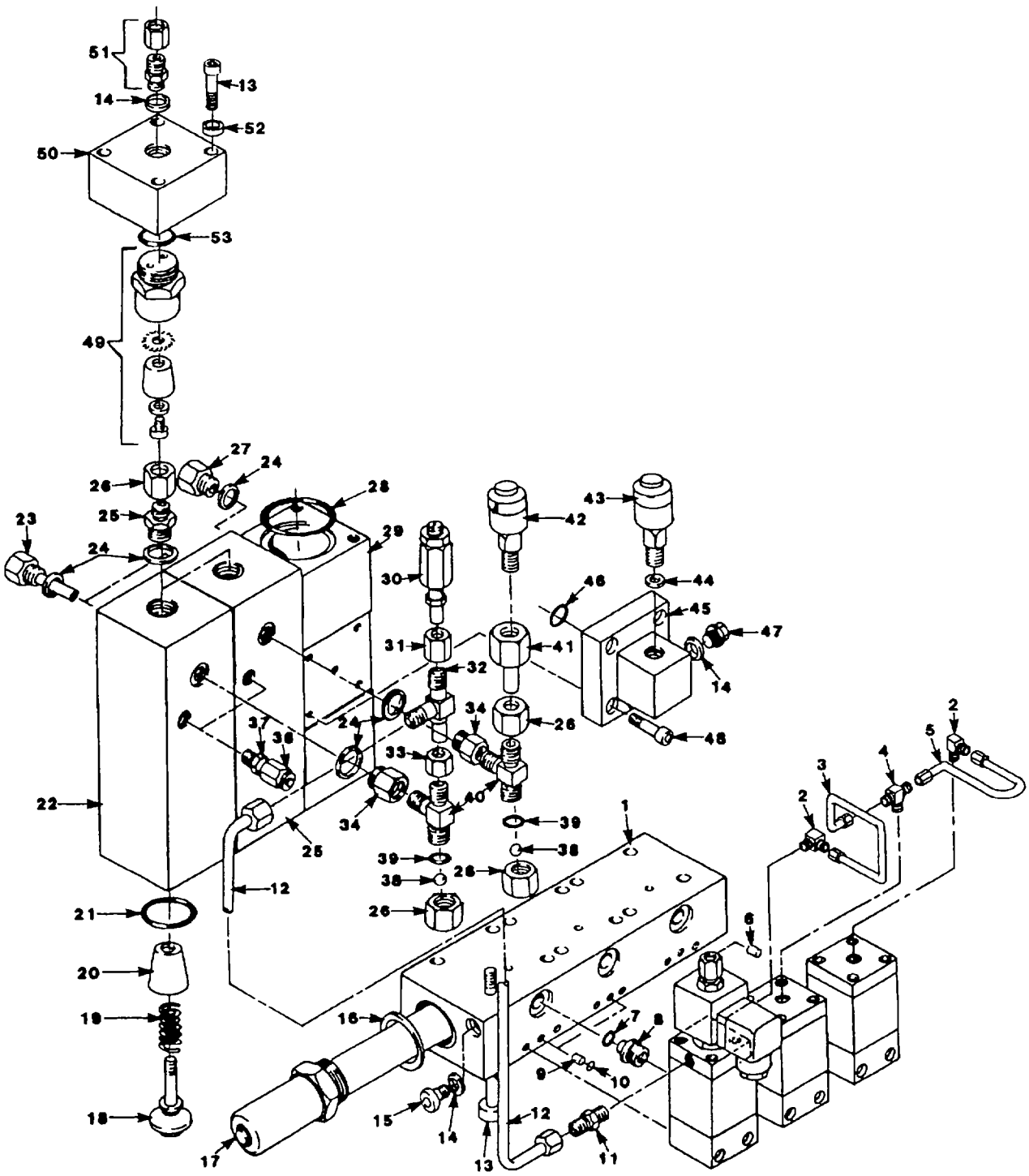


Figure 4-72. Separator Block (Sheet 1 of 2)

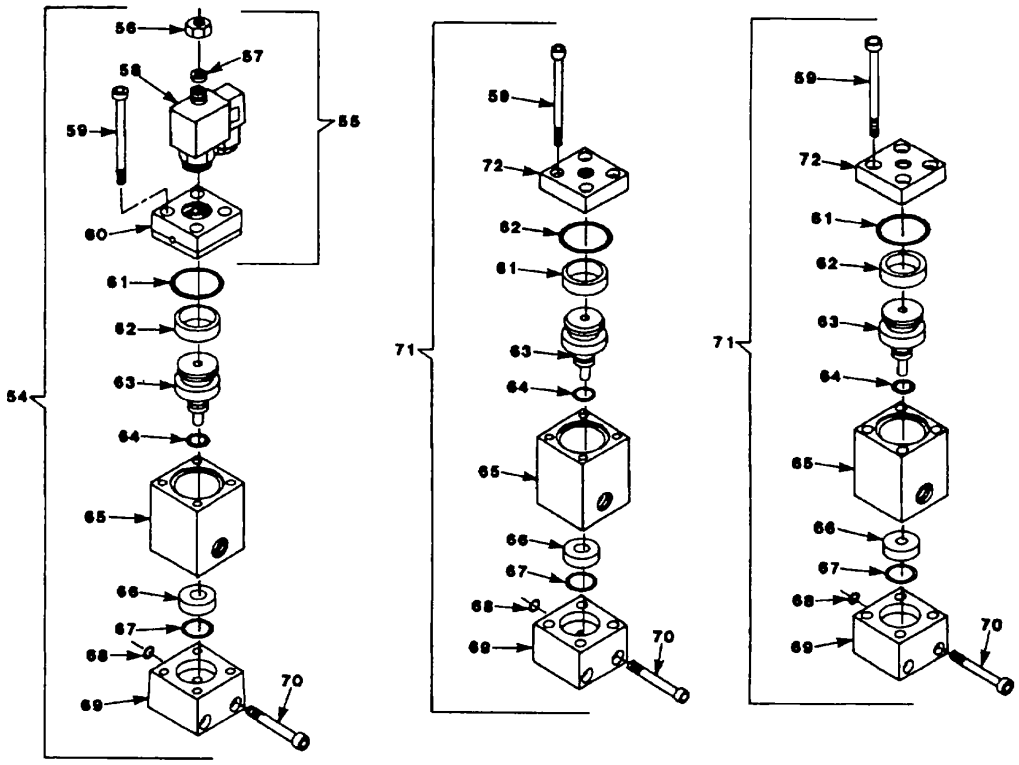


Figure 4-72. Separator Block (Sheet 2 of 2)

4. Remove the two screws securing the condensate heater cover and slide towards the wing harness. Remove the two wires taking note of their position for reassembly.

5. Remove condensate block (22) from unit.

6. Disassemble the vortex element (49) from the head.

7. Remove the four bolts (48) that retain the flange for the final pressure safety valve (43).

8. Remove the four allen head bolts (13) that secure the separator block to the base plate (1).

9. Remove the intermediate pressure relief safety valve (42). Remove the four bolts from the base plate that secure the intermediate separator housing in place. Remove the 0-ring (53) and the vortex element inside the separator housing.

10. Remove the safety valve (30) from the first condensate block. Remove the four bolts that secure the first separator block to the base plate. Remove the 0-ring and the vortex element from the separator block.

11. Remove heater element (17) from base plate.

c. Inspect and clean separator assembly.

CAUTION

All breathing air compressor parts will be cleaned in accordance with the prescribed procedures outlined in NEDU 7121. Refer to Appendix A. Caution must be taken when cleaning parts to ensure that parts are not contaminated. THIS IS YOUR BREATHING AIR.

1. Inspect all 0-rings, pistons, and seats for damage, nicks, or cuts. Replace, if necessary.

2. Inspect the solenoid piston seats (there is a seat on both ends) for unusual wear or damage. Replace, if necessary.

3. Clean out condensation blocks and condensate valves. Inspect for signs of wear or damage.

4. Clean the base and condensate galleys (heater element must be removed). Check for signs of corrosion and damage.

d. Reassembly.

1. Reassemble condensate blocks and install blocks on the condensate base plate.

2. Reassemble the condensate valves ensuring proper assembly for each block.

3. Assemble condensate valves to the condensate block.

4. Assemble the drain solenoid and reinstall on the first condensate drain valve assembly.

5. Reinstall heater assembly.

6. Install the three tubing assemblies on the condensate drain valves.

7. Reinstall condensate block assembly to the compressor and reinstall wires for the heating element. Install solenoid windings over the solenoid posts and secure.

8. Reconnect the six tubing fittings on the condensate blocks.
9. Check for leaks.

4-27. INSTRUMENTS AND CONTROL PANEL ASSEMBLY (VALVES)

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Cloth, Lint-free, item 9 Appendix E
Detergent, Non-ionic, item 13 Appendix E
Teflon Tape, item 30 Appendix E
Water, Distilled, item 32 Appendix E

Equipment condition:
Equipment secured (paragraph 2-11)
Bleed system pressure (paragraph 2-3, b)

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

REPAIR

Service Line Valve

a. Removal.

1. Remove instrument rear panel.

2. Remove service line fitting and service line gauge tube. Remove outlet tube to bulkhead fitting.
3. Remove handle and securing nut from valve.
4. Remove valve.

b. Installation.

1. Replace fittings on new valve by examining old valve and removing one fitting at a time.
2. Install new valve and tighten retaining nut hand-tight.
3. Loosely install outlet to bulkhead fitting, service line gauge tube, and service line.
4. Tighten valve retaining nut and replace handle.
5. Tighten all loose fittings.
6. Perform operator's maintenance and run unit to full operating pressure.
7. Soap test all fittings.
8. Replace instrument rear panel.

Service Line Check Valve.

a. The service line check valve serves a dual purpose in the air system:

1. To prevent air from entering the purifier assembly in the wrong direction of flow.
2. Allows the compressor to match the pressure that is being required by the service line pressure.

b. Service line check valve is suspect when the service line pressure gauge reads higher than the line pressure gauge, and upon opening the service line valve, they immediately equalize.

c. Removal (air bled off system).

1. Remove instrument back panel.
2. Remove service line into check valve and 90-degree elbow.
3. Remove check valve.

NOT
Repair is by replacement only. Do not attempt repair.

d. Install.

1. Install check valve on service valve inlet.
2. Install 90-degree elbow (inlet facing down).
3. Reconnect service line.
4. Perform operator's maintenance and start compressor.
5. Perform leak test and repeat step b.
6. Reinstall instrument rear cover.

4-28. ELECTRICAL SYSTEM

DESCRIPTION

This task covers: Repair. Adjust. Test.

INITIAL SETUP

Tools:
General Mechanic Tool Kit
Multimeter

Equipment conditions:
Engine secured
(paragraph 2-11)

Materials/parts:
None

REPAIR **ADJUST**

a. Condensate Heater/Temperature Sensing Switch.

1. Remove line connections and electrical connection to condensate heater.
2. Remove temperature sensing switch and condensate heater element.
3. Remove heater block from ACD unit.
4. Reconnect heater element to ACD block.
5. Reconnect electrical connections and line connections to condensate heater.

b. High Temperature Cutout Switch.

1. Unscrew connection from fourth state cylinder head of compressor.
2. Remove temperature cutout switch from socket.
3. Replace with identical unit.
4. Connect to fourth stage cylinder head and make electrical inspection.

c. Hourmeter.

1. Remove two leads at the back of the hourmeter.

2. With screwdriver and open end wrench, remove three screws that attach hourmeter to instrument panel.
3. Replace with identical unit.
4. Mount gauge to instrument panel; secure wit three screws and nuts.
5. Make two electrical connections to hourmeter.

d. Ammeter.

1. Remove three electrical leads at the back of the ammeter.
2. Loosen and remove nuts that hold bracket in place.
3. Remove bracket and pull ammeter free.
4. Replace with identical suit.
5. Install new ammeter. Place brackets over studs on ammeter. Secure in place with nuts.
6. Reconnect electrical connections.

e. Stop lever/solenoid.

1. Disconnect electrical connections.
2. Remove bolts and nuts that secure solenoid to stop lever.
3. Replace solenoid.
4. Reattach to engine and connect electrical wires.

TEST

a. Run Solenoid. The run solenoid (figure 4-73) has a dual electromagnetic coil system for energizing and holding the plunger. The holding coil is energized when the switch is in the ON position and the relay latch button is in. Turning the starter switch to the START position energizes the second coil.

NOTE
Two people are required for the following step.

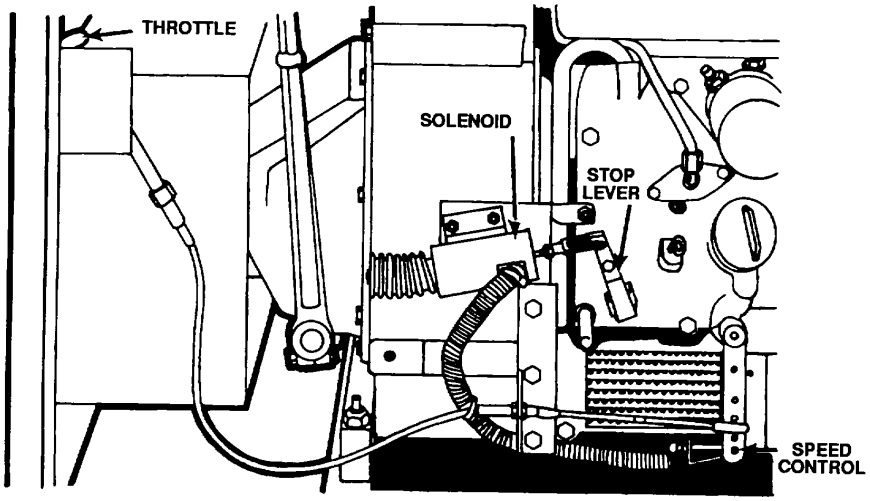


Figure 4-73. Stop Lever/Solenoid Speed Control/Throttle

1. Follow start-up procedures to turn the ignition switch ON, but do not turn to START. With the safety bypass turned on, person No. 1 presses the oil pressure button, while person No. 2 presses the plunger toward the front of the engine. Solenoid should lock in the RUN position. If solenoid does not lock in place, check for voltage between Black No.2 and Red No.9 for 12 volts (figure 4-74). If voltage is present, suspect the solenoid.

2. Attach a multimeter to Black No. 2 and White No. 8. Turn the key to start and watch for 10 to 12-volt reading. If multimeter indicates voltage, suspect the solenoid.

3. Isolate the solenoid if (a) or (b) indicates a bad solenoid. Set multimeter to 200 ohms and do the following:

4. If any values are not within the range in table 4-10, replace the solenoid.

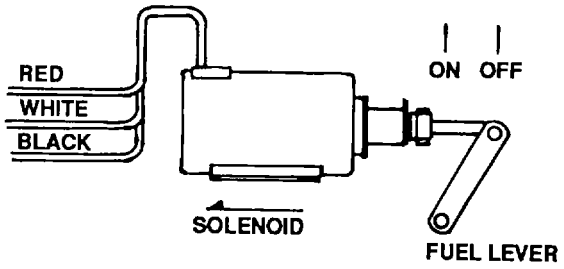


Figure 4-74. Solenoid Wiring

Table 4-10. Run Solenoid Resistance Values

Function	Multimeter Setting	Wire	Wire	Value
Hold	2000	Red #9	Black #2	10 to 20Q
Pull	200w	White #8	Black #2	2 to .3*
N/A	200w	Red #9	White #8	10 to 20Q
N/A	2OK2	All Wire	Body	Open

*Pull coil resistance is difficult to check, but will normally read an open circuit if defective.

NOTE

Ensure that the solenoid body has a proper ground before discarding.

5. Reassemble solenoid on engine, but do not reconnect the black to #2 white.

6. Ground the black wire directly to the solenoid mount frame and attempt restart. If this procedure works, ground the instrument panel to the frame.

NOTE

Do not energize the coil when body is off the condensate valve body. Damage to coil will occur.

b. Condensate Drain Coil.

1. Remove condensate drain coil by loosening the nut on the top and disconnecting the electrical connection.

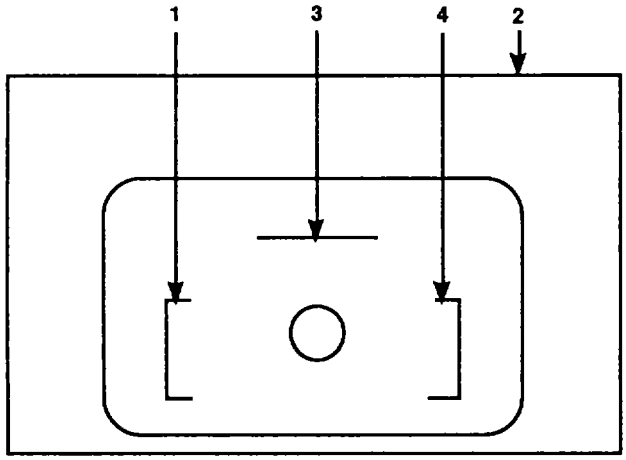


Figure 4-75. Condensate Drain Coil Test Points

2. Using a multimeter on 200 ohms, check for resistance (figure 4-75).

3. If any values are not within the range in table 4-11, replace the coil.

Table 4-11. Condensate Drain Coil Resistance Values

Test	Multimeter Setting	Red Lead	Black Lead	Value
Coil	200 ohms	1	2	5.5 ±10%
Short	200 ohms	3	1 then 2	Open
Short	200 ohms	3	4	Closed
Short	200 ohms	1	4	Open
Short	200 ohms	2	4	Open

4-29. TUBINGS AND FITTINGS

DESCRIPTION

This task covers: Replace

INITIAL SETUP

Tools:
General Mechanics Tool Kit
Swedge Lock Tool(s)

Equipment Conditions:
Equipment secured (paragraph 2-11).
System bled of pressure (paragraph 2-3).

Materials/parts:
Detergent, non-ionic, item 13 Appendix E.

REPLACE

WARNING

Cleanliness is imperative in maintaining and handling diving system components. All tools and parts must be kept free of oil, grease, rust, or other contamination in accordance with accepted Army diving cleaning procedures. Foreign substances within an assembly could result in equipment failure and possible injury or death to personnel.

WARNING

Any break in air system integrity can cause contamination of the air system. Serious injury or death may result due to air system contamination. Follow Army diving cleaning procedures to maintain air system integrity.

a. Remove defective tubing section.
b. Inspect adapter thread for wear or cross-threads. Replace, as necessary.
c. Replace defective tubing with fittings.
d. Bring system to full pressure and soap test new tubing fittings.

CHAPTER 5
GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I.
GENERAL SUPPORT TROUBLESHOOTING

5-1 GENERAL SUPPORT TROUBLESHOOTING PROCEDURES. This section contains general support troubleshooting procedures as authorized by Maintenance Allocation Chart (MAC).

Table 5-1. General Support Troubleshooting

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR
1. Sight glass exhibits air bubbles. Step 1. Check to see if 4th stage outlet valve is defective. Replace outlet valve.
2. Compressor does not attain final pressure. Step 1. Check to see if there is excessive piston clearance. Replace.
3. Final pressure safety valve blows off with no or minimum air delivery from the tap. Step 1. Check to see if pressure regulating valve is adjusted too high or is stuck. Dismantle pressure regulating valve and clean valve. Step 2. Check to see if non-return valve is corroded. Clean if possible or replace. Step 3. Check to see if no air is coming through to filling tap. Clean the sintered filter before the filling tap must be cleaned or exchanged. Step 4. Check to see if final pressure safety valve is defective. Repair or replace, if necessary.
4. Compressor air delivery is insufficient. Step 1. Check to see if intake/discharge valve of 1st stage is malfunctioning. Replace or repair, as required. Step 2. Check the intake/discharge valves of 2nd, 3rd, or 4th stage if intermediate pressure of any stage is too high. Examine intake/exhaust valves of 2nd, 3rd, and 4th stage, respectively; repair, as required. Step 3. Intermediate pressure is too low, there is leakage in the piping system, automatic condensate drain system, or in the start without loading system. Locate and repair leak.

Table 5-1. General Support Troubleshooting (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
COMPRESSOR (Contd)
4. Compressor air delivery is insufficient (Contd). Step 4. Check to see if final pressure rises only to operating pressure of prefinal safety valve. Examine free floating piston of final stage and replace, as required.
ENGINE
5. Engine fails or difficult to start. Step 1. Check to see if fuel feed pump diaphragm is defective. Disassemble and replace diaphragm. Step 2. Check to see if commencement of delivery setting is incorrect. Adjust valve timing. Step 3. Check to see if compression pressure is too low. Replace valves, piston rings, or cylinder, as required. Step 4. Check to see if cylinders and/or piston rings are worn. Replace, as required. Step 5. Check to see if the piston crown clearance is excessive. Adjust as needed.
6. Temperature shutdown activates warning. Step 1. Check to see if fuel delivery timing is incorrect. Adjust timing. Step 2. Check to see if amount of fuel injected is excessive. Adjust timing.
7. Engine gives poor performance. Step 1. Check to see if commencement of delivery setting is incorrect. Adjust timing. Step 2. Check to see if compression pressure is too low. Replace or adjust valves, piston rings, or cylinder liner. Step 3. Check to see if cylinders and/or piston rings are worn. Replace cylinder or piston rings. Step 4. Check to see if piston crown clearance is excessive. Adjust clearance.

Table 5- 1. General Support Troubleshooting (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (Contd)
8. Engine oil pressure zero or too low. Step 1. Check to see if oil control valve is defective. Repair control valve. Step 2. Check to see if lube oil pump is defective. Repair lube oil pump. Step 3. Check to see if main and/or connecting rod bearings are defective. Replace bearings. Step 4. Check to see if cylinder and/or piston rings are worn. Replace cylinders or rings, as required.
9. Engine smokes blue. Step 1. Check to see if cylinders and/or piston rings are worn. Replace cylinders or piston rings.
10. Engine smokes white. Step 1. Check to see if commencement of delivery setting is incorrect. Adjust timing. Step 2. Check to see if compression pressure is too low. Replace piston rings, valves or cylinders, as required. Step 3. Check to see if piston crown clearance is excessive. Adjust clearance.
11. Engine smokes black. Step 1. Check to see if commencement of delivery setting is incorrect. Adjust timing. Step 2. Check to see if amount of fuel being injected is excessive. Adjust timing. Step 3. Check to see if valve clearance is incorrect or valves are worn. Adjust valve clearance or replace valve. Step 4. Check to see if compression pressure is too low. Replace piston rings, valves or cylinders, as required.
12. Engine does not run smoothly. Step 1. Check to see if fuel feed pump is defective (diaphragm). Repair, as required. Step 2. Check to see if commencement of delivery setting is incorrect. Adjust timing.

Table 5- 1. General Support Troubleshooting (Continued)

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (Contd)
12. Engine does not run smoothly (Contd). Step 3. Check to see if compression pressure is too low. Replace piston rings, cylinders, or valves. Step 4. Check to see if cylinders and/or piston rings are worn. Replace cylinders or piston rings. Step 5. Check to see if flexible engine coupling is defective. Overhaul or replace coupling, as required.
13. Engine oil consumption excessive. Step 1. Check valve guides. Repair or replace. Step 2. Check cylinder and piston clearance. Adjust clearance.

Section II.
GENERAL SUPPORT MAINTENANCE PROCEDURES

5-2 GENERAL. This chapter will describe maintenance that must be performed on the engine and compressor assemblies beyond authorized capability of lower levels. This chapter contains maintenance at the General Support Level as authorized by the Maintenance Allocation Chart (MAC).

5-3. UPPER CRANKCASE AND DRIVE GEAR (COMPRESSOR).

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
Feeler gauge (metric)
Mallet

Materials/parts:
Alcohol, Isopropyl, item 1 Appendix E
Apron, Rubber, item 5 Appendix E
Bag, Plastic, item 6 Appendix E
Cloth, Lint-free, item 9 Appendix E
Detergent, Non-ionic, item 13 Appendix E
Gloves, Rubber, item 17 Appendix E
Grease, Halo Carbon, item 19 Appendix E
Shield, Face, item 27 Appendix E
Silicone, RTV Sealant, item 28 Appendix E
Trisodium Phosphate, item 31 Appendix E
Water, Distilled, item 32 Appendix E

Equipment conditions:
Equipment secured (paragraph 2-11)
All cylinders and pistons removed (paragraph 4-6).
Fan and flywheel removed (paragraph 4-9).
Remove rear covers, gears, and belt for oil pump (paragraph 5-4).

a. Crankshaft.

1. Remove the crankshaft, together with the bearing cap, from the crankcase using a mallet.

2. Remove the circlip and press the crankshaft out of the bearing cap.

NOTE

The following checks are to be made every 2000 working hours.

INSPECT

a. Upper connecting rod bearings (small end). The needles of the needle bearing should revolve smoothly after cleaning and show no damage. The same applies to the piston pin.

b. Axial play of the connecting rods on the crankshaft (figure 5-1). Bring all connecting rods to one side. Then determine the axial play by means of a feeler gauge 0.016-inch min. to 0.032-inch max. (minimum 0.4 mm, maximum 0.8 mm).
c. Radial play of the bearings (figure 5-2). The radial play of the connecting rod bearings is correct when all connecting rod small ends can be tilted by 0.4 to 0.8-inch (1 to 2 mm). If these tolerances are not met, replace the complete crankshaft and connecting rod assembly

CAUTION

The replacement of individual connecting rods is not recommended. The bearing play is adjusted at the factory by means of needle cages with various needle diameters.

REPLACE

a. Press the crankshaft into the bearing cap. Replace circlip.
b. Reassemble order of connecting rods.
c. Mounting Order Center Distance of Connecting Rod to Bearing

1.	3rd stage	120 mm
2.	4th stage	120 mm
3.	1st stage	145 mm
4.	2nd stage	170 mm

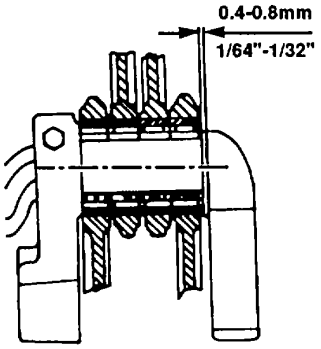


Figure 5-1. Connecting Rod Axial Play

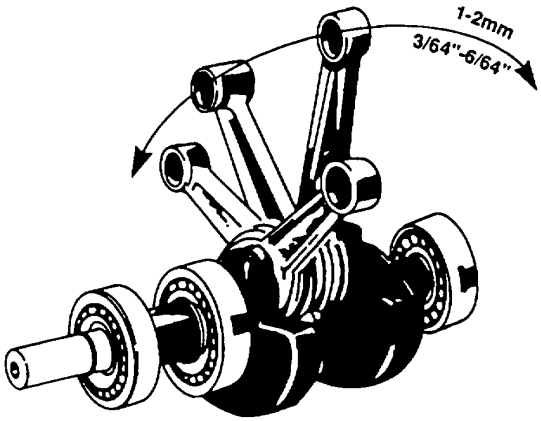


Figure 5-2. Connecting Rod Radial Play

REPAIR

Replace the complete crankshaft and connecting rods if tolerances in step c are not met.

Follow on maintenance:

Replace rear cover, gears, and belt for oil pump (paragraph 5-4).

Replace cooling fan and flywheel (paragraph 4-9).

Replace cylinders and pistons (paragraph 4-6).

5-4. LOWER CRANKCASE AND TENSION PULLEY ASSEMBLY (COMPRESSOR)

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
General Mechanic Tool Kit

Materials/parts:
Alcohol, Isopropyl, item 1 Appendix E
Apron, Rubber, item 5 Appendix E
Bag, Plastic, item 6 Appendix E
Cloth, Lint-free, item 9 Appendix E
Detergent, Non-ionic, item 13 Appendix E
Gloves, Rubber, item 17 Appendix E
Grease, Halo Carbon, item 19
Shield, Face, item 26 Appendix E
Silicone, RTV Sealant, item 28 Appendix E
Trisodium Phosphate, item 31 Appendix E
Water, Distilled, item 32 Appendix E

Equipment conditions:
Equipment secured (paragraph 2-11)
Upper crankcase removed (paragraph 5-3).
Drain oil from crankcase (paragraph 3-16, c).
4th stage valve head removed (paragraph 4-8, c).

REPAIR

NOTE

Disassembly of lower crankcase can be done with the upper crankcase assembled or disassembled. Usually, the upper and lower crankcase are disassembled at the same time. The only exception would be for crankshaft, camshaft bearing, or oil pump failure.

a. Disassembly (disregard, if not needed).

1. Remove the four allen head bolts (2) from the oil pump timing belt cover (1) (figure 5-3).

2. Remove timing belt adjusting pulley (7) and the crankshaft pulley (3). Remove oil pump belt (14).

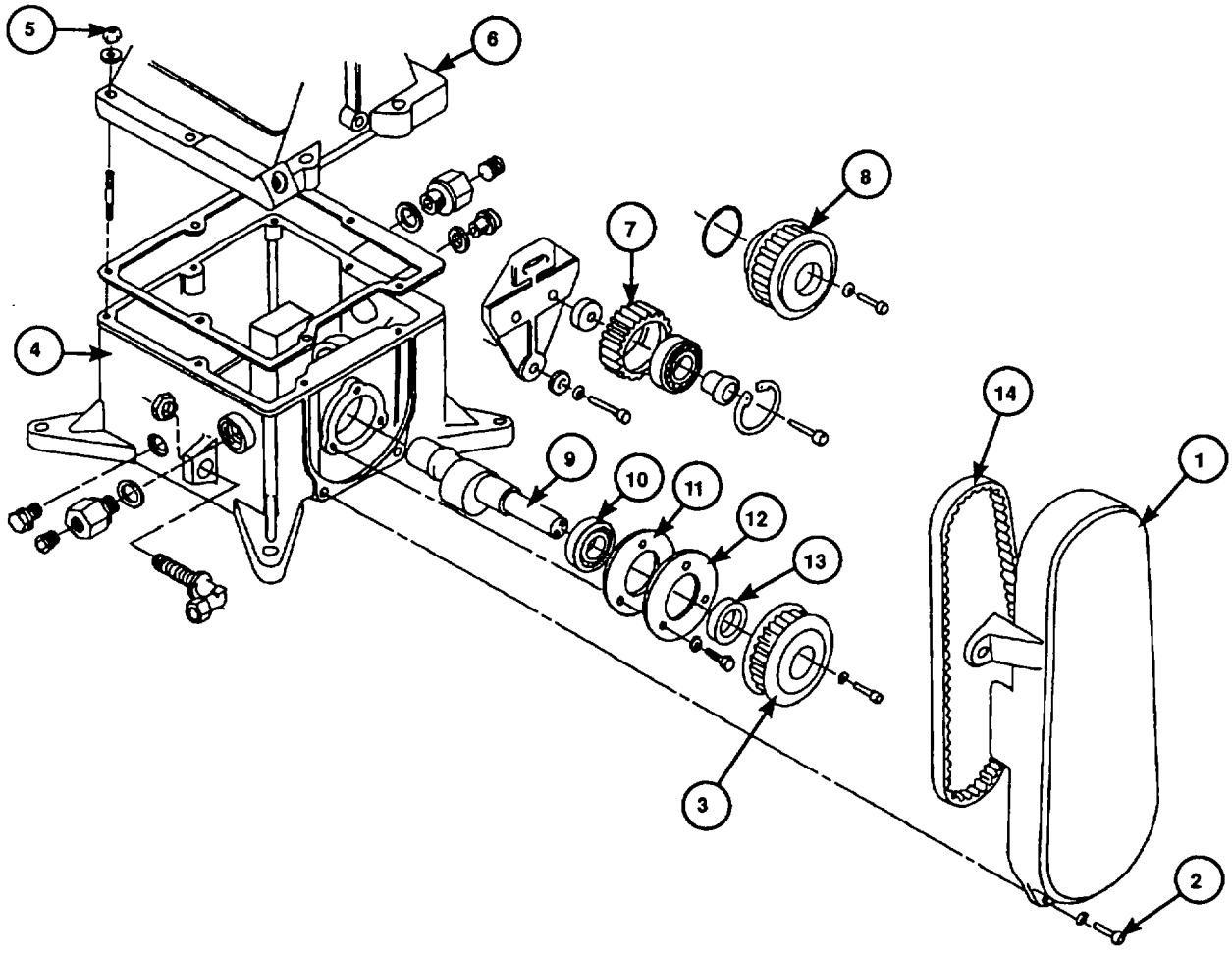


Figure 5-3. Lower Crankcase

NOTE

Need to see lift device notice.

3. Remove the seven nuts (5)that secure the upper crankcase (6) to the lower crankcase (4) and lift the upper crankcase away.
4. Insert.0 mm feeler gauge between cam and pump tappet.
5. Turn drive gear by hand. (It must be possible to rotate the cam; otherwise, fit an additional gasket between pump and housing. No clearance should appear between cam and pump tappet. The tappet must always sit on the cam.)

6. Remove eccentric belt pulley (3), bearing retainer (12), gasket (11), and eccentric shaft (19). Replace bearing (10), gasket (11), and seal (13), if necessary.

7. Inspect timing belt adjusting pulley bearing. Replace, if necessary.

b. Reassembly.

1. Install eccentric shaft (19) in lower crankcase (4) and torque retaining bolts.

2. Install oil pump and perform steps (4 and 5) in paragraph a, above.

3. Assemble upper crankcase (6) to lower crankcase (4) and torque nuts (5). Refer to Appendix F.

4. Assemble the timing belt pulleys (3, 7, and 8) and belt (14). See paragraph 4-6.

5. Install timing belt cover (1) and torque the four allen head bolts (2). Refer to Appendix F.

5-5. ENGINE

DESCRIPTION

This task covers: Repair

INITIAL SETUP

Tools:
Socket spanner, No. 003-0512
Square socket insert, No. 003-0511
Socket spanner, No. 003-0572
Bent socket spanner, No. 003-0425
Puller device, No. 003-0672
Device, No. 003-0500
Device, No. 003-1102
Special device for inserting, No. 003-0670
Special device for inserting, No. 003-0671
Hammer spanner, No. 003-0503
Mandrel, No. 003-0674
Retainer, No. 003-0446
Press-in device, No. 003-0448
Spring compression tool, No. 003-050
Piston ring compressing device, No. 003-04230
Piston Heater, No. 003-0414
Oil bath
Pullers, No. 003-0733
Fitting device, No. 003-2499
Fitting device, No. 003-2398
Retaining ring pliers
Torque wrench

Materials/parts:
Compound, Sealing, item 11 Appendix E
Cloth, lint-free, item 9 Appendix E
Grease, automotive, item 18 Appendix E
Trisodium Phosphase, item 13 Appendix E

Equipment conditions:
V-belts removed (para. 3-16)
Intake manifold removed (para. 3-32)
Cooling system removed (para. 3-33)
Starter removed (para. 3-34)
Alt. V-belt removed (para. 3-35)
Lube oil cooler removed (para. 3-35)
Exhaust manifold removed (para. 3-36)
Alternator removed (para. 3-38)
Piston removed (para. 4-14)
Cylinder head removed (para. 4-15)
Fuel injection pipes removed (para. 4-17)
Fuel pump removed (para. 4-18)
Clutch removed (paragraph 4-23)
Electric connections and instruments removed (para. 4-27 and 4-28)

General.

REPAIR

a. Remove the bottom plate and the upper and front camshaft covers (figure 5-4). Disassemble the eccentric plate ring on the camshaft gear wheel and dismount the camshaft gear wheel (figure 5-5). Remove V-belt pulley (figure 5-6) and unscrew the nut on the flywheel (use hammer spanner No. 003-0670 (figure 5-7) or 2-15/16-inch socket with breaker bar.

b. Apply puller device No.003-0672 to flywheel; exert tension and loosen flywheel by tapping with hammer.

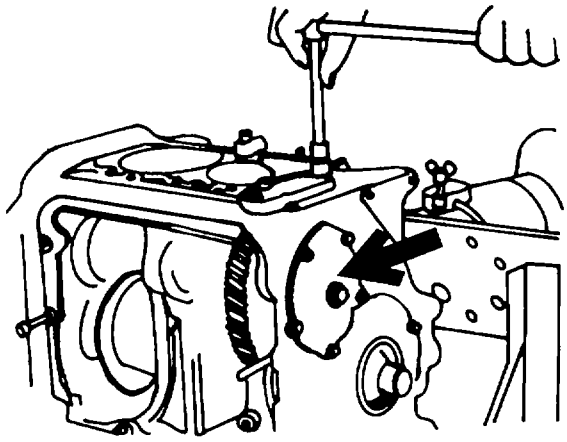


Figure 5-4. Removing Camshaft Cover

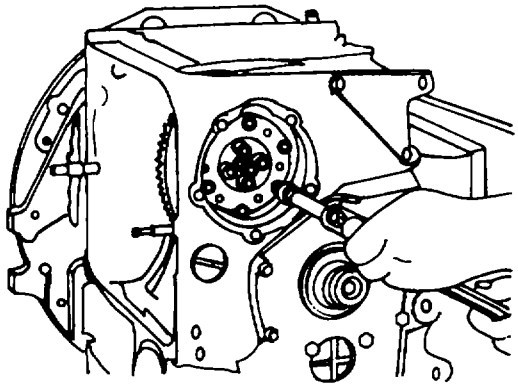


Figure 5-5. Remove the Camshaft Gearwheel

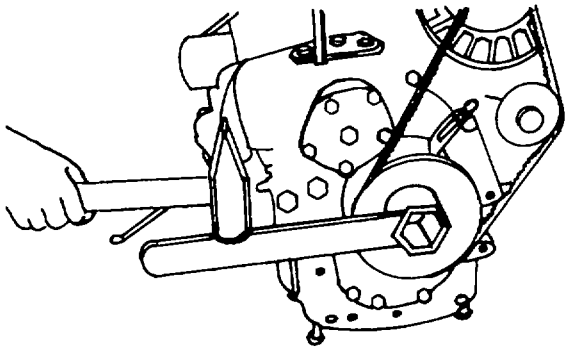


Figure 5-6. Remove V-Belt Pulley Nut

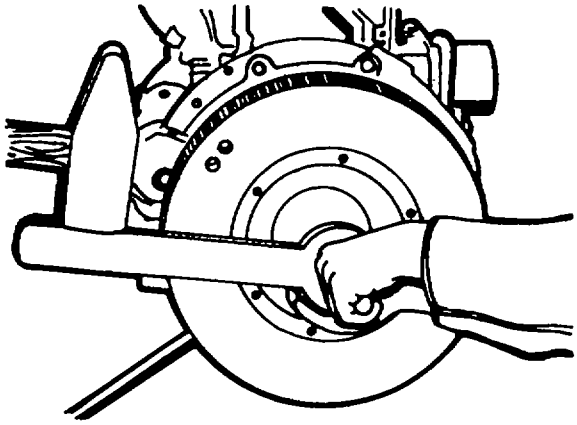


Figure 5-7. Removing Flywheel Nut

NOTE

Turn engine upside-down.

c. Remove upper and front camshaft covers (figure 5-8).

d. Remove the camshaft and tappets (figure 5-9). Mark and disassemble the crankshaft balance weights (figure 5-10). Remove the crankshaft gear wheel with puller No. 003-0672 (figure 5-11).

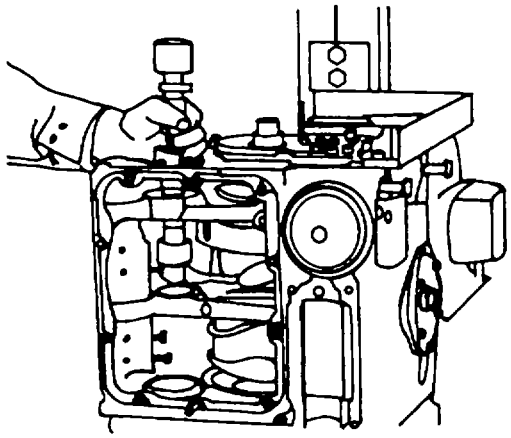


Figure 5-8. Remove Camshaft

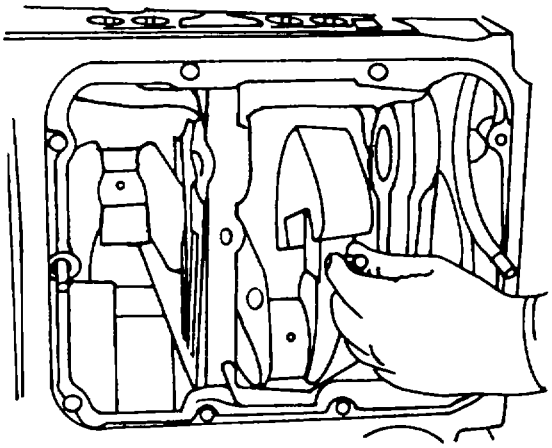


Figure 5-9. Index Marking Balance Weights

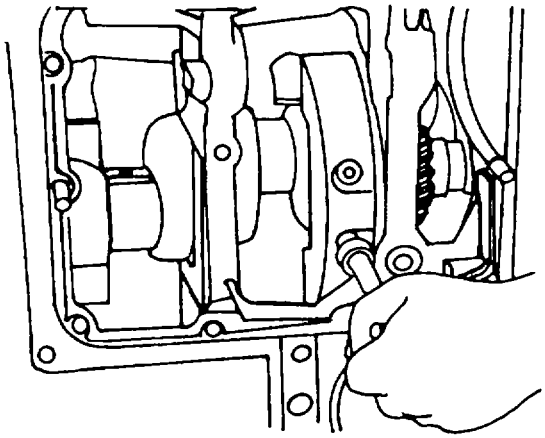


Figure 5-10. Removing Balance Weights

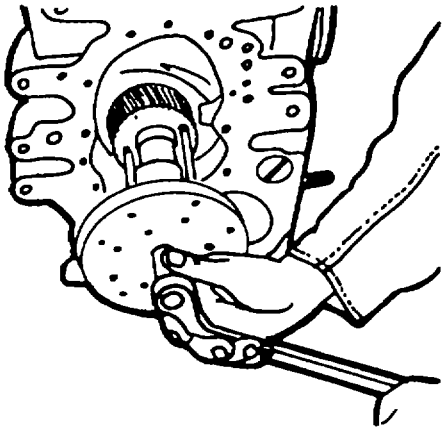


Figure 5-11. Removing Crankshaft Gear Wheel

e. Remove the screws in the front end shield and remove the end shield with the aid of special device No. 003-0671 (figure 5-12).

f. Disassemble the screws in the rear end shield and remove the end shield with the aid of puller device No. 003-0672 (figure 5-13).

g. Remove the lower crankcase cover. Disassemble the cap bolts of the middle crankshaft bearing (use socket spanner No. 003-0572, figure 5-14).

h. Disassemble the crankshaft bearing caps (figure 5-15).

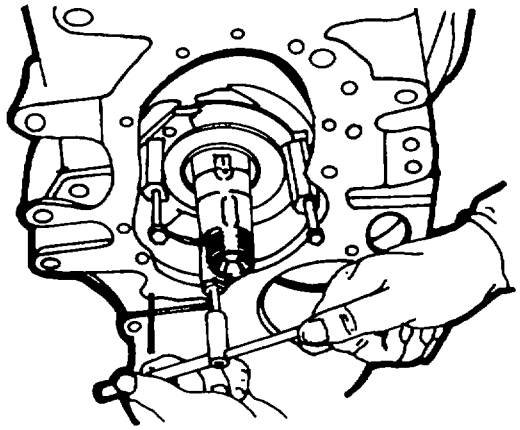


Figure 5-12. Removing Front End Shield

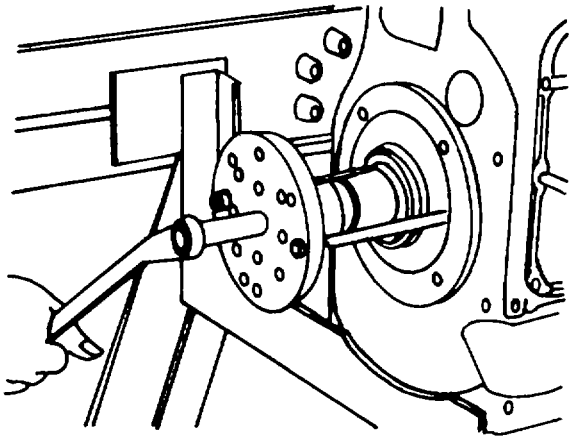


Figure 5-13. Remove the Rear End Shield

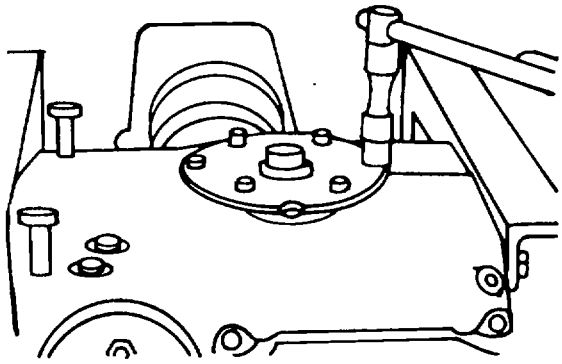


Figure 5-14. Removing the Lower Crankcase Cover

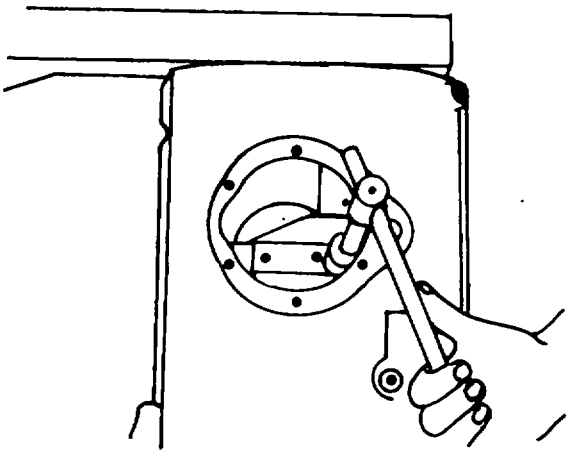


Figure 5-15. Remove Crankshaft Bearing Caps

CAUTION

Ensure the bearing shells do not get damaged.

i. Remove the halves of bearing shells and mark them on the back corresponding to the crankcase. Use an electric scriber. Remove the lubricating oil filter with base plate. Remove the bearing shell in the middle main bearing. Unscrew the oil gallery plugs and piston cooling injection nozzles (figures 5-16 and 5-17). Clean all parts and thoroughly flush all oilways. Do not hot tank.

j. Remove the crankshaft from the flywheel end of the engine (figure 5-18).

k. Check all components to determine whether they are suitable for reuse.

l. Reassembling the Crankshaft Assembly.

NOTE

The bearing must be installed into the front camshaft bearing bore. It is assumed that the bearing is fitted in the front.

1. Turn engine upside down.

2. Determine whether the oil dosing plug is fitted in the oilway of the middle bearing web (figure 5-19, left).

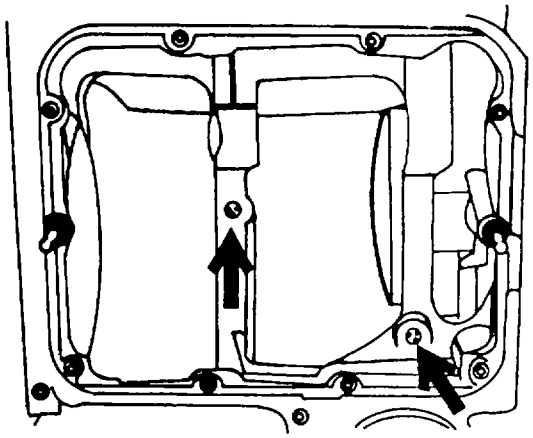


Figure 5-16. Oil Galley Plugs

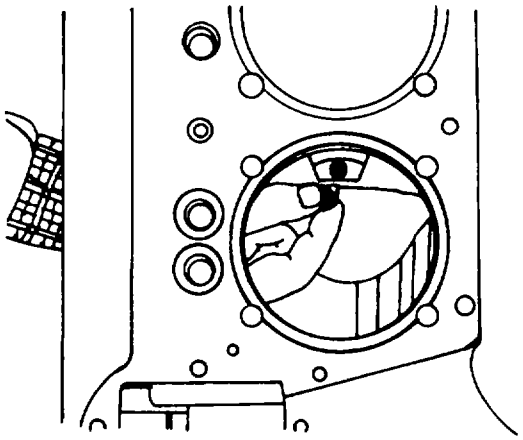


Figure 5-17. Piston Cooling Injection Nozzles

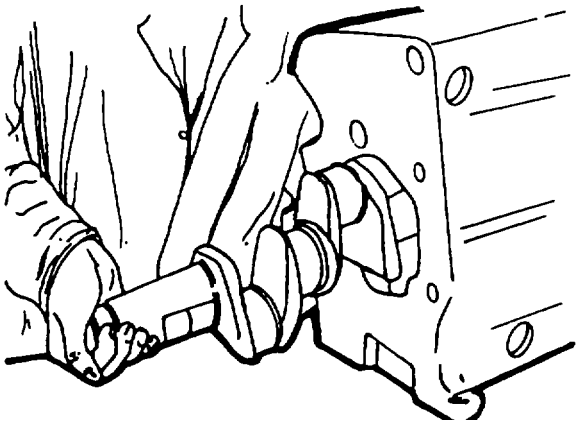


Figure 5-18. Removing/Reinstalling Crankshaft

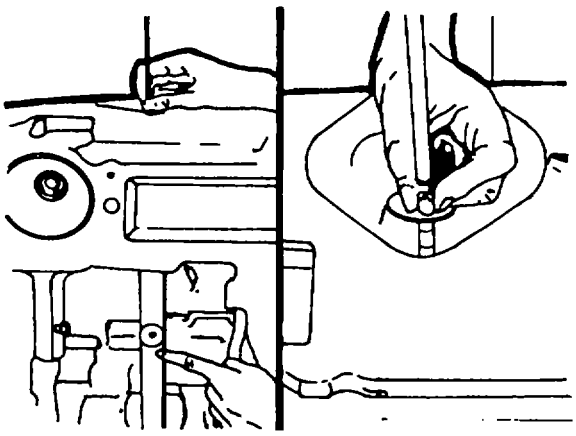


Figure 5-19. Oil Dosing Plug/Installing Oil Dosing Plug

NOTE

It should not be possible to push a piece of 3 mm gauge wire as far as the camshaft bore (figure 5-19, left).

3. If no oil dosing plug is fitted, drive one in with the bore at the front (figure 5-19, right).
4. Check the two studs securing the injection pump.
5. If the studs are damaged or missing, fix new studs.
6. If the sealing cover for the bore at the flywheel end of the camshaft is missing, install a new one; apply jointing compound and caulk (use press-in device No. 003-0448, figure 5-20).
7. If the slotted sealing plug on the front side is missing, screw in a new one; apply jointing compound.
8. Check the three alignment pins on the front of the engine (figure 5-21).
9. If any of the alignment pins are missing or damaged, fit new ones (figure 5-21).
10. Screw in both mounting feet in the bottom face of the crankcase.
11. Screw in the three bottom plugs in the oilways and the sludge drain plug in the filter housing, fitting new gaskets.
12. Install the two screwed plugs, fitted with new gaskets, in the two bearing webs (figure 5-22).

13. Place the crankcase bottom downwards.
14. Screw in the piston cooling oil nozzles, fitted with new gaskets, on both sides of the middle bearing web.
15. Assemble the screwed plug, fitted with a new gasket, in the oil hole in the cylinder head contacting face.
16. Check the ball valve in the base-plate of the lubricating oil filter.
17. If the ball valve in the base plate is damaged or missing, fit a new base-plate.
18. Turn the engine upside down. Install a new gasket and mount the filter and cover (figure 5-23).

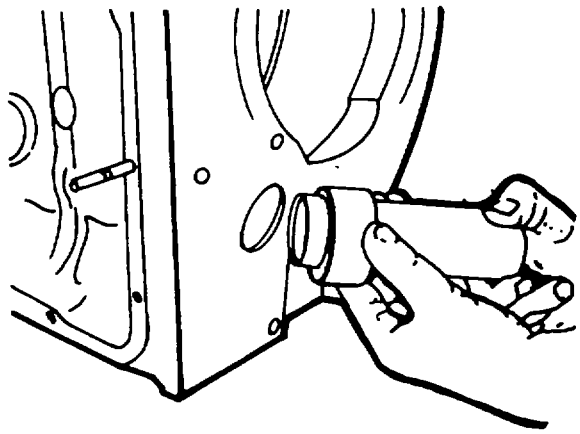


Figure 5-20. Installing Bore Sealing Cover

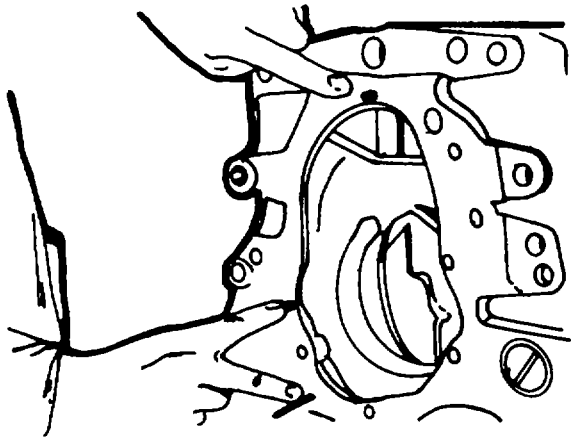


Figure 5-21. Checking Clamping Sleeves

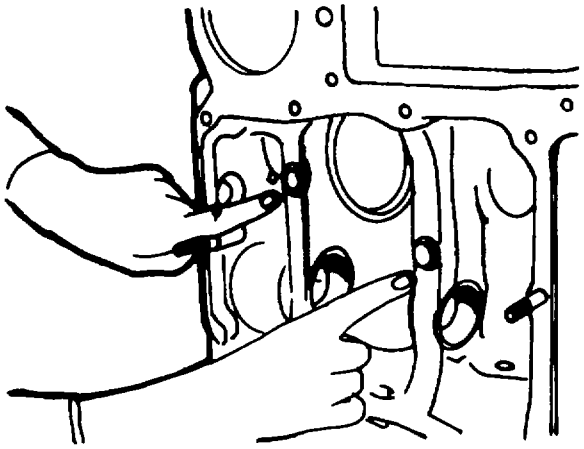


Figure 5-22. Installing Plugs into Bearing Webs

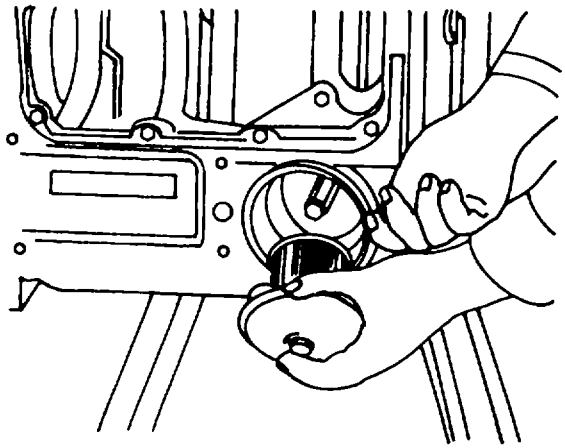


Figure 5-23. Install Oil Filter

19. Turn the engine upside down. Install the halves of bearing shells of the middle crankshaft bearing in the crankcase and bearing cap, respectively; check the identification marks. Fit the halve of thrust ring with the smooth surfaces to the bearing cap and bearing web sides, respectively apply grease to retain them in position (figure 5-24).

NOTE

A locating pin must be inserted on either side of the bearing cap. The thrust ring halves should locate against these pins.

20. Lubricate the middle crankshaft journal with clean engine oil. Install the crankshaft from the flywheel end of the crankcase.

21. A centering sleeve must seat in each of the bolt holes in the bearing cap and bearing web (figure 5-25).

22. Bearing cap must be fitted with its identification number corresponding to and in the same direction as that stamped on the crankcase.

23. Insert the bearing cap bolts. Torque in accordance with the instructions given in torque specifications (use device No. 003-1102, figure 5-26).

24. Oil the journal at the flywheel end of the crankshaft. Pay attention to the race of the rear crankshaft seal. If the crankshaft exhibits a groove due to the rear crankshaft seal, the latter should be moved in the end shield on the flywheel side (use thrust ring of press-in device No. 003-0670).

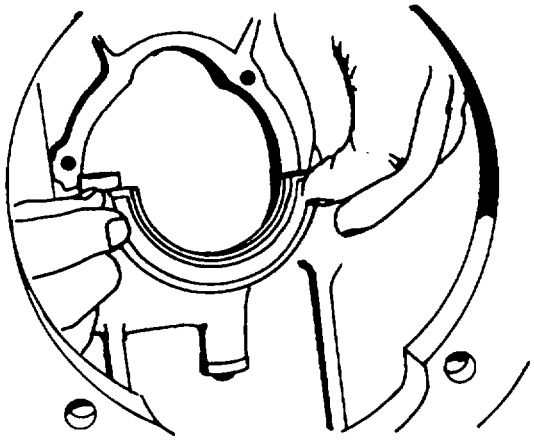


Figure 5-24. Fitting Thrust Ring

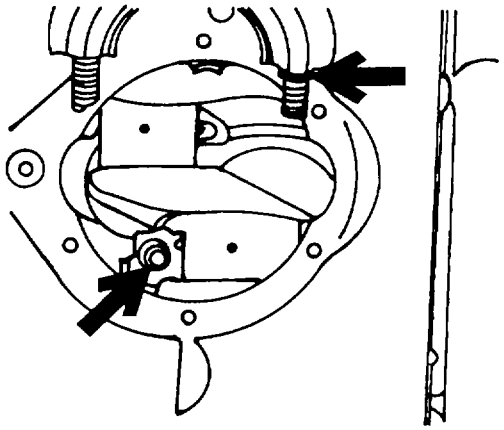


Figure 5-25. Inspect for Dowel Centering Sleeves

25. Slide the sleeve guide over the end of the crankshaft. Fit a new gasket to the end shield; apply grease to hold it in position. Mount the end shield so that its oil hole is in alignment with the oil hole in the crankcase (figure 5-27) (use sleeve guide of press-in device No.003-0670).

26. Press the end shield into position by applying pressure uniformly at diagonal locations (use press-in device No. 003-0670, figure 5-28).

27. Tighten the screws uniformly and in diagonal sequence.

28. Oil the front crankshaft journal and mount the front end shield so that the oil hole points towards the injection pump cover side (figure 5-29).

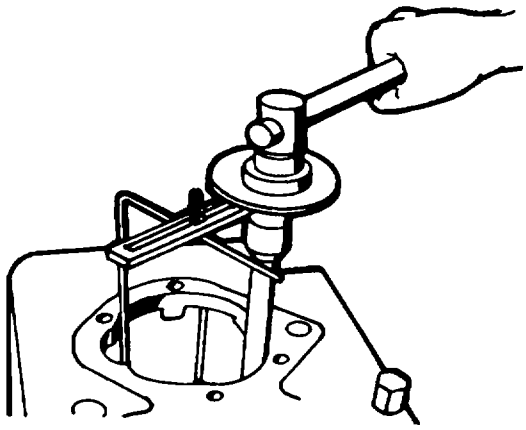


Figure 5-26. Inserting Bearing Cap Bolts (Engine Upside-down)

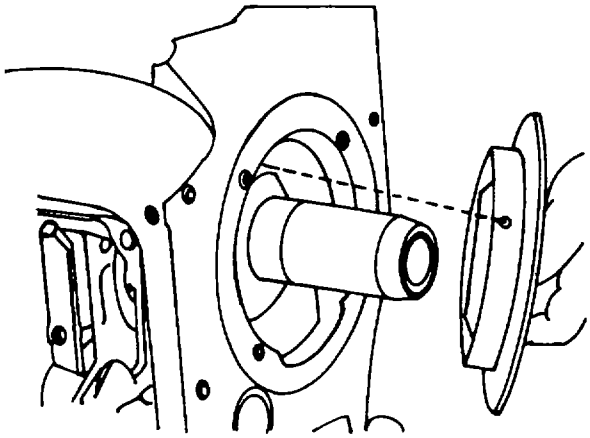


Figure 5-27. Align End Shield Oil Hole

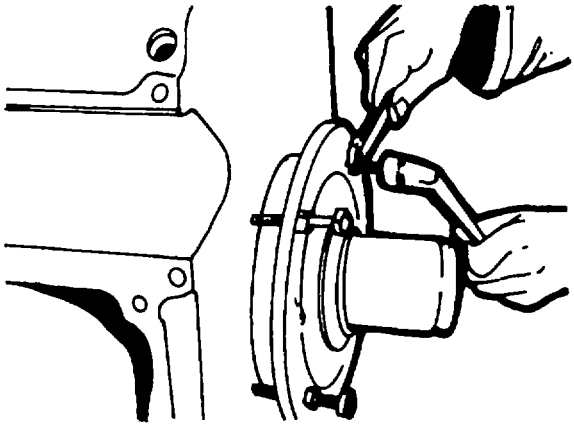


Figure 5-28. Pressing End Shield

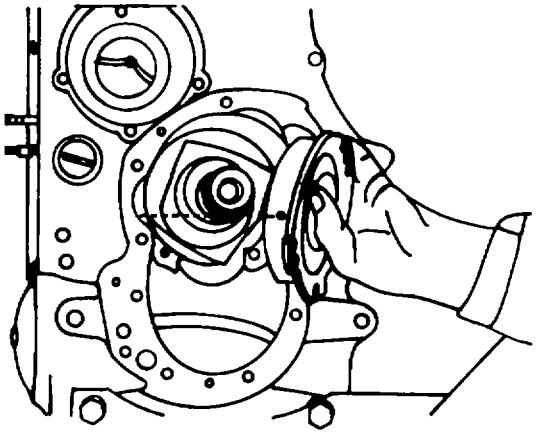


Figure 5-29. Align Oil Holes with Injection Pump Cover

29. With the aid of tool No.003-0671, press in the front end shield uniformly, without forcing it out of square (figure 5-30).
30. Tighten the screws evenly.
31. Press the crankshaft towards the flywheel end and measure the end clearance on the flywheel side of the middle bearing web.
32. The end clearance must be within the range stated in the specifications (table 4-3). If necessary, dismantle the bearing cap and fit suitable thrust ring halves. With the new thrust ring halves, press out the existing ones at the bearing web (figure 5-31).
33. Install the thrust ring halves with the smooth faces to the bearing web or bearing cap. Mount the bearing cap. Recheck the end clearance of the crankshaft and, if necessary, correct.
34. Position the balance weights on the crankshaft, taking care that they are in line with the marks. Tighten and lock down the screws in accordance with torque table H1 (use device No. 003-1102).

NOTE

Engine manufacture recommends new counterweight bolts whenever counterweights are removed.

35. Install the cover on the under side of the crankcase, with a new gasket held in position with grease, so that the radial recess faces the screwed plug in the oilway. Assemble the oil drain plug, fitted with a new gasket (figure 5-32).

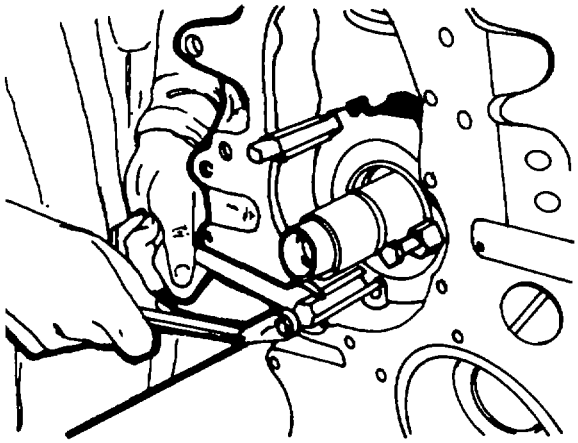


Figure 5-30. Pressing in Front End Shield

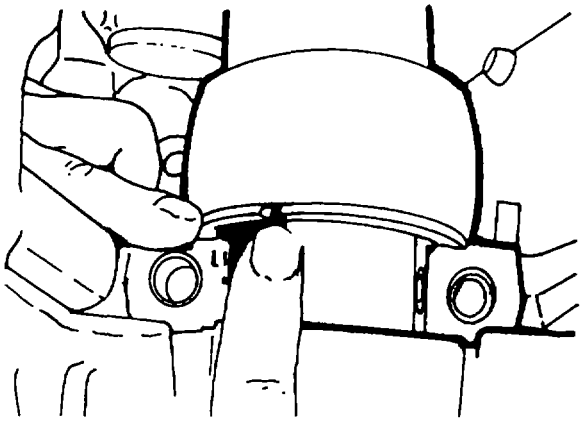


Figure 5-31. Positioning Thrust Rings

36. Insert the tappets. Oil the camshaft journals. Install the camshaft in the bearing bores (figure 5-33).

37. Place the crankshaft right side up.

38. Check the crankshaft gear wheel and install the key if one has not been installed. Heat the crankshaft gear wheel to 212°F (100°C) and mount it bevel side first on the crankshaft 39. Place the thrust washer on the journal at the front end of the camshaft (figure 5-34).

40. Install the camshaft gear wheel so that its tooth marked • engages in the gap between teeth marked • of the crankshaft gear wheel. Align the camshaft to suit the gear wheel (figure 5-35).

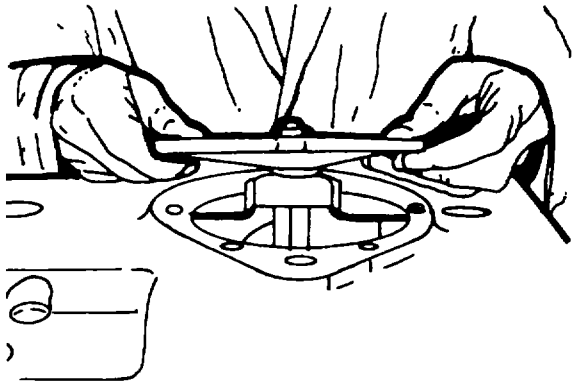


Figure 5-32. Installing Crankcase Cover (Engine Block Upside-down)

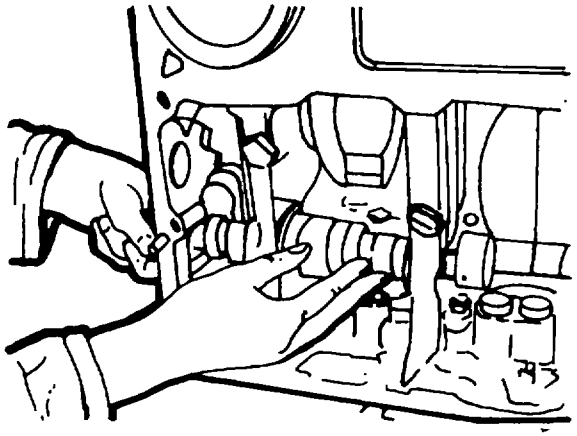


Figure 5-33. Installing Camshaft in Bearing Bores (Engine Block Upside-down)

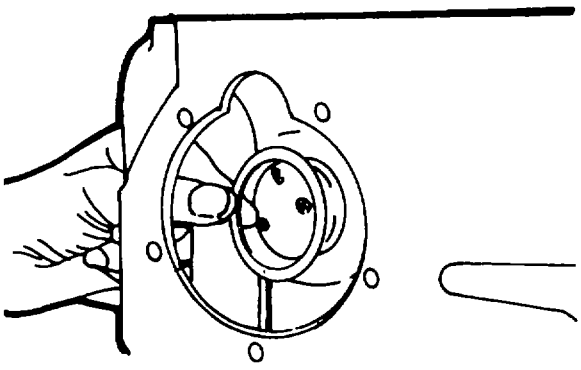


Figure 5-34. Positioning Thrust Washer

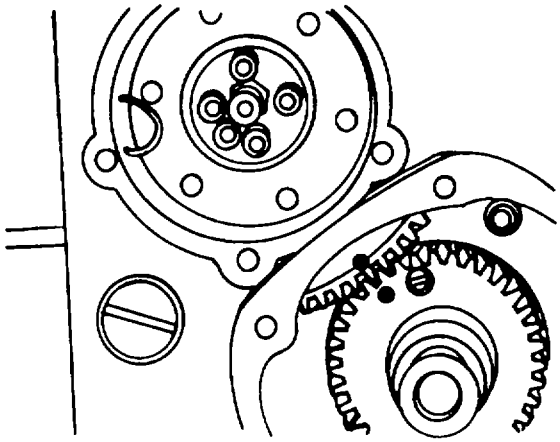


Figure 5-35. Align Timing Marks

41. Secure the camshaft gear wheel in position. Install the eccentric pressed steel ring with the flange on the side, i.e., away from the camshaft gear wheel. Torque to 22 lb-ft (30 Nm). Install hand crank adapter plate and hand crank flange.

NOTE

Radial runout cannot be adjusted.

42. Drive the counterbolt into the camshaft gear wheel so that the distance between its end face and the joint face is equal to the dimension determined at 45° plus 0.039 to 0.079inch (1 to 2 mm).
43. Fit a new gasket, coated with grease so that it stays in position, to the front cover plate of the camshaft and mount the hand crank flange.
44. Check the end clearance of the camshaft.
45. This end clearance must be within the limits stated in the specifications. If it is on the low side, correct by driving the camshaft gear wheel in the direction of the near end cover plate. If it is on the high side, dismantle the camshaft gear wheel and drive the counterbolt outwards by the corresponding amount.
46. Install a new gasket and seal to the front cover; coat the gasket with grease so that it sticks in position and mount the front cover with the oil pump to the engine (figure 5-36).

NOTE

Check the race of the oil seal. If the shaft exhibits a groove, reposition the packing ring in the front cover.

47. Clean the top camshaft cover and install it onto the cylinder head surface. Install a new gasket and coat it with grease to hold it in place.
48. Assemble the front and middle screws to align the pressed steel bottom plate in position. The treaded sleeve must be assembled to the middle screw (figure 5-37).
49. Install the flange mounting plate on the flywheel end.

NOTE

Place a piece of wood or other material under the flywheel end of the crankcase so that the foot on the flange mounting plate stands clear of the bench.

50. Check for pressure of the key for the flywheel. The taper must be dry and free from grease. Insert mandrel No. 003-0674 in the crankshaft and mount the flywheel so that its groove engages the key (figure 5-38).

51. Position the flywheel, torque the nut in accordance with Appendix F (use hammer spanner No. 003-0503).

52. Install the V-belt pulley. The cutout portion of the front end must be in alignment with the key in the crankshaft gear wheel.

53. Position the flywheel; torque the nuts securing the V-belt pulley in accordance with Appendix F (use retainer for V-belt pulley No. 003-0446).

54. Place a new rubber 0-seal, coated with grease, in the joint face of the oil cooler and insert the plain end of the oil pipe in the oil cooler (figure 5-39).

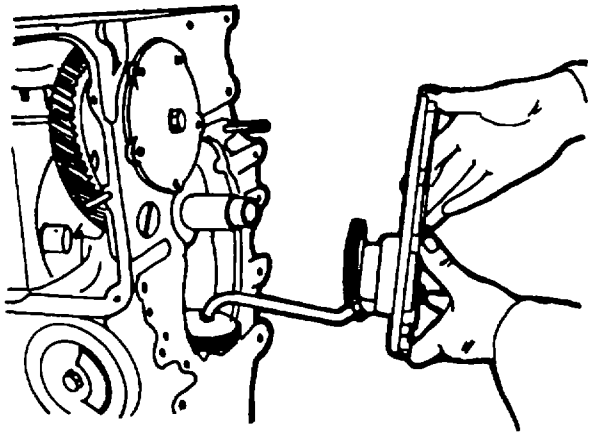


Figure 5-36. Mounting Front Cover with Lube Oil Pump

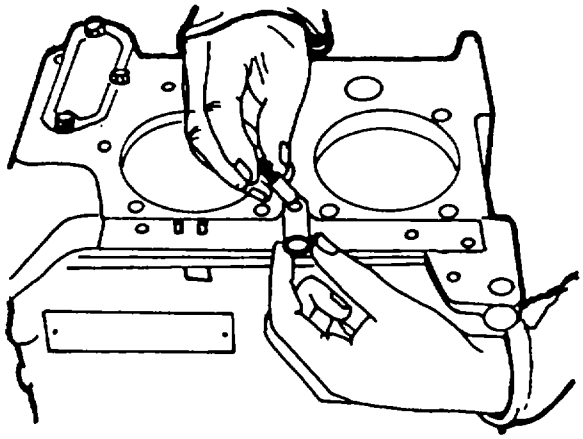


Figure 5-37. Assembling Threaded Sleeve to Middle Screw

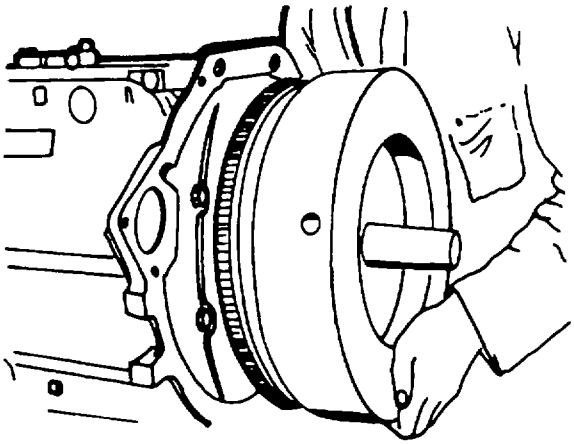


Figure 5-38. Installing Flywheel

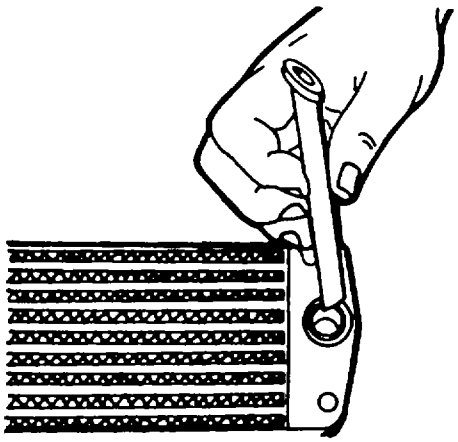


Figure 5-39. Installing Oil Pipe into Oil Cooler

55. Mount the oil cooler so that the oil pipe enters the oilway in the crankcase.

m. Reassembling the Cylinder Unit.

1. Install a circlip in the piston for the location of the piston pin (figure 5-40).

2. Heat piston with the piston heating device No. 003-09414 [temperature about 176°F (80°C)]. Oil the piston pin and piston bush. Secure the opposite end of the piston pin in position. Place the piston on the small end of the connecting rod so that the exhaust air side of the piston (marked on the piston crown) is in the same direction as the open side of the connecting rod bearing. Force in the piston pin.

3. Install the second circlip in the piston for the location of the piston pin. Oil the working surface of the cylinder and the piston. Install the piston rings so that their gaps are equally spaced around the piston.

4. Mount the piston ring compressor and apply tension. Position the piston so that its exhaust air side is on that side of the cylinder recessed for the tappet covers (use piston ring compressing device No. 003-0430).

5. Adhere to cylinder, by means of grease, one shim of 0.008-inch (0.2 mm).

6. Fit the halves of bearing shells in the correspondingly marked connecting rod and bearing cap.

7. Install the cylinder, piston, and connecting rod assembly so that the exhaust air side of the piston faces the tappet bores (figure 5-41).

Figure 5-40. Fitting the Piston Pin

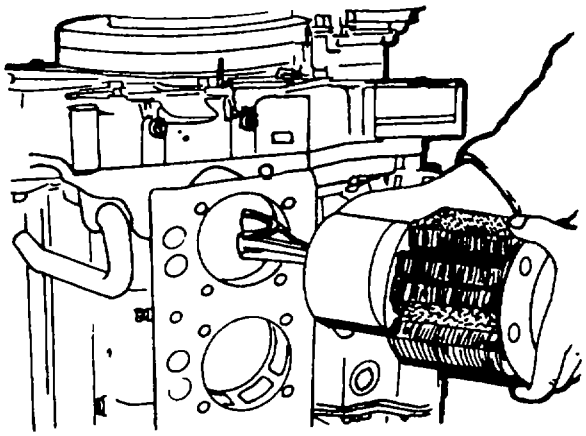


Figure 5-41. Installing Cylinder, Piston, and Connecting Rod

8. Oil the crankpin. Place the connecting rod bearing on the crankpin (figure 5-42).

CAUTION

When rotating the crankshaft, ensure the cylinders do not lift from the contact surface.

9. Assemble the mating cap on the connecting rod bearing. Install new connection rod bolts; tighten and lock down in accordance with Appendix F (use angle-of-turn indicator No. 003-1102).

10. Check rod bearing to crankshaft journal side clearance (table 4-3). Bring the cylinders into alignment.

11. Position the engine right side up.

12. Coat with grease a piece of 0.079-inch (2 mm) gauge lead wire and stick it at right angles to the center line of the engine on the piston crown.

13. Mount the cylinder head. Measure the length of the cylinder head studs.

14. Renew those cylinder head studs that have stretched beyond the limits stated in the specifications (table F-1 of the appendix).

15. Assemble the studs fitted with washers and slightly tighten. Bring the inlet and exhaust flanges of the cylinder heads into alignment; ensure that in doing so the cylinders do not get out of alignment.

16. Torque bolts to 30 Nm (see tightening procedure, table F-1 of the appendix) and tighten through one stage (45 degrees) with the aid of device No. 003-0500 (figure 5-43).

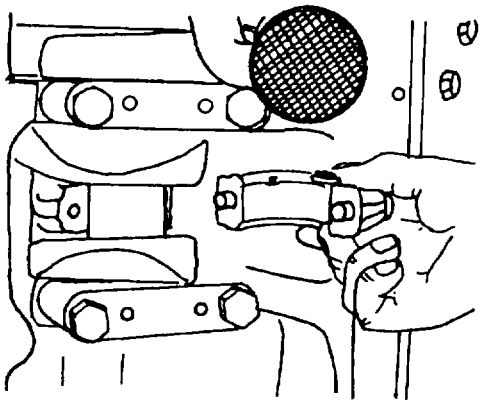


Figure 5-42. Positioning Big End Bearing Bearing on Crankpin

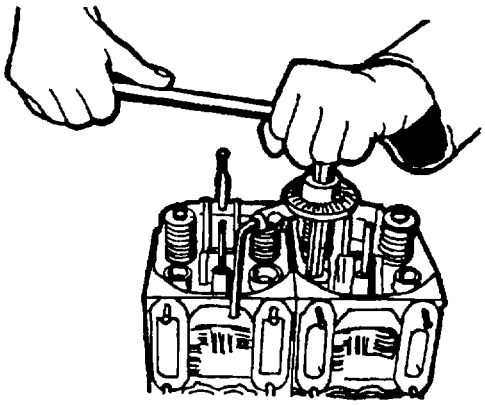


Figure 5-43. Preloading Cylinder Head Bolts

17. Turn the crankshaft through 360 degrees int he direction of engine rotation. Undo the cylinder head and remove the piece of lead wire. Measure the thinnest part of the squeezed wire. For piston crown clearances, see specifications table 4-2.

NOTE

This is the easiest method of getting the correct clearance; if the clearance is too small, remove the cylinder and place the number of shims required below the cylinder or if the clearance is too large, raise the cylinder, cut through the surplus shims with side-cutting pliers, and remove.

18. Adjust clearance by shims: 0.008-inch (0.2 mm), 0.020-inch (0.5 mm), 0.032-inch (0.8 mm), or 0.039-inch (1.0 mm) are available. Keep the number of shims in the stack to an absolute minimum.

19. Reinstall the cylinder head. Refer to 4-11 and Appendix F.

20. Screw plugs into cylinder heads fitted with new gaskets into the holes for the cylinder head studs (use socket spanner No.003-0512 and square socket insert No.44 003-0511, figure 5-44).

21. Assemble and tension the spring by turning (use spring compressor tool No. 003-0501, figure 5-45, left).

22. Install the flat washer with the domed side facing towards the spring. Fit a new sealing ring with the flat side facing towards the end of the push rod tube (figure 5-45, left).

23. At the opposite end of the tube, fit a new sealing ring with the fault side facing towards the shoulder (figure 5-45, right).

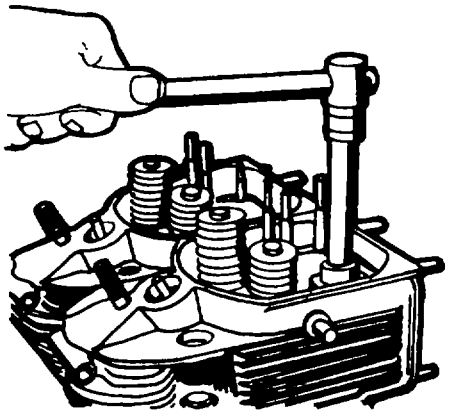


Figure 5-44. Fitting Screw Plugs into Cylinder Head

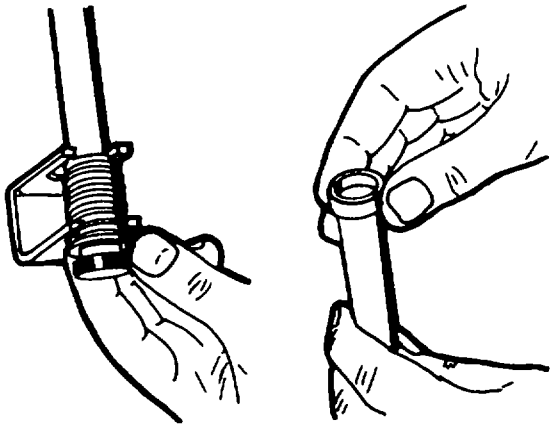


Figure 5-45. Assembling Push Rod Assemblies

24. Insert the two push rod sheaths, spring end first, in the tappet bore in the crankcase and locate the upper end with the gasket in the cone of the cylinder head. Remove the spring tensioner.

25. Assemble the push rods and mount the rocker arm shaft support (figure 5-46). i 26. Adjust the valve clearance and decompressors (refer to 3-22).

27. Place new gasket with sealing compound to rocker chamber cover. Position cover, align, and fit bolt with new washer. See specification data tightening, table F-1.

28. Install injector guide and injector with new washer in cylinder head. Tighten bolts as under specification data. Install thrust piece and place injector clamp in position. Place washer with convex side facing stirrup and screw on nut, and torque. Refer to Appendix F.

n. Reassemble the Engine.

1. Coat a new gasket with grease and place it in position on the injection pump cover. Rotate the camshaft so that the cams that operate the pumping elements face toward the casing. Mount the injection pump cover, ensure the gears are in mesh.

2. Connect the breather pipe and install in the injection pump with gasket sealing compound. Assemble the oil dipstick fitted with a new rubber 0-seal.

3. Assemble the front vertical plate (figure 5-47).

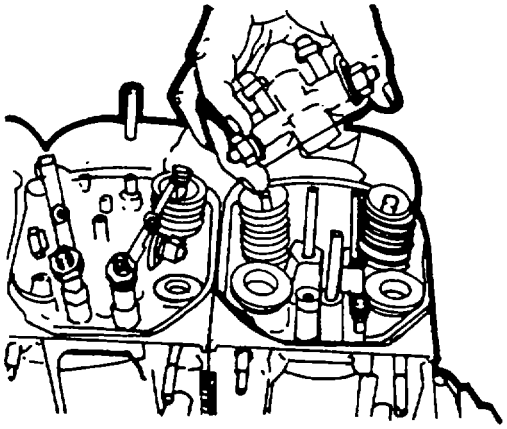


Figure 5-46. Installing Push Rods/ Mount Rocker Arm Shaft Support

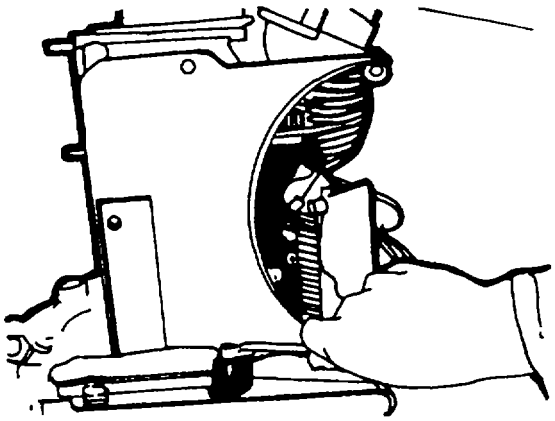


Figure 5-47. Assembling Front Vertical Plate

4. Mount the cooling air blower and check the two V-belt pulleys for alignment (figure 5-48).

5. If the V-belt pulleys are out of alignment, correct by varying the number of shims under the cooling air blower.

6. Attach the exhaust air plate to the front vertical plate (figure 5-49).

7. Mount the vertical plate on the flywheel side of the engine.

8. Install engine head temperature probe. Mount the top cover plate.

9. Connect the fuel lines.

NOTE

Clips should be used to attach the fuel supply line for cylinder #1 to the crankcase and the supply line for cylinder #2 to the front vertical plate. Install a rubber sleeve between the clip and fuel line.

10. Install the fuel return line fitted with new gaskets.

11. Screw on a new fuel filter finger-tight.

12. Hook the top of the air cowling to the upper cover plate and secure at the bottom with a screw.

13. Mount the intake manifold, fitted with new gaskets, with the flat sides facing upwards. Torque to 20 lb-ft.

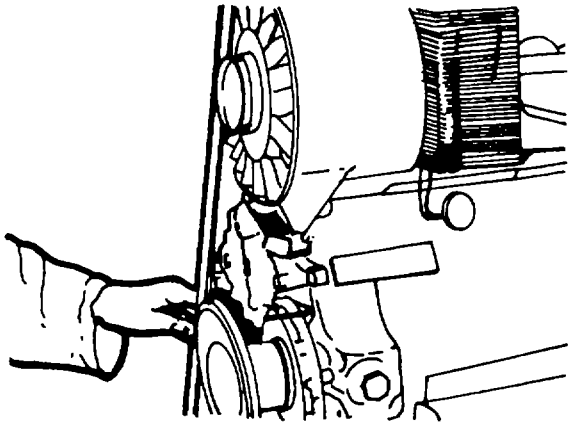


Figure 5-48. Checking Alignment of V-Belts

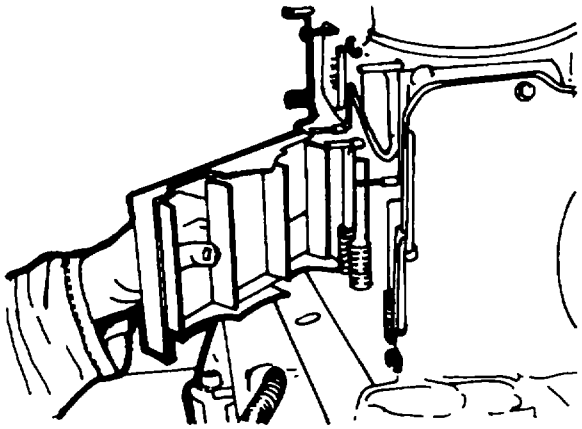


Figure 5-49. Attaching Exhaust Air-Plate to Front Vertical Plate

NOTE

Viewed from the exhaust air side, the intake duct of a cylinder head is on the right-hand side.

14. Mount the exhaust manifold, fitted with new gaskets, with the flat side facing upwards.

15. Close the aperture of the exhaust manifold.

16. Install the generator so that its V-belt pulley is in alignment with the V-belt pulleys of the crankshaft and cooling air blower.

NOTE

Tighten the stud passing through the distance sleeve so that play between the securing flanges is eliminated.

17. Assemble the starter to the mounting flange.

18. Mount the air filter.

o. Set the decompression device (Refer to paragraph 3-23).

p. Starter Gear Ring Removal.

NOTE

Flywheel dismantled.

1. Cut through the starter gear ring with a hard chisel and remove (figure 5-50).

2. Heat the new starter gear ring to a temperature of 250°F (120°C).

3. Position the new starter gear ring with the bevelled side of the teeth facing away from the flywheel.

4. Install the starter gear ring on the flywheel and tap it into position so that it seats against the shoulder.

q. Radial Sealing Ring on Flywheel Side.

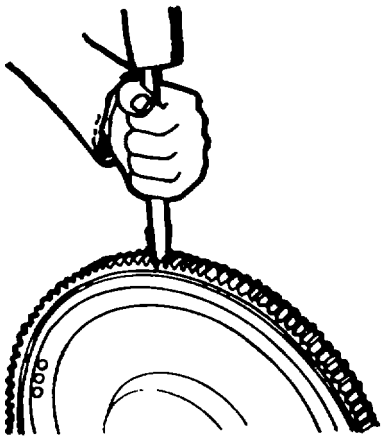


Figure 5-50. Removing Starter Gear Ring

NOTE
Flywheel dismantled.

1. Apply puller No. 003-0733 and draw off radial sealing ring (figure 5-51).
2. Mount guide piece of device onto crankshaft.
3. Lightly grease the sealing lip of the new radial seal.
4. Place seal in position with lip facing inwards and press in with device No. 003-2499 (figure 5-52).

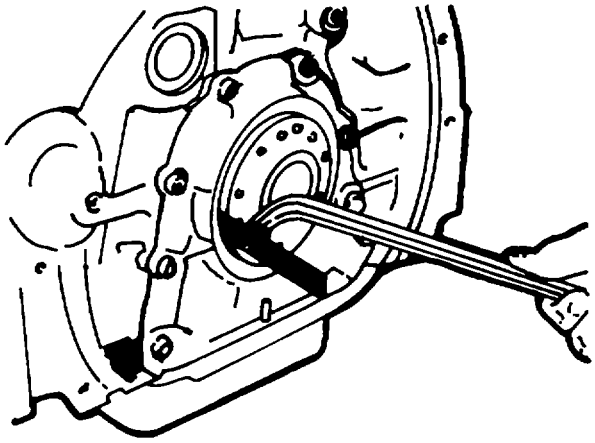


Figure 5-51. Removing Radial Sealing Ring with Puller 003-0733

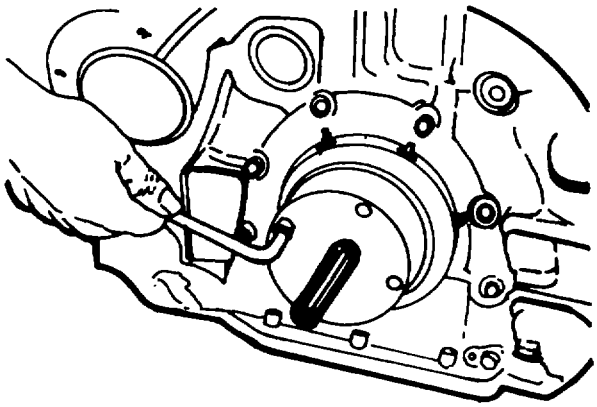


Figure 5-52. Positioning Radial Seal

r. Crankshaft Seal Replacement.

1. Apply puller No. 003-0733 and draw off crankshaft seal (figure 5-53).

2. Grease slightly sealing lip of new radial sealing ring.

3. Install crankshaft seal in such a way that lip faces inwards. Press on ring with installation device (figure 5-54).

NOTE

Pay attention to contact traces of crankshaft seal. If the contact surface shows on the crankshaft (a friction groove caused by the radial ring), displace the latter axially in the front cover.

NOTE

When moving the seal, observe correct depth of installation (pressed in). Depth 1 (figure 5-55), outside flush with front-end cover. Depth 2 (after shifting in front-end cover to be flush inside): maximum 0.039-inch (1.0 mm) (figure 5-51).

s. End Shield on Flywheel Side.

NOTE

Flywheel dismantled.

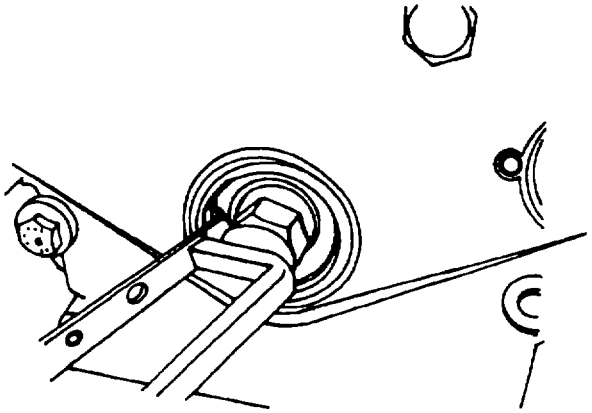


Figure 5-53. Remove Crankshaft Seal

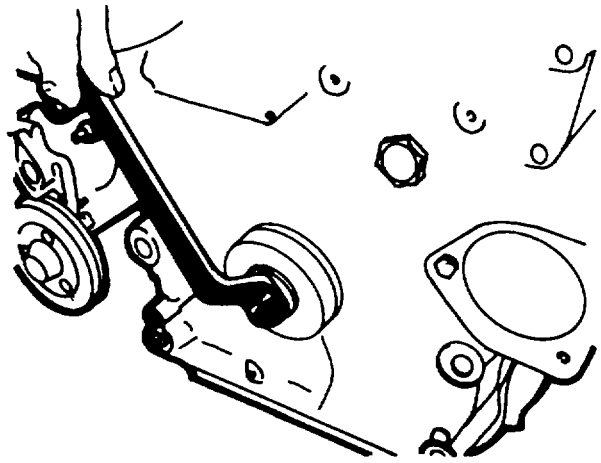


Figure 5-54. Pressing on Radial Seal Ring with Fitting Device

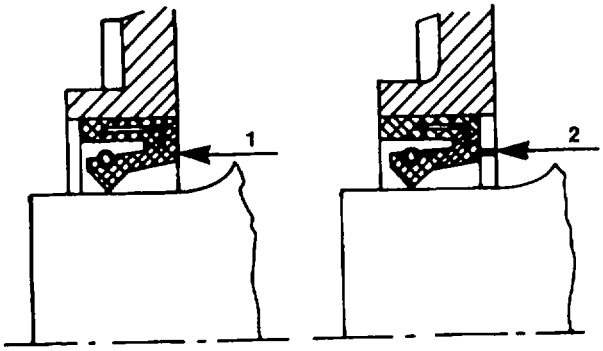


Figure 5-55. Correct Installation of Radial Seal

1. Remove the starter mounting flange. Remove the studs securing the rear end shield and withdraw the end shield with puller device No. 003-0672 (figure 5-56).

2. Remove the gasket. Check the rear end shield. Check the contact surface of the radial sealing ring. If it exhibits a groove, change the location of the radial sealing ring in the end shield.

3. Slide the protective sleeve onto the end of the crankshaft. Coat a new gasket with grease and stick it in position on the end shield. Lightly coat the lip of the radial sealing ring with grease. Position the end shield so that its oil holes register with those in the crankcase (use protective sleeve of special device No. 003-0670).

4. Tighten the nuts of the tool uniformly, in diagonal sequence (use special device No.003-0670).

5. Tighten the studs uniformly and in diagonal sequence.

6. Install the flange mounting plate (figure 5-57).

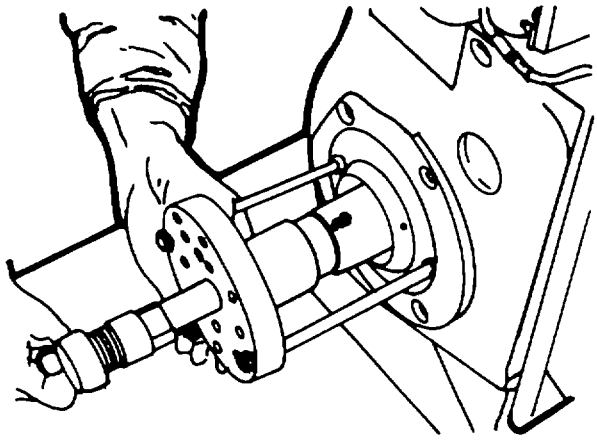


Figure 5-56. Removing End Shield

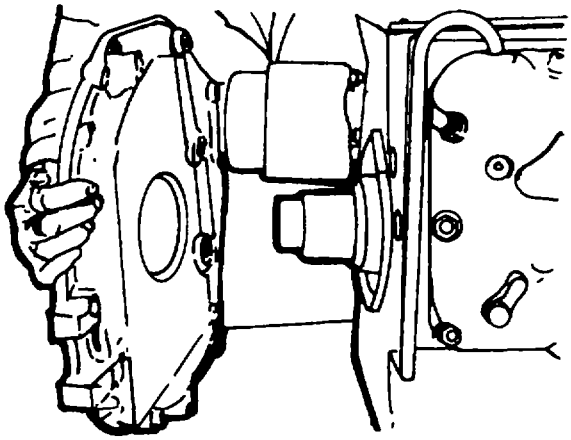


Figure 5-57. Install the Flange Mounting Plate

t. Crankshaft Belt Pulley.

NOTE
Alternator removed.

1. Remove the V-belt and mark the position of the flywheel. Slacken and remove the nuts (figure 5-58) on the V-belt pulley using retainer No. 003-0446.

2. Remove V-belt pulley (figure 5-59).

3. Align the cutout in the V-belt pulley with the feather of the crankshaft gear wheel and slide the V-belt pulley into position.

4. Tighten the nut in accordance with torque specifications listed in Appendix F (use retainer No. 003-0446).

5. Mount and tension the V-belt.

6. Install belt at minimum pulley spacing.

7. Tension the V-belt so that its free movement midway between the two pulleys is 1/8 to 1/2-inch (10 to 15 mm) when pressure is applied with the thumb.

8. Tension belt by swinging alternator outwards. Tighten strap bolt.

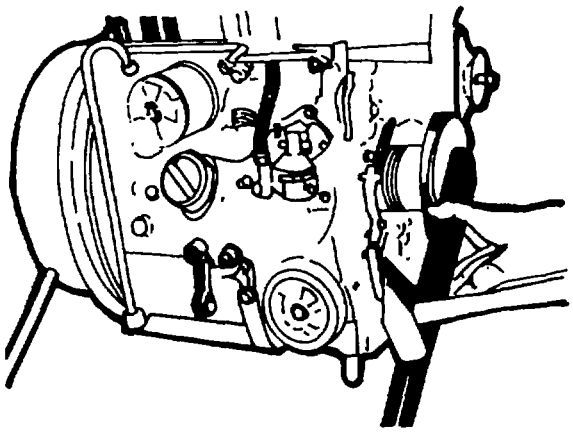


Figure 5-58. Remove Pulley Retaining Nut

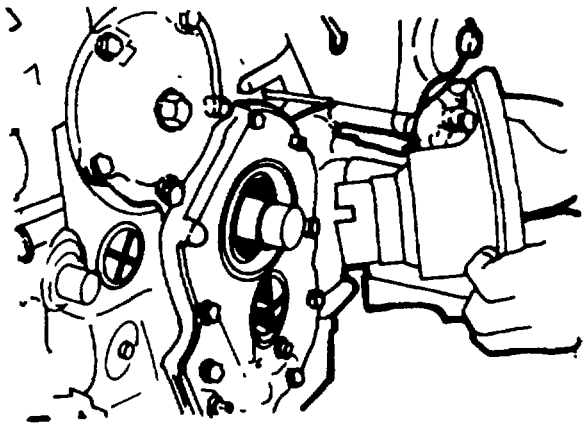


Figure 5-59. Removing V-Belt Pulley

5-6 CRANKCASE (ENGINE)

DESCRIPTION

This task covers: Replace. Repair

INITIAL SETUP

Tools:
- Fixture 003-0500
- Refacing device 003-0505
- Precision gauge
- Nozzle tool 003-0798
- Micrometer

Equipment conditions:
- Engine completely disassembled (paragraph 5-10).
- Crankshaft removed.

Materials/parts:
- Micrometer frame
- Cloth, Lint-free, item 9 Appendix E

General

a. Carefully clean crankcase, particularly the oil ducts; check for free passage.

b. Check walls and bearing webs for cracks.

c. Check condition of bearing bores. If wear marks on bearing shells are not noticeable, check bearing bores with a precision gauge.

NOTE

If there are signs of wear on the bearing shells, the line of bearing housings can be reworked to an oversize outside diameter on a line boring machine. It is not permissible to bore out individual bearing pedestals.

d. Checking the Preload.

1. Install crankshaft bearing caps, observing the numbering, into the crankcase. Preload and tighten bolts according to specifications listed in Appendix F (fixture No. 003-5000).

2. Set precision gauge to the size indicated in table 4-5 using a micrometer frame (nominal or oversize).

3. Measure each main bearing bore at points 1 and 2 plane a, then in the same manner in plane b offset by 90 degrees, in order to determine any contraction, out-of-roundness, or conicity (figure 5-60).

4. If the recorded values correspond to those specified in table 4-5, the respective bearing bore is in an acceptable condition and the required preload will be obtained when new bearing shells are installed.

5. If the threaded bearing bore diameters differ only slightly from the specified values listed in table 4-5, repeat the measurements with the new bearing shells installed.

6. Insert new bearing shells, mount bearing cap, then preload and tighten up according to instructions.

7. Gauge each bore at points 1 and 2 in the vertical and horizontal positions a and b (figures 5-60 and 5-61).

8. If the recordings show that the bearing tolerances are up to 0.0008-inch (0.020 mm) maximum above the values specified in table 4-5, the crankcase is acceptable for further use. Otherwise, it is necessary for the line of bearing housings to be reworked to an oversize outside diameter on a line boring machine. It is not permissible to bore out individual bearing pedestals. Nor is it permissible to restore the required preload by underlying the bearing shells or by reworking the parting faces of the bearing bores.

    a) The main bearing shells are made in two halves and supplied in six dimensions, corresponding to the specified undersizes of the journals (table 4-5). No attempt may be made to recondition the shells.

    b) Standard and oversize wall thickness W (figure 5-62) should be taken from the specifications.

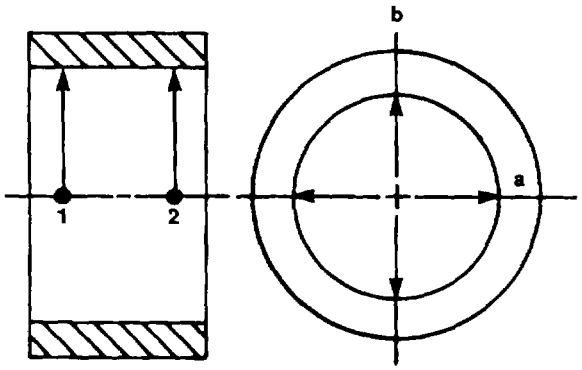


Figure 5-60. Measuring Main Bearing Bore

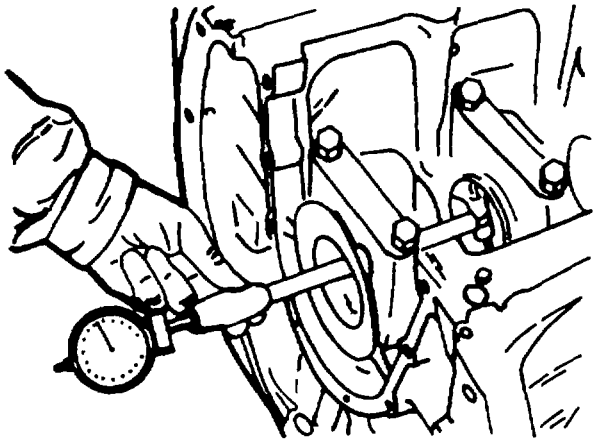


Figure 5-61. Gauging Bearing Bore in the Horizontal Position

9. Measure width of locating bearing journal of the crankshaft (figure 5-63).

10. Assemble the thrust rings on the locating main bearing and calliper the overall width.

11. Measure end clearance. Compare with the values given in the specifications (table 4-5). If necessary, install new stop rings.

12. Remove the radial seal ring from the back-end shield.

13. If the main bearing journal has not been reground and the bearing bushing shows no sign of damage or wear, gauge the bearing bore at two diagonal points.

14. Compare measure values with the specifications in table 4-5. If necessary, fit new bearing bushing.

15. Draw the bearing bushing in flush, align with oil holes in the housing.

16. Install a new radial sealing ring in the back-end shield with the sealing lip facing the bearing bushing; press in so that the back face is flush.

REPAIR REPLACE

e. Reworking Cylinder Seating on Crankcase.

1. Clean the seating area and remove paint residues. Place supporting brackets in position (figure 5-64).

2. Mount refacing device No. 003-0505 and retaining bolts to such an extent that the refacing device is still movable (figure 5-64).

3. Center refacing device by means of the centering fingers (arrows) and fasten (figure 5-65).

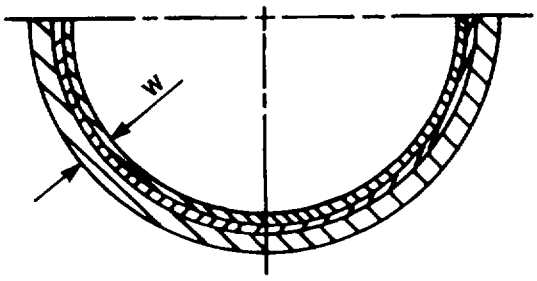


Figure 5-62. Standard and Oversize Wall Thickness

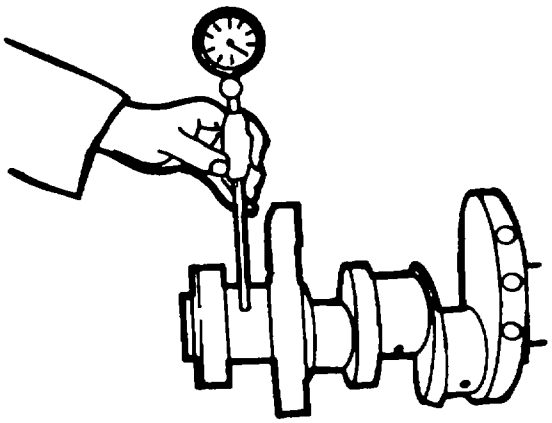


Figure 5-63. Measuring Width of Locating Bearing Journal of Crankshaft

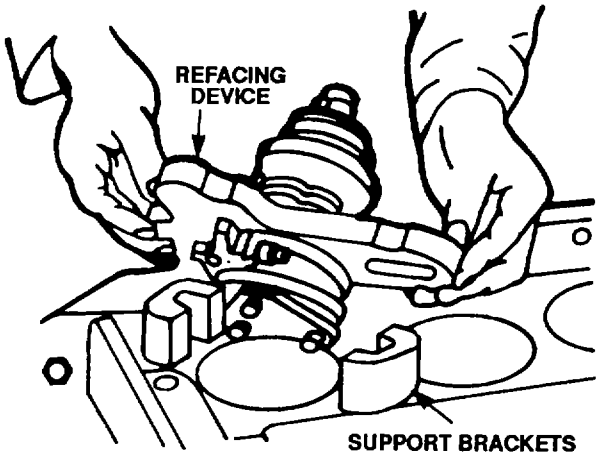


Figure 5-64. Mounting Refacing Device 003-0505

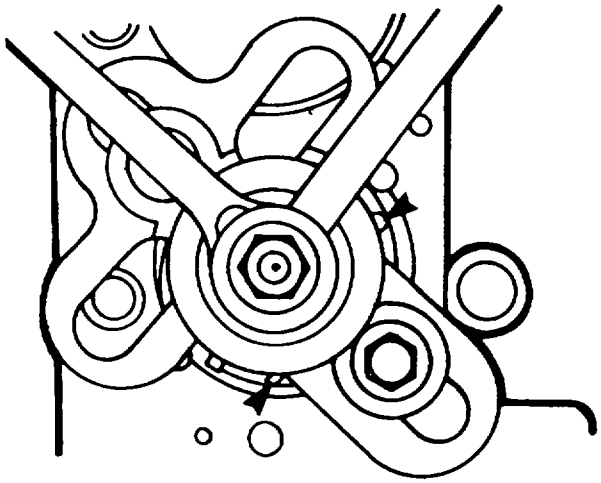


Figure 5-65. Centering Refacing Device

4. Withdraw centering fingers and slide the cutting tool holder out to just above the beginning of the inner diameter of the cylinder seating face to be reworked.

5. By means of the knurled nut, bring the tool holder down towards the face to be reworked until the cutter just contacts. the face.

CAUTION

Adjust feed carefully. A full turn (360 degrees) of the knurled nut feeds the tool holder by 0.059-inch (1.5 mm).

6. Turn back the knurled nut until the cutter is positioned freely above the face to be reworked, distance a (figure 5-66).

7. Return tool holder towards the middle of the bore.

8. By means of the knurled nut, set the tool over and slightly beyond the distance a (point 6) to permit satisfactory refacing of the cylinder seating surface.

NOTE

The selected cutting depth should not exceed O.008-inch (0.2mm). This feed corresponds to a 1/8th turn (45 degrees) of the knurled nut. The smaller the feed, the smaller the depth of roughness of the reworked surface.

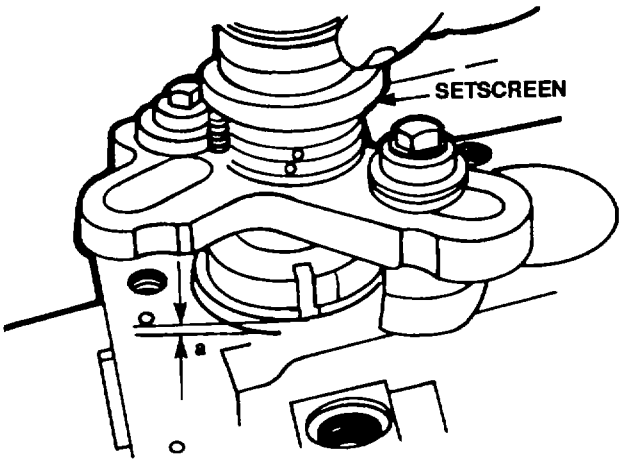


Figure 5-66. Setting the Refacing Tool

9. After adjusting, secure the device by means of the setscrew (figure 5-66).

10. Turn spindle of device clockwise to reface the cylinder seating.

NOTE

The feed is automatic when turning the spindle clockwise.

Remove only so much material as is necessary for obtaining a satisfactory sealing surface.

11. Loosen the setscrew and, by means of the knurled nut, raise the cutter from the reworked surface prior to removing the device.

12. After refacing the cylinder seating, clean the crankcase. The seating surface must be plane and free from grooves.

5-7. CRANKSHAFT (ENGINE)

DESCRIPTION

This task covers: Inspect. Replace. Repair.

INITIAL SETUP

Tools:
Hardness tester.
Micrometer

Equipment conditions:
Crankshaft removed (paragraph 5-10).

Materials/parts:
None

INSPECT

a. Inspect crankshaft for cracks (by magnaflux method).

b. Remove the gear wheel from the crankshaft.

c. Support crankshaft at outer main journals on prism-shaped blocks.

d. Gauging.

1. Determine the hardness of the journal surfaces with a hardness tester (figure 5-67). Conversions of the readings to Rockwell C hardness values, for comparison with the specifications (table 4-5), can be effected with the table included with the instrument.

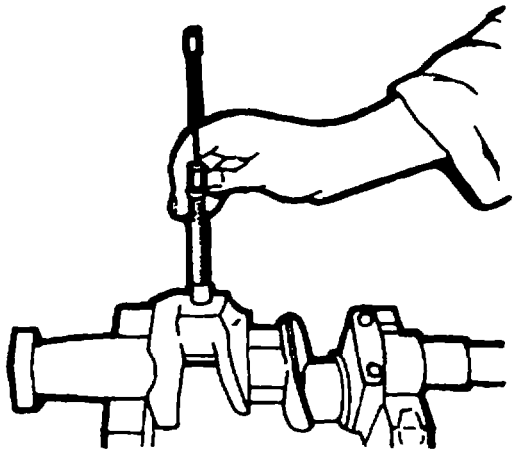


Figure 5-67. Measuring Journal Hardness with Scleroscope

2. Compare the readings with the specifications in table 4-5.

3. Measure all journals at points 1 and 2, in the vertical and horizontal, as indicated by a and b (figure 5-68).

NOTE
Width 3 should also be measured on the journal for a locating bearing.

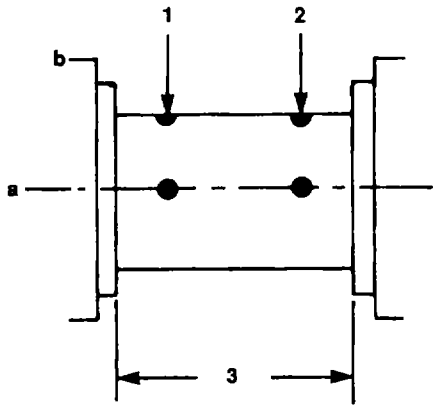


Figure 5-68. Measuring Points on Journal

4. Note the measurements on the inspection records sheets and compare with the specifications in table 4-5.

NOTE
For maximum permissible deviations from roundness, straightness, true run, and parallelism of all shaft journals and crankpins, also adjacent ones, see drawings. Wear limit for ovalness is 0.0008-inch (0.02 mm).

5. With a dial indicator, check the other journals for out-of-trueness (figure 5-69).

6. Check the working surface of the radial packing ring on the flywheel flange.

7. Replace the crankshaft and bearings, if defect.

Legend

I	=	Crankpin
II	=	Main Bearing Journal
Ks	=	Main Bearing Bore
Kz	=	Diameter of Main Bearing Journal
Ls	=	Width of Main Bearing
Lz	=	Length of Journal
Lu	=	Thickness of Thrust Washer (locating bearing)
W	=	Radial Clearance of Main Bearing
Z	=	End Clearance of Main Bearing
r	=	Radius of Journal Fillets
Ps	=	Big End Bearing Bore
Pz	=	Diameter of Crankpin
Bs	=	Width of Crankpin
X	=	Radial Clearance of Big End Bearing
Y	=	End Clearance of Big End Bearing
R	=	Radius of Crankpin Fillets

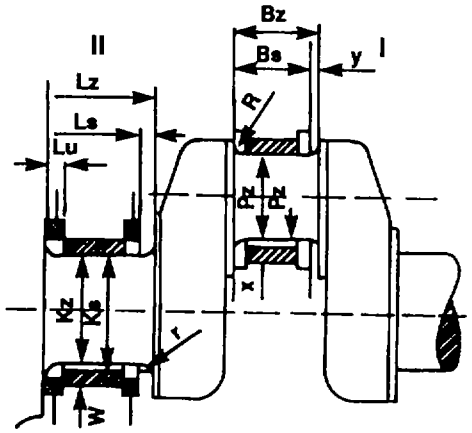


Figure 5-69. Measuring Crankshaft

5-8 CYLINDER HEAD SET (ENGINE).

DESCRIPTION

This task covers: Test. Repair.

INITIAL SETUP

Tools:
- Clamping stand No. 003-0562
- Clamping plate No. 003-0794
- Valve spring compressor No. 0093-0504
- Cutting device No. 003-0426
- Turning fixture No. 003-0621
- Guide mandrel No. 003-0764
- Mandrel for turning off the valve seat rings on lathe No. 003-1234
- drilling device No. 003-0649
- Pilot pin with drilling bushes No. 003-0650

Materials/parts:
- Cloth, Lint-free, item 9 Appendix E

Tools (Contd):
- Special milling cutter, hard metal No. 003-0652
- Arbor assembly
  - Inlet No. 003-0620
  - Exhaust No. 003-0441
- Cutter for valve seat ring, inlet exhaust No. 003-0784
- Arbor assembly No. 003-0453
- Reamer No. 003-0452
- Puller No. 003-0434
- Vinear

Equipment conditions:
- Cylinder head removed (paragraph 4-15).

TEST

a. Bolt the cylinder to the swivel clamping stand (figure 5-70). Dismantle both valves with springs, valve rotator, and washer (use clamping stand No.003-0562 with plate No. 003-0794 and valve spring compressor No. 003-0504).

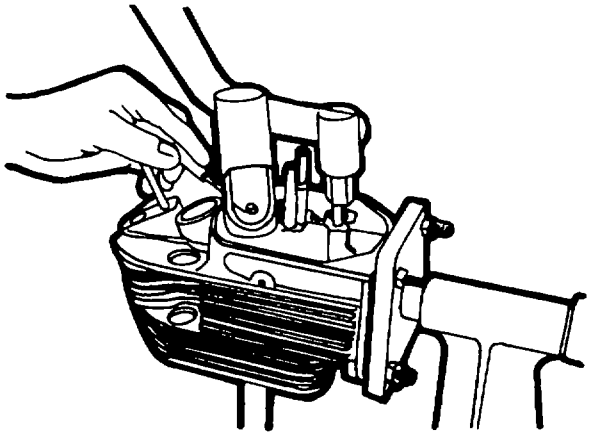


Figure 5-70. Cylinder Head Bolted to Swivel Clamping Stand

b. Clean the cylinder head and inspect for external damage or cracks; renew, if necessary.

c. Check the cylinder head seating surface (figure 5-71). It must be flat and square. It can be refaced provided the distance from the cylinder head sealing surface to the cylinder head crown is not less than the low limit given in the specifications.

REPAIR

NOTE
Measurements to be made with intermediate ring inserted.

a. Slight damage to the cylinder head seating surface can be removed by grinding cylinder head on cylinder head seating area. If more severely damaged, recut with plate mill No. 003-0426, or rework in the turning fixture No. 003-0621.

b. Check cylinder head with fixture in lathe and align.

NOTE
While taking into consideration the permissible tolerance, remove only so much material as is necessary for obtaining a perfect sealing surface.

c. Ensure the intermediate ring is in good condition before placing it in the recess of cylinder head (figure 5-72).

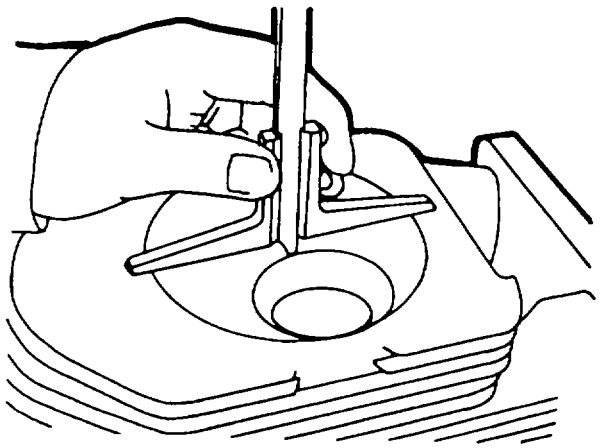


Figure 5-71. Checking the Cylinder Head Seating Surface

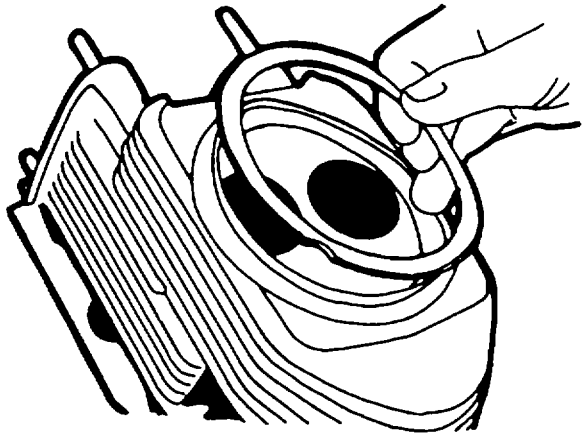


Figure 5-72. Intermediate Ring

d. To determine the wear of the valve seat rings, take a new valve and measure the distance between the valve plate and cylinder head seating surface (with intermediate ring placed in position). For valve recess, see specification data in table 4-4.

e. Renew valve seat rings (alternate methods).

1. Using mandrel No. 003-1234: Install mandrel No. 003-1234 onto the cylinder head. Chuck cylinder head with mandrel in lathe and turn out the worn rings.

2. Install the drilling device No.003-0649 to a drilling machine for cutting out the valve seat rings. Place on the cylinder head and insert the pilot pin with drilling bushes No. 003-0650.

3. Drill out the valve seat rings by means of the hard metal special cutter No. 003-0652.

f. Heat the cylinder head uniformly in a heating cabinet or oven to a temperature of 428°F (220°C). Slip the new ring (available in oversizes) chamfered side first on the drift and seat it (use drift No. 003-0620 for exhaust valve, respectively, figure 5-73).

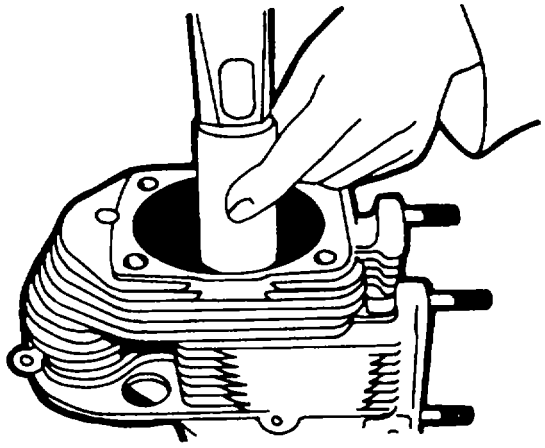


Figure 5-73. Seating New Valve Ring

NOTE

To replace valve seat rings and valve guides, cylinder head should be heated up only once.

g. Reface the seating rings that are not to be renewed. The maximum permissible distance from the center of the valve head to the cylinder head seating surface should not be exceeded (use drift No. 003-0764, reseater with holder for inlet and exhaust valve No. 003-0784).

h. Check the clearance of the valve stems in the guides of both valves. If it exceeds the permissible maximum given in the specifications, fit new guides.

i. Removing and installing a valve guide.

1. Uniformly heat the cylinder head in an oven to a temperature of 428°F (220°C). Do not heat for longer than 30 minutes. Drive out valve guide from the seating ring side (assembly arbor No. 003-0453, figure 5-74).

2. Renew the valve guide. (Valve guides are also available in oversizes.) Fix new securing wire.

3. With the cylinder head heated to 4280F (220'C), drive in from the rocker arm support side the longer end of the valve guide until it seats on the securing wire.

4. Allow the cylinder head to get cold. Then ream the valve guide (use reamer No. 003-0452).

5. Remove, if necessary, by pulling the injector gasket remaining in the cylinder head (use puller No. 003-0434).

6. Check whether the valve rotators work freely; renew, if necessary (figure 5-75).

7. Measure length of valve springs. Refer to specification data in table 4-4.

8. Insert valves.

9. Position the valve springs with the close coils facing the rotator. Install the valves (use valve spring compressor No. 003-0504).

10. Reinstall cylinder heads (paragraphs 4-15).

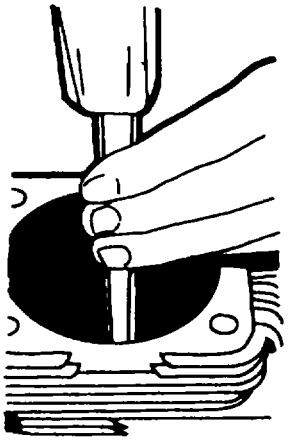


Figure 5-74. Driving Out Valve Guide

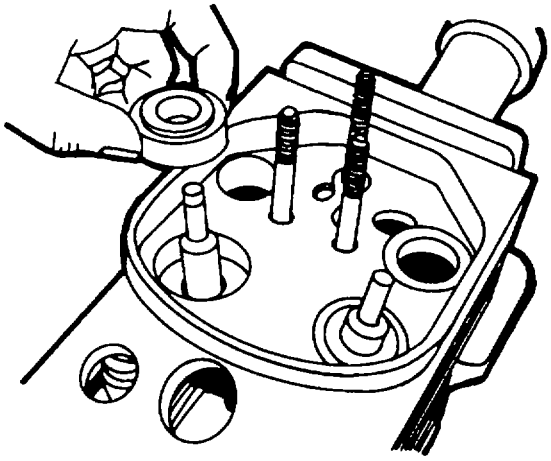


Figure 5-75. Installing Valve Rotators

5-9 CAMSHAFT AND HAND CRANKING ASSEMBLY (ENGINE)

DESCRIPTION

This task covers: Inspect. Replace. Repair.

INITIAL SETUP

Tools:
Removal/installation tool (003-0433)
Micrometer

Equipment conditions:
Fuel injection pump removed (paragraph 4-18).

Materials/parts:
Oil, Lubrication, item 24 Appendix E

INSPECT

a. Camshaft removal and inspection.

NOTE
The plate is eccentric and may have to be rotated to be removed.

1. Dismantle the rocker chamber covers and the rocker arm shaft supports. Remove the push rods. Remove bolts of starting crank bearing and remove crank bearing. Unscrew hex head socket screws from the starting crank plate and remove.

2. Remove the camshaft gear wheel. Remove the thrust washer, hold up the tappets and remove the camshaft and tappets.

b. Checking and replacing camshaft and bearings.

1. Check the camshaft and its gear wheel for damage and visible signs of wear.

2. Measure the journal at the drive end of the camshaft (figure 5-76).

NOTE
The diameter of the journal should not be smaller than the low limit given in the specifications, listed in table 4-5. Replace the camshaft if it is defective.

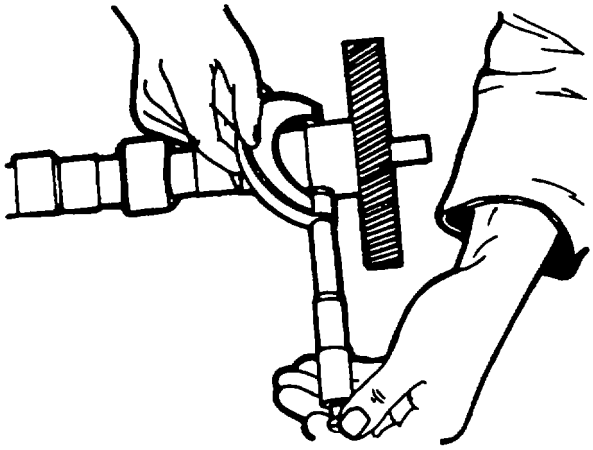


Figure 5-76. Measuring Camshaft Journal from Drive End

3. Inspect the bearing bushing on the camshaft for damage and visible signs of wear.

4. With the aid of a micrometer, set the internal dial indicator set to the normal inside diameter of the camshaft bearing bushing.

5. Measure bearing bore at points 1 and 2 in planes a and b (figures 5-77 and 5-78); check for any constriction, ovalness, and conicity.

6. To replace the bearing bushing, place the special tool on the front end (use removing and replacing tool No. 003-0433).

7. Position end support of the device at the next camshaft bore (arrow). Pull bearing bushing out towards the flywheel end.

8. Position new bearing bushing; ensure the oil holes in the bushing coincide with those in the crankcase.

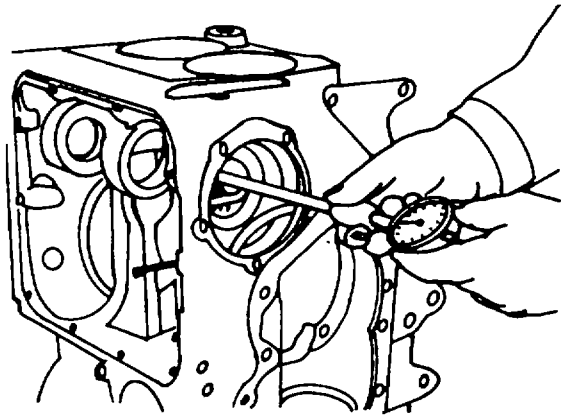


Figure 5-77. Measuring Camshaft Bearing Bore

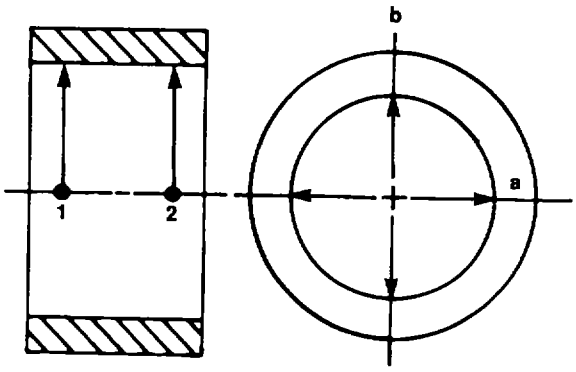


Figure 5-78. Measuring Main Bearing Bore

9. Press in the bearing bushing from the front side; do not permit it to get out of square (use removing and replace tool No. 003-0433). Figure 5-79 shows the installation of the bearing bushing.

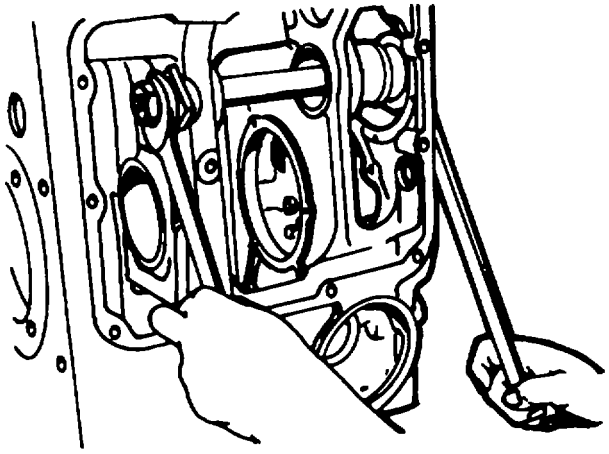


Figure 5-79. Removal/Reinstallation of Bearing Bushing

NOTE
Press in the bearing bushing so that it seats flush with the front end.

REPLACE REPAIR

a. Camshaft reinstallation.

1. Slightly oil the tappets, install and retain them in position (figure 5-80).

2. Install the camshaft from the front (opposite the flywheel end) into the bearing bores (figure 5-81).

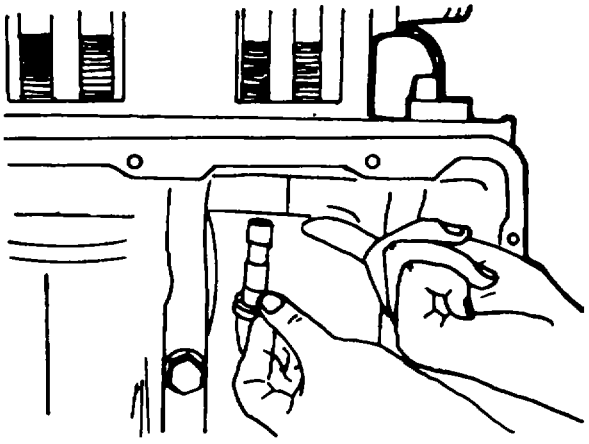


Figure 5-80. Installing Tappets

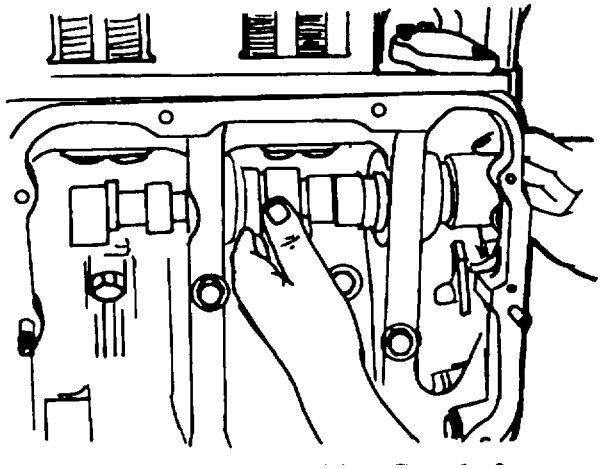


Figure 5-81. Installing Camshaft

CAUTION

Camshafts are designed for duties up to 2,300 rpm. Do not install one type in place of another.

3. Assemble the thrust washer on the camshaft

4. Drive the check pin of the camshaft gear wheel about 0.080 inch (2 mm) in the direction of the marked side.

NOTE

Timing marks may vary from engine to engine.

5. Install the camshaft gear wheel so that the tooth marked 1 engages in the gap between teeth marked 15 and 16 of the crankshaft gear wheel.

OR

5. Install the camshaft gear wheel so that the tooth marked • engages the crankshaft • in a straight line.

6. Rotate the camshaft so that the holes there register with the holes in the camshaft gear wheel.

7. Secure the camshaft gear wheel on the camshaft.

8. Mount the eccentric sheet metal ring on the camshaft gear wheel.

9. Measure the distance from the front face of the front camshaft cover to the joint surface.

10. Drive the check pin in the camshaft gear wheel so that it clears the joint surface by the distance from the front face of the cover plus 0.40 to 0.80 inch (1 to 2 mm).

11. Coat a new gasket with grease and stick it in position on the front of the crankshaft cover. Mount the crank handle bearing cover.

12. Check the end clearance of the camshaft.

13. The end clearance must be within the limits given in the specifications. If it is on the low side, correct by driving the gear wheel slightly in the direction of the front cover of the camshaft. If the end clearance is on the high side, dismantle the camshaft gear wheel and drive the check pin outwards by a corresponding amount.

14. Install the push rods.

15. Mount the rocker arm shaft support.

16. Adjust the valve clearance (paragraph 3-23).

17. Check the gaskets on the cylinder head covers and renew, if necessary. Apply jointing compound when assembling the gaskets.

18. Align and secure in position the cylinder head covers.

19. Reinstall fuel injection pump (paragraph 5-12).

5-10 TIMING GEARS (ENGINE)

DESCRIPTION

This task covers: Replace. Repair.

INITIAL SETUP

Tools:
Screwdriver, metric feeler gauge

Equipment conditions:
The engine must be cold.

Materials/parts:
Cloth, Lint-free, item 9 Appendix E

REPLACE REPAIR

NOTE

Do not change the setting of oil nozzle unless required. With hot engine running at idling, an oil flow to pad of rocker arm must be just noticeable. An excessive oil flow can lead to higher oil consumption.

a. Overhauling the Rocker Arm Bracket.

1. Ensure rod ends are tightly seated and free from wear (figure 5-82).

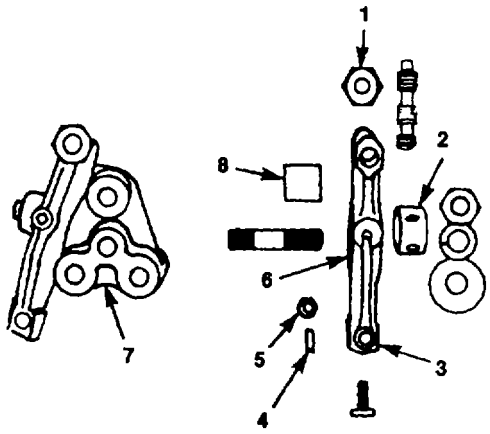


Figure 5-82. Push Rod, Push Rod Tube, and Tappet

2. Ensure rods are straight and the oil hole is free of obstruction.

3. Ensure tubes are straight and free from defects.

4. Ensure tappets are not worn and oil hole is free of obstruction. Replace parts, as required.

b. Checking Push Rods, Push Rod Tubes, and Tappets.

1. Dismantle bracket (7, figure 5-83).

2. Replace any worn parts.

3. Press in bearing bushing (2); ensure the lubrication oil holes are in alignment.

NOTE FOR REFITMENT

The rocker arms (3) are provided with an oil metering screw (4), the chamfered face of which should point to the thrust pad (6). Check that one thread turn of the screw projects beyond the locknut (5).

When the screw is finally adjusted under idling conditions on the engine test bench or in a vehicle, the position of the chamfered face is irrelevant. All you have to ensure is that a small oil flow toward the thrust pad is still visible.

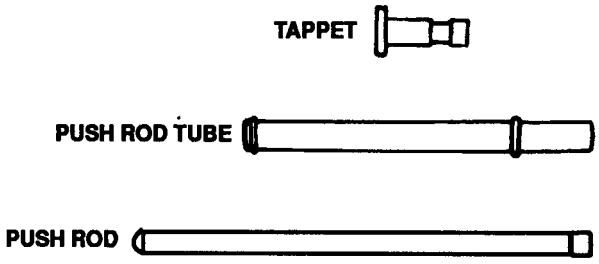


Figure 5-83. Rocker Arm Bracket Assembly

5-11 LUBE OIL PUMP (ENGINE).

DESCRIPTION

This task covers: Inspect. Replace. Repair.

INITIAL SETUP

Tools:
- Puller 144700
- Puller 144750
- Torque Wrench

Materials/parts:
- Cloth, Lint-free, item 9 Appendix E
- Detergent, non-ionic, item 13 Appendix E

Equipment conditions:
1. Equipment secured (paragraph 2-11).
2. Drain oil (paragraph 3-21).
3. Remove belt guard and V-belts (para. 3-35).
4. Remove front pulley.

REPLACE REPAIR

a. Removal.

1. Disconnect oil line at front cover.

2. Remove the outer nine bolts from the front cover (do not remove the two bolts in the center of the cover).

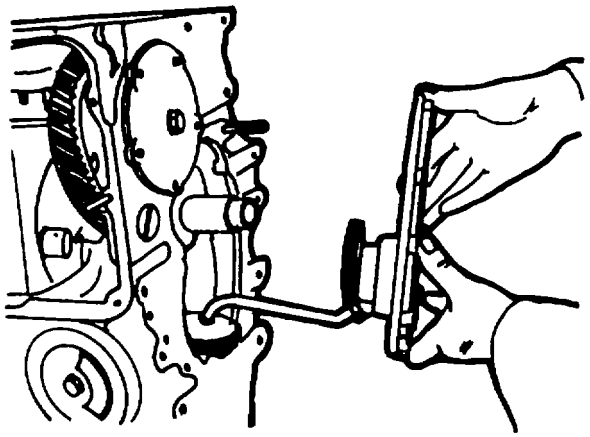


Figure 5-84. Remove Oil Pump

3. Remove the front cover with oil pump attached (figure 5-84).

4. Remove oil pump from front cover and remove pick-up tube.

5. Install pick-up tube on new pump.

b. Installing.

WARNING

When installing oil pump, oil pump should be primed by filling the pump with oil and turning the shaft until oil is pushed from the pressure side of the pump.

1. Install oil pump and pump cover with new gasket.

2. Tighten nut to prescribed torque. See Appendix F.

3. Refill oil to proper level.

INSPECT

c. Checking the Oil Pump.

1. Dismantle the oil pump from the front cover.

2. Check the end clearance of the pump gear on the driving shaft.

3. The end clearance must be within the limits stated in table 4-5. If necessary, fit a new oil pump.

4. Mount the oil pump on the front cover plate.

5-12 FUEL INJECTION PUMP

DESCRIPTION

This task covers: Repair.

INITIAL SETUP

Tools:
Retaining ring pliers
Torque wrench

Equipment condition:
Equipment secured (paragraph 2-11).

CAUTION

Ensure fuel injection pump and work area are maintained free of dirt and foreign material while repairing governor assembly and the barrel and plunger.

REPAIR

a. Governor Assembly.

1. Remove lock wire from the fuel adjustment cap nut.
2. Remove internal C clip against governor gear.

CAUTION

Do not adjust, loosen, or separate fuel adjustment cap nut.

3. Using 1-1/4 inch open end wrench, loosen jam nut and remove fuel adjustment cap assembly.
4. Remove governor assembly.
5. Visually inspect for damaged components. Replace, if necessary.

6. To reinstall the governor assembly, apply grease on sleeve before installing.

7. Install governor assembly, ensuring control lever seats against sleeve.

8. Reinstall fuel adjustment cap assembly and turn in four threads.

9. Reinstall C clip. Tighten fuel adjustment cap assembly.

b. Plunger and Barrel Disassembly.

CAUTION

Roller and tappet assembly is spring-loaded. Use caution when removing tappet body nuts.

1. Remove tappet body nuts. Remove body and tappet assembly (figure 5-85).

WARNING

Fuel timing shims are matched to each pump assembly. Do not interchange shims, barrels, plungers, or metering valves. Serious damage or personnel injury may occur.

2. Remove plunger and control panel assembly

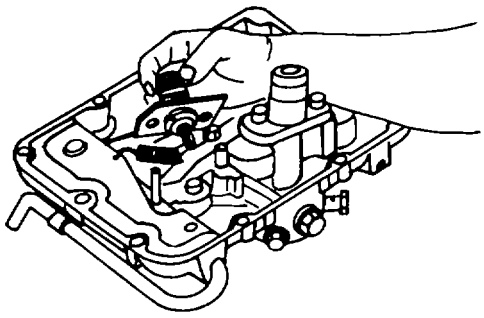


Figure 5-85. Assembled Plunger and Metering Sleeve

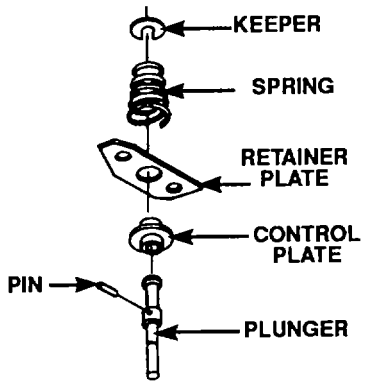


Figure 5-86. Disassembled Plunger and Metering Sleeve

3. Remove two bolts holding flange in place.

4. Remove the spring, fuel metering valve, and copper washer.

5. Remove the barrel by pushing from other side (figure 5-87).

6. Inspect for damaged parts. Replace as required.

c. Reinstall Plunger and Barrel.

1. Copper washer in housing. Install barrel and turn until barrel rests 1/4-inch below surface.

2. Install second copper washer on copper barrel (figure 5-88).

3. Install delivery valve and spring.

4. Install delivery valve holder, finger-tighten.

5. Preassemble and support plate.

6. Install plunger into barrel, ensuring that the metering sleeve notch engages the control lever pin.

7. Place timing shims on spring keeper. Place roller assembly on top of timing shims and install roller body, ensuring that the oil hole is facing up.

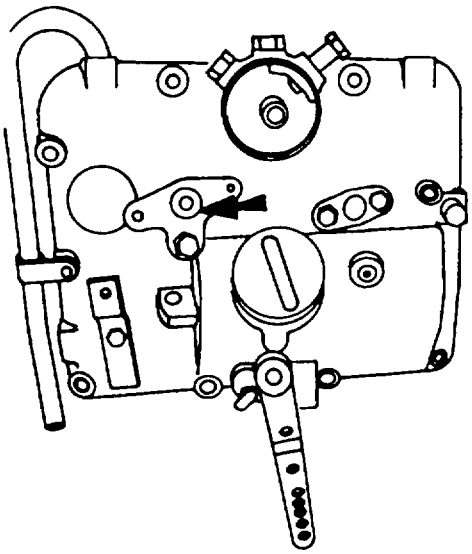


Figure 5-87. Copper Washer and Barrel (Flange Removed)

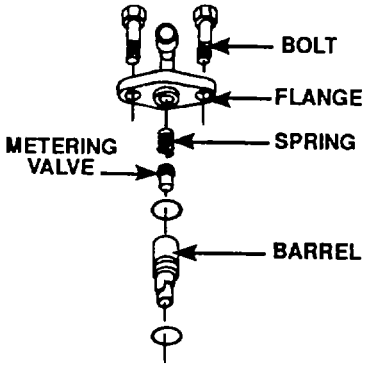


Figure 5-88. Barrel Assembly

8. Install washers and nuts and torque to 18 lb-ft (25 Nm).

NOTE
Two mechanics are required for the following procedure.

9. Push down on both roller assemblies simultaneously, while moving governor weights, to ensure no binding or sticking of the fuel control lever.

5-13 INSTRUMENTS AND CONTROL PANEL.

DESCRIPTION

This task covers: Calibrate.

INITIAL SETUP

Tools:
None

Equipment conditions:
Respective gauges removed from instrument panel.

Materials/parts:
None

CALIBRATE

Gauge calibration should be conducted in accordance with TB-9-4220-216-35, "Calibration Procedures for Pressure Gauges Used with Diving Equipment."

Section III.
PREPARATION FOR STORAGE OR SHIPMENT

5-14 PREPARATION FOR STORAGE OR SHIPMENT.

5-15 PREPARATION FOR SHORT-TERM STORAGE. Short-term storage of the compressor, that is storage of about six months or less, can be accomplished according to the following steps.

WARNING

All work performed on the compressor must be accomplished only while the unit is depressurized.

a. Run the compressor at operating pressure and temperature for 10 minutes.

b. Check the unit for leaks at all pipe connections, filter, purifier, separator, and valves. Tighten couplings and connections as required.

c. After ten minutes of operation, open the outlet valve and allow the compressed air to escape to the atmosphere. Allow the compressor to operate at an adjusted minimum pressure of 1450 psig (100 BAR) using pressure maintaining valve for about five minutes.

d. Shut down the unit after five more minutes of operation and drain off the filter, purifier, and separator by opening the condensate drain cocks. Close the drain cocks after the compressor has been reduced to zero pressure.

e. Install new purifier cartridges (058825 and 068416).

f. Service engine oil bath air cleaner.

g. Install new compressor inlet air cleaner element.

h. Remove prefilter hose (with raincap). Seal opening in air filter housing with tape, MIL-T-22085.

i. Drain fuel from fuel tank. Spray interior of tank with a small quantity of preservation oil P10, grade 30.

j. Change engine oil.

k. Change compressor oil.

l. Loosen drive belt tension.

m. Clean dirt and debris from engine cooling fins.

n. Store in a dry, dust-free room and cover with a plastic film that does not sweat. Remove cover from time to time to clean unit.

5-16 STORAGE LONGER THAN SIX MONTHS. If the compressor unit is to be shut down for a major period, the following preservation measures for antioxidation are recommended.

a. Clean the engine, including the cooling system, with commercial detergent and a high pressure water jet.

b. Run compressor unit for about ten minutes until up to working temperature, then shut down.

c. Drain engine crankcase while still warm and fill with preservative, P-10, grade 10.

d. Pour the oil out of the bowl of the oil bath air cleaner. Clean bowl and fill with anticorrosive oil.

e. Drain compressor crankcase and fill with preservative P-10, grade 10.

f. Start the compressor unit and run for five minutes. Immediately before shutting down, spray two to three fluid ounces of preservative P-10, grade 10, into compressor 1 st stage inlet (after the air cleaner).

g. Shut down compressor unit.

1. Check all pipes, filters, and valves (also safety valves) for leakage.
2. Tighten all couplings, as required.
3. After ten minutes, open the outlet valve and operate the compressor at adjusted minimum pressure (about 100 bar/1,450 psi) using pressure maintaining valve for about five minutes.
4. After the five minutes, shut the system down and completely drain off all separators and filters. Reclose shutoff valve.
5. Remove intake filter/intake pipe completely.
6. Operate compressor again and slowly drip 50 to 100 ccm (.9 to 1.8 cu. in.) into the inlet port with the compressor running. Keep shutoff valve open and condensate drain valves closed.
7. If the inlet port is arranged horizontally, use hose pipe to facilitate the job.

8. After introducing the oil into the inlet port, operate the system for about five minutes and then shut down.
9. Close shutoff valve.
10. Place dust cap N 3627 onto the inlet port.

h. Disengage clutch.

i. Install new purification cartridges.

j. Drain the fuel tank and spray inside of fuel tank with preservative P10, grade 30.

k. Connect a two-chamber fuel source to the auxiliary fuel connection; one chamber to be filled with diesel, the other to be filled with preservative P-9. See figure 5-89.

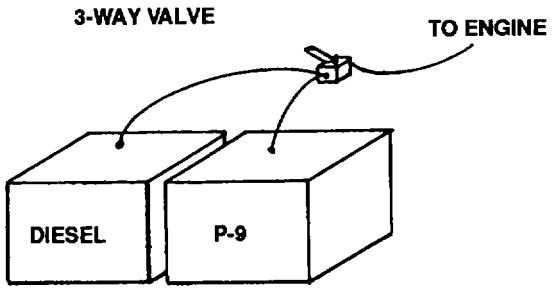


Figure 5-89. Two-Chamber Fuel Source

l. Start the engine, run on diesel for two minutes, then switch to P-9. Run the engine until white smoke starts to come from the engine exhaust. (This coats the pipes, filter, pump, and nozzle, and ensures that the mixture has been distributed to all parts.

m. Detach the rocker chamber covers and spray the rocker chambers with a mixture of diesel fuel and 10 percent anticorrosive. Refit covers.

n. Turn the engine over several times without firing in order to spray the mixture into the combustion chambers.

o. After the engine cools, remove each injector and add one ounce of preservative (P-9) to each cylinder. Replace injectors.

p. Remove V-belts and spray grooves of the V-belt pulleys with an anticorrosive. Before reusing the engine, wipe off the anticorrosive.

q. Apply preservative P-9 to the engine exhaust manifold, pipes, and muffler.

r. Close and secure all valves.

s. Disconnect and remove battery.

t. Close compressor air cleaner inlet, engine air inlet, and exhaust openings with tape.

u. Ensure the compressor is kept indoors in a dry room free of dust. (Cover the compressor with plastic sheets only if it is sure that no sweat water will form under the sheet.)

v. Cover unit with foul weather tarpaulin and secure, using the draw rope furnished.

w. Store in a fully protected storage site.

NOTE

The preservative measures will give the engine a protection of 6 to 12 months, depending on weather effects. Before reusing the engine, replace the preserving mixture with regulator motor oil to API specifications. The anticorrosive oils used should conform to MIL-L-21260 B or TL 9150-037/2 specifications or NATO Code C-640/642.

NOTE

Remove the sheet from time to time and dry the steam off on the outside.

NOTE

If these means of preserving the compressor cannot be carried out and it is intended to take the compressor OUT-OF-SERVICE for more than 2 or 3 years, contact the manufacturer.

5-17 PREVENTIVE MAINTENANCE DURING STORAGE. Operate the compressor once every three months, as follows:

a. Remove the dust cap from the inlet port and install intake filter.

b. Open shutoff valve and allow the system to run about five minutes until air/gas flows out of the valve.

c. Shut down the compressor.

d. Open condensate drain valves, decompress all stages, then reclose valve.

e. Replace the dust cap on the inlet port.

NOTE

After prolonged idle periods, the oil will age in the compressor and the engine and must be drained after three years, at the latest, and replaced by fresh oil. The stated period can only be attained when the crankcase is sealed during the preservation period in accordance with the preservation requirements.

NOTE

After changing the oil, the compressor and the engine have to be turned or operated for the prescribed period.

5-18 REACTIVATING THE COMPRESSOR UNIT.

a. Remove the dust cap from the inlet port.

b. Check the oil level of the compressor.

c. Check the motor/engine in accordance with the manufacturer's instructions.

d. Run the compressor with open filling valves for about five minutes. Check for proper operation of the lubricating system.

e. Close shutoff valve after five minutes and run system up to final pressure until the final pressure safety valve blows.

f. Check the interpressure safety valves for leakage.

g. Establish cause of any fault from the troubleshooting tables; remedy, as required.

h. When running properly, stop the system. The compressor unit is now ready for operation.

APPENDIX A

REFERENCES

A-1 SCOPE.

This appendix lists all forms, field manuals, technical manuals and miscellaneous publications referenced in this manual.

A-2 FORMS.

Quality Deficiency Report SF-368
Packaging Improvement Report ..... DD Form 6
Depreservation Guide ..... DA Form 2258

A-3 TECHNICAL MANUALS.

Repair Parts and Special Tools List, 20 CFM Compressor,
Model K20 ..... TM 5-4310-389-24P
Procedures for the Destruction of Equipment
to Prevent Enemy Use ..... TM 750-244-3

A4 MISCELLANEOUS PUBLICATIONS.

Navy Experimental Diving Unit Instruction
Organizational Level Cleaning of Air and Oxygen Systems ..... NEDU 7121 A

A-5 PAMPHLETS.

The Army Maintenance Management System
(TAMMS) ..... DA PAM 738-750

APPENDIX B
MAINTENANCE ALLOCATION CHART

Section I. INTRODUCTION

B-1 GENERAL.

a. This section provides a general explanation of all maintenance and repair functions authorized at various maintenance levels.

b. The Maintenance Allocation Chart (MAC) in section II designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component will be consistent with the capacities and capabilities of the designated maintenance levels.

c. Section III lists the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from section II.

d. Section IV contains supplemental instructions and explanatory notes for a particular maintenance function.

B-2 MAINTENANCE FUNCTIONS.

a. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and or electrical characteristics with established standards through examination (e.g., by sight, sound, or feel).

b. Test. To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. Service. Operations periodically required to keep an item in proper operating condition, i.e., to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases.

d. Adjust. To maintain or regulate, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to specified parameters.

e. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

f. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments or test, measuring, and diagnostic equipments used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. Remove/Install. To remove and install the same item when required to perform service or other maintenance functions. Installation may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of the equipment or system.

h. Replace. To remove an unserviceable item and install a serviceable counterpart. Replace is authorized by the MAC and is shown as the 3rd position code of the SMR code.

i. Repair. The application of maintenance services, including fault location/troubleshooting, removal/reinstallation, disassembly/reassembly procedures, and maintenance actions to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in apart, subassembly, module (component or assembly), end item, or system.

j. Overhaul. That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications (i.e., DMWR). Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to a like new condition.

k. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours/miles, etc.) considered in classifying Army equipment/components.

B-3 EXPLANATION OF COLUMNS IN THE MAC, SECTION II.

a. Column 1, Group Number. Column 1 lists functional group code numbers; the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. Column 3, Maintenance Function. Column 3 lists the functions to be performed on the item listed in Column 2. (For detailed explanation of these functions, see paragraph B-2.)

d. Column 4, Maintenance Level. Column 4 specifies, by the listing of a work time figure in the appropriate subcolumn(s), the level of maintenance authorized to perform the function listed in Column 3. This figure represents the active time required to perform that maintenance function at the indicated category of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance levels, appropriate work time figures will be shown for each level. The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item, or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (including any necessary disassembly/ reassembly time), troubleshooting/fault location time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized by the MAC. The symbol designations for the various maintenance levels are as follows:

C Operator or crew

O Unit Maintenance

F Intermediate Direct Support Maintenance

H Intermediate General Support Maintenance

D Depot Maintenance

e. Column 5, Tools and Equipment. Column 5 specifies, by code, those common tool sets (not individual tools) and special tools, TDE, and support equipment required to perform the designated function.

f. Column 6, Remarks. This column shall, when applicable, contain a letter code in alphabetic order, which shall be keyed to the remarks contained in Section IV.

B-4 EXPLANATION OF COLUMNS IN TOOL AND TEST EQUIPMENT REQUIREMENTS, SECTION III.

a. Column 1, Reference Code. The tool and test equipment reference code correlates with a code used in the MAC, Section II, Column 5.

b. Column, Maintenance Category. The lowest category of maintenance authorized to use the tool or test equipment.

c. Column 3, Nomenclature. Name or identification of the tool or test equipment.

d. Column 4, National Stock Number. The National Stock Number (NSN) of the tool or test equipment.

e. Column 5, Tool Number. The manufacturer's part number.

B-5 EXPLANATION OF COLUMNS IN REMARKS, SECTION IV.

a. Column 1, Reference code. The code recorded in column 6, Section II.

b. Column 2, Remarks. This column lists information pertinent to the maintenance function being performed as indicated in the MAC, Section II.

Section II. MAINTENANCE ALLOCATION CHART

NOMENCLATURE OF END ITEMS 20 CFM AIR COMPRESSOR, MODEL K20

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
01	Compressor	Inspect	0.1	0.1					
		Test		0.5					
		Service		0.5					
		Adjust		0.5				55	A, B
0101	Crankcase, Upper	Inspect				0.2			
		Replace				4.0			
		Repair				8.0		51,55, 61,62	
010101	Drive Gear	Replace				2.0			
		Repair				4.0		55	
0102	Crankcase, Lower	Remove/ Install		0.2					C
		Repair			2.0	8.0		55,61, 62	
010201	Tension Pulley Assy	Adjust		0.5				55	
0103	Cylinder Block Assy	Inspect			0.1				
		Replace			5.0				
		Repair			2.0			56,62,64 -70,72-75	
0104	Valve Head Assy, 1st Stage	Inspect			0.1				
		Replace			0.3				
		Repair			1.5			55	
0105	Valve Head Assy, 2nd Stage	Inspect			0.1				
		Replace			0.3				
		Repair			1.5			55	
0106	Valve Head assy, 3rd Stage	Inspect			0.1				
		Replace			0.3				
		Repair			1.5			55	

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
0107	Valve Head Assy, 4th Stage	Inspect Replace Repair			0.1 0.3 1.5			55	
0108	Cooling System	Inspect Service Repair		0.1 0.3	3.0			53,55,76, 77	
0109	Flywheel, Fanwheel Assy	Replace Repair		0.1 1.0				8,39,41, 55	
0110	Oil Lubricating System	Repair		2.5				55	
0111	Intake, Filter Assy	Inspect Repair		0.1 1.5				55	
02	Engine	Inspect Test Service Replace Repair	0.1	0.1 1.0 0.8	4.0 6.0	12.0		3,8,10,11, 35-39, 42-46,55 61,62, 67,71	B
0201	Crankcase	Replace Repair				4.0 8.0	4	3,42,44, 46,55,68, 69	
0202	Cylinder	Replace Repair				1.0 1.0		3,55,68,73	
0203	Crankshaft	Inspect Replace Repair				0.2 4.0 6.0		8,36,37, 38,40-45, 55,58,66	

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
0204	Connecting Rod	Inspect			0.1				
		Replace			2.0				
		Repair			3.0			7,34,35, 55,69	
0205	Piston	Inspect			0.2				
		Test			1.0				
		Replace			5.0			1,2,11,13,	
		Repair			7.0			31,32,33, 46,55,57, 59,61, 64,65	
0206	Cylinder Head Set	Test			1.0				
		Remove/ Install	0.1						C
		Replace		1.0				3,7,9-12,	
		Repair			3.0			14-30,46, 55,56,61, 62,64, 65,71	
0207	Camshaft & Hand Cranking Assy	Inspect				0.2			
		Replace				5.0			
		Repair				7.0		3,44,55, 58,62, 66,68	
0208	Timing Gears	Adjust		2.0	2.0				
		Replace				4.0			
		Repair				8.5		3,4,6,55, 71	
0209	Lube Oil Pump	Inspect				1.0			
		Replace				3.0			
		Repair				4.0	4	4,55	
0210	Lube Oil Filter	Replace		0.5				55	

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
0211	Lube Oil Cooler	Inspect		0.2					
		Service		0.2					
		Repair		2.0				55	
0212	Fuel Injector	Repair			1.5			9,10,13, 46,55,60	E
0213	Filter Cartridge	Replace		1.0				54,55	
0214	Injection Pipes	Inspect		0.1					
		Repair		0.3				55	E
0215	Fuel Injection Pump	Inspect		0.1					
		Test			0.2				
		Adjust			1.5				
		Replace			0.7				
		Repair				4.0		5,6,47,48, 55,62,78	
0216	Fuel Feed Pump	Service		0.2					
		Repair			1.0			55	
0217	Fuel Hose	Inspect		0.1					
		Repair		1.0				55	E
0218	Fuel Return Lines	Inspect		0.1					
		Repair		0.5				55	E
0219	Oil Bath Air Cleaner	Service		0.5					
		Replace		0.5					
		Repair		0.5				55	
0220	Intake Manifold Pipe	Inspect		0.1					
		Repair		0.5				55	E
0221	Cooling Air Blower	Replace			0.5				
		Repair			0.5			55,74	

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
0222	Cooling Air Ducting System	Inspect		0.5					
		Service		1.5					
		Repair		1.5				55	E
0223	Starting Motor	Replace		0.5					
		Repair			2.5			52,55	
0224	V-belt Guard	Inspect		0.1					
		Replace		0.5					
		Repair		0.5				55	
0225	Exhaust Manifold Assy	Inspect		0.1					
		Repair		0.5				55	E
0226	Cold Start Aid	Replace		0.5					
		Repair		0.5				55	
0227	Alternator	Test			1.0				
		Replace		0.5					
		Repair			2.5			52,55	
0228	Clutch System	Inspect		0.1					
		Service		0.2					
		Adjust		0.5					
		Replace			2.0				
		Repair			7.0			50,55,74	
022801	Handle Assembly	Replace			1.0			55	
03	Purification System	Inspect		0.1	0.1				
		Service			0.5				
		Repair				2.5		55	
0301	Pressure Maintaining Valve	Inspect			0.1				
		Adjust			0.1				
		Replace				0.2		49,55	
		Repair				0.5			

(1) Group Number	(2) Component/ Assembly	(3) Maintenance Function	(4) Maintenance Level C	O	F	H	D	(5) Tools and Equipment	(6) Remarks
0302	Purifier Chamber	Inspect		0.1					
		Service			0.3				
		Replace			0.2				
		Repair			0.5			49,54,55	
0303	Separator Block	Inspect		0.1					
		Replace			0.5				
		Repair			3.0			55	D
04	Instruments & Control Panel Assy	Inspect	0.1	0.1					
		Calibrate				1.0			F
		Repair		0.7	2.0			55	
05	Electrical System	Inspect	0.1	0.1					
		Test		1.0					
		Adjust			1.0				
		Service		1.0					
		Repair		1.0	2.0			52,55	E
06	Tubing & Fittings	Inspect		0.1					
		Replace			0.3			55	

Section III TOOL AND TEST EQUIPMENT REQUIREMENT

(1) Tool or Test Equipment Ref Code	(2) Maintenance Category	(3) Nomenclature	(4) National/Stock Number (NSN)	(5) Tool Number
1	F	Connector		003-0464 (62445)
2	F	Fitting		100050 (62445)
3	F	Dial Gauge 0.01 mm		003-0543 (62445)
4	F	Adjusting Device		003-0498 (62445)
5	F	Magnetic Graduation		003-1189 (62445)
6	F	Pointer		003-0678 (62445)
7	F	Angle of Turn Indicator		003-0500 (62445)
8	F	Gauge		003-1102 (62445)
9	F	Extractor		003-463 (62445)
10	F	Threaded Piece		003-0422 (62445)
11	F	Socket Wrench		003-0512 (62445)
12	F	Square Recess Socket		003-0511 (62445)
13	F	Puller		003-0434 (62445)
14	H	Clamping Stand		003-0562 (62445)
15	H	Clamping Plate		003-0794 (62445)
16	H	Valve spring		003-0504 (62445)
17	H	Cutter		003-0784 (62445)
18	H	Holder		003-1043 (62445)

(1) Tool or Test Equipment Ref Code	(2) Maintenance Category	(3) Nomenclature	(4) National/Stock Number (NSN)	(5) Tool Number
19	H	Guide Mandrel		003-076 (62445)
20	H	Accessories		003-0642 (62445)
21	H	Mandrel		003-1234 (62445)
22	H	Drilling Device		003-0649 (62445)
23	H	Pilot Pin		003-0650 (62445)
24	H	Assembly Arbor		003-0453 (62445)
25	H	Reamer		003-0452 (62445)
26	H	Assembly Arbor, Inlet		123960 (62445)
27	H	Assembly Arbor, Exhaust		123950 (62445)
28	H	Cutting Device		003-0426 (62445)
29	F	Spring Tensioning Tool		003-0501 (62445)
30	H	Turning Fixture		003-0621 (62445)
31	F	Piston Ring Expander		003-0496 (62445)
32	F	Gauge		003-0438 (62445)
33	F	Piston Ring Squeezer		003-0430 (62445)
34	F	Fixture		003-1079 (62445)
35	F	Bent Socket Spanner		003-0572 (62445)
36	H	Puller Device		003-0672 (62445)
37	H	Special Device		003-0670 (62445)

(1) Tool or Test Equipment Ref Code	(2) Maintenance Category	(3) Nomenclature	(4) National/Stock Number (NSN)	(5) Tool Number
38	H	Special Device		003-0671 (62445)
39	H	Hammer Spanner		003-0503 (62445)
40	H	Fitting Device		003-2498 (62445)
41	H	Fitting Device		003-2499 (62445)
42	H	Puller		003-0733 (62445)
43	H	Mandrel		003-0674 (62445)
44	H	Removing Tool		003-0433 (62445)
45	H	Turning Device		003-0505 (62445)
46	F	Extracting Device		003-0536 (62445)
47	F	High-Pressure Hand Pump		003-0644 (62445)
48	F	Tank		003-0777 (62445)
49	F	Wrench, Bauer Securus		WRH-2 (57328)
50	C	Grease Gun	4930-00-965-0288	
51	H	Press, 1-Ton		3Z915 (16365)
52	0	Multimeter	6625-00-581-2036	
53	F	Wrench, Open End 1-1/16"	5120-00-187-7134	
54	0	Strap Wrench	5120-00-262-8491	
55	0	General Mechanics Tool Set	5180-00-177-7033	
56	H	Milling Cutter		003-0652 (62445)

(1) Tool or Test Equipment Ref Code	(2) Maintenance Category	(3) Nomenclature	(4) National/Stock Number (NSN)	(5) Tool Number
57	F	Piston Heater		003-0414 (62445)
58	H	Retainer		003-0446 (62445)
59	F	Compressograph		003-1056 (62445)
60	0	Battery Hydrometer	6630-00-171-5126	
61	F	Torque Wrench, 30-150 in.-lbs. 1/4" Drive	5120-00-542-4489	
62	F	Torque Wrench, 10-150 ft-lbs. 1/2" Drive	5120-00-902-3549	
63	H	Puller Kit, Mechanical	5120-00-033-5606	
64	F	Pliers, Retaining Ring Set	5120-00-789-0492	
65	F	Outside Micrometer, 0-1"	5210-00-540-2973	
66	F	Outside Micrometer, 2-6"	5210-00-223-9158	
67	F	Inside Micrometer, 1-2"	5210-00-221-1919	
68	F	Inside Micrometer, 2-12"	5210-00-221-1921	
69	F	Gauge Set, Telescoping, 5/16-6"	5210-00-473-9350	
70	F	Gauge, Cylinder, 2-1/2-9"	5210-00-494-1774	
71	F	Caliper, Vinear	5210-00-293-2913	
72	F	Lapping Plate	3460-00-606-7141	66-0646 (05083)
73	0	Tachometer, Hand Held	6680-00-116-0182	336532R91 (29510)
74	F	Piston Ring Compressor (1/2-3-1/4)	5120-00-322-6223	
75	F	Piston Ring Compressor (3-1/2-7)	5120-00-223-8848	
76	0	Gap Gauge, Fitting		MS-1G200 (11704) (62445)
77	0	Gap Gauge, Fitting		MS-1G468 (11704) (62445)
78	F	Special Outfit		3202 (62445)

Section IV.
MAINTENANCE ALLOCATION CHART

REFERENCE CODE	REMARKS
A	Test for air purity standards in accordance with this TM and the U. S. Navy Diving Manual, NAVSEA 0994LP-001-9010.
B	Depot level repair will be performed on a case by case basis subject to funding/ approval by the National Inventory Control Point (NICP).
C	Organizational Level personnel are limited to remove/install of the cover only.
D	Safety Valves are sealed at factory. No repairs authorized.
E	Repair is by replacement of individual components/assemblies.
F	Calibrate every 540 days in accordance with TB 9422G216-35.

APPENDIX C

COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LISTS

SECTION I.
INTRODUCTION

C-1 SCOPE.

This appendix lists components of end item and basic issue items for the K-20, Diving Air Compressor to help you inventory items required for safe and efficient operation.

C-2 GENERAL.

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. Components of End Item. This listing is for informational purposes only, and is not authority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transportation or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts.

b. Section III. Basic Issue Items. These are the minimum essential items required to place the K20, Diving Air Compressor in operation, to operate it, and to perform emergency repairs. Although shipped separately packaged, BII must be with the K-20, Diving Air Compressor, during operation and whenever it is transferred between property accounts. This manual is your authority to request/ requisition replacement BII, based on TOE/MTOE authorization of the end item.

C-3 EXPLANATION OF COLUMNS.

The following provides and explanation of columns found in the tabular listings:

a. Column (1) Figure and Item Number. This column indicates the figure and item number of the RPTSL where the item is shown.

b. Column (2) National Stock Number. Indicates the National stock number assigned to the item and will be used for requisitioning purposes.

c. Column (3) Description. Indicates the Federal item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the CAGE (in parentheses) followed by the part number.

d. Column (4) Unit of Measure (U.M). Indicates the measure used in performing the actual operation/maintenance function. This measure is expressed by a two character alphabetical abbreviation (e.g., ea, in, pr).

e. Column (5) - Quality required (Qty rqr.). Indicates the quantity of the item authorized to be used with/on the equipment.

SECTION II.

COMPONENTS OF END ITEM LIST

(1) Figure and Item No.	(2) National Stock No.	(3) Description CAGE and Part NO.	(4) U/M	(5) Qty Rqd
1-0		Battery 12V (90660) Exide 4-27	ea.	1
		TARP (8D824) CVR-15	ea.	1

SECTION III.

BASIC ISSUE ITEMS

(1) Figure and Item No.	(2) National Stock No.	(3) Description CAGE and Part NO.	(4) U/M	(5) Qty Rqd
		Air Inlet Hose (81518) Type-K		
		Charging Whip (14819) HP778A-12	ea.	1
	4220-01-006-1529	CO_2 Test Tubes	bx.	1
	4220-01-005-8733	CO_2 Test Tubes	bx.	1
	4240-00-022-2946	Hearing Protectors	St.	2
	6665-00-567-0221	Multi Gas Detector Kit	ea.	1
		Operator, Unit and Intermediate (Direct Support, General Support) Maintenance Manual (TM-5-4310-389-14)	ea.	1
		Repair Parts and Special Tools List, TM 54310389-24P	ea.	1

APPENDIX D

ADDITIONAL AUTHORIZATION LIST

NOT APPLICABLE

APPENDIX E

EXPENDABLE SUPPLIES AND MATERIALS LIST

Section I. INTRODUCTION

E-1 SCOPE.

This appendix lists expendable supplies and materials you will need to operate and maintain the K-20, Diving Air Compressor. These items are authorized to you by CA 50-970, Expendable Items (Except Medical, Class V, Repair Parts, and Heraldic Items).

E-2 EXPLANATION OF COLUMNS.

a. Column (1) Item number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 5, Appendix E").

b. Column (2) Level. This column identifies the lowest level of maintenance that requires the listed item.

(enter as applicable)

C - Operator/Crew

O - Organizational Maintenance

F - Direct Support Maintenance

H - General Support Maintenance

c. Column (3) National Stock Number. This is the National stock number assigned to the item; use it to request or requisition the item.

d. Column (4) Description. Indicates the Federal item name, and if required, a description to identify the item. The last line for each item indicates the Commercial and Government Entity Code (CAGEC) in parentheses followed by the part number.

e. Column (5) Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

SECTION II.
EXPENDABLE SUPPLIES AND MATERIALS

(1) Item Number	(2) Level	(3) National Stock Number	(4) Description	(5) U/M
1	F	6810-00-286-5435	Alcohol, Isopropyl	Gl.
2	F	6810-00-983-8551	Alcohol, Isopropyl	Qt.
3	O	8415-00-281-7813	Apron, Rubber	Ea.
4	O	8415-00-281-7814	Apron, Rubber	Ea.
5	O	8415-00-281-7815	Apron, Rubber	Ea.
6	O	8105-00-837-7757	Bag, Plastic	Pk.
7	C	7530-00-222-3524	Book, Record	Ea.
8	O	8020-00-224-8021	Brush, Soft-Bristled	Ea.
9	C	7920-00-044-9281	Cloth, Lint-Free	Ea.
10	F	5350-00-193-1356	Compound, Lapping and Grinding, 600 Grit	Lb.
11	F	8030-00-252-3391	Compound, Sealing	Oz.
12	O	7930-00-985-6911	Detergent, General Purpose MIL-D-16791	Gl.
13	O	7930-00-282-9699	Detergent, Non-ionic, MIL-D-16791, Type I	Gl.
14	O	7930-00-985-6911	Detergent, Non-ionic, MIL-D-16791, Type I	Gl.
15	C	9140-00-286-5294	Fuel, Diesel, VV-F-800	Gl.
16	C	7240-00-550-7364	Funnel, 1 Qt., Strainer with 8-in. flex spout	Gl.
17	O	8415-00-266-8677	Gloves, Rubber	Pr.
18	O	9150-00-190-0705	Grease, Automotive and Artillery (7.5 lb) MIL-G-10925	Lb.
19	F	9150-00-754-2760	Grease, Halo Carbon	Qt.
20	F	9150-00-985-7317	Grease, Lubrication, MIL-G-21164	Cn.
21	C	9150-00-985-7237	Oil, Lubrication, MIL-H-17672 (2135TH)	Gl.
22	C	9150-00-235-9061	Oil, Lubrication, MIL-L-17331 (2190 TEP)	Gl.
23	C	9150-00-235-9062	Oil, Lubrication, MIL-L-17331 (2190 TEP)	Gl.
24	C	9150-00-188-9858	Oil, Lubrication, Engine, MIL-L-2104	Gl.
25	C	7920-00-205-1711	Rags, Wiping	Bx.
26	O	4240-00-240-5141	Shield, Face	Ea.
27		8040-00-225-4548	Silicone, RTV Sealant, Type I	

(1) Item Number	(2) Level	(3) National Stock Number	(4) Description	(5) U/M
28	O	6850-00-281-1985	Solvent, Drycleaning, PD-680	GI.
29	O	8030-00-889-3535	Tape, Teflon, MIL-T-27730, 1/2-in.	RI.
30	O	8030-00-889-3534	Tape, Teflon, MIL-T-27730, 1/4-in.	RI.
31	O	6810-00-141-6078	Trisodium Phosphate	Qt.
32	O	6810-00-297-9540	Water, Distilled, Technical	GI.

APPENDIX F

TORQUE LIMITS

F-1 TIGHTENING HEAVY-DUTY BOLTS AND NUTS.

To prevent faulty assembly, the following information includes instructions on the tightening of heavy duty bolts, because the procedure differs from standard torque methods. The tightening angle is particularly important and, for this reason, Figure F-1 indicates how various angles can be readily obtained by comparison with a clock face.

1. Lubricate threads and seating with motor oil before fitting.
2. Screw the bolts in until they are uniformly positioned ready for pre-loading.
3. Pre-load the bolts to the value stated in the Tightening Table for bolts and nuts (Table F-1).
4. Tighten the bolts according to Table F-1.

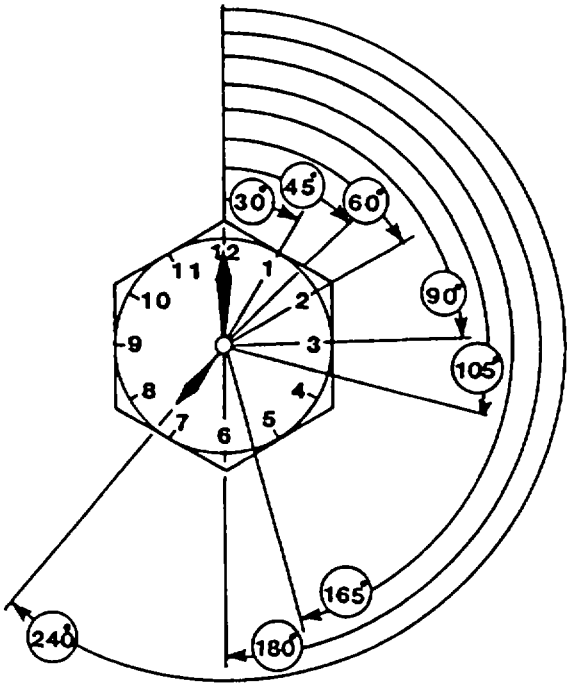


Figure F-1. Tightening Angles

F-2 TIGHTENING INSTRUCTIONS FOR ENGINE BOLTS AND STUDS. All bolts and studs tabulated shall first be hand-tightened to about 30 Nm and then torqued alternately in stages until the specified angle degrees are obtained. Before assembling the bolts and studs, wet the threads and the bearing faces of the heads with motor oil. Tools required, 003-0500 and 003-1102. For specific torque values refer to table F-1 and figure F-1 in the Appendix F.

a. When preloading, hold wrench so the thumb touches the end. Use a torque wrench for torques above 30 Nm.

b. When tightening, tighten crosswise where applicable, through the scheduled angles. For measuring and reading degrees, it is advisable to use tools 003-0500 and 003-1102.

c. Where such devices cannot be used, determine angles by a punch mark on the hexagon.

Table F-1. Tightening Table for Bolts and Nuts

Designation	Part Number or Thread	Pre-loading Nm	Tightening 1st Stage	2nd Stage	3rd Stage	4th Stage	Max
ENGINE							
Bolt, Cylinder head	*210 1681	40	45°	45°	45°	30°	165°
Nut, Connecting rod	M12x1.5x55	30	30°	60°	--	--	90°
Bolt, Bearing cap (main)	M14x110	30	45°	60°	--	--	105°
Nut, Rocker bracket	M8x55	--	--	--	--	--	28 Nm (20.21b-ft)
Nut, Flywheel		50	90°	90°		--	180°
Nut, Injector clamp	M10	--	--	--	--	--	25 Nm (18 lb-ft)
Bolt, V-belt pulley	M35x1.5	50	60°	--	--	--	60°
Bolt, Cooling blower	M12x140	30	30°	60°	--	--	90°
Bolt, Adaptor housing	*216 4062	30	60°	90°	90°	--	240°
Bolt, Oil filter cover	*337 1962	--	--	--	--	--	25 Nm (25 lb-ft)
Union nut injector nozzle		--	--	--	--	--	60-80 Nm
Bolts, Fastening bearing brackets in crankcase		30	60°	--	--	--	105°
Nut, Rocker arm bracket		--	--	--	--	--	28 Nm
Bolt-cylinder hd. rocker chamber cover		7					15 Nm
Bolt, Cooling blower		30					90°
Bolts, Connecting rod		30	60°				90°
Bolts, Main bearing		30	60'				105°
Bolts, Flywheel		30	30°				60°
Bolts, Counterweight		30	30°				60°
Nuts, Flywheel		50					180°
Bolt, V-belt pulley		50					210°
Hex nut injector Nm							25 - 30
Screw cap injector		90					110 Nm
Fuel injector pump drive	M12						60-70 Nm
	M14x1.5						60-70 Nm
	M14x1.5						80-90 Nm

Table F-1. Tightening Table for Bolts and Nuts

Designation	Part Number or Thread	Pre-loading Nm	Tightening 1st Stage	2nd Stage	3rd Stage	4th Stage	Max
COMPRESSOR							
Bolt, Hex and alien head	M6						10 Nm (7 lb-ft)
Bolt, Hex and allen head	M8						25 Nm (18 lb-ft)
Bolt Hex and allen head	M10						45 Nm (32 lb-ft)
Bolt, Hex and allen head	M12						75 Nm (53 lb-ft)
Bolt, Hex and allen head	M14						120 Nm (85 lb-ft)

Pipe connections (swivel nuts): Finger-tight + 1/2 turn

*These are specific part numbers for these items. When being replaced they are not to be confused with standard bolts, as they are tempered for a specific application.

Note

When renewing main and connection rod bearings or after piston seizures, renew the bearing bolts.

INDEX

Subject **Page**

A

C

D

E

INDEX (Continued)

Subject **Page**

E (Contd)

F

INDEX (Continued)

Subject **Page**

G

I

L

O

INDEX (Continued)

Subject **Page**

O (Contd)

P

R

S

INDEX (Continued)

Subject **Page**

T

U

W

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

THOMAS F. SIKORA
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

To be distributed in accordance with DA Form 12-25E, (qty rqr bl no. 2440).

* U.S. GOVERNMENT PRINTING OFFICE: 1991 554-123/20151

These are the instructions for sending an electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16,17, and 27.

From: "Whomever" <whomever-avma27.army.mil>
To: mpmt%avma28@st-louis-emh7.army.mil
Subject: DA Form 2028

1. From: Joe Smith
2. Unit: home
3. Address: 4300 Park
4. City: Hometown
5. St: MO
6. Zip: 77777
7. Date Sent: 19-OCT-93
8. Pub no: 55-2840-229-23
9. Pub Title: TM
10. Publication Date: 04-JUL-85
11. Change Number: 7
12. Submitter Rank: MSG
13. Submitter FName: Joe
14. Submitter MName: T
15. Submitter LName: Smith
16. Submitter Phone: 123-123-1234
17. Problem: 1
18. Page: 2
19. Paragraph: 3
20. Line: 4
21. NSN: 5
22. Reference: 6
23. Figure: 7
24. Table: 8
25. Item: 9
26. Total. 123
27. Text:

This is the text for the problem below line 27.

*U.S. GOVERNMENT PR[ITING OFFICE: 1996 - 755-025/40174

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

THEN...JOT DOWN THE DOPE ABOUT IT ON THIS FORM. CAREFULLY TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL.

SOMETHING WRONG WITH PUBLICATION

FROM: (PRINT YOUR UNIT'S COMPLETE ADDRESS)

DATE SENT

PUBLICATION NUMBER	PUBLICATION DATE	PUBLICATION TITLE

BE EXACT PIN-POINT WHERE IT IS

PAGE NO.	PARA-GRAPH	FIGURE NO.	TABLE NO.

IN THIS SPACE, TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT.

PRINTED NAME, GRADE OR TITLE AND TELEPHONE NUMBER	SIGN HERE

TEAR ALONG PERFORATED LINE

DA FORM 1 JUL 79 2028-2

PREVIOUS EDITIONS ARE OBSOLETE.

P.S.--IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

THE METRIC SYSTEM AND EQUIVALENTS

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3.2808.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu in.
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Square measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.5 inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 feet
1 sq. dekameter (are) = 100 sq. meters = 1.076.4 sq. ft.
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 hectometers = .386 sq. miles

Liquid Measure

1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons
1 liter = 10 deciliters = 33.81 fl. ounces
1 centiliter = 10 milliliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3 38 fl. ounces
1 metric ton = 10 quintals = 1.1 short tons

Approximate Conversion Factors

To change	To	Multiply by
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
sq. inches	sq. centimeters	6.451
sq. feet	sq. meters	.093
sq. yards	sq. meters	.836
sq. miles	sq. kilometers	2.590
acres	sq. hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29.573
pints	liters	.472
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound inches	newton-meters	.11296

To change	To	Multiply by
ounce inches	newton-meters	.0070062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
sq. centimeters	sq. inches	.155
sq. meters	sq. yards	10.764
sq. kilometers	sq. miles	1.196
sq. hectometers	acres	2.471
cubic meters	cubic feet	35.315
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102
pound-feet	newton-meters	1.356

Temperature (Exact)

°F Fahrenheit temperature — 5/9 (after subtracting 32) — Celsius Temperature °C

PIN: 046579-001