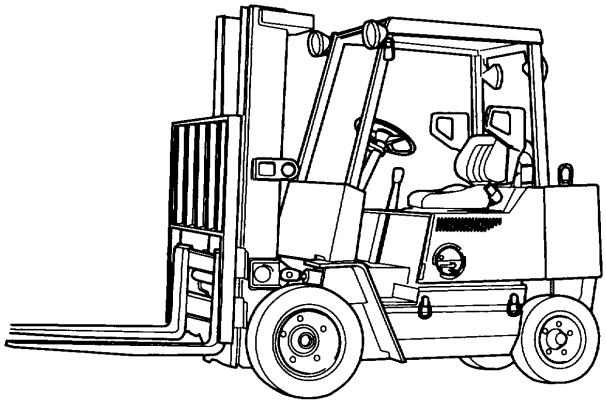
TECHNICAL MANUAL

ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL



TRUCK, FORKLIFT, CLEAN BURN DIESEL, FRONT-LOADING, 4000 LB. CAPACITY, M483 CLARK MODEL GPX 25E DIESEL NSN 3930-01-384-5310

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HEADQUARTERS, DEPARTMENT OF THE ARMY

MAY 1996

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

WARNING

When removing the transaxle with the truck blocked up by the frame, truck can tip backwards due to its heavy counterweight. Both upright and counterweight must be removed before attempting to raise the truck for transaxle removal. Failure to remove both could result in injury or death.

WARNING

Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts skin or eyes. Wear rubber apron to prevent clothing being damaged.

WARNING

The radiator is very hot and pressurized during vehicle operation. Let radiator cool before removing cap. Failure to do so can result in serious bums.

WARNING

Review all described procedures before starting any maintenance or service function. Failure to follow this warning can result in serious injury.

WARNING

Disconnect the battery, before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter or accessories, will cause severe damage to the units and/or wiring and possible injury to personnel.

WARNING

If a booster battery or a fast charger is used, its polarity must be connected correctly to prevent damage to the electrical system components. Connect positive to positive, negative to negative. Connect the negative cable ground connection last (but not to the battery because an explosion could result).

WARNING

Do not smoke or have open flames or sparks in battery charging areas or near batteries. An explosion can result and cause injury or death.

WARNING

This battery contains corrosive acid which can cause injury. If acid contacts your eyes or skin, flush immediately with water for 15 minutes and get medical assistance.

WARNING

Keep clear of equipment when equipment Is being raised or lowered. Equipment may fall and cause serious injury or death to personnel.

WARNING

- **Dry cleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes; and do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for type I dry-cleaning solvent is 100°F (380C) and for type II is 140°F (60°C). Failure to do so may result in injury or death to personnel.**

- **If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.**

- **Never dip or soak electrical components, packings, or rubber, plastic, or Teflon parts in dry cleaning solvent. Solvent can react with material and result in severe damage or destruction of parts.**

WARNING

Park truck in a well-ventilated area. Do not smoke or perform maintenance near open flame or other sources of ignition. Do not disconnect any lines when exhaust manifold is excessively hot or fires may result in injuries and damage to equipment.

WARNING

Stop engine before checking battery terminals or electrical connections. Do not hold ignition wires with bare hands since shocks or other injuries can result. Battery acid can cause corrosive burns. Always wear eye protection. Use of jumper cables or battery charging should be done only as directed by manufacturer's safety instructions.

WARNING

Always put blocks under the carriage and upright rails when necessary to work with upright in an elevated position to prevent injury to personnel.

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

WARNING

- **Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts skin or eyes. Wear rubber apron to prevent clothing being damaged.**

- **Avoid electrolyte contact with skin, eyes, or clothing. If battery electrolyte spills, take immediate action to stop burning effects:**

- External: Immediately flush with cold running water to remove all acid.

- Eyes: Flush with cold water for at least 15 minutes. Seek immediate medical attention.

- Internal: Drink large amounts of water or milk. Follow with milk of magnesia, beaten egg, or vegetable oil. Seek immediate medical attention.

- Clothing or Vehicle: Wash at once with cold water. Neutralize with baking soda or household ammonia solution.

WARNING

Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.

WARNING

- **Use only approved hooks, chains, and connecting links when lifting and handling the upright. Be sure the hoist, hooks, and chain have the correct capacity to safely handle the load.**

- **Attach a chain or sling of correct capacity to the upright and a hoist before removing any tilt cylinder attachment parts. Be sure upright is securely supported by the hoist and slack removed before removing upright mounting trunnion caps. Failure to do so could result in personal injury or death.**

WARNING

Adhesive causes immediate bonding on contact with eyes, skin, or clothing and also gives off harmful vapors. Wear protective goggles and use in well-ventilated area. If adhesive gets in eyes, try to keep eyes open; flush eyes with water for 15 minutes and get immediate medical attention.

WARNING

Battery service must be done by trained personnel. Battery acid can cause severe bums and injury.

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

WARNING

Allow engine to cool before performing maintenance on the muffler, exhaust pipe, exhaust pipe, exhaust manifold. If necessary, use insulated pads and gloves personal injury may result.

WARNING

Attach a chain or sling to the upright and a hoist before removing any tilt cylinder attachment parts.

WARNING

Some brake linings are still made with asbestos which when inhaled has been found to be extremely dangerous. Do not use compressed air to clean the brake shoes or other parts before or after disassembly. Instead wipe down the assembly and then the components with damp, disposable wipers and immediately discard them safely. Avoid breathing dust or injury may result.

WARNING

Attach lifting device to counterweight prior to removing mounting bolts. Do not remove with blocks under counterweight supporting truck. Failure to follow these procedures as shown in this manual can result in severe injury or death.

WARNING

Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/ shield, gloves, etc.) to prevent injury to personnel.

WARNING

Corrosion inhibitor contains alkali. Do not get in eyes; wear goggles/safety glasses when using. Avoid contact with skin. In case of contact, immediately wash area with soap and water. If eyes are contacted, flush eyes with large amounts of water for at least 15 minutes and get immediate medical attention.

WARNING

Do not allow heavy components to swing while hanging by lifting device. Equipment may strike personnel and cause injury.

WARNING

Starting fluids or aids such as ether or gasoline must not be used in a diesel engine air intake system. The use of these fluids will cause severe internal engine damage and/or bodily injury.

WARNING

Do not operate a lift truck or handle loads with the counterweight removed. Failure to follow this message can result in severe injury or death.

WARNING

Do not remove the counterweight unless you have training and are familiar with the correct procedures. Counterweights can fall if not handled correctly and cause severe injury or death.

WARNING

Do not remove the radiator cap when the radiator is hot. Steam of hot coolant from the radiator can cause severe bums. Never remove the radiator cap while the engine is running. Stop the engine and wait until it has cooled.

WARNING

Be sure to stand away from path of the counterweight as it is being lifted and moved. Watch the lifting chains and hooks for any unusual twisting or movement. Do not walk or stand under the forks or injury to personnel could result.

WARNING

If the fork blade at the heel is worn down by more than 10%, the load capacity is reduced and the fork must be replaced.

WARNING

Gasoline is not an acceptable cleaning solvent because of its extreme combustibility. It is unsafe in the workshop environment because it can ignite and cause injury to personnel.

WARNING

Do not use your hands to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or other lines.
Tighten all connections before applying pressure. Keep hands and body away from pin holes and nozzles which eject fluids under high pressure. If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

WARNING

Do not walk or stand under raised forks. The forks can fall and cause injury or death.

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING within 50 feet (15 m) of vehicle.

WARNING

Do not start engine or move truck when anyone is under truck. Severe injury or death could result.

WARNING

Hot engine oil can cause severe bums and personal injury. Care should be exercised when changing oil filter and draining hot oil.

WARNING

Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

WARNING

If NBC exposure is suspected, all air filter media should be handled by personnel wearing protective equipment. Consult your unit NBC Officer or NBC NCO for appropriate handling or disposal procedures.

WARNING

Never lift or block a truck using the counterweight. Failure to follow procedures outlined in this manual can result in injury or death.

WARNING

Personnel working on wheels and tires must be qualified and trained to do wheel and tire maintenance or injury may result.

WARNING

Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.

WARNING

Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.

WARNING

Starting fluids or aids such as ether or gasoline must not be used in a diesel engine air intake system. The use of these fluids will cause severe internal engine damage and/or bodily injury.

WARNING

The overhead guard and mounting is not designed (stressed) to support the weight of the lift truck. Attempting to lift the truck using the overhead guard may result in injury or death to personnel.

WARNING

Be sure truck is parked and positioned in a safe and convenient manner or injury to personnel may result.

WARNING

Do not operate a lift truck if the service or parking brakes are not operating properly.

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

WARNING

- **Stall tests must be performed with the parking brake applied and wheels blocked up above the ground surface to prevent movement. Be careful that the truck does not move unexpectedly when operating the engine and converter at stall. Unexpected movement of the truck could cause injury or death to personnel.**

- **Do not run engine and converter at stall longer than necessary to take the rpm and vacuum readings, or longer than 30 seconds at one time. Then, shift transmission into NEUTRAL for 15 seconds and run the engine at one-half speed for 1-2 minutes to cool torque converter oil. Excessive temperature 250°F (1200C) max will overheat the converter and cause damage to converter, seals, and fluid.**

WARNING

Bodily injury may result during the timing operation of the fuel injection pump if the engine is running. DO NOT attempt to adjust the timing without the pump mounting bolts securely torqued.

WARNING

Be sure transmission directional control is in NEUTRAL and truck prevented from moving when parking brake is released or personal injury may result.

WARNING

Before performing any maintenance work, check the truck for stable condition on the blocking to prevent injury to personnel and damage to equipment.

WARNING

Never continue to operate a truck that has a steering system fault. Injury to personnel may result.

WARNING

Do not operate a lift truck with damaged or missing decals and nameplates. Replace them immediately. They contain important information to prevent injury or damage to equipment.

WARNING

Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. Before disconnecting lines, be sure to relieve all pressure. Before applying pressure to the system, be sure all connections are tight and that lines, pipes, and hoses are not damaged. Use a piece of cardboard, rather than hands, to search for leaks. If injured by escaping fluid, get medical attention at once.

WARNING

For safety when checking or removing battery connections, always first disconnect the negative battery cable at the engine ground connection.

WARNING

To avoid the possibility of personal injury, never work in engine compartment with engine running except when absolutely necessary to check or adjust timing, carburetor, or governor. Take extreme care to keep hands, tools, loose clothing, etc., away from fan and drive belts. Also remove watches, bracelets, and rings.

WARNING

Stop engine before checking battery terminals or electrical connections. Sparks or flames near a battery could cause an explosion or fire. Battery acid can cause corrosive burns. Always wear eye protection. Use of jumper cables or battery charging should be done only as directed by manufacturers' safety instructions.

WARNING

Bodily injury or death may result to individuals during operation of an engine within any enclosure not adequately or properly ventilated. Engine operation in any enclosure requires adequate and proper ventilation to avoid asphyxiation or other interruption of normal breathing. To supply sufficient air to cool the engine, provide air to mix with fuel and to carry away heated air from the building.

WARNING

An upright or carriage can move unexpectedly.

- **Do not walk or stand under raised forks.**
- **Keep clear of load and carriage when making any checks and adjustments.**
- **Keep your arms and fingers away from moving parts of the upright. Do notg reach through upright open areas.**
- **Failure to follow these warnings can result in serious injury.**

CAUTION

Always follow the manufacturer's instructions for the test instrument being used when making connections and tests on electrical circuits or damage to equipment could occur.

Assemble/disassemble hydraulic pump only in a clean, dust free location. Dirt or grit will damage machined surfaces and result in leakage or premature failure.
Be careful when sump is nearly emptied.
Watch for signs of pump cavitation. Do not operate pump after cavitation occurs or damage to equipment may result.

If the oil pressure is erratic or falls below these limits, stop the engine IMMEDIATELY and find the cause of the trouble or damage to equipment could result. Refer to troubleshooting section for this information.

Be sure that the mounting bolts are undamaged and have the correct material (strength and hardness) specification. Do not use substitute, defective, or incorrect mounting bolts. Replace worn or defective bolts or damage to equipment could result.

Be sure there is adequate overhead clearance before raising the upright or damage to equipment could result.
Be sure to secure the load to the fork carriage to keep it from falling off when tilted forward or damage to equipment could result.

Never pour cold water or cold antifreeze into the radiator of an overheated engine. Allow the engine to cool and avoid the danger of cracking the cylinder head or block. Keep engine running while adding coolant.

Damage to the truck can result if any of the warning indicators illuminate when the engine is running. Stop the engine. Do not operate the truck. Report any failures.

Do not add oil until oil level approaches the LOW mark. Then add only enough to bring it to high level-NEVER above. Do not operate the engine with oil level below the low level mark, or damage to equipment may result.

Do not overfill crankcase with engine oil, or serious damage may occur to engine.

Be careful when inspecting or replacing the air filter element to prevent loose dirt from entering the engine air intake housing or hose. Damage to engine may result.

Have missing bolts replaced and loose bolts correctly tightened to the specified torque before operating the truck or damage could result.

CAUTION

Never operate the starter motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating caused by excessive cranking will seriously damage the starter motor.

CAUTION

It is recommended that the engine be removed only as a separate assembly disconnected from the transaxle. Generally, because of height (clearance) limitations, removal of the engine and transaxle as a unit requires extensive disassembly of the front structure of the truck, including removal of the dash and instrument panel. It is much easier and simpler to remove the engine by itself. Engine removal is also made easier with less chance of accidental damage to components when the counterweight and radiator are removed.
For safety and convenience, it is recommended whenever possible to use an overhead hoist to remove the engine from the truck.

CAUTION

The transmission fluid must be at operating temperature of 180-200°F (82-930C) to obtain correct fluid level and pressure readings. Do not attempt to make these checks with cold oil.

CAUTION

Under no circumstances should the engine be allowed to operate at a higher speed than is specified. Severe damage to the engine may result.

CAUTION

When the transaxle is new or rebuilt, it is recommended to change the oil filter after the first 50 hours and again after 100 operating hours. This is to be sure that the oil is cleaned of all harmful particles which may be loosened or flushed off new parts as they wear in. Failure to change the oil filter may result in damage to transaxle.

CAUTION

Use lifting hooks with safety latches to prevent hook from slipping from the lifting eye.

CAUTION

Whenever welding on this vehicle, always disconnect battery cables. Do not put ground strap on lift carriage or mast unless welding on lift carriage or mast.

CAUTION

Never allow cool water to come in contact with the fuel injection pump while the engine is running! Injection pump seizure may result.

CAUTION

Always cover openings with protective caps at any time when lines are disconnected. This will prevent any dirt or foreign matter from entering.

- **The field circuit must never be grounded on this system, between the alternator and the regulator. Grounding of the field terminal either at the alternator or regulator will damage the regulator.**

- **Do not ground the output terminal. Grounding of the alternator output terminal may damage the alternator and/ or circuit and components.**

- **Do not connect battery to the regulator field terminal or damage to the regulator will result.**

- **Do not attempt to polarize the alternator. No polarization is required. Any attempt to do so may result in damage to the alternator, regulator, or circuits.**

- **Be sure the alternator and battery have the same ground polarity. Battery polarity should be checked with a voltmeter before connecting the battery. Reversed battery connections may damage the rectifiers, wiring or other components of the charging system.**

- **If it is necessary to solder any lead to a rectifier lead, use a pair of pliers as a heat dam between the solder joint and the rectifier or damage to the rectifier may result.**

- **Keep serviceable bearing cups and cones matched together. Always replace bearing cups and cones as a set or damage to equipment may result.**

- **Be sure the parking brake is applied and blocks put at the front and rear of drive wheels or damage to equipment may result.**

TECHNICAL MANUAL

HEADQUARTERS
DEPARTMENT OF THE ARMY

No. 10-3930-671-24

Washington, DC, *1 May 1996*

TECHNICAL MANUAL
ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL

TRUCK, FORKUFT, CLEAN BURN DIESEL, FRONT-LOADING, 4000 LB. CAPACITY, M483 CLARK MODEL GPX 25E DIESEL

NSN 3930-01384-5310

REPORTING OF ERRORS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms) or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-automotive and Armaments Command, ATTN: AMSTA-IM-OPIT, Warren, MI 48397-5000. A reply will be furnished to you. You may also provide DA Form 2028-2 information to TACOM via datafax or e-mail. TACOM's datafax number for AMSTA-IM-OPIT is: (810) 574-6323 and the e-mail address is: amstaim-mmaa @ cc.tacom.army. mil.

This manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content specified in AR 25-30, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

Approved for public release; distribution is unlimited.

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SAFETY SUMMARY
GENERAL PRECAUTIONS

The following are general safety precautions and instructions that personnel must understand and apply during many phases of operation and maintenance to ensure personnel safety and health. Portions of this information may be repeated in certain chapters of this publication for emphasis.

Cleaners/Chemicals Handling

Keep cleaners/chemicals in approved safety containers and in minimum quantities. Some cleaners/ chemicals may have an adverse effect on skin, eyes and respiratory tract. Observe manufacturer's WARNING labels and current safety directives. Use cleaners/chemicals only in authorized areas. Consult the local Bioenvironmental Engineer for specific precautions, protective equipment, and ventilation requirements.

Compressed Air
Use of compressed air can create an environment of propelled foreign particles. Air pressure shall be reduced to less than 30 pounds-per-square-inch gauged (psig) and used with effective chip guarding and personal protective equipment.

Batteries
When inspecting batteries, never smoke or expose battery to sparks of flames. Eye protection (face shield), acid resistant rubber apron and gloves must be worn when working around batteries.

Jewelry
Jewelry (rings, bracelets, metal watches, or neck chains) shall not be worn while working on exposed equipment.

Personal Protective Equipment
Wear protective clothing/equipment (gloves, apron, eye protection, protective mask, etc.) approved for the materials, procedures and tools being used as necessary.

GENERAL SAFETY PRACTICES
Read and thoroughly understand all instructions contained in this and all vendor manuals before attempting to operate or service the 4K Forklift Truck.

Only the operator is allowed on the truck during operation.

Clothing worn by all personnel working close to the truck should be close fitting and belted. Loose jackets, shirts, or pants should never be worn because of the danger of getting caught in moving parts.

Be certain that hand brake is set and the direction speed control levers and all switches are in the **OFF** or centered positions before starting the engine.

Make sure everyone is clear of the truck before starting so they cannot be struck by or caught in moving parts.

Keep operator's platform clean. Do not use it as a place to carry loose tools, lunch boxes, etc.

Refuel truck only when engine has been shut off. Do not permit sparks, open flames or smoking within 50 feet of truck when refueling.

Escaping hydraulic fluid under pressure can have sufficient force to penetrate the skin, causing serious personal injury. Before disconnecting lines, be sure to relieve all pressure. Before applying pressure to a system, be sure all connections are tight and that lines, tubes, and hoses are not damaged. Fluid escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood, rather than hands, to search for suspected leaks.

If injured by escaping fluid, get medical attention at once. Serious infection or reaction can result if proper medical treatment is not administered immediately.

SAFETY SUMMARY - Cont.

Refill the radiator only when the engine is stopped. The truck has a pressure cooling system. To avoid being scalded when radiator cap is removed, first turn cap slightly to the stop which allows steam to escape through the overflow pipe. After all pressure is relieved, remove cap.

Never lubricate or service truck when it is operating.

SAFETY SUGGESTIONS FOR OPERATING TRUCK

Be sure all hoods and doors are closed before operating truck.

Be certain the direction/range control levers are in NEUTRAL positions before starting engine.

Check all functions of the truck for proper operation. Never attempt to use a malfunctioning machine.

Never permit anyone to climb or stand on the truck.

Keep all persons clear of forks when operating truck.

Before leaving the operator's seat always be sure that all control switches are in the **OFF** or centered position, hand brake is applied, forks are lowered, and engine is shut off.

Never attempt to attach or remove any part or assembly on the truck while it is operating.

SAFETY SUGGESTIONS FOR SERVICING TRUCK

Before attempting to service, attach, or remove any part of assembly on the truck, make certain that:

(1) All controls and switches are in the OFF or centered position.
(2) Hand brake is applied.
(3) Forks are lowered.
(4) Engine is shut off unless otherwise instructed.

Batteries produce explosive gases. Keep all sparks and open flames away from batteries. If a battery needs recharging, avoid sparks by turning off the charger before making connections or disconnections.

Sulfuric acid in batteries is a poison and could cause severe burns. Avoid contact with skin, eyes, and clothing. When working around batteries, protect eyes and face from battery fluid and possible explosion.

Before starting the engine, be sure there is plenty of ventilation. If it is necessary to operate the engine inside an enclosed service area, be sure exhaust is properly vented.

Make sure everyone is clear of the truck before starting so they cannot be struck by or caught in moving parts.

CHAPTER 1
INTRODUCTION & GENERAL INFORMATION

1-1. INTRODUCTION.

a. Purpose of This Manual. This is a supplemental manual designed to provide information concerning troubleshooting and maintenance at the Organizational, Direct Support, and General Support levels not already covered in vendor manuals for the M483, 4000 lb Forklift Truck, hereafter referred to as the truck, manufactured by Clark Material Handling Company, Lexington, KY, model GPX 25E Diesel (See Figure 1-1). This manual contains the following:

(1) **Chapter 1 Introduction and General Information**: General information about the makeup of this manual, including a general description of the truck and specifications table, are presented in this chapter.

(2) **Chapter 2 Organizational Troubleshooting**: Instructions for troubleshooting at the organizational level are presented in this chapter.

(3) **Chapter 3 Organizational Maintenance**: Instructions for performance of maintenance procedures at the Organizational level are presented in this chapter.

(4) **Chapter 4 Direct Support/General Support Troubleshooting**: Instructions for troubleshooting at the Direct Support/General Support level are provided in this chapter.

(5) **Chapter 5 Direct Support/General Support Maintenance**: Instructions for maintenance procedures at the Direct Support/General Support levels are provided in this chapter.

(6) **Appendices**: Instructions for lubrication and Army-specific and vendor-specific information are arranged as appendices.

b. Function of This Manual. This manual provides instructions, illustrations, and associated data for maintenance and repairs. This manual shall enable an average journeyman to maintain and repair the truck.

c. WARNINGS, CAUTIONS, and NOTES. Warnings, cautions, and notes used in this manual are defined as:

(1) A “warning” identifies an operation or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in damage to, or destruction of, equipment, and/or injury or loss of life.

(2) A “caution" identifies an operation or maintenance procedure, practice, condition, statement, etc., which, if not strictly observed, could result in damage to, or destruction of, equipment or loss of mission effectiveness.

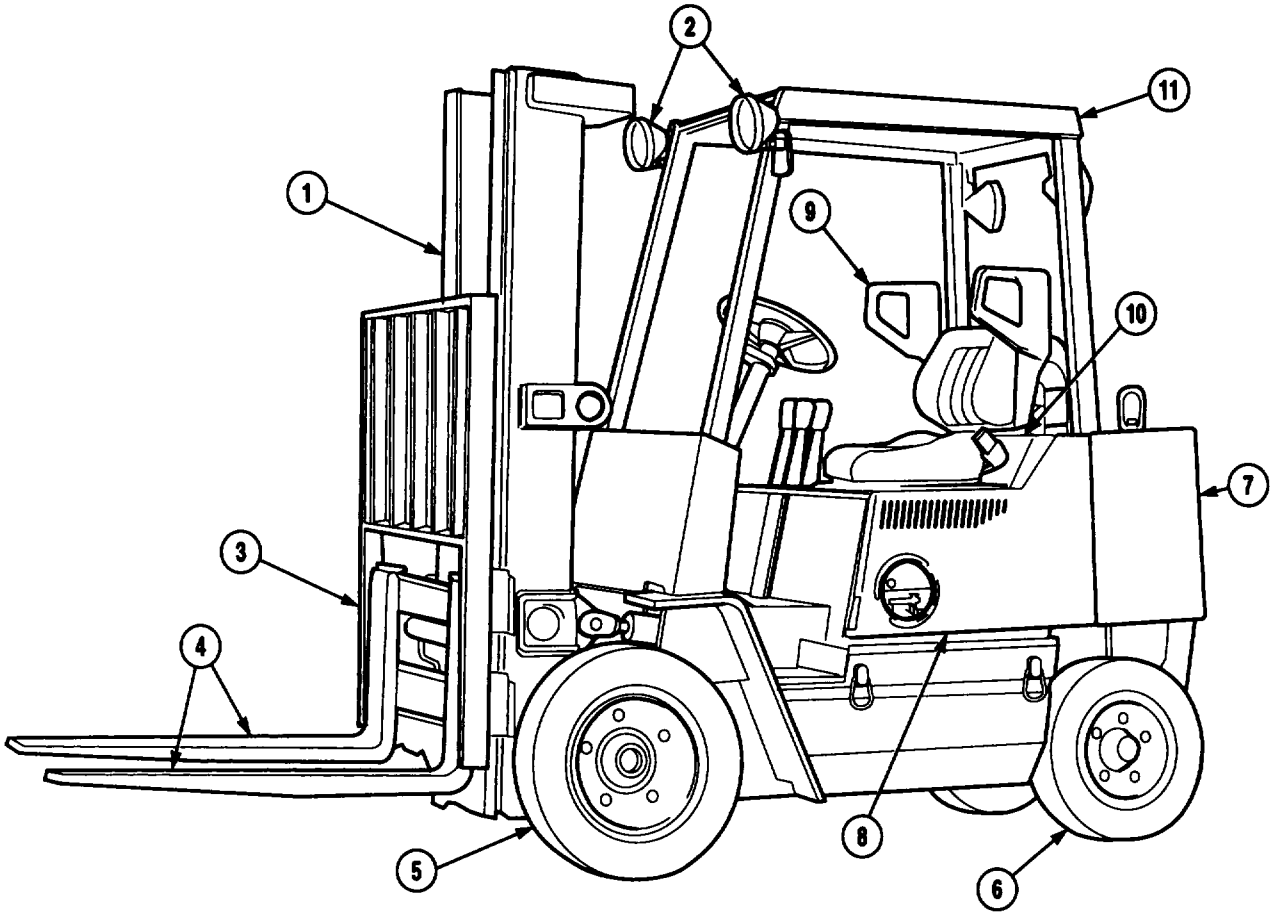
(3) A “note” highlights an essential operation or maintenance procedure, condition, or statement.

1-2. CAPABILITIES.

The truck is a 4-wheeled piece of material handling equipment capable of lifting palletized and certain loose loads, when appropriate, up to a maximum weight of 4000 lb (1814.4 kg). Over smooth and level surfaces, the truck can reach a maximum speed of 12 mph (19.3 kph) unloaded and 11.3 mph (18.1 kph) with a full load when safety conditions merit.

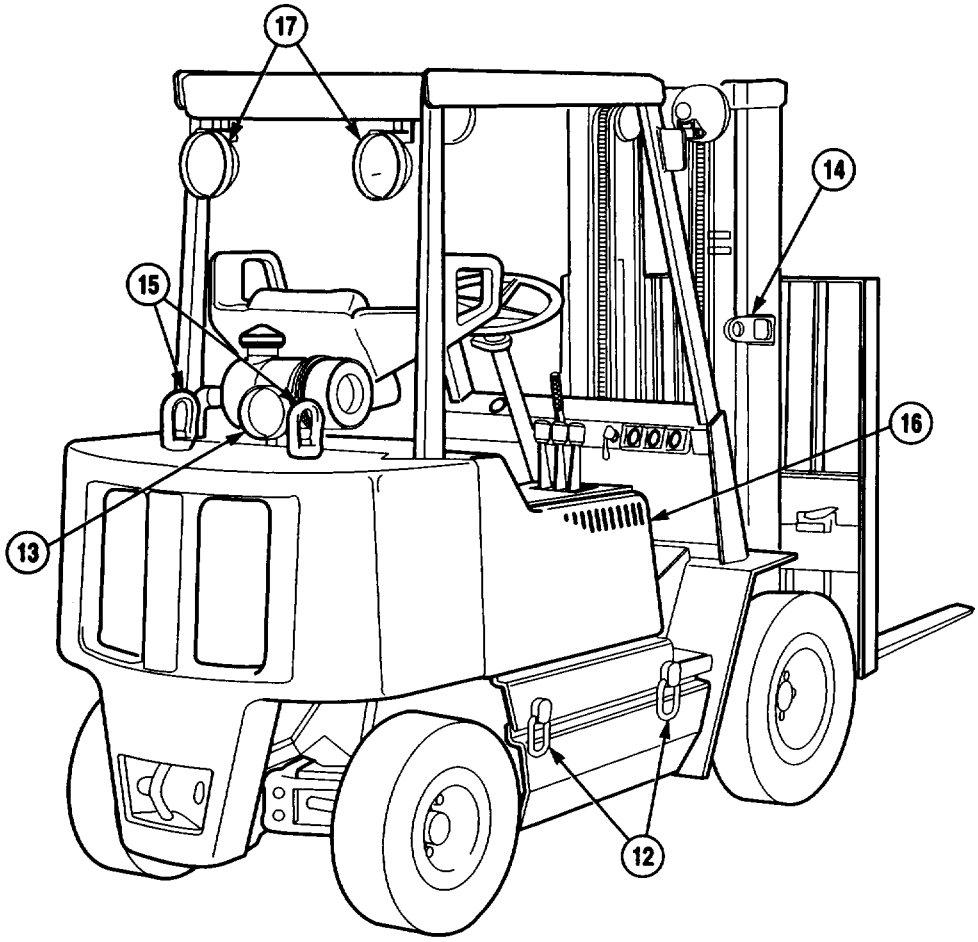
1-3. DESCRIPTION.

Single, solid rubber wheels in front of truck provide stability and ruggedness. Safety equipment consists of an automotive horn operable from steering wheel. Two floodlights on the overhead guard help illuminate the area in front of the truck while two floodlights in the back of the overhead guard illuminate the area behind truck. A brake light at the back of truck illuminates whenever brake or inching pedal is depressed.



1. Mast Assembly
2. Front Floodlights
3. Carriage Assembly
4. Forks
5. Front Wheels
6. Rear Wheels
7. Counterweight
8. Left-Side Hood
9. Operator's Seat
10. Top Hood
11. Overhead Guard

Figure 1-1. M483 4K Forklift Truck - Left Front View (Sheet 1 of 2)



12. Tie Downs
13. Brakelight
14. Front Lift Point
15. Rear Lifting Brackets
16. Right-Side Hood
17. Rear Floodlights

Figure 1-1. M483 4K Forklift Truck - Right Rear View (Sheet 2 of 2)

Table 1-1. Description

Nomenclature	Description
Type of Vehicle	4000 lb Forklift Truck
Manufacturer	Clark Material Handling Company
Model Number	GPX 25E Diesel
Truck Capacity	000 lb (1814.4 kg) 0 24-inch load center
Overall Length	
With Forks	144.9 in (3680 mm)
Without Forks	102.9 in (2614 mm)
Overall Width	82.7 in (2101 mm)
Height (Top of Overhead Guard)	83 in (2108 mm)
Maximum Lift Height	184 in (4674 mm)
Collapsed Mast Height	83 in (2108 mm)
Ground Clearance	
Under Mast	6.25 in (159 mm)
Under Truck	8 in (203 mm)
Weight	9735 lb (8952 kg)
Brakes	
Service	2-wheel Drum
Parking	2-wheel Drum
Maximum Gradeability	
With Load	24%
Without Load	25%
Drawbar Pull	
With Load	12030 lb (53512 N)
Without Load	7670 lb (34118 N)
Travel Speed	
With Load	11.3 mph (18.1 kph)
Without Load	12 mph (19.3 kph)
Turning Radius	134 in (3404 mm)
Wheels	
Size (front)	7.00 x 12
Size (rear)	6.50 x 10
Type	Solid Rubber
Drift	
Lift Cylinders	Should not exceed 0.73 in (18.5 mm) in a 5-minute period
Tilt Cylinders	Should not exceed 1.5 degree in a 5-minute period
Upright Speed	
Lifting - With Load	80 fpm (.41 m/s)
Lifting - Without Load	87 fpm (.44 m/s)
Lowering - With Load	69 fpm (.35 m/s)
Lowering - Without Load	79 fpm (.40 m/s)
Engine	
Manufacturer	Continental
Type	Diesel
Model	TMD 27
Weight (approximate w/accessories)	568 lb (258 kg)
Horsepower	60 hp (44.1 kW) 0 3100 rpm
Torque	119 lb-ft (161 Nom) 0 1600 rpm
Bore/Stroke	3.58 in/4.06 in (91 mm/103.1 mm)

Table 1-1. Description-CONT

Nomenclature	Description
Engine - continued	
Displacement	164 cu in (2.68 l)
Firing Order	1-3-4-2
Compression Ratio	20.5:1
Speed	
Governed Speed (no load)	2600 rpm
Engine Idle	650 rpm
Oil Pressure	40-60 psi (276-414 kPa) with oil at operating temperature
Lubricant	SAE 5W30
Fuel	45 cetane, minimum
Coolant	50/50 Water/Ethylene Glycol type antifreeze with rust and corrosion inhibitors
Drive Belt	
Type	V-belt
Deflection	20 in (5.1 mm) in long span at 2.5-3.2 lbft (3.4-4.3 N) at center of alternator-crankshaft-pulley
System Voltage	12-volt, negative ground
Altemator	12-volt, 62 amp
Batteries (2)	
Type	BCI Group 4D
Cold Crank Current	625 amps at 0°F (-180C)
Reserve Capacity	310 amps min at 80°F (26.7°C)
Starter	TMD27M506 (Nippondenso), 12-volt
Transaxle	
Manufacturer	Clark
Type	1-speed forward and reverse
Model	TA18
Weight	600 lbs (272k)
Hydraulic System	
Filter Size	10 micron
Main Relief Valve Setting	2600-2700 psi (17927-18616 kPa), adjustable
Pump Pressure	11.7 gpm (44.3 l/min) @ 3000 psi (20685 kPa) @ 1800 rpm @ operating temperature
Side Shifter Relief Valve Setting	1925-2075 psi (13270-14307 kPa), adjustable
Steering System	
Pressure	4gpm (15.14 l/min) @ 3000 psi (10685 kPa) @ 1800 rpm 0 operating temperature
Relief Pressure Setting	1200-1300 psi (8274 - 8964 kPa), adjustable
Capacities	
Crankcase	
With Filter	5.5 qt (52 1)
Without Filter	5 qt (4.73 1)
Cooling System	9 qt (8.5 1)
Fuel	8 gal (30 l)
Transaxle (Transmission & Drive Axle)	16 qt (15.1 l)
Hydraulic Tank	5.5 gal (20.8 l)

1-4. PERFORMANCE CHARACTERISTICS.

a. Engine. The truck is powered by a Continental water-cooled, 4-cylinder, in-line diesel engine. Model TMD 27 has 164 cubic inch (2.68 l) displacement which develops 60 hp at 3100 rpm.

b. Transaxle. One-speed transaxle delivers maximum torque, 100 lb-ft at converter stall in both forward and reverse.

c. Upright. Three-stage upright allows loads up to 4000 lbs (1814.4 kg) to be lifted to a maximum height of 184 inches (4674 mm). Hydraulic tilt capability allows a maximum arc of 2.5 + .5 degrees forward tilt and 6 degrees reverse tilt.

d. Lifting Forks. Width between forks is manually adjustable from 0 to 40 inches (0-1016 mm). Forks can be hydraulically shifted left or right, in tandem, 3.9 inches (99 mm) each way for a total distance of 7.8 inches (198.1 mm).

1-5. ENVIRONMENTAL INFORMATION.

The truck has sound suppression, air cleaner with replaceable element, and replaceable engine, transmission, and hydraulic oil filters.

1-6. 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)(Maintenance Management UPDATE).

1-7. DESTRUCTION OF ARMY MATERIAL TO PREVENT ENEMY USE.

Command decision, according to the tactical situation, will determine when the destruction of the truck will be accomplished. A destruction plan will be prepared by the using organization unless one has been prepared by a higher authority. For general destruction procedures for this equipment, refer to TM 750-244-6, Procedures for Destruction of Tank-Automotive Equipment to Prevent Enemy Use (U.S. Army Tank-Automotive Command).

1-8. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATION (EIR).

If your 4000 lb truck 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 our equipment. Let us know why you don't like the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to us at Commander, U.S. Army Tank-Automotive Command, ATTN: AMSTA-QRD, Warren, Michigan 48397-5000. We'll send you a reply

1-9. TOOLS AND TEST EQUIPMENT.

All special tools or test equipment required to maintain the truck in operation are listed in Appendix B.

1-10. SHIPPING AND HANDLING INSTRUCTIONS.

a. Preparing For Shipment. Refer to TB 92300-281-35 for procedures covering preservation of equipment for shipment. General procedures for shipment are found in FM 55-15. Specific information may be found in TM 55-2200-001-12 for rail transport and TB 55-45 for air transport.

b. Administrative Storage. Refer to TM 740-90-1 for instructions covering administrative storage of equipment.

c. Weight Classification. The weight classification of the truck is 4000 lb (1814.4 kg).

1-11. STORAGE DATA.

a. Short-Term Storage (30 days or less):

(1) Start engine and allow to warm up.

(2) Raise and lower forks fully several times.

(3) Fully tilt upright forward and backward several times.

(4) Coat all exposed, polished parts with rust-preventative lubricant.

(5) Extend all hydraulic cylinders, coat rods with bearing grease, and then fully retract cylinders.
(6) Clean truck thoroughly.
(7) Check truck thoroughly for worn or damaged components and repair or replace as required.
(8) Change engine oil and replace oil filter.
(9) Replace air cleaner element.
(10) Fill fuel tank with fuel and add inhibitor.
(11) Clean exterior of engine and coat with rust-preventative lubricant.
(12) Lubricate entire truck per Lubrication Order given in Appendix E.
(13) Park truck with forks fully lowered and spread, upright tilted fully backward, and carriage centered on upright.
(14) Seal all engine openings with weatherproof tape.
(15) Engage parking brake.

b. Long-Term Storage (Longer than 30 days)

(1) Perform all preventive maintenance according to instructions given in Chapter 3.
(2) Start engine and allow to warm up.
(3) Raise and lower forks fully several times.
(4) Fully tilt upright forward and backward several times.
(5) Extend all hydraulic cylinders, coat rods with bearing grease, and then fully retract cylinders.
(6) Check truck thoroughly for worn or damaged components and repair or replace as required.
(7) Change engine oil and replace oil filter.
(8) Clean exterior of engine and coat with rust-preventative lubricant.
(9) Replace air cleaner element.
(10) Fill fuel tank and add 3 ounces (90 ml) of inhibitor to the fuel tank.
(11) Drain hydraulic reservoir, change main hydraulic filters, and fill reservoir with recommended fluid.
(12) Lubricate entire truck per Lubrication Order given in Appendix E.
(13) Park truck with forks fully lowered and spread, upright tilted fully backward, and carriage centered on upright.
(14) Ensure that direction control levers are centered (NEUTRAL).
(15) Engage parking brake.
(16) Remove and clean batteries. Store batteries in a cool, dry place and keep them fully charged.
(17) Disconnect air intake piping from the manifold. Pour 3 ounces (90 ml) of inhibitor into intake system and connect the piping.
(18) Seal all engine openings with weatherproof tape.
(19) Clean exterior of the truck and touch up any scratched, chipped, or painted surfaces.
(20) Coat all unpainted metal surfaces with grease or corrosion inhibitor.

CHAPTER 2

ORGANIZATIONAL TROUBLESHOOTING

2-1. TROUBLESHOOTING INTRODUCTION.

This section contains step-by-step procedures for identifying, locating, and isolating equipment malfunctions.

2-2. TROUBLESHOOTING SYMPTOMS.

Table 2-1 lists the most common malfunctions found during operation of the truck. Tests or inspections and corrective actions should be performed in the order listed. Table 2-2 lists corrective actions that can be performed by unit maintenance. If a malfunction is not listed, or corrective action fails to correct a problem, notify DS/GS maintenance.

2-3. UNIT TROUBLESHOOTING PROCEDURES.

Table 2-2 contains the malfunctions listed in Unit Troubleshooting Symptom Index (Table 2-1), test or inspection instructions required to determine cause of malfunction, and corrective actions for repairing the faulty equipment. Operator Troubleshooting Procedures (TM 10-3930-671-10) should be completed before performing Unit Troubleshooting Procedures.

Table 2-1. Unit Troubleshooting Symptom Index

Troubleshooting Fault		Page
ENGINE		
1.	Engine will not start	2-3
2.	Engine does not run evenly	2-4
3.	A loss of power	2-5
4.	Engine temperature above normal	2-6
5.	Black exhaust smoke	2-7
6.	White exhaust smoke	2-8
7.	Truck slow to accelerate	2-8
8.	Engine knocking	2-9
HYDRAUUC SYSTEM		
9.	No lift, tilt, or sideshift function	2-9
10.	Load cannot be lifted to maximum height	2-9
11.	Oil leaks at top of lift cylinder(s)	2-10
12.	Oil leaks at end of tilt cylinder(s)	2-10
13.	Oil leaks at top or end of sideshift cylinder	2-10
14.	Upright lift speed sluggish	2-10
15.	Pump not delivering hydraulic fluid	2-11
16.	Pump not developing sufficient pressure	2-12
17.	Noisy pump	2-12
18.	Oil leaks at either end of main or auxiliary valve spool	2-13
19.	Spring-centered spools do not return to neutral (main or auxiliary valve)	2-13
20.	No motion, slow or jerky action of hydraulic system	2-13
21.	Load will not hold (downdrift)	2-14
22.	Load drops when spool is moved from neutral to a power position	2-14

Table 2-1. Unit Troubleshooting Symptom Index - CONT:

Troubleshooting Fault		Page
SERVICE BRAKE SYSTEM		
23.	No brake pedal	2-14
24.	Brake pedal spongy	2-15
INCHING BRAKE SYSTEM		
25.	No inching brake pedal	2-16
26.	Inching brake pedal spongy	2-16
STEERING SYSTEM		
27.	No steering	2-17
28.	Hard steering	2-18
TRANSMISSION		
29.	Transmission will not operate in forward or reverse	2-18
30.	Transmission shifts slowly	2-19
31.	Transmission slips	2-20
32.	Transmission lacks power	2-21
33.	Transmission overheats	2-21
ELECTRICAL SYSTEM		
34.	Engine will not crank	2-22
35.	Batteries will not hold a charge	2-24
36.	Gauges do not operate	2-25
37.	Cold start system does not operate	2-25
38.	Horn does not operate	2-25
39.	One or more warning light does not operate	2-26
40.	Seat belt warning light does not operate	2-26
41.	Seat belt buzzer does not operate	2-27
42.	Taillight does not operate	2-27
43.	Brake light does not operate	2-27
44.	Front or rear floodlight(s) does not operate	2-28

Table 2-2. Unit Troubleshooting Procedures

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

ENGINE

1. ENGINE WILL NOT START.

Step 1. Check that engine is cranking.

If engine will not crank, go to step 2.

If engine will crank, go to step 3.

Step 2. Check if engine will turn over manually.

If engine will turn over manually, go to ELECTRICAL SYSTEM 34. ENGINE WILL NOT CRANK.

If engine will not turn over manually, notify DS/GS maintenance.

Step 3. Test fuel shutoff solenoid with key switch in RUN position.

If test result is not 5-11 volts, fuel injection pump faulty. Notify DS/GS maintenance.

If test result is 5-11 volts, go to step 4.

Step 4. Check if fuel lines and fittings are loose.

If fuel lines and/or fittings are loose, tighten or replace; then, bleed fuel system (Appendix F, Fuel System, Section 5.0), and prime fuel system (Appendix F, Diesel Fuel Injection System, Section 5.3).

If fuel lines and fittings are secure, go to step 5.

Step 5. Test fuel supply pressure at engine idle (650-700 rpm).

Disconnect fuel supply line at inlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel supply pump (Para 3-17).

If test results are 1.50 to 2.25 psi, go to step 6.

Step 6. Test fuel filter pressure drop at engine idle (650-700 rpm).

Disconnect fuel supply line at outlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel filter (Para 3-16).

If test results are 1.50 to 2.25 psi, notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
2. ENGINE DOES NOT RUN EVENLY.
Step 1. Check if fuel lines and fittings are loose. If fuel lines and/or fittings are loose, tighten or replace; then, bleed fuel system (Appendix F, Fuel System, Section 5.0), and prime fuel system (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel lines and fittings are secure, go to step 2.
Step 2. Test fuel supply pressure at engine idle (650-700 rpm). Disconnect fuel supply line at inlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel supply pump (Para 3-17). If test results are 1.50 to 2.25 psi, go to step 3.
Step 3. Test fuel filter pressure drop at engine idle (650-700 rpm). Disconnect fuel supply line at outlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel filter (Para 3-16). If test results are 1.50 to 2.25 psi, go to step 4.
Step 4. Test fuel return pressure at engine idle (650-700 rpm). Disconnect fuel return line at outlet side of fuel pump. Test fuel pressure. If test results are not 2.4 psi (16 kPa), fuel line blockage is indicated. Remove and replace fuel return lines (Para 3-17). If test results 2.4 psi (16 kPa), go to step 5.
Step 5. Test coolant temperature after 10 minutes of operation. If coolant temperature is above 217°F (102°C), proceed to 4. ENGINE TEMPERATURE ABOVE NORMAL. If coolant temperature is below 180°F (820C), remove and test thermostat (Appendix F, Cooling System, Section 4.8). Refer to Appendix F, Continental Diesel Engine, Section 4.4, Section 4 to test thermostat. Replace thermostat as necessary. If coolant temperature is normal, go to step 6.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
2. ENGINE DOES NOT RUN EVENLY - CONT.
Step 6. Test cylinder compression. If all cylinders do not read between 325 - 400 psi, go to step 7. If all cylinders read between 325 - 400 psi, go to step 8.
Step 7. Check cylinder head valve clearance. If cylinder head valves are out of adjustment, adjust valves (Appendix F, Engine Valve Clearance Adjustment, Section 4.5). If cylinder head valve clearances are OK, go to step 8.
Step 8. Bleed fuel system (Appendix F, Fuel System, Section 5.0), and prime fuel system (Appendix F, Diesel Fuel Injection System, Section 5.3). If engine still does not run evenly, go to step 9.
Step 9. Check that fuel type is correct type and not contaminated (W-F-800). If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel. If fuel is OK, notify DS/GS maintenance.
3. A LOSS OF POWER.
Step 1. Check if fuel lines and fittings are loose. If fuel lines and/or fittings are loose, tighten or replace; then, bleed fuel system (Appendix F, Fuel System, Section 5.0), and prime fuel system (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel lines and fittings are secure, go to step 2.
Step 2. Test fuel supply pressure at engine idle (650-700 rpm). Disconnect fuel supply line at inlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel supply pump (Para 3-17). If test results are 1.50 to 2.25 psi, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
3. A LOSS OF POWER - CONT.
Step 3. Test fuel filter pressure drop at engine idle (650-700 rpm). Disconnect fuel supply line at outlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel filter (Para 3-16). If test results are 1.50 to 2.25 psi, go to step 4.
Step 4. Test coolant temperature after 10 minutes of operation. If coolant temperature is above 217°F (102°C), proceed to 4. ENGINE TEMPERATURE ABOVE NORMAL. If coolant temperature is below 180°F (820C), remove and test thermostat (Appendix F, Cooling System, Section 4.8). Refer to Appendix F, Continental Diesel Engine, Section 4.4, Section 4 to test thermostat. Replace thermostat as necessary. If coolant temperature is normal, go to step 5.
Step 5. Check that fuel type is correct type and not contaminated (W-F-800). If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel. If fuel is OK, notify DS/GS maintenance.
4. ENGINE TEMPERATURE ABOVE NORMAL.
Step 1. Check radiator for damage or debris that could restrict cooling capability. **WARNING** **Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa).Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.) to prevent injury to personnel.** If radiator is full of debris, use compressed air to blow debris out of radiator. If radiator is damaged, or debris cannot be removed, replace radiator (Appendix F, Engine Removal, Section 4.11). If radiator is OK, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

ENGINE (CONT.)

4. ENGINE TEMPERATURE ABOVE NORMAL - CONT.

Step 2. Check fan belt adjustment.

If fan belt requires adjustment, adjust drive belt (Appendix F, Cooling System, Section 4.8).

If fan belt is OK, go to step 3.

Step 3. Check for faulty radiator cap (Appendix F, Cooling System, Section 4.8).

If radiator cap is faulty, replace radiator cap (Appendix F, Cooling System, Section 4.8).

If radiator cap is OK, go to step 4.

Step 4. Check for faulty thermostat (Appendix F, Cooling System, Section 4.8). Refer to Appendix F, Continental Diesel Engine, Section 4.4, Section 4 to test thermostat.

If thermostat is faulty, replace thermostat (Appendix F, Cooling System, Section 4.8).

If thermostat is OK, go to step 5.

Step 5. Check that fuel type is correct type and not contaminated (W-F-800).

If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel.

If fuel is OK, notify DS/GS maintenance.

5. BLACK EXHAUST SMOKE.

Check that fuel type is correct type and not contaminated (W-F-800).

If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel.

If fuel is OK, notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
6. WHITE EXHAUST SMOKE. Step 1. Check for faulty thermostat (Appendix F, Cooling System, Section 4.8). Refer to Appendix F, Continental Diesel Engine, Section 4.4, Section 4 to test thermostat. If thermostat is faulty, replace thermostat (Appendix F, Cooling System, Section 4.8). If thermostat is OK, go to step 2. Step 2. Check that fuel type is correct type and not contaminated (W-F-800). If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel. If fuel is OK, notify DS/GS maintenance. **7. TRUCK SLOW TO ACCELERATE.** Step 1. Test fuel supply pressure at engine idle (650-700 rpm). Disconnect fuel supply line at inlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel supply pump (Para 3-17). If test results are 1.50 to 2.25 psi, go to step 3. Step 2. Test fuel filter pressure drop at engine idle (650-700 rpm). Disconnect fuel supply line at outlet side of fuel filter. Test fuel pressure. If test results are not 1.50 to 2.25 psi, replace fuel filter (Para 3-16). If test results are 1.50 to 2.25 psi, go to step 4. Step 3. Check that fuel type is correct type and not contaminated (W-F-800). If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel. If fuel is OK, notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
8. ENGINE KNOCKING.
Step 1. Bleed fuel system (Appendix F, Fuel System, Section 5.0), and prime fuel system (Appendix F, Diesel Fuel Injection System, Section 5.3). If engine still knocks, go to step 2.
Step 2. Check that fuel type is correct type and not contaminated (VV-F-800). If fuel is incorrect type or contaminated, drain fuel tank and refill with correct/clean fuel. If fuel is OK, notify DS/GS maintenance.
HYDRAULIC SYSTEM
9. NO LIFT, TILT, OR SIDESHIFT FUNCTION.
Check hydraulic pump output pressure (Appendix F, Hydraulic System, Section 10.0). If hydraulic pump pressure is below 2500 psi (17237 kPa), adjust hydraulic pump (Appendix F, Hydraulic System Relief Pressure Check & Adjustment, Section 10.2). If hydraulic pump pressure is still below 2500 psi (17237 kPa), hydraulic pump is faulty. Notify DS/GS maintenance. If hydraulic pump pressure is 2500 psi (17237 kPa), main hydraulic valve is faulty. Notify DS/GS maintenance.
10. LOAD CANNOT BE LIFTED TO MAXIMUM HEIGHT.
Step 1. Check that upright assembly is adjusted correctly (Appendix F, Upright Maintenance, Section 13.0). If upright assembly is not adjusted correctly, adjust upright assembly (Appendix F, Upright Maintenance, Section 13.1). If upright assembly is adjusted correctly, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONTI

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

HYDRAULIC SYSTEM (CONT.)

10. LOAD CANNOT BE LIFTED TO MAXIMUM HEIGHT - CONT.

Step 2. Check hydraulic pump output pressure (Appendix F, Hydraulic System, Section 10.0).

If hydraulic pump pressure is below 2500 psi (17237 kPa), adjust hydraulic pump (Appendix F, Hydraulic System Relief Pressure Check & Adjustment, Section 10.2).

If hydraulic pump pressure is still below 2500 psi (17237 kPa), hydraulic pump is faulty. Notify DS/GS maintenance.

If hydraulic pump pressure is 2500 psi (17237 kPa), main hydraulic valve is faulty. Notify DS/GS maintenance.

11. OIL LEAKS AT TOP OF LIFT CYLINDER(S).

Step 1. Check lift cylinder vent line for blockage (Appendix F, Upright Maintenance, Section 13.0).

If vent line is blocked, replace vent line (Appendix F, Upright Maintenance, Section 13.1).
If vent line is not blocked, go to step 2.

Step 2. Lift cylinder(s) faulty.

Replace faulty lift cylinder(s). Notify DS/GS maintenance.

12. OIL LEAKS AT END OF TILT CYLINDER(S).

Tilt cylinder(s) faulty.

Replace faulty tilt cylinder(s) (Appendix F, Tilt Cylinder Maintenance, Section 10.7).

13. OIL LEAKS AT TOP OR END OF SIDESHIFT CYLINDER.

Sideshift cylinder faulty.

Replace faulty Sideshift cylinder. Notify DS/GS maintenance.

14. UPRIGHT LIFT SPEED SLUGGISH.

Step 1. Replace hydraulic fluid filter (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

If upright lift speed is still sluggish, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT:

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

HYDRAULIC SYSTEM (CONT.)

14. UPRIGHT LIFT SPEED SLUGGISH - CONT.

Step 2. Remove and clean hydraulic tank strainer (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

If upright lift speed is still sluggish, go to step 3.

Step 3. Check hydraulic pump output pressure (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

If hydraulic pump pressure is below 2500 psi (17237 kPa), replace hydraulic pump. Notify DS/GS maintenance.

If hydraulic pump pressure is 2500 psi (17237 kPa), go to step 4.

Step 4. Check main valve output pressure at any valve outlet port (Appendix F, Hydraulic System Relief Pressure Check & Adjustment, Section 10.2).

If main valve pressure is below 2500 psi (17237 kPa), replace main hydraulic valve. Notify DS/GS maintenance.

If hydraulic pump pressure is 2500 psi (17237 kPa), replace hydraulic pump. Notify DS/GS maintenance.

15. PUMP NOT DELIVERING HYDRAULIC FLUID.

Step 1. Check hydraulic hoses for secure connections.

If one or more hose connections are loose, tighten connections (Para 3-30).

If hose connections are not loose, go to step 2.

Step 2. Replace hydraulic fluid filter (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

If pump still does not deliver hydraulic fluid, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
HYDRAULIC SYSTEM (CONT.)
15. PUMP NOT DELIVERING HYDRAULIC FLUID - CONT.
Step 3. Remove and clean hydraulic tank strainer (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1). If pump still does not deliver hydraulic fluid, replace hydraulic pump. Notify DS/GS maintenance.
16. PUMP NOT DEVELOPING SUFFICIENT PRESSURE.
Step 1. Check hydraulic hoses for secure connections. If one or more hose connections are loose, tighten connections (Para 3-30). If hose connections are not loose, go to step 2.
Step 2. Replace hydraulic fluid filter (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1). If still does not develop sufficient pressure, go to step 3.
Step 3. Remove and clean hydraulic tank strainer (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1). If still does not develop sufficient pressure, replace hydraulic pump., Notify DS/GS maintenance.
17. NOISY PUMP.
Step 1. Check hydraulic hoses for secure connections. If one or more hose connections are loose, tighten connections (Para 3-30). If hose connections are not loose, go to step 2.
Step 2. Replace hydraulic fluid filter (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1). If pump is still noisy, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT:

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

HYDRAULIC SYSTEM (CONT.)

17. NOISY PUMP - CONT.

Step 3. Remove and clean hydraulic tank strainer (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

If pump is still noisy, replace hydraulic pump. Notify DS/GS maintenance.

18. OIL LEAKS AT EITHER END OF MAIN OR AUXILIARY VALVE SPOOL.

Step 1. Main hydraulic control valve faulty.

Replace main hydraulic control valve. Notify DS/GS maintenance.

19. SPRING-CENTERED SPOOLS DO NOT RETURN TO NEUTRAL (MAIN OR AUXILIARY VALVE).

Step 1. Check levers and linkage for binding.

If levers or linkage are binding, adjust or replace levers (Appendix F, Main Hydraulic Control Valve, Section 10.5).

If levers and linkage are OK, main valve faulty. Notify DS/GS maintenance.

Step 2. Main hydraulic control valve faulty.

Repair hydraulic main control valve. Notify DSIGS maintenance.

20. NO MOTION, SLOW OR JERKY ACTION OF HYDRAULIC SYSTEM.

Check levers and linkage for binding.

If levers or linkage are binding, adjust or replace levers (Appendix F, Main Hydraulic Control Valve, Section 10.5).

If levers and linkage are OK, replace relief valve (located in main valve). Notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
HYDRAULIC SYSTEM (CONT.)
21. LOAD WILL NOT HOLD (DOWNDRIFT).
Step 1. Check levers and linkage for correct adjustment. If levers or linkage are not adjusted correctly, adjust or replace levers (Appendix F, Main Hydraulic Control Valve, Section 10.5). If levers and linkage are OK, go to step 2.
Step 2. Check lift cylinder for seeping that would cause downdrift (Appendix F, Upright Maintenance, Section 13.0). If lift cylinder is seeping, repair lift cylinder. Notify DS/GS maintenance. If lift cylinder is OK, replace main hydraulic control valve. Notify DS/GS maintenance.
22. LOAD DROPS WHEN SPOOL IS MOVED FROM NEUTRAL TO A POWER POSITION.
Relief valve faulty. Replace relief valve (located in main valve), notify DS/GS maintenance.
SERVICE BRAKE SYSTEM
23. NO BRAKE PEDAL.
Step 1. Check brake wheel cylinders for external leaks (Appendix F, Transaxle, Section 7.0). If wheel cylinders have external leaks, replace wheel cylinders (Appendix F, TA18 Transaxle, Section 7.6). If wheel cylinders are OK, go to step 2.
Step 2. Cap master cylinder exit port and check brake pedal firmness. If brake pedal is not firm, replace brake master cylinder (Para 3-29). If brake pedal is firm, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

SERVICE BRAKE SYSTEM (CONT.)

23. NO BRAKE PEDAL - CONT.

Step 3. Check for worn brake shoe linings (Appendix F, Transaxle, Section 7.0).

If brake shoe linings are worn, replace brake shoe linings (Appendix F, TA18 Transaxle, Section 7.6).

If brake shoe linings are not worn, go to step 4.

Step 4. Check brake shoe linings adjustment (Appendix F, Brakes, Section 8.0).

If brake shoe linings are out of adjustment, adjust brake shoe linings (Appendix F, Brake & Inching System, Section 8.4).

If brake shoe linings are not out of adjustment, notify DS/GS maintenance.

24. BRAKE PEDAL SPONGY.

Step 1. Check brake pedal adjustment (Appendix F, Brakes, Section 8.0).

If brake pedal is out of adjustment, adjust brake pedal (Appendix F, Brake & Inching System, Section 8.4).

If brake pedal is not out of adjustment, go to step 2.

Step 2. Check brake wheel cylinders for external leaks (Appendix F, Transaxle, Section 7.0).

If wheel cylinders have external leaks, replace wheel cylinders (Appendix F, TA18 Transaxle, Section 7.6).

If wheel cylinders are OK, go to step 3.

Step 3. Check for air in brake system (Appendix F, Brakes, Section 8.0).

If air is in brake system, bleed brake system (Appendix F, Brake Bleeding, Section 8.5).

If no air is in brake system, go to step 4.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
SERVICE BRAKE SYSTEM (CONT.)
24. BRAKE PEDAL SPONGY - CONT.
Step 4. Cap master cylinder exit port and check brake pedal firmness. If brake pedal is not firm, replace brake master cylinder (Para 3-29). If brake pedal is firm, notify DS/GS maintenance.
INCHING BRAKE SYSTEM
25. NO INCHING BRAKE PEDAL.
Step 1. Check inching brake hoses for secure connections (Para 3-29). If inching brake hose connections are loose, tighten connections (Para 3-29). If inching brake hose connections are not loose, go to step 2.
Step 2. Cap inching cylinder exit port and check inching brake pedal firmness. If inching brake pedal is not firm, replace brake master cylinder (Para 3-29). If inching brake pedal is firm, go to step 3.
Step 3. Check inching brake linkage for binding. If inching brake linkage is binding, repair or replace (Para 3-29). If inching brake linkage is not binding, notify DS/GS maintenance.
26. INCHING BRAKE PEDAL SPONGY.
Step 1. Check inching brake hoses for secure connection (Para 3-29). If inching brake hose connections are loose, tighten connections (Para 3-29). If inching brake hose connections are not loose, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT:

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
INCHING BRAKE SYSTEM (CONT.)
26. INCHING BRAKE PEDAL SPONGY - CONT.
Step 2. Check for air in brake system (Appendix F, Brakes, Section 8.0). If air is in brake system, bleed brake system (Appendix F, Brake Bleeding, Section 8.5). If no air is in brake system, go to step 3.
Step 3. Cap inching cylinder exit port and check inching brake pedal firmness. If inching brake pedal is not firm, replace brake master cylinder (Para 3-29). If inching brake pedal is firm, notify DS/GS maintenance.
STEERING SYSTEM
27. NO STEERING.
Step 1. Check power steering system for faulty hoses (Para 3-30). If one or more hoses is faulty, replace hoses (Para 3-30). If hoses are not faulty, go to step 2.
Step 2. Check hydraulic pump output pressure (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1). If hydraulic pump pressure is below 2500 psi (17237 kPa), replace hydraulic pump. Notify DS/GS maintenance. If hydraulic pump pressure is 2500 psi (17237 kPa), go to step 3.
Step 3. Check hydraulic fluid system for air leaks (Appendix F, Hydraulic System Relief Pressure Check & Adjustment, Section 10.2). If air leaks are present, secure connections. If air leaks are not present, faulty steering valve. Notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT:

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

STEERING SYSTEM (CONT.)

28. HARD STEERING.

Step 1. Check steering system relief pressure at the pressure relief valve steering line and pump fitting (Appendix F, Power Steering System-Relief Pressure Setting, Section 9.1).

If steering system relief pressure setting is below 1200 psi (8270 kPa), adjust or replace pressure relief valve. Notify DS/GS maintenance.

If steering system relief pressure setting is between 1200 and 1300 psi (8270-8960 kPa), go to step 2.

Step 2. Check power steering gear hydraulic oil flow (Appendix F, Steering Column and Valve, Section 10.2).

If power steering gear hydraulic oil flow is not 4 gallons per minute (GPM), faulty steering valve, notify DS/GS maintenance.

If power steering gear hydraulic oil flow is 4 gallons per minute (GPM), go to step 3.

Step 3. Check hydraulic fluid system for air leaks (Appendix F, Hydraulic System Relief Pressure Check &Adjustment, Section 10.2).

If air leaks are present, secure connections (Para 3-30).

If air leaks are not present, notify DS/GS maintenance.

TRANSMISSION

29. TRANSMISSION WILL NOT OPERATE IN FORWARD OR REVERSE.

Step 1. Check level and condition of transmission fluid.

If transmission fluid level is low or fluid is bumt, replace transmission fluid (Appendix F, Transmission Troubleshooting, Section 7.2).

If transmission fluid is OK, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT:

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

TRANSMISSION (CONT.)

29. TRANSMISSION WILL NOT OPERATE IN FORWARD OR REVERSE - CONT.

Step 2. Check directional control lever and control lever linkage for correct operation (Appendix F, Transmission Troubleshooting, Section 7.2).

If directional control lever or linkage is out of adjustment or faulty, adjust or replace (Appendix F, Transmission Troubleshooting, Section 7.2).

If directional control lever and linkage are OK, go to step 3.

Step 3. Check directional switches in directional control lever for correct operation (Appendix F, Transmission Troubleshooting, Section 7.2).

If directional switches are faulty, replace directional switches (Appendix F, Transmission Troubleshooting, Section 7.2).

If directional switches are OK, go to step 4.

Step 4. Check converter inlet pressure (charging pump pressure) at regulator valve (Appendix F, Transmission Pressure Checks, Section 7.3).

If converter inlet pressure is not 150-195 psi (1034-1172 kPa) at 1800 rpm, drain and flush hydraulic tank and screen (Appendix F, Transaxle Maintenance, Section 7.1).

If converter inlet pressure is between 150-195 psi (1034-1172 kPa) at 1800 rpm, charging pump faulty. Notify DS/GS maintenance.

30. TRANSMISSION SHIFTS SLOWLY.

Step 1. Check level and condition of transmission fluid.

If transmission fluid level is low or fluid is burnt, replace transmission fluid (Appendix F, Transmission Troubleshooting, Section 7.2).

If transmission fluid is OK, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

TRANSMISSION (CONT.)

30. TRANSMISSION SHIFTS SLOWLY - CONT.

Step 2. Check inching brakes (Inching Brake System, Malfunctions 25 and 26 of this section).

If inching brakes are OK, go to step 3.

If inching brakes are faulty, repair inching brakes (Para 3-29) or notify DS/GS maintenance.

Step 3. Check clutch pressure (Appendix F, Transmission Pressure Tests, Section 7.3).
If clutch pressure is below 135-155 psi (930-1068 kPa) at 650 rpm, go to step 4.

If clutch pressure is 135-155 psi (930-1068 kPa) at 650 rpm, clutch faulty. Notify DS/GS maintenance.

Step 4. Check converter inlet pressure (charging pump pressure) at regulator valve (Appendix F, Transmission Pressure Checks, Section 7.3).

If converter inlet pressure is not 150-195 psi (1034-1172 kPa) at 1800 rpm, drain and flush hydraulic tank and screen (Appendix F, Transaxle Maintenance, Section 7.1).

If converter inlet pressure is between 150-195 psi (1034-1172 kPa) at 1800 rpm, charging pump faulty. Notify DS/GS maintenance.

31. TRANSMISSION SLIPS.

Step 1. Check level and condition of transmission fluid.

If transmission fluid level is low or fluid is burnt, replace transmission fluid (Appendix F, Transmission Troubleshooting, Section 7.2).

If transmission fluid is OK, go to step 2.

Step 2. Check inching brakes (Inching Brake System, Malfunctions 25 and 26 of this section).

If inching brakes are OK, go to step 3.

If inching brakes are faulty, repair inching brakes (Para 3-29) or notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

TRANSMISSION (CONT.)

31. TRANSMISSION SLIPS - CONT.

Step 3. Check clutch pressure (Appendix F, Transmission Pressure Tests, Section 7.3).

If clutch pressure is below 135-155 psi (930-1068 kPa) at 650 rpm, go to step 4.

If clutch pressure is 135-155 psi (930-1068 kPa) at 650 rpm, clutch faulty. Notify DS/GS maintenance.

Step 4. Check converter inlet pressure (charging pump pressure) at regulator valve (Appendix F, Transmission Pressure Checks, Section 7.3).

If converter inlet pressure is not 150-195 psi (1034-1172 kPa) at 1800 rpm, drain and flush hydraulic tank and screen (Appendix F, Transaxle Maintenance, Section 7.1).

If converter inlet pressure is between 150-195 psi (1034-1172 kPa) at 1800 rpm, charging pump faulty. Notify DS/GS maintenance.

32. TRANSMISSION LACKS POWER.

Check converter inlet pressure (charging pump pressure) at regulator valve (Appendix F, Transmission Pressure Tests, Section 7.3).

If converter inlet pressure is not 150-195 psi (1034-1172 kPa) at 1800 rpm, drain and flush hydraulic tank and screen (Appendix F, Transaxle Maintenance, Section 7.1).

If converter inlet pressure is between 150-195 psi (1034-1172 kPa) at 1800 rpm, charging pump faulty, notify DS/GS maintenance.

33. TRANSMISSION OVERHEATS.

Step 1. Check level and condition of transmission fluid.

If transmission fluid level is low or fluid is burnt, replace transmission fluid (Appendix F, Transmission Troubleshooting, Section 7.2).

If transmission fluid is OK, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

TRANSMISSION (CONT.)

33. TRANSMISSION OVERHEATS - CONT.

Step 2. Check oil cooler and oil cooler lines for dirt and/or restrictions (Appendix F, Transaxle Maintenance, Section 7.1).

If oil cooler is dirty or oil cooler lines have restrictions, drain and flush oil cooler (Appendix F, Transaxle Maintenance, Section 7.1) or replace faulty lines (Para 3-30).

If oil cooler is not dirty and oil cooler lines have no restrictions, go to step 3.

Step 3. Check converter inlet pressure (charging pump pressure) at regulator valve (Appendix F, Transmission Pressure Checks, Section 7.3).

If converter inlet pressure is not 150-195 psi (1034-1172 kPa) at 1800 rpm, drain and flush hydraulic tank and screen (Appendix F, Transaxle Maintenance, Section 7.1).

If converter inlet pressure is between 150-195 psi (1034-1172 kPa) at 1800 rpm, charging pump faulty. Notify DS/GS maintenance.

ELECTRICAL SYSTEM

34. ENGINE WILL NOT CRANK.

Step 1. Check continuity across ignition fuse (TB ORD 650).

If ignition fuse has no continuity, replace ignition fuse (Para 3-22).

If ignition fuse has continuity, go to step 2.

Step 2. Check battery connections.

If battery connections are loose and/or corroded, clean, tighten, or replace connections (Para 3-27).

If battery connections are tight and clean, go to step 3.

Step 3. Test batteries (Appendix F, Starting System Troubleshooting, Section 6.11).

If test result indicates batteries are faulty, replace batteries (Para 3-25).

If test result indicates batteries are OK, go to step 4.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ELECTRICAL SYSTEM (CONT.)
34. ENGINE WILL NOT CRANK - CONT. Step 4. Check continuity across battery cables. If battery cable(s) has no continuity, replace battery cable(s) (Para 3-26). If battery cable(s) has continuity, go to step 5. Step 5. Test starter solenoid (Appendix F, Starter Motor Troubleshooting, Section 6.12). If test result indicates starter solenoid is faulty, notify DS/GS maintenance. If test result indicates starter solenoid is OK, go to step 6. Step 6. Test starter motor (Appendix F, Starter Motor Troubleshooting, Section 6.12). If test result indicates starter motor is faulty, notify DS/GS maintenance. If test result indicates starter motor is OK, go to step 7. Step 7. Test starter relay (Appendix F, Starter Motor Troubleshooting, Section 6.12). If test result indicates starter relay is faulty, notify DS/GS maintenance. If test result indicates starter relay is OK, go to step 8. Step 8. Check continuity across master electrical switch (TB ORD 650). If master switch has continuity, go to step 9. If master switch has no continuity, replace master switch (Para 3-22). Step 9. Check for 9-13 volts at ignition switch (TB ORD 650). If 9-13 volts are not present at ignition switch, go to step 10. If 9-13 volts are present at ignition switch, notify DS/GS maintenance. Step 10. Check for faulty neutral start switch (Appendix F, Starting System Troubleshooting, Section 6.11). If neutral start switch is faulty, replace neutral start switch (Para 3-22). If neutral start switch is OK, replace ignition switch (Para 3-22).

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ELECTRICAL SYSTEM (CONT.)
35. BATTERIES WILL NOT HOLD A CHARGE.
Step 1. Check battery connections. If battery connections are loose and/or corroded, clean, tighten, or replace connections (Para 3-27). If battery connections are tight and clean, go to step 2.
Step 2. Test batteries (Appendix F, Starting System Troubleshooting, Section 6.11). If test result indicates batteries are faulty, replace batteries (Para 3-25). If test result indicates batteries are OK, go to step 3.
Step 3. Check continuity across battery cables. If battery cable(s) has no continuity, replace battery cable(s) (Para 3-26). If battery cable(s) has continuity, go to step 4.
Step 4. Check drive belt adjustment. If drive belt requires adjustment, adjust drive belt (Para 3-20). If drive belt is OK, go to step 5.
Step 5. Test voltage regulator (Appendix F, Prestolite Altemator Service Manual, Section 6.9). If test result indicates voltage regulator is faulty, replace voltage regulator (Para 3-21). If test result indicates voltage regulator is OK, go to step 6.
Step 6. Test alternator (Appendix F, Prestolite Alternator Service Manual, Section 6.9). If test result indicates alternator is faulty, replace altemator (Para 3-20). If test result indicates alternator is OK, wire #22 faulty. Notify DS/GS maintenance.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ELECTRICAL SYSTEM (CONT.)
36. GAUGES DO NOT OPERATE.
Step 1. Check sending unit of malfunctioning gauge (TB ORD 650). If sending unit is faulty, replace sending unit (para 3-22). If sending unit is OK, go to step 2.
Step 2. Check continuity of malfunctioning gauge (TB ORD 650). If malfunctioning gauge has no continuity, replace gauge (Para 3-22). If gauge has continuity, notify DS/GS maintenance.
37. COLD START SYSTEM DOES NOT OPERATE.
Step 1. Check continuity of glow plug switch wires #22 and #15 (TB ORD 650). If one or more glow plug switch wires have no continuity, notify DS/GS maintenance. If glow plug switch wires have continuity, go to step 2.
Step 2. Check continuity across glow plug switch (TB ORD 650). If glow plug switch has no continuity, replace switch (Para 3-22). If glow plug switch has continuity, replace glow plugs (Appendix F, Continental Diesel Engine, Section 4.14).
38. HORN DOES NOT OPERATE.
Step 1. Check continuity across horn fuse (TB ORD 650). If horn fuse has no continuity, replace horn fuse (Para 3-22). If horn fuse has continuity, go to step 2.
Step 2. Check continuity across horn button switch (TB ORD 650). If horn button switch has no continuity, replace horn button switch (Para 3-22). If horn button switch has continuity, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ELECTRICAL SYSTEM (CONT.)
38. HORN DOES NOT OPERATE - CONT.
Step 3. Check continuity of horn relay (TB ORD 650). If horn relay has no continuity, replace horn relay (Para 3-22). If horn relay has continuity, replace horn (Para 3-22).
39. ONE OR MORE WARNING LIGHTS DO NOT OPERATE.
Step 1. Check continuity across malfunctioning warning light lamp (TB ORD 650). If warning light lamp has no continuity, replace lamp (Para 3-22). If warning light lamp has continuity, go to step 2.
Step 2. Check continuity across accessory fuse (TB ORD 650). If accessory fuse has no continuity, replace accessory fuse (Para 3-22). If accessory fuse has continuity, go to step 3.
Step 3. Check continuity across warning light switch (TB ORD 650). If warning light switch has no continuity, replace switch (Para 3-22). If warning light switch has continuity, replace warning light lamp assembly (Para 3-22).
40. SEAT BELT WARNING LIGHT DOES NOT OPERATE.
Step 1. Check continuity across seat belt light lamp (TB ORD 650). If seat belt light lamp has no continuity, replace lamp (Para 3-22). If seat belt light lamp has continuity, go to step 2.
Step 2. Check continuity across ignition fuse (TB ORD 650). If ignition fuse has no continuity, replace ignition fuse (Para 3-22). If ignition fuse has continuity, go to step 3.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ELECTRICAL SYSTEM (CONT.)
40. SEAT BELT WARNING LIGHT DOES NOT OPERATE - CONT.
Step 3. Check continuity across timed buzzer relay (TB ORD 650). If timed buzzer relay has no continuity, replace relay (Para 3-22). If timed buzzer relay has continuity, wire harness faulty. Notify DS/GS maintenance.
41. SEAT BELT BUZZER DOES NOT OPERATE.
Check continuity across timed buzzer relay (TB ORD 650). If timed buzzer relay has no continuity, replace relay (Para 3-22). If timed buzzer relay has continuity, wire harness faulty. Notify DS/GS maintenance.
42. TAILLIGHT DOES NOT OPERATE.
Step 1. Check continuity across taillight lamp (TB ORD 650). If taillight lamp has no continuity, replace lamp (Para 3-22). If taillight lamp has continuity, go to step 2.
Step 2. Check continuity across option fuse (TB ORD 650). If option fuse has no continuity, replace option fuse (Para 3-22). If option fuse has continuity, wire harness faulty. Notify DS/GS maintenance.
43. BRAKE LIGHT DOES NOT OPERATE.
Step 1. Check continuity across brake light lamp (TB ORD 650). If brake light lamp has no continuity, replace lamp (Para 3-22). If brake light lamp has continuity, go to step 2.

Table 2-2. Unit Troubleshooting Procedures - CONT.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

ELECTRICAL SYSTEM (CONT.)

43. BRAKE UGHT DOES NOT OPERATE - CONT.

Step 2. Check continuity across option fuse (TB ORD 650).

If option fuse has no continuity, replace option fuse (Para 3-22).

If option fuse has continuity, go to step 3.

Step 3. Check continuity across brake light switch (TB ORD 650).

If brake light switch has no continuity, replace switch (Para 3-22).

If brake light switch has continuity, replace brake light lamp assembly (Para 3-22).

44. FRONT OR REAR FLOODLIGHT(S) DOES NOT OPERATE.

Step 1. Check if one or all floodlights do not operate.

If one floodlight does not operate, go to step 2.

If all floodlights do not operate, go to step 3.

Step 2. Check continuity across malfunctioning floodlight lamp (TB ORD 650).

If floodlight lamp has no continuity, replace floodlight lamp (Para 3-24).

If floodlight lamp has continuity, go to step 4.

Step 3. Check continuity across option fuse (TB ORD 650).

If option fuse has no continuity, replace option fuse (Para 3-22).

If option fuse has continuity, go to step 4.

Step 4. Check continuity across headlamp and/or rear lamp switch (TB ORD 650).

If switch has no continuity, replace switch (Para 3-22).

If switch has continuity, wire harness faulty, notify DS/GS maintenance.

CHAPTER 3

ORGANIZATIONAL MAINTENANCE

3-1. MAINTENANCE INTRODUCTION.

This section contains overhaul procedures for those reparable parts not covered by vendor manuals. In addition to overhaul procedures for reparable assemblies, this section includes instructions, under the headings of:

a. General Removal Instructions
b. General Disassembly Instructions
c. General Cleaning Instructions
d. General Inspection Instructions
e. General Repair Instructions
f. General Assembly and Installation Instructions

These instructions apply to all procedures in this manual.

3-2. GENERAL REMOVAL INSTRUCTIONS.

Before removing any part, check Table 2-1, Unit Troubleshooting Symptom Index, or Table 4-1, DS/GS Troubleshooting Symptom Index, to determine if the trouble is actually in that component. Also, carefully observe the following procedures:

a. Before removing any component of the electrical, hydraulic, or fuel systems, make sure the system is not energized or pressurized. Disconnect the battery ground cable and relieve all pressure from the hydraulic and/or fuel systems.

b. Ensure that adequate clearance exists for removal of the component. Remove adjacent components to the extent necessary to provide adequate working clearance.

c. Before removal, clean exterior parts to remove accumulated mud, tar, grease, or other foreign materials. This will aid the inspection and disassembly process.

d. Use a suitable lifting device with an appropriate chain when lifting heavy objects. Position and attach lifting device so as to remove all strain from the mounting hardware before hardware is removed.

e. To aid in assembly and installation, apply identifying tags to mating ends of electrical, hydraulic, and fuel lines as they are removed or disconnected. Identify parts of similar configuration to ensure correct installation.

f. Note the original position of components before removing. Be sure the original position is restored.

g. Components, even though defective, should be treated as valuable items because of possible reclamation or salvage value.

3-3. GENERAL DISASSEMBLY INSTRUCTIONS.

a. Keep work area clean to avoid contamination of internal parts. This is especially important for disassembly of hydraulic components.

b. Whenever possible, replace all gaskets, packings, and seals removed during repair work. Similarly, all lockwire, lockwashers, cotter pins, and like items should be replaced during assembly.

c. To avoid scratching the sealing surfaces, do not use a metal tool when removing gaskets, packings, or seals. Use a pointed wooden dowel to remove packing from grooves. Use wooden or plastic scrapers on gasket surfaces.

d. Before disassembly of any component, study the exploded-view illustration found in either the vendor manuals, parts catalog, or this repair manual. Pay particular attention to the relationship of internal parts. Being familiar with the construction will speed up disassembly and help avoid improper assembly.

e. To prevent moisture and foreign matter from entering open housings, lines, and other openings, apply protective covers after disassembly. Wrap all parts in clean paper or dip parts in preservation oil.

f. Remove only the parts requiring repair or replacement. Do not disassemble a component any further than necessary.

3-4. GENERAL CLEANING INSTRUCTIONS.

WARNING

- **Dry cleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes; and do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for type I dry-cleaning solvent is 100°F (380C) and for type II is 140°F (600C). Failure to do so may result in injury or death to personnel.**

- **If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.**

- **Never dip or soak electrical components, packings, or rubber, plastic, or Teflon parts in dry cleaning solvent. Solvent can react with material and result in severe damage or destruction of parts.**

a. Clean all metal parts with dry cleaning solvent. Do not use gasoline for cleaning parts.

b. After soaking parts in solvent, wash away deposits by slushing or spraying, and where necessary, by brushing with a soft-bristle, nonmetallic brush moistened in solvent.

WARNING

Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.) to prevent injury to personnel.

c. Use clean, lint-free cloth or filtered, compressed air to dry all metal parts except bearings. Bearings must be allowed to air dry.

d. Ball or roller bearings should be placed in a basket and suspended in a container of dry cleaning solvent overnight. If necessary, use a soft-bristle, nonmetallic brush to remove caked grease and chips. Avoid rotating the bearing before solid particles are removed to prevent damage to bearings. After cleaning, immediately spin bearings in light lubricating oil to remove solvent. Allow excess oil to drip off.

e. Check all oil passages and cavities for cleanliness and freedom from foreign material. A thin, flexible wire should be run through oil passages to make certain they are not clogged. Individual passages that are dirty may be cleaned using a pressure spray gun and dry cleaning solvent.

f. Clean electrical parts such as relays, switches, etc., with a lint-free cloth moistened with dry cleaning solvent.

g. Clean exterior surfaces of the battery with a weak solution of baking soda and water. Apply the solution with a soft-bristle, nonmetallic brush to remove corrosive buildup on the battery cable terminals.

3-5. GENERAL INSPECTION INSTRUCTIONS.

Inspection consists of checking for physical distortions, wear, cracks, and pitting and checking dimensions of parts for compliance with requirements. Clean all parts before inspection. If any defect is found, correct it as outlined under **GENERAL REPAIR INSTRUCTIONS** before assembly.

a. Inspect all surfaces in contact with gaskets, packings, or seals for nicks, burrs, scratches, etc., which might damage the new seal upon assembly.

b. Examine bearings for rusted or pitted cones, balls, or cups. Examine bearing cones and cups for abrasion and serious discoloration. The following are causes for bearing rejection:

(1) Cuts or grooves parallel to ball or roller rotation.
(2) Fatigue pits (as opposed to minor machine marks or scratches).

NOTE

Defects which may cause bearing binding or misalignment are cause for rejection. Nicks or gouges outside cup load areas are not cause for rejection.

c. The following descriptions of wear conditions may help to determine when gear parts are performing satisfactorily:

(1) Normal wear. Loss of metal from surface of gear tooth resulting from unavoidable abrasion, but not to a degree that prevents gear from performing satisfactorily.

(2) Initial pitting. Pitting may occur when gears are first started in service. It may continue only to a stage where high spots have been reduced and there is still enough contact area to carry load without further impairment. This pitting is not necessarily serious.

(3) Destructive pitting. Pitting that continues to progress after initial period of operation, and to such a degree, that there is not enough contact area remaining to carry the load. Rapid destruction may occur from continued operation.

(4) Abrasive wear. Surface damage caused by fine particles carried in lubricant or particles imbedded in tooth surfaces. Particles may be metal detached from gear tooth or bearings, abrasive not completely removed before assembly, sand or scale from casting, or other impurities in oil or surrounding atmosphere.

(5) Slight scoring (scuffing, seizing, or galling). This may be a minor impairment of surface, or of a welding nature showing slight tears and scratches in direction sliding. It starts in areas having high combinations of surface stress and sliding velocity. It usually occurs at or near the tip of the tooth.

(6) Burning. Discoloration and loss of hardness from excessive temperature. This is caused by friction resulting from overload, overspeed, lack of backlash, or faulty lubrication. If discoloring can be wiped off with a clean cloth, it can usually be traced to oil bum stains which are not usually serious.

(7) Rolling. This is a form of plastic yielding (continuous and permanent deformity in any direction without rupture). This results from heavy, even loads and sliding.

d. Inspect shaft splines for wear, pitting, rolling, or peening and for fatigue cracks. In many instances, the same inspection procedure will apply as for gears. However, the condition will usually be much less pronounced.

e. Check all hose surfaces for deterioration and signs of fatigue. Check for breaks caused by sharp kinks or contact with other parts of the forklift. Inspect tubing for kinks. Check for leaks.

f. Inspect all wiring harnesses for chaffed or burned insulation. Inspect all terminal connections for loose connections and broken parts.

g. Visually inspect all castings and weldments for cracks.

3-6. GENERAL REPAIR INSTRUCTIONS.

a. Remove burrs from gear teeth with a fine-cut file or hand grinder.

WARNING

Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.) to prevent injury to personnel.

b. Starter commutators may be polished in a lathe using a strip of 00 sandpaper. After polishing, blow dust and residue from commutator with compressed air.

c. Chassis and exterior painted parts may be resurfaced, where paint is damaged or where parts have been repaired, by using an abrasive disc.

CAUTION

Precautions should be taken to guard other parts of the truck from abrasive dust. Do not work near exposed parts and openings which would allow the dust to reach working parts.

d. Remove residue and oil stain from bearing races with crocus cloth.

e. Before resurfacing, scrape all loose and blistered paint from damaged areas. Sand or buff area to be painted. Remove residual cleaning material with paint thinner and dry thoroughly.

NOTE

The instruction below applies to polished and machined steel parts not protected by cadmium, tin, copper, or other plating or surface treatment. Bare metal must be free of moisture.

f. Bare steel surfaces should be protected from oxidation while awaiting any repair step. Dip or spray parts in corrosion preventive compound. Aluminum parts may require protection in high salt atmospheres.

g. Welding and brazing process may be used to repair cracks in external steel parts, such as brackets, panels, and light framework. These processes should only be attempted when replacement parts are not available. Welding and brazing of castings and running parts or parts under great stress is not permissible, except in emergencies.

h. Whenever installing studs, use a proper driver. Before driving a stud, inspect hole for chips and liquid. Blow out any foreign matter. Start stud by hand. If stud will not start into hole, it is too large or has a defective end thread. Before final insertion, coat thread with a film of antiseize compound. Turn stud in slowly to prevent overheating and galling of casting metal. Drive stud to proper "setting height," which is the total projecting length. While driving, observe required torque (Table 4-2). This must be greater than nut tightening torque for same size bolt but not enough to damage casting as it approaches its correct engagement depth.

i. Replace all broken, worn, burned, or pinched electrical wiring. Wires with several broken strands must be replaced. Broken strands increase the resistance of the wire and impair efficiency of the electrical components, especially the ignition system.

j. Replace all loose electrical connections. If electrical connection is protected with a coating of silicone waterproofing during removal, apply a heavy coating of silicone during installation to electrical connection.

k. Replace all broken, frayed, crimped, or soft flexible lines and hoses. Replace fittings which are stripped or damaged. Replace entire flexible hose if fittings are damaged. Make sure the hose clamps do not crimp hoses. With engine OFF, operate hydraulic controls to relieve all hydraulic pressure prior to working on hoses.

l. Replace any bolt, screw, or nut with damaged threads. Inspect tapped holes for thread damage. If cross-threading is evident, re-tap the hole for next size screw or stud. When re-tapping will result in weakening the part, or when the cost of the part makes re-tapping impractical, replace the damaged part.

3-7. GENERAL ASSEMBLY AND INSTALLATION INSTRUCTIONS.

a. Remove protective grease coatings from new parts before installation.

b. To replace an o-ring, first clean the groove, then stretch packing and place into position. Rotate component on flat surface while applying a downward pressure to uniformly press the o-ring into position.

c. To provide added sealing for gaskets, coat both sides with sealant. Be sure that all traces of the previous gasket and sealant are removed before installing the new gasket.

d. Install oil seals with seal lip facing in, applying an even force to the other edge of seal. Coat oil seals evenly with oil or grease before installing. If oil seals are to be installed over keyed or splined shafts, use a guide to prevent sharp edges of keyway or spline from cutting the leather or neoprene seal. Make certain the guide edges are not sharp and are bent slightly inward so they do not cut the seal.

e. When mounting bearings on shafts, always apply force to the inner bearing cups. When mounting bearings into housing, apply the force to the outer bearing cup.

f. Lubricate all preformed packings with a thin coat of hydraulic fluid before installation.

g. Lubricate bearings before assembly with the lubricant normally used in the related housing or container. This will provide lubrication during the first run-in until lubricant from the system can reach the bearings.

h. Refer to identifying tags and sketches made at removal.

i In general, after a hydraulic component has been removed, or lines have been broken, fill pump/motor and lines with hydraulic fluid upon installation.

j. In a closed loop system, whenever a pump/motor has been diagnosed as faulty, always replace corresponding pump/motor.

k. Test operation after installation. Inspect for leaks, vibration, noise, and misalignment. Recheck after a week of operation.

I. Always change filters after changing a hydraulic component, then again after 50 hours of operation.

3-8. PMCS INTRODUCTORY MATERIAL.

This section contains PMCS instructions for the truck. The PMCS Table contains checks and services necessary to ensure that the truck is ready for operation. Unit PMCS procedures are defined by the MAC. Unit PMCS is performed at the intervals specified in Table 4-1. Operator Preventive Maintenance Checks and Services in TM 10-3930-671-10 should be completed before performing unit PMCS.

3-9. MAINTENANCE FORMS AND RECORDS.

Maintenance forms and records provide permanent records of maintenance services, repairs, and modifications made on the truck. They provide reports to organizational maintenance and the commander, and they serve as a checklist to find out what was wrong with the truck after its last use and whether those faults have been fixed. For information needed on forms and records, see DA Pam 738-750.

3-10. GENERAL PMCS PROCEDURES AND CONDITIONS.

The following paragraph describes general procedures and conditions that should be observed when performing PMCS.

a. General Guidelines.

(1) Limit repairs to those actions necessary to ensure mission reliability, safety of personnel, and prevention of further damage or deterioration. Repairs, replacements, or services for cosmetic purposes are forbidden.

(2) Lube oil sampling. Engine and transmission oils must be sampled at 50 hours of operation or 90 days, whichever occurs first, for Active Army Units. Reserve and National Guard Activities will use 50 hours or 180 days, whichever occurs first, as the prescribed interval. Hydraulic fluid will be sampled once-a-year. Sampling will be performed as prescribed by DA Pam 738-750.

(3) Lube oil filters. Oil filters shall be serviced/cleaned/changed as applicable when they are known to be contaminated or clogged, service is recommended by AOAP laboratory analysis, or at prescribed hard-time intervals.

(4) Hydraulic systems (other than brake systems) may have class III leakage and not be cause for deadlining. Components, such as actuating cylinders, are designed to allow a certain amount of fluid to pass by the ram seal to lubricate the seal and ram. This could be interpreted as a class III leak. The decision as to whether or not the truck should be deadlined is based upon good mechanical knowledge and common sense.

(5) Corrosion prevention and control (CPC). It is important that any corrosion problem with this truck be reported so that the problem can be corrected and improvements can be made to prevent the problem in other trucks. Corrosion should be reported using Standard Form 368, Product Quality Deficiency Report (QDR). Use keywords such **as corrosion, rust**, deterioration, or cracking to ensure that the information is identified as a CPC problem. Send Std Form 368 to Commander, U.S. Army TACOM, Attn: AMSTA-QRD, Warren, MI 48397-5000.

WARNING

• Dry cleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes; and do not breathe vapors. Keep away from heat of flame. Never smoke when using solvent; the flash point for type I dry cleaning solvent is 100°F (380C) and for type II is 140°F (600C).
Failure to do so may result in injury or death to personnel.

• If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.

b. Cleanliness. Dirt, grease, oil, and debris can cover and hide serious problems. Use dry cleaning solvent on all metal surfaces.

c. Bolts, Nuts, and Screws. Check bolts, nuts, and screws for obvious looseness, missing, bent, or broken condition. Look for chipped paint, bare metal, or rust around bolt heads. If any part seems loose, tighten.

d. Welds. Look for loose or chipped paint, rust, or gaps where parts are welded together. If bad welds are found, notify direct support maintenance.

e. Electric Wires and Connectors. Look for cracked or broken insulation, bare wires, and loose or broken connectors. Tighten loose connectors and make sure wires are in good shape. If bad wires or connectors are found, replace as necessary.

f. Hydraulic Lines and Fittings. Look for wear, damage, and leaks and make sure clamps and fittings are tight. Wet spots show leaks, and a stain around a connector or fitting can mean a leak. If a loose fitting or connector causes a leak, tighten it.

g. Damage is defined as: any conditions that affect safety or render the truck unusable for mission requirements.

h. Always perform PMCS in the same order until it becomes a habit. Once practiced, it will be easy to spot anything wrong.

i. If something does not work, refer to troubleshooting instructions in Chapter 2.

j. If anything looks wrong and is too difficult to fix, write it on DA Form 2404 and notify your supervisor.

k. When doing PMCS, take tools and supplies needed to perform all tasks.

3-11. FLUID LEAKAGE DEFINITION.

The following paragraphs describe the different types/classes of leaks and how they affect the status of the truck. Class I and II leaks are considered minor leaks and operations can continue under these conditions. When operating with these types of leaks, fluid levels must be checked regularly as required in the PMCS.

a. **Class I Leaks.** Class I leaks are identified by a wetness or discoloration not great enough to form drops. It is more of a seepage than a leak.

b. **Class II Leaks.** Class II leaks are identified by a flow of fluid great enough to form drops but not great enough to cause the drops to fall from the leak point.

c. **Class III Leaks.** Class III leaks are identified by a flow of fluid great enough to form drops that fall from the leak point.

(1) If a Class III leak is discovered before operating the truck, the truck can be operated as long as the fluid level is between the maximum and minimum points on the dipstick or sight glass. If the fluid level is below the minimum point on the dipstick or sight glass, do not operate the truck until refilled.

(2) If a Class III leak is discovered during operation of the truck, the operation can be completed as long as the leak is drops only and not a steady stream of fluid. The fluid level must also be within its operating range. If the leak is a steady stream and/or fluid level falls below minimum point on dipstick or sight glass, turn off the truck.

(3) If a Class Ill leak is discovered after operation is complete and the truck fluid level is below minimum on dipstick or sight glass, the truck cannot be operated until the leak is repaired.

3-12. PMCS TABLE DESCRIPTION.

The PMCS Table is arranged in columns which inform unit maintenance which item is being inspected/ serviced, when a truck assembly or component should be inspected/serviced, where the item is located, and the procedures necessary to accomplish the task.

a. Item No. The Item No. column provides a logical sequence for performing the PMCS tasks. The items being inspected can be visible, inside, or under the truck.

b. Interval. The Interval column provides the appropriate time interval for performing each task. This column lists the time intervals within which the tasks should be performed. Intervals are broken into two groups: months of operation and hours of operation. In all cases, checks of items in the PMCS table should be performed under whichever interval occurs first.

c. Item to Be Inspected. This column lists the name of the assembly or component to be inspected/ serviced and its location on the truck.

d. Procedure. The Procedure column provides instructions necessary to accomplish the inspection/ service. It also lists important Warnings, Cautions, and Notes related to each task. If a task is covered elsewhere in manual, it is referenced instead by paragraph number rather than being repeated in this column.

Table 3-1. Unit Preventive Maintenance Checks and Services

Mo-Months		Hr-Hours		
Item No.	Interval Mo	Interval Hr	Item to be Inspected	Procedure
1	**1**	**50-250**	Critical Fasteners	Check torque on critical fasteners (Table 3-3).
2	**1**	**50-250**	Engine	Change the engine oil and filter crankcase (Appendix F, Planned Maintenance Procedures, Section 3.2).
3	**1**	**50-250**	Fan Belt	Inspect/adjust fan belt (Appendix F, Cooling System, Section 4.8).
4	**1**	**50-250**	Lift Chain	Check lift chain for proper adjustment and wear (Appendix F, Planned Maintenance Procedures, Section 3.2).
5	**1**	**50-250**	Transaxle	Check transaxle fluid level (Appendix F, Planned Maintenance Procedures, Section 3.2).
6	**1**	**50-250**	Cooling System	Check coolant level (Appendix F, Cooling System, Section 4.8). Inspect coolant hoses (Appendix F, Cooling System, Section 4.8).
7	**1**	**50-250**	Air Intake System	Inspect air hoses/clamps (Appendix F, Engine Air Cleaner, Section 4.9).
8	**1**	**50-250**	Transaxle	Inspect/clean air vent (Appendix F, TA18 Transaxle, Section 7.6). Check/test inching operation (Appendix F, Planned Maintenance Procedures, Section 3.2).
9	**1**	**50-250**	Battery	Check battery (Appendix F, Planned Maintenance Procedures, Section 3.2).
10	**1**	**50-250**	Gauges/indicators	Check operation/functioning of hourmeter, indicator lights, and neutral start switch (Appendix F, Planned Maintenance Procedures, Section 3.2).
11	**1**	**50-250**	Brakes	Check brake fluid reservoir and lines (Appendix F, Planned Maintenance Procedures, Section 3.2). Check/adjust parking brake linkage (TM 10-3930-671-10, Chapter 2).
12	**1**	**50-250**	Steer Axle & Lines	Lubricate steer axle (Appendix E, Lubrication Order).
13	**1**	**50-250**	Tilt Cylinders	Check/adjust tilt cylinders (Appendix F, Tilt Cylinder Maintenance, Section 10.7). Test tilt cylinder drift (Appendix F, Tilt Cylinder Maintenance, Section 10.7). Check/tighten and lubricate tilt cylinder rod ends (Appendix F, Tilt Cylinder Maintenance, Section 10.7).
14	**1**	**50-250**	Upright, Lift Cylinders, Carriage, Forks	Lubricate carriage lift chain (Appendix F, Upright Maintenance, Section 13.1). Check/lubricate side shift assembly (Appendix E, Lubrication Order).

Table 3-1. Unit Preventive Maintenance Checks and Services - CONT.

Mo-Months		Hr-Hours		
Item No.	Interval Mo	Hr	Item to be Inspected	Procedure
				WARNING If NBC exposure is suspected, all air filter media should be handled by personnel wearing protective equipment. Consult your unit NBC Officer or NBC NCO for appropriate handling or disposal procedures.
15	**3**	**500**	Air Cleaner/Intake System	Inspect air cleaner element (Appendix F, Engine Air Cleaner, Section 4.9). Tighten or replace parts as necessary to make sure air intake system does not leak (i.e. cracked hoses, loose clamps, punctures, etc.).
16	**3**	**500**	Hydraulic Tank Breather	Replace hydraulic tank breather (Appendix F, Planned Maintenance Procedures, Section 3.2).
17	**3**	**500**	Engine	Check/tighten valve cover bolts (Para 5-16). Check/ adjust valve tappet clearance (Appendix F, Valve Clearance Adjustment, Section 4.5).
18	**6**	**1000**	Cooling System level with hydrometer test (Appendix F, Cooling System, Section 4.8).	Cooling System Test cooling system protection
				WARNING Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.
19	**6**	**1000**	Batteries	Clean/tighten batteries and cables (Para 3-27, Battery Cable Service).
20	**6**	**1000**	Gauges, Indicators	Inspect wire harness (Appendix F, Electrical System Wiring, Section 6.1).
21	**6**	**1000**	Transmission	Drain and fill transmission (Appendix E, Lubrication Order, and Appendix F, Planned Maintenance Procedures, Section 3.2).

Table 3-1. Unit Preventive Maintenance Checks and Services - CONT.

Mo-Months		**Hr-Hours**		
Item No.	**Interval**		**Item to be Inspected**	**Procedure**
	Mo	**Hr**		
				WARNING Do not change fuel filter when engine is hot; fuel can be ignited by a hot engine.
22	**6**	**1000**	Fuel Filter	Change fuel filter (Para 3-16, Fuel System Service). Bleed fuel system if required (Appendix F, Diesel Fuel System, Section 5.3).
23	**12**	**2000**	Air Cleaner	Replace air cleaner element (Appendix F, Air Filter, Section 4.9).
24	**12**	**2000**	Radiator Cap	Inspect radiator cap. Pressure test radiator cap and cooling system while checking for leaks (Appendix F, Planned Maintenance Procedures, Section 3.2, and Cooling System, Section 4.8).
25	**12**	**2000**	Cooling System	Drain/flush cooling system (Appendix F, Planned Maintenance Procedures, Section 3.2, and Cooling System, Section 4.8). System capacity is 9 qt (8.5 l).
26	**12**	**2000**	Brakes	Check service brake adjustment (Appendix F, Planned Maintenance Procedures, Section 3.2). Check brake pedal adjustment (Appendix F, Brake System, Section 8.4).
27	**12**	**2000**	Hydraulic Tank	Drain and fill hydraulic tank (Appendix F, Planned Maintenance Procedures, Section 3.2, and Hydraulic Sump Fluid and Filter Change, Section 10.1). Change hydraulic tank filter, (Appendix F, Hydraulic Sump Fluid and Filter Change, Section 10.1).
28	**12**	**2000**	Service Brake	Check service brake adjustment and wear (Appendix F, Planned Maintenance Procedures, Section 3.2). Check brake pedal adjustment (Appendix F, Brake System, Section 8.4).
29	**12**	**2000**	Steer Axle and Lines	Lubricate/adjust steer wheel bearings (Appendix E, Lubrication Order). Check power steering relief pressure (Appendix F, Power Steering System Relief Pressure Setting, Section 9.1).

3-13. TORQUE LIMITS.

Table 3-2 provides wet torque values for U.S. standard screws, nuts, and bolts. Table 3-3 provides dry torque values for U.S. standard screws, nuts, and bolts. Table 3-4 provides dry torque values for metric screws, nuts, and bolts. Table 3-5 provides torque values for metric phosphate coated engine screws, nuts, and bolts. Table 3-6 provides dry torque values for fasteners designated as critical to the truck. After assembly or installation procedures, refer to the appropriate table for the correct torque of component fasteners. While performing Unit PMCS procedures, refer to Table 3-6 for the correct torque of critical fasteners.

Table 3-2. U.S. Standard Torque Values (Wet)

*** Designates coarse thread.** **** Designates fine thread.**

SIZE		SAE GRADE NO. 2			SAE GRADE NO. 5		SAE GRADE NO. 6 OR 7		SAE GRADE NO. 8	
Dia. Inches	Threads Per Inch	Millimeters	Pound Feet	Newton Pound	Pound Feet	Newton Meters	Pound Feet	Newton Meters	Pound Feet	Newton Meters
1/4*	20	6.35	4	6	6	8	8	11	9	12
114**	28	6.35	5	7	7	9	9	12	10	14
5/16*	18	7.94	8	11	13	18	16	22	18	24
5/16**	24	7.94	9	12	14	19	18	24	20	27
3/18*	16	9.53	15	20	23	31	30	41	35	47
3/8**	24	9.53	17	23	25	34	30	41	35	47
7/16*	14	11.11	24	33	35	47	45	61	55	75
7/16**	20		25	34	40	54	50	68	60	81
½*	13	12.70	35	47	55	75	70	95	80	108
1/2**	20		40	54	65	88	80	108	90	122
9/16'	12	14.29	50	68	80	108	100	136	110	149
9/166**	18		55	75	90	122	110	149	130	176
5/8*	11	15.88	70	95	110	149	140	190	170	231
5/8**	18		80	108	130	176	160	217	180	244
3/4*	10	19.05	120	163	200	271	240	325	280	380
3/4"*	16		140	190	220	298	280	380	320	434
7/8*	9	22.23	110	149	300	407	400	542	460	624
7/8**	14		120	163	320	434	440	597	500	678
1*	8	25.40	160	217	440	597	600	814	680	922
1**	12	170		231	480	651	660	895	740	1003
1-1/8*	7	25.53	220	298	600	814	840	1139	960	1302
1-1/8**	12	260	353	660	895	940	1275	1080	1464	
1-1/4*	7	31.75	320	434	840	1139	1100	1492	1360	1844
1-1/4**	12	360	488	920	1248	1320	1790	1500	2034	
1-3/8*	6	34.93	420	570	1100	1492	1560	2115	1780	2414
1-3/8**	12		460	624	1260	1709	1780	2414	2040	2766
1-1/2*	6	36.10	560	760	1460	1980	2080	2820	2360	3200
1-1/2**	12		620	841	1640	2224	2320	3146	2660	3607

Table 3-3. U.S. Standard Torque Values (Dry Fasteners)

*** Designates coarse thread.** **** Designates fine thread.**

SIZE			SAE GRADE NO. 2		SAE GRADE NO. 5		SAE GRADE NO. 6 OR 7		SAE GRADE NO. 8	
Dia. Inches	Threads Per Inch	Millimeters	Pound Feet	Newton Pound	Pound Feet	Newton Meters	Pound Feet	Newton Meters	Pound Feet	Newton Meters
1/4	20	6.35	5	7	8	11	10	14	12	16
1/4	28	6.35	6	9	10	14	12	16	14	19
5/16	18	7.94	11	15	17	23	21	28	25	34
5/16	24	7.94	12	16	19	26	24	33	25	34
3/8	16	9.53	20	27	30	41	40	54	45	61
3/8	24	9.53	23	31	35	47	45	61	50	68
7/16	14	11.11	30	41	50	68	60	81	70	95
7/16	20		35	47	55	75	70	95	80	108
1/2	13	12.70	50	68	75	102	95	129	110	149
1/2	20		55	75	90	122	100	135	120	163
9/16	12	14.29	65	88	110	149	135	183	150	203
9/16	18		75	102	120	163	150	203	170	231
5S8	11	15.88	90	122	150	203	190	258	220	298
5/8	18		100	136	180	244	210	285	240	325
3/4	10	19.05	160	217	260	353	320	434	380	515
3/4	16		180	244	300	407	360	488	420	597
7/8	9	22.23	140	190	400	542	520	705	600	814
7/8	14		155	210	440	597	580	786	660	895
1	8	25.40	220	298	580	786	800	1085	900	1220
1	12		240	325	640	868	860	1186	1000	1356
1-1/8	7	25.53	300	407	800	1085	1120	1519	1280	1736
1-1/8	12	340		461	880	1193	1260	1709	1440	1953
1-1/4	7	31.75	420	570	1120	1519	1580	2142	1820	2468
1-1/4	12	460		624	1240	1681	1760	2387	2000	2712
1-3/8	6	34.93	560	759	1460	1980	2080	2820	2380	3227
1-3/8	12	640		868	1680	2278	2380	3227	2720	3688
1-1/2	6	36.10	740	1003	1940	2631	2780	3770	3160	4285
1-1/2	12		840	1139	2200	2983	3100	4204	3560	4827

Table 3-4. Metric Torque Valve (Dry Fasteners)

SIZE		METRIC GRADE 8.8		METRIC GRADE 10.9		METRIC GRADE 12.9	
Dia. Inches	Millimeters	Pound Feet	Newton Meters	Pounds Feet	Newton Meters	Pounds Feet	Newton Meters
.157	4	2	3	3	4	4	5
.197	5	4	5	6	8	7	9
.237	6	7	9	10	14	11	15
.276	7	44	15	16	22	20	27
.315	8	18	24	25	34	29	39
.394	10	32	45	47	64	58	79
.473	12	58	79	83	113	100	136
.630	16	144	195	196	226	235	319
.709	18	190	258	269	365	323	438
.788	20	260	353	366	496	440	597
.867	22	368	499	520	705	678	919
.946	24	470	637	664	900	794	1077
1.064	27	707	959	996	1351	1235	1675
1.182	30	967	1311	1357	1840	1630	2210

Table 3-5. Metric Torque Values (Phosphate Coated Engine Fasteners)

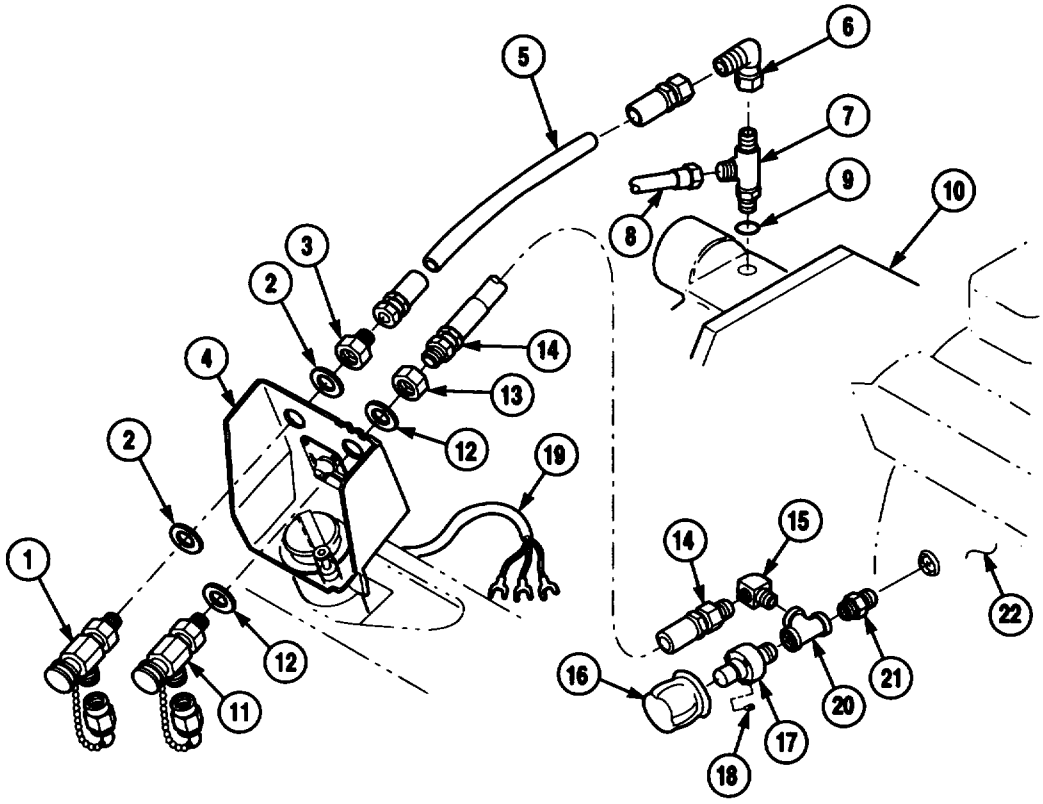
THD SIZE	Class 8.8		Class 9.8	
	LB.FT.	N• m	LB.FT.	N• m
M6	6-8	8-11	6-8	8-11
M8	15-18	20-24	15-18	20-24
M10	25-30	34-40	25-30	34-41
M12	55-60	75-81	55-60	75-81
M14	90-100	122-135-	90-100	122-135
M16	140-150	190-203	140-150	190-203

Table 3-6. Critical Fastener Torque Values (Dry)

Nomenclature	Pound Feet	Newton Meters
Steering Column (Bracket to Frame)	15-18.3	20-25
Seat Mounting Bolts	15-18	20-25
Tilt Cylinder Pin Retainer Bolts		
Rear	21.7-23	29-31
Front	6.7-7.5	9-10
Drive Wheel Lug Nuts	470-530	637-719
Steer Wheel Lug Nuts	265-338	360-458

3-14. OIL SAMPLING VALVE REPLACEMENT.

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) Remove floor panel from forklift (Para 3-36).
(3) To remove transmission oil sampling valve (1) system, proceed as follows:

(a) Remove transmission oil sampling valve (1) and two washers (2) from fitting (3) and shield (4).

(b) Remove fitting (3), hose (5), and fitting (6) from fitting (7).

(c) Remove fittings (3) and (6) from hose (5).

(d) Remove hose (8) from fitting (7).

(e) Remove fitting (7) and seal (9) from transmission (10). Discard seal.

(4) To remove engine oil sampling valve (11) system, proceed as follows:

(a) Remove engine oil sampling valve (11) and two washers (12) from fitting (13) and shield (4).
(b) Remove fitting (13) and hose (14) from fitting (15).

(c) Remove fitting (13) from hose (14).

(d) Remove cover (16) from engine oil pressure sensor (17).

NOTE
Tag and mark all wires prior to removal.

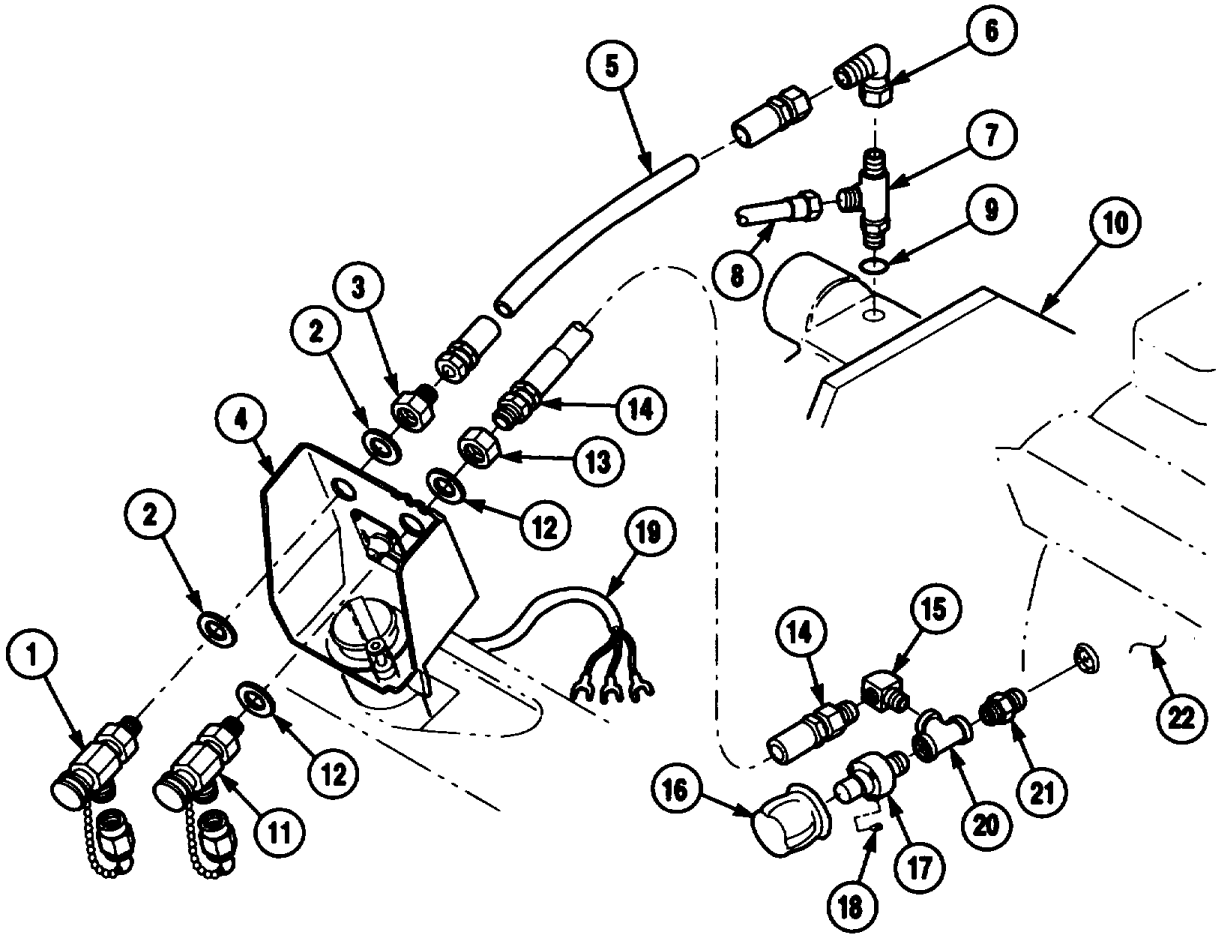
(e) Loosening three screws (18), remove three wires (19) from engine oil pressure sensor (17).

(f) Remove engine oil pressure sensor (17) from fitting (20).

(g) Remove fittings (15), (20), and (21) from engine (22).

(h) Remove fittings (15) and (21) from fitting (20).

b. Installation.



(1) To install engine oil sampling valve (11) system, proceed as follows:

(a) Apply sealant to threads of fittings (21) and (15).

(b) Install fittings (15) and (21) on fitting (20).

(c) Install fittings (15), (20), and (21) on engine (22).

(d) Apply sealant to threads of engine oil pressure sensor (17).

(e) Install engine oil pressure sensor (17) on fitting (20).

(f) Install three wires (1 9) on engine oil pressure sensor (17) with three screws (18) as tagged and marked during ***Removal.***

(g) Install cover (16) on engine oil pressure sensor (17).

(h) Apply sealant to threads of hose (14).

(i) Install hose (14) on fitting (15).

(j) Install fitting (13) on hose (14).

(k) Apply sealant to threads of engine oil sampling valve (11).

(l) Install engine oil sampling valve (11) and two washers (12) on shield (4) and fitting (13).

(2) To install transmission oil sampling valve (1) system, proceed as follows:

(a) Apply sealant on threads of fittings (6 and 7).

(b) Install fitting (7) and seal (9) on transmission (10).

(c) Install fitting (6) on fitting (7).

(d) Install hose (8) on fitting (7).

(e) Install hose (5) on fitting (6).

(f) Install fitting (3) on hose (5).

(g) Apply sealant to threads of transmission oil sampling valve (1).

(h) Install transmission oil sampling valve (1) and two washers (2) on shield (4) and fitting (3).

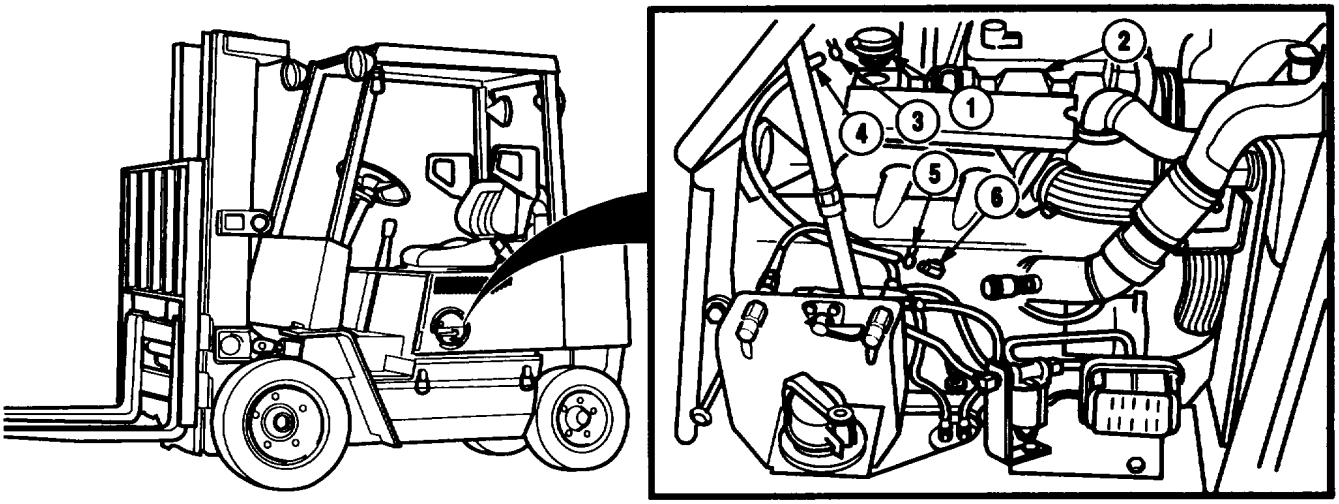
(3) Install floor panel from forklift (Para 3-36).

(4) Connect batteries (Para 3-25).

END OF TASK

3-15. ENGINE OIL BREATHER CAP ASSEMBLY REPLACEMENT.

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) Remove engine oil breather cap (1) from engine (2).

(3) Loosen clamp (3) and remove engine oil breather cap (1) and clamp from hose (4).

(4) Loosen clamp (5) and remove hose (4) and clamp from fitting (6).

b. Installation.

(1) Install hose (4) on fitting (6) with clamp (5).

(2) Install engine oil breather cap (1) on hose (4) with clamp (3).

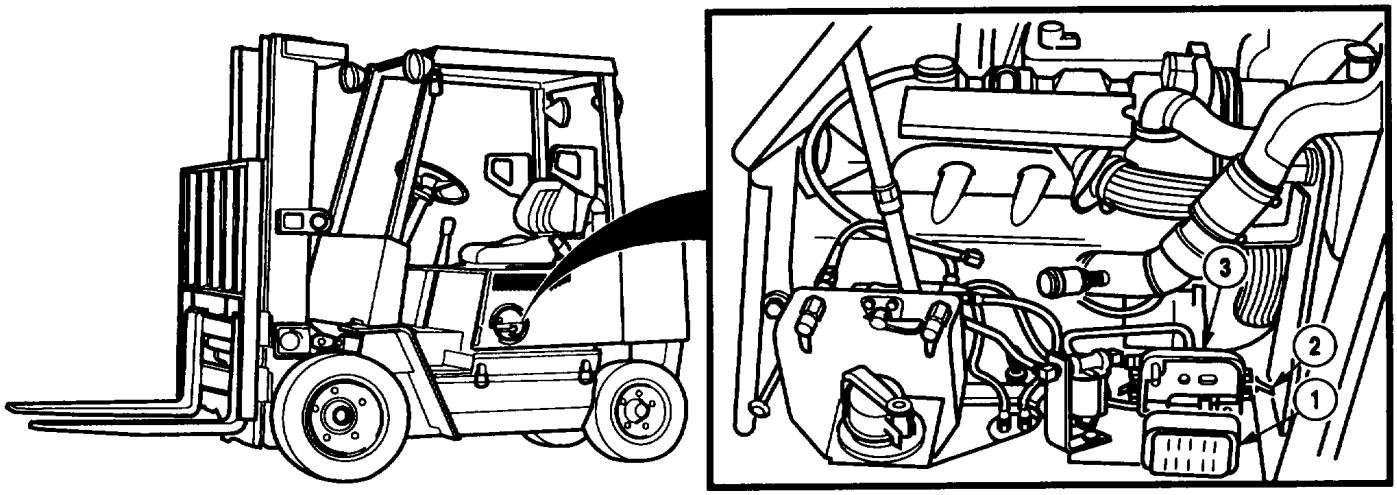
(3) Install engine oil breather cap (1) on engine (2).

(4) Connect batteries (Para 3-25).

END OF TASK

3-16. FUEL SYSTEM SERVICE.

a. Fuel Filter Service.



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(1) To remove fuel filter (1), proceed as follows:

(a) Disconnect batteries (Para 3-25).

NOTE
Prior to removal, position wiping rag under filter to catch any spilled fuel.

(b) Move two fasteners (2) outward and remove fuel filter (1) from fuel filter base (3). Discard filter.

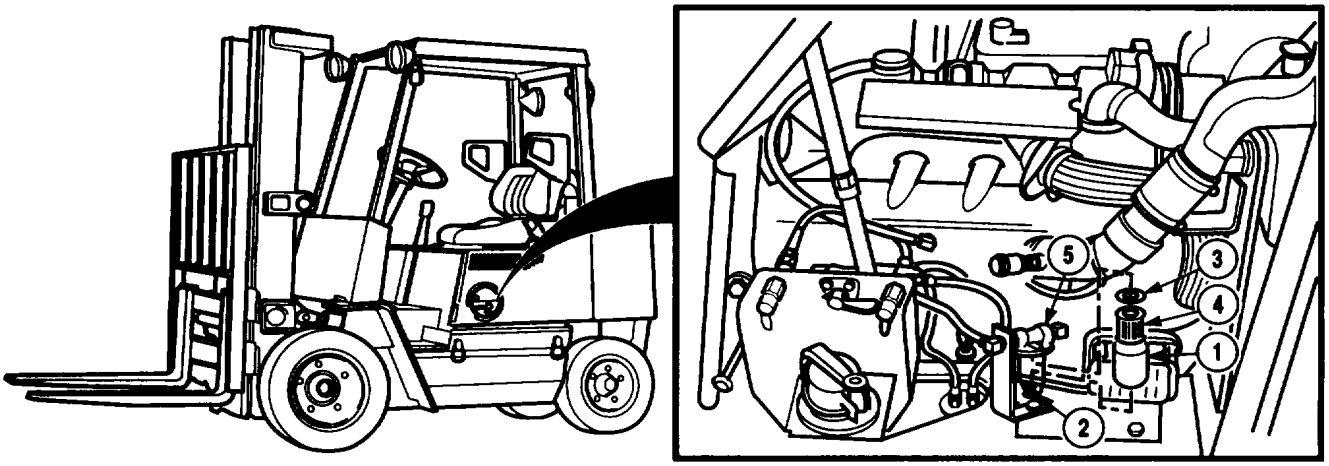
NOTE
Prior to installation, presoak fuel filter with fuel to aid in bleeding during initial startup of engine.

(2) To install fuel filter (1), proceed as follows:

(a) Install fuel filter (1) on fuel filter base (3) with two fasteners (2).

(b) Connect batteries (Para 3-25).

b. Fuel Water Separator Service.



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(1) To remove fuel water separator bowl (1), proceed as follows:

(a) Disconnect batteries (Para 3-25).

NOTE

Prior to removal, position wiping rag under fuel water separator to catch any spilled fuel.

(b) Loosen nut (2) and remove fuel water separator bowl (1), gasket (3), and filter (4) from housing (5). Discard gasket and filter.

(c) Wipe all foreign material from fuel water separator bowl (1).

(2) To install fuel water separator bowl (1), proceed as follows:

(a) Position fuel water separator bowl (1), with gasket (3) and filter (4), in housing (5).

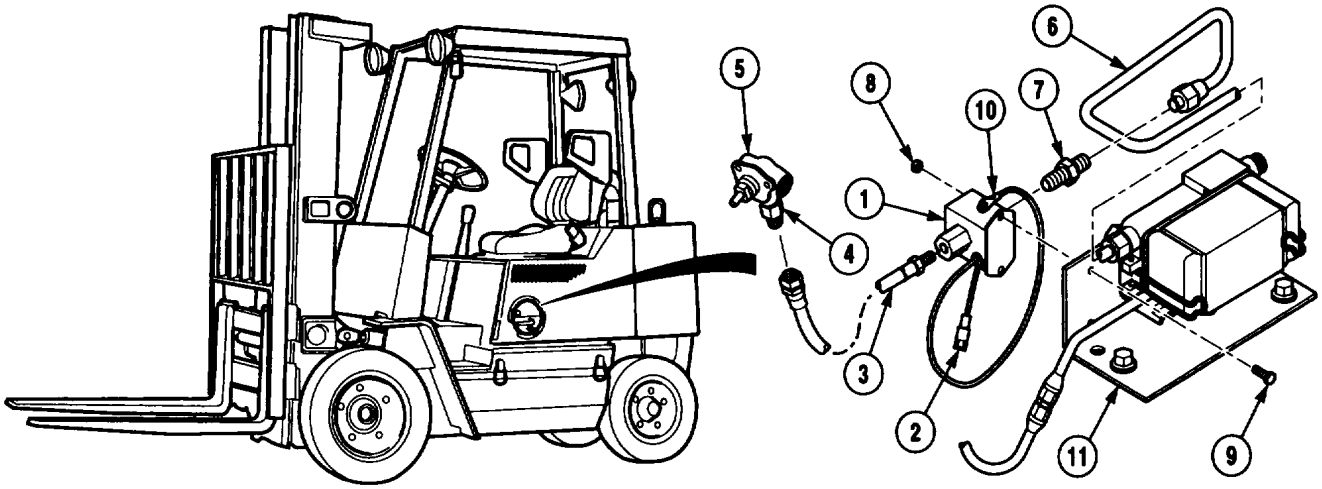
(b) Tighten nut (2) until fuel water separator bowl (1) is securely seated in housing (5).

(c) Connect batteries (Para 3-25).

END OF TASK

3-17. FUEL SYSTEM REPAIR.

a. Fuel Supply Pump Replacement.



(1) Disconnect batteries (Para 3-25).

(2) To remove fuel supply pump (1), proceed as follows:

(a) Disconnect connector (2).

WARNING

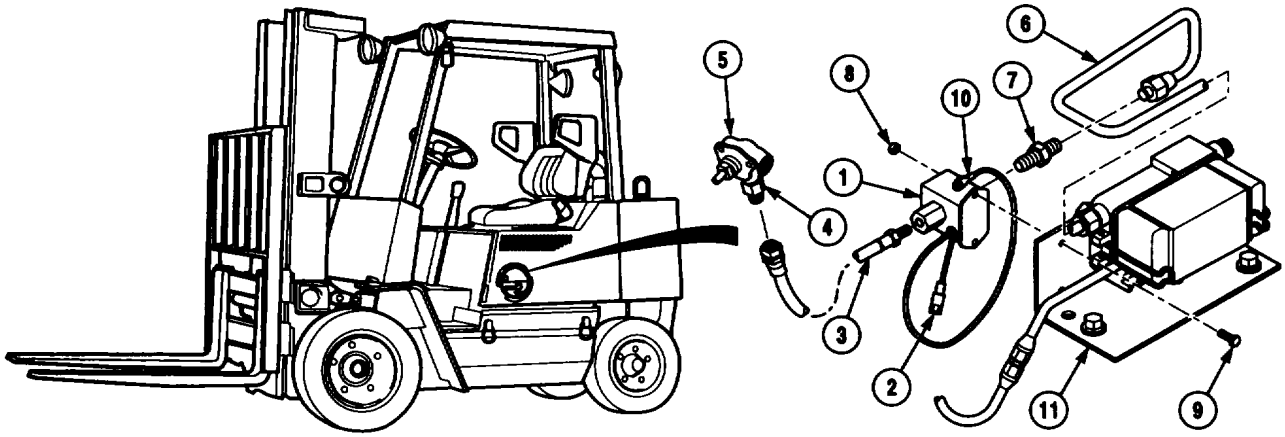
Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE
Prior to removal, position wiping rag under fuel supply pump to catch any spilled fuel.

(b) Remove fuel line (3) from center fitting (4) of fuel shutoff valve (5).

(c) Remove two fuel lines (3 and 6), and fitting (7) from fuel supply pump (1).

(d) Remove two nuts (8), screws (9), ground wire (10), and fuel supply pump (1) from bracket (11).



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE
Prior to installation, position wiping rag under fuel supply pump to catch any spilled fuel.

(3) To install fuel supply pump (1), proceed as follows:
  (a) Install fuel supply pump (1) and ground wire (10) on bracket (11) with two screws (9) and nuts (8). Tighten nuts 71-88 lb-in (8-10 N-m).

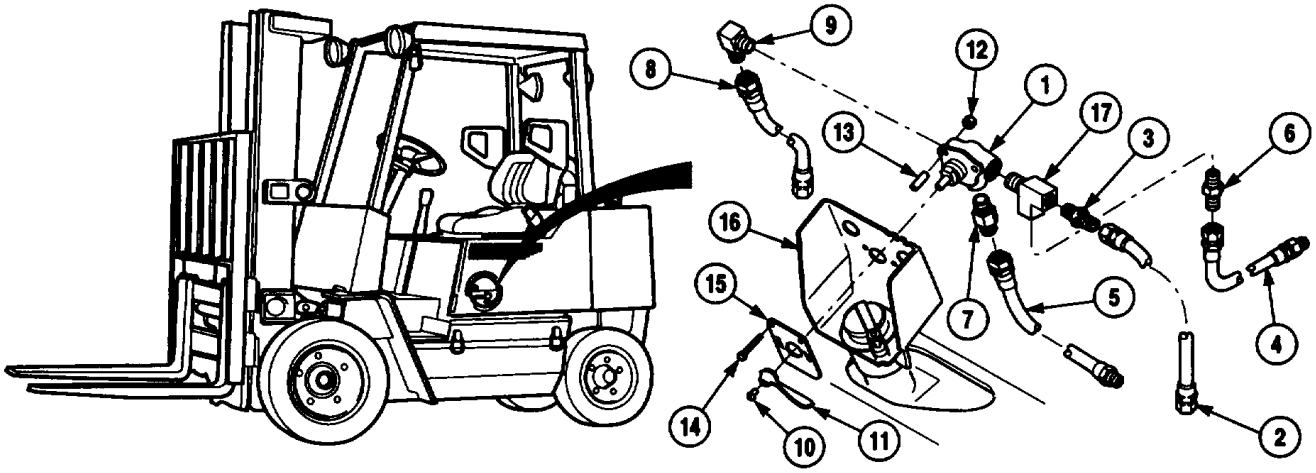
  (b) Install fitting (7) and two fuel lines (5 and 6) on fuel supply pump (1).

  (c) Install fuel line (3) on center fitting (4) of fuel shutoff valve (5).

  (d) Connect connector (4).

(4) Connect batteries (Para 3-25).

b. Fuel Shut-Off Valve Replacement.



(1) Disconnect batteries (Para 3-25).

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

- **Prior to removal, position wiping rag under fuel shutoff valve to catch any spilled fuel.**
- **Tag and mark all fittings and hoses prior to removal.**
- **Note position and alignment of all fittings and hoses prior to removal.**

(2) To remove fuel shutoff valve (1), proceed as follows:

(a) Remove fuel line (2) from fitting (3).

(b) Remove two fuel lines (4 and 5) from two fittings (6 and 7).

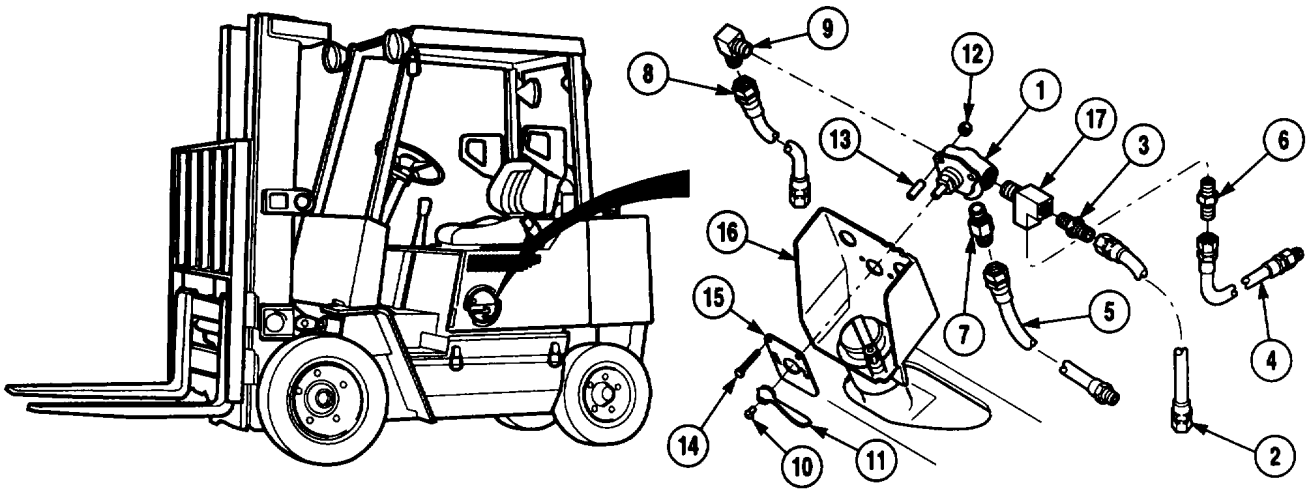
(c) Remove hose (8) from fitting (9).

(d) Remove screw (10) and handle (11) from fuel shutoff valve (1).

(e) Remove two nuts (12), fuel shutoff valve (1), two spacers (13), screws (14), and plate (15) from shield (16).

(f) Remove three fittings (3, 6, and 7) from fitting (17) and fuel shutoff valve (1).

(g) Remove fitting (17) and fitting (9) from fuel shutoff valve (1).



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

Prior to installation, position wiping rag under fuel shut off valve to catch any spilled fuel.

(3) To install fuel shutoff valve (1), proceed as follows:

(a) Apply sealant to threads of fitting (9) and fitting (17).

(b) Install fitting (9) and fitting (17) on fuel shutoff valve (1) as tagged during removal.

(c) Apply sealant to threads of three fittings (3, 6, and 7).

(d) Install two fittings (3 and 6) on fitting (17).

(e) Install fitting (7) on fuel shutoff valve (1).

(f) Install fuel shutoff valve (1) on shield (16) with two screws (14), plate (15), two spacers (13), and two nuts (12). Tighten screws 75-85 lb-in (8-10 Norm).

(g) Install handle (11) on fuel shutoff valve (1) with screw (10).

(h) Install fuel line (8) on fitting (9).

(i) Install two fuel lines (4 and 5) on two fittings (6 and 7).

(j) Install hose (2) on fitting (3).

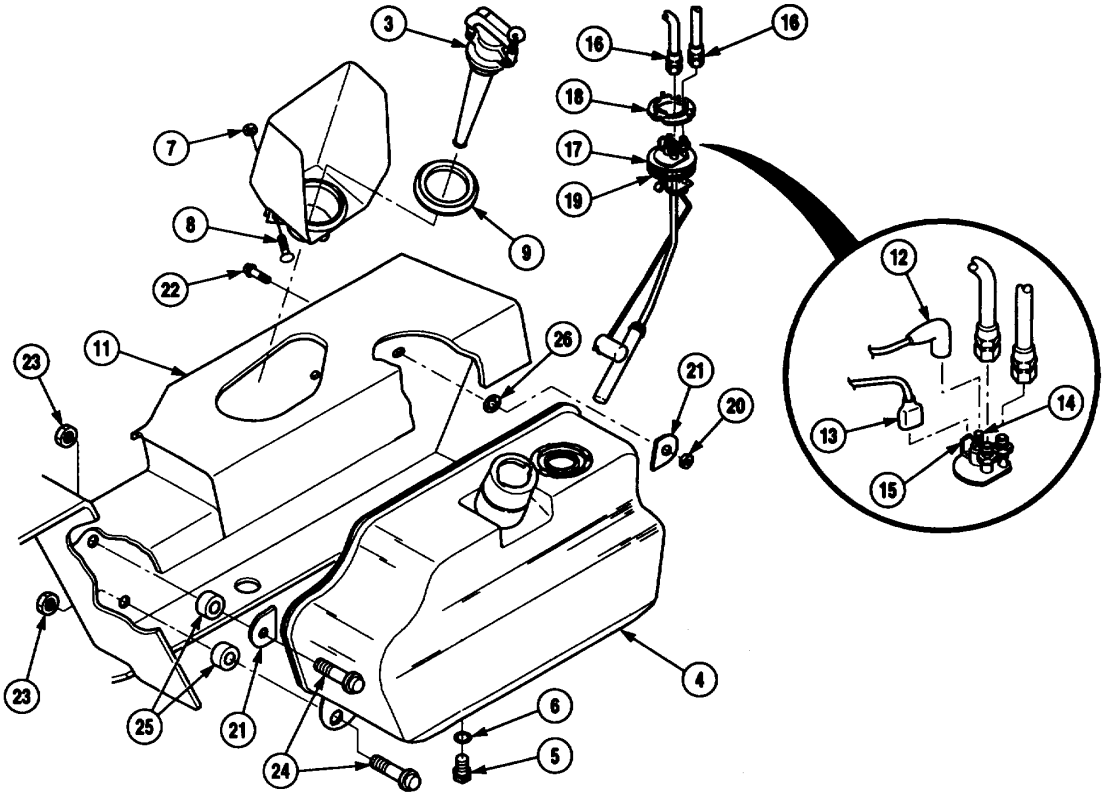
(4) Connect batteries (Para 3-25).

c. Fuel Tank Replacement

(1) Disconnect batteries (Para 3-25).

(2) To remove fuel tank, proceed as follows:

(a) Remove left-side plate [Para 3-36, Step (4)].



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(b) Rotate fuel cap (3) to the left and remove from fuel tank (2).

NOTE
Drain pan must have capacity to hold 8 gal (30 l).

(c) Position appropriate drain pan under fuel tank (2).

(d) Remove plug (3) and washer (4) from fuel tank (2) to drain all fuel from fuel tank.

(e) Remove nut (5), screw (6), seal (7), and shield (8) from fuel tank (2) filler and rest on frame (9). Discard seal.

NOTE
Tag and mark all wires prior to removal.

(f) Remove wires (10 and 11) from terminals (12 and 13).

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE
• Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.

• Tag and mark all fittings and hoses prior to removal.

• Note position and alignment of all fittings and hoses prior to removal.

(g) Remove two fuel lines (14) from fuel gauge sending unit (15).

(h) Remove retainer (16), fuel gauge sending unit (15), and seal (17) from fuel tank (2). Discard seal.

(i) Remove nut (18) and clip (19) from screw (20).

(l) Remove two nuts (21), screws (22), spacers (23), clip (19), and fuel tank (2) from frame (9).

(k) Remove fastener (24) and screw (20) from frame (9). Discard fastener.

(3) To install fuel tank, proceed as follows:

(a) Install screw (20) on frame (9) with fastener (24).

(b) Install fuel tank (2) on frame (9) with two screws (22), spacers (23), clip (19), and two nuts (21), and clip (19) and nut (18). Tighten two nuts (21) 400-440 lb-ft (542-596 N-m) and nut (18) 30-37 lb-ft (40-50 N-m).

(c) Install seal (17) and fuel gauge sending unit (15) on fuel tank (2) with retainer (16).

(d) Install two fuel lines (14) on fuel gauge sending unit (15).

(e) Install wires (10 and 11) on terminals (12 and 13) as tagged and marked during removal.

(f) Install shield (8) and seal (7) on fuel tank (2) filler with screw (6) and nut (5). Tighten nut 15-19 lb-ft (20-25 N-m).

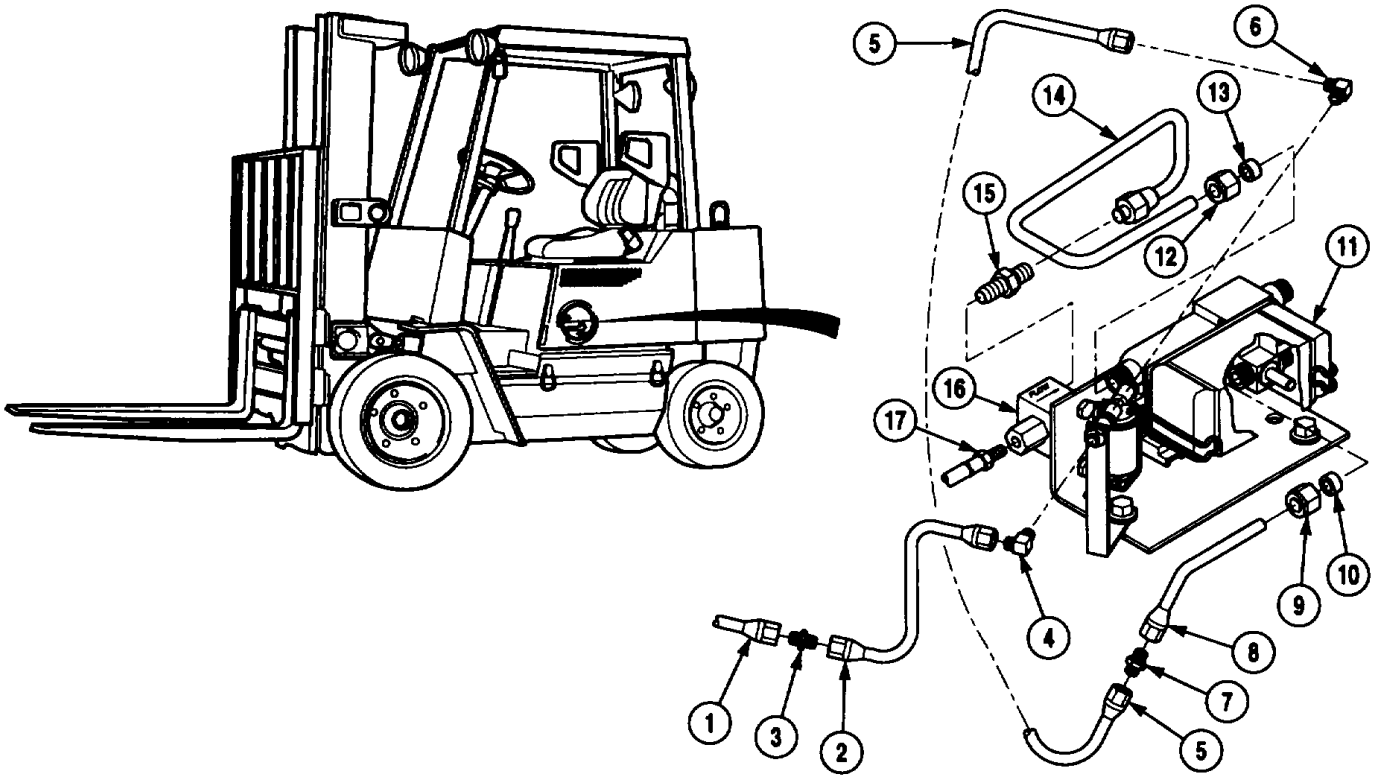
(g) Install washer (4) and plug (3) in bottom of fuel tank (2).

(h) Position fuel cap (1) on fuel tank (2) and turn to right to install.

(i) Install left-side plate [Para 3-36, Step (4)].

(4) Connect batteries (Para 3-25).

d. Fuel Line And Pipe Replacement.



(1) Disconnect batteries (Para 3-25).

(2) To remove fuel lines and pipe, proceed as follows:

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

- **Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.**
- **Tag and mark all fittings and hoses prior to removal.**
- **Note position and alignment of all fittings and hoses prior to removal.**

(a) Remove fuel pipe (1) and fuel line (2) from fitting (3).

(b) Remove fuel line (2) from fitting (4).

(c) Remove fuel line (5) from fittings (6 and 7).

(d) Remove fitting (7) from fuel pipe (8).

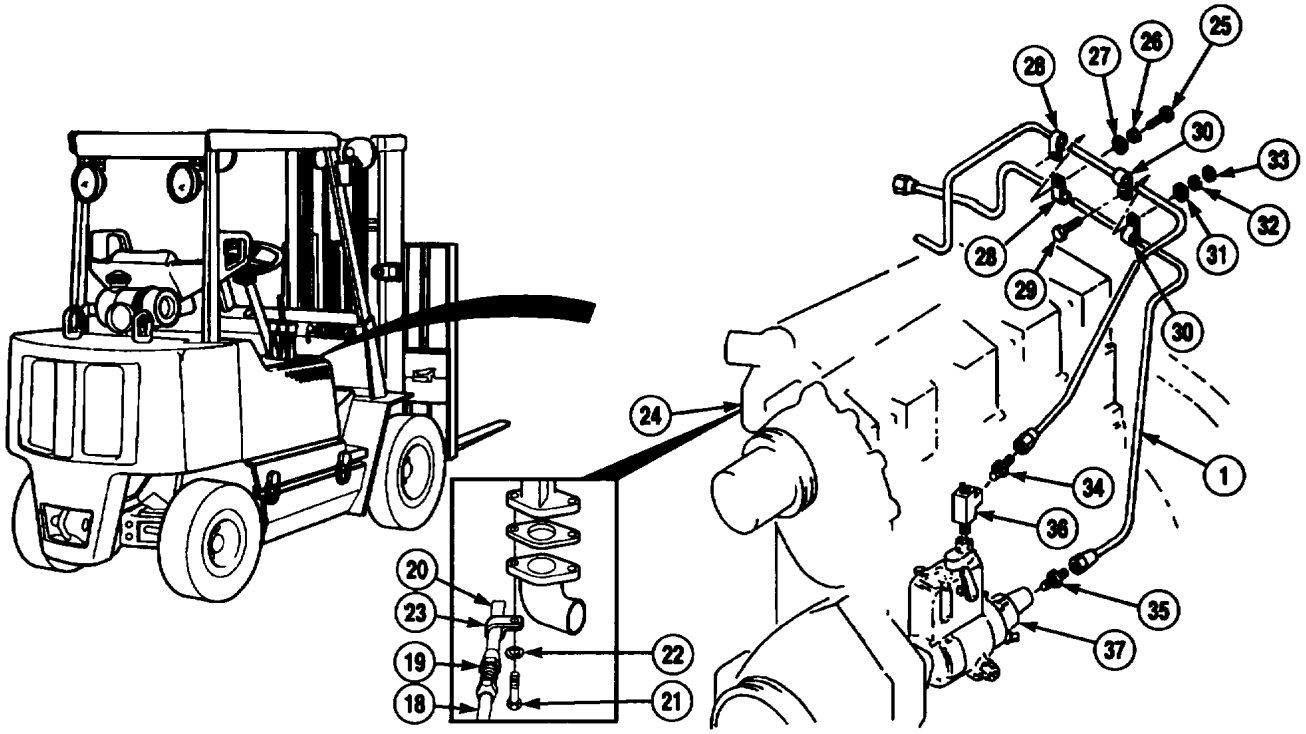
(e) Remove compression nut (9), seal (10), and fuel pipe (8) from filter housing (11). Discard seal.

(f) Remove compression nut (12), seal (13), and fuel pipe (14) from filter housing (11). Discard seal.

(g) Remove fuel pipe (14) from fitting (15).

(h) Remove fitting (15) from fuel pump (16).

(i) Remove fuel supply line (17) from fuel pump (16) and fuel shutoff valve (Para 3-17b).



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

- **Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.**
- **Tag and mark all fittings and hoses prior to removal.**
- **Note position and alignment of all fittings and hoses prior to removal.**

(j) Remove fuel line (18) from fitting (19) and fuel shutoff valve (Para 3-17b).

(k) Remove fitting (19) from fuel pipe (20).

(l) Remove screw (21), lockwasher (22) and clip (23) from fuel pipe (20) and engine (24). Discard lockwasher.

(m) Remove screw (25), lockwasher (26), washer (27), and two clips (28) from fuel pipe (1 and 20) and engine (24). Discard lockwasher.

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(n) Remove screw (29), two clips (30), washer (31), lockwasher (32), and nut (33) from fuel pipes (1 and 20). Discard lockwasher.

(o) Remove two fuel pipes (1 and 20) from two fittings (34 and 35).

(p) Remove two fittings (1) and 35) from fitting (36) and fuel injector pump (37).

(3) To install fuel lines and pipe, proceed as follows:

(a) Install two fittings (34 and 35) on fitting (36) and fuel injector pump (37) as noted during removal.

(b) Install two fuel pipes (1 and 20) on two fittings (34 and 35) as tagged and marked during removal.

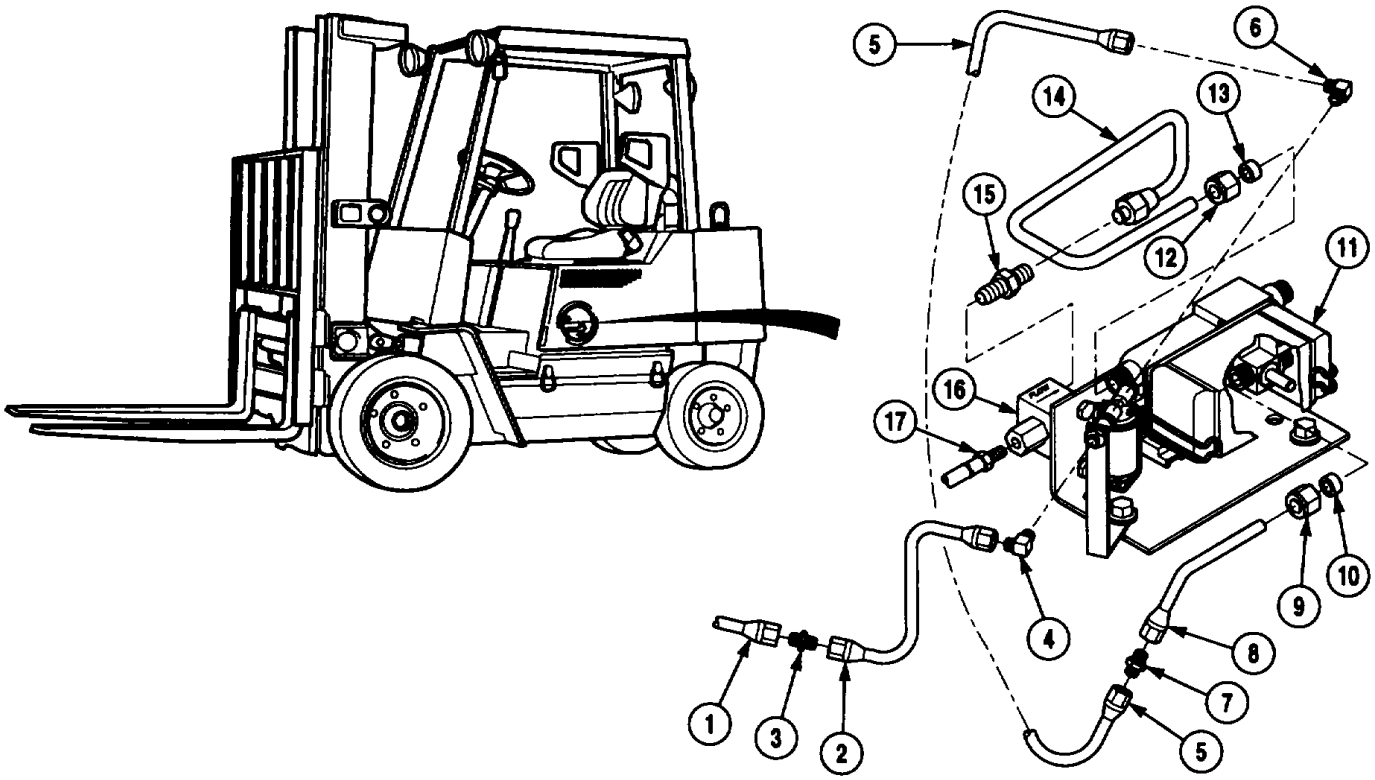
(c) Install two clips (30) on fuel pipes (1 and 20) with screw (29), washer (31), lockwasher (32), and nut (33). Tighten screw 8 Ib-ft (11 N-m).

(d) Install two fuel pipes (1) and (20) on engine (24) with two clips (28), washer (27), lockwasher (26), and screw (25). Tighten screw 8 Ib-ft (11 N-m).

(e) Install clip (23) on fuel pipe (20) and engine (24) with lockwasher (22) with screw (21). Tighten screw 8 Ib-ft (11 Nom).

(f) Install fitting (19) on fuel pipe (20).

(g) Install fuel line (18) on fitting (19) and fuel shutoff valve (Para 3-17b).



(h) Install fuel supply line (17) on fuel pump (16) and fuel shutoff valve (Para 3-17b).

(i) Install fitting (15) on fuel pump (16).

(j) Install fuel pipe (14) on fitting (15).

(k) Install fuel pipe (14) on filter housing (11) with seal (10) and compression nut (12).

(l) Install fuel pipe (8) on filter housing (11) with compression nut (9) and seal (10).

(m) Install fitting (7) on fuel pipe (8).

(n) Install fuel line (5) on fittings (6 and 7).

WARNING

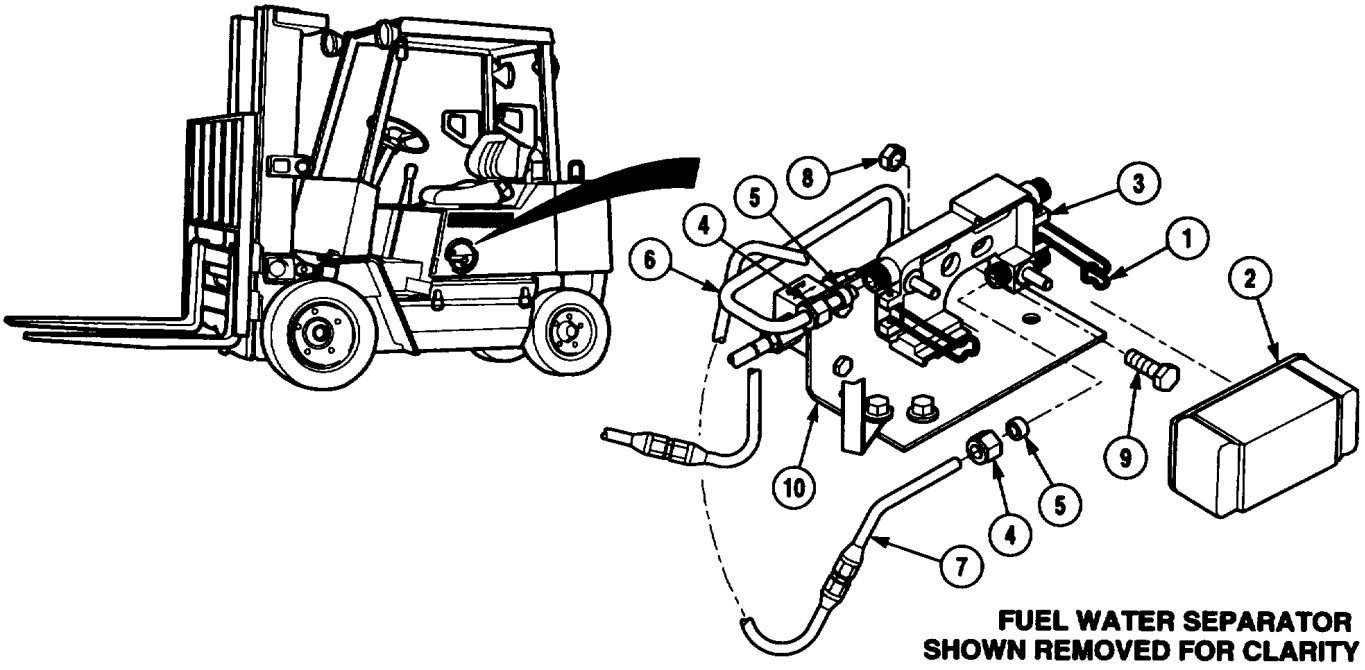
Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(o) Install fuel line (2) on fitting (4).

(p) Install fitting (3) on fuel pipe (1) and fuel line (2).

(4) Connect batteries (Para 3-25).

e. Fuel Filter Unit Replacement.



(1) To remove fuel filter unit, proceed as follows:

(a) Disconnect batteries (Para 3-25).

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

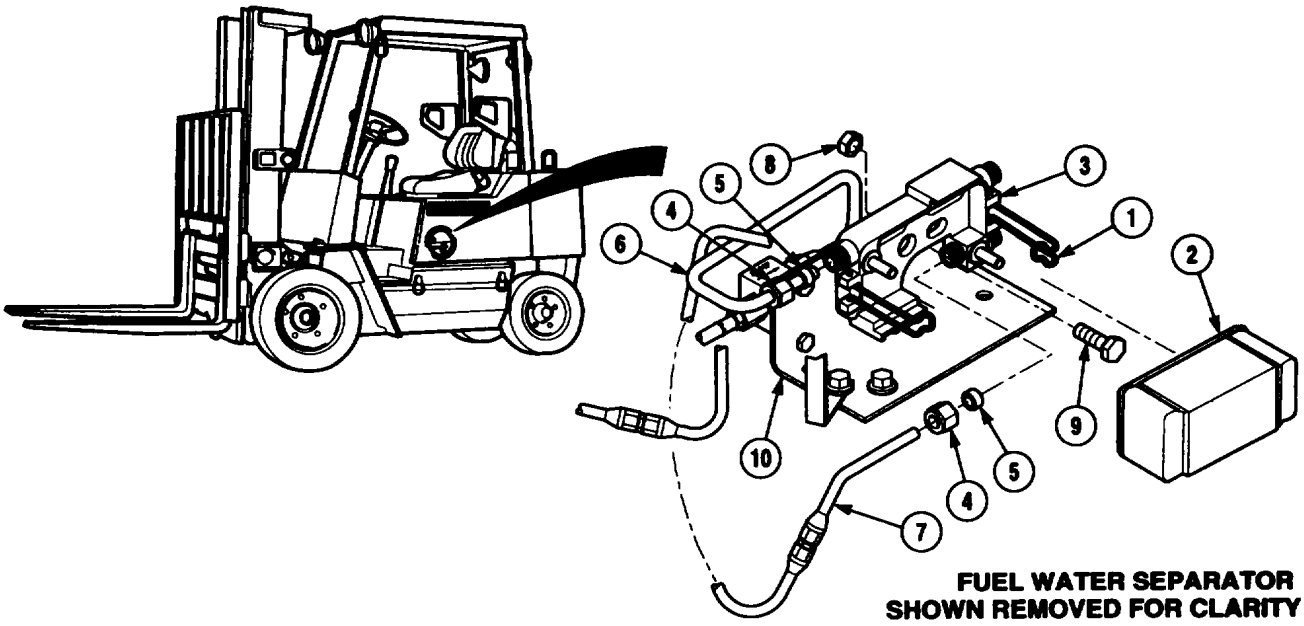
NOTE

- **Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.**
- **Tag and mark all fittings and hoses prior to removal.**
- **Note position and alignment of all fittings prior to removal.**

(b) Move two fasteners (1) outward and remove fuel filter (2) from fuel filter base (3). Discard filter.

(c) Remove two compression fittings (4) and seals (5) of fuel pipes (6 and 7) from fuel filter base (3). Discard seals.

(d) Remove two nuts (8), screws (9), and fuel filter base (3) from bracket (10).



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(2) To install fuel filter unit, proceed as follows:

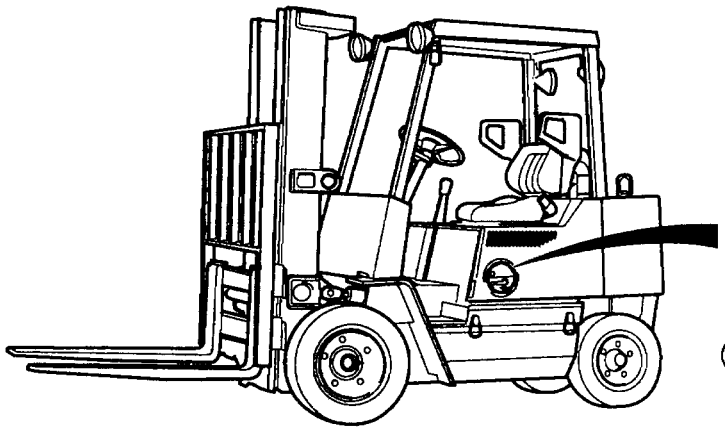
(a) Install fuel filter base (3) on bracket (10) with two screws (9) and nuts (8). Tighten nuts 30-33 lb-ft (40-50 N-m).

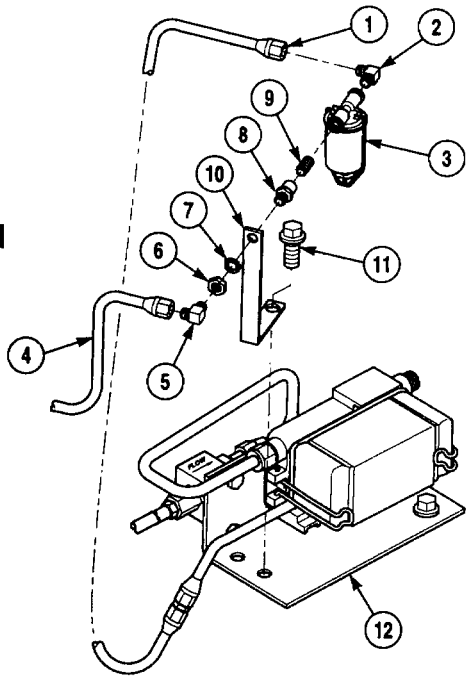
(b) Install fuel pipes (6 and 7) on fuel filter base (3) as noted during removal with two compression fittings (4) and seals (5). Tighten compression fittings 179-190 lb-in (19-21 N-m).

(c) Install fuel filter (2) on fuel filter base (3) with two fasteners (1).

(d) Connect batteries (Para 3-25).

f. Fuel Water Separator Assembly Replacement.





(1) To remove fuel water separator assembly, proceed as follows:

(a) Disconnect batteries (Para 3-25).

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

- **Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.**
- **Tag and mark all fittings and hoses prior to removal.**
- **Note position and alignment of all fittings prior to removal.**

(b) Remove fuel line (1) from fitting (2).

(c) Remove fitting (2) from fuel water separator body (3).

(d) Remove fuel line (4) from fitting (5).

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(e) Remove nut (6) and washer (7) from fitting (8).

(f) Remove fitting (8) and pipe (9) from fuel water separator body (3) and bracket (10).

(g) Remove screw (11) and bracket (10) from bracket (12).

(2) To install fuel water separator assembly, proceed as follows:

(a) Install bracket (10) on bracket (12) with screw (11). Tighten screw 42-48 lb-ft (57-65 N•m).

(b) Apply sealing compound to threads of pipe (9).

(c) Install pipe (9) and fitting (8) in fuel water separator body (3).

(d) Install fitting (8) in bracket (10) with washer (7) and nut (6).

(e) Apply sealing compound to threads of fittings (2 and 5).

(f) Install fitting (5) in fitting (8).

(g) Install fitting (2) in fuel water separator body (3).

(h) Install fuel line (4) on fitting (5).

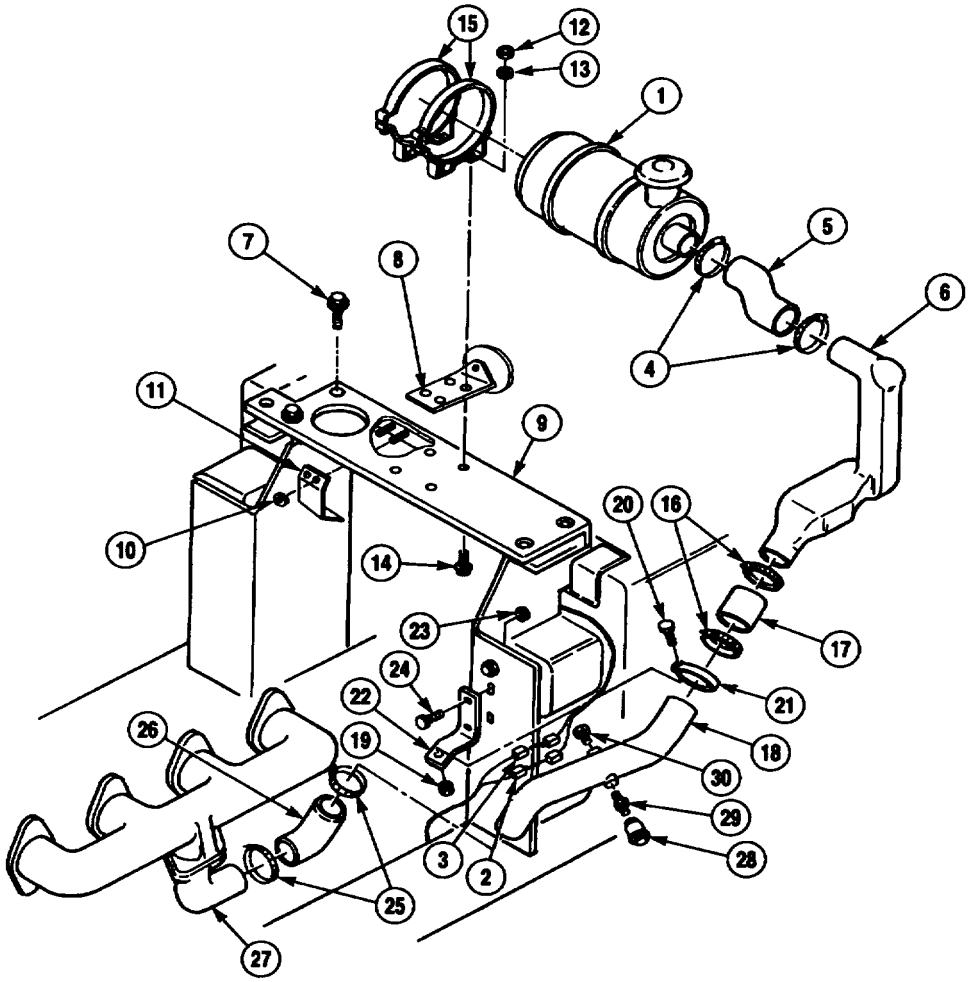
(i) Install fuel line (1) on fitting (2).

(j) Connect batteries (Para 3-25).

END OF TASK

3-18. AIR INTAKE SYSTEM REPLACEMENT.

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) To remove air cleaner assembly (1), proceed as follows:

(a) Disconnect two wires (2) and (3).

(b) Remove two clamps (4) and intake hose (5) from air cleaner assembly (1) and air duct (6).

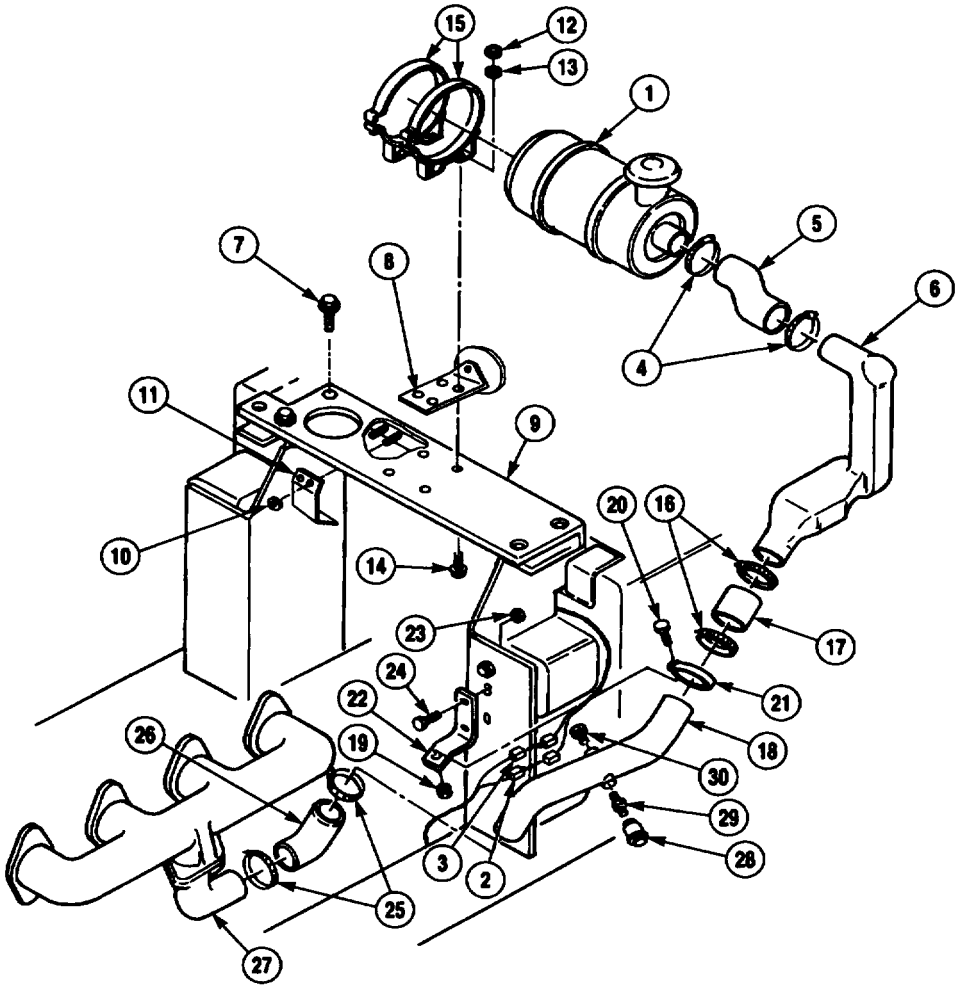
(c) Remove two nuts, clamp, and bracket from muffler [Para 3-19a, Step (3)].

(d) Remove four screws (7), air cleaner assembly (1), bracket (8), and cover plate (9).

(e) Remove two nuts (10) and bracket (11) from cover plate (9).

(f) Remove four nuts (12), washers (13), screws (14), bracket (8), and air cleaner assembly (1) from cover plate (9).

(g) If necessary, loosen and remove two clamps (15) from air cleaner assembly (1).



(g) Loosen two clamps (16) and remove air duct (6) from hose (17).

(h) Remove hose (17) and two clamps (16) from intake tube (18).

(i) Remove nut (19), screw (20), and clamp (21) from intake tube (18) and bracket (22).

(j) Remove two nuts (23), screws (24), and bracket (22).

(k) Loosen two clamps (25) and remove intake tube (18) from air cleaner elbow (26).

(l) Remove air cleaner elbow (26) and two clamps (25) from engine air intake adaptor (27).

(m) Remove air restriction indicator (28) and fitting (29) from intake tube (18).

(n) Remove plug (30) from intake tube (18).

b. Installation.

(1) To install air cleaner assembly (1), proceed as follows:

(a) Apply sealing compound to plug (30).

(b) Install plug (30) on intake tube (18). Tighten 135-145 lb-in (15-16 N•m).

(c) Apply sealing compound to both ends of fitting (29).

(d) Install air restriction indicator (28) on intake tube (18) with fitting (29).

(e) Position air cleaner elbow (26) on engine air intake adaptor (27).

(f) Install intake tube (18) and two clamps (25) on air cleaner elbow (26).

(g) Install bracket (22) with two screws (24) and nuts (23). Tighten 177-221 lb-in (20-25 N•m).

(h) Install clamp (21) on intake tube (18) and bracket (22) with screw (20) and nut (19). Tighten 71-88 lb-in (8-10 N•m).

(i) Install hose (17) on intake tube (18) with clamp (16).

(j) Install air duct (6) on hose (17) with clamp (16).

NOTE

If clamps were removed during removal, perform Step (k). If clamps were not removed, proceed to Step (l).

(k) Install two clamps (15) on air cleaner assembly (1).

(l) Install air cleaner assembly (1) and bracket (8) on cover plate (9) with four screws (14), washers (13), and nuts (12). Tighten 177-221 lb-in (20-25 N•m).

(m) Install bracket (11) on cover plate (9) with two nuts (10). Tighten 168-216 lb-in (19-23 N•m).

(n) Install cover plate (9), bracket (8), and air cleaner assembly (1) with four screws (7). Tighten 30-35 lb-ft (40-50 N•m).

(o) Install bracket and clamp with two nuts on muffler [Para 3-19b, Step (3)].

(p) Install intake hose (5) on air cleaner assembly (1) and air duct (6) with two clamps (4).

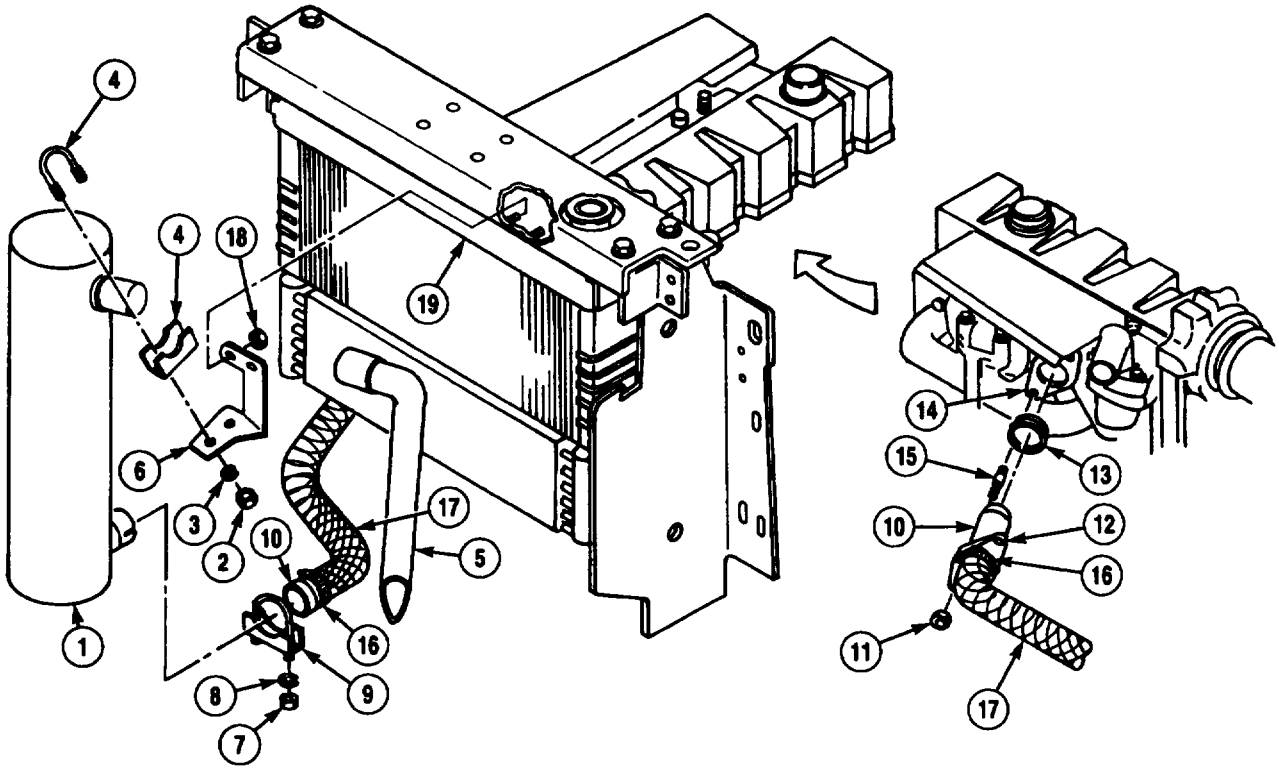
(q) Connect two wires (2) and (3).

(2) Connect batteries (Para 3-25).

END OF TASK

3-19. EXHAUST SYSTEM REPLACEMENT

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) Remove counterweight (Appendix F, Counterweight Maintenance, Section 12.1).

(3) To remove muffler (1), proceed as follows:

NOTE

It may be necessary to tap on muffler to remove exhaust pipe.

(a) Remove two nuts (2), lockwashers (3), u-bolt clamp (4), and exhaust pipe (5) from muffler (1) and bracket (6). Discard lockwashers.

(b) Remove two nuts (7), lockwashers (8), u-bolt clamp (9), and muffler (1) from exhaust pipe (10). Discard lockwashers.

(4) To remove exhaust pipe (10), proceed as follows:

(a) Remove two nuts (11), flange (12), exhaust pipe (10), and exhaust gasket (13) from manifold (14).

(b) f necessary, remove two screws (15) from manifold (14).

(c) Remove two clamps (16) and heat insulator (17) from exhaust pipe (10).

(5) Remove two nuts (18) and bracket (6) from radiator cover (19).

b. Installation.

(1) Install bracket (6) on radiator cover (19) with two nuts (18). Tighten nuts to 168-216 lb-in (19-23 N•m).

(2) To install exhaust pipe (10), proceed as follows:

(a) Install heat insulator (17) on exhaust pipe (10) with two clamps (16).

NOTE

If screws were removed during Removal step [4(b)], perform step (b). If not, proceed to step (c).

(b) Install two screws (15) in manifold (14).

(c) Install exhaust gasket (13), exhaust pipe (10), and flange (12) on manifold (14) with two nuts (11). Tighten nuts 30-35 lb-ft (40-50 N•m).

(3) To install muffler (1), proceed as follows:

(a) Install muffler (1) on exhaust pipe (10) with u-bolt clamp (9), two lockwashers (8), and nuts (7). Tighten nuts to 168-216 lb-in (19-23 N•m).

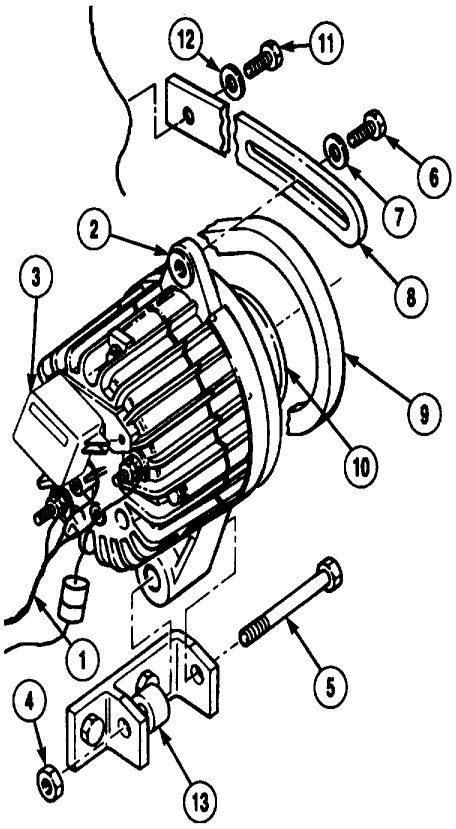
(b) Install exhaust pipe (5) on muffler (1) and bracket (6) with u-bolt clamp (4), two lockwashers (3), and nuts (2). Tighten nuts to 168-216 lb-in (19-23 N•m).

(4) Install counterweight (Appendix F, Counterweight Maintenance, Section 12.1).

(5) Connect batteries (Para 3-25).

END OF TASK

3-20. ALTERNATOR REPLACEMENT



a. Removal.

(1) Disconnect batteries (Para 3-25).

(2) Remove intake tube (Para 3-18a, Steps (2)[h] - (2)[k]).

(3) Remove wiring harness (1) from alternator (2) and regulator (3) [Para 3-21, Steps (4) and (5)].

(4) Loosen nut (4) and screw (5).

(5) Remove screw (6) and washer (7) from alternator (2) and bracket (8).

(6) Remove drive belt (9) from pulley (10).

(7) Remove screw (11), lockwasher (12), and bracket (8). Discard lockwasher.

(8) Remove nut (4), screw (5), spacer (13), and alternator (2).

(9) Remove regulator (3) from alternator (2) [Para 3-21a, Steps (4) - (10)].

b. Installation.

(1) Install regulator (3) on alternator (2) [Para 3-21 b, Steps (1) - (8)].

(2) Install alternator (2) with screw (5), spacer (13), and nut (4). Do not tighten nut.

(3) Install bracket (8) with lockwasher (12) and screw (11).

(4) Install bracket (8) on alternator (2) with screw (6) and washer (7). Do not tighten screw.

(5) Install drive belt (9) on pulley (10).

(6) Position alternator (2) so that deflection on drive belt (9) is not more than .20 in (5.2 mm) or tension is 2.5-3.2 lb-ft (11.1-14.2 N•m). Tighten screw (6).

(7) Tighten nut (4) and screw (5).

(8) Connect wiring harness (1) to alternator (2) and regulator (3) [Para 3-21 b, Steps (7) and (8)].

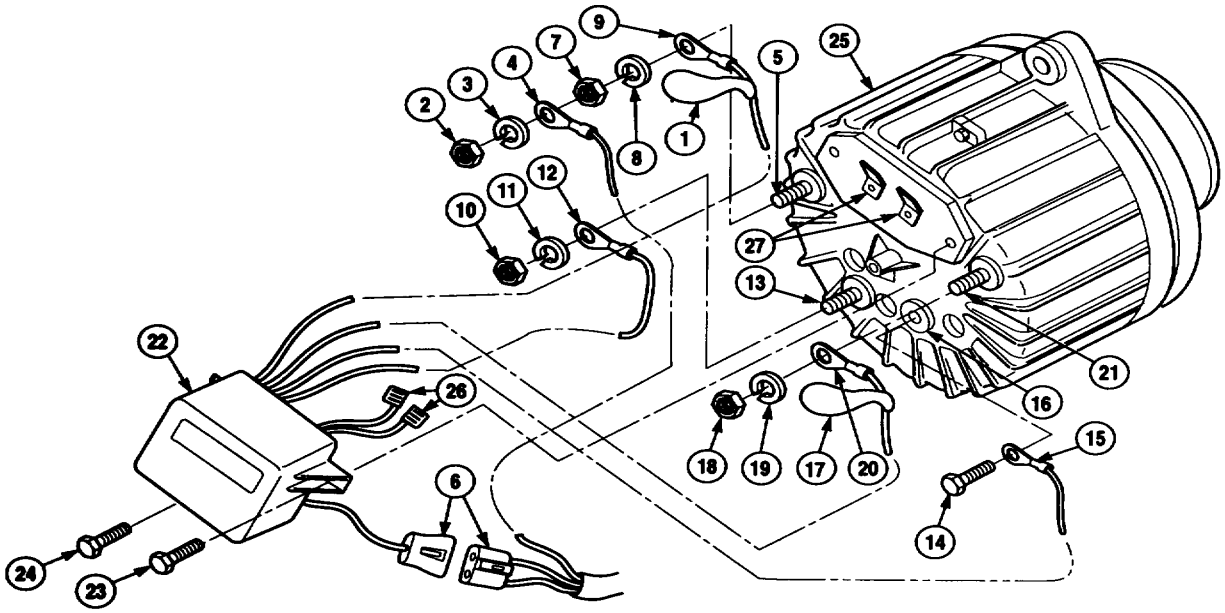
(9) Install intake tube (3-18b, Steps (1)[f] - (1)[i]).

(10) Connect batteries (Para 3-25).

END OF TASK

3-21. REGULATOR REPLACEMENT.

a. Removal



(1) Disconnect batteries (Para 3-25).

NOTE

Tag and mark all wires prior to removal.

(2) Remove intake tube (Para 3-18a, Steps (2)[h] - (2)[k]).

(3) Folding back the terminal cover (1), remove nut (2), lockwasher (3), and harness wire (4) from terminal (5). Discard lockwasher.

(4) Disconnect connector (6).

(5) Remove nut (7), lockwasher (8), and wire (9) from terminal (5). Discard lockwasher.

(6) Remove nut (10), lockwasher (11), and wire (12) from terminal (13). Discard lockwasher.

(7) Remove screw (14) and wire (15) from terminal (16).

(8) Folding back terminal cover (17), remove nut (18), lockwasher (19), and wire (20) from terminal (21). Discard lockwasher.

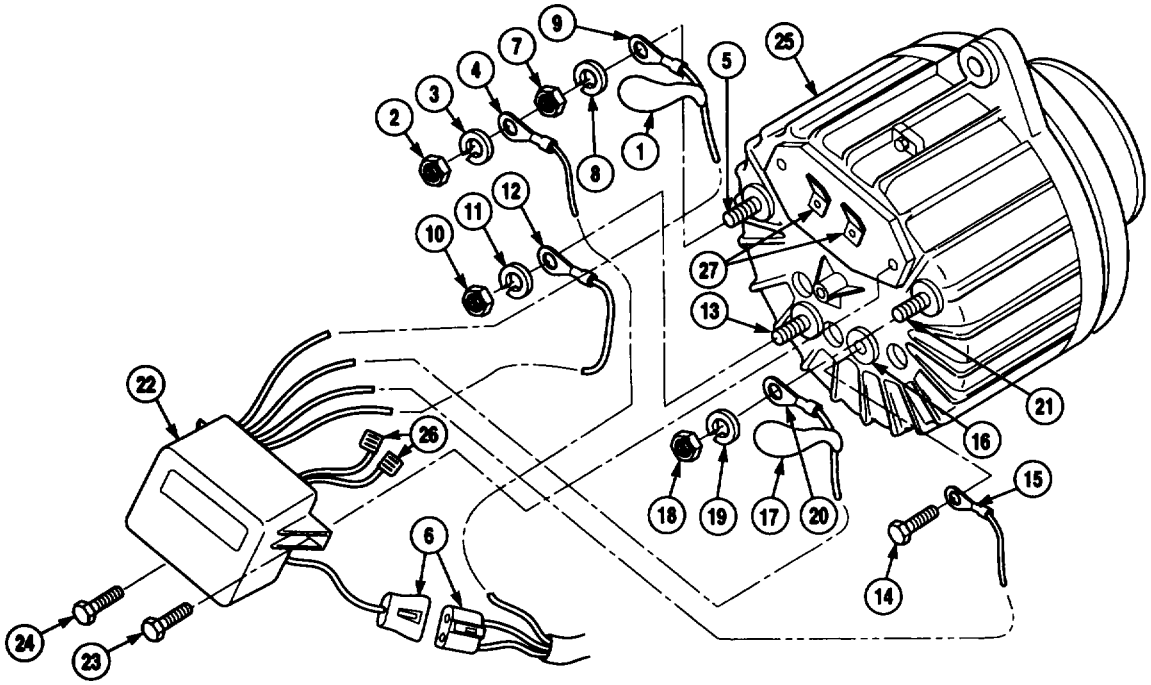
NOTE

Support weight of regulator while removing screws until access can be gained to the wires behind the regulator.

(9) Supporting regulator (22), remove two screws (23), screw (24), and regulator from alternator (25).

(10) Disconnect two connectors (26) from two terminals (27).

b. Installation.



NOTE

Connect all connectors as tagged and marked during Removal.

(1) Connect two connectors (26) to two terminals (27).

(2) Install regulator (22) on alternator (25) with screw (24) and two screws (23).

(3) Folding back terminal cover (17), install wire (20) on terminal (21) with lockwasher (19) and nut (18). Tighten nut.

(4) Install wire (15) on terminal (16) with screw (14).

(5) Install wire (12) on terminal (13) with lockwasher (11) and nut (10). Tighten nut.

(6) Install wire (9) on terminal (5) with lockwasher (8) and nut (7). Tighten nut.

(7) Connect connector (6).

(8) Folding back terminal cover (1), install harness wire (4) on terminal (5) with lockwasher (3) and nut (2).

(9) Install intake tube (Para 3-18b, Step (1)[f] - (1)[i]).

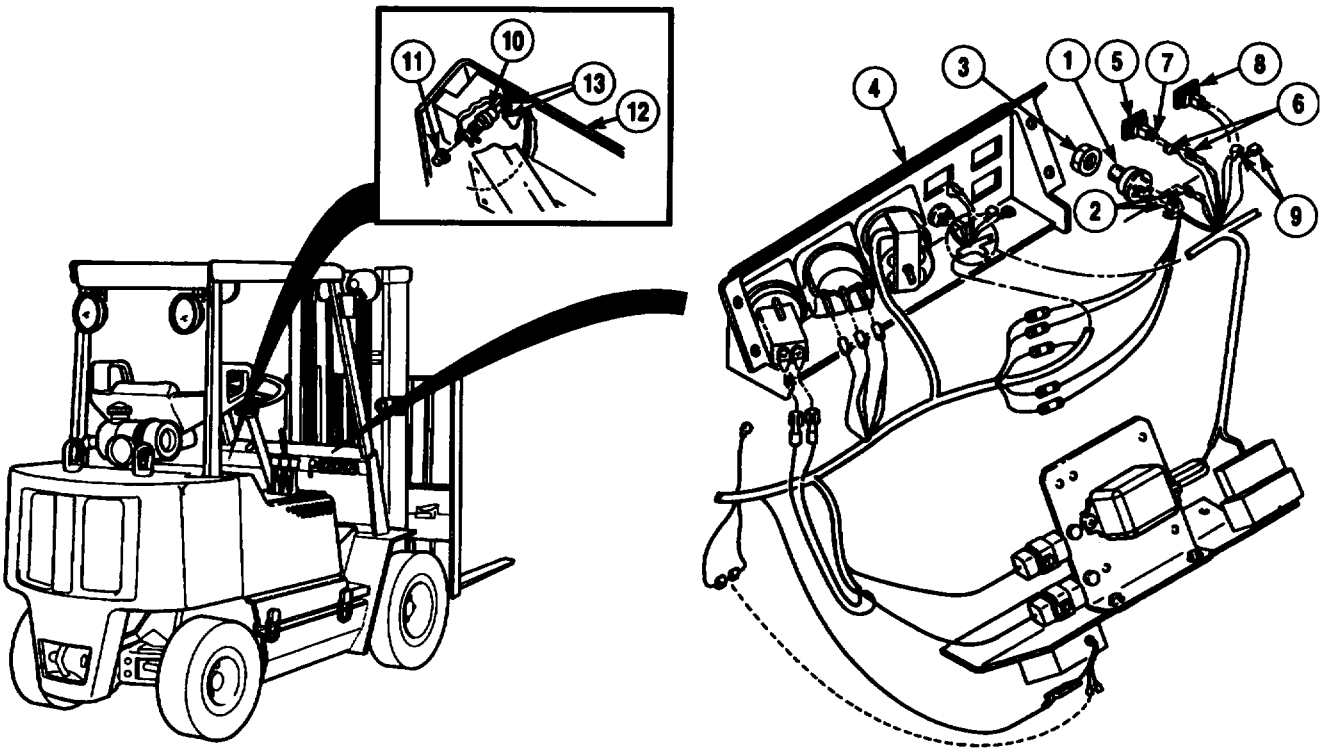
(10) Connect batteries (Para 3-25).

END OF TASK

3-22. ELECTRICAL COMPONENT REPLACEMENT.

a. Switch Replacement.

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove instrument panel (Para 3-36).

NOTE

Tag and mark all wires prior to removal.

(c) To remove ignition switch (1), proceed as follows:

1 Remove two wire connectors (2) from ignition switch (1).

2 Remove nut (3) and ignition switch (1) from instrument panel (4).

(d) To remove Fasten Seatbelt light (5), proceed as follows:

1 Remove two wires (6) from light terminals (7).

2 Remove Fasten Seatbelt light (5) from instrument panel (4).

NOTE

Tag and mark all wires prior to removal.

(e) To remove two light switches (8), proceed as follows:

NOTE

The procedure to remove light switches is the same for both light switches.

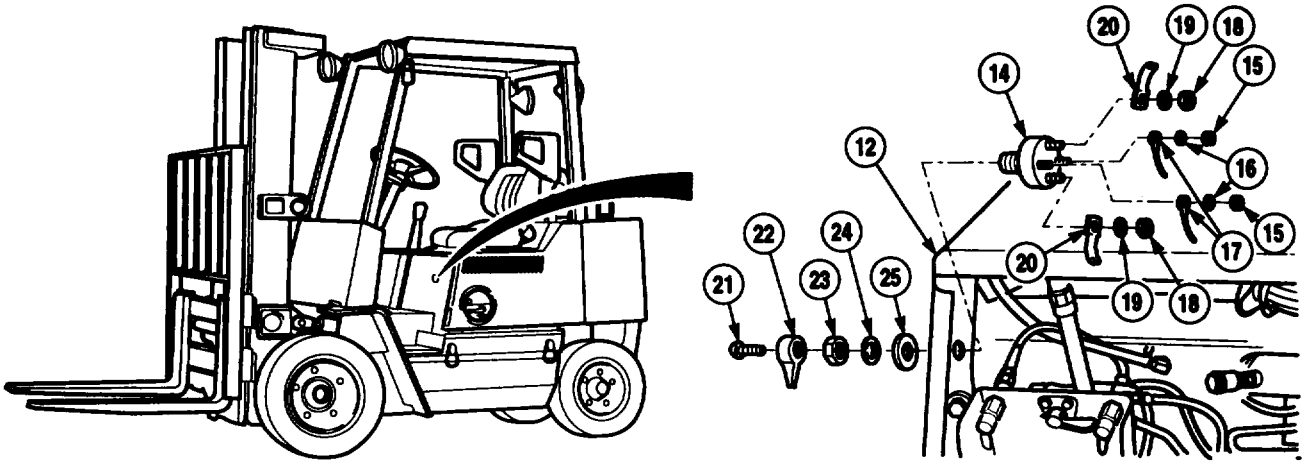
1 Remove two wires (9) from light switch (8).

2 Remove light switch (8) from instrument panel (4).

(f) To remove glow plug switch (10), proceed as follows:

1 Remove button (11) and glow plug switch (10) from forklift (12).

2 Remove two wires (13) from glow plug switch (10).



(g) To remove master power switch (14), proceed as follows:

1 Remove two nuts (15), lockwashers (16), and wires (17) from master power switch (14). Discard lockwashers.

2 Remove two nuts (18), lockwashers (19), and wires (20) from master power switch (14). Discard lockwashers.

3 Remove screw (21), lever (22), nut (23), lockwasher (24), switchplate (25), and master power switch (14) from forklift (12). Discard lockwasher.

(2) Installation.

NOTE

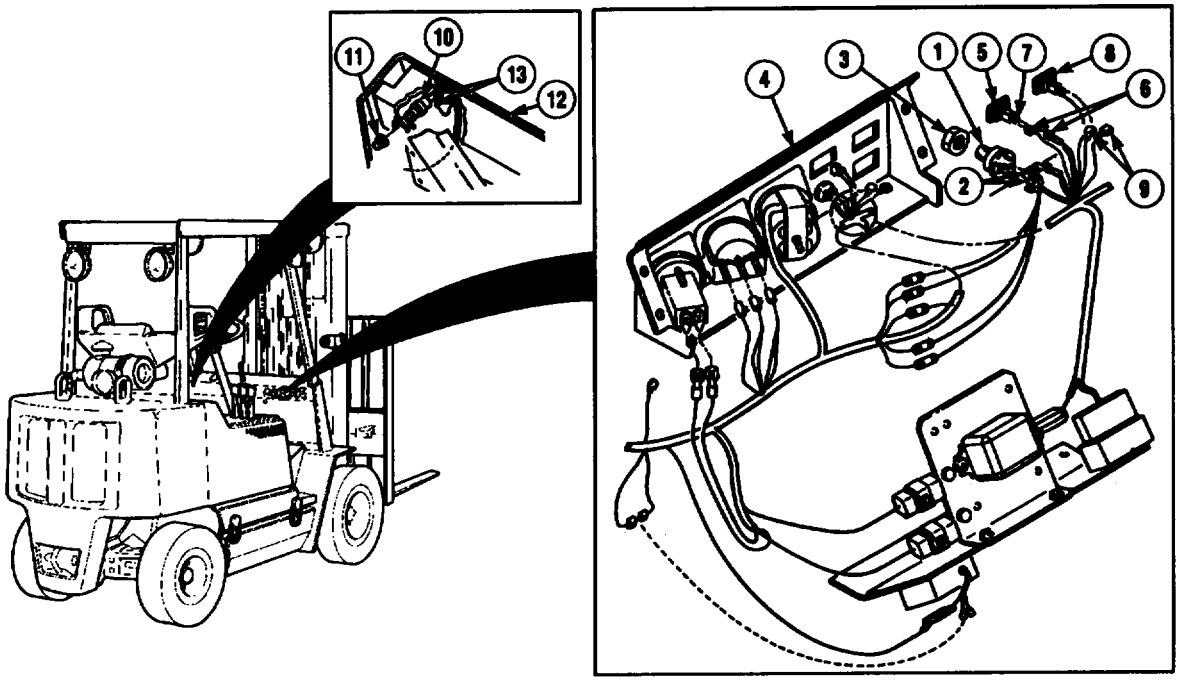
Install all wires on switches as tagged and marked prior to removal.

(a) To install master power switch (14), proceed as follows:

1 Install master power switch (14) on forklift (12) with switchplate (25), lockwasher (24), nut (23), lever (22), and screw (21). Tighten nuts securely.

2 Install two wires (20) on master power switch (14) with two lockwashers (19) and nuts (18).

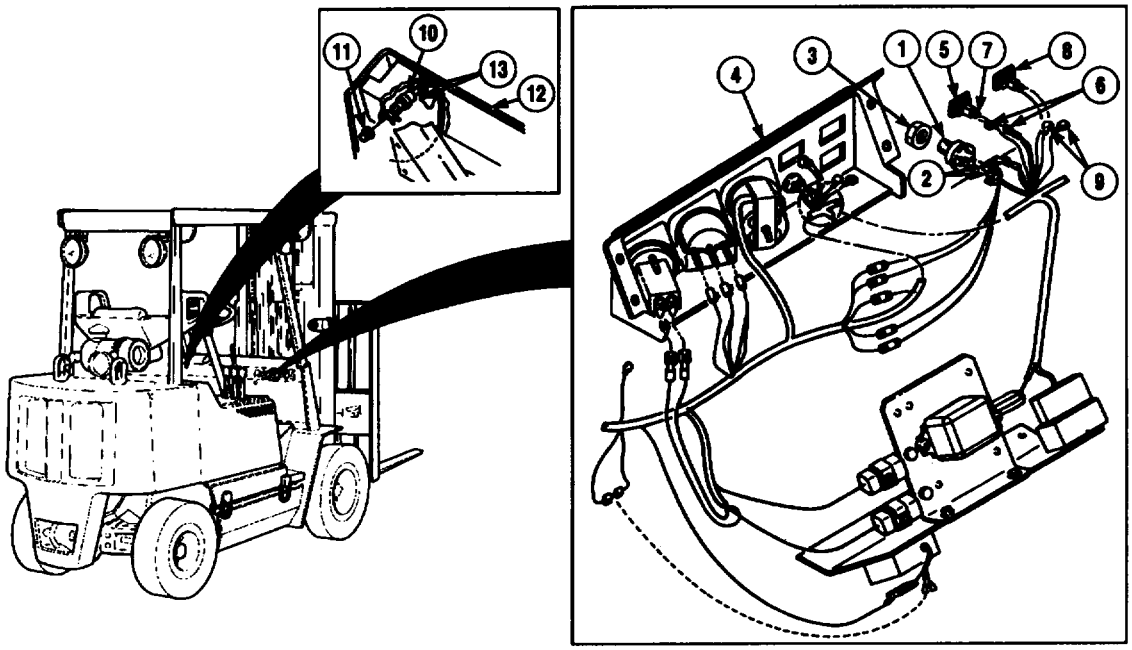
3 Install two wires (17) on master power switch (14) with two lockwashers (16) and nuts (15).



(b) To install glow plug switch (10), proceed as follows:

1 Install two wires (13) on glow plug switch (10).

2 Install glow plug switch (10) in forklift (12) with button (11). Tighten button securely.



(c) To install two light switches (8), proceed as follows:

NOTE
The procedure to install light switches is the same for both light switches.

1 Install light switch (8) in instrument panel (4).

2 Install two wires (9) in light switch (8).

(d) To install Fasten Seatbelt light (5), proceed as follows:

1 Install Fasten Seatbelt light (5) in instrument panel (4).

2 Install two wires (6) on light terminals (7).

(e) To install ignition switch (1), proceed as follows:

1 Install ignition switch (1) in instrument panel (4) with nut (3).

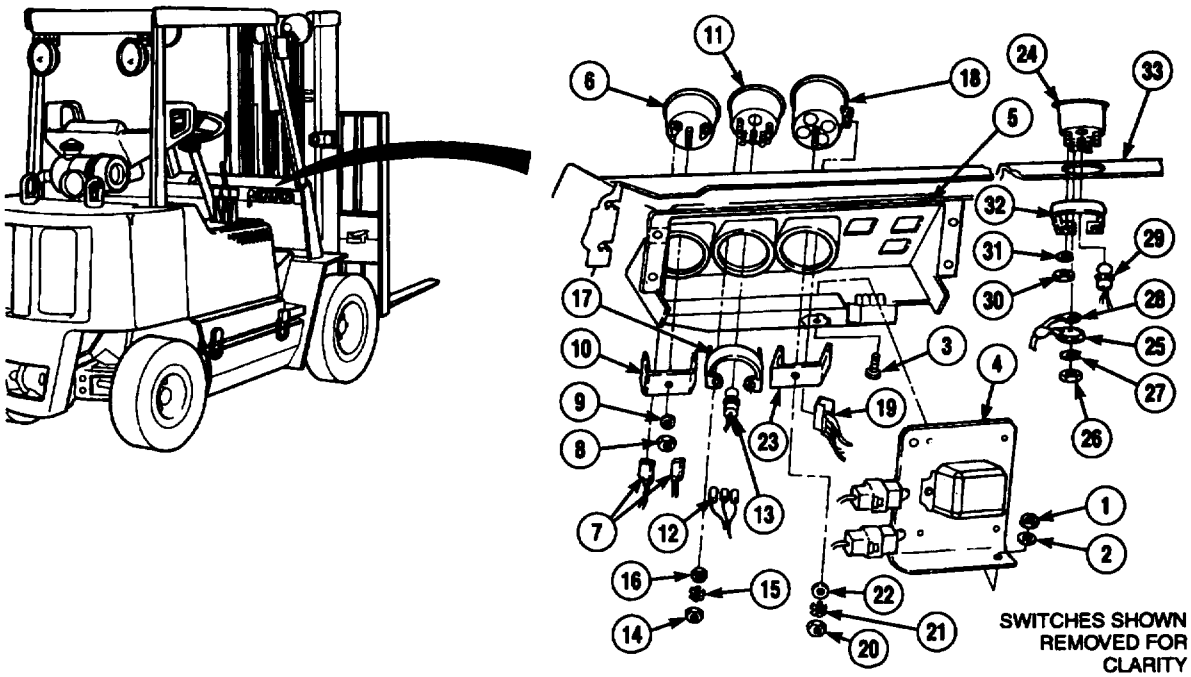
2 Install two wire connectors (2) on ignition switch (1).

(f) Install instrument panel (Para 3-36).

(g) Connect batteries (Para 3-25).

b. Gauge Replacement.

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove instrument panel (Para 3-36).

(c) Remove two nuts (1), washers (2), screws (3), and plate (4) from instrument panel (5).

NOTE

Tag and mark all wires prior to removal.

(d) To remove engine hour meter (6), proceed as follows:

1 Remove two wires (7) from engine hour meter (6).

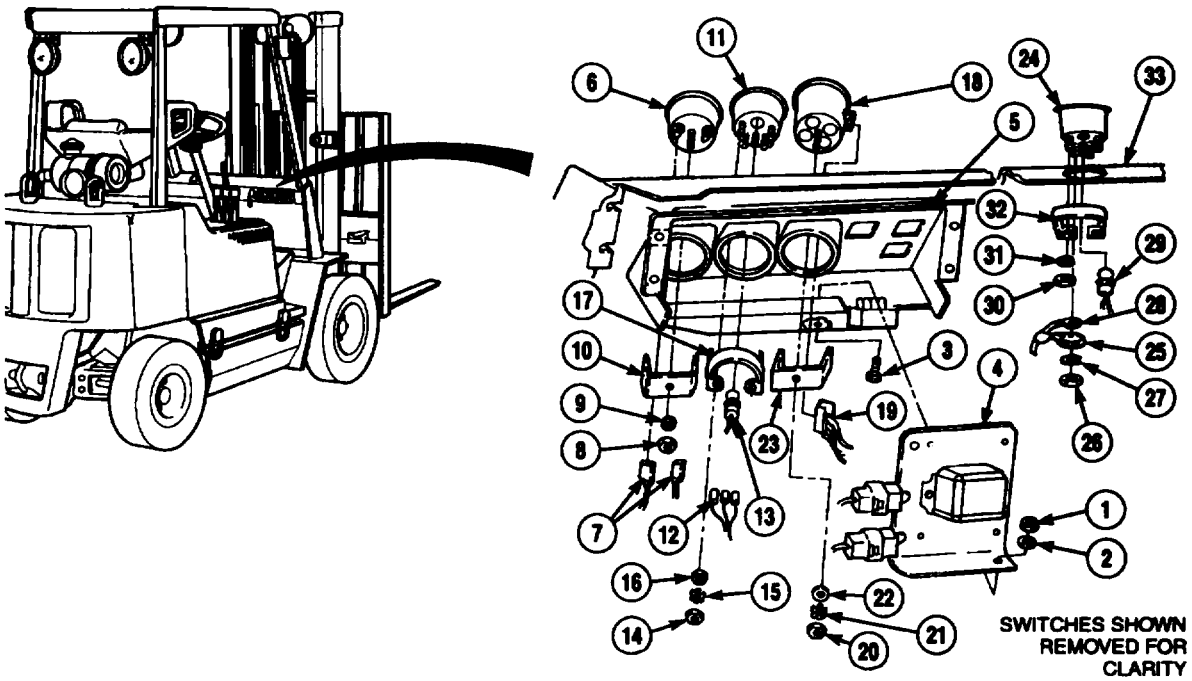
2 Remove nut (8), washer (9), bracket (10), and engine hour meter (6) from instrument panel (5).

(e) To remove fuel gauge (11), proceed as follows:

1 Remove three wires (12) from fuel gauge (11).

2 Remove lamp assembly (13) from fuel gauge (11).

3 Remove two nuts (14), lockwashers (15), nuts (16), bracket (17), and fuel gauge (11) from instrument panel (5). Discard lockwashers.



(f) To remove warning indicator light cluster (18), proceed as follows:

1 Remove connector (19) from warning indicator light cluster (18).

2 Remove nut (20), lockwasher (21), washer (22), bracket (23), and warning indicator light cluster (18) from instrument panel (5). Discard lockwasher.

(g) To remove transmission temperature gauge (24), proceed as follows:

1 Move cover (25) aside and remove three nuts (26), lockwashers (27), and wires (28) from transmission temperature gauge (24). Discard lockwashers.

2 Remove lamp assembly (29) from transmission temperature gauge (24).

3 Remove two nuts (30), lockwashers (31), bracket (32), and transmission temperature gauge (24) from frame (33). Discard lockwashers.

(2) Installation.

NOTE

Install all wires on gauges as tagged and marked prior to removal.

(a) To install transmission temperature gauge (24), proceed as follows:

1 Install transmission temperature gauge (24) in frame (33) with bracket (32), two lockwashers (31), and nuts (30). Tighten nuts securely.

2 Install lamp assembly (29) in transmission temperature gauge (24).

3 Move cover (25) aside and install three wires (28) on transmission temperature gauge (24) with three lockwashers (27) and nuts (26). Tighten nuts securely.

(b) To install warning indicator light cluster (18), proceed as follows:

1 Install warning indicator light cluster (18) in instrument panel (5) with bracket (23), washer (22), lockwasher (21), and nut (20). Tighten nut securely.

2 Install connector (19) on warning indicator light cluster (18).

(c) To install fuel gauge (11), proceed as follows:

1 Install fuel gauge (11) in instrument panel (5) with bracket (17), two nuts (16), lockwashers (15), and nuts (14). Tighten nuts securely.

2 Install lamp assembly (13) in fuel gauge (11).

3 Install three wires (12) in fuel gauge (11).

(d) To install engine hour meter (6), proceed as follows:

1 Install engine hour meter (6) in instrument panel (5) with bracket (10), washer (9), and nut (8). Tighten nut securely.

2 Install two wires (7) on engine hour meter (6).

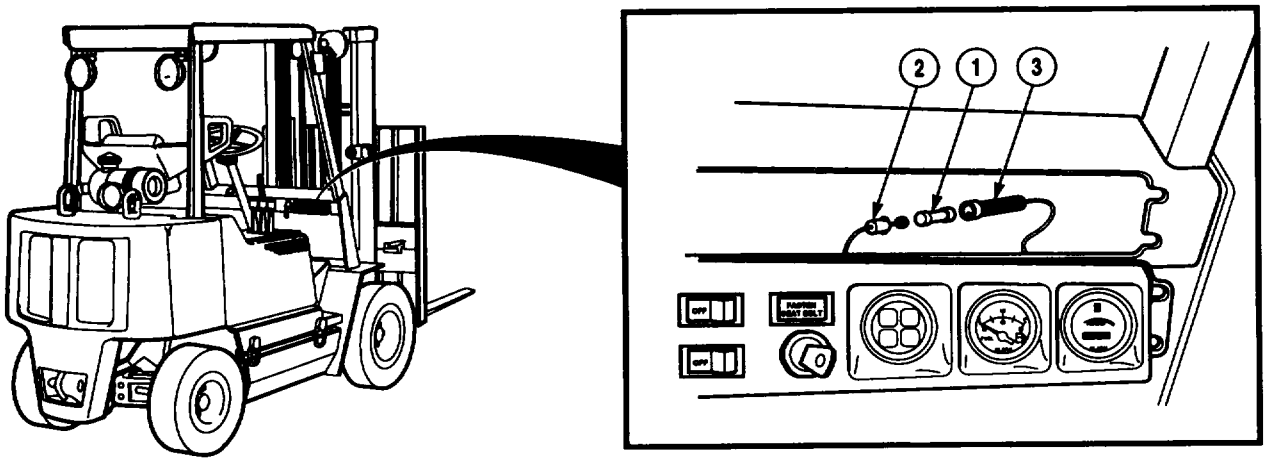
(e) Install plate (4) on instrument panel (5) with two screws (3), washers (2), and nuts (1). Tighten nuts securely.

(f) Install instrument panel (Para 3-36).

(g) Connect batteries (Para 3-25).

c. Fume Replacement.

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove instrument panel (Para 3-36).

WARNING

Wear eye protection and use care when removing fuse caps. Fuse caps and fuses are under spring tension and can act as projectiles when released and could cause severe eye injury.

NOTE

All five fuses are removed the same way.

(c) To remove fuse (1), disconnect cap (2) from fuse holder (3) and remove fuse (1). Discard fuse.

(2) Installation.

NOTE

All five fuses are installed the same way.

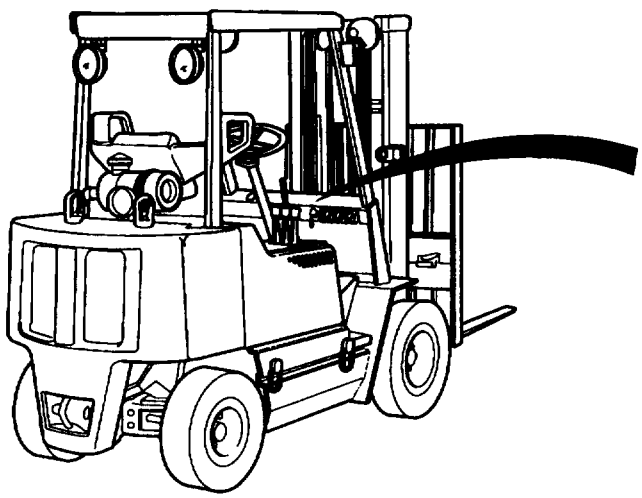
(a) To install fuse, insert fuse (1) in fuse holder (3) and install cap (2).

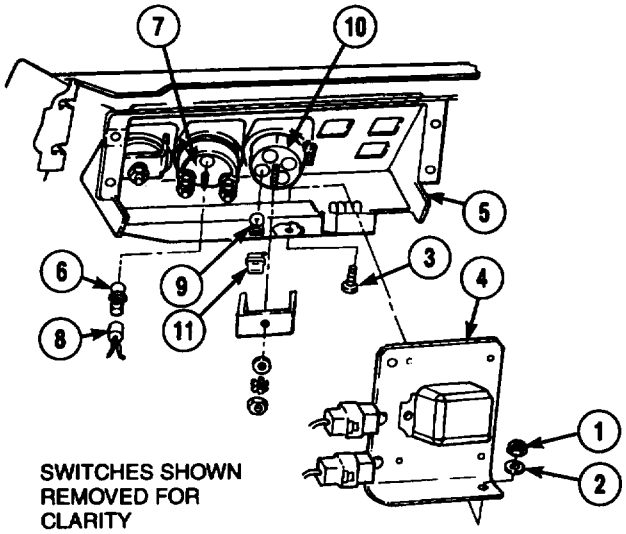
(b) Install instrument panel (Para 3-36).

(c) Connect batteries (Para 3-25).

d. Indicator Lamp Replacement

(1) Removal.





(a) Disconnect batteries (Para 3-25).

(b) Remove instrument panel (Para 3-36).

(c) Remove two nuts (1), washers (2), screws (3), and plate (4) from instrument panel (5).

NOTE

Lamps in fuel gauge and transmission temperature gauge are removed the same way. Fuel gauge is shown.

(d) To remove lamp (6) from fuel gauge (7), proceed as follows:

1 Remove socket assembly (8) from fuel gauge (7).

2 Remove lamp (6) from socket assembly (8).

NOTE

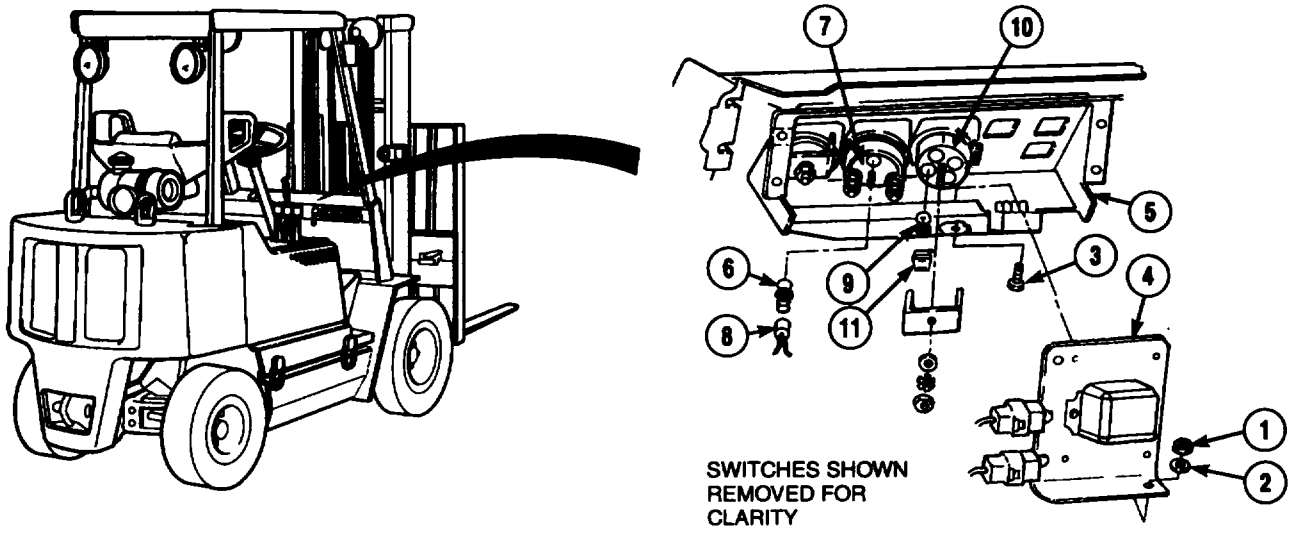
All four lamps in the warning indicator light cluster gauge are removed the same way. Engine oil pressure lamp is shown.

(e) To remove lamp (9) from warning indicator light cluster gauge (10), proceed as follows:

1 Rotate socket (11) to the left and remove from warning indicator light cluster gauge (10).

2 Remove lamp (9) from socket (11).

(2) Installation.



NOTE

All four lamps in the warning indicator light cluster gauge are installed the same way. Engine oil pressure lamp is shown.

(a) To install lamp (9) in warning indicator light cluster gauge (10), proceed as follows:

1 Install lamp (9) in socket (11).

2 Install socket (11) in warning indicator light cluster gauge (10) and rotate socket (11) to the right.

NOTE

Lamps in fuel gauge and transmission temperature gauge are installed the same way. Fuel gauge is shown.

(b) To install lamp (6) in fuel gauge (7), proceed as follows:

1 Install lamp (6) in socket assembly (8).

2 Install socket assembly (8) in fuel gauge (7).

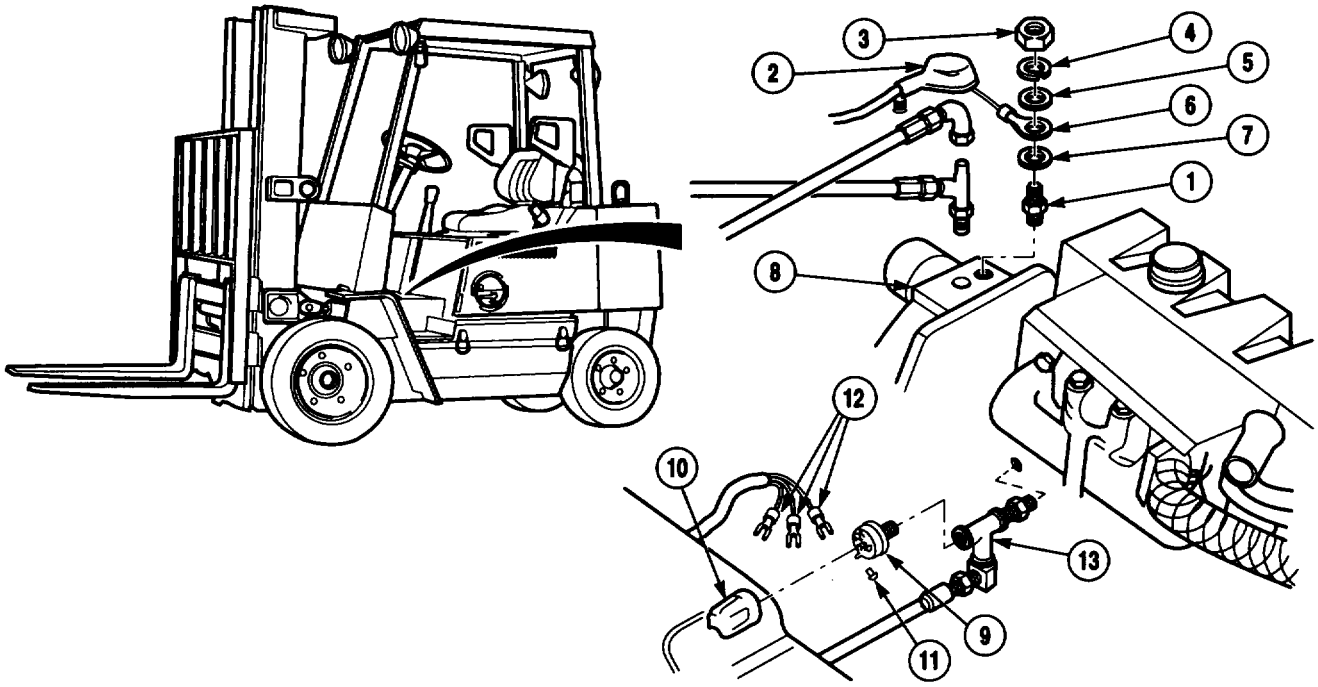
(c) Install plate (4) on instrument panel (5) with two screws (3), washers (2), and nuts (1). Tighten nuts securely.

(d) Install instrument panel (Para 3-36).

(e) Connect batteries (Para 3-25).

e. Sensor Replacement

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove floor panels from forklift (Para 3-36).

NOTE

- **Tag and mark all wires prior to removal.**
- **Cap and plug all lines and fittings during removal.**

(c) To remove transmission oil temperature sending unit (1), proceed as follows:

1 Move cover (2) and remove nut (3), lockwasher (4), washer (5), wire (6), and insulating washer (7) from transmission oil temperature sending unit (1). Discard lockwasher.

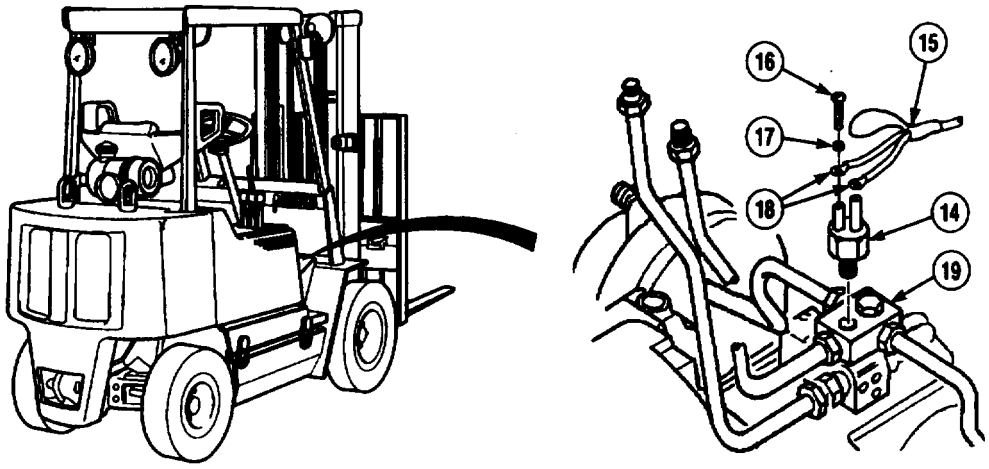
2 Remove transmission oil temperature sending unit (1) from transmission (8).

(d) To remove engine oil pressure sending unit (9), proceed as follows:

1 Remove cover (10) from engine oil pressure sending unit (9).

2 Remove three screws (11) and wires (12) from engine oil pressure sending unit (9).

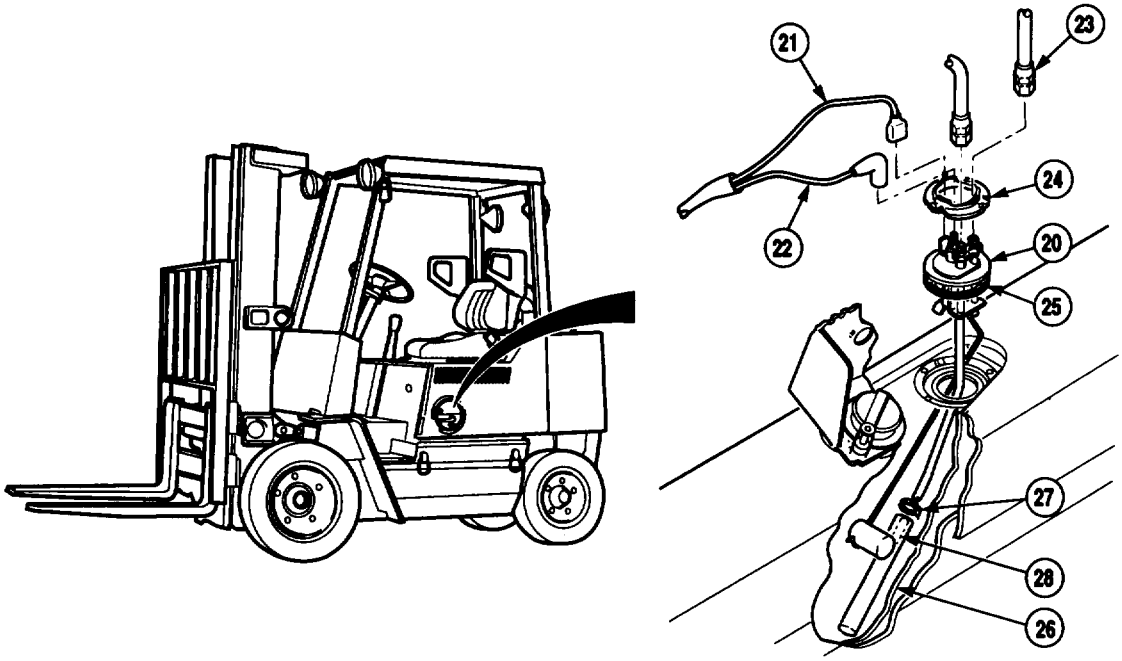
3 Remove engine oil pressure sending unit (9) from fitting (13).



(e) To remove brake light switch (14), proceed as follows:

1 Move cover (15) and remove two screws (16), lockwashers (17), and wires (18) from brake light switch (14). Discard lockwashers.

2 Remove brake light switch (14) from block (19).



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

Prior to removal, position wiping rag under fuel lines to catch any spilled fuel.

(f) To remove fuel gauge sending unit (20), proceed as follows:

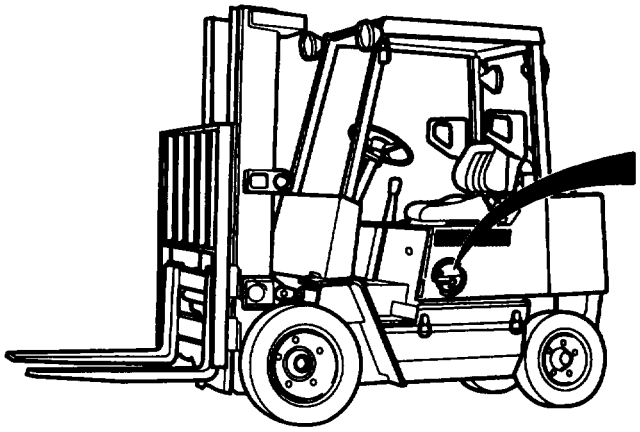
1 Remove wires (21 and 22) from fuel gauge sending unit (20).

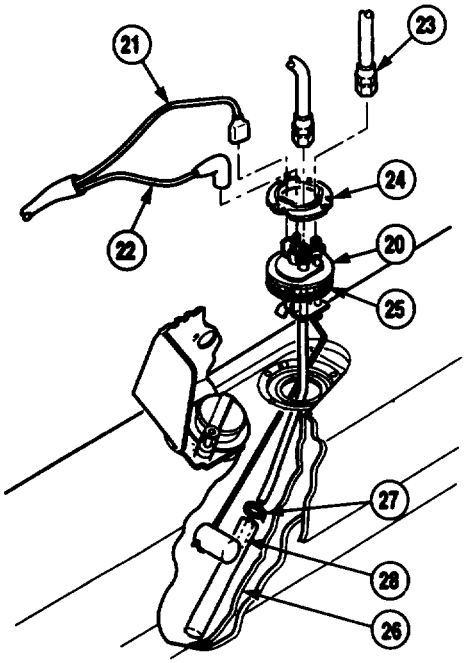
2 Remove two fuel lines (23) from fuel gauge sending unit (20).

3 Remove retainer (24), fuel gauge sending unit (20), and seal (25) from fuel tank (26). Discard seal.

4 Remove clamp (27) and strainer (28) from fuel gauge sending unit (20).

(2) Installation.





WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

Install all wires, fittings, and hoses as tagged and marked prior to removal.

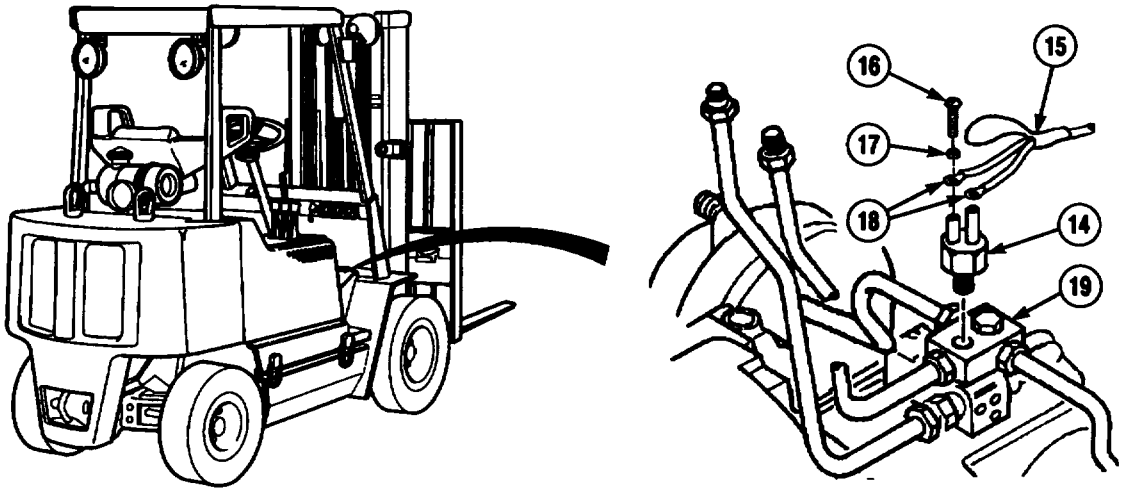
(a) To install fuel gauge sending unit (20), proceed as follows:

1 Install strainer (28) on fuel gauge sending unit (20) with clamp (27).

2 Install seal (25) and fuel gauge sending unit (20) in fuel tank (26) with retainer (24).

3 Install two fuel lines (23) on fuel gauge sending unit (20).

4 Install wires (21) and (22) on fuel gauge sending unit (20).

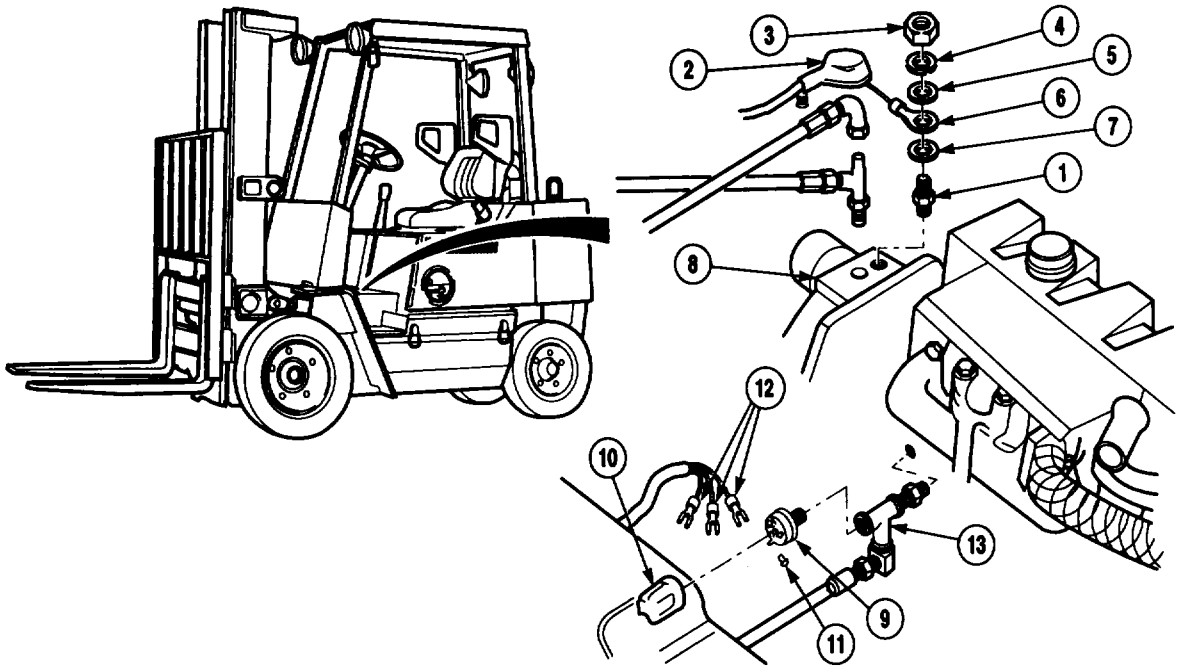


(b) To install brake light switch (14), proceed as follows:

1 Apply sealing compound to threads of brake light switch (14).

2 Install brake light switch (14) on block (19).

3 Move cover (15) and install two wires (18) on brake light switch (14) with two screws (16) and lockwashers (17).



(c) To install engine oil pressure sending unit (9), proceed as follows:

1 Apply sealing compound to threads of engine oil pressure sending unit (9).

2 Install engine oil pressure sending unit (9) on fitting (13).

3 Install three wires (12) on engine oil pressure sending unit (9) with three screws (11).

4 Install cover (10) on engine oil pressure sending unit (9).

(d) To install transmission oil temperature sending unit (1), proceed as follows:

1 Apply sealing compound to threads of transmission oil temperature sending unit (1).

2 Install transmission oil temperature sending unit (1) on transmission (8).

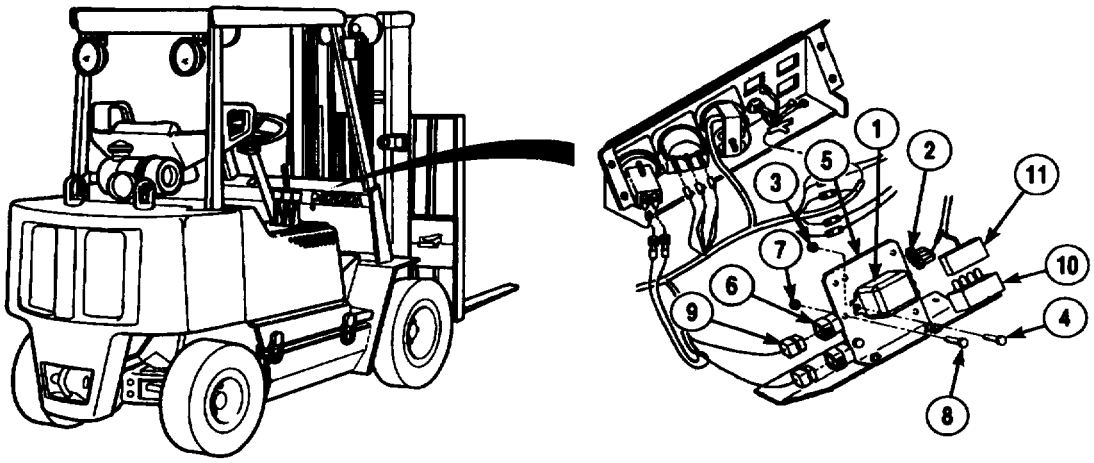
3 Move cover (2) and install insulating washer (7) and wire (6) on transmission oil temperature sending unit (1) with washer (5), lockwasher (4), and nut (3).

(e) Install floor panels on forklift (Para 3-36).

(f) Connect batteries (Para 3-25).

I. Relay Replacement

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove instrument panel (Para 3-36).

NOTE

Tag and mark all wires prior to removal.

(c) To remove neutral start relay (1), proceed as follows:

1 Remove four wires (2) from neutral start relay (1).

2 Remove nut (3), screw (4), and neutral start relay (1) from plate (5).

NOTE

Starter and horn relays are removed in the same manner. Starter relay is shown.

(d) To remove starter relay (6), proceed as follows:

1 Remove nut (7), screw (8), and starter relay (6) from plate (5).

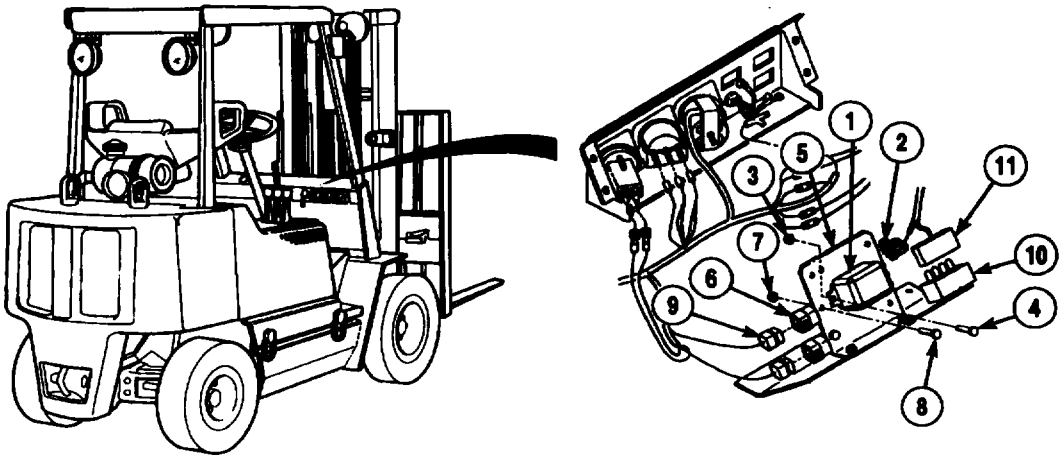
2 Remove connector (9) from starter relay (6).

(e) To remove alarm (10), proceed as follows:

1 Remove connector (11) from alarm (10).

2 Twist alarm (10) half left and remove from plate (5).

(2) Installation.



NOTE

Install all wires on switches as tagged and marked prior to removal.

(a) To install alarm (10), proceed as follows:

1 Position alarm (10) on plate (5) and turn half right.

2 Install connector (11) on alarm (10).

NOTE

Starter and horn relays are installed in the same manner. Starter relay is shown.

(b) To install starter relay (6), proceed as follows:

1 Install connector (9) on starter relay (6).

2 Install starter relay (6) on plate (5) with screw (8) and nut (7). Tighten nut securely.

(c) To install neutral start relay (1), proceed as follows:

1 Install neutral start relay (1) on plate (5) with screw (4) and nut (3). Tighten nut securely.

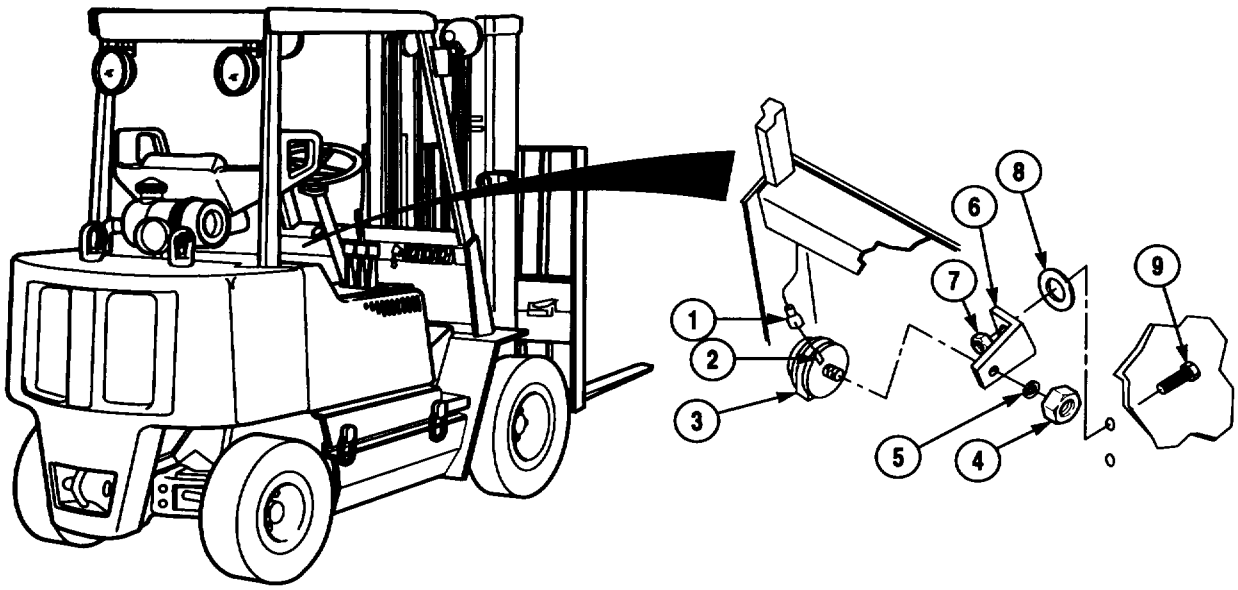
2 Install four wires (2) on neutral start relay (1).

(d) Install instrument panel (Para 3-36).

(e) Connect batteries (Para 3-25).

g. Horn Replacement.

(1) Removal.



(a) Disconnect batteries (Para 3-25).

(b) Remove floor panels (Para 3-36).

(c) Disconnect connector (1) from terminal (2) of horn (3).

(d) Remove nut (4), lockwasher (5), and horn (3) from bracket (6). Discard lockwasher.

(e) Remove two nuts (7), bracket (6), two washers (8), and screws (9).

(2) Installation.

(a) Install bracket (6) with two screws (9), washers (8) and nuts (7). Tighten nuts 70-85 lb-in (8- 10 N•m).

(b) Install horn (3) on bracket (6) with lockwasher (5) and nut (4).

(c) Connect connector (1) to terminal (2) of horn (3).

(d) Install floor panels (Para 3-36).

(e) Connect batteries (Para 3-25).

END OF TASK

3-23. DIRECTIONAL CONTROL SWITCH ASSEMBLY REPLACEMENT.

a. Removal.

(1) Disconnect batteries (Para 3-25).

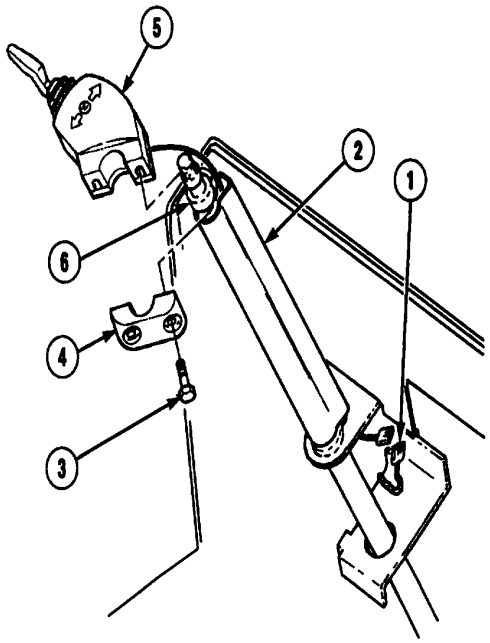
NOTE

Steering wheel has been removed for clarity

(2) Disconnect connector (1).

(3) Remove wire harness protector (2).

(4) Remove two screws (3), cap (4), and switch assembly (5) from steering column (6).



b. Installation.

(1) Install switch assembly (5) on steering column (6) with cap (4) and two screws (3).

(2) Install wire harness protector (2).

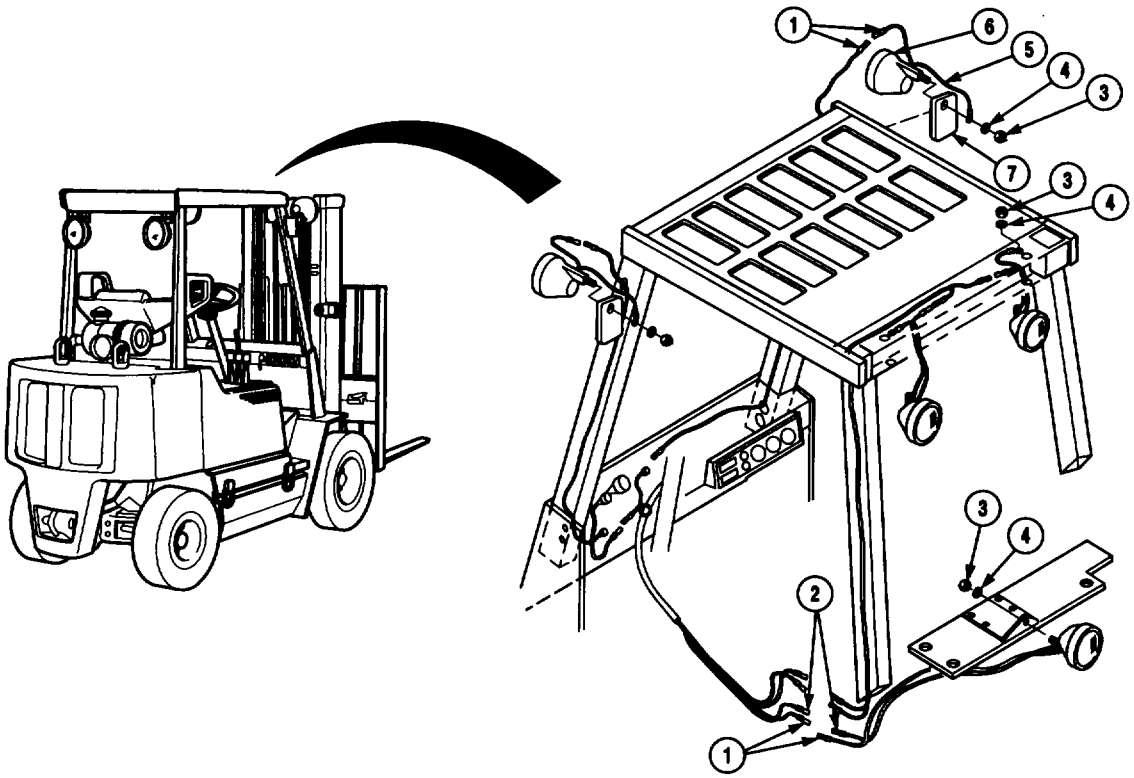
(3) Connect connector (1).

(4) Connect batteries (Para 3-25).

END OF TASK

3-24. FLOOD AND STOP LIGHT REPLACEMENT/REPAIR.

a. Removal.



(1) Disconnect batteries (Para 3-25).

NOTE

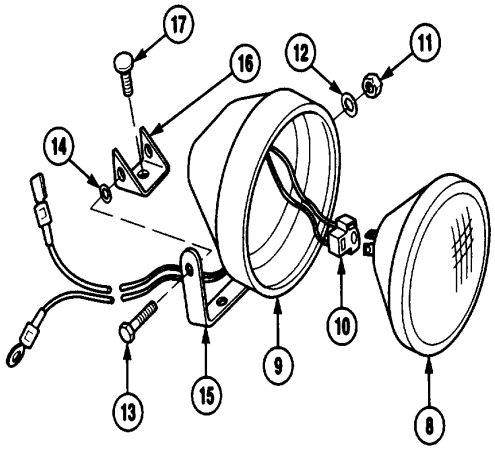
- **All flood lights and stop light are removed in a similar way.**
- **Tag and mark all wires prior to removal.**

(2) Disconnect connectors (1 and 2), as required.

(3) Remove nut (3), lockwasher (4), ground lead (5), and flood light assembly (6) from mount (7). Discard lockwasher.

b. Disassembly.

(1) To disassemble flood lamp, proceed as follows:



CAUTION

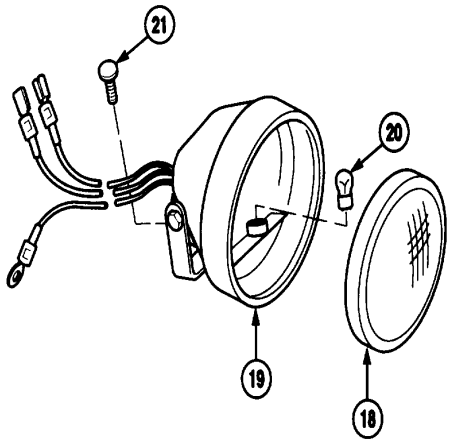
Glass lamp may be difficult to remove from housing. Be careful while removing lamp or damage to flood light may result.

(a) Carefully remove lamp (8) from housing (9).

(b) Disconnect lamp (8) from connector (10).

(c) Remove locknut (11), washer (12), screw (13), two washers (14), brackets (15 and 16), and screw (17) from housing (9). Discard locknut.

(2) To disassemble stop light, proceed as follows:



CAUTION

Glass lens may be difficult to remove from housing. Be careful while removing lens or damage to stop light may result.

(a) Carefully remove lens (18) from housing (19).

(b) Remove lamp (20) from housing (19).

(c) Remove screw (21) from housing (19).

c. Assembly.

(1) To assemble stop light, proceed as follows:

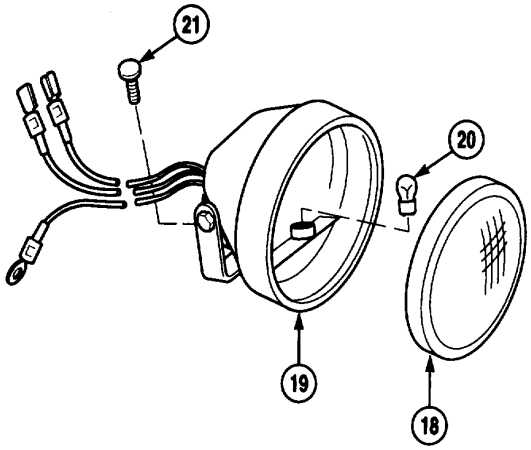
(a) Position screw (21) on housing (19).

(b) Install lamp (20) in housing (19).

CAUTION

Glass lens may be difficult to install in housing. Be careful while installing lens or damage to stop light may result.

(c) Install lens (18) in housing (19).



(2) To assemble flood light, proceed as follows:

(a) Position screw (17) in bracket (16).

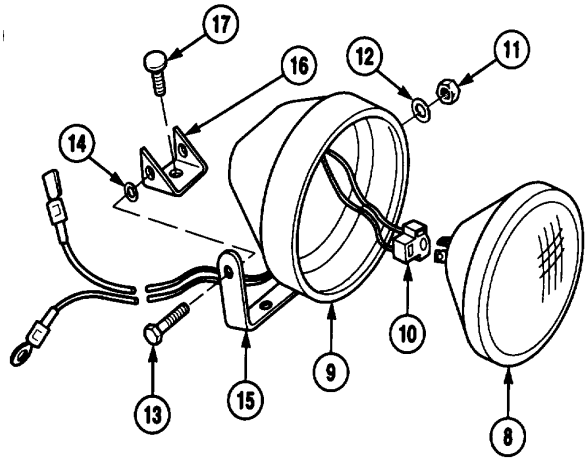
(b) Install brackets (16) and (15) on housing (9) with two washers (14), screw (13), washer (12), locknut (11) and screw (17). Tighten locknut 18 lb-ft (24 N•m).

CAUTION

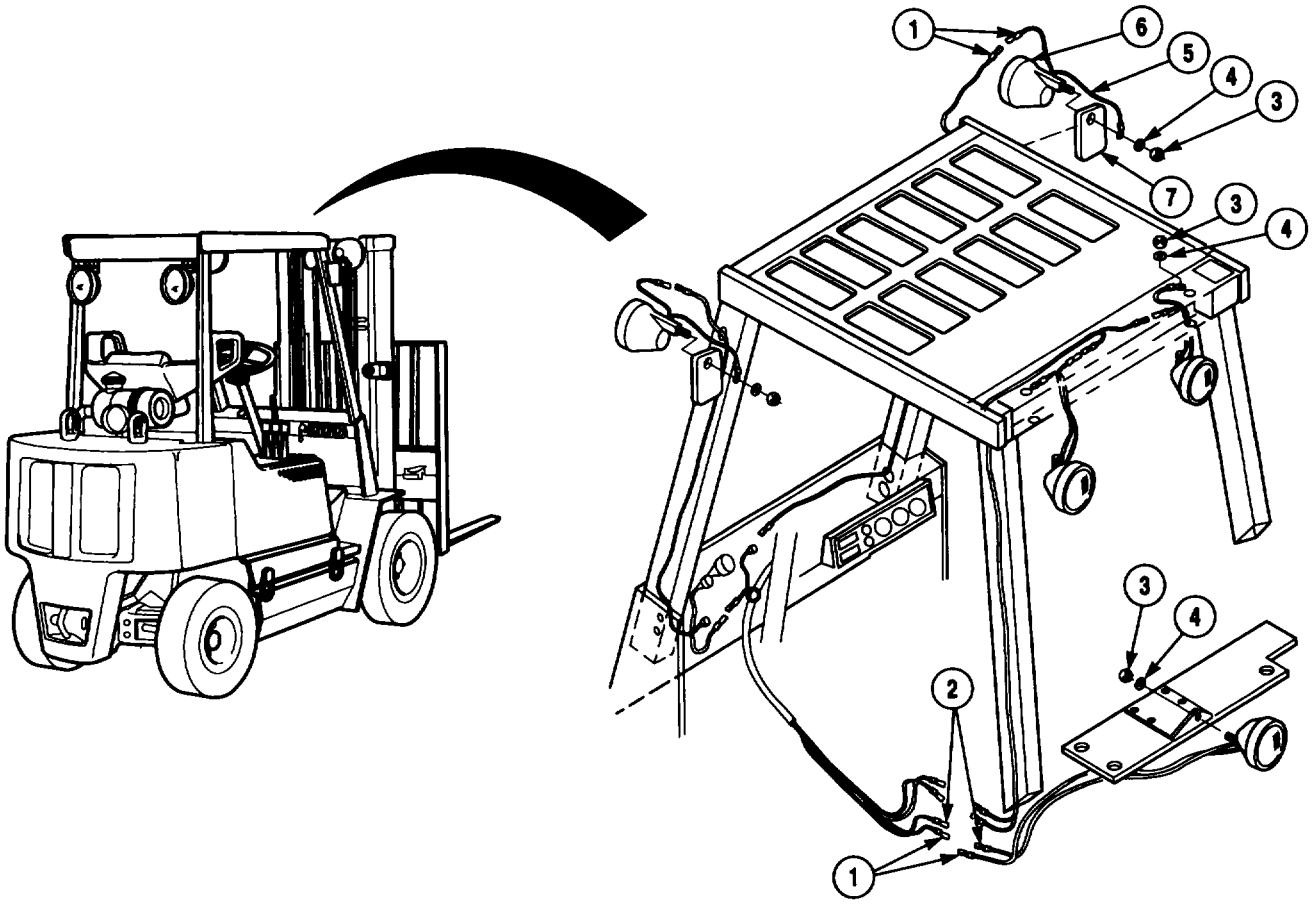
Glass lamp may be difficult to install in housing. Be careful while installing lamp or damage to flood light may result.

(c) Install connector (10) on lamp (8).

(d) Install lamp (8) in housing (9).



d. Installation.



NOTE

All flood lights and stop light are installed in a similar way.

(1) Install flood light (6) on mount (7) with ground lead (5), lockwasher (4), and nut (3).

(2) Connect connectors (1 and 2), as disconnected during ***Removal***.

(3) Connect batteries (Para 3-25).

END OF TASK

3-25. BATTERY REPLACEMENT.

a. Removal.

NOTE

If disconnecting batteries for maintenance procedures, perform Steps (1) through (6)[b] only.

(1) Apply parking brake (TM 10-3930-671-10).

(2) Chock wheels to prevent roll (TM 10-3930-671-10).

(3) Remove right-side hood (TM 10-3930-671-10).

(4) Open left-side hood (TM 10-3930-671-10).

(5) Open top hood (TM 10-3930-671-10).

WARNING

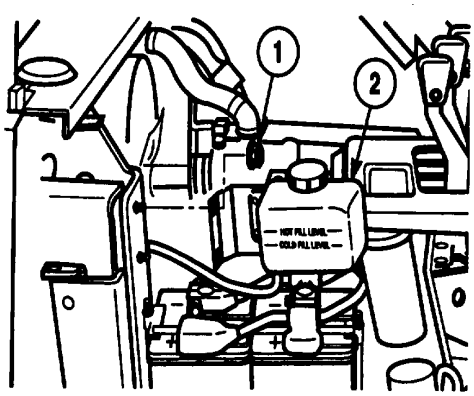
- **Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts skin or eyes. Wear rubber apron to prevent clothing being damaged.**
- **Avoid electrolyte contact with skin, eyes, or clothing. If battery electrolyte spills, take immediate action to stop burning effects:**
  - **External: Immediately flush with cold running water to remove all acid.**
  - **Eyes: Flush with cold water for at least 15 minutes. Seek immediate medical attention.**
  - **Internal: Drink large amounts of water or milk. Follow with milk of magnesia, beaten egg, or vegetable oil. Seek immediate medical attention.**
  - **Clothing or Vehicle: Wash at once with cold water. Neutralize with baking soda or household ammonia solution.**
- **Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.**

NOTE

Tag and mark all wires prior to removal.

(6) To remove batteries, proceed as follows:

(a) Remove two nuts (1) and move cooling system compensation tank and bracket (2) aside.



(b) Loosen two nuts (3) on two negative battery terminal clamps (4).

(c) Remove two negative battery terminal clamps (4) from two negative battery terminals (5).

(d) Raising two battery terminal covers (6), loosen two nuts (7) on two positive battery terminal clamps (8).

(e) Raising two battery terminal covers (6), remove two positive battery terminal clamps (8) from two positive battery terminals (9).

(f) Remove two nuts (10), four washers (11), and battery hold down (12) from two J-bolts (13).

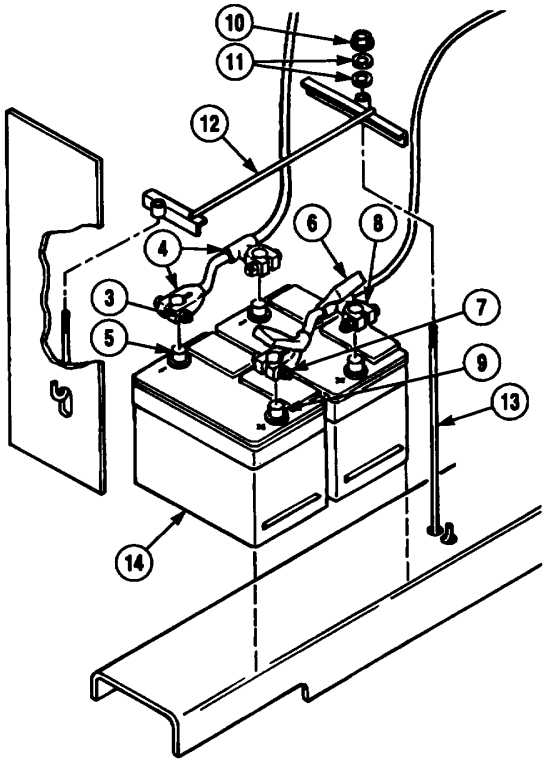
(g) Remove two batteries (14) and position on clean work surface.

b. Installation.

NOTE

If connecting battery after maintenance procedure, perform Steps (1)[f] through (3) only.

(1) To install batteries, proceed as follows:



WARNING

Battery hold down must be installed with the long side toward the front of vehicle. Failure to install in this manner could cause shorting of battery, damage to equipment, and injury to personnel.

(a) Install two batteries (14) in with two J-blots (13), battery hold down (12), four washers (11), and two nuts (10).

WARNING

Corrosion inhibitor contains alkali. Do not get in eyes; wear goggles/safety glasses when using. Avoid contact with skin. In case of contact, immediately wash area with soap and water. If eyes are contacted, flush eyes with large amounts of water for at least 15 minutes and get immediate medical attention.

(b) Coat two positive battery terminals (9) with corrosion preventive compound.

(c) Install two positive battery terminal clamps (8) on two positive battery terminals (9) with two nuts (7).

(d) Position two battery terminal covers (6) on two positive battery terminal clamps (8).

(e) Coat two negative battery terminals (5) with corrosion preventive compound.

(f) Install two negative battery terminal clamps (4) on two negative battery terminals (5) with two nuts (3).

(g) Install cooling system compensation tank and bracket (2) with two nuts (1).

(2) Close top hood (TM 10-3930-671-10).

(3) Close left-side hood (TM 10-3930-671-10).

(4) Install right-side hood (TM 10-3930-671-10).

(5) Remove wheel chocks (TM 10-3930-671-10).

END OF TASK

3-26. BATTERY CABLE REPLACEMENT.

a. Removal.

(1) Apply parking brake (TM 10-3930-671-10).

(2) Chock wheels to prevent roll (TM 10-3930-671-10).

(3) Remove left-side hood (TM 10-3930-671-10).

(4) Open top hood (TM 10-3930-671-10).

(5) Remove right-side hood (TM 10-3930-671-10).

WARNING

- **Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts skin or eyes. Wear rubber apron to prevent clothing damage.**
- **Avoid electrolyte contact with skin, eyes, or clothing. If battery electrolyte spills, take immediate action to stop burning effects:**
  - **External: Immediately flush with cold running water to remove all acid.**
  - **Eyes: Flush with cold water for at least 15 minutes. Seek immediate medical attention.**
  - **Internal: Drink large amounts of water or milk. Follow with milk of magnesia, beaten egg, or vegetable oil. Seek immediate medical attention.**
  - **Clothing or Vehicle: Wash at once with cold water. Neutralize with baking soda or household ammonia solution.**
- **Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.**

NOTE

Tag and mark all wires prior to removal.

(6) To remove battery cables, proceed as follows:

(a) Loosen two nuts (1) on two negative battery terminal clamps (2).

(b) Remove two negative battery terminal clamps (2) from two negative battery terminals (3).

(c) Remove screw (4), negative battery cable (5), and washer (6) from engine (7).

(d) Raising two battery terminal covers (8), loosen two nuts (9) on two positive battery terminal clamps (10).

(e) Raising two battery terminal covers (8), remove two positive battery terminal clamps (10) from two positive battery terminals (11).

(f) Raising cover (12), remove nut (13), lockwasher (14), and positive battery cable (15) from master power switch terminal (16). Discard lockwasher.

b. Installation.

(1) To install battery cables, proceed as follows:

(a) Raising cover (12), install positive battery cable (15) on master power switch terminal (16) with lockwasher (14) and nut (13).

WARNING

Corrosion inhibitor contains alkali. Do not get in eyes; wear goggles/safety glasses when using. Avoid contact with skin. in case of contact, immediately wash area with soap and water. If eyes are contacted, flush eyes with large amounts of water for at least 15 minutes and get immediate medical attention.

(b) Coat two positive battery terminals (11) with corrosion preventive compound.

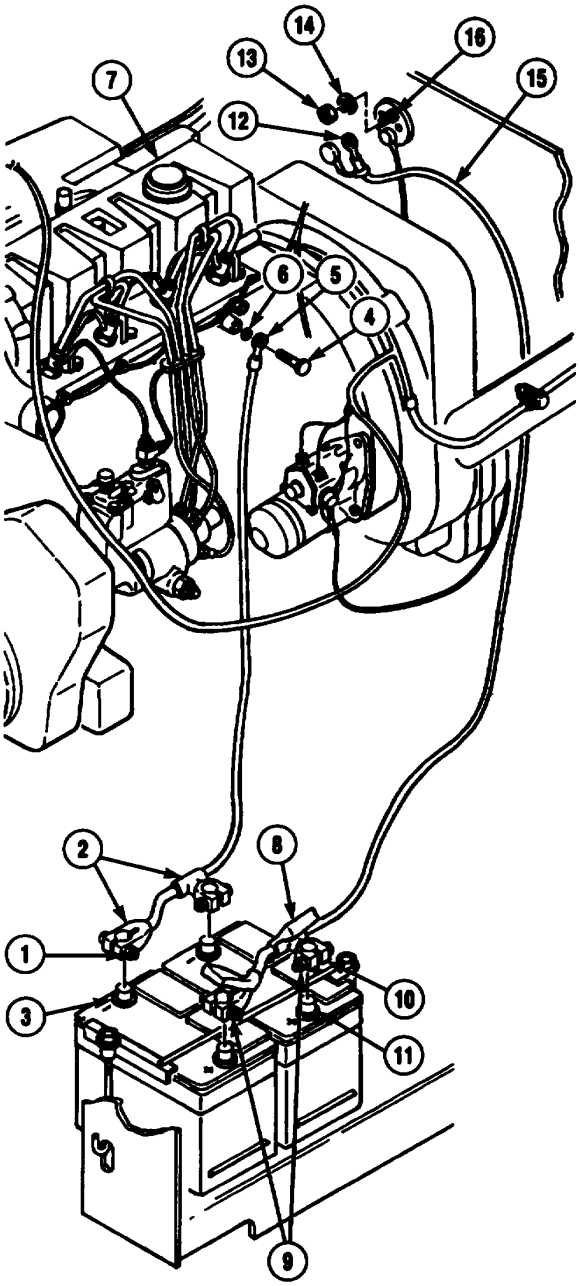
(c) Install two positive battery terminal clamps (10) on two positive battery terminals (11) with two nuts (9).

(d) Position two battery terminal covers (8) on two positive battery terminal clamps (10).

(e) Install washer (6), negative battery cable (5), and screw (4) on engine (7).

(f) Coat two negative battery terminals (3) with corrosion preventive compound.

(g) Install two negative battery terminal clamps (2) on two negative battery terminals (3) with two nuts (1).



(2) Install left-side hood (TM 10-3930-671-10).

(3) Close top hood (TM 10-3930-671-10).

(4) Install right-side hood (TM 10-3930-671-10).

(5) Remove wheel chocks (TM 10-3930-671-10).

END OF TASK

3-27. BATTERY CABLE SERVICE.

a. Removal.

(1) Apply parking brake (TM 10-3930-671-10).

(2) Chock wheels to prevent roll (TM 10-3930671-10).

(3) Remove left-side hood (TM 10-3930-671-10).

(4) Open top hood (TM 10-3930-671-10).

(5) Remove right-side hood (TM 10-3930-671-10).

WARNING

- **Battery acid (electrolyte) is extremely harmful. Always wear safety goggles and rubber gloves, and do not smoke when performing maintenance on batteries. Injury will result if acid contacts skin or eyes. Wear rubber apron to prevent clothing being damaged.**
- **Avoid electrolyte contact with skin, eyes, or clothing. If battery electrolyte spills, take immediate action to stop burning effects:**
  - **External: Immediately flush with cold running water to remove all acid.**
  - **Eyes: Flush with cold water for at least 15 minutes. Seek immediate medical attention.**
  - **Internal: Drink large amounts of water or milk. Follow with milk of magnesia, beaten egg, or vegetable oil. Seek immediate medical attention.**
  - **Clothing or Vehicle: Wash at once with cold water. Neutralize with baking soda or household ammonia solution.**
- **Remove all jewelry such as rings, dog tags, bracelets, etc. If jewelry contacts battery terminal, a direct short may result in instant heating of tools, damage to equipment, and injury or death to personnel.**

NOTE
Tag and mark all wires prior to removal.

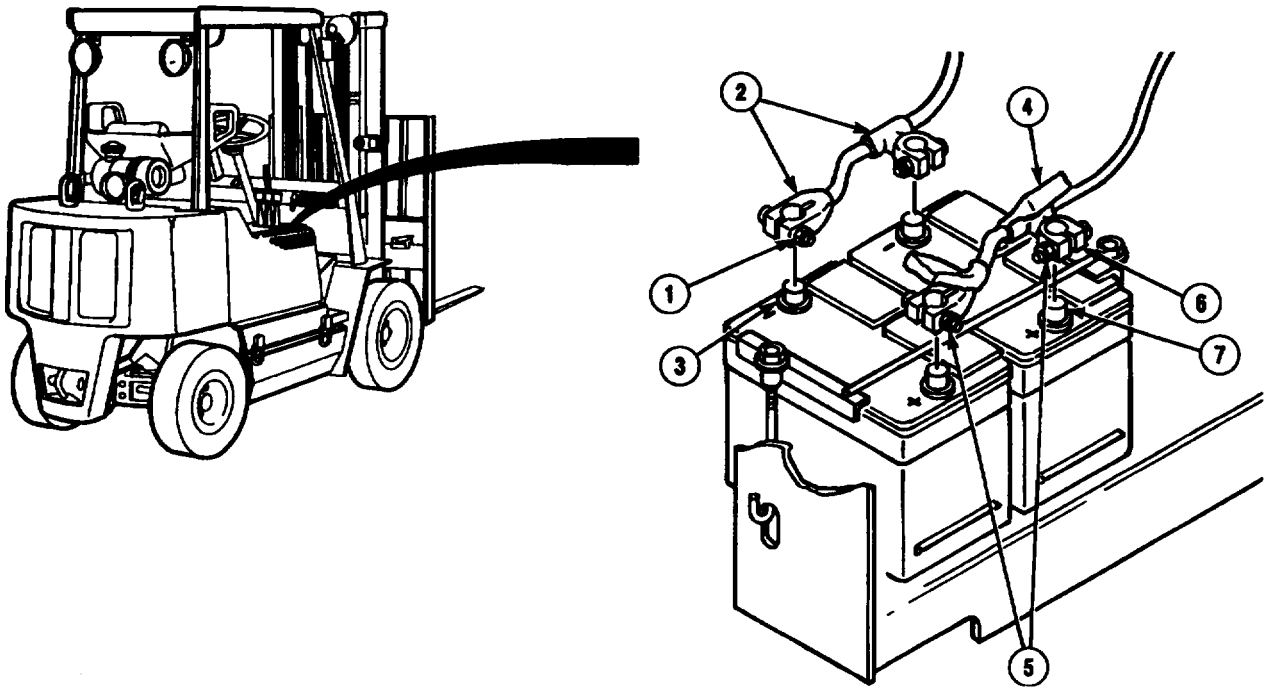
(6) To remove battery cables, proceed as follows:

(a) Loosen two nuts (1) on two negative battery terminal clamps (2).

(b) Remove two negative battery terminal clamps (2) from two negative battery terminals (3).

(c) Raising two battery terminal covers (4), loosen two nuts (5) on two positive battery terminal clamps (6).

(d) Raising two battery terminal covers (4), remove two positive battery terminal clamps (6) from two positive battery terminals (7).



(1) To install battery cables, proceed as follows:

WARNING

Corrosion inhibitor contains alkali. Do not get in eyes; wear goggles/safety glasses when using. Avoid contact with skin. in case of contact, immediately wash area with soap and water. If eyes are contacted, flush eyes with large amounts of water for at least 15 minutes and get immediate medical attention.

(a) Coat two positive battery terminals (7) with corrosion inhibitor.

(b) Install two positive battery terminal clamps (6) on two positive battery terminals (7) with two nuts (5).

(c) Position two battery terminal covers (4) on two positive battery terminal clamps (6).

(d) Coat two negative battery terminals (3) with corrosion preventive compound.

(e) Install two negative battery terminal clamps (2) on two negative battery terminals (3) with two nuts (1).

(2) Install left-side hood (TM 10-3930-671-10).

(3) Close top hood (TM 10-3930-671-10).

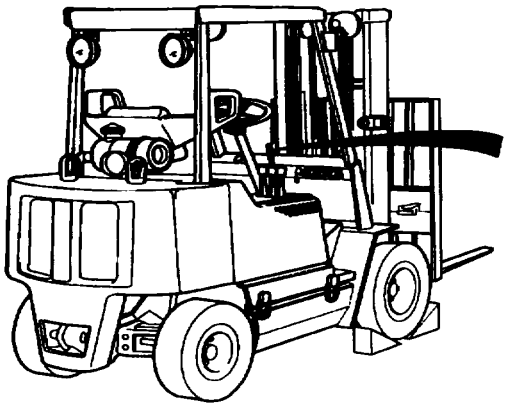
(4) Install right-side hood (TM 10-3930-671-10).

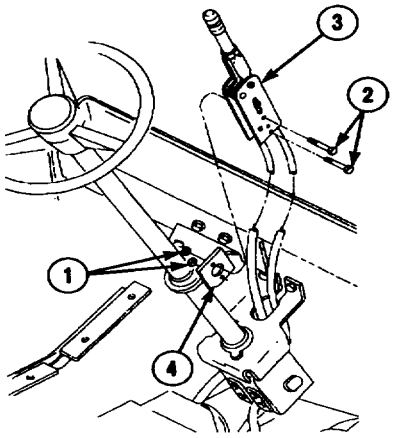
(5) Remove wheel chocks (TM 10-3930-671-10).

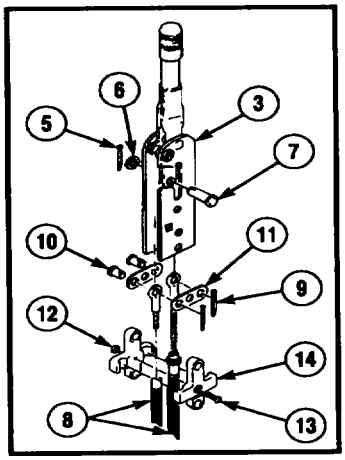
END OF TASK

3-28. PARKING BRAKE LEVER REPLACEMENT.

a. Removal







(1) Chock wheels to prevent roll.

(2) Disconnect batteries (Para 3-25).

(3) Release parking brake (TM 10-3930-671-10).

(4) Remove two nuts (1), screws (2), and brake handle assembly (3) from mounting bracket (4).

(5) Remove cotter pin (5), washer (6), pin (7), and brake cables (8) from brake handle assembly (3). Discard cotter pin.

(6) Remove two cotter pins (9), pins (10), and clamps (11) from brake cables (8). Discard cotter pins.

(7) If necessary, remove nut (12), screw (13), and two fastener halves (14) from brake cables (8).

b. Installation

(1) If removed, install two fastener halves (14) on two brake cables (8) with screw (13) and nut (12).

(2) Install two clamps (11) on two brake cables (8) with pins (10) and cotter pins (9).

(3) Install two brake cables (8) in brake handle assembly (3) with pin (7), washer (6), and cotter pin (5).

(4) Install brake handle assembly (3) on mounting bracket (4) with two screws (2) and nuts (1). Tighten screws 180-220 lb-in (20-25 N•m).

(5) Adjust parking brake assembly (TM 10-3930-671-10).

(6) Apply parking brake (TM 10-3930-671-10).

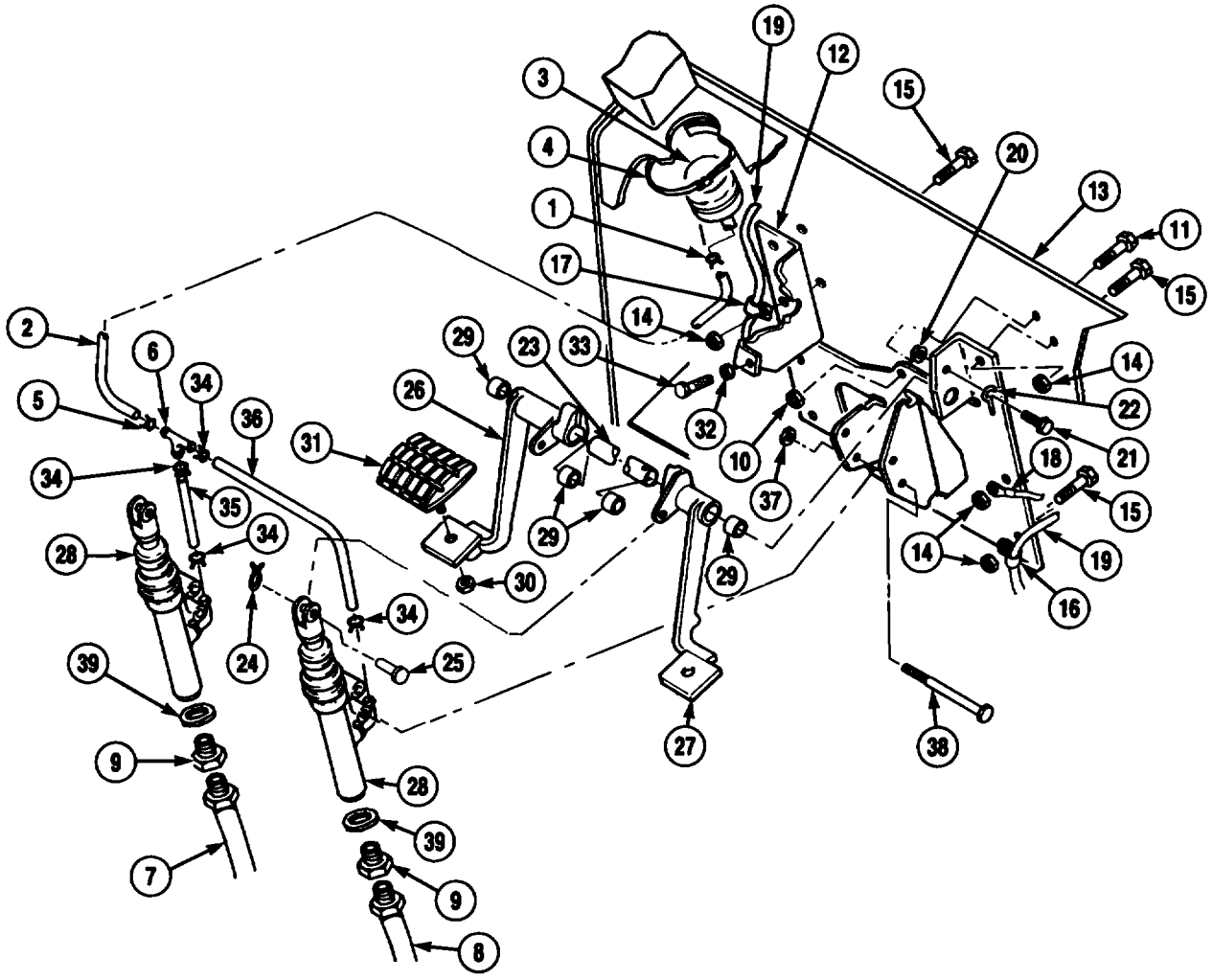
(7) Remove wheel chocks.

(8) Connect batteries (Para 3-25).

END OF TASK

3-29. BRAKE SYSTEM REPAIR.

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) Chock wheels to prevent roll CTM 10-3930-671-10).

(3) Remove instrument panel (Para 3-36).

NOTE

Remove steering column hardware, as required, to access brake components.

(4) Remove steering column from frame (Appendix F, Steering Column and Valve, Section 9.2).

CAUTION

Use care when removing hose from brake fluid reservoir and fitting to breaking connections. Connections can be easily broken, causing damage to equipment.

NOTE

- **Position suitable container with one quart (1 liter) capacity under brake master cylinder.**
- **Tag and mark all wires, lines, and hoses prior to removal.**
- **Use wiping clothes to wipe up any spilled brake fluid.**

(5) Remove clamp (1), cut hose (2) from brake fluid reservoir (3), and drain brake fluid into suitable container.

(6) Loosen clamp (4) and remove brake fluid reservoir (3).

(7) Remove clamp (5) and cut hose (2) from fitting (6). Discard hose.

(8) Remove two remaining hose sections (2) from brake fluid reservoir (3) and fitting (6). Discard hose.

(9) Remove brake lines (7 and 8) from two fittings (9).

(10) With the aid of an assistant, remove nut (10) and screw (11) from bracket (12) and forklift (13).

Note

Note position of wire and strap prior to removal.

(11) Remove six nuts (14), screws (15), two straps (16 and 17), wire (18), two harness sections (19), and bracket (12) from forklift (13) and position on clean work surface.

(12) Remove nut (20), screw (21), and retainer (22) from bracket (12) and pivot (23).

(13) Remove two retainers (24) and pins (25) from pedals (26 and 27), and two brake master cylinders (28).

(14) Remove pivot (23), pedals (26 and 27), and four bushings (29) from bracket (12).

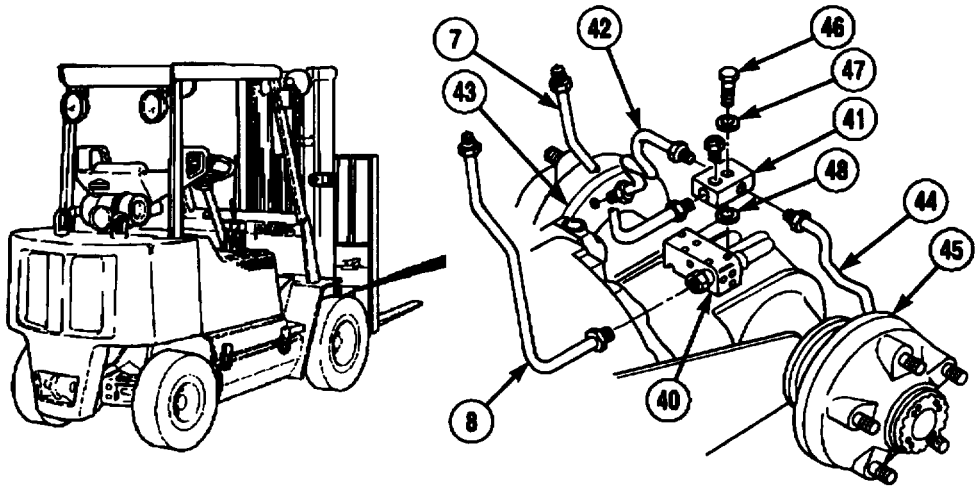
(15) Remove two fasteners (30) and pads (31) from pedals (26) and (27).

(16) Remove locking nut (32) and screw (33) from bracket (12).

(17) Remove four clamps (34), fitting (6), and hoses (35 and 36) from two brake master cylinders (28).

(18) Remove two nuts (37), screws (38), and two brake master cylinders (28) from bracket (12).

(19) Remove two fittings (9) and seals (39) from two brake master cylinders (28). Discard seals.



(20) Remove brake light switch (Para 3-22).

(21) Remove brake line (8) from transmission control cover (40).

(22) Remove brake line (7) from tee (41).

(23) Remove brake line (42) from tee (41) and left hub (43).

(24) Remove brake line (44) from tee (41) and right hub (45).

(25) Remove screw (46), seal (47), tee (41), and seal (48) from transmission control cover (40).

b. Installation..

NOTE

- **Install all wires, lines, and hoses as tagged and marked during Removal.**
- **Use wiping clothes to wipe up any spilled brake fluid.**

(1) Install seal (48), tee (41), and seal (47) on transmission control cover (40) with screw (46). Tighten screw 26-30 lb-ft (35-40 N•m).

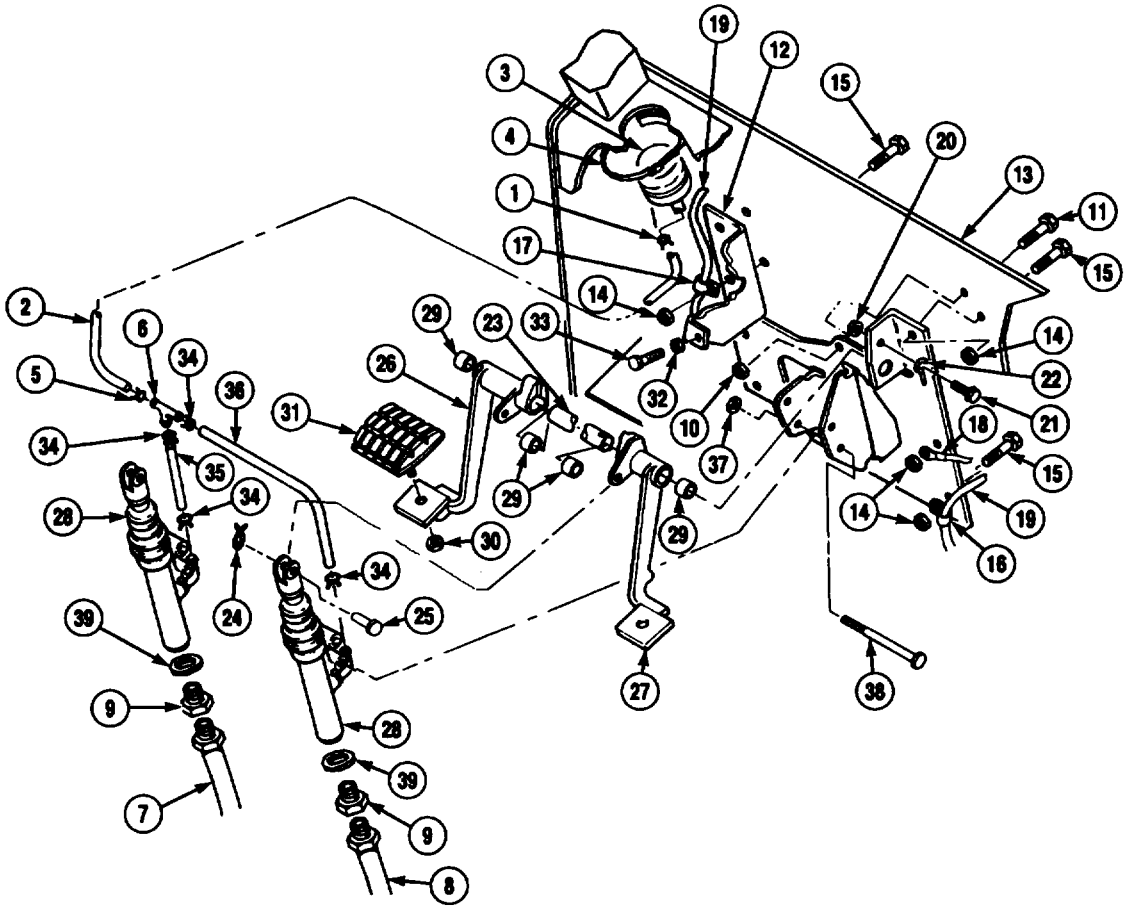
(2) Install brake line (44) on tee (41) and right hub (45).

(3) Install brake line (42) on tee (41) and left hub (43).

(4) Install brake line (7) on tee (41).

(5) Install brake line (8) on transmission control cover (40).

(6) Install brake light switch (Para 3-22).



(7) Install two fittings (9) and seals (39) on brake master cylinders (28). Tighten fittings 150-180 lb-in (17-20 N•m).

(8) Install two brake master cylinders (28) on bracket (12) with two screws (38) and nuts (37). Tighten nuts 7188 lb-in (8-10 N•m).

(9) Install hoses (35 and 36) on two brake master cylinders (28) and fitting (6) with four clamps (34).

(10) Install screw (33) on bracket (12) with locking nut (32).

(11) Install two pads (31) on pedals (26 and 27) with two fasteners (30).

(12) Install pedals (26 and 27) on bracket (12) with four bushings (29) and pivot (23).

(13) Install pedals (26 and 27) on two brake master cylinders (28) with two pins (25) and retainers (24).

(14) Install retainer (22) on pivot (23) and bracket (12) with screw (21) and nut (20). Tighten nut 117-221 lb-in (20-25 N•m).

(15) Install bracket (12) on forklift (13) with six screws (15), two straps (16 and 17), wire (18), two harness sections (19), and six nuts (14). Tighten nuts 117-221 lb-in (20-25 N•m).

(16) With the aid of an assistant, install screw (11) and nut (10) on bracket (12) and forklift (13). Tighten nuts 117-221 lb-in (20-25 N•m).

(17) Install brake lines (7 and 8) on two fittings (9).

CAUTION

Use care when installing hose from brake fluid reservoir and fitting to breaking connections. Connections can be easily broken, causing damage to equipment.

(18) Install new hose (2) on fitting (6) with clamp (5).

(19) Install brake fluid reservoir (3) with clamp (4).

(20) Install new hose (2) on brake fluid reservoir (3) with clamp (1).

(21) Fill brake fluid reservoir (3) with brake fluid (Appendix E, Lubrication Order).

(22) Bleed brake system (Appendix F, Brake Bleeding, Section 8.5).

(23) Install steering column (Appendix F, Steering Column and Valve, Section 9.2).

(24) Install instrument panel (Para 3-36)

(25) Remove wheel chocks (TM 10-3930-671-10).

(26) Connect batteries (Para 3-25).

END OF TASK

3-30. GENERAL HYDRAULIC HOSE REPLACEMENT.

The truck is equipped with four types of hydraulic connections. The following procedures cover removal and installation of one each of these fittings. These procedures will apply to all fittings installed on truck.

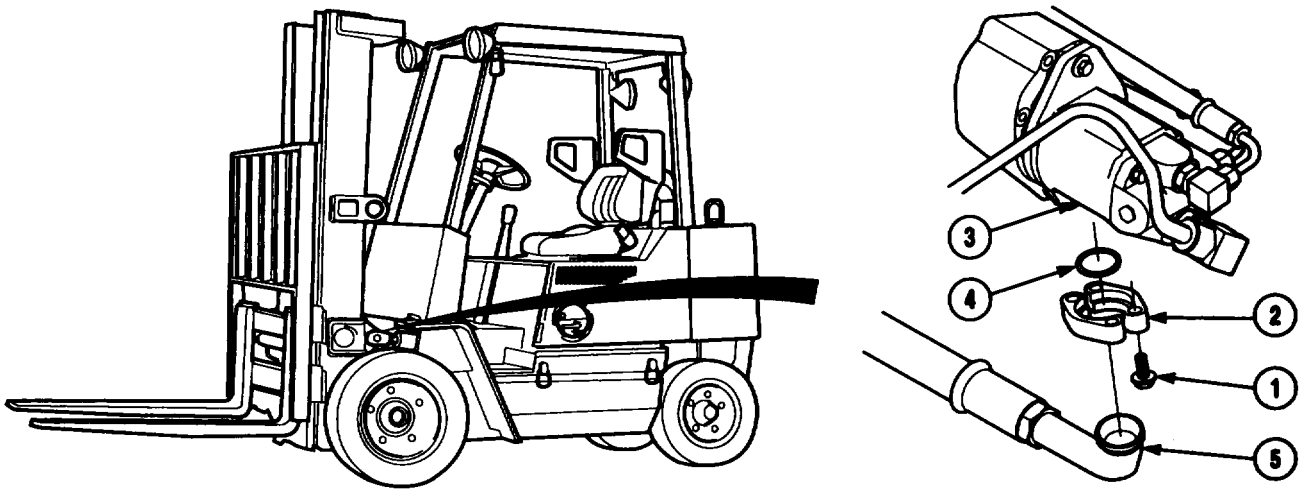
WARNING

Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

NOTE

- **Subparagraphs a. through d. show typical connections and fittings on truck.**
- **This procedure is for reference only to show location of hoses and fittings used on truck. It will never be necessary to remove all hydraulic hoses at one time. Individual procedures will indicate the area where hoses are to be removed and installed.**
- **Some hydraulic fittings will have a preformed packing. Preformed packings should be replaced whenever corresponding fitting is removed.**
- **Place suitable container with a 1 gallon (3.8 liters) capacity under any hydraulic hose that is being disconnected to catch spilling hydraulic fluid.**

a. Clamp Fitting Hose.



(1) Removal.

(a) With forklift turned OFF, operate hydraulic control levers to relieve all pressure from hydraulic system.

(b) Remove four screws (1) from two clamps (2) and main hydraulic pump (3).

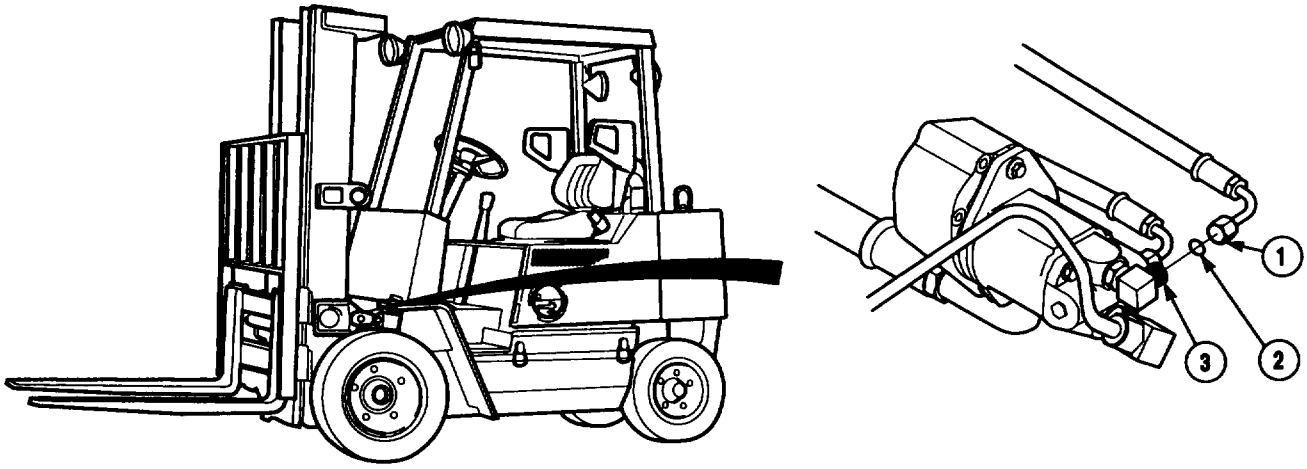
(c) Remove two clamps (2), seal (4), and hose (5). Discard seal.

(2) Installation.

(a) Position hose (5) and seal (4) on main hydraulic pump (3) with two clamps (2) and four screws (1).

(b) Tighten four screws (1) 325-425 lb-in (37-48 N•m).

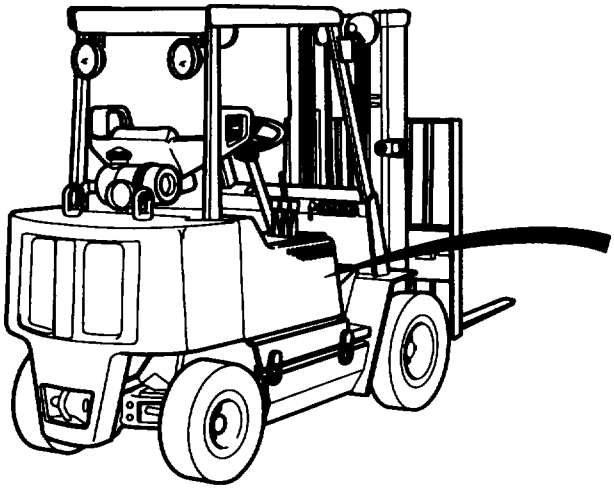
b. Threaded Connector Hose.

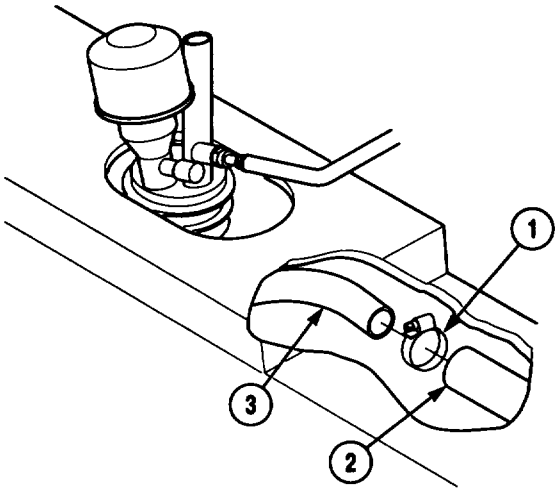


(1) Removal. Remove fitting (1) and seal (2) from fitting (3). Discard seal.

(2) Installation. Install fitting (1) and seal (2) on fitting (3).

c. Compression Clamp Hose.





(1) Removal.

(a) Loosen clamp (1).

(b) Remove hose (2) and clamp (1) from fitting (3).

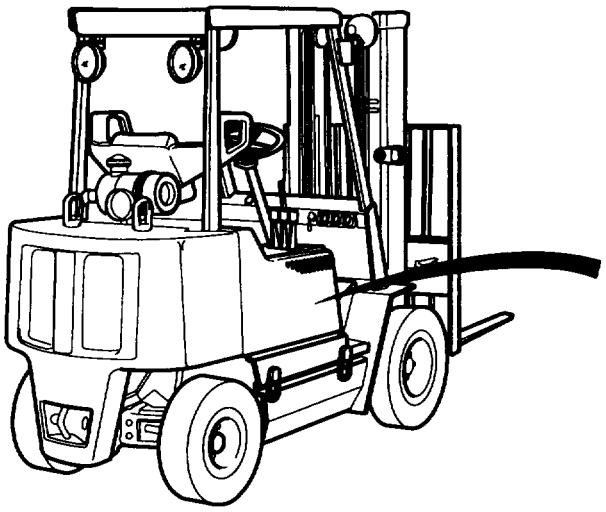
(2) Installation.

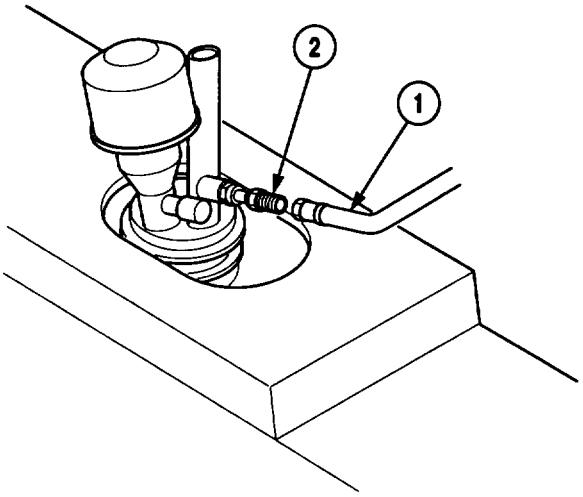
(a) Position hose (2) on fitting (3) with clamp (1).

(b) Tighten clamp (1) on hose (2).

d. Low Pressure Hose.

(1) Removal.





Remove hose (1) from fitting (2).

(2) Installation.

(a) Apply sealant to fitting (2).

(b) Install hose (1) on fitting (2).

END OF TASK

3-31. GENERAL HYDRAULIC PIPING REPLACEMENT.

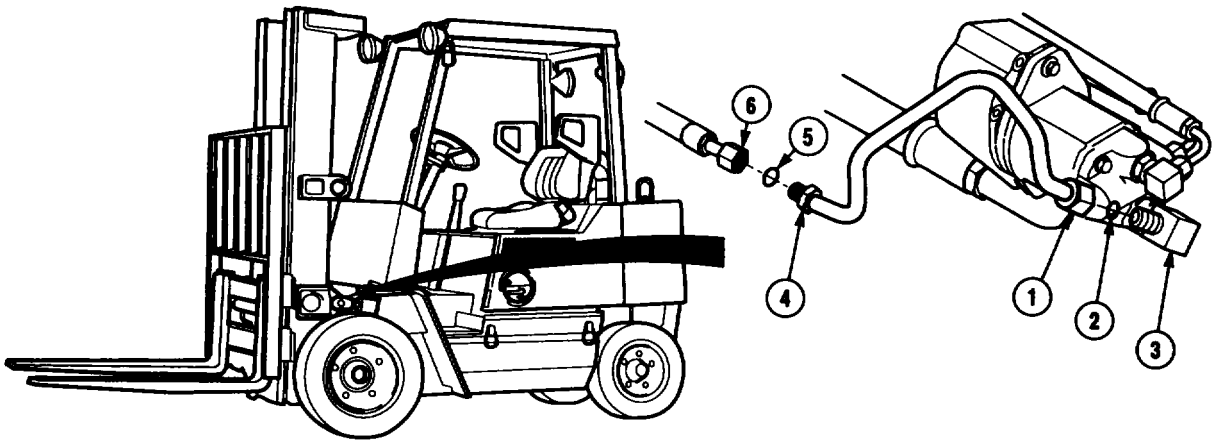
a. Removal. The truck is equipped with rigid hydraulic pipe connections. The following procedures cover removal and installation of these fittings. These procedures will apply to all rigid piping installed on truck.

WARNING

Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

NOTE

- **The subparagraphs show a typical connection and fittings on truck.**
- **This procedure is for reference only to show piping replacement procedures used on truck. It will never be necessary to remove all hydraulic piping at one time. Individual procedures will indicate the area where is to be removed and installed.**
- **Some hydraulic piping will have straps holding it to a stable frame part to reduce vibration during operation.**
- **Some hydraulic pipe fittings will have a preformed packing. Preformed packings should be replaced whenever corresponding fitting is removed.**
- **Place suitable container with a 1 gallon (3.8 liters) capacity under any hydraulic pipe that is being disconnected to catch spilling hydraulic fluid.**



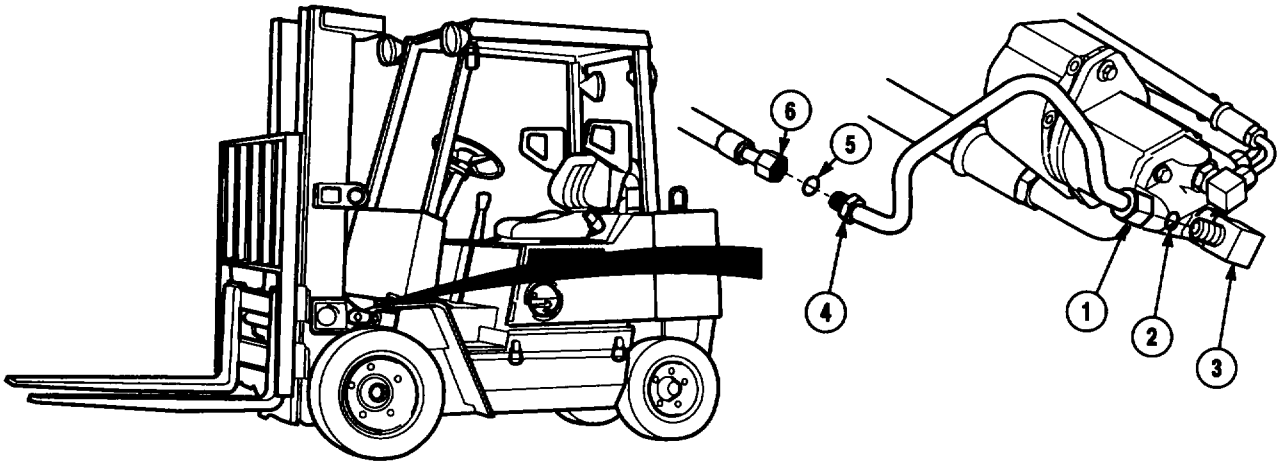
(1) With the forklift turned OFF, operate hydraulic control levers to relieve all pressure from the hydraulic system.

(2) Remove floor panel from forklift (Para 3-36).

(3) Remove hydraulic pipe fitting (1) and seal (2) from fitting (3).

(4) Remove hydraulic pipe fitting (4) and seal (5) from hose (6).

b. Installation.



(1) Install hydraulic pipe fitting (4) and seal (5) on hose (6).

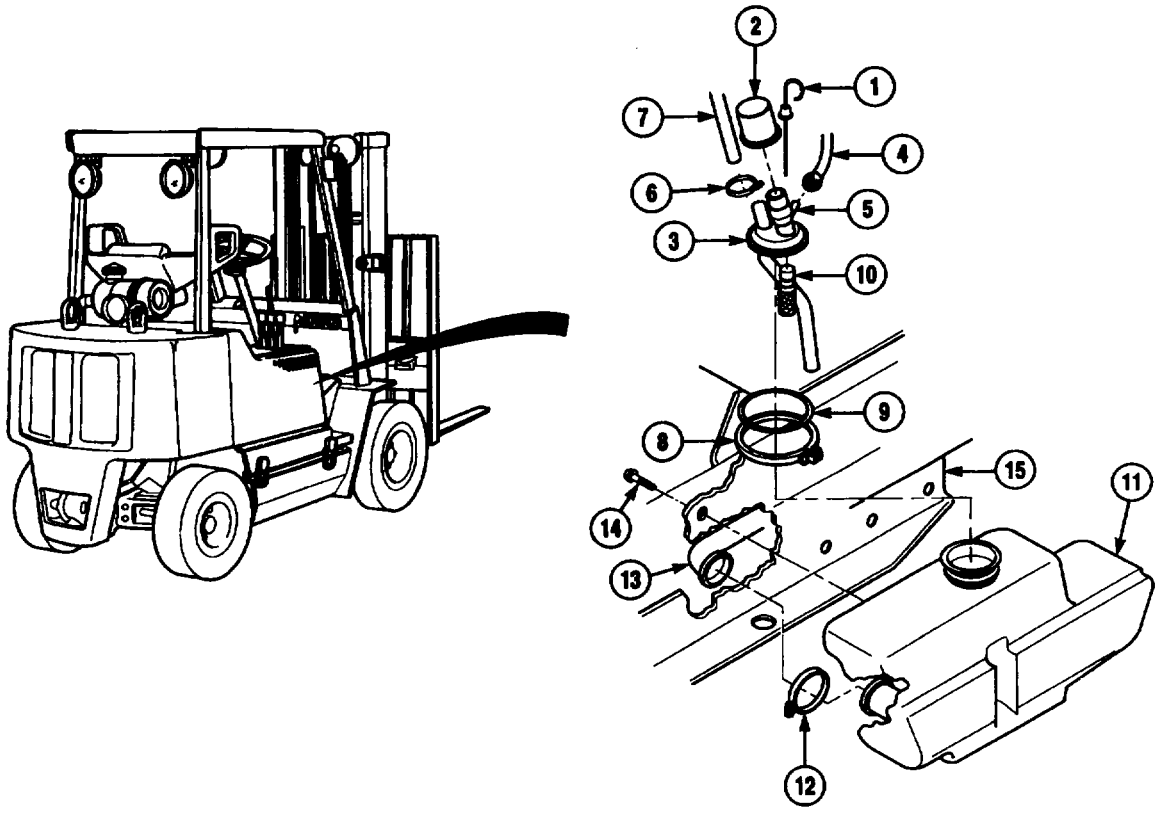
(2) Install hydraulic pipe fitting (1) and seal (2) on fitting (3).

(4) Install floor panel on forklift (Para 3-36).

END OF TASK

3-32. HYDRAULIC RESERVOIR REPLACEMENT.

a. Removal.



(1) Disconnect batteries (Para 3-25).

WARNING

Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

(2) Drain hydraulic reservoir (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

(3) Remove dipstick (1) and breather cap (2) from hydraulic sump cover (3).

(4) Remove hose (4) from fitting (5).

(5) Remove clamp (6) and hose (7) from hydraulic sump cover (3).

(6) Remove clamp (8), seal (9), hydraulic sump cover (3), and screen (10) from hydraulic sump (11). Discard seal.

(7) Remove clamp (12) and pipe (13) from hydraulic sump (11).

(8) Remove two screws (14) and hydraulic sump (11) from frame (15).

b. Installation.

WARNING

Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

(1) Install hydraulic sump (11) on frame (15) with two screws (14). Tighten screws 180-220 lb-in (20-25 N•m).

(2) Install pipe (13) on hydraulic sump (11) with clamp (12).

(3) Install screen (10) and hydraulic sump cover (3) on hydraulic sump (11) with seal (9) and clamp (8).

(4) Install hose (7) on hydraulic sump cover (3) with clamp (6).

(5) Apply sealing compound to threads of fitting (5).

(6) Install hose (4) on fitting (5).

(7) Install breather cap (2) and dipstick (1) on hydraulic sump cover (3).

(8) Replace hydraulic filter (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

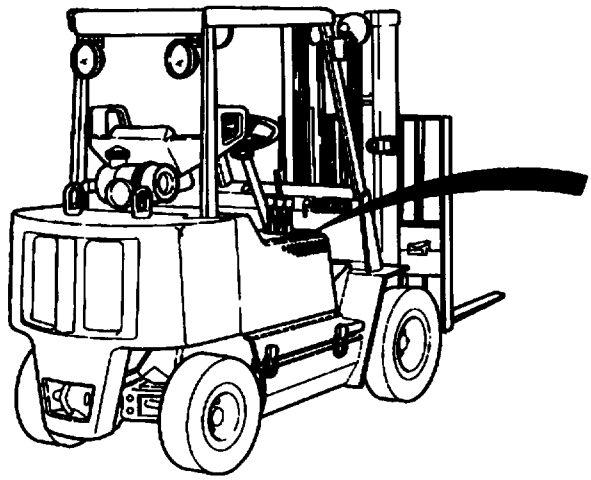
(9) Fill hydraulic reservoir (Appendix F, Hydraulic Sump - Fluid and Filter Change, Section 10.1).

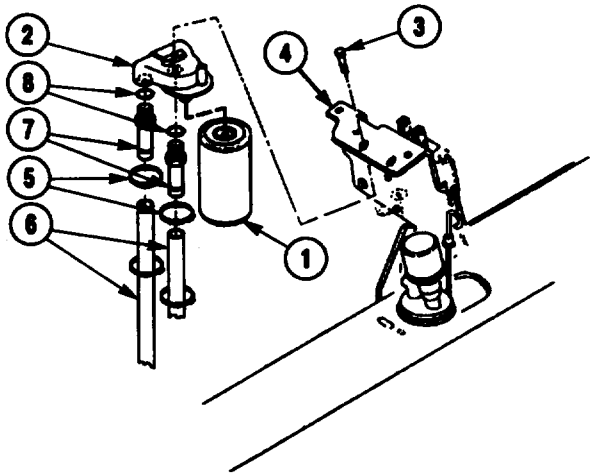
(10) Connect batteries (Para 3-25).

END OF TASK

3-33. HYDRAULIC OIL FILTER BASE ASSEMBLY REPAIR.

a. Removal.





(1) Disconnect batteries (Para 3-25).

(2) Operate hydraulic control valve levers to relieve all pressure from hydraulic system.

(3) Remove valve control cover (Para 3-36, Step a [11]).

WARNING

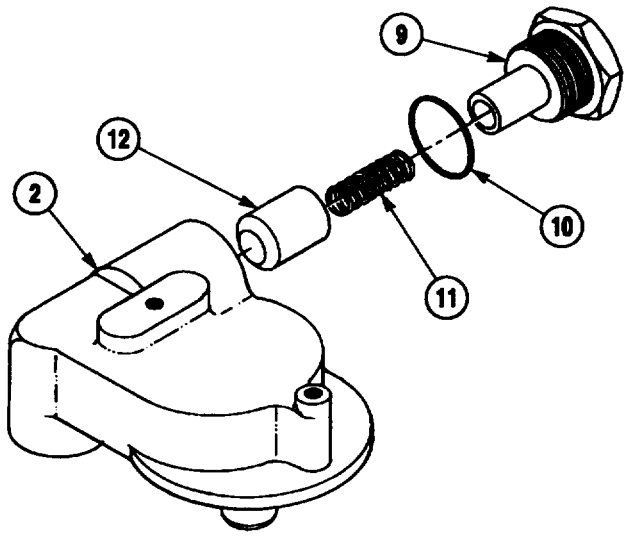
Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.

(4) Remove hydraulic oil filter (1) from base (2).

(5) Remove two screws (3) and base (2) from bracket (4).

(6) Remove two clamps (5) and hoses (6) from two fittings (7).

(7) Remove two fittings (7) and seals (8) from base (2). Discard seals.



WARNING

- **Hydraulic fluid is slippery and can cause personal injury when spilled on a floor or other smooth surface. Precautions should be taken to avoid any spillage and to clean up any spills when they occur.**
- **Use care when removing relief valve plug. Relief valve plug is under spring tension and can act as a projectile when released and could cause severe eye injury.**

b. Disassembly. Remove relief valve plug (9), seal (10), spring (11), and valve (12) from hydraulic oil filter base (2). Discard seal.

c. Assembly. Install valve (12) in hydraulic oil filter base (2) with spring (11), seal (10), and relief valve plug (9).

d. Installation.

(1) Install two fittings (7) and seals (8) in base (2). Tighten fittings 67-75 lb-ft (90-102 N•m).

(2) Install two hoses (6) on two fittings (7) with two clamps (5).

(3) Install base (2) on bracket (4) with two screws (3). Tighten screws 15-18 lb-ft (20-25 N•m).

(4) Install hydraulic oil filter (1) on base (2).

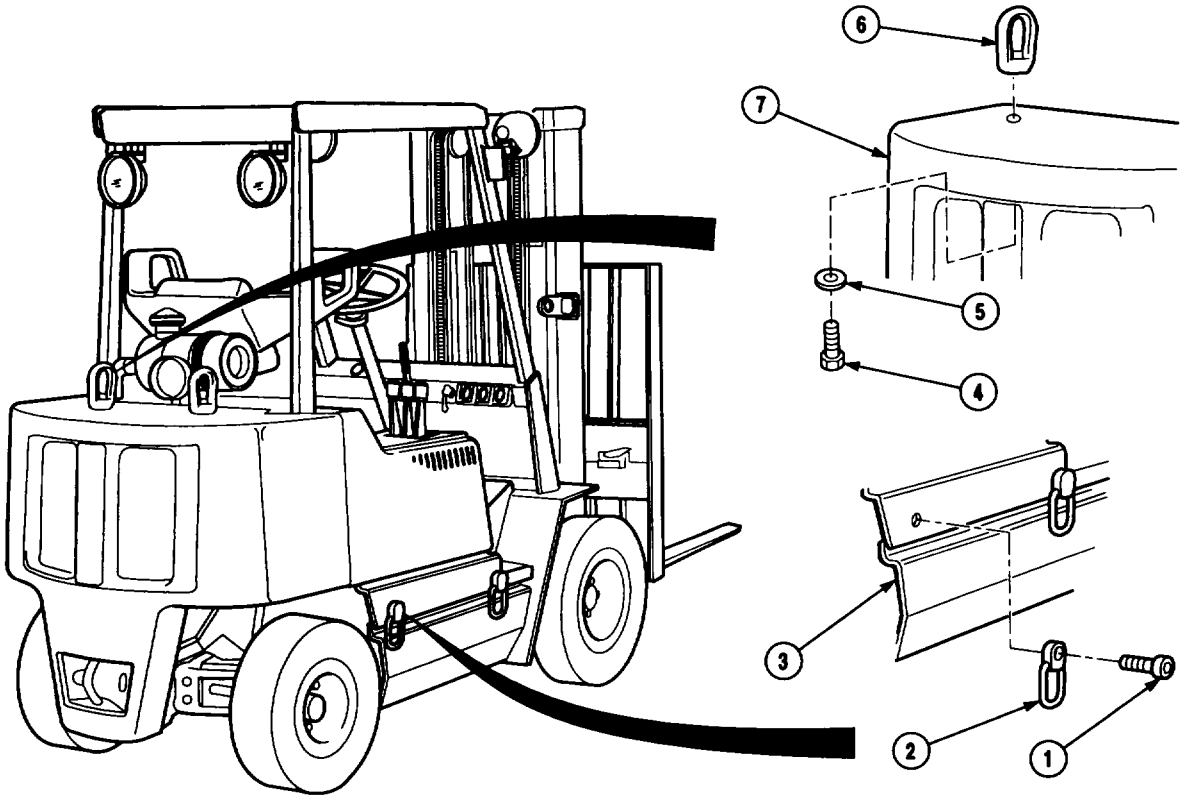
(5) Install valve control cover (Para 3-36, Step b [7]).

(6) Connect batteries (Para 3-25).

END OF TASK

3-34. LIFTING EYE AND TIEDOWN REPLACEMENT.

a. Removal.



NOTE

- **Both lifting eyes are removed in the same way.**
- **All four tiedowns are removed in the same way.**

(1) Remove socket-head screw (1) and tie down (2) from frame (3).

(2) Remove screw (4), washer (5), and lifting eye (6) from counterweight (7).

b. Installation.

NOTE

- **Both lifting eyes are installed in the same way.**
- **All four tiedowns are installed in the same way.**

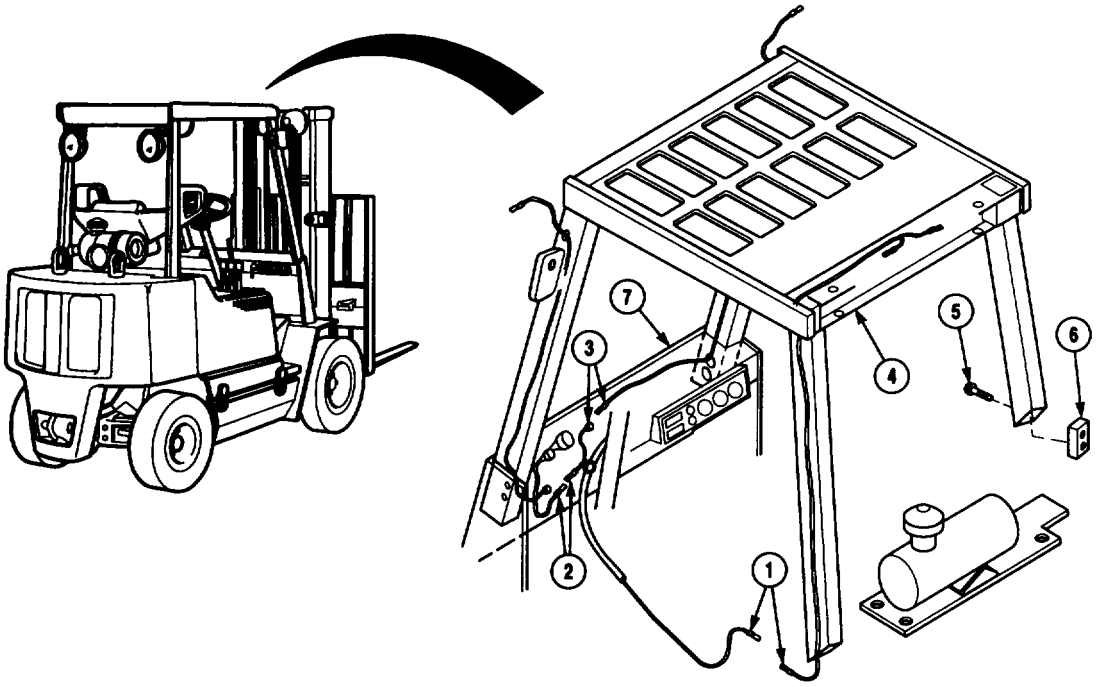
(1) Install lifting eye (6) on counterweight (7) with washer (5) and screw (4). Tighten screw 484-544 lb-ft (656 to 738 N•m).

(2) Install tie down (2) on frame (3) with socket-head screw (1). Tighten socket-head screw 280 lb-ft (380 N•m).

END OF TASK

3-35. OVERHEAD GUARD REPLACEMENT.

a. Removal.



NOTE

- **Remove flood lights only if required.**
- **If removing flood lights, perform Step (1), then proceed to Step (3).**
- **If not removing flood light, start at Step (2).**

(1) Remove flood lights (Para 3-24).

(2) Disconnect batteries (Para 3-25).

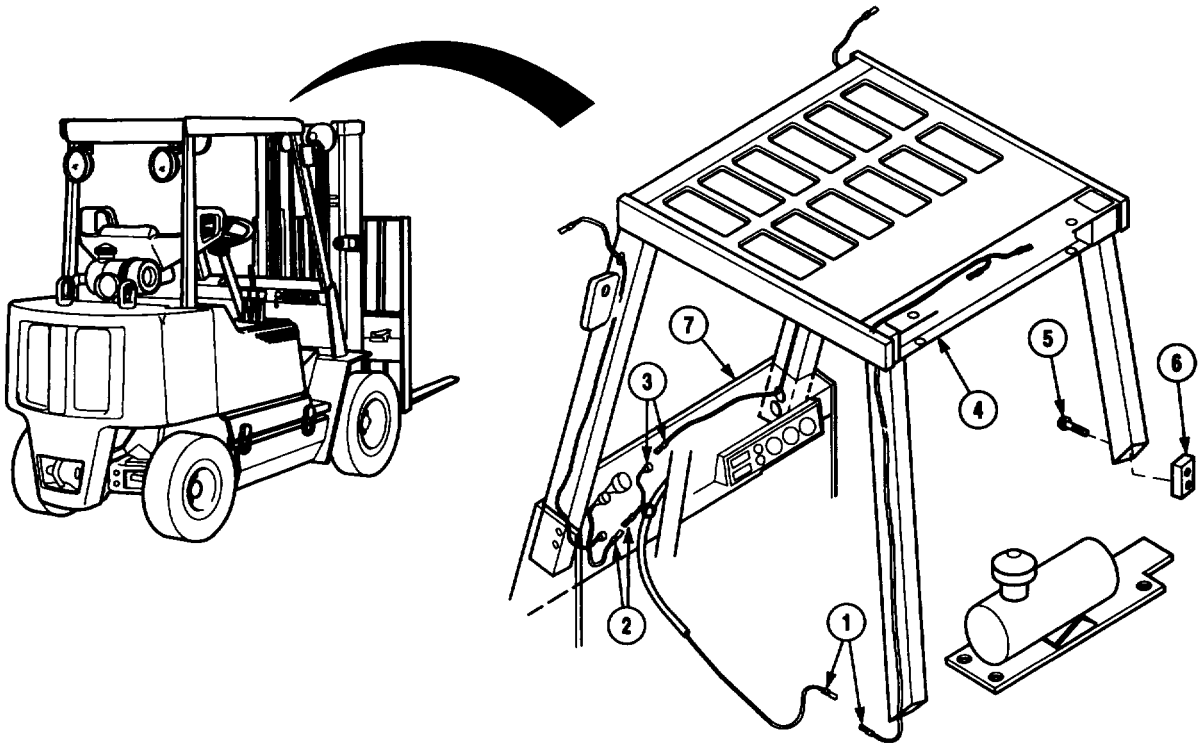
NOTE

Tag and mark all wires prior to removal.

(3) Remove instrument panel (Para 3-36).

(4) Disconnect three connectors (1, 2, and 3).

(5) Remove intake tube (Para 3-18a, Steps (2)[h] - (2)[k]).



WARNING

Overhead guard weighs 195 lb (88 Kg). Ensure suitable lifting device is attached properly to overhead guard prior to removal to prevent injury to personnel.

(6) Attach a suitable lifting device to overhead guard (4) and apply lifting tension.

(7) Remove eight screws (5) and four plates (6) from overhead guard (4).

(8) Remove overhead guard (4) from forklift (7).

b. Installation.

(1) Using a suitable lifting device, install overhead guard (4) on forklift (7) with eight screws (5) and plates (6). Tighten screws 50-55 lb-ft (65-75 N•m)

(2) Install intake tube (Para 3-18, Step (1)[fl - (1)[i]).

(3) Connect three connectors (1, 2, and 3) as tagged and marked during removal.

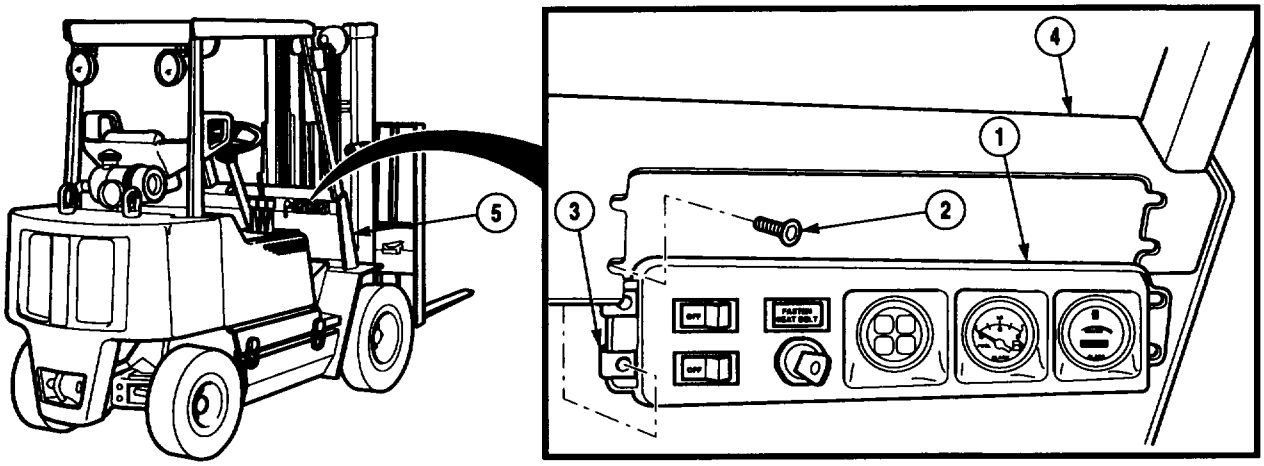
(4) Install instrument panel (Para 3-36).

(5) Install flood lights, as required (Para 3-24).

END OF TASK

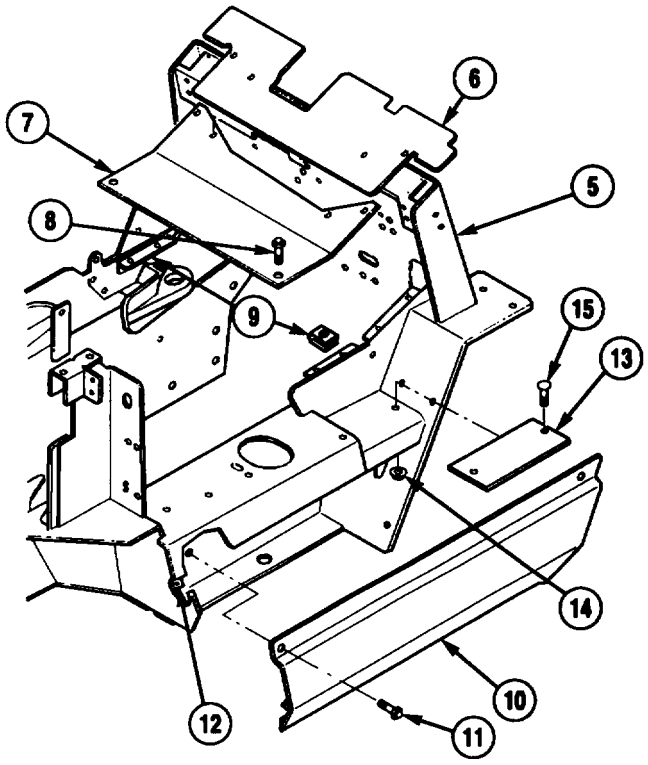
3-36. BODY PANEL REPLACEMENT.

a. Removal.



(1) Disconnect batteries (Para 3-25).

(2) To remove instrument panel (1), remove four screws (2), instrument panel, and four clips (3) from frame (4) of forklift (5).



(3) To remove floor plates (6 and 7), proceed as follows:

NOTE

Remove clips only if required.

(a) Remove four screws (8) and front floor plate (6) from forklift (5).

(b) Remove two screws (8), rear floor plate (7) and four clips (9) from forklift (5).

NOTE

Left- and right-side plates are removed the same way. Right-side plate is shown.

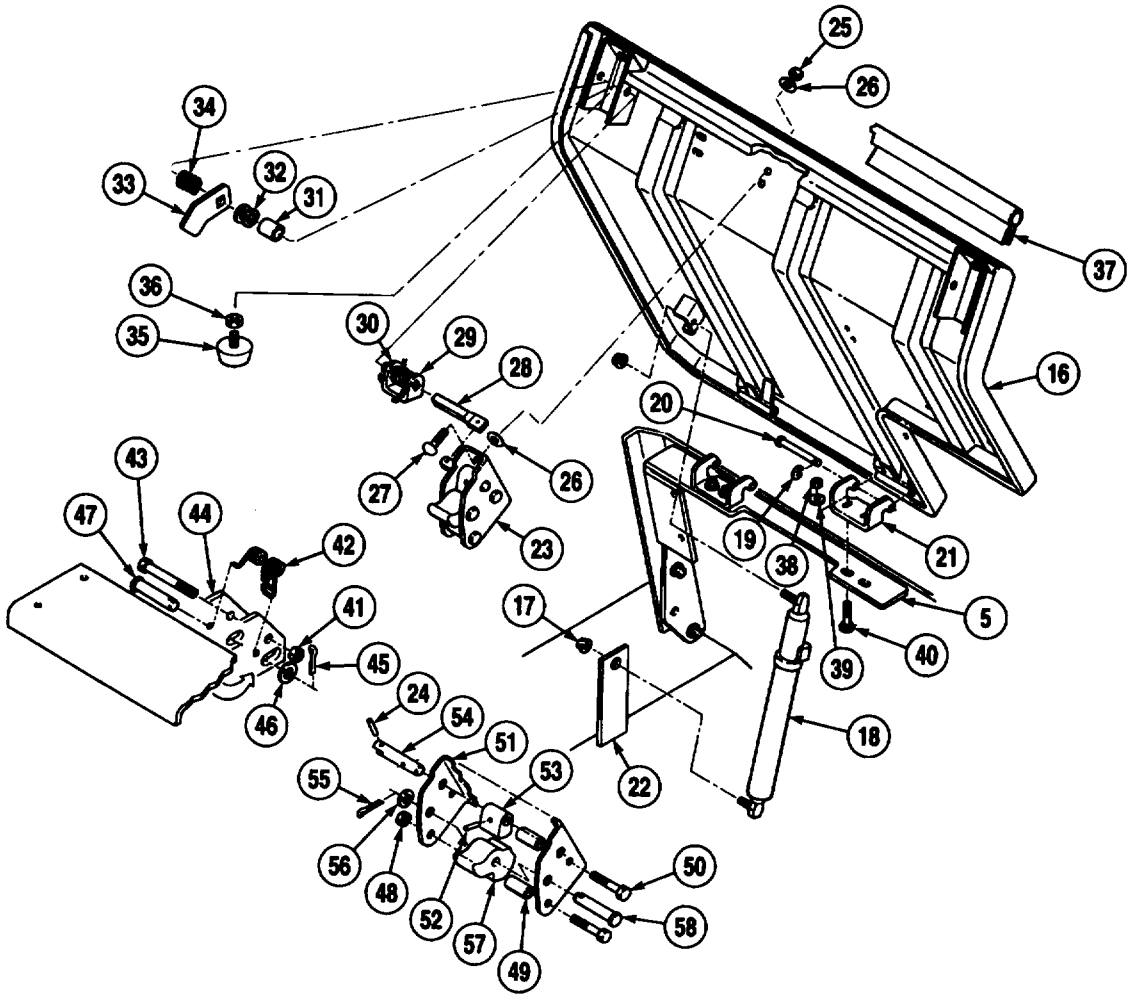
(4) Remove four screws (11), right-side plate (10), and four clips (12) from forklift (5).

NOTE

Left and right step plates are removed the same way. Right step plate is shown.

(5) Remove two nuts (14), screws (15), and step plate (13) from forklift (5).

(6) Remove left-side and right-side hoods (TM 10-3930-671-10).



(7) To remove top hood (16), proceed as follows:

(a) Remove seat from top hood (Para 3-36).

NOTE
Remove insulation only if required.

(b) Remove insulation from top hood (Para 3-37).

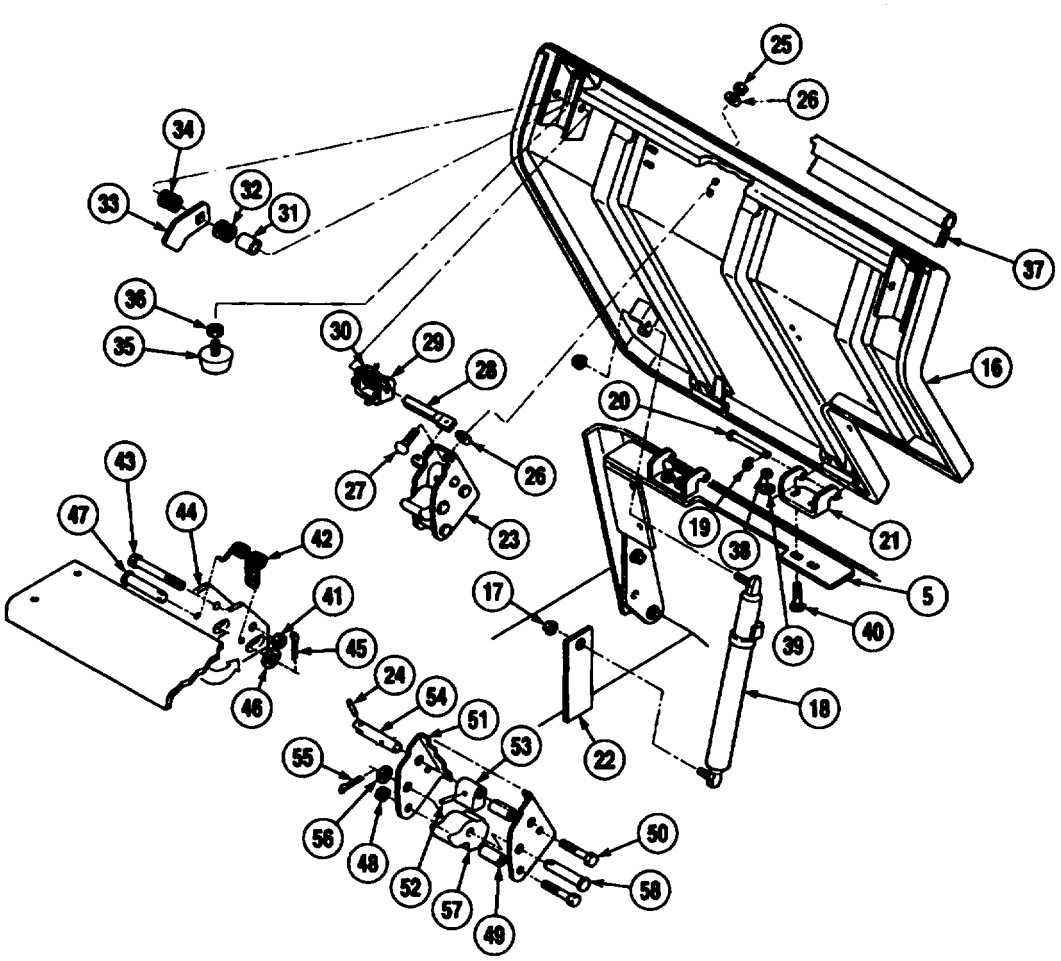
NOTE
Support the weight of the top hood during removal with the aid of an assistant.

(c) With the aid of an assistant, remove two nuts (17) from spring gas cylinder assembly (18).

(d) With the aid of an assistant, remove two retaining rings (19), pins (20), spring gas cylinder assembly (18), and top hood (16) from seat hinge bracket (21) and bracket (22).

(8) To remove hood latch assembly (23), proceed as follows:

(a) Remove pin (24), two nuts (25), four washers (26), two screws (27), and hood latch assembly (23).



WARNING

Use care when removing springs. Latch springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(b) Remove pin (28), lever (29), spring (30), spacer (31), spring (32), handle (33), and spring (34) from top hood (16).

(c) Remove two bumper pads (35) and nuts (36) from top hood (16).

(d) Remove trim seal (37) from top hood (16).

(e) Remove four nuts (38), washers (39), screws (40), and two seat hinge brackets (21) from forklift (5).

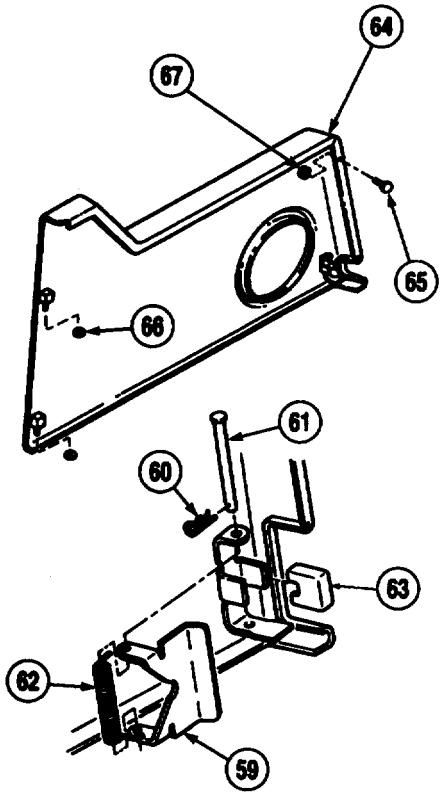
(f) Remove nut (41), spring (42), and screw (43) from bracket (44).

(g) Remove pin (45), washer (46), and pin (47) from bracket (44).

(h) Remove two nuts (48), spacers (49), and screws (50) from latch bracket (51).

(i) Remove pin (52), lock (53), and pivot lock shaft (54) from latch bracket (51).

(j) Remove pin (55), washer (56), latch (57), and pin (58) from latch bracket (51).



NOTE

The procedure to remove side hood latch is the same for both left- and right-side hoods. Left-side hood is shown.

(9) To remove side hood latch (59), proceed as follows:

(a) Remove pin (60) from pin (61).

WARNING

Use care when removing springs. Latch springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(b) Remove pin (61), latch (59), spring (62), and pad (63) from left-side hood (64).

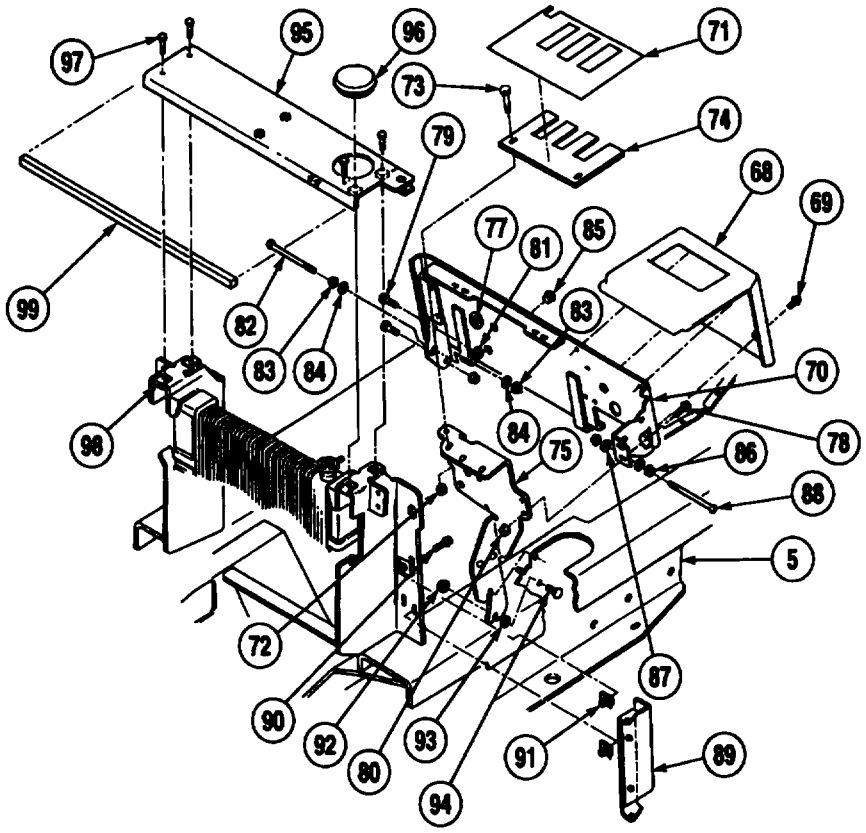
NOTE

The procedure to remove side hood bumpers and rubber washers is the same for both left- and right-side hoods. Left-side hood is shown.

(10) To remove side hood bumpers (65) and rubber washers (66), proceed as follows:

(a) Remove nut (67) and bumper (65) from left-side hood (64).

(b) Remove two rubber washers (66) from left-side hood (64).



(11) To remove cover (68), remove four screws (69) and cover (68) from front assembly plate (70).

(12) Remove rubber mat (71), two nuts (72), screws (73), and plate (74) from valve mounting bracket (75).

(13) To remove front assembly plate (70), proceed as follows:

(a) Remove master power switch (77) from front assembly plate (70) (Para 3-22, Step a(1)[g]).

(b) Remove two screws (78), screws (79), nuts (80), nuts (81), latch stud (82), two nuts (83), washers (84), and front assembly plate (70) from forklift (5).

(c) Remove button plug (85) from front assembly plate (70).

(d) Remove two nuts (86), washers (87), and latch stud (88) from front assembly plate (70).

NOTE

The procedure to remove brackets is the same for both left and right hinge brackets. Right-side hinge bracket is shown.

(14) To remove hinge bracket (89), remove two screws (90), fasteners (91), and hinge bracket (89) from forklift (5).

(15) To remove valve mounting bracket (75), proceed as follows:

(a) Remove hydraulic oil filter base assembly (Para 3-33).

(b) Remove two nuts (92), washers (93), screws (94), and valve mounting bracket (75) from forklift (5).

(16) To remove cover plate (95), proceed as follows:

(a) Remove radiator cap cover (96) from cover plate (95).

(b) Remove four screws (97), cover plate (95), and four fasteners (98) from forklift (5).

(c) Remove seal (99) from cover plate (95).

b. Installation.

(1) To install cover plate (95), proceed as follows:

(a) Install seal (99) on cover plate (95).

(b) Install cover plate (95) on forklift (5) with four screws (97) and four fasteners (98). Tighten screws 30-35 lb-ft (40-50 N•m).

(c) Install radiator cap cover (96) on cover plate (95).

(2) Install valve mounting bracket (75) on forklift (5) with two screws (94), washers (93), and nuts (92). Tighten screws 30-35 lb-ft (40-50 N-m).

(3) Install hydraulic oil filter base assembly (Para 3-33).

NOTE

The procedure to install brackets is the same for both left and right hinge brackets. Right-side hinge bracket is shown.

(4) Install hinge bracket (89) on forklift (5) with two fasteners (91), screws (90), and hinge bracket (89).

(5) To install front assembly plate (70), proceed as follows:

(a) Install latch stud (88) on front assembly plate (70) with two nuts (86) and washers (87).

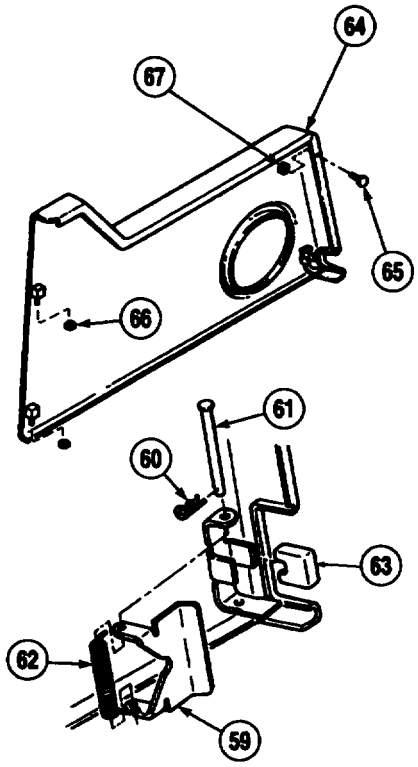
(b) Install two button plugs (85) on front assembly plate (70).

(c) Install front assembly plate (70) on forklift (5) with latch stud (82), two nuts (83), washers (84), screws (78), screws (79), nuts (80), and nuts (81). Tighten screws (71) 30-35 lb-ft (40-50 N•m) and screws (72) 53-59 lb-ft (72-80 N•m).

(d) Install master power switch (77) on front assembly plate (70) (Para 3-22, Step a(2)[a]).

(6) Install plate (74) with rubber mat (71) on valve mounting bracket (75) with two screws (73) and nuts (72). Tighten nuts 30-35 lb-ft (40-50 N•m).

(7) Install cover (68) on front assembly plate (70) with four screws (69). Tighten screws 180-220 lb-in (20-25 N•m).



(8) To install side hood bumpers (65) and rubber washers (66), proceed as follows:

NOTE

The procedure to install side hood bumpers and rubber washers is the same for both left- and right-side hoods. Left side hood is shown.

(a) Install bumper (65) on left-side hood (64) with nut (67).

(b) Install two rubber washers (66) on left-side hood (64).

(9) To install side hood latch (59), proceed as follows:

NOTE

The procedure to install side hood latch is the same for both left- and right-side hoods. Left side hood is shown.

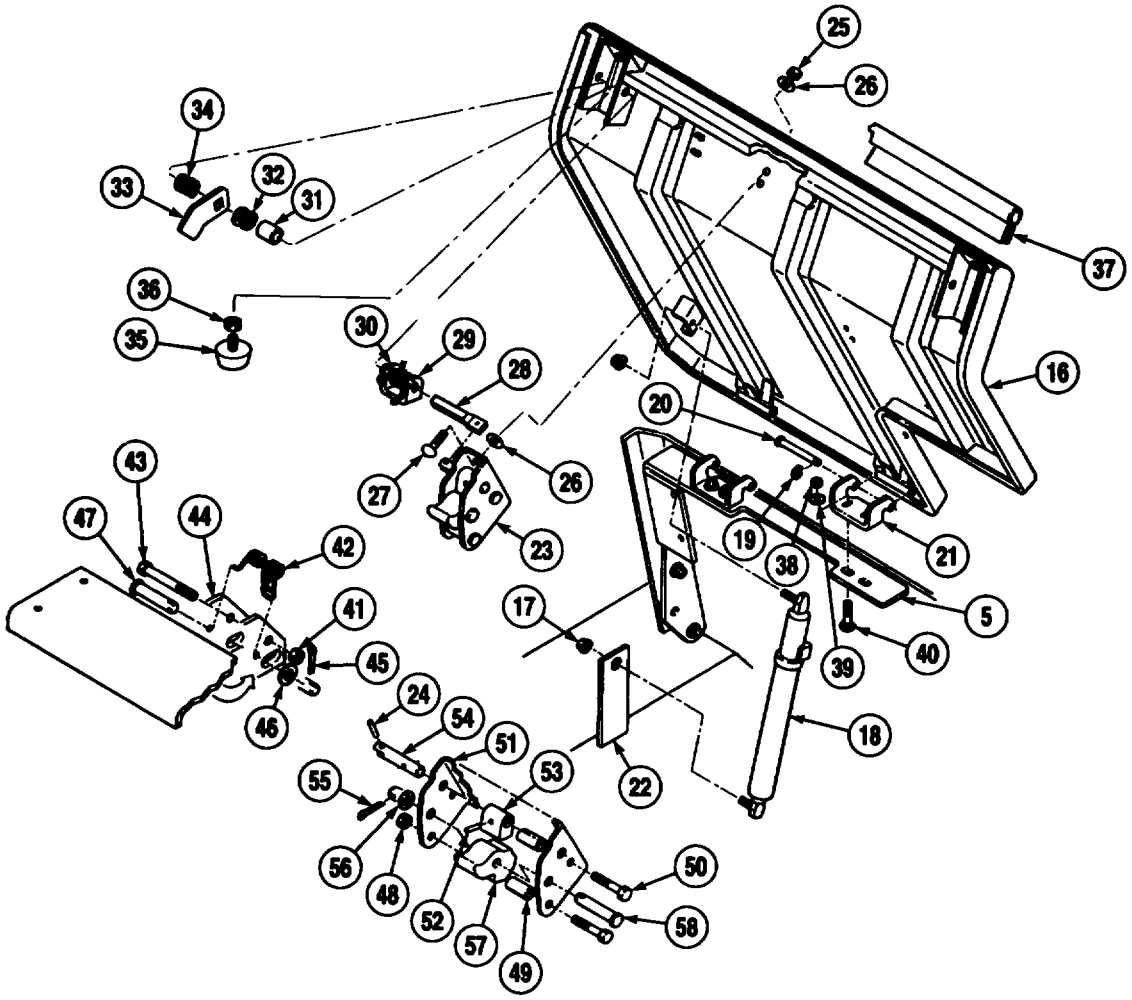
WARNING

Use care when installing springs. Latch springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(a) Install pad (63) on left-side hood (64).

(b) Install latch (59) and spring (62) on left-side hood (64) with pin (61).

(c) Install pin (60) in pin (61).



(10) To install hood latch assembly (23), proceed as follows:

(a) Assemble latch bracket (51) with pin (58), latch (57), washer (56), and pin (55).

(b) Install pivot lock shaft (54) in latch bracket (51) and lock (53) with pin (52).

(c) Install two spacers (49) in latch bracket (51) with two screws (50) and nuts (48). Tighten nut 70-85 lb-in (8-10 N•m).

(d) Install two seat hinge brackets (21) on forklift (5) with four screws (40), washers (39), and nuts (38). Tighten nuts 180-220 lb-in (20-25 N•m).

(e) Install trim seal (37) on top hood (16).

(f) Install two bumper pads (35) and nuts (36) on top hood (16).

WARNING

Use care when installing springs. Latch springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(g) Install spring (34), handle (33), spring (32), spacer (31), lever (29), and spring (30) on top hood (16) with pin (28).

(h) Install hood latch assembly (23) on top hood (16) with pin (24), two screws (27), four washers (26), and two nuts (25). Tighten nuts 180-220 lb-in (20-25 N•m).

WARNING

Use care when installing springs. Latch springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(i) Install spring (42) in bracket (44) with screw (43) and nut (41). Tighten nuts 180-220 lb-in (20-25 N•m).

(j) Install pin (47), in bracket (44) with washer (46), and pin (45).

(11) To install top hood (16), proceed as follows:

NOTE

Support the weight of the top hood during installation with the aid of an assistant.

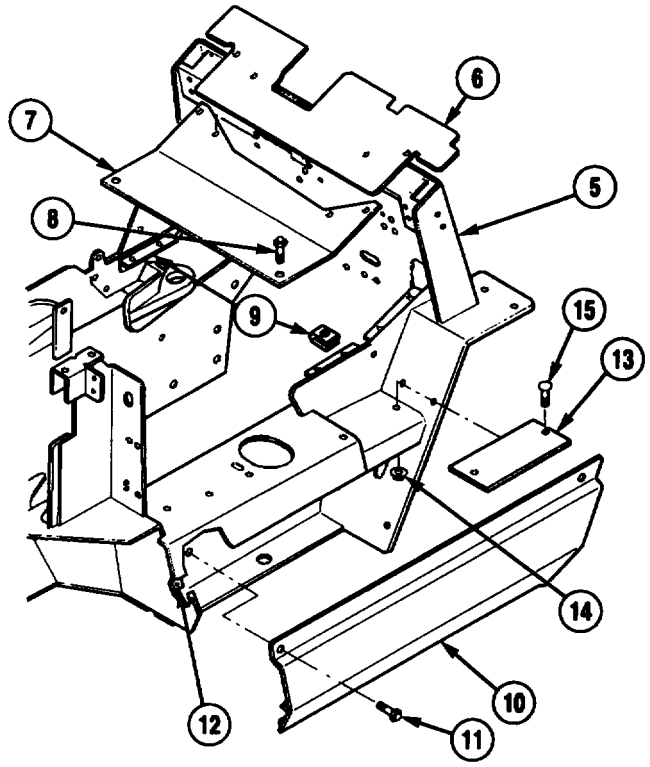
(a) With the aid of an assistant, install top hood (16) on seat hinge bracket (21) and bracket (22) with spring gas cylinder assembly (18), two pins (20), and retaining rings (19).

(b) With the aid of an assistant, install two nuts (17) on spring gas cylinder assembly (18). Tighten nuts 180-220 lb-in (20-25 N•m).

(c) Install insulation on top hood (Para 3-37).

(d) Install seat on top hood (Para 3-36).

(12) Install left-side and right-side hoods (TM 10-3930-671-10).



NOTE

Left and right step plates are installed the same way. Right step plate is shown.

(13) Install step plate (13) on forklift (5) with two screws (15) and nuts (14). Tighten nuts 180-220 lb-in (20-25 N•m).

NOTE

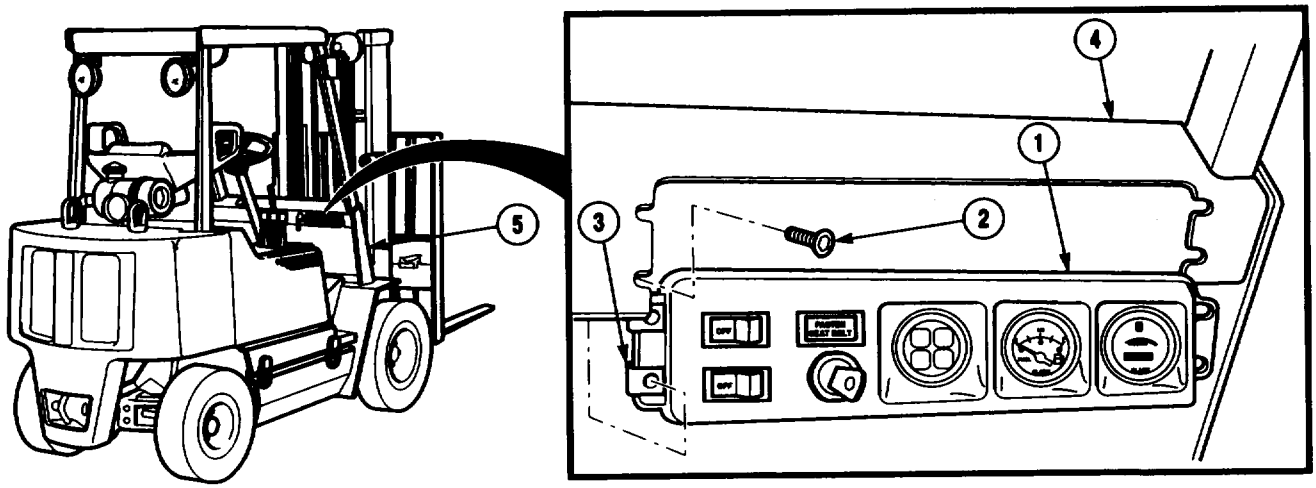
Left- and right-side plates are installed the same way. Right-side plate is shown.

(14) Install right-side plate (10) on forklift (5) with four clips (12) and screws (11). Tighten screws 30-37 lb-ft (40-50 N•m).

(15) To install floor plates (6 and 7), proceed as follows:

(a) Install rear floor plate (7) on forklift (5) with two clips (9) and screws (8). Tighten nuts 180-220 lb-in (20-25 N•m).

(b) Install front floor plate (6) on forklift (5) with four clips (9) and screws (8). Tighten nuts 180-220 lb-in (20-25 N•m).

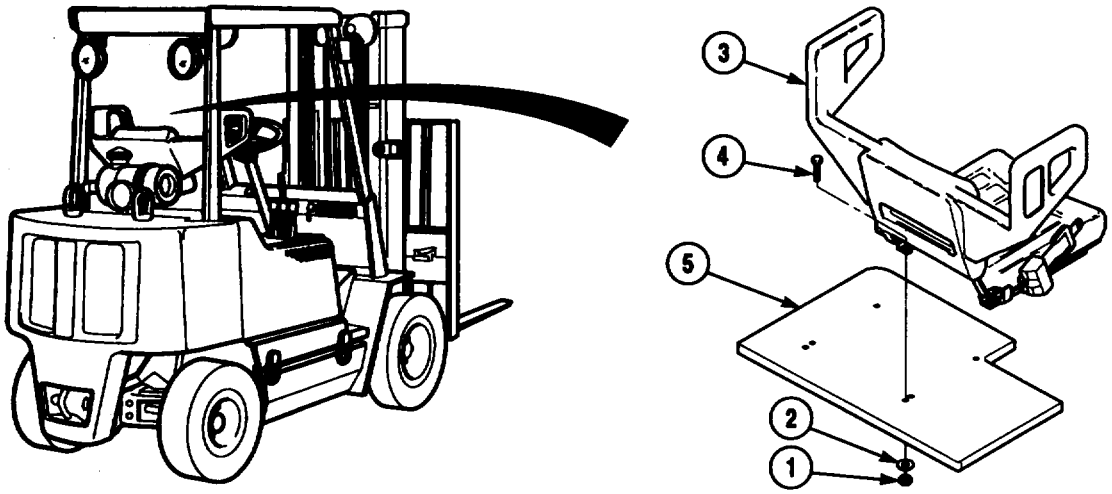


(16) Install instrument panel (1) on frame (4) of forklift (5) with four clips (3) and screws (2). Tighten screws.

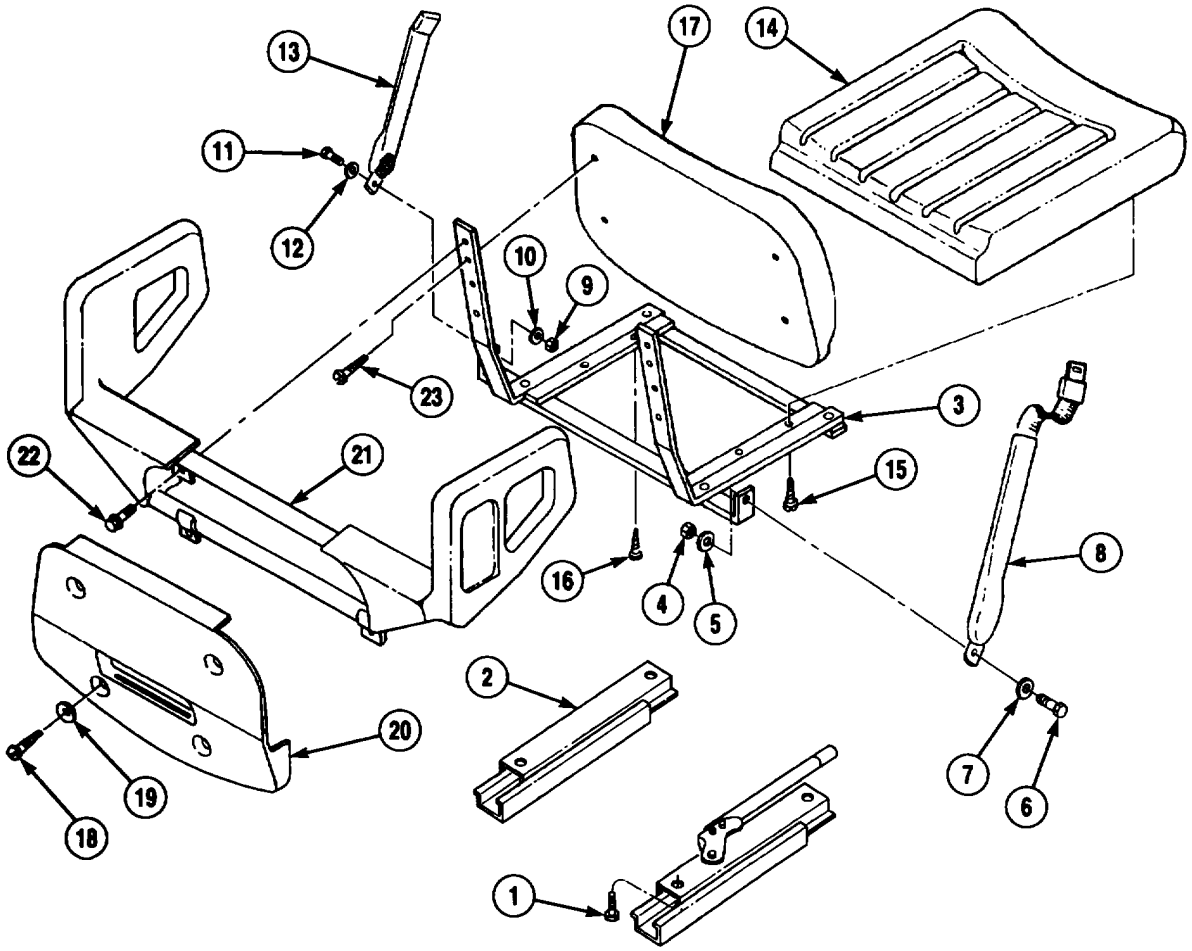
(17) Connect batteries (Para 3-25).

END OF TASK

3-37. SEAT ASSEMBLY REPLACEMENT/REPAIR.



a. Removal Remove four locknuts (1), washers (2), seat assembly (3), and four screws (4) from hood (5). Discard locknuts.



b. Disassembly.

(1) Remove four screws (1) and two seat adjusters (2) from seat frame (3).

(2) Remove nut (4), washer (5), screw (6), washer (7), and seat belt (8) from seat frame (3).

(3) Remove nut (9), washer (10), screw (11), washer (12), and seat buckle (13) from seat frame (3).

(4) If necessary to remove seat cushion (14), remove three screws (15), screw (16), and seat cushion from seat frame (3).

(5) To remove seat back rest cushion (17), proceed as follows:

(a) Remove four screws (18), washers (19), and cover (20) from restraint (21).

(b) Remove four screws (22) and restraint (21) from seat frame (3).

(c) Remove four screws (23) and seat back rest cushion (17) from seat frame (3).

c. Assembly.

(1) To install seat back rest cushion (17), proceed as follows:

(a) Install seat back rest cushion (17) on seat frame (3) with four screws (23).

(b) Install restraint (21) on seat frame (3) with four screws (22).

(c) Install cover (20) on restraint (21) with four washers (19) and screws (18).

(2) If removed, install seat cushion (14) on seat frame (3) with three screws (15) and screw (16).

(3) Install seat buckle (13) on seat frame (3) with screw (11), washer (12), washer (10), and nut (9).

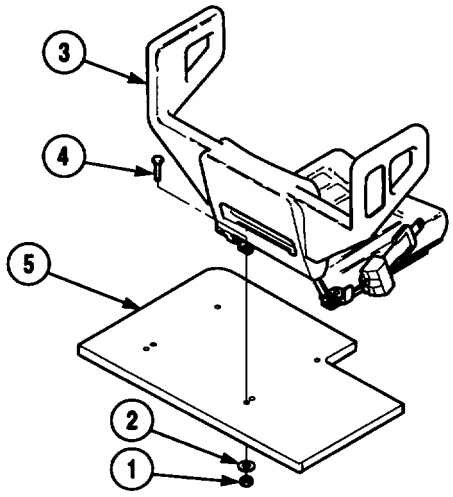
(4) Install seat belt (8) on seat frame (3) with screw (6), washer (7), washer (5), and nut (4).

(5) Install two seat adjusters (2) on seat frame (3) with four screws (1).

d. Installation. Install seat assembly (3) on hood

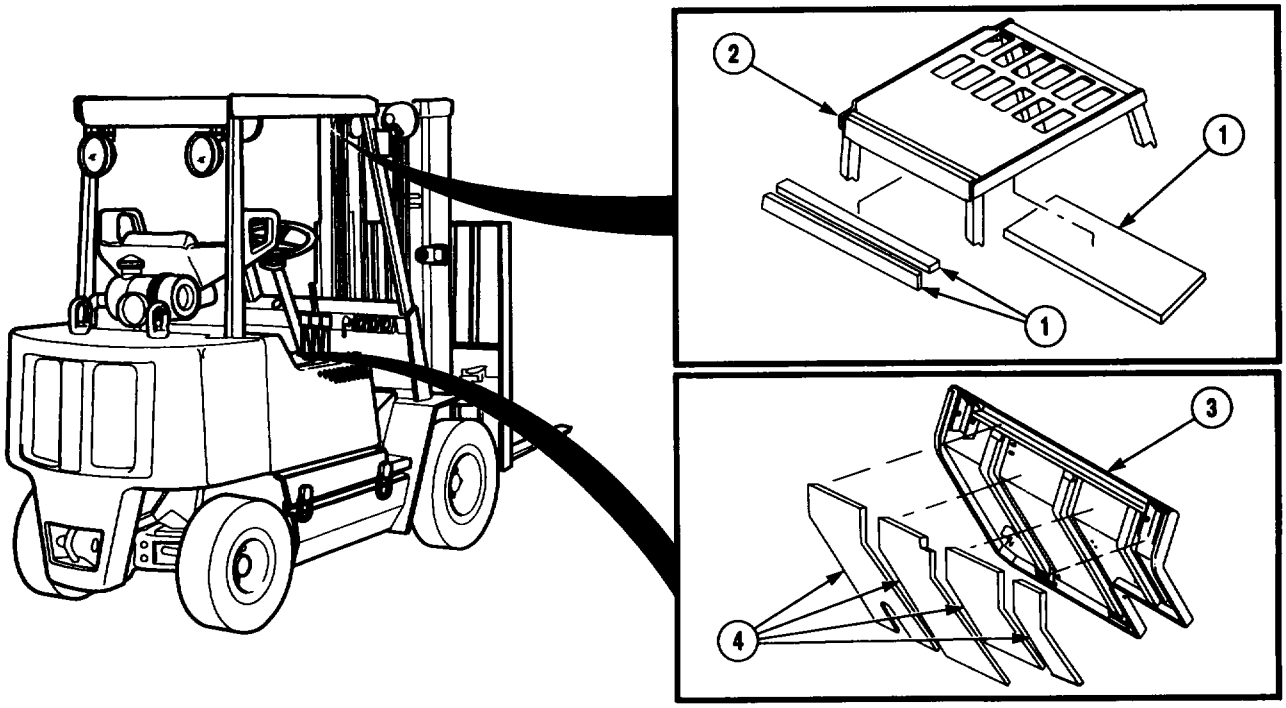
(5) with four screws (4), washers (2), and locknuts (1).

END OF TASK



3-38. INSULATION REPLACEMENT.

a. Removal.



NOTE

Note location and fit of each piece of insulation prior to removal.

(1) Remove three pieces of insulation (1) from overhead guard (2)

(2) Raise and lock top hood (3) in place (TM 10-3930-671-10).

(3) Remove four pieces of insulation (4) from top hood (3).

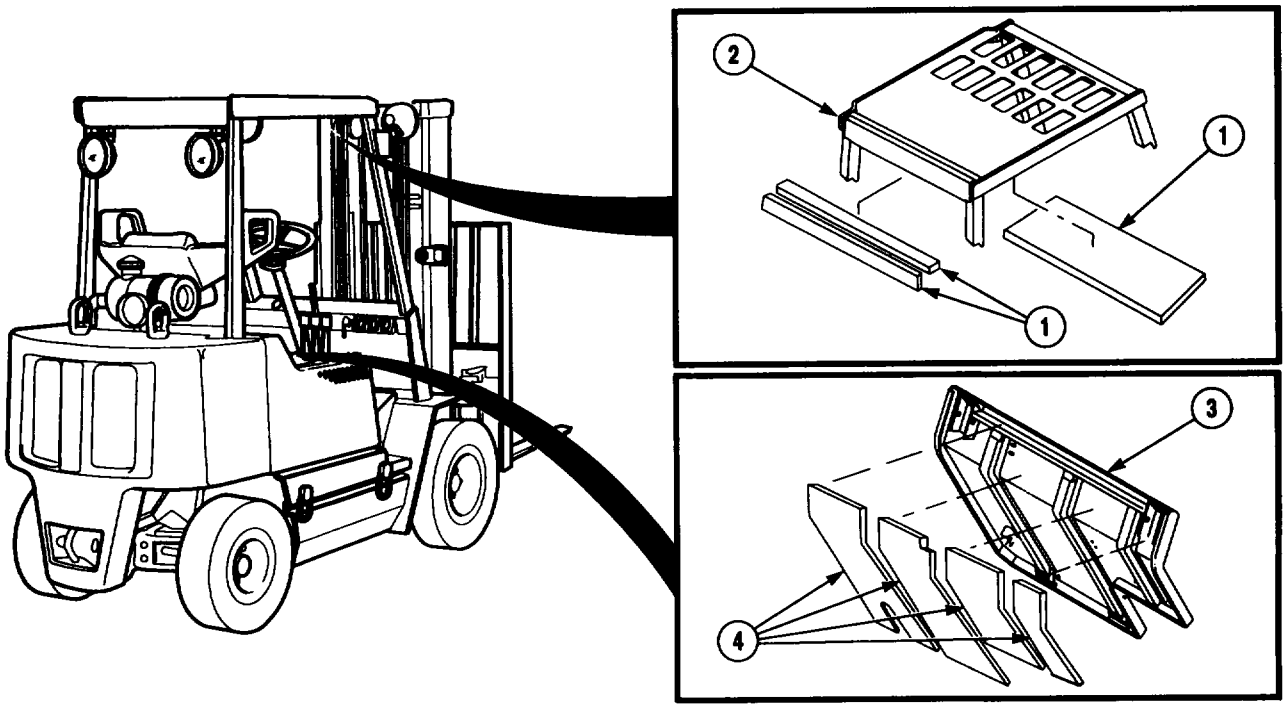
WARNING

- **Drycleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes; and do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for type 1 drycleaning solvent is 100°F (380C) and for type II is 140°F (60°C). Failure to do so may result in injury or death to personnel.**

- **If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.**

(4) Clean surface of overhead guard (2) and top hood (3) thoroughly with drycleaning solvent.

b. Installation.



(1) Cut and trim three pieces of insulation (1) and four pieces of insulation (4) as noted during removal.

WARNING

Adhesive causes immediate bonding on contact with eyes, skin, or clothing and also gives off harmful vapors. Wear protective goggles and use in well-ventilated area. If adhesive gets in eyes, try to keep eyes open; flush eyes with water for 15 minutes and get immediate medical attention.

(2) Apply adhesive to top hood (3).

(3) Position four pieces of insulation (4) on top hood (3) as shown.

(4) Close top hood (3) (TM 10-3930-671-10).

(5) Apply adhesive to overhead guard (2).

(6) Position three pieces of insulation (1) on overhead guard (2) as shown.

END OF TASK

CHAPTER 4

DIRECT SUPPORT/GENERAL SUPPORT TROUBLESHOOTING

4-1. TROUBLESHOOTING INTRODUCTION.

This section contains step-by-step procedures for identifying, locating, and isolating equipment malfunctions.

4-2. TROUBLESHOOTING SYMPTOMS.

Table 4-1 lists the most common malfunctions found during operation of the truck. Tests or inspections and corrective actions should be performed in the order listed. Table 4-2 lists corrective actions that can be performed by DS/GS maintenance. If a malfunction is not listed, or corrective action fails to correct a problem, notify your supervisor.

4-3. DS/GS TROUBLESHOOTING PROCEDURES.
Table 4-2 contains the malfunctions listed in DS/GS Troubleshooting Symptom Index (Table 4-1), test or inspection instructions required to determine cause of malfunction, and corrective actions for repairing the faulty equipment. Unit Troubleshooting Procedures (Table 2-2) should be completed before performing DS/GS Troubleshooting Procedures.

Table 4-1. DS/GS Troubleshooting Symptom Index

Troubleshooting Fault		Page
ENGINE		
1	Engine will not start	4-2
2	Engine does not run evenly	4-2
3	A loss of power	4-2
4	Oil consumption above normal	4-3
5	Black exhaust smoke	4-3
6	White exhaust smoke	4-4
7	Truck slow to accelerate	4-5
8	Engine knocking	4-5

Table 4-2. DS/GS Troubleshooting Procedures.

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

ENGINE

1. ENGINE WILL NOT START.

Step 1. Check for faulty fuel injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3).

If fuel injector(s) is faulty, replace injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3).

If fuel injector(s) is OK, go to step 2.

Step 2. Check that fuel injection pump timing is property set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).

If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).

If fuel injection pump timing is set properly, injection pump is faulty. Replace injection pump (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).

2. ENGINE DOES NOT RUN EVENLY.

Remove fuel injector from cylinder with lowest compression rating, squirt oil into cylinder, install fuel injector, and then check compression at that cylinder (Appendix F, Engine Compression Pressure Check, Section 4.6).

If compression reading rises for that cylinder, faulty compression rings are indicated. Overhaul engine (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8).

If compression reading does not rise for that cylinder, sticking or burnt valve Is indicated. Remove and repair cylinder head assembly (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8).

3. A LOSS OF POWER.

Step 1. Check for faulty fuel injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3).

If fuel injector(s) is faulty, replace injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3).

If fuel injector(s) is OK, go to step 2.

Table 4-2. DS/GS Troubleshooting Procedures - CONT:.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
3. A LOSS OF POWER - CONT.
Step 2. Check that fuel injection pump timing is properly set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is set properly, injection pump is faulty. Replace injection pump (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).
4. OIL CONSUMPTION ABOVE NORMAL.
Step 1. Check engine compression at each cylinder. If compression at any cylinder is below 325 psi (2241 kPa), or compression varies more than 40 psi (276 kPa) across all of the cylinders, go to step 2. If compression at all cylinders is at least 325 psi (2241 kPa), or compression does not vary more than 40 psi (276 kPa) across all of the cylinders, notify supervisor.
Step 2. Remove fuel injector from cylinder with lowest compression rating, squirt oil into cylinder, install fuel injector, and then check compression at that cylinder (Appendix F, Engine Compression Pressure Test, Section 4.6). If compression reading rises for that cylinder, faulty compression rings are indicated. Overhaul engine (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8). If compression reading does not rise for that cylinder, sticking or burnt valve is indicated. Remove and repair cylinder head assembly (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8).
5. BLACK EXHAUST SMOKE.
Step 1. Check for faulty fuel injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is faulty, replace injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is OK, go to step 2.

Table 4-2. DS/GS Troubleshooting Procedures - CONT:

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
5. BLACK EXHAUST SMOKE - CONT.
Step 2. Check that fuel injection pump timing is properly set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is set properly, injection pump is faulty. Replace injection pump (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).
6. WHITE EXHAUST SMOKE.
Step 1. Check for faulty fuel injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is faulty, replace injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is OK, go to step 2.
Step 2. Check that fuel injection pump timing is properly set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is set properly, go to step 3.
Step 3. Check engine compression at each cylinder. If compression at any cylinder is below 325 psi (2241 kPa), or compression varies more than 40 psi (276 kPa) across all of the cylinders, go to step 4. If compression at all cylinders is at least 325 psi (2241 kPa), or compression does not vary more than 40 psi (276 kPa) across all of the cylinders, replace engine head gasket (Appendix F, Continental Diesel Engine, Section 4.14, Section 8).

Table 4-2. DS/GS Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
6. WHITE EXHAUST SMOKE - CONT.
Step 4. Remove fuel injector from cylinder with lowest compression rating, squirt oil into cylinder, install fuel injector, then check compression at that cylinder (Appendix F, Engine Compression Pressure Check, Section 4.6). If compression reading rises for that cylinder, faulty compression rings are indicated. Overhaul engine (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8). If compression reading does not rise for that cylinder, sticking or burned valve is indicated. Remove and repair cylinder head assembly (Appendix F, Continentel Diesel Engine, Section 4.14, Section 8).
7. TRUCK SLOW TO ACCELERATE.
Step 1. Check for faulty fuel injector(s) (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injector(s) is faulty, replace injector(s) (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injector(s) is OK, go to step 2.
Step 2. Check that fuel injection pump timing is properly set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is set properly, injection pump is faulty. Replace injection pump (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).
8. ENGINE KNOCKING.
Step 1. Check for faulty fuel injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is faulty, replace injector(s) (Appendix F, Diesel Fuel Injection System, Section 5.3). If fuel injector(s) is OK, go to step 2.

Table 4-2. DS/GS Troubleshooting Procedures - CONT.

MALFUNCTION TEST OR INSPECTION CORRECTIVE ACTION
ENGINE (CONT.)
8. ENGINE KNOCKING - CONT.
Step 2. Check that fuel injection pump timing is properly set (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5). If fuel injection pump timing is not set properly, set timing (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5)). If fuel injection pump timing is set properly, injection pump is faulty. Replace injection pump (Appendix F, Continentel Diesel Engine, Section 4.14, Section 5).

CHAPTER 5

DIRECT SUPPORT/GENERAL SUPPORT MAINTENANCE

5-1. MAINTENANCE INTRODUCTION.

This section contains overhaul procedures for those reparable parts not covered by vendor manuals. In addition to overhaul procedures for reparable assemblies, this section includes instructions, under the headings of:

a. General Removal Instructions
b. General Disassembly Instructions
c. General Cleaning Instructions
d. General Inspection Instructions
e. General Repair Instructions
f. General Assembly and Installation Instructions

These instructions apply to all procedures in this manual.

5-2. GENERAL REMOVAL INSTRUCTIONS.

Before removing any part, check Table 2-1, Unit Troubleshooting Symptom Index, or Table 4-1, DS/GS Troubleshooting Symptom Index, to determine if the trouble is actually in that component. Also, carefully observe the following procedures:

a. Before removing any component of the electrical, hydraulic, or fuel systems, make sure the system is not energized or pressurized. Disconnect the battery ground cable and relieve all pressure from the hydraulic and/or fuel systems.

b. Ensure that adequate clearance exists for removal of the component. Remove adjacent components to the extent necessary to provide adequate working clearance.

c. Before removal, clean exterior parts to remove accumulated mud, tar, grease, or other foreign materials. This will aid the inspection and disassembly process.

d. Use a suitable lifting device with an appropriate chain when lifting heavy objects. Position and attach lifting device so as to remove all strain from the mounting hardware before hardware is removed.

e. To aid in assembly and installation, apply identifying tags to mating ends of electrical, hydraulic, and fuel lines as they are removed or disconnected. Identify parts of similar configuration to ensure correct installation.

f. Note the original position of components before removing. Be sure the original position is restored.

g. Components, even though defective, should be treated as valuable items because of possible reclamation or salvage value.

5-3. GENERAL DISASSEMBLY INSTRUCTIONS.

a. Keep work area clean to avoid contamination of internal parts. This is especially important for disassembly of hydraulic components.

b. Whenever possible, replace all gaskets, packings, and seals removed during repair work. Similarly, all lockwire, lockwashers, cotter pins, and like items should be replaced during assembly.

c. To avoid scratching the sealing surfaces, do not use a metal tool when removing gaskets, packings, or seals. Use a pointed wooden dowel to remove packing from grooves. Use wooden or plastic scrapers on gasket surfaces.

d. Before disassembly of any component, study the exploded-view illustration found in either the vendor manuals, parts catalog, or this repair manual. Pay particular attention to the relationship of internal parts. Being familiar with the construction will speed up disassembly and help avoid improper assembly.

e. To prevent moisture and foreign matter from entering open housings, lines, and other openings, apply protective covers after disassembly. Wrap all parts in clean paper or dip parts in preservation oil.

f. Remove only the parts requiring repair or replacement. Do not disassemble a component any further than necessary.

5-4. GENERAL CLEANING INSTRUCTIONS.

WARNING

- **Dry cleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes, and do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for type I dry cleaning solvent is 100°F (380C) and for type II is 140°F (60°C). Failure to do so may result in injury or death to personnel.**

- **If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.**

- **Never dip or soak electrical components, packings, rubber, plastic, or Teflon parts in dry cleaning solvent. Solvent can react with material and result in severe damage or destruction of parts.**

a. Clean all metal parts with dry cleaning solvent. Do not use gasoline for cleaning parts.

b. After soaking parts in solvent, wash away deposits by slushing or spraying, and where necessary, by brushing with a soft-bristle, nonmetallic brush moistened in solvent.

WARNING

Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

c. Use clean, lint-free cloth or filtered, compressed air to dry all metal parts except bearings. Bearings must be allowed to air dry.

d. Ball or roller bearings should be placed in a basket and suspended in a container of dry cleaning solvent overnight. If necessary, use a soft-bristle, nonmetallic brush to remove caked grease and chips. Avoid rotating the bearing before solid particles are removed to prevent damage to bearings. After cleaning, immediately spin bearings in light lubricating oil to remove solvent. Allow excess oil to drip off.

e. Check all oil passages and cavities for cleanliness and freedom from foreign material. A thin, flexible wire should be run through oil passages to make certain they are not clogged. Individual passages that are dirty may be cleaned using a pressure spray gun and dry cleaning solvent.

f. Clean electrical parts such as relays, switches, etc., with a lint-free cloth moistened with dry cleaning solvent.

g. Clean exterior surfaces of the battery with a weak solution of baking soda and water. Apply the solution with a soft-bristle, nonmetallic brush to remove corrosive buildup on the battery cable terminals.

5-5. GENERAL INSPECTION INSTRUCTIONS.

Inspection consists of checking for physical distortions, wear, cracks, and pitting and checking dimensions of parts for compliance with requirements. Clean all parts before inspection. If any defect is found, correct it as outlined under GENERAL REPAIR INSTRUCTIONS before assembly.

a. Inspect all surfaces in contact with gaskets, packings, or seals for nicks, burrs, scratches, etc., which might damage the new seal upon assembly.

b. Examine bearings for rusted or pitted cones, balls, or cups. Examine bearing cones and cups for abrasion and serious discoloration. The following are causes for bearing rejection:

(1) Cuts or grooves parallel to ball or roller rotation.

(2) Fatigue pits (as opposed to minor machine marks or scratches).

NOTE

Defects which may cause bearing binding or misalignment are cause for rejection. Nicks or gouges outside cup load areas are not cause for rejection.

c. The following descriptions of wear conditions may help to determine when gear parts are performing satisfactorily: (1) Normal wear. Loss of metal from surface of gear tooth resulting from unavoidable abrasion, but not to a degree that prevents gear from performing satisfactorily.

(2) Initial pitting. Pitting may occur when gears are first started in service. It may continue only to a stage where high spots have been reduced and there is still enough contact area to carry load without further impairment. This pitting is not necessarily serious.

(3) Destructive pitting. Pitting that continues to progress after initial period of operation, and to such a degree, that there is not enough contact area remaining to carry the load. Rapid destruction may occur from continued operation.

(4) Abrasive wear. Surface damage caused by fine particles carried in lubricant or particles imbedded in tooth surfaces. Particles may be metal detached from gear tooth or bearings, abrasive not completely removed before assembly, sand or scale from casting, or other impurities in oil or surrounding atmosphere.

(5) Slight scoring (scuffing, seizing, or galling). This may be a minor impairment of surface, or of a welding nature showing slight tears and scratches in direction sliding. It starts in areas having high combinations of surface stress and sliding velocity. It usually occurs at or near the tip of the tooth.

(6) Burning. Discoloration and loss of hardness from excessive temperature. This is caused by friction resulting from overload, overspeed, lack of backlash, or faulty lubrication. If discoloring can be wiped off with a clean cloth, it can usually be traced to oil bum stains which are not usually serious.

(7) Rolling. This is a form of plastic yielding (continuous and permanent deformity in any direction without rupture). This results from heavy, even loads and sliding.

d. Inspect shaft splines for wear, pitting, rolling, or peening and for fatigue cracks. In many instances, the same inspection procedure will apply as for gears. However, the condition will usually be much less pronounced.

e. Check all hose surfaces for deterioration and signs of fatigue. Check for breaks caused by sharp kinks or contact with other parts of the forklift. Inspect tubing for kinks. Check for leaks.

f. Inspect all wiring harnesses for chaffed or burned insulation. Inspect all terminal connections for loose connections and broken parts.

e. Visually inspect all castings and weldments for cracks.

5-6. GENERAL REPAIR INSTRUCTIONS.

a. Remove burrs from gear teeth with a fine-cut file or hand grinder.

WARNING

Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.) to prevent injury to personnel.

b. Starter commutators may be polished in a lathe using a strip of 00 sandpaper. After polishing, blow dust and residue from commutator with compressed air.

c. Chassis and exterior painted parts may be resurfaced, where paint is damaged or where parts have been repaired, by using an abrasive disc.

CAUTION

Precautions should be taken to guard other parts of the forklift from abrasive dust. Do not work near exposed parts and openings which would allow the dust to reach working parts.

d. Remove residue and oil stain from bearing races with crocus cloth.

e. Before resurfacing, scrape all loose and blistered paint from damaged areas. Sand or buff area to be painted. Remove residual cleaning material with paint thinner and dry thoroughly.

f. Bare steel surfaces should be protected from oxidation while awaiting any repair step. Dip or spray parts in corrosion preventive compound. Aluminum parts may require protection in high salt atmospheres.

NOTE

The above instruction applies to polished and machined steel parts not protected by cadmium, tin, copper, or other plating or surface treatment. Bare metal must be free of moisture.

g. Welding and brazing process may be used to repair cracks in external steel parts, such as brackets, panels, and light framework. These processes should only be attempted when replacement parts are not available. Welding and brazing of castings and running parts or parts under great stress is not permissible, except in emergencies.

h. Whenever installing studs, use a proper driver. Before driving a stud, inspect hole for chips and liquid. Blow out any foreign matter. Start stud by hand. If stud will not start into hole, it is too large or has a defective end thread. Before final insertion, coat thread with a film of antiseize compound. Turn stud in slowly to prevent overheating and galling of casting metal. Drive stud to proper 'setting height," which is the total projecting length. While driving, observe required torque (Table 4-2). This must be greater than nut tightening torque for same size bolt but not enough to damage casting as it approaches its correct engagement depth.

i. Replace all broken, worn, burned, or pinched electrical wiring. Wires with several broken strands must be replaced. Broken strands increase the resistance of the wire and impair efficiency of the electrical components, especially the ignition system.

J. Replace all loose electrical connections.

k. Replace all broken, frayed, crimped, or soft flexible lines and hoses. Replace fittings which are stripped or damaged. Replace entire flexible hose if fittings are damaged. Make sure the hose clamps do not crimp hoses.

l. Replace any bolt, screw, or nut with damaged threads. Inspect tapped holes for thread damage. If cross-threading is evident, re-tap the hole for next size screw or stud. When re-tapping will result in weakening the part, or when the cost of the part makes re-tapping impractical, replace the damaged part.

5-7. GENERAL ASSEMBLY AND INSTALLATION INSTRUCTIONS.

a. Remove protective grease coatings from new parts before installation.

b. To replace an o-ring, first dovetail groove, then stretch packing and place into position. Rotate component on flat surface while applying a downward pressure to uniformly press the o-ring into position.

c. To provide added sealing for gaskets, coat both sides with sealant. Be sure that all traces of the previous gasket and sealant are removed before installing the new gasket.

d. Install oil seals with seal lip facing in, applying an even force to the other edge of seal. Coat oil seals evenly with oil or grease before installing. If oil seals are to be installed over keyed or splined shafts, use a guide to prevent sharp edges of keyway or spline from cutting the leather or neoprene seal. Make certain the guide edges are not sharp and are bent slightly inward so they do not cut the seal.

e. When mounting bearings on shafts, always apply force to the inner bearing cups. When mounting bearings into housing, apply the force to the outer bearing cup.

f. Lubricate all preformed packings with a thin coat of hydraulic fluid before installation.

g. Lubricate bearings before assembly with the lubricant normally used in the related housing or container. This will provide lubrication during the first run-in until lubricant from the system can reach the bearings.

h. Refer to identifying tags and sketches made at removal.

i. In general, after a hydraulic component has been removed, or lines have been broken, fill pump/motor and lines with hydraulic fluid upon installation.

j. In a closed loop system, whenever a pump/motor has been diagnosed as faulty, always replace corresponding pump/motor.

k. Test operation after installation. Inspect for leaks, vibration, noise, and misalignment. Recheck after a week of operation.

l. Always change filters after changing a hydraulic component, then again after 50 hours of operation.

5-8. PMCS INTRODUCTORY MATERIAL.

This section contains PMCS instructions for the truck. The PMCS Table contains checks and services necessary to ensure that the truck is ready for operation. Unit PMCS procedures are defined by the MAC. Unit PMCS is performed at the intervals specified in Table 3-1. Preventive Maintenance Checks and Services in Chapter 2 should be completed before performing unit PMCS.

5-9. MAINTENANCE FORMS AND RECORDS.

Maintenance forms and records provide permanent records of maintenance services, repairs, and modifications made on the truck. They provide reports to organizational maintenance and the commander, and they serve as a checklist to find out what was wrong with the truck after its last use and whether those faults have been fixed. For information needed on forms and records, see DA Pam 738-750.

5-10. FLUID LEAKAGE DEFINITION.

The following paragraphs describe the different types/classes of leaks and how they affect the status of the truck. Class I and II leaks are considered minor leaks and operations can continue under these conditions. When operating with these types of leaks, fluid levels must be checked regularly as required in the PMCS.

a. Class I Leaks. Class I leaks are identified by a wetness or discoloration not great enough to form drops. It is more of a seepage than a leak.

b. Class II Leaks. Class II leaks are identified by a flow of fluid great enough to form drops but not great enough to cause the drops to fall from the leak point.

c. Class III Leaks. Class III leaks are identified by a flow of fluid great enough to form drops that fall from the leak point.

(1) If a Class Ill leak is discovered before operating the truck, the truck can be operated as long as the fluid level is between the maximum and minimum points on the dipstick or sight glass. If the fluid level is below the minimum point on the dipstick or sight glass, do not operate the truck until refilled.

(2) If a Class Ill leak is discovered during operation of the truck, the operation can be completed as long as the leak is drops only and not a steady stream of fluid. The fluid level must also be within its operating range. If the leak is a steady stream and/or fluid level falls below minimum point on dipstick or sight glass, turn off the truck.

(3) If a Class III leak is discovered after operation is complete and the truck fluid level is below minimum on dipstick or sight glass, the truck cannot be operated until the leak is repaired.

5-11. TORQUE LIMITS.

Table 5-1 provides wet torque values for U.S. standard screws, nuts, and bolts. Table 5-2 provides dry torque values for U.S. standard screws, nuts, and bolts. Table 5-3 provides dry torque values for metric screws, nuts, and bolts. Table 5-4 provides torque values for metric phosphate coated engine screws, nuts, and bolts. Table 5-5 provides dry torque values for fasteners designated as critical to the truck. After assembly or installation procedures, refer to the appropriate table for the correct torque of component fasteners. While performing maintenance procedures, refer to Table 5-5 for the correct torque of critical fasteners, as required.

Table 5-1. U.S. Standard Torque Values (Wet)

*Designates course thread. **Designates fine thread.

SIZE			SAE GRADE NO.2		SAE GRADE NO.5		SAE GRADE NO.6 OR 7		SAE GRADE NO.8	
Dia. Inches	Threads Per Inch	Millimeters	Pound Feet	Newton Meters	Pound Feet	Newton Meters	Pound Feet	Newton Meters	Pound Feet	Meters
1/4*	20	6.35	4	6	6	8	8	11	9	12
1/4**	28	6.35	5	7	7	9	9	12	10	14
5/16*	18	7.94	8	11	13	18	16	22	18	24
5/16**	24	7.94	9	12	14	19	18	24	20	27
3/8*	16	9.53	15	20	23	31	30	41	35	47
3/8**	24	9.53	17	23	25	34	30	41	35	47
7/16*	14	11.11	24	33	35	47	45	61	55	75
7/16**	20		25	34	40	54	50	68	60	81
1/2*	13	12.70	35	47	55	75	70	95	80	108
1/2**	20		40	54	65	88	80	108	90	122
9/16*	12	14.29	50	68	80	108	100	136	110	149
9/16**	18		55	75	90	122	110	149	130	176
5/8*	11	15.88	70	95	110	149	140	190	170	231
5/8**	18		80	108	130	176	160	217	180	244
3/4*	10	19.05	120	163	200	271	240	325	280	380
3/4**	16		140	190	220	298	280	380	320	434
7/8*	9	22.23	110	149	300	407	400	542	460	624
7/8**	14		120	163	320		434	440	597	500
1*	8	25.40	160	217	440	597	600	814	680	922
1**	12		170	231	480	651	660	895	740	1003
1-1/8*	7	25.53	220	298	600	814	840	1139	960	1302
1-1/8**	12		260	353	660		895	940	1275	1080
1-1/4*	7	31.75	320	434	840	1139	1100	1492	1360	1844
1-1/4**	12		360	488	920	1248	1320	1790	1500	2034
1-3/8*	6	34.93	420	570	1100	1492	1560	2115	1780	2414
1-3/8**	12		460	624	1260	1709	1780	2414	2040	2766
1-1/2*	6	36.10	560	760	1460	1980	2080	2820	2360	3200
1-1/2**	12		620	841	1640	2224	2320	3146	2660	3607

Table 5-2. U.S. Standard Torque Values (Dry Fasteners)

SIZE			SAE GRADE NO.2		SAE GRADE NO.5		SAE GRADE NO.6 OR 7		SAE GRADE NO.8	
Dia. Inches	**Threads Per Inch**	**Millimeters**	**Pound Feet**	**Newton Meters**	**Pound Feet**	**Newton Meters**	**Pound Feet**	**Newton Meters**	**Pound Feet**	**Newton Meters**
1/4	20	6.35	5	7	8	11	10	14	12	16
1/4	28	6.35	6	9	10	14	12	16	14	19
5/16	18	7.94	11	15	17	23	21	28	25	34
5/16	24	7.94	12	16	19	26	24	33	25	34
3/8	16	9.53	20	27	30	41	40	54	45	61
3/8	24	9.53	23	31	35	47	45	61	50	68
7/16	14	11.11	30	41	50	68	60	81	70	95
7/16	20		35	47	55	75	70	95	80	108
1/2	13	12.70	50	68	75	102	95	129	110	149
1/2	20		55	75	90	122	100	135	120	163
9/16	12	14.29	65	88	110	149	135	183	150	203
9/16	18		75	102	120	163	150	203	170	231
5/8	11	15.88	90	122	150	203	190	258	220	298
5/8	18		100	136	180	244	210	285	240	325
3/4	10	19.05	160	217	260	353	320	434	380	515
3/4	16		180	244	300	407	360	488	420	597
7/8	9	22.23	140	190	400	542	520	705	600	814
7/8	14		155	210	440	597	580	786	660	895
1	8	25.40	220	298	580	786	800	1085	900	1220
1	12		240	325	640	868	860	1186	1000	1356
1-1/8	7	25.53	300	407	800	1085	1120	1519	1280	1736
1-1/8	12		340	461	880	1193	1260	1709	1440	1953
1-1/4	7	31.75	420	570	1120	1519	1580	2142	1820	2468
1-1/4	12		460	624	1240	1681	1760	2387	2000	2712
1-3/8	6	34.93	560	759	1460	1980	2080	2820	2380	3227
1-3/8	12		640	868	1680	2278	2380	3227	2720	3688
1-112	6	36.10	740	1003	1940	2631	2780	3770	3160	4285
1-1/2	12		840	1139	2200	2983	3100	4204	3560	4827

Table 5-3. Metric Torque Values (Dry Fasteners)

SIZE		METRIC GRADE 8.8		METRIC GRADE 10.9		METERIC GRADE 12.9	
Dia. Inches	Millimeters	Pound Feet	Newton Meters	Pound Feet	Newton Meters	Pound Feet	Newton Meters
.157	4	2	3	3	4	4	5
.197	5	4	5	6	8	7	9
2.37	6	7	9	10	14	11	15
2.76	7	11	15	16	22	20	27
3/15	8	18	24	25	34	29	29
3.94	10	32	45	47	64	58	79
.473	12	58	79	83	113	100	136
.630	16	144	195	196	266	235	319
.709	18	190	258	269	365	323	438
.788	20	260	353	366	496	440	597
.867	22	368	499	520	705	678	919
.946	24	470	637	644	900	794	1077
1.064	27	707	959	996	1351	1235	1675
1.182	30	967	1311	1357	1840	1630	2210

Table 5-4. Metric Torque Values (Phosphate Coated Engine Fasteners)

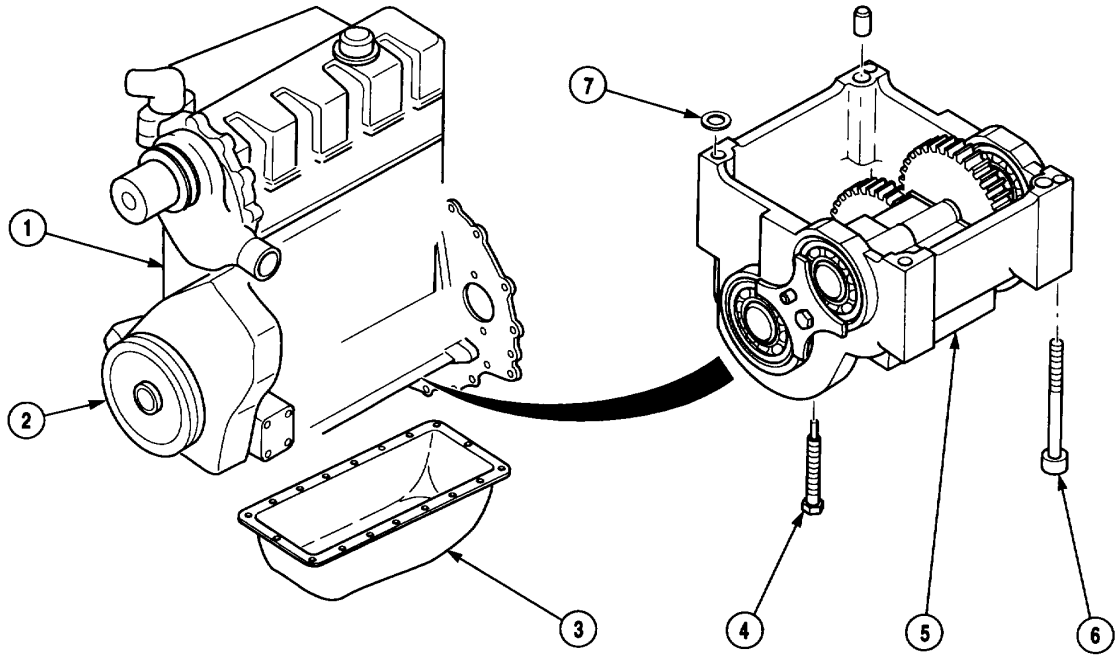
THD SIZE	CLASS 8.8		Class 9.8	
	LB.FT	N•m	LB.FT	N•M
M6	6-8	8-11	6-8	8-11
M8	15-18	20-24	15-18	20-24
M10	25-30	34-40	25-30	34-40
M12	55-60	75-81	55-60	75-81
M14	90-100	122-135	90-100	122-135
M16	140-150	190-203	140-150	190-203

Table 5-5. Critical Fastener Torque Values (Dry)

Nomenclature	Pound Feet	Newton Meters
Engine Mounting Bolts	85-90	116-122
Transmission to Engine Bolts	25-30	33.9-40.5
Torque Converter to Drive Plate Bolts	25-30	33.9-40.5
Drive Axle End Bolts	75-115	102-156
Steer Axle Mounting Bolts	83-95	113-128
Steering Wheel Retaining Nut	32.5-35.5	44-53
Tilt Cylinder Yoke Clamp Bolts	125-140	170-190
Tilt Cylinder Pin Retainer Bolts		
Front	20-22.5	27-30.3
Rear	20-22.5	27-30.3
Counterweight Mounting Bolts	350-400	475-542
Cab Mounting Bolts	70-80	94.5-108
Drive Wheel Lug Nuts	470-530	637-719
Steer Wheel Lug Nuts	265-338	360-458

5-12. ENGINE BALANCER REPAIR.

a. Removal.



(1) Remove engine (1) from forklift (Engine Removal, Appendix F, Section 4.11).

NOTE
No. 1 cylinder is located at the water pump end of the engine.

(2) Position engine crankshaft pulley (2) so that No. 1 piston is in top dead center (TDC) position.

(3) Drain oil from engine (1) (Engine Oil and Filter Change, Appendix F, Section 3.2).

(4) Remove oil pan (3) from engine (1) (Engine Repair & Overhaul, Appendix F, Section 4.14).

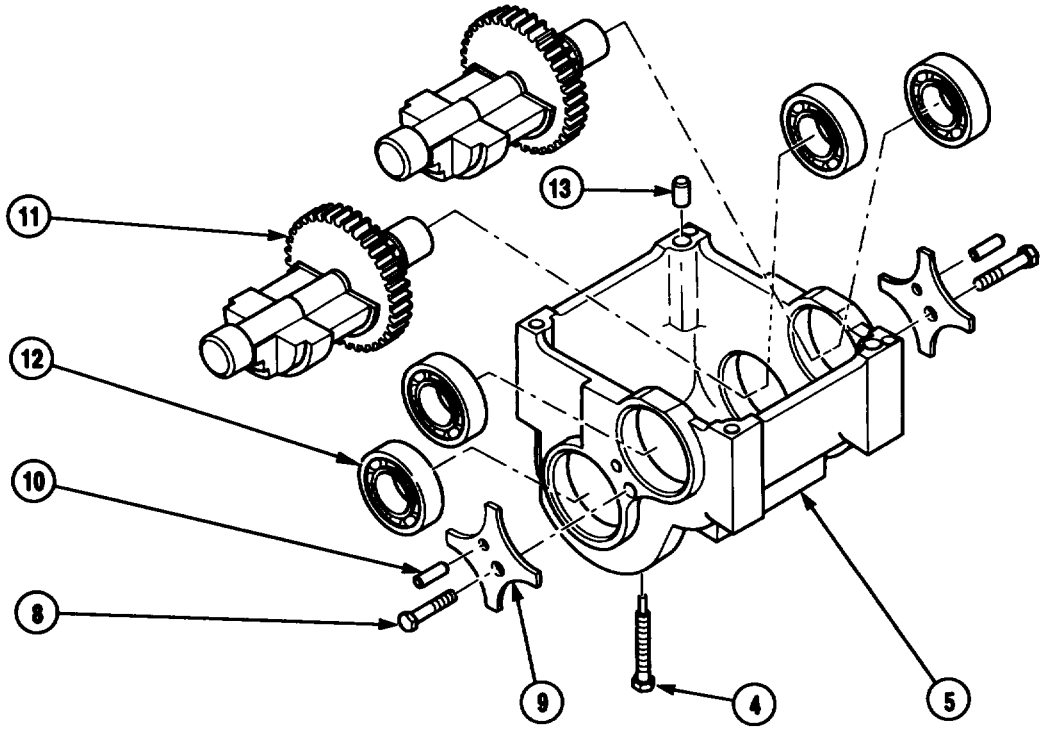
(5) Install locator screw (4) in engine balancer assembly (5).

NOTE
Shims will be between engine balancer assembly and engine block only if required. If present, they will be removed with the engine balancer.

(6) Remove four screws (6), engine balancer assembly (5), and shims (7) from engine (1).

(7) Position engine balancer assembly (5) on clean work surface.

b. Disassembly.



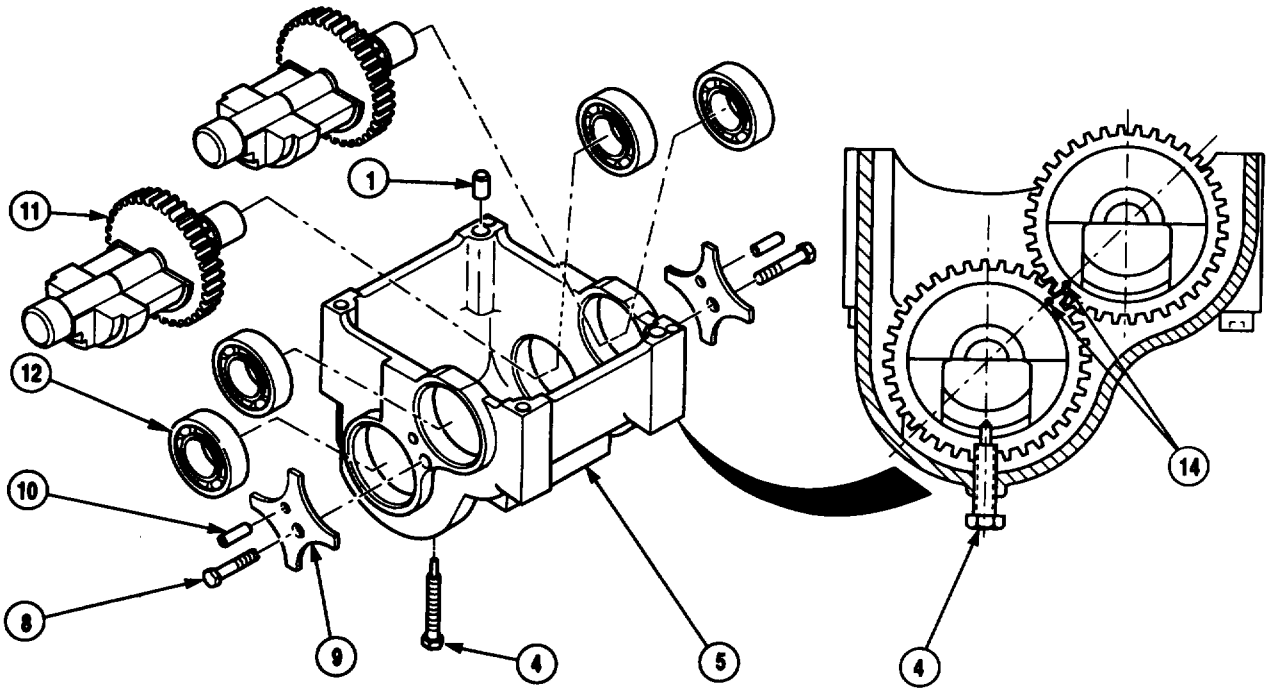
(1) Remove locator screw (4) from engine balancer assembly (5).

(2) Remove two screws (8), bearing retainers (9), and retainer locators (10) from engine balancer assembly (5).

(3) Using press, remove two engine balancer weights (11) and four bearings (12) from engine balancer assembly (5).

(4) Remove balancer frame dowel (13) from engine balancer assembly (5).

c. Assembly.



(1) Install balancer frame dowel (13) in engine balancer assembly (5).

(2) Install two rear bearings (12) in engine balancer assembly (5).

(3) Install rear retainer locator (10), rear bearing retainer (9), and screw (8) on rear of engine balancer assembly (5). Tighten screw 18 lb-ft (25 N•m).

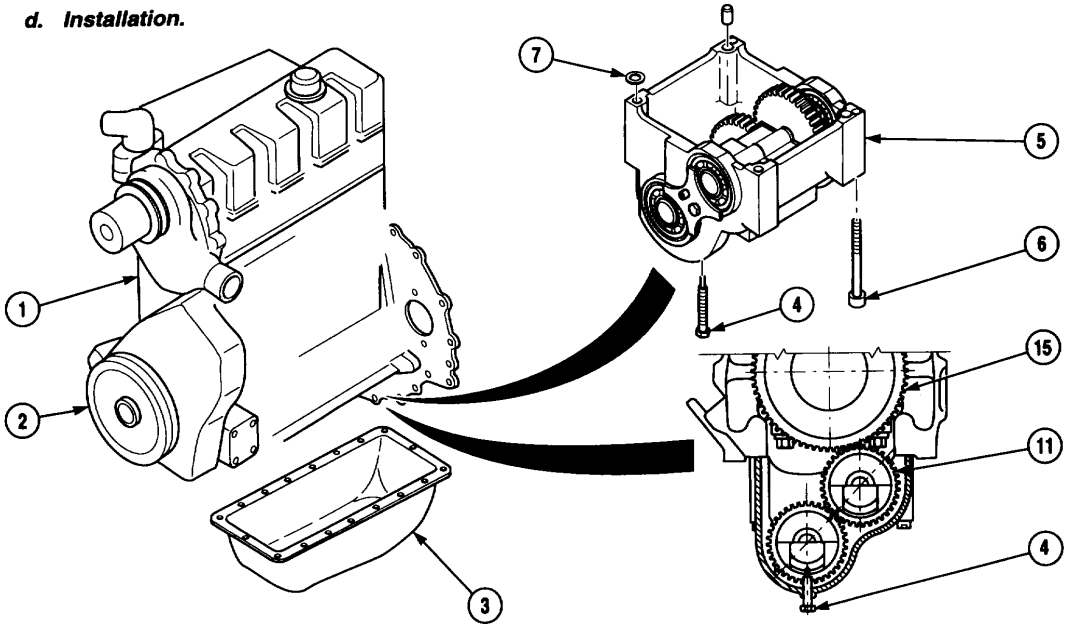
(4) Position two engine balancer weights (11) in engine balancer assembly (5) with dots (14) aligned.

(5) Install two front bearings (12) on two engine balancer weights (11) and in engine balancer assembly (5).

(6) Install front retainer locator (10), front bearing retainer (9), and screw (8) on front of engine balancer assembly (5). Tighten screw 18 lb-ft (25 N•m).

(7) With two dots (14) aligned, install locator screw (4) in engine balancer assembly (5) to hold engine balancer weights (11) stationary.

d. Installation



(1) Position engine balancer assembly (5) on engine (1) with four screws (6).

NOTE

Shims will be added equally between engine balancer assembly and engine block on all four mounting bolts only if required to adjust backlash. The backlash measurement between upper engine balancer weight and crankshaft gear should be .005-.009 in. (.127-.229 mm). Do not install more than two shims thickness.

(2) Measure backlash between upper engine balancer weight (11) and crankshaft gear (15).

NOTE

Perform Steps (3) and (4) if shims are required. If shims are not required, proceed to Step (5).

(3) Remove four screws (6) and engine balancer assembly (5) from engine (1).

(4) Add shims (7) on four screws (6) as determined in Step (2).

(5) Install engine balancer assembly (5) on engine (1) with four screws (6). Tighten screws 28-34 lb-ft (39-47 N•m).

(6) Remove locator screw (4) from engine balancer assembly (5).

(7) Install oil pan (3) on engine (1) (Engine Repair & Overhaul, Appendix F, Section 4.14).

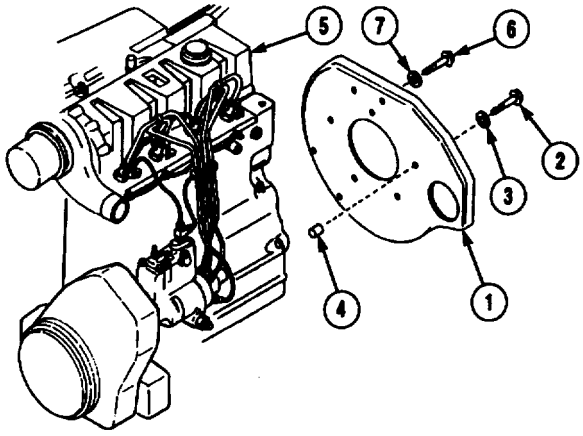
(8) Add oil to engine (1) (Engine Oil and Filter Change, Appendix F, Section 3.2).

(9) Install engine (1) in forklift (Engine Removal, Appendix F, Section 4.11).

END OF TASK

5-13. REAR ENDPLATE REPLACEMENT.

a. Removal.



(1) Remove engine from forklift (Engine Removal, Appendix F, Section 4.11).

(2) Remove starter from engine (Starter Maintenance, Appendix F, Section 6.16).

(3) To remove rear endplate (1), proceed as follows:

(a) Remove five screws (2), washers (3), and two spacers (4) from engine (5) and rear endplate (1).

(b) Remove two screws (6), washers (7), and rear endplate (1) from engine (5).

b. Installation.

(1) To install rear endplate (1), proceed as follows:

(a) Position rear endplate (1) on engine (5) with two washers (7) and screws (6).

(b) Install rear endplate (1) on engine (5) with two spacers (4), five washers (3), and five screws (2). Tighten screws to 45-50 lb-ft (61-68 N•m).

(c) Tighten two screws (6) to 45-50 lb-ft (61-68 N•m).

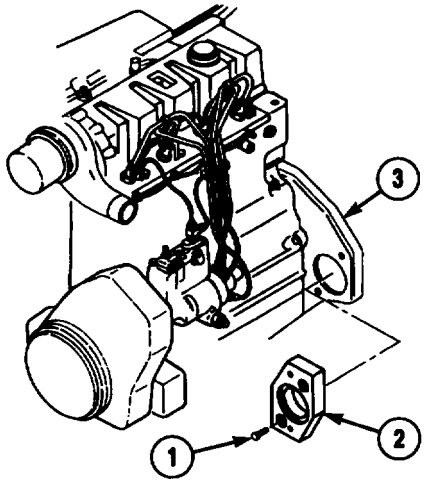
(2) Install starter in engine (Starter Maintenance, Appendix F, Section 6.16).

(3) Install engine in forklift (Engine Removal, Appendix F, Section 4.11).

END OF TASK

5-14. STARTER ADAPTER PLATE REPLACEMENT.

a. Removal.



(1) Remove starter from engine (Appendix F, Starter Maintenance, Section 6.16).

(2) Remove two screws (1) and adapter plate (2) from rear end plate (3).

b. Installation.

(1) Apply sealing compound to two screws (1).

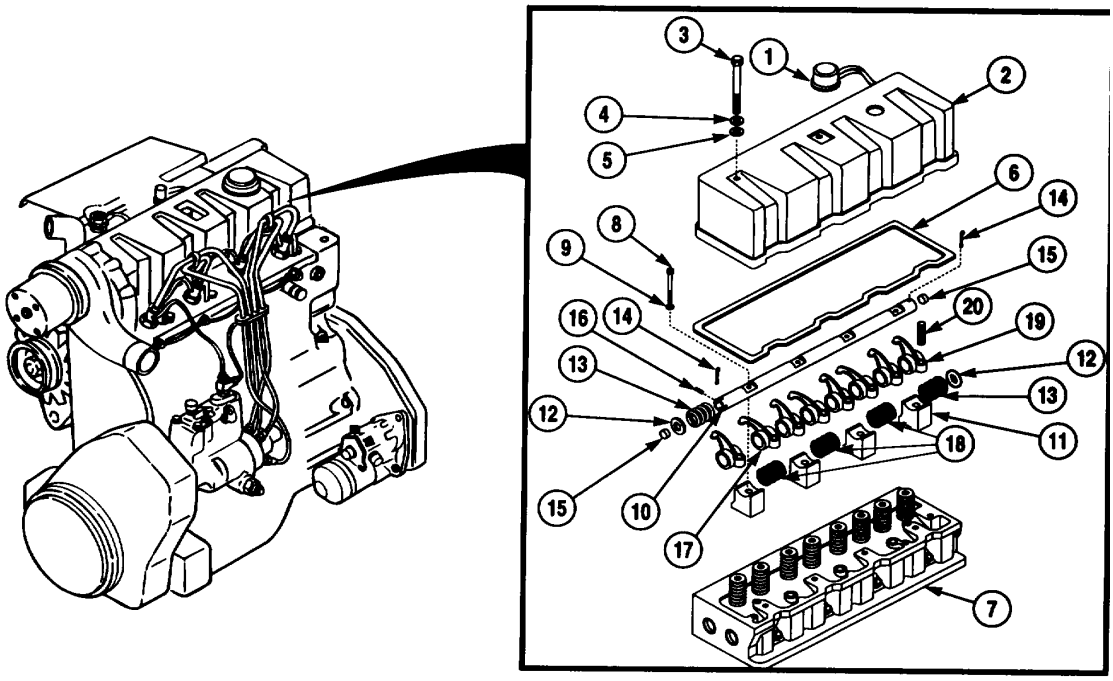
(2) Install adapter plate (2) on rear end plate (3) with two screws (1). Tighten screws to 39 lb-ft (49 N•m).

(3) Install starter on engine (Appendix F, Starter Maintenance, Section 6.16).

END OF TASK

5-15. ROCKER ARM REPLACEMENT.

a. Removal.



(1) Remove oil breather cap (1) from rocker arm cover (2).

(2) Remove three screws (3), washers (4), seals (5), rocker arm cover (2), and gasket (6) from head (7). Discard seals and gasket.

WARNING

Use care when removing and disassembling rocker arm components. Rocker arm components are under spring tension and can act as projectiles when released and could cause severe eye injury.

(3) Remove four screws (8), washers (9), pivot (10), and four supports (11) from head (7).

NOTE
Tag and mark all parts during removal.

(4) Apply pressure on washer (12) and spring (13), as required, and remove pin (14) from pivot (10).

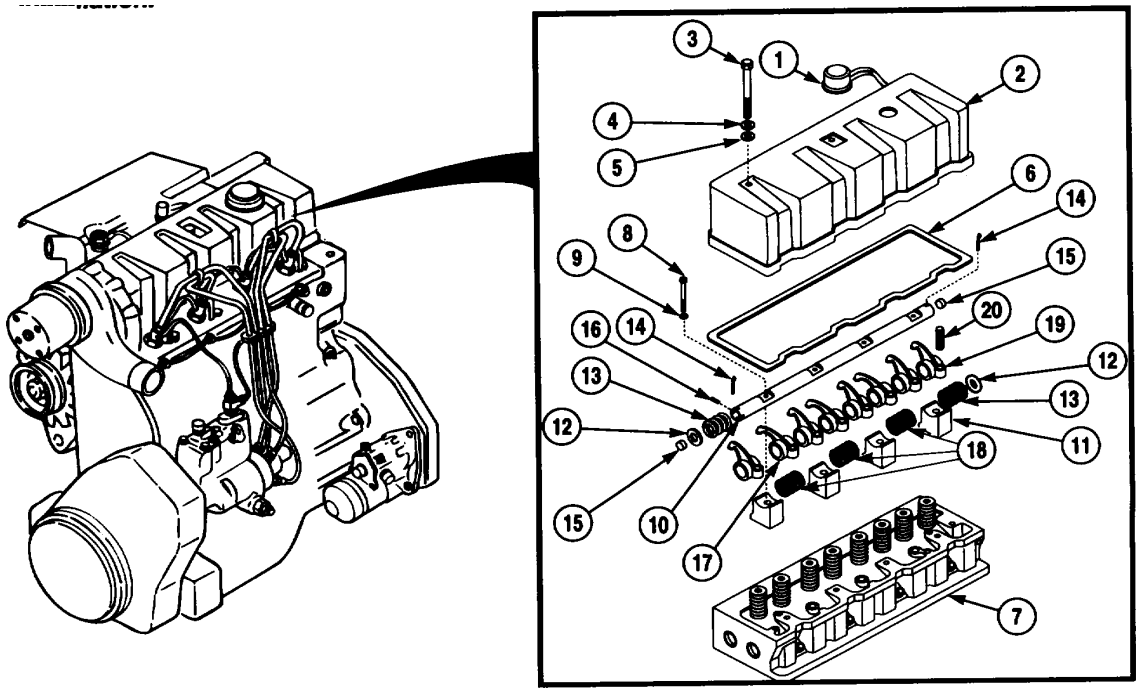
(5) Remove washer (12), spring (13), plug (15), and locator (16) from pivot (10).

(6) Remove four rockers (17), three springs (18), four rockers (19), spring (13), washer (12), pin (14) and plug (15) from pivot (10).

(7) Remove eight adjustors (20) from rockers (17 and 19).

b. Inspection. Inspect all rocker arm assembly parts (Appendix F, Continental Diesel Engine, Section 4.14, Section 8).

c. Installation.



(1) Position eight adjustors (20) in rockers (17 and 19).

WARNING

Use care when assembling and installing rocker arm components. Rocker arm components are under spring tension and can act as projectiles when released and could cause severe eye injury.

(2) Install plug (15), pin (14), washer (12), spring (13), four rockers (19), three springs (18), four rockers (17), spring (13), locator (16), and plug (15) on pivot (10) with washer (12) and pin (14) as tagged and marked during Removal.

(3) Install pivot (10) and four supports (11) on head (7) with four washers (9) and screws (8). Tighten screws 17-20 lb-ft (23-27 N•m).

(4) Adjust rocker arms (Appendix F, Engine Valve Clearance Adjustment, Section 4.5).

(5) Position gasket (6) and rocker arm cover (2) on head (7).

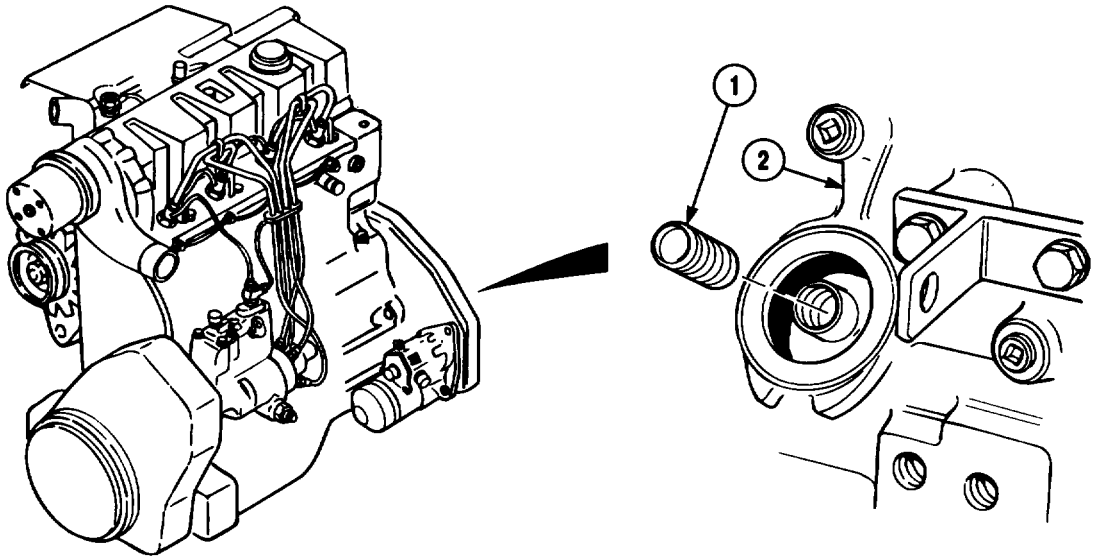
(6) Install rocker arm cover (2) and gasket (6) on head (7) with three seals (5), washers (4), and screws (3). Tighten screws 5-6 Ib-ft (7-8 N•m).

(7) Install oil breather cap (1) on rocker arm cover (2).

END OF TASK

5-16. OIL FILTER ADAPTER REPLACEMENT.

a. Removal.



(1) Remove oil filter (Appendix F, Planned Maintenance Procedures, Section 3.2).

(2) Remove oil filter adapter (1) from engine (2).

b. Installation.

(1) To install oil filter adapter (1), proceed as follows:

(a) Apply sealing compound to oil filter adapter (1).

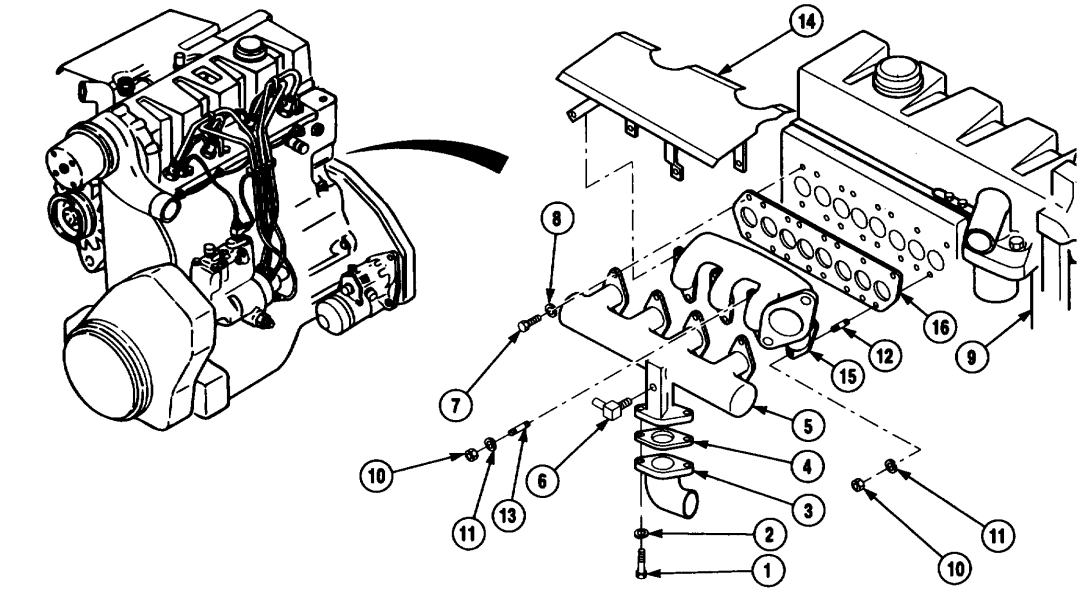
(b) Install oil filter adapter (1) on engine (2).

(2) Install oil filter (Appendix F, Planned Maintenance Procedures, Section 3.2).

END OF TASK

5-17. MANIFOLD REPLACEMENT.

a. Removal.



(1) Remove engine oil breather cap hose (Para 3-15).

(2) Remove two screws (1), lockwashers (2), engine air intake adaptor (3), and gasket (4) from intake manifold (5). Discard lockwashers and gasket.

(3) Remove fitting (6) from intake manifold (5).

(4) Remove eight screws (7), lockwashers (8), and intake manifold (5) from engine (9). Discard lockwashers.

(5) Remove eight nuts (10) and lockwashers (11) from six screws (12) and two screws (13). Discard lockwashers.

(6) Remove shield (14), exhaust manifold (15), and gasket (16) from engine (9). Discard gasket.

(7) Remove six screws (12) and two screws (13) from engine (9).

b. Installation.

(1) Apply sealant to six screws (12) and two screws (13).

(2) Install six screws (12) and two screws (13) on engine (9).

(3) Apply antiseize compound to threads of six screws (12) and two screws (13) on engine (9).

(4) Position gasket (16), exhaust manifold (15), and shield (14) on engine (9) with eight lockwashers (11) and nuts (10).

(5) Position intake manifold (5) on engine (9) with eight lockwashers (8) and screws (7).

(6) Tighten eight nuts (10) and screws (7) 15-18 Ib-ft (20-24 N•m).

(7) Apply sealant to fitting (6).

(8) Install fitting (6) on intake manifold (5).

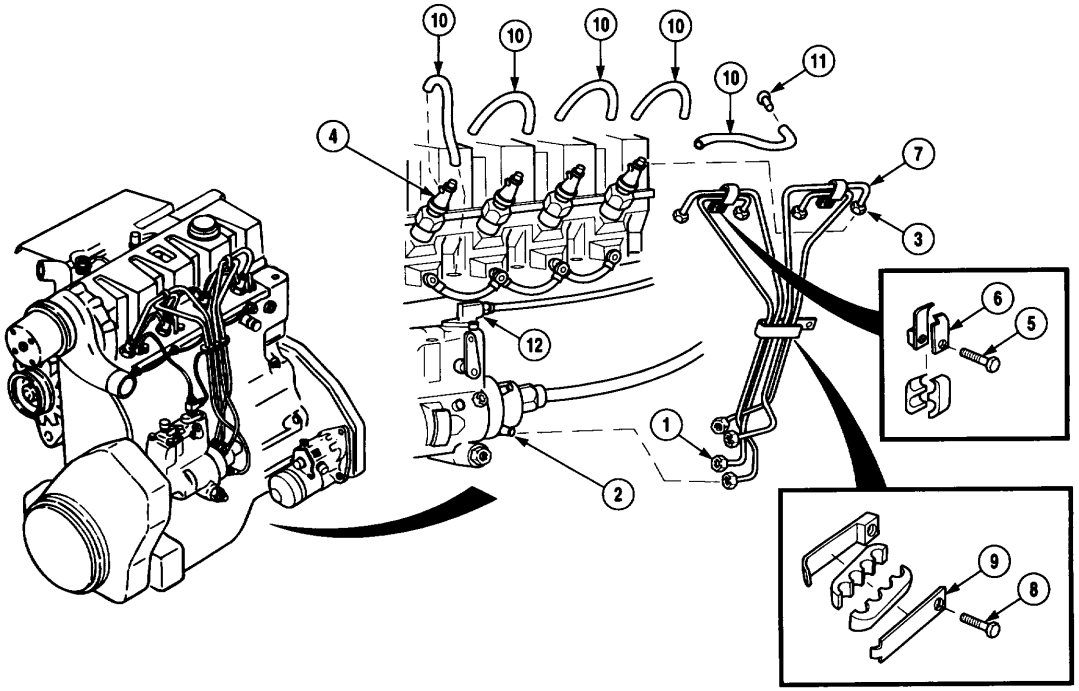
(9) Install gasket (4) and engine air intake adaptor (3) on intake manifold (5) with two screws (1) and lockwashers (2). Tighten screws 15-18 Ib-ft (20-24 N.m).

(10) Install engine oil breather cap hose (Para 3-15).

END OF TASK

5-18. FUEL INJECTOR LINE REPLACEMENT.

a. Removal.



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

•· Position rag under fuel injector lines to catch spilled fuel.

•· Cap and plug all lines and fittings during removal.

(1) Remove four compression nuts (1) from four fuel injector pump fittings (2).

(2) Remove four compression nuts (3) from four fuel injectors (4).

(3) Remove two screws (5) and two clamp assemblies (6) from four fuel injector lines (7).

(4) Remove screw (8) and clamp (9) from four fuel injector lines (7).

(5) Remove five fuel injector return hoses (10) and plug (11) from four fuel injectors (4) and fuel injector pump (12).

b. Installation.

WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

Position rag under fuel injector lines to catch spilled fuel.

(1) Install five fuel injector return hoses (10) and plug (12) on four fuel injectors (4) and fuel injector pump (12).

(2) Position four fuel injector lines (7) together with clamp (9) and screw (8). Do not tighten screw.

(3) Position two clamps (6) on four fuel injector lines (7) with two screws (5). Do not tighten.

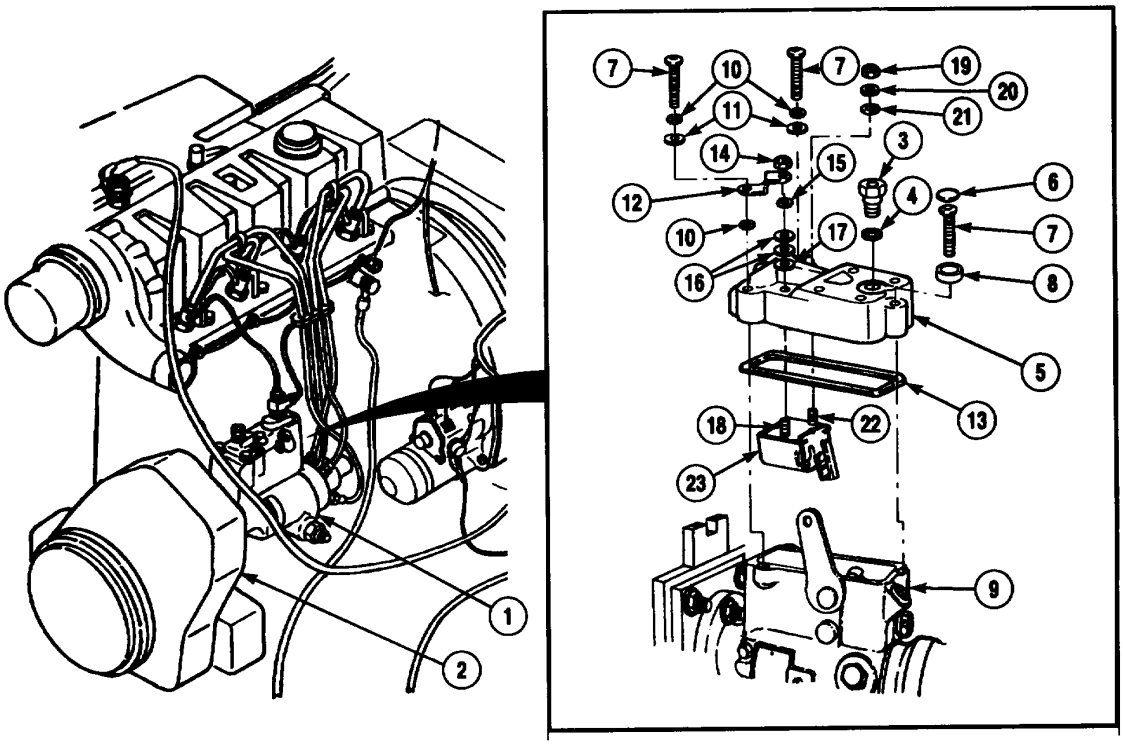
(4) Install four fuel injector lines (7) on four fuel injectors (4) and four fuel injector pump fittings (2) with four compression nuts (3) and four compression nuts (1). Tighten compression nuts 20-25 lb-ft (27-34 N-m).

(5) Tighten two screws (5) and screw (8)

END OF TASK

5-19. FUEL INJECTOR PUMP COVER REPAIR.

a. Removal.



WARNING

Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

NOTE

•· Position rag under fuel injector pump to catch spilled fuel.

•· Cap and plug all lines and fittings during removal.

• Tag and mark all wires and lines prior to removal.

(1) Remove fuel injector pump (1) from engine (2) and position on clean work surface (Appendix F, Fuel System, Section 4.14).

(2) Remove housing pressure regulator (3) and seal (4) from cover (5). Discard seal.

(3) Remove screw cover cap (6), screw (7), and screw cover cup (8) from cover (5) and fuel injector pump body (9).

(4) Remove two screws (7), three lockwashers (10), and two washers (11) from strap (12), cover (5), and fuel injector pump body (9). Discard lockwashers.

(5) Remove cover (5) and seal (13) from fuel injector pump body (9).

(6) Remove nut (14), strap (12), lockwasher (15), two washers (16), and insulating washer (17) from cover (5) and terminal (18). Discard lockwasher.

(7) Remove nut (19), washer (20), and insulating washer (21) from cover (5) and terminal (22).

(8) Remove solenoid (23) from cover (5).

b. Installation.

NOTE

Position rag under fuel injector lines to catch spilled fuel.

(1) Install solenoid (23) on cover (5) with insulating washer (21), washer (20), and nut (19) on terminal (22).

(2) Install insulating washer (17), two washers (16), lockwasher (15), and strap (12) on terminal (18) and cover (5) with nut (14).

(3) Install cover (5) and seal (13) on fuel injector pump body (9) with strap (12), two washers (11), three lockwashers (10), and two screws (7). Do not tighten screws.

(4) Install screw cover cup (8) and screw (7) on cover and fuel injector pump body (9). Tighten three screws (7).

(5) Install screw cover cap (6) on screw (7) and screw cover cup (8).

(6) Install housing pressure regulator (3) and seal (4) on cover (5).

WARNING

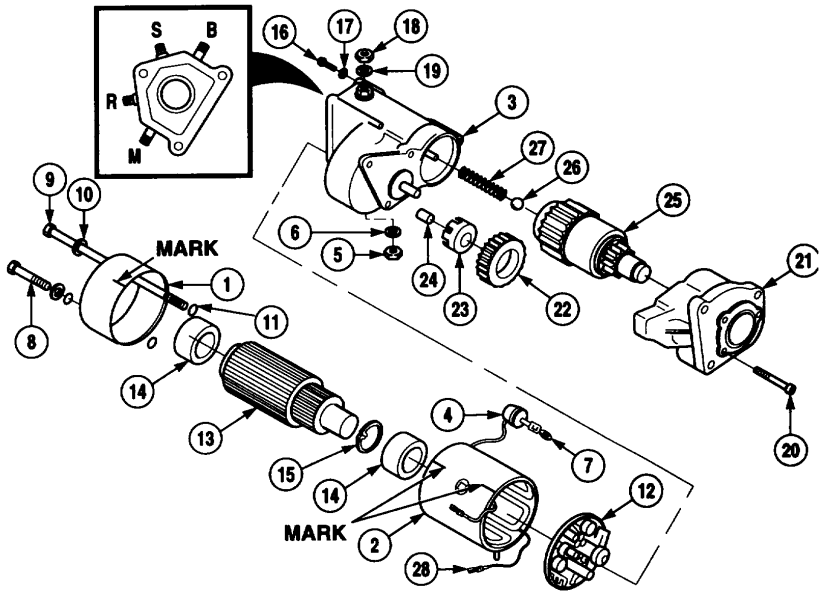
Fuel is very flammable and can explode easily. To avoid serious injury or death, keep fuel away from open fire and keep fire extinguisher within easy reach when working with fuel. Do not work on fuel system when engine is hot. Fuel can be ignited by hot engine. When working with fuel, post signs that read NO SMOKING WITHIN 50 FEET (15 m) of vehicle.

(7) Install fuel injector pump (1) on engine (2) (Appendix F, Fuel System, Section 4.14).

END OF TASK

5-20. STARTER MOTOR REPAIR.

a. Disassembly



(1) Mark frame (1), yoke (2), and switch assembly (3) prior to disassembly to aid in alignment during assembly.

(2) Moving cover (4) aside, remove nut (5), lockwasher (6), and wire (7) from terminal M of switch assembly (3). Discard lockwasher.

(3) Remove screws (8 and 9), two washers (10), seals (11), frame (1), yoke (2), and brush holder assembly (12) from switch assembly (3). Discard seals.

(4) Remove frame (1) from yoke (2) and armature (13).

(5) Remove armature (13) from brush holder assembly (12) and yoke (2).

WARNING

Use care when removing or installing snap or retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(6) Using a press, remove two bearings (14) and snap ring (15) from armature (13).

(7) Remove two screws (16) and lockwashers (17) from terminals R and S of switch assembly (3). Discard lockwashers.

(8) Remove nut (18) and lockwasher (19) from terminal B of switch assembly (3). Discard lockwasher.

(9) Remove three screws (20) and housing (21) from switch assembly (3).

(10) Remove pinion (22), retainer (23), and clutch roller (24) from switch assembly (3).

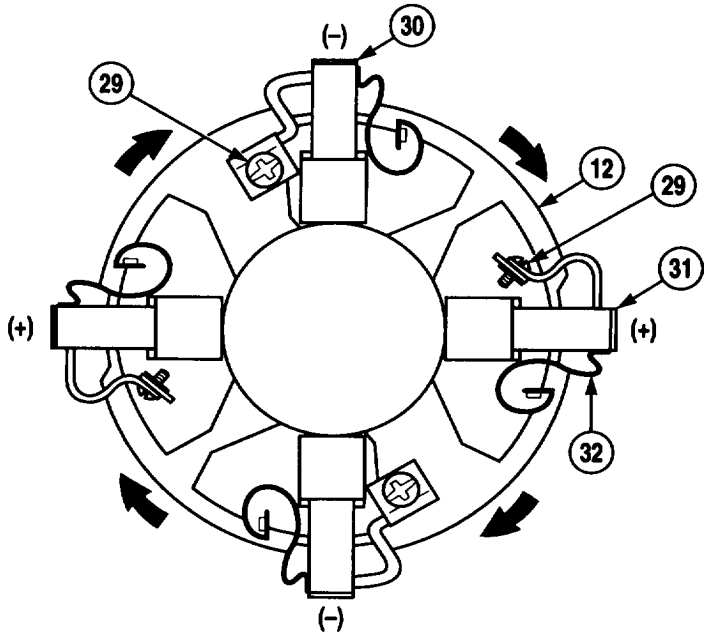
WARNING

Use care when removing clutch subassembly. Clutch subassembly is under spring tension and components can act as projectiles when released and could cause severe eye injury.

(11) Remove clutch subassembly (25), steel ball (26), and spring (27) from switch assembly (3).

NOTE
Tag and mark all wires prior to removal.

(12) Disconnect two field wires (28) from brush holder assembly (12).



NOTE

Tag and mark all brush wires prior to removal if brushes are to be reused.

(13) Loosen four screws (29) and remove two brush (30) wires and two brush (31) wires from brush holder assembly (12).

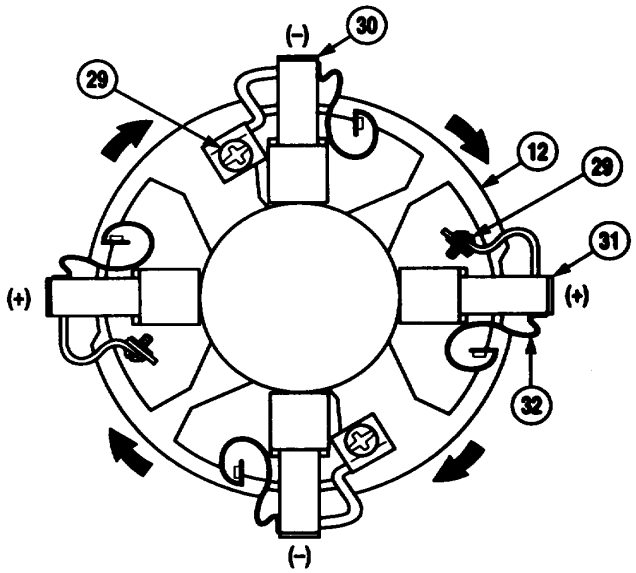
WARNING

Use care when removing brush springs. Brush springs are under spring tension and components can act as projectiles when released and could cause severe eye injury.

(14) Remove four springs (32), two brushes (30), and two brushes (31) from brush holder assembly (12).

b. Inspection. Inspect starter components (Appendix F. Starter Maintenance, Section 6.16).

c. Assembly.



(1) Install four springs (31) in brush holder assembly (12).

WARNING

Use care when installing brush springs. Brush springs are under spring tension and components can act as projectiles when released and could cause severe eye injury.

NOTE

Position brushes part way into brush holder assembly until assembled to armature and yoke.

(2) Pulling to the right on each of four springs (31), install two brushes (30) and two brushes (31) part way in brush holder assembly (12).

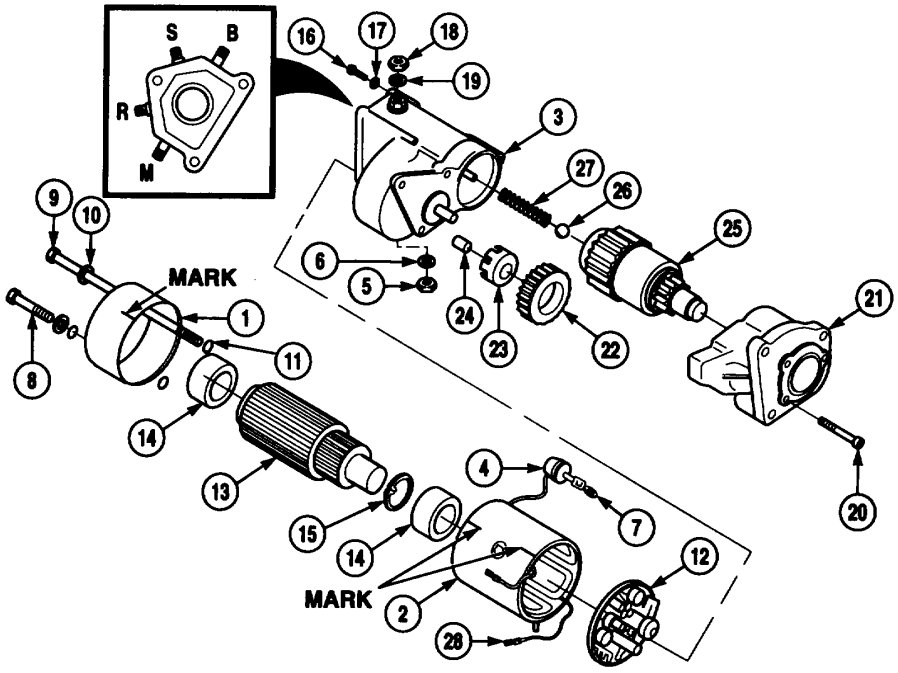
(3) Install two brush (30) wires and two brush (31) wires on brush holder assembly (12) with four screws (29).

(4) Connect two field wires (28) to brush holder assembly (12).

WARNING

Use care when installing clutch subassembly. Clutch subassembly is under spring tension and components can act as projectiles when released and could cause severe eye injury.

(5) Position spring (27), steel ball (26), and clutch subassembly (25) on switch assembly (3).



(6) Install clutch roller (24), retainer (23), and pinion (22) on switch assembly (3).

(7) Install housing (21) on switch assembly (3) with three screws (20).

(8) Install lockwasher (19) and nut (18) on terminal B of switch assembly (3).

(9) Install two lockwashers (17) on terminals R and S of switch assembly (3) with two screws (16).

WARNING

Use care when removing or installing snap or retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(10) Using a press, install snap ring (15) and two bearings (14) on armature (13).

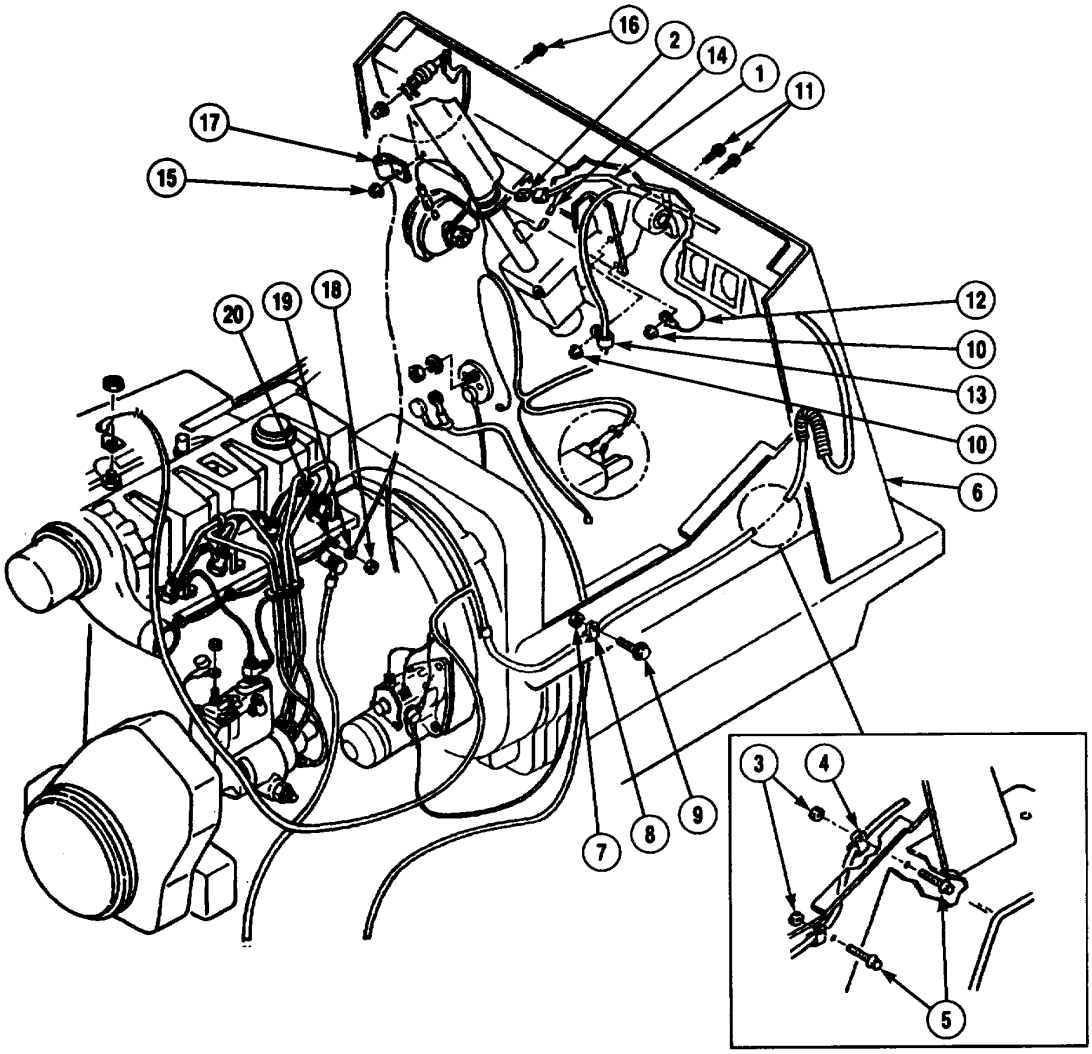
(11) Position armature in yoke (2) and brush holder assembly (12).

(12) Position two brushes (29) and two brushes (30) against armature (13) as prepared in Step 2.

(13) Aligning the marks, install frame (1), yoke (2), and brush holder assembly (12) on switch assembly (3) with two seals (11), washers (10), and screws (8) and (9).

(14) Moving cover (4) aside, install wire (7) on terminal M of switch assembly (3) with lockwasher (6) and nut (5).

5-21. GENERAL WIRE HARNESS REPLACEMENT/REPAIR.



The truck is equipped with two wiring harnesses and several individual wires connected to components to form the electrical system. The following procedures cover removal and installation of each of these harnesses and wires, with component hookup details provided in the paragraphs referenced. These procedures will apply to all electrical components installed on truck. Wire harness repairs will be performed as directed in TB ORD 650, Repair of Ordnance Tracked and Wheeled Vehicle Hull and Chassis Wiring.

a. Removal.

NOTE

- **This procedure is for reference only to show location of wire connections and routing on truck. Normally, it will never be necessary to remove all wiring at one time. Individual procedures will indicate the areas where wires are to be removed and installed on electrical components.**
- **If a portion of the harness requires splicing or other repair, remove only that portion of the harness required for the repair.**
- **Tag and mark all wires prior to removal.**
- **Cut cable ties, as required, during removal.**
- **Note location of cable ties and straps during removal for use during installation.**

(1) Remove battery cables (Para 3-26).

(2) Remove floor panels and left and right lower side panels (Para 3-36).

(3) Disconnect wire harness (1) from gauges, switches, sensors, sending units, lights, alarm, and horn (Para 3-22).

(4) Disconnect wire harness (1) from directional control at connector (2).

(5) Remove two nuts (3), straps (4), and screws (5) from wire harness (1) and frame (6).

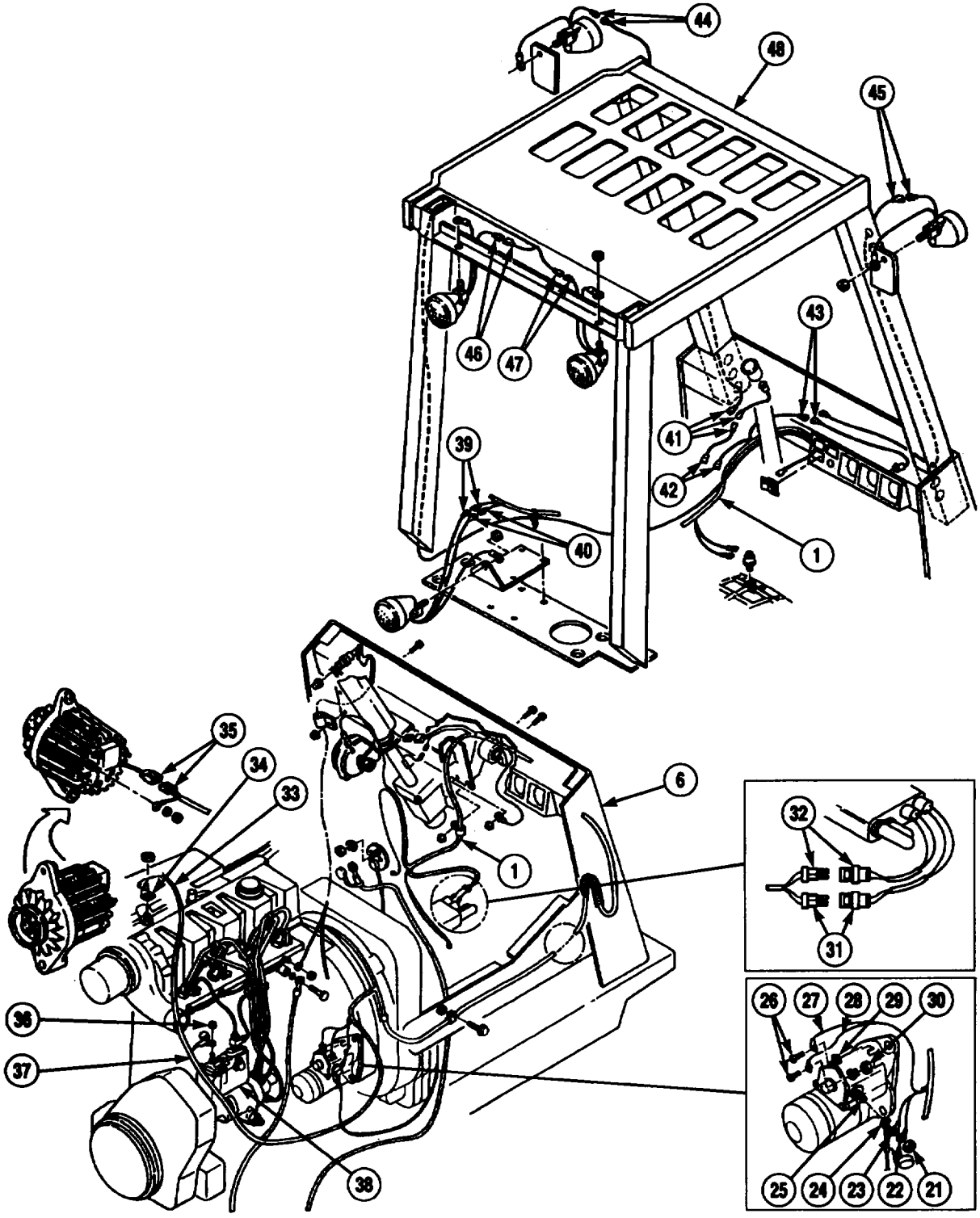
(6) Remove nut (7), strap (8), and screw (9) from wire harness (1) and frame (6).

(7) Remove two nuts (10), screws (11), wire (12), and strap (13) from frame (6).

(8) Disconnect horn connector (14).

(9) Remove nut (15), screw (16), and strap (17) from wire harness (1) and frame (6).

(10) Remove nut (18) and glow plug wire (19) from glow plug (20).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(11) Remove nut (21) and wires (22, 23, and 24) from starter terminal (25).

(12) Remove two screws (26) and wires (27 and 28) from two starter terminals (29 and 30).

(13) Remove two control valve assembly connectors (31 and 32) from wire harness (1).

(14) Remove wire (33) from engine temperature sending unit (34).

(15) Remove wires from alternator (Para 3-20).

(16) Disconnect regulator connector (35) from wire harness (1).

(17) Remove nut (36) and wire (37) from injector pump (38).

(18) Disconnect two stop/tail light connectors (39 and 40).

(19) Disconnect connectors (41 and 42).

(20) Disconnect gauge light connector (43).

(21) Disconnect two front flood light connectors (44 and 45).

(22) Disconnect two rear flood light connectors (46 and 47).

(23) Remove wire harness (1) from frame (6) and overhead guard (48).

b. Installation.

(1) Position wire harness (1) in frame (6) and overhead guard (48).

(2) Connect two rear flood light connectors (46 and 47).

(3) Connect two front flood light connectors (44 and 45).

(4) Connect gauge light connector (43).

(5) Connect connectors (41 and 42).

(6) Connect two stop/tail light connectors (39 and 40).

(7) Install wire (37) on injector pump (38) with nut (36). Tighten nut.

(8) Connect wire harness (1) to regulator connector (35).

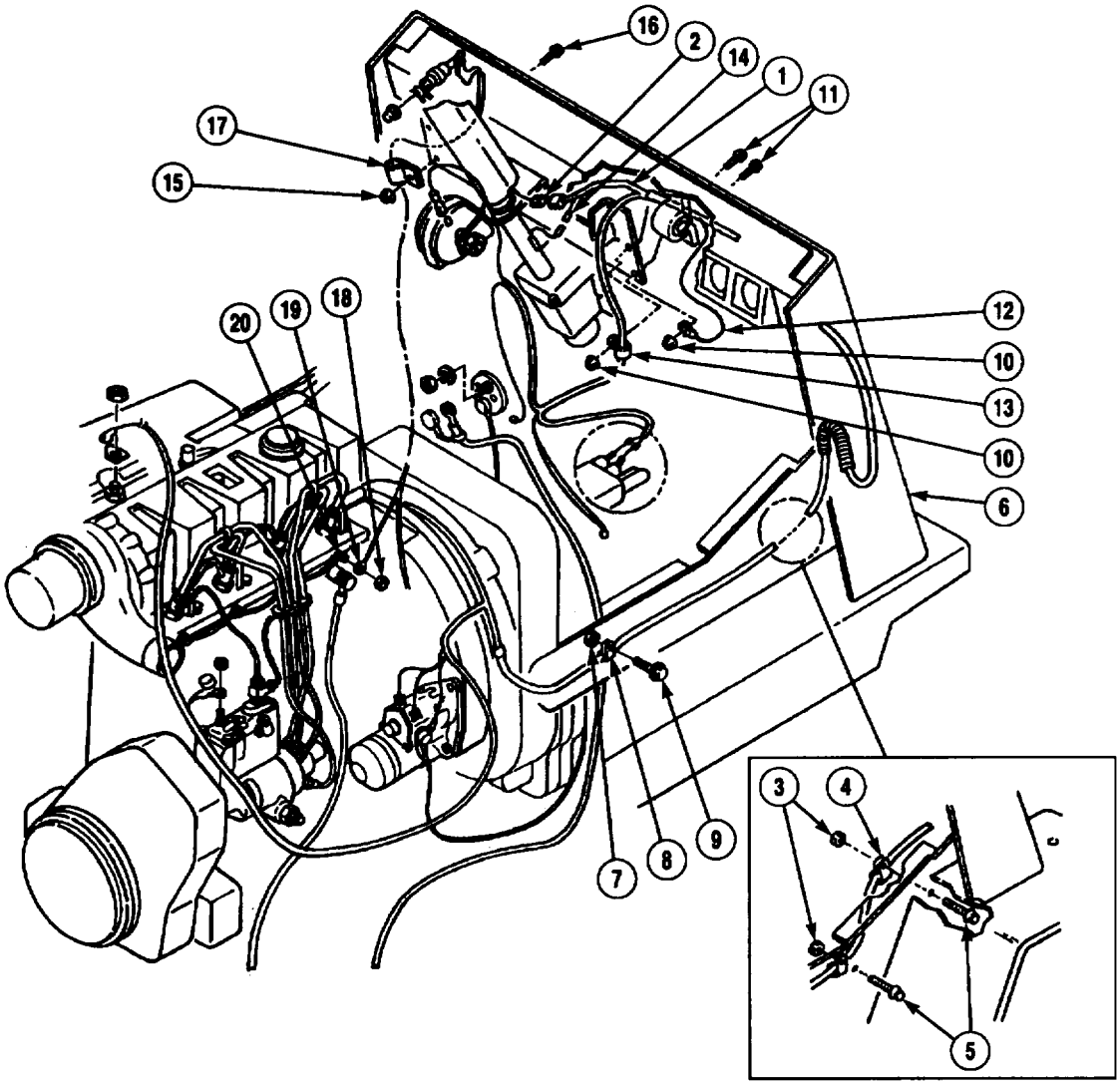
(9) Install wires on alternator (Para 3-20).

(10) Install wire (33) on engine temperature sending unit (34).

(11) Install two control valve assembly connectors (31 and 32) on wire harness (1).

(12) Install two wires (27 and 28) on two starter terminals (29 and 30) with two screws (26). Tighten screws.

(13) Install wires (22, 23, and 24) on starter terminal (25) with nut (21). Tighten nut.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(14) Install glow plug wire (19) on glow plug (20) with nut (18).

(15) Install strap (17) on wire harness (1) and frame (6) with screw (16) and nut (15). Tighten nuts 117-221 lb-in (20-25 N•m)

(16) Connect horn connector (14).

(17) Install wire (12) and wire harness (1) on frame (6) with two screws (11), strap (13), and nuts (10). Tighten nuts 117-221 lb-in (20-25 N•m).

(18) Install wire harness (1) on frame (6) with screw (9), nut (7), and strap (8). Tighten nut 117-221 lb-in (20-25 N•m).

(19) Install wire harness (1) on frame (6) with two screws (5), straps (4), and nuts (3). Tighten nuts 117-221 lb-in (20-25 N•m).

(20) Connect wire harness (1) to directional control at connector (2).

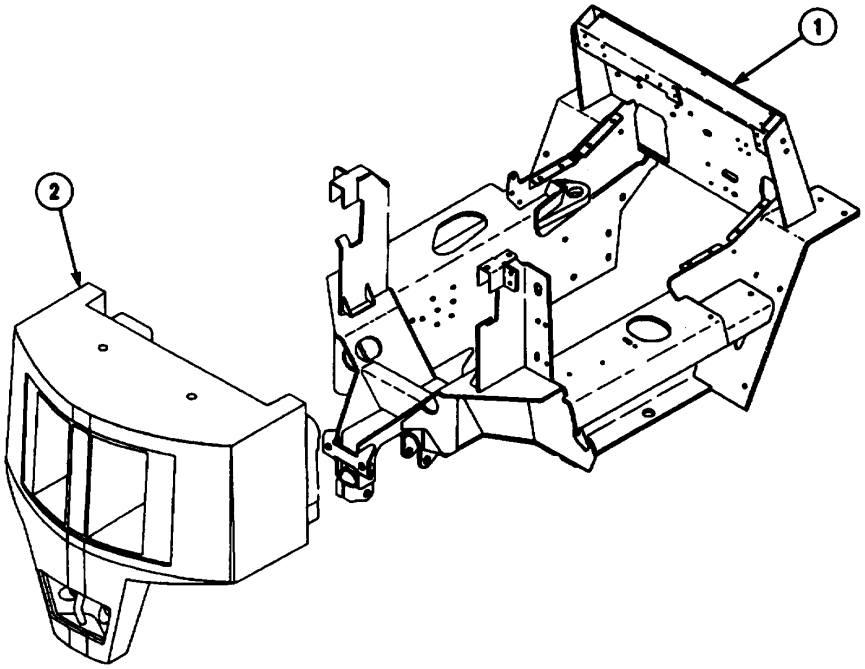
(21) Connect wire harness (1) to gauges, switches, sensors, sending units, lights, alarm, and horn (Para 3-22).

(22) Install floor panels and left and right lower side panels (Para 3-36).

(23) Connect batteries (Para 3-25).

END OF TASK

5-22. MAIN FRAME INSPECTION.



CAUTION

Whenever welding on this vehicle, always disconnect battery cables. Do not put ground strap on lift carriage or mast unless welding on lift carriage or mast.

NOTE

It is only necessary to remove those items which would prevent an accurate inspection of frame assembly. To save time on removal and installation, inspect frame in sections. Remember, much of frame can be inspected from beneath truck. If necessary, refer to TC9-237, Welding Theory and Application.

a. Check for dents or visible cracks in metal on frame (1) and counterweight.

b. Check welds for visible cracks and damage on frame (1).

c. Check screws and screw holes for irregular size and shape on frame (1) and counterweight (2).

d. Check for excessive corrosion and wear on frame (1).

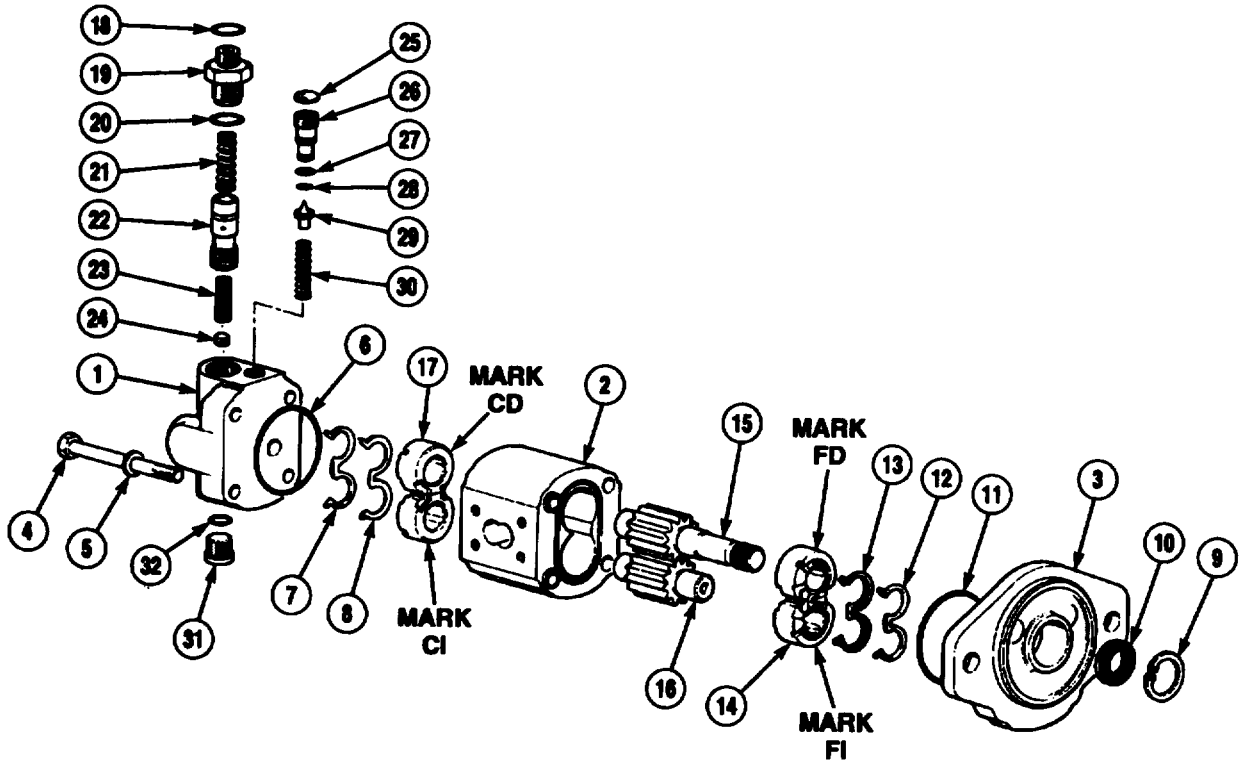
e. Check for chipped paint.

f. If faults are discovered that will impair safe operation, repair immediately.

END OF TASK

5-23. HYDRAULIC PUMP REPAIR.

a. Disassembly.



CAUTION

Disassemble hydraulic pump only in a clean, dust free location. Dirt or grit will damage machined surfaces and result in leakage or premature failure.

(1) Remove hydraulic pump from forklift (Appendix F, Main Hydraulic Pump, Section 10.3)

(2) To disassemble the main hydraulic pump, proceed as follows:

(a) Using a scribe, match mark valve body (1), body (2), and mounting flange (3).

(b) Remove four screws (4) and lockwashers (5) from valve body (1), body (2), and mounting flange (3). Discard jockwashers.

(c) Remove valve body (1), seal (6), backup seal (7), and seal (8) from body (2). Discard seals.

(d) Remove mounting flange (3) from body (2).

WARNING

Use care when removing and installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(e) Remove snap ring (9) and seal (10) from mounting flange (3). Discard seal.

(f) Remove seal (11), backup seal (12), and seal (13) from body (2). Discard seals.

(g) Mark bushing (14) on mounting flange (3) side to indicate driveshaft (15) position as FD and driven gear (16) position as Fl.

(h) Mark bushing (17) on valve body (1) side to indicate driveshaft (15) position as CD and driven gear (16) position as Cl.

(i) Remove bushing (14) from driveshaft (15) and driven gear (16).

(j) Remove bushing (17), driveshaft (15), and driven gear (16) from body (2).

WARNING

Use care when removing spring seat. Spring seat is under spring tension and can act as a projectile when released and could cause severe eye injury.

(k) Remove seal (18), spring seat (19), and seal (20) from valve body (1). Discard seals.

(l) Remove flex spring (21), spool (22), filter (23), and damping orifice (24) from valve body (1). Discard filter.

WARNING

Use care when removing pilot valve seat. Pilot valve seat is under spring tension and can act as a projectile when released and could cause severe eye injury.

NOTE

Core plug is peened in position. Peen may require drilling for removal.

(m) Remove core plug (25), pilot valve seat (26), seal (27), and seal (28) from valve body (1). Discard seals.

(n) Remove pilot valve (29) and spring (30) from valve body (1).

(o) Remove pressure plug (31) and seal (32) from valve body (1). Discard seal.

b. Inspection.

(1) Inspect body for cut-in where gears wipe the body. If body cut-in is not bright and polished, or exceeds .003 in (.08mm), replace body.

(2) Inspect mounting flange and valve body for unusual wear or scoring in the areas around the seals and shaft recess. If there are signs of scoring, replace mounting flange or valve body.

NOTE

It is normal for low-pressure side of bushing to appear slightly more worn.

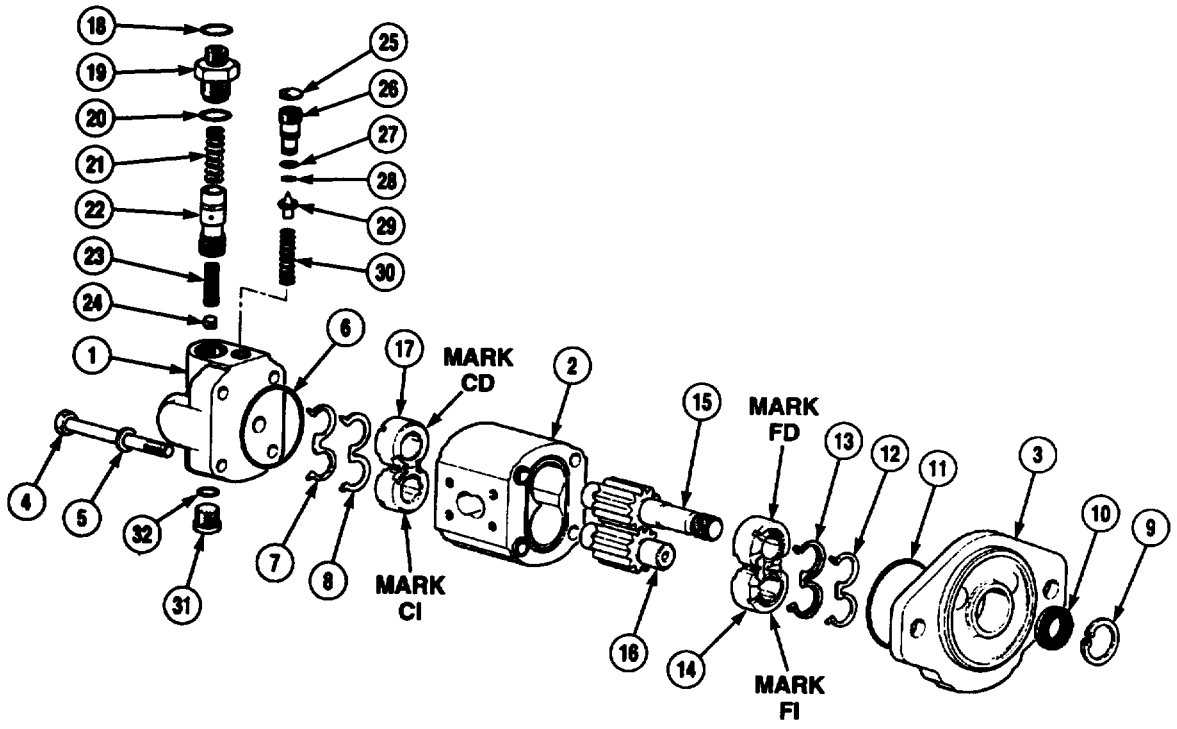
(3) Inspect gear side of bushings for signs of wear or scoring. If bushings appear worn or scored, replace.

(4) Inspect gear side faces for signs of bruising, pitting, or scoring. If bruising, pitting, or scoring are found, replace gears as a set.

(5) Inspect journal bearing surfaces for scoring or bruising. If any scoring or bruising is found, replace gears as a set.

(6) Inspect load sensing orifice for dirt. Clean load sensing orifice, if dirty (Para 5-4).

c. Assembly.



CAUTION

Assemble hydraulic pump only in a clean, dust free location. Dirt or grit will damage machined surfaces and result in leakage or premature failure.

(1) Install seal (32) and plug (31) on valve body (1). Tighten plug 55-59 lb-ft (75-80 N•m).

(2) Position spring (30) and pilot valve (29) in valve body (1).

WARNING

Use care when installing pilot valve seat. Pilot valve seat is under spring tension and can act as a projectile when released and could cause severe eye injury.

(3) Position seal (28), seal (27), and pilot valve seat (26) in valve body (1).

(4) Position damping orifice (24), filter (23), spool (22) and flex spring (21) in valve body (1).

WARNING

Use care when installing spring seat. Spring seat is under spring tension and can act as a projectile when released and could cause severe eye injury.

(5) Install seal (20) and spring seat (19) on valve body (1). Tighten spring seat 74-78 lb-ft (100-105 N•m).

(6) Position seal (18) on spring seat (19).

(7) Position bushing (17) in body (2) as marked during Disassembly.

(8) Install seal (8) and backup seal (7) in body (2).

(9) Install seal (6) on body (2).

(10) Position four screws (4) with lockwashers (5) and valve body (1) on body (2).

(11) Position driveshaft (15) and driven gear (16) in body (2) and bushing (17).

(12) Position bushing (14) in body (2) as marked during Disassembly.

(13) Install seal (13), backup seal (12), and seal (11) in body (2).

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(14) Install seal (10) in mounting flange (3) with snap ring (9).

(15) Apply bearing grease to inner edge of seal (10).

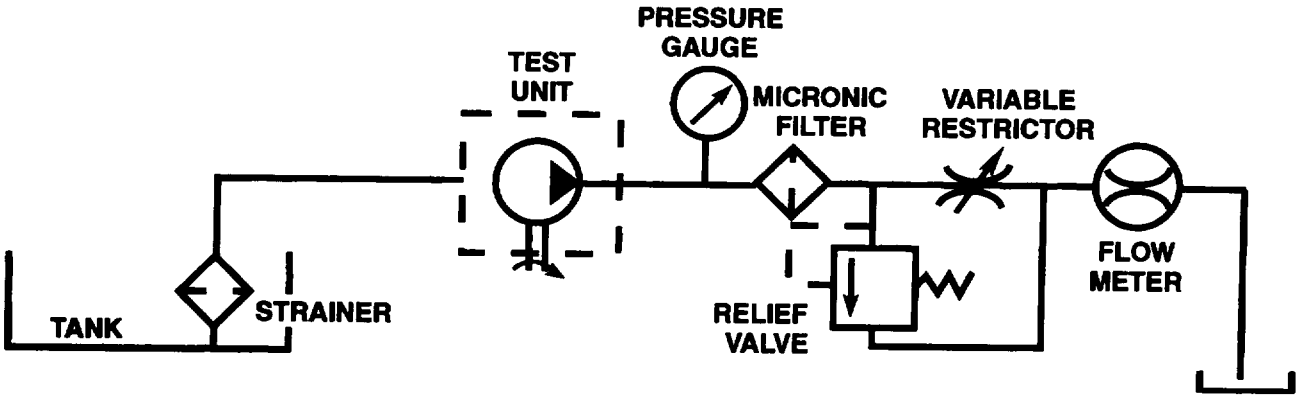
(16) Install mounting flange (3) on body (2) with four screws (4) and lockwashers (5). Tighten screws to 34-38 lb-ft (46-51 N•m).

NOTE

Core plug will be peened in position after pump is run-in and tested or adjusted.

(17) Fill hydraulic pump with oil and test for free movement.

d. Run-In/Test



NOTE

A hydraulic pump that has been reassembled with new gears, bushings, or body must be run-in prior to being subjected to normal working pressures. This is normally performed on a test circuit similar to the diagram above.

(1) Install hydraulic pump on hydraulic test system.

(2) Operate pump at 1500 rpm for one minute at zero psi.

CAUTION

Frequently check the hydraulic test system temperature. Temperature must remain below 176°F (80°C). If temperature reaches 176°F (800C), testing must stop and the pump must be operated for a longer period without pressure.

(3) At one minute intervals, increase pressure by 508 psi (35 bar) until hydraulic pump operating pressure reaches 3045 psi (210 bar).

(4) Operate pump at operating pressure for one minute.

(5) Stop hydraulic test system and allow pressure to drop to zero psi.

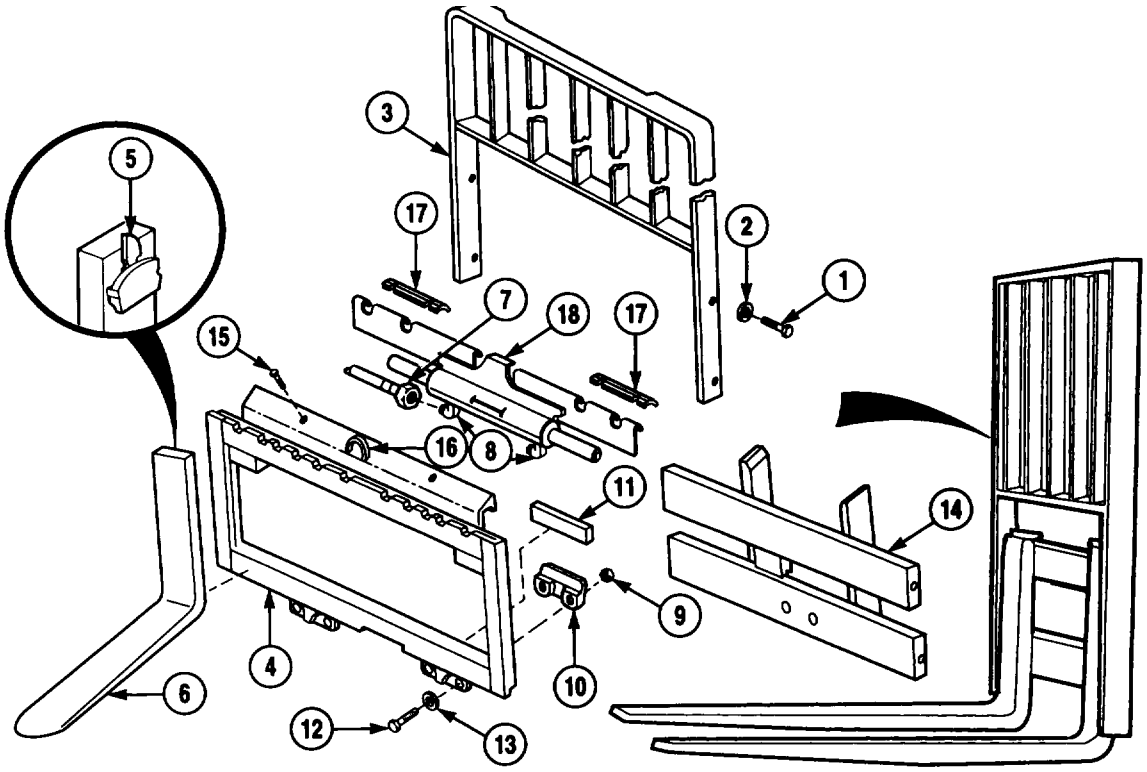
(6) Remove hydraulic pump from hydraulic test system.

(7) Install hydraulic pump on forklift (Appendix F, Main Hydraulic Pump, Section 10.3).

END OF TASK

5-24. CARRIAGE ASSEMBLY REPAIR.

a. Removal.



(1) Remove carriage assembly from forklift (Appendix F, Upright Maintenance, Section 13.1).

(2) To remove the side shifter assembly from lift carriage assembly, proceed as follows:

(a) Remove four screws (1), two washers (2), and backrest (3) from side shifter assembly frame (4).

WARNING

Forks weigh 106 lbs (48 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(b) Lift fork levers (5) and remove two forks (6) from side shifter assembly frame (4).

(c) Disconnect two hydraulic hoses (7) from two elbows (8).

(d) Remove four nuts (9), two lower hooks (10), and lower bearings (11) from four screws (12) and washers (13) securing side shifter assembly frame (4) to lift carriage assembly (14).

(e) Remove two fittings (15) from side shifter assembly frame (4).

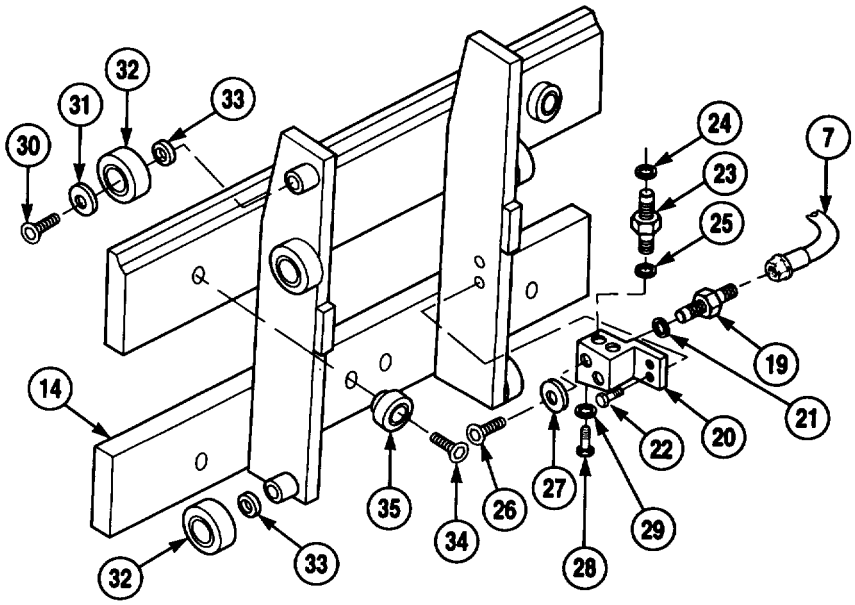
WARNING

- **Keep clear of equipment when equipment is being raised or lowered. Equipment may fall and cause serious injury or death to personnel.**
- **Do not allow heavy components to swing while hanging by lifting device. Equipment may strike personnel and cause injury.**
- **Frame weighs 122 lbs (55 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.**

(f) Attach a suitable lifting device to lifting eye (16) on side shifter assembly frame (4) and remove from lift carriage assembly (14).

(g) Remove two upper bearings (17) and side shift cylinder (18) from lift carriage assembly (14) frame.

b. Disassembly.

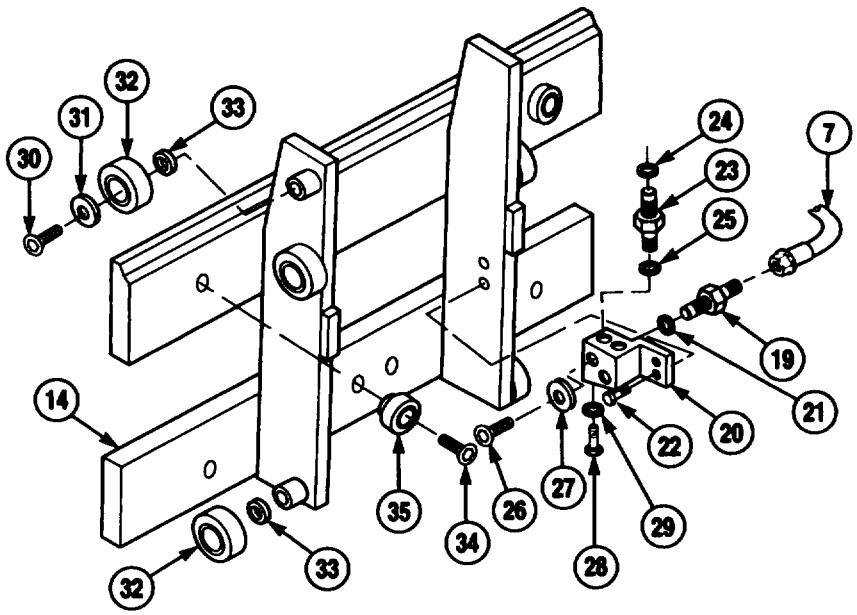


NOTE

Tag and mark all hoses and fittings prior to removal.

(1) Remove two side shifter hydraulic hoses (7) from two fittings (19) on manifold (20) of lift carriage assembly (14).

(2) Remove two fittings (19) and seals (21) from manifold (20). Discard seals.



(3) Remove two screws (22) and manifold (20) from lift carriage assembly (14).

(4) Remove two fittings (23) and seals (24 and 25) from manifold (20). Discard seals.

(5) Remove two plugs (26), seals (27), plugs (28), and seals (29) from manifold (20). Discard seals.

NOTE

Note the number of shims removed so that correct number are installed during assembly.

(6) Remove two screws (30), washers (31), six rollers (32), and shims (33) from lift carriage assembly (14).

(7) Remove two screws (34) and rollers (35) from lift carriage assembly (14).

c. Assembly.

(1) Install two rollers (35) on lift carriage assembly (14) with two screws (34). Tighten screws 38.5-42.6 lb-ft (52.3 - 57.8 N•m).

(2) Install six rollers (32) and shims (33), as noted during Disassembly, with two washers (31) and screws (30) on lift carriage assembly (14). Tighten screws 31.5-34.8 lb-ft (42.8-47.3 N•m).

(3) Install two plugs (26), seals (27), plugs (28), and seals (29) in manifold (20). Tighten plugs (26) 12-13 lb-ft (17-18 N•m) and plugs (28) 70-80 lb-in (8-9 N•m).

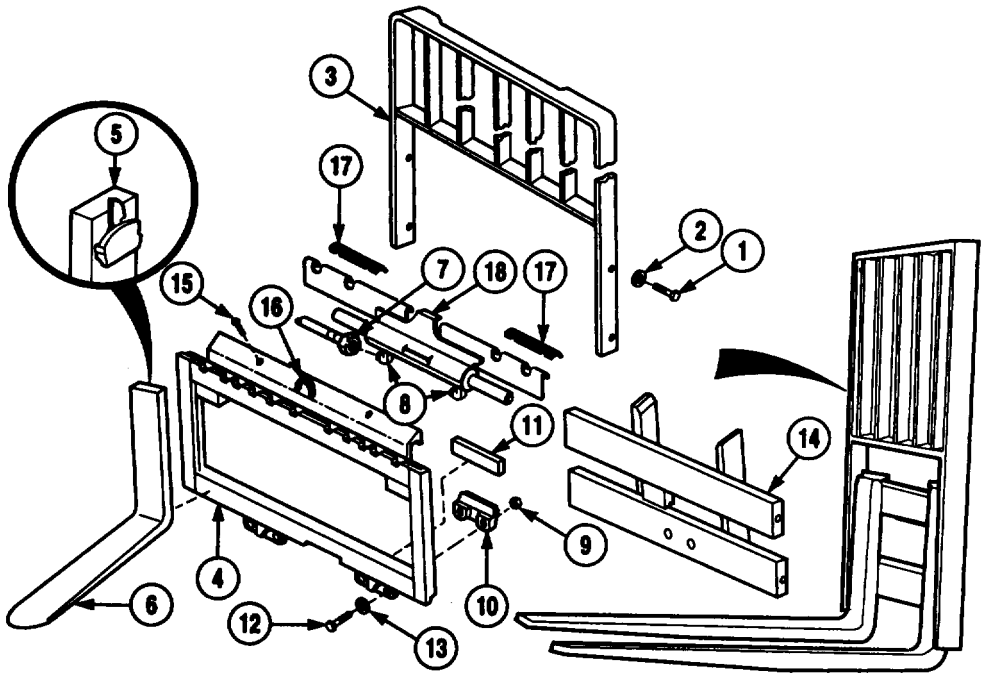
(4) Install two fittings (23) with seals (24 and 25) on manifold (20). Tighten fittings 70-80 lb-in (8-9 N•m).

(5) Install manifold (20) on lift carriage assembly (14) with two screws (22). Tighten screws to 14.8-18.4 lb-ft (20-25 N•m).

(6) Install two fittings (19) and seals (21) on manifold (20). Tighten fittings 70-80 lb-in (8-9 N•m).

(7) Install two side shifter hydraulic hoses (7) on two fittings (19).

d. Installation.



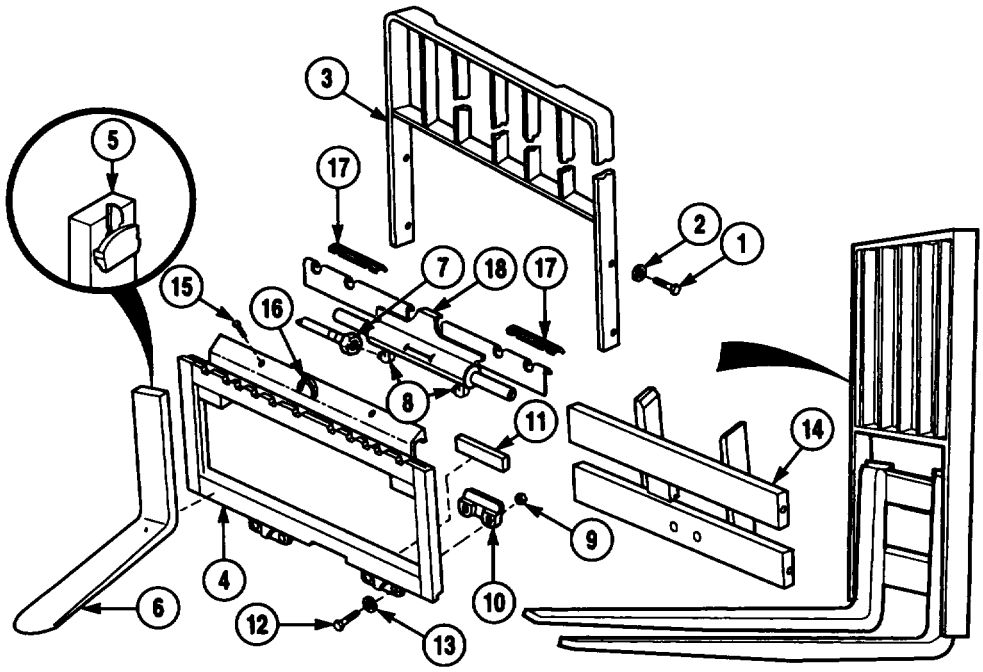
(1) To install side shifter assembly on lift carriage assembly, proceed as follows:

(a) Position side shift cylinder (18) and two upper bearings (17) on lift carriage assembly (14) frame.

WARNING

- **Keep clear of equipment when equipment is being raised or lowered. Equipment may fall and cause serious injury or death to personnel.**
- **Do not allow heavy components to swing while hanging by lifting device. Equipment may strike personnel and cause injury.**
- **Frame weighs 122 lbs (55 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.**

(b) Attach a suitable lifting device to lifting eye (16) on side shifter assembly frame (4) and position on lift carriage assembly (14).



(c) Install two fittings (15) on side shifter assembly frame (4).

(d) Install side shifter assembly frame (4) to lift carriage assembly (14) with two lower bearings (11), lower hooks (10), four screws (12), washers (13), and nuts (9). Tighten screws 115-125 lb-ft (155-170 N•m).

(e) Install two hydraulic hoses (7) on two elbows (8).

WARNING

Forks weigh 106 lbs (48 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(f) Lift fork levers (5) and install two forks (6) on side shifter assembly frame (4).

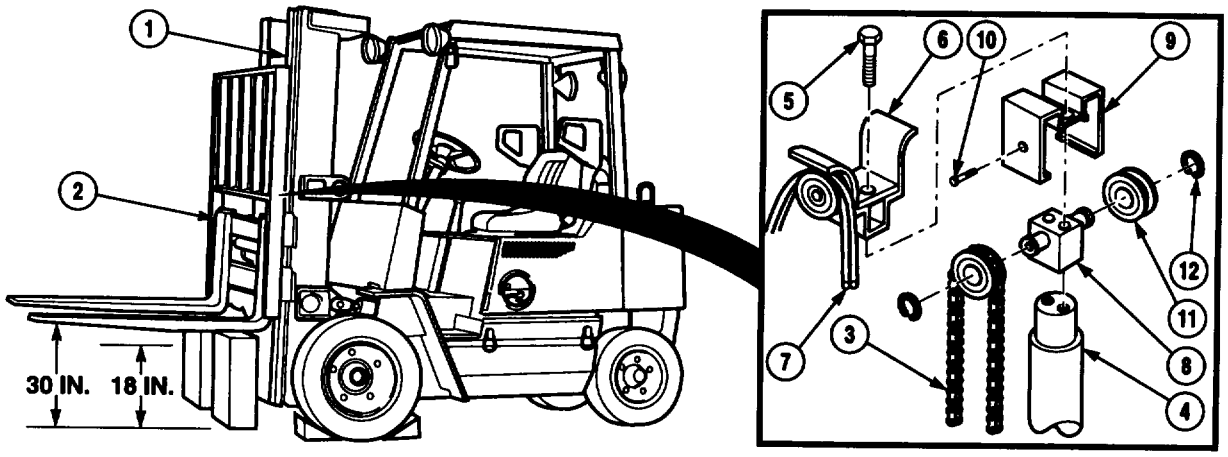
(g) Install backrest (3) on side shifter assembly frame (4) with four screws (1) and two washers (2). Tighten screws 50-60 lb-ft (70-80 N•m).

(2) Install carriage assembly on forklift (Appendix F, Upright Maintenance, Section 13.1).

END OF TASK

5-25. ROLLER SHEAVE REPAIR.

a. Removal.



Note

All hose and chain roller sheaves are removed in a similar manner. The primary lift cylinder chain roller sheave is shown.

(1) Chock forklift wheels (TM 10-3930-671-10).

(2) Remove backrest (Para 5-24).

(3) Position blocks under inner rail of mast (1) and carriage (2) and remove all tension from two chains (3) (TM 10-3930-671-24).

(4) Position carriage (2) on blocks until chain (3) is loose over primary lift cylinder (4).

(5) Ensure engine is OFF (TM 10-3930-671 -10).

(6) Remove two screws (5), bracket (6), and hose sheave assembly (7) from lift chain sheave carrier (8).

(7) Move bracket (6) and hose sheave assembly (7) aside from guard (9) and lift chain sheave carrier (8).

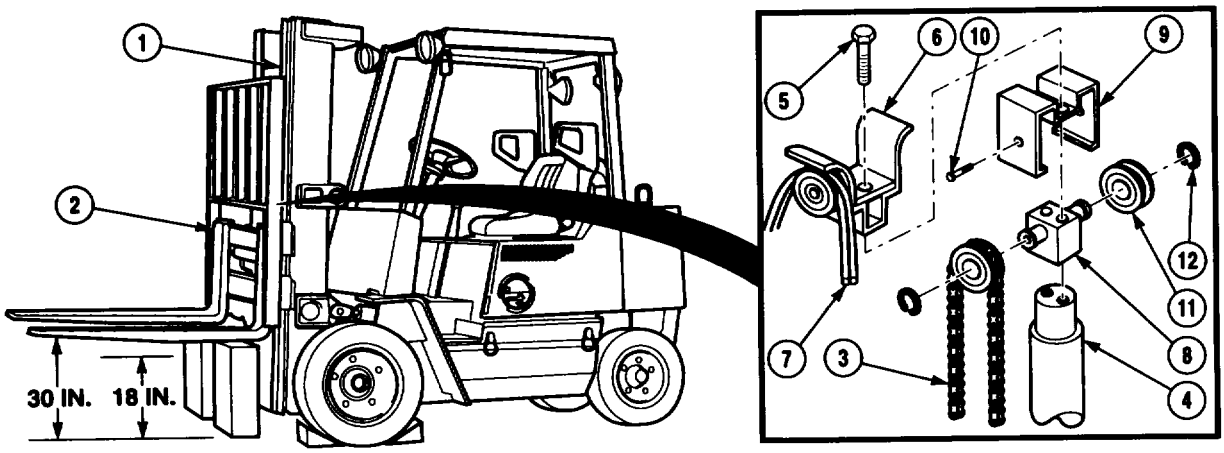
(8) Remove two screws (10), guard (9), and two chains (3) from two lift chain sheaves (11).

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(9) Remove two snap rings (12) and chain roller sheaves (11) from lift chain sheave carrier (8). Discard snap rings.

b. Installation.



WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(1) Install two chain roller sheaves (11) on lift chain sheave carrier (8) with two snap rings (12).

(2) Install two chains (3) and guard (9) on two lift chain sheaves (11) with two screws (10). Tighten screws 55-60 lb-ft (75-81 N•m).

(3) Install hose sheave assembly (7) and bracket (6) on lift chain sheave carrier (8) with two screws (5). Tighten screws 55-60 lb-ft (75-81 N•m).

(4) Start engine (TM 10-3930-671-10).

(5) Apply tension to two chains (3) and remove blocks from under carriage (2) and mast inner rail (1) (TM 10-3930-671-10).

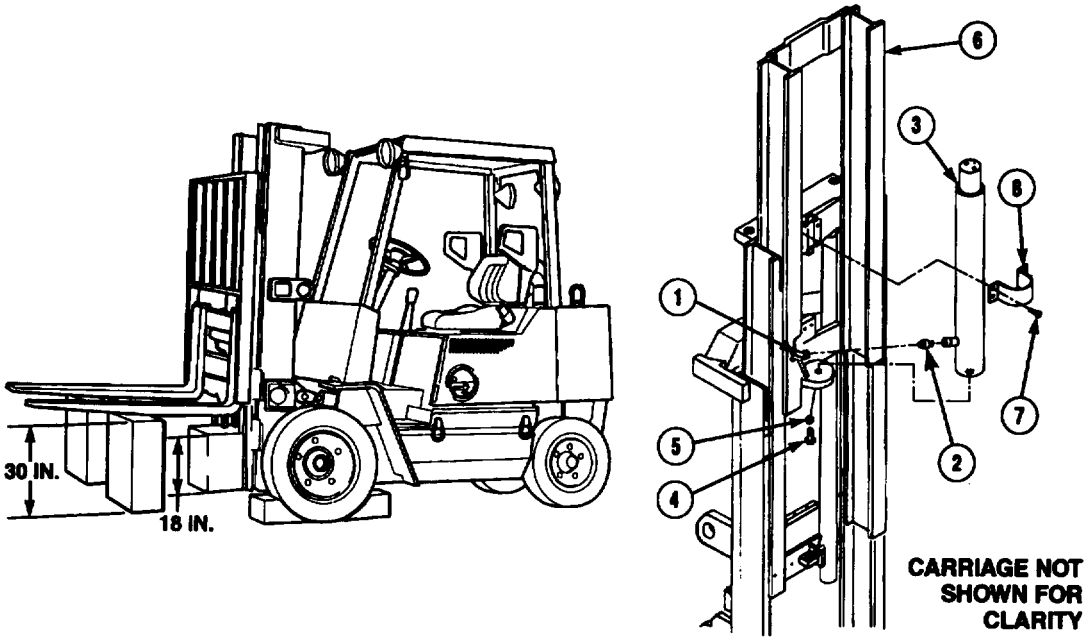
(6) Install backrest on carriage (Para 5-24).

END OF TASK

5-26. LIFT CYLINDER REPLACEMENT/REPAIR.

a. Primary Lift Cylinder.

(1) Removal.



(a) Chock wheels to prevent roll (TM 10-3930-671-10).

(b) Position blocks under mast and carriage (Para 5-26b, Step (1)[b]).

(c) Remove backrest (Para 5-24).

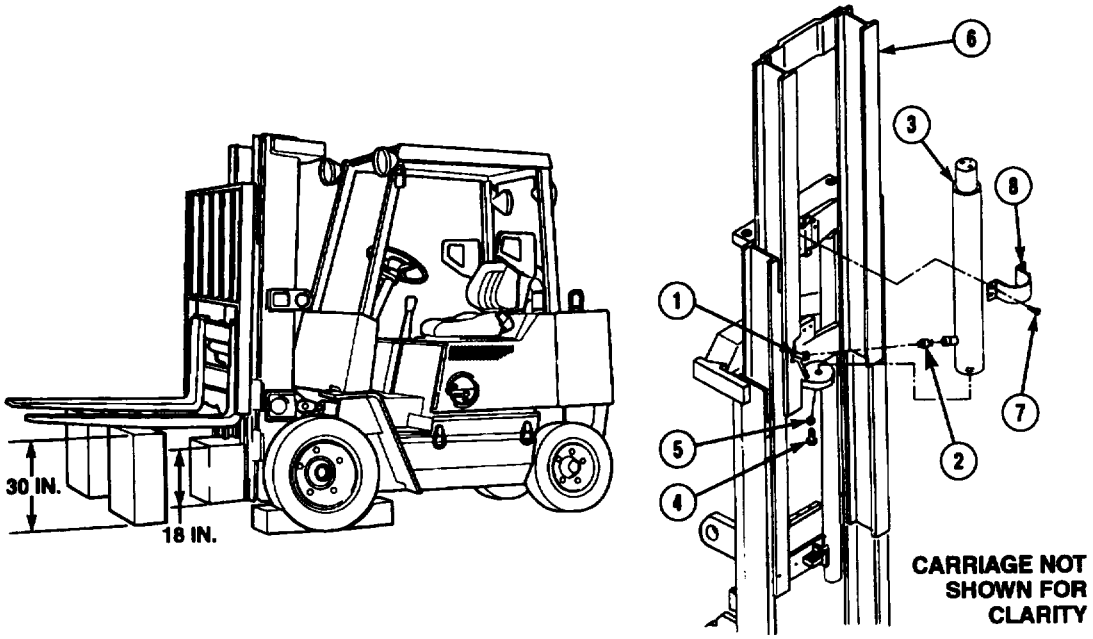
(d) Remove primary lift cylinder chain roller sheave (Para 5-25).

(e) Position drain pan under hose (1) connection to fitting (2).

WARNING

- **Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.**
- **Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. Before disconnecting lines, be sure to relieve all pressure. If injured by escaping fluid, get medical attention at once.**

(f) With the vehicle turned OFF, operate hydraulic control levers to relieve all pressure from hydraulic system.



NOTE

Cap and plug all hoses and fittings during removal.

(g) Remove hose (1) from fitting (2).

(h) Remove fitting (2) from primary lift cylinder (3).

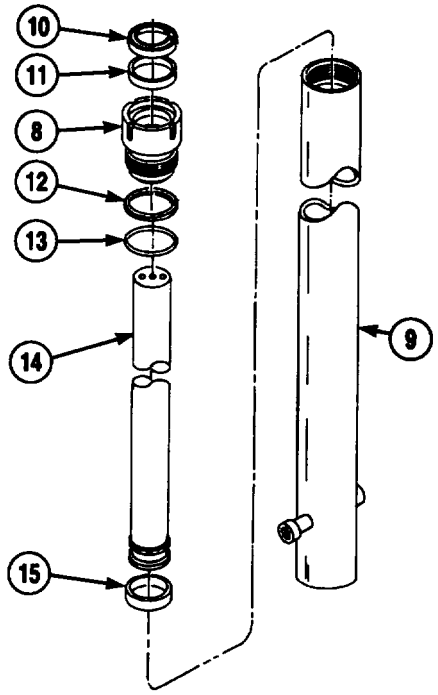
(i) Remove screw (4) and spacer (5) from mast (6) and primary lift cylinder (3).

WARNING

Primary lift cylinder weighs 300 lbs (136 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(j) Using suitable lifting device, remove four screws (7), retainer cap (8), and primary lift cylinder (3) from mast (6) and place on clean work surface.

(2) Disassembly.



WARNING

Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.

(a) Remove cap (8), from barrel assembly (9).

(b) Remove wiper (10) and seal (11) from cap (8). Discard wiper and seal.

(c) Remove backup ring (12), seal (13), and rod (14) from barrel assembly (9). Discard backup ring and seal.

(d) Remove wear ring (15) from rod (14). Discard wear ring.

(3) Assembly.

(a) Install wear ring (15) in rod (14).

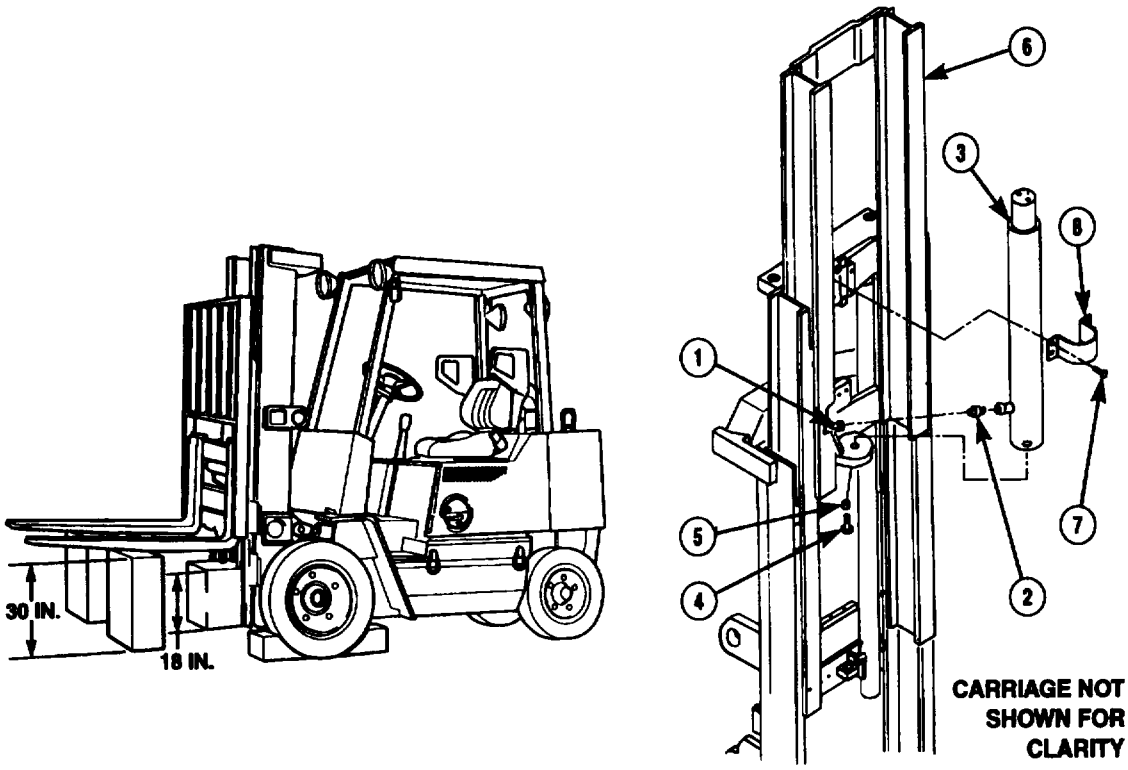
(b) Install rod (14), seal (13), and backup ring (12) in barrel assembly (9).

(c) Install seal (11) and wiper (10) in cap (8).

(d) Apply clean oil to threads of cap (8).

(e) Install cap (8) in barrel assembly (9). Tighten cap 200-250 lb-ft (271-339 N•m).

(4) Installation.



WARNING

Primary lift cylinder weighs 300 lbs (136 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(a) Using suitable lifting device, install primary lift cylinder (3) on mast (6) with four screws (7) and retainer cap (8).

(b) Apply sealant to fitting (2).

WARNING

Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.

(c) Install fitting (2) and hose (1) on primary lift cylinder (3).

(d) Install primary lift cylinder chain roller sheave (Para 5-25).

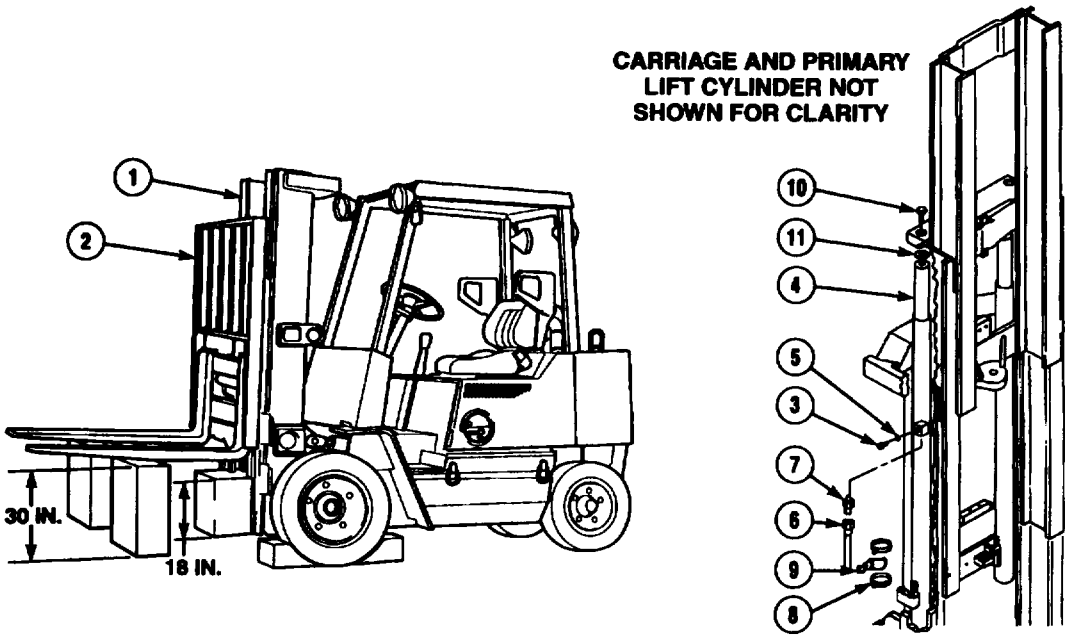
(e) Install backrest (Para 5-24).

(f) Remove blocks from under carriage and mast (Para 5-26b, Step (4)[f]).

(g) Remove chocks from forklift wheels (TM 10-3930-671-10).

b. Final Lift Cylinder.

(1) Removal.



(a) Chock wheels to prevent roll (TM 10-3930-671-10).

(b) Position blocks under inner rails of mast (1) and carriage (2) and remove all tension from chains.

NOTE

- **Cap and plug all hoses and fittings during removal.**
- **Right and left final cylinders are removed the same way. Right final cylinder shown.**

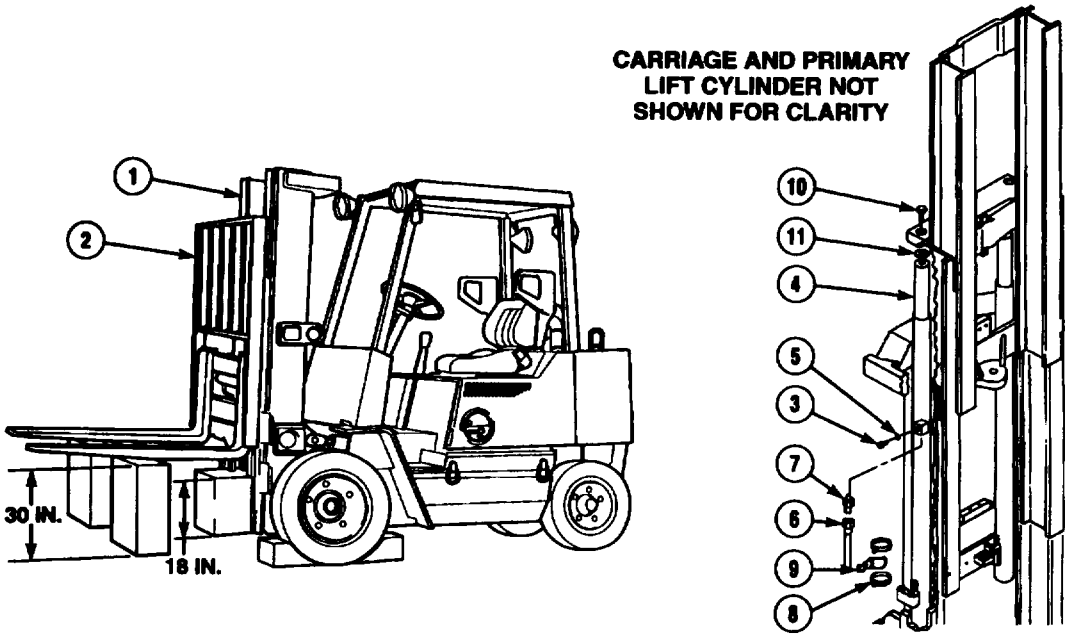
(c) Position drain pan under screw (3) on final lift cylinder (4).

WARNING

- **Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.**
- **Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. Before disconnecting lines, be sure to relieve all pressure. If injured by escaping fluid, get medical attention at once.**

(d) With the vehicle turned OFF, operate hydraulic control levers to relieve all pressure from hydraulic system.

(e) Remove screw (3) and seal (5) from final lift cylinder (4). Discard seal.



(f) Remove hose (6) from fitting (7).

(g) Remove fitting (7) from final lift cylinder (4).

(h) Remove two clamps (8), bracket (9), and hose (6) from final lift cylinder (4).

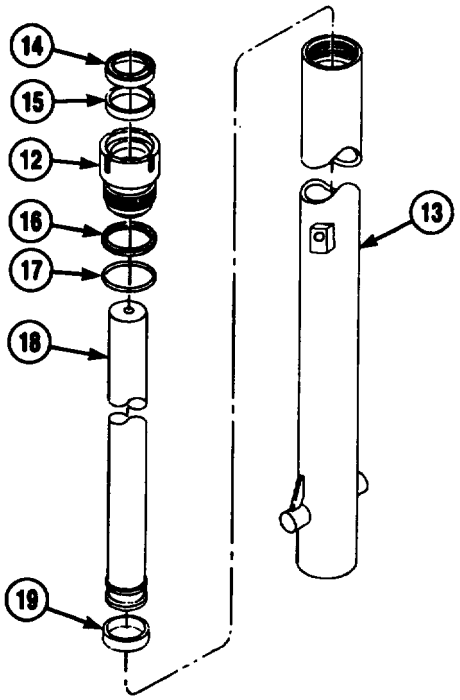
(i) Remove screw (10) and washer (11) from final lift cylinder (4).

WARNING

Final lift cylinder weighs 150 lbs (68 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(j) Using suitable lifting device, remove final lift cylinder (4) from mast (1) and place on clean work surface.

(2) Disassembly.



WARNING

Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.

(a) Remove cap (12), from barrel assembly (13).

(b) Remove wiper (14) and seal (15) from cap (12). Discard wiper and seal.

(c) Remove backup ring (16), seal (17), and rod (18) from barrel assembly (13). Discard backup ring and seal.

(d) Remove wear ring (19) from rod (18). Discard wear ring.

(3) Assembly.

(a) Install wear ring (19) in rod (18).

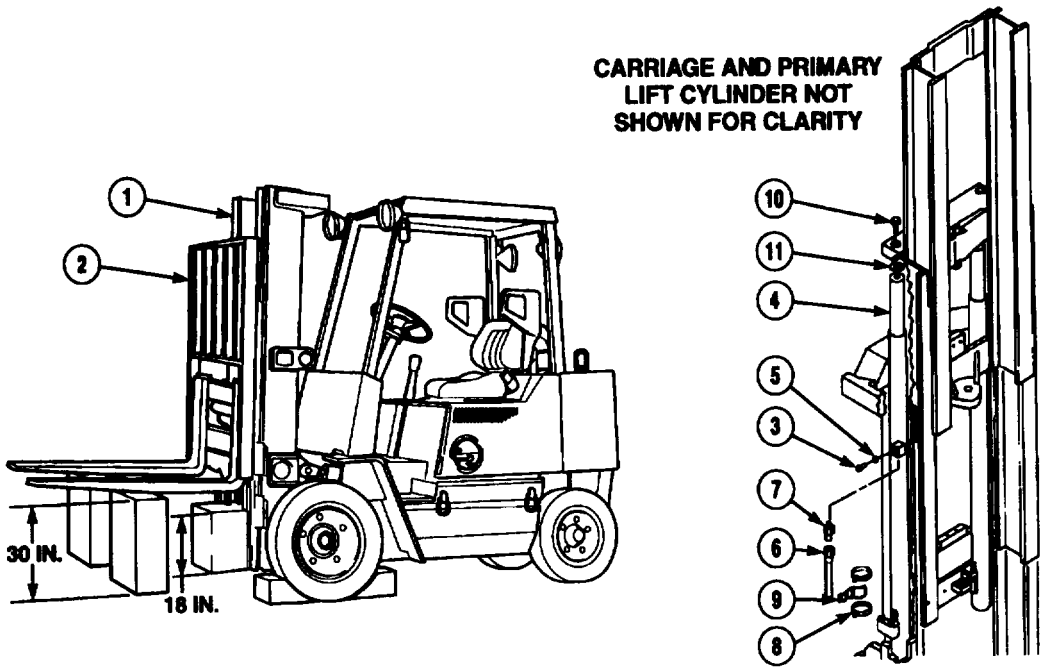
(b) Install rod (18), seal (17), and backup ring (16) in barrel assembly (13).

(c) Install seal (15) and wiper (14) in cap (12).

(d) Apply clean oil to threads of cap (12).

(e) Install cap (12) in barrel assembly (13). Tighten cap 200-250 lb-ft (271-339 N•m).

(4) Installation.



WARNING

Final lift cylinder weighs 150 lbs (68 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(a) Using suitable lifting device, install final lift cylinder (3) on mast (6) with washer (11) and screw (10).

(b) Apply sealant to fitting (7).

WARNING

Spilled hydraulic fluid is slippery. Clean up spilled fluid immediately or injury to personnel may result.

(c) Install fitting (7) and hose (6) on final lift cylinder (4).

(d) Install bracket (9) and hose (6) on final lift cylinder (4) with two clamps (8).

(e) Install screw (3) and seal (5) on final lift cylinder (4).

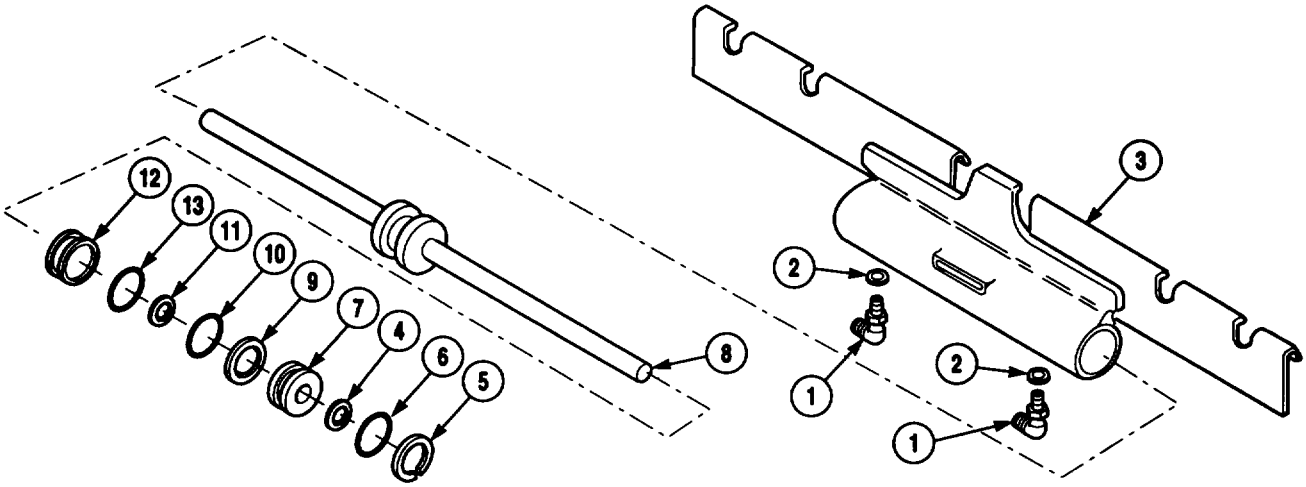
(f) Remove blocks from under inner rails of mast (1) and carriage (2).

(g) Remove chocks from forklift wheels (TM 10-3930-671-10).

END OF TASK

5-27. SIDE SHIFT CYLINDER REPAIR.

a. Removal.



(1) Remove side shift cylinder from side shifter assembly (Para 5-28).

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

NOTE

Both sides of cylinder are disassembled the same way.

(2) Remove two elbows (1) and washers (2) from cylinder (3). Discard washers.

(3) Remove wiper seal (4), snap ring (5), retaining ring (6), retainer (7), and rod (8) from cylinder (3). Discard wiper seal.

(4) Remove backup ring (9), preformed packing (10), and rod seal (11) from retainer (7). Discard backup ring, preformed packing, and rod seal.

(5) Remove bearing ring (12) and piston seal (13) from rod (8). Discard piston seal.
(6) Perform Steps (3) and (4) on opposite end of cylinder.

b. Installation.

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

NOTE

Both sides of cylinder are assembled the same way.

(1) Install piston seal (13) and bearing ring (12) on rod (8).

(2) Install rod seal (11), preformed packing (10), and backup ring (9) on retainer (7).

(3) Install rod (8) and retainer (7) in cylinder (3).

(4) Install retaining ring (6), snap ring (5), and wiper seal (4) on retainer (7).

(5) Perform Steps (2) and (4) on opposite end of cylinder (3).

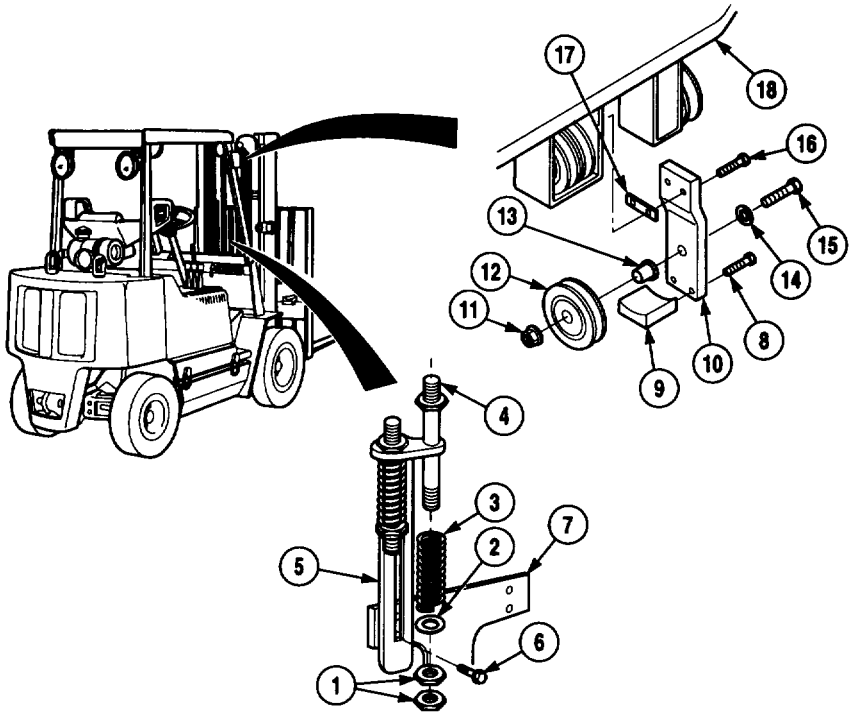
(6) Install two washers (2) and elbows (1) on cylinder (3).

(7) Install side shift cylinder on side shifter assembly (Para 5-24).

END OF TASK

5-28. UPRIGHT REPAIR.

a. Removal.



(1) Remove carriage (Appendix F, Upright Maintenance, Section 13.1).

(2) Remove primary cylinder (Para 5-26).

(3) Remove two final cylinders (Para 5-26).

(4) Remove chains and anchors from upright (Appendix F, Upright Maintenance, Section 13.1).

(5) Remove all hydraulic hoses (Para 3-30).

WARNING

Use care when removing or installing tensioning springs. Tensioning springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

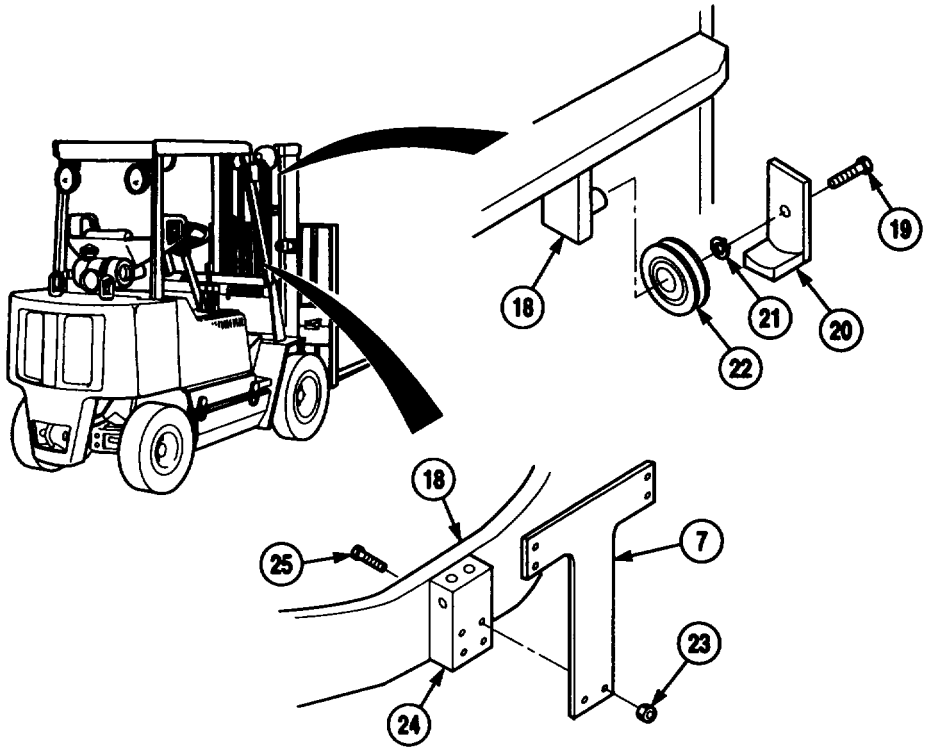
(6) Remove four nuts (1), two washers (2), tensioning springs (3), and pipes (4) from bracket (5).

(7) Remove two screws (6) and bracket (5) from bracket (7).

(8) Remove two screws (8) and guide (9) from bracket (10).

(9) Remove nut (11), roller (12), pivot (13), washer (14), and screw (15) from bracket (10).

(10) Remove two screws (16), bracket (10), and spacer (17) from upright (18).



WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(11) Remove two screws (19), brackets (20), snap rings (21), and rollers (22) from upright (18).

(12) Remove two nuts (23), bracket (7), manifold (24), and two screws (25) from upright (18).

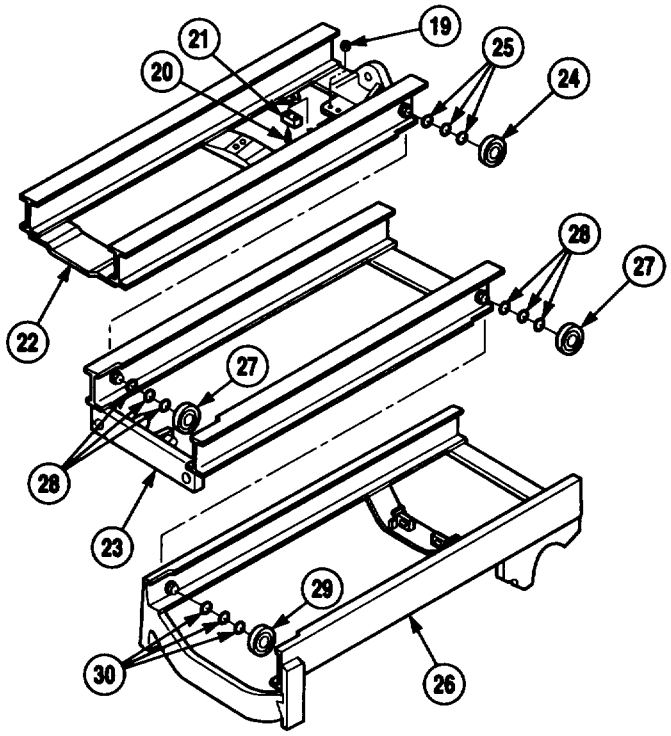
WARNING

Upright rail assemblies weigh a total of 1291 lbs (586 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(13) Using a suitable lifting device, remove upright from forklift (Appendix F, Upright Maintenance, Section 13.1).

(14) Position upright rail assemblies on level work area with mount on the bottom.

b. Disassembly.



(1) Remove three nuts (19), screws (20), and stop block (21).

WARNING

Inner rail weighs 330 lbs (150 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(2) Using a suitable lifting device, remove inner rail (22) from intermediate rail (23).

NOTE

Record number, type, and positions of shims and rollers during removal.

(3) Remove two rollers (24) and shims (25) from inner rail (22).

WARNING

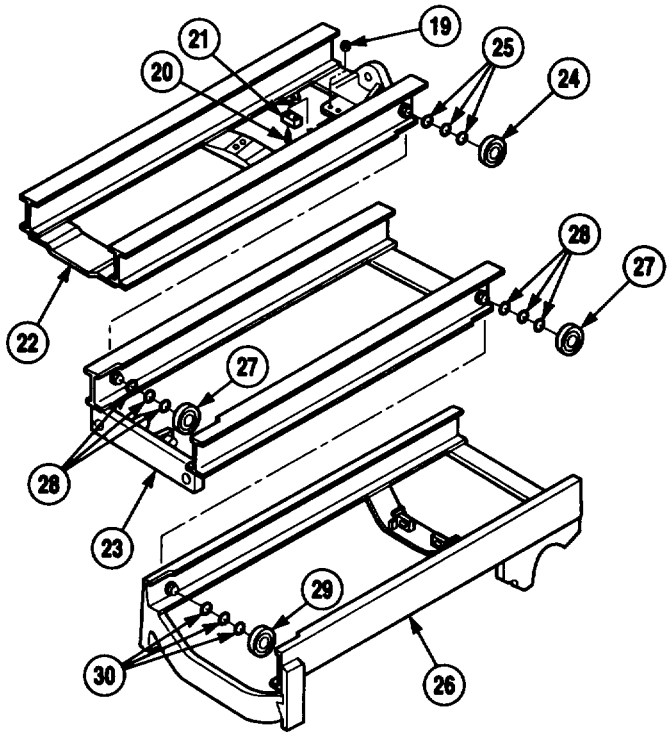
Intermediate rail weighs 361 lbs (164 kg) and outer rail weighs 600 lbs (272 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(4) Using a suitable lifting device, remove intermediate rail (23) from outer rail (26).

(5) Remove four rollers (27) and shims (28) from intermediate rail (23).

(6) Remove two rollers (29) and shims (30) from outer rail (26).

c. Assembly.



NOTE

Install shims and rollers in positions as noted during Disassembly.

(1) Install shims (30) and two rollers (29) on outer rail (26).

(2) Install shims (28) and four rollers (27) on intermediate rail (23).

WARNING

Intermediate rail weighs 361 lbs (164 kg) and outer rail weighs 600 lbs (272 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(3) Using suitable lifting device, install intermediate rail (23) on outer rail (26).

(4) Install shims (25) and two rollers (24) on inner rail (22).

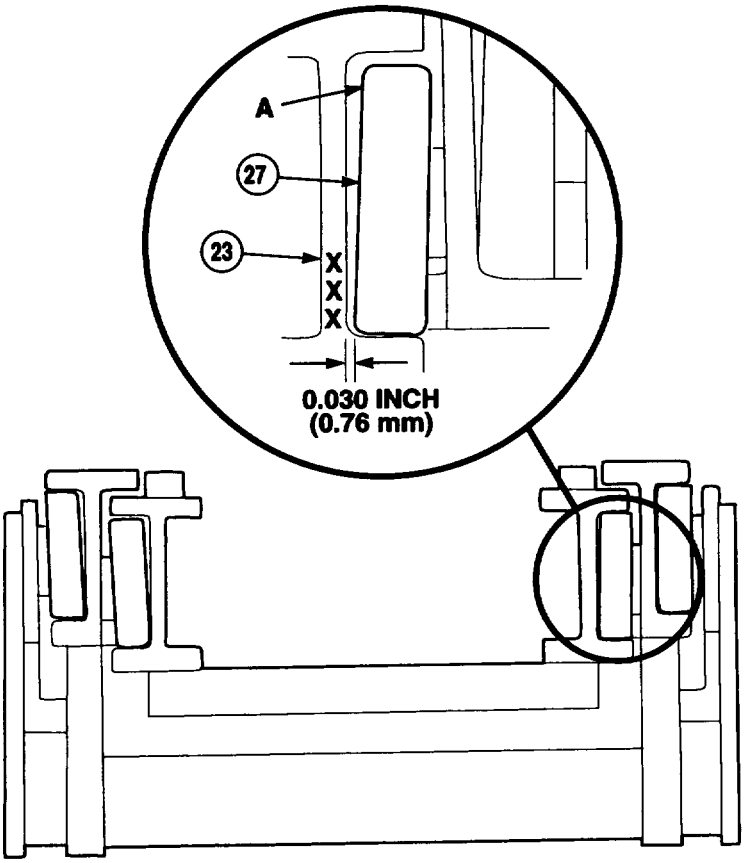
WARNING

Intermediate rail weighs 361 lbs (164 kg) and outer rail weighs 600 lbs (272 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

(5) Using suitable lifting device, install inner rail (22) on intermediate rail (23).

(6) Install stop block (21) on inner rail (22) with three screws (20) and nuts (19). Tighten nuts 52-59 lb-ft (70-80 N•m).

d. Adjustment.



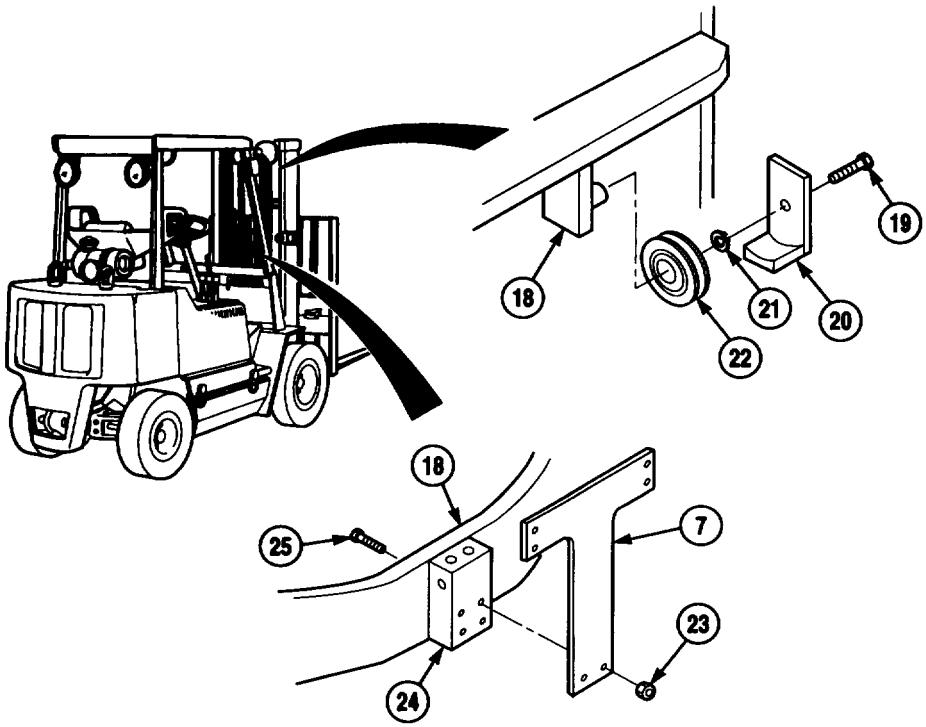
NOTE

- **Use equal number of shims on each side to obtain measured gap no greater than 0.030 in (0.76 mm).**
- **Each rail is shimmed using similar procedure. Inner rail is shown.**

(1) Using a pry bar to apply pressure on roller (27) at point A, measure the clearance between each roller and each rail (23) at the tightest point in its travel.

(2) Add or remove shims equally on each side until the desired gap is acquired.

e. Installation.



WARNING

Upright rail assemblies weigh a total of 1291 lbs (586 kg). Attach suitable lifting device prior to removal or installation to prevent possible injury to personnel.

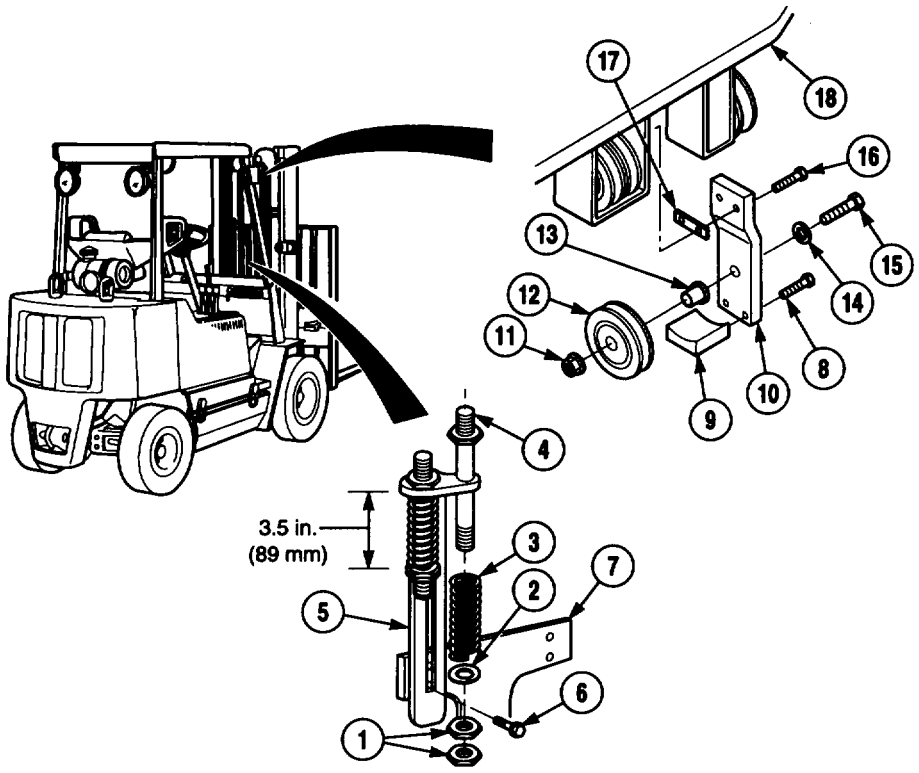
(1) Using a suitable lifting device, install upright on forklift (Appendix F, Upright Maintenance, Section 13.1).

(2) Install manifold (24) and bracket (7) on upright (18) with two screws (25) and nuts (23). Tighten nuts 15-18 lb-ft (20-24 N•m).

WARNING

Use care when removing or installing snap and retaining rings. Snap and retaining rings are under spring tension and can act as projectiles when released and could cause severe eye injury.

(3) Install two rollers (22) and brackets (20) on upright (18) with snap rings (21), as noted during ***Removal***, and two screws (19). Tighten screws 55-60 lb-ft (75-81 N•m).



(4) Install spacer (17) and bracket (10) on upright (18) with two screws (16). Tighten screws 15-18 lb-in (20-25 N•m).

(5) Install roller (12) on bracket (10) with pivot (13), washer (14), screw (15), and nut (11). Tighten nut 52-59 lb-ft (70-80 N•m).

(6) Install guide (9) on bracket (10) with two screws (8). Tighten screws 15-18 lb-ft (20-25 N•m).

(7) Install bracket (5) on bracket (7) with two screws (6). Tighten screws 15-18 lb-ft (20-25 N•m).

WARNING

Use care when removing or installing tensioning springs. Tensioning springs are under spring tension and can act as projectiles when released and could cause severe eye injury.

(8) Install two pipes (4) on bracket (5) with two tensioning springs (3), washers (2), and four nuts (1). Tighten four nuts until spring height measures 3.5 in (89 mm).

(9) Install hydraulic hoses (Para 3-30).

(10) Install chains and anchors on upright (Appendix F, Upright Maintenance, Section 13.1).

(11) Install two final cylinders (Para 5-26).

(12) Install primary cylinder (Para 5-26).

(13) Install carriage (Appendix F, Upright Maintenance, Section 13.1).

END OF TASK

APPENDIX A

REFERENCES

A-1. SCOPE.

This appendix lists all forms, field manuals, technical manuals, and other publications referenced in this manual. Other manuals that should be consulted for additional information about truck operation are also listed herein.

A-2. PUBLICATION INDEX.

The following index should be consulted frequently for late changes or revisions to documents listed herein. This index also lists new publications relating to material covered in this manual.

Consolidated Index of Army Publications and Blank Forms ..... DA Pam 25-30

A-3. FORMS.

The following forms are referenced within this manual. Refer to DA Pam 25-30 for index of blank forms.

Standard Form 46, U.S. Government Motor Vehicle Operator's Identification Card.
Standard Form 91, Operator's Report of Motor Vehicle Accident.
Recommended Changes to DA Publications and Blank Forms (DA Form 2028, 2028-2).
Equipment Inspection and Maintenance Worksheet (DA Form 2404).

Refer to DA Pam 738-750, The Army Maintenance Management System (TAMMS), for instructions on the use of maintenance forms required during the operation of this manual.

A-4. OTHER PUBLICATIONS.

a. Safety.

Prevention of Motor Vehicle Accidents.....AR 385-55
Safety Inspection and Testing of Lifting Devices..... TB 43-0142
First Aid for Soldier.....FM 21-11

b. Vehicle Operation.

Vehicle Recovery Operations.....FM 20-22
Desert Operation.....FM 90-3
Mountain Operation.....FM 90-6
River Crossing.....FM 90-13
Manual for Wheel Vehicle Driver.....FM 21-305

c. Cold Weather Operation and Maintenance.

Operation and Maintenance of Ordnance Material in Extreme Cold
Weather (0 degrees to -65 degrees F) .....FM 9-207
Basic Cold Weather Manual .....FM 31-70
Northern Operations .....FM 31-71

d. Maintenance and Repair.

Charging System Troubleshooting (The Easy Way) ..... DA Pam 750-33
Metal Body Repair and Related Operations..... TC 9-510
Ordnance Tracked and Wheeled Vehicle Hull and Chassis Wiring, Repair of ..... TB ORD 650
Description, Use, Bonding Techniques, and Properties of Adhesives ..... TB ORD 1032
Purging, Cleaning, and Coating Interior Ferrous and Terne Sheet Vehicle Fuel Tanks . TB 43-0212
Use of Antifreeze and Cleaning Compounds in Engine Cooling Systems ..... TB 750-651
Cooling Systems: Tactical Vehicles .....TM 750-254
Rigging TM 5-725
Inspection, Care, and Maintenance of Antifriction Bearings.....TM 9-214
Welding Theory and Application.....TC 9-237
Care and Use of Hand Tools and Measuring Tools .....TM 9-243
Materials Used for Cleaning, Preserving, Abrading, and Cementing Ordnance Material and Related Materials Including Chemicals .....TM 9-247
Painting Instructions for Field Use.....TM 43-0139
Color, Marking, and Camouflage Painting of Military Vehicles..... TB 43-0209
Inspection, Use and Tightening of Metal Fasteners Used on Tank-Automotive EquipmentTB 430218
Operator, Unit, Direct Support, and General Support Maintenance Manual for Repair and Inspection of Pneumatic Tires and Inner Tubes..... TM 9-2610-200-14
Tool Outfit, Hydraulic Systems Test and Repair (HSTRU) ..... TM 9-4940-468-14
Operator, Unit, Direct Support and General Support Maintenance Manual for Lead Acid Storage Batteries ..... TM 9-6140-200-14
Operator's Manual, Truck Forklift, Clean Burn Diesel, Front Loading, 4000 lb. Capacity, M483, Clark Model GPX 25E Diesel TM10-3930-671-10

e. Decontamination.

NBC (Nuclear, Biological, and Chemical) Contamination Avoidance.....FM 3-3
NBC (Nuclear, Biological, and Chemical) Protection .....FM 3-4
NBC (Nuclear, Biological, and Chemical) Decontamination.....FM 3-5
NBC (Nuclear, Biological, and Chemical) Defense .....FM 21-40

f. General.

Transportation Reference Data .....FM 55-15
Transportability Guidance for Application of Blocking, Bracing and Tiedown .... TM 55-2200-001-12
Certification of Military Equipment for Transport in MAC/CRAF Aircraft ..... TB 55-45
Storage & Material Handling Operations..... TM 743-200-1
Standards for Overseas Shipment or Domestic Issue of Special Purpose Vehicles, Combat, Tactical, Construction snd Selected Industrial and Troop Support US Army Tank-Automotive Materiel Readiness Command Managed Items . TB 9-2300-281-35
Principles of Automotive Vehicles .....TM 9-8000
Procedures for Destruction of Tank-Automotive Equipment to Prevent Enemy Use .. TM 750-244-6
Product Quality Deficiency Report..... SF 368
Expendable/Durable Items .....CTA 50-970
Turbine Fuel, Aviation, Kerosene Type, Grade JP-8..... MIL-T-83133
Brake Fluid, Silicone, Automotive, All Weather, Operational and Preservative, Metric ... MIL-B-46178

APPENDIX B

MAINTENANCE ALLOCATION CHART (MAC)

Section I. INTRODUCTION

B-1. GENERAL.

a. This introduction (Section I) provides a general explanation of all maintenance and repair functions authorized at various maintenance levels under the standard Army Maintenance System concept.

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 which are shown on the MAC in column (4) as:

Unit includes two sub-columns, C (operator crew) and 0 (unit) maintenance;

Direct Support includes an F sub-column;

General Support includes an H sub-column;

Depot includes a D sub-column.

c. Section III lists the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from column (5) in section II.

d. Section IV lists any special explanation remarks required for each maintenance function as referred from column (6) in section II.

B-2. MAINTENANCE FUNCTIONS.

Maintenance functions will be limited to and defined as follows:

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 required periodically to keep an item in proper operating condition; e.g., 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 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 equipment 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.

B-2. MAINTENANCE FUNCTIONS (CONT).

g. Remove/Install. To remove and install the same item when required to perform service or other maintenance functions. Install 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 an equipment or system.

h. Replace. To remove an unserviceable item and install a serviceable counterpart in its place. "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/troubleshooting2, removal/installation, and disassembly/assembly3 procedures, and maintenance actions4 to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, 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.

[1]Services - Inspect, test, service, adjust, align, calibrate, and/or replace.

[2]Fault location/troubleshooting - The process of investigating and detecting the cause of equipment malfunctions; the act of isolating a fault within a system or unit under test (UUT).

[3]Disassembly/Assembly - The step-by-step breakdown (taking apart) of a spare/functional group coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).

[4]Actions - Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

B-3. EXPLANATION OF COLUMNS IN 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. End item group number shall be "00."

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.

d. Column (4), Maintenance Level. Column (4) specifies, by the listing of a work time figure in the appropriate sub-column(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 level 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/assembly 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 in the maintenance allocation chart. The symbol designations for the various maintenance levels are as follows:

C	Operator or Crew	L	Specialized Repair Activity (SRA)[5]
O	Organizational Maintenance	H	General Support Maintenance
F	Direct Support.	D	Depot Maintenance

e. Column (5), Tools and Equipment. Column 5 specifies, by code, those common tool sets (not individual tools) and special tools, TMDE, 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.

[5]Specialized Repair Activity (SRA) - This maintenance level is not included in Section II, Column (4), of the Maintenance Allocation Chart. Functions to this level of maintenance are identified by a work-time figure in the 'HW column of Section II, Column (4), and an associated Reference Code is used in Remarks, Column (6). This code is keyed to Section IV, Remarks, and the SRA complete repair application is explained there.

B-4. EXPLANATION OF COLUMNS IN TOOLS 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 (2), Maintenance Level. The lowest level 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), Tool Kit The national stock number of the tool or test equipment.

SECTION II. MAINTENANCE ALLOCATION CHART

(1) Group Number	(2) Component/ Assembly	(3) Main. Function	(4) Maintenance Level Unit C	Unit O	Direct Support F	General Support H	Depot D	(5) Tools and Equipment	(6) Remarks
01	ENGINE								
0100	Engine Assembly:								
	Engine Assembly	Inspect	0.1	0.1				1,2	
		Test		1.0				1,7	
		Service		1.0				1,2	
		Adjust			2.0			1	
		Replace			15.0			1	
		Repair			11.0	35.0		1,6,7	
0101	Crankcase, Block, Cylinder Head:								
	Cylinder	Replace				4.0		1,2	
	Block	Repair				4.0		1,2,6	
	Cylinder Head	Test		0.3					
	Assembly	Replace			3.0			1,2	
		Repair				16.0		1,6	
0102	Crankshaft:								
	Crankshaft	Replace				16.0		1,2	
	Crankshaft Main and	Replace				21.0		1,2	
	Piston Rod Bearings	Replace				21.0		1,2	
	Oil Seals	Inspect			1.0	1			
		Replace			12.0	1			
	Crankshaft Pulley	Replace			4.0	1			
	Crankshaft Gear	Replace			6.0	1			
	Engine Balancer	Replace				6.0		1,2,26	
	Assembly	Repair				6.0		1,2,26	
0103	Flywheel Assembly:								
	Flywheel Assembly	Replace			14.0			1,2	
		Repair			13.0			1,2	
	Rear End Plate	Replace			13.0			1,2	
	Adapter Plate	Replace			2.0			1,2	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
01	ENGINE (CONTINUED)								
0104	Pistons, Connecting Rods:								
	Piston and Connecting	Replace				10.0		1	
	Rod	Repair				1.2		1	
0105	Valves, Camshafts and Timing System:								
	Rocker Arm Covers	Replace			1.0			1	
	Valve	Inspect			1.0			1,2	
		Replace			3.0			1,2	
		Repair			16.0			1,2,6	
	Valve Guide	Inspect			1.0			1	
		Replace			3.0			1,2,3	
	Valve Seat Insert	Replace			3.0			1	
	Camshaft Assembly	Replace				16.0		1	
		Repair				3.0		1,2	
	Tappets	Inspect			3.0			1,2	
		Replace			5.0			1	
	Rocker Arm	Adjust		2.0				1	
		Replace			4.0			1,6	
		Repair			2.0			1,6	
	Push rod	Replace			2.5			1	
	Gear Cover	Replace			8.0			1	
	Timing Gear	Inspect			2.0			1,2	
		Replace			8.0			1	
0106	Engine Lubrication System:								
	Adapter, Oil Filter	Replace			1.0			1	
	Filter, Oil	Replace		0.5				1	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
01	ENGINE (CONTINUED)								
	Oil Sampling Valve	Inspect	0.1						
		Replace		1.0				1	
	Oil Pump	Replace			5.0			1,2	
	Oil Breather	Replace		0.1				1	
	Oil Pan	Replace			4.0			1,6	
0108	Manifolds:								
	Intake Manifold	Inspect			0.5				
		Replace			2.0			2	
	Exhaust Manifold	Inspect		0.5					
		Replace			2.0			2	
03	FUEL SYSTEM								
0301	Carburetor, Fuel Injector:								
	Fuel Injector	Test			1.0			2	
		Replace			2.0			2	
	Fuel Injector Lines and Fittings	Inspect	0.1						
		Replace			1.0			1	
0302	Fuel Pumps:								
	Fuel Injection Pump	Test				1.0			
		Adjust				1.0	1.0	2,7	
		Replace			2.0	1.0	1,2,7		
		Repair				2.0	3.0	2,7,10,11, 12,13,14, 15,16,17, 18,19,20, 21,22,23, 24,27,28 29,30	C,D
	Fuel Injection Pump Timing Gear	Replace			3.0			1	
	Fuel Supply Pump	Replace		1.0				1	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
03	FUEL SYSTEM (CONTINUED)								
0304	Air Cleaner								
	Air Cleaner Assembly	Inspect		0.5					
		Replace		1.0				1,2	
		Repair		1.0				1,2	
	Air Cleaner Element	Service		0.5				1,2	
		Replace		0.5				1,2	
	Tanks, Lines, Fittings:								
	Fuel Lines and Fittings (each)	Inspect	0.2					1,2	
		Replace		0.5				1,2,7	
0306	Tank	Inspect	0.1						
		Replace		3.0				1,2,7	
	Fuel Shut-Off Valve	Inspect		0.5					
		Replace		1.0				1,2	
0308	Engine Speed Govemor and Controls:								
	Govemor	Adjust			1.0			1	
		Replace				2.0		1	
		Repair				2.0		1	
0309	Fuel Filters:								
	Fuel Filter	Service		0.5				1	
		Replace		1.0				1	
	Fuel Water Separator	Service		0.5					
		Replace		1.0				1,2	
0311	Engine Starting Aids:								
	Glow Plugs	Replace		2.0				1	

SECTION II. MAINTENANCE ALLOCATION CHART

(1) Group Number	(2) Component/ Assembly	(3) Main. Function	(4) Maintenance Level Unit C	Unit O	Direct Support F	General Support H	Depot D	(5) Tools and Equipment	(6) Remarks
03	FUEL SYSTEM (CONTINUED)								
0312	Accelerator Throttle or Choke Controls:								
	Accelerator Pedal and Linkage	Adjust			0.5			1	
		Replace			0.5			1	
04	EXHAUST SYSTEM								
0401	Muffler and Pipes:								
	Muffler	Inspect	0.1						
		Replace		2.0				2	
	Pipes	Inspect	0.1						
		Replace		2.0				2	
05	COOLING SYSTEM								
0501	Radiator, Evaporative Cooler, or Heat Exchanger:								
	Radiator	Test		1.0				1,4	
		Inspect	0.1	0.1					
		Service		1.0				1,4	
		Replace		2.0				1,4	
		Repair			2.0	4.0		1,4	
0503	Water Manifold, Headers, Thermostats and Housing Gasket:								
	Thermostat	Inspect		1.0					
		Replace		2.0	1				
0504	Water Pump								
	Water Pump	Inspect		0.5				1,2	
		Replace			4.0			1,2	
0505	Fan Assembly:								
	Fan Assembly	Inspect	0.1						
		Replace		1.0				1,2	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
05	COOLING SYSTEM (CONTINUED)								
	Fan Belts	Inspect	0.1						
		Adjust		0.5				1	
		Replace		0.5				1	
06	ELECTRICAL SYSTEM								
0601	Generator, Alternator:								
	Altemator Assembly	Test		1.0				1,2,7	
		Replace		0.5				1	
		Repair			2.0			1	
0602	Generator Regulator (Voltage):								
	Voltage Regulator	Test		0.5				1,2	
		Replace		0.5				1	
0603	Starting Motor:								
	Starter Motor	Test		1.0				2	
		Replace		1.0				1,2,7	
		Repair			2.0			1,2	
0606	Engine Safety Controls:								
	Neutral Start Switch	Test		0.5				2	
		Replace		0.5				1,2	
0607	Instrument Panel:								
	Instrument Panel	Replace		1.0				1	
	Gauges	Test		0.5					
		Replace		0.5				1,2,7	

SECTION II. MAINTENANCE ALLOCATION CHART

(1) Group Number	(2) Component/ Assembly	(3) Main. Function	(4) Maintenance Level Unit C	Unit O	Direct Support F	General Support H	Depot D	(5) Tools and Equipment	(6) Remarks
06	ELECTRICAL SYSTEM (CONTINUED)								
0608	Miscellaneous Items:								
	Directional Control Switch Assembly	Replace		0.5				1	
0609	Lights:								
	Indicator Lights	Inspect	0.5					1,7	
		Replace		0.5				1,7	
		Repair		0.5				1	
	Flood Lamps	Inspect	0.1						
		Replace		0.5				1	
		Repair		0.5				1,7	
0610	Sending Units and Warning Switches:								
	Transmission Oil Temperature Sensor	Replace		0.5				1,7	
	Engine Oil Pressure Sensor	Replace		0.5				1,7	
	Sending Units (each)	Replace		0.5				1,7	
0611	Horn, Siren:								
	Electric Horn	Replace		0.5				1,7	
	Horn Relay	Replace		0.5				1,7	
	Horn Button	Replace		0.5				1,7	
0612	Batteries, Storage (Wet or Dry):								
	Battery	Inspect	0.1	0.1					
		Test		0.1				1	
		Service		1.0				1	
		Replace		0.5				1	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
06	ELECTRICAL SYSTEM (CONTINUED)								
	Battery Hold Down	Inspect	0.1						
		Replace		0.5				1	
	Cables	Inspect	0.1						
		Service		0.5				1	
		Replace		0.5				1,7	
0613	Hull or Chassis Wiring Harness:								
	Engine Wiring	Replace			2.0			1	A
	Harness	Repair			1.0			1	
	Chassis Wiring	Replace			2.0			1	A
	Harness	Repair			1.0			1	
07	TRANSMISSION								
0702	Opposed Output:								
	Drive Axle	Inspect		0.1					
		Service		1.0				2	
		Replace			2.0			1,2	
		Repair				12.0		1,2,3	
	Transsexual Wheel End Housing	Replace			2.0			1,2	
	Differential	Inspect				1.0			
		Repair				2.0		1,2,3,6	
0708	Torque Converter:								
	Torque Converter	Replace			12.5			1,2,4	
0710	Transmission Assy:								
	Transaxle Assembly	Inspect	0.2						
		Test		1.0					
		Service		2.0					
		Replace			8.0			1,2,6	
		Repair				24.5		1,2,6	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4)					(5)	(6)
			Maintenance Level						
Group Number	Component/ Assembly	Main. Function	Unit C	Unit O	Direct Support F	General Support H	Depot D	Tools and Equipment	Remarks
07	TRANSMISSION (CONTINUED)								
	Transaxle Oil	Inspect	0.1						
	Sampling Valve	Replace		0.1				2	
	Transmission	Inspect	0.2						
	Assembly	Test		1.0					
		Service		2.0					
		Replace			8.0			1,2,6	
		Repair				24.5		1,2,6	
0714	Servo Unit:								
	Control Valve	Replace				3.0		1	
	Assembly	Repair				4.0		1,6	
0721	Coolers, Pumps, Motors:								
	Converter Charging Pump Assembly	Replace				1.0		1	
	Transaxle Filter	Replace			0.5			1	
11	REAR AXLES								
1100	Rear Axle Assembly:								
	Steering Axle	Inspect	0.1						
	Replace				2.0			1,2,6	
	Repair				5.0			1,2,3	
	Steer Axle Knuckle	Replace			1.0			1	
	Repair				1.0			1	
12	BRAKES								
1201	Hand brakes:								
	Parking Brake Lever	Adjust	0.1						
	Assembly	Replace		1.0				1	

SECTION II. MAINTENANCE ALLOCATION CHART

(1) Group Number	(2) Component/ Assembly	(3) Main. Function	(4) Maintenance Level Unit C	Unit O	Direct Support F	General Support H	Depot D	(5) Tools and Equipment	(6) Remarks
		Repair		1.0				1	
12	BRAKES (CONTINUED)								
	Parking Brake	Adjust		0.1				1	
	Linkage	Replace		1.0				1	
1202	Service Brakes:								
	Brakes	Inspect		0.5					
	Brake Assemblies	Replace		2.5				1	
		Repair		3.0				1	
1204	Hydraulic Brake System:								
	Master Cylinder	Replace		2.0				1	
	Brake Lines and Fittings	Replace		2.0				1	
1206	Mechanical Brake System:								
	Brake Pedal and	Adjust		1.0				1	
	Linkages	Replace		2.0				1	
13	WHEELS & TRACKS								
1311	Wheel Assembly:								
	Drive Wheel	Inspect	0.1						
	Assembly	Service		0.5				2	
		Replace		1.0				2	
		Repair		2.0				2	
	Steer Wheel	Inspect	0.1						
	Assembly	Service		0.5					
		Replace		1.0				2	
		Repair		2.0				2	
1313	Tires, Tubes, Tire Chains:								
	Tire	Inspect	0.1						
		Replace		2.0				2,6	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
14	STEERING								
1400	Steering System	Inspect	0.1						
		Service		1.0				1	
1401	Mechanical Steering Gear Assembly:								
	Steering Column	Inspect	0.1						
		Service		0.5					
		Replace		1.0				2	
		Repair			3.0			2	
1411	Hoses, Lines, and Fittings:								
	Hydraulic Lines and Fittings	Inspect	0.2						
		Replace		1.0				1	B
1412	Hydraulic or Air Cylinders:								
	Steering Cylinder Assembly	Inspect	0.1						
		Replace			3.0			1,9	
		Repair				5.0		1,2	
1414	Steering System Valves:								
	Steering Manifold	Replace		1.0				1	
		Repair			0.5			1	
15	FRAME, TOWING ATTACHMENTS, & DRAWBAR SYSTEMS								
1501	Frame Assembly:								
	Frame Assembly	Inspect		0.5					
		Repair				1.0		2,8	
	Tiedown	Inspect	0.1	0.1					
		Replace		1.0				1,2	
	Lift Eyes	Inspect	0.1	0.1				1,2	
		Replace		1.0					

SECTION II. MAINTENANCE ALLOCATION CHART

(1) Group Number	(2) Component/ Assembly	(3) Main. Function	(4) Maintenance Level Unit C	Unit O	Direct Support F	General Support H	Depot D	(5) Tools and Equipment	(6) Remarks
15	FRAME, TOWING ATTACHMENTS, & DRAWBAR SYSTEMS (CONTINUED)								
1502	Counterweights:								
	Counterweight	Inspect	0.1						
		Replace		1.0				1,2	
18	BODY, CAB, & HULL								
1801	Body, Hood, and Cab Assemblies:								
	Overhead Guard	Inspect	0.1						
		Replace		1.0				1,2	
	Panels	Inspect		0.5					
		Replace		0.5				1,2	E
1806	Upholstery Seats and Carpets:								
	Seat Assembly	Inspect	0.1						
		Replace		0.5				1,2	
		Repair		0.5				1,2	
22	BODY, CHASSIS, & HULL ACCESSORY ITEMS								
2210	Data Plates and Instruction Holders:								
	Data Plate (each)	Inspect	0.1						
		Replace		0.5				1	
24	HYDRAULIC AND FLUID SYSTEMS								
2401	Hydraulic Pump:								
	Main Hydraulic Pump Assembly	Test		1.0				1,2	
		Inspect		1.0					
		Replace			2.0			1,2	
		Repair			2.5			1,2	

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
24	HYDRAULIC AND FLUID SYSTEMS (CONTINUED)								
2401	Hydraulic Reservoir Assembly	Inspect	0.1						
		Service		1.0					1,2
		Replace		3.0					1,2
	Hydraulic Filter	Service		0.5					1,2
		Replace		0.5					1,2
2402	Hydraulic Control Valve:								
	Hydraulic Valve Assembly	Adjust			1.0				1,2
		Replace			4.0				1,2,6
		Repair			4.5				1,2,6
2403	Hydraulic Control Levers & Linkage:								
	Hydraulic Control Levers & Linkage	Replace	0.5	1,5					
2404	Hydraulic Tilt Cylinder Tilt Crank:								
	Tilt Cylinders	Test		1.0					1,2
		Adjust		1.0					2
		Replace		1.0					2,3
		Repair	2.0				1,2		
2405	Hydraulic Mast Column:								
	Carriage Assembly	Service	0.5					1,2	
		Adjust			0.5				1,2
		Replace			1.0				1,2
		Repair			5.0				2,3,6
	Backrest Assembly	Inspect	0.1						
		Replace	1.0	1,2					
	Forks	Inspect	0.1						
		Replace	0.5	1,2					

SECTION II. MAINTENANCE ALLOCATION CHART

(1)	(2)	(3)	(4) Maintenance Level					(5)	(6)
			Unit		Direct Support	General Support	Depot		
Group Number	Component/ Assembly	Main. Function	C	O	F	H	D	Tools and Equipment	Remarks
24	HYDRAULIC AND FLUID SYSTEMS (CONTINUED)								
	Chain Assembly, Upright	Inspect	0.1						
		Replace		1.0				1	
		Service		1.5				1	
	Chain Roller Sheaves	Inspect		0.5					
		Replace			0.5			1,2	
		Repair			0.5			1,2	
	Primary and Final Lift Cylinders	Test	0.1						
		Replace			1.0			1,2	
		Repair			1.0	2.0		1,2	
	Hydraulic Sideshift Cylinder	Test	0.1						
		Replace			1.0			1,2	
		Repair			2.0			1,2	
	Upright Assembly	Service		1.5				1,2	
		Adjust		1.0				1,2	
		Replace			5.0			1,2,3,6	
		Repair			8.0			1,2,3,6,8	
	Upright Channel Rollers	Replace			1.5			1	
	Mast Pivot Bearings	Replace			1.5			1	
2406	Strainers, Filters, Lines & Fittings, etc.:								
	Hose Assembly	Inspect	0.5	0.5					
		Replace			1.0			1,2	B
	Hydraulic Oil Filter Base Assembly	Inspect		0.5					
		Replace		1.0				1,2	
		Repair		1.0				1,2	
47	GAGE (NON-ELECTRICAL)								
4702	Air Restriction Indicator	Inspect	0.1						
		Replace		1.0				1	

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/ NATO STOCK NUMBER	TOOL NUMBER
1	O	TOOL KIT, General Mechanic's, Automotive	5180-00-177-7033	SC5180-90-CL-N26
2	O	SHOP EQUIPMENT, Automotive Maintenance and Repair: Common No. 1	4910-00-754-0654	SC4910-95-CL-A74
3	O	SHOP EQUIPMENT, Automotive Maintenance and Repair: Supplemental No. 1	4910-00-754-0653	SC4910-95-CL-A73
4	O	Radiator Pressure Tester	4910-01-018-4373	STZ55A (55719)
5	F	TOOL KIT, General Mechanic's	5180-00-699-5273	SC5180-90-CL-N05
6	F	SHOP EQUIPMENT, Automotive Maintenance and Repair: Field Maintenance, Basic	4910-00-754-0705	SC4910-95-CL-A31
7	F	SHOP EQUIPMENT, Fuel and Electrical System, Engine: Field Maintenance, Basic	4940-00-754-0714	SC4940-95-CL-B20
8	F	SHOP WELDING SET	3433-00-357-6311	SC3433-90-CL-N01
9	F	SHOP EQUIPMENT, Machine Shop	3470-00-754-0708	SC3470-95-CL-A02
10	H	SLEEVE EXTRACTOR, Pressure Regulating		13301
11	H	PUMP HOLDING FIXTURE		19965
12	H	WRENCH, Open End		13379
13	H	REMOVER, Shut-Off Cam		20992
14	H	FIXTURE, Roller to Roller Dimension Setting		19969
15	H	WRENCH, Automatic Advance Plug		14490
16	H	WRENCH, Bristol Socket Cam Advance Screw		15499
17	H	CAM ADVANCE SCREW BUSHING		15500
18	H	SUPPORT, Governor Weight Retainer or Rotor		16313
19	H	EXTRACTOR		26081

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/ NATO STOCK NUMBER	TOOL NUMBER
20	H	COMPRESSOR, Advance Piston Ring		16199
21	H	WINDOW, Advance Test		19918
22	H	GAUGE, Linkage		18914
23	H	SOCKET, Transfer Pump End Cap		20548
24	H	CONNECTOR, Transfer Pressure Gauge		21900
25	H	ADVANCE INDICATOR ASSEMBLY		21733
26	H	SCREW, Locator		915901
27	D	Fuel Injection Test Stand		
28	D	Drive Hub		67-6900
29	D	Adapter Plate Assembly		77-0500
30	D	Fuel Lines, Test Stand (4)		77-0214

SECTION IV. REMARKS

REFERENCE CODE	REMARKS
A	At the 'F' level the entire wire harness is replaced.
B	High pressure hoses are non-repairable.
C	Fuel injection pump repair also requires tools 9 through 24.
D	Tools 28 through 30 are used to test fuel injection pump.
E	Side doors are adjustable.

APPENDIX C

EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST

C-1. SCOPE.

This appendix lists expendable supplies and materials you may need to operate and maintain the 4K Forklift Truck. These items are authorized to you by CTA 50-970, Expendable Items (Except Medical, Class V, Repair Parts, and Hydraulic Lines).

C-2. GENERAL.

a. Column (1) - Item. The number is assigned to the entry in the listing.

b. Column (2) - Level. This column identifies the lowest level of maintenance that requires the listed items.

C - Operator/Crew
0- Organizational Maintenance
F - Direct 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 requires, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses followed by the number.

e. Column (5) - Unit of Measure (UIM). Indicated 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.

Table C-1. Expendable/Durable Supplies and Materials List

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION PART NUMBER AND CAGE	(5) UNIT OF MEAS
1	F		Adhesive, MM-A-1 22	oz
2	O,F		Adhesive-Sealant, Silicone RTV, General Purpose	oz
		8040-00-843-0802	(MIL-A-46106) 3 oz tube	
3	O		Antifreeze, Ethylene Glycol: Inhibited, heavy duty, single package, (MIL-A-46153)	
		6850-00-181-7929	1-gal bottle	gal
		6850-00-181-7933	5-gal can	gal
		6850-00-181-7940	55-gal drum	gal
4	O		Box, shipping, fiberboard (PP-B-636)	
5	F		Brush, brass wire	ea
6	F		Brush, Soft Bristle	ea
7	F	7920-00-205-2401	Brush, Stiff Bristle (MIL-B-43871)	ea
8	F	7920-00-056-5525	Brush, tube, nylon	ea
9	O	5340-00-298-9112	Cap, plastic (MIL-C-5501)	
10			Cleaning Compound, Solvent: Degreasing and Depreserving, self-emulsifying (MIL-C-11090)	
		6850-00-584-4077	1-gal can	gal
		6850-00-224-6665	5-gal can	gal
		6850-00-224-6666	55-gal drum	gal
11	C,F	7930-00-634-3935	Chips, Soap: (P-S-579) 200-lb drum	lb
12	O,F	5350-00-192-5052	Cloth, Abrasive: Crocus, ferric oxide and quartz. Jean cloth backing, exposed coat, 9x11 sheet, 50-sh package, P-C-458, type 1, class 1.	pg.
13	O,F	7902-00-044-9281	Cloth, Lint-Free: (MIL-C-85043) 10-lb box	lb
14	O,F		Compound, Anti-Seize, High Temperature	
		8030-00-597-5367	(MIL-A-907)	
			2-1/2 lb can	lb
	15	5350-00-193-7227	Compound, Lapping and Grinding (A-A-1203)	
			1-lb can	lb

Table C-1. Expendable/Durable Supplies and Materials List - CONT.

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION PART NUMBER AND CAGE	(5) UNIT OF MEAS
16	O,F	8030-00-148-9833	Compound, Sealing, Lubricating, Wicking, Thread Locking, Anaerobic, Single Component (MIL-S-46163) Type I, Grade K	bx
17	O,F		Compound, Sealing, Permatex	
18	O,F	8030-01-054-0740	Compound, Sealing, Pipe Thread	ea
19	F		Compound, Retaining, Loctite (MIL-R-46082)	
		8030-00-181-7603	50cc	cc
		8030-00-181-7529	250cc	cc
20	C,F	7930-00-282-9699	Detergent: Non sudsing, general purpose, liquid (80244) MIL-D-16791 type 1, 1-gal can	gal
21	F		Dye, Marking (Prussian Blue)	
22	O		Fluid, Brake, Silicone: BFS (MIL-B-46176A)	
		9150-01-102-9455	1 -gal can	gal
		9150-01-123-3152	5-gal can	gal
		9150-01-072-8379	55-gal drum	gal
23	F	6850-00-656-0810	Fluid, Calibrating (MIL-C-7024) bulk	gal
24	F		Fluid, Hydraulic, Petroleum base: OHT (MIL-H-6083)	
		9150-00-935-9807	1 -qt can	qt
		9150-00-935-9808	1-gal can	gal
		9150-00-935-9809	5-gal can	can
		9150-00-935-9810	55-gal drum	gal
25	C,F		Grease, Automotive and Artillery (MIL-G-10924)	
		9150-00-065-0029	2 1/4-oz tube	oz
		9150-01-197-7690	1 3/4-lb can	lb
		9150-00-190-0907	35-lb can	lb
26	O,F		Grease, General Purpose, Lithium Base	lb
		9150-01-091-9336	1 1/2-lb can	
27	C,F		Grease, Silicone: Medium (MIL-G-46886)	oz
		9150-00-145-0161	8 oz tube	oz
28	O,F	5510-01-321-1701	Lumber, 4 in. x 4 in. x 14 Ft	ea
29	O	8135-00-753-4662	Material, Barrier, grade C (MIL-B-121)	

Table C-1. Expendable/Durable Supplies and Materials List - CONT

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION PART NUMBER AND CAGE	(5) UNIT OF MEAS
30	O	8135-00-292-9719	Material, Barrier, grade A, (MIL-B-121)	
31	C		Oil, Fuel, Diesel DF-1 Winter (VV-F-800)	
		9140-00-286-5286	Bulk	gal
		9140-00-286-5287	5-gal can	gal
		9140-00-286-5288	55-gal drum, 16 gage	gal
		9140-00-286-5289	55-gal drum, 18 gage	gal
32	C,F		Oil, Fuel, Diesel DF-2 Regular (W-F-800)	
		9140-00-286-5294	Bulk	gal
		9140-00-286-5295	5-gal can	gal
		9140-00-286-5296	55-gal drum, 16-gage	gal
		9140-00-286-5297	55-gal drum, 18 gage	gal
33	H	6850-00-779-6851	Oil, Injector Test	gal
34	C,O		Oil, Lubricating, Gear, GO 75 (MIL-L-2105)	
		9150-01-035-5390	1 -qt can	qt
		9150-01-035-5391	5-gal can	gal
35	C,O		Oil, Lubricating, Gear GO 80/90 (MIL-L-2105)	
		9150-01-035-5393	5-gal can	gal
		9150-01-035-5394	55-gal drum	gal
36	O		Oil, Lubricating, OEA Ice, Subzero (MIL-L-46167)	
		9150-00-402-4478	1 -qt can	qt
		9150-00-402-2372	5-gal can	gal
		9150-00-491-7197	55-gal drum	gal
37	C		Oil, Lubricating, OE/HDO 10 (MIL-L-2104)	
		9150-00-189-6727	1-qt can	qt
		9150-00-186-6668	5-gal can	gal
		9150-00-191-2772	55-gal drum	gal
38	C,O,F	9150-01-152-4117	Oil, Lubricating: Intemal combustion engine, tactical service (MIL-L-2104) (OE/HDO 15/40) 1-qt can	qt
39	C,O,F		Oil, Lubricating, OE/HDO 30 (SAE 30) (MIL-L-2104)	
		9150-00-186-6681	1-qt can	qt
		9150-00-188-9858	5-gal can	gal
		9150-00-189-6729	55-gal drum	gal
40	C,F		Oil, Lubricating, OE/HDO 40 (SAE 40) (MIL-L-2104)	
		9150-00-405-2987	bulk	gal
		9150-00-189-6730	1 -qt can	qt
		9150-00-188-9862	55-gal drum	gal

Table C-1. Expendable/Durable Supplies and Materials List - CONT.

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION PART NUMBER AND CAGE	(5) UNIT OF MEAS
41	C		Oil, Lubricating OE/HDO 50 (MIL-L-2104)	
		9150-00-188-9864	1-qt can	qt
		9150-00-188-9865	5-gal can	gal
		9150-00-188-9867	55-gal drum	gal
42	F		Oil, penetrating (W-L-800)	
		9150-00-261-7899	1 -pt	pt
		9150-00-231-6689	1 -qt	qt
		9150-00-223-4119	1 -gal	gal
43	O	9150-00-153-0207	Oil, preservative, grade 30, type II (MIL-L-21260)	qt
44	O		Oil, preservative (MIL-P-46093)	gal
45	O		Oil, preservative, type P-1 (MIL-P-46002)	gal
46	O		Oil, preservative, type P-6 (MIL-P-116)	gal
47	0		Oil, preservative, type P-9 (W-L-800)	gal
48	0		Oil, preservative, type P-10 (MIL-P-116)	gal
49	0		Oil, preservative, type P-11 (MIL-P-116)	gal
50	O		Oil, preservative, type P-19 (MIL-P-116)	gal
51	F		Paper, Abrasive, Garnet (Emery Cloth) (P-P-121),	
		5350-00-221-0884	80-grit, 50-sheet package	ea
		5350-00-271-7930	180-grit, 100-sheet package	ea
52	O,F		Paper, Abrasive, Silicon Carbide, Waterproof (P-P-101) 50-sheet package	
		5350-00-619-9167	50-grit	
		5350-00-619-9166	80-grit	
		5350-00-264-3485	100-grit	
53			Penetrant, Fluorescent (MIL-C-1949)	
54	O		Polyethylene, black, 6 mil (L-P-378)	
55	O,F		Sealant, Hydraulic	

Table C-1. Expendable/Durable Supplies and Materials List - CONT.

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION PART NUMBER AND CAGE	(5) UNIT OF MEAS
56	O	6810-00-233-1715	Sodium Carbonate, Anhydrous (A-A-41)	lb
57	0, F		Solvent, Drycleaning: (P-D-680) Type II	
		6850-00-664-5685	1-qt can	qt
		6850-00-281-1985	1-gal can	gal
58	0, F	8135-00-178-9200	Tags, Identification (MIL-S-29290) 1,000 per carton	carton
59	O	7510-00-663-3732	Tape, Packaging, Waterproof (PPP-T-60)	rl
60	O	5975-00-984-6582	Ties, Cable: Plastic (MIL-S-291 90)	hd

APPENDIX D

SCHEMATICS AND DIAGRAMS

D-1. INTRODUCTION.

This appendix provides 4K Forklift Truck wiring and hydraulic diagrams. The diagrams are divided into the following areas:

Main Wiring Diagram	Figure D-1
Hydraulic Diagram	Figure D-2
Brake Hydraulic Diagram	Figure D-3

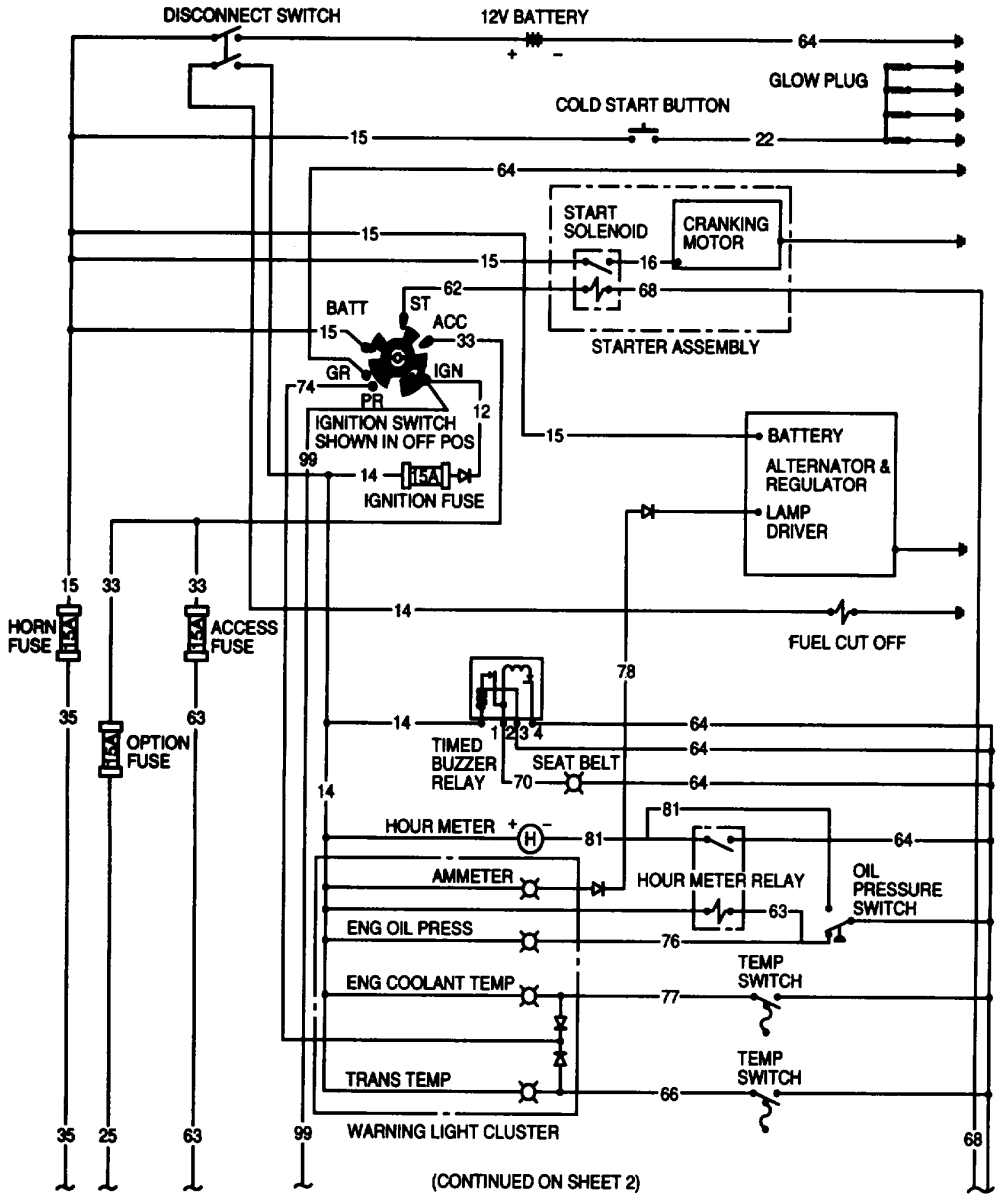


Figure D-1. Main Wiring Diagram (Sheet 1 of 2).

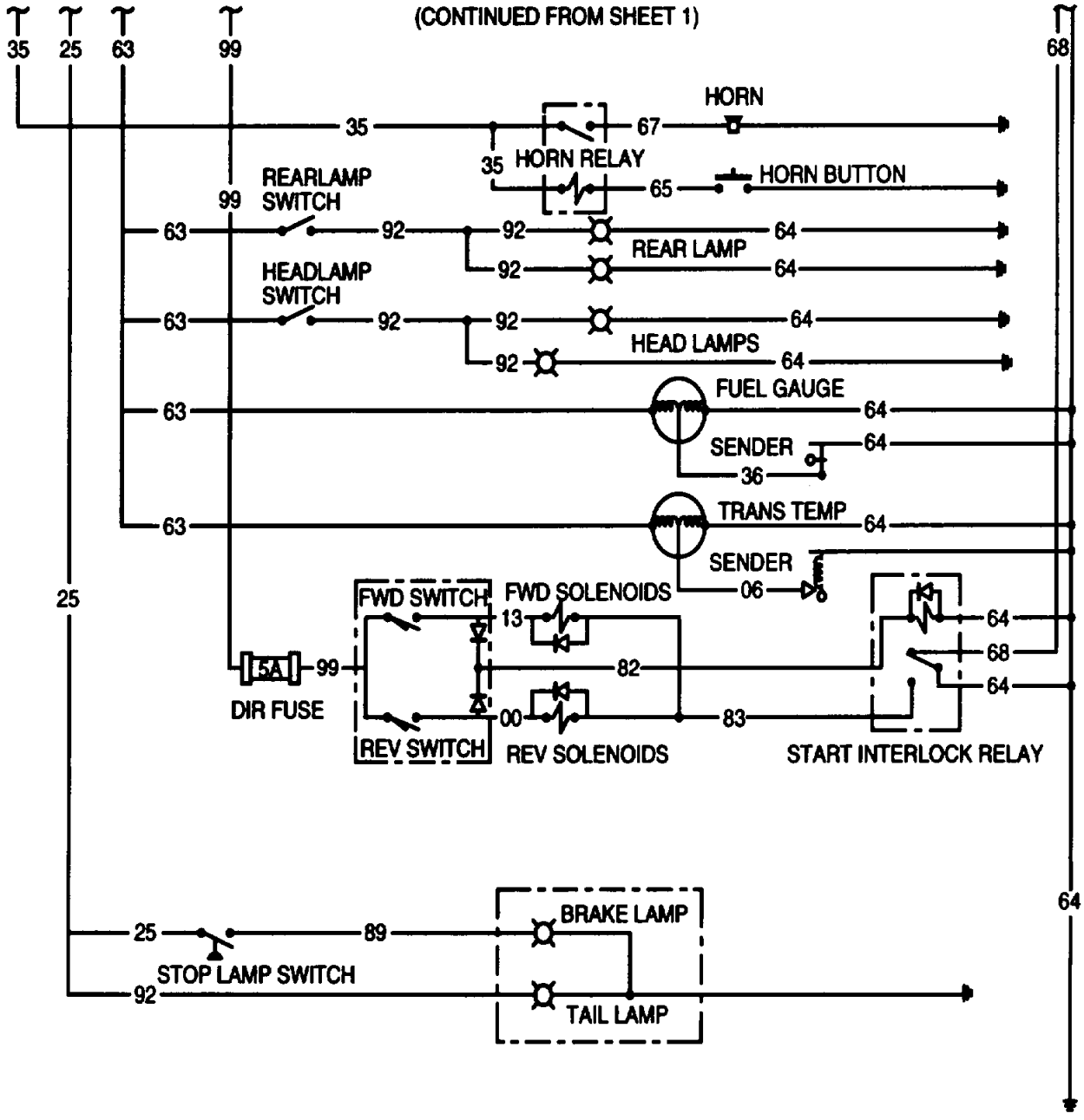


Figure D-1. Main Wiring Diagram (Sheet 2 of 2).

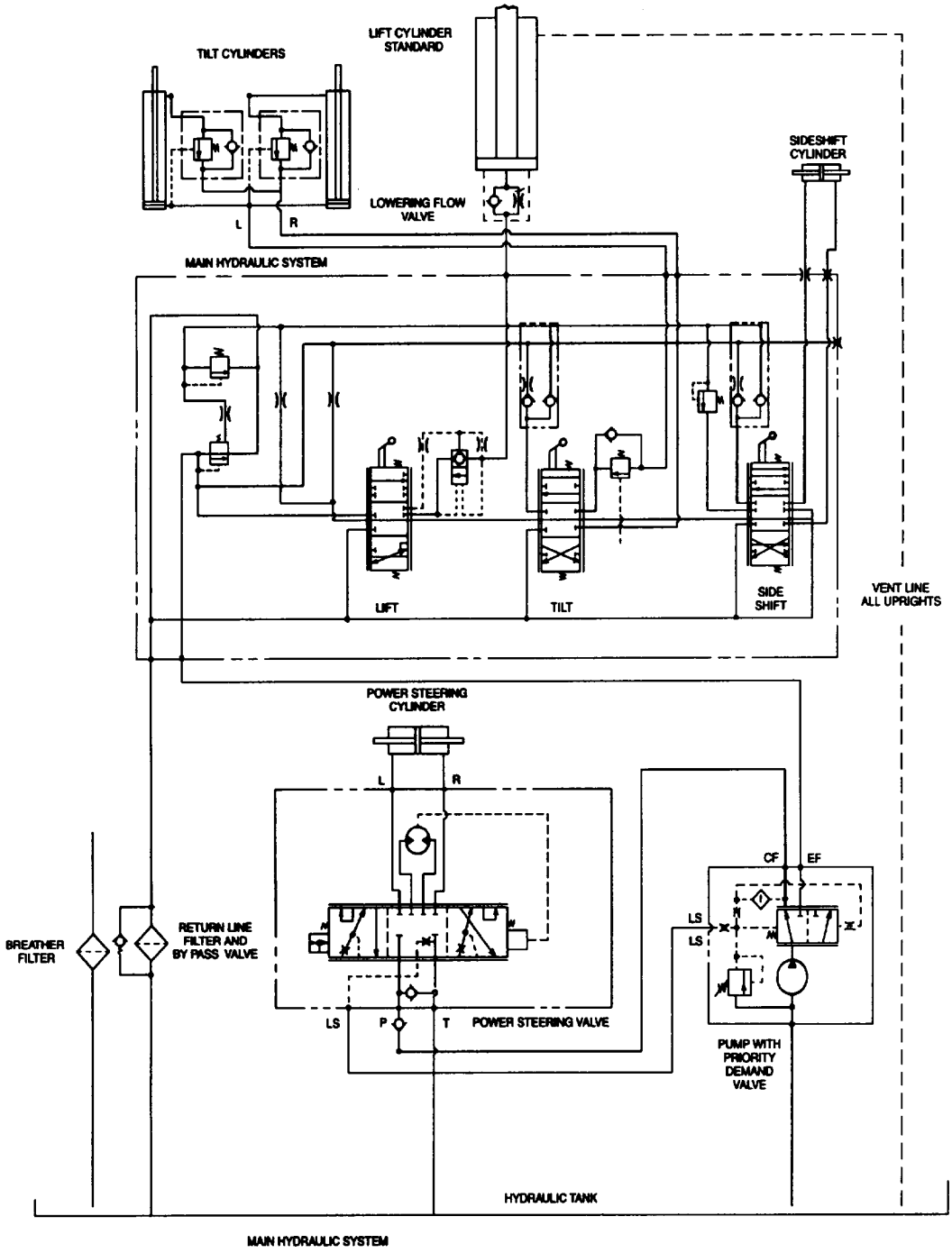


Figure D-2. Hydraulic Diagram.

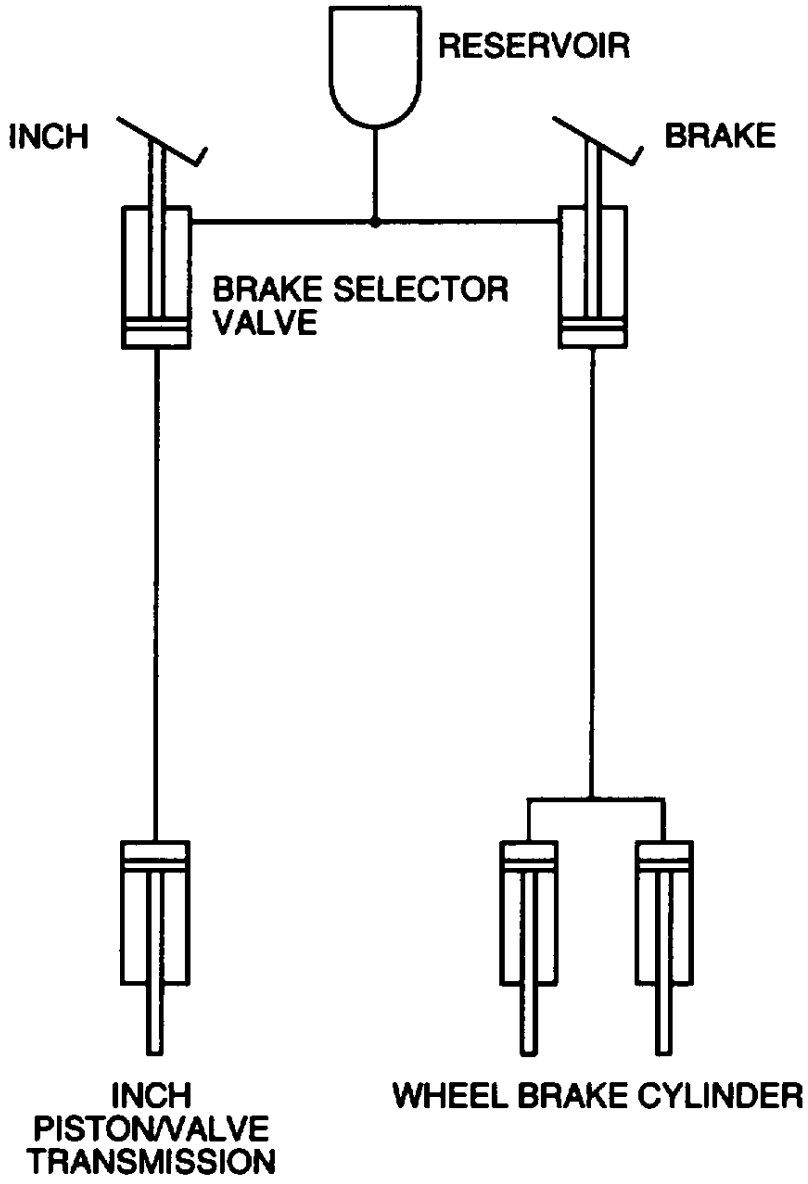


Figure D-3. Brake Hydraulic Diagram.

APPENDIX E
LUBRICATION ORDER

E-1. GENERAL LUBRICATION INSTRUCTIONS.

This section contains lubrication instructions necessary to keep the truck in operating condition. Figures E-1 through E-3 illustrate the truck and locations of lubrication points. The following paragraphs describe the lubrication figures and how they are used.

WARNING

Do not start engine or move truck when anyone is under truck. Severe injury or death could result.

a. Intervals. Intervals (on-condition or hard-time) and the related man-hour times are based on normal operation. The man-hour time specified is the time needed to do all the services prescribed for a particular interval. On-condition (OC) oil sample intervals shall be applied unless changed by the Army Oil Analysis Program (AOAP) laboratory. Change the hard-time interval if lubricants are contaminated or if operating the equipment under adverse operating conditions, including longer-than-usual operating hours. The calendar interval may be extended during periods of low activity. If extended, adequate preservation precautions must be taken. Hard-time intervals will be applied in the event AOAP laboratory support is not available. Hard-time intervals must be applied during the warranty period. Intervals shown in this lubrication section are based on calendar and hourly times or calendar times and mileage. An example of a calendar and hourly lubrication is: M/60 H, in which M stands for monthly and 60 H stands for 60 hours of truck operation. The lubrication is to be performed at whichever interval occurs first for the truck. Special lubrication intervals and services are shown by the use of an asterisk (*) symbol.

b. Determination of Operating Hours. The reading on the hour meter is the basis of all lubrication intervals.

WARNING

• Drycleaning solvent (P-D-680) is TOXIC and flammable. Wear protective goggles and gloves; use only in a well-ventilated area; avoid contact with skin, eyes, and clothes; and do not breathe vapors. Keep away from heat or flame. Never smoke when using solvent; the flash point for Type I drycleaning solvent is 100°F (380C) and for type II is 140°F (600C). Failure to do so may result in injury or death to personnel.
• If personnel become dizzy while using cleaning solvent, immediately get fresh air and medical help. If solvent contacts skin or clothes, flush with cold water. If solvent contacts eyes, immediately flush eyes with water and get immediate medical attention.

c. Clean Fitting Before Lubricating. Clean parts with cleaning solvent. Dry before lubricating.

d. Lubrication After Fording. If fording occurs, lubricate all fittings below fording depth. Fording is not recommended for the truck.

e. Lubrication After High-Pressure Washing. After washing, lubricate all grease fittings and oil can points outside and underneath truck.

f. Level of Maintenance. The lowest level of maintenance authorized to lubricate a point is indicated by either Operator/Crew (C) or unit maintenance (O). Operator can lubricate points authorized for unit

maintenance when authorized by unit maintenance.

g. Oil Filter Statement. Oil filters shall be changed as applicable, when:

(1) They are known to be contaminated or clogged.

(2) Service is recommended by AOAP laboratory analysis.

(3) At prescribed hard-time intervals.

h. AOAP Sampling Interval Statement. Engine oil must be sampled at 50 hours of operation or 90 days, whichever occurs first, for Active Army Units. Reserve and National Guard activities will use 50 hours or 180 days, whichever occurs first, as the prescribed interval. Hydraulic fluid will be sampled once a year.
Sampling will be performed as prescribed by DA Pam 738-750.

I. Warranty Hard-Time Statement. For equipment under manufacturer's warranty, hard-time oil service intervals shall be followed. Intervals shall be shortened if lubricants are known to be contaminated or if operation is under adverse conditions such as longer-than-usual operating hours, extended idling periods, or extreme dust.

j. Lubrication Interval Symbols. The following lubrication interval symbol is used:

H - Hours (operated)

k. ***Lubrication Figure Explanation***. The following lubrication instructions include Figures E-1 through E-3. Figure E-1 identifies locations of grease fittings. Figure E-2 identifies components with fluids and/or filters to be serviced/checked at short-term intervals. Figure E-3 identifies components with fluids and/or filters to be serviced/replaced at long-term intervals. All figures identify component, level required to perform maintenance, time interval to perform maintenance, lubricant used, and component capacity, if applicable.

I. General Engine Oil Checks and Services.

(1) Oil grade requirements are listed on the Lubrication Figures (Figures E-1 through E-3).

WARNING

Hot engine oil can cause severe burns and personal injury. Care should be exercised when changing oil filter and draining hot oil.

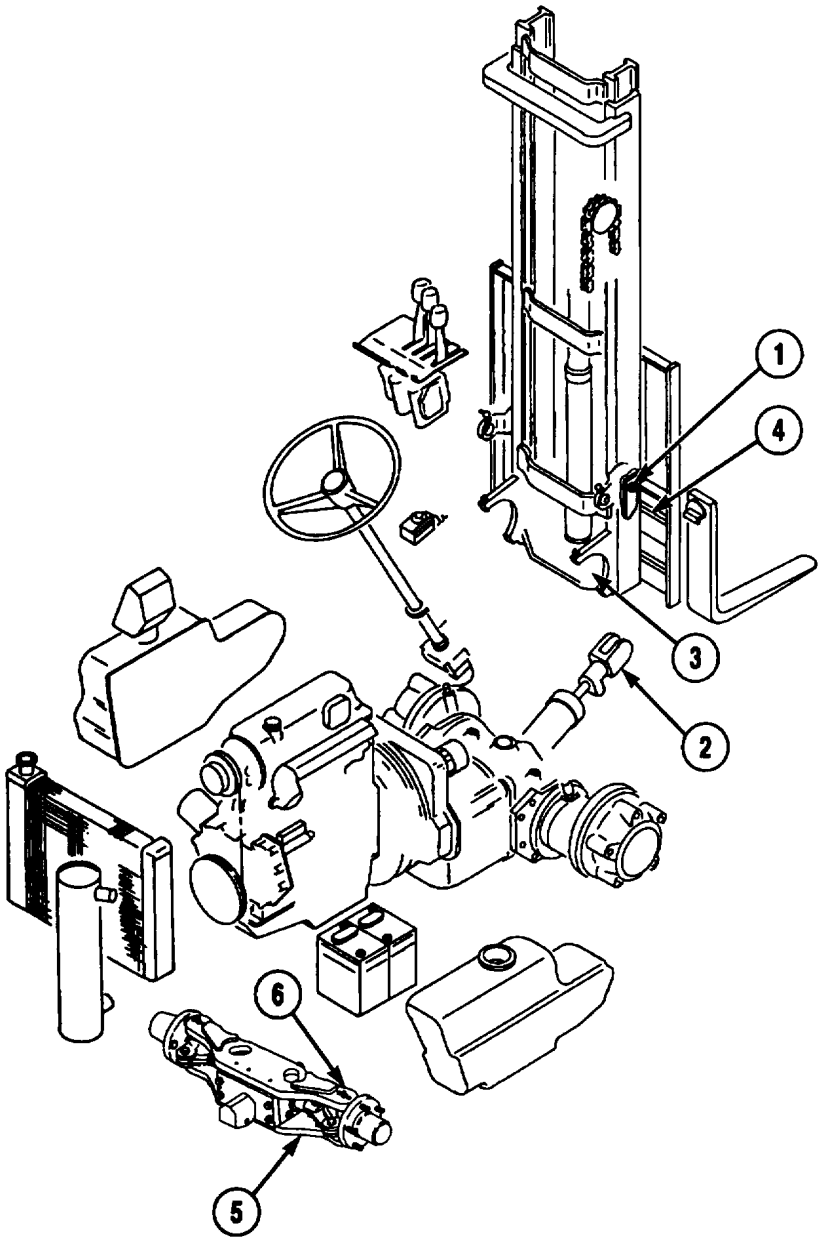
(2) Park truck on level ground and allow it to sit about ten minutes before checking oil level. Parking on level ground provides the most accurate level reading on the dipstick. Waiting ten minutes, before checking oil level, allows all oil to drain into crankcase.
(3) Before changing the engine oil, the engine should run for a few minutes to heat the oil. Warm oil will flow more easily and help to drain all oil sludge from the crankcase.

CAUTION

Do not overfill crankcase with engine oil, or serious damage may occur to engine.

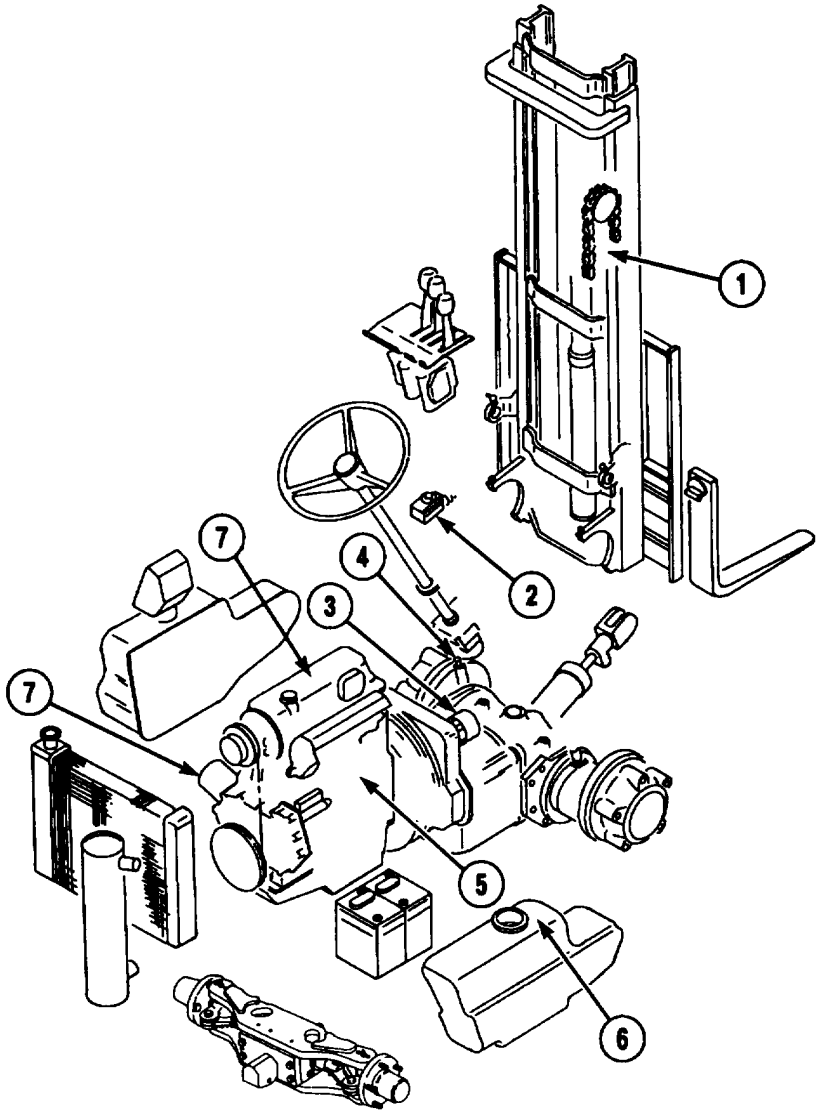
(4) Do not overfill crankcase.

(5) Ensure oil level is correct before operating the truck.



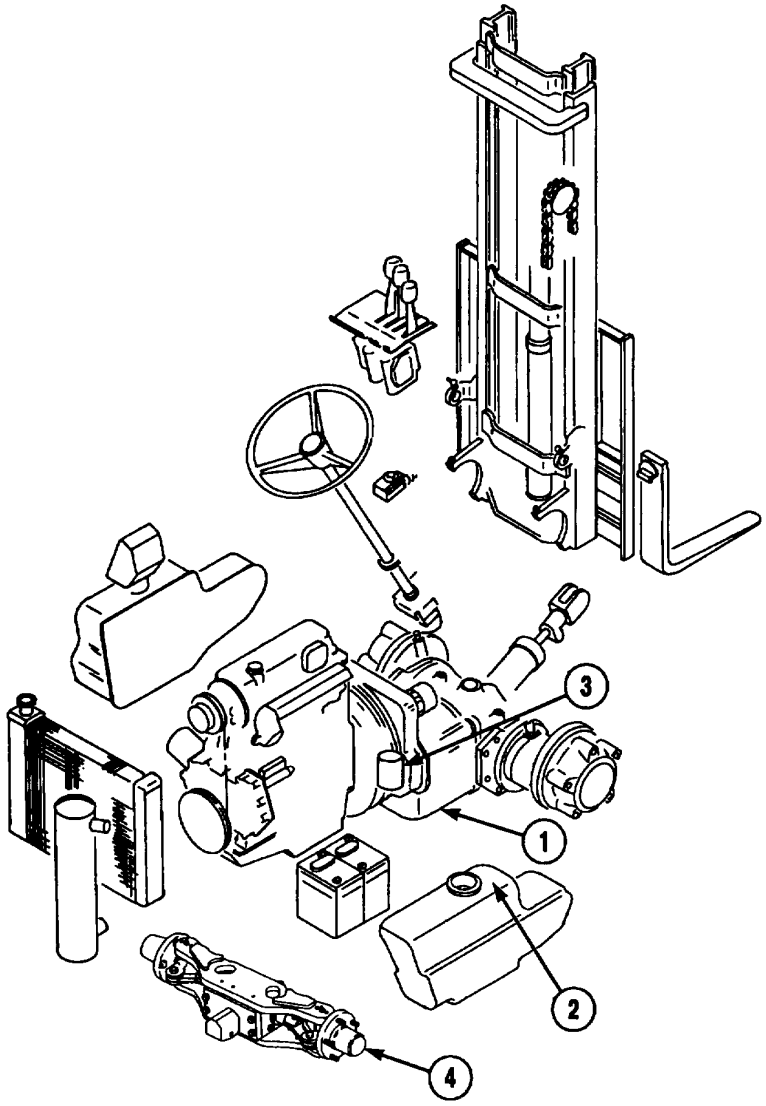
Item	Level	Interval	Lubricant	Capacities
(1) Carriage Rollers	(O)	50H - 25OH/Monthly	GAA (MIL-G-10924)	As Req.
(2) Tilt Cylinder Rod Ends	(O)	50H - 250H/Monthly	GAA (MIL-G-10924)	As Req.
(3) Upright Mounts	(O)	50H - 250H/Monthly	GAA (MIL-G-10924)	As Req.
(4) Side Shift	(O)	50H - 250H/Monthly	GAA (MIL-G-10924)	As Req.
(5) Links	(O)	50H - 250H/Monthly	GAA (MIL-G-10924)	As Req.
(6) Knuckle	(O)	50H - 250H/Monthly	GAA (MIL-G-10924)	As Req.

Figure E-1. Grease Fittings



Item	Level	Interval	Lubricant	Capacities
(1) Lift Chains	(O)	50H - 250H/Monthly	Lube. Oil (MIL-L-2104)	As Req.
(2) Brake Fluid Level	(O)	50H - 250H/Monthly	BFS Silicone (MIL-B-46176)	As Req.
(3) Transaxle Filter	(O)	50H - 250H/Monthly	----	-------
(4) Transaxle Level	(C)	50H - 250H/Monthly	Trans. Fluid (MIL-L-2104)	FULL
(5) Engine Oil Level	(C)	10H - Daily	Engine Oil (MIL-L-2104)	FULL
(6) Hydraulic Tank Level	(O)	50H - 250H/Monthly	OHT Hyd. Fluid (MIL-H-6083)	FULL
(7) Engine Oil and	(O)	50H - 250H/Monthly	Engine Oil (MIL-L-2104)	7 qt (6.61)
Filter Replace	(O)	50H - 250H/Monthly	----	----

Figure E-2. Fluid and Filter Replacement - Short-Term Intervals



Item	Level	Interval	Lubricant	Capacities
(1) Transaxle Oil Replace	(O)	900H-1000H/6 Months	Trans. Fluid (MIL-L-2104)	16 qt (15.11)
(2) Hydraulic Fluid Replace	(O)	2000H/Annually	OHT Hyd. Fluid (MIL-H-6083)	5.5 gal (20.81)
(3) Hydraulic Filter Replace	(O)	2000H/Annually	----	-
(4) Wheel Bearings Repack	(O)	2000H/Annually	GAA (MIL-G-10924)	As Req.

Figure E-3. Fluid and Filter Replacement - Long- Term Intervals

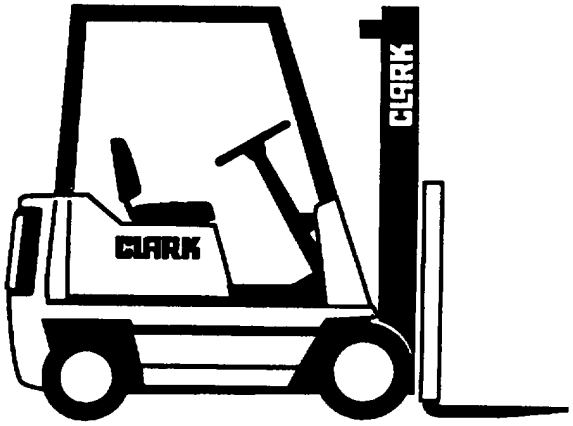
APPENDIX F

COMMERCIAL PLANNED MAINTENANCE AND ADJUSTMENTS

Service
Manual
SM 520

Fork Truck Service Manual

- **Service Specifications**
- **Periodic Maintenance**
- **Repair Procedures**



GPX 25E Diesel

This service publication provides information covering normal service, maintenance and repair of the Clark lift truck noted on the cover. It has been specifically prepared to help owners and service personnel maintain the lift truck in efficient and safe operating condition.

Regular, correct maintenance and care of lift trucks is not only important for long and efficient truck life; it is essential for safe operation. The importance of proper maintenance through planned service, inspection, and qualified repairs cannot be emphasized too strongly.

To assist in keeping lift trucks in good operating condition, this manual includes preventive maintenance procedures to be performed at regular intervals. These are essential to the service life and safe operation of all fork lift trucks. Instructions for safety inspections, operational checks, cleaning, and lubrication are provided for reference in setting-up and conducting a recommended periodic Planned Maintenance (PM) program.

Refer to the Operator's Manual, located on the truck, for additional information on the operation, care, and maintenance of your truck.

Genuine Clark replacement parts should be used for all service and repair requirements. Substitute parts from other sources may be different than original parts and may not meet OSHA or other safety requirements. Any reference to brand names other than Clark in this manual is made simply as an example of the type of tools and materials recommended for use and, as such, should not be considered as an endorsement. Equivalents, if available, may be used.

For more information on maintenance and repair of these trucks, contact your authorized Clark dealer.

NOTICE -The descriptions and specifications included in this manual were in effect at the time of printing. Clark Equipment Company reserves the right to discontinue models at any time, or make improvements and changes in specifications or design without notice and without incurring obligation. Specifications, torques, pressures, measurements, adjustments, illustrations, and other items may change at any time. Contact your authorized CLARK dealer for information on possible updates or revisions.

1989 Clark Equipment Company

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Fuel System (Groups 02, 03)	5
Electrical System (Groups 11-15)	6
Transaxle (Groups 06, 07, 20)	7
Brakes and Inching System (Groups 22, 23)	8
Steering System (Groups 25, 26)	9
Hydraulic System (Groups 28-33)	10
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About This Manual

This manual is intended for use by persons who are trained and authorized to do lift truck maintenance. It is designed to provide essential information about the correct and safe service maintenance and repair of the lift truck by trained mechanics or service technicians.

The Information is organized Into 14 major Parts of related components or topics as outlined by the Table of Contents at the front of the manual:

•**1** General information including precautions and safe maintenance practices.
•**2** Service specifications and reference information including lubricants, capacities, pressures, etc.
•**3** Planned Maintenance (PM) service procedures.
• **4-13** Adjustment, service and repair procedures for truck components.

In Parts 4-13, the detailed service and repair procedures are arranged in Sections for each procedure, component or subsystem. Some Sections include explanations that cover service procedures common to several components or subsystems.

In general, each Section is written to show and describe the general arrangement, adjustment, removal, disassembly, inspection, repair, and assembly steps that are normally required to service the component. Component specifications (as applicable), information notes, and safety messages are included within those procedures. In most cases, specifications are shown in Section 2, Service Specifications, for convenience of reference.

The Table of Contents lists major headings of Parts of the manual. Additional content listings are placed at the beginning of each Section of the manual, subsection, or component heading to simplify reference to multiple topics or procedures covering optional equipment, such as engines and transaxles.

If you cannot find a topic in the respective Table of Contents, check the Alphabetical Subject Index at the back of the manual.

This manual has been made easier to use by providing only specific steps and instructions necessary to explain the activity, component, assembly, or process being worked on. The technician is expected to include obvious additional steps of standard procedure for removal, disassembly, cleaning, inspection, reassembly, installation, etc., as needed.

To be better prepared to do the necessary service work, take time to completely read the entire procedure, including any special instructions, before doing any work.

The technician is cautioned and expected to always work in a safe manner by using the correct procedure. Do not take chances which may result in injuries.

1.0. General Information

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Safe Maintenance Practices

The following instructions have been prepared from current industry and government safety standards applicable to industrial truck operation and maintenance. These recommended procedures specify conditions, methods, and accepted practices that aid in the safe maintenance of industrial trucks. They are listed here for the reference and safety of all workers during maintenance operations. Carefully read and understand these in-

1. Powered industrial trucks can become hazardous if maintenance is neglected. Therefore, suitable maintenance facilities, trained personnel, and procedures must be provided.
2. Maintenance and inspection of all powered industrial trucks shall be done in conformance with the manufacturer's recommendations.
3. A scheduled planned maintenance, lubrication, and inspection program shall be followed.
4. Only trained and authorized personnel should be permitted to maintain, repair, adjust, and inspect industrial trucks, and in accordance with the manufacturer's specifications.
5. Properly ventilate work area, vent exhaust fumes, and keep shop clean and floor dry.
6. Avoid fire hazards and have fire protection equipment in the work area. Do not use an open flame to check for level, or leakage of fuel, electrolyte, or coolant. Do not use open pans of fuel or flammable cleaning fluids for cleaning parts.
7. Before Starting Work On Truck:
   a) Raise drive wheels off of floor or disconnect power source and use blocks or other positive truck-positioning devices.
   b) Put blocks under the upright rails and carriage, innermast(s), or chassis before working on them.
   c) Disconnect battery before working on the electrical system.
8. Operation of the truck to check performance must be conducted in an authorized, safe, clear area.
9. Before Starting To Drive Truck:
   a) Be in operating position.
   b) Disengage clutch on manual transmissions, or apply brake on trucks with powershift transmission.
   c) Put directional control in neutral.
   d) Start engine.
   e) Check functioning of lift and tilt systems, directional and speed controls, steering, brakes, warning devices, and any load handling attachments.
10. Before Leaving Truck:
   a) Stop truck.
   b) Fully lower the load engaging means: upright, carriage, forks, or attachments.
   c) Put directional control in neutral.
   d) Apply the parking brake.
   e) Stop the engine.
   f) Turn off the control of ignition circuit.
   g) Put blocks at the wheels, if truck is on an incline.
   h) Remove the ignition key (OSHA regulation).
11. Brakes, steering mechanisms, control mechanisms, warning devices, lights, governors, lift overload devices, guards and safety devices, lift and tilt mechanisms, articulating axle stops, and frame members must be carefully and regularly inspected and maintained in a safe operating condition.
12. Special trucks or devices designed and approved for hazardous-area operation must receive special attention to ensure that maintenance preserves the original, approved safe operating features.
13. Fuel systems must be checked for leaks and condition of parts. Extra special consideration must be given in the case of a leak in the fuel system. Action must be taken to prevent the use of the truck until the leak has been corrected.
14. All hydraulic systems must be regularly inspected and maintained in conformance with good practice. Tilt and lift cylinders, valves, and other similar parts must be checked to assure that "drift" or leakage has not developed to the extent that it would create a hazard.
15. When working on hydraulic system, be sure the engine is turned off, upright is in its fully-lowered position, and hydraulic pressure relieved in hoses and tubing.
16. Batteries, motors, controllers, limit switches, protective devices, electrical conductors and connections must be inspected and maintained in conformance with good practice. Special attention must be paid to the condition of electrical insulation.

17. To avoid injury to personnel or damage to the equipment, consult the manufacturer's procedures in replacing contacts on any battery connection.

18. Industrial trucks must be kept in a clean condition to minimize fire hazards and help to detect loose or defective parts.

19. The truck manufacturer's capacity, operation and maintenance instruction plates, tags, or decals must be maintained in legible condition.

20. Modifications and additions that affect capacity and safe truck operation must not be done without the manufacturer's prior written approval. Capacity, operation and maintenance instruction plates, tags or decals must be changed accordingly.

21. Care must be taken to assure that all replacement parts, including tires, are interchangeable with the original parts and of a quality at least equal to that provided in the original equipment. Parts, including tires, are to be installed per the manufacturer's procedures.

22. When removing tires, follow industry safety practices.

23. Use special care when removing heavy components from the truck, such as counterweight, upright, engine, transaxle, etc.

24. Before any truck is returned to service it must be safety-checked to insure safe operation.

NOTICE -- Additional operating and maintenance safety instructions are contained in the following publications

ANSI/ASME B56.1 - 1983: Safety Standard for Low Lift and High lift Trucks (Safety Code For Powered Industrial Trucks). Published by: Society of Mechanical Engineers, United Engineering Center, 345 E. 47th Street, New York, N.Y. 10017.

NFPA 505-1982: Fire Safety Standard for Powered Industrial Trucks: Type Designations, Areas of Use, Maintenance and Operation. Available from: National Fire Protection Assoc., Inc., Batterymarch Park, Quincy, MA 02269.

General Industry Standards, OSHA 2206: OSHA Safety and Health Standards (29 CFR 1910), Subpart N-Materials Handling and Storage, Section 1910.178 Powered Industrial trucks. For sale by: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Safety Signs and Messages

SAFETY SIGNS and MESSAGES are placed in conspicuous places throughout this manual and also on the lift truck to provide instructions, and to call attention to specific areas where potential hazards exist and specie precautions should be taken. Be sure to know and understand the meaning of these instructions. Each one i there for a specific purpose. Damage to the truck or death or serious injury to personnel may result if these messages are not followed.

NOTICE This message is used when special information, instructions, or identification is required relating to procedures, equipment, tools, pressures, capacities, and other special data.

IMPORTANT This message is used when special precautions should be taken to ensure a correct action or to avoid damage to or malfunction of the truck or a component.

This message is used as a reminder of safety hazards which can result in personal injury if proper precautions are not taken.

This message is used when a hazard exists which can result in injury or death if proper precautions are not taken.

DANGER This message is used when a hazard exists which can result in injury or death if proper precautions are not taken.

IMPORTANT SAFETY NOTICE

Read and understand all safety precautions and warning before performing repairs on lift trucks.

Appropriate service methods and proper repair procedures are essential to the safe, reliable operation of industrial trucks as well as the personal safety of the individual doing the work. This Service Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure successful repair and reliable truck operation.

There are numerous variations in procedures, techniques, tools, and parts for servicing industrial trucks, as well as in the skill of the individual doing the work. This manual cannot possible anticipate all such variations and provide advice or precautions as to each. Accordingly, anyone departing from the instructions provided in this manual through procedures used or choice of tools, materials, and parts may jeopardize his or her personal safety and/or the safety of the vehicle user.

Improper or careless techniques cause accidents. Don't take chances with incorrect or damaged equipment.
Read and understand the procedures for safe operation and maintenance outlined in this manual.

STAY ALERT! Follow safety rules, regulations, and procedures. Accidents can be avoided by recognizing dangerous procedures or situations before they occur.

DRIVE AND WORK SAFELY and follow the safety signs and their messages displayed on the truck and in this manual.

General Precautions

The following list contains general precautions that should be followed when working on a lift truck:

• **Always wear safety glasses** for eye protection.

• **Remove rings, watches, loose jewelry, and open clothing** before working on a vehicle, to avoid serious injury.

• **Do not smoke** while working on a vehicle.

• **Put ignition switch In the OFF position,** unless otherwise required by the procedure.

• **Set the parking brake**. Place wheel chocks or wood blocks of 4' x 4" size or larger to the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.

• **Use safety stands** whenever a procedure requires you to be under the vehicle.

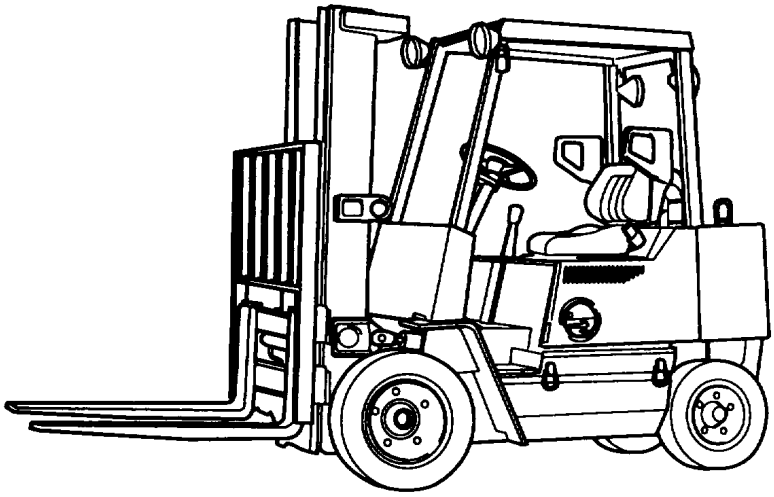
• **Operate the engine only in a well-ventilated area** to avoid the danger of carbon monoxide.

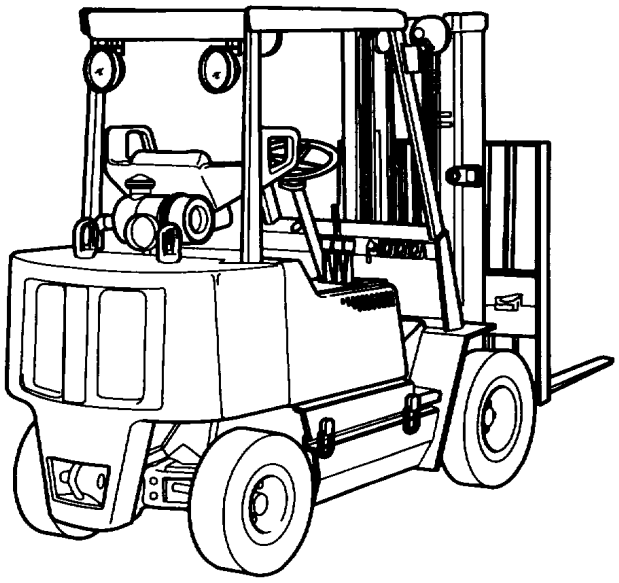
• **Keep hands and other objects clear** of the fan belt and fan blades if it is necessary to work in the engine compartment.

• **Keep yourself and your clothing** away from all moving parts, especially the fan and belts, when the engine is running.

• **Avoid contact with hot metal parts** such as the radiator, exhaust manifold, exhaust pipe, and muffler to prevent serious burns.

Product Identification
Model Nomenclature





Rated Load Capacity @ 024 inch (500 mm) Load Center

Model	**GPX 25E**
Basic Capacity lbs kgs	 4000 (1814)

This is the basic capacity of the truck chassis. The actual capacity of the truck may be less due to the use of high lift uprights and/or attachments.

Model Designation

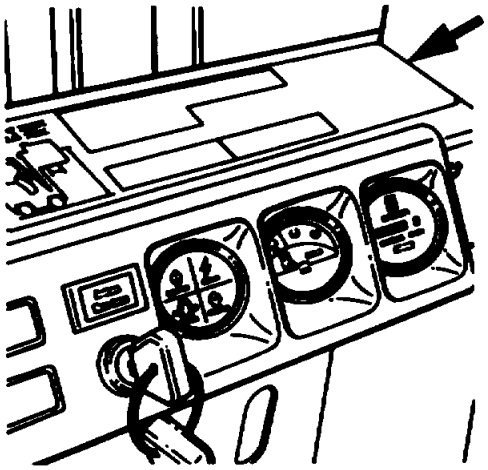
	Engine	Transaxle
Serial No. Prefix	Continental TMD27 Diesel	TA1 8 1-spd
GPX 25E	•	•
• TA18 transaxles incorporate full-floating straight drive axles with drum and- shoe brakes.		

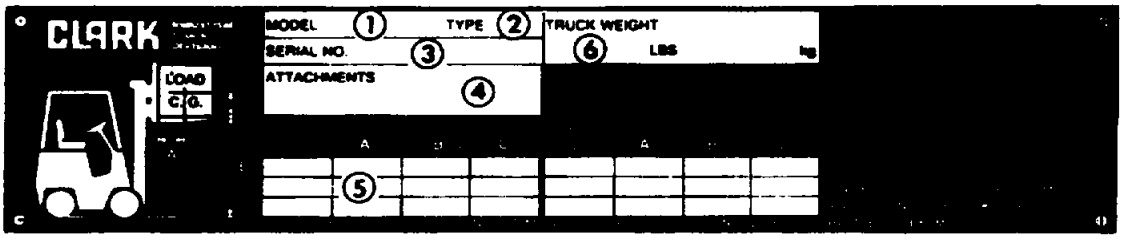
Model Serial Number Code

Pneumatic Tire Trucks Model Designation	Sequence No	Lot No	Plant of Mfr	Plant of Manufacture
GPX 25E	-XXXX	-XXXX	-XX	FB.....Lexington, KY

Product Identification

Truck Data & Capacity Plate (Nameplate)



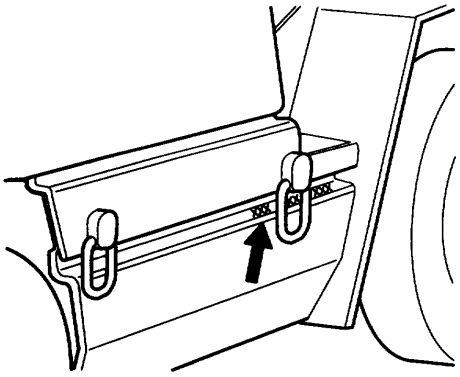


The truck nameplate should be referred to for:

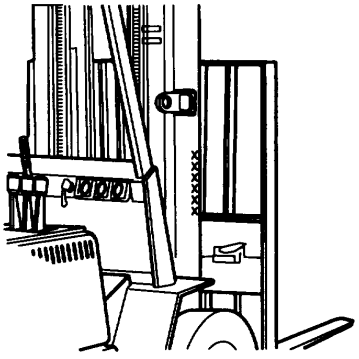
1. Model number
2. UL Type Classification
3. Truck serial number
4. Attachment description
5. Capacity rating, load center, and lifting height data
6. Truck weight, less load

The truck Serial Number is required when requesting information and must always be given when ordering parts. Likewise, the upright Deck Number must be provided on requests for Upright Service or Parts Information.

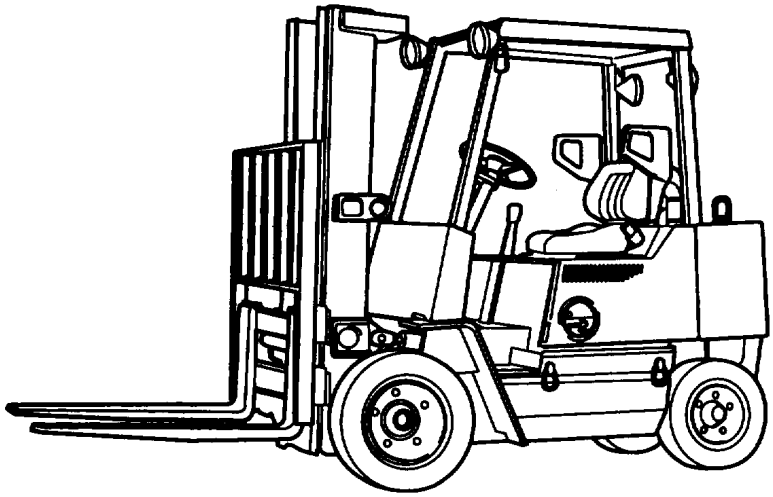
Machine Serial Number

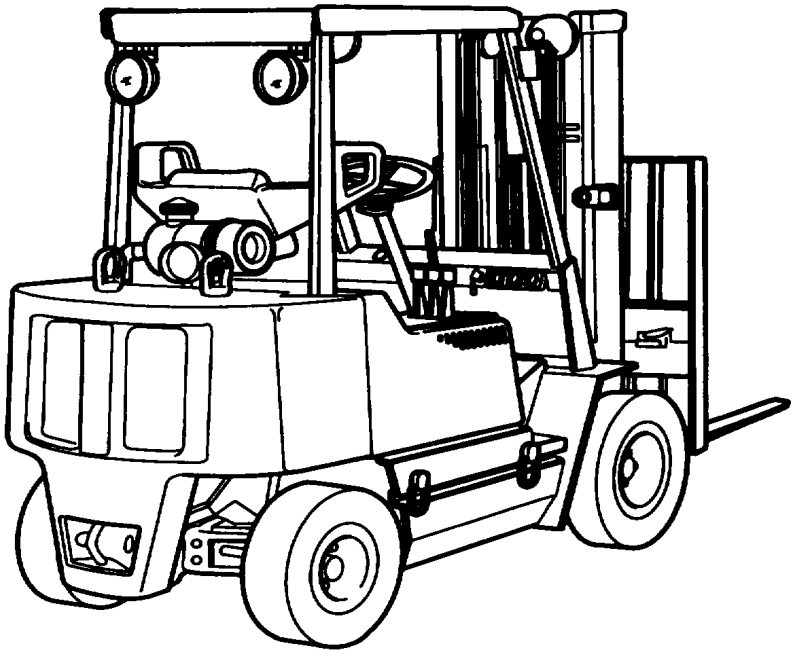


Upright Deck Number



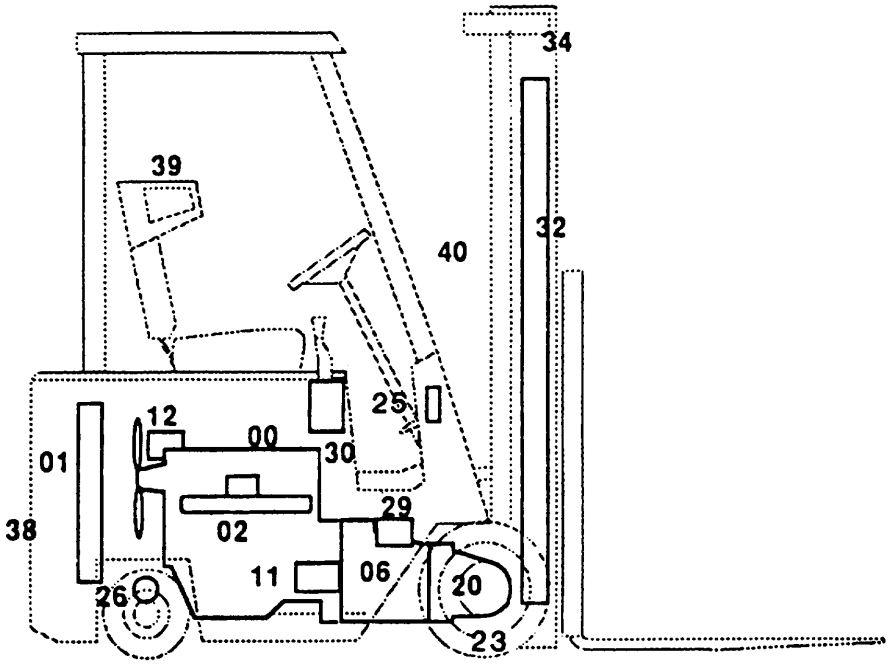
Product Identification
Truck Model Visual Identification





GPX models can be identified by the circular bolt pattern at the center of the drive axle hub.

Component Identification



Truck Systems by Parts GROUP Number

Typical Clark fork lift truck basic parts group number as used In this manual:

00 - Engine
01 - Cooling System
02 - Fuel System, Carburetors, Exhaust
06 - Transaxle (Transmission)
11 - Distributor
12 - Altemator, Starter
20 - Drive Axle (See Transaxle)
23 - Wheels and Tires
23 - Brake System
25 - Power Steering Control
26 - Steer Axle
29 - Hydraulic Pump and Sump
30 - Hydraulic Control Valve
32 - Hydraulic Cylinders
34 - Upright and Carriage
38 - Counterweight
39 - Frame and Chassis Components
40 - Nameplates and Decals

2.0. SPECIFICATIONS

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2.1. Service Specifications

Frame/Chassis

- **Basic design is to metric standard dimensions**
- **Components and hardware dimensions are combination USA inch and metric**
- **Stamped and formed frame, welded construction, 10 mm, except cowl 6 mm**
- **Removable fuel and hydraulic tanks**

Cooling System

• TYPE: Crossflow radiator, with transmission oil cooler in radiator side tank
Coolant recovery system is standard.
• System Pressure (Radiator Cap): 14 psi nominal Limits 12-16 psi (83-110 kPa)
• Thermostat: Open (cracking)175-182°F (65-68°C)
Fully open 202°F (79°C)

Recommended Coolant: 50% water and 50% low-silicate ethylene glycol permanent-type antifreeze containing rust and corrosion inhibitors. Antifreeze protection level -340F (-37°C).

NOTE

The use of only an antifreeze having a low-silicate additive content is strongly recommended. Silicates are added to antifreeze to help protect aluminum cylinder heads in automotive engines. During use, the silicate additives may form gummy deposits that can block and seriously damage a cooling system. Low-silicate antifreeze is available for heavy-duty use. Also, some tap waters react adversely with coolant chemicals. If your local tap water is 'hard," use distilled water.

Electrical System

• System Voltage & Type:	12 volt, negative ground
• Fuses:	AGC 15 amp (in-line in wiring harness)
• Indicator Lamps:	No. 57
• Battery:	12 volt, BCI Group 31
Cold Crank Current:	625 amps 0 OF (17.8°C)
Cranking Voltage:	9.4 volts, minimum
No-load Voltage:	12 volts
Charging Voltage:	13.5 volts, minimum
• Aftemator /Voltage Regulator	Motorola 9DB, 12 volt, 62 amps

Fuel System

Diesel

• Fuel Strainer, Diesel:	In fuel tank
• Fuel Filter, Diesel:	In-line, between fuel supply (transfer) pump and injection pump
Recommended Fuel:	No. 1-D (light fuel) and preferably No. 2 (heavy fuel) Cetane Number 50 desired, 45 minimum Total Sulphur 0.5% maximum

Drive & Steer Tires

Model Series	Model	Drive Tire Size	Steer Tire Size
GPX	GPX 25E	7.00x12	6.50x10

Engine Application

Truck Model	Type	Engine Model Cyls	Displacement
GPX 25E	Diesel	Continental TMD27 4	164 cu in. (2.7 L)

Engine Specifications
CONTINENTAL TMD27 (2.7L)

Basic Specifications

TYPE: 4Cylinder In-Line, 4-Cycle
FUEL: TMD27 Diesel
VALVE ARRANGEMENT: OHV
ROTATION: RH viewed 0 fan end
DISPLACEMENT: 164 CID (2.68 L)
BORE x STROKE: 3.58 x 4.06 in. (91 x 103 mm)
FIRING ORDER: 1-3-4-2
COMPRESSION RATIO: 20.5:1
COMPRESSION PRESSURE:325 psi min 0150 rpm

No. PISTON RINGS:3 (2 Compression, 1 Oil control)
NOMINAL RATED SAE
POWER: 59.0 hp 0 2800 rpm
TORQUE: 119 lb ft (161 Nom)
0 1600 rpm
WEIGHT, (Approx. w/accessories): 568 lb (258 kg)
BALANCING SYSTEM: None
CRANKCASE VENTILATION: Integral closed PCV

Cooling System Capacity: 9.0 qts (8.5L)

WATER PUMP: Centrifugal type
THERMOSTAT: Wax type
Starts To Open At 180°F (82°C)
Fully open 204°F (95°C)
FAN DRIVE RATIO: 1.589:1

Lubricating System

OIL PUMP: Crankshaft-driven, gerotor type
Oil Pressure, Normal: 40-60 psi (276-414 kPa)
At idle 7 psi (48 kPa)
Oil Pressure Switch: Actuates below 4 psi (27 kPa)
OIL FILTER: Full-flow spin-on type
ENGINE OIL CAPACITY, w/Filter: 7.0 qt (6.6L)
VALVE CLEARANCE, Warm: INT .014 in. (0.36 mm)
EXH .018 in. (0.46 mm)

TMD27 Diesel Fuel System

FUEL SUPPLY PUMP: Electric lift pump from fuel tank
Lift Pump Pressure: 1.5-2.25 psi (10-16 kPa)
Lift Pump Max Lift: 10 ft (3m)
INJECTION PUMP: Stanadyne Gear driven
Injector Nozzle Opening Pressure: 2050-2130 psi
Injection Pump Timing: 130-15°BTDC @ 1600 RPM
GOVERNOR: Mechanical, integral w/injection pump
COLD START AID: Glow plugs

Engine Speed Settings

Idle Speed: 650 rpm
(600-700 rpm)
No Load Governed Speed: 2600 rpm
(2550-2650 rpm)

Engine Vacuum Readings (Typical values)

Idle: 17-19 in. Hg
No Load Governed Speed: 13-15 in. Hg
Stall: 1-3 in. Hg
Tilt Bypass: 4-6 in. Hg

Transaxle Application

Truck Model	Transaxle Model Designation	Ratios	Overall	Torque Conv.
GPX 25E	Clark Powershift TA18	1	15.587:1	3.00
Drive Axles	TA18 has straight axle with drum brakes at drive wheels			

Transaxle Specifications
CLARK TA18

General Description	
Single-speed power shift transmission with integral drive axle. Full floating straight axle with self-adjusting drum-and-shoe brakes at drive wheels. Gear-driven pump drive. Direction (shift) control operated electrically. Inching control operated hydraulically. Accumulator-type control valve. Transmission fluid radiator-cooled.	
Basic Specifications	
No. Ratios:	1-speed, forward and reverse
Overall Ratios:	(Fwd) 15.587:1 (Rev) 16.167:1
Transmission Ratio:	(Fwd) 2.798 (Rev) 2.902:1
Drive Axle Ratio:	5.571:1
Ring & Pinion Gear Type:	Spiral Bevel
Differential Type:	2-pinion
Torque Converter Size:	11 in.
Torque Converter Stall Ratio:	3.00:1
Main Hyd Pump Drive Ratio:	1.03 x engine rpm
Charge Pump Flow, min.:	9.1 gpm
Regulator Valve Pressure:	150-190 psi
Convector In/Lube Pressure, min.:	30 psi
Clutch Pressure, Fwd & Rev, max.:	135-170 psi
Dry Weight:	600 lbs
Oil Capacity, Initial Fill:	16 quarts
Oil Capacity, Refill:	13 quarts

Brakes

Service Brake Systems

• GPX 25E has manual hydraulic service brake and inching system, with dual suspended foot pedals.

• GPX 25E has dual (2) separate brake and inching master cylinders. Left foot braking and inching, right foot braking only.

Service Brakes: GPX 25E - TA18 Transaxle

• Brake master cylinder(s), reservoir and lines form closed circuit using standard SAE/DOT 3 ,automotive hydraulic brake fluid.

• Drum-and-shoe brakes at drive wheels. Self adjusting. Mechanically actuated for parking.

TA18 Transaxle

• Service & Parking Brakes:	11.81 in. dia x 2.16 in. wide (300 mm dia x 55 mm wide) (See transaxle for details).
• Master Cylinder - Braking:	0.94 in. bore x 1.125 in. stroke (23.88 x 28.58 mm)
• Master Cylinder - Inching:	0.75 in. bore x 1.125 in. stroke (19.05 x 28.58 mm)
	Note
	Have seals for use with hydraulic brake fluid only.
• Pedal Travel:	**Refer to Section 8.4, Brake & Inching System - Type 2.**
Recommended Brake Fluid:	Heavy-duty hydraulic brake fluid, SAE J1703 spec., or Type DOT, Grade DOT 3 (Grade DOT 5 optional)

Brake-Inching Control System

• First part of pedal motion moves transmission control valve to regulate release of driving clutch pressure. Last part of pedal motion releases clutch entirely, and applies service brakes.

• Hydraulic inching and braking controlled by left foot pedal. Right pedal is brake only.

Steering System

Power Steering System

• Hydrostatic power supplied from main hydraulic pump through priority-demand valve to steering gear.

• Priority-demand valve gives correct oil flow for steering. Overflow returned to lift or tilt system.

• Steering gear control valve directs oil to 2-way steering cylinder on steer axle.

• Steering control acts as pump for emergency manual steering.

• Steer Handwheel: 15-inch diameter

• Handwheel Tums, lock-to-lock, nominal: GPX 5.2/4.9 (4.314.0 after MAR 87)

Relief Pressure Setting *: 1200-1300 psi (8270-8960 kPa)

Steer Axle & Steering Cylinder

Type 2. Fabricated weldment body, w/integral double-acting steering cylinder, straight link ball joints. 1) Steering cylinder: Internal steer stops, through-bolts retain gland ends.

• Forged knuckles

• Straight kingpins in tapered roller bearings

• Steer Cylinder: 2.38-inch diameter

• GPX 2-piece hub & wheel 750turn angle

Main Hydraulic System
System Components

• Sump tank • Main pump • Priority demand valve * Main control valve
• Associated lines & hoses • Full flow, return line oil filter

• Oil from sump tank is fed by gear pump through priority-demand (flow control) valve to main control valve. At priority-demand valve, required flow is diverted to steering system. Oil not used for steering is added to lift of tilt system. Main control valve directs oil to either lift or tilt cylinders. Oil returns to sump through filter.

• Hydraulic sump is separate, removable tank in RH side compartment of frame. Has large top opening with removable cover including full tube/breather, oil level dipstick, and oil filter return line. Cover held on with V-band clamp. Sump breather is standard Clark part.

• Main hydraulic control valve has adjustable system relief valves, and counterbalance valve in tilt circuit with pressure-compensated flow control valve to control tilt speeds. All ports and connecting lines on bottom surface of valve.

• Optional single or double aux sections may be added to outer side of standard (lift/tilt only) main valve.
Aux sections have adjustable relief valve w/optional flow controls for: 2.5, 4.0, 5.5, 7.0, or 10.0 gpm flow.

• Hydraulic system relief pressure is "tuned" (adjusted) to match the truck rated capacity.
Maximum pressure 3000 psi (nominal).
• Main hydraulic valve has diagnostic quick disconnect fitting for checking main hydraulic and steer system pressure.
Main Hydraulic Pump mounted to drive pad on transmission

· Pump RPM:	1.03 x engine rpm	
· Pump Flow:	13.1 gpm (49.6 L/min)	@ 1800 rpm (pump) & 500 psi
	11.7 gpm (44.3 L/min)	@ 1800 rpm (pump) & 3000 psi

Note
Maximum design pressure is 3000 psi (20,700 kPa).

Hydraulic System Main Relief Valve Pressure Settings: (Lift & Tilt)	GPX 25E:	2600-2700 psi (17926-18616 kPa)
Aux Valve Relief Pressure Settings * (Refer to attachment specifications)		• Adjustable up to 19252075 psi (13270-14307 kPa)
Recommended Hydraulic Fluid:		Clark Spec MS-68 Hydraulic Oil with anti-wear additives.

Lift Speeds Nominal performance for upright at full-capacity cut-off height

		TSU UPRIGHT
LIFT SPEED, fpm	Loaded	80 (.41 m/s)
	Empty	87 (.44 m/s)
LOWER SPEED, fpm	Loaded	69 (.35 m/s)
	Empty	79 (.40 m/s)

Maximum Fork Drift, inches (mm): In 5 minutes with capacity load, new truck:

Truck Model	Temperature	UPRIGHT TSU
GPX 25E	800F (26.7-C)	.33 (08.5)
	100°F (37.8-C)	.53 (13.5)
	120°F (48.9°C)	.73 (18.5)

Tilt Cylinders

• **Tilt Cylinder Diameter**:	3.5 in. (88.9 mm) I.D.	
• **Tilt Speed** (Nominal)	Thru 225 MFH:	1.5 to 5.3 degrees/sec
	Above 225 MFH:	1.1 to 2.3 degrees/sec
• **Tilt Drift** - in 5 minutes, w/rated load, new truck:	Temperature	Drift, degrees inches (mm)
	800F (26.7°C)	0.6° .157 in. (4.0 mm)
	100°F (37.8°C)	1.10.276 in. (7.0 mm)
	120°F (48.9°C)	1.50.394 in. (10.0 mm)

Truck Weights - Approximate, with 3-stage upright

Service Weight:	w/o load, lbs	19,735 lb (8952 kg)
Axle Loading:	w/o load, front, lbs	_____
	rear, lbs	_____
Axle Loading:	w/load, front, lbs	_____
	rear, lbs	_____

Counterweight Weight - Minimum, lbs (kgs):

Model	
GPX 25E	3160 (1433)

Fill Capacities - Fluid volumes (approximate):

Fuel Tank - Diesel:	8 gal (30.3L)
Cooling System - TMD27:	9 qt (8.5L)
Engine Oil, w/Filter - TMD27:	7 qt (6.6L)
Transaxle -TA18:	32 pints (15.4L)
Hydraulic Sump Tank- (Total Volume):	8 gal (30.3L)
(Usable Volume):	5.5 gal (20.8L)

Fluid Recommendations

Fuel:	Diesel No. 1-D or No. 2-D (preferred) Distillate, Cetane No. 50 (45 Min)

Engine Oil, Diesel:	Single viscosity motor oil per API Service Classification CD-Service Class D. SE/CD, SF/CD oil classifications may be used. High detergent oils exceed engine manufacturer warranty requirements. Multi-grade oils used should cover the single grade recommendation for the operating ambient temperature.

General Recommendations	Ambient Temperature (Average)	Viscosity
Engine Oil Viscosity	80° F or above (30° C or above)	SAE 40
	32° F to 110° F (0° C to 43 ° C)	SAE 30
	70° F to 0° F (21° C to -17° C)	SAE 20W
	0° F to -30° F (-17° C to -34° C)	SAE 10W

Engine Coolant:	Use a mixture of 50% water and 50% low-silicate ethylene glycol permanent- type antifreeze containing rust and corrosion inhibitors, only. (Protection level -34° F (-37° C) approximately.) See Cooling System, Section 2.1.
Hydraulic Fluid:	Clark Specification MS-68 or MS-226 Hydraulic Oil, with antiwear additives, or equivalent.
Hydraulic Brake Fluid:	Heavy-duty hydraulic brake fluid, SAE J1703b specification; or Type DOT, Grade DOT 3.
Transmission Fluid:	TA18 Transaxle, AMOCO 1000, Texaco 1893 TDH, or Gulf 303 Clark Part No. 2776236

Lubricant Specifications

Motor Oil	
Upright latches, Control rods, Miscellaneous linkage	Motor oil per API Service Classification SE, SF, SE/CD, SF/CD; or MIL-L-2104B; or MIL-L-46152
Multi-Purpose Grease	
Axle ends, Wheel bearings	NLGI Grade No. 1, Lithium soap base grease, with EP additives, CLARK Specification MS-9B and MS-107B, or equivalent
Steer Linkage, Upright Mast, Carriage Rollers, Trunnion Bushings, Tilt Cylinder Rod Ends, Brake Pedal Shaft	NLGI Grade No. 2, Lithium soap base grease, with EP additives, CLARK Specification MS-107C, or equivalent.
Chain Lube	
Upright lift chains	CLARK #886399 Chain and Cable Lube, or equal
Dry-Film Lubricant	
Side shifter, Attachments,	Dow Corning Molykote 321 Bonded Lubricant; Graph-O-Kote #22; Molub-Alloy #369 Dry Lube, or equivalent.
Battery Service	
Unsealed batteries	Distilled water

Critical Fastener Torque Specifications
Truck Chassis - General

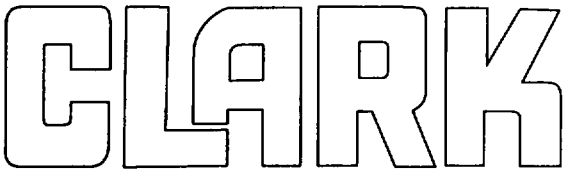
	Tightening Torque, Dry	
	lb ft	**(N·m)**
Drive wheel lug nuts/bolts	470-530	(637-718)
Steer wheel lug nuts/bolts (pneumatic tire only)	265-338	(359-458)
Counterweight mounting bolts (all)	240-265	(320-360)
Overhead guard mounting bolts	50-55	(65-75)
Load backrest extension mounting bolts	177-199	(240-270)
Drive axle to frame mounting bolts	400-440	(542-596)
Steer axle mounting bolts	420-480	(570-650)
Upright trunnion to upright rain mounting bolts	273-302	(370-410)
Upright trunnion cap bolts	55-59	(75-80)
Upright cylinder retaining bolts	53-59	(72-80)
Tilt cylinder yoke clamp bolts	125-140	(170-190)
Steering handwheel retaining nut	35-40	(47-54)
Steering column mtg bolts (to bracket)	6-7	(8-10)
(bracket to cowl)	15-18	(20-25)
Main hydraulic control valve mtg bolts	30-33	(41-45)
Control lever mtg bolts	6-7	(8-10)
Alternator adjusting bracket bolt	15-18	(20-25)
Main hydraulic pump mounting bolts	53-59	(72-80)

NOTE

When checking tightness of major fasteners on new trucks, the values may be less than the recommended specification due to metal deformation and fastener stretch. This is a normal occurrence and does not indicate that the fasteners were not correctly tightened during assembly. Tighten to recommended specifications.

Torque Specifications
TMD27 (2.7 L) Engine

	Tightening Torque, Dry	
	lb ft	**(N•m)**
Oil pan drain plug	43-58	(59-78)
Oil filter	8-9	(10.8-12.7)
Injector nozzles to holder	50-55	(68-75)
Injector to cylinder head	50-55	(68-75)
High-pressure fuel lines	20-25	(27-34)
Engine cylinder head bolts (screw size M10) cold	50-55	(68-75)
(screw size M12) cold	90-95	(122-129)
Engine cylinder head bolts (screw size M10) warm	45-50	(61-68)
(screw size M12) warm	80-85	(109-115)
Rocker cover	5-6	(7-8)
Intake/exhaust manifold mounting nuts (M8)	15-18	(20-24)
Intake exhaust manifold mounting nuts (M10)	25-30	(34-40)
Oil pan	10-14	(14-19)
Gear covers, water pump	25-30	(34-40)
Starter mounting bolts	30-35	(40-50)
Crankshaft pulley	120-130	(163-176)
Fan mounting bolts	15-18	(20-25)
Flywheel	50-55	(68-75)
Torque converter mtg bolts	15-18	(20-25)



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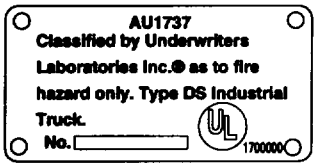

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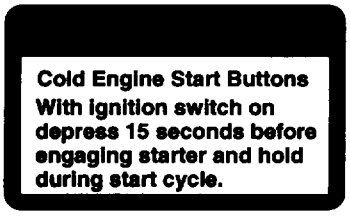

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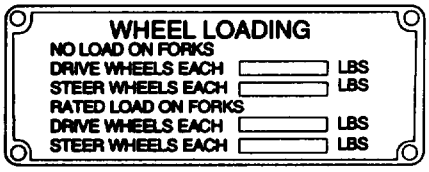

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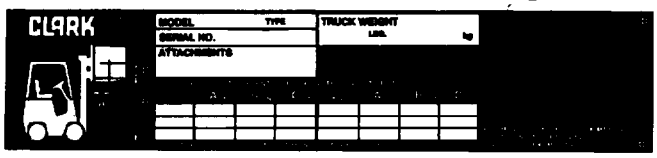

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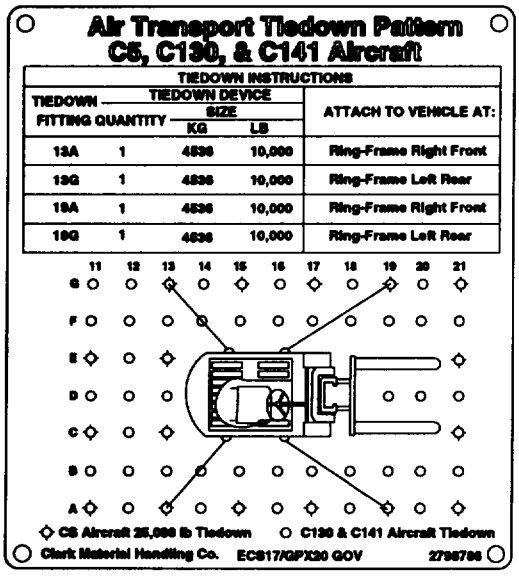

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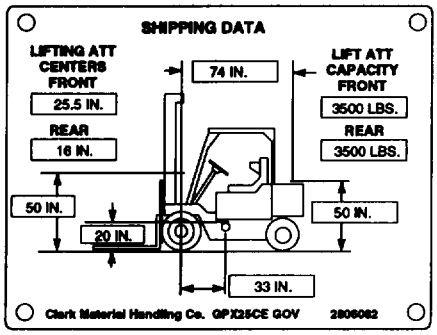

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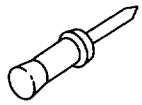
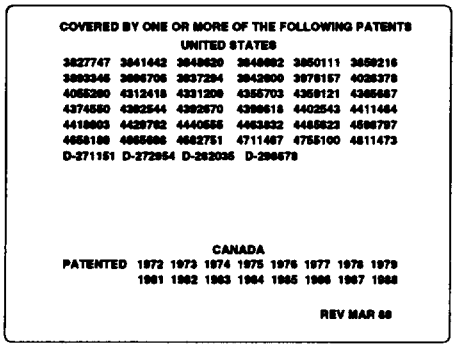


POP-RIVET



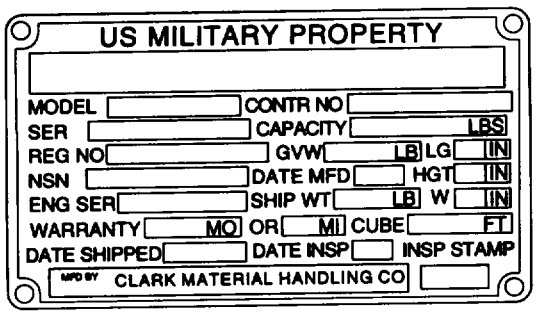
H

NOTE

Pop-Rivets are used to attach data plates.

A	CLARK 3 in. Logo	F	Tiedown Pattern Decal
B	UL Class 'DS' Plate	G	Shipping Data Decal
C	Cold Start Decal	H	Universal Patents Decal
D	Wheel Loading Plate		
E	Nameplate		

Data Plate and Decal Location Specifications



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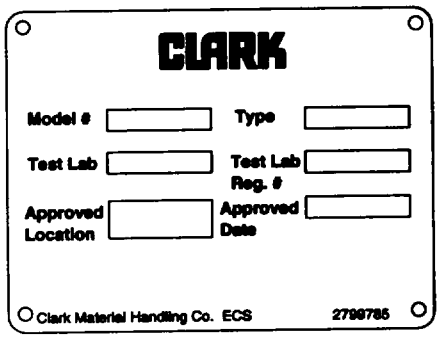

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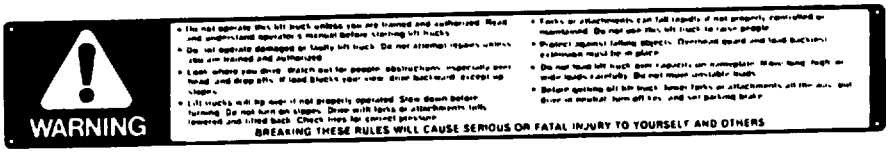

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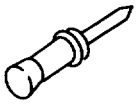

POP-RIVET

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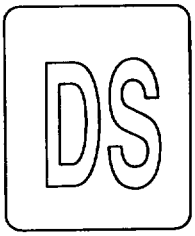

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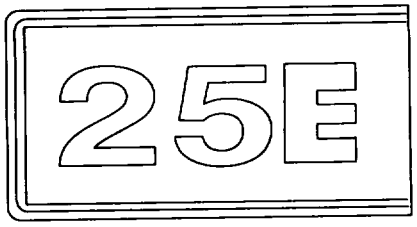


N

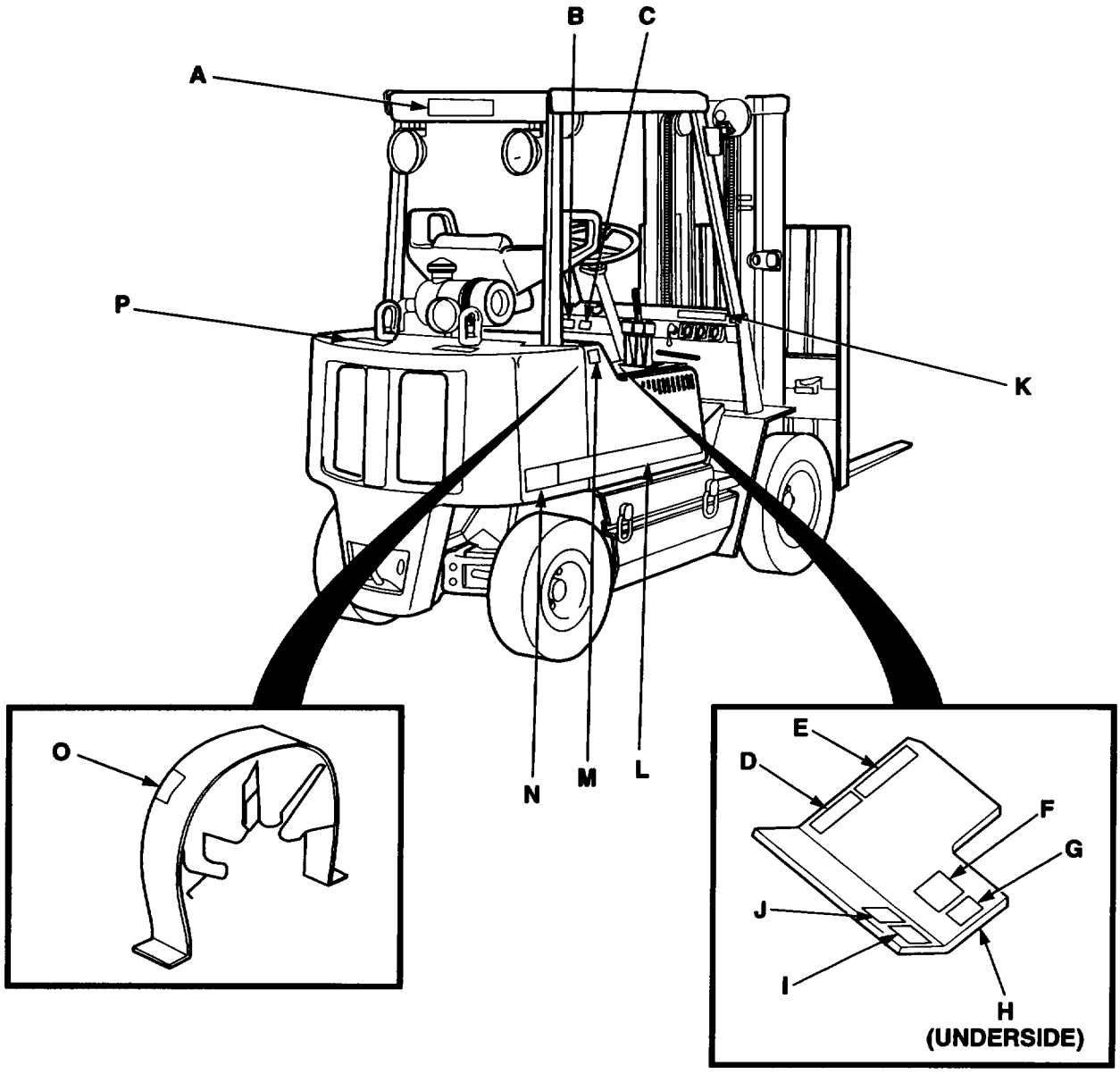
O

P

NOTE
Pop-Rivets are used to attach data plates.

I	Military Identification Plate	N	"25' Decal - Right Side
J	Safety Rating Plate	O	Fan Warning Decal (Both Sides)
K	Engineering Safety Instruction Plate	P	'LIFT HERE" Decal (Both Sides)
L	CLARK GPX Logo Decal - Right Side		
M	UL 'DS" Decal (Both Sides)		

Data Plate and Decal Location Specifications



Data Plate and Decal Location Specifications

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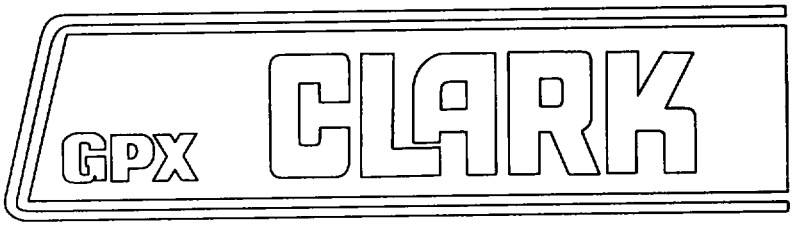

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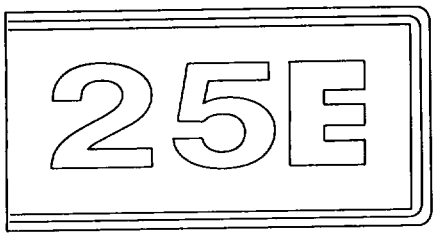

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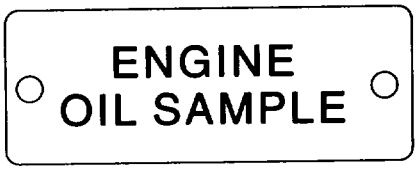

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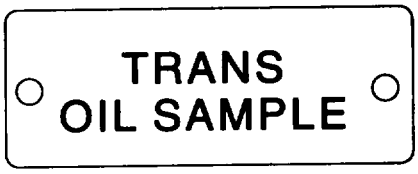

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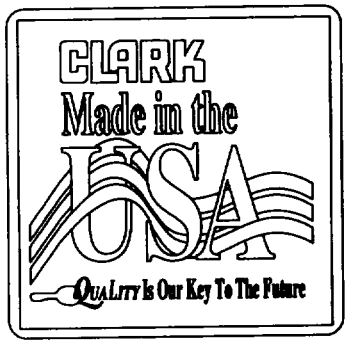

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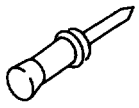
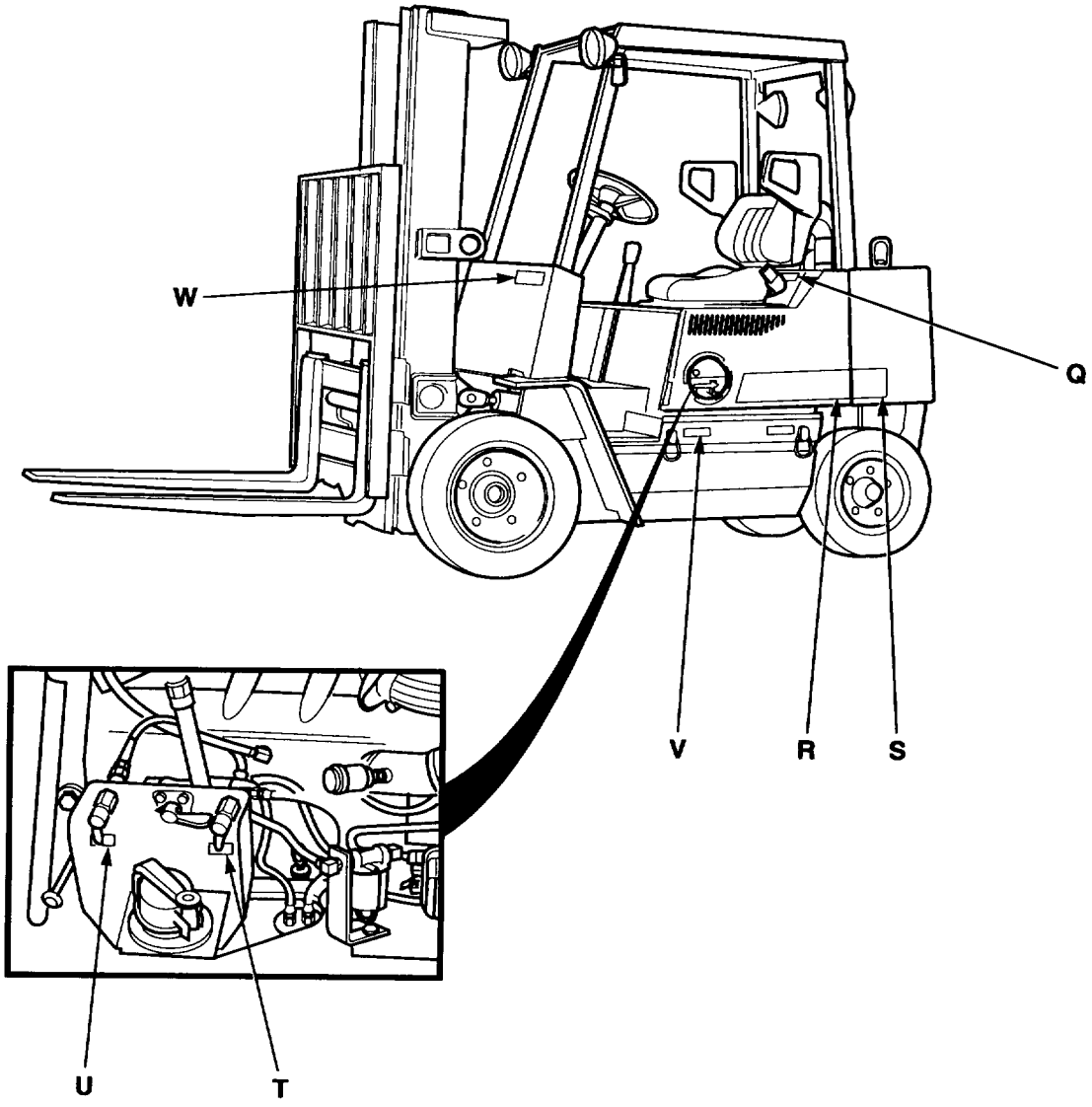


POP-RIVET

NOTE
Pop-Rivets are used to attach data plates.

Q	IMPORTANT - Seat Deck Latch Decal	U	Transmission Oil Sample Nameplate
R	CLARK GPX Logo Decal - Left Side	V	Tiedown Decal
S	"25' Decal - Left Side	W	Made in USA Decal
T	Engine Oil Sample Nameplate		

Data Plate and Decal Location Specifications



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3.0. PLANNED MAINTENANCE

3.1 PM Schedules F-37

3.2 Planned Maintenance Procedures F-41

3.3 Machine Jacking and Blocking F-59

F-35 (F-36 blank)

3.1. PM Schedules

Planned Maintenance (PM) F-37
PM Service Intervals F-38
Safety and Operational Checks F-39
Recommended PM and Lubrication Schedule F-40

Planned Maintenance (PM)

A safety inspection of a lift truck should always be made before operating it. The purpose of this daily check is to look for obvious damage and maintenance problems, and to have minor adjustments and repairs made to correct any unsafe condition.

The Operator's Manual attached to the truck outlines the daily inspection.

NOTE

The Occupational Safety and Health Act (OSHA) requires that the user examine his trucks before each shift to be sure they are in safe working order. Defects when found shall be immediately reported and corrected. The truck shall be taken out of service until it has been restored to safe operating condition.

PM Program

In addition to the daily inspection, Clark strongly recommends that you set up and follow a periodic planned maintenance and safety inspection program (PM) in accordance with the guidelines offered here.

Performed by a trained and authorized mechanic on a regular basis, the PM program provides the opportunity to make thorough inspections and checks on the safe condition of your truck.

Necessary adjustments and repairs can be done during the PM, which will increase the life of components and reduce unscheduled downtime.

The need for major adjustments, repairs, or replacements is found and corrections made as required; not after failure has occurred.

The PM can be scheduled to meet your needs; the specific schedule (frequency) for these PM inspections will depend on the conditions of your particular application and lift truck usage.

The recommended planned maintenance and lubrication schedule lists those items considered essential to the safety, life, and performance of your truck with typical recommended service intervals. Brief procedures for inspections, operational checks, cleaning, lubrication, and adjustments are included for your reference.

Also noted is the PM inspection and report form which may be obtained from your local Clark dealer.

Your local authorized Clark dealer is also prepared to help you with your PM and repair programs if you want assistance. He has trained service personnel who know your lift truck and are authorized to check and repair your truck according to the respective safety regulations to keep it operating safely and efficiently.

PM Service Intervals

Typical Operating Conditions

NOTE

Since the operating environment of lift trucks varies widely, the following descriptions are highly generalized and should be applied as actual conditions dictate.

Time intervals between PMs are largely determined by operating conditions. For example, operation in sandy, dusty locations requires shorter maintenance intervals than operation in clean warehouses. The indicated intervals are intended for normal operation. To allow better understanding of this aspect, the following clarification should be made:

Normal Typically, four to eight hours of operation, mostly in buildings or in clean, open air, smooth floors, and pavement.

Severe Prolonged operating hours or constant usage. Rough floors, broken semi-improved pavement.

Extreme
1. In sandy or dusty locations, e.g., airborne abrasives or contaminants.
2. High-temperature environments.
3. Environments with extreme temperature changes.
4. Rough floors and pavement.
5. Extensive brake application.

If your fork lift truck is used in severe or extreme operating conditions, you must shorten the maintenance intervals accordingly.

Recommended PM Intervals

The maintenance time intervals referred to in this manual relate to truck operating hours as recorded on the hourmeter and based on experience which Clark has found to be appropriate under typical (normal or average) operating conditions, as follows:

A =	8 - 10	hours, or daily
B =	50 - 250	hours, or every month (Typical PM interval)
C =	450 - 500	hours, or every 3 months
D =	900 -1000	hours, or every 6 months
E =	2000	hours, or every year

Safety and Operational Checks

PM Interval

A =	8 - 10	hours, or daily
B =	50 - 250	hours, or every month (Typical PM interval)
C =	450 - 500	hours, or every 3 months
D =	900 -1000	hours, or every 6 months
E =	2000	hours, or every year

Daily Maintenance Checklist	A	B	C	D	E
Check truck for obvious damage and leaks	•				
Check fuel system for leaks, etc.	•				
Check capacity, warning plates, decals	•				
Check condition of tires and wheels	•				
Check wheel lug nuts or bolts (loose, missing, broken, torque)	•				
Check engine oil level	•				
Check engine coolant level (radiator & recovery tank)	•				
Check fuel level	•				
Check hydraulic sump oil level	•				
Check gauges and instruments	•				
Check warning lights and hourmeter	•				
Check horn operation and other warning devices	•				
Check steering operation	•				
Check service brake operation	•				
Check parking brake operation	•				
Check parking brake linkage for damage, wear, broken parts	•				
Check directional control operation	•				
Check accelerator and engine speed operation	•				
Check lift, tilt, and sideshift operation	•				
Check overhead guard condition and bolts	•				
Check upright, lift chains, and fasteners	•				
Check load backrest extension and forks	•				
Check seat deck hold-down latch for correct locking	•				

Recommended PM and Lubrication Schedule

PM Interval:

A = 8-10 hours, or daily
B = 50-250 hours, or every month (Typical PM interval)
C = 450-500 hours, or every 3 months
D = 900-1000 hours, or every 6 months
E = 2000 hours, or every year
† = 800 hours after initial readjustment

Note

* Oil change interval may be determined by commercial laboratory analysis of oil.
** Air filter change interval may be determined by installing air cleaner restriction indicator. *(See Section 4.9, Air Filter)*

PM Checklist	A	B	C	D	E
Check truck visually and inspect components		•			
Test drive truck - Check functional performance		•			
Air clean truck and radiator		•			
Check torque on critical fasteners		•			
Lubricate truck (See component)		•			
Change engine oil (*)		•			
Change engine oil filter		•			
Clean/replace engine air filter (**)		•			
Inspect/adjust fan belts			•		
Change (drain/flush) engine coolant					•
Check engine ignition and timing			•		
Engine tune-up					•
Check battery			•		
Check transaxle fluid level		•			
Change transaxle fluid (drain and replace)				•	
Change (replace) transaxle oil filter			•		
Clean transaxle air vent		•			
Check brake condition and wear					•
Check transaxle mounting and fasteners		•			
Lubricate steer axle linkage		•			
Check/lubricate steer axle wheel bearings					•
Change (replace) hydraulic sump oil filter and breather			•		
Change (replace) hydraulic sump fluid and oil filter					•
Lubricate tilt cylinder rod ends and upright trunnions		•			
Check lift chain adjustment and wear		•			
Check/lubricate lift chains		•			
Readjust engine valve clearance		•		†	

3.2. Planned Maintenance Procedures

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Visual Inspection F-41
Functional Tests F-45
Operational Tests - Test Drive F-49
Lubrication, Fluids, and Filters F-49
Air Cleaning F-55
Critical Fastener Torque Checks F-56

PM Program

A planned maintenance program of regular, routine inspections and lubrication is important for long life and trouble-free operation of your lift truck. Make and keep records of your inspections. Use these records to help establish the correct PM intervals for your application and to indicate maintenance required to prevent major problems from occurring during operation.

PM Report Form

As an aid in performing and documenting your PM inspections, Clark has prepared a "GAS LPG or DIESEL PLANNED MAINTENANCE REPORT" form. Copies of this form may be obtained from your Clark dealer. We recommend that you use this form as a checklist and to make a record of your inspection and truck condition.

A checkmark or entry is made on the PM Report Form when the PM is performed. Please note the special coding system for indication the importance of needed repairs and/or adjustments.

Do not make repairs or adjustment unless authorized to do so.

Safety Precautions

- **Remove jewelry** (watch, rings, bracelets, etc.) before working on truck.
- **Disconnect the battery** ground (-) cable from the engine before working on electrical components.
- **Wear safety glasses**. Wear a safety (hard) hat in industrial plants and in special work areas where protection is necessary or required.

Visual Inspection

The objective of the visual inspection is to be sure that all components of the truck are:

1) in place
2) attached securely
3) in a safe and proper operating condition

WARNING

Do not use your hand to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnection hydraulic or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. If *any* fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

CAUTION

Do not operate a lift truck with damaged or missing decals and nameplates. Replace them immediately. They contain important information.

1. First, perform a visual inspection of the truck and its components. Walk around the truck and take note of any obvious damage and maintenance problems. Check for loose fasteners and fittings and loose sheet metal.

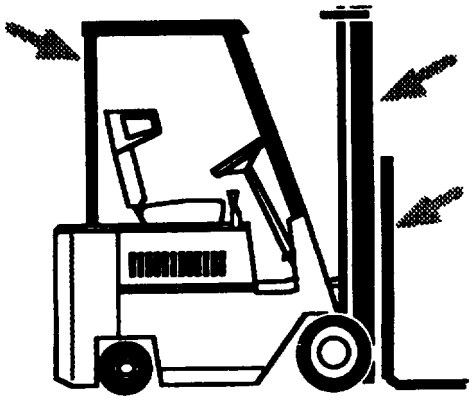
2. Be sure to make a thorough inspection of the critical components that handle or carry the load.

3. Check to be sure all capacity, safety, and warning plates or decals are attached and legible.

4. Inspect the truck, before and after starting engine, for any signs of external leakage: fuel, engine coolant, transmission fluid, etc.

5. Check for hydraulic oil leaks and loose fittings. *Do not use bare hands to check*. Oil may be hot or under pressure.

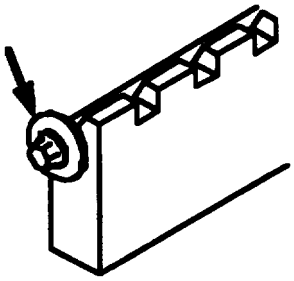
Overhead Guard, Load Backrest, Fork Retainers



1. Be sure overhead guard, load backrest extension, finger guards, and any other safety devices are in place, undamaged, and attached securely.

2. Check overhead guard for damage. Be sure it is properly positioned and all mounting fasteners are in place and tight.

3. Check load backrest for damage. Inspect the welds on the carriage and load backrest for cracks. Be sure that the mounting fasteners are all in place and tight.



4. If load backrest has been removed, a bolt and washer must be in place on each end of the top fork bar to act as a fork stop.

Upright and Lift Chains

NOTE

Uprights and lift chains require special attention and maintenance to maintain them in safe operating condition.

1. Inspect the upright assembly: rails, carriage rollers, lift chains, lift and tilt cylinders.

   - Look for obvious wear and maintenance problems, and damaged or missing parts.

   - Look for any loose parts or fittings. Check for leaks, any damaged or loose rollers, and rail wear. Check for metal flaking in the roller pathways.

   - Carefully check the lift chains for wear, rust and corrosion, cracked or broken links, stretching, etc.

   - Check that the lift chain anchor fasteners and locking means are in place and tight.

   - Check and adjust fork height to prevent fork wear.

2. Be sure all safety guards and chain retainers are in place and not damaged. Inspect the carriage stops and cylinder retainer bolts. Check all welded connections.

3. Inspect all lift line hydraulic connections for leaks.

4. Check the lift cylinder rods for wear marks, grooves, and scratches.

5. Check the cylinder seals for leaks.

Forks

NOTE

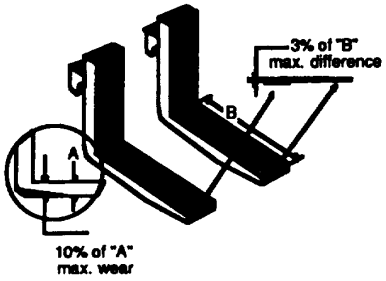
- If the fork blade at the heel is worn down by more than 10%, the load capacity is reduced and the fork must be replaced.
- If the fork blades are obviously bent or damaged, have them inspected by a trained maintenance person.

1. Inspect the load forks for cracks, breaks, bending, and wear. Move the forks together side-by-side. The fork top surfaces should be level and even with each other. The height difference between both fork tops should be no more than 3% of the fork length. Replace bent forks.
2. At each PM interval, an inspection of the forks must be made to check for wear. Check the amount of wear at the heel of the fork. See Table 1 below.
3. Inspect the forks for twists and bends.

To Check - Put a 2' thick metal block, at least 4" wide by 24” long, on the blade of the fork with the 4" surface against the blade.

Put a 24” carpenter square on the top of the block and against the shank.

Check the fork 20” above the blade to be sure it is not bent more than 1-inch maximum.



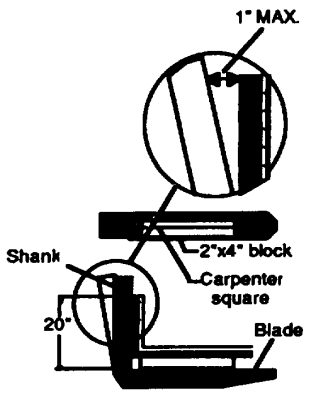


Table 1. Fork Wear Chart

NOTE

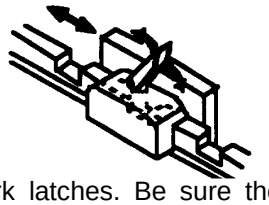
The % capacity reductions are based upon wear only. Other factors such as cracks, cuts, holes, etc., may further reduce the capacity of the fork

Allowable wear of fork thickness at heel of fork:

10% Wear: Forks must be scheduled for replacement. With 10% wear, the forks are adequate for only approximately 80% of rated capacity. Forks may be used only until replacements are available.

20% Wear: Forks are unsafe and must be removed from service immediately.

NEW Standard Fork Thickness, Inches	**REPLACE** Nominal 10% Wear Thickness, Inches	**SAFETY HAZARD** Nominal 20% Wear Thickness, Inches
1.25	1.12	1.00
1.50	1.38	1.19
1.75	1.56	1.38
2.00	1.81	1.62
2.25	2.00	1.81
2.50	2.25	2.00



4. Inspect the fork latches. Be sure they are not damaged or broken and that they operate freely and lock correctly. Check the fork stop pins (or optional bolt and washer) for secure condition.

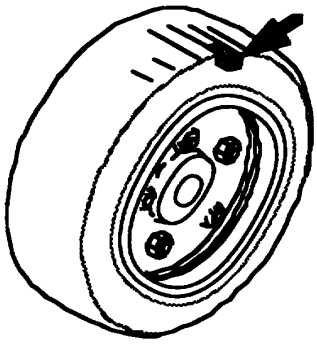
Wheels & Tires

WARNING

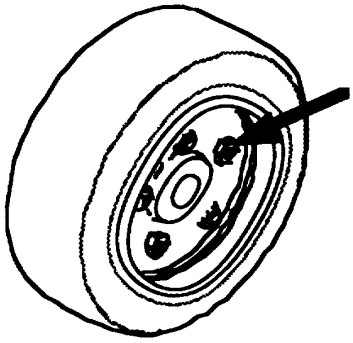
Personnel working on wheels and tires must be qualified and trained to do wheel and tire maintenance or injury may result.

CAUTION

Have missing bolts replaced and loose bolts correctly tightened to the specified torque before operating the truck.



1. Check the condition of the drive and steer wheels and tires. Remove objects embedded in the tread. Inspect tires for excessive wear and breaks or “chunking out," and bond failure between the tire and rim.



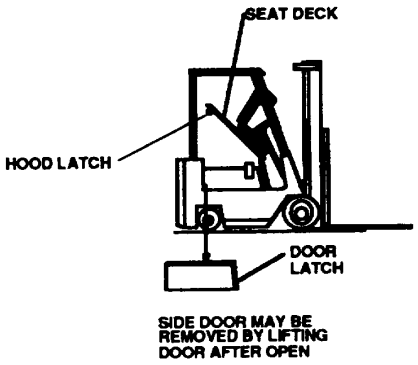
2. Check all wheel lug nuts or bolts to be sure none are loose or missing.

Refer to Section 11.1, Tire and Wheel Maintenance, for additional information.

Engine & Accessories
Engine Compartment Access

WARNING

To avoid the possibility of personal injury, never work in engine compartment with engine running except when absolutely necessary to check or adjust timing, carburetor, or governor. Take extreme care to keep hands, tools, loose clothing, etc., away from fan and drive belts. Also remove watches, bracelets, and rings.



1. Unlatch and open each side door for access to the engine compartment.

2. From left side, unlatch and lift the seat deck. The seat deck latches are underneath at the rear. Rotate the latch to unlock.

3. Inspect the engine assembly and accessories. Check for any leakage of oil or coolant. Inspect the engine mounts for damage and loose bolts.
4. Inspect the fan blades for looseness and damage. Inspect fan belt(s) for wear and damage. Check radiator hoses, hose clamps, and fittings.
5. Inspect exhaust system pipes and connections. Be sure that the tail pipe is directed to blow exhaust gases towards rear of truck and away from radiator.
6. Inspect the fuel system.
7. Check the hydraulic system components, hoses, piping, and connections. Check for wear, leakage, and damage. Check rear tilt cylinder anchor pins.
8. Inspect all control pedals, levers, and linkages, including seat and seat mounting.

Air Cleaner

NOTE

Air cleaner should not be serviced unless the air restriction indicator shows service is required. Do not “over-service”.

1. Check air cleaner mounting and connections. Be sure the air cleaner hose is securely connected (not loose or leaking).

2. Inspect the engine air filter element for damage and contamination (excessive dirt build-up and clogging). When replacing the air filter element, always inspect the air intake passages for evidence of dirt. Clean (wipe out) the housing. Change the engine air filter every 50 to 250 hours, depending upon the application and operating conditions, except as noted below.

Battery

WARNING

- Do not smoke or have open flames or sparks in battery charging areas or near batteries. An explosion can result and cause injury or death.
- This battery contains corrosive acid which can cause injury. If acid contacts your eyes or skin, flush immediately with water for 15 minutes and get medical assistance.

1. Inspect the battery and mounting. Check battery cables for wear. Be sure the cable terminals are tight and clean.
2. Inspect the battery for any damage, cracks, leaking condition, etc. If the terminals are corroded, clean and protect them. If your battery has removable vent caps, check to be sure the cells are all filled. Refill with distilled water to bottom of vent cap opening.

3. Be sure vent caps (as applicable) are properly sealed in battery top to avoid spillage.

Functional Tests

Check that all controls and systems are functioning correctly.

Safety Equipment

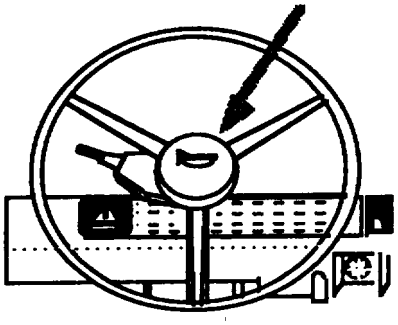
CAUTION

Damage to the truck can result if any of the warning indicators illuminate when the engine is running. Stop the engine. Do not operate the truck. Report any failures.

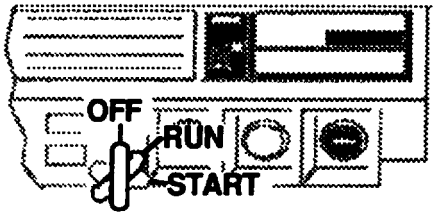
NOTE

To avoid starting engine when checking warning lights, move directional control lever from 'N" (neutral) briefly only, while turning key switch to START position.

1. Test horn, lights, and all other safety equipment and accessories. Be sure they are properly mounted and working correctly.



2. Press horn button to check horn function. If the horn or any other part does not operate, report the failure and have it repaired before truck is put back into operation.



3. Test the neutral start switch.

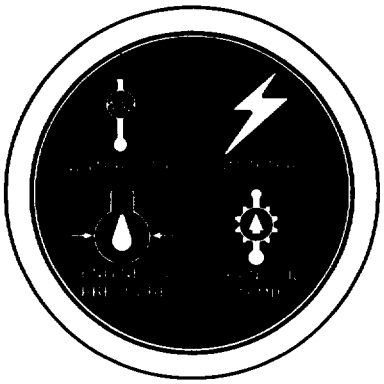
    a) Apply parking brake.
    b) Put direction control in neutral (N).
    c) Turn key switch momentarily to START position. Check if engine starter operates. Turn key switch OFF.
    d) Move direction control lever to FORWARD position. Repeat Step 3.
    e) Move control to REVERSE position. Repeat Step 3.

The engine starter should operate only with direction control in NEUTRAL (N) position. If the starter operates in FORWARD or REVERSE position, a) the neutral start switch has a fault, or b) transmission shift linkage may require adjustment.

4. Test the anti-restart feature of the key switch.

    a) Start engine.
    b) Attempt to restart engine.
    c) Switch should not allow restart.

5. Check fuel level and that fuel gauge is operating.



6. Test the warning indicator lights.

To Check:

- From OFF position, turn key switch to RUN position to check AMMETER and ENG OIL PRESS indicator lights.
- Turn key switch to START position to check WATER TEMP and TRANS OIL TEMP indicator lights.

Hourmeter

1. Start the engine.

2. Check hourmeter for operation, with engine running. The hourmeter is controlled by engine oil pressure. It operates only when the engine is running. Report any malfunction or damage. **Write the hourmeter reading on PM report form.**

Refer to Operator's Manual for additional information on how your truck operates.

Engine

1. Test engine starting and operating condition.

If there are engine starting and operating problems, please refer to Part 4, Engine.

2. Test the engine exhaust system and muffler for excessive noise level and leakage. Accelerate the engine several times. Check the exhaust coming from the tail pipe. The exhaust should be invisible or clear (colorless). A stream of black smoke generally indicates a mixture that is too rich (excessive fuel consumption). A stream of blue smoke generally indicates excessive oil consumption.

3. Test the engine idle speed and no-load governed speed adjustment. Check for obvious engine overspeeding due to faulty engine governor operation.

4. Listen for misfiring, excessive valve tappet noise, and any unusual engine noise--engine *knocking," etc. Also, listen for any unusual noise from the transmission, charging pump, or main hydraulic pump.

5. If necessary, perform a stall test to determine engine performance.

Refer to Section 4. 7, RPM, Vacuum & Stall Tests.

Brake & Hydraulic Controls

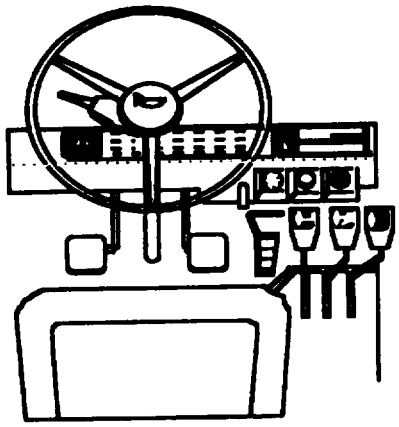
WARNING

Do not operate a lift truck if the service or parking brakes are not operating properly.

NOTE

A low pedal reserve (clearance at floor plate) is normal.

1. Inspect the brake linkage for excessive wear or freeplay. Look for any irregular wear in the brake linkage rod connections to the brake pedal.
2. Operate service and parking brakes, all hydraulic controls: lift, tilt, and auxiliary (if installed), accelerator, directional controls, and steering system. Be sure all controls operate freely and return to neutral properly.



3. Check shift (directional) controls for correct operation and NEUTRAL position.
4. Check the service brake system. Push the brake pedal fully down and hold. The brakes should be applied before pedal reaches the floor plate.
   a) Check for feeling of solid resistance when the pedal stops. The pedal must feel firm and not move down farther after it stops.
   b) If the pedal continues to creep downwards, report the failure. Do not operate the truck until the brakes are repaired.
5. Check the function of the parking brake. Release, then apply the parking brake with the lever. When correctly adjusted, the lever should snap-lock easily into the over-center applied position.
6. Check parking brake holding capability and adjustment. Park truck on a grade and apply parking brake. The parking brake should hold a lift truck with rated load on a 15% grade. When the lever is released, the brake shoes should not drag.

Steering System

WARNING

Never continue to operate a truck that has a steering system fault. Injury to personnel may result

NOTE

The steering system, steer axle, and steering linkage should be inspected periodically for abnormal looseness and damage, leaking seals, etc. Check for any changes in steering action. Hard steering, excessive free-play (looseness), or unusual sounds when turning or maneuvering indicates a need for inspection and servicing.

1. With engine idling, check steering system by moving steering handwheel in a full right turn, then in a full left turn. Return handwheel (steer wheels) to the straight-ahead position.
2. The steering components should operate smoothly when the steering wheel is turned. Listen for the steering pressure relief valve to bypass when the steer wheels hit the stops. The engine should not "lug down or stall. If it does, the engine idle speed is too slow, or power steering system relief pressure valve may be malfunctioning.
3. Turning effort should be the same in either direction. The truck should drive in a straight line without drifting to either side.

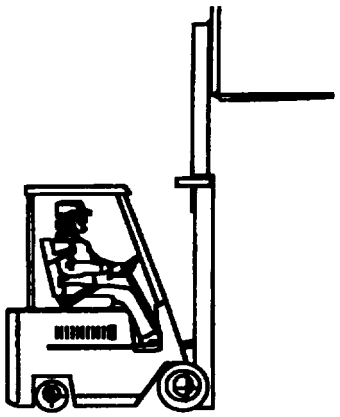
Lift Mechanism & Controls

WARNING

Be sure there is adequate overhead clearance before raising the upright or damage to equipment, or injury could result.

NOTE

It is recommended that these tests be conducted with a rated capacity load, if possible.



1. Cycle (raise to full height and then lower) the upright at both slow and fast speed, with the rails tilted slightly backwards. Watch the upright assembly as it rises.
   a) All movements of the upright, fork carriage, and lift chains must be even and smooth, without binding or jerking motion.
   b) Watch for chain wobble or looseness; the chains should have equal tension and move smoothly without noticeable wobble.
2. Check for correct function of the lift control lever and main hydraulic valve. Listen for abnormal noise in the hydraulic valve, main hydraulic pump, and system components.
3. If the maximum fork height is not reached, this indicates there is an inadequate (low) oil level in the hydraulic sump tank, severe binding within the upright, or chains are too long.
4. Observe the upright assembly: rails, rollers, carriage, lift chains, and cylinders as they move.
   a) The fork carriage should move smoothly when raised or lowered from any height position.
   b) Check for binding or excessive free-play (looseness) between the carriage and the upright rails and rollers.
   c) Check for proper sequencing.
   d) Listen for abnormal noises.
   e) If there is excessive clearance between the rails and channels, the need for upright roller adjustment is indicated.
   f) If the rails or carriage bind or hesitate when lowering, this indicates either damaged rollers or incorrect roller adjustment.
5. Check the upright for excessive downdrift. Stop the fork carriage in an intermediate position. Observe whether it holds its position or slowly drifts downward. If the fork carriage does not hold its position when stopped, the upright may have too much downdrift due to wear of the cylinder seals. Conduct an upright cylinder downdrift test, with rated load, as needed.

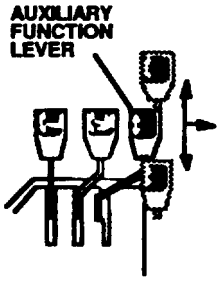
Refer to Section 2.1, Service Specifications.

6. Test the tilt control. Check for excessive tilt cylinder drift.

Refer to Section 2. 1, Service Specifications and Section 10. 7, Tilt Cylinder Maintenance.

7. Test the correct tilt cylinder rod adjustment (upright racking). Check tilt cylinder rod-to-rod end engagement: must have minimum engagement equal to rod diameter.
8. Check for correct fork height adjustment.

Auxiliary Function Control



If lift truck is equipped with an optional attachment, an additional control lever will be mounted to the right of the tilt control lever. The lever must be pushed to the right before moving it forward and back to operate the attachment, or auxiliary function. Check the control for correct function by briefly operating the attachment.

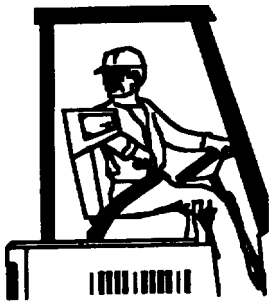
Push Forward To:	*Pull Back To:*
• Lower	• Raise
• Tilt Forward	• Tilt Backward
• Rotate to Left	• Rotate to Right
• Side Shift to Left	• Side Shift to Right
• Open Clamp	• Close Clamp
• Extend Push-Pull	• Retract Push-Pull

Operational Tests-Test Drive

NOTE

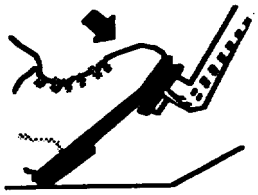
It is recommended that these tests be conducted with a rated capacity load, if possible.

BUCKLE-UP *- Always wear the seat belt when operating a lift truck.*



1. Check all around to be sure that your intended path of travel is clear of obstructions and pedestrians.

2. Test the truck for general correct operation and drive train function by driving truck in both the forward and reverse directions first in a straight line and then, slowly, through a series of full right and left turns.



3. Test service brake operation. Apply and release the brakes several times before driving the truck. Note any change in pedal height each time pedal is depressed. Changes in pedal height could indicate air in the system or a fluid leak. Check the brakes while driving to ensure proper operation.
4. Test transmission operation. Drive at various speeds and operating conditions in both FORWARD and REVERSE. Listen for any unusual drive train or other running noises, such as wheel bearing noise, vibration, etc.
5. When you have competed the operational tests, park and leave truck according to standard shutdown procedures.
6. Make a record of all maintenance and operating problems you find.

Lubrication, Fluids, & Filters

Check fluid levels and other components within the engine compartment

Engine Cooling System

WARNING

Do not remove the radiator cap when the radiator is hot. Steam from the radiator can cause severe burns. Never remove the radiator cap while the engine is running. Stop the engine and wait until it has cooled. Even then, use extreme care when removing the cap from the radiator. It is good safety practice to use a shop cloth to cover the radiator cap while it is being removed. Wrap the cloth around the cap and turn it slowly to the first stop. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, press down on the cap with the cloth in place, turn it and remove it. Stand clear of the radiator opening; hot coolant may splash out. Failure to follow these instructions could result in serious personal injury from hot coolant or steam blowout and/or damage to the cooling system or engine.

NOTE

Remove cap only when the engine is cold.

When servicing the engine coolant or checking coolant level by removing the radiator cap:

a) Turn the cap slowly to release any pressure that may be in the radiator.

b) Push the cap fully down and turn to release and remove the cap.

Coolant Level
Checking Coolant

WARNING

Do not remove the radiator cap when the radiator is hot. Steam of hot coolant from the radiator can cause severe burns. Never remove the radiator cap while the engine is running. Stop the engine and wait until it has cooled. Remove the radiator cap only with engine stopped and when engine is cold.

NOTE

For maximum cooling efficiency, always keep the cooling system filled with the recommended coolant mixture, year around at all ambient temperatures.

The cooling system is initially filled with a factory-installed solution of 50% water and 50% permanent-type antifreeze containing rust and corrosion inhibitors. You should leave it in year around. Plain water may be used only in an emergency, but replace it with the specified coolant as soon as possible to avoid damage to the system or engine. With only water in the system, do not let the engine run hot. DO NOT USE ALCOHOL OR METHANOL ANTIFREEZE.

Use of high-quality antifreeze having a low-silicate additive content is strongly recommended. Low-silicate antifreeze is available for heavy-duty use.

Refer to Section 2.1, Service Specifications, Cooling System.

NOTE

Fork lift truck applications require also checking the coolant level directly in the radiator. Lift truck radiators will plugup and overheat, which will force coolant into overflow reservoir and on out at the cap. This results in a low coolant level which exposes the transmission oil cooler causing engine/transaxle overheating.

1. The coolant level should be at the "Cold level" line on coolant recovery bottle when engine is cold.
2. Coolant level in the radiator should also be checked at least once a day (or every 8 hours of operation) to make sure radiator is 100% full at all times.
3. The correct FULL level is 0.5-0.75 in (13-20 mm) below bottom edge of filler neck opening.

General Procedures

NOTE

If coolant has to be added more than once a month or if you have to add more than one quart at a time, check the cooling system for leaks, or for other reasons, e.g., cooling system overheating. See below.

NOTE

If the condition of the used coolant indicates severe contamination, rust deposits, scale or oil in the system, it may be necessary to clean and flush cooling system with a commercial cleaner.

1. If level is low, add a 50/50 mixture of specified coolant and water to the correct fill level.
2. Inspect the coolant condition. Look for excessive contamination, rust, oiliness, and gummy deposits (see discussion under Engine Coolant Change below) in the coolant solution. The coolant should have a clean appearance.
3. Check the PM time interval for need to change (drain and replace) coolant.
4. Check condition of radiator cap upper and lower seals (with overflow reservoir, cap has two seals) and radiator filler neck for damage. Be sure they are clean. Replace cap, as necessary. Check overflow hose for clogging and damage.
5. If the cooling system requires the addition of a large quantity of coolant, and the engine has been overheating:
    a) Inspect radiator for blockage of air flow through the fins. Air clean the radiator.
    b) Check fan belt and cooling fan drive control (as applicable).
    c) Check and be sure fan is not installed backwards (a common problem).
    d) Check engine oil to see if it contains coolant.
    e) Pressure test the radiator cap. Replace if faulty.
    f) Pressure test the radiator and cooling system. Repair any leaks or blockage.
    g) Test the engine thermostat. Replace as needed.

It is recommended to drain and replace the engine coolant every 2000 hours, or once a year.
Refer to Section 4.8, Cooling System.

Engine Oil Level Check

NOTE

It is normal to add some oil between oil changes. Keep the oil level above the ADD mark on the dipstick by adding oil as required. DO NOT OVERFILL. Use the correct oil as specified in Section 2.1, Service Specifications.

1. Check the engine oil level every 8 hours according to engine oil dipstick and procedures specified for your engine model as further noted below.
2. Pull the dipstick out, wipe it clean with a clean wiper, and reinsert it fully into the dipstick tube. Remove the dipstick and check the oil level.
3. Check the PM time interval (operating hours), or the condition of the oil to determine if it needs to be changed.

TMD27 (2.7 L) Engine Oil Level

CAUTION

Do not add oil until oil level approaches the low mark. Then add only enough to bring it to high level NEVER above. Do not operate the engine with oil level below the low level mark or damage to equipment may result.

Check the oil level with engine stopped. Allow 5 minutes for the oil level to stabilize. Oil level should be at the upper level marking (MAX) on dipstick. Add recommended oil, as needed. Wait for 5 minutes after adding oil and check the oil level again. DO NOT OVERFILL.

Engine Oil & Filter Change

It is recommended to:

- *Drain and replace the engine crankcase oil every 50 to 250 operating hours. See NOTE below.*
- *Replace the engine oil filter at every oil change.*
- *Drain and replace engine oil in a new or rebuilt engine after the first 50 hours of operation.*
- *Drain old oil after truck has been in operation and engine (oil) is hot (at operating temperature).*

NOTE

Do not exceed 250 hours. The time interval for changing engine oil will depend upon your application and operating conditions. To determine the correct schedule for your truck, it is suggested that you periodically submit engine oil samples to a commercial laboratory for analysis of the condition of the oil.

Refer to Section 4.1, Engine Oil and Filter Change, for additional information.

1. Remove drain plug at bottom of oil pan and drain the oil completely.
2. Remove the old oil filter.
3. Install new oil filter. Follow installation instructions printed on the filter. Check that O-ring seal is oiled and correctly in place.
4. Install drain plug and refill crankcase with fresh engine oil through the rocker cover oil filler opening.
5. Wait 5 minutes after adding oil and then check the oil level.
6. Start the engine and allow it to run at idle for several minutes. Check the oil filter and drain plug for leakage. Recheck oil level as noted above.

Refer to Section 2. 1, Service Specifications, for engine oil specifications for your engine model.

OIL PERFORMANCE DESIGNATION To help achieve proper engine performance and durability, use only engine lubricating oils of the proper quality. These oils also help promote engine efficiency which results in improved fuel economy. A symbol has been developed by the API (American Petroleum Institute) to help you select the proper engine oil. It should be included on the oil container you purchase. For diesel engines, it is recommended that you use API Service Classification CD, Service Class D motor oils.

Recommendations For Engine Oil Viscosity	
Ambient Temperature (Average)	Viscosity
80°F or above (300C or above)	SAE 40
32° to 110°F (0° to 430C)	SAE 30
70° to 0°F (21° to -170 C)	SAE 20W
0° to -30°F (-17" to -34"C)	SAE 10W

Engine Fuel System

Diesel

1. Clean and inspect the fuel filler cap and seal for damage, correct sealing, and function. Be sure the air vent in cap is open.
2. Inspect the fuel system components and lines for condition and leakage.
3. Remove and inspect the engine fuel filter, if a problem with fuel flow has been reported. Test fuel filter for fuel flow restriction and clean or replace the filter per PM schedule.

Brake Fluid Reservoir

NOTE

Use SAE/Type DOT 3 or Equal Hydraulic Brake Fluid only. Refer to *Specifications*.

Check the brake fluid level in the reservoir mounted in cowl. The FULL level is at the top ring on reservoir. Clean the cap and top of reservoir before removing cap. Add recommended fluid, as needed.

Refer to Part 8, Brakes, for additional information.

Hydraulic Sump Fluid Level Check

Correct fluid level is important for proper hydraulic system operation:

- *Low fluid level can cause pump damage.*
- *Overfill can cause loss of fluid or lift system malfunction.*
- *Because of the expansion of fluid as its temperature rises, it is preferable to check the fluid level at operating temperature (after approximately 30 minutes of truck operation).*

1. Check the hydraulic sump tank fluid level daily.
2. To check fluid level, park truck on a level surface and apply the parking brake. Put upright in a vertical position and lower fork carriage fully down.
3. Pull the dipstick out, wipe it with a clean wiper, and reinsert it fully into the dipstick tube. Remove the dipstick and check the oil level.
4. Keep the oil level above the LOW mark on the dipstick by adding recommended hydraulic fluid only as required. DO NOT OVERFILL.
5. Check the PM time interval (operating hours) or the condition of the hydraulic fluid (age, color, clarity, contamination, etc.) to determine if it needs to be changed. Change (replace) the oil, as necessary.

Refer to Section 2.1, Service Specifications, for hydraulic oil specifications.

Hydraulic Fluid & Filter Change

It is recommended to:

- *Drain and replace the hydraulic sump fluid every 2000 operating hours, or sooner, as required.*
- *Replace the hydraulic oil filter at every oil change, or every 500 hours, whichever occurs sooner.*
- *Replace the sump tank breather/fill cap every 500 operating hours, or as required.*

There is no drain plug in the hydraulic sump tank. The hydraulic fluid can be changed by one of the following methods:

1. Removal of the hydraulic sump tank cover assembly and pumping the fluid out by suction using a separate pump and hose.
2. By connecting a quick-disconnect coupling to the test port and pumping the fluid out using the truck hydraulic system. This method may be used most easily and satisfactorily for routine changes of the fluid.

Refer to Section 10. 1, Main hydraulic System Maintenance, for additional information.

Hydraulic Oil Filter

Remove and replace the hydraulic system fluid filter per recommended PM schedule, or as may be required by truck operating conditions and usage.

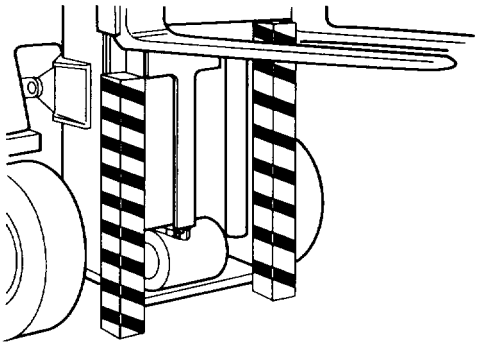
Refer to Section 10. 1, Main Hydraulic System Maintenance, for additional information.

Sump Tank Breather Maintenance

1. Remove the sump tank breather/fill cap and inspect for excessive (obvious) contamination and damage.
2. Replace the breather/fill cap, per recommended PM schedule, or as required by operating conditions.

Refer to Section 10.1, Main Hydraulic System Maintenance, for additional information.

Access To the Transaxle



Transaxle Fluid

WARNING

An upright or carriage can move unexpectedly. Chain or block the carriage and each rail. FAILURE TO FOLLOW THIS WARNING CAN RESULT IN SERIOUS INJURY

NOTE

If you are unfamiliar with this procedure, please refer to Section 3.3, Machine Jacking and Blocking, for information on blocking the upright in raised position.

The best method to use for reaching the transaxle checkpoints (oil level/filler plug and drain plugs) is dependent upon the style of upright, carriage, and attachments on your truck. One method is to raise the upright carriage to provide easier access to the transaxle from the front. See illustration.

Apply the parking brake and block the wheels. Be sure to put blocking under the carriage and upright rails.

Transaxle Fluid Level Check

1. Check the transaxle fluid level with:
   - Truck on a level surface.
   - Engine idling w/transmission in NEUTRAL.
   - Oil at operating temperature.
2. Check the PM time interval (operating hours), or the condition of the oil to determine if the transaxle fluid needs to be changed.

Refer to Section 7.1, Transaxle maintenance: Fluid and Filter Change, for further information.

Transaxle Fluid Change

It is recommended to:

- *Drain and replace the transaxle fluid every 1000 operating hours.*
- *Drain the oil when it is warmed to operating temperature.*

Refer to Section 7.1, Transaxle maintenance: Fluid and Filter Change, for further information.

Transaxle Oil Filter Change

- *Replace the transaxle oil filter every 500 operating hours. See CAUTION below.*

CAUTION

When the transaxle is new or rebuilt, it is recommended to change the oil filter after the first 50 hours and again after 100 operating hours. This is to be sure that the oil is cleaned of all harmful particles which may be loosened or flushed off new parts as they wear in. Failure to change the oil filter may result in damage to transaxle.

Refer to section 7.1, Transaxle Maintenance: Fluid and Filter Change, for further information.

Truck Chassis Inspection and Lubrication

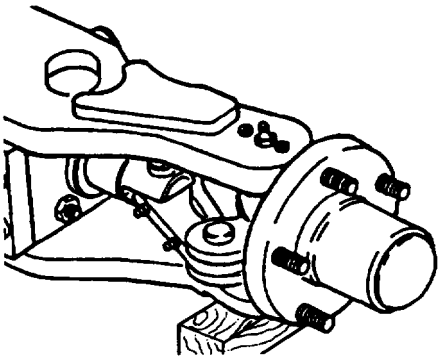
WARNING

Do not raise truck by lifting under the counterweight. Be sure to put blocking under the frame to keep the truck safe.

NOTE

Lubrication and inspection of truck chassis components, including steer wheels, steer axle linkage, steering cylinder, and wheel bearings will be easier if the truck is raised and blocked up under the frame.

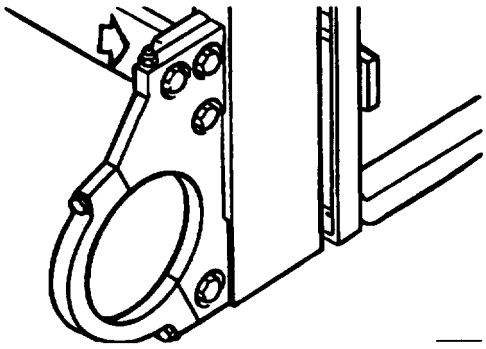
Refer to Section 3.3, Machine Jacking and Blocking, for additional information.



1. Inspect the steering cylinder piston rod, seals, and fasteners for damage, leaks, and looseness.
2. Lubricate the steer axle linkage: rod ends and linkage pivot points. Be sure to clean the grease fittings before lubricating and remove the excess grease from all points after lubricating.
3. Lubricate miscellaneous linkage, as needed.

Upright & Tit Cylinder Lubrication

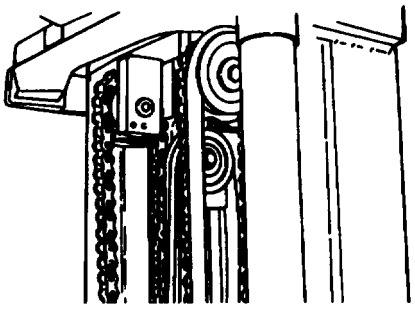
1. Clean the fittings and lubricate the tilt cylinder rodend bushings, front and rear.



2. Clean the fittings and lubricate the upright trunnion bushings.

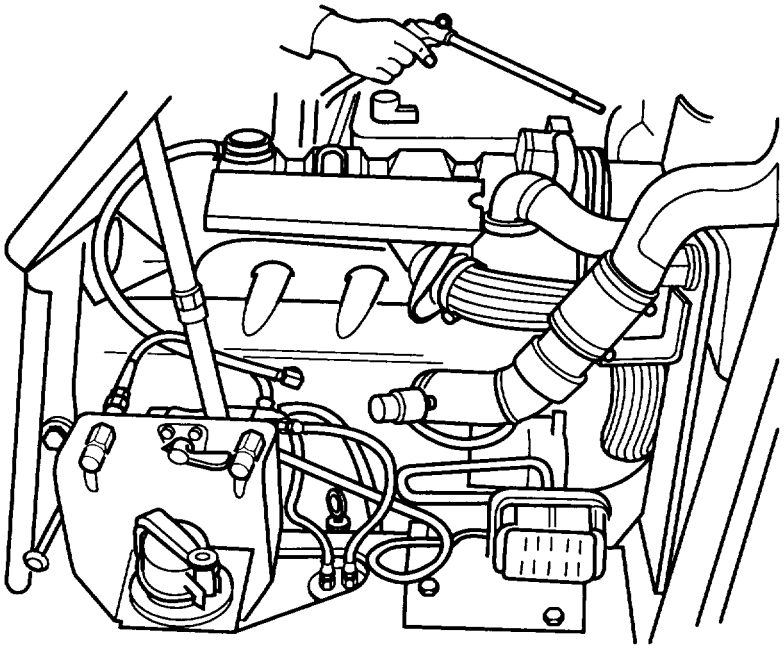
Lift Chains

NOTE
Do not lubricate the carriage roller rails.



1. Lubricate the entire length of the upright and carriage chains with Clark Chain and Cable Lube.
2. In dirty applications, use 'dry-type" chain lubricant, e.g., Dri-Slide.

Air Cleaning



Typical View Showing Secondary Air Cleaning Procedure (Blowing From Engine Side).

WARNING

Wear suitable eye protection and protective clothing or injury could result.

NOTE

Use care when air cleaning radiator. Air pressure may bend radiator fins.

Always maintain a lift truck in clean condition. Do not allow dirt, dust, lint, or other contaminants to accumulate on the truck. Keep the truck free from leaking oil and grease. Wipe up all oil spills. Keep the controls and floorboards clean, dry, and safe. A clean truck makes it easier to see leakage and loose, missing, or damaged parts. A clean truck will run cooler.

The environment in which a lift truck operates will determine how often and to what extent cleaning is necessary. The radiator, especially, may require daily air cleaning to ensure correct cooling. If air pressure does not remove heavy deposits of grease, oil, etc., it may be necessary to use steam or liquid spray cleaner.

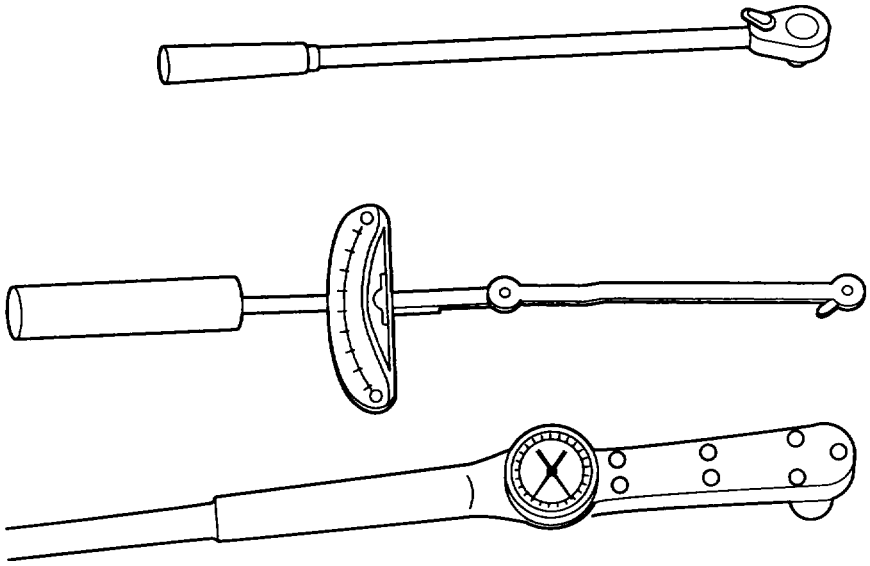
1. Lift trucks should be aircleaned at every PM interval, and otherwise as often as required.
2. Air cleaning should be done using an air hose with special adapter or extension having a control valve and nozzle to direct the air properly.
3. Use clean, dry, low-pressure compressed air; restrict air pressure to 100 psi (690 kPa), maximum.

Refer to Paragraph 5-4 for additional information on the use of air nozzles and air cleaning procedures.

4. Air clean the:
   a) Radiator, from both sides: first from counterweight side (to loosen and clean away dirt opposite of fan air flow), then blow away loosened dirt and clean radiator from engine side.
   b) Engine and accessories.
   c) Driveline, transaxle, and related components.
   d) Steer axle and steer cylinder.
   e) Upright assembly.
   f) Tilt cylinders.
   g) Hydraulic control valve.

Critical Fastener Torque Checks

Refer to Section 2.1, Service Specifications, for Critical Fastener Torque Chart.



View Showing Typical Torque Wrenches.

NOTE

When practical, always torque the nut while holding bolt stationary.

Fasteners in highly loaded (critical) components can quickly fall if they become loosened; also, loose fasteners can cause damage or failure of the components. For safety, it is important that the correct torque be maintained on all critical fasteners of components which directly support, handle, or control the load, and protect the operator.

Check torque of critical items, including:

- Overhead guard.
- Transaxle mounting.
- Drive and steer wheel mounting.
- Counterweight mounting.
- Load backrest extension.
- Tilt cylinder mounting and yokes.
- Upright mounting and components.
- Chain anchors.
- Engine mounts.

Critical Fastener Torque Checks (Cont'd)

NOTE

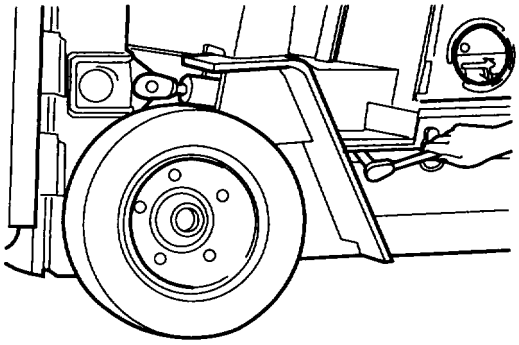
The following items illustrate procedures for critical torque checks for selected items.

Transaxle Mounting

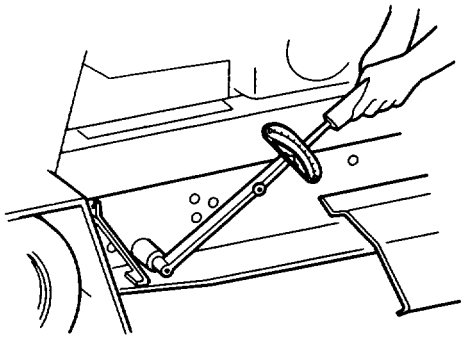
Mounting bolts, nuts, washers, and threaded holes are not to be lubricated. Impact wrenches to be used only to snug-up the fasteners. Torque measuring wrench must be used to obtain final torque values.

NOTE

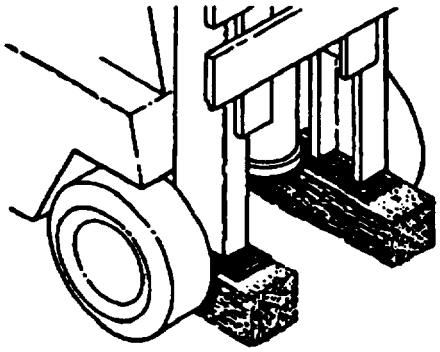
Also check drive wheel bearings when wheels are blocked up. See Section 3.2.



1. Remove the frame side compartment doors from each side of the truck.

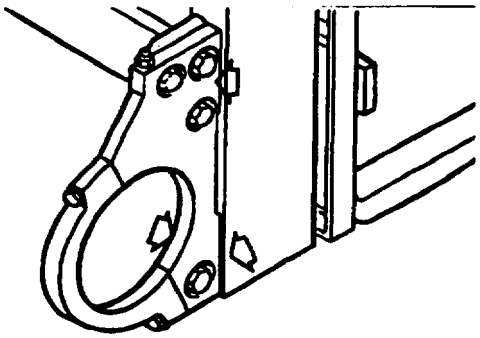


2. Check transaxle mounting bolts and nuts for correct torque. Tighten each bolt to torque spec: 400-440 lb-ft (542-597 N•m).



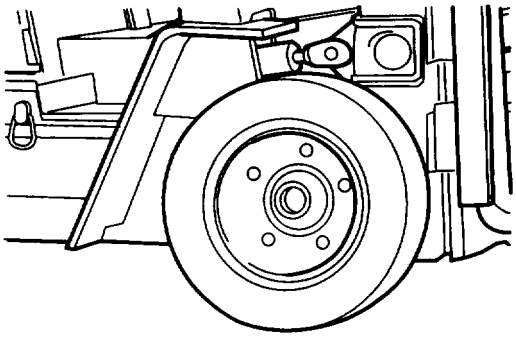
1. Raise drive wheels off the floor. With upright in full back tilt, place wood blocking beneath rails or upright.
2. Check the transaxle mounting bolts and nuts for correct torque.
3. After checking upright mounting as noted below, install drive wheels.

Upright Mounting



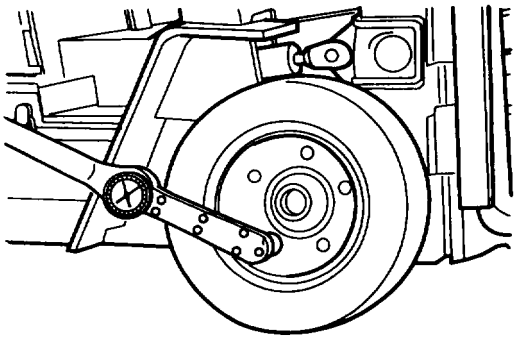
1. Check the upright trunnion bearings for wear. Check the trunnion brackets for cracks or damage.
2. Check the upright mounting bracket bolts. Be sure no bolts are missing. Tighten each bolt to correct torque spec: 273-302 lb-ft (370-410 N•m).
3. Check tilt cylinder mounting and attachment fasteners for safe installation. Tighten tilt cylinder yoke clamp bolts to torque spec: 120-140 lb-ft (163-190 Nom).
4. Check and tighten the load backrest extension mounting bolts to torque spec: 177-199 lb-ft (240-270 N•m).

Critical Fastener Torque Checks (Cont'd) Drive Wheel Bearings



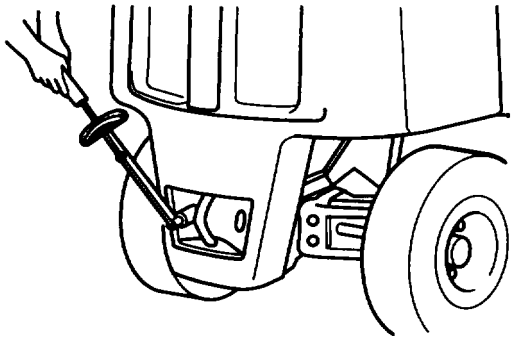
1. Raise drive wheels off the floor. Check for free rotation of the drive wheels. Check for looseness (excessive free-play) of the wheel bearings. Hold the drive wheel and try to move it by rocking from side to side and by pulling or pushing in and out along the spindle centerline.
2. Check for a maximum of 0.003 inch (0.08 mm) of end play. If bearings are loose, the truck should be scheduled for further service.
3. Lower drive wheels to floor and remove blocking.

Drive and Steer Wheel Mounting



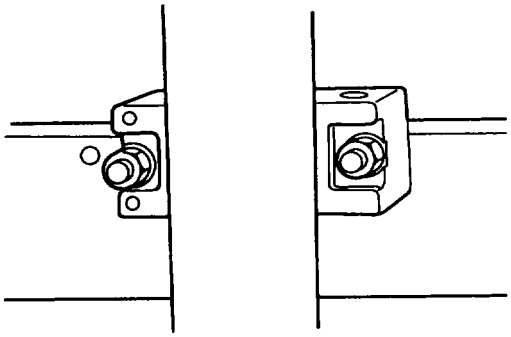
1. Inspect and tighten drive wheel lug nuts to torque spec: 470-530 Ib-ft (637-719 N•m).
2. Inspect and tighten steer wheel lug nuts to torque spec: 265-338 Ib-ft (360-458 N•m).

Counterweight Mounting



1. Check and tighten both inside and outside counterweight mounting bolts to torque spec: 240-265 Ib-ft (325-360 Nom).
2. Check and tighten all overhead guard mounting bolts to torque spec: 50-55 Ib-ft (68-75 N-m).
3. Inspect and tighten the driver's seat mounting bolts. Torque spec: 15-22 Ib-ft (20-30 N-m).

Upright Cylinder Mounting



Inspect and tighten all upright cylinder mounting and retaining bolts to correct specifications.

3.3. Machine Jacking and Blocking

Raising Drive Wheels Off Floor F-59
Blocking The Upright In Raised Position F-59
Raising Rear Of Truck F-60
Raising Entire Truck F-60
Raising Truck With A Hoist F-61
Lifting And Jacking Points F-62
Shipping Tiedown Instructions F-62

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements, and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

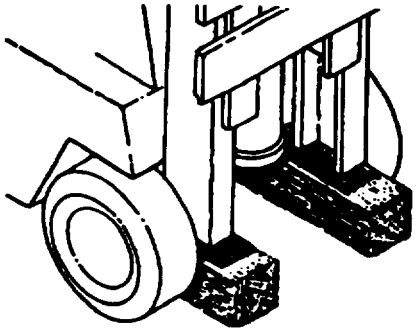
NOTE

To perform these service procedures, it is recommended that you first:

- Park truck on a hard, level, and solid surface, such as a concrete floor with no gaps or breaks.
- Put upright in vertical position and fully lower the forks or attachment.
- Put all controls in neutral. Turn key switch OFF.
- Apply the parking brake.

Raising Drive Wheels Off Floor

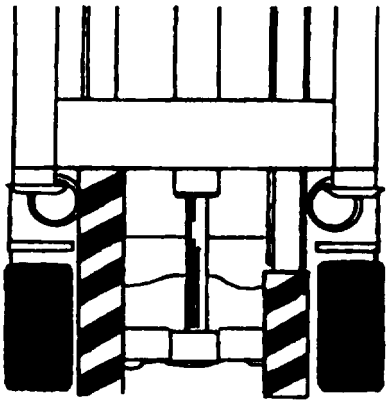
This procedure uses the upright as a lever to lift the drive wheels off the floor and prevent accidents due to inadvertent powering of the drive wheels.



1. Park truck safely.
2. Be sure upright trunnion bolts are tight.
3. Start the engine. Tilt the upright fully back. Adjust upright height as necessary to put blocking underneath.
4. Put a solid 4x4 inch hardwood block under the front section of each upright rail. Put a .125-.250 inch thickness steel plate on top of each block.
5. **Tilt upright fully forward**. This action should raise the drive wheels off the floor. Release the tilt control lever and turn engine OFF.
6. Check for safe clearance between drive wheels and floor and blocks.
7. **Check for stable condition of the truck**. Be sure that the blocks are located securely under the upright rails before operating the drive or working on truck.
8. Lower the drive wheels to the floor and remove the blocks by reversing the above procedure.

Blocking The Upright In Raised Position

This procedure is used to safely provide clearance for access from the front of truck to components on or near the drive axle.



1. Park truck safely.
2. Put blocks in front of and behind drive wheels.

3. Put wooden support blocks conveniently near upright rails before raising the upright. Use two 4x4 inch hardwood blocks or equal, of approximate lengths shown.
4. Start engine and raise the upright carriage.
5. Hold the taller block against inner rail and lower the upright until carriage rests on block.
6. Hold the shorter block against the outer rail and lower the upright until inner rail rests on the block.
7. Reverse the procedure to remove blocking.

Raising Rear of Truck

The truck may be raised at the rear by jacking and blocking under the center of the frame member at either the front or rear steer axle mounting, or under the center section of the steer axle.

Refer to Section 2.1, Specifications, for truck weights.

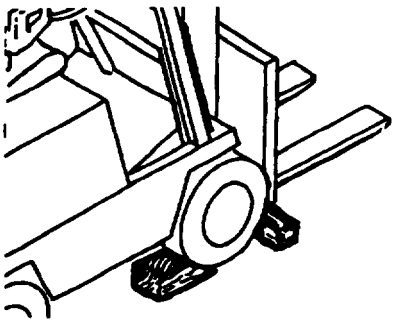
WARNING

- Never lift or block a truck using the counterweight. Failure to follow procedures outlined in this manual can result in injury or death.
- Before performing any maintenance work, check the truck for stable condition on the blocking to prevent injury to personnel and damage to equipment.

NOTE

If there is insufficient clearance under frame for your jack, the truck may first be driven onto shims, such as 1'x6"x12" pieces of board, to increase the truck frame underclearance.

Put an equal amount of blocks under each side of the truck to provide a level working position. Individual pieces of blocking with minimum length equal to the width of the truck are recommended.



1. Park truck safely. Put blocks at front and rear of drive wheels.
2. Put a floor jack under the rear of truck frame. NEVER PUT THE JACK UNDER THE COUNTERWEIGHT.
3. Raise the truck only as high as necessary to perform the maintenance work.
4. Put blocks at both sides of the truck, fully under the frame main side structure. Put the blocks in front of but close to. the counterweight and steer wheels for best truck stability.
5. Lower the truck onto the blocks and remove the jack.
6. When maintenance work is completed, lower the rear of truck to the floor by reversing the above procedure.

Raising Entire Truck

Refer to Section 2.1, Specifications, for truck weights.

WARNING

When removing the transaxle with the truck blocked up by the frame, truck can tip backwards due to its heavy counterweight. Both upright and counterweight must be removed before attempting to raise the truck for transaxle removal.

WARNING

When jacking side of truck, be sure upright is lowered fully and do not raise one side of the truck more than about 2 inches higher than the other, to avoid tipping truck over laterally.

If the upright and transaxle are removed, the truck will tip backwards off any blocking under the frame. The back of the truck must be supported by blocking under the steer axle to prevent movement.

The reverse is also true. If the counterweight is removed while the truck is up on blocks, the weight of the upright and transaxle will cause the truck to tip on the front blocks and fall forward.

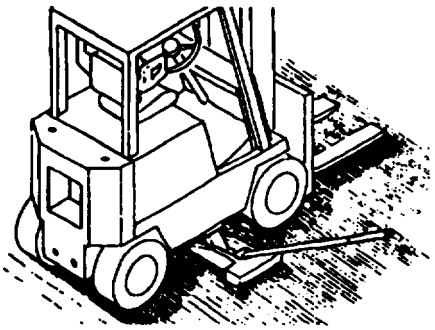
- Removing counterweight from blocked-up truck: Truck will tip forward.
- Removing upright/transaxle from blocked-up truck: Truck will tip backwards.

Be sure to put the jack(s) squarely and fully under the main side structure of the frame. **DO NOT PUT THE JACK(S) UNDER THE OUTER COVERS WHICH ENCLOSE THE FUEL AND HYDRAULIC SUMP TANKS.**

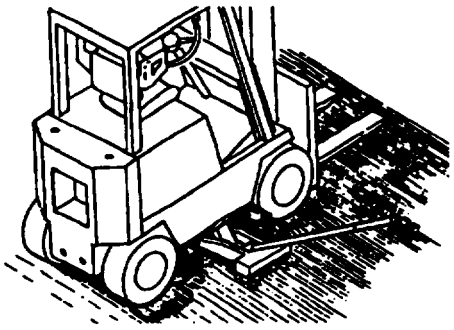
Before performing any maintenance work, check the truck for stable condition on the blocking.

NOTE

Depending on jack height, shims under the tires may be needed for clearance to allow removal of jack.



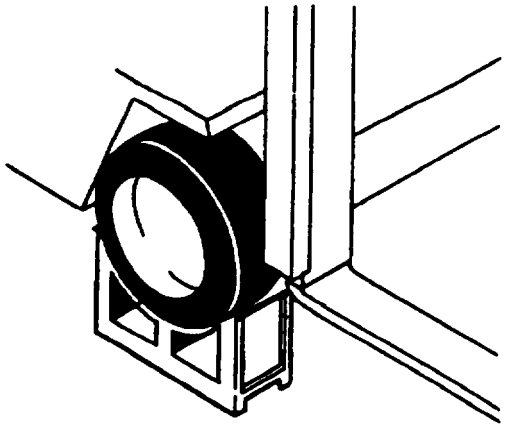
1 Park truck safely. **Lower upright fully**.
2. If necessary, drive truck onto shim plates to increase underclearance. Two jacks may be used, one on each side of the truck.
3. Put the jack(s) under side frame near the center of the truck.



4. Carefully raise the truck one side at a time, only as high as necessary to do the maintenance work and not more than a maximum of 6 inches, total.
5. Put blocks under the side frame, at each side of the jack. Put (spread) the blocks close to the steer and drive wheels for maximum stability.
6. If using one jack, lower the truck onto the blocks and move the jack to the opposite side. Repeat the lifting procedure.
7. Put the same size blocks under each side of the truck so it will be level.
8. When maintenance work is completed, lower the entire truck to the floor by reversing the lifting procedure. Lower the truck one side at a time, while carefully removing the blocks. Check to be sure no tools or equipment are under the truck or wheels.

Raising Truck With A Hoist

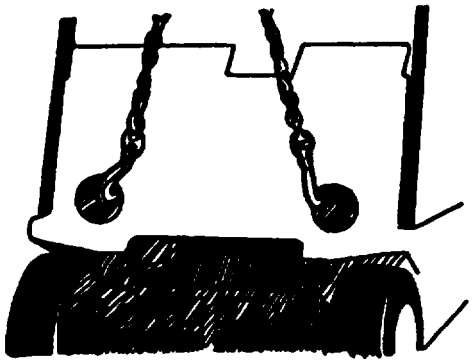
When suitable equipment is available, the front of the truck may be raised by means of a hoist and wheel cradles placed under the wheels.



WARNING

When lifting the front of the truck, watch truck for signs of lateral instability. It may tip sideways. You may have to support or guide the side of the truck or overhead guard to prevent tipping.

1. Attach a hoist with chains of correct capacity.



2. To raise the front of the truck with upright removed, use two chains hooked into the cowl at the cutout holes for the tilt cylinders, or the upper tie bar on the upright. Lift truck up and place wheel cradles under the front wheels. Lower truck wheels onto the cradles.
3. When maintenance work is completed, lower the truck to the floor by reversing the lifting procedure. Check to be sure no tools or equipment are under the truck or wheels.

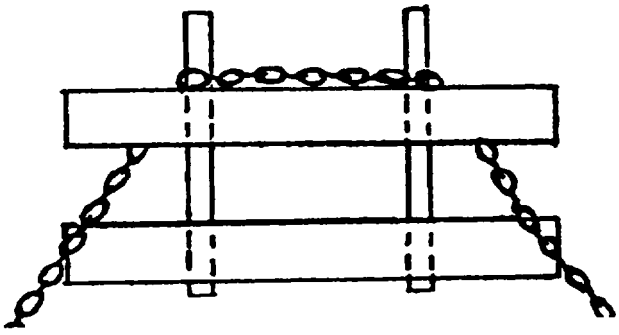
Lifting and Jacking Points

WARNING

The overhead guard and mounting are not designed (stressed) to support the weight of the lift truck. Attempting to lift the truck using the overhead guard may result in injury or death to personnel.

Shipping Tiedown Instructions

1. Front of Truck



A. With Upright and Carriage Installed

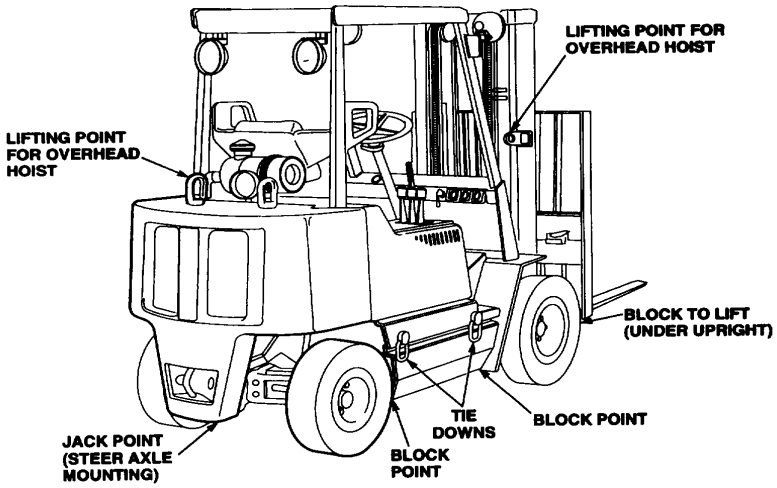
- Lower the carriage fully.
- Put a tiedown (e.g., chain) between the carriage fork bars as shown in illustration.
- Attach chain to side tie downs.

B. Without An Upright and Carriage Installed

- Attach chain to side tiedowns.

2. Rear of Truck

Attach chain to side tiedowns.



4.0. ENGINE

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4.2 Engine Troubleshooting F-67

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4.1. Engine Maintenance - Oil and Filter Change

Oil Change Frequency F-65
Oil Level Check Procedures F-65
Oil and Filter Change Procedures F-66

Oil Change Frequency

NOTE

The time interval for changing engine oil will depend upon your application and operating conditions. To determine the correct schedule for your truck, it is suggested that you periodically submit engine oil samples to a commercial laboratory for analysis of the condition of the oil.

Engine oil does not "wear out." However, the lubricating oil in internal-combustion engines becomes contaminated from the by-products of combustion: dirt, water, unburned fuel entering the crankcase, and the detergents holding the carbon particles in suspension in the crankcase.

Motor oils used for internal-combustion engine lubrication perform many useful functions including: dissipating heat, sealing piston rings, preventing metal-to-metal contact wear, and reducing power loss through friction.

The lubricating oil recommendation is based upon engine design, type of service, and the ambient temperature in which the engine is operating. High quality oils are required to ensure maximum performance, long engine life, and minimum cost of operation.

The schedule for changing oil is directly dependent upon the operational environment. An extremely clean operation could go 150-250 hours, while a dirty operation (foundry or cement factory) could be 50 hours or less. See Section 3, Recommended PM and Lubrication Schedules.

To help ensure that your lift truck's engine continues to perform at peak efficiency, Clark recommends the use of improved motor oils that meet the American Petroleum Institute (API) designations as outlined below. Look for the API Service Symbol on the oil container. OIL PERFORMANCE DESIGNATION To help achieve proper engine performance and durability, use only engine lubricating oils of the proper quality.

These oils also help promote engine efficiency which results in improved fuel economy. A symbol has been developed by the API (American Petroleum Institute), SAE and ASTM to help you select the proper engine oil. It should be included on the oil container you purchase. For diesel engines, it is recommended that you use API Service Classification CD, Service Class D motor oils.

General Recommendations For Engine Oil Viscosity

Ambient Temperature (Average)	Viscosity
80°F or above (300C or above)	SAE 40
320F to 110°F (0°C to 430°C)	SAE 30
70°F to 0°F (21°C to-17°C)	SAE 20W
0°F to -30°F (-17°C to -340°C)	SAE 10W

Multi-grade oils used, such as SAE 5W-20, SAE 10W30, and SAE 15W-50, should cover the single-grade recommendation for the ambient temperature involved.

Oil Level Check Procedures

CAUTION

Do not add oil until oil level approaches the LOW mark. Then add only enough to bring it to high level---NEVER above. Do not operate the engine with oil level below LOW level mark or damage to equipment may result.

NOTE

It is normal to add some oil between oil changes. Keep the oil level above the ADD mark on the dipstick by adding oil as required. DO NOT OVERFILL. Use the correct oil as specified in Section 2.1, Service Specifications.

The dipstick indicates the high and low oil level in the crankcase. Make allowance for additional oil drainage back into oil pan if engine has not been stopped 15 minutes. The most efficient oil level is between the two dipstick levels.

1. Check the engine oil level every 8 hours according to engine oil dipstick and procedures specified below.
2. Pull the dipstick out, wipe it with a clean wiper, and reinsert it fully into the dipstick tube. Remove the dipstick and check the oil level.
3. Check the PM time interval (operating hours), or the condition of the oil, to determine if it needs to be changed.

Oil and Filter Change Procedures

It is recommended to:

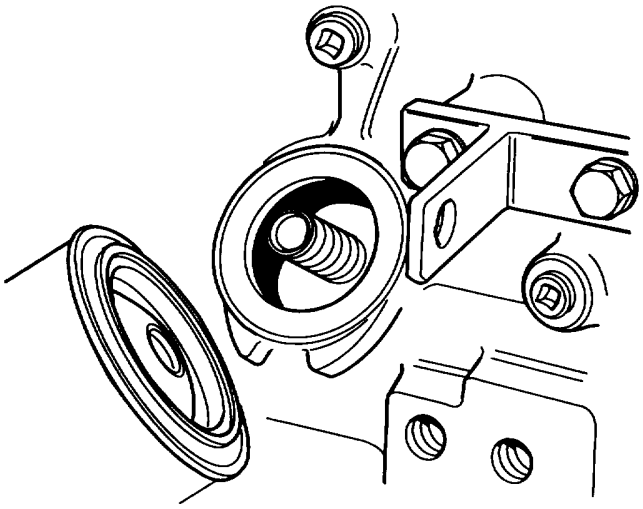
- *Drain and replace the engine crankcase oil every 50 to 250* operating hours. See NOTE 4.1-1.*
- *Replace engine oil filter at every oil change.*
- *Drain and replace engine oil in a new or rebuilt engine after the first 50 hours of operation.*
- *Drain old oil after truck has been in operation and engine (oil) is hot (at operating temperature).*
- *Do not exceed 250 hours.*

Refer to Section 2.1, Service Specifications, for engine oil specifications for your engine model.

NOTE

Raise and block-up the truck under the frame to give easier access to the engine drain plug. Refer to Section 3.3, Machine Jacking and Blocking.

1. To drain the engine oil, put a low flat drain pan under the truck. Remove drain plug at bottom of oil pan and drain the oil completely.
2. Remove the engine oil filter. If necessary, use a standard filter wrench.



3. Install new oil filter. Follow installation instructions printed on the outside surface of the filter. Check that the oil seal is lubricated and correctly in place.
4. Clean and inspect the oil drain plug and seal. Replace the drain plug and/or seal if damaged.
5. Install drain plug. Remove oil drain pan.
6. Remove and inspect the condition of the engine oil filler cap located on top of the engine valve cover. Replace cap if it is damaged or the seal is broken.
7. Refill the crankcase with fresh engine oil through the rocker cover oil filler opening.
8. Wait several minutes after adding oil and then check the oil level.
9. Start the engine and allow it to run at idle for several minutes. Check the oil filter and drain plug for leakage.
10. Check the engine oil level with the engine stopped. Refer to procedures noted above for your engine model.

4.2. Engine Troubleshooting

Troubleshooting Guide F-68

When diagnosing and correcting the cause of trouble with a diesel engine, do not begin by disassembling components. Instead, start by analyzing the complaint or symptoms. Then, systematically determine the probable cause. Make a preliminary investigation of the trouble as follows:

1. Check with the operator or his supervisor before you start troubleshooting. Ask the operator the following:
   a. Did you hear any unusual noise?
   b. Is the trouble accompanied by any other faulty conditions?
   c. When did trouble occur?
   d. How did the trouble happen? Did the trouble happen suddenly? Any abnormality before the trouble happened?
   e. Had the engine recently been repaired when the trouble occurred? When?
   f. Has the same trouble occurred before?

2. If it is necessary to operate a faulty engine for the purpose of troubleshooting, be sure to ask for the user's consent about possible progress of the trouble which could result from the operation.

3. Be sure the problem exists. If it is difficult to judge whether a faulty condition is to be regarded as a trouble or not, use the troubleshooting chart as a guide.

4. It is possible to avoid unnecessary disassembly work by diagnosing the cause of the trouble accurately on the basis of the questions asked of the user and the information in the troubleshooting chart. Take the time necessary for sufficient preliminary investigation. Hasty disassembly work can also make it difficult to reproduce the troubled condition and, sometimes, leads to disappearance of the evidence of the cause of the trouble.

5. Start with the easiest and least time-consuming solution. When several items are suspected to be the cause of the trouble, examine them, starting with the easiest one.

6. Try to think of the reason why the trouble happened. Do not confine your effort to the correction of the present trouble, but try to detect the fundamental cause, if any, of the trouble and correcting or adjusting it.

7. A good rule to follow in locating trouble is to never make more than one adjustment at a time. Locate the trouble by a process of elimination. The cause is usually simple, rather than mysterious and complicated.

The following troubleshooting guide lists most of the usual complaints or troubles encountered in routine operation of all diesel engines, with probable cause and troubleshooting procedure.

Troubleshooting Guide

WARNING

Starting fluids or aids such as ether or gasoline must not be used in a diesel engine air intake system. The use of these fluids will cause severe internal engine damage and/or bodily injury.

A. Engine Won't Turn Over

1. Dead or weak battery	Recharge or replace battery.
2. Inadequate battery capacity	Replace battery.
3. Poor ground connection	Inspect, clean, tighten ground cable.
4. Loose or faulty wiring connections	Clean, tighten, repair connections.
5. Starting switch faulty	Replace switch or relay.
6. Faulty neutral start switch	Replace.
7. Starter motor defective	Check brushes, commutator, drive spring, and mounting bolts (ground).
8. Internal engine seizure	Turn engine manually. If unable to do this, check for foreign objects in gears, on top of piston, or for piston seizure.

B. Engine Turns But Won't Start

1. Fuel shut-off solenoid failure	Using voltmeter, check solenoid with key switch in RUN position. If voltage: replace solenoid. No voltage: check for opening in wiring to solenoid.
2. No fuel supply to pump	Fill fuel tank or open shut-off valve.
3. Air in fuel injection lines	Check connections and bleed fuel system.
4. Clogged or dirty fuel filters	Disassemble and clean primary filter and replace secondary filter if clogged.
5. Air filter plugged	Replace.
6. Cranking speed slow (under 250 rpm)	Recharge or replace battery; check starter and repair, if necessary.
7. Water in diesel fuel	Drain fuel system; refill with clean fuel or strain fuel through chamois and bleed system.
8. Wrong injection pump timing	Retime pump to engine per specifications.
9. Low compression pressure	See recommendations under item G.
10. Glow plugs faulty or inoperative	Replace or repair.

C. Engine Runs "Rough" With Excessive Vibration

NOTE

A characteristic of a fuel injection pump is that if engine misfiring occurs, and it is traced to a certain cylinder in which no combustion is taking place, the cause might be an injector sticking open in the cylinder which immediately precedes that cylinder in the engine firing order. During injection to the cylinder which has the injector sticking in the open position, the fuel rushes into that cylinder with no restriction whatsoever, causing a scavenging effect in the pump distributor rotor and a void which cannot be recharged to a sufficient degree to provide opening pressure of fuel to the following injector. Hence, no combustion can take place. Please note this well, as knowledge of this characteristic might provide a great saving in service time in such a situation.

1.	Misfiring cylinder(s)	Loosen fuel line to injector one at a time. No noticeable change indicates that cylinder is misfiring. Clean and test injector for pressure, leakage, and spray pattern.
2.	Too low operating temperature (below 1650F)	Check thermostat.
3.	Air in fuel lines	Check connections; bleed fuel system.
4.	Clogged air cleaner	Clean and service air cleaner; tighten connections.
5.	Engine idles too slowly	Adjust to correct idle speed specification.
6.	Poor fuel	Use diesel fuel that meets specifications.
7.	Faulty head gasket	Replace.

D. Loss of Power

1.	Wrong injection pump timing	Retime pump to engine per specifications.
2.	Air in fuel lines	Check connections and bleed fuel system.
3.	Clogged or dirty fuel filters	Clean primary filter and replace secondary filter, if necessary.
4.	Restriction in air flow	Service air cleaner and connections.
5.	Poor fuel	Use recommended diesel fuel specification.
6.	Poor compression	See recommendations under item G.
7.	Injector nozzles faulty	Clean and test faulty nozzle for pressure leakage and spray pattern.
8.	Injection pump faulty	Remove and have checked at an authorized service center.

E. Overheating

1.	Lack of coolant/low coolant level in radiator	Add coolant. Tighten hose connections; repair leaks as required.
2.	Engine oil level is low	Add oil; inspect for cause.
3.	Fan belt(s) slipping	Inspect belt condition; adjust tension.
4.	Fan installed backwards	Remove and install correctly.
5.	Radiator fins plugged (dirty) or core clogged	Clean cooling system or replace radiator.
6.	Rust and scale buildup in radiator or engine block	Clean cooling system or overhaul.
7.	Overloading of engine	Reduce load. Keep engine speed up.
8.	Thermostat sticking or inoperative	Remove, clean, check/replace thermostat.
9.	Fuel injection timing wrong	Retime pump per specifications.
10.	Excessive back pressure in exhaust system	Inspect/clean muffler and exhaust system.
11.	Leaking exhaust pipe	Repair or replace.
12.	Water pump faulty	Repair or replace.

F. Excessive Smoke

White Smoke - May indicate misfiring.

1.	Low engine temperature (cold engine)	Check thermostat. Increase engine temperature.
2.	Faulty injectors	Cut out individual injectors with engine running. Clean and test faulty nozzle for pressure, leakage, and spray pattern.
3.	Poor Fuel	Use diesel fuel per specifications.
4.	Poor compression	See Item G. Recommendations.
5.	Coolant leak into combustion chamber	Check head gasket.
6.	Insufficient lubricating oil	Check oil level.

Blue Smoke - Indicates high oil consumption

1.	Worn or stuck piston rings	See Item I. High Oil Consumption.
2.	Low engine coolant temperature	Check thermostat.
3.	Worn valve guides, valve stem, or valve stem seals	Replace.

Black Smoke

1.	Excessive fuel rate	Check pump by authorized service center.
2.	Overloading of engine	Reduce load. Keep engine speed up.
3.	Restriction in air supply	Service air cleaner and connections.
4.	Low engine coolant temperature	Check thermostat.
5.	Faulty injectors	Test and repair or replace.

G. Poor Compression (Under 325 psi @ 150 rpm)

1.	Valves holding open - no tappet clearance	Adjust tappet clearance per specifications.
2.	Leaky cylinder head gasket	Clean head and block surfaces. Replace gasket and torque bolts to specification.
3.	Wrong valve timing	Check and correct, as necessary.
4.	Burned or sticking valves or incorrect valve timing	Clean and grind valves. Reface or replace, as necessary.
5.	Broken or weak valve springs	Check and replace springs not to specs.
6.	Piston rings worn or broken	Replace with recommended service kit.
7.	Worn pistons and cylinder bores	Overhaul, rebore, and replace pistons.

H. Low Oil Pressure

1.	Low oil level	Add oil to correct dipstick level.
2.	Oil pressure gauge or line faulty	Inspect lines. Check with master gauge.
3.	Oil viscosity too light, or oil diluted	Change oil to correct specifications.
4.	Dirt in relief valve or broken spring	Clean valve, or replace spring.
5.	Oil suction screen plugged	Remove screen and clean in solvent.
6.	Worn bearings	Replace.
7.	Worn oil pump	Remove, repair, or replace pump.
8.	Oil pick-up tube O-ring damaged or missing	Replace.
9.	Oil leaks	Locate and repair.

I. High Oil Consumption

1.	Oil leaks	Locate and repair.
2.	Oil level maintained too high	Maintain oil level between HIGH and LOW marks on dipstick.
3.	Incorrect grade of oil used	Use recommended type and SAE viscosity.
4.	Clogged crankcase breather	Check and clean thoroughly.
5.	Oil pressure too high; relief valve stuck	Clean, free-up valve, check spring tension.
6.	Piston rings not properly run-in	Break-in all new and rebuilt engines per recommendations.
7.	Worn, broken, or stuck piston rings and clogged oil control rings	Overhaul and re-ring with recommended service piston rings.
8.	Worn pistons or cylinder bores	Overhaul and rebuild engine, as required.
9.	Worn bearings and valve guides	Overhaul and replace, as required.
10.	Worn or damaged intake valve seals	Replace.

J. Poor Fuel Economy

1.	Operating with low coolant temperature	Maintain (79 - 85°C) 175 - 185°F for maximum economy and performance.
2.	Wrong fuel	Use diesel fuel that meets specifications.
3.	Loss of power	Follow Item D. Recommendations.
4.	Incorrect injection pump timing	Follow recommended timing procedure.
5.	Nozzles faulty	Locate faulty injector; clean and test for pressure, leakage, and spray pattern.
6.	Incorrect tappet clearance	Adjust tappets per specifications.

K. Sudden Stopping

1.	No Fuel	Refill fuel tank and bleed fuel system.
2.	Restriction in fuel flow	Clogged or dirty filters. Check lines for obstruction or break.
3.	Air in fuel lines	Bleed fuel system.
4.	Transfer pump faulty	Replace transfer pump.
5.	Water in fuel	Drain system and refill with clean fuel or strain fuel through chamois.
6.	Internal engine seizure	Turn engine manually. If unable to do so, check for foreign object in combustion chamber, or for piston or bearing seizure.
7.	Faulty electrical shut-off on injection pump	Repair or replace.

L. Engine Knocks & Noises

Combustion Knocks (Excessive)

1.	Overloading ('Lugging')	Reduce load or increase speed.
2.	Poor quality fuel	Use only No. 2 diesel engine fuel oil for best performance and economy.
3.	Injection timed too early	Follow recommended timing procedure.
4.	Injection nozzle sticking	Remove nozzle, check opening pressure, clean and adjust.

Mechanical Knocks

1.	To locate knock	"Short out" cylinders by loosening fuel line to nozzle one at a time. If no change in sound, knock is not occurring in that cylinder.
2.	Main bearings	Heavy, dull knock when accelerating under load. Examine bearing lining for wear or excessive clearance. Replace, as necessary.
3.	Connecting rod bearings	Noise appears at idle or light load and disappears at full load. Overhaul engine.
4.	Loose piston pin	Sharp metallic rap at idling speed or when starting cold. Replace pin with oversize.
5.	Broken piston ring or pin	Sharp, clicking noise that cannot be eliminated by shorting out. Remove pistons, and replace piston pin or rings, as necessary.
6.	Tappet noise	Check clearances; adjust to specifications.
7.	Timing gear noise	Loose or worn gears rattle. Check gear fit and examine teeth. Refit new set of gears if loose or worn badly.

4.3. Engine Tune-Up

Tune-Up Preparation F-73
Preliminary Checks F-74
Cranking Test F-75
Tune-Up Procedures F-76
Tune-Up Completion F-77

Engine Tune-Up *consists of:*

1) *Preliminary checks to be sure that all engine systems are functioning correctly, and*
2) *Tune-up procedures, which include performing tests, making minor adjustments and replacing minor components as necessary to bring an engine up to its peak level of performance.*

Also refer to Section 4.2, Engine Troubleshooting.

Tune-Up Preparation

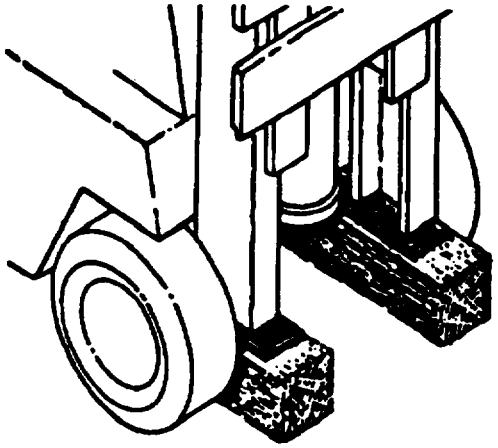
WARNING

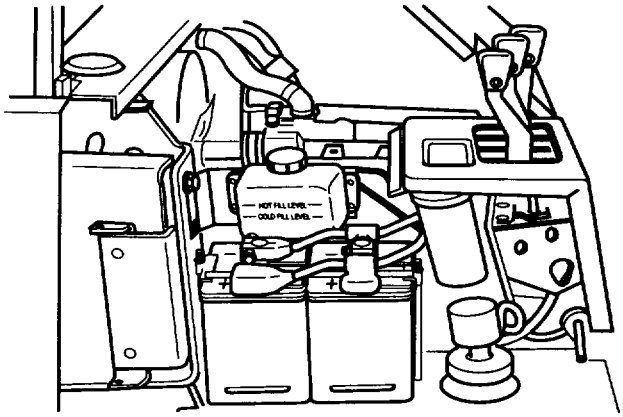
- Park truck in a well-ventilated area. Do not smoke or perform maintenance near open flame or other sources of ignition. Do not disconnect any lines when exhaust manifold is excessively hot or fire may result in injuries and damage to equipment.
- Stop engine before checking battery terminals or electrical connections. Do not hold ignition wires with bare hands since shocks or other injuries can result. Battery acid can cause corrosive burns. Always wear eye protection. Use of jumper cables or battery charging should be done only as directed by manufacturer's safety instructions.

NOTE

Prior to performing this service procedure, it is recommended that you first:

- Put blocks under the upright rails.
- Raise the drive wheels off the floor.
- Return all controls to NEUTRAL, apply the parking brake, and turn key switch OFF, except as noted.





Open and remove both side doors, and raise the seat deck. Be sure the seat deck support is securely latched.

Minimum Tools Required

- Tachometer
- Voltmeter
- Timing Light
- Torque Wrenches
- Vacuum Gauge
- Jumper Wire

Preliminary Checks

WARNING

For safety when checking or removing battery connections, always disconnect the negative battery cable at the engine ground connection first.

CAUTION

Be careful when inspecting or replacing the air filter element to prevent dirt from entering the engine air intake housing. Damage to engine may result.

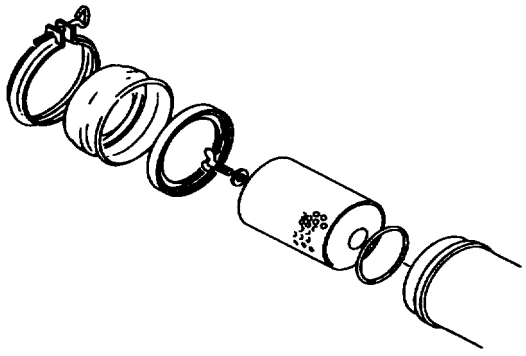
NOTE

The following quick, simple checks should always be made to make sure that basic and easy to find troubles are not the cause of poor engine performance. Once you have eliminated these items you can check into the other possible causes of poor engine performance.

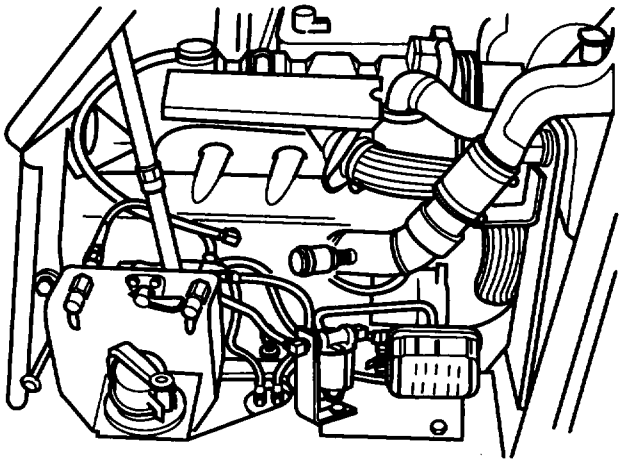
The following preliminary tests show whether the basic engine systems are functioning and that charging and cranking systems are okay or in need of repair. Remove the voltmeter after these tests are made.

Blow-by, circulated into intake manifold, maintains crankcase pressure within a narrow range regardless of operating speed or load. Servicing of the PCV system is usually confined to cleaning PCV orifice and/or valve along with cleaning the air inlet, where applicable. All connections must be air tight.

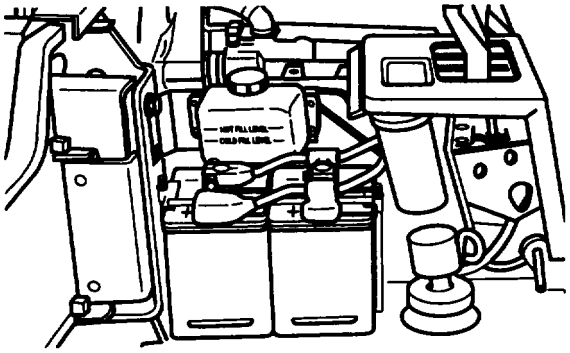
1. Check engine oil and coolant levels.



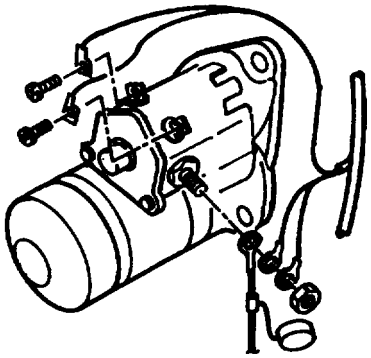
2. Check engine air filter. A clogged filter will cause engine power loss. Replace, as needed.
3. Check air intake tubes for signs of filter leakage.
4. Check crankcase breather system to be sure it is functioning correctly. Check the following and, if necessary, clean or replace faulty parts.
   a) Breather hoses for damage, cracks, and clogging.
   b) Rocker cover and intake manifold fitting holes for clogging.



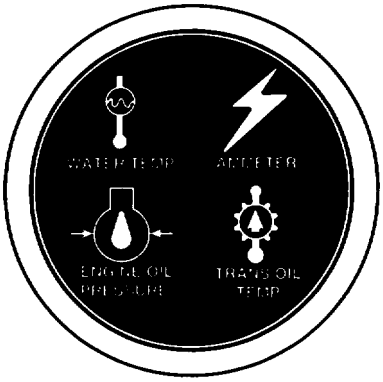
   c) Repair or replace as required.



5. Check battery for damage and cleanliness of terminals. Remove the boot covers to expose terminal connections. Clean battery terminals and cable connections if they are dirty and corroded. Check battery terminal cable connections for tightness. Replace boots over terminals after inspection. If necessary, wash battery with a mild solution of baking soda and water. First, make sure that cell vent caps are tight to ensure that soda solution does not contaminate battery electrolyte.



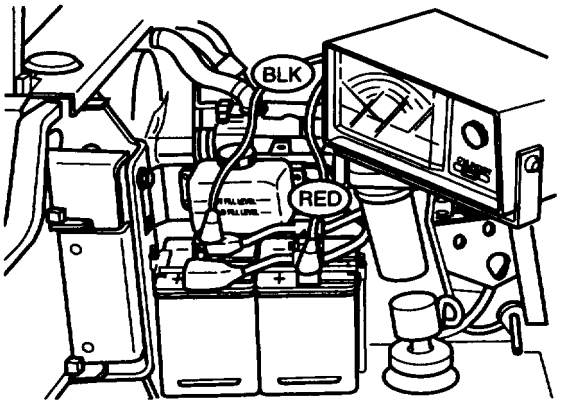
6. Be sure battery negative (ground) cable is securely connected to engine block. Check engine starter cable connections.
7. Start the engine.



8. With engine running, look at battery charge indicator. The light should not be illuminated, indicating voltage output from the alternator.
9. Check fuel gauge to be sure fuel level is adequate, to ensure that low fuel level will not affect other tests of engine performance.

Cranking Test

10. If there is indication of a faulty battery, or if engine cranking speed is slow, perform a cranking test, as follows:
    a) Disable the fuel injection system. Disconnect the electrical power wire from the fuel shut-off solenoid terminal of the injector pump.



    b) Then, connect a voltmeter across the battery terminals. Crank the engine for 15 seconds.
    c) During cranking the battery voltage should exceed 9.6 volts. Battery voltage of less than 9.4 9.6 volts indicates trouble in the battery, cables, or starter.
    d) Immediately after cranking, battery no load voltage should be 12 volts, minimum. The voltmeter should show a quick response. If the voltage is less than 12 volts or the voltmeter has a sluggish response, it is an indication of a battery problem.
    e) If battery no-load voltage returns to 12 volts immediately after cranking but there is low cranking voltage (e.g., 8 volts), the problem is in the cables or starter. First, inspect the cables for loose burned terminal connections. Then, remove and check the starter. Rebuild or replace, as required.
    f) Connect the electrical power wire to the fuel shut-off solenoid terminal of the injector pump and start and accelerate engine to a steady speed of 1800 2000 rpm.
    g) Charging system output voltage should be between 12.5 13.5 volts.

Battery

11. If the battery has been "running down" (discharging), or if engine cranking speed is low, check the alternator circuit and battery. See cranking test above.

Tune-Up Procedures

1. Stall Test

WARNING

- Stall tests must be performed with the parking brake applied and wheels blocked up above the ground surface to prevent movement. Be careful that the truck does not move unexpectedly when operating the engine and converter at stall. Unexpected movement of the truck could cause injury or death to personnel.
- Do not run engine and converter at stall longer than necessary to take the rpm readings, or longer than 30 seconds at one time. Then, shift transmission into NEUTRAL for 15 seconds and run the engine at one-half speed for 1-2 minutes to cool torque converter oil. Excessive temperature 250°F (120^0C) max will overheat the converter and cause damage to converter, seals, and fluid.

NOTE

A stall test is perhaps the most important and useful test for quickly determining engine condition. Stall tests should be a part of all engine tune-ups and must be carefully conducted and analyzed to pinpoint specific problems.

A stall test must include RPM, vacuum, and hydraulic pressure measurements to accurately diagnose specific problem areas. For this reason, stall testing is described in a separate, detailed section noted below.

Engine speed and vacuum checks with engine under load are made to also determine whether major components or systems other than the engine are causing problems.

If stall speed is low, do not automatically blame the torque converter. Carefully check engine condition. Frequently, an obstruction, e.g., carbon plugging, in the air intake or exhaust system is the problem.

First, perform a stall test to determine engine condition and whether engine and other components are functioning correctly. Check:

1) Idle speed and vacuum.
2) No-load governed speed and vacuum.
3) Speed and vacuum in hydraulic (tilt) bypass.
4) Engine stall speed and vacuum.

Refer to Section 4.7, RPM, Vacuum, & Stall Tests, for procedures and analysis of test results.

Also see Section 2. 1, Service Specifications.

2. Idle Speed

Check engine idle speed and adjust idle setting if idle speed is not correct.

Refer to Section 4.10 for Idle Adjustment.

TMD27 Engine 650 rpm (600 700 rpm)

Refer to Section 2.1, Service Specifications.

3. Compression Check

If the stall speed reading is not in the correct range or the engine runs erratically, perform an engine compression check. This will check the condition of the piston rings and engine valves.

Refer to Section 4.6, Engine Cylinder Compression Test and Section 2.1, Service Specifications.

4. Valve Clearance Settings

If the engine compression test indicates a valve problem, or valve train is noisy, check and adjust valve (tappet) clearances, as necessary.

Refer to Section 4.5, Valve Clearance Adjustment and Section 2.1, Service Specifications.

5. Cooling System

NOTE

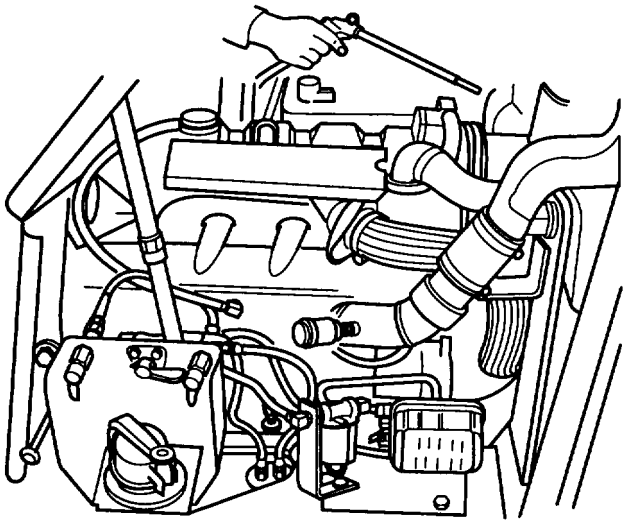
- Fan blades should engage 1/3 of the depth of the radiator shroud.
- The fan is designed as a "pusher-type" fan, i.e., to push air through the radiator. The fan blades should be installed with their curve to push air into the radiator as they turn in the direction of right-hand engine rotation.

a. If there is an indication of engine overheating, perform a complete check of the engine cooling system.

WARNING

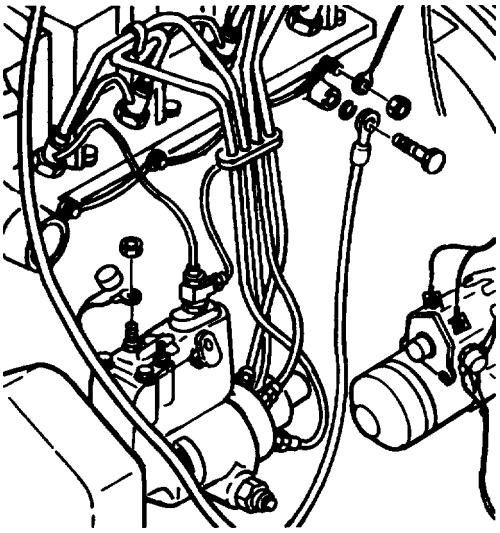
Compressed air used for cleaning purposes must not exceed regulated 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/ shield, gloves, etc.) to prevent injury to personnel.

b. Inspect the radiator for damage and clogging from dirt contamination. Air clean the radiator if it has not already been cleaned as part of the PM procedure. Air pressure should not exceed 30 psi (207 kPa).



c. Check to be sure that the fan blades are not loose or damaged and that the fan is installed correctly (Fan installed backwards is a common problem).
d. Check the fan drive belt for proper tension and adjust, as necessary. If tension is low, the belt will slip. If belt tension is too high, the bearings and seals in the water pump and alternator can be damaged.
e. Check the exhaust pipe to be sure that exhaust is not blowing into radiator.
f. As a final step, if necessary:
    1) Pressure test the cooling system.
    2) Pressure test the radiator cap.
    3) Check the thermostat.
    4) Check the coolant for freeze protection level.
    5) Check overflow reservoir and hoses.

6. TMD27 [2.7L] Diesel Engine



a. Check glow plugs and inspect glow plug wiring. Repair or replace, as needed.
b. Inspect fuel lines for leaks. Adjust fuel control linkage and accelerator pedal linkage to allow for full travel of arm on fuel injection pump, as necessary.

Refer to Section 5.3, Diesel Fuel System, for additional information.

7. Re-check Engine Performance

a. Remove the tachometer, vacuum gauge, and timing light.
b. Stall Test. Run a stall test to check engine performance after tune-up.

Tune-Up Completion

When you have systematically completed these tune-up procedures, you should have been successful in restoring the engine to its peak level of performance, or otherwise determined the need for additional maintenance or repair of the engine.

a. Lower and latch the seat deck. *Be sure seat deck is correctly latched*. Install and close the side doors. Lower the drive wheels to the floor and remove any blocking, if used.
b. Test drive the truck.
c. Clean up any loose dirt and spills. Wipe off the truck.

4.5. Engine Valve Clearance Adjustment

Preliminary Service Preparation..... F-79
General Procedures F-79
Valve Clearance Check F-80
Valve Clearance Adjustment F-80
TMD27 (2.7 L) Engine Procedures..... ..... F-81

Valve Tappet Clearance Adjustment

1. *Disassemble or move accessory components as necessary for removal of valve cover.*
2. *Remove valve cover.*
3. *Check and re-torque cylinder head bolts, as specified.*
4. *Check and adjust tappets when clearance is found to be incorrect.*
5. *Reassemble valve cover and accessories.*

NOTE

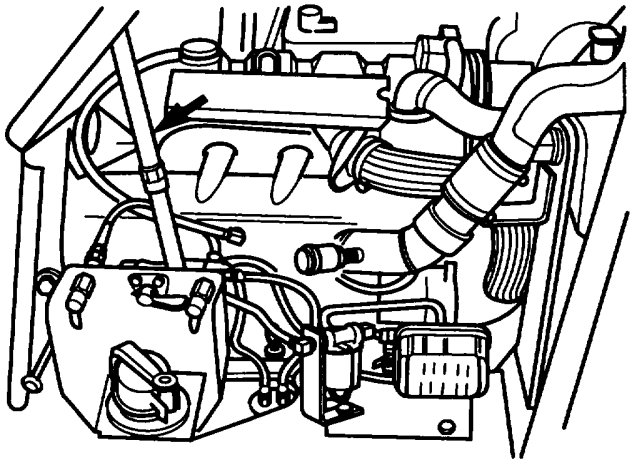
- Prior to performing this service procedure, It is recommended that you first: * Park truck on a solid, level surface.
- Lower forks or attachment fully down.
- Return all controls to NEUTRAL, apply the parking brake, and turn key switch OFF.
- It is recommended to use a go/no go feeler gauge.

Minimum Tools Required

- Wrenches.
- Pliers, or hose clamp tool.
- Screwdriver, or valve adjustment tool.
- Thickness (feeler) gauge

Preliminary Service Preparation

1. If truck has not been operating, start the engine and warm it up to normal operating temperature. Coolant temperature should be 176-194°F (80-90°C).
2. Turn ignition key switch OFF.



3. Open and remove both side doors, and raise the seat deck. Be sure the seat deck support is securely latched.

General Procedures

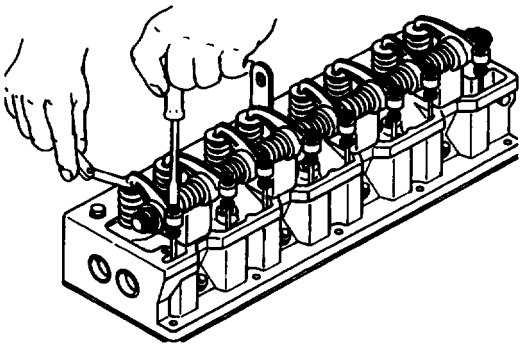
1. Clean and remove all loose dirt from around valve cover before removing.
2. Removal of all diesel fuel injectors will allow the engine to be rotated more easily.
3. Be sure to blow dirt from around fuel injectors prior to removal.
4. When specified, check and retighten cylinder head bolts to the correct torque specification in the specified tightening sequence before adjustment of valve clearance.
5. Check and adjust valve clearance with engine warm (at operating temperature) and stopped.

Valve Clearance Check

1. Check and adjust valve clearances in the same sequence as engine firing order. This makes the job simpler when rotating the engine crankshaft to move the valves into he correct position for checking clearance.
2. No. 1 cylinder is at fan-end of engine.
3. Check and adjust valve clearance with engine stopped
   (a) In sequence of firing order starting with No. 1 cylinder, rotate the engine clockwise (looking at fan-end) until the respective cylinder piston is at top dead center (TDC) on the compression stroke.
   (b) When each cylinder piston is at TDC on compression stroke, both intake and exhaust valves are closed and maximum clearance exists between rocker arms and valve stems.
   (c) The engine crankshaft can be rotated by using the fan belt or crank pulley to move each cylinder piston to the TDC position.
   (d) The correct TDC position for each cylinder can be determined by: a) placing a finger over the injector hole on the compression stroke, or b) checking clearance at the rocker arms and valve stems of the subject cylinder combined with the position of the rocker arms on alternate cylinders (see "Valve Rocking Procedure" below).

Valve Rocking Procedure

When No. 1 is at TDC, the valves are 'rocking' (the period between the opening of the intake valve and the closing of the exhaust valve) on No. 4 cylinder. No. 4 exhaust valve is nearly fully up (closing) and the intake valve is just starting its downward stroke. At this point, No. 1 intake and exhaust valves and rocker arms should be in the up (free) position. Follow the firing order sequence to determine the "rocking' position of valves on alternate cylinders from the cylinder being adjusted.



4. Check the clearance between the intake and exhaust valve stems and the rocker arms using a flat thickness (feeler) gauge.

NOTE

It is recommended to use a go/no go feeler gauge.

5. The valves are adjusted correctly when the thickness gauge moves in the clearance gap with a small amount of friction (slight drag).
6. If the thickness gauge moves freely and without a slight drag on it, valve clearance is too great (excessive). Valve clearance adjustment is required.
7. If the feeler gauge cannot be inserted between the valve stem and rocker arm, valve clearance is too small. Valve clearance adjustment required.

Valve Clearance Adjustment

1. To adjust valve tappet clearance, put feeler gauge between rocker arm and valve stem and turn adjusting screw until there is a small amount of friction on the gauge while moving it.
2. Tighten the locknut while holding the adjusting screw in position.
3. Check valve clearance again after tightening the locknut. Readjust, as necessary.

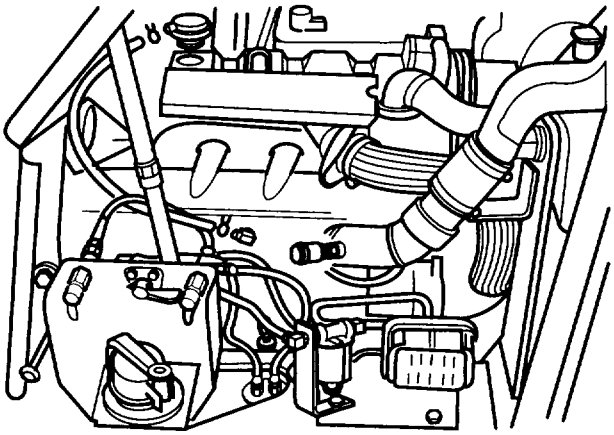
TMD27 (2.7 L) Engine Procedures

Refer to Page 4.5-2, General Procedures for Valve Clearance Check and Adjustment.

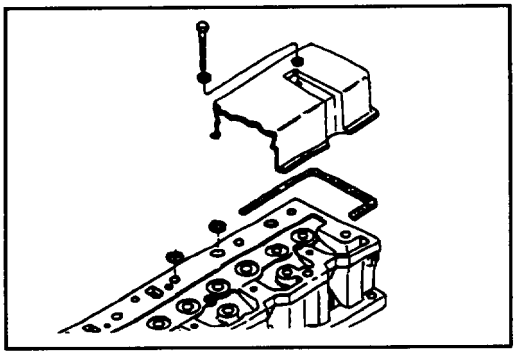
Firing Order:		1-3-4-2
Valve Clearance Settings, Warm:	INT	.014 in. (0.36 mm)
	EXH	.018 in. (0.46 mm)

Reference Section 2.1, Service Specifications.

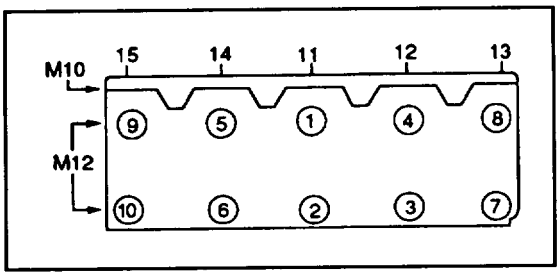
1. Check and adjust valve clearance with engine warm and not running. Warm engine up if necessary.
2. Disconnect the fuel shutoff solenoid. Remove fuel injectors.
3. By inspection of your engine, disassemble any components which must be removed and/or moved out of the way before removing the rocker cover.



4. Remove crankcase oil filler cap with rocker cover breather (PCV) hose. Clean around valve cover before removing.



5. Remove the rocker cover bolts and washers. Remove rocker cover and gasket. Inspect cover and gasket for damage. Replace gasket, as needed.



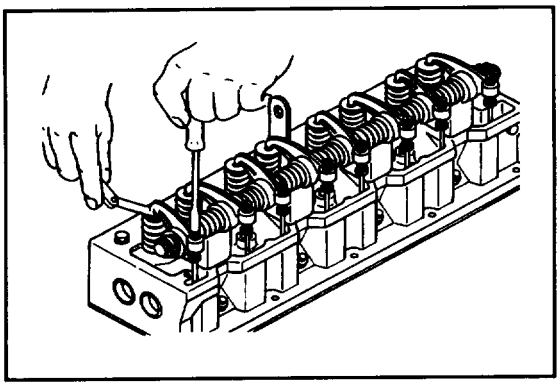
6. **IMPORTANT** - Check and retighten cylinder head bolts to correct torque specification before adjustment of tappets. Follow numerical sequence shown above. Hand torque to following specifications:

Engine Cylinder Head Bolt
Torque Specs

(Cold)	Bolt Size	
	M10	50-55 lb-ft (68-75 N•m)
	M12	90-95 lb-ft (122-129 N•m)

(Warm)		
	M10	45-50 lb-ft (61-68 N•m)
	M12	80-85 lb-ft (109-115 N•m)

Reference Section 2.1, Service Specifications.



7. Check and adjust valve clearances in same sequence as engine firing order: 1-3-4-2.
8. Reassemble valve cover and accessories.
9. Install fuel injectors using new heatshield washers. Tighten injectors to torque specification: 52 lb-ft (70 N•m). Connect fuel lines. Bleed fuel system.

4.6. Engine Compression Pressure Test

Diesel Engine Test Procedure F-83

Engine Compression Test *procedures consist of removing Injectors, installing a compression test pressure gauge to the cylinder being tested, and cranking the engine while the pressure is being measured.*

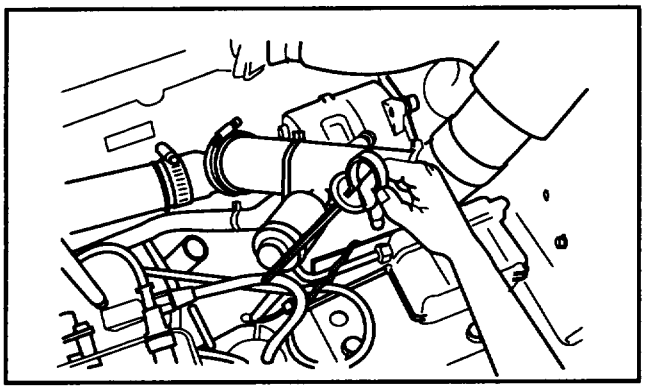
The information in this section describes general engine cylinder compression test procedures illustrated with typical views of the subject activity.

NOTE

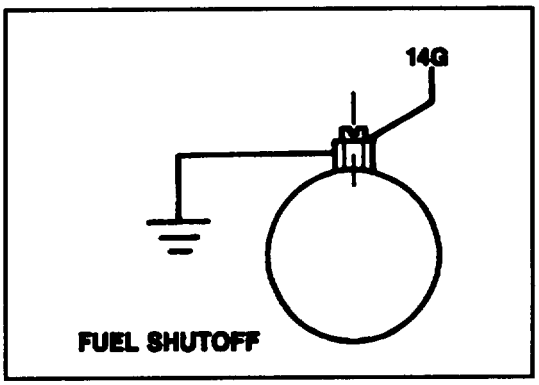
To perform this service procedure, it is recommended that you first:

- Park truck safely.
- Apply parking brake. Block wheels.
- Return all controls to NEUTRAL and turn key switch OFF, except as noted.

Diesel Engine Typical Compression Test Procedure



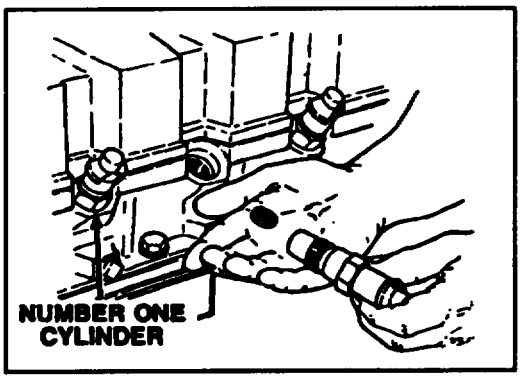
1. Be sure that crankcase oil is at the proper level. Bring engine up to normal operating temperature. Stop the engine.



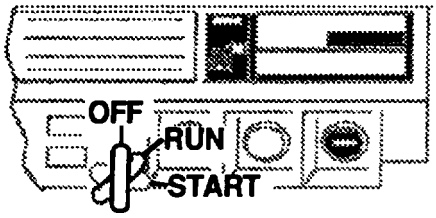
2. Disconnect the fuel shut-off solenoid so the engine will not start.

WARNING

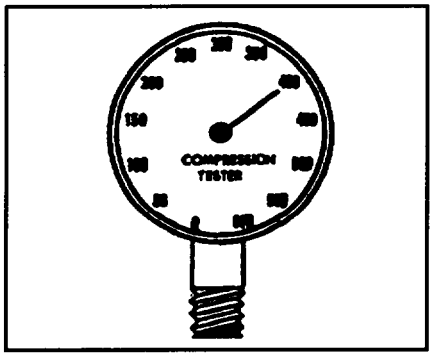
Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. Before disconnecting lines, be sure to relieve all pressure. If Injured by escaping fluid, get medical attention at once.



3. Remove the injector and seat washer from the No.1 cylinder.

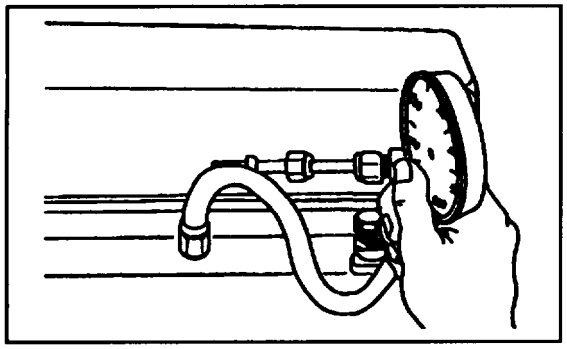


4. Clean the injector bore and crank the engine to blowout any loose carbon particles.

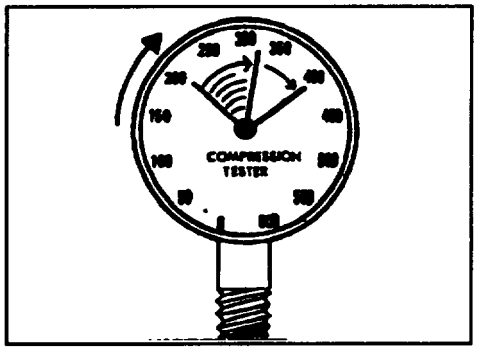


5. Install high-range compression gauge with the appropriate adapters, as necessary. A new seat washer should be used.

Injector Thread: M24 x 2

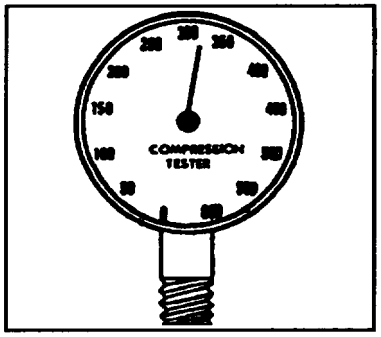


6. Connect the compression test gauge.



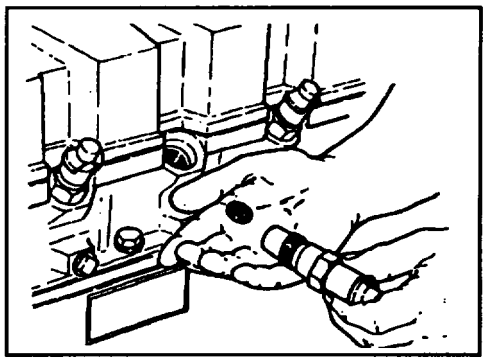
7. Crank the engine for 5 compression strokes or until the reading stops increasing.
8. Observe and record the readings for all cylinders.

Analysis of Diesel Compression Pressure Readings



1. All cylinders should read between 325 - 400 psi @ 150 rpm.
   1) A low, even compression in two adjacent cylinders indicates a cylinder head gasket leak.
   2) A reading of 20 psi above the other cylinders indicates high carbon deposits on the piston and cylinder head.
   3) A reading of more than 20 psi below the other cylinders indicates leakage at the cylinder head gasket, valves, or piston rings.
2. To determine if the rings or valves are at fault, perform a static leak-down test. Follow the instructions that are provided in your leak-down test equipment.

Test Completion

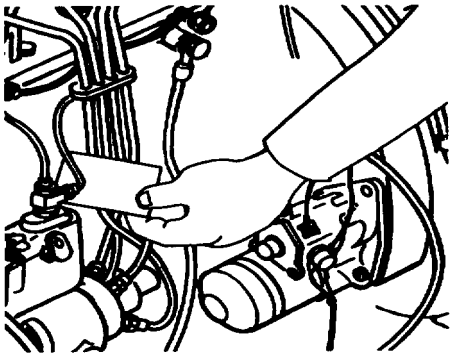


1. Install the injectors.

NOTE

When installing injectors in the engine cylinder head, it is essential that a new, correct type heat-shield washer be fitted between the nozzle cap and the cylinder head.

2. Tighten injectors evenly to torque specification: 52 lb-ft (70 N•m).



3. Connect the fuel lines.
4. Bleed fuel system of air.

WARNING

Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. Before disconnecting lines, be sure to relieve all pressure. Before applying pressure to the system, be sure all connections are tight and that lines, pipes, and hoses are not damaged. Use a piece of cardboard, rather than hands, to search for leaks. If injured by escaping fluid, get medical attention at once.

4.7. Engine RPM & Stall Tests

Engine RPM at Idle F-88
Engine RPM at Max No-Load Governed Speed F-88
Full Throttle Engine Stall RPM F-89
Analysis of Stall Test F-90
Transmission Pressure Checks F-91
Test Completion F-91

These tests are performed to:

1. Check engine condition and correct function.
2. Check for correct engine speed settings and speed control function.
3. Check whether major components or systems other than the engine have problems or are causing problems.

Tests include:

1. Engine idle speed and vacuum.
2. Engine maximum no-load governed speed and vacuum.
3. Engine speed and vacuum at hydraulic tilt bypass (relief pressure).
4. Engine stall speed and vacuum.

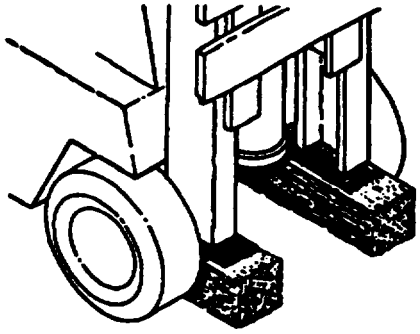
Minimum Tools Required:

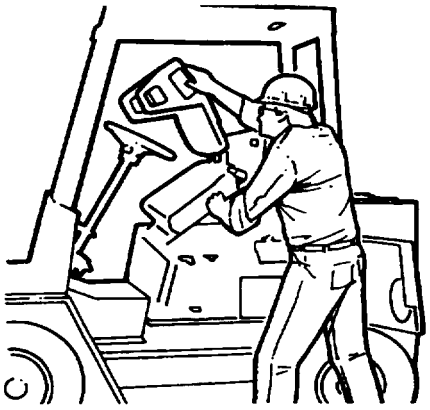
- Tachometer
- Vacuum gauge

NOTE

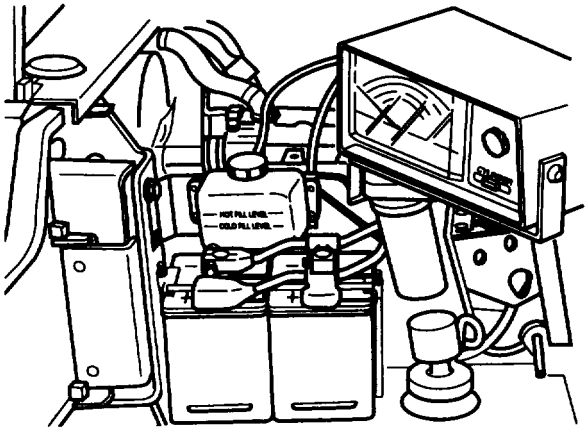
Prior to performing this service procedure, it is recommended that you first:

- Park truck safely.
- Return all controls to neutral.
- Put blocks under the upright rails and raise the drive wheels off the ground, except as otherwise noted.

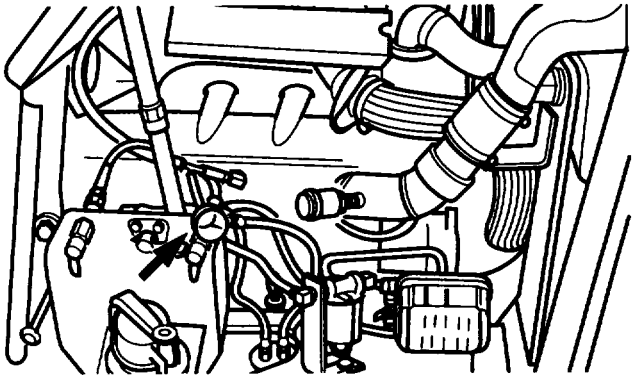




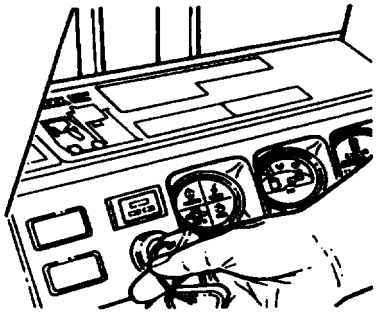
1. Open and remove both side doors, and raise the seat deck. Be sure the seat deck support is securely latched.



2. Connect a tachometer.



3. Check all throttle control linkage for complete and free movement.



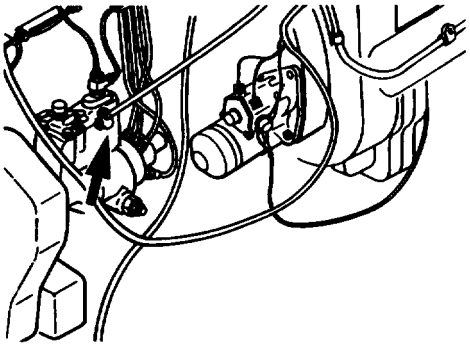
4. Start the engine and let it warm up until it runs evenly and accelerates smoothly when you push on the accelerator pedal.

Allow the engine to warm up to operating temperature before putting it under any load conditions.

Engine RPM at Idle

Engine Idle Speed Chart

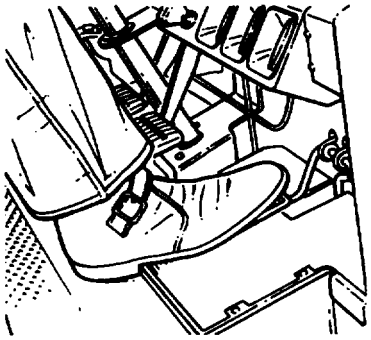
Truck Engine Model	*Idle Speed Setting*
TMD27 Engine	650 rpm, nominal Range:600-700 rpm



Check the engine idle speed. If idle speed is not within specification, adjust the idle screw setting, as necessary.

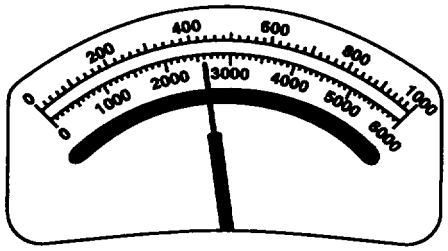
Refer to Section 4.10, Engine Adjustments.

Engine RPM At Max No-Load Governed Speed



Push the accelerator pedal slowly to its maximum travel (fully down position). When the governor begins

taking control of the throttle, slight variation (hunting) in engine speed may occur. This should not be considered an abnormal condition. When the engine speed has stabilized, check maximum no-load governed speed.



Engine No-Load Governed Speed Chart

Truck, Engine Model	*No-Load Speed Setting*
TMD27 Engine	2600 rpm, nominal Range: 2550 2650 rpm

Truck, Engine Model	*Engine Hydraulic By-Pass Speed*
TMD27 Engine	2000 2200 rpm, approximately

Full Throttle Engine Stall RPM

WARNING

- Stall tests must be performed with the parking brake applied and wheels blocked up above the ground to prevent movement. Be careful that the truck does not move unexpectedly when operating the engine and converter at stall. Unexpected movement of the truck could cause injury or death to personnel.
- Do not run engine and converter at stall longer than necessary to take the rpm readings or longer than 30 seconds at one time. Then, shift transmission into NEUTRAL for 15 seconds and run the engine at one half speed for 1-2 minutes to cool torque converter oil. Excessive temperature 250°F (120°C) max will overheat the converter and cause damage to converter, seals, and fluid.

NOTE

- Hydraulic bypass test must be done first to be sure that the engine is running properly.
- Be sure that transaxle fluid level has been checked and is correct, and all mechanical checks of shift linkage and brake-inching pedal adjustment have been made before running a stall test.

Refer to Section 7.2, Transmission Troubleshooting.

- Add load on forks to increase weight and prevent inadvertent drive wheel spin.
- Use of the service brakes (with inching) will release the transmission clutches and prevent stalling of the torque converter.
- A stall test is perhaps the most important and useful test for quickly determining engine condition.

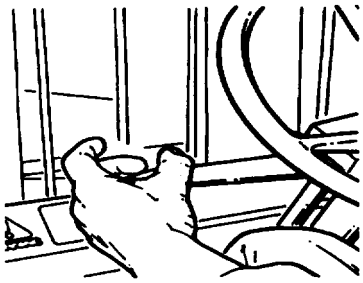
The parking brake should hold the truck from moving under full stall torque. If not, it requires adjustment, or the service brakes need adjustment or servicing.

NOTE

Prior to performing stall test, it is recommended that you first:

- Park truck safely.
- Return all controls to neutral.
- Put blocks under upright rails and raise the drive wheels off the ground.
- Put blocks under frame.
- to Part 8, Brakes.

Refer to Part 8, Brakes



1. Put directional control level in FORWARD (or REVERSE), as applicable, depending upon truck position to barrier.
2. To test all clutch assemblies in the transmission, check stall speeds and vacuum with transmission in forward and reverse.
3. Check stall speed at full throttle. Slowly push the accelerator pedal to its maximum travel (fully down) position and hold while doing test.

Stall tests should be a part of all engine tune-ups and must be carefully conducted and analyzed to pinpoint specific problems.

Stall tests must include RPM and hydraulic pressure measurements to accurately diagnose specific problem areas.

Engine speed checks with engine under load are made to also determine whether major components or systems-other than the engine-are causing problems.

Full Throttle Stall Speed Chart

TMD 27 Engine	2100 rpm, nominal Range: 2000 2500 rpm

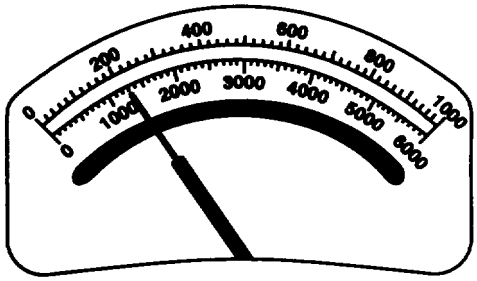
Analysis of Stall Test

NOTE

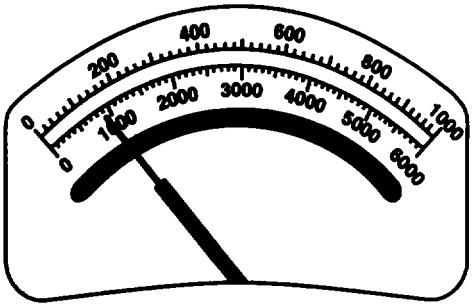
- If stall speed is low, do not automatically blame the torque converter. Carefully check engine condition. Frequently an obstruction, e.g. carbon plugging, in the air intake or exhaust system is the problem.

- When high stall speed is found, perform transmission pressure tests (see following) to help isolate the problem area.

1. Operation at nominal stall speed is an indication that:
   a) Engine performance is good (correct).
   b) Torque converter is operating correctly.
   c) Transmission clutch packs are operating correctly (not slipping).

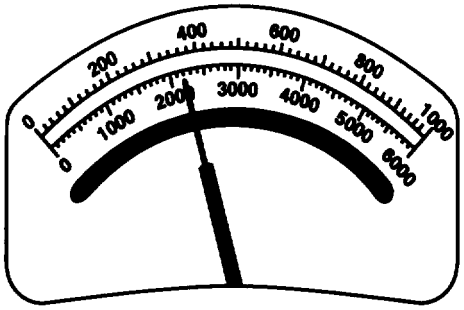


2. Below normal stall rpm is typically 1500 - 1800 rpm. **Low stall rpm** is an indication that the:
   a) Engine performance is faulty (needs tune-up or repair).
   b) Hydraulic pump is defective or return line is blocked. Repeat hydraulic bypass test.
   c) Transmission and torque converter are in satisfactory condition (performance is correct).



3. Very low stall rpm (750 - 1500 rpm) is an indication that:
   a) Torque converter stator is slipping. Repair of torque converter is required.
   b) Engine has an obstruction in air intake or exhaust system.

4. High stall rpm (greater than 2400 rpm) is an indication of:



   a) Low transmission clutch pressures, due to:

      (1) Inching pedal linkage requires adjustment.
      (2) Stuck inching valve.
      (3) Weak (worn) transmission charging pump.
      (4) Faulty transmission pressure regulator valve.

   b) Transmission clutch pack disc slippage due to low pressure (see above), or glazing on the disc surfaces.
   c) Torque converter blade (fin) damage (loose, bent, or broken).
   d) Converter spline worn.

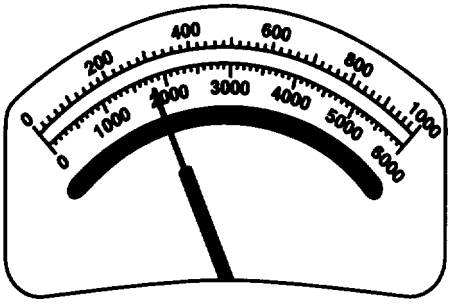
Transmission Pressure Checks

Perform a complete check of transmission pressures, including individual clutch apply pressures. Refer to section 7.3, Transmission Pressure Checks.

1. If transmission pressures are correct, check further for:

   a) Clutch disc glazing,
   b) Torque converter blade damage, or
   c) Converter spline wear.

2. To do this, stall the engine at full throttle for 30 seconds, let the engine speed return to idle, then accelerate the engine speed slowly again to full throttle.



   a) If stall rpm returns to normal, this is an indication that the clutch discs are glazed.
   b) If stall rpm is greater than normal, this is an indication that the torque converter fins are damaged, splines are worn, or clutch is worn or damaged. Transmission repair is required.

Test Completion

1. When engine RPM and stall tests are completed, turn the engine off.
2. Remove the tachometer.
3. Lower and latch the seat deck. Be sure that the seat deck is correctly latched. Install and close the side doors.
4. Raise the truck and remove blocking, if used. Lower the drive wheels to the floor.

4.8. Cooling System

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Cooling System Troubleshooting

It is important to control the temperature range of the coolant in order to maintain best engine efficiency. The efficiency of the cooling system can be affected by any of the following:

Engine Running Too Hot

- Coolant level is low.
- Plugged radiator (internal or external).
- Faulty radiator cap.
- Fan belt slipping.
- Fan blades reversed.
- Defective viscous fan drive.
- Damaged or collapsed coolant hoses.
- Missing or damaged fan shroud or shields on radiator.
- Air entrained in cooling system.
- Ignition timing late or severely retarded.
- Excessive exhaust system back pressure.
- Missing or improperly adjusted exhaust tailpipe.
- Engine oil level is low.
- Engine oil needs changing.
- Faulty thermostat.
- Defective temperature gauge.
- Clogged water passages in engine.
- Worn or broken water pump.
- Worn internal engine parts.
- Leaking head gasket.
- Engine being overloaded.
- Brakes dragging.
- Transmission fluid level low.
- Transmission slipping.
- Transmission damaged or improperly adjusted.
- Locked converter stator.

Engine Running Too Cold

- Faulty thermostat.
- Defective temperature gauge.

Oil In Coolant or Coolant In Crankcase

- Leaking head gasket.
- Cylinder head bolts not tight.
- Cylinder head cracked.
- Engine cylinder block water jackets cracked.
- Cylinder liner seals leaking (when applicable).
- Transmission oil cooler leak.

Water Pump Leaking

- Worn or broken water pump gasket.
- Worn pump shaft and/or seal.
- Pump body cracked or damaged.

Water Pump Making Noise

- Worn pump shaft or bearings loose or worn.
- Pump impeller broken.
- Loose fan belt.
- Bent or broken fan blade.
- Fan hitting engine or shroud.

Engine Coolant Specification

Refer to Section 2. 1, Service Specifications, Cooling System.

NOTE

- **For maximum cooling efficiency, always keep the cooling system filled with the recommended coolant mixture year around and at all ambient temperatures.**
- **The use only of an antifreeze having a low-silicate additive content is strongly recommended. Silicates are added to antifreeze to help protect aluminum cylinder heads in automotive engines. During use, the silicate additives may react to form gummy deposits that can block and seriously damage a cooling system. Low-silicate antifreeze is available for heavy duty use. Also, some tap waters react adversely with coolant chemicals. If your local tap water is "hard," use distilled water.**
- **The cooling system is initially filled with a factory installed solution of 50% water and 50% permanent type antifreeze containing rust and corrosion inhibitors. You should leave it in year around. Plain water may be used only in an emergency, but replace it with the specified coolant as soon as possible to avoid damage to the system or engine. With only water in the system, do not let the engine run hot.**
- **DO NOT USE ALCOHOL OR METHANOL ANTIFREEZE.**

Add to or fill radiator only with recommended coolant mixture of 50% water and 50% low-silicate ethylene glycol permanent-type antifreeze containing rust and corrosion inhibitors.

Engine Coolant Level Check

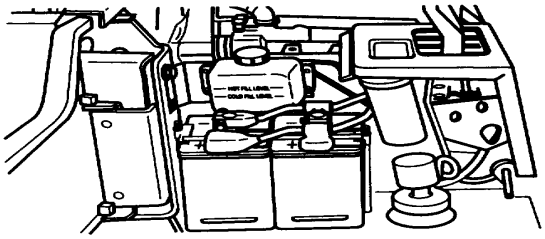
WARNING

Do not remove the radiator cap when the radiator is hot. Steam or hot coolant from the radiator can cause severe burns. Never remove the radiator cap while the engine is running. Stop the engine and wait until it has cooled.

Remove the radiator cap only with engine stopped and when engine is cold.

NOTE

Fork lift truck applications require also checking the coolant level directly in the radiator. Lift truck radiators will plug-up and overheat which will force coolant into overflow reservoir and on out at the cap. This results in a low coolant level which exposes the transmission oil cooler causing engine/transaxle overheating.



1. The coolant level should be at the "COLD" level line on coolant recovery bottle when engine is cold.
2. Coolant level in the radiator should also be checked at lease once a day (or every 8 hours of operation) to make sure radiator is 100% full at all times.
3. First, turn the cap slowly to release any pressure that may be in the radiator. Then, push the cap fully down and turn to release and remove the cap.

General Procedures

NOTE

If coolant has to be added more than once a month or if you have to add more than one quart at a time, check the cooling system for leaks, or other reasons, e.g. cooling system overheating. See below.

Open vent (petcock) on water pump when filling cooling system.

1. If coolant level in the radiator or overflow reservoir is low, add a 50/50 mixture of specified coolant and water to the correct fill level.
2. If the cooling system requires the addition of a large quantity of coolant, and the engine has been overheating:
   a) Inspect radiator for blockage of air flow through the fins. Air clean the radiator.
   b) Check the tailpipe. Be sure exhaust flow is not blowing into the radiator.
   c) Check fan belt and cooling fan drive control (as applicable).
   d) Check and be sure fan is not installed backwards (a common problem).

e) Check engine oil to see if it contains coolant.
f) Check that radiator cap has correct pressure rating. Replace if incorrect.
g) Pressure test the radiator cap. Replace if faulty.
h) Pressure test the radiator and cooling system. Repair any leaks or blockage.
i) Test the engine thermostat. Replace as needed.

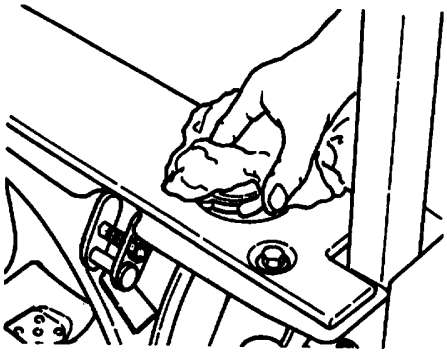
Cooling System Inspection

WARNING

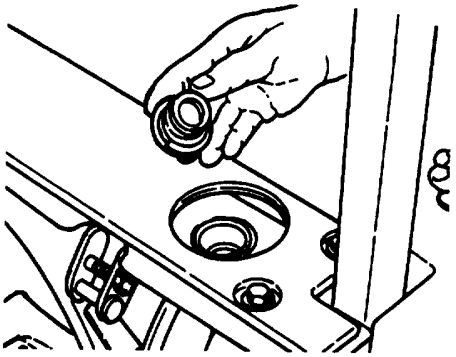
Use extreme care when removing the cap from the radiator. It is good safety practice to use a shop cloth to cover the radiator cap while it is being removed. Wrap the cloth around the cap and turn cap slowly to the first stop. Step back while the pressure is released from the system. When you are sure all of the pressure has been released, press down on the cap with the cloth in place, turn, and remove the cap. Stand clear of the radiator opening; hot coolant may splash out. Failure to follow these instructions could result in serious personal injury from hot coolant or steam blowout and/or damage to the cooling system or engine.

NOTE

A coolant solution containing 50% ethylene glycol provides freezing protection to -34°F (-37°C).

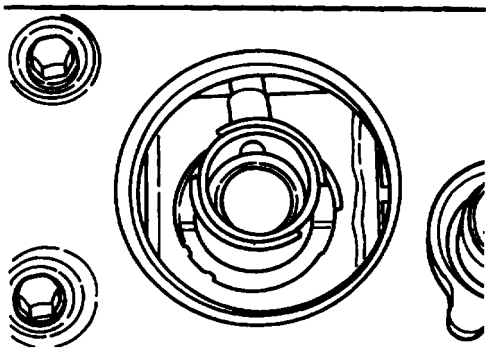


1. Remove the radiator cap.
2. Inspect the condition of the coolant. Look for excessive contamination, rust, or oiliness, and gummy deposits in the coolant solution. The coolant should have a clean appearance.
3. **Check the PM time Interval,** or the condition of the coolant, to determine if it needs to be changed (drained and replaced).

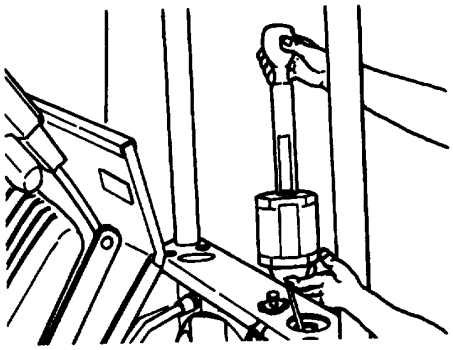


4. Inspect the radiator cap. Check condition of upper and lower rubber seals (with overflow reservoir, cap has two seals). Check the seal holder and spring for correct movement and operation. The rubber seal face should be clean and not damaged. Look for nicks and cracks in the seals. Replace the cap if it is defective.
5. Be sure the radiator cap has the correct pressure rating. System Pressure (Radiator Cap) 14 psi, nominal.

Refer to Section 2.1, Service Specifications, Cooling System.



6. Inspect the radiator cap sealing surfaces located in the radiator filler neck. Look for nicks, deep scratches, or damage which may cause radiator cap leakage.
7. Inspect the overflow pipe and tubing for clogging damage and wear. Clean the overflow pipe. Remove any contaminants that can cause restriction. Replace the tubing if it is faulty.
8. Inspect and clean the overflow reservoir, as needed.



9. Use a coolant tester to test the low temperature protection ("freeze") level (proportion of ethylene glycol to water) of the coolant solution. Add coolant solution (antifreeze and/or water) to provide maximum cooling system protection (50/50 mixture).

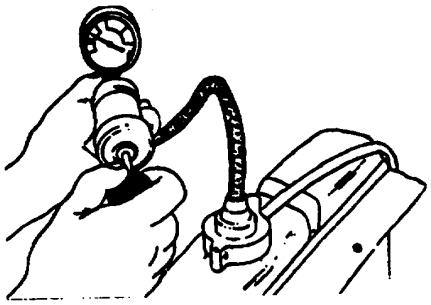
Cooling System Pressure Tests

If the need is indicated for further maintenance and testing of the cooling system, check for both external and internal leaks in the cooling system with an accurate pressure pump and gauge tester.

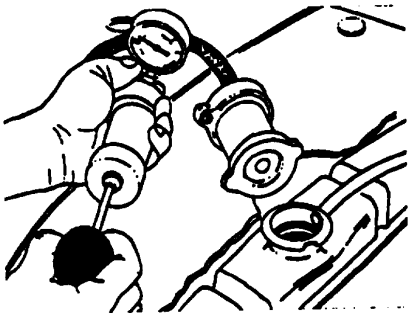
Cooling System Pressure (radiator cap): 14 psi (12-16psi)

Refer to Section 2.1, Service Specifications, Cooling System.

Radiator & Cooling System



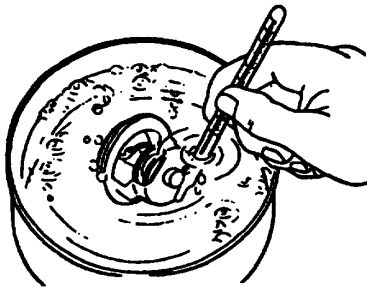
1. Pressure test the radiator cap to determine if it is holding the correct pressure. Wash cap in clean water to remove dirt or scale from sealing surfaces. Wet rubber sealing surfaces and install cap tightly on the tester. Pressurize tester and radiator cap.
2. The gauge pressure reading should be within the specified limits of the cap relief pressure. If the test relief pressure either exceeds or is below the specified limits, replace cap.



Radiator Cap

1. Pressure test the radiator and cooling system to determine if it will hold the correct pressure without leaks or failure. Wet the rubber sealing surfaces and install the tester cap tightly on the radiator filler neck. Apply pressure to the cooling system equal to the radiator cap specified relief pressure.
2. Observe gauge reading for approximately 2 minutes. Pressure should not drop during this time. If pressure drops, check for leaks in radiator, radiator cap, hoses, connections, engine components, etc.

Thermostat



1. Remove and test the engine thermostat to determine if it closes correctly and opens at the specified temperature.

2. Place thermostat fully immersed in a pan of water. Heat the pan slowly while stirring water to produce an even temperature. Use a thermometer to measure the temperature at which the thermostat valve cracks (starts to open) and, when it is fully open, measure the valve lift distance of the fully opened valve. If test results are not to specification, replace thermostat.

3. Replace the thermostat if even a slight opening of the valve at normal temperature is found or if its appearance shows any breakage. If the sensing part is damaged, the thermostat valve will remain closed.

Engine Coolant Change

It is recommended to drain and replace the engine coolant every 2000 hours, or once a year.

Cooling System Capacity: 9 quarts (8.5 L).

Refer to Section 2.1, Service Specifications.

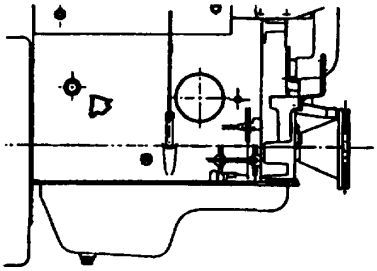
Draining Radiator & Cooling System

WARNING

The radiator is very hot and pressurized during vehicle operation. Let radiator cool before removing cap. Failure to do so can result in serious burns.

NOTE

The radiator does not have a drain fitting.



1. Place a large drain pan (minimum capacity 11 q [10.4 L]) under radiator and engine.
2. Remove the radiator cap.
3. Loosen hose clamp and remove the lower coolant hose from radiator. Drain coolant into drain pan.
4. Remove coolant drain plug from engine block. Drain coolant into drain pan.
5. Inspect coolant hoses and clamps to determine if they need to be replaced.

Cleaning & Flushing Cooling System

NOTE

If the condition of the used coolant indicates severe contamination, rust deposits, scale, or oil in the system, it may be necessary to clean and flush cooling system with commercial cleaner. Choose a product from a reliable manufacturer and follow the manufacturer's recommendations in its use.

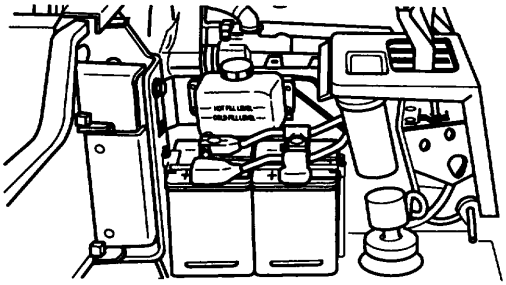
1. Install lower radiator hose.
2. Install coolant drain plug in engine block.
3. Fill cooling system and perform the cleaning and flushing operation in accordance with the recommended procedure.
4. Drain radiator and cooling system completely, as noted above.
5. Remove drain pan.

Filling Cooling System

NOTE

To cycle coolant from the recovery reservoir into the radiator, run engine until it reaches operating temperature, then stop the engine. Check coolant level in the coolant recovery reservoir when engine is cold.

With entire cooling system drained, the following procedure should be used to ensure complete fill:



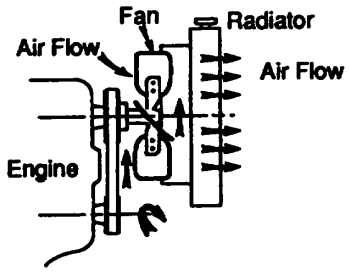
1. Fill radiator to the bottom of the filler neck opening with new coolant. Use recommended mixture only.
2. Install radiator cap securely.
3. Fill the coolant recovery (overflow) bottle reservoir to the 'COLD' level line with coolant mixture.
4. Start and run engine until radiator upper hose is warm, indicating thermostat is open and coolant is circulating through the system. Check for leaks at the hose connections and engine block plug.
5. Check coolant level in recovery reservoir when coolant is cold. Add coolant as required to the correct fill level.

Fan

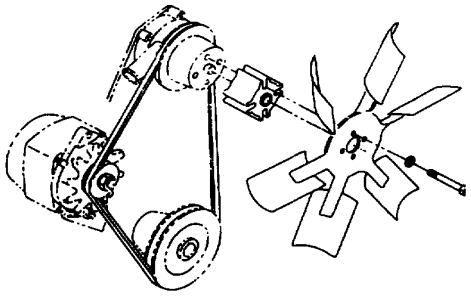
NOTE

If the fan has been installed backwards, about 50% of its cooling capacity is lost.

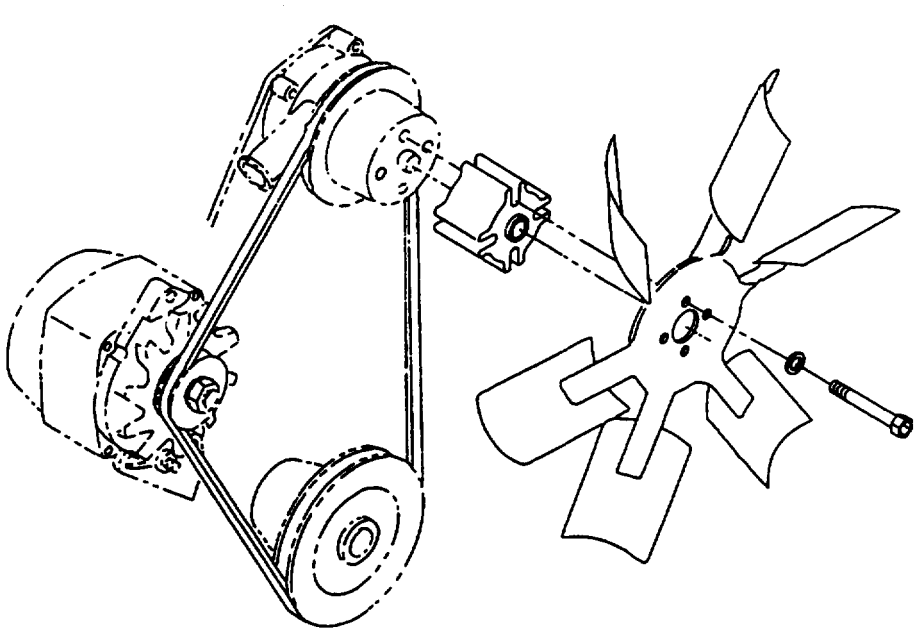
The fan is designed as a "pusher-type' fan, i.e. to push air through the radiator. The fan blades should be installed with their curve to push air into the radiator as they turn in the direction of right-hand engine rotation.



1. Check for loose fan mounting screws.
2. Inspect fan blades for damage.
3. Check for fan installed backwards (This is a common problem). If fan is installed backwards, remove and install correctly.



Cooling Fan Installation



Fan Belt

1. Inspect fan belt and pulleys for damage.
2. Fan belt must not have any cracks or contact bottom of pulley grooves.
3. Be sure there is no oil on fan belt.
4. If fan belt is worn, oily, or damaged, clean or replace, as necessary.
5. Fan belt adjustment not OK :Adjust, as necessary.

Fan Belt Tensioning

NOTE

Particular attention should be paid to V-belt tension, as slipping belts are the cause of many other problems in accessory drives as well as in the cooling system. Low belt tension can Induce slipping, with resultant excessive belt and pulley wear.

A slipping belt will not drive the alternator to full output, eventually leading to battery discharge problems. A belt which has been slipping will be glazed and cracked. Such a belt should be replaced. Excessive belt tension will create an overload condition in the alternator front bearing and in water pump bearings.

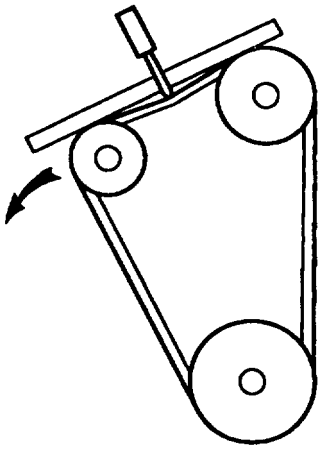
Fan Belt Tension Specification

CAUTION

When tensioning fan belt, tighten drive belts by applying pressure to the alternator front housing only. DO NOT apply pressure to the rear housing or stator or damage to equipment may result.

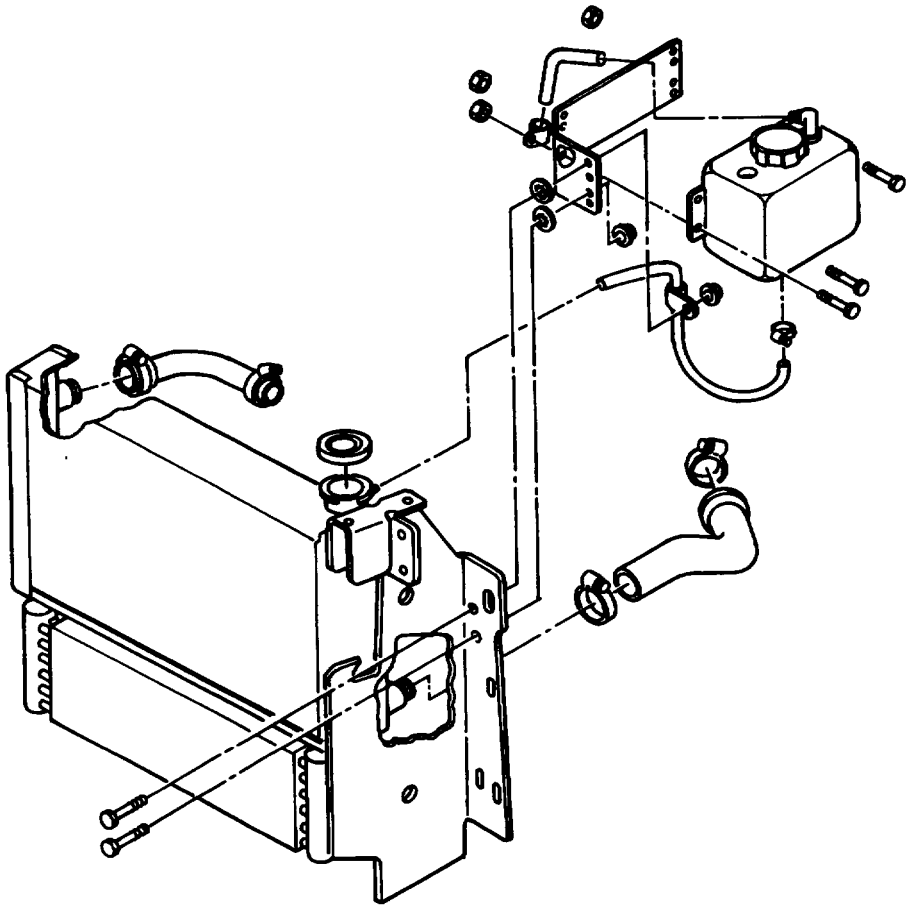
NOTE

New belt will lose a substantial amount of the original tension in the first few hours of operation as the belt seats into the pulleys and should be retensioned accordingly. Adjust belt tension to 2.5 - 3.2 lb ft (11.1 - 14.2 N•m) @ .20 in (5.2 mm) deflection at midpoint of span.

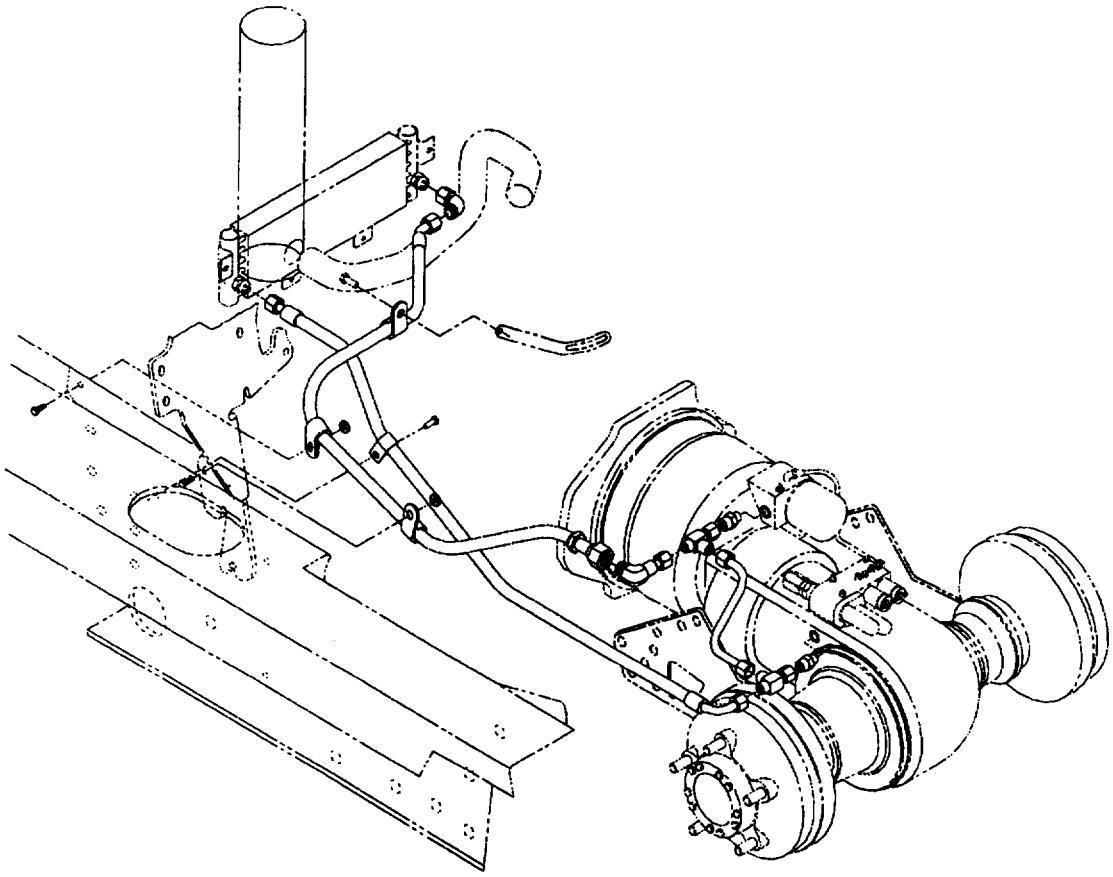


1. The fan belt is tensioned by adjusting the alternator.
2. Loosen bolt at alternator adjusting strap, tighten belt as required, and retighten bolt. Cooling System

Cooling System



Transmission Cooling Lines
TA18 Transaxle



F-101 (F-102 blank)

4.9. Engine Air Cleaner

Air Cleaner Maintenance F-103
Air Cleaner F-104
Air Cleaner Assembly F-105
Air Cleaner Removal F-106
Air Cleaner Installation F-106
Canister Dry Air Filter Service F-106

General Procedures

The reason for providing an air cleaner for the engine is to protect the engine; that is, to prevent abrasive dust and dirt from entering the cylinders and causing excessive wear. All air contains some dust and dirt, but the industrial environment in which many lift trucks operate can contain an extremely high concentration of abrasive dust, loose fibers, or other contaminants. Without an air filter (or with an air filter element or hoses and clamps that are damaged and leaking), engine wear life can be shortened dramatically. For example, a 1/4 teaspoon of dust per hour can ruin an engine in one, 8-hour day.

A clogged air filter will cause engine power loss and poor fuel economy.

It is, therefore, extremely important to properly service the air cleaner on a regular basis and to maintain the engine air intake system in a clean, secure condition (tight connections and good hoses without leaks).

The operating environment dictates the air cleaner service periods. In extremely dusty or dirty operations, this may be as often as once or twice daily.

Air Cleaner Maintenance

In general, it is recommended to replace the engine air filter element every 50 to 250 hours of engine operation, depending upon the application and operating conditions, except as noted below.

CAUTION

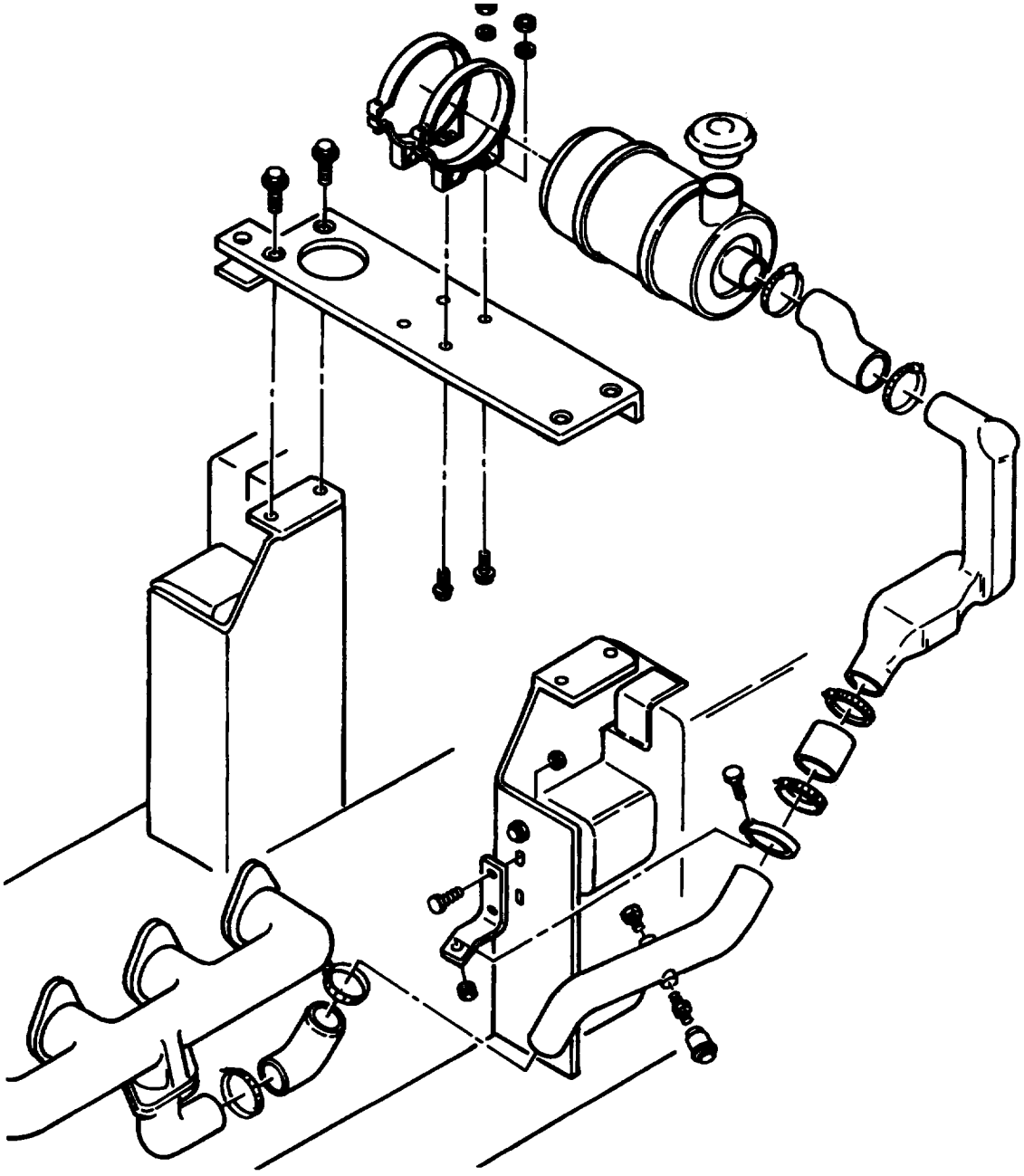
Be careful when inspecting or replacing the air filter element to prevent loose dirt from entering the engine air intake housing or hose. Damage to engine may result.

NOTE

Truck air cleaner should not be serviced unless the air restriction indicator shows service is required. Do not "over- service."

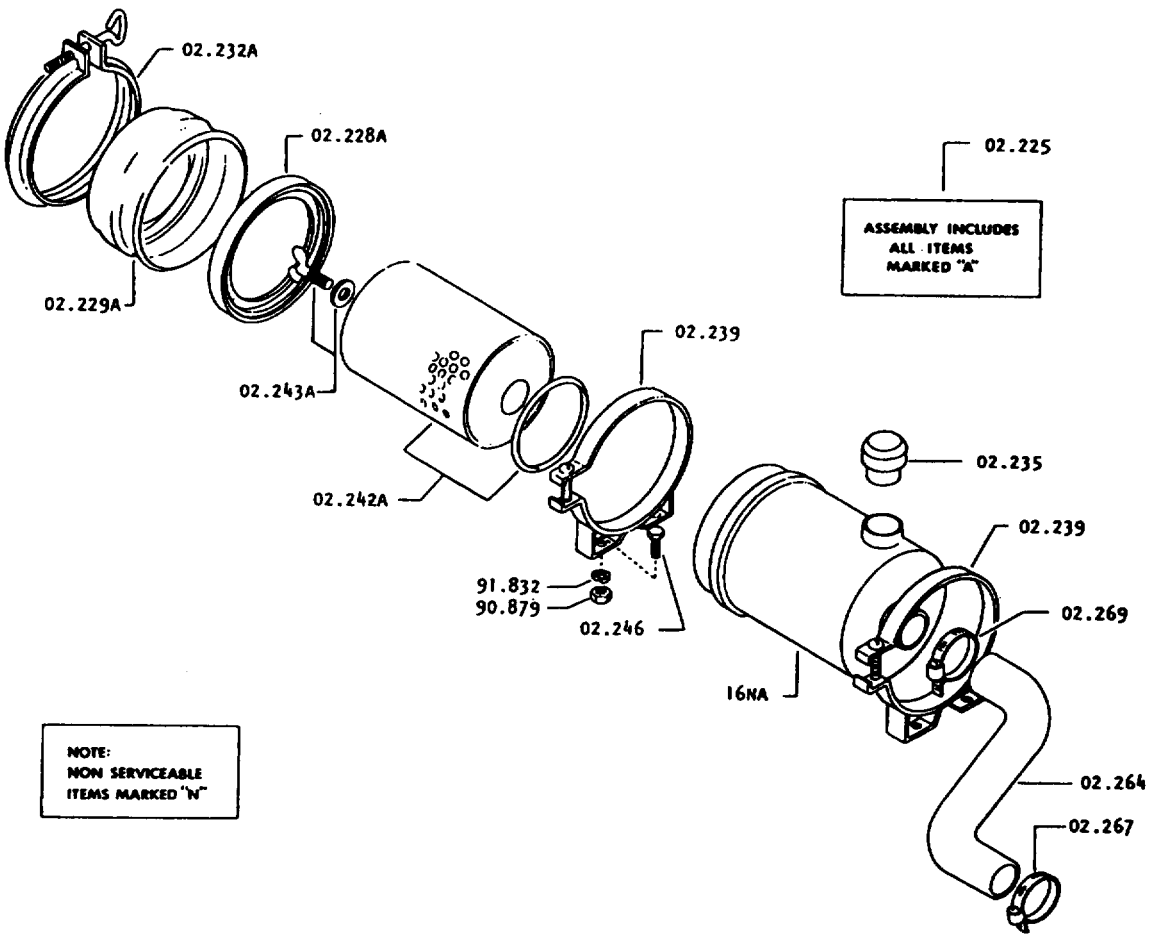
1. Inspect the air filter element for damage and contamination (excessive dirt build-up and clogging). Replace, as required.
2. When replacing the air filter element, always inspect the air intake passages for evidence of dirt build-up. Clean (wipe out) the housing. Remove and clean the hose to carburetor air horn, as necessary.
3. Check air cleaner mounting and connections. Be sure the air cleaner hose is securely connected (not loose or leaking).

Air Cleaner
GPX Model (Diesel)

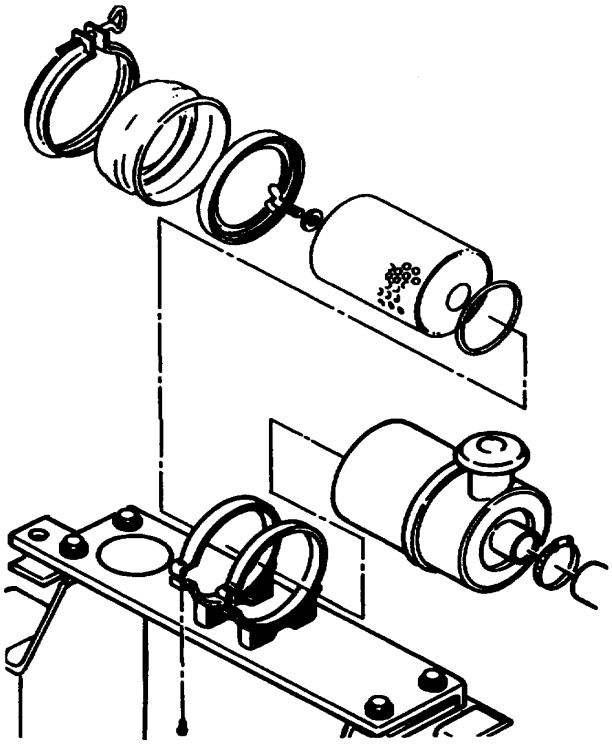


F-104

Air Cleaner Assembly
GPX Model - Diesel



Air Cleaner Removal

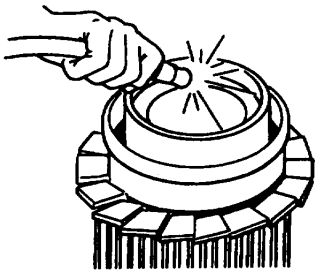


1. Remove the filter cover and filter assembly.
2. Remove the 2 bolts that mount the air cleaner housing to the frame.
3. Loosen the clamp on the air cleaner hose at the air horn.
4. Remove the air cleaner housing and hose from the truck.

Air Cleaner Installation

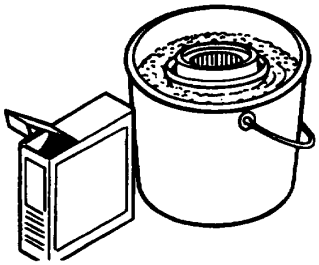
Installation is in reverse order of removal Mounting bolt tightening torque specification: 53 - 58 lb ft (72 - 82 N•m).

Canister Dry Air Filter Service



1. Remove the air cleaner and clean the dust out with compressed air.

2. Check it for holes by shining a light through it.



3. If it is still serviceable, finish cleaning according to instructions on the filter. If not serviceable, replace with a new one.

4.10. Engine Adjustments

Engine Adjustment F-107
Idle Speed Adjustment F-108
Accelerator Pedal & Linkage F-108
Throttle Linkage Adjustment F-108
Governor Adjustment F-110

Engine Adjustment

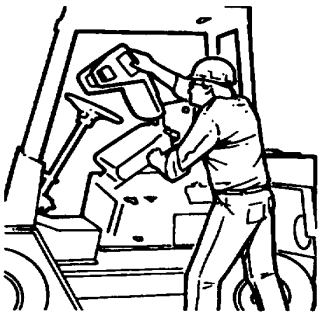
Engine Adjustment
Procedures Include:

1. Throttle Linkage.
2. Governor Adjustment.

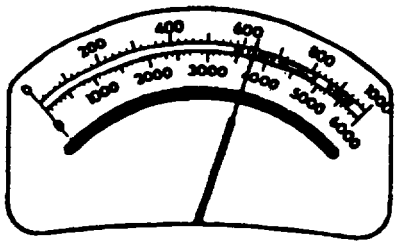
NOTE

To perform this service procedure, it is recommended that you first:

- Park truck safely.
- Apply the parking brake. Block the wheels.
- Return all controls to NEUTRAL and turn key switch OFF, except as noted.



1. Open engine compartment and raise the seat deck. *Be sure the seat deck support is securely latched.*
2. Check the condition of the accelerator control and throttle linkage to the fuel control to be sure it operates freely. Press the accelerator pedal to accelerate the engine speed and let it return to idle. Check to be sure that the throttle arm idle stop screw makes contact with the idle stop tab on the throttle lever, or idle stop pin on the carburetor.
3. If the idle stop tab or screw does not contact the idle stop, check for damage to or binding of the link- age, or defective throttle return springs.
4. The condition of both accelerator return springs should be checked for signs of wear or failure.
5. Adjust or repair linkage before making adjustments to the idle speed setting.



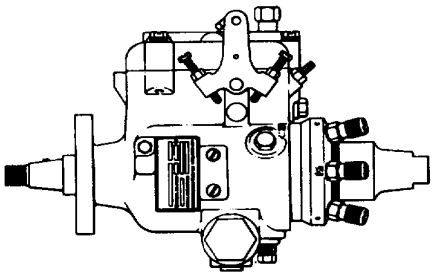
6. Check the idle speed setting using tachometer.

Idle Speed Adjustment

1. Connect a tachometer to the engine.

2. Adjust the idle speed setting by turning the idle stop screw clockwise to increase speed or counter-clockwide to decrease speed. Speed should be adjusted until engine idles at 600 - 700 rpm.

3. Remove the tachometer from the engine.



Accelerator Pedal and Linkage

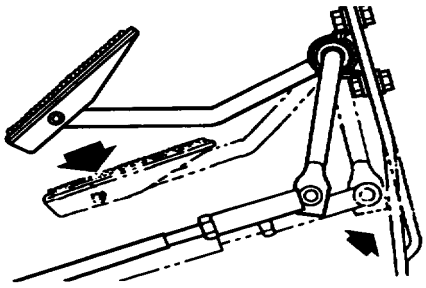
NOTE

The accelerator throttle linkage assembly should not require periodic adjustment. Check pedal linkage for correct operation. (With engine not running)

1. Check accelerator pedal travel. Move accelerator pedal to the fully-down position. The pedal should stop without hitting the floorplate *(normally there should be clearance between the pedal arm and the floorplate. This may vary in some installations).*

2. Remove the floorplates and open engine compartment side door for access to throttle linkage.

3. Check for correct linkage adjustment. Move accelerator pedal to the fully-down position.



4. Pedal travel should be stopped by the lower pedal lever striking against the inside of frame cowl, Figure 1.

Throttle Linkage Adjustment Procedure

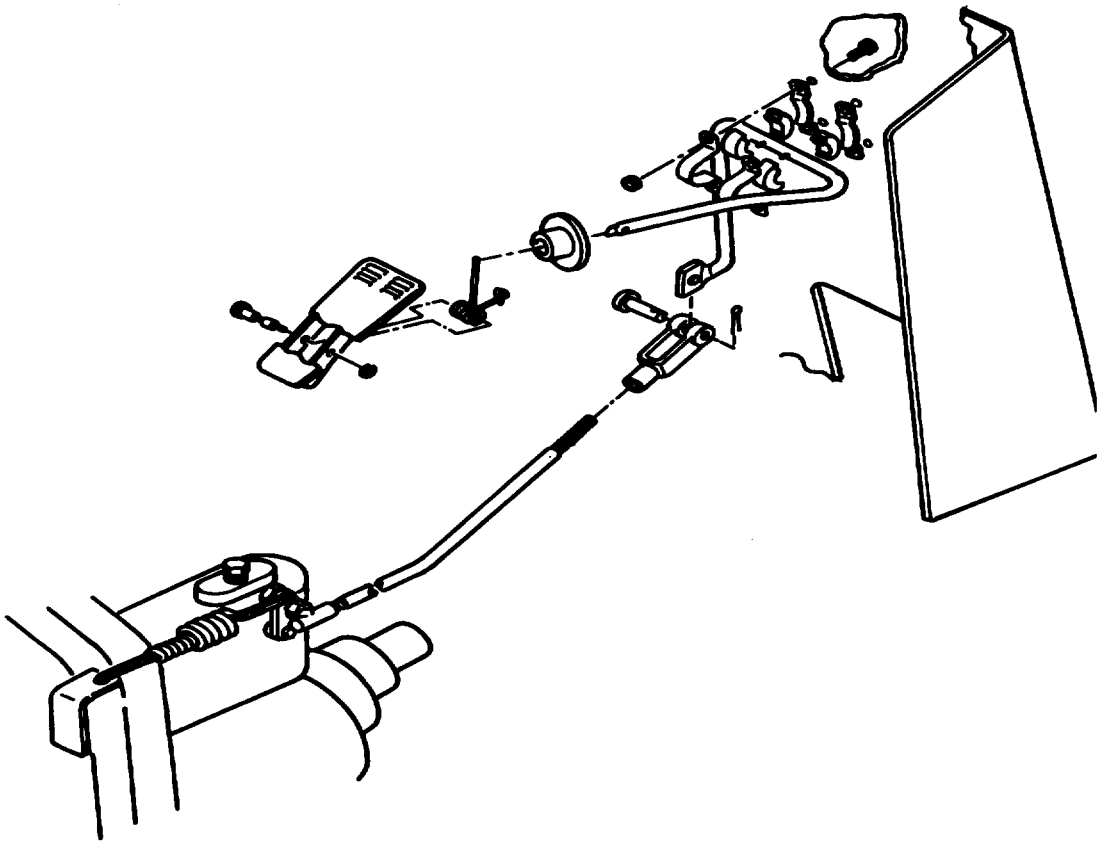
NOTE

The throttle linkage adjustment procedure is the same for all models, except Step 5, as noted below.

To adjust the throttle linkage, you must change the length of the control rod between accelerator pedal lever and the fuel control linkage as follows:

1. Loosen the lock nut on clevis rod end at accelerator pedal lever.
2. Remove cotter pin and clevis pin from rod end. Disconnect control rod from accelerator pedal lever.
3. Position accelerator lever assembly against cowl. Pull the accelerator control rod until fuel control lever is at wide-open throttle position.
4. Adjust clevid rod end as necessary until it aligns with hole in accelerator pedal lever (with lever against cowl).
5. After adjustment of throttle linkage, assemble rod end to accelerator pedal lever. Install clevis pin and cotter pin.
6. Tighten lock nut on control rod against rod end.
7. Check throttle linkage for correct adjustment.

Throttle Linkage Adjustment Procedure (Cont'd)



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Governor Adjustment

The function of the governor is to limit the maximum speed of the engine to:

1. Protect the main hydraulic pump.
2. Limit the maximum travel speed of the truck.
3. Prevent runaway or excessive engine rpm.

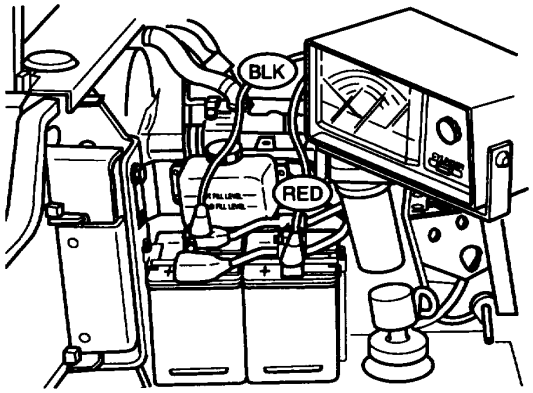
Normally, adjustment of the governor is not required. The correct no-load governed speed setting adjustment is made at the factory and the governor sealed before shipment. The seal should not be broken unless it is necessary, e.g., during engine overhaul. When the governor is replaced or readjusted, install a new seal. All operators should be instructed not to break the seal to tamper with the governor.
When engine speed is increased from idling speed by pushing on the accelerator pedal quickly, slight variations ("hunting") in engine speed may occur. This should not be considered an abnormal condition requiring governor adjustment.

NOTE

- **Be careful in making adjustments when the engine is operated at high speeds.**
- **Be sure that the drive wheels are raised off the floor, or blocked securely to prevent movement.**
- **Return all controls to NEUTRAL.**
- **Apply the parking brake.**

Preliminary Service Preparations

1. Open and remove both side doors and raise the seat deck. *Be sure that the seat deck support is securely latched.*



2. Connect a tachometer, or a combination test instrument.

Governor Adjustment Procedures

1 - Maximum Speed Setting

CAUTION

Under no circumstances should the engine be allowed to operate at a higher speed than is specified. Severe damage to the engine may result.

NOTE

When fitting a replacement fuel pump, or in the event of maximum speed screw having been moved, the maximum no-load speed must be checked and re-set, as necessary.

The maximum no-load speed will vary according to application. For details, reference should be made to the code number stamped on the fuel pump data plate. The last four numbers un the code indicated the speed setting required, e.g., 2600 rpm in following example:

Code Example: --AS62/800/02600

2 - Idle Speed Setting

The engine idling speed is adjusted by the idle screw. With the engine warm and running, turn the screw clock-wise to increase engine speed and counterclockwise to decrease idle speed.

4.11. Engine Removal
General Procedures

Truck Preparation Check List F-111
Engine Mounts F-112
Engine Removal Preparation F-112
Engine Removal F-116
Engine Installation F-117
Engine Installation Checklist F-117

CAUTION

It is recommended that the engine be removed only as a separate assembly disconnected from the transaxle. Generally, because of height (clearance) limitations, removal of the engine and transaxle as a unit requires extensive disassembly of the front structure of the truck, including removal of the dash and instrument panel. It is much easier and simpler to remove the engine by itself. Engine removal is also made easier with less chance of accidental damage to components when the counterweight and radiator are removed.
For safety and convenience, it is recommended whenever possible to use an overhead hoist to remove the engine from the truck.

NOTE

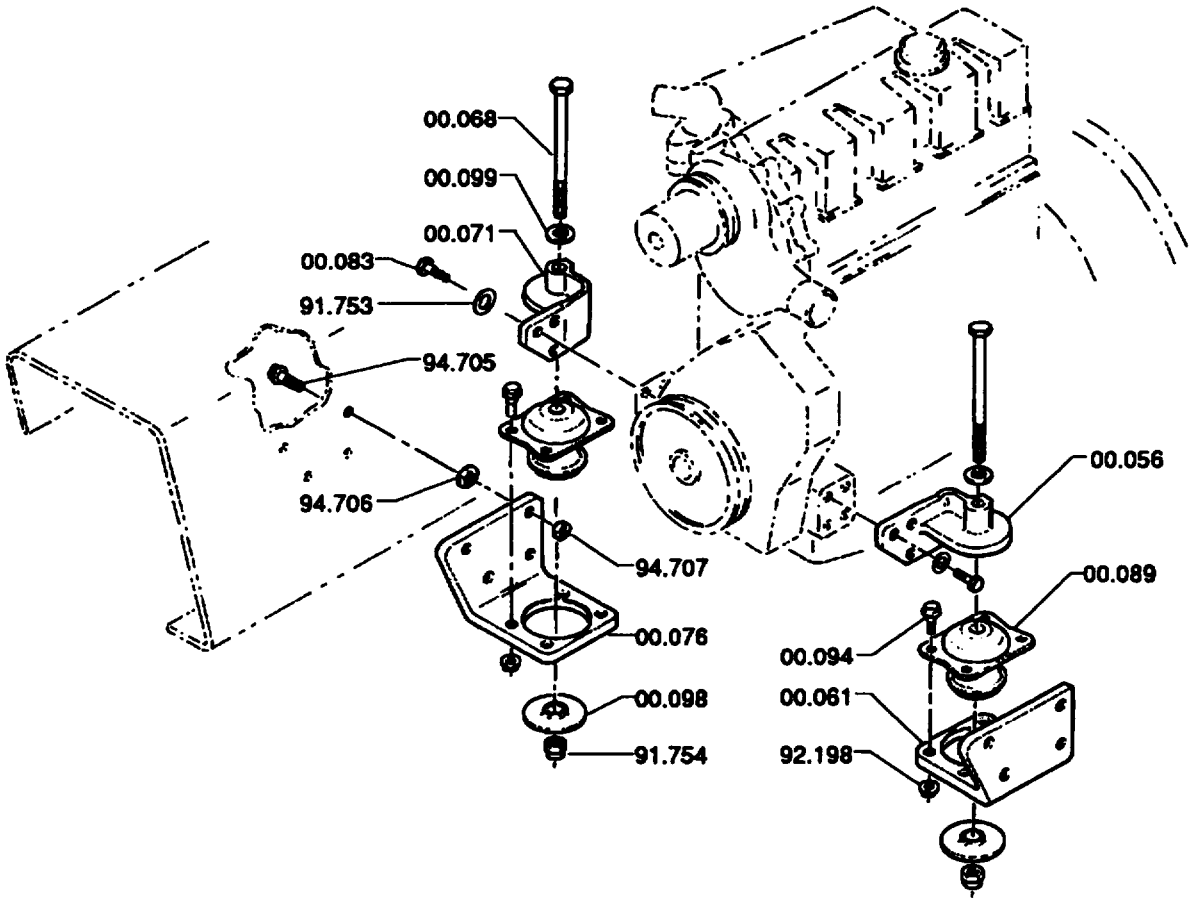
- **The information in this section describes general engine removal procedures Illustrated with typical views of the subject activity. Please check your engine model for specific component arrangement and corresponding service requirement.**

- **Prior to performing this service procedure, it is recommended that you first:**
  - **Park truck on a hard, level and solid surface, such as a concrete floor with no gaps or breaks.**
  - **Put upright in a vertical position and fully lower the forks or attachment.**
  - **Put all controls in neutral. Turn key switch OFF.**
  - **Apply the parking brake. Block drive wheels.**

Truck Preparation Checklist
The major part of engine removal consists of preparation (undressing) of the truck as necessary to allow engine removal. The following check list outlines the major steps.

1. Turn ignition switch OFF.
2. Open engine compartment. Remove side doors. Remove floor boards.
3. Disconnect battery ground (-) cable from engine connection first. Disconnect battery (+) cable from starter connection. Remove battery, as necessary for access.
4. Remove overhead guard.
5. Remove counterweight.
6. Remove top hood and seat assembly.
7. Remove main hydraulic valve cover. Loosen and remove firewall.
8. Loosen main hydraulic control valve mounting plate and tilt plate and main valve forward. Leave hoses attached to main valve. Disconnect selected hydraulic lines, only as determined by inspection as necessary for clearance.
9. Disconnect intake air cleaner hose. Remove air cleaner assembly for clearance and better access.
10. Remove muffler and tail pipe assembly. Disconnect and remove exhaust pipe from engine.
11. Remove radiator cover trim, sound seals, engine compartment sound seal plate, and radiator upper support.
12. Drain the radiator. Remove upper and lower radiator hoses. Disconnect coolant overflow line from radiator.
13. Disconnect transmission cooling lines at the radiator.
14. Remove radiator.
15. Remove wiring connections from alternator, starter, starter relay, coil, and engine sending units. Disconnect or remove wiring harness(es), as determined by inspection as necessary.
16. Disconnect accelerator control rod from carburetor or fuel control. Disconnect choke control wire (gasoline).
17. Disconnect fuel line(s) from engine.
18. Remove engine flywheel to torque converter attachment.
19. Remove flywheel housing or mounting plate to transmission housing attachment.
20. Remove front engine support mountings.
21. Move engine rearwards to disengage from transaxle. Carefully remove (hoist) engine from truck chassis.

Engine Mounts
GP Model - TMD27 (2.7L) Engine



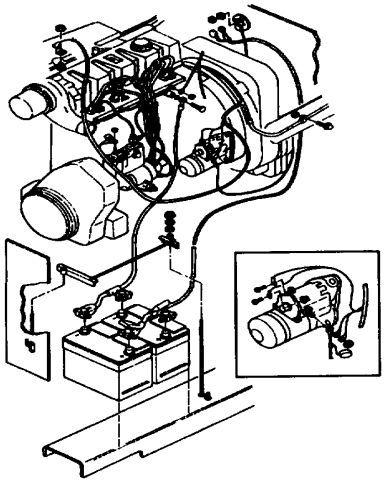
Engine Removal Preparation

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

1. Park truck safely.

2. Open engine compartment. Remove the engine compartment side doors by lifting upward and off the pivot pins Remove floorboards. *Reference Section 12.2 for illustration and parts nomenclature.*



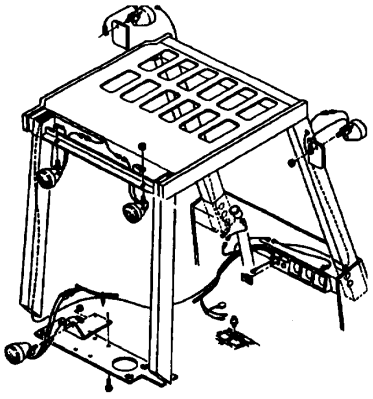
3. Disconnect battery ground cable from the engine ground connection first to prevent accidental sparking. Disconnect battery (+) cable from starter connection.

WARNING

Heavy components can fall and cause severe injury. Keep your feet and body clear at all times.

NOTE

- **Inspect your truck for locations of battery cable ground (-) and starter (+) connections. Reference Section 6. 1, Wiring.**
- **Disconnect floodlight wiring prior to overhead guard removal.**



4. Remove the overhead guard (OHG).Attach a chain hoist or sling of proper capacity to the top portion of the OHG and lift slightly to remove all chain slack. Remove the two fastener bolts on each side connecting the rear legs of OHG to the frame. Remove four fastener bolts (two per leg) connecting the front legs to cowl. Lift OHG off twck and store in a safe place. *Reference Section 12.2, Chassis Components.*

WARNING

Do not remove the counterweight unless you have training and are familiar with the correct procedures. Counterweights can fall if not handled correctly and cause severe injury or death.

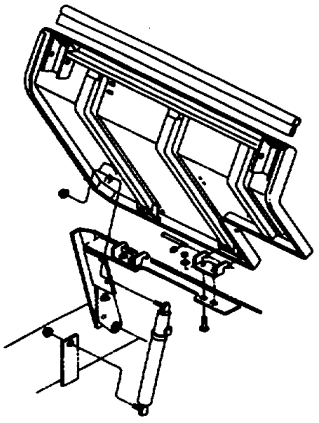
5. Remove the two mounting bolts at the outer lower end of the counterweight (near the tow-pin). Remove the two fasteners (one each side) attaching the counterweight to the frame in the engine compartment. Reference Section 12.1, Counterweight Maintenance.

CAUTION

The frame has hooks which support and hold the counterweight in place when correctly installed. Normally, the counterweight is held from falling off by these hooks when the fasteners are removed. However, be sure the hoist and lifting chains are securely attached to and supporting the counterweight before these fasteners are removed. Carefully lift and move the counterweight from the truck and store in a safe position.

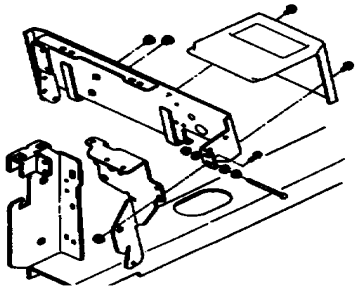
NOTE

Some support cylinders may have snap-on ball joints. Remove the pivot pins. Lift the seat deck off the truck and store in a safe position.



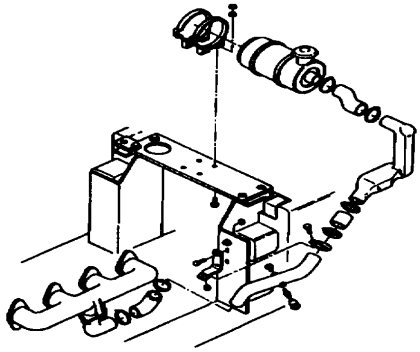
6. Remove the top hood (seat deck) and drivers seat as an assembly. The seat deck is retained by two pivot pins and a gas assist (support) cylinder. *Reference Section 12.2, Chassis Components.*

   First lift the seat to the fully-raised position. Use a chain hoist or similar holding means to support the seat deck in this position. Remove the clips retaining the pivot pins. Loosen and remove the nut holding the support cylinder to the frame bracket and disconnect the cylinder. *Reference Section 12.2, Chassis Components.*

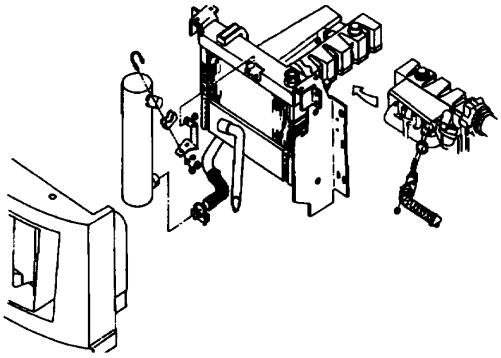


7. Remove the main hydraulic valve cover. Loosen and remove the firewall (plate assembly).

8. Loosen attachment of the main hydraulic control valve mounting plate. Tilt plate and main valve forward. Leave hoses attached to main valve. However, you may find that selected hydraulic lines will have to be removed or moved for clearance. Determine this based on your truck model installation.

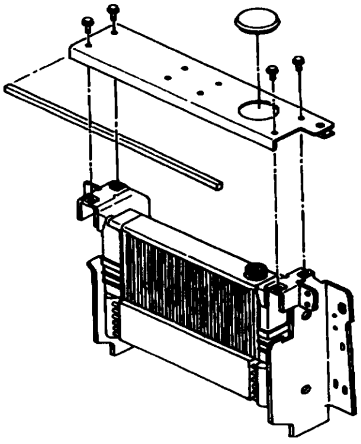


9. Disconnect the air cleaner nose from engine air intake. It is recommended to remove the engine air cleaner assembly from the truck for better access and clearance. *Reference Sections 4.12, 4.13,.4.14, Engine Components.*

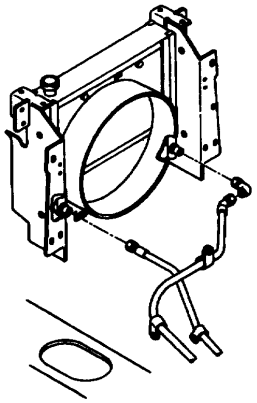


10. Remove the muffler and tailpipe. These can be removed as an assembly by removing the bolt holding muffler bracket to radiator upper support, or muffler can be separated by removing upper damp. First, loosen or remove the clamp on lower end of the muffler connection to exhaust pipe. Separate muffler from exhaust pipe.

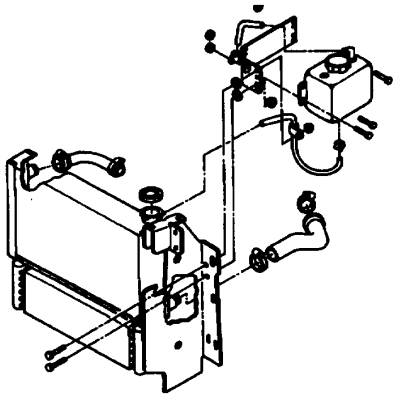
11. Remove the exhaust pipe. Disconnect the exhaust pipe from the engine exhaust manifold by removing the fasteners at the manifold flange joint and removing the exhaust pipe together with the gasket and seals, as applicable. *Reference Section 12.2, Chassis Components.*



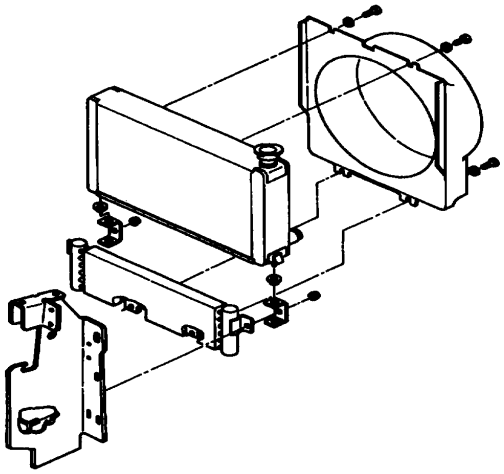
12. Remove radiator cover trim plate, sound seals, engine compartment sound seal plate, and radiator upper support.



13. Disconnect the transmission cooling lines from the radiator. Note or mark which is the upper or lower line and where it connects to the radiator. Put plugs in the radiator and caps on the ends of the lines to prevent drainage and entrance of dirt.

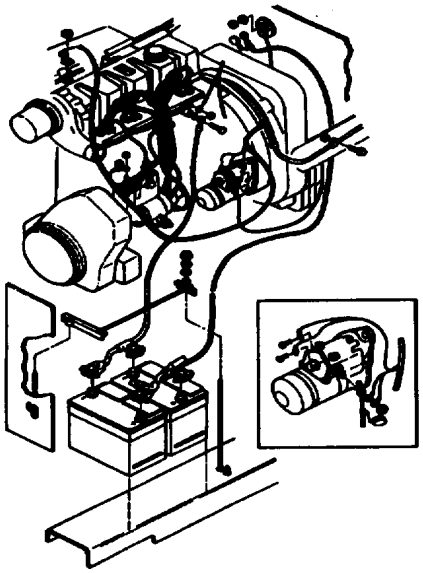


14. Drain the cooling system. Drain cooling system by removing lower hose from the radiator and coolant drain plug from engine block.
15. Loosen the hose clamps from the inlet and outlet water hoses and remove the hoses from the radiator and engine.
16. Disconnect coolant overflow line from radiator. *Reference Section 4.8, Cooling System.*

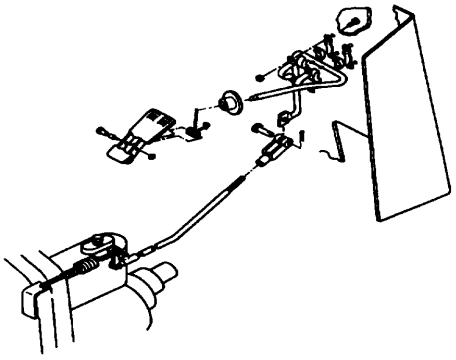


NOTE
Oil cooler is replaced with radiator.

17. Remove the radiator. Lift the radiator out of truck and store in a safe location.
18. Remove the radiator fan shroud.



19. Disconnect or remove wiring connections from alternator, starter, starter relay, coil, engine sending units, etc. Disconnect or remove and move wiring harness(es), as determined by inspection as necessary. *Reference Section 4.10, Engine Adjustments.*



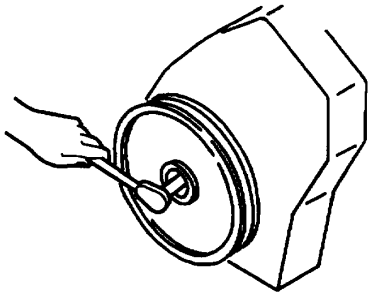
20. Disconnect accelerator linkage from engine connections.
21. Disconnect the fuel line(s) from engine connection at fuel pump inlet or engine fuel system. Reference Sections 5.1, 5.2, 5.3, Fuel System, for illustration and parts nomenclature.
22. Inspect truck for any other components that must be removed or disconnected before engine can be removed.

Engine Removal

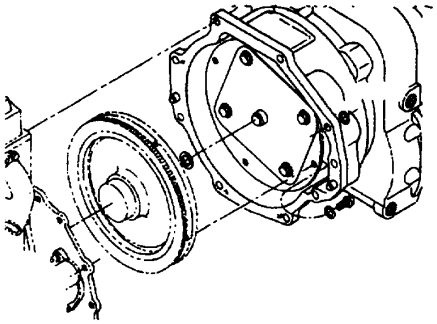
WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

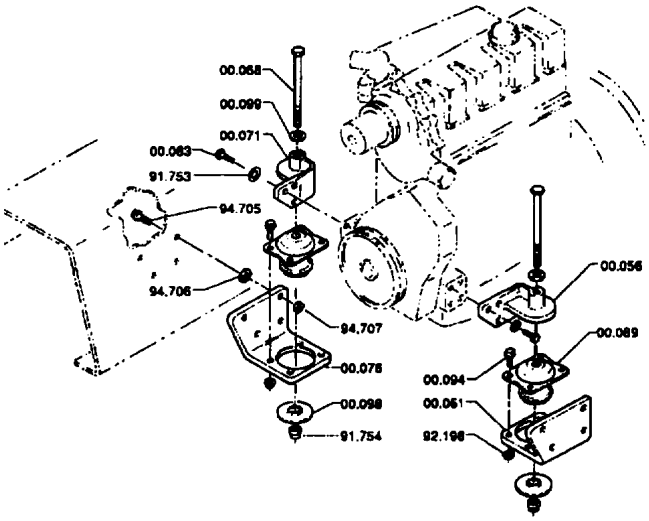
1. Connect an OSHA approved lifting cradle or section of lift chain of correct capacity to the engine lifting eyes, using bolts to fasten the chain to the eyes. Connect a chain hoist to this lift chain and raise slightly to remove all slack.



2. Use a socket wrench on the crankshaft pulley to rotate the engine flywheel to provide access to each torque converter fastener bolt by moving the fastener into a position where it can be reached through the access opening in the converter or flywheel housing. *Reference Section 7.4, Transaxle Removal*



3. Remove the fasteners attaching the torque converter to the flywheel. These can be reached by using the access hole in the flywheel housing. Reach through opening in flywheel housing with socket wrench to loosen and remove mounting bolts.
4. Remove the converter housing to engine rear mounting plate or flywheel housing fasteners.



5. Remove the engine mount fasteners from RH and LH front engine mounts. *Reference Pages 4.11-2, -,3, -4.*

CAUTION

Check and be sure all connecting parts, as necessary, have been detached from the engine and moved out of the way and that the hoist and supporting equipment are safely and securely attached to engine.

6. Carefully separate engine from transmission converter housing by moving engine towards rear of truck while supporting with chain hoist. Move engine far enough to allow the torque converter pilot shaft to slip out of flywheel pilot hole. It may be necessary to use prybars to disengage the assemblies. If the assemblies refuse to part, check to be sure all fasteners have been removed. Note - The converter stays with the transmission. Check TA18 transaxles for converter pilot shaft spacer. Spacer must be used when reinstalling engine.
7. Carefully and slowly lift the engine from truck with the chain hoist. Watch the engine as it is being moved to avoid bumping against truck and damaging engine components.
8. When engine is removed from truck, store it in a safe manner using adequate blocking to prevent it from tipping and falling.

Engine Installation

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

1. Connect an OSHA approved lifting cradle or section of lift chain of correct capacity to the engine lifting eyes, using bolts to fasten the chain to the eyes. Use a chain hoist to lift and handle engine.
2. TA18 transaxle. Be sure the converter pilot shaft spacer is installed.

NOTE

Align the mating holes for attaching the flywheel to the transmission torque converter as close as possible before starting the engine installation. If the mounting bolt holes in each unit are aligned, e.g., with the horizontal and vertical axis, they will be close to alignment when the units are assembled together.

3. Be sure the area for installing the engine is cleared of all wiring, hoses or other obstructions.
4. Proceed to install engine in approximate reverse order of removal.

ENGINE INSTALLATION CHECKLIST

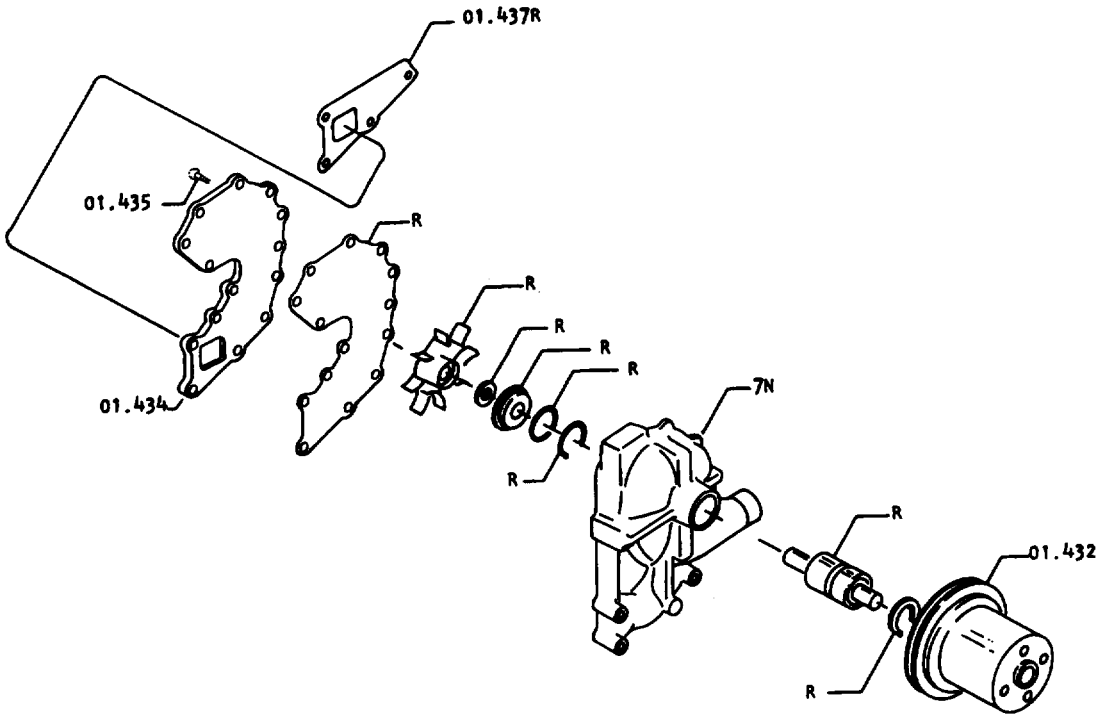
1. Carefully lower engine into truck chassis. Move engine forward to assemble to transaxle.
2. Install flywheel housing or mounting plate to transmission housing attachment.
3. Install engine flywheel to torque converter attachment.
4. Install front engine support mountings.
5. Install fuel line(s) to engine.
6. Assemble accelerator control rod to carburetor or fuel control. Reconnect choke control wire (gasoline).
7. Reconnect wiring connections to alternator, starter, starter relay, coil, and engine sending units. Reconnect wiring harness(es), as necessary.
8. Install radiator.
9. Install transmission cooling lines to the radiator.
10. Install upper and lower radiator hoses. Reconnect coolant overflow line to radiator. Fill radiator with specified coolant.
11. Install radiator upper support, engine compartment sound seal plate, sound seals, and radiator cover trim.
12. Install and reconnect exhaust pipe to engine. Install muffler and tail pipe assembly.
13. Install air cleaner assembly. Reconnect intake air cleaner hose.
14. Install or reassemble and tighten main hydraulic control valve mounting plate. Reconnect selected hydraulic lines, as necessary.
15. Install or tighten firewall. Install main hydraulic valve cover.
16. Install top hood and seat assembly.
17. Install counterweight.
18. Install overhead guard.
19. Install battery, as necessary. Reconnect battery (+) cable to starter connection. Reconnect battery ground (-) cable to engine connection last.
20. Install floor boards. Install side doors. Close engine compartment.
21. After engine installation is completed, be sure to check all fluid levels e.g., engine oil, coolant, hydraulic fluid, etc.

4.13. Engine Components
GPX, Model - TMD27 (2.7L) Engine

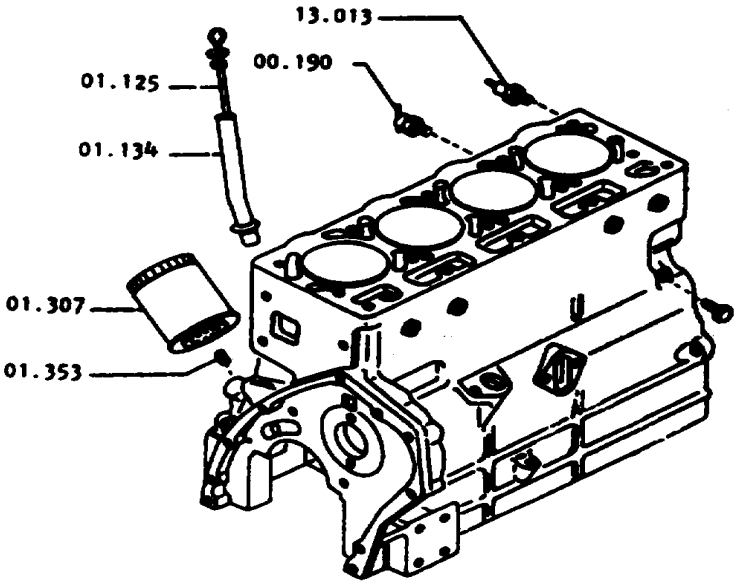
Water Pump Assembly F-119
Crankcase Ventilation, Oil Filter.....F-120
Rocker Cover, Cylinder Head & Gasket F-121
Oil Pump, Oil Pan.....F- 122
Intake and Exhaust Manifold, Gaskets F-123
Exhaust System F-124

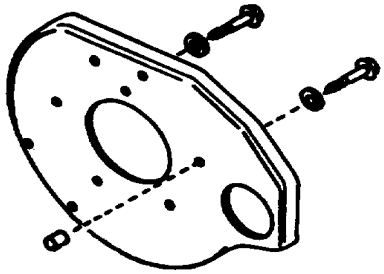
This section presents general information on selected engine sub-assemblies showing components that are generally serviceable from the outside of engine without major disassembly of the engine proper. It is provided for information and reference only to assist service personnel in understanding and identifying components and their assembly relationship.

Water Pump Assembly



Crankcase Ventilation, Oil Filter
GPX, Model - TMD27 (2.7L) Engine



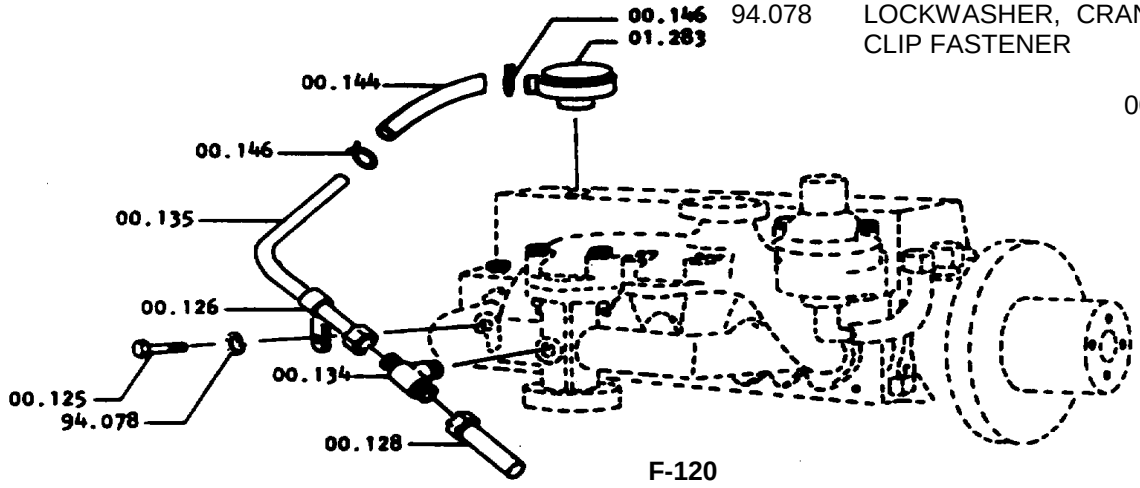


00-805 JAN 86

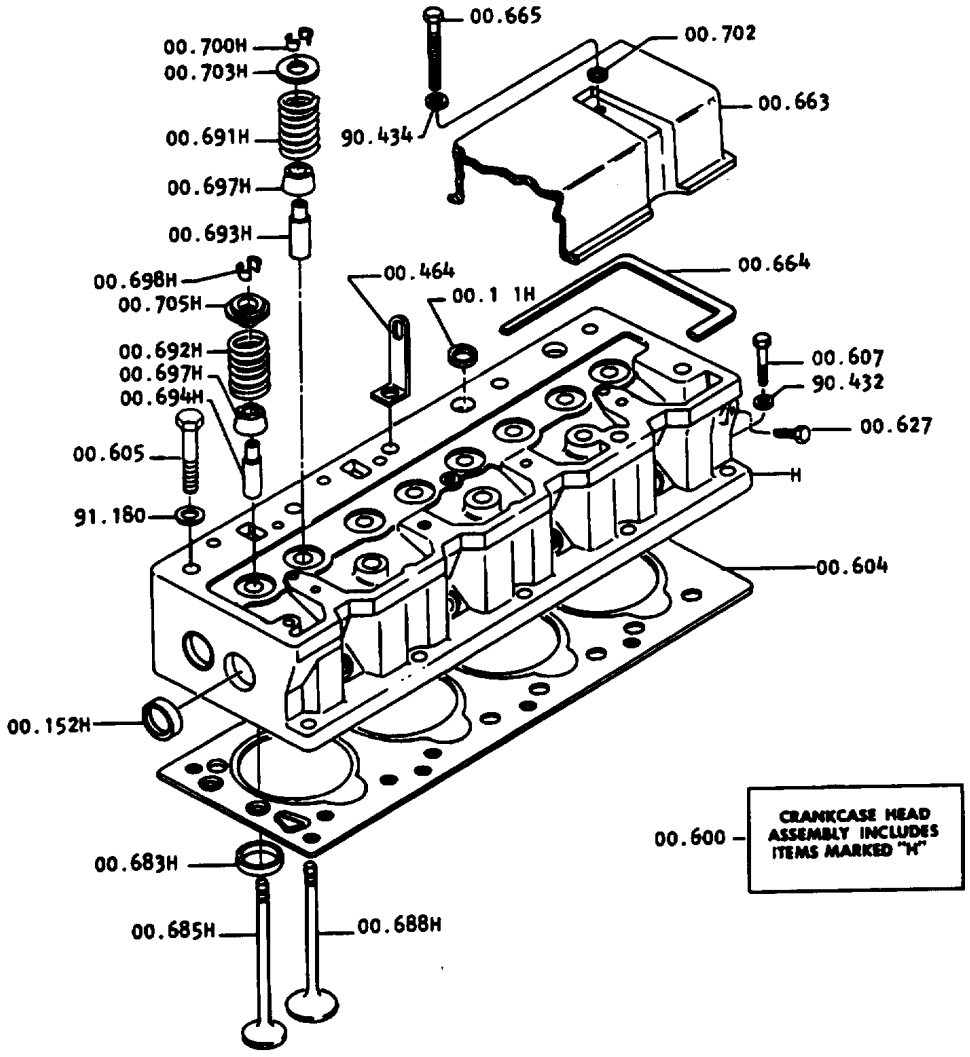
00.190	DRAIN COCK, CRANKCASE
01.125	DIPSTICK, CVWCA&SE OIL LEVEL
01.134	ADAPTOR, CRANKCASE OIL LEVEL DIPSTICK
01.307	FILTER, ENGINE OIL
01.353	ADAPTOR, ENGINE OIL FILTER
13.013	CONTROL, OIL PRESSURE INDICATOR

00.125	FASTENER, CRANKCASE VENT LINE CLIP
00.126	CLIP, CRANKCASE VENT LINE
00.128	FITTING, CRANKCASE VENT LINE
00.134	FITTING, CRANKCASE VENT LINE
00.135	LINE, CASE VENTILATION
00.144	LINE, CRANKCASE VENTILATION
00.146	CLAMP, CRANKCASE VENT LINE
01.283	CAP, CRANKCASE OIL FILLER
94.078	LOCKWASHER, CRANKCASE VENT LINE CLIP FASTENER

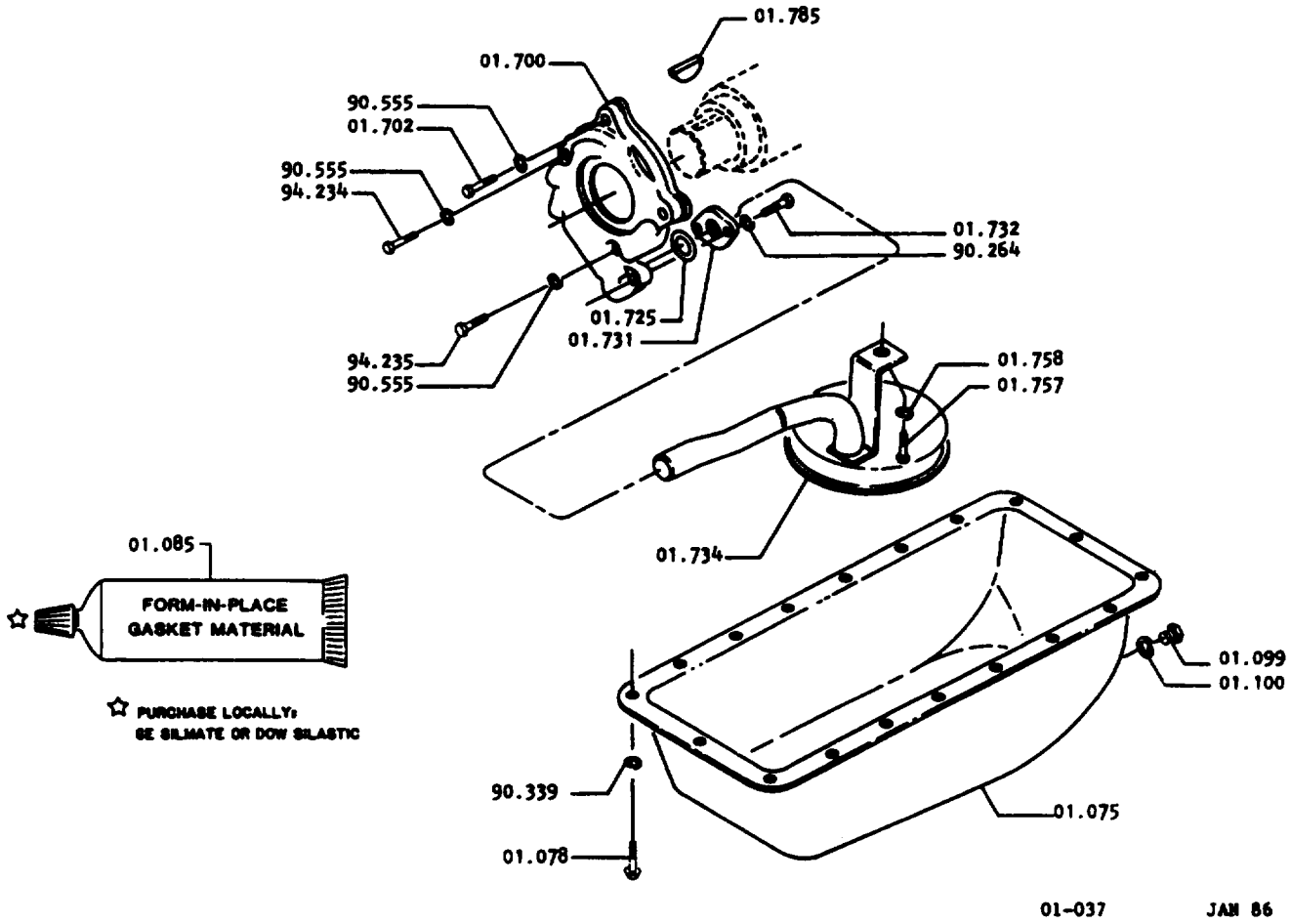
00-416 JAN 86



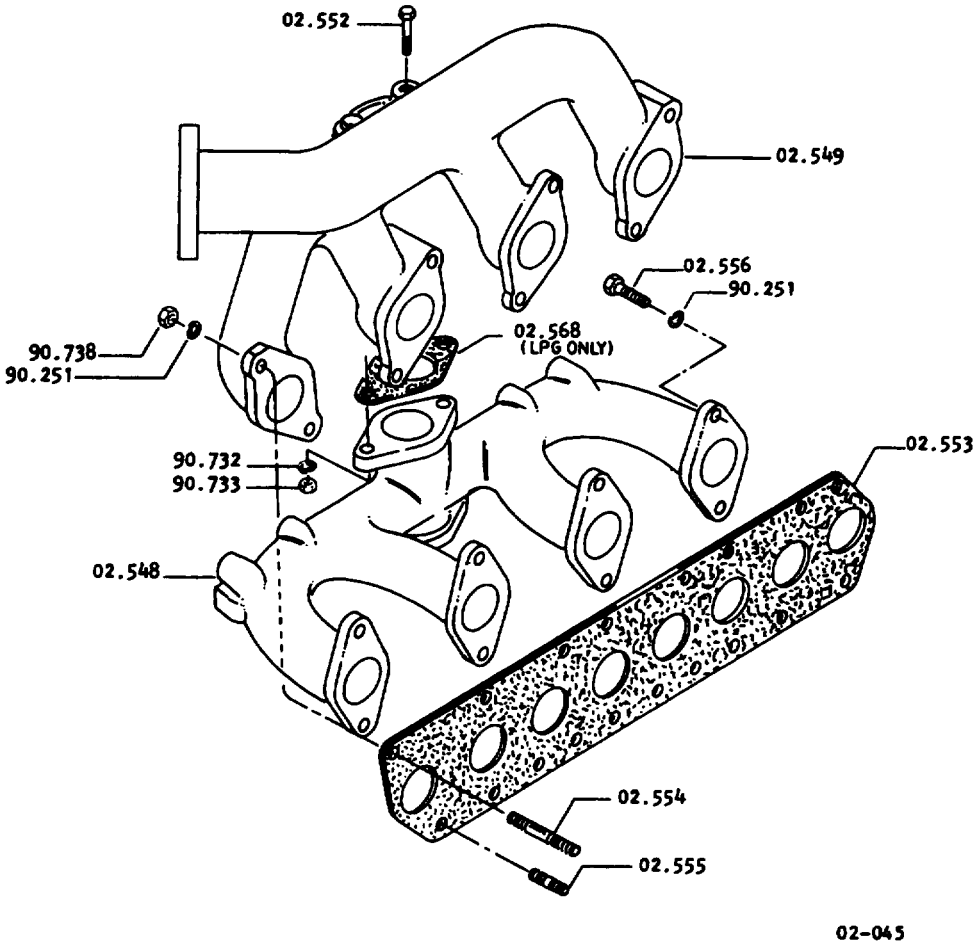
Rocker Cover, Cylinder Head & Gasket
GPX, Model - TMD27 (2.7L) Engine



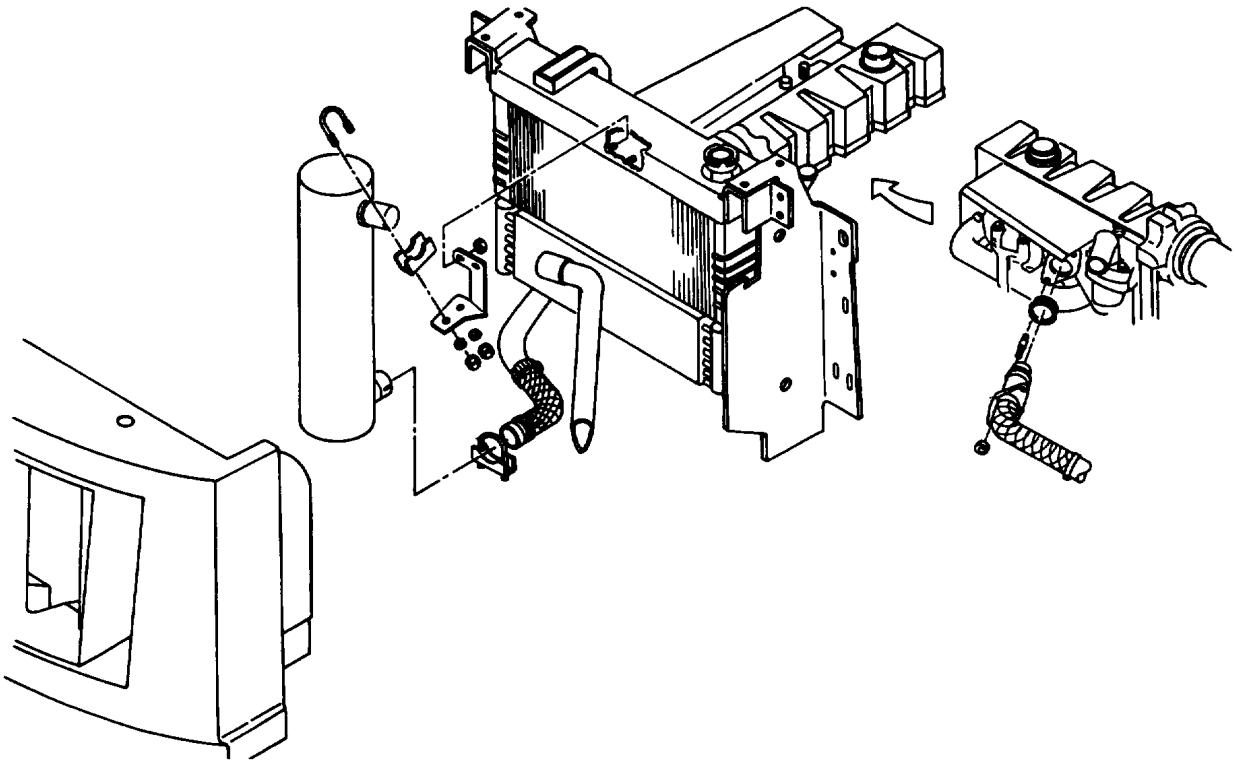
Oil Pump, Oil Pan
GPX, Model - TMD27 (2.7L) Engine



Intake and Exhaust Manifolds, Gaskets
GPX, Model - TMD27 (2.7L) Engine



Exhaust System
GPX, Model - TMD27 (2.7L) Engine



F-124

4.14. Continental Diesel Engine

Pages within the Continental Diesel Engine Manual are numbered consecutively within Appendix F. However, for ease of reference, the original sectional numbers have been retained. Sectional numbers can be found in the black bar at the beginning of each section. Section references in the text of the engine manual only refer to the original section numbers.

CONTINENTAL
DIESEL ENGINE

TMD 27

OPERATOR'S
GUIDE &
REPAIR
MALUAL

F-127 (F-128 blank)

IMPORTANT
READ THESE INSTRUCTIONS CAREFULLY

All points of operation and maintenance have been covered as carefully as possible but, if further information is required, send inquiries to the factory for prompt attention.

When writing to the factory, ALWAYS GIVE THE MODEL, SPECIFICATION, AND SERIAL NUMBER of the engine referred to.

Starting & Operating New Engines

Careful breaking-in of a new engine will greatly increase its life and result in trouble-free operation. A factory test is not sufficient to establish the polished bearing surfaces, which are so necessary to the proper performance and long life of an engine. These can only be obtained by running a new engine carefully and under reduced loads for a short time.

• Be sure the engine is filled to the proper level with a good quality engine oil.

• For proper procedures to follow when breaking-in a new engine, see "Testing Rebuilt Engine".

The various bearing surfaces in a new engine have not been glazed, as they will be with continued operation, and it is in this period of "running in" that special care must be exercised; otherwise, the highly desired glaze will never be obtained. A new bearing surface that has once been damaged by carelessness will be ruined forever.

IMPORTANT SAFETY NOTICE

Proper repair is important to the safe and reliable operation of an engine. This Repair Manual outlines basic recommended procedures, some of which require special tools, devices, or work methods.

Improper repair procedures can be dangerous and could result in injury or death.

READ AND UNDERSTAND ALL SAFETY PRECAUTIONS AND WARNINGS BEFORE PERFORMING REPAIRS ON THIS ENGINE

Warning labels have also been put on the engines to provide instructions and identify specific hazards which, if not heeded, could cause bodily injury or death to you or other persons.
These labels identify hazards which may not be apparent to a trained mechanic. There are many potential hazards for an untrained mechanic and there is no way to label the engine against all such hazards. These warnings in the Repair Manual and on the engine are identified by this symbol:

Operations that may result only in engine damage are identified in the Repair Manual by this symbol:

Wis•Con Total Power cannot anticipate every possible circumstance that might involve a potential hazard; therefore, the warnings in this manual are not all-inclusive. If a procedure, tool, device, or work method not specifically recommended by Wis•Con Total Power is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the engine will not be damaged or made unsafe by the procedures you choose.

IMPORTANT: The information, specifications, and illustrations in this manual are based on information that was available at the time it was published. The specifications, torques, pressures of operation, measurements, adjustments, illustrations, and other product items can change at any time. These change can affect the starting any job. For parts, or information, contact Wis• Con Total Power, Memphis, Tennessee.

WARNING

Most subsystems used in conjunction with Wis•Con Total Power industrial engines, including (but not limited to) radiators, hoses, fans, fuel tanks, fuel lines, or other fuel system components, batteries, electrical connections, or other electrical components, clutches, transmissions, hydraulic pumps, and generators, are not supplied by Wis•Con Total Power. These items are provided by the manufacturer of the end item in which the engine is used. Some of the dangers associated with servicing such items are generally mentioned in this manual; however, the appropriate handbooks and safety instructions provided by the manufacturer of the end item should always be consulted prior to the undertaking of any work on subsystems attached to the engine, to avoid any hazards inherent to these subsystems.

WARNING

- **Read and observe all individual safety warnings as you use this manual to operate, service, or repair your engine.**
- **Always exercise caution whenever working with an engine or any associated system.**
- **Injuries may be caused by lack of care when working with, or near, moving parts, hot parts, pressurized systems, electrical equipment, or fuel systems.**
- **Always wear eye and hearing protection when working on or near engines.**
- **Improper attire such as loose clothing, ties, rings, soft shoes, or bare feet could be hazardous and should be avoided when servicing engines.**
- **Use or service of the engine-including the use of modified parts or materials-not in accordance with manufacturer's specifications could damage your engine or cause personal injury.**

WARNING

Some equipment and materials used in the overhaul or maintenance of an engine such as machine tools, electrical equipment, compressed air, solvents, gasoline, or other fuels may be dangerous and can cause injury. Always observe safety precautions.

CONTENTS
CONTINENTAL INDUSTRIAL ENGINES

SECTION 1
General Information ..... Page F-135

SECTION 2
Operating Instructions ..... Page F-137

SECTION 3
Lubrication ..... Page F-143

SECTION 4
Cooling System ..... Page F-145

SECTION 5
Fuel System ..... Page F-151

SECTION 6
Charging System ..... Page F-159

SECTION 7
Preventive Maintenance ..... Page F-163

SECTION 8
Engine Repair & Overhaul ..... Page F-167

SECTION 9
Deleted

SECTION 10
Torque Specifications ..... Page F-189

SECTION 11
Limits and Clearance Data ..... Page F-191

INDEX ..... Page F-193

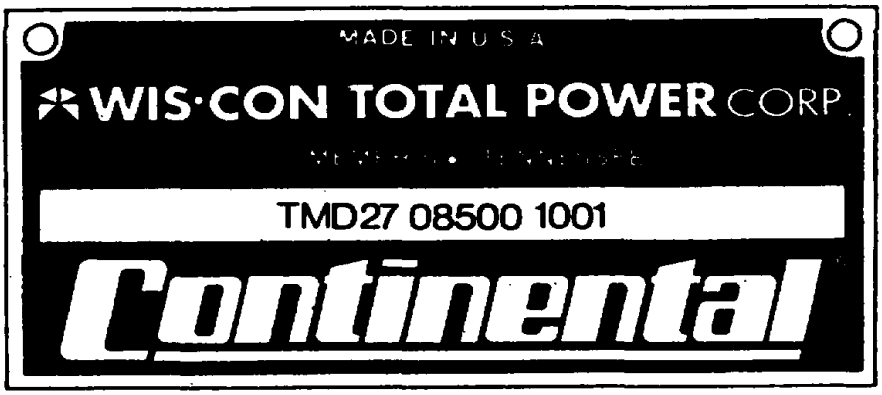
CONTINENTAL Industrial Engines

MODEL	TMD 27	
	METRIC	ENGLISH
No. of Cylinders	4	4
Bore & Stroke	91 x 103.2	(3.58 x 4.06)
Displacement	2.68 L	(164) CID
Compression Ratio	20.5:1	20.5:1
Max. Oil Pressure*	2.8- 4.1 Bar	(40. 60 PSI)
Min. Oil Pressure (Idling)	0.5 Bar	7 PSI
Firing Order	1-3-4-2	1-3-4-2
Main Brg. Frt.	73 x 23.8	(2.88 x .94)
Main Brg. Int.	(2)73 x 23.8	(2.88 x .94)
Main Brg. Thrust	73 x 31.8	(2.88 x 1.25)
Main Brg. Rear	73 x 23.8	(2.88 x .94)
Conn. Rod Brg	49.2 x 24.5	(1.94 x .96)
Oil Capacity		
Crankcase	4.73 L	(5.0 Quarts)
Filter	47 L	(0.5 Quart)
Total	5.2	(5.5 Quarts)
Valve Clearance		
Intake	3636	(.014)
Exhaust	446	(.018)
Water Capacity		
Engine	3.6 L	(3.8 Quarts)
Weight (Approx.)		
(With Accessories)	253 Kg	(557 lbs.)

* Higher oil pressure may be experienced during cold starts.

INFORMATION FOR ORDERING PARTS

When ordering parts, refer to the engine nameplate attached to side of the cylinder block, which lists the model and serial number. In most cases a specification number is listed. This data is of vital importance in obtaining the correct parts: always include this information on your parts order.



Typical Nameplate

Section 1 - General Information

CONTINENTAL DIESEL ENGINE
Continental Diesel Engines are Comet V Combustion Chamber Indirect Injection Diesel Engines.

The combustion chamber design has been tailored for the required turbulence, charge flow, and burning characteristics to provide dependable and economical heavy duty service.

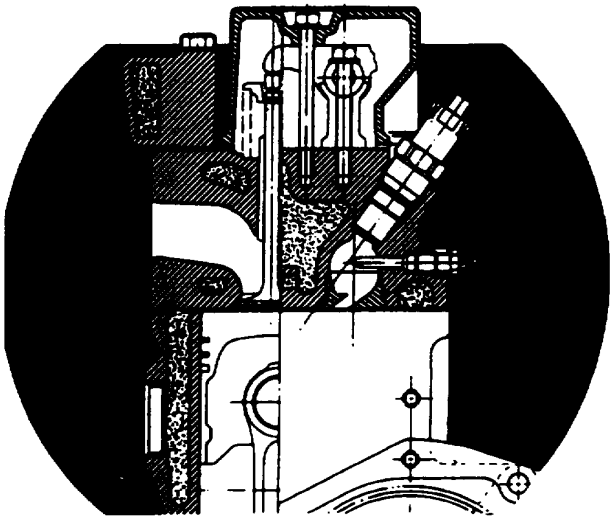
Some of the principal design features are:

1. **Individual Porting** - of the intake manifold whereby each cylinder is fed with the air charge individually and is not influenced by other cylinders of the engine.

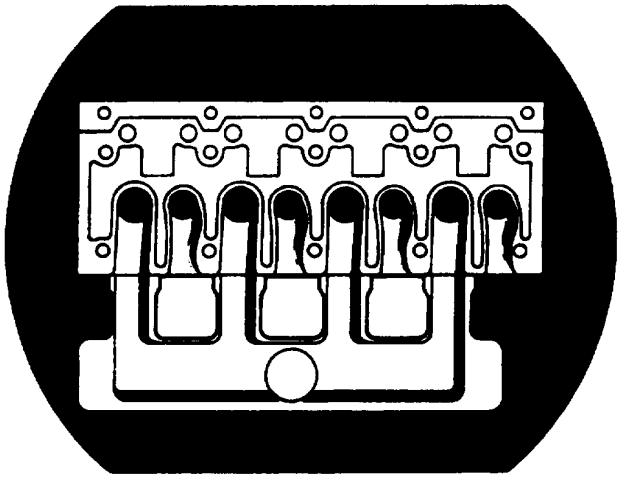
This is accomplished by casting the cylinder head with individual intake valve passages for each cylinder and connecting these passages to an intake manifold which also has individualized passages for each cylinder.

2. **Water Jackets** - completely surround all cylinder bores to a depth sufficient to cover the hot piston ring travel, resulting in minimum bore distortion for good oil control yet maintaining low heat rejection to the coolant.

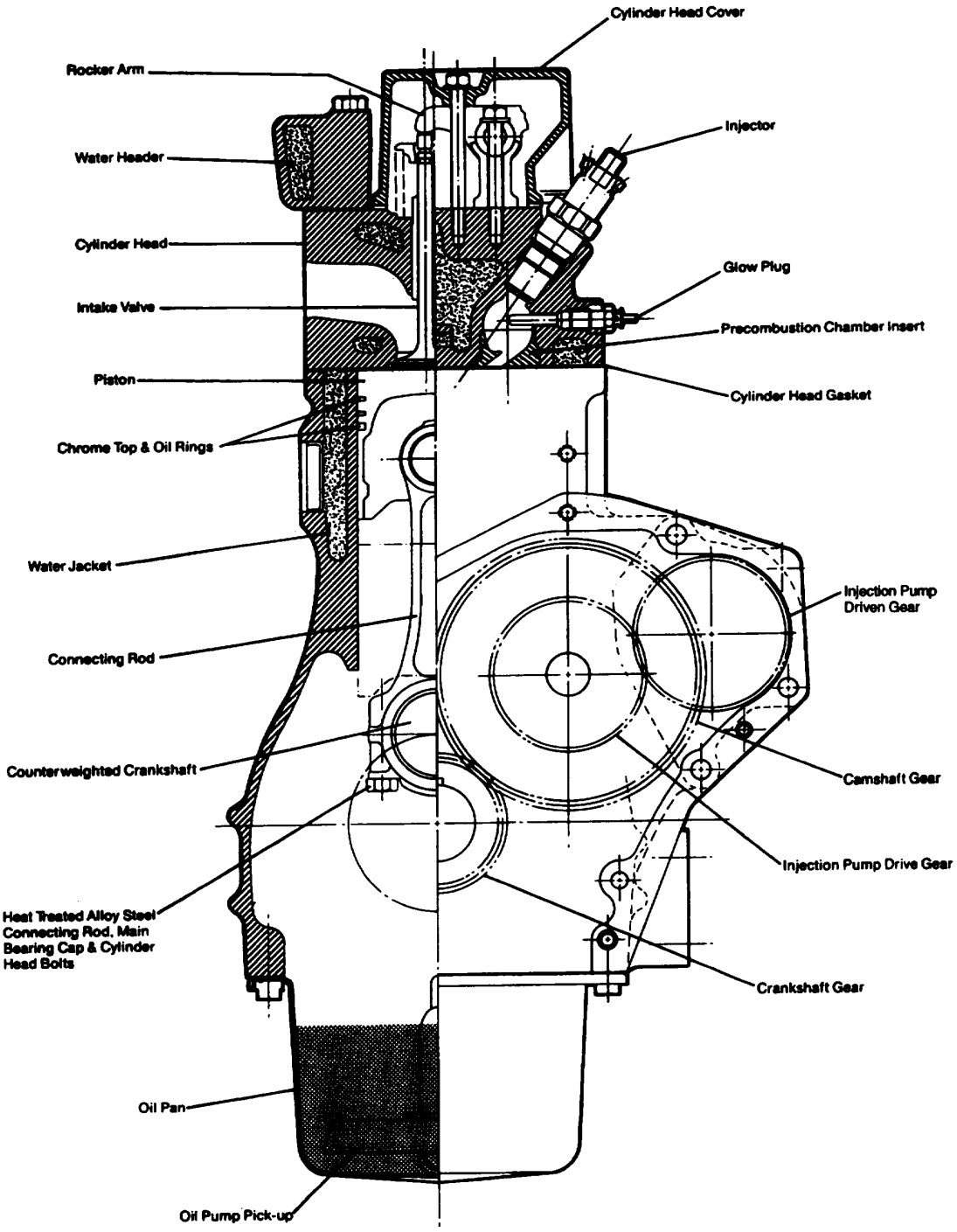
CHOICE OF FUELS - Continental Industrial Diesel Engines have been tailored for heavy duty operation for use with #1 or #2 diesel fuel that meet a minimum cetane number of 45 *(see fuel recommendations, Section 5).*



OHV Design



Individual Porting



Cross section of typical Wis-Con Continental Industrial Diesel

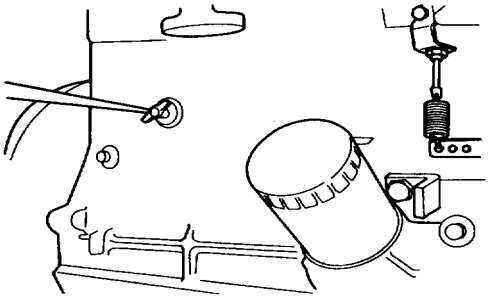
Section 2- Operating Instructions

The person operating the engine naturally assumes responsibility for its care while it is being operated. This is a very important responsibility since the care and attention given the engine goes a long way in determining how long a period it will operate satisfactorily before having to be shut down for repairs.

The operating and preventive maintenance instructions for the diesel engines are simple and should be followed without deviation.
The entire aim in setting forth these instructions is to give you a benefit of the knowledge and experience gained over a long period of collaboration between Engineering Research and Field Service.

PREPARATION OF A
NEW ENGINE FOR OPERATION
Before placing a new engine in operation, it must be thoroughly inspected for external damage and particular attention paid to the following items:

1. **Close Water Drain Cock** on the side of the block (in some cases, this may be a pipe plug).



Fill radiator and water jacket with coolant. (See Cooling System Section 4)

FUEL INJECTION PUMP

The function of a diesel fuel injection pump is to accurately meter and deliver fuel to a nozzle in each cylinder and to inject it at high pressure into the combustion chamber at precisely timed intervals. The extreme precision necessary can well be appreciated since this cycle must be repeated thousands of times per minute with virtually no variation in timing or amount of fuel injected.

2. Fill Crankcase With Oil - Use the oil recommended for the ambient temperature *(see chart).*
3. Fill Fuel Tank- *See fuel recommendations, Section 5.*

WARNING

Stop engine before checking battery terminals or electrical connections. Sparks or flames near a battery could cause an explosion or fire. Battery acid can cause corrosive bums. Always wear eye protection. Use of Jumper cables or battery charging should be done only as directed by manufacturers' safety Instructions.
Read and observe safety warnings on pages 1 and 2.

4. Electrical Connections - Check storage battery terminals and all electrical connections.

STARTING THE ENGINE

WARNING

Bodily injury or death may result to individuals during operation of an engine within any enclosure not adequately or properly ventilated. Engine operation in any enclosure requires adequate and proper ventilation to avoid asphyxiation or other Interruption of normal breathing. To supply sufficient air to cool the engine, provide air to mix with fuel and to carry away heated air from the building.

If the engine is new or rebuilt or if fuel filters have been serviced or any low pressure lines disconnected, fuel system must be bled to remove any air that may have become trapped in the system.
Bleed the entire fuel system. Detailed Instructions for bleeding the Injection systems are given in Section 5.

STARTING PROCEDURE

WARNING

Starting fluids or aids such as ether or gasoline must not be used In a diesel engine air Intake system. The use of these fluids will cause severe Internal engine damage and/or bodily Injury. Read and observe warnings on pages 1 and 2.

1. Ensure speed selector is in NEUTRAL position. Starting engine under load throws overload on starter and battery.
2. Make sure electric shut-off is wired to permit fuel flow when the starter switch is in the "START" and "RUN" positions.
3. If the fuel pump is fitted with a mechanical shutoff, move the control to full open.
4. Move switch to START position and start engine.
5. Adjust throttle to idle at 800 to 1200 R.P.M. for a few minutes to circulate and Warm the oil. Then open throttle to about half speed until the coolant reaches 38°C (100°F).
6. If engine fails to start, turn switch to the "OFF position and repeat the above steps. If starting is not attempted within 15 to 20 seconds, repeat the pre-heat sequence.
7. If engine still does not start refer to Trouble Shooting, Section 9.
8. Check Oil Pressure.

MODEL	OIL PRESSURE
TMD	2.8 - 4.1 Bar (40 - 60 PSI)

***Higher oil pressure my be experienced during cold starts.**

9. Check Water Temperature.

10. CAUTION: After starting new engine - run it at idle for 5 minutes, then stop engine and recheck oil level in crankcase - then bring oil level to high mark on dipstick.

IMPORTANT! Breaking in a new or rebuilt engine for peak performance and economical operation, the following adjustments should be made at end of first 50 hr. operation.

1. Adjust valve tappets to specified clearances.
2. Adjust idle speed to equipment manufacturer's recommendation.

WARM-UP NEW ENGINES

When new engines in distributors' or dealers' stock, showrooms, etc. are started up for any reason, they should be brought up to operating temperature in order to eliminate all condensation before stopping.

If they are stopped while still cold, condensation will settle on valve stems and guides, as well as other moving parts, and rust and sludge will form. Soon valves, rings, etc. will be stuck by this rusting and sludging action.

Engine should be operated long enough to bring oil and water temperature to normal operating temperature; be sure breather or ventilation system is open so vapor can be expelled.

STOPPING THE ENGINE

1. Disengage Power Take-Off.
2. Reduce engine Speed to Idle - if hot, run engine at idle for several minutes to cool.
3. Move switch to OFF position.
4. If the fuel pump is fitted with a mechanical shut off, move the control to full close.

11 "MUSTS " FOR YOUR ENGINES

1. **OIL PRESSURE** - should be up to recommended pressure at operating speed and over 0.5 Bar (7 PSI) at idle (800-1200 R.P.M.)

2. **AMMETER** - should register "CHARGING" at all times engine is running-a voltage regulator may limit it to a very low reading).

3. **WATER TEMPERATURE** - normal operation 81 2 C - 96-C (178 - 205°F). Higher temperatures are acceptable with pressurized systems. Overheating is detected by loss of coolant. "FREQUENT READINGS OF GAUGE SHOULD BECOME A HABIT".

4. **MUFFLER RESTRICTION** - should not exceed 508mm (20") water. Inspect mufflers periodically for restrictions to prevent burned valves.

5. **CLEAN AND SERVICE AIR CLEANER** - as recommended to maintain its efficiency.

6. **WHEN ENGINE IS OVERHEATED** - do not add water - allow engine to cool so as to prevent cracking the cylinder block, or cylinder head.

7. **AVOID COLD-SLUDGE CONDENSATION** - by protecting unit to maintain crankcase temperature over 135°F (57"C). Use a proper temperature range thermostat and warm engine up thoroughly.

8. **BREAKING IN A NEW OR REBUILT ENGINE** for peak performance and economical operaton the following adjustments should be made at end of first day's operation;
   1. Adjust valve tappets to specified clearances.
   2. Adjust idle speed to equipment manufacturer's recommendation.

9. **FOLLOW PREVENTIVE MAINTENANCE SCHEDULES RECOMMENDED** - this will avoid troubles which might cause expensive breakdowns and maintain your engine for dependable and economical operation.

10. **IDLING ENGINE** - slow engine down to low idle for about 5 minutes, after each operating period, before stopping - too rapid cooling down may cause distortion.

11. **CLEAN, WATER FREE FUEL** - is vitally important to the operation of your engine and fuel injection system. Injection pump warranty will be affected if pump failure results from water in the fuel. When the presence of water in the fuel is suspected, the filter bowl should be drained daily until the amount of water so removed indicates that less frequent draining will be adequate to prevent water from entering the fuel injection pump. If more than a tea-cup full of water is drained off, the source of ingress must be found or else the filter bowl must be drained at more frequent intervals.

COLD WEATHER OPERATION Battery condition is very important for proper starting.

The oil used during cold weather should have a cold test below the lowest anticipated temperatures that will be encountered during its use. The multigrade lubricating oils 5W-20 and 1 O0W-30 are ideal for cold starting with its reduced initial drag until warmed up, when they assume the characteristics of the heavier oil.

Sludge formation at low temperatures is a close second to dirt in causing engine damage and wear. This is formed by the piston combustion gases mixing with the fine oil mist in the crankcase and condensing on a cold surface. This condensation forms both a sulphuric and sulphurous acid which combines with the oil to become a highly injurious sludge. This dew point is about 1350F (570C) . When crankcase temperatures are higher, the contaminated gases remain in gaseous form and the engine operates clean as long as breather system is kept clean-however temperatures below this will result in injurious sludge formation. It is vitally important therefore to maintain oil and crankcase temperatures above 1350F (57°C) as shown on the following chart:

REACTIONS WITHIN ENGINE CRANKCASE TO TEMPERATURES DURING OPERATION

ENGINE SERIES	SEE CHART
TMD	Page 68

ITEM	THD SIZE	MAT'L CLASS	TORQUE	
			N·m	LB.FT.
Connecting Rods CAUTION: High limit is maximum. DO NOT Torque beyond high limit.	3/8	SAE GR 8	61-68	45-50
Main Bearing Caps	M14	12.9	150-162	110-120
Flywheels	M10	12.9	68-75	50-55
Flywheel Housings Rear End Plates	M10	12.9	61-68	45-50
Manifolds (Seezpruf)	M8	8.8/9.8	20-24	15-18
	M10	8.8/9.8	34-40	25-30
Gear Covers Water Pumps	M10	8.8/9.8	34-40	25-30
Oil Pans (Sheet Steel)	M8	9.8	14-19	10-14
Oil Pump To Engine	M8	8.8/9.8	20-24	15-18
Rocker Shaft Supports	M8	8.8/9.8	23-27	17-20
Accessories And Misc. Brackets	M6	8.8/9.8	8-11	6-8
	M8	8.8/9.8	20-24	15-18
	M10	8.8/9.8	34-40	25-30
	M12	8.8/9.8	75-81	55-60
	M14	8.8/9.8	122-135	90-100
	M16	8.8/9.8	190-203	140-150
Camshaft Nuts (cast iron camshaft)	7/8		88-95	65-70
Crankshaft Pulley	M16	8.8	163-176	120-130
Glow Plugs	M12		31-38	23-28
Nozzle To Holder	M22		68-75	50-55
Fuel Injection Pump Driven Gear To Fuel Injection Pump	5/16	8	27-34	20-25
*Injector to Cylinder Head	M24		68-75	50-55
Rocker Cover	M8	9.8	7-8	5-6
High Pressure Fuel Lines	M12		27-34	20-25

*Always use a new steel heat shield washer between injector and cylinder head.

When sludging conditions prevail, the oil should be examined daily and changed as it may freeze, or clog the inlet strainer and cause bearing or oil pump failures. pumps in the field.

High Altitude Operation - if engine is to be run continuously at a high altitude (above 5000 ft.) the pump calibration should be modified to maintain an acceptable smoke level. Contact manufacturer for recommendations.

NOTE

Some high altitude fuel delivery curve shaping can be performed on some STANADYNE fuel injection pumps in the field.

High Temperature Operation-for every 10OF (50C) above 850F (29.40C) inlet air temperature power loss of 1% results.

ENGINE PREPARATION FOR WINTER USE

More than 90% of the hard starting complaints in cold weather are the direct result of inadequate attention to preparation for winter use and proper maintenance. An engine not properly prepared requires more cranking energy and time, which puts a heavy load on batteries. So, invariably, batteries run down and the engine is blamed for hard starting. Putting your engine in proper condition and keeping it that way pays big dividends by reducing costly down time. Use the checklist which follows to get your engine ready for winter. Then use the winter maintenance schedule to keep it in peak operating condition during the winter months.

CHECKLIST

WARNING

Stop engine before checking battery terminals or electrical connections. Sparks or flames near a battery could cause an explosion or fire. Battery acid can cause corrosive burns. Always wear eye protection. use of jumper cables or battery charging should be done only as directed by manufacturers' safety instructions.

1. ELECTRICAL SYSTEM

A. Battery - replenish water and test for condition and state of charge. Replace if required.
B. Wiring - check battery cables, connections and other wiring. Be sure connections are clean and tight and that cables and wiring insulation are in good condition.
C. Alternator and Regulator - run the engine and check the ammeter to be sure the alternator is charging and the regulator is functioning properly. Check and adjust alternator belt tension.

2. COOLING SYSTEM

WARNING

If the coolant Is hot or If the engine has been running, loosen the pressure cap to the first stop and let the pressure out of the cooling system before removing the radiator cap.

Check radiator, hoses and engine for water leaks. Tighten hose clamps, repair leaks and install antifreeze to the level required for winter protection.

3. LUBRICATION SYSTEM

A. Drain oil and change filter. Add oil of the proper winter grade.
B. There are several different types and manufacturers of transmissions and powertake-offs. Caution should be used when determining the proper seasonal grade lubricant to assist in cold weather starting.

4. FUELSYSTEM

A. Check the fuel stop and throttle control for satisfactory operation and adjust as required.
B. Fuel filters - must be checked more often, particularly the primary stage filter, to remove all the moisture and condensation separated from the fuel, otherwise this may freeze and stop the fuel flow.
C. Clean fuel - handled by a reliable source having a cetane number of 45 minimum, is a definite requirement for easy starting and efficient operation. We cannot caution you too seriously about obtaining fuel from a reliable source.
D. Fuel recommendations - the type of fuel to be used should be suitable for the ambient temperature to be expected. To insure against condensation in the fuel tank, fill to capacity at the end of each operating period.

5. EXHAUST SYSTEM

A. Check the rain cap, if supplied, for proper operation and repair as required.

6. INTAKE AIR SYSTEM

A. Be sure all hoses and clamps are properly seated and tight.

B. Check instructions on the air cleaner decal. Service dry-type air cleaner as specified.

7. MISCELLANEOUS

A. Normal starting using the glow plugs supplied as standard equipment should be accomplished down to -20°C (-4°F). Contact Wis-Con Total Power for special starting aids for colder temperatures.

B. Check and adjust tappets.

WINTER MAINTENANCE

1. Perform maintenance in accordance with instruction manuals.
2. Change oil as recommended in Section 3.

WARNING

Starting fluids or aids such as ether or gasoline must not be used In a diesel engine air Intake system. The use of these fluids will cause severe Internal engine damage and/or bodily Injury.

3. If unit is only used for short periods and does not get thoroughly warm, operate it for at least an hour once a week to get it thoroughly warm. This will avoid excessive sludge in the oil and reduce dilution of oil with raw fuel in the crankcase.

PREPARATION OF ENGINE FOR SEASONAL STORAGE (90 DAYS TO 6 MONTHS)

1. **Run engine** - To thoroughly warm-up oil in crankcase.
2. **Stop engine -** And drain crankcase oil.
3. **Refill crankcase** - With SAE No. 10 engine preservative oil which meets MIL-L21 260 Grade 1 specification.
4. **Fill cooling system** - With a solution containing a rust inhibitor.
5. **Drain fuel tank and filters** - Refill with about 2 gallons of a 50-50 mixture of pure white kerosene and SAE No. 10 engine oil.
6. Bleed the system as detailed in Section 5.
7. Start engine and run it at half speed for 15 minutes when the oil will have circulated through the injection pump, lines, and injectors.
8. Seal the air vent in the tank or filler cap with waterproofed adhesive tape.
9. Drain crankcase.
10. Drain cooling system completely.
11. **Clean exterior engine surfaces** - After engine has cooled; removing all grease or other foreign matter. Never wash a hot injection pump with cold water while engine is running.
12. **Seal all openings air-tight** - With adhesive tape that will not absorb or retain moisture.

Section 3- Lubrication

ENGINE LUBRICATION SYSTEM

Continental industrial diesel engines have full pressure lubrication to all main, connecting rod, and camshaft bearings-as well as rocker arms and timing gears. Tappets are lubricated by overhead oil return.

OIL PUMP

On all engines, a large capacity gerotor-type oil pump is driven off the crankshaft and protected by a screened inlet.

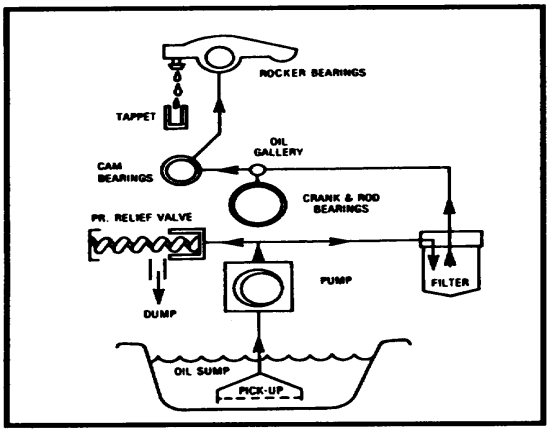
A bypass valve maintains suitable oil pressure from idle to maximum speed automatically. Higher oil pressure may be experienced during cold starts.

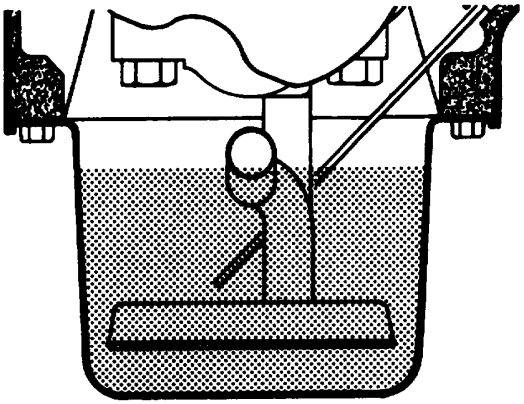
Refer to Section 2 for complete oil pressure figures.

CAUTION

If the oil pressure s erratic or falls below these limits, atop the engine IMMEDIATELY and find the cause of the trouble or damage to equipment could result Refer to troubleshooting section for this Information.

A full flow oil filter is provided to remove dirt and foreign elements from the oil. The removal of grit, sludge, and foreign particles causes filter elements to clog and become ineffective unless they are normally replaced every 100 hours, or more often if conditions require.



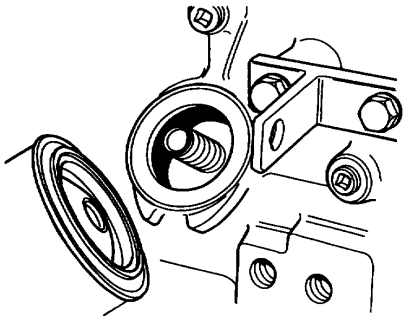


OIL CHANGE FREQUENCY

Engine oil does not Swear out"-however, the lubricating oil in internal-combustion engines becomes contaminated from the by-products of combustion: dirt, water, and unburned fuel entering the crankcase, and the detergents holding the carbon particles in suspension in the crankcase.

NOTE

On engines equipped with remote oil filters, always fill the oil filters element with motor oil prior to Installation. Failure to do so may result In engine damage due to momentary oil starvation at start up.



ON Filter

The schedule for changing oil is directly dependent upon the operational environment: an extremely clean operation could go 100 hours while a dirty operation (foundry or cement factory) could be 50 hours or less (See suggested oil and filter change intervals).

LUBRICATION RECOMMENDATIONS

Motor oils used for internal-combustion engine lubrication perform many useful functions including: dissipating heat, sealing piston rings, preventing metal to-metal contact wear, and reducing power loss through friction.

The lubricating oil recommendation is based upon engine design, type of service, and the atmospheric temperature prevailing. High quality oils are required to ensure maximum performance, long engine life, and minimum cost of operation.

Continental industrial diesel engines operate in a wide range of service conditions and seasonal temperatures, so our recommendations are given for various types of service and ambient temperatures.

API SERVICE DESIGNATIONS

We recommend using oil described below for all continental industrial diesel applications.

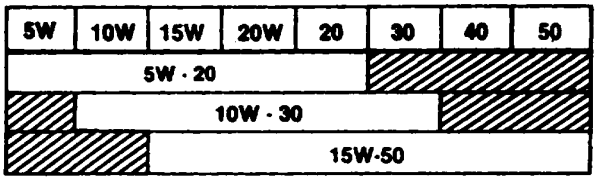
CD - Service Class D

Service typical of industrial diesel engines operating under engine manufacturer's warranties. High detergent exceeds engine manufacturer warranty requirements.

SE/CD..... Oil Classifications may be used.
SFICD..... Oil Classifications may be used.
SG ..... Oil Classifications may be used.

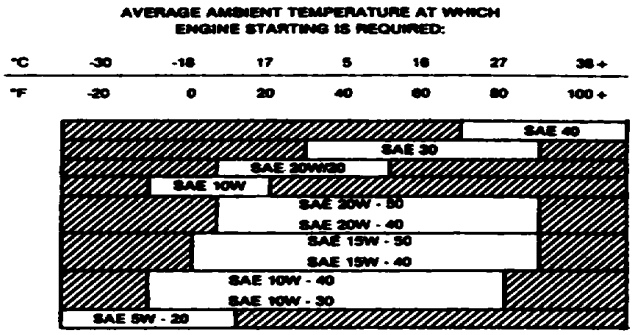
SAE OIL BODY GRADES

The oil grades available from the lightest (SAE 5W) to the heaviest (SAE 50) are:



Multi-grade oils such as SAE 5W-20 and SAE 15W-50 have the starting grade characteristics of the lighter oils and, after warm-up, have the running characteristics of the heavier grade.

The following SAE grades are general recommendations for Continental industrial diesel engines during changing seasonal atmospheric temperatures:



For engines in continuous duty oil viscosity should be based on sump oil temperature.

Sump Oil Temperature	SAE Grade
210-250°	40
(99-121 °C)	30
160-210° F)	10W-30, 10W-40
(71-99° C)	20W-40, 15W-40
	20W-50, 15W-50
130-160°F	20
(55-71°C)	10W-30, 10W-40

The Multi-grade oil used should cover the single grade recommendation for the atmospheric temperature involved, e.g. SAE 10W-30 covers SAE-10W, SAE-20W, SAE 20, and SAE 30.

SUGGESTED OIL & OIL FILTER CHANGE INTERVALS

Continuous Duty at Continuous Duty Rating		Light Duty Operation (25% Max.Continuous Rating) end Standby
CLEAN ENVIRONMENT	**DIRTY ENVIRONMENT**	
100 Hrs. Max.	50 Hrs.	200 Hrs. Max.

NOTE

1. **Lube oil and filter must always be changed after the first 50 hours of operation of a now or rebuilt engine.**
2. **Environmental, Installation, fuel system, and general engine conditions can all Influence lubricant performance. Lube oil analysis programs are recommended In all applications for optimum engine performance and life.**

Standard Continental supplied starters and alternators have sealed bearings requiring no lubrication. Check your specification for accessories which may require periodic lubrication.

Section 4- Cooling System

The function of the cooling system is to prevent the temperatures in the combustion chamber from damaging the engine and at the same time keep the operating temperatures within safe limits.

Maintaining the cooling system efficiency is important, as engine temperatures must be brought up to and maintained within satisfactory range for efficient operation; however, this system must be kept from overheating in order to prevent damage to valves, pistons, and bearings.

CAUTION

Never pour cold water or cold anti-freeze into the radiator of an over-heated engine. Allow the engine to cool and avoid the danger of cracking the cylinder head or block. Keep engine running while adding coolant.

COOLING SYSTEM

All Continental industrial diesel engines have the coolant force-circulated by a water pump and use a thermostat and by-pass system to control the temperature range.

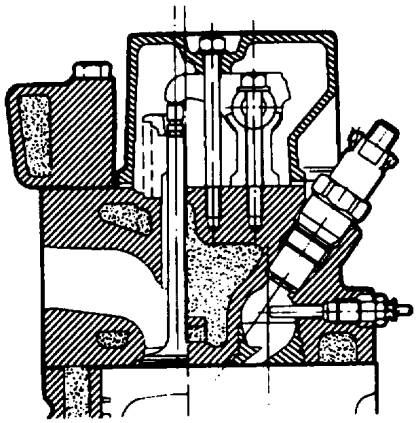
The coolant from the pump enters the front of the block, passing along and between the cylinder bores and is metered by the head gasket into and across the cylinder head to cool the pre-combustion chambers, valve seats, and guides.

Upon leaving the cylinder head, the coolant enters the thermostat housing, in which is mounted the positive shut-off thermostat that controls the opening to the radiator or heat exchanger. Upon being discharged from the thermostat housing, the coolant enters the radiator or heat exchanger, depending upon the application, where it is cooled before reentry into the engine. Continental industrial diesel engines operate most efficiently with coolant temperatures of 1800 - 200°F (810 93°C) and a thermostat and bypass system is used to control these temperatures.

The thermostat valve remains closed and only allows the coolant to circulate within the engine itself until normal operating temperatures are reached. This provides for both rapid and even temperature increase of all engine parts during the warm-up period. When desired temperature is reached, the thermostat valve opens allowing all the coolant to circulate through both the engine and radiator while shutting-off the bypass system.

IMPORTANT

Present thermostats begin to open at 81°C (180"F) and are fully open at 940C (202°F). Operation of engines in this temperature range is not harmful. However, temperature gauges are not always accurate and may sometimes Indicate higher than actual temperature. This can lead operators to believe engines are overheating when they are actually operating normally.



Sectional View showing Coolant Passages in Head & Block

EXPANSION OF WATER

Water has always been the most commonly used coolant for internal combustion engines because it has excellent heat transfer ability and is readily obtained everywhere. Like all liquids, it expands when heated (the rate of expansion being 1/4 pint per gallon (1/32 liter per liter) when the temperature is raised from 40° to 180°F (40 to 81°C).

For example: If a 4 gallon cooling system is filled completely full of water at 40°F (4°C), 1 pint will be lost through the radiator overflow pipe by the time the water temperature reaches 180°F (81°C).

WATER FILTERS

In some areas, the chemical content of the water is such that even the best of rust inhibitors will not protect the cooling system from the formation of rust and scale.

There are instances where this corrosive element has eaten holes through cast iron parts such as water pump impellers and bodies. This condition is caused by electrolysis taking place in the parts involved. Where these conditions exist, water filters should be incorporated in the assembly to remove these troublesome elements and off-set the electrolytic action.

EFFECT OF ALTITUDE ON COOLING

Water boils at 212°F (100°C) under atmospheric pressure at sea level. This pressure becomes less at higher altitudes and the reduced pressure causes water and other liquids to boil at a lower temperature.

ANTI-FREEZES

Water freezes at 32°F (0°C), forming solid ice and expanding about 9% in volume-which causes tremendous pressure and serious damage when allowed to freeze inside the cooling system. When operating temperatures are below 32°F (0°C), an anti-freeze liquid must be added which will lower the freezing point to a safe margin below the anticipated temperature of outside air. Permanent anti-freeze will also raise the boiling temperature of the coolant. The correct proportion of anti-freeze is also important when the engine is to be operated under high ambient temperature conditions.

ANTIFREEZE	OPERATING TEMPERATURE RANGE		
	+32° to 10° F (0° TO 12° C)	+10° to 10° F (12° C to 23° C)	10° to 30° F (23° C to 34° C)
ETHYLENE GLYCOL (permanent type) When there are no leaks add water only to make up for evaporation.	RATIO ETHYLENE GLYCOL TO WATER		
	1 to 4	2 to 5	1 to 1

CORROSION INHIBITORS

WARNING

Corrosion inhibitors can cause damage to the eyes or skin. n contact is made, immediately wash skin with water. For the eyes, Immediately flush the eyes with water for several minutes. In either event, seek prompt medical attention.

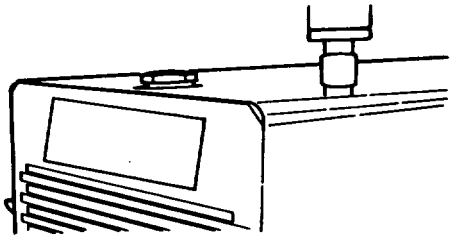
Water forms rust due to its natural tendency to combine chemically with iron and air in the system. Rust inhibitors for water are inexpensive, simple to use and make cleaning and flushing necessary only after long periods of operation.

The addition of a corrosion inhibitor is not necessary if an anti-freeze containing a rust inhibitor is used.

RADIATOR

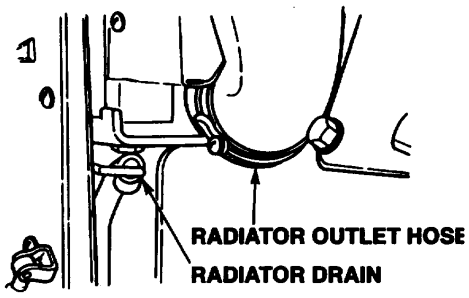
The radiator or heat exchanger consists of a series of metal tubes through which the coolant is circulated. In standard radiator design fins are connected to the metal tubes to give an extended surface through which heat can be dissipated. It is important that these tubes be kept clean on the inside and the fins free of dirt on the outside so the maximum heat transfer can take place in the radiator.

Blowing out between the fins of the radiator, using compressed air, in a direction opposite to that of the fan circulated air, will serve to keep the cooling surfaces of the core free of dirt and other particles. Operating conditions will determine the frequency of this service. Every 500 hours of operation the radiator and cooling system should be well cleaned and flushed with clean water.



Radiator Coolant Inlet

Wherever possible, only soft clean water should be used in the cooling system. Hard water will cause scale to form in the radiator and the engine water jackets and cause poor heat transfer. Where the use of hard water cannot be avoided an approved water softener can be used.



CLEANING COOLING SYSTEM

Deposits of sludge, scale and rust on the cooling surfaces prevent normal heat transfer from the metal surfaces to the coolant and, in time, render the cooling

system ineffective to properly maintain normal operating temperatures. The appearance of rust in the radiator or coolant is a warning that the corrosive inhibitor has host its effectiveness and should be cleaned before adding fresh coolant.

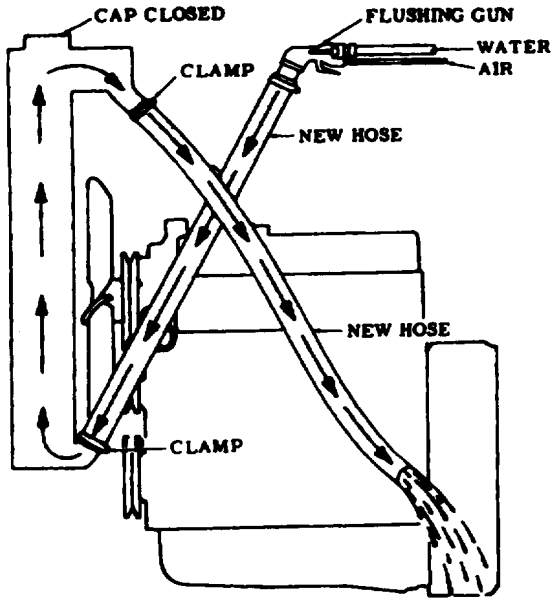
Dependable cleaning compounds should be used. Follow the procedure recommended by the supplier. This is of prime importance because different cleaners vary in concentration and chemical compositions. After cleaning and flushing, the system should be filled with an approved anti-freeze compound containing a rust and corrosion inhibitor.

REVERSE FLOW FLUSHING

Whenever a cooling system is badly rustclogged as indicated by overflow loss or abnormally high operating temperatures, corrective cleaning by reverse flow flushing will most effectively remove the heavy deposits of sludge, rust and scale. The reverse flow flushing should be performed immediately after draining the cleaning solution. It is advisable to flush the radiator first, allowing the engine to cool as much as possible.

Reverse flush the radiator, as follows:

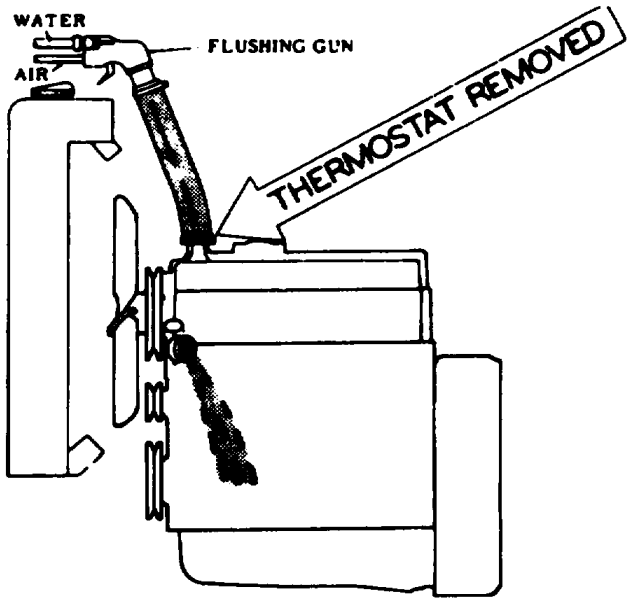
1. Discontent the hoses at the engine.
2. Put radiator cap on tight.
3. Clamp the flushing gun in the lower hose with a hose clamp.
4. Turn on the water and let it fill the radiator.



5. Apply air pressure gradually, to avoid radiator damage.
6. Shut off the air, again fill the radiator with water and apply air pressure. Repeat until the flushing stream runs out clear.
7. Clean and inspect radiator cap.

To reverse, flush the engine water jacket:

1. Remove the thermostat.
2. Clamp the flushing gun in the upper hose.
3. Partly close the water pump opening to fill the engine jacket with water before applying the air.
4. Follow the same procedure outlined above for the radiator by alternately filling the water jacket with water and blowing it out with air 5.5 Bar (80 PSI) until the flushing stream is clear.



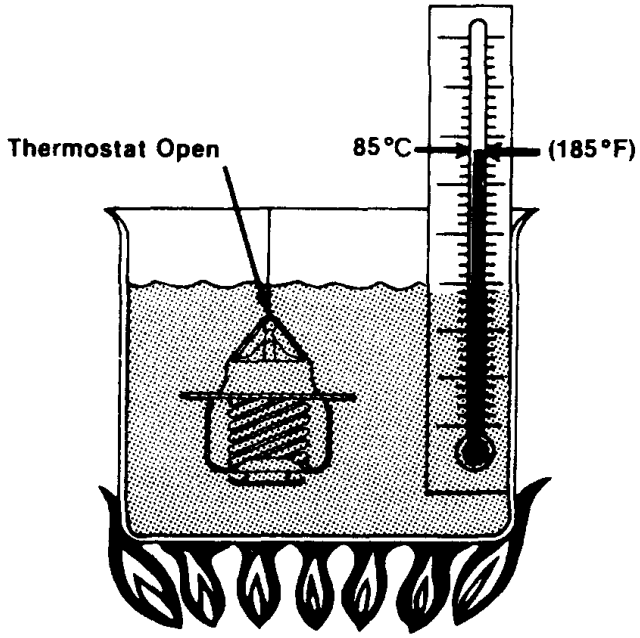
TESTING THERMOSTAT

Remove the water outlet elbow. Before testing, clean and examine the thermostat. If the valve can be pulled or pushed off its seat with only a slight effort when cold or it does not seat properly, the unit is defective and should be replaced.

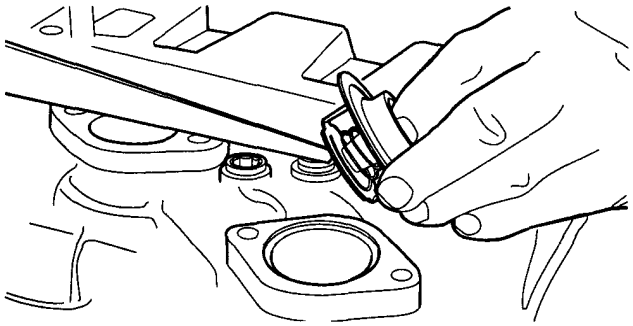
Thermostat operation can be checked In the following method:

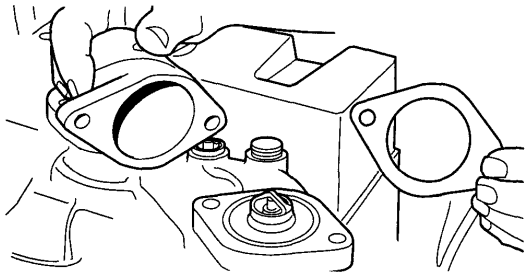
1. Hang thermostat by its frame in a container of water so that it does not touch the bottom.
2. Heat the water slowly and check temperature with a thermometer.
3. If the valve does not start to open at temperatures of 180 - 200"F 81- 930C or it opens well before the 180°F (81 C) point Is reached, the thermostat should be replaced.

When replacing the thermostat in the water header be sure the counterbore is clean.



When installing a new thermostat in the water header make sure that the temperature sensing unit goes in first or faces toward the cylinder head.





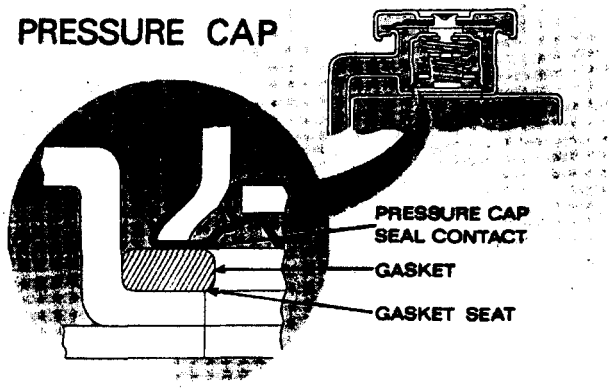
Assemble new water outlet elbow mounting gasket Thermostat flange must seat in counter-bore with gas ket sealing contact between it and the outlet elbow.

RADIATOR PRESSURE CAP

WARNING

If the coolant Is hot or if the engine has been running, loosen the pressure cap to the first stop and let the pressure out of the cooling system before removing the radiator cap.

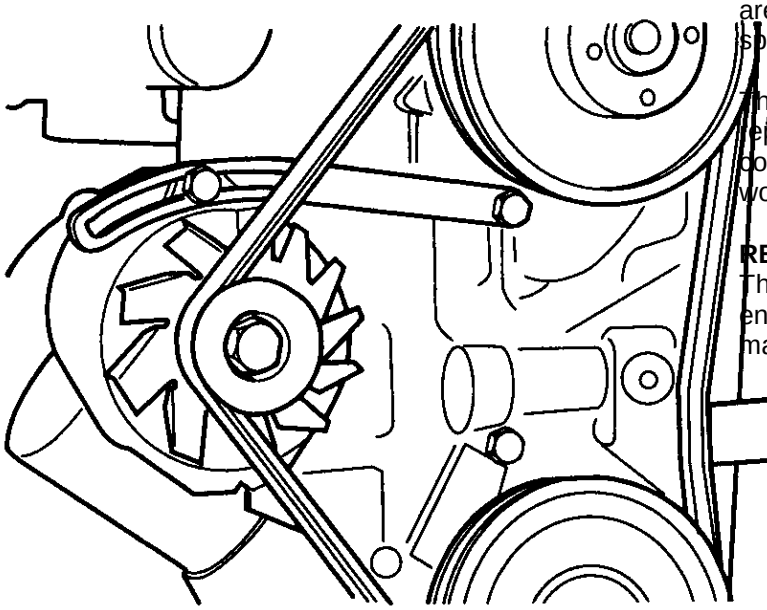
Many operations use a pressure cap on the radiator to prevent overflow loss of coolant during normal operation. This spring-loaded valve in the cap closes the outlet to the overflow pipe of the radiator and thus seals the system, so that pressure developing within the system raises the boiling point of the coolant and allows higher temperatures without overflow loss from boiling. Most pressure valves open at 0.3 or 1.0 Bar (4 1/2 or 15 PSI), allowing steam and water to pass out the overflow pipe, however, the boiling point of the coolant at this pressure is 224°F (107'C) or 248OF (120'C) at sea level. When a pressure cap is used an air tight cooling system is necessary with particular attention to tight connections and a radiator designed to withstand the extra pressure.



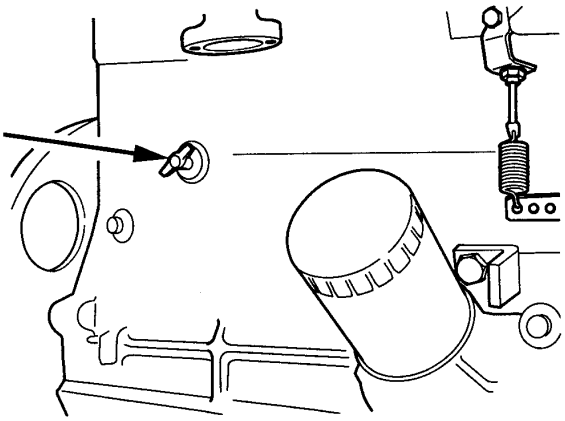
FAN BELT TENSION

When tightening fan belts, loosen the alternator adjusting bolts and pull out on the alternator by hand until the belt is just snug. Under no circumstances should a pry bar be used on the alternator to obtain fan belt tension or damage to the bearings will result.

When adjusted correctly the fan belt deflection on the long side should not exceed 1/2" (13mm) .



CYLINDER BLOCK COOLANT DRAINS When the cooling system is to be completely drained, there is a drain plug on the right hand side of the cylinder block which drains all coolant which might be trapped in the base of the block.



WATER PUMP

The water pump is located on the front of the cylinder block and is driven by the fan belt from the crankshaft pulley. The inlet of the water pump is connected to the lower radiator connection and the outlet flow from the pump is through integral passages cast in the block.

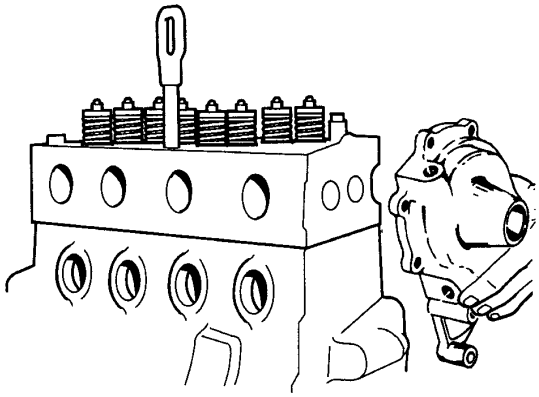
No lubrication of the pump is required as the bearings are of the permanently sealed type and are packed with special lubrication for the life of the bearing.

The water pump requires no attention other than bearing replacement when it shows excessive looseness or if a coolant leak develops which shows a damaged or badly worn seal that needs replacement.

REMOVING WATER PUMP

The water pump assembly can be removed from the engine as a unit for service or repair in the following manner:

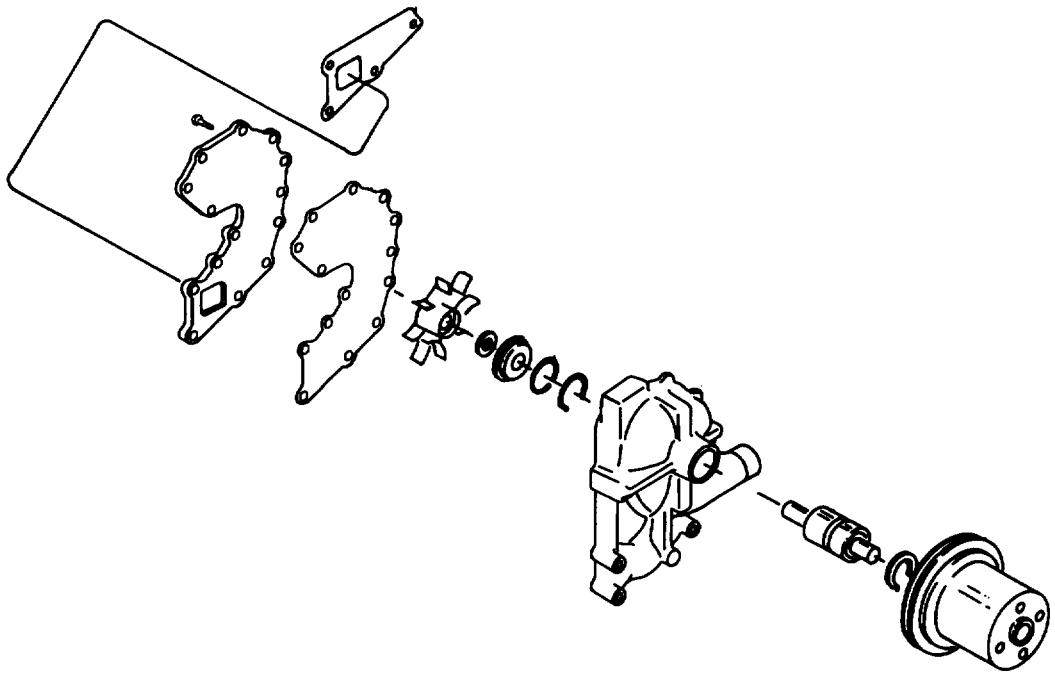
1. Drain coolant.
2. Remove fan by taking out four cap screws.
3. Loosen alternator so that fan belt can be slacked off enough to slide over pulley.
4. Remove fasteners holding the pump body to the front of the block and remove the pump assembly.



DISASSEMBLY OF WATER PUMP

When replacement of any internal parts becomes necessary, disassembly must be in the following sequence in order to prevent damage to the pump.

1. Use puller to remove fan hub from shaft.
2. Remove countersunk screws holding cover and remove cover and gasket.
3. Use puller to remove impeller taking precautions to prevent damage to the casting.
4. Remove seal.
5. Remove lock rings holding bearing and shaft assembly in body after which shaft can be forced out through the front with an arbor press or lead hammer. DO NOT ATTEMPT TO DRIVE WATER PUMP SHAFT OUT THROUGH REAR OF HOUSING. To do so will damage the housing beyond repair.



Disassembling Water Pump

REASSEMBLY AND INSTALLATION

1. Reassemble pump, replacing worn or failed parts. Seal contact surfaces must be smooth and flat. The bushing should be replaced if scored or cut. A light film of lubricant applied to the face of the seal will facilitate seating and sealing.
2. Use thick soapsuds on both the seal and shaft when assembling in order to prevent damage to the seal.
3. The fan hub must be installed prior to replacing rear plate. The shaft must be supported during this operation to prevent damage to the seal and bushing.
4. Mount pump assembly on block using a new housing gasket.
5. Install fan belt and adjust belt tension to have 112' (13mm) deflection on long side. Pull out the alternator by hand, as bearing damage will result with a pry bar.
6. Refill cooling system.

WARNING

Smoking or open flame should be avoided any time the fuel system Is being repaired or serviced. The area should be property ventilated. Improper handling of fuel could result in an explosion or fire causing bodily injury to yourself or others.

The basic purpose of the fuel system is to store, convey, and inject the fuel into the engine. The fuel transfer pump draws the fuel from the supply tank, forces it through the filters, and delivers it to the injection pump. The fuel injection pump places it under the high pressure required for mechanical atomization, meters it with great accuracy, distributes it in the proper sequence to the various cylinders, commences the individual injections with fine precision in timing, and produces uniformly, through the nozzles, the correct pattern of spray for the combustion chamber.

The injection system of a diesel engine includes an injection pump assembly complete with govemor, fuel supply pump, fuel filters, high-pressure steel lines connecting the pump discharge outlets to the nozzles, and nozzle holders and nozzle assemblies, one for each cylinder. Not the least of these are the filtration elements, as fine particles of dirt in the fuel are extremely destructive to high-pressure pumps of any description.

Carelessness or too frequent removal of elements of the fuel injection system for "inspection" or "cleaning" is generally far more harmful than beneficial, due to the danger that dirt will enter the exposed connections and the possibility of mishandling the equipment through lack of knowledge of its design and construction. Various components are made with the utmost precision and may be easily damaged when removed.

CAUTION

There should be no tampering with the injection pump assembly, or removal of It for inspection, unless engine operation is seriously Impaired and the cause of the difficulty Is directly traceable to the pump unit.

It should be borne in mind that minor troubles, such as suction leaks at joints in the supply line can cause erratic engine behavior. It is unlikely that the injection pump itself would require overhaul before it has several thousand hours of operation. All injection pumps should be calibrated and repaired at authorized service stations, unless factory trained personnel are available with the proper tools and test equipment.

ELECTRIC FUEL TRANSFER PUMP

Many Continental TMD Industrial engines use electric fuel pumps to transfer fuel from the fuel tank to the fuel injection pump. These electric pumps are usually mounted to the crankcase fuel pump pad cover where a mechanical fuel pump would normally be mounted.

Electric fuel pumps will operate without having to crank the engine over. This makes them extremely useful when bleeding the air from the fuel system (see Bleeding the Fuel System). They draw little battery current and only a slight drain is usually seen on the storage battery during the bleeding process.

When fuel pump trouble is suspected, always check that the pump is getting voltage from the ignition circuit and that the BLACK ground wire is intact before declaring the pump is bad! A "quick" test for voltage is to turn the ignition switch "on" and feel the body of the pump. You can actually feel the pump operating and hear it ticking if the work area is quite enough. If you can’t hear or feel the fuel pump operating, check for actual battery voltage to the unit before declaring it to be bad Using a Voltmeter or test light, check for voltage at the first wire connection closest to the electric fuel pump. This connection is usually found at the fuel shutoff solenoid on the fuel injection pump.

If no voltage is present - check the equipment electrical circuit for blown fuses; broken wires; bad switches; etc. If voltage is present at the fuel pump, make one last test before declaring the pump bad l Loosen the fuel line fitting on the inlet fuel line on the injection pump. Fuel should flow and the pump should begin ticking if it is operating properly.

If the pump is operating, but volume or flow needs to be checked - simply disconnect the fuel inlet line from the fuel injection pump and turn the ignition switch on.

Be prepared, with a container, to catch the fuel as it comes out of the open line. A steady solid stream of fuel indicates that the fuel pump is probably okay for continued use. A broken stream with bubbles and dribbles or no fuel at all indicates the fuel pump is probably bad or that there are restrictions somewhere in the fuel circuit. There could also be an air leak in the fuel pickup line on the suction side of the pump causing the pump to cavitate.

If restrictions are suspected in the fuel circuit, they are most likely found to be either plugged fuel filters or trash on the inlet side of the electric fuel pump.

BLEEDING THE FUEL SYSTEM

Bleeding is necessary on initial installation of the fuel injection system after any subsequent removal and if the system should be drained after having run out of fuel.

NOTE

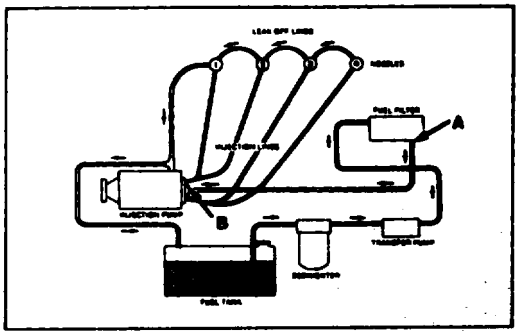
Electrical equipment such as starters should be shielded with non-conductive material during the bleeding process to prevent damage from fuel entry. Also, be certain that all transmissions, gearboxes, hydraulic control, etc., are in a neutral position before attempting to crank the engine. If a wheel vehicle is involved, be certain that the wheels are "chocked" and the parking brake is set.

STANADYNE Fuel System

1. Turn the ignition switch to the 'ON position.
2. Loosen the filter outlet connection (A), or the fuel injection pump inlet connection (B)whichever is the higher, and allow fuel to flow until free of air. Tighten the connection.

NOTE

If connection (A) is inaccessible due to the type of filter In use, loosen connection (B).



Typical STANADYNE Fuel System Schematic'

3. Loosen any two injector high-pressure pipe nuts at the injector end. Set the accelerator to the fully open position and with the ignition switch "ON," crank the engine until fuel free from air flows. Tighten the line nuts.
4. Start the engine.

FUEL FILTERS

Clean fuel is a must in diesel operation. Extreme conditions may require additional filters to provide longer filter change periods--when clean fuel is not available. Continental diesels are normally equipped with the filter installed between the fuel injection pump and the transfer pump outlet-so the filter is on the pressure side of the transfer pump.

The period for changing the element will largely depend upon the quality and condition of the fuel available. Under normal conditions, the element should be renewed every 400 hours. This period should be decreased if unavoidable contamination of the fuel is experienced.

NOTE

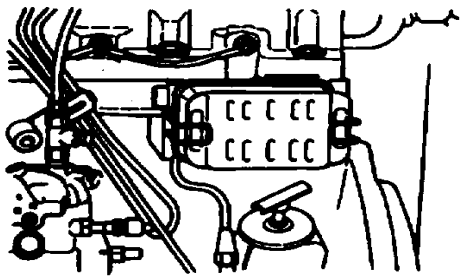
Electrical equipment such as staners should be shielded with non-conduction material during filter replacing and priming to prevent fuel entry.

STANADYNE FUEL FILTER

NOTE

This fuel filter is not a water separator. If water contamination is anticipated, an additional primary fuel filter and water separator should be installed before the fuel transfer pump.

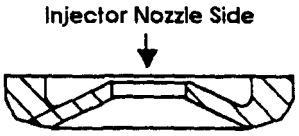
No attempt should be made to clean this type element. It should be replaced at the regularly scheduled periodic maintenance interval or if there is reason to believe that it is plugged. To replace the metal canister element, simply release the two spring clamps and pull the old element off the filter bracket. Lube the new element grommets with clean diesel fuel and push into place. Snap the spring clamps into position and bleed the fuel system.



Stanadyne Fuel Filter (# TMD20F00400)

INJECTORS

When replacing injectors in the cylinder head it is essential that a new heat shield washer be fitted between the nozzle cap and the cylinder head (Reference Section 8, Heat Shield & Injector).



Side View

Tighten injectors evenly to 50-55 lb-ft (70 N.m). Injectors should be taken out only if engine is malfunctioning as outlined below:

1. Misfiring.
2. Knocking in one (or more) cylinder(s).
3. Engine overheating.
4. Loss of power.
5. Smoky exhaust (black or white).
6. Increased fuel consumption.
7. To perform a compression test.

The faulty injector or injectors may be located by loosening the line fitting nut on each, in turn, with the engine running at a fast idle. This allows the fuel to escape and not enter the cylinder. The injector least affecting the engine performance should be removed from the cylinder head and reconditioned or replaced.

CAUTION

No attempt should be made to adjust the Injection pressure without a proper testing pump and pressure gauge. It is Impossible to adjust the setting of the Injector with any degree of accuracy without proper equipment.

TESTING

Injectors should not be disassembled unless testing shows that cleaning or other service is needed. Any disassembly of the fuel injectors should be done in an extremely clean work area. The exterior of the injectors should be rinsed with cleaning solution before testing. Be careful not to flush any debris into the open ports of the injector.

Before testing each injector, turn it upside down and shake it. This may get rid of any debris that has just entered the nozzle during the removal and cleaning process.

Use a special hydraulic injector tester equipped with a filter so that only clean oil enters the injector. There are many testers on the market-follow the manufacturer's instructions for correct and safe operation of the test equipment chosen.

WARNING

Bodily injury may result during this operation if care is not exercised. The high velocity of spray may puncture the skin and cause blood poisoning. Keep hands and face away from the nozzle spray.

Before testing, determine the brand name of the fuel injector about to be tested. TMD engines currently use injectors made by two different companies. One company is CAV, the other is STANADYNE. They look very much alike, but are never mixed together on any one engine because of different operating pressures. The nozzles are identified by very small lettering on the outside of the nozzle as follows:

STANADYNE - stamped just under the bleed-off tubes.

After having identified the nozzle, connect it to the tester.

STEP 1: Set tester so that it will apply pressure and then work the pump handle several sharp strokes. This will dislodge some light carbon buildup from the tip of the nozzle and may remove any very fine dirt particles in the nozzle cavities.

STEP 2: Now work the pump handle slowly and observe the opening pressure. Compare to the following chart.

STANADYNE
Acceptable Pressure Limits
*New Injector = 2150 - 2250 PSI (148.2- 155.1 BAR)
**Service Injector = 1925 - 2250 PSI (132.7- 155.1 BAR)

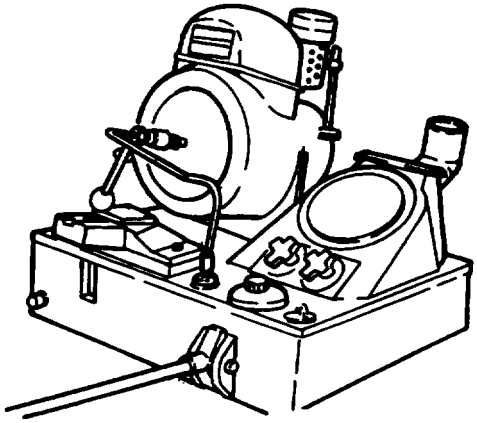
* A new injector is an injector with no engine "run time" on it.

** A service injector is considered to be any injector that has been in use or any injector that has been reconditioned and no new parts were involved. The lower acceptable limit figures for the service injectors are necessary due to nozzle needle embedment and spring relaxation that takes place after a nozzle has been put into use.

Injectors that fail to meet the acceptable pressure limits should be adjusted by adding or subtracting shims.
Replace any injector that cannot be adjusted to meet pressure limit specifications.

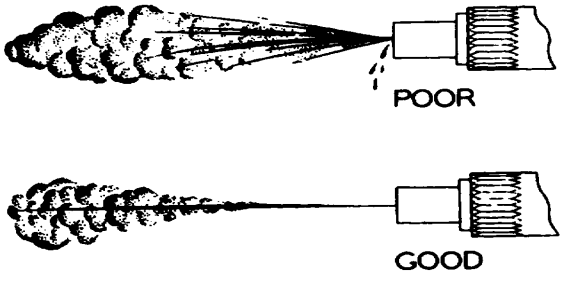
NOTE

It is always a good practice to have all the injectors of any one engine set as nearly alike as possible. This makes for a smoother running engine.



Checking Injector Opening Pressure

STEP 3: Once the pressure setting has been confirmed, check the nozzle spray pattern. Hold constant pressure on the tester lever to maintain the opening pressure of the nozzle. Watch for dribble from the spray orifice which indicates a bad seal. Also, look for leaks along the body of the nozzle holder itself which indicates a leak between the holder and the valve body lapped surfaces.



Nozzle Spray Patterns

STEP 4: Now work the pump handle rapidly (about 100 strokes per minute) and observe the spray pattern produced.· Check that spray pattern is a 'straight shot" or that isn't aimed off to one side. The spray pattern should exit the injector in the form of a thin line stream that gradually gets a little wider before developing into a small mist cloud out at the end.

FUEL INJECTION PUMP

The function of a diesel fuel injection pump is to accurately meter and deliver fuel to a nozzle in each cylinder and to inject it at high pressure into the combustion chamber at precisely timed intervals. The extreme precision necessary can well be appreciated since this cycle must be repeated thousands of times per minute with virtually no variation in timing or amount of fuel injected.

Removal of the Fuel Injection Pump

Remove all high-pressure fuel lines being careful not to bend them. Disconnect any low-pressure fuel lines, linkage rods, or electrical wires that need to come off to allow injection pump removal from the engine. Remove the three long bolts that go completely through the timing gear cover and remove the injection pump. DO NOT separate the injection pump from the adaptor mounting plate unless absolutely necessary. This will save you much time during reinstallation of the pump if the pump is going back onto the same engine.

STANADYNE MODEL
DB2 INJECTION PUMP

The model DB2 injection pump is described as an opposed-plunger, inlet-metered, positive-displacement, distributor-type pump. The DB2 pump incorporates a single pumping chamber. Precise distribution between cylinders, inherent in the pump design, and the ability to preset fuel flow eliminates lengthy periods on the test stand. The pump is self-lubricated, and contains essentially the same number of parts regardless of the number of cylinders served.

Working Principle

The main rotating components are the drive shaft, transfer pump blades, distributor rotor, and governor.
The drive shaft engages the distributor in the hydraulic head. The drive end of the DB2 rotor incorporates two pumping plungers.
The plungers are actuated toward each other simultaneously by an internal cam ring through rollers and shoes which are carried in slots at the drive end of the rotor. The number of cam lobes normally equals the number of engine cylinders.

The transfer pump at the rear of the rotor is of the positive-displacement, vane type and is enclosed in the end cap. The end cap also houses the fuel inlet strainer and transfer pump pressure regulator. The face of the regulator assembly is compressed against the liner and distributor rotor and forms an end seal for the transfer pump. The injection pump is designed so that end thrust is against the face of the transfer pump pressure regulator. The distributor rotor incorporates two charging ports to service all heads outlets to the injection lines. The hydraulic head contains the bore in which the rotor revolves, the metering valve bore, the charging ports, and the head discharge fittings. The high-pressure injection lines to the nozzles are fastened to these discharge fittings. The DB2 pump contains its own mechanical governor, capable of close speed regulation, the centrifugal force of the weights in their retainer is transmitted through a sleeve to the governor arm and through a positive linkage to the metering valve. The metering valve can be closed to shut off fuel through solid linkage by an independently operated shutoff lever, or by an electrical solenoid. The automatic advance is a hydraulic mechanism which advances or retards the pumping cycle.

Short Method STANADYNE Re-installing & Timing the Original Fuel Injection Pump & Adaptor Plate Onto the Engine From Which It Was Removed.

This method is identical to the STANADYNE Long Method that follows, except that you omit the first five (5) steps when performing the Short Method.

NOTE

There Is a chisel-type scribe mark that is stamped Into the Injection pump mounting flange and the adaptor mounting plate. In most cases at the end of Step 15, these two marks will line up. However, don't be alarmed if they miss lining up by a small distance.

The most important point about timing the STANADYNE injection pump is the alignment of the **internal** timing marks (Ref. Step 15) and the corresponding location of the front pulley timing mark (Flywheel timing mark on some engines). See Appendix F Section 2.1, Service Specifications, or the setting required on your particular engine.

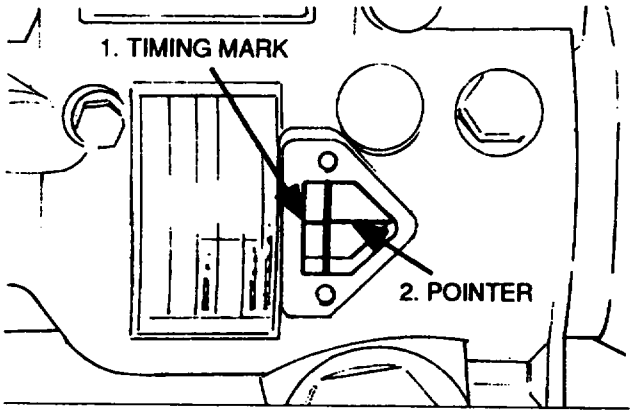
Long Method STANADYNE Installing & Timing a New or Reconditioned (or Other Than Original) Fuel Injection Pump.

WARNING

Bodily Injury may result during the timing operation of the fuel Injection pump of the engine Is running. DO NOT attempt to adjust the timing without the pump mounting bolts securely torqued.

1. Grind or file off any existing scribe mark that may be on the injection pump adaptor mounting plate. A new plate will have no scribe mark.
2. Install a new gasket to the front of the injection pump.
3. Install the adapter mounting plate onto the injection pump using the M8 screws, flat washers, and lock washers. Tighten screws finger-tight.
4. Install the injection pump gear along with alignment dowel pin onto the injection pump shaft. Use three M8 screws and lock washers for mounting the gear.
5. Hold the gear in soft-jawed vise and torque the three M8 screws to 20 25 lb-ft (27 34 N•m).
6. Install a new O-ring into the groove on the adaptor mounting plate.
7. Lightly lubricate the O-ring with motor oil.
8. Rotate the crankshaft pulley clockwise (viewed from the front) until the notch on the pulley is at the timing setting prescribed in Appendix F, Section 2.1, Service Specifications.
9. Check that the engine is on the compression stroke by looking for the single beveled tooth on the rear side of the injection pump drive gear. The injection pump drive gear is the smaller of the two gears visible in the opening where the injection pump mounts to the engine. If the beveled tooth is not visible in the opening, simply rotate the crankshaft one revolution clockwise and it will be. This is very important because this engine will run with the injection pump installed 180° out of time. However, it runs very poorly in that condition.
10. Remove the timing hole cover from the side of the injection pump housing.

11. Turn the injection pump gear until the internal timing marks are lined up (See Below).



Turn the injection pump gear until timing mark is aligned with the pointer

12. Guide the injection pump into position and install the three long M10 mounting bolts, lock washers, and nuts that secure the adaptor mounting plate to the engine. Torque the M10 bolts to 25-30 lb-ft (34-40 N•m).

13. Inspect the internal timing marks again. The two marks should look like one unbroken horizontal line. If not, you must judge as to whether the pump gear is one tooth or more out of time or if a minor rotation of the injection pump body will align the marks. If the marks are far apart, repeat step 12 because the pump gear is probably out of time. If the marks are very close together, rotate the body of the injection pump one way or the other until the marks line up.

14. Torque the three M8 bolts that fasten the injection pump to the adaptor plate to 15-18 lb-ft (20-24 N•m).

15. Recheck the timing marks after eliminating the backlash and play that may be in the timing gear train. This is done by rotating the crank pulley counterclockwise approximately 1/4 turn (viewed from the front). Then, rotate the crank pulley clockwise until it is back to the prescribed timing position. Check the internal timing marks once again and adjust if needed.

16. Install the timing hole cover and gasket onto the injection pump housing.

NOTE

Leave any two of the fuel line nuts loose at the nozzles for Bleeding the Fuel System.

17. Install the high-pressure fuel lines and torque the fuel line nuts to 20-25 lb-ft (27-34 N•m).

18. Reconnect all electrical wires; linkage rods; low-pressure fuel lines, etc.

19. Bleed the fuel system.

FUEL RECOMMENDATIONS

Diesel fuel selection, handling, and filtration is of great importance. The fuel not only supplies the energy for all the work done by the engine-it also lubricates the parts of the fuel injection system which operate with very close tolerances. Fuel that contains water, abrasives, or sulphur in excess of our recommended specifications can cause extensive damage to the injection pump and engine.

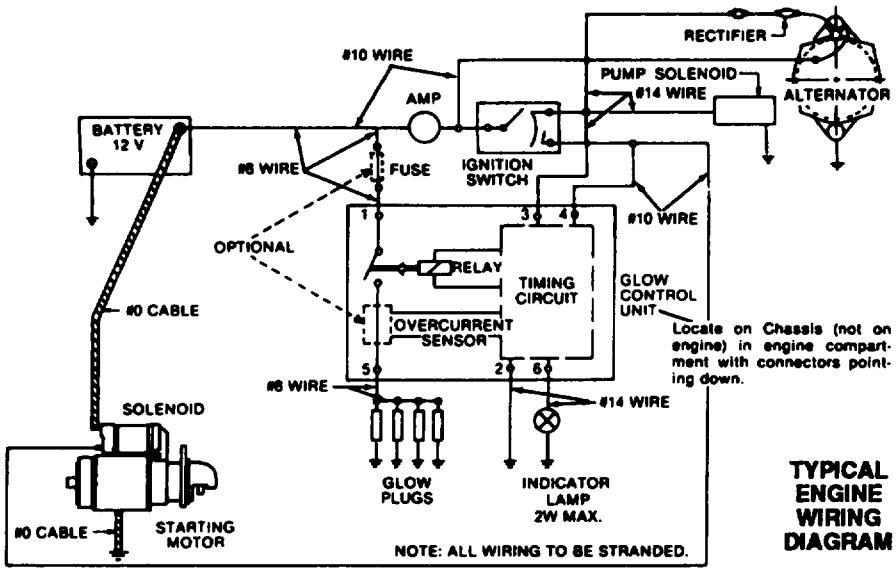
DIESEL FUEL SPECIFICATIONS

Continental diesels have been designed and developed to use ONLY No. 1-D (light fuel) and preferably No. 2D (heavy fuel)-which can be a cracked residual, a blend of preferably a straight-run distillate having the following characteristics: Refer to Section 2 for seasonal fuel recommendations.

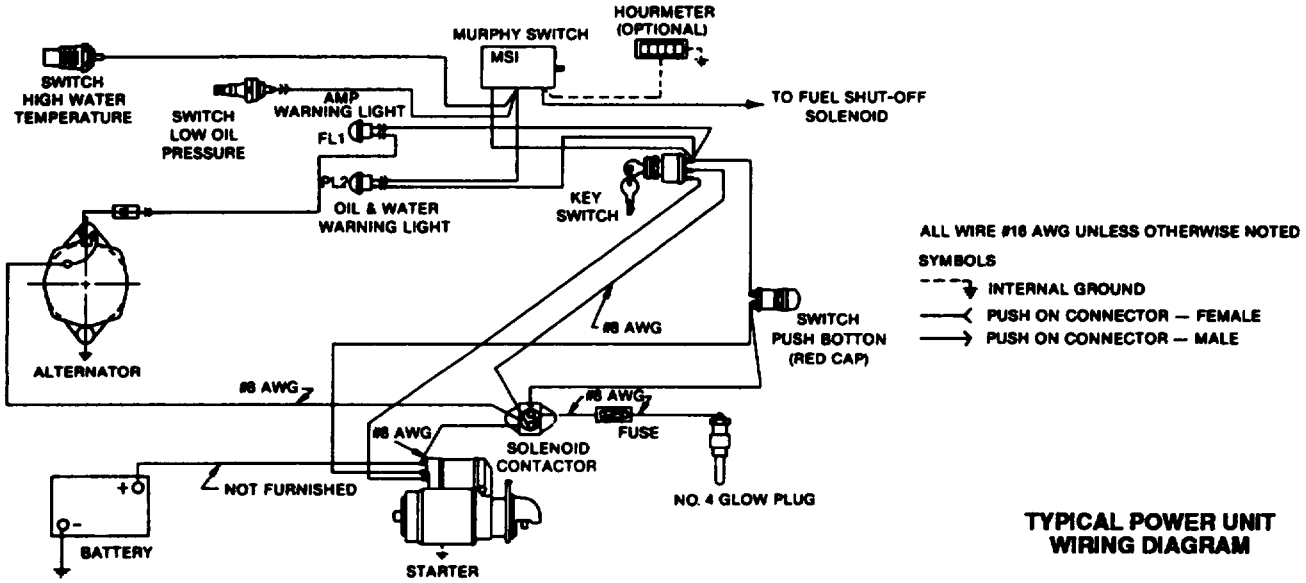
(listed in order of importance)

DIESEL FUEL CHARACTERISTICS	EFFECT	RECOMMENDED LIMITS
Cetane Number	Indicative of Ignition Quality, Higher number-better Starting and Idling.	50 desired 45 minimum
Volatility: Initial Boiling Point	To prevent premature vaporization during hot weather operation.	320°F. minimum
50% recovery 90% recovery End Point	Less smoke with fuel at low 50% and 90% Recovery Temperatures. Higher end points only partially burn, causing build up of deposits in energy cell and nozzle, causing pintle sticking and smoke	550°F. Maximum 650°F. Maximum 700°F. Maximum
Distillation Recovery	Lower % recovery indicates heavy oil fractions which cause smoke and poor combustion.	98%
SU Viscosity 100°F. (38 C)	Viscosity is a measure of flow resistance-the low limit minimizes leakage and lubrication and the higher limit insures penetration and atomizations.	31 - 40 seconds
Water and Sediment	Water in fuel causes corrosion, rapid pump wear and clogged fillers.	.05% maximum by volume
Pour Point	Fuel Oil must be in fluid state to prevent clogging due to congealing wax.	10° below lowest anticipated operating temperature
A.P.I. Gravity @ 60°F.	Lower Gravity Fuels contain more heat Units/Gal	30 minimum (A.P.I. Degrees)
Total Sulphur	Sulphurous acids corrode and increase engine wear.	.5% maximum
Corrosion (Copper) 3 Hours @ 212°F.	Discoloration or pitting on polished copper strip shows same effect on engine parts.	pass test
Ash	Amount of non-combustible material is abrasive and causes pump wear.	.01% maximum by weight

Section 6 - Charging System



TYPICAL ENGINE WIRING DIAGRAM



TYPICAL POWER UNIT WIRING DIAGRAM

CHARGING SYSTEM

The charging circuit consists primarily of an alternator, regulator, battery, and wiring. When analyzing the charging circuit, the components should be checked in the following order:

I. Wiring

Wiring in the charging circuit should be carefully inspected for frayed insulation or other damage, and replace any wiring that is defective. Also inspect all connections to the alternator, regulator, and battery (including all ground connections), and clean and tighten as required.

II. Battery

Battery condition is very important for proper starting.

The lead-acid storage battery, used on automotive and industrial applications, is an electrochemical device for converting chemical energy into electrical energy. It has two major functions:

1. It provides a source of current for starting the engine.
2. It can, for a limited time, furnish current when the electrical demands of the unit exceed the output of the alternator.

WARNING

Stop engine before checking battery terminals or electrical connections. Sparks or flames near a battery could cause an explosion or fire. Battery acid can cause corrosive bums. Always wear eye protection. Use of jumper cables or battery charging should be done only as directed by manufacturers' safety instructions.

Refer to equipment manufacturer for battery recommendations.

III. Alternator

The alternator differs from the conventional D.C. shunt generator in that the armature is the stationary member and is called the stator: while the field is the rotating member and is called the rotor. Alternating current is rectified (changed to direct current) by means of diode rectifiers rather than mechanically with brushes coming into contact with the various segments of the rotating armature on the generator. With this construction, the higher current values involved in the armature or stator may be conducted to the external circuit through fixed leads and connections rather than through the rotating commutator and brushes as in D.C. generator. The comparatively small values of current supplied to the field may be conducted without difficulty through small brushes and rotating slip rings. The alternator is somewhat lighter and more compact in design than the conventional D.C. generator of comparable electrical size and is equally as simple to service and test. Each bearing is prelubricated which eliminates the need for periodic lubrication.

Precautions to be observed when testing or servicing the alternator system:

1. **Disconnect the battery** before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter, or accessories will cause severe damage to the units and/or wiring.
2. **To avoid damage to the regulator, do not, at anytime, connect battery to the regulator field terminal.**
3. **The field circuit must never be grounded, on this system, between the alternator and the regulator.** Grounding of the field terminal either at the alternator or regulator will damage the regulator.
4. **If it is necessary to solder any lead to a rectifier lead,** use a pair of pliers as a heat dam between the solder joint and the rectifier.
5. **The alternator must not be operated on open circuit with the rotor winding energized.**
6. **Do not attempt to polarize the alternator.** No polarization is required. Any attempt to do so may result in damage to the alternator, regulator, or circuits.
7. **Grounding of the alternator output terminal may damage the alternator and/or circuit and components.**
8. **Reversed battery connections may damage the rectifiers, wiring, or other components of the charging system.** Battery polarity should be checked with a voltmeter before connecting the battery.
9. **If a booster battery or fast charger is used, Its polarity must be connected correctly to prevent damage to the electrical system components (positive to positive, negative to negative.)**

IV. Regulator

Most regulators are fully transistorized and completely sealed. These cannot be adjusted or repaired, and it can be assumed that this type regulator will outlive the other components in the charging system.

Other regulators are adjusted and repaired in accordance with the manufacturer's instructions.

Installation of Regulator for Alternator

To ensure proper operation and to protect the alternator and regulator, the following steps should be observed during installation.

1. Make sure regulator is of the same voltage and polarity as the alternator and battery.
2. Disconnect battery cable at battery terminal.
3. Make sure the mounting area of the alternator and regulator base are clean and make a good tight connection.
4. Connect alternator in accordance with the manufacturer's instructions.
5. Do not flash field or ground terminals of the regulator.
6. Reconnect battery cable.
7. Start engine and observe ammeter. A "high" charge rate is normal for the first few minutes, but will decrease as the battery recharges.

Note

When servicing the charging system, never remove a unit until tests have shown it to be defective. Reference always should be made to the manufacturer's maintenance manuals for complete troubleshooting instructions.

Section 7 - Preventive Maintenance

In order to obtain maximum efficiency from your diesel engine, a definite maintenance program should be setup and followed. Haphazard maintenance will only lead to faulty engine performance and shorten engine life. All moving parts in the engine are subject to wear; however, wear **can be reduced** by careful operation and a planned maintenance program.

In general, diesel engine operation demands careful attention to the cleanliness of air, fuel and oil and maintaining coolant operating temperatures of 81°-93°C (180°-200°F.). The following pages, covering **Daily, 50, 250, 400 and 500** hour maintenance, have been worked out with our field service division as "Minimum Requirements" to keep your engine in dependable operating condition.

DAILY PREVENTATIVE MAINTENANCE SCHEDULE

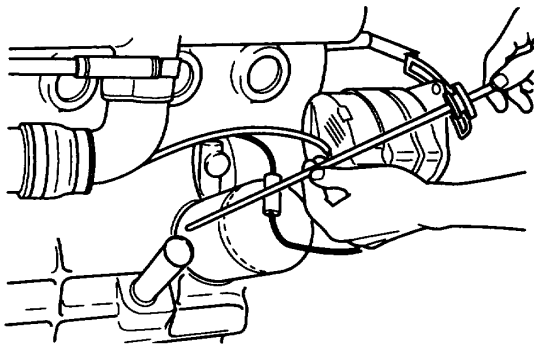
1. OVERALL VISUAL INSPECTION OF ENGINE

Look for evidence of fluid leaks on floor, cylinder head and block, indicating loose fuel, oil or water connections-**tighten If found.**

2. CHECK OIL LEVEL OF ENGINE

The dipstick indicates the high and low oil level in the crankcase-make allowance for additional oil drainage back into oil pan if engine has not been stopped 15 minutes. The most efficient oil level is between the two dipstick levels.

IMPORTANT: Do not add oil until oil level approaches the low mark-then add only enough to bring it to high level NEVER above. Do not operate the engine with oil below low level mark.



Check Oil Level of Engine

3. CHECK RADIATOR

Fill radiator with a clean 50/50 water/anti-freeze mixture to normal level maintained due to expansion when heated. Visually inspect fan and belt for condition and adjustment.

4. FILL FUEL TANK

Fill fuel tank at end of day's operation to prevent condensation forming in tank. Clean filler cap and area around spout before filling to prevent entrance of dust into fuel system.

5. CHECK AIR CLEANER

All engines, when operating, consume several thousand cubic feet of air per hour. Since dusty air is full of abrasive matter, the engine will soon wear excessively if the air cleaner does not remove the dust before entering the cylinders. On any air cleaner, operating environment dictates the air cleaner service periods. In extremely dusty operations, this may be once or twice daily. In dust protected areas the air cleaner should be serviced when changing oil. One basic type of air cleaner is normally used-the dry replaceable element type.

DRY-TYPE REPLACEABLE AIR FILTER

Dry-type air filters are standard equipment on many engines and it is most important that the dirt buildup in the cartridge does not reduce the air flow sufficient to cause a noticeable loss in power. They should normally be serviced every 50 hours in the following steps: (Extreme conditions will require daily cleaning). Remove cover and cartridge after removing wing bolt do not allow dirt to fall into the exposed carburetor.

CAUTION

Do not damage the gasket selling surface or bend the outer screen portion of the cartridge while cleaning. Replace the cartridge If in doubt

Clean cartridge by gently tapping flat on a smooth horizontal surface to loosen and remove the heavier dirt deposits.

The cartridge can also be cleaned with compressed air, but it is important to use the following guidelines:

ALWAYS keep air pressure adjusted to less than 30 psi (2 Bar).

WARNING

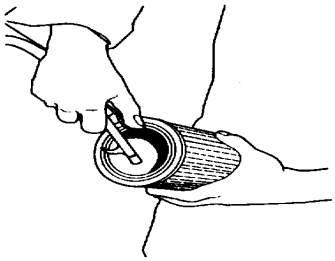
Wear protective glasses or a face protector whenever air hoses are used. Never use air pressure that Is more than 2 Bar (30 pounds per square inch) and make sure the air line Is equipped with a water filter to prevent damage to parts.

- **ALWAYS keep the tip of the air nozzle or air hose at least 2 inches (50mm) from the paper portion of the cartridge.**
- **ALWAYS blow the cartridge clean from the inside out.**

CAUTION

Failure to comply with the above guidelines will damage the cartridge and lead to severe engine damage. Replace the cartridge If in doubt!

- **Do not wash or oil cartridge.**



Cleaning Dry Type Air Filter

Wipe inside screen, cartridge gasket surface, inside cover, and mounting seat before installing element.

Place cartridge on mounting seat make sure outer edge of cartridge fits inside edge of bottom plate.

Replace cover and assemble wing bolt finger tight to insure air filter seal.

REPLACING NEW CARTRIDGE

Replace immediately if bent, crushed, or damaged. Dry-type air cleaners are efficient only as long as top and bottom sealing edges are not damaged.

Also, surface of air cleaner base and cover where air cleaner cartridge seals must be clean and not damaged, such as dents or bends.

Often in cleaning the cartridge it is tapped against surfaces that are not flat, thus damaging sealing edges. Regardless of how clean the paper is, **if edges are damaged, dirt will enter the engine.**

The element should be replaced every 250 hours or when servicing does not result in full power recovery whichever occurs first.

Under extreme dust conditions, more frequent replacement will be required.

NOTE

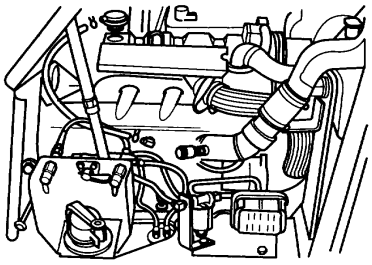
A 1/4 teaspoon of dust per hour can ruin an engine In one 8 hour day.

PCV SYSTEM

All connections must be air tight.

Blow-by circulates into the intake manifold maintaining crankcase pressure within a narrow range regardless of operating speed or load.

servicing of the PCV system is confined to checking the conditions of the hoses and connections.



Typical Continental Motors PCV System Installation

CHECK OIL PRESSURE

Note oil pressure gauge which should indicate the following pressure range at full throttle and a minimum of 0.5 Bar (7 pounds) pressure at idling speed.

MODEL	OIL PRESSURE
TMD	2.8 - 4.1 Bar (40-60 PS)

Higher oil pressures may be experienced during cold starts.

NOTE ANY UNUSUAL NOISE

Operators familiar with daily engine operation soon become alert to any noise not normally present. This is very valuable in correcting defects in the early stages and preventing expensive repairs or delays.

EVERY 50 HOURS

1. REPEAT DAILY OPERATIONS OUTUNED
Follow previous instructions.

2. CHANGE CRANKCASE OIL
Engine life is dependent upon clean oil being circulated to all moving parts; therefore, the frequency of oil changes and oil filter replacement is very important and should be made at regular, scheduled periods.

The schedule for changing oil is directly dependent upon the operational environment: an extremely clean operation could go 100 hours while a dirty operation (foundry or cement factory) could be 50 hours or less.

Replace the oil filter element every time the oil is changed.

Thoroughly clean the sealing surfaces before replacing new element and gasket.

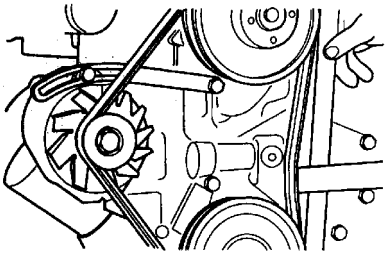
Do not put kerosene into the crankcase. The best method is to drain the oil when the engine is thoroughly heated-which will carry off most of the sediment.

Some operators unwisely put kerosene in the crankcase after draining the engine oil, then turn the engine over with the starter in the belief they are doing a better job of crankcase cleaning.

In doing this, kerosene is circulated through the oil pump, the main oil header, and the branches leading into the engine bearings, thereby washing away the protective oil film. In addition, some of the kerosene will be trapped and remain to thin out the new oil, reducing its lubricating qualities.

3. SERVICE AIR CLEANER
Clean element with compressed air (See Daily Instructions). Be sure that no unfiltered air can enter the engine.

4. CHECK FAN BELT TENSION
Inspect wear condition of fan belt; note alignment and check belt tension which should allow not over 13ram (1/2") deflection on the long span.

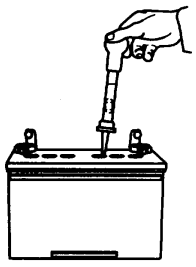

Fan Belt Tension

5. CHECK BATTERY

WARNING

Stop engine before checking battery terminals or electrical connections. Sparks or flames near a battery could cause an explosion or fire. Battery acid can cause corrosive burns. Always wear eye protection. Use of jumper cables or battery charging should be done only directed by manufactures' safety instructions.

Check specific gravity of each cell-which should be at feast 1.250. Add distilled water, if required, to raise level 9.5mm (3/8') above the separators.


Checking Battery

Particular attention should be given the battery during cold weather. The cranking power of a fully charged battery @27°C (80°F) is reduced 60% @ -18"C (0°F)but yet the power required to crank the engine is 2 1/2 times greater at -18°C (0°F) than 0 27°C (80°F).

6. DRAIN WATER FROM FUEL FILTER(S)
Note: Some fuel filters are not equipped with a water drain (See Fuel Filters, Section 5).

7. ADJUST IDLE SPEED TO EQUIPMENT MANUFACTURERS RECOMMENDATION
Repeat again at end of 500 hours.

EVERY 250 HOURS

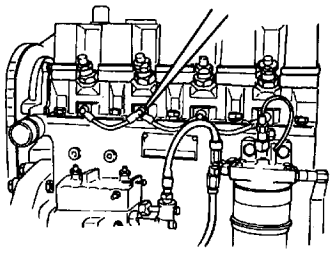
1. REPEAT DAILY & 50-HOUR SCHEDULES
Follow previous Instructions.

2. CLEAN EXTERIOR OF ENGINE
Use steam if available, otherwise any good commercial engine cleaner to wash down the engine.

CAUTION

Never allow cool water to come in contact with the fuel injection pump while the engine Is running! Injection pump seizure may result.

3. CHECK GLOW PLUGS
Inspect glow plug wiring.



Glow Plugs

4. IF DRY REPLACEABLE ELEMENT AIR CLEANER IS USED, REPLACE ELEMENT

5. FIRST 250 HOURS RECOMMEND ADJUSTING VALVE TAPPET CLEARANCE

EVERY 400 HOURS

1. REPEAT DAILY AND 50-HOUR SCHEDULES
Follow previous Instructions.

2. FUEL SYSTEM (See fuel filters Section 5)
-Replace fuel filter element.
-Inspect mounting and gaskets.
-Check all connections for leaks.

1. REPEAT DAILY 50 HOUR AND 250 HOUR SCHEDULES

2. COOLING SYSTEM
Clean radiator core by blowing out with compressed air.
-Inspect radiator mounting.
-Inspect water pump and connections for leaks.
-Check fan and accessory drive belts.

EVERY 500 HOURS

3. ADJUST VALVE TAPPET CLEARANCE
Check and adjust intake and exhaust valve tappets to following clearances at operating temperature.

MODEL	INTAKE	EXHAUST
TMD	0.36mm (.014")	0.46mm (.018')

4. SAFETY AND THERMAL CONTROLS
Inspect control wires and connections.

Section 8 - Engine Repair & Overhaul

This section includes instructions for repairs and overhaul of the component units of Continental industrial diesel engines.

Provide a clean place to work and clean the engine exterior before you start disassembling-dirt causes engine failures.

Many shop tools have been developed to save time and assure good workmanship; these should be included in your equipment.

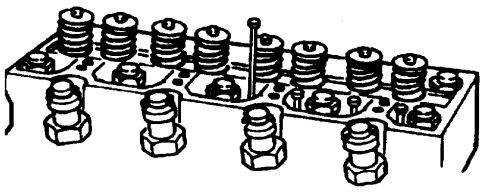
Use only genuine Continental parts in Continental engines since years of development and testing have gone into these specifications to assure maximum life and performance.

CYLINDER HEAD

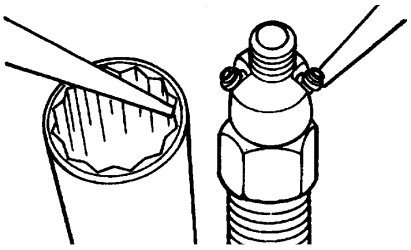
The cylinder head is the most important part of the engine assembly since it contains the complete combustion chamber including valves, fuel injection nozzles, glow plugs, and cored passages for air, exhaust and water flow.

Removing the Cylinder Head

1. Drain water from engine and disconnect radiator or heat exchanger hoses.
2. Remove cylinder head cover by removing the cap screws holding the cover to the cylinder head.
3. Remove rocker arm shaft assembly and push rods. Grip the push rods and snap them sideways out of the tappet sockets as shown in the illustration. This method serves to break the hydraulic connection and permits lifting the push rods out and leaving the tappets in place.
4. Disconnect the injectors and leak-off lines at both the nozzle and pump connections.



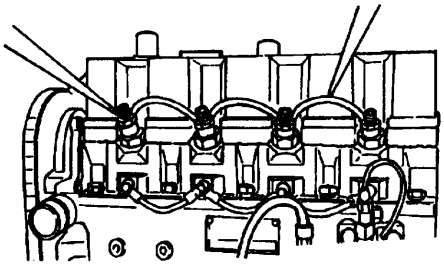
Removing Push Rod from Ball Socket of Tappet



Socket Relief Clearance

Caution should be used when replacing the fuel injectors to prevent loosening the injector leak-off nipples.

Be sure to cut a relief in the inside of your socket for clearance. This will prevent an interference between the socket and the leak-off nipple.

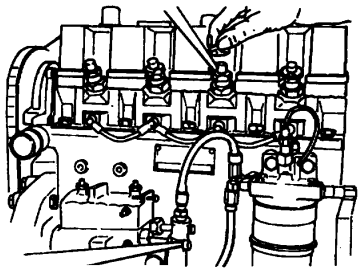


Disconnecting Injector Leak-off Line

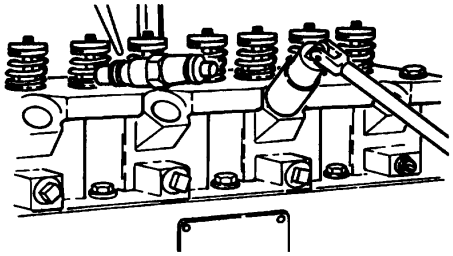
CAUTION

Always cover openings with protective caps at any time when lines are disconnected. This will prevent any dirt or foreign matter from entering.

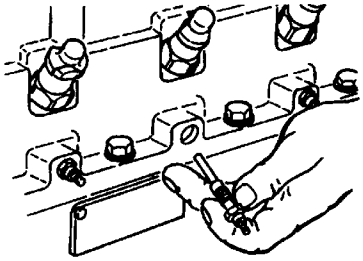
5. Remove injection nozzle assemblies. Place a protective cap over ends of injector for keeping openings clean. Refer to fuel injection system for testing procedures.



Capping Injector Connection



Injector with Protective Caps and Nozzle Removal

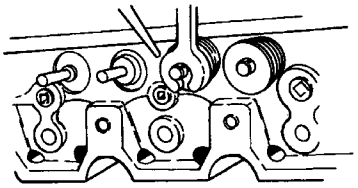


Glow Plugs

7. Loosen and remove the capscrews holding the cylinder head to the block.
8. Lift the cylinder head off the engine and carry to a clean bench for further disassembly.

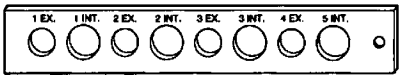
DISASSEMBLY OF CYLINDER HEAD

1. Using a C-type valve spring compressor, remove the valve spring retainer locks, retainers, rotors, springs and oil seals on valve stems placing all parts in a container of solvent.



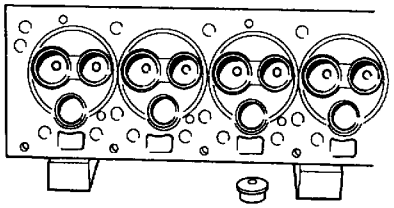
Removing Valve Springs

2. Remove the valves and place them in order in a rack with holes numbered for both intake and exhaust so they will not be mixed in handling.

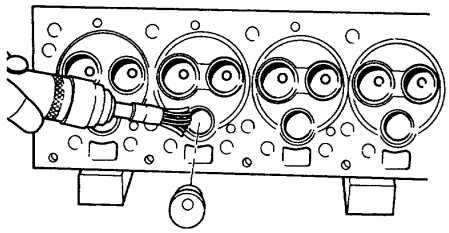


Valve Rack

3. Remove precombustion chamber inserts from cylinder head and place in a rack indicating the cylinder from which each was removed.



Pre-combustion Chamber Inserts



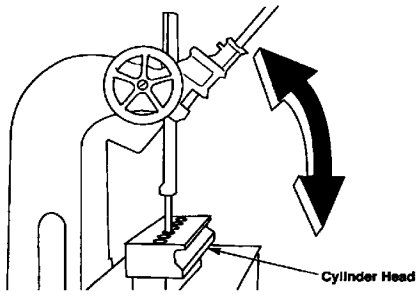
Cleaning Combustion Pocket

Clean and insert combustion pocket. Inspect carefully for cracks.

4. Remove all carbon from combustion areas using scraper and wire brush.
5. Clean the cylinder head thoroughly with a solvent or degreasing solution and blow it off with air pressure. Inspect carefully for cracks.

VALVE GUIDES

1. Clean the valve stem guides, removing lacquer or other deposits. Do not use tools that remove metal.
2. Check guides for wear by using a telescope gauge and 1" micrometer. Replace all guides that are worn bell-mouthed or have increased .0015" (0.038mm) in diameter. See Limits and Clearance Section for maximum diameter permissible to determine actual amount it has increased. Remove all valve guides when necessary by pressing them out from the combustion chamber side.
3. Replace worn guides as required by pressing in new guides to the correct depth as given in the Valve Guide Data figure on the following page.



Removing Valve Guides from Combustion Chamber Side

CAUTION

When replacing guides do not ream since these are all pre-reamed before being ferrox coated-any further reaming will remove the coating and damage guides.

VALVE SEAT INSERTS (IF SUPPLIED)

1. The exhaust valve seat insert is held in place by a shrink fit.

   Inspect all exhaust valve inserts in the head and replace any that are loose, cracked or other wise damaged. Use puller for removing faulty insert.

2. When required to replace with new insert, clean and counterbore for .010" (0.25mm) larger insert using counterbore tool with correct fitting pilot. When machining the counterbore, be sure to go deep enough with the tool to clean up the bottom so that the insert will have full contact to carry away the heat.

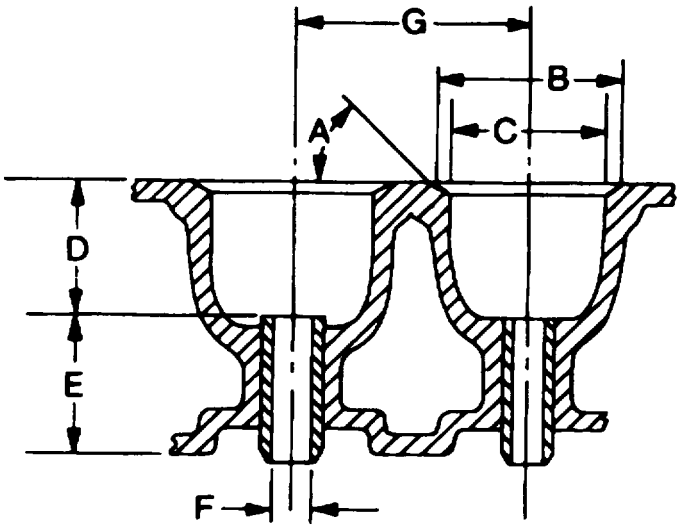
   Continental does not recommend installing new inserts having the same outside diameter as the one removed.

   New insert installation must have a press fit. Chill insert in container with dry ice for 20 minutes before assembling.

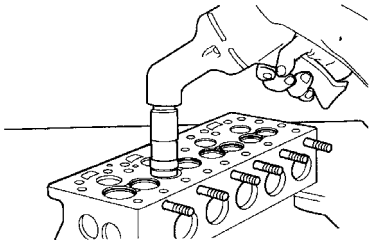
   Insert may then be installed in the counterbore using a piloted driver and arbor press, without the possibility of shearing the side walls. This assures it being seated firmly on the bottom of the counterbore.

3. Grind the intake and exhaust valve seats in the head in accordance with instructions in the Valve Guide Data figure. Before removing the arbor, indicate the seat. Total indicator reading of the runout must not be more than .002" (0.05mm) . Use a pilot having a solid stem with a long taper, as all valve seats must be ground concentric and square with either new or worn valve stem guide holes.

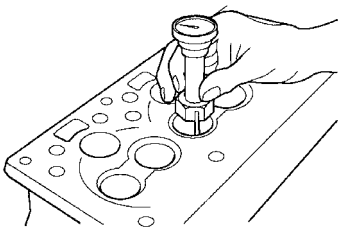
VALVE GUIDE DATA



		Model TMD	
		Intake	**Exhaust**
A	Valve Seat Angle	30°15’	45°15’
B	Diameter of Seat	39.77 (1.566)	33.50 (1.319)
C	Diameter of Choke	35.0 (1.38)	29.0 (1.14)
D	Distance (From Bottom of Cylinder Head)	43.0 (1.69)	43.0 (1.69)
E	Length of Guide	60.4 (2.38)	60.4 (2.38)
F	Inside Diameter Guide	8.717/8.692 (.3432/.3422)	8.717/8.692 (.3432/.3422)
G	Distance Intake to Exhaust	47.65 (1.876)	—



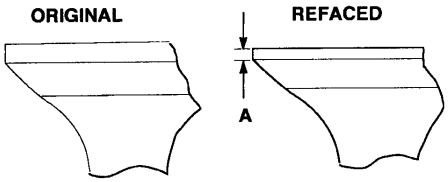
Grinding Valve Seat



Indicating Valve Seat

VALVES

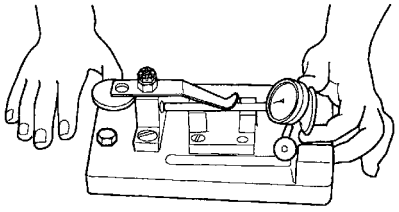
1. Inspect valves for condition and replace any that are "necked", cracked or burned, also any of which valve stems are bent or worn more than .002" 0.05mm over the maximum allowable limits. Reface or replace all valves.



IF AREA "A" IS LESS THAN 50% OF ORIGINAL, DISCARD VALVE

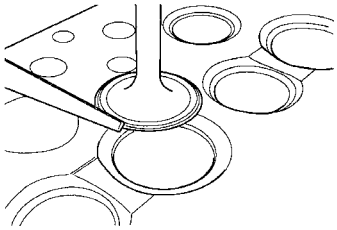
Allowable Head Thickness of Refaced Valves

2. All valves having less than 50% margin thickness (outer edge of valve head) after refacing has been completed must be replaced. To check this dimension, compare the refaced valve with a new valve.



Checking Valve Face in "V" Blocks

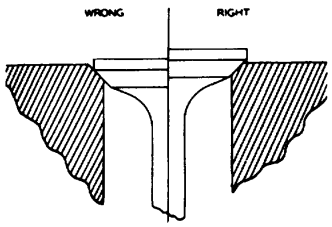
3. Check all refaced or new valves in V-blocks with indicator to determine if the contact face is true with the stem within .002" (0.05mm). If not, repeat the refacing operation.
4. After the valves and seats have been refaced and reground, coat the seat lightly with Prussian blue and drop the valve into position, oscillating it slightly to transfer the blue pattern to the valve face. This should show a contact width of 1/16' to 3/32" (1.62 to 3.2mm) and should fall well within the width of the valve face, leaving at least 1/64" (0.4mm) on either side where the blue does not show. If the contact is over 3/32" (3.2mm) wide, the seat in the head may be narrowed by using a 150 stone to reduce the outside diameter or using a 6(0 or 750 stone to increase the inside diameter.



Checking for Proper Valve Seating

Never allow valves to set down Inside the seat.

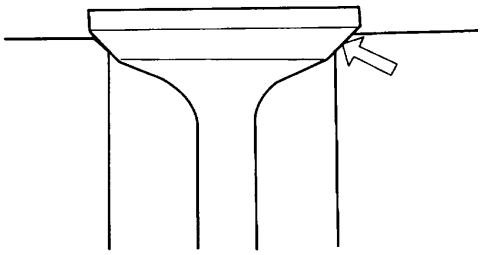
After the narrowed-down seat is brought within specifications, the seat should be retouched lightly with the original stone to remove burrs or feathered edge.



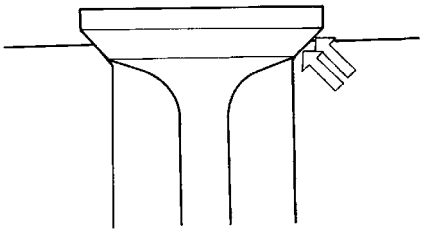
Valve Position in Head

"A poor valve grinding job cannot be corrected by valve lapping."

For example, after the valve has been hand lapped, it would look like this when cold. The thin line visible here shows where the valve lapped into its seat. Keep in mind that the engine is now at rest and cold.



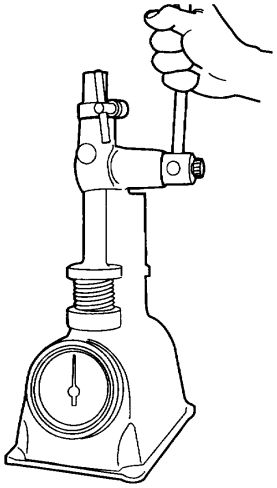
This illustration shows the same valve only now it has reached normal operating temperature. Notice that the lapped area of the valve and the seat no longer match each other. This is perfectly normal due to expansion of the valve. Now you can see that the effects of the lapping job are lost completely. So remember...do not lap valves in after grinding.



5. Coat the valve stem with a light film of engine oil.

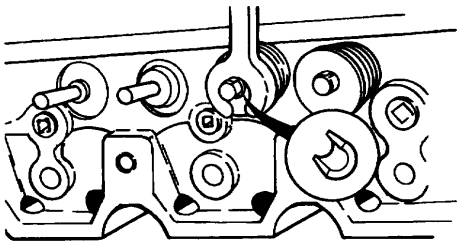
VALVE SPRINGS

1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length.



Valve Spring Tester

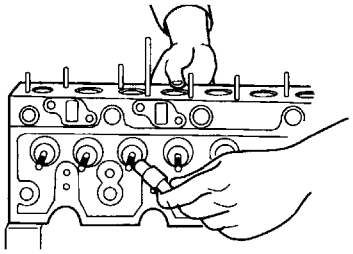
Springs, when compressed to the "valve open" or “valve closed" length, must fall within the specifications shown on the Limits and Clearance chart when new, and must not show more than 10% loss to re-use.



Valve Assembly

2. All intake and exhaust valves have umbrella seals. Soak in boiling water for several minutes prior to installation.

3. Reassemble the valves and springs in the head with the seal, retainer, and retainer lock.



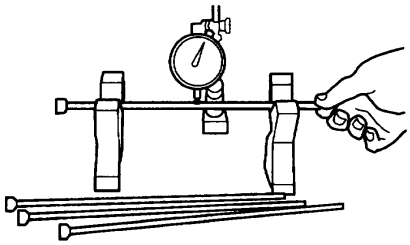
Installing Umbrella Seals

ROCKER ARMS

1. Inspect the rocker arm shaft for wear. If the shaft has "shoulders" on it due to wear, replace. Blow out oil holes with air.
2. Examine rocker arms for cracks, condition of valve contact surface and worn bores. Replace all defective rocker arms or any having over .005" (0.13mm) clearance between shaft and arm.
3. Inspect the rocker arm brackets for cracks or other damage.

VALVE PUSH RODS

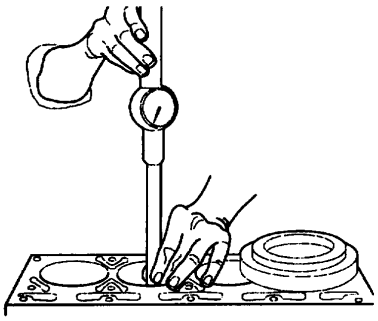
1. Inspect push rods for bends or twist and examine the ball and cup ends for excessive wear. Replace rods that are faulty or excessively worn.
2. To prevent damage to push rods, replace after the cylinder head is installed.



Push Rod Inspection for Runout

CHECKING BORE WEAR

1. Clean the ring of carbon from around the top of the cylinder bore formed above the travel of the top ring.
2. Determine the original diameter of the cylinder barrel by checking this unworn area with an inside micrometer or a dial bore gauge at intervals of approximately 45°.

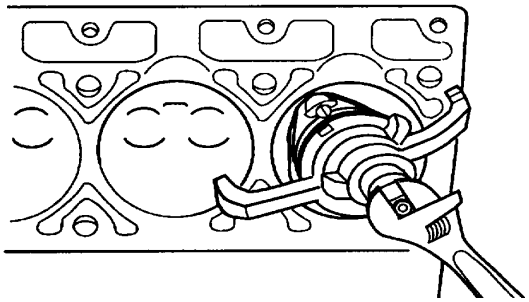


Measuring Original Bore Diameter Above Ring Travel

3. Check in same manner the top of the ring travel area approximately 1/4" (6mm) below the shoulder.
4. The maximum difference in the above checks, indicates the amount of cylinder bore wear. If less than .008" (0.20mm), re-ringing will be suitable and if over .008" (0.20mm) re-boring is recommended.

PREPARING CYLINDER WALLS FOR RE-RINGING OR RE-BORING

1. Ridge ream the cylinders to remove the unworn area at the top so that the new rings when assembled will not bump and distort both themselves and the piston lands.



Ridge Reaming Top of Cylinder

Several good makes of ridge reamers are available which will ream the top of the bore in direct relation to the worn area so that, should the worn area be off-center slightly, there will be no partial ridge remaining.

2. Drain the crankcase and remove the oil pan.

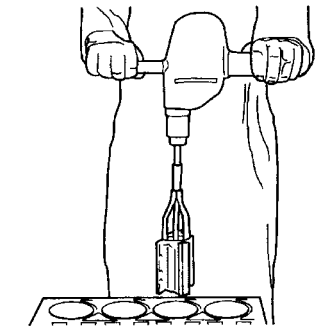
3. Remove the cap screws holding the connecting rod caps to the rod. Keep the cap and bolts in numerical order so that when the pistons and rods are removed from the engine, the cap can be reassembled and kept with its mating part.

4. Push the pistons and connecting rods up through the top of the cylinder, carrying with them all the carbon and metal chips left from the cleaning and ridge reaming operation. When doing this, every precaution must be taken to prevent damage to cylinder bores by the sharp comers and rough edges of the connecting rods.

5. It is important to remove the glaze on the cylinder bores by using a cylinder hone, with an adjustable stone tension, in order to assure quick seating of the new piston rings. If the cylinder glaze is not removed, you will have no assurance as to when the rings will begin to function properly and control the oil; this is especially true when chrome rings are used.

The following step-by-step procedure Is recommended:

a. To get the correct crosshatch pattern with a cylinder hone, use a top quality electric drill with a speed of 500 R.P.M. or less and 280 grit stones.



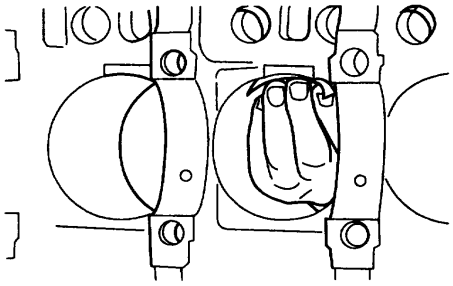
Honing Cylinders

b. Cover the entire crankshaft with a clean, slightly oily cloth to prevent abrasives and dirt from getting on the crankshaft.

c. Remove the excess carbon deposits from the top of the cylinder wall before beginning the glaze breaking operation (this is to prevent loading the stones).

d. Insert hone in cylinder and expand to cylinder wall with slight tension. Using a clean brush, wet cylinder wall and stones with kerosene. Use a hand drill and surface hone cylinder with a rapid up and down motion to produce a good crosshatch pattern. Apply kerosene continuously and increase tension on hone adjustment until a good pattern and finish is obtained. A smooth, bright finish of 10 to 15 micro inches (0.25 0.38 micro meters) is desired.

The honing operation will produce a sharp edge at the bottom of the bores. Upon completion of the honing operation, remove this sharp edge with a piece of number 500 emery cloth. If this edge is not removed, it can cause shaving of the piston skirts.

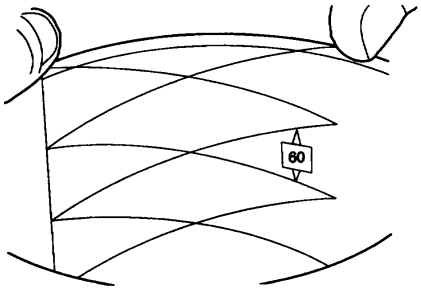


Removing Sharp Edge After Honing

e. Clean the loose abrasives from the stones by using kerosene and a wire brush.

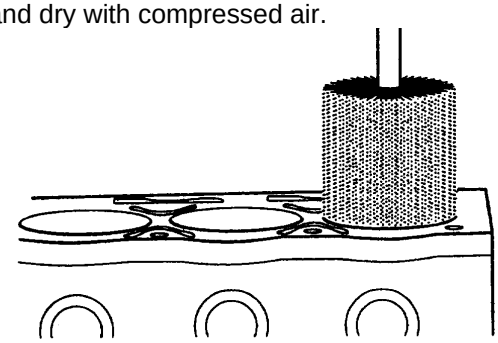
IMPORTANT: Stones must be used wet. Keep applying kerosene during honing to prevent stones from drying out and causing an incorrect honing pattern.

f. The most desirable cylinder finish is10-1 5 micro inches (0.25 -0.38 micro meters); with this finish, the depressions in the surface tend to keep a supply of lubrication between the mating parts: this finish can be obtained by using 280 grit stones on the hone.



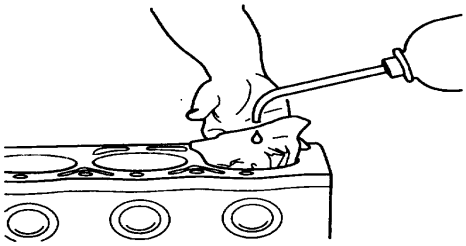
esirable Crosshatch Pattern Obtained with a Cylinder Hone

After all honing operations are complete, thoroughly wash the bores with soap, hot water, and a stiff brush to remove all traces of grit. Kerosene or other solvents will not remove the grit. Rinse the block with clean, clear water and dry with compressed air.



Cleaning Bores

When you have finished cleaning the block, run a clean, dry paper towel through the bores. The paper towel should come out clean.



Oiling Bores

If not, the bores must be rewashed. As soon as the bores have dried, lubricate with engine oil immediately to prevent rust. This completes the honing operation.

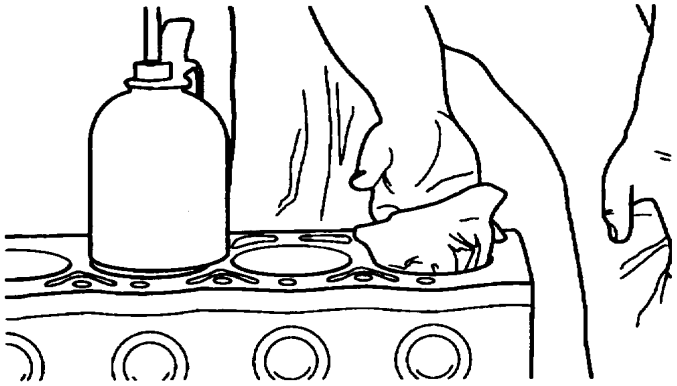
PISTONS

Check the pistons for excessive ring groove wear, and replace any that exceed the allowable limits in our Limits and Clearance Data.

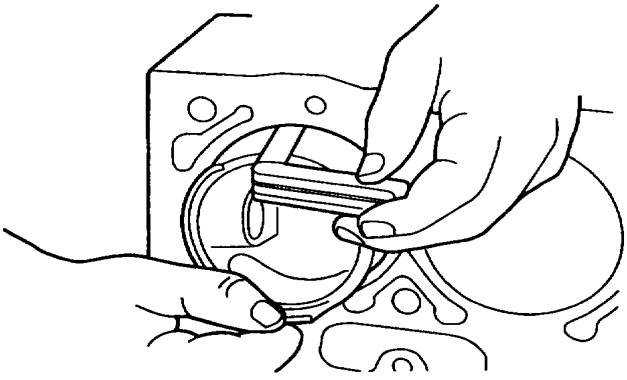
The cylinder walls and pistons must be perfectly clean and dry when fitting pistons in the cylinder bores. Pistons should be fitted with the block and piston at room temperature 68°to 70°F(20°C 21°C).

PISTON FIT ON STANDARD PISTONS (with 5 to 10 lbs (2.3 to 4.5 kg) Pull) TMD series .003" (0.08mm)

Check the piston fit in the bore using a half-inch wide strip of feeler stock (of the thickness specified in the Limits and Clearance Chart) the feeler being attached to a small scale of approximately 15 lbs (7 kg) capacity.



Checking Block for Cleanliness

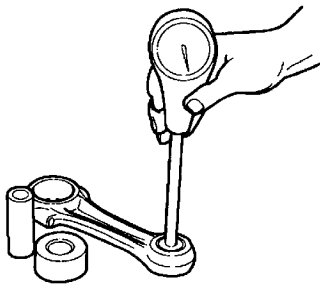


Checking Piston Fit in Bore

When the correct fit is obtained you must be able to withdraw the feeler with a pull of 5-10 pounds (2.3-4.5 kg) on the scale, with the feeler inserted between the piston and the cylinder mid-way between the piston pin bosses where the diameter of the piston is the greatest. Check the fit of the piston when it is approximately 2" (50mm) down to the cylinder bore in an inverted position.

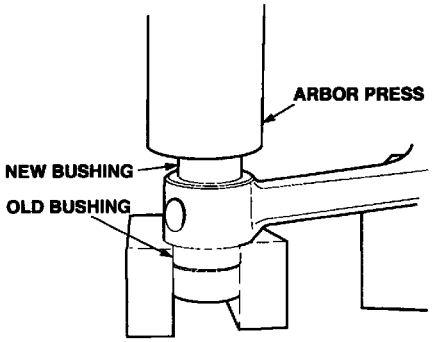
PISTON PINS

Check the bushing in the upper end of the connecting rod for wear. If worn and you are using the original pistons, an oversize piston pin may be obtained in .003 or .005" (0.08 or 0.13mm) oversize.



Checking Piston Pin Bushing for Wear

The piston pin hole in the piston and the bushing in the connecting rod may be honed to increase their diameter to obtain the desired fit as shown in our Limits and Clearance Chart.



Pressing in Piston Pin Bushing

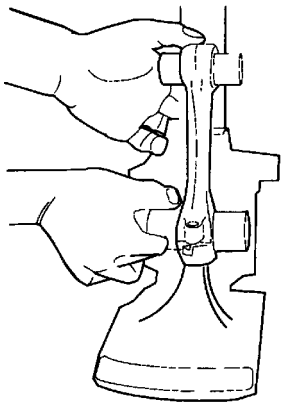
Note that, while the chart specifies a light press of the pin in the piston, there is a definite clearance of the piston pin in the connecting rod.

CONNECTING RODS

Replace the bushing in the connecting rod if new pistons are used. Using the arbor press, press out the old bushing and press in the new one making sure the oil supply holes line up-after which the bushing must be honed to obtain the correct fit of the pin in the bushing as shown on Limits and Clearance Chart. If there is an excess of stock in the piston pin bushing, it may be reamed first, then honed. In any event, the final operation should be done with a hone to obtain the desired fit with better than 75% bearing area contact on the pin.

PISTON & CONNECTING ROD ASSEMBLY

1. Assemble the pistons on the connecting rod. Heating them in hot water will facilitate assembly. When heated, the piston pin will enter the piston very easily and can be tapped through the connecting rod and into place without distorting the piston. The snap rings must be assembled in the grooves, making sure they are fully seated in place.
2. The piston pin hole in the connecting rod must be parallel to and in plane with, the large bore in the bearing end of the connecting rod.

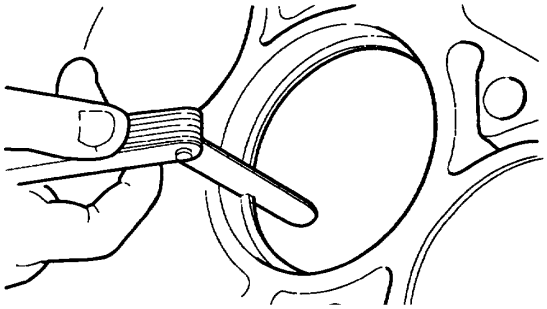


Checking Connecting Rod for Twist and Alignm

This may be checked on a fixture with the piston pin assembled in the rod before assembling the piston; but regardless of this preliminary check the completed piston and rod assembly must be rechecked and there must not be more than .002" (0.05mm) twist or out of squareness checked over a spread of approximately 4" (100mm). If excessive, replace the rod. Pistons are cam and taper ground, and this must be taken into consideration when checking alignment of the assembly, since the diameter in line with the piston pin would be less at the top of the skirt than at the bottom.

PISTON RINGS

Check the piston rings in the cylinder for gap.



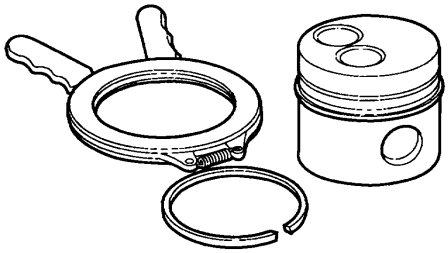
Checking Ring Gap

To do this, insert a piston in the cylinder bore in an inverted position and then insert each ring one at a time about 2" (50mm) down in the bore. If the ring does not have sufficient end gap clearance, file one end of the ring until sufficient clearance is obtained. Check the gap between the ends of the ring with a feeler gauge in accordance with specifications shown in the Limits and Clearance Chart. Prior to installing the rings on the piston, check each ring in its respective groove to the limits specified in the manual. If ring-to-land clearance exceeds maximum serviceable limits, pistons must be replaced.

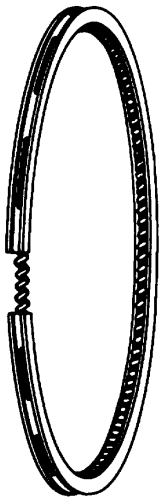
Checking Ring Clearance in Groove

RECOMMENDED METHOD OF INSTALLING PISTON RINGS

1. Prior to ring assembly check the ring grooves for nicks and burrs. This is done by rotating each unassembled ring around its groove to be sure of free action.

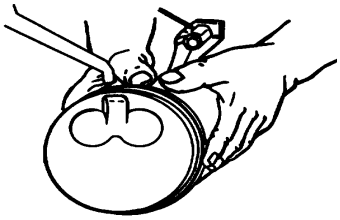


Installing Rings with Ring Expander Tool



Oil Ring

2. The oil ring should be installed first on the piston, from the top side so skirt will not be scratched.

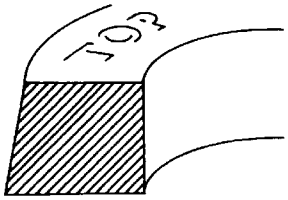


Oil Piston and Rings

3. To install the balance of the rings, use a ring tool with recess side up and place the ring in with the bottom side up. Start with the lowest ring first.

    a. Position ring in the tool so the expanding fingers will fully engage both ends.

    b. Apply pressure on handles so ring is completely expanded. Pass the expanded ring and tool recessed side down over the piston to the proper groove.



Install Tapered Rings with "Top" Side Up

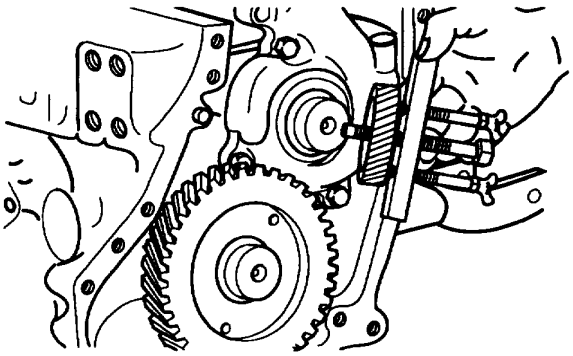
CAUTION

Some piston rings are taper faced. These are clearly marked 'TOP" on the side to be up when assembled on piston, and some rings have the top side marked with a color band or a PIP mark. The pistons have offset piston pins. Be sure to Install pistons with notch or arrow In top toward the front of the engine.

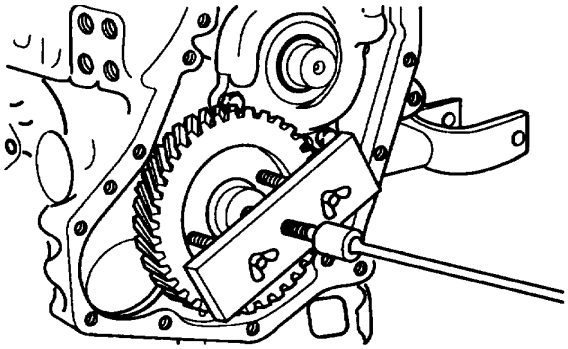
4. When pistons are ready for installation in the cylinders, oil generously. Compress rings carefully using a good ring compressor and a light tap on the head of the piston will allow the assembly to go into the cylinder very easily. If any difficulty in tapping piston and ring assembly into the cylinder is encountered, the compressor should be removed and rings checked for correct installation in the groove.

CRANKSHAFT & MAIN BEARINGS

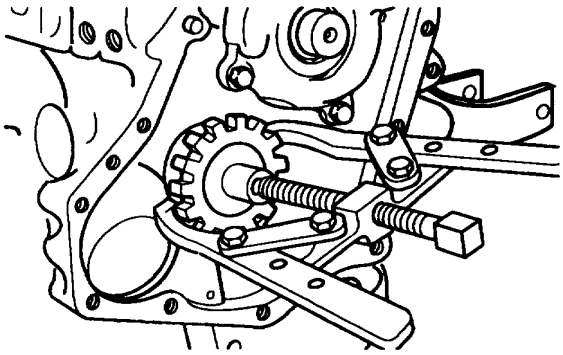
1. Using a puller, remove pulley from crankshaft.
2. Remove screws and remove gear cover.
3. Remove the crankshaft gear and woodruff keys.
4. Using a puller, remove cam gear and injection pump drive gears.
5. Remove the oil pump and key by removing cap screws holding pump to front of the engine.



Removing Crank Gear



Removing Cam Gear with Puller

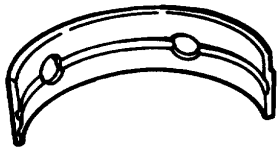


Removing Injection Pump Drive Gear

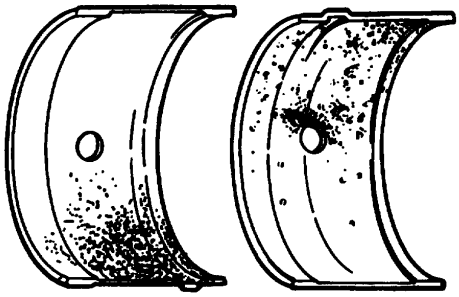
6. Remove each main bearing cap, one at a time, and inspect the bearing and crankshaft journals. If there is any indication of flaking out, scoring or actual wear - they must be replaced.

BEARINGS

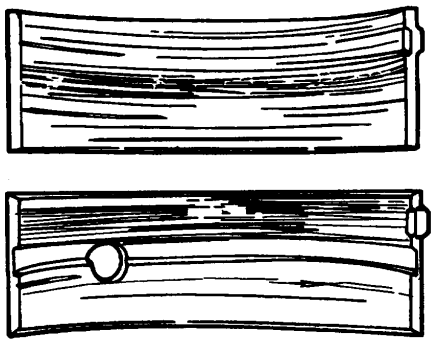
Tri-metal bearings when new are smooth and highly polished. However, a very few hours of operation will change their appearance completely. The bearing



Appearance of a Good Bearing

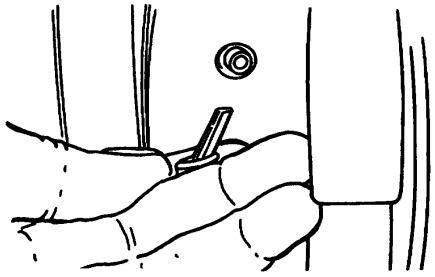


Bearing Damage Due to Corrosion



Scored Bearing Due to Dirt or Lack of Oil

surface becomes a leaden gray in color and develops minute craters, almost cellular in appearance. This appearance is a natural characteristic of this type of bearing and in no way indicates failure.

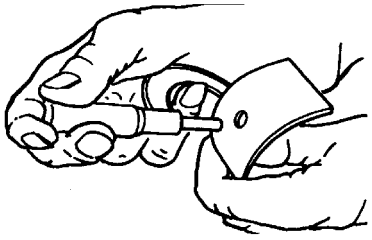


7. If the visual inspection appears satisfactory, they should be removed and checked for thickness using a ball micrometer.

To remove the upper half of the bearing shell use a special tool obtainable at most parts houses, which is a pin with an angular head. It may be inserted in the oil hole of the crankshaft and as the crankshaft is turned in a clockwise direction, the head of this pin picks up the bearing shell and forces it out of the bore in the block. The thickness of the bearing shells is given in the Limits and Clearance Chart, and if this thickness has been reduced more than 0.013mm (.0005') beyond the maximum allowable tolerance the bearing shell must be replaced.

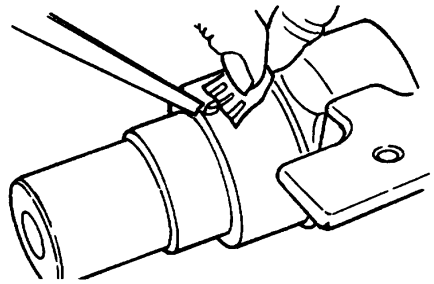
CAUTION

The upper main bearing shells are grooved. The lower main bearing shells on some models, are not. The ungrooved bearing shell must be placed in the bearing cap, not In the block, or oil to the bearing will be cut off and damage to engine will result.



8. If visual inspection of the crankshaft shows no indication of excessive wear or scoring, the clearance of the bearing should be checked.

9. Check each bearing, one at a time, by using a piece of Plastigage of a diameter specified to check certain clearances.



Checking Bearing Clearance with Plastigage

By placing the Plastigage on the crankshaft bearing surface and tightening the bearing and cap in place the width of the Plastigage after crushing will determine the bearing clearance.

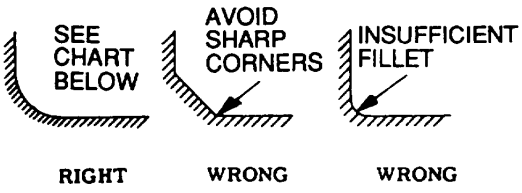
CAUTION

When using Plastigage method DO NOT TURN the crankshaft as that would destroy the Plastigage.

If crankshaft is scored, or worn enough so that new bearings will not fit with the required clearance, it should be removed and reground.

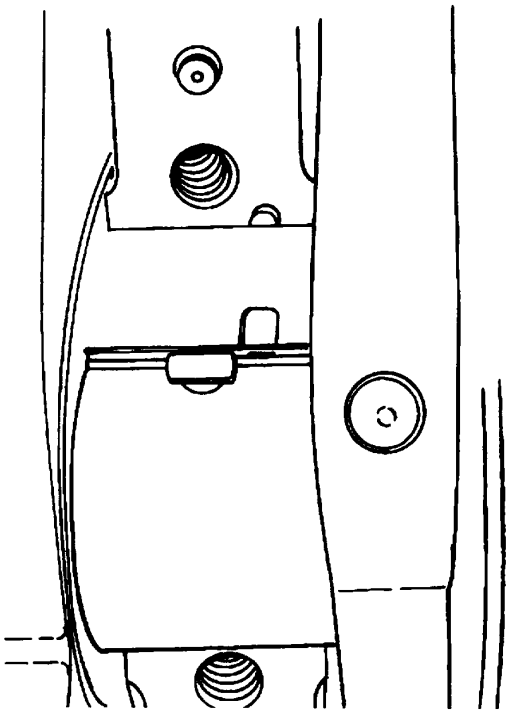
Standard crankshafts may be reground to decrease the diameter a maximum of 1.0mm (.040").

Before shaft is reground, it must be checked for straightness and straightened if necessary to be within 0.05mm (.002") indicator reading. When reground, the fillet radii must be within dimensional limits and must be perfectly blended into thrust and bearing surfaces. **Crankshafts must be nitempered after regrinding.**



TMD	2.8 R (.11") on all crankpins 3.0 R (.12") on all mains

Crankshaft Fillet Radii



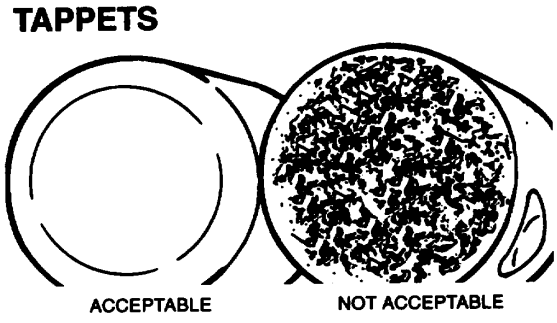
Replacing Bearing

CAMSHAFT

1. Remove the screws holding the camshaft thrust plate to the front of the cylinder block, which makes it possible to pull the camshaft forward out of the bearings.
2. Measure the camshaft bearing journals and bores. If clearance is equal to orgreaterthan the amount indicated underwear limits, check the diameter of the camshaft journals to determine the next step. Excess wear at these positions require replacement of the shaft.
3. If the front camshaft journal bore becomes worn beyond limits, there is a service camshaft bushing available.
4. Tappets can then be lifted out and lined up in sequence, for installation in the same location unless inspection shows that they require replacement.

CAUTION

When Installing camshaft, use special care to prevent camshaft bumping and loosening expansion plug at rear of crankcase causing an oil leak.



Valve Tappet Wear Comparison

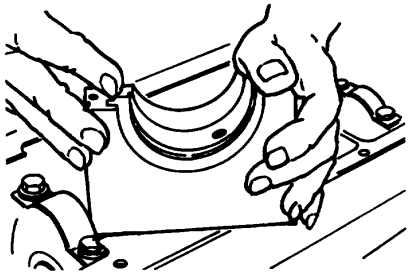
1. Inspect each tappet carefully. Two or three small pits on the contact face is acceptable; more than that calls for replacement of the tappet. A damaged tappet could mean possible damage to the camshaft.

2. Check the outside diameter with a micrometer to determine if replacement is necessary because of wear. Refer to limits and clearance section.

REAR CRANKSHAFT OIL SEALS

The overhead valve engines have the rear crankshaft oil seals incorporated in the combination rear main bearing cap and filler block.

The rear crankshaft oil seal has a stiffener ring imbedded in the rubber and no metal retainer is required.



Installing Seal in Rear Main Bearing Cup and Filler Block

The overhead valve engines have a good, trouble-free rear crankshaft oil seal if carefully installed.

IMPORTANT: Installing rear oil seals correctly demands careful workmanship. Install seal with lip pointing toward engine.

Worn oil seals should be replaced in the following manner:

1. Remove rear bearing cap and filler block assembly by using a puller.

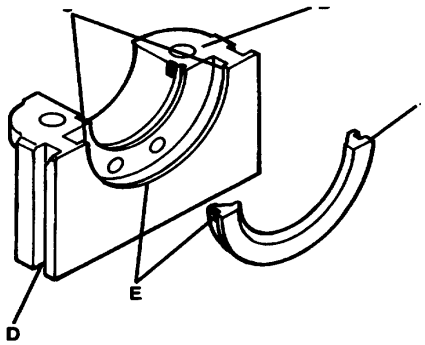
Remove old seals and thoroughly clean all contact surfaces.

2. Install crankshaft oil seals "A" on engine block and main bearing cap.

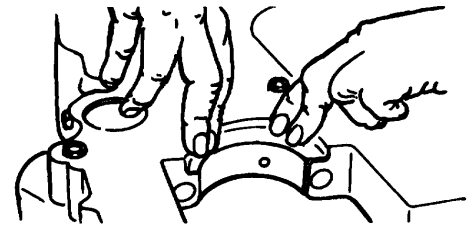
Before installing break edge 'C" slightly on both cap and block to avoid cutting the seals during installation and coat seal edge 'E", contacting the groove with sealing compound.

NOTE

This oil seal can be Installed without removing the crankshaft in this case, use only light grease in the seal groove to assist sliding the seal in place. Apply pressure to the seal so that it will hug the crankshaft which will also help moving it In place.

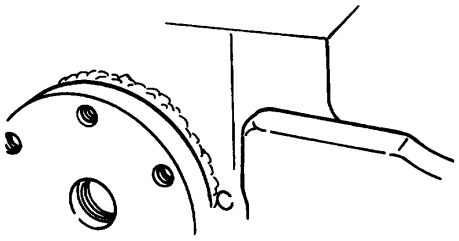


Filler Block and Seal



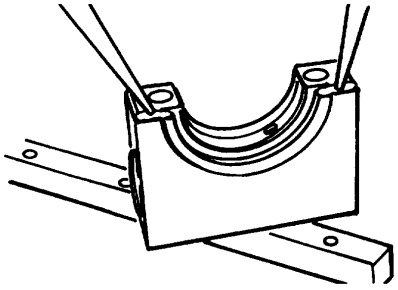
Crankshaft Oil Seal Block

3. Apply a light coat of cement (national oil seal or EC-847) to the butting ends of the crankshaft oil seal halves. Allow to become tacky before assembling. Lightly coat the crankshaft contact edge of the seal with graphite grease to prevent damage prior to use.
4. Install crankshaft.
5. Apply a light coating of RTV gasket material to surface "B" and graphite grease to the oil seal lip. Carefully install the combination rear bearing cap and filler block on to the dowels. Insert the capscrews and torque to 150-162 N•m (110-120 Lb. Ft.)



Applying RTV to Rear Filler Block

6. After the rear cap is in place and torqued, inject RTV into each side seal slot "D" as shown in illustration. Force the RTV into the channels until a steady flow comes out the corner chamfers.

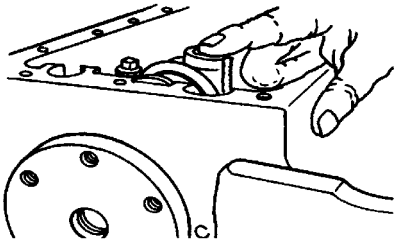


Installing RTV in Rear Block Channels

NOTE

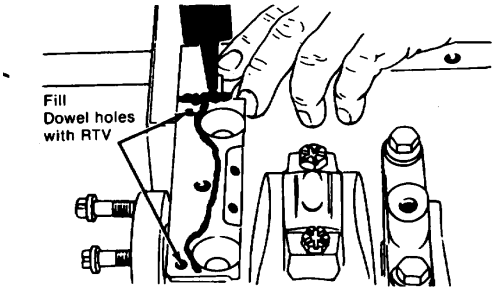
0il leakage will occur if any voids are left along these slots.

7. Dip the curing insert in clean water. Install curing insert until approximately 5/8" protrudes from slot. Cut off flush with pan rail. This insert insures complete cure of the RTV.



Install Curing Insert

8. Prior to installing oil pan, apply a small bead of RTV material to the rear bearing cap and filler block as shown.

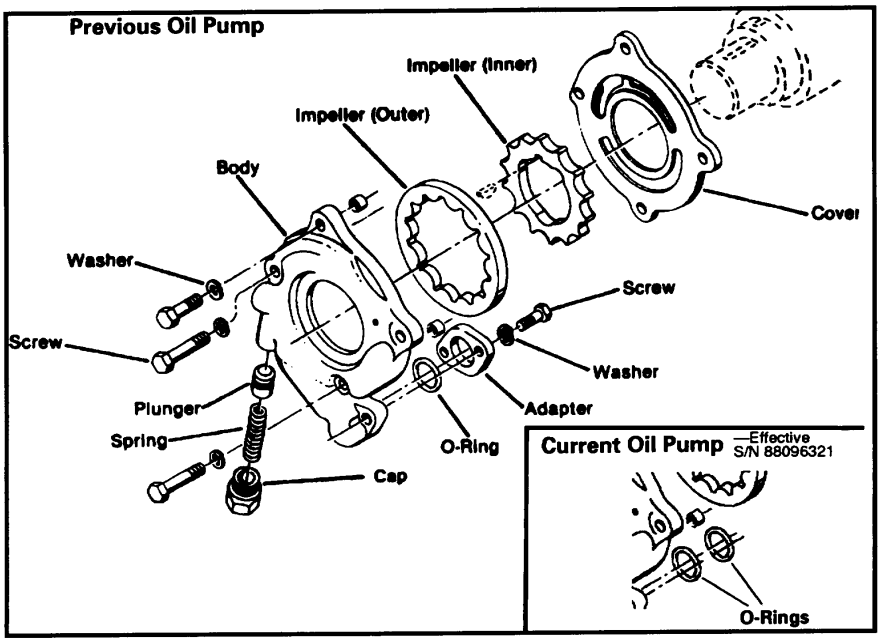


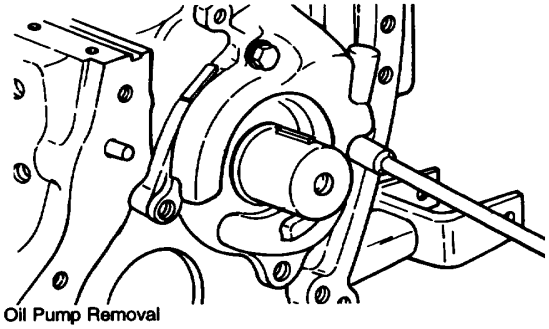
Applying RTV to Rear Bearing Cap and Filler Block

OIL PUMP

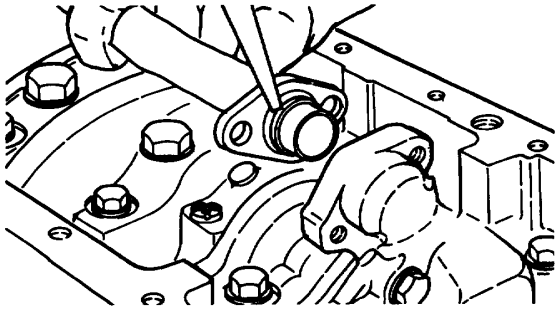
The oil pump is assembled to the front of the cylinder block and front main bearing cap and is held in place by capscrews.

The pump is driven by a hardened key mounted in the crankshaft.





Oil Pump Removal



O-Ring at Pump Inlet

When the pump is removed and disassembled, examine the impellers, cover, and cavity for wear; inspecting the key and keyway at the same time. If scored or worn badly they must be replaced.

Examine the pick-up screen for clogging or damage.

Examine the O-Ring at the pump inlet. If damaged, replace. **Two O-Rings are required after S/N 88096321**.

Engine oil pressure must be maintained to specification for satisfactory engine life.

The oil pump must be fully seated in the counterbore. No gaskets are used in this assembly.

Install mounting cap screws and tighten to 15-18 lb-ft (20-24 N•m)

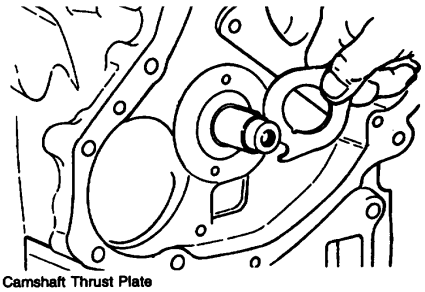
NOTE

When replacing any oil pumps on engines built before SIN 88096321, the oil suction tube must be replaced also.

TIMING GEARS

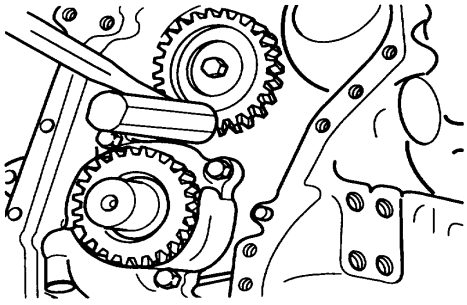
1. Timing gears should be inspected for excessive wear and/or pitting and replaced if necessary.

2. Examine the camshaft thrust plate carefully for scoring and wear and if any indication of either shows. a new thrust plate should be assembled.

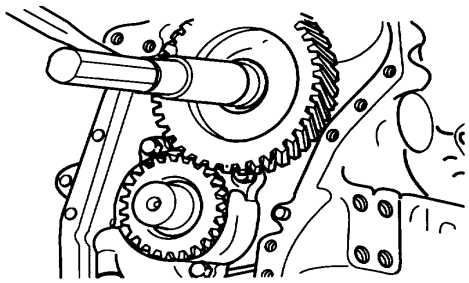


Camshaft Thrust Plate

3. Assemble the injection pump drive gear with key and cam gear to the cam shaft by driving or pressing each on, at the same time holding the camshaft forward with suitable bar through the fuel pump opening in the block so there is no possibility of the camshaft bumping the expansion plug at the rear end and forcing it out of position, thus causing an oil leak.

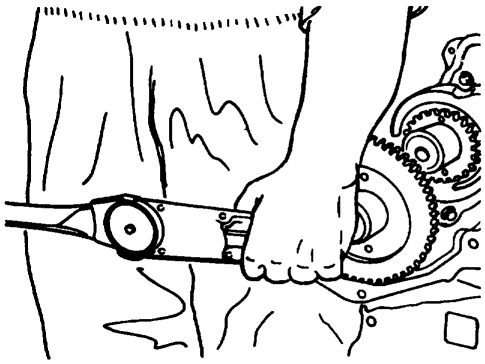


Installing Injection Pump Drive Gear



Installing Camshaft Gear

Assemble camshaft nut and torque to specification (See torque specifications section). Do not use impact wrench or over torque cam nut.

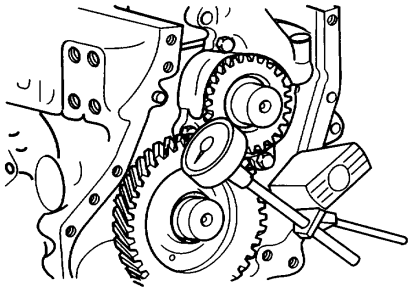


Torquing Cam Gear Nut

Check camshaft end play as shown in illustration. Refer to limits and clearance section for correct dimension.

CAUTION

NEVER USE THE CAMSHAFT NUT TO PRESS THE GEAR ONTO THE CAMSHAFT. This will break the threaded end off cast Iron camshafts.

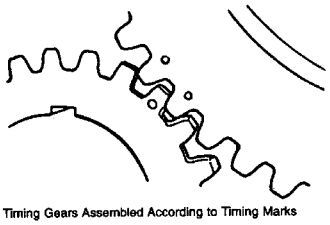


Checking Camshaft End Play

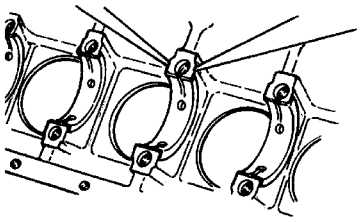
4 Drive the crank gear on the shaft making sure that the marked teeth on the cam gear straddle the marked tooth on the crank gear, which assures you of the crankshaft and camshaft being in time.

CRANKSHAFT END PLAY

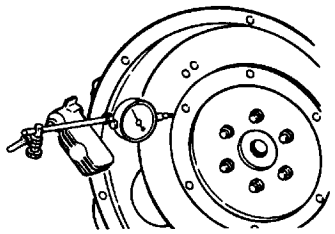
The crankshaft end play is controlled by the center flanged bearing. No shims are required. Using a dial indicator, check the crankshaft end play. If the end play exceeds .007" (0.18mm) replace the flanged bearing. End play should be between the .0067" (0.17mm) and .0015" (0.04mm) limits.



Timing Gears Assembled According to Timing Marks



Flanged Bearing Controls Crankshaft End Play



Checking Flywheel Run-Out

The flywheel is machined and balanced so that the clutch face and locating counterbore will run true with its axis.

Mount an indicator on the flywheel housing and check the flywheel for runout. Caution: When checking runout remove glow plugs to allow engine to be turned over freely.

The indicator should be set up so that it contacts the clutch face or the vertical surface of the clutch counterbore, then turn the flywheel at least one full revolution at the same time holding against the crankshaft to offset the possibility of end play.

Excessive runout of the flywheel, in either position, is probably caused by dirt in or damage to counterbore locating the flywheel on the crankshaft flange. Re-locate the indicator to check the inside diameter of the counterbore. In both cases the maximum indicator reading must not be more than .008" (0.20mm).

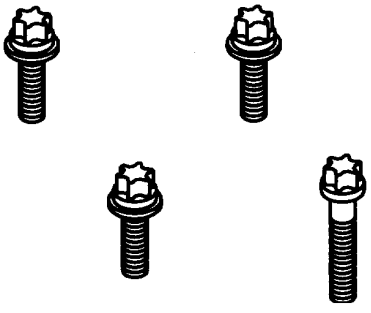
When assembled, mount the indicator on the flywheel so that it contacts the housing face and turn the crankshaft, at the same time holding against it to counteract end play. The maximum indicator reading must not exceed .008" (0.20mm).

FLYWHEEL & FLYWHEEL HOUSING

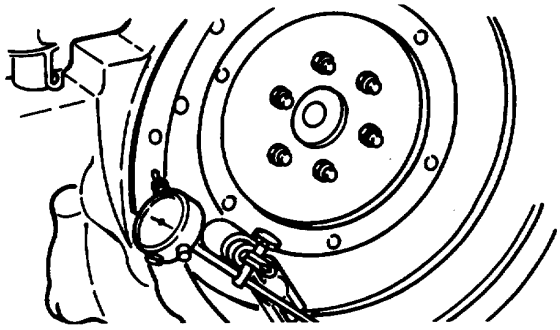
Install flywheel housing using special cap screws.

NOTE

Special capscrews having sealing bands are used In the upper holes to mount the flywheel housing to the cylinder block. These special capscrews must be used to prevent oil leakage.

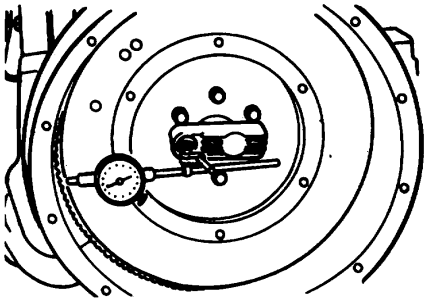


Special Capscrews



Checking Flywheel Housing Face

Re-locate the indicator to contact the housing bore and check this in the same manner. The same runout limits prevail.



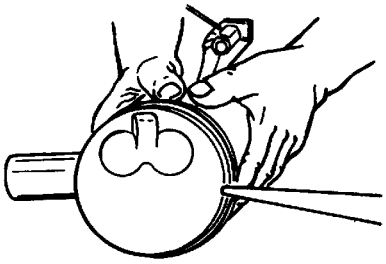
Checking Housing Bore

REASSEMBLING ENGINE

In the foregoing, we have outlined procedures for checking, repairing or replacing the many wearing parts in the engine.

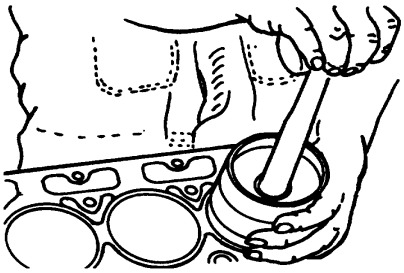
In most cases, the instructions have covered the reassembly of parts or subassemblies made up of several parts.

When reassembling pistons and connecting rods, use a good ring compressor and oil the bores thoroughly. A hammer handle may be used to bump the pistons out of the ring compressor in-to the c linder bore.



NOTE

The pistons have offset piston pins. Be sure to install pistons with notch or arrow in top toward the front of the engine.



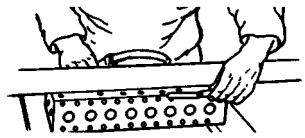
Installing Pistons

Once more, we call attention to care demanded to prevent connecting rods damaging the cylinder bore finish and at the same time as they are assembled over the crank pin, locate them carefully in order to protect the bearing surfaces.

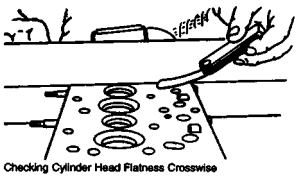
Always lubricate the bearings with clean engine oil when assembling, and tighten them to the torque specified.

INSTALLING HEAD

1. Make sure that gasket contact surfaces on the head and block are clean, smooth and flat. Check flatness with straight edge and feeler gauge in three positions lengthwise and five crosswise. The maximum permissible is 0.10mm (.004") low in the center lengthwise, gradually decreasing towards the ends, or 0.076mm (.003") crosswise or in localized low spots. If these limits are exceeded, replace the cylinder head.

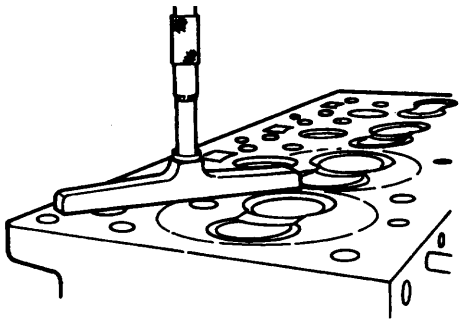


Checking Cylinder Head Flatness Lengthwise



Checking Cylinder Head Flatness Crosswise

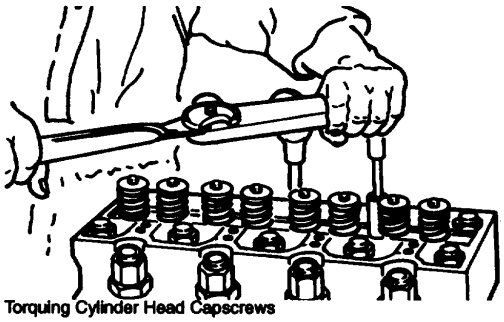
2. Install precombustion chamber inserts, making sure they are fully seated. Insert projection in reference with cylinder head surface is flush to .003" (0.076 mm) projection.



Precombustion Insert Projection

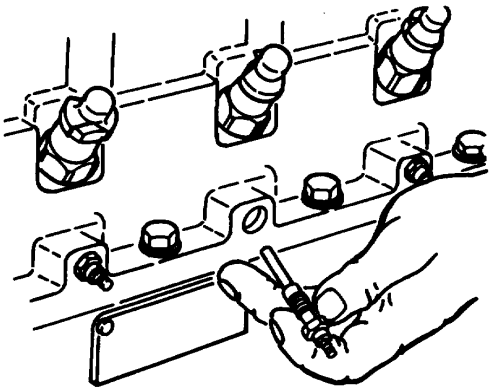
3. Use new cylinder head gasket, which is precoated, thus no cement is required.
4. Using a chain hoist, lower the cylinder head assembly evenly over the locator stud. Replace the locator stud with the proper cylinder head cap screw.

5. Before installing any head cap screws in the block, be sure the threads in the block and on the cap screws have been properly cleaned. Should these tapped holes need cleaning or reconditioning, care should be taken to use the proper tap.
   Tap: M 10 x 1.5 CLASS 6G
   M 12 x 1.54 CLASS 6G 6.
6. The cylinder head cap screws require no sealant but should be installed with a **very light coating** of engine oil or lubriplate to reduce friction and insure proper clamp load and head cap screw torque. Tighten with torque wrench in recommended sequence to the correct torque shown in torque chart in Section 10*, by going over them two times before* pulling them down to the final torque specifications on the third round.



Torquing Cylinder Head Capscrews

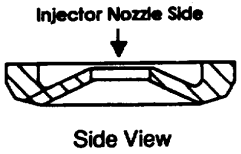
7. Install the injectors and glow plugs at this point. Having the injectors and glow plugs in now eliminates the risk of dirt and foreign objects falling into the cylinder.



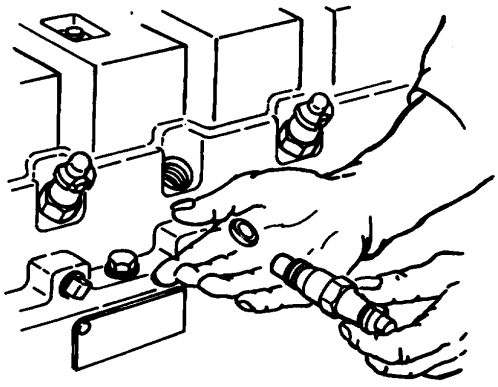
Installing Glow Plugs

NOTE

Always use new steel heat should washers when installing injectors in cylinder head.



Side View



Installing Heat Shield and Injector

INSTALLING OIL PAN

Before assembling the oil pan, make sure the contact surfaces are flat and clean of any gasket material or oil.

A form-in-place gasket material is used for sealing the engine oil pan to the crankcase. The form-in-place gasket should be applied to the oil pan and filler blocks as shown here.

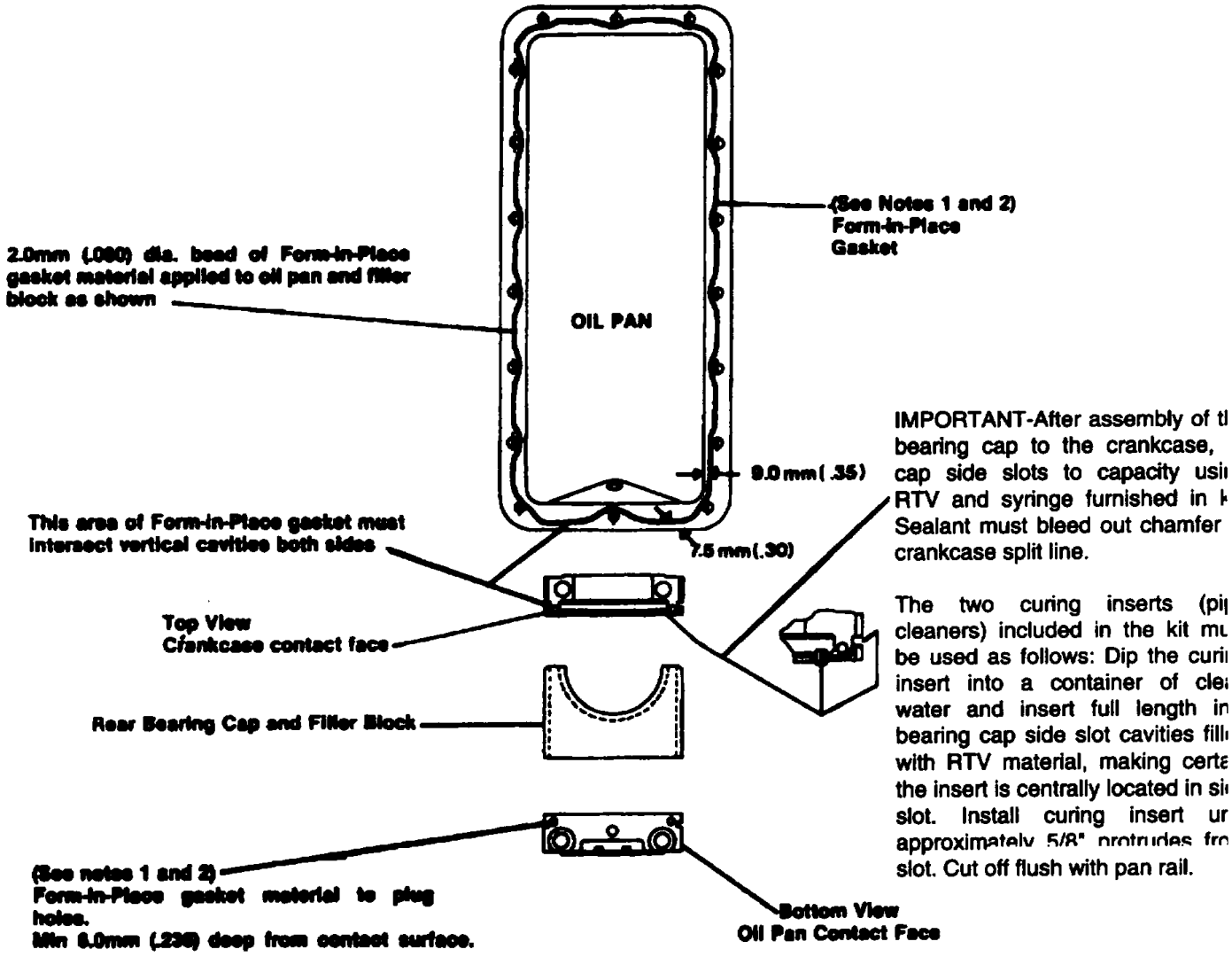
Tighten the screws in accordance with limits prescribed in the torque char to avoid looseness or overstressing.

NOTE

1. **Parts must be assembled within 20 minutes after applying gasket material.**
2. **Caution must be used In handling the gasket materials. Read labels.**

When engine is completely assembled and filled with proper oil *(see Lubrication section),* set tappets according to the following chart.

MODEL	INTAKE	EXHAUST
TMD	0.14" (0.36 mm)	0.18" (0.46 mm)



Typical RTV Pan Application for the Diesel Overhead Valve Engine

Section 10 - Torque Specifications

NOTE

The following torque values are based on phosphate-coated fasteners (Class 10.9 & 12.9) and black oxide-coated fasteners (Class 8.8 & 9.8).

ITEM	THD SIZE	MAT'L CLASS	TORQUE	
			N•m	lb-ft
Connecting Rods				
CAUTION: High limit is maximum DO NOT Torque beyond high limit.	3/8	SAE GR 8	6168	4550
Main Bearing Caps	M14	12.9	150-162	110-120
Flywheels	M10	12.9	68-75	50-55
Flywheel Housings Rear End Plates	M10	12.9	61-68	45-50
Manifolds	M8	8.8/9.8	20-24	15-18
(Seezpruf)	M10	8.8/9.8	34-40	25-30
Gear Covers Water Pumps	M10	8.8/9.8	34-40	25-30
Oil Pans (Sheet Steel)	M8	8.8/9.8	14-19	10-14
Oil Pump To Engine	M8	8.8/9.8	20-24	15-18
Rocker Shaft Supports	M8	8.8/9.8	23-27	17-20
Accessories And Misc. Brackets	M6	8.8/9.8	8-11	6-8
	M8	8.8/9.8	20-24	15-18
	M10	8.8/9.8	34-40	25-30
	M12	8.8/9.8	75-81	55-60
	M14	8.8/9.8	122-135	90-100
	M16	8.8/9.8	190-203	140-150
Camshaft Nuts (cast iron camshaft)	718		88-95	65-70
Crankshaft Pulley	M16	8.8	163-176	120-130
Glow Plugs	M12		31-38	23-28
Nozzle To Holder	M22		68-75	50-55
Fuel Injection Pump Driven Gear To Fuel Injection Pump	5116 8	27-34	20-25	
*Injector to Cylinder Head	M24		68-75	50-55
Rocker Cover	M8	9.8	7-8	5-6
High Pressure Fuel Lines	M12		27-34	20-25

'Always use a new steel heat shield washer between injector and cylinder head.

NOTE

The following torque values are to be used only if torque value for specific part to be installed is not listed on preceding sheets.

THD SIZE	TORQUE (Phosphate Coated Fasteners)					
	Class 8.8		Class 9.8		Class 10.9	
	N m	lb-ft	N m	lb-ft	N m	lb-ft
M6	8-11	6-8	8-11	6-8		
M8	20-24	15-18	20-24	15-18		
M10	34-40	25-30	34-40	25-30		
M12	75-81	55-60	75-81	55-60		
M14	122-135	90-100	122-135	90-100		
M16	190-203	140-150	190-203	140-150		
M20						

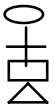
PROPERTY CLASS MARKING

BOLTS AND SCREWS:

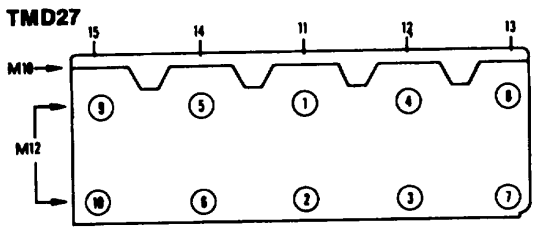
The property class symbols for metric bolts and screws are given in table at right. Marking shall be located on the top of the head. Alternatively, the marking may be indented on the side of the head for hex head products.

STUDS:

All metric studs used on TMD engines are of property class 10.9. If marked, marking will be at nut end.

PROPERTY CLASS	IDENTIFICATION SYMBOL	
	BOLTS, SCREWS AND STUDS	STUDS SMALLER THAN M12
8.8	8.8	
938	9.8	
10.9	10.9	
12.9	12.9	

CYLINDER HEAD



Cold Torquing Procedure

Step 1. Torque with Hand Torque Wrench to:

Screw Size	lb-ft	N-m
(SH) M12	30-35	41-47
(HH) M10	10-15	14-20
(HH) M12	25-30	34-41

Step 2. Torque with Hand Torque Wrench to:

Screw Size	lb-ft	N-m
(SH) M12	60-65	81-88
(HH) M10	20-25	27-34
(HH) M12	55-60	75-81

Step 3. Torque with Hand Torque Wrench in one single smooth motion:

Screw Size	lb-ft	N-m
(SH) M12	95-100	129-136
(HH) M10	35-40	47-54
(HH) M12	90-95	122-129

Hot Retorquing Procedure

Step 4. Retorque with Hand Torque Wrench (after engine reaches normal operating temperature) to the following values, in one single smooth motion:

Screw Size	lb-ft	N-m
(SH) M12	85-90	115-122
(HH) M10	30-35	41-47
(HH) M12	80-85	108-115

NOTE: (SH) = Socket Head Cap Screw (HH) = Hex Head Cap Screw

Torque all cylinder head capscrews using the proper torquing sequence shown here.

Section 11 - Limits and Clearance Data

NOTE
Dimensions shown are for standard engines.

ENGINE MODEL VALVE GUIDE (INTAKE & EXHAUST)	TMD METRIC	(ENGLISH)
Length	60.4	(2 3/8)
Outside Dia.	16.700/16.675	(.6575/.6565)
Stem. Hole Dia.	8.717/8.692	(.3432/.3422)
*Wear Limits-Max. Dia.	8.775	(.3447)
VALVES, INTAKE		
Stem Dia.	8.660/8.642	(.3409/.3402)
*Wear Limits, Min. Dia	8.592	(.3383)
Seat Angle	29°45'	(29°45')
Stem Clearance Limits	0.075/0.032	(.0030/.0012)
*Wear Limits-Max. Cl.	0.0125	(.0049)
Desired Stem Clear.	0.053	(.0021)
VALVES, EXHAUST		
Stem Dia.	8.640/8.622	(.3402/.3394)
*Wear Limits-Min. Dia.	8.575	(.3376)
Seat Angle	44°45'	(44°45')
Stem Clearance-Limits	0.095/0.052	(0.0037/.0020)
*Wear Limits-Max. Cl.	0.142	(.0056)
Desired Stem Clar.	0.073	(.0029)
VALVE SPRINGS		
Outside Dia.	34.85	(1.372)
Length-Valve Closed	42.0	(1.6535)
Load-Valve Closed	24KgF	(52.8#)
*Wear Limits-Min. Wgt.	21.5KgF	(47.3#)
Length-Valve open	32.88	(1.294)
*Wear Limits-Min. Wgt.	47.54KgF 42.5KgF	(104.6#) (93.5#)

ENGINE MODEL CAMSHAFT		TMD METRIC	(ENGLISH)
Brg. Journal Dia.	#1	47.511/47.486	(1.8705/1.8695)
	#2	44.336/44.311	(1.7455/1.7445)
	#3	44.336/44.311	(1.7455/1.7445)
		42.749/42.723	(1.6830/1.6820)
*Wear Limits-Min. Dia. 1.025(.001)Under Shaft Diameter Minimum New			
Bore-Inside Dia.	#1	47.625/47.600	(1.8750/1.8740)
	#2	44.450/44.425	(1.7500/1.7490)
	#3	42.862/42.837	(1.6875/1.6865)
Bore-Clearance Limits		0.139/0.089	(.0055/.0035)
End Play		0.38/03178	(.0015/.0070)
CONNECTING RODS			
Bush. Hole Dia.		30.175/30.150	(1.1880/1.1870)
Brg. Hole Dia.		52.375/52.362	(2.0620/2.0615)
Brg. Thickness		1.567/1.554	(.0617/.0612)
*Wear Limits-Min. Thk.		1.542	(.0607)
Dia. - Crank Pin		49.212/49.187	(1.9375/1.9365)
*Wear Limits-Min. Dia.		49.162	(1.9355)
Clearance Limits		0.080/0.016	(.0031/.0006)
Desired Clearance		0.048	(.0019)
*Wear Limits-Max. Cl.		0.091	(.0036)
Side Play		0.28/0.15	(.011/.006)
Desired Side Play		0.20	(.008)
MAIN BEARINGS			
Dia. Of Brg. Bore in Block		78.019/78.00	(3.0716/3.0709)
Brg. Thickness		2.484/2.471	(.0978/.0973)
*Wear Limits-Min. Thk.		2.459	(.0968)
Dia. Of Main Brg. Jr.		72.974/72.944	(2.8730/2.8718)
*Wear Limits-Min. Dia.		72.918	(2.8708)
Clearance Limits		0.133/0.058	(.0052/.0023)
Desired Clearance		0.096	(.0038)
C/S End Play		0.17/0.04	(.0067/.0015)
PISTON PLAY			
Length		71.0/70.7	(2.795/2.783)
Diameter		28.575/28.571	(1.1250/1.1248)
*Wear Limits-Min. Dia.		28.562	(1.1245)
Desired Fit		Light Push	
Bush. Hole Dia.-Fin.		28.598/28.588	(1.1259/1.1255)
*Wear Limits-Max. Dia.		28.623	(1.1269)
Pin Cl. In Bushing		0.013/0.028	(0.0005/0.0011)
Desired Pin Fit		0.020	0.0008
TAPPET			
Outside Dia.		25.324/25.311	(.9970/.9965)
Bore in Block		25.364/25.344	(.9986/.9978)
*Wear Limits		0.13	(.005)

ENGINE MODEL	TMD	
PISTONS	**METRIC**	**(ENGLISH)**
Cylinder Dia	91.039191.000	(3.584213.5827)
*Wear Limits-Cyl. Bore	0.20	(.008)
Piston Pin Hole Dia	28.583128.578	(1.125311.1251)
Ring Groove Width--#1	2.56012.540	(.10081.1000)
Max. Wear Limit Width	2.611	(1.028)
Ring Groove Width #2- Max Wear	2.06012.040	(.08111.0803)
Limit Width #2-	2.111	(.0831)
Ring Groove Width #3	4.06014.040	(.15981.1591)
'Max Wear Limit Width	4.109	(.1618)
Piston Fit-Feeler Gauge	0.08	(.003)
Lbs. Pull	2.3-4.5Kg	(5-10#)
PISTON RINGS		
Ring Width--1	2.49012.478	(.0980/.0976)
'Wear Limits-Min. Width	2.423	(.0954)
Ring Width-#2	1.990/1.978	(.07831.0779)
'Wear Limits-Min. Width	1.923	(.0757)
Ring Width #3	3.99013.978	(.15711.1566)
Wear Limits-Min. Width	3.927	(.1546)
Ring Gap Clear-#1	0.40/0.65	(.0161.026)
Ring Gap Clear-#2	0.4010.65	(.0161.026)
Ring Gap Clear-#3	0.3010.60	(.0121.024)
Ring Side Clear-#1	0.08210.050	(.00321.0020)
Ring Side Clear-#2	0.08210.050	(.0032/.0020)
Ring Side Clear-#3	0.08210.050	(.00321.0020)

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NOTE

Read and observe all individual safety warnings as you use this manual to operate, service, or repair your engine. See pages 1 and 2.

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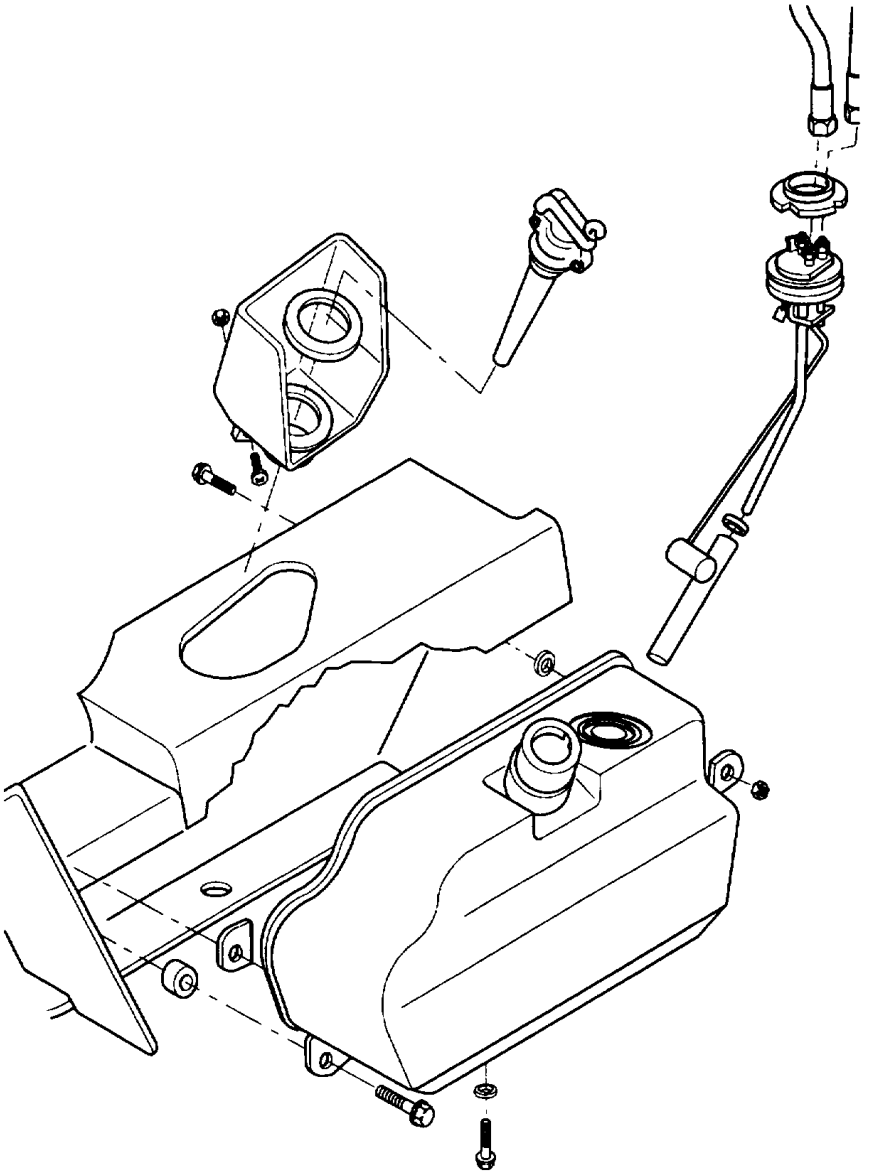
Fuel Tank Installation
GPX - TMD 27 [2.7L] Engine



5.1. Fuel Systems Maintenance

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General Procedures

WARNING

Park truck in a well-ventilated area. Clean up all fuel spills. Do not smoke or perform maintenance near open flame or other sources of ignition. Sparks can ignite diesel fuel vapors. A fire or explosion can result causing injury or death.

Fuel Tank

The removeable fuel tank for diesel engines is mounted in the left side of the truck frame. It may be removed for cleaning and inspection, repair or replacement as shown the on preceding page.

Fuel Lines

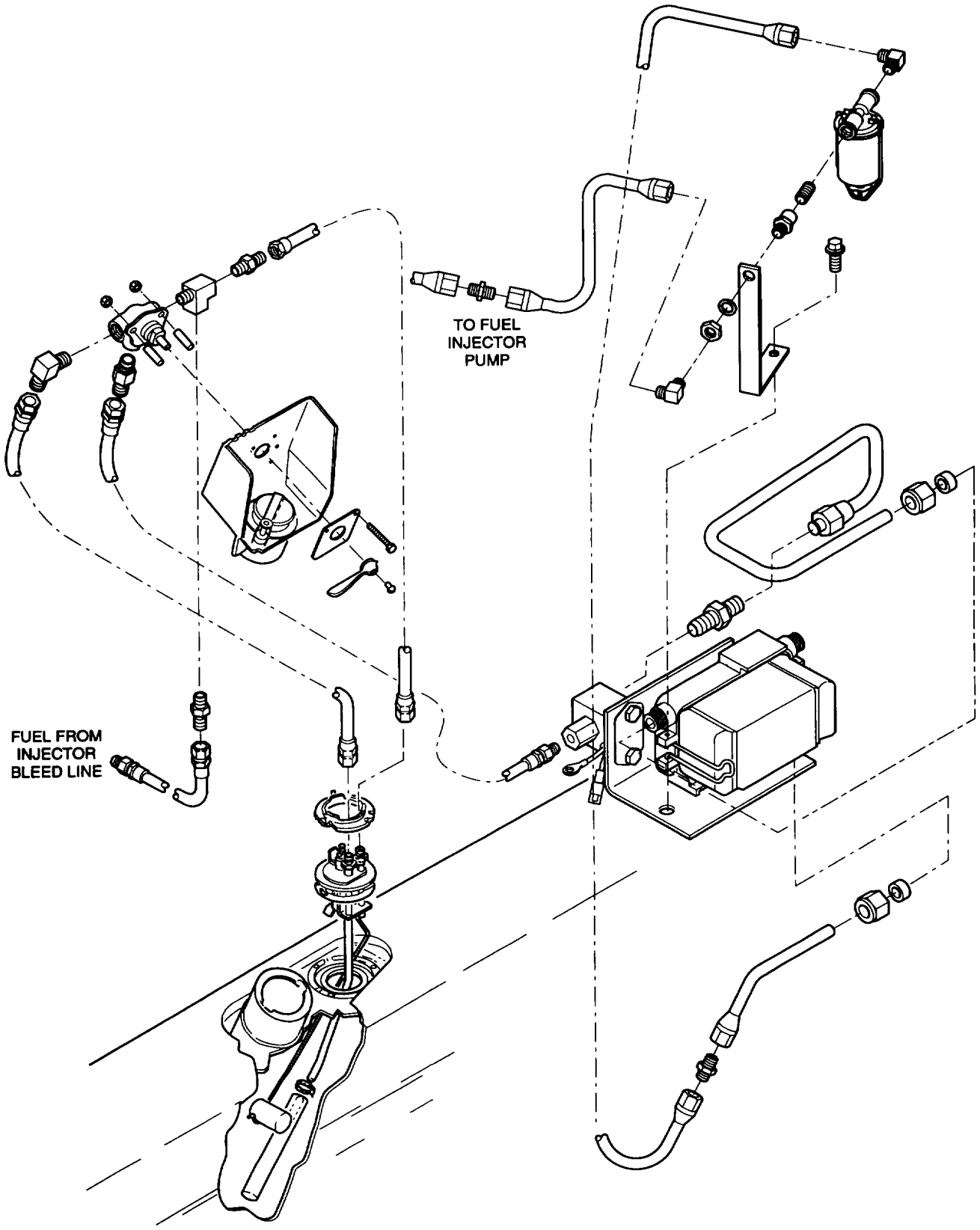
The fuel gauge sender and fuel strainer are mounted to a cover plate assembly on an opening in the top of the fuel tank adjacent to the filler neck opening shown by the illustration on the following the page.

The separate fuel lines and fittings for TMD 27 [2.7L] engine are also shown on the following page.

Diesel Powered Trucks

Refer to Section 5.3, Diesel Fuel Injection System.

Fuel lines
GPX-TMD 27 [2.7L] Engine



5.3. Diesel Fuel Injection System

TMD27 (2.7L) Diesel Engine

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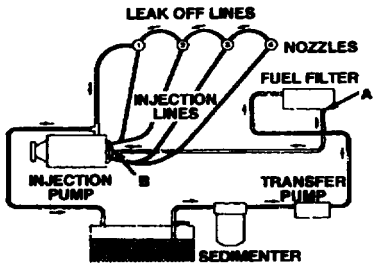
Description and Operation

The basic function of the diesel fuel system is to store, deliver, and inject fuel into the engine.

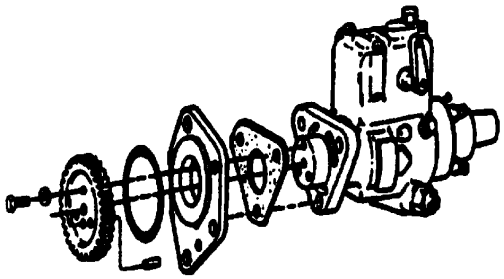


The fuel injection system of a diesel engine includes a fuel supply pump, fuel filters, an injection pump assembly complete with governor, high-pressure steel lines connecting the pump discharge outlets to the injector nozzles, and nozzle holders and nozzle assemblies, one for each cylinder.

The electric fuel transfer (supply) pump draws the fuel from the fuel tank, forces it through the filters, and delivers it to the injection pump. The fuel injection pump places it under the high pressure required for mechanical atomization, precisely meters the fuel, and distributes it in the proper timing sequence to the nozzles which produce the correct uniform pattern of spray for the combustion chambers.

The fuel filter elements play a key part in the injection system, since fine particles of dirt in the fuel are extremely destructive to all high-pressure pumps.

Careless or too-frequent removal of elements of the fuel injection system for "inspection" or "cleaning" is generally far more harmful than beneficial, due to the danger that dirt will enter the exposed connections



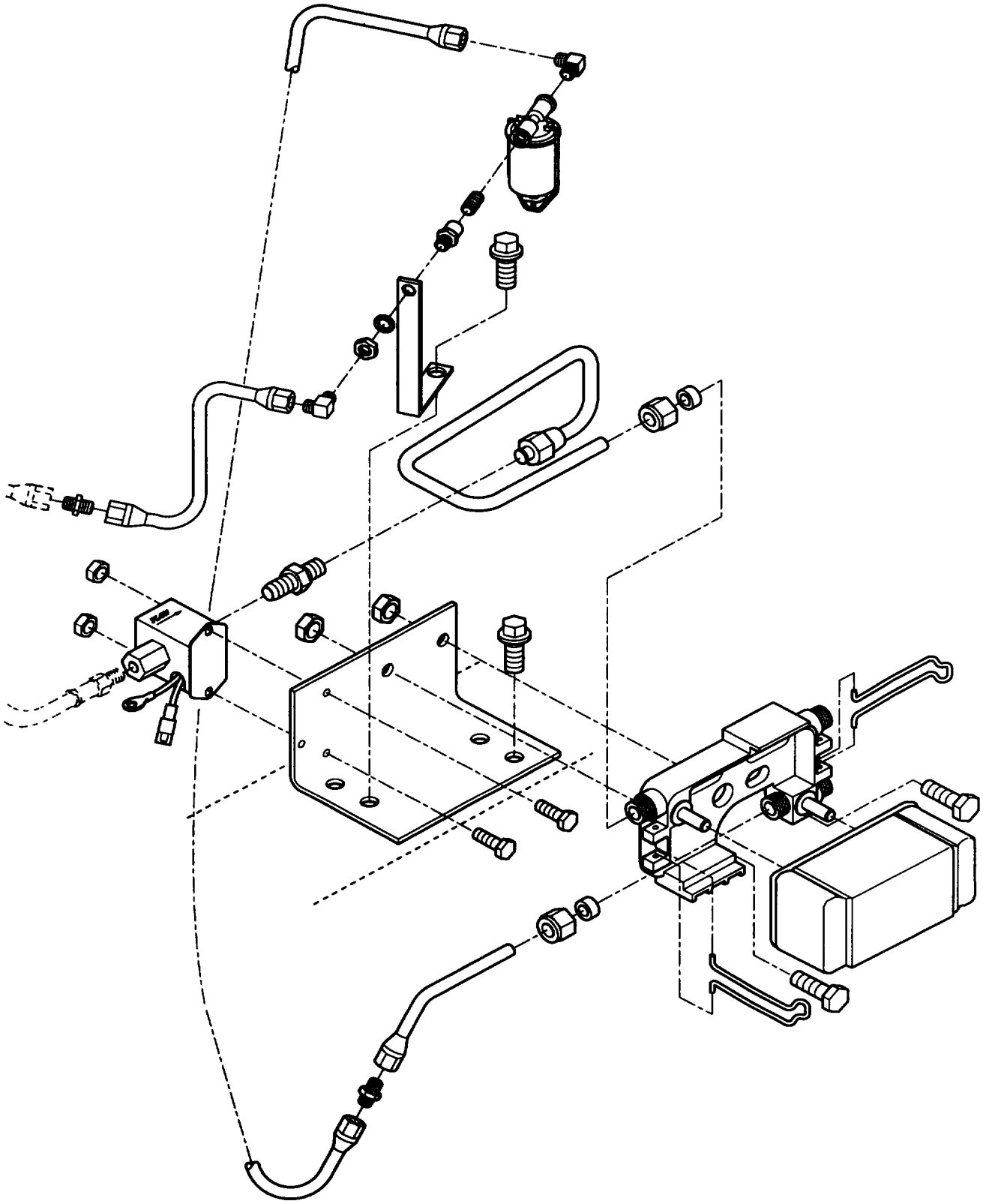
and the possibility of mishandling of parts. Various components are made with the utmost precision and may be easily damaged when removed. Unnecessary entry into the fuel system could cause needless service.

It should be kept in mind that minor troubles, such as suction leaks at joints in the supply line, can cause poor or erratic performance. It is unlikely that the injection pump would require service or overhaul before several thousand hours of operation.

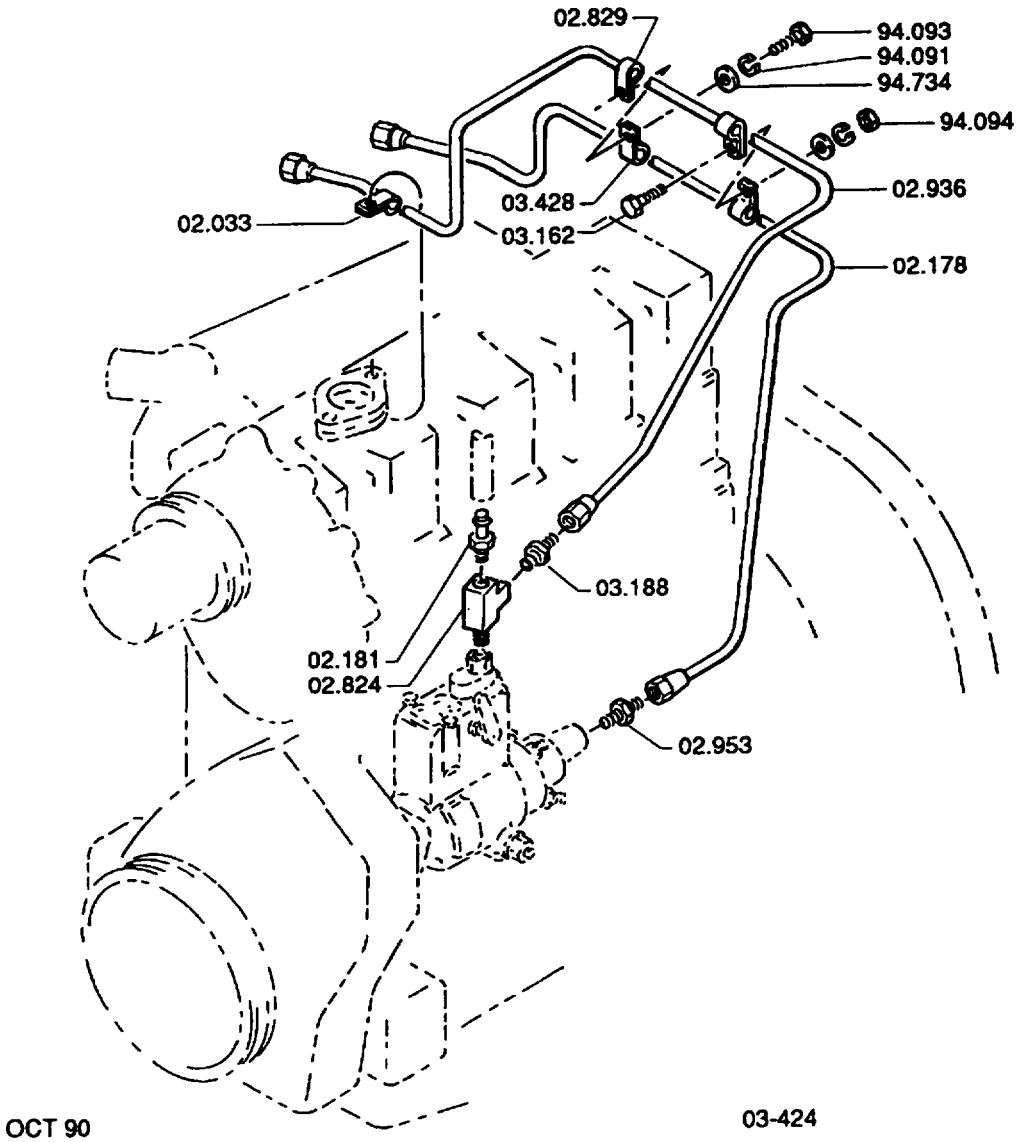
NOTE

There should be no tampering with the injection pump assembly, or removal of It for Inspection, unless engine operation Is seriously Impaired and the cause of the difficulty Is directly traceable to the pump unit.

Engine Fuel Lines - TMD27 (2.7L) Diesel Engine

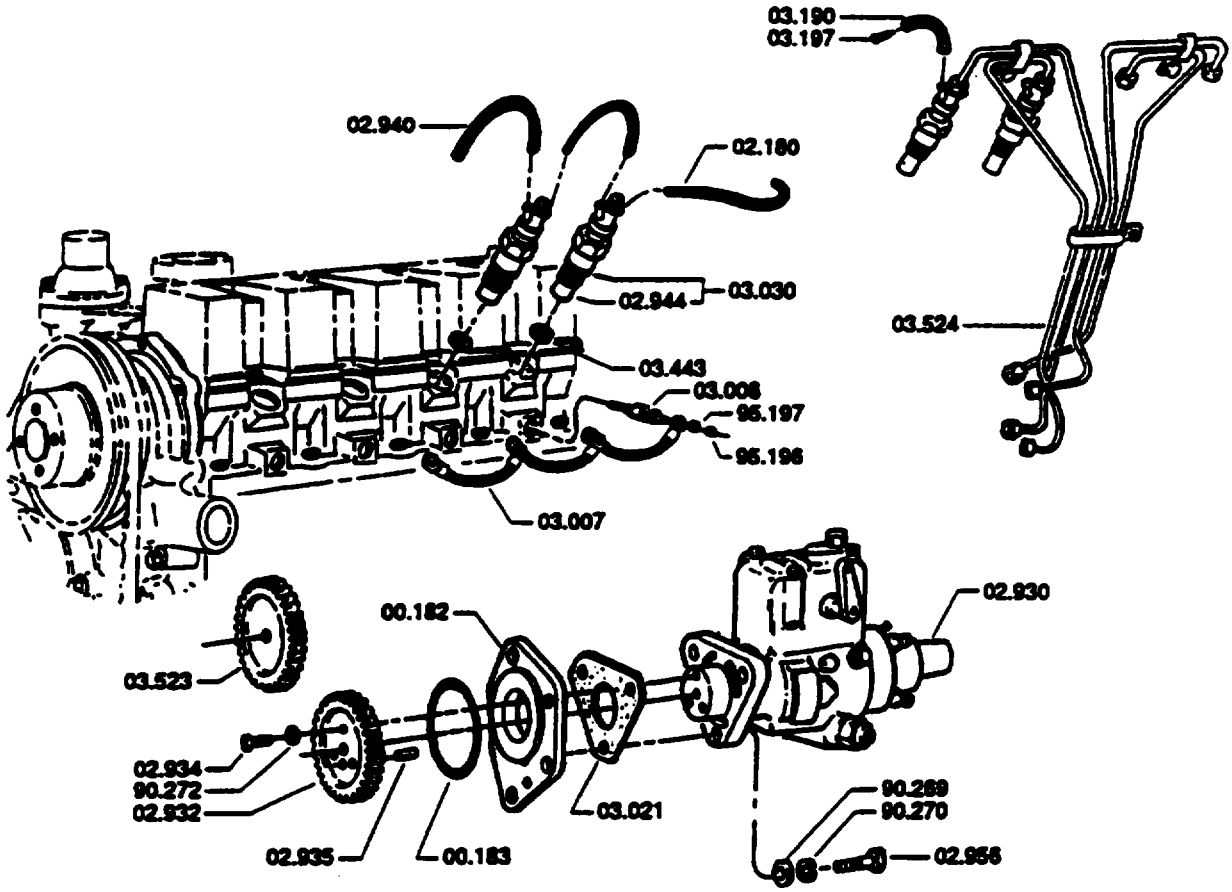


Engine Fuel Lines - TMD27 (2.7L) Engine



00.000	Engine Assembly (Continued)
02.033	Clip, Fuel Tank Return Line
02.178	Line, Fuel Filter Outlet
02.181	Fitting, Fuel Return Line
02.824	Fitting, Fuel Return Line
02.829	Clip, Fuel Return Line
02.936	Line, Fuel Tank Return
02.953	Fitting, Fuel Injection Pump
03.162	Fastener, Fuel Line Clip
03.188	Fitting, Fuel Return Line
03.428	Clip, Fuel Line
94.091	Lockwasher, Fuel Line Clip Fastener
94.093	Fastener, Fuel Line Clip
94.094	Fastener, Fuel Line Clip
94.734	Washer, Fuel Line Clip Fastener

Fuel Injection - TMD27 (2.7L) Diesel Engine



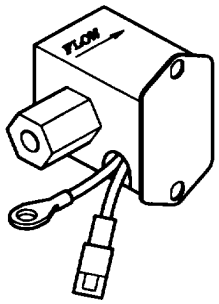
FUEL INJECTION SYSTEM 02674-1

00.000	Engine Assembly (Continued)
00.182	Adaptor, Fuel Injection Pump
00.183	Seal, Fuel Injection Pump Adaptor
02.180	Line, Fuel Return
02.930	Pump Assembly, Fuel Injection
02.932	Gear, Injection Pump (Driven)
02.934	Fastener, Injection Pump Drive Gear
02.935	Key, Injection Pump Drive Gear
02.940	Line, Injector Leak-Off
02.944	Nozzle, Fuel Injector
02.956	Fastener, Fuel Injection Pump
03.006	Heater, Cold Start
03.007	Wire, Cold Start Heater Feed
03.021	Gasket, Fuel Injection Pump Mounting
03.030	Injector Assembly, Fuel
03.190	Line, Fuel Return
03.197	Plug, Fuel Return Line
03.443	Shield, Injector Nozzle Heat
03.523	Gear, Fuel Injection Pump (Drive)
03.524	Assembly, Fuel Injector Lines
90.269	Washer, Fuel Injection Pump Fastener
90.270	Lockwasher, Fuel Injection Pump Fastener
90.272	Lockwasher, Pump Drive Gear Fastener
95.196	Nut, Cold Start Heater Terminal
95.197	Lockwasher, Cold Start Heater Terminal

WARNING

Smoking or open flame should be avoided any time the fuel system is being serviced or repaired. The work area should be properly ventilated. Clean up all fuel spills. Improper handling of fuel could result in an explosion or fire causing bodily Injury to yourself or others.

Fuel Supply (Transfer) Pump



The electric fuel supply pump is a solenoid-operated, plunger-type pump mounted on the engine cylinder block fuel pump pad and operated from the truck battery electrical system. It is completely sealed against fuel leakage and has the ability to prime itself and the filter without engine cranking.

The fuel pump is energized in the ignition circuit which ensures prompt filling of the fuel filter and fuel line to effect easy starting.

Fuel Pump Troubleshooting

When fuel pump trouble is suspected, disconnect the fuel line at the input side of the fuel injection pump. Turn ignition switch ON. Pump fuel into a small container, then place your finger on the outlet side of the fuel line. If the pump stops or ticks very infrequently, the pump and fuel line connections are satisfactory. Remove your finger from the fuel line, and if ample fuel flows, the pump is satisfactory.

If the pump ticks (pumps) with your finger on the fuel line, it may mean that there is a leak in the fuel supply line. Check for loose fittings or damaged fuel lines. Repair or replace, as necessary.

If the fuel does not flow and/or the pressure is below 1.50-2.25 psi [77-116 mm Hg] range, the pump should be replaced.

WARNING

Before disconnecting lines, be sure to relieve all pressure. Before applying pressure to the system, be sure all connections are tight and that lines, pipes and hoses are not damaged. Use a piece of cardboard, rather than hands, to search for leaks. Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal Injury. If Injured by escaping fluid, get medical attention at once.

Priming the Fuel System

Priming is necessary on initial installation of the fuel injection system, after any subsequent removal, and if the system should be drained by running out of fuel. Before priming and venting the fuel system, be sure that the outside of the vent screws and surrounding area is thoroughly clean to prevent dirt and foreign matter from entering the system.

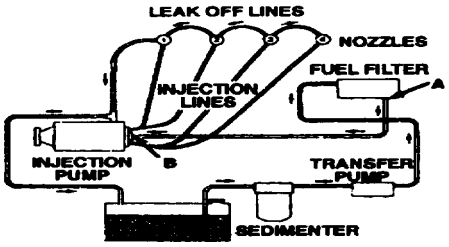
NOTE

Electrical equipment such as starters should be shielded to prevent fuel damage during priming.

1. Loosen the filter outlet (A), or the fuel injection pump inlet connection (B) whichever is at the highest point, and allow fuel to flow until free of air. Tighten connections.

NOTE

Filters of the four-boas type must also be vented at the plugged boss; this must be done regardless of the height of the filter in the system.



2. Loosen the vent valve fitted on one of the two hydraulic head locking screws (C), and the vent screw (D) on the governor housing. When fuel free of air flows from the vents, tighten the housing vent screw and then the governor vent screw.

3. Loosen any two injector high-pressure pipe nuts at the injector end. Set the accelerator to the fully-open position. Crank engine until clean fuel (free of air) flows. Tighten nuts.

4. Check Operation
   a) Energize the glow plugs.
   b) Start the engine.

Fuel Filters

Clark diesels are normally equipped with the fuel filter installed between the transfer pump outlet and the fuel injection pump, thus placing the filter on the pressure side of the transfer pump.

The PM interval for changing the filter element will largely depend upon the quality and condition of the fuel available. Under normal conditions, the element should be replaced every 400 hours. This interval should be reduced if incidental contamination of the fuel is experienced.

NOTE

- **Clean fuel Is a must In diesel operation. When clean fuel Is not consistently available, additional filters may be required for reliable engine operation.**
- **Electrical equipment, such as starters, should be protected against fuel damage during filter replacement and priming.**

Fuel Filter Replacement

The fuel filter is a paper-element type. No attempt should be made to clean the element. It should be replaced when periodic maintenance is being carried out.

1. Remove filter bowl.
2. Discard the dirty element. Remove and discard the upper and lower element sealing washers and O-ring from the center stud.
3. Clean the inside of the bowl and center tube.
4. Fit the new upper and lower sealing washers. Install new O-ring on the center stud. Place the new filter element in position and install the bowl. Tighten center stud.
5. Vent (bleed) the fuel system (refer to Section 5.3, Priming the Fuel System).

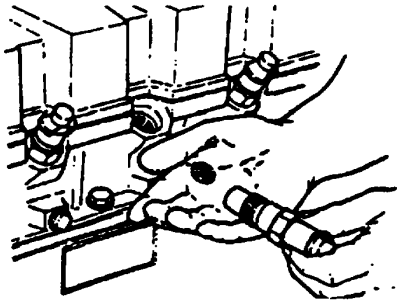
6. **Fuel Injectors**

Injectors should be removed (taken out) only if the engine is malfunctioning, as follows:

1) Misfiring.
2) Knocking in one or more cylinders.
3) Engine overheating.
4) Loss of power.
5) Smoky exhaust (black or white).
6) Increased or excessive fuel consumption.

WARNING

Do not use your hands to check for fuel leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious Injury. Relieve pressure before disconnecting fuel lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which elect fluids under high pressure. If Injured by escaping fluid, get medical attention at once. If any fluid Is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.



1. When installing injectors in the engine cylinder head it is essential that a new, correct type heat shield washer be fitted between the nozzle cap and the cylinder head.
2. Tighten injectors evenly to 52 lb ft [71 N•m] torque.

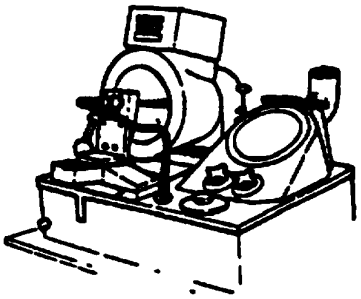
Fuel Injector Testing

WARNING

Bodily Injury may result during this procedure if care is not taken. Keep hands and face away from nozzle spray. The high velocity of oil spray may puncture the skin and cause blood poisoning. If injured by escaping fluid, get medical attention at once.

NOTE

Injection should not be disassembled unless testing shows that cleaning or other servicing Is needed.



Injectors are tested by using a special hydraulic injector tester, bolted to a bench with a small fuel oil supply tank with filter included to ensure that only clean fuel enters the injector. A high-pressure injection line is used to connect the outlet of the tester to the injector.

NOTE

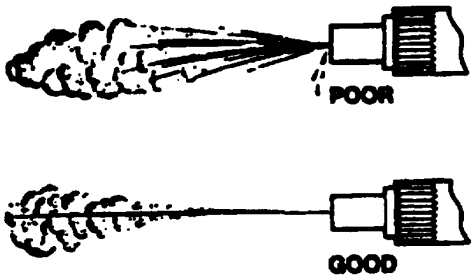
The Injector test gauge should not be subjected to shock pressure. Keep the gauge valve open only when reading pressure.

1. Close gauge valve and work pump handle several sharp strokes to dislodge any carbon or dirt particles in nozzle cavities.
2. Open gauge valve, work pump slowly, and observe nozzle opening pressure. (Specification: 2050-2130 psi). If opening pressure is not correct, remove nozzle from nozzle holder and shim as required to obtain 2050-2130 psi. If shims are not available, replace nozzle.

NOTE

It is desirable to have all injectors set as nearly alike as possible in the same engine.

3. Maintain a pressure of 2050-2130 psi and watch for dribble from spray orifice, indicating a bad seat; or "weeping" around cap nut, indicating a leak between the holder and valve body lapped surfaces.

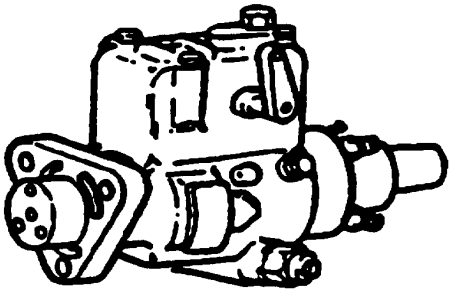


4. Close gauge valve and observe spray characteristics while working the tester about 100 strokes per minute. "Flags," heavy ends, deflected core, or a spray pattern that is not symmetrical are undesirable. Repair or replace faulty parts as necessary. A target 12" from the nozzle end, with bullseye level with pintle will show any deflection of spray pattern.

Injection Pump

WARNING

Before disconnecting lines, be sure to relieve all pressure. Before applying pressure to the system, be sure all connections are tight and that lines, pipes, and hoses are not damaged. Use a piece of cardboard, rather than hands, to search for leaks. Escaping fluid under pressure can have sufficient force to penetrate the skin, causing personal injury. If injured by escaping fluid, get medical attention at once.



The fuel injection pump, flange mounted to the engine, is a compact, self-contained, distributor-type unit incorporating a sensitive all-speed governor. It has a relatively simple design that utilizes no ball or roller bearings, gears, or highly-stressed springs. The number of working parts remains the same regardless of the number of cylinders the pump is required to serve.

It is constructed to be oil tight. During operation, all moving parts are lubricated and cooled by fuel under pressure. No additional lubrication system is required. Pressure maintained within the pump housing prevents the ingress of dust, water, or other foreign matter.

Fuel injection is effected by a single element having twin opposed plungers located within a transverse bore in a central rotating member. This acts as a distributor and revolves in a stationary member known as the hydraulic head. The pump plungers are actuated by lobes on an internal cam ring. Fuel is accurately metered to the pumping element, and the high-pressure charges are distributed to the engine cylinders at the required timing intervals through ports in the rotor and the hydraulic head.

The internal cam ring, mounted in the pump housing, operates the opposed pump plungers through cam rollers carried in shoes sliding in the rotor body. The plungers are forced inwards simultaneously as the rollers contact the diametrically-opposed cam lobes. This is the injection stroke. The plungers are returned by pressure of the in flowing fuel during the charging stroke. The pump rotor is driven by the engine through pinned hub and gear.

Most pumps have an automatic device which varies the point of commencement of injection.

The single pumping element ensures uniform delivery of fuel to each cylinder, and eliminates having to balance the deliveries from each of the high-pressure delivery lines.

The integral governor is a mechanical flyweight type which gives accurate control of engine speed under all load conditions. The governor flyweight assembly is mounted on the drive shaft and is contained entirely within the pump body. Linkage transmits the movement of the governor flyweights to the control lever on the metering valve. The governor control mechanism is enclosed in a housing mounted on the pump body.

Injection Pump Overhaul

Dismantling, assembly, testing, and adjustment of the injection pump must be carried out by trained personnel, using specialized tools and test apparatus.

Timing Of Injection Pump To The Engine

Injection pumps must be installed on the engine in accurate alignment and timed to correct relation with the engine crankshaft for proper engine operation with maximum power and economy and to prevent complaints of hard starting, overheating, uneven running, and excessive smoking.

Timing a fuel injection pump to a diesel engine is similar to, and simpler than, timing a gasoline engine ignition system. Both require precision to ensure the correct timing as recommended by the engine manufacturer.

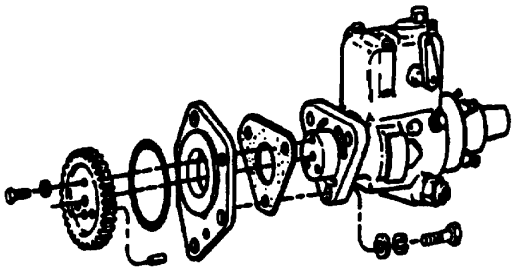
Under normal operation or during routine maintenance it will probably not be necessary to time the injection pump. However, i the pump is removed or a new pump installed, it must be timed according to the following procedures.

Reinstalling & Timing the Original Fuel Injection Pump

WARNING

Bodily Injury may result during the timing operation of the fuel injection pump n the engine Is running. Do not attempt to adjust the timing without the pump mounting bolts securely torqued.

1. Install new gasket on the pump face and install pump on the pump adapter plate.
2. Install adapter plate mounting bolts finger tight.

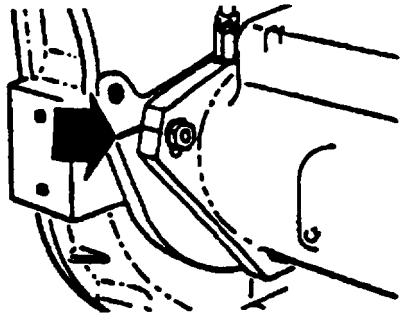


3. Install the alignment dowel through gear into the pump drive shaft.

NOTE

The remaining hole in the pump gear is for timing the pump to the engine.

4. Mount the drive gear to the pump drive shaft using three (3) screws and washers. Tighten screws to 20-25 lb ft [27-34 N•m] torque.
5. Install new 0-ring on hub of the pump adapter plate.
6. Turn engine crankshaft until #1 cylinder is at TDC on compression stroke with beveled gear tooth on the driver gear (mounted behind cam gear) approximately centered in hole in rear of gear case.
7. Remove screw plug in front cover of gear case. This is for the purpose of installing a timing pin. Use a 15/64" drill as a timing pin.
8. Install fuel injection pump and adapter. Turn pump and pump gear until pump can be installed with the timing pin (15/64" drill) passing through the hole in the pump gear.



9. Rotate the pump adapter plate and align scribe marks.
10. Install and tighten adapter mounting bolts and screws.
11. Remove the timing pin (15/64" drill) and replace the screw plug and washer.
12. Rotate the injection pump to align the scribe mark on the pump flange and on the pump adapter plate.
13. Tighten pump mounting bolts.
14. Attach high-and low-pressure fuel lines and hoses.
15. Attach wire to cut-off solenoid.
16. Connect throttle control linkage.
17. Check Operation

NOTE

It is strongly recommended that a diesel Injection timing light be used to check Injection timing.

a) Start engine.
b) Run engine at 1600 rpm idle.
c) Check pump timing. Dynamic timing should be 13°-15° BTDC @ 1600 rpm, no-load.

Installing & Timing
A New Fuel Injection Pump

WARNING

Bodily Injury may result during the timing operation of the fuel injection pump n the engine is running. Do not attempt to adjust the timing without the pump mounting bolts securely torqued.

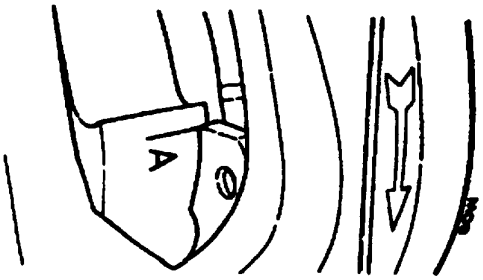
NOTE

To obtain access to the Internal timing marks, the original manufacturer's sell will have to be broken. These sea is should therefore be removed only by authorized personnel who must reseal when the adapter plate or cover is replaced. Otherwise, the warranty may become void.

1. Repeat preceding Steps 1 thru 11 of Reinstalling & Timing the Original Fuel Injection Pump.
2. Rotate crankshaft until #1 piston is on compression stroke and timing mark 13°-150 BTDC lines up with the pointer in bell housing or crankshaft pulley.

NOTE

Be sure that #1 piston is on compression stroke by turning both push rods by hand, Indicating both valves are closed.



3. Remove inspection plate on the injection pump housing. Turn pump until Line "A" on the drive shaft lines up with the flat end of the circlip.
4. Tighten pump mounting bolts.
5. Rotate crankshaft approximately 500 counterclock-wise. Then rotate clockwise, stopping at 13°- 150 BTDC. Recheck that Line 'A" is still in line with flat end of circlip. If not, reset.
6. Replace inspection plate on the injection pump.
7. Repeat preceding Steps 14 thru 17.
8. Restamp the pump to adapter scribe marks.

Fuel Recommendations

Diesel fuel selection, handling, and filtration Is of great importance. The fuel not only supplies the energy for all the work done by the engine, it also lubricates the parts of the fuel injection system which operate with very close tolerances. Fuel that contains water, abrasives, or sulphur in excess of the recommended specifications can cause extensive damage to the injection pump and engine.

Diesel Fuel Specifications

TMD27 diesel engines have been designed and developed to use No. 1-D (light fuel) and preferably No. 2 (heavy fuel), which can be a cracked residual, a blend of preferably a straight-run distillate having characteristics including the following selected items:

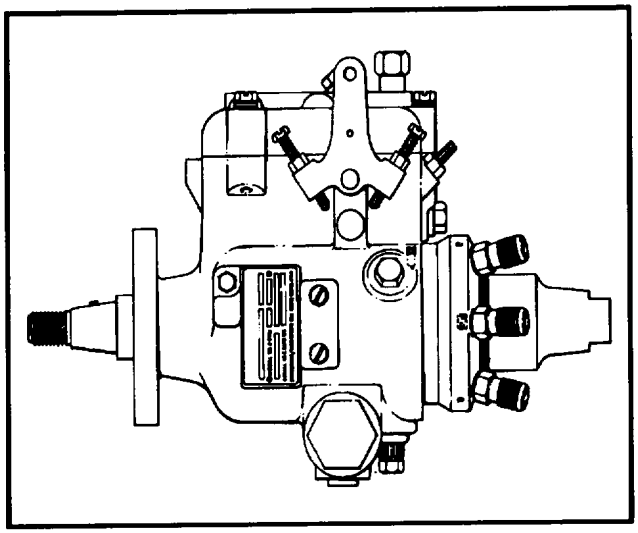
Cetane Number ..... 50 desired, 45 minimum
Water and Sediment ..... 0.05% maximum by weight
Total Sulphur ..... 0.5% maximum

5.11. Fuel Injection Pump

OPERATION AND INSTRUCTION MANUAL
MODEL DB2 PUMP

Note

Injector pump for eight cylinder engine is shown. Procedures for four cylinder engine are similar.



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Diesel Systems

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General

A. PURPOSE OF THE MANUAL

This manual is expressly intended to provide sufficient information for qualified technicians experienced in diesel engines and diesel injection equipment, to disassemble and reassemble the Roosa Master DB2-type fuel injection pump and to make such adjustments and parts replacements as may be needed. It is recommended that an inexperienced person refrain from making adjustments and repairs, as such action may result in very extensive damage to the pump and possibly to the engine.

No service should be performed on the pump before making a careful study of this manual and becoming familiar with the principles and instructions which follow. Since several critical adjustments of the injection pump are required which cannot readily be made on the engine, it is necessary that the service be performed in a facility equipped with the proper special tools and an approved, motorized test stand.

This manual completely describes the operating principles of the pump and most accessories. Only through a thorough knowledge of these principles can the serviceman locate and correct possible operational defects.

B. MODEL NUMBER SYSTEM

It is necessary to understand the model number system for reference to the proper sections of this manual covering operation and maintenance of the pump.

EXAMPLE:

	a	b	c	d	e
Model Number	DB2	6	33	JN	3000

a. DB2-D Series Pump, 13-Rotor, 2nd generation
b. 6- Number of cylinders. (Available in 2, 3, 4, 6 and 8 cylinder configurations.)
c. 33- Abbreviation of plunger diameter.
25-.250"(6.35mm) 31- .310"'(7.87mm)
27- .270"(6.86mm) 33- .330"(8.38mm)
29- .290"(7.37mm) 35- .350"(8.89mm)
d. JN -Accessory code (See S.B. No. 63)
The code pertains to combinations of special accessories such as electrical shutoff, automatic advance, variable speed droop adjustment, etc. See the proper service bulletin or manual section for operation and construction of these accessories.

Include this in any reference to the pump.
e. 3000 - Specification Number
Determines selection of parts and adjustments for a given application. Must be included in any reference to the pump.

NOTE

Pump rotation and method of mounting are provided under special notes on individual pump specifications.

C. GENERAL INFORMATION

In a diesel engine, air is drawn into the cylinder through the intake valve and compressed. A metered quantity of fuel is then injected into the cylinder, producing a combustible mixture. This mixture ignites from heat of compression, and the expanding gases force the piston downward.

The function of a diesel fuel injection pump is to accurately meter and deliver fuel to a nozzle in each cylinder and to inject it at high pressure into the combustion chamber at precisely timed intervals. The extreme precision necessary can well be appreciated since this cycle must be repeated thousands of times per minute with virtually no variation in timing or amount of fuel injected. The injection pump is truly the heart of the diesel engine.

ROOSA MASTER
MODEL DB2 DIESEL INJECTION PUMP

The model DB2 injection pump is described as an opposed-plunger, inlet-metered, positive-displacement, distributor-type pump. The DB2 pump incorporates a single pumping chamber. Simplicity, the prime advantage of Roosa Master design, contributes to lower initial cost, greater reliability, ease of service and lower maintenance cost.

The necessity for cost reduction is more apparent in the small diesel engine where the injection equipment represents a greater percentage of the cost. Since the basic model has but 100 odd parts, and only four main rotating members, there is less chance of failure. Repairs are generally inexpensive. Today's small, high-output engines have created a need for improved, yet low cost, injection equipment capable of higher speed operation, quieter running and lower exhaust emissions.

Precise distribution between cylinders, inherent in the pump design, and the ability to preset fuel flow eliminates lengthy periods on the test stand. The pump is self-lubricated, contains essentially the same number of parts regardless of the number of cylinders served, and operates in any position.

IMPROVED DESIGN FEATURES

The addition of the Model DB2 injection pump to the Roosa Master line of fuel injection equipment incorporates many design improvements and has been durability tested for more than 200,000 hours prior to release for production.

IMPROVED DESIGN FEATURES INCLUDE:

1. Housing
    a. Cast-in, hardened throttle bosses.
    b. Larger diameter advance bosses.
    c. Cast-in wrench boss for timing (on some models).
    d. New straight thread return oil fitting.
2. Head and Rotor
    a. Easily accessible vent wire assembly.
    b. Integral angled discharge fittings.
3. Automatic Advance
    a. Sintered metal cam standard on light duty applications.

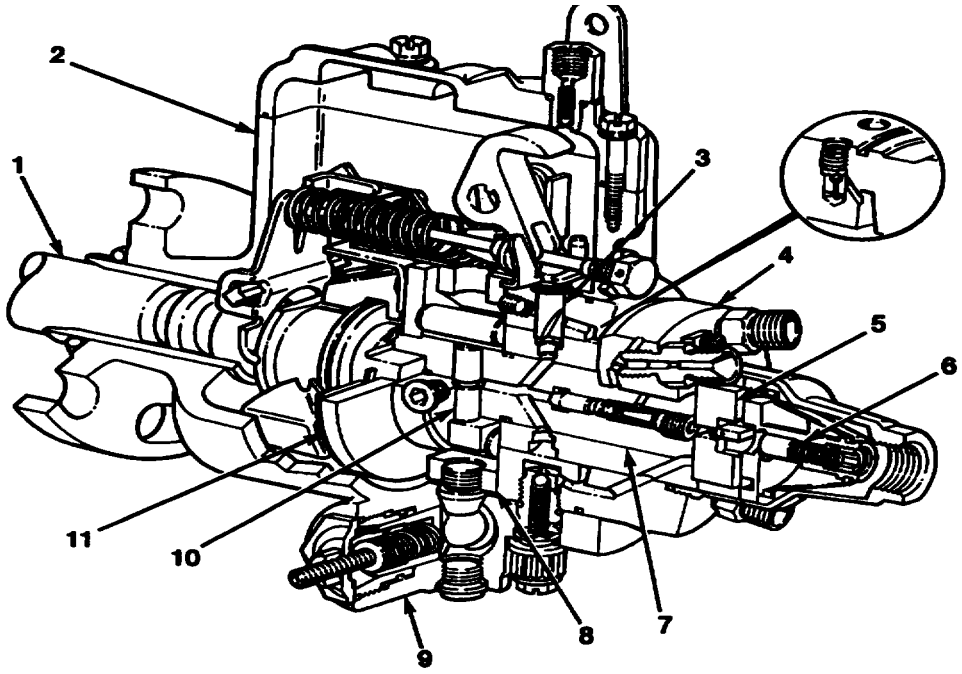


Figure 1.0

A. COMPONENTS AND FUNCTIONS

It is necessary to become familiar with the function of the main components to understand the basic operating principles of the Roosa Master Model DB2 pump. See cutaway view (Figure 1.0) for construction details.

MAIN COMPONENTS

1. Drive Shaft
2. Housing
3. Metering Valve
4. Hydraulic Head Assembly
5. Transfer Pump Blades
6. Pressure Regulator Assembly
7. Distributor Rotor
8. Internal Cam Ring
9. Automatic Advance (Optional)
10. Pumping Plungers
11. Governor

The main rotating components are the drive shaft (1), transfer pump blades (5), distributor rotor (7), and governor (11).

With reference to Figure 1.0, the drive shaft engages the distributor rotor in the hydraulic head. The drive end of the DB2 rotor incorporates two pumping plungers. The plungers are actuated toward each other simultaneously by an internal cam ring through rollers and shoes which are carried in slots at the drive end of the rotor. The number of cam lobes normally equals the number of engine cylinders.

The transfer pump at the rear of the rotor is of the positive-displacement, vane-type and is enclosed in the end cap. The end cap also houses the fuel inlet strainer and transfer pump pressure regulator. The face of the regulator assembly is compressed against the liner and distributor rotor and forms an end seal for the transfer pump. The injection pump is designed so that end thrust is against the face of the transfer pump pressure regulator. The distributor rotor incorporates two charging ports and a single axial bore with one discharge port to service all head outlets to the injection lines.

The hydraulic head contains the bore in which the rotor revolves, the metering valve bore, the charging ports and the head discharge fittings. The high-pressure injection lines to the nozzles are fastened to these discharge fittings.

The DB2 pump contains its own mechanical governor capable of close speed regulation. The centrifugal force of the weights in their retainer is transmitted through a sleeve to the governor arm and through a positive linkage to the metering valve. The metering valve can be closed to shut off fuel through a solid linkage by an independently operated shutoff lever, or by an electrical solenoid.

The automatic advance is a hydraulic mechanism which advances or retards the pumping cycle.

B. MOUNTING FLANGES

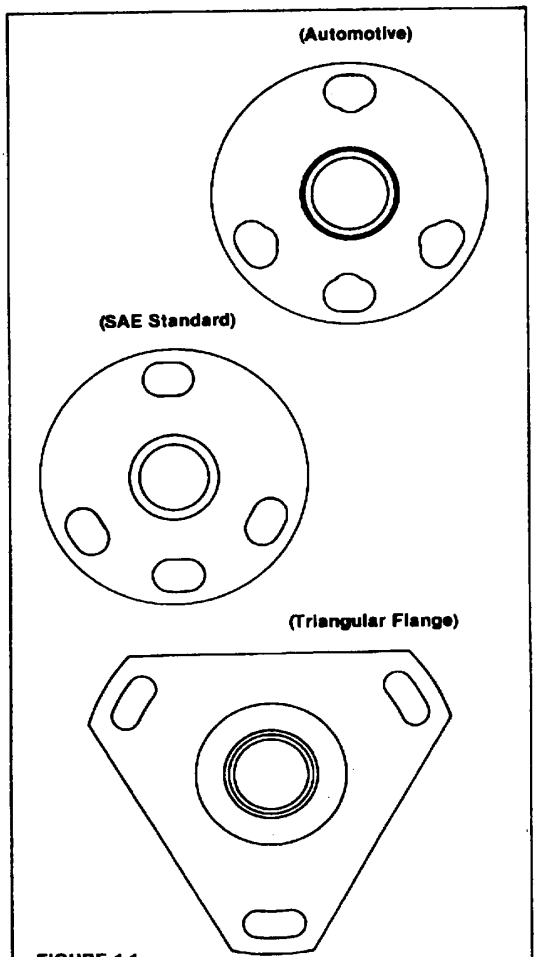


FIGURE 1.1

Shown above are the typical DB2 mounting flange configurations. These are the three most common types. Note that the automotive flange has scalloped slots to enable it to be mounted on a standard pump holding fixture.

C. FUEL FLOW

The operating principles of the pump can be understood more readily by following the fuel circuit during a complete pump cycle cutaway, (Figure 1.2) and fuel flow schematic (Figure 1.3). Also, see exploded view of the rotor assembly (Figure 1.4).

Fuel is drawn from the supply tank through filters into the pump inlet through the inlet filter screen (1) by the vane-type fuel transfer pump (2). Some fuel is bypassed through the pressure regulator assembly (3) to the suction side.

Fuel under transfer pump pressure flows through the center of the transfer pump rotor, past the rotor retainers (4) into a circular groove on the rotor. It then flows through a connecting passage (5) in the head to the automatic advance (6), up through a radial passage (7) and then through a connecting passage (8) to the metering valve. The radial position of the metering valve, controlled by the governor, regulates flow of the fuel into the radial charging passage (9) which incorporates the head charging ports.

As the rotor revolves, the two rotor inlet passages (10) register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber. With further rotation, the inlet passages move out of registry and the discharge port of the rotor registers with one of the head outlets. While the discharge port is opened, the rollers (11) contact the cam lobes forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

Self-lubrication of the pump is an inherent feature of the Roosa Master design. As fuel at transfer pump pressure reaches the charging ports, slots on the rotor shank allow fuel and any entrapped air to flow into the pump housing cavity.

In addition, an air vent passage (12) in the hydraulic head connects the outlet side of the transfer pump with the pump housing. This allows air and some fuel to be bled back to the fuel tank via the return line. The fuel thus bypassed fills the housing, lubricates the internal components, cools and carries off any small air bubbles. The pump operates with the housing completely full of fuel; there are no dead air spaces anywhere within the pump.

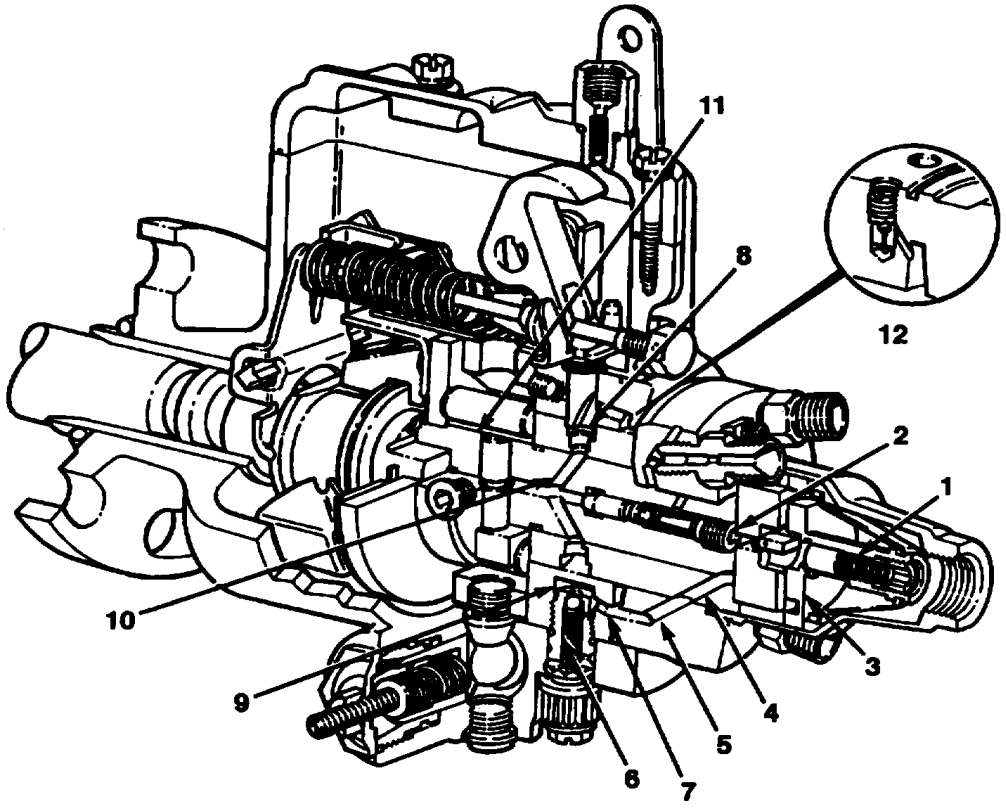


FIGURE 1.2

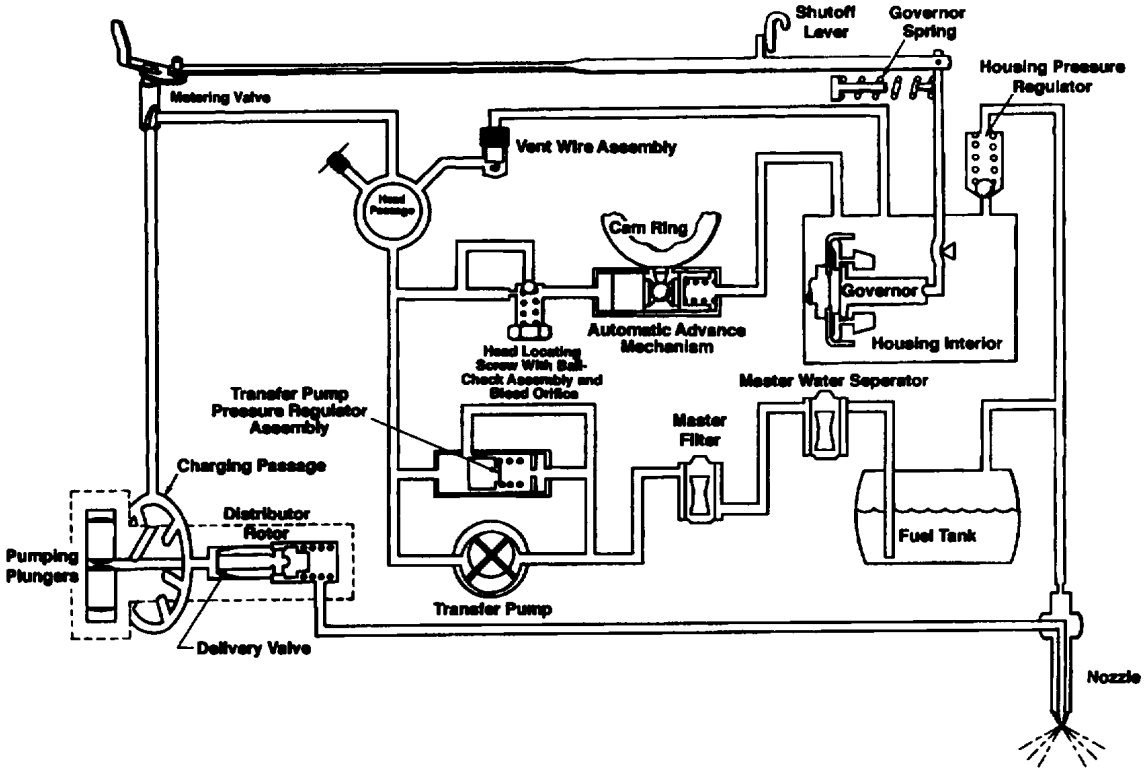


FIGURE 1.3

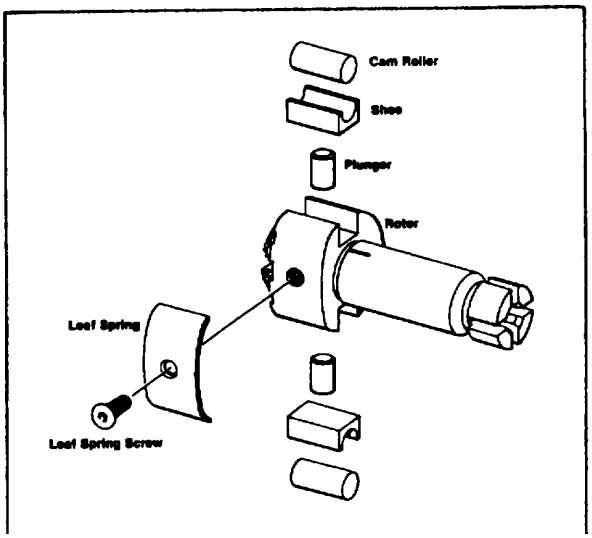


FIGURE 1.4.

D. TRANSFER PUMP

The positive-displacement, vane-type fuel transfer pump consists of a stationary liner and spring-loaded blades which are carried in slots in the rotor. Since the inside diameter of the liner is eccentric to the rotor axis, rotation causes the blades to move in the rotor slots.

This blade movement changes the volume between the blade segments.

Transfer pump output volume and pressure increases as pump speed increases. Since displacement and pressure of the transfer pump can exceed injection requirements, some of the fuel is recirculated by means of the transfer pump regulator to the inlet side of the transfer pump.

Figure 1.5 illustrates the pumping principle. Radial movement causes a volume increase in the quadrant between blades 1 and 2 (Figure 1.5a). In this position, the quadrant is in registry with a kidney-shaped inlet slot in the top portion of the regulator assembly. The increasing volume causes fuel to be pulled through the inlet fitting and filter screen into the transfer pump liner. Volume between the two blades continues to increase until blade 2 passes out of registry with the regulator slot. At this point, the rotor has reached a position where outward movement of blades 1 and 2 is negligible and volume is not changing (Figure 1.5b). The fuel between the blades is being carried to the bottom of the transfer pump liner.

As blade 1 passes the edge of the kidney-shaped groove in the lower portion of the regulator assembly (Figure 1.5c), the liner, whose inside diameter is eccentric to the rotor, compresses blades 1 and 2 in an inward direction (Figure 1.5a). The volume between the blades is reduced and pressurized fuel is delivered through the groove of the regulator assembly, through the transfer pump, through the rotor, past the rotor retainers and into a channel on the rotor leading to the hydraulic head passages. Volume between blades continues to decrease, pressurizing the fuel in the quadrant, until blade 2 passes the groove in the regulator assembly.

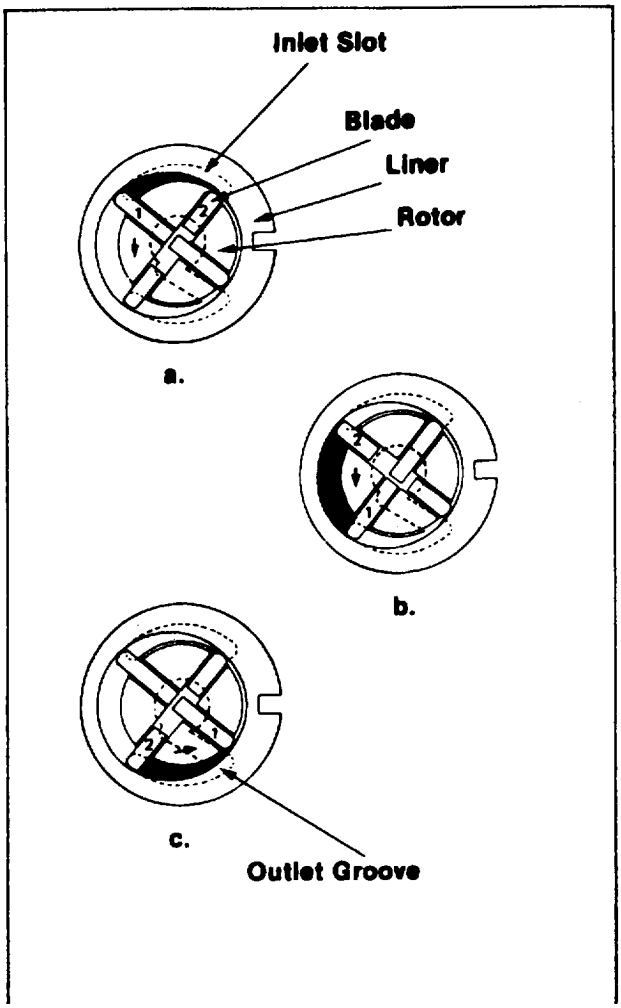


FIGURE 1.5.

REGULATOR ASSEMBLY OPERATION

Figure 1.6 shows the operation of the pressure regulating piston while the pump is running. Fuel output from the discharge side of the transfer pump forces the piston in the regulator against the regulating spring. As flow increases, the regulating spring is compressed until the edge of the regulating piston starts to uncover the pressure regulating slot "S" (Figure 1.6b). Since fuel

pressure on the piston is opposed by the regulating spring, the delivery pressure of the transfer pump if controlled by the spring rate and size of the regulating slot "A." Therefore, pressure increases with speed.

A high-pressure relief slot 'B" is incorporated in some regulators as part of the pressure regulating slot to pre vent excessively high transfer pump pressure, if the engine or pump is accidentally overspeeded.

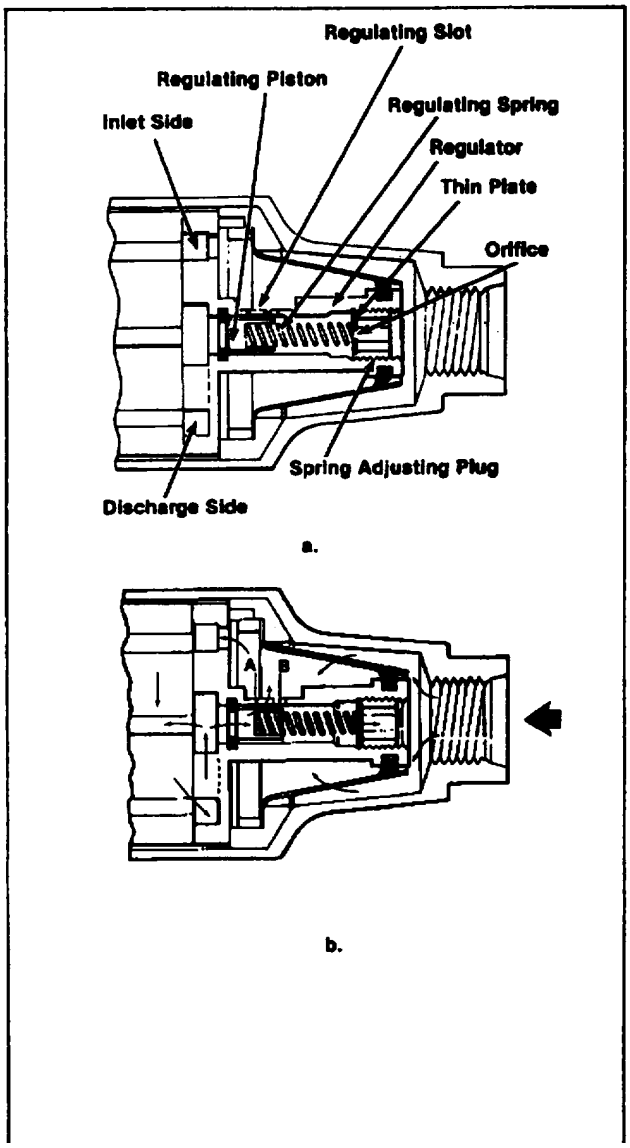


FIGURE 1.6.

VISCOSITY COMPENSATION

The DB2 transfer pump works equally well with different grades of diesel fuel and varying temperatures, both of which affect fuel viscosity. A unique and simple feature of the regulating system offsets pressure changes caused by viscosity difference. Located in the spring adjusting plug is a thin plate incorporating a sharpedged orifice. The orifice allows fuel leakage past the piston to return to the inlet side of the pump. Flow through a short orifice is virtually unaffected by viscosity changes. The biasing pressure exerted against the back side of the piston is determined by the leakage through the clearance between the piston and the regulator bore and the pressure drop through the sharpedged orifice. With cold or viscous fuels, very little leakage occurs past the piston. The additional force on the back side of the piston from the viscous fuel pressure is slight. With hot or light fuels, leakage past the piston increases. Fuel pressure In the spring cavity increases also, since flow past the piston must equal flow through the orifice. Pressure rises due to increased piston leakage and pressure rises to force more fuel through the orifice. This variation in piston position compensates for the leakage which would occur with thin fuels and design pressures are maintained over a broad range of viscosity changes.

E. CHARGING AND DISCHARGING

Charging Cycle

As the rotor revolves (Figure 1.7), the two inlet passages in the rotor register with ports of the circular charging passage. Fuel under pressure from the transfer pump, controlled by the opening of the metering valve, flows into the pumping chamber forcing the plungers apart.

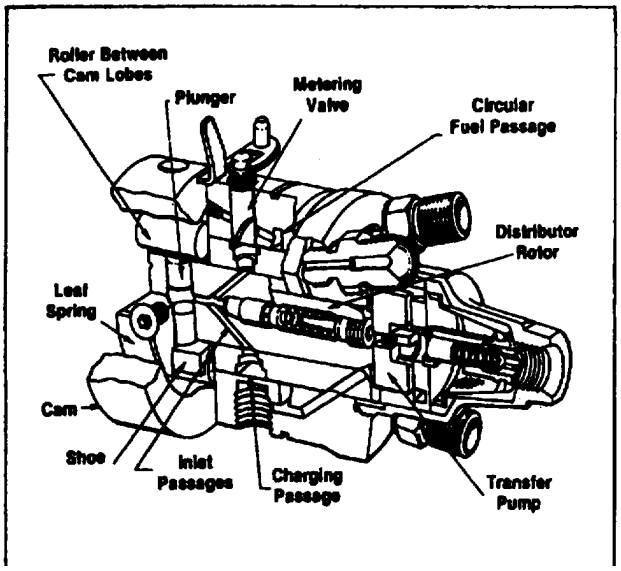


FIGURE 1.7.

The plungers move outward a distance proportionate to the amount of fuel required for injection on the following stroke. If only a small quantity of fuel is admitted into the pumping chamber, as at idling, the plungers move out a short distance. Maximum plunger travel and, consequently, maximum fuel delivery are limited by the leaf spring which contacts the edge of the roller shoes. Only when the engine is operating at full load will the plungers move to the most outward position. Note that while the angled inlet passages in the rotor are in registry with the ports in the circular charging passage, the rotor discharge port is not in registry with a head outlet (Figure 1.7). Note also that the rollers are off the cam lobes. Compare their relative positions (Figures 1.7 and 1.8).

Discharge Cycle

As the rotor continues to revolve (Figure 1.8), the inlet passages move out of registry with the charging ports. The rotor discharge port opens to one of the head outlets. The rollers then contact the cam lobes forcing the shoes in against the plungers and high-pressure pumping begins.

Beginning of injection varies according to load (volume of charging fuel), even though rollers may always strike the cam at the same position. Further rotation of the rotor moves the rollers up the cam lobe ramps pushing the plungers inward. During the discharge stroke, the fuel trapped between the plungers flows through the axial passage of the rotor and discharge port to the injection line. Delivery to the injection line continues until the rollers pass the innermost point on the cam lobe and begin to move outward. The pressure in the axial passage is then reduced, allowing the nozzle to close. This is the end of delivery.

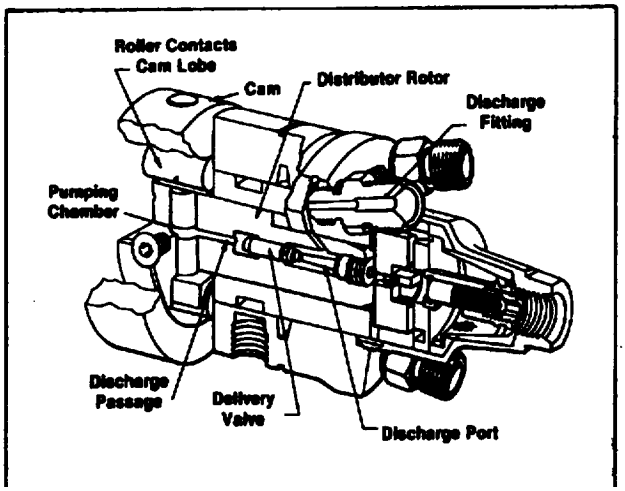


FIGURE 1.8.

F. DELIVERY VALVE

The delivery valve (Figures 1.9a through 1.9d) rapidly decreases injection line pressure after injection to a predetermined value lower than that of the nozzle closing pressure. This reduction in pressure permits the nozzle valve to return rapidly to its seat, achieving sharp delivery cutoff and preventing improperly atomized fuel from entering the combustion chamber.

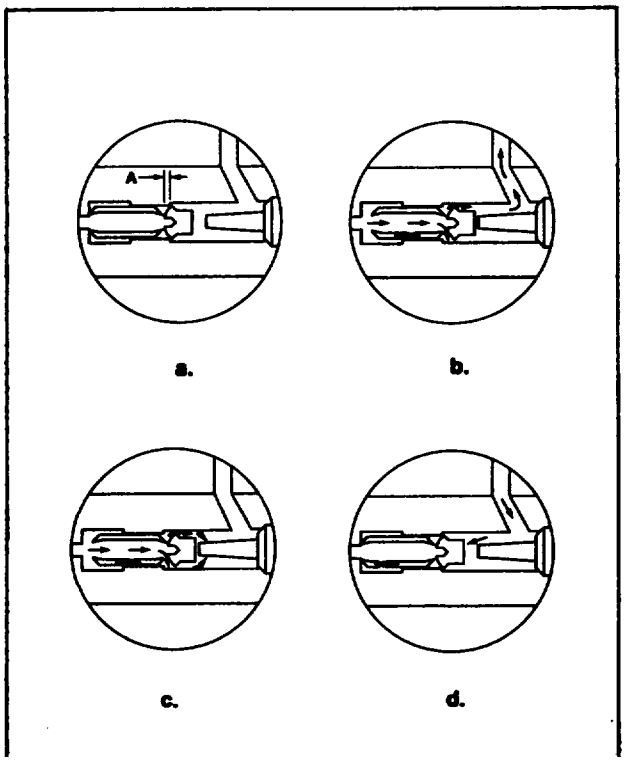


FIGURE 1.9.

The delivery valve operates in a bore in the center of the distributor rotor. Note that the valve requires no seat only a stop to limit travel. Sealing is accomplished by the close clearance between the valve and bore into which it fits. Since the same delivery valve performs the function of retraction for each injection line, the result is a smooth running engine at all loads and speeds.

When injection starts, fuel pressure moves the delivery valve slightly out of its bore and adds the volume of its displacement, section "A," to the delivery valve spring chamber. Since the discharge port is already opened to a head outlet, the retraction volume and plunger displacement volume are delivered under high pressure to the nozzle. Delivery ends when the pressure on the plunger side of the delivery valve is quickly reduced.

due to the cam rollers passing the highest point on the cam lobe.

Following this, the rotor discharge port closes completely and a residual injection line pressure is maintained. Note that the delivery valve is only required to seal while the discharge port is opened. Once the port is closed, residual line pressures are maintained by the seal of the close fitting head and rotor.

G. RETURN OIL CIRCUIT

Fuel under transfer pump pressure is discharged into a vent passage in the hydraulic head (Figure 1.10). Flow through the passage is restricted by a vent wire assembly to prevent excessive return oil and undue pressure loss. The amount of return oil is controlled by the size of wire used in the vent wire assembly, i.e. the smaller the wire the greater the flow and vice versa. The vent wire assembly is available in several sizes in order to meet the return oil quantities called for on the specification. Note that this assembly is accessible by removing only the governor cover. The vent passage is located behind the metering valve bore and connects with a short vertical passage containing the vent wire assembly and leads to the governor compartment.

Should a small quantity of air enter the transfer pump, it immediately passes to the vent passage as shown. Air and a small quantity of fuel then flow from the housing to the fuel tank and via the return line.

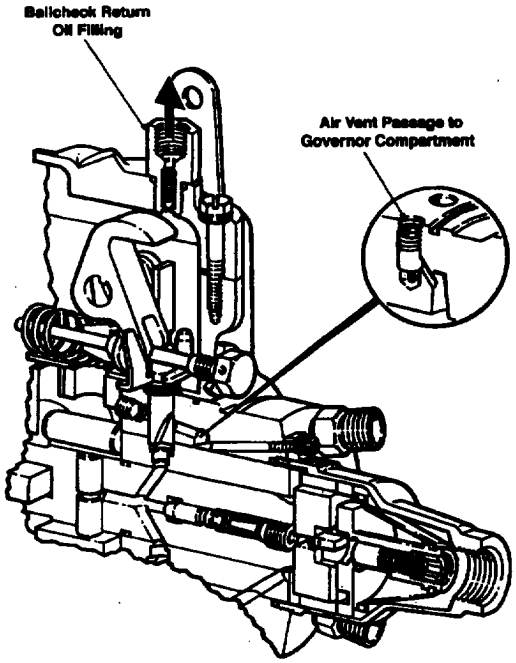


FIGURE 1.10.

Housing pressure is maintained by a spring-loaded ballcheck return fitting in the governor cover of the pump.

H. MECHANICAL ALL SPEED GOVERNOR

The governor serves the purpose of maintaining the desired engine speed within the operating range under various load settings.

In the mechanical governor (Figure 1.11), the movement of the weights acting against the governor thrust sleeve rotates the metering valve by means of the governor arm and linkage hook. This rotation varies the registry of the metering valve opening to the passage from the transfer pump, thereby controlling the quantity of fuel to the plungers. The governor derives its energy from weights pivoting in the weight retainer. Centrifugal force tips them outward, moving the governor thrust sleeve against the governor arm, which pivots on the knife edge of the pivot shaft and, through a simple, positive linkage, rotates the metering valve. The force of the weights against the governor arm is balanced by the governor spring force, which is controlled by the manually positioned throttle lever and vehicle linkage for the desired engine speed.

In the event of a speed increase due to a load reduction, the resultant increase in centrifugal force of the weights rotates the metering valve clockwise to reduce fuel. This limits the speed increase (within the operating range) to a value determined by governor spring rate and setting of the throttle.

When the load on the engine is increased, the speed tends to reduce. The lower speed reduces the force generated by the weights permitting the spring force to rotate the metering valve in the counterclockwise direction to increase fuel. The speed of the engine at any point within the operating range is dependent upon the combination of load on the engine and the governor spring rate and setting as established by the throttle position. A light idle spring is provided for more sensitive regulation when weight energy is low in the low end of speed range. The limits of throttle travel are set by adjusting screws for proper low idle and high idle positions.

A light tension spring on the linkage assembly takes up any slack in the linkage joints and also allows the shutoff mechanism to close the metering valve without having to overcome the governor springing force. Only a very light force is required to rotate the metering valve to the closed position.

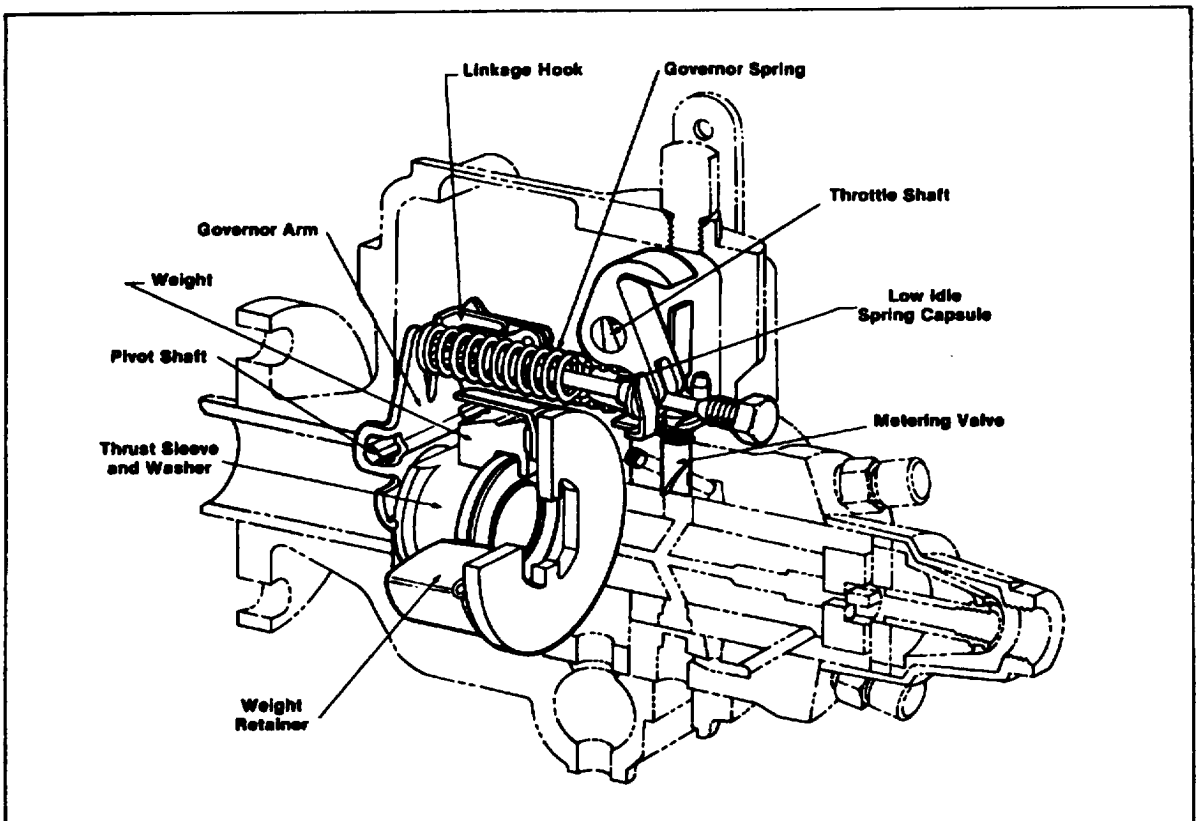


FIGURE 1.11.

J. AUTOMATIC ADVANCE-SPEED RESPONSIVE

The Roosa Master design permits the use of a simple, direct-acting hydraulic mechanism, powered by fuel pressure from the transfer pump, to rotate the cam slightly and vary delivery timing. The advance mechanism advances or retards start of fuel delivery in response to engine speed changes. In most injection systems, the actual beginning of delivery of fuel at the nozzle will start later (in engine degrees of rotation) as the speed increases.

Compensating inherent injection lag improves highspeed performance of the engine. Starting delivery of fuel to the nozzle earlier when the engine is operating at higher speed ensures that combustion takes place when the piston is in its most effective position to produce optimum power with minimum specific fuel consumption and minimum smoke.

The advance pistons located in a bore in the housing engage the cam advance screw and move the cam (when fuel pressure moves the power piston) opposite the direction of rotor rotation (Figures 1.12 and 1.13). Fuel under transfer pump pressure is fed through a drilled passage in the hydraulic head which registers with the bore of the head locating screw. Fuel is then directed past the spring-loaded ballcheck in the bore of the head locating screw. It then enters the groove on the outside diameter of the screw which registers with a drilled passage in the housing leading to the power piston side of the automatic advance assembly.

A groove around the power piston plug and a drilled passage allow the fuel to enter the advance piston bore. Fuel pressure against the piston must overcome the opposing spring force plus the dynamic injection loading on the cam in order to change the cam position. The spring-loaded ballcheck in the bore of the head locating screw prevents the normal tendency of the cam to return to the retard position during injection by trapping the fuel in the piston chamber. When engine speed decreases, the hydraulic pressure is reduced and the spring returns the cam to a retarded position in proportion to the reduction in speed. The fuel in the piston chamber is allowed to bleed off through a control orifice located below the ballcheck valve in the head locating screw.

At low speeds, because transfer pump pressure is comparatively low, the cam remains in the retarded position. When engine speed increases, transfer pump

pressure rises and moves the piston in the advanced direction. Advance piston movement is related to speed. Total movement of the cam is limited by the piston length.

A "trimmer screw" is provided to adjust advance spring preload which controls start of cam movement. It can be incorporated at either side of the advance mechanism and may be adjusted on the test bench while running (Figure 1.13).

SPEED ADVANCE OPERATION

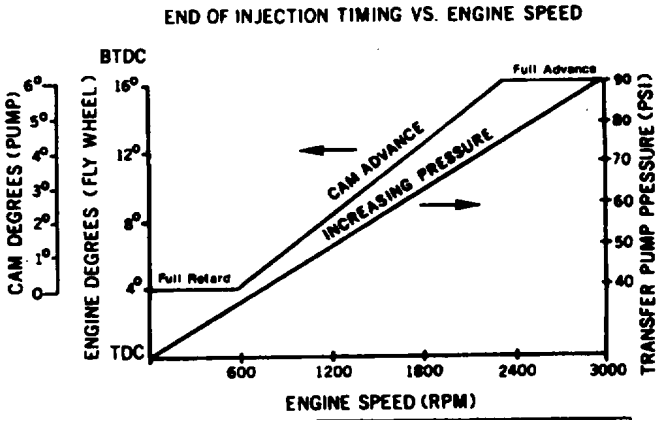


FIGURE 1.12.

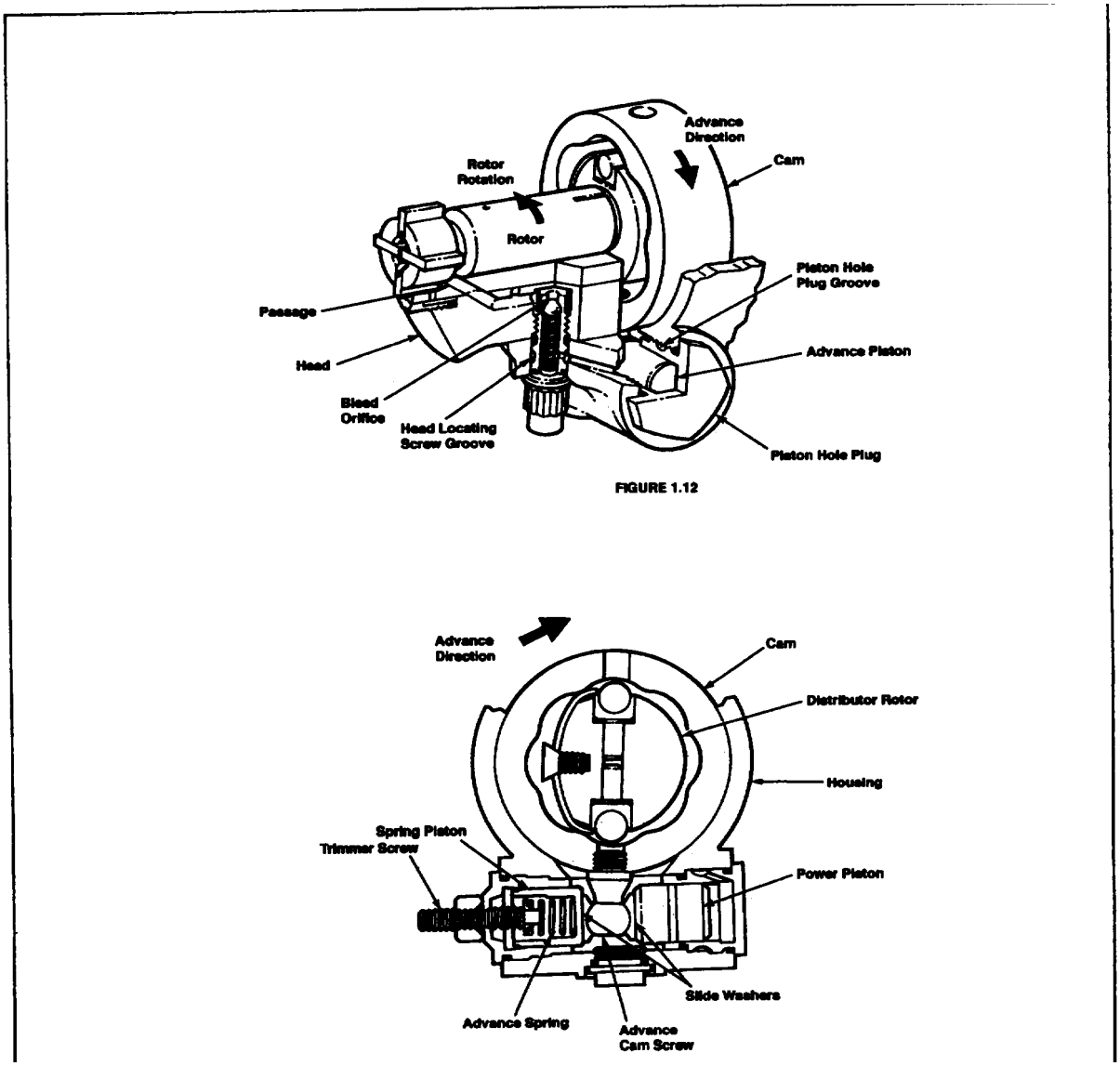


FIGURE 1.13.

SECTION 3 DISASSEMBLY

Study the manual first. Before commencing disassembly of the pump, cover inlet and outlet holes, remove all external grease and dirt by washing the unit with diesel fuel and blowing it off with filtered compressed air. It must be constantly kept in mind that dirt, dust and foreign matter are the greatest enemies of the fuel injection pump. As an added precaution to prevent dirt from entering the fuel system while servicing the pump, it is essential that a clean work space, clean tools and clean hands be used.

NOTE

All seals and gaskets should be discarded during disassembly. A clean pan should be available in which the parts may be placed during disassembly, and a pan of clean diesel fuel or calibrating oil must be available in which the parts may be flushed. It is recommended that these be deep pans with rounded comers to lessen the chances of dirt pockets.

STEP 1 Remove the pilot tube seal (Figure 3.1).

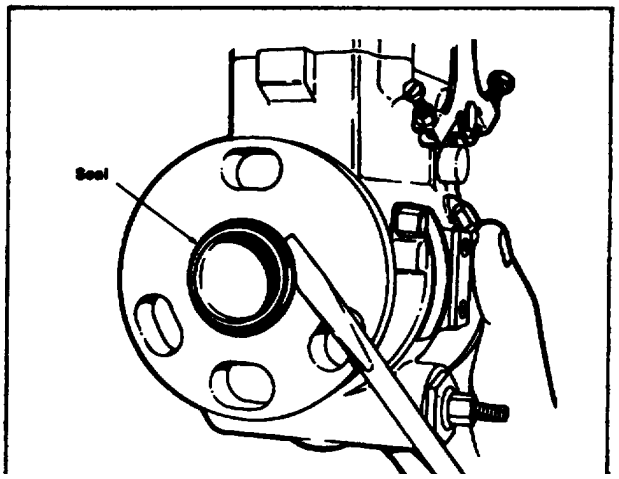


FIGURE 3.1

STEP 2 Mount the pump in a holding fixture. Always use a fixture to avoid pump sliding out and becoming damaged, never clamp the pump in a vise. Remove all lead plumb sealing wires. Unscrew the three cover holddown screws (Figure 3.2a).

Remove the governor control cover and cover gasket (Figure 3.2b).

STEP 3 Remove the shutoff cam by rotating the shutoff lever to the wide open throttle (WOT) position. Place shutoff cam remover, with tab beneath the shorter leg

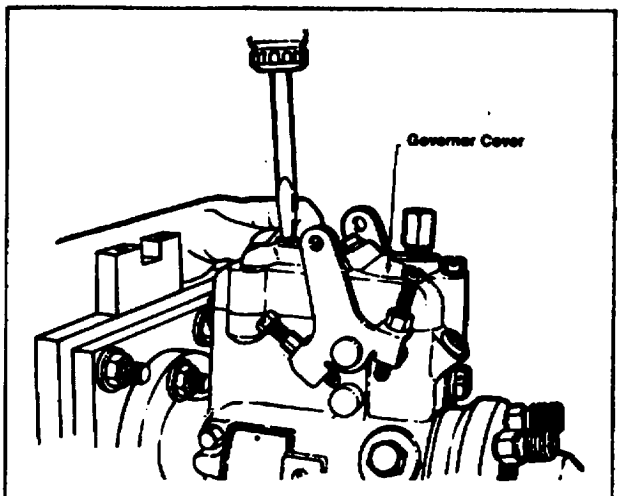


FIGURE 3.2a.

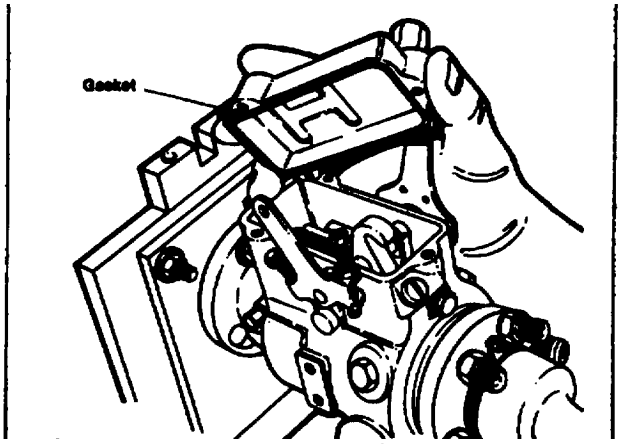


FIGURE 3.2b.

of the shutoff cam, on the shutoff shaft and pry gently, sliding the cam off the shaft assembly (Figure 3.3). Discard the shutoff cam.

NOTE

Do not reuse this shutoff cam, use new cam.

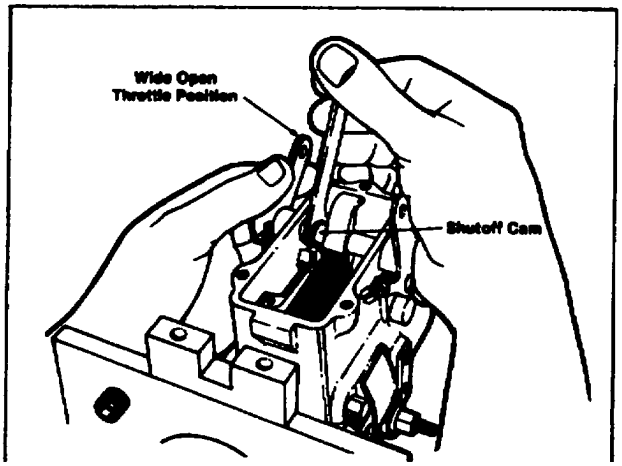


FIGURE 3.3.

STEP 4 Withdraw the throttle shaft assembly and throttle shaft lever from the shutoff lever assembly (Figure 3.4).To aid in correct reassembly, note the position of the throttle shaft lever key in relationship to the groove of the throttle shaft assembly.

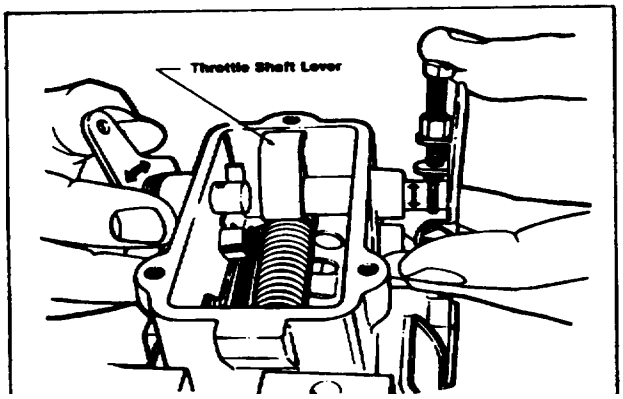


FIGURE 3.4

STEP 5 Loosen the guide stud (Figure 3.5a).

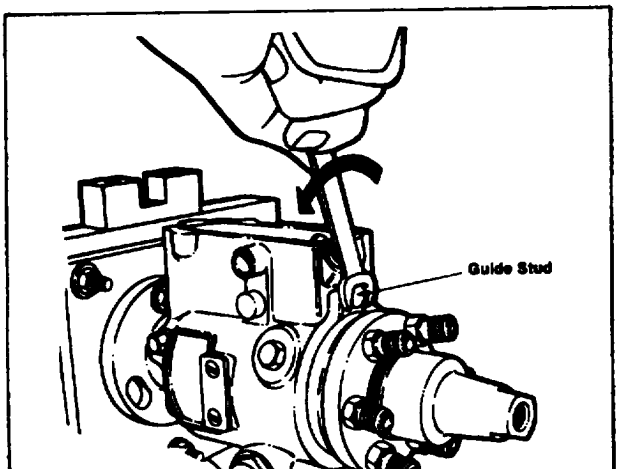


FIGURE 3.5a

While holding the governor spring firmly between the thumb and forefinger, withdraw guide stud and lift out governor spring and components (Figure 3.5b).

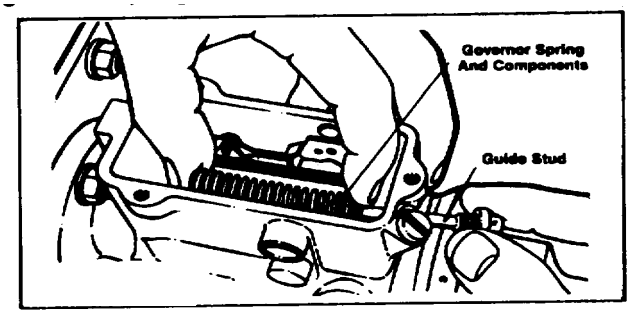


FIGURE 3.5B.

STEP 6 While depressing the metering valve assembly, raise the governor linkage hook assembly from the metering valve arm pin. While holding the governor arm forward, pull the linkage hook back slightly to disengage it from the governor arm (Figure 3.6). Place it over the side of the housing. Do not disengage the linkage spring.

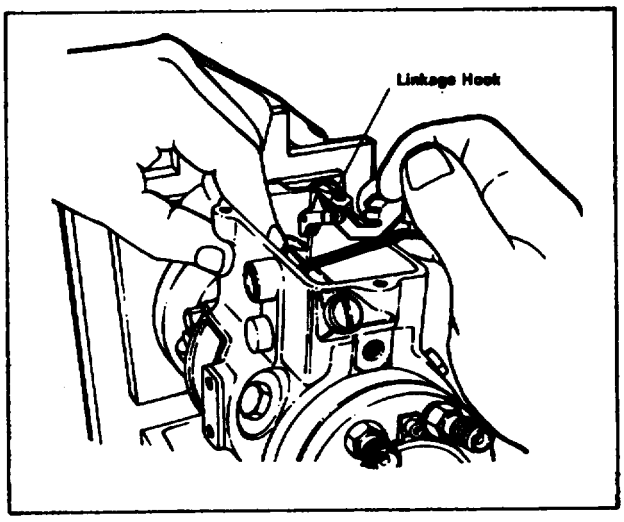


FIGURE 3.6.

STEP 7 Remove the metering valve assembly (Figure 3.7).

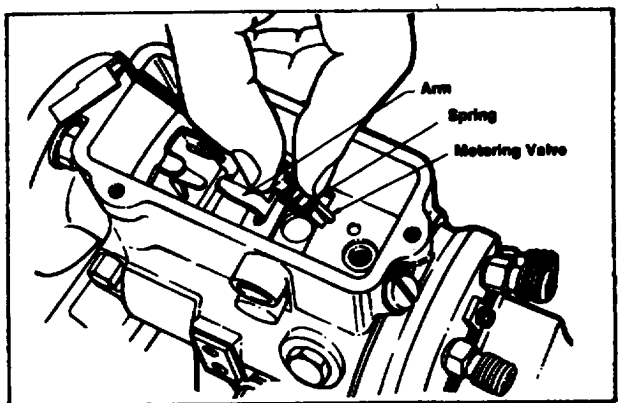


FIGURE 3.7

STEP 8 Loosen and remove the vent wire screw assembly using the socket head wrench (Figure 3.8).

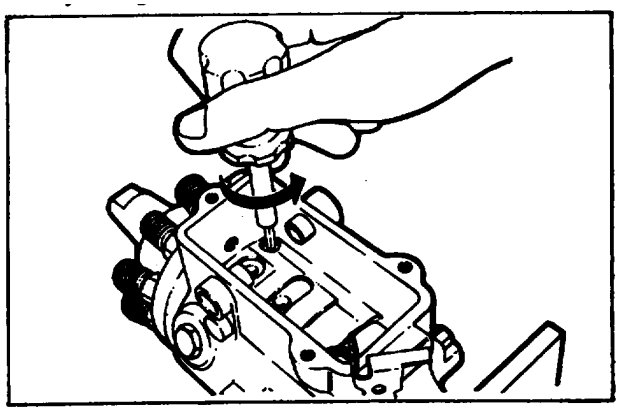


FIGURE 3.8

STEP 9 Loosen and remove transfer pump end cap locking screw, plate and seal from the hydraulic head (Figure 3.9).

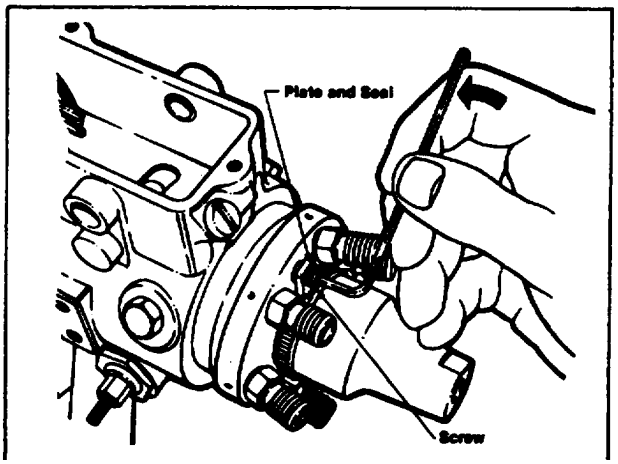


FIGURE 3.9.

STEP 10 Loosen and remove the transfer pump end cap assembly, using the end cap socket (Figures 3.1 Oa and 3.10b).

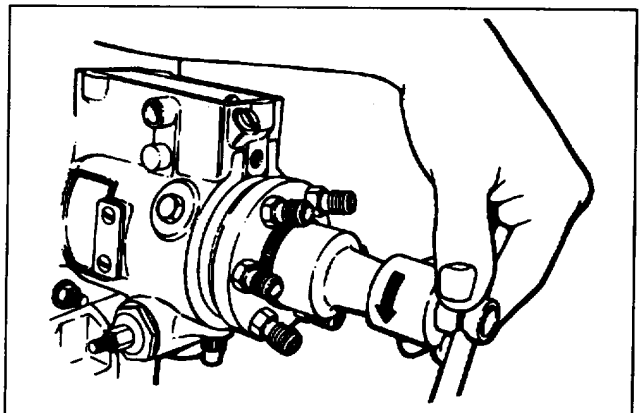


FIGURE 3.10a.

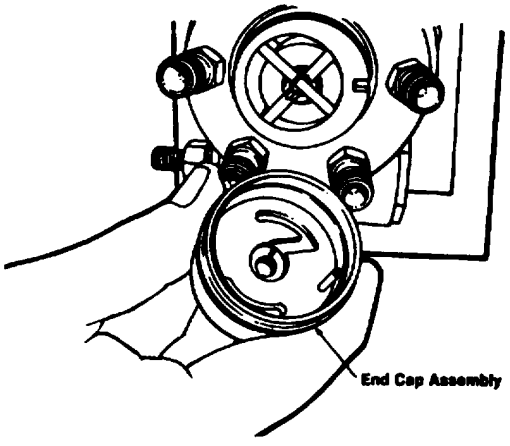


FIGURE 3.10b.

STEP 11 Disassemble the transfer pump regulator components (Figure 3.11). Remove the inlet filter screen seal. Remove the end plate adjusting plug assembly with socket head wrench. Shake the regulating spring and piston out of the regulating assembly. Using pressure regulating sleeve extractor, remove the regulating piston seal from the regulator.

NOTE

Some present regulators have metal piston seals and do not have to be removed.

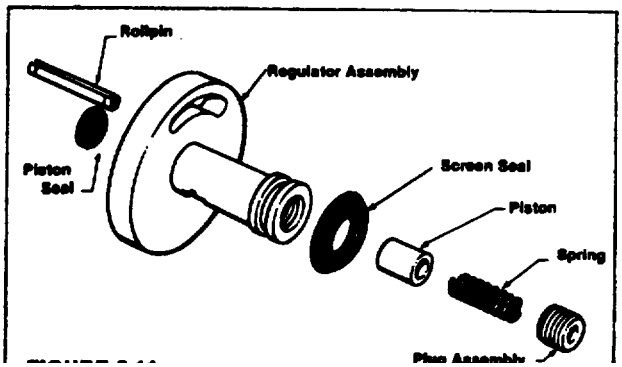


Figure 3.11.

STEP 12 Remove the transfer pump blades and liner (Figure 3.12).

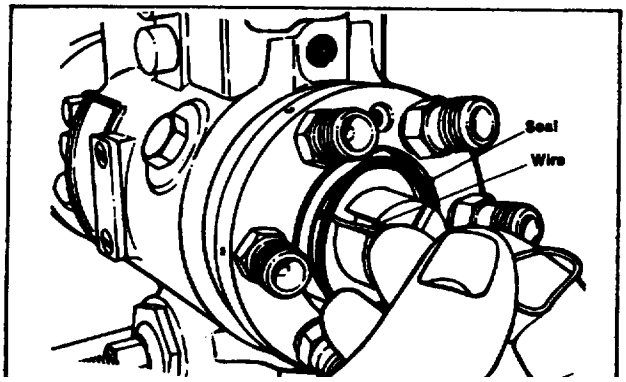


FIGURE 3.12.

STEP 13 Remove the transfer pump end cap seal (Figure 3.13).

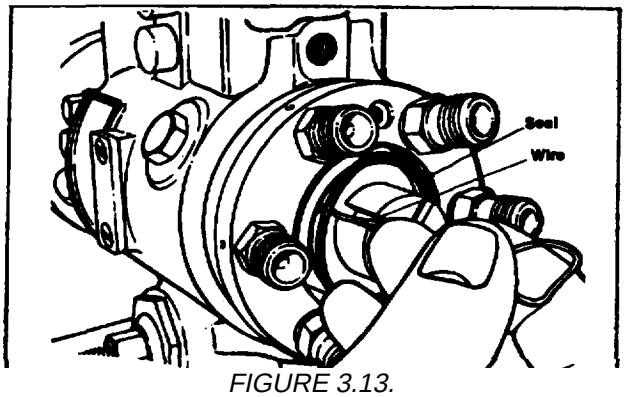


FIGURE 3.13.

STEP 14 Loosen the head locking screws and remove one screw (Figure 3.14).

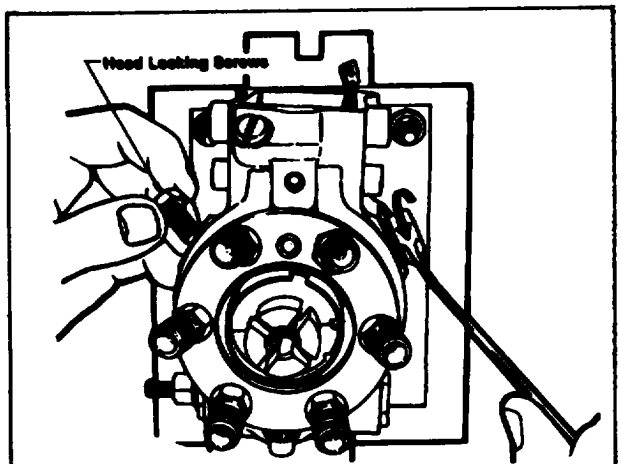


FIGURE 3.14.

STEP 15 Invert the pump and holding fixture in the vise. Loosen and remove the head locating screw using a 7/16" deep well socket (Figures 3.15a and 3.15b).

NOTE

On pumps without an advance system, remove the cam locating screw and proceed to STEP 19.

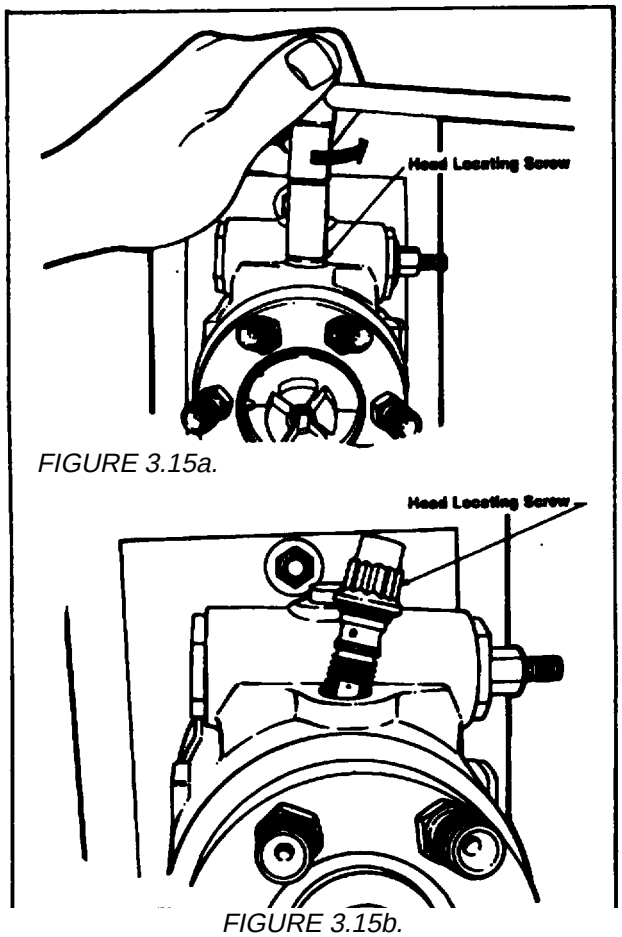


FIGURE 3.15a.

FIGURE 3.15b.

STEP 16 Tap the advance screw hole plug lightly with a hammer to loosen (Figure 3.16a).

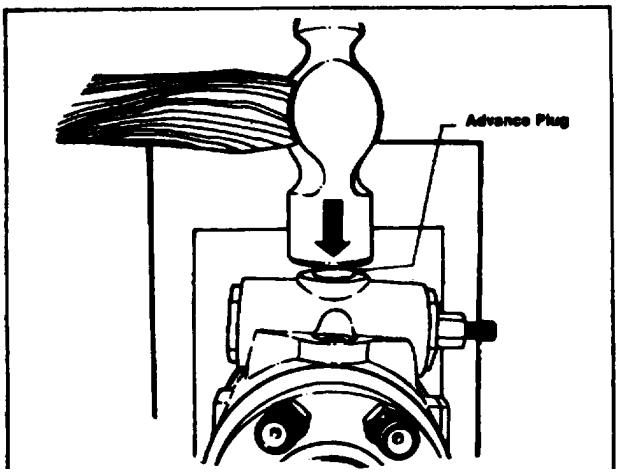


FIGURE 3.16a.

Loosen and remove the advance screw hole plug using plug wrench (Figures 3.16b and 3.16c).

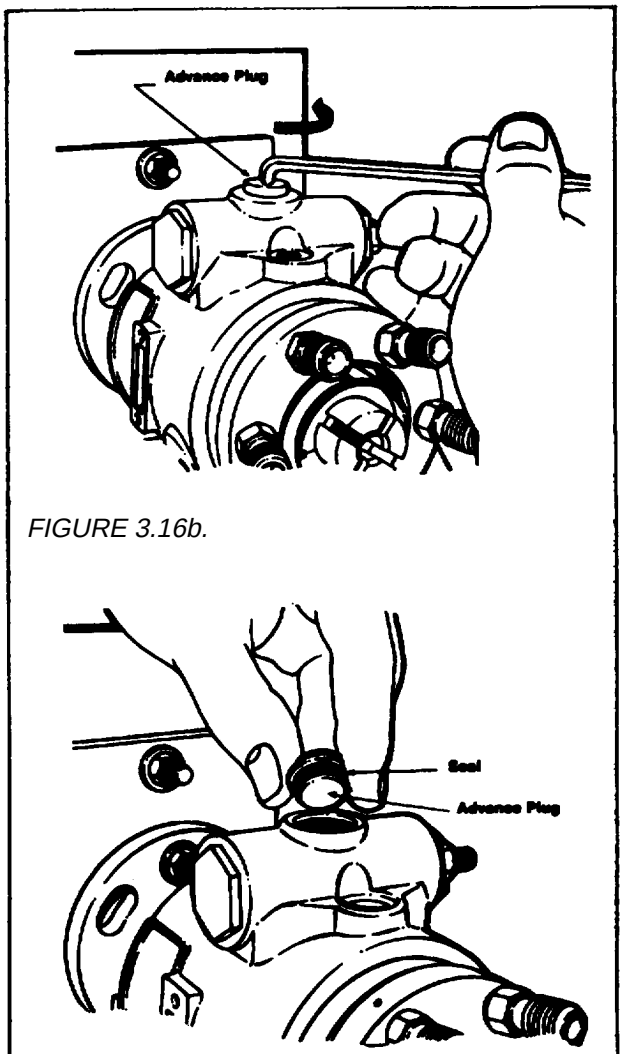


FIGURE 3.16b.

FIGURE 3.16c.

STEP 17 Using the plug wrench, loosen and remove the spring side advance piston hole plug (Figure 3.17a)

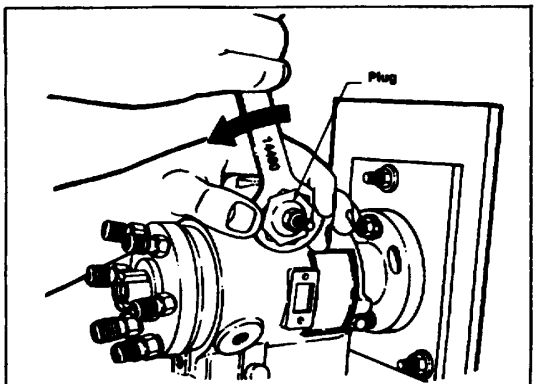


FIGURE 3.17a.

Remove the plug, piston and slide washer (Figure (Figure 3.17b).

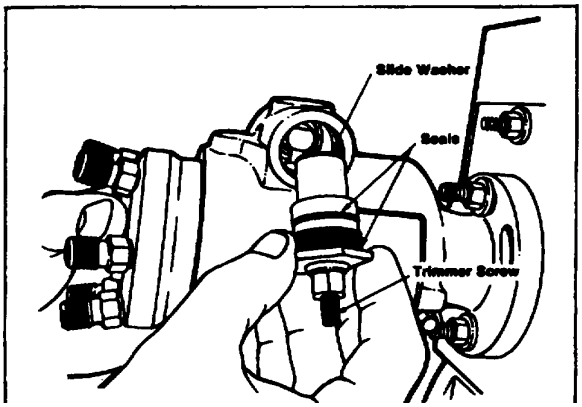


FIGURE 3.17b.

STEP 18 Loosen and remove the power side advance piston hole plug (Figure 3.18a).

Remove the plug, piston, spring and slide washer (Figure 3.18b).

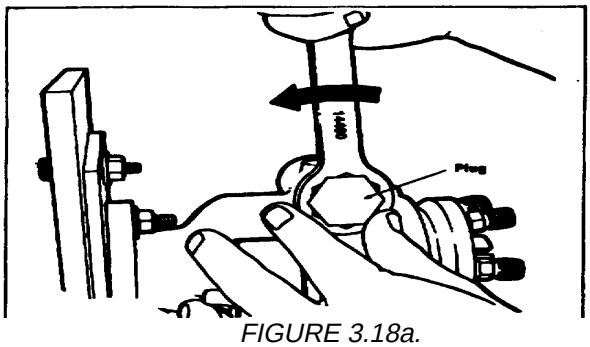


FIGURE 3.18a.

NOTE

The sides of the housing, just above the advance boss, bear a 'C' or 'CC' marking to denote pump rotation. The power side piston is located in the side of the housing which is marked with the letter indicating rotation.

Disassemble the auto advance components (Figure 3.18c). Invert spring side piston hole plug and let the piston, spring and guide fall into your hand.

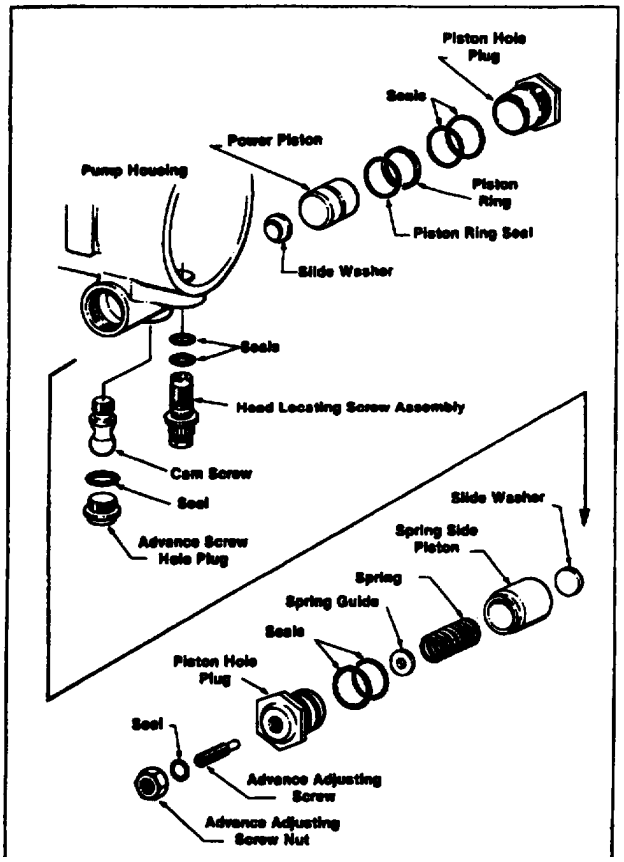


FIGURE 3.18c.

To remove the power piston from its plug, hold the plug in one hand and rap it sharply into the palm of your other hand (Figure 3.18d). The piston will slide out. Remove the piston ring and seal from the power piston.

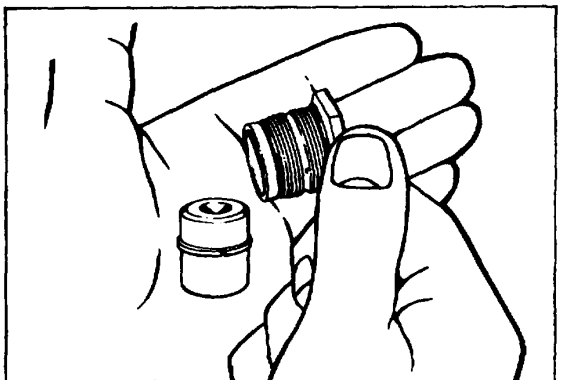


FIGURE 3.18d.

Assemble Bristol Socket Cam Advance Screw Wrench and Cam Advance Screw Bushing into the advance screw plug hole (Figure 3.18e).

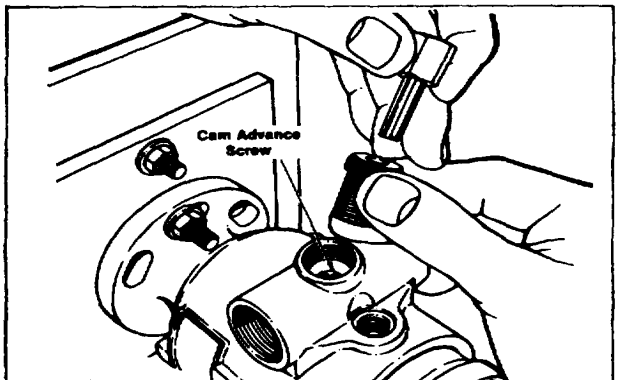


FIGURE 3.18e.

Loosen and remove the cam advance screw (Figure 3.18f).

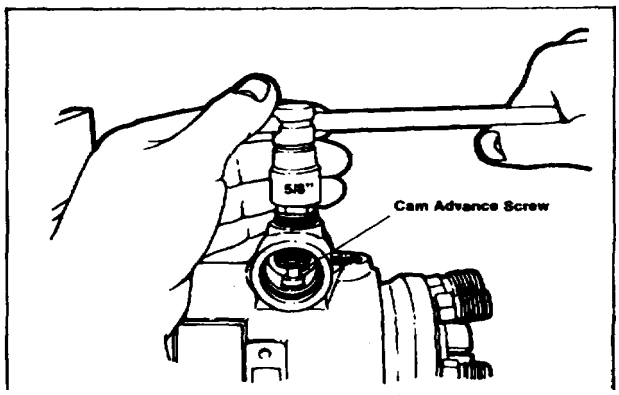


FIGURE 3.18f.

STEP 19 Return the pump and holding fixture as a unit to its initial position in the vise with the rear of the hydraulic head tilted slightly downward. Remove the remaining head locking screw and remove the hydraulic head assembly by grasping with both hands and withdrawing with a slight rotary motion (Figures 3.19a and 3.19b).

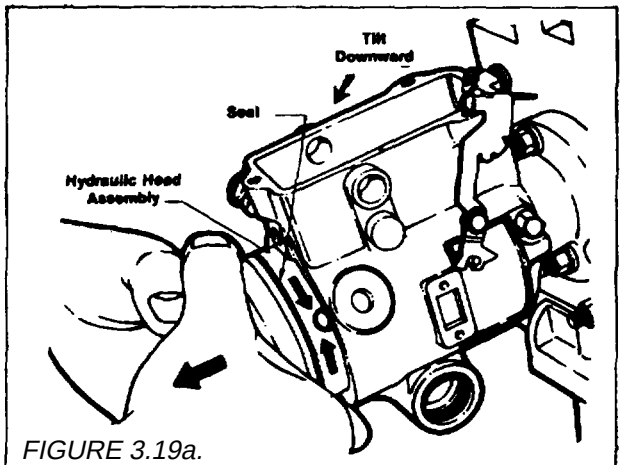


FIGURE 3.19a.

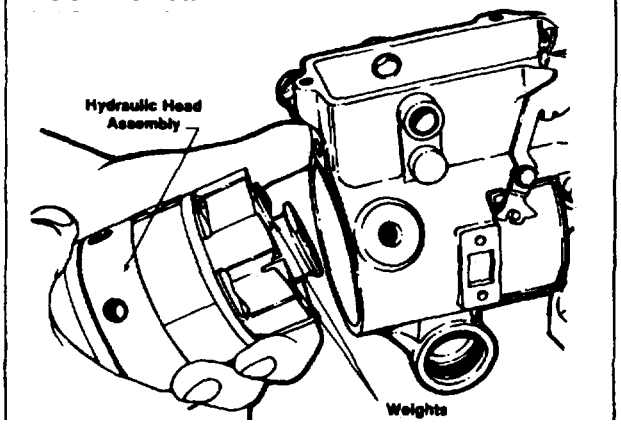


FIGURE 3.19b.

STEP 20 To disassemble the governor, invert the hydraulic head and let the weights, governor thrust sleeve and washer fall into your hand (Figure 3.20). Place the head and rotor assembly on top of pump holding fixture.

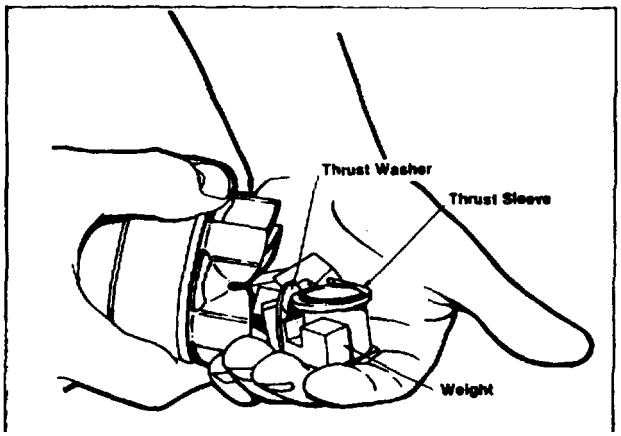


FIGURE 3.20.

STEP 21 Loosen and remove one pivot shaft retainer nut and seal (Figure 3.21 a).

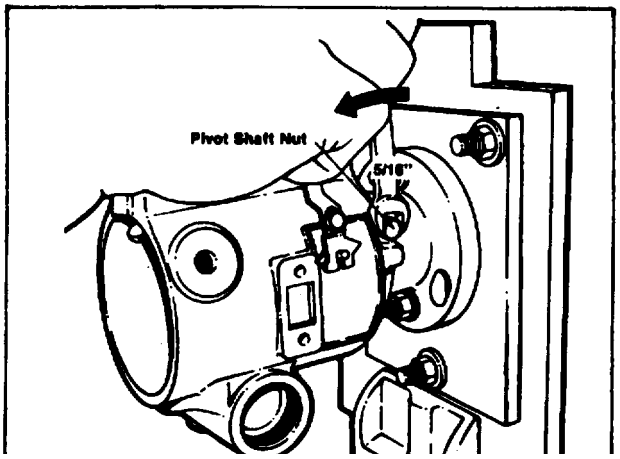


FIGURE 3.21a.

The governor arm, pivot shaft and linkage hook assembly may now be removed (Figure 3.21b).

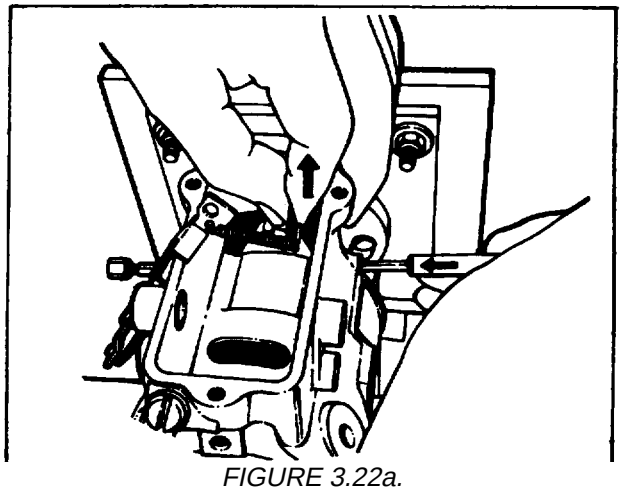


FIGURE 3.22a.

STEP 22 Lift the liner locating ring from the rotor retainers (Figure 3.22a).

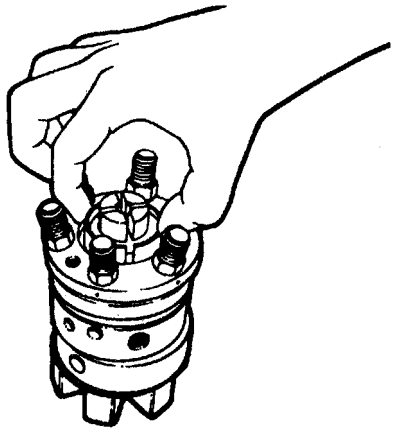


FIGURE 3.22a

Remove the rotor retainers (Figure 3.22b).

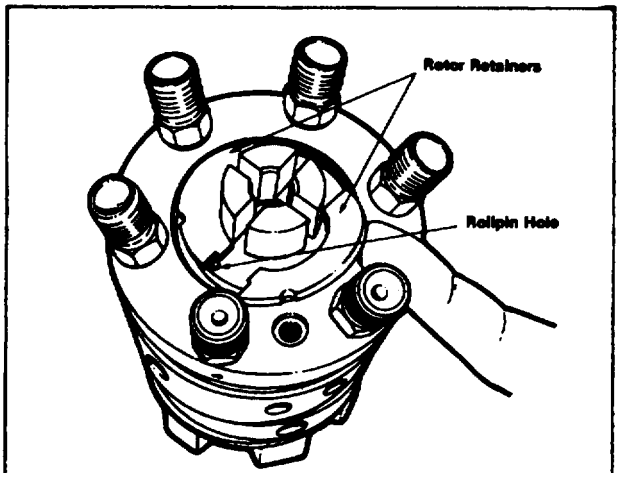


FIGURE 3.22b.

STEP 23 Turn the head and rotor assembly over and place it on the discharge fittings. Using the snap ring remove the snap ring holding the retainer assembly to the rotor (Figure 3.23a).

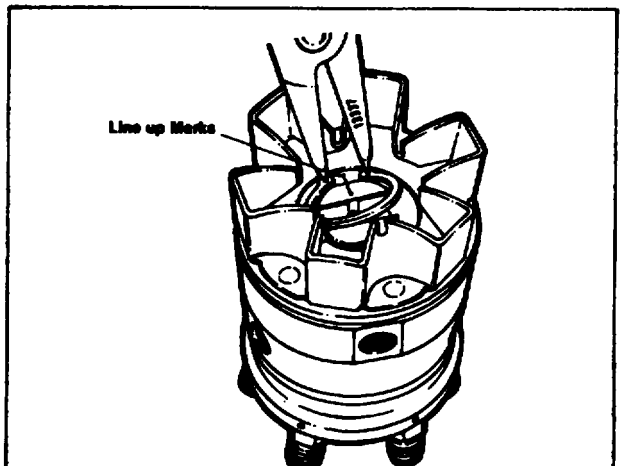


FIGURE 3.23a.

Remove the weight retainer assembly from the rotor (Figure 3.23b).

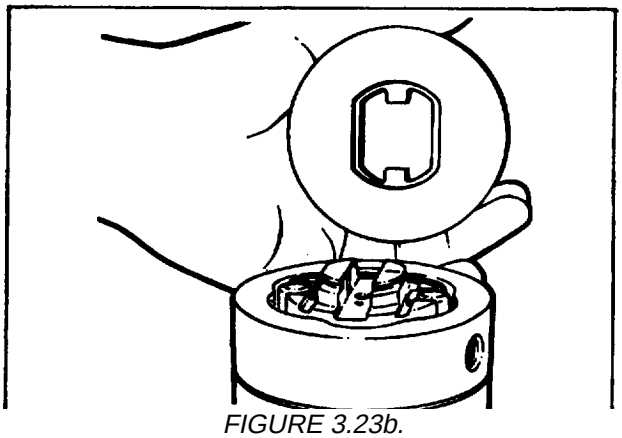


FIGURE 3.23b.

STEP 24 Remove the cam ring (Figure 3.24). 3.26b).

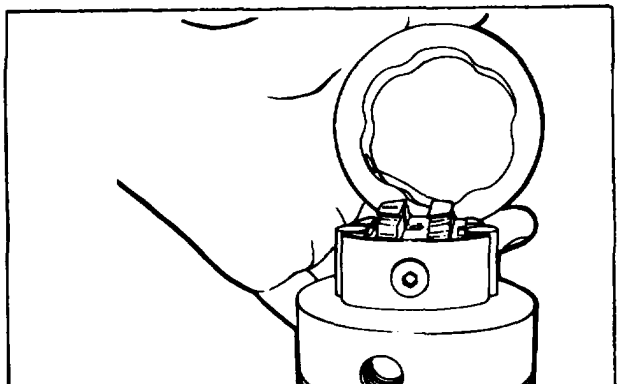


FIGURE 3.24.

STEP 25 Check and record the roller to roller dimension as instructed in Step 3 of reassembly (Figure 5.3). Compare this dimension with that called for on the pump specification (Figure 3.25).

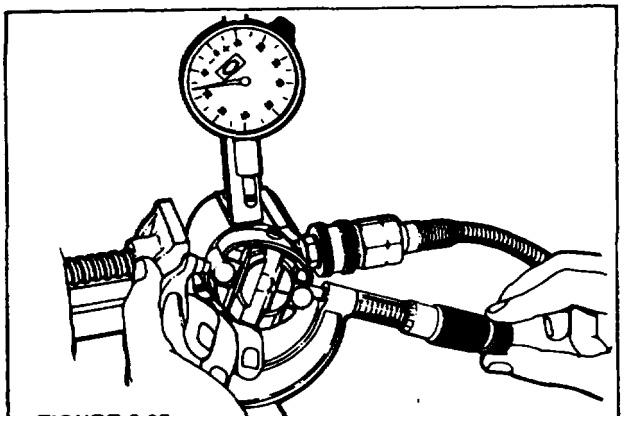


FIGURE 3.25.

STEP 26 Using socket head wrench, remove the leaf spring adjusting screw. Remove the leaf spring (Figure 3.26a). In some cases, a shim is used beneath the leaf spring to limit the maximum roller to roller dimension to .005" above the specification. If a shim is present, remove it at this time. Be sure to reinstall the shim during the reassembly.

Remove the shoes and rollers from the rotor (Figure 3.2b).

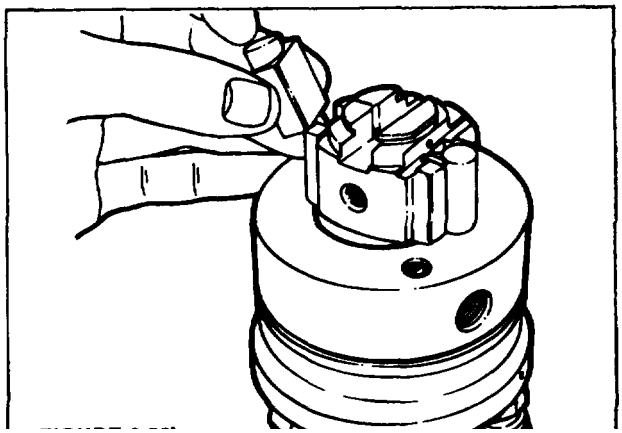


FIGURE 3.26b.

Use pressure regulating sleeve extractor to push the pumping plungers from their bore. Handle all parts carefully with clean hands wet with calibrating fluid (Figure 3.26c).

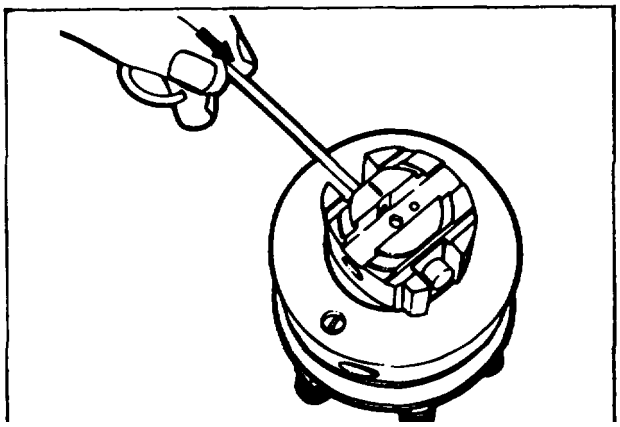


FIGURE 3.26c..

STEP 27 Lift the rotor from the head (Figure 3.27).

NOTE

Do not handle the precision ground surface of the rotor.

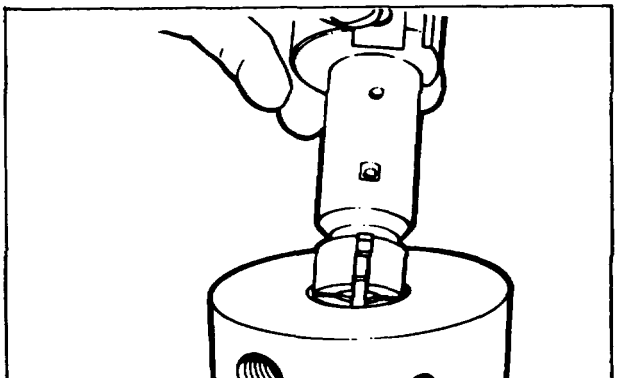
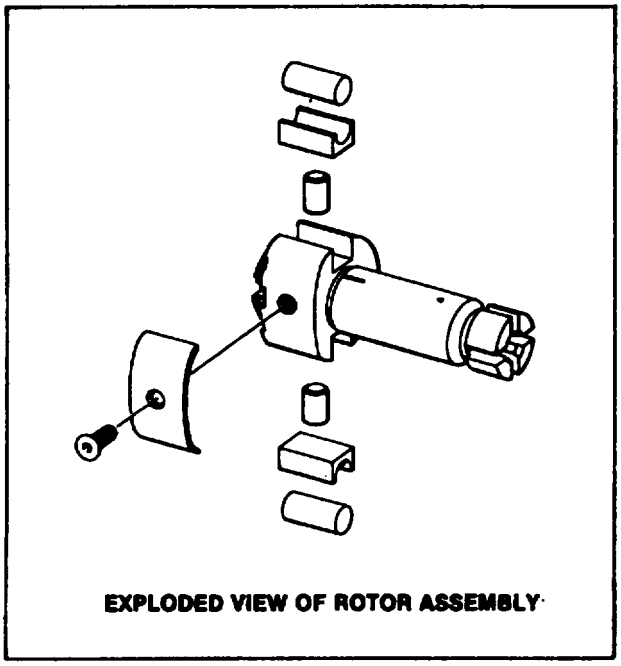


FIGURE 3.27.



STEP 28 Support the rotor in the rotor support tool and use a socket head wrench to remove the delivery valve stop screw. The delivery valve stop and spring may now be removed (Figure 3.28). Discard the delivery valve stop. If the delivery valve does not slide freely from its bore, use extractor to remove it.

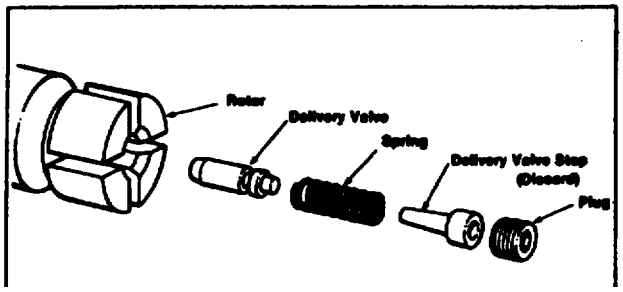


FIGURE 3.28.

STEP 29 To remove the arm from the metering valve, place the metering valve in one of the holes provided in the top of the fixture 19965. Use a soft-faced mallet to tap the arm off of the valve (Figure 3.29).

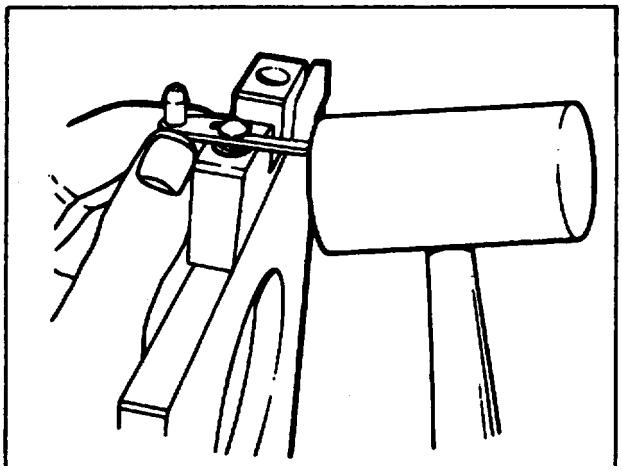


FIGURE 3.29.

NOTE

Older style mounting plates may not have holes drilled in the top for Inserting and removing the metering valve arm.

Modify the mounting plate by drilling two holes, 17/64' (6.75mm) and 21/64" (8.33mm) as shown.

SECTION 4
PARTS INSPECTION

A. GENERAL INSPECTION

Dirt is the greatest enemy of the fuel injection pump Keep the work area clean.

Parts must be washed in a suitable solvent and then placed in a clean pan containing fresh fuel or calibrating oil.

B. DETAILED INSPECTION

Examine all parts in accordance with instructions which follow: Discard flexible retaining ring, all O-rings, seals and gaskets. Replace with appropriate Roosa Master gasket kits. Examine all springs for fretting, wear, distortion or breakage. Clean and carefully check all bores, grooves and seal seats for damage or wear of any kind.

Replace damaged or worn parts as necessary.

PART GROUP	PART	Excessive Wear	Foreign Material or Rust	Nicks or Chipping	Scratches or Scores	Thread Damage	Cracks	Distortion	Freedom of Movement	SPECIFICALLY INSPECT:
Housing & Housing		X	X	X	X	X	X	X		See Supplementary Inspection 1
Drive	Drive Shaft	X	X	X	X	X	X	X		
Hydraulic Head & Rotor	Hydraulic Head	X	X	X	X	X	X			
	Vent Wire Assembly		X						X	See Supplementary Inspection 2
	Discharge Fittings	X	X	X	X	X	X			Inside diameter of discharge fittings, sealing area for wear, nick & scores
	Distributor Rotor		X	X	X	X	X	X	X	See Supplementary Inspection 3
	Delivery Valve	X	X	X	X		X		X	See Supplementary Inspection 4
	Plungers	X	X	X	X				X	See Supplementary Inspection 5
	Cam Rollers Shoes	X	X	X	X	X			X	See Supplementary Inspection 6
	Leaf Spring(s) & Screw(s)	X	X	X		X	X			See Supplementary Inspection 7
	Cam	X	X	X	X		X	X		See Supplementary Inspection 8
	Governor Weight Retainer	X	X	X	X	X				Where weights pivot in retainer rocket, also E ring area for wear, loose pins
	Governor Weights	X	X	X	X	X				See Supplementary Inspection 9
	Governor Thrust Washer	X	X	X	X	X	X			Contact areas for excessive wear
	Governor Thrust Sleeve	X	X	X	X	X				Points of contact with governor arm for excessive wear
Transfer Pump	End Cap	X	X	X	X					
	Inlet Screen	X	X	X						Screen and soldered area for breakage
	End Plate Adi. Plug		X			X				Tighten es in regulator, plugged orifice, loose plate
	Regulating Piston	X	X	X	X	X				
	Regulator	X	X	X	X	X	X			Inside diameter of regulator
	Blades	X	X	X	X	X				See Supplementary Inspection 10
	Liner wear	X	X	X	X					Inside diameter in high-pressure area for
	Rotor Retainers	X	X	X	X					
Governor	Pivot Shaft	X	X	X		X		X		Chipped or worn knife edge
	Arm	X	X	X			X	X	X	Points of contact with sleeve & pivot alt for extreme wear
	Metering Valve	X	X	X	X	X	X			Contact area body for excessive wear
	Metering Valve Arm	X	X	X	X		X	X		Inspect pin for wear or looseness
Linkage	Linkage Hook	X	X	X	X	X	X	X	X	Metering valve pin hole
Advance	Piston	X	X	X	X				X	
	Cam Advance Screw	X	X	X	X	X	X		X	
	Plugs	X	X	X	X	X	X	X	X	Bore for excessive wear
	Head Locating Screw		X	X	X	X	X			Orifice

C. SUPPLEMENTARY INSPECTION

1. Drive Shaft Measure the distance across the flats of the drive tang which must not be less than .305" (7.75mm). The shaft diameter in the drive shaft seal area must be free of nicks and scratches for the seals to function properly. Moderate shaft wear from the seal lips is normal (Figure 4.1).

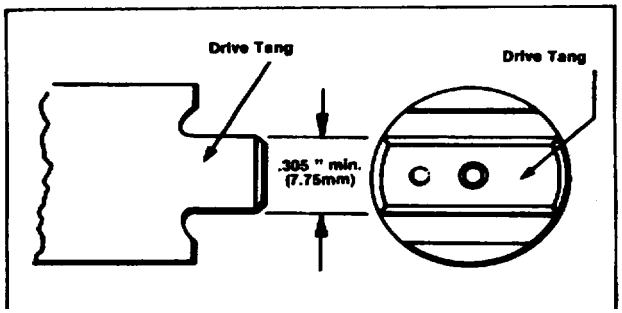


FIGURE 4.1.

2. Hydraulic Head Check the vent wire assembly in the hydraulic head for freedom of movement. If the wire is free, flush the head and blow out all passages with clean, dry air (Figure 4.2). If vent wire is stuck in screw assembly, remove and replace after a thorough cleaning of the assembly and hydraulic head passage.

CAUTION

Do not immerse this head in solvent for extended periods; sealant damage will result.

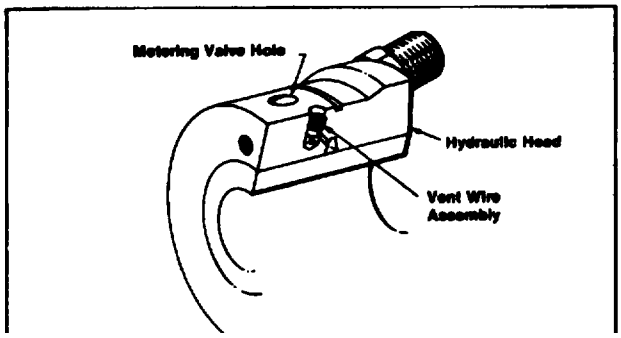


FIGURE 4.2.

3. Distributor Rotor Examine the radii contacted by the leaf spring and the tang slot for excessive wear. Check all slots, charging and discharge ports for chipping of edges or dirt, and the rotor shank for major scratches. Slight erosion on the edge of the discharge port is considered normal. If damage or excessive wear is apparent, the head and rotor must be replaced as a matched unit. Final check for excessive wear on the rotor should be performed on the test stand by checking for minimum cranking delivery.

4. Delivery Valve Inspect delivery valve retraction cuff for chipping or erosion of edges (Figure 4.4).

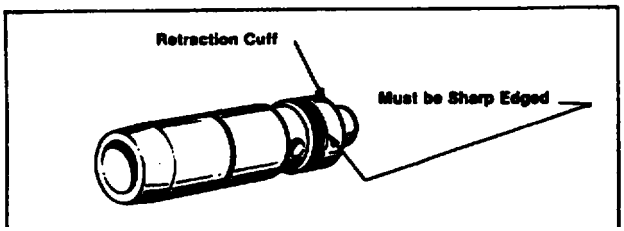


FIGURE 4.4.

5. Plungers While holding the rotor under clean oil, insert the plungers into their bore. With thumb and forefinger over the shoe slots, tilt from side to side several times to determine complete freedom of movement. Interchanging or reversing their initial positions may be necessary, as these are matched parts. If the plungers are sticking, but not visibly damaged, clean both plungers and bore with a soft brush and a solvent such as lacquer thinner or acetone (Do not force plungers into their bore and do not handle rotor shank.) (Figure 4.5).

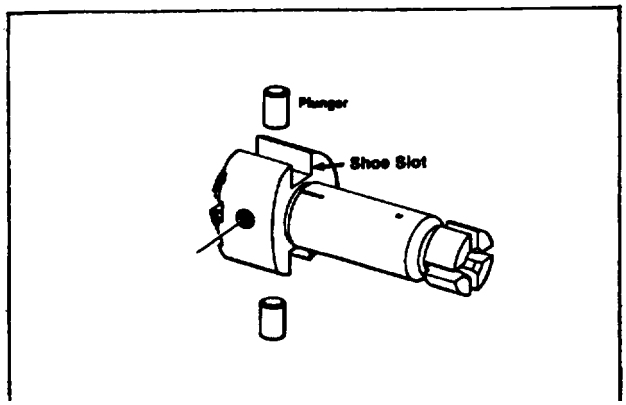


FIGURE 4.5.

6. Cam Rollers and Shoes Check each roller in its shoe for freedom of rotation. Inspect the top edge of each shoe, where retained by the leaf spring, for chipping or excessive wear. Inspect roller and shoe for abrasive wear patterns as illustrated (Figure 4.6).

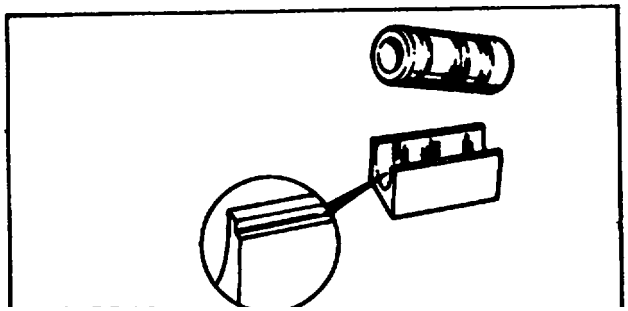


FIGURE 4.6.

7. Leaf Spring and Screw Check for excessive wear at points where the spring contacts the radii on the rotor and along the steps that retain the roller shoes (Figure 4.7). Check the adjusting screw for tightness in the rotor.

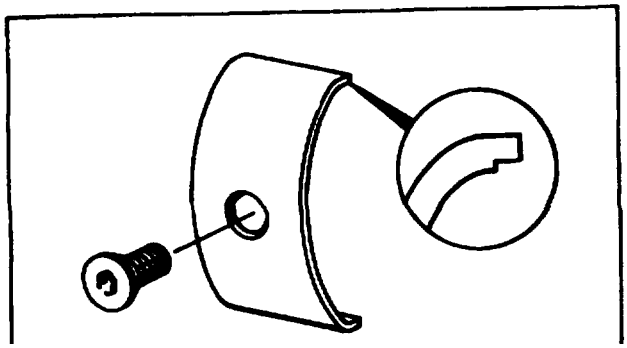


FIGURE 4.7.

8. Cam Since only the working portions of the lobes on the inside diameter are ground, any tool marks between lobes should not be considered as damage. The mottled appearance of the cam is from heat treatment rather than from operation. Carefully inspect the cam lobes and edges of all flat surfaces. If there is evidence of spalling or flaking out, replace with a new cam (Figure 4.8).

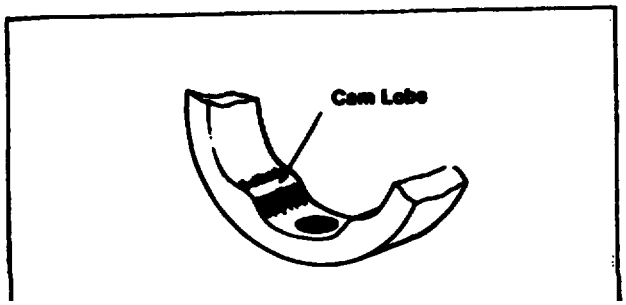


FIGURE 4.8.

9. Governor Weights Check pivot points (heel and toe) of all weights for excessive wear (Figure 4.9).

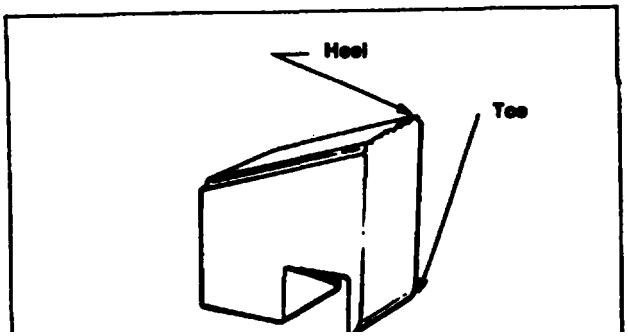


FIGURE 4.9.

10. Transfer Pump Blade Inspect with the utmost care. Check for chipping on any of the edges, including spring bore edges, pitting, imbedded foreign particles or scoring on the rounded edges. Determine blade wear by measuring the length (0.538" min. [13.67mmD. Inspect flat surfaces visually for deep scores (Figure 4.10). f any discrepancies are noted, replace both blade sets and springs.

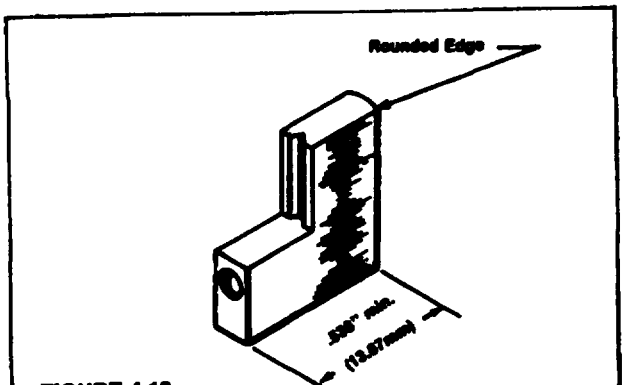


FIGURE 4.10.

SECTION 5 REASSEMBLY

STEP 1 Rinse rotor thoroughly in clean fuel or calibrating oil. Place the rotor on rotor support and secure rotor support in vise. Install the delivery valve to its bore using extractor. Make sure it slides freely in its bore.

NOTE

Do not mistake slight interference of the retractor collet in the bore for delivery valve sticking. If the valve is not secured straight and tight in the retractor collet, the collet diameter can drag in the rotor bore.

Install delivery valve spring and a new delivery valve stop to the rotor bore (Figure 5.1). Installation of a used stop can result in leakage and low output at cranking speeds. Start the delivery valve retaining screw into the bore using the hex end of the delivery valve Extractor. Tighten the screw to the specified torque.

CAUTION

Excessive tightening of this screw may cause seizure of the hydraulic head and rotor assembly. Insufficient torque may cause leaking and hard starting.

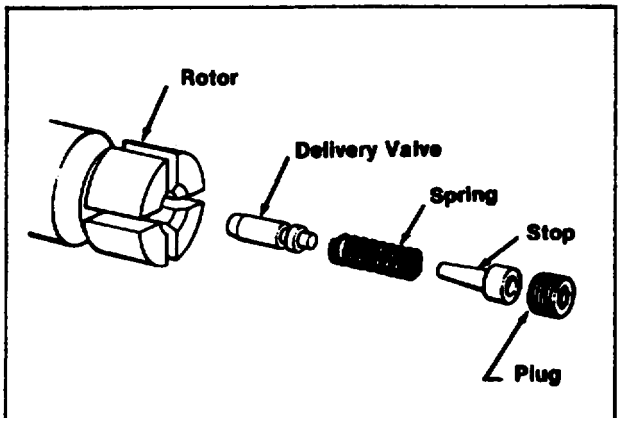


FIGURE 5.1.

DELIVERY VALVE REPLACEMENT

Delivery valves of various retraction values are used for different applications. Correct part numbers are found on individual pump specifications. The letters 'OV" etched on the base of the rotor indicate a .001' oversize delivery valve bore. A rotor so marked must use a .001" oversize delivery valve. Part numbers for both standard and oversize valves are listed on individual pump specifications. The oversize valve is also identified by blackening on both ends and in the groove on the delivery valve shank.

STEP 2 Remove the rotor from the holding fixture and submerge it in clean calibrating oil. Install the pumping plungers and check them for freedom of movement. Assemble the leaf spring, leaf spring adjusting screw and shim (if used) to the rotor (Figure 5.2).

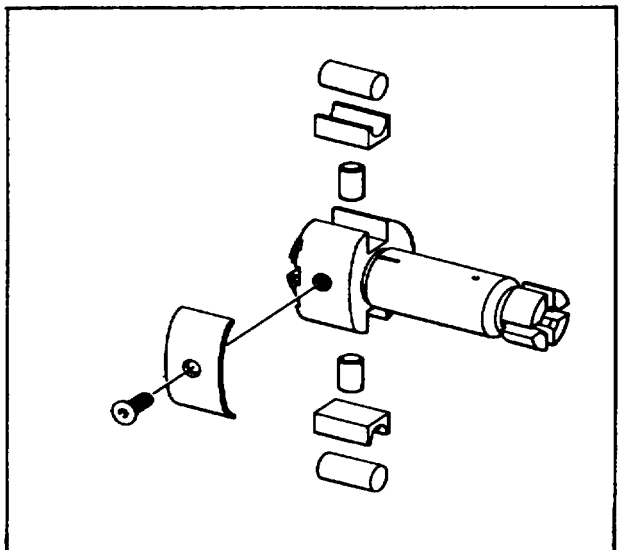


FIGURE 5.2.

PLUNGER REPLACEMENT

Since the plungers are positioned centrally in the bore during operation and their travel is extremely short, wear of plungers is negligible. Replacement, however, may be made in instances where rust or damage in handling has occurred. Plungers of any given nominal diameter are graded in four select fit sizes: A, B, C, and D. The rotor is etched with the letter indicating bore size. This mark is found on the base of the rotor. If plunger replacement is required, check the size designation on the rotor and use the plunger of corresponding part number as indicated on individual specifications. For example: A .330" diameter plunger bears basic part No. 11076 and the graded sizes, A through D, bear part No. 11077 through 11080, respectively. The replacement plungers for a .330' diameter plunger pump with a rotor marked C" would be part No. 11079. Always refer to correct individual specifications for part numbers.

NOTE

A limited number of pumps will have a "-2" etched on the rotor following the letter grading code. This mark indicates a .002" (.05rm) oversize plunger bore. Replacement should be ordered according to the oversize plunger group shown on individual specifications.

STEP 3 Install roller to roller dimension setting fixture in a vise (clamping on the flat) so that the air inlet hole is not covered by the vise. Assemble a 1.4" 18 N.PT. fitting to the air inlet of the fixture. This fitting should be adapted to a supply of clean, filtered, compressed air, regulated to a pressure between 40 and 100 p.s.i. Handle the rotor carefully, holding the rollers and shoes in their slots. Install the rotor assembly to the fixture on the air inlet side. Using a micrometer, measure the roller-to-roller dimension (Figure 5.3) (distance between the outer surfaces of the opposed cam rollers) and compare this with the specification. To set the roller-to roller dimension to the pump specification, turn the leaf spring adjusting screw inward (clockwise) to increase and outward (counterclockwise) to reduce the roller to-roller dimension.

NOTE

The roller-to-roller setting provides a completely accurate maximum fuel adjustment and it should not differ from that shown in the applicable specification.

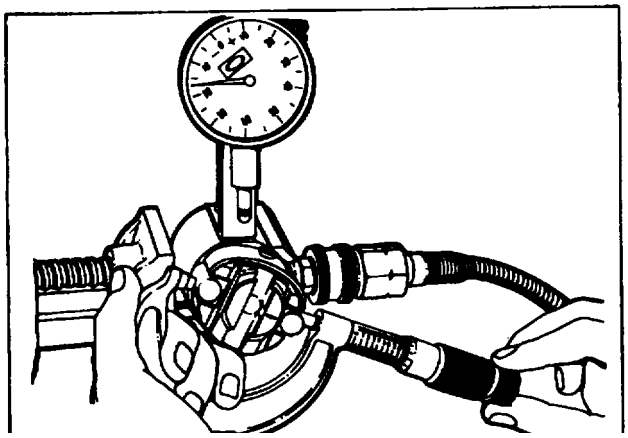


FIGURE 5.3.

A centrality check is now required. Refer to specifications page for allowable tolerances and check as follows:

a. After setting the roller-to-roller dimension to the amount indicated on the specification, rotate the rotor until one roller is aligned with the dial indicator plunger. Slide the indicator inward until the plunger depresses it at least .010" (.25mm). Lock the indicator retaining screw. 'Zero" the indicator on high point of roller by rotating knurled dial.

b. Rotate rotor (either direction) until the other roller depresses the dial indicator plunger.

c. If roller centrality is beyond specified tolerance (see injection pump specification), roller and/or shoes can be interchanged. Recheck centrality after each change and be sure to recheck the roller-to-roller dimension.

STEP 4 Rinse the hydraulic head assembly in clean calibrating oil. Remove the rotor assembly from the fixture, taking care that the shoes and rollers do not leave their respective slots and rinse in oil. Carefully, insert the rotor assembly into the hydraulic head (Figure 5.4).

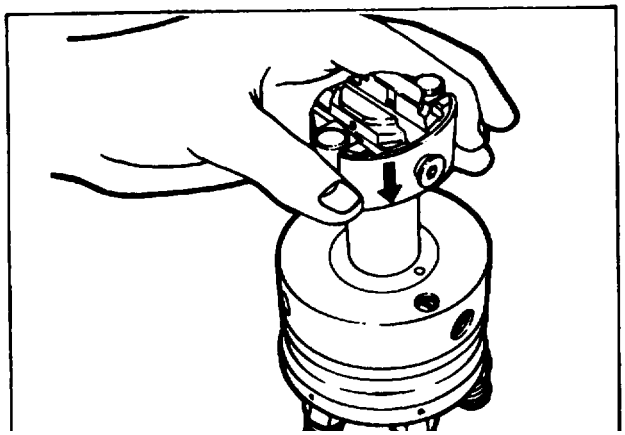


FIGURE 5.4.

STEP 5 Place the cam ring onto the head and rotor assembly with directional arrow indicating the direction of rotation of the pump (Figure 5.5) (Pump rotation is expressed as viewed from the drive end.). If the cam ring is installed incorrectly, the pump will not be in time with the engine.

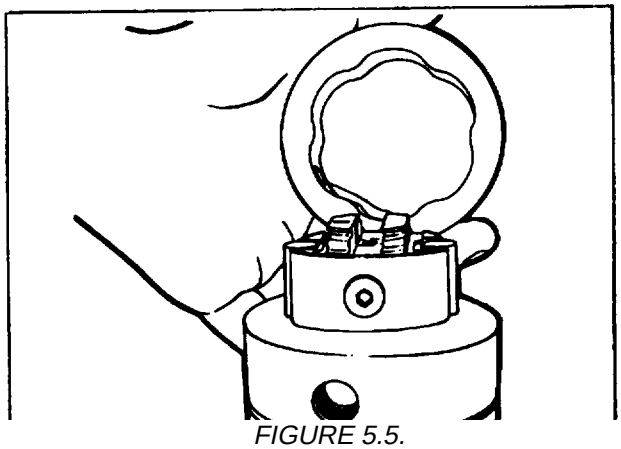


FIGURE 5.5.

STEP 6 Place the weight retainer assembly on the rotor (Figure 5.6a).

Make sure the assembly marks on the rotor and the retainer line up with each other. Assemble the snap ring to its groove (Figure 5.6b).

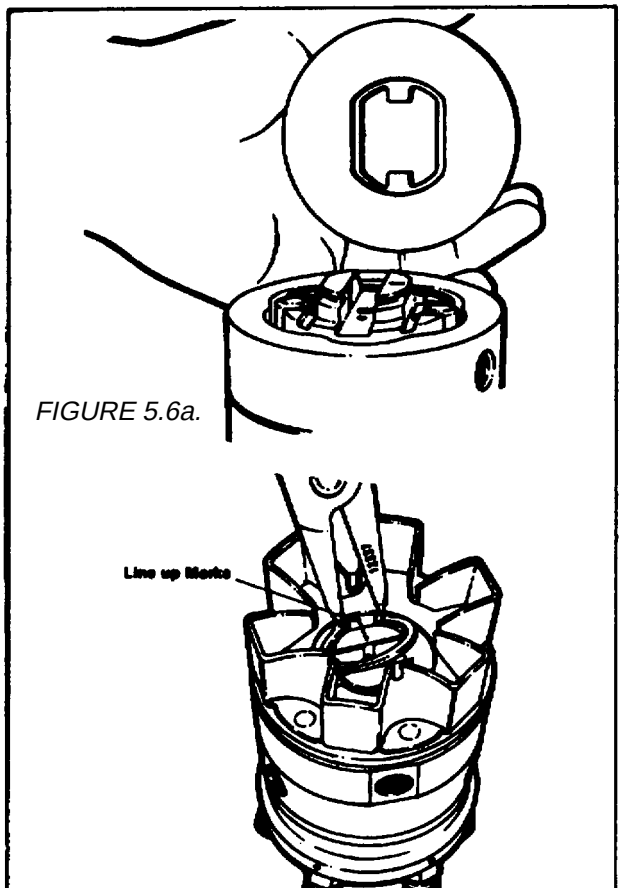


FIGURE 5.6a.

FIGURE 5.7a

STEP 7 While holding the assembly carefully so the rotor will not fall out, invert the entire unit so it rests on the weight retainer. Assemble the rotor retainers to the head and rotor with the cutout portions meeting over the rollpin hole in the hydraulic head (Figure 5.7a).

Place the liner locating ring over the rotor retainers and bottom it against the head (Figure 5.7b). Position the split in the ring 90° from the split in the retainers.

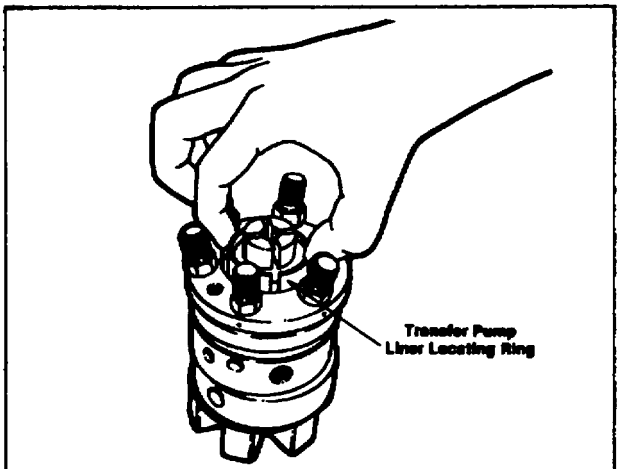


FIGURE 5.7b.

STEP 8 Install the new transfer pump end cap seal into the hydraulic head (Figure 5.8). This seal has an oval cross section and can be identified by rolling it between the fingers. Be sure to push the seal all the way into its groove.

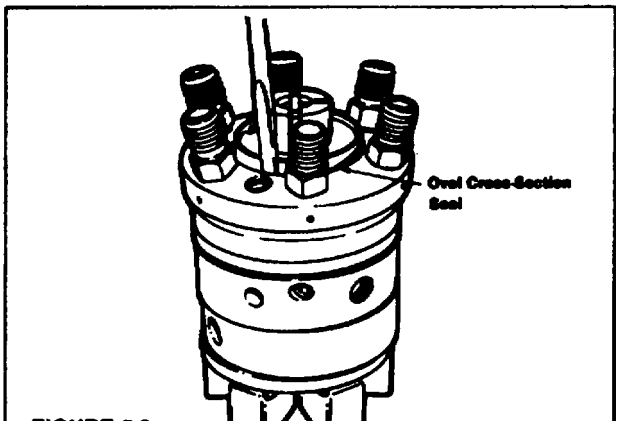


FIGURE 5.8.

STEP 9 Insert the transfer pump liner so that the slot is in line with the hole which the regulator assembly rollpin enters (Figure 5.9a).

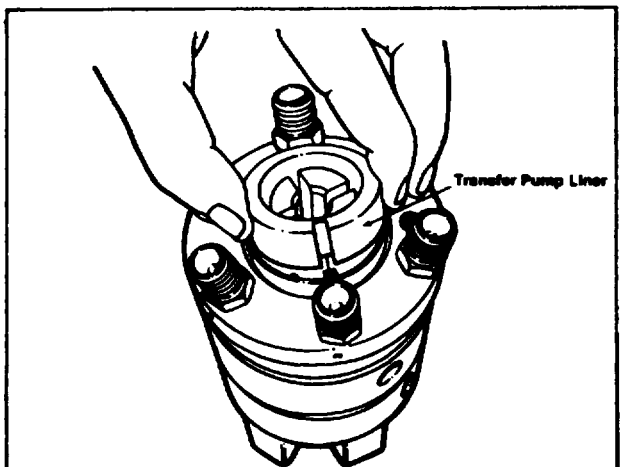


FIGURE 5.9a.

Assemble springs to transfer pump blade halves and install the blades in their slots in the rotor (Figure 5.9b). The blade springs must be fully compressed as they are installed and care should be taken not to cock the blades during installation, as the sharp edge of the liner can score the blade ends.

NOTE

A number of rotors have oversized blade slots (.001 in. [.0254mm] wider than normal). Oversized blade should always be tried first when assembling a pump. If oversized blades fit any of the slots, they should be used in those slots. It is permissible to use both oversize and standard size blades in the same rotor.

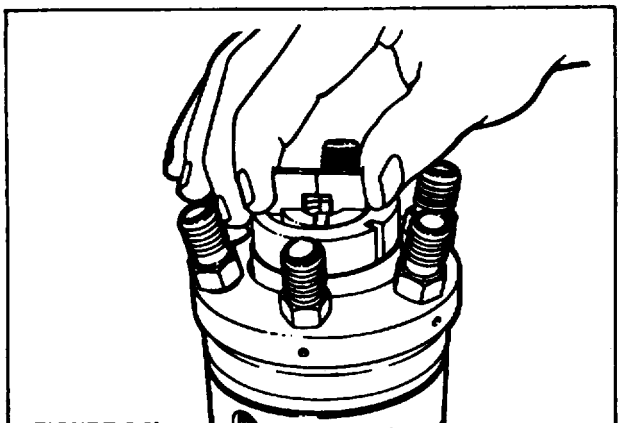


FIGURE 5.9b.

STEP 10 Assemble the transfer pump regulator components (Figure 5.10a). Install the inlet filter screen seal on the regulator. Using regulating sleeve adapter, place the regulating piston seal in the groove of the regulator. Do not roll the seal over when assembling.

NOTE

Some DB2 models no longer use this seal, but instead have a bushing pressed into the regulator in its place. This bushing should not be removed and, when present, no seal is required.

Install the piston to the regulator with the hollow end facing the spring or the threaded end of the bore. Install the regulating spring and adjusting plug. This plug contains the viscosity compensating orifice and should be installed so that the top of the screw is flush with the end of the regulator assembly. Using regulating sleeve adapter, check the regulating piston for freedom of movement in its bore.

CAUTION

Turn the adjusting plug in until it is flush with end of regulator so damage to the pump will not result from excessive transfer pump pressure when the pump is operated.

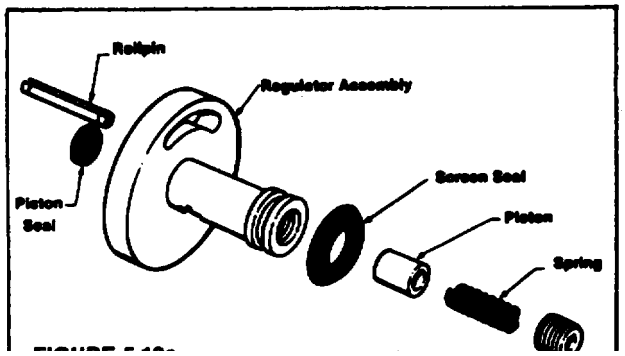


FIGURE 5.10a.

Assemble the regulator to the liner (Figure 5.10b). Check that the liner locating pin is in the correct hole in the regulator for proper pump rotation. On the face of the regulator "C" or "CC" is stamped for clockwise or counterclockwise pump rotation.

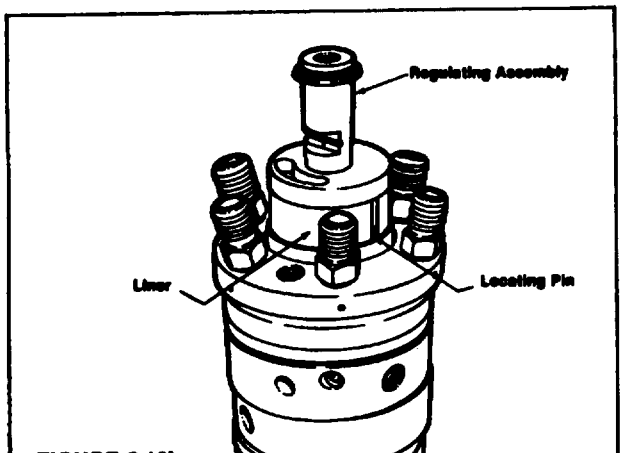


FIGURE 5.10a.

Assemble the filter screen to the pressure plate and install the screen retaining ring (Figure 5.10c).

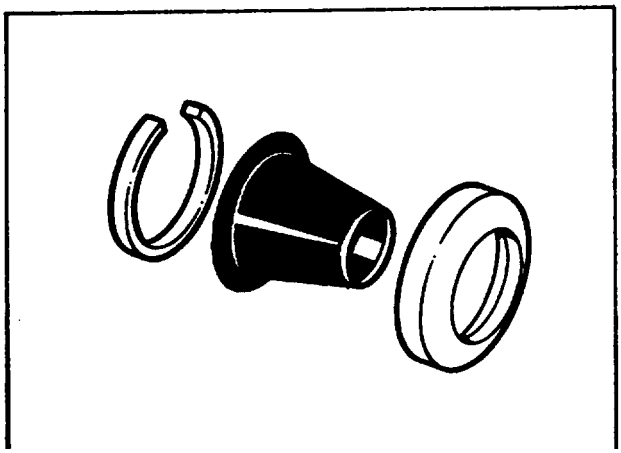


FIGURE 5.10c.

Install the assembled pressure plate and screen onto the transfer pump regulator assembly (Figure 5.10Od).

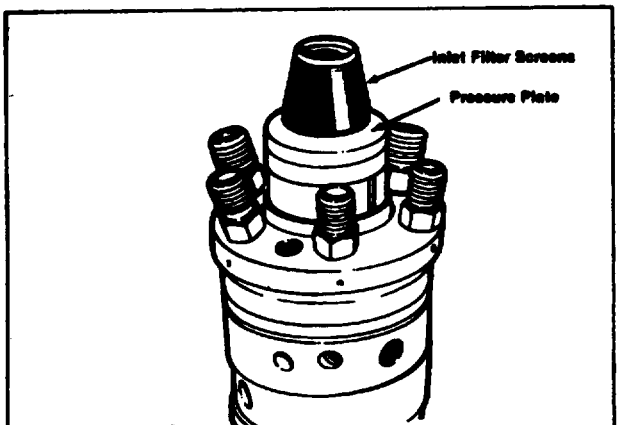


FIGURE 5.10d.

Coat the beveled surface of the pressure plate and the threads on the outside diameter of the end cap with clean grease.

Install the transfer pump end cap and thread into the hydraulic head by applying a slight pressure on top of the end cap. Rotate the cap counterclockwise until a slight “click" is heard, now turn the cap clockwise by hand until tight (Figure 5.10e).

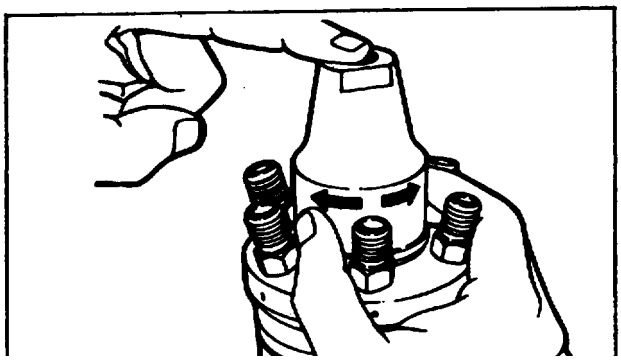


FIGURE 5.10e.

STEP 11 Place the governor arm in position in the housing (Figure 5.11a).

NOTE

Insert the pivot shaft, with the knife edge mating with the groove in the governor arm.

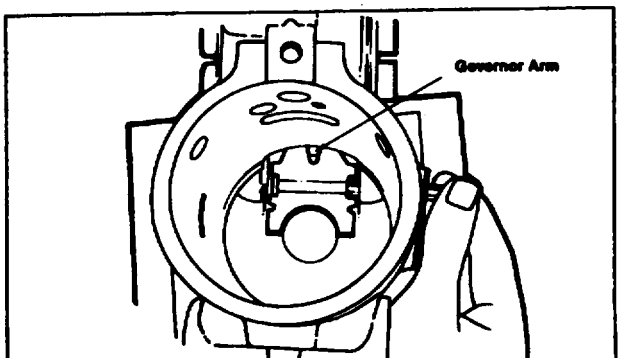


FIGURE 5.11a.

Assemble pivot shaft seals and nuts to the shaft and tighten both nuts successively to specified torque (Figure 5.11b).

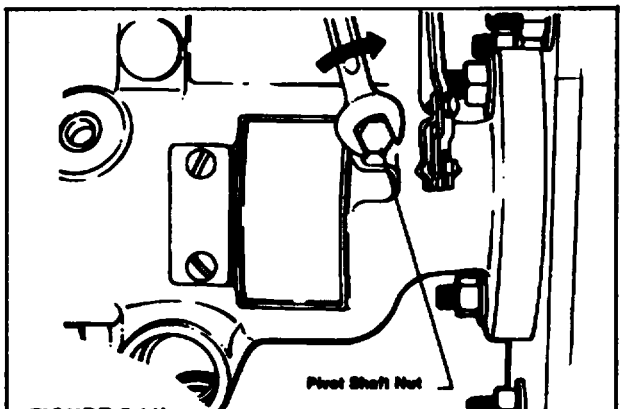


FIGURE 5.11b.

STEP 12 Install the governor weights into the governor weight retainer as shown in Figure 5.12a.

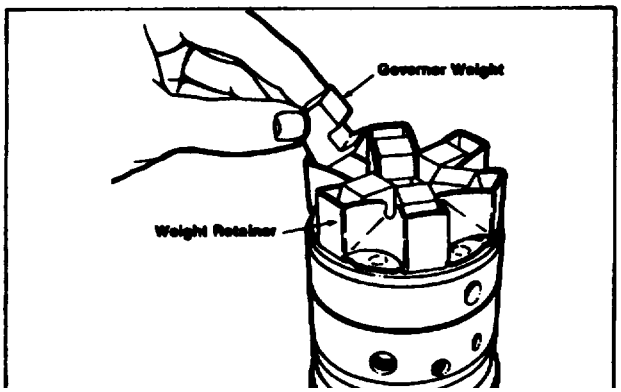


FIGURE 5.12a.

Insert the governor thrust washer and thrust sleeve into the lower slots of the governor weights by tilting the weights outward slightly. The two deep grooves of the thrust sleeve should face upward as installed (Figure 5.12b). Sight across the tops to the assembled weights. They should all be level and collapsed against the thrust sleeve.

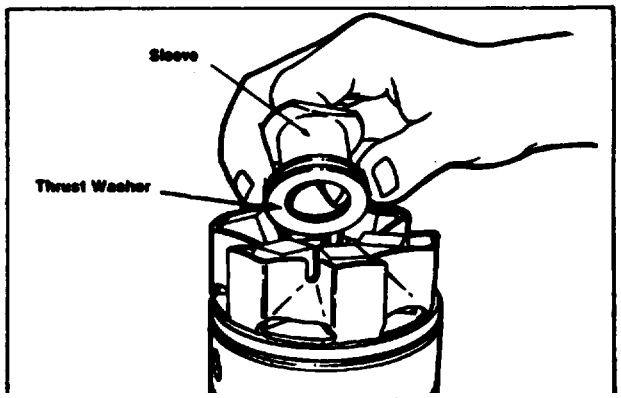


FIGURE 5.12b.

STEP 13 The hydraulic head and rotor assembly, including the transfer pump assembly, cam ring and governor assembly, are now ready to be put into the housing. Install a new seal on the hydraulic head after first greasing it slightly. Apply a light film of clean grease around the inside edge of the housing and tilt the housing slightly downward at the rear to aid in assembly. Rotate the cam ring so that the unthreaded hole is in line with the metering valve bore. This will ensure proper position of the cam ring. Grasp the hydraulic head firmly in both hands and insert it into the housing bore with a slight rotary motion (Figures 5.13a and 5.13b). Do not force. If the assembly should jam during insertion, withdraw and start over.

Exercise care not to insert the head assembly too far into the housing. Pushing the head in too far will damage the seal on the hydraulic head and result in leakage.

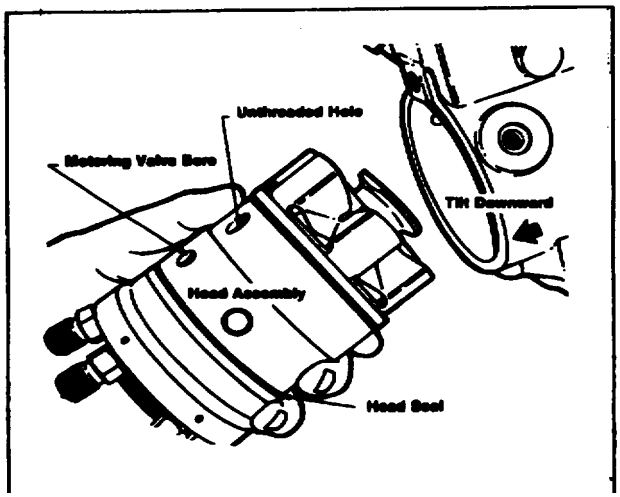


FIGURE 5.13a.

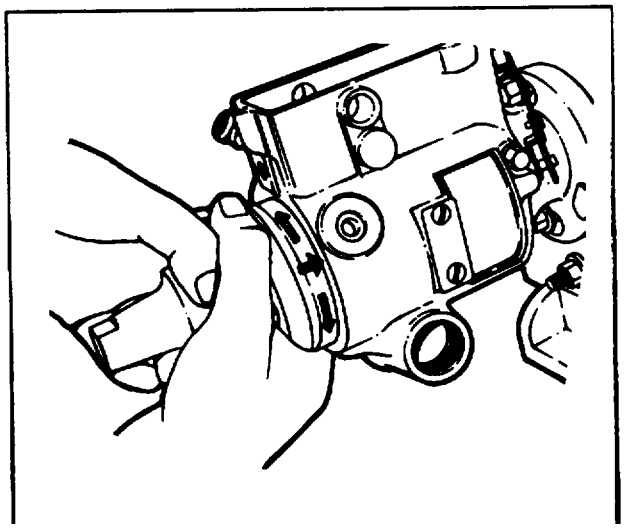


FIGURE 5.13b.

STEP 14 Rotate the head assembly until the head locking screw holes line up with their corresponding holes in the housing. Insert the two head locking screws finger tight (Figure 5.14). Do not tighten with a wrench until STEP 27.

To prevent the governor weights from becoming dislodged from the retainer, a drive shaft should now be installed in the pump. When the pump is fully assembled, the throttle should be wired in the wide open throttle (WOT) position and the shaft may then be removed.

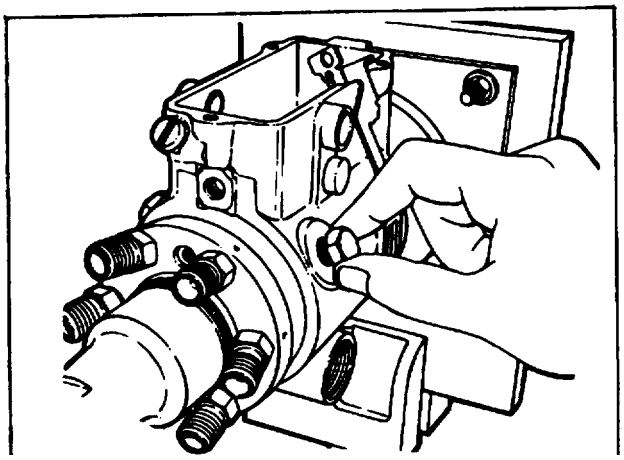


FIGURE 5.14.

STEP 15 Install the vent wire screw assembly (Figure 5.15). Tighten to 25-30 in.-lbs. (3-3.5 Nom).

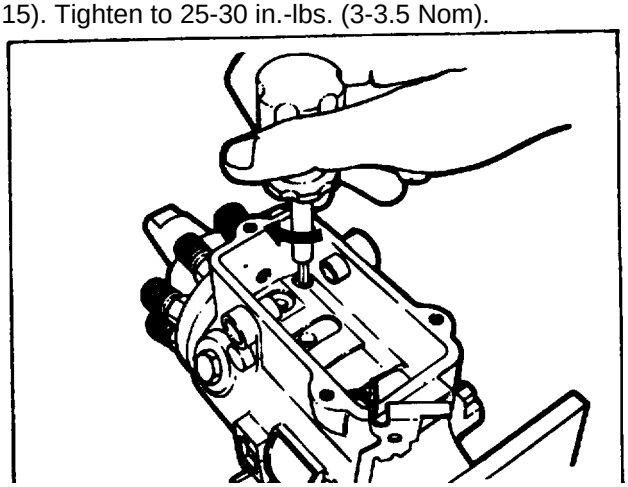


FIGURE 5.15.

STEP 16 Assemble the metering valve arm, shim and spring to the metering valve (Figure 5.16a). Exercise care not to distort any of the components.

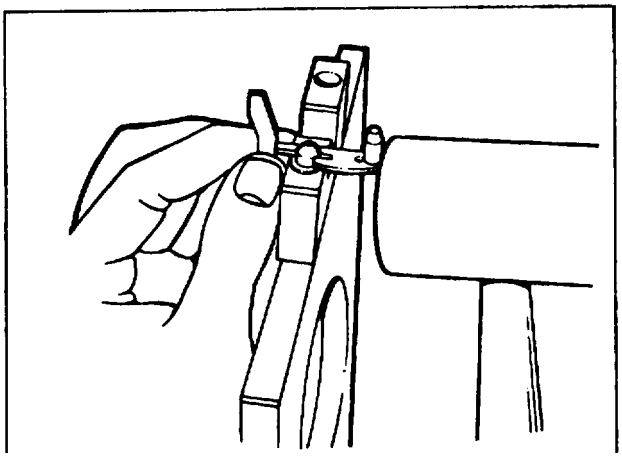


FIGURE 5.16a.

Place the metering valve assembly into its bore (Figure 5.16b). Depress and rotate the valve several times to ensure freedom of movement. If valve sticks, rinse off with clean calibrating fluid. Never use an abrasive; the special surface treatment provided will be damaged.

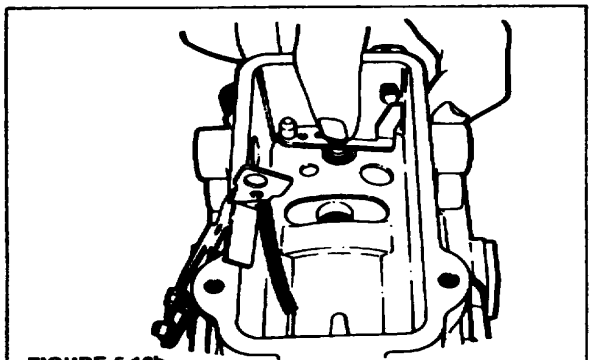


FIGURE 5.16b.

STEP 17 Depress the metering valve assembly and install the guide stud and new guide stud washer into the housing and tighten (Figure 5.17a).

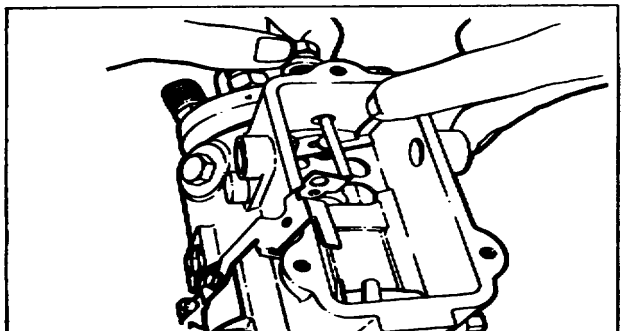


FIGURE 5.17a.

NOTE

**** Use grease sparingly as it can plug the return fitting and pump will not bleed air from housing during start-up.***

Pull back the governor linkage hook, stretching the spring just enough to assemble the hook correctly to the fork on the governor arm. Position the opposite end of the hook over the pin on the metering valve arm (Figure 5.17b). Check all of the governor parts for freedom of movement.

NOTE
Do not twist spring.

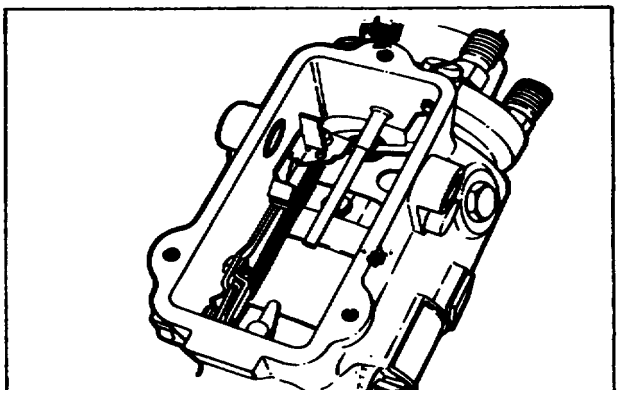


FIGURE 5.17b.

Assemble the governor spring, spring retainer, idle spring and idle spring guide on the bench (Figure 5.17c).Apply a light film of grease to the parts in order to keep them in place while assembling. Install the spring components onto the guide stud as shown.

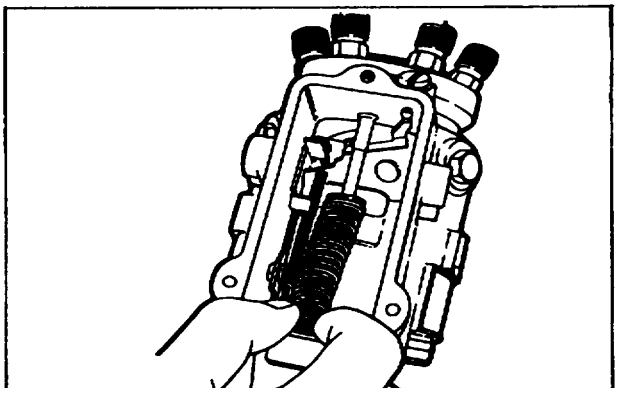


FIGURE 5.17c.

STEP 18 Install new Mylar washers and seals to the throttle and shutoff shafts. Apply a light film of grease to each seal.* Assemble the throttle shaft assembly partially through its bore in the housing. Slide the throttle shaft lever over the throttle shaft so that the projection in the throttle shaft lever bore engages the rear key way on the shaft. Position the forked end of the throttle lever so that it straddles the guide stud. Assemble the shutoff shaft assembly with a slight rotary motion, so as not to damage the seal. If the throttle shaft lever is correctly installed, rotating the throttle shaft assembly

to the rear will cause compression of the governor spring (Figure 5.18).

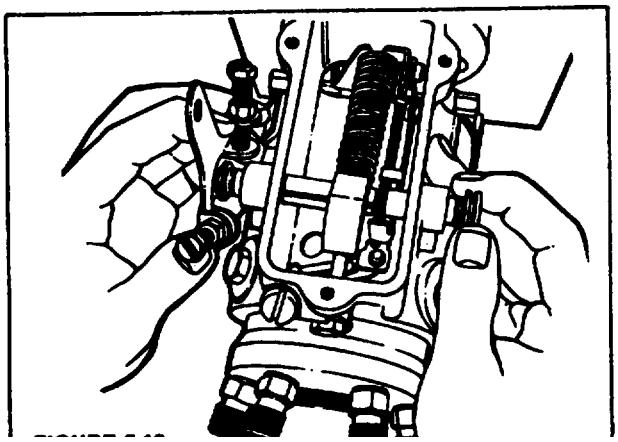


FIGURE 5.18.

STEP 19 Invert the pump and holding fixture in the vise. Apply a light film of grease to the head locating screw. Insert the screw and thread deeply into head hand tight. Using a 7/16' deep well socket and torque wrench, tighten to specification.

NOTE

If screw is not seated properly into the head, the seal may be sheared during tightening (Figures 5. 19a and 5. 19b).

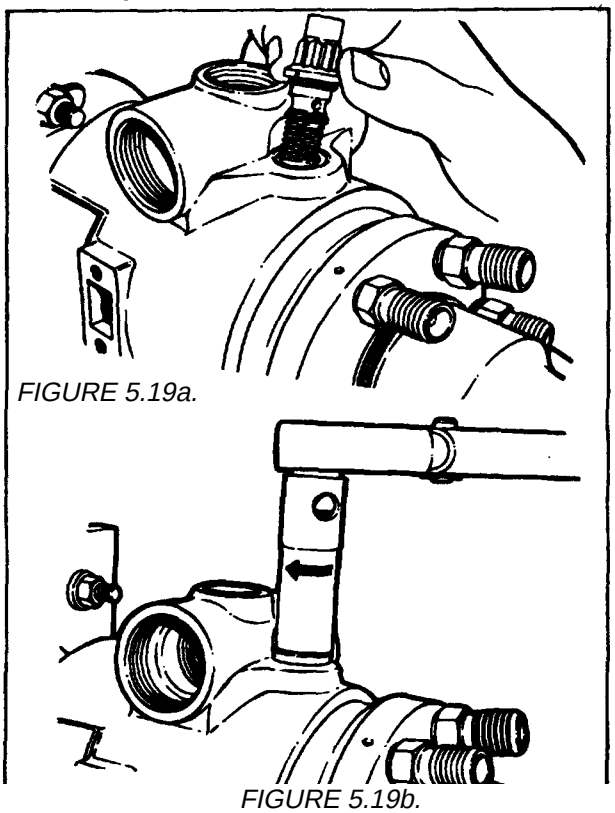


FIGURE 5.19a.

FIGURE 5.19b.

STEP 20 Install the cam advance screw (Figure 5.20). Assemble the bristol socket cam advance screw wrench and cam advance screw bushing into the advance screw hole plug. Tighten the cam screw to the specified torque. Check cam ring for freedom of movement (locking down the screw can sometimes twist the cam). If cam is not free, tap the screw lightly with a brass rod.

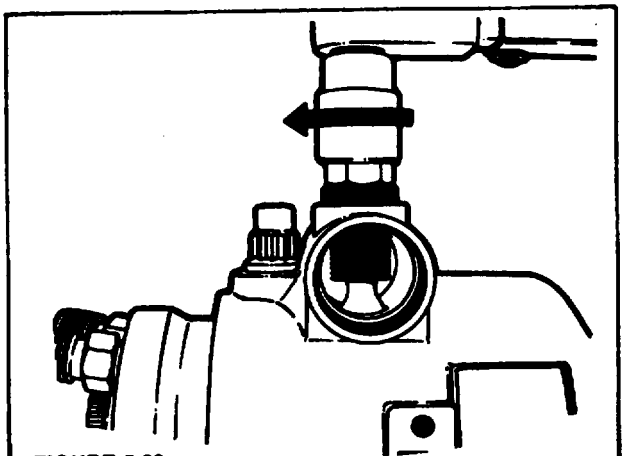


FIGURE 5.20.

STEP 21 Assemble the automatic advance components (Figure 5.21a). Install the piston ring seal and ring into

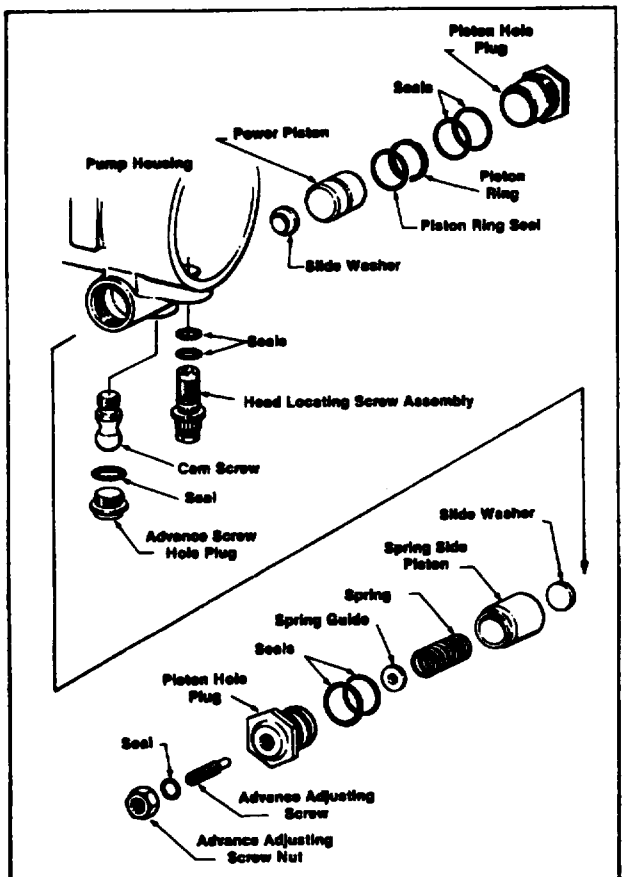


FIGURE 5.21a.

the groove of the advance power piston. Assemble the advance adjusting screw to the piston hole plug. Install new seals to the piston hole plugs. Assemble the spring guide and spring to the adjusting screw. Install the pistons to the piston hole plugs. Use piston ring compressor to aid in installing the power piston. Use care not to damage the ring during installation of the assembly to the piston hole plug. Install the adjusting screw nut and a new seal.

Install the advance piston assemblies into the pump housing (Figure 5.21 b). A small amount of grease applied to the end of the pistons will keep the slide washers in place during assembly.

NOTE

The sides of the housing near the advance boss bear a "C" or 'CC" to denote pump rotation. The power piston is located on the side marked -C" for a clockwise rotating pump and vice versa.

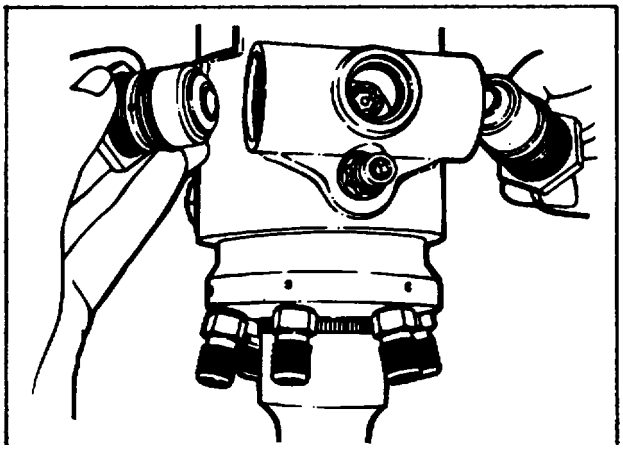


FIGURE 5.21b.

Install the advance screw hole plug and new seal into the housing and tighten using plug wrench (Figure 5.21c).

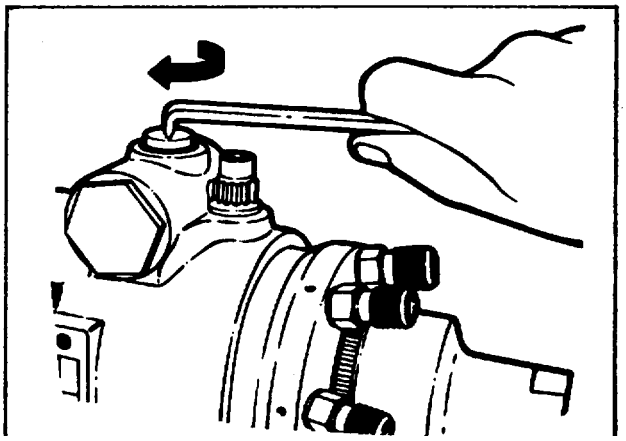


FIGURE 5.21c.

Tighten the advance piston hole plugs to the specified torque (Figure 5.21d).

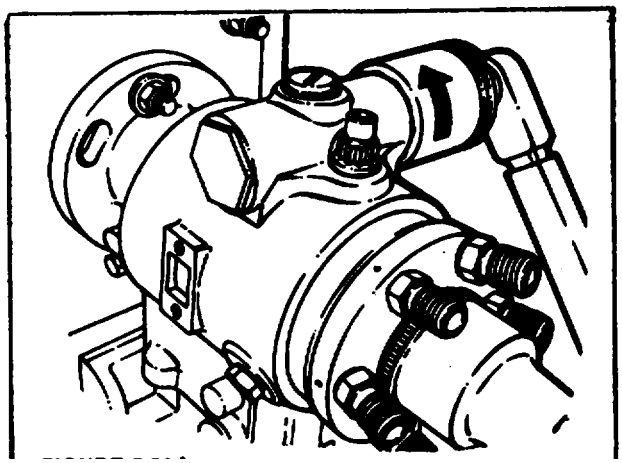


FIGURE 5.21d.

STEP 22 Invert the pump and fixture in the vise. Prior to measuring and adjusting the linkage gap, hold throttle lever in wide open position and rotate the drive shaft in the proper direction of rotation until a slight 'click" is heard, as the toes of the governor arm engage slots in the thrust sleeve. The torque screw (if used) should be backed out. With the throttle lever held in wide open position, use linkage gauge to check the clearance between the rear of the shutoff shaft and the vertical tab on the linkage hook (refer to pump specifications for correct dimension.). Adjustment of this clearance is made by using linkage wrench to change the effective length of the linkage hook. Loosen the adjusting screw and slide linkage to maximum open length. In sert linkage gauge between vertical tab and shutoff shaft, and slide linkage hook together from the rear until face of tab is flush against gauge. Tighten adjusting screw. Check adjustment and reset if required (Figure 5.22).

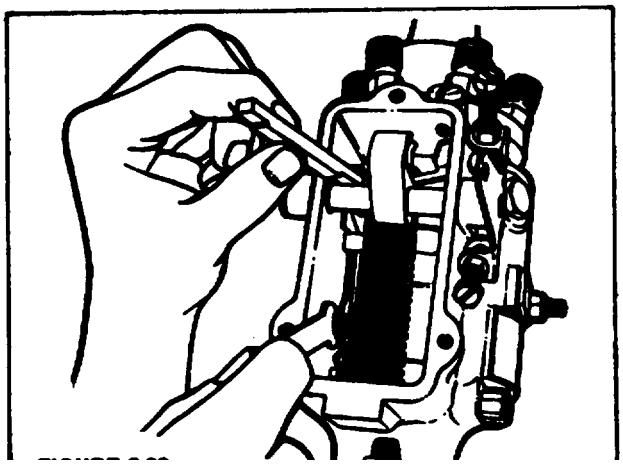


FIGURE 5.22.

STEP 23 Compress both sides of the throttle and shutoff shaft and install a new shutoff cam and/or a new throttle shaft retainer clip as needed with the straight inner edge engaging the slot. The cam or clip should snap into position when installed correctly (Figure 5.23).

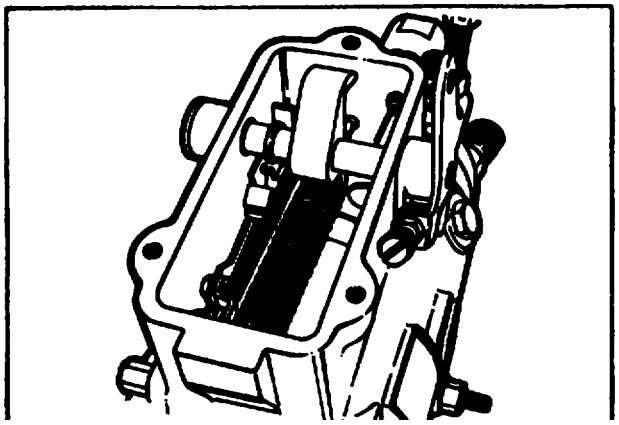


FIGURE 5.23.

STEP 24 Assemble a new gasket to governor control cover and install cover on pump. Slip the flat washers and lock washers onto cover screws and tighten to the specified torque (Figure 5.24).

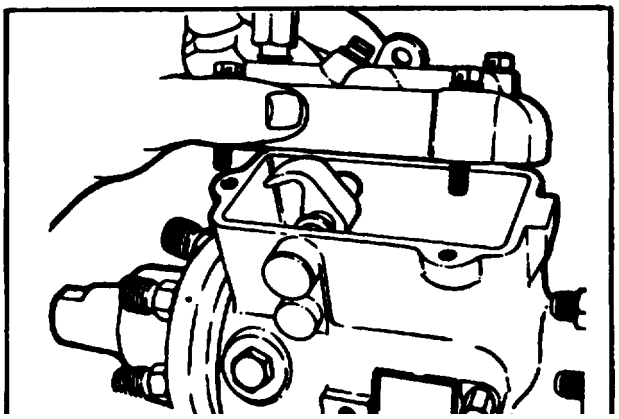


FIGURE 5.24.

STEP 25 Insert end cap plug tool in the end cap and tighten to specified torque, using appropriate end cap wrench (Figure 5.25a).

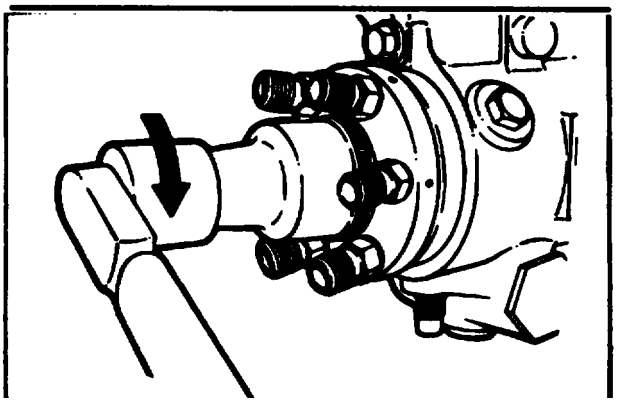


FIGURE 5.25a.

CAUTION

The standard transfer pump end cap inlet requires a special inlet fitting with an 0o" ring seal (1/2-20 straight thread). Do not use a tapered pipe thread type fitting as this could bottom and result in seizure of the head and rotor assembly and damage to the end cap threads.

Assemble the end cap locking plate, seal and screw to the head and tighten to the specified torque (Figure 5. 25b).

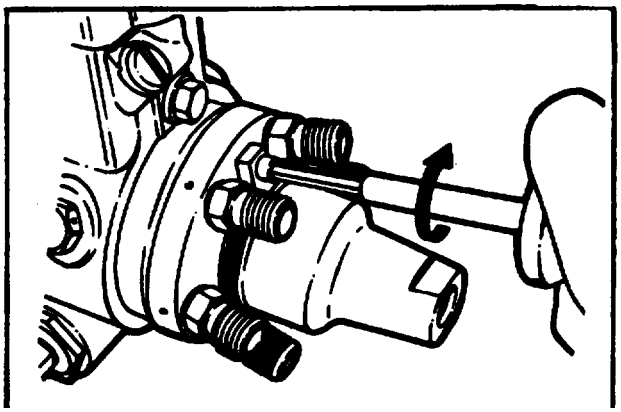


FIGURE 5.25b.

STEP 26 Tighten the two head locking screws to the specified torque (Figure 5.26).

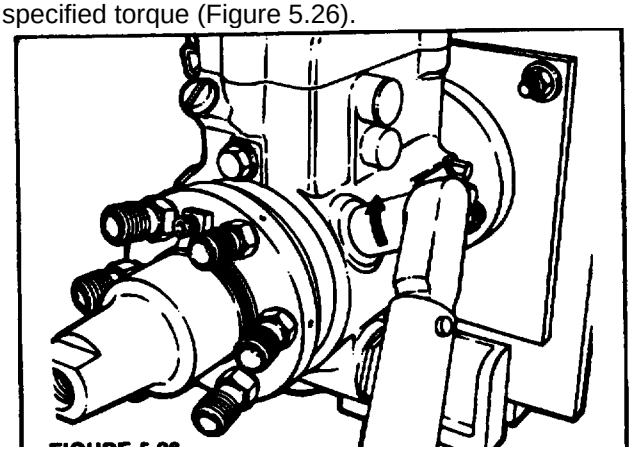


Figure 5.26

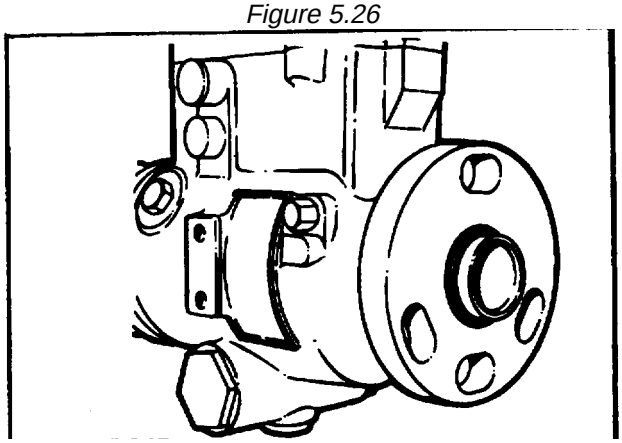


Figure 5.27

STEP 27 Remove the pump from holding fixture and install the pump flange seal (Figure 5.27).

SECTION 6 ACCESSORIES

FLEXIBLE GOVERNOR DRIVE

An optional flexible retaining ring is available in the Model DB2 pump. This ring serves as a cushion between the governor weight retainer and the weight retainer hub. It is designed to absorb torsional loading and vibrations transmitted to the pump from the engine as well as those created within the pump itself. In doing so, it allows for smoother governor operation under all speed and load conditions and reduces wear of the pump drive shaft tang and governor parts.

ELECTRICAL SHUTOFF

Electrical shutoff devices are available as an option in both Energized to Run (ETR) and Energized to Shutoff (ETSO) models for the DB2 pump. These solenoids are included in various applications to control the run and stop functions of the engine. They accomplish this by positively stopping fuel flow to the plungers, thereby interrupting injection.

TORQUE SCREW

Torque is commonly defined as the turning moment or "lugging ability" of an engine. Maximum torque varies at each speed in the operating range for two reasons: (1) as engine speed increases, friction loses progressively increase and, (2) combustion chamber efficiency drops due to loss of volumetric efficiency (breathing ability of an engine), and due to reduction of time necessary to completely and cleanly bum the fuel In the cylinder. Since the torque increases with increased load conditions, a predetermined point at which maximum torque is desired may be selected for any engine. Thus, as engine RPM decreases, the torque generally increases toward this preselected point. This desirable feature is called 'Torque Back-Up." In the Roosa Master pump, three basic factors affect Torque Back-Up.
These are:

1. Metering valve opening area.
2. Time allowed for charging.
3. Transfer pump pressure curve.

Of these, the only control between engines for purposes of establishing a desired torque curve is the transfer pump pressure curve and metering valve opening, since the other factors involved are common to all engines. Torque control in Roosa Master fuel injection pumps is accomplished in the following manner:

The manufacturer determines at what speed for a specific application he wants his engine to develop its maximum torque. The maximum fuel setting is then adjusted for required delivery during dynamometer test. This delivery must provide acceptable fuel economy. The engine is then brought to full load governed speed. The fuel delivery is then reduced from that determined by the maximum fuel setting by turning in an adjustment or 'torque screw' (Figure 6.0), which moves the metering valve toward the closed position. The engine Is now running at full load governed speed. When the engine Is operating at high idle speed, no-load, the quantity of fuel delivered Is controlled only by governor action through the metering valve. At this point, the torque screw and maximum fuel adjustment have no effect. As load is applied, the quantity of fuel delivered is controlled only by governor action and metering valve position until full-load governed speed is reached. At this point, further opening of the metering valve is prevented by its contact with the previously adjusted torque screw. Thus, the amount of fuel delivered at full-load governed speed is controlled by the torque screw and not by the roller-to-roller dimension. As additional load Is applied and engine RPM decreases, a greater quantity of fuel is allowed to pass into the pumping chamber due to the increased time of registration of the charging ports. During this phase of operation, the metering valve position remains unchanged, still being held from further rotation by the torque screw. As engine RPM continues to decrease under increasing load, the rotor charging ports remain in registry for a longer time period allowing a larger quantity of fuel into the pumping chamber. Fuel delivery increases until the predetermined point of maximum torque is reached.

At this point, the quantity of fuel is controlled by the roller-to-roller dimension. It must be remembered that torque adjustment on the Roosa Master pump may be properly carried out only during dynamometer or bench test. It should not be attempted on a unit in the field without means of determining actual fuel delivery.

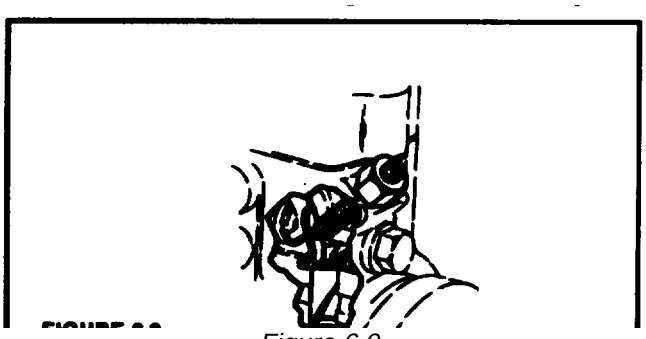


Figure 6.0

SECTION 7
TEST BENCH REQUIREMENTS & PROCEDURES

SPECIAL TEST BENCH REQUIREMENTS

Any test is only as good as the testing equipment employed. Incorporation of quality test equipment and adherence to specifications and the following test procedures will reduce testing inaccuracies to a minimum.

a) Calibrating Nozzles: Several different types of calibrating nozzles will be required for testing the various DB2 pump models. Be sure to use only the type of nozzle called for on the individual specification. Some of the permissible types are listed below:

TYPE	OPENING PRESSURE -p.s.i.
DN12SD12	2500 - (170 ATS)
AMBAC PCU25DO50.5 Orifice Plate (SAE Std.)	3000 - (204 ATS)
AMBAC TSE77110 - 518 .5 Orifice Plate	1700 - (116 ATS)

Use of the SAE 1150 orifice plate nozzle is described in SAE recommended practices J968c and J969b.

b) Injection Lines: Several injection line sizes (length and I.D.) have been released for service use. Use test injection lines equal in diameter to those installed on the TMD 27 engine.

c) Calibrating Oil: Use calibrating fluid or injector test oil listed in Appendix C. Calibrating oil should be changed every three months or 200 pumps (whichever comes first).

d) Calibrating Oil Temperature: The temperature of the oil in the test bench must be maintained within 1100115°F while testing Roosa Master fuel injection equipment.

NOTE

This reading should be taken as close to inlet as possible. The test bench should be equipped with a heater and thermostatic control to maintain this temperature.

e) Test Bench: Mount and drive the DB2 pump models according to the test bench manufacturer's instructions. In addition, the test stand coupling should be of the self-aligning, 'zero" backlash type; similar to the Thomas Coupling types or Robert Bosch (SAEJ969b).

GENERAL TEST PROCEDURE

a) Install applicable transfer pump inlet connector, using two (2) wrenches so that the pump outlet fitting does not get moved at the same time. Install transfer pressure gauge connector. Install a shutoff valve to isolate the gauge when not in use. Connect a pressure gauge to the 21900 adapter. Some automotive DB2 pumps require 114 of one degree setting accuracy. If so specified, remove the timing line cover and replace with the advance gauge. If the advance gauge is not required, replace the timing line cover with the advance test window.

b) Determine proper direction of pump rotation from the specification. Rotation is determined as viewed from the drive end of the pump.

c) If the pump is equipped with an "Energized-to-Run" electric shutoff device, energize it at the lowest speed with 12 volts. Move pump throttle lever to full load position. When transfer pump is primed, allow fuel to bleed for several seconds from loosened injection line nuts at the nozzles. Tighten line nuts securely.

NOTE

Roosa Master pump specifications list fuel delivery in cubic millimeters/stroke. Some test benches measure fuel flows in cubic centimeters (milliliters). To convert from mm^3/stroke to CC's use the following formula:

$$\textit{Delivery in CC' s} = \frac{mm^3/\text{Stroke} \times \text{No. of Strokes}}{1000}$$

EXAMPLE: If the Specification calls for 72 mm^3/stroke and the test stand counter has been set for 500 strokes, simply substitute these numbers into the formula and calculate as follows:

$$\text{Delivery in CC's} = \frac{72 \times 500}{1000} = 36 \text{ CC's}$$

Bear in mind when testing Roosa Master pumps that our specifications refer to engine RPM (ERPM) and that most test bench tachometers register pump RPM which is 1/2 engine speed for four stroke cycle engines.

d) Operate pump at 1000 ERPM wide open throttle (WOT) for 10 minutes. Dry pump off completely with compressed air. Observe for leaks and correct as necessary. Back out the high idle, low idle, and torque screw (if equipped).

NOTE

Refer to pump specification for correct sequence of test stand adjustments. Pressurize the transfer pump inlet to the amount indicated on specification or to a maximum of 5 p.s.i., if not otherwise indicated.

e) Vacuum Check: Close valve in fuel supply line. At 400 ERPM, the transfer pump must be capable of creating a vacuum of at least 18" of mercury. n it does not, check for air leaks between pump inlet and shutoff valve or deficiency in transfer pump components.

f) Fill graduates to bleed air from test stand and to wet graduates.

g) Check the return oil quantity by directing the return oil flow into an appropriately calibrated graduate for a given time. See individual specifications for allowable quantity and ERPM at which to make the check.

h) Operate at the specified speeds with wide open throttle and observe transfer pump pressure. Adjust pressure regulating spring plug to raise or lower transfer pump pressure.

CAUTION

Under no circumstances should 130 p.s.i. transfer pump pressure be exceeded. Damage to equipment would result.

i) To adjust pressure, remove the line to the transfer pump inlet connector and use a socket head wrench to adjust the plug. Clockwise adjustment increases pressure. Do not over-adjust.

NOTE

Transfer pump pressure gauge must be isolated by the shutoff valve at the injection pump when checking fuel delivery and advance movement

j) Check for minimum delivery at cranking speed.

k) Operate at high speed and adjust high idle screw to obtain the specified delivery. Recheck transfer pump pressure upon completion of this adjustment.

m) Adjust the low idle screw to the correct low idle delivery.

n) Automatic Advance: Check the cam position at specified points in the speed range. Adjust trimmer screw, as required, to obtain proper advance operation. Each line on advance gauge equals two pump degrees. After setting the advance, check to see that the cam returns to its initial position at 0 RPM. Recheck transfer pump pressure after setting advance and correct if necessary.

p) Record fuel delivery at check points shown on the pump specification. ROLLER SETTINGS SHOULD NOT BE READJUSTED ON THE TEST BENCH. Experience has proven that micrometer and dial indicator settings provide more consistent, accurate results in performance. Variations in test bench drives, instrumentation, nozzles lines and fuels in different areas sometimes result in nonconforming flow readings.

q) While operating at full-load governed speed, set torque screw (if employed) to specified delivery. Recheck the transfer pump pressure and advance movement upon completion of this adjustment.

r) Recheck delivery at lowest speed checkpoint.

s) Check governor cutoff at specified speed.

t) Check electric shutoff (if equipped) at speeds indicated on specification.

u) Remove the pump from the test stand and assemble all sealing wires. Pump is now ready for installation to engine.

INJECTION PUMP
SERVICE AND ASSEMBLY SPECIFICATIONS
Model Number: DB2429-4179

NOTE

THIS SPECIFICATION DEVELOPED WITH ISO LONG INLET STUD. ALL SPEEDS ARE IN ENGINE RPM UNLESS OTHERWISE NOTE D. USE LATEST REVISION FOR ALL REFERENCED DOCUMENTS.

WOT= WIDE OPEN THROTTLE **H. I. = HIGH IDLE** **L.I . = LOW IDLE**

PUMP CALIBRATION CHECKS:

AS RECEIVED FOR SERVICE:
1. 1000 RPM (WOT): OPERATE PUMP FOR 10 MINUTES TO BRING TO OPERATING TEMPERATURE AND CLEAR AIR FROM SYSTEM.
2. 3150 RPM (H.I.): RESET HIGH IDLE SCREW TO OBTAIN 17-20 mm^3/STROKE, IF NECESSARY.
3. CHECK POINTS:

RPM	POS.	mm^3/STROKE		ADVAN
a	150	WOT	31 MIN	---
b	400	WOT*	4 MAX	---
c	650	L.I.**	8-11	---
d	1400	WOT	---	0^0-1^0
e	2000	WOT	45-51	2^0-4^0
f	3000	WOT	45-49	5^0-6^0
g	3000	WOT*	4 MAX.	---
h	3150	WOT	17-20	---
I.	3200	WOT	5 MAX.	---

*ELECTRONIC SHUTOFF DE-ENERGIZED
**RESET USING LOW IDLE SCREW, IF NECESSARY

PUMP SETTINGS:
(FOLLOWING PUMP SERVICE):
1. ROLLER TO ROLLER DIMENSION:
   1.976" ± .001" (50.19 ± .025 mm)
   MAXIMUM ECCENTRICITY:
   .004" (0.1 mm) T.I.R.
2. GOV. LINKAGE GAP:
   .125" TO .165" (3.2 - 4.2 mm)
   (USE KIT #23093 8.8.95).
3. 1000 RPM (WOT): OPERATE PUMP FOR 10 MINUTES TO BRING TO OPERATING TEMPERATURE AND CLEAR AIR FROM SYSTEM
4. 400 RPM (WOT):
   a. CHECK SHUTOFF 4 mm^3/STROKE, MAX
   b. CHECK FOR MINIMUM TRANSFER PUMP LIFT OF 18" HG. (60 kPa).
5. 3000 RPM (WOT):
   a. SET TRANSFER PUMP PRESSURE FOR 95-100 PSI (65590 kPa).
   b. ADJUST RETURN OIL TO 225-475 CC/MIN RECHECK TRANSFER PUMP PRESSURE

PUMP SETTINGS: (CONT'D.)

   c. CHECK HOUSING PRESSURE FOR 4-8.5 PSI, (28-59 kPa).
6. 2000 RPM (WOT): SETADVANCE TRIMMER SCREW FOR 3.0°.
7. 3000 RPM (WOT): SET ROERTOROLLER FUEL DELIVERY: 46.5-47.5 mm's/STROKE.
8. SET TORQUE SCREW SO AS NOT TO IMPEDE METERING VALVE MOVEMENT UNLESS NEEDING RESET FOR HIGH ALTITUDE APPLICATIONS PER CUSTOMER REQUIREMENTS.
9. 3150 RPM (WOT): ADJUST HIGH IDLE-SCREW TO OBTAIN 17-20 mm^3/STROKE.
10. 650 RPM (L.I.): SET LOW IDLE TO OBTAIN 8-11 mm^3/STROKE.
11. CHECK POINTS:

RPM	INITL POS.	mm^3/STROKE	ADVANCE	T.P. PRESS.
150	WOT	33 MIN.	--	10 MIN.**
400	WOT'	4 MAX	-	---
650	L .I	8-11	-	---
1400	WOT	---	0°-1°	---
2000	WOT	46-50	2.5°-3.50	---
3000	WOT	46.5-47.5	$5°6^0$	95-100**
3000	WOT	4 MAX	---	---
3150	WOT	17-20	---	---
3200	WOT	5 MAX	---	---

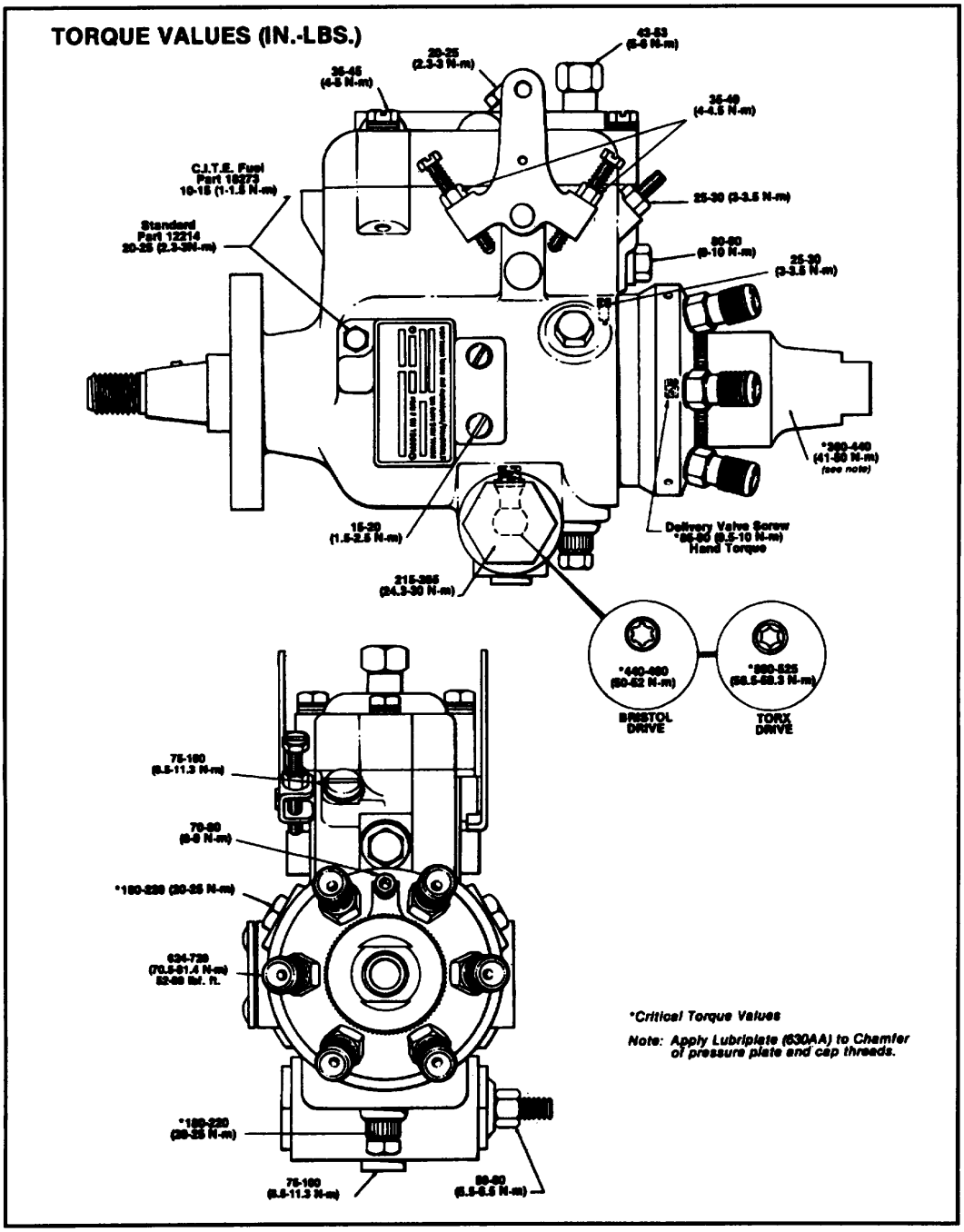
*ELECTRONIC SHUTOFF DE-ENERGIZED
** (69 kPa) *** (655 690 kPa)

12. SPECIAL NOTES:
   a. TORQUE ALL FASTENERS.
   b. RESET HIGH IDLE SCREW TO OBTAIN 17-20 mm/'STROKE AT THE HIGH IDLE SPEED CORRESPONDING TO THE FULL LOAD RPM STAMPED ON THE NAME PLATE.

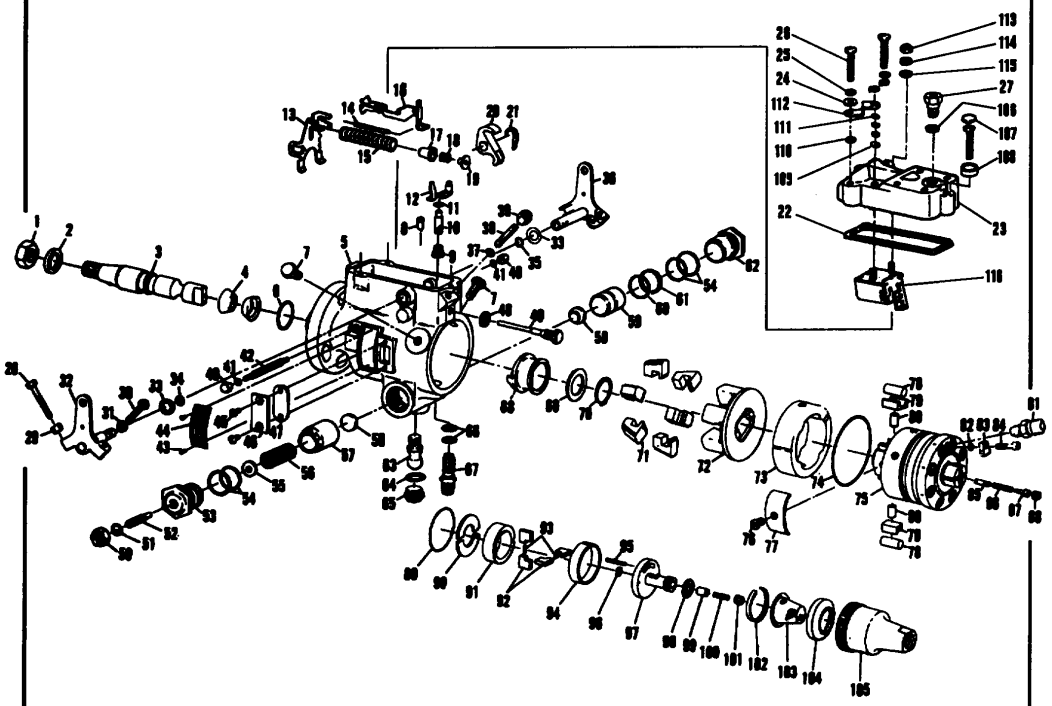
FULL LOAD	HIGH IDLE	GOV. CUT-OFF
2800	2975	3025
2600	2800	2850

   c. SAFETY WIRE ALL FASTENERS.
   d. CHECK ELECTRIC SHUTOFF (PARA XX).

SECTION 9 - GENERAL DATA



EXPLODED VIEW



1. NUT, driveshaft
2. WASHER, drive shaft
3. SHAFT, drive
4. SEAL, pump flange
5. HOUSING ASSEMBLY, pump
6. SEAL, pump flange
7. SCREW, head locking
8. SCREW ASSEMBLY, vent
9. SPRING, metering valve
10. VALVE, metering
11. SHIM, metering valve
12. ARM ASSEMBLY, metering valve
13. ARM, governor
14. SPRING, linkage hook
15. SPRING, governor
16. LINKAGE ASSEMBLY, governor hook adjust
17. RETAINER, spring
18. SPRING, idling
19. GUIDE, idling spring
20. LEVER, throttle shaft
21. CAM, shut-off
22. GASKET, governor
23. COVER, governor control
24. WASHER, cover screw
25. LOCKWASHER, cover screw
26. SCREW, cover hold-down
27. CONNECTOR ASSEMBLY, return line
28. SCREW, low idle adjusting
29. NUT, low idle screw
30. SCREW, high idle adjusting
31. NUT, high idle adjusting
32. SHAFT ASSEMBLY, throttle
33. WASHER, throttle shaft seal
34. SEAL, throttle shaft
35. SEAL, shut-off shaft
36. SHAFT ASSEMBLY, shut off
37. SEAL, torque screw
38. SCREW, torque
39. NUT, torque screw
40. NUT, pivot screw
41. SEAL, pivot shaft
42. SHAFT, governor arm pivot
43. SCREWS, nameplate
44. PLATE, name
45. SCREW, timing line cover
46. COVER, timing line
47. GASKET, timing line cover
48. WASHER, guide stud
49. STUD, guide
50. NUT, advance adjustment screw
51. SEAL, advance adjustment screw
52. SCREW, advance adjusting
53. PLUG, piston hole (trimmer side)
54. SEAL, piston hole plug
55. GUIDE, advnce adjustment spring
56. SPRING, advance adjusting
57. PISTON, spring
58. WASHER, slide
59. PISTON, power
60. SEAL, piston ring
61. RING, piston
62. PLUG, piston hole (power side)
63. SCREW, cam advance
64. SEAL, advance screw hole plug
65. PLUG, advance screw hole
66. SEAL, head locating screw
67. SCREW, ASSEMBLY, head locating
68. SLEEVE, governor thrust
69. WASHER, governor thrust sleeve
70. RING, governor cage retaining
71. WEIGHT, governor
72. RETAINER ASSEMBLY, governor weight
73. CAM RING
74. SEAL, hydraulic head
75. HEAD AND ROTOR ASEMBLY
76. SCREW, leaf spring
77. SPRING, leaf
78. ROLLER, cam
79. SHOE, cam roller
80. PLUNGERS
81. FITTING, discharge
82. SEAL, locking plate
83. PLATE, locking
84. SCREW, locking plate
85. VALVE, delivery
86. SPRING, delivery valve
87. STOP, delivery valve
88. SCREW, deliver valve
89. SEAL, delivery pump
90. RETAINERS, rotor
91. LINER, transfer pump blade
92. BLADES, transfer pump
93. SPRINGS, transfer pump blade
94. RING, liner locating
95. ROLLPIN, regulator
96. SEAL, inlet filter screen.
97. REGULATOR ASSEMBLY, transfer pump
98. SEAL, inlet filter screen
99. PISTON, regulating
100. SPRING, regulating
101. PLUG ASSEMBLY, end plate adjust
102. RING, filter screen retaining
103. SCREEN, inlet filter
104. PLATE, transfer pump pressure
105. CAP, transfer end
106. SEAL, O-ring
107. CAP, cover screw
108. CUP, cover screen
109. WASHER, plain
110. LOCKWASHER, tooth
111. LOCKWASHER, tooth
112. STRAP, terminal ground
113. LOCKNUT
114. NUT, terminal contact
115. WASHER, terminal insulation
116. SOLENOID, 12V ETR

6.0. ELECTRICAL SYSTEM
(Schematics and Wiring Diagrams shown in Appendix D)

6.1 Electrical System Wiring F-257
6.2 Deleted

6.3 Deleted

6.4 Deleted

6.5 Deleted

6.6 Deleted

6.7 Deleted

6.8 Alternator Maintenance F-261
6.9 Prestolite Alternator Service Manual F-267

6.10 Deleted

6.11 Starting System Troubleshooting F-297

6.12 Starter Motor Troubleshooting F-307
6.13 Deleted

6.14 Deleted

6.15 Deleted

6.16 Starter Maintenance F-311

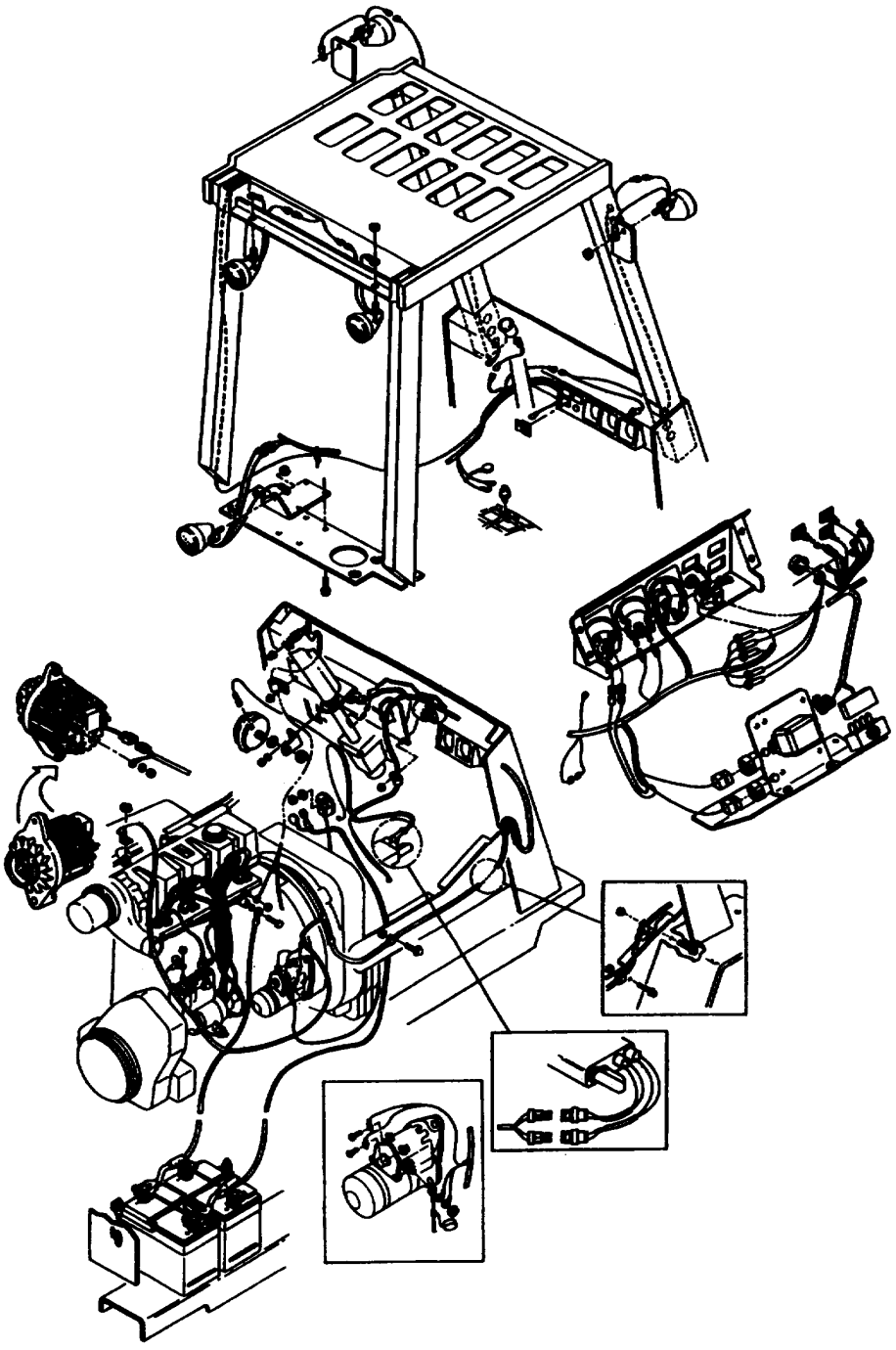
6.1. Electrical System Wiring

Truck Wiring: GPX Model - TMD 27 (2.7L) Engine F-258
Electrical Assemblies Mounting - TMD 27 (2.7L) Engine F-259

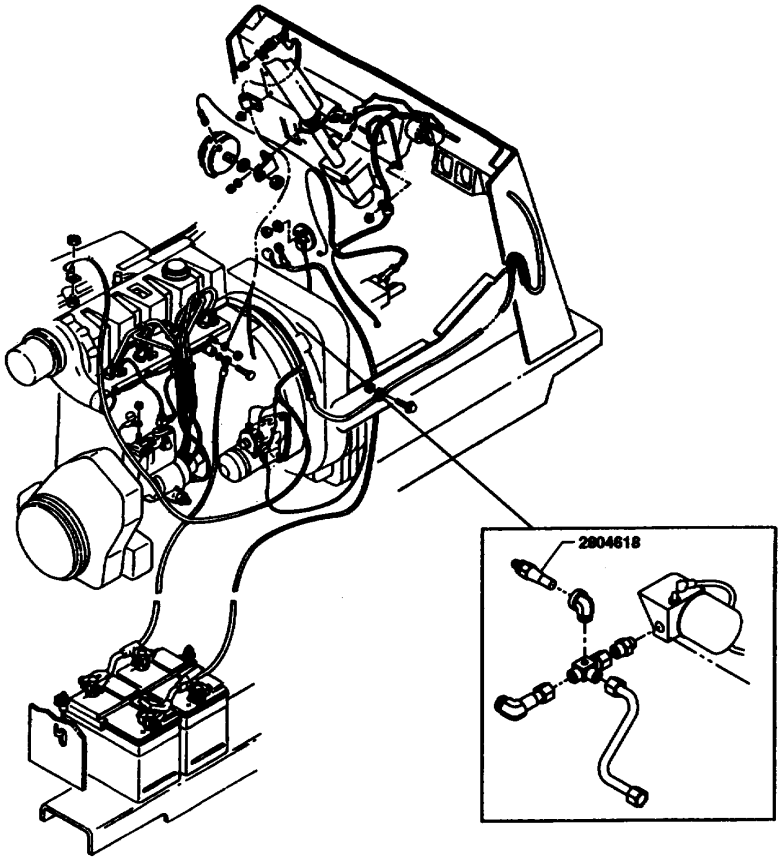
For Reference Only

NOTICE - This section presents typical wiring arrangements and accessory information for the truck and engine for reference only. Please refer to wiring diagrams furnished in Appendix D. Only the Parts Manual should be used for ordering parts.

Truck Wiring
GPX - TMD 27 (2.7L) Engine



Electrical Assemblies Mounting
Model - TMD 27 (2.7L) Engine



6.8. Alternator Maintenance

Troubleshooting Guide F-261
Alternator Maintenance Precautions F-262
Alternator Inspection F-262
Troubleshooting Procedures F-262
Alternator Installation F-264
Altemator Mounting Parts - GPX Model - TMD 27 [2.7L] Engine ... F-265

Troubleshooting Guide

Problem	*Probable Cause*	*Corrective Action*
1 Battery undercharged a) ammeter (if used) indicates constant discharge b) indicator lamp remains on	**1 Defective cables, dirty posts, corroded terminals, etc. as needed.** **2. Loose or broken belt** **3. Worn or broken brushes** **4. Defective alternator system**	1 Check, clean, repair or replace 2. Check belt. 3. Replace brush assembly. 4. Repair or replace alternator.
2. Battery undercharged a) indicator lamp OFF with key ON and engine stopped. (Normal condition is lamp ON)	**1. Indicator lamp burned out or defective wiring harness.** **2. Plug at rear of altemator.** **3. Broken brush** **4. Defective alternator system**	1. Check bulb & harness. 2. Check plug to ensure it is fully seated. 3. Replace brush assembly. 4. Replace regulator.
3. Battery overcharges a) excessive use of water b) ammeter (if used) shows constant excessive charge. c) voltmeter indicates greater than 14.5 volts (connected across battery with no load) with engine idling.	**1. Plug at rear of alternator or wiring harness.** **2. Defective alternator system.**	1. Repair or replace components. 2. Repair or replace regulator.
4. Battery charges at idle, but discharges under load conditions	**1. Slipping belts. or replace, as necessary.** **2. Altemator defective**	1. Check belts and adjust tension 2. Repair or replace alternator.
5. Indicator lamp glows slightly under moderate load; battery appears charged.	**1. Defective diode trio**	1. Replace diode trio.

Also refer to: Section 6.9, Prestolite Altemator Service Manual.

Alternator Maintenance Precautions

WARNING

- **Disconnect the battery, before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental grounding or shorting at the regulator, alternator, ammeter or accessories, will cause severe damage to the units and/or wiring and possible injury to personnel.**
- **If a booster battery or a fast charger is used, its polarity must be connected correctly to prevent damage to the electrical system components. Connect positive to positive, negative to negative. Connect the negative cable ground connection last (but not to the battery because an explosion could result).**

CAUTION

- **The field circuit must never be grounded on this system, between the alternator and the regulator. Grounding of the field terminal either at the alternator or regulator will damage the regulator.**
- **Do not ground the output terminal. Grounding of the alternator output terminal may damage the alternator and/or circuit and components.**
- **Do not connect battery to the regulator field terminal or damage to the regulator will result.**
- **Do not attempt to polarize the altemator. No polarization is required. Any attempt to do so may result in damage to the alternator, regulator, or circuits.**
- **Be sure the alternator and battery have the same ground polarity. Battery polarity should be checked with a voltmeter before connecting the battery. Reversed battery connections may damage the rectifiers, wiring or other components of the charging system.**

NOTE

- **Do not short across or ground any of the terminals on the alternator or in the charging circuit, except as specifically instructed in a troubleshooting procedure.**
- **The alternator must not be operated on open circuit with the rotor winding energized. Check all terminals for tight connections.**

Alternator Inspection

1. Inspect the terminals for corrosion and loose connections.
2. Inspect wiring for damaged or worn insulation.
3. Check mounting bolts for tightness.
4. Check the alternator drive belt for wear, correct alignment and correct tension.

NOTE

When servicing the charging system, never remove a unit until tests have shown it to be defective.

Troubleshooting Procedures

NOTE

Following these procedures in the order presented will lead to the location and correction of charging system defects in the shortest possible time. Usually only a portion of these procedures will need to be performed. It will never be necessary to perform all the procedures in order to locate the trouble.

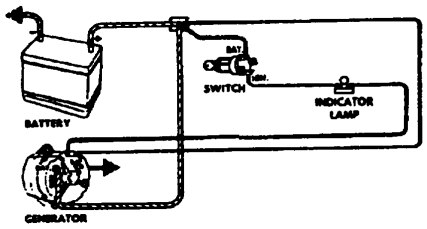


Figure 1.

1. A basic wiring diagram showing charging circuit connections is shown in Figure 1.

Refer to Section 6.1, Electrical System Wiring, for additional information.

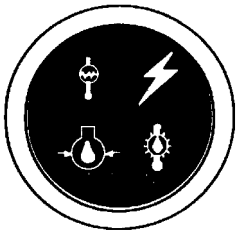


Figure 2.

2. Trouble in the charging system will show up as one or more of the following conditions:

A. Abnormal charge indicator lamp operation.

B. Abnormal charging system operation.

A. Abnormal Charge Indicator Lamp Operation

Check the indicator lamp for normal operation as shown below.

Ignition Switch	Lamp	Engine
OFF	OFF	STOPPED
ON	ON	STOPPED
ON	OFF	RUNNING

If the (ammeter) charge indicator lamp operates normally, proceed to "B. Abnormal Charging System Operation". Otherwise, proceed to one of the following three **abnormal** conditions.

1. Switch Off, Lamp On. In this case, disconnect the two leads from the generator No. 1 and No. 2 terminals. If the lamp stays on, there is a short between these two leads. If the lamp goes out, replace the rectifier bridge. This condition will cause an undercharged battery. Remove and repair the altemator.
2. Switch On, Lamp Off, Engine Stopped. This condition can be caused by the defects listed in Item 1 above, or by an open in the circuit. To determine where an open exists, proceed as follows:

    a. Check for a blown fuse, a burned-out bulb, defective bulb socket, or an open in No. 1 lead circuit between alternator and ignition switch.
    b. If no defects have been found, proceed to "B. Abnormal Charging System Operation".

3. Switch On, Lamp On, Engine Running. Check for a blown fuse between indicator lamp and ignition switch. The other possible causes of this condition are covered in "B. Abnormal Charging System Operation" section.

    If a defect has been found and corrected at this point, no further checks need be made.

B. Abnormal Charging System Operation

1. Be sure that an undercharged condition (discharged battery) has not been caused by ignition key switch or other accessories having been left on for extended periods.
2. Check the alternator drive belt for damage and proper tension.
3. If a battery defect is suspected, check condition of the battery.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the connectors at the alternator and connections at the battery.
5. With ignition switch ON and all wiring harness leads connected, connect a voltmeter from:

    a. Alternator BAT terminal to ground.
    b. Alternator No. 1 terminal to ground.
    c. Altemator No. 2 terminal to ground.

    A zero reading indicates an open between voltmeter connection and battery. Repair as required.
6. With all accessories turned off, connect a voltmeter across the battery. Operate engine at moderate speed (1500-1800 rpm). If voltage is 15.5 volts or more (12-volt system), remove alternator for repair.
7. If previous Steps 1 thru 6 check satisfactorily, check alternator as follows:

    a. Disconnect battery ground cable.
    b. Connect an ammeter in the circuit at the BAT terminal of the alternator.
    c. Reconnect battery ground cable.
    d. Connect a carbon pile across the battery. Turn on all accessories.
    e. Disconnect ignition coil. Crank engine for 15 seconds with coil disconnected. Connect coil. Start engine and operate engine at max no-load governed speed. Adjust carbon pile as required to obtain maximum current output. Ammeter should read within 10 amps of rating.
    f. If ampere output is within 10 amps of rated output as stamped on alternator frame, alternator most likely is not defective. Recheck Steps 1 thru 6.

IMPORTANT - If output in amperes is correct, but charge indicator lamp stays on, check diode trio and rectifier bridge.

Alternator Installation

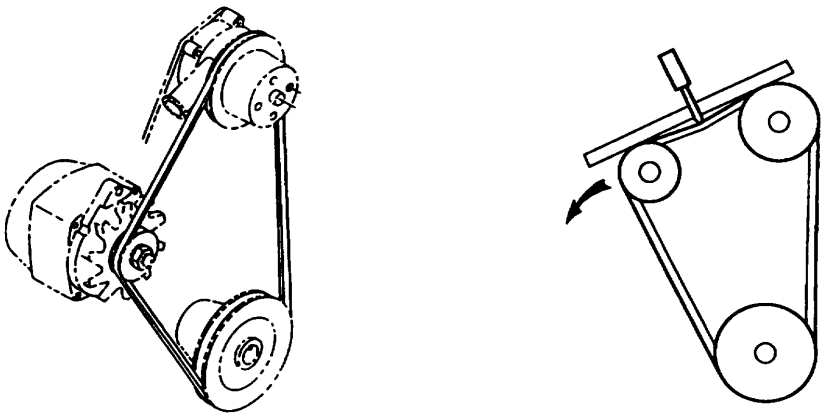


Figure 4. V-Belt Tensioning

Alternator Drive (Fan) Belt

1. Inspect fan belt and pulleys for damage.
2. Fan belt must not have any cracks or contact bottom of pulley grooves.
3. Be sure there is no oil on fan belt.
4. Fan belt worn, oily or damaged: Clean or replace as necessary.
5. Fan belt adjustment not OK: Adjust as necessary.

Fan Belt Tensioning

NOTE

Particular attention should be paid to V-belt tension, as slipping belts are the cause of many other problems in accessory drives as well as in the charging system. Low belt tension can induce slipping, with resultant excessive belt and pulley wear, and overheating of the front alternator bearing.

A slipping belt will not drive the alternator to full output, eventually leading to battery discharge problems.

A belt which has been slipping will be glazed and cracked. Such a belt should be replaced.

Excessive belt tension will create an overload condition in the alternator front bearing and in water pump bearings.

Fan Belt Tension Specification

Adjust belt tension to 2.5-3.2 lb-ft. (11.1-14.2 N) .20 in (5.2 mm) deflection at midpoint of span.

1. The fan belt is tensioned by adjusting the alternator.
2. Loosen bolt at alternator adjusting strap, tighten belt as required, and retighten bolt.

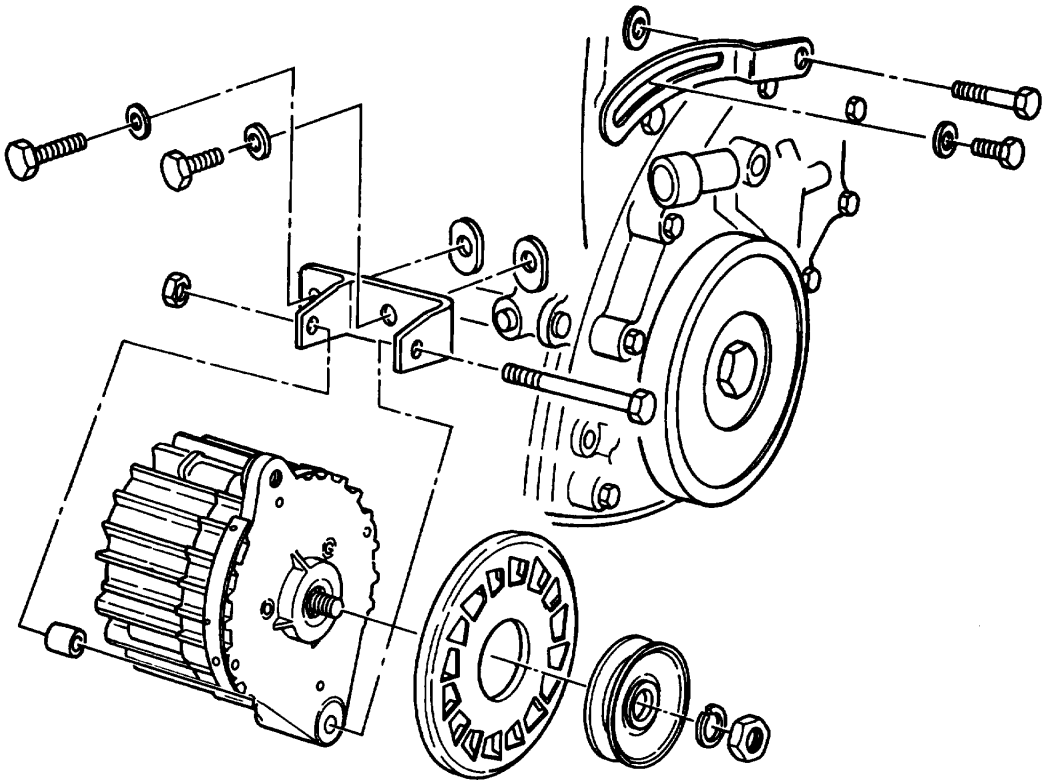
CAUTION

When tensioning fan belt, tighten drive belt by applying pressure to the alternator front housing only. DO NOT apply pressure to the rear housing or stator.

NOTE

New belts will lose a substantial amount of the original tension in the first few hours of operation as the belt seats into the pulleys and should be retensioned accordingly.

Alternator Mounting Parts
GPX Model - TMD 27 [2.7L] Engine



6.9. Prestolite Alternator Service Manual

Pages within the Prestolite Altemator Service Manual are numbered consecutively within Appendix F. However, for ease of reference within this manual, original figure numbers have been retained. All general information is applicable to the 22, 30, and 45 amp altemators, except where a specific model is specified.

‘TA’ series alternator systems

TA SERIES ELECTRONIC ALTERNATOR SYSTEM FOR 22, 30 & 45 AMPERE 12 VOLT NEGATIVE GROUND APPLICATION

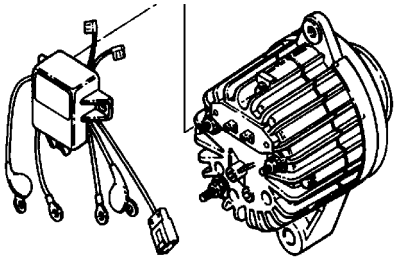


FIGURE NO. 1

GENERAL DESCRIPTION - The Prestolite "TA" series alternator system, is designed for dusty or hazardous environment such as; industrial, agricultural or marine service. The alternator is not waterproof and should not be submerged.

The voltage regulator is an electronic switching device that limits system voltage by turning current to the field (rotor) winding "on and off' at a high rate of speed. Temperature compensation is provided in the regulator circuit.

ELECTRICAL SPECIFICATIONS - Figures 2, 3, and 3.1 depict, in graph form, the stabilized characteristics of the 22, 30, and 45 ampere, "TA" altemators.

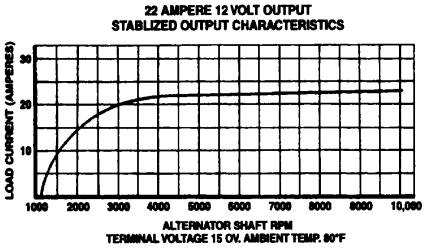


FIGURE NO. 2

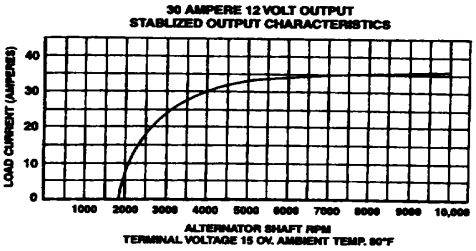


FIGURE NO. 3

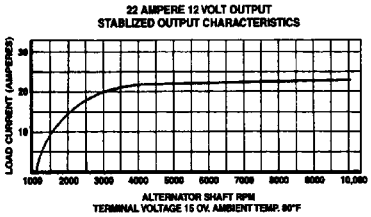
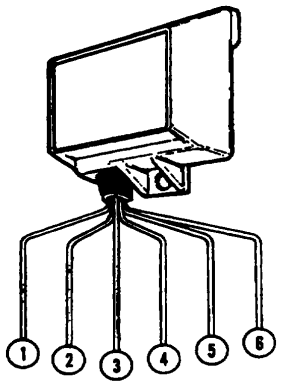


FIGURE NO. 3.1

TA ALTERNATOR SYSTEM REGULATOR INFORMATION

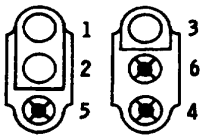
The TA 22 and 30 amp systems utilize the epoxy filled, "RS" series regulator (Figure Number 4) and the 45 amp system uses the 'RF' series regulator (Figure 4.1).



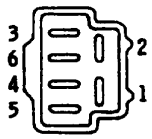
RS2JC1 Regulator

1- BROWN - Indicator Light.
2- VIOLET - Ignition Switch.
3- GREEN - Field.
4- BLACK - Ground.
5- RED - Battery "(+)" Terminal.
6- YELLOW - Stator Connection.

RS2-1	RS2J1 RS2J1-A RS2J1-B	
1- ORANGE	ORANGE	Indicator Light
2- BLUE	VIOLET	Ignition Switch
3- GREEN	GREEN	Field
4- BLACK	BLACK	Ground
5- RED	RED	Battery Pos.
6- YELLOW	YELLOW	Stator Connection

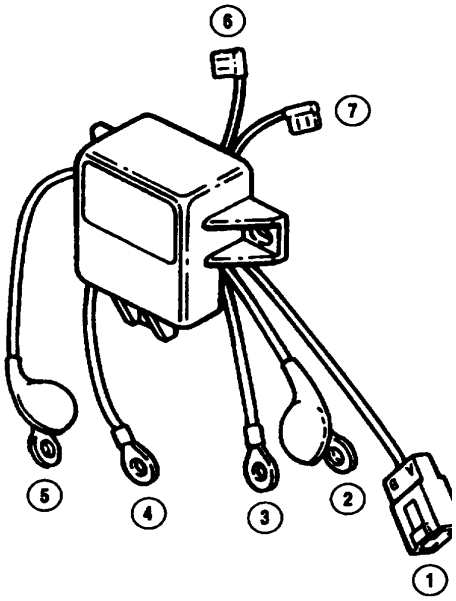


RS2-1 & RS2JC1 CONNECTORS



RS2J1, RS2J1-A & B CONNECTOR

Figure No. 4



8RF2030

1- YELLOW - Indicator Light.
2- YELLOW - Stator (AC).
3- BLACK - Ground (B-).
4- RED - Battery (B+).
5- YELLOW - Stator (AC).
6- GREEN - Field.
7- GREEN - Field.

Figure No. 4.1

CIRCUIT DESCRIPTION

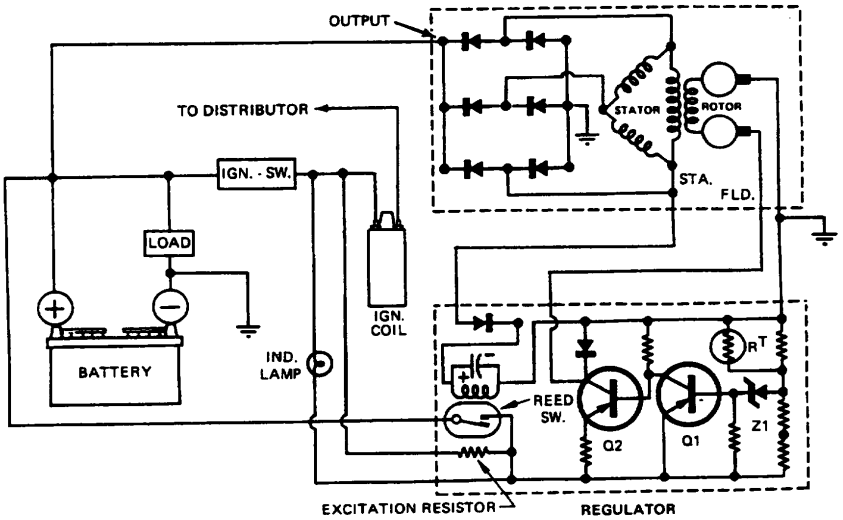
ALTERNATOR - The alternator produces power in the form of three phase alternating current and voltage. The alternating current is rectified to direct current by a three phase full wave rectifier circuit, using six silicon rectifier diodes. Since the diodes will pass current in only one direction (from altemator to battery), the altemator does not require the use of a cut out relay (Figures No. 5 and No. 5.1). The alternator output current is controlled by the current flow through the field coil, (rotor). The amount of current required is determined and controlled by the regulator. Since there is very little residual magnetism in the alternator, it is necessary to supply a small amount of excitation current to the field (rotor) to start the process of current generation. The excitation resistor (Intemal to the regulator), supplies this starting current when the ignition is turned on. Once the alternator is excited, a voltage is developed at the regulator input terminal and the voltage regulator takes over control of the system voltage.

REGULATOR (22/30 Amp Systems)- The voltage regulator is a standard Prestolite regulator. A coil operated reed switch is enclosed in the regulator housing and serves to sense regulator input voltage at a specific point, usually at the starter or battery positive (+) terminal. The altemator output from the stator terminal of the alternator energizes the reed switch coil. When the alternator is not charging, the reed switch is open. The regulator and alternator field (rotor) are disconnected from the battery (Figure No.'s 5 and 5.1). Turning the ignition (control) switch "on", allows initial field (rotor) activating energy to flow from the battery positive (+), through the ignition switch, to the excitation resistor and charge indicator lamp, through the input circuit of the regulator to the field (rotor) winding. The reed switch is by-passed at this time and the charge indicator lamp will glow.

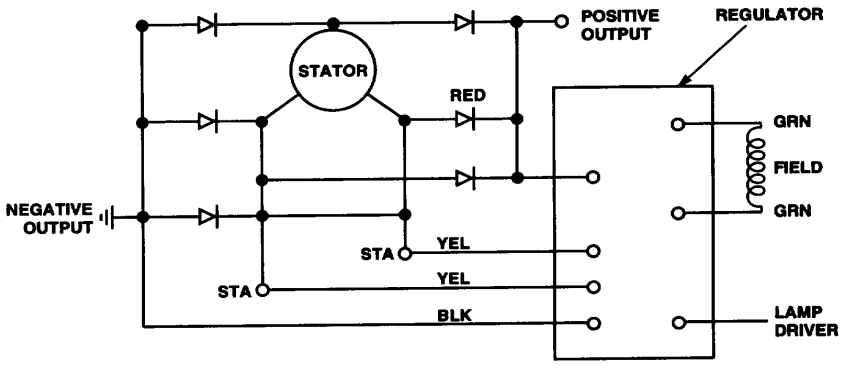
As the alternator develops a charge, part of the AC component is sensed at the stator (STA) terminal of the alternator and is conducted through a diode (coil rectifier), in the regulator, to the reed switch coil to ground. The magnetized coil turns the reed switch "on", connecting the regulator input directly to the battery positive (+) terminal. The charge indicator lamp will be turned off due to equal voltage at both lamp terminals. This direct sensing technique provides a true battery voltage to the regulator and is not subject to improper readings, due to circuit loss.

REGULATOR (45 Amp Systems)- The regulator basically acts as a multifunction circuit to operate. It is a three part circuit: 1) Turn on (self-excited AC turn on, 2) Regulation, and 3) Lamp Driver Circuit.

ALTERNATOR



22 / 30 Amp Systems with regulator
FIGURE NO. 5



45 Amp System with Regulator
FIGURE NO. 5.1

The lamp driver function works off AC taps. The lamp turns off at a voltage > 9 volts. When AC tap potential drops below 6 volts the lamp turns back on (FIGURE NO. 5.2).

When the ignition switch is "on" and the alternator is not spinning, the indicator lamp will be "on". With the alternator spinning, the regulator turns Non" at approximately 800-1000 RPM (rotor RPM) and AC voltage generated in stator windings is amplified by the turn-on circuit in voltage regulator. Once this point is reached, the power transistor is turned "on", allowing the rotor to be magnetized (Full Field). When this condition is reached, the alternator starts to charge (Rotor speed reaches approximately 1700 RPM). The lamp will turn "off" when a voltage at the AC Tap is $\geq$ to 9 volts. System voltage is at 14.3 $\pm$ .2 volts.

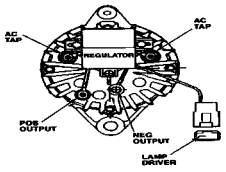
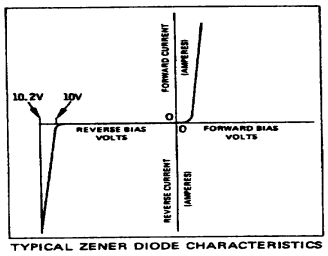


FIGURE NO. 5.2

ZENER DIODE - The Zener diode is a rather unique diode; the ability to pass current in the forward bias mode of the Zener diode is similar to the "normal" characteristics of an ordinary diode. However, in the reverse bias direction, the Zener diode has the ability at a predetermined voltage to literally "destroy" its' high reverse bias characteristic, thus allowing current to flow through it.



TYPICAL ZENER DIODE CHARACTERISTICS

FIGURE NO. 6

The above may be seen more clearly by observing Figure No. 6. Figure No. 6 shows the typical operating characteristics of a 1 O0V Zener diode. This can be seen when starting at the zero bias point and moving to the right, or in to the forward bias area. Almost immediately, the diode allows current to flow, identical to the operational characteristic of a "normal" diode. Now,

observing the area to the left of the zero line or the reverse bias area, it can be seen that until the 10V point is reached, the Zener diode again acts electrically similar to a normal diode, in the reverse bias direction it will not allow current to flow. The instant the voltage rises above 10 volts the Zener diode "breaks down", allowing current to flow. The ability of the Zener diode to "break down", arid then heal itself as the voltage swings above and below the avalanche point of the Zener diode is utilized to switch the associated components in the regulator "on" and "off, switching the field current won" and "off, which in turn holds the system voltage to a predetermined value.

THERMISTOR - Thermistor (RT) is a temperature sensitive resistor, in the regulator voltage divider network, designed to provide a varying resistance with changes in regulator temperature. With the thermistor, the charging voltage is automatically in- creased slightly to overcome the tendency of a cold battery and electrolyte to resist the charging force. The thermistor will decrease charging voltage at higher temperatures as the warm battery and electrolyte will accept the charging force at a lower charging voltage. A typical temperature-resistance characteristic curve is shown in Figure No.7.

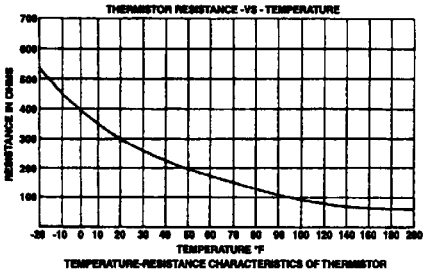


FIGURE NO. 7

With the above information understood, the operation of the voltage regulator system will be easy to follow. (Figure No. 8).

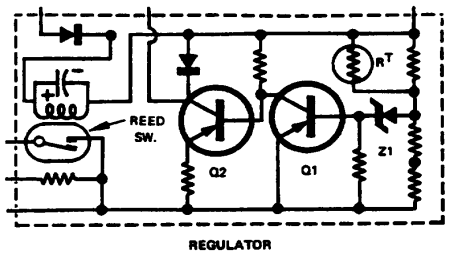


FIGURE NO. 8

SYSTEM VOLTAGE - When the voltage system rises above a set value, the Zener diode (ZI) permits current to flow in the base of the driver transistor (Q1). This causes transistor 01 to turn "on" and reverse bias output transistor 02, this in turn will turn "of' the current applied to the alternator field. The instant the system voltage drops below the predetermined value, the Zener diode stops conducting. When the Zener diode stops conduction, forward bias is removed from the driver transistor 01 and it stops conducting. This in turn allows Q2 to begin conduction, allowing field current to be applied to the altemator. As can be seen, the on-off effect of output transistor 02 is essentially that of a switch allowing alternator field current to be turned "on" and "off, to maintain a specific voltage.

BATTERY INSTALLATION & CHARGING PRECAUTIONS

CAUTION

Observe proper polarity when installing battery. Ground polarity of battery and ground polarity of altemator, must be the same. Reverse polarity will destroy the rectifier diodes in altemator. As a precautionary measure, disconnect positive (HOT) battery terminal when charging battery In vehicle. Connecting charger in reverse will destroy the rectifier diodes in the altemator.

TEST PRECAUTIONS - DO NOT, under any circumstances, short the field terminal of the altemator to ground, as permanent damage to the regulator may occur.

DO NOT, disconnect the voltage regulator while the altemator is operating, because of the large transient spike that occurs when disconnection takes place. permanent damage to the regulator will occur.

DO NOT, disconnect the altemator output lead from the altemator while the alternator is operating, as damping effect of the battery will be lost. The voltage will rise to an extreme value and permanent damage to the alternator will occur.
DO NOT, remove the altemator from vehicle without first disconnecting the grounded battery cable.

ELECTRICAL TEST PROCEDURE

PREUMINARY INSPECTION - Prior to electrical testing, a thorough visual inspection is required to eliminate associated conditions that may be interpreted as a defective alternator or voltage regulator.

Check all electrical leads and connections. Repair or replace necessary parts. Check alternator drive belt and pulleys. Severe operating conditions will accelerate belt and pulley wear. Tighten belt to avoid slippage.

Check alternator brushes for wear. Replace if worn more then half their original length. While the brush cavity is exposed, check and clean slip rings, if required. Use a fine grade of crocus cloth.

Inspect filter (radio) capacitors for possible open or shorted components, when used.

The battery used in electrical testing must be of correct voltage and must be in good condition, and fully charged. lf a slave or jumper battery is used in testing, it should meet all requirements and must be securely connected to avoid accidental loss of connection, observe polarity.

IN-VEHICLE ALTERNATOR SYSTEM TEST

Test Equipment Requirements: Volt ampere tester, such as Sun Electric Model VAT20, or equivalent, with meter ranges as shown below.

1. DC ammeter 0 - 150 amp scale and 0-5 amp field current
2. AC/DC voltmeter - 0 - 20 Volts Scale
3. Rheostat - 50 ohms, 100 watts, 1/4 Ohm Resistor
4. Carbon pile - 600 amp, such as Sun BST-6, or equivalent
5. In-circuit diode tester, such as Sun RDT or equivalent.
6. Test lamp - 12 Volt DC.
7. Ohmmeter - Any commercial type

The alternator service technician is required to test the charging system on the vehicle, or to 'bench test", the components to determine if disassembly and repairs are needed.

It is impossible to include accurate and complete wiring diagrams of all vehicles using the "TA" alternator system. Certain general circuits, essential and common for all applications, are listed.

All grounds are labeled as GND, or with the ground symbol, and are considered 'NEGATIVE", (NEG) (-) where the insulated or ungrounded circuit is "POSITIVE", (POS.) (+).

The panel ammeter shown in test circuit diagrams may not exist in certain vehicles, in such instances, the ammeter circuit becomes a simple conductor.

The charge indicator lamp, shown in test circuit diagrams may be eliminated in favor of a 75 ohm resistor, one or the other is required to provide controlled alternator excitation at low rotor speed.

The key type ignition switch in our diagrams may be an oil pressure switch, or some other control, however, the function remains the same, to switch alternator excitation current "on and off,. The switch must be in good working order.

REED SWITCH AND POSITIVE RECTIFIER DIODE TEST (22/30 Amp Systems)- With ignition switch off, engine not running, temporarily disconnect battery ground cable from battery. Connect test AMMETER, using 0-50 ampere scale, between alternator output terminal and original output lead. Secure leads and reconnect battery (Figure No. 9).

Connect test VOLTMETER as follows: negative lead to negative battery terminal, positive lead to points STA., FLD. and OUTPUT, in that order. With voltmeter, connect to STA. then FLD. in both tests, meters should read "Zero". Move positive lead to OUTPUT terminal, meter should read battery voltage 12.0 to 12.6 volts. Ammeter should read "Zero" amperes.

If voltmeter at test point STA. indicates above "Zero" volts, one of the positive rectifying diodes is shorted. Test ammeter will indicate current discharge. Remove alternator from engine and make necessary repairs.

If voltmeter at test point FLD., indicates above zero volts, there is a fault in the regulator allowing the reed switch to remain closed. The test ammeter will indicate current discharge and the charge indicator lamp may glow. Replace regulator and retest.

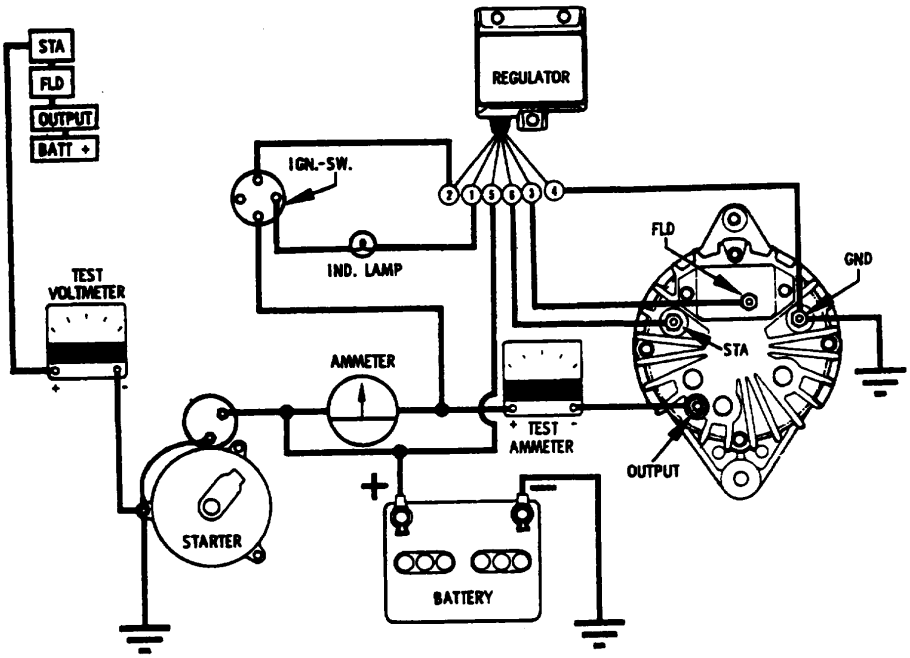


FIGURE NO. 9.

LAMP CIRCUIT TEST (45 Amp Systems)- With ignition switch on, lamp on, and engine not running, connect a DC voltmeter to Test Point I as shown in Figure 9.1. A plus 12.0-12.6 volts measurement should be noted on the DC voltmeter. If you receive a low voltage measurement at Test Point 1, check battery and terminal connections.

Connect positive voltmeter lead on one of the AC Tap terminals Test Point 2). The DC voltmeter should show 30-60 mV. Repeat this procedure on the other AC Tap terminal. If you receive zero voltage at either AC Tap terminal, replace regulator.

Connect positive DC voltmeter lead on Lamp Driver lead (Test Point 3). A measurement of 100+ mV should be noted. If you obtain a measurement of 100+mV, replace lamp.

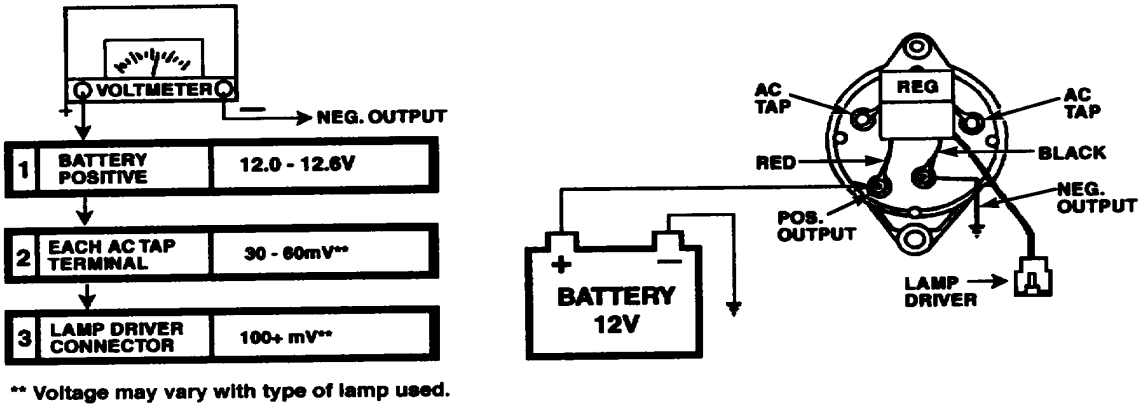


FIGURE NO. 9.1

SHORTED RECTIFIER DIODE TEST(45 Amp Systems)- With ignition switch off and engine not running, connect a DC voltmeter to Test Point 1 as shown in Figure 9.2. A plus 12.0-12.6 volts measurement should be noted on the DC voltmeter. If you receive a low voltage measurement at Test Point 1, check battery and terminal connections.

Connect positive voltmeter lead on one of the AC Tap terminals (Test Point 2). The DC voltmeter should not show any voltage. Repeat this procedure on the other AC Tap terminal. Any voltage at either AC Tap terminal indicates a shorted positive rectifier diode in the alternator. Repair alternator.

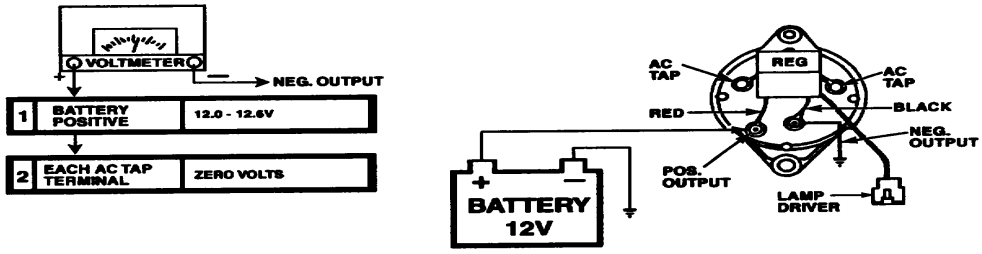


FIGURE NO. 9.2

RELD EXCITATION VOLTAGE TEST (22/30 Amp Systems)- Ammeter remains connected as in Figure No. 9. Move positive voltmeter lead to the alternator FLD., field terminal (Figure No. 10). Meter should read zero volts. Turn ignition switch on, voltmeter should read 2.0 to 3.0 volts. Ammeter should show a slight discharge .1 to .3 amperes, if other electrical accessories are not operating. If the voltage is higher than 3.0 volts. the field circuit is defective.

The regulator circuit may be checked by disconnecting the field lead from the field terminal. Connect voltmeter positive lead to the field lead, voltmeter should read 8 to 12 volts, indicating that the difficulty is in the altemator.

If the voltmeter reads zero volts in either step, check regulator connecting plug, ignition switch, charge indicator lamp and all related wiring. If correct readings are obtained, or after correction of fault, proceed with next step.

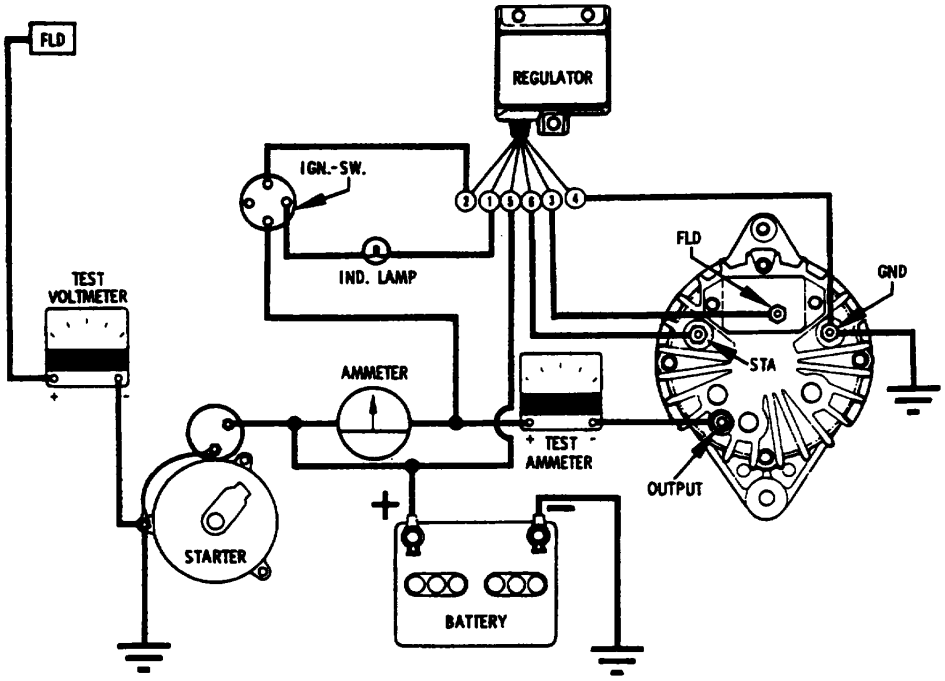


FIGURE NO. 10

FIELD CURRENT DRAW TEST - KEY OFF:

ENGINE NOT RUNNING (22/30 Amp Systems)- This test requires the temporary application of a controlled load across the battery in order to measure field current draw at a common reference voltage point, 10.0 volts (Figure No.11).

Turn control knob of carbon pile off, connect load leads across battery terminals. Remove lead from alternator field terminal. Turn control knob of 50 ohm rheostat off, connect leads to field terminal and output terminal of the alternator. Switch test ammeter to low scale 0-5 amoeres.

Connect voltmeter as follows: negative lead to alternator ground terminal, positive lead to alternator output terminal. At this point, test voltmeter should indicate battery voltage. Test ammeter should indicate zero amperes.

Slowly reduce the resistance of the 50 ohm rheostat, observe the action of the test ammeter. If reduction of rheostat resistance can be fully completed without causing test ammeter to indicate more than 1.5 amperes, there are no shorts or grounds, in the rotor (field) circuit.

If test ammeter tends to read in excess of 3.0 amperes, it is necessary to discontinue the test until the condition of the rotor winding, brush system and slip rings, has been determined. Possible sources of difficulty may be; shorted rotor turns, accidental grounding of the brush shunt leads, shorted rotor rings, perhaps from foreign material being embedded between the rings. Check for missing or broken insulators. Repair as necessary, continue test.

With test rheostat at minimum resistance, note the voltmeter and test ammeter readings. Slowly increase load of carbon pile until voltmeter reads 10.0 volts.
Note the test ammeter reading, it should be: .55 to 1.15 amperes 0 10V (700 to 800F). Proceed with next step if correct reading is noted.

Reverse carbon pile load knob immediately after test to avoid discharging battery, but leave load leads connected to the battery.

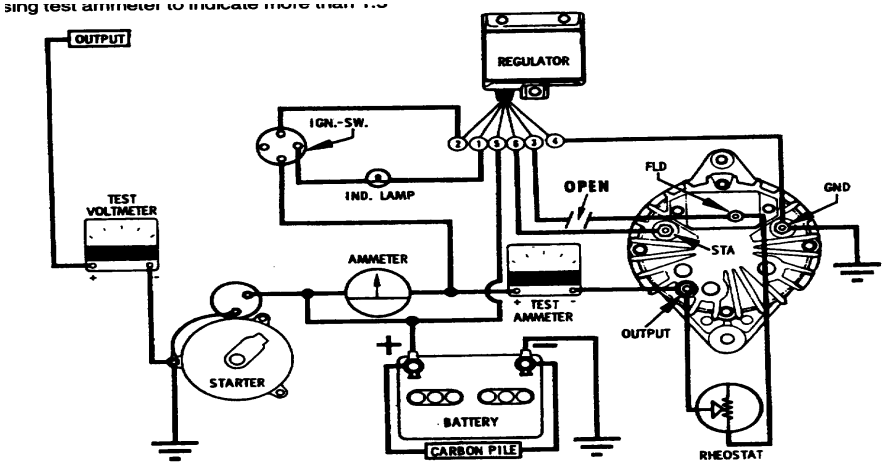


FIGURE NO. 11

FIELD CIRCUIT TEST (45 Amp Systems)- With the engine not running, remove the regulator from the alternator and disconnect leads F1 and F2 from field terminals Fl and F2. Connect field rheostat and jumper (JU) to the appropriate terminals as shown in in the applicable ground system (Figure No. 11.1). Disconnect grounded battery cable and place test ammeter switch to a current range of approximately 0 to 10 amperes. Set control knob of field rheostat to maximum resistance position and connect as shown in Figure No. 11.1. The rheostat will protect the ammeter from damage if the field circuit is shorted.

Reconnect battery ground cable and slowly reduce rheostat resistance and note the rise in the ammeter reading. Stop test if meter indicates more than 5.0 amperes. Altemator disassembly may be necessary to correct condition.

If entire rheostat resistance can be eliminated with test ammeter below 5.0 amperes, the indicated current is the field current draw. If the test ammeter fluctuates when the rotor is moved slightly, the brushes and slip rings require cleaning.

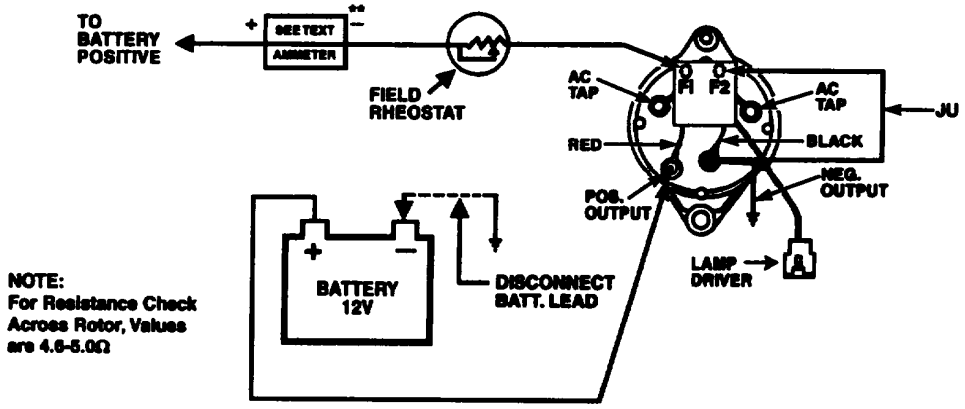


FIGURE NO. 11.1

TESTING FOR REGULATOR VOLTAGE SETTING (22/30 Amp Systems)- This test requires the application of a 1/4 ohm series resistance between alternator output terminal and output lead, to reduce charging current to approximately 8 to 10 amperes (Figure No. 12). Reducing current output will allow system voltage to rise to the operating level of the voltage regulator.

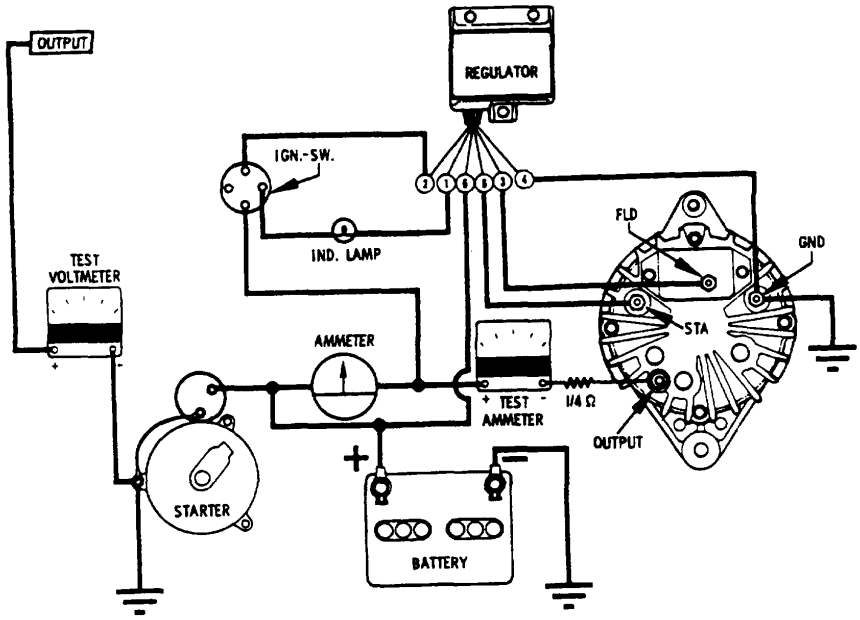


FIGURE NO. 12.

The 1/4 ohm resistance may be incorporated in many commercial volt-ammeter assemblies (Figure No. 13.). Switching the system knob from direct to 1/4 ohm is all that is required to establish series resistance. Separate 1/4 ohm resistors are available and easily inserted in the system as shown in Figure No. 14.

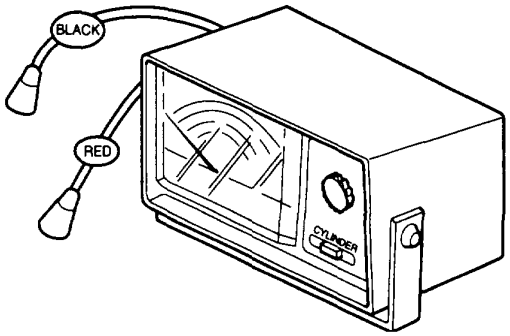


FIGURE NO. 13.

FIGURE NO. 14.

Before starting engine, switch system knob of ammeter to DIRECT, or if a separate resistor is used, by-pass resistor with short, heavy (No. 10 wire) jumper cable. (Carbon Pile is not used). Start engine and run for 5 minutes at fast idle to normalize temperature of components. Insert series resistance in circuit, with knob or removing jumper on separate resistor. Charging current should drop to 8-10 amperes, voltmeter will indicate voltage regulator setting, refer to Table No. 1, for temperature corrected settings.

TABLE 1.

Temperature In Degrees (^{O} F)	0^{O}	20^{O}	40^{O}	60^{O}	80^{O}	100^{O}	120^{O}	140^{O}	160^{O}
Minimum Output Terminal Voltage (10 Amp Load)	14.60	14.45	14.26	14.13	13.95	13.80	13.65	13.60	13.30
Maximum Output Terminal Voltage (10 Amp Load)	15.40	15.25	15.08	14.92	14.75	14.60	14.45	14.28	14.13

REGULATOR AMBIENT TEMPERTUER

If higher voltage is indicated, check regulator leads 3 and 4 for secure connections. A jumper cable with insulation piercing alligator clips (Figure No. 15) may be used to by-pass any plug-in connector that may present an intermittent circuit (Figure No. 16). Repair or replace doubtful leads or connectors.

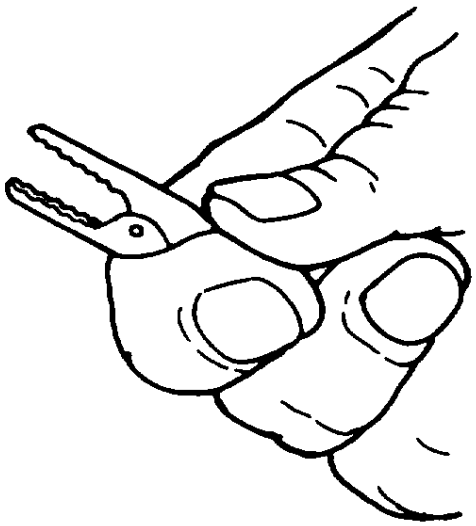


FIGURE NO.15.

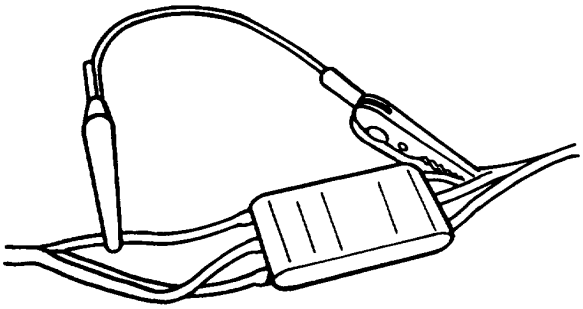


FIGURE NO. 16.

VOLTAGE REGULATOR SETTING TEST (45Amp Systems)- Connect 1/4 ohm resistor and the test ammeter to system as shown in Figure 16.1, start engine, and accelerate engine to a fast idle. The 1/4 ohm resistor is positioned in series with the test ammeter, then applied to the circuit as shown in Figure 16.1. The resistor will reduce charging current to less than 10 amperes, thus allowing charging voltage to rise to the regulator controlled maximum. If test result indicates a lower voltage, voltage regulator may be defective. High voltage may be due to a high resistance regulator ground circuit (black lead), or to a defective voltage regulator. Repair or replace regulator.

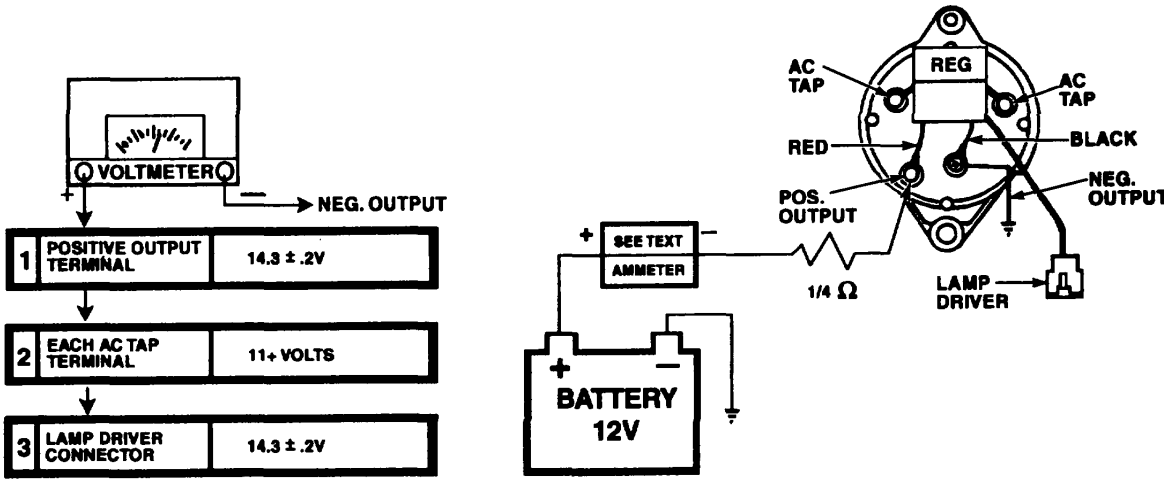


FIGURE NO. 16.1.

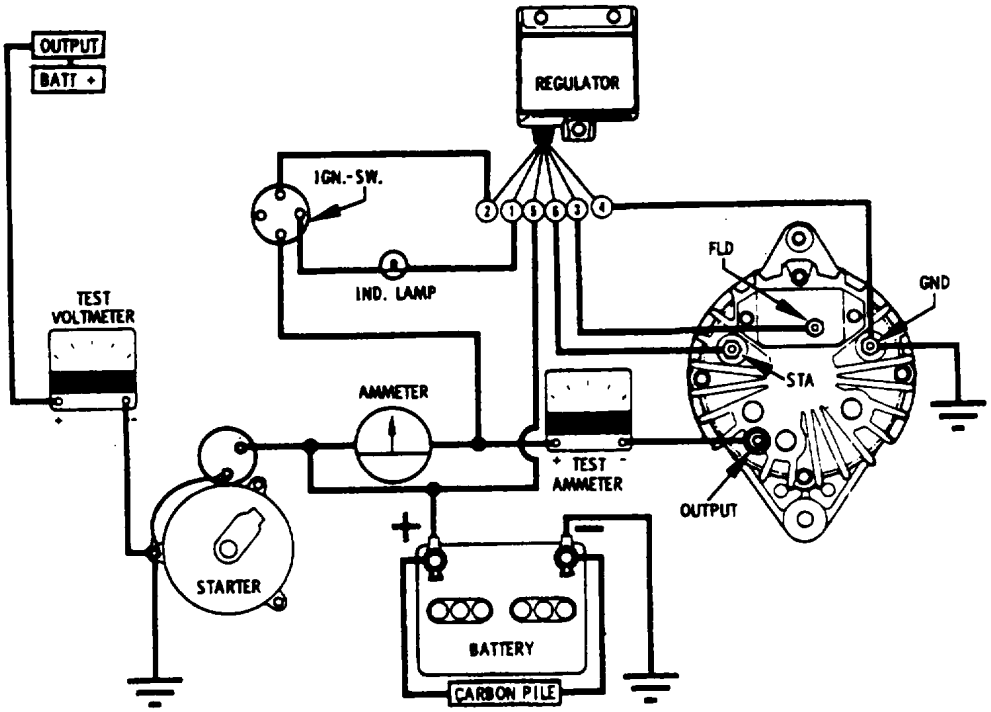


FIGURE NO. 17.

TABLE 2.

Models	Acceptable Minimum Output at Alternator Temperature of 75°F
22 Amperes	18 to 20 Amperes
30 Amperes	28 to 30 Amperes
45 Amperes	40 to 45 Amperes

ALTERNATOR OUTPUT AND SYSTEM TEST - This test will determine if the alternator is capable of producing a minimum rated output. The charging circuit is also tested under partial load to determine if there is excessive voltage loss between the alternator and battery. The test ammeter remains connected in series with alternator output to battery. Carbon pile, with load control knob turned off, is connected across the battery. Connect voltmeter, negative lead to alternator ground terminal, positive lead to alternator output terminal (Figure No. 17).

Start engine and run at 700 to 1000 rpm. Slowly apply carbon pile load until alternator produces 10 ampere output. Let engine operate in this manner for 5 minutes to stabilize component temperature. Increase engine speed to provide 3000 to 4000 alternator rpm. Repair punctured insulation with tape. Regulator may require replacement, if circuit inspection fails to locate difficulty. A low voltage reading would indicate a defective voltage regulator. Remove or switch out 1/4 ohm resistor immediately after test. Reconnect output lead to alternator output terminal.

Increase carbon pile load on the battery so alternator will develop its' minimum rated output, indicated in Table No. 2. Voltage must remain between 13.0 - 15.0 volts. If minimum rated output cannot be reached, the alternator will require disassembly and repairs.

System voltage loss, due to loose connections, etc., is determined while the alternator is producing 10 ampere output. The voltage measured across the battery should be within 0.3 volts of voltage measured from the alternator output and ground terminals. Turn carbon pile control knob off after test to avoid discharging battery. Make necessary repairs to insulated or ground circuit to correct any deficiency.

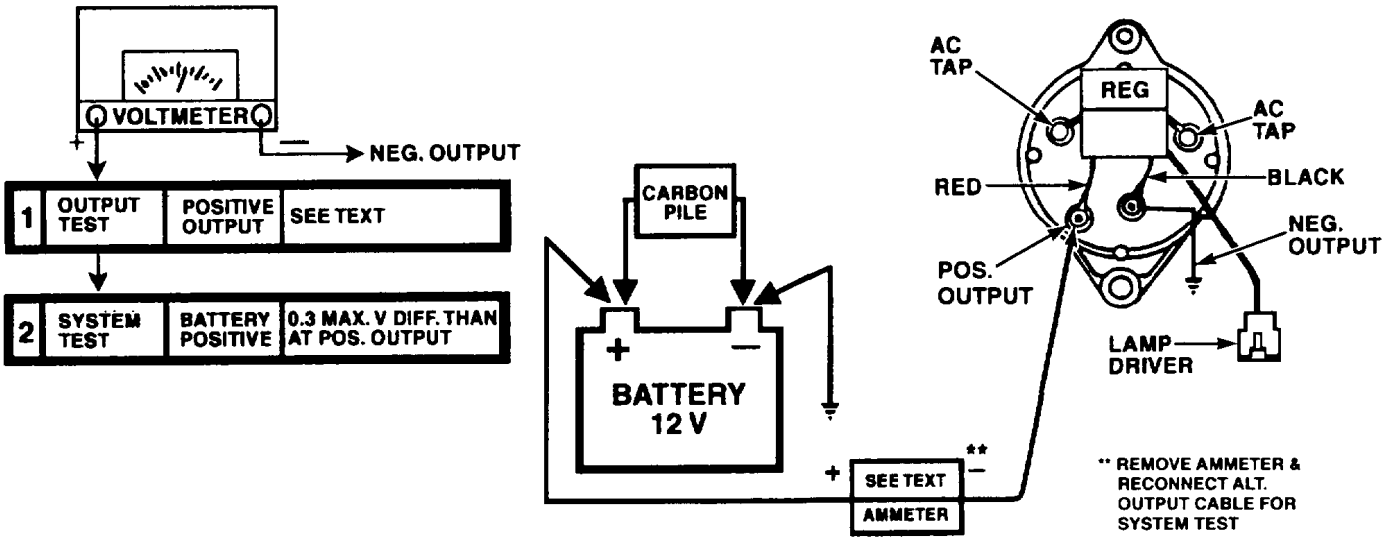


FIGURE NO. 17.1.

ALTERNATOR OUTPUT AND SYSTEM TEST (45 Amp Systems) - This test will determine if the alternator is capable of producing a minimum rated output. Position load control knob of carbon pile to the "OFF" position prior to connecting leads to battery terminals. The test requires that a test ammeter be set to the 0-200 ampere scale, and connected in series with the alternator positive output terminal and battery positive terminal, as shown in Figure No. 17.1.

Start the engine and allow it to run for a few minutes to stabilize component temperatures. Adjust engine speed to 3000-5000 alternator rpm. Apply carbon pile load to the battery to induce highest alternator current output.
Note voltage output. Minimum acceptable (hot) alternator output should be 41-45 amperes. Output voltage must remain between 13.0 and 15.0 volts.

If alternator cannot produce the required output, remove from engine and rebuilt. Reduce carbon pile load on battery immediately after testing to avoid discharging battery.

System voltage drop, between the alternator and the battery, is tested with the alternator producing 10 amperes. The maximum allowable voltage drop, between alternator and battery is .3 (three tenths) volt. Excess voltage loss may require cleaning and tightening of all circuit connections or replacement of output cables between the alternator and the battery.

ALTERNATOR DISASSEMBLY & COMPONENT TESTS

BRUSH ASSEMBLY REMOVAL

1. Remove regulator to gain access to the brush assembly cover (Figure No. 18).

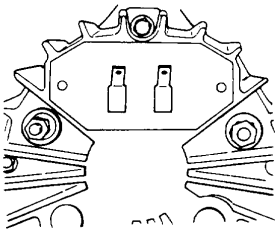


FIGURE NO. 18.

2 With brush assembly cover pulled down and away from back housing, remove two 8 X 1/2" tapping screws retaining brush assembly to housing (Figure No. 19).

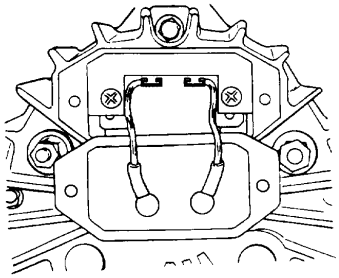


FIGURE NO. 19.

3. To remove brush assembly from the rear housing, grasp field terminal and gently apply outward pressure to brush assembly to clear two positioning tabs on rear housing. As brush assembly clears tabs, continue to pull the brush assembly down and away from housing (Figure No. 20).

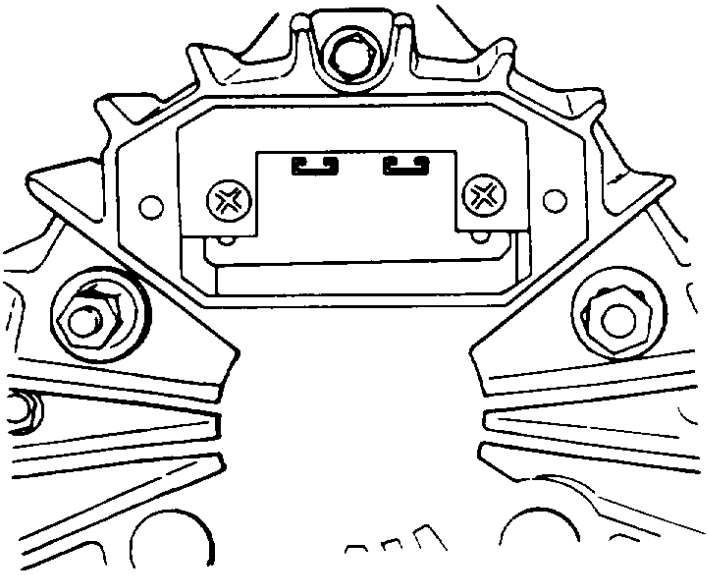


FIGURE NO. 20.

If in the process of brush removal, the brush cover gasket (Figure No. 21) should become damaged or torn, it must be replaced and positioned properly.

NOTE

The brush shunt lead insulator insures that the brush assembly braided leads (Figure No. 21) do not touch the rear housing and ground the field. Should this insulator become damaged, or torn, in the removal of brush assembly, it must be replaced and positioned properly.

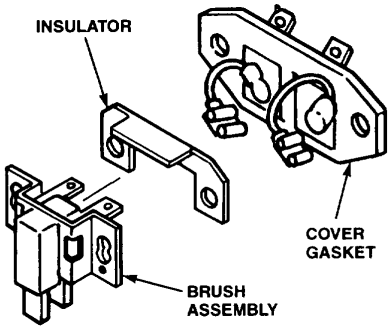


FIGURE NO. 21.

BRUSH ASSEMBLY INSUALTION TEST -

A. Insulation Test: Connect ohmmeter or a test lamp (12 volts) to field terminal and bracket (test points A and D, as shown in Figure No. 22.

Resistance should be high (infinite) or test lamp should not light. If resistance is low, or test lamp lights, brush assembly is shorted and must be replaced.

CAUTION

Alternator brush is constructed of semi-soft material that is easily broken. Use care not to chip brush during testing.

B. Continuity Test: Connect an ohmmeter to field terminal and brush (test points A and C). Use an alligator clip to assure good contact to brush. Resistance reading should be zero. Move brush and brush lead wire to make certain that the brush lead wire connections are not intermittent. Resistance reading should not vary when brush and lead wire is being moved around.

C. Connect ohmmeter to bracket and grounded brush (test points D and E). Resistance reading should be zero. Repeat same test on brush lead wire as described in paragraph "B".

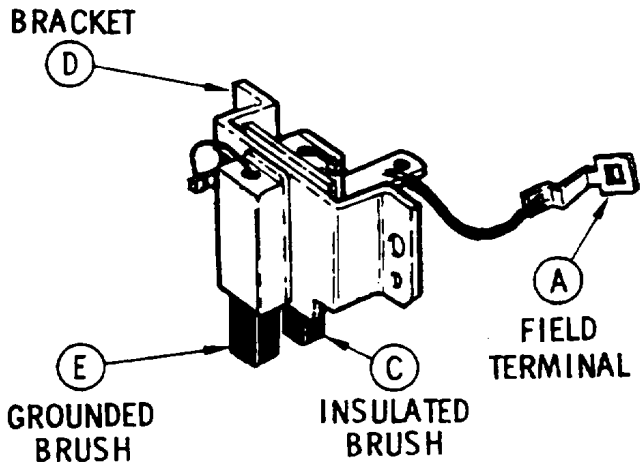


FIGURE NO. 22.

REAR HOUSING REMOVAL -

1. Remove four 1032 X 31/8" through bolts which retain rear housing to front, Figure No. 23.

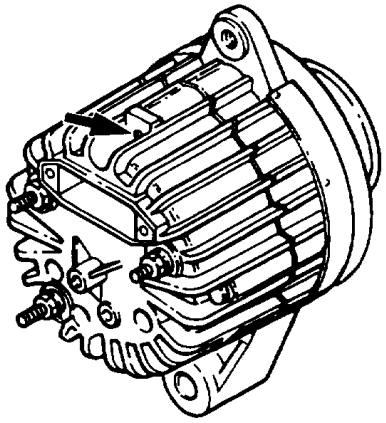


FIGURE NO. 23.

2. Using two screwdrivers, gently apply equal pressure to release the rear housing from front (Figure No. 24). Care should be taken when prying the housing apart to avoid damage to the metal facing of the rear or front housings. When the pressure seal has been released, the rear housing may be grasped and lifted gently from the front housing. The rear housing will only "pull away" from the front, the distance of the length of the diode leads from the stator (Figure No. 25).

NOTE

At this time, inspect the housing gasket. Should the gasket show signs of damage, it should be replaced.

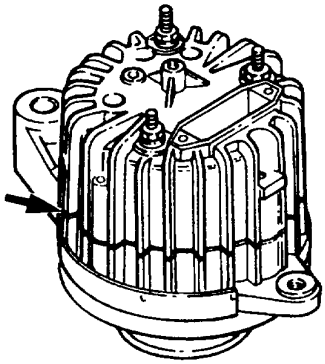


FIGURE NO. 24.

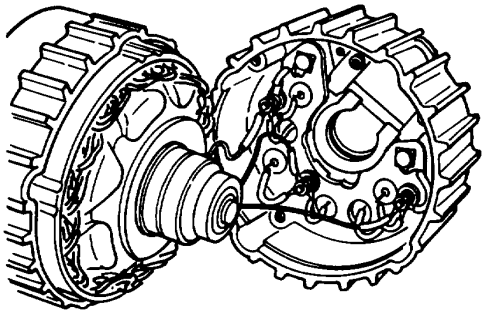


FIGURE NO. 25.

DIODE HEAT SINK REMOVAL-

1. Remove three 10-24 x 3/8" hex nuts, retaining stator leads to heat sink terminal screws (Figure No. 26) Lift stator leads off, separate stator from the rear housing.

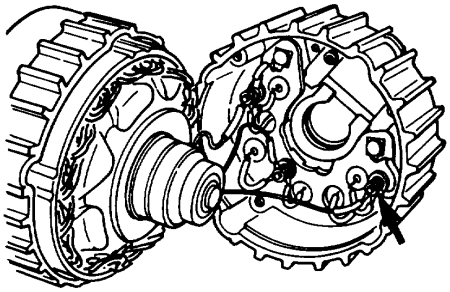


FIGURE NO. 26.

2. Holding the rear housing on its' side, remove the two 10-24 hex nuts and one 1/4-28 nut. Then, remove the split lockwashers and remaining nuts, washers, etc. (Figure No. 27).

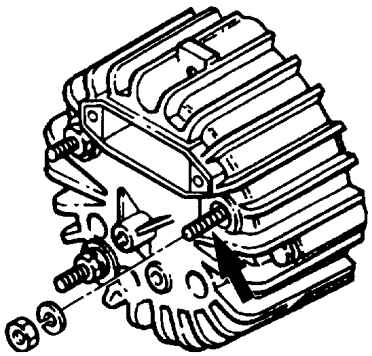


FIGURE NO. 27.

3. Remove the three black leads from the heat sink screws and gently push the heat sink out of the housing. Observe loose leads as plate is being removed, so as not to damage leads (Figure No. 28).

NOTE

Three mica insulators are set against the inside of the rear housing and insulate positive heat sink from rear housing (Figure No. 28). The mica insulators are retained by a recess in the rear housing, plus the use of silicon grease.

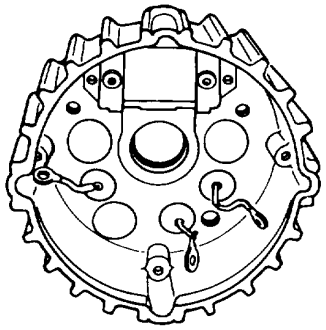


FIGURE NO. 28.

OUT OF CIRCUIT RECTIFIER DIODE TEST - If a commercial alternator rectifier diode tester is available, follow manufacturer's instructions to test all diodes. Do Not Use 120 Volt AC test lamp.

A 12 Volt battery operated test lamp may be used if a commercial tester is not available. Connect one test lead to diode heat sink, the other to each diode wire terminal, Figure No. 29, then repeat test with test leads reversed. Lamp should light with leads in one position, but should not light with test leads reversed. All diodes in heat sink (Figure No. 29) or rear housing (Figure No. 30) should show the same results.

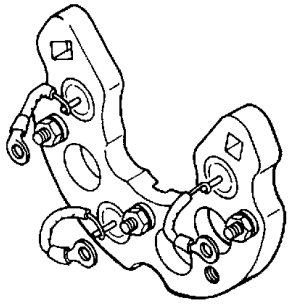


FIGURE NO. 29.

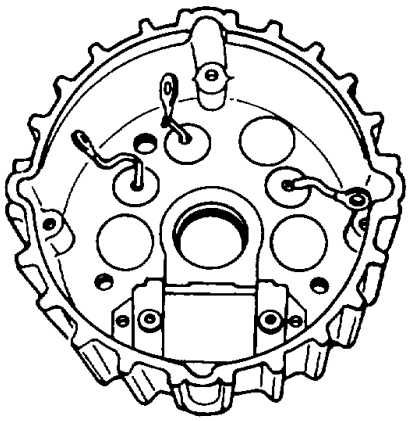


FIGURE NO. 30.

If lamp lights, regardless of how test leads are switched, the diode is shorted. If lamp fails to light in either test, the diode is open. Replace defective diodes, observe correct polarity by color of stamping used to list part number on diode.

REPLACING DEFECTIVE RECTIFIER DIODES-

Note, head of output stud, is a metal to metal contact.

Figure No. 31 shows three positive, rectifier diodes, and terminal studs assemblied in the positive heat sink.

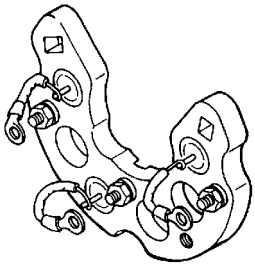


FIGURE NO. 31.

The negative, rectifier diodes, are pressed in the rear housing (Figure No. 32).

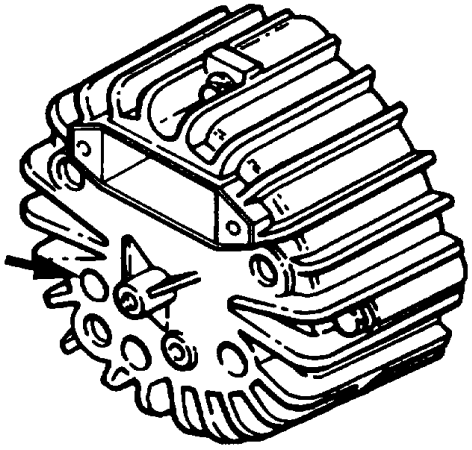


FIGURE NO. 32.

CAUTION

Do not attempt to substitute a replacement diode and solder the lead to the diode stem. The internal heat of the alternator may rise to the point, to soften solder.

The rectifying diode used in the 'TA" alternator have their leads welded, not soldered, to the stems (Figure No. 33).

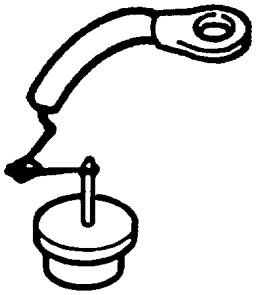


FIGURE NO. 33.

Defective diodes may be pressed out of the heat sink or the rear housing using regular diode service tools. In every case, support the underside of the casting involved to prevent breakage (Figure No's. 34 & 35).

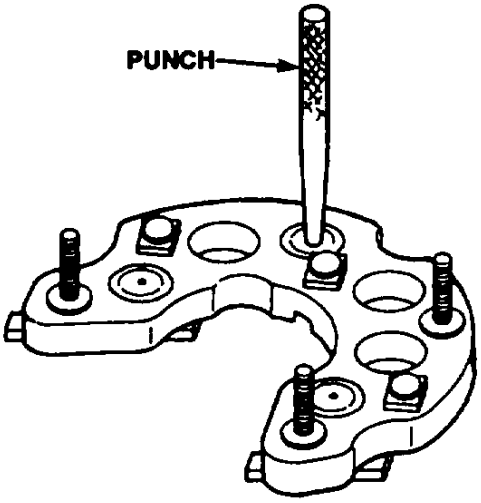


FIGURE NO. 34.

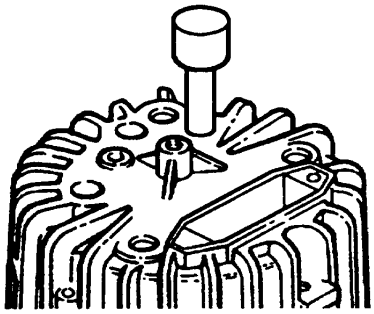


FIGURE NO. 35.

Do not press diodes into same fluted opening of heat sink, a slight twist will allow new diode to cut its own opening providing more efficient transfer of heat from the diode. A typical diode installation tool is shown in (Figure No. 36).

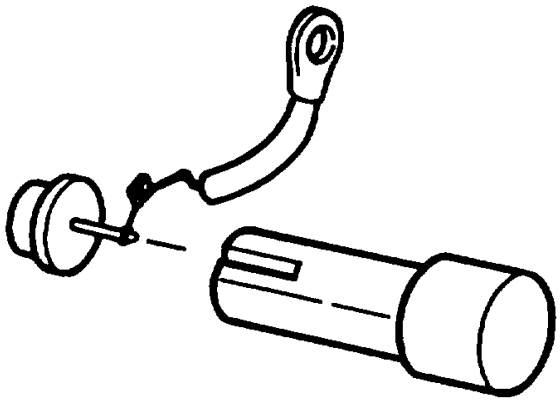


FIGURE NO. 36.

Replace rear housing or heat sink if either is cracked while exchanging diodes. Retest diodes after assembly prior to attaching circuit leads.

STATOR REMOVAL-

1. Grasping the stator, apply pressure to separate stator from housing (Figure No. 37).

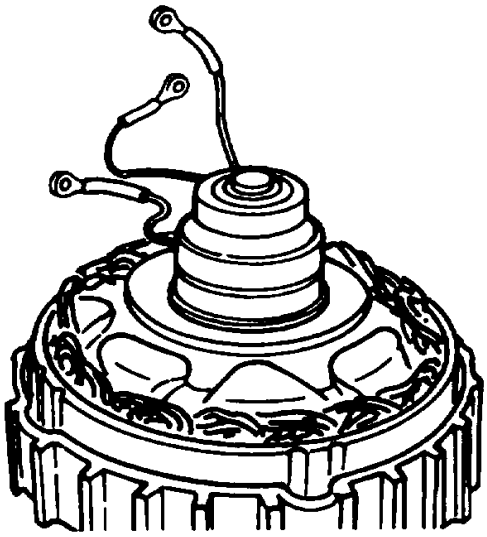


FIGURE NO. 37.

All connections of the TA stator are either welded or crimped and should not be taken apart. Do not attempt to solder replacement leads to the ends of the windings.

The test procedure for each type stator is different, due to the fourth test point on the Wye stator. The objective is the same. The tests must indicate that: (1) all windings are a complete circuit. (2) They are not short circuited to each other. (3) The windings are not grounded. Discoloration of the enamel on the windings is evidence of overheating and may cause a shorted condition. Test stator leads as indicated in Figure No's. 38 & 39.

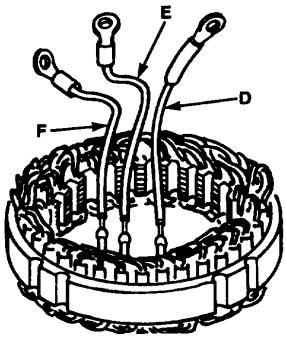


FIGURE NO. 38.

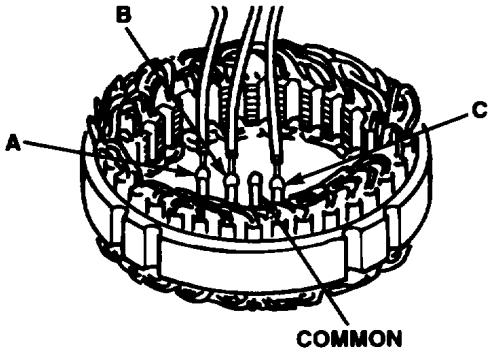


FIGURE NO. 39.

STATOR SERVICE OPERATIONS - The alternator stator consists of three individual windings wound on a common core or lamination. The lamination is Insulated tor durability (Figure No. 40).

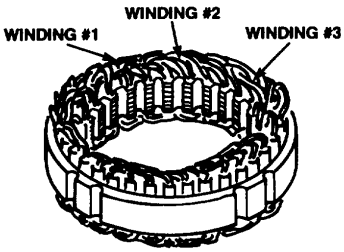
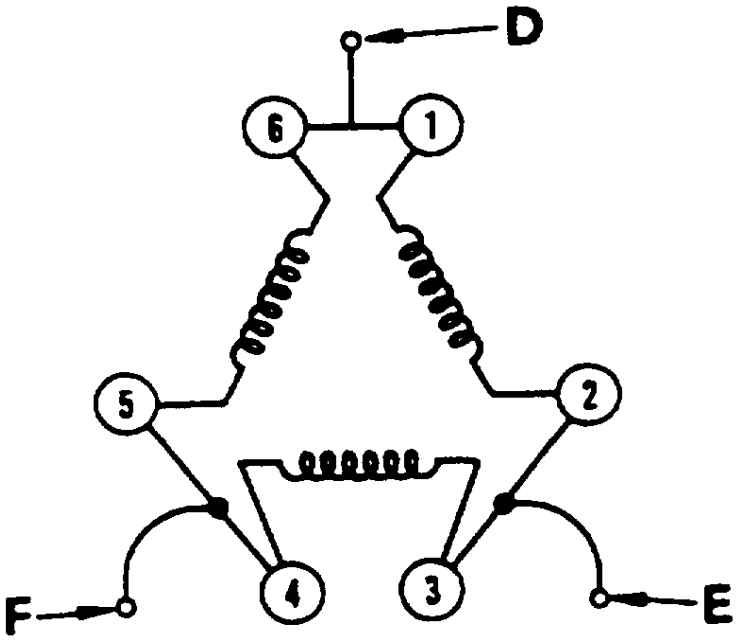


FIGURE NO. 40.

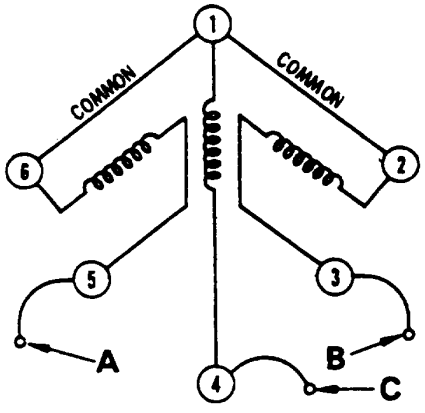
The usual reference to alternator stators concerns the method of terminating the ends of the three windings. They may be connected in a Wye, or a Delta circuit (Figure No's. 41 and 42). The Delta circuit used in 30 and 45 ampere TA alternators, does not have the common termination, just three connecting leads for the rectifying diodes (D - E - F), (Figure No. 41).



DELTA TYPE WINDING

FIGURE NO. 41.

The Wye circuit used in 22 ampere TA alternators, provides a common winding termination, plus three leads to connect the stator to the rectifying diodes (A - B - C) (Figure No. 42).



WYE TYPE WINDING

FIGURE NO. 42.

PULLEY REMOVAL - The various pulleys applicable to the TA alternator, are of a slip type fit. A Woodruff key is incorporated on the rotor shaft for "keying" of the pulley and fan. To remove the nut and lockwasher, clamp the pulley in a vise, using an old oversized belt to protect

the pulley from damage by the vise jaws (Figure No. 43).After pulley mounting nut, and split lock-washer have been removed, the alternator should "pull" back and away from pulley.

NOTE

Should pulley be "frozen" to rotor shaft, while supporting alternator, strike end of shaft with a wooden mallet, plastic hammer or a special puller to break pulley free from shaft.

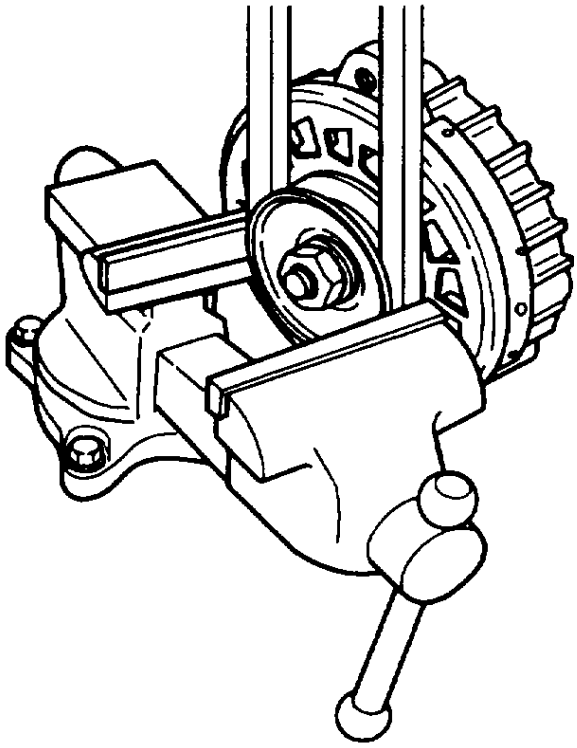


FIGURE NO. 43.

ROTOR REMOVAL FROM FRONT HOUSING -

1. Remove three 8-32 Phillips head, machine screws and lockwashers from the front housing (Figure No. 44).

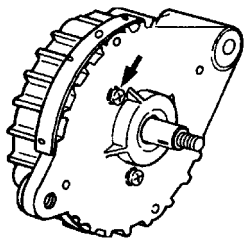


FIGURE NO. 44.

2. Number 5 Woodruff key may be removed by replacing pulley nut oh rotor shaft, with screwdriver wedged between Woodruff key and nut, pry downward to release Woodruff key from shaft (Figure No. 45).

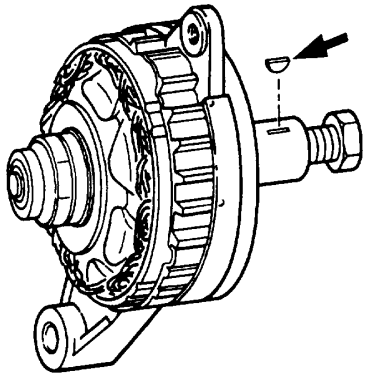


FIGURE NO. 45.

3. Holding the front housing, as shown in Figure No. 46, gently tap the front of the rotor shaft on a wooden block to free rotor and front bearing from the front housing.

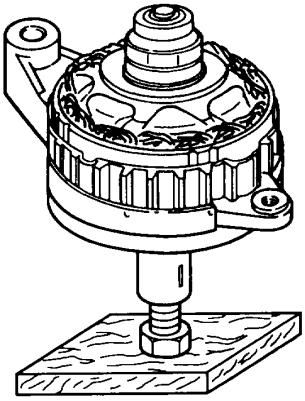


FIGURE NO. 46.

NOTE

Inspect felt dust shield for damage, replace if necessary. Install in recess as shown in Figure No. 47.

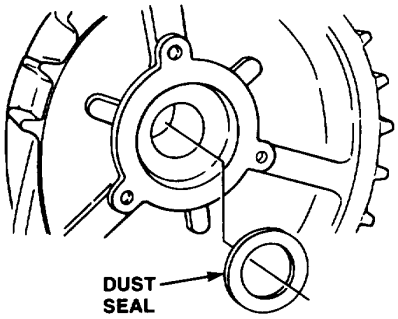


FIGURE NO. 47.

ROTOR ELECTRICAL TEST AND INSPECTION -
Check rotor assembly for the following (Figure No. 48):

A. Continuity and current draw of rotor winding.
   1. .55 to 1.5 ampere at 1 0.Ovolts(70°toB° F).
   2. 11.0 to 12.5ohms.

B. Grounded slip ring, ring connecting cables or rotor winding.
   1. No circuit from either ring to rotor body.

C. Condition of slip rings.
   1. Clean brush contacting surfaces with fine crocus cloth, wipe dust off.
   2. If surface is damaged beyond restoration, replace rotor assembly.
   3. Do not machine surface of slip rings.

D. Rear bearing assembly.
   1. If loose or dry, replace bearing.

E. Rotor shaft and body assembly.
   1. Worn key slot.
   2. Worn bearing surface, front area.
   3. Scuff marks on pole fingers.
   4. Stripped threads.

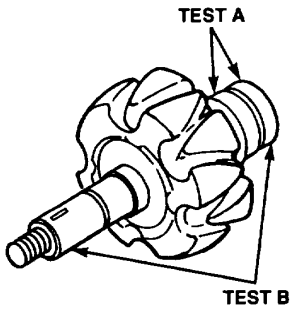
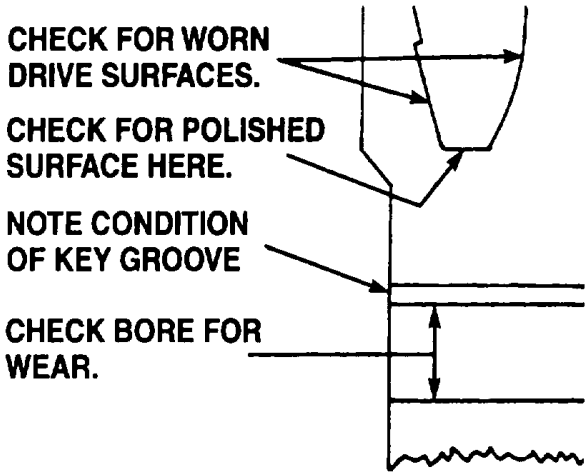


FIGURE NO. 48.

F. Examine the pulley for wear or fracture and inspect key-way for wear. Check the fan for bent or missing fins and possible wear of the mounting hole from running loose. Reuse if in good-condition (Figure No. 49).



CROSS-SECTION OF TYPICAL PULLEY SHOWING INSPECTION POINTS.

FIGURE NO. 49.

FRONT BEARING REMOVAL - Use bearing puller to pull bearing off shaft, if the bearing is to be reused, puller must contact inner race only (Figure No. 50).

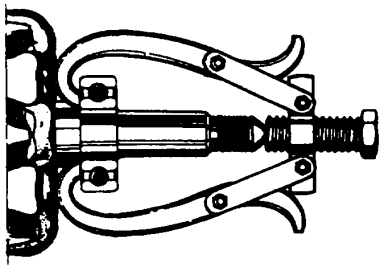


FIGURE NO. 50.

REAR BEARING REMOVAL The rear bearing is a press fit to the rear rotor shaft. Any commercial bearing puller may be used to remove the rear bearing from the shaft (Figure No. 51). Pull on the inner race if bearing is to be reused.

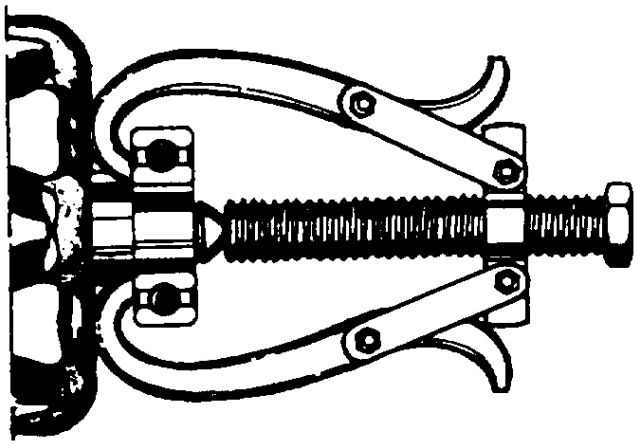


FIGURE NO. 51.

When replacing alternator bearings, it is essential that the replacement bearing be equal to original equipment.

The TA bearings have special clearance between races and bearings, plus they are lubricated with high temperature BRB No. 2 or Andok 260 grease. Refer to Parts List for recommended bearings.

ASSEMBLY OF FRONT HOUSING - Make certain that bearing cavity in front housing is clean and felt dust seal is installed in recess. Press bearing into housing, using driver tool that exerts pressure on outer race only.
Apply only sufficient pressure to seat bearing, against bottom of cavity (Figure No. 52). Install bearing retainer, secure with the attaching screws.

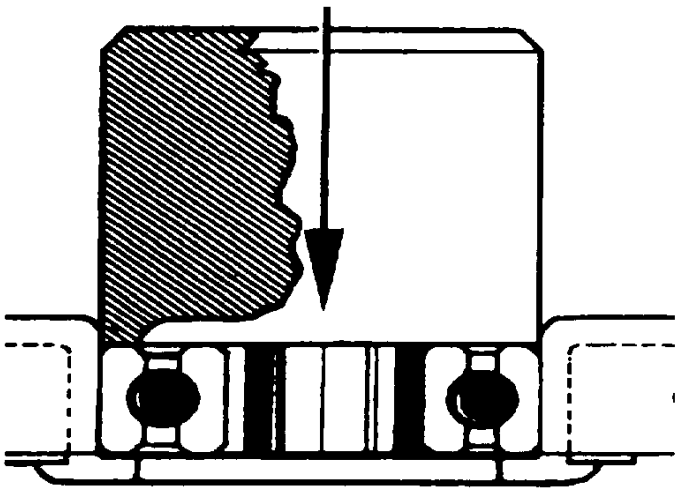


FIGURE NO. 52.

Support bottom of rotor on suitable press, using driver that contacts inner bearing race, press assembled front housing and bearing on rotor shaft. Use only sufficient pressure to seat bearing on shoulder of shaft (Figure No. 53).

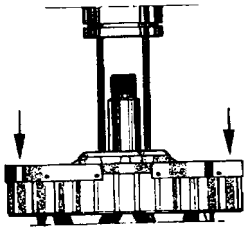


FIGURE NO. 53.

INSTALLATION OF REAR BEARING - Support front rotor shaft in press, using drive that contacts inner race, press rear bearing on shaft uo to the shoulder (Figure No. 54).

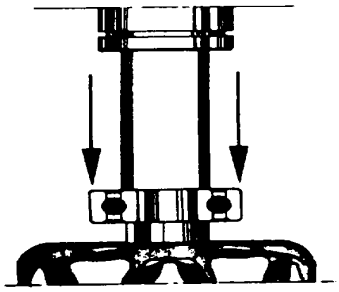


FIGURE NO. 54.

Install new rear bearing retainer in rear bearing cavity (Figure No. 55).

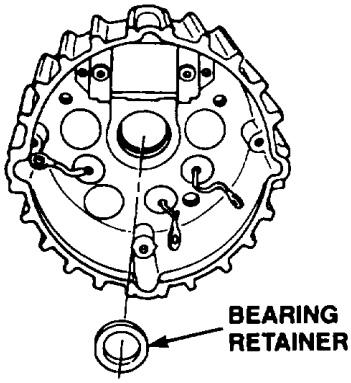


FIGURE NO. 55.

ASSEMBLE HEAT SINK TO REAR HOUSING - The positive rectifier diode heat sink is electrically insulated from the rear housing by fiber insulators and three mica disc insulators. The carriage bolts used for stator and ground terminals are insulated from the heat sink. The 1/4" output terminal bolt is a metal to metal contact with the positive heat sink (Figure No. 56).

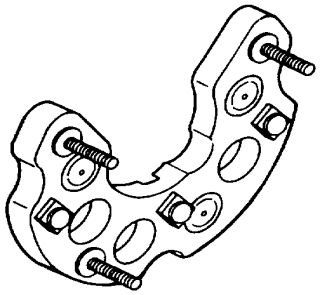


FIGURE NO. 56.

Place each diode terminal screw through a square molded insulator, position in recess of heat sink (Figure No. 57). Place fiber insulating washer, flat steel washer, lockwasher and nut over each screw, tighten securely (Figure No..58).

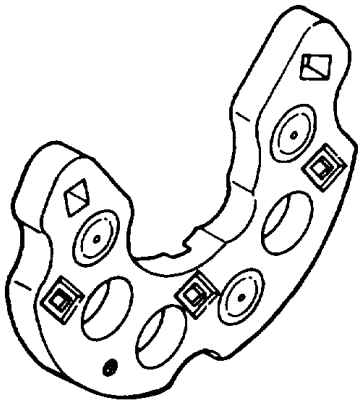


FIGURE NO. 57.

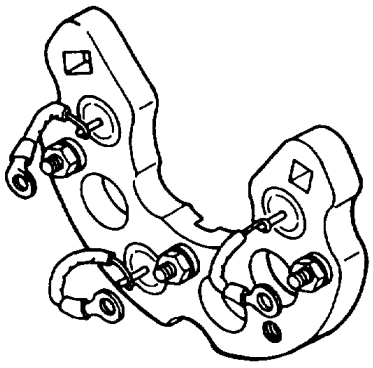


FIGURE NO. 58.

Figure 59 shows the stator tap lead terminal placed over the stator terminal bolt, inserted through a square molded insulator in the heat sink.

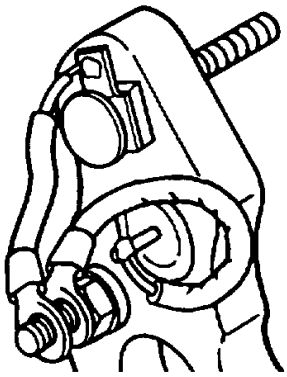


FIGURE NO. 59.

Figure 60 shows assembly of ground terminal bolt and insulators.

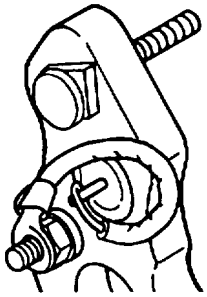


FIGURE NO. 60.

In Figure 61, note insulating washers over output and ground terminal bolts. The fiber washer for the stator terminal is placed over the plastic insulating sleeve. Both are placed over the stator terminal bolt (Figure No. 62).

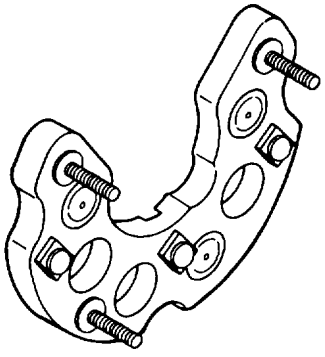


FIGURE NO. 61.

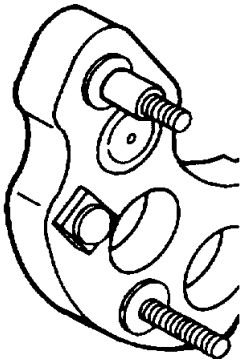


FIGURE NO. 62.

Apply a thin layer of silicon grease to one side of the three, mica discs before they are placed in the recessed area inside the rear housing (Figure No. 63)

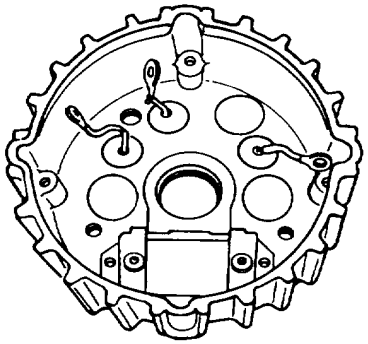


FIGURE NO. 63.

Carefully slide heat sink into rear housing, guiding terminal bolts through the casting. Make certain that all insulating washers are properly positioned. Install external insulating washers on output and stator bolts, follow with flat washers, lockwashers and nuts. The ground terminal bolt is a metal to metal contact, requiring a lockwasher and nut to secure connection (Figure No. 64).

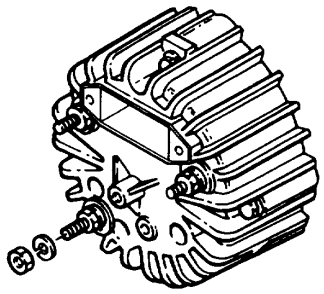


FIGURE NO. 64.

ASSEMBLE STATOR TO REAR HOUSING - Place stator in rear housing, with leads extended toward heat sink. Assemble diode and stator leads to diode terminal screws. When properly assembled, each screw will hold a black lead from a negative diode, a red lead from a positive diode and a lead from the stator. The terminal screw nearest to the stator terminal, will also hold the stator tap lead wire.

Install washers and nuts, secure. Arrange all leads to prevent accidental contact with surfaces or through bolts. Align stator slots with through bolt holes.

ASSEMBLE FRONT AND REAR HOUSING - Place front housing, with rotor assembled, in a vise, drive end down. Place sealing gasket over top edge of-front housing. Place rear housing and heat sink assembly over top end of rotor, align bearing cavity and press halves together.

Position gasket to align with through bolts. Install bolts and tighten securely. Spin rotor by hand to insure proper assembly.

INSTALL BRUSH ASSEMBLY AND COVER - Place insulator over brush assembly, slide into brush cavity, position with alignment pins. Secure insulator and brush assembly to rear housing with screws. Connect brush lead to cover. Place gasket in recess area, install brush cover, secure with screws.

INSTALL PULLEY AND FAN - Place pulley soacer over rotor shaft, install Woodruff key in slot. Place fan and pulley on shaft and install lockwasher and nut. Secure nut at 35 to 50 ft. lbs. Spin rotor by hand to insure fan does not rub housing. This completes the assembly of the alternator.

ALTERNATOR OPERATING TEST (LESS REGULATOR) -

Mount alternator in test fixture capable of providing 3000 to 4000 alternator RPM, in either direction. Connect circuit leads as shown in (Figure No. 65).

Turn drive motor on, adjust to obtain 3000 to 4000 alternator rotor speed. Reduce resistance of field rheostat to zero. Alternator should commence to charge and reach rated output in amperes, within the recommended speed range. Obtaining rated output, alternator is suitable for installation.

Do not operate alternator for more than a few minutes in this manner, due to the lack of voltage control.

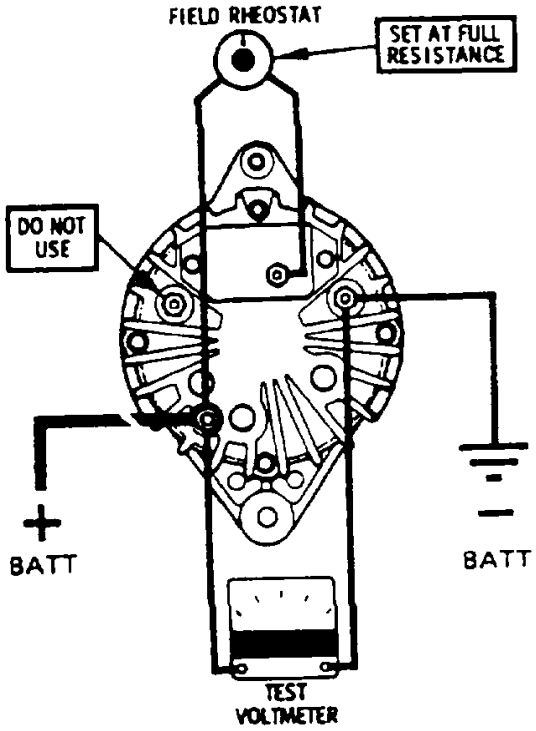


FIGURE NO. 65.

When reinstalling alternator on engine, accurately align alternator and engine drive pulley (Figure No. 66).

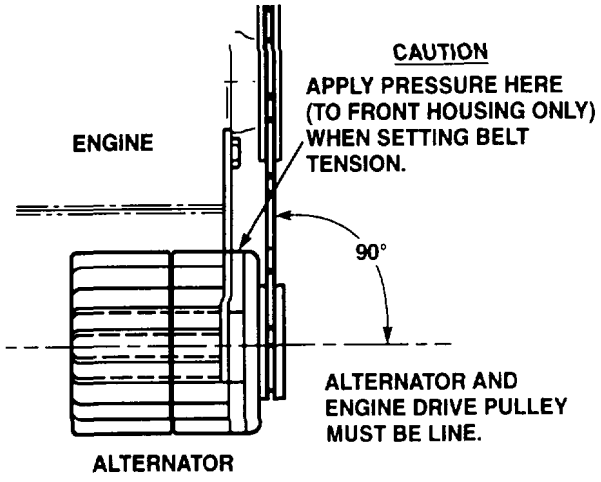


FIGURE NO. 66.

To tighten belt, press against front housing, near alternator fan. Do not apply pressure to alternator rear housing. Set belt tension per manufacturer's recommended specifications and tighten all bolts. If manufacturer's specifications are not readily available, set belt tension tight enough so that the belt on alternator fan pulley will not slip when attempting to rotate alternator fan by hand.

6.11. Starting System Troubleshooting

Troubleshooting Procedures F-297
Starting System Mechanical Checks F-298
Starting System Electrical Checks F-299
Volt Drop Tests F-303

Troubleshooting Procedures

When diagnosing and correcting the cause of trouble with an engine starting system, do not begin by disconnecting wires or disassembling components. Instead, start by analyzing the complaint or symptoms. Then, systematically determine the probable cause. Make a preliminary investigation of the trouble, as follows:

1. Check with the operator or his supervisor before you start troubleshooting. Ask the operator the following:
   a) When did the trouble occur?
   b) Is the trouble accompanied by any other faulty conditions?
   c) How did the trouble happen? Did the trouble happen suddenly? Any abnormality before the trouble happened?
   d) Had the engine or truck electrical system recently been repaired when the trouble occurred? When?
   e) Has the same trouble occurred before?
   f) Does trouble occur when hot, cold or both?
2. Be sure the problem exists. If it is difficult to judge whether a faulty condition requires repair, perform all of the diagnostic electrical checks and tests.
3. It is possible to avoid unnecessary disassembly work by diagnosing the cause of the trouble accurately on the basis of the questions asked of the user. Take the time necessary for sufficient preliminary investigation. Hasty disassembly work can also make it difficult to reproduce the troubled condition and, sometimes, lead to disappearance of the evidence of the cause of the trouble.
4. Start with the easiest and least time consuming solution. When several items are suspected to be the cause of the trouble, examine them, starting with the easiest one.
5. Try to think of the reason why the trouble happened. Do not confine your effort to the correction of the present trouble, but try to detect the fundamental cause, if any, of the trouble and correcting or adjusting it.
6. A good rule to follow in locating trouble is to never remove or make an adjustment to more than one component at a time. Locate the trouble by a process of elimination. The cause is usually simple, rather than mysterious and complicated.
7. When troubleshooting an engine cranking or starting system, keep in mind that more than the starter is involved. The cranking motor is only one of the elements in the starting system. The motor, battery, wiring, and switches all make up the system and each contributes to the proper functioning of that system.
8. It will be helpful to have a good understanding of solenoid, motor, and circuit operation.
9. The following is an important point. The starter demands high current flow from the battery to perform its job. It is essential that the switches, wiring, and connections do not have high resistance which can cause arcing or heat damage to components and excessive battery current use during starter operation. All electrical connections must be clean and tight for minimum resistance. This is especially important for the battery cable connections at the battery terminals.
10. The starter is a special type electric motor that operates on low dc voltage and must be able to withstand extremely high current. The high current carrying requirement means that the motor can be operated for only short periods of time. To prevent overheating, periods of operation of more than 30 seconds in duration are not recommended.

WARNING

Battery service must be done by trained personnel. Battery acid can cause severe burns and injury.

NOTE

To perform this service procedure, it is recommended that you first:

- truck safely.
- Apply parking brake and block drive wheels.
- Return all controls to neutral and turn ignition key OFF, except as otherwise noted.

Refer to Section 2. 1, Service Specifications, Section 4.3, Engine Tune- Up, and Section 6.1, Electrical System Wiring.

Minimum Tools Required

- Digital voltmeter.
- Volt-ohm meter.
- Battery tester.

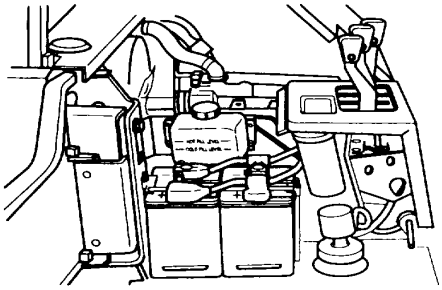
WARNING

Remove all jewelry (watch, rings, bracelets, etc.) before working on electrical systems. Severe burns can result from contact with electrical circuits.

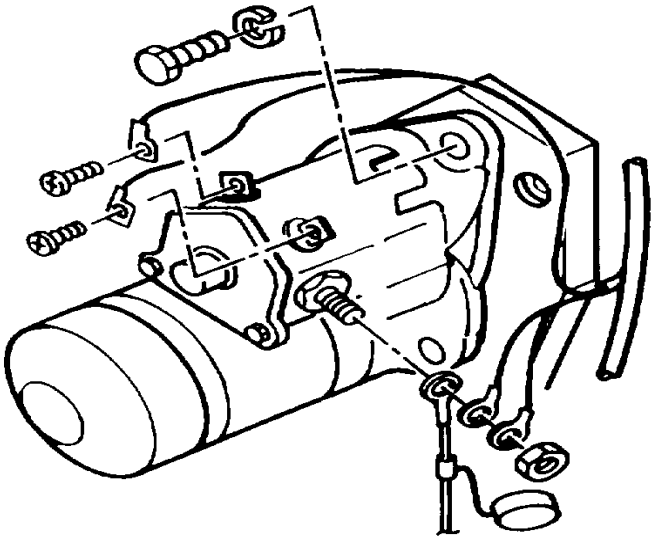
CAUTION

Always follow the manufacturer's instructions for the test instrument being used when making connections and tests on electrical circuits or damage to equipment could occur.

Starting System Mechanical Checks

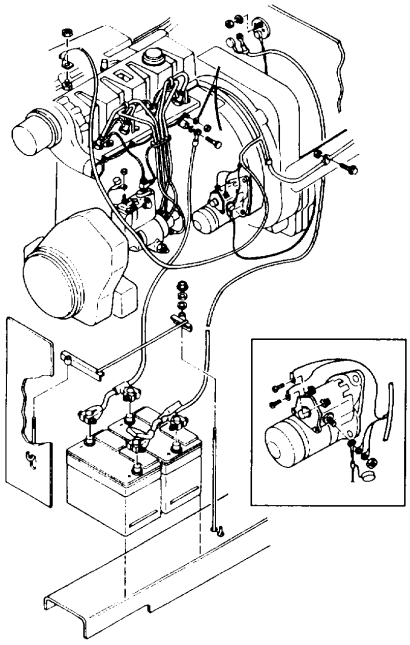


1. **Check the battery.**
   Be sure that the battery is in good condition and fully charged before attempting to test the starter and wiring circuit for problems. It is recommended that you perform a voltmeter test and a battery load test.



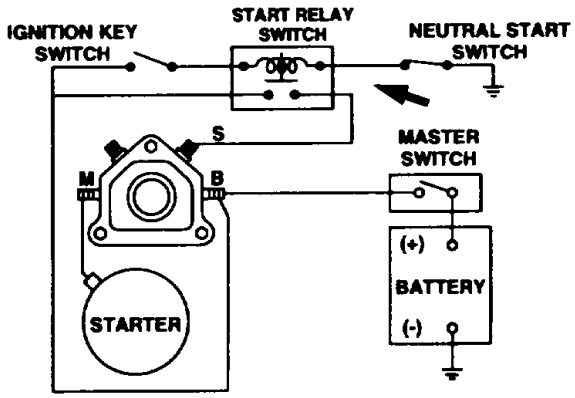
2. **Check starter mounting bolts.**
   The bolts which mount the starter motor to the flywheel housing must be kept tightened to the correct torque. The starter must be held tightly in the proper mounting position for correct engagement with the engine flywheel to prevent damage to both starter pinion and ring gear teeth, and to provide starter ground circuit.

Refer to Section 2. 1, Service Specifications, for starter mounting bolt tightening torque.



3. Check the wiring.

Inspect the wiring for damage. Inspect all connections to starter motor, solenoid, starter relay, ignition switch, neutral start switch, any other control switch, and battery, including ground connections.
Clean and tighten all connections as needed.



4. Check starter relay (magnetic switch), neutral start switch, and ignition key switch to determine their condition. With switches closed, use a voltmeter to check the circuit for continuity. Replace defective switches and wiring as required.
5. Check fuses.

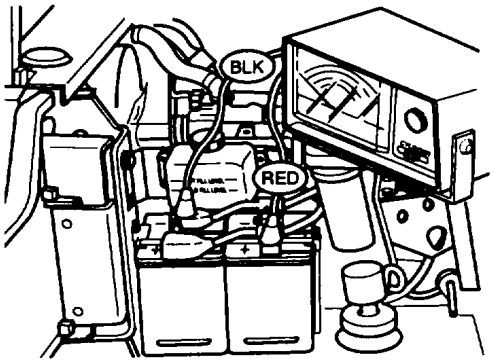
Starting System Electrical Checks

NOTE
When servicing the starting system, never remove a unit until tests have shown it to be defective.

The following describes typical troubleshooting procedures for two of the most common starting system problems.

Slow or Sluggish Cranking
Slow or sluggish cranking is one of the more complex problems to solve. The battery, wiring, switches, starter motor and engine are all factors that must be checked to determine where the problem is.

1. Disconnect the fuel shut-off solenoid. This will prevent the engine from accidentally being started while performing starting system electrical checks and cranking tests.



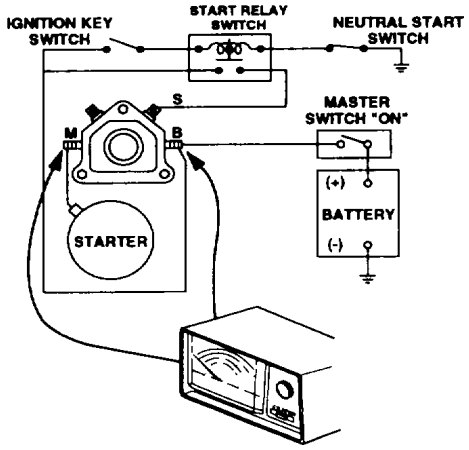
2. Perform a battery load test. Connect a voltmeter across the battery terminals. Crank the engine for 15 seconds. Measure the voltage on the voltmeter.

See following procedures.

a) Voltage less than 9.6 volts. Check battery and connections. If the voltage drops below 9.5-9.7 volts at temperature of 70-80'F [21-27'C]:
   (1) Test the battery with a voltmeter. If the battery is discharged or suspected of being defective, charge it and test it per recommended procedures.
   (2) Replace the battery, if necessary.
   (3) Be sure that the correct battery (size and rating) is installed in the truck.
   (4) Check for bad connections at battery terminals.
   (5) Clean and tighten all battery connections.

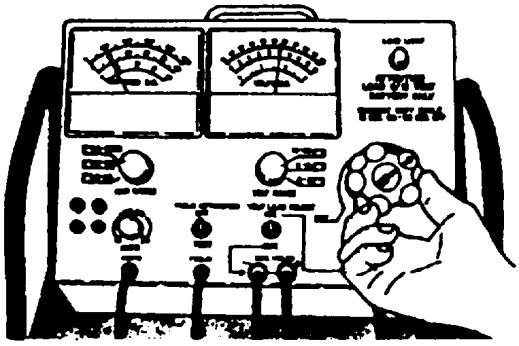
b) Voltage above 9.6 volts. If the voltage stays above 9.6 volts:

(1) Be sure all battery connections are clean and tight.



(2) Test the current draw of the starter. Connect an ammeter and carbon pile battery load tester in parallel with the battery terminal of the starter solenoid and ground (frame or battery negative terminal). **Be sure that the tester, is turned OFF**.

Clip-on inductance tester may be used.



(3) Increase the load (current) until the same voltage is reached as measured when cranking the engine. Note the ammeter reading. Turn OFF the load. The ammeter reading indicates the cranking system current draw.

(4) Compare the measured system draw with the typical current requirements of the diesel engine lift truck system.

Typical starter current draw: 180-220 amps.

c) Low current means high circuit resistance. Clean connections or replace wiring.

(1) If the current draw is low, measure the voltage drops in the starter motor circuit (see Starting System Electrical Checks) while cranking the engine. Large drops of over 0.4-1 volt indicate the need to clean and tighten connections or replace wiring in that portion of the circuit.

(2) Use volt-drop test to find source of high resistance.

d) High current means high drag resistance.

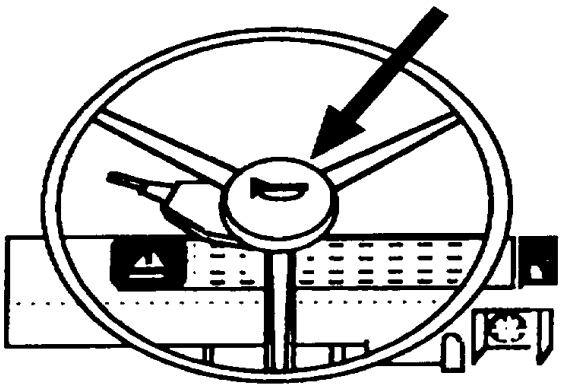
(1) If excessive current is observed, then either a poor engine condition exists, such as tight rings, tight bearings, or lack of lubrication, or the starter motor needs to be removed and repaired. The starter motor should be checked for tight bearings, pole shoe rubbing, and shorted or grounded armature or field coils.

(2) Use torque wrench to measure force required to turn engine over.

Nothing Happens When Start Attempt Made

1. If the starter motor won't crank the engine, it may be simply a poor electrical contact that is the problem. Loose or corroded battery connections can slow down or stop a starter motor. A loose connection may allow enough current to pass to operate some electrical accessories but not the starter motor.
2. The problem may be either a defective or discharged battery.
3. The problem may be an open circuit, loose connection, or other defect in the starter motor, solenoid switch, starter relay, neutral start switch, ignition switch, or the wiring.
4. The best procedure in diagnosing this type of starting problem is to systematically check the possible trouble points, starting with the easiest.

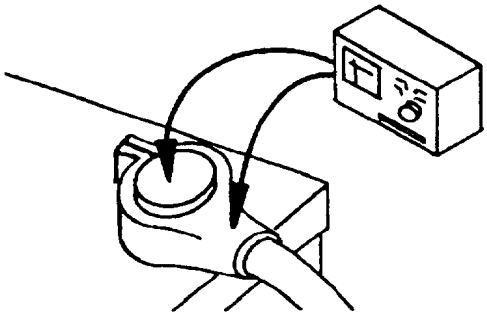
See following procedures.



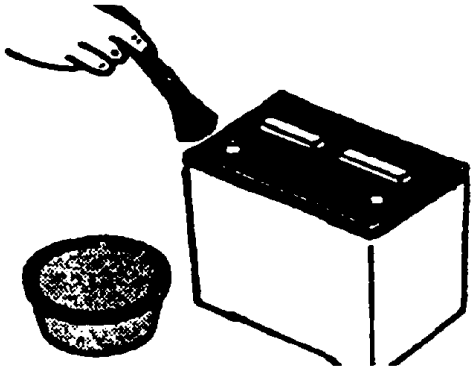
a) Check the neutral start switch. Try moving jiggling) the directional control lever in the NEUTRAL position, or shifting into NEUTRAL while turning the ignition key switch to the START position. The key switch must be turned back to the OFF position each time before turning to the START position.
b) Check the connections at the battery. They should be free from corrosion and securely tightened. If heat is felt at any of the connections, this is an indication that a poor connection exists.

WARNING

To be safe when checking or removing battery connections for cleaning, first disconnect the negative battery cable at the end where it is attached to the engine or frame ground connection. Then, try to move (twist) the cable connectors at the battery back and forth to be sure that they are tight.



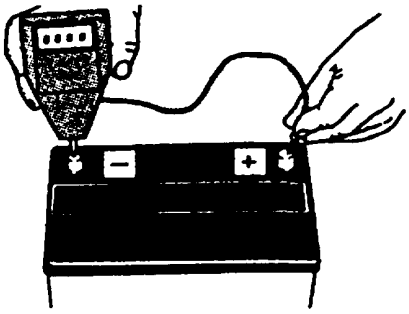
(1) Perform a volt drop test on the battery post terminal connections.
Refer to Starting System Electrical Checks.



(2) If the connections are tight but need cleaning, remove the cables and clean the battery posts and the inside of the cable connectors, using a wire brush or a special battery terminal cleaning tool to remove the oxidation film. Also, remove any contamination and sulfate deposits that may have formed on the battery. Clean the battery with a solution of baking soda and water. Rinse with clean water. Be careful not to get any cleaner or dirt in the battery vent holes.

(3) Reconnect the battery cables in reverse order of removal, by connecting positive (+) cable first, then negative (-) cable, and attaching the negative cable to the engine or frame ground last. This way, any spark that is produced will be far from the battery. Wipe the battery clean with a cloth or paper towel.

(4) Try starting the engine again.



(5) If the starter still does not operate, check the charge condition of the battery with a hydrometer or digital voltmeter.

c) If the battery is discharged, it may be defective or it may be because the charging system is not working properly. If the battery case is not cracked or damaged and otherwise appears to be in good condition, recharge the battery and see whether it holds the charge. Also, check the charging system.
Refer to Alternator Maintenance Procedures.

d) Check the fan/alternator drive belt for damage and correct tension. Replace or adjust the belt, as necessary.

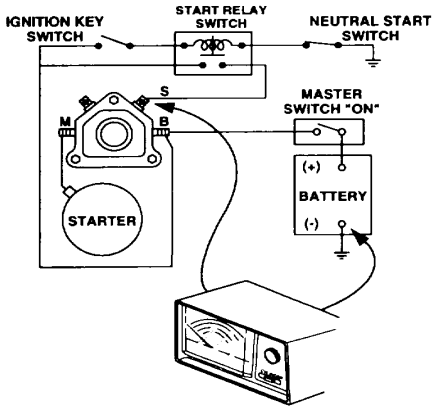
NOTE

• Just as a discharged battery is not necessarily bad, a charged battery is not necessarily good. An old, or defective battery may show a full charge but be unable to produce adequate electrical energy to meet the heavy load demand of the starter motor. The only way to tell is with a load test.

• Battery must be fully charged to perform load test.

e) Perform a load test to determine whether the battery is good or defective. If the starter still does not crank the engine, you will need to use a battery tester. Disconnect the battery cables at the terminals. Either remove the battery for testing, or connect the tester to the battery in the truck. Refer to the manufacturer's instructions for recommended load test procedure using a battery tester. **Battery defective**: replace battery. **Battery good:** continue in service Replace the battery, if necessary. Reconnect the battery cables in the correct order of installation (ground cable last).

f) If the battery and its connections check out satisfactorily but the starter still won't crank the engine, the problem is probably in the starter motor, the solenoid switch, the starter relay, the ignition switch, or the wiring.



g) Check voltage at the starter solenoid "switch" (S) (I) (R) terminal, while attempting to crank the engine. Connect the voltmeter between the "switch" terminal and the frame (body) of the starter motor or the battery negative terminal, and try to crank the engine.

NOTE

The ignition switch has a circuit through the starter relay (magnetic switch) and neutral start switch, separate from the circuit through the starter relay to the starter solenoid.

(1) If voltage is 0 or less than 7 volts, check for wiring continuity (broken, loose, or disconnected wire) or defective switches such as the ignition key switch or starter relay (magnetic switch). Also, check the starter motor-to-engine block ground connection and the battery negative (ground) cable connections.

(2) If the voltage is over 7 volts, the starter solenoid is defective and must be repaired or replaced.

Volt Drop Tests 3

The objective of volt drop tests is to check circuit resistances of wiring and starter motor circuit in order to locate trouble spots.

1. **Check voltage drops with engine cranking**. The procedure is to look at resistance in terms of the voltage drop across a portion of the circuit while the engine is being cranked.

WARNING

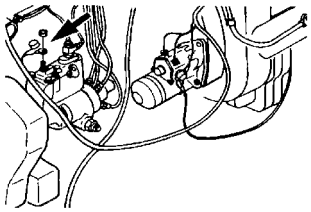
For safety when checking or removing battery connections, always first disconnect the negative battery cable at the engine ground connection.

NOTE

• The following tests assume that the engine is in good operating condition and the battery is at or close to full charge.

• Rule of thumb formula for measuring voltage drops: Maximum circuit voltage drop- 0.20 volts per 100 amps.

2. **Prevent engine from starting when cranking.**

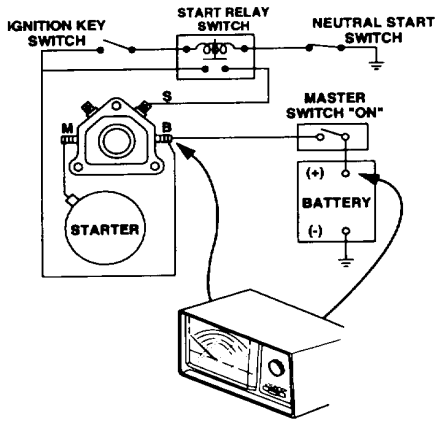


Disconnect the fuel shut-off solenoid so the engine will not start.

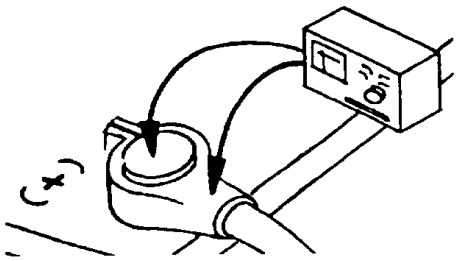
CAUTION

Never operate the starter motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating caused by excessive cranking will seriously damage the starter motor.

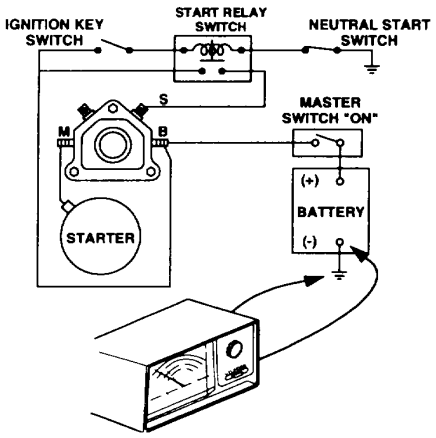
3. **Crank engine and read voltage**



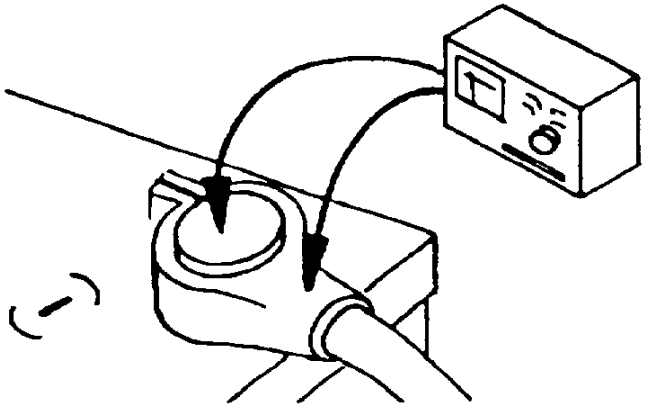
a) Check battery positive cable and connections. Connect a voltmeter from the positive (+) battery terminal to the "Battery" terminal on the starter solenoid. With the voltmeter set on its lowest scale, crank the engine for 15 seconds, and measure the voltage. A reading higher than 0.4 volts indicates high resistance. Check the cable for loose connections or the battery terminal connection for corrosion.



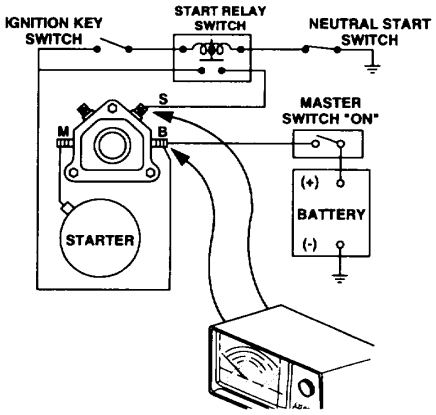
b) To check positive post battery terminal connection, connect voltmeter from the battery post to the terminal on cable. Crank the engine. A voltage reading above 0 volts indicates a poor connection. Clean the terminal post and cable end. Tighten bolt.



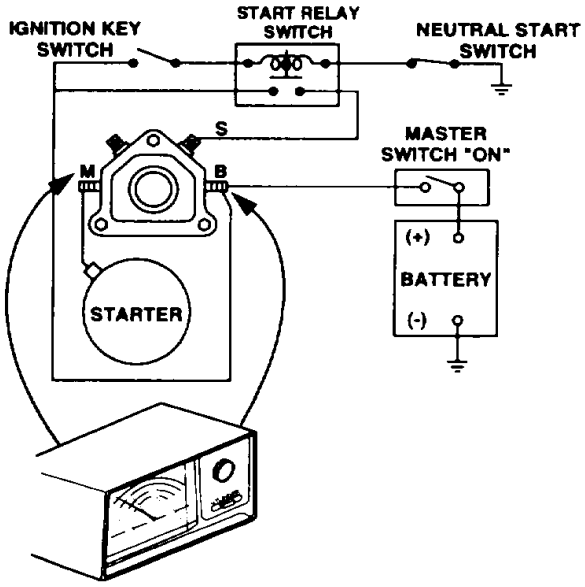
c) Check battery negative (ground) cable and connections. Connect a voltmeter from the negative battery terminal to the bolt that mounts the battery negative cable to the ground connection on the engine or frame. While cranking the engine, a voltmeter reading higher than 0.4 volts indicates excessive resistance. Check the cable for loose connections or the battery terminal for corrosion. Clean and tighten the terminal post and cable ends.



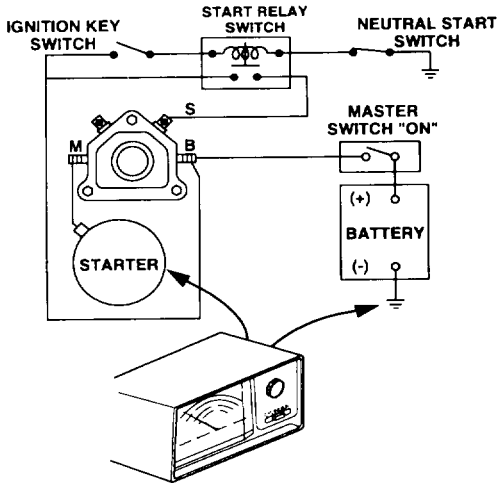
d) To check negative post battery terminal connection, refer to positive post test above.

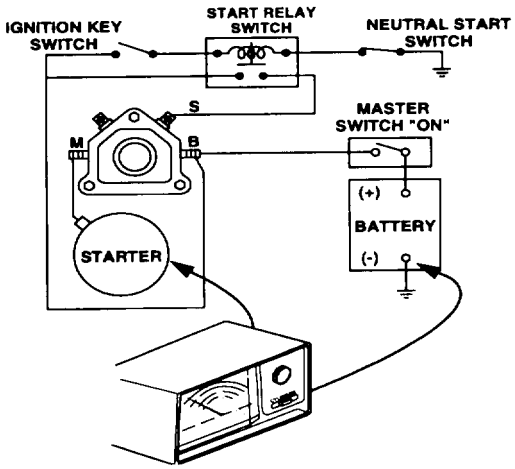


e) Check key switch, starter relay, and solenoid circuit. Connect a voltmeter across the "Battery" terminal of the solenoid and the "Switch" terminal of the solenoid. A voltmeter reading of 1.02.0 volts is expected with the engine cranking. A reading of more than 2 volts indicates excessive resistance. Check the wiring, connections, and switches in this portion of the circuit.



f) Check the starter solenoid disc contact. Connect a voltmeter across the solenoid "Battery" terminal and the solenoid motor terminal. With the engine cranking, a voltage reading of less than 0.2 volts should be measured. A reading higher than 0.2 volts indicates excessive resistance within the solenoid. Check the solenoid contact disc and terminals.





g) Check starter ground circuit. Connect a voltmeter from the frame (body) of the starter motor to either a point on the engine flywheel housing or the bolt that mounts the battery negative cable to the ground connection on the engine or frame. While cranking the engine, a reading higher than 0.2 volts indicates excessive resistance. Clean the starter mounting bolts and flange.

Alternate - Connect the voltmeter from the frame of the starter motor to the battery negative terminal post. While cranking, a reading higher than 0.4-0.6 volts indicates excessive resistance.
Clean starter mounting flange and bolts, check battery negative cable for damage, and clean and tighten battery cable connections.

6.12. Starter Motor Troubleshooting

On-Vehicle Troubleshooting F-307
Starter Motor Tests F-307
Starter Solenoid Volt Drop Test F-308
Starter No-Load Test F-309
No-Load Test Diagnosis F-310
Starter Disassembly F-310

On-Vehicle Troubleshooting
For additional information please refer to:

- Section 2. 1t Service Specifications

- Section 4.3t Engine Tune-Up
- Section 6. 1t Electrical System Wiring
- Section 6. 11t Starting System Troubleshooting.

WARNING

• Battery service must be done by trained personnel.
• Battery acid can cause severe burns and injury.

• Remove all jewelry (watch, rings, bracelets, etc.) before working on electrical systems. Severe burns can result from contact with electrical circuits.

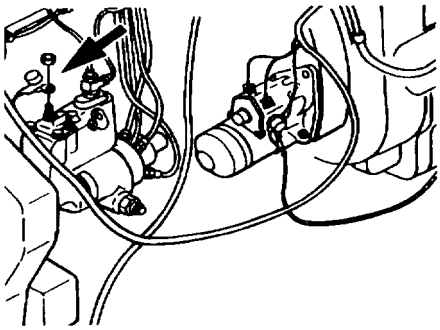
NOTE

To perform this service procedure, it is recommended that you first:

• Park truck safely.
• Apply parking brake and block drive wheels.
• Return all controls to neutral and turn ignition key OFF, except as otherwise noted.

Always follow the manufacturer's instructions for the test instrument being used when making connections and tests on electrical circuits.

Minimum Tools Required
• Digital voltmeter.
• Volt-ohm meter.
• Battery tester.



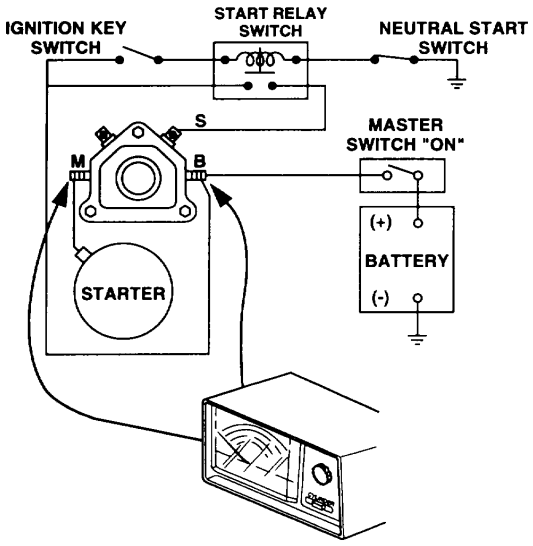
Disconnect the fuel shut-off solenoid. This will prevent the engine from accidentally being started while performing starting system electrical checks and cranking tests.

Starter Motor Tests

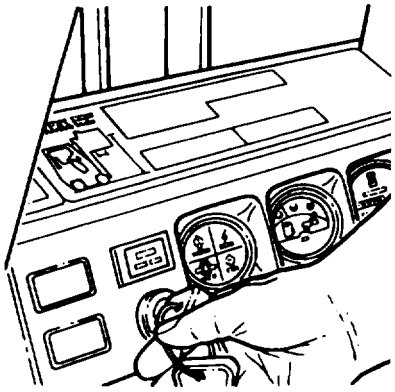
1. Starter Solenoid Volt Drop Test

Use the lowest volt scale on the voltmeter to measure the solenoid voltage while the starter is cranking the engine

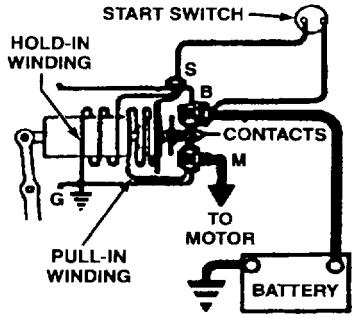
2. Disc Contact Test



a) Turn the analyzer function switch to the volt-drop scale.
b) On the starter solenoid, connect the positive (+) analyzer cable to the solenoid "Battery" terminal post and the negative (-) analyzer cable to the solenoid motor terminal post.

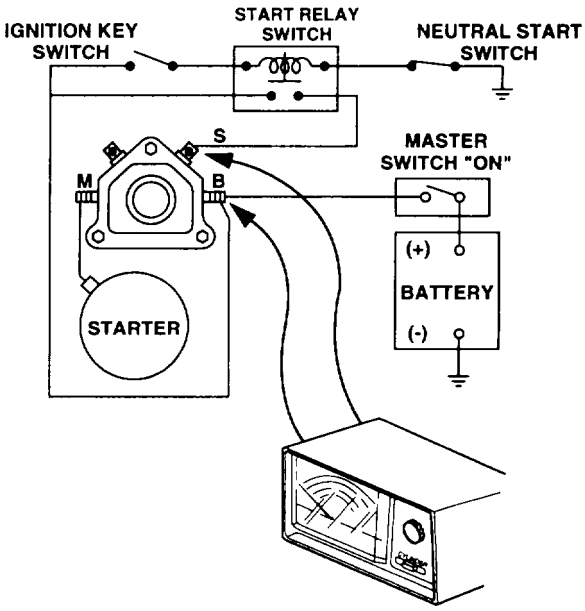


c) Turn ignition key switch to the START position and crank the engine for 15 seconds, maximum. Turn key switch OFF.

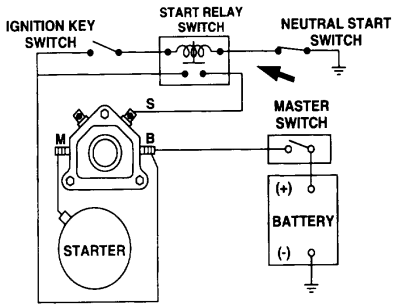


Diagnosis of results: While cranking the engine, a voltmeter reading higher than 0.2 volts indicates excessive resistance within the solenoid switch assembly. For example, the solenoid disc contact is good if the voltage is 0.1-0.2 volts. The solenoid disc contact is faulty if the voltage is 0.21-0.55 volts. Check and clean or repair the solenoid switch contact disc and terminals.

Starter Solenoid Volt Drop Test



1. Turn the analyzer function switch to the volt-drop scale.
2. On the starter solenoid, connect the positive (+) analyzer cable to the solenoid "Battery" terminal post and the negative (-) analyzer cable to the solenoid terminal post.
3. Turn ignition key switch to the START position and crank the engine for 15 seconds, maximum. Check the voltmeter reading. Turn key switch OFF.



Diagnosis of results: With the engine cranking, a voltmeter reading of more than 2 volts indicates excessive resistance in solenoid circuit. For example, the solenoid is good if the voltage drop is 0.1-1.25 volts. Voltage readings of 1.25 volts and higher indicate faulty connections, wiring, switches, or starter relay. Check the wiring, connections, and switches in this portion of the circuit.

Starter Removal May Be Necessary

If all other components of the starting system (battery, starter solenoid, starter relay, switches, and wiring) are in satisfactory condition, and the engine is known to be functioning correctly, but starter does not operate or operate correctly, the starter may have to be removed from the engine for further testing and repair or replacement.

Starter Motor Inspection

With the starter removed from the engine, the pinion should be checked for freedom of operation by turning it on the screw shaft. The armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely, the motor should be disassembled without further tests. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

Starter No-Load Test

CAUTION

• Be sure switch is OPEN before connections or disconnections are made.

• Do not apply voltage above what is specified. Excessive voltage may cause the armature to throw windings.

NOTE

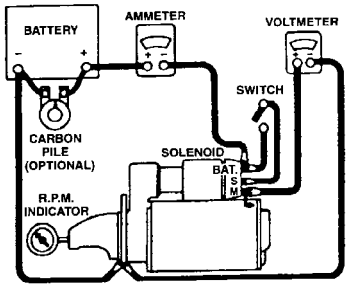
It is not necessary to obtain the exact voltage specified, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher, the rpm will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value.

To obtain full performance data on a starter motor or to determine the cause of abnormal operation, the motor should be subjected to a "no-load" test. This test is performed, as described below, with the starter removed from the engine.

The no-load test may point to specific defects which can be verified with tests when disassembled. Also, the no-load test can identify open or shorted fields, which are difficult to check when disassembled. The no-load test also can be used to indicate normal operation on a repaired motor before installation.

No-Load Test Procedure

To perform the no-load test, connect the starter motor in series with a fully-charged 12-volt battery, as described below. Use an RPM indicator to measure armature speed. Then read the current draw and the armature speed and compare these readings with the values listed in the motor specifications.



1. Connect a voltmeter from the motor terminal to the motor frame.
2. Connect the motor and an ammeter in series with a fully-charged 12-volt battery and a switch in the OPEN position from the solenoid battery terminal to the solenoid switch (R) terminal.
3. Hold the RPM indicator against the exposed end of the armature shaft.
4. Close the switch and compare the rpm, current, and voltage readings with the specifications.
5. Be sure that the switch is OPEN before making any disconnections.

No-Load Test Diagnosis

1. Rated current draw and speed indicates normal condition of the cranking motor.
2. Low free speed and high current draw indicates: a) Too much friction - tight, dirty, or worn bearings, bent armature shaft, or loose pole shoes allowing armature to drag.
   b) Shorted armature. This can be further checked on a growler after disassembly.
   c) Grounded armature or fields. Check further after disassembly.
3. Failure to operate with high current draw indicates: a) A direct ground in the terminal or fields.
   b) "Frozen" bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates: a) Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
   b) Open armature coils. Inspect the commutator for badly burned bars after disassembly.
   c) Broken brush springs, worn brushes, high insulation between the commutator bars, or other causes which would prevent good contact between the brushes and commutator.
5. Low no-load speed and low current draw indicates high internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.
6. High free speed and high current draw indicates shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

Starter Disassembly

If the starter motor does not perform in accordance with the listed specifications, it may need to be disassembled for further testing of the components.

Normally, the starter motor should be disassembled only so far as is necessary to repair or replace the defective parts.

Refer to Starter Repair (Para 5-20).

6.16. Starter Maintenance

GPX 25E Diesel, Model TMD27 (2.7L) Engine

Description F-311
Specifications F-311
Starter Motor Assembly F-312
Before Disassembly Tests F-313
Starter Removal F-313
Starter Overhaul Disassembly F-314
Parts Inspection and Cleaning F-314
Starter Reassembly F-315
Testing F-315

This section describes the reduction-type starters for TMD27 (2.7L) engines in GPX 25E Diesel trucks.

Description

The starter can be roughly divided into the following sections:

1. A series wound motor section that develops the cranking drive power.
2. A reduction gear set.
3. An over-running clutch section.
4. An electromagnetic switch (solenoid) section.

Starter Motor Lubrication

All bearings are sealed and require no periodic lubrication.

Starter Motor Brush Check

The brushes are not accessible without removal of the motor and/or disassembly of the commutator end cover. Service the brushes during overhaul.

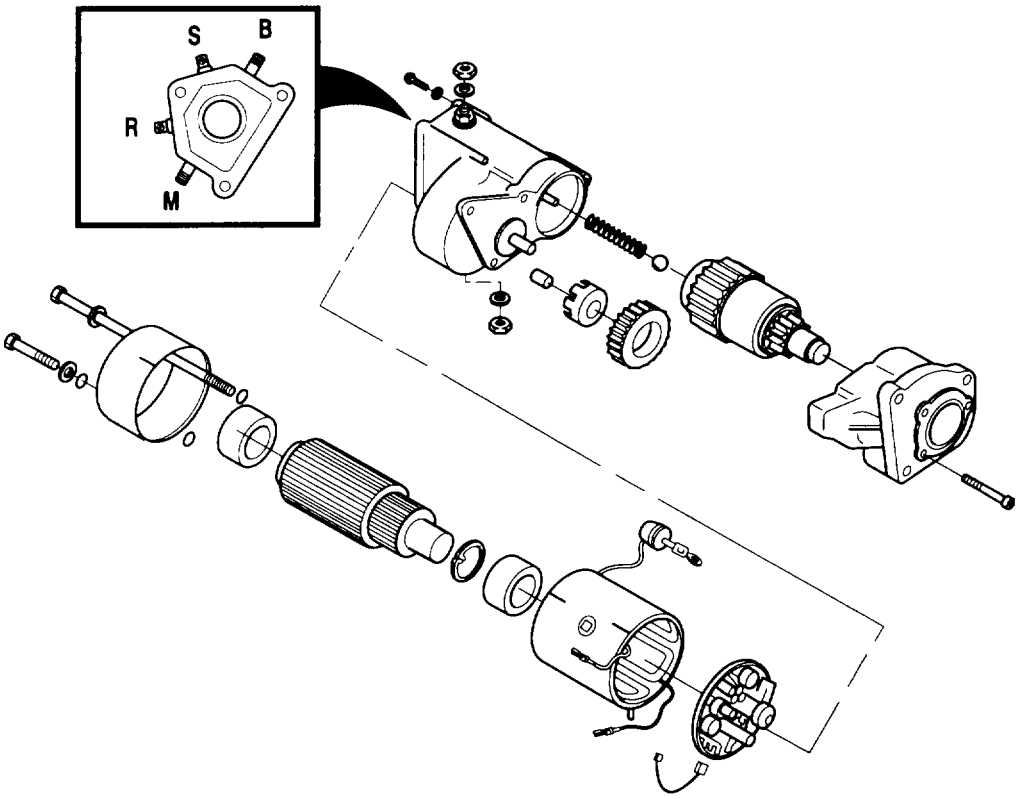
Specifications

Type:	Reduction-type, solenoid shift, positive engagement
Make:	Nippodenso
Voltage:	12 volt
Rotation:	CW, viewed from drive end
Solenoid switch:	
Working (pull-in) voltage (V)	8 maximum

TMD27 Diesel Engine Starter

Reference: TMD27M516	
No-Load Characteristics:	
Terminal Voltage (V)	11
Current (A)	220 maximum
Speed (rpm)	4200 minimum
Load Characteristics:	
Terminal Voltage (V)	7
Current (A)	890 maximum
Speed (rpm)	940 minimum

Starter Motor Assembly - Reduction-type
TMD27 (2.7L) Diesel Engine



F-312

Before Disassembly Tests
For additional information, please refer to:
Section 2.1, Service Specifications
Section 4.3, Engine Tune-Up
Section 6. 1, Electrical System Wiring
Section 6. 11, Starting System Troubleshooting
Section 6.12, Starter Motor Troubleshooting

WARNING

Remove all jewelry (watch, rings, bracelets, etc.) before working on electrical systems. Severe burns can result from contact with electrical circuits.

CAUTION

Always follow the manufacturer's instructions for the test instrument being used when making connections and tests on electrical circuits.

1. Starting Circuit Troubleshooting

Refer to Section 6. 11, Starting System Troubleshooting, and Section 6. 12, Starter Motor Troubleshooting, for additional starter problem troubleshooting procedures.

Many of the problems related to the starter can be found without removing the starter. If a starter problem is suspected, it is suggested to check the following items before removing the starter from the engine.

a. Check battery:
   1) electrolyte level and adequate charging.
   2) terminals for tightness and corrosion.
   3) for cracked case or damaged cells.

b. Check starter terminals for tightness and corrosion.
c. Starting circuit wiring for grounding or opens.
d. Starter for poor grounding.
e. Starter switch relay for improper function.
f. Ignition key switch for improper function.
g. Starter solenoid switch for improper function.

If no abnormality has been found with the circuit, remove the starter from the engine and test it.

2. No-Load Test

Refer to Section 6. 12, Starter Motor Troubleshooting.

The starter may be considered normal if it runs smoothly with the current and speed showing the specified standard values when the specified battery voltage is applied.

If any abnormality is found during the no-load test, disassemble and inspect the starter.

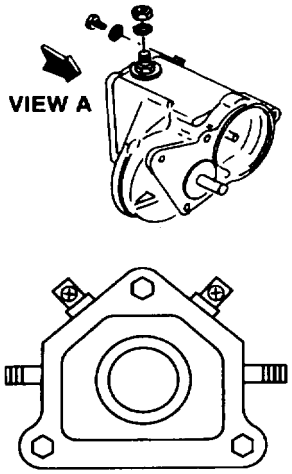
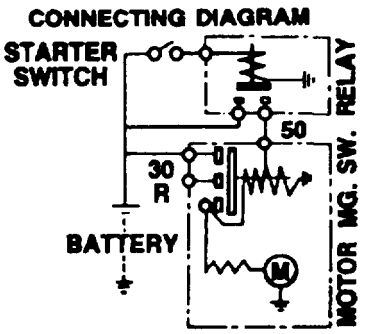


Figure 1. Starter Solenoid.

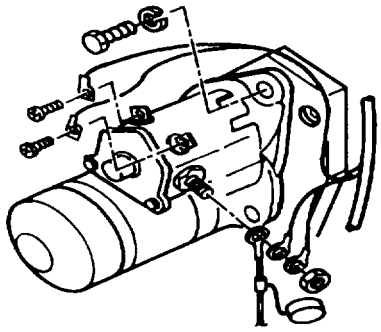


Starter Removal

NOTE

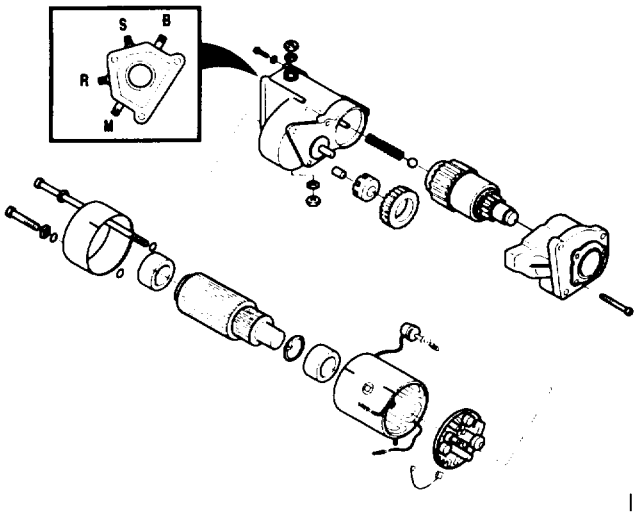
To perform this procedure, it is recommended that you first:

- Remove left-and right-side doors.
- Open top hood.
- Remove cooling system compensation tank.
- Tag and mark all wires prior to removal.
- Remove nut, screw, and strap, and move hose from bracket.
- Unhook throttle spring.
- Remove nut, washer, and throttle linkage from fuel injector pump.



1. Remove the battery ground () cable.
2. Disconnect wiring from the starter and solenoid.
3. Remove the starter mounting bolts (2).
4. Remove the starter.

Starter Overhaul Disassembly



1. Remove terminal nut on solenoid that connects motor to solenoid terminal.
2. Remove the 2 long screws that attach motor to gear housing.
3. Remove motor assembly.
4. Remove 3 Phillips-head screws from solenoid cap assembly.
5. Slide out solenoid plunger assembly and plunger dampener spring.
6. Position housing so output shaft is in view.
7. Remove 3 Phillips-head screws which secure solenoid housing to gear housing.
8. Remove 2 Phillips-head screws on motor brush-end.
9. Remove brushes from brush plate assembly.
10. Remove armature from frame assembly.

Parts Inspection and Cleaning

NOTE

All bearings are sealed and require no lubrication. Do not attempt to wash and lubricate bearings. If inspection reveals a bad bearing, they must be replaced. Replace bearings by pressing on armature shaft.

1. Inspect all gears for wear, chipping, or binding.
2. Inspect all bearings for wear and dirt contamination. Be sure bearings turn smoothly without binding. Replace any bearings or gears which are found to be damaged or worn.
3. Inspect for damage to gear drive and wear on armature shaft. Replace armature if gear is worn.
4. Inspect commutator. Look for discoloration and grooves. If grooved, turn commutator on lathe.
5. Inspect solenoid wiring for dust and dirt. Look for evidence of overheating. Check insulation for discoloration and heat damage.
6. Inspect solenoid contactor ring and solenoid contactors for excessive wear, dirt, and pitting. Replace if damaged or worn.
7. Inspect brushes, brush springs, and shunt wires for wear and/or damage. Replace, as necessary.
8. Inspect motor fields for evidence of heat damage. Check for shorting using a volt-ohmmeter. Replace, as necessary.
9. Clean all parts thoroughly prior to reassembly.

Starter Reassembly

1. Reinstall armature assembly in motor housing.

2. Attach brush shunt wires to brush housing. Be sure brushes have the proper shape, and full contact with commutator surface.

3. Lubricate gear end of armature shaft with Lubriplate, or equivalent.

4. Install brush cover plate.

5. Install motor on solenoid housing, making sure keyway is in place and motor is keyed in location.

6. Secure motor with 2 long screws.

7. Install solenoid assembly taking care not to damage terminal insulators.

8. Lubricate solenoid dampener spring.

9. Be sure contactor ring is in good condition, clean, and free from grease.

10. Install solenoid end cap.

11. Connect wire to terminal on solenoid.

12. Tighten all screws and all nuts to specifications.

Testing

Conduct a no-load bench test prior to installation to ensure proper operation.
Refer to Section 6. 12, Starter Motor Troubleshooting.

7.0. TRANSAXLE

Spiral Bevel & Hyphoid Tooth Bearing Contact Chart F-318

7.1 Transaxle Maintenance F-319

7.2 Transmission Troubleshooting F-323

7.3 Transmission Pressure Checks F-327

7.4 Transaxle Mounting Removal/Installation F-329

7.5 Transaxle Overhaul - General Procedures F-341

7.6 TA18Transaxle F-345

7.7 Deleted

7.8 Deleted

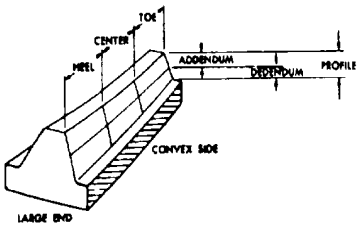
7.9 Deleted

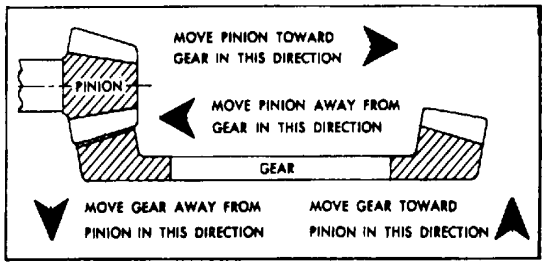
7.10 Deleted

7.11 Deleted

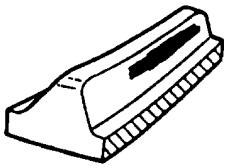
7.12 Directional Control Linkage F-379

Spiral Bevel & Hyphoid Tooth Bearing Contact Chart





All contact bearings shown below are on the right-hand spiral ring-gear-the drive is on the convex side of the tooth.



All contact bearings shown below are on right-hand spiral ring gear - the drive is on the convex side of the tooth.

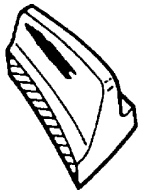
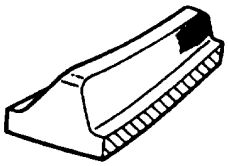


FIG. 1



TYPICAL PREFERRED BEARING ON BOTH SIDES OF TOOTH WHILE UNDER A LIGHT LOAD.

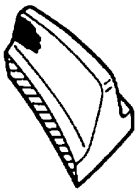
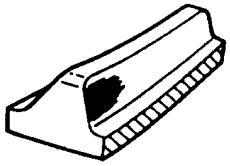
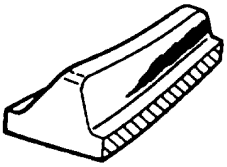


FIG. 2



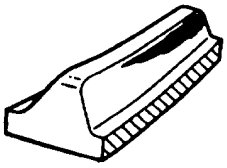
TOE BEARING ON BOTH SIDES OF TOOTH - GEAR SET NOISY. TO MOVE BEARING TOWARD HEEL INCREASE BACKLASH WITHIN LIMITS BY MOVING GEAR AWAY FROM PINION.

FIG. 3



HEEL BEARING ON BOTH SIDES OF TOOTH - GEAR SET NOISY AND COULD RESULT IN EARLY GEAR FAILURE. TO MOVE BEARING TOWARD TOE, DECREASE BACKLASH WITHIN LIMITS BY MOVING GEAR TOWARD PINION.

FIG. 4



LOW BEARING ON GEAR AND HIGH BEARING ON PINION. CORRECT BY PULLING PINION AWAY FROM GEAR (INCREASE MOUNTING DISTANCE).

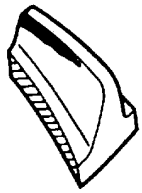
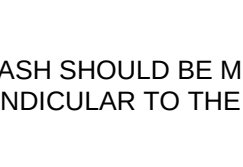


FIG. 5



HIGH BEARING ON GEAR AND LOW BEARING ON PINION. CORRECT BY MOVING PINION IN TOWARD GEAR (DECREASE MOUNTING DISTANCE).

BACKLASH

BACKLASH SHOULD BE MEASURED WITH A DIAL INDICATOR RIGIDLY MOUNTED WITH THE STEM PERPENDICULAR TO THE TOOTH SURFACE AT THE EXTREME HEEL.

7.1. Transaxle Maintenance
Fluid and Filter Change

Access To Transaxle Service Points F-319
TA18 Service Points F-320
Transaxle Fluid Level Check F-320
Correct Oil Level F-320
Transaxle Fluid and Filter Change F-320

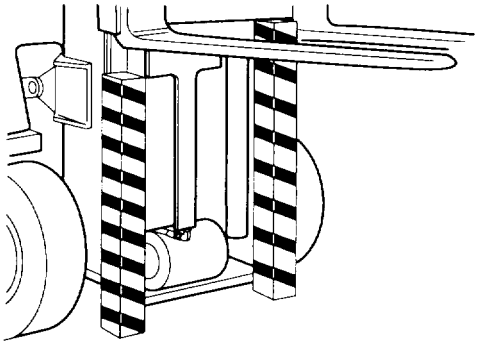
Refer to Section 1.0, General Information, for information on identifying truck and transaxle models.

NOTE

To perform this service procedure, it is recommended that you:

- Park the truck in a level position.
- Return all controls to neutral.
- Apply the parking brake and block the wheels.

Access To Transaxle Service Points



The best service method for reaching the transaxle check points (dipstick, oil level/filler plug, drain and inspection plugs) is dependent upon the style of upright, carriage and attachments on your truck. One method is to raise and block up the upright carriage to provide easier access to the drive axle.

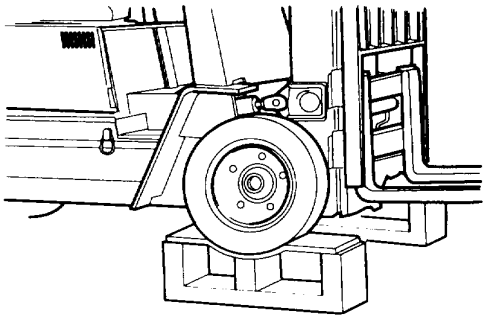
Be sure to put blocking under the carriage and upright rails for safety.

WARNING

Do not walk or stand under raised forks. The forks can fall and cause injury or death.

NOTE

Frequent changes of transmission fluid and filters is an inexpensive way to protect and prolong the safe operating life of an essential and relatively more valuable major component such as the transaxle. Extending the recommended intervals at which transaxle fluid and filters are changed should be considered only after careful evaluation of your operating conditions and/or analysis of the condition of the oil. Because the oil is heated to very high temperatures when a torque converter and transmission are operated under heavy or sustained working conditions, it will "wear out" (break down) and lose its lubricating ability due to oxidation. When this happens, it will cause rapid wear and damage to seals, bearings and clutch plates, resulting in the need for a much more costly transmission rebuild.

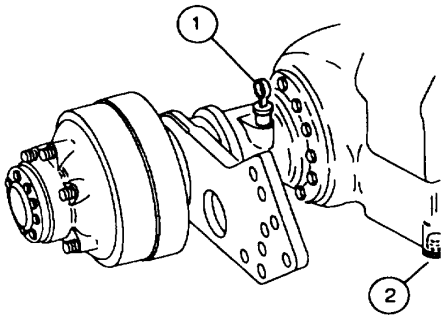


NOTE

When suitable equipment is available, the truck may be raised or hoisted up and placed in a level position on wheel cradles to allow access under the axle and transmission section. Otherwise, raise the fork carriage only high enough to provide access to the axle.

TA18 Service Points

Refer to Section 7.6, TA 18 Transaxle, for additional information.



The TA18 transaxle has two service openings:

1 Dipstick/oil fill tube, in left side axle housing
2 Drain plug, in bottom of transmission case

IMPORTANT
Recommended lubricant for TA18 transaxle:
AMOCO 1000, Texaco 1893 TDH, or Gulf 303 **Part No. 2776236**

Transaxle Fluid Level Check

Check the transaxle fluid level with: ·

- Truck on a level surface
- Engine idling w/transmission in NEUTRAL
- Oil at operating temperature (180-200-F)

Check the PM time interval (operating hours), or the condition of the oil to determine if the transaxle fluid needs to be changed.

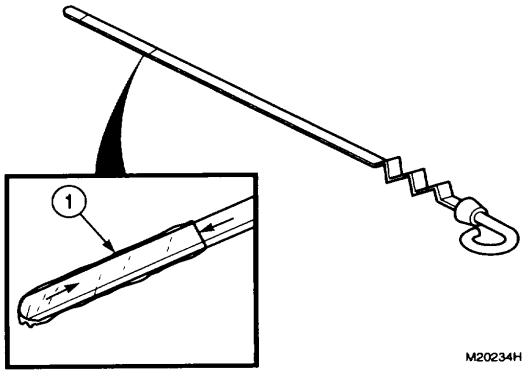
NOTE

Also refer to Section 2.1, Service Specifications, for transaxle-model recommended oil specification.

See illustration above.

Clean area around oil fill tube before removing dipstick. Pull dipstick out. Remove all oil from dipstick with a clean wiper and push it fully back into oil fill tube. Remove dipstick to check oil level.

Correct Oil Level



1. **The oil level is correct (FULL)** when oil can be measured on the dipstick.

2. **Add recommended fluid only**, as required.

3. **After adding oil to transaxle,** wait several minutes until oil has distributed evenly throughout the sump. Check for correct oil level. Do not overfill.

Transaxle Fluid and Filter Change:

Drain and Refill

It is recommended to:

- Drain and replace the transaxle fluid every 1000 operating hours.
- Remove and clean the transmission sump oil strainer screen each time the transmission fluid is changed (on applicable models).
- The oil should be drained when it is warmed to operating temperature, 160-200°F (82-93°C).
- Replace the transaxle oil filter every 500 operating hours or every 6 months, whichever occurs first. *See below.*

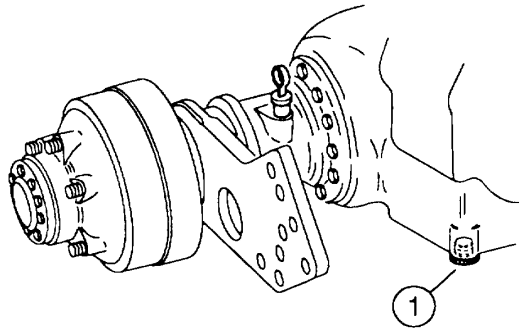
CAUTION

When the transaxle is new or rebuilt, it is recommended to change the oil filter after the first 50 hours and again after 100 operating hours. This is to ensure that the oil is cleaned of any harmful particles which may be loosened or flushed off new parts as they wear in. Failure to change the oil filter may result in damage to transaxle.

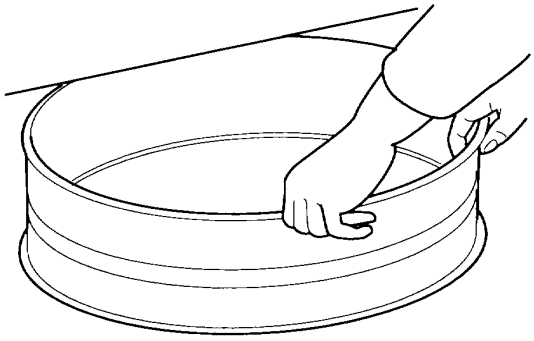
Draining The Transaxle

Minimum Tools Required:

- 22 mm socket wrench
- 1/2" square drive
- Drain pan



1. The transaxle oil is drained from drain plug in transmission case (1).



2. Put a flat drain pan of 20 quarts (19 L) capacity minimum, under drain opening.

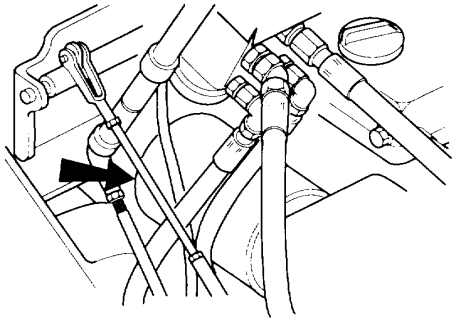
3. Remove the drain plug. Inspect the plug and seal for damage. Replace as necessary.

Changing Transaxle Oil Filter

1. Remove the floorboards.

NOTE

The oil filter is mounted near the top of converter housing above transmission.



2. Remove old oil filter.

NOTE

Take special care when removing filter to avoid oil In filter from draining onto floor. Loosen filter using a filter wrench. It is recommended to use a socket and band-type wrench working from the front of truck. Remove filter while holding a pad of cloth or other absorbent material under the open end to absorb any excess oil that may drain from the filter.

3. Install new oil filter. Follow the installation instructions printed on filter.

4. Install control rod(s), if removed as noted above.

Refilling the Transaxle

After drive axle and transmission housing has drained completely:

1. Install drain plug.
2. Remove dipstick and fill transaxle to LOW mark on dipstick (transaxle and oil cold).
3. Operate as noted in Step 4. When transaxle fluid is at operating temperature (1 80-200°F), recheck level. Oil should be at full mark. If not, fill to FULL mark. Do not overfill.
4. Start the engine and run at idle speed (650 rpm) in NEUTRAL for 2-3 minutes to prime the converter and cooler lines.
5. Recheck oil level with engine running at idle speed. Add oil to bring the oil level to ADD mark on dipstick. When oil temperature is hot (180-200°F), make final oil level check. Oil level should be at FULL mark. Do not overfill.
6. Check for leaks at drain plug and oil filter
7. Finish by cleaning up and removing any pans, blocking, etc., used.

7.2. Transmission Troubleshooting

Troubleshooting Techniques F-323
Powershift Transmissions F-323
Troubleshooting Guide F-323
Troubleshooting Procedures F-324
Converter Stall Procedure F-324

Troubleshooting Techniques

The following information is presented as an aid to isolating and determining the specific problem area on a transmission that is not functioning correctly.

When troubleshooting a "transmission" problem, it should be kept in mind that the transmission is only the central unit of a group of related powertrain components. Proper operation of the transmission depends on the condition and correct functioning of the other components of the group. Therefore, to properly diagnose a suspected problem in the transmission, it is necessary to consider the transmission fluid, charging pump, torque converter, transmission assembly, oil cooler, filter, connecting lines and controls, including the engine, as a complete system.

By analyzing the principles of operation together with the information in this section, it should be possible to identify and correct any malfunction which may occur in the system.

Powershift Transmissions

Hydratork (powershift with torque converter) transmission troubles fall into two general categories: mechanical problems and hydraulic problems.

In addition to the mechanical components, all of which must be in the proper condition and functioning correctly, the correct functioning of the hydraulic circuit is most important. Transmission fluid is the "life blood" of the transmission. It must be supplied in an adequate quantity and delivered to the system at the correct pressures to ensure converter operation, to engage and hold the clutches from slipping and to cool and lubricate the working components.

Troubleshooting Guide

Refer to the following list of symptoms for the diagnosis of typical transmission troubles.

Low Clutch Pressure

1. Low transmission fluid level.
2. Clutch pressure regulating valve spool stuck open.
3. Stuck inching valve.
4. Inching/brake pedal not returned to full up position.
5. Defective or worn charging pump.
6. Broken or worn clutch shaft or piston sealing rings.
7. Clutch piston bleed valve stuck open.
8. Accumulator piston rings worn or broken.

Low Converter Out Pressure
Low Charging Pump Output

1. Low fluid level.
2. Suction screen has restriction.
3. Defective or worn charging pump.

Overheating Unit Getting Too Hot

1. Low fluid level.
2. Worn charging pump.
3. Worn oil sealing rings.
4. Dirty oil cooler.
5. Restriction in cooler line.

Noise In Converter

1. Defective converter.

Loss of Power

1. Low engine RPM @ converter stall. Tune engine.
2. Overheating See above items.

Troubleshooting Procedures

The two most important transmission troubleshooting procedures are 1) check fluid level and 2) run a stall test.

1. **Fluid Level Check** - Before checking the transmission clutches, torque converter, charging pump and hydraulic circuit for speeds, pressures and/or rate of oil flow, it is important to check the oil level in the transmission (transaxle). The transmission fluid must be at the correct (full) level. All clutches and the converter and its fluid circuit lines must be fully charged (filled) at all times.

   CAUTION

   The transmission fluid must be at operating temperature of 180-200°F (82-93°C) to obtain correct fluid level and pressure readings. Do not attempt to make these checks with cold oil.

2. To raise the oil temperature to this specification, it is necessary to either operate (work) the truck under load, or briefly run the engine with the converter at stall. See converter stall procedure for warming the oil below.

Converter Stall Procedure

NOTE

Running the truck when up on blocks will not be adequate to warm the oil.

Part Throttle Converter Stall Procedure To Warm Transmission Oil

Stall operation must be performed with the parking brake applied and wheels blocked up above the ground surface to prevent movement. Use of the service brakes (with inching) will release the transmission clutches and prevent stalling of the torque converter.

WARNING

Be careful that the truck does not move unexpectedly when operating the engine and converter at stall rpm. Unexpected movement could cause injury or death to personnel.

1. Apply the parking brake and block/support the drive axle on blocks so that the drive wheels do not touch the ground surface.
2. Put directional control lever in FORWARD (or REVERSE, as applicable).
3. If 2-speed transmission, put speed control lever in "2" (HIGH).
4. With engine running, slowly increase engine speed to approximately one-half throttle (1200-1500 rpm) and operate as noted (see CAUTION below) until transmission (converter outlet) oil temperature reaches the operating range.

Full Throttle Converter Stall Procedure

1. Proceed as per Steps 1, 2, & 3 above, except check stall speed at full throttle during test.

   CAUTION

   Do not operate the converter at stall condition longer than 30 seconds at one time. Then, shift transmission into neutral for 15 seconds with engine speed at approximately one-half throttle. Repeat procedure until desired operating temperature has been reached. Excessive temperature (250°F max. [120°C]) will overheat the converter and cause damage to converter, seals and fluid.

2. Full Throttle Stall Test Use a full throttle (full power) stall test to identify transmission, converter or engine problems.

Refer to Section 4. 7, Engine RPM, Vacuum & Stall Tests.

3. Transmission Pressure Checks Transmission problems can be isolated by the use of pressure tests. When the stall test indicates slipping clutches, then measure clutch pack pressure to determine if the slippage is due to low pressure or clutch plate friction material failure. In addition, converter charging pressure and transmission lubrication pressure may also be measured.

Refer to Section 7.3, Transmission Pressure Checks.

4. **Mechanical Checks** - Prior to checking any part of the system for hydraulic function (pressure testing), the following mechanical checks should be made:
   a) Be sure all control lever linkage is properly connected and adjusted in each segment and at all connecting points.
   b) Check shift levers and rods for damage and restrictions that could prevent full travel movement. Move the levers by hand at the control valve. If the control spool does not actuate fully, the problem may be in the control cover and valve

assembly. If the controls are actuated electrically, check the wiring and electrical components.

c) Check the service brake and inching pedal for correct adjustment and travel. Be sure the pedal moves freely and returns fully.

d) Be sure all components of the cooling system are in good condition and operating correctly. The radiator must be clean to maintain the proper cooling and operating temperatures for the engine and transmission. Air clean the radiator, if necessary.

e) The engine must be operating correctly. Be sure it is correctly tuned and adjusted to the correct idle and no-load governed speed be measured.

Refer to Section 7.3, Transmission Pressure Checks.

7.3. Transmission Pressure Checks

Test Preparation F-327
Pressure Test Procedure F-327
Pressure Specifications F-327
Pressure Check Points F-327

Test Preparation

Before making any transmission pressure checks, please refer to Section 7.2 Transmission Troubleshooting.

IMPORTANT Be sure that:

1) Transaxle fluid level is correct and oil warmed to operating temperature.
2) All mechanical checks have been completed.

NOTE

To perform this service procedure, it is recommended that you first:

- Put blocks under the upright rails and raise the drive wheels off the floor.
- Return all controls to neutral.
- Block the steer wheels.
- Apply the parking brake to prevent drive wheel movement.

Minimum Tools Required

- It is recommended to use a hydraulic transmission test manifold, or conventional pressure gauge with 0-300 Ps pressure range, w/hose and fittings.
- Tachometer

Pressure Test Procedure

Making a transmission pressure check consists of installing a pressure gauge into the hydraulic circuit at the proper test point, operating the system at the specified conditions, and recording the pressure reading. ***Compare the test pressure readings to the design specifications, and refer to the troubleshooting guide, Section 7.2, for diagnosis of the probable trouble.***

1. Open the engine compartment and remove the floorboards to provide access to the transmission check points.

2. Install the tachometer.

3. Clean the transmission in the areas of the pressure check point plugs. Be careful to prevent dirt and contaminants from entering check ports.

4. Remove the plug and install pressure gauge into each respective check port where pressure is to be measured.

5. Clutch pressure is measured with the respective clutch engaged. Put the directional control (FORWARD or REVERSE) lever, or speed control (LOW) lever in correct position for engagement of clutch being tested.

IMPORTANT Do not apply service brake while making clutch pressure checks. Use of the service brakes (w/ inching) will release clutch pressure and prevent accurate pressure readings.

6. Start and operate engine at the specified speed(s) while taking the pressure readings.

7. Make a record of each pressure reading for your reference.

8. When each pressure check is completed, stop the engine, remove pressure gauge, and install and tighten the plug in the check port.

9. When all pressure checks have been completed, remove tachometer, replace any components that may have been removed for access to the check points, install floorboards, close engine compartment, lower drive wheels to floor, and remove blocks.

Pressure Specifications

Refer to Transaxle Model on following pages. Also refer to GROUP 2, Service Specifications, for transmission model being checked.

Pressure Check Points

Refer to Transaxle Model on following pages.

TA18 Transmission Pressure Specifications

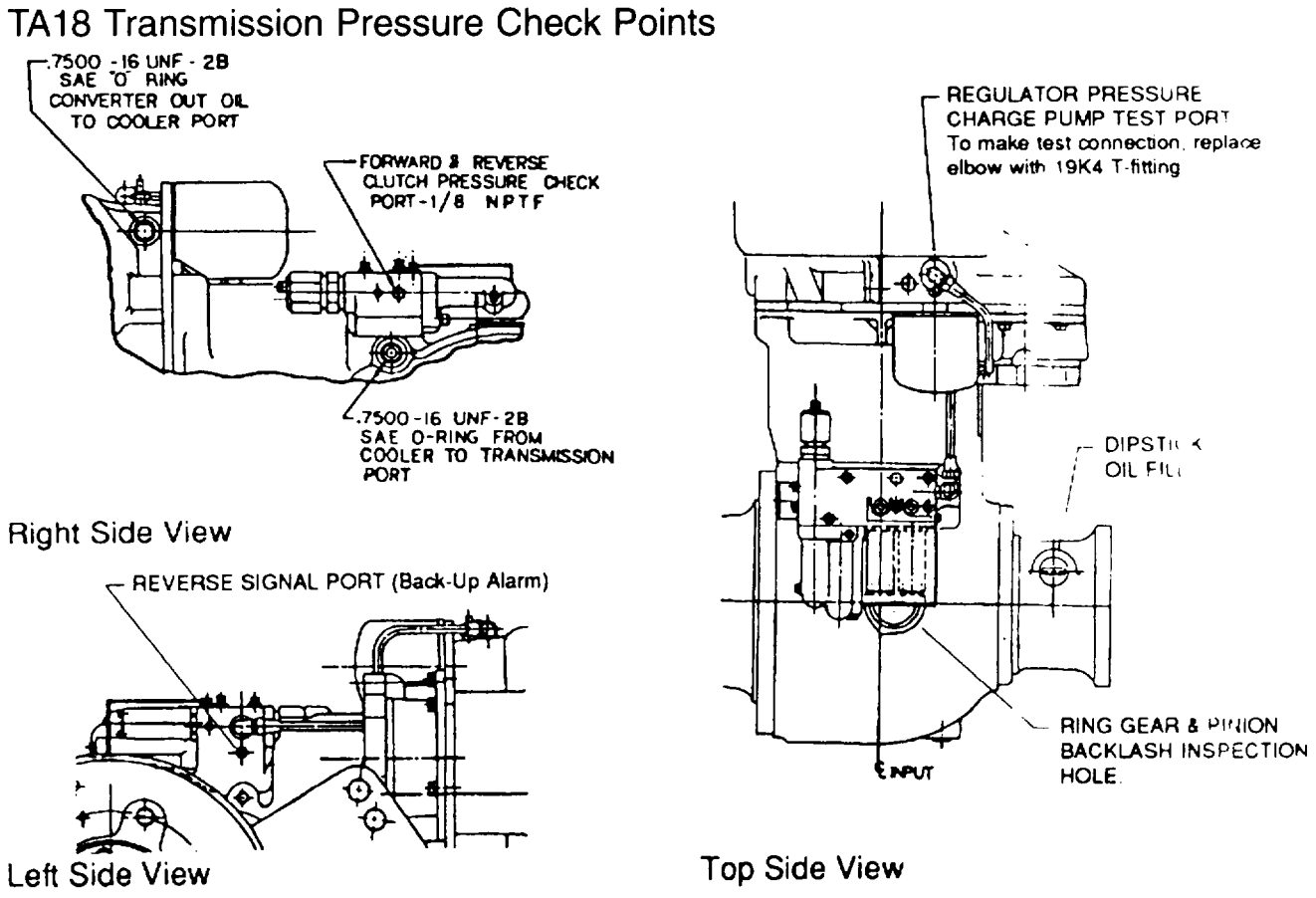
- Regulator Valve Pressure:.....150-195 psi [1034-1172 kPa] @ 1800 rpm
  Check Point: Oil supply line at converter
- Converter In/Lube Pressure: .....30 psi minimum [206 kPa] @ 1800 rpm
  Check Point: Return from cooler
  Converter Safety Valve Pressure: .....120-130 psi [827-896 kPa] @ 1800 rpm
  (Trans in NEUTRAL) .....(Reference only)
  .....with line to cooler blocked
  Check Point: None

- Clutch Pressure: .....135-155 psi [930-1068 kPa] @ 650 rpm idle
  (Forward, Reverse applied).....Normally 15 psi less than regulator pressure (135 psi min)
  Check Point: At control valve (1/8 NPTF)
- Clutch Pressure:.....Same as regulator valve pressure
  (in NEUTRAL)

Notes:

1. All rpm's noted are engine speed.
2. All clutch pressures are at engine idle speed with clutch engaged, unless otherwise noted.
3. IMPORTANT - Oil at operating temperature 180-200°F (82-93'C)
4. Refer to following illustrations for check point locations.

TA18 Transmission Pressure Check Points



7.4. Transaxle Mounting Removal/Installation General Procedures

Transaxle Mounting Parts F-330
Transaxle Removal F-331
Transaxle Installation F-337

This section outlines general procedures for removal and installation of the transaxle.

WARNING

All tools and lifting equipment must be in good condition, meet the load capacity requirements and have OSHA labels when required. Tools with defects can have failures causing severe injury or death.

The transaxles are mounted in the truck chassis similarly with one-piece mounting brackets which are a part of the transaxle assembly.

WARNING

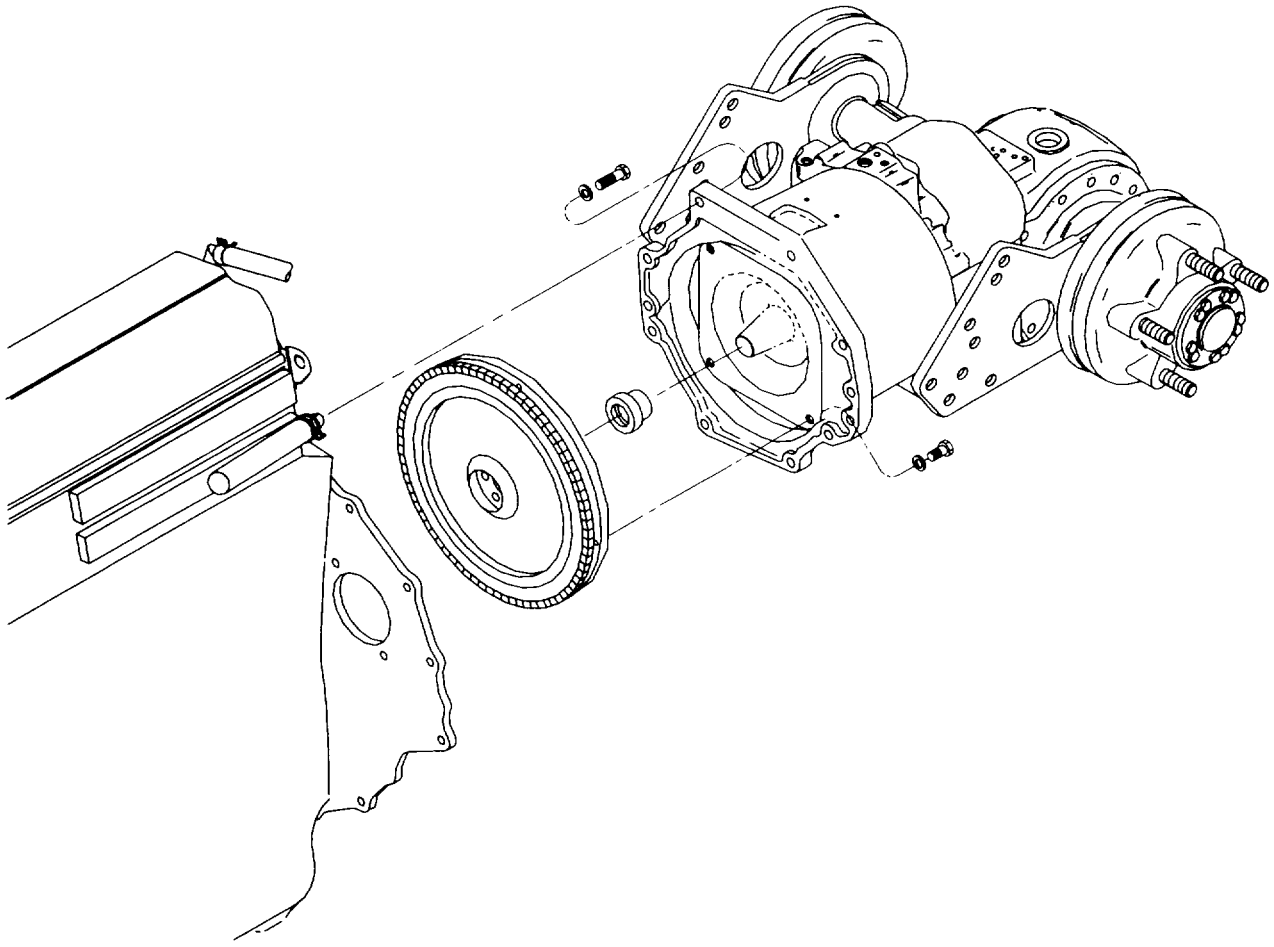
- **Disconnect the battery and remove all jewelry before working on any electrical system. Severe burns can result from contact with electrical systems.**
- **If the upright and transaxle are removed, the truck will tip backwards off any blocking under the frame. The back of the truck must be supported by blocking under the steer axle to prevent movement**.
- **The reverse is also true. If the counterweight is removed while the truck is up on blocks, the weight of the upright and transaxle will cause the truck to tip on the front blocks and fall forward.**
  - Removing counterweight from blocked-up truck: Truck will tip forward.
  - Removing upright/transaxle from blocked-up truck: Truck will tip backwards.

NOTE

To perform these service procedures, it is recommended that you first:

- **Park truck on a hard, level and solid surface, such as a concrete floor with no gaps or breaks.**
- **Put upright in vertical position and fully lower the forks or attachment.**
- **Put all controls in neutral.**
- **Turn key switch OFF.**
- **Apply the parking brake**.

Transaxle Mounting Parts
Model TA18 Transaxle

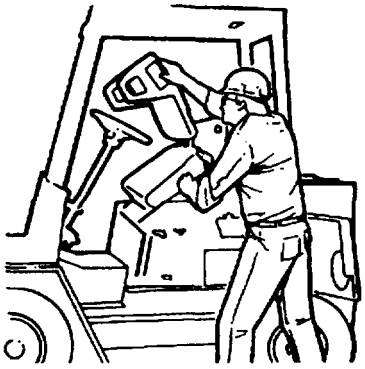


F-330

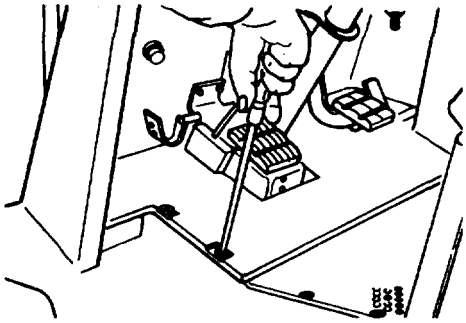
Transaxle Removal

WARNING

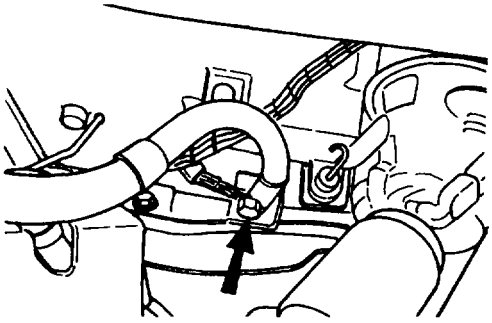
Be sure truck is parked and positioned in a safe and convenient manner or injury to personnel may result.



1. Open engine compartment.



2. Remove the floor boards.



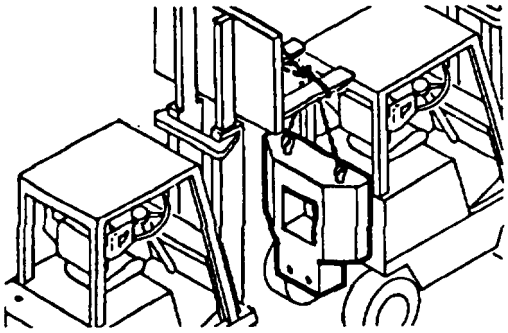
For safety when checking or removing battery connections, always first disconnect the negative battery cable at the engine ground connection.

3. Disconnect battery ground cable from the engine ground connection.

WARNING

- **Do not remove the counterweight unless you have training and are familiar with the correct procedures. Counterweights can fall if not handled correctly and cause severe injury.**

- **When removing the transaxle with the truck blocked up by the frame, truck can tip backwards due to its heavy counterweight. Both upright and counterweight must be removed before attempting to raise the truck for transaxle removal. Failure to remove both could result in injury or death.**

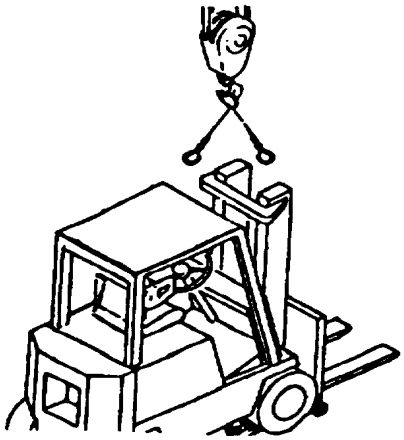


4. Remove the counterweight.

Refer to Section 12.1, Counterweight Maintenance, Removal and Installation.

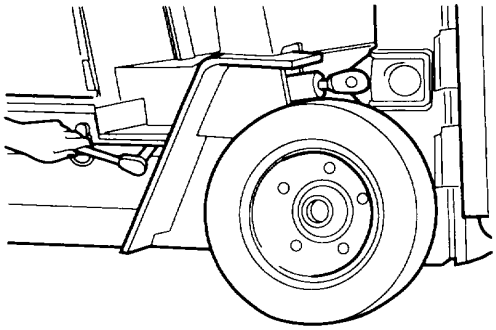
WARNING

Attach a chain or sling to the upright and a hoist before removing any tilt cylinder or upright attachment parts. Be sure to secure and support upright from falling before removing tilt cylinders. Failure to secure upright could result in injury or death.



5. Remove the upright.

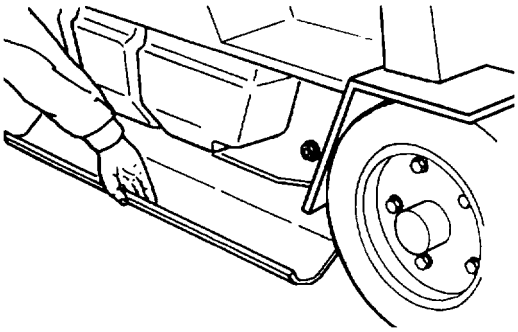
Refer to Section 13. 1, Upright Removal.



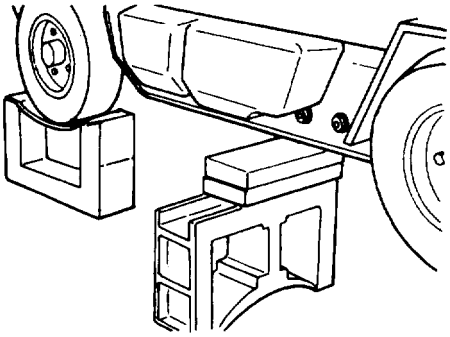
6. Loosen and remove frame side door panel fasteners.

WARNING

Heavy components can fall and cause severe injury. Keep your feet and body clear at all times.



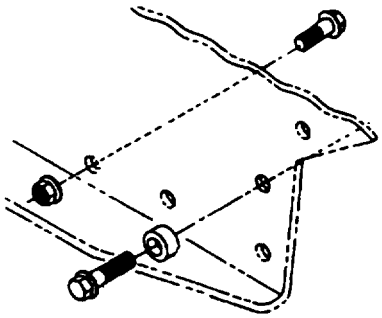
7. Remove frame side compartment doors from each side of the truck.



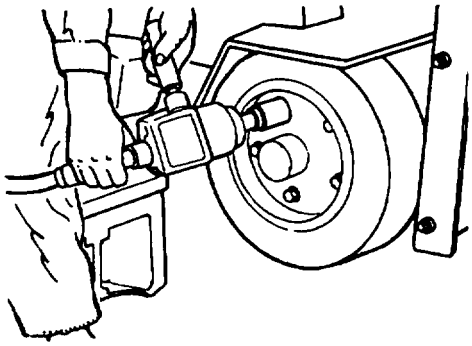
8. Use a safety-inspected and approved hoist or other lifting device of adequate capacity. Raise truck up 12-14 in. (305-356 mm) off the floor. Put wheel cradles of correct capacity under the steer wheels. Put narrow metal or hardwood blocks under the front sides of frame.

CAUTION

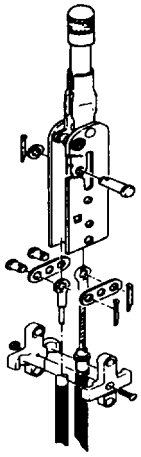
Be sure truck is correctly raised and safely blocked using metal or hardwood blocks under the frame. Be sure the blocking will permit removal and installation of the transaxle without disturbing the blocking.



9. Loosen the transaxle mounting bracket to frame fasteners. Do not remove fasteners at this time.



10. Remove the drive wheels.



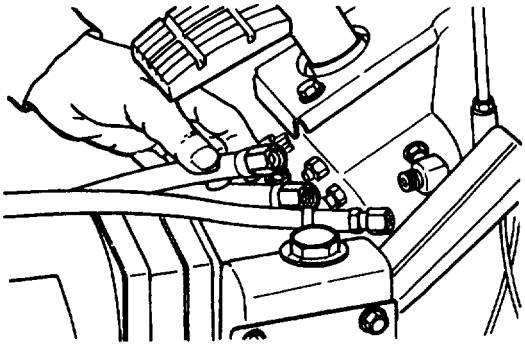
11. Disconnect the parking brake linkage. Disassemble and remove parking brake lever and cable assembly from steering column mounting. Requires loosening and removal of steering column lower mounting bracket.

Refer to Section 8. 1, Service Brake and Inching Systems.

12. Disconnect wiring leads from control valve.

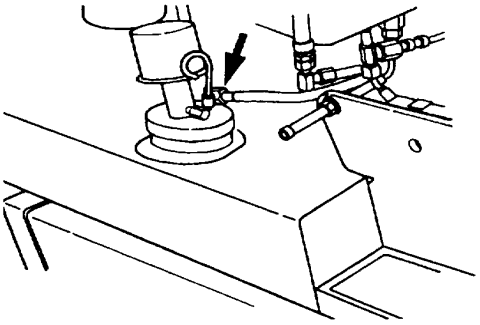
Refer to Section 7.12, Directional (Shaft) Control Linkage.

13. Remove the accelerator linkage, as required, to permit transaxle removal. Check by inspection to determine necessity to remove.

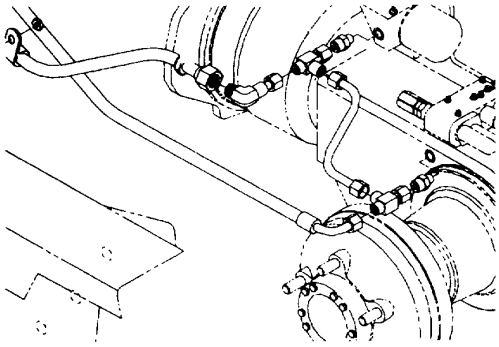


14. Disconnect the power steering lines from the steering gear (valve) and move out of the way. Plug fittings and cap open ends of lines to prevent drainage and entrance of dirt. Mark, tag or otherwise identify the proper position of the lines to be sure of correct reassembly.

Refer to Section 9.0, Steering System.

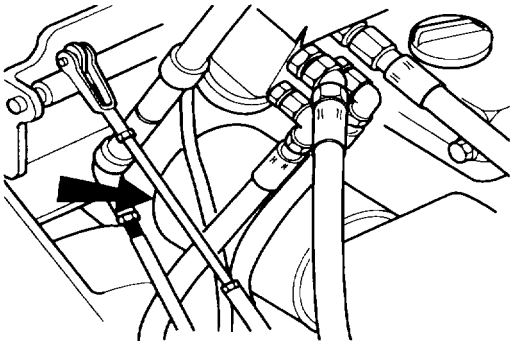


15. Remove the steer valve sump return line at the sump tank inlet. Plug fittings and cap open ends of lines to prevent drainage and entrance of dirt.



16. Disconnect the transmission cooling lines at the transaxle and move out of the way. Plug fittings and cap open ends of lines to prevent drainage and entrance of dirt. Mark each line to ensure its correct position at assembly.

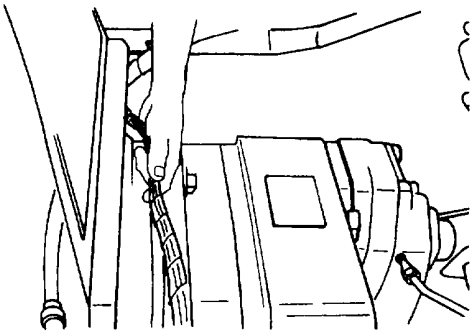
Refer to Section 4.8, Cooling System.



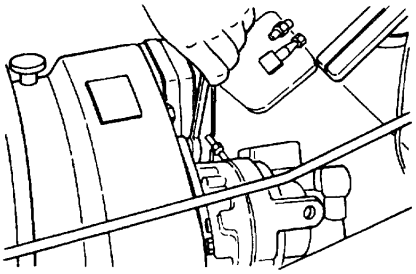
17. Remove the transmission oil filter.

18. Disconnect the brake lines.

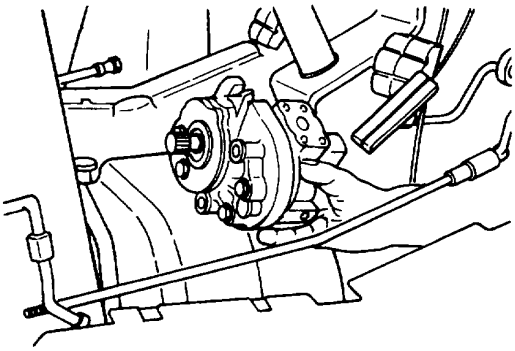
Refer to Section 8.4, Brake and Inching System.



19. Adjust the position of the wiring harness, which passes over the top of the transmission, to move it safely out of the way when transmission is removed.



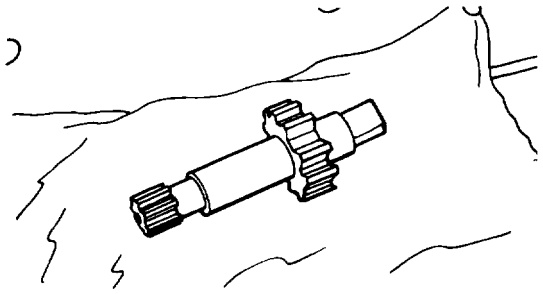
20. Remove the hydraulic lines from the main hydraulic pump. *See Section 10.0*. Plug fittings and cap open ends of lines to prevent drainage and entrance of dirt.



NOTE

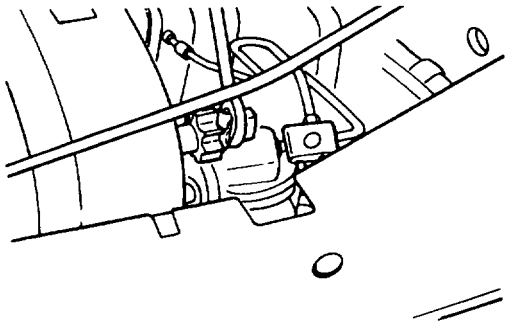
Remove main pump for access to pump drive for rotating torque converter.

21. Loosen and remove the main pump mounting bolts.



22. Remove main pump and gasket from aux pump drive pad on transmission.

23. A tool to fit into the aux pump drive sprocket, for rotating the torque converter and flywheel and provide access to converter mounting fasteners, can be made from a discarded pump shaft by grinding a wrench flat on the shaft.



24. Fit the rotation tool into the aux pump drive spline and, using a wrench, slowly move the converter and flywheel from one fastener position to the next.

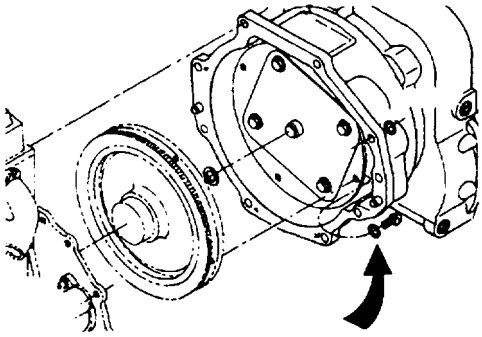
NOTE

If a discarded pump shaft is not available, a flat bar may be ground to fit into the splines to rotate the flywheel.

CAUTION

Be careful not to damage the splines when inserting the bar or equipment failure may result.

Alternate Procedure: The engine flywheel can be rotated by using the fan belt or crank pulley.



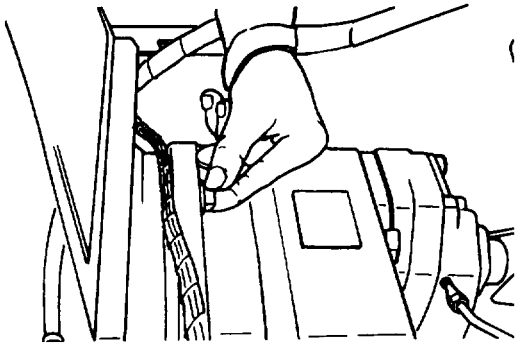
TA 18 Transaxle Converter Fasteners (4)

25. Remove the fasteners attaching the torque converter to the flywheel. Use the rotation tool noted above to rotate the converter and flywheel to provide access to each fastener by moving the fastener into a position where it can be reached through the access opening in the converter or flywheel housing.

26. Arrange blocking or other engine support means under the rear of engine, e.g. at engine rear plate or flywheel housing, to support engine when transaxle is removed.

NOTE

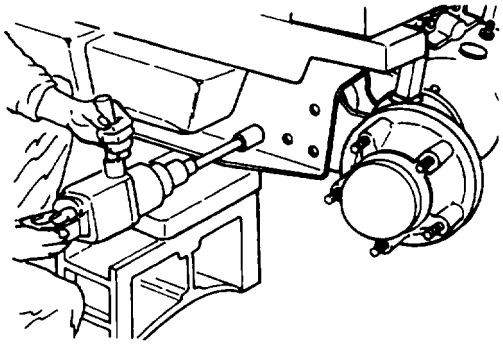
If a lift truck is used to support the transaxle while removing, put the forks close together and in a position under the unit to fully support it. Raise the forks until they touch the transaxle. If a floor jack is used, carefully put it in position to safely support the transaxle.



27. Remove the converter housing to engine real mounting plate or flywheel housing fasteners.

NOTE

Check and be sure all connecting parts, as necessary, have been detached from the transaxle and moved out of the way and that the supporting equipment is in a position that will safely lower and remove the transaxle assembly from under the truck chassis.



28. Remove transaxle mounting bracket-to-frame fasteners.

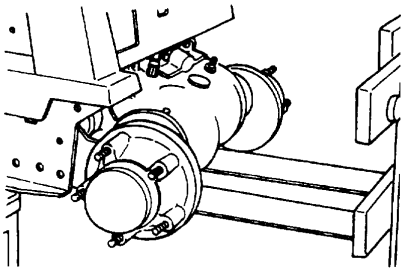
WARNING

Heavy components can fall and cause severe injury. Keep your feet and body clear at all times.

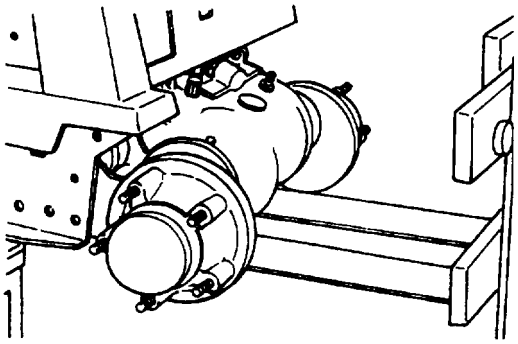
29. Carefully separate the converter housing and transaxle assembly from the engine. It may be necessary to use prybars to disengage the assemblies. If the assemblies refuse to part, check to make sure all fasteners have been removed.

NOTE

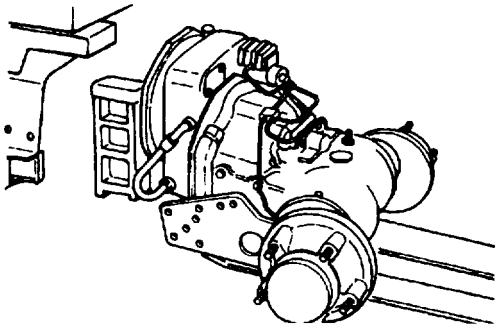
The converter stays with the transmission.



30. Carefully move and lower the transaxle away from the engine. Be sure all fasteners, wiring, connecting lines, etc., have been removed and/or moved out of the way. Check to be sure engine support blocking is secure.



31. Carefully remove transaxle assembly from frame. Be sure frame blocking is not disturbed by movement of the transaxle during removal.



32. Lower the assembly to the floor and move the lifting equipment away. If a floor jack is being used, be sure to put stable blocking under the transaxle assembly to allow removal of the jack.

Transaxle Installation

*See **IMPORTANT** installation information at right. Install the brake and inching lines, as applicable.*

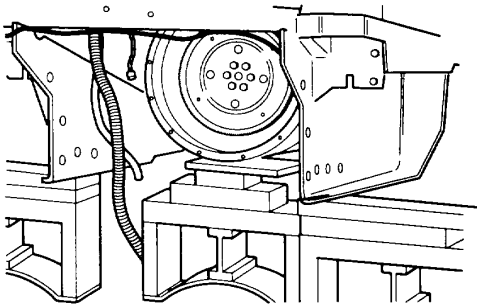
1. Be sure the converter pilot shaft spacer is installed.

WARNING

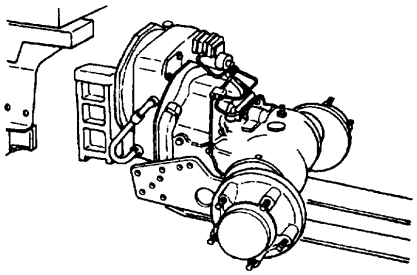
Check the blocking supporting the truck chassis and engine. Be sure it is secure. Keep your feet and body clear at all times. Failure to properly block forklift could result in injury or death.

NOTE

Align the mating holes for attaching the converter to the flywheel as close as possible before starting the installation. If the four holes in each unit are aligned, e.g. with the horizontal and vertical axis, they will be close to alignment when the units are assembled.



2. Make sure the truck chassis and engine are safely blocked up and the area for installing the transaxle is cleared of wiring, hoses or other obstructions. The blocking underneath the frame sides should be 12 to 14 inches high.

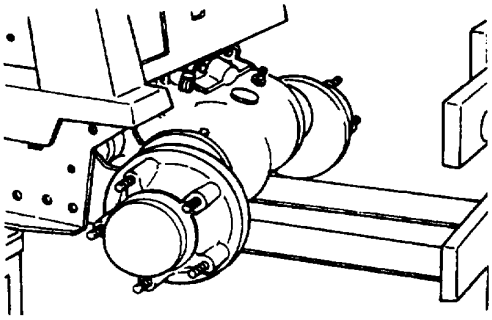


3. Use a lift truck, portable floor jack or similar means of adequate capacity to support the transaxle assembly. If a fork truck is used, carefully put the forks under the transmission case making sure it is secure and stable on the forks. If a floor jack is used, make sure the transaxle assembly is securely supported on the lifting surface.

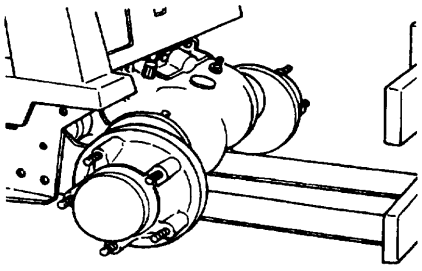
NOTE

Note the following items with installing the drive axle-to frame mounting bolts:

Make sure all dirt, paint, rust, grease and oil are removed from all mounting surfaces before installation. Make sure the bolts, nuts, and threads in the brackets and axle are clean and dry before installation and applying torque. Mounting bolts, nuts and threaded holes are to be unlubricated. Impact wrenches are to be used only to snug up fasteners. Torque wrench must be used to obtain final torque values.



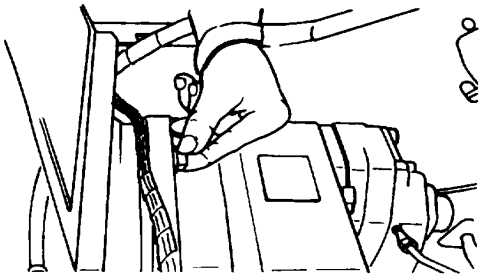
4. Carefully raise the transaxle assembly and move it into the frame from the front of the truck. Be sure all items within the mounting area are clear and will not be hit or damaged as the transaxle assembly is moved into position.



5. Continue moving the transaxle into position. Carefully align the transaxle with the rear plate or flywheel housing of the engine. Guide the pilot shaft of the torque converter into the pilot bore on the engine flywheel. It may be necessary to move the transaxle up or down or to tilt it as it is moved into assembly with the engine.

NOTE

It is recommended that 1) the converter housing to flywheel housing and 2) transaxle mounting bracket fasteners be first installed and only lightly tightened (snugged up) while final alignment of the assembly is being made, then final-tightened to torque spec.

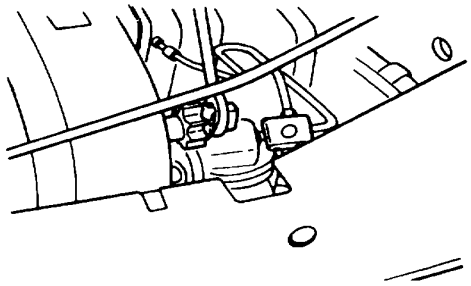


6. Install but do not final-tighten the fasteners attaching the converter housing to the engine rear plate or flywheel housing. Lightly tighten the bolts to pull the converter housing into place.

NOTE

Axle mounting bracket bolts, nuts, washers and holes are not to be lubricated. Impact wrenches are to be used only to snug up the fasteners. Torque wrench must be used to obtain final torque values.

7. Install, *but do not final-tighten*, the transaxle mounting bracket-to-frame fasteners. Lightly tighten the bolts to pull the brackets into place.



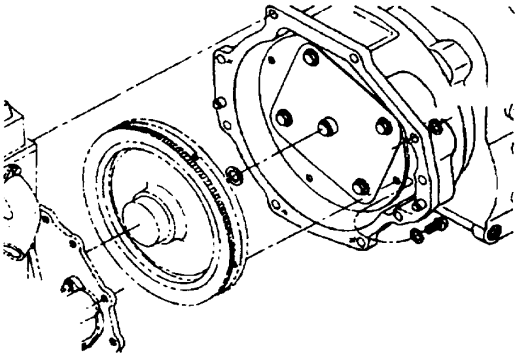
8. Install the four (4) fasteners attaching the torque converter to the flywheel. Tighten the torque converter mounting fasteners to torque spec: 30-35 lb-ft (40-50 N•m).

NOTE

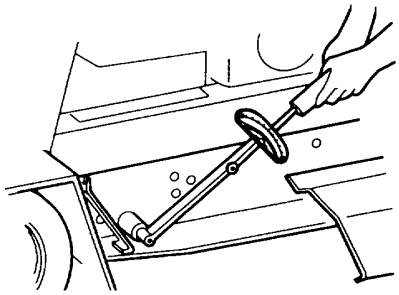
Be careful not to drop these fasteners down into the housing. They are difficult to retrieve. These fasteners are installed and tightened, one at a time, through the access hole in the flywheel or converter housing by carefully aligning the bolt holes in both parts, installing the fastener and then rotating the flywheel to the next bolt hole.

Use the special rotation tool described earlier to adjust the torque converter position for installation of the first fastener, and then to rotate the torque converter and flywheel for installation of the remaining fasteners.

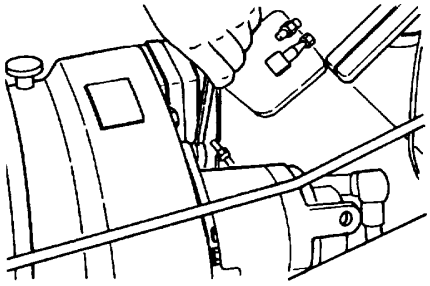
Alternate Procedures: The engine flywheel can be rotated by using the fan belt or crank pulley.



9. Final tighten the converter housing to engine rear plate or flywheel housing fasteners to torque spec: 30-35 lb-ft (40-50 N-m).



10. See note preceding Step 7. Final tighten the transaxle mounting bracket-to-frame fasteners to torque spec: 400-440 lb-ft (542-596 Nom).



NOTE

Be sure new or rebuilt pump is well oiled prior to installation.

11. Install the main hydraulic pump on transmission using a new gasket. Install and tighten pump mounting bolts to torque spec: 37-41 lb-ft (50-56 N•m)

Refer to Section 10.3, Main Hydraulic Pump Removal/ Installation.

12. Install the hydraulic lines to main pump. Be sure the O-ring seals are properly positioned.

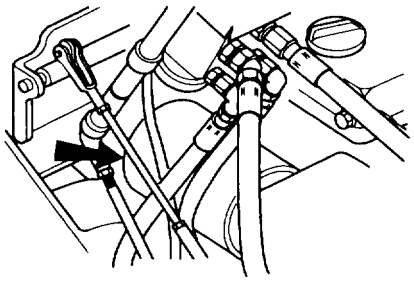
Refer to Section 10.0, Main Hydraulic and Steering Lines.

13. Reconnect the brake lines. See Section 8.4.

14. Tighten brake line tube fittings to torque spec; 135-145 lb-in (15-16 N-m).

NOTE

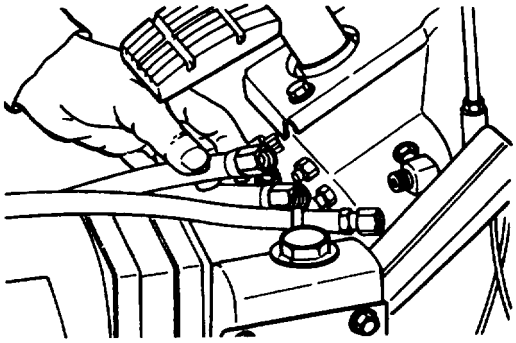
After installation of transaxle in the truck, the entire brake system must be bled to remove all air from the system according to recommended brake bleeding procedure. Refer to Section 8.5, Brake Bleeding Procedures (TA18 transaxle).



15. Install new transmission oil filter.

16. Install the transmission cooling lines to the transaxle. Be sure they are in the correct position (refer to the markings placed on them at removal).

Refer to Section 4.8 Cooling System.



17. Install the power steering lines to the steering gear (valve). Be sure they are installed to the correct ports (refer to the markings placed on them at removal).

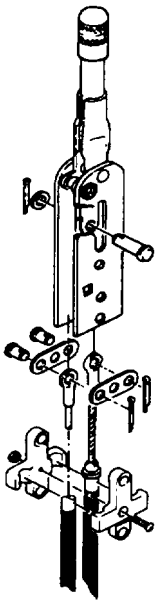
Refer to Section 9. , Steering System and Section 10.0, Main Hydraulic and Steering Lines.

18. Connect the steer valve sump return line at the sump tank inlet.

19. Install the accelerator linkage, as required.

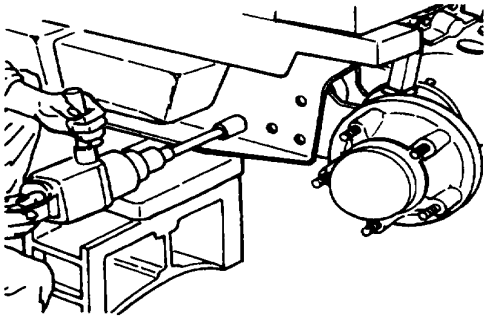
20. Reconnect the directional control (shift) linkage. Reconnect wiring leads to control cover solenoid terminals. Check the markings on them to be sure each is installed on the correct solenoid.

Refer to Section 7.12, Directional Control Linkage.

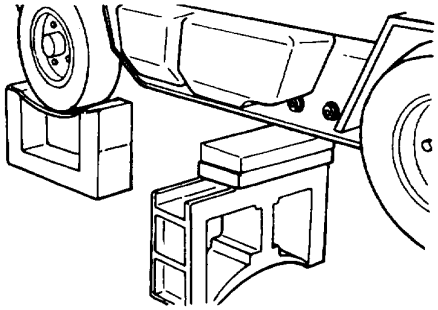


21. Install the parking brake linkage. Install parking brake lever and cable assembly on steering column mounting. Install steering column lower mounting bracket.

Refer to Section 8. 1, Service Brake and Inching Systems.

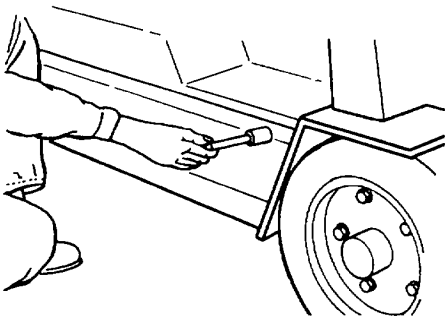


22. Install the drive wheels. Tighten the wheel lug nuts to torque spec: 470-530 lb-ft (637-718 N•m)



23. Inspect to make sure all parts have been reassembled and installed correctly.

24. Raise truck, remove blocking and carefully lower truck to the floor. Remove lifting equipment.



25. Install frame side compartment doors. Tighten fasteners to torque spec: 30-35 lb-ft (40-50 N-m).

26. Install the upright. Refer to Section 13.1, Upright.

27. Install the counterweight.

Refer to Section 12.1, Counterweight Maintenance, Removal and Installation.

28. Reconnect battery ground cable to the engine ground connection.

29. install floor boards and close engine compartment.

7.5. Transaxle Overhaul
General Procedures

Disassembly F-341
Cleaning F-341
Inspection F-342
Repair and Replacement F-342
Reassembly F-344

Disassembly

It is assumed in the detailed disassembly instructions that the transmission fluid has been drained from transaxle, the necessary controls, linkages and hydraulic lines are disconnected and the transaxle if removed from truck chassis.

Follow closely each procedure in the detailed instructions, making use of the text, illustrations and photographs provided.

1. **Cleanliness** Provide a clean place to work. It is important that no dirt or foreign material enters the unit during repairs. Dirt is an abrasive and can damage bearings. It is always good practice to clean the outside of the unit before starting the planned disassembly.

2. **Assemblies** When disassembling the various assemblies, such as the clutches, idler shaft and wheel ends, lay all parts on a clean bench in the same sequence as removed. This procedure will simplify reassembly and reduce the possibility of losing parts.

3. **Using Tools To Move Parts** Always apply force to shafts, bearings, housings, etc., with restraint. Movement of some parts is restricted. Never apply force to the part being driven after it stops solidly. The use of soft hammers, bars and mauls for all disassembly work is recommended.

4. **Bearings** Carefully wash and relubricate all reusable bearings as removed and protectively wrap until ready for use. Remove bearings planned to be reused with pullers designed for this purpose.

5. **Snap Rings** Remove snap rings with pliers designed for this purpose. Snap rings removed in this manner can be reused, if they are not sprung or loose in the groove.

Cleaning

WARNING

Gasoline is not an acceptable cleaning solvent because of its extreme combustibility. It is unsafe in the workshop environment because it can ignite and cause injury or death to personnel.

1. Proper cleaning requires complete disassembly.

2. Wash steel parts with machined surfaces in a commercial solvent.

3. Clean the inside and outside of bearing caps, housings, etc. Cast parts which do not have machined or polished surfaces may be cleaned in hot solution.

4. Wash castings or other rough parts in solvent or clean in hot solution tanks using mild alkali solutions, heating parts thoroughly before rinsing.

5. Rinse all parts thoroughly. Dry immediately with clean rags. Lightly oil parts and wrap in corrosion resistant paper if not reused immediately. Store parts in a clean, dry place.

6. Clean bearings thoroughly in approved solvent until completely cleaned. Dry bearings using moisture-free compressed air. Be careful to direct air stream across bearing to avoid spinning.

7. Do not spin bearings when drying them. Bearings may be rotated slowly by hand to facilitate drying.

Inspection
All transaxle components should be closely inspected after cleaning and before reassembly, to determine which require replacement. Check each part carefully for abnormal or excessive wear and damage to determine reuse or replacement.

Careful and complete inspection of all parts is very important. Replacement of all parts showing indication of wear, overstressing or damage will save time and money at a later date.

In General:
Inspect steel parts for notches, visible steps or grooves.

Look for scuffing, deformation or discoloration related to improper lubrication.

Inspect gear teeth for signs of excessive wear, pitting or cracking along contact lines. Check tooth contact pattern.

Inspect machined surfaces of cast or malleable parts for cracks, scoring and wear. Look for elongation of drilled holes, wear on machined surfaces and nicks or burrs in mating surfaces.

Inspect fasteners for rounded heads, bends, cracks or damaged threads.

All housings should be inspected for cracks or leaks, loose studs or cross-threaded holes.

Any damage which affects the alignment or structural integrity of the housing requires replacement. Repair by welding or straightening should not be attempted.

This process can affect the housing metallurgy and cause it to fail completely when under load.

Repair and Replacement
Replace lower-cost parts such as thrust washers, seals, etc., that protect the transaxle from premature wear and do not add greatly to the cost of rebuild.

Replace heavily worn but unbroken parts.

Steel parts such as shafts or gears are not repairable.

If worn or damaged, they should be replaced, along with mating parts as necessary.

Seals and washers should be routinely replaced. Fasteners with self-locking patches may be reused if secured with several drops of Loctite #277.

Transaxle housing repairs are limited to removal of nicks or burrs on machined surfaces or replacement of damaged studs.

Since the cost of a new part is generally a small fraction of the total cost of downtime and labor, avoid reusing a questionable part which could lead to additional repairs and expense soon after initial reassembly. To aid in determining the reuse or replacement of any transaxle part, consideration should also be given to the unit's history, hours of use, application, etc.

Recommended inspection procedures are provided in the following checklist.

A. Bearings

1. Wash all bearings in clean solvent. Check balls, cages or retainers, rollers and raceways for pitting, discoloration and spalled areas. Replace bearings that are pitted, discolored or spalled.
2. Always replace bearing cups and cones as a set. Do not replace a bearing or race separately.
3. Lubricate bearings that are not pitted, discolored or spalled and check for axial and radial clearances.
4. Replace bearings with excessive clearances.
5. Check bearing fits. Bearing inner races should be tight to shaft; outer races slightly tight to slightly loose in housing bore. If bearing spins freely in bore, however, housing should be replaced.
6. After inspection, lubricate bearings with clean oil and wrap in a lint-free cloth or clean paper to protect them until installation.

B. Gears and Shafts

1. Check gear teeth for frosting and pitting. Frosting of gear tooth faces presents no threat of transmission failure. Often in continued operation of the unit, frosted gears will "heal" and not progress to the pitting stage. And in most cases, gears with light to moderate pitted teeth have considerable gear life remaining and can be reused. But gears with advanced-stage pitting should be replaced.
2. If Magnaflux process is available, use it to check parts for damage.
3. If gear teeth show areas where the case-hardening is worn through or cracked, the gear must be replaced.
4. Inspect all shafts to be sure they are not bent or cracked and that splines are not damaged.

C. Splines

Check splines on all shafts and gears for abnormal wear. If splines are severely worn or pitted, replace the specific part affected.

D. Reverse Idler Gear Assemblies

Check for excessive wear from action of roller bearings.

E. Clutch Plates

1. Inspect clutch plates for excessive wear (shown by worn dimples or friction surfaces) and for evidence of excessive heating of plates (blue color indicating excessive heating) or warped plates.
2. Examine clutch disc internal and external teeth for evidence of excessive wear.
3. All damaged plates must be replaced with new plates.

F. O-Rings and Gaskets

1. Check all O-rings for cracks or distortion. Replace if worn. It is good practice to replace all O-rings at overhaul.
2. Replace all gaskets at overhaul.
3. O-rings and seals should be lubricated with transmission fluid before assembly.

G. Oil Seals

1. Check oil seals for nicks, wear and breaks. If sealing action of lip has been destroyed, replace seal. It is good practice to replace all oil seals at overhaul.
2. Extra care should be used when seals are installed to prevent damage to the seal. Seal lips and sealing surfaces can be easily nicked and damaged, thereby destroying the sealing ability.

H. Housings

Check all housings for damage, cracks and wear. Replace damaged housings, as needed.

I. Capscrews, Threaded Fasteners and Snap Rings

1. Inspect all fasteners for damage and wear. Replace all damaged fasteners.
2. Snap rings are to be installed with flat side away from load. Replace any damaged or suspect snap rings.

Reassembly

Be sure that interiors of all housings are clean. It is important that dirt and other foreign materials be kept out of the transaxle during reassembly. Dirt is an abrasive and can damage polished surfaces of bearings and washers. Use certain precautions, as listed below, during reassembly.

1. **GASKETS** - As applicable, when gaskets are required, use new gaskets as the transaxle is being rebuilt. Be sure all gaskets are installed. An omission of any gasket can result in oil leakage.
2. **CAPSCREWS AND THREADED FASTENERS** Use only threaded fasteners of the correct part number and material specification. Replace all fasteners which have a questionable condition. Apply lubricant or thread compound only as specified. Be sure all fasteners are installed (none omitted) and torqued to the correct specification.
3. **O-Rings** - Lubricate all O-rings with transmission fluid.
4. **ASSEMBLY** - Refer to the illustrations and photographs provided in the detailed disassembly instructions as a guide to reassembly.
5. **INITIAL LUBRICATION** - Coat all washers and splines of shafts with Lubriplate during reassembly to prevent scoring and galling.
6. **BEARINGS** - Use of the proper bearing installation tool is recommended for the installation of bearings. The proper tool applies equal force to both bearing races, preventing damage to balls/rollers and races while maintaining correct bearing alignment with bore and shaft. Avoid using a tubular or sleeve-type driver, whenever possible.

TORQUE RECOMMENDATIONS - Correct torque application is extremely important to ensure long transaxle life and dependable performance. Over-tightening or under-tightening can result in a loose installation and, in many instances, eventually cause damage to transaxle gears, shafts and/or bearings. Use a torque wrench whenever possible to attain recommended torque ratings. Refer to Section 2, Service Specifications, for torque recommendations.

TOOL REFERENCE - Some repair procedures in this manual may show the use of specialized tools. Their actual use is recommended as they make transaxle repair easier and faster and prevent costly damage to critical parts.

But for the most part, ordinary mechanic's tools such as socket wrenches, screwdrivers, etc., and other standard shop items such as a press, mauls and soft bars are all that is needed to successfully disassemble and reassemble the transaxle.

7.6. TA18 Transaxle

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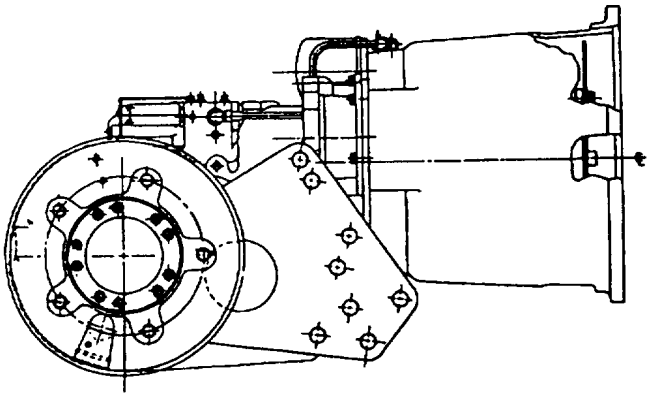
Specifications F-346
TA 18 Service Maintenance F-348
General Arrangement F-350
Parts Nomenclature F-351
Transaxle Overhaul F-359
Service Brake Adjustment F-377

Description and Operation



Refer to Section 2.1, Service Specifications for TA-18

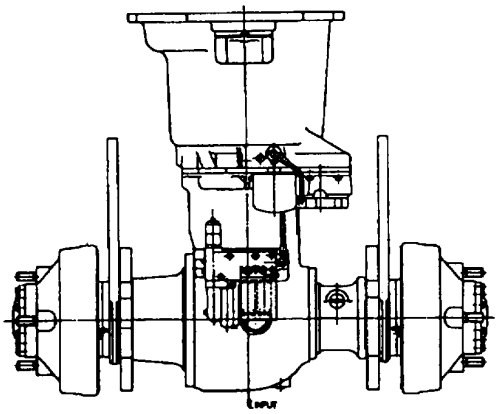
Clark Model TA18 transaxle assembly includes:
- Torque converter
- Single-speed forward and reverse power shift transmission with integral differential and drive axle
- Full-floating straight drive axle-drum-and shoe brakes
- Gear-driven pump drive
- Electric shift control, hydraulic inching control

Powerflow is from torque converter turbine to turbine (clutch) shaft and gears then thru either forward gear or reverse idler shaft to output gear mounted on final drive pinion shaft.

Transmission and differential housed in one-piece transmission case. Torque converter housing joined to transmission case through an adaptor (or spacer) plate. Adaptor plate holds converter stator support and reverse idler outer bearing.

Pump drive driven by converter impeller hub gear through idler gear to pump gear mounted on charging pump shaft.

Final drive pinion gear shaft mounted in tapered roller bearings at both ends in transmission case, and adjusted for mounting distance and ring and pinion gear contact by shim pack installed behind inner tapered roller bearing cup at pinion gear in transmission case. Pinion shaft bearing preload is adjusted with shims behind outer bearing cone on pinion shaft.



Final drive ring gear bolted to differential carrier. Differential supported by opposed tapered roller bearings mounted on inner ends of wheel end housings, which are bolted to openings in transmission case at the sides of the differential. Differential bearing preload and ring gear clearance (backlash) is maintained by shims placed behind differential bearing cones on wheel end housings. Adjustment of differential bearing preload or ring gear backlash requires trial assembly, checking, and disassembly of wheel end housings until correct adjustment is obtained.

Drive axle wheel hubs/brake drums supported by double tapered roller bearings on outer end of wheel end housings. Drive axle shaft flanges bolted to wheel hubs and full-floating in differential. Service brake backing plates bolted to mounting flanges on wheel end housings. Wheel bearings lubricated from transaxle sump.

Control valve mounted on pad at top of transmission case. Oil from charging pump flows thru filter and pressure regulator to control valve thru external oil supply

line. Oil from control valve delivered to clutches thru passages in housing and oil distributor sleeve and seal rings at forward-clutch end of turbine/clutch shaft. Excess pump oil volume and converter-out oil flows to oil cooler and returns to transmission housing at base of control valve then thru center of turbine/ clutch shaft back to converter.

Specifications

Model:	Clark TA18 Transaxle
No. Ratios	I-speed, forward and reverse
Overall Ratios:	(Fwd) 15.857:1 (Rev) 16.168:1
Transmission Ratio:	(Fwd) 2.846:1 (Rev) 2.902:1
Drive Axle Ratio	5.571:1
Ring & Pinion Gear Type:	Spiral bevel
Differential Type:	2-pinion
Torque Converter Size:	11 inch
Torque Converter Stall Ratio:	3.00:1
Main Hyd Pump Drive Ratio:	1.03 x Engine rpm
Charge Pump Flow, min.:	9.1 gpm @ 1800 rpm
Regulator Valve Pressure:	150-190 psi
Converter In/Lube Pressure, min.:	30 psi
Clutch Pressure, Fwd & Rev, max:	135-170 psi
Dry Weight:	600 lbs.
Oil Capacity, Initial Fill:	16 quarts
Oil Capacity, Refill:	13 quarts
Transmission Fluid:	AMOCO 1000, Texaco 1893 TDH

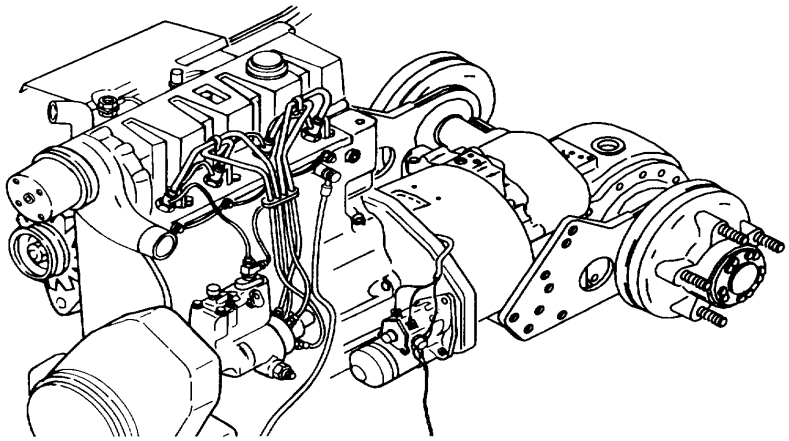


Figure 1. GP X 25 Powertrain: TMD27 (2.7L) engine and TA18 transaxle (right side view)

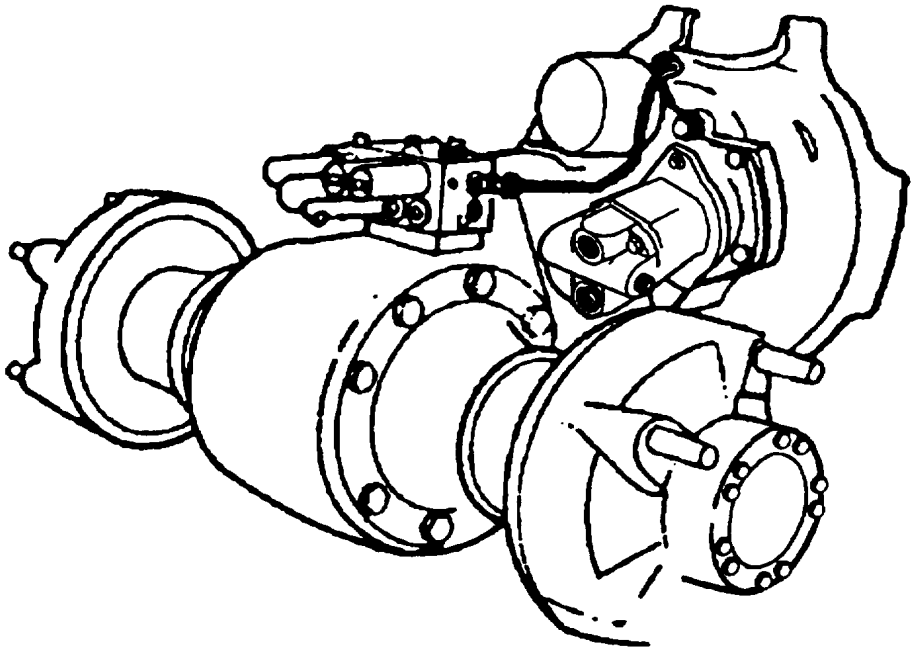


Figure 2. TA18 transaxle (3/4 left front view)

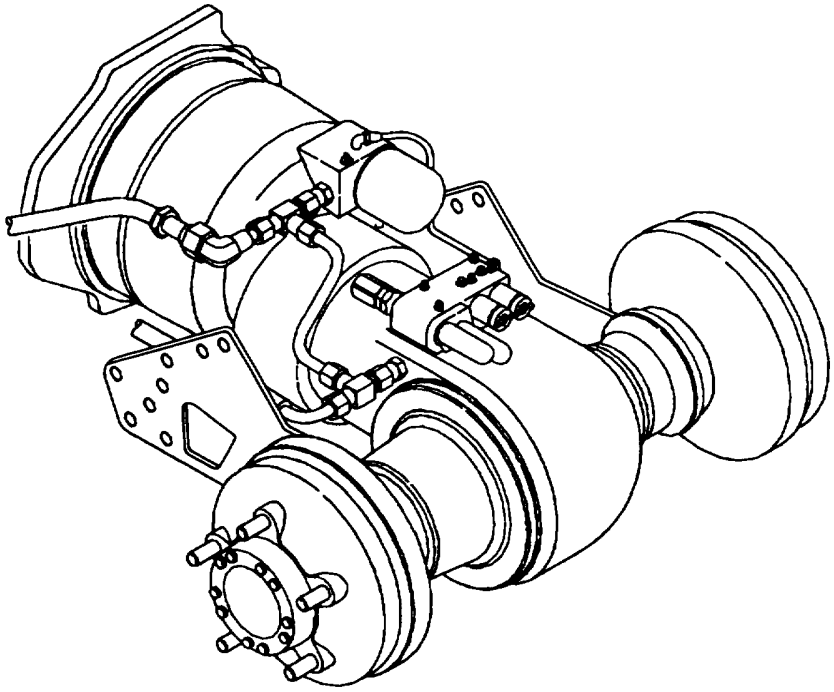
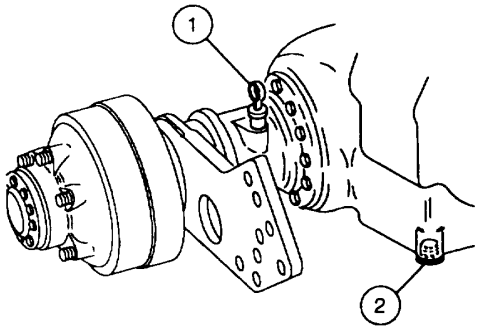


Figure 3. TA18 transaxle (3/4 right front view)

TA18 SERVICE MAINTENANCE



The TA18 transaxle has two service openings:

1. Dipstick/oil fill tube, in left side axle housing.
2. Drain plug, in bottom of transmission case.

Fluid Level Check

Check the transaxle fluid level with:

- Truck on a level surface.
- Engine idling with transmission in NEUTRAL.
- Oil at operating temperature (1800 - 2000F)

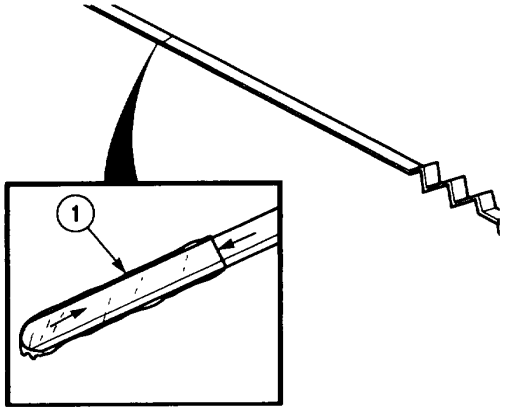
1. Clean area around oil filler before removing dipstick. Pull dipstick out. Remove all oil from dipstick with a clean wiper and push it back into filler tube. Remove dipstick to check oil level.
2. **The oil level is correct** when oil can be measured between the marks on dipstick.
3. **Add recommended fluid only**, as required.
4. **After adding oil** to transaxle, wait several minutes until oil has distributed evenly throughout the unit. Check for correct oil level. *Do not overfill.*

NOTICE
The follow lubricant is recommended for best operation of the TA18 transaxle:
AMOCO 1000, or Texaco 1893 TDH **Clark Part No. 2776236**

Fluid and Filter Change

It is recommended to:

- Drain and replace the transaxle fluid every 1000 operating hours.
- The oil should be drained when warmed to operating temperature, 180°-200°F (82°-93°C).
- Replace the transaxle oil filter every 500 operating hours. See NOTE below.



TA 18 Transaxle dipstick/oil fill tube.

NOTE

When the transaxle is new or rebuilt, it is recommended to change the oil filter after the first so hours and again after 100 operating hours.

1. Remove drain plug from bottom of transmission case. Drain old oil into suitable drain pan.
2. Remove old oil filter. The oil filter is mounted near the top of converter housing above transmission.

NOTE

Take special care when removing the filter to avoid oil remaining in filter from draining onto floor. Loosen the filter using a filter wrench. Remove filter while holding a pad of cloth or other absorbent material under the open end to absorb any excess oil that may drain out of filter.

3. Install a new oil filter. Follow the installation instructions printed on filter.

Refilling The Transaxle

After drive axle and transmission housing has drained completely:

1. Install drain plug.
2. Remove dipstick and fill transaxle to FULL mark on dipstick. *Do not overfill.*
3. Start the engine and run at idle speed (500-700 rpm) in NEUTRAL for 2-3 minutes to prime the converter and cooler lines.
4. Recheck oil level with engine running at idle speed. Add oil to bring oil level to ADD mark on dipstick. When oil temperature is hot (180 - 200°F), make final oil level check. Oil level should be at FULL mark.
5. Check for leaks at drain plug and oil filter.

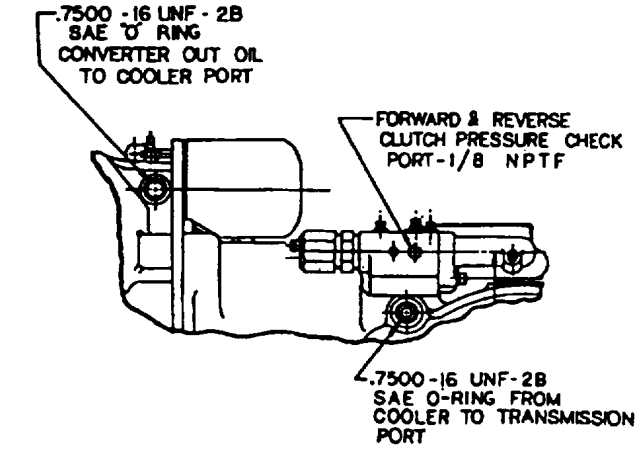
TA18 Transmission Pressure Specifications

- Regulator Valve Pressure: ..... 150-195 psi - 1800 rpm (1034-1172 kPa)
  Check Point: Oil supply line at converter
- Converter In/Lube Pressure: ..... 30 psi minimum - 1800 rpm (206 kPa)
  Check Point: Return from cooler
- Converter Safety Valve Pressure: ..... 120-130 psi - 1800 rpm (827-896 kPa) (Reference only)
  (Trans in NEUTRAL) ..... with line to cooler blocked
  Check Point: None
- Clutch Pressure: ..... 135-155 psi - 600 rpm idle (930-1068 kPa)
  (Forward, Reverse applied) ..... Normally 15 psi less than regulator pressure (135 psi min)
  Check Point: At control valve (1/8 NPTF)
- Clutch Pressure: ..... Same as regulator valve pressure
  (in NEUTRAL)

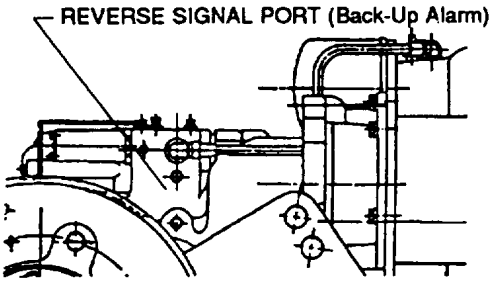
Notes:

1. All rpm's noted are engine speed.
2. All clutch pressures are at engine idle speed with clutch engaged, unless otherwise noted.
3. IMPORTANT - Oil at operating temperature 180-200°F (82-93°C)
4. Refer to following illustrations for check point locations.

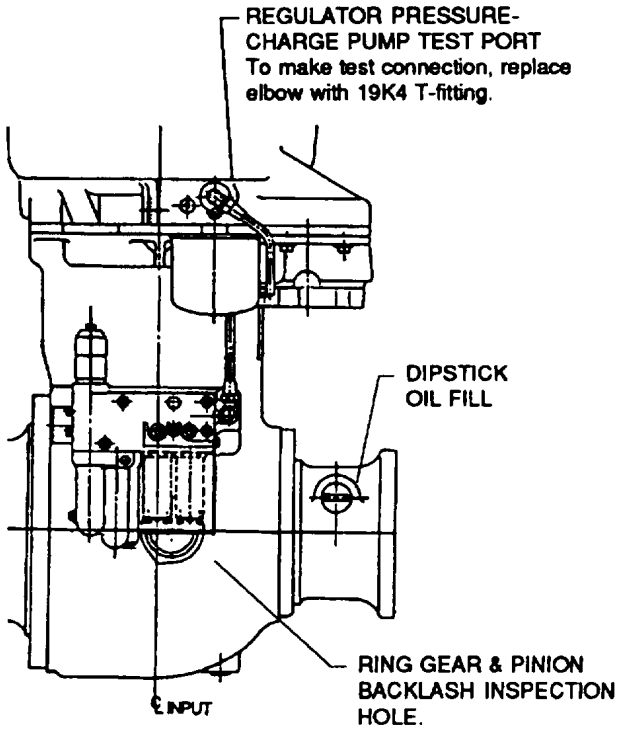
TA18 Transmission Pressure Check Points



Right Side View

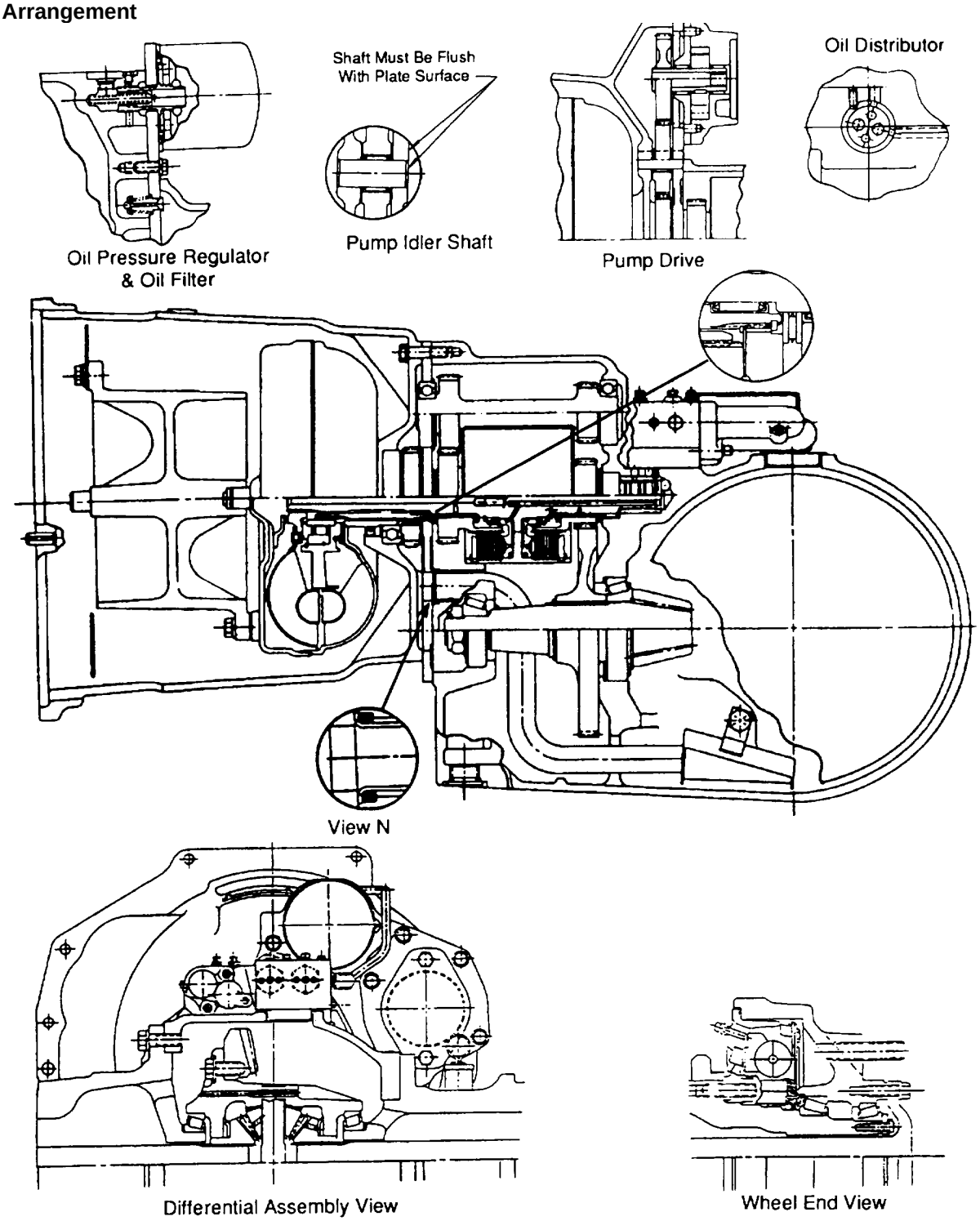


Left Side View



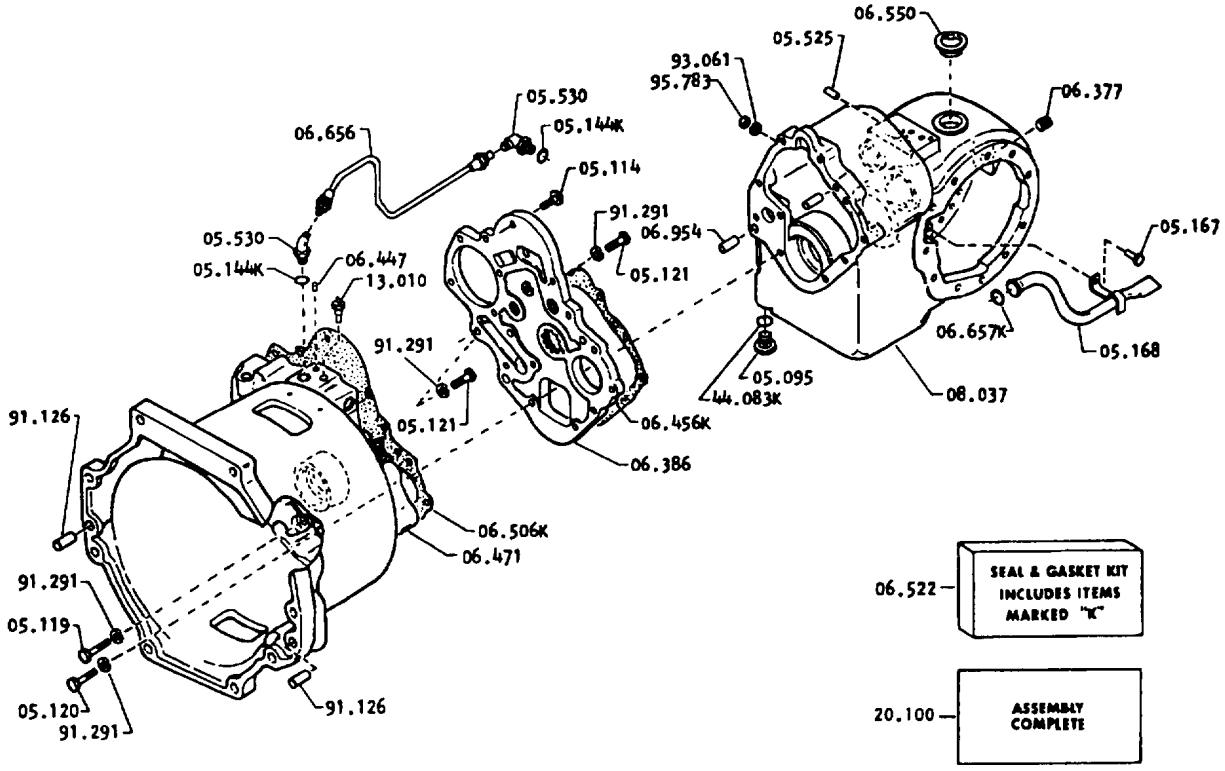
Top Side View

General Arrangement



Parts Nomenclature

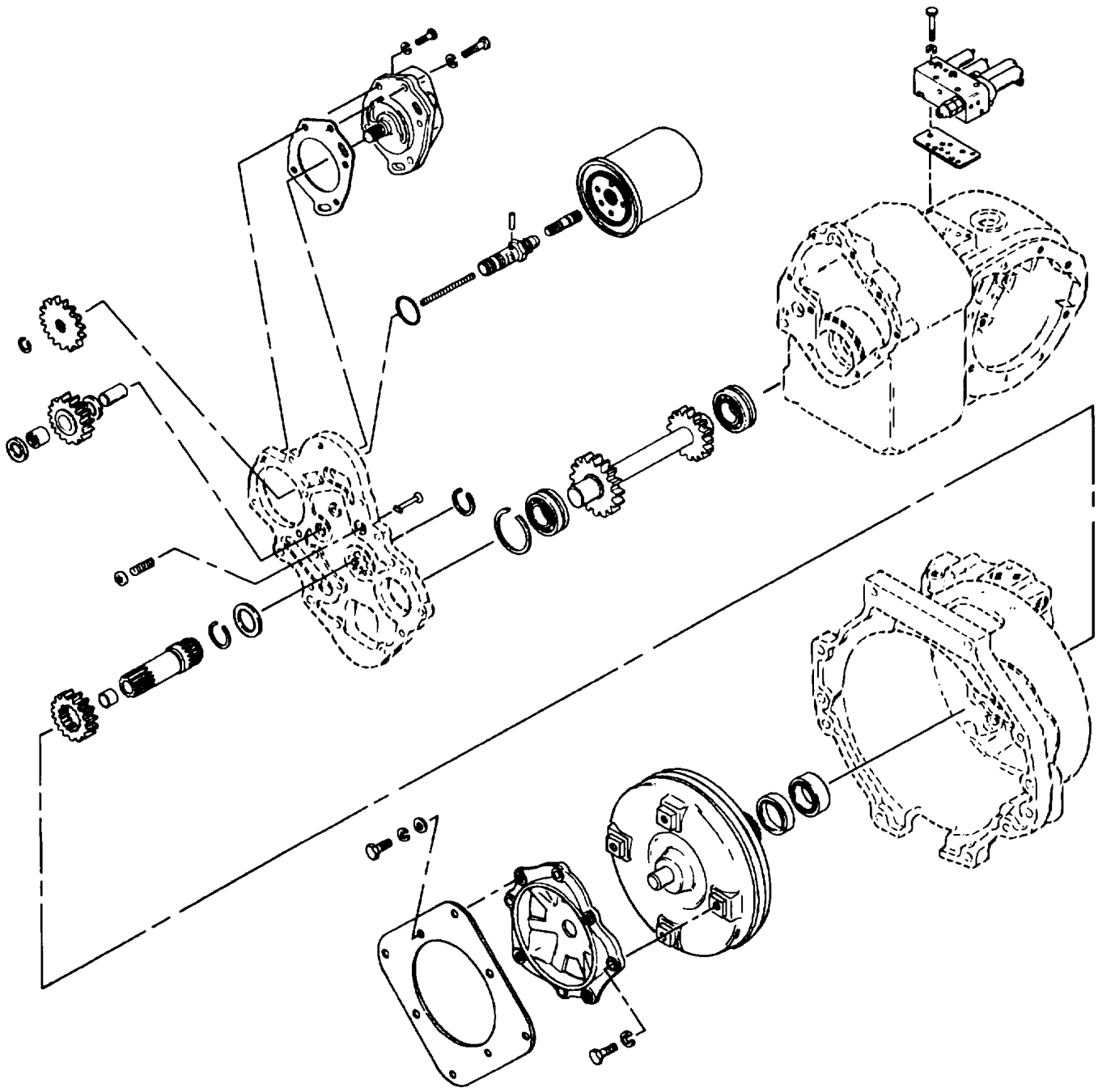
**Converter Housing, Adapter Plate,
Transmission Case, Oil Lines**



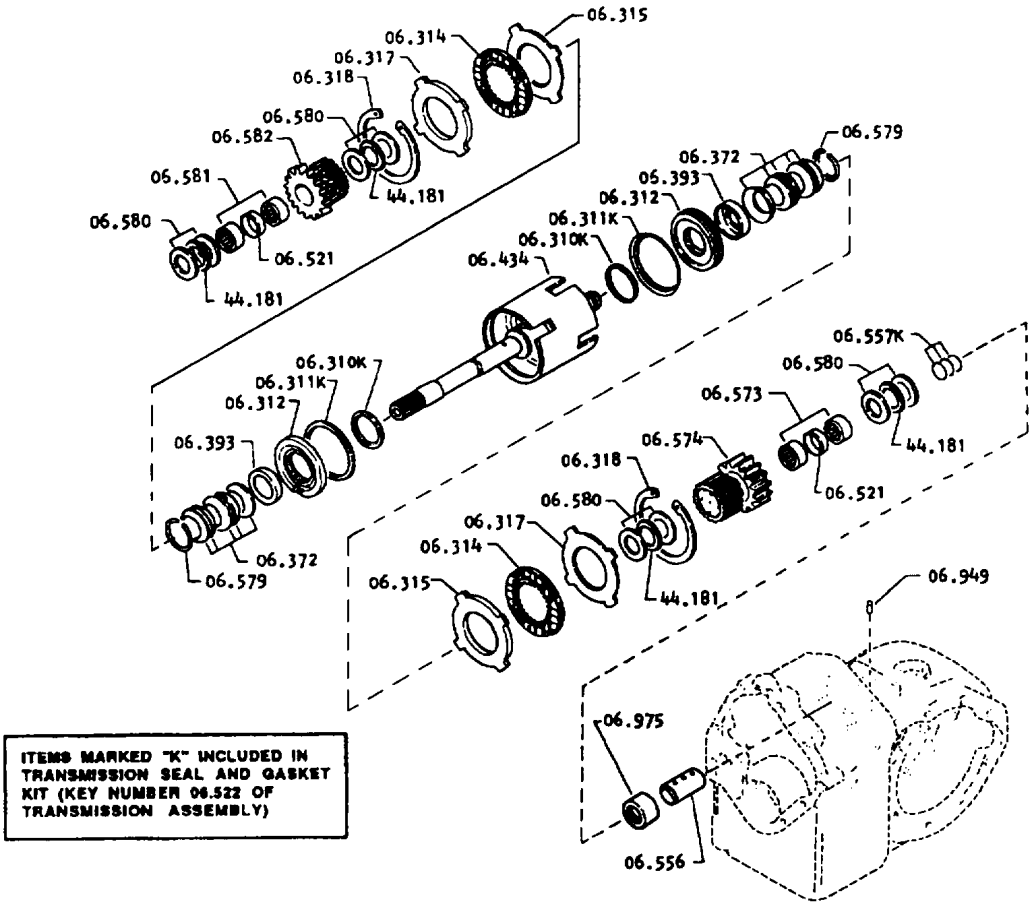
06602-1

20.100	TRANSAXLE ASSEMBLY (CONT'D.)	06.471	HOUSING, CONVEITER
05.095	PLUG, OIL DRAIN	06.506	GASKET, CONVERTER HOUSING TO ADAPTOR
0S.114	FASTENER, CONVERTER HOUSING	06.522	SEAL AND CASKET KIT, TRANSMISSION
05.119	FASTENER. CONVERTER HOUSING	06.550	COVER. TRANSMITSSION COVER
05.120	FASTENER, CONVERTER HOUSING	06.656	LINE, CONVERTER PUMP SUPPLY
05.121	FASTENLR, CONVERTER ROUSING	06.657	SEAL, SUCTION TUBE
05.144	SEAL, CONVERTER PUMP SUPPLY LINE FITTING	06.954	DOWEL, TRANSMISSION HOUSING ALIGCENT
05.167	FASTENER, SUCTION TUBE	08.037	HOUSING, TRANSMISSION
05.168	TUBE, SUCTION	13.010	CONTROL, CONVERTER TEPECRATURE SIGNAL
05.525	PLUG, TRANSMISSION DRAIN	44.083	SEAL, TRANSMISSION DRAIN PLUG
05.530	FITTING, CONVERTER PUMP SUPPLY LINE	91.126	DOWEL, CONVERTER HOUSING ALIGNMENT
06.377	PLUG, TRANSNISSION SUHP LEVEL	91.291	LOCKWASHER, CONVERTER HOUSING FASTENER
06.386	PLATE, CONVERTER TO TRANSMISSION ADAPTOR	93.061	WASHER, SUCTION TUBE FASTENER
06.447	PLUG, CONVERTER HOUSING	95.783	NUT, OIL SUCTION TUBE FASTENER
06.456	GASKET, TRANSMISSION HOUSING TO ADAPTOR		

Torque Converter, Charging Pump, Oil Filter, Stator Support, Reverse Idler gear & Shaft, Pump Idler Gear, Control Cover

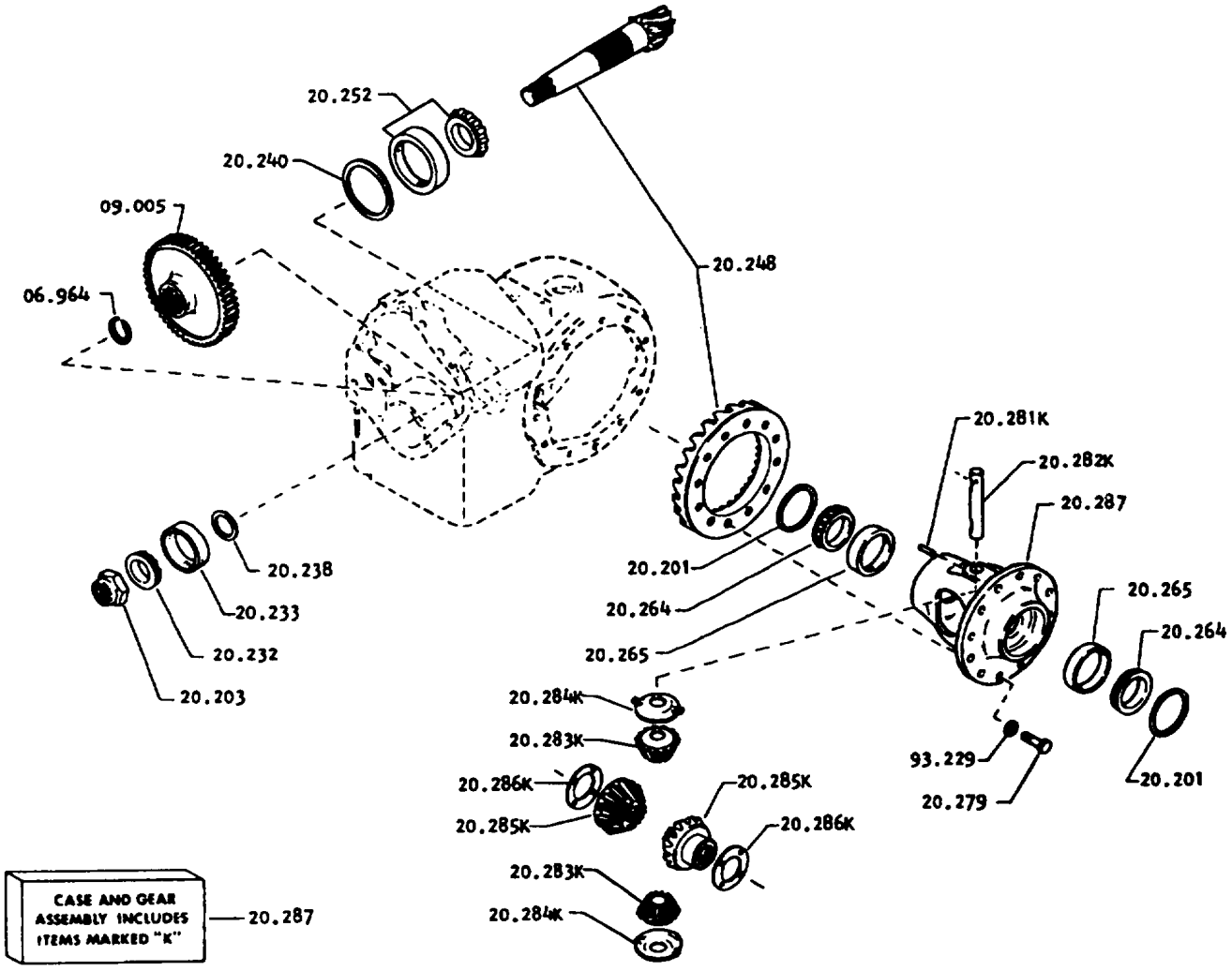


Forward & Reverse Clutch Pack



06601-1

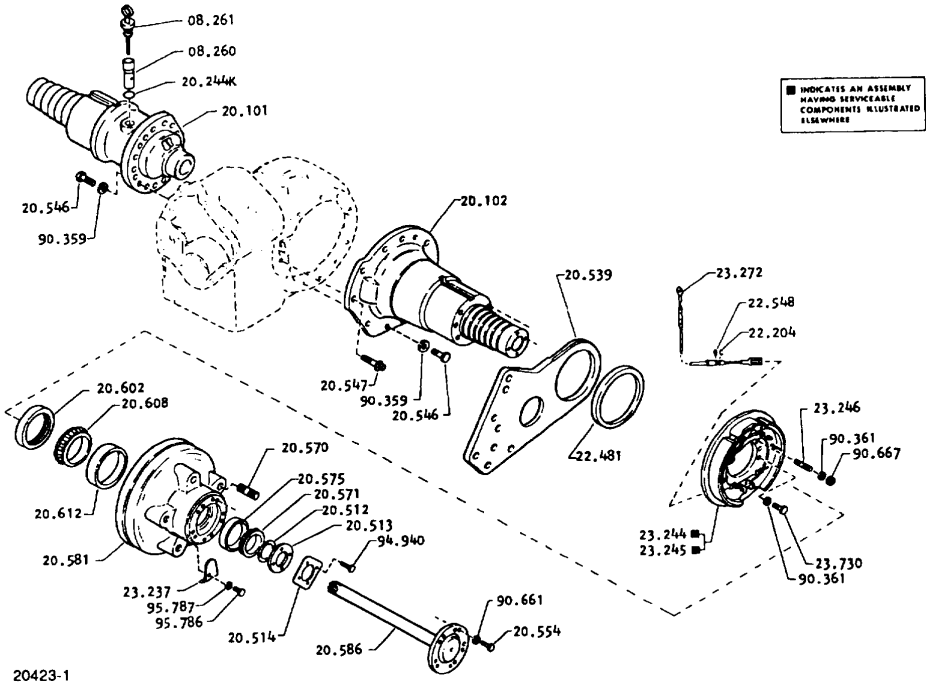
20.100	TRNJSAXLE ASSEHBLY (CONT'D.)
06.310	SEAL, CLUTCH PISTON (INNER)
06.311	SEAL, CLUTCH PISTON (OUTER)
06.312	PISTON, CLUTCH
06.314	DISC, CLUTCH (INNER)
06.315	DISC, CLUTCH (OUTER)
06.317	PLATE, CLUTCH DISC END
06.318	RETAINER, CLUTCH DISC END PLATE
06.372	SPRING, CLUTCH RELEASE
06.393	PLATE, CLUTCH PISTON WEAR
06.434	SHAFT ASSDEILY, TURBINE AND CLUTCH DRUMI
06.521	SPACER, CLUTCH GEAR BEARING
06.556	DISTRIBUTOR, CLUTCH BEARING OIL
06.557	SEAL, DISTRIBUTOR OIL
06.573	BEARING, FORWARD CLUTCH GEAR
06.574	GEAR, FORWARD CLUTCH
06.579	RETAINER, CLUTCH SPRING SEAT
06.580	WASHER. CLUTCH HUB GEAR THRUST
06.581	REARING, REVERSE CLUTCH GEAR
06.582	GEAR, REVERSE CLUTCH
06.949	PIN, CLUTCH OIL DISTRIBUTOR
06.975	BEARING, TURBINE SHAFT REAR
44.181	BEARING, CLUTCH HUB GEAR THRUST



20422-1

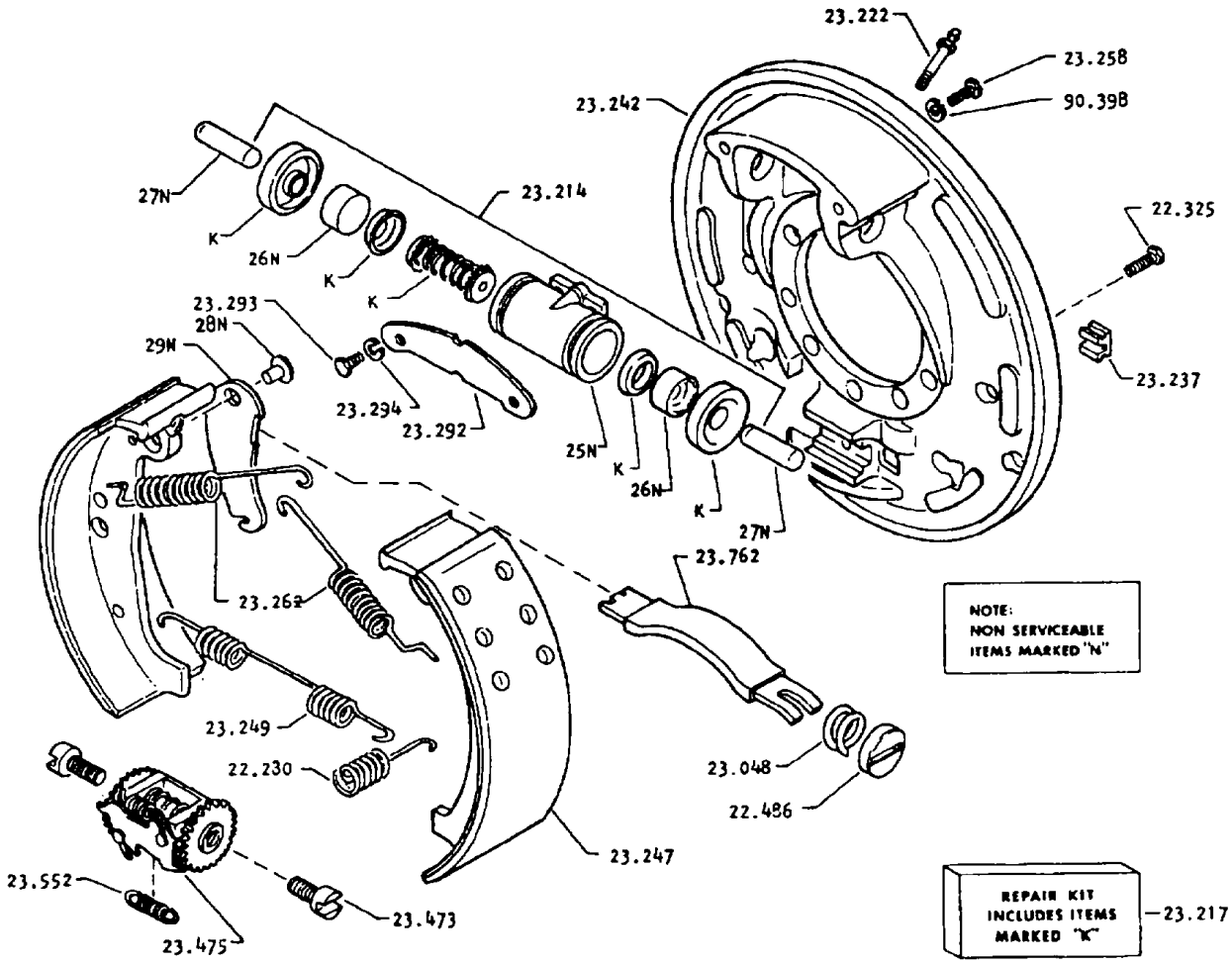
20.100	TRANSAXLE ASSEMBLY (CONT'D
06.694	RETAINER, TRANSMISSION OUTPUT
09.005	GEAR, TRANSMISSION OUTPUT
20.201	SHIM, DIFFERENTIAL BEARING CARRIER
20.203	NUT, DIFFERENTIAL PINION DRIVE GEAR
20.232	CONE, DIFFERENTIAL DRIVE PINION (OUTER BEARING)
20.233	CUP, DIFFERENTIAL PINION (OUTER BEARING)
20.238	SHIM, DIFFERENTIAL PINION BEARING (OUTER)
20.240	SHIMS, DIFFERENTIAL DRIVE PINION BEARING (INNER)
20.248	RING & PINION GEAR SET, DIFFERENTIAL DRIVE
20.252	BEARING, DIFFERENTIAL PINION INNER
20.264	CONE, DIFFERENTIAL BEARING
20.265	CUP, DIFFERENTIAL BEARING
20.279	FASTENER, DIFFERENTIAL DRIVE RING GEAR
20.281	LOCKS, DIFFERENTIAL SIDE PINION PIN
20.282	PIN, DIFFERENTIAL SIDE PINION
20.283	GEAR, DIFFERNTIAL SIDE PINION
20.284	WASHER, DIFFERENTIAL SIDE PINION THRUST
20.285	GEAR, DIFFERENTIAL SIDE
20.286	WASHER, DIFFERENTIAL SIDE GEAR THRUST
20.287	CASE & GEAR ASSEMBLY, DIFFERENTIAL
93.229	WASHER, RING GEAR FASTER

Drive Axle Wheel End Housings, Axle Shaft, Wheel Hub & Brake, Mounting Bracket



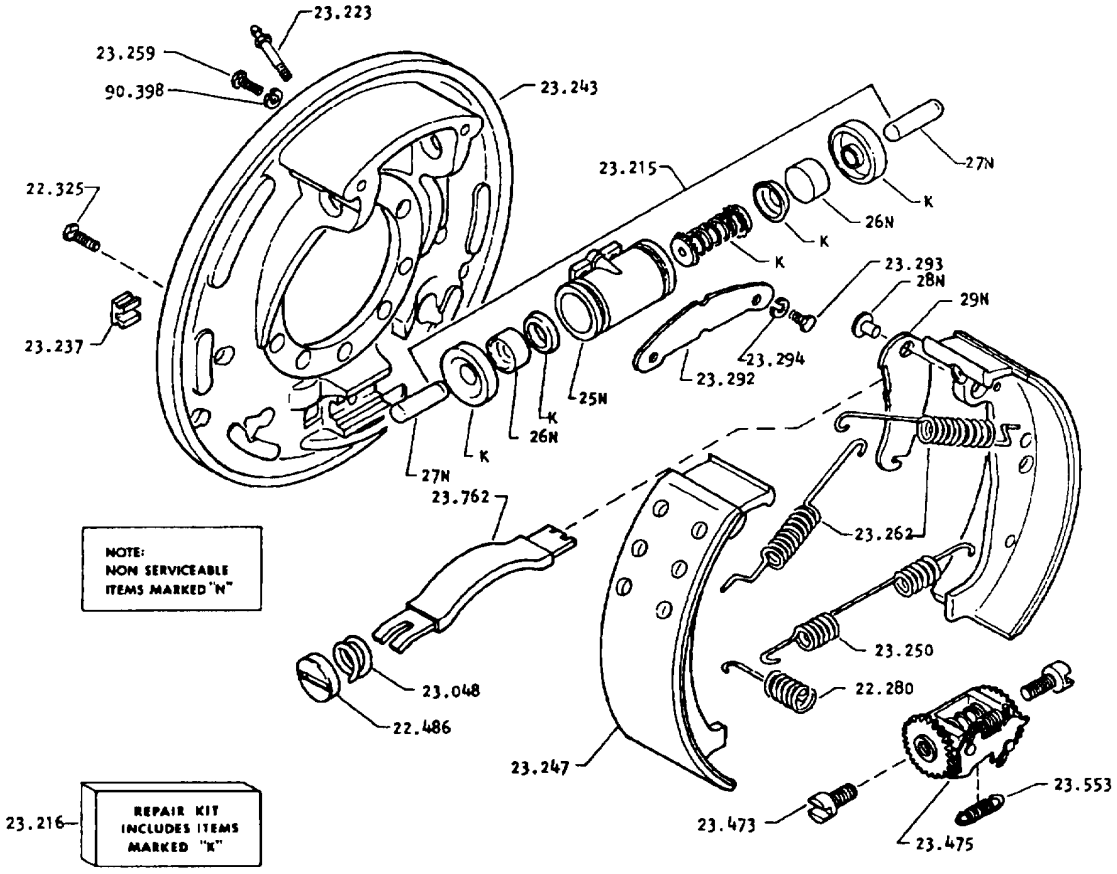
20.100	TRANSAXLE ASSEMBLY (CONT'D.)
08.260	TUBE, TRAN OIL LEVEL DIPSTICK SUPPORT
08.261	DIPSTICK, TRANSMISSION OIL LEVEL
20.101	HOUSING, TRANSAXLE WHEEL END - LH
20.102	HOUSING, TRANSAXLE WHEEL END - RH
20.244	SEAL, TRANSMISSION OIL LEVEL
20.512	SHIM, DRIVE AXLE HUB BEARING
20.513	RETAINER, DRIVE AXLE HUB BEARING
20.514	LOCKPLATE, DRIVE AXLE HUB BEARING RETAINER
20.539	SUPPORT, DRIVE AXLE SPINDLE (RH)
20.546	FASTENER,DRIVE AXLE END
20.547	FASTENER,DRIVE AXLE END
20.554	FASTENER,DRIVE AXLE HUB CAP
20.570	FASTENER,DRIVE WHEEL MOUNTING
20.571	CONE, DRIVE AXLE HUB OUTER BEARING
20.575	CUP, DRIVE AXLE HUB OUTER BEARING
20.581	HUB, DRIVE AXLE
20.586	SHAFT, DRIVE AXLE
20.602	SEAL, DRIVE AXLE HUB INNER OIL
20.608	CONE, DRIVE AXLE HUB BEARING
20.612	CUP, DRIVE AXLE HUB BEARING
22.204	CLIP, PARKING BRAKE CABLE RETAINING
22.481	SPACER, VHEEL BRAKE ASSEMBLY
22.548	SEAL, PARKING BRAKE CABLE
23.237	COVER, RH BRAKE ADJUSTOR
23.244	BRAKE ASSEMBLY, RH DRIVE WHEEL
23.245	BRAKE ASSEMBLY, LH DRIVE VHEEL
23.246	FASTENER, BRAKE ASSEMBLY,
23.272	CABLE, PARKING BRAKE
23.730	FASTENER, BRAKE ASSEMBLY
90.359	LOCKUASHER, DRIVE AXLE END FASTENER
90.361	LOCRVASNER, BRAKE ASSEMBLY FASTENER
90.661	LOCKVASHER, DRIVE AXLE HUB CAP FASTENER
90.667	NUT, WHEEL BRAKE ASSEMBLY FASTENER
94.940	FASTENER, HUB BEARING RETAINER LOCKPLATE
95.786	FASTENER, BRAKE ADJUSTOR ACCESS HOLE COVER
95.787	LOCKVASHER, ACCESS HOLE COVER FASTENER

Brake Assembly LH



22121-1

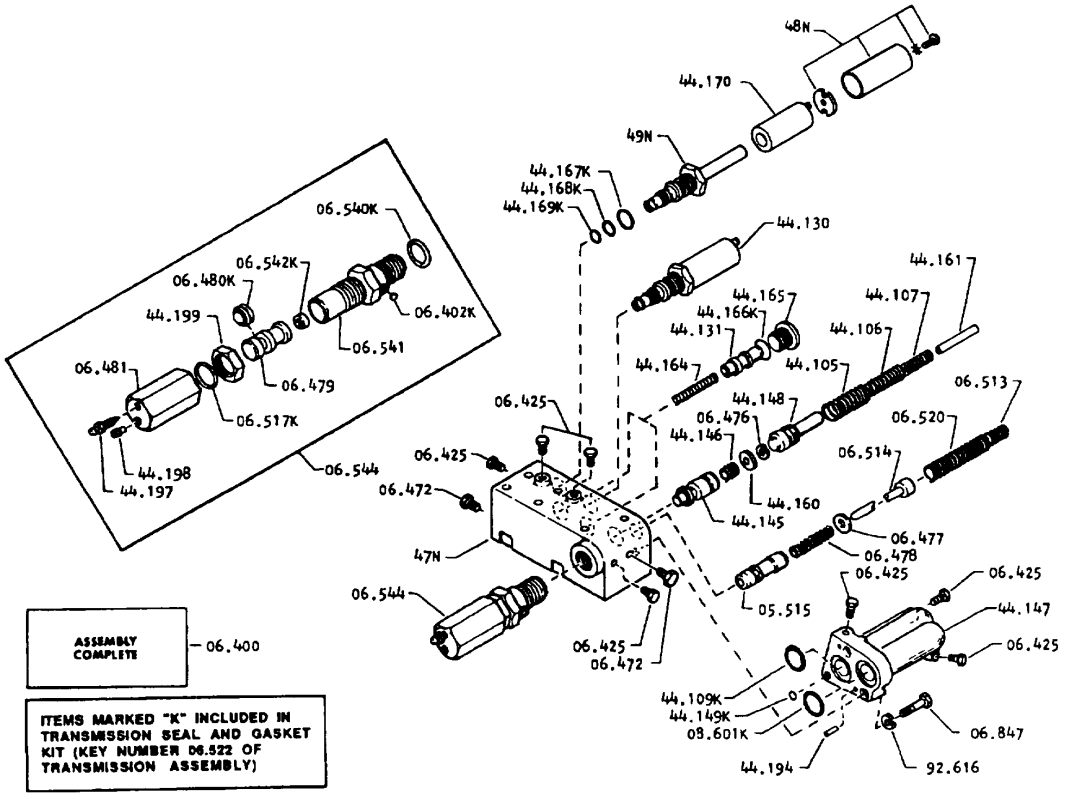
23.245	BRAKE ASSEBLY - LH	23.293	CAPSCREW, BRAKE SHOE ANCHOR
22.280	SPRING. BRAKE SHOE GUIDE	23.294	LOCKWASHER, RRAKE SHOE ANCHOR FASTENER
22.325	CAPSCREU, BRAKE SHOE ADJUSTOR	23.473	CUIDE, BRAKE SHOE ADJUSTOR
22.486	SEAT,PARKING BRAKE OPERATING ARN ANTI RATTLE SPRG	23.475	ADJUSTOR, BRAKE SHOE
23.048	SPRING,PARKING BRAKE OPERATING ARN ANT RATTLE	23.552	SPRING. BRAKE SHOE ADJUSTOR LK
23.214	CYLINDER ASSEIBLY, BRAKE - LH	73.762	ARM,PARKINC BRAKE OPERATING
23.217	REPAIR KIT, CYLINDER ASSEIBLY LN	90.398	WASHER, BRAKE CYLINDER FASTENER
23.222	SCREW, BRAKE CTLINDER BLEEDER LN	25N	USE 23.214
23.237	DUST COVER, IRAKE ADJUSTOR	26N	USE 23.214
23.242	PLATE, BRAKE BACKING - LH	27N	USE 23.214
23.267	SHOE & LININC SET, BRAKE (AXLE SET)	28N	RIVET USE 23.247
23.249	SPRING, BRAKE SHOE RETURN LN	29HN	CABLE LMER USE 23.247
23.258	CAPSCREW, BRAKE CYLINDER LH		
23.262	SPRING, BRAKE SHOE RETURN (CYLINDER END)		
23.292	ANCHOR, BRAKE SHOE		



22120-1

23.244	BRAKE ASSENLY - RH	23.293	CAPSCREW, BRAKE SHOE ANCHOR
22.280	SPRING, BRAKE SHOE GUIDE	23.294	LOCKWASHER, BRAKE SHOE ANCHOR FASTENER
22.325	CAPSCREW, BRAKE SHOE ADJUSTOR	23.473	GUIDE, BRAKE SHOE ADJUSTOR
22.486	SEAT, PARKING BRAKE OPERATING ARM ANTI-RATTLE SPRG	23.475	ADJUSTOR, BRAKE SHOE
23.048	SPRING, PARKING BRAKE OPERATING ARM ANTI-RATTLE	23.553	SPRING, BRAKE SHOE ADJUSTOR - RH
23.215	CYLINDER ASSEMBLY, BRAKE RH	23.762	ARM, PARKING BRAKE OPERATING
23.216	REPAIR KIT,CYLINDER ASSEMBLY RH	90.398	WASHER, BRAKE CYLINDER FASTENER
23.223	SCREW,BRAKE CYLINDER BLEEDER RH	25N	USE 23.215
23.237	DUST COVER, BRAKE ADJUSTOR	26N	USE 23.215
23.243	PLATE, BRAKE BACKING RH	27N	USE 23.215
23.247	SHOE & LINING SET, BRAKE (AXLE SET)	28N	RIVET USE 23.247
23.250	SPRING, BRAKE SHOE RETURN RH	29N	CABLE LEVER USE 23.247
23.259	CAPSCREW, BRAKE CYLINDER RH		
23.262	SPRING, BRAKE SHOE RETURN (CYLINDER END)		
23.292	ANCHOR, BRAKE SHOE		

Control Cover



06.400	CONTROL COVER ASSEHBLY. TRANSNISSION	44.130	SOLENOID ASSL!BLT, CONTROL SELECTOR
05.515	SPOOL. INCHING VALVE	44.131	SPOOL. FORIARD AND REVERSE VALVE
06.402	VENT, CONTROL COVER	44.145	SPOOL. MODULATOR VALVE
06.425	PLUG, CONTROL COVER HOUSING	44.46	SPRING, HODULATOR VALVE
06.472	PLUG, CONTROL COVER HOUSING	44.147	HOUSING. TRANSMISSION ACCUMULATOR
06.476	RETAINER, ACCUMULATOR VALVE PISTON	44.148	SPOOL, ACCUMULATOR VALVE
06.477	WASNER, INCHING VALVE PISTON	44.149	SEAL. ACCUMULATOR HOUSING
06.478	SPRING, INCHING VALVE PISTON RETURN	44.160	SEAT, NODULATOR VALVE SPOOL SPRING
06.479	PISTON, INCHING VALVE ACTUATOR	44.161	STOP. ACCUMULATOR VAJ.VE SPOOL
06.480	SEAL, INCHING ACTUATOR PISTON	44.164	SPRING. PORWARD AND REVERSE VALVE SPOOL RETURN
06.481	FITTING. INCHING VALVE ACTUATOR INLET	44.165	CAP. PORWARD AND REVERSE VALVE SPOOL
06.513	SPRING, INCHING VALVE INNER	44.166	SEAL, FORWARD AND REVERSE VALVE SPOOL CAP
06.514	ROD. INCHING VALVE	44.167	SEAL, CONTROL SELECTOR SOLENOID VALVE
06.517	SEAL, INCHING VALVE PISTON PORT PITTING	44.168	SEAL, CONTROL SELECTOR SOLENOID VALVE
06.520	SPRING, INCHING VALVE OUTER	44.169	SEAL. CONTROL SELECTOR SOLENOID VALVE
06.540	SEAL, INCHING PISTON HOUSING	44.170	COIL. CONTROL SELECTOR SOLENOID VALVE
06.541	HOUSING. INCRING PISTON	44.194	LOCATOR, CONTROL COVER
06.542	SEAL. INCHING ACTUATOR ROD	44.197	LEEDER., CONTROL VALVE SLAVE CYLINDER
06.544	ROUSING ASSEBLY. INCHING ACTUATOR	44.198	SEAT, SLAVE CYLINDER BRAKE LINE
06.847	FASTENER, ACCUMULATOR HOUSING	44.199	NUT, SLAVE CYLINDEI ADJUSTING
08.601	SEAL, ACCUMULATOR HOUSING	92.616	LOCIWASRER. ACCUMULATOR HOUSING FASTENER
44.105	SPRING, ACCUMULATOR OUTER	47N	HOUSING USE 06.400
44.106	SPRING. ACCUMULATOR NIDDLE	48N	COVER, SOLENOID USE 44.130
44.107	SPRING, ACCUMULATOR INNER	49N	SPOOL, SOLENOID USE 66 130
44.109	SEAL, ACCUMULATOR HOUSING		

Transaxle Overhaul
TA 18 1-speed Transaxle

1. Disassembly

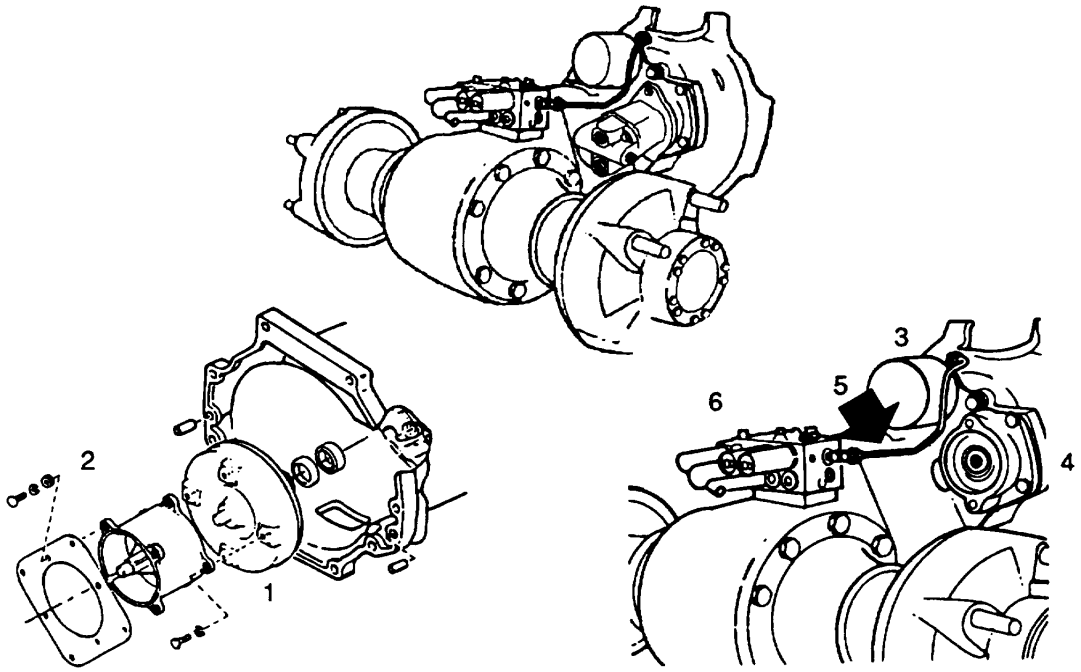
1. **Before attempting any or overhaul of this assembly,** please read through the entire disassembly and assembly procedures first.

NOTICE-Cleanliness is of extreme importance in the repair and overhaul of this assembly.

2. **The exterior surface** of the unit MUST be thoroughly cleaned of all dirt and foreign substances to prevent contamination of the parts during disassembly and overhaul. Perform all disassembly and assembly work in a clean area. Protect all components from dust and dirt while repairs are being made.

3. **Keep all parts in order** as disassembly progresses. Take care to properly identify each parts and its order of removal. If necessary, keep notes and put markings on parts using a non-destructive marker such as felt-tipped pen.

A. Remove Auxiliary Subassemblies

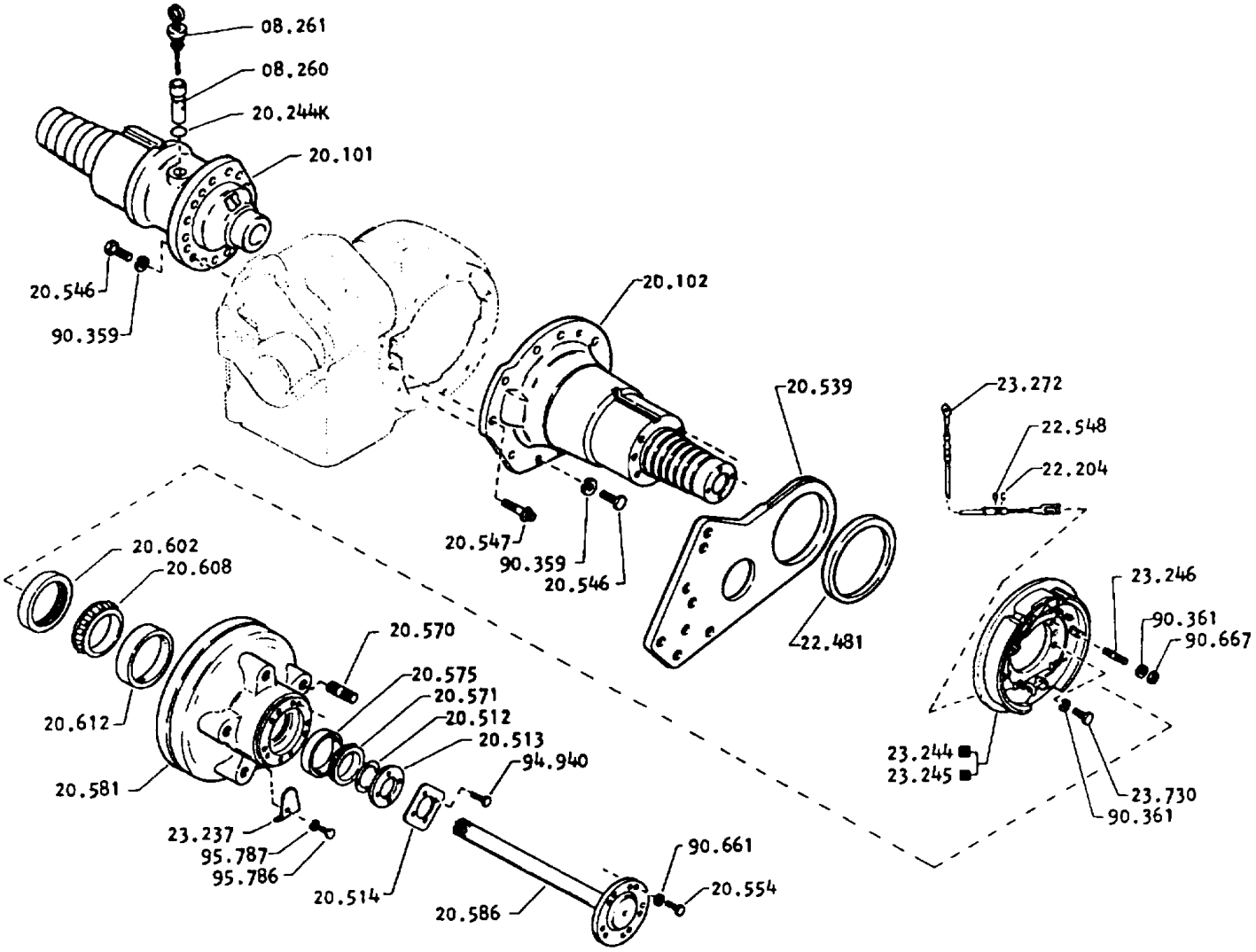


1. Remove torque converter assembly by carefully sliding it off the turbine (clutch) shaft and stator support.
2. Disassembly converter drive plate and adapter, ass need.

Remove the :

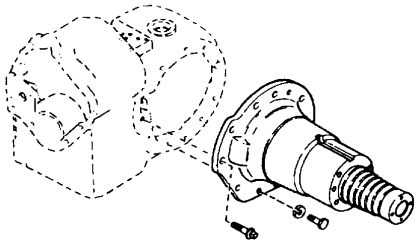
3. Oil filter.
4. Charging pump.
5. Oil supply line assembly.
6. Transmission control valve assembly.

B. Wheel End Disassembly



1. Loosen and remove the axle shaft fasteners.
2. Remove axle shaft.
3. Unbend (straighten) the lockplate tabs from the bolt heads of the wheel bearing retainer plate fasteners.
4. Remove the bearing retainer plate fasteners.
5. Remove the lockplate, bearing retainer plate and wheel bearing shims.
6. Pull wheel hub out to loosen bearing (you may have to tap on hub or pry at brake backing plate), remove outer wheel bearing, then remove the wheel hub/brake drum assembly with inner wheel bearing and oil seal *.

IMPORTANT - This oil seal is a type that seals internally, and is lined with sealing compound on the inner diameter that sticks and seals to the spindle. Removing the wheel hub from the spindle breaks that seal. Replace with new seal each time that the wheel hub is removed from wheel end housing.

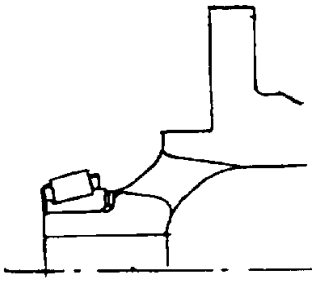


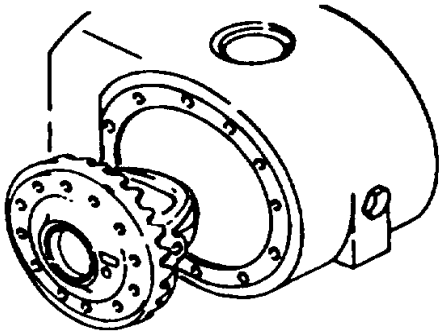
NOTE

If performing brake overhaul only, proceed to Step 12.

7. Before removal of wheel end housing, mark the housing and the transmission case for same location matching at reassembly. Loosen and remove the housing bolts and washers.
8. Remove wheel end housing from transmission case.
9. If the differential bearing on the inner end of the wheel end housing is to be removed and replaced, use a bearing puller, if necessary. Wire bearing shims to wheel end housing for storage until reassembly.

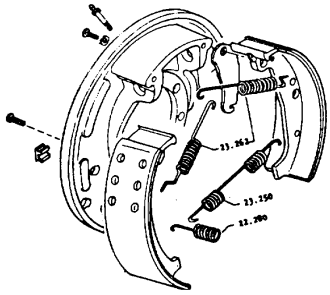
10. *Repeat* procedures of Steps 1 thru 9 for opposite wheel end disassembly.





11. Remove the differential assembly from transmission.

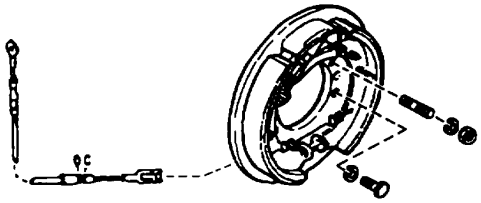
Brake Assembly Removal
Brake Removal Is Optional
for Brake Overhaul as Necessary



12. Remove the upper brake shoe return springs.
13. Remove lower return spring.
14. Remove brake shoe hold-down (guide) springs.
15. Disconnect parking brake cable Remove the brake shoes.
16. Remove brake backing plate fasteners and washers.

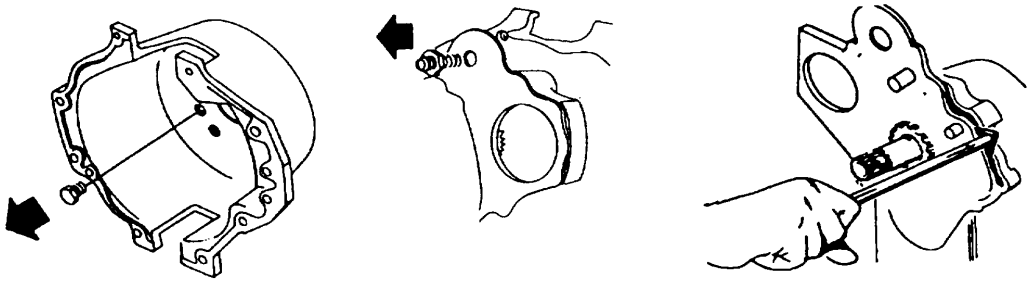
WARNING

Some brake linings are still made with asbestos which when inhaled has been found to be extremely dangerous. Do not use compressed air to clean the brake shoes or other parts before or after disassembly. Instead wipe down the assembly and then the components with damp, disposable wipers and immediately discard them safely. Avoid breathing dust or injury may result.



17. Remove backing plate and parking brake cable assembly from wheel end housing.
18. Remove drive axle support and spacer from wheel end housing.

C. Separation of Converter Housing and Adaptor Plate

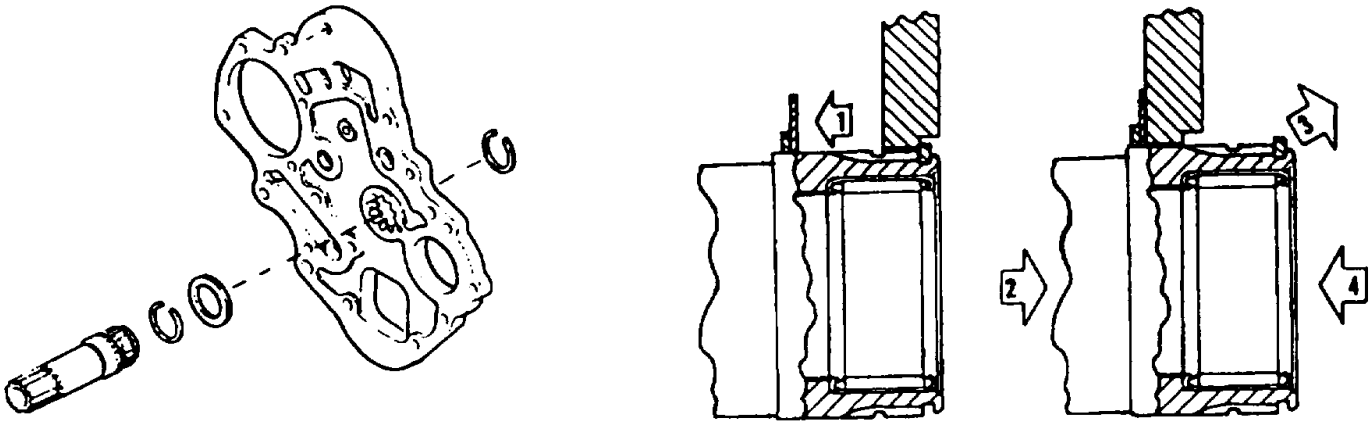


1. Remove the fasteners and washers which mount the converter housing to transmission case through the adaptor plate.
2. From other side, remove the bolts and washers which mount adaptor (spacer) plate to converter housing.
3. Remove the clutch pressure-regulating valve sleeve assembly (also oil filter mounting base).

IMPORTANT - Pry only at the dowel pins to remove adaptor plate. Dowel pins must be removed before reassembly. *See later instructions*.

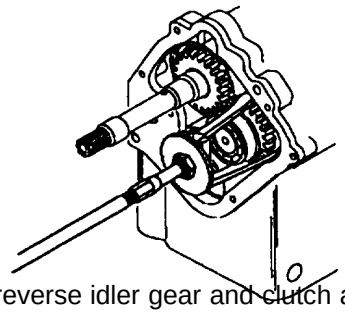
4. Separate converter housing from adaptor plate.
5. Remove impeller hub gear from stator support.
6. Remove pump drive idler gear and bearing, outer and inner thrust washers, and idler shaft.
7. Remove adaptor plate from transmission case.

D. Stator Support Removal From Adaptor Plate

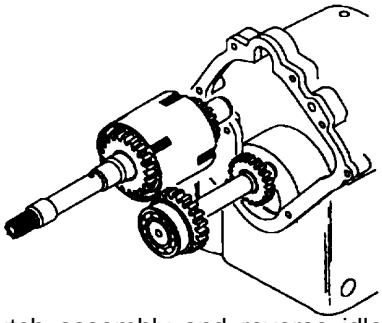


1. The stator support is held in place by two retaining rings, one on each side of the adaptor plate.
2. To remove stator support:
   a) Remove front (converter end) retaining ring from ring groove and move ring and impeller gear thrust washer toward stator support seal surface.
   b) Push stator support to the rear (towards transmission side) far enough to expose rear retainer ring.
   c) Remove rear retaining ring.
   d) From the front, pull stator support from adaptor plate.

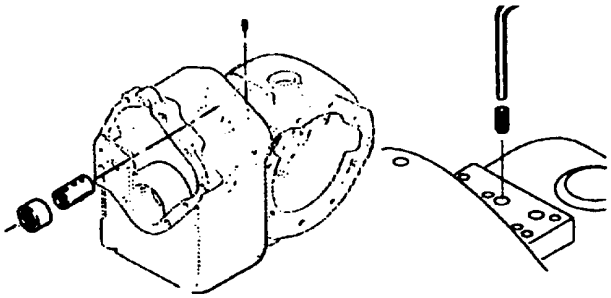
E. Clutch Assembly, Idler Gear, & Pinion Shaft Removal



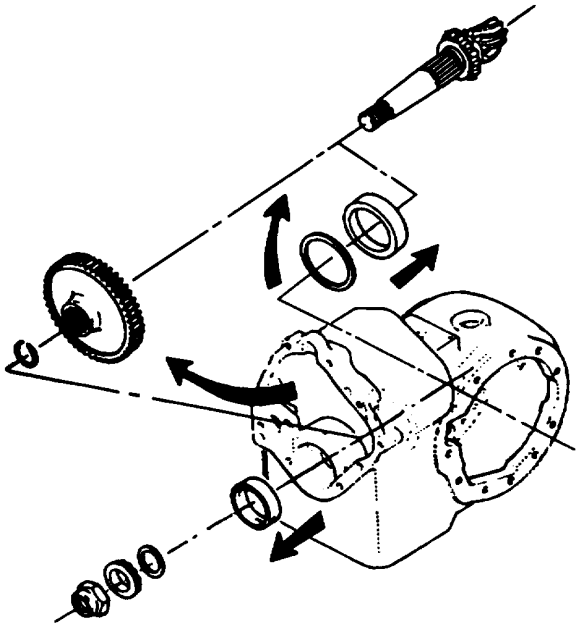
1. Move the reverse idler gear and clutch assembly apart far enough to allow the idler shaft to be pulled out of the inner being.



2.Remove the clutch assembly and reverse idler shaft together.



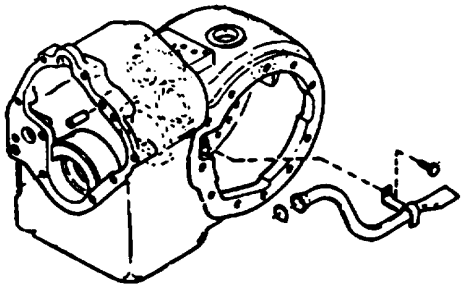
3. Remove the turbine (clutch) shaft rear bearing.
4. Remove the clutch shaft oil distributor retaining set screw (internal hex) from valve mounting base.
5. Remove the oil distributor. *Note the recess in distributor for retaining set screw.*



6. Loosen and remove the pinion shaft nut. Hold or block the pinion shaft with a brass bar or similar soft material to prevent turning.
7. Remove the pinion shaft outer bearing and shims. Keep the shims with the bearing and pinion shaft.
8. Remove output gear retaining ring from pinion shaft (inside transmission case).
9. Remove output gear (move pinion shaft away).
10. Remove pinion shaft and inner bearing through differential housing.
11. If pinion bearings are to be replaced, drive the cups from housing, from inside transmission case.
12. Remove inner pin ion bearing cup and shims from differential side.

NOTE

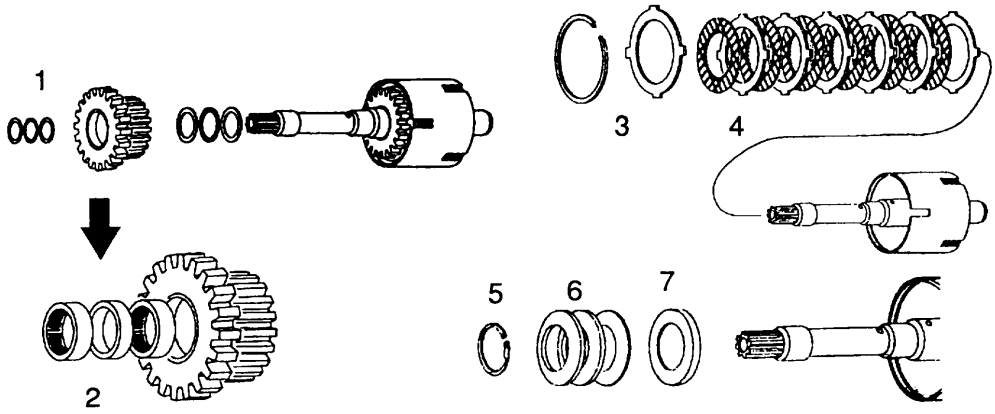
Wire shims to transmission housing for storage until reassembly.



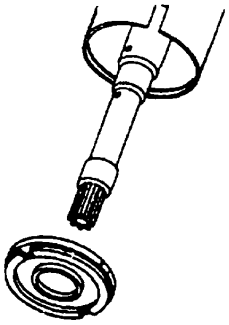
13. As required, remove oil suction (pickup) tube assembly from transmission case.

F. Clutch Disassembly

(Forward & Reverse Clutch Procedure Are the Same)
Reverse Shown Being Disassembled

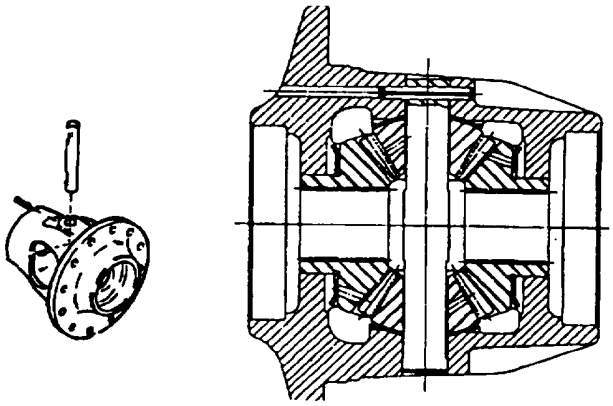


1. Remove outer clutch hub gear thrust bearing and thrust washers, clutch hub gear, and inner clutch hub thrust bearing and thrust washers.
2. Disassemble the two clutch gear bearings and spacer from internal bore of clutch gear hub.
3. Remove clutch disc end plate retainer ring and clutch disc end plate.
4. Remove inner and outer clutch discs.
5. Remove clutch return spring retainer ring.
6. Remove clutch return (release) springs (Belleville washers). Note assembly arrangement.
7. Remove clutch piston wear plate.



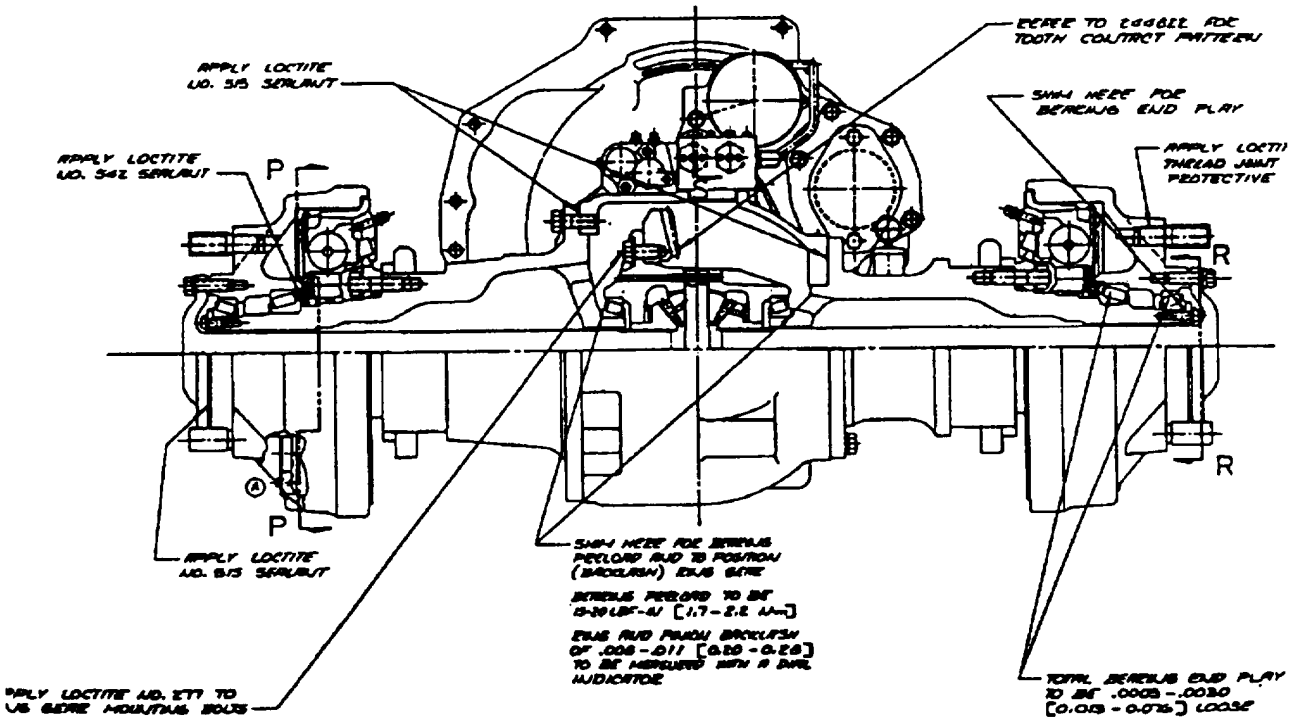
8. Remove clutch piston by turning clutch upside down and tapping the shaft on a block of wood.
9. Remove and discard clutch piston sealing rings.
10. *Repeat* procedures, Steps 1 through 9, for forward clutch disassembly.

G. Differential Disassembly



1. Use a small drift pin or rod to remove the differential pinion pin lock pin.
2. Remove the pinion pin.
3. Rotate the pinion gears and washers to remove them from the differential housing.

Transaxle Reassembly

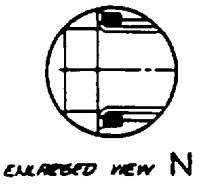


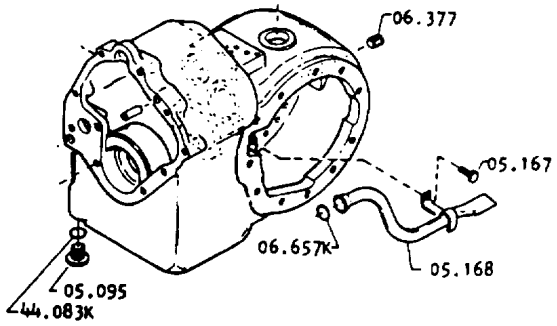
Assembly Notes:

1. Use Permatex and Loctite only where specified.
2. All lead-in chamfers for oil seals, piston ring grooves and O-rings must be smooth and free from burrs. Inspect at assembly.
3. Lubricate all piston ring grooves, clutch plates and O-rings with oil before assembly.
4. Apply a thin coating of grease between seal lips of lip-type oil seals prior to assembly.
5. Apply a very light coating of Permatex No. 2 to O.D. of all seals and hole plugs before assembly.
6. Apply a light coating of Loctite No. 592 to all uncoated pipe plugs.
7. After assembly of parts using Permatex or Loctite, there must not be any free or excess material that could enter the oil system.
8. Brush light coating of Texaco 8570 or equivalent oil, on tapered bearings and bushing bores.

Oil Suction Tube

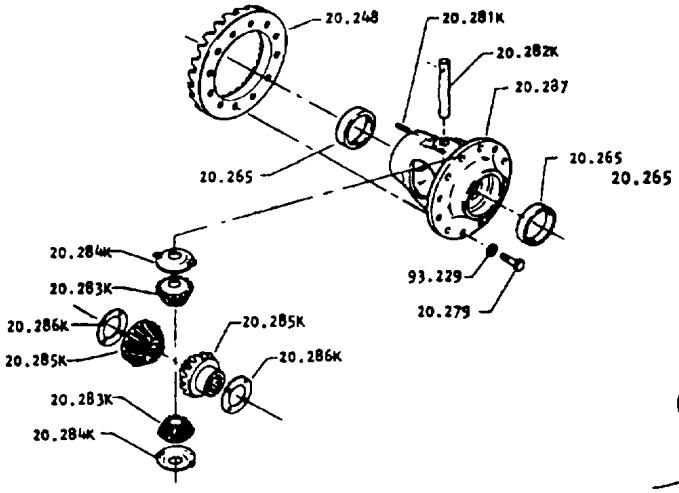
1. As required, install oil suction (pickup) tube assembly In transmission case Insert tube end through housing opening, Install seal on tube, then pull tube with seal back into place *See enlarged view N*. Install and tighten mounting bolt.

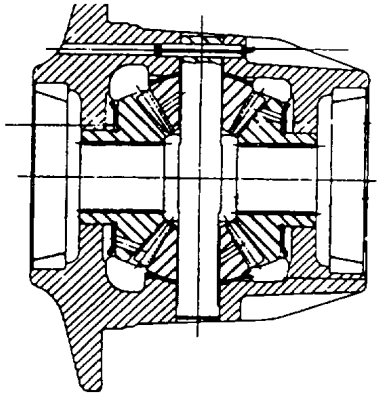


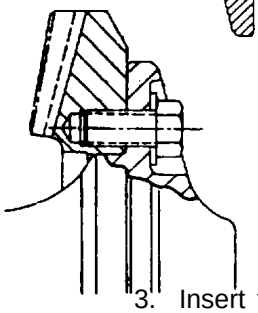


A. Differential Assembly

Before reassembly, clean, Inspect and lubricate all parts.







1. Position the side gears and washers in the differential assembly.
2. Locate both pinion gears and washers on the side gears.

NOTE

The pin ion gears must be located across from each other and then rotated into position to align the holes in the pinions with the hole in the housing.

3. Insert the pinion pin (1) in the housing aligning the hole in the pin with the hole in the housing.
4. Install the pinion pin lock pin (2).
5. If removed or replaced, install bearing cups in ends of differential carrier case.
6. If ring gear was removed or replaced, install the ring gear on differential. Apply Loctite thread locker #277 to the ring gear screws and tighten to torque spec: 128-141 lb-ft. (173-191 N.M.).

B. Trial Wheel End Assembly for Differential Bearing Preload Check (Pinion Gear Not Installed)

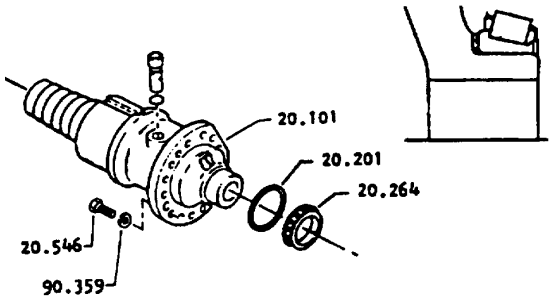
The purpose of this trial assembly is to determine the total combined shim pack thickness to be installed under the differential carrier bearings when replacement (new) parts have been installed. Later procedures for checking gear backlash and tooth contact are used to determine the individual shim pack thickness to be installed under each bearing cup.

1 - No New Parts Installed

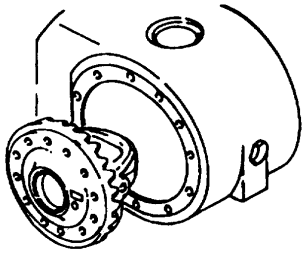
If all original parts are reused, use original shim pack thickness and proceed to: D. Pinion Gear Installation

2 - New Parts Installed

If differential carrier, carrier bearings, or wheel end housings have been replaced (new), use the following procedure:



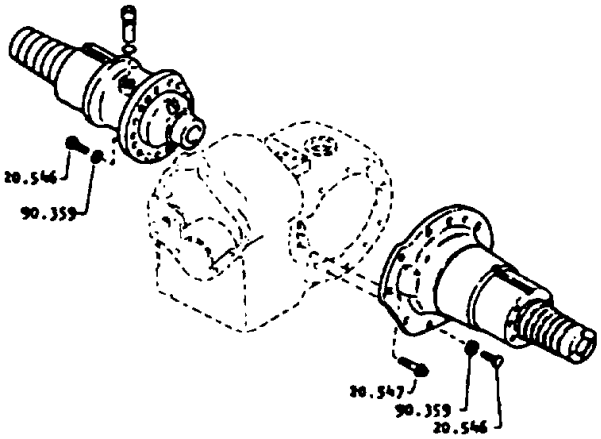
1. Install the differential bearing shims and tapered bearing cone on the wheel end housing. Start with original shim pack thickness.



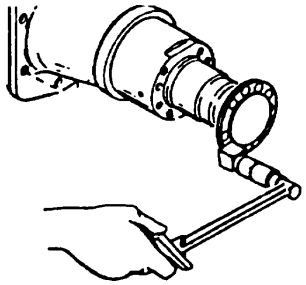
Note

Force a small shop cloth or rag into the differential side gears and pinions to prevent them from turning.

2. Position the differential in the transmission case.



3. Mount wheel end housings to the transmission case in position as marked at disassembly. Be sure differential and bearing cups are aligned with bearings on wheel end housing. Install attaching bolts and washers and tighten fully.



4. Temporarily install axle shaft into side gear of the differential (w/side gear blocked to prevent turning).
5. Measure the differential bearing rolling-torque pre-load with a torque wrench.

Correct preload torque: 15-20 lb-in. (1.7-2.3 N.M.)

NOTE

Remove wheel end housings, remove bearing and add or remove differential bearing shims behind bearing cone to obtain the proper preload torque. Repeat above procedure.

6. After correct bearing preload is set, remove the axle shaft and wheel end housings.
7. Remove differential assembly.

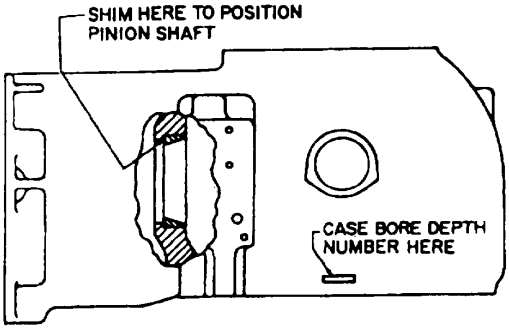
Remove shop cloth that was used to block gears from turning.

C. Pinion Gear Shimming

1 - No Replacement of Gears or Housings
If the ring and pinion gear or the transmission case *was not replaced*, use original shim pack thickness and proceed to: **D. Pinion Gear Installation**

PINION INNER BEARING SHIM PACK NEW THICKNESS SELECTION
If ring and pinion gears or transmission case replaced:

2 - Transmission Housing Replaced
If the transmission case was replaced, the following procedure must be used to set the correct ring gear and pinion contact:



On the new transmission case, a dimension for the case bore depth will be stamped on the location shown above.

SHIM PACK THICKNESS CALCULATIONS
The following conditions are used to calculate the shim pack thickness to be installed.

A = Nominal pinion mounting distance 5.900 in. (149.860 mm).

B = Typical pinion mounting distance (which is etched on the outer diameter of the ring gear).

C = Case bore depth (stamped on the case).

D = Nominal shim pack of .034 in. (0.86 mm)

E = Final shim pack to be installed under the inner pinion bearing cup to position the pinion shaft.

NOTE

If original shim pack is lost or must be replaced, use D Nominal shim pack thickness of .034 in. (0.86 mm). Check new shim pack dimension by measuring thickness. Substitute new thickness for original (old) thickness where shown.

The following examples show sample calculations for determining the shim pack thickness to be installed under the pinion inner bearing:

Example 1					
D	.034	B	5.906		(.041)
C	+.007	A	-5.900		(-.006)
E =	(.041	-	.006)	=	(.035)
Example 2					
D	.034	B	5.905		(.032)
C	-.002	A	-5.900		(-.005)
E =	(.032	-	.005)	=	(.027)
Example 3					
D	.034	B	5.900		(.037)
C	+.003	A	-5.895		(+.005)
E =	.037	+	.005	=	(.042)
Example 4					
D	.034	B	5.900		(.032)
C	-.002	A	-5.895		(+.005)
E =	.032	+	.005	=	(.037)

1. If the case bore depth (stamped on case) has a "+" (plus) sign, add (C) to the nominal shim pack (D).
2. If the case bore depth (stamped on case) has a "-" (minus) sign, subtract (C) from the nominal shim pack (D).
3. If the nominal mounting distance 5.900 in. (149.860 mm) is smaller than the mounting distance etched on the ring gear, subtract (A) 5.900 in. (149.860 mm) from (B) the etched mounting distance. Subtract this answer from the answer of 'D" and 'C". See examples 1 and 2.
4. If the mounting distance etched on the ring gear is smaller than the nominal mounting dimension 5.900 in. (149.860 mm), subtract the etched mounting distance from 5.900 in. (149.860 mm).

This difference is added to the answer of "D" and "C". *See examples 3 and 4 above*.

3- Ring and Pinion Gear Replaced

If only the ring and pinion were changed, the following procedure is used:

SHIM PACK THICKNESS CALCULATIONS Use a micrometer to measure the original shim pack thickness.

1. If the new pinion mounting distance (etched on ring gear) is larger than the pinion mounting distance (etched on original ring gear), you must subtract the difference (see following example):

5.904 etched on new ring gear
-5.901 etched on original ring gear
0.003 difference

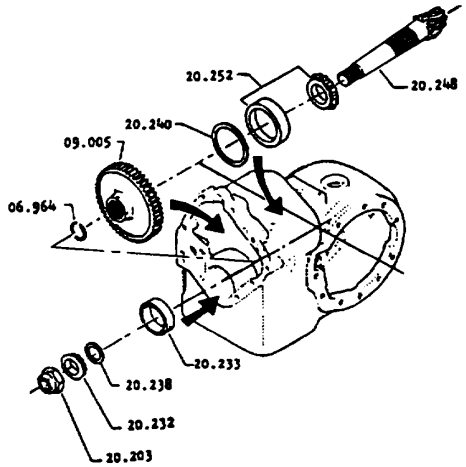
0.031 original shim pack
-0.003 difference
0.028 FINAL SHIM PACK (E)

2. If the new pinion mounting distance is smaller than the pinion mounting distance on the original ring gear, you must add the difference (see following example).

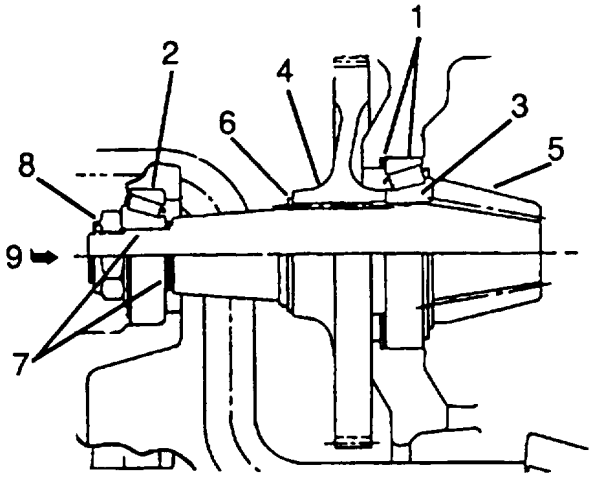
5.905 etched on new ring gear
-5.901 etched on original ring gear
0.004 difference

0.031 original shim pack
+0.004 difference
0.035 FINAL SHIM PACK (E)

D. Pinion Gear Installation



1. Install the pinion inner bearing cup shim pack and bearing cup in the transmission case.
2. If outer bearing is removed or replaced, install outer pinion bearing cup in transmission case.
3. Assemble the inner pinion bearing on the pinion shaft.
4. Position the output gear in the case with the long hub of the gear outward as shown.
5. Position the pinion shaft and inner bearing into the case and through the output gear.
6. Install the output gear retainer ring on the pinion shaft. Be sure the retainer ring is fully seated into the ring groove.



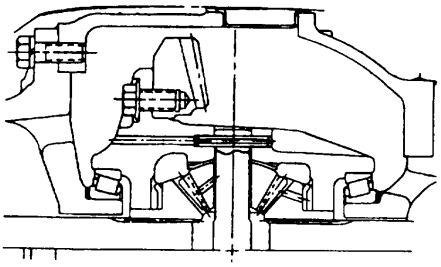
7. Assemble the outer bearing shims and outer p i n ion bearing on the pinion shaft. If a new pinion shaft is used, a nominal shim pack of .062 in. (1.575 mm) can be used initially.
8. Install the pinion shaft nut and tighten to torque spec: 200-250 lb-ft. (271-339 Nom). Hold or block the pinion shaft with a brass bar or similar soft material to prevent the shaft from turning.
9. With pinion shaft free to turn, use a torque wrench to measure the pinion shaft bearing rolling-torque preload.

Preload torque spec. 7-15 lb-in. (0.8-1.6 N-m)

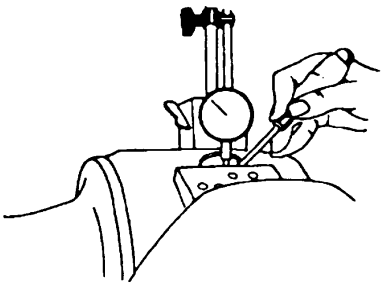
NOTE

Remove pin ion shaft nut and bearing and add or remove shims behind pinion shaft outer bearing cone to set correct bearing preload torque.

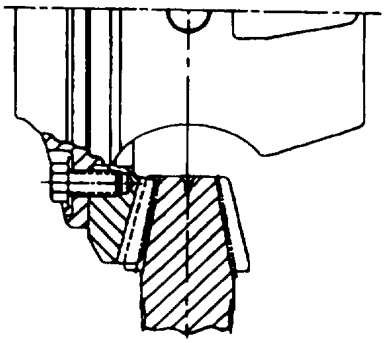
E. Trial Wheel End Assembly For Ring & Pinion Gear Contact & Backlash Check (Pinion Gear & Differential Installed)



1. Position the differential assembly in transmission case.
2. Assemble the wheel end housings on the transmission case as marked at disassembly. Align with differential bearings.
3. Install the wheel end housing bolts and washers. Tighten bolts to torque spec; 80-88 lb-ft. (108-119 N•m).

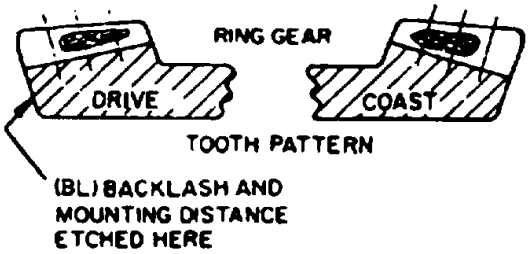


4. Check ring and pinion gear backlash. Open the inspection cover on the top of the differential case Set up and position a dial indicatoron a ring gear tooth to check the ring gear to pinion backlash. Hold pinion, move ring gear within backlash free play range several times. Backlash should be measured at 3 places minimum around the ring gear (rotate ring gear).



The backlash must be as indicated on the outer diameter of the ring gear as "BL".

To set the correct backlash, shims behind the tapered bearings on the wheel end housings are removed from one side and added to the other. Remove the wheel end housings, remove bearings and move shims. Repeat above assembly and checking procedure.



5. Check ring and pinion gear tooth bearing contact pattern.

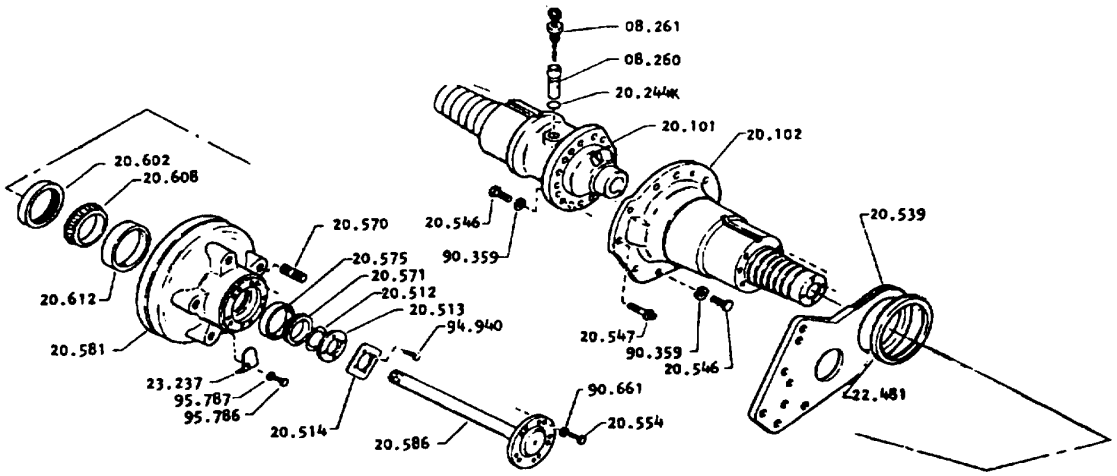
• Also refer to Spiral Bevel and Hypoid Tooth Bearing Contact Chart, Section 7.0.

To check the ring gear and pinion for proper tooth contact pattern (correct position). apply a coating of gear checking compound. e.g., red lead. to the ring gear teeth Rotate the ring and pinion gears through a minimum of one revolution Apply a load (hold by hand) to the gears as they are turned When the ring gear is turned the compound is squeezed away by the contact action at the teeth, leaving bare area that are the exact shape. size and area of the tooth contact pattern.

Check the tooth contact area on the drive (convex) side of the ring gear teeth See figure above for typical correct tooth contact pattern If the tooth contact is not as shown, recheck the pinion mounting procedure and also the ring and pinion backlash reading. Disassemble the parts, add or remove, or move shims as needed to adjust pin ion or ring gear position and backlash and recheck.

IMPORTANT- Each time the ring gear or pinion is moved, the backlash and the bearing preloads must be checked and reset as needed.

F. Wheel End Final Assembly



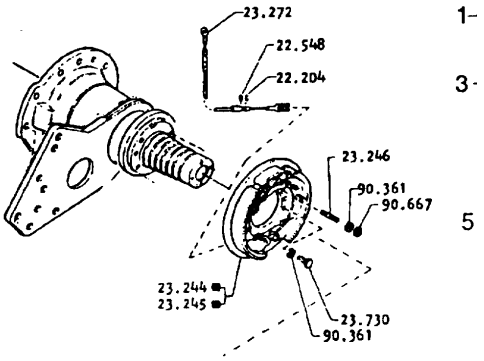
Before final assembly, clean and lubricate all parts thoroughly.

After the correct ring gear and pinion backlash and tooth contact is set:

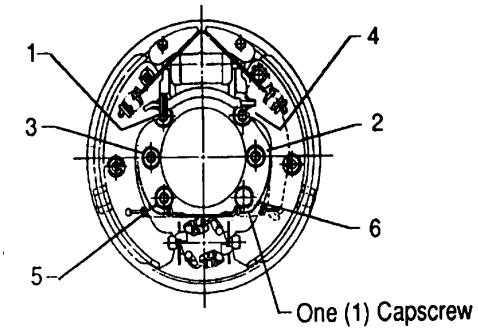
1. **Remove both wheel end housings and apply a film of Loctite #515 to the flange on housing.** Spread the material evenly on the flange around the bolt holes.
2. **Position the wheel ends on transmission case.** Be sure differential bearings are aligned and fitted correctly.
3. **Apply a thread locking compound,** e.g., Loctite #515 as follows:
   a) On bolts, capscrews and studs (anchor end), apply compound on the female threaded component part.
   b) On nuts, apply compound to the male thread of mating fastener.
   c) Apply compound to coat the full length and circumference of thread engagement.
   d) Remove excess compound from mating parts after fastener installation.
4. **Install the wheel end housings to transmission case**. Install washers and mounting bolts. Tighten bolts to torque spec: 80-88 lbft. (108-119 N.M.).
5. **If brakes were removed, install drive axle mounting support and space**r on each axle end.

Install brake assemblies

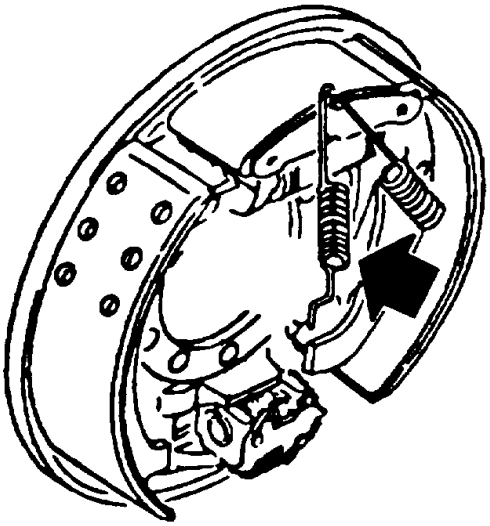
As required



1. Insert parking brake cable (through the opening noted at disassembly) in the brake backing plate.



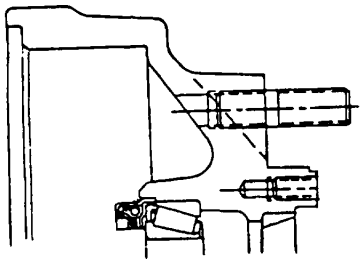
2. Install backing plate over(s) studs with washers and nuts. Install one (1) cap screw and washer per brake, located closest to parking brake cable connection.
3. Tighten the fasteners in the sequence shown to torque spec: 115-129 lb-ft (156-175 Nom).



4. Connect parking brake cable to the notch in the brake cam.
5. Assemble the brake shoes and hold-down springs on backing plate.
6. Install lower return spring.
7. Install upper return springs.

NOTICE - For brake adjustment, refer to **J. Service Brake Adjustment** procedure.

Wheel Hub Assembly

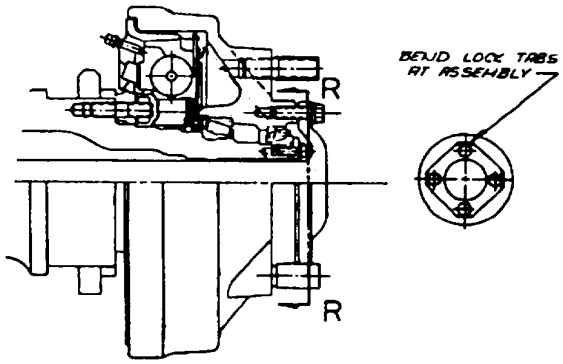


1. Install the outer and inner bearing cups.
2. Position inner tapered bearing in bearing cup.
3. Apply a very light coating of Loctite #515 to outer diameter of a new wheel hub oil seal and install seal in wheel hub.

NOTICE -A special driver, Chicago Rawhide Part No. 448-5, is used to install the wheel hub oil seal.

IMPORTANT - It is mandatory to replace the wheel hub oil seal whenever the hub is removed from spindle This oil seal is a type that seals internally, and is lined with sealing compound on the inner diameter that sticks and seals to the spindle. Removing the wheel hub from the spindle breaks that seal. The seal cannot be reused.

4. Position wheel hub assembly on the wheel end spindle. Be careful when sliding oil seal onto wheel end housing. Support the wheel hub to avoid seal dragging over spindle.
5. Install wheel hub outer tapered bearing.
6. Install wheel bearing shims, retainer plate, retainer lockplate and capscrews.



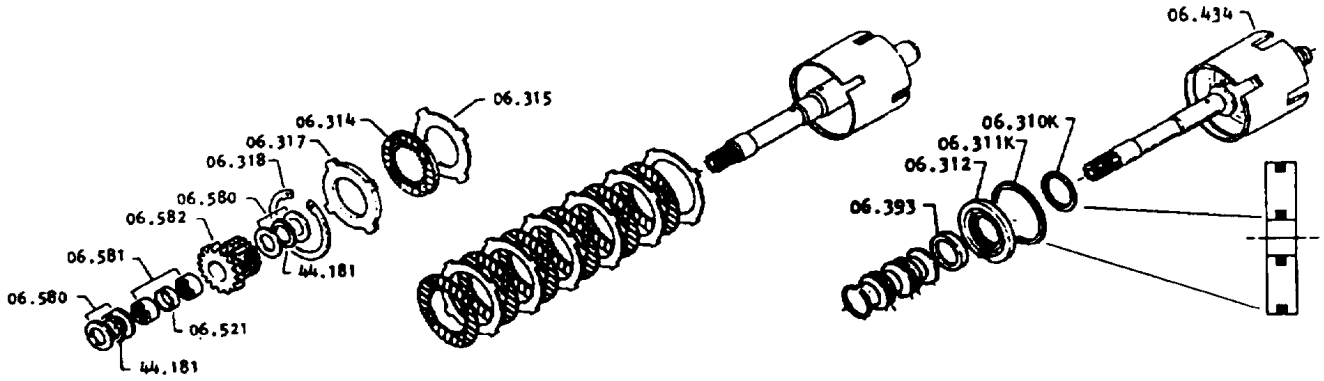
7. Tighten bearing retainer capscrews to torque spec: 12-16 Ibf.ft. (16-22 N.M.)
8. Use a dial indicator to check bearing endplay.

Correct endplay .0005-.0030 in. (0,013-0,076 mm)

Add or subtract shims under bearing retainer plate to obtain the correct end play.

9. When endplay is correct, bend the tabs of the lockplate against the capscrew heads to lock them.
10. Apply a film of Loctite #515 to the axle shaft flange. Spread evenly around the bolt holes.
11. Apply Loctite #515 to threaded holes in the wheel hub.
12. Install axle shaft in wheel end. Rotate shaft to align axle shaft splines with side gears in differential.
13. Install axle shaft mounting screws. Tighten to torque spec: 80-88 lb-ft. (108-119 N• m).

G. Clutch Assembly



Forward clutch reassembly is the same as reverse clutch (shown).

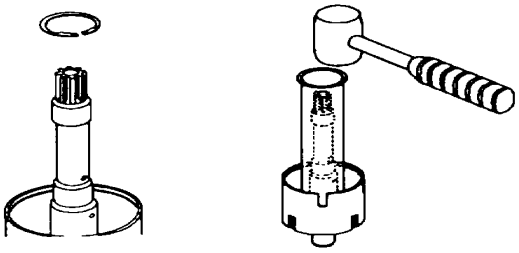
NOTICE - Before reassembly, clean, inspect and lubricate all parts with a light layer of engine oil.

1. Install new clutch piston inner and outer oil seal rings in piston grooves. See figure above.

IMPORTANT - The rings must be sized before piston installation onto shaft and into the clutch drum:

- Sizing is best accomplished by rotating the piston while holding a round object against the new seal rings.
- Rotate the piston until the seal rings are sized flush with the inner and outer diameters of the piston.

2. Install clutch piston over turbine (clutch) shaft and into clutch drum.
3. Install clutch piston wear plate (flange towards piston).
4. Install piston return springs (Belleville washers). Install first washer with large diameter of bevel toward wear plate. Alternate five (5) washers.



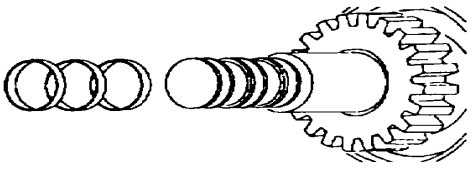
5. Position return spring retainer ring on clutch shaft. Start ring on shaft with snapring pliers.
6. Install retainer ring using a sleeve with the proper inner diameter to fit over shaft and against retainer ring. A sharp blow with a sott hammer will compress springs and seat retainer ring. Be sure ring is seated fully in position in ring groove.
7. Install the first outer (steel) clutch disc against clutch piston. Next, install first inner (friction) clutch disc. Alternate outer and inner discs to install a total of 6 outer steel plates and 6 inner friction plates.
8. Install clutch disc end plate.
9. Install end plate retainer ring.
10. Check clutch disc clearance. See note below.

NOTE

Both clutch packs (Forward and Reverse) must be checked for clutch disc clearance:

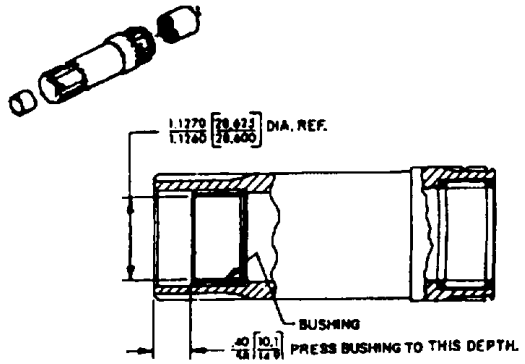
1) Stand the clutch assembly on end. The clutch discs on the bottom will fall to the end plate.
2) Measure the distance between the clutch piston and the first steel disc by inserting a feeler gauge through the slots in the clutch drum.
3) Required clearance is .048-.105 in. (1.222.66 mm)
4) If clearance is greater than .105 in. (2.66 mm), add one steel disc under the end plate.

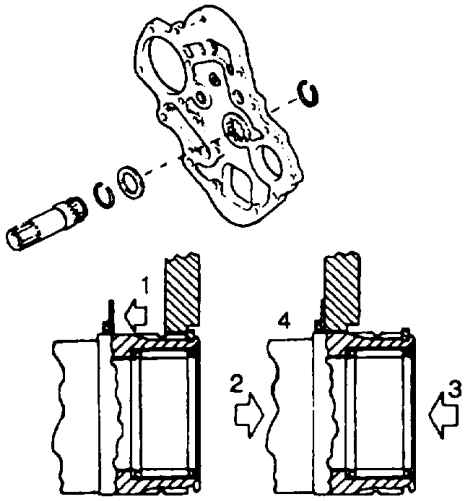
11. Install inner clutch gear thrust bearing set (thrust bearing between 2 thrust washers).
12. Assemble clutch gear bearing (spacer between bearings) into clutch gear hub.
13. Install clutch gear into clutch assembly by aligning the clutch hub teeth with the clutch inner discs. Be sure the clutch hub is fully in position in the clutch assembly. Do not force this operation.
14. Install outer clutch gear thrust bearing set, with thrust bearing between thrust washers, against clutch gear.
15. Repeat assembly procedures, Steps 1 through 14, for forward clutch.



16. After forward clutch is assembled, install new oil distributor seal rings on clutch shaft. Apply grease to rings to facilitate assembly into oil distributor.

H. Stator Support Assembly



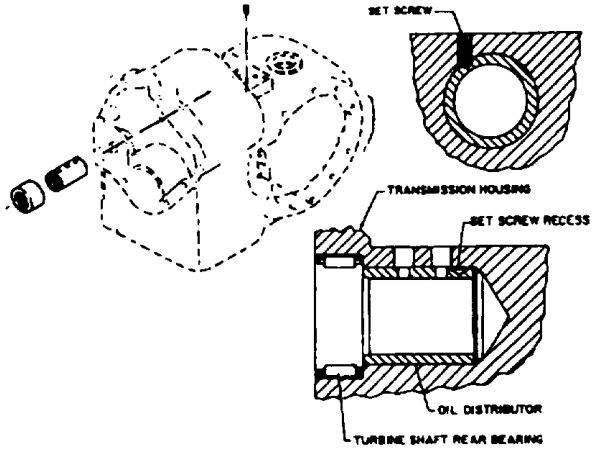


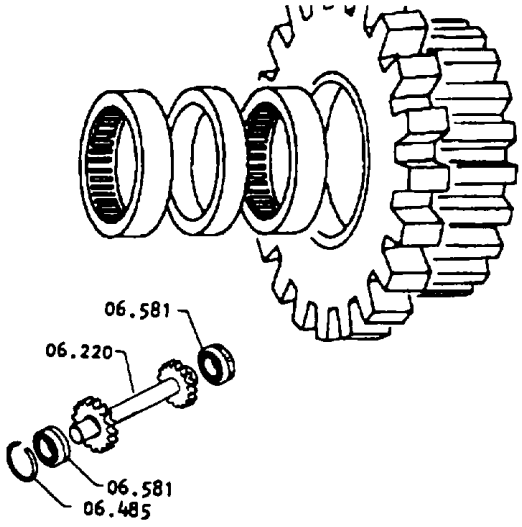
1. Install the turbine shaft bushing and clutch outer pilot bearing into stator support. Press the bushing to the specified depth.
2. Install stator support assembly in adapter plate (Reverse of disassembly procedure):

1 - Assemble front retainer ring on stator support but do not install in front ring groove; temporarily position it beyond the groove to the forward end of the rear spline. Position the impeller hub gear thrust washer on stator support and against retainer ring.

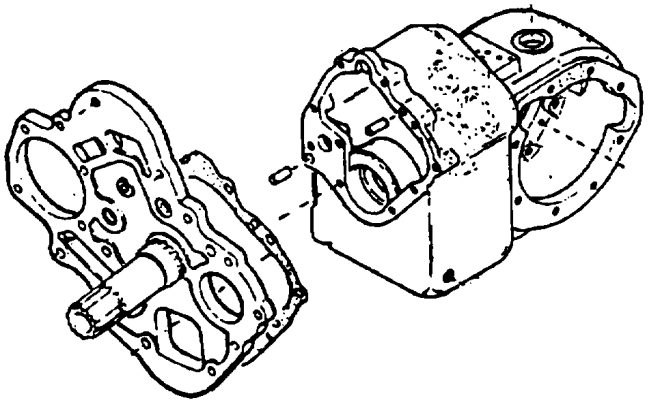
2 - From the front, assemble stator support into spacer plate. Push stator support through plate until rear retainer ring groove is exposed. Install rear retainer ring.
3 - Push stator support toward the front until rear ring shoulders against spacer plate.
4 - Push thrust washer back against plate and install front retainer ring in groove.

I. Transmission Assembly





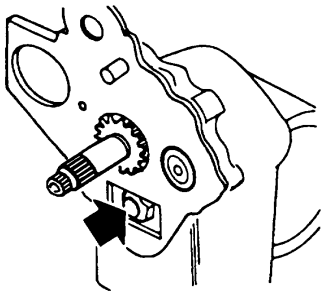
1. Install the clutch shaft oil distributor in transmission case with the recess in the distributor lined up with retaining set screw hole in valve housing pad.
2. Install the oil distributor retaining set screw.
3. Install turbine (clutch) shaft inner (rear) bearing.
4. Install reverse idler shaft inner (rear) bearing.
5. Install clutch and idler gear shafts. The forward and reverse clutch assembly and the reverse idler gear must be assembled in the transmission case together. Carefully move and align the clutch shaft oil seal rings through the rear bearing and into the oil distributor. Be sure the reverse idler is fully in



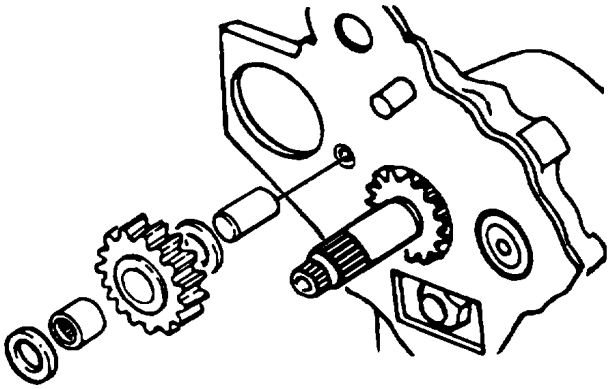
6. Install adapter plate on transmission case.
   1) Remove dowel pins from adapter plate
   2) Install (position) a new transmission to adapter plate gasket on the transmission case. shaft. Install idler gear outer thrust washer.
   3) Carefully align the adapter plate over the turbine (clutch) shaft and on the transmission case.
   4) Tap adapter plate into position tight against the transmission case. Install the dowel pins to hold plate in position.

Note

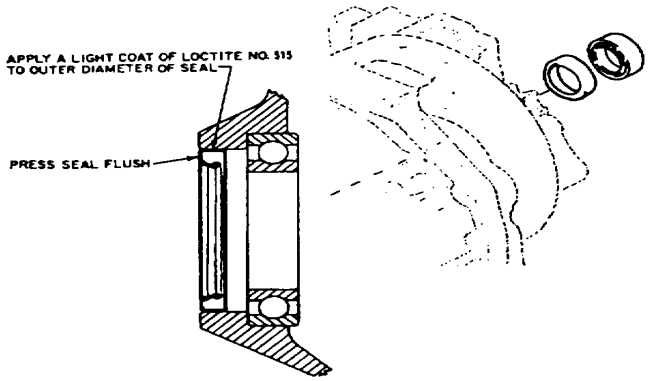
Dowel pins should project 1/4" out of adapter plate for installation into converter housing.



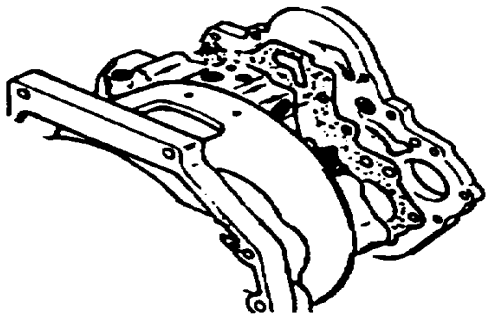
7. Turn the pinion shaft (using the nut) and the turbine shaft to check if the unit is binding. If both shafts turn freely with spacer plate tight against transmission case, proper assembly is completed. If binding is detected, the unit must be disassembled and reassembled.



8. Install impeller hub gear on stator support.
9. Install pump idler shaft in spacer plate. Install idler gear inner thrust washer.
10. Install pump drive idler gear and bearing on idler

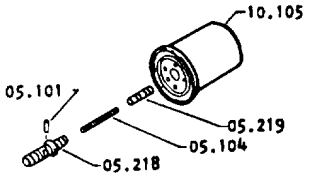


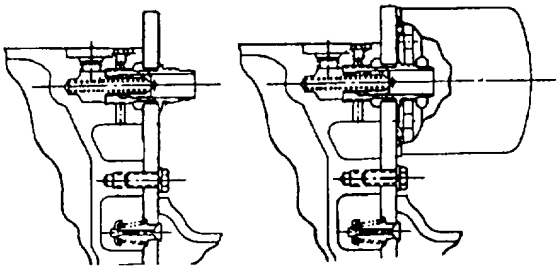
11. Install the converter bearing and impeller hub oil seal in converter housing, as illustrated. Apply a thin coating of grease between seal lops prior to further assembly.



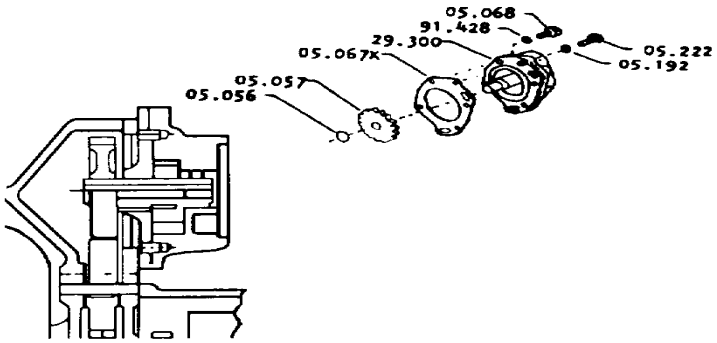
12. Install (position) a new spacer plate to converter housing gasket on the spacer plate.

13. Install converter housing on adapter plate (fit over dowels) and to transmission case. Be careful not to damage converter housing oil seal when moving over the stator support.
14. Install adapter plate to converter housing and converter housing to transmission housing attaching screws and lockwashers. Tighten to torque spec: 23-25 lb-ft. (31-34 Nom).

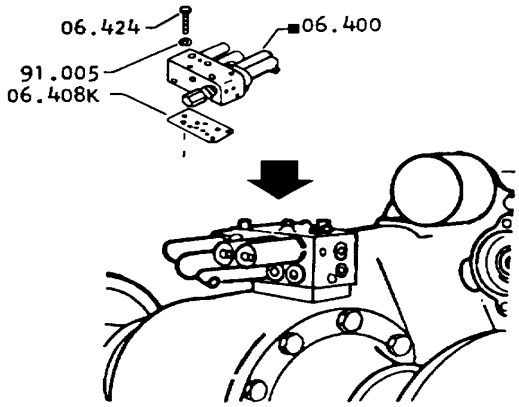




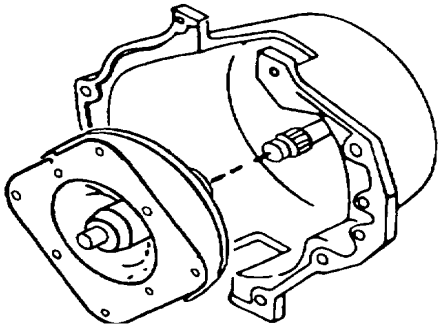
15. Install oil pressure regulator valve sleeve assembly through the spacer plate and into converter housing. Tighten regulator sleeve to torque spec: 45-50 lb-ft. (61-68 Nom).
16. Install oil filter on regulator sleeve per instructions on filter.



17. Install charging pump with attaching bolts and washers and tighten to torque spec: 12-16 lb-ft. (16-22 N.m).



18. Install control valve assembly to transmission case with attaching bolts and washers and tighten to torque spec: 12-16 lb-ft. (16-22 Nom).
19. Install oil supply tube assembly.



20. Install torque converter assembly by sliding onto stator support. Carefully align splines with stator and impeller hub gear. Again use care not to damage converter housing oil seal.

Service Brake Adjustment

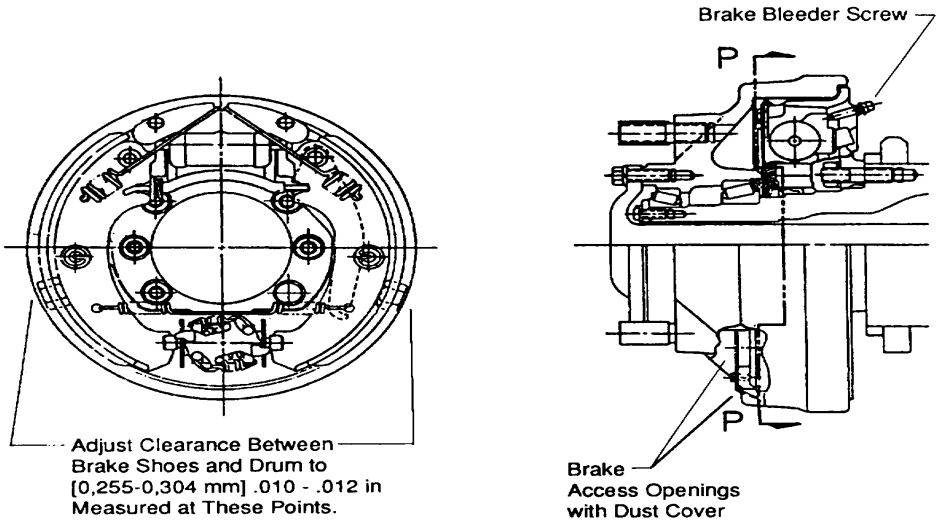


Figure 4. Service Brake Installation

NOTE

- **Engine should not be running.**
- **Remove key for safety.**
- **Be sure transmission directional control is in NEUTRAL and truck prevented from moving when parking brake is released.**

1. The service brakes on the TA18 transaxle may be adjusted from the inner side through the backing plate (all models), or from the outer side through access openings in the wheel hub/brake drum (later models).
2. Brake clearance is measured between brake shoe and drum, with brakes fully released. Brake Clearance: .010-.012 in. (0.255-0.304 mm)
3. Release parking brake.

IMPORTANT - Do not overtighten brakes. It is very difficult to release the ratchet wheel pawl and back off adjustment of the brake.

1. Adjustment thru Backing Plate

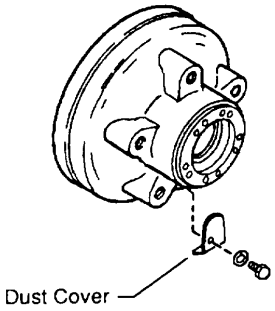
1. Remove the 4 dust plugs in brake backing plate.
2. Use a feeler (thickness) gauge to check the clearance between each shoe and drum. Use a screw driver or equivalent tool to rotate the adjustor ratchet wheel in the brake.

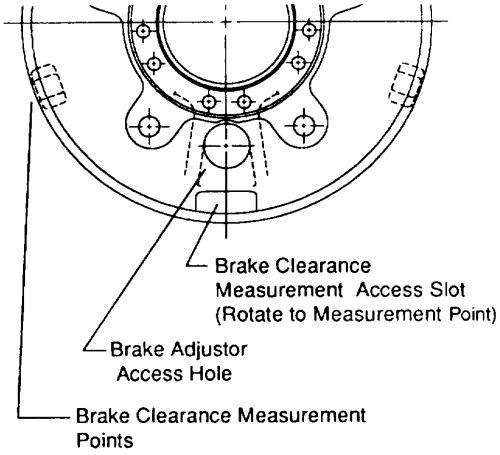
WARNING

Some brake linings are still made with asbestos which when inhaled has been found to be extemely dangerous. Do not use compressed air to clean the brake shoes or other parts before or after disassembly. Instead wipe down the assembly and then the components with damp, disposable wipers and immediately discard them safely. Avoid breathing any dust or injury may result.

3. Use a screwdriver to push on and release the ratchet pawl when it is necessary to vback off adjustment (increase clearance) of the brake.
4. Carefully adjust clearance between brake shoes and drum to .010-.012 in. (0.255-0.304 mm) measured at dust plug openings at outer sides of backing plate.
5. Replace the dust plugs in brake backing plate when adjustment is completed

Service Brake Adjustment (Continued)





2. Adjustment thru Wheel Hub

Openings in the wheel hub/brake drum have been provided for easier access to check and adjust the service brakes from the outer side. Requires removal of drive wheel and tire assembly. Some models may have only a slot for measuring brake clearance; adjustment is made through the plug openings on backing plate. Later models have a slot and circular opening for access also to the adjustor. The opening is enclosed with a dust cover held in place by a single screw.

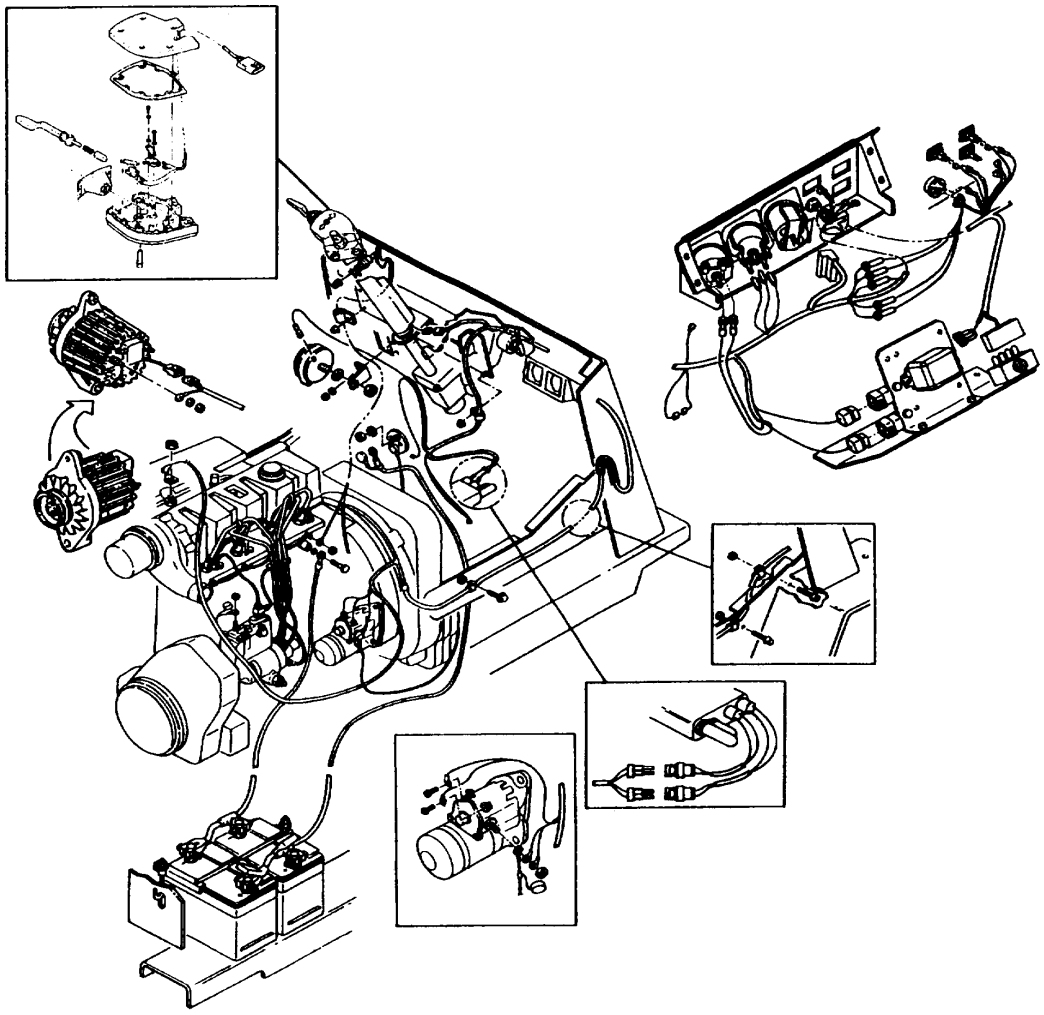
1. Remove wheel and tire assembly from wheel hub.
2. Remove dust cover from access opening in wheel hub/brake drum.
3. Use a feeler (thickness) gauge to check the clearance between each shoe and drum. Use a screwdriver or equivalent tool to rotate the adjustor ratchet wheel in the brake.
4. Use a tool with a hook to pull on and release the ratchet pawl when it is necessary to back off adjustment (increase clearance) of the brake.

IMPORTANT- Do not overtighten brakes. It is very difficult to release the ratchet wheel pa wl and back off adjustment of the brake.

5. Carefully adjust clearance between brake shoes and drum to .010-.012 in. (0.255-0.304 mm) measured at slot opening. Move slot by rotating brake drum to check clearance at positions shown by Fig. 4**, J. Service Brake Adjustment** on each brake shoe.
6. After adjusting brakes, install dust cover over access opening in wheel hub.
7. Install wheel and tire assembly on drive axle wheel hub.
8. Install wheel mounting lug nuts and tighten to torque spec: 470-530 lb-ft. (637-718 N•m).

7.12. Directional Control Linkage
Transmission Shift Controls

Directional Control
TA18 Transaxle



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8.0. BRAKES

8.1 Service Brake & Inching Systems F-383

8.2 Deleted

8.3 Deleted

8.4 Brake & Inching System F-385

8.5 Brake Bleeding F-395

F-381 (F-382 blank)

8.1. Service Brake & Inching Systems

Description and Operation.....F-383
Parking Brake Linkage F-384

This section reviews the arrangements of brake and inching systems and components used in GPX25 E truck.

Description and Operation
The GPX25 E has a manual (not powered) hydraulic service brake system, with dual suspended foot pedals which are connected to dual individual master cylinders*. The master cylinder applies pressure through the brake lines to the brake (wheel) cylinders located in either brakes at the wheels

**See Section 2.0, Product Specification Changes.*

The GPX25 E incorporates a hydraulic inching system in combination with the service brake system master cylinder and pedal arrangement, as described later. In all cases, the left-hand pedal is intended for inching use and the right-hand foot pedal is provided for normal braking control of the truck.

Type 2 Dual Master Cylinders

Type:	Dual (2) master cylinders with separate circuits for inching and braking.
Arrangement:	Brake master cylinders (2) mounted in vertical position under dash and connected directly to individual brake pedals. Separate remote-mounted reservoir mounted in upper left corner of dash.
Effective Date:	Mid 1989 Lot 7158 and above
Transaxle Model.	TA18

With Type 2 dual master cylinder system, the right-hand pedal is separate and used for braking only. The right-hand pedal and cylinder operate the brake system and the left-hand pedal and cylinder operate the inching system. Left-hand pedal actuates right-hand pedal to provide braking also. See inching operation below.

TA1 8 Transaxle
Type 2 Dual Master Cylinders Only
Master cylinders, reservoir and lines form a closed circuit *using conventional 5A E/ Type DOT 3 automotive hydraulic brake fluid.*

Brake and inching master cylinders are mounted vertically side-by-side under dash and connected directly to foot pedals. Master cylinders are single-action type with no residual check valve. Separate remote-mounted reservoir is installed in upper left corner of dash. Master cylinders are equipped with seals for use with hydraulic brake fluid only.

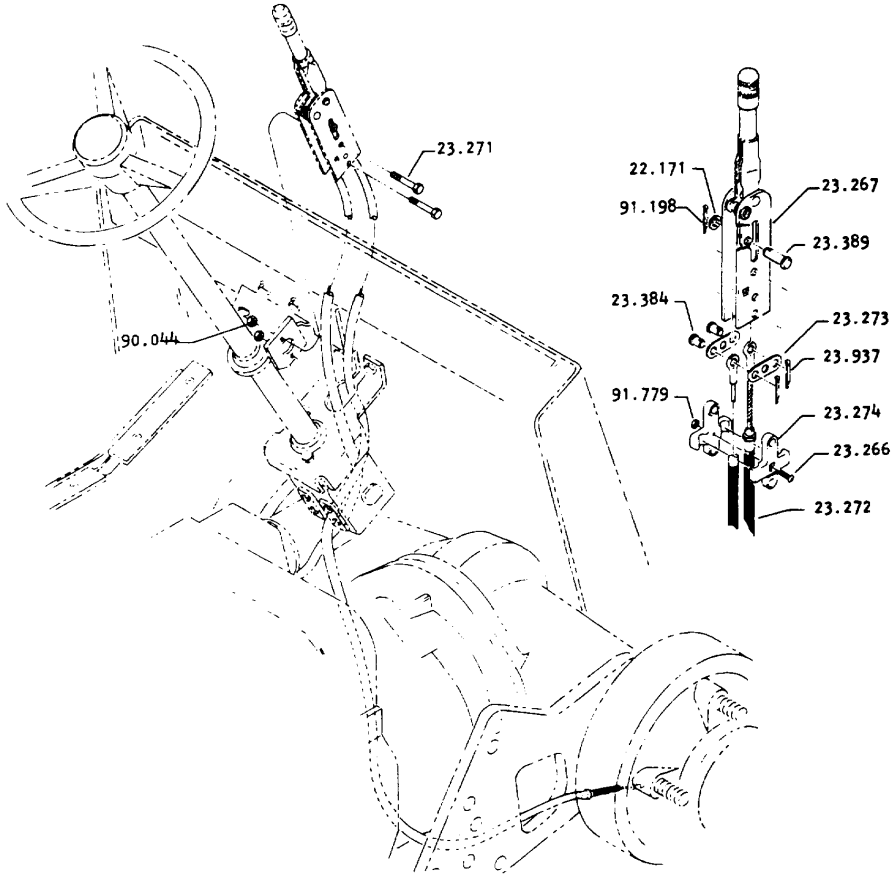
Service brakes are hydraulically-actuated, self-adjusting drum-and-shoe brakes at the drive wheels. Service brake assemblies are part of the transaxle assembly, and are mechanically-actuated for parking.

Inching Control System
Control of the inching function is provided by a combined "left foot inching and braking" action. The first part of the pedal motion moves the transmission control valve to regulate release of the driving clutch pressure, which allows the clutch to slip and produce only the driving force and speed desired.

The last part of the pedal motion releases the clutch entirely and applies the service brakes.

With Type 2 dual master cylinder system, hydraulic inching is incorporated into only the left-hand pedal. Left-hand pedal actuates right-hand pedal to provide braking also. Right-hand pedal is separate and used for braking only with TA18 transaxle.

Parking Brake Linkage Installation
TA18 Transaxle



22.171 WASHER, PARKING BRAKE CABLE END RETAINER

23.266 FASTENER, PARKING BRAKE CABLE CLAMP

23.267 LEVER, PARKING BRAKE

23.271 FASTENER, PARKING BRAKE LEVER

23.272 CABLE, PARKING BRAKE

23.273 CLAMP, PARKING BRAKE LEVER TO CABLE

23.274 CLAMP., PARKING BRAKE CABLE

23.384 RETAINER, PARKING BRAKE LINE

23.389 RETAINER, PARKING BRAKE CABLE END

23.937 RETAINER, PARKING BRAKE EQUALIZER

90.044 NUT, PARKING BRAKE LEVER FASTENER

91.198 RETAINER, PARKING BRAKE CABLE END PIN

91.779 NUT, PARKING BRAKE CABLE CLAMP FASTENER

23-940 MAR 85

8.4. Brake & Inching System
Type 2 Dual Master Cylinders

Brake Pedal & Linkage F-386
Hydraulic Brake & Inching Lines F-387
Inching Troubleshooting Guide F-388
Brake & Inching Pedal Adjustment F-390
Service Brake Adjustment F-392
Parking Brake Linkage F-394

This section outlines information for service maintenance of the brake and inching system for GPX25 E truck models.

NOTE

Care must be taken when servicing to be sure to use the correct fluid, as noted.
Refer to Section 2.1, Service Specifications.

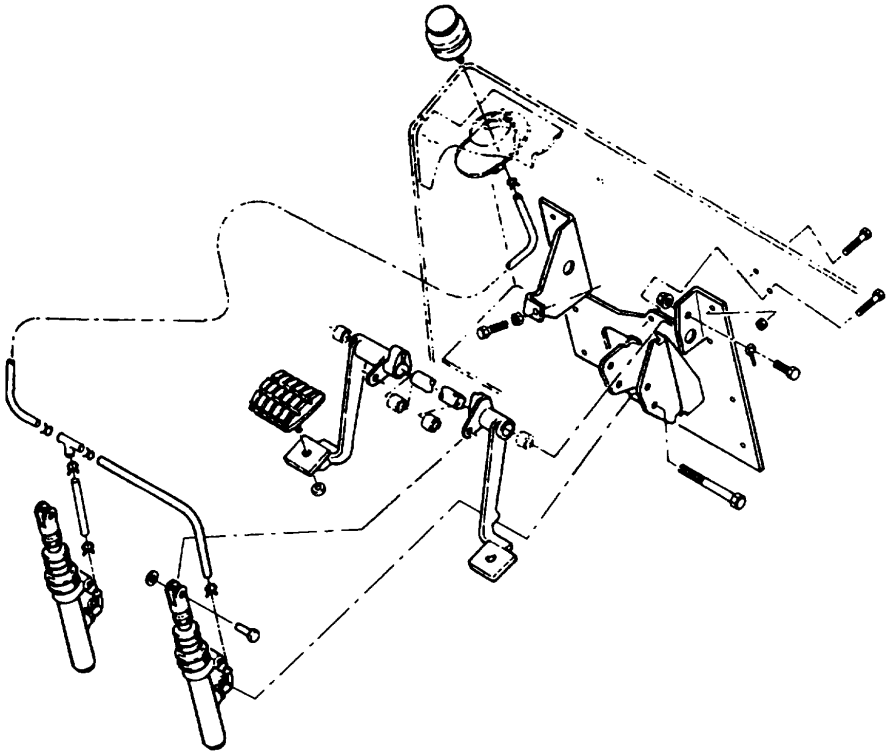
Service Brakes

The service brakes are mounted externally on the drive axle and may be accessed for servicing by removing the axle shaft, drive wheel hub and brake drum assembly.
Refer to Section 7.6, TA 18 Transaxle.

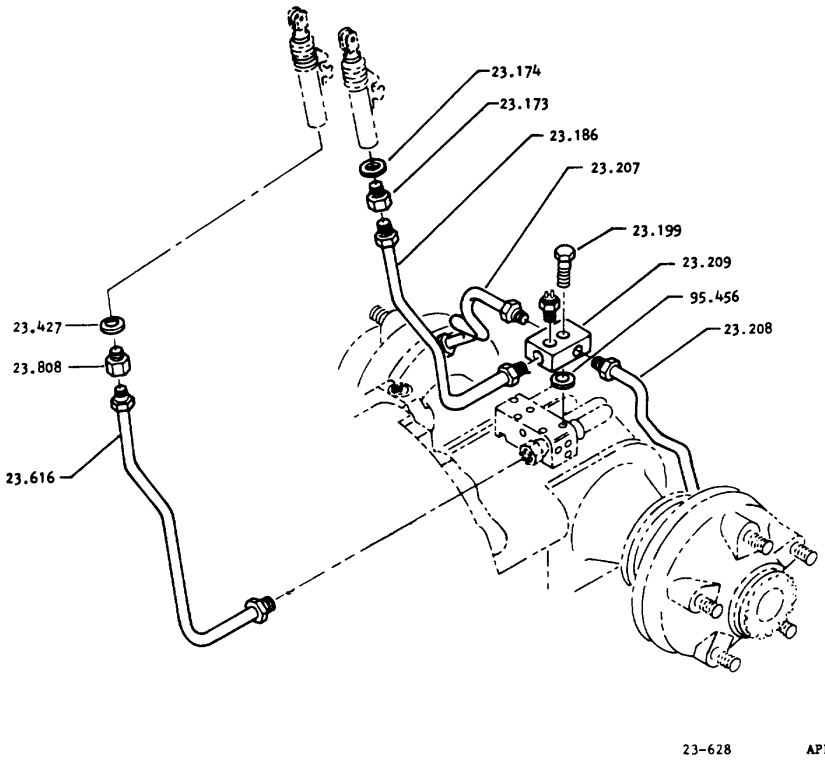
Inching Control System

With Type 2 dual (2) master cylinder system, hydraulic inching is incorporated into only the left-hand pedal, as noted above.

Brake Pedal & Linkage -Type 2
TA18 Transaxle



Hydraulic Brake & Inching Lines - Type 2
TA18 Transaxle



23.173	FITTING, BRAKE HASTER CYLINDER OUTLET
23.174	SEAL, BRAKE MASTER CYLINDER OUTLET FITTING
23.186	LINE, BRAKE MASTER CYLINDER OUTLET
23.199	FASTENER, BRAKE LINE TEE
23.207	LINE, BRAKE WHEEL CYLINDER INLET - LH
23.208	LINE, BRAKE WHEEL CYLINDER INLET - RH
23.209	TEE, BRAKE LINE
23.427	SEAL, INCHING MASTER CYLINDER OUTLET FITTING
23.616	LINE, BRAKE MASTER CYLINDER OUTLET
23.808	FITTING, INCHING MASTER CYLINDER OUTLET
95.456	WASHER, BRAKE LINE TEE FASTENER

Inching Troubleshooting Guide

Inching and braking system for trucks with TA18 transaxle

Condition *Probable Cause*	*Remedy*
1-Will not inch and/or partial clutch disengagement.	
1. Air in lines prevents adequate inching slave cylinder movement.	1) Bleed inching system. Check if truck inches correctly. 2) If air entrapment remains a problem after bleeding inching system: a) Remove the bolt-on casting from the front side of the control valve. b) Bleed down brake pedal and block pedal, as noted in inching bleeding procedures. c) Stroke the inching pedal 3-7 times until pedal abruptly bottoms out. Push in the plunger which protrudes from the control valve while bleeding at transaxle slave cylinder bleeding screw. Repeat until all air has been evacuated from system. d) Reinstall casting. Be sure no dirt has entered the control valve and the 3 O-rings are properly installed. e) Remove brake pedal block. Recheck if truck will inch.
2. Inching actuation system leaking. 1) Loose fitting 2) Stripped fitting 3) Loose bleeder screw 4) Defective master cylinder	1) Tighten fitting correctly. 2) Replace fitting (typically a brass adapter fitting). 3) Tighten bleeder screw. 4) Replace master cylinder.
3. No inching pedal freeplay. (1 /4-inch nom. travel required at pedal foot pad)	1) Adjust pedal stop screw. 2) If full adjustment can not be made and if head of stop screw is on under side of bracket, then remove screw and install with head on top of bracket. Readjust.
4. Inching push rod too short / master cylinder does not travel fully. (Note - Pedal up height is directly related to stroke) 4) Brake applied before inching complete.	1) Check if adjustable pushrod is correctly on inching side and not on the brake side. 2) Check for correct quantity of adjustor washers on adjustable inching pushrod assembly. 3) Check pushrod lengths: brake pushrod hole center to end =4.41 in.(112 mm); inching pushrod (with no washers) = 4.33 in. (110 mm). 4) Check brake shoe gap adjustment. Back off if clearance is less than than .010 in.
5. Transmission slave cylinder piston stuck. 1) Piston seal missing, damaged, swelled, etc. 2) Piston or cylinder scored. 3) Piston or seal installed backwards.	1) Replace seal. 2) Replace slave cylinder. 3) Reinstall parts correctly.

Inching Troubleshooting Guide

Inching and braking system for trucks with TA18 transaxle

Condition	*Probable Cause*	*Remedy*
1 - Will not inch and/or partial clutch disengagement. *(Cont'd)*		
6	Transmission inching valve spool sticking.	
	1) Spool or bore scored or burrs evident.	1) Replace control valve body if in bore. Replace spool if spool bad or repair by smoothing with crocus cloth.
	2) Contamination	2) Disassemble and wash.
	3) Inching spool oversize or not concentric.	3) Replace spool.
	4) Inching bore undersize or not concentric.	4) Replace valve body.
7.	Inching spool does not fully travel.	1) Bleed down brake pedal and block as noted In bleeding procedure. 2) Measure clutch pack pressure with parking brake applied. inching pedal fully depressed and engine idling. 3) Clutch pressure should be 6-12 psi. If greater, replace inching balance spring.
8.	Clutch piston bleed hold plugged.	1) Complete transaxle removal, disassembly and cleaning required.
9.	Clutch return spring stack has too high or too low spring force.	1) Remove and repair transaxle.
2- Will not inch in reverse only.		
1.	Lube oil leaking into reverse clutch.	1) Remove and repair transaxle.
3- Abrupt shift from neutral to reverse or forward.		
1.	Contamination in modulator.	1) Remove modulator spool and clean orifice in spool.
2.	Modulator spool or bore burrs.	1) Replace control valve body if in bore. Replace spool if spool bad, or repair by smoothing with crocus cloth.

Brake & Inching Pedal Adjustment
Type 2 Dual Mater Cylinders

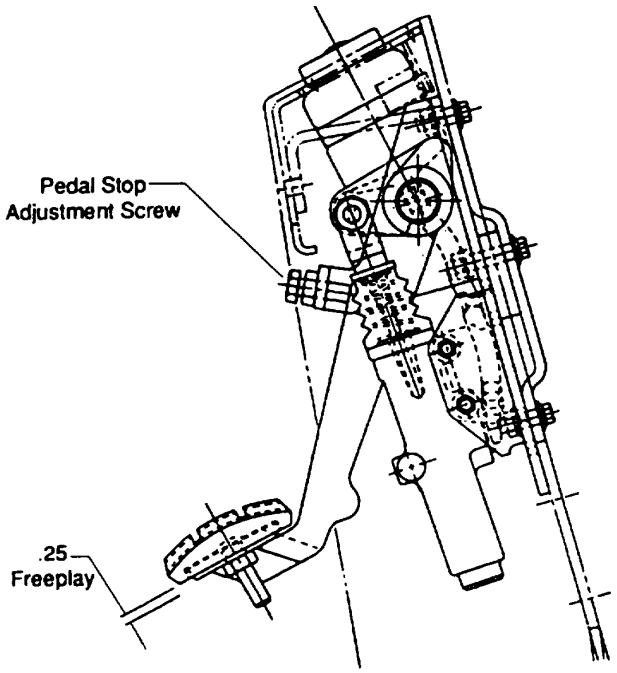


Figure 1. Brake & Inching Pedal Linkage Installation

1. The service brake and inching pedal linkage installation is designed to require a minimum of maintenance and adjustment. Periodic adjustment is not required.
2. Brake linkage adjustment should be made only when it has been found that inching and/or brake response is inadequate or incorrect:
   a) Pedals do not return fully (insufficient freeplay), or
   b) Full inching or brake master cylinder stroke is not obtained, or
   c) Inching/brake overlap is unsatisfactory.
3. Two adjustments may be made in the brake & inching pedal linkage:
   a) Adjust the number of washers on inching pedal pushrod for brake overlap:
      • To increase brake overlap, remove washers to suit desired overlap'. All washers may be removed if required.

NOTE

Change from standard may affect brake life or glaze brake linings if used frequently with light application.

      • To decrease brake overlap, add washers to suit desired overlap. 4 washers total max.
   b) Adjust pedal-up stop screw for correct pedal freeplay (master cylinder pushrod clearance).
      • Brake & Inching Pedal Freeplay 1/4-inch, nominal 1/8-3/8 in. (3.2-9.5 mm) travel @ foot pad
4. Bleed brake and inching system thoroughly before adjusting.

Brake & Inching Pedal Adjustment (Cont'd)

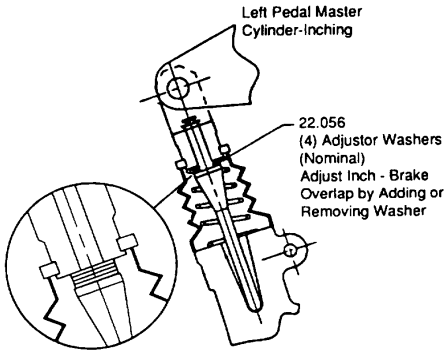


Figure 2. Left-Hand Pedal - Inching Master Cylinder

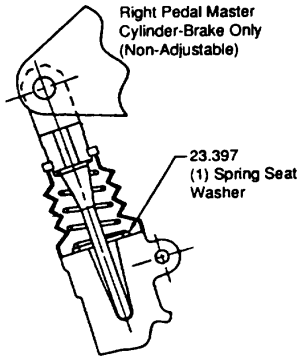


Figure 3. Right-Hand Pedal - Brake Master Cylinder

Inching/Brake Overlap Adjustment

1. Be sure there is no entrapped air in system. Bleed system thoroughly.
2. After bleeding system, inching system may be adjusted from nominal by adding or removing adjustor washers from inching push rod assembly.

NOTE

The nominal or standard installation for adjustor washers on inching pedal is 4 washers (0.040 in. nominal thickness each).

3. To increase overlap (reduce truck rollback and increase inching sensitivity, i.e. reduce pedal stroke between transmission disengagement and brake application): Remove one (1) washer; test truck for inch-brake operation. Additional washers may be removed, one at a time, to achieve desired inching-to-braking response. All washers may be removed if required.

NOTE

Excessive overlap will cause transmission overheating and brake wear because transmission will not be sufficiently disengaged as brakes are applied.

4. To decrease overlap (decrease inching-to-braking response or sensitivity): Add one (1) washer; test truck for inch-brake operation. Additional washers may be added, one at a time, while testing to achieve desired inching-to-braking response. Four (4) washers total max.

Pedal Up Stop (Freeplay) Adjustment

Adjust pedal height such that when pedal is fully returned, brake and inching master cylinders are not engaged. Inching pedal must have .125-.375 in. (3.2-9.5 mm) freeplay at foot pad.

NOTE

The standard position for the stop screw is with the head and locknut installed on the top (outer) side of bracket. If 0.25-inch nominal freeplay cannot be achieved, adjusting bolt may be installed from opposite side.

Service Brake Adjustment
TA18 Transaxle

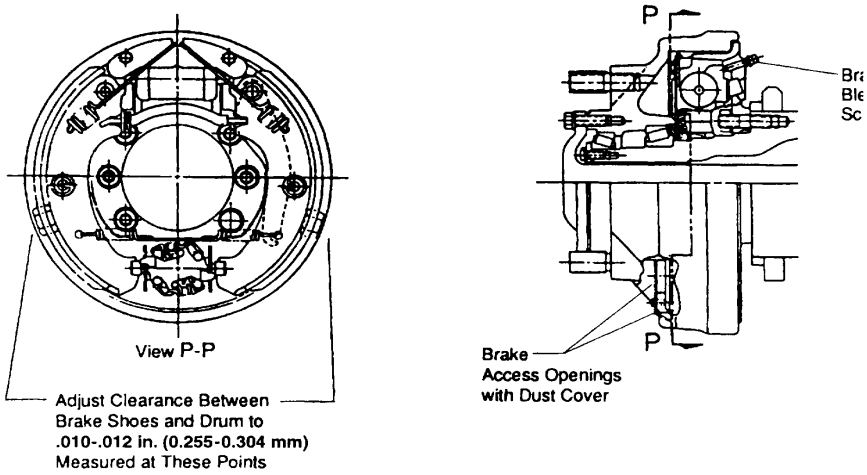


Figure 4. Service Brake Installation

NOTE

Prior to performing this service procedure, it is recommended that you first:

- Remove key for safety.
- Be sure transmission directional control is in NEUTRAL and truck is prevented from moving when parking brake is released

1. The service brakes on the TA18 transaxle may be through the backing adjusted from the inner side through the backing plate or from the outer side through access openings in the wheel hub/brake drum (later models).
2. Brake clearance is measured between brake shoe and drum, with brakes fully released. Brake Clearance: .010-.012 in. (0. 255-0.304 mm)
3. Release parking brake

NOTE

Do not overtighten brakes. It is very difficult to release the ratchet wheel pawl and back off adjustment of the brake.

Adjustment Thru Backing Plate

1. Remove the 4 dust plugs in brake backing plate.
2. Use a feeler (thickness) gauge to check the clearance between each shoe and drum. Use a screwdriver or equivalent tool to rotate the adjustor ratchet wheel in the brake.

WARNING

Some brake linings are still made with asbestos which when inhaled has been found to be extremely dangerous. Do not use compressed air to clean the brake shoes or other parts before or after disassembly. Instead, wipe down the assembly and then the components with damp, disposable wipers and immediately discard them safely. Avoid breathing dust or injury may result.

3. Use a screwdriver to push on and release the ratchet pawl when it is necessary to back off adjustment (increase clearance) of the brake.
4. Carefully adjust clearance between brake shoes and drum to .010-.012 in. (0.255-0.304 mm) measured at dust plug openings at outer sides of backing plate.
5. Replace the dust plugs in brake backing plate when adjustment is completed.

Service Brake Adjustment (cont'd)
TA1 8 Transaxle

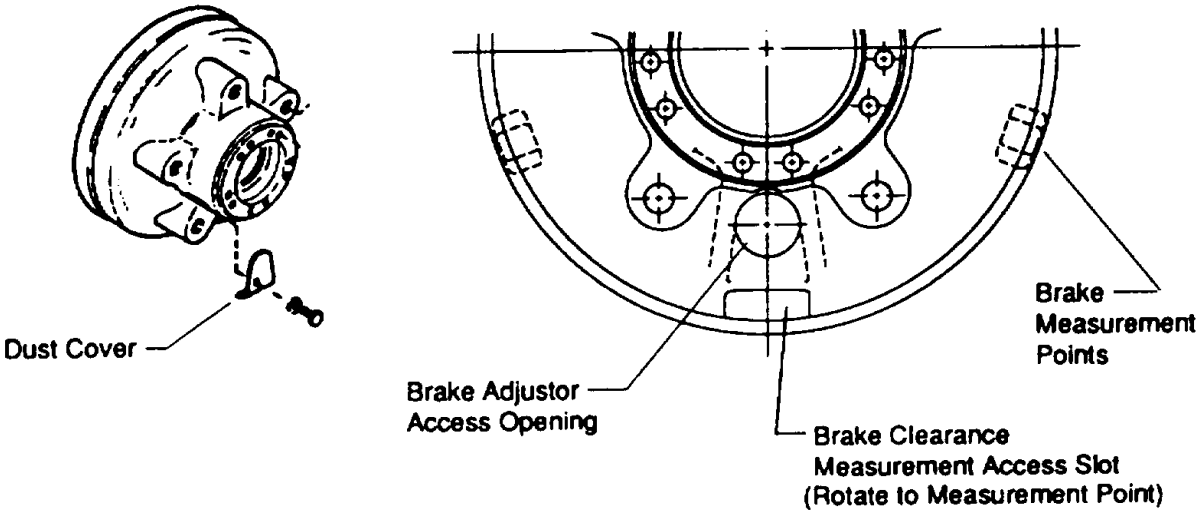


Figure 2. Service Brake Access Openings in Wheel Hub

Adjustment Thru Wheel Hub

NOTE

Openings in the wheel hub/brake drum have been provided for easier access to check and adjust the service brakes from the outer side. The opening is enclosed with a dust cover held in place by a single screw.

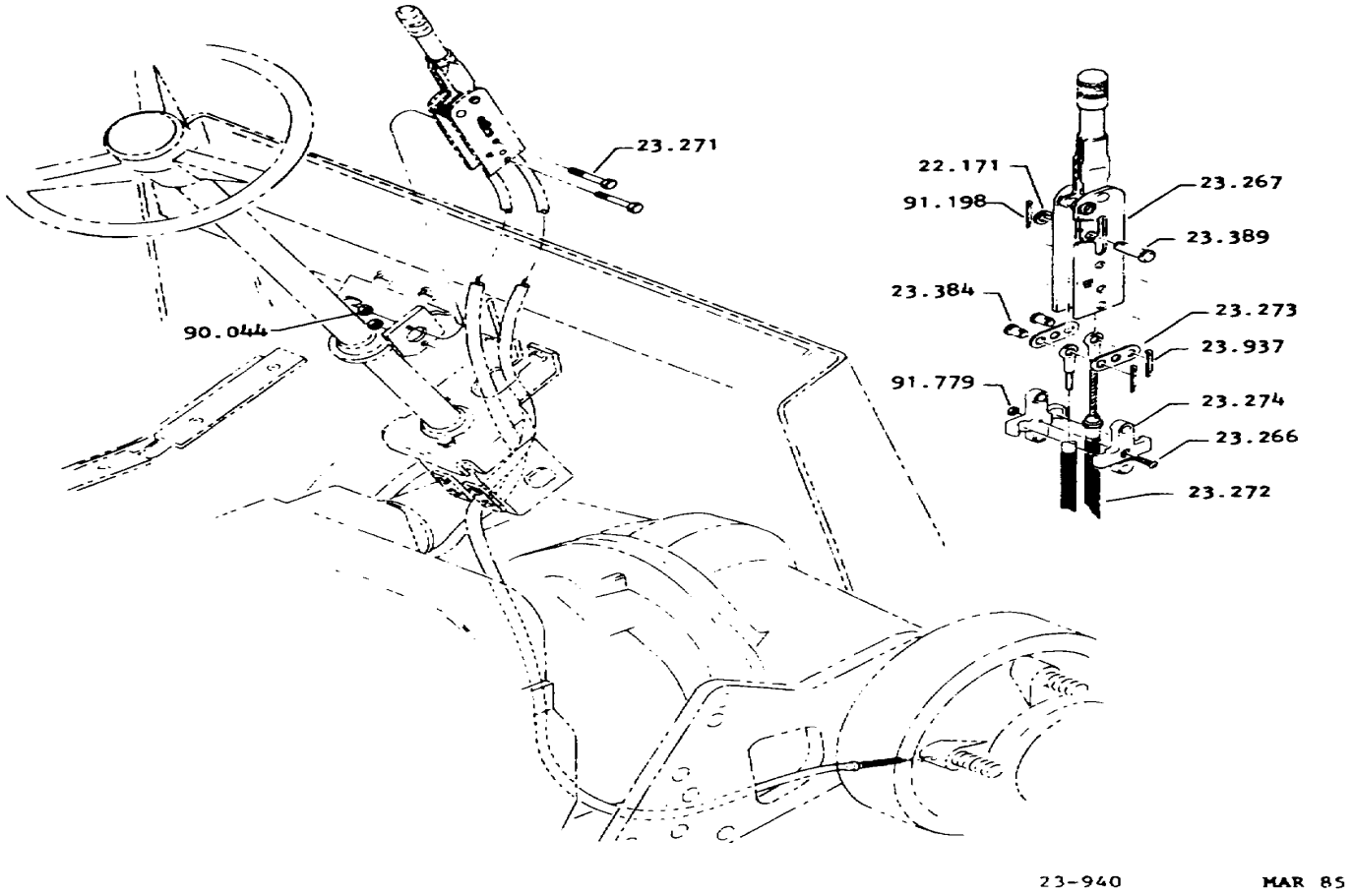
1. Remove wheel and tire assembly from wheel hub.
2. Remove dust cover from access opening in wheel hub/brake drum
3. Use a feeler (thickness) gauge to check the clearance between each shoe and drum. Use a screwdriver or equivalent tool to rotate the adjustor ratchet wheel in the brake.
4. Use a tool with a hook to pull on and release the ratchet pawl when it is necessary to back off adjustment (increase clearance) of the brake.

NOTE

Do not overtighten brakes. It is very difficult to release the ratchet wheel pawl and back off adjustment of the brake.

5. Carefully adjust clearance between brake shoes and drum to .010-.012 in. (0.255-0.304 mm) measured at slot opening. Move slot by rotating brake drum to check clearance, at positions shown by Fig.4, on each brake shoe.
6. After adjusting brakes, install dust cover over access opening in wheel hub.
7. Install wheel and tire assembly on drive axle wheel hub.
8. Install wheel mounting lug nuts and tighten to torque spec: 470-530 lb-ft (637-718 N-m).

Parking Brake Linkage - Type 2
TA1 8 Transaxle



22.171	WASHER, PARKING BRAKE CABLE END RETAINER	23.384	RETAINER, PARKING BRAKE LINE
23.266	FASTENER, PARKING BRAKE CABLE CLAMP	23.389	RETAINER, PARKING BRAKE CABLE END
23.267	LEVER, PARKING BRAKE	23.937	RETAINER, PARKING BRAKE EQUALIZER
23.271	FASTENER, PARKING BRAKE LEVER	90.044	NUT, PARKING BRAKE LEVER FASTENER
23.272	CABLE, PARKING BRAKE	91.198	RETAINER, PARKING BRAKE CABLE END PIN
23.273	CLAP,. PARKING BRAKE LEVER TO CABLE	91.779	NUT, PARKING BRAKE CABLE CLAMP FASTENER
23.274	CLAP, PARKING BRAKE CABLE		

8.5. Brake Bleeding
Type 2 Dual Master Cylinders
TA18 Transaxle

Brake & Inching Circuit Bleeding F-395
Hydraulic Brake Fluid and Bleeding Precautions F-396
Bleeding Procedures F-396
Brake & Inching Circuit F-397
Pressure Bleeding Procedure F-397
Manual Bleeding Method - Service Brake Circuit F-398
Manual Bleeding Method - Inching Circuit F-399

Brake & Inching Circuit Bleeding

The purpose of bleeding the brakes is to remove any entrapped air in the brake and inching system which would make the brake or inching pedal feel "spongy" and allow the pedal to travel without proper build-up of hydraulic pressure, thereby losing effective braking and inching.

Normally, a minimum of brake bleeding will be required. The combined brake and inching circuit is designed to place the brake fluid reservoir at the highest point in the circuit. This ensures that the major part of any air that has entered the system will flow upwards and vent into the reservoir. The recommended brake bleeding procedures outlined below are intended to dislodge and remove any entrapped air from the circuit.

NOTE

To perform this service procedure, it is recommended that you first:

- Park truck on a level surface
- Return all controls to neutral and turn ignition key switch OFF, unless otherwise directed.
- Remove key from switch.
- Apply parking brake and block drive wheels.

GPX Model TA18 Transaxle

Bleed brakes with engine off (not running). Check frequently and keep master cylinder reservoir filled during bleeding.

NOTE

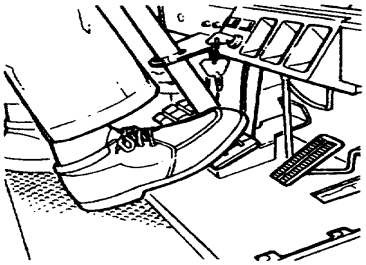
Use SAE/Type DOT 3 Heavy-Duty brake fluid.

Hydraulic Brake Fluid & Bleeding Precautions

1. Do not mix different types or brands of brake fluid.
2. Clean the top and cap of brake fluid containers before opening.
3. Do not use brake fluid which is contaminated or that is cloudy, opaque, an emulsion, separated into layers or contains moisture.
4. Always store brake fluid in the original container and keep airtight. Do not use (reuse) brake fluid containers for any other purpose.
5. Use only new brake fluid for bleeding and cleaning of brake system parts, as applicable.
6. Never save or reuse brake fluid once it has been in any brake system.
7. Clean the filler cap and top of master cylinder before removing cap.
8. Do not open master cylinder in a dusty area or where rain, snow and other contaminants can enter the fluid.
9. Drain and flush the entire system if the fluid in the master cylinder looks dirty, cloudy, is emulsified, separated into layers or contains water or other foreign liquid.
10. Before bleeding, make all necessary adjustments to pedal travel and repairs on lines, hoses, cylinders, etc.
11. Clean off bleeder screws before bleeding brakes.
12. Do not use brake bleeding equipment for any other purpose.
13. As applicable, use only pressure bleeders which prevent aeration of fluid. Pressure bleeder must be set to 14.5-17.4 psi (100-120 kPa). Higher pressure can cause fluid aeration. Be sure that pressure bleeder is in safe operating condition.
14. Before attaching pressure bleeder to master cylinder, fill cylinder completely full, and also fill the bleeder hose with fluid.
15. Follow brake bleeding procedures exactly as described.

Bleeding Procedures
Type 2 Dual Master Cylinders
TA1 8 Transaxle

Service Brake & Inching Circuit



1. Check the existing condition. Push on the brake pedal and inching pedal several times to get a feel of the pedals as they move, and note how system reacts.

WARNING

Be sure transmission directional control is in NEUTRAL and truck prevented from moving when parking brake is released or personnel injury may result.

2. Release the parking brake.

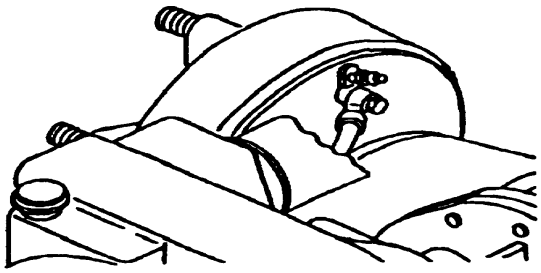


Figure 1. Brake Bleeder Screw Location

3. Brake bleeder screws are located in each wheel end of the drive axle at the inner top side of the brake backing plate.

Brake & Inching Circuit
TA18 Transaxle

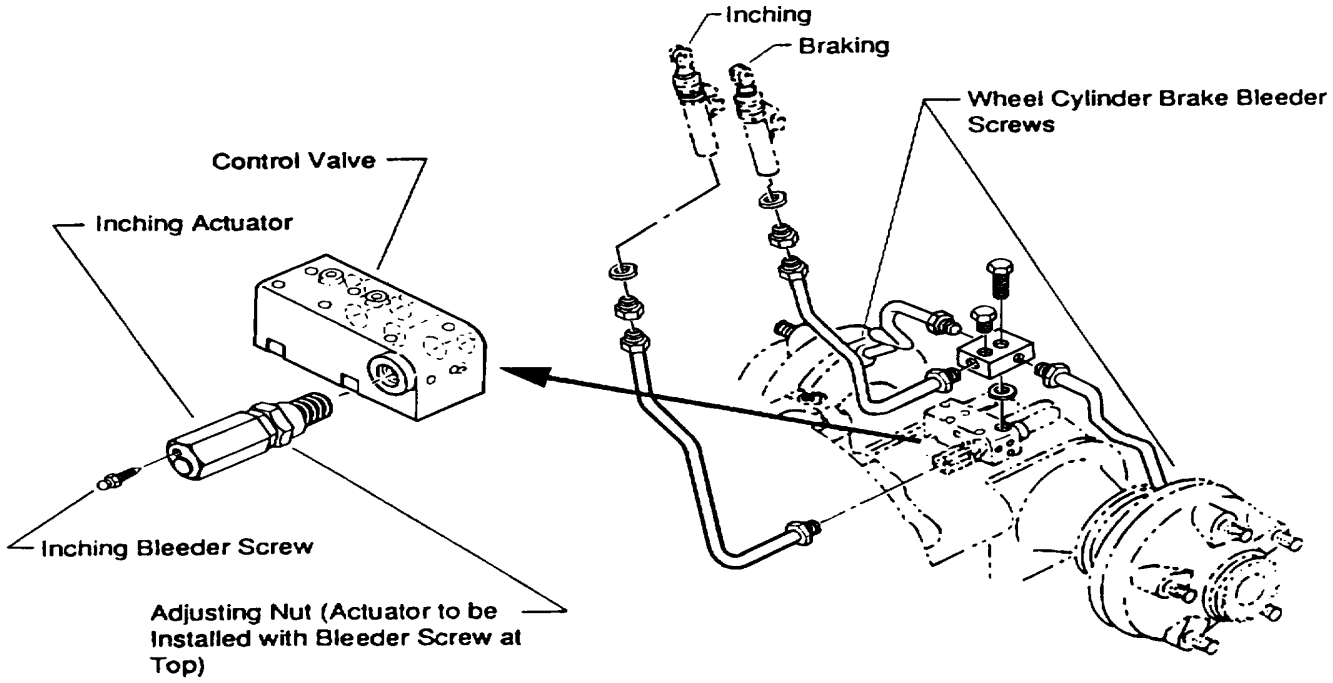


Figure 2. Brake & Inching Circuit Installation, with View of Inching Actuator

4. Inching circuit bleeder screw is installed in the end of inching actuator (slave cylinder) on control valve on transaxle, adjacent to inching control line. *See Figure 2*.

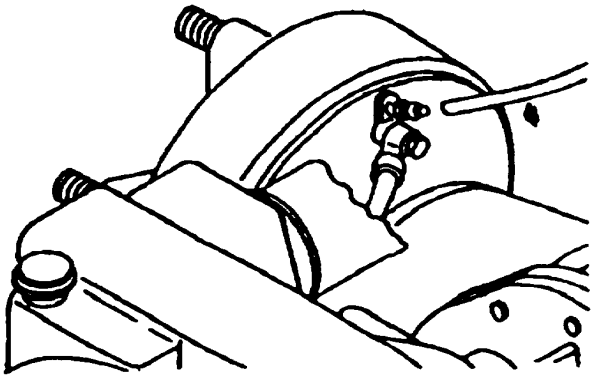
NOTE

Inching actuator housing is designed to be adjustable for positioning the bleeder screw at the top, using the adjusting nut. To adjust, loosen adjusting nut, rotate actuator to place bleeder screw at top, then tighten nut to lock actuator in place.

Pressure Bleeding Procedure
"Bottom Up" Bleeding With Pressure Bleeder

1. Inching bleeder screw closed.
2. Brake bleeder screws closed.
3. Remove cap from brake fluid reservoir.
4. Connect inching filler hose to inching bleeder screw and open bleeder screw.
5. Wait until brake fluid reservoir is 50% full.
6. Pump inching (left) pedal 5-10 strokes (with quick return strokes and 1-2 second intervals between strokes) while filling.
7. Tighten inching bleeder screw after reservoir is 75% full.
8. Install brake filler hose on right-side brake bleeder screw.
9. Install brake drain overflow hose on left-side brake bleeder screw.
10. Loosen both brake bleeder screws.
11. Fill brake lines (fluid will drain from reservoir after Step 10 until Step 11 is started).
12. Wait until a steady flow is achieved from left brake bleed drain line with no air bubbles.
13. Close left-side brake bleeder screw.
14. Wait until reservoir fluid level starts to rise.
15. Stroke brake (right) pedal 5-10 times with quick return strokes and 1-2 second intervals between strokes.
16. Close right-side brake bleeder screw.
17. Remove filler hoses.
18. Install cap on brake fluid reservoir.

Optional Procedure
Manual Brake Bleeding

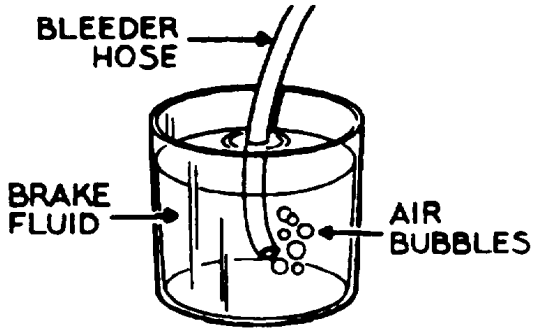


1 When bleeding the brakes manually, it is recommended to install temporary bleed drain lines on the bleeder screws. Use an adequate length of flexible tubing (e.g. clear plastic) having an inside diameter to fit tightly over the bleeder screw opening to prevent air from entering. This allows bleeding to be done quickly and cleanly.

NOTE

If drain lines are not used, the bleeder screw must be altematively opened and closed in sequence while bleeding the system, as described in Manual Bleeding Procedure below.

2. Install bleed drain on each bleeder screw. Fit the drain tube only over the outer end of the bleeder screw, leaving wrench clearance at the bottom.



3. Immerse the open end of each drain line in a jar partially filled with clean hydraulic brake fluid. Put the jar in a position above the level of the bleeder screws and where you can watch for air bubbles in the fluid.
4. When moving the brake pedal, be sure that the open end of the bleed drain lines are always immersed in the jar of clean fluid to prevent air from reentering the system. Watch for air bubbles escaping from the bleed lines.

Manual Bleeding Method -
Service Brake Circuit
Alternate method if pressure bleeder is not available.

NOTE

When bleed drain lines are not installed (see Optional Procedures) the bleeder screws must be opened during brake pedal downward movement, and closed before and during brake pedal upward return movement, to prevent air from entering the system during pedal return stroke.

1. Open the bleeder screw of the brake circuit being bled.
2. Push (stroke) the brake pedal fully down slowly several times (5-10 times minimum).
3. Check and refill brake fluid reservoir with recommended hydraulic brake fluid. Keep reservoir filled during bleeding.
4. When the bleeding fluid appears to be free of air bubbles, tighten the bleeder screw and test the brake pedal action.
5. Push on the brake pedal and hold in the fully-down position. Check for a feeling of solid resistance when the brake pedal stops. The pedal must feel firm and not move down farther after it stops.
6. If the brake pedal motion or feel is not correct:
   a) First, push the pedal fully down several times, with the bleeder screws closed. This will give movement to the brake fluid and wheel cylinder pistons to aid in dislodging any remaining entrapped bubbles of air. Wait several minutes.
   b) Then, repeat the bleeding procedure, as previously described.
   c) Test the brake pedal action.
7. If necessary, bleed the inching circuit.

Manual Bleeding Method -Inching Circuit
Alternate method if pressure bleeder is not available.

NOTE
This method may have to be repeated several times.

1. Bleed down brake pedal and block the pedal, as follows:
   a) Push (depress) brake pedal down as a brake bleeder screw is opened at the wheel brake.
   b) When pedal is fully depressed, close bleeder screw and block pedal in the fully down position.
2. Depress inching pedal while cracking bleeder screw at inching actuator on transmission control valve, as follows:
   a) While pushing on the inching pedal, loosen the bleeder screw in the inching slave cylinder housing on the transaxle to allow a slight flow of fluid to be forced out of the bleeder screw.
   b) Tighten bleeder screw as inching pedal stops moving downwards and before releasing the inching pedal.
3. Repeat above procedure once. Tighten the bleeder screw.
4. Remove brake pedal block and check if truck inches correctly.
5. Test the brake and inching pedal action.
6. If necessary, repeat the brake and inching circuit bleeding procedures until pedal action and feel is correct.
7. When the brake and inching bleeding is completed satisfactorily:
   a) Apply parking brake.
   b) Remove bleed drain lines (as applicable) and tighten bleeder screws.
   c) Check and fill brake fluid reservoir with recommended hydraulic brake fluid.

NOTE
If air entrapment remains a problem after bleeding inching system as noted above.

Refer to Section 8.4, Brake System-Type 2, Inching Troubleshooting Guide, Item 1, Air in lines.

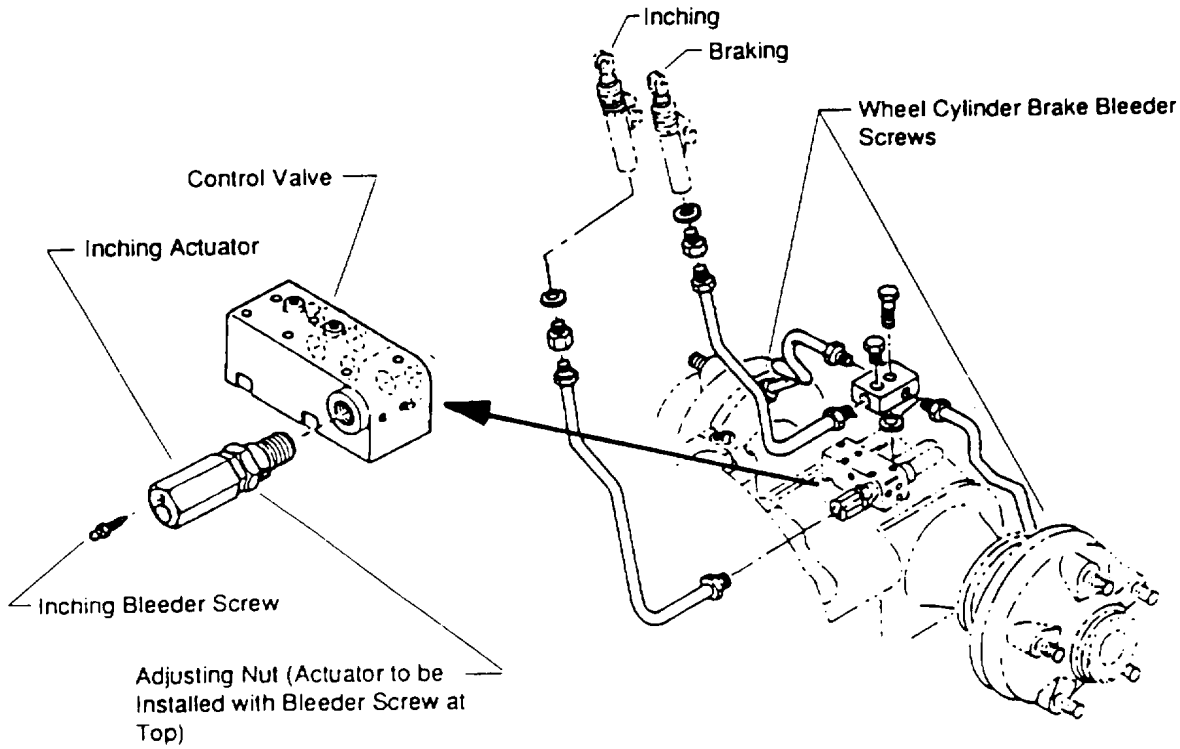


Figure 3. Brake & Inching Circuit Installation, with View of Inching Actuator

9.0. Steering System

Power Steering Lines Installation F-402

9.1 Power Steering System-Relief Pressure Setting F-403

9.2 Steering Column and Valve F-405

9.3 Steering Column - Removal/Installation F-407

9.4 Steering Valve Overhaul F-413

9.5 SteerAxles F-419

9.6 Steer Axle - Wheel Bearing Maintenance F-421

9.7 Steer Axle - Removal/Installation F-425

9.8 Deleted

9.9 Deleted

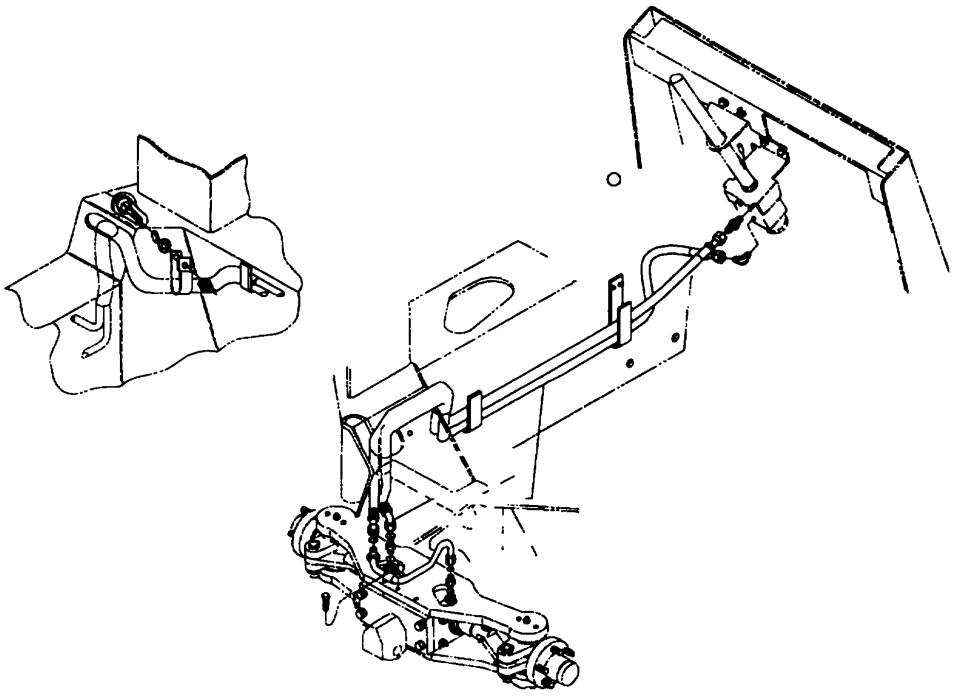
9.10 Deleted

9.11 Deleted

9.12 Steer Axle Overhaul F-431

9.13 Steering Cylinder Overhaul F-441

Power Steering Lines Installation
Steer Axle



F-402

9.1. Power Steering System
Relief Pressure Setting

Description and Operation..... F-403
Relief Pressure Setting Check F-403

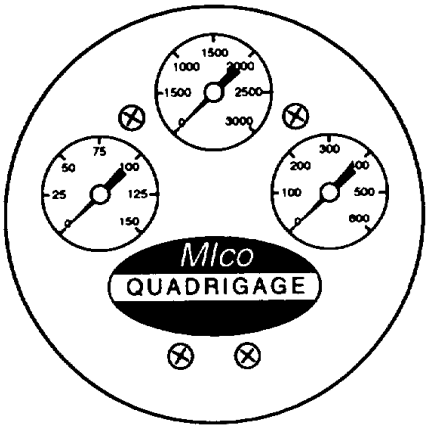
Description and Operation

All GPX 25E trucks have a hydrostatic power steering system, which is supplied with oil pressure from the main hydraulic system pump through a steering pressure relief (flow control) valve to the steering gear. The steering handwheel operates the steering gear control valve unit which directs all flow to the two-way steering cylinder on the steer axle.

The steering system relief pressure is controlled by the pressure relief valve which is adjustable.

Steering system relief pressure should be checked frequently, since relief pressure settings above the specified values can cause failure of the hydraulic lines, seals in the steering gear, and/or ball joint breakage on the steer axle.

Steering System Relief Pressure Setting:
1200-1300 psi (8270-8960 kPa)



Steering system relief pressure setting may be checked using a MICO QUADRIGAGE or with a conventional pressure gauge 0-3000 psi (0-20,700 kPa) .

Relief Pressure Setting Check

WARNING

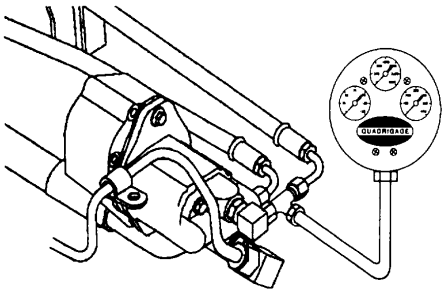
Do not use your hands to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Keep hands and body away from pin holes and nozzles which eject fluids under high pressure. If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

Note

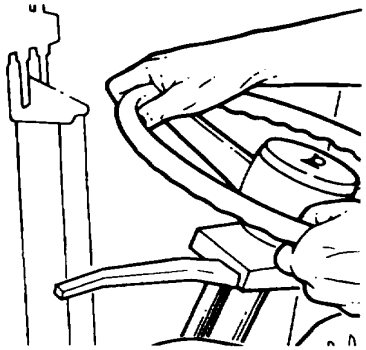
- The following procedure may be used to check steering system relief pressure only. If relief pressure is not correct, it may be from dirt in the valve or worn parts, including steering control valve and main hydraulic pump. Generally, if the relief pressure measured when the steering system is in bypass is not correct, the pressure relief valve should be adjusted or replaced.
- To perform this service procedure, it is recommended that you first:
  - Park truck on a level surface. Lower the upright.
  - Put blocks under the upright rails and raise the drive wheels off the floor.
  - Return all controls to neutral, apply parking brake, and turn key switch OFF, except as directed.

This procedure requires installation of a pressure gauge at the gauge port of the main hydraulic pump, and measurement of the pressure while the steering handwheel is turned fully in one direction to put the steering system in bypass.

1. Remove two screws and shield from frame.



2. Clean the steering hose fitting and connect the pressure gauge to the steering line and pump fitting.
3. Start the engine and let it warm up until it runs smoothly.
4. Check steering system relief pressure setting at full throttle. Accelerate engine to no-load governed speed (full throttle) and hold at this speed while taking the pressure readings.

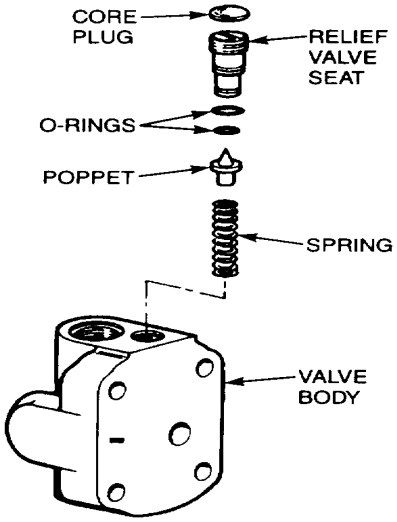


5. Turn the steering handwheel in one direction until steering cylinder reaches its stop (relief bypass). Hold steering handwheel in relief position until pressure reading is taken, and then release.

CAUTION

Do not operate system over relief bypass any longer than required to read the pressure gauge or damage to equipment may result.

6. When the steering system relief pressure reading has been obtained, turn the engine off. Pressure should read between 1200-1300 psi (82708960 kPa).



7. To adjust steering pressure relief valve, proceed as follows:

   a. Carefully remove the core plug of the steering pressure relief valve on the main pump by prying the plug out.

   b. Clockwise adjustment of the relief valve seat raises the pressure setting at which the valve relieves pressure; counterclockwise adjustment lowers the pressure setting at which the valve relieves pressure.

3. Restart engine and repeat steps to read and adjust the relief pressure setting until correct relief pressure is set.

   a. Once you adjust to the correct pressure setting, reset the core plug in the valve bore.

   b. If the correct relief pressure cannot be gained, consider overhauling or replacing both the priority valve and the pressure relief valve.

9. Disconnect the pressure gauge and install the shield on the frame with two screws. Tighten screws 177-221 lb-in (20-25 Norm).

9.2. Steering Column and Valve (Steering Gear)

Description and Operation F-405
Steering Troubleshooting F-405
Steering Column & Valve Mounting F-406

Description and Operation

NOTE

The nomenclature used in describing service procedures for the power steering system control components reflects the change in technology of hydrostatic steering systems as compared to manual steering systems, and differs in some areas from that used in the Service Parts system. In the Service Parts Book and illustrations in this manual, the steering column and valve assembly is referred to as the steering gear assembly; the steering valve (or steering control unit) is referred to as the power steering gear box assembly; and the steering column is referred to as the steering gear shaft assembly.

The power steering control unit is a remote positioning control valve that senses the input signal from the steering handwheel, multiplies this signal to assist in reducing the steering effort and causes the steering axle to turn the wheels to the desired position by supplying hydraulic pressure to the steering cylinder.

The steering valve is connected to the bottom of the steering column. When the steering wheel is turned, it is linked mechanically to the steer valve spool and causes this spool valve to shift from its closed neutral position to a "turn" position that allows oil under pressure to flow to the steering cylinder.

When the steering handwheel stops turning, centering springs in the valve automatically center the spool, stopping the flow of oil pressure to the cylinder.

The low pressure oil from the opposite side of the steering cylinder is returned through the opposite port in the valve. It is controlled by the same spool as the high pressure port.

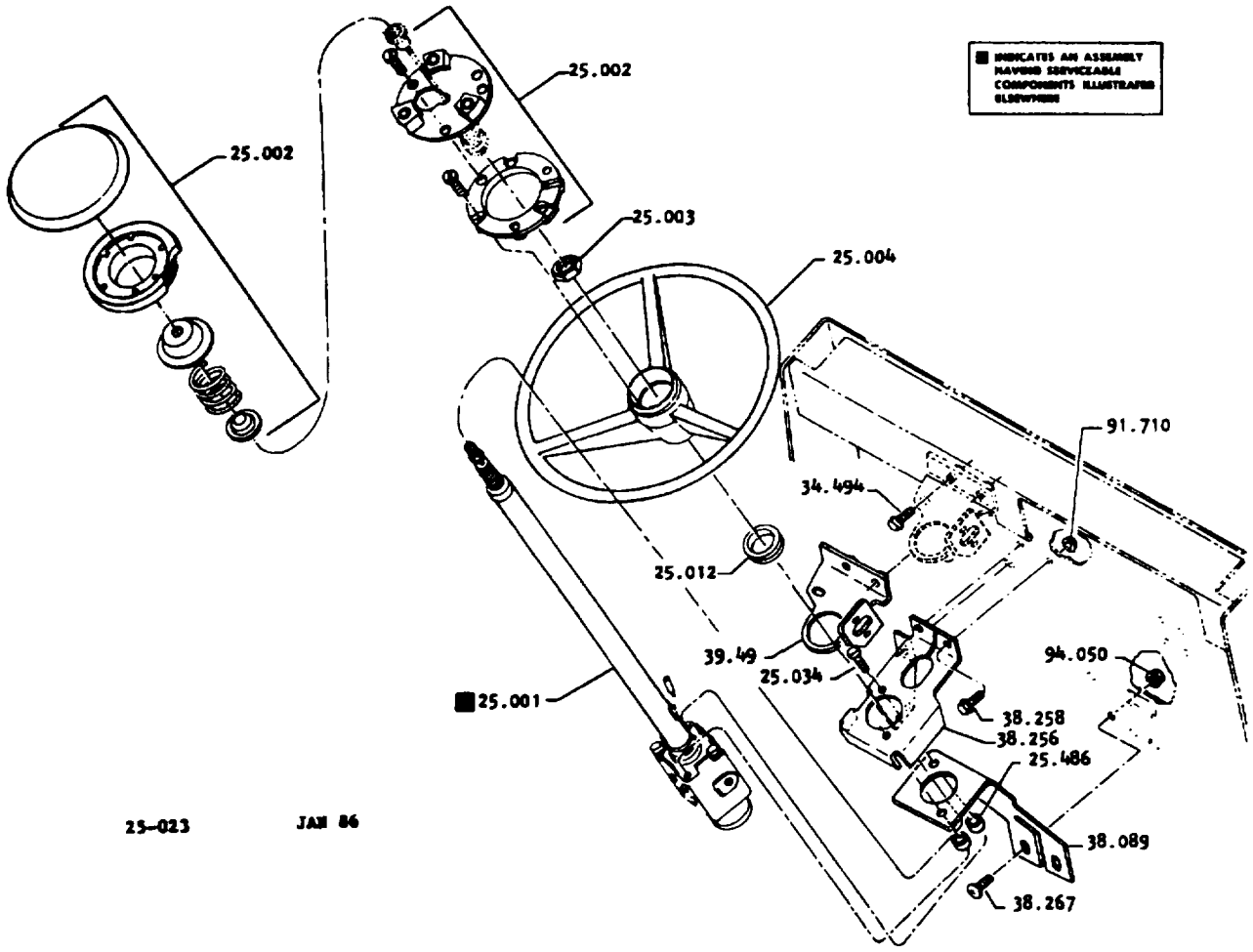
In the event of a pump failure, the steering control unit can generate sufficient hydraulic power by movement of the steering handwheel to serve as a limited steering method. An internal check valve automatically closes to divert this generated oil flow to the proper port of the steering cylinder. The handwheel turning effort is considerably higher, however, than with power steering.

Steering Troubleshooting

The following list of symptoms and possible causes are the most common steering system problems encountered.

Troubleshooting Guide	
1.	**High number of handwheel turns**
	1) Steering cylinder seal leakage 2) Worn steering valve
2.	**Handwheel steering effort too high**
	1) Relief valve setting too low 2) Axle load too heavy 3) Defective steering valve
3.	**Steering handwheel spins freely**
	1) Air in system (cavitation) 2) Low oil supply 3) Defective steering valve
4.	**Truck turns in wrong direction**
	1) Hydraulic lines not installed correctly
5.	**Handwheel kickback**
	1) Check valve faulty (or not in system) 2) Improperly timed steer valve
6.	**Slow steer response**
	1) Oil viscosity too heavy 2) Defective steering valve

Steering Column & Valve Mounting



25.001	GEAR ASSEMBLY, STEERING
21.002	KIT, HORN BUTTON
25.003	FASTENER, STEERING HANDWHEEL
25.004	HANDWHEEL, STEERING
25.012	CUSHION, STEERING COLUMN
25.034	FASTENER, STEERING GEAR MOUNTING
25.486	SPACER, STEERING GEAR MOUNTING
38.089	BRACKET, STEERING GEAR MOUNTING
38.256	BRACKET, STEERING GEAR MOUNTING
38.258	FASTENER STEERING GEAR BRACKET ATTACHING
38.267	FASTENER, STEERING GEAR BRACKET
39.493	BRACKET, STEERING COLUMN
39.494	FASTENER, STEERING COLUMN BRACKET
91.710	NUT, STEERING GEAR BRACKET FASTENER
94.050	NUT, STEERING GEAR MOUNTING BRACKET FASTENER

9.3. Steering Column
Removal/installation

Horn Button & Steering Wheel Disassembly F-407
Steering Column & Valve Removal F-408
Steering Column & Valve Reassembly F-409
Horn Button & Steering Wheel Reassembly F-411
Steering Control Valve F-412

Removal

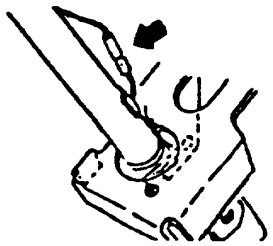
WARNING

Be sure tuck is parked and positioned in a safe and convenient manner or injury to personnel may result. *Refer to Section 9.2, Steering Column & Valve.*

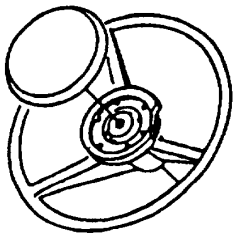
Horn Button &
Steering Wheel Disassembly
(As Required)

IMPORTANT - For safety, when checking or removing battery connections, always first disconnect the negative battery cable at the engine ground connection.

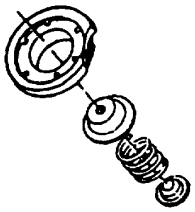
1. It is recommended that you first disconnect the battery ground (-) cable from the engine ground connection.
2. Remove the floor boards.



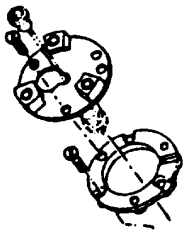
3. Disconnect horn wire at base of column.



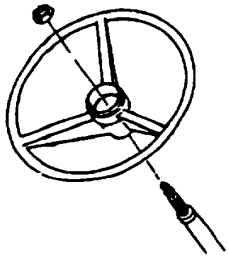
4. Remove the flexible horn button cover from steering handwheel hub.



5. Use a screwdriver in slot in horn button cover plate and rotate cover in steering wheel hub to unlock from tabs in hub. Remove cover plate.
6. Remove spring cover, spring and spring seat.



7. Loosen screws holding outer retaining plate. Push horn switch (arrow) to side and out of slot, allowing outer retainer plate to be lifted off.
8. Remove screws holding inner retainer and remove inner retainer.



9. Loosen and remove steering wheel nut.
10. Remove steering wheel.

Steering Column & Valve Removal
Refer to Section 9.2. Steering Column & Valve.

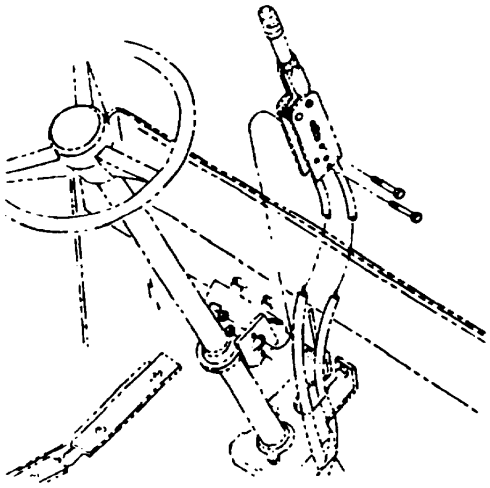
1. Disconnect horn wire at base of column, if not previously done.

Refer to Section 9. 0,

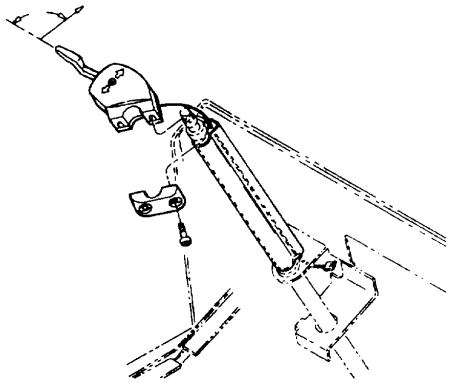
NOTE

Mark or tag all hose fittings to the steering gear for reference at reassembly. Thoroughly clean around all fittings before disconnecting hydraulic lines.

2. Loosen and remove steering lines from steering control unit fittings. Cap ends to prevent oil leakage. If necessary, tie loose lines to truck out of way.

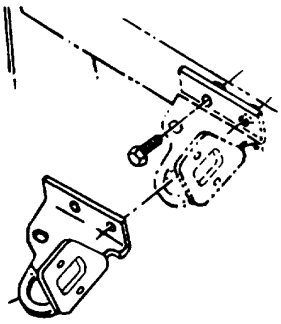


3. Remove parking brake control lever assembly from upper steering column bracket. Move out of way.

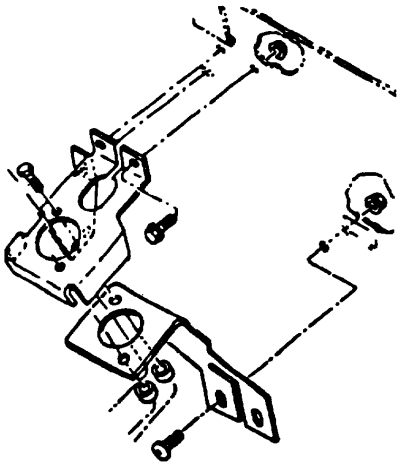


Refer to Section 7.9, Directional Control Linkage.

4. Remove fasteners holding (lower) directional control lever shaft bracket to steering gear mounting bracket.
5. Remove fasteners from cap and remove upper directional control lever linkage bracket (clamped to steering column).
6. Remove directional control linkage assembly or move out of way.



7. Remove fasteners attaching steering column bracket to cowl.

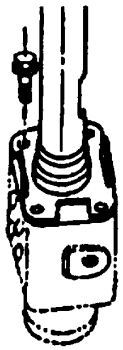


8. Remove fasteners holding upper and lower steering gear mounting brackets to cowl.
9. Remove steering column and gear assembly with brackets.

NOTE

Perform Steps 10-12 as required after removing steering wheel.

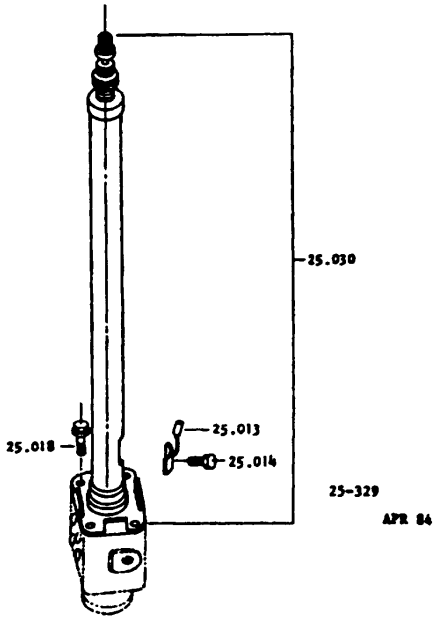
10. Remove upper bracket and grommet by pulling upward and off steering column.
11. Disassemble and remove fasteners and lower bracket from steering gear. Be sure spacers are removed and saved. Remove lower bracket upward off steering column.



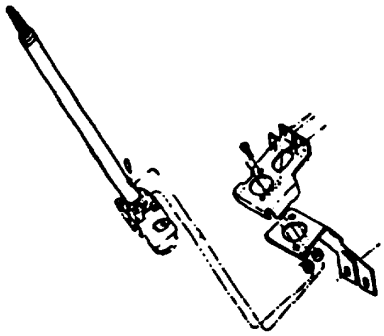
12. Disassemble steering gear (control valve) from

Installation

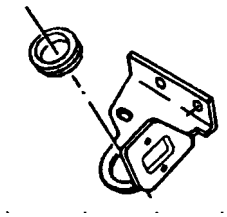
Steering Column & Valve Reassembly



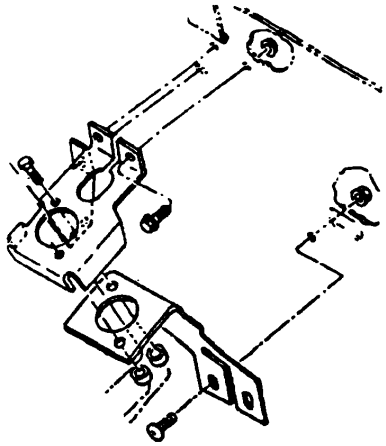
1. Assemble steering gear (control valve unit) to steering column, as required.



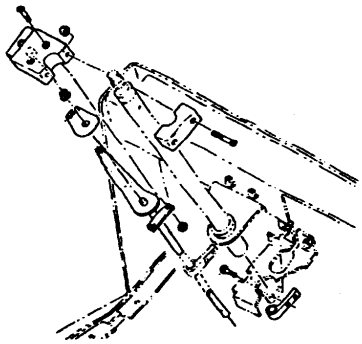
2. Install lower and upper steering gear mounting steering column, as required. brackets over steering column.
3. Install spacers between lower bracket and gear, then install fasteners. Tighten to 70-80 lb-ft (8-10 N•m) in torque.



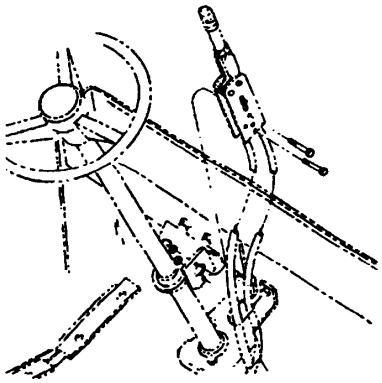
4. Install (upper) steering column bracket with steering column grommet fitted in place in bracket over steering column.



5. Align steering column assembly in truck and install fasteners mounting (lower) steering gear mounting brackets to cowl. After final alignment, tighten to torque spec: 180-220 lb-in (20-25 N•m).
6. Install fasteners mounting (upper) steering column bracket to cowl. After final alignment, tighten to torque spec: 190-220 lb-in (20-25 N•m).



7. Assemble directional control linkage.
8. Position directional control lever linkage bracket and cap on steering column and install fasteners.
9. Install (lower) directional control lever to steering gear mounting bracket.

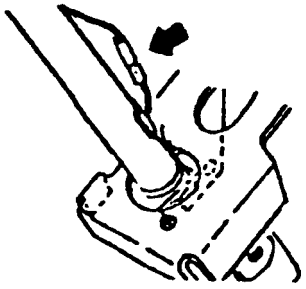


10. Install parking brake lever assembly on (upper) steering column bracket.

11. Inspect condition of O-rings prior to installation. Replace with new O-rings as needed.
12. Check correct port position of each line and install the steering hydraulic lines to steering gear. Be sure O-rings are in correct position on fittings and that port seal surfaces and fittings are clean. Tighten fittings to 70-80 lb-in (8-9 N•m) torque.

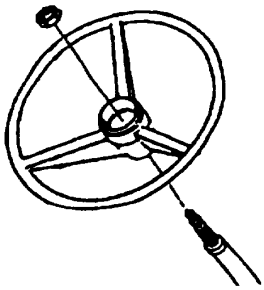
NOTE

For convenience, hydraulic lines may be installed after Step 6.

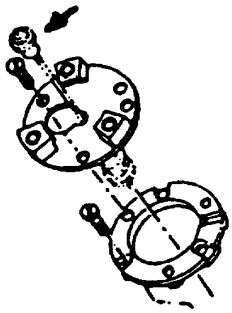


13. Connect the horn wire.

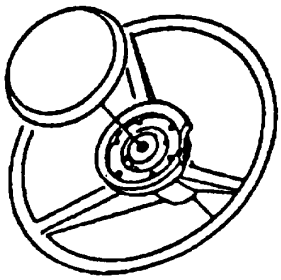
Horn Button
& Steering Wheel Reassembly
(As Required)



1. Install steering wheel on steering column shaft.
2. Install steering wheel retaining nut and tighten to 35-40 lb-ft (47-54 N•m) torque.



3. Install horn button switch inner retainer.
4. Install horn button switch outer retainer plate making sure horn switch (arrow) is fitted into slot and centered in retaining plate.



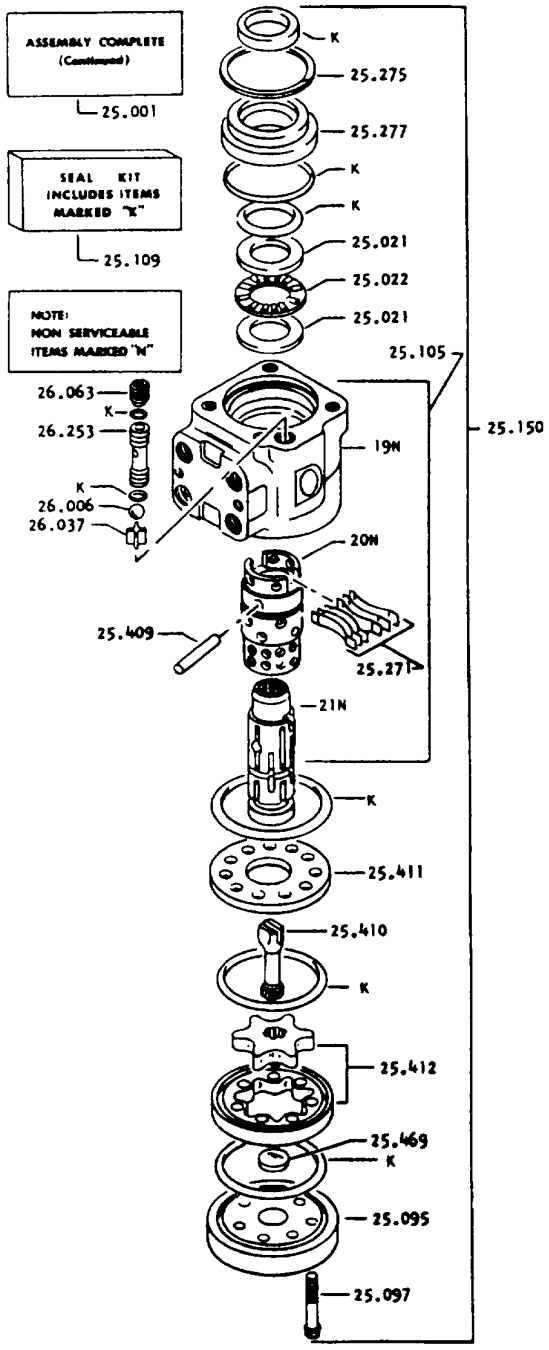
5. Install horn button switch spring seat, spring, spring cover and horn button cover.

NOTE

Put screwdriver in slot in horn button cover and push down-ward while rotating cover to engage the tabs in steering wheel hub.

6. Press horn control cover into position. Make sure flexible prongs engage horn button cover hole to hold it in place. Cover must fit tightly to wheel hub to ensure waterproof cover.
7. Reconnect battery ground (-) cable to the engine ground connection.
8. Install floor boards.
9. Check for correct assembly. Start engine and operate truck steering system. Turn truck in both directions to make sure of correct hydraulic line connections.
10. Test horn operation to make sure of proper connection of wires.

Steering Control Valve



STEERING GEAR

25.001 GEAR ASSEMBLY, STEERING (CONTINUED)
25.021 RACE. STEER SHAFT THRUST BEARING
25.022 BEARING, STEER SHAFT THRUST
25.095 COVER. STEER GEAR PUMP END
25.097 CAPSCREW. STEER GEAR PUMP END COVER
25.105 VALVE ASSEMBLY. STEER GEAR
25.109 SEAL KIT, STEER GEAR
25.150 GEAR BOX ASSEMBLY, POWER STEERING
25.271 SPRING, STEER GEAR SALVE CENTERING
25.275 RETAINER. STEER GEAR VALVE HOUSING COVER
25.277 COVER, STEER GEAR VALVE HOUSING
25.409 TRUNNION, STEER GEAR PUMP DRIVE
25.410 SHAFT, STEER GEAR PUMP DRIVE
25.411 WEAR PLATE, STEER GEAR DRIVE
25.412 PUMP CARTRIDGE, STEER GEAR
25.469 SPACER, STEER GEAR PUMP DRIVE SHAFT
26.006 BALL, STEER GEAR CHECK VALVE
26.037 RETAINER, STEER GEAR CHECK VALVE
26.063 PLUG, STEER GEAR CHECK VALVE CHANNEL
26.253 SEAT. STEER GEAR CHECK VALVE
19N HOUSING. STEER GEAR VALVE USE 25.105
201 SLEEVE, STEER GEAR VALVE USE 25.105
21N SPOOL. STEER GEAR VALVE USE 25.105

9.4 Steering Valve Overhaul (Steering Control Unit)

Steering Valve Disassembly F-413
Parts Inspection F-415
Steering Valve Reassembly F-415

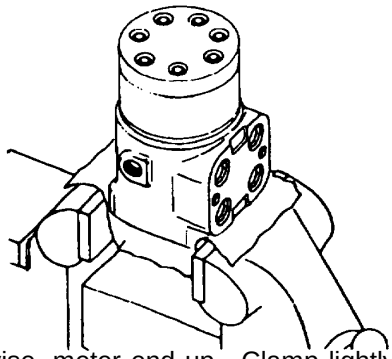
Steering Valve Disassembly

Cleanliness is extremely important when repairing a steering control unit. Work in a clean area. Before disconnecting lines, clean port area of unit thoroughly. Use a wire brush to remove foreign material and debris from around exterior joints of the unit.

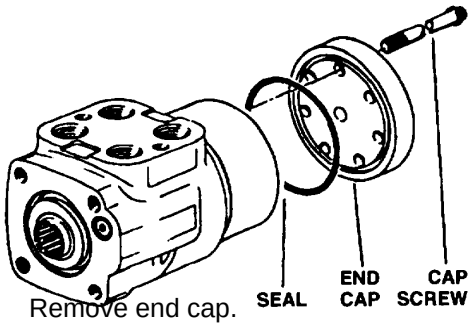
NOTE

Although not all illustrations show the unit in a vise, it is recommended to keep the unit in the vise during disassembly. Follow the clamping procedures explained throughout the text.

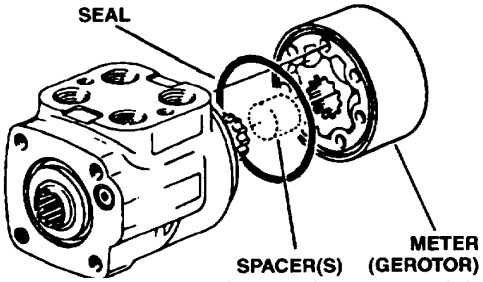
Meter (Gerotor) End



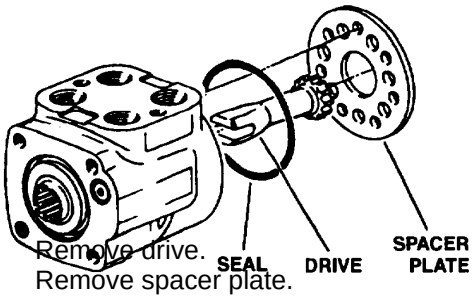
1. Clamp unit in vise, meter end up. Clamp lightly on edges of mounting area, as shown. Use protective material on vise jaws. Do not over-tighten jaws.
2. Remove 5/16-inch capscrews.



3. Remove end cap.
4. Remove seal from end cap.

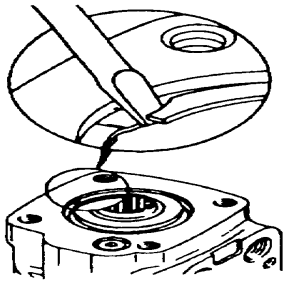


5. Remove meter (gerotor). Be careful not to drop star (rotor).
6. Remove seal from meter.
7. Remove drive spacer(s).

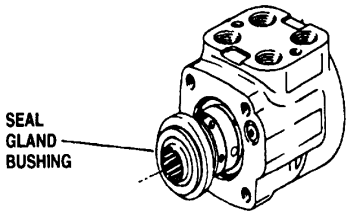


8. Remove drive.
9. Remove spacer plate.
10. Remove seal from housing.

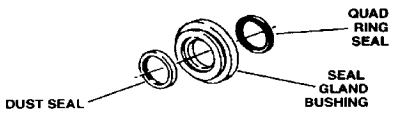
Control End



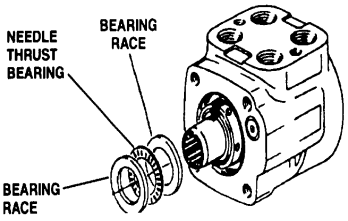
11. Remove housing from vise and place on a clean soft cloth to protect surface finish. Use a thin-bladed screwdriver to pry retaining ring from housing.



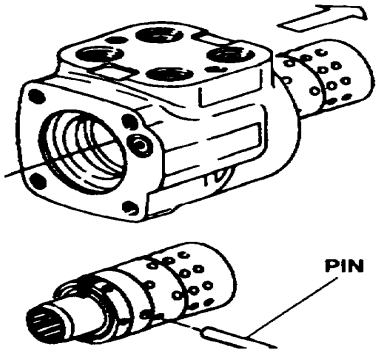
12. Rotate spool and sleeve until pin is horizontal. Push spool and sleeve assembly forward with your thumbs just far enough to free seal gland bushing from housing. Remove bushing.



13. Remove quad ring seal from seal gland bushing.
14. Use a thin-bladed screwdriver to pry dust seal from seal gland bushing. Do not damage bushing.



15. Remove 2 bearing races and the needle thrust bearing from spool and sleeve assembly.

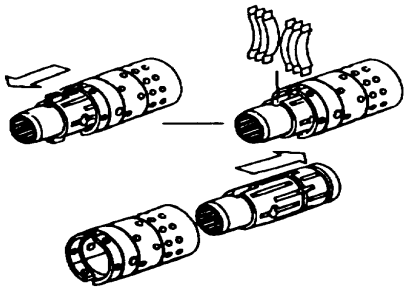


16. Remove spool and sleeve assembly from 14-hole end of housing.

NOTE

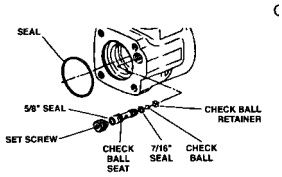
Do not bind spool and sleeve in housing. Rotate spool and sleeve assembly slowly when removing from housing.

17. Push pin from spool and sleeve assembly.



18. Push spool partially from control end of sleeve, then remove six (6) centering springs from spool carefully by hand. Note their position in the unit before they are removed.

19. Push spool back through and out of sleeve. Rotate spool slowly when removing from sleeve.



20. Remove seal from housing.
21. Remove set screw from housing.
22. Screw a 1/8" - 24 NC machine screw into end of check ball seat. Then pull on screw with pliers to lift seat out of housing.
23. Remove two (2) seals from check valve seat.
24. Tip housing to remove check ball and check ball retainer.

Parts Inspection

Inspect all parts for damage, cracks, broken parts, damaged threads, corrosion or erosion of surfaces, worn spots, nicks, or scratches.

Check all mating surfaces. Replace any parts that have scratches or burrs that could cause leakage. Discard all old seals and replace with new ones.

Clean all metal parts in clean solvent. Blow dry with air. Do not wipe dry with cloth or paper towel because lint or other matter can get into the hydraulic system and cause damage. Do not use a coarse grit or try to file or grind these parts.

If parts are left exposed, cover them with a clean cover to prevent airborne dust from collecting on them.

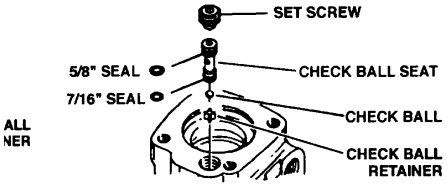
Steering Valve Reassembly

NOTE

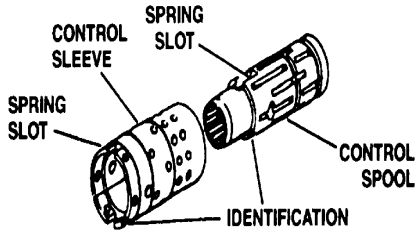
Lubricate all seals (with exception of new quad ring seal) with clean petroleum jelly such as Vaseline.Do not use excessive lubricant on seals for meter (gerotor) section.

Make sure all parts are clean and free of dust. Before assembly, lightly coat all internal metal parts with oil.

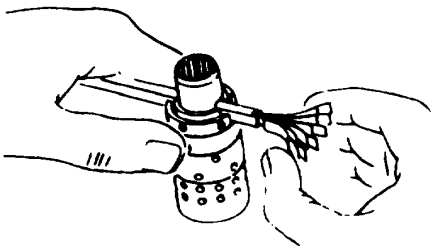
Control End

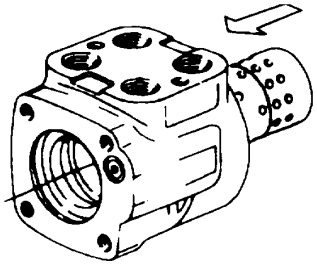


1. Use a needle-nosed pliers to lower check ball retainer into check valve hole of housing. Make sure retainer is straight (not tilted on edge) in housing.
2. Install check ball in housing.
3. Lubricate 5/8" diameter seal and 7/16" diameter seal. Install seals on check ball seat, as above.
4. Lubricate check ball seat and seals thoroughly before installing seat in housing. When installing seat, do not twist or damage seals. Install check ball seat in housing; insert open end of seal first. Push check ball seat into bottom of hole.
5. Install set screw. Use a 5/1 6"Allen wrench to torque set screw to 100 lb-in (11 N•m). To prevent interference of parts, make sure top of set screw is slightly below housing mounting surface.

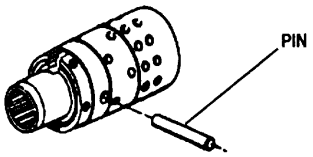


6. Assemble spool and sleeve carefully so that the spring slots line up at the same end. Rotate spool while sliding parts together. Some spool and sleeve sets have identification marks; align these marks. Test for free rotation. Spool should rotate smoothly in sleeve with finger tip force applied at splined end.





7. Bring spring slots of both parts in line and stand parts on end of bench. Insert spring installation tool through spring slots of both parts. Position 3 pairs of centering springs or (2 sets of 3 each) on bench so that extended edge is down and arched center section is together. In this position, insert one end of entire spring set into spring installation tool, as shown.
8. Compress extended end of centering spring set and push into special sleeve assembly withdrawing installation tool at the same time.
9. Center the spring set in the parts so that they push down evenly and flush with the upper surface of the spool and sleeve.

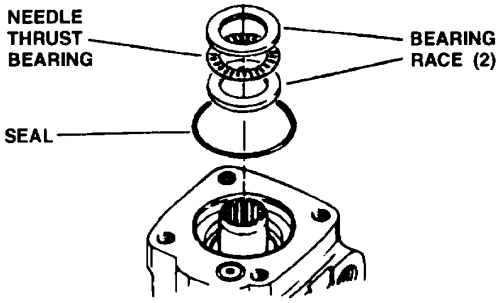


10. Install pin through spool and sleeve assembly until pin becomes flush at both sides of sleeve.

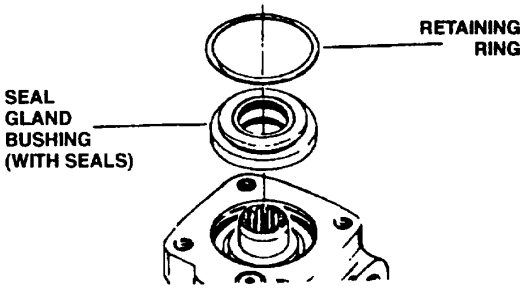
11. Position the spool and sleeve assembly so that the splined end of the spool enters the 14-hole end of the housing first.

NOTE

Be extremely careful that the parts do not tilt out of position while being installed. Push parts gently into place with slight rotating action; keep pin nearly horizontal. Bring the spool assembly entirely within the housing bore until the parts are flush at the meter end or 14-hole end of housing. Do not pull the spool assembly beyond this point to prevent the cross pin from dropping into the discharge groove of the housing. With the spool assembly in this flush position, check for free rotation within the housing by turning with light fingertip force at the splined end.



12. Place housing on clean, lint-free cloth. Install 2 1/8" diameter seal in housing.
13. Install 2 bearing races and the needle thrust bearing in the order shown above.
14. Install 1-1/4" diameter dust seal in seal gland bushing; flat or smooth side of dust seal must face down towards bushing.
15. Install dry quad ring seal in seal gland bushing. Smooth seal in place with your finger. Do not use any seal that falls freely into pocket or bushing. Seal should not "fall" into place, but should require light force to seat.

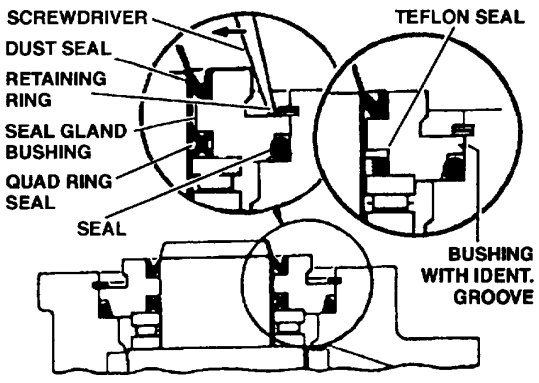


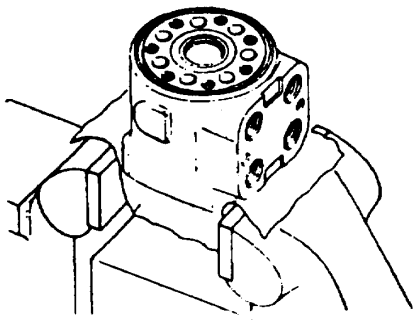
16. Install seal gland bushing over the spool end with a twisting motion. Tap the bushing in place with a rubber hammer. Make sure the bushing is flush against the bearing race.

NOTE

On those units which use the Teflon seal, install the Teflon back-up ring into the recess cut into the seal gland bushing. Install the Teflon seal over the spool end, then carefully install the seal gland bushing over the spool end using a rotary motion.

Note that the seal gland bushing which is used with the Teflon seal is not the same as the seal gland bushing used with the standard quad-ring seal. The seal gland bushing with the Teflon seal has an identification groove cut into the out diameter of the bushing. The grooved bushings can only be used with the Teflon seals and the non-grooved bushings used only with the quad-ring seals.





17. Install retaining ring in housing. After installing ring, tap on ring or pry with screwdriver around entire circumference of ring to properly seat ring in groove.

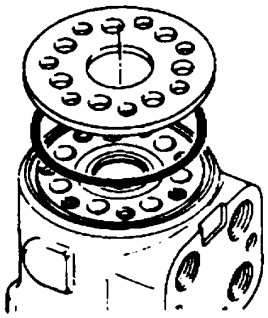
18. Clamp housing in vise, as shown. Clamp lightly on edges of mounting area. Do not overtighten jaws.

CAUTION

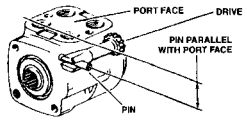
Clean the upper surface of the housing by wiping with the palm of clean hand. Clean each of the flat surfaces of the meter section parts in a similar way when ready for reassembly. Do not use cloth or paper to clean surfaces.

NOTE

Check to ensure that the spool and sleeve are flush or slightly below the surface of the housing.



19. Install 3" diameter seal in housing.
20. Install spacer plate. Align bolt holes in spacer plate with tapped holes in housing.



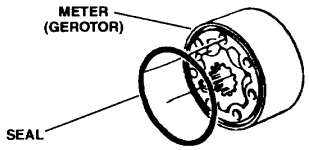
21. Rotate spool and sleeve assembly until pin is parallel with port face. Install drive, making sure you engage drive with pin.

CAUTION

Failure to properly install may cause unit to self-steer and cause damage to equipment.

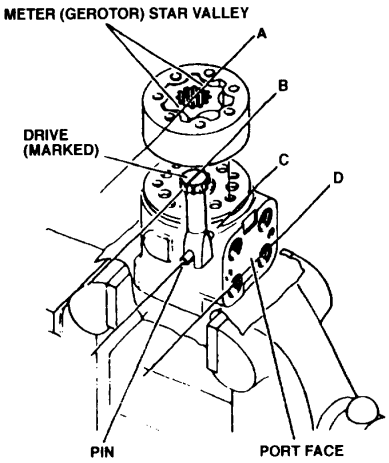
NOTE

To ensure proper alignment, mark spline end of drive shaft with line parallel to slot on other end before installing

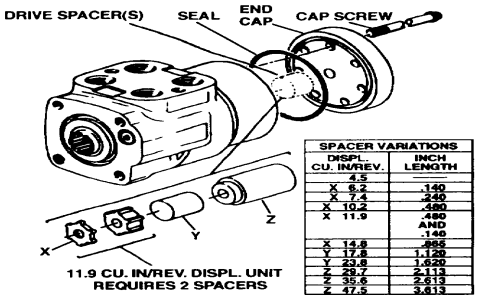


22. Install 3" diameter seal in meter (gerotor).

METER (GEROTOR) STAR VALLEY

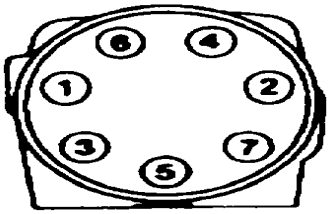


23. With seal side of meter toward spacer plate, align star valleys on drive. Note the parallel relationship of reference lines A, B, C and D in figure above. Align bolt holes without disengaging meter from drive. Be sure star has engaged spline in position shown.



SPACER VARIATIONS	
DISPL. CU. IN/REV.	INCH LENGTH
4.5	—
X 9.2	.140
X 7.4	.240
X 10.2	.480
X 11.9	.480 AND .140
X 14.8	.895
Y 17.8	1.120
Y 23.8	1.620
Z 29.7	2.119
Z 35.6	2.613
Z 47.5	3.613

24. Install drive spacer(s), when used, in meter.
25. Install 3" diameter seal in end cap.
26. Install end cap on gerotor and align holes.



27. Install 7 dry capscrews in end cap. Retighten screws to initial torque of 150 lb-in (17 N•m) in the sequence shown above.
28. Inspect the assembly to be sure all parts have been installed and fasteners correctly installed and tightened.

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9.5 Steer Axles

Background F-419
Steer Axle Specifications.....F-419
Mounting.....F-419
Steer Axle - (Type 2) F-420

This section reviews the arrangement of the steer axle assembly and components used in GPX 25 E Diesel trucks.

For clarity in distinguishing the applicable service procedures, the axle arrangement is referred to by (Type) for Service Manual reference only.

Background

Since the initial release of GCS/GPS 17-30 trucks there have been design changes and product improvements in the original 5-8000 steer axles which affect service procedures.

A major change in style of the main body and steering cylinder has been introduced in later (mid 1989) truck models.

Steer Axle Specifications

One-piece fabricated main body assembly using steel box-type construction. Steering cylinder is an integral separate 2-way actuator mounted within the main body and joined to steering knuckles by links. All bearings are replaceable and have lubrication fittings.

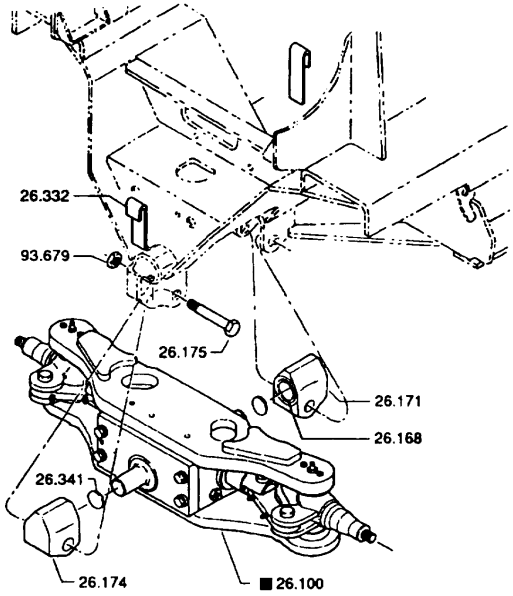
Mounting

The mounting installation of the steer axle in the truck chassis axle are to be noted for service maintenance. *Refer to Section 9. 7, Steer Axle Removal/Installation*.

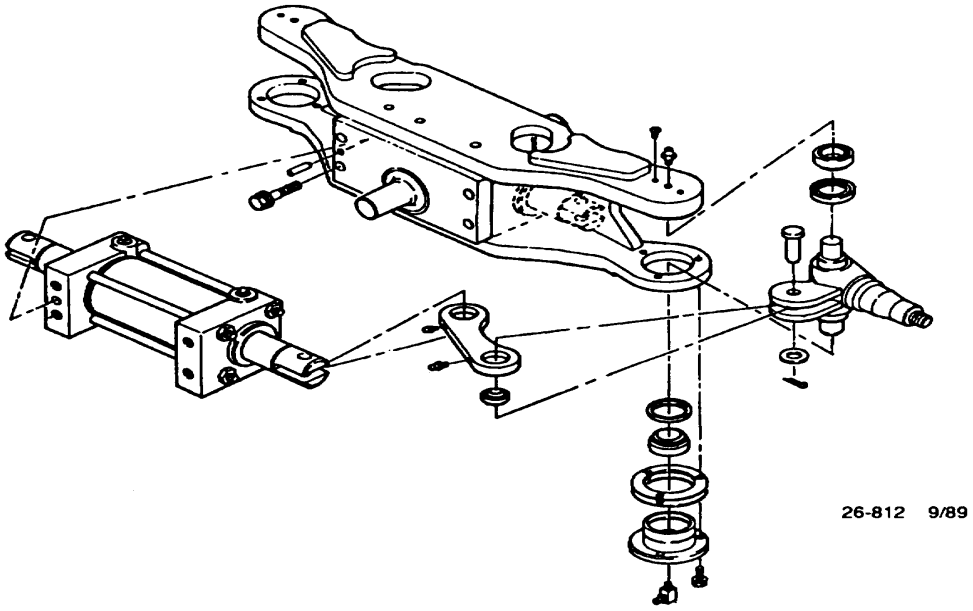
Steer Axle - (Type 2)
GPX Model
Refer top Section 9.7 for removal.
Refer to Section 9.12 and 9.13 for overhaul.

Steer Axle Mounting

26.100	Steer Axle Assembly
26.168	Bushing, Steer Axle Pivot
26.171	Silent Block, Steer Axle Mounting Front
26.175	Fastener, Steer Axle Silent Block
26.332	Shim, Steer Axle Silent Block
26.341	Spacer, Steer Axle Pivot Bushing
93.679	Nut, Steer Axle Silent Block Fastener



26-344 12/89



9.6. Steer Axle
Wheel Bearing Maintenance

Steer Wheel Bearing Check F-421
Steer Wheel Bearing Adjustment F-421
Steer Wheel Bearing Lubrication F-422

Steer Wheel Bearing Check

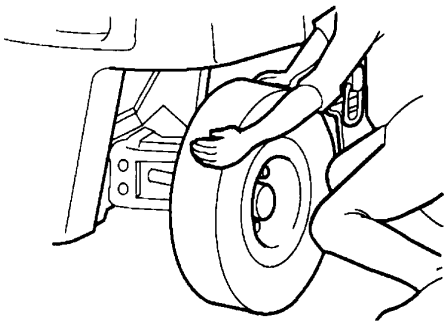
NOTE

To perform this service procedure, it is recommended that you first:

- Park truck on level surface and fully lower upright.
- Return controls to neutral, apply parking brake and turn key switch OFF.
- Lift and block truck up to raise steer wheels off the floor.

Refer to Section 3. 3, Machine Jacking & Blocking.

1. Be sure that truck is parked and blocked up correctly and safely to raise steer wheels off the floor.



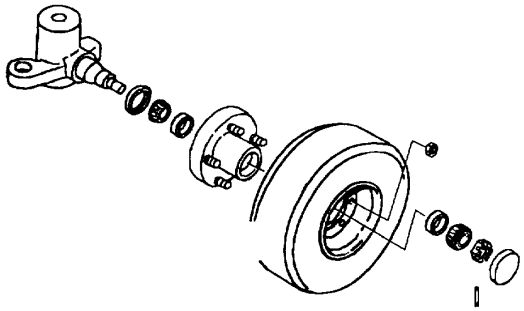
2. To check the steer wheel bearings for excessive free play or looseness, grasp the wheel with both hands and try to move it by a rocking motion, side to side or top to bottom. Also, try to pull it in and out along the wheel spindle. Watch for excessive free play in wheel bearings or steering knuckle bearings. There should be a small amount of free movement. The maximum allowable end play is .003 inch (0.08 mm). If the wheel has excessive end play, the bearings require additional service and/or adjustment.

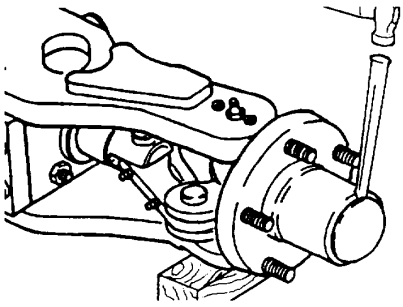
NOTE

Generally, wheel bearings need adjustment only after many hours of operation. It is recommended that you clean and repack the bearings before adjustment. Check hour meter total hours and refer to Section 3.1, Recommended PM and Lubrication Schedule. See steer wheel bearing lubrication procedure below.

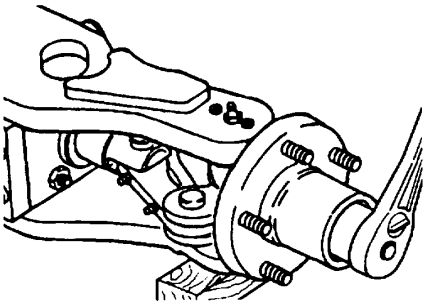
Steer Wheel Bearing Adjustment

The steer wheel bearings are retained and adjusted by the wheel spindle nut.





1. Remove hubcap by first loosening by tapping gently on the outer edge of hubcap in space at end of hub with a hammer and chisel. You may have to further loosen and finish removing the hubcap using a pry bar.
2. Remove cotter pin.



3. Loosen spindle (bearing adjusting) nut. (If nut completely removed, see below).

4. After spindle nut is loosened, hit the top of wheel (tire) to loosen (unseat) the bearings. This moves the bearings free of their seated, running position.

5. Tighten spindle (bearing adjusting) nut until there is a slight binding or drag in the bearings as wheel is rotated by hand in both directions. Then, back nut off to nearest slot in nut and lock with cotter pin. Bend tabs on cotter pin.
6. Check again for correct bearing adjustment by rotating the wheel by hand. Wheel should rotate freely or with only slight "drag." Readjust bearings by adjusting spindle nut, as necessary, to avoid binding in bearings.
7. Pack the area around spindle nut with grease.
8. Install hubcap by tapping into place with a rubber or plastic-faced hammer.

Steer Wheel Bearing Lubrication
(Clean, Repack & Adjust Bearings)

Refer also to wheel bearing adjustment procedures noted previously.

WARNING

Be sure truck is parked and blocked up correctly and safely to prevent injury to personnel or damage to equipment.

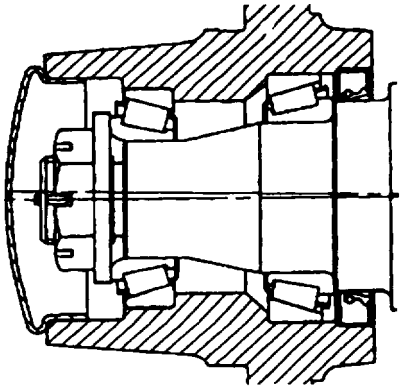
1. Raise steer wheels off the floor.

Refer to Section 3.3, Machine Jacking & Blocking.

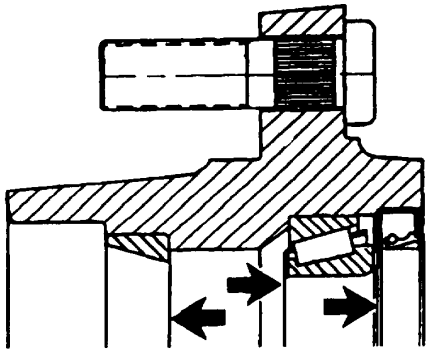
NOTE

Because of the heavy weight of the wheel and tire, it is suggested to first remove the wheel and tire assembly from hub when servicing the bearings to avoid damage to the grease seal when the wheel hub is moved off or on the spindle. It also makes the work simpler and easier.

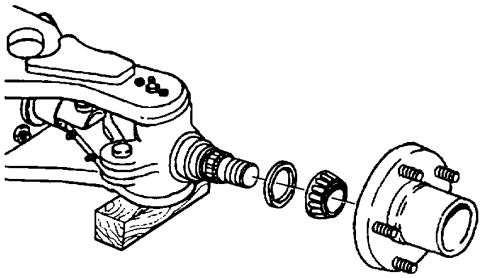
2. Loosen wheel bolts or lug nuts before completely raising rear wheels off the floor.
3. Lower truck onto blocking. Remove wheel bolts or lug nuts, and then wheel assembly from the hub.



4. Loosen and remove the hubcap from wheel hub. You may have to lightly tap hub cap with a hammer and chisel and use a pry bar to loosen. Be careful not to damage mounting surfaces.
5. Clean the excess grease from around the spindle nut.
6. Remove cotter pin, loosen and remove spindle nut and bearing washer.
7. Pull out on the wheel hub slightly to loosen bearings, then remove outer bearing.
8. Pull the wheel hub off the spindle. Support the wheel hub to avoid dragging the grease seal at the back side across the thread on spindle end.
9. Clean the old grease out of center of wheel hub.



10. To remove inner bearing and seal, lay wheel (or hub) down with outer edge up (support hub on blocking). Remove the inner bearing cone and grease seal, using a brass drift pin, rod or piece of pipe to drive the bearing and seal out of the hub.

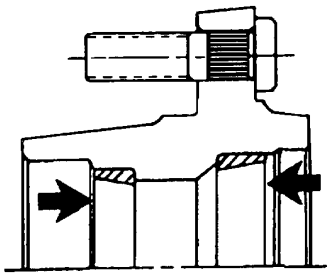


11. Clean and inspect the bearing cups and cones for wear or other damage. Replace, as necessary.

CAUTION

Keep serviceable bearing cups and cones matched together. Always replace bearing cups and cones as a set or damage to bearing may result.

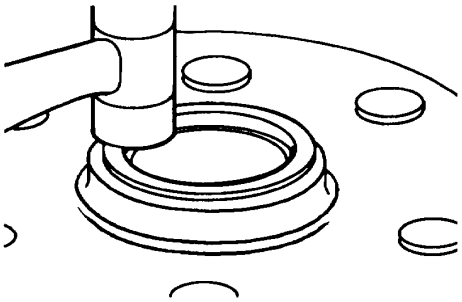
12. Inspect grease seal for wear and damage. Replace as necessary. It is recommended to install a new grease seal whenever old one is removed.
13. If bearings require replacement, use a standard puller to remove bearing cups from wheel hub.



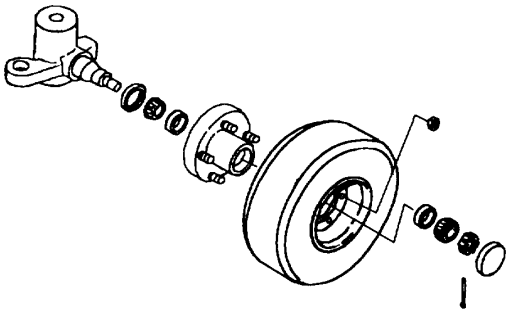
14. Install new bearing cups by pressing into wheel hub. Be sure cups are fully seated in bore.

15. Perform recommended Greasing Procedure:
    a) Use Grade No. 1 Lithium soap base multi-purpose grease, Clark MS-9B or equivalent.
    b) Pack bearings with grease before assembly.
    c) Pack cavity in hub between bearings one-half full with grease at assembly.
    d) Apply coating of Grade No. 2 EP Lithium soap base multi-purpose grease, Clark MS-107C or equivalent, to inside diameter of oil seals prior to assembly.

16. Pack the bearings with grease and install the inner bearing in the hub.



17. Install new grease seal in wheel hub inner bore. Apply coating of Grade No. 2 EP Lithium soap base grease, Clark MS-1 07C or equivalent, to inside diameter of seal lips prior to assembly, then install seal in hub bore. Carefully press or tap grease seal into place with a soft-faced mallet until seal is seated in bottom of hub bore.
18. Install wheel hub on spindle. Be careful not to damage seal lip when moving the hub over the end of spindle and threads.
19. Install the outer wheel bearing after it has been packed with grease.



20. Install bearing washer and nut and tighten spindle (bearing adjusting) nut until there is a slight binding or drag in the bearings as wheel is rotated by hand in both directions. Then, back nut off to nearest slot in nut and lock with cotter pin. Bend tabs on cotter pin.
21. Recheck for correct bearing adjustment by rotating the wheel by hand. Wheel should rotate freely or with only slight "drag." Readjust bearings by adjusting spindle nut as necessary to avoid binding in bearings.
22. Pack the area around spindle nut with grease.
23. Install hubcap by tapping into place with a rubber or plastic-faced hammer.
24. Install wheel and tire assembly, as applicable.

9.7. Steer Axle Removal/Installation

Steer Axle Removal F-425
Steer Axle Mounting Parts F-426
Steer Axle Installation F-428

Steer Axle Removal

NOTE

To perform this service procedure, it is recommended that you first:

- **Park truck on level surface and fully lower upright.**
- **Return controls to neutral, apply parking brake, and turn key switch OFF.**
- **Block the drive wheels.**
- **Lift and block truck up to raise steer wheels off the floor.**

WARNING

Do not remove the counterweight unless you have training and are familiar with the correct procedures. Counterweights can fall if not handled correctly and cause severe injury or death.

1. It is recommended that the counterweight be removed before starting removal of the steer axle. Refer to Section 12. 1, Counterweight Maintenance, Removal, & Installation.

2. Before completing the raising and lowering of truck onto blocks, if axle is to be disassembled this is a convenient time to remove pneumatic tires and wheels to facilitate clearance for moving axle from under the truck.

3. Loosen wheel bolts or lug nuts before completely raising steer wheels off the floor. After lowering truck onto blocking, remove wheel nuts, and then wheel assembly from the hub.

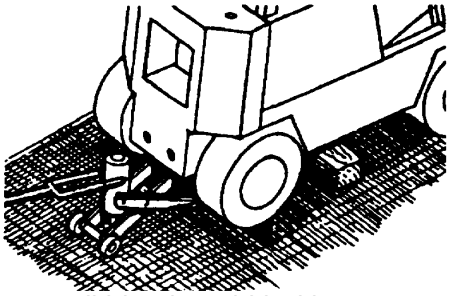
WARNING

Do not raise truck by hoisting on overhead guard or by jacking or lifting on counterweight.

4. Use an approved chain hoist or equivalent lifting method to raise rear of truck frame approximately 12 in. [300 mm] off the floor, or high enough for steer tires to clear floor.

Refer to Section 3.3, Machine Jacking and Blocking.

5. Truck may also be raised with floor jack placed under center section of steer axle only.



6. Put solid hardwood blocking, e.g., 12"x12" solid timber, under the frame. Be sure the blocks will not interfere with the axle as it is being removed.

7. Lower the truck onto the blocks and remove the jack.

WARNING

Before performing any maintenance work, check the truck for stable condition on the blocking to prevent injury to personnel and damage to equipment.

Steer Axle Mounting Parts

See Section 9.0 for Power Steering Lines.
Refer to Section 9.5 for (Type 2) steer axle mounting.

NOTE

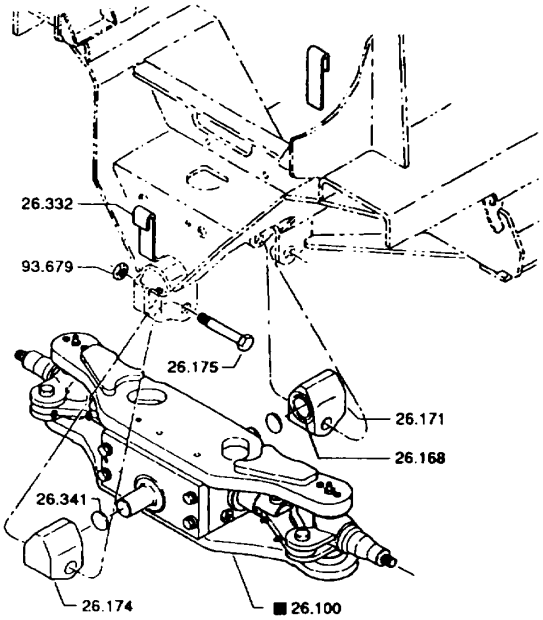
Refer to the appropriate Customer Service Parts Book for the correct service replacement parts to be used during reassembly and installation of steer axle.

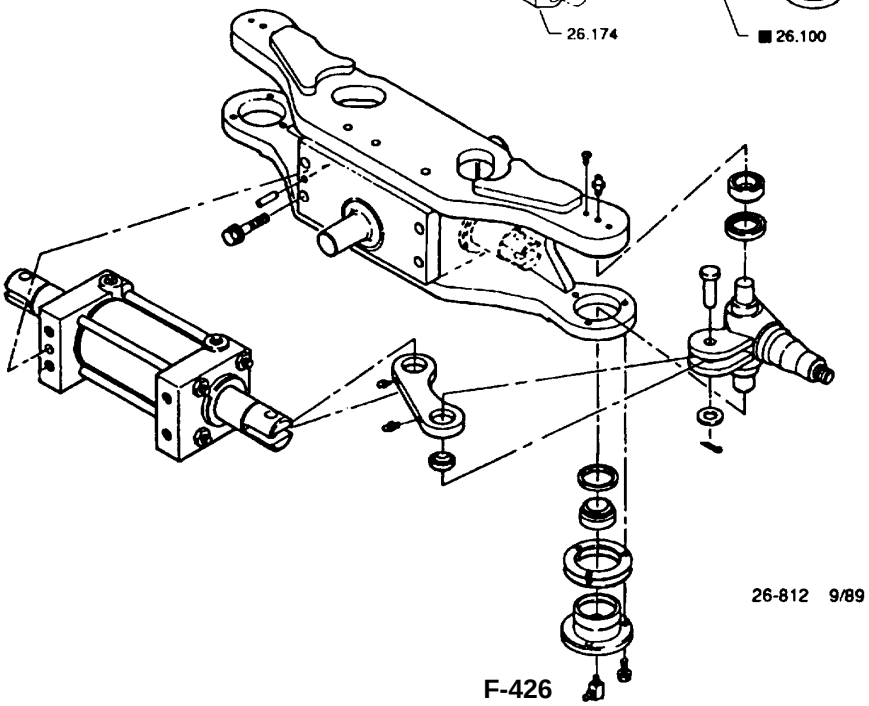
Shim Installation Procedure

1. Install shims between ends of silent blocks and frame socket, as needed to eliminate free play.
2. Before assembly of axle in frame, install front shim. Remove is axle cannot be installed. Add rear shim if remaining axle free play clearance permits.
3. Pean the bottom edge or corners of the shims to bend them over the frame to lock the shims in place.

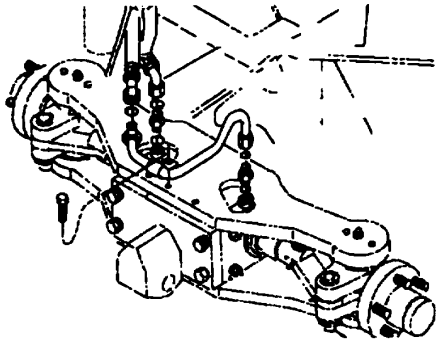
Steer Axle Mounting

26.100 Steer Axle Assembly
26.168 Bushing, Steer Axle Pivot
26.171 Silent Block, Steer Axle Mounting Front
26.174 Silent Block, Steer Axle Mounting Rear
26.175 Fastener, Steer Axle Silent Block
26.332 Shim, Steer Axle Silent Block
26.341 Spacer, Steer Axle Pivot Bushing
93.679 Nut, Steer Axle Silent Block Fastener



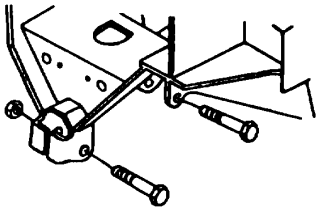


F-426



Refer to Section 9.0 Power Steering Lines.

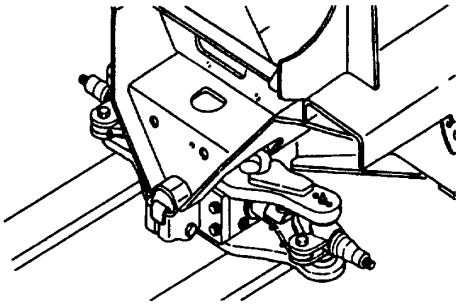
8. Loosen and remove hydraulic steering lines from steering cylinder. Plug fittings and cap open ends of lines to prevent entrance of dirt.



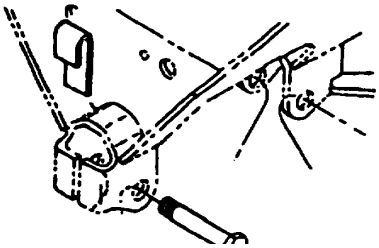
9. Loosen and remove nuts from silent block mounting bolts, front and rear.

NOTE

Axle must be supported before any other attaching fasteners are removed. See Step 11.



10. If another lift truck is used to temporarily support axle while removing, put forks in center of carriage about 12 inches apart. Move forks under axle and raise it just to remove its weight from mounting bolts. Or use a portable floor jack to carefully support the axle at its center section.



11. Then, remove the two silent block mounting bolts. Note - Shims, if installed, may be removed.

12. Lower the axle allowing its weight to pull the silent blocks out of frame trunnions (recesses). Watch the silent blocks to be sure they release freely from frame. You may have to loosen blocks with a pry bar if they bind.

13. Carefully withdraw the axle from beneath the truck and move to safe storage.

NOTE

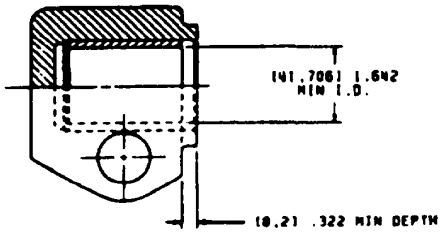
On *some* early models, removal of the silent blocks after a long period of usage may be difficult. Routine removal of the silent blocks from the steer axle trunnions (pivot pins) is not recommended unless they have obvious wear damage or failure. If removal by conventional pulling methods is not successful, they then must be removed by destruction of the silent block assembly using a cutting torch and/or hammer and chisel to separate them from the axle trunnions. Be sure that the axle trunnions are not damaged.

Steer Axle Installation

Installation is the reverse of removal. Also refer to removal procedures noted above.

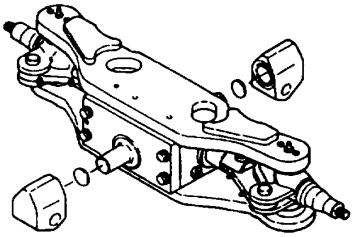
NOTE

Make sure truck is correctly raised and safely blocked using hardwood blocks under the frame. Be sure the blocking will permit installation of the axle without disturbing the blocking.

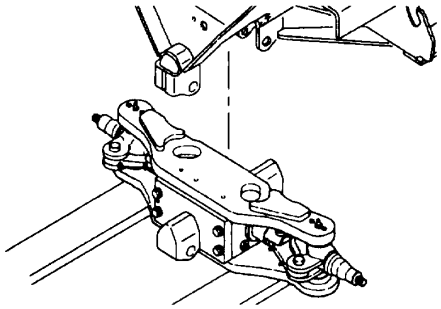


NOTE

Bushing must be pressed into silent block to .322 in. (0.2 mm) minimum depth from end of casting.



1. If silent blocks have been removed from axle, install new silent block assemblies and thrust washers (or spacers, as applicable, depending on steer axle model). See Section 9.5.
2. Make sure that the silent blocks are positioned correctly front and rear on the steer axle trunnions at the start of installation. Align the silent blocks square with the axle.

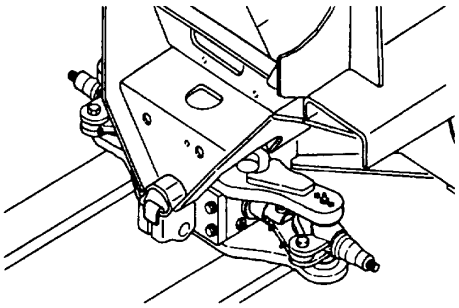


3. Use a fork lift truck or mobile floor jack to temporarily support and raise the axle into place under the truck. If another lift truck is used to handle axle, center the forks with about 12 inches spread between them. Place steer axle assembly in secure position on fork tips.

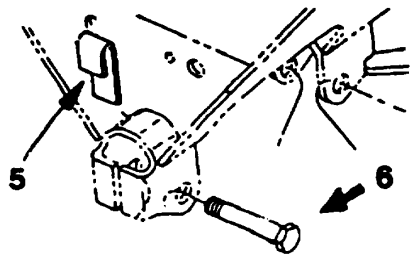
If hydraulic jack is used, be sure axle is securely supported on jack pad.

WARNING

Heavy components can fall and cause severe injury. Keep your body clear at all times.



4. Install axle assembly into frame by slowly raising it up while guiding silent block bushings into frame sockets.

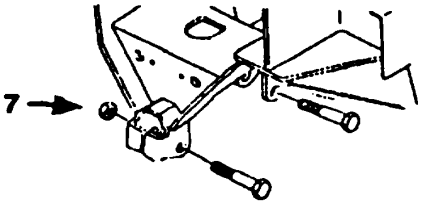


5. Install shims between ends of silent blocks and frame socket, as applicable.

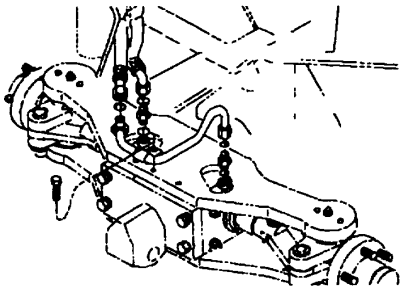
NOTE

- **Before assembly of axle in frame, install front shim. Remove if axle cannot be installed. Add rear shim if remaining axle free play clearance permits.**
- **Pean the bottom edge or corners of the shims to bend them over the frame to lock the shims in place.**

6. Install silent block mounting bolts through frame socket holes and silent block. front and rear.

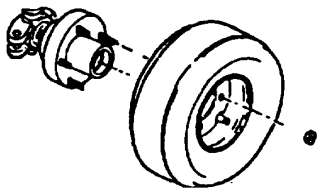


7. Install nuts on silent block fasteners and tighten to torque spec: 420-480 lb-ft. (570-650 N•m).
8. Remove temporary axle support from under truck.



Refer to Section 9.0, Power Steering Lines.

9. Connect the hydraulic lines to steering cylinder. Tighten fittings to torque spec: 70-80 lb-in. (8-9 N•m).

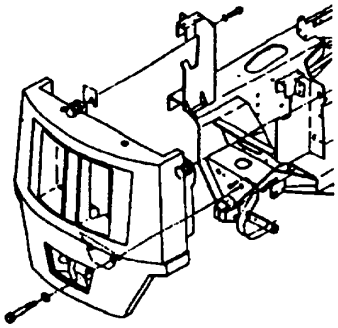


10. As applicable, install pneumatic wheel and tire assemblies.

Steer Wheel

Mounting Bolt Torque: 359-458 N-m 265-338 lb-ft.

11. Carefully raise the truck of' the blocking using an adequate overhead chain hoist or equivalent safe method. Remove the blocking and lower the truck to the floor.



12. Install counterweight, if removed.

Refer to Section 12. 1, Counterweight Maintenance, Removal and Installation.

Check Operation

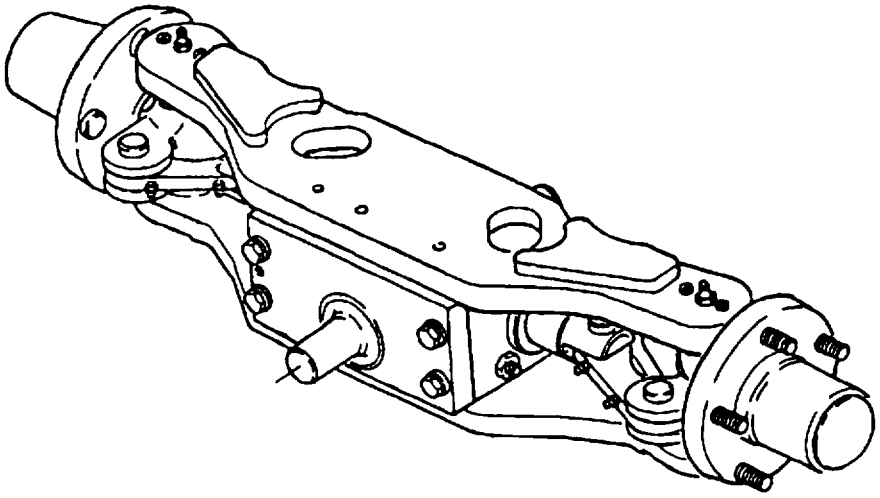
13. Check the axle and steering system for proper operation. Start the engine and operate the steering gear to move the steer wheels to maximum travel in both directions. Note any unusual motion or noise.

If the system appears to be operating correctly, drive the truck slowly. Fully steer the vehicle in each direction and check response.

14. Check steering cylinder hose line connections and cylinder rod seals for any evidence of oil leakage.

9.12. Steer Axle Overhaul
(Type 2)

Steer Axle Type 2 ..... F-431
Preparation for Disassembly F-431
Steer Axle - (Type 2) Parts Nomenclature F-432
Disassembly F-433
Parts Inspection F-436
Assembly F-437



Steer Axle Type 2
Refer to Section 9.7, Steer Axle Removal/Installation, for removal of steer axle assembly from truck.

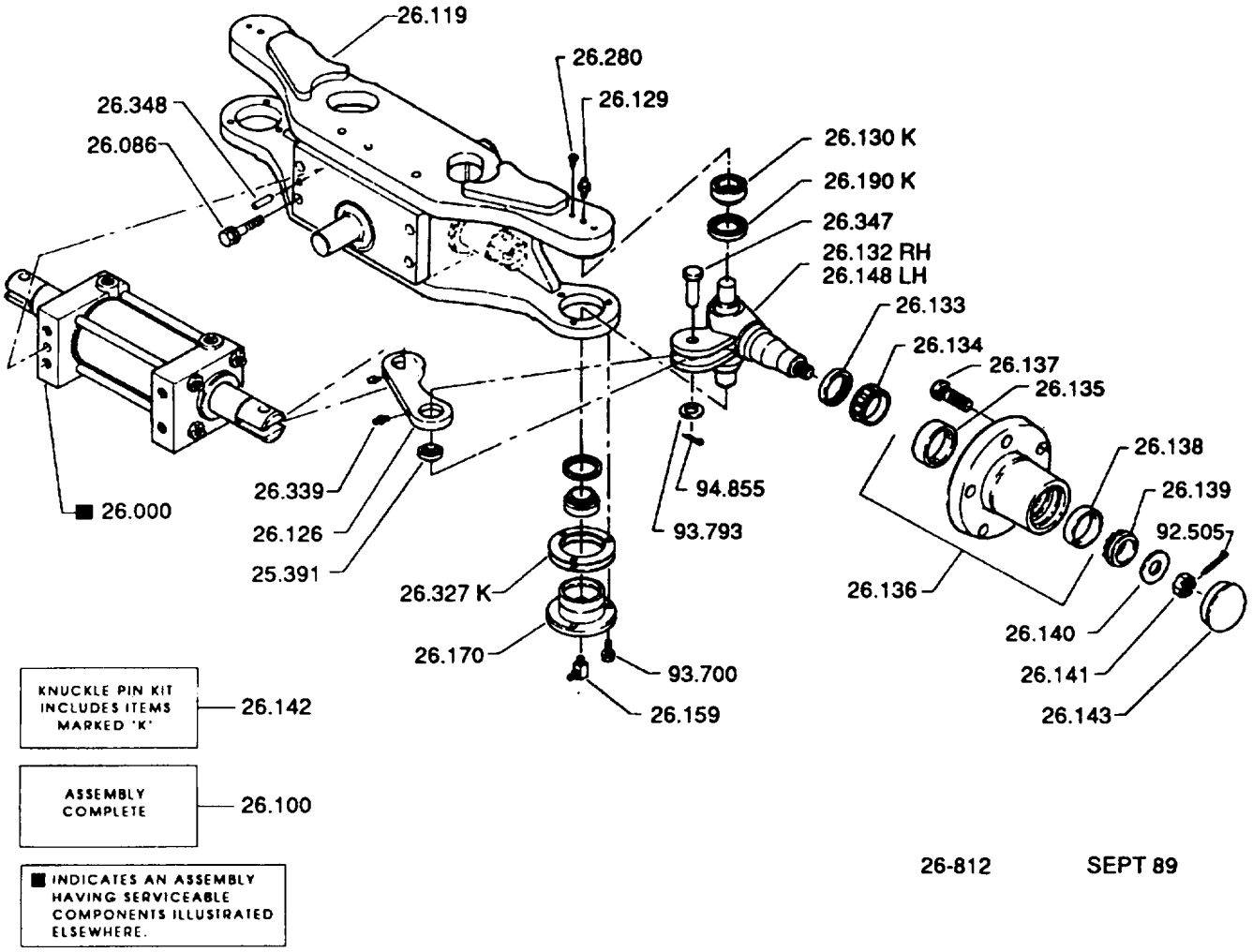
This steer axle has a one-piece fabricated main body assembly using steel box-type construction. The steering cylinder is an integral separate 2-way actuator mounted within the main body and joined to steering knuckles by links. All bearings are replaceable and have lubrication fittings.

Preparation for Disassembly

NOTE
Cleanliness is of extreme importance in the repair and overhaul of this assembly.

1. **Before starting disassembly**, thoroughly clean the axle assembly of all accumulations of dirt, oil, corrosion and other substances to prevent contamination of the parts during disassembly and over-haul.
2. **Work in a clean area.**
3. **Keep all parts in order** as disassembly progresses. Take care to properly identify each part and its order of removal. If necessary, keep notes and put markings on parts using a non-destructive marker such as a felt-tipped pen.

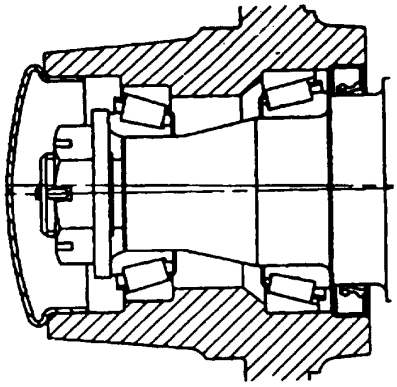
Steer Axle - *(Type 2)* Parts Nomenclature



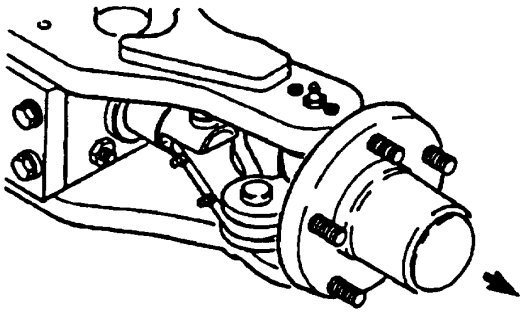
26.100	Axle Assembly, Steer	26.141	Nut, Steer Axle Hub Bearing
25.391	Bearing, Steer Arm	26.142	Pin Kit, Steer Axle Knuckle
26.000	Cylinder Assembly, Steering	26.143	Cap, Steer Axle Hub
26.086	Fastener, Steer Cylinder Mounting	26.148	Knuckle, Steer Axle (LH)
26.119	Axle, Steer	26.159	Lub Fitting, Steer Axle Knuckle Lower
26.126	Arm, Steer Axle Tie Rod	26.170	Cover, Steer Axle Knuckle Pin
26.129	Lub Fitting, Steer Axle Knuckle	26.190	Seal, Steer Axle Knuckle Pin
26.130	Bearing, Steer Axle Knuckle Pin	26.280	Plug, Steer Axle Knuckle Pin
26.132	Knuckle, Steer Axle (RH)	26.327	Shim Set, Steer Axle Knuckle Pin Bearing
26.133	Seal, Steer Axle Hub	26.339	Lub Fitting, Steer Arm
26.134	Cone, Steer Axle Hub Inner Bearing	26.347	Pin, Steer Arm
26.135	Cup, Steer Axle Hub Inner Bearing	26.348	Locator, Steer Cylinder
26.136	Hub, Steer Axle	92.505	Cotter Pin, Steer Axle Hub Fastener
26.137	Fastener, Steer Wheel	93.700	Capscrew, Steer Axle Knuckle Pin Cover
26.138	Cup, Steer Axle Hub Outer Bearing	93.793	Washer, Steer Arm Pin
26.139	Cone, Steer Axle Hub Outer Bearing	94.855	Retainer, Steer Arm Pin
26.140	Washer, Steer Axle Hub Bearing		

Disassembly

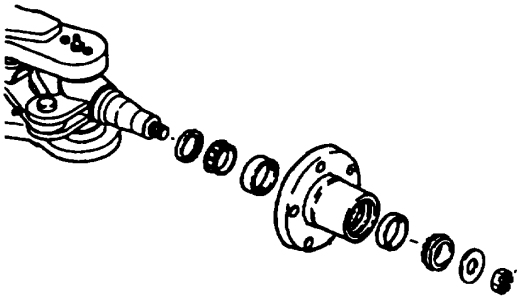
Wheel Hub Disassembly



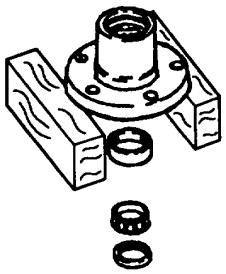
1. Remove wheel lug nuts and then wheel assembly from the hub.



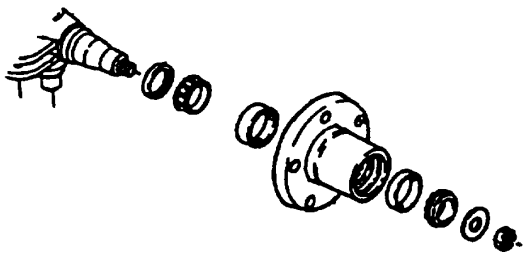
2. Loosen and remove hubcap from wheel hub. You may have to first loosen it by lightly tapping on outer edge in space at end of hub with a hammer and chisel and then use a pry bar to finish removing. Be careful not to damage mounting surfaces.
3. Clean the excess grease from around spindle nut.



4. Remove cotter pin. Loosen and remove spindle nut and bearing washer.
5. Pull out on the wheel hub slightly to loosen bearings then remove outer bearing.
6. Remove wheel hub from spindle. Support the wheel hub to avoid dragging the grease seal at the back side across the thread on spindle end.



7. Remove inner bearing and grease seal from hub. To remove the inner bearing and seal, lay wheel (or hub) down with outer edge up (support hub on blocking or center of pneumatic wheel). Remove the inner bearing cone and grease seal using a brass drift pin, rod or piece of pipe of the same diameter as bearing to drive the bearing and seal out of the hub.
8. Clean old grease out of center of wheel hub.

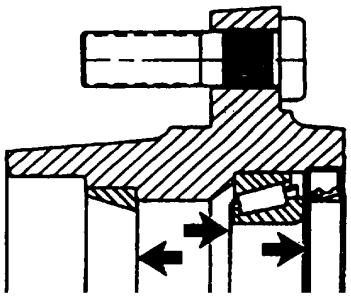


9. Clean all parts in approved cleaning solvent. Inspect the bearings and bearing cups for scratches, cracks, glazing, rust pitting, flat spots and other wear. Replace damaged parts.

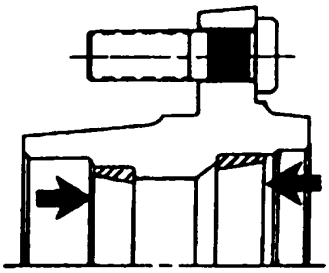
NOTE

Keep serviceable bearing cups and cones matched together.

Always replace bearing cups and cones as a set.



10. If bearings require replacement, use a standard puller to remove bearing cups from wheel hub.
11. Discard grease seal. Replace with new at assembly.



12. Install new bearing cups by pressing into wheel hub. Take care to apply an even force to the bearing cup to prevent cracking during installation. Be sure that each bearing cup is fully seated (bottomed out) against shoulder in hub bore.

Power Steering Cylinder and Tie Rod Arms Removal

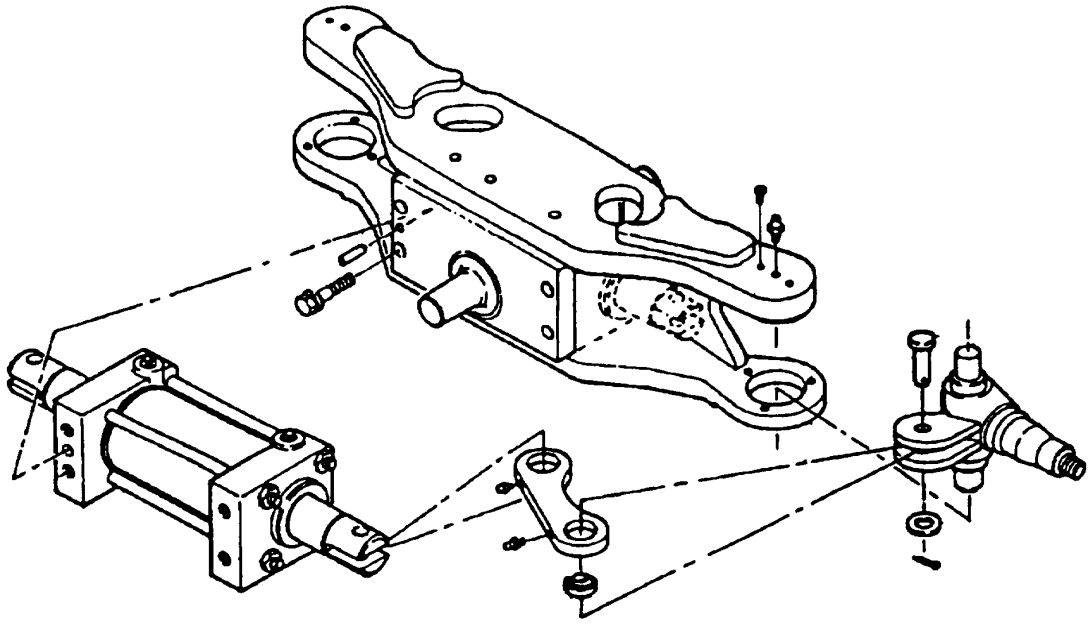


Figure 2.

1. Remove cotter pin and washer from steer arm pin at each steering knuckle. Remove the pin and disassemble tie rod arm (steer link) from each steering knuckle.

NOTE
Pins from cylinder-rod end of tie rod arms can be removed after removal of cylinder from axle, Step 5 below.

2. Loosen and remove the four steering cylinder mounting fastener bolts. Inspect the tie rod arm bearings for wear and damage.

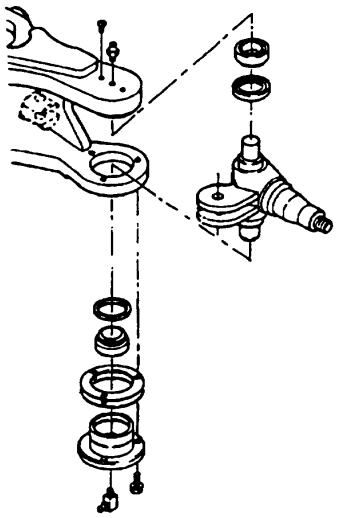
3. Remove steering cylinder from steer axle body.
4. Check steering cylinder locator pin which should remain pressed in axle body.
5. Disassemble the tie rod arms from each end of steering cylinder rod.

Steering Cylinder Disassembly
Refer to Section 9.13, Steering Cylinder Overhaul (Type 2).

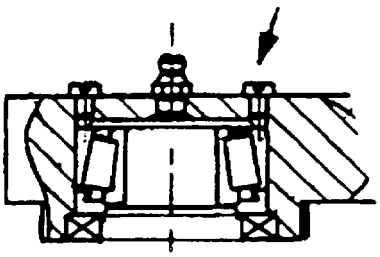
Tie Rod Arm Bearings

Inspect the tie rod arm bearings for wear and damage. If these bearings require replacement, remove them by use of an arbor press or by carefully driving them out using a metal tool such as a section of pipe or tubing of the correct size. Install new bearings by pressing into place.

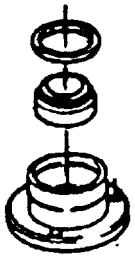
Steering Knuckle & Knuckle Pin Bearing
Disassembly



1. Loosen and remove the 3 capscrews from the knuckle pin cover (bearing cup retainer) on bottom of axle.
2. Remove the knuckle pin cover, bearing cup and cone, grease seal assembly and bearing preload shim set from bottom end of knuckle and pilot bore in axle body.
3. Remove bearing preload shim set from flange of knuckle pin cover.
4. Remove the knuckle by pulling it out of the upper bearing. Use a soft-faced hammer to tap on the knuckle arm if it tends to stick in the bearing.



5. Remove the upper knuckle pin bearing and knuckle pin seal by driving the bearing cup out of the bore in axle body. Remove the 2 screw plugs in top of axle body at the knuckle bearing bore. Use a thin rod or drift pin to drive the bearing cup, cone and seal out of the housing bore. The seal only can be removed by prying from the axle body.



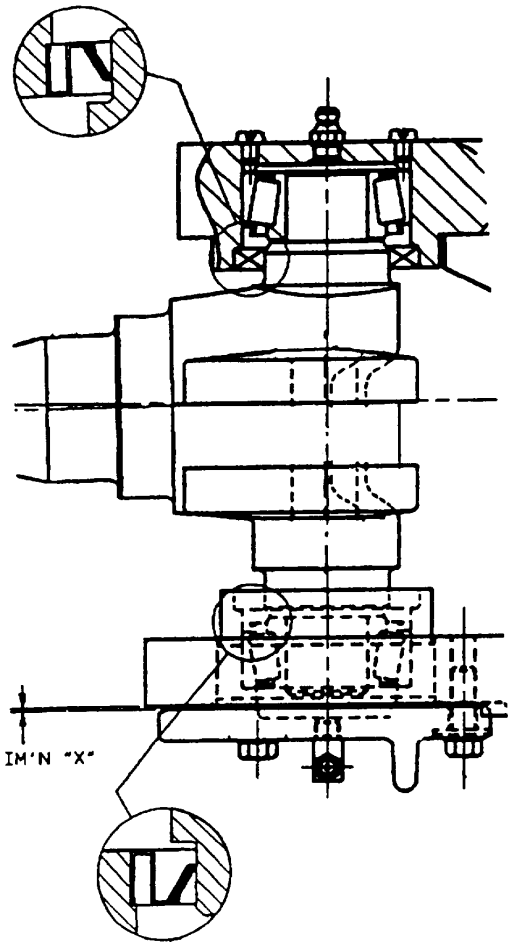
6. Disassemble the knuckle pin cover by pulling the bearing cup, bearing cone and oil seal from the inner bores of the cover. Use a gear puller with internal fingers to remove the bearing cup.

7. Repeat for disassembly of knuckle at opposite end of axle.

Parts Inspection

1 **Clean** all bearings, cups, seals, pins, etc., in an approved cleaning solvent.
2. Check the steering arms to be sure they are not bent or twisted. Check all threaded parts for damage.
3. **Inspect** the axle body to be sure the welds are sound. Look for damaged areas and make sure the frame has not been warped or bent.
4. **Replace** all parts which show damage.
5. If parts are to be left exposed before reassembly, coat all mating surfaces of parts with a light layer of engine oil.

Assembly
Steering Knuckle & Knuckle Pin Bearings
Reassembly



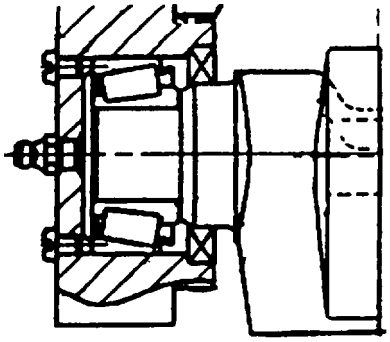
Recommended Greasing Procedure:

1) Use Grade No. 1 EP Lithium soap base multipurpose grease, Clark MS-9B or equivalent.

2) All tapered roller bearings to be packed with grease before assembly.

3) Tie rod bearings to be filled using a grease gun after axle is reassembled.

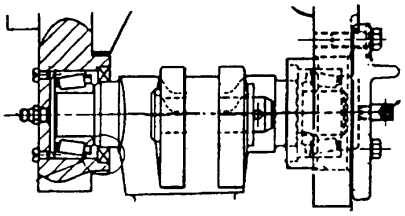
4) Apply coating of Grade No. 2EP Lithium soap base multi-purpose grease, Clark MS-107C or equivalent, to inside diameter of oil seals prior to assembly.



1. Turn axle body upside down or on its side so that knuckle centerline is horizontal to simplify installation of bearings, seal and steering knuckle.
2. Correctly apply grease to (pack) upper knuckle pin bearing and lubricate knuckle pin seal. See above for recommended greasing procedure.
3. Install (press) the upper knuckle bearing cup fully into steering knuckle upper trunnion bore in axle body.
4. Assemble upper bearing cone into bearing cup.
5. Install (press) new knuckle pin seal into and against shoulder in seal recess in axle body. Seal should be flush with outer surface of axle body. Upper seal lip should be pointing down or towards knuckle.
6. Be sure to reinstall the 2 bearing-removal screw plugs in top of axle body.
7. Apply grease to (pack) lower knuckle bearing and lubricate oil seal. See above for recommended greasing procedure.
8. Install (press) lower knuckle bearing cup fully into bore in knuckle pin cover (bearing cup retainer).
9. Assemble lower bearing cone into bearing cup.
10. Install (press) new knuckle pin seal into and against shoulder in seal recess in knuckle pin cover. Seal should be flush with open end of cover. Lower seal lip should be pointing up or towards knuckle.
11. Carefully install knuckle through seal and into upper bearing in steer axle body.

NOTE

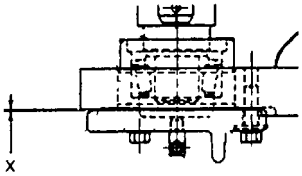
Check to be sure RH and LH parts are installed in correct location.



12. (Omit installation of shim pack.) Assemble the knuckle pin cover, bearing and seal assembly through lower bore in axle body and onto lower knuckle pin.
13. Prior to installation of knuckle pin cover (bearing cup retainer) capscrews, apply 80-100 lb-ft (109136 N-m) load against knuckle pin cover while rotating steer knuckles back and forth 3 or 4 times thru approximately 900 to seat the knuckle pin bearings.

NOTE

Knuckle pin cover capscrews may be installed and partially tightened to seat the knuckle pin bearings.

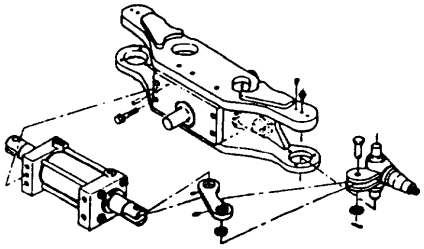


14. With a thickness gauge, measure the clearance (dimension X) between the axle body and the knuckle pin cover.
15. Select appropriate shims from shim pack that will add up to a total shim thickness of .005-.009 in. (0.127-0.229 mm) ***less*** than dimension X.
16. Remove knuckle pin cover. Install correct shim pack as determined above. Reinstall knuckle pin cover.
17. Tighten knuckle pin cover capscrews to torque spec: 15-18 lb-ft (20-25 N•m).
18. Check the installation of the knuckle to be sure that it is free to rotate in the bearings without binding.
19. Repeat above procedures for opposite end of axle.

Steering Cylinder Reassembly

Refer to Section 9.13, Steering Cylinder Overhaul (Type 2).

Steering Cylinder and Tie Rod Arm Installation



1. Assemble tie rod arm (link) into each end of the steering cylinder piston rod. Install pin and washer. Install new cotter pins and bend tabs to lock.
2. Assemble the steering cylinder into axle frame. Be sure the locator pin is installed in correct position.

NOTE

If new locator dowel pin is to be installed, press pin 0.087 in. (0.0-2.2 mm) below outer surface of axle body.

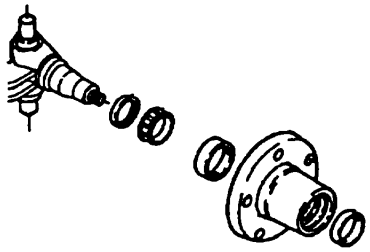
3. Install the four steering cylinder mounting bolts.
4. Tighten steer cylinder mounting bolts to torque spec: 125-140 lb-ft (170-190 N•m).
5. Install tie rod arms into steering knuckles. Install pin and washer. Install new cotter pins and bend tabs to lock.
6. Check to be sure all lube fittings are installed. Fill all lubrication points with correct lubricant.

Refer to Recommended Greasing Procedure.

Wheel Hub Assembly

If you are unfamiliar with this procedure, please refer to Section 9.6, Steer Axle Wheel Bearing Maintenance for additional information.

Refer to Section 11, page 11.0-2, for cushion steer wheel bearing cup nomenclature.



1. If bearings are to be replaced and bearing cups were removed, install new bearing cups by pressing or driving into place in wheel hub.

Refer to Section 9.6, Steer Axle Wheel Bearing Maintenance.

NOTE

Keep serviceable bearing cups and cones matched together. Always replace bearing cups and cones as a set.

Recommended Greasing Procedure:

1) Use Grade No. 1 EP Lithium soap base multi-purpose grease, Clark MS-9B or equivalent.
2) All tapered roller bearings to be packed with grease before assembly.
3) Tie rod bearings to be filled using a grease gun after axle is reassembled.
4) Apply coating of Grade No. 2EP Lithium soap base multi-purpose grease, Clark MS-107C or equivalent, to inside diameter of oil seals prior to assembly.

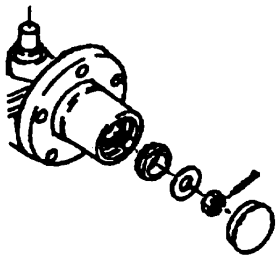
2. Pack the bearing with grease and install the inner bearing in the hub.
3. Apply lubricant to and install new grease seal in wheel hub bore.

See above for greasing procedure.

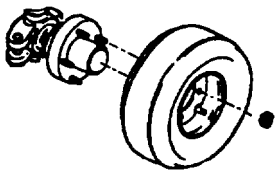
4. Install wheel hub on spindle.

NOTE

Be careful not to damage seal lip when moving the hub over the end of the spindle and threads. Support the wheel hub to avoid dragging the grease seal at the back side over the spindle.



5. First pack with grease and then install the outer wheel bearing.
6. Install bearing washer and nut and tighten spindle (bearing adjusting) nut until there is a slight binding or drag in the bearings as wheel or hub is rotated by hand in both directions. Then, back nut off to nearest slot in nut and lock with cotter pin. Bend tabs on cotter pin.
7. Recheck for correct bearing adjustment by rotating the wheel by hand. Wheel should rotate freely or with only slight "drag". Readjust bearings by adjusting spindle nut as necessary to avoid binding in bearings.
8. Pack the area around spindle nut with grease.
9. Install hubcap by tapping into place with rubber or plastic-faced hammer.



10. Install wheel and tire assembly on hub.
11 Install wheel mounting lug nuts. Tighten wheel mounting nuts to torque spec: 265-338 lb-ft (359458 N•m).

9.13. Steering Cylinder Overhaul (Type 2 Steer Axle)

Preparation For Disassembly F-441
Parts Nomenclature F-442
Disassembly F-443
Inspection F-443
Reassembly F-443
Bench Test F-443

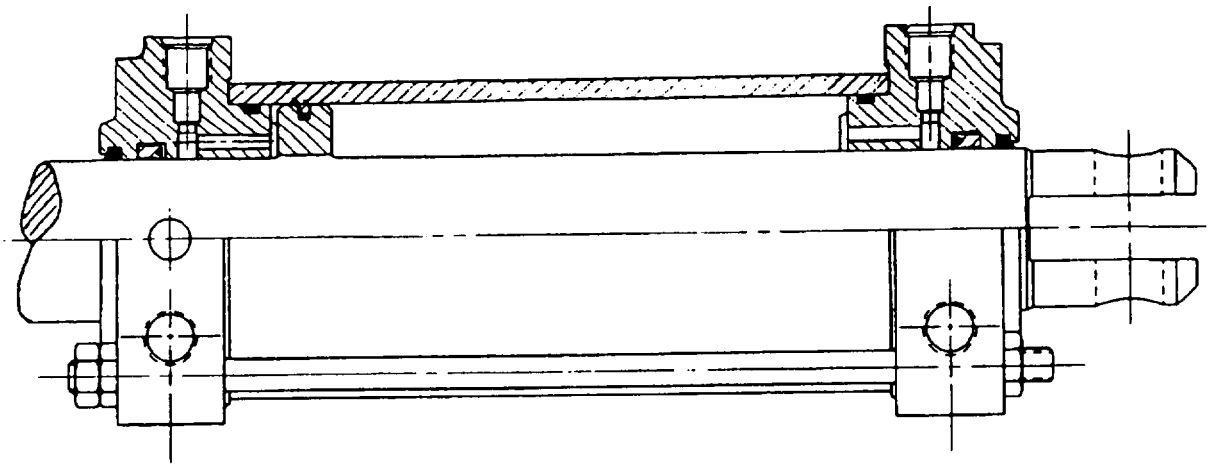


Figure 1. Steering Cylinder Cross-section (Type 2 Steer Axle)

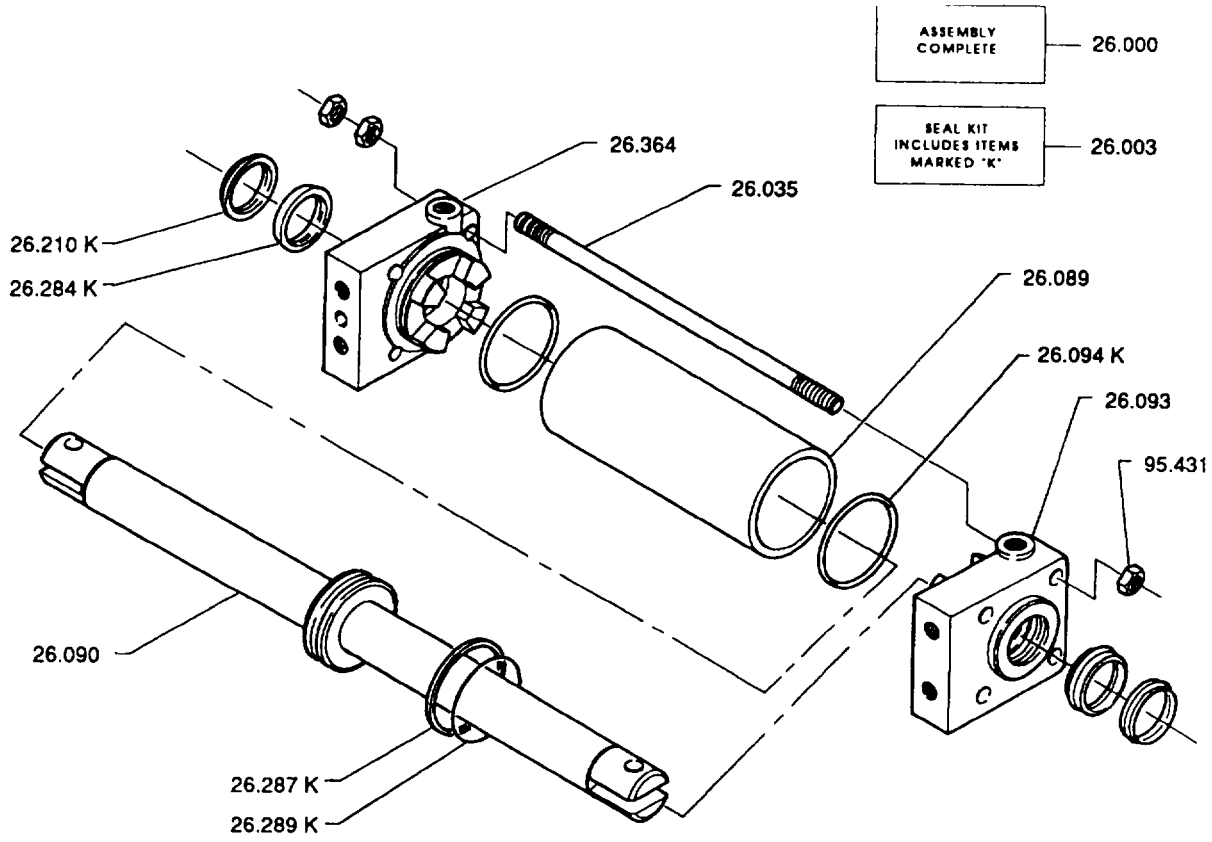
***(Type 2 Axle)* Steering Cylinder**

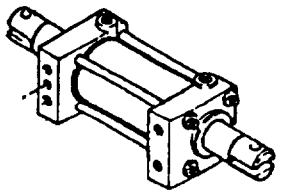
Refer to Section 9.5 for steer axle type specifications and steering cylinder description. Refer to Section 9.8 for removal of steering cylinder.

Preparation For Disassembly

1. Overhaul steering cylinder only in a clean, dustfree location, using clean tools and equipment. Dirt or grit will damage the highly-machined surfaces and will result in leakage or premature failure of components. Cleanliness of the hydraulic circuit is extremely important to the proper operation and maintenance of the system. **Be sure the work area is clean.**
2. Before disassembly, the exterior of the steering cylinder should be carefully cleaned to remove all dirt and grease accumulation.
3. Be sure all hydraulic oil has been removed from the cylinder. Stroking the piston rod will help force the oil out.
4. Before starting disassembly, the steering cylinder should be carefully examined to determine if there is any evidence of external damage.

Power Steering Cylinder - (Type 2 Steer Axle)
Parts Nomenclature





26.000	Cylinder Assembly, Steering
26.003	Seal Kit, Steering Cylinder Assembly
26.035	Fastener, Steering Cylinder Thru
26.089	Barrel, Steering Cylinder
26.090	Piston & Rod, Steering Cylinder
26.093	Gland, Steering Cylinder RH
26.094	Seal, Steering Cylinder Gland
26.210	Wiper, Steering Cylinder Rod
26.284	Packing, Steering Cylinder Gland
26.287	Seal, Steering Cylinder Piston
26.289	Expander, Steering Cylinder Piston Seal
26.364	Gland, Steering Cylinder LH
95.431	Nut, Steering Cylinder Thru Fastener

Disassembly

1. Take note that the cylinder has right-hand and left-hand glands. Mark the glands, cylinder barrel and cylinder rod for installation in the same position at reassembly.
2. Carefully clamp LH gland end in a vise to hold while disassembling.
3. Loosen and remove the thru-fastener nuts on the RH gland (single nut) end. Hold thru-fastener from turning with wrench on inner nut on LH end. Remove the thru-fastener threaded rods.
4. Remove RH gland from cylinder barrel. Use a soft-faced hammer to tap on the gland and separate it from the cylinder barrel. Pull the gland off the piston rod.
5. Remove the piston & rod assembly from the cylinder barrel.
6. Remove the cylinder barrel from LH gland.
7. Remove the piston seal and piston seal expander from piston. Replace with new parts at assembly.
8. Remove the gland seal, rod wiper and gland packing from gland and discard. Replace with new seals at assembly.

Inspection

1. Carefully clean all parts in an approved solvent and place on a clean surface.
2. Check the piston for chips, cracks and looseness. Check the piston rod for damage and bending. Look for scratches, grooves, gouges, pitting, corrosion or other evidence of unusual wear. Minor surface damage may be repaired by use of fine abrasion cloth or stoning. Deeper damage will require replacement of piston rod assembly.
3. Check piston rod ends and connecting pin holes for damage. Make sure the threads on thru-fasteners are undamaged.
4. Carefully inspect the cylinder barrel internal bore for wear, scratches, corrosion or other damage. Check the outside for damage.
5. Inspect the cylinder ports and threads in the glands to be sure they are free of contamination and that the threads are not damaged.
6. Check the seal bores and groove of the glands to be sure they are undamaged. Check for corrosion and pitting.
7. Put a light coating of hydraulic fluid on all parts. If parts are to be left disassembled for a period of time, e.g. overnight, they should be covered with a clean cloth.

Reassembly

NOTE

- **Be sure inside of cylinder and all parts are clean and lubricated before starting reassembly.**
- **Assemble piston and glands into cylinder carefully to prevent damage to seal lips and 0rings. Seals may be lubricated with hydraulic oil to assist assembly. All parts should be reassembled in the same position as marked at disassembly.**

1. Install new piston seal expander and piston seal on piston.
2. Install new gland packing and rod wiper in gland end and new gland seal on each gland.

CAUTION

Be sure the gland packing and rod seal are installed in the correct direction or damage to equipment could result.

3. Carefully assemble piston and rod into cylinder barrel.
4. Assemble glands onto piston rod. Check for correct position of RH and LH parts.
5. Assemble glands into cylinder barrel. Again check for correct positioning of RH and LH parts and cylinder ports.
6. Assemble thru-fasteners into glands. Hold thru-fasteners from turning with wrench on outer nut on LH end. Install and tighten fastener nuts to torque spec: 30-33 lb-ft (40-45 N•m).

NOTE

Steer cylinder mounting surfaces on glands to be parallel within .012 in. (0.3 mm).

7. Check the correct positioning of parts and make sure the cylinder rod and piston move freely in the cylinder.

Bench Test

Connect pressure source in turn at each port. Extend piston rod at each side and test with internal pressure of 2000 psi. At this pressure no leakage must occur.

10.0. HYDRAULIC SYSTEM

Hydraulic System Schematic Diagram F-446

Main Hydraulic System - Description & Operation F-447

Lift and Tilt Lines F-448

10.1 Hydraulic Sump - Fluid and Filter Change F-449

10.2 Hydraulic System Relief Pressure Check & Adjustment F-455

10.3 Main Hydraulic Pump F-457

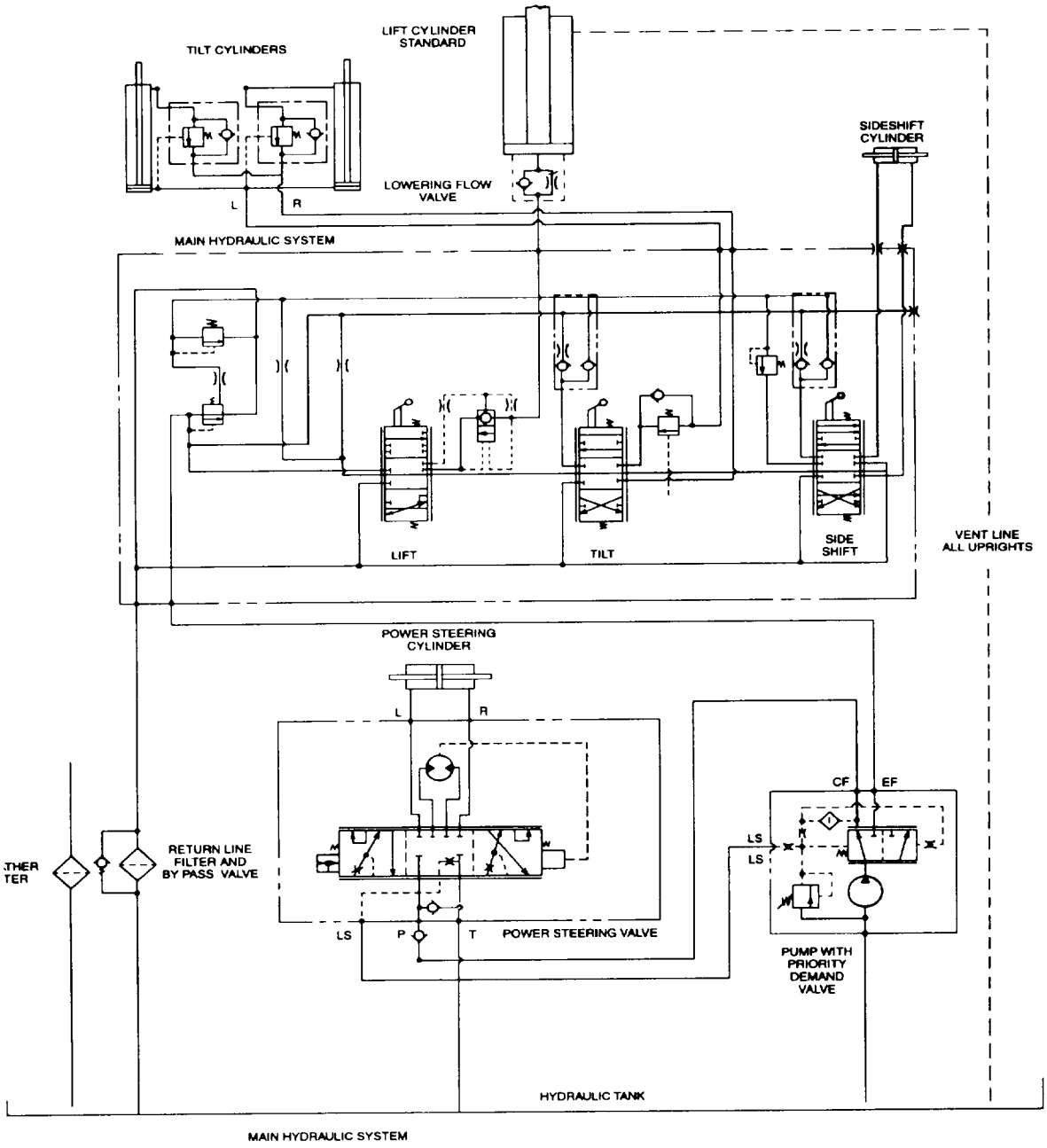
10.4 Deleted

10.5 Main Hydraulic Valve F-459

10.6 Main Hydraulic Valve Overhaul F-465

10.7 Tilt Cylinder Maintenance F-471

Hydraulic System Schematic Diagram

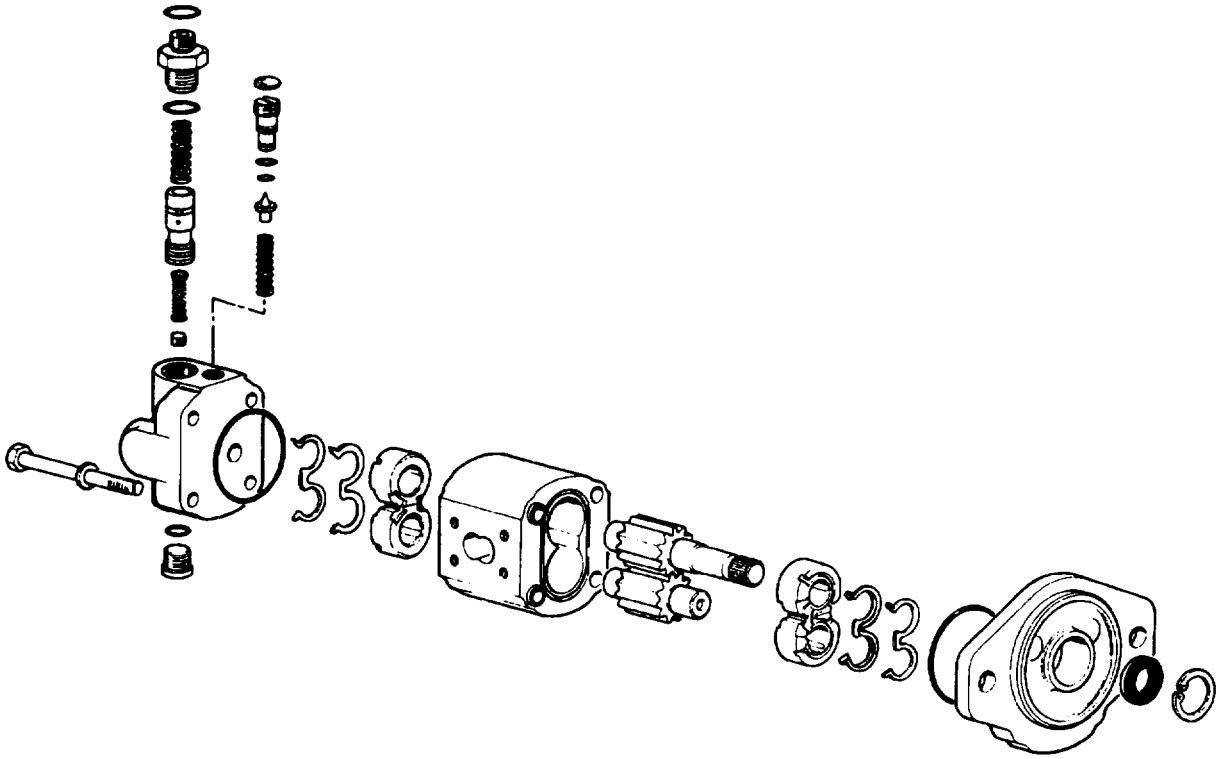


Main Hydraulic System

Description and Operation

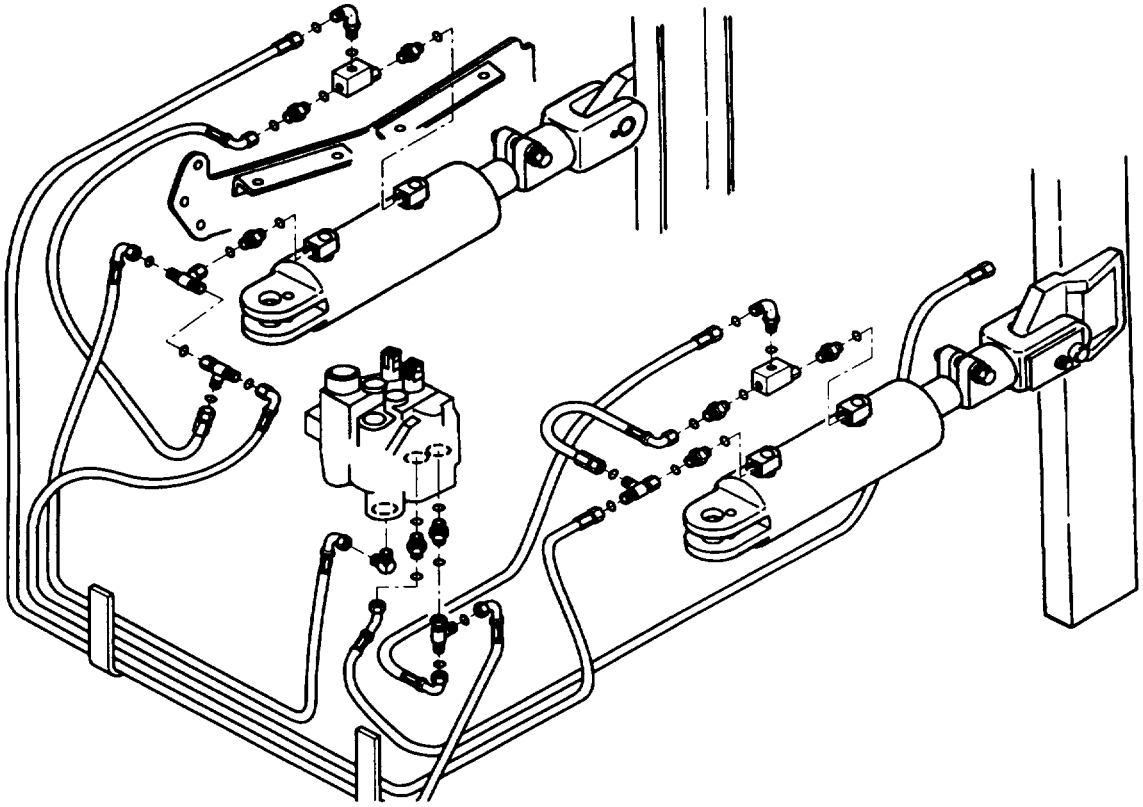
The main hydraulic system consists of the hydraulic sump tank, main hydraulic pump, hydraulic oil filter, main control valve, steering priority demand valve and associated hydraulic lines and hoses.

The hydraulic sump is a separate, removable tank installed in the right-hand side compartment of the truck frame. It has a large opening at the top with a removable cover which includes the fill filter return tube/ breather, oil level dipstick, and oil line. The cover is held on with a V-band clamp for positive sealing and ease of servicing. The sump breather is a standard Clark part. From the sump tank, oil is fed by the main gear-type pump through the steering priority demand valve to the main control valve. The priority demand (flow control) valve diverts the necessary flow to the steering system. From the main control valve oil is directed to either the lift cylinders or the tilt cylinders. Oil returns to the sump tank through the full-flow return line filter. The spin-on, throwaway hydraulic oil filter fits on a threaded adapter base mounted near the sump tank cover. The main hydraulic pump is mounted to an SAE pad on the transmission driven by either a silent chain or direct gear drive train from the engine.



F-447

Lift and Tilt Lines

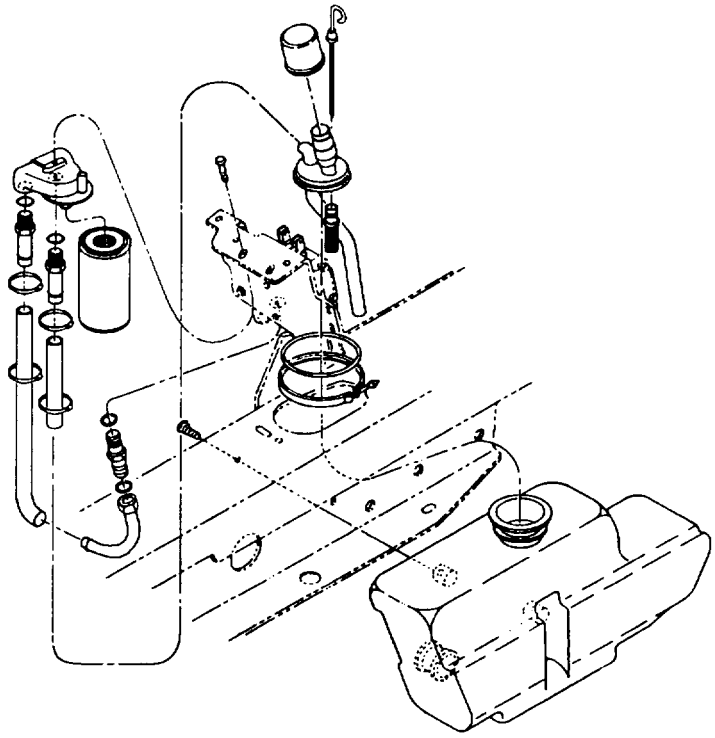


F-448

10.1. Hydraulic Sump - Fluid and Filter Change

Hydraulic Sump and Filter Installation....F-449
Hydraulic Sump Fluid Level Check....F-450
Sump Tank Breather Maintenance....F-450
Oil Filter Maintenance....F-450
Hydraulic System Fluid and Filter Change....F-451
Check Operation of Hydraulic System....F-453
Hydraulic Oil Filter and Base Assembly Parts....F-454

Hydraulic Sump and Filter Installation

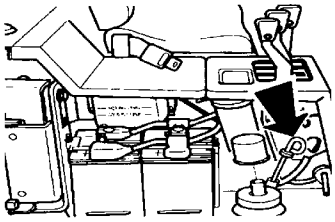


Hydraulic Sump
Fluid Level Check

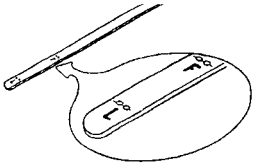
NOTE

Check the hydraulic sump tank oil level with:

- **Truck on a level surface.**
- **Engine stopped.**
- **Upright in a vertical position.**
- **Fork carriage fully down.**
- **Oil at operating temperature.**



1. Pull the dipstick out, wipe it with a clean wiper, and push it back into the dipstick tube. Remove the dipstick again and check the oil level indication.



2. The hydraulic system oil level should be between the oil level markings on the dipstick.

NOTE

Approximately 1.0 gal (3.BL) of hydraulic oil is required to fill the hydraulic tank from the L (Low) mark to the F (Full) mark. DO NOT OVERFILL.

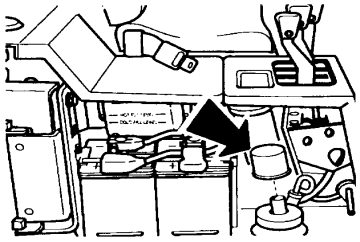
3. Add recommended fluid only, as required.

NOTE

Remove or pull dipstick part way out to vent air from tank while filling.

4. Check the time (hours) of usage and condition of the hydraulic fluid (age, color or clarity, contamination, etc.). Replace fluid, as required.

Sump Tank Breather Maintenance



1. Remove the hydraulic sump tank breather/fill cap and inspect for contamination and damage.
2. Replace the breather/fill cap every 500 hours, or as required by operating conditions.

Oil Filter Maintenance

1. Check the PM time interval for need to change hydraulic oil filter.
2. Change (replace) the hydraulic oil filter every 500 hours and at every sump oil change, or as required by operating conditions.
3. Check for leaks after installation of filter when truck is started.

WARNING

Do not use your hands to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

Hydraulic System
Fluid and Filter Change

NOTE

It is recommended to:

- **Drain and replace the hydraulic sump fluid every 2000 operating hours, or once a year.**
- **Replace the hydraulic oil filter every 500 hours and at each oil change.**
- **Replace the sump tank breather/fill cap every 500 operating hours.**

There is no drain plug in the hydraulic sump tank. Unless the sump tank is to be removed for other repair or maintenance, the hydraulic fluid can be changed by using one of the following methods:

METHOD 1. Removal of the hydraulic sump cover assembly and pumping the fluid out by suction using a separate pump and hose. This method should be used when the hydraulic fluid is severely contaminated, e.g., after a pump or other major hydraulic component failure.
METHOD 2. Pumping the fluid out by using the truck hydraulic system. This method may be used most easily and satisfactorily for routine changes of the fluid. Both methods are described below.

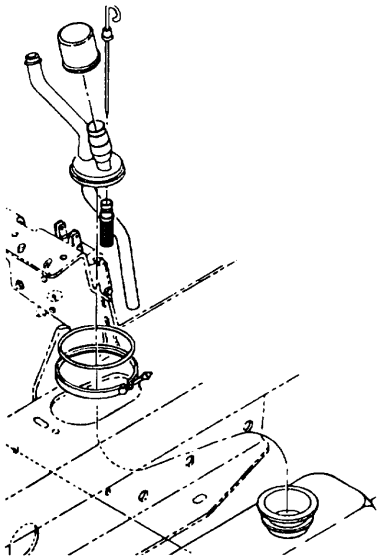
NOTE

To perform this service procedure, it is recommended that you first:

- **Park truck on a level surface.**
- **Put the upright in a vertical position and lower the carriage fully down.**
- **Return all controls to neutral and turn key switch OFF, except as otherwise directed.**
- **Apply the parking brake and block the wheels.**

Open the engine compartment for access to main valve, sump tank fill cap/breather and oil filter.

METHOD 1 Fluid Change



1. Loosen the sump tank cover clamping ring and remove the cover assembly and seal from the tank. Store temporarily in a manner to keep it from being damaged or contaminated with dirt (Suggestion: Wrap with clean plastic).
2. Insert suction hose from the separate pump into the sump tank to pump out the hydraulic fluid (or use a siphon hose to drain the fluid from tank).

NOTE

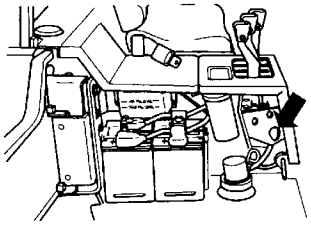
If old oil is extremely dirty, it is advisable to flush the tank with clean oil to remove all contaminants.

3. Examine the screen in the cover assembly. If dirty, it should be cleaned thoroughly.
4. Reinstall the sump cover assembly. Be sure the seal is properly seated. Tighten clamping ring.
5. Refill sump tank with recommended fluid and replace filter and breather cap as noted after Method 2 description below.
   Hydraulic Sump Tank Capacity,
   Useable Volume: 5.5 gal (20.82 L).

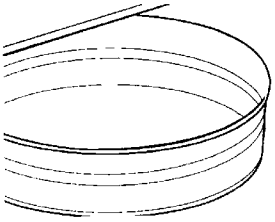
METHOD 2 - Fluid Change

NOTE

If old oil is excessively dirty or hydraulic system contaminated, refer to METHOD 1 procedures for draining and flushing tank.



1. Locate the hydraulic system pressure diagnostic check port.
2. Remove the snap-on cap and connect a suitable drain hose line to the diagnostic check port. Use quick-disconnect adapter fitting, Clark Part No. 3797029.



NOTE

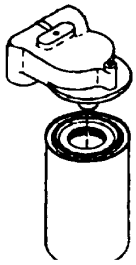
You will need a drain pan of 5.5 gal minimum capacity, or other method of disposal, for collecting the used oil. Be sure the outlet end of the drain line is directed into the pan and held from moving when pressurized.

3. With direction control in NEUTRAL, start the engine and let it run at idle speed to operate the main hydraulic pump. Do not accelerate engine speed. A steady stream of used oil should flow from the drain line.
4. Continue operation until sump tank is emptied. This point will be reached when the pump starts to cavitate. When cavitation occurs you will notice a change in the sound of the pump. Also, watch the drain line. The oil flow will become erratic or will stop when the pump can no longer pick up oil from the sump tank.

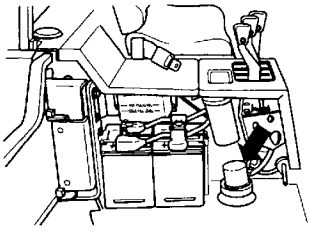
CAUTION

Be careful when sump is nearly emptied. Watch for signs of pump cavitation. Do not operate pump after cavitation occurs or damage to equipment may occur.

5. Stop the engine. Turn key switch OFF as soon as pump cavitation is noted.
6. Disconnect drain hose from the truck. Replace cap on the hydraulic pressure check port fitting.



7. Remove and discard used oil filter. Install a new hydraulic oil filter.



8. Remove the used sump tank fill cap/breather.

NOTE

Use recommended fluid only. Refer to Group 2.1, Service Specifications, for fluid specifications.

9. Fill sump tank with new fluid. **DO NOT OVERFILL.**

NOTE

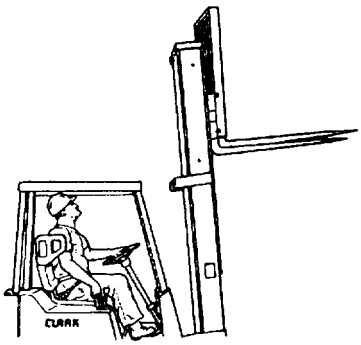
Remove or pull dipstick part of the way out to vent air from tank while refilling.

10. Install new sump breather cap.

Check Operation of Hydraulic System

WARNING

Be sure there is adequate overhead clearance before raising the upright or damage to equipment or injury could result

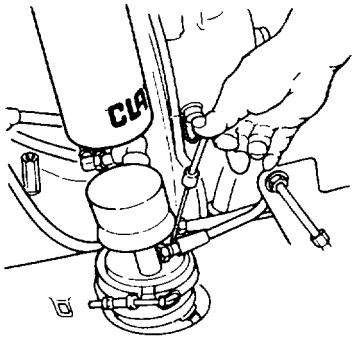


1. Start the engine and operate the hydraulic system. Cycle the hydraulic system several times. Raise the lift carriage to the highest position and lower fully down.

WARNING

Do not use your hands to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Keep hands and body away from pin holes and nozzles which eject fluids under high pressure. If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

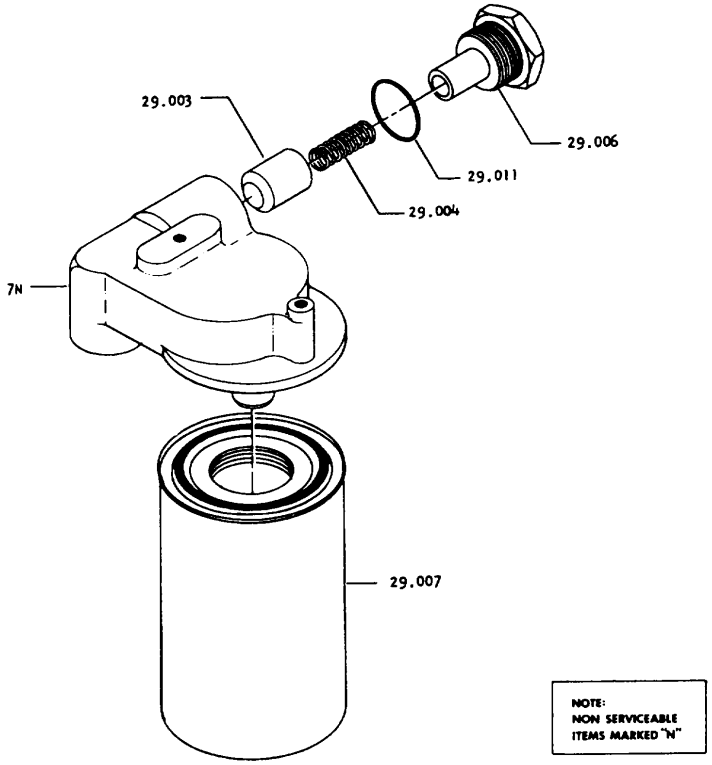
2. Check for leaks. Clean up any oil spills.



3. Check hydraulic sump fluid level. Add fluid, as necessary, to bring the oil level to the correct FULL level as shown on dipstick. Do not overfill.
4. Stop the engine. Turn key switch OFF. Close the engine compartment. Remove blocks from the wheels, if used.

This completes the procedure for changing the hydraulic fluid and filter.

Hydraulic Oil Filter and Base Assembly Parts



29.000 HYDRAULIC OIL FILTER

29.003 VALVE, HYDRAULIC OIL FILTER RELIEF

29.004 SPRING, HYDRAULIC OIL FILTER RELIEF VALVE

29.006 PLUG, HYDRAULIC OIL FILTER RELIEF VALVE

29.007 CARTRIDGE, HYDRAULIC OIL FILTER

29.011 SEAL, HYDRAULIC OIL FILTER RELIEF VALVE

7N BASE, HYDRAULIC OIL FILTER USE 29.000

10.2. Hydraulic System Relief Pressure Check & Adjustment

Relief Pressure Check and Adjustment Procedure F-455
Relief Pressure Setting Check F-455
Hydraulic System Relief Pressure Specifications F-456
Relief Pressure Adjustment F-456

Relief Pressure Check and Adjustment Procedure

Following is the general procedure for checking an setting main hydraulic valve lift and auxiliary relief pressure, for the GPX 25 E truck.

Hydraulic system relief pressure setting may be checked using with a conventional pressure gauge with suitable pressure range calibration. A gauge with capacity range of 0 to 4000 psi (0 to 27580 kPa) mini mum is recommended.

NOTE

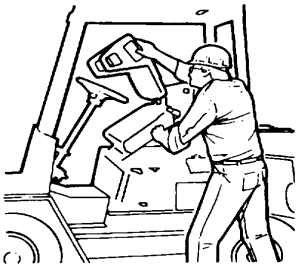
To perform this service procedure, It is recommended that you first:

- **Park truck on a level surface and fully lower the upright.**
- **Put blocks under the upright rails and**
- **Raise the drive wheels off the floor.**
- **Return all controls to neutral, apply parking brake, and turn key switch OFF, except as directed.**

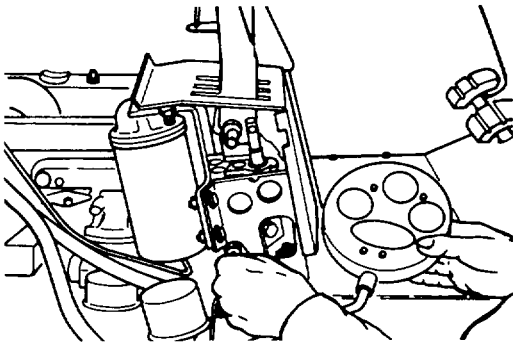
WARNING

Do not use your hands to check for hydraulic leakage. Use a piece of cardboard or paper to search for leaks. Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Keep hands and body away from pin holes and nozzles which eject fluids under high pressure. If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

Relief Pressure Setting Check



1. Open the engine compartment side door (RH or LH door, as noted later) and raise the seat deck. Be sure the seat deck support is securely latched.

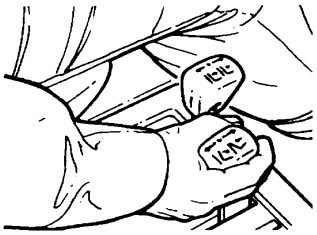


2. The diagnostic check port quick-disconnect fitting (with cap) for making hydraulic system pressure checks is located on the right-hand side of the main hydraulic valve. See notice below.

3. Remove the cap and connect pressure gauge to the diagnostic check port fitting on the valve.

4. Start the engine and let it warm up until it runs smoothly.

5. Check hydraulic system relief pressure setting at full throttle. Accelerate the engine to no-load governed speed (full throttle), and hold at this speed while obtaining the pressure readings.



6. Move the tilt control lever to full back (or forward) tilt relief position. Hold tilt control in relief position until pressure reading is obtained, and then release.

NOTE

Do not operate system over relief any longer than required to read the pressure gauge.

Hydraulic System Relief Pressure Specifications

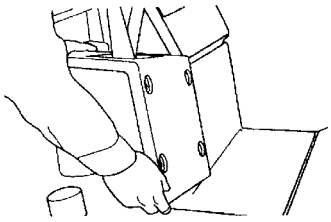
GPX 25E	2600-2700 psi

Reference Section 2. 1, Service Specifications.

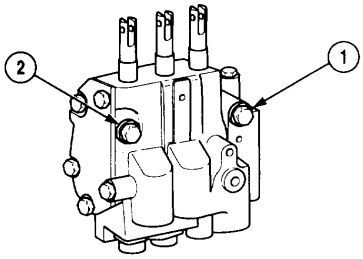
Relief Pressure Adjustment

NOTE

If adjustment is necessary, do not exceed the relief pressure setting specified for the truck model capacity rating. Changing the pressure will not increase lifting capacity or lifting speed.



1. Remove the valve cover from the seat support plate for access to the relief valve adjustment screws on the main valve.



2. The main hydraulic system relief (1) and aux relief (2) valve adjustment screws are located on the upper front side of the main valve.

To adjust, loosen the lock nut, reset and tighten lock nut. Turn adjustment screw clockwise (CW) to increase pressure. Turn counterclockwise (CCW) to decrease pressure.

3. If pressure relief valve needs to be adjusted, loosen the lock nut, hold the control lever in relief position, and turn the relief pressure adjustment screw until pressure gauge reads the correct relief pressure setting. Tighten the lock nut.
4. **IMPORTANT** - Recheck the relief pressure setting. With engine running at full throttle, move the control lever to relief position and read the pressure gauge. This is to verify that relief pressure setting has not been changed during the tightening of the locknut.
5. If pressure setting is not correct, repeat the adjustment procedure.
6. When relief pressure setting is correct, disconnect the pressure gauge. Put the cap on the quick disconnect fitting. Install the cover enclosing main valve.
7. Close the engine compartment, remove blocking, and lower drive wheels to the floor.

This completes the procedure for checking and adjusting main hydraulic relief pressure.

10.3. Main Hydraulic Pump Removal/Installation

Pump Specifications F-457
Pump Troubleshooting F-457
Main Pump Mounting Installation F-458
Pump Removal F-458
Pump Installation F-458

Pump Specifications

The main hydraulic (lift) pump is a fixed-displacement, high-performance, pressure-compensated gear pump. The pump is mounted to a drive pad on the transmission driven either by a gear train or silent chain drive from the torque converter impeller.

Model	Displacement cu in/rev	Speed rpm	Pressure psi	Flow gpm
S205-12	1.45	1800	3000	9.6

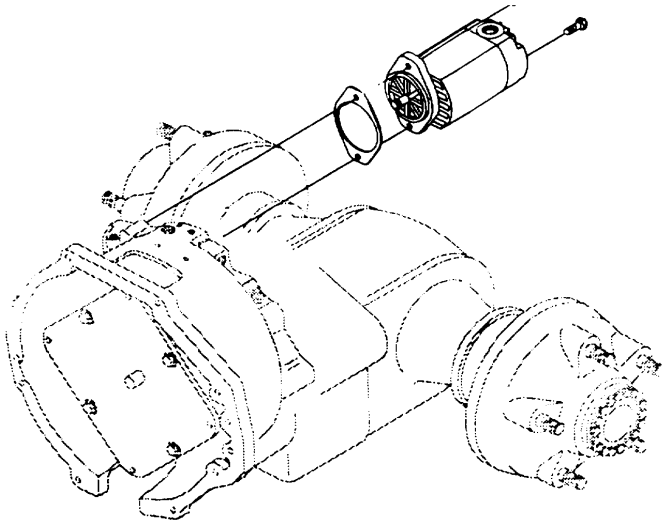
Rotation viewing drive end: ..... Clockwise
Inlet port: ..... 1-1/16-12 UN
Outlet port: ..... 7/8-14 UN

Pump Troubleshooting

If a hydraulic system or pump problem is evident, before removing and/or disassembling the lift pump, check the following list of problems and solutions. It could save time, work and cost.

1.	**Noisy Pump**	
1)	Low oil level	Check/fill sump
2)	011 too heavy	Change to correct viscosity
3)	Inlet line restriction	Check for foreign material, clean filter or strainer
4)	Air leak In inlet line	Check plumbing tightness
2.	**Low Pump Output (Low Flow)**	
1)	Cavitating pump	See 1. Noisy Pump above
2)	Air in fluid	Wrong fluid-Drain/refill w/correct oil
3)	System relief valve set too low/high, stuck or leaking	Correct relief valve, pump may be OK
4)	Overheated oil	Correct oil temperature problem
5)	Contaminated fluid	Correct, inspect & rebuild
6)	Pressure loading seal collapsed	Replace, rebuild
7)	Gear face, body or cover nicks	Repair, rebuild
8)	Excessive side loading, wear plate tight in body bore, pinched thrust plate	Inspect & rebuild
3.	**Foaming Oil**	
1)	Cavitating pump	See 1. Noisy Pump above
2)	Wrong fluid	Drain and refill w/correct oil
4.	**Heated Pump and/or Oil**	
1)	Thin oil	Drain/fill with correct oil
2)	Contaminated oil	Drain/clean filter/fill
3)	Cavitating pump.	See 1. Noisy Pump above
4)	Drive shaft misaligned	Check mounting & alignment
5)	Axial loading on drive shaft and shaft alignment	Check shaft end clearance Check for worn key/spline
6)	Relief valve usually in bypass	Check relief setting
5.	**Shaft Seal Leakage**	
1)	Damaged or worn seal	Replace
2)	Shaft scratched or worn	Repair (polish or replace)
2)	Front cover bearing out of position	Replace front cover assembly
3)	Shaft seal housing bore scratched	Same as 2
4)	Improper fit of shaft	Same as 2
5)	Contamination	Inspect & rebuild
6)	Pump run w/wrong rotation pressure loading seals	Replace shaft &
7)	Shaft scratched or seal nicked	Repair (polish shaft) or replace shaft seal and gear
8)	Seal installed backwards	Inspect & rebuild
6.	**External Leakage**	
1)	Faulty seal gasket	Replace
2)	Damaged surfaces on body or cover	Correct & replace as req'd
3)	Distorted seal gasket	Correct & replace as req'd
4)	Excessive system pressure	Correct as req'd
7.	**Failure to Build Pressure**	
1)	Defective relief valve	Repair and reset valve
2)	Low oil supply	Fill sump

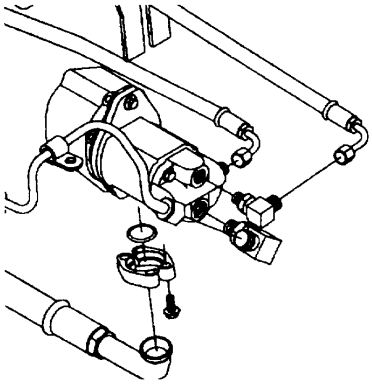
Main Pump Mounting Installation
GPX Model - TA18 Transaxle



Pump Removal

WARNING

Be sure truck is parked in a safe manner with upright in the fully lowered position or personnel injury could result.



Refer to Illustration, Section 10.0.

1. Remove floor board.
2. Remove inlet and outlet lines from pump and cap the ends. Place the open ends of lines in an out of the way position that will prevent oil spillage.
3. Remove the fasteners attaching pump to transmission.
4. Remove pump and gasket.

Pump Installation

NOTE

Be sure new or rebuilt pump is well oiled prior to installation.

1. Install pump on transmission using a new gasket. Install and tighten pump mounting fasteners to torque spec: 37-41 lb-ft (50-56 N•m).
2. Install the hydraulic lines on pump making sure the O-ring seals are properly positioned.

NOTE

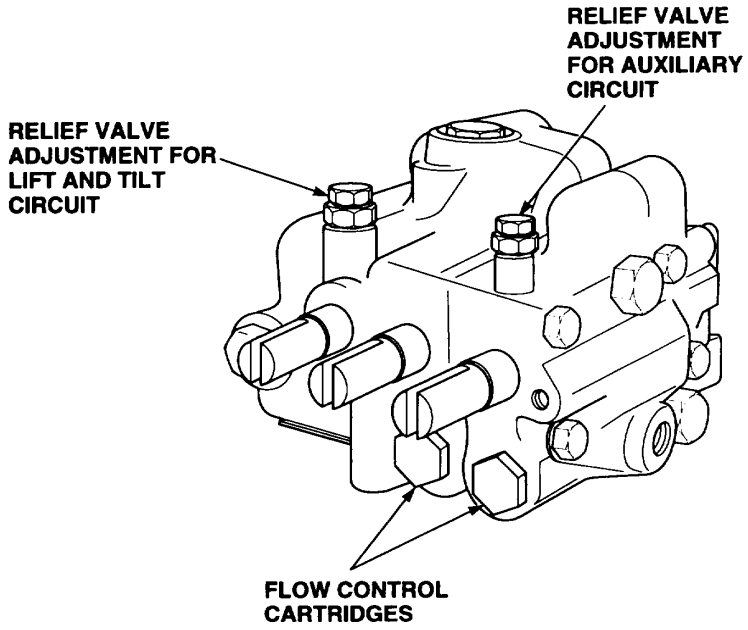
Always replace hydraulic sump oil filter when installing new or rebuilt pump.

3. Replace the floorboard.
4. Start the engine and note If pump is running properly and not making any unusual noise.
5. Check pump output. Cycle (raise and then lower) the upright several times. Tilt the upright fully forward and back, and again listen for any unusual pump noise.

10.5. Main Hydraulic Control Valve

Description and Operation.....F-459
Main Hydraulic Valve Mounting & Control Lever Linkage (Typical).....F-460
Main Hydraulic Valve Removal.....F-461
Main Hydraulic Valve Installation.....F-462
Troubleshooting Guide.....F-463

Description and Operation



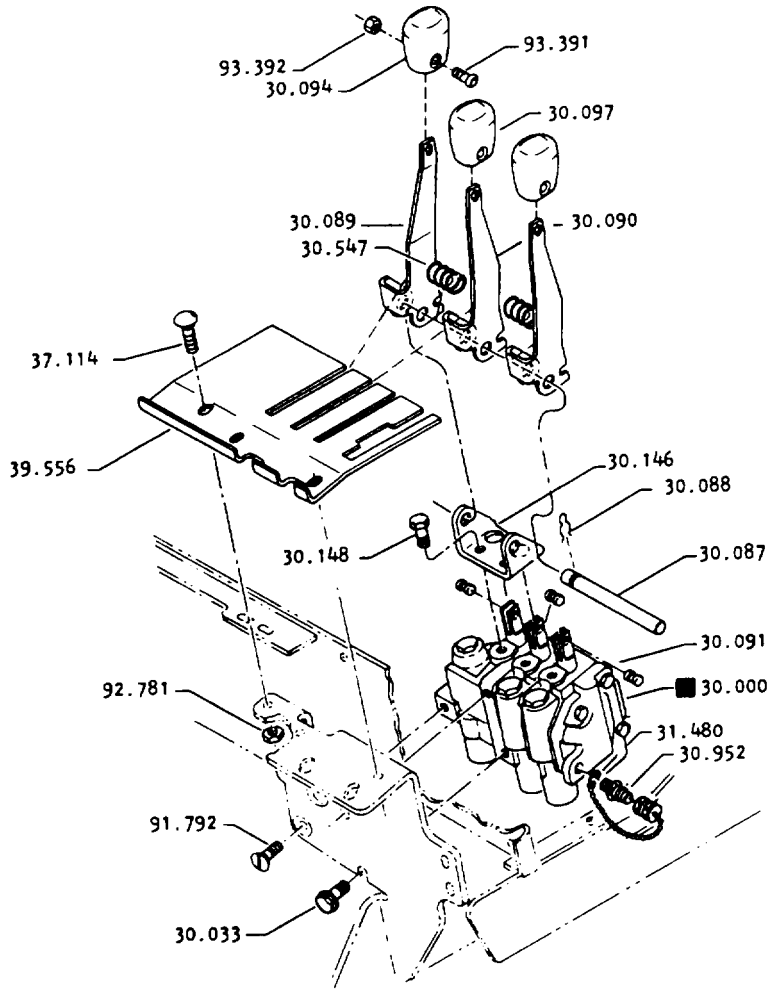
The main hydraulic control valve features an open-center, parallel-circuit type modular design. It has adjustable system pressure relief valve and counterbalance (tilt lock) valve in the tilt circuit with pressure-compensated flow control to regulate lift speeds. All ports and connecting lines are on the bottom of the valve.

When lift attachments are used, an auxiliary section may be added to the outer (RH) side of the standard (lift/tilt only) main valve. The optional aux sections also have an adjustable relief valve and can be assembled with optional flow control levels. The aux valve section is added to the main valve by first removing a cover plate and then bolting the add-on section to the valve.

The valve is adjustable for pressure and flow requirements for lift, tilt and auxiliary functions. The hydraulic system relief pressure level is "tuned" (adjusted) to match the need of each truck capacity. Pressure is tuned by adjustable screws. Flow is tuned with interchangeable flow cartridges.

The valve spools are arranged in standard sequence (from the operator's position) to first provide lift control, then tilt, and finally auxiliary control. The control levers are spring-loaded (by the valve spool centering springs) to return them to neutral when released. Oil flow is controlled by the amount or distance the control handles are moved. Excess oil flow is returned to the sump. A check valve prevents reverse flow.

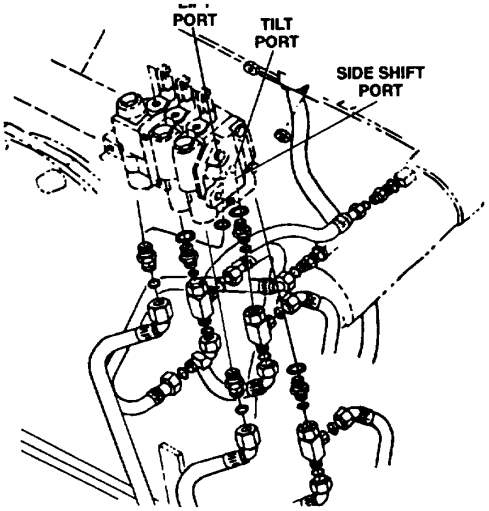
Main Hydraulic Valve Mounting and Control Lever Linkage (Typical)



Main Hydraulic Valve Removal

1. Park truck in a safe position and fully lower the upright.
2. Return all controls to neutral, apply the parking brake, stop the engine and turn key switch OFF.
3. Be sure there is no hydraulic pressure applied to the system by attachments.
4. Open the engine compartment and remove floorboards.
5. Loosen and remove valve cover fasteners. Remove valve cover enclosing main valve.
6. Air clean the hydraulic valve and fillings.

Refer to illustration, Section 10.0.



7. Loosen and remove all hydraulic lines from the valve.

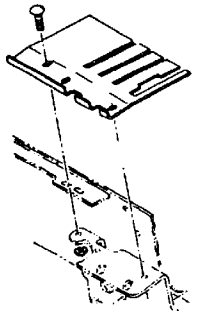
Note

Mark or tag each line as removed to assure correct position of line at assembly.

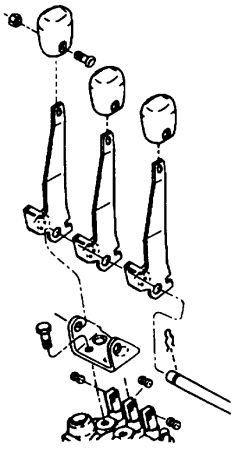
8. Cap ends of lines to keep them clean. Tie ends of lines to truck to prevent loose ends dropping and leaking oil onto floor.

Valve Control Linkage Disassembly

Refer to illustration, Section 10. 5.



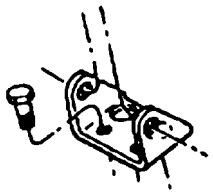
9. Loosen and remove the nuts from the two mounting bolts at underside of plate and remove valve lever top plate from the valve.



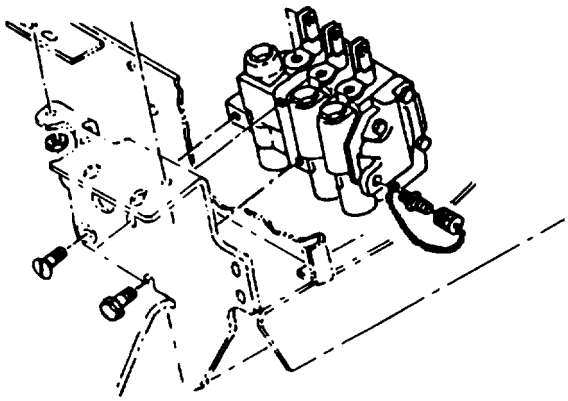
10. Remove spring clip retainer and remove valve control lever pivot pin.
11. Remove valve control levers by rotating forward to disengage from valve spools.

Note

Be careful not to lose the small pins (30.091) that connect the valve levers to the valve spools.



12 Remove fastener bolts and lift off the valve control lever mounting bracket assembly.

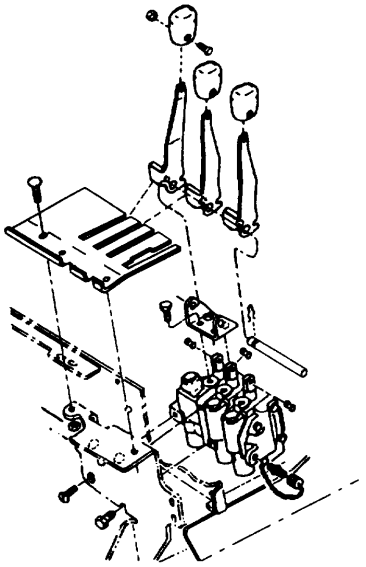


13. Loosen and remove valve mounting fasteners from rear side of mounting plate.
14. Remove valve assembly from truck.

Note

Be sure to clean up any oil spills and dry the floor to prevent accidents.

Main Hydraulic Valve Installation



Install valve by reversing procedures of removal.

1. Position the main valve on the valve mounting plate. Install valve mounting fasteners and tighten to the correct torque.
2. Install the hydraulic lines on the proper ports. Make sure all lines are routed correctly in the truck and are not kinked, as applicable.
3. Install valve control lever mounting bracket on top of valve, control levers and pins, pivot pin and retainer clip, and top plate.
4. Install the valve cover over valve and tighten the fasteners.
5. Start and operate the truck and hydraulic system. Check the system for leaks.
6. Check the operation of the valve and hydraulic system by moving the valve control levers to the various positions.
7. Check the relief valve setting, if valve was disassembled or overhauled.

Refer to Section 10.2, Hydraulic System Relief Pressure Check & Adjustment.

Troubleshooting Guide

	Trouble	*Probable Cause*	*Remedy*
1.	**Oil leaks at either end of spool**		
	1)	Defective O-ring seals.	Replace O-ring seals.
2.	**Spring-centered spools do not return to neutral**		
	1)	Broken springs.	Replace springs.
	2)	Entrapped foreign particles.	Clean system and valve.
	3)	Bent spool.	Replace with new spool or valve section.
	4)	Misalignment of linkage.	Check linkage for binding, repair.
3.	**No motion, slow or jerky action of hydraulic system**		
	1)	Relief valve not properly set, stuck in place and/or worn.	Clean, repair, readjust.
	2)	Dirt or foreign particles lodged between relief valve control poppet and seat.	Disassemble, clean and reassemble.
	3)	Valve body cracked inside.	Replace valve section.
	4)	Spool not moved to full stroke.	Check travel, linkage.
4.	**No relief valve action (high pressure)**		
	1)	Small particle of dirt plugging orifice in relief valve subassembly.	Remove relief valve and check, clean hole.
	2)	Relief valve sub-assembly installed backwards.	Disassemble, install correctly.
5.	**Load will not hold**		
	1)	Oil bypassing between spool and body.	Replace valve.
	2)	Spool not centered.	Refer to above spool remedies.
	3)	Oil bypassing piston in load cylinder	Repair or replace load cylinder.
6.	**Load drops when spool is moved from NEUTRAL to a power position**		
	1)	Dirt or foreign particles lodged between check valve ball and seat.	Disassemble, clean and reassemble.
	2)	Scored or sticking check valve.	Replace poppet.

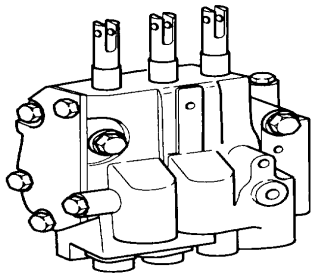
10.6. Main Hydraulic Valve Overhaul

Preparation For Disassembly F-465
Disassembly F-465
Main Hydraulic Valve Assembly Parts F-466
Cleaning, Inspection and Repair F-469
Reassembly F-470
Hydraulic Valve Relief Pressure Settings F-470

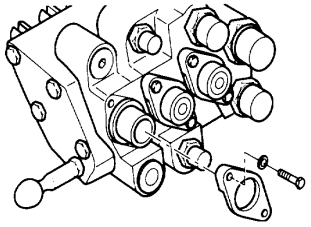
Preparation For Disassembly

CAUTION

Overhaul valve only in a clean, dust-free location, using clean tools and equipment. Dirt or grit will damage the highly-machined surfaces and will result in leakage or premature failure of components. Cleanliness of the hydraulic circuit is extremely important to the proper operation and maintenance of the system. Be sure the work area Is clean or equipment failure could result.



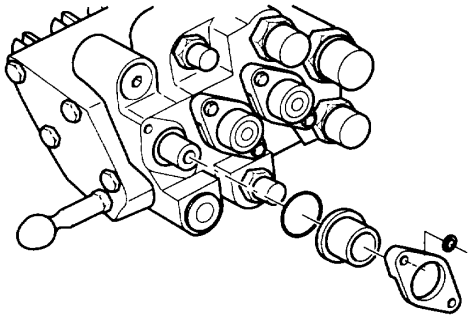
1. Clean outside of valve with a good grade of solvent and dry thoroughly.
2. Before starting disassembly, the valve should be carefully examined to determine if there is any evidence of external damage.



1. Position the valve with its mounting face on the work surface. Note that the top of each spool has a marking to designate the function.

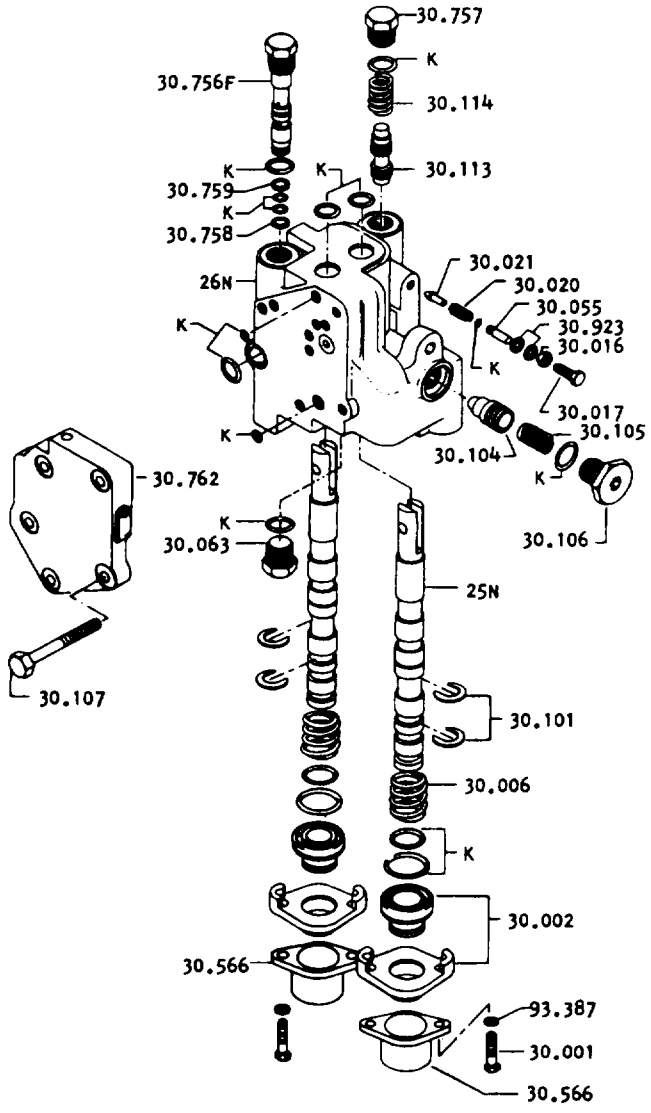
W = Lift Spool A = The Spool D = Aux. Spool

NOTE
Keep parts in order as removed and avoid mixing of sections.

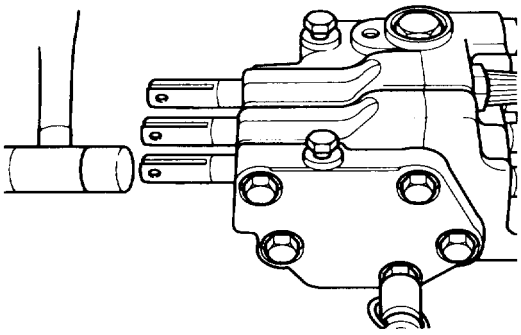


2. Disassemble each valve spool, one at a time, from bottom of valve. Loosen and remove the fasteners, then remove the cover (retainer and sleeve) and O-ring from each spool section of the valve body.

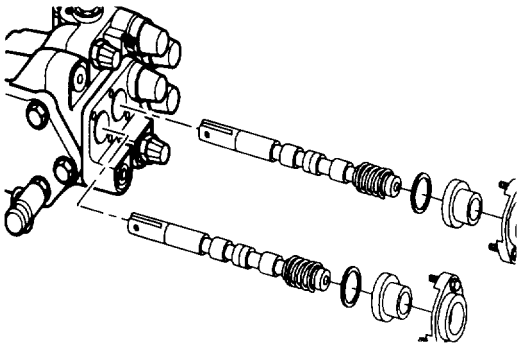
Main Hydraulic Valve Assembly Parts
(Basic Lift-Tilt Valve shown)



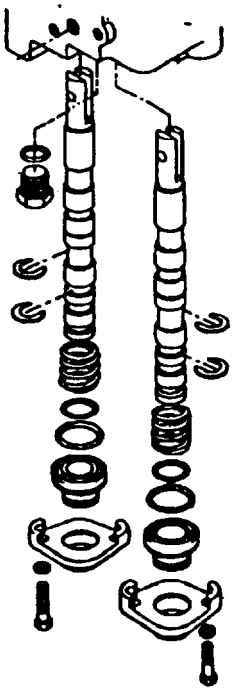
30.000	VALVE ASSEMBLY, HYDRAULIC	
30.001	FASTENER, HYD VAL SPOOL CENTERING SPRING COVER	
30.002	COVER, HYD VALVE SPOOL CENTERING SPRING	
30.006	SPRING, HYDRAULIC VALVE SPOOL CENTERING	
30.016	NUT, HYD VAL RELIEF VAL POPPET ADJ SCREW LOCK	
30.017	SCREW, HYD VALVE RELIEF VALVE POPPET ADJUSTING	
30.020	SPRING, HYDRAULIC VALVE RELIEF VALVE POPPET	
30.021	POPPET, HYDRAULIC VALVE RELIEF VALVE	
30.032	SEAL KIT, HYDRAULIC VALVE	
30.055	PLUNGER, HYDRAULIC VALVE RELIEF VALVE POPPET	
30.063	PLUG, HYDRAULIC VALVE PRESSURE PORT	
30.101	RETAINER, HYD VALVE SPOOL CENTERING SPRING	
30.104	POPPET, HYDRAULIC VALVE CHECK VALVE	
30.105	SPRING, HYDRAULIC VALVE CHECK VALVE POPPET	
30.106	PLUG, HYDRAULIC VALVE CHECK VALVE	
30.107	FASTENER, HYDRAULIC VALVE THRU	
30.113	POPPET, HYDRAULIC VALVE CHECK VALVE	
30.114	SPRING, HYD VALVE CHECK VALVE POPPET	
30.566	DUST SHIELD, HYDRAULIC VALVE SPOOL	
30.756	FLOW CONTROL, HYDRAULIC VALVE TILT SECTION	
30.757	PLUG, HYDRAULIC VALVE CHECK VALVE	
30.758	BACK-UP RING, HYD VAL FLOW CONTR CARTRIDGE SEAL	
30.759	BACK-UP RING, HYD VAL FLOW CONTR CARTRIDGE SEAL	
30.762	END COVER, HYDRAULIC VALVE	
30.923	SHIM, HYDRAULIC VALVE RELIEF VALVE ADJUSTOR	
93.387	WASHER, HYD VAL SPOOL CENTERING SPRING COV FAS	
25N	SPOOL, HYDRAULIC VALVE	USE 30.000
26N	BODY, HYDRAULIC VALVE	USE 30.000

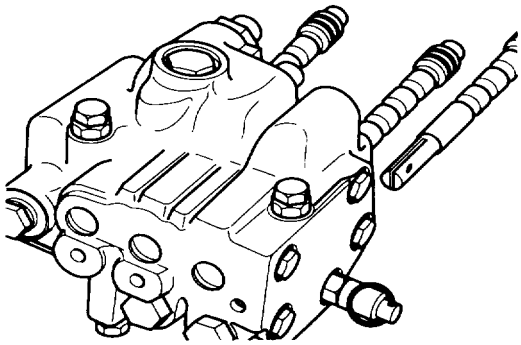


3. Remove the valve spools by tapping lightly on the valve). top end with a soft-faced hammer to drive them out of the valve body.



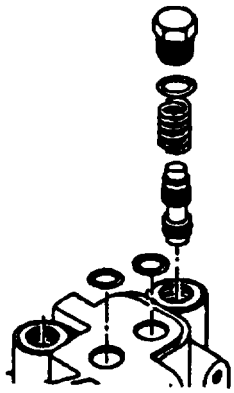
4. Arrange the parts in the sequence of removal.



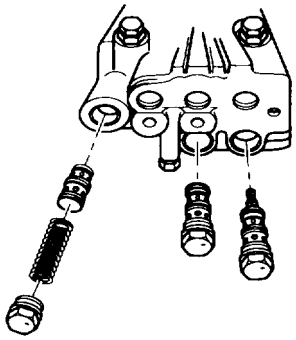


5. Next, remove the hydrostat (secondary stage relief First, remove the plug.

Torque specification: 25 Ib-ft (34 N•m).



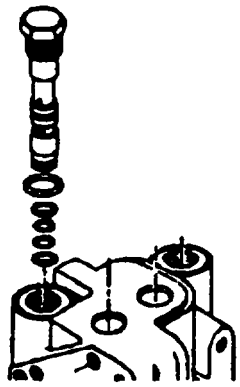
6. Then, remove the O-ring, the poppet valve spring and the relief valve poppet.



7. Remove the tilt flow control cartridge(s).

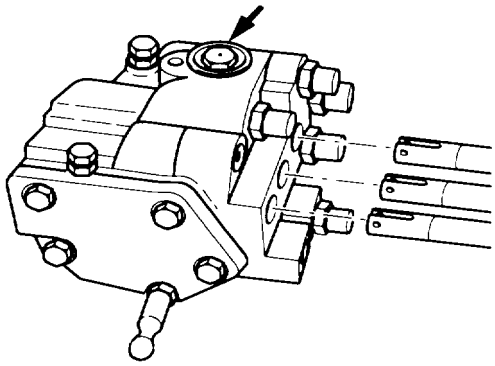
NOTE

The flow control cartridges have left-hand threads.
Torque specification: 25 Ib-ft (34 N•m).



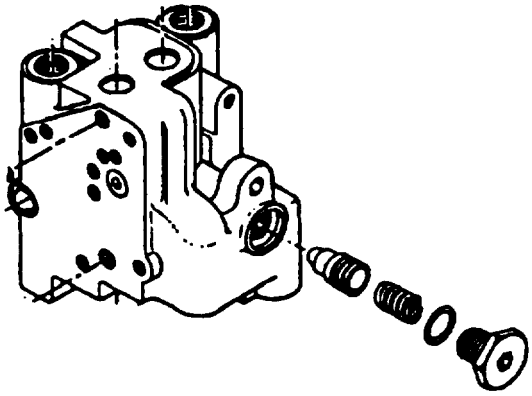
NOTE

Be sure to use the correct flow control cartridge for the upright height installed on the truck. Refer to upright deck number stamped on the outer rail assembly.

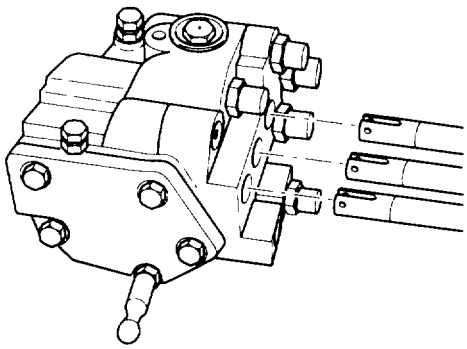


8. Loosen and remove the load drop check valve plug on the side of the valve body.

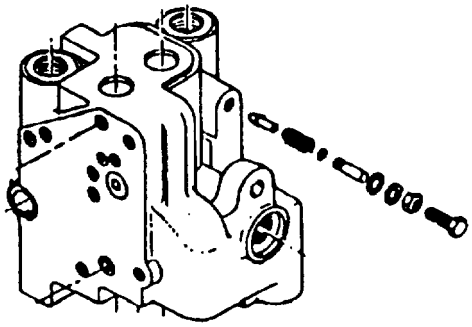
   Torque specification: 25 lb-ft (34 Nom).



9. Remove the O-ring, the check valve spring and poppet.



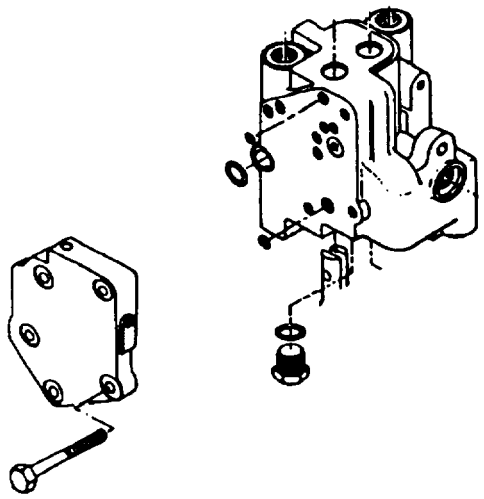
10. Remove the adjustable pilot relief valve. To remove the relief valve parts, loosen the locknut and then remove (turn) the adjusting screw out of the valve body.



11. Carefully remove the adjuster shims and the relief valve plunger. Then, remove the seal, valve spring and poppet. Be sure to keep the parts in correct order as removed.

NOTE

- Be sure that the relief valve adjuster shims are saved and correctly installed when valve is reassembled. These shims must always be in place for correct operation of the valve.
- The pressure relief setting must be reset after reassembly and installation in the truck.



12. Remove the end cover only if there is need for further inspection and cleaning of contaminants in the valve. To remove, loosen and remove the fasteners and lift the end cover off the valve body. Remove the O-ring seals.

Cleaning, Inspection and Repair

1. Discard all old seals. Wash all parts in a clean mineral oil solvent and place them on a clean surface for inspection.

2. Carefully remove any burrs by light stoning or lapping. Be sure there is no paint or burrs on mating surfaces of valve bodies.

3. Inspect valve spools and bores for burrs and scoring. If scoring is not deep enough to cause objectionable leakage, the surfaces can be stoned or polished with crocus cloth. If scoring is excessive, valve body and spool must be replaced. Check each valve spool for free movement in its bore.

4. Inspect the relief valve for damage. Check the relief valve for smooth free movement in its bore. The valve poppet should move easily from only the force of its own weight.

5. Inspect the valve body to make sure it has not been physically damaged. Examine all threads to be sure they are clean and not damaged or burred. Inspect all bores and poppet seats.

6. All springs should be free of corrosion and not broken or bent.

7. If parts must be left unassembled for a period of time or overnight, cover with a lint-free clean material.

Reassembly

Refer to Disassembly instructions for important information on reassembly.

1. Assemble valve in reverse order of disassembly.

2. Coat all parts with clean hydraulic oil to facilitate assembly and provide initial lubrication. Petroleum jelly can be used to hold seal rings in place during assembly.

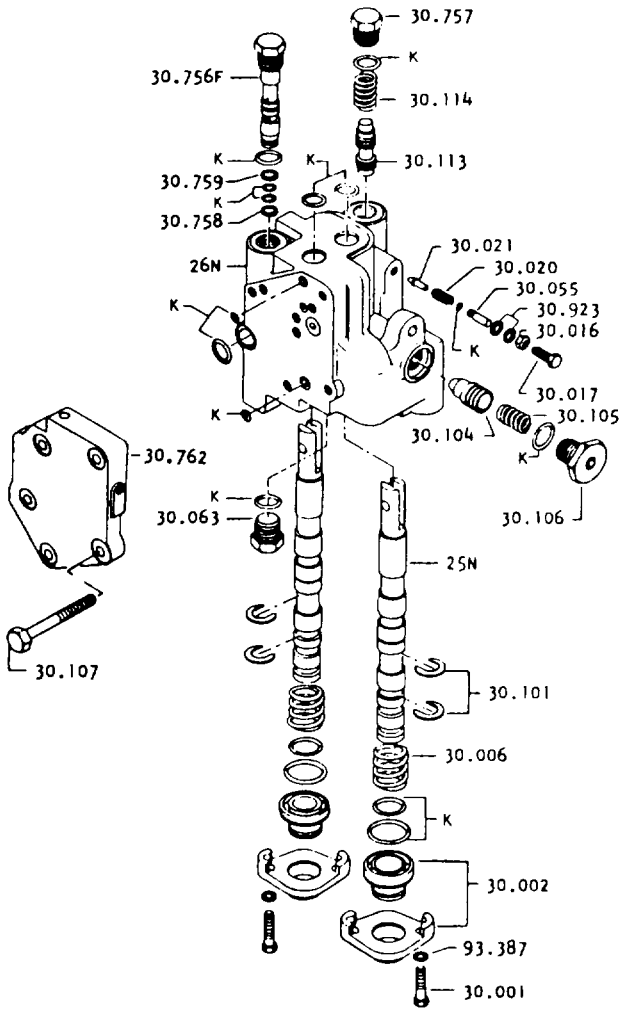
3. Use new O-rings and seals for all parts.

4. Install seal rings and the seal ring retainer in the grooves in body of each inlet and center section. Use petroleum jelly to hold the seals in place. Carefully place the sections together in the same order in which they were removed.

Hydraulic Valve Relief Pressure Settings

After overhaul of the main hydraulic valve, the hydraulic system relief pressure and auxiliary valve relief pressure settings must be checked and reset after reassembly of the valve and installation in the truck.

Refer to Section 10.2, Hydraulic System Relief Pressure Check & Adjustment.



10.7. Tilt Cylinder Maintenance

Tilt Cylinder Drift Test F-471
Tilt Cylinder Adjustment F-472
Tilt Cylinder Removal F-473
Tilt Cylinder Mounting Installation F-474
Tilt Cylinder Assembly Parts F-476
Tilt Cylinder Overhaul F-477
Tilt Cylinder Installation F-480

Tilt Cylinder Drift Test

To check tilt cylinder drift, a rated capacity load is placed on the forks, lifted up and held to determine how much the position of the tilt cylinder rods moves or changes (drifts) in a specified length of time.

Refer to Section 2. 1, Service Specifications for tilt cylinder drift specifications.

It is recommended that a test load, made up of a full capacity load equally distributed on a 48" x 48" pallet, be used. The material used to make up the test load must be arranged (stacked) to provide load stability and must not extend beyond the pallet. It must be secured on the pallet. Refer to the truck nameplate for capacity rating.

1. Adjust fork width to maximum which will accommodate the test load. Space forks as wide as possible to provide even distribution of weight.
2. Position the load on forks. Keep forks level during pick up. Enter pallet with test load as far as possible; test load and/or pal let should be in contact with load back rest.
3. Raise carriage and test load 12-15 inches [305381 mm] off the floor. Tilt the upright to full back position.
4. Shut off the truck. Turn key switch OFF.
5. Measure and mark the initial position of the tilt cylinder rod (see Figure 1).

Note

An alternate procedure is to measure the change in the inclined angle of the upright, using a protractor and level, or inclinometer.

6. Let upright with test load stand for the specified test time.

7. Mark the new position of the tilt cylinder rod or upright.

8. Measure the change in dimension or angle from the initial reference mark.

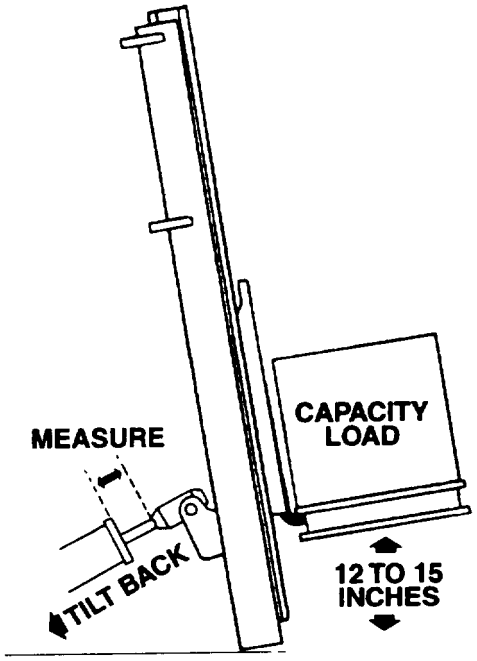


Figure 1.

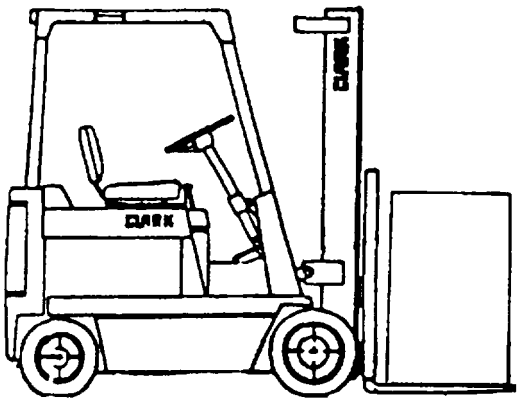
9. Compare the change in dimensions with the specifications.
10. Excessive tilt cylinder drift indicates faulty or worn tilt cylinder seals. Remove tilt cylinders for inspection and repair, as necessary.

Tilt Cylinder Adjustment

Upright twisting (racking) occurs when tilt cylinder strokes are unequal due to misadjusted rod ends, and/or tolerance stackup in parts.

1. Check condition of the tilt cylinder, rod end, mounting pins, piston rod, rod wiper, cylinder gland, etc., for excessive wear or damage. Make repairs before making twisting adjustment.

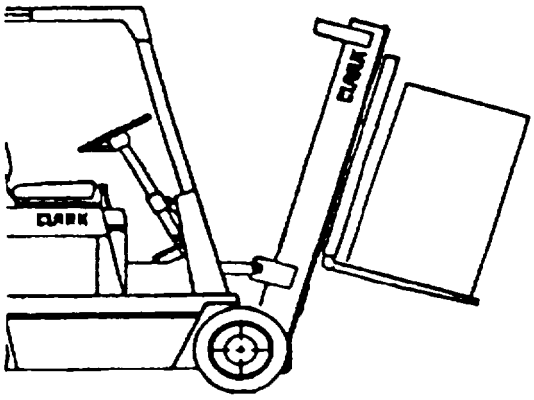
Test For Upright Racking



2. Use a capacity load (see truck nameplate) centered on the forks. Raise the upright only to the height that will allow the fork tips to clear the floor when tilted fully forward.

CAUTION

Be sure to secure the load to the fork carriage to keep it from falling off when tilted forward or damage to equipment could result.

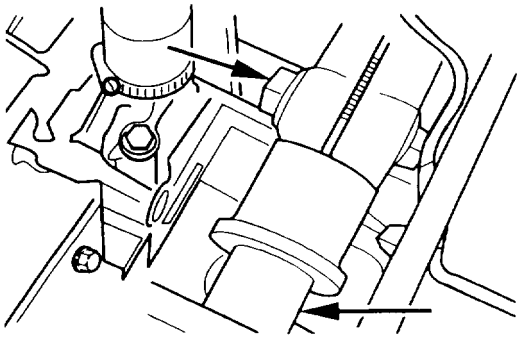


3. Slowly tilt upright fully forward.

4. Watch both piston rods for equal movement and upright for twisting. Note if upright "racks" (is twisted during its movement by unequal stroke of tilt cylinders).

NOTE

Correct the twisting effect by shortening the cylinder that is the longest length. Forward twisting must be adjusted before backward twisting. If forward adjustment is not needed, continue with Step 7.

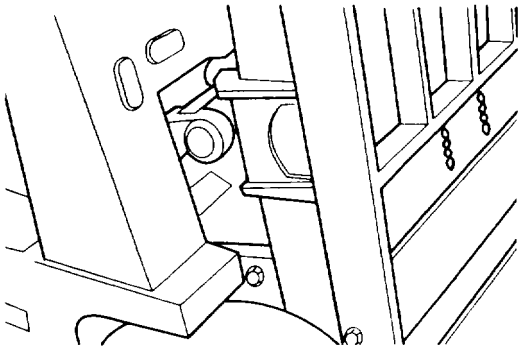


5. To adjust, loosen rod end clamp bolt on the tilt cylinder that extends the farthest, and turn piston rod into rod end to shorten.

NOTE

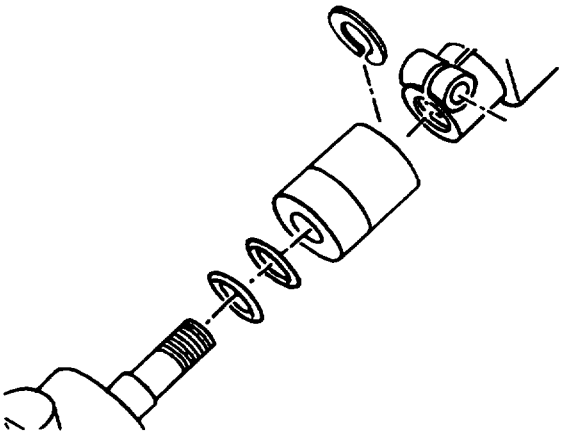
Use wrench flat on rod end under spacer (if installed). Move spacer for access.

6. Continue to turn rod into rod end until tilt cylinder strokes are equal. Tighten rod end clamp bolt.

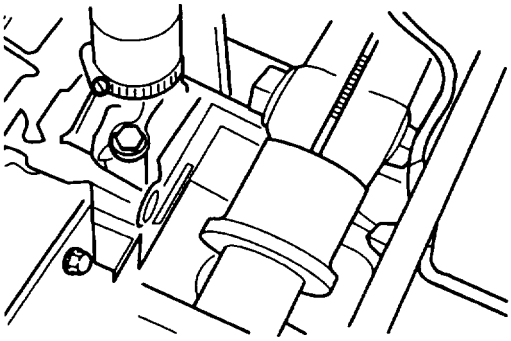


Backward Adjustment

7. Slowly tilt upright fully backwards while watching piston rods. They should both bottom out at the same time. If they don't, adjust backward tilt as follows.



8. Stop the upright when the first tilt cylinder bottoms out against its rod spacer. Use rod shims to fill in the space between the rod end and spacer on the opposite tilt cylinder.



NOTE

Shown is a standard tilt cylinder with spacer. Uprights with MFH of more than [3912 mm] 154 in. use spacers to restrict back tilt.

9. After the excess space is taken up by the adjusting shims, retest the full forward and backward tilt for correct adjustment.

Tilt Cylinder Removal

Refer to tilt cylinder mounting illustration.

NOTE

To perform this service procedure, it is recommended that you first:

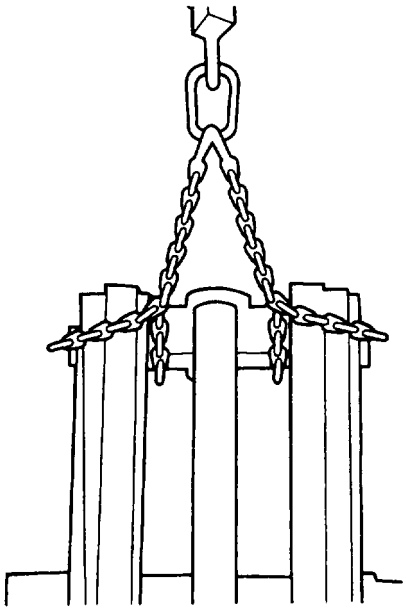
- Park truck on a level surface.
- Put the upright in a vertical position and lower the carriage fully down.
- Return all controls to neutral and turn key switch OFF.
- Apply the parking brake and block the wheels.

1. Be sure all hydraulic attachments are secured and upright and carriage are in the fully-lowered position.

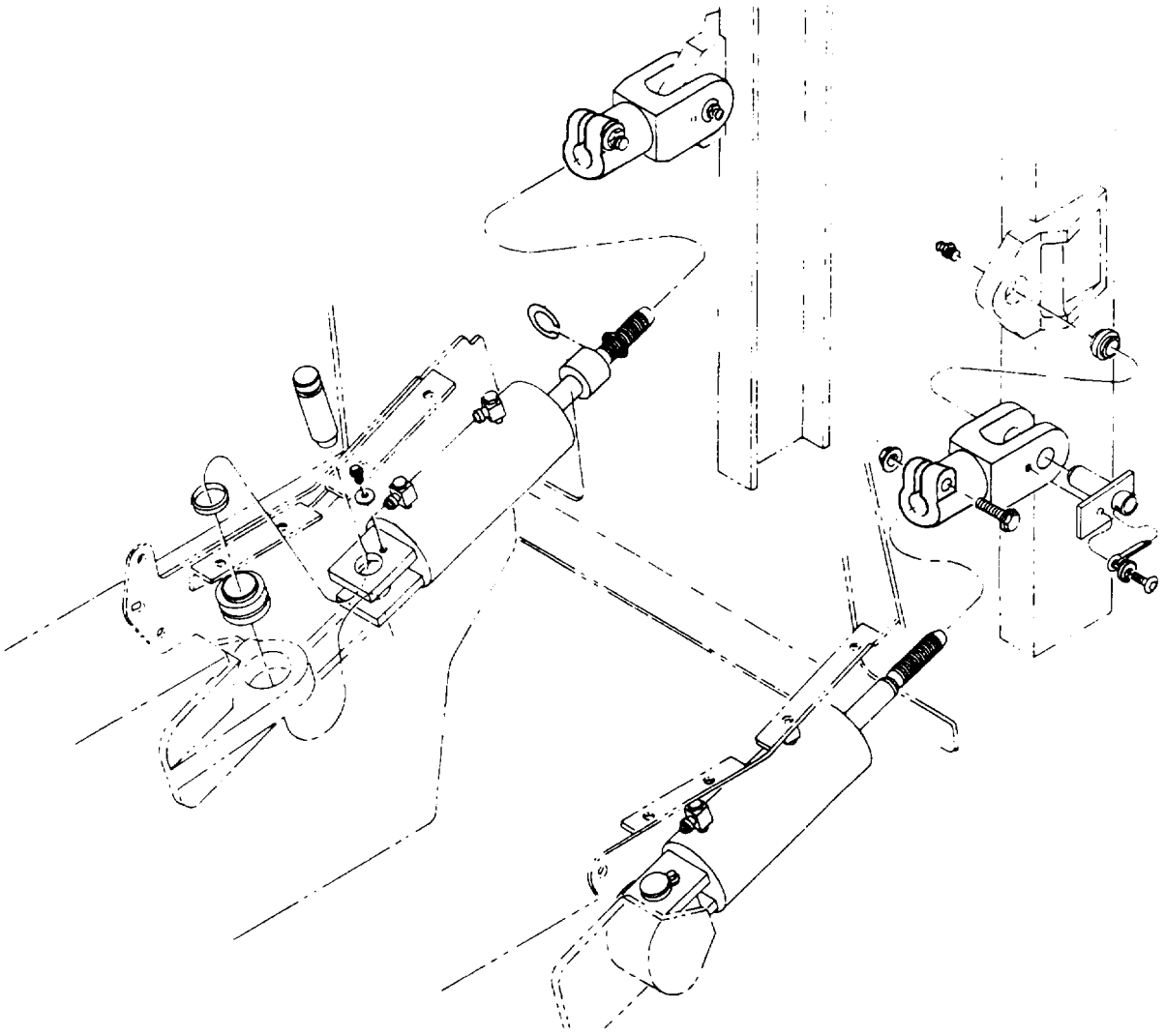
2. If both tilt cylinders are to be removed, the upright must be supported by use of an overhead chain hoist of adequate capacity.

WARNING

Attach a chain or sling to the upright and a hoist before removing any tilt cylinder or upright attachment parts. Be sure to secure and support upright from falling before removing tilt cylinders. Failure to secure upright could result in injury or death.



Tilt Cylinder Mounting Installation



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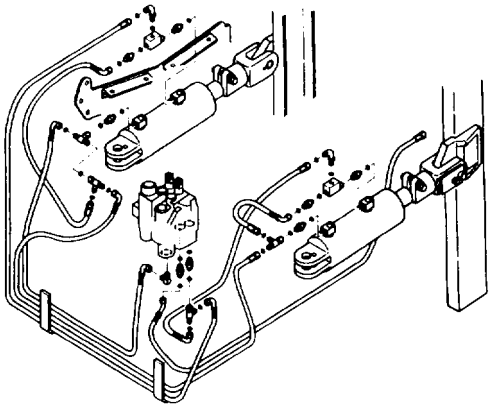
3. Be sure to secure and support upright from falling before removing tilt cylinders.

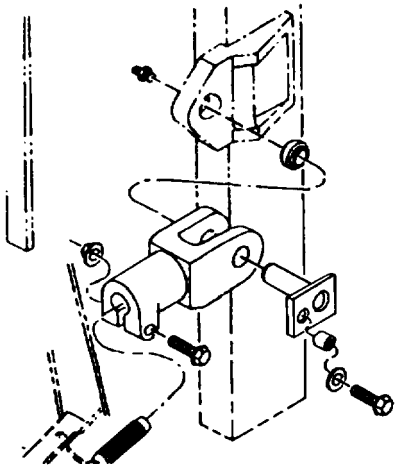


4. Remove the floorboards.

NOTE

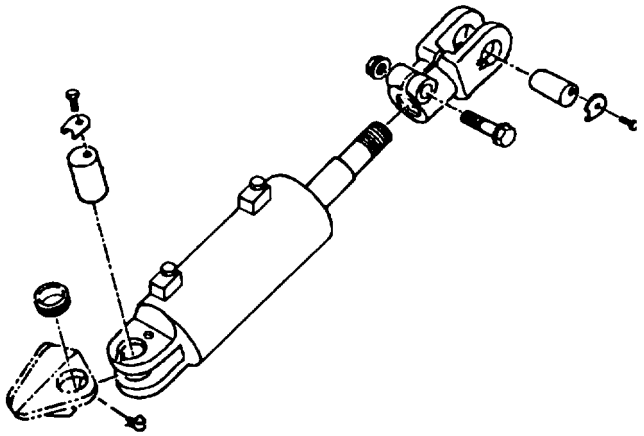
Put a drain pan under the truck at each tilt cylinder position when removing hydraulic lines. Refer to Illustration.

5. Disconnect the hydraulic tilt lines from the tilt cylinders and cap the ends of the lines and fittings to prevent contamination of the lines.

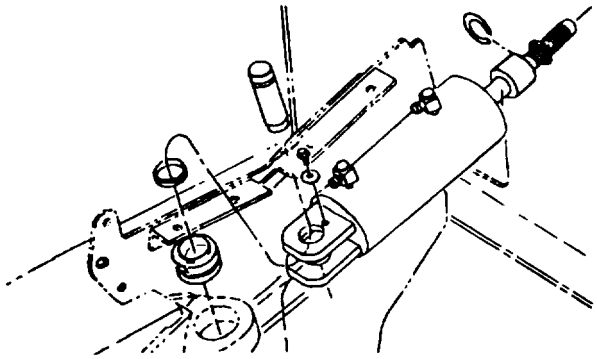


6. Loosen and remove the capscrew and rod end pin from the tilt cylinder forward end at upright. Remove the mounting pin and separate the tilt cylinder from the upright bracket. Remove rod end pin bearing.

Retainer bolt torque spec: 6-7 lb-ft. (8-10 N•m).



7. Mounting pin retainment.



8. Loosen and remove capscrew and retainer washer (or plate) from anchor end (rear) of tilt cylinder. Remove the mounting pin and separate the tilt cylinder from the frame bracket. Remove anchor pin bearing and spacer.

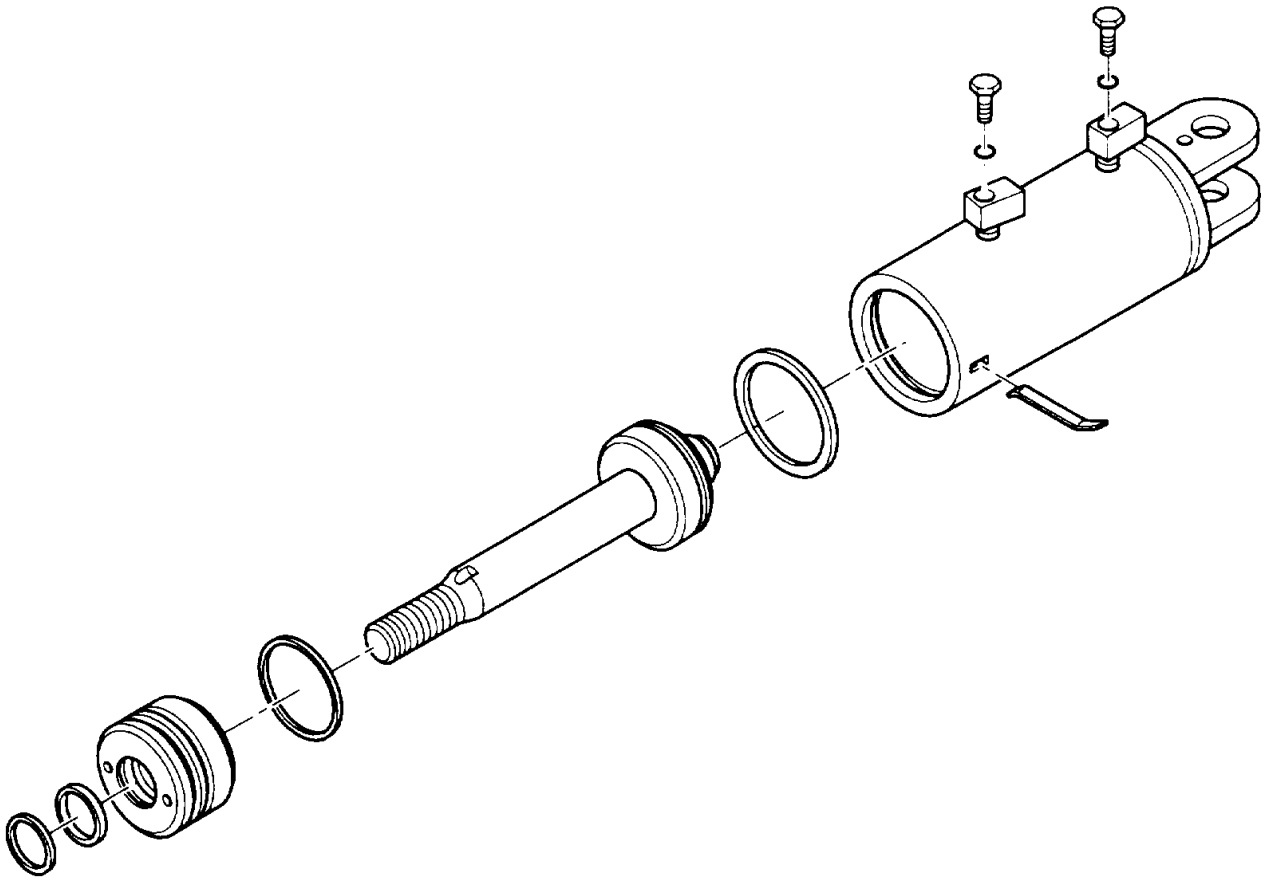
9. Remove tilt cylinder from the truck.

Rod End Removal

Refer to illustrations above.

10. Fully loosen rod end fastener bolt. Remove rod end by unscrewing from tilt cylinder piston rod. Hold rod using wrench flat on piston rod.

Tilt Cylinder Assembly Parts



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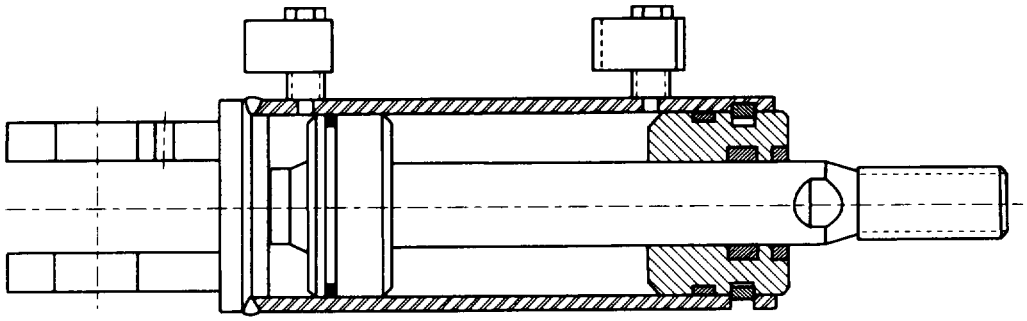
Tilt Cylinder Overhaul



Preparation For Disassembly

CAUTION

Overhaul tilt cylinder only in a clean, dust-free location, using clean tools and equipment. Dirt or grit will damage the highly-machined surfaces and will result in leakage or premature failure of components. Cleanliness of the hydraulic circuit is extremely important to the proper operation and maintenance of the system. Be sure the work area is clean or equipment failure could result.

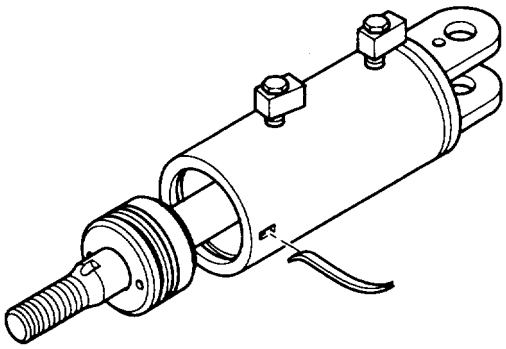
1. Before disassembly, the exterior of the tilt cylinder should be carefully cleaned to remove all dirt and grease accumulation.

2. Be sure all hydraulic oil has been removed from the cylinder. Stroking the piston rod will help force the oil out.

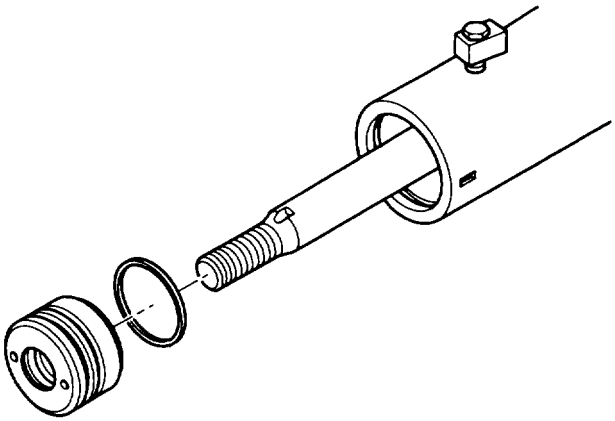
3. Before starting disassembly, the tilt cylinder should be carefully examined to determine if there is any evidence of external damage.

Disassembly

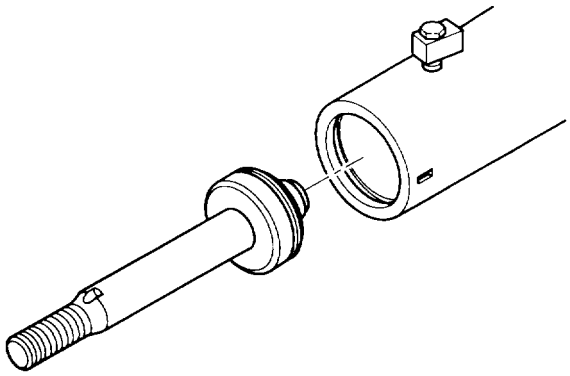
The tilt cylinder assembly can be held by clamping the base end or the barrel in a vise while disassembling. Be careful not to use excessive force when clamping on the barrel.



1. Loosen and remove the gland retainer.



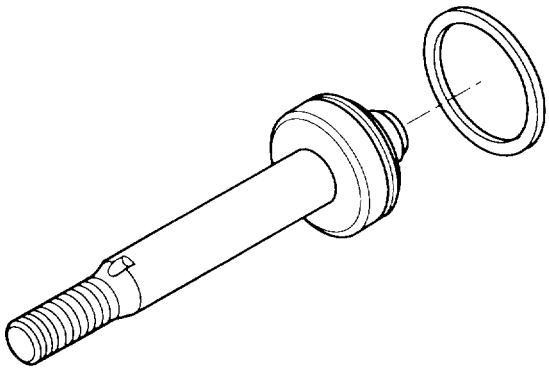
2. Remove the gland and seal assembly from tilt cylinder barrel.



3. Carefully pull the rod and piston assembly from the cylinder barrel.

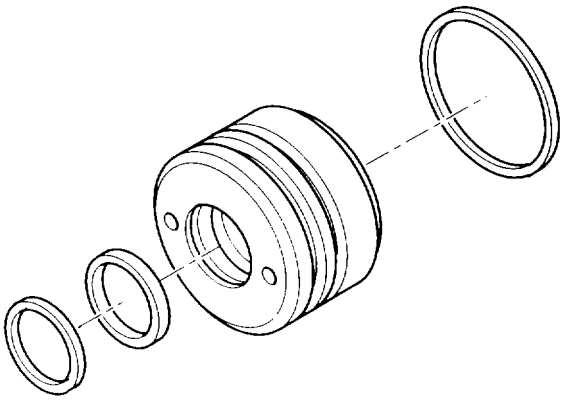
WARNING

The use of compressed air to blow the piston out of the barrel is not recommended. High-pressure air can result in piston and rod being ejected at high velocity (explosively), causing severe injury to personnel and property damage.



4. Remove both sets of piston seals and back-up rings. Discard old seals.

5. After cleaning and inspection (see below), install new seals and back-up rings.



6. Remove the gland seal, gland packing and piston rod wiper. Discard old seals.

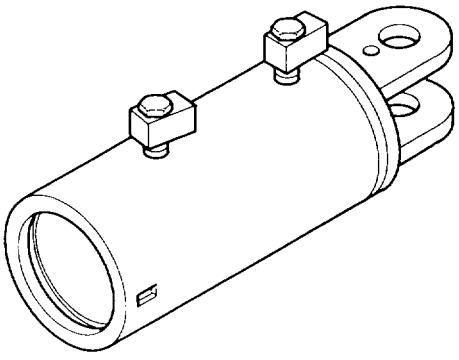
7. After cleaning and inspection (see below), install new gland seal, packing and rod wiper.

Inspection

1. Carefully clean all parts in an approved solvent and place on a clean surface.

2. Check the piston rod for damage. Look for gouges, scratches, corrosion or evidence of unusual wear. Minor surface damage may be repaired by use of fine abrasion cloth or stoning. Deeper damage will require replacement of piston rod assembly.

3. Be sure the threads on rod are undamaged.



4. Inspect the tilt cylinder barrel internal bore for wear, scratches or other damage. Check the outside for damage. Inspect all welds for cracks.

Deep gouges or pitted surfaces require replacement of parts.

Check the threaded section of the cylinder to be sure threads are undamaged. Check the gland nut and base end and ports for cracks or damage that could cause failure. Inspect the ports to be sure they are free of contamination and that the threads are clean and not damaged.

5. Put a light coating of hydraulic fluid on all parts. If parts are to be left disassembled for a period of time, e.g., overnight, they should be covered with a clean cloth.

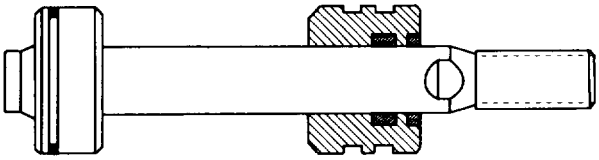
Reassembly

NOTE

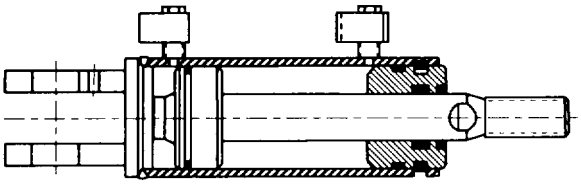
Be sure inside of cylinder and all parts are clean before starting reassembly.

1. Install new seals, as previously noted.

2. Reassemble cylinder carefully to prevent damage to seal lips and O-rings. Seals may be lubricated with hydraulic oil to assist assembly into cylinder barrel.

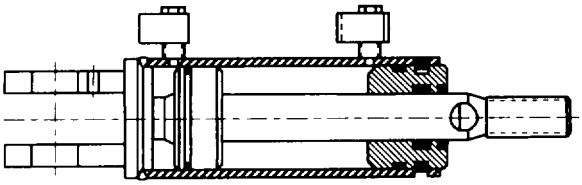


3. Install cylinder gland on piston rod. Use gentle pressure and careful movements to avoid damage to the gland packing and rod wiper when these parts are moved over the piston rod end.



4. Install piston into cylinder barrel. Be careful not to damage the piston seals when installing the piston into end of cylinder.

5. Then, install gland into cylinder. Be careful not to damage gland seal.



6. Install and correctly tighten the gland nut.

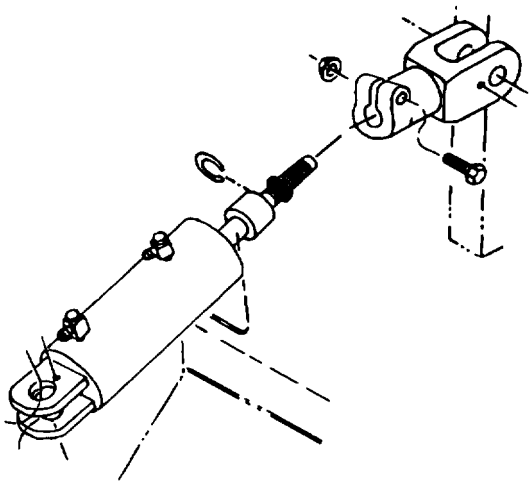
Tightening torque spec: [67-81 Nm] 50-60 lbf. ft.

WARNING

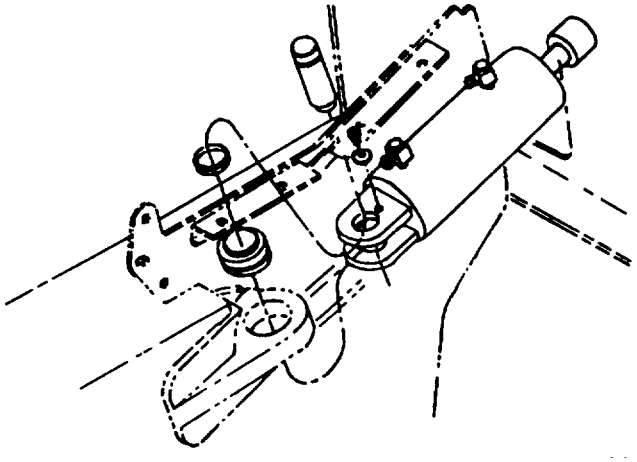
Be sure gland nut is tightened to correct torque. Insufficient torque may cause inadvertent loosening and failure of tilt cylinder during operation resulting in load shifting and possible injury to personnel.

7. Check the assembly by making sure the piston slides freely in and out of the cylinder.

Rod End Assembly



Tilt Cylinder Installation

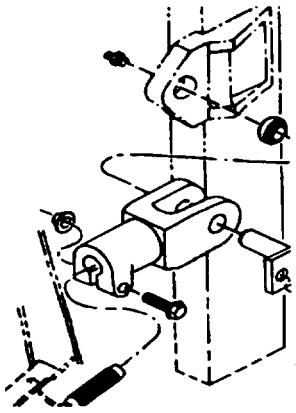


1. Repack anchor pin and rod end pin bearings with Grade No. 2 Lithium soap base multipurpose. grease, Clark MS-107C or equivalent, before installation.

2. Install anchor pin bearing and spacer into frame socket.

3. Position tilt cylinder in its mounting location over frame socket and bearing. Install the anchor pin.

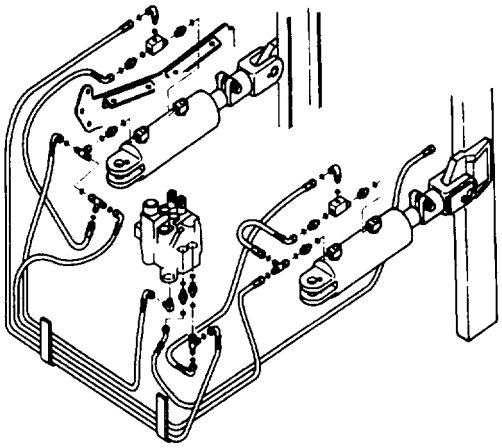
4. Install anchor pin retainer washer and capscrew.



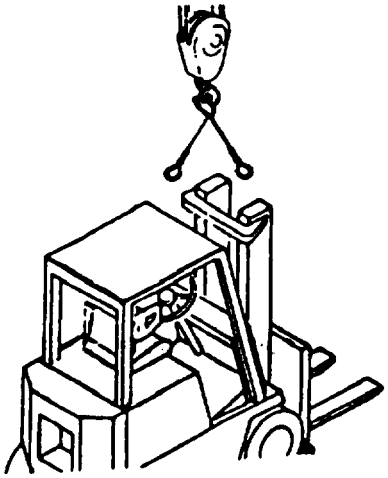
5. Install rod end pin bearing in upright bracket.

6. Align rod end yoke with upright bracket and install rod end pin through the yoke and bearing. Move upright as necessary for alignment.

7. Install the rod end pin retainer. Install and tighten pin retainer fastener.



8. Install the hydraulic tilt lines.



9. Remove chain hoist and lift chain from upright.

11.0. WHEEL AND TIRES

11.1 Tire and Wheel Maintenance F-483

11.2 Deleted

F-481 (F-482 blank)

11.1. Tire and Wheel Maintenance

General Maintenance F-483
Wheel Removal/Installation F-483
Tire Nomenclature F-484

General Maintenance

Tire Inspection

1. Inspect tires and remove objects (nails, metal fragments, etc.) embedded in the tread of the tire. Be careful not to cause further damage to tire when removing these objects.

2. Check tire for damage from chunking or heat damage. This is a judgement requirement for replacement. In general, if the damage is greater than .5 in. (12 mm) deep and involves more than 4 in2 (650 mm2), it will usually affect the tire performance and the tire should be replaced.

3. Look for bulges or other evidence of internal damage. Replace all tires that show evidence of internal damage.

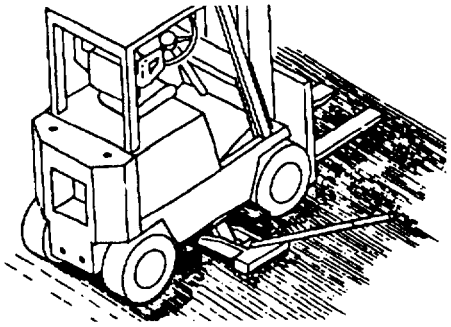
Wheel Removal /Installation

NOTE

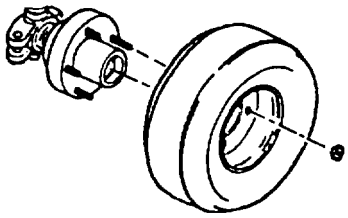
To perform this service procedure, it is recommended that you first:

- Park truck on a level surface.
- Put upright in vertical position and lower carriage fully down.
- Return all controls to neutral and turn key switch OFF.
- Apply parking brake. Block steer wheels.

Removal



1. Use a portable jack of correct capacity (8000 lb [3629 K]) placed under the frame of truck to raise wheel off floor. Position blocks under frame beside jack.



2. Remove wheel mounting lug nuts. Remove the tire and wheel assembly from axle hub.

Installation

1. Reverse the procedure of removal.

NOTE

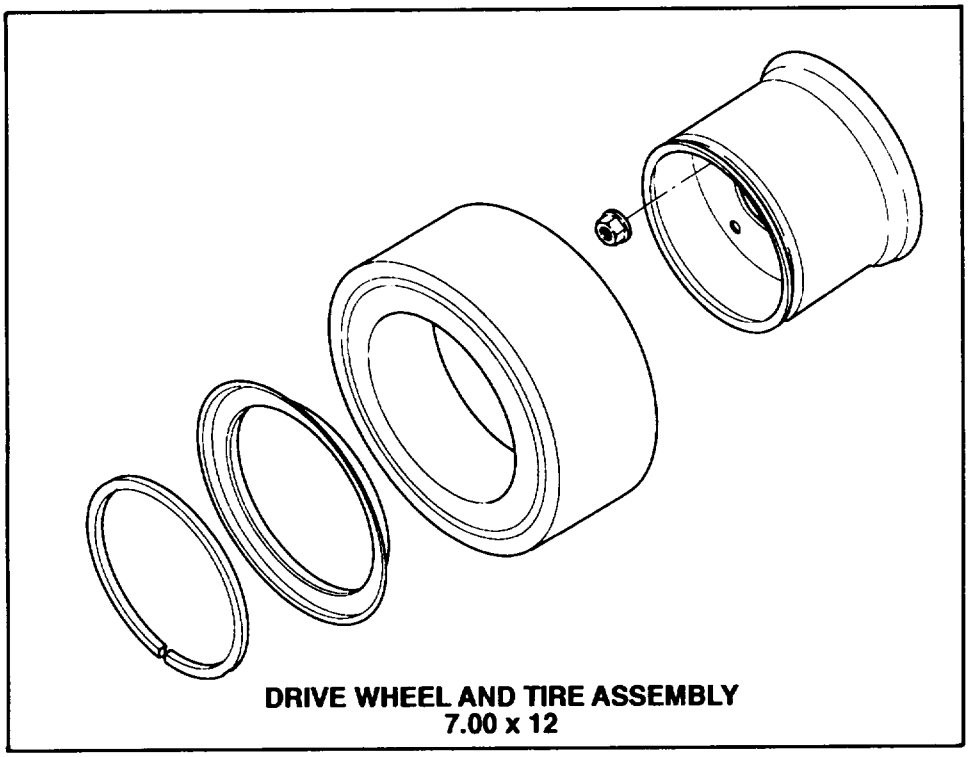
- If installing drive wheel, perform step 2.
- If installing steer wheel, perform step 3.

2. Install drive wheel assembly on trans-axle hub. Install wheel mounting lug nuts and tighten to torque spec: 470-530 Ib-ft (637-718 Nom).

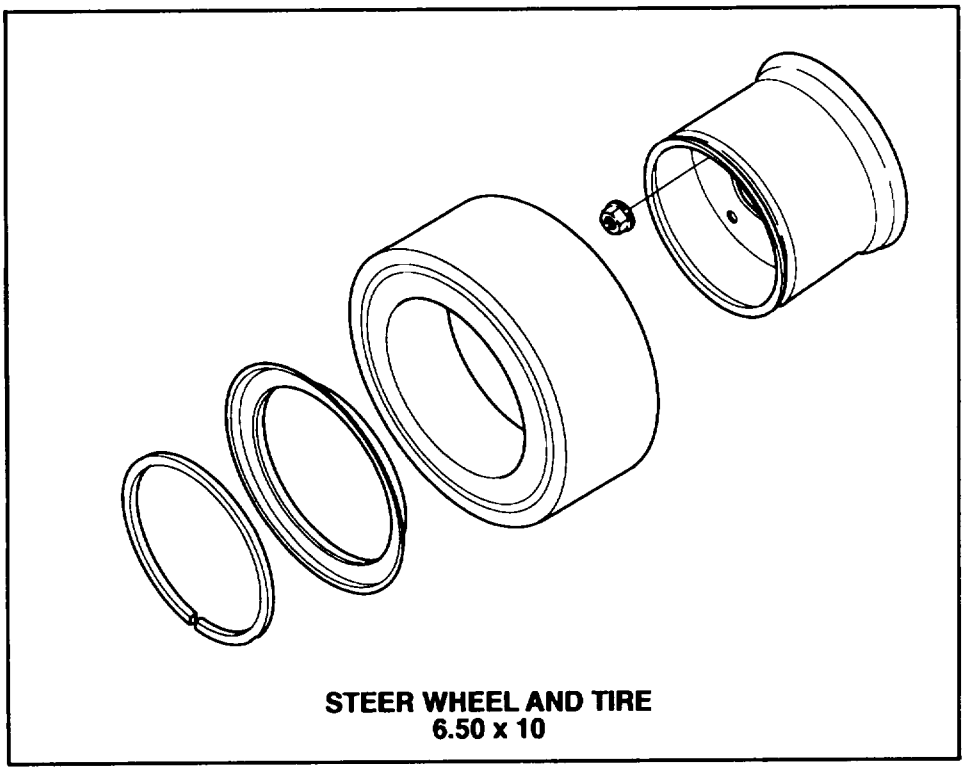
3. Install steer wheel and tire on steer axle. Install wheel mounting lug nuts and tighten to torque spec: 265-338 Ib-ft (360-458 N-m).

4. Lower truck to floor and remove jack.

Tire Nomenclature



DRIVE WHEEL AND TIRE ASSEMBLY
7.00 x 12



STEER WHEEL AND TIRE
6.50 x 10

12.0. Counterweight and Chassis

12.1 Counterweight Maintenance F-487

12.2 Deleted

F-485 (F-486 blank)

12.1. Counterweight Maintenance

Maintenance - General F-487
Counterweight Removal F-487
Counterweight Mounting F-488
Counterweight Removal F-489
Counterweight Inspection F-492
Counterweight Installation F-493

Maintenance-General

The counterweight must be maintained in good condition and securely attached to the lift truck. Because of its heavy weight and bulky mass, the counterweight must be carefully supported and handled. Store at floor level in a stable position to be sure it will not fall or tip, causing either damage or injury.

WARNING

Do not operate a lift truck or handle loads with the counterweight removed. Failure to follow this message can result in severe injury or death.

Counterweight Removal

Counterweights can be removed by one of two methods:

1) Using a hoist or overhead crane.
2) Using another lift truck as a hoist.

WARNING

All tools and lifting components used in these procedures must be in good condition, meet the load requirements, and have OSHA approval labels when required.

NOTE

Prior to performing this service procedure, it is recommended that you first:

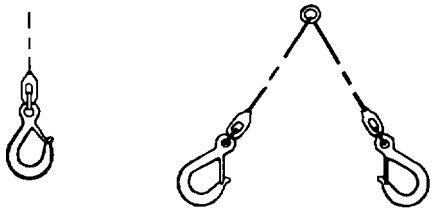
- Park truck on a solid, level surface.
- Lower forks or attachment fully down.
- Put all controls in neutral, apply the parking brake, and turn key switch OFF.

Minimum Tools Required

- Wheel blocks
- Eye bolts and lifting chains, sling, or spreader bar
- Torque wrench, 0-1000 lb-ft (0-1356 N-m) capacity
- Overhead hoist with adequate capacity

WARNING

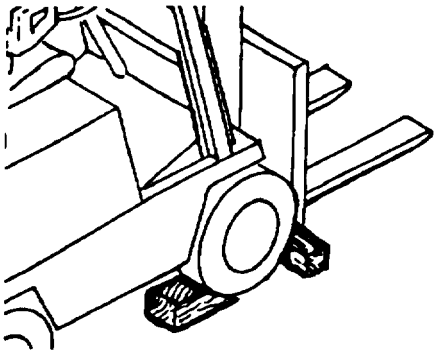
Attach lifting device to counterweight prior to removing mounting bolts. Do not remove with blocks under counterweight supporting truck. Failure to follow these procedures as shown in this manual can result in severe injury or death.



NOTE

Use lifting hooks with safety latches to prevent hook from slipping from the lifting eye.

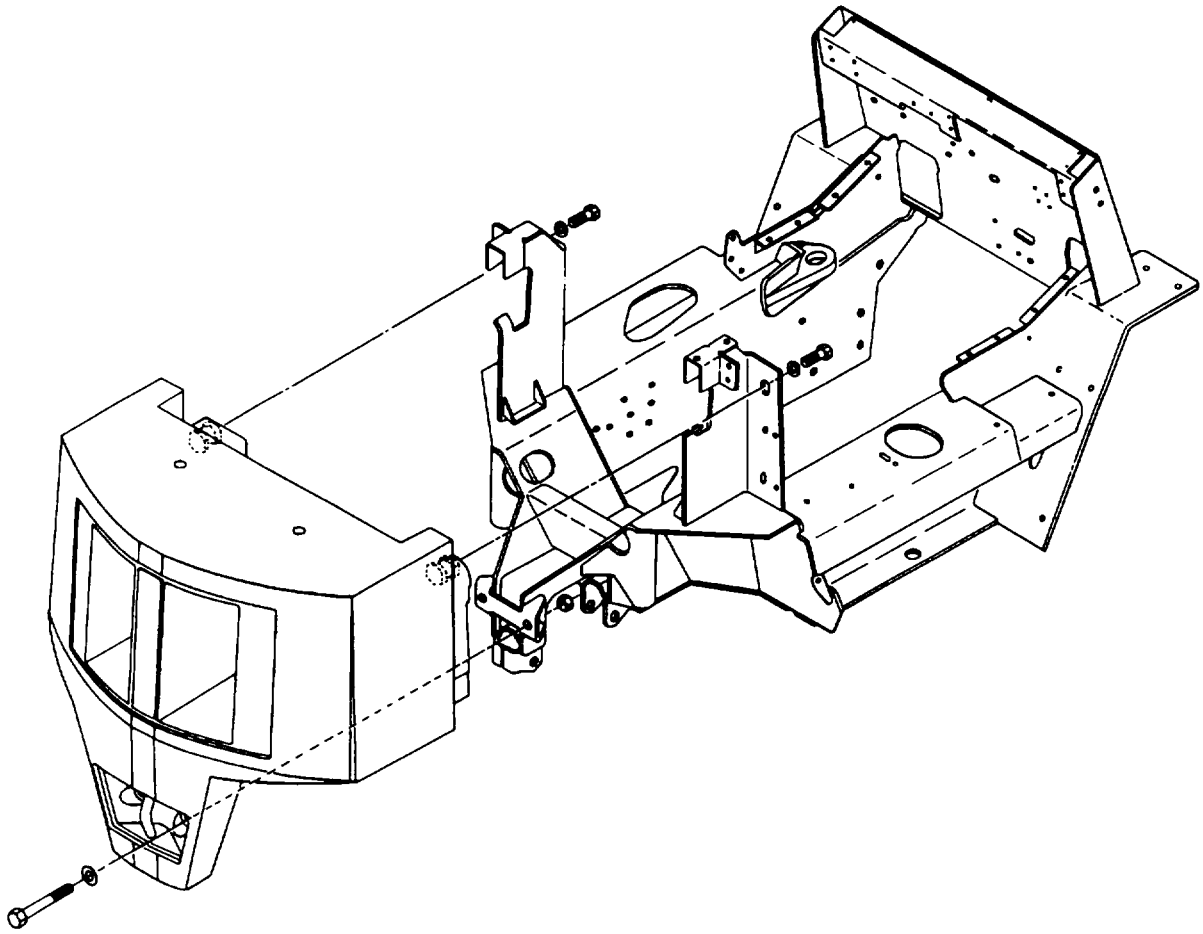
Refer to Section 2. 1, Service Specifications, for information on counterweight weights.



Put chocks at the drive wheels, as directed.

Counterweight Mounting

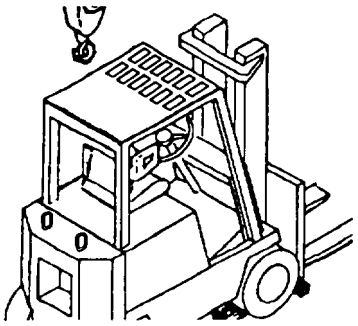
Do not remove the counterweight unless you have training and are familiar with the correct procedures. Counterweights can fall if not handled correctly and cause severe injury or death.



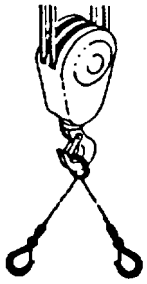
F-488

Counterweight Removal

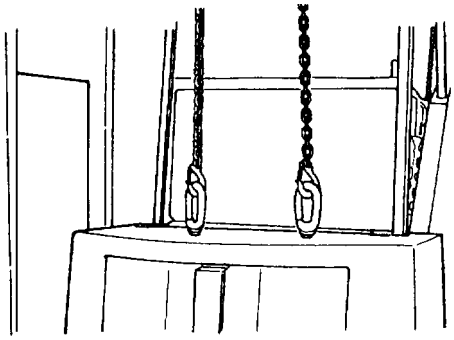
A. Using a Hoist or Overhead Crane



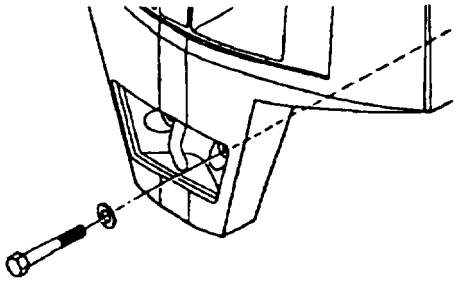
1. Move the lift truck as required into the correct position under the hoist. Apply the parking brake and put blocks at the front and rear of the drive wheels.



2. Install lifting chains, sling, or spreader bar on the hoist hook.



3. Attach the lifting chain hooks to the lifting eyes in counterweight. Raise hoist as necessary to remove (take up) slack in lifting chain to support the weight of the counterweight.



4. Remove the counterweight mounting bolts. Refer to Counterweight Mounting for locations.

5. Open the engine compartment side doors and raise the seat deck. Remove two inner counterweight fasteners which attach counterweight to frame inside the engine compartment.

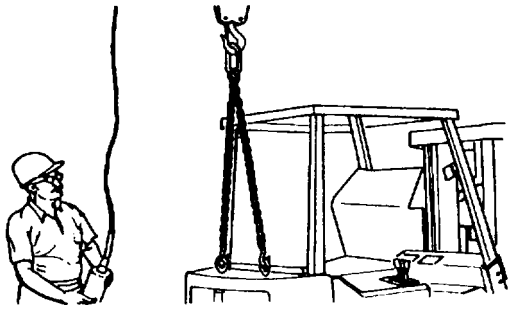
6. Remove two outer fasteners attaching counterweight to frame at the bottom. Refer to Counterweight Mounting for locations.

WARNING

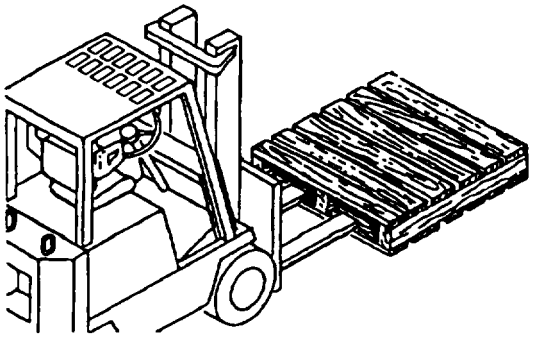
Heavy components can fall and cause severe injury. Keep your feet and body clear at all times.

CAUTION

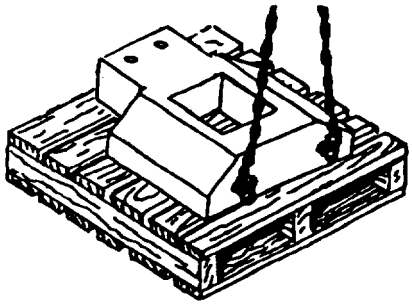
The frame has hooks which support and hold the counterweight in place when correctly installed. Normally, the counterweight is held from falling off by these hooks when the fasteners are removed. Be sure the hoist and lifting chains are securely attached to and supporting the counterweight before these fasteners are removed.



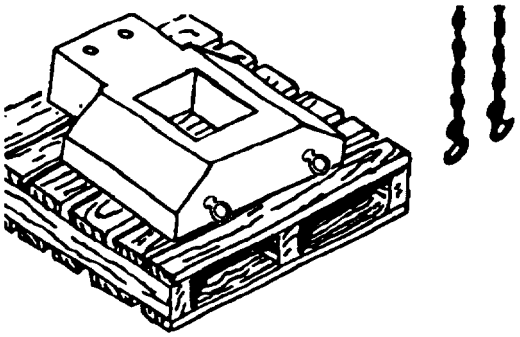
6. Lift counterweight up to clear the frame and remove from truck. Lower the counterweight to floor level, then move it slowly and carefully to transport and store in a safe location.



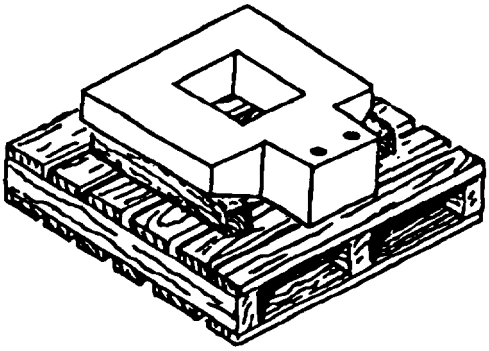
7. It is recommended to use a load platform (pallet, or equivalent) in good condition and of adequate capacity for temporary or permanent storage, and for movement (transport) of the counterweight.



8. Carefully lower the counterweight onto the load platform or floor. When storing, always put the counterweight in a stable position with the broad, flat side down.



9. Remove the lifting chains or sling.



10. If counterweight must be stored on its curved side for inspection or servicing, be sure to put adequate blocking at each side to prevent rolling or shifting.

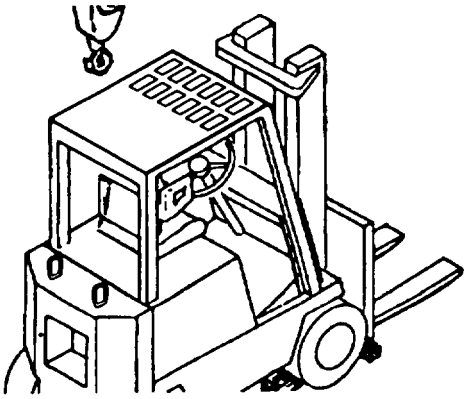
B. Using Another Lift Truck As A Hoist

WARNING

Be sure that hoist lift truck has enough capacity to lift the counterweight or injury to personnel could result.

NOTE

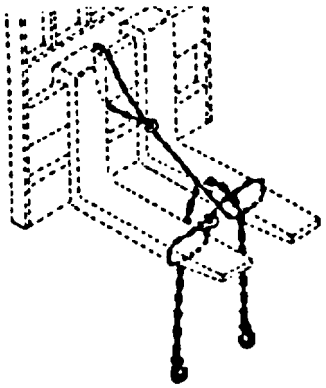
It is recommended that this procedure be conducted by a crew of two. One crew member should attend the counterweight while the other operates the hoist truck.



1. Move the lift truck into a convenient position with adequate clearance for maneuvering of the hoist truck.

CAUTION

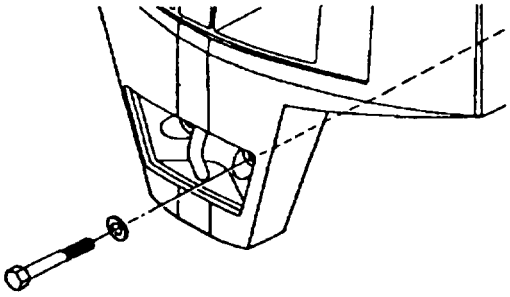
Be sure the parking brake is applied and blocks put at the front and rear of drive wheels or damage to equipment could result.



2. Install lifting chains, sling, or spreader bar on the forks of the hoist truck. Be sure to wrap a safety chain around the forks and fork bar to prevent hoist chain from slipping off the tip of forks.
3. Attach the lifting chain hooks to the lifting eyes in counterweight. Raise the forks of the hoist truck as necessary to remove (take up) slack in lifting chains.

CAUTION

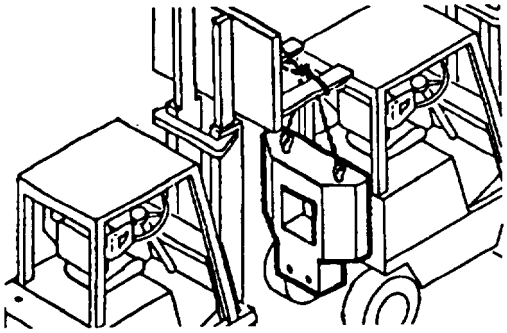
Be sure that forks of hoist truck are adjusted to remove all slack in the lifting chains and pick up (support) the weight of the counterweight before bolts are removed.



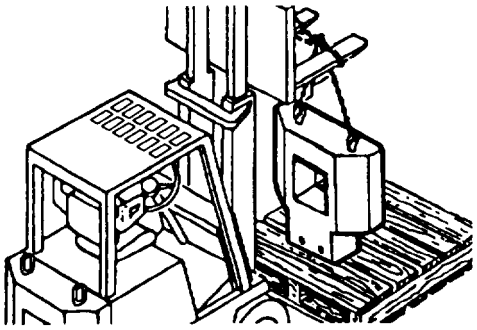
4. Loosen and remove counterweight mounting bolts. Refer to Counterweight Mounting for locations.

WARNING

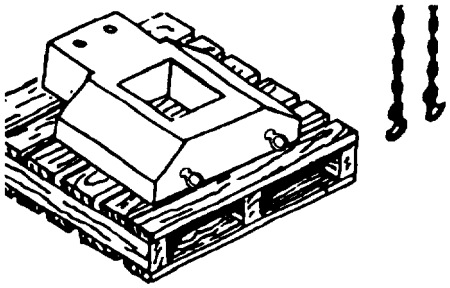
Be sure to stand away from path of the counterweight as it is being lifted and moved. Watch the lifting chains and hooks for any unusual twisting or movement. Do not walk or stand under the forks or injury to personnel could result.



5. Carefully lift counterweight from the truck.

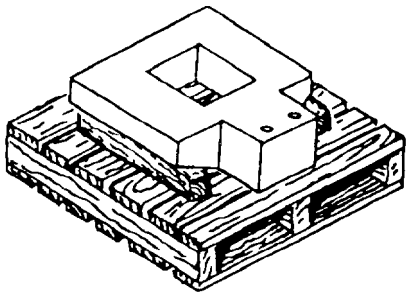


6. Move the truck slowly to prevent swinging of the counterweight.



7. Refer to previous procedures for moving and storing counterweight.

Counterweight Inspection



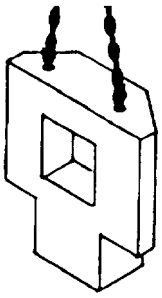
1. Perform a full inspection of the entire counterweight when it is removed from the truck.

2. Inspect all surfaces for damage and cracks, particularly the inner areas which may be inaccessible when Installed.

3. Carefully check all areas around bolt holes, openings, and cast-in thread inserts for loose sections of material, looseness of the inserts, and damaged threads.

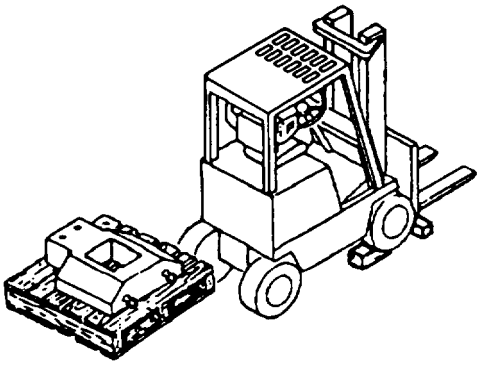
4. Check the threaded nut plate which retains the outer (lower) mounting bolts.

5. Inspect the mounting bolts for worn condition and damaged threads.



6. Inspection of the counterweight may most easily be made while the counterweight is supported by the hoist during removal. Lower the counterweight to the floor.

Counterweight Installation



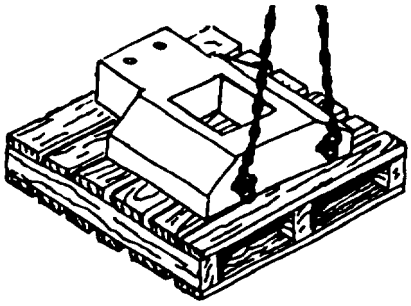
WARNING

Be sure to stand away from path of the counterweight as it is being lifted or moved. Watch the lifting chains and hooks for any unusual twisting or movement. Do not walk or stand under forks or injury to personnel could result.

NOTE

Procedures for installing counterweight with forklift or with hoist or overhead crane are similar. Refer to appropriate removal procedure for instructions in proper chain hookup.

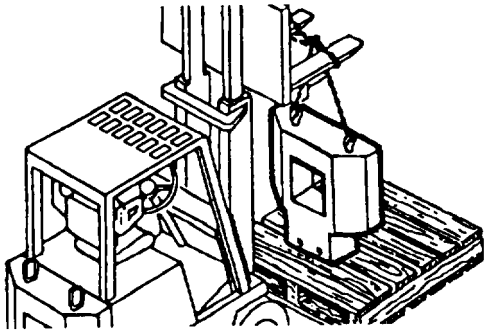
1. Apply the parking brake and put blocks at the front and rear of the drive wheels.



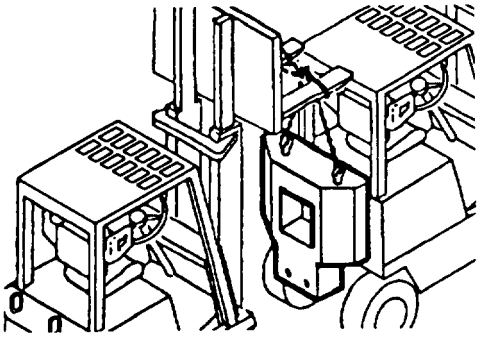
2. Attach the lifting chain hooks to the lifting eyes. Be sure lifting hooks are correctly attached and latches are undamaged and operating correctly. Raise hoist or hoist-truck forks to remove (take up) slack in the lifting chains.

WARNING

Heavy components can fall and cause severe injury. Keep your feet and body clear at all times.



3. Carefully operate overhead hoist or hoist-truck to lift and move counterweight. Keep counterweight close to floor while moving. Move hoist slowly to avoid swinging of counterweight.



4. Carefully raise counterweight into position and align the mounting holes. Be sure the hooks on frame engage the mating recesses in counterweight. Lower the hoist to leave a small amount of slack in the chain.

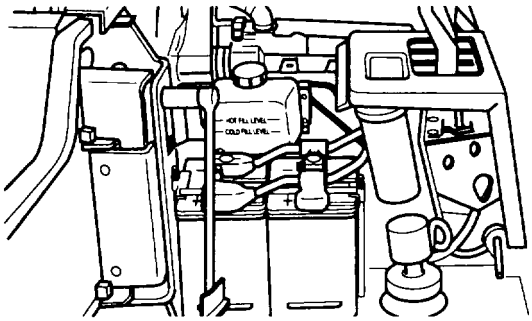
WARNING

- Use only original equipment fasteners when installing counterweights.
- Torque to specifications shown in this manual.
- Failure to follow these instructions may result in severe injury or death.

5. Install the counterweight mounting bolts (2 outer and 2 inner) and tighten sufficiently to draw the counterweight into position. Shims (38.853) may be required for correct alignment of the counterweight. Check the counterweight for correct position and alignment when the bolts are tightened.

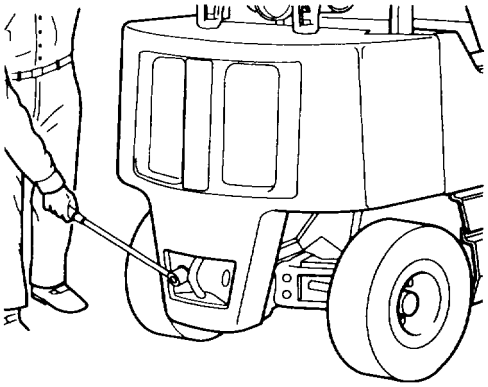
CAUTION

Be sure that the mounting bolts are undamaged and have the correct material (strength and hardness) specification. Do not use substitute, defective, or incorrect mounting bolts. Replace worn or defective bolts or damage to equipment could result.



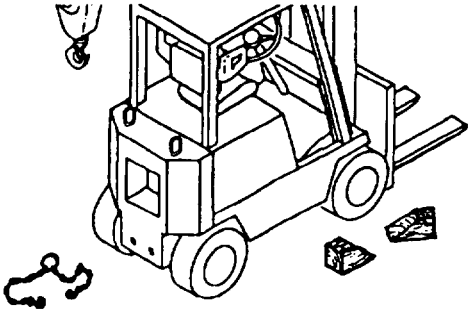
6. Tighten inner counterweight mounting bolts to correct torque.

Torque specification: 251-280 lb-ft (340-380 Nom).



7. Tighten outer counterweight mounting bolts to correct torque.

Torque specification: 251-280 lb-ft (340-380 N•m).



8. Lower the hoist and disconnect the lifting chains or sling. Remove chocks from drive wheels.

13.0. Upright Maintenance

13.1 Upright Maintenance F-497

13.2 Deleted

13.3 Triple Stage Upright F-507

F-495 (F-496 blank)

Upright Down Drift (Fork Drift) Test F-497
Upright Maintenance F-498
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Upright Removal..... F-502
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Installation F-504
Upright Installation..... F-505

Upright Down Drift (Fork Drift) Test

To check upright (fork) drift, a rated capacity load is placed on the forks, lifted up and held to determine how much the position of the lift cylinder(s) change (drift) in a specified length of time.
Refer to Section 2. 1, Service Specifications, for maximum fork drift specifications.
It is recommended that a test load, made up of a full capacity load equally distributed on a 48" x 48" pallet, be used. The material used to make up the test load must be arranged (stacked) to provide load stability and must not extend beyond the pallet. It must be secured on the pallet. Refer to the truck nameplate for capacity rating.

WARNING

An upright or carriage can move unexpectedly.

- Do not walk or stand under raised forks.
- Keep clear of load and carriage when making any checks and adjustments.
- Keep your arms and fingers away from moving parts of the upright. Do not reach through upright open areas.
- Failure to follow these warnings can result in serious injury.

1. Adjust fork width to maximum which will accommodate the test load. Space forks as wide as possible to provide even distribution of weight.

2. Position the load on forks. Keep forks level during pick up. Enter pallet with test load as far as possible; test load and/or pallet should be in contact with load back rest.

3. Raise carriage and test load 12-15 inches (305-381 mm) off the floor. Tilt upright slightly backward (approximately 1-2 degrees from vertical) at the same time.

4. Shut off the truck. Turn key switch OFF.

5. Stand at one side of the upright, not under the load, and measure and mark the initial position of the upright rails with a pencil or marker (see Figure 1).

6. Let upright with test load stand in the raised position for the specified test time.

7. Check the movement of the reference mark. Mark the new position of the upright by making a new mark on the movable rail in line with original mark on fixed rail.

8. Determine the change in position by measuring the distance between marks on rails. Make a record of this dimension.

9. Compare the change in dimensions with the specifications.

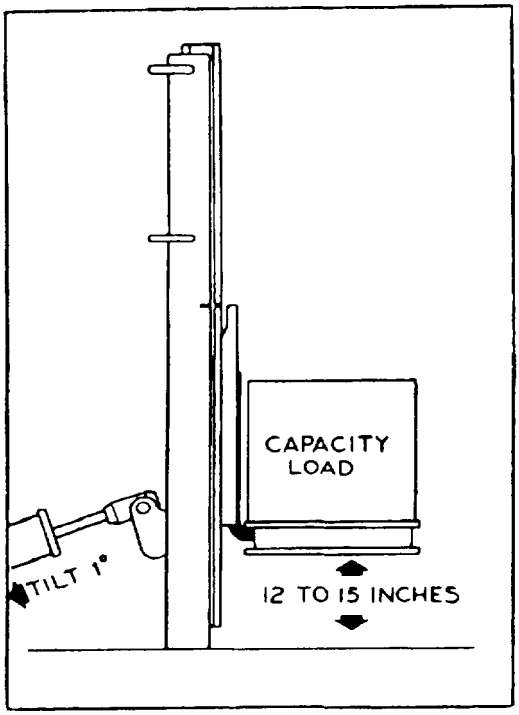


Figure 1. Mark initial position on rail.

10. Excessive fork drift indicates faulty or worn lift cylinder seals. Remove lift cylinder(s) for inspection and repair, as necessary.

Upright Maintenance

It is recommended to perform the following service maintenance at every truck PM, or as otherwise specified.

1. Inspect the upright assembly: rails, carriage rollers, lift chains, and lift and tilt cylinders.
   a) Look for obvious wear, maintenance problems, and damaged or missing parts.
   b) Inspect all lift line hydraulic connections for leaks.
   c) Check the cylinder seals for leaks.
   d) Check the lift cylinder rods for wear marks, grooves, and scratches.
   e) Check for any loose parts or fittings. Check for any damaged or loose rollers, and rail wear. Check for metal flaking in the roller pathways.
   f) Carefully inspect the lift chains for wear, rust and corrosion, cracked or broken links, stretching, etc.
   g) Check that the lift chain anchor fasteners and locking means are in place and tight.
   h) Check that the lift and carriage chains are correctly adjusted to have equal tension.
2. Be sure all safety guards and chain retainers are in place and not damaged. Inspect the carriage stops and cylinder retainer bolts. Check all welded connections.
3. Check for interference of hoses, chains, etc., during lift operation.
4. Check lift chain adjustment and adjust fork height to prevent fork wear.
5. Inspect and lubricate lift chains. During inspection, check for a layer of oil on the external chain surfaces.
6. Check upright trunnion bearings for wear. Check trunnion brackets for cracks or damage. Check upright trunnion cap bolts for correct torque and that no bolts are missing.
7. Check upright mounting bracket fasteners. Tighten each bolt to correct torque specification.
8. Keep piston rods and tops of cylinders clean.
9. Always keep piston rods in retracted position when upright is not in use.
10. When operating in corrosive environments, inspect the lift chains every 50 hours.
11. Perform upright shim inspection at least every 500 hours of operation

WARNING

This section describes procedures which can produce unexpected movement of the upright rails and other parts.

- Do not walk or stand under raised forks.
- Keep clear of load and carriage when making any checks and adjustments.
- Keep your arms and fingers away from moving parts of the upright.
- Do not reach through upright open areas.
- Review all described procedures before starting any maintenance or service function. Failure to follow this warning can result in serious injury.

Lift Chain Maintenance

Lift chains are very important components of fork lift trucks. The chain system on your upright was designed for safe, efficient, and reliable transmission of lifting force from hydraulic cylinder to the forks. Safe use of your truck with minimum down time depends on the correct care and maintenance of the lift chains. Most complaints of unacceptable chain performance are a result of poor maintenance. Chains need periodic maintenance to give maximum service life.

Lift Chain Lubrication

The most important consideration in field maintenance of lift chains is lubrication. The lift chains operate under heavy loadings and will function more safely and have longer life if they are regularly and correctly lubricated. It is very important to protect lift chains from corrosion, whether in service or in storage, because corrosion will reduce the load carrying capacity. There must be a layer of oil on the chains at all times. Heavy motor oil may be used as a lubricant and corrosion inhibitor.

Chain lubricant should be applied in a manner such that the lubricant penetrates into the chain joints to prevent wear. Lubricate the full length of all strands.

1. Inspect and lubricate the lift chains every truck PM.
2. Under some operating conditions, e.g. in very dirty or corrosive environments, it may be necessary to inspect and lubricate the chains between PMs.
3. Use lubricant as specified in Lubrication Order (Refer to Appendix E).

Lift Chain (Fork Height) Adjustment

NOTE

It is important to make the lift chain adjustment check with a rated load to be sure that the chains are stretched to their maximum length.

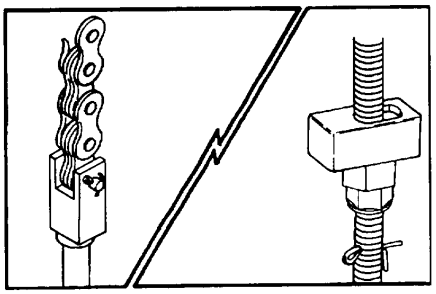


Figure 2. Typical view of chain anchors.

The lift chains are mounted to the chain anchors on the lift carriage and at the chain anchor rods near the lift cylinder piston head. The lift chains can be adjusted by loosening or tightening the chain anchor nuts.

Lift chains should be adjusted to provide equal tension in each strand of chain. Lift chains are correctly adjusted if the lower fork carriage rollers reach their end (lowest) position approximately 0.50 inch (13 mm) from the lower edge of the inner rail. This also positions the bottom of the forks the same (equal) distance above the floor.

1. To check this dimension, raise the carriage to a height that exposes several inches of the inner rail at the roller path. Apply a layer of grease to the roller path on the inner rail. Lower the carriage, pick up a rated capacity load, tilt the upright back slightly, and raise the load until the carriage rollers have passed over the greased area. Lower the load completely and remove the load from the forks. Raise the carriage again to expose the inner rail. You can now check the roller path pattern in the grease and determine the correct adjustment of the chains.
2. Adjust lift chains as necessary.
3. Inspect the lift chain anchors at both ends of chain.

Be sure both nuts, for each chain anchor, are in place.

Be sure there is a cotter pin in the end of each anchor.

4. As an alternate check procedure, the lift carriage chains should be adjusted so that the bottoms of the forks are 0.50 inch (12.1 mm) above the floor.

Lift Chain Inspection and Measurement for Wear

WARNING

Do not attempt to repair a worn chain. Replace worn or damaged chain or injury to personnel and damage to equipment could result.

1. Inspect the lift chains every truck PM (50-250 hours). When operating in corrosive environments, inspect the chains every 50 hours.
2. During inspection, check for the following chain conditions:

- Rust and corrosion
- Cracked plates
- Raised or turned pins
- Tight joints
- Wear, e.g. worn pins or holes

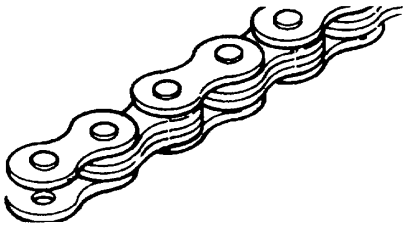


Figure 3. Illustration of typical chain wear and damage.

3. When the pins or holes become worn, the chain becomes longer. When a section of chain is 3 per cent (%) longer than a section of new chain, the chain is worn out and must be discarded.
4. Chain wear can be measured by using a chain scale or a steel tape measure. When checking chain wear, be sure to measure a segment of chain that moves over a sheave.

5. Do not repair chains by cutting out the worn sec tion and joining in a new piece.
6. If part of a chain is worn, replace all the chains or the truck.

Lift Chain Inspection and Wear Criteria

NOTE

Take measurement while chain is under tension when lifting a small load.

1. **New Chain Length** - The distance from the firs pin counted to the last pin counted in a span while the chains are lifting a small load.
2. **Worn Chain Length** - See (1) above.
3. **Span** - The number of pins in the length (segment, of chain to be measured, including the first one.
4. **Pitch** - The distance from the center of one pin to the center of the next pin.

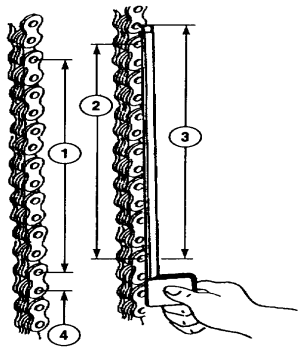


Figure 4. Measuring chain for wear, using tape measure.

Table of Chain Dimensions

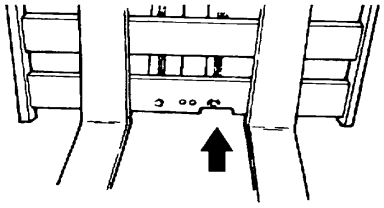
Leaf Chain

Chain No.	Pitch	Span	Worn Chain Length
BL800	1.00 in. (25.4 mm)	13	12.375 in. (314.3 mm)

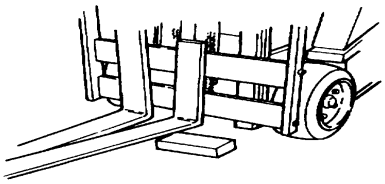
Lift Chain Replacement

1. ***All*** chains must be replaced if any strand has wear of 3% or more, or if any of the chain-damage conditions noted previously are found during inspection.
2. Replace all chains as a set (in pairs). It is impossible to keep a balanced loading and wear life between chains if a new chain is put into service opposite an old chain. Inequities between the new and the older, worn chain will cause problems in keeping chain tension equal, accelerated wear, and probable early failure.
3. Order replacement chains as required.
4. Do not remove the factory lubrication from new chains. It helps prevent wear and corrosion. If the original lubricant has dried or been removed, apply lubricant as specified in Lubrication Order (Appendix B).
5. Do not paint new chain before or after installation. Paint may help prevent corrosion, but will also prevent lubricant from reaching the pins for good joint lubrication.
6. Carefully inspect the chain anchors and sheaves. Broken, cracked, or worn anchors must be replaced. Replace worn sheaves, and check the sheave bearings for wear.
7. Use new anchor pins when installing new chains.
8. Adjust the tension on new chains.
9. Lubricate chains when they are installed on the upright.

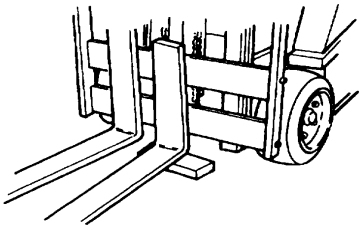
Fork Removal



1. Release the fork latches and move each fork to the notch on bottom of carriage.



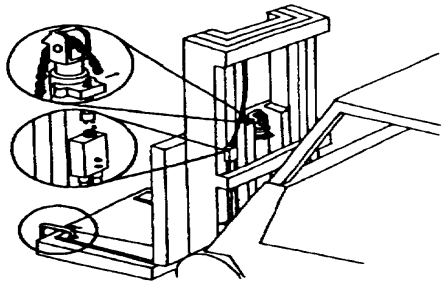
2. Lift each fork and put a block under it near the heel.



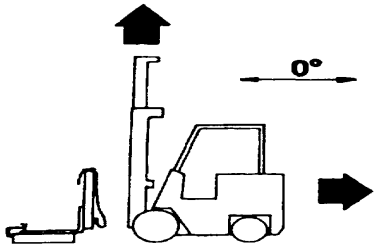
3. Push down on tip of fork to disengage from carriage. Move both forks out of the way.
4. Reverse this procedure for fork installation.

Carriage Removal (TSU) Triple Stage Upright

1. Apply parking brake and block steer wheels.
2. Start engine, set tilt to 00 vertical, and raise forks a minimum of 6 inches (152 mm).
3. Put a good, substantial pallet under the forks.
4. Turn key switch OFF. Place directional control in NEUTRAL.
5. Lower carriage and forks onto the pallet and continue to lower until the primary (center mounted) cylinder piston rod is completely collapsed into the cylinder.
6. Use a C-clamp to clamp one fork to the pallet. This will prevent carriage from falling over after it is removed from the inner rails.
7. Remove the cotter pins and (carriage) chain anchor pins, located near the top rear of the primary cylinder, and disconnect lift chains. Lay the chains over the carriage.



8. Remove the hydraulic hose leading to the primary (center mounted) cylinder, at the top of divertor valve block, located on the left side of upright.
9. Plug hydraulic line with a #12 plug and put a #12 cap on the divertor valve fitting. Tighten cap. This will allow hydraulic raising of the upright without extending the primary cylinder.
10. As applicable on some models, remove upper primary hose retainment bracket located on left underside of top tie bar.



11. Remove steer wheel blocks. Start engine and raise upright until inner rail clears the rollers on carriage. Release parking brake and slowly back truck away from carriage.

Upright Removal

WARNING

- **Use only approved hooks, chains, and connecting links when lifting and handling the upright. Be sure the hoist, hooks, and chain have the correct capacity to safely handle the load.**
- **Attach a chain or sling of correct capacity to the up right and a hoist before removing any tilt cylinder at tachment parts. Be sure upright is securely supported by the hoist and slack removed before removing up right mounting trunnion caps. Failure to do so could result in personal injury or death.**

NOTE

To perform this service procedure, it is recommended that you first:

- **Park truck on a level surface.**
- **Put the upright in a vertical position and lower the carriage fully down.**
- **Return all controls to neutral.**
- **Turn key switch OFF.**
- **Apply parking brake and block steer wheels.**

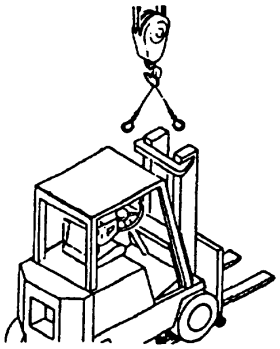
NOTE

Typical upright weights may range from 1500 lbs (680 kg) to in excess of 2000 lbs (910 kg).

Keep RH and LH caps matched to respective brackets. Caps are not interchangeable. Caps must always be reinstalled in same original top-to-bottom position.

Refer to upright mounting parts illustration and to tilt cylinder mounting illustration.

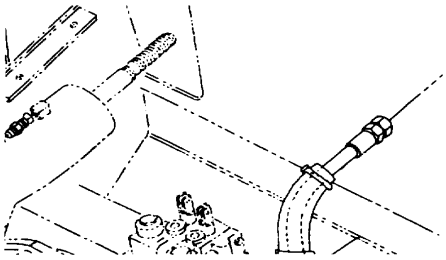
1. Remove all hydraulic attachments and equipment, forks, etc.
2. Put blocks on both sides of the steer wheels.
3. Raise the front of the truck and put blocking under each side of the frame.
4. Remove drive wheels. For best access to upright mounting trunnion fasteners.
5. Attach lifting chains and hoist to upright.



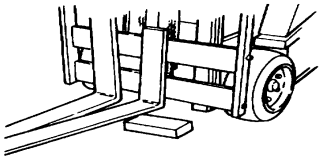
Be sure to secure and support the upright from falling **before** removing the tilt cylinders. The upright must be supported by use of an overhead chain hoist of adequate capacity.

6. Disconnect the hydraulic lift line(s).

Refer to lift & tilt lines illustration, Page 10.0-8.



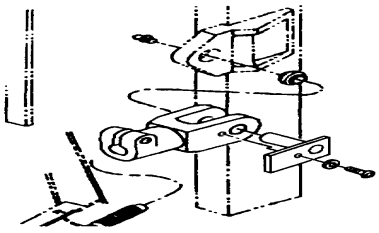
a. Put a pan under drive axle to catch hydraulic fluid. Disconnect the hydraulic lift line to the lift cylinder. Cap or plug the ends of the line and fittings to prevent drainage and contamination of the lines.



b. Disconnect the lift cylinder vent line.
c. Remove (pull) the vent line from the hose retainers on lift cylinder.

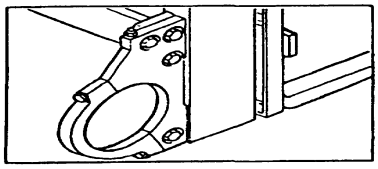
7. Disconnect tilt cylinders.

Refer to tilt cylinder mounting illustration, Section 10.7.



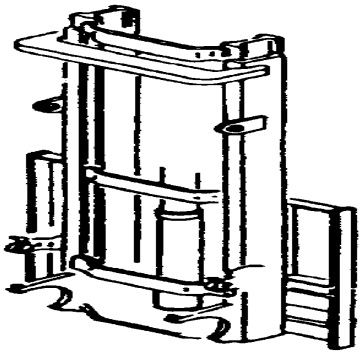
a. Loosen and remove the capscrew and rod end pin retainer (or plate) from the tilt cylinder forward end at upright.
b. Remove the mounting pin and separate the tilt cylinder rod end from the upright bracket.
c. Remove rod end pin bearing from upright bracket, as required.

8. Remove upright mounting trunnion caps.



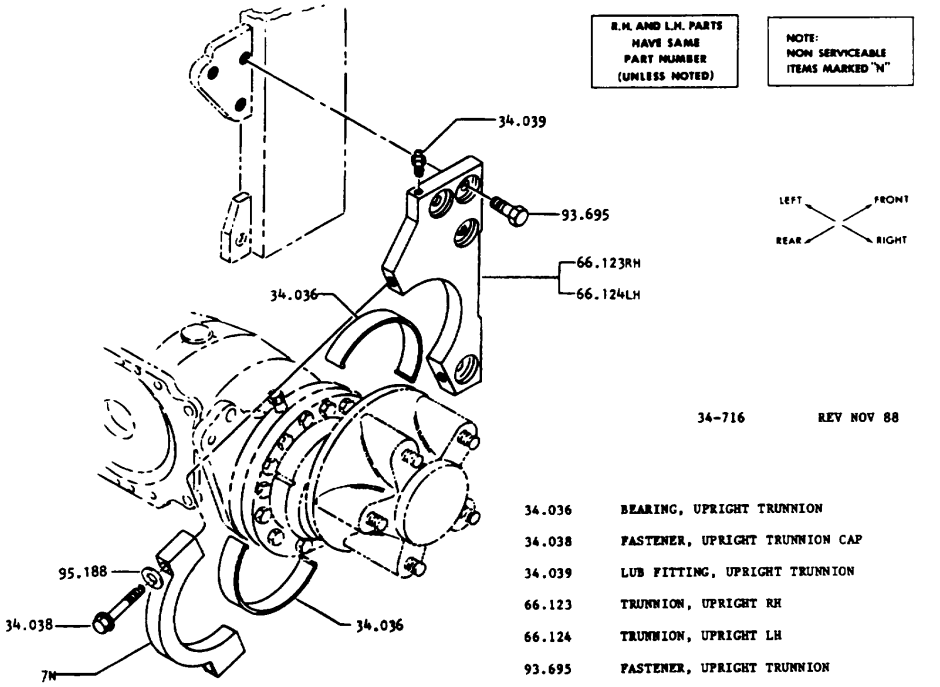
aScribe a match mark on the top of each upright mounting trunnion and cap for matching at assembly.
b. Loosen and remove the upright trunnion cap fasteners. Remove trunnion caps. Trunnion cap bolt torque spec: 55-59 lb ft (75-80 Nom).
c. Remove the upright trunnion bearings from drive axle.
d. Carefully inspect trunnion bearings for wear, cracks, broken pieces, or other damage. Replace trunnion bearings at assembly, as necessary.

9. Remove upright from truck and store out of the way.



a. Raise upright slightly to disengage trunnion brackets from drive axle.
b. Move upright carefully away from truck and to a safe storage position.

Upright Mounting Parts



Upright Mounting

NOTE

Clean threads of capscrews and trunnion brackets to remove all lubricants. Apply Loctite No. 271 (red) or equiv. to bolt threads at assembly.

1. Install mounting brackets on upright. Tighten bolts to torque spec: 273-302 lb ft (370-410 Norm).
2. Install trunnion bearings on axle and trunnion cap. Apply generous coating of Grade #1 Lithium soap base multi-purpose grease to trunnion bearings at installation. Fill bearings (lube fitting) after installation with same grease.
3. Install trunnion caps. Install bolts (and washers, if specified). Tighten bolts to torque spec: 55-59 lb ft (75-80 N-m).

Installation

WARNING

Use only approved hooks, chains, and connecting links when lifting and handling upright. Be sure the hoist, hooks, and chain have the correct capacity to safely handle the load.

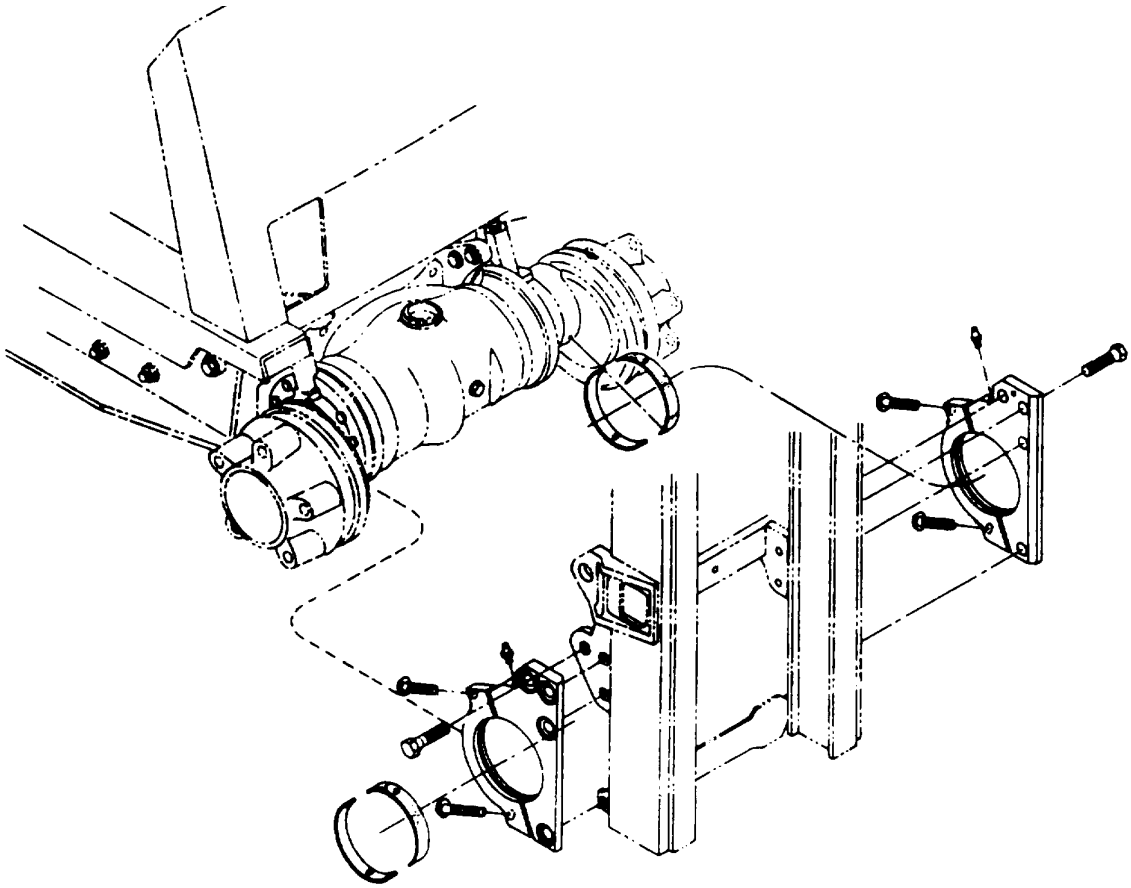
NOTE

This discussion covers typical upright installation on a truck separate from the previous removal procedure. Some steps may be eliminated if upright is being reinstalled after removal as previously described.

Clean threads of capscrews and trunnion brackets to remove all lubricants. Apply Loctite No. 271 (red) or equiv. to bolt threads at assembly.

1. Put blocks at both sides of steer wheels.

Upright Installation

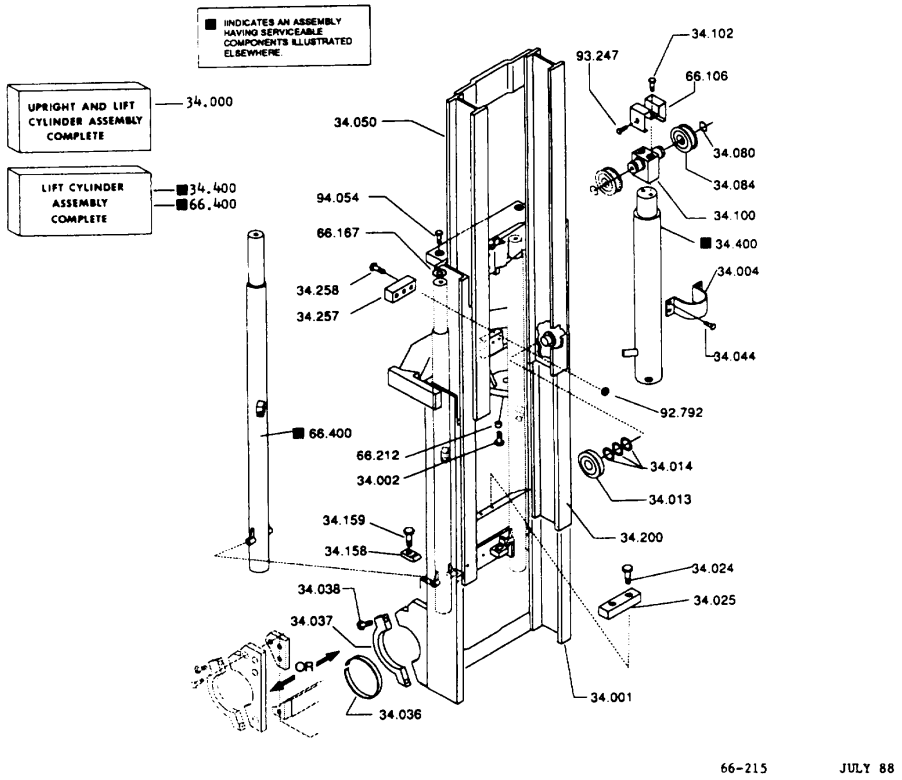


2. Raise the front of truck. Put blocking under each side of the frame.
3. Remove drive wheels. For best access to upright mounting trunnion fasteners.
4. As required, install upright mounting brackets on upright. See Note above. Tighten bolts to torque spec: 273-302 lb ft (370-410 Nom).
5. Attach lifting chains and hoist to upright.
6. Lift and move upright into position to install on truck.
7. Install trunnion bearings on axle and trunnion cap. Apply generous coating of Grade #1 Lithium soap base multipurpose grease to trunnion bearings. Fill bearings (lube fitting) after installation with same grease.
8. Install RH and LH trunnion caps. See Note above. Install bolts (and washers, if specified)Tighten bolts to torque spec: 55-59 lb ft (75-80 N^0m).
9. Connect the tilt cylinders to upright. Be sure to install rod end pin bearing with grease fitting in upright. See Section 10.7.
10. Connect the hydraulic lift line(s).
11. Install drive wheels.
12. Raise truck and remove blocking from under the frame. Remove hoist.
13. Install hydraulic attachments and equipment as applicable, forks, etc.

13.3. Triple Stage Upright (TSU)

Triple Stage Upright Assembly F-508
Primary Lift Cylinder - TSU Upright F-509
Final Lift Cylinder - TSU Upright F-510
Lift Cylinder Piping - TSU Upright F-511
Lift Chain - TSU Upright F-512

Triple Stage Upright Assembly



34.000 UPRIGHT & LIFT CYLINDER ASSEMBLY, COMPLETE
34.001 OUTER RAIL WELDED ASSEMBLY, UPRIGHT
34.002 FASTENER, LIFT CYLINDER
34.004 CAP, LIFT CYLINDER RETAINER
34.013 ROLLER, UPRIGHT
34.014 SHIM, UPRIGHT ROLLER
34.024 FASTENER, OUTER RAIL STOP BLOCK PAD
34.025 PAD, OUTER RAIL STOP BLOCK
34.036 BEARING, UPRIGHT TRUNNION
34.037 CAP, UPRIGHT TRUNNION
34.038 FASTENER, UPRIGHT TRUNNION CAP
34.044 FASTENER, LIFT CYLINDER ANCHOR
34.050 INNER RAIL WELDED ASSEMBLY, UPRIGHT
34.080 RETAINER, LIFT CHAIN SHEAVE
34.084 SHEAVE, LIFT CHAIN
34.100 CARRIER, LIFT CHAIN SHEAVE
34.102 RETAINER, LIFT CHAIN SHEAVE CARRIER
34.158 RETAINER, LIFT CYLINDER (FINAL)
34.159 FASTENER, LIFT CYLINDER RETAINER
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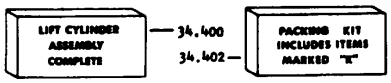
34.257 STOP BLOCK, UPRIGHT RAIL
34.258 FASTENER, UPRIGHT RAIL STOP BLOCK
34.400 LIFT CYLINDER ASSEMBLY (PRIMARY)
66.106 GUARD, LIFT CHAIN SHEAVE SAFETY
66.167 SHIM, LIFT CYLINDER UPPER
66.212 SPACER, LIFT CYLINDER FASTENER
66.400 CYLINDER ASSEMBLY, FINAL LIFT
92.792 NUT, RAIL STOP BLOCK FASTENER
93.247 FASTENER. LIFT CHAIN SHEAVE SAFETY GUARD
94.054 FASTENER, FINAL LIFT CYLINDER (UPPER)

Primary Lift Cylinder - TSU Upright



34.400	LIFT CYLINDER ASSEMBLY
34.401	BARREL ASSEMBLY, LIFT CYLINDER
34.402	PACKING KIT, LIFT CYLINDER
34.443	WEAR RING, LIFT CYLINDER PISTON
34.469	SEAL, GLAND CAP TO LIFT CYLINDER
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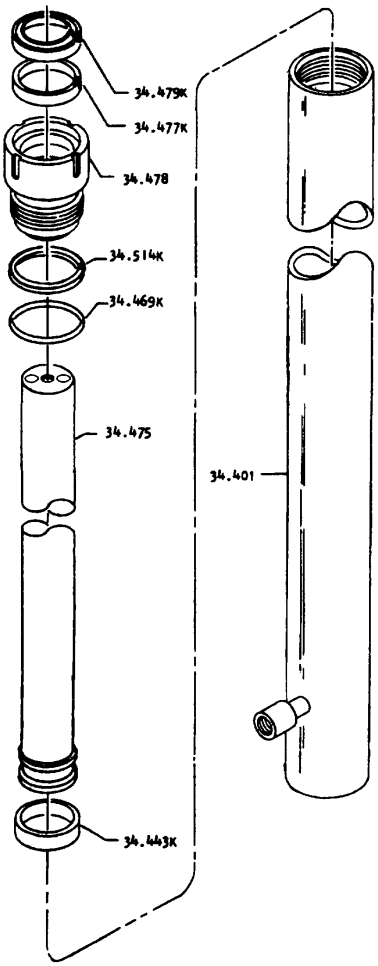
34.514	BACK-UP RING, LIFT CYLINDER GLAND SEAL



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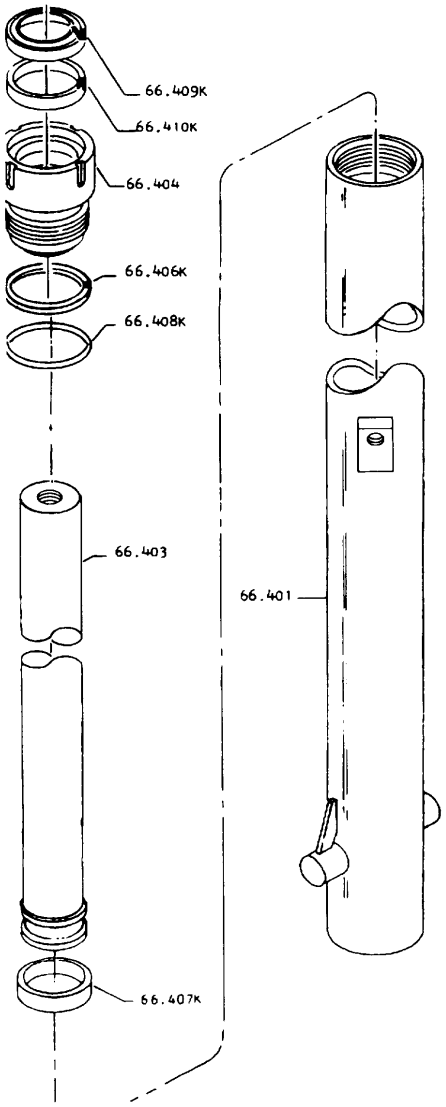
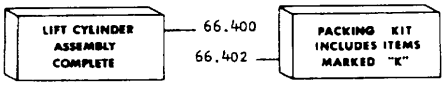
Final Lift Cylinder - TSU Upright





66.400	CYLINDER ASSEMBLY, FINAL LIFT
66.401	BARREL, FINAL LIFT CYLINDER
66.402	PACKING KIT, FINAL LIFT CYLINDER
66.403	PISTON ROD, FINAL LIFT CYLINDER
66.404	CAP, FINAL LIFT CYLINDER GLAND
66.406	BACK-UP RING, FINAL LIFT CYLINDER GLAND CAP
66.407	WEAR RING, FINAL LIFT CYLINDER PISTON
66.408	SEAL, FINAL LIFT CYLINDER GLAND CAP
66.409	WIPER, FINAL LIFT CYLINDER PISTON ROD
66.410	SEAL, FINAL LIFT CYLINDER PISTON ROD

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Lift Cylinder Piping - TSU Upright

28.726	SHEAVE, LIFT CYLINDER HOSE
28.727	PIVOT, LIFT CYLINDER HOSE SHEAVE
28.729	LINE, LIFT CYLINDER (PRIMARY)
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28.740	BRACKET, LIFT CYLINDER HOSE MOUNTING
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31.033	CLAMP, LIFT CYLINDER LINE
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94.176	NUT, LIFT CYLINDER LINE CLAMP FASTENER
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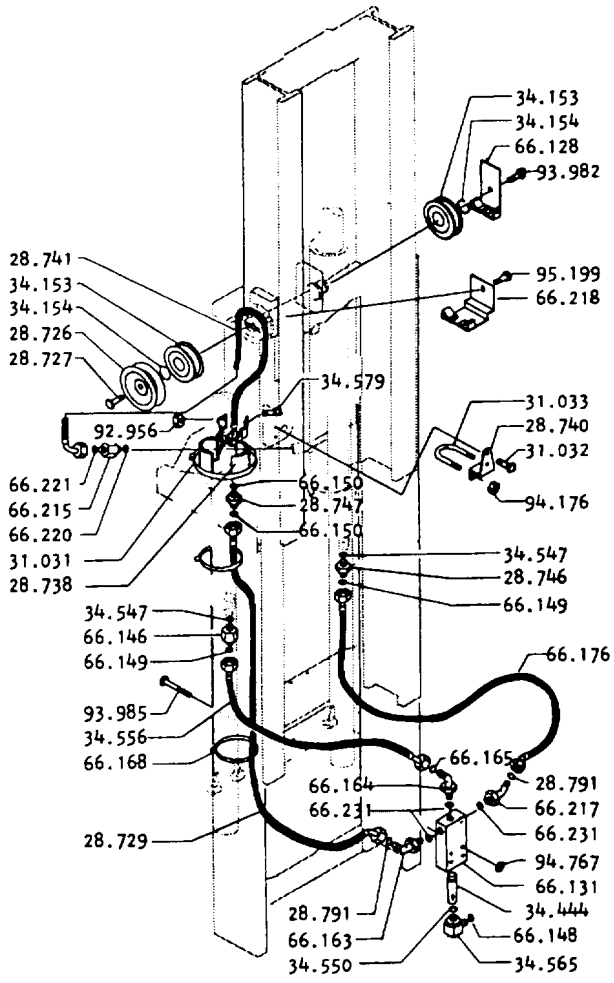

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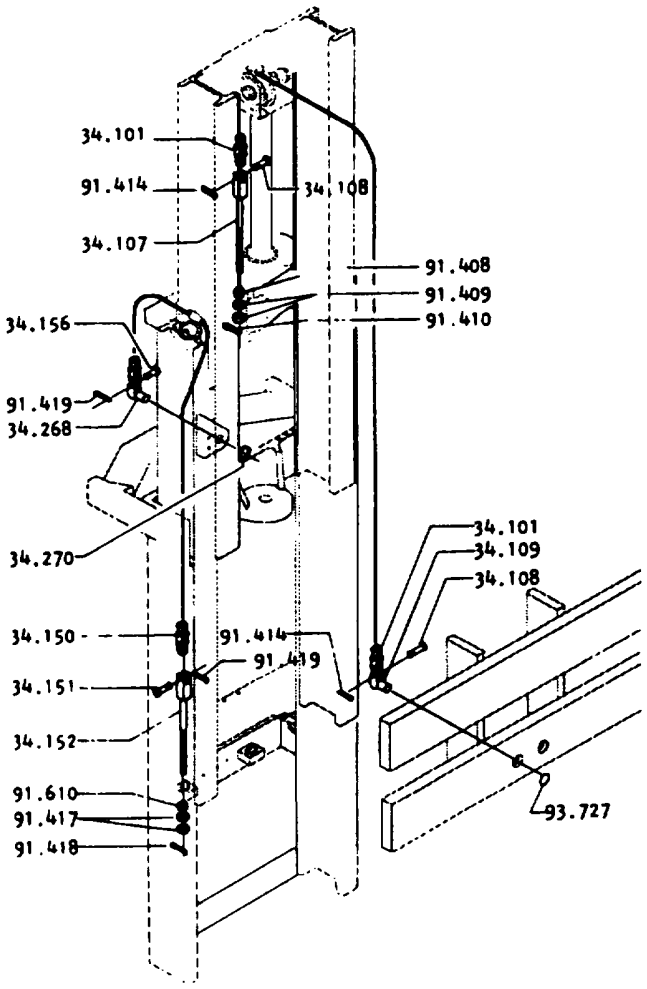
Lift Chain - TSU Upright



34.101	CHAIN, LIFT
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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches

1 Meter = 100 Centimeters = 1,000 Millimeters = 39.37 Inches

1 Kilometer = 1,000 Meters = 0.621 Miles

SQUARE MEASURE

1 Sq Centimeter = 100 Sq Millimeters = 0.155 Sq Inches

1 Sq Meter = 10,000 Sq Centimeters = 10.76 Sq Feet

1 Sq Kilometer = 1,000,000 Sq Meters = 0.386 Sq Miles

CUBIC MEASURE

1 Cu Centimeter = 1,000 Cu Millimeters = 0.06 Cu Inches

1 Cu Meter = 1,000,000 Cu Centimeters = 35.31 Cu Feet

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces

1 Liter = 1,000 Milliliters = 33.82 Fluid Ounces

TEMPERATURE

5/9 (°F -32) = °C

212° Fahrenheit is equivalent to 100° Celsius

90° Fahrenheit is equivalent to 32.2° Celsius

32° Fahrenheit is equivalent to 0° Celsius

9/5 C° +32 = F°

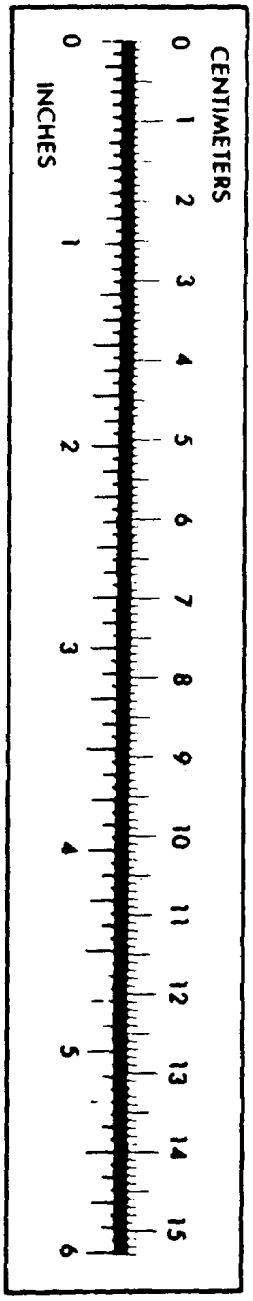
WEIGHTS

1 Gram = 0.001 Kilograms = 1,000 Milligrams = 0.035 Ounces

1 Kilogram = 1,000 Grams = 2.2 Lb.

1 Metric Ton = 1,000 Kilograms = 1 Megagram = 1.1 Short Tons

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds Per Square Inch	Kilopascals	6.895
Miles Per Gallon	Kilometers Per Liter	0.425
Miles Per Hour	Kilometers Per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds Per Square Inch	0.145
Kilometers Per Liter	Miles Per Gallon	2.354
Kilometers Per Hour	Miles Per Hour	0.621