TAYLOR-DUNN®

The Best Way To Go About Your Business

TIGER TRACTOR
A TAYLOR-DUNN® COMPANY

Models Inlcuded: TC-030-60
Equipped with Ford DSG 2.3L Engine

MANUAL MC-TC50-03EF

FedEx Spec # 105361000

Operation, Troubleshooting and Replacement Parts Manual

FedEx Express

Published: 10/18/2010
Revision: A, 10/18/2010

Serial number Range:
183230 through 186045

Tiger Tractor

FedEx Model TC-030-60 (TC-50)

Operator and Service Manual Section Index

This quick reference section index guide will assist you in locating a desired topic or procedure.

Refer to each sectional Table of Contents for the page number location for specific topics or procedures.

Introduction

Contents

ABOUT THIS MANUAL

The purchase of this vehicle shows a belief in high quality products manufactured in the USA. Tiger Manufacturing® (a Division of Taylor-Dunn®), a leading manufacturer of Industrial Tow Tractors and Ground Support Equipment since 1990, wants to be sure this vehicle provides years of reliable service. Please continue to read this manual and enjoy this high quality Tiger Manufacturing® vehicle.

This manual is to serve as a guide for the service, repair, and operation of Tiger Manufacturing® vehicles and is not intended as a training guide. Tiger Manufacturing® has made every effort to include as much information as possible about the operation and maintenance of this vehicle.

Included in this manual are:

- Vehicle Description
- Safety Rules and Guidelines
- Operational Information
- Operator Responsibilities
- Owner Responsibilities
- Control Operation and Location Information
- Maintenance and Troubleshooting Information
- Standard Parts List

Before servicing, operating, training or performing maintenance on this or any other Tiger Manufacturing® vehicle, read the appropriate Tiger Manufacturing® manual.

Each Tiger Manufacturing® manual references the applicable models and serial numbers on the front cover.

Please, be aware of all cautions, warnings, instructions, and notes contained in this manual.

WHO SHOULD READ THIS MANUAL

This manual is intended for use by anyone who is going to operate, own, perform maintenance on, service, or order parts for this Tiger Manufacturing® vehicle. Each person should be familiar with the parts of this manual that apply to their use of this vehicle.

RESPONSIBILITIES

Of the Owner...

The owner of this or any Tiger Manufacturing® vehicle is responsible for the overall maintenance and repairs of the vehicle, as well as the training of operators. Owners should keep a record of conducted training and maintenance performed on the vehicle. (OSHA Regulation, 29 CFR 1910.178 Powered Industrial Truck Operator Training).

Of the Operator...

The operator is responsible for the safe operation of the vehicle, preoperational and operational checks on the vehicle, and the reporting of any problems to service and repair personnel.

Of the Service Personnel...

The service personnel are responsible for the service and maintenance of the vehicle. At no time should a service person allow any untrained personnel to service or repair this or any Tiger Manufacturing® vehicle. For the purposes of training, a qualified service person may oversee the repairs or services being made to a vehicle by an individual in training. At no time should an untrained individual be allowed to service or repair a vehicle without supervision. This manual is not a training guide.

Of the Passengers ...

The passengers are responsible to remain fully seated, keeping their hands, arms, and legs inside the vehicle at all times. Each passenger should be fully aware of the vehicle's operation. All forms of recklessness are to be avoided. Do not engage in horseplay.

HOW TO USE THIS MANUAL

This manual is organized into Five Chapters containing several sections each:

CHAPTER 1 - GENERAL DESCRIPTION AND OPERATING INSTRUCTIONS

This section describes the major components and how to properly use the Equipment.

CHAPTER 2 - MAINTENANCE

This section outlines the preventative maintenance schedules, general troubleshooting, removal and installation of various components and includes wiring diagrams and hydraulic schematics.

CHAPTER 3 - OVERHAUL AND MAJOR REPAIRS

This section describes general removal and installation of the three majors assemblies (engine, transmission and drive axle). For detailed information for overhauling major assemblies refer to CHAPTER 5.

CHAPTER 4 - ILLUSTRATED PARTS LIST

This section provides an illustrated view of various assemblies. The illustrations are accompanied by tables identifying the parts.

CHAPTER 5 - MANUFACTURERS APPENDICES

This section provides Detailed Maintenance and Repair data for the Major assemblies (Engines, Transmission, Drive Axle, ETC).

HOW TO IDENTIFY YOUR VEHICLE

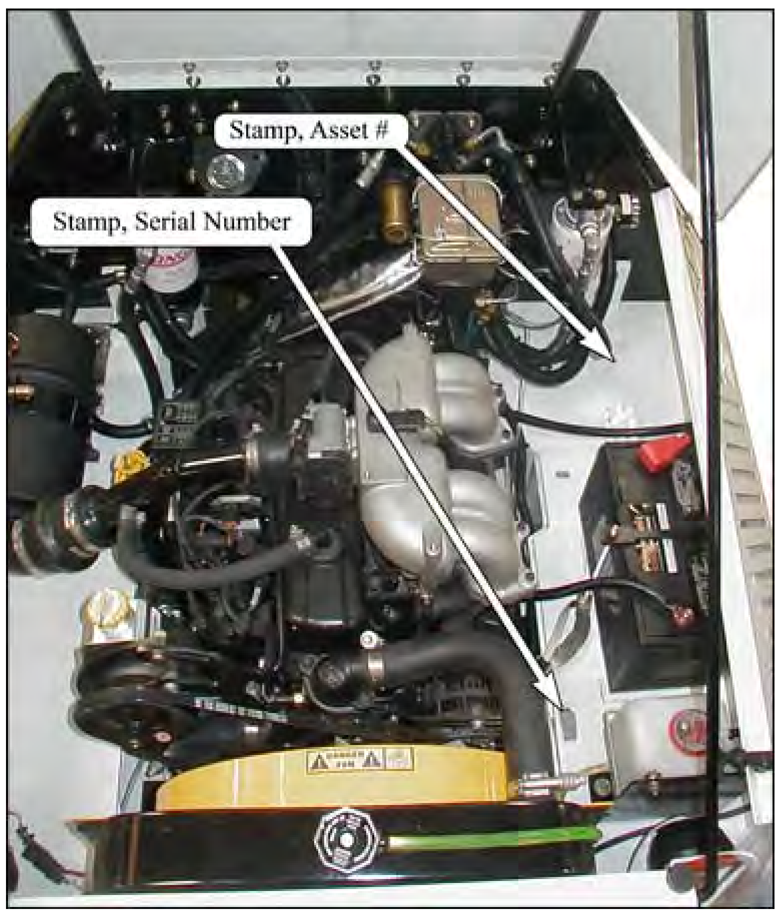
This manual applies to vehicles with the same model and serial numbers listed on the front cover.

These vehicles are designed for driving on smooth surfaces in and around facilities such as industrial plants and airports. They are not to be driven on public highways.

WARNING: **This vehicle is not designed to be driven on public roads or highways. It is available in maximum designed speed of 15 mph. Do not exceed the maximum designed speed. Exceeding the maximum designed speed may result in steering difficulty, and / or loss of control. Do not exceed locally imposed speed limits. Do not tow this vehicle at more than 5 mph.**

The locations of the model and serial numbers are illustrated below:

Data Plate



TAKING DELIVERY OF YOUR VEHICLE

Inspect the vehicle immediately after delivery. Use the following guidelines to help identify any obvious problems:

- Examine the contents of all packages and accessories that may have come in separate packages with the vehicle.
- Make sure everything listed on the packing slip is there.
- Check that all wire connections, battery cables, and other electrical connections are secure.
- Check the tire pressure, tightness of lug nuts, and for any signs of damage.

Check the operation of each of the following controls or components:

- Accelerator
- Brake
- Hand Parking Brake (optional)
- Ignition Switch
- Shifter
- Headlights and Brake/Tail lights
- Steering Wheel
- Horn

What To Do If a Problem is Found

If there is a problem or damage as a result of shipping, note the damage or problem on the bill of lading and file a claim with the freight carrier. The claim must be filed within 48 hours of receiving the vehicle and its accessories. Also, notify Tiger Manufacturing® of the claim.

If there is a problem with the operation of the vehicle, DO NOT OPERATE THE VEHICLE. Immediately contact Tiger Manufacturing® and report the problem. The report must be made within 24 hours of receiving the vehicle and its accessories.

WARNING: **Only properly trained personnel authorized to repair, modify, or adjust any part of this or any Tiger Manufacturing® vehicle is a factory authorized service technician. Repairs made by unauthorized personnel may result in damage to the vehicles systems which could lead to an unsafe condition resulting in severe bodily injury and/or property damage. Unauthorized repairs may also void the vehicles warranty.**

CHAPTER 1
GENERAL DESCRIPTION AND OPERATING INSTRUCTIONS
TABLE OF CONTENTS

THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 1
SECTION 1: DESCRIPTION

1. Purpose of Equipment

The Tiger tow tractor is designed for airline, industrial, commercial, and railroad material towing operations. The engine, transmission, and driveline are designed to deliver high-towing capacity with smooth operation. The physical layout of the Tiger tow tractor combines easy-to-operate controls, specially designed safety features, and easy access for maintenance.

2. Description of Unit

The Tiger tow tractor is a four-wheeled, two-wheel-drive towing vehicle powered by an industrial engine, an automatic transmission, and a heavy-duty drivetrain. The unit is approximately 103.5" long (less hitch), 55.5" wide and 63" high (less cab) with a wheel base of 58.5". The total weight of the unit depends on the drawbar pull and the options installed. The total weight can vary from 4200 to 7800 lbs.

3. Physical Description of Major Components

Introduction: The physical descriptions that follow are meant to help the reader gain a better understanding of the major systems that are part of the Tiger tow tractor.

A. Engine:
The Tiger tow tractor is equipped with a heavy duty industrial engine.
Engine Specifications:
Please refer to the engine manufacturer's data in **Chapter 5 - Manufacturer's Appendices**.

B. Transmission:
The Tiger tow tractor is equipped with a heavy-duty industrial automatic transmission.
The transmission is equipped with three speeds forward and one reverse.

C. Drive Axle:
The drive axle is designed specifically for industrial use. Various gear ratios are available depending on customer requirements.

D. Drive Shaft:
The drive shaft uses two universal joints and a sliding spline coupling to deliver effective and quiet power transfer between the transmission and drive axle.

CHAPTER 1
SECTION 1: DESCRIPTION (CONT)

3. Physical Description of Major Components (Cont)

E. Service Brake:

The service brake system consists of a dual-system hydraulic design with a split reservoir master cylinder equipped with a hydraulic assist. There are two calipers per rear wheel.

F. Parking Brake:

The parking brake is operated by a mechanical lever that actuates a drum and band at the transmission output or a caliper and disc at the drive axle input.

G. Suspension:

Both the drive axle and steer axle use semi-elliptic, multi-leaf springs.

H. Steer Axle:

The Tractor is equipped with a heavy duty steer axle. Steering is controlled Hydrostatically through the use of hydraulic power supplied by an engine driven pump resulting in smooth and comfortable control of the tractor.

I. Wheels:

The standard front wheels are approximately 6.5” wide, 15” outside diameter with a five-hole bolt pattern. The standard rear wheels are approximately 7” wide, 28” outside diameter with an eight-hole bolt pattern.

J. Tires:

Pneumatic -

Pneumatic tires have a tubeless design and are rated for the specific weight, depending on the model and capacity, of the tractor. Pneumatic tires are best suited for maximum traction and a smoother ride.

Solid-mount and poly-fill -

when operating conditions cause frequent punctures or other physical damage to the tires, standard pneumatic tires can be filled with a poly-fill compound. The resulting ride is rough when compared to pneumatic tires. Another alternative in severe conditions is solid-mounted tires. These too, ride rough, but can reduce down time when applied in the right conditions.

K. Fuel System:

The fuel varies with fuel type, typically the system consist of the fuel cell, connecting lines, filters, and fuel pump. The gasoline fuel cell is constructed from stainless steel with welded seams and is pressure-tested to ensure safe operation. With a capacity of 13 gallons, it is generally sufficient for an eight-hour shift. The Liquid Propane fuel cells are constructed from Steel or Aluminum. European models feature a 64 Liter capacity fuel cell and North American models feature a 33 Pound capacity fuel cell.

L. Electrical System:

Electrical power is supplied by means of a heavy duty alternator and is stored by an industrial 12-volt storage battery with a negative chassis ground.

CHAPTER 1
SECTION 1: DESCRIPTION (CONT)

3. Physical Description of Major Components (Cont)

M. Chassis:

The chassis is a heavy-duty welded unibody fabricated from 6” channel steel beams.
The cross members are fabricated from 4” by 6” steel angle.
The side panels are also welded to the frame.

N. Towing Hitch:

The tractor can be supplied with several different types of towing hitches mounted both front and rear. The two most common are the “E” Hitch (usually mounted rear) and the Pintle Hitch. Any style hitch can be welded or bolted to the tractor, and generally will tow anything up to the drawbar pull limit of the tractor.

O. Seats/Seat Belts:

The seats provided with the tractor vary with customer specifications. Generally, the seats provided are ergonomically designed to reduce operator fatigue and are adjustable to ease operation. Seat belts are optional.

P. Cab:

One common option for the tractor is a cab. This allows for greater operation comfort when outdoor use is the norm. The cab options include a dome light, windshield wiper, heater/defrost, and a fan.

Q. Fasteners:

Tiger tractors are designed for easy access for maintenance and service. To help with this, special fasteners are used in certain areas such as the engine side panels and the dash board. In other areas, weld nuts are used so that service personnel can remove panels with ease.

R. Hood Gas Struts:

Tiger tractors use gas struts to assist in opening and holding the hood open.

<u>To open hood:</u> disengage hood latches at each front corner, lift hood up and engage hood prop rod.

<u>To close the hood:</u> disengage prop rod, lower hood and secure with latches.

THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 1
SECTION 2: OPERATION

1. Controls and Instruments

A. Parking Brake:

The parking brake lever is located to the right of the operator. Pulling the lever towards the rear of the tractor will engage the parking brake. Pushing the lever forward disengages the parking brake. The parking brake lever is adjustable, turning the handle to the right increases brake force, turning to the left decreases force on the brake. If parking brake requires adjustment contact properly trained maintenance personnel.

WARNING: FOR THE SAFETY OF THE OPERATOR AND OTHERS, THE PARKING BRAKE MUST BE ENGAGED WHENEVER THERE IS NO OPERATOR IN THE DRIVER'S SEAT AND WHENEVER THE ENGINE IS OFF.

B. Service Brake:

The service brake pedal is located directly below the steering wheel. By using his/her foot, the operator can apply pressure to the pedal, thereby engaging the hydraulic braking system and slowing the tractor down. Greater force will give greater braking effect.

C. Instruments:

Gasoline powered tractors are equipped with a Fuel Level Gauge on the dash panel, this indicates the level of fuel in the fuel cell. Liquid Propane powered units are equipped with a fuel level gauge mounted to the fuel cell. All units are equipped with an Hour Meter (located on the firewall in the engine compartment) it shows how many hours the engine has been running and is used by service personnel to determine when periodic maintenance is to be performed. (It does not operate when the engine is “Off” and the ignition switch is “On”).

CHAPTER 1
SECTION 2: OPERATION (CONT)

1. Controls and Instruments (cont)

D. Electrical Accessories:

1. Wiper Switch:

The windshield wiper switch (if equipped) is located on the dash to the right of the steering wheel. There are two versions of the switch; one toggles right and left; and the other toggles up and down. One the one that toggles right and left, left is “Off” and right is “On”. One the one that toggles up and down, down is “Off” and up is “On”.

2. Blower Switch:

On units equipped with heaters, the blowers switch is located on the dash to the right of the steering wheel. It has three speeds. Rotating the switch fully counterclockwise turns it “Off”. Clockwise from “Off”; is “Low”,” Medium” and” High” settings.

3. Fan Switch:

On units equipped with fans for operator comfort, the switch is located on the fan. It has two speeds. When the switch is centered, it is “Off”.

4. Dome Light:

On units equipped with a dome light, the switch is located on the dome light.

E. Shifter:

The shifter is located to the right of the operator. It allows the operator to select the direction of travel. On two-speed models, it is labeled with “R” for Reverse, “N” for Neutral, and “D” for Drive or forward.

Your vehicle is equipped with a Shift Inhibitor Lockout that prevents changing gears unless the brake pedal is firmly depressed. There is a green indicator lamp on the transmission tunnel in front of the shifter. Before attempting to move the shift lever, firmly apply the foot brake untill the light turns on.

F. Ignition Switch:

The ignition switch is located on the dash panel to the left of the steering column. It has three positions: Fully counterclockwise is the “Off” position, clockwise from “Off” is “Run”, then “Start”. The ignition switch has an ‘Anti-Restart” feature. This feature will not allow the starter to be engaged more than one time without returning the switch to the ‘Off’ position before attempting a restart. This protects the starter from the damage that is caused when the starter is engaged while the engine is running.

CHAPTER 1
SECTION 2: OPERATION (CONT)

1. Controls and Instruments (cont)

G. Accelerator Pedal:

The accelerator pedal is located on the floorboard in front of the operator and to the right of the brake pedal. It is used to control engine speed. When the transmission is in gear, pressing down on the accelerator pedal will increase the speed of the tractor (either forward or reverse). Using greater pressure will cause faster acceleration. It is best to use enough pressure to obtain a smooth acceleration.

WARNING: ALWAYS CHECK FOR PERSONNEL OR OBJECTS BEFORE MOVING TRACTOR IN ANY DIRECTION.

H. Steering:

The steering wheel is located directly in front of the operator. It controls the direction the front wheels turn, and thereby which direction the tractor is traveling.

I. Hood Gas Struts:

These gas struts assist in opening and holding the hood over the engine compartment. To open hood: disengage hood latches at each front corner, lift hood up and engage prop rod. To close hood, disengage prop rod and lower hood. Secure with latches.

2. Safety Precautions

A. General

WARNING: FAILURE TO COMPLY WITH THE OPERATING PROCEDURES CONTAINED IN THIS MANUAL CAN RESULT IN SERIOUS INJURY OR DEATH. DO NOT MODIFY UNIT IN ANY MANNER. TIGER MANUFACTURING CORPORATION HAS TAKEN A GREAT CARE TO PRODUCE EQUIPMENT THAT IS SAFE AND FUNCTIONAL. HOWEVER, SAFETY OF THE OPERATOR AND THE SURROUNDING WORKING AREAS IS GREATLY DEPENDANT UPON THE OPERATOR AND HIS/HER KNOWLEDGE OF THIS UNIT'S OPERATION.

CAUTION: EVERYONE WHO IS TO OPERATE THE EQUIPMENT MUST READ AND UNDERSTAND THE INFORMATION CONTAINED IN THE OPERATION SECTION OF THIS MANUAL. TIGER MANUFACTURING CORPORATION RECOMMENDS TO OUR CUSTOMERS THAT OPERATORS BE REQUIRED TO READ THE OPERATION SECTION. THEY SHOULD SIGN A FORM, STATING THEY HAVE READ THE OPERATING INSTRUCTIONS AND THAT THEY UNDERSTAND THE CONTENTS THEREOF. MISUSE OF THIS EQUIPMENT CAN USE DAMAGE TO THE EQUIPMENT AND SURROUNDING PROPERTY.

CHAPTER 1
SECTION 2: OPERATION (CONT)

2. Safety Precautions (cont)

B. Operator's Responsibilities:

Always check for a clear path in the direction of travel. Sound horn before backing unit, when entering or crossing any existing traffic, and when turning blind corners. Be aware of your surroundings, of personnel, and other equipment.

Always check unit prior to use for proper operation of the following systems: parking brake, horn, lights, tires, steering, and service brakes. If any of these systems are not operational, report them and do not operate unit until problems are corrected.

Always engage parking brake before starting or dismounting unit for any length of time.

Always bring unit to a complete stop and allow unit to return to idle before shifting from "Forward" to "Reverse" or "Reverse" to "Forward".

Never dismount or allow passengers to mount or dismount the unit without coming to a complete stop and engaging the parking brake.

Never carry more passengers than the unit is designed to carry.

WARNING: NEVER ALLOW ANY PART OF YOUR OR YOUR PASSENGER'S BODY TO EXTEND BEYOND THE OUTER PERIMETER OF THE UNIT. COMING INTO CONTACT WITH STATIONARY OBJECTS WHILE UNIT IS IN MOTION CAN CAUSE SERIOUS INJURY OR DEATH.

Always keep hands and other body parts away from moving or rotating parts such as tires, wheels, engine pulleys, and axles. Always wear protective footwear or other appropriate clothing when working around unit.

Always check that the load is secure and properly connected to the unit before moving.

Always allow plenty of braking distance, taking into consideration the load being towed and the driving conditions.

Do not operate at speeds inconsistent with conditions. Slow unit down when turning corners. Remember when towing heavy loads that turning sharp corners at any speed can cause the load to shift or turn over. The load could also continue traveling in a straight line, causing the tractor and load to be at right angles to each other, resulting in jackknifing.

Never use the unit to push a load.

Always use the hitch when towing loads.

Never exceed the towing capacity of the unit.

CHAPTER 1
SECTION 2: OPERATION (CONT)

2. Safety Precautions (cont)

B. Operator's Responsibilities (cont):

Do not attempt to adjust engine speed governor or any other safety-related item. Report all defects to trained maintenance.

Do not adjust or bypass electrical safety systems.

Never remove radiator cap when engine is hot. Serious injury can result.

Do not refuel unit while engine is running.

Do not refuel near any source of ignition. Do not smoke while refueling.

Do not fill fuel cell above bottom of filler tube screen. Clean up any spilled fuel.

Do not store fuel in containers not specifically made for the fuel used.

Do not store fuel near ignition source.

Do not use the unit's battery to start other equipment.

Never drive unit on grade greater than 15 degrees.

Know and follow your employer's safety rules and the rules in this manual.

C. Mechanic's Responsibilities:

When operating unit, follow the operator's responsibilities stated above.

Do not wear jewelry or loose clothing while working on the unit. These and similar items can get caught in moving parts and can cause serious injury.

Always keep hands and other body parts away from moving or rotating parts such as tires, wheels, engine pulleys, and axles. Always wear protective footwear or other appropriate clothing such as gloves when working around unit.

Never attempt to adjust belt tensions while engine is running.

Always remove positive battery cable when working under unit or working in engine compartment. Do not smoke while working in engine compartment. Battery fumes and fuel vapors are EXPLOSIVE.

CHAPTER 1
SECTION 2: OPERATION (CONT)

2. Safety Precautions (cont)

C. Mechanic's Responsibilities (cont):

Use care when handling battery. If any electrolyte is spilled on you or your clothing, flush area with large quantities of water. Wear gloves when cleaning up spilled electrolyte.

WARNING: BATTERY ELECTROLYTE IS ACID AND POISONOUS. IF ANY IS SPILLED ON YOUR SKIN OR CLOTHING, FLUSH IMMEDIATELY WITH AMPLE AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. IF IN EITHER CASE A BURNING SENSATION OR BURN IS PRESENT, SEEK MEDICAL ATTENTION. IF ANY ELECTROLYTE IS INGESTED, SEEK MEDICAL ATTENTION IMMEDIATELY.

Do not short out battery; serious injury might result.

Do not remove radiator cap while engine is hot. Coolant is under pressure and will spray if cap is removed, causing serious burns.

Do not touch engine, exhaust system, or hydraulic lines while engine is hot. Serious burns can result.

Always check safety-related items whenever servicing unit. Some of these include service brakes, brake-fluid level, parking brake adjustment, steering, lights, wheels, tires, tire pressure, and horn.

Always use jack stands when working under unit. If using a hydraulic lift, make sure the safety latch is in place before starting work.

Avoid using harsh chemicals or solvents on wiring, other composite or plastic parts and on painted surfaces.

Always check cables and belts when unit is in for service.

Never attempt to disassemble any tire-and-wheel assembly without first deflating the tire completely.

Never reuse damaged parts in a tire-and-wheel assembly.

Always use safety cage or a proper mechanical apparatus when disassembling and re-assembling tire-and-wheel assemblies.

Always check all fasteners on the unit while unit is in for any types of service. Use grade eight hardware where replacement is required.

Always check the torque on the wheel lug nuts. Using a torque wrench, retighten the lug nuts. (Front, 90 to 100 ft-lbs; rear 9/16 studs, 110 to 120 ft-lbs).

CHAPTER 1
SECTION 2: OPERATION (CONT)

3. Procedures

A. Preliminary checks:

Check the following items as the start of each shift:

Fuel level

Tire pressure and tire condition

Engine oil level

Engine coolant level at the coolant recovery tank

Parking brake

Service brake

Brake fluid level

Lights

Horn

Seat belts (if equipped)

B. Driving Instructions:

1. Starting unit:
   a. Apply parking brake.
   b. Remove wheel chocks (if equipped).
   c. Using your left hand turn and hold ignition key fully clockwise to crank engine. When engine starts, let the ignition switch return to the “Run” position.

2. Driving unit:
   a. Turn lights on.
   b. Fasten seat belt (if equipped).
   c. Firmly apply service brake so that the Shift Inhibitor light is on.
   d. Release parking brake.
   e. Check for objects or personnel in the intended direction of travel.
   f. Place transmission shifter in desired gear.
   g. Place both hands on steering wheel.
   h. Slowly release service brake.
   i. Slowly depress accelerator pedal until desired travel speed is reached.
   j. Adjust speed to driving conditions.
   k. Slow unit and sound horn when turning blind corners.
   l. Slow unit and sound horn when approaching other equipment and personnel.

3. To slow or stop unit:

   Slowly release accelerator pedal and gently depress service brake, if needed.

4. To stop unit quickly:

   Release accelerator pedal and press hard on service brake.

CHAPTER 1
SECTION 2: OPERATION (CONT)

3. Procedures (cont)

B. Driving Instructions (cont):

5. To change direction:
   - a. Come to a complete stop, holding service brake down so that the shift inhibitor light is on.
   - b. Check for objects or personnel in intended direction of travel.
   - c. Place transmission shifter in desired gear.
   - d. Place both hands on steering wheel.
   - e. Slowly release service brake.
   - f. Slowly depress accelerator pedal until desired travel speed is reached
   - g. Adjust speed to driving conditions.
   - h. Slow unit and sound horn when turning blind corners.
   - i. Slow unit and sound horn when approaching other equipment and personnel.

6. To dismount or park unit:
   - a. Come to a complete stop in an area out of the path of other traffic or at a designated parking zone. Take care not to block safety zones, loading ramps, or footpaths with the unit or with the load.
   - b. After coming to a complete stop, hold service brake down.
   - c. Place transmission in Neutral.
   - d. Engage parking brake; release service brake.
   - e. Turn lights off.
   - f. Turn ignition switch off (fully counterclockwise).
   - g. Remove seat belt (if applicable).
   - h. Check for traffic before dismounting.
   - i. If unit is equipped with wheel chocks, place chocks under the front and back of the left rear wheel.

CHAPTER 1
SECTION 2: OPERATION (CONT)

3. Procedures (cont)

C. Towing Instructions:

WARNING: DO NOT EXCEED THE TOWING CAPACITY OF THE UNIT. THIS WEIGHT LIMIT INCLUDES ALL ITEMS IN TOW AND LOADS THEY CONTAIN.

CAUTION: BEFORE TOWING ANY LOAD, CHECK THE FOLLOWING ITEMS –

CONDITION OF TOWING HITCH.
CONDITION OF TOW BAR.
CONDITION OF ALL WHEELS AND TIRES.
CONDITION OF BULKHEAD COVERS (IF EQUIPPED).
CONDITION AND PRESENCE OF SAFETY CHAINS.

1. To tow:
   a. Check the load. Be sure all parcels are secured.
   b. Back unit up to load and attach load to towing hitch. When dismounting unit -place transmission in Neutral and apply parking brake.
   c. Attach safety chains.
   d. Disengage trailer's parking brake and remove chock blocks. Watch for any movement in the load when disengaging trailer brake or removing chock blocks.
   e. While towing, make your starts and stops as smooth as possible, allowing for slack in the load's towing system.
   f. When approaching traffic or making turns, slow unit and sound horn.
   g. Be aware of other units and personnel.
   h. Make wide turns allowing clearance for complete load.
   i. Adjust speed to load and driving conditions.
   j. When approaching a bridge, make sure the combined weight of the unit and load does not exceed the load limit of the bridge.
   k. When destination is reached, place unit in Neutral and apply parking brake. Apply trailer brake or place chock blocks under load wheels. Disconnect load from towing hitch and safety chains.

CHAPTER 1
SECTION 2: OPERATION (CONT)

3. Procedures (cont)

D. Emergency Procedures:

CAUTION: AS THE OPERATOR, YOU WILL HAVE THE GREATEST IMPACT ON THE GENERAL SAFETY OF YOUR ENVIRONMENT. AS YOU GET USE TO A PARTICULAR PIECE OF EQUIPMENT, YOU ARE IN A BETTER POSITION THAN ANYONE ELSE TO NOTE MALFUNCTIONS OR ABNORMALITIES. DO NOT ATTEMPT TO CORRECT THESE PROBLEMS YOURSELF; REFER REPAIRS TO THE PROPER DEPARTMENTS. HOWEVER, IF THE PROBLEM HAS TO DO WITH A SAFETY-RELATED PART OF THE UNIT (SERVICE BRAKES, PARKING BRAKE, STEERING, ETC.), REPORT THE PROBLEM USING YOUR EMPLOYER'S PROCEDURES. DO NOT OPERATE UNIT UNTIL THE PROBLEM IS CORRECTED.

IN CASE OF FIRE: Bring unit to a complete stop, place transmission in Neutral. Engage parking brake and shut unit down. Exit unit and call for help.

FIRE EXTINGUISHER: Some units are equipped with fire extinguishers. If you feel confident in its operation in advance of an emergency, you will most likely use it properly. If after reading this procedure you still do not feel confident in its operation, check with your supervisors. In some cases, in-service training is available by qualified instructors who will not only explain operation, but will demonstrate its proper use. Fire extinguishers are classified by the type of fire for which they are designed to extinguish or put out.

The following list describes types of Fire Extinguishers

Class A: Ordinary Combustibles – wood, cloth, paper, rubber, most plastics, and other common materials that burn easily.

Class B: Flammable Liquids – gasoline, oil, grease, tar, oil-based paints, lacquer and flammable gas.

Class C: Electrical Equipment – energized electrical equipment, wiring, fuse panels, circuit breakers, machinery and appliances.

Use of a Dry chemical – Type ABC will extinguish the fire classes shown above.

To use a dry chemical, ABC-type extinguisher (the type offered as an option with Tiger Tractors):

1. Stand back about 10 feet from fire.
2. Pull ring pin, while holding extinguisher upright.
3. Aim at base of flames.
4. Squeeze handle to release chemical.
5. Sweep from side to side at base of flames.

CHAPTER 1
SECTION 2: OPERATION (CONT)

3. Procedures (cont)

D. Emergency Procedures (cont):

SERVICE BRAKE FAILURE: If the service brake system fails, the parking brake can be used to slow the unit quickly. Disengaging the accelerator (if engaged) will also have the effect of slowing the unit. Once the unit is idle, gradually engaging the parking brake will make for a smooth stop.

STEERING FAILURE: In the event the steering fails, slow unit as quickly as conditions permit. Engage parking brake and shut down unit.

TIRE FAILURE: If you experience a tire “blow out” or a flat tire while operating the unit, slow unit to a complete stop, Engage parking brake and shut down unit.

ENGINE FAILURE: If the engine fails, locks up, makes loud knocking sounds, oil pressure drops too low, or if unit is overheating, slow to a complete stop, engage parking brake and shut down unit. Report the problem to propely trained maintenance personell.

PARKING BRAKE FAILURE: If you are on the unit – stay on the unit. Start engine (if unit is not running) and engage service brake to stop unit. If you can get help, have someone place wheel chocks under the unit’s tires, then shut down unit. If you cannot get help, drive unit to a curb on a slight incline. If unit is facing downhill, turn front wheels into the curb and slowly allow front wheels to touch the curb. If unit is facing uphill, bring unit alongside curb (within 6”), stop unit, and turn wheels away from the curb, allowing unit to slowly touch the curb. In any case, DO NOT exit unit if it continues to roll.

If unit is unoccupied and rolling, Tiger Manufacturing does NOT recommend that anyone attempt to mount the unit. Stay out of the unit’s path, warn others, and wait until the unit stops before mounting it to correct the problem.

THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 1
SECTION 3: SPECIFICATIONS AND CAPABILITIES

1. Dimensions and Weights:

Length (excluding coupler) .... 103.5 inches
Width .... 55.5 inches
Height (without cab) .... 63.0 inches
Height (with cab) .... 80.0 inches
Wheel Base .... 58.5 inches
Minimum Ground Clearance .... 6.5 inches
Angle of Approach .... 24.14 degrees
Angle of Departure .... 28.14 degrees
Ramp Breakover Angle .... 18.44 degrees
Turning Radius .... 115.0 inches
Approximate Weight (without cab)
TC-50 .... 6700 pounds
Cab .... 750 pounds
NOTE: Weight will vary depending on options

2. Capabilities:

Drawbar pull capacities by model
TC-50 (rear hitch) .... 5,000 pounds
TC-50 (side hitch) .... Per FedEx Specification 095361000, 8-20-09, 3.3:
"12,000# wheeled load"
Drawbar pull capacity is the amount of weight the unit will pull in a straight line on a level surface (clean, dry brushed concrete or equivalent), measured at hitch.

3. Engine:

Please refer to the engine manufacturer's data in **"Chapter 5 - Manufacturer's Appendices"**.

CHAPTER 1
SECTION 3: SPECIFICATIONS AND CAPABILITIES (CONT)

4. Cooling System:

NOTE: For the type of cooling system, Please refer to the engine manufacturer's data in **"Chapter 5 - Manufacturer's Appendices"**.

System Capacity .... (Approximate) 3 gallons

5. Transmission:

Type .... Automatic transmission – three -speed with torque converter.
Cooling .... External Transmission oil cooler with inline filter.
Fluid Capacity .... 12.25 quarts (approx).
Fluid Specification .... Type F, Ford ESP-M2C138-CJ

6. Drive Axle:

Type .... Heavy-duty differential drive axle with double reduction gearbox.
Final Drive Ratio 20:1
Lubricant Capacity .... 7 quarts (approx)
Fluid Specification .... SAE 80W-90, GL-5
Refer to Maintenance Section for filling instructions.

7. Drive Shaft:

Type .... Universal joint, slip-yoke type axle.
Lubricant Type .... NLGI Grade No. 2 Lithium grease
Refer to Maintenance Section for service instructions.

CHAPTER 1
SECTION 3: SPECIFICATIONS AND CAPABILITIES (CONT)

8. Braking Systems:

A. Service Brake
Type .... Brake pedal connected to the power booster and
.... master cylinder with dual (split) ports connected to
.... rear dual caliper/disc brakes (front brakes optional)
Fluid Specification .... SAE, DOT 3

B. Parking Brake
Type .... Lever-operated independent park brake.

9. Suspension:

Type .... Semi-elliptical leaf springs mounted to frame,
.... both front and rear

10. Steering:

Type .... Hydrostatic (Hydraulic assist) Power Steering.
Type of Steer .... Front-wheel only
Refer to unit sections for service data.

11. Tires:

Type, Front .... 6.50 x 10 – Industrial
Pressure, Front .... 100 psi (cold)
Type, Rear .... LT225/75R16 – Industrial
Pressure, Rear .... 80 psi (cold)

12. Fuel System:

Fuel Type .... Varies with application.
Fuel-cell Capacity (gasoline / diesel) ...... 13 US Gallons
.... Fuel cell is constructed from Stainless steel.
Fuel Pump Type .... Electric

13. Electrical Systems:

Type .... 12 volt, negative ground
Battery .... 650 CCA, Group 31 (Heavy Duty) with 3/8-16 Studs
Alternator .... Heavy Duty, 70 Amp output

CHAPTER 1
SECTION 3: SPECIFICATIONS AND CAPABILITIES (CONT)

14. Chassis:

Type .... All-steel welded unibody, bolt-on firewall and rear deck.

15. Towing Hitch:

Type Rear .... E-Hitch featuring an alloy steel 1-1/4" pin and manual cable
.... release, rated for unit's towing capacity.
Type Side .... Manufactured to FedEx Specifications.
Type Front .... Optional

16. Instrumentation:

Switches (Standard) .... Ignition (anti-restart, with or without key).
Gauges .... Fuel level (gasoline and diesel); hour meter (mounted in
.... engine compartment). Low fuel level warning (LPG),
.... Mechanical fuel level indicator on tank (LP-CE).

CHAPTER 1
SECTION 4: OPTION LIST

Option	Desc
TT-010-51	STANDARD PARTS TC 30/60 FEDEX
TT-020-52	FRAME TC-30/60 FEDEX, DSL/GAS
TT-030-54	BALLAST TC-50, FEDEX*
TT-040-60	ENGINE, FORD, 2.3L, C6, FEDEX
TT-050-54	XMSN C6 W/O BK, HI-ST W/FILTER
TT-051-55	SHIFT INHIBITOR FWD/REV XM FX
TT-060-52	REAR AXLE 20:1, TA267 BRZ BUSH
TT-070-56	FUEL CELL 13 GAL, STAINLESS
TT-080-59	STRG HYDR0, BRK/FLTR, FEDEX
TT-090-51	LIGHTS HEAD/BRK/TAIL/REV FEDEX
TT-110-49	SEAT,FEDEX,SHORTENED LEVER
TT-110-58	HIP RESTRAINT PASSENGER L/CAB
TT-110-59	HIP RESTRAINT, DRIVER LESS/CAB
TT-120-68	REAR E-HITCH, 1-1/4 PIN FEDEX
TT-120-69	SIDE HITCH (FEDEX)
TT-160-55	PAINT FEDEX BLK/WHITE
TT-180-50	DECALS, FEDEX STD
TT-500-60	DRIVE SHAFT 2.3L C6 W/O BRK
TT-051-50	SHIFTER F N R
TT-100-51	KEYLESS IGNITION
TT-110-51	SEAT PASS BUCKET
TT-150-50	TIRES FRONT 6.50X10 LRE 2PC
TT-150-51	TIRES REAR LT225/75R16 LRD 1PC

TAYLOR-DUNN®
MANUFACTURING

Notes:

Green Since 1949

CHAPTER 1
SECTION 5: STORAGE

1. One to Six Months

A. Engine:
For Refer to **Chapter 5 - Manufacturer's Appendices**.

B. Battery:
1. Remove the battery and store separate from unit.
   NOTE: Store in a safe location where the temperature does not fall below 32 deg. Fahrenheit (0 deg. Celsius). Cover to protect from moisture and dirt.
2. Check battery monthly and charge as needed.

C. Tires and Wheels:
1. Raise unit so that tires are off the ground and place unit on jack stands.
2. Reduce pressure in tires from 20-15 psi.
3. Spray tires with a rubber preservative.
4. Grease wheel bearings and chassis.

D. Place a warning sign on the steering wheel to inform others that the unit is in storage.

Message should read:

Vehicle requires service before use –
Refer to vehicle service manual for
procedure to return to service.

CHAPTER 1
SECTION 5: STORAGE

2. Extended Period

A. Engine:
1. Refer to **Chapter 5 - Manufacturer's Appendices**.

B. Fuel:
1. Drain fuel from fuel cell.
2. Drain fuel from fuel lines.

C. Battery:
1. Disconnect battery and remove from unit. Store in a safe location where the temperature does not fall below 32 deg. Fahrenheit (0 deg. Celsius). cover to protect from moisture and dirt.
2. Check battery monthly and chage as needed.

D. Tires and Wheels:
1. Raise unit so that tires are off the ground and place unit on jack stands.
2. Reduce pressure in tires from 20-15 psi.
3. Spray tires with a rubber preservative.
4. Grease wheel bearings and chassis.

E. Transmission:
1. Drain transmission and fill with new fluid.

F. Chassis:
1. Lubricate all moving parts.
2. Touch up paint.
3. Coat all bear metal with metal preservative or a light coating of grease or oil.
4. Cover seat if unit is stored outside.

G. General:
1. Place a "Caution" sign on the unit's steering wheel to inform others that the unit is in storage and has no oil or coolant in the engine and no gear oil in the drive axle and reduction gearbox.

Message should read:

> Vehicle requires service before use –
> Refer to vehicle service manual for
> procedure to return to service.

NOTE: Prolonged storage can damage engine, axle and transmission seals.

CHAPTER 1
SECTION 5: REMOVING FROM STORAGE

A. Engine:
1. Refer to **Chapter 5 - Manufacturer's Appendices**.

B. Fuel:
1. Fill the fuel cell.

C. Battery:
1. Install a fully charged battery.

D. Tires and Wheels:
1. Inspect tread and sidewalls for damage.
2. Inflate tires to proper tire pressure.

E. Transmission:
1. Drain transmission and fill with new fluid.

F. Drive Axle:
1. Check and fill drive axle with oil as needed.

G. Chassis:
1. Lubricate all moving parts.

TAYLOR-DUNN® MANUFACTURING

Notes:

Green Since 1949

CHAPTER 2
MAINTENANCE
TABLE OF CONTENTS

SECTION 1 - PREVENTATIVE MAINTENANCE

SECTION 2 - TROUBLESHOOTING

SECTION 3 - REMOVAL AND INSTALLATION

SECTION 3 - REMOVAL AND INSTALLATION (cont)

SECTION 4 - ELECTRIC AND HYDRAULIC DIAGRAMS

THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE

1. Maintenance Chart

OPERATION	DAILY	Weekly (40 HRS)	Monthly (200 HRS)	Every two months (400 HRS)	Semi-Annual (1200 HRS)	Annually (2400 HRS)
CHECK ENGINE OIL LEVEL						
CHECK ENGINE COOLANT LEVEL						
CHECK FUEL LEVEL						
CHECK TRANSMISSION FLUID LEVEL						
CHECK SERVICE BRAKE OPERATION						
CHECK PARKING BRAKE OPERATION						
CHECK TIRE PRESSURE						
EXAMINE TIRES FOR WEAR OR DAMAGE						
CHECK HORN OPERATION						
CHECK ALL LIGHTS FOR PROPER OPERATION						
CHECK BRAKE AND BACKUP LIGHTS						
CHECK FOR LEAKS (OIL, FUEL, COOLANT ETC)						
CHECK SERVICE BRAKE FLUID LEVEL						
CHECK BATTERY CONDITION						
CHECK CHARGING SYSTEM						
RE-TORQUE WHEEL NUTS						
CHECK DRIVE AXLE GEAR OIL LEVEL						
CHECK DRIVE AXLE MOUNTING						
CHECK EXHAUST SYSTEM FOR DAMAGE OR WEAR						
CHECK ENGINE AIR CLEANER						
CHECK ENGINE AIR INTAKE SYSTEM						
CHECK FRONT AXLE FOR DAMAGE AND WEAR						
CHECK AND ADJUST SERVICE BRAKE						
CHECK AND ADJUST PARKING BRAKE						
CHECK ENGINE COOLING HOSES						
CHECK DRIVE BELTS FOR WEAR, ADJUST TENSION						
CLEAN ENGINE AND RADIATOR						
CHANGE ENGINE OIL						
CHANGE ENGINE OIL FILTER						
CHANGE ENGINE AIR CLEANER						
LUBRICATE DRIVESHAFT						
LUBRICATE FRONT AXLE AT FITTINGS						
LUBRICATE BRAKE PEDAL						
LUBRICATE THROTTLE LINKAGE						
REPLACE ENGINE PCV VALVE						
LUBRICATE FRONT WHEEL BEARINGS, CHECK FOR WEAR						
LUBRICATE AND CHECK ALL STEERING COMPONENTS						
CHANGE DRIVE AXLE GEAR OIL						
CHANGE ENGINE FUEL FILTER						
CHECK SUSPENSION FOR DAMAGE OR WEAR						
CHANGE TRANSMISSION FLUID AND FILTER						
ADJUST TRANSMISSION INTERMEDIATE BAND (FORD C6)						
CHANGE HYDRAULIC BRAKE FLUID						
CHECK ENGINE PER MANUFACTURES REQUIREMENTS						

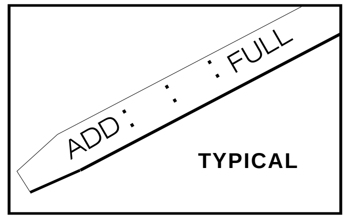
THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

2. Daily

A. Check engine oil:

Check oil level on engine's dipstick. Maintain the level between the "Add" and "Full" marks. If the engine has been running ; allow a few minutes before checking to allow oil to drain down.



CAUTION: DO NOT OPERATE THE ENGINE IF THE OIL IS BELOW THE "ADD" MARK ON THE DIPSTICK.

To add oil:

1. Using the same type of oil that is in the crankcase, gradually add oil through the cap in the top of the valve cover.
2. Do not overfill.
3. It is normal for the unit to require some oil to be added between oil changes. The amount will vary depending on the condition of the unit and the operating environment.

B. Check engine coolant level:

Check engine coolant level in the coolant-recovery tank located in the front side of the engine compartment. Maintain the level between the "Full Hot" and "Full Cold" marks (depending upon engine temperature). If no coolant is visible in the recovery tank, let the engine cool completely and check the level in the radiator. Maintain this level approximately ¾" below the fill neck. (NOTE: Be sure to add coolant to the recovery tank also).

WARNING: ENGINE COOLANT IS UNDER PRESSURE WHEN UNIT IS HOT. DO NOT REMOVE RADIATOR CAP UNTIL UNIT HAS COOLED. SEVERE BURNS CAN RESULT FROM EXPOSURE TO HOT ENGINE COOLANT.

C. Check fuel level:

Check the fuel level on the fuel gauge. (Ignition must be on.) Fill unit at the beginning of each shift. The capacity of the fuel cell should be enough for one eight hour shift. However, this is dependent upon usage. If it is noted that the unit runs short of fuel during use, the fuel should be checked twice (or more) during each shift.

To add fuel -

1. Shut down unit.
2. Set parking brake.
3. Turn ignition off.
4. Open fuel cap and add fuel until fuel reaches the bottom of the filler tube.
5. Close cap.
6. Clean up any spilled fuel, and put unit back into service.

WARNING: FUEL IS EXTREMELY FLAMMABLE. DO NOT ADD FUEL NEAR ANY OPEN FLAMES OR OTHER SOURCES OF IGNITION.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

2. Daily (cont)

D. Check transmission fluid level:
Check the transmission fluid level on the dipstick located in the engine compartment, right – rear of the engine. Always check this when the engine is warm and running, transmission is in Neutral, and the parking brake is on. Maintain this level between the “Add” and “Full” marks on the dipstick. Do not overfill. Add fluid as needed through the dipstick tube.

E. Check service brake operation:
Start unit and depress service brake pedal. The pedal should stop 1” to 2” from the firewall. The pedal should be firm and should not fade. Next, while holding the service brake on, disengage parking brake, check for clear path, and check to be sure that service brake operates smoothly and does not grab while making a slow, smooth stop.

F. Check parking brake operation:
On a level surface with parking brake engaged, start unit, apply service brake (check for a clear path), shift unit into “Forward”, and slowly release service brake. The unit should remain stationary. If it rolls, adjustment is required (see adjustment section). Place unit in neutral, shutdown engine and engage parking brake prior to dismounting.

G. Check tire pressure:
Using a tire pressure gauge, check the tire pressure and adjust within 3 psi of its recommended pressure.
Front... 100 psi (cold)
Rear .... 80 psi (cold)

H. Check tires for wear and damage:
Examine tires and check for objects lodged in the tread, objects puncturing the tire, damaged side walls, bulges, tread depth (should not be less than 1/16”), and uneven tread wear, etc. If any other these conditions exist, the tire must be replaced or repaired.

I. Check horn:
With the ignition switch on (unit not running), press the horn button and hold for one to two seconds. The button should press easily and the horn should be very loud.

J. Check all lights for proper operation:
With the ignition switch on (unit is not running), pull light switch out to turn lights on. Walk around the unit and note headlamp , tail lamp, dash lamp shifter lamp operation. If unit is equipped with turn signals, check the pilot light (should be on at all times), then check the individual lamps, front and rear, left and right. Also check the operation of the hazard indicator by pulling out the slide switch and checking that all four lamps blink. If the unit is equipped with a beacon, this should operate continuously when ignition switch is in the “Run” position. Finally, check any other installed lighting options.

NOTE: On units equipped with the accessory shutdown system the unit must be started for electrical accessories to operate (set parking brake before test).

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

2. Daily (cont)

K. Check brake and backup lights:

Turn ignition switch to the "Run" position. Do not start unit. Place the shifter in the "Reverse" position and check the backup lamps for operation. Return shifter to the "Neutral" position when finished. Set parking brake to start unit. Apply service brake and have some check the brake lamps for proper operation. Turn unit to the "Off" when finished.

NOTE: On units equipped with the accessory shutdown system the unit must be started for electrical accessories to operate (set parking brake before test).

L. Check for leaks:

With the unit off and the parking brake set, check the following for signs of fluid leakage: fuel lines, brake lines, transmission cooling lines, engine cooling hoses, radiator, engine valve cover, engine oil pan, transmission pan and rear axle.

3. Weekly (40 HRS)

A. Check service brake fluid level:

With unit off and parking brake set, remove the cover on the service brake master cylinder and check the level of fluid. Add fluid if needed. While cover is off, examine the condition of the fluid for any signs of contamination from rust water, etc. Replace cover.

B. Check battery condition:

On "maintenance-free" batteries, check the voltage with the engine off and no accessories running. This should measure between 11 and 13 volts. If it is below 10 volts, check charging system for faults. If no faults are found in the charging system, replace the battery. Also check the battery case for cracks, bulges, or electrolyte leaks. If any of these problems are noted, replace the battery.

C. Check charging system:

Set parking brake and start unit. Turn lights on and note the reading on the voltmeter. This should be 14-16 volts. If the unit fails this test, refer to the troubleshooting section for repair procedures.

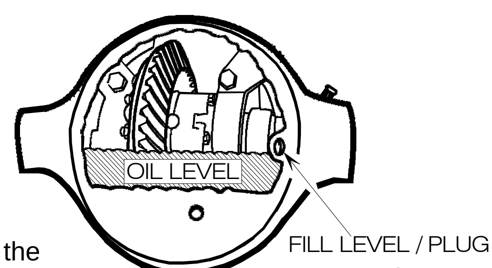
D. Torque wheel lug nuts:

Using a torque wrench, retighten the lug nuts.

Front, 1/2 studs .... 90-110 ft-lbs
Rear, 9/16 studs .... 110-120 ft-lbs

G. Check drive axle oil level:

Park unit on a level surface. Check only when unit is cold. Clean area around fill plug. Oil level should be even with the bottom of the fill hole. If oil level is high, catch excess oil in a drain pan and let it drain down to the bottom of the fill hole. If oil level is low, add the specified oil through the fill hole until the level is even with the bottom of the hole. Replace plug. Tighten to 35-50 ft-lbs.



CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

3. Weekly (40 HRS) (cont)

F. Check drive axle mounts:
Raise unit and support it on jack stands. Examine drive axle mounts for loose or damaged parts. Replace any defective parts. Lower unit.

G. Check exhausts system for wear or damage:
Raise unit and support it on jack stands. Examine the exhaust system starting at the front of the unit, moving to the rear. Look for holes, cracks, dents, and damage that might restrict the flow of exhaust. Repair or replace defective parts. Lower unit.

H. Check engine air filter and intake system:
With the engine off, remove engine air filter cover and inspect the air filter elements for excessive dirt. Replace if needed. Clean the air filter housing before replacing the cover. Check condition of air intake tube and couplings, replace worn components.

I. Check front axle for wear:
Raise front end of unit and support it on jack stands. Examine front axle assembly. Look for loose or damaged parts. Repair or replace defective parts. Lower unit.

4. Monthly (200 HRS)

A. Check and adjust service brake:
Check the distance from the pedal arm to the dash panel, the pedal should be within 1/8” to 1/4” of touching the dash panel . Adjust distance by disengaging the trunion from the brake pedal and turning out being sure that when the trunion is installed the pedal does not hit the dash panel. If pedal is depressed and touches the firewall then the booster and – or master cylinder need to be serviced.

B. Check and adjust parking brake:
With unit on a dry, level surface, engage parking brake and start unit. Press and hold the service brake pedal and put unit in its highest forward gear (Drive). Slowly release service brake. The unit should not move while parking brake is engaged. Put transmission in Neutral or Park and shut unit down. If adjustment is needed (unit not running), chock wheels, disengage parking brake lever, turn the end of the lever clockwise to increase force on parking brake and recheck. If adjustment cannot be made with lever, refer to Chapter 3 OVERHAUL & MAJOR REPAIR for overhaul instructions.

C. Check engine cooling system hoses:
With the unit off and the parking brake set, raise and support hood. Allow the engine to cool. Check all hoses for bulges or cracks. Also check clearance around hoses to be sure they are not rubbing against anything that may cause damage. Replace any defective parts.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

4. Monthly (200 HRS) (cont)

D. Check drive belts for wear, adjust tension:

With the unit off and the parking brake set, raise and support hood. Allow the engine to cool. Check all drive belts for excess wear or cracks. Replace any defective belts. For V-Belts Tiger Manufacturing recomends using a V-Belt tension gauge to check the tension on each drive belt. For Engine serpintine drive belt service refer to **Chapter 5 - Manufacturer's Appendices.**

E. Clean engine and radiator:

With the unit off and the parking brake set, raise and support hood. Allow the engine to cool. (Do not clean engine when unit is hot). Remove engine side panels. Using a pressure washer or steam cleaner, clean built-up dirt from engine and engine compartment. Also examine the radiator. Remove any loose debris and wash if needed. Replace side panels and lower hood.

F. Change engine oil:

With the unit on a clean, level surface – engine off and cool – set parking brake. Raise the front of the unit if needed. Support it on jack stands. Place a drain pan under unit's oil sump (drain pan capacity should be greater than 6 US quarts). Carefully remove the drain pan plug from the oil sump and allow old oil to drain out. Replace plug. Raise and support hood. Remove oil fill cap located on the top of the engine valve cover and add 4 US quarts of approved oil (see **Chapter 5 - Manufacturer's Appendices**). Check the oil level on the engine's dipstick. Maintain the level between the "Add" and "Fill" marks. Gradually add oil through the top of the valve cover until the unit is full.

G. Change engine oil filter:

With unit off (and cool) and parking brake set, raise hood. Place a drain pan under the oil filter. Remove old filter using an oil filter wrench and place in drain pan. Clean and inspect gasket surface. Remove any old gasket material. Install a new oil filter. Be sure to apply a thin film of fresh oil to the gasket before install. Hand-tighten new filter. Tighten ¼ turn beyond the point where the gasket makes contact.

NOTE: Drain oil from old filter and discard old filter following local and federal regulations. Collected waste oil can be sent to a recycler.

H. Change engine air filter:

With unit off and parking brake set, raise hood. Remove air filter cover. Remove and replace filter. Replace cover and lower hood.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

4. Monthly (200 HRS) (cont)

I. Lubricate front axle at grease fittings:

With unit off, raise unit and support it on jack studs. Carefully examine the following for looseness, excess wear or damage. Starting at the steering cylinder, check the connecting links between the wheels (ball joints, tie rods, etc.). Locate and lubricate the grease fittings (8 total), 2 per steering knuckle (top and bottom, apply the specified grease until new grease is seen coming from between the shims and thrust bearings); two on the steering cylinder; and two on the tie rod assembly. Lower unit.

J. Lubricate parking brake linkage:

Raise unit and support on jack studs. Examine the pivot points in the parking brake for excessive wear. Repair if needed. Using dry silicone based lubricant, lubricate each pivot point in the linkage. Lower unit and place wheel chocks under rear wheels. Disengage parking brake and apply dry silicone to each of the lever's pivot points. Engage and disengage several times to distribute lubricant. Engage brake and remove wheel chocks.

K. Lubricate throttle linkage:

Using dry silicone based lubricant, lightly lubricate the pivot on the base of the accelerator pedal.

5. Every Two Months (400 HRS)

A. Check engine idle speed:

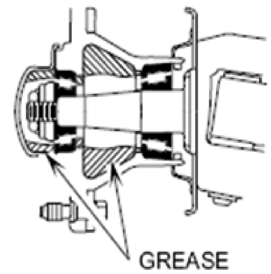
Refer to engine manufacturer's data in **Chapter 5 - Manufacturer's Appendices** for proper procedure.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

5. Every Two Months (400 HRS) (cont)

B. Lubricate front wheel bearings. Check for wear:

With the engine off and the parking brake set, raise the front of the unit until front wheels are off the ground. Support it on jack stands. Work with one side at a time. Remove the wheel. Remove and disassemble the hub. Clean old grease from all parts. Discard old seals. Examine the bearing for wear and damage. Replace worn or damaged parts. Lubricate the bearing journals with specified grease. Using a pressure packer or by hand, pack new grease into wheel bearings, forcing all air out between rollers and cage. Pack grease into hub as shown in the figure. Install inner and outer cones into the hub. Install new seals. Install the hub assembly on the spindle. Tighten the inner bearing nut to 30 ft-lbs, tighten again finger tight. Install lockwasher and locknut (fold lockwasher down over inner nut and up over outer nut). Hub should turn by hand with a small amount of effort. End play of .001 to .005 is normal. Install cover. Install wheel and torque lug nuts to 100 ft-lbs. Lower unit.



C. Lubricate and check all steering components:

With the engine off and parking brake set, raise front of the unit until front wheel are off of the ground. Support on jack stands. Grab hold of each wheel at the top and bottom and move it back and forth, then up and down. While moving it, examine wheel in relation to the spindle and to the front axle. Note the amount of play in each direction. If the wheel moves back and forth, it might indicate wear of the front wheel bearings. Likewise, if motion is noted up and down, the king pin or its bearings might be worn. If so, service is needed. If not, proceed by applying the specified grease to the grease fittings until new grease purges from joints. Examine steer cylinder for leaks or wear. Refer to unit repair section if service is needed. Lower unit.

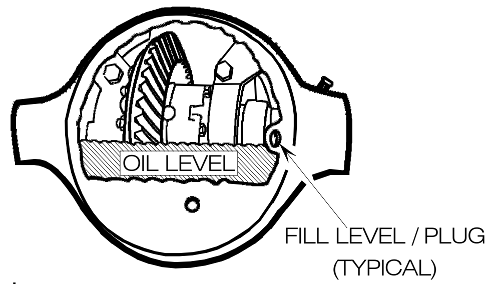
NOTE: DO NOT attempt to straighten bent steering components. Replace any damaged parts with new components.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

6. Semi-Annual (1200 HRS)

A. Change drives axle gear oil:

Place wheel chocks under front wheels. Raise rear of unit until rear tires are off the ground. Support unit on jack studs. Place a pan under rear axle. Remove drain plug on the bottom of the axle and allow old oil to drain out. Replace drain plug. Remove fill plug and refill axle with he specified oil until the oil level is even with the bottom of the fill hole. Replace fill plug. Lower unit.



B. Change engine fuel filter:

Refer to engine manufacturer's data in **Chapter 5 - Manufacturer's Appendices** for proper procedure.

C. Check all suspension components:

With unit off and parking brake set, raise unit until wheels are off the ground. Support with jack stands. Remove the wheels. Examine the front and rear suspension or wear. Look for loose or broken parts. Check leaf springs for loose hardware or broken leafs. Replace any damaged parts with new components. Replace wheels. Lower unit.

D. Change transmission fluid and filter (Ford C6):

With unit off and parking brake set, raise unit and support it on jack stands. Allow unit to cool. Place a large drain pan under the transmission. Loosen pan bolts to allow fluid to drain. Once fluid has drained down to the level of the pan flange, carefully remove pan and drain. Examine the condition of the fluid drained from the unit. If fluid is burned or contains large metal flecks or shavings, the transmission must be disassembled and repaired. Refer to repair section for further information. Clean pan of all sludge and oil. Remove old gasket material. Remove the filter and replace with new filter. Using a new gasket, replace the pan. Torque the pan bolts to 12-16 ft-lbs. Lower unit and raise hood. Using the specified fluid, add 3 quarts of new transmission fluid. Start unit and allow it to reach operating temperature. Place unit in its lowest forward gear and allow transmission to engage. Return shifter to Neutral. Check the level of fluid on dipstick. Add fluid until the level is between “Add” and “Full” marks. Shut unit down. Close hood.

7. Annual (2400 HRS)

A. Adjust transmission intermediate band (Ford C6 only):

With unit off and parking brake set, raise unit and support it on jack stands. Clean area around band adjusting screw (the band adjusting screw is located just above the shift linkage). Remove and discard the locknut. Install a new locknut, leaving it loose. Tighten adjusting screw to 10 ft-lbs. Back off exactly 1.5 turns. Hold adjusting screw in place and tighten locknut to 35 ft-lbs. Lower unit. Test drive unit.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

7. Annual (2400 HRS) (cont)

B. Change hydraulic brake fluid:

With unit off and parking brake set, raise unit until wheel are off the ground. Support on jack stands. Raise and support hood. Clean areas around bleeder valves on each slave cylinder. One at a time attach a hose to the bleeder valve. Place a drain pan under hose to catch old fluid. Open bleeder valve and press service brake pedal to force old fluid out. Repeat for each slave cylinder until system is empty. Examine the condition of the old fluid, checking for signs of rust or water. If significant amounts of rust are found in old fluid, it might indicate corrosion in the brake lines. Examine the brake lines for signs of fluid leakage, checking along the full length of the line, at the connections and at the hoses. Proceed by bleeding the air out of the system (requires two people). Fill master cylinder with the specified new brake fluid. Do not use old fluid. Replace cover and pump up master cylinder by repeatedly pressing service brake pedal. Holding pressure on the pedal, attach a hose to one of the slave cylinder bleeder valves and place the other end of the hose in container filled halfway with fresh brake fluid, holding end of the hose under the surface of the fluid. Holding pressure on the pedal, open the bleeder valve until pedal bottoms out. Close valve before pumping pedal up again. Repeat procedure until all the air is out of the brake line. Periodically check and top off master cylinder with new brake fluid. Do not allow master cylinder to run dry or you will have to bleed all the lines again. Repeat procedure for each slave cylinder until all air is out of the system. Top off master cylinder and test-drive unit before placing unit back in service.

8. Adjustments

A. Parking brake:

With unit off and parked on a dry, level surface, chock wheels. Disengage parking brake lever. Turn the end of the lever clockwise to increase force on parking brake and recheck. If adjustment cannot be made with the lever, refer to Chapter 3 Overhaul & Major Repairs Section for instructions.

B. Service brake:

Check the distance from the pedal arm to the dash panel, the pedal should be within 1/8” to 1/4” of touching the dash panel . Adjust distance by disengaging the trunion from the brake pedal and turning out being sure that when the trunion is installed the pedal does not hit the dash panel. If pedal is depressed and touches the firewall then the booster and – or master cylinder need to be serviced.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

8. Adjustments (cont)

C. Front wheel toe-in:

Slowly drive unit in a straight line for at least 15 feet, allowing unit to steer itself for the last five feet. This sets the wheels in line for adjustment. Measure the distance between the front edge of the rims and back edge of the rims. The front edge should measure 1/8” less distance than the back edge. Adjustment is made by loosen the back locknuts on the tie rod ends and turning the tie rod until proper adjustment is achieved. Tighten locknuts and recheck toe-in.

D. Steering (hydrostatic steering):

With unit off and parking brake set, raise front of unit until front wheels are off the ground. Support unit on jack stands. Keep hands clear of moving components. With engine off have someone turn the steering fully left to right, observe the steering stops. The steering cylinder should be setup so that the steer axle hits the steering stops just before the steering cylinder reaches it’s full stroke (steering angle should be approximately the same in both directions). The steering may take slightly more turns of the steering wheel when turning left than turning right. This is normal for Hydrostatic Steering systems. If adjustments are required (or steering cylinder or tie rod ends are replaced).Start setup by turn steering wheel fully right (fully retract steering cylinder). Set the overall length of the retracted cylinder to approximately 16.875”, re-install and check for equal steering angle (not number of turns). Once steering angles are as close to equal as they can be adjust the steering stops so they touch the steer arms before the steering cylinder is fully retracted or fully extended. This will help prevent damage to the steering cylinder should the tires hit an object when in a tight turn. Tighten jam nuts against steering cylinder. It is required to use blue thread locker on tie rod ends.

E. Shifter linkage and switch:

With the unit off and the parking brake set, raise unit and support on jack stands. Place the shifter in Neutral. Disconnect linkage by removing the nut that hold the lower ball stud to the transmission linkage. Place the transmission in Neutral. Replace ball stud. When both the transmission and the shifter are in Neutral, the linkage should not be in a bind. If adjustment is required, disconnect linkage by removing the nut from the lower ball stud. Turn shifter rod end in or out as needed and recheck. To check switch operation, place unit in Reverse. Turn ignition switch to “Start” position. Starter should not engage. Return switch to “Run” position (engine off) and check back up lamps for operation. Replace unit in “Forward” and turn ignition switch to “Start”. Starter should not engage. Return unit to Neutral. Turn ignition switch to “Start”. Starter should not engage. Turn unit to “Off”. If adjustment is needed, place unit in “Reverse” and turn ignition switch to the “Run” position. The backup lamps should now operate. Loosen one of the nuts holding the shaft of the switch in the bracket and move switch up and down to find the outside limits of the operation of the Reverse lamp switch. Place the switch in the center of this range and secure in place. Recheck operation. Lower the unit.

CHAPTER 2
SECTION 1: PREVENTATIVE MAINTENANCE (CONT)

8. Adjustments (cont)

F. Cab doors:

Ensure that the unit is off and parking brake is set. Each of the three hinges are secured to the door with two bolts. If the door is out of alignment, loosen all but the top and bottom hinge bolts. Carefully loose the top or bottom bolt and move door to its proper position. Tighten bolt and recheck alignment. Readjust if needed. Once door is aligned, tighten all the hinge bolts. If the latching mechanism needs adjustment, remove the inside door cover. Loosen the mounting bolts and slide latch up or downas needed. Tighten bolts and recheck. Once alignment is correct, replace inside door cover.

9. Fluid / Lubrication Specifications

A. Engine:

Refer to **Chapter 5 - Manufacturer's Appendices** .

B. Transmission:

Use automatic transmission fluid type F or Ford specification number ESP-M2C138-CJ.

C. Drive axle / reduction gearbox:

SAE 80W-90, GL-5.

D. Hydrostatic Steering:

Universal Automotive Power steering fluid compatible with General Motors, Ford and Chrysler power steering pumps.

E. Front axle:

NLGI grade 2, lithium 12-hydroxy stearate general-purpose grease.

F. Front wheel bearings:

NLGI grade 2, lithium 12-hydroxy stearate general-purpose grease.

G. Service brake hydraulic system:

D.O.T. 3 hydraulic brake fluid.

H. Service-brake-pedal linkage:

Dry-Silicone based Lubricant.

I. Parking-brake linkage:

Dry-Silicone based Lubricant.

J. Door latches:

SAE 10W Oil.

TAYLOR-DUNN® MANUFACTURING

Notes:

CHAPTER 2
SECTION 2: TROUBLESHOOTING

1. Engine

A. Engine Will Not Crank -

1. Check the battery with a test light or voltmeter.
   Light should be bright or voltage should be 12 volts (+1 vdc or -2 vdc). If not, check the condition of the battery and the water level. If battery has electrolite and case is in good condition, proceed to Step 2. If battery is bad, replace or repair battery.
2. Check the charge state of the battery with a hydrometer.
   If the battery is less than 3/4 charges, recharge battery and retest. If battery is charged, proceed to Step 3.
3. Check the condition of the battery cables and cable connections.
   Examine the full length of the positive and negative battery cables for any indication of damage. Replace cables if needed. Clean the ends of the cables. (First disconnect the negative battery cable for safety). Apply a coating of die-electric grease to the cable ends and reassemble. If problem continues, proceed to Step 4.

CAUTION: DISABLE IGNITION SYSTEM WHILE PERFORMING TESTS UNDER SECTIONS A4-7.

4. Check the ignition switch.
   Using a test light or voltmeter, check the voltage at the “Batt” terminal on the ignition switch. Light should be bright or voltage should be 12 volts. If not, check the wiring from the switch to the fuse block and check the fuse. If fuse is bad, replace and recheck unit. If there is power to the “Batt” terminal, connect the test light or voltmeter to the “ST” terminal and switch to the “Start” position. If light does not light or no (low 90% battery voltage) voltage is noted, the ignition switch is bad. Replace. If light is bright or voltage is present, proceed to Step 5.
5. Check the Neutral safety switch operation (place unit on jack stands).
   Connect a jumper wire in the connector going to the shifters “C” and “D” terminals and turn the ignition switch to “Start”. If engine cranks, the Neutral safety switch needs adjustment or replacement. If engine does not crank, proceed to Step 6.
6. Check the condition of the Engine Starting System.
   Refer to **Chapter 5 - Manufacturer’s Appendices** for procedures.

B. Engine Cranks But Will Not Start -

1. Check for fuel in fuel cell. If empty or extremely low, add fuel and recheck. If unit has fuel, proceed to step 2.
2. Check the power to the Engine Electrical system (reference pages 2.4.2 and 2.4.4).
   Turn the ignition switch to the “Run” position. With a voltmeter, check the voltage to pin ‘A’ on J23 (wire #45). This should be within 90% of battery voltage. If good, refer to the engine data in **Chapter 5 - Manufacturer’s Appendices** for detailed troubleshooting of the engine electrical system; If not, check wiring to the connector. Check circuit breaker #8. Check for proper operation of the accessory relay (K1).

CHAPTER 2
SECTION 2: TROUBLESHOOTING

2. Drive Train

A. Transmission Functioning Properly, Unit Will Not Move -

1. Examine the parking brake system.

   Be sure that the linkage moves freely and that the drum is free when brake is disengaged. Repair as needed. If parking brake is functioning properly, proceed to Step 2.

2. Check that the rear axle is not locked up.

   Raise unit until wheels are off the ground and support the unit on jack stands. Remove the drive shaft from the unit. Check the drive shaft for frozen universal joints. Replace defective parts and reinstall drive shaft. If drive shaft is functioning, try turning one of the rear axles. It should turn with some resistance and the other wheel should turn in the opposite direction. Have someone hold one wheel and turn the other. Note that the input flange on the reduction gearbox moves when the wheel is turned. If the drive line is functioning properly, examine suspension for damage and check operation of front wheel bearings. If rear axle will not move. proceed to Step 3.

3. Check the service brake calipers.

   Raise unit until wheels are off the ground and support unit on jack stands. Remove rear wheel. Remove the brake calipers and tie them back so that no weight is on the brake line hoses. Reinstall wheels. Try turning one of the rear wheels. It should turn with some resistance and the other wheel should turn in the opposite direction. Have someone hold one wheel and turn the other. Note that the input flange on the reduction gearbox moves when the wheel is turned. If rear axle is locked up it must be disassembled for further diagnosis. Refer to **Chapter 5 - Manufacturer's Appendices**, rear axle Maintenance Section, for overhaul procedures. If rear axle is functioning properly, proceed to the service brake troubleshooting section.

B. Rear Axle Makes Excessive Noise -

1. Check the level of lubricant in the axle.

2. If problem persists, drain and replace lubricant.

   Check condition of old lubricant for signs of metal shavings. If problem persists or signs of excessive wear are found in the old lubricant, the axle should be disassembled for further diagnosis. Refer to **Chapter 5 - Manufacturer's Appendices**, rear axle maintenance, for overhaul procedures.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

3. Steering

A. Steering is Extremely Hard or is Locked Up -

1. Check hydraulic fluid level.

   Check power steering fluid reservoir (top-front left side of engine). If reservoir is empty fill to proper level and check operation. Check for leaks or damaged components. If power steering pump was run for an extended period without fluid it could be damaged beyond repair. If pump is working yet steering is still hard proceed to Step 2.

2. Check steering (Hydrostatic Steering).

   Raise the front end of the unit until wheels are off the ground and support unit on jack stands. Disconnect the steering cylinder from the steering control arm. Allow free end of cylinder to hang in and area that it will not touch anything while it is moving. Attempt to turn the steering, if it is still hard or locked the problem is in the hydraulic steering system. Check the steering cylinder or steering valve. Disconnect battery and remove steering cylinder. Drain fluid from cylinder and check to see if it moves freely. If not replace cyclinder, if it does reinstall it in the unit and replce the steering control valve.

   If steering wheels turns freely, the problem is in the steering axle assembly. Proceed to Step 3.

4. Check front axle assembly.

   Check the ball joints in the tie rod assembly to be sure they move freely. If not, replace defective parts and recheck unit. If tie rod is functioning properly, remove the tie rod. Check each steering knuckle by moving each wheel side to side. They should turn freely. If not, the king pin needs to be serviced. Repair or replace defective parts. Do not try to straighten any bent components. If any part of the steering assembly is cracked or bent, it must be replaced.

B. Steering is Loose -

1. Check steering (hydrostatic steering).

   Raise the front end of the unit until wheels are off the ground and support unit on jack stands. Check the steering cylinder and steering arm. This connection should move with some resistance but should not be loose. If tie rods are loose, replace the loose end(s), Grease joint.Recheck steering. If functioning properly, proceed to Step 3.

2. Check front axle assembly.

   Check the tie rod assembly joints. These should turn with some resistance. They should not be loose. If tie rod ends are loose, replace and retest unit. If tie rod is functioning properly, remove the tie rod. Try moving the steering knuckle assembly back and forth and up and down. The king pins should have no more than 0.065” movement up and down, and 0.010” back and forth. Repair or replace defective parts. Do not reuse or repair any bent or cracked steering components. Defective parts must be replaced.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

4. Service Brakes

A. Pedal Resting, But Height is Low -

1. Check the distance from the pedal arm to the dash panel.

   The pedal should be within 1/8" to 1/4" of touching the dash panel . Adjust distance by disengaging the trunion from the brake pedal and turning out being sure that when the trunion is installed the pedal does not hit the dash panel. If pedal is depressed and touches the firewall then the booster and – or master cylinder need to be serviced. Recheck height. If pedal height is still low, proceed to Step 2.

2. Check the master cylinder piston.

   Remove the master cylinder from the booster. Check the piston. This should be resting against the snap ring at the open end of the cylinder. If not, the master cylinder must be replaced.

B. Pedal is Spongy or Fades -

1. Bleed brakes to remove any air trapped in the system.

   With unit off and parking brake set, raise unit until wheels are off the ground and support unit with jack stands. Raise and support the hood. Clean areas around the bleeder valves on each slave cylinder. One at a time, attach a hose to the bleeder valve. Place a drain under the hose to catch old fluid. Open bleeder valve and press service brake pedal to force old out. Repeat for each slave cylinder until system is empty. Examine the condition of the old fluid. Check for signs of rust or water. If significant amounts of rust are found in the old fluid, it might indicate corrosion in the brake lines. Examine the brake lines for signs of fluid leakage. Check along the full length of the line, at the connections, and at the hoses. Check hoses for bulges that might indicate the hose is bad. Replace defective parts. Proceed by bleeding the air out of the system. (This requires two people). Fill master cylinder with specified new brake fluid (do not reuse old fluid). Replace cover and pump up master cylinder by repeatedly pressing service brake pedal. Holding pressure on the pedal, attach a hose to one of the slave cylinder bleeder valves and place the other end of the hose in a container filled halfway with fresh brake fluid. Hold end of hose under the surface of the fluid. Holding pressure on the pedal, open the bleeder valve until pedal bottoms out. Close valve before pumping pedal up again. Repeat the procedure until all of the air is out of the brake line. Periodically check and top off the master cylinder with new brake fluid. Do not allow master cylinder to run dry or you will have to bleed all the lines again. Repeat procedure for each slave cylinder until all air is out of the system. Top off master cylinder and recheck unit before placing unit back into service. If problem persist, proceed to Step 2.

2. Check cylinders for bad seals.

   Check each of the slave cylinders for signs of fluid leakage. If leaks are found, repair the cylinder. If all slave cylinders are functioning properly and there is no air in the system, the seals on the master cylinder plunger are bad or the master cylinder bore is scratched or damaged. Replace master cylinder.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

4. Service Brakes (cont)

C. Excessive Effort Needed To Operate Brakes -

1. Examine the full length of the brake lines.
   Start at the master cylinder and follow the lines back to the slave cylinder. Look for signs of fluid leakage, physical damage, or kinks. Repair any defective lines and recheck the unit. If unit is still hard to brake, proceed to Step 2.
2. Check cylinders for bad seals.
   Check each of the slave cylinders for signs of fluid leakage or rust and corrosion. If leaks are found or if cylinder is rusted, repair the cylinder. If all slave cylinders are functioning properly, the master cylinder plunger may be frozen or the master cylinder bore is scratched, damaged or rusted. Replace master cylinder.

D. Brakes Grab or Pull -

1. Check the brake pads for excessive wear.
   If pads are worn beyond serviceable life, (generally a minimum depth of 1/32" above the rivets), replace pads and recheck unit. If pads are good, proceed to Step 2.
2. Examine the full length of brake lines.
   Start at the master cylinder and follow lines back to the slave cylinders. Look for signs of fluid leakage, physical damage or kinks. Repair any defective lines and recheck unit. If brakes still grab, proceed to Step 3.
3. Check slave cylinders for bad seals.
   Check each of the slave cylinders for signs of fluid leakage or rust and corrosion. If leaks are found, if cylinder is rusted, or if cylinder does not move freely, replace the cylinder. If all slave cylinders are functioning properly, proceed to Step 4.
4. Check the pedal linkage for wear and sticking parts.
   If linkage is not moving freely, repair or replace defective parts. If linkage is free, proceed to Step 5.
5. Check the caliper mounting plate for loose hardware or broken mounting tabs.
   Also check caliper casting and mounts for damage. Repair or replace defective parts as needed. If all mounting hardware and parts are functioning, proceed to Step 6.
6. Check wheel bearings.
   Examine the wheel bearings for excessive play. Also check axle / bearing seals for signs of lubricant leakage. Repair worn bearings or replace defective seals.

E. Brakes Drag (not releasing) -

1. Examine the full length of the brake lines.
   Start at the master cylinder and follow lines back to the slave cylinders. Look for signs of fluid leakage, physical damage or kinks. Repair any defective lines and recheck unit. If brakes still grab, proceed to Step 2.
2. Check slave cylinder for bad seals.
   Check each of the slave cylinders for signs of fluid leakage or rust and corrosion. If leaks are found, if cylinder is rusted, or if cylinder does not move freely, repair the cylinder. If slave cylinders are functioning properly, proceed to Step 3.
3. Check the pedal linkage for wear and sticking parts.
   If linkage is not moving freely, repair or replace defective parts. If linkage is free, proceed to Step 4.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

4. Service Brakes (cont)

E. Brakes Drag (not releasing) (cont) -

4. Check the caliper mounting plate.
   Repair or replace defective parts as needed. If all mounting hardware and parts are functioning, proceed to Step 5.
5. Check the wheel bearings.
   Examine wheel bearing for excessive play. Check the axle / bearing seals for signs of lubricant leakage. Repair worn bearings or replace defective seals.

F. Noise -

1. Check the brake pads for excessive wear.
   If pads are worn beyond service cable life, (generally a minimum depth of 1/32" above the rivets), replace pads and recheck unit. If pads are good, proceed to Step 2.
2. Check the caliper mounting plate for loose hardware or broken mounting tabs.
   Check the caliper casting and mounts for damage. Check the alignment in relation to the disk. Repair or replace defective parts as needed. If all mounting hardware and parts are functioning, proceed to Step 3.
3. Examine the wheel bearings for excessive play.
   Check the axle / beating seals for signs of significant leakage. Repair worn bearings or replace defective seals.

5. Parking Brake

A. Brake Not Holding (weak) -

1. Check the adjustment of the brakes.
   With the unit off and parked on a dry, level surface, chock wheels. Disengage parking brake lever. Turn the end of the lever clockwise to increase force on parking brake and recheck. If adjustment cannot be made, proceed to Step 2.
2. Check the condition of linkage.
   With the unit off, place chock blocks under the front wheels. Raise the unit until the rear wheels are off the ground. Support the unit on jack stands. Examine the parking brake linkage. Look for excessive wear, cracks, or broken parts. Replace defective parts. If adjustment still cannot be made, overhaul the parking brake.

B. Brake Will Not Engage (handle not fully engaging) -

1. Check the adjustment of the brake.
   With the unit off and parked on a dry, level surface, chock wheels. Disengage parking brake lever. Turn the end of the lever clockwise to increase force on parking brake and recheck. If adjustment cannot be made, proceed to Step 2.
2. Check the condition of linkage and cable.
   With the unit off, place chock blocks under the front wheels. Support unit on jack stands. Examine the parking brake linkage and cable. Look for excessive wear, cracks, or broken parts. Replace defective parts. If adjustment still cannot be made, overhaul the parking brake.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems

A. Headlights:

1. Not Working (both) -

With the ignition switch on (unit is not running), pull light switch out to turn lights on. If the headlamp, tail lamp, dash lamp shifter lamp operation are likewise not working, the problem is either in the switch or the power to the switch. Check the fuse supplying the circuit. If the fuse is good, use a voltmeter to check the power to and through the headlamp switch. Determine if there is power (90% or more of battery voltage) on both sides of the switch. If power goes to the switch bit will not conduct through it while the switch is on, replace the switch. If the tail lamps, dash lamps, and shifter lamps are working, check the wiring to the headlights. Using a voltmeter or test lamp with the ignition switch and the head lamp switch on, check the power lead to each lamps for power. If no power is present, the wiring to the headlamps is bad. Check the wiring for damage. If there is power to the lamps, check the grounding side of the lamps for a good ground. If there is a good ground and power, the lamps are bad. Replace the lamps.

2. Not Working (one) -

Replace the lamp and recheck. If headlamp is still not working, use a voltmeter or test lamp with the ignition switch and headlamp switch one to check the power lead to the lamp for power. If no power is present, the wiring to the headlamp is bad. Check the wiring for damage. If there is power to the lamp, check the grounding side of the lamp for a good ground.

B. Back-Up Lights:

1. Not Working (both) -

a. Using a test light or voltmeter, check for voltage to the backup lights.

Place unit in Reverse (engine not running) and turn ignition switch to the “Run” position (Do not start unit). Check for power to the backup lights. If power is present, replace the bulbs. If not, proceed to Step b.

b. Check the fuse or circuit breaker.

Refer to the wiring diagram to determine which fuse or circuit breaker supplies power to the backup light switch. Using a test lamp or voltmeter, with the ignition switch on, check the power on both sides. If not, replace the fuse or circuit breaker and recheck the circuit. If the light still remains inoperative, proceed to Step c.

c. Check the backup light switch.

Raise the unit until the wheels are off the ground and support unit on jack stands. Disconnect the shifter switch from the wiring harness. Using a piece of wire, short between the “A” and “B” terminals in the shifter connector on the harness. Turn the ignition switch to the “Run” position. (Do not start unit). Check the backup lights for operation. If lights are working, the problem is in the backup light switch. The switch is either bad or maladjusted. Refer to the adjustment section (2-1; 1H) and attempt to adjust switch. If switch continues to fail operation, replace the switch and readjust. If lights do not work with jumper installed; check the wiring to the switch. Using a test lamp or voltmeter, check for power at terminal “A”, or sometimes “B”, with the ignition switch on.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems (cont)

B. Back-Up Lights (cont):

1. Not Working (both) (cont) -

c. Check the backup light switch (cont).

There should be power to one terminal or the other. Of not, and the fuse or circuit breaker is good; the wiring to the switch is bad. If there is power to the switch and the switch is good; the wiring from the switch to the backup lights is bad.

2. Not Working (one) -

a. Check the backup light bulb.

Using a test light or voltmeter, check for voltage to the malfunctioning backup light. Place unit in Reverse (engine not running). Turn ignition switch to the "Run" position. (Do not start unit).

b. Check the power to the malfunctioning backup light.

If power is present, replace the bulb. If not, check the wiring to the bulb.

C. Parking Lights / Dash Lights:

1. Lamp Not Working (one) -

The parking lights, dash lamps, and shifter lamp are all connected through the same circuit. If only one of the lamps in the circuit is malfunctioning, replace the lamp and recheck. If the single lamp continues to malfunction, check the socket and wiring to the lamp.

2. Lamp(s) Not Working (most or all) -

a. Since the parking lamp is wired through the same circuit as the headlamps, check the headlamps for operation. If the headlamps are not functioning as well, check the circuit breaker supplying power to the circuit. If the circuit breaker is good, check the headlamp switch. If the switch is good, check the wiring to the switch.

b. If the headlamps are working, check for power at one of the dash lamp sockets. If powers is present, check and replace each lamp. If no power is present, check the wiring to each branch of the circuit, starting at the dash lamps back to the switch. Then check from the dash lamps to the rest of the circuit.

D. Brake Lights:

1. Brake light not working (one) -

a. Check for malfunctioning lamp.

Replace the brake / tail lamp assemble and recheck. If unit continues to malfunction, check the power to the lamp assembly. (Have someone press and hold the service brake pedal). Repair the defective wiring, if necessary. Note that the power is routed through a connector at the turn signal switch (or a jumper plug) located in the dash panel. If power is getting through, check for a good ground.

2. Brake light(s) Not Working (both) -

a. Check the power to the circuit.

Locate the brake light switch in the engine compartment connected to the brake lines. Using a voltmeter or test light, with the ignition switch on (engine not running), check the power to the brake switch. If no power is present, check the circuit breaker to the circuit. If the circuit breaker is good, check the wiring to the switch.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems (cont)

D. Brake Lights (cont):

2. Brake light(s) Not Working (both) (cont) -

a. Check the power to the circuit (cont).

If power is present, have someone apply pressure to the service brake pedal and check for power on the output of the switch. If no power is transferred through the switch, the switch might be bad. Turn ignition switch off. Using a test lead jumper across the service brake switch terminals, making sure the jumper does not contact any ground, turn the ignition switch on (engine not running). If the brake lights come on; the problem is in the switch itself (replace switch) or the brake system might not be developing enough pressure to activate the switch (bleed air from system).

b. Check power to the brake lights.

Pull the connector from one of the brake lights. Turn the ignition switch on (engine not running). Have someone depress the service brake pedal. Using a voltmeter or test lamp, check for power to the connector. If power is getting through, check for a good ground to the lamps. If both power and grounding are good, replace the lamp assemblies and recheck.

c. Check the wiring to the brake lights.

Starting from the service brake switch, check the wiring to the brake lights. If the unit is equipped with turn signals, the problem might be in the turn signal switch. If the unit is not equipped with turn signals, the wiring to the lights is still routed under the dash panel to a jumper plug where the turn signal switch would normally be connected.

E. Turn Signals (if equipped):

1. Turn Signals Not Working (one) -

Check bulb or lamp assembly. If a replacement assembly or bulb is available, replace malfunctioning lamp. If not, use a voltmeter or test lamp to see if power is getting to the lamp socket or assembly with the ignition switch on (engine not running) and turn signal switch in the appropriate position. If voltage is present and the bulb or assembly continues to be defective, check for a good ground. If no voltage is present, check the wiring between the malfunctioning lamp or assembly and the turn signal switch. If the wiring is good and the other positions work on the turn signal switch, the switch is defective. Replace turn signal switch.

2. Turn Signal(s) Not Working (both lamps on one side) -

If both lamps on one side (right or left) work and the other side does not , check the wiring to the turn signal switch. If wiring is good, check each lamp or assembly as described above (E1). If the lamps or assemblies check out and the wiring is good, replace the turn signal switch.

3. Turn Signals Not Working (all) -

Check power to the circuit. Locate the three-prong flasher in the dash panel assembly. Using a voltmeter or test lamp, with the ignition switch on (engine not running), check for power to the center terminal in the connector. If no power is present, check the fuse or wiring to the flasher.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems (cont)

E. Turn Signals (if equipped) (cont):

3. Turn Signals Not Working (all) (cont) -

If power is present, replace the flasher and recheck unit. If all lamps and assemblies continue malfunctioning, check each lamp or assembly as described above (E1). If problem persists, replace the turn signal switch.

F. Horn:

1. Horn Not Working -

a. Check for power to the horn relay.

Remove the plug from the horn relay, locate the line coming from the circuit breaker, and check for power with a test lamp or voltmeter (ignition switch on, engine not running). If no power is present, check the circuit breaker supplying the circuit. If power is present, proceed to Step b.

b. Check for relay operation.

Turn the ignition switch to the “Run” position. Do not start motor. Have an assistant depress the horn button while checking the output from the relay to the horn. If no power is present, check for a defect in the horn button circuit to ground. If the relay has power and a good ground from the horn button, replace the relay. If power is getting to the horn but the horn will not sound, check for a good ground to the horn. If the horn has power and a good ground, replace the horn.

G. Windshield Wiper:

1. Wiper Not Working -

Turn the ignition switch to the “Run” position. Do not start engine. Turn the wiper switch to the “On” position and, using a test lamp or voltmeter, check for power at the wiper motor. If power is present, check for a good ground. If power is getting to the motor and it has a good ground, repair the motor. If there is no power getting to the motor, check the switch. Turn the ignition switch to the “Off” position. Disconnect the positive cable from the battery. Have an assistant help to remove the dash panel assembly. Place the dash panel face-down on the seats. Be sure that there are no electrical terminals in the dash panel touching ground. Reconnect the battery. Turn the ignition switch to the “Run” position. (Do not start motor). Using a test lamp, check the power to the wiper switch. If no power is present, check the circuit breaker to the switch or the wiring to the switch. Be sure to return the ignition switch to the” Off” position and disconnect the battery’s positive cable before installing the dash panel.

H. Blower, Heater:

1. Blower Not Working -

Turn the ignition switch to the “Run” position. Do not start engine. Turn the heater switch to the “High” position and, using a test lamp or voltmeter, check the power at the blower motor. If power is present, check for a good ground. If power is getting to the motor and it has a good ground, replace the motor. If there is no power getting to the motor, check the switch. Turn the ignition switch to the “Off” position. Disconnect the positive cable from the battery. Have an assistant help remove the dash panel assembly.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems (cont)

H. Blower, Heater (cont):

1. Blower Not Working (cont) -

Place the dash panel face down on the seats. Be sure that there are no electrical terminals in the dash panel touching ground. Reconnect battery. Turn the ignition switch to the "Run" position. (Do not start the motor). Using a test lamp, check for power to the heater switch. If no power is present, check the circuit breaker to the switch, or the wiring to the switch. If power is good to the switch, replace the switch. Be sure to turn the ignition switch to the "Off" position and disconnect the battery's positive cable before reinstalling the dash panel.

I. Fan, Cab Accessory (if equipped):

1. Fan Not Working -

Turn the ignition switch to the "Run" position. (Do not start engine). Disconnect the fan from the cab wiring harness. Using a test lamp or voltmeter, check for power at the harness terminal. If no power is present, check the fuse or switch's circuit breaker and wiring. If power is present, check for good ground. If power is getting to the fan and it has good ground, check the switch. Remove the fan from the mounting plate. Turn the ignition switch to the "Run" position. (Do not start the motor). Using a test lamp, check for power running through the heater switch. If power is getting through the switch, replace the fan. If no power is getting through the switch, replace the switch.

J. Charging System:

1. Charging System Not Working -

a. Check for good ground to the alternator.

Raise and support the hood. Start the engine. Using a voltmeter, check for voltage between the alternator housing and the negative battery terminal. This should be less than one volt. If it is greater than one volt, shut engine off and check the mounting bolts for corrosion and / or possibly loose hardware.

WARNING: DO NOT ALLOW ANY PART OF YOUR BODY, CLOTHING OR EQUIPMENT GET NEAR MOVING ENGINE PARTS. SERIOUS INJURY CAN RESULT IF YOU COME INTO CONTACT WITH MOVING ENGINE PARTS.

b. Check for power to the alternator field terminal.

Start engine. Using a voltmeter, check the voltage at the two-wire connector on the alternator. There is one white wire and one red wire in the connector. The red wire is to the alternator field terminal and should be 90% or more of the battery voltage. If low or no voltage is present, shut unit down and check the diode located under the dash panel assembly. Remove the diode from the harness. Turn the ignition switch to the "Run" position. (Do not start the unit). Check for power to the diode connector. If no power is present, check the circuit breaker supplying the circuit. If power is present, replace the diode.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Electrical Systems (cont)

J. Charging System (cont):

1. Charging System Not Working (cont) -

c. Check the power to the alternator terminal lamp.

Start the engine. Using a voltmeter, check the voltage at the two-wire connector on the alternator. There is one white wire and one red wire in the connector. The white wire is to the alternator's charge indicator and should be 60% or more of the battery voltage. If low or no voltage is present, shut unit down and check the resistor located under the dash panel assembly. Remove the resistor from the harness. Turn the ignition switch to the "Run" position. (Do not start unit). Check for power to the resistor connector. If no power is present, check the fuse or circuit breaker supplying the circuit. If power is present, replace the resistor. Refer to **Chapter 5 - Manufacturer's Appendices** for more information about servicing the alternator itself.

CHAPTER 2
SECTION 2: TROUBLESHOOTING

6. Transmission

DIAGNOSIS AND TESTING

Troubleshooting the automatic transmission is simplified by using the proven methods of diagnosis. One of the most important things to remember is that there is a definite procedure to follow. Do not try to short cut or take it for granted that someone else has done the critical checks or adjustments. The following procedures are recommended for checking and/or verifying that the various components are adjusted and operating properly. If an Automatic Transmission Tester is used, Rotunda model 014-00737 or equivalent, follow the manufacturers instructions.

GENERAL INFORMATION

All automatic transmissions are equipped with high temperature resistant seals. This includes those seals used on the manual and kickdown levers, the 0-rings and oil pan gasket. Under no conditions should older design seals be used on the transmissions, except the regular service replacement oil pan gasket, which is of special leak prevention design. This should still be used.

Transmission Fluid Level Check

CAUTION: Vehicle should not be driven if fluid level is below the "DO NOT DRIVE" hole.

Transmission—Operating Temperature

The automatic transmission should be checked at an operating temperature of 66 degrees to 77 degrees C (150 degrees to 170 degrees F) (dipstick is hot to the touch). The operating temperature may be obtained by driving 24-32 km (15 to 20 miles) of city-type driving with the outside temperature above 10 degrees C (50 degrees F).

CAUTION: If vehicle has been operated for an extended period at high speed, or in city traffic in hot weather, or vehicle is being used to pull a trailer, to obtain an accurate reading, the fluid has to cool, usually about 30 minutes after engine has been turned off.

Transmission—Room Temperature

If the transmission is not at an operating temperature of 66 degrees to 77 degrees C (150 degrees to 170 degrees F) and it becomes necessary to check the fluid level (such as pre-delivery), the fluid may be checked at room temperature, 21 degrees to 35 degrees C (70 degrees to 95 degrees F) (dipstick cool to touch).

Dipstick Reading

Refer to Fig. 2.

The fluid level on the dipstick should be within the cross hatched area at operating temperature. The fluid level on the dipstick should read between the holes at room temperatures.

Check the fluid as follows:

NOTE: It may be necessary to remove the air inlet tube located directly in the way of access to the dipstick.

1. With the transmission in PARK, engine at idle rpm, foot brakes applied, and vehicle on level surface, move the transmission/selector lever through each range, allowing time in each range to engage transmission. Return to PARK, applying parking brake fully, and block the wheels. Do not turn off the engine during the fluid level check.
2. Clean all dirt from the transmission fluid dipstick cap before removing the dipstick from the filler tube.
3. Pull the dipstick out of the tube, wipe it clean, and push it all the way back into the tube. Be sure it is fully seated.
4. Pull the dipstick out of the filler tube again, and check the fluid level.

IMPORTANT: The fluid level indication on the dipstick will be different at operating temperature and room temperature. For the correct fluid level reading on the dipstick, follow the appropriate instructions stated previously.

Before adding fluid, be sure that the correct type will be used. If in doubt, check the Vehicle Certification Label affixed to the left front door lock face panel or door pillar for the Transmission/Transaxle Code. Also, the fluid is stamped on the dipstick.

CAUTION: Use of a fluid other than specified could result in transmission malfunction and/or failure.

If necessary, add enough fluid through the filler tube to raise the level to the correct position. Do not overfill the transmission, because it will result in foaming, loss of fluid through the vent, and possible transmission malfunction. If overfill occurs, excess must be removed.

5. Install the dipstick, making sure it is fully seated in the tube.

If the transmission fluid level is correctly established at 21 degrees to 35 degrees C (70 degrees to 95 degrees F), it will appear in the cross hatch area on the dipstick when the transmission reaches an operating temperature of 66 degrees to 77 degrees C (150 degrees to 170 degrees F). Do not overfill or underfill.

Overfill can cause the fluid to foam and spill out through the transmission vent resulting in a transmission malfunction.

Underfill can result in transmission loss of engagement or slipping. This condition is most evident in cold weather or when the vehicle is parked or being driven on a hill.

If the transmission fluid level is checked when the fluid is at room temperature, the dipstick could indicate that fluid should be added if the dipstick is misread. If fluid is added at this time, an overfill condition could result when the fluid reaches operating temperatures of 66 degrees to 77 degrees C (150 degrees to 170 degrees F) (dipstick hot to touch).

Refer to the specifications at the end of this Section for automatic transmission fluid requirements and capacities.

Transmission Fluid Condition Check

1. Make the normal fluid check according to the above procedure.

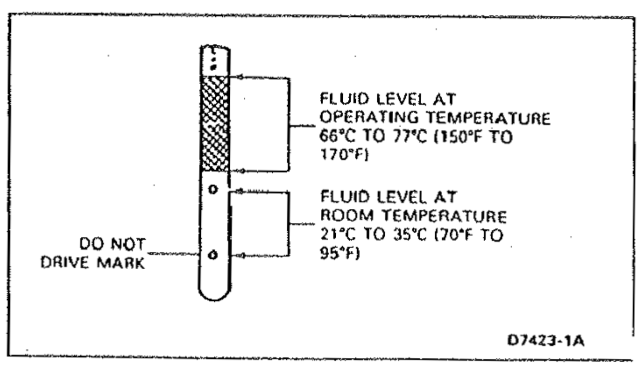


FIG. 2. Dipstick Reading— C6

2. Observe color and odor of the fluid. It should be dark reddish not brown or black. A burnt odor can sometimes indicate that there is an overheating condition or clutch disc or band failure.
3. Use an absorbent white facial tissue paper to wipe the dipstick. Examine the stain for evidence of solids (specks of any kind) and for antifreeze signs (gum or varnish on dipstick).

   NOTE: Fluid used with the automatic transmission contains a detergent which retains in suspension particles generated during normal transmission use. This characteristic may result in a dark coloring of the fluid and does not by itself indicate malfunction or need for repair.

   If specks are present in the oil or there is evidence of antifreeze, the transmission oil pan must be removed for further inspection. If fluid contamination or transmission failure is confirmed by further evidence of coolant or excessive solids in the oil pan, the transmission must be disassembled and completely cleaned and repaired. This includes cleaning the torque converter and transmission cooling system. It would be a waste of time to perform any further checks before cleaning and repairing the transmission.

   During disassembly and assembly, all overhaul checks and adjustments of clearances and end play must be made.

High or Low Fluid Level

A fluid level that is too high will cause the fluid to become aerated. Aerated fluid will cause low control pressure, and the aerated fluid may be forced out the vent.

A fluid level that is too low can affect the operation of the transmission. Low level may indicate fluid leaks that could cause transmission damage.

Fluid Level High Before Starting Engine—OK During Normal Check

1. Check for correct operation of drainback valve in stator support.
2. Check pump bushing.
3. Replace or repair pump if required.

Transmission Fluid Cooler Flow Check

The linkage, fluid level and control pressure must be within specifications before performing this flow check.

Remove the transmission dipstick from the filler tube. Place a funnel in the transmission filler tube. Raise the vehicle, remove the cooler return line from its fitting in the case. Attach a hose to the cooler return line and fasten the free end of the hose in the funnel installed in the filler tube.

Start the engine and set idle speed at 1000 rpm with the transmission in neutral.

Observe the fluid flow at the funnel. When the flow is "solid" (air bleeding has been completed), the flow should be liberal. If there is not a liberal flow at 1000 rpm in neutral, low pump capacity, main circuit system leakage, or cooler system restriction is indicated.

Check both metal cooler lines between the transmission and radiator for restrictions. Check for restrictions in the metal or rubber cooler lines to and from the auxiliary cooler, if the vehicle is so equipped. Visually check and physically feel all bends for kinks, especially rubber cooler lines, that would restrict flow and could result in transmission overheating or lack of lubrication.

To separate transmission trouble from cooler system trouble, observe the flow at the transmission case converter-out fitting.

Transmission Fluid Leakage Checks

Check the speedometer cable connection at the transmission. Replace the rubber seal if necessary (if so equipped).

Leakage at the oil pan gasket often can be stopped by tightening the attaching bolts to the proper torque. If necessary, replace the gasket.

Check the fluid filler tube connection at the transmission case. If leakage is found, install a new O-ring. The filler tube brackets should align properly and be attached to the transmission or engine locations.

Check the fluid lines and fittings between the transmission and the cooler in the radiator tank for looseness, wear, or damage. If leakage is found, tighten the fitting, or replace the damaged parts (Fig. 3).

Check the engine coolant in the radiator. If transmission fluid is present in the coolant, the cooler in the radiator is probably leaking.

The cooler can be further checked for leaks by disconnecting the lines from the cooler fittings and applying 345-517 kPa (50-75 psi) air pressure to the fittings. Remove the radiator cap to relieve the pressure build up at the exterior of the oil cooler tank. If the cooler is leaking and/or will not hold pressure, the cooler must be replaced. Cooler replacement is described in the Cooling System Section of Group 27.

If leakage is found at either the downshift control lever shaft or the manual lever shaft, replace either or both seals.

Inspect the pipe plug on the left front side of the transmission case. If the plug shows leakage, tighten the plug to specifications. If leakage continues, replace the plug. On a C6 transmission, inspect the TV pressure plug on the right rear side of the case.

Transmission	Radiator		Transmission		Fluid Line Nut	
	ft-lbs	N·m	ft-lbs	N·m	ft-lbs	N·m
C6	8-12	11-16	18-23	24-31	12-18	17-24

CD3141-2D

FIG. 3 Cooler Line Fitting Torque Specifications evident. If the plug shows leakage, coat the threads with Motorcraft Sealing Compound or equivalent and tighten the plug to specification as listed at the end of the appropriate transmission Section. If leakage continues, replace the plug.

When a converter drain plug leaks, remove the drain plug with a six-point wrench. Coat the threads with Motorcraft Sealing Compound or equivalent and install the plug. Tighten the drain plug to specification as listed at the end of this Section. **Fluid leakage from the converter housing may also be caused by engine oil leaking past the rear main bearing, or from oil galley plugs, or power steering oil leakage from steering system. Be sure to determine the exact cause of the leak before starting repair procedures.**

Oil-soluble aniline or fluorescent dyes premixed at the rate of 1/2 teaspoon of dye powder to 0.23 liter (1/2 pint) of transmission fluid have proved helpful in locating the source of fluid leakage. Such dyes may be used to determine whether an engine oil or transmission fluid leak is present, or if the fluid in the oil cooler leaks into the engine coolant system. A black light must be used with the fluorescent dye solution.

Fluid Leakage in Converter Area

In diagnosing and correcting fluid leaks in the front pump and converter area, use the following procedures to locate the exact cause of the leakage. Leakage at the front of transmission, is evidenced by fluid around the converter housing, may have several sources. By careful observation, it is possible in many instances, to pinpoint the source of the leak before removing the transmission from the vehicle. The paths which the fluid takes to reach the bottom of the converter housing are shown in (Fig. 4).

1. Fluid leaking by the front pump seal lip will tend to move along the drive hub and onto the back of the impeller housing. Except in the case of a total seal failure, fluid leakage by the lip of the seal will be deposited on the inside of the converter housing only, near the outside diameter of the housing.
2. Fluid leakage by the outside diameter of the seal and front pump body will follow the same path which the leaks by the front pump seal follow.
3. Fluid that leaks by a front pump-to-case bolt will be deposited on the inside of the converter housing only. Fluid will not be deposited on the back of the converter.
4. Leakage by the front pump-to-case gasket may cause fluid to be deposited inside the converter housing, or it may seep down between the front of the case and converter housing.
5. Fluid leakage from the converter drain plugs or converter-to-flywheel stud weld will appear at the outside diameter of the converter on the back face of the flywheel, and in the converter housing only near the flywheel.

Engine oil leaks are sometimes improperly diagnosed as transmission front pump seal leaks. The following areas of possible leakage should also be checked to determine if engine oil leakage is causing the problem:

a. Leakage at the rocker arm cover (valley cover) may allow oil to flow over the converter housing or seep down between the converter housing and cylinder block, causing oil to be present in or at the bottom of the converter housing.

b. Oil galley plug leaks will allow oil to flow down the rear face of the block to the bottom of the converter housing.

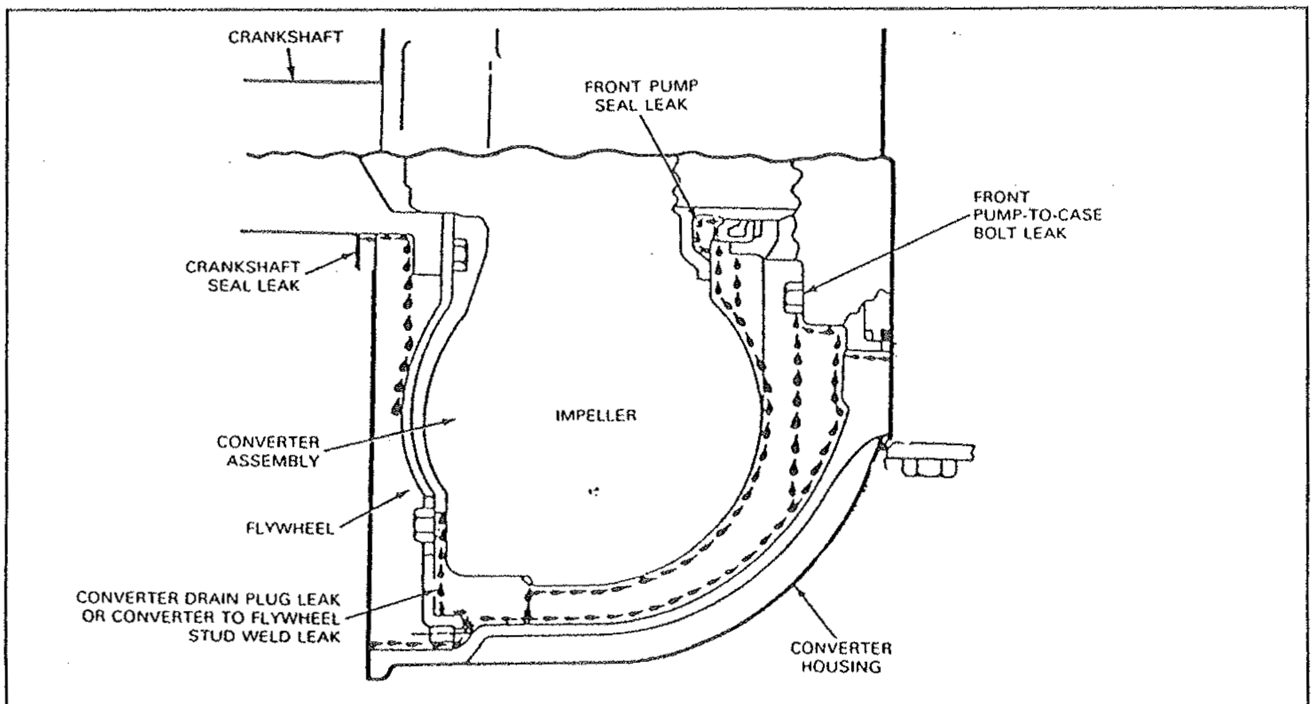


FIG. 4 Converter Leakage—Fluid Path

c. Leakage by the crankshaft seal will work back to the flywheel, and then into the converter housing.

Fluid leakage from other areas, such as the power steering system forward of the transmission, could cause fluid to be present around the converter housing due to blow back or road draft. The following procedures should be used to determine the cause of the leakage before any repairs are made.

a. Remove the transmission dipstick and note the color of the fluid. Original factory-fill fluid is dyed red, to aid in determining if leakage is from the engine or transmission. Unless a considerable amount of makeup fluid has been added or the fluid has been changed, the color should assist in pinpointing the leak. Since road draft may cause leaking power steering fluid to be present on the transmission, this leakage, if present, should be eliminated before checking the transmission for fluid leakage.

b. Remove the converter housing cover. Clean off any fluid from the top and bottom of the converter housing, front of the transmission case, and rear face of the engine and engine oil pan. Clean the converter area by washing with a suitable non-flammable solvent, and blow dry with compressed air.

c. Wash out the converter housing, the front of the flywheel, and the converter drain plugs. The converter housing may be washed out using cleaning solvent and a squirt-type oil can. Blow all washed areas dry with compressed air.

d. Start and run the engine until the transmission reaches its normal operating temperature. Observe the back of the block and top of the converter housing for evidence of fluid leakage. Raise the vehicle on a hoist and run the engine at fast idle, then at engine idle, occasionally shifting to the drive and reverse ranges to increase pressure within the transmission. Observe the front of the flywheel, back of the block (in as far as possible), and inside the converter housing and front of the transmission case. Run the engine until fluid leakage is evident and the probable source of leakage can be determined.

Converter Leakage Check

If welds on the torque converter indicate leakage, remove the converter and make the following check.

Assemble a Rotunda 021-00054 Torque Converter Leak Detector or an equivalent to the converter. Test the converter for leaks following the directions supplied with the detector kit.

Control Pressure Test

C6

There are two methods of performing the control pressure test. One is to perform the test using the engine vacuum. The second method is to use a remote vacuum source such as the one provided in the distributor tester or a hand operated vacuum pump.

Engine Vacuum Pressure

When the vacuum diaphragm unit is operating properly and the manual and downshift linkage is adjusted properly, all the transmission shifts (automatic and kickdown) should occur within the road speed limits listed in the Technical Service Bulletin—Special Specifications Issue.

If the shifts do not occur within limits, or the transmission slips during shift point, use the following procedure to determine whether the engine, transmission, linkage, vacuum diaphragm unit or valve body is causing the condition.

1. Attach a tachometer to the engine and a vacuum gauge, Rotunda Number 059-00008, or equivalent to the transmission vacuum line at the manifold vacuum port (Fig. 5).
2. Attach a pressure gauge to the control pressure outlet at the transmission (Fig. 6).

   CAUTION: Pressure gauges affect the shift quality of the transmission. Care should be taken NOT to accelerate or decelerate rapidly. Possible transmission failure could result.
3. Firmly apply the parking brake and start the engine.
4. Adjust the engine idle speed to the specified rpm, using the carburetor idle adjustment screw. If the

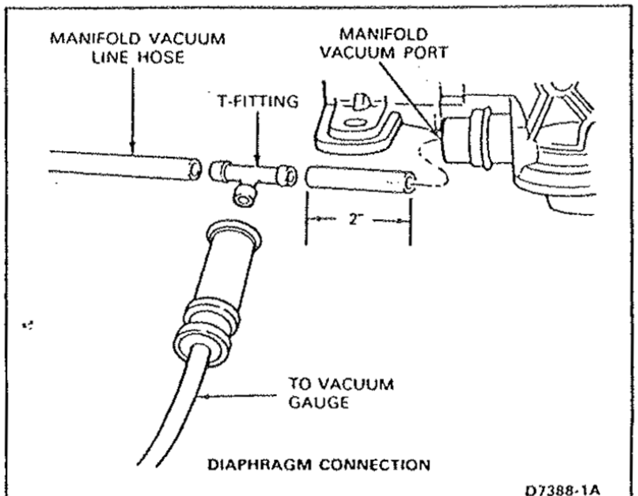


FIG. 5 Typical Vacuum Test Line Connections

*May be purchased as a separate item.

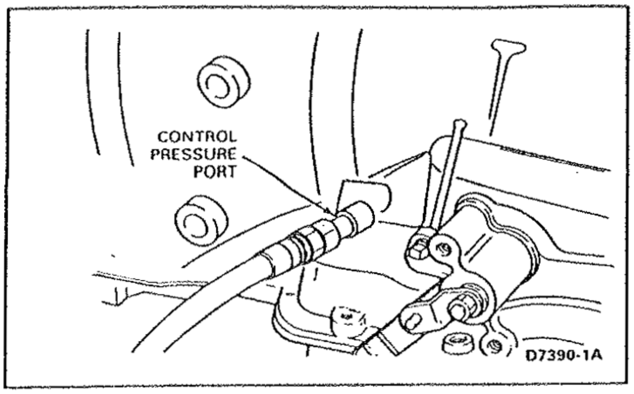


FIG. 6 Control Pressure Connecting Point—C6 Transmissions

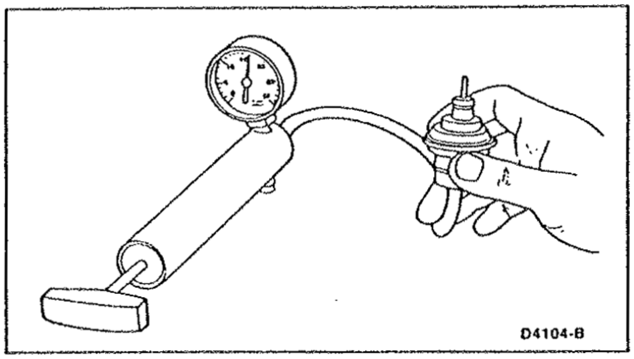


FIG. 7 Testing Transmission Vacuum Unit for Leakage

engine idle speed cannot be brought within limits, check the throttle for a binding condition. If linkage is satisfactory, check for vacuum leaks in the transmission diaphragm unit (Fig. 7) and its connecting tubes and hoses. Check all other vacuum operated units (such as the power brake) for vacuum leaks. Refer to the appropriate brake Section in Group 12.

Refer to the two control pressure diagnostic guides in Fig. 8 to show what components are inoperative when the control pressure test is not within specifications. Do not proceed with the main diagnosis guide until you have made any repairs, as required, and the control pressure is within specifications as listed in the Technical Service Bulletin—Special Specifications Issue.

Vacuum Pump Method

C6

Disconnect and temporarily plug the vacuum line at the vacuum diaphragm unit. Attach a vacuum pump to the vacuum diaphragm. Apply both the parking and service brakes. Start the engine and vacuum pump. Set the vacuum at 15 inches, read and record the control pressure in all selector positions. Run the engine up to 1000 rpm, and reduce the vacuum to 10 inches. Read and record the control pressure in D, 2 and 1. Keep the engine rpm at 1000 and reduce the vacuum to 1 inch. Read and record the control pressure in D, 1, 2 and R.

Refer to the two control pressure diagnostic guides in Fig. 8 to show what components are inoperative when the control pressure test is not within specifications. Do not proceed with the main diagnosis guide until you have made any repairs, as required, and the contr pressure is within specifications as listed in th Technical Service Bulletin—Special Specificatior Issue.

Vacuum Diaphragm Test—On Vehicle

C6

To check the vacuum diaphragm unit, start th vacuum pump and set the regulator knob so that th vacuum gauge reads 18 inches with the end of th vacuum hose blocked off. Then connect the vacuu hose to the diaphragm unit. If the gauge still reads 1 inches, the vacuum diaphragm unit is not leaking. If th reading does not remain at 18 inches, but drops, th vacuum diaphragm unit is leaking. Replace the vacuu diaphragm unit. Also, if automatic transmission fluid present in the vacuum side of the diaphragm or in th vacuum hose, the diaphragm is leaking and must b replaced.

Vacuum Diaphragm Test—Off Vehicle

C6

To check the vacuum unit for diaphragm leakag remove the unit from the transmission. Use a distribut tester equipped with a vacuum pump or Rotund Vacuum Tester 021-00014 or equivalent (Fig. 7). Set th regulator knob until the vacuum gauge reads 18 inche with the end of the vacuum hose blocked off.

Connect the vacuum hose to the manifold vacuu port as shown in Fig. 7. If the gauge still reads 1 inches, the vacuum unit diaphragm is not leaking. second leakage check can be made as the hose removed from the transmission vacuum unit. Hold finger over the end of the control rod. When the hose removed, the internal spring of the vacuum unit shoul push the control rod outward. If the vacuum diaphrag needs replacing, install a new unit that has bee released for service. Vacuum diaphragm assemb identification is given at end of this Section.

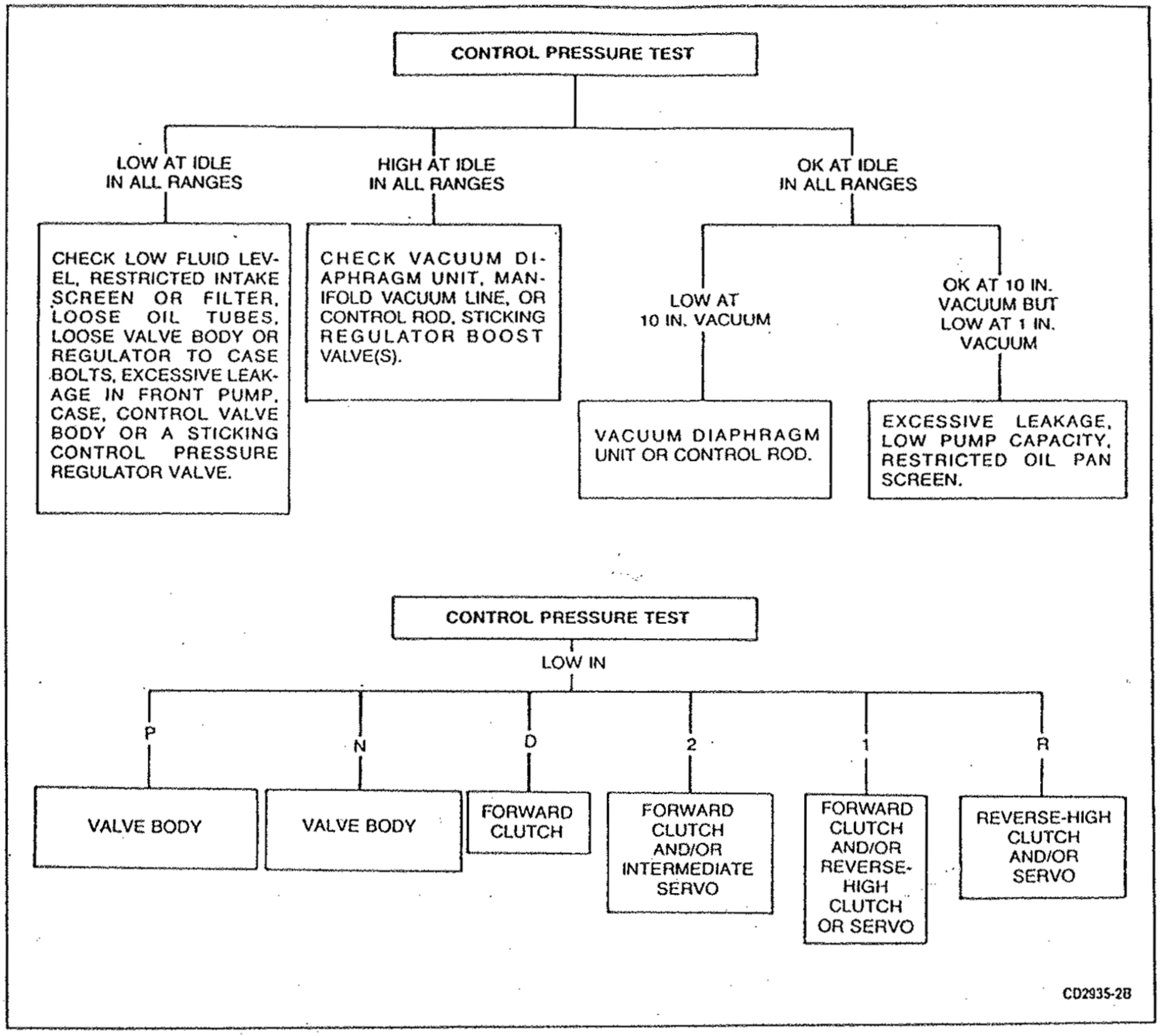


FIG. 8 Control Pressure Test Charts—C6

2. Connect a 300 psi gauge to the line pressure port on the case left side just above the control lever (Fig. 9). Have sufficient flexible hose to make the gauge accessible while operating the engine.

3. Connect a 0-100 psi pressure gauge to the TV port on the right side of the case (see Fig. 9). Have sufficient flexible Hose to make the gauge accessible while operating the engine.

CAUTION: Pressure gauges affect the shift quality of the transmission. Care should be taken NOT to accelerate or decelerate rapidly. Possible transmission failure could result.

NOTE: W.O.T. readings are to be made at full stall. However, be sure to run the engine at fast idle in neutral for cooling between test.

4. Run the engine until it is hot.

CAUTION: Idle pressure must be read with the throttle off the fast idle cam.

5. Apply the service and parking brakes firmly and shift through all the ranges. Record the line pressure and the throttle pressure and compare it with specifications.

After making the control pressure tests, analyze the results to relate to the conditions in Figs. 10, 11 and 12.

Keep in mind that clutch and servo leakage may or may not show up on the control pressure test. This is because (1) the pump has a high output volume and the leak may not be severe enough to cause a pressure drop; and (2) orifices between the pump and pressure chamber may maintain pressure at the source, even with a leak downstream. Pressure loss caused by a less-than-major leak is more likely to show up at idle than at W.O.T. where the pump is delivering full volume.

Conversely, if you are manipulating the T.V. linkage to simulate W.O.T., but actually testing at idle, the leak is more likely to cause a pressure loss in the W.O.T. position.

To further isolate leakage in a clutch or servo circuit, it is necessary to remove the oil pan and valve body, and to perform case air pressure tests.

Governor Check

C6

The governor can be checked at the same time as the Control Pressure Test is performed and in the same manner.

Raise the vehicle with an axle or frame hoist so that the rear wheels are clear of the floor. Disconnect and plug the vacuum line to the vacuum diaphragm unit. Connect the line from the distributor tester if available to the vacuum diaphragm unit. Vacuum pump can be used with an extended vacuum hose to operate from within the vehicle.

CAUTION: Never exceed 96 km (60 mph) speedometer speed.

Place the transmission in D (DRIVE), no load on the engine and apply 10 inches of vacuum to the vacuum diaphragm unit. Increase the speed slowly and watch the speedometer. Check the mph at which the control pressure cutback occurs. It should occur between 16-32 km (10-20 mph).

NOTE: After each test, move the selector to N (neutral) and run the engine at 1000 RPM to cool the transmission.

The governor is good if the cutback occurs within these specifications. If the cutback does not occur within specifications, check shift speeds to verify that it is the governor and not a stuck cutback valve, then repair or replace the governor.

Shift Point Checks

Road Test

C6

This check will determine if the governor pressure and shift control valves are functioning properly.

Check the minimum throttle upshifts in D (DRIVE). The transmission should start in first gear, shift to second, and then shift to third, within the shift points listed in Technical Service Bulletin—Special Specifications Issue.

With the transmission in third gear, depress the accelerator pedal through the detent (to the floor). The transmission should shift from third to second or third t first, depending on the vehicle speed.

Check the closed throttle downshift from third to firs by coasting down from about 48 km (30 mph) in thir gear. The shift should occur within the limits listed in th Specifications.

When the selector lever is at 2 (SECOND), th transmission can operate only in second gear.

With the transmission in third gear and road spee over 80 km (50 mph) the transmission should shift t second gear when the selector lever is moved from I (DRIVE) to 2 (SECOND) or 1 (FIRST).

The transmission will downshift from second or thir to first gear when this same manual shift is made belo approximately 48 km (30 mph) with a C6 transmissior

Refer to the band application chart in Fig. 14 to aid i diagnosis of transmission conditions.

In Shop

A shift test can be performed in the shop to chec shift valve operation, governor circuits, shift del pressures, throttle boost and downshift valve actior

Raise the vehicle with an axle or frame hoist so th the rear wheels are clear of the floor. Disconnect an plug the vacuum line to the vacuum diaphragm ur

(C6). Connect the line from the distributor tester vacuu pump to the vacuum diaphragm unit.

CAUTION: Never exceed 96 km (60 mp speedometer speed.

1. To check the shift valves and governor circui apply 18 inches of vacuum to the transmissi vacuum diaphragm unit. Place the transmission Drive and make a minimum throttle 1-2 and 2 shift. At the shift points you will see t speedometer needle make a momentary surge a feel the driveline bump. If the shift points are wit specification, the 1-2 and 2-3 shift valves a governor are OK.

   If the shift points are not within specificati perform a Governor Check to isolate the proble

   NOTE: After each test, move the selector lever Neutral, run the engine at 1000 rpm to cool t transmission.

2. To check the shift delay pressures and thro boost, decrease the vacuum at the vacu diaphragm to 0-2 inches. Make a 1-2 shift test. the shift point raises to specification, the thro boost and shift delay systems are functioning.
3. To check downshift valve action. Leave t vacuum to the vacuum diaphragm at 0-2 inch Position the downshift linkage in the wide op throttle position (through the detent) and rep the 1-2 shift test. The speed at the shift po should be higher.

   Shift speed specifications can be found in t Technical Service Bulletin—Special Specificatio Issue.

Air Pressure Checks

C6

A NO DRIVE condition can exist, even with correct transmission fluid pressure, because of inoperative clutches or bands. On automatic transmissions, an erratic shift can be caused by a stuck governor valve. The inoperative units can be located through a series of checks by substituting air pressure for fluid pressure to determine the location of the malfunction.

When the selector lever is at 2 (second) a NO DRIVE condition may be caused by an inoperative forward clutch. A NO DRIVE condition at D (drive) may be caused by an inoperative forward clutch or one-way clutch. When there is no drive in 1 (low) the difficulty could be caused by improper functioning of the forward clutch or simultaneous malfunction of the low-reverse band and the one-way clutch. Failure to drive in R (Reverse) could be caused by a malfunction of the reverse-high clutch or low-reverse band or clutch.

When you have a slip problem but don't know whether it is in the valve body or in the hydraulic system beyond the valve body, the air pressure tests can be very valuable.

To make the air pressure checks, loosen the oil pan bolts and lower one edge to drain the transmission fluid. Remove the oil pan and the control valve body assembly. The inoperative clutches or bands can be located by introducing air pressure into the various transmission case passages (Figs. 15 and 16).

Forward Clutch

Apply air pressure to the transmission case forward clutch passages (Figs. 15 and 16). A dull thud can be heard when the clutch piston is applied. If no noise is heard, place the finger tips on the input shell and again apply air pressure to the forward or front clutch passage. Movement of the piston can be felt as the clutch is applied.

Governor

Apply air pressure to the control pressure to governor passage (Figs. 15 and 16) and listen for a sharp clicking or whistling noise. The noise indicates governor valve movement.

Reverse-High Clutch

Apply air pressure to the reverse-high clutch (Figs. 15 and 16). A dull thud indicates that the reverse-high or rear clutch piston has moved to the applied position. If no noise is heard, place the finger tips on the clutch drum and again apply air pressure to detect movement of the piston.

Intermediate Servo

Hold the air nozzle in the front servo apply tube or the intermediate servo apply passages (Figs. 15 and 16).

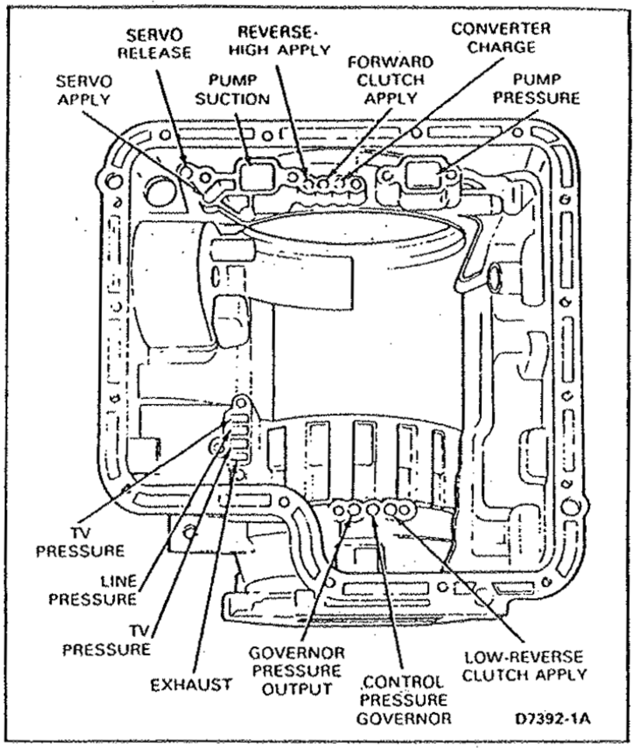


FIG. 15 Case Fluid Passage Hole Identification—C6 Automatic

Operation of the servo is indicated by a tightening of the front or intermediate band around the drum on C6 transmissions. Continue to apply air pressure to the servo apply tube or passage, and introduce air pressure into the front release tube or the intermediate servo release passage. The front or intermediate servo should release the band against the apply pressure.

Low-Reverse Clutch C6 Only

Apply air pressure to the low-reverse clutch apply passage (Fig. 15). A dull thud should be heard if the clutch is operating properly. If the passages are clear, remove the clutch assemblies, and clean and inspect the malfunctioning clutch to locate the trouble.

Diagnosis Guides

The diagnosis guides in this Section can be used as an aid when diagnosing automatic transmissions.

DIAGNOSIS — AUTOMATIC TRANSMISSION

CONDITION	POSSIBLE CAUSE	RESOLUTION
Slow initial engagement.	1. Improper fluid level.	1. Perform fluid level check.
	2. Damaged or improperly adjusted linkage.	2. Service or adjust linkage.
	3. Contaminated fluid.	3. Perform fluid condition check.
	4. Improper clutch and band application, or low main control pressure.	4. Perform control pressure test.
Rough initial engagement in either forward or reverse. Rough initial engagement — AOD.	1. Improper fluid level.	1. Perform fluid level check.
	2. High engine idle.	2. Adiust idle to specifications.
	3. Automatic choke on (warm temp.).	3. Disengage choke.
	4. Looseness in the driveshaft, U-joints or engine mounts.	4. Service as required.
	5. Improper clutch or band application, or oil control pressure.	5. Perform control pressure test.
	6. Sticking or dirty valve body.	6. Clean, service or replace valve body.
Harsh engagements — (warm engine).	1. Improper fluid level.	1. Perform fluid level check.
	3. Engine curb idle too high.	3. Check engine curb idle.
	4. Valve body bolts — loose/too tight.	4. Tighten to specification.
	5. Valve body dirty/sticking valves.	5. Determine source of contamination. Service as required.
No/delayed forward engagement (reverse OK).	1. improper fluid level.	1. Perform fluid level check.
	2. Manual linkage — misadjusted/ damaged.	2. Check and adjust or service as required.
	3. Low main control pressure. (Leakage.) Forward clutch stator support seal rings leaking (#3, #4).	3. Control pressure test, note results.
	4. Forward clutch assembly burnt/ damaged/leaking check ball in cylinder/ leaking piston seal rings.	4. Perform air pressure test.
	5. Valve body bolts — loose/too tight.	5. Tighten to specification.
	6. Valve body dirty/sticking valves.	6. Determine source of contamination. Service as required.
	7. Transmission filter plugged.	7. Replace filter.
	8. Pump damaged/leaking.	8. Visually inspect pump gears. Replace pump if necessary.
No/delayed reverse engagement (forward OK).	1. Improper fluid level.	1. Perform fluid level check.
	2. Manual linkage misadjusted/damaged.	2. Check and adjust or service as required.
	3. Low main control pressure in reverse. Reverse clutch stator support seal rings leaking (#1, #2). High reverse clutch OK.	3. Control pressure test.

DIAGNOSIS — AUTOMATIC TRANSMISSION (Continued)

CONDITION	POSSIBLE CAUSE	RESOLUTION
No/delayed reverse engagement (forward OK) (continued).	4. Reverse clutch assembly burnt/worn/ leaking check ball in piston/leaking piston seal rings.	4. Perform air pressure test.
	5. Valve body bolts loose/too tight.	5. Tighten to specification.
	6. Valve body dirty/sticking valves.	6. Determine source of contamination. Service as required.
	7. Transmission filter plugged.	7. Replace filter.
	8. Pump damaged.	8. Visually inspect pump gears. Replace if necessary.
No/delayed reverse engagement and/or no engine braking in manual low ①.	1. Improper fluid level.	1. Perform fluid level check.
	3. Low reverse servo piston seal leaking.	3. Check and replace piston seal.
		4. Perform air pressure test.
	5. Planetary low one way clutch damaged.	5. Deterine cause of condition. Service as required.
No engine braking in manual second gear.	1. Intermediate band out of adjustment.	1. Adjust intermediate band.
	2. Improper band or clutch application, or oil pressure control system.	2. Perform control pressure test.
	3. Intermediate servo leaking.	3. Perform air pressure test of intermediate servo for leakage. Service as required.
	4. Intermediate one way clutch damaged.	4. Replace.
	5. Polished or glazed band or drum.	5. Service or replace as required.
Forward engagement slips/shutters/ chatters.	1. Improper fluid level.	1. Perform fluid level check.
	3. Manual linkage misadjusted/damaged.	3. Check and adjust or service as required.
	4. Low main control pressure.	4. Control pressure test.
	5. Valve body bolts — loose/too tight.	5. Tighten to specification.
	6. Valve body dirty/sticking valves.	6. Determine source of contamination. Service as required.
	7. Forward clutch piston ball check not seating/leaking.	7. Replace forward clutch cylinder. Service transmission as required.
	8. Forward clutch piston seals cut/worn.	8. Replace seals and service clutch as required.
	10. Low one way clutch (planetary) damaged.	10. Determine cause of condition. Service as required.
Reverse shudder/chatters/slips.	1. Improper fluid level.	1. Perform fluid level check.
	2. Low main control pressure in reverse.	2. Control pressure test.
	3. Low — reverse servo/ leaking.	3. Air pressure test; visually inspect seal rings and piston bore.
	4. Low (planetary) one-way clutch damaged.	4. Determine cause of condition. Service as required.
	5. Reverse clutch drum bushing damaged.	5. Determine cause of condition. Service as required.
	6. Reverse clutch stator support seal ring/ring grooves worn/damaged.	6. Determine cause of condition. Service as required.
	7. Reverse clutch piston seals cut/worn.	7. Determine cause of condition. Service as required.
	8. Reverse band out of adjustment or damaged.	
	9. Looseness in the driveshaft, U-joints or engine mounts.	9. Service as required.

DIAGNOSIS — AUTOMATIC TRANSMISSION

CONDITION	POSSIBLE CAUSE	RESOLUTION
No drive, slips or chatters in first gear in D. All other gears normal.	1. Damaged or worn planetary one-way clutch.	1. Service or replace one-way clutch.
No drive, slips or chatters in second gear.	1. Intermediate band out of adjustment (C6). 4. Improper band or clutch application, or control pressure. 5. Damaged or worn intermediate servo piston seals and/or internal leaks. 6. Dirty or sticking valve body. 7. Polished, glazed intermediate band or drum (C6).	1. Adjust intermediate band. 4. Perform control pressure test. 5. Perform air pressure test. 6. Clean, service or replace valve body. 7. Replace or service as required.
Starts up in 2nd or 3rd.	1. Improper band and/or clutch application, or oil pressure control system. 3. Damaged or worn governor. Sticking governor. 4. Valve body loose. 5. Dirty or sticking valve body. 6. Cross leaks between valve body and case mating surface.	1. Perform control pressure test. 3. Perform governor check. Replace or service governor, clean screen. 4. Tighten to specification. 5. Clean, service or replace valve body. 6. Service or replace valve body and/or case as required.
Shift points incorrect.	1. Improper fluid level. 2. Vacuum line damaged, clogged or leaks (C6). 6. Improper clutch or band application, or oil pressure control system. 7. Damaged or worn governor. 8. vacuum diaphragm bent sticking or leaks, (C6). 9. Dirty or sticking valve body.	1. Perform fluid level check. 2. Perform vacuum supply test. 6. Perform shift test and control pressure test. 7. Service or replace governor — clean screen. 8. Replace. 9. Clean, service or replace valve body.
All upshifts harsh/delayed or no upshifts.	1. Improper fluid level. 3. Manual linkage — misadjusted/damaged. 4. Governor sticking. 5. Main control pressure too high. 6. Valve body bolts — loose/too tight. 7. Valve body dirty/sticking valves.	1. Perform fluid level check. 3. Check and adjust or service as required. 4. Perform governor test. Service as required. 5. Control pressure test. Service as required. 6. Tighten to specification. 7. Determine source of contamination. Service as required.
All upshifts harsh/delayed or no upshifts (continued).	8. Vacuum leak to diaphragm unit (C6).	8. Check vacuum lines to diaphragm unit. Service as necessary. Perform vacuum supply and diaphragm tests.

REMOVAL AND INSTALLATION

Vacuum Diaphragm C6

Removal and Installation

1. Disconnect the hose from the vacuum unit.
2. Remove the vacuum unit retaining bracket bolt and bracket (Fig. 28). **Do not pry or bend the bracket.** Pull the vacuum unit from the transmission case.
3. Remove the vacuum unit control rod from transmission case.
4. Install the vacuum unit control rod in transmission case.
5. Push the vacuum unit into the case and secure with the retaining bracket and bolt. Tighten the bolt to 17-21 N·m (12-16 ft-lbs) on C6 transmissions.
6. Install the vacuum unit hose to the diaphragm connector.

Transmission Fluid Drain and Refill

Normal maintenance and lubrication requirements do not necessitate periodic automatic transmission fluid changes.

If a major repair, such as a clutch band, bearing, etc., is required in the transmission, it will have to be removed for service. At this time the converter, transmission cooler and cooler lines must be thoroughly flushed to remove any dirt.

When used under continuous or severe conditions, the transmission and the torque converter should be drained and refilled with the specified fluid at intervals directed in the maintenance or owners manual.

Refer to the Truck Performance Specifications Book or the end of this Section for fluid requirements.

NOTE: Fluid level indicator should be used to determine actual fluid requirements. Check fluid level when the transmission is at normal operating temperature. Do not overfill.

Procedures for partial drain and refill, due to in-vehicle repair operation, are as follows:

C6 Transmissions

1. Raise the vehicle on a hoist or jack stands.
2. Place a drain pan under the transmission.
3. Loosen the pan attaching bolts and drain the fluid from the transmission.
4. When fluid has drained to the level of the pan flange, remove the rest of the pan bolts working from the rear and both sides of the pan to allow it to drop and drain slowly.
5. When all fluid has drained from the transmission, remove and thoroughly clean the pan and the screen. Discard the pan gasket.
6. Place a new gasket on the pan, and install the pan on the transmission. Tighten the bolts to specifications.
7. Add 4.7 liters (5 quarts) shallow pan, or 5.6 liters (6 quarts) deep pan of fluid to the transmission through the filler tube.
8. Check the fluid level.

Fluid Cooler Lines

When fluid leakage is found from the fluid cooler, cooler must be replaced. Cooler replacement described in the Cooling System Section of Group 27.

When one or more of the fluid cooler steel tubes must be replaced, each replacement tube must be fabricated from the same size steel tubing as the original line.

Using the old tube as a guide, bend the new tube as required. Add the necessary fittings, and install the tube.

After the fittings have been tightened, add fluid as needed, and check for fluid leaks.

CLEANING AND INSPECTION

Transmission

It is important to completely clean all transmission components, including converter, cooler, cooler lines, main control valve body, governor, all clutches, and all check balls after any transmission servicing that generates contamination. These contaminants are a major cause for recurring transmission troubles and must be removed from the system before the transmission is put back into service. The cleaning of debris from the direct clutch piston, the forward clutch cylinder, and reverse clutch piston check balls are often omitted. This omission can lead to a repeat servicing of the transmission.

During overhaul inspect all hardware for evidence overheating. Any overheating will be indicated by h stained blue surfaces.

Clean the parts with suitable solvent and use moisture-free air to dry off all the parts and clean out fluid passages.

The composition clutch plates, bands and synthetic seals should not be cleaned in a vapor degreaser or with any type of detergent solution. To clean these parts, wipe them off with a lint-free cloth. New clutch plates or bands should be soaked in transmission fluid specified for that transmission type for fifteen minutes before being assembled.

Control Valve Body

1. Clean all parts thoroughly in clean solvent, and blow dry with moisture-free compressed air. **If the valve body-to-screen gasket is removed on a C6 Transmission, the gasket should not be cleaned in a degreaser, solvent or any type of detergent solution. To clean the gasket, wipe it off with a lint-free cloth.**
2. Inspect all valve and plug bores for scores. Check all fluid passages for obstructions. Inspect the check valve for free movement. Inspect all mating surfaces for burrs or distortion. Inspect all plugs and valves for burrs or scores. Use crocus cloth to polish valves and plugs. Avoid rounding the sharp edges of the valves and plugs with the cloth.
3. Inspect all springs for distortion. Check all valves and plugs for free movement in their respective bores. Valves and plugs, when dry, must fall from their own weight in their respective bores.
4. On a C6 transmission, inspect the separator plate screen for obstructions. The screen must be clean and free of foreign material. If contaminated, remove it from separator plate, clean in a suitable solvent, and thoroughly blow clean with compressed air.
5. Roll the manual valve on a flat surface to check for bent condition.

Intermediate Servo

C6

1. Inspect the servo bore for cracks and the servo piston for damage, and the piston bore and the servo piston stem for scores. Check fluid passages for obstructions. Replace damaged seals.
2. Check the servo spring and servo band strut(s) for distortion.
3. Inspect the cover seal and gasket cover sealing surface for damage.

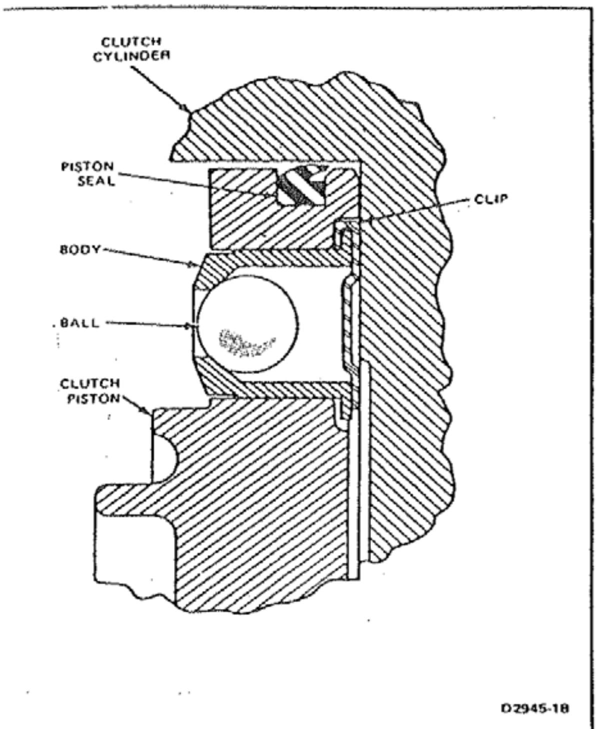
Governor

1. Inspect the governor valves and bores for scores. Minor scores may be removed from the valves with crocus cloth. Replace the governor if the valves or body is deeply scored.

3. Check for free movement of the valves in the bores. The valves should slide freely of their own weight in the bores when dry. Inspect fluid passages in the valve body and counterweight for obstructions. **All fluid passages must be clean.**
4. Inspect the mating surfaces of the governor body and governor distributor (C6) for burrs and distortion. Mating surfaces must be smooth and flat.
5. Check the mating surface of the governor valve and the counterweight on Automatic Overdrive transmission for burrs or scratches.

Front Pump

1. Inspect the mating surfaces of the pump body and case for burrs.
2. Inspect the drive and driven gear bearing surface for scores and check gear teeth for burrs.
3. Inspect the front pump seal for cuts or nicks, and the pump bushing for scoring.
4. Check the fluid passages for obstructions.
5. If any parts are found damaged or worn, replace the pump as a unit. Minor burrs and scores may be removed with crocus cloth.
6. On a C6 and AOD transmission, check the large seal ring groove of the pump body for damage. Check the gasket mating surface of the pump body for damage.



3. 29 Clutch Piston Check Ball

leverse-High Clutch—C6—Reverse Clutch—

. Inspect the drum band surface, the bushing, and thrust surfaces for scores. Minor scores may be removed with crocus cloth. **Badly scored parts must be replaced.**

. Inspect the clutch piston bore and the piston inner and outer bearing surfaces for scores. Check the air bleed ball valve in the clutch piston for free movement. Check the orifice to make sure it is not plugged.

. Check the fluid passages for obstructions. All fluid passages must be clean and free of obstructions.

. Inspect the clutch plates for wear, scoring, and fit on the clutch hub serrations. Replace all plates that are badly scored, worn, or do not fit freely in the hub serrations.

. Inspect the clutch pressure plate for scores on the clutch plate bearing surface. Check the clutch release spring(s) for distortion.

. The clutch piston has a check ball similar to Fig. 29. Inspect the check ball for freedom of movement and proper seating.

'orward Clutch

. Inspect the clutch cylinder thrust surfaces, piston bore, and clutch plate serrations for scores or burrs. Minor scores or burrs may be removed with crocus cloth. Replace the clutch cylinder if it is badly scored or damaged.

2. Check the fluid passage in the clutch cylinder for obstructions. Clean out all fluid passages. Inspect the clutch piston for scores and replace if necessary. Inspect the piston check ball for freedom of movement and proper seating (Fig. 29).

3. Check the clutch release spring (C6 only) for distortion and cracks. Replace the spring if distorted or cracked.

4. Inspect the composition clutch plates, steel clutch plates, and clutch pressure plate for worn or scored bearing surfaces. Replace all parts that are deeply scored.

5. Check the clutch hub thrust surfaces for scores and the clutch hub splines for wear.

6. Check the splines on the stator support for wear. Inspect the bushing in the stator support for scores. Check the input shaft (C6) for damaged or worn splines. Replace shaft if the splines are excessively worn.

Direct Clutch Piston Check Ball Leakage Procedure

Direct clutch piston check ball—Inspect the piston check ball for freedom of movement. Improper seating of check ball will cause leakage. Leakage can be detected by turning the piston upside down (flat side of piston facing you) allowing the check ball to seat in the piston. Pour a small quantity of solvent over the check ball. If solvent drips past the check ball, replace the piston.

Low—Reverse Clutch—C6

1. Inspect the clutch cylinder piston bore and clutch plate serrations for scores or burrs. Minor scores or burrs may be removed with crocus cloth. Replace the case if it is badly scored or damaged.
2. Check the fluid passage in the case for obstructions (Fig. 16). Clean out all fluid passages. Inspect the clutch piston for scores and replace if necessary.
3. Check the piston return springs for distortion. Check the piston return spring retainer for flatness.
4. Inspect the composition clutch plates, steel clutch plates and clutch pressure plate for worn or scored bearing surfaces. Replace all parts that are deeply scored.
5. Check the clutch hub splines.

Planetary One-Way Clutch

1. Inspect the intermediate outer and inner races for scores or damaged surface areas where rollers contact the races.

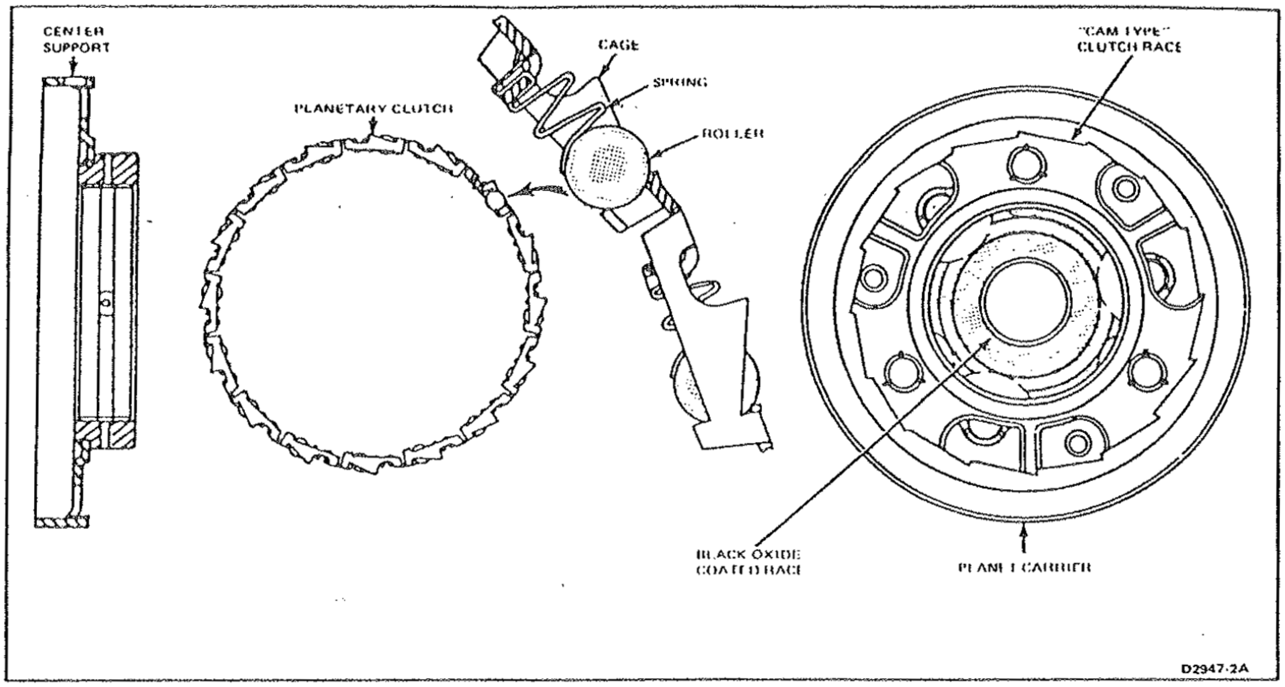


FIG. 30 Roller Type Planetary Clutch, Carrier and Center Support-

Converter and Fluid Cooler

When internal wear or damage has occurred in the transmission, metal particles, clutch plate material, or band material may have been carried into the converter and oil cooler. These contaminants are a major cause of recurring transmission troubles and MUST be removed from the system before the transmission is put back into service.

Whenever a transmission has been disassembled to replace worn or damaged parts or because the valve body sticks from foreign material, the converter and oil cooler MUST be cleaned by using the Rotunda torque Converter Cleaner (model 014-00028) or equivalent. Under NO circumstances should an attempt be made to clean converters by hand agitation with solvent.

Converter End Play and One Way Clutch Check

The Tools T76L-7902-C and T77L-7902-R shown in Fig. 31 are used to check the converter one-way clutch.

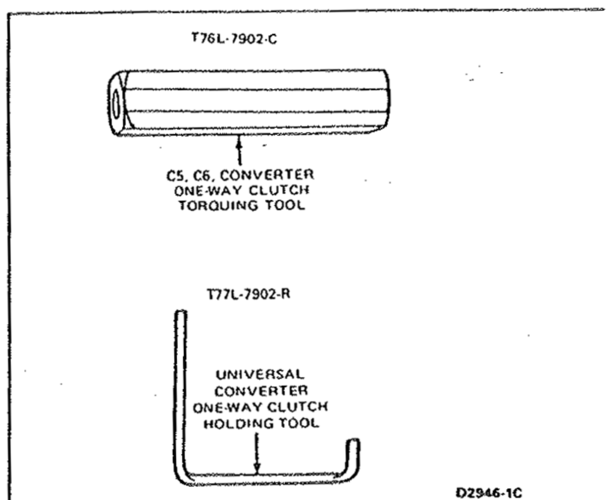


FIG. 31 Converter One Way Clutch Check Tools

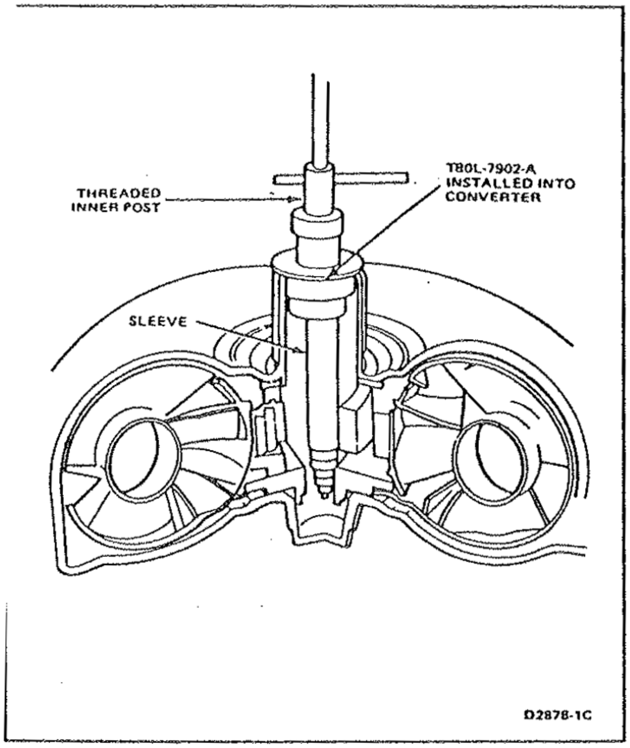


FIG. 32 End Play Checking Tool Installed

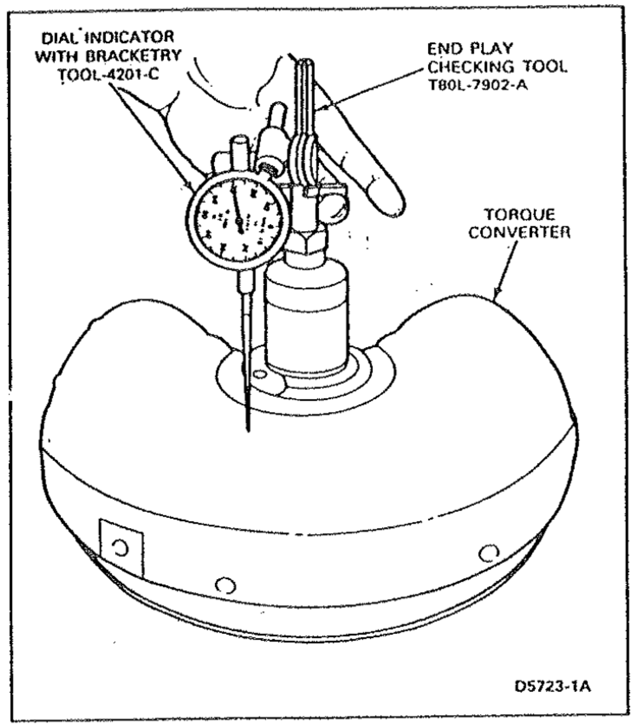


FIG. 33 Checking Stator and Turbine End Play

End Play Check

1. Insert Tool T80L-7902-A into the converter pump drive hub until it bottoms (Fig. 32).
2. Expand the sleeve in the turbine spline by tightening the threaded inner post, (Fig. 32), until the tool is securely locked into the spline.
3. Attach a dial indicator (with bracketry) TOOL-4201-C to the tool (Fig. 33). Position the indicator button on the converter pump drive hub, and set the dial face at 0 (zero).
4. Lift the tool upward as far as it will go and note the indicator reading. The indicator reading is the total end play which the turbine and stator share. Replace the converter unit if the total end play exceeds the limits. End play specifications are listed at the end in the specifications section of this Section.
5. Loosen the threaded inner post to free the tool, and then remove the tool from the converter.

Converter One-Way Clutch Check

1. Insert the one way clutch holding Tool T77L-7902-R (Fig. 34), in one of the grooves in the stator thrust washer.
2. Insert the one way clutch torquing Tool, (T77L-7902-B) in the converter pump drive hub so as to engage the one way clutch inner race, (Fig. 34).
3. Attach a torque wrench to the one way clutch torquing tool. With the one way clutch holding tool held stationary, turn the torque wrench counterclockwise. The converter one way clutch should lockup and hold a 14 N·m (10 ft-lbs) force. The converter one way clutch should rotate freely in a clockwise direction. Try the clutch for lockup and hold in at least five different locations around the converter.
4. If the clutch fails to lock up and hold at 14 N·m (10 ft-lbs) torque, replace the converter unit.

Stator to Impeller Interference Check

1. Position the front pump assembly on a bench with the spline end of the stator shaft pointing up (Fig. 36).
2. Mount a converter on the pump with the splines on the one-way clutch inner race engaging the mating splines of the stator support. The converter hub will then engage the pump drive gear.
3. Hold the pump stationary and try to rotate the converter counterclockwise. The converter should rotate freely without any signs of interference or scraping within the converter assembly.
4. If there is an indication of scraping, the trailing edges of the stator blades may be interfering with the leading edges of the impeller blades. In such cases, replace the converter.

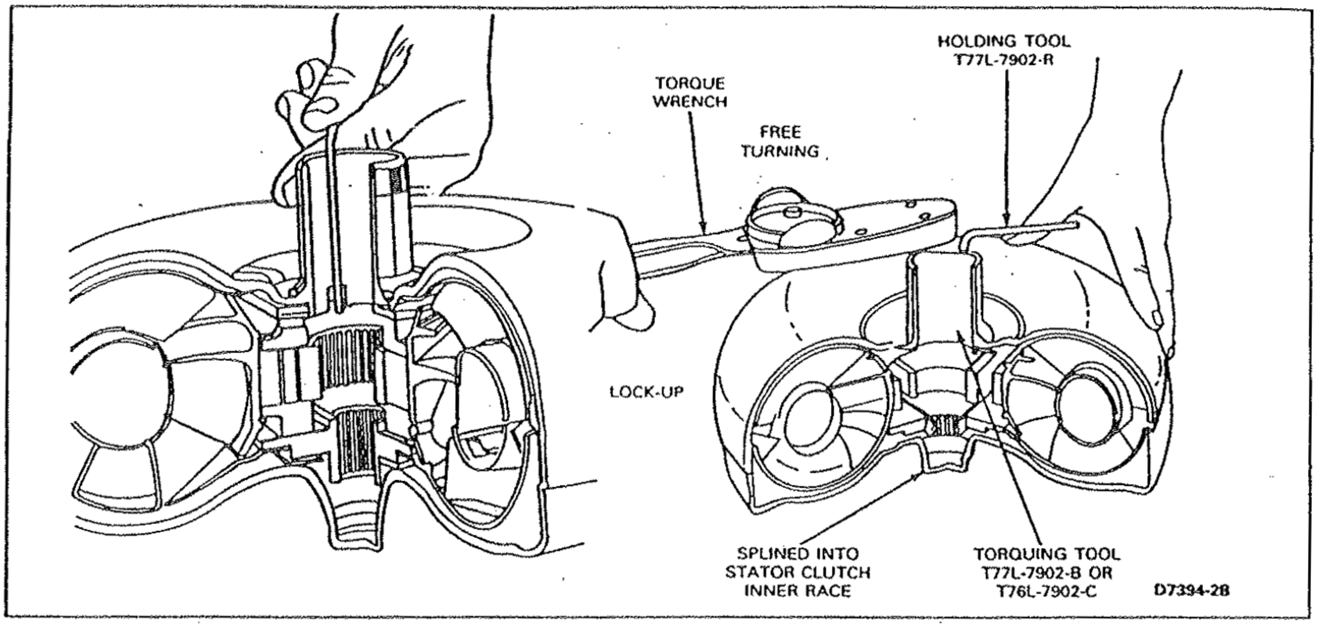


FIG. 34 Checking Converter One-Way Clutch

Stator to Turbine Interference Check—C6

1. Position the converter on the bench front side down.
2. Install a front pump assembly to engage the mating splines of the stator support and stator, and pump drive gear lugs.
3. Install the input shaft, engaging the splines with the turbine hub (Fig. 37).
4. Hold the pump stationary and attempt to rotate the turbine with the input shaft. The turbine should rotate freely in both directions without any signs of interference or scraping noise.
5. If interference exists, the stator front thrust washer may be worn, allowing the stator to hit the turbine. In such cases, the converter must be replaced.

Check the converter crankshaft pilot for nicks or damaged surfaces that could cause interference when installing the converter into the crankshaft. Check the converter front pump drive hub for nicks or sharp edges that would damage the pump seal

Pinion Carriers

C6

Individual parts of the planet carriers are not serviceable.

1. Check the pins and shafts in the planet assemblies for loose fit and/or complete disengagement. Use a new planet assembly if either condition exists. Before installing a planet assembly, the shaft retaining pins should be checked for adequate staking. If necessary, restake the pins before installation. When restaking, the retaining pins must not be driven into the carrier any further than 1.01mm (0.040 inch) below the surface of the carrier.
2. Inspect the pinion gears for damaged or excessively worn teeth.
3. Check for free rotation of the pinion gears.

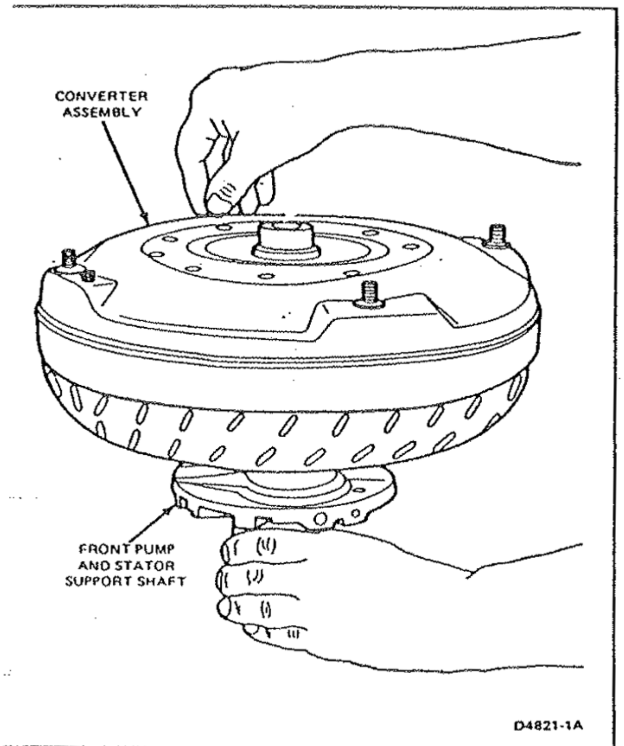


FIG. 36 Stator to Impeller Interference Check

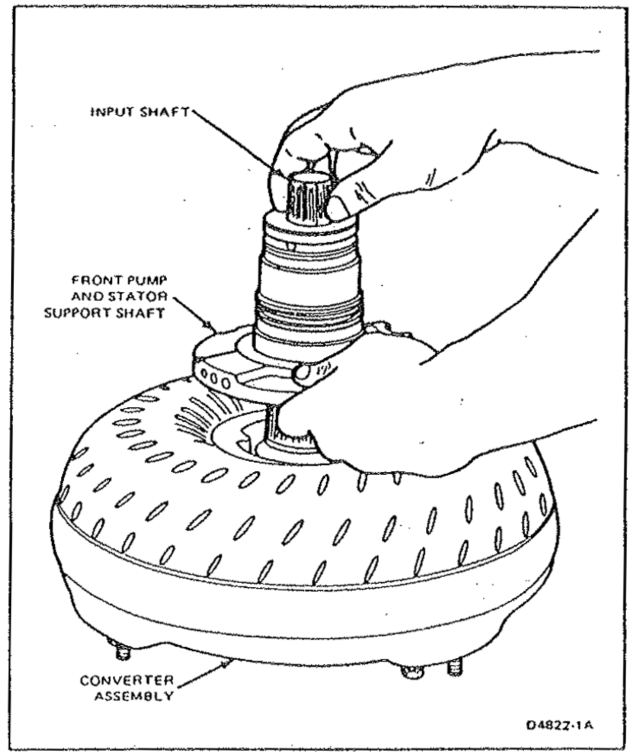


FIG. 37 Stator to Turbine Interference Check—C6

Stator Support

C6

1. Inspect the stator support splines for burrs and wear.
2. Check the oil ring grooves in the stator support for nicks, burrs or damaged edges.
3. Check the front and rear bushings of the stator support for wear or scoring.

Case

Inspect the case for cracks and stripped threads. Inspect the gasket surfaces and mating surfaces for burrs. Check the vent for obstructions, and check all fluid passages for obstructions and leakage (Figs. 15, 16 and 17).

Inspect the case bushing for scores. Check all parking linkage parts for wear or damage.

If a transmission case thread is damaged, service kits may be purchased from local jobbers. To repair a damaged thread, the following procedures should be carefully followed.

1. Drill out the damaged threads **using the same drill size as the thread outside diameter.** For example, use a 5/16 inch drill for a 5/16-18 thread.
2. Select the proper special tap and tap the drilled hole. The tap is marked for the size of the thread being repaired. Thus, the special tap marked 5/16-18 will not cut the same thread as a standard 5/16-18 tap. The tap cuts a thread large enough to accommodate the insert, and after the insert is installed, the original thread size (5/16-18) is restored.
3. Select the proper coil inserting tool. These tools are marked with the thread size being repaired. Place the insert on the tool and adjust the sleeve to the length of the insert being used. Press the insert against the face of the tapped hole. Turn the tool clockwise and wind the insert into the hole until the insert is 1/2 turn below the face.
4. Working through the insert, bend the insert tang straight up and down until it breaks off at the notch.
5. Improperly installed inserts can be removed with the extractor tool. Place the extractor tool in the insert with the blade resting against the top coil 1/4 to 1/2 turn away from the end of the coil. Tap the tool sharply with a hammer until the blade cuts into the insert. Exert downward pressure on the tool and turn counterclockwise until the insert is removed.

SPECIFICATIONS

VACUUM DIAPHRAGM ASSEMBLY SPECIFICATION

Transmission Type	Diaphragm Type	Diaphragm Part No.	Identification	Throttle Valve Rod # Part No. (7A380)	Length	Identification
C6	HAD	D7AP-7A337-AA	Part No. Stamped	C4AP-A	1.677-1.667	No Color
	SAD	D70P-7A377-BA	1 Green Stripe	D1AF-BA	1.727-1.717	Purple Daub
	SAD	D4TP-7A377-BA	1 Black Stripe	D3AF-DA	1.611-1.601	Yellow Daub
	SAD	D5AP-7A377-AA	1 Purple Stripe	D3AP-EA	1.644-1.634	Blue Daub
				D3AP-FA	1.660-1.650	Green Daub
				D3AP-GA	1.710-1.700	White Daub
				D8AP-AA	1.694-1.684	Brown Daub

\# Selective fit rods
SAD — Single Area Diaphragm
S-SAD — Super Single Area Diaphragm
HAD — High Altitude Diaphragm

CD2948-2E

AUTOMATIC TRANSMISSION REFILL CAPACITY — C5, C6 AND AOD AUTOMATIC TRANSMISSION

	Transmission Type	Engine	Approximate Refill Capacity① U.S. Quarts	Imperial Quarts	Liters
	C6②	4.9L (300 CID) I-6	11-3/4	9.4	11.2

①Approximate dry capacity, includes cooler and lines. Fluid level indicator should be used to determine actual fluid requirements and fluid specifications. Check level at normal operating temperature. DO NOT OVERFILL.

TORQUE-CONVERTER END-PLAY

Transmission Model	Converter End-Play: New or Rebuilt Converter mm	Inch	Used Converter mm	Inch
C6	0.533 Max.	0.021 Max.	1.01 Max.	0.040 Max.

STALL SPEED SPECIFICATIONS

Vehicle Application	Engine Disp.	Transmission Type	Converter Size	Stall Speed Min.	Max.
	4.9L	C6	12"	1616	1871

SPECIAL SERVICE TOOLS

Tool Number	Description
Tool-4201-C	Dial Indicator with Bracketry
Tool-7000-DD	Rubber Tip For Air Nozzle
Tool-7000-DE	Air Nozzle Assembly
T82L-7006-A	Air Pressure Check Plate
T82P-7006-C	Cap Screws for Air Pressure Check Plate
T76L-7902-C	Converter Clutch Torquing Tool
T77L-7902-R	Converter Clutch Holding Tool
T77L-7902-B	Converter Clutch Torquing Tool
T80L-7902-A	Torque Converter End Play Checking Tool
T83L-7902-A	Converter Checking Tool Kit
T83L-7902-A1	Torque Adapter Turning Tool
T83L-7902-A2	Pilot Guide
T83L-7902-A3	Holding Fixture
T80L-77030-B	Servo Piston Remover

ROTUNDA EQUIPMENT

Model	Description
014-00028	Torque Converter Cleaner
021-00054	Torque Converter Leak Tester
014-00737	Automatic Transmission Tester
021-00014	Vacuum Tester
059-00008	Vacuum and Pressure Tester

CD4825-1E

Notes:

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

1. Engine side panels

A. Removal:

Raise and support hood. Locate each of the fasteners on the side panel in their respective spring sockets. Turn each of the fasteners ¼ turn counterclockwise. The panel should be free for removal.

B. Installation:

Raise and support hood. Locate each of the fasteners on the side panel in their respective spring sockets. Turn each of the fasteners ¼ turn clockwise to engage the retaining spring. Some pressure applied to the panel towards the engine compartment might be necessary.

2. Hood

A. Removal:

Raise and support hood. Remove the dash panel (See Maintenance. Section / Removal & installation / 4A). Remove the center four mounting bolts from the hinge at the firewall. Using a wax pencil or similar on-permanent marker, mark the position of the hinge in relation to the firewall. If unit is equipped with gas struts, have an assistant hold hood in a vertical position. Remove gas struts by pulling them off their ball stud mounts. Close hood and remove last two mounting bolts. With an assistant's help, lift hood vertically and carry it over the front of the unit. When clear of unit, set in a safe location with its mounting hardware.

B. Installation:

Using an assistant, lift hood up and over the front of the unit and set in place. Locate and install the two outermost mounting bolts. Locate the position markers on the hinge and firewall, position hood accordingly, and tighten outer two mounting bolts. Raise and support hood. If unit is equipped with gas struts, install them by pressing them on their ball stud mounts. Locate and install the remaining four mounting bolts. Tighten all bolts. Lower hood.

3. Transmission Cover Panel

A. Removal:

1. Remove the shifter as described in Maintenance. Section / Removal & Installation / 17A.
2. Locate and remove the four mounting bolts from the panel.
   Lift panel vertically and place cover and mounting bolts in a safe location.

B. Installation:

1. Lower panel into place. Locate and install mounting bolts.
2. Install the shifter as described in Maintenance. Section / Removal & Installation; 17B.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

4. Dash Panel

A. Removal:

Raise hood. Disconnect battery. Have someone assist in removing dash panel. Place a piece of cardboard or shop cloths on transmission cover panel and floorboard to protect finish from damage. Locate and remove the mounting bolts at each end of the dash panel. Lower dash panel assembly to rest on transmission cover panel and floorboard.

B. Installation:

Have someone assist in installing dash panel. Lift the dash panel assembly into place. Be sure to route the wiring harness up and over the brake pedal bracket. Do not allow harness to be pinched by any part of the dash panel. Locate and install the mounting bolts. Reconnect battery. Lower hood.

5. Steering valve, Column and Steering Wheel

A. Removal:

1. Remove dash panel as described in Maintenance. Section / Removal & Installation; 4A
2. Remove horn button, disconnect horn wire, remove steering wheel retaining nut and pull steering wheel (may require use of steering wheel puller).
3. Remove upper steering column U-Bolt. Remove any wire-ties around steering column.
4. Raise and support hood, remove left engine side panel.
5. Place drain pan on ground directly below steering valve to catch any fluid lost.
6. Label hoses according to the ports on the steering valve (T-Tank, P-Pressure, R-Right and L-Left).
7. Remove hoses from steering valve.
8. Unplug horn wire.
9. Remove the four bolts securing the valve and column to the lower mounting bracket, both components can now be removed.

B. Installation:

1. Installation is the reverse of the removal process. Before reinstalling dash be sure to tie back wiring using new wire ties if necessary.
2. Check power steering fluid level prior to starting engine, running pump dry can damage the pump. Recheck fluid level after cycling steering left-right several times to be sure all air has been purged from lines.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

6. Steer Axle

A. Removal:

1. Raise and support hood. Disconnect battery. Raise unit and support it on jack stands.
2. Remove the front wheels as described in Maintenance. Section / Removal & Installation; 9A.
3. Remove brake lines and Hydraulic hoses, mark hydraulic hoses by position (left or right).
4. Place a floor jack under the center of the steer axle assembly. Raise jack until it just starts to raise the steer axle assembly.
5. Remove the hardware securing the steer axle assembly to the front leaf springs. Use caution when removing the last bolt. If the weight is not evenly distributed across the floor jack, the steer axle might tilt to one side. If this starts to happen, reinstall one bolt on each side and reposition the floor jack as needed.
6. Slowly lower steer axle.

B. Installation:

1. Place steer axle on floor jack, balanced at center. Roll steer axle under front of unit to approximately center of front leaf springs. Note the position of the centering pins on the springs. These must line up with the dowel holes in the top of the axle assembly.
2. Slowly raise steer axle until it just contacts the springs. Check the alignment of the centering pins in relation to the dowel holes on the axle. Position axle to accept pin and complete raising axle into place.
3. Install the four U-bolts and tighten.
4. Lower and remove floor jack.
5. Install brake lines and steering cylinder hoses.
6. Install the front wheels as described in Maintenance. Section / Removal & Installation; 9B.
7. Lower unit. Reconnect battery. Lower hood.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

7. Front Springs

A. Removal:

1. Set parking brake and chock wheels.
2. Raise front of unit until front wheels are off the ground. Support on jack stands.
3. Place a floor jack under the steer axle on the side of the spring to be removed. Raise jack until it contacts the steer axle.
4. Remove the two U-bolts securing the steer axle to the spring.
5. Lower the floor jack until the steer axle is just clear of the spring (be careful not to damage hoses)..
6. Hold spring so that it does not fall. Locate and remove the bolt passing under the rearward end of the spring. Remove the bolt passing through the front of the spring. It might be necessary to use a drift to drive out the bolts. Remove the spring. Discard old mounting bolts.
7. Using an appropriate-sized drift, press out old bushing.
8. Using safety solvent, clean all dirt and grease from the spring.
9. Inspect spring for broken or fatigue parts. Replace spring if any defects are found.

B. Installation:

1. Using an appropriate-sized drift, press in a new bushing.
2. Using new mounting bolts, lift spring into place and secure with two bolts. Tighten front bolt to 80 ft-lbs. Tighten rear bolt until nut just contacts bracket.
3. Slowly raise steer axle until it just contacts the springs. Check alignment of the centering pin in relation to the dowel hole on the axle, position axle to accept pin, and complete raising the axle.
4. Install the two U-bolts and tighten.
5. Remove floor jack.
6. Lower unit.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

8. Rear Springs

A. Removal:

1. Raise unit until wheels are off the ground. Support on jack stands.
2. Place a floor jack under the drive axle on the side to be removed. Raise jack until it contacts the drive axle. Raise up ½".
3. Remove the two U-bolts and mounting plate.
4. Slowly lower the drive axle until it clears the spring.
5. Remove the nuts from the front and rear mounting bolts. Loosen the bolts.
6. Hold the spring to keep it from falling free. Remove the two mounting bolts. (It might be necessary to use a drift to drive out the bolts.) Remove the spring. Discard mounting bolts and nuts.
7. Using an appropriate-sized drift, drive out the bushing from the spring.
8. Using safety solvent, clean all dirt and grease from the spring.
9. Inspect the spring for signs of excessive wear. If any defects are found, replace spring.

B. Installation:

1. Using an appropriate-sized drift, press in a new bushing.
2. Lift spring into place and install two mounting bolts and locknuts.
3. Tighten the front bolt to 80 ft-lbs. Tighten the rear bolt until the locknut just contacts the bracket.
4. Raise drive axle until it is in contact with the spring.
5. Place the U-bolt mounting plate over the nut located on the top of the spring.
6. Install the two U-bolts and evenly tighten nuts to 110 ft-lbs.
7. Remove the floor jack.
8. Install wheels.
9. Lower unit.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

9. Wheels and Tires

A. Removal:

1. Set parking brake. Raise unit near the wheel / tire assembly to be removed. Raise until wheel / tire is off the ground.
2. Remove the lug nuts. Pull wheel off.
3. Inspect wheel / tire assembly. If any part of the assembly shows excessive wear, replace it.
4. If it is necessary to remove the tire from the wheel, use appropriate tools for the job. When removing tires from wheels the tire must be completely deflated before servicing.

WARNING: **SERIOUS INJURY CAN RESULT IF TWO-PIECE (SPLIT-RIM) WHEELS ARE NOT DEFLATED BEFORE PERFORMING SERVICE.**

WARNING: **USE TOOLS SPECIFICALLY DESIGNED FOR SERVICING TIRES AND WHEELS. FOLLOW THE MANUFACTURER'S INSTRUCTIONS. PERSONAL INJURY OR DAMAGE TO THE WHEEL / TIRE ASSEMBLY CAN RESULT.**

B. Installation:

1. Lift wheel / tire assembly into place over the wheel lugs.
2. Using a torque wrench, tighten the lug nuts.

   Front, 1/2 studs .... 90-110 ft-lbs
   Rear, 9/16 studs .... 110-120 ft-lbs
3. Lower unit.
4. Re-Torque the lug nuts after 24 hours of service.

NOTE: When tighten lug nuts, it is a good practice to alternate lugs nuts across the wheel, rather than moving from one to the next in a circle.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

10. Service Brake Pedal

A. Removal:

1. Engage parking brake.
2. Raise and support hood. Disconnect the battery.
3. Remove the dash panel as described in Maintenance. Section / Removal & Installation; 4A.
4. Locate and remove cotter pin and washer connecting the pedal to the pivot.
5. Locate and remove the shoulder bolt on which the pedal pivots. The pedal will now be free to be removed from the booster linkage. Remove pedal.
6. Inspect bushings and shoulder bolt for signs of excessive wear. If shoulder bolt shows any signs of wear, replace it. If bushings are worn, replace the pedal assembly.
7. Clean all dirt and grease from the pedal assembly.

B. Installation:

1. Apply small amount of grease to the bushings.
2. Install the pedal assembly onto the linkage to the booster.
3. Lift pedal into place and secure with shoulder bolt and nut. Tighten nut to 40 ft-lbs.
4. Place washer over pin connecting pedal to booster. Install new cotter pin.
5. Adjust pedal height as described in maintenance section.
6. Install dash panel as described in Maintenance. Section / Removal & Installation; 4B.
7. Reconnect battery. Lower hood.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

11. Master Cylinder, Service Brake

A. Removal:

1. Raise and support hood. Disconnect battery.
2. Place shop towels under master cylinder to catch any spilled brake fluid.
3. Using a flare-nut wrench, loosen and remove the two brake lines at the master cylinder.
4. Locate and remove the two nuts securing the master cylinder to the booster. The master cylinder should now be free for removal.
5. Drain the old brake fluid into a waste-oil container.
6. Using safety solvent, clean all dirt and grease from master cylinder.
7. Replace seals as required. If cylinder is rusted, use a brake cylinder hone to polish the surface before reinstalling piston and seals. If cylinder is scored deeply, or if piston is damaged, replace the assembly as a complete unit.

B. Installation:

1. It is very important to “bench bleed” the master cylinder before installing back into unit. This is described below:
   a. Place the master cylinder in a vise. Clamp just enough to securely hold master cylinder. (Placing a shop towel over each jaw of the vise will help reduce marring the outer surface of the master cylinder).
   b. Place shop towel under the master cylinder.
   c. Put pipe plugs into each of the outlet ports. Finger-tighten plugs.
   d. Fill master cylinder with new brake fluid. (Never reuse old brake fluid; it retains moisture and can cause rust to form inside the brake system).
   e. Pump the piston until no bubbles can be seen in the reservoir. Do not allow reservoir to empty while performing this operation.
   f. Tighten plugs. Try depressing the piston. It should not move (or it will move only a small amount) if all air has been purges from the master cylinder. If it moves, repeat the previous steps.
   g. Place the master cylinder on the vacuum booster and secure in place with nuts.
   h. Using a flare-nut wrench, install and tighten the brake lines.
   i. Bleed brakes as described in Chapter 2 Section 1 - Annual Maintenance (7B).
   j. Remove shop towels; reconnect battery, and lower hood.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

12. Brake Booster

A. Removal:

1. Raise and support hood. Disconnect battery.
2. Locate and remove the cotter pin and washer connecting the brake pedal assembly to the booster.
3. Remove the two mounting nuts holding the brake master cylinder to the booster. Pull master cylinder free of the booster.
4. Remove the hoses from the booster.
5. Remove the dash panel as described in Maintenance. Section / Removal & Installation; 4A.
6. Locate and remove the four bolts mounting the booster to the firewall. Remove the booster.

B. Installation:

1. Installation is the reverse of removal.

13. Parking Brake Linkage and Lever (disc type parking brake)

A. Removal:

1. Raise unit until wheels are off the ground. Support on jack stands.
2. Disengage parking brake. Locate and remove the cotter and clevis pin connecting the parking brake lever assembly to the brake cable.
3. Remove the transmission cover as described in Maintenance. Section / Removal & Installation; 3A.
4. Locate and remove the four bolts securing the parking brake lever to its mounting bracket. The assembly should now be free to be lifted up and out.
5. Using safety solvent, clean all dirt and grease from the lever assembly.
6. Inspect all parts of the assembly. If any of the parts are worn, replace the assembly.

B. Installation:

1. Using dry silicone, lubricate all pivoting or moving parts of the brake lever assembly.
2. Lower lever assembly into its mounting bracket. Secure in place with four bolts.
3. Install transmission cover as described in Maintenance. Section / Removal & Installation; 3B.
4. Locate and install linkage from the lever to the cable. Install clevis and new cotter pin.
5. Lower unit. Adjust parking brake by turning the end of the lever. Turning clockwise increases force on the brake and counterclockwise decreases force. If adjustment cannot be made on lever; refer to the next section for information on adjusting the brake assembly.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

14. Parking Brake

A. Removal (disc style parking brake):

1. Raise unit until wheels are off the ground. Support unit on jack stands.
2. Disconnect battery, Disengage parking brake.
3. Locate and remove the clevis and cotter pins connecting the parking brake cable to the lever on the brake caliper.
4. Remove the U-Bolt connecting the parking brake cable to the bracket on the parking brake caliper.
5. Remove the two bolts retaining the cable mounting bracket from the parking brake caliper.
6. Remove the parking brake caliper as described in the manufacturer's data in **Chapter 5 - Manufacturer's Appendices.**
7. If parking brake disc needs to be replaced remove drive-shaft as described in Maintenance. Section / Removal & Installation; 18A.
8. Remove input flange from drive axle.

B. Installation (disc style parking brake):

1. If disc was removed install new disc on drive axle input flange in the same orientation as old one was removed.
2. Install input flange on drive axle (using flat washer and nut), tighten nut to 250 Ft-Lbs.
3. Install driveshaft as described in Maintenance. Section / Removal & Installation; 18B, use blue thread locker on bolts.
4. Install parking brake caliper as described in manufacturer's data in **Chapter 5 - Manufacturer's Appendices.**
5. Adjust parking brake caliper as described in manufacturer's data in **Chapter 5 - Manufacturer's Appendices.**
6. Install parking brake cable bracket, use blue threadlocker on bolts and torque to 30 Ft-Lbs.
7. Turn top of parking brake lever fully counterclockwise to loosen adjustment as far as possible.
8. Install parking brake cable on bracket. Loosen jam nut against clevis, adjust clevis on cable so clevis pin can be installed without moving parking brake lever (on caliper assembly). Install clevis pin and new cotter pin (do not bend cotter pin at this point).
9. Check parking brake lever, adjust the parking brake lever by turning the end of the lever clockwise to increase the force on the parking brake. If proper adjustment can be obtained the finish installing cotter pin (bend ends) and then tighten jam-nut against clevis. If not then loosen parking brake lever again and then remove clevis pin at brake caliper and turn clevis in 2 turns and reinstall clevis pin and cotter pin. Repeat these steps until adjustment is complete (once complete properly install cotter pin and tighten jam nut against clevis).
10. Connect battery.
11. Lower unit. Test operation.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

15. Exhaust System

A. Removal:

1. Raise and support the hood.
2. Raise unit until wheels are off the ground. Support on jack stands.
3. Allow the section of the engine exhaust system to be removed to cool before servicing.
4. Remove the tail pipe as described below:
    a. Remove the U-bolt connecting the tail pipe to the catalytic muffler.
    b. Remove the U-bolt connecting the tail pipe to the rear hanger and remove the tail pipe from the muffler.
5. Remove the catalytic muffler as described below:
    a. Remove the tail pipe as stated above.
    b. Remove the U-bolt connecting the catalytic muffler to the head-pipe pipe.
    c. Remove the two bolts holding the muffler clamps to the frame and then remove the muffler.
6. Remove the head pipe as described below:
    a. Remove the tail pipe as described above.
    b. Remove the catalytic muffler as described above.
    c. Remove the oxygen sensor from the head pipe.
    d. Remove the two bolts holding the head pipe flange to the exhaust manifold. This will free the head pipe for removal.

B. Installation:

1. Installation is the reverse of removal, use all new hardware and head pipe flange gasket.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

16. Fuel Cell

A. Removal:

1. Raise and support hood.
2. Disconnect battery.
3. Engage parking brake.
4. Raise unit off the ground, support on jack stands.
5. Place a drain pan under fuel cell. Remove the drain plug from the bottom of the fuel cell and remove fuel. Replace plug when fuel cell is empty and transfer fuel to an approved container.

WARNING: FUEL IS EXTREMELY FLAMMABLE. DO NOT HANDLE FUEL NEAR ANY OPEN FLAMES OR OTHER SOURCE OF IGNITION.

6. Remove the fuel lines connected to the fuel cell.
7. Locate and remove the wire to the sending unit.
8. Remove the right engine side panel as described Maintenance Section / Removal & Installation; 1A.
9. Remove the fuel cap from the fuel cell by turning cap counterclockwise.
10. Remove the fuel pocket from fuel-cell filler tube.
11. Locate and remove the four mounting bolts holding the fuel-cell mounting bracket to the chassis. This will free the fuel cell for removal. Keep bracket and spacers together for installation of new cell.

B. Installation:

1. Transfer the fuel-level sending unit from the old fuel cell to the new fuel cell as described in Maintenance. Section / Removal & Installation; Step 20.
2. If new fuel cell is not supplied with the fuel pickup tube, transfer it from the old fuel cell.

   Use Teflon thread sealing tape on the threads of the tube assembly. Be sure the pickup-tube outlet is in the same position on the new fuel cell as it was on the old one.
3. Position tank and spacers on fuel-cell mounting bracket. Lift assembly into place and secure with four bolts, nuts, and lock washers.
4. Install fuel pocket on fuel-cell filler tube.
5. Install fuel cap on filler tube.
6. Install the right engine side panel as described in Maintenance. Section / Removal & Installation; 1B.
7. Connect the fuel sender wire to the sending unit.
8. Connect the fuel lines.
9. Lower unit. Connect battery. Lower hood.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

17. Shifter

A. Removal:

1. Raise unit until wheel are off the ground. Support on jack studs.
2. Place shifter into Neutral.
3. Locate and remove nut from the shift rod end at the transmission. Remove the rod end from the transmission linkage.
4. Disconnect the connector from the shift switch to the wiring harness.
5. Locate and remove the four cap screws on the side of the shifter's mounting bracket. The shifter should now be free to lift up and out of the bracket.
6. Using safety solvent, remove all dirt and grease from the assembly.
7. If shifter rod is to be replaced or relocated to a new shifter, take note of the hole in which the trunnion is located and replace in same location.

B. Installation:

1. Apply a small amount of grease where the trunnion mounts the shifter rod to the shifter.
2. Lower shifter into place. Be sure shift rod falls on the left side of the transmission. Secure shifter with four cap screws.
3. Place shifter in Neutral.
4. Place transmission linkage in Neutral.
5. Lift shift rod to transmission linkage. It should go into the top hole of the transmission linkage. If adjustment is required, loosen the jam nut and adjust lower end of shift rod until the end lines up with the upper hole in the transmission linkage. Tighten jam nut. Secure shift rod end to transmission linkage with nut.
6. Connect shifter to wiring harness.
7. Lower unit, engage parking brake, and test shifter to be sure the gear pattern shifts correctly.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

18. Drive Shaft

A. Removal:

1. Raise and support unit on jack studs.
2. Locate and remove the four bolts securing the drive shaft to the input flange of the drive axle. The drive shaft will now be free to remove.
3. Place a drain pan under rear of transmission.
4. Push driveshaft forward (into transmission), move rear end of driveshaft to the right side of the drive axle and then pull driveshaft out of transmission.
5. Using safety solvent, clean all old grease from drive shaft and U-joints.
6. Inspect all bearings and bearing surfaces for any signs of wear or heat damage. If any part of the U-joint shows any defect, replace the entire U-joint.
7. Using safety solvent, clean all old grease and dirt from slip yoke assembly.
8. Inspect the drive shaft for any signs of excessive wear. If any defects are found, replace drive shaft.
9. Inspect transmission output seal, if it has become brittle or shows signs of leaking replace.

B. Installation:

1. Assemble slip yoke to driveshaft.
2. Apply a light coating of transmission fluid to the outside of the slip yoke.
3. Carefully Insert the slip yoke into the output seal of the transmission.
4. Place rear flange of driveshaft into input flange of drive axle, align bolt holes.
5. Install new bolts and toplock nuts using blue thread locker, tighten to 40 Ft-Lbs
6. Lower unit.
7. Operate engine until unit is warm, check and fill transmission fluid as needed. Test operation.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

19. Radiator

A. Removal:

1. Raise and support hood. Disconnect battery.
2. Allow engine to completely cool.
3. Slowly remove the radiator cap. Do not remove cap until engine has cooled. Hot engine coolant can cause serious injury.
4. Locate and remove the coolant overlow line next to the radiator filler neck.
5. Place a 4-gallon drain pan under radiator drain petcock.
6. Open the petcock and allow the coolant to drain then close the petcock.
7. Remove the upper and lower radiator hoses.
8. Remoe the hose from the power steering reservoir and drain the reservoir.
9. Remove the power steering reservior from the upper shroud.
10. Remove the upper fan srhoud.
11. Remove the fan.
12. Remove the lower shroud.
13. Remove the two transmission hoses. Plug the hoses so that the transmission fluid is not lost.
14. Remove the four nuts holding the radiator to the radiator mounts and remove the radiator.

B. Installation notes:

Install in reverse order of removal.

Check condition of radiator mounts. Replace if they are cracked or brittle.

Check condition of upper and lower radiator hoses, replace if necessary.

Confirm drain petcock is closed before filling with fluid.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

20. Electrical Accessories

A. Main Accessory Relay -

1. Removal:
   - a. Remove the dash panel, described in Maintenance Section / Removal & Installation; 4A
   - b. Locate and remove the power cables from the left side of the relay (wire #2 and #4).
   - c. Locate and remove the single cable from the right side of the relay (wire #7).
   - d. Locate and remove the 2-wire connector from the bottom of the relay.
   - e. Locate and remove the two mounting bolts. Remove the solenoid.
2. Installation:
   - a. Position new relay over mounting holes in firewall. Secure in place with two bolts, nuts, and lock washers. Tighten nuts to 20 ft-lbs.
   - b. Connect the two wire connector to the bottom of the solenoid.
   - c. Connect the single cable to the right side of the solenoid (wire #7).
   - d. Connect the remaining cables to the left side of the solenoid (wire #2 and #4).
   - e. Install the dash panel, described in Maintenance Section / Removal & Installation;4B.

B. Fuel Gauge -

1. Removal, Fuel Level Gauge (Gasoline models only).
   - a. Remove the dash panel as described in Maintenance Section / Removal & Installation; 4A.
   - b. Remove the dash lamp from the gauge.
   - c. Remove the ground wire from the center terminal.
   - d. Remove the sender wire from the “S” terminal.
   - e. Remove the power wire(s) from the “I” terminal.
   - f. Locate and remove the two nuts from the mounting bracket.
   - g. Remove gauge.
2. Installation, Fuel Level Gauge (Gasoline models only).
   - a. Install new gauge into dash panel. Place bracket onto back of gauge. Place two nuts and lock washers onto mounting studs. Do not tighten.
   - b. Rotate gauge in dash panel until the face is reading in an upright position. Tighten mounting nuts.
   - c. Install power wire to the “I” terminal (blue wire).
   - d. Install sender wire to the “S” terminal (green wire).
   - e. Install ground wire to the center terminal (white wire).
   - f. Install the dash lamp.
   - g. Install the dash panel as described in Maintenance. Section / Removal & Installation; 4A.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

20. Electrical Accessories (cont)

C. Hourmeter -

1. Removal (Hourmeter):
   a. Remove hourmeter bracket from firewall (engine compartment, right side).
   b. Remove the power wire from the "+" terminal.
   c. Remove the sender wire from the "-" terminal.
   d. Locate and remove the nuts from the mounting studs. Remove the meter.
2. Installation (Hourmeter):
   a. Insert hour indicator into the bracket. Place mounting ring on mounting studs and secure with two nuts and lock washers. Do not tighten.
   b. Rotate indicator until face is reading in the upright position. Tighten mounting nuts.
   c. Install power wire to the "+" terminal.
   d. Install sender wire to the "-" terminal.
   e. Reinstall bracket on firewall.

D. Sending Units -

1. Removal (Accessory Oil pressure, Hourmeter):
   a. Locate oil sending unit at left rear side of engine and disconnect wire(s).
   b. Place a shop towel under sender to catch any spilled oil.
   c. Remove the sending unit.
2. Installation (Accessory Oil pressure, Hourmeter):
   a. Cover threads of new sending unit with Teflon tape.
   b. Install sender into block, tighten sender.
   c. Connect wire(s).
   d. Remove shop towel.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

20. Electrical Accessories (cont)

D. Sending Units (cont) -

3. Removal (Fuel):

   a. Locate the fuel-level sender on the fuel cell and remove sender wire.

   b. Open gas cap to allow pressure to equalize.

WARNING: FUEL IS EXTREMELY FLAMMABLE. DO NOT HANDLE FUEL NEAR ANY OPEN FLAMES OR OTHER SOURCE OF IGNITION.

   c. Locate and remove the six mounting screws in the top of the sender.

   d. Lift sender from the fuel cell, noting the position of the float arm. It is important to orient new sender in the same position.

4. Installation (Fuel):

   a. Place new gasket on fuel cell.

   b. Orient new sender in the same position as one removed.

   c. Install sender and secure with six mounting screws. Tighten evenly.

   d. Close gas cap.

   e. Install wire on sender.

E. Switches, General -

1. Removal:

   a. Remove the panel to which the switch is mounted.

   b. Note the location of the wires on the switch.

   c. Remove wires. Remove switch. (In most cases the old switch can be removed with wires still attached. Therefore, when a new switch is installed, the wires can be transferred).

2. Installation:

   a. Install new switch.

   b. Install wires as noted.

   c. Install panel.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

20. Electrical Accessories (cont)

F. Horn, Horn Button and Horn Relay -

1. Removal (Horn):
    a. Disconnect wire.
    b. Remove mounting nut. Remove old horn.
2. Installation (Horn):
    a. Position horn so that the outlet faces forward. Place in bracket and secure in place with nut.
    b. Connect wire.
3. Removal (Horn Switch):
    a. Disconnect wires from horn switch.
    b. Remove horn switch from floorboard.
4. Installation (Horn Switch):
    a. Install switch on floorboard.
    b. Connect wire to horn switch.
5. Removal (Horn Relay):
    a. Cut and remove wire tie.
    b. Remove connector from horn relay.
6. Installation (Horn Relay):
    a. Install connector.
    b. Use nylon wire tie to tie relay to steering column.

G. Brake Light Switch -

1. Removal:
    a. Locate brake light switch under master cylinder and remove wires.
    b. Place shop towels under switch to catch spilled brake fluid.
    c. Remove brake light switch.
2. Installation:
    a. Cover threads of new switch with Teflon tape.
    b. Install new switch in tee block and tighten.
    c. Connect wires.
    d. Bleed air from brake system as described in Chapter 2 Section 1 - Annual Maintenance (7B)
    e. Remove shop towels.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

20. Electrical Accessories (cont)

H. Back-Up Light / Neutral Safety Switch -

1. Removal:
   a. Remove the shifter as described in Maintenance Section / Removal & Installation; 19A.
   b. Locate and remove the actuator rod from the switch.
   c. Remove the mounting nut from the switch and remove switch.
2. Installation:
   a. Place switch into mounting hole with wire on the outside of switch and secure in place with mounting nut.
   b. Install actuator rod O-ring and secure with lock nut. Tighten until O-ring just Starts to compress.
   c. Adjust switch as described in Chapter 2 Section 1 - Adjustments ; 8E
   d. Install shifter as described in Maintenance Section / Removal & Installation; 17B.

I. Lights, General -

1. Removal:
   a. Disconnect light from harness.
   b. Remove cover (if necessary). Remove mounting hardware. Remove light assembly. (It might be necessary to remove connector housings in order to get connector through some mounting brackets).
2. Installation:
   a. Place light in or over mounting area. Secure in place with mounting hardware.
   b. Connect light to harness.
   c. Install cover (if necessary).

J. Light Bulbs, General -

1. Removal:
   a. Remove cover or remove lamp from housing.
   b. Install cover or install lamp into housing.

CHAPTER 2
SECTION 3: REMOVAL AND INSTALLATION

21. Seats, Seat Belts

A. Removal (Seats):

1. Locate and remove the four nuts securing the seat rails to the chassis. Lift seat assembly from chassis.
2. Locate and remove the four bolts securing the seat rails to the seat.

B. Installation (Seats);

1. Place seat rails onto bottom of the seat. Secure in place with four bolts and lock washers.
2. Place four spaces over mounting holes in chassis.
3. Place four carriage bolts into seat rails and lower seat assembly onto chassis. Secure with four bolts and lock washers.

C. Removal (Seat Belts):

1. Remove bolts securing belt assembly to chassis. Remove seat belts.

D. Installation (Seat Belts):

1. Position new seat belt assemblies over holes in chassis mounting brackets. Secure in place with bolts and lock nuts.
2. Tighten lock nuts until they touch brackets, allowing seat belt assemblies to pivot on bolts.

THIS PAGE
INTENTIONALLY
LEFT BLANK

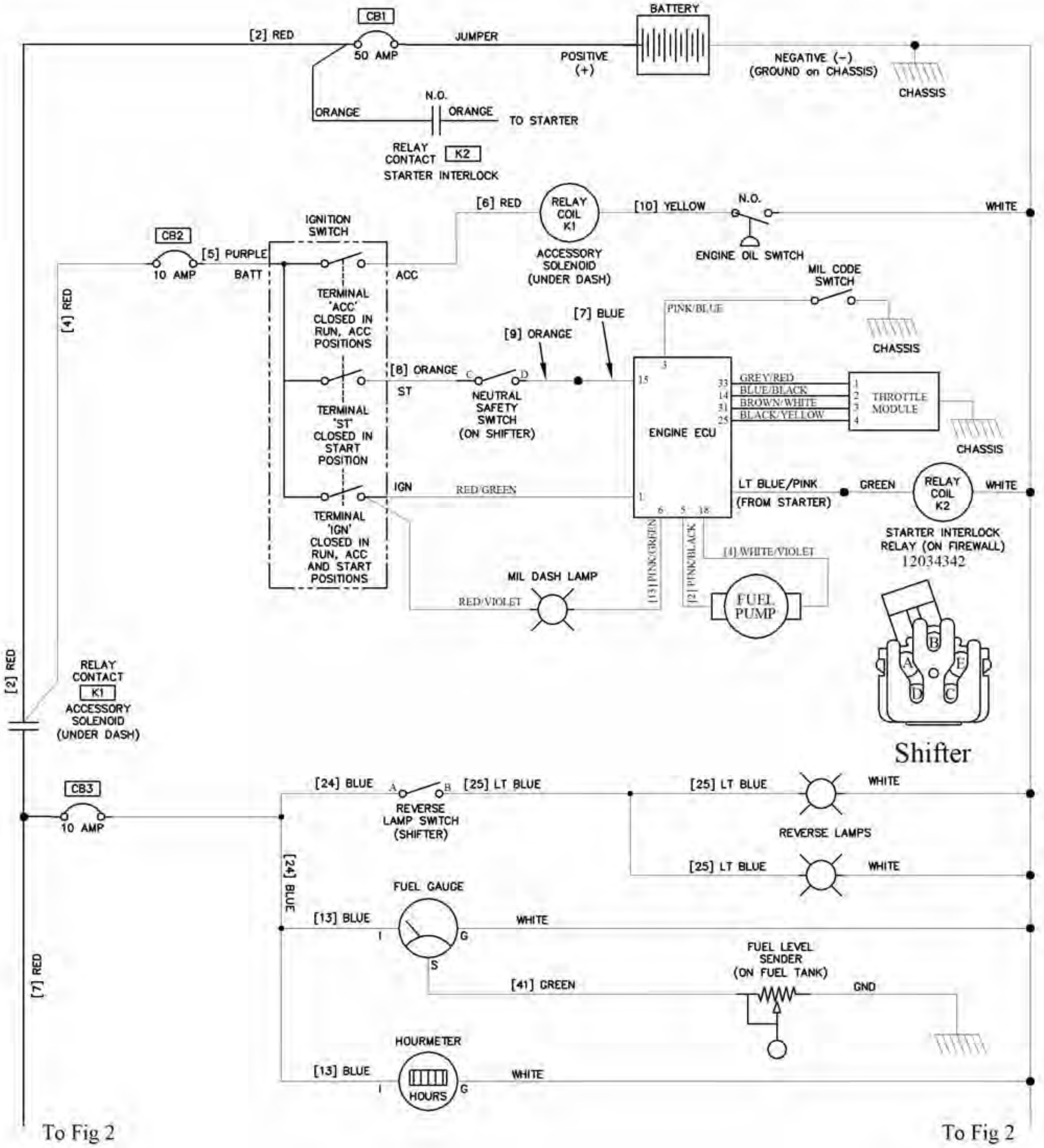


FIG. 1

See SCH-00038 for full size drawing

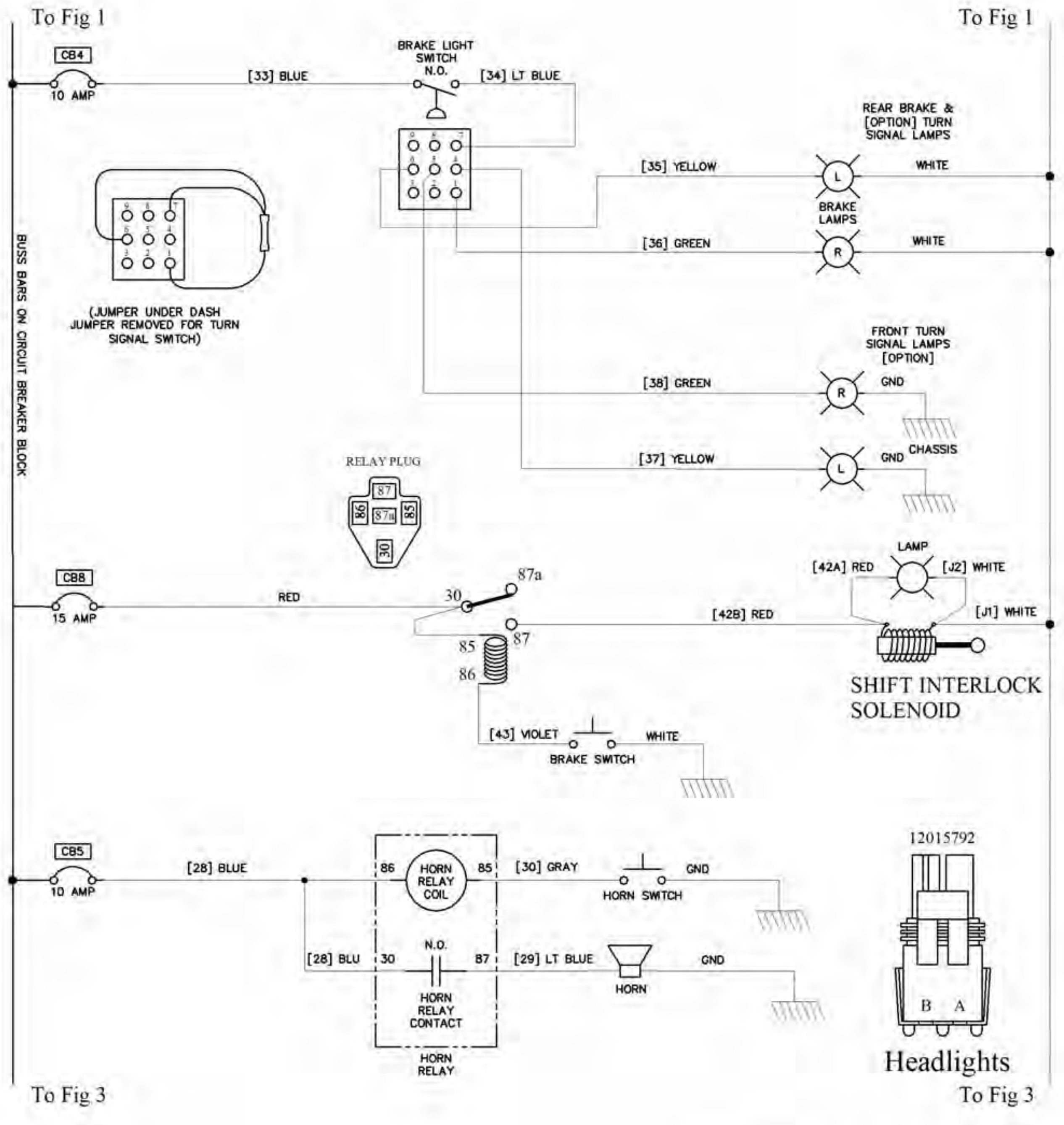


FIG. 2

See SCH-00038 for full size drawing

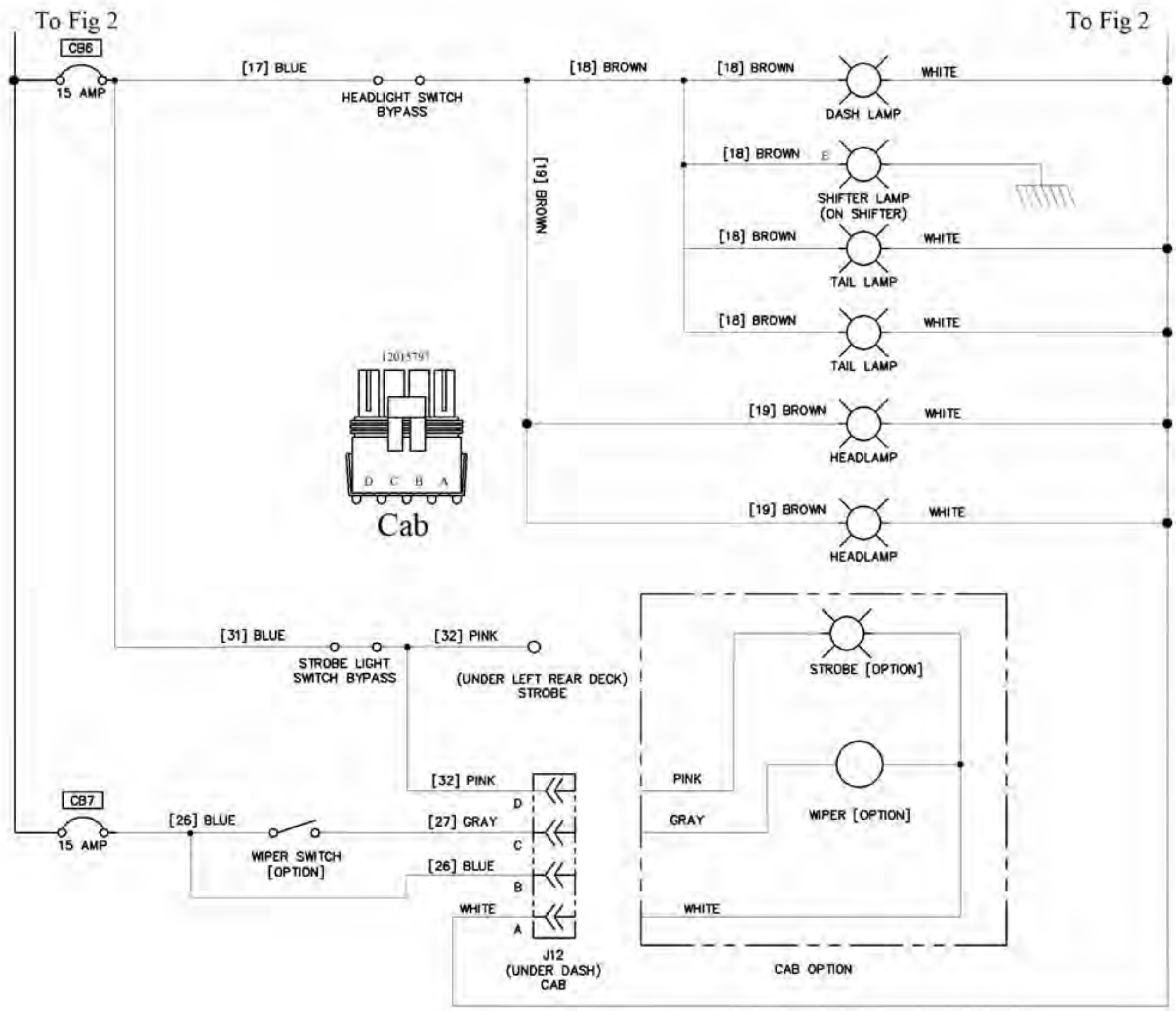
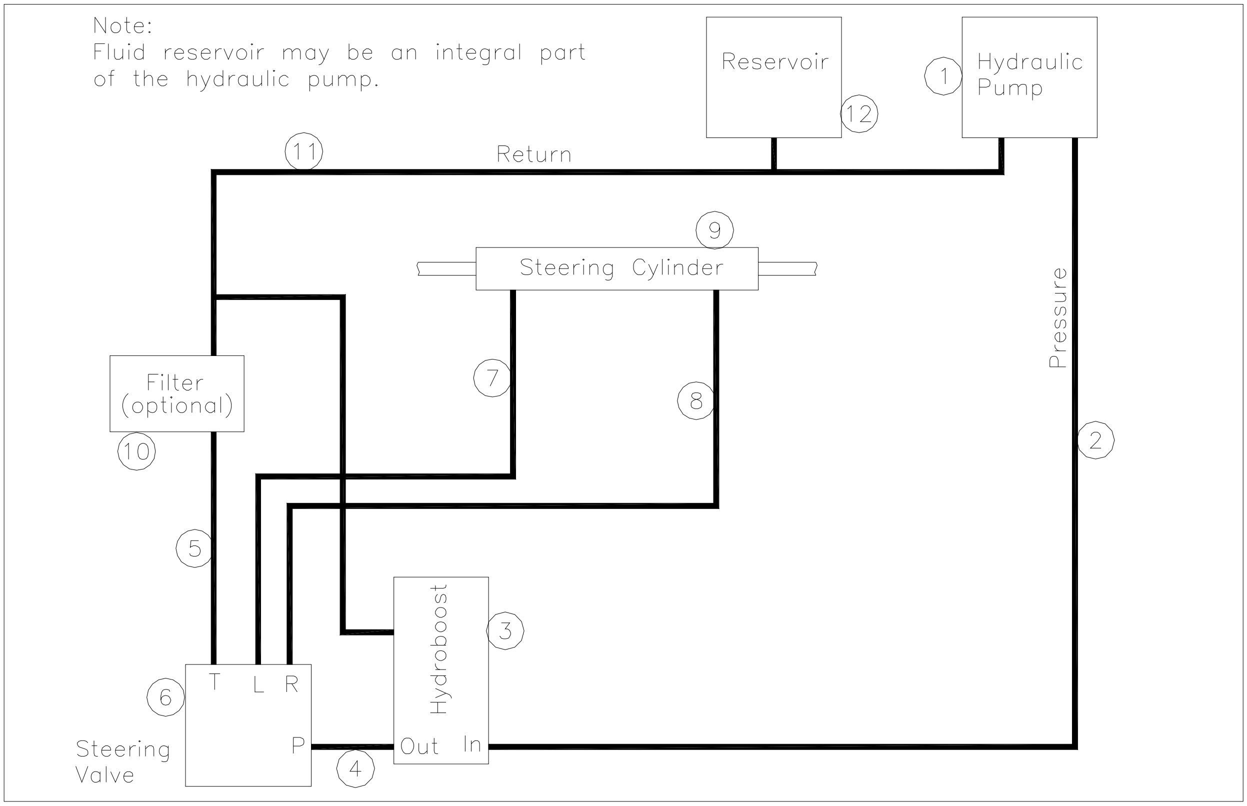


FIG. 3

See SCH-00038 for full size drawing



ITEM	DESCRIPTION	LOCATION
1	Power Steering Pump	Engine (front right)
*	Power Steering Pump Pulley	Power Steering Pump
*	Adaptor, Power Steering Outlet	Power Steering Pump
2	Hose Assy., Pump to Hydroboost	Between Pump and Hydroboost
3	Brake Hydroboost	Left Side of Firewall, Engine Compartment
4	Hose Assy., hydroboost to Steering Valve	Between Hydroboost and Steering valve (port 'P')
5	Hose Assy., Return Line	Between Hydroboost, Steering Valve (port 'T') and Filter
6	Steering Control Valve	Left Side of Firewall, Engine Compartment
*	Fitting, Straight #8 SAE o-ring to #6 JIC	Steering Control Valve
*	Fitting, 90 degree #8 SAE o-ring to #6 JIC	Steering Control Valve
7	HOSE ASSY, LEFT Steering CONTROL	Steering valve Port 'L' to Steering Cylinder
8	HOSE ASSY, RIGHT STEERING CONTROL	Steering VALVE PORT 'R' TO Steering CYLINDER
9	Steering cylinder Assembly	Front Axle Assembly
*	FITTING 3/8 MALE PIPE TO #6 JIC	Steering Cylinder
10	Hydraulic Filter Assembly	Left Side of Firewall, Engine Compartment
*	Fitting, 1/2 Male Pipe to #6 JIC	Hydraulic Filter Assembly
*	Fitting, 3/4 Male Pipe to 1/2 Female Pipe	Hydraulic Filter Assembly
11	Hose Assembly, Filter to Reservoir	Between Filter and Reservoir
12	Power Steering Fluid Reservoir	Engine (front left)

ENGINE WIRING

The Ford DSG engine wiring diagram is too large to br shown on this page size.

A full size copy of the diagram is included on the vehhicle CD.

The diagram number is SCH-00039.

CHAPTER 3
OVERHAUL AND MAJOR REPAIR
TABLE OF CONTENTS

SECTION 1 - REMOVAL AND INSTALLATION OF MAJOR ASSEMBLIES

SECTION 2: Repair

CHAPTER 3
SECTION 1: REMOVE AND INSTALL

Introduction:

The information contained in this chapter is intended to show how to remove and install the major components of the tow tractor. Removal and installation of minor components (IE Driveshaft) are covered in chapter two section three.

WARNING: THESE COMPONENTS ARE EXTREMELY HEAVY, GREAT CARE MUST BE TAKEN TO ENSURE THE SAFETY OF THE MECHANICS PERFORMING THE WORK. USE APPROVED HOISTING AND JACKING PROCEDURES AND EQUIPMENT DESIGNED FOR THE TASKS. SECURE THE LOADS PROPERLY AND KEEP HANDS AWAY FROM ALL PINCH POINTS.

1. Drive Axle:

A. Removal:

1. Remove rear wheels.
2. Remove drive shaft.
3. Locate and disconnect the brake hoses from the axle to the frame.
4. Place a floor jack under each end of the axle and under the reduction gearbox. Evenly raise jacks until they just start to lift the axle.
5. Locate and remove the four (4) U-bolts mounting the axle and under the gearbox. Evenly raise jacks until they just start to lift the axle.
6. Slowly lower each jack until jacks are completely lowered.
7. Slide axle out to the side, use hydraulic equipment or hoists to assist in handling axle.

B. Installation:

1. Place axle on three (3) floor jacks. One under each end and one under the reduction gearbox.
2. Position axle spring plates under rear springs of unit.
3. Evenly raise axle until it contacts springs.
4. Locate and install the four (4) U-bolts and locknuts over axle and into U-bolt plates placed on top of springs, evenly tightening locknuts to 110 ft-lb.
5. Remove floor jacks.
6. Install the brake lines from the axle to the frame.
7. Install the drive shaft.
8. Bleed brake system.
9. Install the rear wheels.
10. After 24 hours of service, recheck torque on U-bolt nuts and lug nuts.

CHAPTER 3
SECTION 1: OVERHAUL AND MAJOR REPAIR

2. Transmission:

A. Removal:

1. Raise and support hood, disconnect battery.
2. Raise unit until wheels are off the ground, support on jack stands.
3. Place transmission in neutral.
4. Remove drive shaft.
5. Locate and remove the two (2) transmission cooling lines.
6. Disconnect shift rod from selector lever.
7. Place a transmission jack stand under transmission pan and secure in place with four (4) bolts. Raise jack until it starts to lift transmission.
8. Locate and remove the bolt securing rubber isolator to the transmission mount.
9. Locate and remove the four (4) bolts securing transmission mount to chassis, remove mount.
10. Remove the inspection cover from between the transmission and adapter.
11. Remove the four (4) lock nuts securing the torque converter to the flywheel (it will be necessary to rotate the flywheel). This can be done carefully using a socket on the crankshaft pulley at the front of the engine.
12. Remove the bolts securing the transmission to the engine, take note where the bolts are removed from as some of them may be different lengths.
13. Lower transmission and remove from unit.

B. Installation:

1. Raise transmission into place.
2. Align torque converter mounting studs with mounting holes in flywheel.
3. Secure transmission to engine with mounting bolts.
4. Secure torque converter to flywheel using four (4) new locknuts and blue threadlocker.
5. Raise rear transmission mount into place and secure with four (4) bolts and lock washers.
6. Place transmission rubber isolator in transmission mount secure with bolt.
7. Remove transmission jack, replace any cover bolts removed for jack.
8. Install drive shaft.
9. Locate and install transmission cooling lines.
10. Lower unit, connect battery and lower hood.
11. Engage parking brake and place unit in neutral.
12. If fluid was not added before transmission was installed, add fluid now.
13. Start unit and check for leaks, allow unit to reach operating temperature. Check fluid level and add fluid as required.

CHAPTER 3
SECTION 1: OVERHAUL AND MAJOR REPAIR

3. Engine:

A. Removal:

1. Raise and support hood, disconnect battery.
2. Raise unit and support on jack stands.
3. Remove radiator.
4. Remove transmission.
5. Lower unit.
6. Remove hood.
7. Remove engine side panels.
8. Remove fuel line from fuel pump (or LP line from Megajector).

WARNING: GASOLINE AND LIQUID PROPANE ARE EXTREMELY FLAMMABLE. DO NOT HANDLE FUEL NEAR ANY OPEN FLAMES OR OTHER SOURCE OF IGNITION.

9. Label and remove wiring from engine.
10. Remove grounding strap from left side of the engine.
11. Remove heater hose if unit is equipped with a heater.
12. Locate and remove the mounting bolts securing the engine mounts.
13. Hoist engine straight up until oil pan clears obstacles.

B. Installation:

1. Hoist engine into place and secure mounts with two (2) bolts.
2. Install transmission.
3. Install radiator.
4. Install fuel line to fuel pump (or LP line to Megajector).
5. Install heater hose if unit is equipped with a heater.
6. Install wiring as removed.
7. Install grounding strap on the left side of the engine.
8. Install hood.
9. Install engine side panels.
10. Fill all fluids (oil, anti-freeze, and transmission) to proper levels.
11. Lower unit, connect battery, and test unit for proper operation.

THIS PAGE
INTENTIONALLY
LEFT BLANK

CHAPTER 3
SECTION 2: REPAIR

Introduction:

The information contained in this chapter is intended to show how to repair the major components of the tow tractor.

WARNING: THESE COMPONENTS ARE EXTREMELY HEAVY, GREAT CARE MUST BE TAKEN TO ENSURE THE SAFETY OF THE MECHANICS PERFORMING THE WORK. USE APPROVED HOISTING AND JACKING PROCEDURES AND EQUIPMENT DESIGNED FOR THE TASKS. SECURE THE LOADS PROPERLY AND KEEP HANDS AWAY FROM ALL PINCH POINTS.

1. Drive Axle:

Refer to Chapter 5, Manufacturer Supplements

2. Engine:

Refer to Chapter 5, Manufacturer Supplements

CHAPTER 3
SECTION 1: REPAIR

1. Transmission:

DESCRIPTION

The C6 transmission is a three speed unit Capable of providing automatic upshifts and downshifts through the three forward gear ratios. The transmission Is also capable of providing manual selection of first and second gears.

Fig. 1 shows the location of the converter, front pump, clutches, gear train and most of the Internal parts used in the C6 transmission. The identification tag (Fig. 2), is attached to the intermediate servo lower front cover bolt. The first line On the tag shows the transmission model prefix and suffix. A number appearing after the suffix indicates that the internal parts in the transmission have been changed after initial production start-up. For example, a PGD-BN model transmission that has been changed internally would read PGD-BN1. Both transmissions are basically the same, but some service parts in the PGN-BN transmission are slightly different than the PGD-BN1 transmission. **Therefore, it is important that the codes on the transmission identification tag be checked when ordering parts or making inquiries about the transmission.**

The hydraulic control system schematic is shown in Fig. 3. The converter housing and the fixed splines which engage the splined outside diameter of the low-reverse clutch steel plates, are both cast integrally into the case.

Only one (intermediate) band is used in the C6 transmission. This along with the forward clutch is used to obtain intermediate gear.

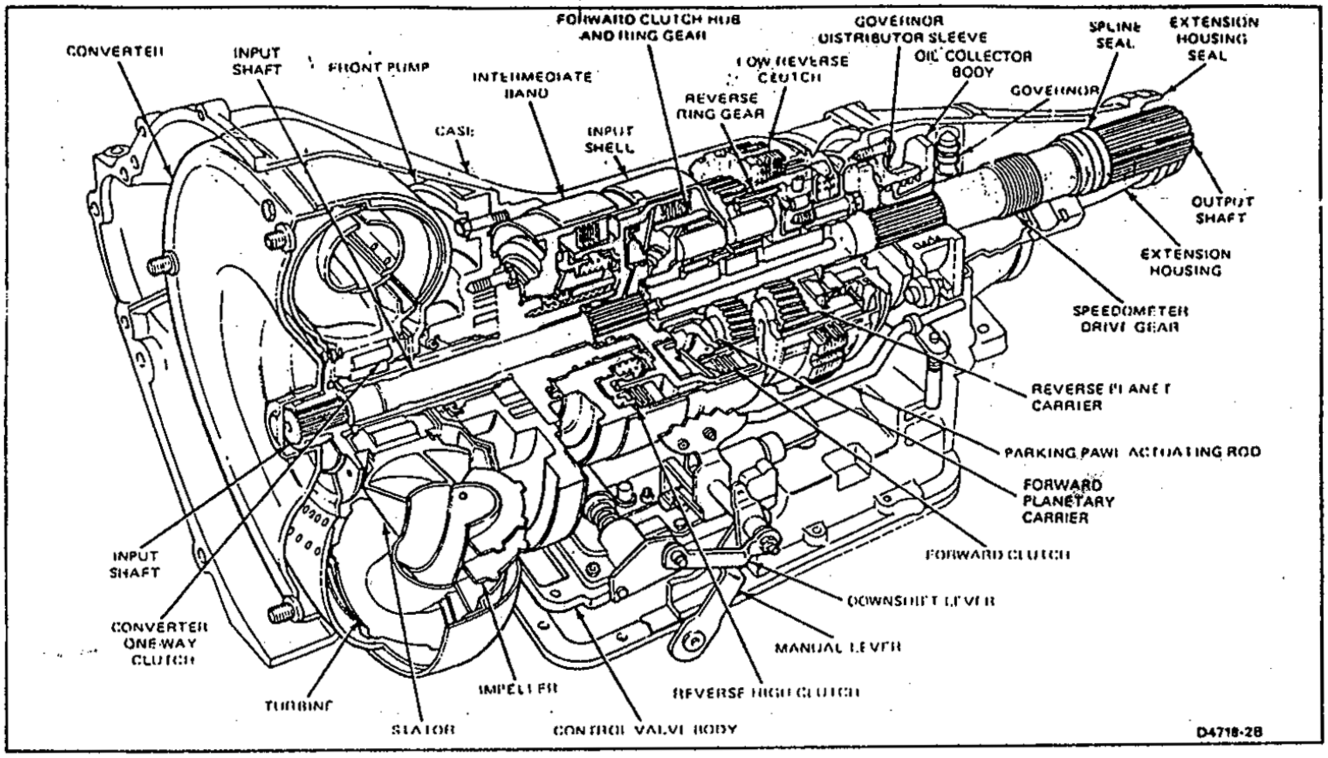


FIG. 1 C6 Automatic Transmission—Sectional

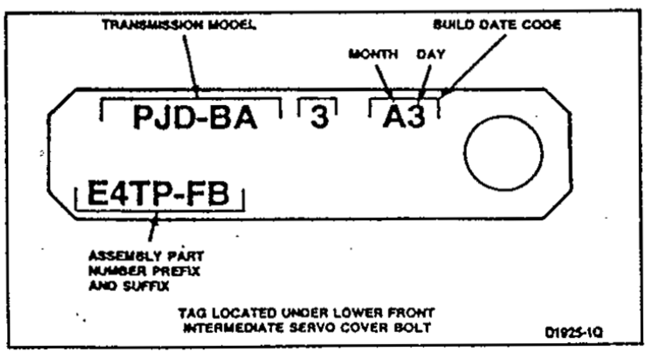


FIG. 2 Identification Tag

DIAGNOSIS AND TESTING

Refer to Section 2 General Automatic Transmission Service.

ADJUSTMENTS

The only adjustment on the transmission are the intermediate band

To prevent damage to the transmission and to assure proper band adjustment, it is essential that the tools and procedures described here are used whenever the band is adjusted.

Intermediate Band Adjustment

1. Raise the vehicle on a hoist or jack stands.
2. Clean all the dirt from the band adjusting screw. Remove and discard locknut.
3. Install a new locknut and tighten the adjusting screw to 14 N·m (10 ft-lbs) torque (Fig. 5).
4. **Back off the adjusting screw exactly 1-1/2 turns.**
5. Hold the adjusting screw from turning and tighten the locknut to 48-61 N·m (35-40 ft-lbs).
6. Lower the vehicle.

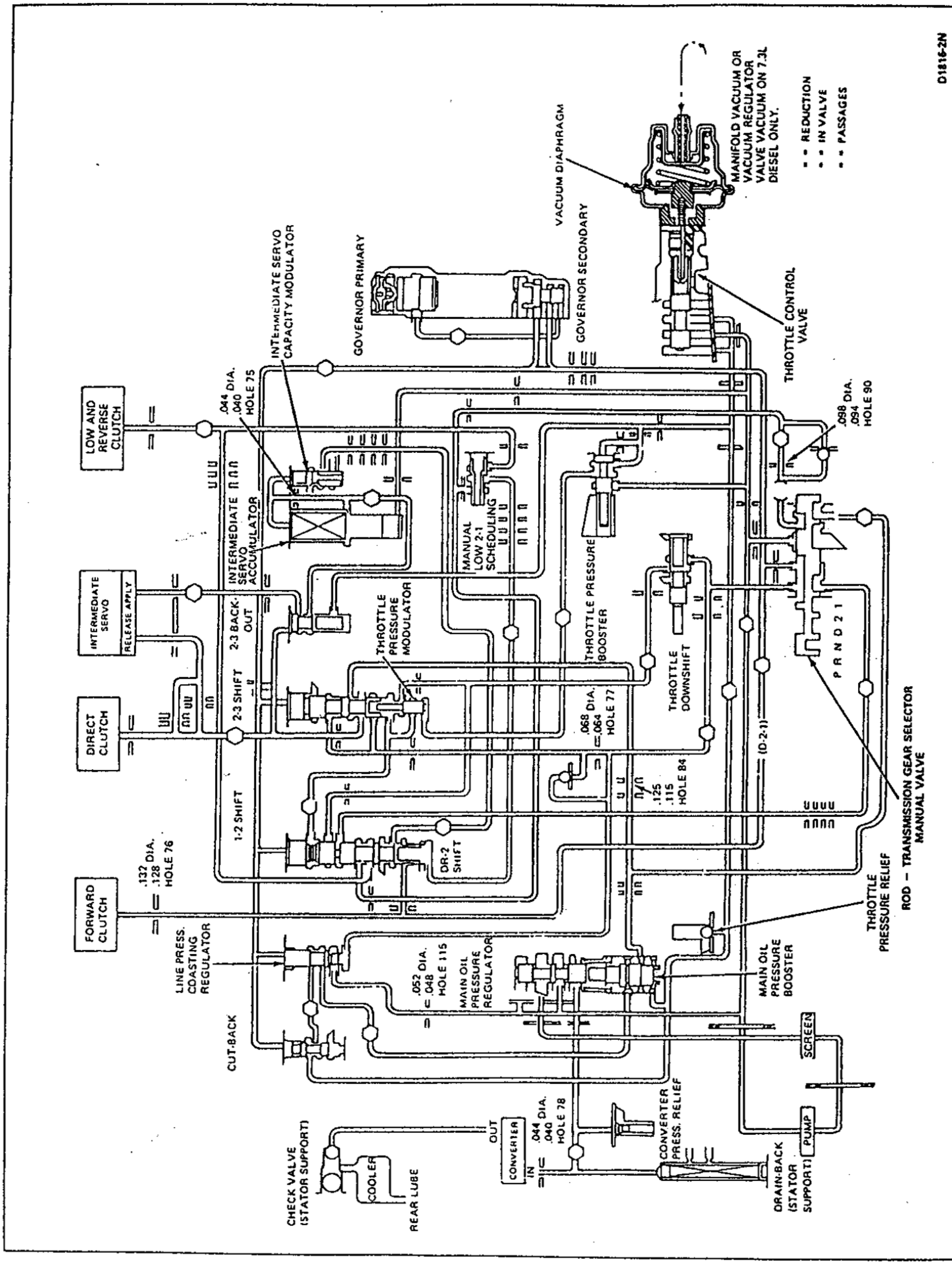


FIG. 3 Hydraulic Control System—C6 Transmission

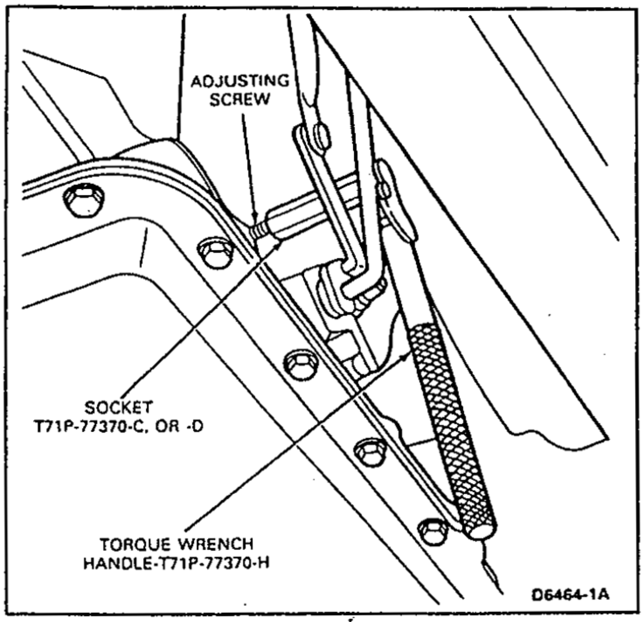


FIG. 5 Adjusting Intermediate Band

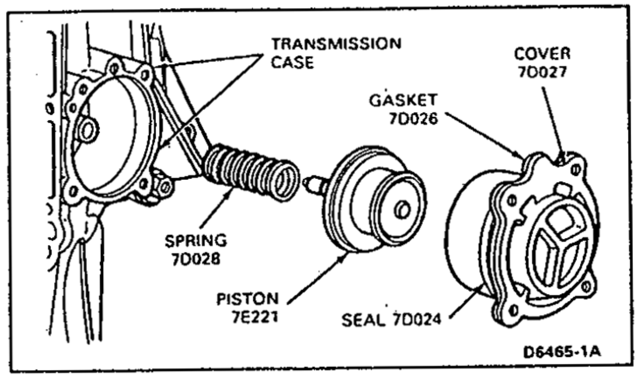


FIG. 10 Intermediate Servo Disassembled—Typical

Control Valve Body

Refer to Fig. 17.

Removal

1. Raise the vehicle on a hoist or jack stands.
2. Place a drain pan under the transmission and loosen the bolts holding the transmission pan to drain the fluid from the transmission.
3. Remove the transmission pan attaching bolts from both sides and the rear to allow the fluid to drain further. Finally, remove the remainder of the attaching bolts. Remove the pan and gasket. Remove and discard the nylon shipping plug from the pan. This plug is used to retain transmission fluid within the transmission during shipment and should be discarded when the oil pan is removed.
4. Remove the valve body attaching bolts and remove the valve body from the case.

Installation

1. Position the valve body to the case making sure that the selector and downshift levers are engaged. Install and tighten the attaching bolts to 11-14 N·m (95-125 in.-lbs).
2. Clean the transmission pan and gasket surfaces thoroughly.
3. Using a new pan gasket, install attaching bolts securing the pan to the transmission case. Tighten the attaching bolts to 10.5-17 N·m (8-12 ft-lbs).
4. Lower the vehicle and fill the transmission to the correct level with the specified fluid.

Intermediate Servo

(Refer to Fig. 10).

Removal

1. Raise the vehicle on a hoist or stands.
2. Remove the bolts that secure the engine rear support to the transmission extension rear support and insulator assembly to the crossmember.
3. Remove the two crossmember-to-frame attaching bolts, and the bolts attaching the gussets to the crossmember if so equipped.
4. Raise the transmission high enough to remove the weight from the crossmember and remove the crossmember.
5. Disconnect the muffler inlet pipe from the exhaust manifolds and allow the pipe to hang.
6. Place a drain pan under the servo. Remove the bolts that attach the servo cover to the transmission case.
7. Remove the cover, piston, spring and gasket from the case, screwing the band adjusting screw inward as the piston is removed. This places enough tension on the band to keep the struts properly engaged in the band end notches while the piston is removed.
8. Apply air pressure to the port in the servo cover to remove the piston and rod.
9. Replace the complete piston and rod assembly if the piston or piston sealing lips are damaged, (Fig. 10).
10. Remove the seal from the cover.

Installation

1. Dip the new seal in transmission fluid.
2. Install a new seal on the cover.
3. Coat new gasket with petroleum jelly, and position on the servo cover.
4. Dip the piston in transmission fluid and install it in the cover.

Governor

Removal

1. Remove the extension housing as outlined in this Section.
2. Remove the four governor body-to-oil-collector attaching bolts (Fig. 15).
3. Remove the governor from the collector body flange.
4. Refer to the Disassembly and Assembly Section of this Section for Governor repair operations.

Installation

1. Secure the governor (Fig. 15) to the oil collector flange with the attaching bolts. Tighten the bolts to 10.5-13.5 N·m (90-120 in.-lbs).
2. Re-install the extension housing as outlined in this Section.

DISASSEMBLY AND ASSEMBLY

Transmission

Refer to Fig. 38.

Before removing any of the subassemblies, thoroughly clean the outside of the transmission to prevent dirt from entering the mechanical parts.

During the repair of the subassemblies, certain general instructions which apply to all units of the transmission must be followed. Following these instructions will avoid unnecessary repetition.

Handle all transmission parts carefully to avoid nicking or burring the bearing or mating surfaces. Lubricate all internal parts of the transmission with clean automatic transmission fluid before assembly.

Do not use any other lubricants except on gaskets and thrust washers. These may be coated with petroleum jelly to facilitate assembly. Always use new gaskets and seals when assembling a transmission. Refer to Section 17-01, General Automatic Transmission Service for Cleaning and Inspection Procedures.

Tighten all bolts and screws to the recommended torque as outlined in specifications at end of this Section.

Disassembly

1. Remove the converter, and mount the transmission in holding fixture Rotunda Model 014-00106 or equivalent, (Fig. 16).

   NOTE: If equipped, remove and discard the nylon shipping plug from the pan. This plug is used to retain transmission fluid within the transmission during shipping. It should be discarded when the oil pan is removed.

2. Remove the 17 fluid pan attaching bolts. Remove the pan and gasket.
3. Remove the eight valve body attaching bolts. Lift the valve body (Fig. 17) from the transmission case.

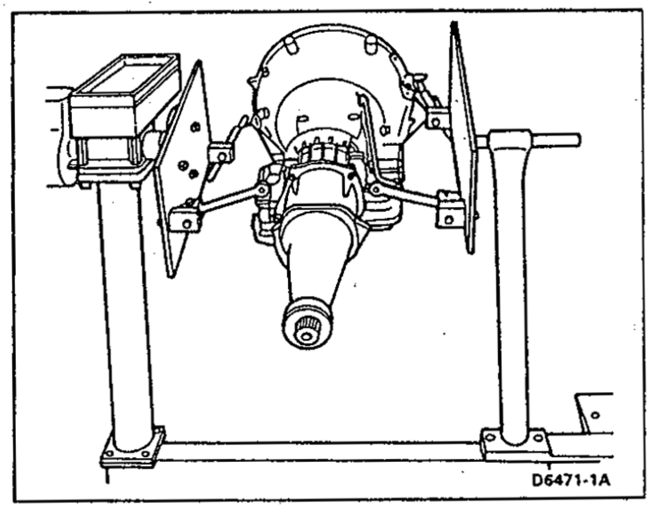


FIG. 16 Transmission Mounted in Holding Fixture

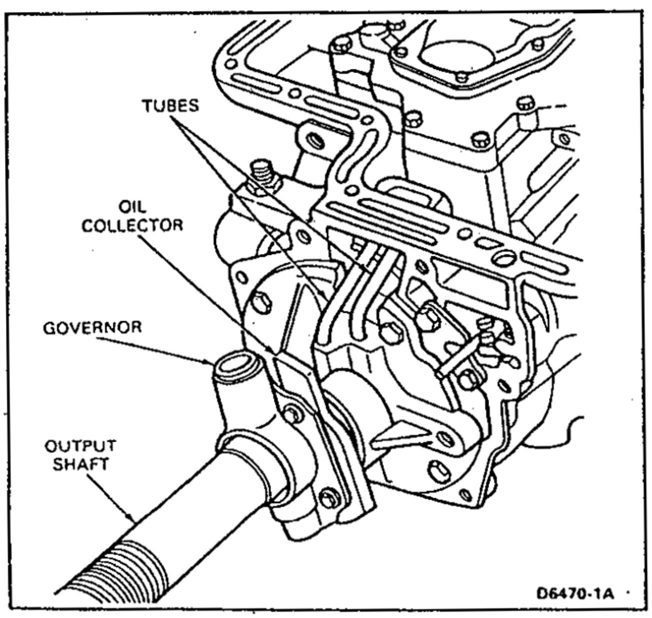


FIG. 15 Governor Installed

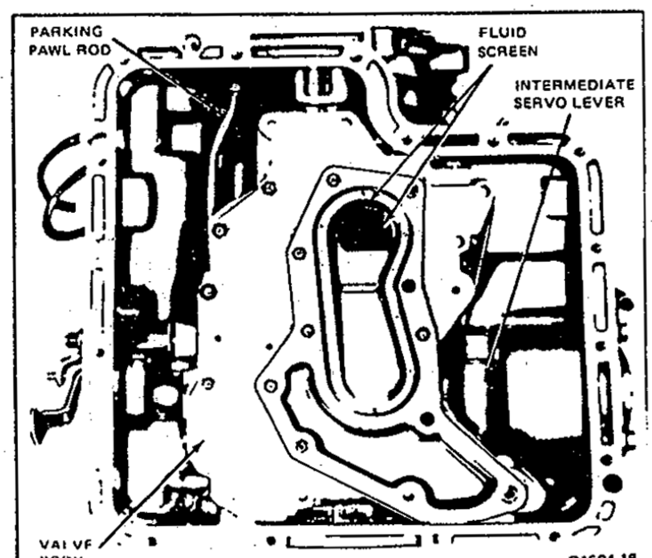


FIG. 17 Transmission With Pan Removed

4. Attach a dial indicator TOOL-4201-C or equivalent to the front pump as shown in Fig. 18. Install Extension Housing Seal Replacer T61L-7657-B in the extension housing to center the output shaft.

5. Pry the gear train to the rear of the case and at the same time, press the input shaft inward until it bottoms, (Fig. 18). Set the dial indicator to read zero.

6. Pry the gear train forward, (Fig. 18), and note the amount of gear train end play on the dial indicator. Record the end play to facilitate assembling the transmission. Remove the dial indicator from the pump and the tool from the extension housing.

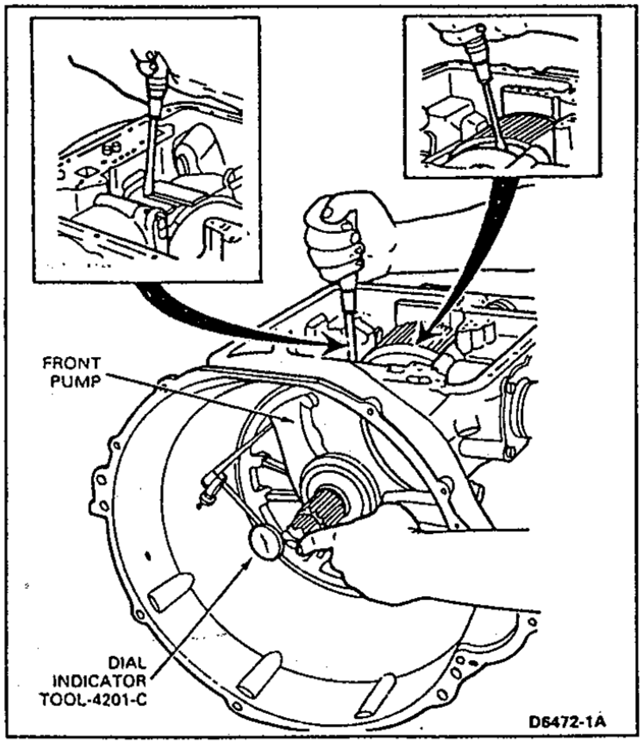


FIG. 18 Checking Gear Train End Play

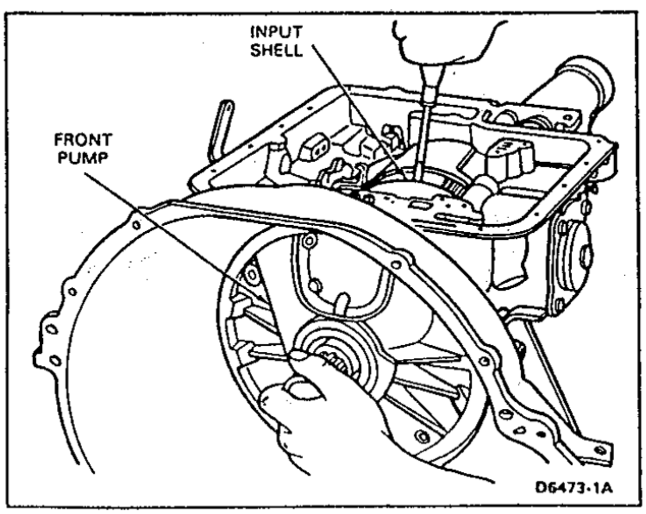


FIG. 19 Removing Front Pump

7. Remove the vacuum diaphragm, valve rod and the throttle valve from the bore in the rear of the case. Slip the input shaft out of the front pump.

8. Remove the front pump attaching bolts. Pry the gear train forward as shown in Fig. 19 to remove the pump.

9. Loosen the band adjustment screw and remove the two struts.

10. Rotate the band 90 degrees counterclockwise to align the ends with the slot in the case (Fig. 20). Slide the band off the reverse-high clutch drum.

11. Remove the forward part of the gear train as an assembly as shown in Fig. 21.

12. Remove the bolts that attach the servo cover to the transmission case.

13. Remove the cover, piston, spring and gasket from the case.

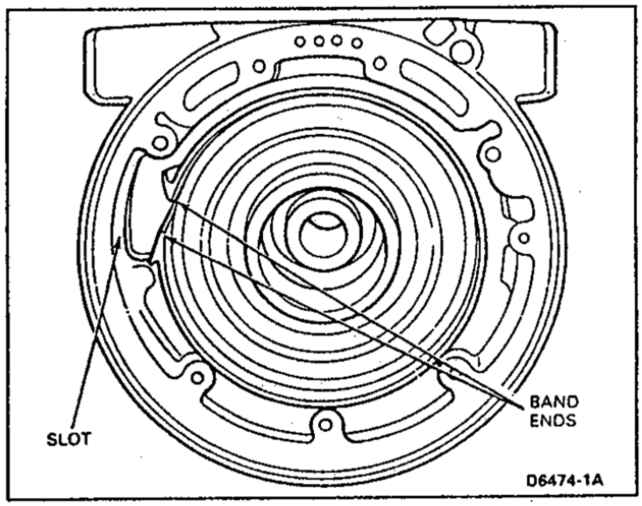


FIG. 20 Removing or Installing Band

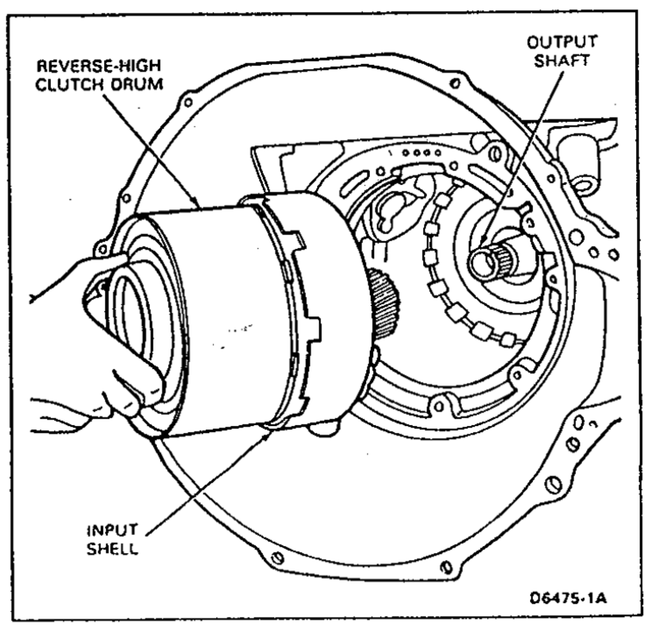


FIG. 21 Removing or Installing Forward Part of Gear Train

14. Remove the large snap ring that secures the reverse planet carrier in the low-reverse clutch hub. Lift the thrust washers and planet carrier from the drum.
15. Remove the snap ring, (Fig. 22), that secures the reverse ring gear and hub on the output shaft. Slide the ring gear and hub off the shaft. Remove the thrust washer.
16. Rotate the low-reverse clutch hub in a clockwise direction and at the same time, withdraw it from the case.
17. Remove the reverse clutch snap ring from the case, then remove the clutch discs, plates and pressure plate from the case.
18. Remove the extension housing attaching bolts from the case. Remove the extension housing and gasket.
19. Slide the output shaft (with governor and oil collector) assembly from the transmission case.
20. Remove the distributor sleeve attaching bolts and remove the sleeve, parking pawl gear and the thrust washer.

    If the thrust washer is staked in place, use a sharp chisel and cut off the metal from behind the thrust washer. Be sure to clean the rear of the case with air pressure or a suitable solvent to remove any metal particles.
21. Remove the one-way clutch inner race attaching bolts from the rear of the case. Remove the inner race and reverse clutch spring retainer assembly from inside of the case.
22. Remove the low-reverse clutch piston from the case using TOOL-7000-DE or equivalent as shown in Fig. 23.

Assembly

1. Place the transmission case in a holding fixture.
2. Tap the low-reverse piston into place in the case with a clean rubber hammer.
3. Install the low-reverse clutch spring retainer assembly and retainer assembly in the clutch piston.
4. Hold the one-way clutch inner race in position and install the attaching bolts. Tighten bolts to 25-33 N·m (18-25 ft-lbs).
5. Place the transmission case on the bench with the front end facing downward.
6. Position the parking gear thrust washer and the gear on the case (Fig. 31). **Do not re-stake the thrust washer.**
7. Position the collector and tubes in place on the rear of the case. Install the attaching bolts and tighten to 17-21 N·m (12-16 ft-lbs).
8. Install the output shaft, and governor as an assembly.
9. Place a new gasket on the rear of the transmission case. Position the extension housing on the case and install the attaching bolts. Tighten the attaching bolts to 34-47 N·m (25-35 ft-lbs).
10. Place the transmission case in the holding fixture.
11. Coat new gasket with petroleum jelly and position on the servo cover.
12. Position the servo spring on the piston rod.
13. Insert the servo piston rod in the case. Install the servo cover with the attaching bolts, making sure that the identification tag is in place. Tighten the attaching bolts to 19-27 N·m (14-20 ft-lbs).
14. Align the low-reverse clutch hub and one-way clutch with the inner race at the rear of the case. Rotate the low-reverse clutch hub clockwise while applying pressure to seat it on the inner race.
15. Install the low-reverse clutch plates, starting with the wave plate next to the piston and following with steel and friction plates alternately. Retain them with petroleum jelly. If new composition plates are being used, soak them in clean transmission fluid, Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2QDX or DDX (ESP-M2C166-H), or equivalent for fifteen minutes before installation. Install the pressure plate and the snap ring. Test the operation of the low-reverse clutch by applying air pressure at the clutch pressure apply hole in the case.

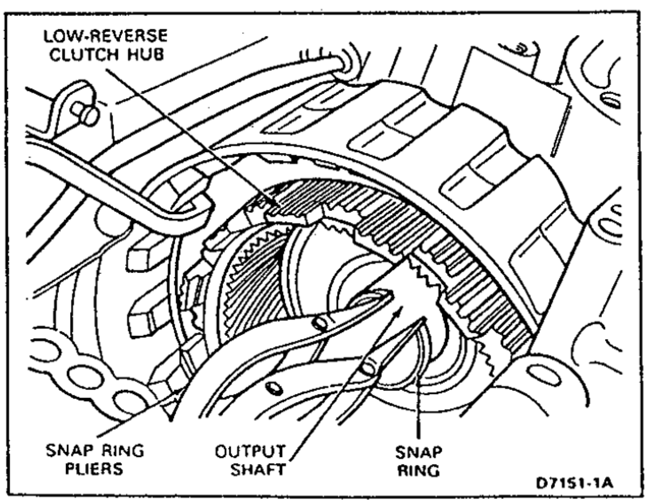


FIG. 22 Removing or Installing Reverse Ring Gear Hub, Snap Ring

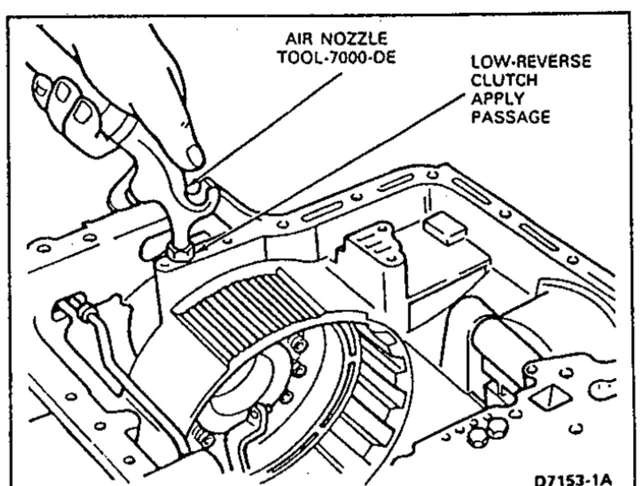


FIG. 23 Removing Low-Reverse Clutch Piston

16. Install the reverse planet ring gear thrust washer and the ring gear and hub assembly. Insert the snap ring in the groove on the output shaft.
17. Assemble the front and rear thrust washers onto the reverse planet assembly; retain with petroleum jelly. Insert the assembly into the ring gear and install the snap ring.
18. Set the reverse-high clutch assembly on the bench, with the front end facing down. Install the thrust washer on the rear end of the reverse-high clutch assembly. Retain the thrust washer with petroleum jelly and insert the splined end of forward clutch into the open end of the reverse-high clutch with splines engaging the direct clutch friction plates (Fig. 38).
19. Install the thrust washers and retain them with petroleum jelly, on the front end of the forward planet ring gear and hub. Insert the ring gear into the forward clutch.
20. Install the thrust washer on the front end of the forward planet assembly. Retain the washer with petroleum jelly and insert the assembly into the ring gear. Install the input shell and sun gear assembly.
21. Install the reverse-high clutch assembly, forward clutch assembly, forward planet assembly and drive input shell, and sun gear as an assembly into the transmission case.
22. Insert the intermediate band into the case around the reverse-high clutch drum. Install the struts and tighten the band adjusting screw sufficiently to retain the band.
23. Place a selective thickness bronze thrust washer on the rear shoulder of the stator support and retain it with petroleum jelly. If the end play was not within specification when checked prior to disassembly, replace the washer with one of proper thickness. Refer to specifications at the end of this Section for selective thrust washer thicknesses.

    Using two 5/16-inch bolts three inches long, make two alignment studs. Cut the heads from the bolts and grind a taper on the cut end. Temporarily install the two studs opposite each other in the mounting holes of the case. Slide a new gasket onto the studs. Position pump on case, being careful not to damage the large seal on the outside diameter of the pump housing, (removing the aligning studs).

    Install six of the seven mounting bolts and tighten to 22-40 N·m (16-30 ft-lbs).
24. Adjust the intermediate band as detailed under Adjustments and install the input shaft with the long splined end inserted into the forward clutch assembly.
25. Install Tool 4201-C or equivalent at the seventh pump mounting bolt (Fig. 18) and check the transmission end play as in steps 4, 5 and 6 of Disassembly. (See specifications at the end of this Section.) Remove the tool.

    Install the seventh pump mounting bolt and tighten to 22-40 N·m (16-30 ft-lbs).
26. Install the main control valve body on the case, making sure that the levers engage the valves properly and tighten the attaching bolts to 11-14 N·m (95-125 in.-lbs). Install the primary throttle valve, rod, and the vacuum diaphragm in the case. Tighten the diaphragm attaching bolt to 17-21 N·m (12-16 ft-lbs).
27. Install a new pan gasket and the pan. Tighten the bolts to 10.5-17 N·m (8-12 ft-lbs).
28. Install the converter assembly.
29. Install the transmission in the vehicle as detailed under Removal and Installation.

Control Valve Body

Disassembly

The valve body-to-screen gasket should not be cleaned in a degreaser solvent or any type of detergent solution when disassembling the main control. To clean the gasket, wipe it off with a lint-free cloth.

1. Remove the nine screws that attach the screen to the lower valve body (Fig. 24) and remove screen and gasket (Fig. 25).
2. Remove the five upper-to-lower valve body and hold-down plate attaching screws. Remove the seven attaching screws from the underside of the lower valve body (Fig. 24).
3. Separate the bodies and remove the separator plate and gasket. **Be careful not to lose the check valves and springs.** Remove and clean the separator plate screen if necessary (Fig. 25).
4. Remove the manual valve retaining pin from the upper valve body (Fig. 26).
5. Slide the manual valve (Fig. 26) out of the valve body.
6. Cover the downshift valve bore with a finger, then working from the underside of the body remove the downshift valve retainer. Remove the spring and downshift valve (Fig. 26).
7. Apply hand pressure on the pressure boost valve sleeve end and remove the sleeve retaining clip from the under side of the body. Slowly release hand pressure and remove the sleeve and the pressure boost valve. Remove the two springs, the spring and the main regulator valve from the bore.
8. Apply pressure on the throttle boost valve retaining plate and remove the two attaching screws. Slowly release the pressure and remove plate, throttle pressure boost valve and spring, and the manual low 2-1 scheduling valve and spring from the body (Fig. 26).
9. Apply pressure on the remaining valve retaining plate and remove the eight attaching screws.
10. Hold the valve body so that the plate is facing upward. Slowly release the pressure and remove the plate.
11. Remove the spring and the intermediate servo modulator valve (Fig. 26) from the valve body.
12. Remove the intermediate servo accumulator valve and springs.
13. Remove the 2-3 back-out valve and spring.
14. Remove the 2-3 shift valve, spring and the throttle modulator valve and spring.
15. Remove the 1-2 shift valve, DR-2 shift valve and the spring from the valve body.

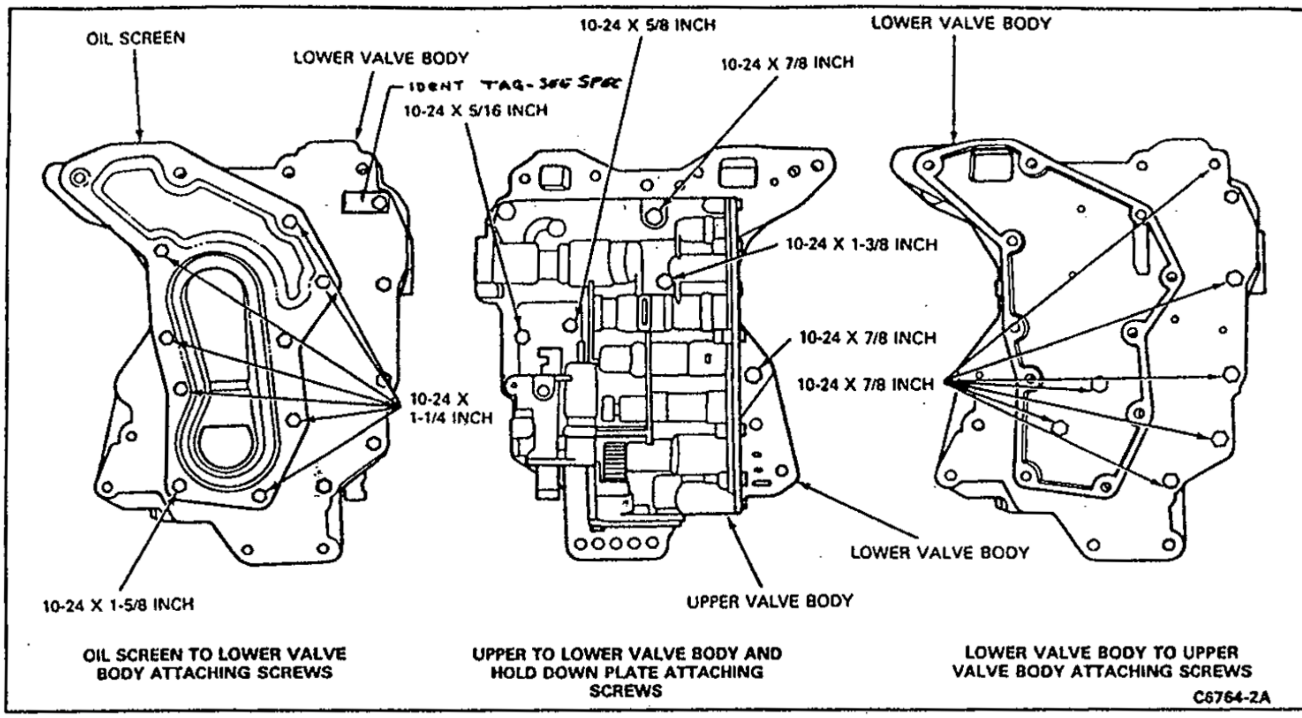


FIG. 24 Control Valve Body and Screen Attaching Screws

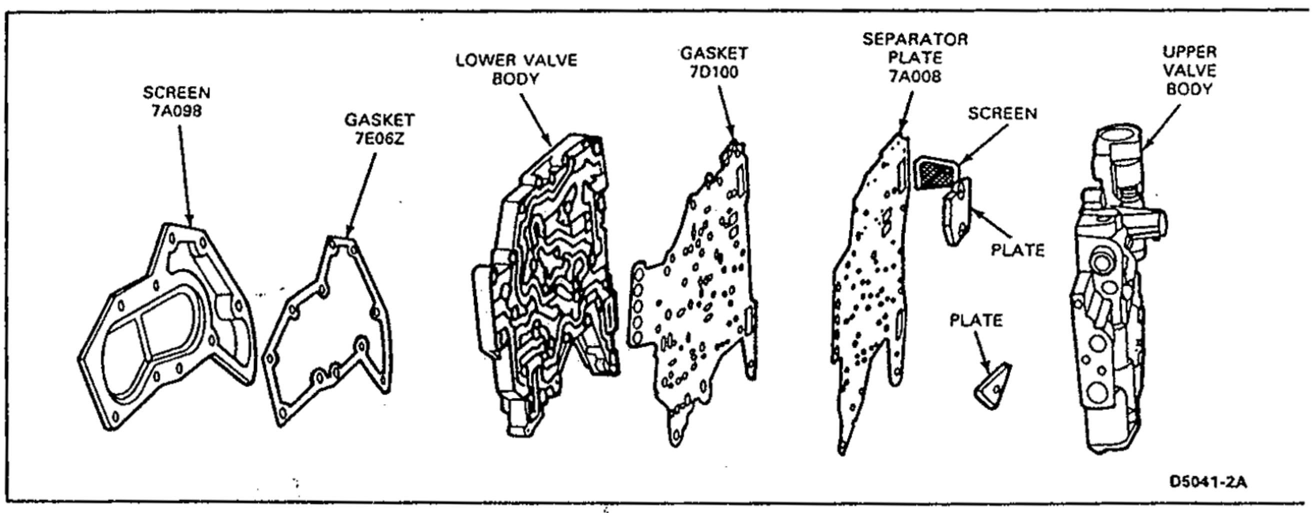


FIG. 25 Upper and Lower Valve Bodies Disassembled

16. Remove the line pressure coasting regulator valve, (Fig. 26) from the body.
17. Remove the cutback control valve to complete the disassembly of the control valve.

Assembly

1. Place the downshift valve and spring in the valve body. Compress the spring and install the retainer from the underside of the body (Fig. 27).
2. Place the valve body on a clean surface with the passage side facing up. Place the converter relief valve spring in its bore (Fig. 27). Coat the converter pressure relief valve with petroleum jelly and place it on top of the spring. Place the 2-3 shift valve check ball in its cavity. Place the throttle pressure relief valve spring in its bore (Fig. 27). Coat th throttle pressure relief valve check ball wit petroleum jelly and place it on top of the spring Place the reverse clutch check ball in its cavity
3. Install the separator screen in the separator plate it was previously removed. **Be sure the scree tabs are flush with the separator plate surfac** Carefully position the separator plate and ne gasket on the lower valve body. Place the tw hold-down plates on the separator plate and insta the attaching screws finger tight.
4. Place the lower body and plate assembly on th upper valve body (Fig. 24) and install the attachir screws finger tight.

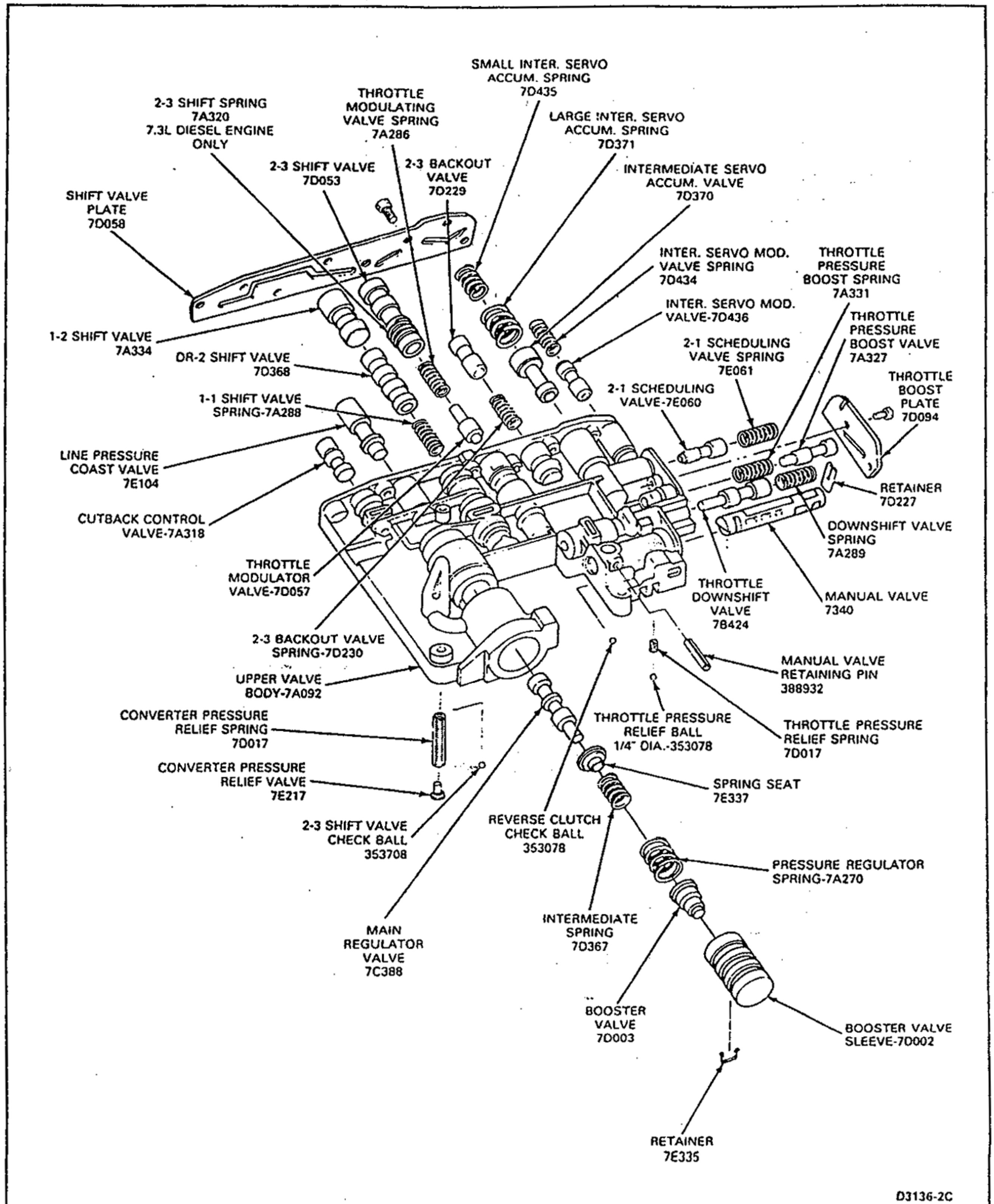


FIG. 26 Upper Valve Body Disassembled

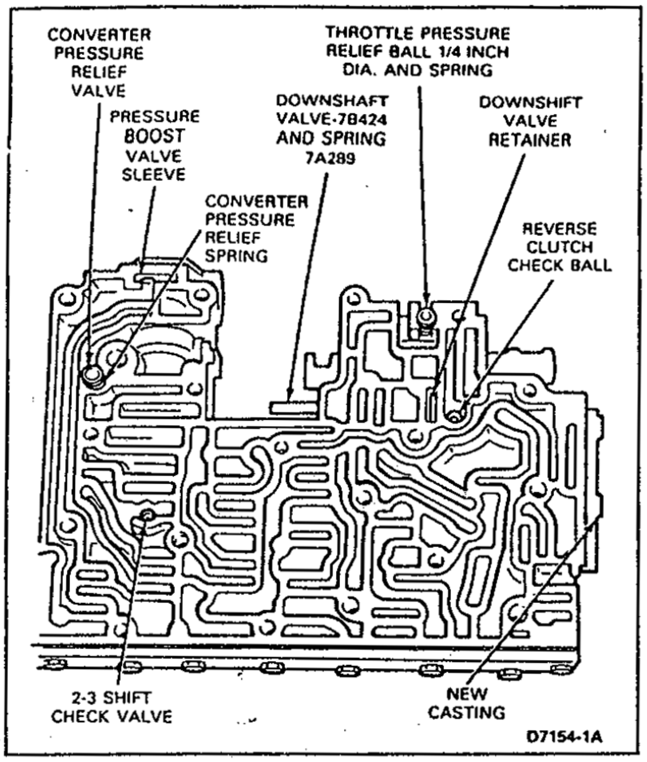


FIG. 27 Downshift Valve and Spring, Converter Pressure Relief Valve, Throttle Pressure Relief Valve Check Ball, and 2-3 Shift Check Valve Locations

5. Install the oil screen screws loosely, without the screen, to properly align the upper and lower valve bodies, gasket and separator plate.
6. Tighten the two bolts that are covered by the screen to 5.0-6.2 N·m (40-55 in.-lbs).
7. Remove the oil screen attaching screws and place the gasket and oil screen in position on the lower valve body. Re-install the screen attaching screws (Fig. 24).
8. Tighten all the valve body and screen attaching screws to 5.0-6.2 N·m (40-55 in.-lbs).
9. Place the cutback control valve (Fig. 26) and the line pressure coasting regulator valve in the valve body.
10. Place the one spring, DR-2 shift valve and the 1-2 shift valve in the body.
11. Place the throttle modulator valve and spring and the 2-3 shift valve (and spring on 7.3L Diesel) in the valve body.
12. Place the spring and the 2-3 backout valve in the valve body.
13. Place the two springs and the intermediate servo accumulator valve in the valve body.
14. Place the intermediate servo modulator valve and spring in the body.
15. Carefully place the valve retaining plate on the body and secure it with the eight attaching screws. Tighten the two hex washer head screws to 2.5-5.0 N·m (20-45 in-lbs). Tighten the remaining six screws to 2.5-4.5 N·m (20-40 in-lbs).
16. Place the throttle pressure boost valve and spring in the valve body. Place the manual low 2-1 scheduling valve and spring in the valve body and install the retaining plate. Tighten the attaching screws to 2.5-5.0 N·m (20-45 in.-lbs).
17. Place the spring seat on the stem of the main regulator valve so that the retainer flange is next to the valve shoulder. Place the main regulator valve, spring seat, two springs, pressure boost valve and sleeve in the bore. Apply hand pressure on the end of the pressure boost valve sleeve and install the spring clip retainer in the groove on the under side of the body so that the clip is inserted into the end groove in the sleeve. Be sure that the pressure boost valve sleeve is free in its bore.
18. Place the manual valve in the valve body and install the retaining pin in the body.

Intermediate Servo

(Refer to Fig. 10).

Disassembly

1. Apply air pressure to the port in the servo cover to remove the piston and rod.
2. Replace the complete piston and rod assembly if the piston or piston sealing lips are unserviceable or damaged.
3. Remove the seal and gasket from the cover.

Assembly

1. Dip the new seals in transmission fluid.
2. Install new seal and gasket on the cover.
3. Dip the piston in transmission fluid, Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H), or equivalent and install it in the cover.

Governor

Disassembly

1. Remove the governor body attaching bolts and remove the governor.
2. Remove and discard the snap ring that secures the governor oil collector body on the output shaft (Fig. 28) and slide the governor off the front of the shaft.
3. Remove the seal rings from the oil collector body.

Assembly

1. Carefully install new seal rings on the oil collector body.
2. Working from the front end of the output shaft, slide the governor oil collector body into place on the shaft. Install a new snap ring to secure it. Make sure that the snap ring is seated in the groove.
3. Position the governor assembly on the oil collector body (Fig. 28) and secure with the attaching screws. Tighten screws to 10.5-13.5 N·m (90-120 in.-lbs).

Downshift and Manual Linkage

Disassembly

1. Remove the nut and lockwasher that secures the outer downshift lever to the transmission and remove the lever.

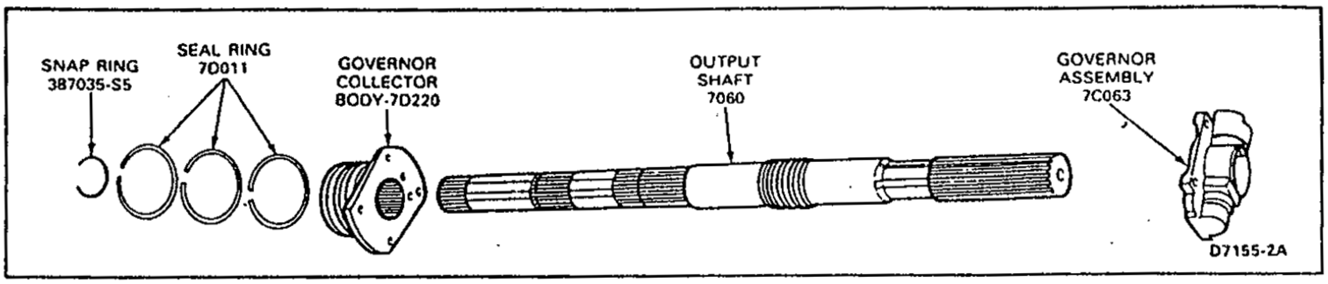


FIG. 28 Output Shaft Disassembled

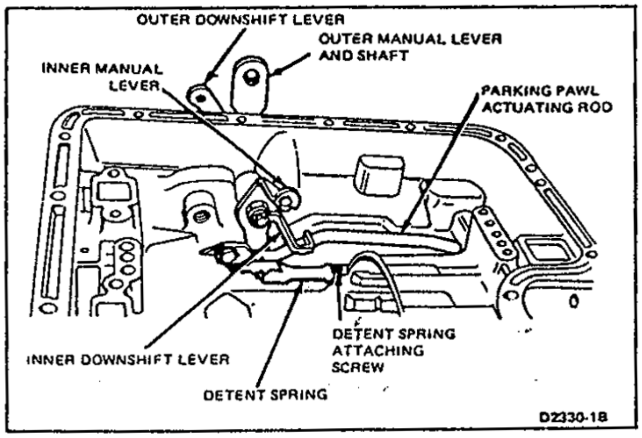


FIG. 29 Downshift and Manual Linkage

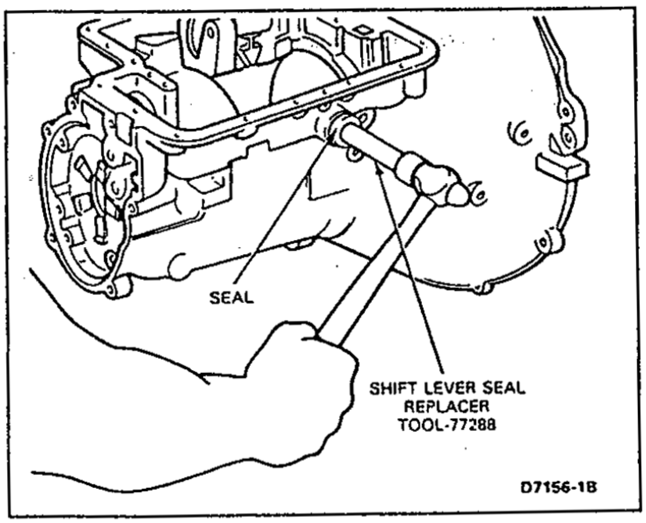


FIG. 30 Installing Manual Lever Seal

2. Slide the inner downshift lever assembly out from the inside of the case (Fig. 29). Remove the seal from the recess in the manual lever shaft.

4. Remove the C-ring securing the parking pawl actuating rod to the manual lever. Remove the rod from the case.

5. Remove the nut securing the inner manual lever to the shaft. Remove the inner lever from the shaft. Slide the outer lever and shaft from the case.

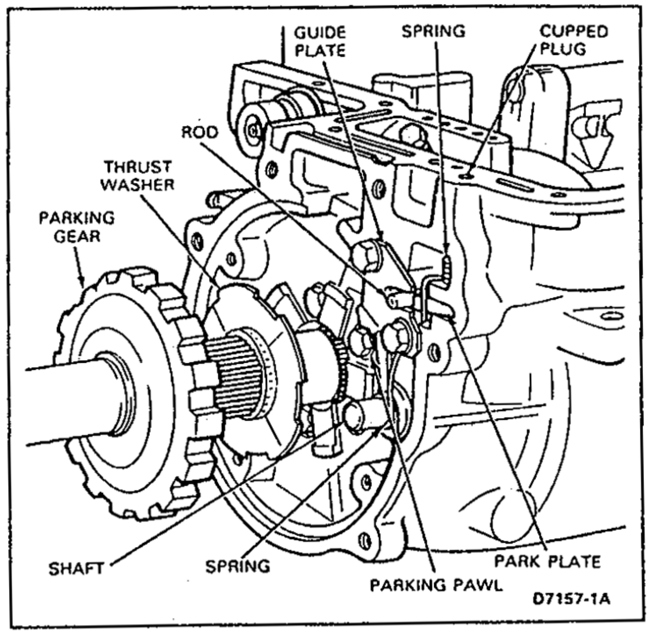


FIG. 31 Parking Pawl Mechanism

6. Remove the seal from the case with Tools T59L-100-B, Slide Hammer and T58L-101-B, Puller Attachment, or equivalents.

Assembly

1. Dip the new seal in transmission fluid Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H), or equivalent and install it in the case using TOOL-77288 or equivalent as shown in Fig. 30.

2. Slide the outer manual lever and shaft in the transmission case.

3. Position the inner lever on the shaft, making sure the leaf spring roller is positioned in the inner manual lever detent. Install the attaching nut. Tighten the nut to 41-54 N·m (30-40 ft-lbs). Install the parking pawl actuating rod and secure it to the inner manual lever with a C-ring.

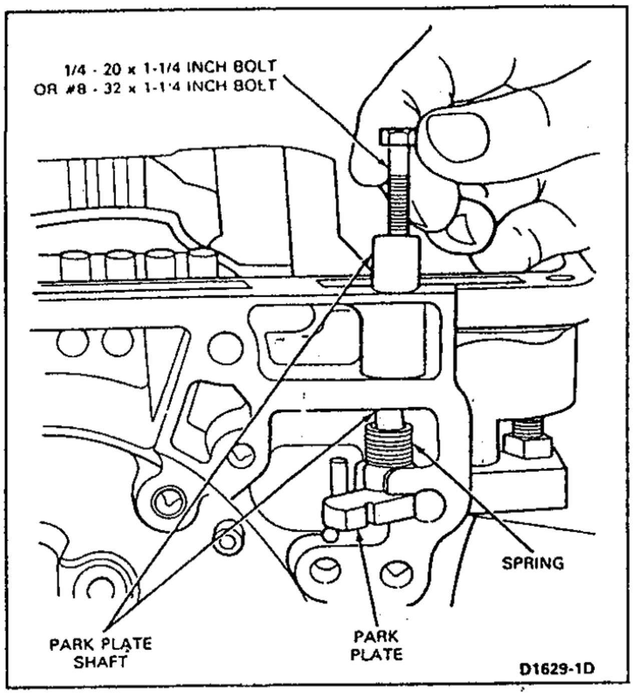


FIG. 32 Removing Park Plate

6. Install a new downshift lever seal in the recess of the outer lever shaft. Slide the downshift lever and shaft into position.
7. Place the outer downshift lever on the shaft and secure it with a lockwasher and nut. Tighten nut to 17-21 N·m (12-16 ft-lbs).

Parking Pawl Linkage

Disassembly

1. Remove the bolts securing the parking pawl guide plate to the case (Fig. 31). Remove the plate.
2. Remove the spring, parking pawl and shaft from the case.
3. Working from the pan mounting surface, drill a 1/8 inch diameter hole through the center of the cupped plug. Pull the plug from the case with a wire hook.
4. Unhook the end of the spring from the park plate slot to relieve the tension.
5. Thread a 1/4-20 inch or 8-32 x 1-1/4 inch screw (Fig. 32) into the park plate shaft. Pull the shaft from the case with the screw. Remove the spring and park plate.

Assembly

1. Position the spring and park plate in the case and install the shaft. Place the end of the spring into the slot of the park plate.
2. Install a new cupped plug to retain the shaft.
3. Install the parking pawl shaft in the case. Slip the parking pawl and spring into place on the shaft.
4. Position the guide plate on the case, making sure that the actuating rod is seated in the slot of the plate. Secure the plate with two bolts and lockwashers. Tighten bolts to 17-21 N·m (12-16 ft-lbs).

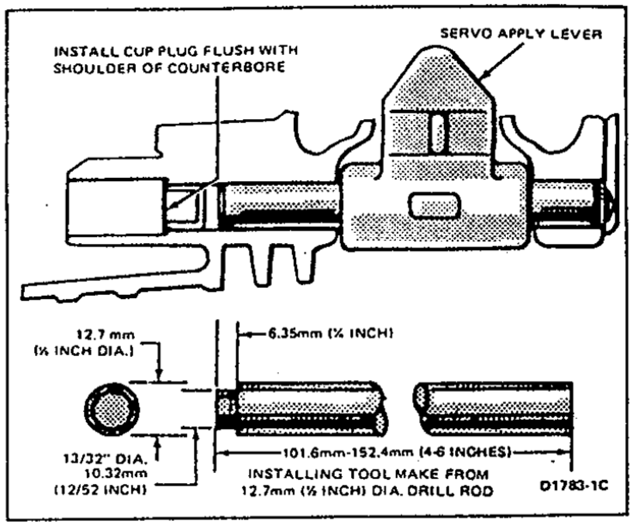


FIG. 33 Servo Apply Lever Installation

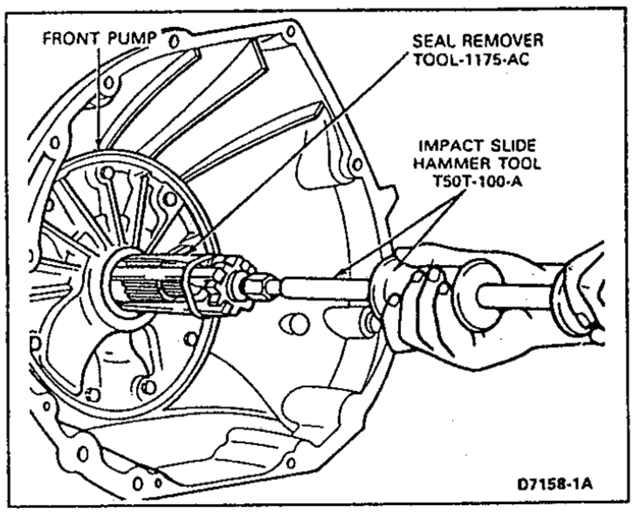


FIG. 34 Removing Front Pump Seal

Servo Apply Lever

Disassembly

1. Working from inside of the transmission case, carefully drive on the servo apply lever shaft to remove the cup plug. The shaft (Fig. 33) can be withdrawn from the case by hand.

Assembly

1. Hold the servo apply lever in position and install the new shaft.
2. Using the fabricated tool shown in Fig. 33, drive the cup plug into position in the case. Be sure the plug is flush with the shoulder of the counterbore. The cup plug may be coated with Threadlock and Sealer, EOAZ-19554-AA (ESE-M4G204-A) or equivalent, before installation.

Front Pump

The front seal can be replaced after the pump has been installed on the transmission using T50T-100-A and TOOL-1175-AC or equivalent for removal, and

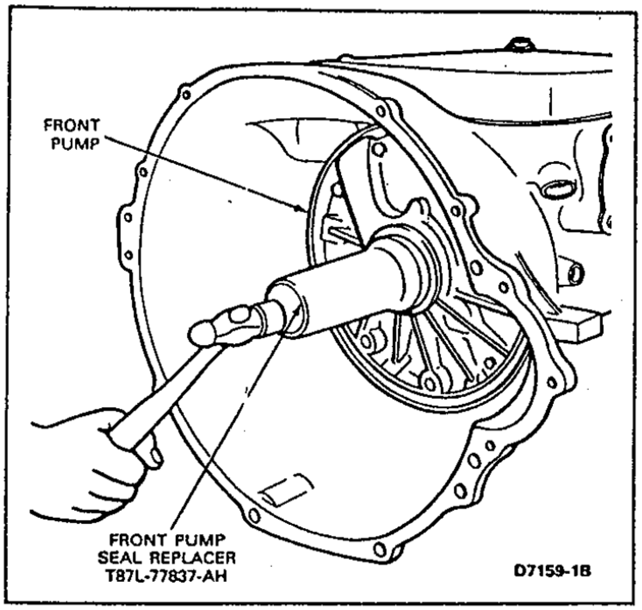


FIG. 35 Installing Front-Pump Seal

T87L-77837-AH or equivalent for installation (Figs. 34 and 35).

Disassembly

1. Remove the two seal rings and the selective thrust washer (Fig. 36).
2. Remove the large square-cut seal from the outside diameter of the pump housing.
3. Remove the five bolts that secure the stator support to the pump housing. Lift the support from the housing.
4. Remove the drive and the driven gear from the housing.
5. If the pump housing bushing is worn or damaged, replace it using the handle and Tool T66L-7003-C2 or equivalent shown in Fig. 37.

   Place the new bushing in position, making sure the half moon slot in the bushing is on top and in line with the oil lube hole near the seal bore. Press the bushing in 1.52-2.03mm (0.060-0.080 inch) below the front face of the bushing bore. Use Tool T66L-7003-C2 or equivalent and handle to seat the bushing properly. After assembly, the half moon slot must be in past the lube hole to provide proper lubrication.

Assembly

1. Install the drive and driven gears in the pump housing. **Each gear has either an identification mark or chamfered teeth on one face. The identification mark or the chamfered surface on each gear must be installed toward the front of the pump housing.**
2. Position the stator support in the pump housing and install the five attaching bolts. Tighten bolts to 17-21 N·m (12-16 ft-lbs).
3. Carefully install two new seal rings on the stator support. Make sure that the ends of the rings are engaged to lock them in place. Install a new square-cut seal on the outside diameter of the pump housing.
4. Install the selective thrust washer. **Make sure that the correct thickness selective washer is being used to obtain the specified end play.** Refer to Specifications at end of this Section.
5. Place the pump on the converter, making sure that the drive gear engages the converter hub. Rotate the pump to make sure that the gears rotate freely.

Reverse-High Clutch

Disassembly

1. Separate the drive train as shown in Fig. 38. Remove the pressure plate snap ring as shown in Fig. 39.
2. Remove the pressure plate and the drive and driven (internal and external spline) clutch plates (Fig. 40).
3. Install Clutch Spring Compressor, Tool T65L-77515-A (Fig. 41) on the reverse-high clutch drum. Make sure that the legs clear the snap ring enough to remove it. Remove the snap ring and remove the tool.

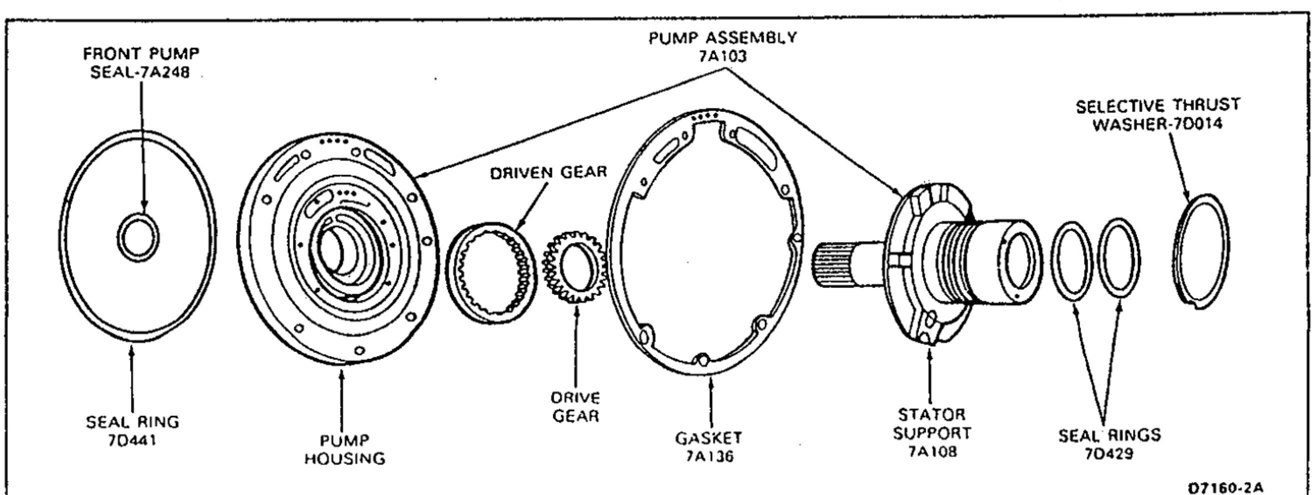


FIG. 36 Front Pump Disassembled

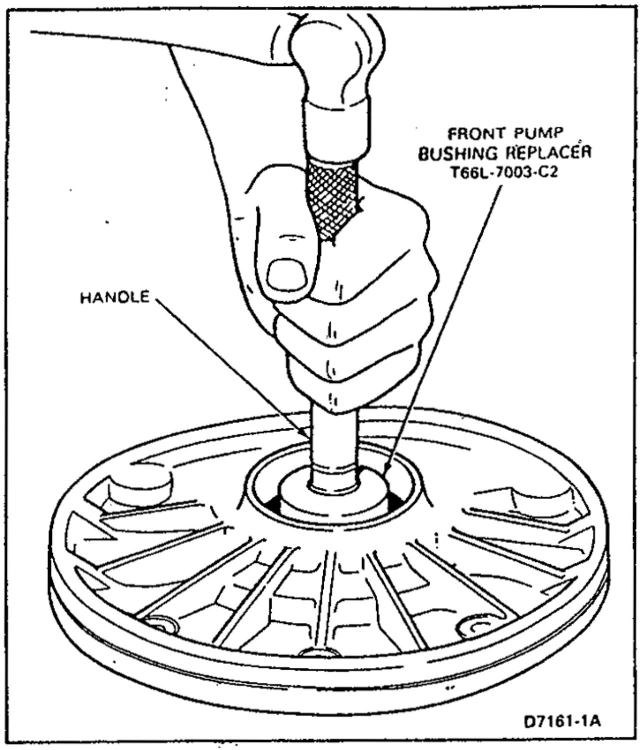


FIG. 37 Replacing Front Pump Housing Bushing

4. Remove the spring retainer and the piston return springs.
5. Apply air pressure to the piston apply hole in the clutch hub using TOOL-7000-DE or equivalent (Fig. 42) and remove the piston.
6. Remove the piston outer seal from the piston and the inner seal from the clutch drum (Fig. 40).
7. Remove the front and rear bushings from the clutch drum if they are worn or damaged. To remove the front bushing, use a cape chisel and cut along the bushing seam until the chisel breaks through the bushing wall. Pry the loose ends of the bushing up with an awl and remove the bushing. To remove the rear bushing, use Tool T69L-7D044-B or equivalent shown in Fig. 43, and press the bushing from the drum.

Assembly

1. If the clutch drum bushings were removed, position the drum in a press and press new bushings into the drum with the Tool T69L-7D044-B or equivalent shown in Figs. 43 and 44.
2. Dip the new seals in transmission fluid and install one on the drum and one on the piston.
3. Install the piston in the clutch drum.
4. Position the piston return springs in the piston sockets (Fig. 45). Place the spring retainer on the springs.
5. Install Clutch Spring Compressor, Tool T65L-77515-A (Fig. 41) and compress the springs. Make certain that the spring retainer is centered while compressing the springs. Install the snap ring. **Before releasing the pressure on the tool, make certain that the snap ring is positioned inside of the four snap ring guides on the spring retainer.**
6. Clutch plate usage varies with each model, refer to the specifications at end of this Section for the number of plates required. Dip the clutch plates in clean transmission fluid. Install the clutch plates alternately starting with a steel drive (internal) plate (Fig. 40). When new composition clutch plates are used, soak the plates in automatic transmission fluid, Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H) or equivalent, for 15 minutes before they are assembled.
7. After all clutch plates have been installed, position the pressure plate in the clutch drum. Install the pressure plate (selective) snap ring.
8. With a feeler gauge, check the clearance between the pressure plate and snap ring (Fig. 46).
9. The pressure plate should be held downward as the clearance is checked. The clearance should be 0.558-0.914mm (0.022-0.036 inch). If the clearance is not within specifications, selective thickness snap rings are available in the following thicknesses: 1.42-1.52mm (0.056-0.060 inch). 1.65-1.75mm (0.065-0.069 inch), 1.87-1.98mm (0.074-0.078 inch), 2.10-2.20mm (0.083-0.087 inch), 2.33-2.43mm (0.092-0.096 inch), 2.79-2.89mm (0.110-0.114 inch) and 3.25-3.35mm (0.128-0.132 inch). Install the correct size snap ring and re-check the clearance.

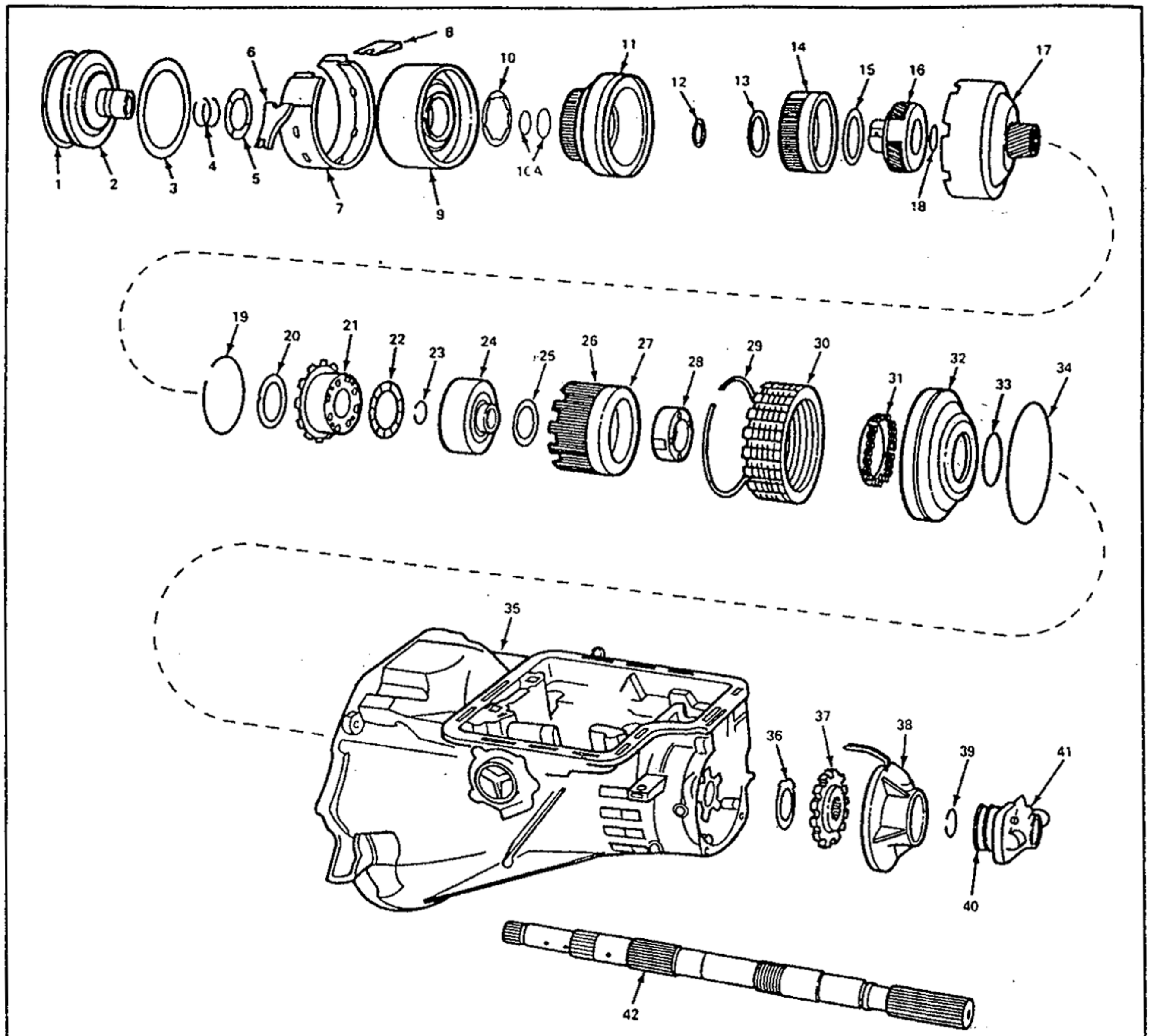
Forward Clutch

Disassembly

1. Remove the clutch pressure plate snap ring (Fig 47).
2. Remove the rear pressure plate, the drive and driven plates, wave plate, and the forward pressure plate from the clutch hub (Fig. 48).
3. Remove the snap ring (Fig. 49) that secures the disc spring in the clutch cylinder. Remove the disc spring and steel ring using Tool T65L-77515-A.
4. Apply air pressure to the clutch cylinder using TOOL-7000-DE or equivalent (Fig. 50) to remove the piston.
5. Remove the seal from the piston and the seal from the clutch hub (Fig. 48).

Assembly

1. Dip two new seals in transmission fluid, Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H) or equivalent. Install the smaller seal on the clutch hub and the lip seal on the clutch piston.
2. Install the clutch piston and lip seal with Lip Seal Protector, T77L-77548-A, (Fig. 51).
3. Position the installation tool into the forward clutch cylinder, so that the bore of the tool is aligned with the piston bore in the cylinder. Press the piston into the cylinder until it bottoms in the bore. Remove the installation tool.
4. Make sure that the steel pressure ring is in the groove on the piston. **Position the disc spring in the cylinder with the dished face downward.** Install the spring as shown in Fig. 49 so that the



1. FRONT PUMP SEAL RING-7D441
2. FRONT PUMP-7A103
3. GASKET-7A136
4. SEAL RINGS
5. NUMBER 1 THRUST WASHER (SELECTIVE)
6. STRUT INTERMEDIATE BRAKE BAND-7D029
7. INTERMEDIATE BRAKE BAND ASSEMBLY-7D029
8. STRUT INTERMEDIATE BRAKE BAND ANCHOR-7D430
9. REVERSE-HIGH CLUTCH ASSEMBLY
10. NUMBER 2 THRUST WASHER
10A. FORWARD CLUTCH SEAL RINGS
11. FORWARD CLUTCH ASSEMBLY
12. NUMBER 3 THRUST WASHER NEEDLE BEARING
13. NUMBER 4 THRUST WASHER
14. FORWARD PLANET RING AND HUB ASSEMBLY-7D392
15. NUMBER 5 THRUST WASHER
16. FORWARD PLANET ASSEMBLY 7A298
17. INPUT SHELL-7D064 AND SUN GEAR ASSEMBLY-7D063
18. NUMBER 6 THRUST WASHER NEEDLE BEARING
19. SNAP RING
20. NUMBER 7 THRUST WASHER
21. REVERSE PLANET ASSEMBLY 7D006
22. NUMBER 8 THRUST WASHER
23. REVERSE RING GEAR AND HUB RETAINING RING
24. REVERSE RING GEAR-7A153 AND HUB-7D164
25. NUMBER 9 THRUST WASHER
26. LOW-REVERSE CLUTCH HUB 7B067
27. ONE-WAY CLUTCH-7A089
28. ONE-WAY CLUTCH INNER RACE 7D171
29. SNAP RING
30. LOW-REVERSE CLUTCH PLATES
31. LOW-REVERSE PISTON RETURN SPRING AND RETAINER-7D406
32. LOW-REVERSE PISTON-7D402
33. INNER SEAL
34. OUTER SEAL
35. CASE-7005
36. NUMBER 10 THRUST WASHER
37. PARKING GEAR-7A223
38. GOVERNOR DISTRIBUTOR SLEEVE-7C232
39. SNAP RING
40. GOVERNOR COLLECTOR-7D220
41. GOVERNOR-7C063
42. OUTPUT SHAFT-7060

D3138-2C

FIG. 38 Drive Train Disassembled—Typical pressure ring and spring are in contact. Secure the disc with the retaining snap ring.

5. Install the forward pressure plate with the flat side up and the beveled side downward. Dip the clutch plates in clean transmission fluid (Specification Motorcraft MERCON® Multi-Purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H) or equivalent). Next, install the wave plate, then a steel plate and a composition driven plate. Install the remaining plates in this sequence (Fig. 48).

Refer to the Specification at end of this Section for the number of plates required. The last plate installed will be the rear pressure plate. Install the snap ring and make certain that it seats fully in the groove.

6. With a feeler gauge, check the clearance between the snap ring and the pressure plate (Fig. 52). Downward pressure on the plate should be maintained when making this check. Clearance should be 0.533-1.168mm (0.021-0.046 inch).

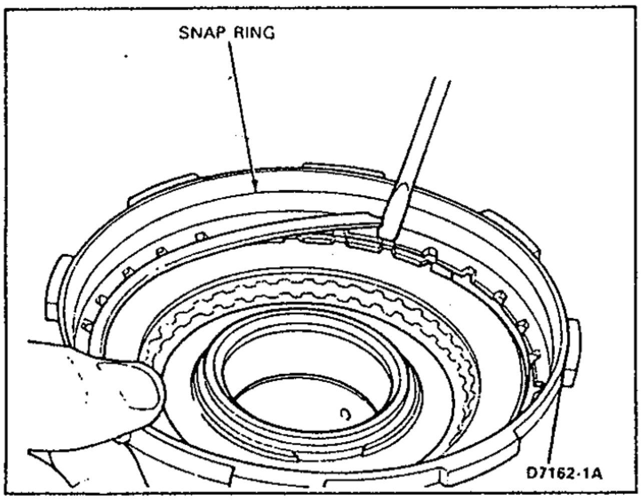


FIG. 39 Removing or Installing Reverse-High Clutch Pressure Plate Snap Ring

7. If the clearance is not within specifications, selective snap rings are available in the following thicknesses: 1.42-1.52mm (0.056-0.060 inch), 1.65-1.75mm (0.065-0.069 inch), 1.87-1.98mm (0.074-0.078 inch), 2.10-2.20mm (0.083-0.087 inch), 2.33-2.43mm (0.092-0.096 inch), 2.79-2,89mm (0.110-0.114 inch) and 3.25-3.35mm (0.128-0.132 inch). Insert the correct size snap ring and recheck the clearance.

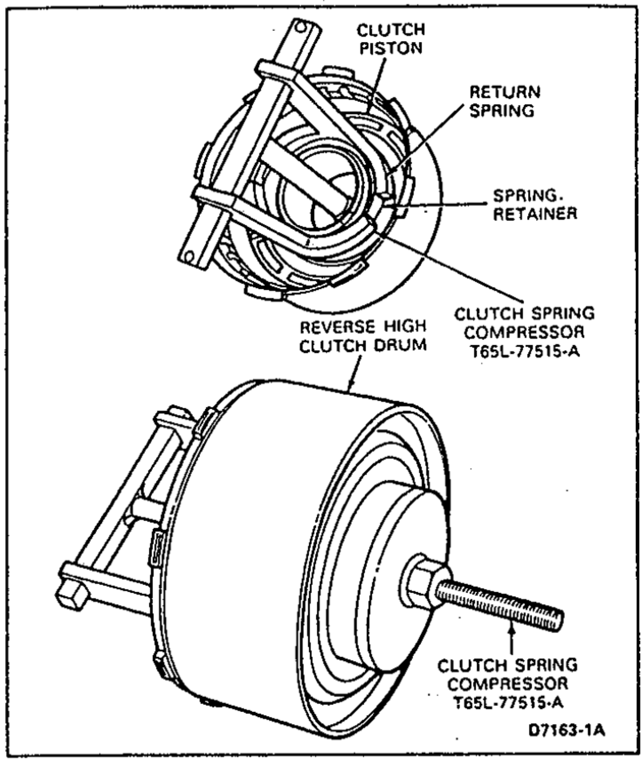


FIG. 41 Removing or Installing Reverse—High Clutch Piston Snap Ring

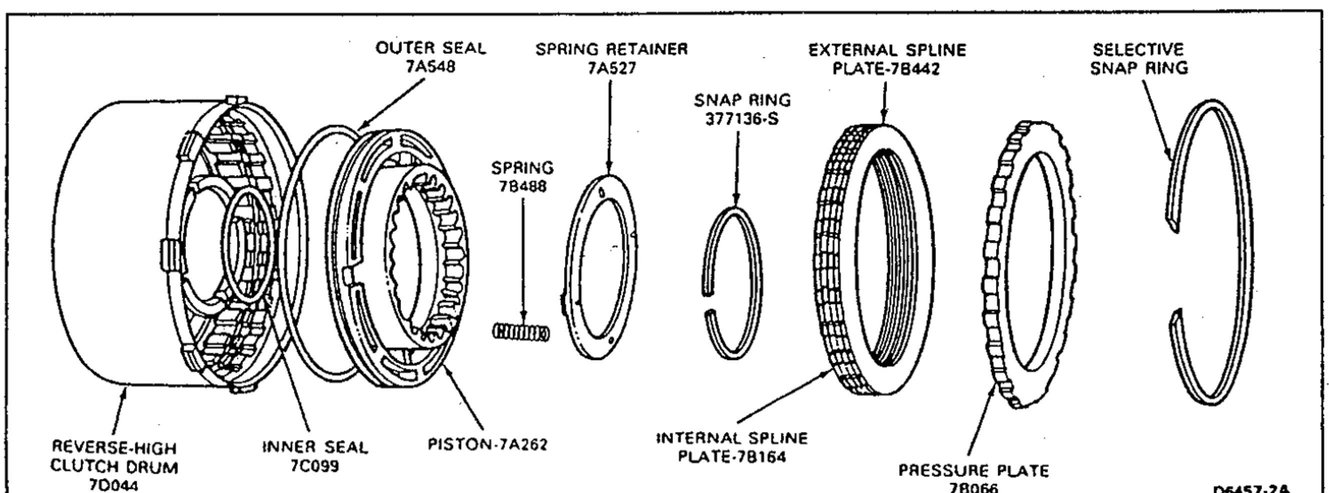


FIG. 40 Reverse-High Clutch Disassembled

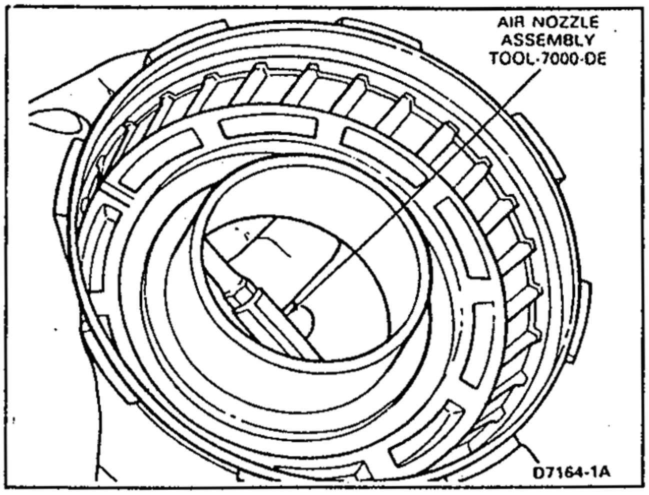


FIG. 42 Removing Reverse-High Clutch Piston

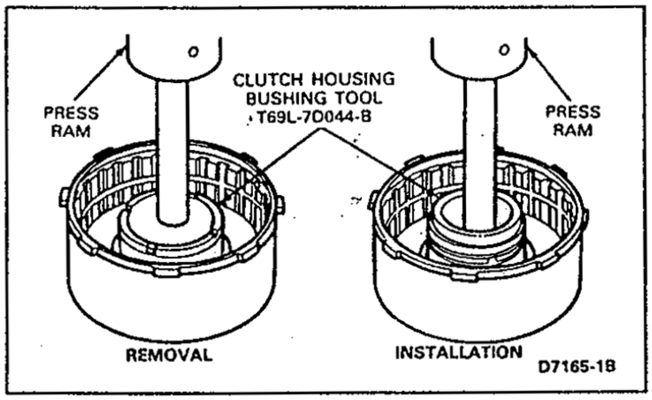


FIG. 43 Replacing Reverse-High Clutch Rear Bushing

Input Shell and Sun Gear

Disassembly

1. Remove the rear snap ring from the sun gear as shown in Fig. 53.
2. Remove the thrust washer wear plate from the input shell and sun gear (Fig. 54).
3. Working from inside the input shell remove the sun gear. Remove the snap ring from the gear.

Assembly

1. Install the forward snap ring on the forward end (short end) of the sun gear (Fig. 54). Working from inside the input shell, slide the sun gear and snap ring into place making sure that the longer end is at the rear (Fig. 54).
2. Place the thrust washer wear plate on the sun gear and install the rear snap ring.

Output Shaft Hub and Ring Gear

Disassembly

1. Remove the hub snap ring (Fig. 55) from the ring gear.
2. Lift the hub from the ring gear.

Assembly

1. Position the hub in the ring gear.

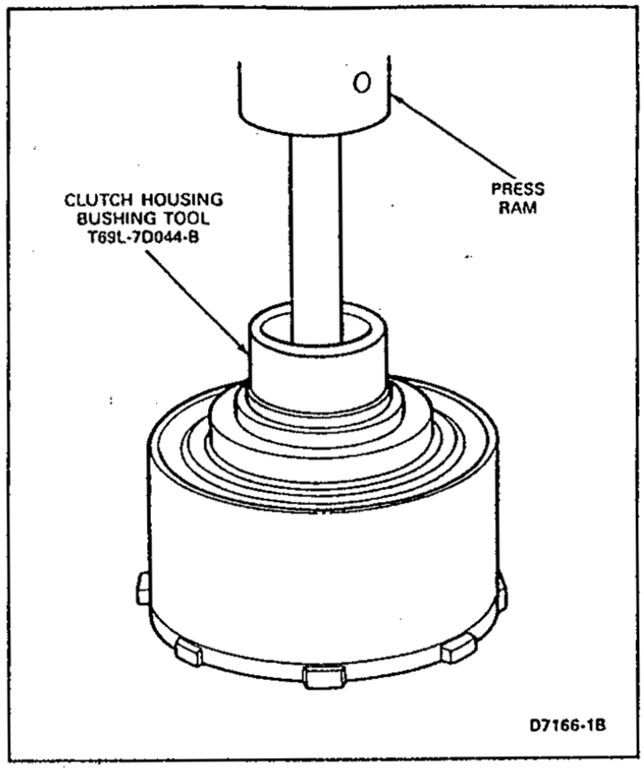


FIG. 44 Installing Reverse-High Clutch Front Bushing

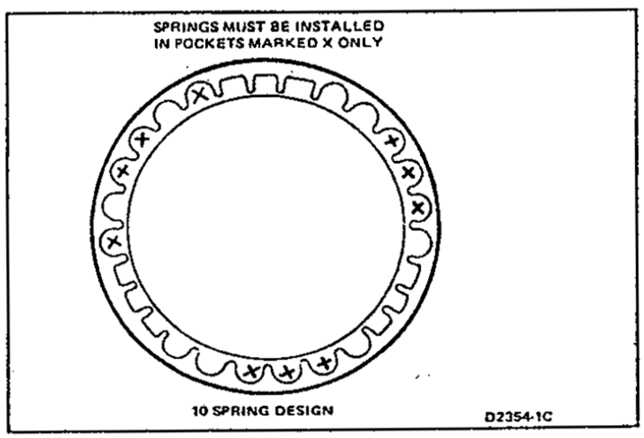


FIG. 45 Reverse-High Clutch Piston Return Spring Locations

2. Secure the hub with the snap ring. Make certain that the snap ring is fully engaged with the groove.

One-Way Clutch

Disassembly

1. Remove the snap ring and bushing from the rear of the low-reverse clutch hub (Fig. 56).
2. Remove the rollers from the spring assembly and lift the spring assembly from the hub.
3. Remove the remaining snap ring from the hub.

Assembly

1. Install a snap ring in the forward snap ring groove of the low-reverse clutch hub.

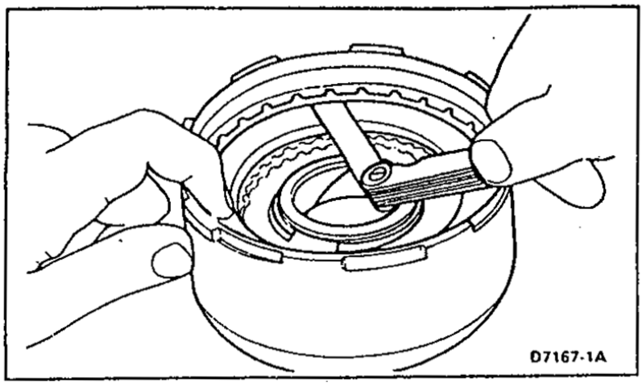


FIG. 46 Checking Reverse-High Clutch Snap Ring Clearance

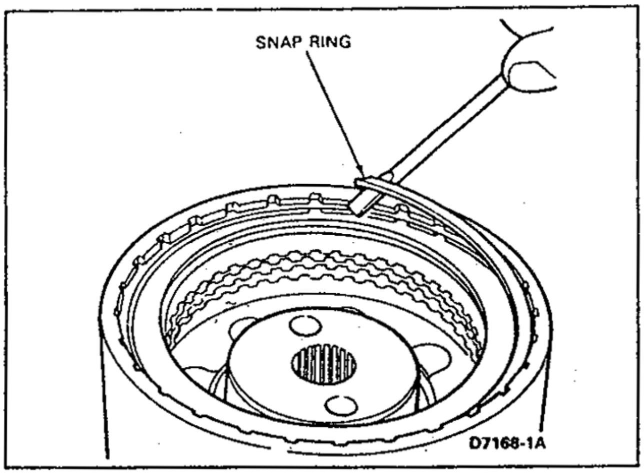


FIG. 47 Removing Forward Clutch Pressure Plate Snap Ring

2. Place the low-reverse clutch hub on the bench with the forward end down (Fig. 57).
3. Install the one-way clutch spring assembly on top of the snap ring.
4. Install a roller into each of the spring assembly compartments (Fig. 56).
5. Install the bushing on top of the spring assembly.
6. Install the remaining snap ring at the rear of the low-reverse clutch hub to secure the assembly (Fig. 56).

Low-Reverse Clutch Piston

Disassembly

1. Remove the inner and the outer seal from the low-reverse clutch piston (Fig. 38).

Assembly

1. Dip the two new seals in clean transmission fluid, Motorcraft MERCON® Multi-purpose Automatic Transmission Fluid XT-2-QDX or DDX (ESP-M2C166-H) or equivalent.
2. Install the seals on the piston.

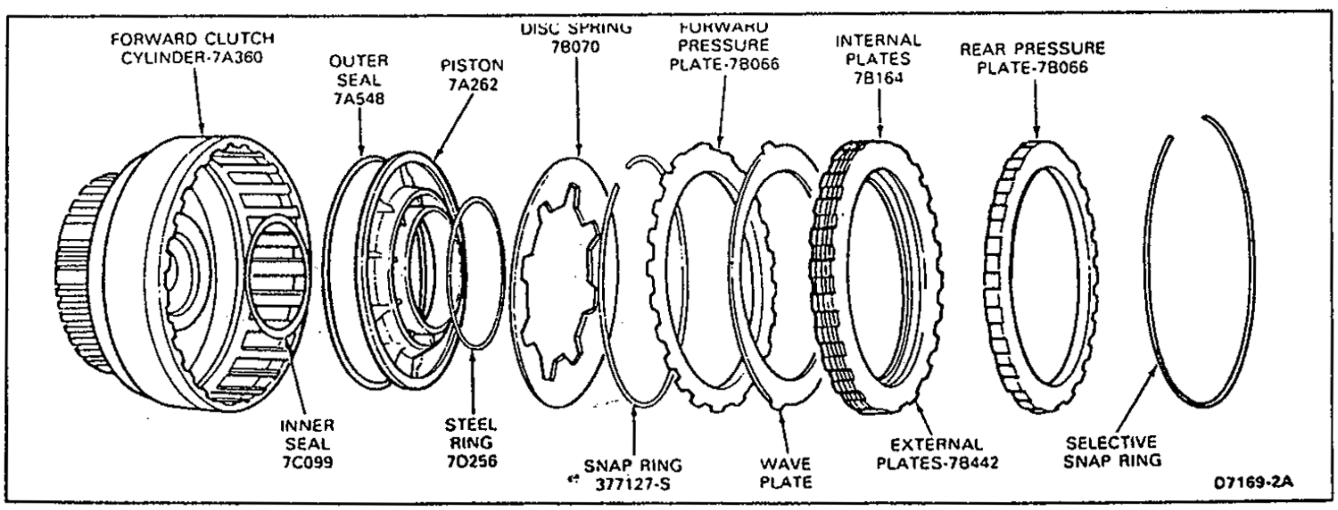


FIG. 48 Forward Clutch Disassembled

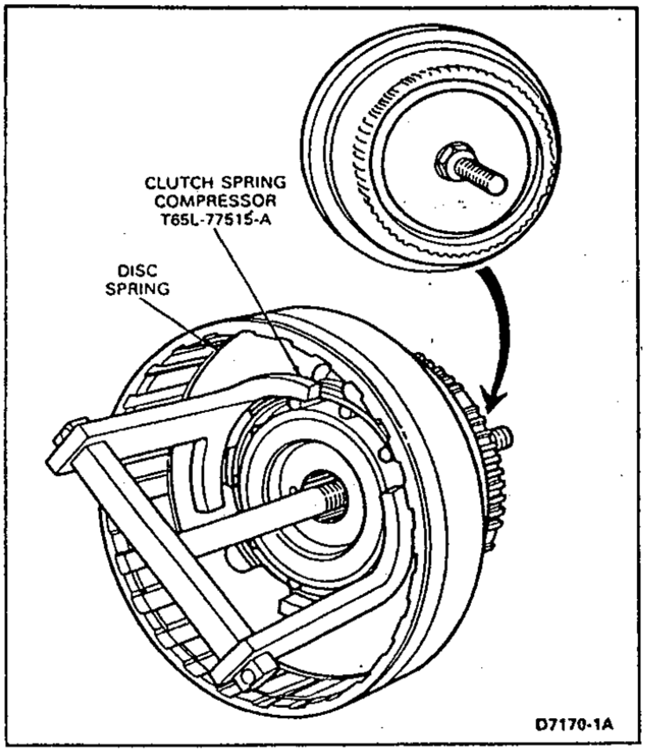


FIG. 49 Removing or Installing Disc Spring

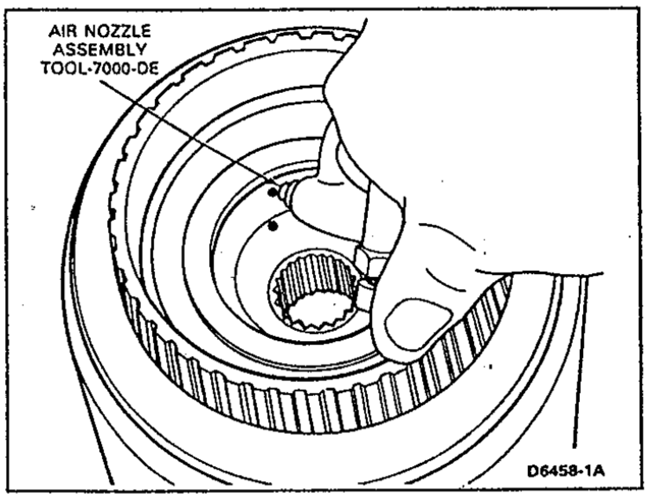


FIG. 50 Removing Forward Clutch Piston

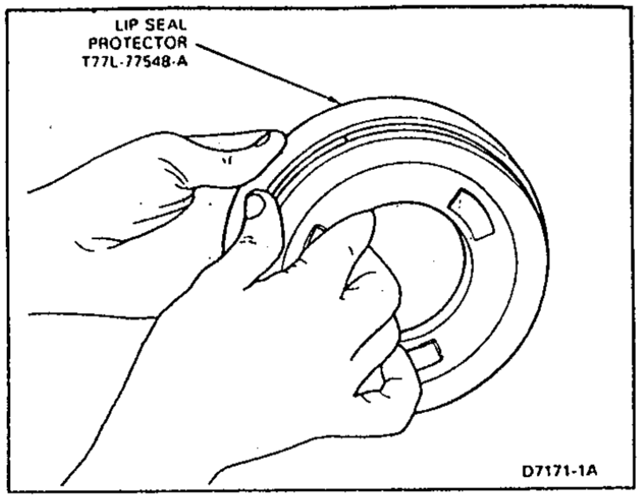


FIG. 51 Installing Forward Clutch Piston and Lip Seal

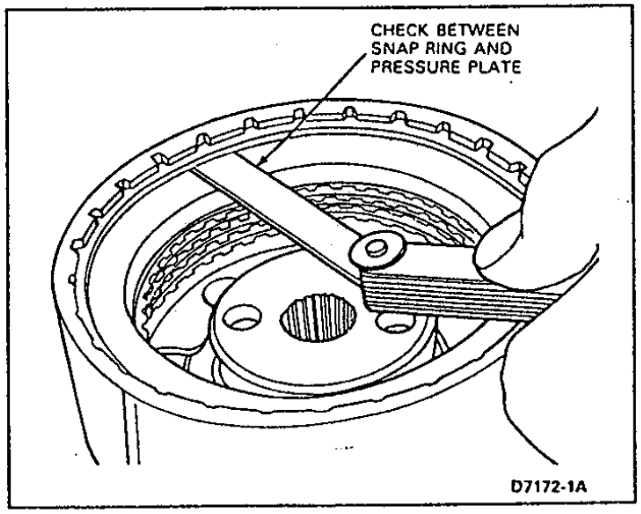


FIG. 52 Checking Forward Clutch Clearance

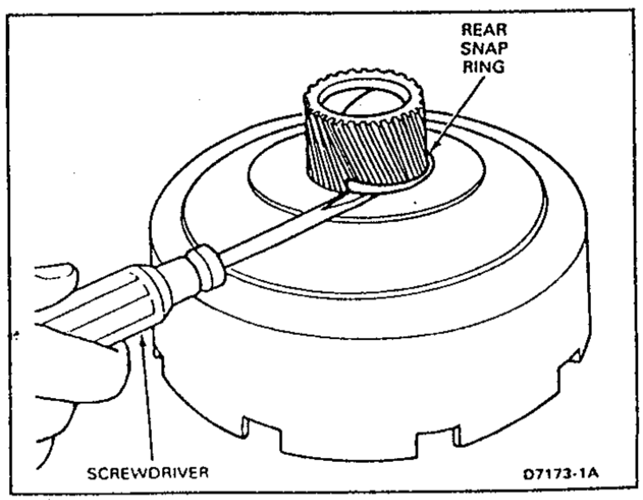


FIG. 53 Removing Sun Gear Snap Ring

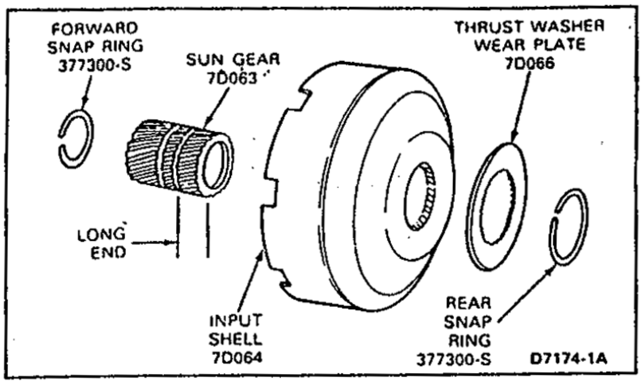


FIG. 54 Input Shell and Sun Gear Disassembled

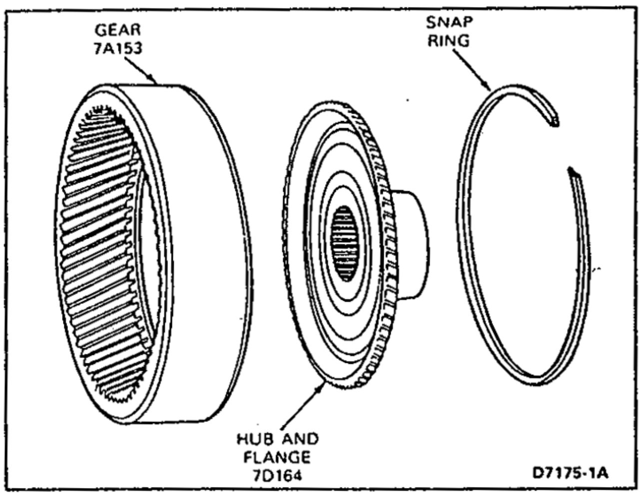


FIG. 55 Output Shaft Hub and Ring Gear

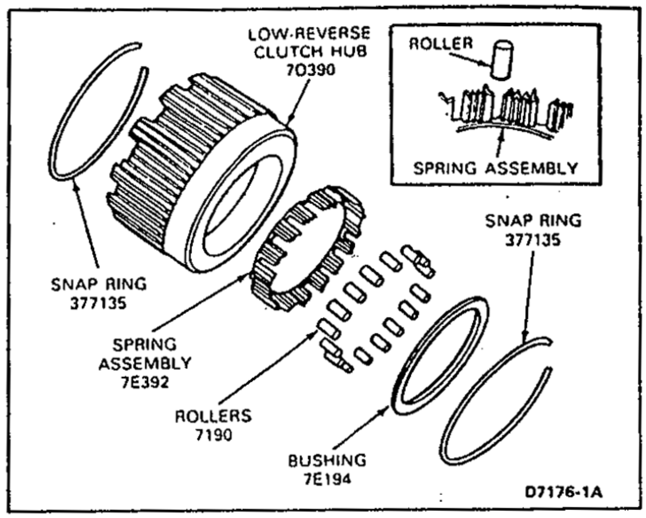


FIG. 56 One-Way Clutch Disassembled

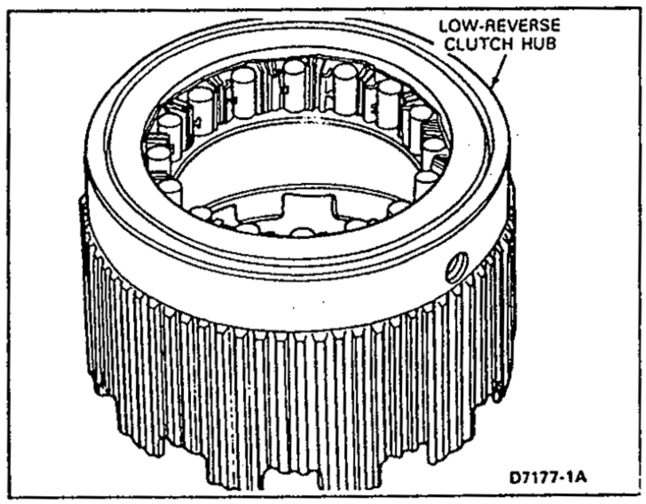


FIG. 57 One-Way Clutch Installed

SPECIFICATIONS

C6 — TRANSMISSION REFILL CAPACITY

Vehicle	U.S. Quarts	Capacity Imperial Quarts	Liters
	11-3/4	9.4	11.2
	13-1/2	10.8	12.7

SELECTIVE THRUST WASHERS (FRONT PUMP SUPPORT)

Identification Color	Thickness	
	MM	Inch
Blue	1.42-1.52	0.056-0.060
Natural (White)	1.85-1.95	0.073-0.077
Red	2.23-2.33	0.088-0.092

TRANSMISSION CLUTCH PLATE USAGE

Transmission Model	Steel	Friction	Clearance	
			MM	Inch
Forward Clutch				
PGD, PJD	4①	4	0.533-1.168	0.021-0.046
High Clutch				
PGD, PJD	3	3	0.558-0.914	0.022-0.036
Reverse Clutch				
PJD	5②	5	—	—
PGD	4②	4	—	—

①Plus a waved plate (7E457) next to inner pressure plate.
②Plus a waved plate next to the piston.

CLUTCH SNAP RINGS

Part Number	Thickness		Forward	High
	MM	Inch		
377434	1.52-1.42	0.060-0.056	X	X
377126	1.75-1.62	0.069-0.064		X
377127	1.98-1.87	0.078-0.074	X	X
377128	2.20-2.10	0.087-0.083		X
377444	2.43-2.33	0.096-0.092	X	X
386841	2.89-2.79	0.114-0.110	X	
386842	3.35-3.25	0.132-0.128	X	

CHECKS AND ADJUSTMENTS

Operation	Specification
Transmission End Play	0.203-1.117 mm. (0.008-0.044 inch) (Selective Thrust Washers Available)
Torque Converter End Play	New or rebuilt 0.533 mm. (0.021 inch) max. Used 1.016 mm. (0.040 inch) max. ①
Intermediate Band Adjustment	Remove and discard locknut. Install new locknut. Adjust screw to 14 N•m (10 ft-lbs) torque, then back off 1-1/2 turns. Hold screw and tighten locknut to 54 N•m (40 ft-lbs)
Forward Clutch Pressure Plate-to-Snap Ring Clearance	0.533-1.168 mm. (0.021-0.046 inch)

Operation	Specification
Selection Snap Ring Thickness	1.42-1.52 mm. (0.056-0.060 inch) 1.62-1.75 mm. (0.064-0.069 inch) 1.87-1.98 mm. (0.074-0.078 inch) 2.10-2.20 mm. (0.083-0.087 inch) 2.33-2.43 mm. (0.092-0.096 inch) 2.79-2.89 mm. (0.110-0.114) 3.25-3.35 mm. (0.128-0.132 inch)
Reverse-High Clutch Pressure Plate-to-Snap Ring Clearance	0.558-0.914 mm. (0.022-0.036 inch)
Selective Snap Ring Thickness	1.42-1.52 mm. (0.056-0.060 inch) 1.62-1.75 mm. (0.064-0.069 inch) 1.87-1.98 mm. (0.074-0.078 inch) 2.10-2.20 mm. (0.083-0.087 inch) 2.33-2.43 mm. (0.092-0.097 inch)

①To check end play, exert force on checking tool to compress turbine to cover thrust washer wear plate. Set indicator at zero.

CD2845-2J

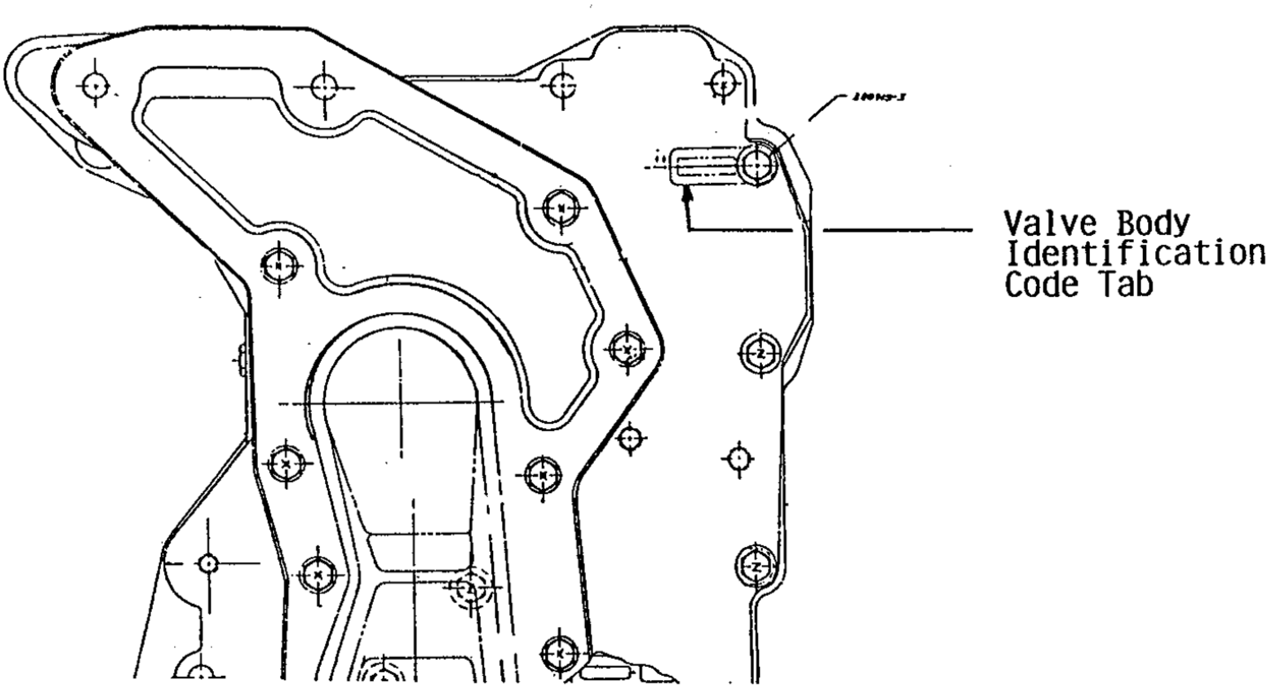


Figure 58 - Valve Body Identification

Valve Body Identification Codes

2 Speed		3 Speed	
MD	MP	LN	LZ
ME	MS	LM	MA
MG	MT	LP	MB
MF	MU	LT	MC
MH	MV	LU	M3
MJ	MW	LY	
MK	MX		
ML	MY		
MM			

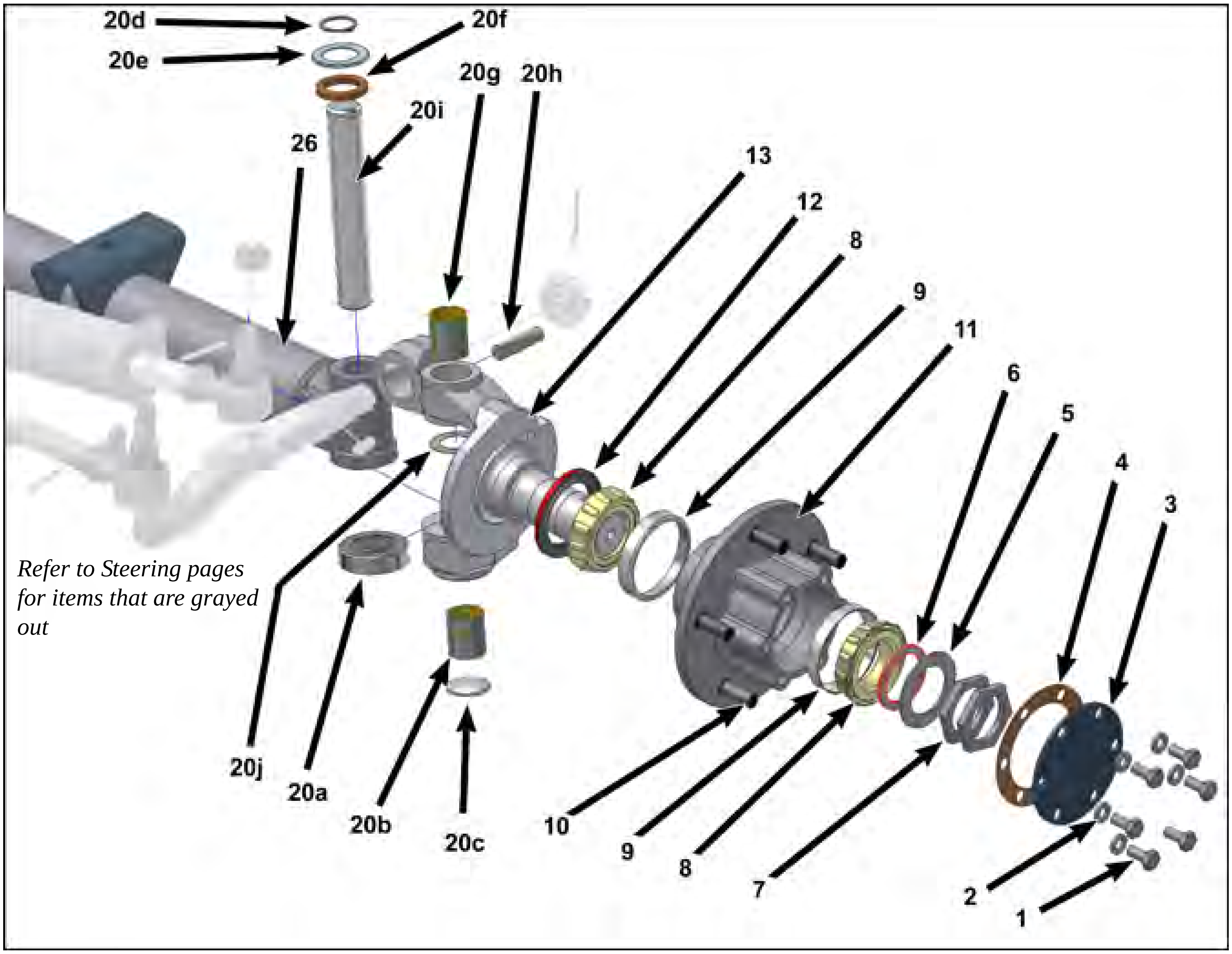
Chapter - 4

Illustrated Parts

TABLE OF CONTENTS

Model TC-030-60, FedEx Specification Only

Axle Assembly, Front

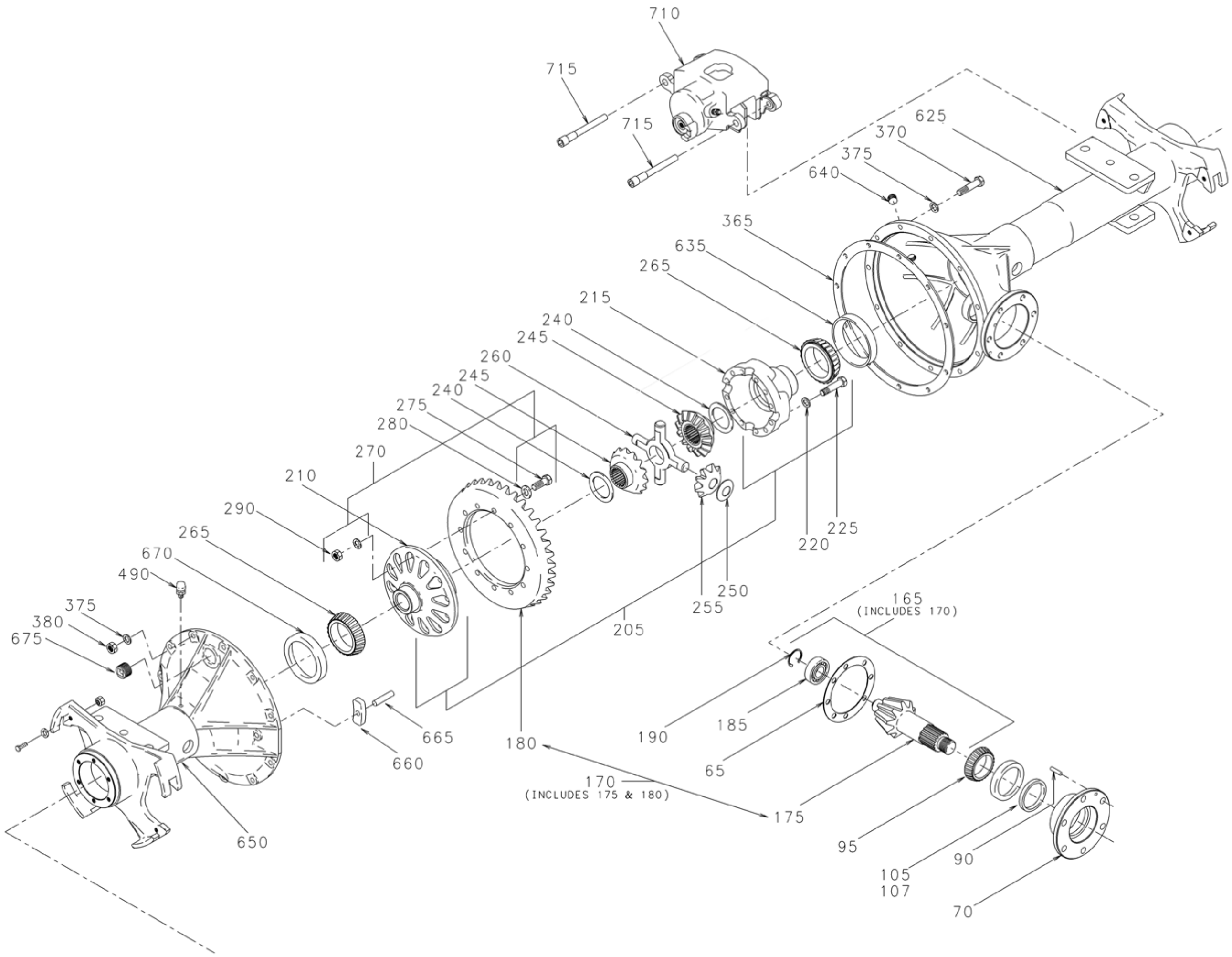


Axle Assembly, Front

Item No.	Part No.	Description	Qty
1	88-401-46	Bolt	12
2	88-401-96	Washer	12
3	500845	Hub Cap	2
4	500844	Gasket	2
5	500841	Washer	2
6	500843	Washer	2
7	500842	Nut	4
8	500849	Bearing	4
9	500850	Race	4
10	500898	Wheel Stud	10
11	500846	Hub	2
12	500851	Seal	2
13	501042 501041	Knuckle, Right Knuckle, Left	1 1
20	500857	Kit, King Pin (left and right)	1
26	14-900-14	Axle Beam	1
-	500571	Grease Fitting, King Pin Bushing	4
-	A10621	Shim, King Pin	-

** Not available at time of printing*

Axle Assembly, Rear Secondary Gears



Axle Assembly, Rear Secondary Gears

Item No.	Part No.	Description	Qty
	504595	Complete Axle Assembly	1
65	A10641	Gasket	1
70	A11451	Bearing cage assembly	1
90	A11432	Roll pin	1
95	A10182	Inner cone bearing	1
105	A11472	Shim pac	0
165	A11484	Pinion gear assembly	1
170	A11485	Ring and Pinion gear	1
180	A11487	Pinion gear	1
185	A11488	Bearing	1
190	A11489	Lock ring	1
205	A11452	Differential housing assembly	1
210	A11490	Differential flange	1
215	A11491	Differential housing	1
220	A10163	Washer	8
225	A10162	Cap screw	8
240	TIG-2001-119	Thrust washer	2

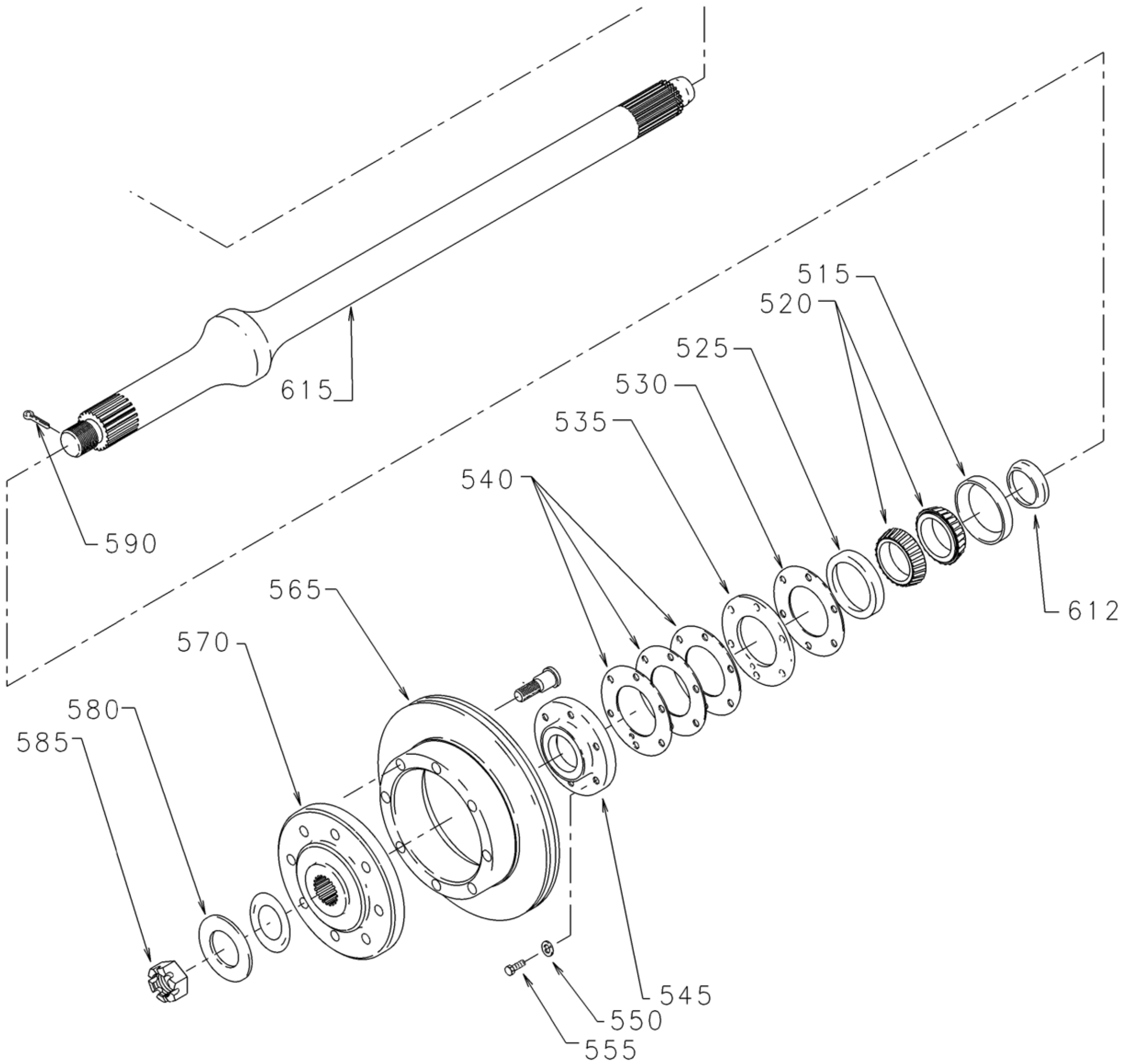
Axle Assembly, Rear Secondary Gears (cont'd)

Item No.	Part No.	Description	Qty
245	TIG-2001-121	Axle gear	2
250	TIG-2001-127	WASHER, PINION THRUST	4
255	A10164	Differential gear	4
260	TIG-2001-123	Differential spider	1
265	A10167	Bearing	2
270	TIG-2001-291	Hardware kit	1
275	A11427	Cap screw	12
280	A10174	Washer	12
290	A10384	Nut	12
365	TIG-2001-157	Gasket	1
370	A11468	Cap screw	11
375	A10174	Washer	11
380	A10384	Nut	11
490	A10178	Breather	1
625	A11495	Housing	1
635	A10166	Bearing Race	1
640	A10179	Plug	1
650	A11496	Housing	1
660	A10193	Thrust block	1
665	TIG-2001-263	Pin	1
670	A10166	Bearing race	1
675	A11429	Plug, magnetic	1
710	See rear brakes	Brake assembly	4
715	A11498	Pin, sliding	8

Axle Assembly

	504595	Complete assembly as pictured below

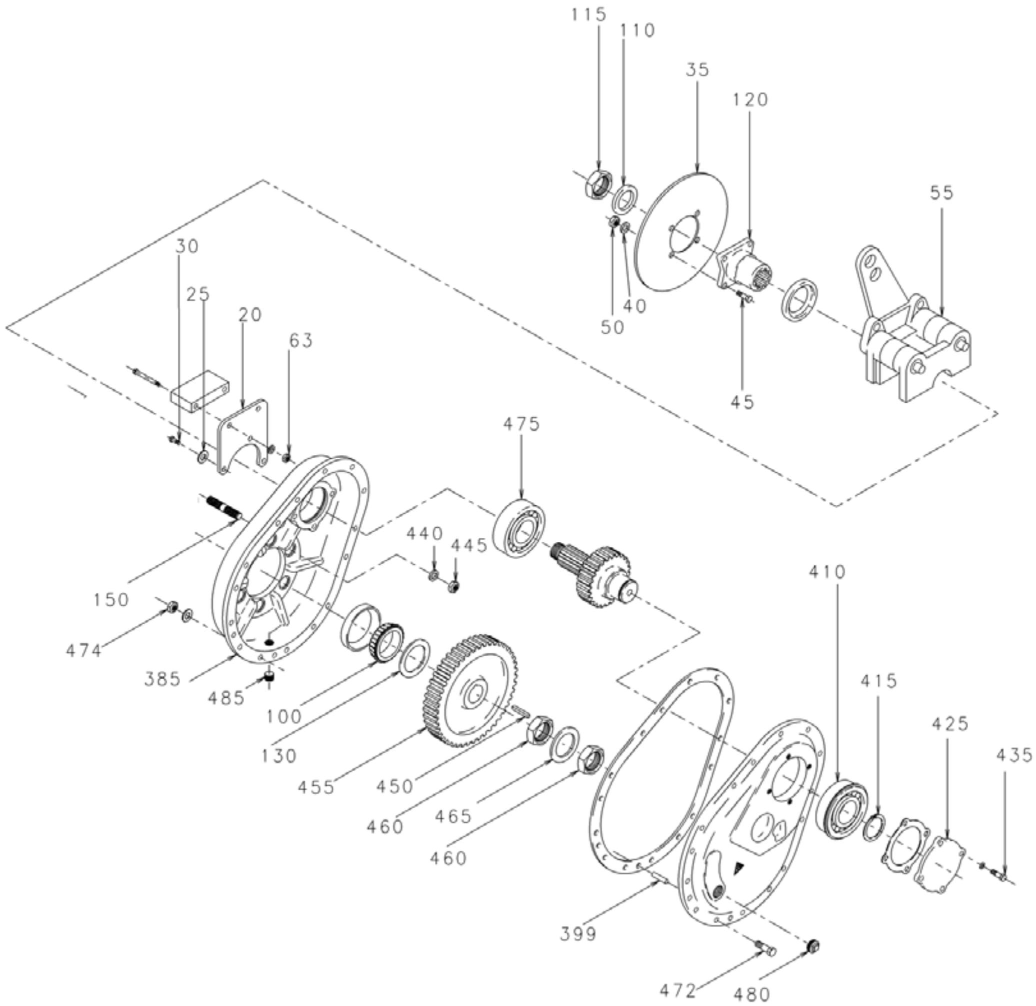
Axle Assembly, Rear Axles



Axle Assembly, Rear Axles

Item No.	Part No.	Description	Qty
515	A11418	Bearing race	1
520	TIG-2001-169	Bearing	2
525	A11418	Bearing race	1
530	TIG-2001-175	Gasket	1
535	A11425	Spacer	1
540	A11434	Shim, 0.003	5
	A11436	Shim, 0.005 (package of 10)	4
	A11437	Shim, 0.010 (package of 5)	3
545	A11454	Seal	1
550	401602	Washer	6
555	A11469	Cap screw	6
565	404217NS	Brake rotor	2
570	A11492	Hub	2
580	TIG-2001-187	Washer	2
585	TIG-2001-189	Nut	2
590	A11462	Cotter	2
612	A11493	Collar	1
615	A11494	Shaft assembly	1

Axle Assembly, Rear Primary Gears



Axle Assembly, Rear Primary Gears

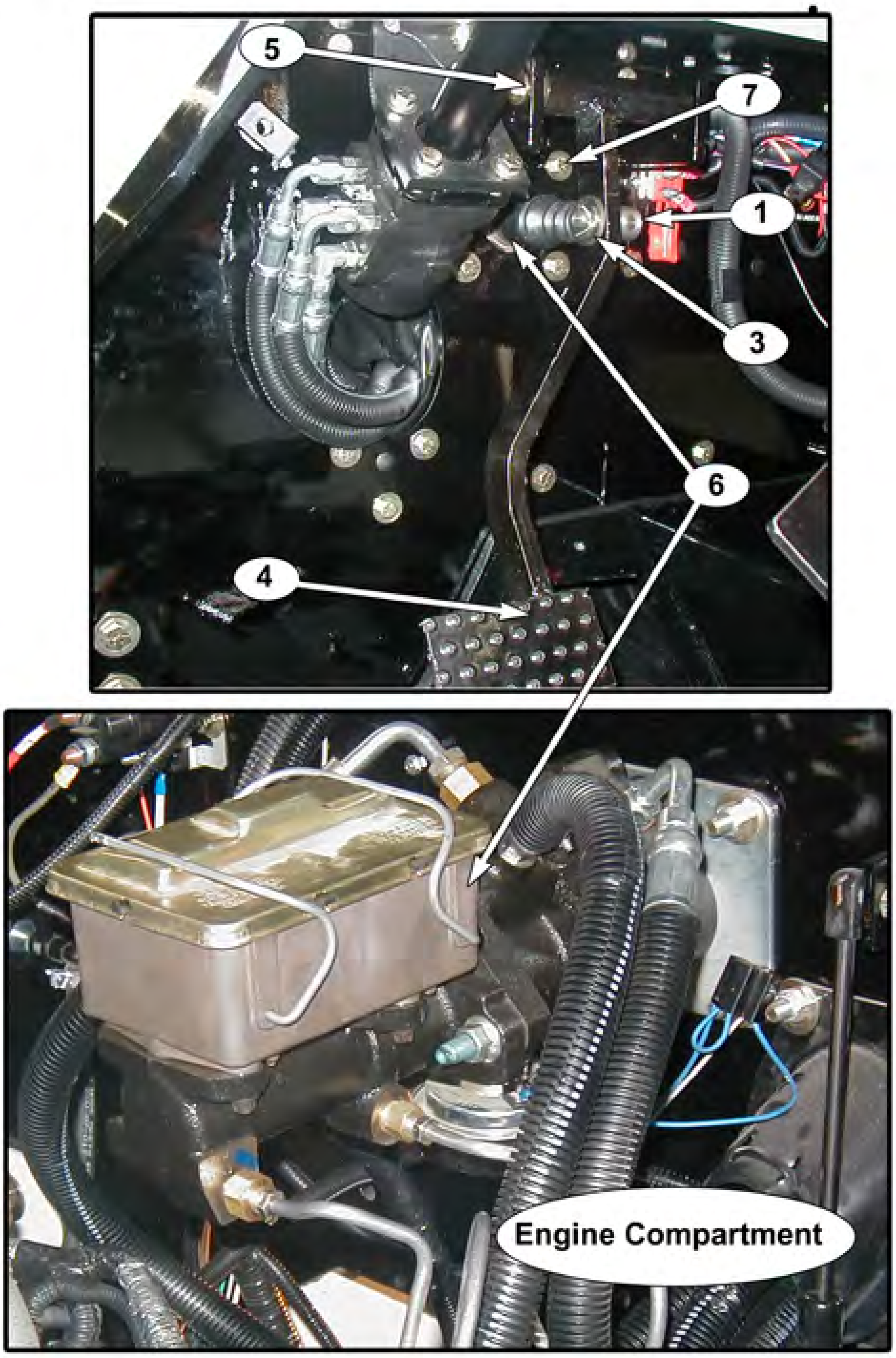
Item No.	Part No.	Description	Qty
20	A11479	Brake adaptor	1
25	88-401-95	Washer	3
30	A11471	Cap screw	3
35	A11480	Brake disc	1
40	A10165	Washer	4
45	A11467	Cap screw	4
50	A11481	Nut	4
55	A11482	Brake assembly	1
63	A11483	Lock nut	2
100	A10182	Bearing	1
110	TIG-2001-231	Washer	1
115	A11421	Nut	1
120	TIG-2001-233	Flange	1
130	34475	Washer	1
150	A11450	Stud	6
385	A10642	Gear case assembly	1

Axle Assembly, Rear Primary Gears (cont'd)

Item No.	Part No.	Description	Qty
399	TIG-2001-263	Dowel	
410	A11423	Bearing	
415	A11430	Snap ring	1
425	A11445	Bearing cap	1
435	A11471	Cap screw	6
440	TIG-2001-217	Washer	6
445	401577	Nut	6
450	A11428	Key	2
455	TIG-2001-323	Gear	1
460	A10189	Nut	2
465	A10190	Locking washer	1
472	A11467	Cap screw	15
474	A11465	Nut	15
475	A11422	Bearing	1
480	A11466	Plug	1

** Not available at time of printing*

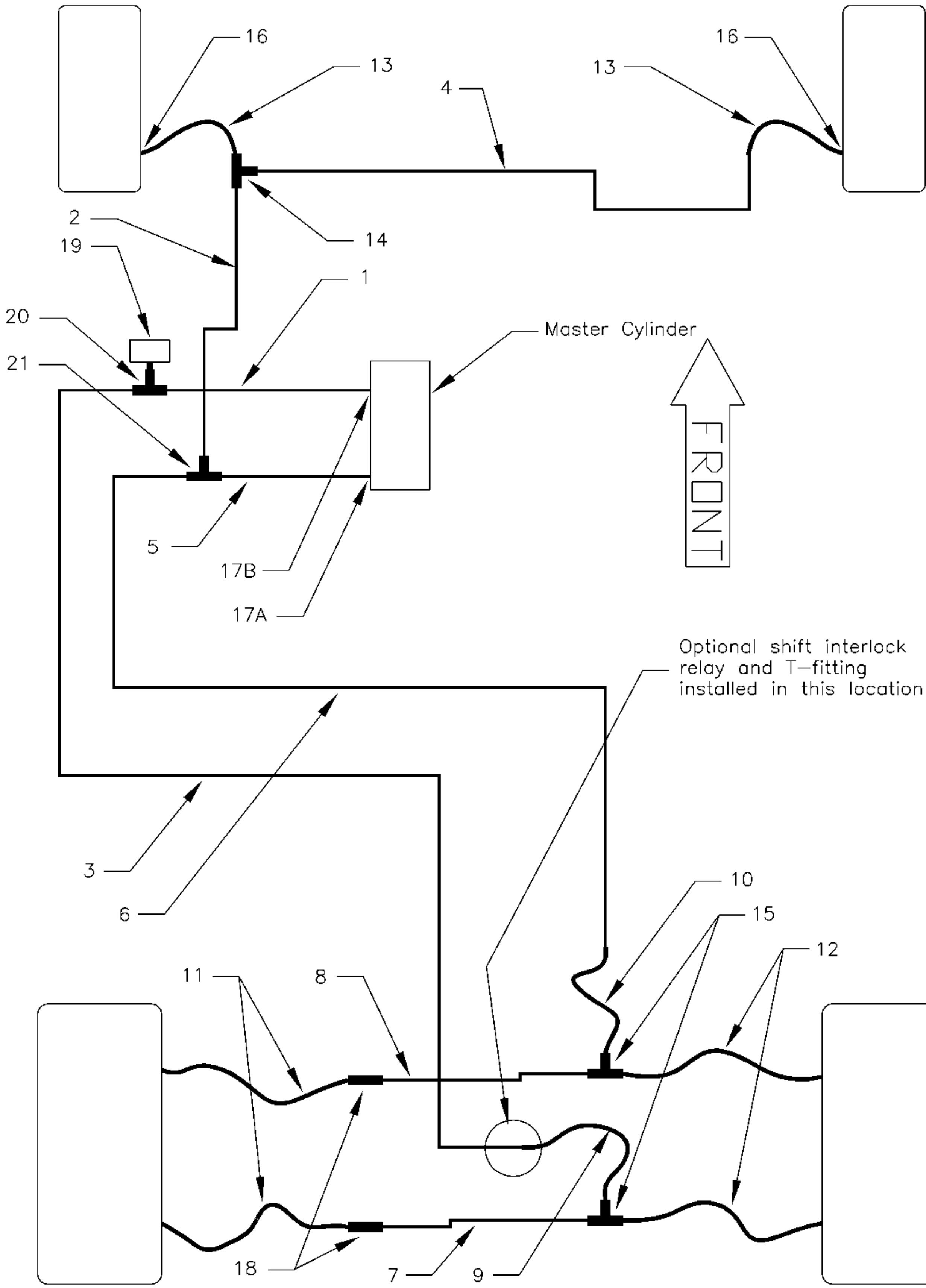
Brakes, Brake Pedal Linkage



Brake Pedal Linkage

Item No.	Part No.	Description	Qty
1	503249	Pivot, Push Rod	1
	88-402-84	Jam Nut	1
2	-	-	-
3	88-402-85	Washer, Push Rod Pivot	2
	500563	Cotter Pin	1
4	502855	Brake Pedal, includes bushings	1
5	500185	Bolt, Pedal Pivot	1
	88-401-80	Nut	1
	503191	Bushing	2
	88-402-85	Washer, 1/2, Spacer	1
	88-401-95	Washer, 3/8	1
6	505502	Hydroboost Assembly	1
7	88-401-48	Bolt	4
	88-401-95	Washer	8
	88-401-80	Nut	4

Brakes, Brake Lines



Brake Lines

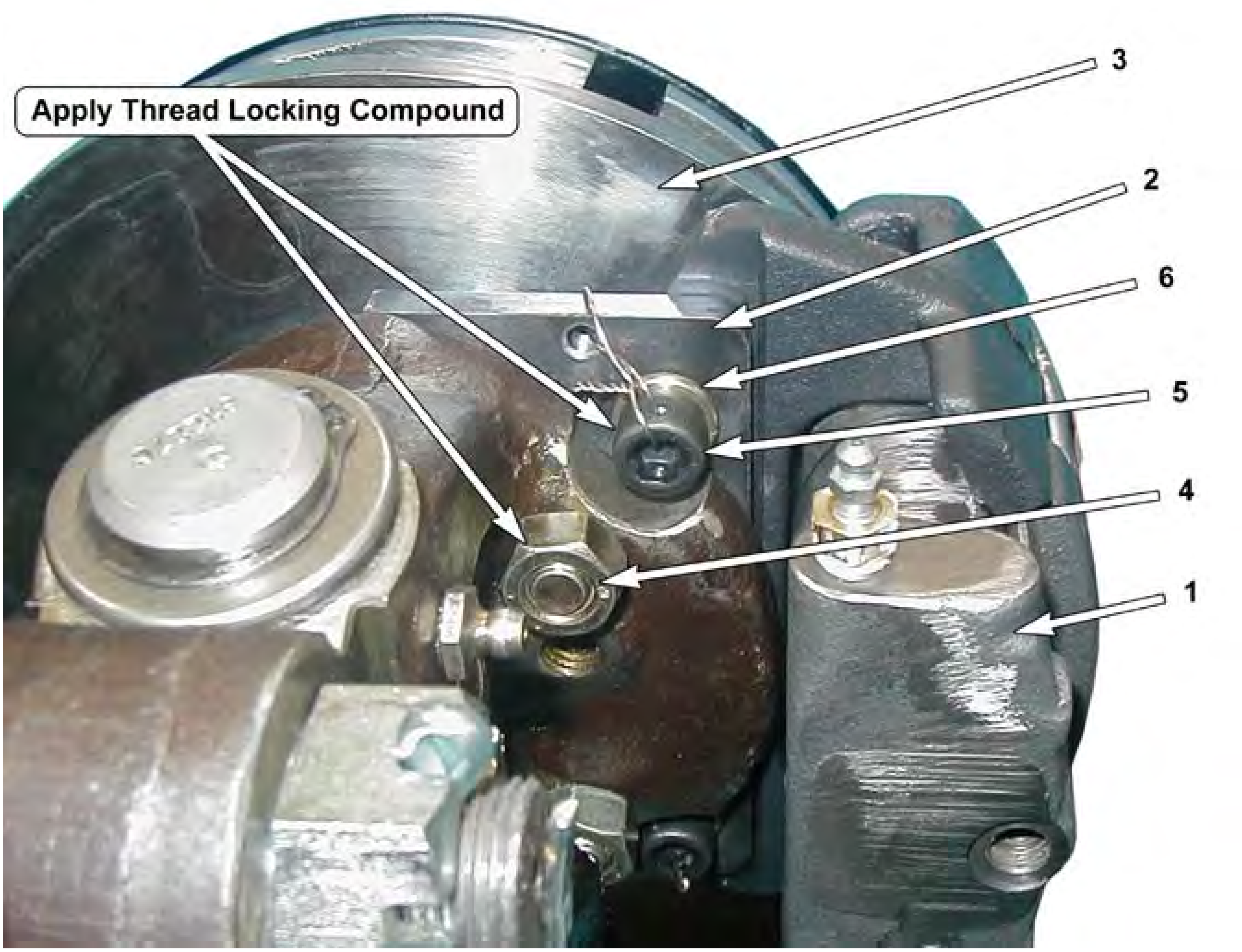
Item No.	Part No.	Description	Qty
1	500591	Brake Line, Master Cylinder (front port) to Front T Fitting	1
2	503206	Brake Line, T to Left Front Brake Hose	1
3	500148A	Brake Line, T to Rear Axle (rear calipers)	1
4	503207	Brake Line, Front Left Hose to Front Right Hose	1
5	500591	Brake Line, Master Cylinder (rear port) to T fitting	1
6	500147	Brake Line, T to Rear Axle (front calipers)	1
7	500146	Brake Line, Rear Axle Rear Calipers	1
8	500145	Brake Line, Rear Axle Front Calipers	1
9	504592	Brake Hose, Brake Line to Rear Axle Rear Calipers	1
10	504592	Brake Hose, Brake Line to Rear Axle Front Calipers	1
11	504590 500576	Brake Hose, Rear Left Caliper Copper washer	2 2
12	504590 500576	Brake Hose, Rear Right Caliper Copper washer	2 2
13	504592	Brake Hose, Front	2
14	502518	Brake Fitting, Front T	1
15	98-515-92	Brake Fitting, Rear T, W / Mounting bracket	2
16	99-525-25	Brake Fitting, Front Caliper	2
17A	500195	Brake Fitting, Master Cylinder	1
17B	502198	Brake Fitting, Master Cylinder	1
18	500159	Brake Fitting, Coupler, Rear Axle	2
19	500552	Brake Light Switch, Hydraulic	1
20	504084	Brake Fitting, Brake light Switch	1
21	502013	Brake Fitting, T	1
Not Shown	500243	Hose Clamp, Rear Axle Brake Lines	1

Note: Front brakes are optional, item #'s: 2, 4, 13, 14, 16, 21. For rear brake only, item 21 is replaced with 18.

Brakes, Front Axle

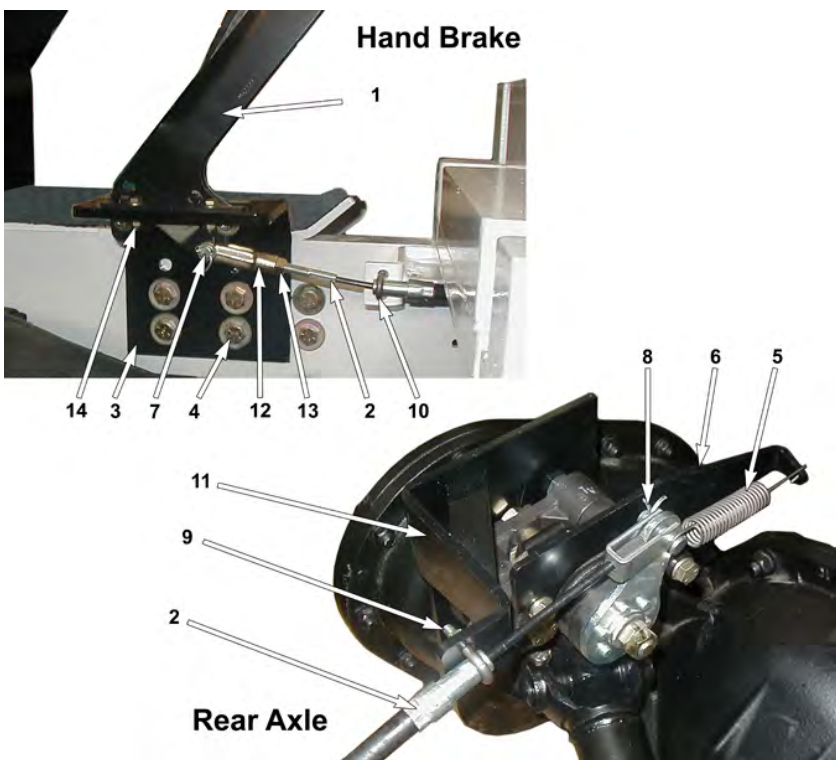
Front Brakes

Item No.	Part No.	Description	Qty
1	500673	Caliper Assembly, Left	1
	500673	Caliper Assembly, Right	1
2	500375	Mounting Bracket	2
3	500374	Rotor	2
4	88-402-07	Bolt, 7/16 Grade 8	4
	88-402-28	Nut, Reversable Lock	4
5	88-401-77	Bolt, Caliper Mounting	4
6	88-401-96	Washer, Split Lock, Caliper Mounting	4
	41-348-62	Kit, Brake Pad, Includes 4 pads and safety wire	-
-	505879	Safety Wire (for #5)	Per Ft.



Brakes, Parking Brake

Item No.	Part No.	Description	Qty
1	500543	Handle, Park Brake	1
2	506314	Cable, Park brake	1
3	500022-V6	Bracket, Handle Mounting	1
4	88-402-48 88-402-67 88-402-85 88-402-75	Bolt, Bracket to Frame, Front Bolt, Bracket to Frame, Rear Washer, Bracket to Frame Nut, Bracket to Frame	2 2 8 4
5	500864	Spring, Return	1
6	41-386-03	Mount, Return Spring	1
7	96-772-00 500563	Clevis Pin, Handle Cotter Pin	1 1
8	96-772-00 500563	Clevis Pin, Caliper Cotter Pin	1 2
9	501277	U-bolt, Rear Cable Mount	1
10	501277	U-bolt, Front Cable Mount	1
11	41-386-00 88-402-75	Bracket, Rear Cable Mounting Nut, Mounting	1 2
12	96-762-00	Clevis	1
13	88-119-80	Nut	1
14	88-400-02 88-400-90 88-400-78	Bolt, Handle Mounting Washer Nut	4 8 4
-	501273 245437 Refer to Carlisle Parts manual for other components	Caliper Assembly CALIPER PAD SET PARKING BRAKE	1
-	501272	Brake Rotor	1
-	500587	Bracket, Park Brake	1



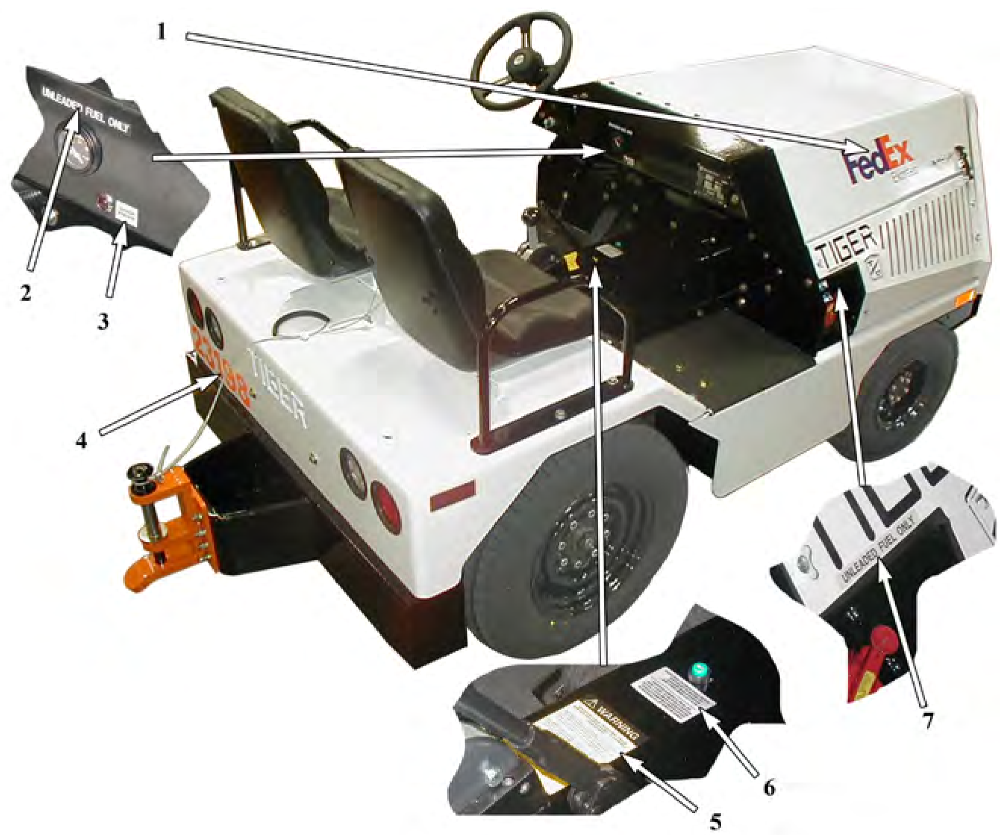
Brakes, Rear Axle

Brakes, Rear Axle

Item No.	Part No.	Description	Qty
	504350	Caliper Assembly	4
	41-490-43	Kit, Brake Pad Replacement	1

Decals

Item No.	Part No.	Description	Qty
1	502177	FedEx	2
2	500235-W	Unleaded Fuel, White Text	1
3	504938	Check Engine	1
4	94-318-80	Asset #, specify # when ordering	
5	500233	Operation	1
6	501040-7	Shift Inhibitor	1
7	500235	Unleaded Fuel, Black Text	1
8	500237	Fan Warning	1
Not Shown	94-384-27	Set, Decals for components under dash	1



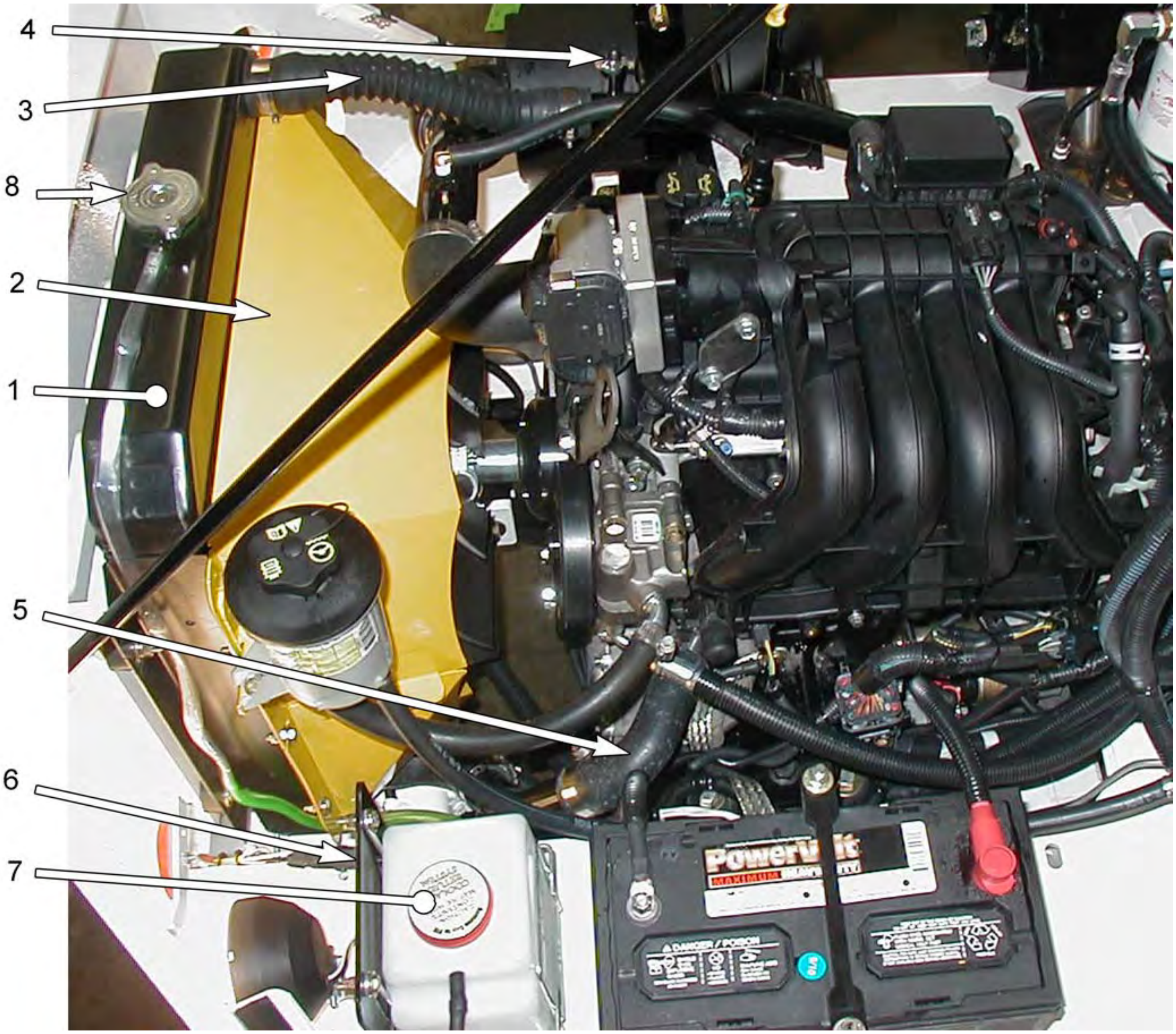
Electrical, Miscellaneous

Item No.	Part No.	Description	Qty
	75-153-78	CABLE,BATTERY POS,RED 1 GA 16"	1
	75-153-79	CABLE BATTERY,NEG BLK 1 GA 21"	1
	500364	Boot, Battery Cable	4
	500117	BATTERY, GROUP 31 HEAVY DUTY	1
	500098	Battery Hold Down Bar	1
	502556A	Boot, Positive	1
	50-243-16	Rod, Hold Down	2
	500263	GROUND STRAP, ENG TO CHASSIS	1
	500560	HOUR METER SWITCH	1
	500586	Horn	1
	500558-A	Horn relay	1
	502136	Horn Switch	1
	75-152-65	HARNESS, ADAPTOR, HORN >	1
	500781	CIRCUIT BREAKER \ 10A	4
	500782	CIRCUIT BREAKER \ 50A	1
	502533	Boot, 50A Circuit Breaker	1
	500787	CIRCUIT BREAKER \ 15A	2
	500788	Mount, Circuit breaker	2
	500789	Buss Bar, 4-holes	1
	500790	Buss Bar, 3-holes	1
	500791	Buss Bar, 2-holes	1
	502496	Accessory Relay	1
	500105-A	Solenoid, Starter Interlock	1
	74-000-00	Hour Meter	1
	506327	Mounting Bracket	1
	71-100-00	Switch, Toggle	1
	75-153-60	HARNESS,MAIN,TIGER,TC30,FEDEX	1
	75-153-61	HARNESS,POWER,TC30/60	1
	75-147-27	Harness, Intermediate Engine and Pedal	1
	75-153-77	HARNESS, FORD STARTER TC30/60>	1
	500759-0250	WIRE LOOM NYLON 1/4	Per Foot
	500759-0350	WIRE LOOM \ 3/8" \ NYLON	Per Foot
	500759-0500	WIRE LOOM \ 1/2" \ NYLON	Per Foot
	500759-0750	LOOM, NYLON 3/4"	Per Foot
	500283-1	CLAMP CBL 1/4 X 1/2 INSUL(#4)	-
	500283-11	CLMP, CABLE, 1/2 X 1/2 (#8)	-
	500283-2	CLAMP CBL 3/8 X 1/2 INSUL	-
	500283-3	CLAMP CBL 3/4 X 1/2 INSUL	-
	500283-12	CLAMP CBL 3/4 X 3/4 INSUL	-
	500283-7-A	CLAMP CBL 2 X 1/2 INSUL	-
	500283-8	CLAMP CBL 1-1/8 X 1/2 INSUL	-
	500283-10	CLAMP CBL 2 X 3/4 INSUL	-

Engine

Item No.	Part No.	Description	Qty
	30-700-00	BRACKET,ECU MOUNT,FEDEX	1
	4-2778901	MOUNT-ENGINE (65 DURO)	2
	505893	ENGINE, FORD 2.3L GAS	1
	506243	FRAME MOUNT, 2.3L FORD	2
	506283	WLD, MOTOR MNT RH 2.3L FORD	1
	506284	WLD, MOTOR MNT LH 2.3L FORD	1
	66-000-07	OIL SENDING BLOCK 2.3L FORD	1
	67-500-50 503772 30-790-00	Throttle Pedal Assembly Mounting Bracket, Throttle Assembly Cover, Throttle Assembly	1 1 1
	67-500-14	Oil Filter	1

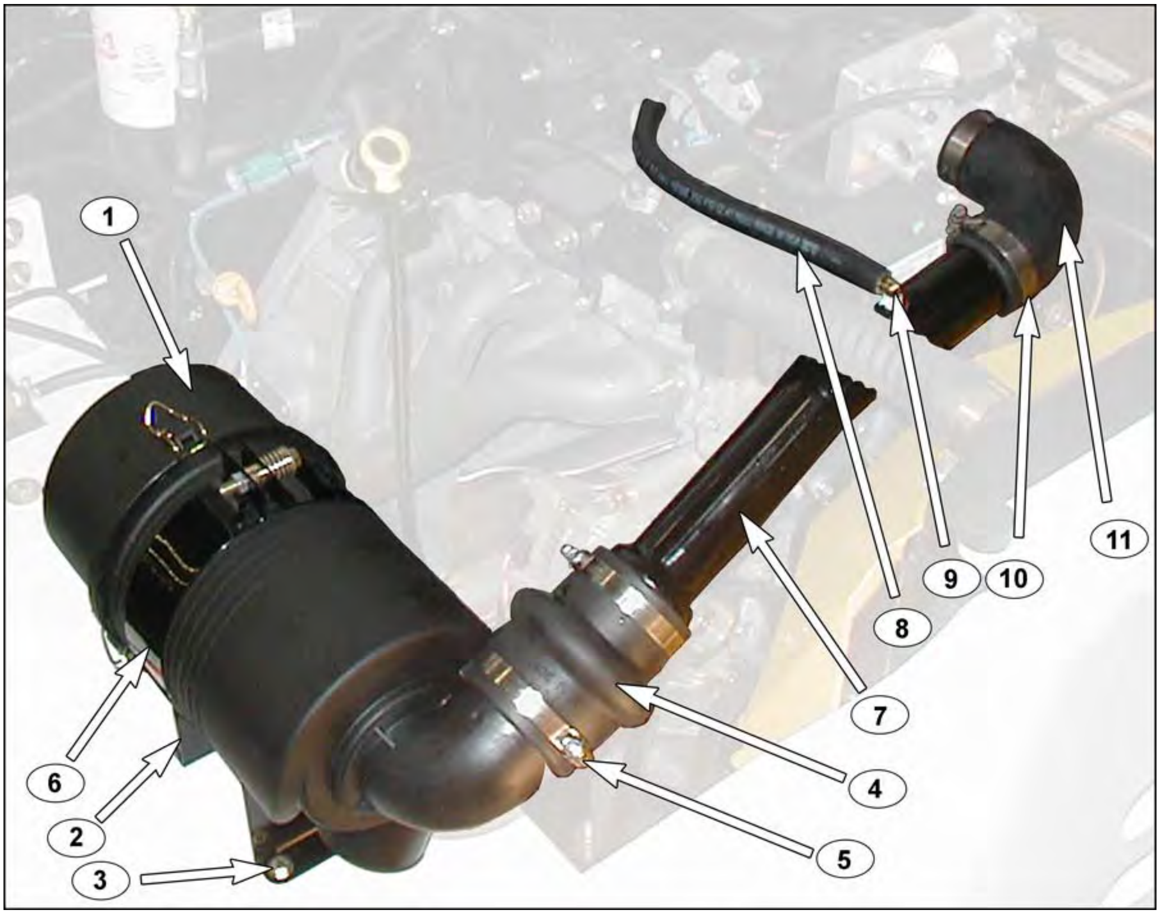
Engine, Cooling System



Engine, Cooling System

Item No.	Part No.	Description	Qty
1	500103-V6	RADIATOR, INLET @ RT	1
	500111-A	Mount	4
	88-401-31	Nut	8
	88-404-40	Washer, Flat	8
	88-401-41	Washer, Lock	8
2	30-810-05	WELDMENT,PS BRACKET AND FAN	1
	66-000-23	SHROUD, FAN, BOTTM HALF, FEDEX	1
3	66-400-60	HOSE, RADIATOR, UPPER, 2.3	1
	506338	Clamp, Hose	2
4	66-000-40	CAP, COOLANT, 5/16	1
	504661	Clamp, Hose	1
5	506334	Lower Hose Assembly, Top Hose	1
	503800	Lower Hose Assembly, Bottom Hose	1
	66-400-61	Lower Hose Assembly, Coupler	1
	506338	Clamp, Hose	3
	506344	Clamp, Hose (lower radiator)	1
6	01-900-60	Mount, Coolant Overflow	1
7	500130	Kit, Coolant Overflow	1
8	500262	Cap, Radiator	1

Engine, Air Cleaner



Item No.	Part No.	Description	Qty
1	500805-7-A 67-500-01	Air Filter Assembly Filter element	1 1
2	504558	Mounting Bracket, Frame	1
3	88-401-02 88-401-40 88-401-31	Bolt Washer Nut	4 8 4
4	505788	REDUCER, 3"-2.5", AIR INLET	1
5	502131	Clamp	2
6	500805-7-B	Clamp, Mounting Bracket	1
7	66-001-70	WELD,AIR INTAKE TUBE	1
8	98-540-02	Hose, PCV Valve	1 foot
9	504943	Fitting	1
10	506344	Clamp	
11	505787	ELBOW, AIR INLET, 2"	1

Exhaust

Item No.	Part No.	Description	Qty
	01-300-39	HANGER,TAILPIPE,BRKTC3060	1
	500555	CLAMP\MUFFLER\2"	1
	505735	CLAMP, MUFFLER, 1 3/4"	1
	503954	MUFFLER WRAP 2"	Per Foot
	506296	HANGER, CAT-CONV 2.3L FORD	2
	66-400-08	HANGER, EXHAUST, RUBBER	1
	66-400-34	EXHAUST, HEAD PIPE, TC3060,FED	1
	66-400-36	EXHUST,PIPE,TAIL, TC3060,FEDEX	1
	67-500--19	Muffler, Catalytic Converter	1

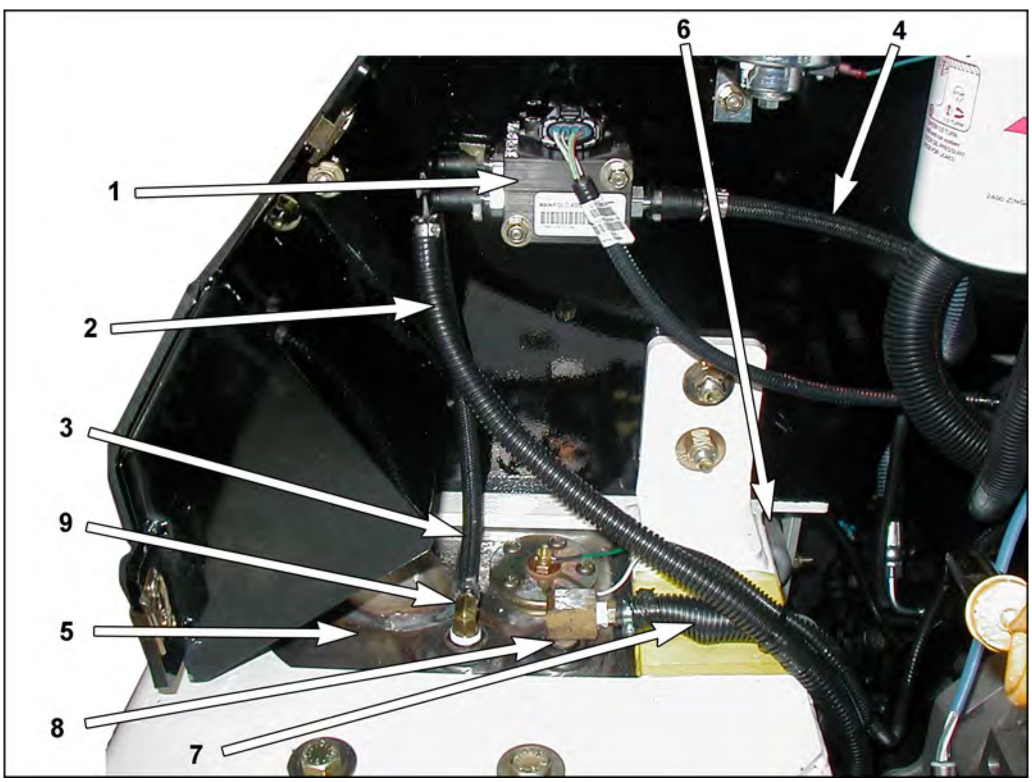
Frame and Body

Item No.	Part No.	Description	Qty
-	*	Frame, standard	
	500033	Hood, Gasoline model	1
	500140	Hinge	1
	500589	Handle, Hood	2
	500574	Latch, Hood	2
	500557	Bump Stop	2
	500362	Gas Spring, Hood	2
	500363	Ball Stud	4
	500052-A	Prop Rod, Hood	1
	500051	Clip, Prop Rod	1
	500054	Bracket, Prop Rod	1
	500363	BALL STUD \ LIFT SPRING >	2
	504445	Engine Cowling, Right	1
	504446	Engine Cowling, Left	1
	500220-G	Cowling Mounting Grommet	16
	500220-R	Cowling Mounting Receptacle	8
	500220-WS	Cowling Mounting Wing Stud	8
	500020	Transmission Cover	1
	500298-A	Boot, Parking Brake Handle	1
	500624	Gasket, Left Rear	Per Foot
	500975	Gasket, Right Rear	Per Foot
	500628	TRIM, DOUBLE LIP	Per Foot
	500539	Bracket, Shifter Mounting	1
	500284-B	Driver Seat	1
	88-401-31	5/16 NC HEXNUT GR8	4
	88-401-40	5/16 FLW THRU-HARD GR8	4
	88-401-41	5/16 SPLKWASH GR8	4
	500284-B	Passenger Seat	1
	88-401-31	5/16 NC HEXNUT GR8	4
	88-401-40	5/16 FLW THRU-HARD GR8	4
	88-401-41	5/16 SPLKWASH GR8	4
	505303	HIP RESTRAINT, TC-30/60, Passenger	1
	88-402-47	1/2 X 1 3/4 NC HEXHDSCR GR8	3
	88-402-75	1/2 NC TOPLKNT GR9	3
	88-148-61	1/2 SAE FLAT WASHER GR2	6
	00-900-13	HIP RESTRAINT, DRIVER,TC-30/60	1
	88-402-47	1/2 X 1 3/4 NC HEXHDSCR GR8	3
	88-402-75	1/2 NC TOPLKNT GR9	3
	88-148-61	1/2 SAE FLAT WASHER GR2	6
	504438	Pocket, Fuel Filler	1
	500581	COLLAR \ FUEL POCKET	1
	00-900-10	Firewall, Gasoline model	1
	504669	Hole Plug, 5/16	3
	505313	Hole Plug, 3/8	4
	500338	PLATE, COVER, FLYWHEEL HOUSING	1
	500077	Plug, Defrost Vent	1

Fuel System, Gasoline

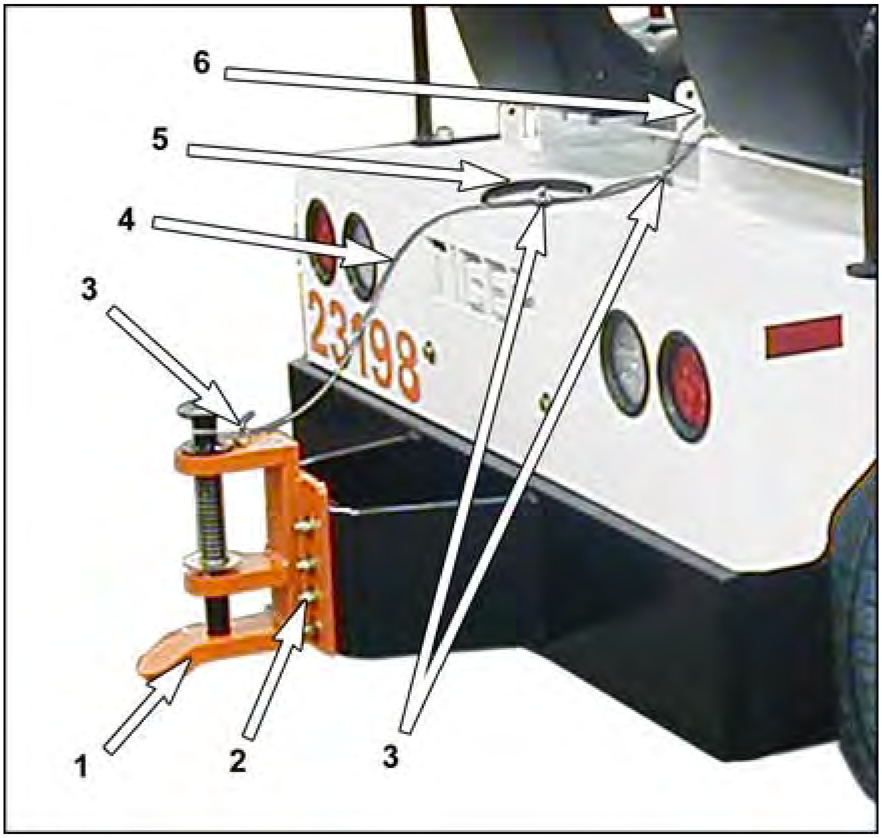
Item No.	Part No.	Description	Qty
1	67-500-18	Pressure Regulator	1
2	98-545-09	Fuel Line Assembly, Secondary Filter to Regulator	1
3	98-545-18	Fuel Line Assembly, Return to Tank	1
4	98-545-07	Fuel Line Assembly, Regulator to Engine	1
5	505995	Tank, Fuel (Stainless, FedEx spec)	1
	500024	Mount	1
	500547	Fuel Level Sender	1
	505461	Fuel Cap	1
	500201	FTG, 5/16 INV FL - 1/4 MPT	1
	504942	Barb Fitting, Hose	2
	504087	Reducer 3/8 - 1/4 NPT	1
	88-402-46	1/2 X 1 1/2 NC HEXHDSCR GR8	4
	88-402-75	1/2 NC TOPLKNT GR9	4
	88-402-85	1/2 FLW THRU-HARD GR8	8
6	67-500-04	Fuel Pump	1
7	98-545-19	Fuel Line Assembly, Tank to Primary Filter	1
8	66-410-50	Fuel pickup tube (in fuel tank)	1
9	502799	Fitting, Elbow	1
-	05-211-05	Filter, Primary (before pump)	1
-	67-500-15	Filter, Secondary (after pump)	1
-	504085	BKT FUEL FILTER	1
-	98-545-08	Fuel Line, Primary Filter to Fuel Pump	1
-	98-545-17	Fuel Line, Fuel Pump to Secondary Filter	1 foot

The primary fuel filter is located in front of the pump
The secondary fuel filter is located under the passenger side floorboard below the pump.



* Not available at time of printing

Hitch, Rear

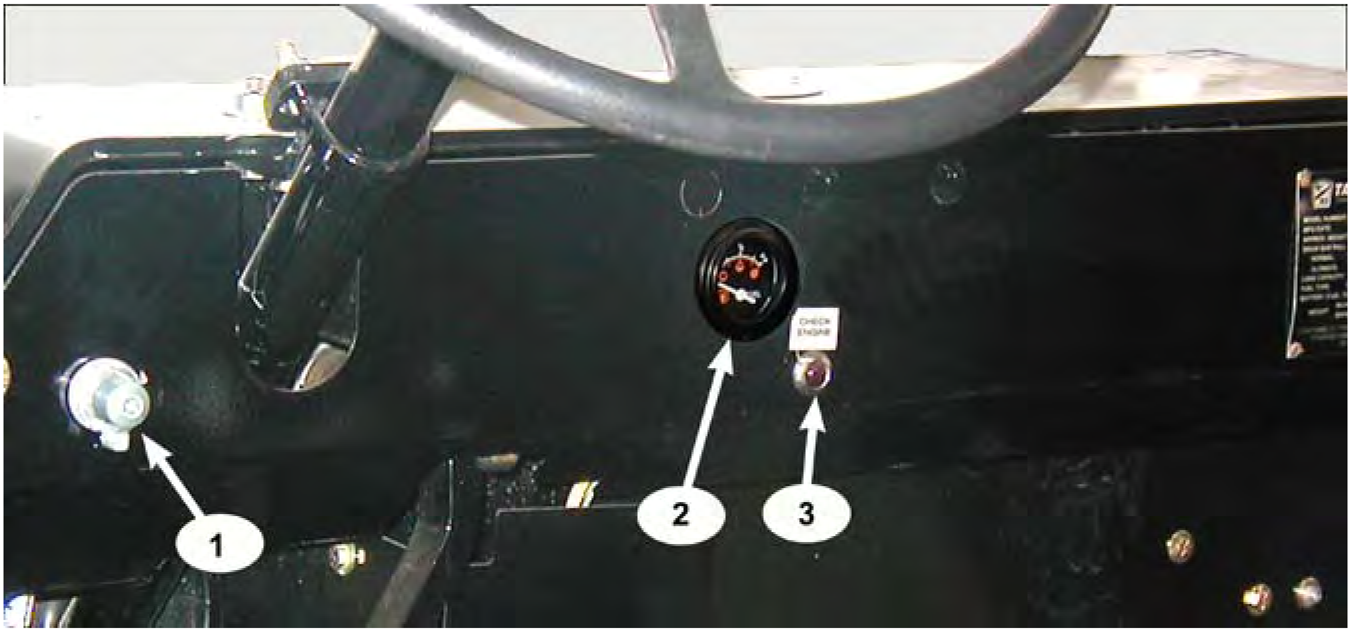


Item No.	Part No.	Description	Qty
1	503479	Hitch	1
2	88-402-67 88-402-85 88-402-75	Bolt Washer Nut	8 16 8
3	503056	Cable Clamp	3
4	500232-C	Cable	7 feet
5	500249	Grip	9.6 inches
6	88-401-20 88-401-40 88-401-31 88-401-41	Eye bolt Washer Nut Split Lock Washer	1 2 2 1

Hitch, Side (optional)

Item No.	Part No.	Description	Qty
1	506377	WLD, SIDE HITCH FRT BRKT	1
2	500383	HITCH SIDE FEDEX	1
3	506373	Rear Bracket	1
4	500385	SIDE HITCH \ BLADE	1
5	500384	Link	2
6	88-403-41	3/4 X 8 NC HEXHDSCR GR8	2
	88-403-70	Nut	2
	88-403-80	Washer	4
7	88-402-49	1/2 X 2 1/2 NC HEXHDSCR GR8	4
8	88-402-47	1/2 X 1 3/4 NC HEXHDSCR GR8	2
-	88-402-85	1/2 Flat Washer	8
-	88-402-75	1/2 Lock Nut	6
9	88-401-50	3/8 X 2 NC HEXHDSCR GR8	2
	88-401-80	Nut	2
	88-401-95	Flat Washer	4
-	87-074-00	Grease Fitting	1

Instrument Panel, FedEx

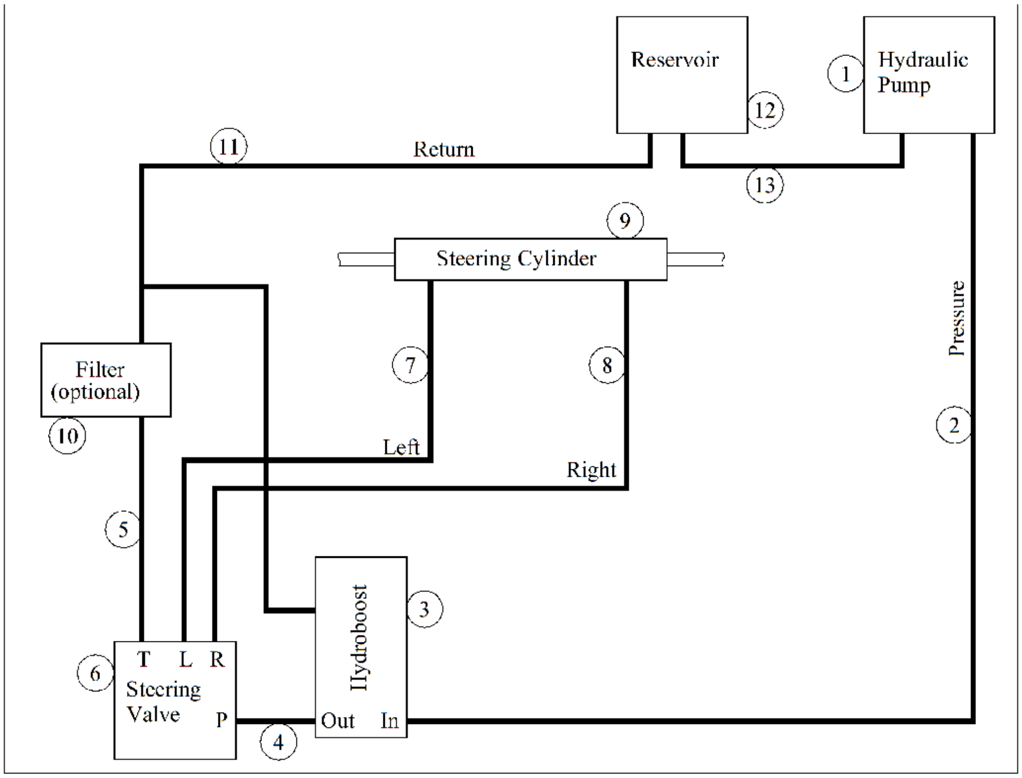


Item No.	Part No.	Description	Qty
1	500128	Switch, Ignition (keyless)	1
2	500546	Gauge, Fuel	1
3	See Lights	Light, Check Engine	1
-	506257	Panel, Formed (FedEx)	1
-	88-401-47	Bolt, Panel Mounting	2
-	88-401-95	Washer, Panel Mounting	2
-	88-401-96	Lock Washer, Panel Mounting	2
-	97-211-30	U-nut	2

Lights, FedEx

Item No.	Part No.	Description	Qty
1	505999	Headlight	2
2	503415	Taillight	2
3	506201	Backup Light	2
4	504420	Reflector, Front Round	2
5	502142	Reflector, Side, Red	2
6	502143	Reflector, Side, Amber	2
7	72-028-41 502321	MIL Light, Lens Only Bulb	1 1
8	502321	Bulb, Shift Light	1
-	502321	Bulb, Fuel Gauge	1

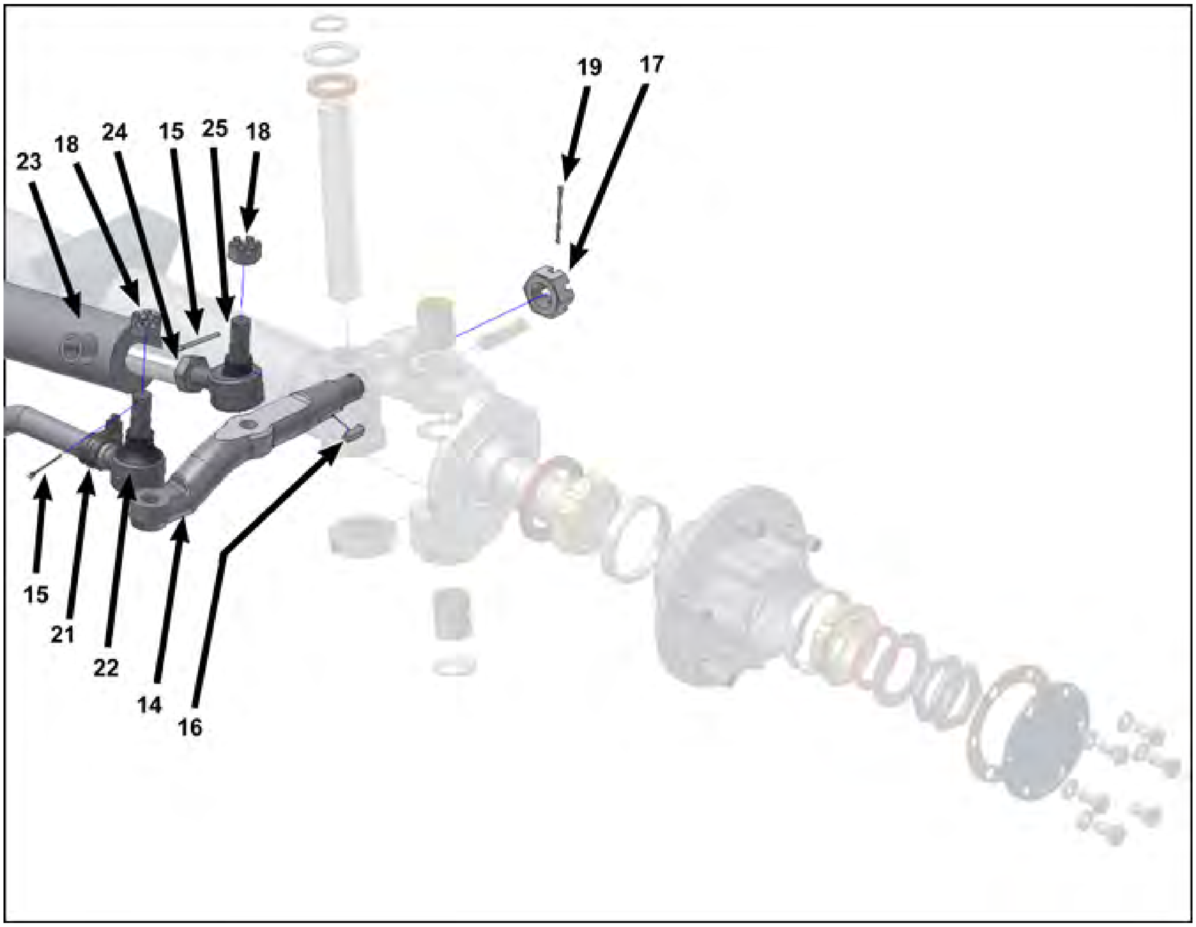
Steering, Hydrostatic, Hydraulics



Item No.	Part No.	Description	Qty
1	Part of engine assy.	Hydraulic Pump	-
2	506290	Hose, Pressure to Brake Hydroboost	1
3	See Brake Pedal	Brake Hydroboost	1
4	99-530-34	Hose, Pressure to Steering Valve	
5	99-530-33	Hose, Steering Valve to Filter	1
6	201038	Steering Control Valve	1
	504125	Fitting, 90 Degree Swivel	2
	504124	Fitting, Adapter	2
	502134	Boot, Rubber	1
	504577	Mounting Ring for Rubber Boot	1
	503716	Mounting Bracket	1
7	99-530-27	Hose, Left Steering	1
8	99-530-26	Hose, Right Steering	1
9	See mechanical parts	Steering Cylinder	1
	504121	Fitting, Hose	1
	504121	Fitting, Hose	1
10	201134	Filter Assembly	1
	99-528-00	Replacement Cartridge	1
	76744	Fitting, 90Degree	2
	90536	Fitting, Adapter	2
11	99-530-29	Hose, Return Line Assembly	1
12	506304	Fluid Reservoir	1
13	99-530-28	Hose, Suction	1
-	504596	Hose clamp (Hydroboost & Pump return lines)	2
-	201037	Steering Column	1

** Not available at time of printing*

Steering, Hydrostatic, Mechanical

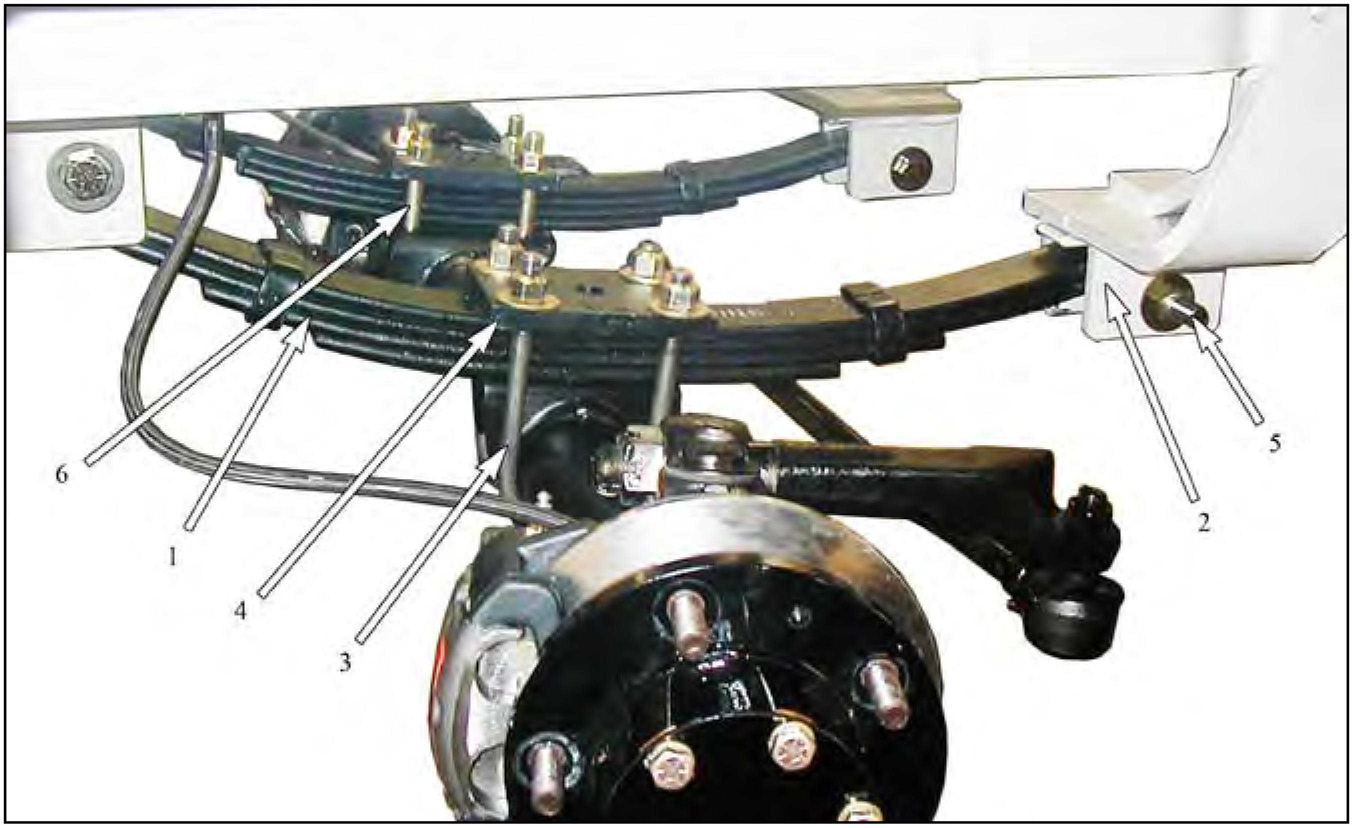


Steering Hydrostatic

Item No.	Part No.	Description	Qty
14	14-900-10 504381	Steering Arm, Right Steering Arm, Left	1 1
15	500563	Cotter Pin	4
16	500838	Key	2
17	500837	Nut, Castle	2
18	-	Nut, Castle, included w ball joint	4
19	88-527-16	Cotter Pin	2
20	-	-	-
21	86-510-00	Clamp, Ball Joint	2
22	18-000-11 18-000-10	Ball Joint, Left Thread Ball Joint, Right Thread	1 1
23	201030A	Steering Cylinder	1
24	201032	Jam Nut	2
25	18-000-10	Ball Joint, Right Thread	2
-	14-900-11	Tie Rod	1
-	201039 201283	Steering Wheel Nut	1 1
-	88-128-13	Bolt, Steering Stop	2
-	500840	Nut, Steering Stop Bolt	2

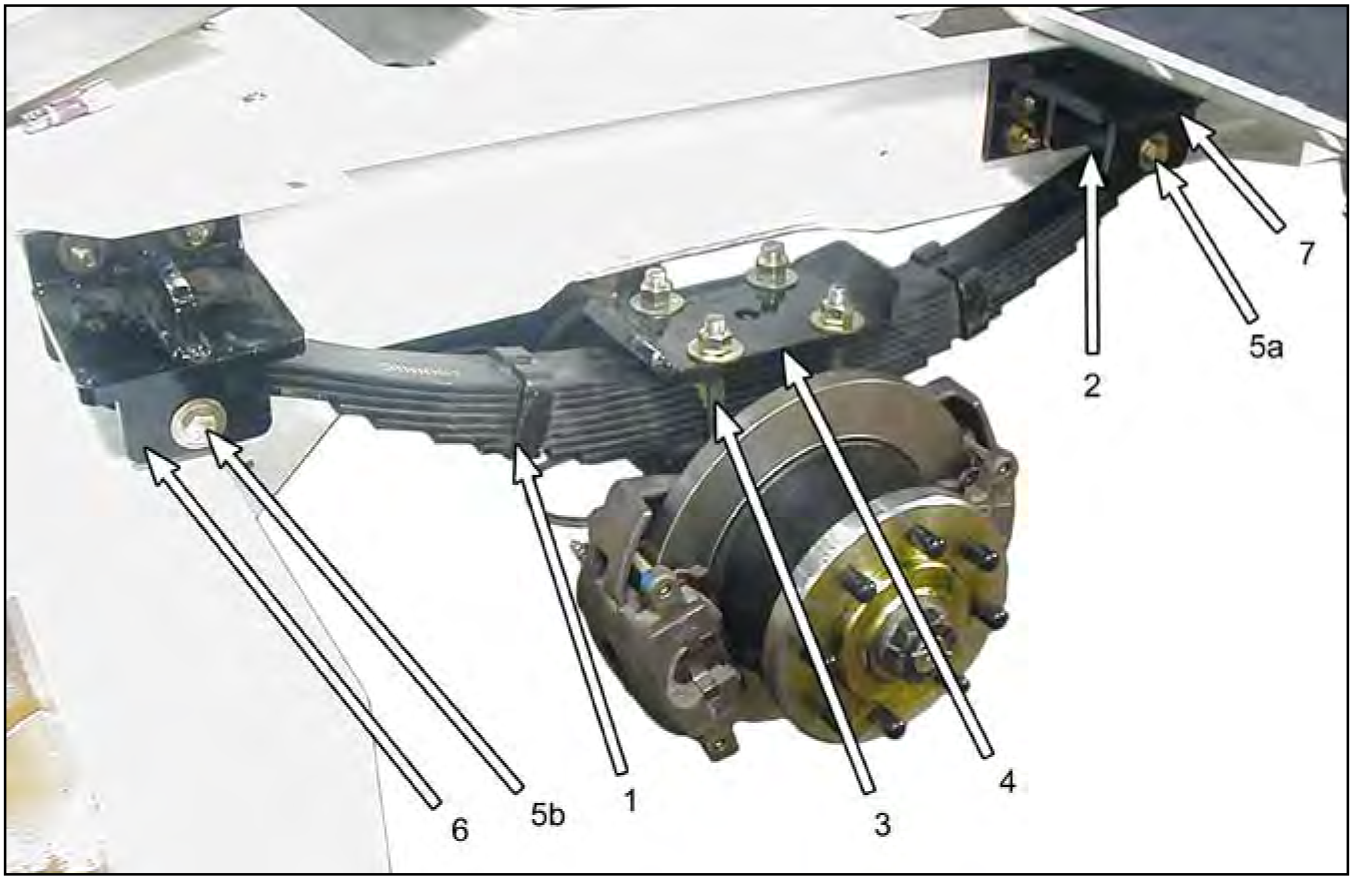
FedEx

Suspension, Front



Item No.	Part No.	Description	Qty
1	500582	Spring, Leaf	2
2	500583	Bushing, Spring Eye	4
3	500046 88-402-75 88-402-85	U-bolt Nut, U-bolt Washer	2 4 4
4	500045	Plate, U-bolt	2
5	88-402-94 88-403-10 88-403-05	Bolt, Spring Eye Washer Nut	4 8 4
6	88-402-52 88-402-75 88-402-85	1/2 X 4 NC HEXHDSCR GR8 Nut Washer	4 4 8

Suspension, Rear



Item No.	Part No.	Description	Qty
1	500061	Spring, Leaf	2
2	32-000-04	Bushing, Spring Eye	4
3	500055	U-bolt,Driver side Inner (long)	1
	500059	U-bolt, (short)	3
	88-403-28	Nut	8
	88-403-10	Washer	8
4	506319	Plate, U-bolt	2
5a	88-402-94	Bolt, Spring Eye, Front	2
5b	88-402-95	Bolt, Spring Eye, Rear	2
	88-403-10	Washer	8
	88-403-05	Nut	4
6	500012	Spring Mount, Right Rear	2
7	500008	Spring Mount, Left Rear	2
	88-402-75	**Bolt, Spring Mount, Short	14
	88-402-67	**Bolt, Spring Mount, Long	2
	88-402-85	Washer, Spring Mount	8
	88-402-75	Nut, Spring Mount	16

** *- Two long bolts are installed in the front right spring mount, front holes only. Also hold park brake mount.*

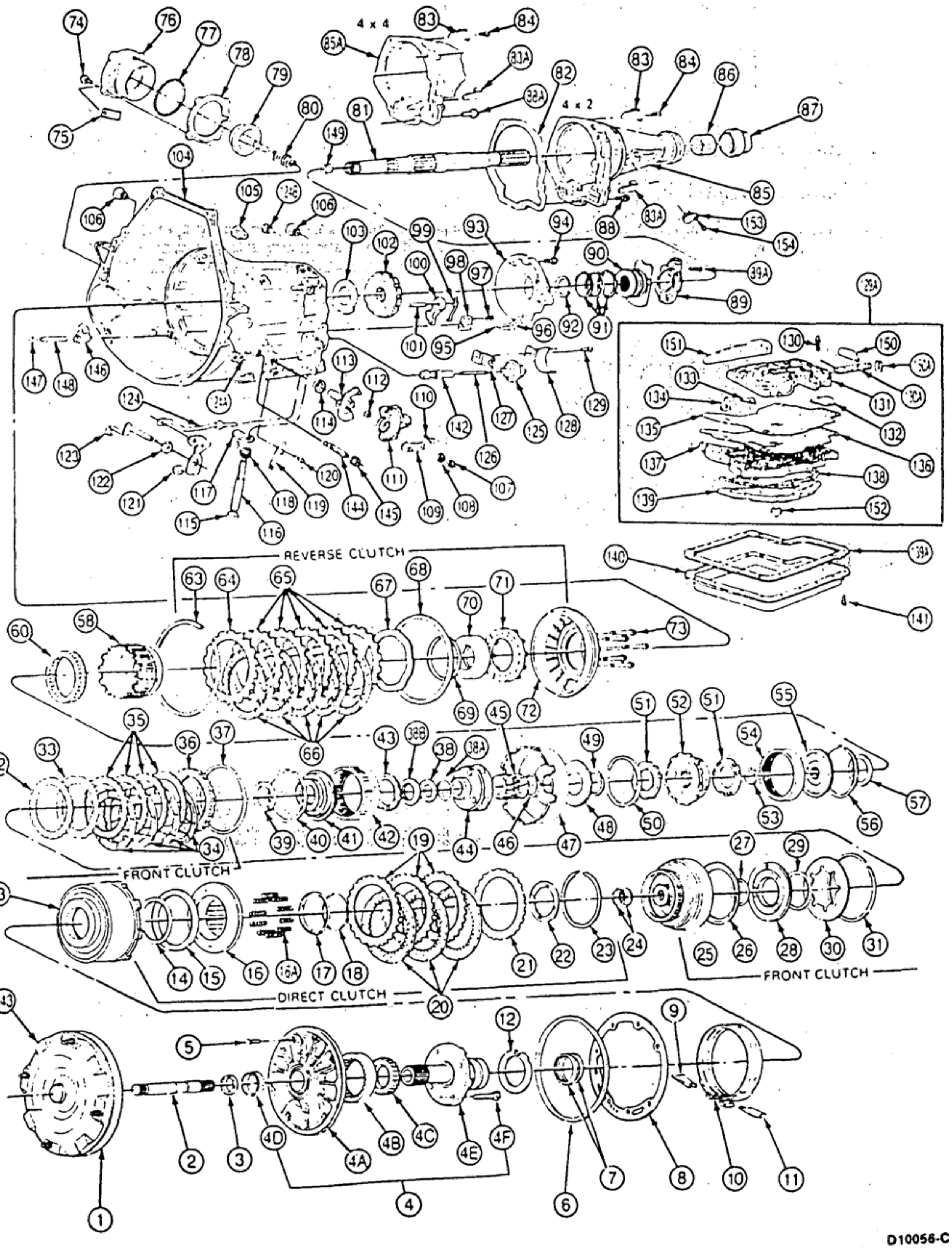
Transmission Assembly / Drive Shaft

Item No.	Part No.	Description	Qty
See bulletin BUL-10-02-001		Transmission Assembly	1
	500011-V6	MOUNT BRKT TRANS F4.9	1
	502246	TRANS MOUNT \ ISOLATOR	1
	502324	DIPSTICK TUBE FORD C6	1
	66-900-10	Dipstick, Yellow	1
	201134	Filter, External	1
	99-528-00	Replacement Cartridge	1
	76744	Fitting, 90Degree	2
	90536	Fitting, Adapter	2
	99-530-40	Hose assembly, Radiator to Transmission	1
	99-530-41	Hose Assembly, Filter to Radiator	1
	99-530-42	Hose Assembly, Transmission to Filter	1
	503829	Fitting, Radiator Transmission Cooler	2
	503052	Shifter Assembly	1
	504092	Switch, Reverse/Neutral	1
	504746	Shift Rod	1
	500529	Rod End	1
	501245	Arm, Shifter	1
	502737	Spacer, 1/2”	1
	502587	Kit, Shift Inhibitor	1
	-	Kit includes: solenoid, pressure switch, relay, indicator light, decal	
	236440	Solenoid	1
	72-028-42	Light Assembly	1
	502321	Bulb	1
	274561	Pressure Switch	1
	500656	Relay	1
	501040-11	Fitting, pressure switch	1
	81-200-07	Drive shaft	1
	86-553-10	U-Joint, Front	1
	86-553-117	U-Joint, Rear	1
	500810	FLEX PLATE	1
	500811	RING/FLEX PLATE/USE W/500810	1
	502427	BOLT/SPECIAL FLEXPLATE C6	6

** Not available at time of printing*

Transmission Components (p1)

C6 Automatic Transmission, Exploded View



Transmission Components (p2)

Item	Part Number	Description
1	7902	Torque Converter
2	7017	Input Shaft
3	—	Front Oil Pump Seal (Part of 7A103)
4	7A103	Front Oil Pump Assembly
4A	—	Front Oil Pump Body (Part of 7A103)
4B	—	Pump Driven Gear (Part of 7A103)
4C	—	Pump Drive Gear (Part of 7A103)
4D	—	Front Oil Pump Bushing (Part of 7A103)
4E	—	Front Pump Support (Part of 7A103)
4F	20346-S8	Hex Head Bolt (Part of 7A103)
5	58619-S2	Bolt
6	7A248	Front Oil Pump Seal — Large
7	7D025	Intermediate Brake Drum Seal (2 Req'd)
8	7A136	Oil Pump Gasket
9	7D029	Intermediate Brake Band Strut
10	7D034	Intermediate Band
11	7D430	Intermediate Band Anchor Strut
12	7D014	Thrust Washer — No. 1
13	7D044	Intermediate Brake Drum
14	7E056	Direct Clutch Piston Oil Seal — Inner
15	7A548	Direct Drive Clutch Piston Oil Seal — Outer
16	7A262	Direct Clutch Piston
16A	7B488	Direct Clutch Piston Spring — (10 Req'd)
17	7A527	Clutch Piston Spring Retainer
18	377136-S	Direct Drive Clutch Piston Spring Retainer Ring
19	7B442	Direct Clutch External Spline Plate — (Steel)
20	7B164	Direct Clutch Internal Spline Plate — (Friction)
21	7B066	Direct Drive Clutch Pressure Plate
22	7C096	Intermediate Brake Drum Thrust Washer — No. 2
23	377126-128-S 377437 377444-S	Retaining Ring
24	7D019	Forward Clutch Cylinder Seal (2 Req'd)
25	7A360	Forward Clutch Cylinder Assembly
26	7A548	Forward Clutch Piston Oil Seal — Outer
27	7A548	Forward Clutch Piston Oil Seal — Inner
28	7A262	Forward Clutch Piston
29	7D256	Forward Clutch Piston Spring Ring
30	7B070	Forward Clutch Piston Disc Spring
31	377127-S	Retaining Ring
32	7B066	Forward Clutch Pressure Plate — Front
33	7E085	Forward Clutch Pressure Spring
34	7B164	Forward Clutch Internal Spline Plate — (Friction)
35	7B442	Forward Clutch External Spline Plate — (Steel)
36	7B066	Forward Clutch Pressure Plate — Rear
37	377127-S 377437-S 377444-S 386841-2-S	Retaining Ring
38	7D234	Forward Clutch Hub Thrust Bearing Assembly — No. 3 and No. 6 (2 Req'd)
38A	7D235	Forward Clutch Hub Thrust Race
38B	7D236	Forward Clutch Hub Thrust Race
39	7D090	Forward Clutch Hub Thrust Washer — No. 4
40	377132-S	Retaining Ring
41	7B067	Forward Ring Gear Hub
42	7D392	Forward Ring Gear
43	7A166	Planet Carrier Thrust Washer — No. 5
44	7A398	Forward Planet
45	7D063	Sun Gear Assembly
46	377300-S	Front Retainer
47	7D064	Input Shell
48	7D066	Input Shell Thrust Washer
49	377300-S	Rear Retainer
50	377155-S	Retaining Ring
51	7D423	Reverse Planet Carrier Thrust Washer — No. 7 and No. 8
52	7D006	Reverse Planet
53	387031-S5	Retaining Ring
54	7A153	Ring Gear
55	7D164	Output Shaft Hub
56	377132-S	Retaining Ring
57	7D422	Output Shaft Hub Thrust Bearing — No. 9
58	7B067	Reverse Clutch Hub
60	7A089	Overrunning Clutch
63	385044-S	Retaining Ring
64	7B066	Reverse Clutch Pressure Plate
65	7B442	Reverse Clutch External Spline Plate — (Steel)
66	7B164	Reverse Clutch Internal Spline Plate — (Friction)

(Continued)

(Continued)

Transmission Components (p3)

Item	Part Number	Description
67	7E085	Reverse Clutch Pressure Spring
68	7D403	Reverse Clutch Piston Outer Seal
69	7D404	Reverse Clutch Piston Inner Seal
70	—	Overrunning Clutch Race — Inner (Part of 7D164)
71	7D406	Reverse Clutch Retainer and Spring Assembly.
72	7D402	Reverse Clutch Piston
73	7D167	Overrunning Clutch to Case Bolt (5 Req'd)
74	57633-S2	Bolt, (4 Required)
75	—	Transmission Model Identification Tag (Not Serviced)
76	7D027	Intermediate Band Servo Cover
77	7D024	Intermediate Band Servo Cover Piston Seal — Large
78	7D026	Intermediate Band Servo Cover Gasket
79	7D021	Intermediate Band Servo Piston and Rod Assembly
80	7D028	Intermediate Band Servo Piston Spring
81	7060	Output Shaft
82	67-500-12	Extension Housing Gasket
83	7G496	Vacuum Tube Retainer (2 Req'd — 4x2)
83A	7G496	Vacuum Tube Retainer (2 Req'd — 4x4)
84	380209-S	Bolt, 4 Req'd
85	7A039	Extension Housing — (4x2)
85A	7A039	Extension Housing — (4x4)
86	7A034	Extension Housing Bushing
87	7052	Extension Housing Oil Seal
88	380207-S2	Bolt (2 Req.d — 4x2 Only)
88A	58642-S2	Bolt (2 Req d — 4x4 Only)
89	7C063	Governor Body Assembly
89A	34805-S8	Bolt, 4 Req'd
90	7D220	Governor Body Oil Collector Body
91	7D011	Governor Housing Seal Ring (3 Req'd — 2 Teflon, 1 Cast Iron)
92	387035-S5	Retaining Ring
93	7C232	Oil Distributor Sleeve
94	20386-S8	Bolt, 4 Req'd
95	7D000	Oil Distributor Tube — Inlet
96	7D000	Oil Distributor Tube — Outlet
97	379058-S	Screw and Washer Assembly
98	7D419	Park Rod Guide Plate (Serviced in Kits Only)
99	7D070	Parking Pawl Return Spring
100	7A441	Parking Brake Pawl
101	7D071	Parking Pawl Shaft

(Continued)

Item	Part Number	Description
102	7A233	Output Shaft Park Gear
103	7B368	Output Shaft Thrust Washer — No. 10
104	7005	Case
105	7034	Vent
106	7D273	Oil Tube Connector (2 Required)
107	33798-S8	Nut — 5/16
108	34806-S7	Hex Lock Washer
109	7A394	Downshift Control Outer Lever
110	55651-S2	Screw and Washer Assembly
111	7A247	Park/Neutral Position Switch
112	386078-S	Throttle Control Outer Lever Seal
113	7A256	Manual Control Lever
114	7B498	Manual Control Lever Oil Seal
115	6572	Parking Plate Shaft Plug
116	7D418	Parking Plate Shaft
117	7D414	Parking Rod Support Plate
118	7D417	Parking Plate Torsion Spring
119	7A261	Manual Valve Detent Lever Spring
120	56501-S2	Hex Flg Bolt, 1/4-20 x .50
121	7A115	Manual Valve Detent Lever — Inner (Serviced in Kits Only)
122	380525-S	Hex Lock Nut, 9/16-18
123	7D261	Downshift Detent Lever — Inner
124	7D411	Parking Pawl Actuating Rod (Serviced in Kits Only)
124A	87650-S	Pipe Plug — 1/8-27 Dryseal Tapered Thread (Used in Case for Measuring Pump Pressure)
124B	87650-S	Pipe Plug — 1/8-27 Dryseal (Used in Case for Measuring Throttle Valve Pressure)
125	7A377	Throttle Valve Control Diaphragm Assembly
126	7A380	Throttle Control Valve Rod
127	7F006	Vacuum Diaphragm Clip
128	7F013	Vacuum Diaphragm Heat Shield
129	56119-S	Hex Flg Head Bolt, 5/16-18 x .82 — (7F013, 7F006 and 7A377 to 7005)
129A	7A100	Main Control Assembly
130	7D075	Inner Downshift Lever Stop (Part of 7A100)
130A	7326	Gear Selector Valve Rod
131	7A092	Upper Control Valve Body (Part of 7A100)
132	7C056	Main Control Valve Body Reinforcement Plate (Part of 7A100)

(Continued)

Transmission Components (p4)

Item	Part Number	Description
133	7D259	Main Control Valve Body Separator Plate Reinforcement (Part of 7A100)
134	7E387	Main Control Pump Inlet Screen
135	7A008	Valve Body Separating Plate (Part of 7A100)
136	7D100	Valve Body Separating Plate Gasket
137	7A101	Lower Control Valve Body (Part of 7A100)
138	67-500-13	Oil Pan Screen Gasket
139	7A098	Oil Screen
139A	7A191	Oil Pan Gasket
140	7A194	Transmission Oil Pan — (Shallow — 4x2) — (Deep — 4x4)
141	378782-S	Bolt
142	7D080	Primary Throttle Valve
143	87650-S	Converter Drain Plug, 1/8-27, Dryseal Tapered Thread

(Continued)

Item	Part Number	Description
144	7A178	Adjusting Screw (Reverse Band)
145	375185-S100	Nut
146	7330	Intermediate Servo Band Lever
147	7E206	Intermediate Band Servo Lever Shaft Retainer
148	7D433	Intermediate Band Adjusting Lever Shaft
149	378259	Cup Plug
150	7D094	Throttle Pressure Booster Valve Plate (Not Serviced Separately)
150A	7D227	Throttle Pressure Valve Secondary Spacer
151	7D058	Shift Valve Plate (Not Serviced Separately)
152	7A102	Lower Main Control Valve Body Suction Tube
153	7H183	Extension Housing Plug (Used to Plug Speedometer Gear Hole)
154	57621-S2	Screw and Washer Assembly, 1/4-20 x .62

Wheels and Tires

Item No.	Part No.	Description	Qty
	503343	Wheel Assembly, Front, 650 x 10	2
	500164	Tire, 6.50 x 10, includes tube	
	500972	Wheel, 10 x 5.5	
	502758	Wheel Assembly, Rear	2
	500257	Tire, LT225-75R16 LR-D (tubeless)	
	500684	Wheel, 16 x 6	
	500218	Valve Stem	

CHAPTER 5
MANUFACTURER SUPPLEMENTARY MANUALS
SECTION INDEX

ENGINE DISTRIBUTORS INC.

OPERATOR HANDBOOK

DSG 423

LIQUEFIED PETROLEUM GAS (LPG) GASOLINE (EFI) & NATURAL GAS (NG) ENGINES

EDI 1060020
JULY, 2006

Power Products

Powertrain Assemblies & Components
Provided By Ford Component Sales

WARNING:

WARNING: ENGINE EXHAUST, SOME OF ITS CONSTITUENTS, AND CERTAIN VEHICLE COMPONENTS CONTAIN OR EMIT CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER AND BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM. IN ADDITION, CERTAIN FLUIDS CONTAINED IN VEHICLES AND CERTAIN PRODUCTS OF COMPONENT WEAR CONTAIN OR EMIT CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER AND BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM.

FORD DSG-423 ENGINES

GASOLINE (EFI)
LIQUEFIED PETROLEUM GAS (LPG)
NATURAL GAS (NG)

EDI policy is one of continuous improvement and while every effort is made to ensure that this publication is up to date and correct in all respects, the right to change prices, specifications and equipment at any time without notice is reserved. Accordingly this publication is not to be regarded as a final description of any individual engine.

CONTENTS

CONTENTS

CONTENTS

HEALTH & SAFETY

WARNING: THE FOLLOWING HEALTH AND SAFETY RECOMMENDATIONS SHOULD BE CAREFULLY OBSERVED.

Carrying out certain operations and handling some substances can be dangerous or harmful to the operator if the correct safety precautions are not observed. Some such precautions are recommended at the appropriate points in this book.

While it is important that these recommended safety precautions are observed, care near machinery is always necessary, and no list can be exhaustive. ALWAYS BE ON YOUR GUARD!

General Guidelines:

The following recommendations are for general guidance:

1. Always wear correctly fitting protective clothing which should be laundered regularly. Loose or baggy clothing can be extremely dangerous when working on running engines or machinery. Clothing which becomes impregnated with oil or other substances can constitute a health hazard due to prolonged contact with the skin even through underclothing.
2. So far as practicable, work on or close to engines or machinery only when they are stopped. If this is not practicable, remember to keep tools, test equipment and all parts of the body well away from the moving parts of the engine or equipment—fans, drive belts and pulleys are particularly dangerous. The electric cooling fan used on some installations is actuated automatically when the coolant reaches a specified temperature. For this reason, care should be taken to ensure that the ignition/isolating switch is OFF when working in the vicinity of the fan as an increase in coolant temperature may cause the fan suddenly to operate.
3. Avoid contact with exhaust pipes, exhaust manifolds and silencers when an engine is, or has recently been running; these can be very hot and can cause severe burns.
4. Many liquids used in engines or vehicles are harmful if taken internally or splashed into the eyes. In the event of accidentally swallowing gasoline (petrol), oil, diesel fuel, antifreeze, battery acid etc., DO NOT ENCOURAGE VOMITING AND OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

Wear protective goggles when handling liquids which are harmful to the eyes; these include ammonia and battery acid. If any of these substances are splashed in the eyes, wash out thoroughly with clean water and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

Important Safety Notice

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all industrial engines as well as the personal safety of the individual doing the work. This operator handbook provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing equipment, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that neither personal safety nor equipment integrity are compromised by the choice of methods, tools or parts.

Notes, Cautions, and Warnings

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES gives you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the equipment. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on the equipment.

GENERAL WARNINGS:

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the equipment.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake (if equipped) when working on the equipment. If you have an automatic transmission, set it in PARK REVERSE (engine off) or NEUTRAL (engine on) unless instructed otherwise for a specific operation. Place wood blocks (4”x 4” or larger) to the front and rear surfaces of the tires to provide further restraint from inadvertent equipment movement.
- Operate the engine only in a well ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the equipment.
- To reduce the risk of injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on the equipment. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

FORWARD

This book contains operating and maintenance instructions for the engine(s) listed on the title page.

The life of your engine unit and the delivery of the high performance built into it will depend on the care it receives throughout its life. It is the operator's responsibility to ensure that the engine is correctly operated and that the maintenance operations outlined in this book are carried out regularly after the specified hours of operation have been reached. We consider it to be in your interests to enlist the aid of an authorized EDI Distributor, not only when repairs are required but also for regular maintenance. Distributors are listed at the back of this handbook.

Regular maintenance will result in minimal operating costs.

Engines manufactured by Ford Motor Company are available through EDI Distributors. When in need of parts or service, contact your local EDI Authorized Distributor.

Where the terms “Right” or “Left” occur in this publication, they refer to the respective sides of the engine when viewed from the rear or flywheel end.

Pistons and valves are numbered from the front or timing cover end of the engine commencing at No. 1.

You may find that your engine assembly includes optional equipment not specifically covered in the following text. Nevertheless, the maintenance procedures outlined in this book still apply to your engine

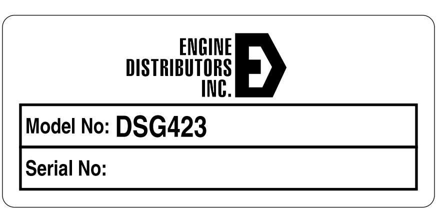
ENGINE IDENTIFICATION

It is important that you have as complete identification of the engine as possible in order to provide the correct replacement parts. New engines being shipped include a standard parts listing describing the parts which does not tell the owner the part number. It remains a distributor function to identify the part number.

The key to identifying the engine is the identification decal mounted on the engine rocker cover. That decal provides not only the engine serial number, but also the exact model or type, options and S.O. (Special Order). The combination of that data permits you to isolate the precise engine, build level and customer so you can determine the correct replacement parts.

U.S.A. Engine Identification Decal

An identification Decal is affixed to the valve cover of the engine. The decal contains the engine serial number which identifies this unit from all others. Use all numbers when seeking information or ordering replacement parts for this engine.



Federal Emissions Warranty Statement

Engine Distributors, Inc. (EDI) warrants that your new **(2006 or later model year)** off-road large spark-ignition (LSI) is designed, built, and equipped to meet the applicable EPA emissions requirements and is free from defects in factory supplied materials and workmanship that could prevent it from conforming with these requirements.

EDI provides the following emissions warranty coverage for your new off-road LSI engine:

- Three (3) years or 2500 hours, whichever occurs first, for emissions-related parts (see list below).
- Five (5) years or 3500 hours, whichever occurs first, for high-priced emissions-related parts (see list below).

In cases where the Original Equipment Manufacturer has sourced components from suppliers other than EDI, the Original Equipment Manufacturer will be responsible for warranty related to these components.These parts are noted in the “What is Covered” section with the statement “(Supplied and Warranted by Original Equipment Manufacturer)”.

You will not be charged for repair, replacement, or adjustment of defective emissions-related parts listed below.

Concerning parts that should be replaced during scheduled maintenance, these parts remain under warranty until the first scheduled maintenance specified in the maintenance schedule or the applicable coverage period listed above, whichever occurs first.

California Emission Control Warranty Statement

Your Warranty Rights and Obligations

The **California Air Resources Board** and Engine Distributors, Inc. (EDI) are pleased to explain the **emission control system warranty** on your **2006 or later model year** compliant certified off-road large spark-ignition engine. In California, new off-road large spark-ignition (LSI) engines must be designed, built and equipped to meet the State's stringent anti-smog standards. EDI must warrant the emission control system on your compliant certified engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the carburetor, regulator, or fuel-injection system, ignition system, engine computer unit (ECM), catalytic converter, and air induction system. Also included may be sensors, hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, EDI will repair your LSI compliant certified engine at no cost to you including diagnosis, parts and labor.

In cases where the Original Equipment Manufacturer has sourced components from suppliers other than EDI, the Original Equipment Manufacturer will be responsible for warranty related to these components. These parts are noted in the “What is Covered” section with the statement “(Supplied and Warranted by Original Equipment Manufacturer)”.

Manufacturer's Warranty Coverage:

The **2006 or later** off-road large spark-ignition compliant certified engines are warranted for **three (3) years or 2500 hours, whichever occurs first**. High cost emission related parts are warranted for **five (5) years or 3500 hours, whichever occurs first.** If any emission-related part on your engine fails to perform as designed within the warranty period, the part will be repaired or replaced by EDI (see list below).

Owner's Warranty Responsibilities:

As the off-road LSI engine owner, you are responsible for the performance of the **required maintenance listed in your owner's manual**. EDI recommends that you retain all receipts covering maintenance on your off-road engine, but EDI cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.

As the off-road large spark-ignition engine owner, you should however be aware that EDI may deny you warranty coverage if your off-road large spark-ignition engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your compliant certified engine is designed to operate on **gasoline or liquefied propane gas** when properly equipped. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.

You are responsible for initiating the warranty process. The ARB suggests that you present your off-road large spark-ignition engine to an EDI distributor as soon as a problem exists. The warranty repairs should be completed by an authorized EDI distributor or service dealer as expeditiously as possible.

If you have any questions regarding your warranty rights and responsibilities, you should contact an EDI customer service representative at
1 800 220 2700

What Is Covered?

The Federal and California emission warranties cover the following parts.

1. Air / Fuel Feedback Control System and Sensors
2. Air Induction System (Supplied and Warranted by Equipment Manufacturer)
3. Carburetor system (internal parts and/or pressure regulator or fuel mixer or injection system)
4. Catalytic Converter
5. Electronic Engine Control Sensors and Switches
6. Electronic Ignition System
7. Exhaust Manifold and Gaskets
8. Exhaust Pipe between Exhaust Manifold and Catalyst (Supplied and Warranted by Equipment Manufacturer)
9. Fuel Injection System
10. Fuel Injector Supply Manifold
11. Fuel Pump
12. Fuel Pressure Regulator
13. Gaseous Fuel System Assembly
14. Idle Air Control Valve Block off Plate and Gasket
15. Ignition Coil and/or Control Module
16. Intake Manifold and Gaskets
17. Malfunction Indicator Lamp
18. PCV System and Oil Filler Cap
19. Engine Performance Module
20. Solenoid Assembly - Carburetor Feedback Control
21. Spark Control Components
22. Spark Plugs and Ignition Wires
23. Synchronizer Assembly
24. Thermostat Assembly
25. Throttle Body Assembly and Gaskets

NOTE: All emissions related bulbs, hoses, clamps, brackets, tubes, gaskets, seals, belts, connectors, fuel lines, and wiring harnesses used with the above components are also covered.

Components That Are Considered High Priced Parts

1. Catalytic Converter
2. Catalytic Converter Muffler
3. Engine Performance Module
4. Engine Wiring Harness
5. Fuel System (Gaseous) - Mixer
6. Fuel System (Gaseous) - Regulator, Fuel Pressure
7. Fuel System (Gaseous) - Trimming Device

PARTS AND SERVICE

Replacement parts can be obtained through your local EDI Distributors listed in the back portion of this handbook. They also may be found in the yellow pages under “Engines” or contact EDI at: 1-800 220 2700.

EDI Distributors are equipped to perform major and minor repairs. They are anxious to see that all of your maintenance and service needs are quickly and courteously completed.

SERVICE LITERATURE

A service manual can be purchased from your EDI distributor. This publication will provide the necessary servicing and overhaul information for your engine.

- SERVICE MANUAL EDI 1060040
- PART LIST EDI 1060030
- OPERATORS HANDBOOK EDI 1060020

BEFORE OPERATING THE ENGINE

1. Before operating a new engine it should be thoroughly inspected to ensure that during transit and installation it has not suffered damage likely to affect its subsequent operation. Controls and instruments should be studied carefully in order that their functions are thoroughly understood.
2. Check that the radiator (where applicable) is full and top off as necessary -- Refer to “Cooling System” on page 28 for recommended coolant mixtures.
3. In the case of marine/industrial engines, ensure that there is coolant in the degas/expansion tank (where applicable).

CAUTION: Under no circumstances may the engine be started without liquid in the cooling system.

4. Check the engine oil level and top up or fill as necessary -- Refer to “Check Engine Oil Level” on page 24. For the correct type and grade of oil -- Refer to “Recommended Lubricants” on page 22.
5. Ensure that the battery is fully charged and, if necessary, top up with distilled water.

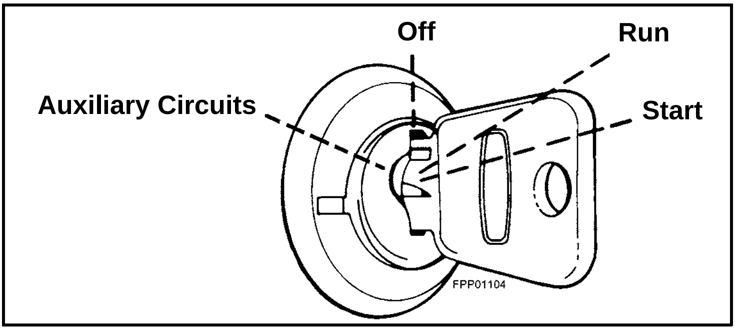
NOTE: Ensure that ALL wiring ground connections are properly made to a clean point on the chassis/frame.

6. The engine must be started in accordance with the starting instructions -- Refer to “STARTING THE ENGINE” on page 15.

OPERATING CONTROLS

Ignition or Isolation Switch

An ignition or isolation switch is usually fitted which connects the engine starter motor and other electrical equipment to the battery. The switch can be moved to any of the four positions shown by rotating the key. These positions are:



1. Auxiliary Circuits - When moved to this position the auxiliary electrical equipment such as radios and heater fans, can be operated without also connecting the starting circuit with the battery.
2. Off - When set to this position, the switch disconnects the auxiliary electrical equipment and the starting circuit from the battery. The key can be removed from the switch when it is in this position; this will help to prevent unauthorized operation of the engine.
3. Run - This switch position connects the auxiliary circuits as described previously, and the alternator is given initial excitation via the battery.

4. Start - In this position, the starter solenoid is energized and the starter motor cranks the engine. The switch, when released, automatically returns to the RUN position.

Safety Switch (where fitted)

A low oil pressure/high water temperature safety switch may be fitted. This automatically shuts off the ignition when the oil pressure drops below a pre-set value, or when the water temperature rises above a pre-set value. A button on the instrument panel is used to override the safety switch when starting the engine. The safety switch override button must be depressed to start the engine.

NOTE: With safety shut-down incorporated, oil pressure below 6 psi and/or coolant temperature goes above 250° F, will shut-down ignition system. Corrective action must be taken and key recycled to restart.

Power Take-off (where fitted)

The power take-off control handle allows engagement and disengagement of the power take-off clutch. Moving the lever towards the engine engages the clutch and moving the lever away from the engine disengages the clutch.

When moving the handle to engage the clutch and pick up the load, do so in a smooth manner. Moving the clutch handle too slowly will cause slippage and wear, while moving it too fast will cause quick engagement and possible damage to the power take-off, engine or driven equipment. The normal force required to engage the clutch is 55 lbf (245 N) for the over-centre type and 25 lbf (110 N) for the spring loaded type.

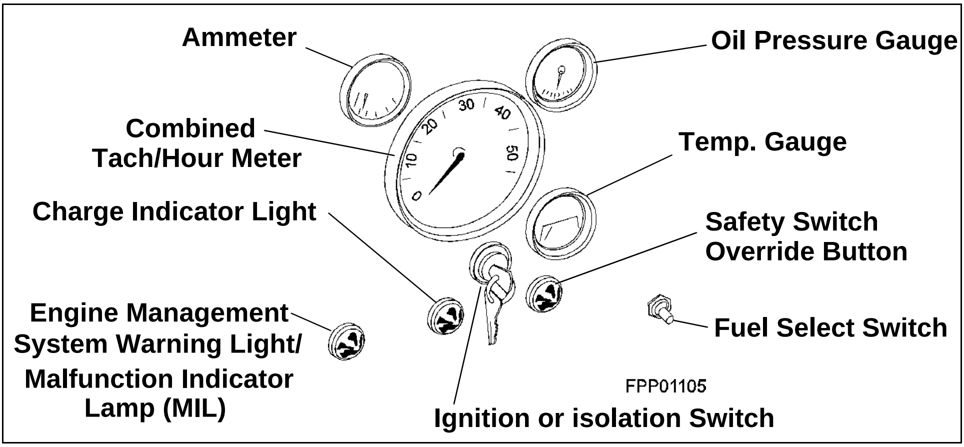
Throttle Control (where fitted)

The throttle control adjusts engine speed. Initial engine speed adjustment is obtained by pressing the throttle control release button while pulling the throttle knob out to increase the engine speed or pushing it in to decrease the engine speed.

A final fine speed adjustment is obtained by turning the throttle control counterclockwise to increase engine speed or clockwise to decrease engine speed.

INSTRUMENTS

Your Engine Distributors, Inc. (EDI) Powered Equipment will have been fitted with instruments selected by the manufacturer. The types of instruments most likely to be encountered are detailed here. A typical instrument panel is shown below.



Ammeter (Where Fitted)

This instrument registers the charging current which is being passed to the battery from the alternator. It also registers a discharge equivalent to the amount of current being used by the electrical equipment when the alternator is not charging.

Battery Condition Indicator (Where Fitted)

This is sometimes fitted instead of an ammeter and measures the battery voltage thus indicating the state of charge of the battery.

Tachometer (Where Fitted)

The tachometer indicates the actual engine running speed in crankshaft revolutions per minute.

Hourmeter (Where Fitted)

This instrument records the number of hours of operation which the engine has completed at the rated rpm. It is frequently combined with the tachometer and is used to determine when an engine service operation is required. If no hourmeter is fitted, a log should be kept.

Oil Pressure Gauge (Where Fitted)

The oil pressure gauge registers the lubricating system pressure in bar (kgf/cm^2 or lbf/in^2) and should be frequently observed to ensure that the system is functioning correctly.

Temperature Gauge (Where Fitted)

The temperature gauge enables a close check to be kept on the coolant temperatures.

Malfunction Indicator Light (Where Fitted)

Used on all industrial engines. This light will illuminate whenever there is an engine malfunction such as low oil pressure, high engine temperature, fuel injection system fault. The engine can be programmed to shut down in the event of a malfunction.

Charge Indicator Light (Where Fitted)

If an alternator is fitted to your engine, a charge indicator light will also be fitted. The light will glow when the isolating switch is in the RUN position with the engine stationary and will therefore serve as a reminder either to turn the isolating switch to the OFF position or to start the engine. Once the engine has started, the charge indicator light should cease glowing.

Safety Switch Override Button (Where Fitted)

This must be depressed when starting the engine, as the safety switch operates when the oil pressure falls due to the engine stopping -- Refer to “Safety Switch (where fitted)” on page 13.

Ignition or Isolation Switch

-- Refer to “Ignition or Isolation Switch” on page 12.

Fuel Select Switch (Where Fitted)

This switch is incorporated for use with dual fuels. Switch must point to selection of fuel being used.

STARTING THE ENGINE

⚠

WARNING: ALL INTERNAL COMBUSTION ENGINES GIVE OFF VARIOUS FUMES AND GASES WHILE RUNNING. DO NOT START OR RUN THE ENGINE IN A CLOSED OR POORLY VENTILATED BUILDING WHERE THE EXHAUST GASES CAN ACCUMULATE. AVOID BREATHING THESE GASES AS THEY MAY CONTAIN POISONOUS CARBON MONOXIDE WHICH CAN ENDANGER YOUR HEALTH OR LIFE IF INHALED STEADILY FOR EVEN A FEW MINUTES.

Initial Start-up

On initial start-up follow the daily regular maintenance schedule illustration -- Refer to “RECOMMENDED MAINTENANCE SCHEDULES” on page 21.

To Start From cold

1. Where possible, disconnect the driven equipment, eg, fully depress the clutch where a manual transmission is fitted.

   If your unit is equipped with the engine warning light system, always turn the ignition switch to the ON position to make sure that each warning light is operating before starting engine.
2. Switch on the ignition and operate the starter motor until the engine fires.

NOTE: Where a safety switch is fitted, the override button must be depressed while the engine is being cranked.

3. Set the throttle to give a fast idle speed until normal operating temperature is reached (where fitted).

NOTE: For EFI Governor application there is no throttle cable. Turn key to crank to start engine. When engine starts release key to run position. The ECM will adjust speed for cold start and altitude automatically.

CAUTION: If the engine stalls or falters in starting, wait 3-4 seconds before re-engaging starter. This will prevent possible damage to the starter or engine. The starter should not operate for periods longer than 30 seconds at a time. An interval of at least two minutes should be observed between such cranking periods to protect the starter from overheating.

STOPPING THE ENGINE

Normal Conditions

Following normal operating conditions, lower the engine speed to idle, disengage the clutch, and then turn the ignition switch to the OFF position. If the engine has been running under high power, let it run at fast idle speed a few minutes to cool the engine down.

Abnormal Conditions

Under abnormally overheated conditions, the engine may continue to run after the ignition switch is turned off. If this case is ever encountered, turn on the ignition switch immediately and allow the engine to idle until it has cooled enough to stop. If the engine is overheated due to loss of coolant, it is best to stop the engine immediately, if necessary by applying the load. Add engine oil if necessary, then after the engine has returned to a normal temperature, add coolant slowly until the radiator is full.

WARNING: TO REDUCE THE RISK OF INJURY WHEN CHECKING A HOT ENGINE. COVER THE RADIATOR CAP IN A THICK CLOTH AND TURN IT SLOWLY COUNTERCLOCKWISE TO THE FIRST STOP. AFTER THE PRESSURE HAS BEEN COMPLETELY RELEASED, PRESS THE CAP DOWNWARD AND FINISH REMOVING THE CAP.

The above instructions also apply to engines that stop due to operation of the low oil pressure/high water temperature safety switch. However, if the engine stops due to low oil pressure, do not restart until the cause has been determined and corrected -- Refer to “Recommended Lubricants” on page 22.

RUNNING-IN PROCEDURE

A new or reconditioned engine must not be run at high speeds or on full load for the first 25 hours. The load and speed may be increased to a maximum over this period. After the first 50 hours running, carry out the maintenance operations listed -- Refer to “RECOMMENDED MAINTENANCE SCHEDULES” on page 21.

Check the instruments frequently and keep the coolant and oil filled to their recommended levels.

FUEL RECOMMENDATION

This engine is designed to operate on dry fuel such as LPG Grade HD5 or NG (1050 BTU/ft.^{3}).

CAUTION: Use of commercial and non-commercial fuels rated lower than the grades specified above may cause persistent, heavy spark knock, which can lead to engine damage. If your engine knocks heavily, or if you hear continuous spark knock while maintaining constant operating speeds, consult your distributor or another qualified technician.

Fuel Quality

Using a high quality gasoline will help maintain the power, fuel economy and emissions performance of your engine. A properly formulated gasoline will be comprised of well refined hydrocarbons and chemical additives and will perform the following functions:

- Minimize varnish, lacquer, and other induction system deposits.
- Prevent gum formation or other deterioration during storage.
- Protect fuel tank and other fuel system components from corrosion or degradation.
- Provide the correct seasonally and geographically adjusted volatility. This will provide easy starting in the winter and avoid vapor lock in the summer.
- Avoid fuel system icing.

In addition, the fuel will be free of water, debris, and other impurities.

We also recommend that the fuel supply be kept fresh; when the equipment is in storage (especially in hot weather), the fuel tank should be kept at least 3/4 full.

If you anticipate storage of your engine in excess of two months, consult your distributor or other qualified technician. Also refer to the information on storage in the “Maintenance Instructions” section of this manual.

Alcohol Gasoline Blends (Gasohol)

Gasohol is a mixture of gasoline and ethanol or methanol.

CAUTION: If not properly formulated with appropriate cosolvents and corrosion inhibitors, such blends may cause performance problems or damage emissions and fuel system materials. Discontinue use if performance problems occur. To avoid jeopardizing the engine warranty and incurring unnecessary repair cost, do not use blends containing more than 10% ethanol by volume or 5% methanol by volume, or blends that do not contain cosolvents and corrosion inhibitors. Do not use such fuels unless they are unleaded.

Ethanol ($C8H16$) is an alcohol based fuel. There are basically two ways to produce ethanol. One way is the fermentative method. This method is based on the fermentation of ethanol from corn, sugar cane, cellulose, and other alternative crops. The other way is the catalytic hydrolysis of ethylene, a petroleum product, is the primary synthetic method. Compared to gasoline the energy content of ethanol is 66%. Ford engines should operate satisfactory on gasohol blends using unleaded gasoline and containing no more than 10% ethanol by volume. Cosolvents and corrosion inhibitors must also be added. The blend must also have an octane (anti-knock) index of 87 or 89, reference to engine specification section.

Methanol (CH30H) is also an alcohol based fuel. It can be produced in several ways. One is from natural gas. This process is an inefficient nonviable method of production. Another method is from coal. The problem with methanol produced from coal is that it yields a higher carbon dioxide emission. However coal reserves are much greater than oil or natural gas. A long-term supply of methanol can also be produced from biomass and urban refuse. The biomass process to methanol is prohibitive due to the amount of nonrenewable energy input required for conversion. Compared to gasoline the energy content of methanol is only 49%. Ford engines should operate satisfactory on gasohol blends using unleaded gasoline and containing no more than 5% methanol by volume. Cosolvents and corrosion inhibitors must also be added. The blend must also have an octane (anti-knock) index of 87 or 89, reference to engine specification section.

Gasohol, a mixture of gasoline and ethanol (grain alcohol), is available in some areas outside Europe. Ford engines should operate satisfactory on gasohol blends containing no more than 10% ethanol by volume and having an octane (anti knock) index of 87 or 89, reference engine specifications.

CAUTION: In some cases, methanol (wood alcohol) or other alcohols may be added to gasoline. Ford engines should operate satisfactory on blends containing up to 5% methanol by volume when cosolvents and other necessary additives are used. If not properly formulated with appropriate cosolvents and corrosion inhibitors, such blends may cause performance problems or damage emissions and fuel system materials. Insufficient data is available to insure the suitability of all methanol/gasoline blends at this time. To avoid jeopardizing your engine warranty or incurring unnecessary repairs costs, DO NOT USE blends containing more than 5% methanol by volume, or blends that do not contain cosolvents and corrosion inhibitors.

If you are uncertain as to the presence of alcohols in the gasoline you are purchasing, check the label on the pump or ask the station attendant.

CAUTION: Discontinue use of any gasohol or alcohol/gasoline blend if performance problems occur. Do not use such fuels unless they are UNLEADED.

NOTE: It is highly recommended that a Fuel Stabilizer, Ford Part Number E8AZ-19C544-A or an equivalent additive be used for any length of storage. It is imperative in any application where the fuel will not be consumed within thirty days. Refer to “STORAGE” in this section for further information.

LUBRICATION AND MAINTENANCE

The importance of correct lubrication, periodic inspection and adjustment cannot be over-emphasized. It will determine, to a very large extent, the service the engine will give. Detailed instructions regarding this maintenance are given in the following pages.

Your Authorized EDI Distributor listed in the back section of this manual, will be pleased to carry out this regular maintenance for you. The various maintenance operations are listed -- Refer to “RECOMMENDED MAINTENANCE SCHEDULES” on page 21.

When carrying out any of the following maintenance operations, any fault or malfunction should be reported immediately to the supervisor or person responsible for engine overhaul or repair.

The following Maintenance Schedules give the maximum recommended service periods. Since operating conditions can vary, it may be advisable to carry out some operations, for example, changing the engine oil, at an interim period. Your operating experience is the best guide for determining this time.

RECOMMENDED MAINTENANCE SCHEDULES

Hours Running Or Miles Driven → / Maintenance Operation ↓	Daily	After 1st 50 hrs. (2500 km or 1500 miles)	Every 100 hrs. (5000 km or 3000 miles)	Every 200 hrs. (10,000 km or 6000 miles)	Every 400 hrs. (20,000 km or 12,000 miles)	Every 800 hrs. (40,000 km or 24,000 miles)	Every 4 years max.	Details on Page #
Check engine oil level and top up if necessary	X	X	X	X	X	X		24
Check engine coolant level and top up if necessary with correct mixture	X	X	X	X	X	X		26
Check visually for oil, fuel or coolant leaks	X	X	X	X	X	X		
Lubricate PTO release bearing	X	X	X	X	X	X		
Check all instruments, controls and warning lights. Check hot and cold starting functions	X	X	X	X	X	X		
Check coolant, oil, fuel, exhaust and vacuum hoses/pipes for leaks, damage, deterioration and correct routing. Check all visible electrical wiring for security, correct routing and evidence of chafing or heat damage		X	X	X	X	X		
Change engine oil and renew engine oil filter					X	X		23
Lubricate PTO bearings			X	X	X	X		
Check condition and adjust tension of drive belt(s)				X	X	X		26
*Check gasoline fuel filter element and renew as necessary				X	X	X		
*Check dry fuel filter element and renew as necessary				X	X	X		
Renew air cleaner element					X	X		27
Spark plugs: Clean, adjust and test or replace					X	X		25
*Check all nuts & bolts for tightness					X	X		
*Adjust PTO clutch release & shaft bearings					X	X		
Renew PCV valve						X		27
Clean PCV hoses, tubes and fittings						X		27
Clean coolant filler cap. Renew cap if seal has deteriorated							X	

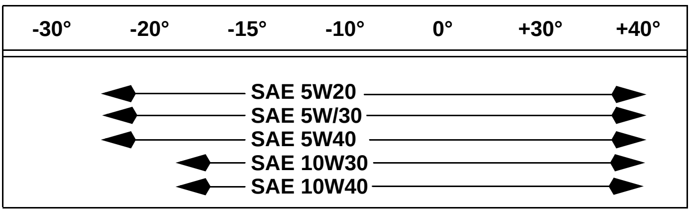
*It is recommended that this operation is carried out by an authorized EDI Distributor. Depending upon the quality of the fuel used, it may be necessary to renew the filter element more frequently.

RECOMMENDED MAINTENANCE OPERATIONS

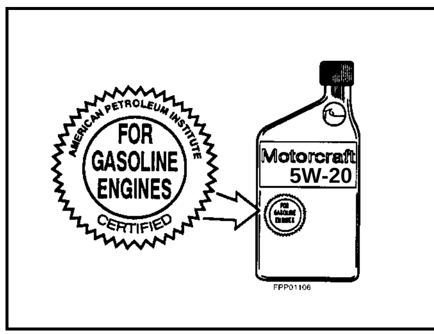
Recommended Lubricants

CAUTION: Do not use supplemental oil additives or other engine treatments. They are unnecessary and could, under certain conditions, lead to engine damage which is not covered by EDI warranty.

Lubricating oil cleanliness is vital for the successful operation of your engine. The oil should be stored under the cleanest possible conditions.When changing or topping-up engine oil use only clean receptacles. Do not allow the oil to come into contact with rubber hoses on the engine.



CAUTION: Use Ford/Motorcraft “Formula E” SAE 5W-20 engine oil or equivalent that meets Ford Specification WSS-M2C930-A (API Classification – SJ). If SJ oils are not available, SH oils are acceptable. Use only engine oil displaying the American Petroleum Institute Certification Mark on the front of the container, or API specification SH, or SJ.



NOTE: EDI industrial engines are designed to perform with engine oils that are licensed by the American Petroleum Institute (API), and oils carrying the most current API classification should be used. API classifications are broken into two categories, gasoline and diesel engines. API’s classification is designated by a two letter system. The first letter, the prefix, designates gasoline or diesel. An “S’’ designates gasoline and a “C’’ designates diesel. The second letter in the system designates the level of the classification. It should be noted that alternative fuel engines fall into the “gasoline’’ API category.

Gasoline engines that are converted for LPG or Natural Gas applications must use oils labeled SH and/or SJ. Do not use oils that are specifically formulated for Diesel Engines only. CC or CD classification, even when labeled Heavy Duty or for Natural Gas Engines, are not acceptable. The use of SAE 5W-20 is recommended for all temperatures:

Used Engine Oils

WARNING: PROLONGED AND REPEATED CONTACT MAY CAUSE SERIOUS SKIN DISORDERS INCLUDING DERMATITIS AND SKIN CANCER.

WARNING: AVOID EXCESSIVE CONTACT—WASH THOROUGHLY AFTER CONTACT. KEEP OUT OF THE REACH OF CHILDREN.

WARNING: PROTECT THE ENVIRONMENT: IT IS ILLEGAL TO POLLUTE DRAINS, WATER COURSES OR SOIL. USE AUTHORIZED FACILITIES FOR DISPOSAL. IF IN DOUBT, CONTACT YOUR LOCAL AUTHORITY FOR ADVICE.

WARNING: DO NOT HANDLE A HOT OIL FILTER WITH BARE HANDS. CONTINUOUS CONTACT WITH USED MOTOR OIL HAS CAUSED SKIN CANCER IN LABORATORY MICE. PROTECT YOUR SKIN BY WASHING WITH SOAP AND WATER IMMEDIATELY AFTER CONTACT.

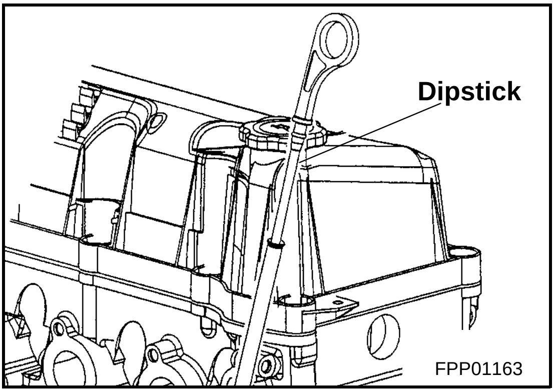
Change Engine Oil

1. Warm the engine to normal operating temperature.
2. Make sure that the equipment is standing level and that the engine is stopped.
3. Obtain a sufficiently large draining pan to accommodate the engine oil -- Refer to “Service Oil fill capacity (including filter):” on page 36.
4. Remove the oil filler cap from the rocker cover, remove the drain plug from the oil pan and drain the oil into the draining pan.

NOTE: Modern high performance oils have a cleaning action on the engine which may turn the oil dark, but does not necessarily indicate inadequate oil changes.

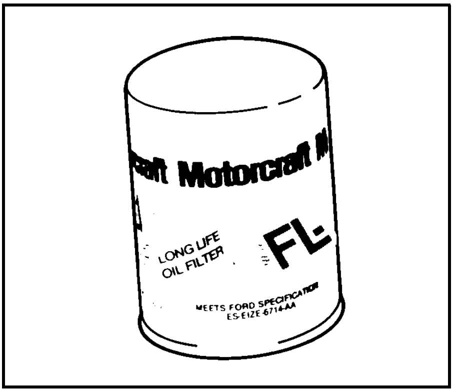
5. Replace and tighten the drain plug, then fill the engine via the filler neck in the rocker cover with the correct quantity of oil -- Refer to “SPECIFICATIONS” on page 36.
6. Replace the oil filler cap and run the engine for no more than 30 seconds.
7. Check the oil level as described in the following section.

Check Engine Oil Level



1. Make sure the equipment is standing level and that the engine is stopped.
2. Pull out the dipstick and wipe it with a clean rag.
3. Insert the dipstick fully and again remove it. At no time should the level of the oil fall below the lower mark on the dipstick.
4. If necessary, top up to the dipstick higher mark with an approved type and grade of oil.
5. Replace the dipstick, ensuring that it is fully inserted into its tube to maintain a sealed crankcase condition

Renew Engine Oil Filter



Your engine is equipped with a Motorcraft oil filter. A filter of this quality should be used throughout the life of the engine. It is designed to protect your engine by filtering harmful abrasive and sludgy particles without clogging up or blocking the flow of the oil to vital engine parts. This filter is especially designed for use in engines built by Ford to give successful operation with the recommended oil filter change intervals. Contact your nearest EDI distributor listed in the back section to obtain the correct filter. Before commencing, place a drain pan beneath the filter to catch any spilt oil.

1. Using a suitable strap wrench, unscrew the oil filter canister.
2. Thoroughly clean oil filter housing face.
3. Partly pre-fill the new filter with clean engine oil of the correct type and grade. Apply a thin film of clean engine oil to the oil filter sealing ring.
4. Screw on new oil filter canister until sealing ring abuts the filter head and tighten a further 1/2 turn. Do NOT use a strap wrench or similar tool to tighten the filter canister.
5. Run engine and check for any leaks from oil filter.
6. Stop engine, allow oil to settle and top up as necessary.

Gasoline Fuel System - EFI

In the event that your engine is equipped with an EFI (Electronic Fuel Injection) system follow normal maintenance service. Any necessary service repairs should be made by your EDI Distributor. The adjusting procedure requires the use of tools which are not readily available to consumers. Please contact EDI Distributors listed in the back section of this manual.

Fuel Filter - EFI

The fuel filter is located between the fuel tank and the fuel pump.

Ignition System - DIS

The Distributorless Ignition System (DIS) used on this engine does not have a distributor or vacuum advance mechanism. Ignition timing is set by design and cannot be readily changed. In the event that the engine is converted to alternative fuels, the timing can be re-set by trained technicians. Please contact an EDI Distributor listed at the back of this manual.

Renew Spark Plugs

Spark plugs are located in the top center of the cylinder head. The ignition system is a Coil-on-plug design, which eliminates the need for a distributor, rotor and wires. Each spark plug is powered by it's own coil located directly above the spark plug. Access to the spark plug is gained by removing the coil retaining bolt and coil.

Electronic Actuator

In the event that your engine is equipped with an electronic actuator, no adjustment can be made.

Check Condition of Ancillary Drive Belts

⚠

WARNING: ENGINE SHOULD BE STOPPED AND ANY REMOTE STARTER DISABLED BEFORE CHECKING BELTS.

The serpentine ancillary belt used to drive the generator and water pump, is tensioned automatically and does not require adjustment.

The belts should be visually inspected for signs of wear or damage. It should be renewed if necessary. Refer to Service Manual.

NOTE: May be purchased from your local EDI Distributor listed on the back of this handbook.

Check Engine Coolant Level

⚠

WARNING: TO REDUCE THE RISK OF INJURY WHEN CHECKING A HOT ENGINE. COVER THE RADIATOR CAP WITH A THICK CLOTH AND TURN IT SLOWLY COUNTER-CLOCKWISE TO THE FIRST STOP. AFTER THE PRESSURE HAS BEEN COMPLETELY RELEASED, PRESS DOWNWARD AND FINISH REMOVING CAP. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD RESULT IN DAMAGE TO THE COOLING SYSTEM OR ENGINE AND/ OR PERSONAL INJURY.

CAUTION: Do not add coolant to an engine that has become overheated until the engine cools. Adding coolant to an extremely hot engine can result in a cracked block or cylinder head.

1. Allow the engine to cool down to 40°C (110°F).
2. Turn the radiator expansion/degas tank filler cap through 90° in a counter-clockwise direction. Pause to allow any pressure to drop, then turn cap fully counterclockwise and remove it.
3. The quantity of coolant in the expansion/degas tank is a direct indication of the coolant level in the complete system. The acceptable level of coolant in the expansion/degas tank is shown by the level indicators moulded into the tank wall. Top up as necessary with a mixture of plain water and antifreeze -- Refer to “Cooling System” on page 28 for information on mixing antifreeze solutions.

NOTE: It is essential that only the correct type of antifreeze is used -- Refer to “Cooling System” on page 28.

4. Replace the filter cap and turn down tightly.

Renew Air Cleaner Element

Your air cleaner filters air entering the engine induction system and acts as a silencer and a flame arrester. Air that contains dirt and grit produces an abrasive fuel mixture, and can cause severe damage to the cylinder walls and piston rings. Damage to the cylinder walls and piston rings will cause high oil consumption and short engine life. A restricted or dirty air cleaner will also cause a rich fuel mixture. Thus, it is extremely important that the air cleaner be serviced at recommended intervals.

CAUTION: Service the air cleaner more frequently under severe dust conditions to prevent engine damage.

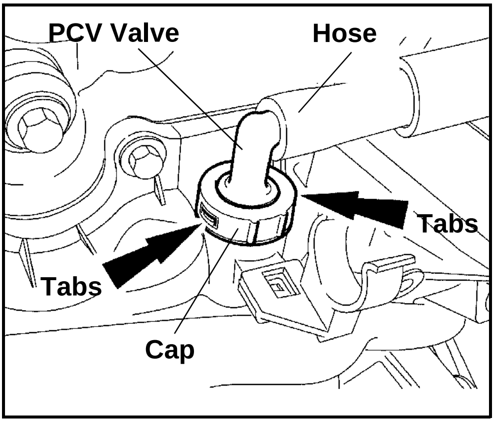
1. Release the air cleaner lid retaining hardware.
2. Lift the air cleaner lid clear of the air cleaner body, then remove the air cleaner element and discard it.
3. Wipe the inside of the air cleaner body and lid clean, using a lint-free rag.
4. Insert the new element, ensuring that it fits properly and install air cleaner lid.

Renew PCV Valve

The PCV valve is located in the oil separator on the left side of engine. Remove and replace as follows:

1. Gently pry cap off of two tabs.
2. Remove hose from PCV valve.
3. Remove PCV valve from oil separator.
4. Reverse procedure to install.

NOTE: A small amount of oil can be used to aid in installation.



GENERAL MAINTENANCE INFORMATION

The following section outlines some aspects of general maintenance which will be of value to the operator.

Cooling System

To obtain maximum engine service life, its operating temperature must be maintained by an efficient cooling system.

CAUTION: Under no circumstances should the engine be started without liquid in the cooling system. This may cause permanent damage to the engine.

CAUTION: The use of straight water as a coolant will cause permanent damage to the engine.

Inspect the exterior of the radiator for obstructions, remove all bugs, dirt or foreign material with a soft brush or cloth.

Use care to avoid damaging the fins. If available, use low pressure compressed air or a stream of water in the opposite direction to normal airflow. Check all hoses and connections for leaks. If any of the hoses are cracked, frayed, or feel spongy, they should be replaced.

CAUTION: Never use a cold coolant mixture to top-up the radiator or degas tank of a hot engine if the coolant level is very low; this could cause serious engine damage.

The radiator or degas tank is equipped with a pressure cap. It is dangerous to remove this when the system is very hot.

WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. TO REDUCE THE RISK OF HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE DEGAS BOTTLE WHEN REMOVING THE PRESSURE RELIEF CAP, WAIT UNTIL THE ENGINE HAS COOLED DOWN TO AT LEAST 40°C (110°F).

1. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

In territories where freezing conditions may occur, the coolant should consist of a mixture of 50% plain water and 50% Motorcraft Premium Gold coolant, or equivalent. This antifreeze contains additional corrosion inhibitors designed to provide lasting protection for the engine.

Motorcraft Premium Gold engine coolant, or equivalent, has long life characteristics and if the concentration is kept to a maximum of 50% it will provide adequate frost protection and inhibiting for the life of the engine.

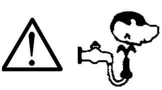
NOTE: If a major component of the cooling system is renewed such as the radiator, water pump etc., the system should be flushed and re-filled with a 50% solution of Motorcraft Premium Gold engine coolant, or equivalent, and clean water.

In territories where the ambient temperature is such that no protection against freezing is required, it is recommended that a 25% concentration of Motorcraft Premium Gold engine coolant, or equivalent, is used. This will protect water pumps, core plugs, thermostat housings and radiators against corrosion for the life of the engine and raise boiling point when used at this concentration. See previous Note on renewing cooling system components.

The antifreeze concentration in a cooling system can be determined by using a suitable hydrometer.

- A reading of 1080 represents a 50% antifreeze concentration.
- A reading of 1040 represents a 25% antifreeze concentration.
- A reading of 1000 represents plain water.

CAUTION: Do not add or mix an orange-colored extended life coolant, such as Motorcraft Specialty Orange engine coolant with factory filled coolant WSS-M97B44-D. Mixing Motorcraft Specialty Orange engine coolant or any orange colored extended life product, with factory filled coolant, can result in degraded corrosion protection.



WARNING: ANTIFREEZE CONTAINS MONO ETHYLENE GLYCOL AND OTHER CONSTITUENTS WHICH ARE TOXIC IF TAKEN INTERNALLY AND CAN BE ABSORBED IN TOXIC AMOUNTS ON REPEATED OR PROLONGED SKIN CONTACT. PERSONS USING ANTIFREEZE ARE RECOMMENDED TO ADHERE TO THE FOLLOWING PRECAUTIONS:

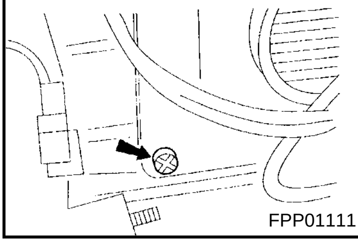
- **ANTIFREEZE MUST NEVER BE TAKEN INTERNALLY. IF ANTIFREEZE IS SWALLOWED ACCIDENTALLY, MEDICAL ADVICE SHOULD BE SOUGHT IMMEDIATELY.**
- **PRECAUTIONS SHOULD BE TAKEN TO AVOID SKIN CONTACT WITH ANTIFREEZE. IN THE EVENT OF ACCIDENTAL SPILLAGE ONTO THE SKIN, ANTIFREEZE SHOULD BE WASHED OFF AS SOON AS PRACTICABLE. IF CLOTHING IS SPLASHED WITH ANTIFREEZE, IT SHOULD BE REMOVED AND WASHED BEFORE BEING WORN AGAIN, TO AVOID PROLONGED SKIN CONTACT.**
- **FOR REGULAR AND FREQUENT HANDLING OF ANTIFREEZE, PROTECTIVE CLOTHING (PLASTIC OR RUBBER GLOVES, BOOTS AND IMPERVIOUS OVERALLS OR APRONS) MUST BE USED TO MINIMIZE SKIN CONTACT.**

Draining, Flushing and Filling the Cooling System

⚠

WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. TO REDUCE THE RISK OF HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE DEGAS BOTTLE WHEN REMOVING THE PRESSURE RELIEF CAP, WAIT UNTIL THE ENGINE HAS COOLED DOWN TO AT LEAST 40°C (110°F).

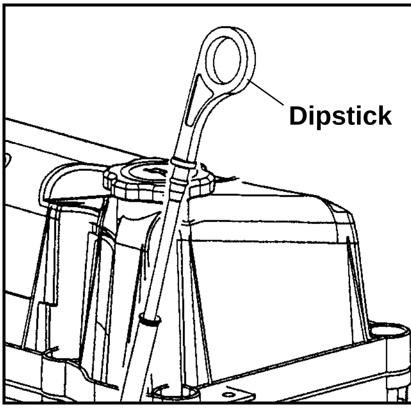
Radiator Drain Cock



1. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.
3. Remove the radiator expansion/ degas tank filler cap, then open the radiator drain cock, where fitted, or detach the bottom radiator hose.
4. Flush the system with water using a hose until clean water emerges and allow all water to drain out. Close the drain cock (or replace the bottom radiator hose). Recover all old antifreeze and dispose of properly. Contact your local municipal government for the proper disposal.
5. Fill the system with the correct coolant mixture via the expansion/degas tank filler neck. Fill the system slowly, to avoid air locks, up to the ‘maximum’ mark on the degas tank.
6. Run engine and check hose connections for leaks. Check, and, if necessary, top up the coolant in the radiator or degas tank.

Engine Lubrication System

The lubrication system should be maintained regularly -- Refer to “RECOMMENDED MAINTENANCE SCHEDULES” on page 21, with the correct grade of lubricant as specified in the maintenance summary -- Refer to “Recommended Lubricants” on page 22. The system is of the force feed type, the lubricating oil being circulated to the engine bearings under pressure by an oil pump driven from the camshaft drive chain belt.



The dipstick provides some guide to the condition of the oil. An additive type of oil keeps soot in suspension, and even a small amount of soot causes the oil to darken rapidly.

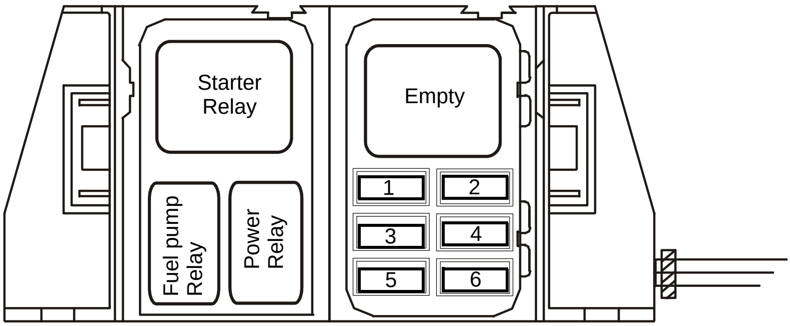
However, if the dipstick is found to be heavily coated with sludge, then obviously the oil should be changed.

Electrical System

A NEGATIVE EARTH (NEGATIVE GROUND) SYSTEM IS USED.

GCP - Power Distribution Box

Part of -5250010- Wiring Harness



Fuse	Amps	Circuits protected
1	10	Battery Voltage to EPR
2	5	Ignition Voltage to GCP and Relays
3	10	Battery Voltage to GCP
4	15	Fuel pump
5	15	Battery Voltage out of Power Relay
6	-	Not used

Generator

This is mounted on a bracket at the front of the engine and is driven from the crankshaft by a serpentine belt.

The charging rate is adjusted automatically by the built-in regulator to provide sufficient electric current to keep the battery fully charged under normal operating conditions.

The generator requires no lubrication or maintenance.

⚠

WARNING: IT IS ESSENTIAL THAT THE WIRING CONNECTIONS TO THE GENERATOR ARE NOT REMOVED WHILE THE ENGINE IS RUNNING, AS THIS WILL RESULT IN DAMAGE TO THE REGULATOR OR PERSONAL INJURY.

Storage

NOTE: It is highly recommended that a fuel stabilizer, Ford Part Number E8AZ-19C544-A or an equivalent additive be used for any length of storage. It is imperative in any application where the fuel will not be consumed within thirty days. Ford Fuel stabilizer comes in an 8 fl.oz. bottle for consumer use and should be available through all EDI Distributors. The correct ratio is 2 oz. Stabilizer to 5 gallons of gasoline. Without the use of an additive, the unused fuel in your fuel tank can and will go sour in a very short period of time, causing varnish and contaminants to form. This causes problems in fuel delivery by clogging fuel injectors.

Storage - One Month

- Add fuel stabilizer (see previous note).
- While the engine is running, treat upper cylinders by spraying engine fogging agent (from your local aftermarket supplier) into the air intake for about two minutes. Open throttle for short burst of speed, shut off engine and allow it to come to a stop while continuing to spray into air intake.
- Leave spark plugs in holes or seal spark plug holes with suitable threaded metal plugs and cover all openings into engine with dust-proof caps or shields (suitable non-hygroscopic material).
- If engine is less transmission, spray flywheel and ring gear with mixture of one part recommended engine oil, and one part Stoddard Solvent or equivalent.
- Check coolant protection. Store indoors in dry area.

Storage - Indefinite Period

- Add fuel stabilizer (see previous note).
- Drain crankcase completely and refill with recommended engine oil, (SAE 10) or equivalent.
- Run engine until completely out of fuel. Gasoline only: Restart and run on unleaded gasoline, mixed with stabilizer, for at least 10 minutes. While engine is still running and at completion of above run, treat upper cylinders by spraying fogging agent into the air intake for about two minutes. Open throttle for short burst of speed, shut off engine and allow it to come to a stop while continuing to spray into air intake.
- Check coolant protection
- Disconnect and remove battery.
- Clean exterior surface of engine.
- Leave spark plugs in holes or seal spark plug holes with suitable threaded metal plugs.
- Seal all openings in engine and accessories with non-hygroscopic material. Mask off all areas to be used for electrical contacts.
- Make sure all surfaces are dry, then spray all taped openings, all engine accessories including ignition wiring, and all exterior surfaces of engine with Insulation Compound.
- If engines are equipped with automotive type clutch, block clutch in slightly disengaged position so that lining and pressure plates are not in contact.

ENGINE SYSTEM CHECK

GCP System Check

NOTE: Items listed in the possible cause column generally do not set a diagnostic trouble code (DTC) or illuminate the MIL light.

NOTE: EDI engines are used in many different applications and equipment. When performing any system diagnosis be aware of any OEM inputs or equipment monitoring devices that may have an effect on the engine's performance or any of the engine's operating systems.

Engine Performance - No Load

SYMPTOM	POSSIBLE CAUSE
Engine Runs Briefly and Shuts Down	• Loss of Spark • Frozen Fuel Regulator (Dry Fuel) • Low Fuel Pressure • Air Inlet Restriction • Wiring Failure • IPM/EPM Failure
Engine Cranks But No Start	• Faulty OEM Drivers Safety Shut-Off Seat Switch • Coil Power Loss • IPM/EPM Ground Loss • IPM/EPM Power Loss • Severe Vacuum Leak (Dry Fuel) • Air Inlet Restriction • Air Inlet Leak (Dry Fuel) • Fuel Lock-Off Inoperative (Dry Fuel) • Wiring Failure • Low Fuel Pressure • Ancillary Components Binding
Engine Runs Poorly	• High Fuel Pressure • Low Fuel Pressure • Contaminated Fuel • Incorrect Fuel Select Table Selected • Wrong IPM/EPM Installed • Actuator Air Blockage • Map Sensor Leak • Fuel Contaminated • Noise Suppression Capacitor Failure • Improper PCV Routing • Valve Timing • Low Cylinder Compression
Engine Cranks Slowly	• Excessive Engine Load (Hydraulic Pump Failing, Binding Ancillary Drive Components) • Low Battery Voltage • Incorrect Battery Specifications • Incorrect Battery Cable Size • Starter Relay • Starter Failure (Excessive Drain)

SYMPTOM	POSSIBLE CAUSE
Engine Does Not Crank	• Dead Battery • Ground Loss • Ancillary Components Binding or Seized • OEM Shutdown - Oil Level Safety • Starter Lockout Relay Failure • Ignition Switch Failure • Bad Starter • Crank Control Wire Failure • Loose Connection or Corrosion

Engine Performance - While Under Load

SYMPTOM	POSSIBLE CAUSE
Engine Stalls/Quits	• Faulty OEM Drivers Safety Shut-off Seat Switch • Low Battery Voltage • Low Fuel Pressure • OEM Safety Shutdowns • Bad MAP Sensor • Air Restriction • Coil Failure • Fuel Mixer Binding (Dry Fuel)
Runs Rough	• Ground Loss • Misrouted Spark Plug Wires • Fuel System Failure • Vacuum Leak • Wiring Failure • Low Fuel Pressure • Spark Plugs Fouled • Incorrect Valve Timing
Misses	• Fuel System Failure • Misrouted Spark Plug Wires • Spark Plug Gap Too High • Spark Plugs Fouled • Cracked Spark Plug Insulator • Incorrect Valve Timing • Compression Loss
Hesitation/Stumble	• Low Fuel Pressure • Spark Plugs Fouled • MAP Sensor Vacuum Signal Loss
Surge	• Low Fuel Pressure • Map Sensor Failure • Application or Ancillary System Momentarily Binding During Load or Unload
Backfires	• Faulty OEM Drivers Safety Shut-off Seat Switch • Fouled Spark Plugs • Spark Plug Wire Broke • IPM/EPM Momentary Ground Loss • Excess Lean Condition • Fuel Lock-Off Leaking (Dry Fuel) • Intake Manifold Leak • Bad Intake Valve

SYMPTOM	POSSIBLE CAUSE
Lack of Power	• Ancillary Components Binding • Intake Air Restriction • Crossed Spark Plug Wires • Spark Plugs Fouled • Fuel System Failure • Low Fuel Pressure • Low Cylinder Compression
Spark Knock	• Poor Quality or Contaminated Fuel • Carbon Build-up • Wrong Spark Plugs (Too High Heat Range) • Fuel Delivery System • PCV System • Fuel Selection Timing • Cylinder Hot Spots

Engine Concerns

SYMPTOM	POSSIBLE CAUSE
Oil System Concerns - High Oil Consumption	• Positive Crankcase Ventilation (PCV) System • Oil Viscosity • External Leaks • Improper Oil Dipstick • Valve Seals • Cylinder Wall Taper Excessive • Worn Piston Rings
Cooling System Concerns	• Trapped Air • Worn Drive Belt • Worn Water Pump • Stuck Thermostat • Plugged Radiator (Internal & External) • Dry Fuel System Running Rich
Exhaust System Concerns (visible smoke) **- Black Smoke**	 • Ignition System • Fuel Delivery System • Sticking Fuel Injector • High Fuel Pressure
- Blue Smoke	• PCV System • Worn Piston Rings • Worn Valve Guides
Fuel System Concerns	• Leaky Lines • Contaminated Fuel • Excessive Alcohol in Fuel • Incorrect Octane Rating
Engine Noise	• Low Oil Pressure • Oil Filter Restriction

SPECIFICATIONS

General Specifications	
Engine Type:	I-4 cylinder 4 stroke spark ignition.
Liter/CID:	2.3 / 140
Bore: mm (inch)	87.5 mm (3.44 in.)
Stroke: mm (inch)	94 mm (3.70 in.)
Number of cylinders:	4
Compression Ratio:	9.7:1

Fuel System	
LPG Type: Fuel Specification:	Liquefied Petroleum Gas Fumigation EN589 (European) HD5 (USA)
NG Type: Fuel Specification:	Natural Gas Fumigation 38.7 MJ/m^3 (UK) 39.0 MJ/m^3 (USA)
Gasoline Fuel Specification:	Gasoline (petrol) Unleaded 87 or 89 Octane (Gasoline blends not to exceed 10% Ethanol by volume Octane Index of 87 or 89).
Fuel Pump Pressure Normal:	75 psi

Lubrication System	
Max. Oil Pressure:	Hot@2000 rpm: 200-268 kPa (29-39 psi)
Oil Type:	Super Premium SAE5W20 WSS M2C930-A
Service Oil fill capacity (including filter):	4.0 qt. (3.78 L) = 3.5 qt. Pan + 0.5 qt. filter
Oil filter	Ford Service Part Number:1S7G 6714 DA Motorcraft: FL 910

Cooling System	
Thermostat:	Type: Wax element Commences opening: 88.9°C Fully open:100°C
Coolant	50% Motorcraft Premium Gold engine coolant plus 50% clear water Ford Specification: WSS-M97B51-A1

Drive Belts	
Front end accessory drive belt & tension	Serpentine belt with automatic tension control.

Electrical System	
Polarity:	Negative to earth (ground)
Battery Capacity:	750 CCA / 140 RC
Generator Drive Belt Tension (8K Poly Belt):	Tension is within specification if the tensioner is within the indicator markings
Generator Output	95 Amp

Ignition System	
Spark Plug (see Note)	Type: AGSF32YPC Gap: 1.25 - 1.35 mm (0.049 - 0.053 in.)
Firing Order	1-3-4-2

TIGHTENING TORQUES

ITEM	Nm	FT. LB.	LB. IN.
Oil Pan Drain Plug	28	21	
Spark Plugs	15	11	
Oil Filter			25-151.6

CONVERSION TABLE

TO CONVERT FROM TO	TO FROM	MULTIPLY BY DIVIDE BY
	Distance	
inches	mm	25.4
inches	m	0.0254
feet	mm	304.8
feet	m	0.3048
yards	m	0.9144
mile	km	1.609
	Area	
in^2	mm^2	645.16
$ft.^2$	m^2	0.0929
yds^2	m^2	0.8361
	Volume	
in^3	cm^3	16.3871
in^3	1 liter	0.016387
pint (us)	1 liter	0.47318
pint (uk)	1 liter	0.56826
quart (us)	1 liter	0.94635
gallon (us)	1 liter	3.7854
gallon (uk)	1 liter	4.5461
$ft.^3$	1 liter	28.3168
$ft.^3$	m^3	0.02832
	Mass	
oz.	g	28.3495
lb.	kg	0.45359
ton (US)	tonne	0.90718
ton (UK)	tonne	1.01605
	FORCE	
lbf	N	4.44822
	PRESSURE & STRESS	
kpa	Bar	0.01
lbf/in^2 (psi)	N/m^2	6894.76
lbf/in^2 (psi)	Bar	0.0689
lbf/in^2 (psi)	N/mm^2	0.00689
lbf/m^2 (psi)	mmHg	51.715
“H2O	mmH2O	25.4
“Hg	mmHG	25.4
ton $(US)/in^2$	N/mm^2	13.7894
ton $(UK)/in^2$	N/mm^2	15.4443
	VELOCITY	
ft./sec.	m/s	0.3048
ft./sec.	km/h	1.09728
miles/h	m/s	0.44694
miles/h	km/h	1.609
	ACCELERATION	
$ft./sec^2$	m/s^2	0.3048
	ENERGY	
Btu	J	1055.06
Kcal	J	4186.8
HP.h	kW.h	0.7457
PS.h	kW.h	0.7355
	TORQUE	
lb./ft.	Nm	1.35582
	POWER	
HP	kW	0.7457
PS	kW	0.7355
HP	PS	1.01387
	SPECIFIC FUEL CONSUMPTION	
lb./hp.h	g/kW.h	608.277

EDI DISTRIBUTORS

AUSTRALIA	Lees Industries Australia PTY Ltd.	1224 Lytton Road Hemmant, Brisbane Wynnum Central Queensland 4178 Australia	: 61-7-3390-5522 : 61-7-3390-7571

Europe

FINLAND	Masino OY	Karkikuja 3, FIN-01740 Vantaa Finland	: 358-9-476-800 : 358-9476-80300
FRANCE	Fornaut S.A.	45, Rue Charles Nodier, 93310 Le-Pre-St.-Gervais France	: 33-148-450-394 : 33-148-457-504
GERMANY	I.M.A -H.-D Groeschler GmbH H.D. Groschler	Westring 41 D-33818 Leopoldshoehe Germany	: 49-5202-987-510 : 49-5202-987-515
	Sauer & Sohn Sauer Motive Systems	Gross Zimmerner Strasse 51 D-64807 Dieburg Germany	: 49-6071-206-330 : 49-6071-206-219
GREAT BRITAIN	Dalton Power Products Ltd. (Main Office)	Unit 6, Autumn Park Industrial Estate Dysart Road, Grantham Lincolnshire NG31 7DD England	: 44-1476-576-666 : 44-1476-577-127
	Dalton Power Products Ltd.	Suite 3, Concord House Concord, Washington Tyne & Wear NE37 1AS England	: 44-191-416-1922 : 44-191-415-3682
	Dalton Power Products Ltd.	Ellesmere Street Manchester M15 4LP England	: 44-161-833-2932 : 44-161-834-8465
	Hendy Power	School Lane Chandlers Ford Industrial Estate, Eastleigh, Hampshire SO53 4DG England	: 44-2380-579-800 : 44-2380-271-471
	Power Torque Engineering	Herald Way, Binley, Coventry Warwickshire CV3 2RQ England	: 44-2476-635-757 : 44-2476-635-878
ITALY	Compagnia Technica Motori S.p.A.	Via Magellano 1, I-20090 Cesano Boscone, (Milano) Italy	: 39-02-450 581 : 39-02-450 582 60/62
SWITZERLAND	Minelli AG	Mattenstr. 3, CH-8330 Pfäeffikon (ZH) Switzerland	: 41-1-950-1720 : 41-1-950-1132

New Zealand

NEW ZEALAND	Lees Industries Group Delta Centre	345 Gt. South Road Takanini Papakura, Auckland New Zealand	: 64-9-299-6019 : 64-9-298-9986

North America - Canada

BRITISH COLUMBIA	Industrial Engines Ltd.	1020 Cliveden Ave. Delta, Annacis Island, British Columbia, Canada, V3M 5R5	: 1-604-525-8529 1-877-438-6560 : 1-604-525-0974
ONTARIO, QUEBEC, MONITOBA	M-K Power Products Corp.	5641 McAdam Road Mississauga, Ontario, Canada, L4Z-1N9	: 1-905-890-5323 CAN 1-800-263-5011 : 1-905-890-6660
ALBERTA, SASKATCHEWAN	Industrial Engines, Ltd.	14335 12th Avenue Edmonton, Alberta Canada, T5L 2R8	: 1-780-484-6213 CAN 1-866-484-6213 : 1-780-732-0400
NOVA SCOTIA, NEW BRUNSWICK, NEW FOUNDLAND, PRINCE EDWARD ISLAND	Lunenburg Industrial Foundry & Engineering	53 Falkland Street, PO 1240 Lunenburg, Nova Scotia Canada, BOJ 2C0	: 1-902-634-8827 : 1-902-634-8886

North America - United States

ALABAMA	M&I Engine Company, Inc.	30762 State Highway 181 Daphne, AL 36526	: 1-251-626-8080 1-800-633-1834 : 1-251-626-2744
ALASKA	E.C. Power Systems	6051 S. 194th Street Kent, WA 98032	: 1-253-872-7011 1-800-247-5899 : 1-253-872-6947
ARIZONA	E.C. Power Systems	8360 E. Via de Ventura Blvd., Suite L-200 Scottsdale, AZ 85258	: 1-480-905-5585 : 1-503-224-3907
ARKANSAS -(Northern)	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
-(Extreme Southern Territory)	Lightbourn Equipment Co.	13649 Beta Road Dallas, TX 75244	: 1-972-233-5151 : 1-972-661-0738
CALIFORNIA	Powertech Engines Inc. (Main Office)	2933 E. Hamilton Avenue Fresno, CA 93721	: 1-559-264-1776 1-800-891-1776 : 1-559-264-2933
	Powertech Engines Inc.	2003 Leghorn Street Mountainview, CA 94043	: 1-650-968-2434 : 1-650-969-1267
	Powertech Engines Inc.	1410 South Acacia Avenue, Suite B Fullerton, CA 92831	: 1-714-635-1774 1-800-784-1776 : 1-714-635-1771
COLORADO	Industrial Power Systems, Inc. Engine Division	3233 Oakland Street Aurora, CO 80010	: 1-303-360-7110 1-800-678-3673 : 1-303-360-7519
CONNECTICUT	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
DELAWARE	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)

North America - United States (Continued)

DISTRICT OF COLUMBIA	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
FLORIDA	Engine Distributors, Inc.	259 Ellis Rd So. Jacksonville, FL 32254	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
GEORGIA - (Western) - (Central)	Engine Distributors, Inc.	303 Interstate Drive Archdale, NC 27263	: 1-336-434-6616 1-800-220-7080 : 1-336-434-6612
- (Southeastern Corner)	Engine Distributors, Inc.	259 Ellis Rd So. Jacksonville, FL 32254	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
HAWAII	Powertech Engines Inc. (Main Office)	2933 E. Hamilton Avenue Fresno, CA 93721	: 1-559-264-1776 1-800-891-1776 : 1-559-264-2933
IDAHO	E.C. Power Systems	4499 Market Street Boise, ID 83705	: 1-208-342-6541 1-800-354-6767 : 1-208-345-4308
ILLINOIS - (Central) - (North Central) - (Northeastern)	Engine Power, Inc.	1830 Executive Drive Oconomowoc, WI 53066	: 1-262-567-8575 1-800-242-2289 : 1-262-567-2556
- (Southern)	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
- (Northwestern)	Anderson Industrial Engines	5532 Center Street Omaha, NE 68106	: 1-402-558-8700 1-800-747-1438 : 1-402-558-8249
INDIANA	Engine Power, Inc.	1830 Executive Drive Oconomowoc, WI 53066	: 1-262-567-8575 1-800-242-2289 : 1-262-567-2556
IOWA	Anderson Industrial Engines	5532 Center Street Omaha, NE 68106	: 1-402-558-8700 1-800-747-1438 : 1-402-558-8249
KANSAS	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
KENTUCKY - (Western)	Engine Power, Inc.	1830 Executive Drive Oconomowoc, WI 53066	: 1-262-567-8575 1-800-242-2289 : 1-262-567-2556
- (Eastern)	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
LOUISIANA	Lightbourn Equipment Co.	13649 Beta Rd., Dallas, TX 75244	: 1-972-233-5151 : 1-972-661-0738
	Lightbourn Equipment Co.	8272 El Rio, Suite 110, Houston, TX 77054	: 1-713-741-2003 : 1-713-741-1909

North America - United States (Continued)

MAINE	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
MARYLAND	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
MASSACHUSETTS	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
MICHIGAN - (Lower Peninsula)	Engine Center, Inc.	2351 Hilton Road Ferndale, MI 48220	: 1-248-399-0002 1-800-726-8870 : 1-248-399-3142
- (Upper Peninsula)	Engine Power, Inc.	1830 Executive Drive Oconomowoc, WI 53066	: 1-262-567-8575 1-800-242-2289 : 1-262-567-2556
MINNESOTA	Northern Power Products, Inc.	2859 Lexington Avenue S. Eagan, MN 55121	: 1-651-452-8900 1-800-284-6247 : 1-651-452-9182(Sales) 1-651-452-9047(Parts)
MISSISSIPPI - (Northern)	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
- (Southern)	Lightbourn Equipment Co.	8272 El Rio, Suite 110, Houston, TX 77054	: 1-713-741-2003 : 1-713-741-1909
MISSOURI	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
MONTANA - (Eastern) - (Central)	Industrial Power Systems, Inc. Engine Division	3233 Oakland Street Aurora, CO 80010	: 1-303-360-7110 1-800-678-3673 : 1-303-360-7519
- (Western)	E.C. Power Systems	4499 Market Street Boise, ID 83705	: 1-208-342-6541 1-800-354-6767 : 1-208-345-4308
NEBRASKA	Anderson Industrial Engines	5532 Center Street Omaha, NE 68106	: 1-402-558-8700 1-800-747-1438 : 1-402-558-8249
NEVADA	Powertech Engines Inc.	2933 E. Hamilton Avenue Fresno, CA 93721	: 1-559-264-1776 1-800-891-1776 : 1-559-264-2933
NEW HAMPSHIRE	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
NEW JERSEY	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)

North America - United States (Continued)

NEW MEXICO - (Southern)	E.C. Power Systems	8360 E. Via de Ventura Blvd., Suite L-200 Scottsdale, AZ 85258	: 1-480-905-5585 : 1-503-224-3907
- (Northern)	Industrial Power Systems, Inc. Engine Division	3233 Oakland Street Aurora, CO 80010	: 1-303-360-7110 1-800-678-3673 : 1-303-360-7519
NEW YORK - (New York City) - (Nassau Co.) - (Suffolk Co.)	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
- (Upstate) - (Hudson Valley)	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
NORTH CAROLINA	Engine Distributors, Inc.	303 Interstate Drive Archdale, NC 27263	: 1-336-434-6616 1-800-220-7080 : 1-336-434-6612
NORTH DAKOTA	Northern Power Products, Inc.	2859 Lexington Avenue S. Eagan, MN 55121	: 1-651-452-8900 1-800-284-6247 : 1-651-452-9182(Sales) 1-651-452-9047(Parts)
OHIO - (Central)	Graham Ford, Inc.	707 W. Broad Street Columbus, OH 43216	: 1-614-464-6006 1-800-837-7070 : 1-614-464-6013
- (Northern)	North Coast Ford Industrial, Inc.	11885 Bellaire Road Cleveland, OH 44135	: 1-216-251-5800 1-800-423-1316 : 1-216-251-8675
- (Southern)	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
OKLAHOMA - (Except Panhandle)	Kansas City Power Products	7714 Melrose Lane Oklahoma City, OK 73127	: 1-405-491-9491 1-800-654-3673 : 1-405-491-9495
- (Panhandle)	Lightbourn Equipment Co.	13649 Beta Road, Dallas, TX 75244	: 1-972-233-5151 : 1-972-661-0738
OREGON	E.C. Power Systems	1805 N.W. 21st Avenue Portland, OR 97210	: 1-503-224-3623 1-800-452-1511 : 1-503-224-3907
PENNSYLVANIA - (Eastern)	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
- (Western)	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
RHODE ISLAND	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)

North America - United States (Continued)

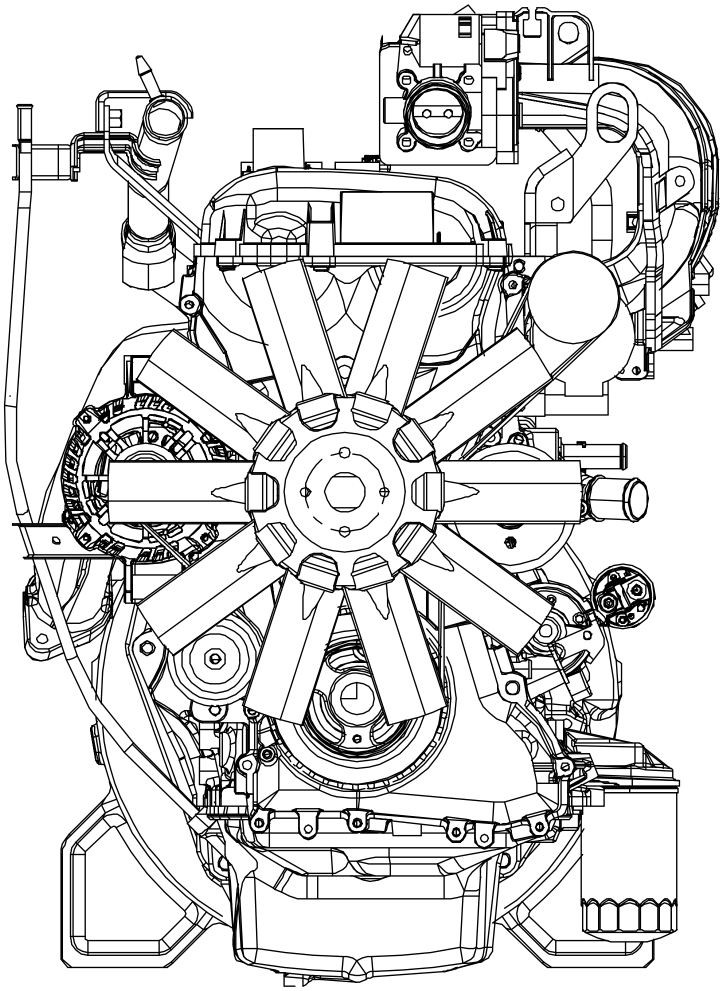
SOUTH CAROLINA	Engine Distributors, Inc.	303 Interstate Drive Archdale, NC 27263	: 1-336-434-6616 1-800-220-7080 : 1-336-434-6612
SOUTH DAKOTA	Northern Power Products, Inc.	2859 Lexington Avenue S. Eagan, MN 55121	: 1-651-452-8900 1-800-284-6247 : 1-651-452-9182(Sales) 1-651-452-9047(Parts)
TENNESSEE - (Central) - (Eastern)	M&I Engine Company, Inc.	30762 Highway 181 Daphne, AL 36526	: 1-251-626-8080 1-800-633-1834 : 1-251-626-2744
- (Western)	Kansas City Power Products, Inc.	80 South James Kansas City, KS 66118	: 1-913-321-7040 1-800-486-5277 : 1-913-321-7341
TEXAS	Lightbourn Equipment Co.	13649 Beta Rd., Dallas, TX 75244	: 1-972-233-5151 : 1-972-661-0738
	Lightbourn Equipment Co.	8272 El Rio, Suite 110, Houston, TX 77054	: 1-713-741-2003 : 1-713-741-1909
UTAH - (Northern)	Industrial Power Systems, Inc. Engine Division	2492 W. Custer Road Salt Lake City, UT 84104	: 1-801-908-8099 1-800-678-3673 : 1-303-360-7519
- (Southern)	E.C. Power Systems	3683 West 2270 South, Suite A, Salt Lake City, UT 84120	: 1-801-886-1424 1-800-462-3370 : 1-801-886-1464
VERMONT	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
VIRGINIA - (Central) - (Eastern)	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	: 1-856-228-7298 1-800-220-2700 : 1-856-228-5657(Parts) 1-856-228-5531(Sales)
- (Southwestern)	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
WASHINGTON	E.C. Power Systems	6051 S. 194th Street Kent, WA 98032	: 1-253-872-7011 US 1-800-247-5899 : 1-253-872-6947
WEST VIRGINIA	Pitt Auto Electric Co. Industrial Engine Division	1241 Freedom Road Cranberry Twp., PA 16066	: 1-724-778-8200 US: 1-800-367-3463 : 1-724-778-8206
WISCONSIN - (Eastern) - (Central)	Engine Power, Inc.	1830 Executive Drive Oconomowoc, WI 53066	: 1-262-567-8575 1-800-242-2289 : 1-262-567-2556
- (Northwestern)	Northern Power Products, Inc.	2859 Lexington Avenue S. Eagan, MN 55121	: 1-651-452-8900 1-800-284-6247 : 1-651-452-9182(Sales) 1-651-452-9047(Parts)
WYOMING	Industrial Power Systems, Inc. Engine Division	3233 Oakland Street Aurora, CO 80010	: 1-303-360-7110 1-800-678-3673 : 1-303-360-7519

Engine Distributors, Inc.
400 University Court
Blackwood, NJ 08012
1-856-228-7298
1-800-220-2700
1-856-228-5657(fax parts)
1-856-228-5531(fax sales)

ENGINE
DISTRIBUTORS
INC.

DSG-423
2.3 LITER

INDUSTRIAL ENGINE SERVICE MANUAL



Powertrain Assemblies
& Components Provided
By Ford Component Sales

Ford
Power
Products

EDI 1060040
AUG, 2007

Section Index

EDI policy is one of continuous improvement and while every effort is made to ensure that this publication is up to date and correct in all respects, the right to change prices, specifications and equipment at any time without notice is reserved. Accordingly this publication is not to be regarded as a final description of any individual engine.

HEALTH & SAFETY

WARNING: THE FOLLOWING HEALTH AND SAFETY RECOMMENDATIONS SHOULD BE CAREFULLY OBSERVED

WARNING: CARRYING OUT CERTAIN OPERATIONS AND HANDLING SOME SUBSTANCES CAN BE DANGEROUS OR HARMFUL TO THE OPERATOR IF THE CORRECT SAFETY PRECAUTIONS ARE NOT OBSERVED. SOME SUCH PRECAUTIONS ARE RECOMMENDED AT THE APPROPRIATE POINTS IN THIS BOOK.

WARNING: WHILE IT IS IMPORTANT THAT THESE RECOMMENDED SAFETY PRECAUTIONS ARE OBSERVED, CARE NEAR MACHINERY IS ALWAYS NECESSARY, AND NO LIST CAN BE EXHAUSTIVE. ALWAYS BE CAUTIOUS TO AVIOD POTENTIAL SAFETY RISKS.

The following recommendations are for general guidance:

1. Always wear correctly fitting protective clothing which should be laundered regularly. Loose or baggy clothing can be extremely dangerous when working on running engines or machinery. Clothing which becomes impregnated with oil or other substances can constitute a health hazard due to prolonged contact with the skin even through underclothing.

2. So far as practicable, work on or close to engines or machinery only when they are stopped. If this is not practicable, remember to keep tools, test equipment and all parts of the body well away from the moving parts of the engine or equipment—fans, drive belts and pulleys are particularly dangerous. The electric cooling fan used on some installations is actuated automatically when the coolant reaches a specified temperature. For this reason, care should be taken to ensure that the ignition/isolating switch is OFF when working in the vicinity of the fan as an increase in coolant temperature may cause the fan suddenly to operate.

3. Avoid contact with exhaust pipes, exhaust manifolds and silencers when an engine is, or has recently been running; these can be very hot and can cause severe burns.

4. Many liquids used in engines or vehicles are harmful if taken internally or splashed into the eyes. In the event of accidentally swallowing gasoline (petrol), oil, diesel fuel, antifreeze, battery acid etc, do NOT encourage vomiting and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

Wear protective goggles when handling liquids which are harmful to the eyes; these include ammonia and battery acid. If any of these substances are splashed in the eyes, wash out thoroughly with clean water and OBTAIN QUALIFIED MEDICAL ASSISTANCE IMMEDIATELY.

WARNING:

WARNING: ENGINE EXHAUST, SOME OF ITS CONSTITUENTS, AND CERTAIN VEHICLE COMPONENTS CONTAIN OR EMIT CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER AND BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM. IN ADDITION, CERTAIN FLUIDS CONTAINED IN VEHICLES AND CERTAIN PRODUCTS OF COMPONENT WEAR CONTAIN OR EMIT CHEMICALS KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER AND BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM.

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all industrial engines 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 reliability.

01

INDEX

Subject **Page**

INDEX (CONT.)

Subject **Page**

GENERAL INFORMATION

Introduction

This section covers various engine tests, adjustments, service procedures and cleaning/inspection procedures. Engine assembly and service specifications appear at the end of the Section 02.

For engine disassembly, assembly, installation, adjustment procedures and specifications, refer to Section 02.

This engine incorporates a closed-type crankcase ventilation system.

To maintain the required performance level, the fuel system, ignition system and engine must be kept in good operating condition and meet recommended adjustment specifications.

Before replacing damaged or worn engine components such as the crankshaft, cylinder head, valve guide, valves, camshaft or cylinder block, make sure part(s) is not serviceable.

WARNING: TO AVOID THE POSSIBILITY OF PERSONAL INJURY OR DAMAGE, DO NOT OPERATE THE ENGINE UNTIL THE FAN BLADE HAS FIRST BEEN EXAMINED FOR POSSIBLE CRACKS OR SEPARATION.

CAUTION: Use of abrasive grinding discs to remove gasket material from the engine sealing surfaces during repair procedures can contribute to engine damage and wear. Airborne debris and abrasive grit from the grinding disc may enter the engine through exposed cavities causing premature wear and eventual engine damage.

Engine Distributors Inc. (EDI) does not recommend using abrasive grinding discs to remove engine gasket material. Use manual gasket scrapers for removing gasket material from the engine sealing surfaces.

Take added care to prevent scratching or gouging aluminum sealing surfaces.

Safety Notice

There are numerous variations in procedures, techniques, tools and parts for servicing equipment, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that neither personal safety nor equipment integrity are compromised by the choice of methods, tools or parts.

Notes, Cautions, and Warnings

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES gives you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the equipment. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on the equipment.

GENERAL WARNINGS:

TO HELP AVOID INJURY:

- **ALWAYS WEAR SAFETY GLASSES FOR EYE PROTECTION.**
- **USE SAFETY STANDS WHENEVER A PROCEDURE REQUIRES YOU TO BE UNDER THE EQUIPMENT.**
- **BE SURE THAT THE IGNITION SWITCH IS ALWAYS IN THE OFF POSITION, UNLESS OTHERWISE REQUIRED BY THE PROCEDURE.**
- **SET THE PARKING BRAKE (IF EQUIPPED) WHEN WORKING ON THE EQUIPMENT. IF YOU HAVE AN AUTOMATIC TRANSMISSION, SET IT IN PARK (ENGINE OFF) OR NEUTRAL (ENGINE ON) UNLESS INSTRUCTED OTHERWISE FOR A SPECIFIC OPERATION. PLACE WOOD BLOCKS (4”X 4” OR LARGER) TO THE FRONT AND REAR SURFACES OF THE TIRES TO PROVIDE FURTHER RESTRAINT FROM INADVERTENT EQUIPMENT MOVEMENT.**
- **OPERATE THE ENGINE ONLY IN A WELL VENTILATED AREA TO AVOID THE DANGER OF CARBON MONOXIDE.**
- **KEEP YOURSELF AND YOUR CLOTHING AWAY FROM MOVING PARTS WHEN THE ENGINE IS RUNNING, ESPECIALLY THE FAN BELTS.**
- **TO PREVENT SERIOUS BURNS, AVOID CONTACT WITH HOT METAL PARTS SUCH AS THE RADIATOR, EXHAUST MANIFOLD, TAIL PIPE, CATALYTIC CONVERTER AND MUFFLER.**
- **DO NOT SMOKE WHILE WORKING ON THE EQUIPMENT.**
- **ALWAYS REMOVE RINGS, WATCHES, LOOSE HANGING JEWELRY, AND LOOSE CLOTHING BEFORE BEGINNING TO WORK ON THE EQUIPMENT. TIE LONG HAIR SECURELY BEHIND THE HEAD.**
- **KEEP HANDS AND OTHER OBJECTS CLEAR OF THE RADIATOR FAN BLADES. ELECTRIC COOLING FANS CAN START TO OPERATE AT ANY TIME BY AN INCREASE IN UNDERHOOD TEMPERATURES, EVEN THOUGH THE IGNITION IS IN THE OFF POSITION. THEREFORE, CARE SHOULD BE TAKEN TO ENSURE THAT THE ELECTRIC COOLING FAN IS COMPLETELY DISCONNECTED WHEN WORKING UNDER THE HOOD.**

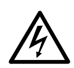
Battery Handling and Charging

The handling and correct use of lead acid batteries is not as hazardous provided that sensible precautions are observed and that operatives have been trained in their use and are adequately supervised.

It is important that all labelling on the battery is carefully read, understood and complied with. The format of the following symbols and labels is common to most brands of lead acid battery.

FPP01101

Typical Battery Labelling

	Explosive gases		Read relevant instructions
	Eye protection must be WORN.		Keep away from children
	No smoking or naked flames.	 Pb	Do not dispose of as household waste.
	Corrosive acid		Recycle (via recognized disposal system).
	Flush eyes immediately when contacted with acid		Electrical current may cause injury to personnel
	Caution/important notice.		

NOTE: Observe all manufacturers' instructions when using charging equipment.

CAUTION: Batteries should not be charged in the vehicle or equipment. May damage electrical components.

Forward

This book contains service information for the engine(s) listed on the title page.

The life of your engine unit and the delivery of the high performance built into it will depend on the care it receives throughout its life. It is the operator's responsibility to ensure that the engine is correctly operated. We consider it to be in your interests to enlist the aid of an authorized EDI Distributor, not only when repairs are required but also for regular maintenance. Distributors are listed at the back of this manual.

Engines manufactured by Ford Motor Company are available through EDI Distributors. When in need of parts or service, contact your local Authorized Distributor. In overseas territories, in the event of difficulties, communicate directly with the supervising EDI affiliated Company in your area whose address appears at the end of this book.

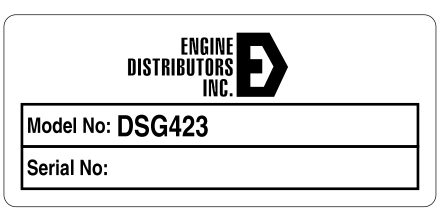
Where the terms "Right" or "Left" occur in this publication, they refer to the respective sides of the engine when viewed from the rear or flywheel end.

Pistons and valves are numbered from the front or timing cover end of the engine commencing at No. 1.

You may find that your engine assembly includes optional equipment not specifically covered in the following text. Nevertheless, the service procedures outlined in this book still apply to your engine.

Engine Identification

Because Ford Power Products markets such a wide range of industrial gasoline and diesel engines - manufactured both in the U.S. and overseas - it is important that you have as complete identification of the engine as possible in order to provide the correct replacement parts. Review the list in the back of this book, for an EDI distributor in your area. You can obtain a standard parts listing describing the parts. It remains a distributor function to identify the part number.



An identification Decal is affixed to the valve cover of the engine. The decal contains the engine serial number which identifies this unit from all others. Use all numbers when seeking information or ordering replacement parts for this engine.

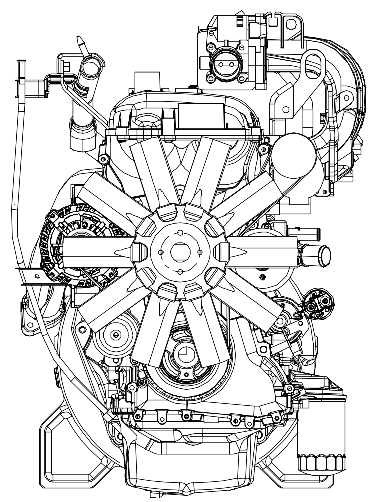
Parts and Service

Replacement parts can be obtained through your local EDI Distributor listed in the back portion of this manual. They also may be found in the yellow pages under "Engines" or contact EDI directly at **1 800 220 2700**.

EDI Distributors are equipped to perform major and minor repairs. They are anxious to see that all of your maintenance and service needs are quickly and courteously completed.

Description and Operation

Section 01 of this manual covers general procedures and diagnosis of the engine system, including base engine repair procedures, that would be common to most engines. Refer to Section 02 for more specific service information on the **DSG-423** engine.

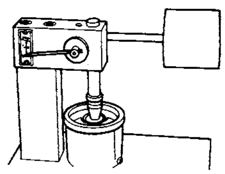
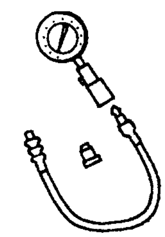
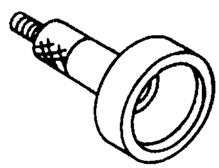
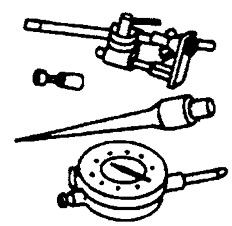
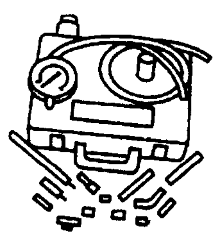
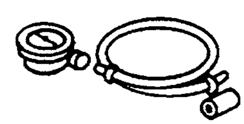


The **DSG-423** engine incorporates a closed positive crankcase ventilation system and an exhaust emission control system.

The engine's, fuel, ignition, emissions system and exhaust system all affect exhaust emission levels and must be maintained according to the maintenance schedule. Refer to the Maintenance and Operator's Handbook or contact your nearest EDI distributor listed in the back of this manual.

DIAGNOSIS AND TESTING

Special Tools

 FPP10023	Commercially Available Leakdown Tester	 FPP10024	Compression Tester 014-00707 or Equivalent
 FPP10025	Cup Shaped Adapter TOOL-6565-AB or Equivalent	 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent
 FPP10027	Engine Cylinder Leak Detection/Air Pressurization Kit 014-00705 or Equivalent	 FPP10028	Engine Oil Pressure Gauge T73L-6600-A
 FPP10029	12 Volt Master UV Diagnostic Inspection Kit 164-R0756 or Equivalent	 FPP10030	Vacuum/Pressure Tester 164-R0253 or Equivalent

Special Service Tools called for by the procedures can be obtained by calling:

1-800-ROTUNDA (1-800-768-8632).

Inspection and Verification

1. Verify the customer concern by operating the engine to duplicate the condition.
2. Visually inspect for obvious signs of mechanical and electrical damage:

- Engine coolant leaks.
- Engine oil leaks.
- Fuel leaks.
- Damaged or severely worn pads.
- Loose mounting bolts, studs, and nuts.

3. If the inspection reveals obvious concerns that can be readily identified, repair as required.
4. If the concerns remain after the inspection, determine the symptoms and go to the symptom chart.

Symptom Chart

Condition	Possible Source	Action
Difficult Starting	Damaged starting system.	Refer to Section 07.
	Damaged charging system/battery.	Refer to Section 06.
	Burnt valve.	Replace valve.
	Worn piston.	Replace piston and pin.
	Worn piston rings or worn cylinder.	Repair or replace cylinder blocks.
	Damaged cylinder head gasket.	Replace cylinder head gasket.
	Damaged fuel system.	Refer to Section 04.
	Damaged ignition system.	Refer to Section 03.
	Spark plugs gapped incorrectly.	Check plug gap.
	Damaged hydraulic tappet or hydraulic lash adjuster.	Replace tappet or lash adjuster.
Poor Idling	Damaged hydraulic lash adjuster or hydraulic lash adjuster.	Replace hydraulic lash adjuster or hydraulic lash adjuster.
	Damaged hydraulic lash adjuster guide or hydraulic lash adjuster.	Replace hydraulic lash adjuster guide or hydraulic lash adjuster.
	Improper valve-to-valve seat contact.	Replace valve or valve seat.
	Damaged cylinder head gasket.	Replace cylinder head gasket.
	Malfunctioning or damaged fuel system.	Refer to Section 04 of this manual*.
	Malfunctioning or damaged ignition system.	Refer to Section 03 of this manual*.
	Spark plugs gapped incorrectly.	Check plug gap.
	Malfunctioning or damaged IAC motor or system.	Refer to Section 03 of this manual.
Abnormal combustion	Damaged hydraulic lash adjuster or hydraulic lash adjuster.	Replace hydraulic lash adjuster or hydraulic lash adjuster
	Damaged hydraulic lash adjuster guide or hydraulic lash adjuster.	Replace hydraulic lash adjuster guide or hydraulic lash adjuster.
	Burnt or sticking valve.	Repair or replace valve.
	Weak or broken valve spring	Replace valve spring
	Carbon accumulation in combustion chamber.	Eliminate carbon buildup.
	Malfunctioning or damaged fuel system	Refer to Section 04 of this manual*.
	Malfunctioning or damaged ignition system.	Refer to Section 03 of this manual*.

Condition	Possible Source	Action
Excessive Oil Consumption	Worn piston ring groove.	Replace piston and pin.
	Sticking piston rings.	Repair or replace piston rings.
	Worn piston or cylinders.	Repair or replace piston or cylinder blocks.
	Worn valve stem seal.	Replace valve stem seal.
	Worn valve stem or valve guide.	Replace valve stem and guide.
	Leaking oil.	Repair oil leakage.
	Worn piston rings.	Replace piston rings.
	Plugged PCV system.	Service PCV system.

Condition	Possible Source	Action
Engine Noise	Excessive main bearing oil clearance.	Adjust clearance or replace main bearing.
	Seized or heat damaged main bearing.	Replace main bearing.
	Excessive crankshaft end play.	Replace crankshaft thrust main bearing.
	Excessive connecting rod bearing oil clearance.	Replace connecting rod.
	Heat damaged connecting rod bearing.	Replace connecting rod bearing.
	Damaged connecting rod bushing.	Replace connecting rod bushing.
	Worn cylinder.	Repair or replace cylinder blocks.
	Worn piston or piston pin.	Replace piston or piston pin.
	Damaged piston rings.	Replace piston rings.
	Bent connecting rod.	Replace connecting rod.
	Malfunctioning hydraulic lash adjuster or hydraulic lash adjuster.	Replace hydraulic lash adjuster or hydraulic lash adjuster.
	Excessive hydraulic lash adjuster or hydraulic lash adjuster clearance.	Adjust clearance or replace hydraulic lash adjuster guide or hydraulic lash adjuster.
	Broken valve spring.	Replace valve spring.
	Excessive valve guide clearance.	Repair clearance or replace valve guide/stem.
	Malfunctioning or damaged cooling system.	Refer to Section 05.
	Malfunctioning or damaged fuel system.	Refer to Section 04.
	Leaking exhaust system.	Repair exhaust leakage.
	Improper drive belt tension.	Refer to Section 05.
	Malfunctioning generator bearing.	Refer to Section 06 for diagnosis and testing of the generator.
	Loose timing chain/belt.	Adjust or replace timing chain/belt.
	Damaged timing belt tensioner.	Replace timing belt tensioner.
	Malfunctioning water pump bearing.	Replace water pump.
Insufficient Power	Malfunctioning hydraulic lash adjuster or hydraulic lash adjuster.	Replace hydraulic lash adjuster or hydraulic lash adjuster.
	Damaged hydraulic lash adjuster guide or hydraulic lash adjuster.	Replace hydraulic lash adjuster guide or hydraulic lash adjuster.
	Compression leakage at valve seat.	Repair or replace valve, valve seat or cylinder head.
	Seized valve stem.	Replace valve stem.
	Weak or broken valve spring.	Replace valve spring.
	Damaged cylinder head gasket.	Replace cylinder head gasket.
	Cracked or distorted cylinder head.	Replace cylinder head.
	Damaged, worn or sticking piston ring(s).	Repair or replace piston ring(s).
	Worn or damaged piston.	Replace piston.
	Malfunctioning or damaged fuel system.	Refer to Section 04.
	Malfunctioning or damaged ignition system.	Refer to Section 03.
	Damaged or plugged exhaust system.	Repair or replace exhaust system.

PCV System Malfunction

A malfunctioning Positive Crankcase Ventilation System (closed type) may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the PCV system and making an air bypass or idle speed adjustment.

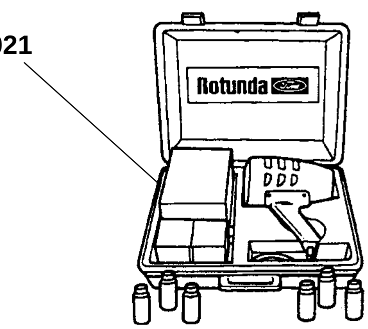
CAUTION: The removal of the PCV system from the engine will adversely affect fuel economy and engine crankcase ventilation with resultant shortening of engine life.

Engine Oil Leaks

NOTE: When diagnosing engine oil leaks, the source and location of the leak must be positively identified prior to service.

Prior to performing this procedure, clean the cylinder block, cylinder heads, valve covers, oil pan and flywheel with a suitable solvent to remove all traces of oil.

Oil Leak Detector Y112-R0021



Fluorescent Oil Additive Method

Use a 12 Volt Master UV Diagnostic Inspection Kit, such as the Rotunda Oil Leak Detector Y112-R0021 or equivalent, to perform the following procedure for oil leak diagnosis.

1. Clean the engine with a suitable solvent to remove all traces of oil.
2. Drain engine oil crankcase and refill with recommended oil, premixed with Diesel Engine Oil Dye 164-R3705 meeting Ford specification ESE-M9C103-B1 or equivalent. Use a minimum 14.8 ml (0.5 ounce) to a maximum 29.6 ml (1 ounce) of fluorescent additive to all engines. If the oil is not premixed, fluorescent additive must first be added to crankcase.
3. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the 12 Volt Master UV diagnostic Inspection Kit. A clear bright yellow or orange area will identify the leak. For extremely small leaks, several hours may be required for the leak to appear.
4. If necessary, pressurize the main oil gallery system to locate leaks due to improperly sealed, loose or cocked plugs.
5. Repair all leaks as required.

Pressure Method

The crankcase can be pressurized to locate oil leaks. The following materials are required to fabricate the tool to be used:

- air supply and air hose
- air pressure gauge that registers pressure in 4 kPa (1 psi) increments
- air line shutoff valve
- appropriate fittings to attach the above parts to oil fill, PCV grommet hole and crankcase ventilation tube
- appropriate plugs to seal any openings leading to the crankcase
- a solution of liquid detergent and water to be applied with a suitable applicator such as a squirt bottle or brush

Fabricate the air supply hose to include the air line shutoff valve and the appropriate adapter to permit the air to enter the engine through the crankcase ventilation tube. Fabricate the air pressure gauge to a suitable adapter for installation on the engine at the oil filler opening.

CAUTION: Use extreme caution when pressurizing crankcase. Applying air pressure above specified pressure risks damage to seals, gaskets and core plugs. Under no circumstances should pressure be allowed to exceed 27 kPa (4 psi)

Testing Procedure

- Open the air supply valve until the pressure gauge maintains 20 kPa (3 psi).
- Inspect sealed or gasketed areas for leaks by applying a solution of liquid detergent and water over areas for formation of bubbles which indicates leakage.

Leakage Points - Above Engine

Examine the following areas for oil leakage.

- valve cover gaskets
- intake manifold gaskets
- cylinder head gaskets
- oil filter
- oil pump (if external)
- oil level indicator tube connection
- oil pressure sensor

Leakage Points - Under Engine

- oil pan gaskets
- oil pan sealer
- oil pan rear seal
- engine front cover gasket

- crankshaft front seal
- crankshaft rear oil seal

Leakage Points - with Flywheel Removed

NOTE: Air leakage in the area around a crankshaft rear oil seal does not necessarily indicate a crankshaft rear oil seal leak. However, if no other cause can be found for oil leakage, assume that the crankshaft rear oil seal is the cause of the oil leak.

NOTE: Light foaming equally around valve cover bolts and crankshaft seals is not detrimental; no repairs are required.

- rear main bearing cap and seals
- flywheel mounting bolt holes (with flywheel installed)
- camshaft rear bearing covers or pipe plugs at the end of oil passages (except for overhead cam)

Oil leaks at crimped seams in sheet metal parts and cracks in cast or stamped parts can be detected when pressurizing the crankcase.

Compression Tests

Compression Gauge Check

1. Make sure the oil in the crankcase is of the correct viscosity and at the proper level and that the battery is properly charged. Operate until the engine is at normal operating temperature. Turn the ignition switch to the OFF position, then remove all the spark plugs.
2. Set the throttle plates in the wide-open position.
3. Install a Compression Tester such as Rotunda Compression Tester 059-R0009, or equivalent, in the No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. With the ignition switch in the OFF position, and using the auxiliary starter switch, crank the engine a minimum of five compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes.

Test Results

The indicated compression pressures are considered within specification if the lowest reading cylinder is within 75 percent of the highest reading. Refer to the Compression Pressure Limit Chart.

If one or more cylinders reads low, squirt approximately one tablespoon of clean engine oil meeting Ford specification ESE-M2C153-E on top of the pistons in the low-reading cylinders. Repeat the compression pressure check on these cylinders.

Example Readings

If, after checking the compression pressures in all cylinders, it was found that the highest reading obtained was 1351 kPa (196 psi), and the lowest pressure reading was 1069 kPa (155 psi), the engine is within specification and the compression is considered satisfactory.

Compression Pressure Limit Chart

MAX-MIN kPa (psi)	MAX-MIN kPa (psi)	MAX-MIN kPa (psi)	MAX-MIN kPa (psi)
924 - 696 (134 - 101)	1131 - 848 (164 - 123)	1338 - 1000 (194 - 146)	1154 - 1158 (224 - 168)
938 - 703 (136 - 102)	1145 - 855 (166 - 124)	1351 - 1014 (196 - 147)	1558 - 1165 (226 - 169)
952 - 717 (138 - 104)	1158 - 869 (168 - 126)	1365 - 1020 (198 - 148)	1572 - 1179 (228 - 171)
965 - 724 (140 - 106)	1172 - 876 (170 - 127)	1379 - 1034 (200 - 150)	1586 - 1186 (230 - 172)
979 - 738 (142 - 107)	1186 - 889 (172 - 129)	1303 - 1041 (202 - 151)	1600 - 1200 (232 - 174)
933 - 745 (144 - 109)	1200 - 903 (174 - 131)	1407 - 1055 (204 - 153)	1055 - 1207 (153 - 175)
1007 - 758 (146 - 110)	1214 - 910 (176 - 132)	1420 - 1062 (206 - 154)	1627 - 1220 (154 - 177)
1020 - 765 (148 - 111)	1227 - 917 (178 - 133)	1434 - 1075 (208 - 156)	1641 - 1227 (238 - 178)
1034 - 779 (150 - 113)	1241 - 931 (180 - 135)	1448 - 1083 (210 - 157)	1655 - 1241 (240 - 180)
1048 - 786 (152 - 114)	1225 - 936 (182 - 136)	1462 - 1089 (212 - 158)	1669 - 1248 (242 - 181)
1062 - 793 (154 - 115)	1269 - 952 (184 - 138)	1476 - 1103 (214 - 160)	1682 - 1262 (244 - 183)
1076 - 807 (156 - 117)	1282 - 965 (186 - 140)	1489 - 1117 (216 - 162)	1696 - 1269 (246 - 184)
1089 - 814 (158 - 118)	1296 - 972 (188 - 141)	1503 - 1124 (218 - 163)	1710 - 1202 (248 - 186)
1103 - 872 (160 - 120)	1310 - 979 (190 - 142)	1517 - 1138 (220 - 165)	1724 - 1289 (250 - 187)
1110 - 834 (161 - 121)	1324 - 993 (192 - 144)	1631 - 1145 (222 - 166)	

Interpreting Compression Readings

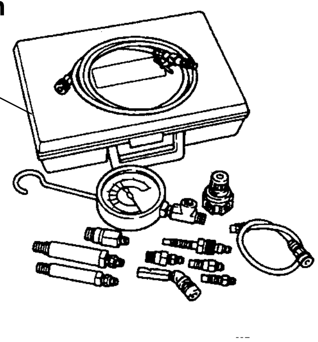
1. If compression improves considerably, with the addition of oil, piston rings are faulty.
2. If compression does not improve with oil, valves are sticking or seating improperly.
3. If two adjacent cylinders indicate low compression pressures and squirting oil on each piston does not increase compression, the head gasket may be leaking between cylinders. Engine oil or coolant in cylinders could result from this condition.

Use the Compression Pressure Limit Chart when checking cylinder compression so that the lowest reading is within 75 percent of the highest reading.

Cylinder Leakage Detection

When a cylinder produces a low reading, use of the Engine Cylinder Leak Detection/Air Pressurization Kit, such as the Rotunda Pressurization Kit 014-00705, or equivalent, will be helpful in pinpointing the exact cause.

Rotunda Pressurization Kit 014-00705



The leakage detector is inserted in the spark plug hole, the piston is brought up to dead center on the compression stroke, and compressed air is admitted.

Once the combustion chamber is pressurized, a special gauge included in the kit will read the percentage of leakage. Leakage exceeding 20 percent is excessive.

While the air pressure is retained in the cylinder, listen for the hiss of escaping air. A leak at the intake valve will be heard in the throttle body. A leak at the exhaust valve can be heard at the tail pipe. Leakage past the piston rings will be audible at the positive crankcase ventilation (PCV) connection. If air is passing through a blown head gasket to an adjacent cylinder, the noise will be evident at the spark plug hole of the cylinder into which the air is leaking. Cracks in the cylinder blocks or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator.

Oil Leak and Valve Stem Seal Test

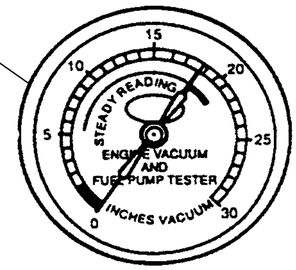
The cylinder leakage detector tests for engine oil leaks and checks the valve stem seals for leakage.

1. Plug all crankcase openings except the one used for connecting the leakage detector.
2. Connect the Engine Cylinder Leak Detection/Air Pressurization Kit to a crankcase opening (an oil level indicator tube is convenient). Adjust the air pressure to approximately 34 kPa (5 psi).
3. Using a solution of liquid soap and water, brush the solution along the gasket sealing surfaces and bearing seals. Look for bubbles or foam.
4. Remove the spark plugs and rotate the crankshaft slowly with a wrench. Check for large amounts of air escaping into the cylinders as each intake valve and exhaust valve opens.
5. The spark plugs on the leaking cylinders will probably show deposits of burned oil.

Intake Manifold Vacuum Test

Bring the engine to normal operating temperature. Connect a Vacuum/Pressure Tester, such as Rotunda Vacuum/Pressure Tester 059-00008 or equivalent, to the intake manifold. Run the engine at the specified idle speed.

Vacuum Pressure Tester 059-00008



The vacuum gauge should read between 51-74 kPa (15-22 in-Hg) depending upon the engine condition and the altitude at which the test is performed. Subtract 5.5 kPa (1 in-Hg) from the specified reading for every 500 meters (1,000 feet) of elevation above sea level.

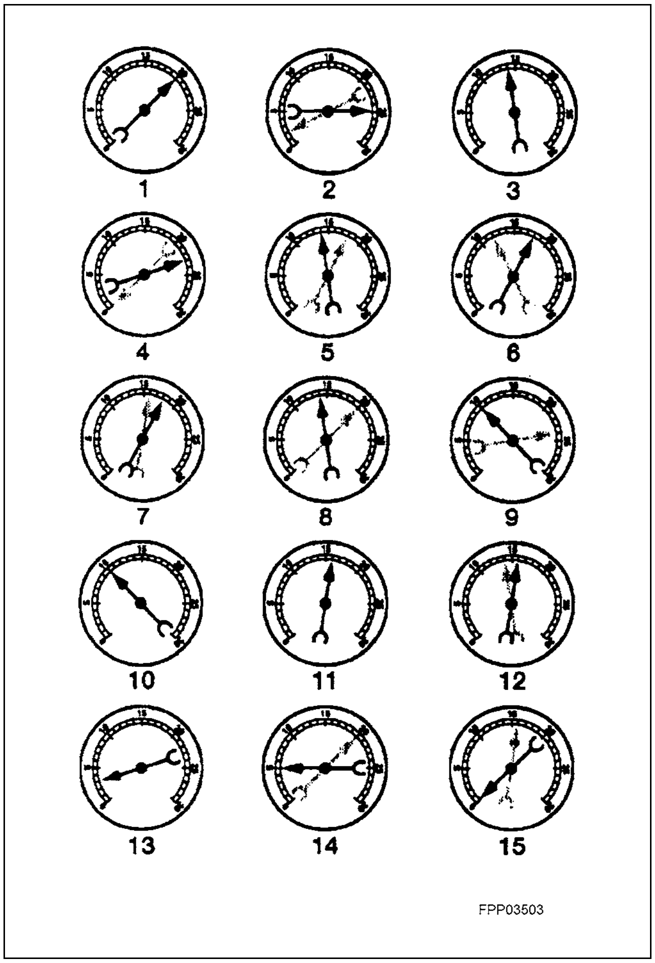
The reading should be quite steady. If necessary, adjust the gauge damper control (where used) if the needle is fluttering rapidly. Adjust the damper until the needle moves easily without excessive flutter.

Interpreting Vacuum Gauge Readings

A careful study of the vacuum gauge reading while the engine is idling will help pinpoint trouble areas. Always conduct other appropriate tests before arriving at a final diagnostic decision. Vacuum gauge readings, although helpful, must be interpreted carefully.

Most vacuum gauges have a normal band indicated on the gauge face.

The following are potential gauge readings. Some are normal; others should be investigated further.



1. NORMAL READING: Needle between 51-74 kPa (15-22 in-Hg) and holding steady.
2. NORMAL READING DURING RAPID ACCELERATION AND DEACCELERATION: When the engine is rapidly accelerated (dotted needle), the needle will drop to a low reading (not to zero). When the throttle is suddenly released, the needle will snap back up to a higher than normal figure.
3. NORMAL FOR HIGH-LIFT CAMSHAFT WITH LARGE OVERLAP: The needle will register as low as 51 kPa (15 in-Hg) but will be relatively steady. Some oscillation is normal.
4. WORN RINGS OR DILUTED OIL: When the engine is accelerated (dotted needle), the needle drops to 0 kPa (0 in-Hg). Upon deceleration, the needle runs slightly above 74 kPa (22 in-Hg).
5. STICKING VALVES: When the needle (dotted) remains steady at a normal vacuum but occasionally flicks (sharp, fast movement) down and back about 13 kPa (4 in-Hg), one or more valves may be sticking.
6. BURNED OR WARPED VALVES: A regular, evenly-spaced, downscale flicking of the needle indicates one or more burned or warped valves. Insufficient hydraulic lash adjuster or hydraulic lash adjuster (HLA) clearance will also cause this reaction.
7. POOR VALVE SEATING: A small but regular downscale flicking can mean one or more valves are not seating.
8. WORN VALVE GUIDES: When the needle oscillates (swings back and forth) over about a 13 kPa (4 in-Hg) range at idle speed, the valve guides could be worn. As engine speed increases, the needle will become steady if guides are responsible.
9. WEAK VALVE SPRINGS: When the needle oscillation becomes more violent as engine rpm is increased, weak valve springs are indicated. The reading at idle could be relatively steady.
10. LATE VALVE TIMING: A steady but low reading could be caused by late valve timing.
11. IGNITION TIMING RETARDING: Retarded ignition timing will produce a steady but somewhat low reading.
12. INSUFFICIENT SPARK PLUG GAP: When spark plugs are gapped too close, a regular, small pulsation of the needle can occur.
13. INTAKE LEAK: A low, steady reading can be caused by an intake manifold or throttle body gasket leak.
14. BLOWN HEAD GASKET: A regular drop of approx. 33-50 kPa (10-15 in-Hg) can be caused by a blown head gasket or warped cylinder head-to-cylinder block surface.
15. RESTRICTED EXHAUST SYSTEM: When the engine is first started and is idled, the reading may be normal, but as the engine rpm is increased, the back pressure caused by a clogged muffler, kinked tail pipe or other concerns will cause the needle to slowly drop to 0 kPa (0 in-Hg). The needle then may slowly rise. Excessive exhaust clogging will cause the needle to drop to a low point even if the engine is only idling.

When vacuum leaks are indicated, search out and correct the cause. Excess air leaking into the system will upset the fuel mixture and cause concerns such as rough idle, missing on acceleration or burned valves. If the leak exists in an accessory unit such as the power brake booster, the unit will not function correctly. Always fix vacuum leaks.

Excessive Engine Oil Consumption

The amount of oil an engine uses will vary with the way the equipment is driven in addition to normal engine-to-engine variation. This is especially true during the first 340 hours or 16,100 km (10,000 miles) when a new engine is being broken in or until certain internal engine components become conditioned. Engines used in heavy-duty operation may use more oil. The following are examples of heavy-duty operation:

- severe loading applications
- sustained high speed operation

Engines need oil to lubricate the following internal components:

- cylinder block, cylinder walls
- pistons, piston pins and rings
- intake and exhaust valve stems
- intake and exhaust valve guides
- all internal engine components

When the pistons move downward, a thin film of oil is left on the cylinder walls. As the engine is operated, some oil is also drawn into the combustion chambers past the intake and exhaust valve stem seals and burned.

The following is a partial list of conditions that can affect oil consumption rates:

- engine size
- operator driving habits
- ambient temperature
- quality and viscosity of the oil

Operating under varying conditions can frequently be misleading. An engine that has been run for short hours or in below-freezing ambient temperatures may have consumed a “normal” amount of oil.

However, when checking engine oil level, it may measure up to the full mark on the oil level dipstick due to dilution (condensation and fuel) in the engine crankcase. The engine might then be run at high speeds where the condensation and fuel boil off. The next time the engine oil is checked, it may appear that a liter (quart) of oil was used in about 3 to 3-1/2 hours.

This perceived 3 to 3-1/2 hours per liter (quart) oil consumption rate causes customer concern even though the actual overall oil consumption rate is about 50 hours per liter (quart).

Make sure the selected engine oil meets Ford specification WSS-M2C153-F and the recommended API performance category “SJ” or higher and SAE viscosity grade as shown in the equipment Owner’s or Operators Engine handbook. It is also important that the engine oil is changed at the intervals specified. Refer to the Engine Operator’s handbook.

Oil Consumption Test

The following diagnostic procedure is used to determine the source of excessive internal oil consumption.

NOTE: Oil use is normally greater during the first 300 hours of service. As hours increase, oil use generally decreases. Engines in normal service should get at least 31.7 hours per quart (900 miles per quart) after 300 hours of service. High speeds, heavy loads, high ambient temperature and other factors may result in greater oil use.

1. Determine customer’s engine load habits, such as sustained high speed operation, extended idle, heavy work loads and other considerations.
2. Verify that the engine has no external oil leak as described under Engine Oil Leaks in the Diagnosis and Testing portion of this section.
3. Verify that the engine has the correct oil level dipstick.
4. Verify that the engine is not being run in an overfilled condition. Check the oil level at least five minutes after a hot shutdown with the engine/vehicle parked on a level surface. In no case should the level be above the top of the cross-hatched area and the letter F in FULL. If significantly overfilled, perform steps 5 through 9. If not proceed to step 10.
5. Drain the engine oil, remove and replace the oil filter and refill with one quart less than the recommended amount.
6. Run the engine for three minutes (10 minutes if cold), and allow the oil to drain back for at least five minutes with the engine/vehicle on a level surface.
7. Remove oil level dipstick and wipe clean.

CAUTION: Do not wipe with anything contaminated with silicone compounds.

8. Reinstall the oil level dipstick, being sure to seat it firmly in the oil level indicator tube. Remove the oil level dipstick and draw a mark on the back (unmarked) surface at the indicated oil level. This level should be about the same as the ADD mark on the face of the oil level dipstick.
9. Add one quart of oil. Restart the engine and allow to idle for at least two minutes. Shut off the engine and allow the oil to drain back for at least five minutes. Mark the oil level dipstick, using the procedure above. This level may range from slightly below the top of the cross-hatched area to slightly below the letter F in FULL.
10. Record the vehicle mileage or hours.

11. Instruct the customer to run engine as usual and perform the following:
    - Check the oil level regularly at intervals of 3 to 3-1/2 hours.
    - Return to the service point when the oil level drops below the lower (ADD) mark on the oil level dipstick.
    - Add only full quarts of the same oil in an emergency. Note the mileage at which the oil is added.
12. Check the oil level under the same conditions and at the same location as in Steps 7-9.
    - Measure the distance from the oil level to the UPPER mark on the oil level dipstick and record.
    - Measure the distance between the two scribe marks and record.
    - Divide the first measurement by the second.
    - Divide the hours run during the oil test by the result. This quantity is the approximate oil consumption rate in hours per quart.
13. If the oil consumption rate is unacceptable, proceed to next step.
14. Check the positive crankcase ventilation (PCV) system. Make sure the system is not plugged.
15. Check for plugged oil drain-back holes in the cylinder heads and cylinder blocks.
16. If the condition still exists after performing the above steps, proceed to next step.
17. Perform a cylinder compression test -- Refer to“Compression Tests” on page 12 or perform a cylinder leak detection test with Engine Cylinder Leak Detection/Air Pressurization Kit -- Refer to“Cylinder Leakage Detection” on page 13. This can help determine the source of oil consumption such as valves, piston rings or other areas.

NOTE: After determining if worn parts should be replaced, make sure correct replacement parts are used.

18. Check valve guides for excessive guide clearances. REPLACE all valve stem seals after verifying valve guide clearance.
19. Worn or damaged internal engine components can cause excessive oil consumption. Small deposits of oil on the tips of spark plugs can be a clue to internal oil consumption. If internal oil consumption still persists, proceed as follows:
    - Remove the engine from the vehicle and place it on an engine work stand. Remove the intake manifolds, cylinder heads, oil pan and oil pump.
    - Check piston ring clearance, ring gap and ring orientation. Repair as required.
    - Check for excessive bearing clearance. Repair as required.
20. Perform the oil consumption test to confirm the oil consumption concern has been resolved.

Oil Pressure Test

1. Disconnect and remove the oil pressure sensor from the engine.
2. Connect the Engine Oil Pressure Gauge and Transmission Test Adapter to the oil pressure sender oil gallery port.
3. Run the engine until normal operating temperature is reached.
4. Run the engine at 3000 rpm and record the gauge reading.
5. The oil pressure should be within specifications.
6. If the pressure is not within specification, check the following possible sources:
    - insufficient oil
    - oil leakage
    - worn or damaged oil pump
    - oil pump screen cover and tube
    - excessive main bearing clearance
    - excessive connecting rod bearing clearance

Valve Train Analysis – Static

With engine off and valve cover removed, check for damaged or severely worn parts and correct assembly. Make sure correct parts are used with the static engine analysis as follows.

Rocker Arm

- Check for loose mounting bolts, studs and nuts.
- Check for plugged oil feed in the rocker arms or cylinder head.

Camshaft Roller Followers and Hydraulic Lash Adjusters

- Check for loose mounting bolts on camshaft carriers.
- Check for plugged oil feed in the camshaft roller followers, hydraulic lash adjusters (HLA) or cylinder heads.

Camshaft

- Check for broken or damaged parts.
- Check the bolts on the intake manifold.

Push Rods (if equipped)

- Check for bent push rods and restricted oil passage.

Valve Springs

- Check for broken or damaged parts.

Valve Spring Retainer and Valve Spring Retainer Keys

- Check for proper seating of the valve spring retainer key on the valve stem and in valve spring retainer.

Valve Spring Retainer Keys

- Check for proper seating on the valve stem.

Valves and Cylinder Head

- Check the head gasket for proper installation.
- Check for plugged oil drain back holes.
- Check for worn or damaged valve tips.
- Check for missing or damaged guide-mounted valve stem seal.
- Check collapsed lash adjuster gap.
- Check installed valve spring height.
- Check for missing or worn valve spring seats.
- Check for plugged oil metering orifice in cylinder head oil reservoir (if equipped).

Static checks (engine off) are to be made on the engine prior to the dynamic procedure.

Valve Train Analysis – Dynamic

Start the engine and, while idling, check for proper operation of all parts. Check the following:

Rocker Arm

- Check for plugged oil in the rocker arms or cylinder head.
- Check for proper overhead valve train lubrication.

If insufficient oiling is suspected, accelerate the engine to 1200 rpm ± 100 rpm with the PTO in NEUTRAL or load removed and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and rocker arms are well oiled or, with the valve covers off, oil splash may overshoot the rocker arms. If oiling is insufficient for this to occur, check oil passages for blockage.

Push Rods (if equipped)

- Check for bent push rods and restriction in oil passage.

Positive Rotator and Valve Spring Retainer Keys

- Check for proper operation of positive rotator.

Valves and Cylinder Head

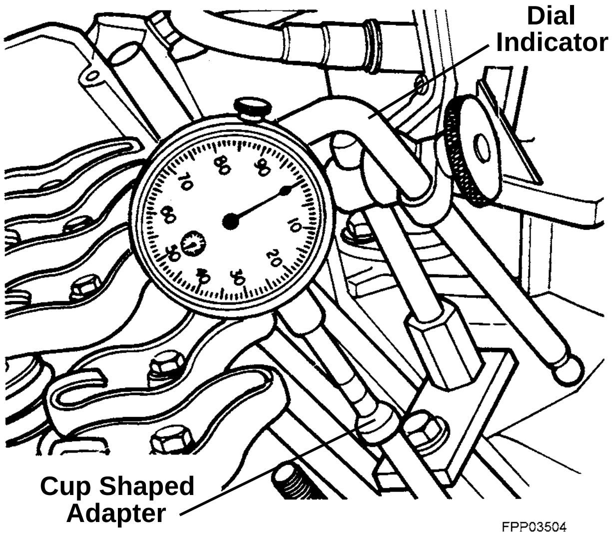
- Check for plugged oil drain back holes.
- Check for missing or damaged valve stem seals or guide mounted valve stem seals.

If insufficient oiling is suspected, check oil passages for blockage, then accelerate the engine to 1200 rpm with the PTO in NEUTRAL or load removed and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and camshaft roller followers are well oiled. With the valve covers off, some oil splash may overshoot camshaft roller followers.

Camshaft Lobe Lift

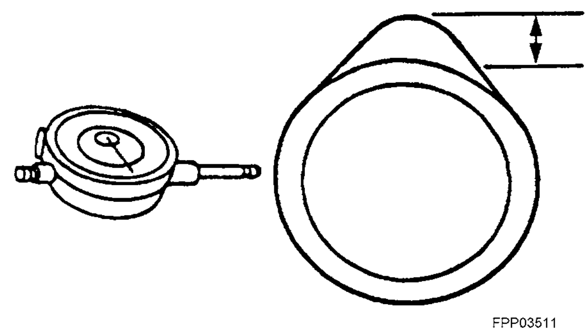
Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the rocker arm seat bolts, rocker arm seat and rocker arms (if equipped).



Typical Engine with Push Rods

3. Make sure the lash adjuster is seated against camshaft. Install the dial Indicator with Bracketry so the ball socket adapter of the indicator is on top of the hydraulic lash adjuster or the Cup Shaped Adapter is on top of the push rod and in the same plane as the lash adjuster push rod movement.
4. On engines with overhead cam, install the dial Indicator with Bracketry so the plunger is on top of the camshaft lobe and in the same plane as the camshaft lobe movement.



5. Remove the spark plugs.
6. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch in the OFF position. Bump the crankshaft over until the indicator is measuring on the base circle of the camshaft lobe (in its lowest position). If checking during engine assembly, turn the crankshaft using a socket or ratchet.
7. Zero the dial indicator. Continue to rotate the crankshaft slowly until the camshaft lobe is in the fully-raised position (highest indicator reading).

NOTE: If the lift on any lobe is below specified service limits, the camshaft and any component operating on worn lobes must be replaced.

8. Compare the total lift recorded on the dial indicator with specifications.
9. To check the accuracy of the original dial indicator reading, continue to rotate the crankshaft until the indicator reads zero.
10. Remove the dial indicator, adapter and auxiliary starter switch.
11. Reinstall components as necessary.

CAUTION: Do not rotate the crankshaft until lash adjusters have had sufficient time to bleed down. To do otherwise may cause serious valve damage. Manually bleeding-down lash adjusters will reduce waiting time.

Hydraulic Valve Lash Adjuster

Hydraulic lash adjuster noise can be caused by any of the following:

- excessively collapsed lash adjuster gap
- sticking lash adjuster plunger
- lash adjuster check valve not functioning properly
- air in lubrication system
- leakdown rate too rapid
- excessive valve guide wear

Excessive collapsed lash adjuster gap can be caused by loose rocker arm seat bolts/nuts, incorrect initial adjustment or wear of lash adjuster face, or worn roller lash adjusters, push rod, rocker arm, rocker arm seat or valve tip. With lash adjuster collapsed, check gap between the valve tip and the rocker arm to determine if any other valve train parts are damaged, worn or out of adjustment.

A sticking lash adjuster plunger can be caused by dirt, chips or varnish inside the lash adjuster.

A lash adjuster check valve that is not functioning can be caused by an obstruction such as dirt or chips that prevent it from closing when the camshaft lobe is lifting the lash adjuster. It may also be caused by a broken check valve spring.

Air bubbles in the lubrication system will prevent the lash adjuster from supporting the valve spring load. This can be caused by too high or too low an oil level in the oil pan or by air being drawn into the system through a hole, crack or leaking gasket on the oil pump screen cover and tube.

If the leakdown time is below the specified time for used lash adjusters, noisy operation can result. If no other cause for noisy lash adjusters can be found, the leakdown rate should be checked and any lash adjusters outside the specification should be replaced.

Assembled lash adjusters can be tested with Hydraulic lash adjuster Leakdown Tester to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance while under a 22.7 kg (50 lb.) load. Test the lash adjusters as follows:

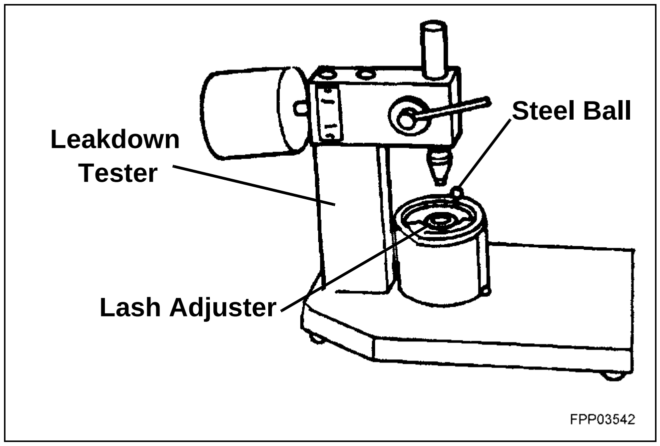
Leakdown Testing

NOTE: Do not mix parts from different hydraulic lash adjusters. Parts are select-fit and are not interchangeable.

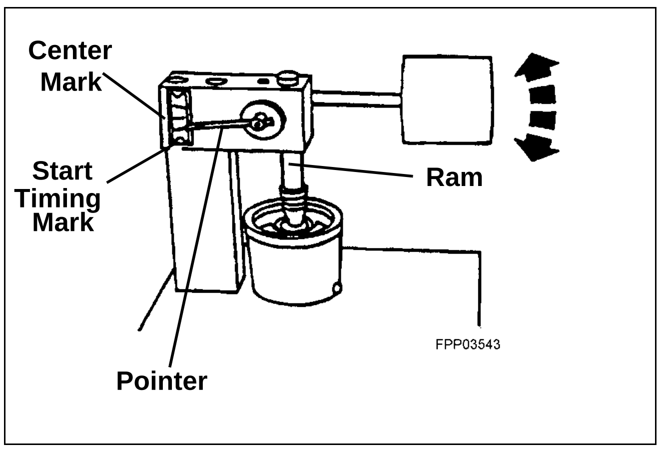
1. Clean the lash adjuster to remove all traces of engine oil.

NOTE: Lash adjusters cannot be checked with engine oil in them. Use only testing fluid. New hydraulic lash adjusters are already filled with testing fluid.

2. Place the lash adjuster in the tester with the plunger facing upward. Position the steel ball provided in the plunger cap. Add testing fluid to cover the hydraulic lash adjuster and compress Leakdown Tester until the hydraulic lash adjuster is filled with testing fluid and all traces of air bubbles have disappeared. The fluid can be purchased from the tester's manufacturer. Using kerosene or any other fluid will not provide an accurate test.



3. Adjust the length of the ram so the pointer is just below the start timing mark when the ram contacts the hydraulic lash adjuster. Start Timing as the pointer passes the start timing mark and end timing as the pointer reaches the center mark.



4. A satisfactory lash adjuster must have a leakdown rate (time in seconds) within specified minimum and maximum limits.
5. If the lash adjuster is not within specification, replace it with a new lash adjuster. Do not disassemble and clean new lash adjusters before testing because oil contained in the new lash adjuster is test fluid.
6. Remove the fluid from the cup and bleed the fluid from the lash adjuster by working the plunger up and down. This step will aid in depressing the lash adjuster plungers when checking valve clearance.

GENERAL SERVICE PROCEDURES

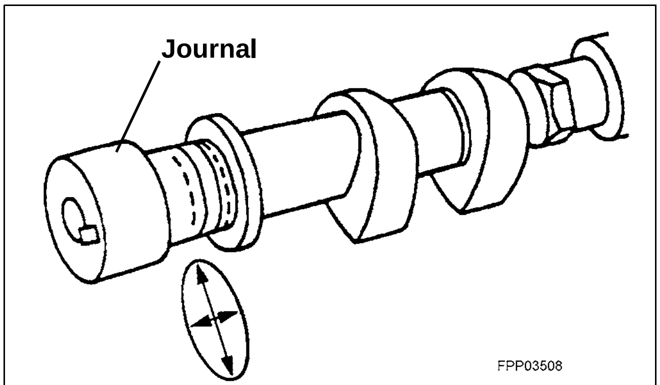
WARNING: TO AVOID THE POSSIBILITY OF PERSONAL INJURY OR DAMAGE TO THE EQUIPMENT, DO NOT OPERATE THE ENGINE UNTIL THE FAN BLADE HAS BEEN EXAMINED FOR POSSIBLE CRACKS AND SEPARATION.

NOTE: Illustrations are typical and may not reflect your particular engine. Specifications show the expected minimum or maximum condition.

NOTE: If a component fails to meet the specifications, it is necessary to replace or refinish. If the component can be refinished, wear limits are provided as an aid to making a decision. Any component that fails to meet specifications and cannot be refinished must be replaced.

Camshaft Journal Diameter

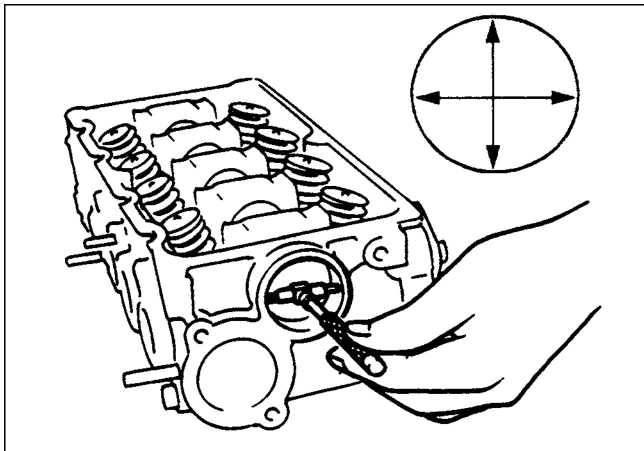
- Measure each camshaft journal diameter in two directions.
- If it is out of specification, replace as necessary.

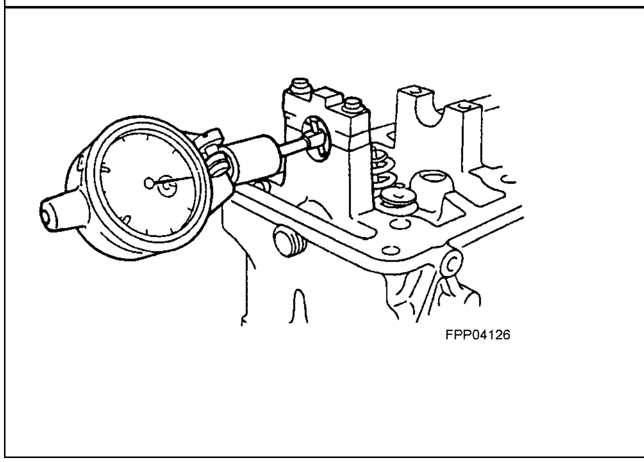


Camshaft Journal Clearance

NOTE: The camshaft journals must meet specifications before checking camshaft journal clearance.

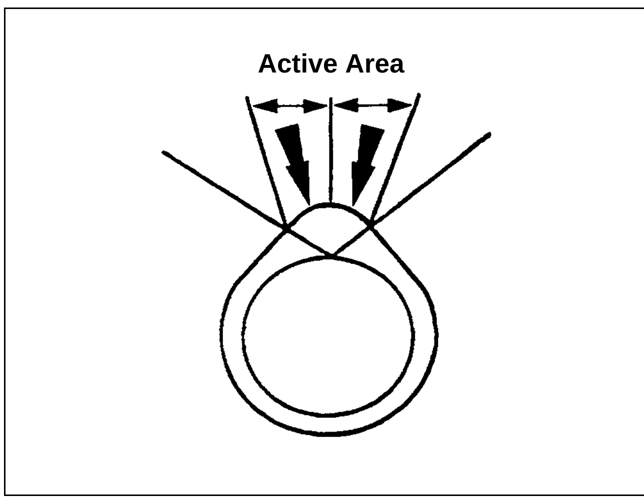
- Measure each camshaft bearing in two directions.
- Subtract the camshaft journal diameter from the camshaft bearing diameter





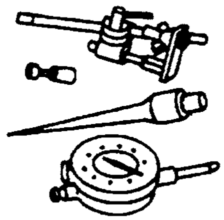
Camshaft Lobe Surface

- Inspect camshaft lobes for pitting or damage in the active area. Minor pitting is acceptable outside the active area
.

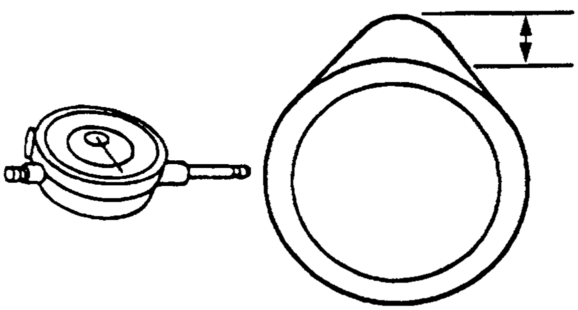


Camshaft Lobe Lift

Special Tool(s)

 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

1. Use the Dial Indicator with Bracketry to measure camshaft intake lobe lift.

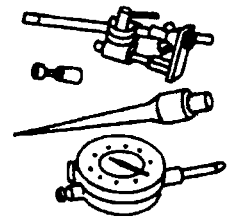


FPP03511

2. Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the camshaft lobe lift.
3. Use the Dial Indicator with Bracketry to measure camshaft exhaust lobe lift.
4. Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the camshaft lobe lift.

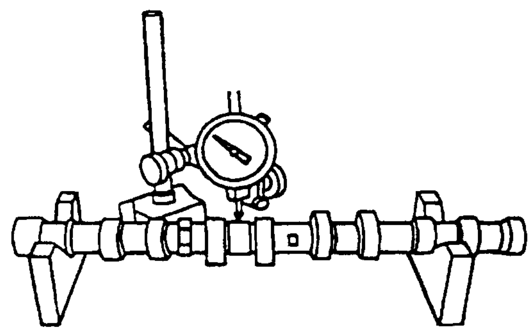
Camshaft Runout

Special Tool(s)

 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: Camshaft journals must be within specifications before checking runout.

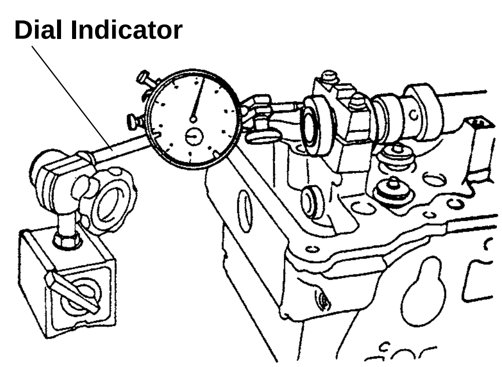
- Use the Dial Indicator with Bracketry to measure the camshaft runout.
- Rotate the camshaft and subtract the lowest dial indicator reading from the highest dial indicator reading.



FPP03512

Camshaft End Play

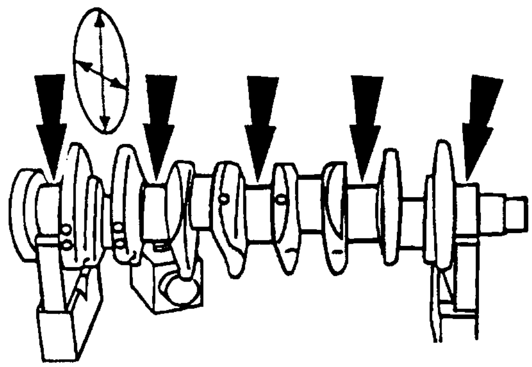
- Move camshaft to the rear.
- Zero dial indicator.
- Move camshaft to the front.
- Compare end play with specifications.



FPP04127

Crankshaft Main Bearing Journal Diameter

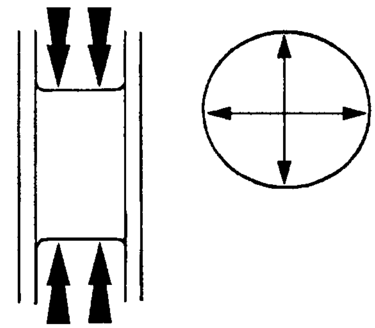
- Measure each of the crankshaft main bearing journal diameters in at least two directions.
- If it is out of specification, replace as necessary.



FPP03513

Crankshaft Main Bearing Journal Taper

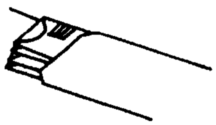
- Measure each of the crankshaft main bearing journal diameters in at least two directions at each end of the main bearing journal.
- If it is out of specifications, replace as necessary.



FPP03514

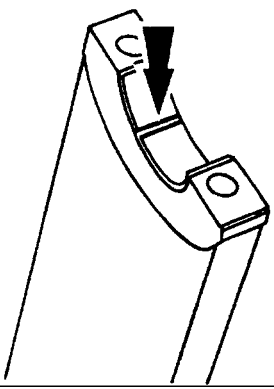
Crankshaft Main Bearing Journal Clearance

Special Tool(s)

 FPP10031	Plastigage® D81L-6002-B or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: Crankshaft main bearing journals must be within specifications before checking journal clearance.

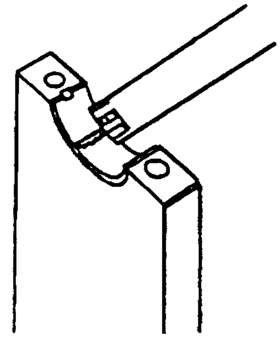
1. Remove the crankshaft main bearing caps and bearings.
2. Lay a piece of Plastigage® across the face of each crankshaft main surface.



FPP03515

NOTE: Do not turn the crankshaft while doing this procedure.

3. Install and remove the crankshaft main bearing cap.
4. Verify the crankshaft journal clearance.
   - If it is out of specification, replace as necessary

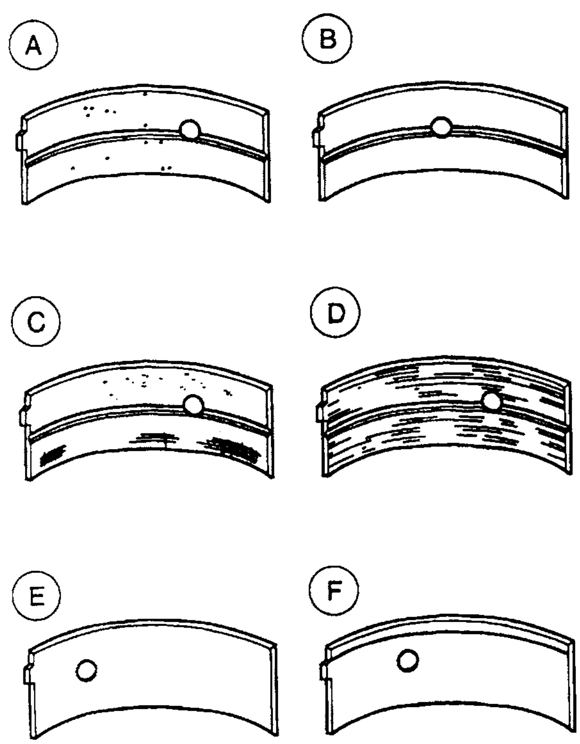


FPP03516

Bearing Inspection

Inspect bearings for the following defects. Possible causes are shown:

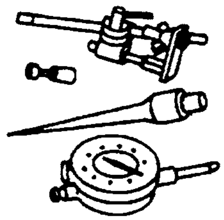
- Cratering – fatigue failure (A)
- Spot polishing – improper seating (B)
- Scratching – dirty (C)
- Base exposed – poor lubrication (D)
- Both edges worn – journal damaged (E)
- One edge worn – journal tapered or bearing not seated (F)



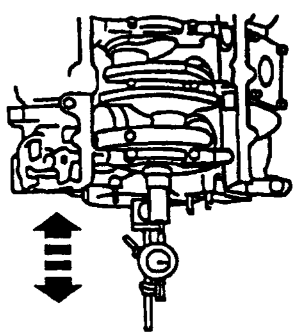
FPP03517

Crankshaft End Play

Special Tool(s)

 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

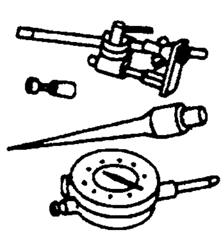
1. Measure the crankshaft end play. Use the Dial Indicator with Bracketry to measure crankshaft end play.
2. Position the crankshaft to the rear of the cylinder block.
3. Zero the Dial Indicator with Bracketry.


FPP03518

4. Move the crankshaft to the front of the cylinder block. Note and record the camshaft end play.
   - If camshaft end play exceeds specifications, replace the crankshaft thrust washers or thrust bearing.

Crankshaft Runout

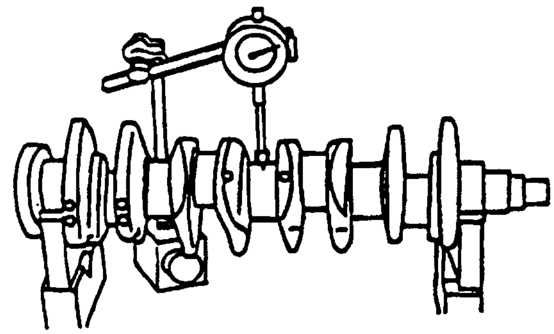
Special Tool(s)

 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: Crankshaft main bearing journals must be within specifications before checking runout.

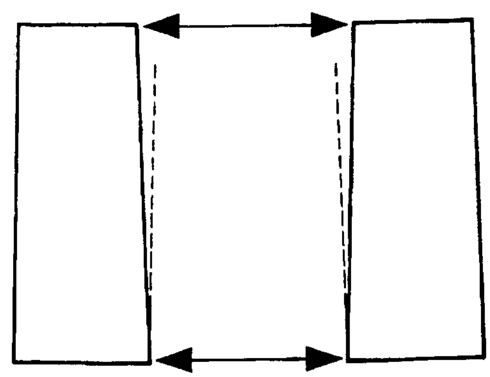
Use the Dial Indicator with Bracketry to measure the crankshaft runout.

- Rotate the crankshaft and subtract the lowest dial indicator reading from the highest dial indicator reading to figure the crankshaft runout. If it is out of specification, replace as necessary.


FPP03519

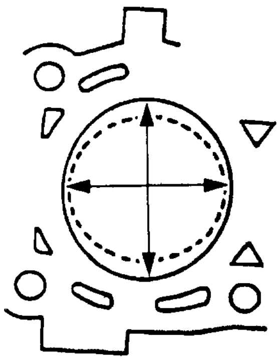
Cylinder Bore Taper

Measure the cylinder bore at the top and bottom. Verify the cylinder bore is within the wear limit. The difference indicates the cylinder bore taper. Bore the cylinder to the next oversize.


FPP03520

Cylinder Bore Out-of-Round

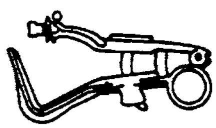
Measure the cylinder bore in two directions. The difference is the out-of-round. Verify the out-of-round is within the wear limit and bore the cylinder to the next oversize limit.



FPP03521

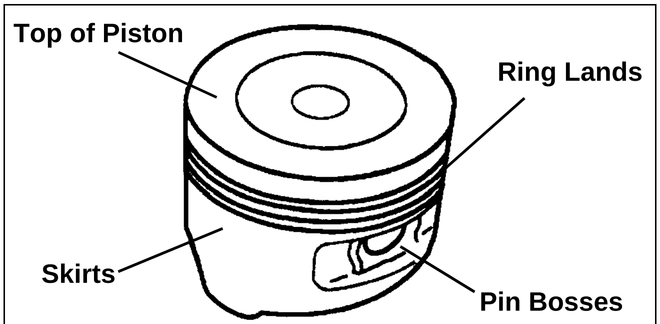
Piston Inspection

Special Tool(s)

 FPP10032	Piston Ring Groove Cleaner D81L-6002-D or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

CAUTION: Do not use a caustic cleaning solution or a wire brush to clean the pistons or possible damage can occur.

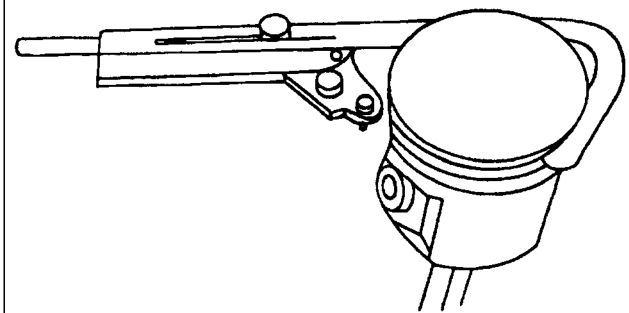
1. Clean and inspect the ring lands, skirts, pin bosses, and the tops of the pistons. If wear marks or polishing is found on the piston skirt, check for a bent or twisted connecting rod.



FPP03522

2. Use the Piston Ring Groove Cleaner to clean the piston ring grooves.

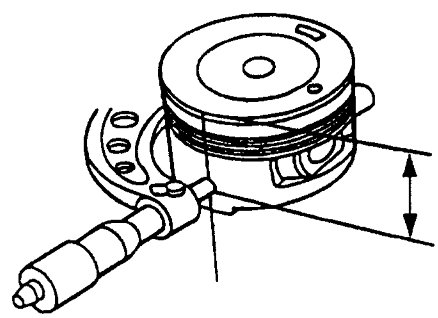
- Make sure the oil ring holes are clean.



FPP03523

Piston Diameter

- Measure the piston skirt diameter.



FPP03524

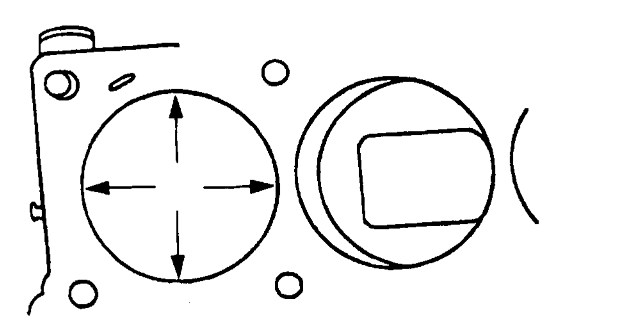
Piston to Cylinder Bore Clearance

Subtract the piston diameter from the cylinder bore diameter to find the piston-to-cylinder bore clearance.

Piston Selection

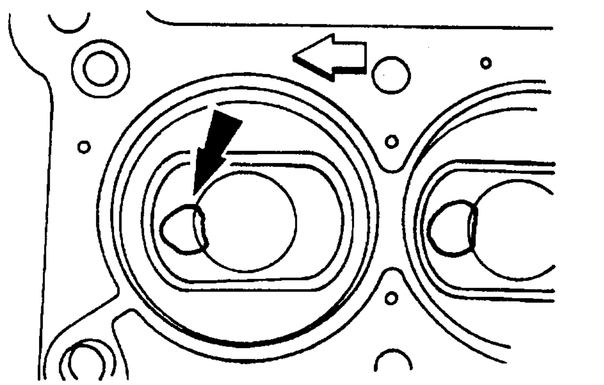
NOTE: The cylinder bore must be within the specifications for taper and out-of-round before fitting a piston.

1. Select a piston size based on the cylinder bore.



FPP03525

NOTE: For precision fit, new pistons are divided into three categories within each size range based on their relative position within the range. A paint spot on the new pistons indicates the position within the size range.

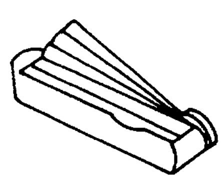


FPP03526

2. Choose the piston with the proper paint color.
   - Red – in the lower third of the size range.
   - Blue – in the middle third of the size range.
   - Yellow – in the upper third of the size range.

Piston Ring End Gap

Special Tool(s)

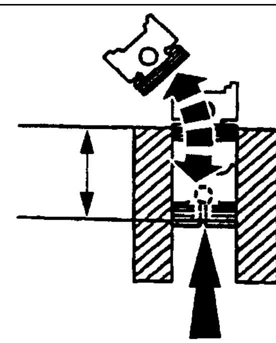
 FPP10033	Feeler Gauge D81L-4201-A or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

CAUTION: Use care when fitting piston rings to avoid possible damage to the piston ring or the cylinder bore.

CAUTION: Piston rings should not be transferred from one piston to another to prevent damage to cylinder worn or piston.

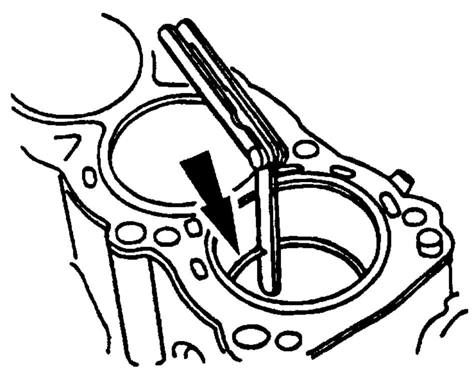
NOTE: Cylinder bore must be within specification for taper and out-of-round to fit piston rings.

1. Use a piston without rings to push a piston ring in a cylinder to the bottom of ring travel.



FPP03527

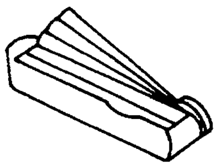
2. Use a feeler gauge to measure the top piston ring end gap and the second piston ring end gap.



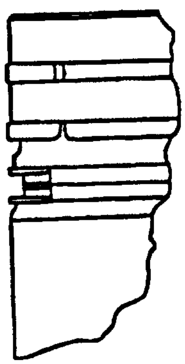
FPP03528

Piston Ring-to-Groove Clearance

Special Tool(s)

 FPP10033	Feeler Gauge D81L-4201-A or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

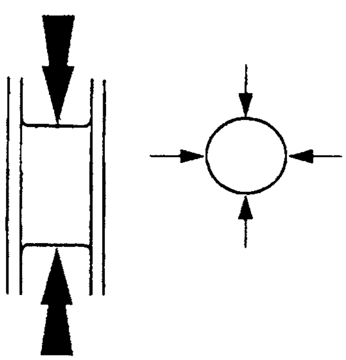
1. Inspect for a stop in the grooves.
2. Measure the piston-to-groove clearance.



FPP03529

Crankshaft Connecting Rod Journal Diameter

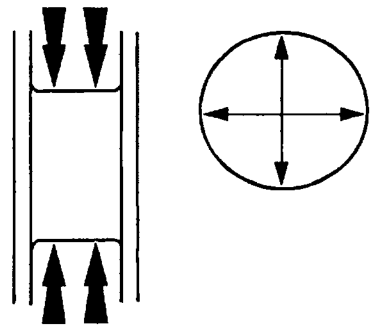
- Measure the crankshaft connecting rod journal diameters in at least two directions perpendicular to one another. The difference between the measurements is the out-of-round. Verify the journal is within the wear limit specification.



FPP03530

Crankshaft Connecting Rod Journal Taper

- Measure the crankshaft rod journal diameters in two directions perpendicular to one another at each end of the connecting rod journal. The difference in the measurements from one end to the other is the taper. Verify measurement is within the wear limit.



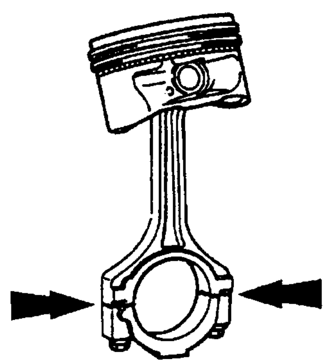
FPP03531

Connecting Rod Cleaning

CAUTION: Do not use a caustic cleaning solution or damage to connecting rods can occur.

NOTE: The connecting rod large end is mechanically split or cracked to produce a unique parting face. This produces a locking joint. Parts are not interchangeable.

- Mark and separate the parts and clean with solvent. Clean the oil passages.

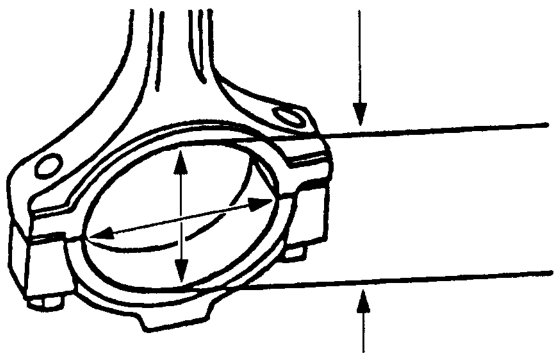


FPP03532

Connecting Rod Larger End Bore

CAUTION: The connecting rod bolts are torque to yield and must be discarded and replaced after this diagnostic test.

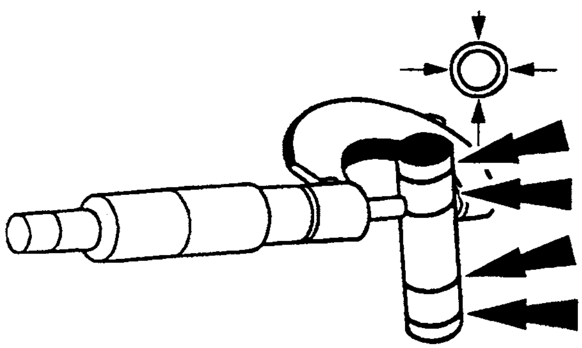
- Measure the bore in two directions. The difference is the connecting rod bore out-of-round. Verify the out-of-round is within specification.



FPP03533

Piston Pin Diameter

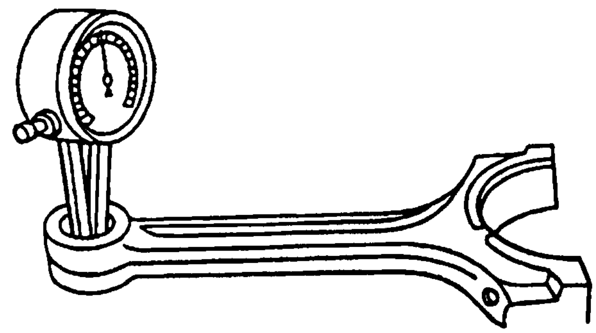
- Measure the piston pin diameter in two directions at the points shown. Verify the diameter is within specifications.



FPP03534

Connecting Rod Bushing Diameter

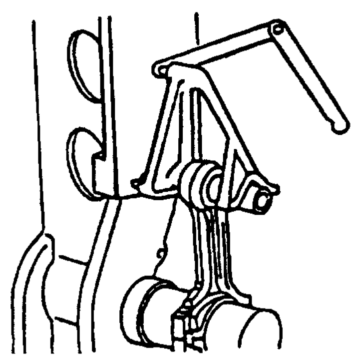
- Measure the inner diameter of the connecting rod bushing. Verify the diameter is within specification.



FPP03535

Connecting Rod Bend

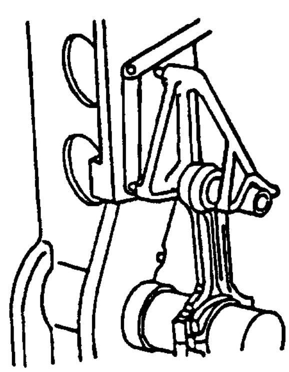
- Measure the connecting rod bend on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the bend measurement is within specification.



FPP03536

Connecting Rod Twist

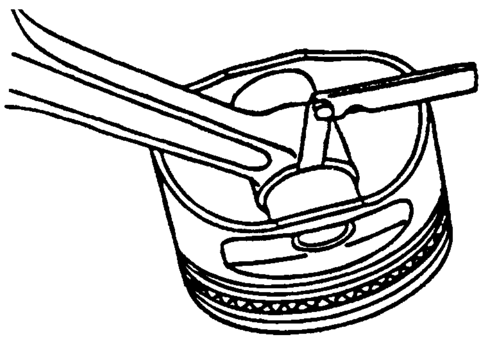
- Measure the connecting rod twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the measurement is within specification.



FPP03537

Connecting Rod Piston Pin Side Clearance

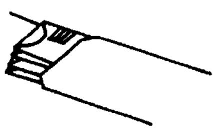
- Measure the clearance between the connecting rod and the piston. Verify the measurement is within specification.



FPP03538

Connecting Rod Journal Clearance

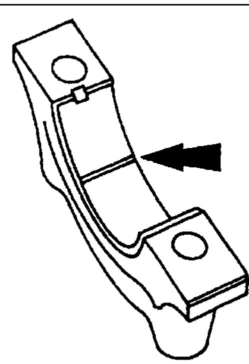
Special Tool(s)

 FPP10031	Plastigage® D81L-6002-B or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: The crankshaft connecting rod journals must be within specifications to check the connecting rod bearing journal clearances.

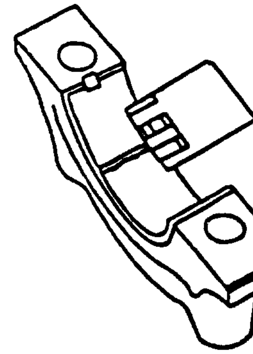
CAUTION: The connecting rod bolts are torque to yield and must be discarded and replaced after this diagnostic test.

1. Remove the connecting rod bearing cap.
2. Position a piece of Plastigage® across the bearing surface.



NOTE: Do not turn the crankshaft during this step.

3. Install and torque to specifications, then remove the connecting rod bearing cap.
4. Measure the Plastigage® to get the connecting rod bearing journal clearance. The Plastigage® should be smooth and flat. A change width indicates a tapered or damaged connecting rod bearing or connecting rod.

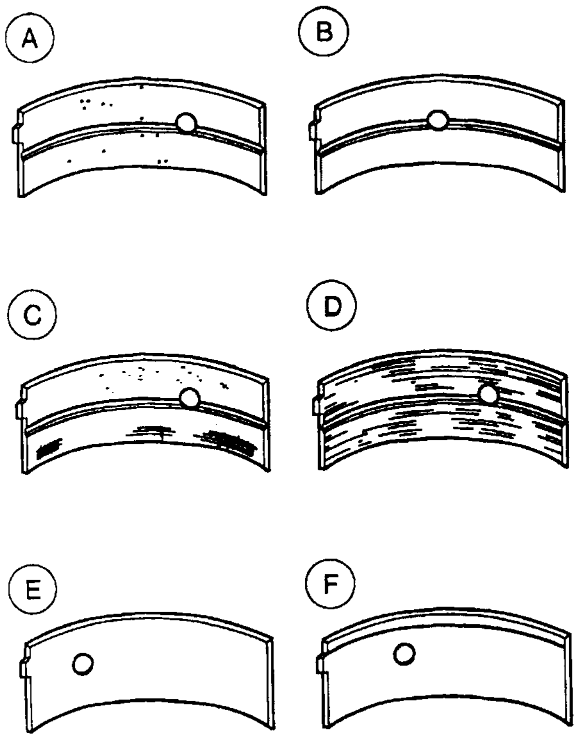


FPP03540

Bearing Inspection

Inspect bearings for the following defects. Possible causes are shown:

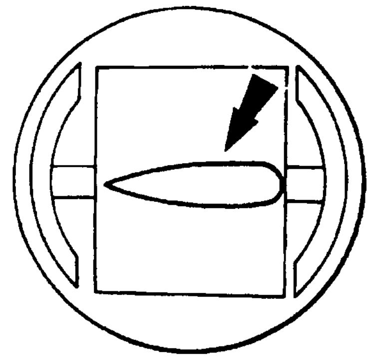
- Cratering – fatigue failure (A)
- Spot polishing – improper seating (B)
- Scratching – dirty (C)
- Base exposed – poor lubrication (D)
- Both edges worn – journal damaged (E)
- One edge worn – journal tapered or bearing not seated (F)



FPP03517

Roller Follower Inspection

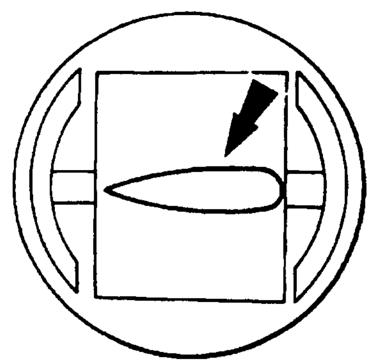
- Inspect the roller for flat spots or scoring. If any damage is found, inspect the camshaft lobes and hydraulic lash adjusters for damage.



FPP03541

Hydraulic Lash Adjuster Inspection

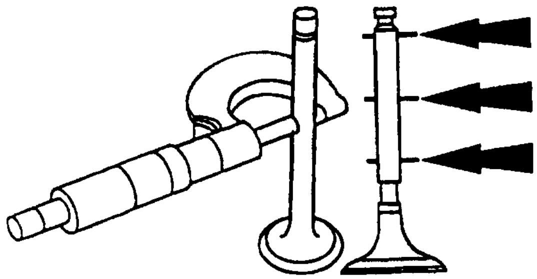
- Inspect the hydraulic lash adjuster and roller for damage. If any damage is found, inspect the camshaft lobes and valves for damage.



FPP03541

Valve Stem Diameter

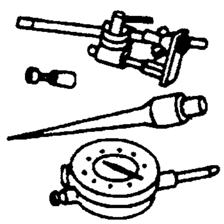
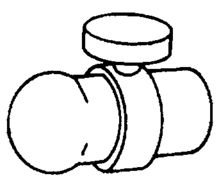
- Measure the diameter of each intake and exhaust valve stem at the points shown. Verify the diameter is within specification.



FPP03544

Valve Stem-to-Valve Guide Clearance

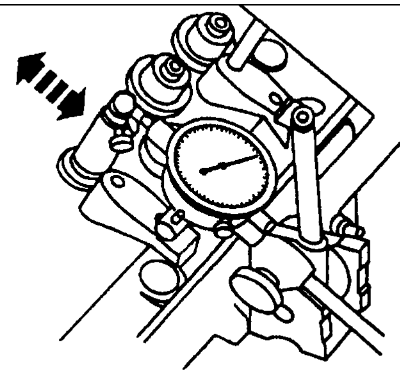
Special Tool(s)

 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent
 FPP10034	Valve Stem Clearance Tool TOOL-6505-E or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: Valve stem diameter must be within specifications before checking valve stem to valve guide clearance.

NOTE: If necessary, use a magnetic base.

1. Install the Valve Stem Clearance Tool on the valve stem and install the Dial Indicator with Bracketry. Lower the valve until the Valve Stem Clearance Tool contacts the upper surface of the valve guide.
2. Move the Valve Stem Clearance Tool toward the Dial Indicator and zero the Dial Indicator. Move the Valve Stem Clearance Tool away from the Dial Indicator and note the reading. The reading will be double the valve stem-to-valve guide clearance. Valves with oversize stems will need to be installed if out of specification.

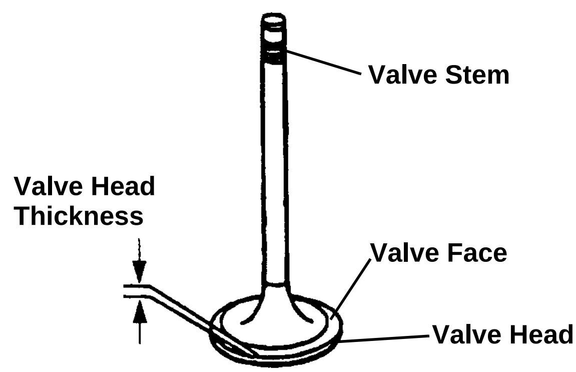


FPP03545

Valve Inspection

Inspect the following valve areas:

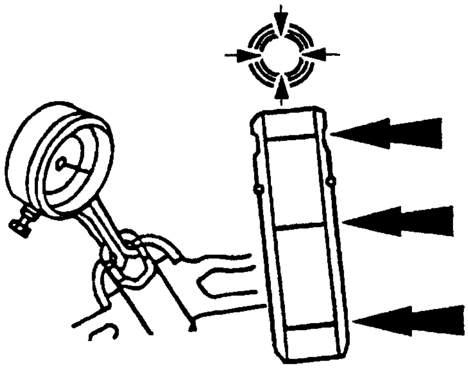
- The end of the stem for grooves or scoring.
- The valve face and the edge for pits, grooves or scores.
- The valve head for signs of burning, erosion, warpage and cracking. Minor pits, grooves and other abrasions may be removed.
- The valve head thickness for wear.



FPP03546

Valve Guide Inner Diameter

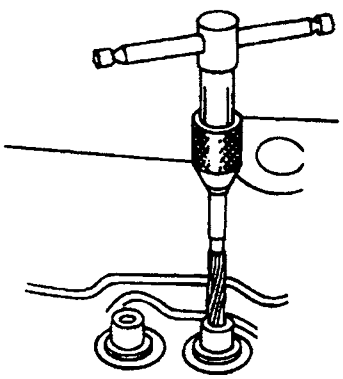
1. Measure the inner diameter of the valve guides in two directions where indicated.
2. If the valve guide is not within specifications, ream the valve guide and install a valve with an oversize stem or remove the valve guide and install a new valve guide.



FPP03547

Valve Guide Reaming

1. Use a hand-reaming kit to ream the valve guide.

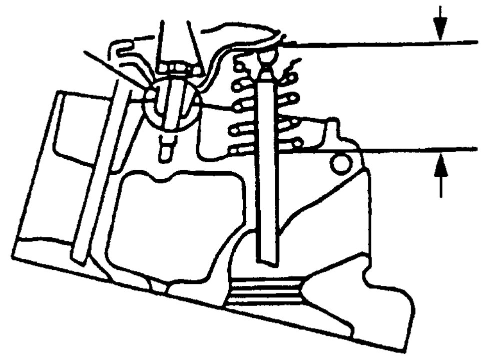


FPP03548

2. Reface the valve seat.
3. Clean the sharp edges left by reaming.

Valve Spring Installed Length

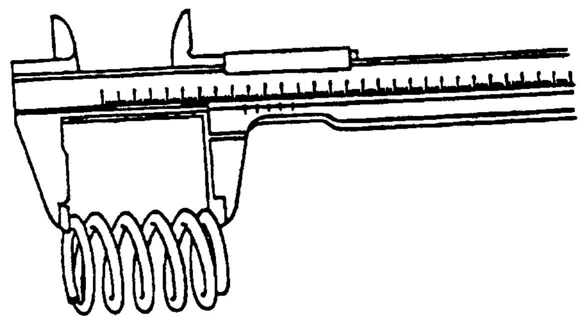
- Measure the installed length of each valve spring.



FPP03549

Valve Spring Free Length

- Measure the free length of each valve spring.

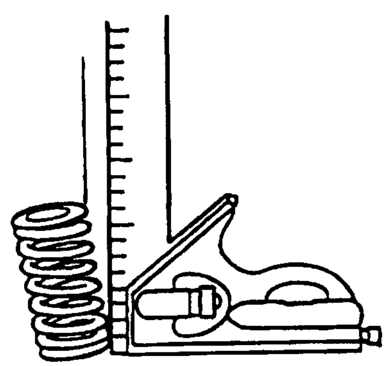


FPP03550

Valve Spring Out-of-Square

Measure the out-of-square on each valve spring.

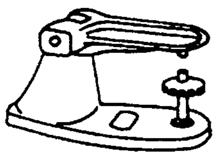
- Turn the valve spring and observe the space between the top of the valve spring and the square. Replace the valve spring if out of specification.



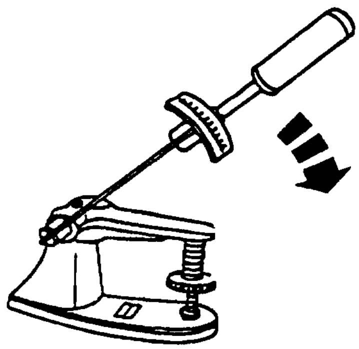
FPP03551

Valve Spring Compression Pressure

Special Tool(s)

 FPP10035	Valve/Clutch Spring Tester TOOL-6513-DD or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

- Use the Valve/Clutch Spring Tester to check the valve springs for proper strength at the specified valve spring length.

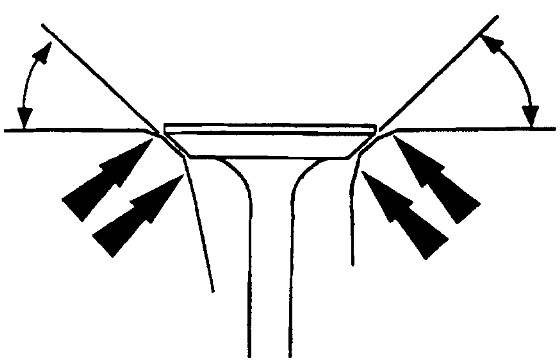


FPP03552

Valve and Seat Refacing Measurements

NOTE: After grinding valves or valve seats, check valve clearance.

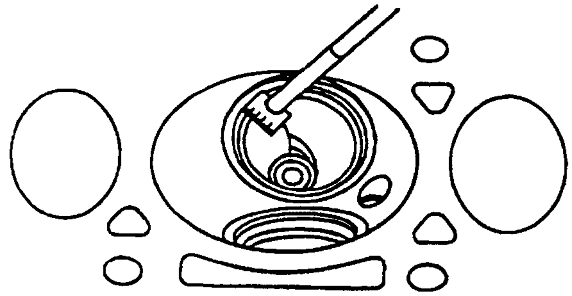
- Check the valve seat and valve angles.



FPP03553

Valve Seat Width

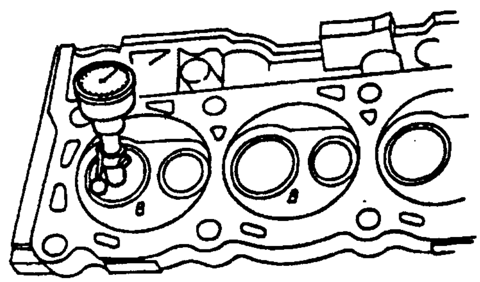
- Measure the valve seat width. If necessary, grind the valve seat to specification.



FPP03554

Valve Seat Runout

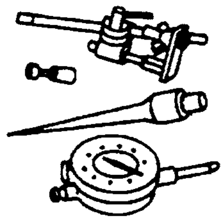
- Use the Valve Seat Runout Gauge to check valve seat runout.



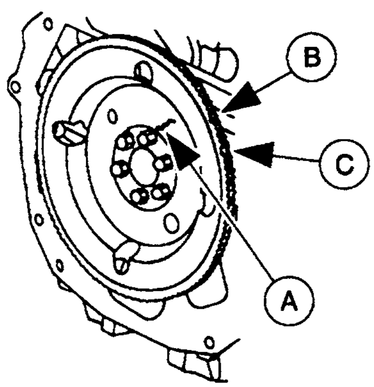
FPP03555

Flywheel Inspection

Special Tool(s)

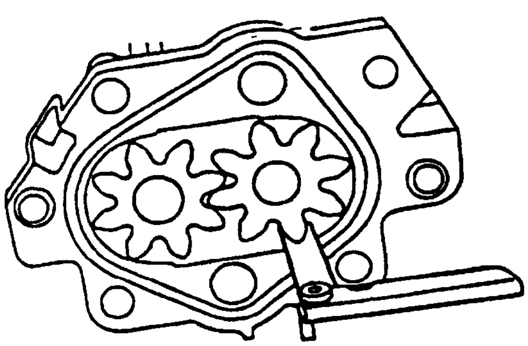
 FPP10026	Dial Indicator with Bracketry TOOL-4201-C or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

1. Inspect the flywheel for:
   - Cracks (A).
   - Worn ring gear teeth (B).
   - Chipped or cracked ring gear teeth (C).
2. Inspect the flywheel ring gear runout.



Oil Pump Gear Radial Clearance

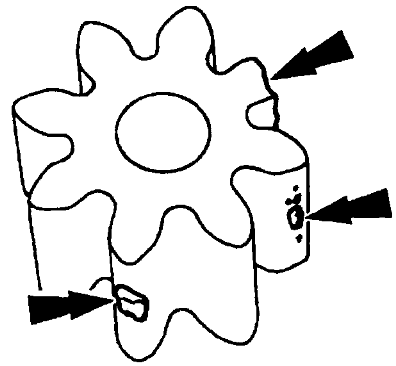
- Measure the clearance between the rotor and the pump housing.



FPP03557

Oil Pump Rotor Inspection

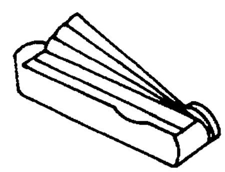
- Inspect the oil pump rotor tips for damage or wear.



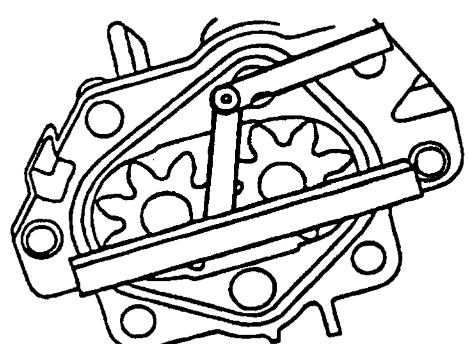
FPP03558

Oil Pump Side Clearance

Special Tool(s)

 FPP10033	Feeler Gauge D81L-4201-A or Equivalent
 FPP10036	Straight Edge D83L-4201-A or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

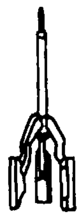
- Place the Straight Edge across the top of the oil pump and rotors and use the Feeler Gauge to measure the clearance between the rotors and the Straight Edge.



FPP03559

Cylinder Bore Honing

Special Tool(s)

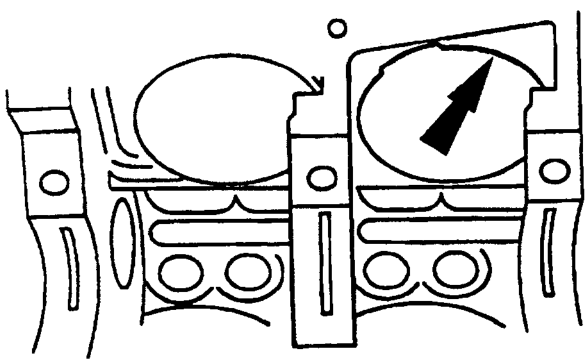
 FPP10037	Engine Cylinder Hone Set T73L-6011-A Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

NOTE: Before any cylinder bore is honed, all main bearing caps must be installed so the crankshaft bearing bores will not become distorted.

NOTE: To correct taper or out-of-round, bore the cylinder block.

NOTE: Honing should be done when fitting new piston rings or to remove minor surface.

- Hone with the Engine Cylinder Hone Set, at a speed of 300-500 rpm and a hone grit of 180-220 to provide the desired cylinder bore surface finish.



FPP03560

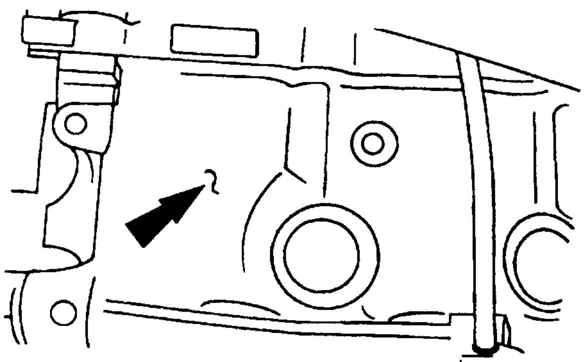
Cylinder Bore Cleaning

CAUTION: If these procedures are not followed, rusting of the cylinder bores may occur.

1. Clean the cylinder bores with soap or detergent and water.
2. Thoroughly rinse with clean water and wipe dry with a clean, lint-free cloth.
3. Use a clean, lint-free cloth and lubricate the cylinder bores.
   - Use Engine Oil XO-10W30-QSP or -DSP or equivalent meeting Ford specification ESE-M2C153-E.

Cylinder Block Repair - Cast Iron Porosity Defects

CAUTION: Do not attempt to repair cracks, areas where temperature will exceed 260°C (500°F) or areas exposed to engine coolant or oil. These areas will not repair and could cause future failure.



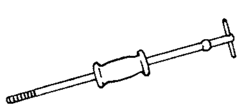
FPP03561

Repair porosity defects with an epoxy sealer meeting Ford specification M3D35-A (E).

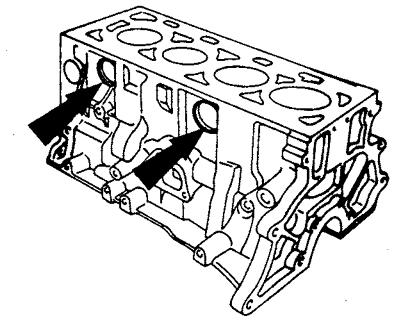
1. Clean the surface to be repaired to a bright, oil-free metal surface.
2. Chamfer or undercut the repair area to a greater depth than the rest of the cleaned surface. Solid metal must surround the area to be repaired.
3. Apply the epoxy sealer and heat-cure with a 250-watt lamp placed 254 mm (10 inches) from the repaired surface, or air dry for 10-12 hours at a temperature above 10°C (50°F).
4. Sand or grind the repaired area to blend with the general contour of the surface.
5. Paint the surface to match the rest of the cylinder block.

Cylinder Block Core Plug Replacement

Special Tool(s)

 FPP10000	Impact Slide Hammer T50T-100-A Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

1. Use a slide hammer or tools suitable to remove the cylinder block core plug.



FPP04161

2. Inspect the cylinder block plug bore for any damage that would interfered with the proper sealing of the plug. If the cylinder block plug bore is damaged, bore for the next oversize plug.

NOTE: Oversize plugs are identified by the OS stamped in the flat located on the cup side of the plug.

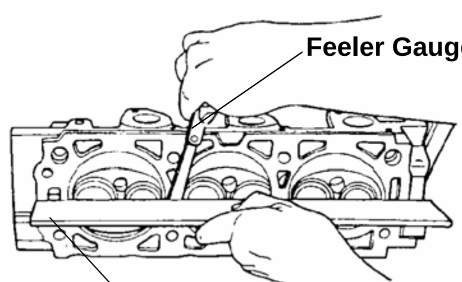
3. Coat the cylinder block core plug and bore lightly with Threadlock® 262 E2FZ-19554-B or equivalent meeting Ford specification WSK-M2G351-A6 and install the cylinder block core plug.

Cylinder Head - Distortion

Special Tool(s)

 FPP10036	Straightedge 303-D039 (D83L-4201-A) or equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

- Use a straight edge and a feeler gauge to inspect the cylinder head for flatness. Compare with specifications. If the cylinder head is distorted, install a new cylinder head.



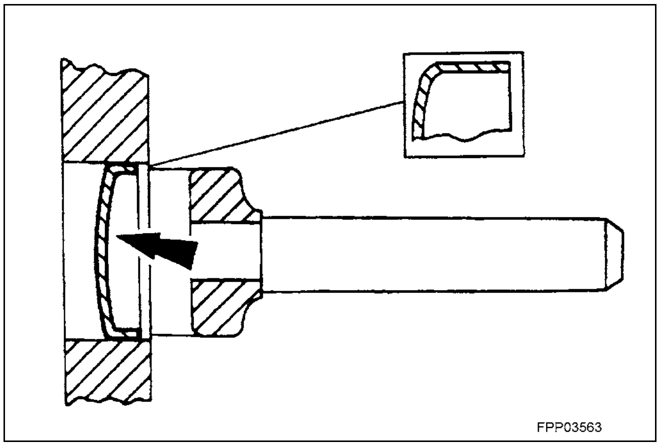
FPP04065

Cylinder Block Core Plug – Cup-Type

CAUTION: Do not contact the flange when installing a cup type cylinder block core plug as this could damage the sealing edge and result in leakage.

NOTE: When installed, the flanged edge must be below the chamfered edge of the bore to effectively seal the bore.

- Use a fabricated tool to seat the cup type cylinder block core plug.



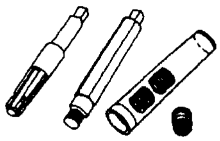
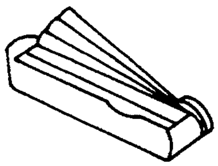
Cylinder Block Core Plug – Expansion-Type

CAUTION: Do not contact the crown when installing an expansion type cylinder block core plug. This could expand the plug before seating and result in leakage.

- Use a fabricated tool to seat the expansion type cylinder block core plug.

Spark Plug Thread Repair

Special Tool(s)

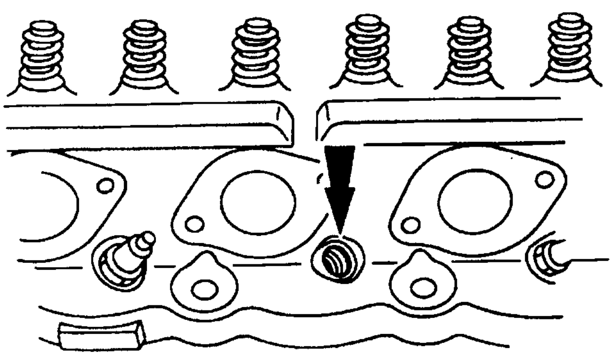
 FPP10038	Tapersert Installation Kit 107-R0921 or Equivalent
 FPP10033	Feeler Gauge D81L-4201-A or Equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

CAUTION: The cylinder head must be removed from the engine before installing a tapersert. If this procedure is done with the cylinder head on the engine, the cylinder walls can be damaged by metal chips produced by the thread cutting process.

CAUTION: Do not use power or air-driven tools for finishing taperserts.

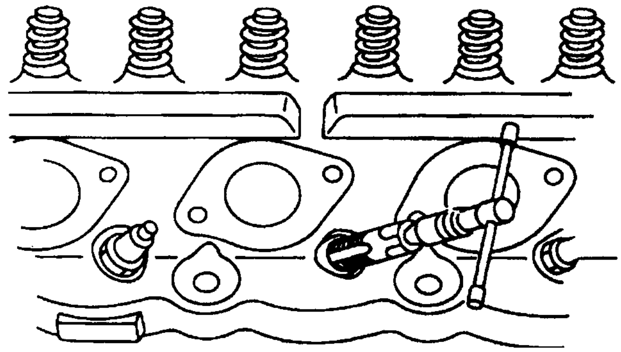
NOTE: This repair is permanent and will have no effect on cylinder head or spark plug life.

1. Clean the spark plug seat and threads.



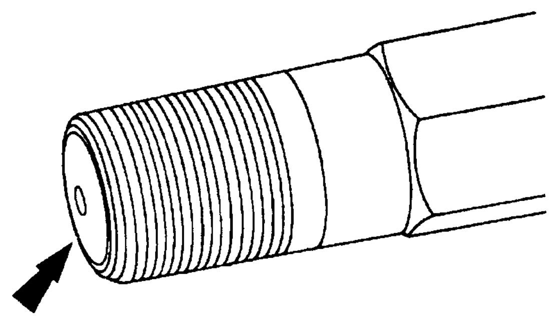
FPP03564

2. Start the tap into the spark plug hole, being careful to keep it properly aligned. As the tap begins to cut new threads, apply aluminum cutting oil
.



FPP03565

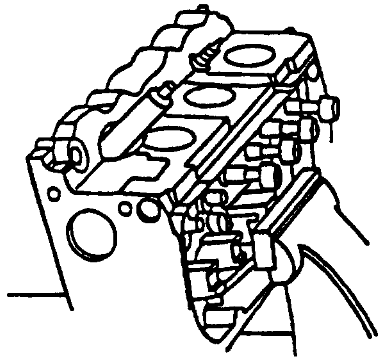
3. Continue cutting the threads and applying oil until the stop ring bottoms against the spark plug seat.
4. Remove the tap and metal chips.
5. Coat the threads of the mandrel with cutting oil. Thread the tapersert onto the mandrel until one thread of the mandrel extends beyond the tapersert.



FPP03566

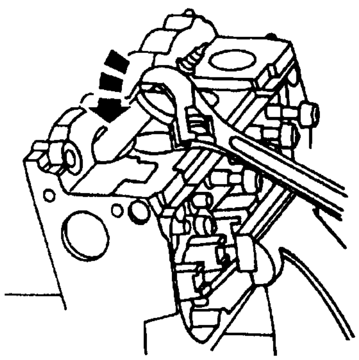
NOTE: A properly installed tapersert will be either flush with or 1.0 mm (0.039 inch) below the spark plug gasket seat.

6. Tighten the tapersert into the spark plug hole.



FPP03567

7. Turn the mandrel body approximately one-half turn counterclockwise and remove.



FPP03568

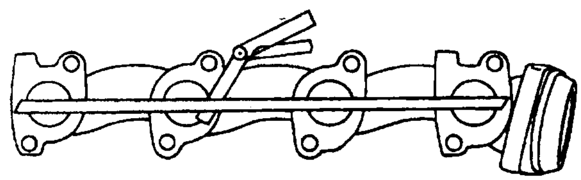
Exhaust Manifold Straightness

Special Tool(s)

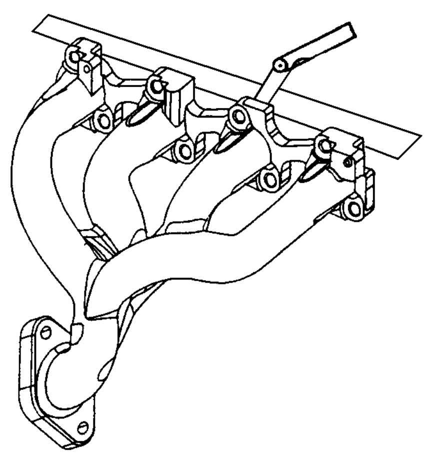
 FPP10036	Straightedge 303-D039 (D83L-4201-A) or equivalent Special Service Tools called for by the procedures can be obtained by calling: 1-800-ROTUNDA (1-800-768-8632)

- Place the Straightedge across the exhaust manifold flanges and check for warping with a feeler gauge.

NOTE: The exhaust manifold shown is a typical exhaust manifold.



FPP03569



SPECIFICATIONS

GENERAL SPECIFICATIONS	
Epoxy Sealer	M3D35-A (E)
Threadlock 262 E2FZ-19554-B	WSK-M2G351-A6
Super Premium SAE5W20	WSS M2C930-A

NOTE: Ford engines are designed to perform with engine oils that are licensed by the American Petroleum Institute (API), and oils carrying the most current API classification SJ or greater must be used.

NOTE:

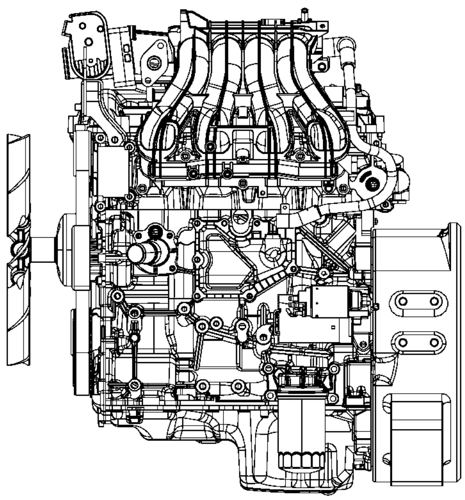
INDEX

Subject **Page**

INDEX

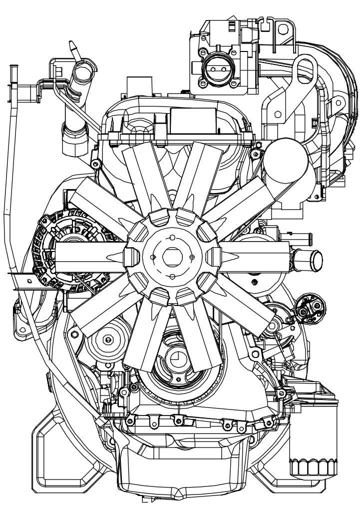
Subject **Page**

GENERAL INFORMATION



Engine

The DSG 423 is a 4 valve per cylinder, dual overhead cam engine. The engine block is cast aluminum with iron cylinder liners. Connecting rods are made of sintered metal, the crankshaft is nodular iron with five main bearings. The cam cover, oil pan and front cover are also made of aluminum.



The dual camshafts are chain driven with an automatic tensioning system. The valve train components are alternate fuel ready. Spark is delivered by an individual coil on plug ignition system. A broadband knock sensor is calibrated for individual cylinder use.

All fuels are controlled in closed loop. Gasoline is delivered by sequential port fuel injection. The electronic engine management system has built in engine protection against:

- detonation
- high coolant temperature
- low oil pressure
- engine overspeed
- starter engagement while engine is running.

NOTE: A set of metric wrenches are required to service the DSG 423 engine.

WARNING: TO AVOID THE POSSIBILITY OF PERSONAL INJURY OR DAMAGE, DO NOT OPERATE THE ENGINE UNTIL THE FAN BLADE HAS BEEN FIRST EXAMINED FOR POSSIBLE CRACKS OR SEPARATION.

Positive Crankcase Ventilation System

This engine is equipped with a positive, closed-type crankcase ventilation system, which recycles crankcase vapors to the intake manifold.

Engine Cooling System

The 2.3L engine is liquid cooled, using an engine mounted coolant pump and external radiator. This is a full flow system regulated by a thermostat, located behind the water outlet connection. The thermostat controls and maintains engine temperature.

Refer to Section 05 of this manual for more information on the cooling system.

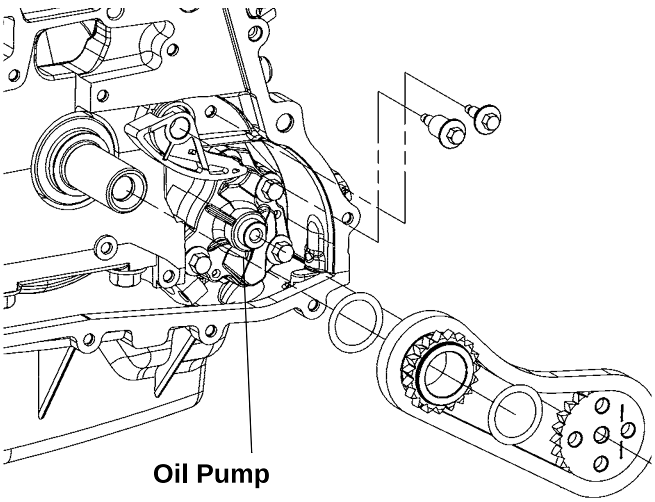
Lubrication System

The engine lubrication system consists of:

- Oil pan.
- Oil pump screen cover and tube.
- Oil pump.
- Oil filter.
- Passageways in the cylinder block, crankshaft, camshaft and cylinder head.

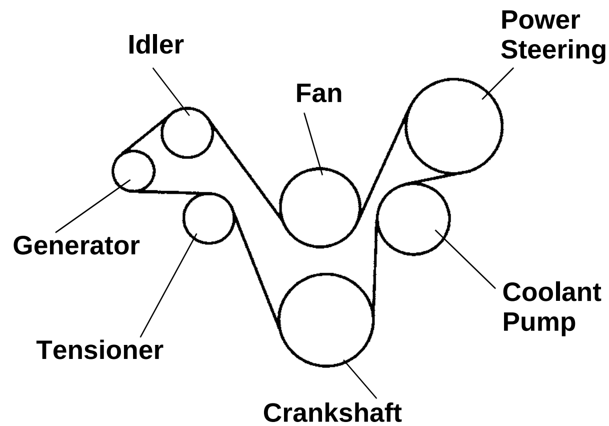
The oil pan is pressure-cast aluminum and serves as both an oil reservoir and engine bottom cover. The oil pan has reinforcing ribs which strengthen the pan, reduce engine noise transmission, and aid in oil cooling.

The oil pump is mounted to the engine block and is driven by chain from the crankshaft. Oil cooling jets spray to the underside of the piston skirt.



Drive Belt System

Engine accessories, such as the generator and water pump, are driven by a single serpentine belt. Tension is automatically adjusted by a tensioner.



Ignition System

The ignition used on the 2.3L engine is an Electronic Distributorless Ignition System (EDIS). Individual ignition coils are located directly above each spark plug and are used to ignite the fuel in the cylinders.

Refer to Section 03 of this manual for more information on the ignition system.

Fuel System

The fuel system includes a remote mounted electric fuel pump. The pump regulates and maintains fuel flow, through an in-line fuel filter to the electronic actuator mounted on the intake manifold.

The engine can be adapted for dry fuel use. Refer to Section 04 of this manual for more information on the fuel system.

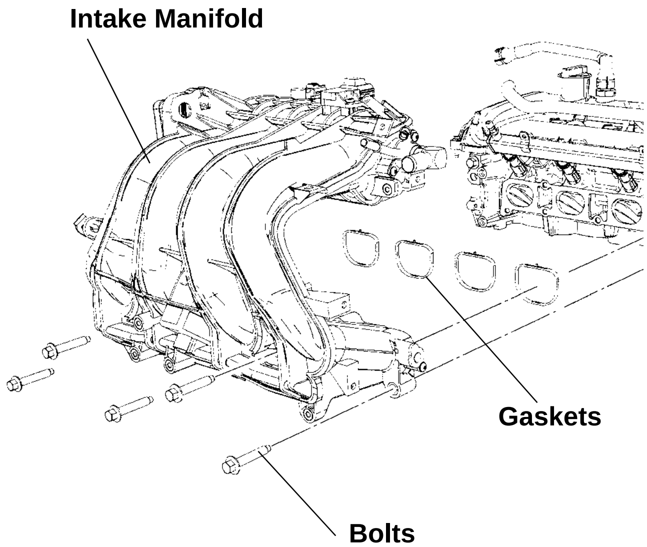
REMOVAL & INSTALLATION

Intake Manifold - Removal

1. Drain the engine cooling system -- Refer to Section 5.
2. Remove and/or disconnect components to allow access and removal of the intake manifold. Label if necessary to allow for correct reinstallation.

CAUTION: Relieve fuel system pressure before disconnecting fuel supply lines -- refer to Section 4.

3. Remove fuel supply connections -- refer to Section 4.



4. Remove 5 bolts and the intake manifold.

CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

5. Clean the sealing surface of the cylinder head with silicone gasket remover and metal surface prep.

⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

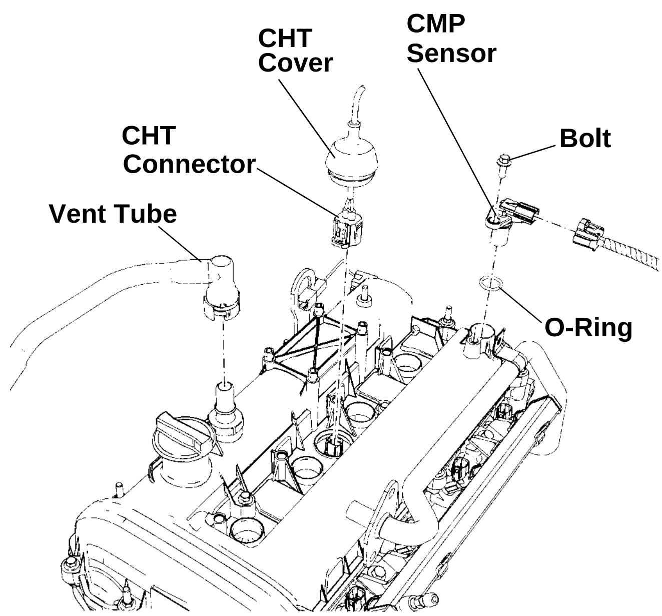
6. Remove and discard intake manifold gaskets.

Intake Manifold - Installation

1. Install new intake gaskets.
2. Position intake manifold and install 5 bolts.
   - Tighten to 18 Nm (13 lb-ft).
3. Reconnect fuel supply connections -- refer to Section 4.
4. Reinstall or connect any components that were removed or disconnected.
5. Fill and bleed the engine cooling system -- refer to Section 5.

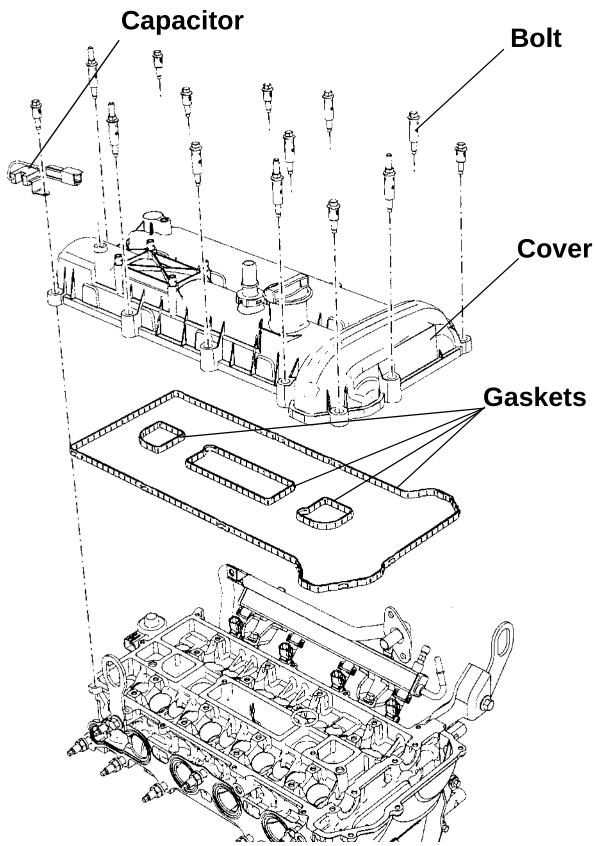
Camshaft Cover - Removal

1. Disconnect negative battery cable -- refer to Section 6.
2. Remove intake manifold -- Refer to“Intake Manifold - Removal” on page 6 of this section.
3. Remove and/or disconnect components to allow access and removal of the camshaft cover. Label if necessary to allow for correct reinstallation.



4. Disconnect CHT sensor connector.
5. Disconnect ignition coil connectors.
6. Disconnect Camshaft Position (CMP) Sensor connector.
7. Remove CMP Sensor.
8. Disconnect crankcase ventilation tube quick connect coupling.

9. Remove bolts and camshaft cover.



10. Remove and discard gaskets.

CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

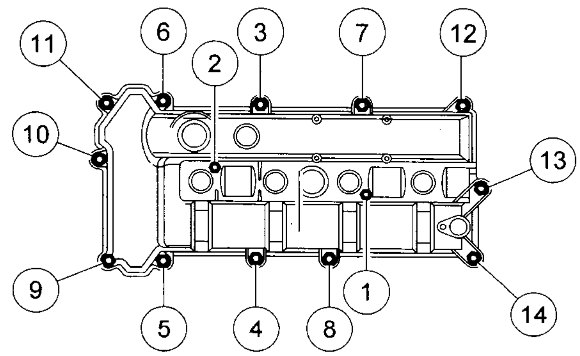
11. Clean the sealing surface of the cylinder head with silicone gasket remover and metal surface prep.

⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

Camshaft Cover - Installation

1. Install new gaskets.
2. Position camshaft cover and install bolts in sequence shown.
   - Tighten to 10 Nm (89 lb-in).



Tightening Sequence

3. Reconnect crankcase ventilation tube.

NOTE: Apply clean engine oil to CMP sensor o-ring seal prior to installation.

4. Install CMP sensor and bolt.
   - Tighten to 7 Nm (62 lb-in).
5. Reconnect CMP sensor, ignition coil and CHT Sensor connectors.
6. Reinstall or connect any other components that were removed or disconnected
7. Install intake manifold -- Refer to“Intake Manifold - Installation” on page 6 of this section.
8. Reconnect negative battery cable -- refer to Section 6.

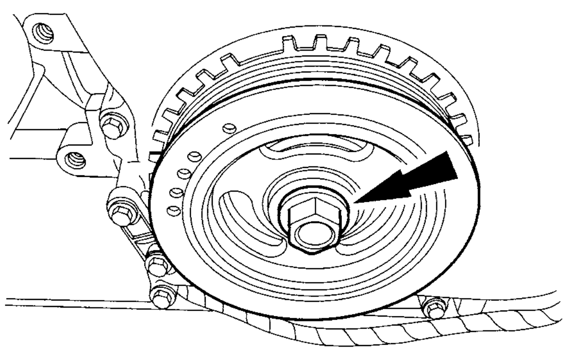
Crankshaft Pulley - Removal

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

1. Remove and/or disconnect components to allow access and removal of the crankshaft pulley. Label if necessary to allow for correct reinstallation.
2. Remove the drive belt -- refer to Section 6.
3. Remove the camshaft cover -- Refer to“Camshaft Cover - Removal” on page 6 of this section.

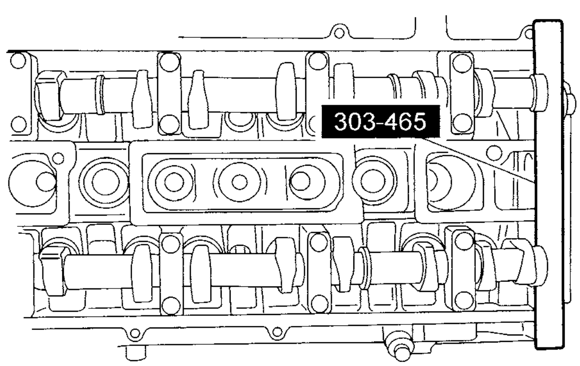
CAUTION: Failure to position the No.1 piston at top dead center (TDC) can result in damage to the engine. Turn the engine in the normal direction of rotation only.

4. Using the crankshaft pulley bolt, turn the crankshaft clockwise to position the No. 1 piston at TDC.



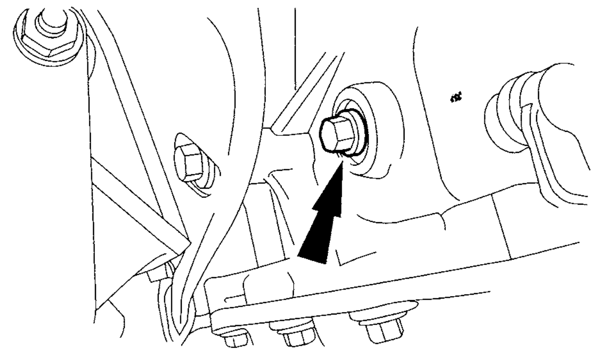
CAUTION: The special tool 303-465 is for camshaft alignment only. Using this tool to prevent engine rotation can result in engine damage.

5. Install special tool 303-465 in the slots on the rear of both camshafts.



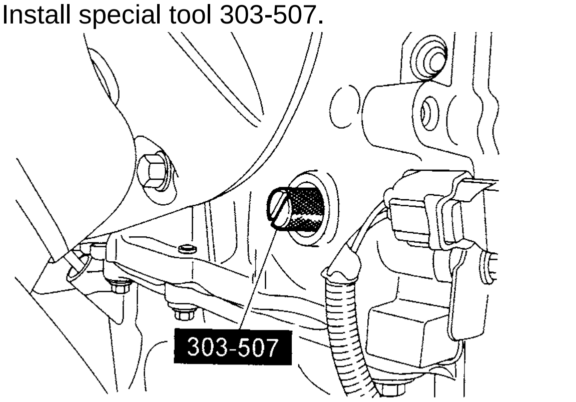
NOTE: Camshaft timing slots are offset. If special tool cannot be installed, rotate crankshaft one complete revolution clockwise to correctly position camshafts.

6. Remove plug bolt.

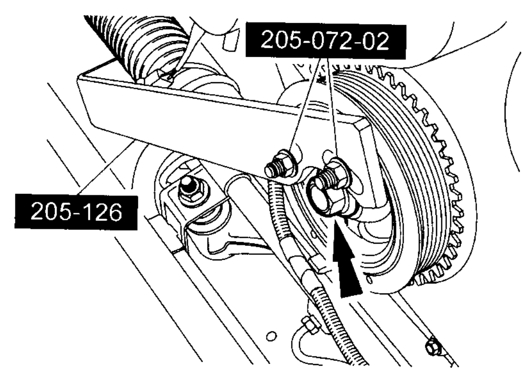


CAUTION: Installing special tool in this next step will prevent engine from being rotated in the clockwise direction. However, the engine can still be rotated in the counterclockwise direction. Only turn the engine in the normal direction of rotation.

7. Install special tool 303-507.

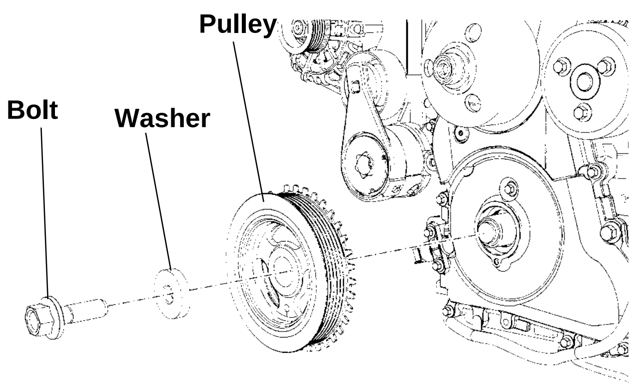


8. Install special tools 205-126 and 205-072-02



CAUTION: Failure to hold the crankshaft pulley in place during bolt loosening can cause damage to the engine.

9. Remove bolt, washer and pulley. Discard crankshaft pulley bolt.



Crankshaft Pulley - Installation

CAUTION: Do not reuse the crankshaft pulley bolt.

1. Apply clean engine oil on the crankshaft front seal and install crankshaft pulley, washer and hand tighten new bolt.

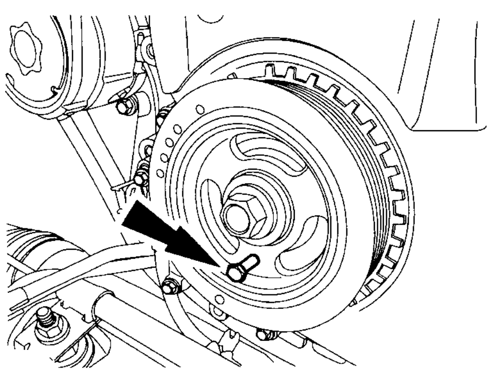
CAUTION: Only hand-tighten the bolt or damage to the front cover can occur.

NOTE: This next step will correctly align the crankshaft pulley to the crankshaft.

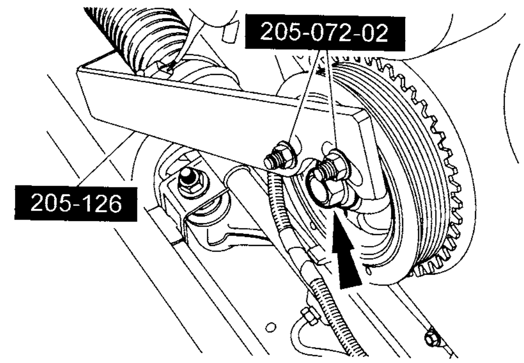
2. Install a standard 6mm x 18mm bolt as shown and thread it into the front cover.

NOTE: Rotate the crankshaft pulley as necessary to align the bolt hole.

CAUTION: Failure to hold the crankshaft pulley in place during bolt tightening can cause damage to the engine front cover.



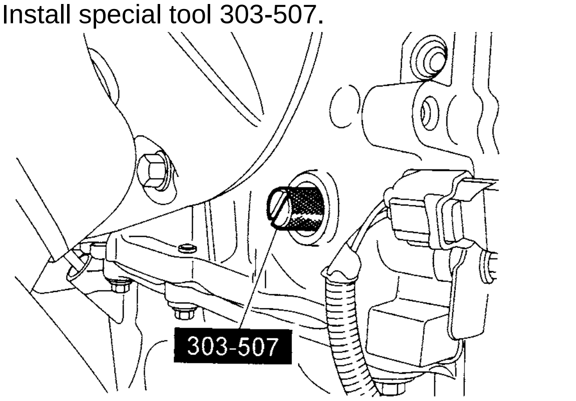
3. Using special tools 205-126 and 205-072-02 to hold the crankshaft pulley in place, tighten the crankshaft pulley bolt in 2 stages:
   - Stage 1: Tighten to 100 Nm (74 lb-ft).
   - Stage 2: Rotate an additional 90 degrees.



4. Remove all special tools and 6 mm bolt.

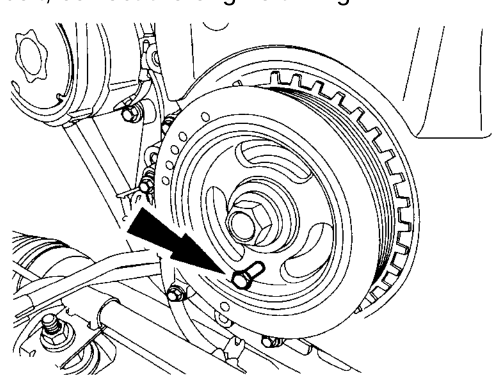
CAUTION: Only turn the engine in the normal direction of rotation.

5. Turn the engine 2 complete revolutions, then continue to turn until piston is at TDC.
6. Install special tool 303-507.

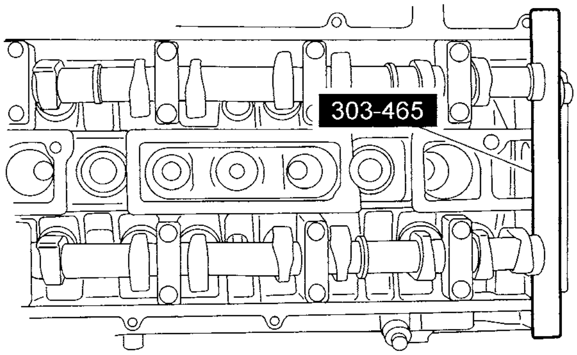


CAUTION: Only hand tighten the bolt in the next step or damage to the front cover can occur.

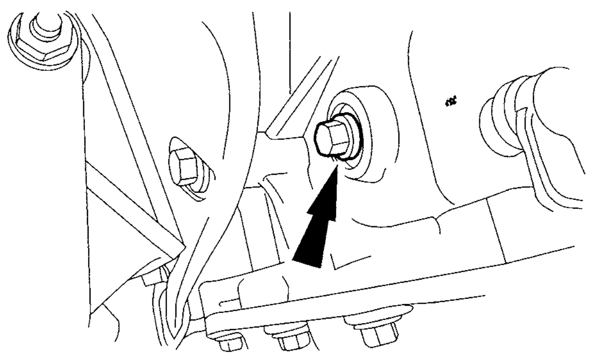
7. Using the 6mm x 18 mm bolt, check the position of the crankshaft pulley. If it is not possible to install this bolt, correct the engine timing.



8. Using special tool 303-465, check the position of the camshaft. If it is not possible to install the special tool, correct the engine timing.



9. Remove all special tools and 6mm bolt.
10. Install the plug bolt.
    - Tighten to 20 Nm (15 lb-ft).



11. Install camshaft cover -- Refer to“Camshaft Cover - Installation” on page 7 of this section.
12. Install accessory drive belt -- refer to Section 6.
13. Install or reconnect any other components that were removed or disconnected.

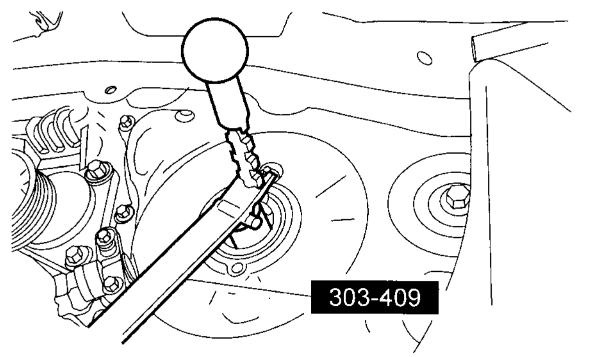
Crankshaft Front Seal - Removal

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

1. Remove and/or disconnect components to allow access and removal of the crankshaft front seal. Label if necessary to allow for correct reinstallation.
2. Remove crankshaft pulley -- Refer to“Crankshaft Pulley - Removal” on page 8 of this section.

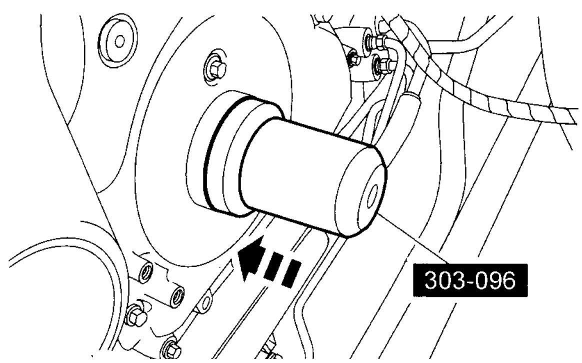
CAUTION: Use care not to damage the engine front cover or the crankshaft when removing the seal.

3. Using special tool 303-409, remove the crankshaft front seal.



Crankshaft Front Seal - Installation

1. Lubricate the new crankshaft front seal with clean engine oil prior to installation.
2. Using special tool 303-096, install the crankshaft front seal.



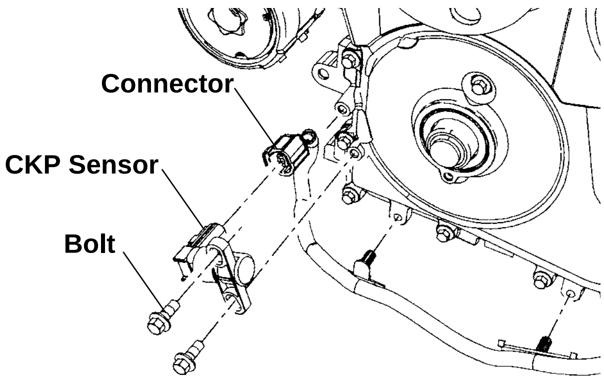
3. Install the crankshaft pulley -- Refer to“Crankshaft Front Seal - Installation” on page 10 of this section.
4. Install or reconnect any other components that were removed or disconnected.

Engine Front Cover - Removal

1. Disconnect the negative battery cable -- refer to Section 6.

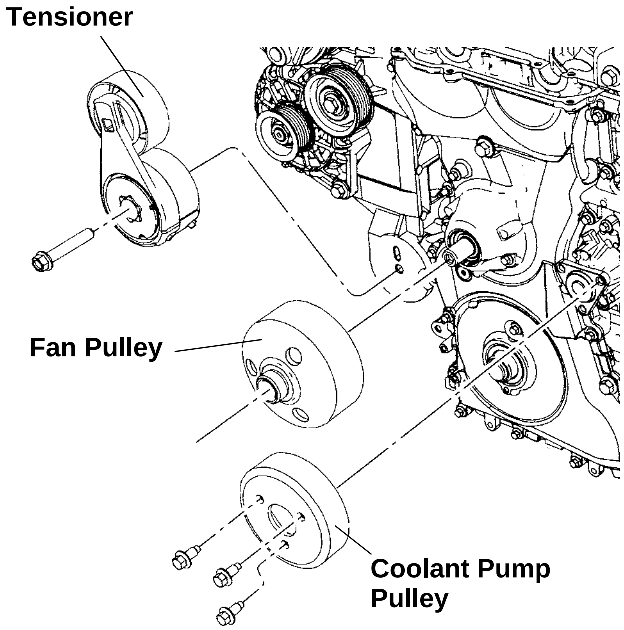
CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

2. Remove and/or disconnect components to allow access and removal of the engine front cover. Label if necessary to allow for correct reinstallation.
3. Remove the crankshaft pulley -- Refer to“Crankshaft Pulley - Removal” on page 8 of this section.
4. Disconnect Crankshaft Position (CKP) Sensor connector.

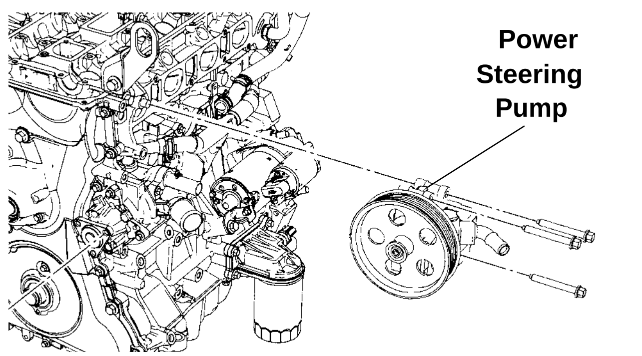


CAUTION: A new CKP Sensor must be installed whenever the old sensor is removed.

5. Remove the CKP Sensor and discard.
6. Remove bolt and accessory drive tensioner.



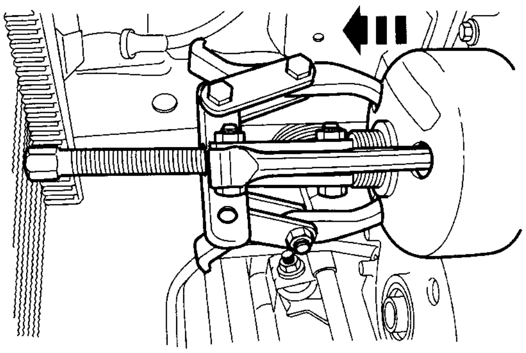
7. Remove the three bolts and the coolant pump pulley.
8. Remove three bolts and power steering pump and set aside.



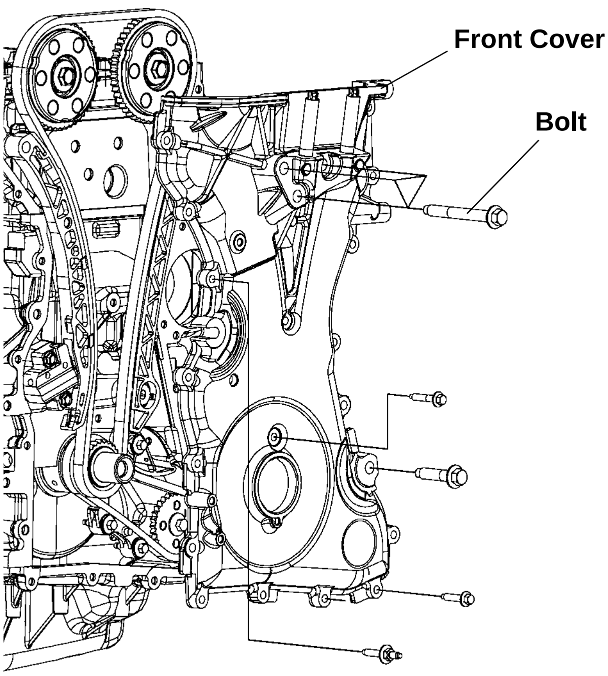
CAUTION: There is one bolt behind the cooling fan drive pulley. This bolt can be accessed by lining up one of the holes in the pulley with the bolt.

NOTE: The next step is only necessary if a new front cover is being installed.

9. Using a 3 jaw puller, remove the fan drive pulley.



10. Remove bolts and engine front cover.



CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

11. Clean the sealing surface with silicone gasket remover and metal surface prep.

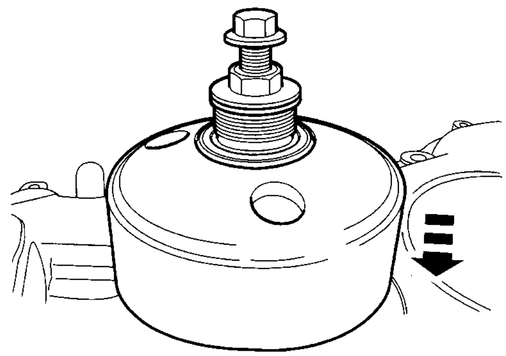
⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

Engine Front Cover - Installation

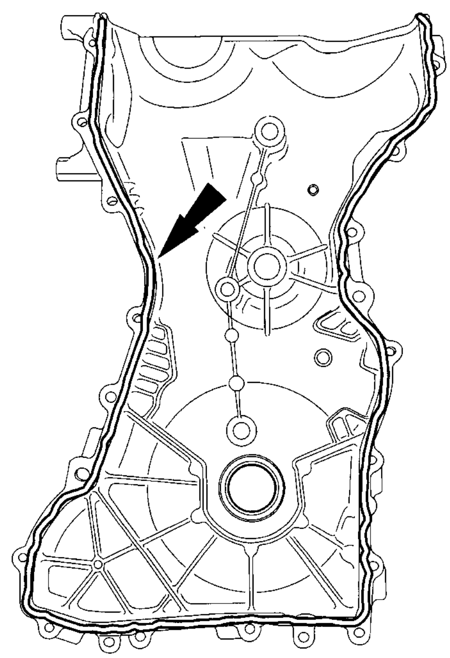
NOTE: This step is needed only if a new front cover is being installed.

1. Install the fan drive pulley, using a nut and bolt with flat washers as shown below.

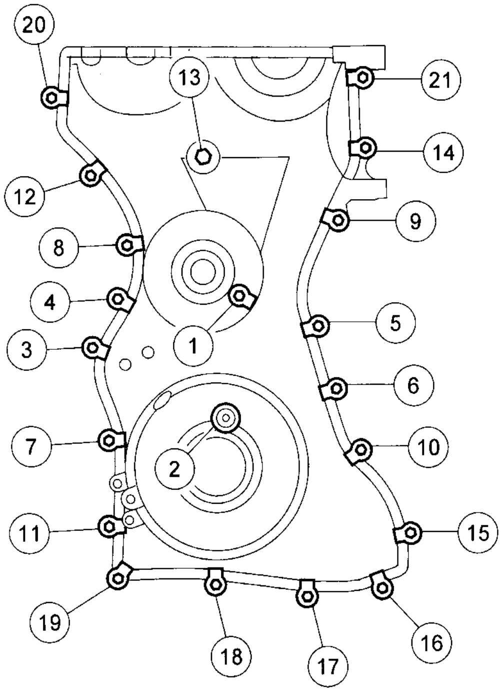


NOTE: If not secured within 4 minutes, the sealant must be removed and the sealing area recleaned as before. Refer to previous CAUTION & WARNING.

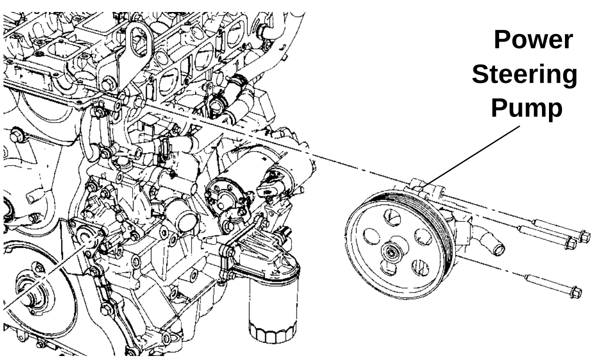
2. Apply a 2.5 mm (0.1 in) bead of silicone gasket and sealant to the cylinder head and oil pan joint areas and also to front cover as shown below.



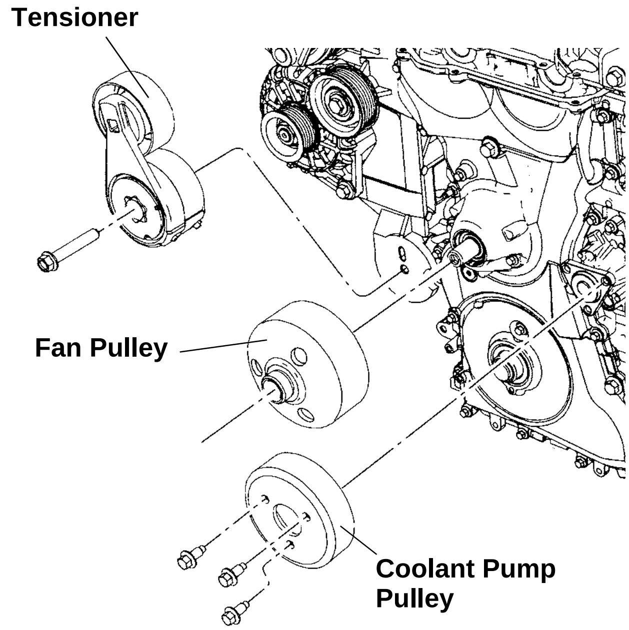
3. Install the front cover and tighten the bolts in the sequence shown to the following specifications:
    - Tighten 8 mm bolts to 10 Nm (89 lb-in)
    - Tighten 10 mm bolts to 25 Nm (18 lb-ft)
    - Tighten 13 mm bolts to 48 Nm (35 lb-ft).



4. Position the power steering pump and install the bolts:
    - Tighten to 25 Nm (18 lb-ft).



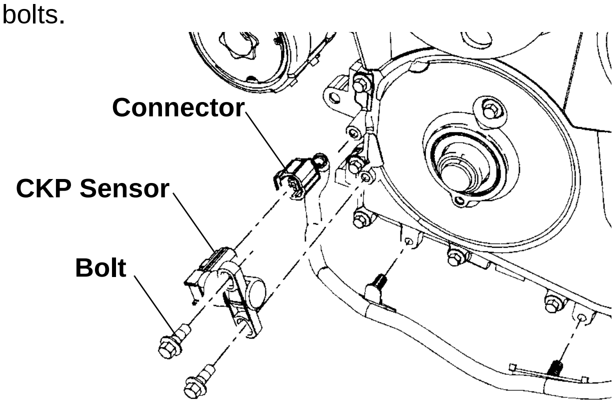
5. Position the coolant pump pulley and install the 3 bolts:
    - Tighten to 25 Nm (18 lb-ft).



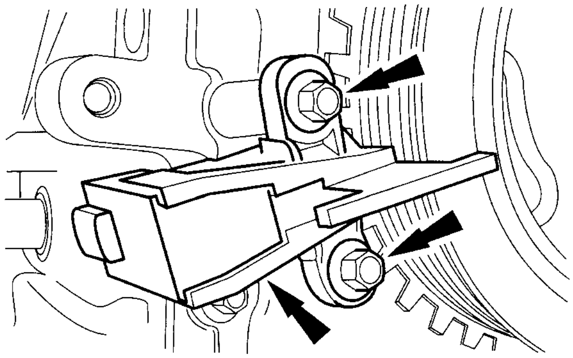
6. Install the accessory drive belt tensioner and the bolt:
    - Tighten to 50 Nm (37 lb-ft).

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

7. Install the crankshaft pulley -- Refer to“Crankshaft Pulley - Installation” on page 9 of this section.
8. Position a new CKP Sensor and loosely install the 2 bolts.



9. Adjust the CKP with the alignment tool supplied with the new sensor. The tool must engage a tooth of the vibration damper. Tighten 2 bolts:
   - Tighten to 7 Nm (62 lb-in).

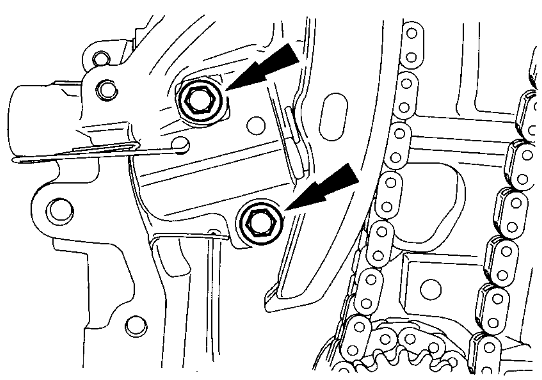


10. Connect CKP Sensor connector.
11. Connect battery negative cable -- refer to Section 6.
12. Install or reconnect any other component removed or disconnected.

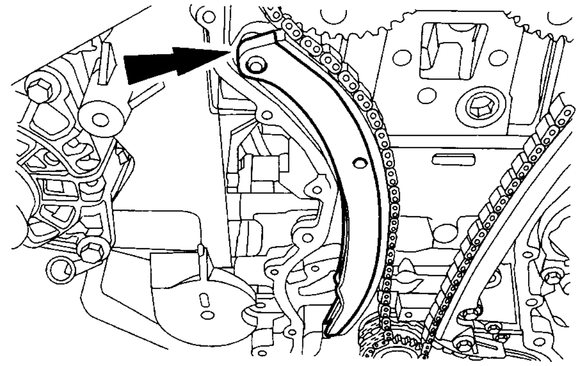
Timing Drive Components - Removal

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

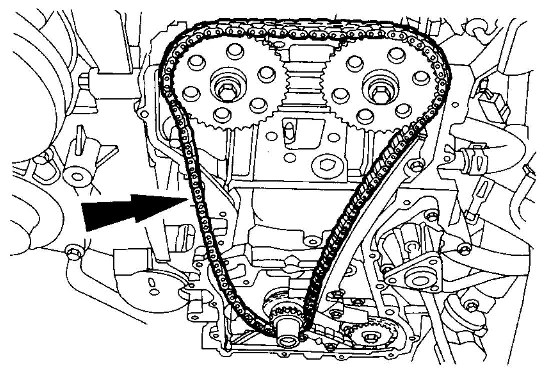
1. Remove and/or disconnect components to allow access and removal of the timing drive components. Label if necessary to allow for correct reinstallation.
2. Remove the engine front cover -- Refer to“Engine Front Cover - Removal” on page 11 of this section.
3. Compress the timing chain tensioner, and insert a paper clip into the hole. Remove the 2 bolts and the timing chain tensioner.



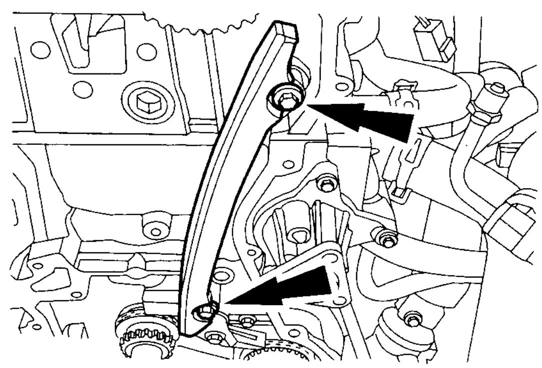
4. Remove the right timing chain guide.



5. Remove the timing chain.

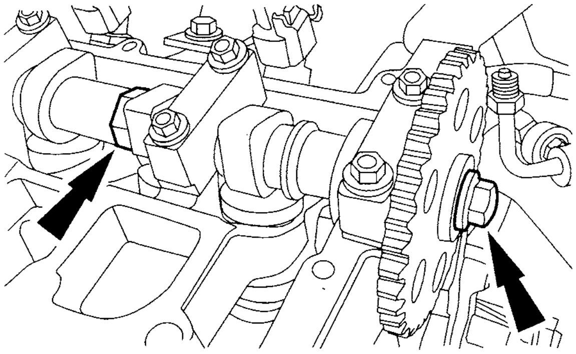


6. Remove the 2 bolts and left timing chain guide.



CAUTION: Do not rely on the Camshaft Alignment Plate to prevent camshaft rotation. Damage to the tool or the camshaft can occur.

7. If necessary, remove the bolts and the camshaft sprockets.



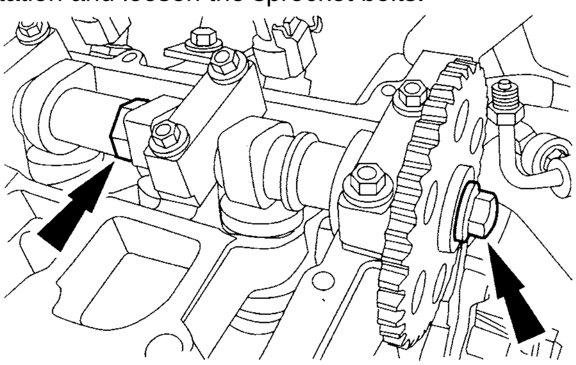
NOTE: Use the flats on the camshaft to prevent camshaft rotation.

Timing Drive Components - Installation

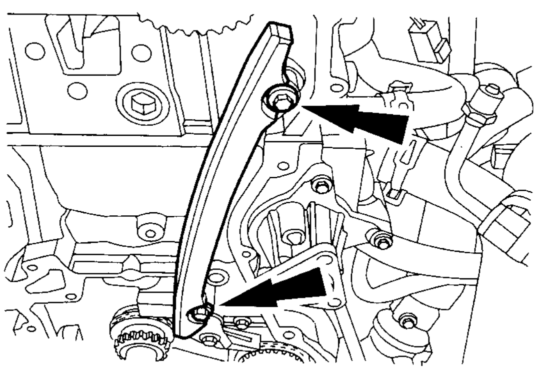
CAUTION: Do not rotate the camshafts. Damage to the valves and pistons can occur.

CAUTION: Do not rely on the Camshaft Alignment Plate to prevent camshaft rotation. Damage to the tool or the camshaft can occur.

NOTE: If the camshaft sprockets were not removed, use the flats on the camshafts to prevent camshaft rotation and loosen the sprocket bolts.

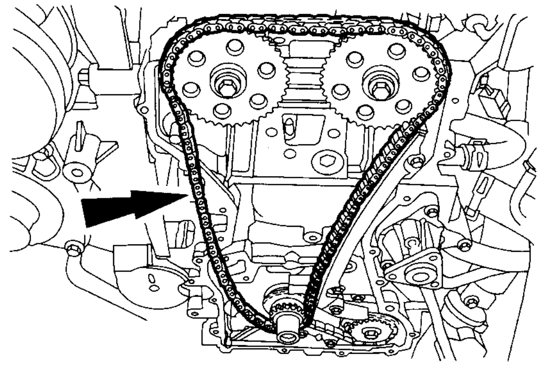


1. If removed, install the camshaft sprockets and the bolts finger tight.
2. Install the left timing chain guide and 2 bolts:

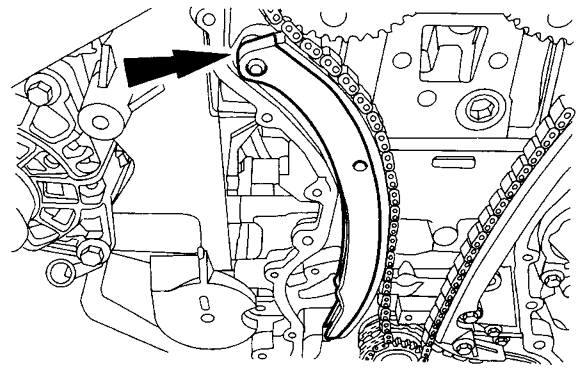


- Tighten to 10 Nm (89 lb-in).

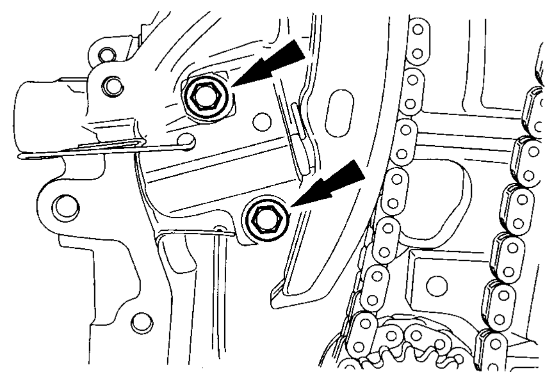
3. Install the timing chain.



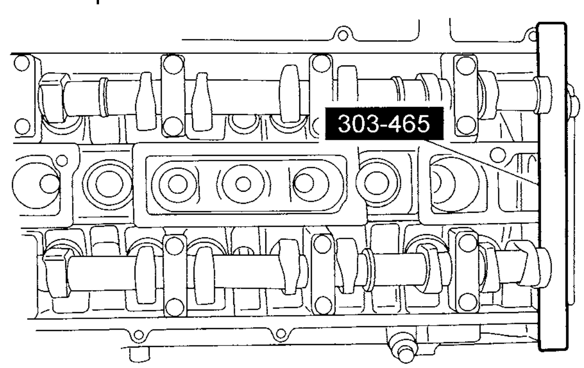
4. Install the right timing chain guide.



5. Position the timing chain tensioner and install the 2 bolts:
   - Tighten to 10 Nm (89 lb-in).
   - Remove the paper clip to release the piston.

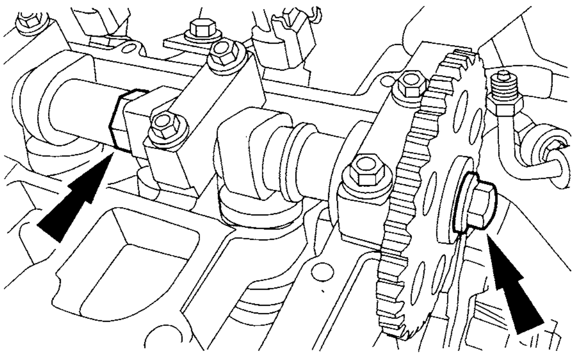


6. Install special tool 303-465.



CAUTION: Do not rely on the Camshaft Alignment Plate to prevent camshaft rotation. Damage to the tool or the camshaft can occur.

7. Using the flats on the camshaft to prevent camshaft rotation, tighten the sprocket bolts:
   - Tighten to 65 Nm (48 lb-ft).



8. Install the front cover -- Refer to“Engine Front Cover - Installation” on page 12 of this section.
9. Install or reconnect any other component removed or disconnected.

Valve Spring - Removal

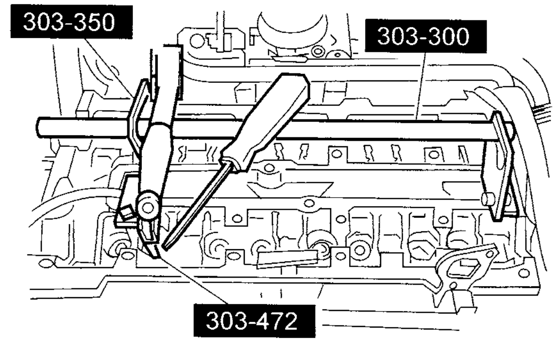
CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

1. Remove the valve tappets -- Refer to“Valve Tappet - Replacement” on page 18 of this section.

WARNING: ALWAYS WEAR PROTECTIVE GOGGLES WHEN WORKING WITH COMPRESSED AIR. THIS CAN PREVENT INJURY. FAILURE TO FOLLOW THESE INSTRUCTIONS CAN RESULT IN PERSONAL INJURY.

CAUTION: Use compressed air at 7-10 bars (100-150 psi). Do not disconnect the compressed air from the cylinder until the valve spring, valve retainer and valve spring retainer keys are installed.

1. Remove spark plug of the cylinder being serviced.
2. Using special tools, apply compressed air to the cylinder of the valve spring being removed.
3. Using special tools 303-350, 303-300 and 303-472, compress valve spring and remove the retainer keys using some grease and a small screwdriver.



4. Remove the valve spring retainer and valve spring.

NOTE: Place all parts in order to one side.

CAUTION: Keep air pressure in cylinder until valve spring is reinstalled.

Valve Spring - Installation

CAUTION: Check that there is no dirt or particles within the valve stem grooves. Check the seating of the valve collets.

1. Install the valve spring and retainer.
2. Using special tools, compress valve spring and install the valve retainer keys.
3. Release spring and check that keys are seated properly.
4. Remove air supply and all special tools.
5. Install the valve tappets -- Refer to“Valve Tappet - Replacement” on page 18 of this section.
6. Install spark plug:
   - Tighten to 15 Nm (11 lb-ft).

Valve Seal - Removal

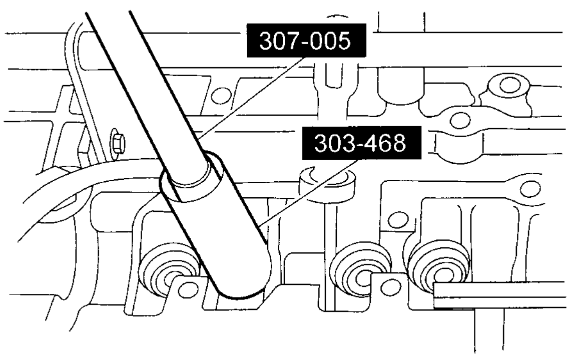
CAUTION: During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces, that enters the oil passages, coolant passages or the oil pan can cause engine failure.

1. Remove camshafts -- Refer to“Camshafts - Removal” on page 18 of this section.

CAUTION: If the camshafts and valve tappets are to be reused, mark the location of the valve tappets to make sure they are assembled in their original positions.

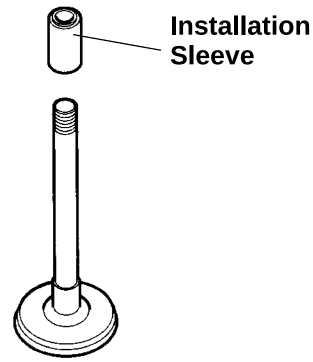
NOTE: The number on the valve tappets only reflects the digits that follow the decimal. For example, a tappet with the number 0.650 has the thickness of 3.650 mm.

2. Remove the valve tappets -- Refer to“Valve Tappet - Replacement” on page 18 of this section.
3. Remove valve spring assembly -- Refer to“Valve Spring - Removal” on page 16 of this section.
4. Using special tools 307-005 and 303-468, remove and discard the valve seal.

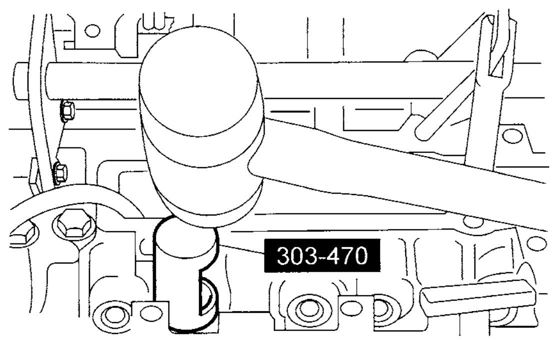


Valve Seal - Installation

1. Install the valve stem seal installation sleeve.



2. Using special tool 303-470, install a new valve seal.



3. Install valve spring -- Refer to“Valve Spring - Installation” on page 16 of this section.
4. Install tappets -- Refer to“Valve Tappet - Replacement” on page 18 of this section.

CAUTION: If reusing tappets, install in original locations.

5. Install camshafts -- Refer to“Camshafts - Installation” on page 18 of this section.
6. Repeat for each cylinder being serviced.

Valve Tappet - Replacement

CAUTION: During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces, that enters the oil passages, coolant passages or the oil pan can cause engine failure.

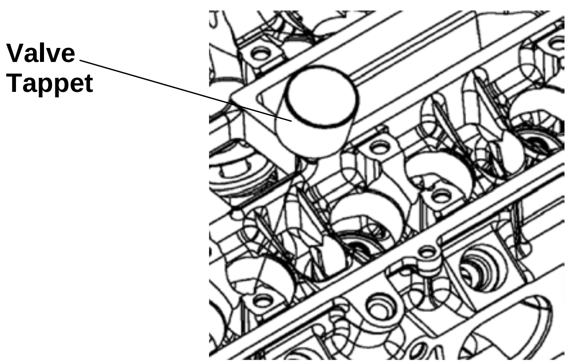
NOTE: Valve tappets are select fit and the valve clearance must be checked before removing the tappets -- Refer to"Valve Clearance Check" on page 45 of this section.

1. Remove camshafts -- Refer to"Camshafts - Removal" on page 18 of this section.

CAUTION: If the camshafts and valve tappets are to be reused, mark the location of the valve tappets to make sure they are assembled in their original positions.

NOTE: The number on the valve tappets only reflects the digits that follow the decimal. For example, a tappet with the number 0.650 has the thickness of 3.650 mm.

2. Remove and inspect valve tappets.
3. Reverse procedure to install.



NOTE: Coat valve tappets with clean engine oil prior to installation.

Camshafts - Removal

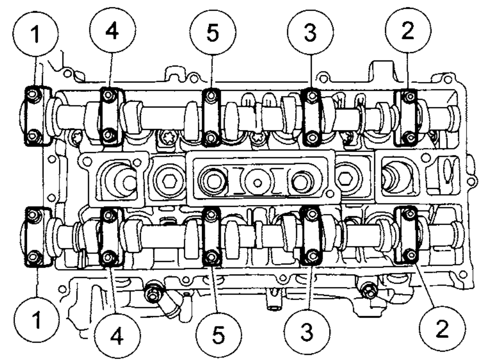
CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

1. Remove and/or disconnect components to allow access and removal of the timing drive components. Label if necessary to allow for correct reinstallation.
2. Remove timing chain and sprockets -- Refer to"Timing Drive Components - Removal" on page 14 of this section.

CAUTION: Failure to follow the camshaft loosening procedure can result in damage to the camshafts.

NOTE: Note the position of the lobes on the No. 1 cylinder before removing the camshafts for assembly reference.

3. Loosen the camshaft bearing cap bolts, in sequence shown, one turn at a time.



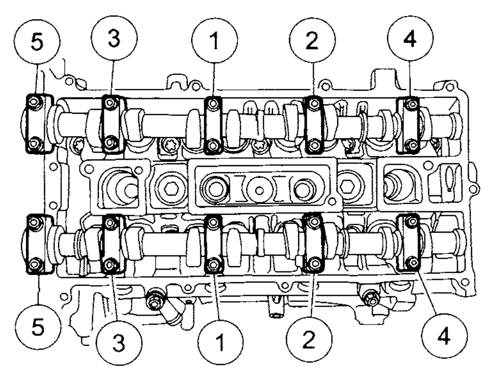
4. Repeat until all tension is released from the camshaft bearing caps.
5. Remove bearing caps and camshafts.

Camshafts - Installation

CAUTION: Install the camshafts with the alignment slots in the camshafts lined up so the camshaft alignment plate can be installed without rotating the camshafts. Make sure the lobes on the No. 1 cylinder are in the same position as noted in the removal procedure. Rotating the camshafts when the timing chain is removed, or installing the camshafts 180 degrees out of position, can cause severe damage to the valves and pistons.

NOTE: Lubricate the camshaft journals and bearing caps with clean engine oil prior to installation.

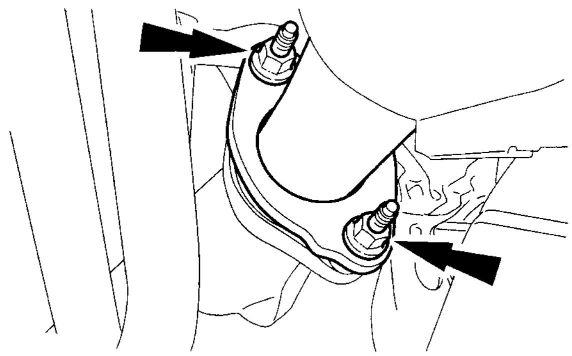
1. Install the camshafts and bearing caps. Tighten bolts in the sequence shown in 3 stages:
   - Stage 1: Tighten one turn at a time until tight
   - Stage 2: Tighten bolts to 7 Nm (62 lb-in)
   - Stage 3: Tighten bolts to 16 Nm (12 lb-ft).



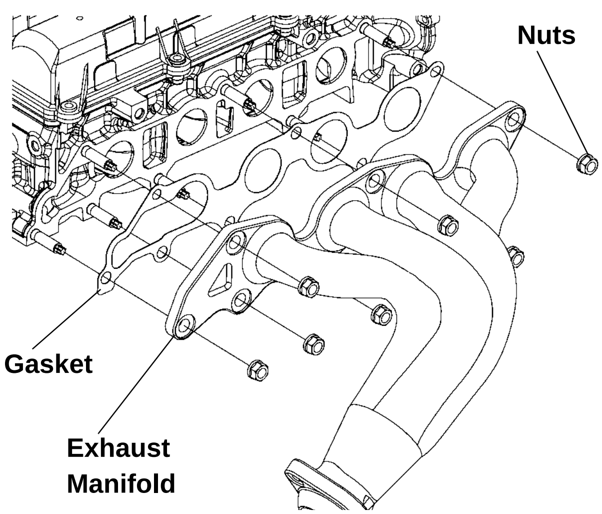
2. Install timing chain and sprockets -- Refer to“Timing Drive Components - Installation” on page 15 of this section.
3. Install or reconnect any other components removed or disconnected.

Exhaust Manifold - Removal

1. Disconnect negative battery cable -- refer to Section 6.
2. Remove and/or disconnect components to allow access and removal of the exhaust manifold. Label if necessary to allow for correct reinstallation.
3. Remove accessory drive belt -- refer to Section 6.
4. Drain the engine cooling system -- refer to Section 5.
5. Disconnect exhaust pipe from manifold.



6. Remove oil level indicator -- Refer to“Oil Level Indicator & Tube - Replacement” on page 24 of this section.
7. Remove generator support bracket -- refer to Section 6.
8. Remove nuts, exhaust manifold and gasket (discard nuts and gasket)



9. Remove and discard exhaust manifold studs.
10. Inspect manifold for flatness -- refer to Section 1.

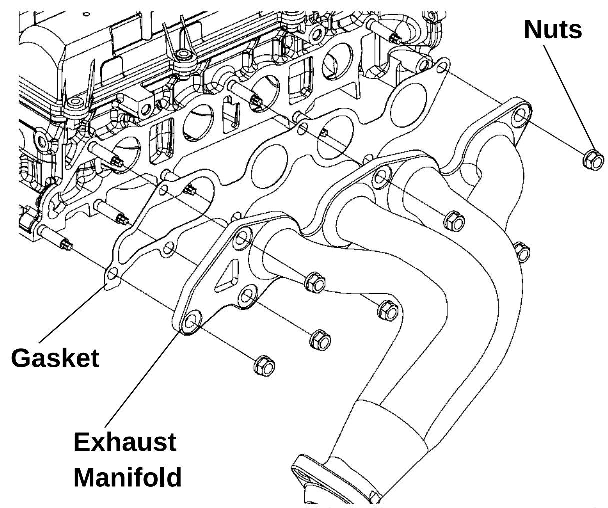
CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

11. Clean the sealing surface with silicone gasket remover and metal surface prep.

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

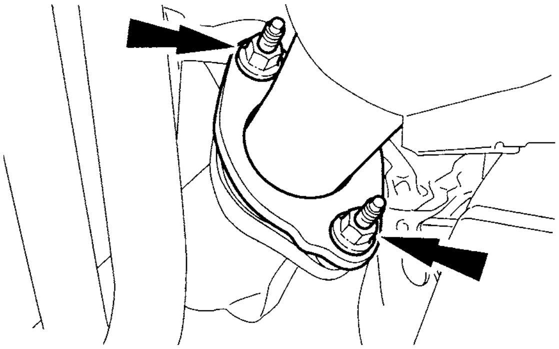
Exhaust Manifold - Installation

1. Install new studs:
   - Tighten to 17 Nm (13 lb-ft).
2. Install new gasket.
3. Position exhaust manifold and install nuts:
   - Tighten to 54 Nm (40 lb-ft).



4. Install generator support bracket -- refer to Section 6.
5. Install oil level indicator -- Refer to“Oil Level Indicator & Tube - Replacement” on page 24 of this section.

6. Install exhaust pipe to manifold.

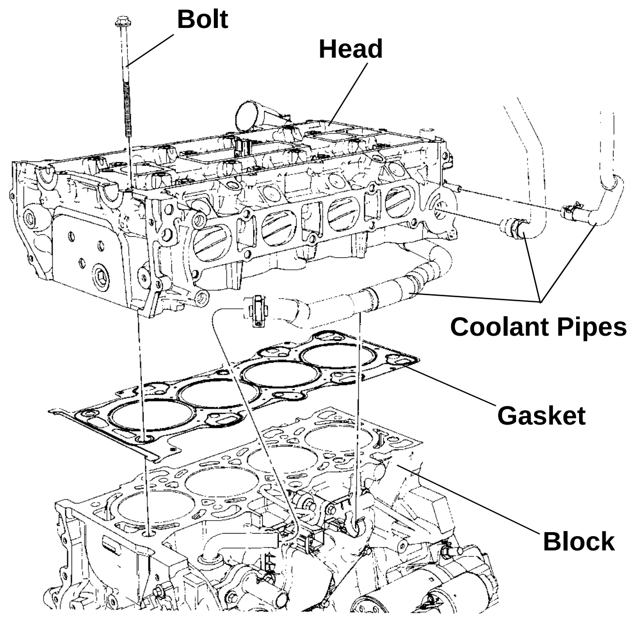


7. Install accessory drive belt -- refer to Section 6.
8. Connect battery negative cable -- refer to Section 6.
9. Install or reconnect any other components removed or disconnected.

Cylinder Head - Removal

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

1. Disconnect negative battery cable -- refer to Section 6.
2. Remove and/or disconnect components to allow access and removal of the cylinder head. Label if necessary to allow for correct reinstallation.
3. Remove camshaft cover -- Refer to“Camshaft Cover - Removal” on page 6 of this section.
4. Remove the camshafts -- Refer to“Camshafts - Removal” on page 18 of this section.
5. Remove exhaust manifold -- Refer to“Exhaust Manifold - Removal” on page 19 of this section.
6. Remove fuel rail -- refer to Section 4.
7. Remove and discard cylinder head bolts.



8. Remove and discard gasket.
9. Inspect mating surfaces -- refer to Section 1.

Cylinder Head - Installation

CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old head gasket.

1. Clean the mating surface of cylinder head and block, with silicone gasket remover and metal surface prep. Remove all traces of gasket, sealant, oil and coolant.

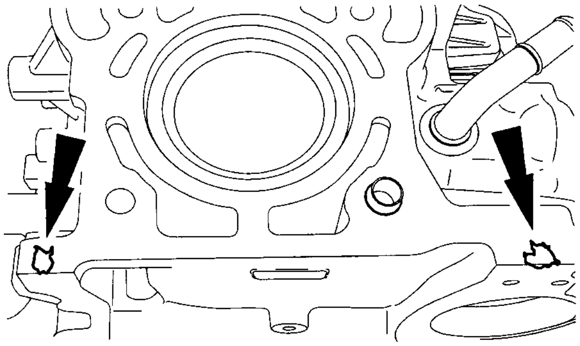
⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

CAUTION: Failure to follow this procedure can cause future oil leakage.

NOTE: Do not attempt to make the metal shiny. Some staining of the metal surfaces is normal.

2. Apply silicone gasket and sealant to the locations shown.

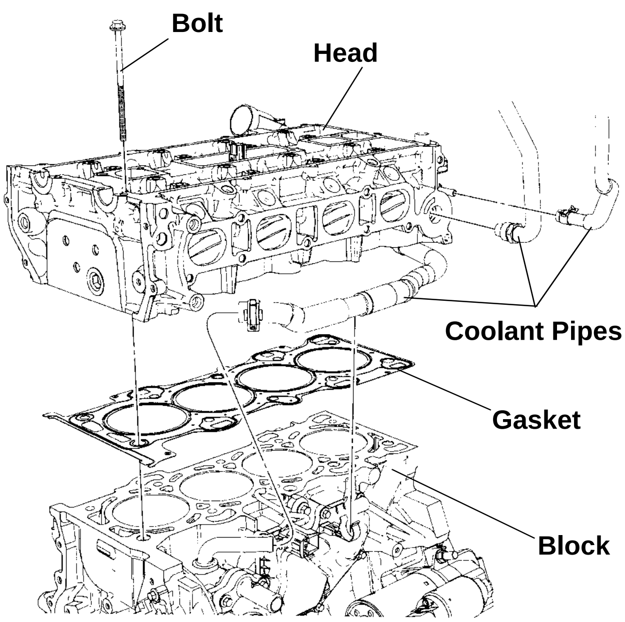


NOTE: If not secured within 4 minutes, the sealant must be removed and the sealing area recleaned as before. Refer to previous CAUTION & WARNING.

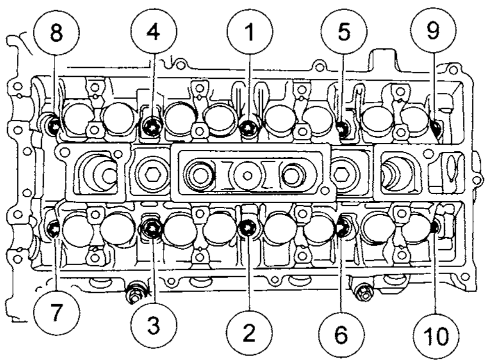
3. Install a new cylinder head gasket.
4. Lubricate new cylinder head bolts with clean engine oil.

CAUTION: Cylinder head bolts are torque-to-yield and must not be reused. New bolts must be installed.

5. Install cylinder head carefully.



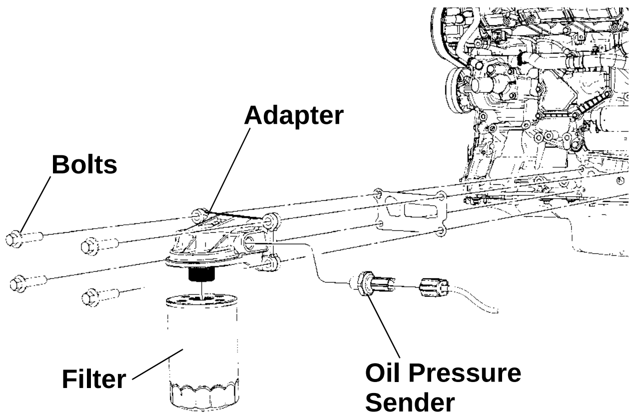
6. Tighten bolts in sequence shown in 5 stages:
   - Stage 1: Tighten to 5 Nm (44 lb-in)
   - Stage 2: Tighten to 15 Nm (11 lb-ft)
   - Stage 3: Tighten to 45 Nm (33 lb-ft)
   - Stage 4: Tighten an additional 90 degrees
   - Stage 5: Tighten an additional 90 degrees.



7. Install fuel rail -- refer to Section 4.
8. Install exhaust manifold -- Refer to“Exhaust Manifold - Installation” on page 19 of this section.
9. Install camshafts -- Refer to“Camshafts - Installation” on page 18 of this section.
10. Install camshaft cover -- Refer to“Camshaft Cover - Installation” on page 7 of this section.
11. Install or reconnect any other component that was removed or disconnected.
12. Reconnect negative battery cable -- refer to Section 6.

Oil Filter Adapter - Removal

1. Disconnect negative battery cable -- refer to Section 6.
2. Remove and/or disconnect components to allow access and removal of the oil filter adapter. Label if necessary to allow for correct reinstallation.
3. Drain the engine oil.
4. Disconnect the oil pressure sender connector.
5. Remove the oil pressure sender -- Refer to“Oil Pressure Sender - Replacement” on page 23 of this section.



6. Remove and discard the oil filter.
7. Remove 4 bolts and oil filter adapter.
8. Remove and discard the gasket.

Oil Filter Adapter - Installation

CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

1. Clean the mating surface of adapter and block, with silicone gasket remover and metal surface prep.

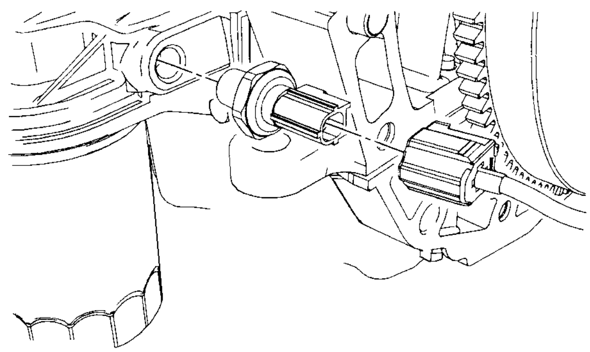
⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

2. Using a new gasket, install the oil filter adapter and 4 bolts:
   - Tighten to 25 Nm (18 lb-ft).
3. Install a new oil filter.
4. Apply thread sealant with PTFE to the oil pressure sender threads and install the sender:
5. Tighten to 15 Nm (11 lb-ft).
6. Connect oil pressure sender connector.
7. Fill the engine with clean engine oil.
8. Run the engine and check for leaks.
9. Install or reconnect any other component that was removed or disconnected.

Oil Pressure Sender - Replacement

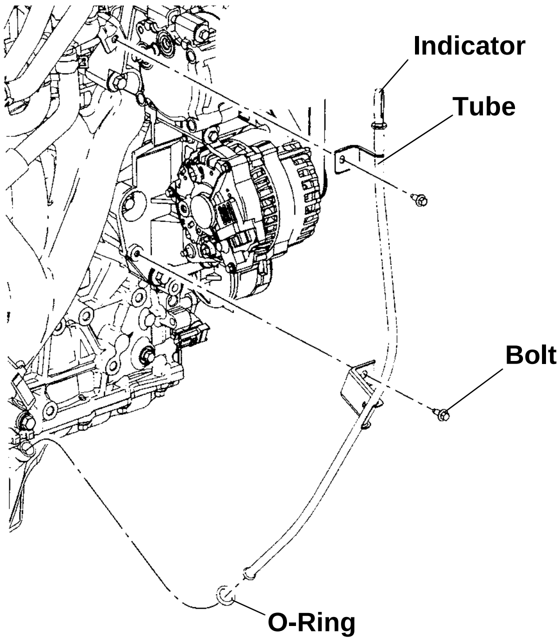
1. Disconnect negative battery cable -- refer to Section 6.
2. Remove and/or disconnect components to allow access and removal of the oil pressure sender. Label if necessary to allow for correct reinstallation.
3. Disconnect the oil pressure sender connector.
4. Remove the oil pressure sender.



5. Apply thread sealant with PTFE to the oil pressure sender threads and install the sender:
6. Tighten to 15 Nm (11 lb-ft).
7. Connect oil pressure sender connector.

Oil Level Indicator & Tube - Replacement

1. Remove and/or disconnect components to allow access and removal of the oil level indicator & tube. Label if necessary to allow for correct reinstallation.
2. Remove the oil level indicator.

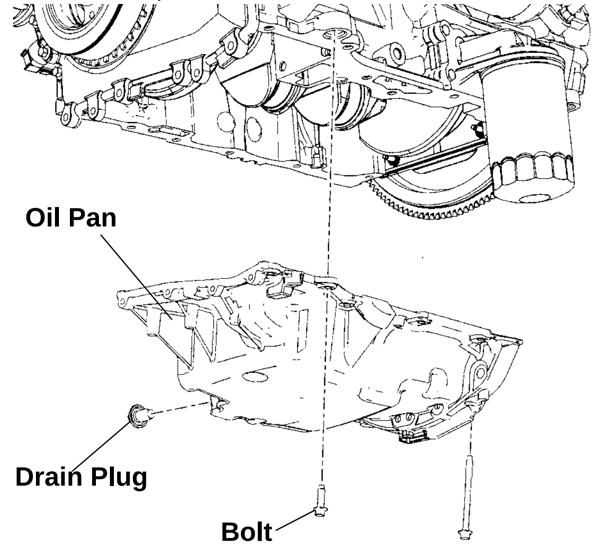


3. Remove the 2 bolts and tube.
4. Remove and discard the o-ring.
5. Reverse procedure to install:
   - Install a new o-ring
   - Apply clean engine oil to o-ring
   - Tighten bolts to 10 Nm (89 lb-in).

Oil Pan - Removal

CAUTION: Failure to follow this procedure can cause future oil leakage.

1. Remove and/or disconnect components to allow access and removal of the oil pan. Label if necessary to allow for correct reinstallation.
2. Drain the engine oil.
3. Remove oil level indicator & tube -- Refer to“Oil Level Indicator & Tube - Replacement” on page 24 of this section.
4. Remove oil pan and bolts.



CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraping tool to remove all traces of old sealant.

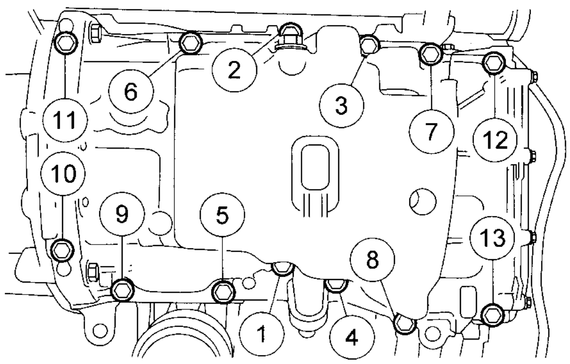
5. Clean the mating surface of oil pan and block, with silicone gasket remover and metal surface prep.

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

Oil Pan - Installation

NOTE: If not secured within 4 minutes, the sealant must be removed and the sealing area recleaned as before. Refer to previous CAUTION & WARNING.

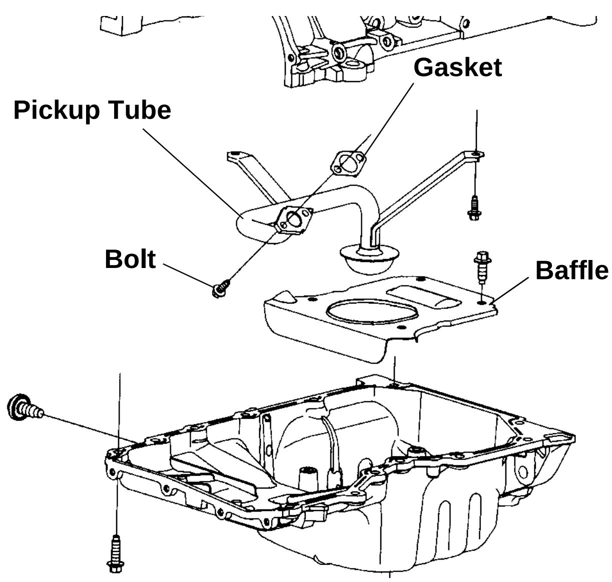
1. Apply a 2.5 mm (0.1 in) bead of silicone gasket and sealant to the oil pan. Install the oil pan and bolts in sequence shown:
   - Tighten to 25 Nm (18 lb-ft).



2. Install oil level indicator and tube -- Refer to“Oil Level Indicator & Tube - Replacement” on page 24 of this section.
3. Install drain plug:
   - Tighten to 28 Nm (21 lb-ft).
4. Fill engine with clean engine oil.
5. Install or reconnect any other component that was removed or disconnected.

Oil Pickup Tube - Replacement

1. Remove the oil pan -- Refer to“Oil Pan - Removal” on page 24 of this section.
2. Remove bolts and oil pickup tube.



3. Remove gasket and discard.
4. Clean the sealing surface with metal surface prep.

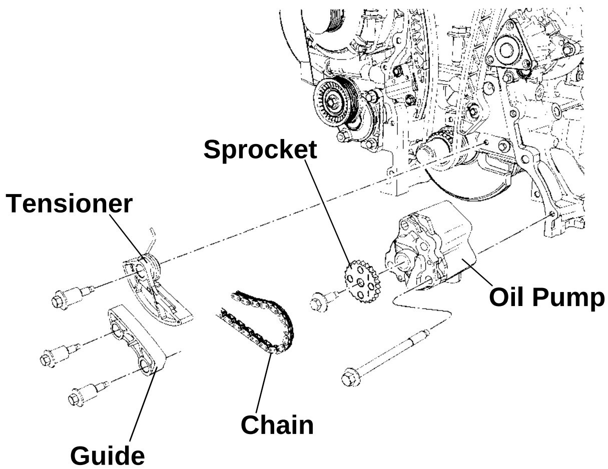
⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

5. Reverse procedure to install:
   - Use a new gasket
   - Tighten bolts to 10 Nm (89 lb-in).

Oil Pump - Removal

1. Remove and/or disconnect components to allow access and removal of the oil pump. Label if necessary to allow for correct reinstallation.
2. Remove engine front cover -- Refer to“Engine Front Cover - Removal” on page 11 of this section.
3. Remove oil pan -- Refer to“Oil Pan - Removal” on page 24 of this section.
4. Remove oil pickup tube -- Refer to“Oil Pickup Tube - Replacement” on page 25 of this section.
5. Release the tension on the tensioner spring and remove the bolt and tensioner.



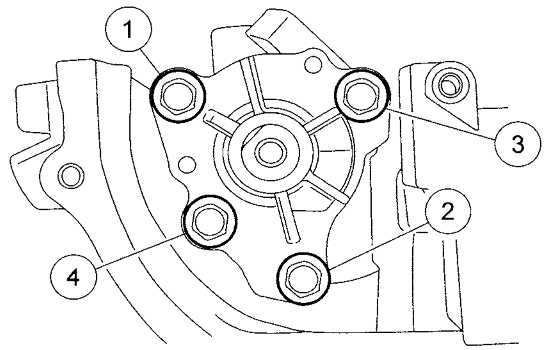
6. Remove 2 bolts and oil pump chain guide.
7. Remove oil pump chain.
8. Remove bolt and oil pump sprocket.
9. Remove 4 bolts and oil pump.

Oil Pump - Installation

1. Clean the oil pump and block mating surface with metal surface prep.

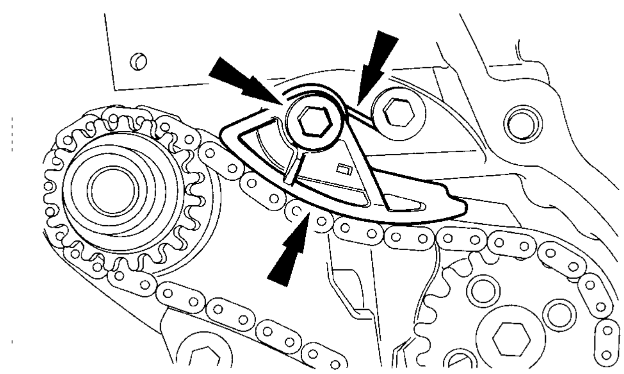
WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

2. Install oil pump and 4 bolts in sequence shown in 2 stages:
   - Stage 1: Tighten to 10 Nm (89 lb-in)
   - Stage 2: Tighten to 20 Nm (15 lb-ft).



Tightening Sequence

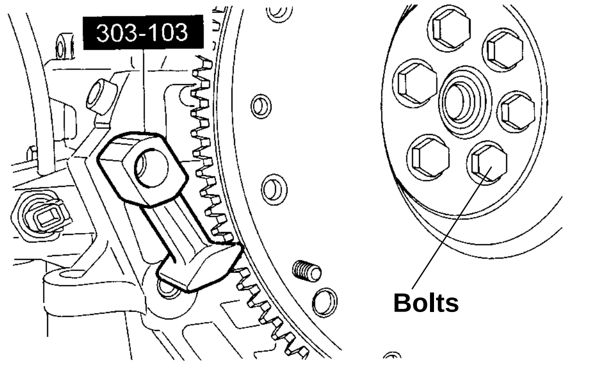
3. Install sprocket and bolt:
   - Tighten to 25 Nm (18 lb-ft).
4. Install the chain onto the sprockets.
5. Install guide and 2 bolts:
   - Tighten to 10 Nm (89 lb-in).
6. Install tensioner and bolt:
   - Hook tensioner spring around the shoulder bolt.
   - Tighten to 10 Nm (89 lb-in).



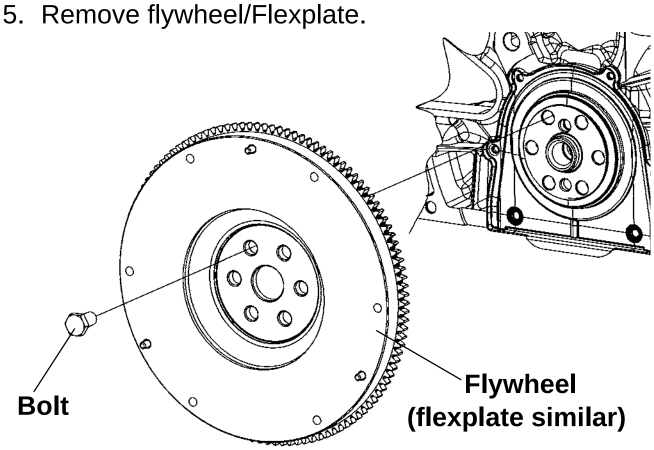
7. Install pickup tube -- Refer to“Oil Pickup Tube - Replacement” on page 25 of this section.
8. Install oil pan -- Refer to“Oil Pan - Installation” on page 25 of this section.
9. Install engine front cover -- Refer to“Engine Front Cover - Installation” on page 12 of this section.
10. Install or reconnect any other component that was removed or disconnected.

Flywheel/Flexplate - Replacement

1. Remove any components necessary to gain access to the flywheel/flexplate.
2. Remove the transmission or PTO.
3. Remove the pressure plate and clutch if equipped.
4. Remove bolts using tool 303-103.

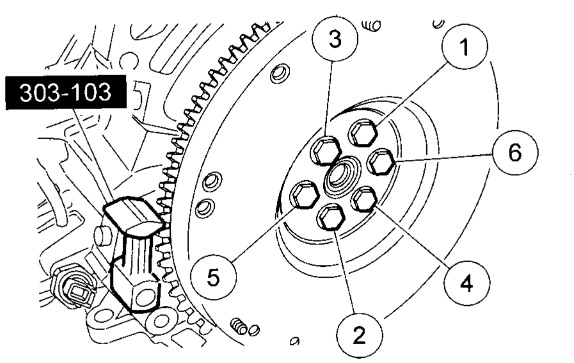


5. Remove flywheel/Flexplate.



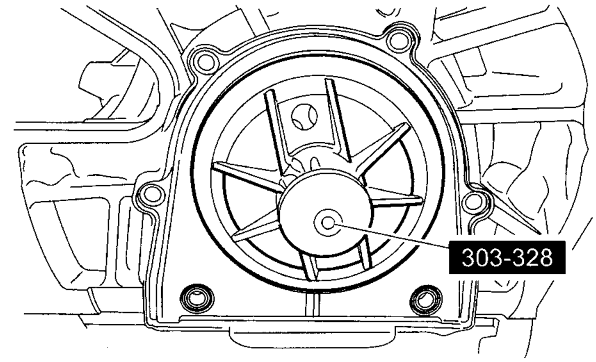
CAUTION: Special bolts are used for installation. Do not use standard bolts.

6. Reverse procedure to install. Tighten bolts in sequence shown in three stages:
   - Stage 1: Tighten to 50 Nm (37 lb-ft)
   - Stage 2: Tighten to 80 Nm (59 lb-ft)
   - Stage 3: Tighten to 112 Nm (83 lb-ft).



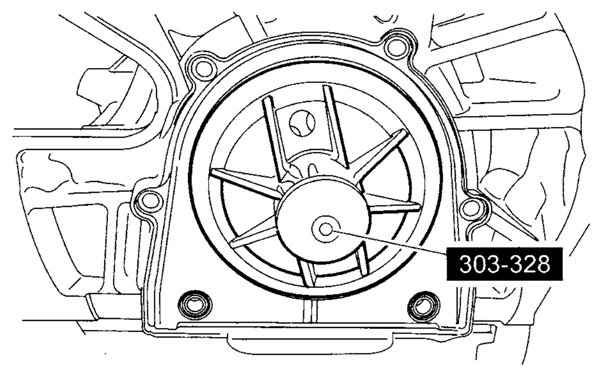
Crankshaft Rear Seal/Retainer - Removal

1. Remove and/or disconnect components to allow access and removal of the rear seal. Label if necessary to allow for correct reinstallation.
2. Remove flywheel or flexplate -- Refer to“Flywheel/ Flexplate - Replacement” on page 27 of this section.
3. Remove oil pan -- Refer to“Oil Pan - Removal” on page 24 of this section.
4. Remove bolts and retainer plate.

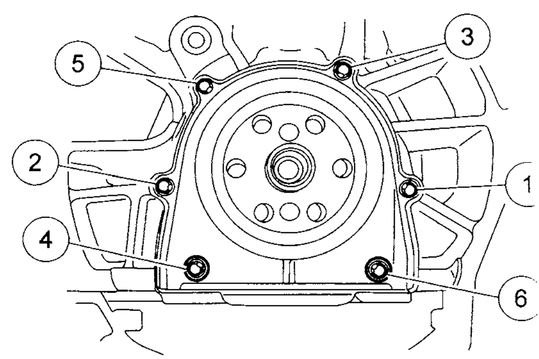


Crankshaft Rear Seal/Retainer - Installation

1. Using special tool 303-328, position rear oil seal with retainer plate onto crankshaft.



2. Install 6 bolts in the sequence shown:
   - Tighten to 10 Nm (89 lb-in).



3. Install oil pan -- Refer to“Oil Pan - Installation” on page 25 of this section.
4. Install flywheel or flexplate -- Refer to“Flywheel/ Flexplate - Replacement” on page 27 of this section.
5. Install or connect any other component removed or disconnected.

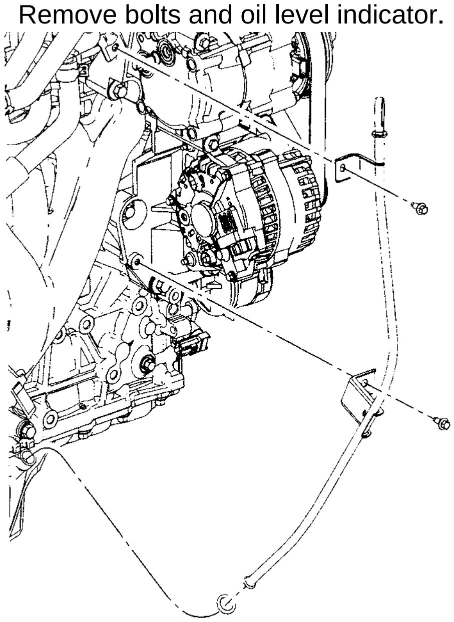
DISASSEMBLY & ASSEMBLY

Engine Disassembly

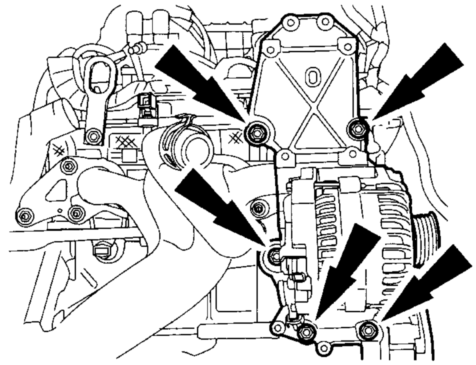
CAUTION: During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces can enter the oil passages, coolant passages or the oil pan, and cause engine failure.

CAUTION: Due to the precision fit and timing of the balancer shaft assembly, it cannot be removed from the engine block.

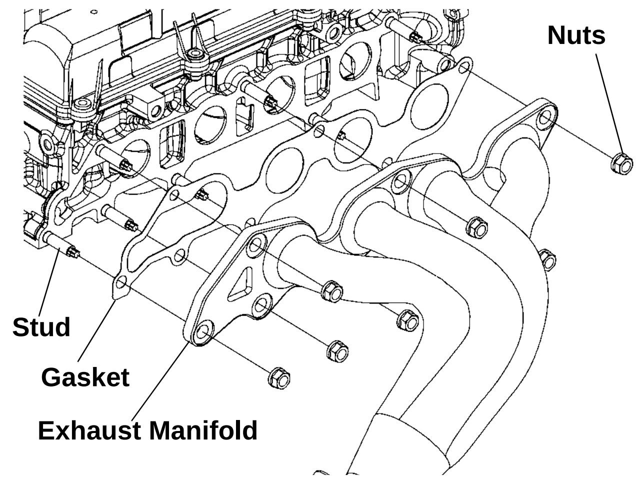
1. Remove engine from equipment and mount on an engine stand -- Refer to“Flywheel/Flexplate - Replacement” on page 27 of this section.
2. Remove the drivebelt.
3. Remove bolts and oil level indicator.



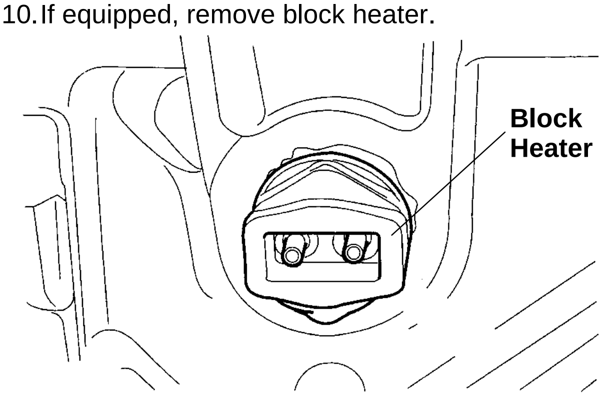
4. Remove all coolant pipes and hoses.
5. Remove A/C compressor (if equipped).
6. Remove generator and bracket assembly.



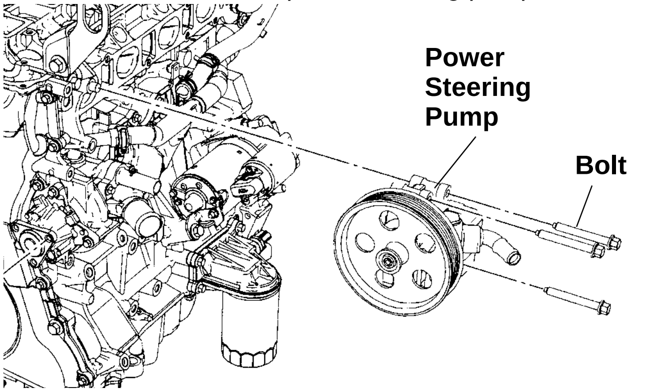
7. Remove nuts and exhaust manifold. Discard nuts.



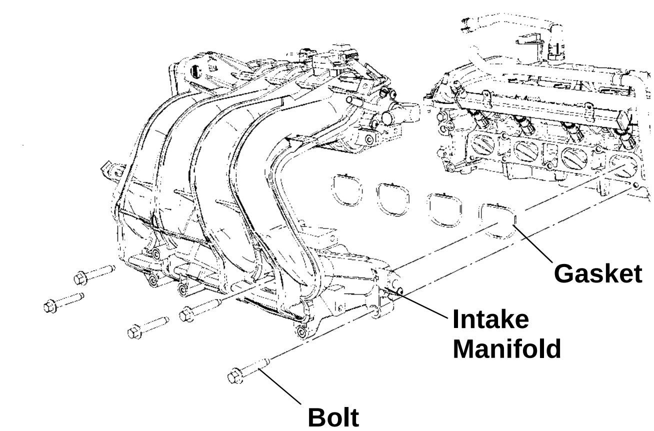
8. Remove and discard exhaust manifold gasket and studs.
9. Inspect exhaust manifold for flatness -- refer to Section 1.
10. If equipped, remove block heater.



11. Remove 4 bolts and power steering pump.

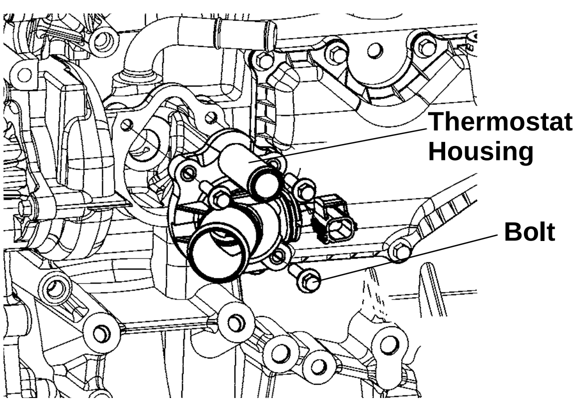


12. Remove 5 bolts and intake manifold.

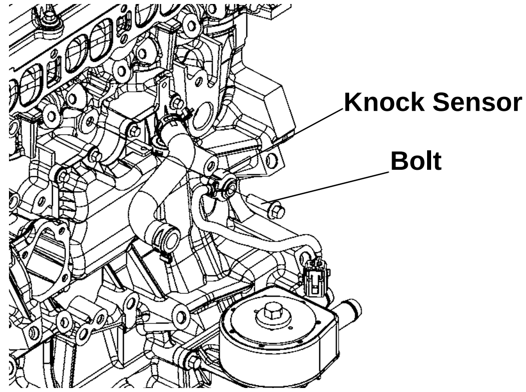


13. Remove ignition coils.

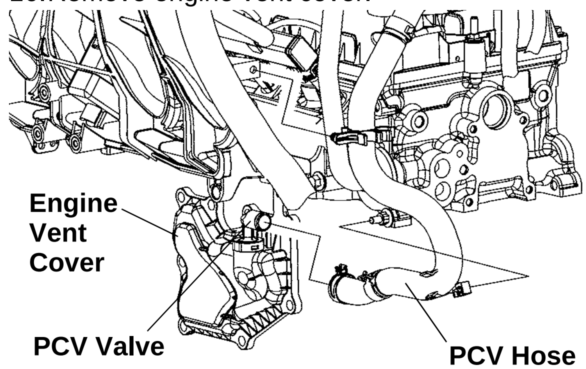
14. Remove 3 bolts and thermostat housing.



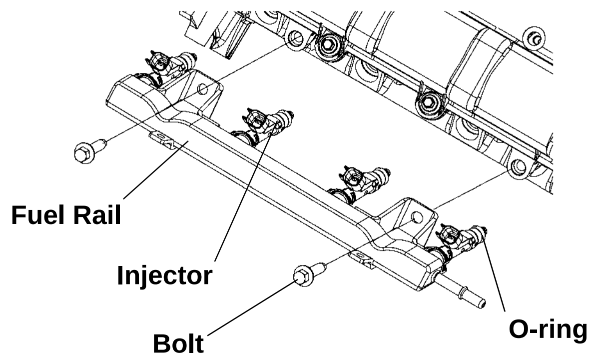
15. Remove knock sensor.



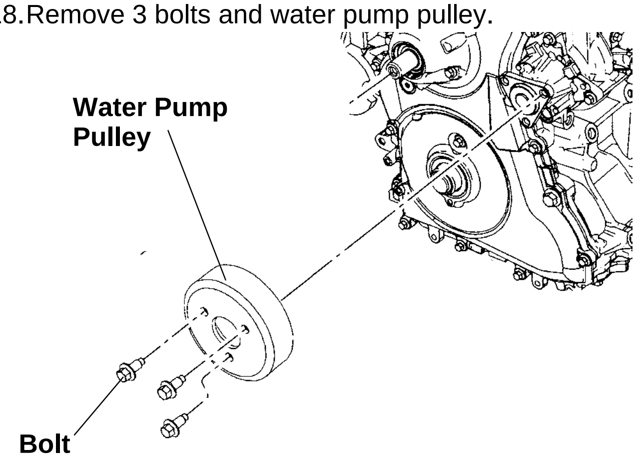
16. Remove engine vent cover.



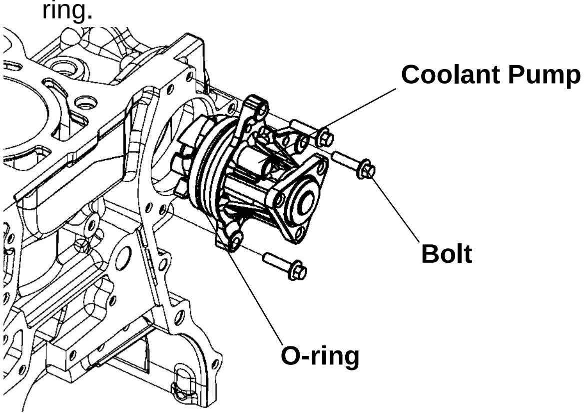
17. Remove fuel rail and injectors. Discard o-rings.



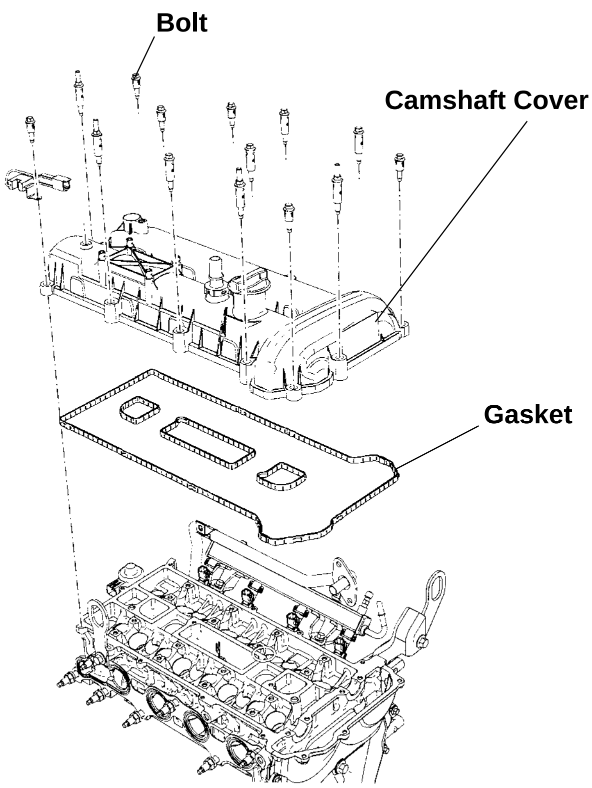
18. Remove 3 bolts and water pump pulley.



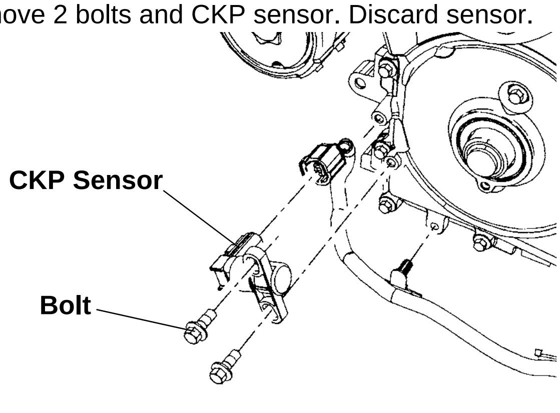
19. Remove 3 bolts and coolant pump. Discard the o-ring.



20. Remove camshaft cover.



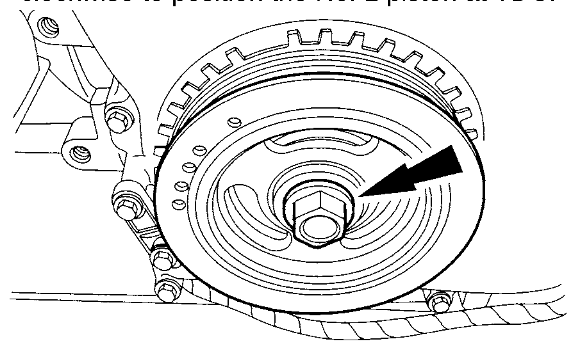
21. Remove 2 bolts and CKP sensor. Discard sensor.



CAUTION: Failure to position the No. 1 piston at top dead center (TDC) can result in damage to the engine. Turn the engine in the normal direction of rotation only.

CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

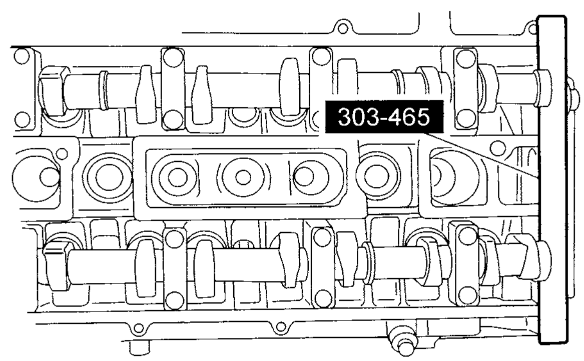
22. Using the crankshaft pulley bolt, turn the crankshaft clockwise to position the No. 1 piston at TDC.



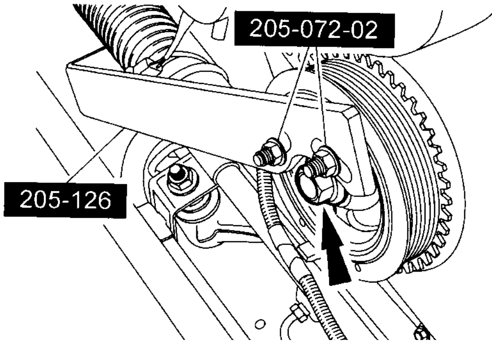
CAUTION: The special tool 303-465 is for camshaft alignment only. Using this tool to prevent engine rotation can result in engine damage.

NOTE: The camshaft timing slots are offset. If the special tool cannot be installed, rotate the crankshaft one complete revolution clockwise to correctly position the camshafts.

23. Install special tool 303-465 in the slots on the rear of both camshafts.



24. Install special tools 205-126 & 205-072-02.



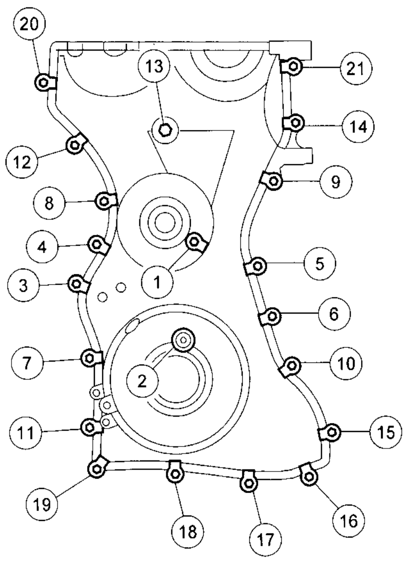
CAUTION: Failure to hold the crankshaft pulley in place during bolt loosening can cause damage to the engine.

25. Using the special tools, remove bolt, washer and crankshaft pulley. Discard the bolt.

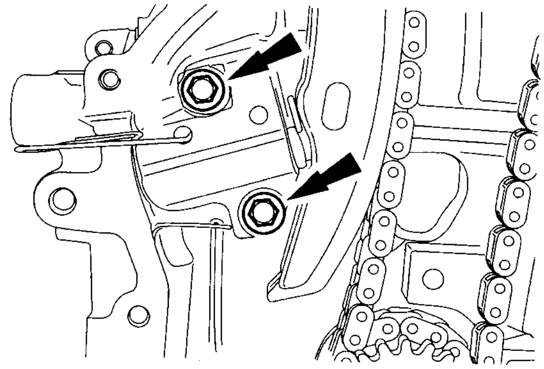
CAUTION: There is one front cover bolt behind the cooling fan drive pulley.

26. Remove bolt behind cooling fan drive pulley through one of access holes.

27. Remove all front cover bolts and front cover.

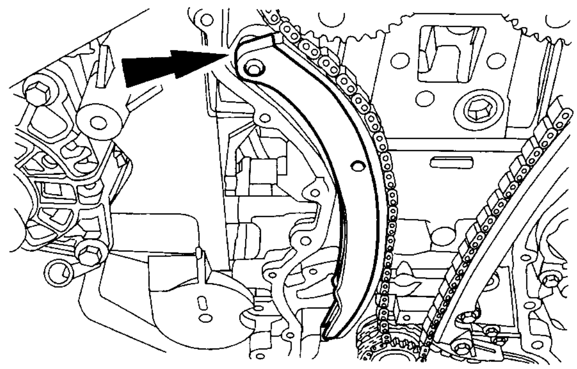


28. Compress the timing chain tensioner and insert a paper clip into the hole.

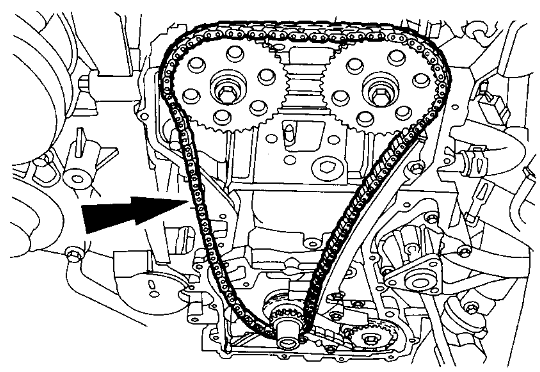


29. Remove 2 bolts and tensioner.

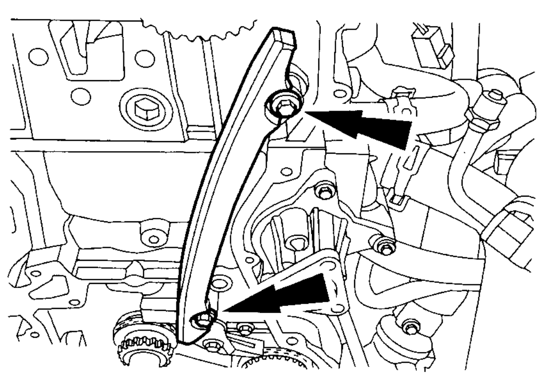
30. Remove right timing chain guide.



31. Remove timing chain.

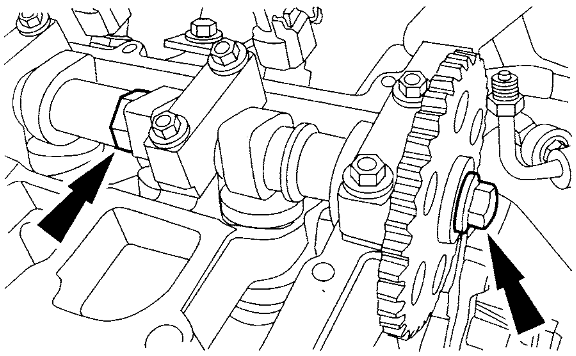


32. Remove 2 bolts and left timing chain guide.

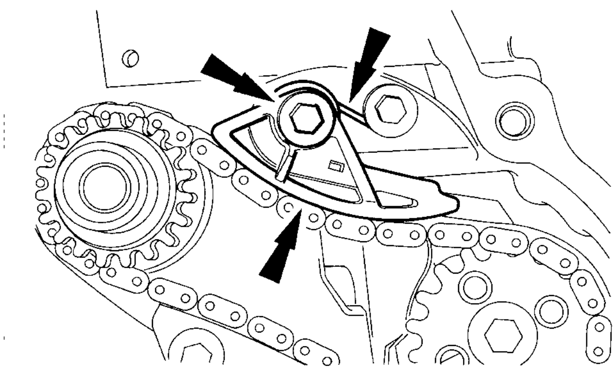


CAUTION: Do not rely on camshaft alignment plate to prevent camshaft rotation. Damage to the tool or the camshaft can occur.

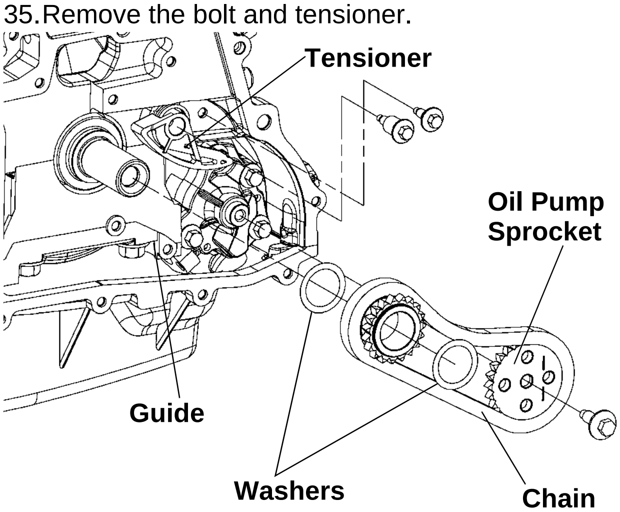
33. Using a wrench on the camshaft flats, remove bolts, washers and sprockets.



34. Release tension on oil pump chain tensioner.



35. Remove the bolt and tensioner.



36. Remove bolts and guide.

37. Holding oil pump sprocket in place, remove bolt, chain, sprockets and diamond washers.

38. Remove special tool 303-465.

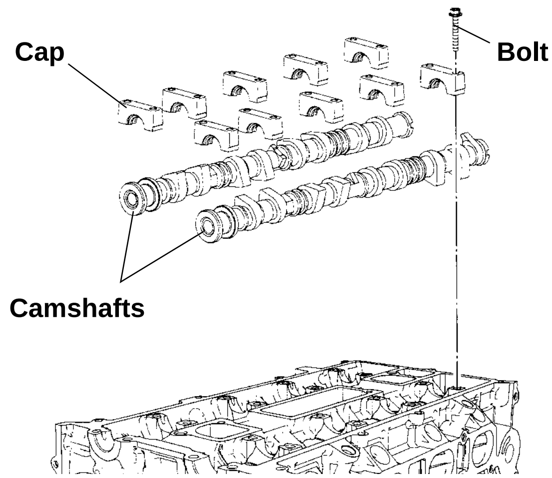
CAUTION: Failure to follow the camshaft loosening procedure can result in damage to the camshafts.

NOTE: Note the position of the lobes on the number one cylinder before removing the camshafts for assembly reference.

39. Remove the camshaft bearing caps as follows:

- Loosen the camshaft bearing cap bolts in the sequence shown one turn at a time
- Repeat until all the tension is released from the camshaft bearing caps.
- Remove the bearing caps.

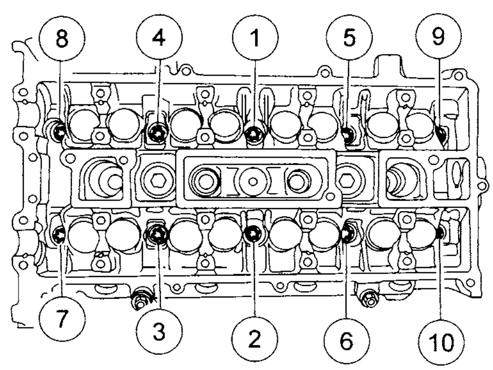
40. Remove the camshafts.



CAUTION: The cylinder head must be cool before removing it from the engine. Cylinder head warpage can result if a warm or hot cylinder head is removed.

CAUTION: The cylinder head bolts must be discarded and new bolts must be installed. They are tighten-to-yield designed and cannot be reused.

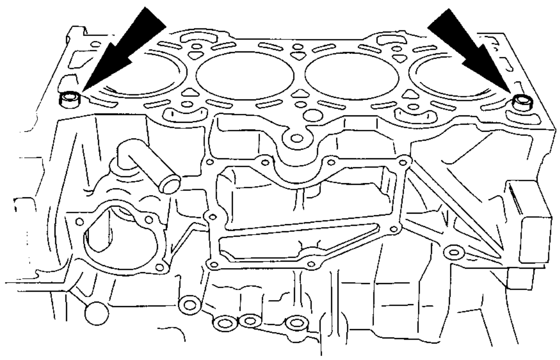
41. Remove and discard cylinder head bolts.



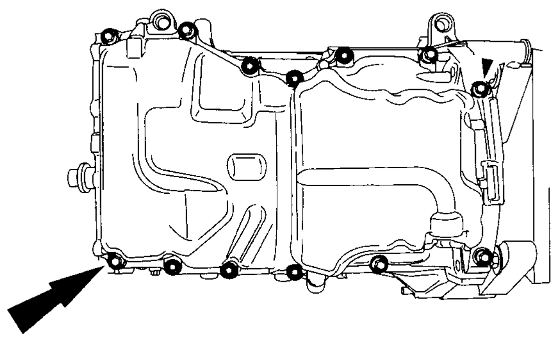
42. Remove cylinder head.

43. Remove and discard the gasket.

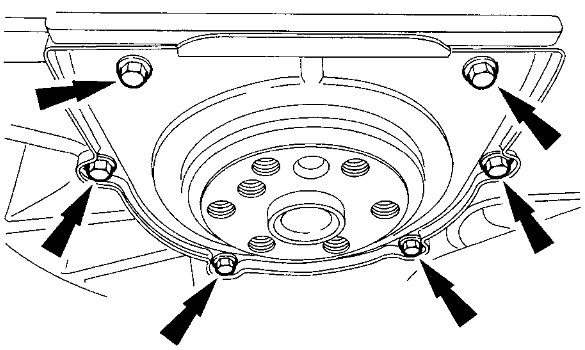
44. Remove the cylinder head alignment dowels.



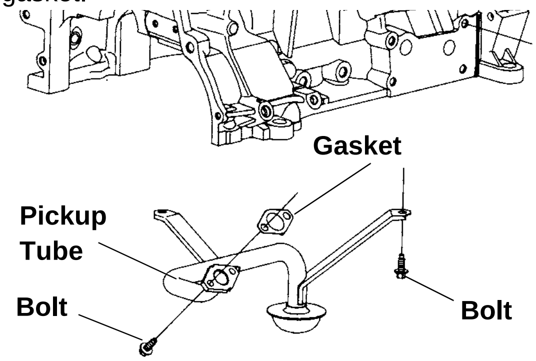
45. Remove bolts and oil pan.



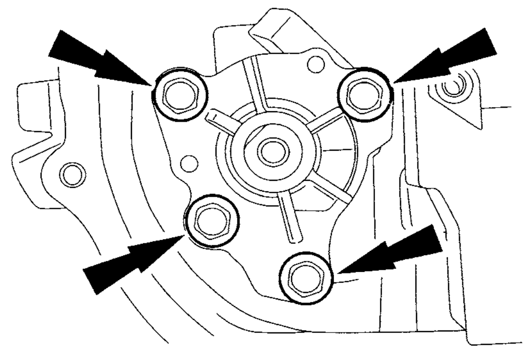
46. Remove bolts and rear seal retainer plate.



47. Remove bolts, oil pump pickup tube and discard gasket.



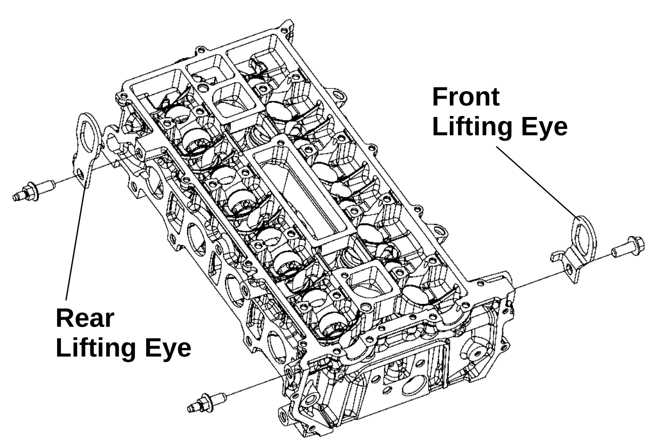
48. Remove 4 bolts and oil pump.



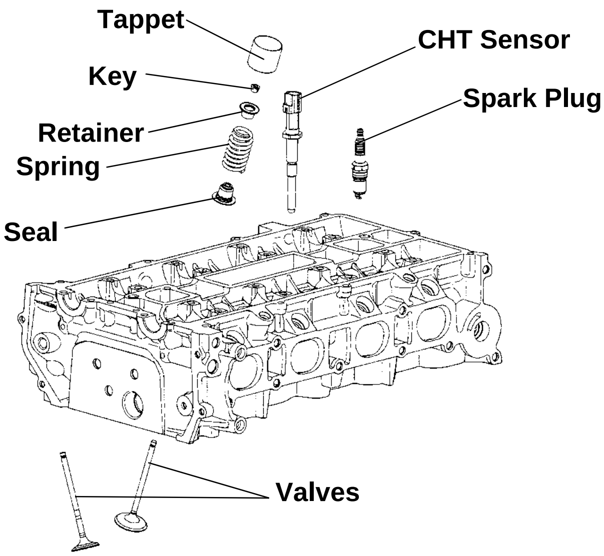
49. Remove and discard oil pump gasket.

Cylinder Head Disassembly

1. Remove rear lifting eye and front bracket.



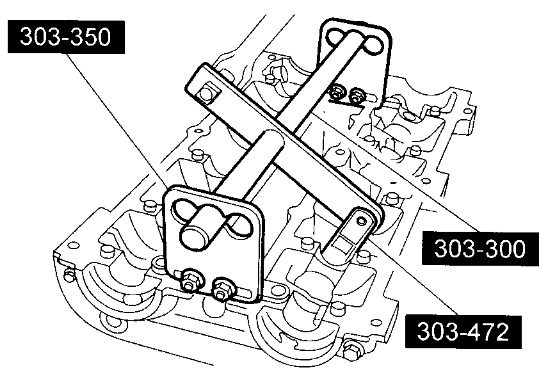
2. Remove cylinder head temperature (CHT) sensor.



3. Remove coolant outlet pipe.
4. Remove spark plugs and discard.

CAUTION: Note location of the tappets prior to removal.

5. Remove 16 valve tappets.
6. Using special tools 303-350, 303-300 & 303-472, compress valve spring and remove valve spring retainer keys, retainers and springs.



7. Remove all special tools.

CAUTION: Note location of valves if they are to be reused.

8. Remove valves.
9. Using special tools 303-005 and 303-468, remove and discard valve stem seals.
10. Inspect valve, valve springs, retainers and keys -- refer to Section 1.

Engine Cleaning

During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces can enter the oil passages, coolant passages or the oil pan, and cause engine failure.

Place clean shop towels over exposed engine cavities. Carefully remove the towels so foreign material is not dropped into the engine.

CAUTION: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges that make leak paths. Use a plastic scraping tool to remove all traces of the gasket material and sealant.

CAUTION: Aluminum surfaces are soft and can be scratched easily. Never place the cylinder head gasket surface, unprotected, on a bench surface.

To clean residual sealant, oil, coolant and gasket material from sealing area, use silicone gasket remover and metal surface prep. A second application may be required if traces of silicone or gasket material remain.

Allow to dry until there is no sign of wetness, or 4 minutes, whichever is longer. Failure to follow this procedure can cause future oil leakage.

⚠

WARNING: OBSERVE ALL WARNINGS AND CAUTIONS AND FOLLOW ALL APPLICATION DIRECTIONS CONTAINED ON THE PACKAGING OF THE SILICONE GASKET REMOVER AND METAL SURFACE PREP.

NOTE: Do not attempt to make metal shiny. Some staining of metal surfaces is normal.

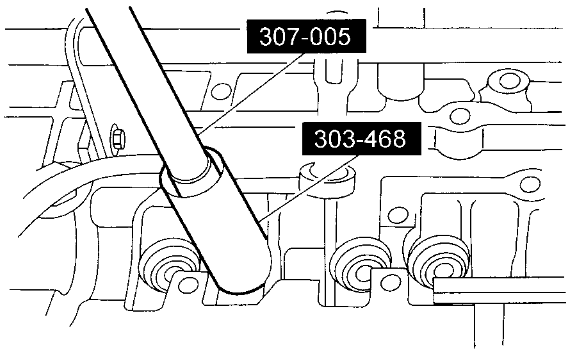
Cylinder Head Assembly

CAUTION: If installing original valves, make sure they are installed in the same position as removed.

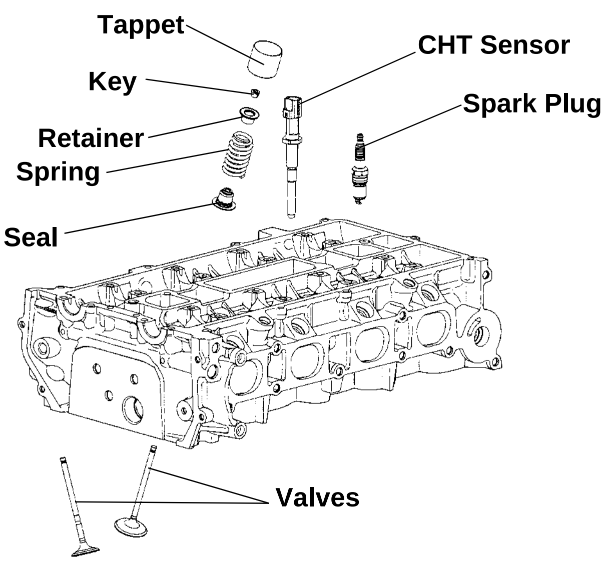
1. Coat valve stems and guides with clean engine oil and install into cylinder head.

CAUTION: Use protector provided with replacement kit to prevent damage to the valve seals.

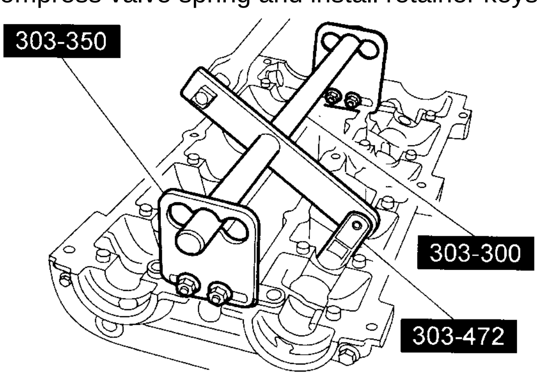
2. Using special tool 303-470, install valve seals onto the guides.



3. Position valve springs and retainers.



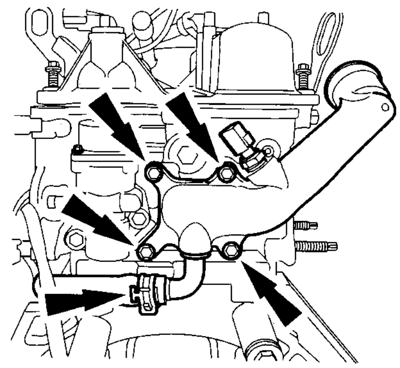
4. Using special tools 303-350, 303-300 and 303-472, compress valve spring and install retainer keys.



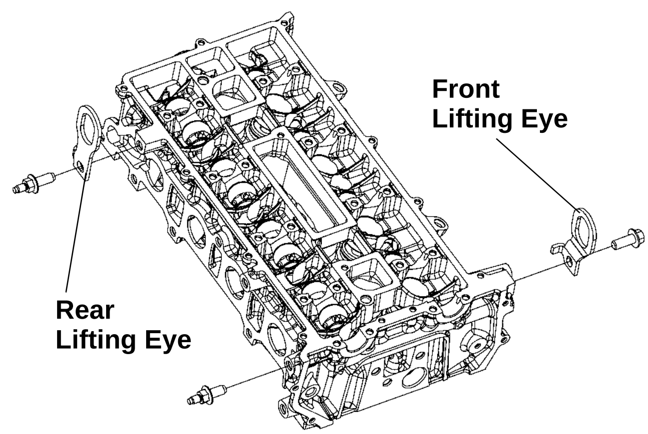
NOTE: Make sure keys are seated properly.

CAUTION: Be sure to install tappets in the same location as removed.

5. Install 16 valve tappets.
6. Install a new CHT Sensor:
   - Tighten to 12 Nm (9 lb-ft).
7. Install 4 new spark plugs (properly gapped):
   - Tighten to 15 Nm (11 lb-ft).
8. Using a new gasket, install coolant outlet pipe and 4 bolts:
   - Tighten to 10 Nm (89 lb-in).



9. Install rear lifting eye and front lifting eye bracket:
   - Tighten to 45 Nm (33 lb-ft).

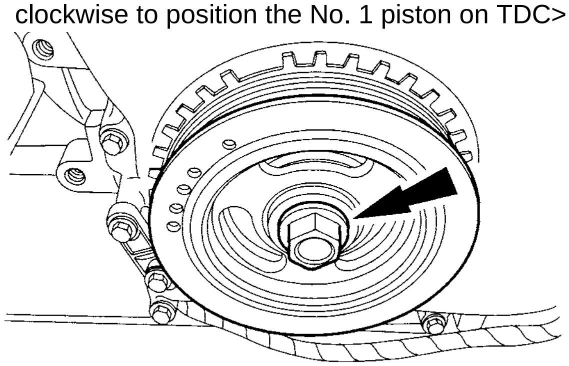


Engine Assembly

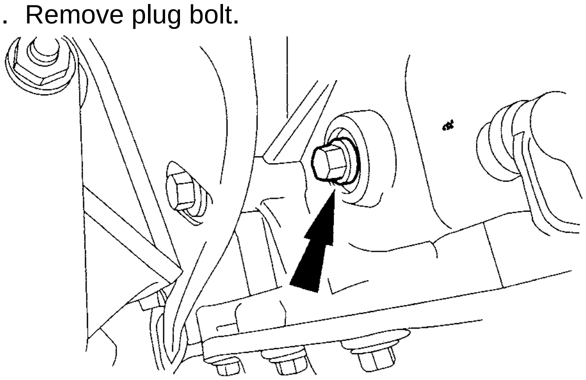
CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. For that reason, the crankshaft sprocket is also unfastened if you loosen the pulley. Therefore, the engine must be retimed each time the damper is removed. Otherwise severe damage can occur.

CAUTION: Failure to position the No. 1 piston at top dead center (TDC) can result in damage to the engine. Turn the engine in the normal direction of rotation only.

1. Using the crankshaft pulley bolt, turn the crankshaft clockwise to position the No. 1 piston on TDC>

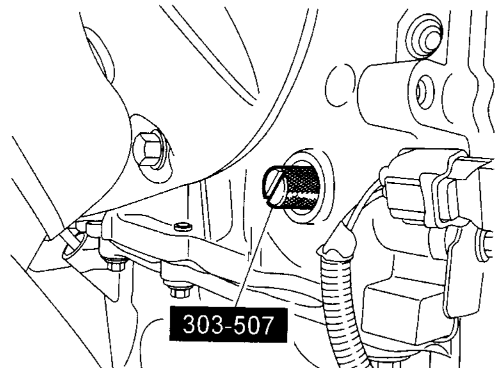


2. Remove plug bolt.

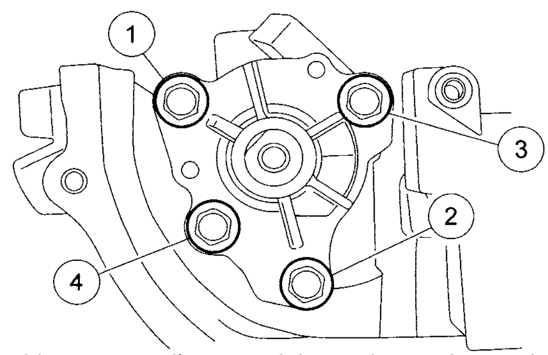


CAUTION: Only turn the engine in the normal direction of rotation. Installing the special tool in this next step will prevent the engine from being rotated in the clockwise direction. However, the engine can still be rotated in the counterclockwise direction.

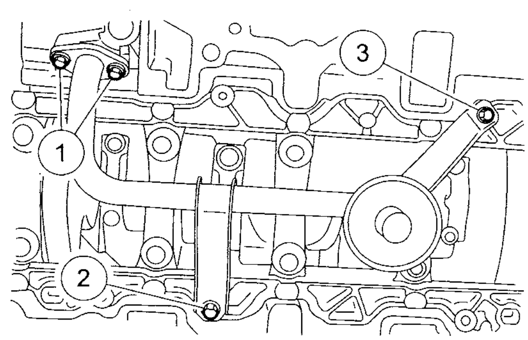
3. Install special tool 303-507.



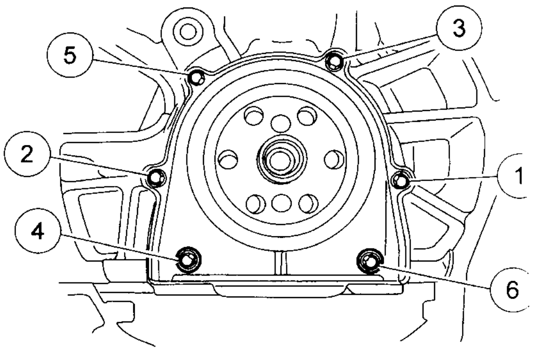
4. Position the oil pump assembly and tighten the bolts in the sequence shown in 2 stages:
   - Stage 1: Tighten to 10 Nm (89 lb-in)
   - Stage 2: Tighten to 20 Nm (15 lb-ft).



5. Position a new oil pump pickup tube gasket and the pickup tube, and tighten 4 bolts in the sequence shown:
   - Tighten to 10 Nm (89 lb-in).

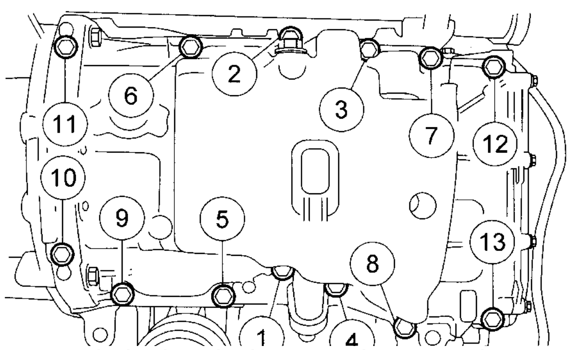


6. Using special tool 303-328, install a new crankshaft rear seal and retainer plate assembly. Tighten bolts in the sequence shown:
   - Tighten to 10 Nm (89 lb-in).

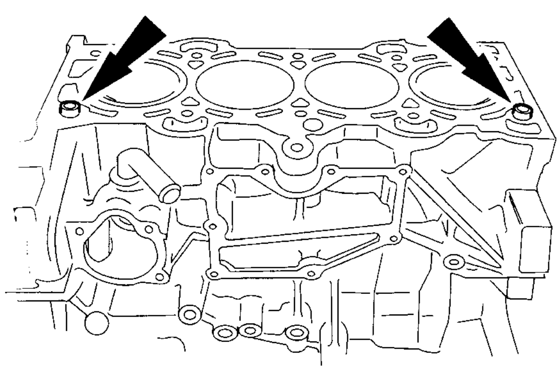


NOTE: If oil pan is not secured within 4 minutes, the sealant must be removed and the sealing area recleaned -- Refer to“Engine Cleaning” on page 34 of this section.

7. Apply a 2.5 mm (0.1 in) bead of silicone gasket and sealant to the oil pan. Install the oil pan and bolts. Tighten in the sequence shown:
   - Tighten to 25 Nm (18 lb-ft).

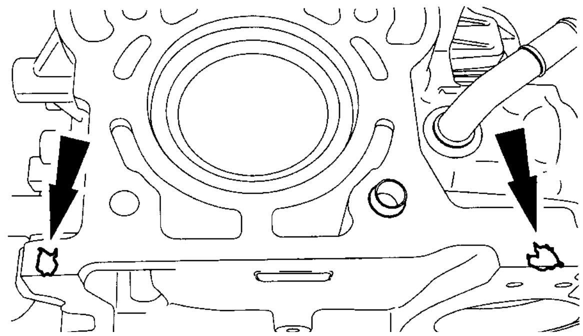


8. Install cylinder head alignment dowels until fully seated in block.



NOTE: If cylinder head is not secured within 4 minutes, the sealant must be removed and the sealing area recleaned -- Refer to“Engine Cleaning” on page 34 of this section.

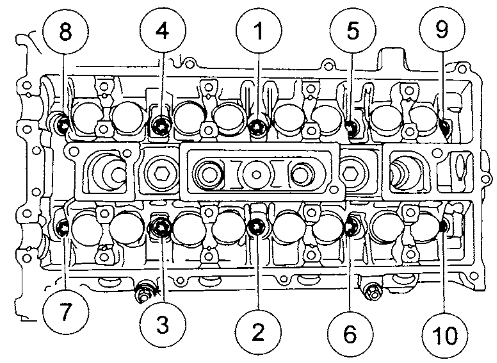
9. Apply silicone gasket and sealant to the locations shown.



10. Install a new gasket and position cylinder head.

CAUTION: Do not reuse cylinder head bolts.

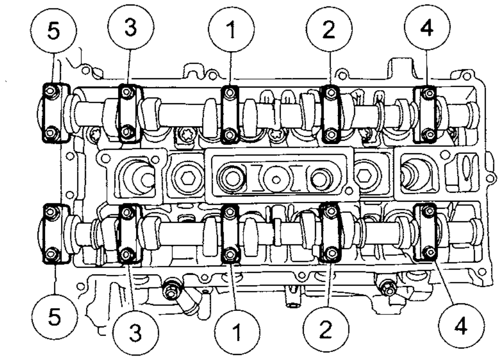
11. Lubricate new bolts and install in the sequence shown in 5 stages:
   - Stage 1: Tighten to 5 Nm (44 lb-in)
   - Stage 2: Tighten to 15 Nm (11 lb-ft)
   - Stage 3: Tighten to 45 Nm (33 lb-ft)
   - Stage 4: Tighten an additional 90 degrees (1/4 turn)
   - Stage 5: Tighten an additional 90 degrees (1/4 turn).



CAUTION: Install the camshafts with alignment slots in the camshaft lined up so the camshaft alignment plate can be installed without rotating the camshafts. Make sure the lobes on the No.1 cylinder are in the same position as noted in the disassembly procedure. Rotating the camshafts or installing the camshafts 180 degrees out of position can cause severe damage to the valves and pistons.

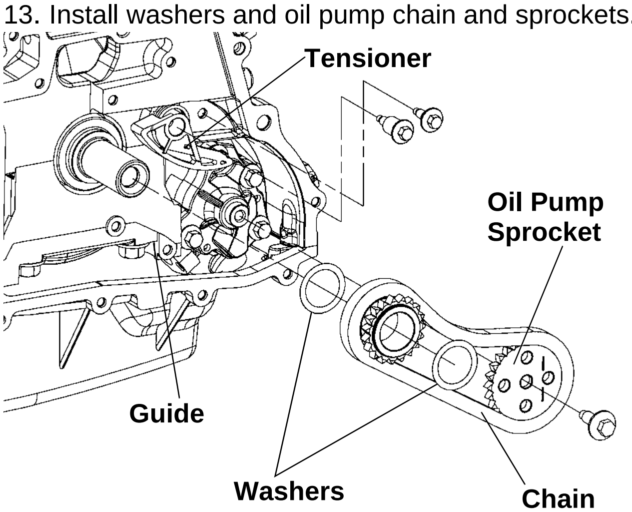
NOTE: Lubricate camshaft journals and bearing caps with clean engine oil.

12. Install the camshafts and bearing caps. Tighten bolts in sequence shown in three stages:
    - Stage 1: Tighten finger tight
    - Stage 2: Tighten to 7 Nm (62 lb-in)
    - Stage 3: Tighten to 16 Nm (12 lb-ft).

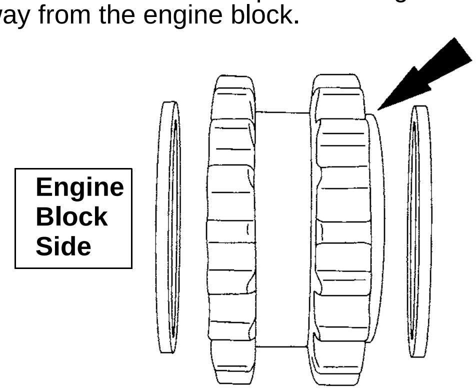


CAUTION: The crankshaft, the crankshaft sprocket and the pulley are fitted together by friction, with diamond washers between the flange faces on each part. The diamond washers must be installed correctly or severe engine damage can result.

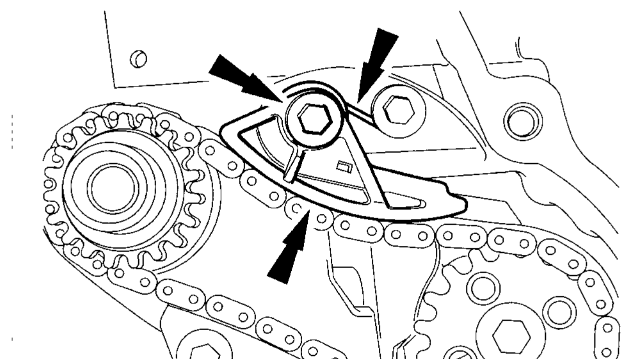
13. Install washers and oil pump chain and sprockets.



NOTE: The crankshaft sprocket flange must be facing away from the engine block.

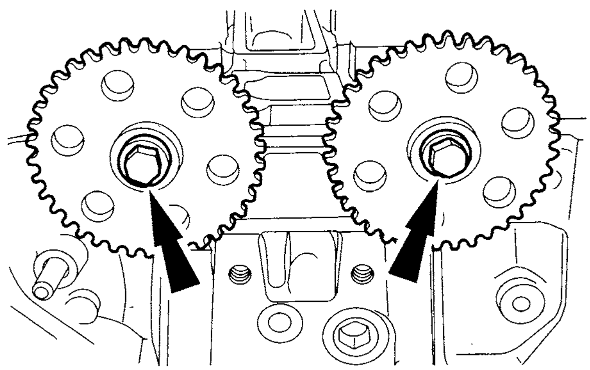


14. Holding the oil pump chain sprocket in place, tighten oil pump sprocket bolt:
    - Tighten to 25 Nm (18 lb-ft).
15. Install oil pump chain guide and shoulder bolt:
    - Tighten to 10 Nm (89 lb-in).
16. Install oil pump chain tensioner. Hook spring around shoulder bolt and tighten:
    - Tighten to 10 Nm (89 lb-in).



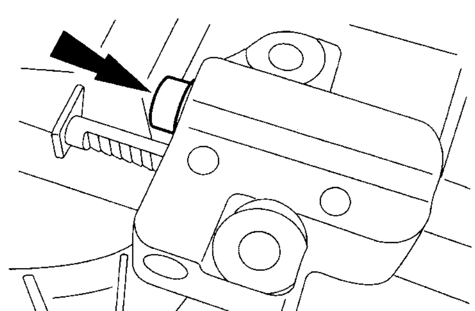
NOTE: Sprockets must turn freely on the camshafts.

17. Position camshaft sprockets and loosely install bolts.

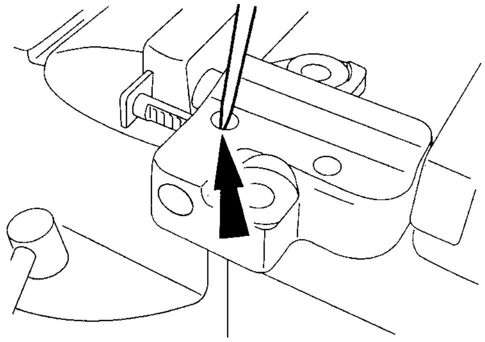


CAUTION: Do not compress the ratchet assembly. This will damage the ratchet assembly.

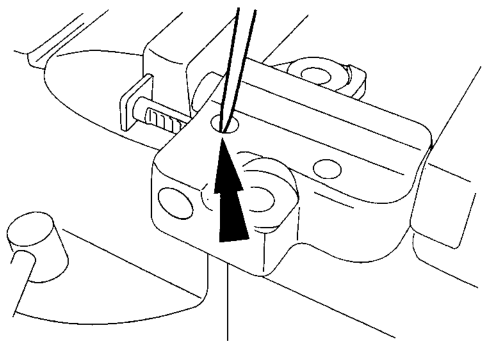
18. Using the edge of a vise, compress the timing chain tensioner plunger.



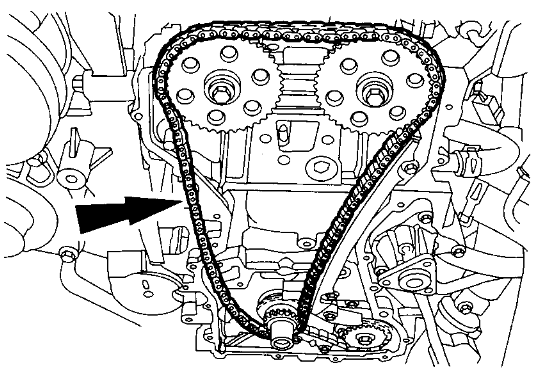
19. Using a small pick, push back and hold the ratchet mechanism.



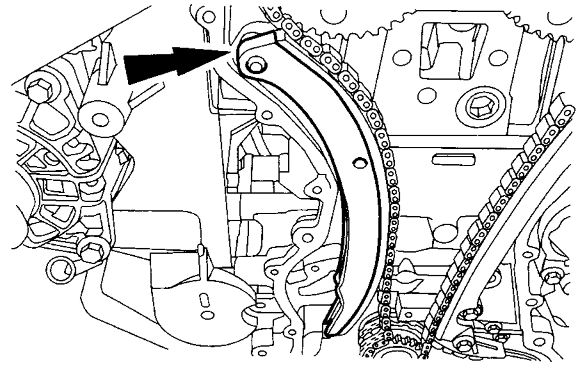
20. While holding the ratchet mechanism, push the ratchet arm back into the tensioner housing.



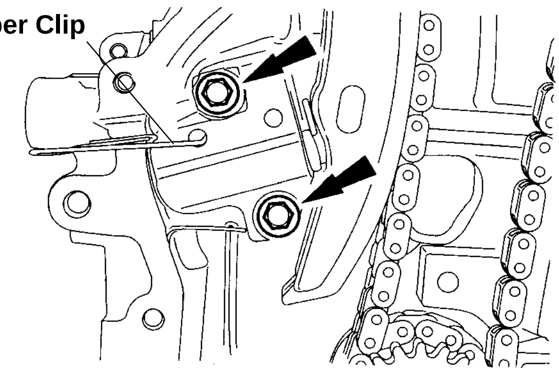
21. Install a paper clip into the hole in the tensioner housing to hold the ratchet assembly and the plunger in during installation.
22. Install the timing chain.



23. Position timing chain guides and install guide bolts:
    - Tighten to 10 Nm (89 lb-in).

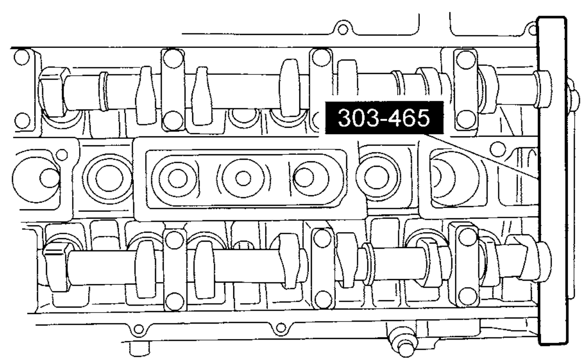


24. Install timing chain tensioner and 2 bolts. Remove the paper clip to apply tension to chain:
    - Tighten to 10 Nm (89 lb-in).

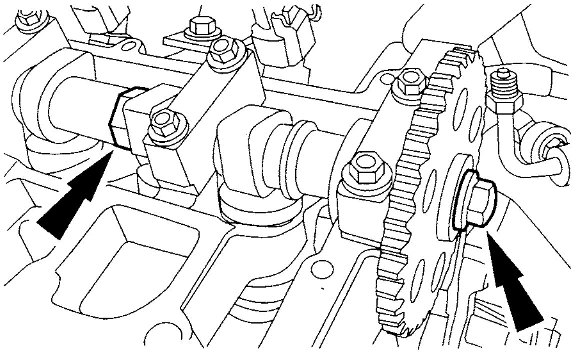


CAUTION: The special tool 303-465 is for camshaft alignment only. Using this tool to prevent engine rotation can result in engine damage.

25. Install special tool 303-465 in the timing slots on rear of both camshafts. Timing slots are offset from the centerline of the camshaft.



NOTE: Use a wrench on the flats between cylinders No.1 and No. 2 to hold the camshafts in place.

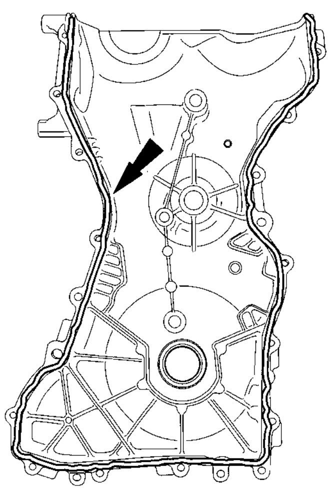


26. Tighten camshaft sprocket bolts:

- Tighten to 65 Nm (48 lb-ft).

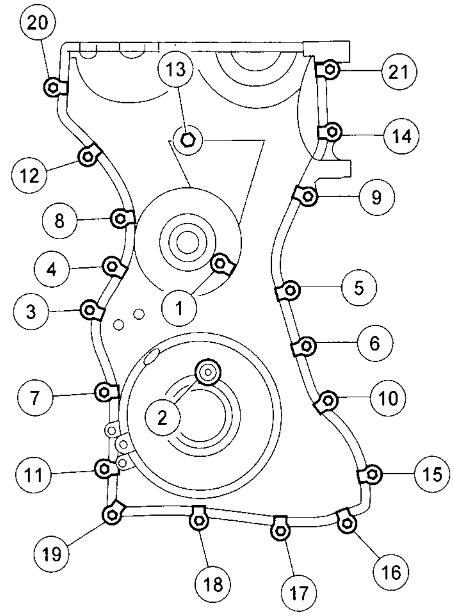
NOTE: If front cover is not secured within 4 minutes, the sealant must be removed and the sealing area recleaned -- Refer to"Engine Cleaning" on page 34 of this section.

27. Apply a 2.5 mm (0.1 in) bead of silicone gasket and sealant to the front cover, and to block as shown.



28. Install the front cover and bolts. Tighten in the sequence shown in 3 stages:

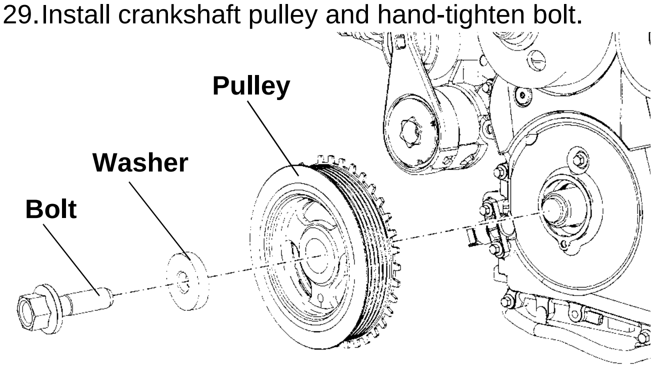
- Stage 1: Tighten 8mm bolts to 10 nm (89 lb-in)
- Stage 2: Tighten 10 mm bolts to 25 Nm (18 lb-ft)
- Stage 3: Tighten 13 mm bolts to 48 Nm (35 lb-ft).



CAUTION: Do not reuse crankshaft pulley bolt.

NOTE: Apply clean engine oil to crankshaft front seal area prior to installing.

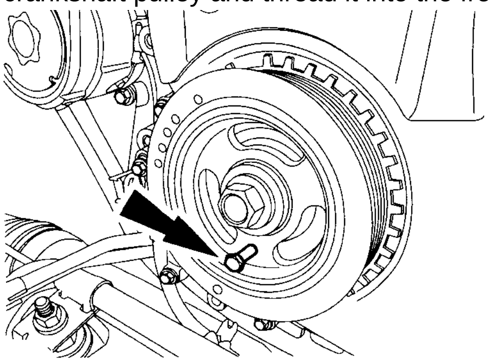
29. Install crankshaft pulley and hand-tighten bolt.



CAUTION: Only hand tighten crankshaft pulley bolt or damage to front cover can occur.

NOTE: This next step will correctly align crankshaft pulley to crankshaft.

30. Install a standard 6 mm x 18 mm bolt through the crankshaft pulley and thread it into the front cover.

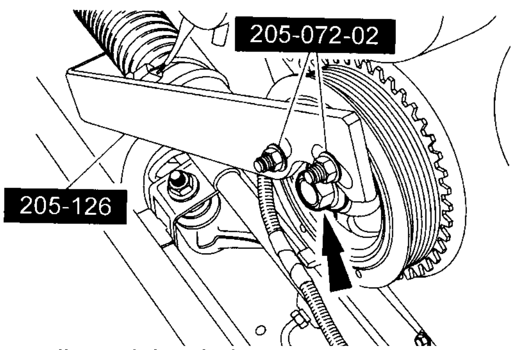


31. Rotate the crankshaft pulley as necessary to align the bolt holes.

CAUTION: Failure to hold the crankshaft pulley in place during bolt tightening can cause damage to the engine front cover.

32. Using special tools 205-072-02 and 205-126, hold crankshaft pulley in place and tighten crankshaft pulley bolt in 2 stages:

- Stage 1: Tighten to 100 Nm (74 lb-ft).
- Stage 2: Rotate an additional 90 degrees.

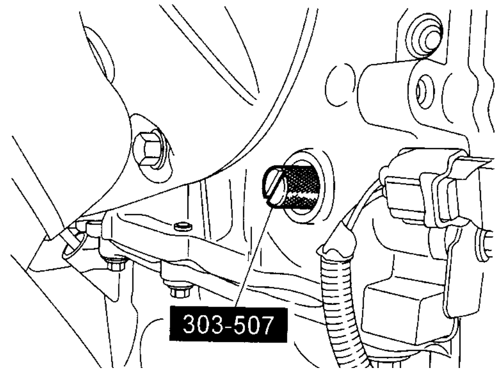


33. Remove all special tools (205-072-02, 205-126, 303-507, 303-465) and 6mm bolt.

CAUTION: Only turn engine in the normal direction of rotation.

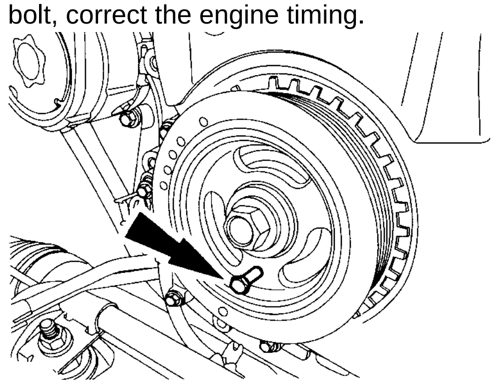
34. Turn the engine 2 complete revolutions, then continue turning in same direction until the No. 1 piston is at top dead center (TDC).

35. Install special tool 303-507.

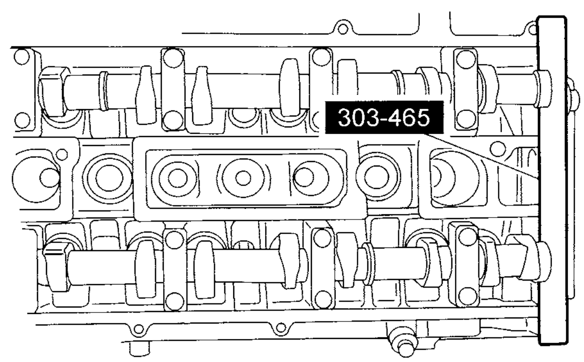


CAUTION: Only hand tighten the bolt in this next step or damage to the front cover can occur.

36. Using a 6mm x 18 mm bolt, check the position of the crankshaft pulley. If it is not possible to install the bolt, correct the engine timing.

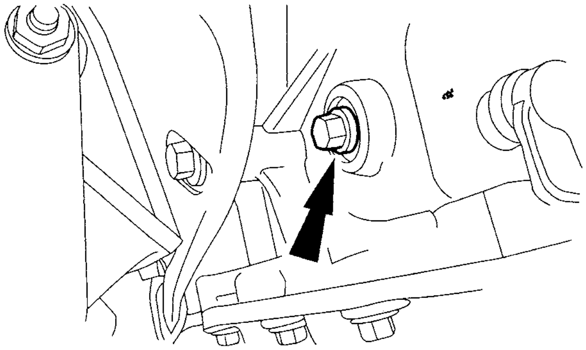


37. Using special tool 303-465, check the position of the camshafts. If it is not possible to install the special tool, correct the engine timing.

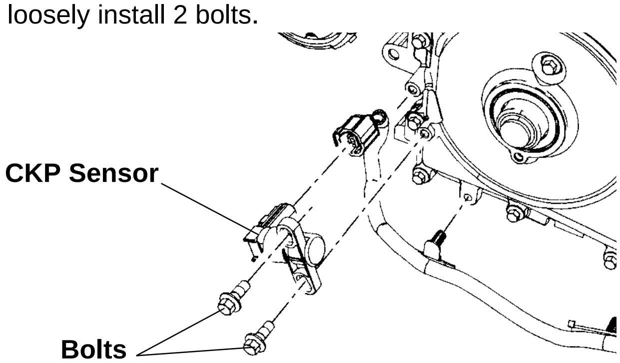


38. Remove all special tools (303-507, 303-465) and 6mm bolt.

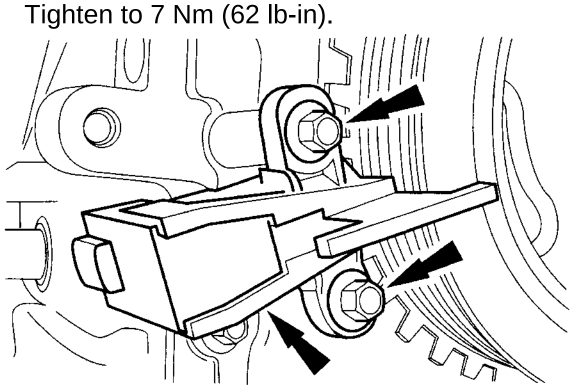
39. Install the plug bolt:
   - Tighten to 20 Nm (15 lb-ft).



40. Position a new crankshaft position (CKP) sensor and loosely install 2 bolts.

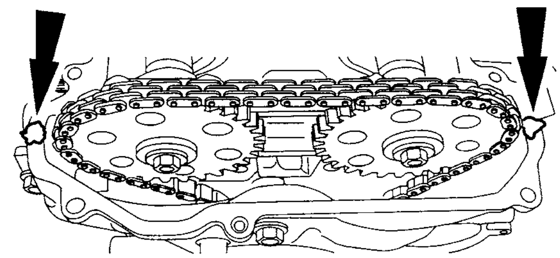


41. Using alignment tool that came with new sensor, adjust CKP alignment. The tool must engage a tooth of the damper, then tighten bolts:
   - Tighten to 7 Nm (62 lb-in).

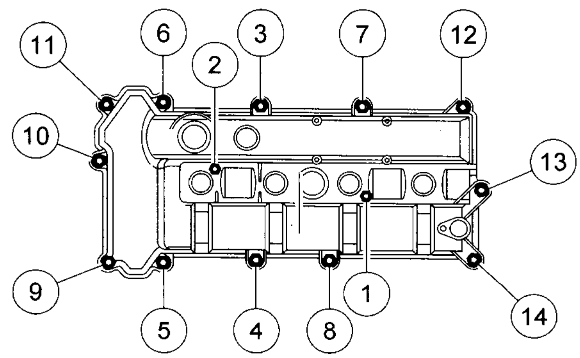


NOTE: If camshaft cover is not secured within 4 minutes, the sealant must be removed and the sealing area recleaned -- Refer to“Engine Cleaning” on page 34 of this section.

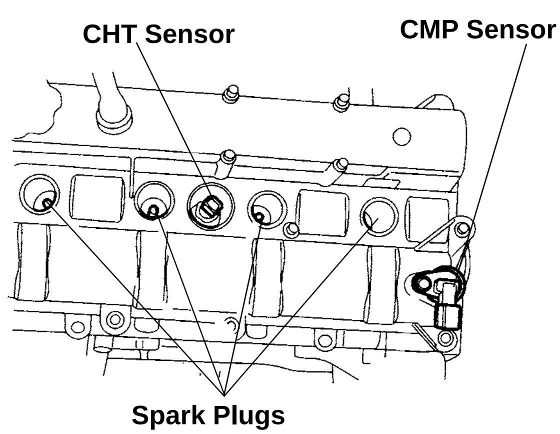
42. Apply silicone gasket and sealant to the locations shown.



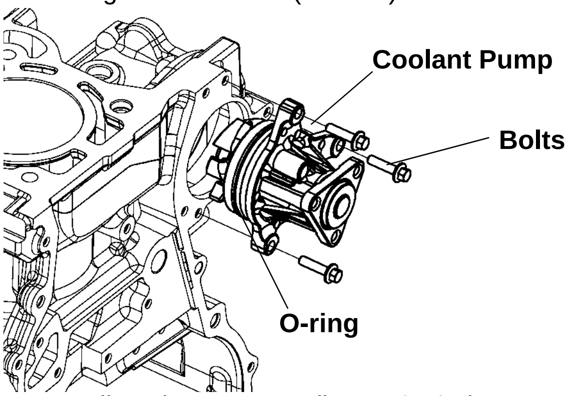
43. Install camshaft cover and tighten bolts in sequence show:
   - Tighten to 10 Nm (89 lb-in).



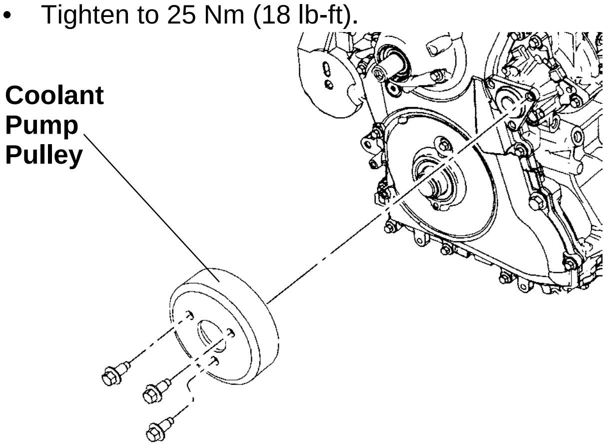
44. Install camshaft position (CMP) sensor and bolt:
   - Tighten to 7 Nm (62 lb-in).
45. Install cylinder head temperature (CHT) sensor:
   - Tighten to 12 Nm (9 lb-ft).
46. Install spark plugs:
   - Tighten to 15 Nm (11 lb-ft).



47. Lubricate a new coolant pump o-ring seal with clean engine coolant and install coolant pump and 3 bolts:
    - Tighten to 10 Nm (89 lb-in).

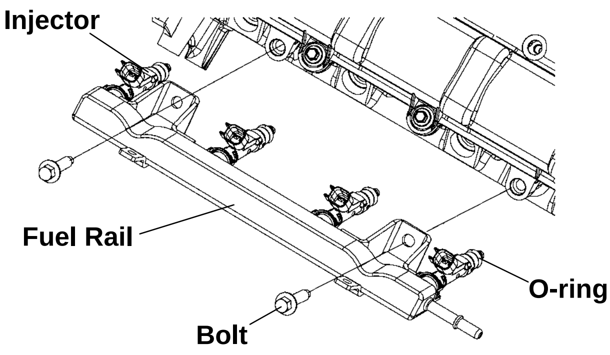


48. Install coolant pump pulley and 3 bolts:
    - Tighten to 25 Nm (18 lb-ft).



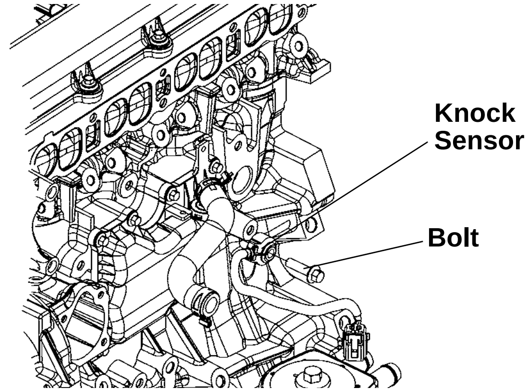
NOTE: Lubricate new fuel injector o-ring seals with clean engine oil prior to installation.

49. Using new o-ring seals, install fuel rail assembly and bolts:
    - Tighten to 25 Nm (18 lb-ft).

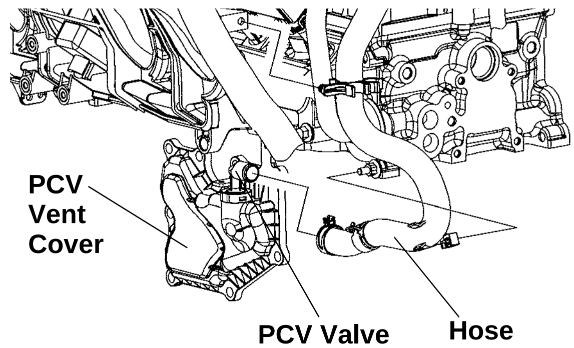


CAUTION: The knock sensor (KS) must not touch the engine vent cover.

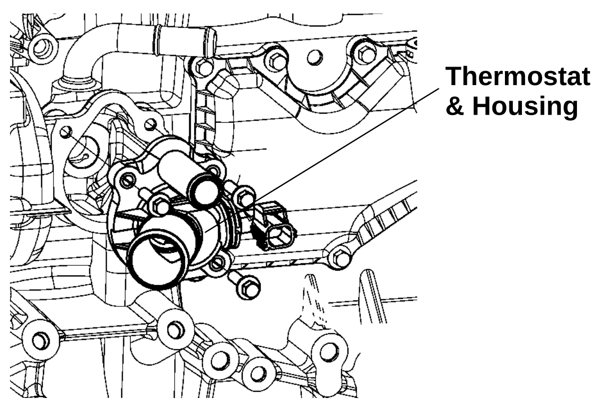
50. Install knock sensor:
    - Tighten to 20 Nm (15 lb-ft).



51. Install engine vent cover and bolts:
    - Tighten to 10 Nm (89 lb-in).



52. Using a new gasket, install thermostat, housing and 3 bolts:
    - Tighten to 10 Nm (89 lb-in).

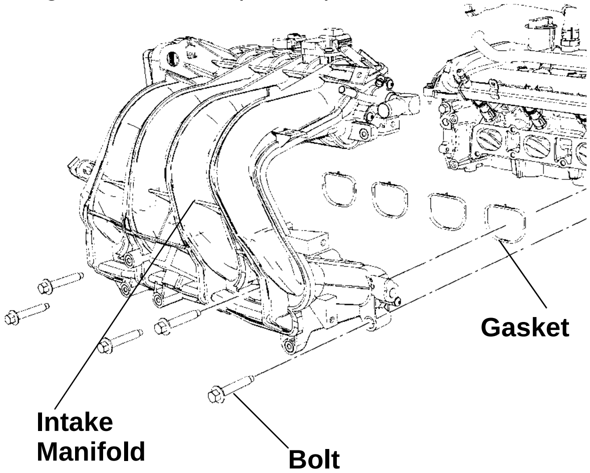


NOTE: Apply silicone dielectric compound to inside of spark plug boot area prior to installation of coils.

53. Install coils over spark plugs and tighten bolts:
    - Tighten to ???????????????????
54. Make any connections that will not be accessible after intake manifold is installed.
55. Inspect and install new intake manifold gaskets if necessary.

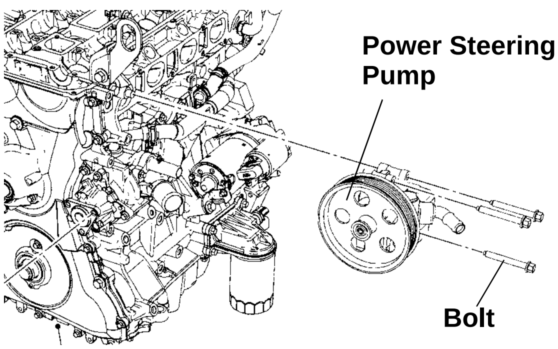
56. Install intake manifold and bolts:

- Tighten to 18 Nm (13 lb-ft).

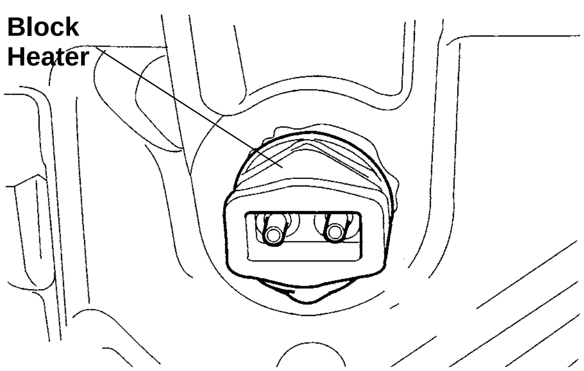


57. Install power steering pump and bolts:

- Tighten to 25 Nm (18 lb-ft).

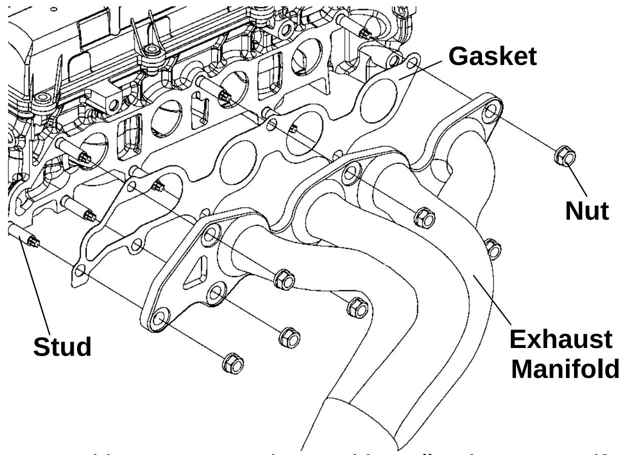


58. Install block heater (if equipped).



59. Install 7 new exhaust manifold studs:

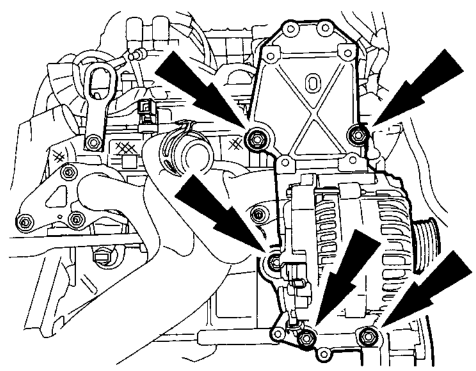
- Tighten to 17 Nm (13 lb-ft).



60. Position a new gasket and install exhaust manifold and 7 new nuts:

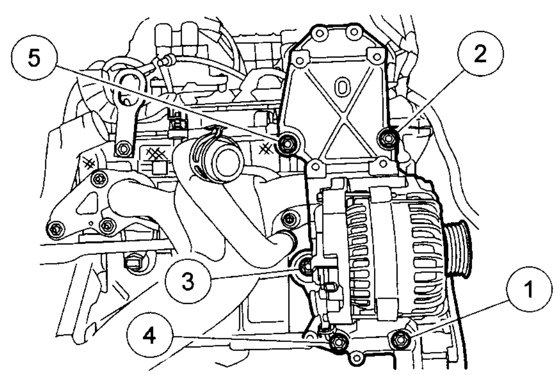
- Tighten to 54 Nm (40 lb-ft).

61. Install generator and support bracket.



62. Tighten bolts in the sequence shown in 2 stages:

- Stage 1: Tighten finger tight
- Stage 2: Tighten to 47 Nm (935 lb-ft).

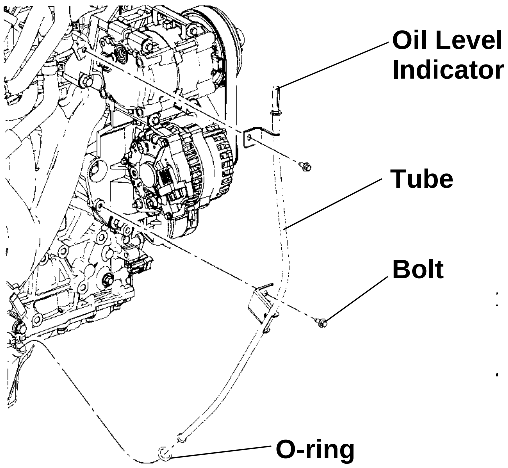


63. Install A/C compressor (if equipped) and bolts:

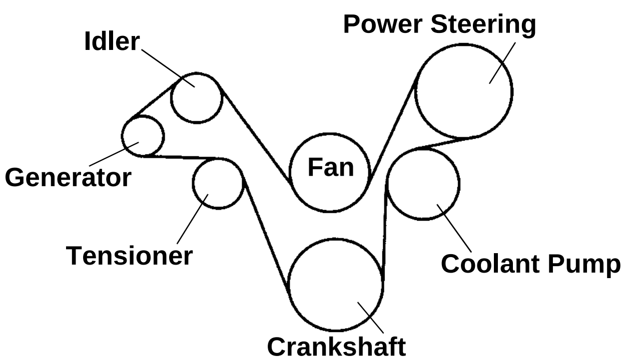
- Tighten to 25 Nm (18 lb-ft).

64. Install oil level indicator tube:

- Tighten to 10 Nm (89 lb-in).



65. Install accessory drive belt.

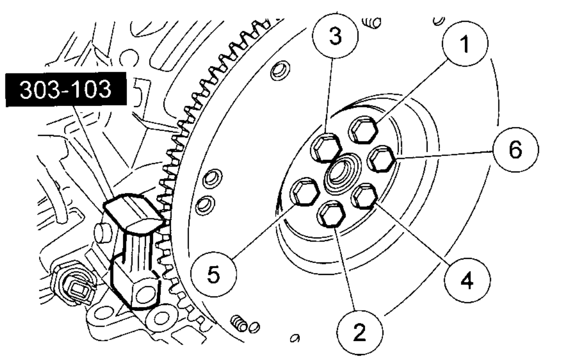


66. Install any tubes, hoses or components removed or disconnected.

67. Remove engine from engine stand and install flywheel or flexplate.

68. Using special tool, tighten bolts in the sequence shown in 3 stages:

- Stage 1: Tighten to 50 Nm (37 lb-ft)
- Stage 2: Tighten to 80 Nm (59 lb-ft)
- Stage 3: Tighten to 112 Nm (83 lb-ft).



69. Lubricate transmission input shaft pilot bearing with grease.

ADJUSTMENTS

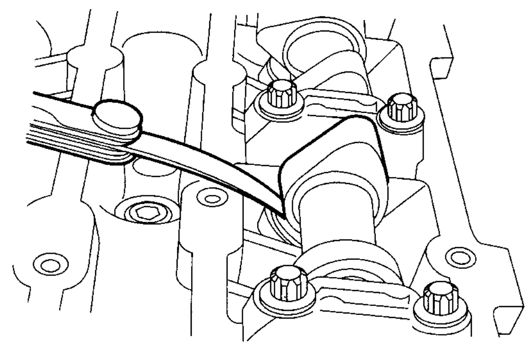
Valve Clearance Check

1. Remove camshaft cover -- Refer to“Camshaft Cover - Removal” on page 6 of this section.

CAUTION: Turn the engine clockwise only, and use the crankshaft bolt only.

2. Use a feeler gauge to measure each valve’s clearance and record its location. A mid range clearance is most desirable:

- Intake: 0.22-0.28 mm (0.008-0.011 inch)
- Exhaust: 0.27-0.33 mm (0.010-0.013 inch)



NOTE: Measure each valve’s clearance at base circle with lobe pointed away from the tappet, before removing camshafts. Failure to measure all clearances prior to removing camshafts will necessitate repeated removal and installation and wasted labor time.

3. Select tappets and mark location using the following formula:

- tappet thickness = measured clearance, plus base tappet thickness, minus most desirable thickness.

NOTE: If any tappets do not measure within specifications, install new tappets in those locations -- Refer to“Valve Tappet - Replacement” on page 18 of this section.

SPECIFICATIONS

General Specifications

Item	Specification
Motorcraft Metal Surface Prep ZC-31	—
Silicone Gasket Remover ZC-30	—
Silicone Gasket and Sealant TA-30	WSE-M4G323-A4
Motorcraft SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP (in Canada Motorcraft SAE 5W-20 Super Premium Motor Oil CXO-5W20-LSP12) or equivalent	WSS-M2C930-A
Motorcraft Premium Gold Engine Coolant VC-7-A (in California, Oregon and New Mexico VC-7-B, in Canada CVC-7-A) or equivalent (yellow color)	WSS-M97B51-A1
Multi-Purpose Grease XG-4 and/or XL-5	ESB-M1C93-B
Thread Sealant with PTFE TA-24	WSK-M2G350-A2
Displacement	2.3L
No. of cylinders	4
Bore/stroke	87.5/94.0
Firing order	1-3-4-2
Oil pressure (hot @ 2000 rpm)	29-39 psi 200-268 kPa
Oil capacity	3.5 qts. + 0.5 qt. with filter
Cylinder Block	
Cylinder bore diameter	87.5-87.53 mm (3.444-3.445 in)
Out of round	0.008 mm (0.0003 in)
Main bearing bore diameter	57.020-57.038 mm (2.244-2.245 in)
Head face flatness	0.1 mm/general 0.05 mm/200 x 200 (0.0003 in/general) (0.0019 in/7.87 x 7.87)
Piston	
Diameter (1)	87.5-87.51 mm (3.444-3.445 in)

General Specifications (Continued)

Item	Specification
Diameter (2)	87.51-87.52 mm (3.4452-3.4456 in)
Diameter (3)	87.52-87.53 mm (3.444-3.446 in)
Piston to bore clearance	0.025-0.045 mm (0.0009-0.0017 in)
Ring groove width — top	1.203-1.205 mm (0.0473-0.0474 in)
Ring groove width — 2nd	1.17-1.19 mm (0.0.460-0.0468 in)
Ring groove width — oil	2.501-2.503 mm (0.0984-0.0985 in)
Piston skirt coating thickness	0.008-0.020 mm (0.0003-0.0007 in)
Piston Pin	
Diameter	20.995-21.0 mm (0.8266-0.8268 in)
Length	59.6-60.4 mm (2.346-2.377 in)
Piston to pin clearance	0.008-0.016 mm (0.0003-0.0006 in)
Pin to rod clearance	Press fit
Cylinder Head	
Exhaust valve lift (in @ zero lash)	7.4 mm (0.2913 in)
Intake valve lift (in @ zero lash)	7.9 mm (0.3110 in)
Valve guide diameter	5.509-5.539 mm (0.216-0.218 in)
Valve seat width — intake/exhaust	0.99-1.84 mm (0.038-0.072 in)
Valve seat angle	45 degrees
Valve seat runout	0.075 mm (0.0029 in)
Valve lash adjustor bore diameter	31.00-31.03 mm (1.220-1.221 in)
Cam bore diameter	25.015-25.040 mm (0.984-0.985 in)
Valve	
Valve head diameter — intake	34.85-35.15 mm (1.372-1.383 in)
Valve head diameter — exhaust	29.85-30.15 mm (1.175-1.187 in)
Valve stem diameter — intake	5.470-5.485 mm (0.2153-0.2159 in)
Valve stem diameter — exhaust	5.465-5.480 mm (0.2151-0.2157 in)

General Specifications (Continued)

Item	Specification
Valve stem to guide clearance — intake	0.0027 mm (0.0009 in)
Valve stem to guide clearance — exhaust	0.0029 mm (0.0011 in)
Valve face runout	0.05 mm (0.001 in)
Valve face angle	45 degrees
Valve Spring — Compression Pressure	
Intake and exhaust (installed)	38.667 lbs
Intake (valve open) 8.9 mm (0.35 in) of lift	97.032 lbs
Exhaust (valve open) 7.4 mm of lift	93.338 lbs
Free length	44.92 mm (1.768 in)
Assembled height	37.9 mm (1.492 in)
Crankshaft	
Main bearing journal diameter	51.980-52.000 mm (2.046-2.047 in)
Production repair	51.730-51.750 mm (2.036-2.037 in)
Main bearing clearance	0.019-0.035 mm (0.0007-0.0013 in)
Connecting rod journal diameter	49.980-50.000 mm (1.967-1.968 in)
Production repair	49.730-49.750 mm (1.957-1.958 in)
End play	0.22-0.43 mm (0.008-0.016 in)
Rings	
Width — top	1.17-1.185 mm (0.0460-0.0466 in)
Width — 2nd	1.197-1.199 mm (0.0471-0.0472 in)
Width — oil	2.38-2.45 mm (0.093-0.096 in)
Ring gap (in bore) — top	0.16-0.31 mm (0.006-0.012 in)
Ring gap (in bore) — 2nd	0.33-0.48 mm (0.012-0.018 in)
Ring gap (in bore) — oil	0.2-0.7 mm (0.007-0.027 in)
Valve Tappet	
Diameter	30.97-30.98 mm (1.2192-1.2196 in)

General Specifications (Continued)

Item	Specification
Tappet to valve clearance — intake	0.22- 0.28 mm (0.008-0.011 in)
Tappet to valve clearance — exhaust	0.27-0.33 mm (0.010-0.013 in)
Tappet to bore clearance	0.02-0.06 mm (0.0007-0.0023 in)
Camshaft	
Lobe lift — intake	8.24999 mm (0.324 in)
Lobe lift — exhaust	7.80007 mm (0.307 in)
Runout (1)[a]	0.03 mm (0.001 in)
Thrust clearance	0.09-0.24 mm (0.003-0.009 in)
Journal diameter	24.96-24.98 mm (0.982-0.983 in)
Journal to bore clearance	0.035-0.080 mm (0.001-0.003 in)
Connecting Rod	
Bearing clearance	0.027-0.052 (0.001-0.002 in)
Bearing thickness	1.496-1.520 mm (0.058-0.059 in)
Crank bore diameter	53.025-53.045 mm (2.087-2.088 in)
Pin bore diameter	20.965-20.985 mm (0.825-0.826 in)
Length (center to center)	154.8 mm (6.094 in)
Side clearance	1.95-3.05 mm (0.076-0.120 in)
Axial clearance	0.14-0.36 mm (0.005-0.014 in)

a No. 3 Journal — Supported by No. 1 and No. 5 Journals.

All dimensions are in mm unless noted.

Torque Specifications

Description	Nm	lb-ft	lb-in
Accelerator control splash shield	8	—	71
A/C manifold tube bolt	20	15	—
A/C compressor bolts	25	18	—
Camshaft sprocket bolt	65	48	—
Camshaft bearing caps[a]	—	—	—
Coolant outlet pipe bolts	10	—	89

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Coolant pump pulley bolts	25	18	—
Coolant thermostat bolts	10	—	89
Coolant pump bolts	10	—	89
Coolant outlet (front) connector bolts	25	18	—
Crankcase ventilation cover bolts	10	—	89
Cylinder head bolts[a]	—	—	—
Crankshaft pulley bolt[a]	—	—	—
Crankshaft position sensor	7	—	62
Crankshaft oil seal retainer[a]	—	—	—
Engine ground cable-to-cylinder head stud bolt	10	—	89
Exhaust gas recirculation (EGR) tube bracket bolt	10	—	89
EGR outlet tube-to-intake manifold flange bolts	20	15	—
Engine wire harness bulkhead connector bolt	10	—	89
EGR outlet tube-to-cylinder head fitting	55	41	—
Exhaust manifold-to-exhaust inlet pipe nuts	40	30	—
Engine support insulator nuts	102	75	—
Engine-to-transmission bolts	48	35	—
Engine front cover bolts[a]	—	—	—
Engine lifting eye bolts	45	33	—
EGR valve bolts	25	18	—
Exhaust manifold-to-cylinder head studs	17	13	—
Exhaust manifold-to-cylinder head nuts	54	40	—

Torque Specifications (Continued)

Description	Nm	lb-ft	lb-in
Fan shroud bolts	7	—	62
Flywheel bolt[a]	—	—	—
Generator bolts	25	18	—
Generator/A/C compressor support bracket bolts	48	35	—
Intake manifold bolts	18	13	—
Knock sensor	20	15	—
Oil pressure sensor	15	11	—
Oil level indicator tube bolt	10	—	89
Oil pump sprocket bolt	25	18	—
Oil pump pickup tube and screen bolts	10	—	89
Oil drain plug	28	21	—
Oil filter adaptor bolts	25	18	—
Oil pan bolts[a]	—	—	—
Oil pump-to-cylinder block bolts	20	15	—
Oil pump chain tensioner bolts	10	—	89
Oil pump chain guide bolts	10	—	89
Power steering pump bolts	25	18	—
Power steering pressure tube nut	20	15	—
Powertrain control module (PCM) electrical connector bolt	6	—	53
PCM harness ground cable nut	10	—	89
Starter motor bolts	25	18	—
Transmission access cover bolt	10	—	89
Timing peg plug	20	15	—
Torque converter-to-flywheel nuts	35	26	—
Transmission lines bracket bolt	28	21	—
Timing chain guide bolts	10	—	89

Torque Specifications (Continued)

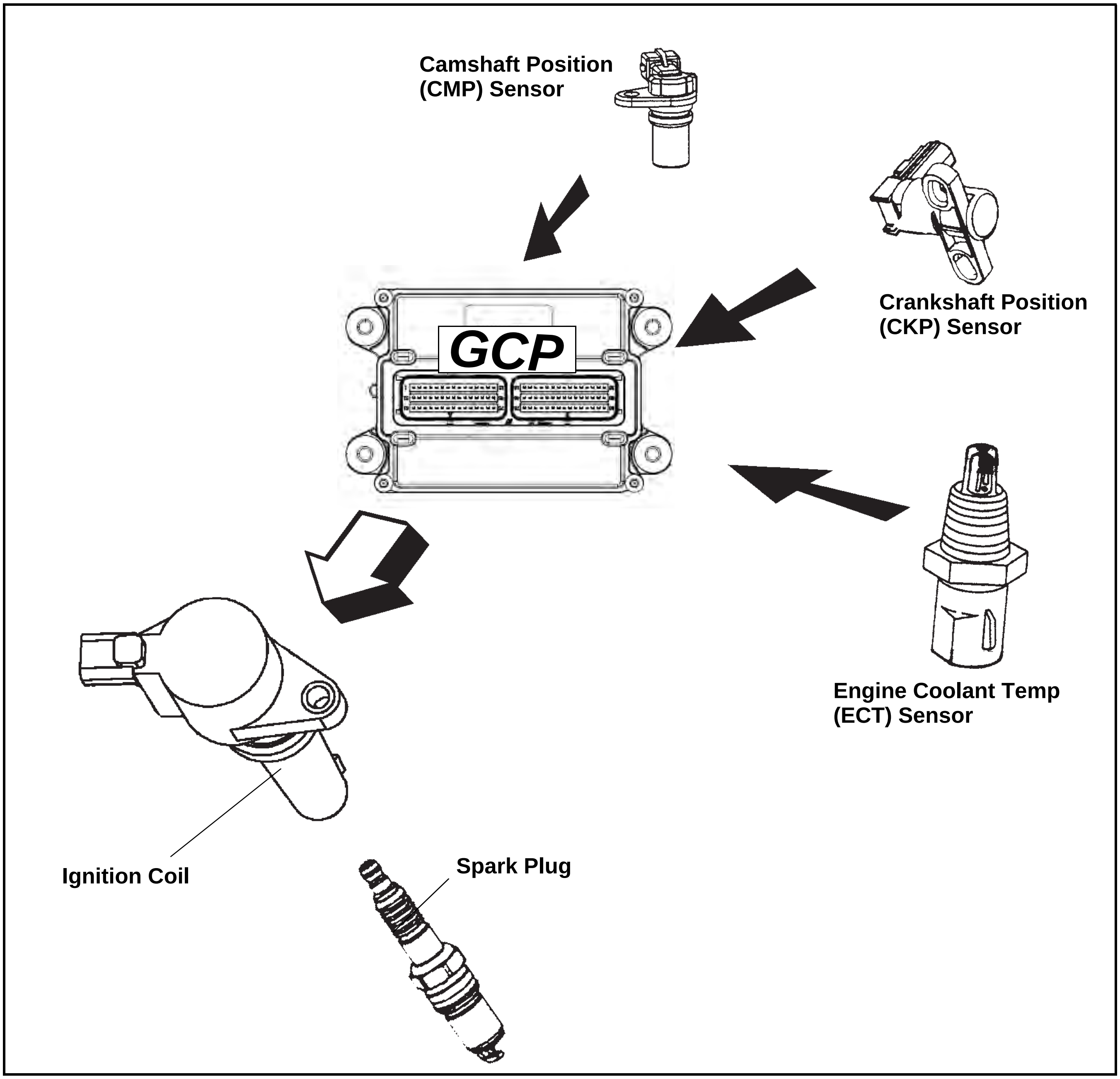
Description	Nm	lb-ft	lb-in
Timing chain tensioner bolts	10	—	89
Valve cover bolts	10	—	89

a Refer to the procedure in this section.

INDEX

Subject **Page**

GENERAL INFORMATION



Description

The DSG-423 engine is equipped with an individual coil on plug electronic ignition system. The brain of this system is the Electronic Engine Control (GCP) Module which receives inputs from the following:

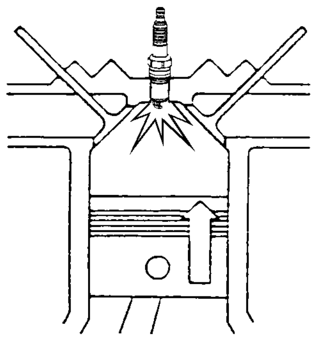
- Crankshaft Position (CKP) Sensor
- Camshaft Position (CMP) Sensor
- Engine Temperature Sensor

From these inputs, the GCP module computes spark strategy (spark advance) to obtain optimum engine performance for correct input conditions, through the following outputs:

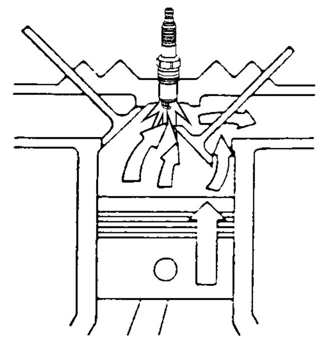
- Ignition Coils
- Spark Plugs.

⚠

WARNING: HIGH TENSION VOLTAGE PRODUCED BY A DISTRIBUTORLESS IGNITION SYSTEM IS HIGHER THAN FOR A CONVENTIONAL IGNITION SYSTEM. WHEN CARRYING OUT SERVICE OPERATIONS ON AN ENGINE EQUIPPED WITH DISTRIBUTORLESS IGNITION, IT IS IMPORTANT TO BE AWARE OF THE ABOVE POINT AS WELL AS ALL THE USUAL SAFETY MEASURES TO PREVENT THE POSSIBILITY OF ELECTRIC SHOCKS.



Compression Stroke



Exhaust Stroke

Operation

With this system, the GCP monitors the engine speed and operating temperature and decides what degree of spark advance is correct for all of the operating conditions. Because timing is set for life inherently in the design of the engine, and there are no moving parts in the ignition system itself, no maintenance is required except for periodic spark plug checks. The system provides for fixed spark advance at start-up, for cold weather starting, and for “average value” default settings in case of component failure. Particular attention has been given to spark optimization for excellent fuel economy in the warm-up mode.

The spark plugs are paired so that one plug fires during the compression stroke and its companion plug fires during the exhaust stroke. The next time that coil is fired, the plug that was on exhaust will be on compression, and the one that was on compression will be on exhaust. The spark in the exhaust cylinder is wasted (referred to as the “waste spark”) but little of the coil energy is lost.

Engine Speed and Crankshaft Position

The crankshaft position and speed information comes to the GCP from the Crankshaft Position (CKP) Sensor, mounted near the crankshaft pulley. The CKP Sensor is triggered by teeth on a trigger wheel located on the crankshaft pulley. The pulse frequency indicates crankshaft speed and a missing tooth indicates crankshaft position.

Engine Temperature

The Engine Coolant Temperature (ECT) Sensor sends engine temperature information to the GCP. It is located in the rear coolant outlet pipe.

Fuel Octane Level Adjustment

In the event that the engine is operated on dry fuels such as natural gas, compressed natural gas (CNG), or liquefied petroleum gas (LGP), timing can be modified by GCP “Fuel Type”.

Ignition Coil Driver

The GCP switches 4 individual ignition coils on and off at the correct times to give the desired spark advance. Ignition timing is adjusted constantly by the GCP. Many factors including all the sensor inputs, affect the final ignition setting.

Run Mode

The GCP interprets engine speed above 200 rpm as Run Mode. The Base Spark advance (BSA) is calculated by the GCP processing the engine speed input.

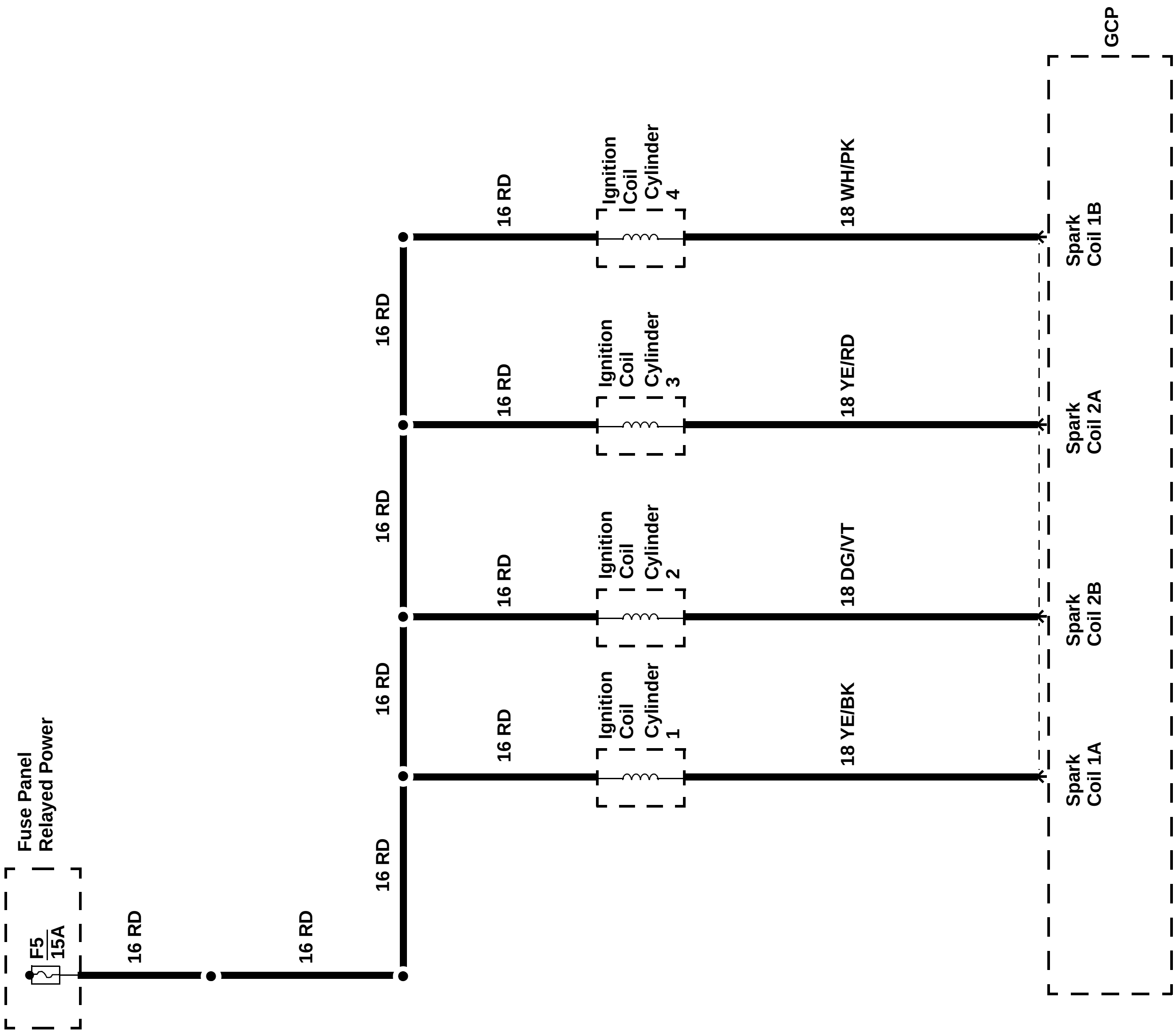
Transient Mode

This function is to provide detonation protection when the engine load is increased rapidly by fast opening of the throttle plate.

Overspeed Mode

If the engine speed exceeds 4000 rpm the dwell will be reduced until the speed drops below 4000 rpm.

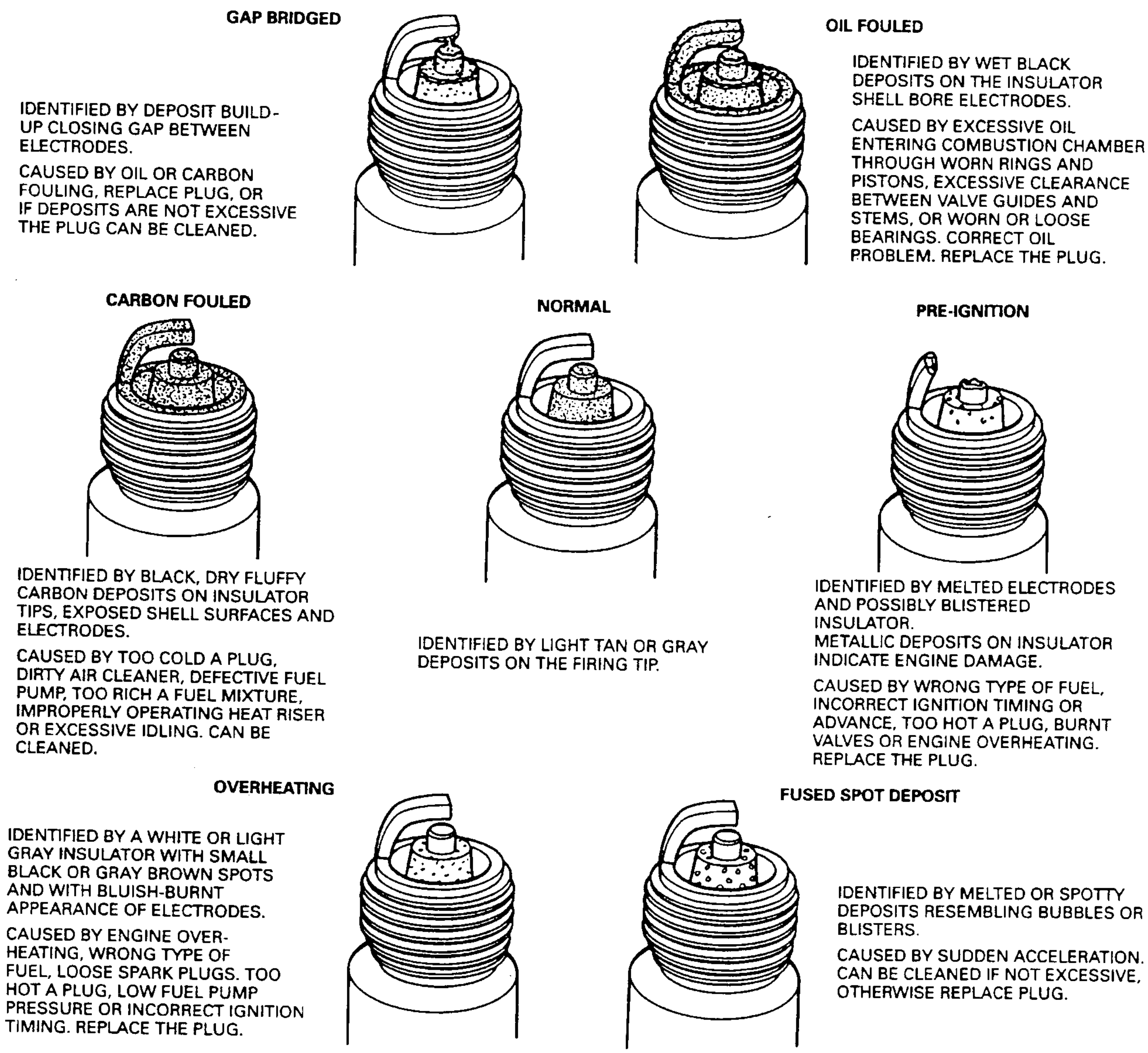
Wiring Diagram



DIAGNOSIS AND TESTING

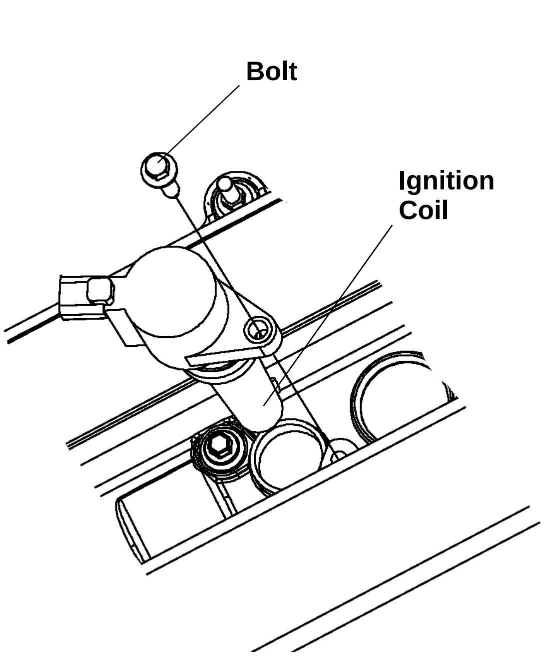
Spark Plug Inspection

Inspect the spark plug tip as in the chart below:



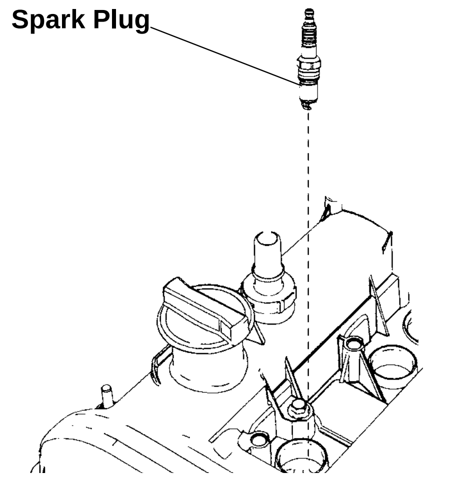
REMOVAL AND INSTALLATION

Ignition Coil - Replacement



1. Remove and/or disconnect components to allow access and removal of the ignition coil. Label if necessary to allow for correct reinstallation.
2. Disconnect electrical connector.
3. Remove bolt.
4. Remove ignition coil.
5. Reverse procedure to install:
    - Inspect for cracks, carbon tracking or dirt
    - Apply silicone dielectric compound to the inside of coil.

Spark Plug - Removal



1. Remove ignition coil -- Refer to“Ignition Coil - Replacement” on page 6 of this section.
2. Loosen spark plugs and remove any dirt or foreign material from spark plug areas of cylinder head with compressed air.
3. Remove spark plugs and mark location using a piece of masking tape.
4. Inspect condition of spark plug -- Refer to“Spark Plug Inspection” on page 7 of this section.

Spark Plug - Installation

1. Apply a few drops of engine oil to spark plug threads near tip.
2. Adjust spark plug gap to: 1.25 - 1.35 mm (0.049 - 0.053 in.).
3. Install spark plugs (to original locations) and tighten to 11 lb.ft. (15 Nm).
4. Install coil -- Refer to“Ignition Coil - Replacement” on page 6 of this section.

SPECIFICATIONS

GENERAL SPECIFICATIONS	
Firing Order	1-3-4-2
Spark Plug	Type: AGSF32YPC Gap: 1.25 - 1.35 mm (0.049 - 0.053 in.)
Silicone Brake Caliper Grease and Dielectric Compound XG-3-A	ESE-M1C171-A

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
Spark plugs	15	11	132
Coil bolts	8	6	71

INDEX

04

CAUTIONS & WARNINGS

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE REPAIRING OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED TO PREVENT ACCIDENTAL SPRAYING OF FUEL, CAUSING A FIRE HAZARD. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

WARNING: DO NOT CARRY PERSONAL ELECTRONIC DEVICES SUCH AS CELL PHONES, PAGERS OR AUDIO EQUIPMENT OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENTS. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND CAN BE IGNITED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

WARNING: THESE PROCEDURES INVOLVE FUEL HANDLING. BE PREPARED FOR FUEL SPILLAGE AT ALL TIMES AND ALWAYS OBSERVE FUEL HANDLING PRECAUTIONS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

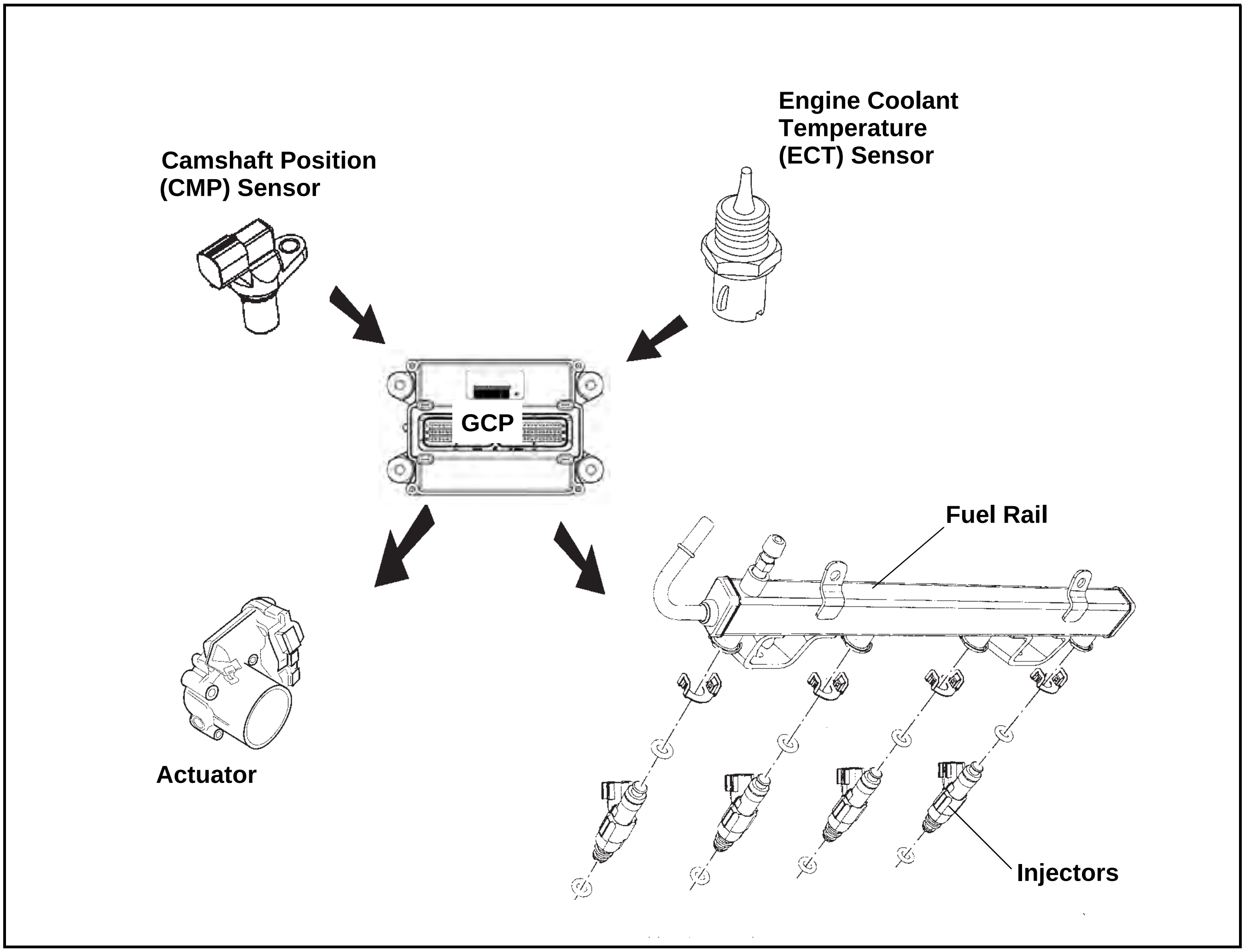
CAUTION: If the liquid or vapor tube is damaged (torn, holes or delaminated), a new tube assembly must be installed. Do not use aftermarket sleeving. Do not re-adhere loose sleeving material.

CAUTION: Fuel injection equipment is manufactured to very precise tolerances and fine clearances. It is therefore essential that absolute cleanliness is observed when working with these components. Always cap off any open orifices or tubes.

CAUTION: When reusing liquid or vapor tube connectors, make sure to use compressed air to remove any foreign material from the connector retaining clip area before separating from the tube. Apply clean engine oil to the end of the tube before inserting the tube into the connector.

CAUTION: To ensure absolute cleanliness is observed when working with fuel system components, always cap off any open orifices or tubes.

GENERAL INFORMATION - GASOLINE



Description

The fuel system delivers fuel by an electronic fuel pump. A fuel pressure regulator controls fuel pressure and also contains a fuel filter. The Electronic Control Module (GCP) uses information from various sensors and controls fuel delivery to the cylinders by individual fuel injectors mounted in the cylinder head near each intake valve. Air delivery is controlled by an actuator.

Fuel Rail

The fuel rail is mounted to the top of the engine and distributes fuel to the individual injectors. Fuel is delivered to the fuel inlet tube of the fuel rail by the fuel lines and hoses.

Fuel Injector

The fuel injector is a solenoid operated device mounted to the cylinder head. The GCP energizes the solenoid, which opens a valve to allow fuel delivery into the cylinder.

Camshaft Position (CMP) Sensor

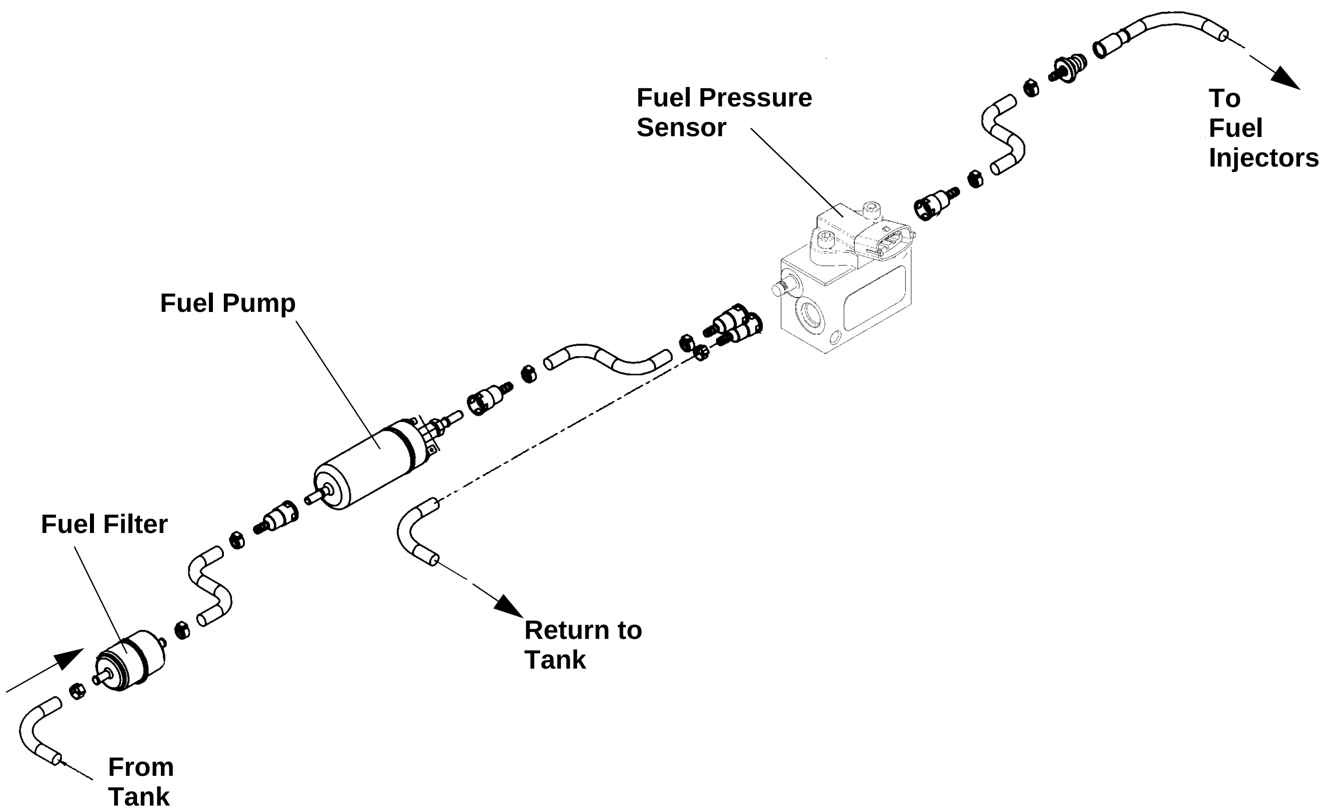
The Camshaft Position (CMP) Sensor is mounted in the camshaft cover. This signal is sent to the GCP which uses it to indicate the position of the #1 piston during its power stroke. The GCP uses the CMP signal as a "sync pulse" to trigger the injectors in the proper sequence. This allows the GCP to calculate true sequential fuel injection (SFI) mode of operation.

Engine Coolant Temperature (ECT) Sensor

The Engine Coolant Temperature (ECT) Sensor is a thermistor mounted in the engine coolant stream in the rear coolant outlet pipe. The GCP uses this information to calculate the correct air/fuel mixture which varies with engine temperature.

Actuator

The actuator controls air delivery into the cylinders. An integral Throttle Position (TP) Sensor sends a signal to the GCP indicating throttle position. The GCP calculates fuel delivery based on throttle valve angle (operator demand).



Operation

The fuel delivery system starts with the fuel in the tank. Fuel is drawn up to the fuel pump through a pre-filter. The electric fuel pump then delivers the fuel to the fuel rail and injectors. The GCP controls the fuel pump to deliver fuel pressure required by the injectors. The GCP monitors system pressure through a fuel pressure sensor.

Fuel is injected under pressure in a conical spray pattern at the opening of the intake valve. There is a return line to the tank with a small orifice to prevent vapor lock in the pump

An actuator controls air supply to the intake manifold. Governor settings are not adjustable. They can only be programmed by authorized personnel only. Contact your local EDI Distributor listed in the back of this manual for further information.

CAUTION: Do not force the throttle plate open. This may cause permanent damage to the actuator.

A pressure relief valve is located on the fuel rail. This is used to read fuel pressure and also to relieve fuel pressure prior to component replacement.

The GCP controls the amount of fuel/air delivery - refer to Section 8 for further information on Electronic Engine Control.

Fuel System Requirements

Fuel Tanks

The DOEM or OEM supplies the tanks. There must be a fuel outlet and a fuel inlet. The gas cap must also be vented.

Wet Fuels

The following fuels must all be unleaded and clean:

- Gasoline/petrol: This engine is designed to operate on unleaded 87 or 89 octane gasoline.
- Gasohol/Ethanol: A mixture of gasoline and ethanol (grain alcohol) containing up to 10% ethanol by volume with properly formulated cosolvents and other necessary additives. Blends index of 87 or 89.
- Gasohol/Methanol: A mixture of gasoline and alcohol (wood alcohol, etc.) containing up to 5% methanol by volume with properly formulated cosolvents and other necessary additives. Blends index of 87 or 89.

Fuel Pump

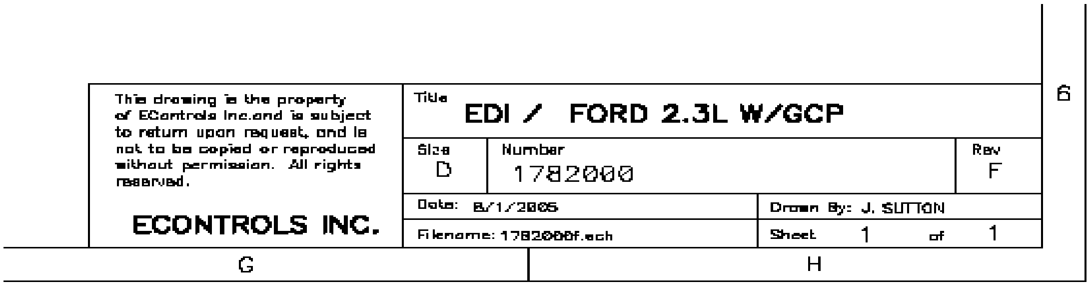
The fuel pump must be mounted on the frame rail, not on the engine. It must also be mounted in packed foam.

CAUTION: The electric fuel pump MUST NOT be mounted directly on the engine assembly, as engine vibration will shorten the life of the pump.

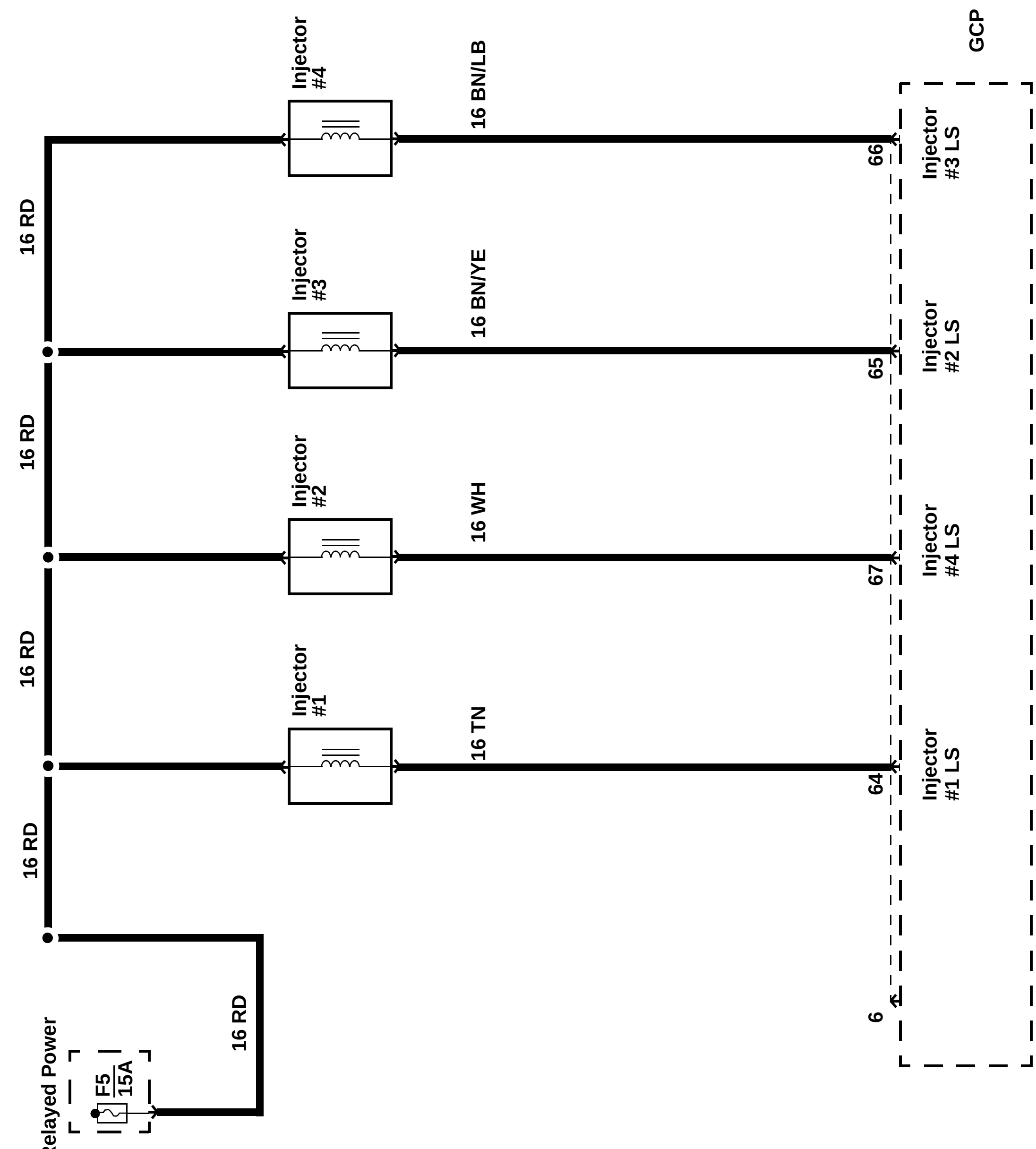
Wiring Diagrams

Revision Level

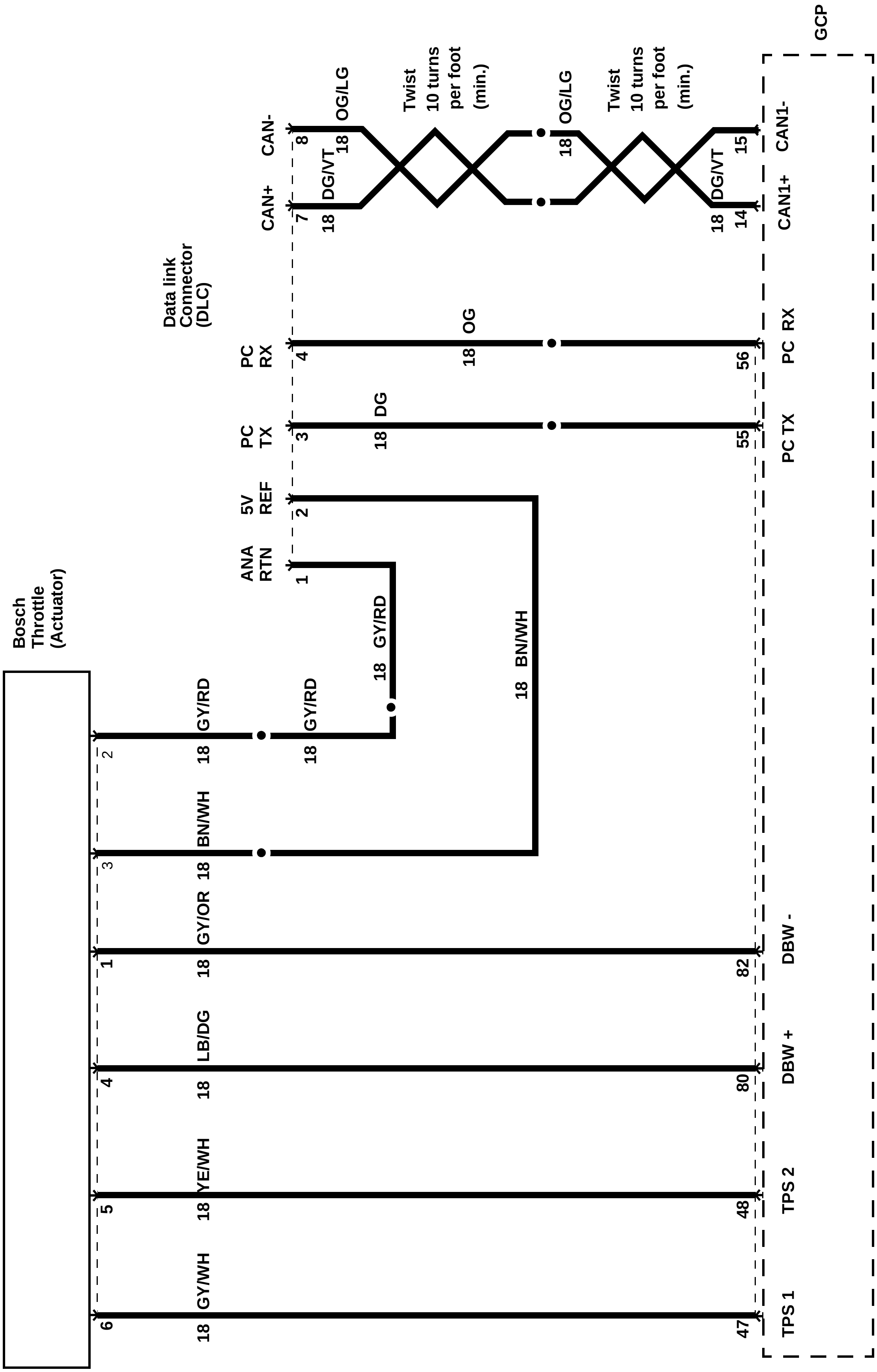
The following wiring schematics are taken from the wiring diagram labeled below:



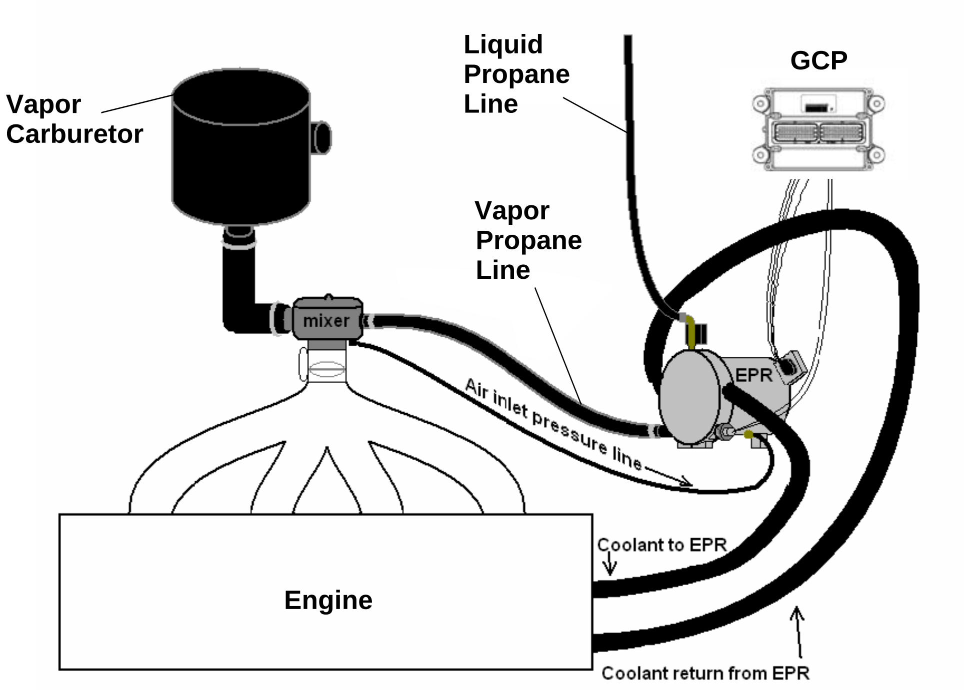
Fuel Injectors



Actuator / Data Link Connector (DLC)



GENERAL INFORMATION - DRY FUEL



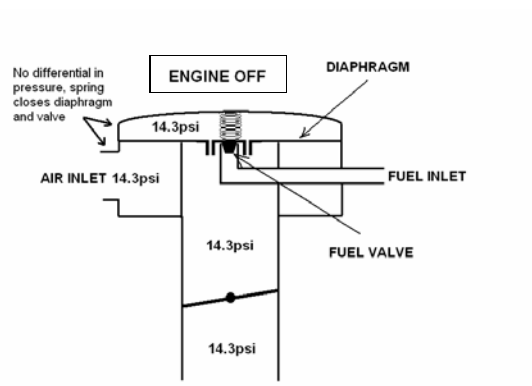
Description

This engine with the proper fuel equipment, can also operate on dry fuel such as LPG Grade HD5 and natural gas (1050 BTU/ft^3). Natural Gas fuel specification must meet or exceed 38.7 MJ/m^3 (UK) 39.0 MJ/m^3 (USA).

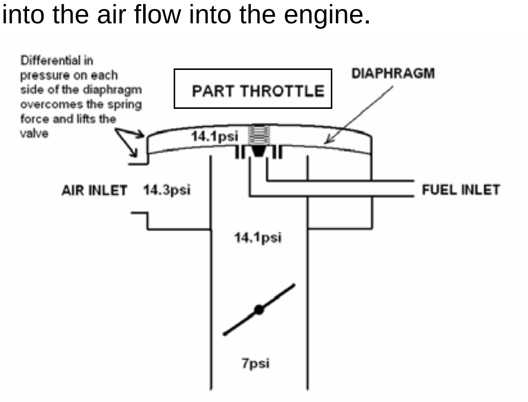
Vaporized propane is introduced into the engine with a Vapor Carburetor. Pressure is regulated by an Electronic Pressure Regulator (EPR) which is controlled by the GCP. Coolant is circulated through the EPR.

Operation

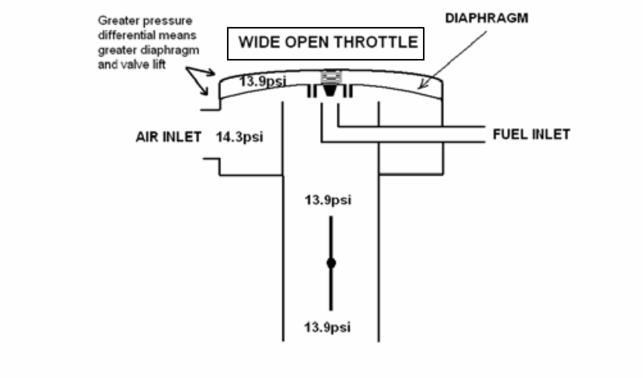
The dry fuel vapor carburetor is a device by which fuel can be added to passing air flow. The amount of fuel added is related to the amount of air passing through the carburetor.



The variable venturi carburetor controls fuel flow based on a differential pressure across the diaphragm. The more air the engine demands, the lower the pressure in the throat and hence on the top of the diaphragm. When the pressure on the top of the diaphragm is low enough, the diaphragm overcomes the spring force holding it down and lifts and allows fuel to be drawn from the fuel port into the air flow into the engine.

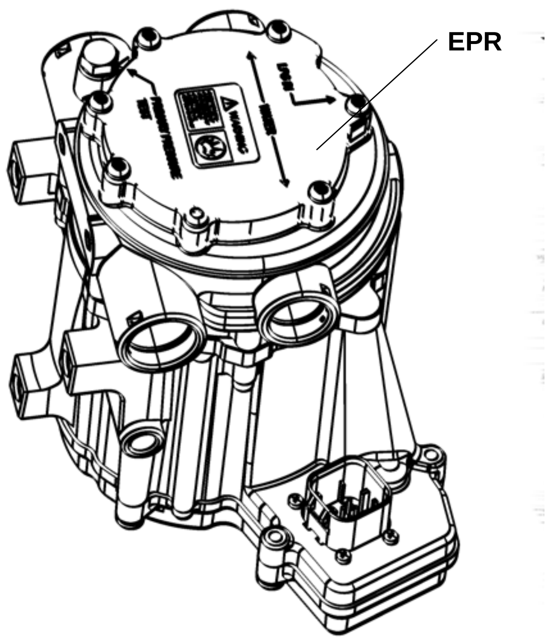


The greater the airflow into the engine, the greater the pressure drop across the diaphragm and the more lift occurs on the fuel valve. This allows more fuel to be drawn into the engine.



While the carburetor is designed to mix the fuel and air and adjust fuel to match the speed and load of the engine, it has only “ballpark” accuracy. This accuracy is not fine enough to achieve emissions targets. To achieve accurate fueling, the air inlet pressure to the carburetor is controlled by an Electronic Pressure Regulator (EPR).

The EPR serves two functions; to vaporize the liquid propane and to control the vapor pressure to the mixer.



As the propane vaporizes, the EPR monitors and controls the vapor pressure to the mixer in reference to the inlet air pressure to the carburetor.

The EPR receives a pressure command from the GCP called “Delta P” which is the difference between fuel vapor pressure and the air inlet pressure. This has been calibrated for all speeds and loads. There is a sensor internal to the EPR that measures the actual “Delta P” of the delivered fuel.

The actuator of the EPR will then drive the diaphragm of the vaporizer to adjust the fuel pressure to the carburetor so that the actual “Delta P” matches the Delta P command from the GCP.

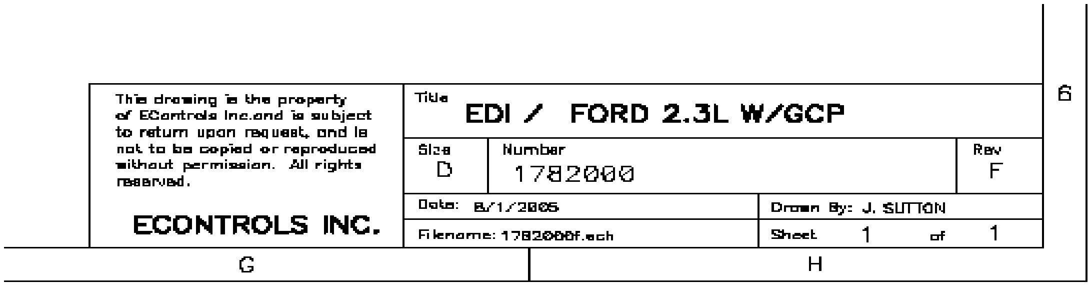
This provides an extremely accurate open loop type of fuel control. There is also a dry fuel temperature sensor for increased pressure command accuracy.

After a preset time has passed, the engine will go into closed loop control, using information from the pre and post oxygen sensors to allow further adjustement to meet emissions regulations.

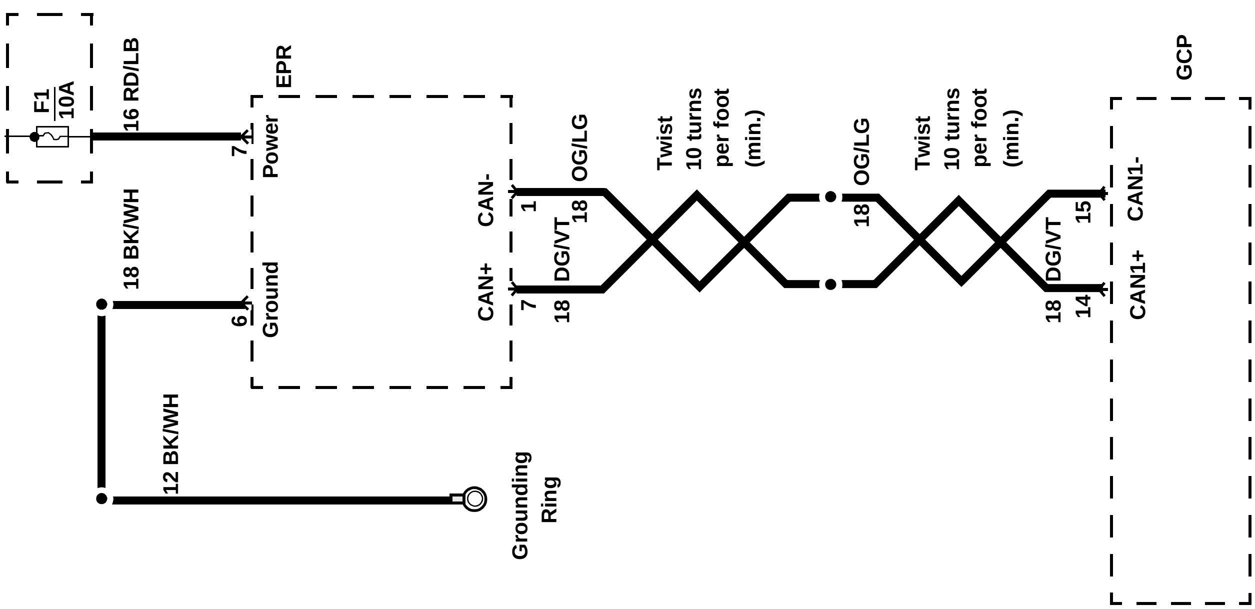
Wiring Diagrams

Revision Level

The following wiring schematics are taken from the wiring diagram labeled below:



Engine Controls - Dry Fuel EPR



DIAGNOSIS AND TESTING - LPG

Symptom Chart

Symptom	Go to
Engine Cranking But Will Not Start	Page 12
Engine Starts But Has Rough Idle	Page 14
Engine Idles with Rough Acceleration at Load	Page 16
Engine Is Unable To Reach Full Power	Page 18
Overall Power Loss	Page 12
Engine Misses	Page 20
Backfire	Page 22
Emissions Failure (Rich Mixture)	Page 24
Emissions Failure (Lean Mixture)	Page 25
Engine Overheats	Page 27
Engine Stops Running (Dies)	Page 28

Preliminary Test

This Pinpoint Test checklist is your guide to the most probable causes of an engine performance complaint when the malfunction is due to the fuel system.

Test Step		Result	Action to Take
1	Inspect installation. • Check fuel hose for kings. • Check fuel hose lengths, orientation and presence of parts. **Is everything OK?**	**Yes** **No**	Go to Step 2.. Repair as necessary.
2	Inspect Fuel System for Supply Leaks. • Key OFF. • Check for leaks or damaged supply lines from the fuel tank to the fuel lockoff. **Are there any leaks present?**	**Yes** **No**	Repair the leak. Go to Step 3.
3	Inspect the Fuel System for any loose wires or hoses. • Key OFF. • Check the Fuel Lockoff connection and FCV valve connection. • Check the vacuum hoses to the FCV valve and carburetor for any damage or leakage. **Is there any damaged or loose wires or vacuum hoses?**	**Yes** **No**	Repair or Replace as Necessary. Go to Step 4.
4	Check for fuel system leaks? • Key ON. • Check the fuel system for leaks. • Key OFF. **Are there any leaks present?**	**Yes** **No**	Repair the Leak. Go to Step 5.
5	Check Carburetor air inlet for obstructions. • Remove the air cleaner. **Are there any obstructions in the air inlet of the carburetor?**	**Yes** **No**	Remove the obstruction, re-install the aircleaner and attempt to start. Proceed to appropriate Troubleshooting Section.

Diagnostic Charts

Perform the preliminary test before proceeding.

Engine Cranking But Will Not Start

Step	Test Step	Result	Action to Take
1	Check fuel tank. **Is fuel tank empty?**	**Yes**	Fill or replace the fuel tank. (Do not exceed 80% of liquid capacity)
		No	Go to Step 2.
2	Check fuel valve. **Is liquid fuel valve closed ?**	**Yes**	Slowly Open the Fuel Valve.
		No	Go to Step 3.
3	Check the excess flow valve. **Is excess flow valve tripped and closed?**	**Yes**	Reset excess flow safety valve • Close the main fuel valve. • Wait for a clicking sound from the excess flow valve indicating the valve has reset. • Slowly open the main fuel valve.
		No	Perform Preliminary Test before proceeding to Step 4.
4	Check fuelock supply voltage. • Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
		No	Go to Step 5.
5	Check primary fuel pressure to regulator. • Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Key ON. **Is the pressure less than "X" psi?**	**Yes**	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test steps 4-5, if pressure is still less than specified the fuelock is faulty. Replace the fuel lock.
		No	Go to Step 6.
5	Check for icing or freezing of the Regulator. • Key ON. • Check for ice or frost build up on the converter casing and outlet port. • Key OFF. **Is ice present?**	**Yes**	The presence of ice on the converter without the engine cranking, indicates the possibility of a fuel leak past the primary seat of the converter. See section 475R-1 for service of the converter.
		No	Go to Step 6.

Engine Cranking But Will Not Start (Continued)

Test Step		Result	Action to Take
7	Check FCV vacuum fitting bypass port.	**Yes**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port**
• The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve. **Is this bypass closed with dirt or debris?**		**No**	Go to Step 8.
8	Check for stuck primer button.	**Yes**	Try and free the primer button. If you cannot reseat the primer then see section 475R-1 for servicing the converter.
• Key Off. • Press the primer button on the converter once to assure the primer is not sticking open. A small amount of fuel that is trapped between the fuel lock and the converter should pass through to the carburetor. **Is the primer button stuck in the depressed position?**		**No**	Go to Step 9.
6	Check regulator operation.	**Yes**	The Regulator is malfunctioning. See section 475R-1 for service of the converter.
• Using Woodward WTK-1 test kit, install the secondary pressure gauge as described in section G-1. (note: the secondary spring color and pressure range) • Crank the engine **Is the pressure less than "X" psi?**		**No**	Go to Step 7.
7	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 8.
8	Check air valve operation.	**Yes**	Replace the carburetor and retest.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • Crank the engine and observe the amount of measured vacuum. **Is the measured vacuum outside the specifications?**		**No**	Refer to Diagnostic Aids below.

Diagnostic Aids

Fuel Lock Solenoid :The fuel lock is an electronic solenoid that is opened to allow fuel flow when the key is turned ON. High temperatures may cause the solenoid to become intermittent, not opening to supply sufficient fuel pressure.

Fuel Filter:There is a filter element located in the inlet of the fuel lock which may become clogged and limit fuel flow, especially at low tank pressures. Check the filter and replace or clean as necessary.

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly.

Regulator Assembly (Converter): If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Engine Starts But Has Rough Idle

Test Step		Result	Action to Take
1	Check for icing or freezing of the Regulator.	**Yes**	The presence of ice on the converter, with the engine running, indicates the possibility of a coolant supply problem. Check Coolant level and the coolant system for leaks. Check for proper coolant type
• With the Engine at Idle. • Check for ice or frost build up on the converter casing and outlet port. **Is ice present?**		**No**	Go to Step 2.
2	Check for stuck primer button.	**Yes**	Try and free the primer button. If you cannot reseat the primer then see section 475R-1 for servicing the converter.
• Key Off. • Press the primer button on the converter once to ensure the primer is not sticking open. A small amount of fuel that is trapped between the fuel lock and the converter should pass through to the carburetor. **Is the primer button stuck in the depressed position?**		**No**	Go to Step 3.
3	Check FCV for operation.	**Yes**	This would indicate the engine is too lean at idle. Possible causes: • Plugged bypass port, go to Step 4. • Faulty FCV valve connection, go to Step 5. • GCP fault .
• With the Engine at Idle. • Disconnect the vacuum hose from the FCV valve to the regulator. **Does the idle run smooth with the hose disconnected?**		**No**	Go to Step 6.
4	Check FCV vacuum fitting bypass port.	**Yes**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port!**
• The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve **Is this bypass partially closed with dirt or debris?**		**No**	Go to Step 5.
5	Check FCV supply voltage.	**Yes**	12 volt FCV circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
• Key OFF. • Disconnect FCV connector from harness. • With the engine at idle. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**		**No**	Go to Step 6.

Engine Starts But Has Rough Idle (Continued)

Test Step		Result	Action to Take
2	Check regulator operation.	**Yes**	The Regulator is malfunctioning. See section 475R-1 for service of the converter.
• Using Woodward WTK-1 test kit, install the primary and secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • With the engine at idle. **Are the pressures less than "X" psi?**		**No**	Go to Step 3.
3	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 4.
4	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle observe the amount of measured vacuum. **Is the measured vacuum outside the specifications?**		**No**	The Idle mixture may be mis-adjusted. Refer to Diagnostic Aids Below.

Diagnostic Aids

Fuel Lock Solenoid :The fuel lock is an electronic solenoid that is opened to allow fuel flow when the key is turned ON. High temperatures may cause the solenoid to become intermittent, not opening to supply sufficient fuel pressure.

Fuel Filter:There is a filter element located in the inlet of the fuel lock which may become clogged and limit fuel flow, especially at low tank pressures. Check the filter and replace as necessary.

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly.

Idle Mixture Adjustment:The idle mixture adjustment is pre-set at the factory with a tamper proof seal installed.

Regulator Assembly: If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding

Engine Idles With Rough Acceleration At Load

Test Step		Result	Action to Take
1	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 2.
2	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine accelerating observe the amount of measured vacuum. **Is the measured vacuum non-linear and outside the specifications?**		**No**	Go to Step 3.
3	Check regulator fuel supply.	**Yes**	The fuel filter may be restricting flow or the fuel lock may be intermittent. Go to Step 4.
• Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Accelerate to induce symptom. **Is the primary pressure less than "X" psi or fluctuating?**		**No**	Go to Step 5.
4	Check fuelock supply voltage.	**Yes**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
• Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector **Is the voltage less than 11.5 volts?**		**No**	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test Step 3, if pressure is still less than specified replace the fuel lock and re-test before moving to Step 5.
5	Check regulator operation.	**Yes**	Remove the vacuum hose from the FCV valve to the regulator. If the pressure is not -1.5 inches of w.c., the Regulator is malfunctioning. See section 475R-1 for service of the regulator.
• Using Woodward WTK-1 test kit, install the primary and secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • Accelerate to induce symptom. **Are the pressures less than "X" specified?**		**No**	Go to ???????.

Engine Idles With Rough Acceleration At Load (Continued)

Test Step		Result	Action to Take
6	Check FCV operation. • Accelerate engine to induce symptom. • Disconnect the vacuum hose from the FCV valve to the regulator. **Does the engine accelerate smooth with the hose disconnected?**	**Yes**	This would indicate the engine is too lean. Possible causes: • Plugged bypass port, go to Step 7. • Faulty FCV valve connection, go to Step 8. • GCP fault.
		No	Go to Step 9.
7	Check FCV vacuum fitting bypass port. • The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve. **Is this bypass partially closed with dirt or debris?**	**Yes**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port.**
		No	Go to Step 8.
8	Check FCV supply voltage. • Key OFF. • Disconnect FCV connector from harness. • With engine at idle and upon acceleration. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt FCV circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause
		No	Refer to section 475-1 for servicing the carburetor. Also refer to the Diagnostic Aids below.

Diagnostic Aids

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly. If no other problems have been identified and the mixer has been serviced, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding

Engine Is Unable To Reach Full Power

Test Step		Result	Action to Take
1	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 2.
2	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine accelerating observe the amount of measured vacuum. **Is the measured vacuum non-linear and outside the specifications?**		**No**	Go to Step 3.
2	Check regulator fuel supply.	**Yes**	The fuel filter may be restricting flow or the fuel lock may be intermittent. Go to Step 3.
• Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Accelerate to induce symptom. **Is the primary pressure less than "X" psi or fluctuating?**		**No**	Go to Step 4.
3	Check fuelock supply voltage.	**Yes**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
• Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector **Is the voltage less than 11.5 volts?**		**No**	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test Step 2, if pressure is still less than specified replace the fuel lock and re-test before moving to Step 4.
4	Check regulator operation.	**Yes**	Remove the vacuum hose from the FCV valve to the regulator. If the pressure is not -1.5 inches of w.c., the Regulator is malfunctioning. See section 475R-1 for service of the regulator.
• Using Woodward WTK-1 test kit, install the primary and secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • Accelerate to induce symptom. **Are the pressures less than "X" specified?**		**No**	Go to ????????.

Engine Is Unable To Reach Full Power (Continued)

Test Step		Result	Action to Take
6	Check FCV operation. • Accelerate engine to induce symptom. • Disconnect the vacuum hose from the FCV valve to the regulator. **Does the engine accelerate to full power with the hose disconnected?**	**Yes**	This would indicate the engine is too lean. Possible causes: • Plugged bypass port, go to Step 7. • Faulty FCV valve connection or vacuum leaks, go to Step 8. • GCP fault.
		No	Go to Step 9.
7	Check FCV vacuum fitting bypass port. • The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve. **Is this bypass partially closed with dirt or debris?**	**Yes**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port.**
		No	Go to Step 8.
8	Check FCV supply voltage. • Key OFF. • Disconnect FCV connector from harness. • With engine at idle and upon acceleration. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt FCV circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause
		No	Refer to section 475-1 for servicing the carburetor. Also refer to the Diagnostic Aids below.
9	Check FCV operation. • Accelerate Engine to induce symptom. • Disconnect the vacuum hose from the FCV valve to the regulator. **Does the engine accelerate to full power with the hose disconnected?**	**Yes**	This would indicate the engine is too lean. Possible causes: • Plugged bypass port, go to Step 7. • Faulty FCV valve connection or vacuum leaks, go to Step 8. • GCP fault.
		No	Refer to section 475-1 for servicing the carburetor. Also refer to the Diagnostic Aids below.

Diagnostic Aids

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly. If no other problems have been identified and the mixer has been serviced, replace the fuel management assembly with a known good part of the same pressure range. Retest

.

Overall Power Loss

After performing the Preliminary Test, refer to “Unable to reach Full Power” Chart.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Engine Misses

	Test Step	Result	Action to Take
1	Check regulator fuel supply. • Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • With the Engine at Idle or on acceleration, to induce symptom **Is the primary pressure less than "X" psi or fluctuating?**	**Yes**	The fuel filter may be restricting flow or the fuel lock may be intermittent. Go to Step 2.
		No	Go to Step 3.
2	Check fuelock supply voltage. • Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
		No	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test step 1, if pressure is still less than specified replace the fuel lock and re-test before moving to Step 3.
3	Check regulator operation. • Using Woodward WTK-1 test kit, install the primary and secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • At Idle or accelerate to induce symptom. **Are the pressures less than "X" specified?**	**Yes**	Remove the vacuum hose from the FCV valve to the regulator. If the pressure is not -1.5 inches of w.c., the Regulator is malfunctioning. See Section 475R-1 for service of the regulator.
		No	Go to Step 4.
4	Check FCV operation. • At Idle or accelerate Engine to induce symptom. • Disconnect the vacuum hose from the FCV valve to the regulator **Does the engine continue to miss with the hose disconnected?**	**Yes**	This would indicate the engine is experiencing a momentary mixture change. Possible causes: • Faulty FCV valve connection or vacuum leaks, go to Step 5. • GCP fault.
		No	Go to Step 6.
5	Check FCV supply voltage. • Key OFF. • Disconnect FCV connector from harness. • With engine at idle and upon acceleration. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt FCV circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause..
		No	Refer to section 475-1 for servicing the carburetor. Also refer to the Diagnostic Aids below.

Engine Misses (Continued)

Test Step		Result	Action to Take
4	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 5.
5	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum outside the specifications?**		**No**	Refer to Diagnostic Aids Below.

Diagnostic Aids

Fuel Lock Solenoid :The fuel lock is an electronic solenoid that is opened to allow fuel flow when the key is turned ON. High temperatures may cause the solenoid to become intermittent, not opening to supply sufficient fuel pressure.

Fuel Filter:There may be a strainer element located in the inlet of the fuel lock which may become clogged and limit fuel flow, especially at low tank pressures. Check the filter and replace as necessary.

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly. Also check the mixer adapter plates for leakage past the carburetor.

Regulator Assembly: If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Engine Backfires

	Test Step	Result	Action to Take
1	During Start-up, check for fuel lock leakage (not closing). • Close the tanks main fuel valve. • Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Key OFF. • Slowly open the main fuel valve **Do you measure any fuel pressure?**	**Yes**	This would indicate the fuel lock is not closing and allowing fuel to pass in the OFF position. Replace the Fuel Lock.
		No	Go to Step 2.
2	With engine running, check primary fuel pressure to regulator. • With the primary pressure gauge installed as described in section 475G-1, measure the supply pressure. • Key ON, Engine Running. **Is the pressure less than "X" psi?**	**Yes**	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test, if pressure is still less than specified the fuelock is faulty. Replace the fuel lock.
		No	Go to Step 3.
3	With engine running, check regulator operation. • Using Woodward WTK-1 test kit, install the primary and secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • With the engine at idle or accelerate to induce symptom. **Are the pressures less than "X" specified?**	**Yes**	Remove the vacuum hose from the FCV valve to the regulator. If the pressure is not -1.5 inches of w.c., the Regulator is malfunctioning. See section 475R-1 for service of the regulator.
		No	Go to Step 4.
4	Check FCV operation. • At idle or accelerate Engine to induce symptom. • Disconnect the vacuum hose from the FCV valve to the regulator **Is the backfire present with the hose disconnected?**	**Yes**	This would indicate the engine is experiencing a momentary mixture change. Possible causes: • Faulty FCV valve connection or vacuum leaks, go to Step 5. • GCP fault.
		No	Go to Step 6.
5	Check FCV Supply Voltage. • Key OFF. • Disconnect FCV connector from harness. • With engine at idle. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt FCV circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
		No	Go to Step 6.

Engine Backfires (Continued)

Test Step		Result	Action to Take
4	Check carburetor air valve for binding. • Key ON, Engine Running. • With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**	**Yes** **No**	Refer to section 475-1 for servicing the carburetor. Go to ?????????.
7	Check air valve operation. • Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum outside the specifications?**	**Yes** **No**	Refer to section 475-1 for servicing the carburetor. Refer to Diagnostic Aids Below.

Diagnostic Aids

Fuel Lock Solenoid :The fuel lock is an electronic solenoid that is opened to allow fuel flow when the key is turned ON. High temperatures may cause the solenoid to become intermittent, not opening to supply sufficient fuel pressure.

Fuel Filter:There is a filter element located in the inlet of the fuel lock which may become clogged and limit fuel flow, especially at low tank pressures. Check the filter and replace as necessary.

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly. Also check the mixer adapter plates for leakage past the carburetor.

Regulator Assembly: If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest..

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Emission Failure - Rich Mixture

Test Step		Result	Action to Take
1	Check for clogged or restricted air filter.	**Yes**	This would indicate a clogged air cleaner as the cause. Replace as necessary.
• Remove the air filter. • Start the engine and re-check emission levels. **Has the (rich) emission failure been eliminated?**		**No**	Go to Step 2.
2	Check carburetor air valve for binding.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**		**No**	Go to Step 3.
3	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum outside the specifications?**		**No**	Go to Step 4.
4	Check regulator operation.	**Yes**	The Regulator is functioning properly and the problem is with the FCV valve or vacuum hoses. Inspect the vacuum hoses and fittings, replace as necessary. Replace the FCV valve and retest.
• Using a secondary pressure gauge described in section 475G-1. (note: the secondary spring color and pressure range) • Start the engine. **Is the pressure constant and at -1.5 inches of w.c. as specified?**		**No**	The Regulator is malfunctioning. See section 475R-1 for service of the regulator.

Diagnostic Aids

Regulator Assembly (Converter & FCV): If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Emission Failure - Lean Mixture

	Test Step	Result	Action to Take
1	Check regulator fuel supply. • Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Start the engine to induce the failure. **Is the primary pressure less than "X" psi or fluctuating?**	**Yes** **No**	The fuel filter may be restricting flow or the fuel lock may be intermittent. Go to Step 2. Go to Step 3.
2	Check fuelock supply voltage. • Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes** **No**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause. Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test step Step 1, if pressure is still less than specified replace the fuel lock and re-test before moving to Step 3.
3	Check regulator operation. • Using Woodward WTK-1 secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • Remove the vacuum hose from the FCV valve to the regulator. • Start the engine. **Is the pressure constant and at -1.5 inches of w.c. as specified?**	**Yes** **No**	The Regulator is functioning properly and the problem is with the FCV valve, vacuum hoses or carburetor. Go to Step 4. The Regulator is malfunctioning. See section 475R-1 for service of the regulator. Repair or replace as necessary.
4	Check FCV vacuum fitting bypass port. • The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve. **Is this bypass partially closed with dirt or debris?**	**Yes** **No**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port.** Go to Step 5.
4	Check carburetor air valve for binding. • With the air cleaner removed, pull the air valve piston upwards to ensure free movement of the carburetor air valve. **Is the air valve binding?**	**Yes** **No**	Refer to section 475-1 for servicing the carburetor. Go to Step 5.

Emission Failure - Lean Mixture (Continued)

Test Step		Result	Action to Take
5	Check air valve operation. • Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum non-linear and outside the specifications?**	**Yes**	Refer to section 475-1 for servicing the carburetor.
		No	Check the adapter plates between the mixer and the manifold for leaks. If none can be found, service the carburetor (see section 475-1) and retest. If the failure is still present replace the FCV valve.

Diagnostic Aids

Regulator Assembly (Converter & FCV): Check the regulator primer button for slight sticking or a small leak around the seat. This may be enriching the mixture enough for a failure. If a leak is found, see section 475R-1 for servicing the regulator. If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Engine Overheats

Test Step		Result	Action to Take
1	Check for icing or freezing of the Regulator.	**Yes**	The presence of ice on the converter, with the engine running, indicates the possibility of a coolant supply problem. Check Coolant level and the coolant system for leaks. Check for proper coolant type.
• With the Engine at Idle. • Check for ice or frost build up on the converter casing and outlet port. **Is ice present?**		**No**	Go to Step 2.
2	Check regulator operation.	**Yes**	The Regulator is functioning properly and the problem may be with the FCV valve, vacuum hoses or carburetor. Go to J3.
• Using Woodward WTK-1 secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • Start the engine. **Is the pressure constant and at -1.5 inches of w.c. as specified?**		**No**	The Regulator is malfunctioning. See section 475R-1 for service of the regulator. Repair or replace as necessary.
3	Check air valve operation.	**Yes**	Refer to section 475-1 for servicing the carburetor.
• Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum non-linear and outside the specifications?**		**No**	Service the carburetor (see section 475-1) and retest. Refer to the Diagnostic Aids below.

Diagnostic Aids

Regulator Assembly (Converter & FCV): Overheating is typically related to a cooling or coolant problem. There is a possibility of a gasket leak inside the regulator, which would allow coolant to pass through to the fuel supply. This may effect the emissions if large enough. In this situation the coolant level should consistently drop, as coolant is lost through the fuel path. Refer to section 457R-1 for servicing the regulator. If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

The pinpoint tests below should be performed after the preliminary tests and "Engine Cranks but Will Not Start" chart Steps 1-3. Any electrical diagnostics should have been performed to eliminate any sensor, GCP or solenoid valve problems before proceeding.

Engine Stops Running - Dies

Step	Test Step	Result	Action to Take
1	Check for icing or freezing of the regulator. • With the Engine at Idle. • Check for ice or frost build up on the converter casing and outlet port. **Is ice present?**	**Yes**	The presence of ice on the converter, with the engine running, indicates the possibility of a coolant supply problem. Check Coolant level and the coolant system for leaks. Check for proper coolant type.
		No	Go to Step 2.
2	Check FCV vacuum fitting bypass port. • The bypass port is located on the back of the 90 degree elbow which connects the vacuum line from the converter to the FCV valve. **Is this bypass partially closed with dirt or debris?**	**Yes**	Clean out bypass with a .050 size pin or drill bit and retest. **CAUTION: Do not enlarge the by-pass port.**
		No	Go to Step 3.
3	Check regulator fuel supply. • Using Woodward WTK-1 test kit, install the primary pressure gauge as described in section 475G-1. • Start the engine to induce the failure. **Is the primary pressure less than "X" psi or fluctuating?**	**Yes**	The fuel filter may be restricting flow or the fuel lock may be intermittent. Go to Step 4.
		No	Go to Step 5.
4	Check fuelock supply voltage. • Key OFF. • Disconnect Fuelock connector from harness. • Key ON. • Using a high impedance DVOM, check for 12 volt supply at the harness connector. **Is the voltage less than 11.5 volts?**	**Yes**	12 volt fuelock activation circuit is open, shorted to ground or the GCP module is faulty. Check wiring, connectors and fuses for possible cause.
		No	Fuel filter element may be clogged, inspect and/or replace the fuel filter as described in section 475F-1. Repeat test Step 3, if pressure is still less than specified replace the fuel lock and re-test before moving to Step 5.
5	Check regulator operation. • Using Woodward WTK-1 secondary pressure gauge as described in section 475G-1. (note: the secondary spring color and pressure range) • Remove the vacuum hose from the FCV valve to the regulator. • Start the engine. **Is the pressure constant and at -1.5 inches of w.c. as specified?**	**Yes**	The Regulator is functioning properly and the problem may be with the FCV valve, vacuum hoses or carburetor. Go to Step 6.
		No	The Regulator is malfunctioning. See section 475R-1 for service of the regulator. Repair or replace as necessary.

Engine Stops Running - Dies (Continued)

Test Step		Result	Action to Take
6	Check air valve operation. • Using the WTK-1 test kit, connect the vacuum gauge between the carburetor and the FCV valve to measure the carburetor air valve vacuum (AVV). • With the engine at idle and accelerating observe the amount of measured vacuum. **Is the measured vacuum non-linear and outside the specifications?**	**Yes**	Refer to section 475-1 for servicing the carburetor.
		No	Service the carburetor (see section 475-1) and retest. Refer to the Diagnostic Aids below.

Diagnostic Aids

Fuel Lock Solenoid :The fuel lock is an electronic solenoid that is opened to allow fuel flow when the key is turned ON. High temperatures may cause the solenoid to become intermittent, not opening to supply sufficient fuel pressure.

Fuel Filter:There is a filter element located in the inlet of the fuel lock which may become clogged and limit fuel flow, especially at low tank pressures. Check the filter and replace as necessary.

Fuel Line Restrictions:The vehicle specifications table specifies the fuel line to be a certain size. If the fuel line from the tank to the fuel lock is not the proper size, or any valves or fittings with flow restrictive characteristics are used, the fuel flow will not be sufficient to the converter with low tank pressure. Correct any fuel line or fitting restrictions.

Mixer Assembly (Carburetor):It is possible that a backfire may have caused the fuel valve to partially come off of it's retainer and restrict fuel, check the mixer fuel valves, see section 475-1 for disassembly. Also check the mixer adapter plates for leakage past the carburetor.

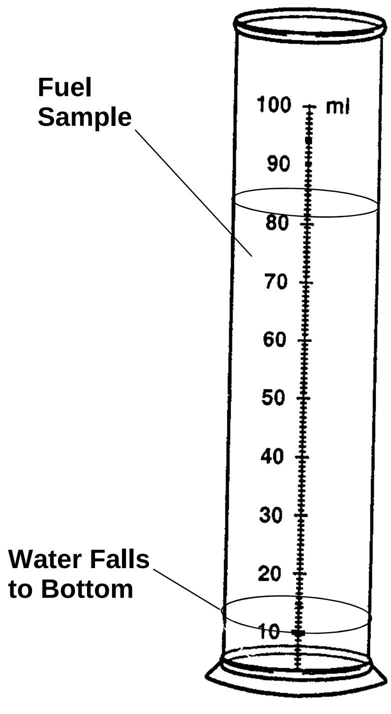
Regulator Assembly (Converter & FCV): If no other problems have been identified, replace the fuel management assembly with a known good part of the same pressure range. Retest.

DIAGNOSIS AND TESTING - GASOLINE

NOTE: For diagnosis of Electronic Engine Control - refer to Section 08.

Visual Inspection

Check for dirt or water in the fuel tank. Water and dirt that accumulate in the fuel tank can cause a restricted fuel line, filter or a malfunction of the fuel pump. Condensation, which is the greatest source of water entering the fuel tank, is formed by moisture in the air when it strikes the cold interior walls of the fuel tank.



Check the fuel filter. If the accumulation of dirt and water in the filter is excessive, the fuel tank should be removed and flushed, and the line from the fuel pump to the tank should be blown out.

Check fuel lines for damage. Air leakage in the fuel inlet line can cause low fuel pump pressure and volume.

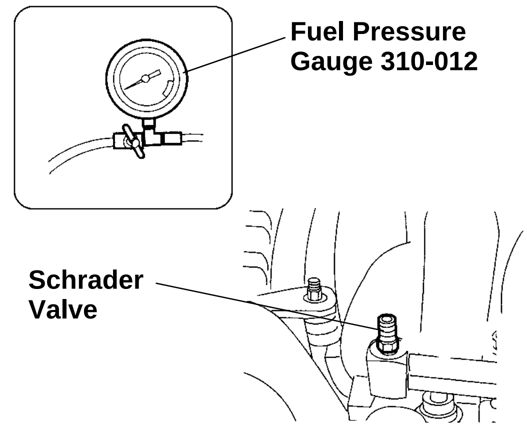
Check fuel tank vent. A restricted fuel tank vent can cause low fuel pump pressure and volume and can result in collapsed inlet hoses or a collapsed fuel tank. High or low pressure are the two most likely fuel pump troubles that will affect engine performance. Low pressure will cause a lean mixture and fuel starvation at high speeds, and excessive pressure will cause high fuel consumption and possible flooding.

Fuel Pressure Check

WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Remove the Schrader valve cap and attach a fuel pressure gauge.
2. Bleed air from guage line into a suitable container.
3. Fuel pressure should be as follows:

- Key on, Engine off: 414-448 kPa (60-65 psi)
- Engine running: 414-448 kPa (60-65 psi)



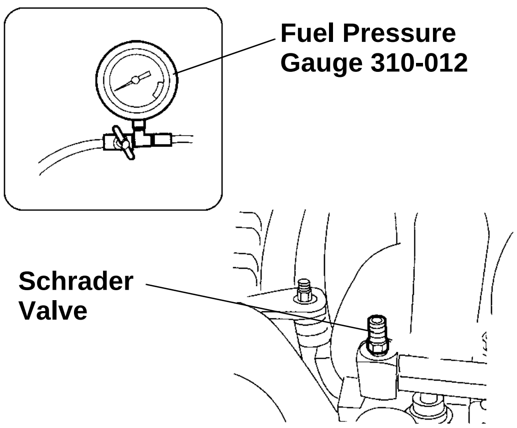
If fuel pressure is insufficient, check for a clogged pump filter, screen or fuel filter. Also check for a break or restriction in the fuel lines. If fuel pump is inoperative, check for damaged or loose ground or improper wiring. Make sure fuel lines connections area tight and not leaking.

GENERAL SERVICE PROCEDURES

Fuel Pressure Relief

WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Disconnect the negative battery cable -- refer to Section 6.
2. Remove the Schrader valve cap and attach a fuel pressure gauge.



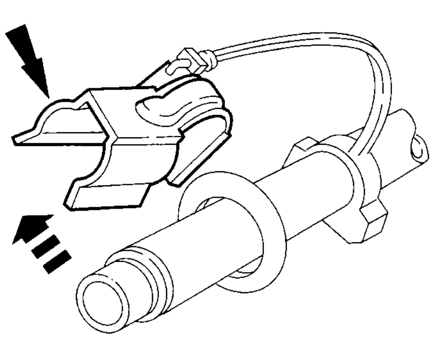
WARNING: OPEN MANUAL VALVE SLOWLY TO RELIEVE SYSTEM PRESSURE.

3. Open the manual valve on the pressure gauge and drain some fuel into a suitable container.
4. Fuel pressure is now relieved from system.

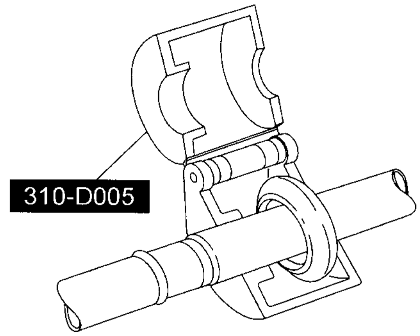
Spring Lock Coupling - Type I - Disconnect

WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

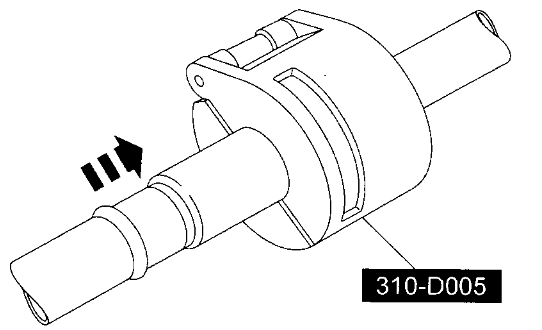
1. Relieve the fuel system pressure -- Refer to“Fuel Pressure Relief” on page 31 of this section.
2. If equipped, remove the fuel tube clip.



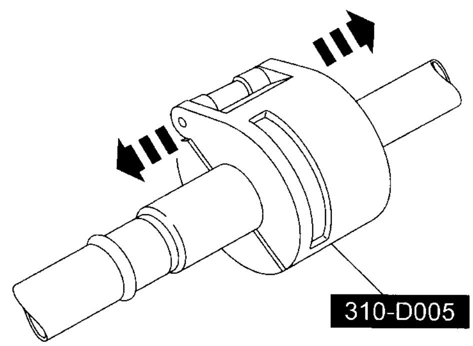
3. Install special tool 310-D005 as shown.



4. Close and push the special tool into the open side of the cage.



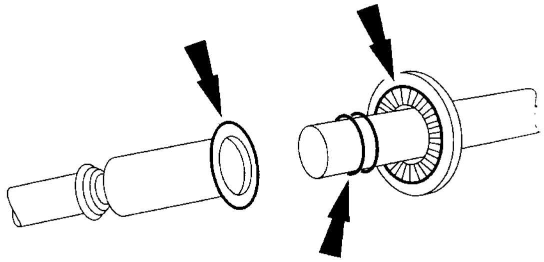
5. Separate the fitting.



Spring Lock Coupling - Type I - Connect

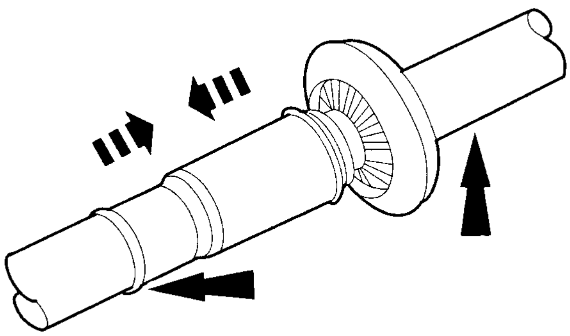
1. Inspect and clean both the coupling ends and install new o-ring seals and garter springs if necessary.

2. Lubricate o-ring seals with clean engine oil.



CAUTION: Make sure the fuel tube clicks into place when installing the tube. To make sure that the fuel tube is fully seated, pull on the tube.

3. Fit the male fitting into female end and push until the garter spring snaps over the flared end of the female fitting.



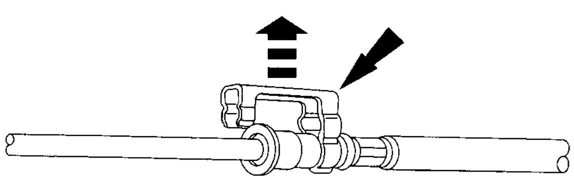
4. Make sure the coupling is engaged by pulling on the lines and install the safety clip.

Spring Lock Coupling - Type II - Disconnect

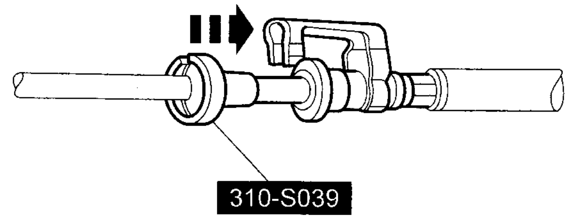
⚠

WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

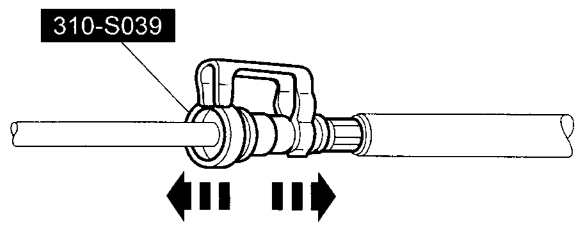
1. Relieve the fuel system pressure -- Refer to“Fuel Pressure Relief” on page 31 of this section.
2. Disconnect the safety clip from the male hose.



3. Install the fuel tube disconnect tool 310-S039 and push into fitting.



4. Separate the fitting.

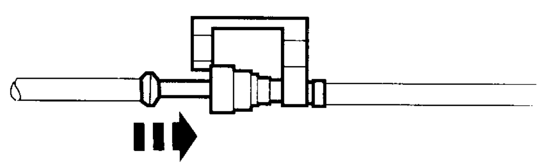


Spring Lock Coupling - Type II - Connect

1. Inspect for damage and clean fittings.

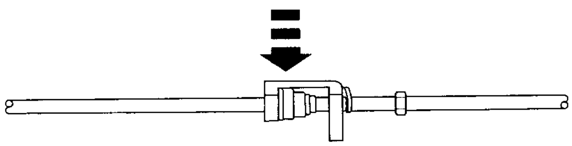
CAUTION: Make sure the fuel tube clicks into place when installing the tube. To make sure that the fuel tube is fully seated, pull on the tube.

2. Lubricate the tube end with clean engine oil to ease assembly.
3. Align and push the tube into the fitting until you hear a click.



4. Pull on the fitting to make sure it is fully engaged,

then install safety clip.

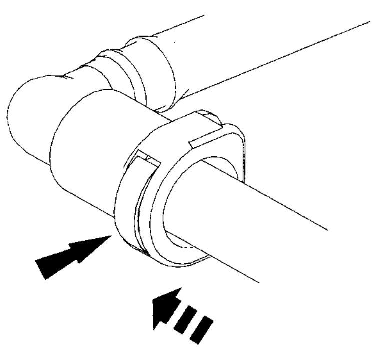


Quick Connect Coupling - Type I - Disconnect

WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

CAUTION: Do not use any tools. Use of tools may cause a deformity in the coupling components which can cause fuel leaks.

1. Relieve the fuel system pressure -- Refer to“Fuel Pressure Relief” on page 31 of this section.
2. Press the fuel tube quick connect coupling button and pull fuel tube to disconnect.

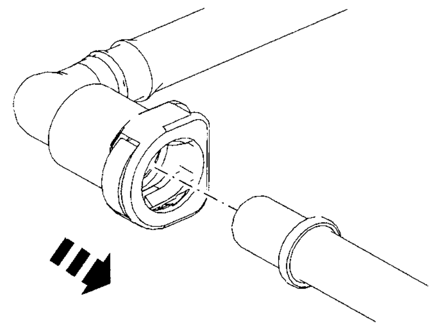


Quick Connect Coupling - Type I - Connect

1. Inspect for damage and clean fittings.

CAUTION: Make sure the fuel tube clicks into place when installing the tube. To make sure that the fuel tube is fully seated, pull on the tube.

2. Lubricate the o-ring seals with clean engine oil.
3. Install the quick connect coupling onto the tube until it is fully seated.



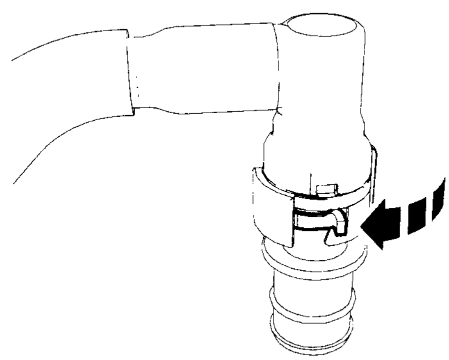
4. Pull on the fitting to make sure it is fully engaged.

Quick Connect Coupling - Type II - Disconnect

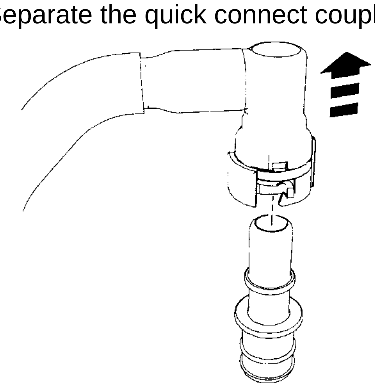
WARNING: REFER TO WARNINGS AT THE BEGINNING OF THIS SECTION.

CAUTION: Do not use any tools. Use of tools may cause a deformity in the coupling components which can cause fuel leaks.

1. Relieve the fuel system pressure -- Refer to“Fuel Pressure Relief” on page 31 of this section.
2. Release the locking tab on the quick connect coupling.



3. Separate the quick connect coupling from the fitting

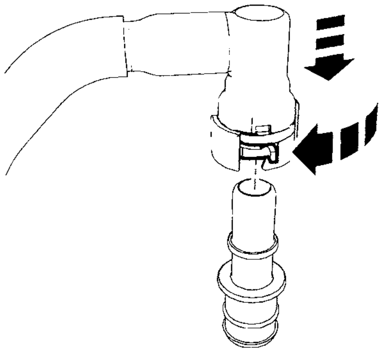


Quick Connect Coupling - Type II - Connect

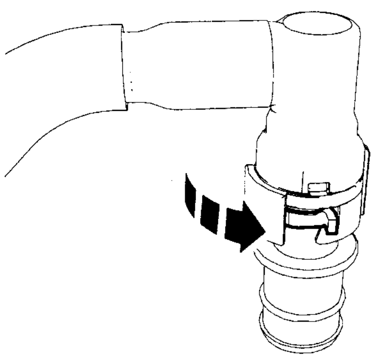
1. Inspect for damage and clean fittings.

CAUTION: Make sure the fuel tube clicks into place when installing the tube. To make sure that the fuel tube is fully seated, pull on the tube.

2. Lubricate the o-ring seals with clean engine oil.
3. Release the locking tab and install the quick connect coupling onto the fitting.



4. Position the locking tab into the latched position.



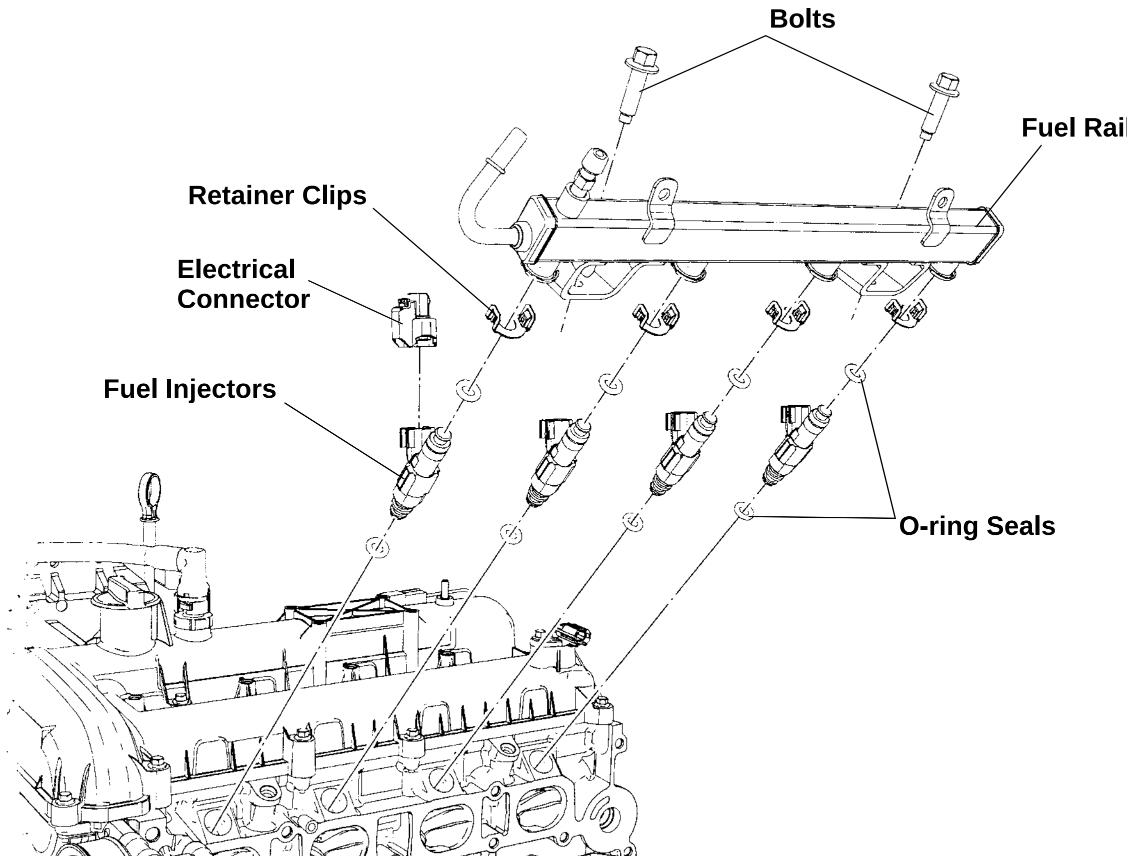
5. Pull on the fitting to make sure it is fully engaged.

REMOVAL AND INSTALLATION

Fuel Rail & Injectors - Replacement

WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL-RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.

WARNING: FUEL IN THE FUEL SYSTEM REMAINS UNDER HIGH PRESSURE EVEN WHEN THE ENGINE IS NOT RUNNING. BEFORE WORKING ON OR DISCONNECTING ANY OF THE FUEL LINES OR FUEL SYSTEM COMPONENTS, THE FUEL SYSTEM PRESSURE MUST BE RELIEVED. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.



1. Disconnect the battery ground cable.
2. Remove and/or disconnect components to allow access and removal of the fuel rail & injectors. Label if necessary to allow for correct reinstallation.

CAUTION: After disconnecting fuel lines, plug the ends to prevent fuel leakage.

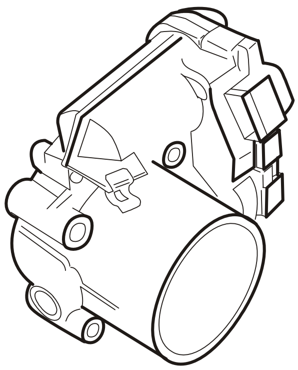
3. Disconnect fuel lines -- Refer to“General Service Procedures” on page 31of this section.
4. Disconnect injector electrical connectors.
5. Remove bolts.
6. Carefully remove the fuel rail and injector assembly.
7. If necessary, remove the retaining clips and separate the fuel injectors from the fuel rail - discard the o-rings.

CAUTION: Use o-ring seals that are made of special fuel-resistance material. The use of ordinary o-rintg seals can cause the fuel system to leak. Do not re-use the o-ring seals

8. Reverse procedure to install:
   - Lubricate new o-rings with clean engine oil
   - Tighten fuel rail bolts to 25 Nm (18 lb-ft).

Actuator - Removal

1. Remove and/or disconnect components to allow access and removal of the actuator. Label if necessary to allow for correct reinstallation.
2. Disconnect air cleaner components from actuator.
3. Disconnect accelerator cable.
4. Disconnect electrical connectors.
5. Remove nuts.
6. Remove actuator and gasket.



Actuator - Installation

1. Inspect gasket and install a new one if necessary.
2. Position actuator onto studs.
3. Install nuts:
   - Tighten to ????
4. Reconnect electrical connectors.
5. Reconnect accelerator cable.
6. Reconnect air cleaner components to actuator.
7. Install or connect any other component removed or disconnected.

SPECIFICATIONS

GENERAL SPECIFICATIONS	
Fuel pressure	414-448 kPa (60-65 psi)
Motorcraft SAE 5W20 Super Premium	WSS-M2C930-A

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
Fuel rail bolts	25	18	

INDEX

Subject **Page**

CAUTIONS & WARNINGS

WARNING: THE RADIATOR OR DEGAS TANK IS EQUIPPED WITH A PRESSURE CAP. IT IS DANGEROUS TO REMOVE THIS WHEN THE SYSTEM IS VERY HOT.

WARNING: NEVER REMOVE THE PRESSURE RELIEF CAP WHILE THE ENGINE IS OPERATING OR WHEN THE COOLING SYSTEM IS HOT. MAY CAUSE PERSONAL INJURY OR DAMAGE TO COOLING SYSTEM OR ENGINE. TO REDUCE THE RISK OF HAVING SCALDING HOT COOLANT OR STEAM BLOW OUT OF THE DEGAS BOTTLE WHEN REMOVING THE PRESSURE RELIEF CAP, WAIT UNTIL THE ENGINE HAS COOLED DOWN TO AT LEAST 40°C (110°F).

1. Wrap a thick cloth around the pressure relief cap and turn it slowly one-half turn counterclockwise. Stepping back while the pressure is released from the cooling system.
2. When you are sure all the pressure has been released, (still with a cloth) turn counterclockwise and remove the pressure relief cap.

WARNING: ANTIFREEZE CONTAINS MONO ETHYLENE GLYCOL AND OTHER CONSTITUENTS WHICH ARE TOXIC IF TAKEN INTERNALLY AND CAN BE ABSORBED IN TOXIC AMOUNTS ON REPEATED OR PROLONGED SKIN CONTACT. PERSONS USING ANTIFREEZE ARE RECOMMENDED TO ADHERE TO THE FOLLOWING PRECAUTIONS:

- **ANTIFREEZE MUST NEVER BE TAKEN INTERNALLY. IF ANTIFREEZE IS SWALLOWED ACCIDENTALLY, MEDICAL ADVICE SHOULD BE SOUGHT IMMEDIATELY.**
- **PRECAUTIONS SHOULD BE TAKEN TO AVOID SKIN CONTACT WITH ANTIFREEZE. IN THE EVENT OF ACCIDENTAL SPILLAGE ONTO THE SKIN, ANTIFREEZE SHOULD BE WASHED OFF AS SOON AS PRACTICABLE. IF CLOTHING IS SPLASHED WITH ANTIFREEZE, IT SHOULD BE REMOVED AND WASHED BEFORE BEING WORN AGAIN, TO AVOID PROLONGED SKIN CONTACT.**
- **FOR REGULAR AND FREQUENT HANDLING OF ANTIFREEZE, PROTECTIVE CLOTHING (PLASTIC OR RUBBER GLOVES, BOOTS AND IMPERVIOUS OVERALLS OR APRONS) MUST BE USED TO MINIMIZE SKIN CONTACT.**

CAUTION: Under no circumstances should the engine be started without liquid in the cooling system. This may cause permanent damage to the engine.

CAUTION: The use of straight water as a coolant will cause permanent damage to the engine.

CAUTION: Never use a cold coolant mixture to top-up the radiator or degas tank of a hot engine if the coolant level is very low; this could cause serious engine damage.

CAUTION: In territories where freezing conditions may occur, the coolant should consist of a mixture of 50% plain water and 50% Motorcraft Premium Gold coolant, or equivalent. This antifreeze contains additional corrosion inhibitors designed to provide lasting protection for the engine.

CAUTION: Only this antifreeze, or proprietary antifreeze meeting Ford specification WSS-M97B51-A1 should be used when topping-up or re-filling the cooling system. Do not mix coolant types.

CAUTION: Do not add or mix an orange-colored extended life coolant, such as Motorcraft Specialty Orange engine coolant with factory filled coolant WSS-M97B44-D. Mixing Motorcraft Specialty Orange engine coolant or any orange colored extended life product, with factory filled coolant, can result in degraded corrosion protection.

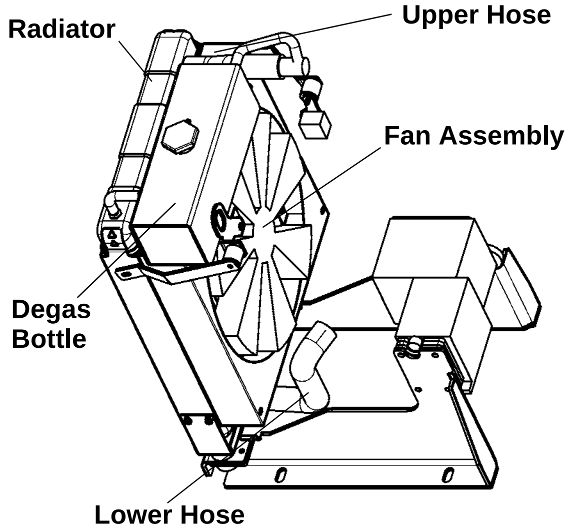
CAUTION: If there is engine coolant in the engine oil or transmission fluid, the cause must be corrected and oil/fluid changed or major component damage can occur.

CAUTION: When removing coolant, the coolant must be recovered in a suitable, clean container for reuse. If the coolant is contaminated, it must be recycled or disposed of correctly.

WARNING: DO NOT STAND INLINE WITH OR NEAR THE ENGINE COOLING FAN BLADE WHEN REVVING THE ENGINE. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

CAUTION: Under no circumstances should the drive belt, tensioner or pulleys be lubricated as potential damage to the belt material and tensioner dampening mechanism will occur. Do not apply any fluids or belt dressing to the drive belt or pulleys.

GENERAL INFORMATION



Description

The cooling system consists of the following:

- Engine Coolant Temperature (ECT) Sensor
- Cylinder Head Temperature (CHT) Sensor
- Fan Assembly
- Radiator and Cap
- Thermostat and Housing
- Degas Bottle
- Engine Block Heater
- Coolant pump
- Coolant

Walter C. Avrea, the owner of patents 3,601,181 and RE27,965, has granted Ford Motor Company rights with respect to cooling systems covered by these patents.

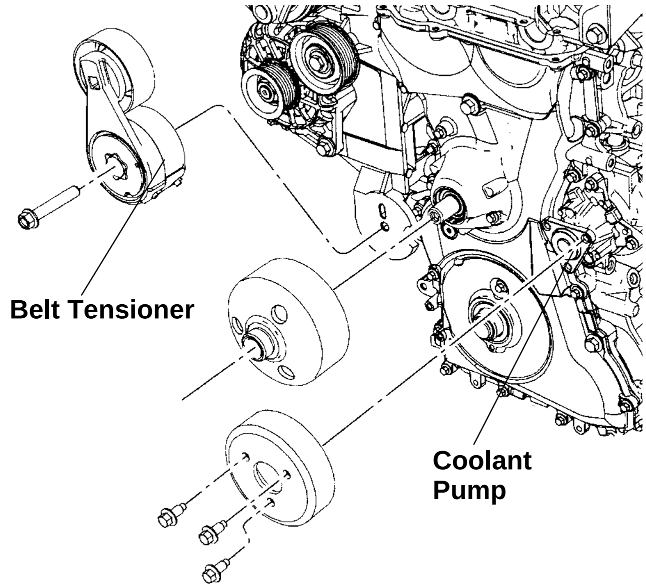
The ECT Sensor is used by the GCP to obtain coolant temperature information. Refer to Section 8 for further information on this sensor.

The coolant fan blade can either draw or push air through the radiator to help cool the system coolant. The fan clutch is a thermostatic-controlled clutch that controls the fan drive.

The radiator allows excess heat to be transferred to the air. The radiator tanks can not be repaired. The radiator cap maintains system pressure. This pressure raises the boiling point of the coolant and helps prevent vapor locks in the engine block and cooling system.

The thermostat prevents coolant flow until it reaches a specified temperature. At this temperature, it will open and allow coolant flow through the engine and radiator. The thermostat and housing are serviced as a unit.

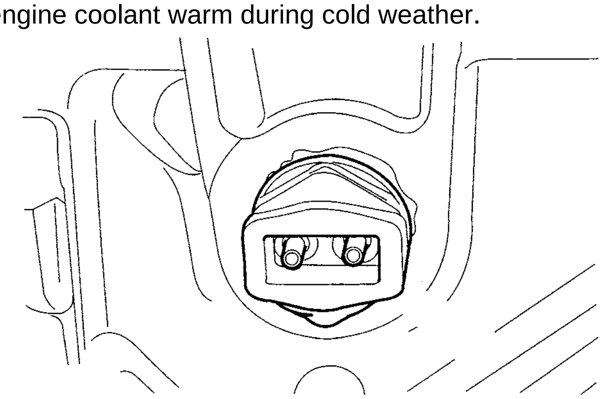
The radiator degas bottle holds a surplus coolant when the engine is hot. It also replenishes coolant back to the system as it cools. The degas bottle allows air separation during operation which reduces engine hot spots.



The coolant pump circulates the coolant through the engine block and cylinder heads to the thermostat. If the thermostat is closed, the coolant returns to the coolant pump through a bypass hose. Once the coolant reaches a specified temperature, the thermostat will open, allowing the coolant to flow to the radiator for heat transfer and back to the coolant pump inlet.

Engine coolant provides freeze and boil protection to the engine and cooling components. In order to obtain these protections, the engine coolant must be maintained at the correct concentration and fluid level in the degas bottle or coolant expansion tank.

The engine block heater is an optional electrical heating element installed in the core plug opening. It uses a standard 110 volt electrical supply. The heater keeps engine coolant warm during cold weather.



Coolant is made up of a 50/50 mix of ethylene glycol permanent antifreeze and water. This mixture is to be used year-round with temperatures above -34.4°C (-30°F). If recycled coolant is used, it must meet Ford specification ESE-M97B44-A or WSS-M97B44-D.

CAUTION: Not all coolant recycling processes produce coolant which meets Ford specification ESE-M97B44-A or WSS-M97B44-D. Use of coolant that does not meet specifications may harm engine and cooling system components.

CAUTION: Do not use alcohol type antifreeze, alkaline brine solutions, or 100,000 mile, red in color antifreeze. This may cause serious engine cooling system damage.

DIAGNOSIS AND TESTING

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

Begin diagnosis by verifying the customer's concern by operating the engine to duplicate the condition. The most frequent cooling system complaints are leakage and overheating. Either of these problems will soon render the engine inoperable.

Perform a visual inspection. If the inspection reveals an obvious concern that can be readily identified, repair as necessary. If the concern remains after the inspection, determine the symptom(s) and go to the Symptom Chart. The Symptom Chart lists cooling system problems, their possible cause and recommended correction.

Visual Inspection

Check for leaks or damage at:

- all hoses, connections and hose clamps
- radiator seams, core and drain petcock
- all block core plugs and drain plugs
- edges of all cooling system gaskets
- transmission oil cooler (if equipped)
- coolant pump shaft and bushing
- thermostat, head and intake manifold gaskets
- coolant pump
- degas bottle
- heater core (if equipped)
- fan and fan clutch
- engine coolant temperature sensor and wiring
- drive belt.

NOTE: A small amount of antifreeze coming out the coolant pump weep hole may be considered normal.

Examine oil dipstick for evidence of coolant contaminated engine oil (white milky appearance). check radiator for evidences of oil in coolant (leakage at transmission oil cooler if equipped).

Some engines use an ethylene glycol base antifreeze solution to which the manufacturers have added a dye color. The dye color makes the antifreeze solution an excellent leak detector. If this type of solution is not being used in the cooling system, a vegetable dye may be added to aid in locating external leakage.

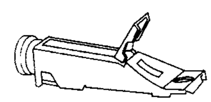
Coolant Inspection

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

Check level and condition of coolant:

- A dark brown color could indicate a stop leak was used.
- A light or reddish brown color indicates that rust may be present in the cooling system. Flush the system and refill with the correct mixture of distilled water and premium engine coolant.
- An iridescent sheen on top of the coolant could indicate a trace of oil is entering the system.
- A milky brown color may indicate that either engine oil or transmission fluid is entering the cooling system. If transmission fluid is suspected, it may be entering through the transmission cooler in the radiator. If engine oil is suspected, the cause may an internal leak in the engine.

Coolant Range Check



If the engine coolant appearance is acceptable, test the engine coolant freezing point and concentration level.

The antifreeze concentration in a cooling system can be determined by using a suitable hydrometer or a battery/antifreeze tester.

The freezing point should be in the range -45°C to -23°C (-50°F to -10°F). If the equipment is run in cold climates colder than -36°C (-34°F), it may be necessary to increase the coolant concentration to get adequate freeze protection.

Maximum coolant concentration is 60% coolant to 40% distilled water. If coolant tests too strong, remove some of the coolant and ad distilled water until the readings are acceptable.

Minimum coolant concentration is 40% coolant to 60% distilled water. If coolant tests too weak, drain some coolant out and add straight coolant until readings are acceptable.

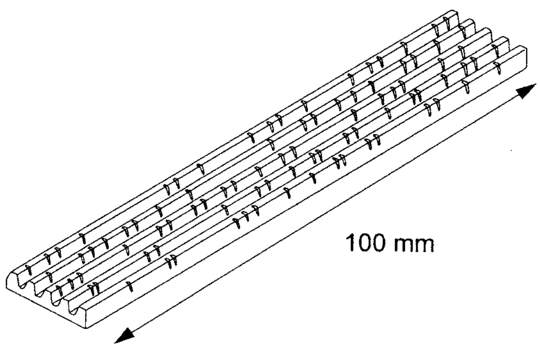
Drive Belt Inspection

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

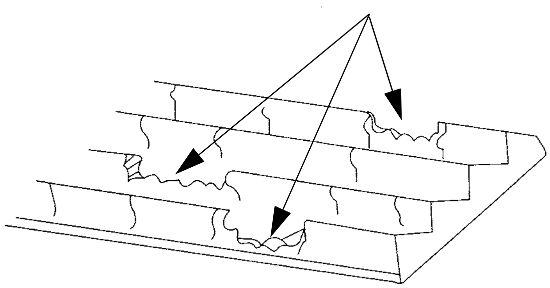
With engine running, observe the belt movement. It should respond when engine is accelerated rapidly. If tensioner moves excessively without rapid acceleration, Install a new belt. If excessive movement still exists, install a new tensioner.

Visually inspect the belt for obvious signs of damage.

- Up to 15 cracks in a rib over a distance of 100 mm (4.0 in) can be considered acceptable.

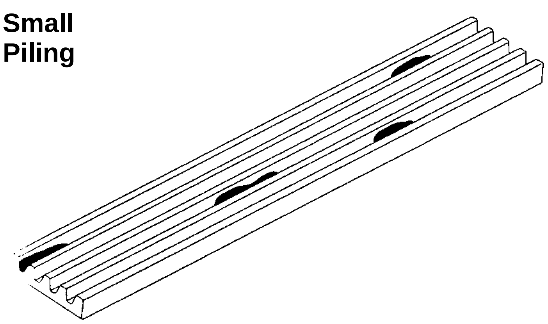


- If cracks are beyond acceptable or, any chunks are found to be missing from the ribs, a new belt must be installed.



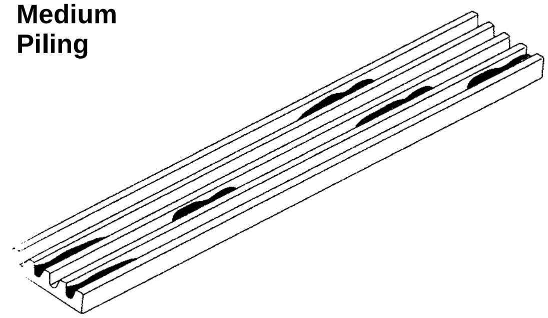
- Small scatted deposits of rubber material (known as piling) is not a concern.

Small Piling



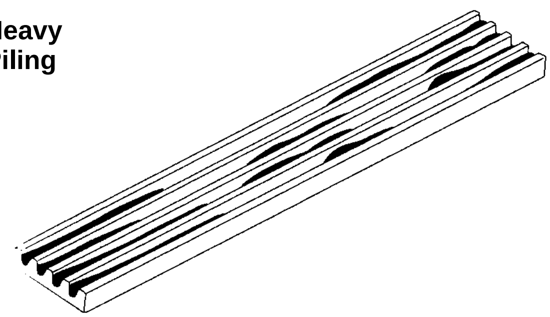
- Longer deposits building up to 50% of the rib height is also not a concern, except it can result in excessive noise.

Medium Piling

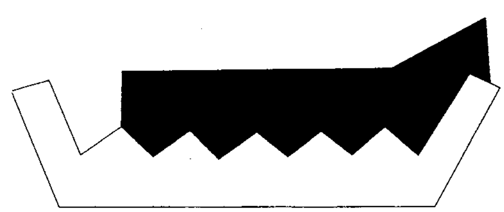


- If heavy deposits are apparent, resulting in noise and belt instability, install a new belt.

Heavy Piling



- Drive belt squeal that is short and intermittent is expected and considered normal. Constant or reoccurring drive belt squeal can occur with a damaged pulley bearing, fluid contamination, or a loose belt.
- Also check for belt misalignment which can cause a chirping noise. If misalignment is found, check the tensioner for damage, especially the mounting pad surface. Check for a damaged pulley that wobbles. Check mounting brackets for tightness and for any interference.



- Check tensioner with a suitable release tool that it moves without sticking or binding.
- With belt off, check that all pulleys rotate freely without binding.

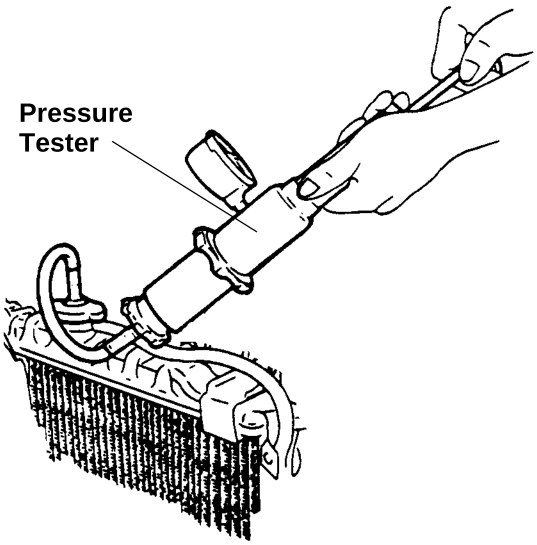
CAUTION: Incorrect drive belt installation will cause excessive drive belt wear and can cause the belt to come off the pulleys.

Symptom Chart

Refer to the following Diagnosis Chart for cooling system problems, their possible cause and recommended correction.

CONDITION	POSSIBLE SOURCE	ACTION
Loss of coolant	• Pressure cap and gasket • Leakage • External leakage • Internal leakage	• Inspect, wash gasket and test. Replace only if cap will not hold pressure to specification. • Pressure test system. • Inspect hose, hose connection, radiator, edges of cooling system gaskets, core plugs and drain plugs, transmission oil cooler lines, water pump, heater system components. Repair or replace as required. • Disassembly engine as necessary - check for:cracked intake manifold, blown head gaskets, warped head or block gasket surfaces, cracked cylinder head or engine block.
Engine Overheats	• Low coolant level • Loose fan belt • Pressure cap • Radiator obstruction • Closed thermostat • Fan drive clutch • Ignition • Temp gauge or cold light • Engine • Coolant mixture	• Fill as required. Check for coolant loss. • Adjust. • Test. Replace if necessary. • Remove bugs, leaves, etc. • Test, Replace if necessary. • Test, replace if necessary. • Check timing and advance. Adjust as required. • Check electrical circuits and repair as required. • Check water pump, block for blockage. • 1/2 water and 1/2 permanent anti-freeze mixture.
Engine fails to reach normal operating temperature	• Open thermostat • Temperature gauge or cold light	• Test, replace if necessary. • Check electrical circuits and repair as required.

Cooling System Pressure Test



WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Remove the radiator cap from the radiator filler neck.

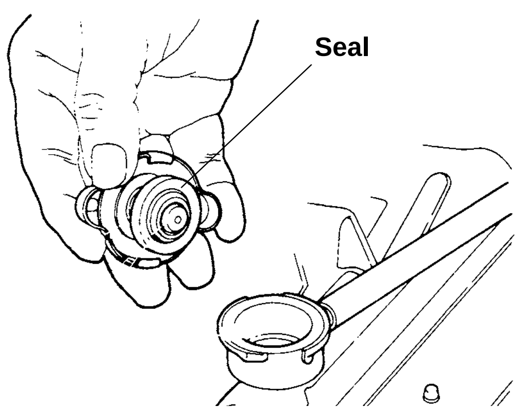
CAUTION: Do not pressurize the cooling system beyond 138 kPa (20 psi).

2. Fill the radiator as needed.
3. Fit the pressure tester to the radiator neck.
4. Pump the cooling system to a maximum of 138 kPa (20 psi) and hold for 2 minutes.
5. If the pressure drops within this time, inspect for leaks and repair as necessary.

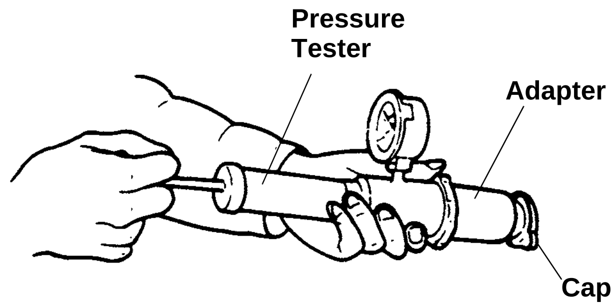
Radiator Cap Pressure Test

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Inspect radiator cap and seals for damage or deterioration - replace as necessary.



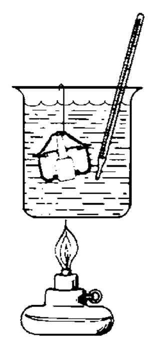
2. Fit the radiator cap to the pressure tester using an adapter.



NOTE: If the plunger of the pressure tester is depressed too fast, an incorrect pressure reading will result.

3. Slowly pump the pressure tester until the gauge stops increasing and note the highest pressure reading.
4. Release the pressure and repeat the test.
5. Install a new radiator cap if the pressure is not 124 kPa (18 psi).

Thermostat Operational Check



1. Hold thermostat up to the light.
2. Visually check the valve to be sure it is air tight.
   - Leakage of light all around the valve (at room temperature) indicates a bad thermostat.
   - A slight leakage of light at one or two locations on the perimeter of the valve is normal.
3. Place the thermostat and a thermometer in water.
4. Gradually increase the water temperature
5. Replace thermostat if it does not open at the specified temperatures:
   - Starts to open: 90°C (194°F)
   - Fully open: 97 - 106°C (206.6 - 222.8°F)

GENERAL SERVICE PROCEDURES

Draining the Cooling System

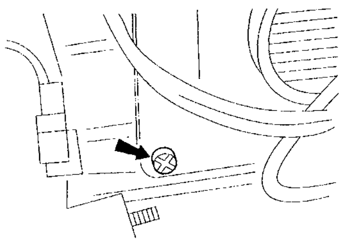
WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Remove radiator cap.

CAUTION: The coolant must be recovered in a suitable, clean container for reuse. If the coolant is contaminated, it must be recycled or disposed of correctly.

2. Open drain cock at radiator and drain old coolant from engine into a suitable container. Close the drain cock when finished.

Radiator Drain Cock



3. If necessary, remove the lower radiator hose to completely drain the system. Reinstall when finished.
4. If rust, sludge or other foreign material are present in the old coolant, system should be flushed -- Refer to“Flushing the Cooling System” on page 9 of this section.

Flushing the Cooling System

To remove rust, sludge and other foreign material from the cooling system, use Rotunda Cooling System Cleanser. Removal of such material restores cooling efficiency and avoids overheating.

Always remove the thermostat prior to pressure flushing. A pulsating or reversed direction of flushing water flow will loosen sediment more quickly than a steady flow in the normal direction of coolant flow.

In severe cases where cleaning solvents will not properly clean the cooling system for efficient operation, it will be necessary to use the pressure flushing method. Various types of flushing equipment are available. Follow manufacturer’s operating instructions.

Filling the Cooling System

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

Coolant is made up of a 50/50 mix of ethylene glycol permanent antifreeze and distilled water. This mixture is to be used year-round with temperatures above -34.4°C (-30°F). If recycled coolant is used, it must meet Ford specification ESE-M97B44-A or WSS-M97B44-D.

CAUTION: Not all coolant recycling processes produce coolant which meets Ford specification ESE-M97B44-A or WSS-M97B44-D. Use of coolant that does not meet specifications may harm engine and cooling system components.

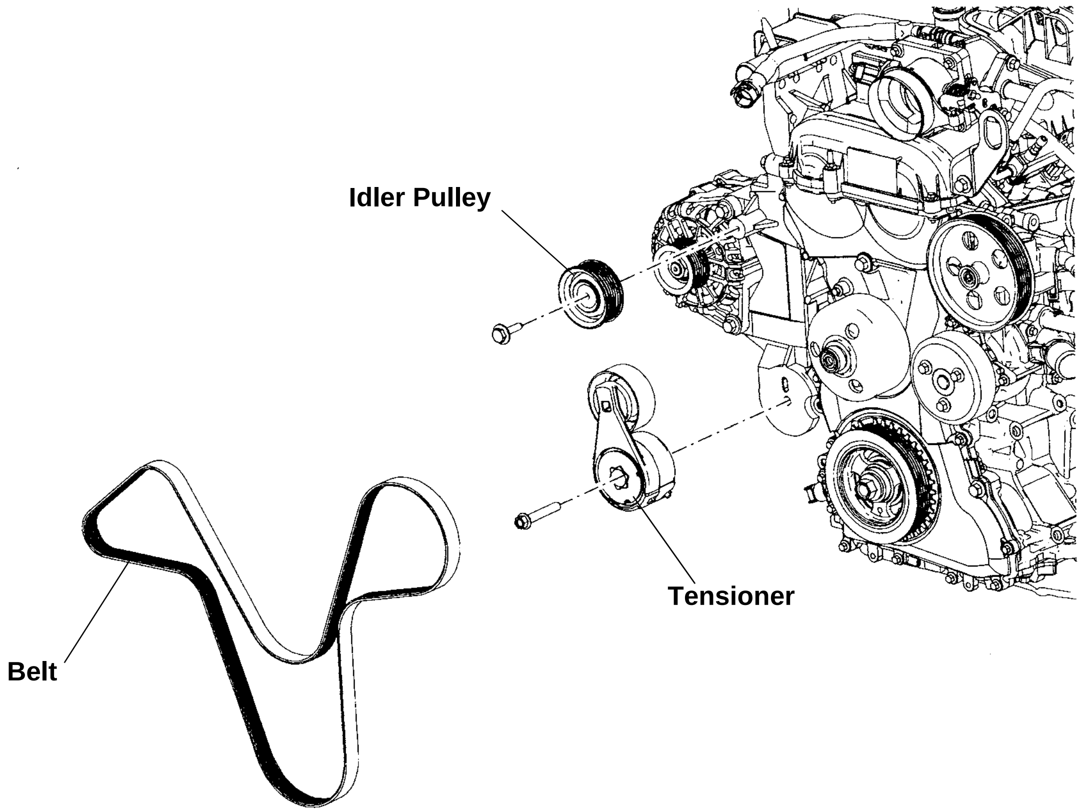
The engine cooling system is filled with Motorcraft Premium Gold Engine Coolant. Always refill the cooling system with the same coolant that was drained from the system, Do not mix coolant types.

CAUTION: Do not use alcohol type antifreeze, alkaline brine solutions, or 100,000 mile - red in color antifreeze. This may cause serious engine cooling system damage.

NOTE: The use of stop leak may change the color of the coolant.

1. Make sure the radiator drain cock is completely closed.
2. Fill the system with the proper coolant mix.
3. Start engine and hold at 2,500 rpm engine speed for approximately 8 minutes until thermostat opens.
4. Maintain 2,500 rpm for an additional 3 minutes. Add coolant as necessary.
5. Increase engine speed to 4000 rpm and hold for 5 seconds.
6. Return engine speed to 2,500 rpm and hold for an additional 3 minutes.
7. Stop the engine and check for leaks.
8. Verify correct fluid level after engine cools for 20 minutes. Top off the degas bottle to “max” line.

REMOVAL AND INSTALLATION



NOTE: If a major component of the cooling system is renewed such as the radiator, water pump etc., the system should be flushed and re-filled with a 50% solution of Motorcraft Premium Gold engine coolant, or equivalent, and clean water -- Refer to“Flushing the Cooling System” on page 9 of this section.

Drive Belt - Removal

NOTE: Note belt routing for installation purposes.

1. Rotate tensioner counterclockwise to relieve belt tension.
2. Remove belt.
3. Inspect belt and pulleys -- Refer to“Visual Inspection” on page 5 in this section.

Drive Belt - Installation

1. Rotate tensioner counterclockwise to relieve tension.
2. Route belt correctly and release tensioner onto belt.
3. Run engine for a minute and then turn off.
4. Recheck belt routing and groove alignment.

Belt Tensioner - Replacement

1. Remove drive belt -- Refer to“Drive Belt - Removal” on page 10 of this section.
2. Remove bolt.
3. Remove belt tensioner.
4. Reverse procedure to install:
   - Tighten bolt to 47 Nm (35 lb-ft).

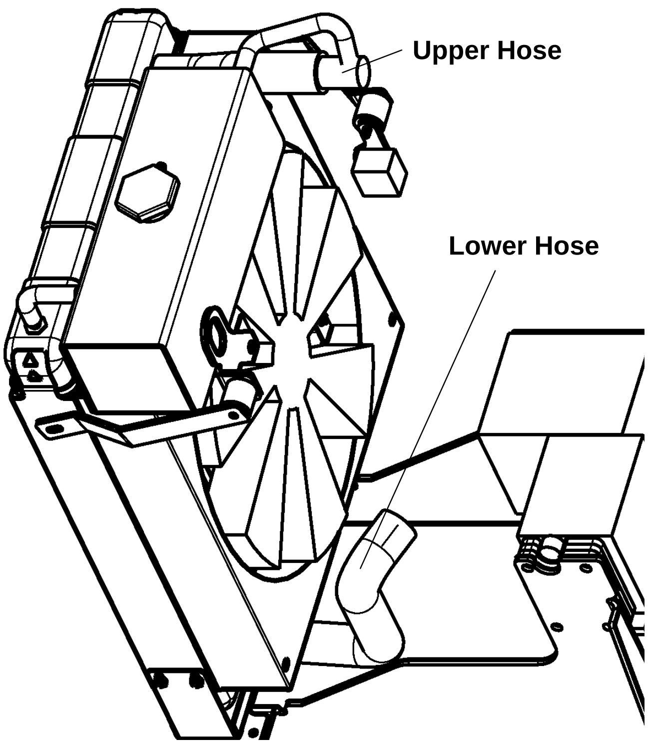
Idler Pulley - Replacement

1. Remove drive belt -- Refer to“Drive Belt - Removal” on page 10 of this section.
2. Remove belt idler pulley assembly.
3. Reverse procedure to install:
   - Tighten to 47 Nm (35 lb-ft).

Radiator Hose - Removal

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Drain the cooling system -- Refer to“Draining the Cooling System” on page 9 of this section.
2. Loosen the clamps at each end of the hose to be removed.
3. Slide the hose off the radiator connection and the engine water outlet connection.



Radiator Hose - Installation

1. Position the clamps at least 1/8 inch from each end of the hose.
2. Coat the connection areas with an approved water-resistant sealer and slide the hose on the connection.

NOTE: Make sure the clamps are beyond the bead and placed in the center of the clamping surface of the connections.

3. Tighten the clamps.
4. Fill the system with coolant -- Refer to“Filling the Cooling System” on page 9 of this section.
5. Operate the engine for several minutes, then check the hoses and connections for leaks.

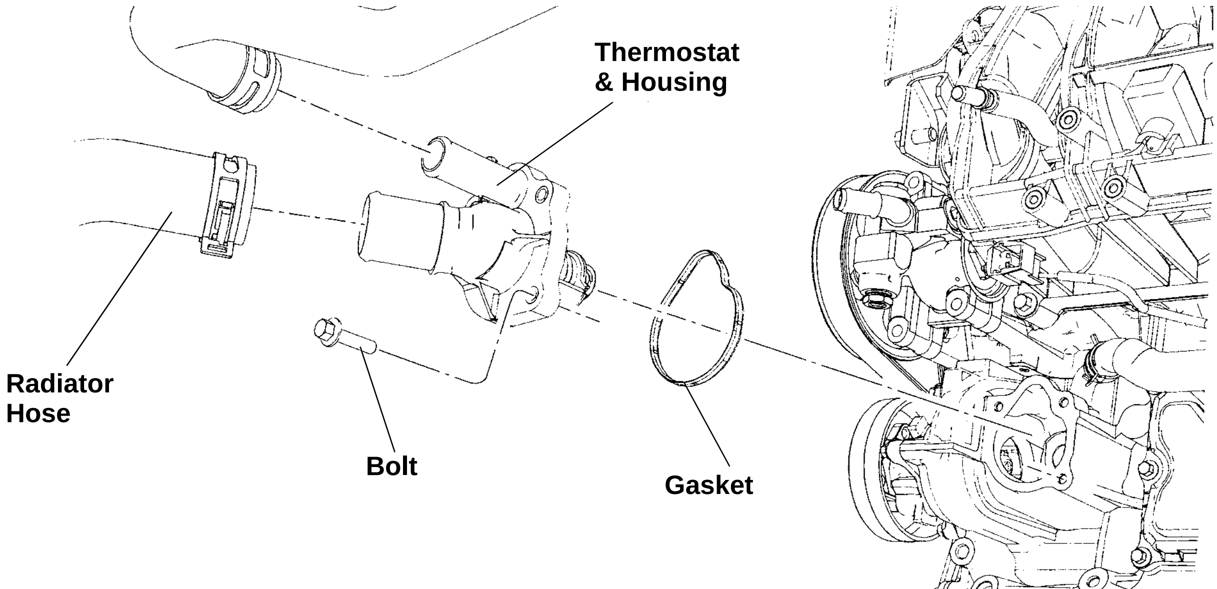
Thermostat & Housing - Replacement

⚠

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

NOTE: The thermostat and housing are serviced as an assembly.

1. Allow the engine to cool down until the coolant has lowered in temperature to below 110°F.
2. Drain the radiator so coolant level is below the thermostat -- Refer to"Draining the Cooling System" on page 9 of this section.
3. Remove or disconnect components as necessary to gain access to the thermostat housing.
4. Disconnect the lower radiator hose.

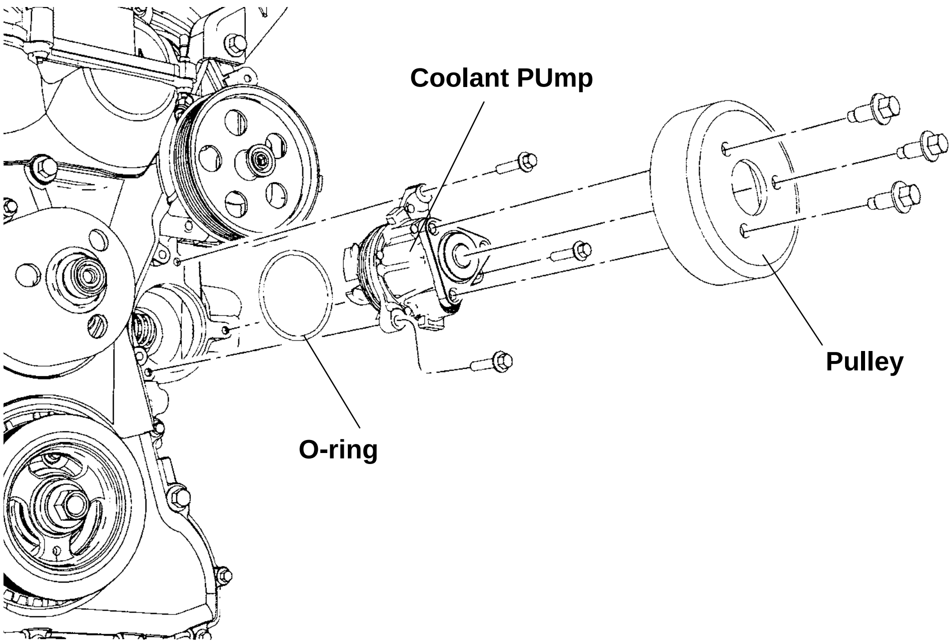


5. Remove bolts and thermostat housing.
6. Reverse procedure to install:
   - Clean and inspect gasket, install a new gasket if necessary.
   - Tighten bolts to 10 Nm (89 lb-in).

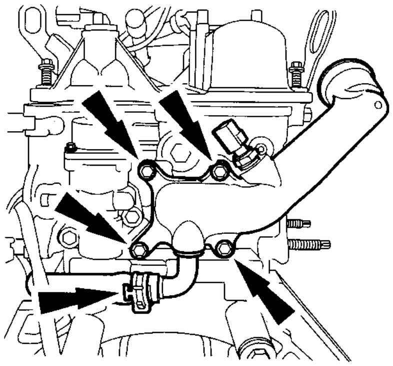
Coolant Pump - Replacement

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Drain the cooling system -- Refer to“Draining the Cooling System” on page 9 of this section.
2. Remove or disconnect components as necessary to gain access to the coolant pump.
3. Remove the drive belt -- Refer to“Drive Belt - Installation” on page 10 of this section.
4. Remove 3 bolts and coolant pump pulley.
5. Remove 3 bolts and coolant pump.



6. Reverse procedure to install:
   - Lubricate coolant pump o-ring with clean coolant.
   - Tighten coolant pump bolts to 10 Nm (89 lb-in)
   - Tighten pulley bolts to 25 Nm (18 lb-ft)



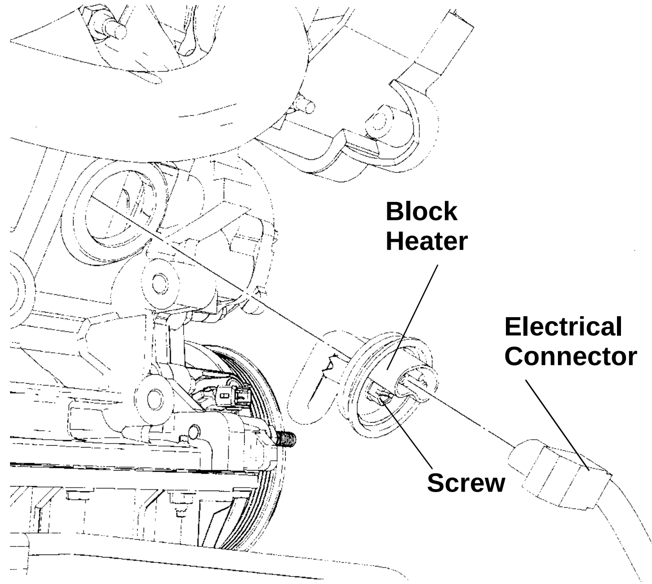
Outlet Pipe - Replacement

WARNING: REFER TO CAUTIONS AND WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Drain the cooling system -- Refer to“Draining the Cooling System” on page 9 of this section.
2. Remove or disconnect components as necessary to gain access to the outlet pipe.
3. Disconnect hoses from outlet pipe.
4. Disconnect electrical connector at ECT Sensor.
5. Remove bolts and outlet pipe.
6. Reverse procedure to install:
   - Clean gasket mating surfaces
   - Install new gasket
   - Tighten bolts to 10 Nm (89 lb-in).

Block Heater - Replacement

1. Drain the cooling system -- Refer to“Draining the Cooling System” on page 9 of this section.
2. Disconnect the block heater electrical connector.

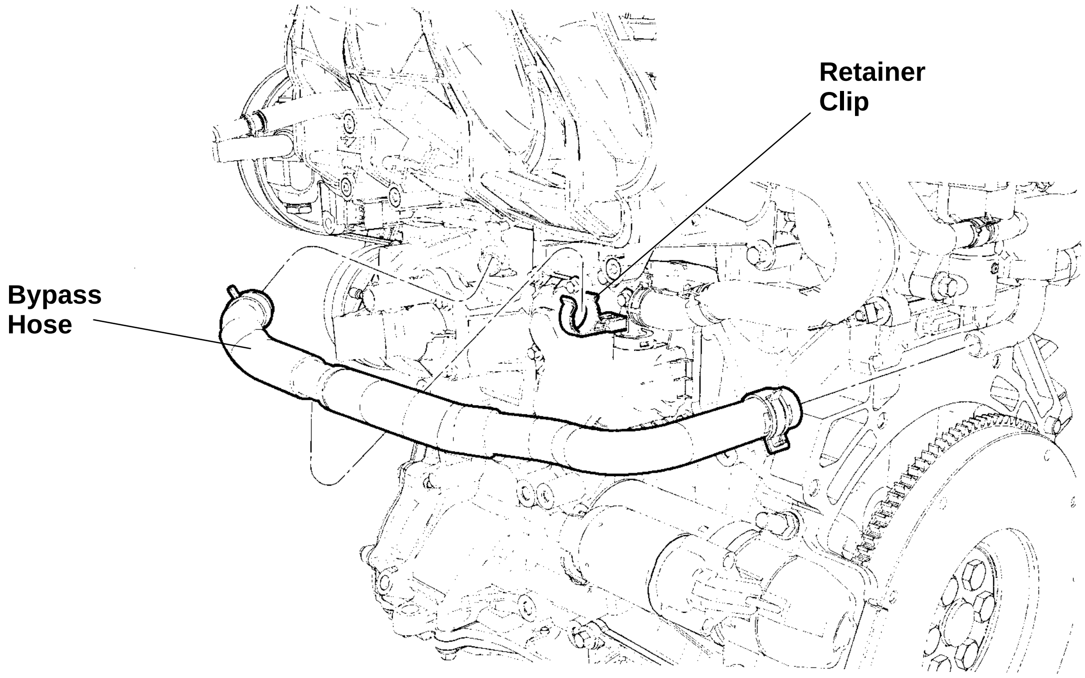


NOTE: Do not loosen the screw more than necessary for removal.

3. Loosen the block heater screw and twist and slide the block heater to release the retainer clip. Discard the retainer clip and remove the block heater.
4. Reverse procedure to install.

Coolant Bypass - Replacement

1. Drain the cooling system -- Refer to“Draining the Cooling System” on page 9 in this section.
2. Remove or disconnect components as necessary to gain access to the bypass hose.
3. Detach coolant bypass hose from the routing clip.



4. Disconnect the coolant bypass hose from the tubes.
5. Reverse procedure to install.

SPECIFICATIONS

GENERAL SPECIFICATIONS	
Coolant/Water Mixture	50/50
Pressure Relief Cap Opening Pressure kPa (psi)	89 - 124 kPa (13 - 18 psi)
Radiator Pressure Test	138 kPa (20 psi)
Thermostat start to open temperature	90°C (194° F)
Thermostat full open temperature	97 - 106°C (206 - 222° F)
Coolant Specification WSS-M97B51-A1	Motorcraft Premium Gold Engine Coolant

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
Block heater screw	2		18
Coolant pump pulley bolts	25	18	
Coolant pump to block bolts	10		89
Draincock	2		18
Thermostat housing bolts	10		89

INDEX

Subject **Page**

CAUTIONS & WARNINGS

FPP01101

Typical Battery Labeling

The handling and correct use of lead acid batteries is not as hazardous provided that sensible precautions are observed and that operatives have been trained in their use and are adequately supervised. It is important that all labeling on the battery is carefully read, understood and complied with. The format of the following symbols and labels is common to most brands of lead acid battery.

CAUTION: Observe all manufacturers' instructions when using charging equipment.

WARNING: BATTERIES NORMALLY PRODUCE EXPLOSIVE GASES WHICH CAN CAUSE PERSONAL INJURY. THEREFORE, DO NOT ALLOW FLAMES, SPARKS OR ANY IGNITED OBJECT TO COME NEAR THE BATTERY. WHEN CHARGING OR WORKING NEAR A BATTERY, ALWAYS SHIELD YOUR EYES. ALWAYS PROVIDE VENTILATION.

WARNING: WHEN LIFTING A BATTERY, ALWAYS LIFT WITH A BATTERY CARRIER OR WITH YOUR HANDS ON OPPOSITE CORNERS. EXCESSIVE PRESSURE ON THE END WALLS COULD CAUSE ACID TO SPEW THROUGH THE VENT CAPS, RESULTING IN PERSONAL INJURY.

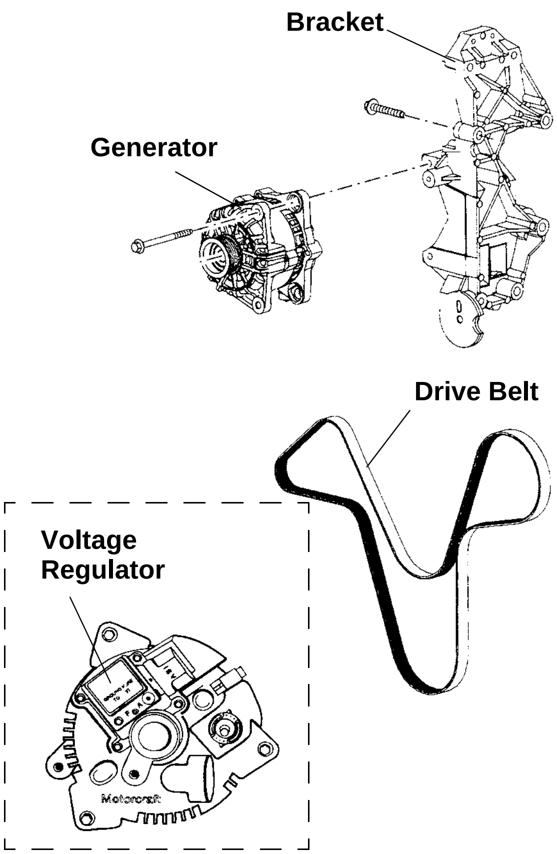
WARNING: IT IS ESSENTIAL THAT THE WIRING CONNECTIONS TO THE GENERATOR ARE NOT REMOVED WHILE THE ENGINE IS RUNNING, AS THIS WILL RESULT IN DAMAGE TO THE REGULATOR OR PERSONAL INJURY.

WARNING: KEEP BATTERIES OUT OF THE REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH THE SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, CALL A PHYSICIAN IMMEDIATELY. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

NOTE: Battery posts and cable clamps must be clean and tight for accurate meter indications.

CAUTION: Always remove the negative cable first to prevent possible arcing possibly damaging other electrical components.

GENERAL INFORMATION



Description

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

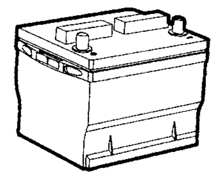
The charging system consists of a generator, voltage regulator and battery. A serpentine belt drives the generator from the crankshaft pulley -- refer to Section 5 for information on the drive belt.

The generator produces alternating current which is subsequently converted to direct current

The charging rate is adjusted automatically by the built-in regulator to provide sufficient electric current to keep the battery fully charged under normal operating conditions.

Battery power

The battery is a 12 volt DC source connected in a negative ground system. There are three main functions of the battery:



- To supply power to the starter and ignition system so the engine can be cranked and started.
- To supply extra power required when the equipment load requirements exceed the supply from the charging system.
- To act as a voltage stabilizer by smoothing out or reducing temporary high voltages within the electrical system.

Operation

With the ignition on, voltage is applied to the voltage regulator. This turns the regulator on, allowing current to flow from the battery to the generator field coil.

When the engine is started, the generator begins to generate alternating current (AC) which is internally converted to direct current (DC). This current is then supplied to the equipment electrical system through the B+ terminal of the generator.

Once the generator begins generating current, a voltage signal is taken from the generator stator and fed back to the regulator. This voltage feedback signal (typically half the battery voltage) is used to turn off the warning indicator.

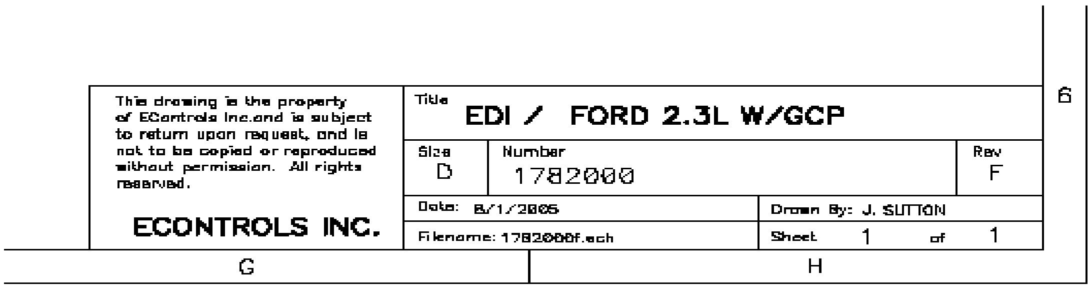
With the system functioning normally, the generator output current is determined and compared to a set voltage internal to the regulator, and the regulator controls the generator field current to maintain the correct generator output.

The set voltage varies with temperature and typically is higher in cold temperatures and lower in warm temperatures. This allows for better battery recharge in the winter and reduces the chance of overcharging in the summer.

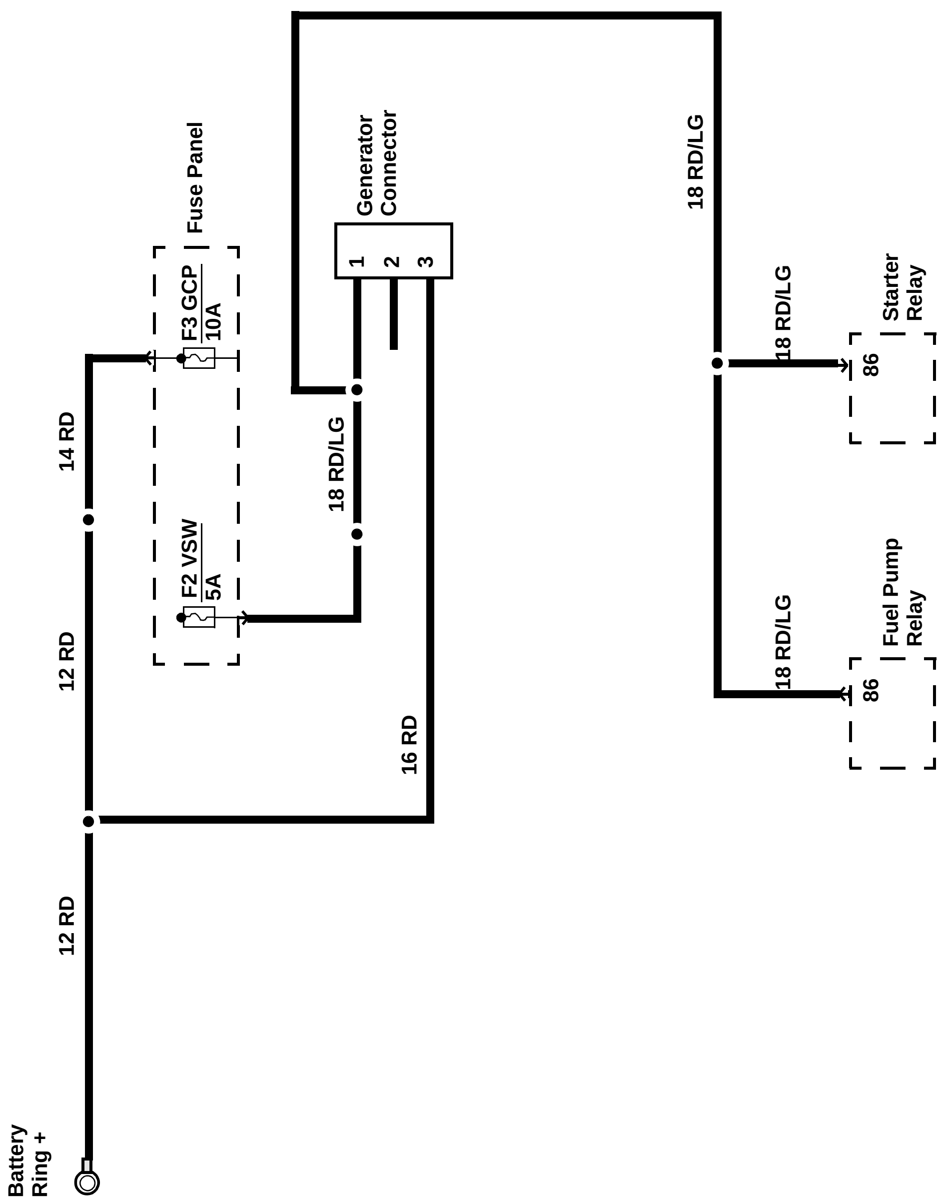
Wiring Diagram

Revision Level

The following wiring schematics are taken from the wiring diagram labeled below:



Charging System



DIAGNOSIS AND TESTING

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

NOTE: When the battery is disconnected and connected, some abnormal symptoms may occur while the GCP relearns its adaptive strategy. The engine may need to run to relearn its strategy.

Preliminary Checks

Before beginning test procedures, check battery cables and generator wiring (especially grounds) for clean, tight connections. Wires and connectors should not be damaged or corroded.

Perform the following checks before any testing:

- Loose or corroded connections at battery, grounded starter motor cutout relay or engine.
- Inspect all connectors for loose or damaged pins, wires, etc.
- Make sure the batteries are at 75% state of charge (SOC) or higher. This represents an open circuit voltage (OCV) of 12.4 volts. Batteries with an OCV of 12 volts or less are either completely discharged or have a dead cell.
- Check the generator drive belt tension. This will cause low generator output.
- Check any light or indicator lamp filaments that are suspected of being open (burned out). This is done to avoid unnecessary extensive circuit checks.
- If a fuse is blown, locate the cause of the overload condition and repair it. The common procedure is as follows: isolate sections of the circuit, by disconnecting connectors, and measure the resistance to ground to find the circuit that is shorted to ground. Then locate the damaged spot in the wire or connector and repair.
- Excessive battery drain due to lamps left on, damaged or misadjusted switch, accessories left on, etc.

Warning Indicator Check

Check the operation of the charging system warning indicator as follows:

- Ignition OFF = Indicator should be OFF.
- Ignition ON, Engine OFF = Indicator should be ON.
- Ignition ON, Engine ON = Indicator should be OFF.

Symptom Chart

CONDITION	POSSIBLE SOURCE	ACTION
Dead battery. **Battery will not stay charged.** **Slow crank.** **Low battery voltage.** **No generator output.**	• Key-off battery drain. • Open/voltage drop in B+ circuit. • Open voltage drop in A circuit. • Open/high resistance in I circuit. • Voltage regulator. • Generator.	Repair as necessary
Indicator lamp on with engine running.	• Open "A" circuit. • Shorted "I" circuit. • Open/high resistance in "S" circuit. • Voltage regulator. • Generator.	Repair as necessary.
Indicator lamp flickers or intermittent.	• Loose connection to generator, voltage regulator or battery. • Loose fuse or poor connection in "A" circuit. • Loose brush holder screw. • Voltage regulator. • Generator.	Repair as necessary.
Battery over charging (battery voltage greater than 15.5 volts).	• Voltage drop in "A" circuit. • Voltage drop in "I" circuit. • Poor ground. • Voltage regulator. • Generator.	Repair as necessary.
Indicator lamp off, key on, engine not running.	• Open/high resistance in "I" circuit. • Burned out bulb. • Poor ground. • "S" circuit shorted to B+. • Voltage regulator. • Generator.	Repair as necessary.
Generator noisy.	• Accessory drive belt. • Accessory brackets. • Bent generator pulley. • Generator. • Other components.	Repair as necessary.
Indicator lamp on, key off.	• Lamp circuit shorted to B+. • Improper lamp circuit wiring.	Repair as necessary

Battery Drain Test

⚠

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

A defective component or wiring defect may be causing a small current drain that is less than the fuse rating for the circuit so the fuse does not open. Perform the following to determine if an excessive drain is occurring:

NOTE: Batteries should be fully charged for the following test.

⚠

WARNING: DO NOT ATTEMPT THIS TEST ON A LEAD-ACID BATTERY THAT HAS RECENTLY BEEN RECHARGED. EXPLOSIVE GASES MAY CAUSE PERSONAL INJURY. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

CAUTION: To prevent damage to the meter, do not crank engine or operate accessories that draw more than 10A.

1. Allow the engine to sit with the ignition off for at least 40 minutes to allow the GCP to power down.
2. Connect a fused (10A) jumper wire between the negative battery cable and post to prevent the GCP from resetting and to catch capacitive drains.
3. Disconnect the negative battery cable without breaking the connection of the jumper wire.

NOTE: It is very important that continuity between the negative battery cable and post is not broken. If it is, the entire procedure must be repeated so the GCP can power down again.

4. Connect an ammeter between the negative battery cable and post. The meter should have a 10 amp capability.

NOTE: If after this next step, the meter settings need to be switched or the test leads need to be moved to another jack, the jumper wire must be reinstalled to avoid breaking continuity.

5. Remove the jumper wire and note the amperage draw:
   - There should not be any more than 50 mA (0.050 amp) draw.
   - If excessive, remove fuses one at a time until the circuit with the excessive draw is located.
   - Use the wiring diagram to locate any circuits that do not pass through the fuse box.
   - Disconnect the generator connections to check for an internal short causing an excessive draw.

Battery Load Test

⚠

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Disconnect both battery terminal cables. Check the battery visually.
2. Examine the hydrometer eye (if no eye go to next step).
   - Eye shows green - go to step 4.
   - Eye shows dark - recharge, then go to step 4.
   - Eye shows yellow - replace battery.
3. Apply a 300 amp load for 15 seconds. Turn off load and wait one minute.
   - If 12.4 volts or more - go to step 4.
   - If less than 12.4 volts - recharge, then repeat step 3.
4. Apply a test load equal to 50% of the battery CCA rating at - 17.8° C (0°F). After 15 seconds, **with the load still applied**, measure and record terminal voltage ___________. Turn the load OFF.
5. Estimate the battery temperature. If measured voltage does not meet or exceed the value shown in the following table, replace the battery.

Temp. °C	21.1°	10°	-1.1°	-9.4°	-17.8°
Temp. °F	70°	50°	30°	15°	0°
Min. Volts	9.6	9.4	9.1	8.8	8.5

6. Clean all cable ends and terminals of the battery with a wire brush.

Generator Output Test

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

CAUTION: To prevent damage to the generator, do not make jumper wire connections except as directed.

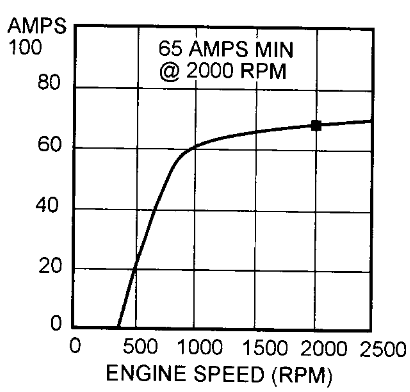
CAUTION: Do not allow any metal object to come in contact with the housing and the internal diode cooling fins with the ignition on or off. A short circuit may result and burn out the diodes.

In order to check the generator, the use of rotunda Starting and charging System Tester 078-00005 (VAT-40) or equivalent, is recommended.

NOTE: Refer to the test equipment user's manual for complete directions on examining the charging system.

NOTE: Turn off all lamps and accessories.

1. Switch the tester to ammeter function.
2. Connect the positive and negative leads of the tester to the battery.
3. Connect current probe to generator B+ terminal to measure generator output.
4. With the engine running at 2000 rpm, adjust the VAT-40 or equivalent load bank to determine the output of the generator. Generator output should be greater than values given in the graph below.



Generator Voltage Test

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Switch the tester to the voltmeter function.
2. Connect the positive lead to the generator A-terminal connector and the negative lead to ground.
3. Turn off all electrical accessories.
4. With the engine running at 2000 rpm, check the generator voltage.
5. Voltage should be between 13.0-15.5 volts.

GENERAL SERVICE PROCEDURES

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

Battery Cleaning and Inspection

Keeping the battery top clean and dry reduces the need for service and extends battery life. Also, make certain the cable clamps are tightly fastened to the battery posts. If corrosion is found, disconnect the cables and clean clamps and posts with a wire brush. Neutralize the corrosion with a solution of baking soda and water. After installing cables, apply a small quantity of Premium Long-Life Grease XG-1-C or -K or equivalent grease meeting Ford specification ESA-M1C75-B to each battery post to help prevent corrosion.

Battery Tools

Anyone working with a battery needs the proper tools. Using the right tools will prevent damage to the battery, battery cables and battery hold down clamp.

Tools and equipment manufactured for servicing batteries have parts insulated to help prevent arcing should the tool be dropped or placed accidentally between a terminal and some other contact surface.

Clamp Puller

Use a clamp puller to remove a cable clamp from the battery terminal. With the jaws gripping the underside of the cable clamp, pull the clamp up by means of pressure exerted against the top of the battery terminal. Proper use of this tool avoids the damaging lateral or twisting forces that result when using a pry bar or pliers.

Battery Clamp Spreader

The spreader is used to expand the cable clamp after it has been removed from the terminal and the clamp bolt has been loosened. The cable clamp can then be easily placed in its correct position completely on the terminal.

Terminal Cleaning Brush

The terminal cleaning brush is designed with units to clean both tapered battery terminal and the mating surface of the cable clamp.

Carrier

WARNING: GRIPPING THE END WALLS ON THE PLASTIC-CASED BATTERY COULD CAUSE ELECTROLYTE TO SPEW FROM SOME OF THE CELLS, RESULTING IN PERSONAL INJURY AND POSSIBLY CAUSE DAMAGE TO SOME OF THE INTERNAL COMPONENTS.

Use a suitable battery carrier for lifting and transporting the battery. The illustration shows a clamp-type carrier used to grip the sidewalls of the container just below the lip of the cover. The carrier is used on the sidewalls, rather than the end walls, since the sidewalls have additional strength from the inner cell partitions. This is particularly important with the plastic-cased battery which has end walls that are flexible.

Battery Charging

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

NOTE: If excessive gassing or electrolyte spewing occurs during the charge, discontinue charging. The battery has reached serviceable charge. If the battery will not accept at least 5A after 20 minutes of charging, replace the battery.

WARNING: WEAR SAFETY GLASSES. BATTERY CHARGING CAN BE DANGEROUS. WHILE BEING CHARGED, THE BATTERY PRODUCES A POTENTIALLY EXPLOSIVE MIXTURE OF HYDROGEN AND OXYGEN GASSES. KEEP SPARKS, FLAMES AND LIGHTED CIGARETTES AWAY FROM BATTERIES. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH LARGE AMOUNTS OF WATER. GET MEDICAL ATTENTION.

Inspect and service any of the following pre-existing conditions before recharging a discharged battery -- Refer to“Preliminary Checks” on page 5 of this section.

Cold batteries will not readily accept a charge. Therefore, batteries should be allowed to warm up to approximately 5°C (41°F) before charging. This may require four to eight hours at room temperature depending on the initial temperature and battery size.

A battery which has been completely discharged may be slow to accept a charge initially, and in some cases may not accept charge at the normal charger setting. When batteries are in this condition, charging can be started by use of the dead battery switch on chargers so equipped.

To determine whether a battery is accepting a charge, follow charger manufacturer’s instructions for use of dead battery switch. If switch is the spring-loaded type, it should be held in the ON position for up to three minutes.

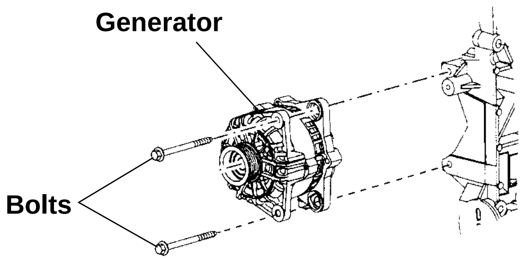
After releasing switch and with charger still on, measure battery voltage. If it shows 12 volts or higher, the battery is accepting a charge and is capable of being recharged. However, it may require up to two hours of charging with batteries colder than 5°C (41°F) before charging rate is high enough to show on the charger ammeter. It has been found that all non-damaged batteries can be charged by this procedure. If a battery cannot be charged by this procedure, it should be replaced.

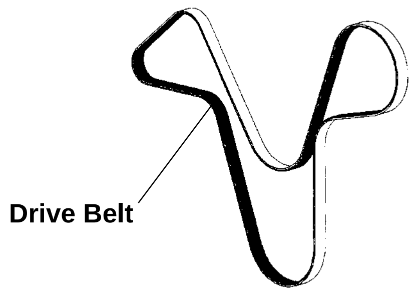
A rapid recharge procedure has been developed for recharging batteries that only need a quick recharge. This can be due to battery in-service no-start battery failures (engine will not crank due to low battery state of charge) or battery discharged due to key-off loads.

The battery can be rapidly recharged by using either of the following methods.

- Perform a two-hour charge using 20A constant current (manual setting on charger).
- Perform a two-hour charge using a constant potential (automatic setting on charger).

REMOVAL AND INSTALLATION



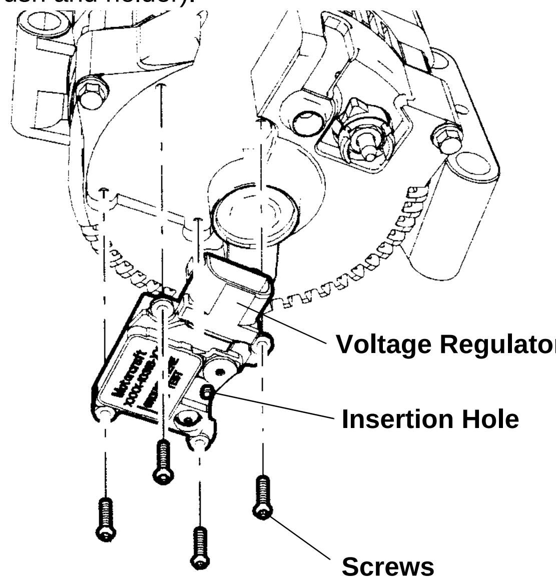


Generator - Replacement

1. Disconnect battery negative cable -- Refer to“Battery Cleaning and Inspection” on page 9 of this section.
2. Remove or disconnect any component to allow access and removal of generator.
3. Remove drive belt -- refer to Section 5.
4. Remove 2 bolts and position the generator aside.
5. Disconnect electrical connector.
6. Remove generator.
7. Reverse procedure to install:
   - Tighten generator bolts to 25 Nm (18 lb-ft).
   - Tighten B+ terminal to 8 Nm (71 lb-in).

Voltage Regulator - Replacement

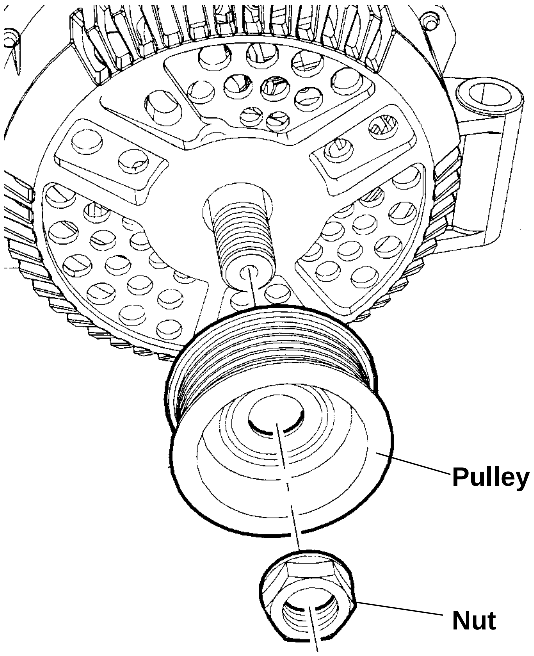
1. Remove the generator -- Refer to“Generator - Replacement” on page 11 of this section.
2. Remove 4 screws and voltage regulator (includes brush and holder).



3. Reverse procedure to install:
   - Insert a wire into the insertion hole to hold the brushes during assembly. Remove wire when done.
   - Tighten screws to 3 Nm (27 lb-in).

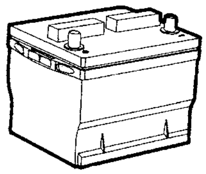
Generator Pulley - Replacement

1. Remove generator assembly -- Refer to“Generator - Replacement” on page 11 of this section.
2. Remove nut.



3. Remove pulley.
4. Reverse procedure to install:
   - Tighten nut to 109 Nm (80 lb-ft).

Battery - Removal



WARNING: WHEN LIFTING PLASTIC CASED BATTERY, EXCESSIVE PRESSURE ON THE END WALLS COULD CAUSE ACID TO SPEW THROUGH THE VENT CAPS, RESULTING IN PERSONAL INJURY, DAMAGE TO THE EQUIPMENT OR BATTERY. LIFT WITH A BATTERY CARRIER OR WITH YOUR HANDS ON OPPOSITE CORNERS.

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES, OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN OR EYES, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES AND GET PROMPT MEDICAL ATTENTION. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

CAUTION: Care should be taken when removing or replacing the cable clamp bolts so that the battery terminal is not subjected to any excessive lateral or twisting forces. Such forces could cause major damage to the internal components of the battery, and leakage at the terminals.

1. Remove battery cables from battery terminals (battery ground cable first).
2. Remove battery hold down components.

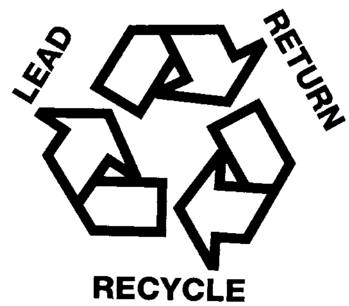
CAUTION: When lifting a plastic-cased battery, excessive pressure on the end walls could cause acid to spew through the vent caps, resulting in personal injury, damage to the equipment or battery. Lift with a battery carrier or with your hands on opposite corners.

3. Remove battery from equipment.

Battery - Installation

1. Clean cable terminals and battery hold down clamp with a wire brush. Replace all cables or parts that are worn or frayed.
2. Clean battery tray with a wire brush and scraper.
3. Place battery in battery tray with positive and negative cables in same position as when removed.
4. Assemble and tighten battery hold down clamp so battery is secure. Do not tighten excessively.
5. Secure cables to proper terminals. Tighten to 6 Nm (53 lb-in). Apply petroleum jelly to terminals.

Ford Motor Company strongly recommends that lead-acid batteries be returned to an authorized recycling facility for disposal.



SPECIFICATIONS

GENERAL SPECIFICATIONS	
Generator output	65/110 max. amps @ 1800 - 6000 generator rpm (approx. 500 - 2000 engine rpm).
Battery	Motorcraft 12 Volt 540 CCA (at -18°C (0°F) 58 amp/hr.
Battery Charging Voltage	13 - 15.5 volts

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
Generator mounting bolts	25	18	
Regulator attachment screws	3		27
Battery cable nuts	6		53
Generator pulley nut	109	80	
Generator wiring nuts	8		71

SPECIAL TOOLS	
VAT-40 Starting/charging Tester	078-00005

INDEX

Subject **Page**

CAUTIONS & WARNINGS

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS “ELECTRICALLY HOT” AT ALL TIMES. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

WARNING: WHEN WORKING IN THE AREA OF THE STARTER MOTOR, BE CAREFUL TO AVOID TOUCHING HOT EXHAUST COMPONENTS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

CAUTION: A protective cap or boot is provided over the battery input terminal and must be reinstalled after removal.

CAUTION: Be sure to disconnect the battery ground cable before repairing the starter motor.

WARNING: HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

WARNING: TO AVOID INJURY, USE PARTICULAR CARE WHEN CONNECTING A BOOSTER BATTERY TO A DISCHARGED BATTERY.

GENERAL INFORMATION

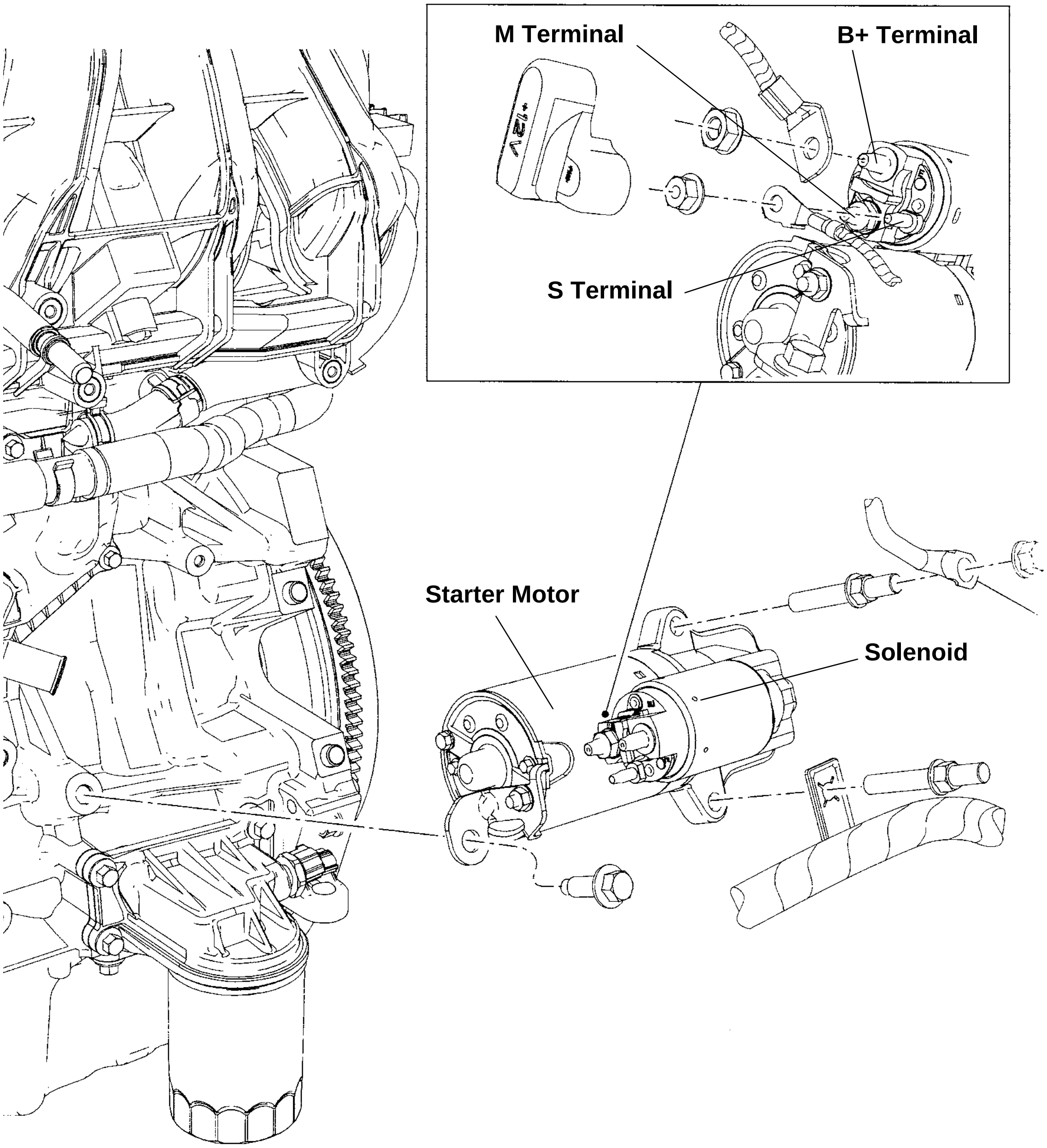
Description

The starter motor provides the rotation of the engine crankshaft, through the flywheel, that is needed to start the engine.

The starter system consists of:

- starter motor
- starter solenoid
- starter relay
- battery.

The starter motor is a permanent magnet, gear reduction type. It runs on 12 volts DC current. The starter solenoid is integral to the motor and a relay is also used. Refer to section 6 for information on the battery.



Operation

When the ignition is turned to the start position, the starter relay switches power to the starter solenoid, causing the starter motor to engage (transmission must be in PARK or NEUTRAL).

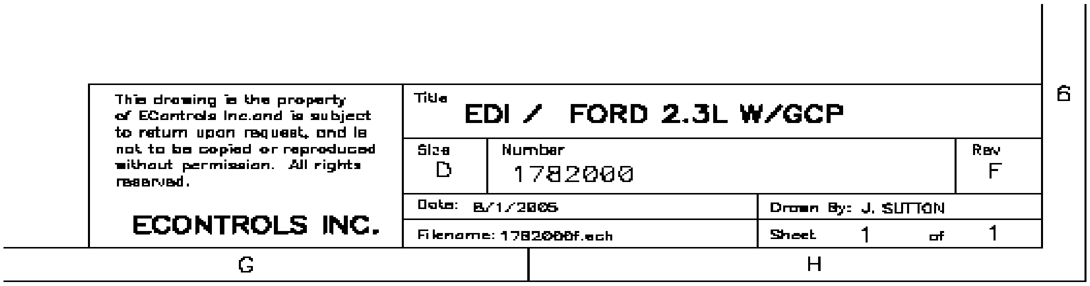
Battery power is always present at the starter motor B+ terminal. The starter motor relay, when energized, sends current to the starter motor “S” terminal, which causes the motor’s shaft to rotate. When the starter switch is released, a spring returns the solenoid to the released position.

(??Is there any info on a starter lockout circuit??)

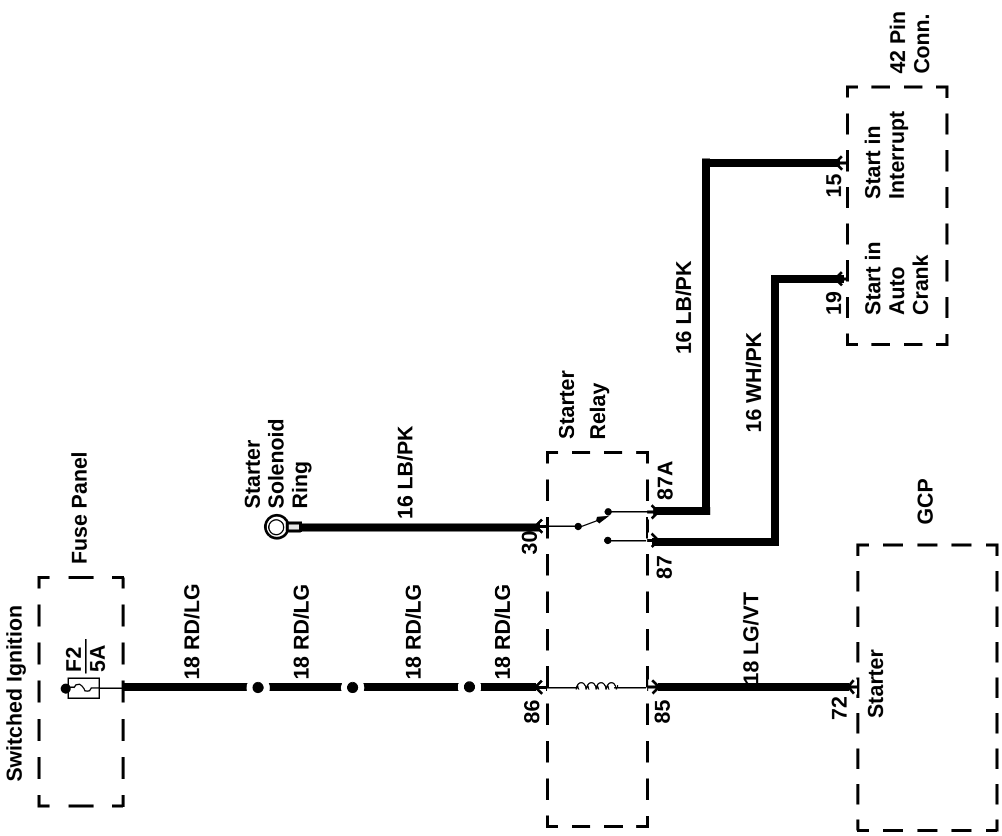
Wiring Diagram

Revision Level

The following wiring schematics are taken from the wiring diagram labeled below:



Starting System



DIAGNOSIS AND TESTING

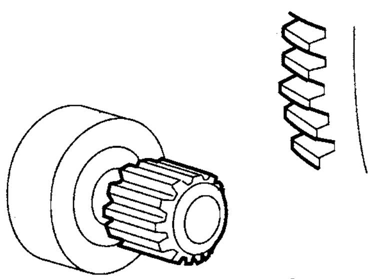
WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

NOTE: When testing with a meter, always make connections with the component terminal rather than at the wiring end connector. Making connection with the wiring end connector can result in a false reading, because the meter will not pick up any high resistance between the wiring connector and the component.

Visual Inspection

CAUTION: Be sure to disconnect battery negative cable before servicing starter.

- Verify the concern by operating the starting system to duplicate the conditions.
- Inspect starting system for loose connections.
- Check the wear patterns on the starter drive and the flywheel ring gear. If the starter drive gear and the flywheel ring gear are not fully meshing or the gears are milled or damaged, replace the starter motor and if necessary, replace flywheel ring gear.



If the inspection reveals an obvious concern that can be readily identified, repair as necessary.

If the concern remains after the inspection, note condition and continue diagnosis using the symptom chart.

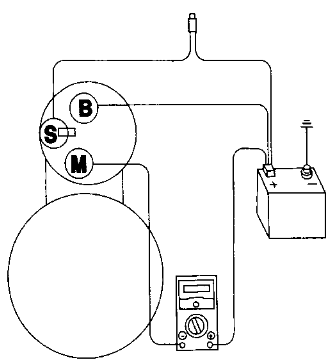
Symptom Chart

CONDITION	POSSIBLE SOURCE	ACTION
Starter does not crank (audible click may or may not be heard)	Open fuse	Check fuse continuity
	Low battery	Refer to battery diagnosis in section 6
	Defective remote relay	Check relay
	Open circuit or high resistance in external feed circuit to starter solenoid	Check starter wiring
	Defective starter	Replace starter motor
	Defective neutral park switch	Replace switch
Unusual starter noise	Starter not mounted flush (cocked)	Realign starter on transmission bell housing or SAE housing
	Noise from other components	Investigate other powertrain accessory noise contributors
	Ring gear tooth damage or excessive ring gear runout	Replace flywheel ring gear
	Defective starter	Replace starter motor
Starter spins but the engine does not crank	Starter not mounted flush (cocked)	Realign starter on transmission bell housing or SAE housing
	Ring gear tooth damage	Replace flywheel ring gear
Starter cranks but engine does not start	Problem in fuel system	Refer to fuel system section 4
	Engine related problem	Refer to Section 01, Diagnosis and Testing
Starter cranks slowly	Low Battery	Charge or replace battery -- refer to section 6
	High resistance or loose connections in starter solenoid battery feed or ground circuit.	Check that all connections are secure
	Ring gear runout excessive	Replace ring gear
	Defective starter	Replace starter motor
Starter remains engaged and runs with engine	Shorted ignition switch	Replace ignition switch
	Battery cable touching solenoid “S” terminal (defective or mispositioned cable)	Replace or relocate cable
	Defective starter	Replace starter motor
Starter clicks and engages but engine will not crank	Hydrolocked cylinder	Remove all plugs one at a time while checking for fluid in cylinders
	Seized main or rod bearing	Repair as needed - Refer to Section 01

Motor Feed Circuit - Voltage Drop Test

Slow cranking is often caused by high resistance in the battery cables or connections, especially in cold weather. After all batteries check good and terminals are clean and tight, check the starter motor feed circuit:

1. Connect a remote starter switch between the starter "S" terminal and the battery positive (+) terminal.
2. Connect a digital multimeter positive lead to the battery positive (+) post. Connect negative lead to the starter solenoid "M" terminal.

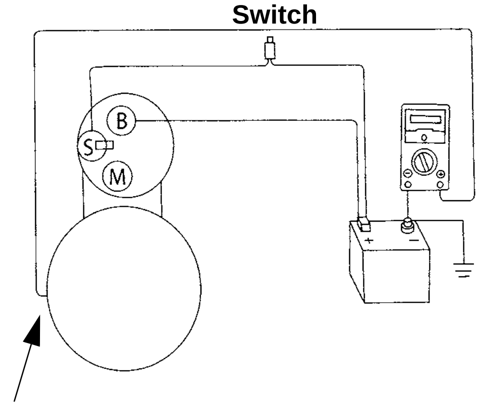


3. Engage the remote starter switch. Read and record the voltage. The voltage reading should be 0.5 volt or less.
   - If 0.5 volt or less -- refer to starter motor ground circuit test.
   - If greater than 0.5 volt, indicating excessive resistance, move the negative lead to the "B" terminal as shown and repeat the test. If voltage reading at the "B" terminal is lower that 0.5 volt, the concern is either in the connections at the starter solenoid or in the solenoid contacts. By moving the lead toward the battery and checking each mechanical connection point, the excessive voltage drop can be located. When the high reading disappears, the last mechanical point that was checked is the concern. Clean or repair as necessary.

Starter Motor - Ground Circuit Check

A slow cranking condition can be caused by resistance in the ground or return portion of the cranking circuit. Check the voltage drop in the ground circuit as follows:

1. Connect a remote starter switch between the starter solenoid "S" termingal and the battery positive (+) post.



2. Connect a digital multimeter positive (+) lead to the starter motor housing (the connection must be clean and free of rust or grease).
3. Connect the negative (-) lead of the voltmeter to the negative (-) battery terminal.
4. Engage the remote starter switch and crank the engine. Read and record the voltage reading.
   - A reading of 0.2 volt or less indicates a good ground connection.
   - If reading is more than 0.2 volts, clean all ground connections and retest. If still too high replace battery negative cable.

NOTE: If the voltage reading is less than 0.2 volt and the engine still cranks slowly, install a new starter motor.

GENERAL SERVICE PROCEDURES

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

Jump Starting

For cases of a starter that cranks the engine very slowly, connect a 12 volt booster battery to the system. To avoid damage to the equipment and battery or the possibility of personal injury, follow these instructions and precautions:

WARNING: HYDROGEN AND OXYGEN GASES ARE PRODUCED DURING NORMAL BATTERY OPERATION. THIS GAS MIXTURE CAN EXPLODE IF FLAMES, SPARKS OR LIGHTED TOBACCO ARE BROUGHT NEAR THE BATTERY. WHEN CHARGING OR USING A BATTERY IN AN ENCLOSED SPACE, ALWAYS PROVIDE VENTILATION AND SHIELD YOUR EYES.

WARNING: KEEP OUT OF REACH OF CHILDREN. BATTERIES CONTAIN SULFURIC ACID. AVOID CONTACT WITH SKIN, EYES OR CLOTHING. ALSO, SHIELD YOUR EYES WHEN WORKING NEAR THE BATTERY TO PROTECT AGAINST POSSIBLE SPLASHING OF THE ACID SOLUTION. IN CASE OF ACID CONTACT WITH SKIN, EYES OR CLOTHING, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF 15 MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.

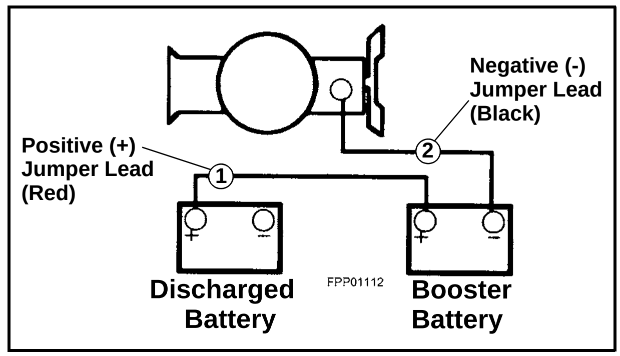
CAUTION: Do not disconnect the battery of the engine to be started. Disconnecting the battery could damage the equipment's electronic system.

WARNING: MAKING THE FINAL CABLE CONNECTION COULD CAUSE AN ELECTRICAL SPARK NEAR THE BATTERY AND COULD CAUSE AN EXPLOSION. REFER TO WARNING AT THE BEGINNING OF THE JUMP STARTING PROCEDURE.

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER UNDERHOOD WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.

WARNING: TO AVOID INJURY, USE PARTICULAR CARE WHEN CONNECTING A BOOSTER BATTERY TO A DISCHARGED BATTERY.

1. Position equipment so jumper cables will reach, being careful that equipment does not touch each other.



NOTE: Be sure to disconnect battery negative cable before servicing starter.

2. Connect one end of positive red jumper cable (+) 1 to positive terminal of discharged battery and other end to positive terminal of booster battery.
3. Connect one end of negative black jumper cable (-) 3 to negative terminal of booster battery. Connect other end to an engine bolthead or good metallic contact spot on engine of equipment to be started. NOT TO NEGATIVE (-) BATTERY TERMINAL.
4. Make sure jumper cables are not in way of moving engine parts.
5. Start engine with good battery. Run engine at a moderate speed.
6. Start engine with discharged battery. Follow starting instructions in the Operator handbook.
7. Completely discharged batteries may require an electrical load to initialize charging.
8. Remove cables in exact REVERSE sequence. Begin by removing negative cable from engine that had discharged battery.

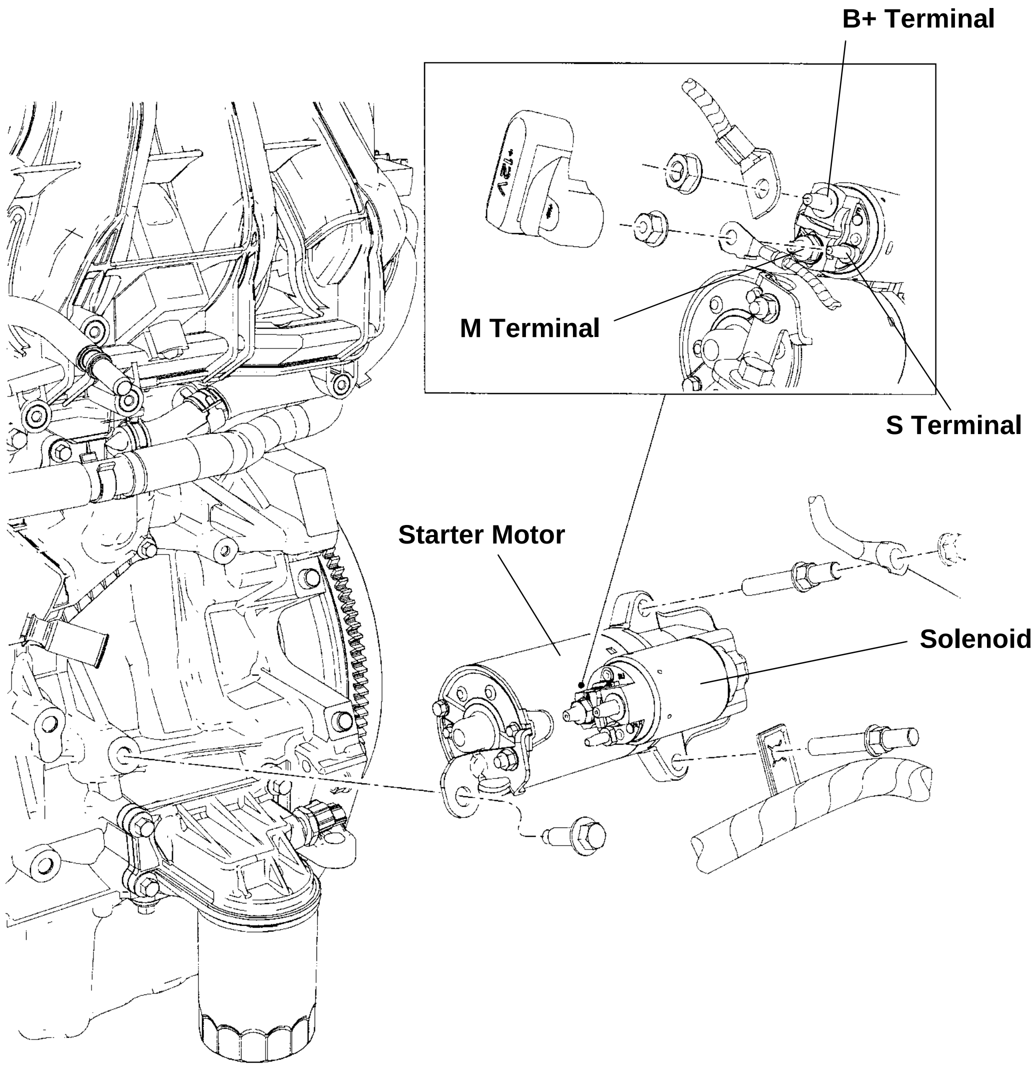
If the starter does not turn the engine over, even with the booster battery attached, refer to Diagnosis.

REMOVAL AND INSTALLATION

WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

Starter Motor - Replacement

WARNING: WHEN SERVICING STARTER OR PERFORMING OTHER WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.



WARNING: REFER TO CAUTIONS & WARNINGS AT THE BEGINNING OF THIS SECTION.

1. Disconnect negative battery cable.
2. Remove any component to allow access and removal of the starter motor.
3. Remove terminal cover and nuts.
4. Remove starter mount bolts.
5. Reverse procedure to install:
    - Tighten "B" and "M" nuts to 12 Nm (9 lb-ft)
    - Tighten "S" nut to 5 Nm (44 lb-in)
    - Tighten mount bolts to 25 Nm (18 lb-ft).

SPECIFICATIONS

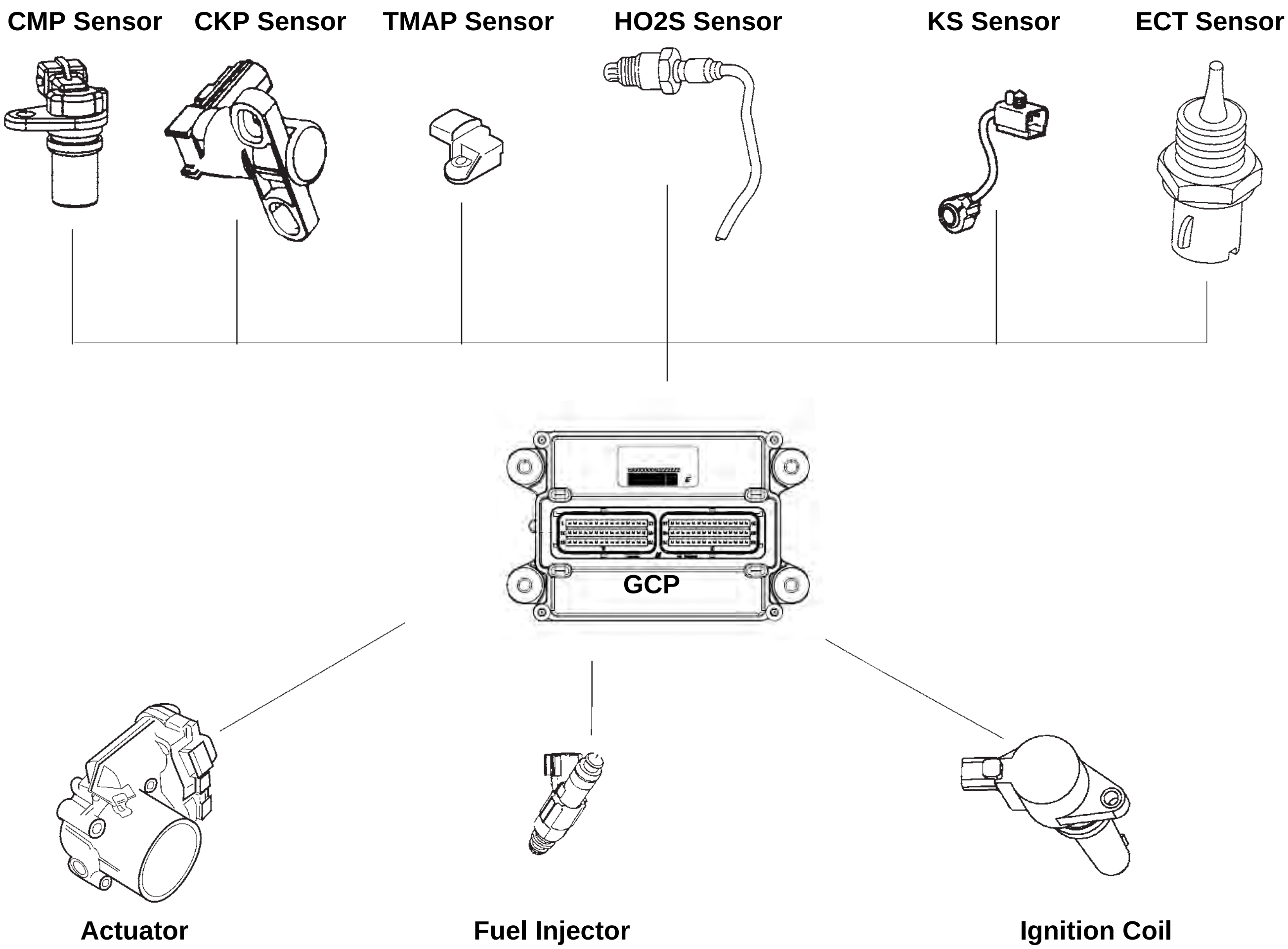
GENERAL SPECIFICATIONS	
Current draw NO load	60 - 80 AMPS
Current draw NORMAL load	
Current draw MAX. load	800 AMPS
Minumum stall torque (@5 volts)	14.7 Nm (16 lb-ft)
Cranking speed	140 - 220 RPM
Max. voltage drop (normal operating temp.)	

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
Mounting bolts/nuts/studs	27	20	
Battery cable nuts	6		53
Solenoid terminal nut	5		44
Solenoid terminal B+ nut	12	9	

SPECIAL TOOLS	
VAT-40 Starting/charging Tester	078-00005

GENERAL INFORMATION

GCP and Sensors



Engine Control Module (GCP)

The Engine Control Module (GCP) has the following features:

- Programmable four speed electronic governing, throttle-by-wire or variable speed control governing.
- Programmable emergency warning/shut-down feature for high water temperature, low oil pressure, etc.
- Starter lockout.
- Auto crank
- Programmable overspeed protection.
- Automatic altitude compensation.
- Sequential port fuel injection (gasoline) with pressure regulator to precisely control fuel delivery.
- Dry fuel lockout controlled by the GCP produces a reliable transition when switching fuels.
- Certified closed loop dry fuel control.
- Configurable inputs available based on customer requirements.
- Configurable outputs available based on ECT, RPM or MAP signals and customer requirements.
- Diagnostic software allows viewing of historical and active faults with on-demand diagnostics to assist technicians and reduce equipment downtime.

The Engine Control Module (GCP) engine control system is a complete engine control system for Ford industrial engines running on gasoline, propane or natural gas. Each module can be set up to run an engine on any two of the three fuels in certified closed-loop control, with virtually transparent on-the-fly fuel switching.

Each module can also be set up to run on a variety of electronic governing:

- It can be programmed to provide up to four specific speeds with use of a matching toggle switch.
- It can be programmed to provide an infinite variety of

speeds (with customer-specified minimum and maximum) based on a variable signal input.

- It can be an electronic replacement for a throttle cable with maximum speed governing (throttle-by-wire).
- Or it can switch between throttle-by-wire and a second fixed or variable input based on a neutral/parking brake signal.

With the GCP system, a laptop and a communications cable, diagnosis becomes simpler. The technician can either view engine data with a real time graphing program, or store that data into a numeric data file.

Every time a fault is set, the laptop will give you detailed information about the fault, including:

- when it happened
- if the fault still exists
- a list of essential engine data from the time of the fault.

It can also display a 10 second graph of critical engine data, from 8 seconds before the fault occurred to two seconds after. And if you only want to view engine parameters and fault codes, all you need is a Personal Digital Assistant (PDA) and our easy to load software and a communications cable.

With many OEMs using control modules to control their machinery, the GCP has the ability to communicate engine data to and receive commands from other control modules through a Controller Area Network (CAN) link, with messages written in the J1939 protocol. This allows large amounts of data to move throughout the machine through only two wires, and can be used to run some module based gauge packages.

The GCP also carries auxiliary features that can be programmed to control OEM devices, allowing the OEM to eliminate components from their machinery.

The GCP is also equipped with multiple safety and protection devices that protect the user and engine from hazards such as:

- over speed
- over temperature
- over voltage
- low oil pressure
- unauthorized tampering
- over cranking starter motor.

The GCP controls the following:

- Fuel metering system
- Ignition timing
- On-board diagnostics for engine functions

The GCP constantly observes the information from various sensors. The GCP controls the systems that affect engine performance. The GCP performs the diagnostic function of the system. It can recognize operational problems, alert the operator through the Malfunction Indicator Lamp (MIL), and store diagnostic trouble codes (DTC's). DTC's identify the problem areas to aid the technician in making repairs.

The GCP supplies either 5 or 12 volts to power various sensors or switches. The power is supplied through resistances in the GCP which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 meg-ohms input impedance is required to ensure accurate voltage readings. The GCP controls output circuits such as the fuel injectors, electronic governor, etc., by controlling the ground or the power feed circuit through transistors or other solid state devices.

The GCP is designed to maintain exhaust emission levels to government mandated standards while providing excellent operation and fuel efficiency. The GCP monitors numerous engine functions via electronic sensors such as the throttle position (TP) sensor and the heated oxygen sensor (HO2S).

GCP Inputs (operating conditions read)

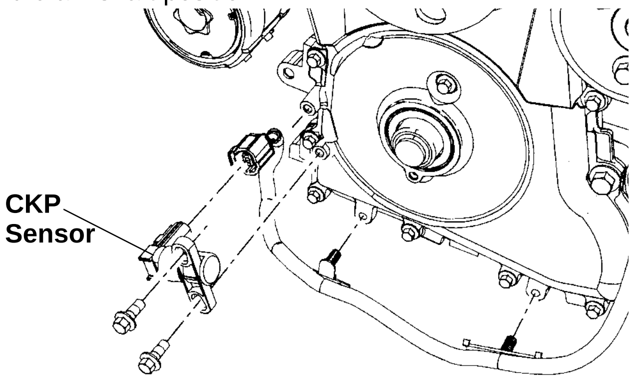
- Engine Coolant Temperature
- Crankshaft Position
- Exhaust Oxygen Content
- Manifold Absolute Pressure
- Battery Voltage
- Throttle Position / Electronic Actuator
- Fuel Pump Voltage
- Intake Air Temperature
- Camshaft Position

GCP Outputs (systems controlled)

- Fuel control
- Electronic Throttle Control
- Electric Fuel Pump
- Diagnostics - Malfunction Indicator Lamp (check engine lamp)
- Diagnostics - Data Link Connector (DLC)

Crankshaft Position (CKP) Sensor

The Crankshaft Position (CKP) Sensor provides a signal used by the Engine Control Module (GCP) to calculate the ignition sequence. The sensor initiates the reference pulses which the GCP uses to calculate RPM and crankshaft position.

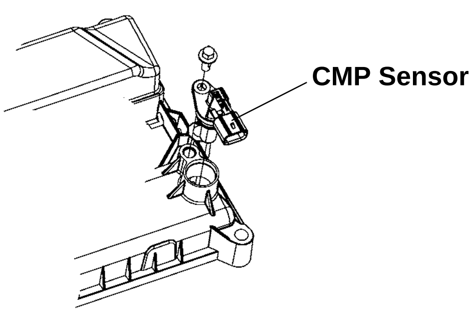


Camshaft Position (CMP) Sensor

The Camshaft Position (CMP) Sensor uses a variable reluctor sensor to detect camshaft position. The CMP signal is created as piston #1 is a pre-determined number of degrees after top dead center on the power stroke.

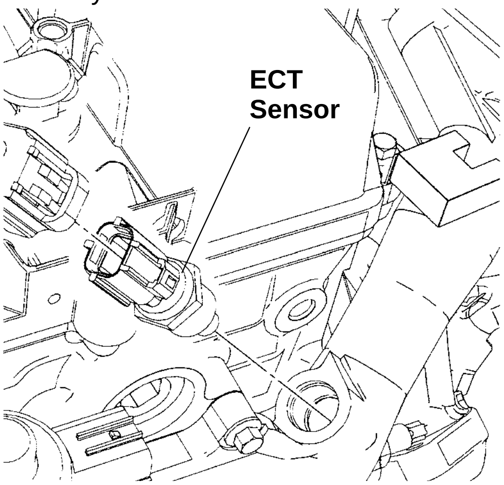
The Camshaft Position (CMP) Sensor sends a CMP signal to the GCP. The GCP uses this signal as a “sync pulse” to trigger the injectors in the proper sequence. The GCP uses the CMP signal to indicate the position of the #1 piston during its power stroke. The CMP uses a Hall Effect sensor to measure piston position. This allows the GCP to calculate true sequential fuel injection (SFI) mode of operation. If the GCP detects an incorrect CMP signal while the engine is running, DTC 245 will set.

If the CMP signal is lost while the engine is running, the fuel injection system will shift to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine will continue to run. As long as the fault (DTC 244) is present, the engine can be restarted. It will run in the previously established injection sequence.



Engine Coolant Temperature (ECT) Sensor

The Engine Coolant Temperature (ECT) Sensor is a thermistor (a resistor which changes value based on temperature) mounted in the engine coolant stream. Low coolant temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The GCP supplies a 5 volt signal to the ECT sensor through resistors in the GCP and measures the voltage. The signal voltage will be high when the engine is cold and low when the engine is hot. By measuring the voltage, the GCP calculates the engine coolant temperature. Engine coolant temperature affects most of the systems that the GCP controls.

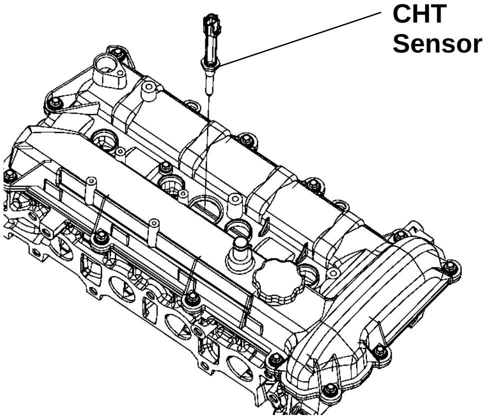


After engine start-up, the temperature should rise steadily to about 85°C (185°F). It then stabilizes when the thermostat opens. If the engine has not been run for several hours (overnight), the engine coolant temperature and intake air temperature displays should be close to each other. A fault in the engine coolant sensor circuit will set a DTC 221 or DTC 222.

TEMP. C°	TEMP. F°	NOM Rt, (OHMS)	NOM E_{OUT} (VOLTS)
-40	-40	925,021	4.54
-35	-31	673,787	4.50
-30	-22	496,051	4.46
-25	-13	368,896	4.41
-20	-4	276,959	4.34
-15	5	209,816	4.25
-10	14	160,313	4.15
-5	23	123,485	4.02
0	32	95,851	3.88
5	41	74,914	3.71
10	50	58,987	3.52
15	59	46,774	3.32
20	68	37,340	3.09
25	77	30,000	2.86
30	86	24,253	2.62
35	95	19,716	2.39
40	104	16,113	2.15
45	113	13,236	1.93
50	122	10,926	1.72
55	131	9,061	1.52
60	140	7,548	1.34
65	149	6,332	1.18
70	158	5,335	1.04
75	167	4,515	.91
80	176	3,837	.79
85	185	3,274	.70
90	194	2,804	.61
95	203	2,411	.53
100	212	2,080	.47
105	221	1,801	.41
110	230	1,564	.36
115	239	1,363	.32
120	248	1,191	.28
125	257	1,044	.25
130	266	918	.22
135	275	809	.19
140	284	715	.17
145	293	633	.15
150	302	563	.14
Voltage values calculated for VREF = 5 volts (may vary ± 15% due to sensor and VREF variations)			

Cylinder Head Temperature (CHT) Sensor

The Cylinder Head Temperature (CHT) Sensor is a thermistor which changes its resistance based on the temperature of cylinder head. Low temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The GCP supplies a 5 volt signal to the sensor through a resistor in the GCP and monitors the signal voltage. The signal voltage will be high when the cylinder head is cold and low when the cylinder head is hot. By measuring the voltage, the GCP calculates the cylinder head temperature. The CHT sensor signal is used to adjust spark timing according to the incoming air density.



Heated Oxygen Sensor (HO2S)

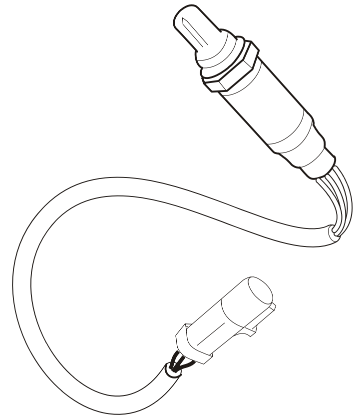
The Heated Oxygen Sensor (HO2S) is mounted in the exhaust stream where it can monitor the oxygen content of the exhaust gas. The oxygen present in the exhaust gas reacts with the sensor to produce a voltage output. This voltage should constantly fluctuate from approximately 100mV to 900 mV, when the engine is running in closed loop fuel control.

The Heated Oxygen Sensor (HO2S) voltage can be monitored on an IBM PC compatible computer with diagnostic software. By monitoring the voltage output of the oxygen sensor, the GCP calculates the pulse width command for the injectors to produce the proper combustion chamber mixture.

The 4-wire HO2S indicates whether the air/fuel ratio is rich or lean with respect to stoichiometry. The signal from this sensor contains valid air/fuel ratio information only when the sensor element has reached its normal operating temperature. The 4-wire HO2S also has an isolated case ground which goes to Signal Return (SIGRTN) either in the processor (as a dedicated HO2S ground) or as a jumper to SIGRTN in the wiring harness.

Low HO2S voltage indicates a lean mixture which will result in a rich command to compensate.

High HO2S voltage indicates a rich mixture which will result in a lean command to compensate.



Specifications

- Accuracy of measurement: ±1.5%
- Operating Temp. Range: 350°C to 850°C (sensor tip)
- Sensor Response Time: 300-1500 msec.
- Heater Current Draw: 1 A steady state
- Voltage Output:
  0 - 450 mV (lean exhaust gas)
  450 - 1000 mV (rich exhaust gas)

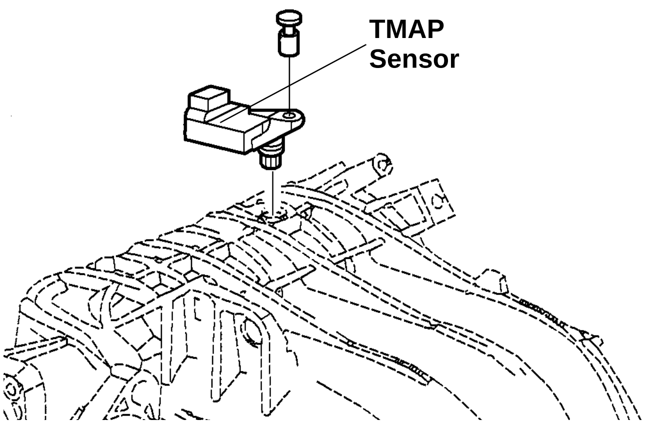
Temperature Manifold Absolute Pressure (TMAP) Sensor

The Temperature Manifold Absolute Pressure (TMAP) Sensor responds to changes in intake manifold pressure (vacuum). The TMAP sensor signal voltage to the GCP varies from below 2 volts at idle (high vacuum) to above 4 volts with the ignition ON, engine not running or at wide-open throttle (low vacuum).

The TMAP sensor consists of a pressure sensing element (capacitor) and signal conditioning electronics. The capacitor has a vacuum/pressure reference which results in one surface (diaphragm) of the capacitor being partially deflected. Further changes in pressure produce corresponding changes in the deflection of the diaphragm and therefore a change in capacitance. This capacitance change is converted to a frequency by the conditioning electronics.

The TMAP sensor is used to determine the following:

- Engine vacuum level for engine control purposes.
- Barometric pressure (BARO).



Specifications:

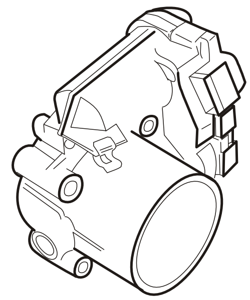
- Range of Measurement: 1.7 - 15.2 psi.
- Measurement Accuracy: ± 0.2 psi
- Sensor Response Time: 3-15 msec.
- Resolution: 0.02 psi

Present design: Silicon Capacitive Absolute Pressure (SCAP) sensor with a maximum operating temperature of 100°C. The output is a 50% duty cycle wave form whose frequency is proportional to the pressure input.

Throttle Position (TP) Sensor / Electronic Actuator

The Throttle Position (TP) Sensor is a dual track rotary potentiometer that uses a variable resistive element which is packaged inside a plastic housing. The resistive element varies linearly and is directly proportional to the throttle plate angle. The GCP applies reference voltage and ground to the sensor and monitors the sensor's ratio metric output voltage to determine precise throttle position. The electronic actuator has two TP outputs that the GCP monitors.

The Electronic Actuator consists of a throttle body, an electronically-actuated throttle plate, and a built-in throttle position (TP) Sensor.



The Electronic Actuator also acts as an idle air control (IAC) valve. Changes in engine load are detected by the GCP by comparing manifold absolute pressure (TMAP) with throttle position. When the GCP detects a change in engine load, it can adjust idle speed by changing the PWM signal to the actuator.

As the throttle valve opens, the output increases so that at wide open throttle (WOT), the output voltage should be above 4 volts.

The GCP calculates fuel delivery based on throttle valve angle (operator demand). A hard failure in the TP sensor 5 volt reference or signal circuits for greater than 2 consecutive seconds will set a DTC 531 or DTC 533. A hard failure with the TP sensor ground circuit for more than two consecutive seconds may set DTC 532. If any (TP) DTC is set the GCP will shut down the engine immediately.

Specifications:

- Range of Measurement: 0-85° (angular)
- Measurement Accuracy: ±2% of VREF
- Resolution: 0.5° max.

Fuel System Components - Gasoline

The fuel metering system is made up of the following parts:

- The fuel injectors
- The fuel rail
- The fuel filter
- The GCP
- The Crankshaft Position (CKP) Sensor
- The Camshaft Position (CMP) Sensor
- The fuel pump
- The fuel pump relay
- Heated Oxygen (HO2S) Sensor
- Temp/Manifold Absolute Pressure (TMAP) Sensor

The basic function of the air/fuel metering system is to control the air/fuel delivery to the engine. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each intake valve.

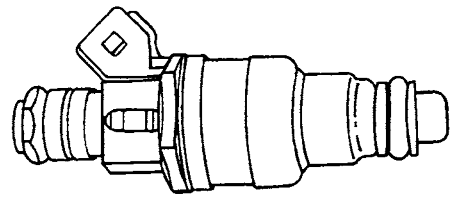
The fuel metering system starts with the fuel in the fuel tank. The fuel is drawn up to the fuel pump through a pre-filter. The electric fuel pump then delivers the fuel to the fuel rail through an in-line fuel filter. The pump is designed to provide fuel at a pressure above the pressure needed by the injectors. A fuel pressure regulator in the fuel filter assembly keeps fuel available to the fuel injectors at a constant pressure. ?A return line delivers unused fuel back to the tank?.

The main control sensor is the heated oxygen sensor (HO2S) located in the exhaust system. The HO2S tells the GCP how much oxygen is in the exhaust gas. The GCP changes the air/fuel ratio to the engine by controlling the amount of time that the fuel injector is "ON". The best mixture to minimize exhaust emissions is 14.7 parts of air to 1 part of gasoline by weight, which provides the most efficient combustion. Because of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a "closed loop" system.

The GCP monitors signals from several sensors in order to determine the fuel needs of the engine. Fuel is delivered under one of several conditions called "modes". All modes are controlled by the GCP. Refer to "Open Loop and Closed Loop Operation" for more information.

Fuel Injector

The Electronic Fuel Injection (EFI) fuel injector is a solenoid operated device controlled by the GCP. The GCP energizes the solenoid, which opens a valve to allow fuel delivery.

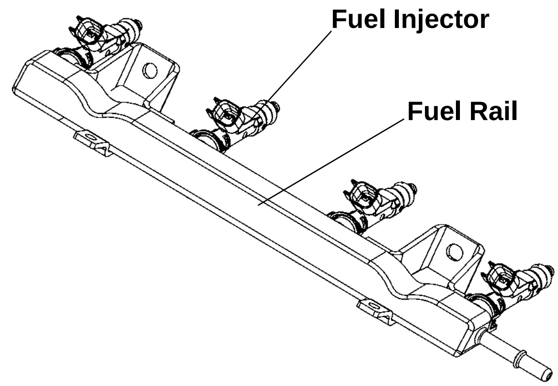


The fuel is injected under pressure in a conical spray pattern at the opening of the intake valve. Excess fuel not used by the injectors passes through the fuel pressure regulator before being returned to the fuel tank.

A fuel injector which is stuck partly open will cause a loss of fuel pressure after the engine is shut down, causing long crank times.

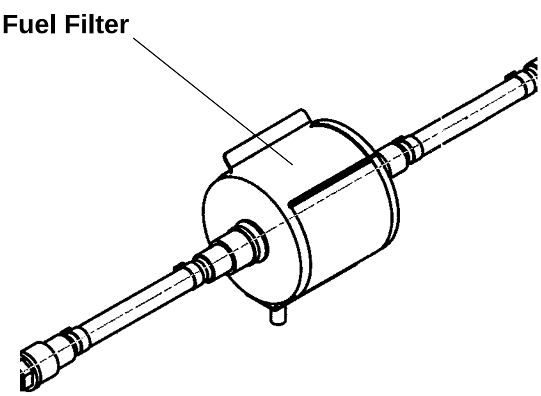
Fuel Rail

The fuel rail is mounted to the top of the engine and distributes fuel to the individual injectors. Fuel is delivered to the fuel inlet tube of the fuel rail by the fuel lines.



Fuel Filter

The fuel filter is an inline filter assembly. Refer to Section 4 for information on relieving fuel pressure, disconnecting fuel lines and fuel filter replacement.



Fuel Pump Electrical Circuit

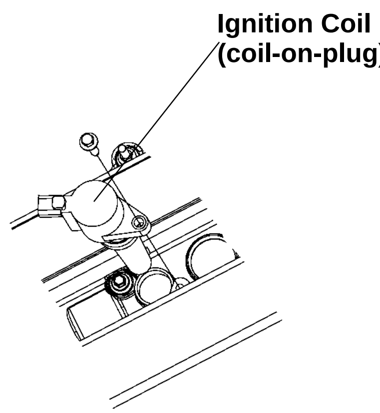
When the key is first turned “ON”, the GCP energizes the fuel pump relay for two seconds to build up the fuel pressure quickly. If the engine is not started within two seconds, the GCP shuts the fuel pump off and waits until the engine is cranked. When the engine is cranked and crankshaft position signal has been detected by the GCP, the GCP supplies 12 volts to the fuel pump relay to energize the electric fuel pump.

An inoperative fuel pump will cause a “no-start” condition. A fuel pump which does not provide enough pressure will result in poor performance.

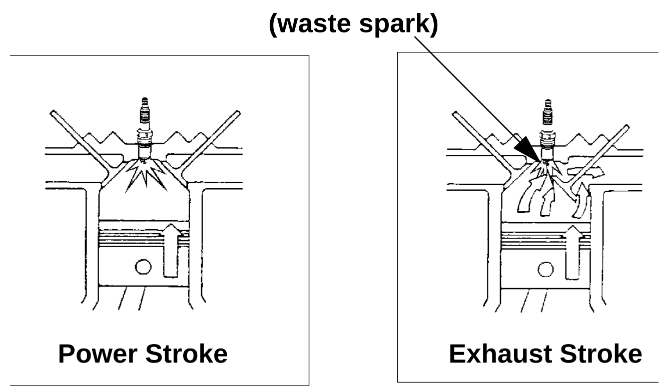
Coil-on-plug Ignition

The coil-on-plug ignition system controls fuel combustion by providing a spark to ignite the compressed air/fuel mixture at the correct time. To provide optimum engine performance, fuel economy, and control of exhaust emissions, the GCP controls the spark advance of the ignition system. Coil-on-plug ignition has the following advantages over a mechanical distributor system:

- No moving parts
- Less maintenance
- Remote mounting capability
- No mechanical load on the engine
- More coil cooldown time between firing events
- Elimination of mechanical timing adjustments
- Increased available ignition coil saturation time
- Elimination of high tension wires



The coil-on-plug design has individual coils mounted directly over each spark plug. Each cylinder is paired with its opposing cylinder in the firing order, so that one cylinder on compression fires simultaneously with the opposing cylinder on exhaust. The spark that occurs in the cylinder on the exhaust stroke is referred to as a “waste spark”.



The primary coils in the coil pack are triggered by the “ignition coil feed#1” and ignition coil feed #2” signals from the GCP.

Open Loop and Closed Loop Operation

NOTE: No DTC will be set unless engine has operated in closed loop status for more than 6 seconds.

The GCP will operate in the following two modes:

- Open loop
- Closed loop

When the engine is first started, the system is in “open loop” operation. In open loop, the GCP ignores the signal from the Heated Oxygen Sensor (HO2S). It uses a pre-programmed routine to calculate the air/fuel ratio based on inputs from the TP, ECT, TMAP & CKP sensors.

The system remains in open loop until the following conditions are met:

- The ECT has reached 95°F (35°C).
- 15 seconds has elapsed since starting the engine.

After these conditions are met, the engine is said to be operating in “closed loop”. In closed loop, the GCP continuously adjusts the air/fuel ratio by responding to signals from the HO2S (except at wide-open throttle). When the HO2S reports a lean condition (low sensor signal voltage), the GCP responds by increasing the “on” time of the fuel injectors, thus enriching the mixture. When the HO2S reports a rich condition (high sensor signal voltage), the GCP responds by reducing the “on” time of the fuel injectors, thus leaning out the mixture.

Adaptive Learn

Adaptive Learn is a fuel correction coefficient that is derived from the closed loop correction and is stored in the GCP’s memory.

The normal purpose of the Adaptive Learn is to compensate fuel flow for the following:

- Fuel composition variance
- Engine wear
- Component variation
- Component degradation

The GCP system will operate in closed loop plus adaptive learn when the ECT reaches 165°F.

NOTE: The adaptive learn coefficient will get erased if battery power falls below 9.5 volts.

GCP Service Precautions

The GCP is designed to withstand normal current draws associated with engine operation. When servicing the GCP, observe the following guidelines:

- Do not overload any circuit.
- When testing for opens and shorts, do not ground or apply voltage to any of the GCP’s circuits unless instructed to do so.
- When measuring voltages, use only a digital voltmeter with an input impedance of at least 10 megohms.
- Do not employ any non-standard practices such as charging the battery with an arc welder.
- Take proper precautions to avoid static damage to the GCP. Refer to “electrostatic Discharge Damage” for more information.

Use of Circuit Testing Tools

Do not use a test light to diagnose the engine electrical systems unless specifically instructed by the diagnostic procedures. A test light can put an excessive load on a GCP circuit and result in component damage. For voltage measurements, use only a digital voltmeter with an input impedance of at least 10 megohms.

Electrostatic Discharge Damage

Electronic components used in the GCP are often designed to carry very low voltage. Electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to some electronic components. By comparison, it takes as much as 4000 volts for a person to feel the spark of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction.

An example of charging by friction is a person sliding across a seat.

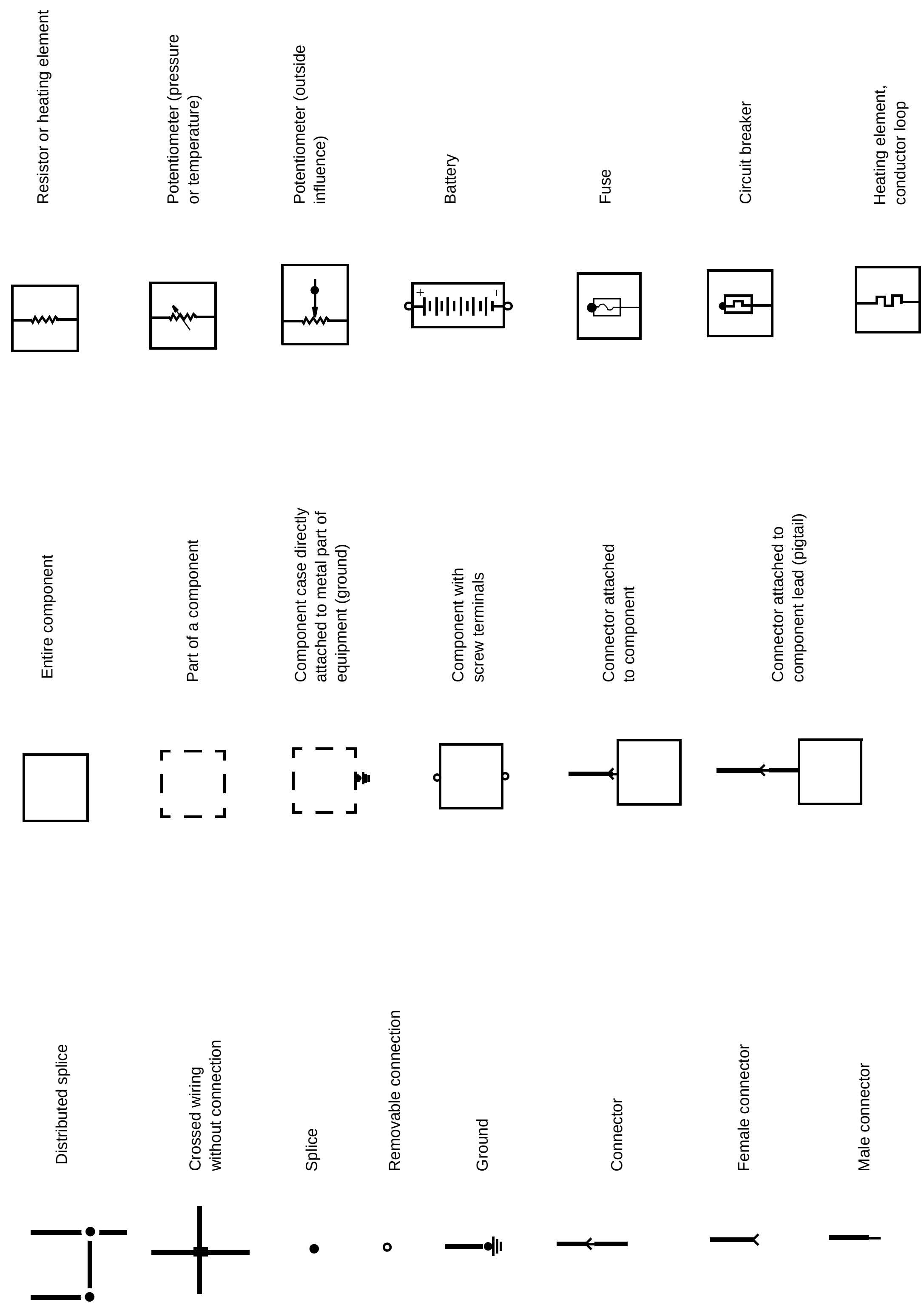
Charge by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore it is important to use care when handling and testing electronic components.

CAUTION: To prevent possible electrostatic discharge damage, follow these guidelines:

- Do not touch the GCP connector pins or soldered components on the GCP board.
- Do not open the replacement part package until the part is ready to be installed.
- Before removing the part from the package, ground the package to a known good ground on the equipment.
- If the part has been handled while sliding across a seat, while sitting down from a standing position, or while walking a distance, touch a known good ground before installing the part.

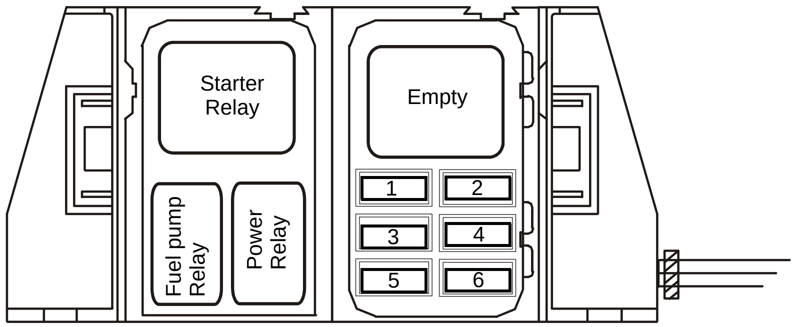
Diagrams and Schematics

Symbols



GCP - Power Distribution Box

Part of -5250010- Wiring Harness



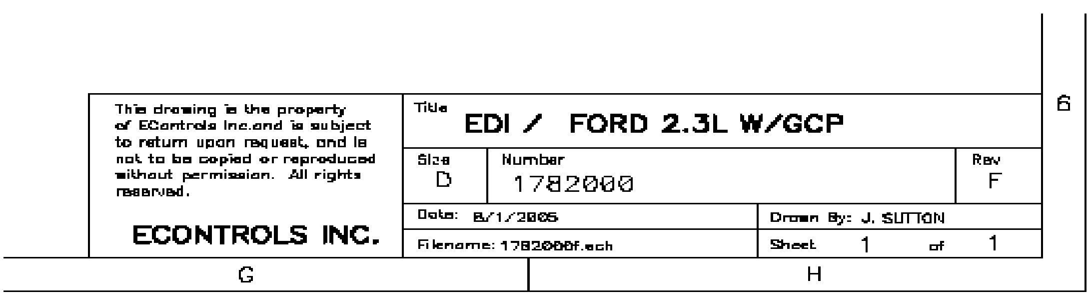
Fuse	Amps	Circuits protected
1	10	Battery Voltage to EPR
2	5	Ignition Voltage to GCP and Relays
3	10	Battery Voltage to GCP
4	15	Fuel pump
5	15	Battery Voltage out of Power Relay
6	-	Not used

Wire Colors

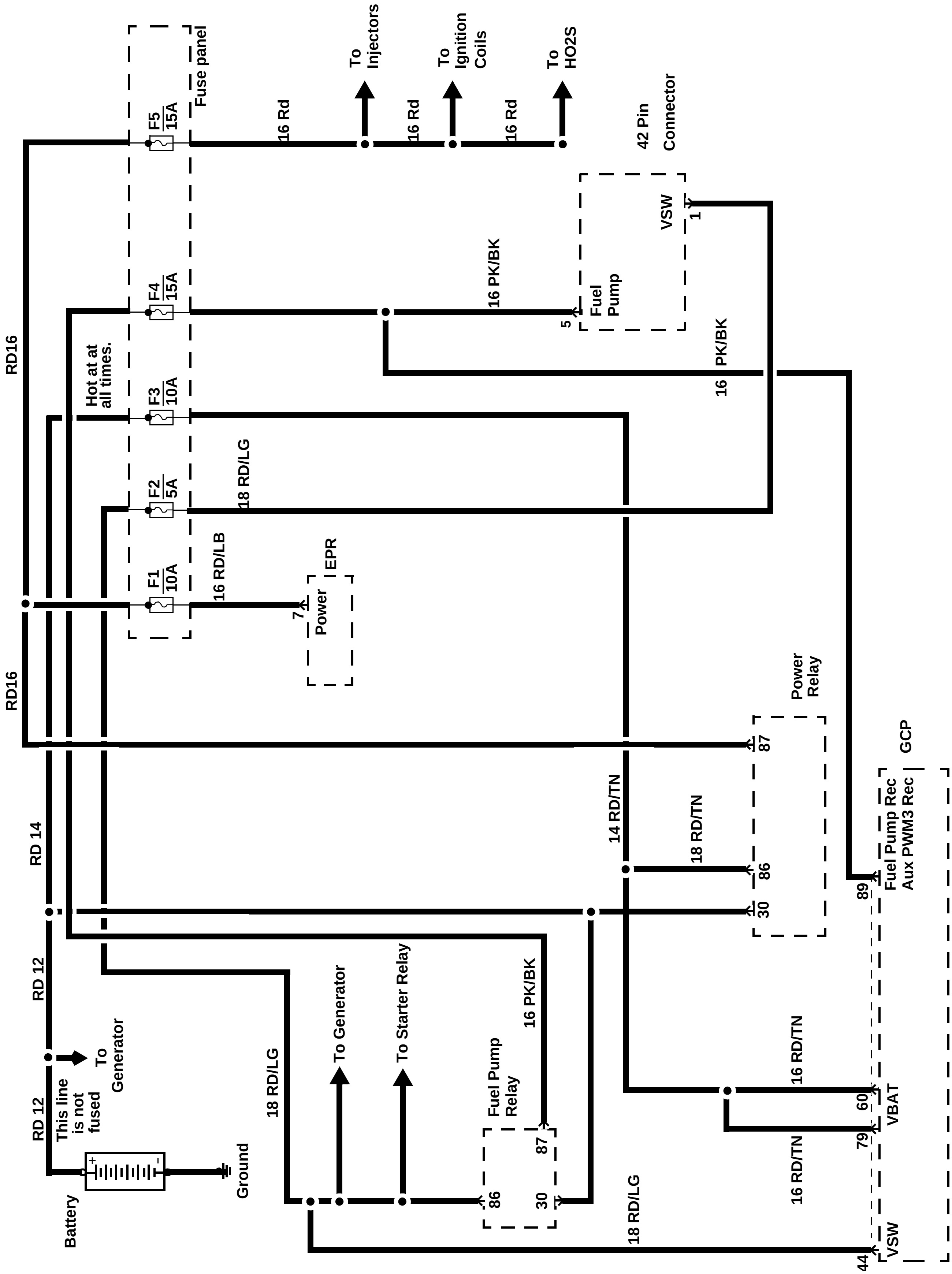
Symbol	Color
BK	BLACK
BN	BROWN
BU	BLUE
DB	DARK BLUE
DG	DARK GREEN
GN	GREEN
GY	GRAY
LB	LIGHT BLUE
LG	LIGHT GREEN
NA	NATURAL
OG	ORANGE
PK	PINK
RD	RED
SR	SILVER
TN	TAN
VT	VIOLET
WH	WHITE
YE	YELLOW

Revision Level

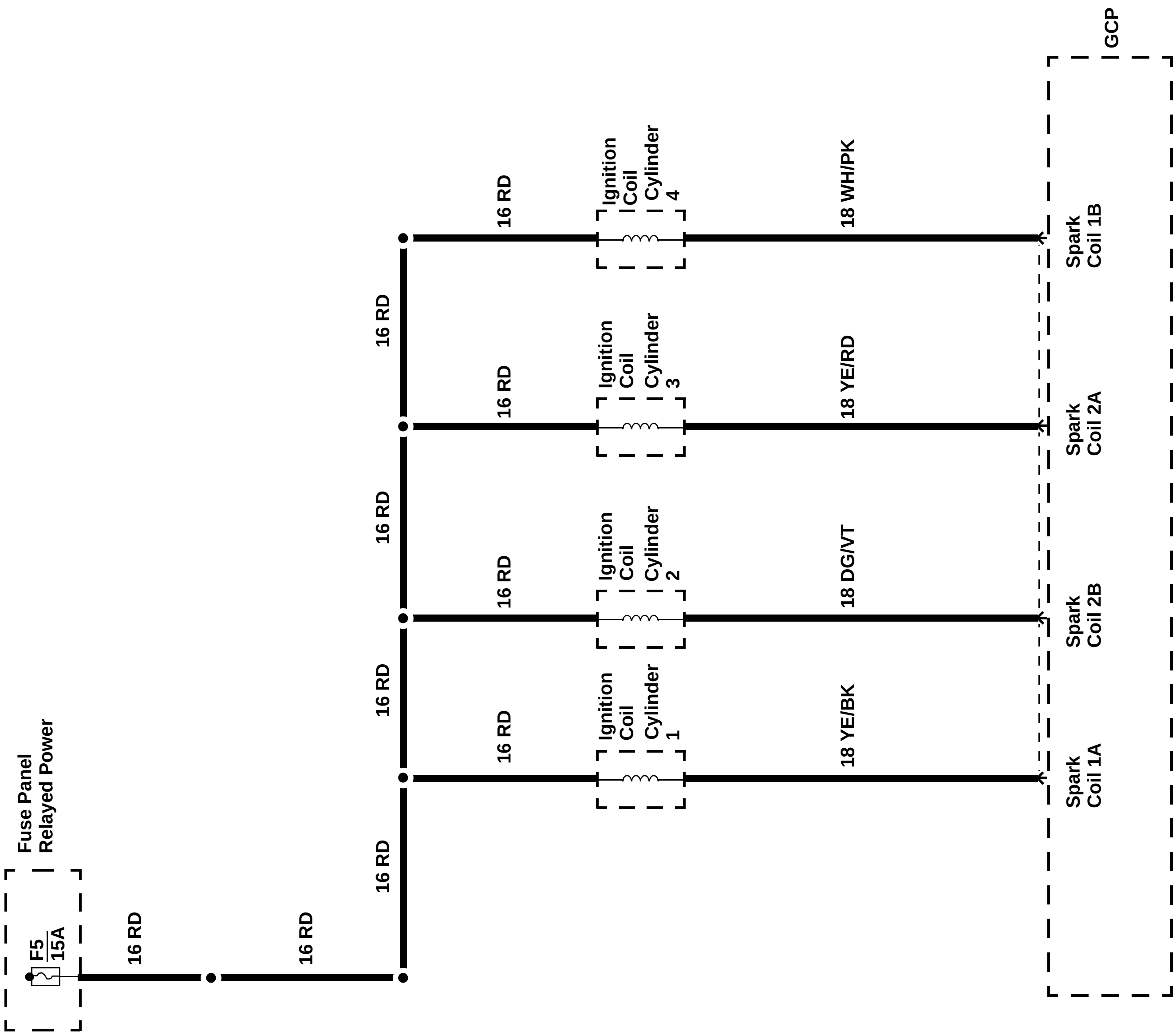
The following wiring schematics are taken from the wiring diagram labeled below:



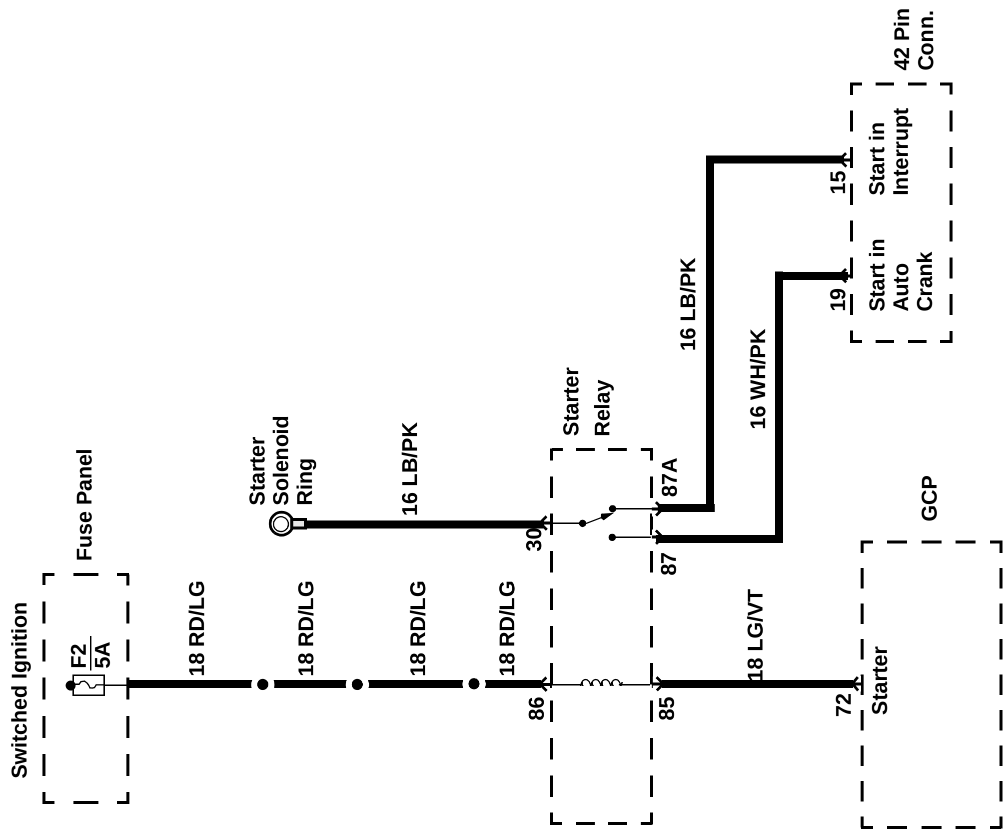
Power Distribution



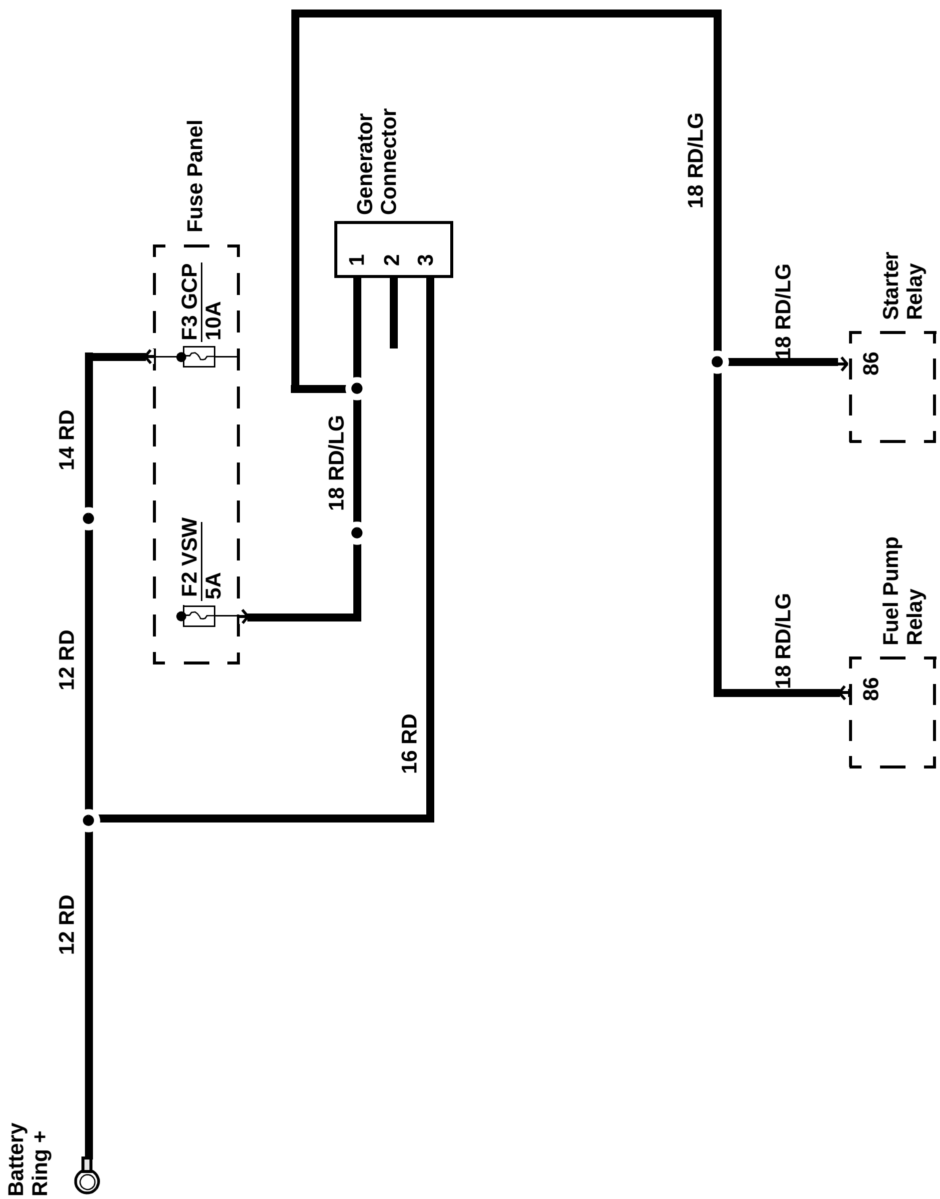
Ignition System



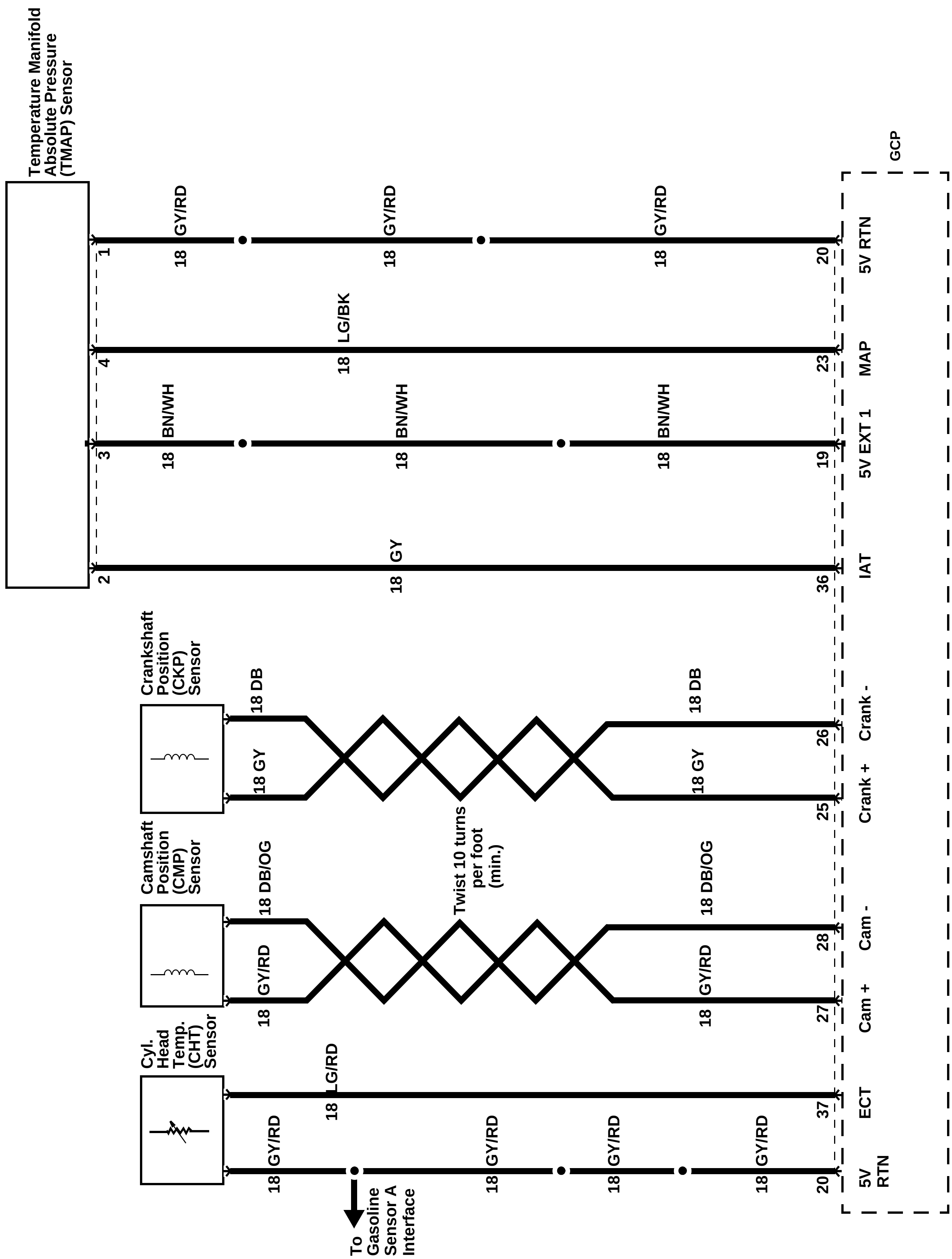
Starting System



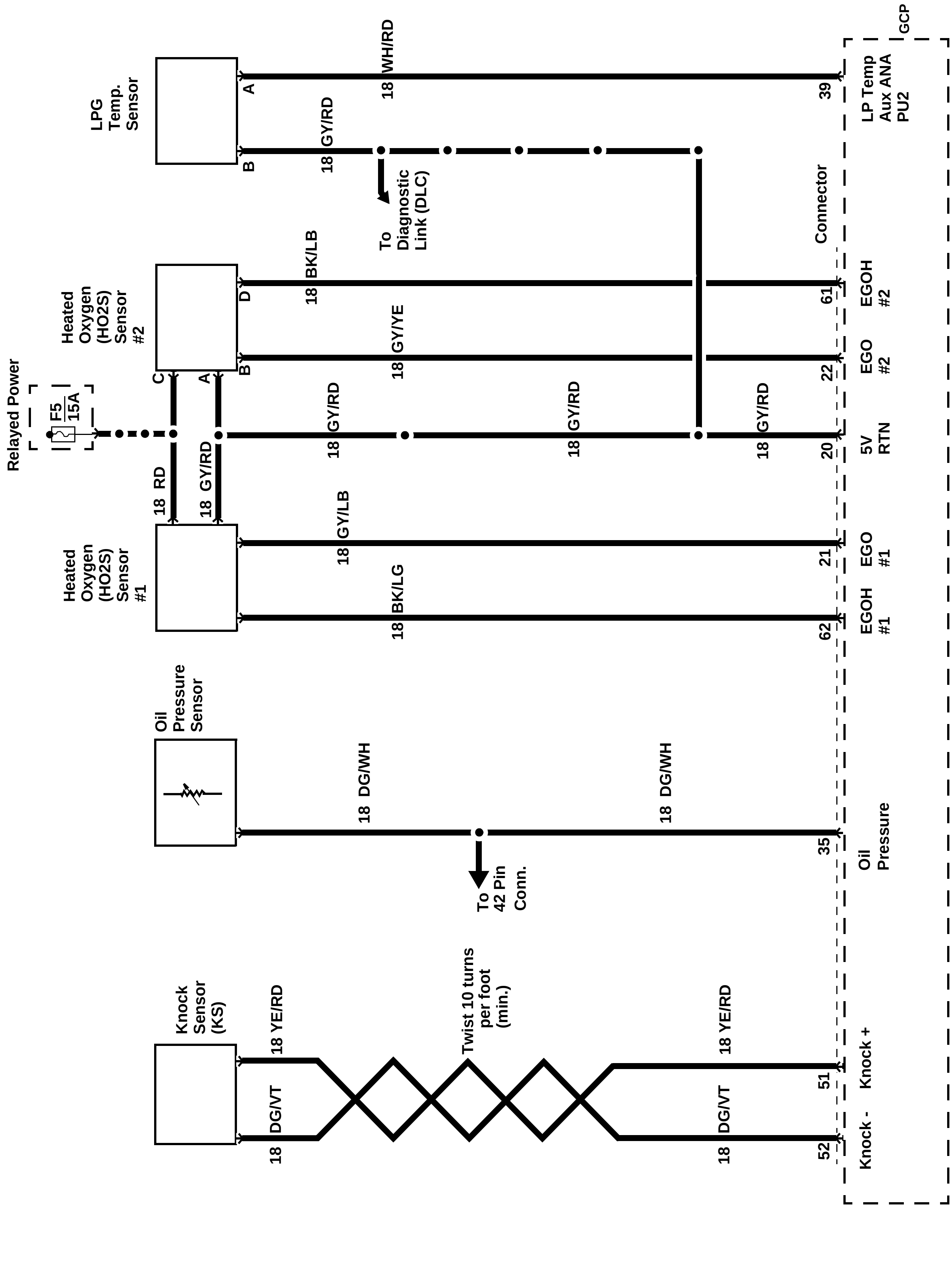
Charging System



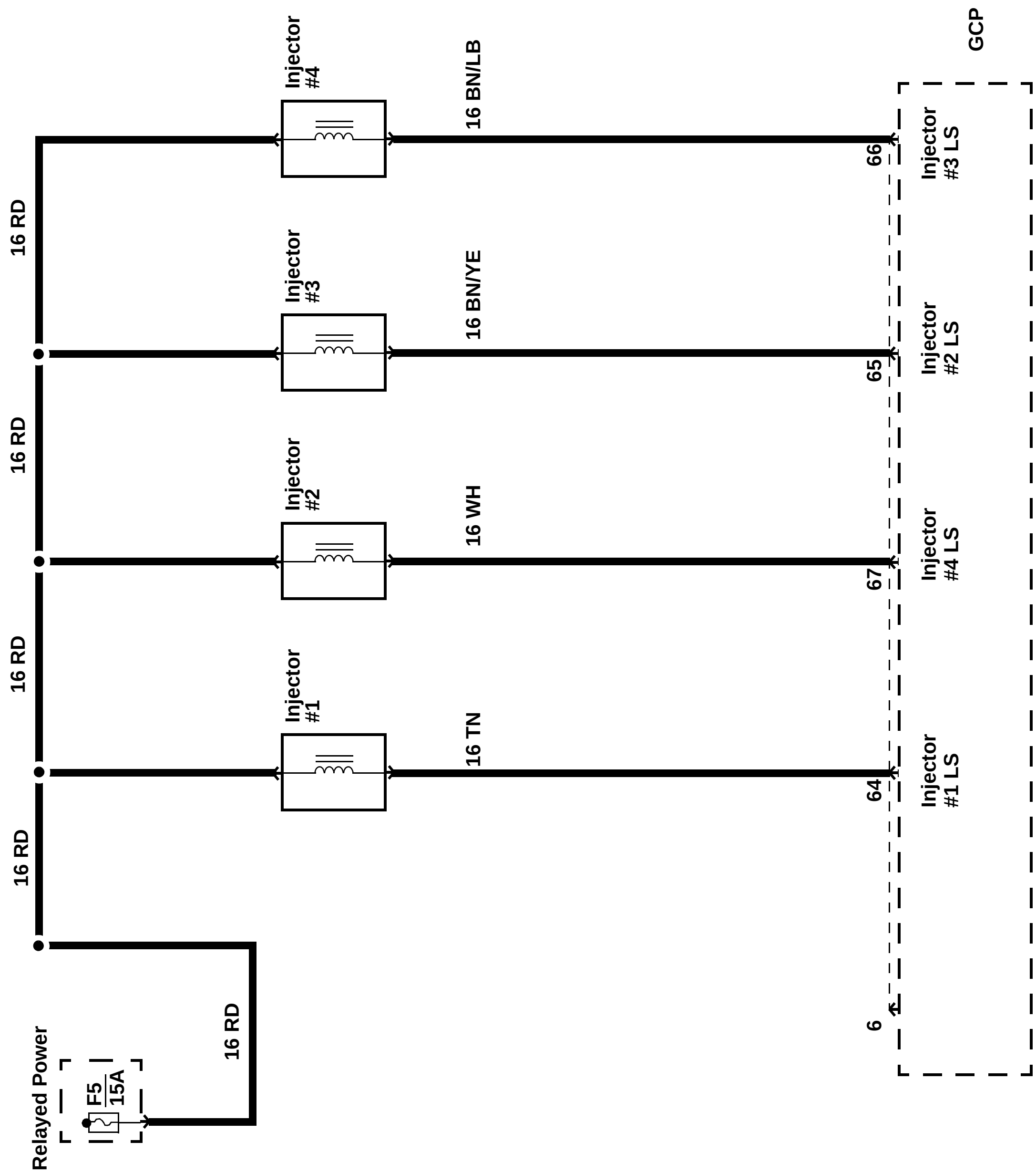
Engine Controls - Sensors (1 of 2)



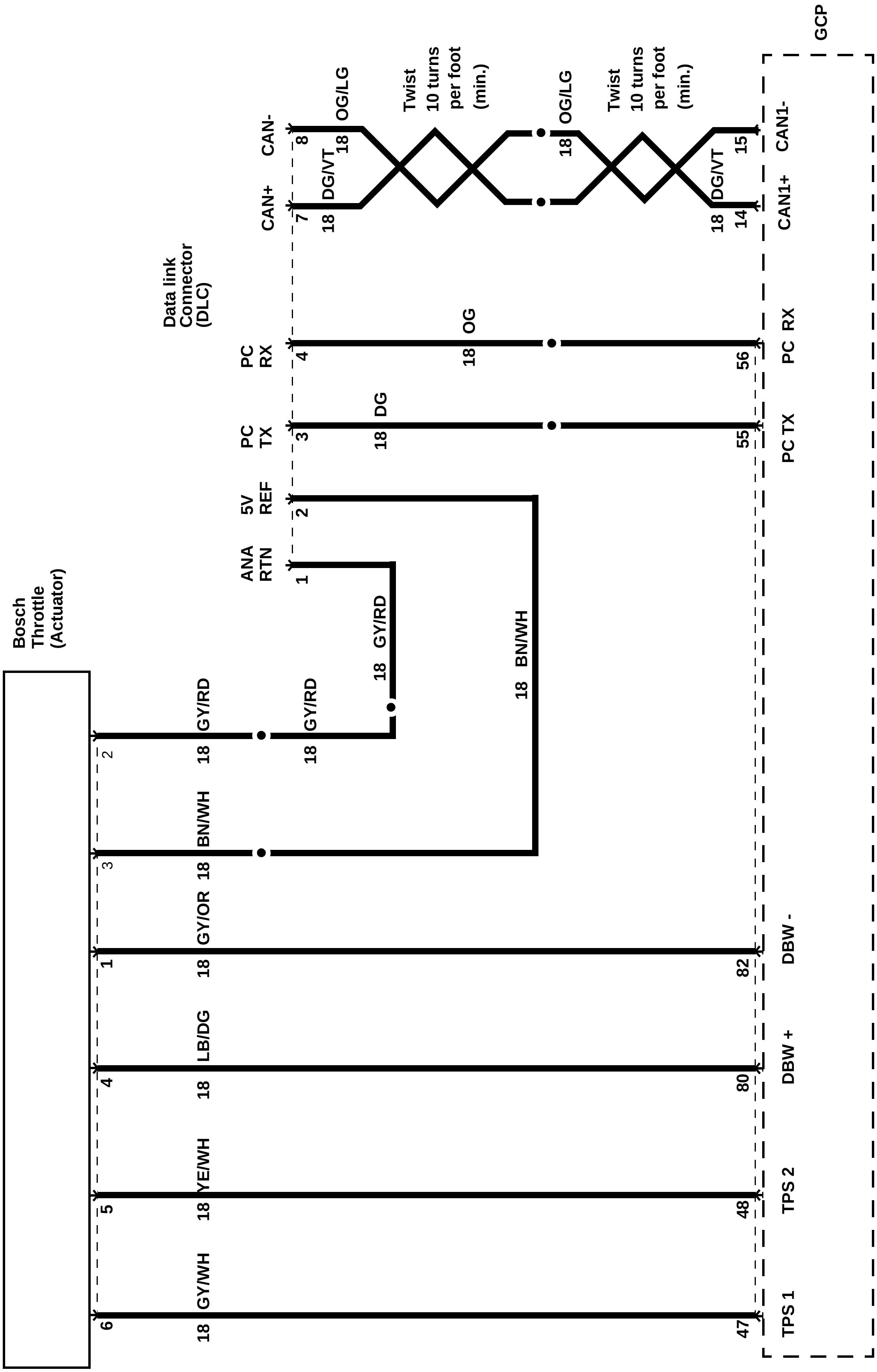
Engine Controls - Sensors (2 of 2)



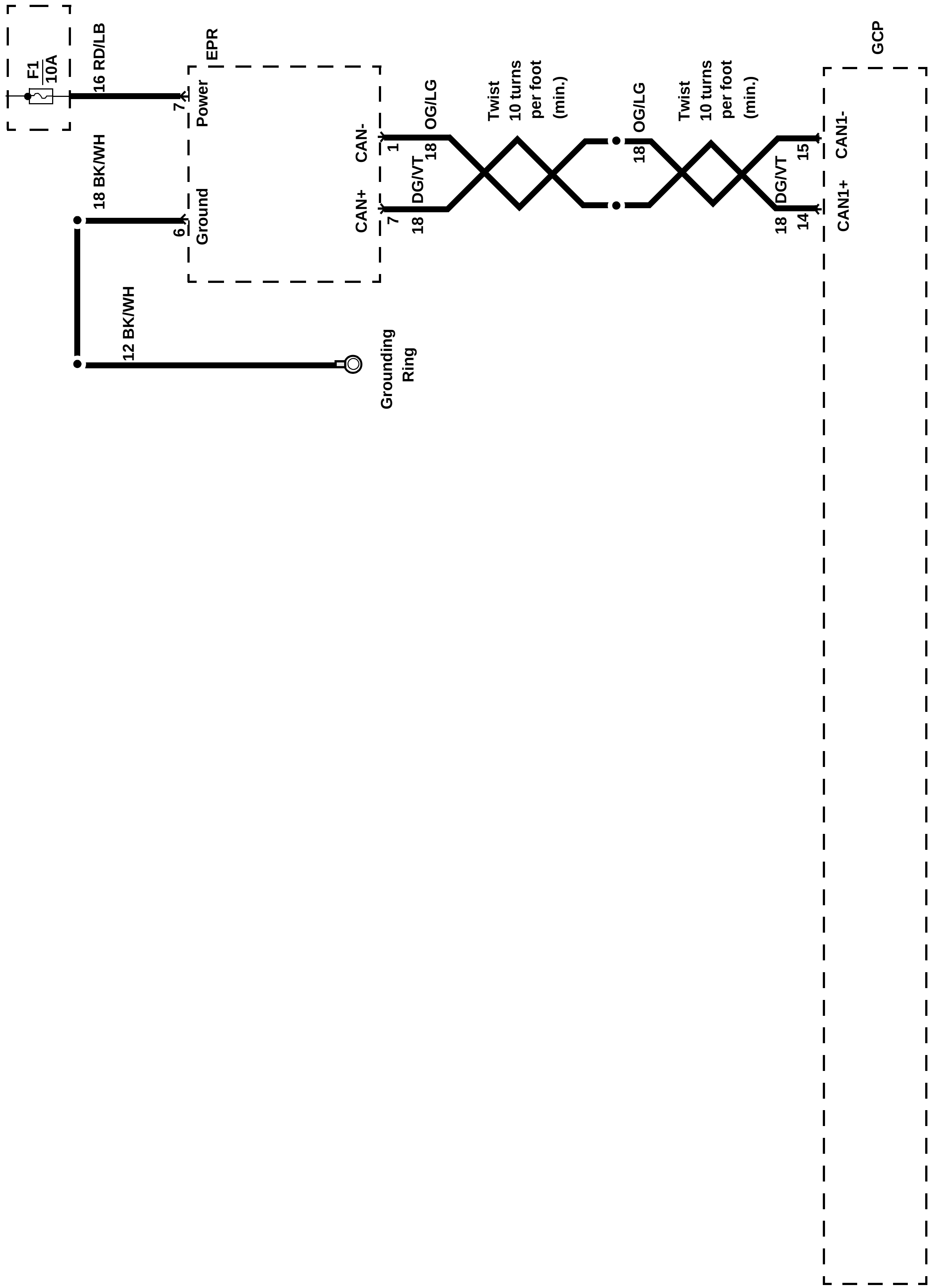
Fuel Injectors



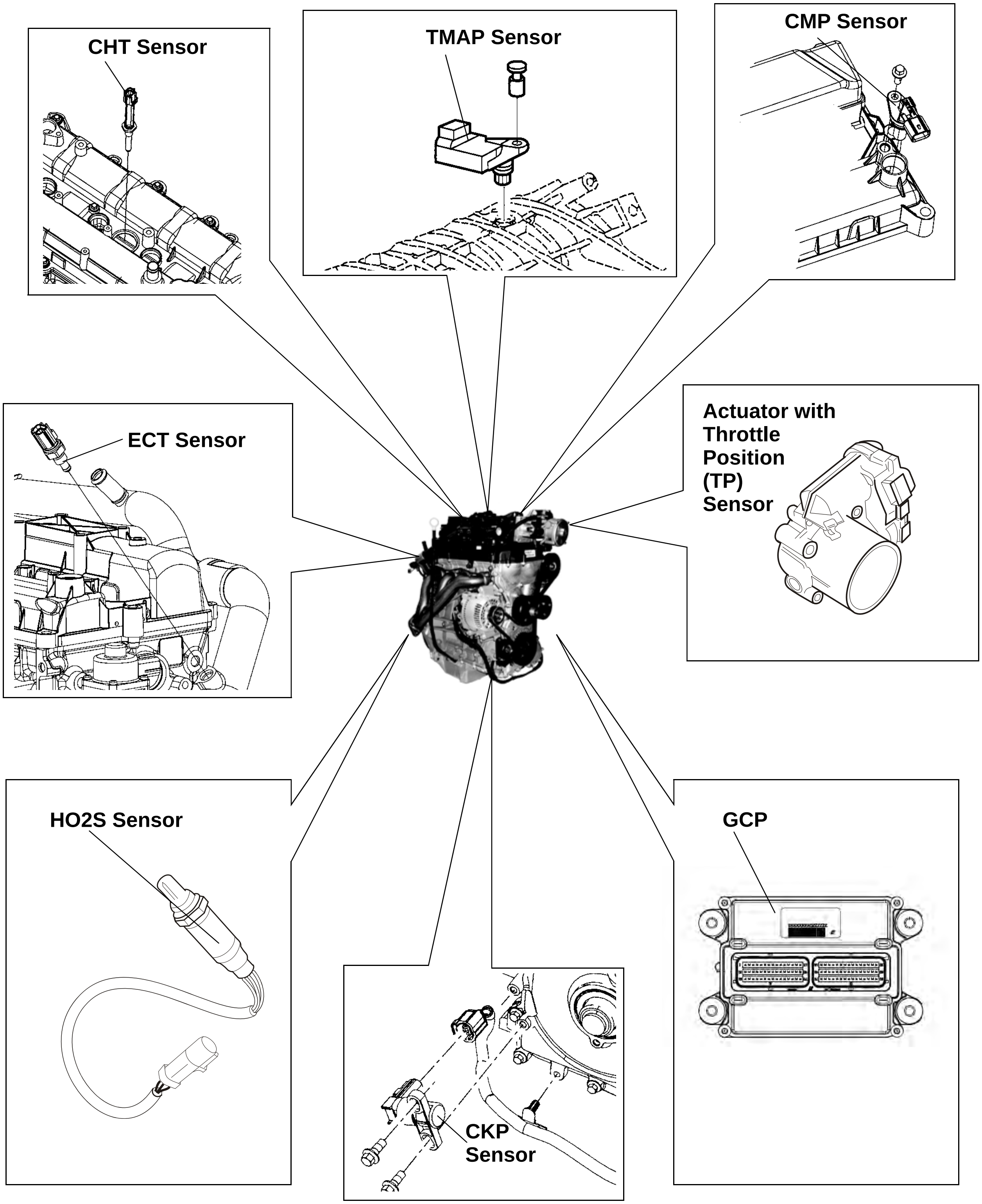
Engine Controls - Actuator / Data Link Connector (DLC)



Engine Controls - Dry Fuel EPR



Engine Component Locator View



DIAGNOSIS AND TESTING

Diagnostic Approach

Use the following step by step approach when diagnosing an engine performance problem:

1. Verify the concern and determine if it is a deviation from normal operation.
2. Once the concern has been verified, preliminary checks can be done. Conduct a thorough visual inspection, be alert for unusual sounds or odors, and gather diagnostic trouble code (DTC) information.
3. If a diagnostic trouble code (DTC) is stored, follow the designated DTC chart exactly to make an effective repair.
4. If no DTC is stored, select the symptom from the symptom charts and follow the suggestions to complete the repair.
5. If no matching symptom is available, analyze the complaint and develop a plan for diagnostics utilizing the wiring diagrams, technical assistance and repair history.
6. Some diagnostic charts contain diagnostic aids which give additional information about a system. Be sure to use all of the information that is available to you.

GCP Diagnostic Overview

FORD Diagnostic Trouble Codes are set when the FORD system GCP runs a diagnostic self-test and the test fails. When a DTC is set, the FORD system GCP will illuminate the Malfunction Indicator Lamp (MIL) on the instrument panel and save the code in memory. The FORD system GCP will continue to run the self-test unless the DTC is an oxygen sensor lean, oxygen sensor rich, or a GCP related DTC. If the system continues to fail the test, the lamp will stay illuminated and the DTC is current (ACTIVE). All DTC's are stored as historical faults until they are cleared. All DTC's except the GCP related DTC's will automatically clear from memory if the DTC does not reset within 50 consecutive engine run cycles.

While a Diagnostic Trouble Code is current for a sensor, the FORD system GCP may assign a default limp home value and use that value in its control algorithms. All of the FORD system diagnostic self-tests run continuously during normal engine operation.

The Diagnostic Trouble Codes can be read by using either the Malfunction Indicator Lamp (MIL) or a Laptop computer. Refer to Using a Laptop Computer to Diagnose the FORD System and Using a Diagnostic Jumper to Diagnose the FORD System, located in this section. Diagnostic Trouble Codes can be cleared from memory with a laptop computer or by turning the ignition key to the OFF position and removing the FORD system main power fuse (F3) for 15 seconds.

If more than one DTC is detected, begin with the lowest number DTC and diagnose each problem to correction unless directed to do otherwise by the fault tree. The DTC's are numbered in order of importance. Having DTC 112 and DTC 122, both concerning the oxygen sensor, is possible. By repairing DTC 112 first, the problem causing the DTC 122 may also be corrected.

On-Board Diagnostics - GCP

The diagnostic tests and circuit charts are designed to assist the technician to locate a faulty circuit or component through a process of logical decisions. The tests and charts are prepared with the requirement that the engine functioned correctly at the time of assembly and that there were not multiple faults present.

There is a continuous self-diagnosis on certain control functions. This diagnostic capability is complimented by the diagnostic procedures contained in this section. The language for communicating the source of the malfunction is a system of diagnostic trouble codes. When a malfunction is detected by the Engine Control Module (GCP), a Diagnostic Trouble Code (DTC) is set and the Malfunction Indicator (MIL) lamp will be illuminated (refer to MIL DTC Retrieval Procedure for process description) -- Refer to“Diagnosis Using a Personal Computer” on page 26 or Palm Pilot Diagnosis, for information regarding performing GCP and engine control system diagnosis.

Engine Control Module (GCP) Limp Home Mode Strategy

The GCP has four settings for limp home mode. Depending on what Diagnostic Trouble Code (DTC) is set, one or more of the limp home modes will be in effect.

The four limp home modes are as follows:

Power Derate 1

The actuator is limited to a maximum opening of 50%. If “Power Derate 1” is active, it will remain active until the active DTC goes away.

The following DTC's will cause Power Derate 1 to take affect:

- DTC 223: CHT/ECT higher than expected 1. (CHT/ECT is greater than 240 °F).
- DTC 213: IAT higher than expected 1. (IAT is greater than 200°F).
- DTC 253: Knock sensor open. (1.6L and 4.2L only)
- DTC 254: Excessive knock signal. (1.6L and 4.2L only)
- DTC 511: FPP1 high voltage.
- DTC 512 FPP1 low voltage.
- DTC 521: FPP2 high voltage.
- DTC 522: FPP2 low voltage.
- DTC 545: IVS/Brake interlock failure.

Power Derate 2

The actuator is limited to a maximum opening of 20%. If "Power Derate 2" is active, it will remain active until the active DTC goes away and the ignition input to the GCP (usually the ignition switch) is cycled.

- DTC 513: FPP1 higher than IVS limit.
- DTC 514: FPP1 lower than IVS limit.
- DTC 523: FPP2 higher than IVS limit.
- DTC 524: FPP2 lower than IVS limit.
- DTC 515: FPP1 higher than FPP2.
- DTC 516: FPP1 lower than FPP2.
- DTC 353: MegaJector delivery pressure higher than expected.
- DTC 354: MegaJector delivery pressure lower than expected.
- DTC 355: MegaJector communication lost.
- DTC 363: MegaJector internal actuator fault detection.
- DTC 364: MegaJector internal circuitry fault detection.
- DTC 365: MegaJector internal communication fault detection.
- DTC 611: COP failure (Internal GCP failure).
- DTC 614: RTI 1 loss (internal GCP failure).
- DTC 655: RTI 2 loss (internal GCP failure).
- DTC 656: RTI 3 loss (internal GCP failure).
- DTC 613: A/D loss (internal GCP failure).
- DTC 612: Invalid interrupt (internal GCP failure).
- DTC 615: Flash checksum invalid (internal GCP failure).
- DTC 616: RAM failure (internal GCP failure).

Fault Low Rev Limit

The engine RPM will be limited to a maximum of 1600 RPM. If the "Fault Low Rev Limit" is active, it will remain active until the active DTC goes away and the ignition input to the GCP (usually the ignition switch) is cycled.

- DTC 511: FPP1 high voltage.
- DTC 512: FPP1 low voltage.
- DTC 513: FPP1 higher than IVS limit.
- DTC 514: FPP1 lower than IVS limit.
- DTC 523: FPP2 higher than IVS limit.
- DTC 524: FPP2 lower than IVS limit.
- DTC 515: FPP1 higher than FPP2.
- DTC 516: FPP1 lower than FPP2.
- DTC 545: IVS/Brake interlock failure.

Force to Idle

The engine RPM will be limited to a maximum of 800 RPM. If the "Force to Idle" is active, it will remain active until the active DTC goes away.

- DTC 511: FPP1 high voltage.
- DTC 512: FPP1 low voltage.
- DTC 521: FPP2 high voltage.
- DTC 522: FPP2 low voltage.
- DTC 513: FPP1 higher than IVS limit.
- DTC 514: FPP1 lower than IVS limit.
- DTC 523: FPP2 higher than IVS limit.
- DTC 524: FPP2 lower than IVS limit.
- DTC 515: FPP1 higher than FPP2.
- DTC 516: FPP1 lower than FPP2.

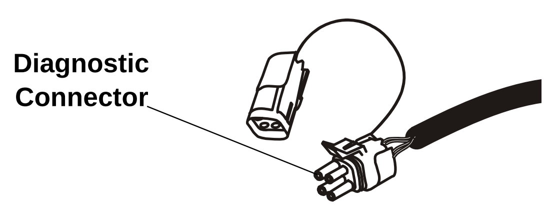
Intermittent MIL

Conditions that are only present from time to time are called intermittents. To resolve intermittents, perform the following steps:

1. Evaluate the history of DTC's observed with this particular engine.
2. Evaluate the symptoms and conditions described by the customer.
3. Use strategy-based diagnosis, especially where it relates to the elimination of bad connectors and wiring.
4. When using a personal computer with Ford software, data-capturing capabilities are available that can assist in detecting intermittents. Contact an EDI customer service representative at (**1 800 220 2700**) for more information.

Malfunction Indicator Lamp (MIL) DTC Retrieval Procedure

NOTE: DTC's can be retrieved from the engine control module (GCP) by using either the MIL or an IBM compatible personal computer or hand held Palm Pilot® using the optional serial interface available. Refer to Equipment Setup for information about using a personal computer to assist with unit diagnosis.



DTC's can be retrieved by shorting the Self Test Input (STI) connector to ground. The STI circuit is a white/purple wire exiting pin 3 of the 42 pin connector. The STI white/purple wire branches off to terminal "A" of the 4 pin diagnostic connector. If no DTC is stored with key on/engine off (KOEO), a DTC 123 is flashed, indicating that all systems are OK.

During key on/engine running (KOER) operation, with no DTCs stored, the MIL is not illuminated. If during

KOER operation a DTC is stored, the MIL will illuminate and remain on steady if the code is active.

MIL Bulb Test

The MIL bulb test occurs KOEO with the STI connector not grounded. The MIL bulb will stay on and remain on if no DTCs are present. If DTCs are present (except DTC 123), the MIL bulb will blink. If the MIL bulb does not illuminate when bulb test is performed, access diagnostic software and view the fault indicator on screen. If the screen fault indicator is illuminated and the MIL light is not, inspect the bulb and replace it if damaged. If bulb is OK or does not illuminate after replacement, refer to MIL circuit test procedure. Once MIL bulb illumination has been verified or established, DTCs can be extracted from the MIL as follows:

DTC Extraction

- KOEO, short the STI circuit to a known good ground. There will be a 5 second delay before DTCs begin flashing.

When extracting DTCs via the MIL the following apply:

- The flashing MIL is on for 0.4 second and off for 0.4 second.
- The MIL is off for 1.2 seconds between digits of three digit DTCs.
- The MIL is off for 2.4 seconds between DTCs.
- Each DTC repeats 3 times before the next stored DTC begins flashing.
- Up to 6 DTCs can be stored.
- Once all stored DTCs are flashed, the process repeats with the first stored DTC.
- DTCs are flashed in the order in which they were set.

Once the DTC(s) is retrieved, refer to the appropriate DTC chart for explanation of what caused the DTC to set. Perform component and circuit test as required to conduct repair.

Diagnosis Using a Personal Computer

Equipment Requirements

You will need a laptop computer (with a serial port) or personal digital assistant (PDA) and a communications cable/interface cable kit:

- Kit for laptop part #: PN 2U1L-6K947-AA
- Kit for PDA or laptop part #: PN 2U1E-6K947-AA

The required software is available from your local EDI distributor or you can download it from: web.fpp.ford.com

Laptop Requirements:

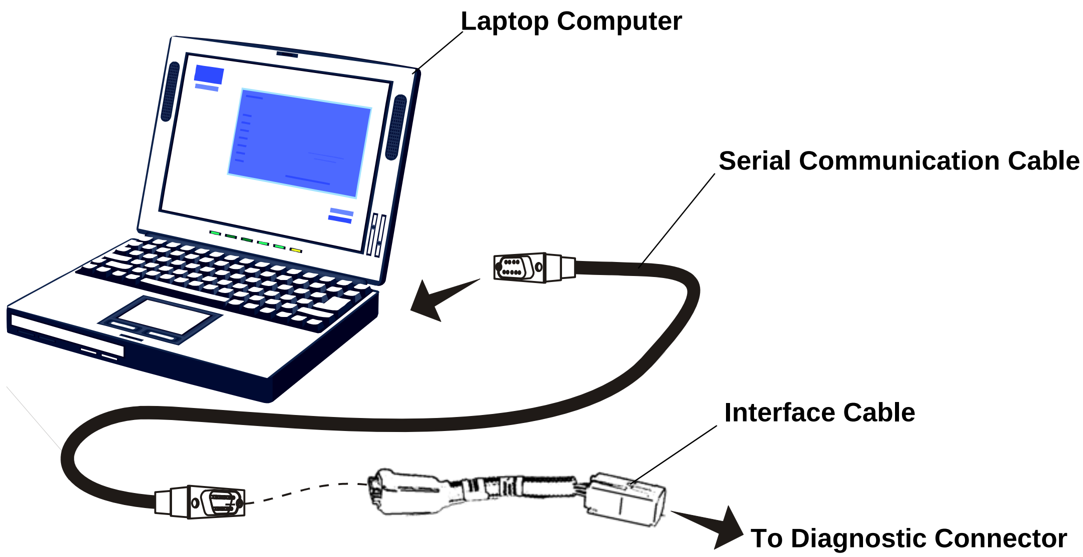
- Serial port
- 800 x 600 dpi screen
- Windows 95 or newer operating system
- No speed minimum
- 32 MB of RAM

PDA Requirements:

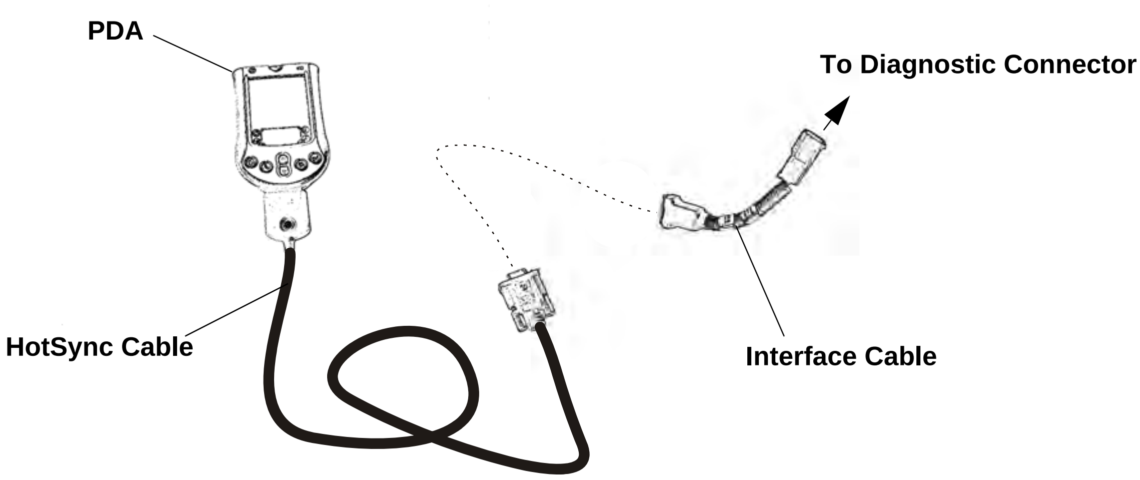
- Palm OS 3.0 software
- 64 K RAM

Interface Hook-up

For connection to a laptop, use kit PN 2U1L 6K947-AA. Connect serial cable to RS232 port on the back of the laptop computer. Connect interface cable to serial cable. Connect interface cable to the 4 pin diagnostic connector on the engine harness.



For connection to a PDA, use kit PN 2U1E-6K947-AA. Connect as shown below:



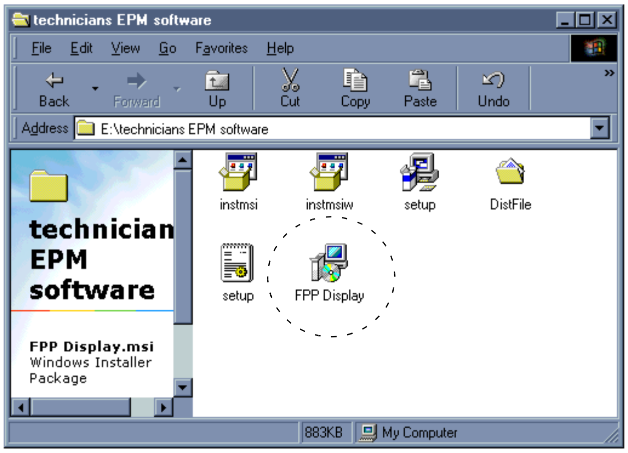
GCP Software Installation

Insert CD into CD-ROM drive.

Double click “My Computer” Icon.

Double Click CD-ROM drive letter

This will display the contents of the CD as shown.

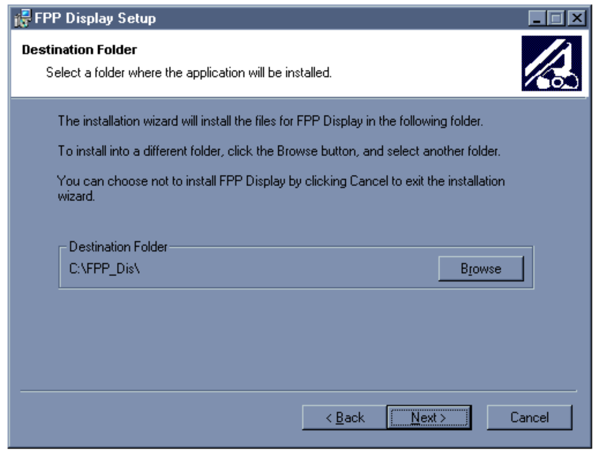


Double click FPP Display icon.

You will now see a welcome screen.

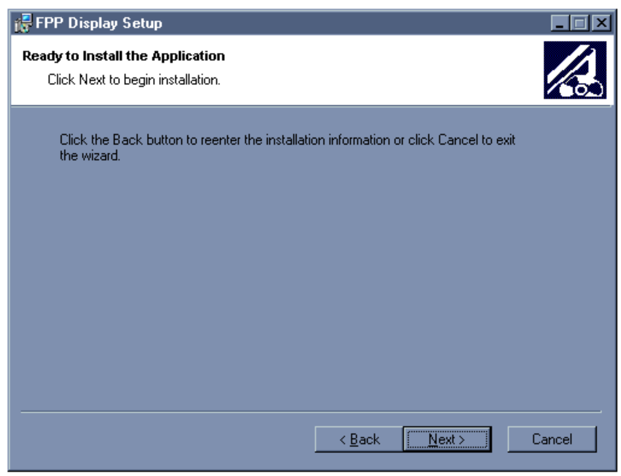
Click next.

A screen will pop up telling you the name of the destination folder.



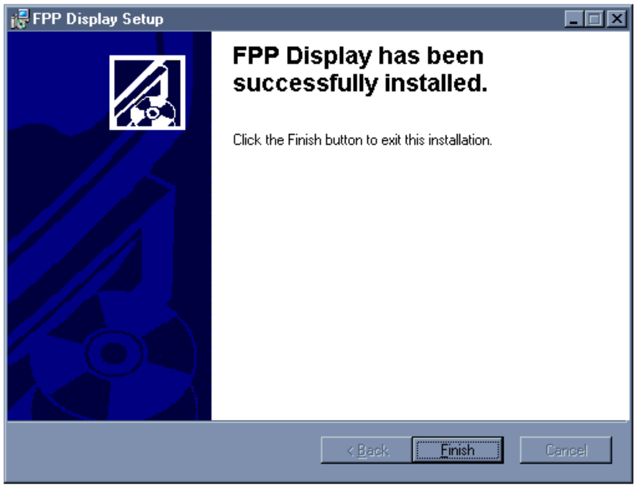
Click next.

You will now see a screen telling you it is ready to install the software.



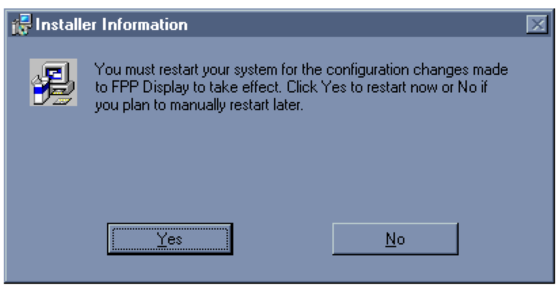
Click next.

You will see an Installation Success" screen when the software is finished installing.



Click Finish.

A screen will pop up asking if it is ok to reboot your system.



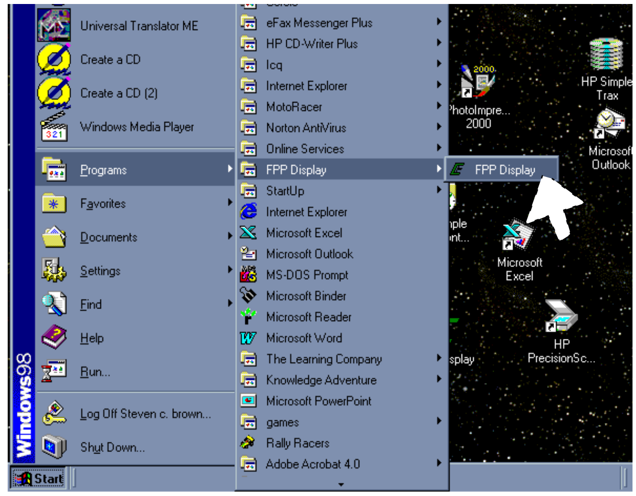
Click yes.

Your system will shut down and reboot.

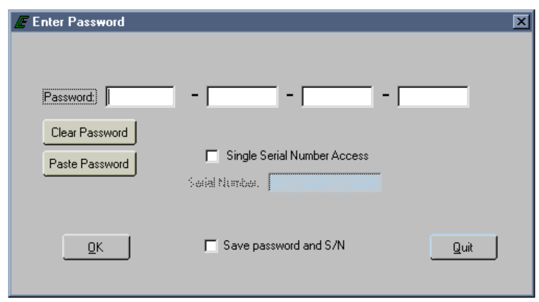
The software is now installed on your system in a folder called “FPP Display”. Refer now to “Using Technicians GCP Software” in this Section.

Using GCP Software - Menu Functions

You can begin using the technicians GCP software after installation, by clicking Start - Programs - FPP Display - FPP Display as shown.



Type in the Password which can be found on the label of the CD-ROM.

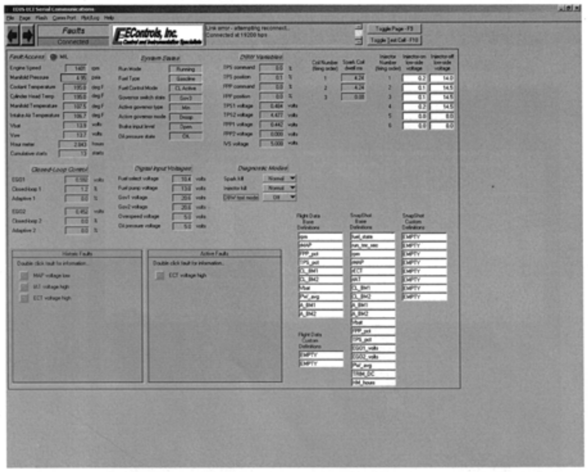


Place the ignition key in the ON position.

The FORD system Gauge screen should now appear and a green banner in the upper left hand corner will read “Connected”.

Diagnostic Trouble Codes

The System Fault screen is used to view and clear DTC's, which have been set.



Checking Diagnostic Trouble Codes

The System Fault screen contains a listing of all of the Historic and Active DTC's set within the FORD system. If a DTC is stored in memory, the screen will display that fault in the Historic Faults column. If the fault condition currently exists, the DTC will also show up in the Active Faults column.

Opening Diagnostic Trouble Codes

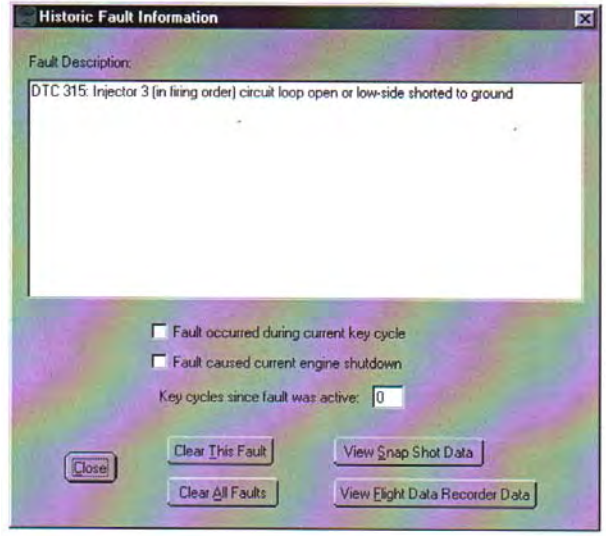
To open a DTC, click on the DTC in the Historic Faults column. A DTC Dialog Box will pop up on the screen. The DTC Dialog Box contains the following useful information:

- If the fault occurred during the current key cycle.
- If the fault caused current engine shutdown.
- How many key cycles since the fault was active.
- Snapshot Data (explained later).
- Flight Data Recorder (explained later).

The DTC Dialogue Box also allows you to clear a single fault by clicking on the "Clear This Fault" button and it allows you to clear all faults by clicking on the "Click All Faults" button.

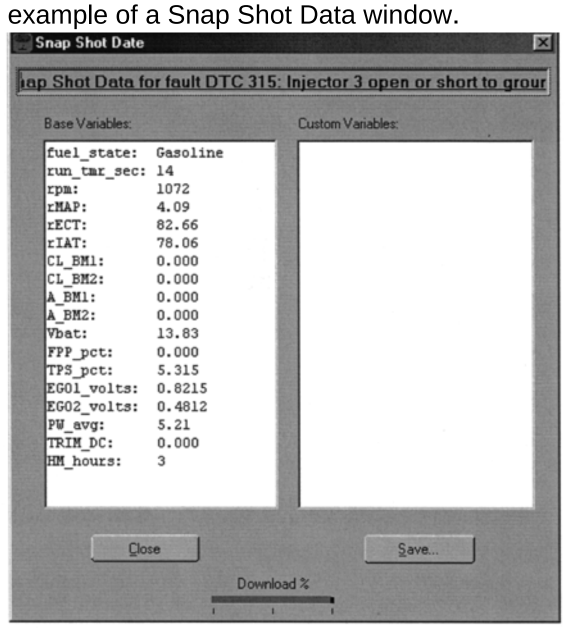
NOTE: Record faults before clearing them. This will aid in diagnosis.

Hear is an example of a DTC Dialogue Box.



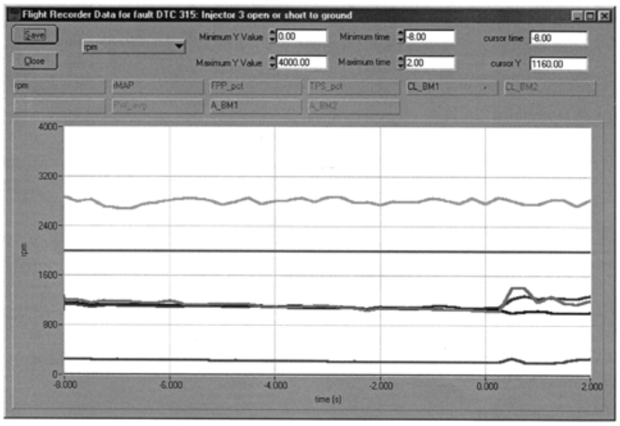
Snap Shot Data

The Snap Shot Data is a listing of specific engine system variables. These variables are recorded by the GCP at the instant the DTC sets. By clicking on the "View Snap Shot Data" button, a new window will pop up and you will be able to view these variables. Here is an example of a Snap Shot Data window.



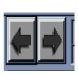
Flight Data Recorder

The Flight Data Recorder is also a listing of specific engine system variables. These variables are recorded by the GCP for an interval of 10 seconds. The 10 second interval includes 8 seconds before the DTC sets and 2 seconds after the DTC sets. By clicking on the “View Flight Data Recorder Data” button, a new window will pop up and you will be able to view these variables. Here is an example of a flight Data Recorder Data window.



The FAULTS screen shows the following:

- Fault Access
- System States
- DBW Variables
- Closed Loop Control
- Digital Input Voltages
- Diagnostic Modes
- Historic Faults
- Active Faults

Use the  keys at the upper left corner

or the “page” command to toggle the three main screens (GAUGES, FAULTS AND RAW VOLTS).

NOTE: F9 key will toggle to the last screen you were on.

Data Stream - Reading Sensor & Actuator Values

Most applicable sensor and actuator values are displayed on the Gauges Screen. The display shows the voltage the FORD system GCP is reading and, for sensors, the sensor value in engineering units.

This is one of three main screens (GAUGES, FAULTS AND RAW VOLTS).

The GAUGES screen shows the following:

- Manifold Absolute Pressure (MAP)
- Engine Coolant Temperature (ECT)
- Intake Air Temperature (IAT)
- Throttle Position (TP)
- Foot Pedal Position (FPP)
- Battery Voltage
- Engine speed (RPM)
- Exhaust Gas Oxygen (HO2S)
- Hour meter
- Number of continuous starts
- Run mode, power mode and fuel type

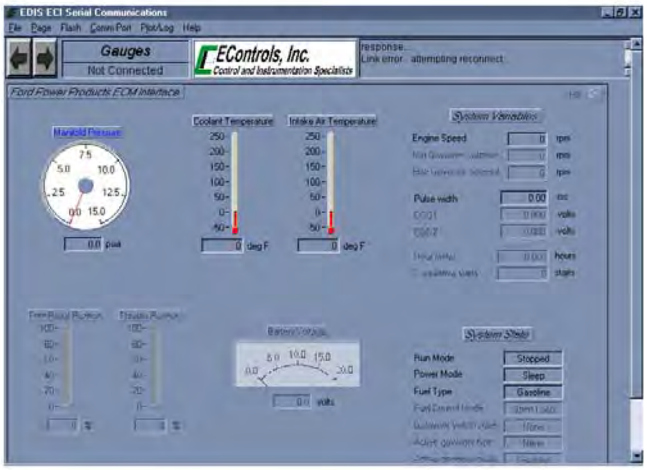
Use the  keys at the upper left corner

or the “page” command to toggle the three main screens (GAUGES, FAULTS AND RAW VOLTS).

NOTE: F9 key will toggle to the last screen you were on.

NOTE: If a DTC for a sensor is current, the engineering value for that sensor may be a default, limp home value and the voltage value will be the actual sensor voltage. Use the voltage value when performing diagnostics unless directed to do otherwise by the diagnostic trouble tree.

Plotting and Data Logging



Recording the values and voltages can be a very useful tool while diagnosing engine problems. The FORD diagnostic software includes real time **plotting** and real time **logging** capabilities. These features enhance the ability to diagnose and repair possible problems with the FORD system. Both plotting and logging allows the user to record, in real time, any variable that can be seen in the FPP_Dis software. In order to record variables, the FPP_Dis software must be "Connected" to the GCP.

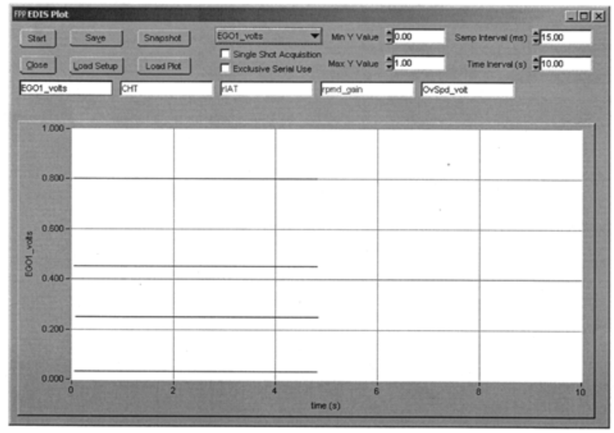
Plotting

To plot a variable, you must first "TAG" the variable. To do this, use the mouse to right click on the variable. The variable will highlight in green to let you know it is "TAGGED".

Next, press the "P" key or click the Plot/Log button and then click the Plot Tags button to invoke the plotting feature. This begins the plot function and you can observe the plotted variables. The plot sweeps from right to left. To stop the plotting feature, simply click the "STOP" button. To restart the plotter, click on the "START" button. The maximum number of variables that can be plotted at one time is 10. The range of the selected variables will be shown on the Y-axis and the time will be shown on the x-axis. You may change the desired time interval and sample interval for the plot by stopping the plot and typing in a new intervals.

The plot can be saved to the PC by stopping the plot and clicking the "SAVE" button. When saving a plot, you will have to type in a filename. Plot files can later be viewed with the edis_saplot software located in the Windows Start Programs FPP_Dis folder, or the data can be viewed in Notepad or Excel.

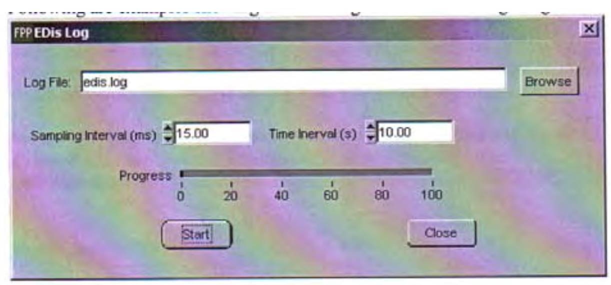
Here is a sample of a plot.

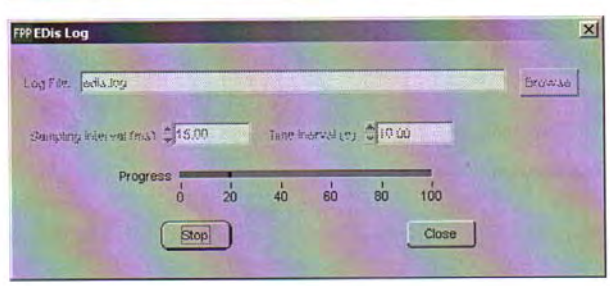


Logging

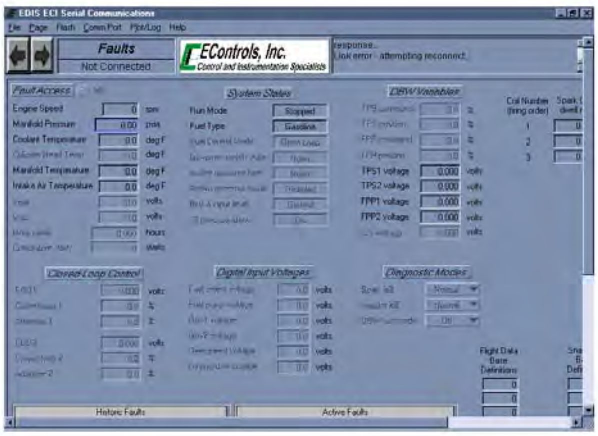
Logging variables means the variables are stored to the PC. During logging, there is no plot shown on the screen. To log variables you must first "TAG" the variables by right clicking them (same as plotting). Next, click on Plot / Log and then Log Tags. An "Edis Log" window will pop up. You can type in a custom log File name or select a custom folder to save the log file to. The default filename is "edis.log" and the default folder is FPP_Dis. The sample interval and time interval can also be changed from the default. To start logging, click on the "START" button. You will see the progress bar moving from 0 to 100%. When the logging is complete, you can close the Edis Log box or start another log file. If you start another log file, you must change the Log File name or the first log file will be overwritten. To view the contents of a saved log file, you can use Notepad or Excel.

The following are examples showing the Edis Log box before starting a log file and during a log file.





Ignition System Test



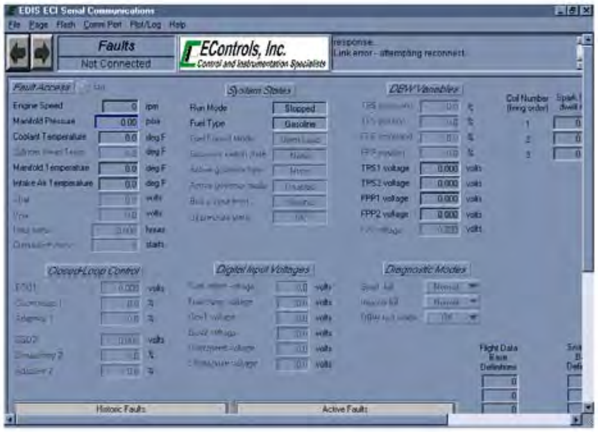
The Spark Kill diagnostic mode allows the technician to disable the ignition on individual cylinders. If the Spark Kill diagnostic mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Spark System Test mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Ignition Ouputs

To disable the ignition system for an individual cylinder, use the mouse to highlight the “Spark Kill” button and select the desired coil. The spark output can be re-enabled by using the mouse to highlight the “Spark Kill” button and selecting “Normal”. If the engine is running below 1000 RPM, the spark output will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the spark output will stay disabled for 5 seconds and then re-set. This test mode has a timeout of 10 minutes. Record the rpm drop related to each spark output disabled.

The Spark outputs are arranged in the order which the engine fires, not by cylinder number.

Injector Test

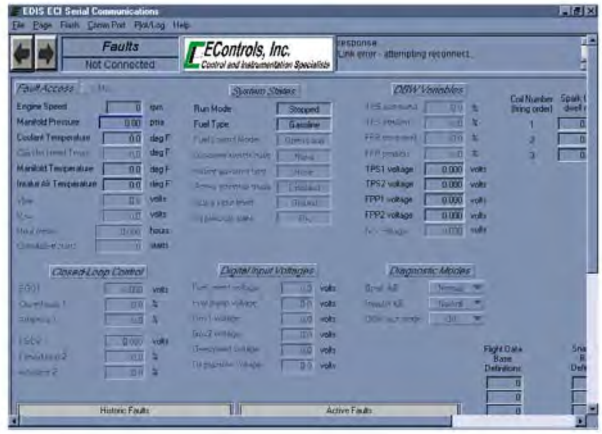


The Injector Kill mode is used to disable individual fuel injectors. If the Injector Kill mode is selected with the engine running below 1000 RPM, the minimum throttle command will lock into the position it was in when the test mode was entered. If the Injector Kill mode is selected with the engine running above 1000 RPM, the throttle will continue to operate normally.

Disabling Injectors

To disable an injector, use the mouse to select the desired injector. The word “Normal” will change to the Injector you have selected. The injector driver can be re-enabled by selecting again. If the engine is running below 1000 RPM, the injector driver will stay disabled for 15 seconds and then re-set. If the engine is running above 1000 RPM, the injector driver will stay disabled for 5 seconds and then re-set. Record the change in rpm or closed loop multiplier while each driver is disabled.

Throttle Test



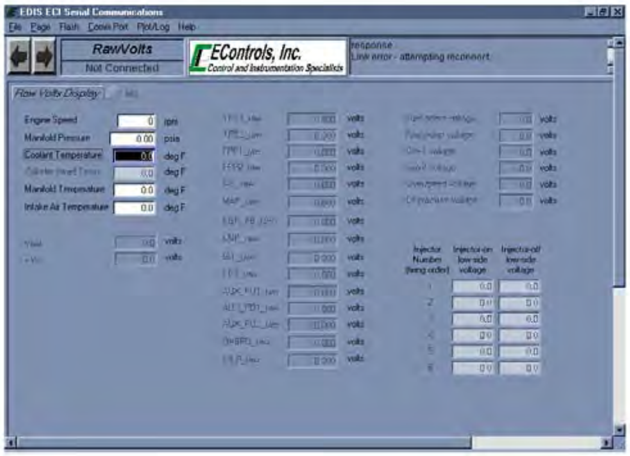
To select this test mode the engine must be off, but the key must be in the ON position.

The DBW Test mode allows the technician to control the throttle directly (without the engine running) with the foot pedal or entering a number into the “TPS Command” box. It is used during the diagnostic routines specified for FPP and TPS related faults.

FPP position displays the current position of the foot pedal as a percentage. FPP volts display the voltage that the GCP is reading from the FPP sensor.

TPS Command displays the commanded throttle position expressed as a percentage, which is being sent to the throttle. TPS Position is the actual percent of throttle opening being sent to the GCP from the throttle. TPS volts display the actual TPS signal voltage the GCP is receiving from the throttle.

RAW VOLTS Screen



The RAW VOLTS screen shows actual voltage readings from various circuits.

Use the  keys at the upper left corner

or the “page” command to toggle the three main screens (GAUGES, FAULTS AND RAW VOLTS).

NOTE: F9 key will toggle to the last screen you were on.

Visual Inspection

Perform a careful visual and physical engine inspection before performing any diagnostic procedure. Perform all necessary repairs before proceeding with additional diagnosis, this can often lead to repairing a problem without performing unnecessary steps. Use the following guidelines when performing a visual/physical inspection check:

- Inspect engine for modifications or aftermarket equipment that can contribute to the symptom; verify that all electrical and mechanical loads or accessory equipment is “OFF” or disconnected before performing diagnosis.
- Inspect engine fluids for correct levels and evidence of leaks.
- Inspect vacuum hoses for damage, leaks, cracks, kinks and improper routing, inspect intake manifold sealing surface for a possible vacuum leak.
- Inspect PCV valve for proper installation and operation.
- Inspect all wires and harnesses for proper connections and routing; bent or broken connector pins; burned, chafed, or pinched wires; and corrosion. Verify that harness grounds are clean and tight.
- Inspect GCP, sensors and actuators for physical damage.
- Inspect GCP grounds for cleanliness, tightness, and proper location.
- Inspect fuel system for adequate fuel level, and fuel quality (concerns such as proper octane, contamination, winter/summer blend).
- Inspect intake air system and air filter for restrictions.
- Inspect battery condition and starter current draw.

If no evidence of a problem is found after visual inspection has been performed, proceed to “Diagnostic System Check”

Intermittent Problems

NOTE: An intermittent problem may or may not turn on the MIL or store a DTC. Do not use the DTC charts for intermittent problems. The fault must be present to locate the problem.

NOTE: Most intermittent problems are caused by faulty electrical connections or wiring. Perform a careful visual inspection for the following conditions:

- Poor mating of the connector halves or a terminal not fully seated in the connector (backed out).
- Improperly formed or damaged terminals
- Improper contact tension. All connector terminals in the problem circuit should be carefully checked.
- Poor terminal-to-wire connections. This requires removing the terminal from the connector body to check.
- Improperly installed aftermarket equipment or accessories.

Operate the engine with accessories “OFF” and a suitable multimeter connected to the suspected circuit. An abnormal voltage when the malfunction occurs is a good indication that there is a fault in the circuit being monitored.

To check GCP for loss of diagnostic code memory, disconnect the MAP sensor connector and idle the engine until the MIL illuminates. Perform MIL DTC retrieval procedure. DTC should be stored and kept in memory when the ignition is turned “OFF”. If not, the GCP is faulty. When this test is completed, make sure that you clear the DTC from memory. An intermittent MIL with no stored DTC may be caused by the following:

- Ignition coil shorted to ground and arcing at plugs.
- MIL circuit to GCP shorted to ground.
- Poor GCP grounds.

Symptom Charts

NOTE: If you have a symptom of the pedal not working, and no DTC is set, go to the voltage screen and check pedal voltage. If pedal voltage is.75-1.25 volts, and idle validation switch says you're at idle - replace the pedal.

NOTE: Items listed in the possible cause column generally do not set a diagnostic trouble code (DTC) or illuminate the MIL light.

NOTE: EDI engines are used in many different applications and equipment. When performing any system diagnosis be aware of any OEM inputs or equipment monitoring devices that may have an effect on the engine's performance or any of the engine's operating systems.

Engine Performance - No Load

SYMPTOM	POSSIBLE CAUSE
Engine Runs Briefly and Shuts Down	• Loss of Spark • Frozen Fuel Regulator (Dry Fuel) • Low Fuel Pressure • Air Inlet Restriction • Wiring Failure • GCP Failure
Engine Cranks But No Start	• Faulty OEM Drivers Safety Shut-Off Seat Switch • Coil Power Loss • GCP Ground Loss • GCP Power Loss • Severe Vacuum Leak (Dry Fuel) • Air Inlet Restriction • Air Inlet Leak (Dry Fuel) • Fuel Lock-Off Inoperative (Dry Fuel) • Wiring Failure • Low Fuel Pressure • Ancillary Components Binding
Engine Runs Poorly	• High Fuel Pressure • Low Fuel Pressure • Contaminated Fuel • Incorrect Fuel Select Table Selected • Wrong GCP Installed • Actuator Air Blockage • Map Sensor Leak • Fuel Contaminated • Noise Suppression Capacitor Failure • Improper PCV Routing • Valve Timing • Low Cylinder Compression
Engine Cranks Slowly	• Excessive Engine Load (Hydraulic Pump Failing, Binding Ancillary Drive Components) • Low Battery Voltage • Incorrect Battery Specifications • Incorrect Battery Cable Size • Starter Relay • Starter Failure (Excessive Drain)
Engine Does Not Crank	• Dead Battery • Ground Loss • Ancillary Components Binding or Seized • OEM Shutdown - Oil Level Safety • Starter Lockout Relay Failure • Ignition Switch Failure • Bad Starter • Crank Control Wire Failure • Loose Connection or Corrosion

Engine Performance - While Under Load

SYMPTOM	POSSIBLE CAUSE
Engine Stalls/Quits	• Faulty OEM Drivers Safety Shut-off Seat Switch • Low Battery Voltage • Low Fuel Pressure • OEM Safety Shutdowns • Bad MAP Sensor • Air Restriction • Coil Failure • Fuel Mixer Binding (Dry Fuel)
Runs Rough	• Ground Loss • Misrouted Spark Plug Wires • Fuel System Failure • Vacuum Leak • Wiring Failure • Low Fuel Pressure • Spark Plugs Fouled • Incorrect Valve Timing
Misses	• Fuel System Failure • Misrouted Spark Plug Wires • Spark Plug Gap Too High • Spark Plugs Fouled • Cracked Spark Plug Insulator • Incorrect Valve Timing • Compression Loss
Hesitation/Stumble	• Low Fuel Pressure • Spark Plugs Fouled • MAP Sensor Vacuum Signal Loss
Surge	• Low Fuel Pressure • Map Sensor Failure • Application or Ancillary System Momentarily Binding During Load or Unload
Backfires	• Faulty OEM Drivers Safety Shut-off Seat Switch • Fouled Spark Plugs • Spark Plug Wire Broke • GCP Momentary Ground Loss • Excess Lean Condition • Fuel Lock-Off Leaking (Dry Fuel) • Intake Manifold Leak • Bad Intake Valve
Lack of Power	• Ancillary Components Binding • Intake Air Restriction • Crossed Spark Plug Wires • Spark Plugs Fouled • Fuel System Failure • Low Fuel Pressure • Low Cylinder Compression
Spark Knock	• Poor Quality or Contaminated Fuel • Carbon Build-up • Wrong Spark Plugs (Too High Heat Range) • Fuel Delivery System • PCV System • Fuel Selection Timing • Cylinder Hot Spots

Engine Concerns

SYMPTOM	POSSIBLE CAUSE
Oil System Concerns **- High Oil Consumption**	• Positive Crankcase Ventilation (PCV) System • Oil Viscosity • External Leaks • Improper Oil Dipstick • Valve Seals • Cylinder Wall Taper Excessive • Worn Piston Rings
Cooling System Concerns	• Trapped Air • Worn Drive Belt • Worn Water Pump • Stuck Thermostat • Plugged Radiator (Internal & External) • Dry Fuel System Running Rich
Exhaust System Concerns (visible smoke)	
- Black Smoke	• Ignition System • Fuel Delivery System • Sticking Fuel Injector • High Fuel Pressure
- Blue Smoke	• PCV System • Worn Piston Rings • Worn Valve Guides
Fuel System Concerns	• Leaky Lines • Contaminated Fuel • Excessive Alcohol in Fuel • Incorrect Octane Rating
Engine Noise	• Low Oil Pressure • Oil Filter Restriction

Engine Control Module (GCP) - Diagnostic Trouble Codes

CAUTION: When checking codes with the diagnostic software, the DTC terminal can NOT be grounded.

CAUTION: Removing battery power before accessing diagnostic program will erase all codes recorded.

This section contains circuit description information and troubleshooting charts on all the DTC's obtained by diagnostic software or a Malfunction Indicator Lamp (MIL). When diagnostic trouble codes are obtained by a Malfunction Indicator Lamp (MIL), the following sequence will be flashed:

- 123 will flash 3 times to indicate the beginning of the flash code display sequence.
- Any active DTC's will flash 3 times each.
- 123 will flash 3 times indicating the end of the code display sequence.

If code 123 is the only code present, the system does not have any active codes - all systems are working fine.

If an active DTC is present, refer to the corresponding DTC chart. Begin with the lowest number code first.

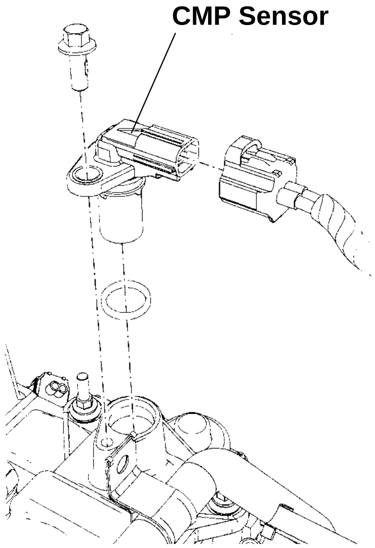
NOTE: If you have a symptom of the pedal not working, and no DTC is set, go to the voltage screen and check pedal voltage. If pedal voltage is .75 - 1.25 volts, and idle validation switch says you're at idle - replace the pedal.

Diagnostic Trouble Code (DTC)	
DTC 111	Closed Loop Multiplier High (LPG)
DTC 112	HO2S Open/Inactive (Bank 1)
DTC 113	HO2S Open/Inactive (Bank 2)
DTC 121	Closed Loop Multiplier High Bank 1 (Gasoline)
DTC 122	Closed Loop Multiplier Low Gank 1 (Gasoline)
DTC 124	Closed Loop Multiplier Low (LPG)
DTC 125	Closed Loop Multiplier High (Natural Gas)
DTC 126	Closed Loop Multiplier Low (Natural Gas)
DTC 131	Closed Loop Multiplier High Bank 2 (Gasoline)
DTC 132	Closed Loop Multiplier Low Bank 2 (Gasoline)
DTC 141	Adaptive Lean Fault (High Limit - Gasoline)
DTC 142	Adaptive Rich Fault (Low Limit Gasoline)
DTC 143	Adaptive Learn High (LPG)
DTC 144	Adaptive Learn Low (LPG)
DTC 145	Adaptive Learn High (Natural Gas)
DTC 146	Adaptive Learn Low (Natural Gas)
DTC 161	System Voltage Low
DTC 162	System Voltage High
DTC 211	IAT High Voltage
DTC 212	IAT Low Voltage
DTC 213	IAT Higher Than Expected 1
DTC 214	IAT Higher Than Expected 2
DTC 215	Oil Pressure Low
DTC 221	CHT/ECT High Voltage
DTC 222	CHT/ECT Low Voltage
DTC 223	CHT Higher Than Expected 1
DTC 224	CHT Higher Than Expected 2
DTC 231	MAP High Pressure
DTC 232	MAP Low Voltage
DTC 234	BP High Pressure
DTC 235	BP Low Pressure
DTC 242	Crank Sync Noise
DTC 243	Never Crank Synced At Start
DTC 244	Camshaft Sensor Loss
DTC 245	Camshaft Sensor Noise
DTC 253	Knock Sensor Open
DTC 254	Excessive Knock Signal
DTC 311	Injector Driver #1 Open
DTC 312	Injector Driver #1 Shorted
DTC 313	Injector Driver #2 Open
DTC 314	Injector Driver #2 Shorted
DTC 315	Injector Driver #3 Open
DTC 316	Injector Driver #3 Shorted
DTC 321	Injector Driver #4 Open
DTC 322	Injector Driver #4 Shorted
DTC 351	Fuel Pump Loop Open or High Side Short to Ground
DTC 352	Fuel Pump High Side Shorted to Power

Diagnostic Trouble Code (DTC)	
DTC 353	MegaJector Delivery Pressure Higher than Expected
DTC 354	MegaJector Delivery Pressure Lower than Expected
DTC 355	MegaJector Communication Lost
DTC 361	MegaJector Voltage Supply High
DTC 362	MegaJector Voltage Supply Low
DTC 363	MegaJector Internal Actuator Fault Detection
DTC 364	MegaJector Internal Circuitry Fault Detection
DTC 365	MegaJector Internal Communication Fault Detection
DTC 411	Coil Driver #1 Open
DTC 412	Coil Driver #1 Shorted
DTC 413	Coil Driver #2 Open
DTC 414	Coil Driver #2 Shorted
DTC 511	FPP1 High Voltage
DTC 512	FPP1 Low Voltage
DTC 513	FPP1 Higher Than IVS Limit
DTC 514	FPP1 Lower Than IVS Limit
DTC 521	FPP2 High Voltage
DTC 522	FPP2 Low Voltage
DTC 531	TPS1 (Signal Voltage) High
DTC 532	TPS1 (Signal Voltage) Low
DTC 533	TPS2 (Signal Voltage) High
DTC 534	TPS2 (Signal Voltage) Low
DTC 535	TPS1 Higher Than TPS2
DTC 536	TPS1 Lower Than TPS2
DTC 537	Throttle Unable to Open
DTC 538	Throttle Unable to Close
DTC 545	Governor Interlock Failure
DTC 551	Max Govern Speed Override
DTC 552	Fuel Rev Limit
DTC 553	Spark Rev Limit
DTC 611	COP Failure
DTC 612	Invalid Interrupt
DTC 613	A/D Loss
DTC 614	RTI 1 Loss
DTC 615	Flash Checksum Invalid
DTC 616	RAM Failure
DTC 631	External 5V Ref Lower Than Expected
DTC 632	External 5V Ref Higher Than Expected
DTC 655	RTI 2 Loss
DTC 656	RTI 3 Loss

REMOVAL AND INSTALLATION

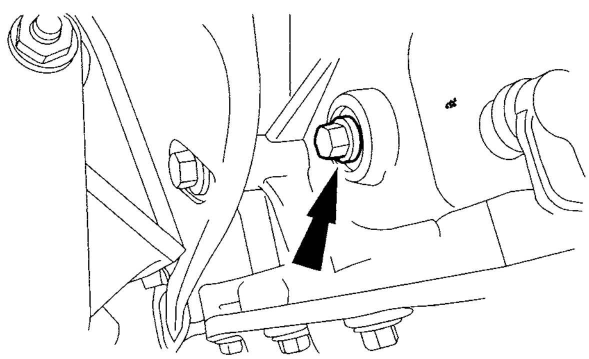
Camshaft Position (CMP) Sensor - Replacement



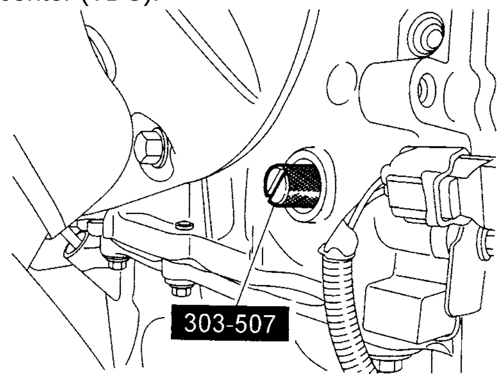
1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the CMP Sensor.
3. Disconnect CMP electrical connector.
4. Remove bolt and CMP Sensor.
5. Reverse procedure to install:
   - Use a new o-ring seal
   - Lubricate o-ring with clean engine oil prior to installation
   - Tighten bolt to 7 Nm (62 lb-in).

Crankshaft Position (CKP) Sensor - Removal

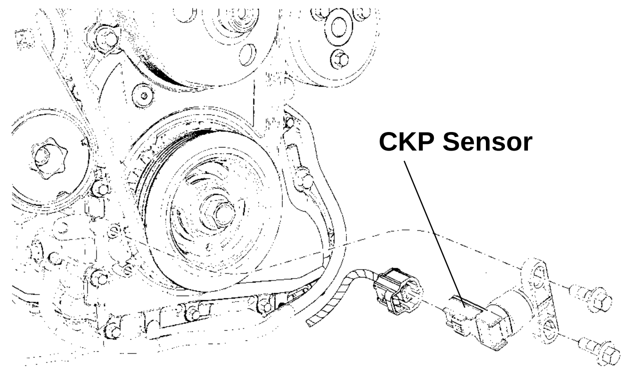
1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the CKP Sensor.
3. Disconnect CKP electrical connector.
4. Remove plug.



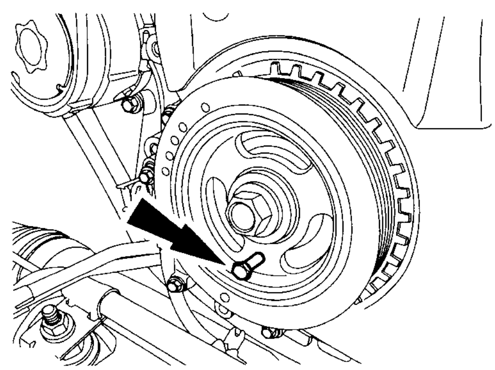
5. Install special tool 303-507 and turn the crankshaft pulley bolt to position the No. 1 cylinder at top dead center (TDC).



6. Remove 2 bolts and CKP sensor.



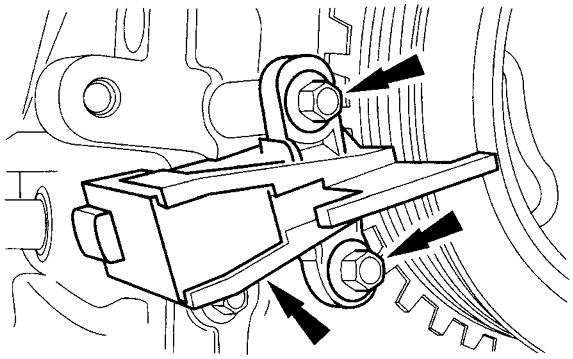
7. Install an M6 bolt in the position shown.



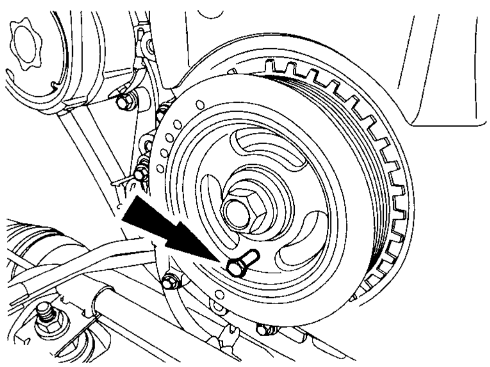
Crankshaft Position (CKP) Sensor - Installation

1. Position CKP sensor and loosely install the 2 bolts.

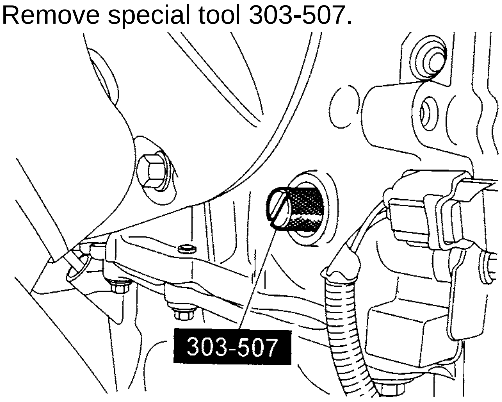
NOTE: The CKP sensor alignment tool is supplied with the new sensor and is not available separately.



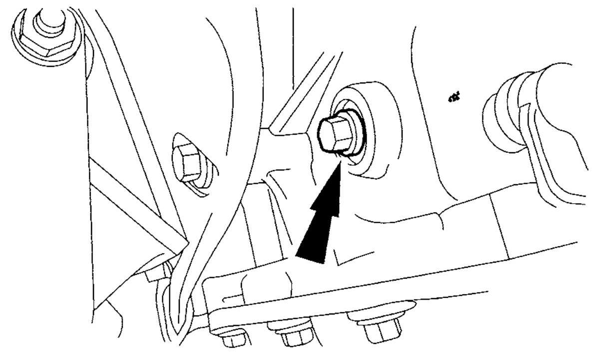
2. Adjust the CKP sensor with the alignment tool and tighten 2 bolts.
   - Tighten to 7 Nm (62 lb-in).
3. Connect CKP sensor electrical connector
4. Remove the M6 bolt.



5. Remove special tool 303-507.

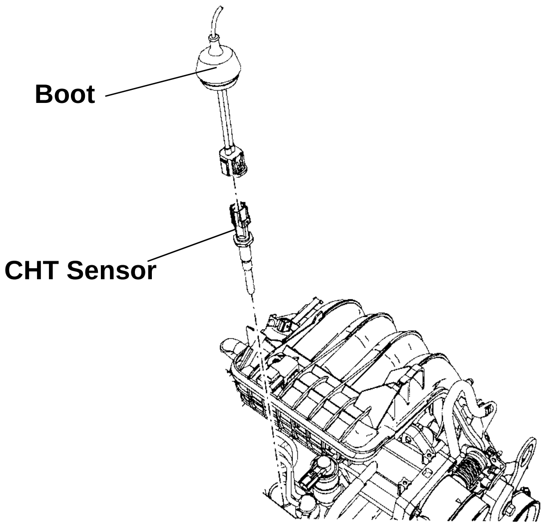


6. Install the plug:
   - Tighten to 10 Nm (89 lb-in)



7. Reconnect or install any other component that was removed.
8. Reconnect battery cable -- refer to section 6.

Cylinder Head Temperature (CHT) Sensor - Replacement

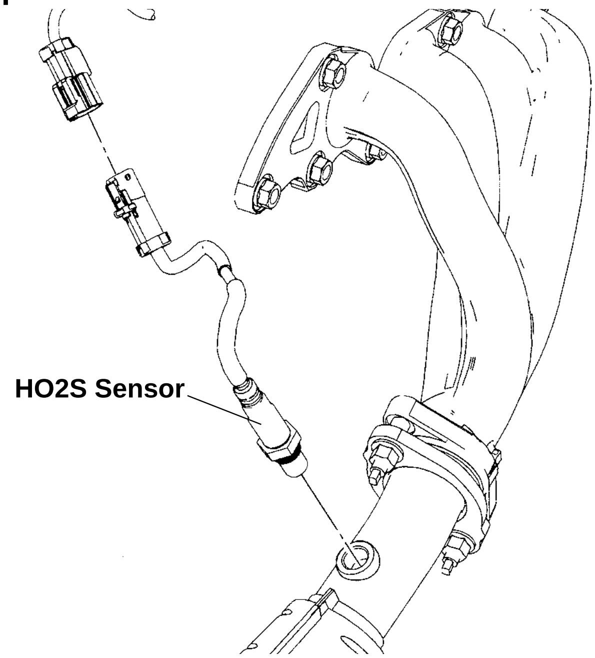


1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the CHT Sensor.
3. Pull back the CHT sensor cover and disconnect electrical connector.
4. Remove the CHT Sensor.
5. Reverse procedure to install:
    - Tighten CHT sensor to 12 Nm (9 lb-ft).

Engine Coolant Temperature (ECT) Sensor - Replacement

(??need procedure??)

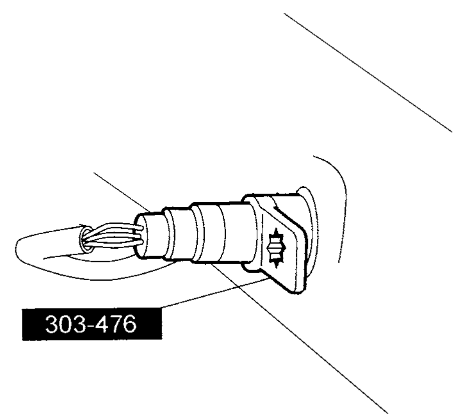
Heated Oxygen Sensor (HO2S) - Replacement



1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the HO2S Sensor.
3. Disconnect HO2S electrical connector.

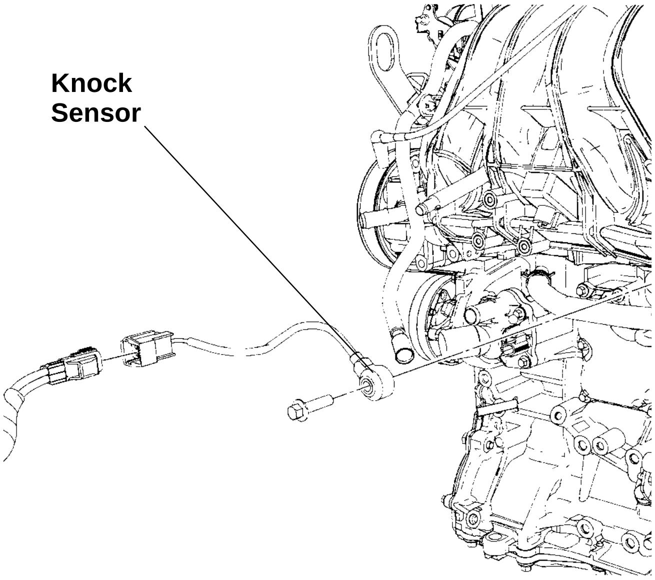
NOTE: Use penetrating oil to assist in removal.

4. Remove HO2S sensor using special tool 303-476.



5. Reverse procedure to install:
    - Apply a light coat of anti-seize lubricant to the threads of the sensor.
    - Tighten sensor to 40 Nm (30 lb-ft).

Knock Sensor (KS) - Replacement

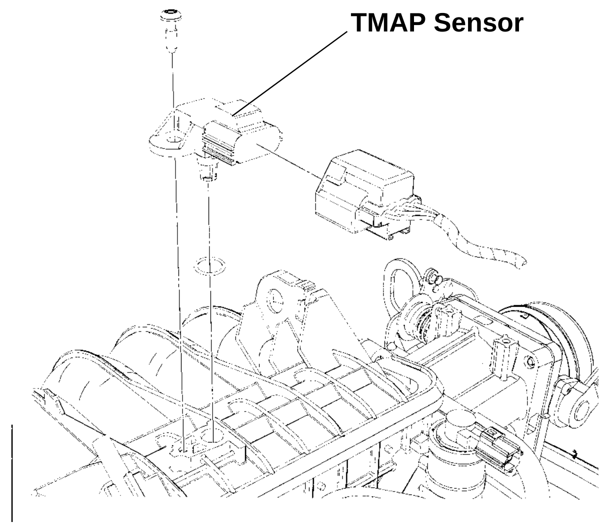


1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the knock sensor.
3. Disconnect KS sensor electrical connector.

NOTE: The KS sensor is a one-time use item and a new KS sensor must be installed.

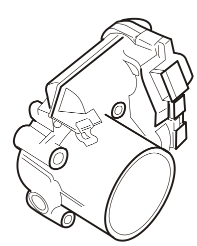
4. Remove bolt and KS sensor and discard sensor.
5. Reverse procedure to install:
    - Install a new KS sensor
    - Tighten bolt to 20 Nm (15 lb-ft).

Temperature Manifold Absolute Pressure (TMAP) Sensor - Replacement



1. Disconnect battery ground cable -- refer to section 6.
2. Remove or disconnect any component to allow access and removal of the TMAP sensor.
3. Disconnect TMAP electrical connector.
4. Remove bolt and TMAP Sensor.
5. Reverse procedure to install:
    - Use a new o-ring seal
    - Tighten bolt to ?? Nm (?? lb-??).

Actuator/Throttle Position (TP) Sensor - Replacement



(??need procedure??)

SPECIFICATIONS

GENERAL SPECIFICATIONS	

TORQUE SPECIFICATIONS			
Description	Nm	lb.ft.	lb.in.
CHT Sensor	12		9
CMP Sensor	7		62
CKP Sensor	7		62
ECT Sensor			
HO2S Sensor	40	30	
Knock Sensor	20	15	
TMAP Sensor			

SPECIAL TOOLS	
HO2S Removal Tool	303-476

INDEX

Subject	Page

INTRODUCTION

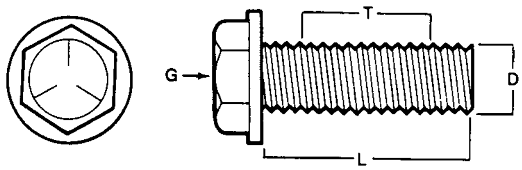
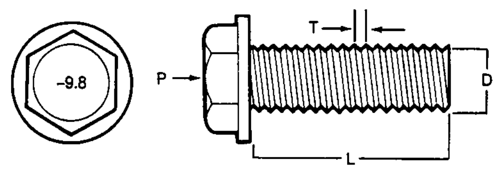
Most threaded fasteners are covered by specifications that define required mechanical properties, such as tensile strength, yield strength, proof load and hardness. These specifications are carefully considered in initial selection of fasteners for a given application. To ensure continued satisfactory vehicle performance, replacement fasteners used should be of the correct strength, as well as the correct nominal diameter, thread pitch, length, and finish.

Most original equipment fasteners (English or Metric system) are identified with markings or numbers indicating the strength of the fastener. These markings are described in the pages that follow. Attention to these markings is important to ensure that the proper replacement fasteners are used.

Further, some metric fasteners, especially nuts, are colored blue. This metric blue identification is in most cases a temporary aid for production start-up, and color will generally revert to normal black or bright after start-up.

English or Metric system fasteners are available through your Ford Parts and Service operation.

NOMENCLATURE FOR BOLTS

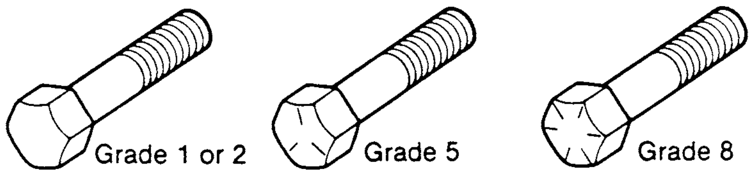
English System Bolt, 1/2 - 13 x 1	**Metric System Bolt, M12 - 1.75 x 25**
 FPP03570	 FPP03571
G = Grade Marking (bolt strength) L = Length (inches) ** T = Thread Pitch (thread/inch) D = Nominal Diameter (inches)	P = Property Class (bolt strength) * L = Length (millimeters) ** T = Thread Pitch (thread width crest to crest mm) D = Nominal Diameter (millimeters)

* The Property class is an Arabic numeral distinguishable from the slash SAE English grade system.

** The length of all bolts is measured from the underside of the head to the end.

BOLT STRENGTH IDENTIFICATION

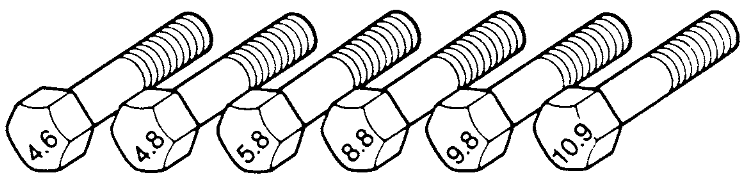
English System



FPP03572

English (inch) bolts: Identification marks correspond to bolt strength, increasing number of slashes represent increasing strength.

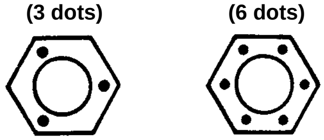
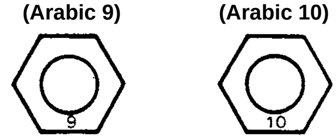
Metric System



FPP03573

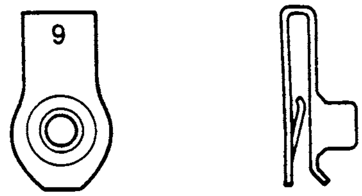
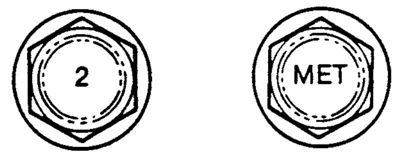
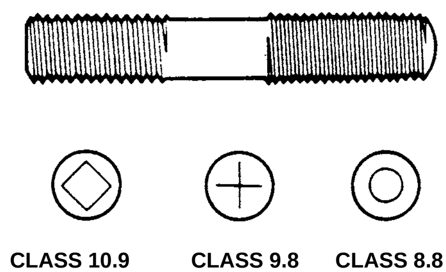
Metric (mm) bolts: Identification class numbers correspond to bolt strength, increasing numbers represent increasing strength. Common metric fastener bolt strength property are 9.8 and 10.9 with the class identification embossed on the bolt head.

HEX NUT STRENGTH IDENTIFICATION

<table>
<tr><th>English System - Grade Identification</th><th>Metric System - Class Identification</th></tr>
<tr><td>HEX NUT Grade 5 (3 dots) HEX NUT Grade 8 (6 dots)

FPP03574</td><td>HEX NUT Property Class 9 (Arabic 9) HEX NUT Property Class 10 (Arabic 10)

FPP03575</td></tr>
<tr><td>Increasing dots represent increasing strength.</td><td>May also have blue finish or paint daub on hex flat. Increasing numbers represent increasing strength.</td></tr>
</table>

OTHER TYPES OF PARTS

Metric identification schemes vary by type of part, most often a variation of that used of bolts and nuts. Note that many types of English and Metric fasteners carry no special identification if they are otherwise unique.

Stamped U-Nuts	 FPP03576
Tapping, thread forming and certain other case hardened screws	 FPP03577
Studs, Large studs may carry the property class number. Smaller studs use a geometric code on the end.	 FPP03578

ENGLISH/METRIC CONVERSION

TO CONVERT FROM TO	TO FROM	MULTIPLY BY DIVIDE BY
Distance		
inches	mm	25.4
inches	m	0.0254
feet	mm	304.8
feet	m	0.3048
yards	m	0.9144
mile	km	1.609
Area		
in^2	mm^2	645.16
$ft.^2$	m^2	0.0929
$ft.^2$	cm^2	6.45
yds^2	m^2	0.8361
Volume		
in^3	cm^3	16.3871
in^3	mm^3	16387.0
in^3	1 liter	0.016387
$yard^3$	m^3	0.7646
pint (us)	1 liter	0.47318
pint (uk)	1 liter	0.56826
quart (us)	1 liter	0.94635
gallon (us)	1 liter	3.7854
gallon (uk)	1 liter	4.5461
$ft.^3$	1 liter	28.3168
$ft.^3$	m^3	0.02832
Mass		
oz.	g	28.3495
lb.	kg	0.45359
ton	kg	907.18
ton (US)	tonne	0.90718
ton (UK)	tonne	1.01605
Density		
Force		
lbf	Newton (N)	4.44822
kilogram	Newton (N)	9.807
ounce	Newton (N)	0.2780
Pressure & Stress		
1000 kpa	Bar	1000
lbf/in^2 (psi)	kPa	6.895
lbf/in^2 (psi)	N/M^2	6894.76
lbf/in^2 (psi)	Bar	0.0689
lbf/in^2 (psi)	N/mm^2	0.00689
lbf/m^2 (psi)	mmHg	51.715
“H2O	kPa	0.2491
“H2O	mmH2O	25.4
“Hg	mmHG	25.4
ton (US)/in^2	N/mm^2	13.7894
ton (UK)/in^2	N/mm^2	15.4443
Velocity		
ft./sec.	m/s	0.3048
ft./sec.	km/h	1.09728
miles/h	m/s	0.44694
miles/h	km/h	1.609
Acceleration		
in./sec^2	m/s^2	0.0254
ft./sec^2	m/s^2	0.3048
Light		
foot candle	lumens/sq meter	10.764

TO CONVERT FROM TO	TO FROM	MULTIPLY BY DIVIDE BY
Energy		
kW.h	Joules (J)	3,600,000
lb/ft	Joules (J)	1.3558
Btu	Joules (J)	1055.06
Kcal	Joules (J)	4186.8
HP.h	kW.h	0.7457
PS.h	kW.h	0.7355
Temperature		
degree Farenheit (°F)	degree Celsius (°C)	(°F-32) x 0.556
Torque		
lb./ft.	Nm	1.35582
lb./in.	Nm	0.11298
Power		
HP	kW	0.7457
PS	kW	0.7355
HP	PS	1.01387
Specific Fuel Consumption		
lb./hp.h	g/kW.h	608.277
miles/gal	kilometers/liter (km/L)	0.4251
gal/miles	liters/kilometer (L/km)	2.3527

DECIMAL AND METRIC EQUIVALENTS

FRACTIONS	DECIMAL INCH	METRIC MM
1/64	.015625	.397
1/32	.03125	.794
3/64	.046875	1.191
1/16	.0625	1.588
5/64	.078125	1.984
3/32	.09375	2.381
7/64	.109375	2.778
1/8	.125	3.175
9/64	.140625	3.572
5/32	.15625	3.969
11/64	.171875	4.366
3/16	.1875	4.763
13/64	.203125	5.159
7/32	.21875	5.556
15/64	.234375	5.953
1/4	.250	6.35
17/64	.265625	6.747
9/32	.28125	7.144
19/64	.296875	7.54
5/16	.3125	7.938
21/64	.328125	8.334
11/32	.34375	8.731
23/64	.359375	9.128
3/8	.375	9.525
25/64	.390625	9.922
13/32	.40625	10.319
27/64	.421875	10.716
7/16	.4375	11.113
29/64	.453125	11.509
15/32	.46875	11.906
31/64	.484375	12.303
1/2	.500	12.7
33/64	.515625	13.097
17/32	.53125	13.494
35/64	.546875	13.891
9/16	.5625	14.288
37/64	.578125	14.684
19/32	.59375	15.081
39/64	.609375	15.478
5/8	.625	15.875
41/64	.640625	16.272
21/32	.65625	16.669
43/64	.671875	17.066
11/16	.6875	17.463
45/64	.703125	17.859
23/32	.71875	18.256
47/64	.734375	18.653
3/4	.750	19.05
49/64	.765625	19.447
25/32	.78125	19.844
51/64	.796875	20.241
13/16	.8125	20.638
53/64	.828125	21.034
27/32	.84375	21.431
55/64	.859375	21.828
7/8	.875	22.225
57/64	.890625	22.622
29/32	.90625	23.019
59/64	.921875	23.416
15/16	.9375	23.813
61/64	.953125	24.209
31/32	.96875	24.606
63/64	.984375	25.003
1	1.00	25.4

TORQUE CONVERSION

Newton Meters (Nm)	Pound Feet (lb-ft)
1	0.7376
2	1.5
3	2.2
4	3.0
5	3.7
6	4.4
7	5.2
8	5.9
9	6.6
10	7.4
15	11.1
20	14.8
25	18.4
30	22.1
35	25.8
40	29.5
50	36.9
60	44.3
70	51.6
80	59.0
90	66.4
100	73.8
110	81.1
120	88.5
130	95.9
140	103.3
150	110.6
160	118.0
170	125.4
180	132.8
190	140.1
200	147.5
225	166.0
250	184.4

Newton Meters (Nm)	Pound Feet (lb-ft)
1	1.356
2	2.7
3	4.0
4	5.4
5	6.8
6	8.1
7	9.5
8	10.8
9	12.2
10	13.6
15	20.3
20	27.1
25	33.9
30	40.7
35	47.5
40	54.2
45	61.0
50	67.8
55	74.6
60	81.4
65	88.1
70	94.9
75	101.7
80	108.5
90	122.0
100	135.6
110	149.1
120	162.7
130	176.3
140	189.8
150	203.4
160	216.9
170	230.5
180	244.0

J1930 TERMINOLOGY LIST

Certain Ford Component names have been changed in this Service Manual to conform to Society of Automotive Engineers (SAE) directive J1930.

SAE J1930 standardizes automotive component names for all vehicle manufacturers.

New Term	New Acronym	Old Terms (Acronyms)
Accelerator Pedal	AP	Accelerator
Air Cleaner	ACL	Thermac Air Cleaner
Air Cleaner Element	ACL Element	Air Cleaner Element (ACL Element)
Air Cleaner Housing	ACL Housing	Air Cleaner Housing (ACH)
Air Cleaner Housing Cover	ACL Housing Cover	Air Cleaner Housing Cover (ACL Housing Cover)
Air Conditioning	A/C	Air Conditioning (AC)
Air Conditioning Clutch	A/C Clutch	Air Conditioning Clutch (ACC)
Air Conditioning Cycling Switch	A/C Cycling Switch	Air Conditioning Cycling Switch (ACCS)
Air Conditioning Sensor	A/C Sensor	Air Conditioning Sensor (A/C Sensor)
Air Conditioning System	A/C System	Air Conditioning System (SCS)
Automatic Transaxle	A/T	Electronic Automatic Transaxle (EATX)
Automatic Transmission	A/T	Electronic Automatic Transmission (EATX)
Barometric Pressure	BARO	Barometric Pressure (BARO)
Barometric Pressure Sensor	BARO Sensor	- Absolute Pressure Sensor (APS) - Barometric Pressure Sensor (BP Sensor
Battery Positive Voltage	B+	Battery Positive Voltage (B+)
Camshaft Position	CMP	Sync Pickup
Camshaft Position Sensor	CMP Sensor	- Camshaft Position Sensor (CPS) - Camshaft Sensor - Cylinder Identification Sensor (Cylinder ID Sensor) (CID)
Canister	Canister	Canister
Carburetor	CARB	Feed Back Carburetor (FBC)
Central Multiport Fuel Injection	Central MFI	- Central Multiport Fuel Injection (CMFI) - Fuel Injection (FI)
Charge Air Cooler	CAC	- After Cooler - Inter Cooler
Closed Loop	CL	Closed Loop System (CLS)
Closed Throttle Position	CTP	Closed Throttle Position (CTP)
Closed Throttle Position Switch	CTP Switch	Closed Throttle Switch
Clutch Pedal Position	CPP	Clutch Pedal Position (CPP)
Clutch Pedal Position Switch	CPP Switch	- Clutch Engage Switch (CES) - Clutch Start Switch - Clutch Switch
Compact Disc Read Only memory	CDROM	Compact Disc Read Only Memory (CDROM)

New Term	New Acronym	Old Terms (Acronyms)
Continuous Fuel Injection	CFI	- Continuous Injection System (CIS) - Continuous Injection System - Electronic (continuous Injection System-E) (CIS-E) - Fuel Injection (FI) - K-Jetronic - KE-Jetronic - KE-Motronic
Continuous Fuel Injection system	CFI System	Continuous Injection System (CIS)
Continuous Trap Oxidizer	CTOX	- Continuous Trap Oxidizer (CTO) - Trap Oxidizer - Continuous (TOC)
Crankshaft Position	CKP	- Crankshaft Position (CP) - Position Indicator Pulse (PIP)
Crankshaft Position Sensor	CKP Sensor	- Crankshaft Position Sensor (CPS) - Crank Angle Sensor
Data Link Connector	DLC	- Assembly Line Communication Link (ALCL) - Assembly Line Diagnostic Link (ALDL) - Self Test Connector - Vehicle in Process Connector (VIP Connector)
Diagnostic Test Mode	DTM	Modes
Diagnostic Trouble Code	DTC	Self Test Codes
Differential Pressure Feedback Gas Recirculation System	Differential Pressure Feedback EGR System	Differential Pressure Feedback EGR System
Direct Fuel Injection	DFI	- Direct Injection (DI) - Direct Injection - Diesel (DID) - Fuel Injection (FI)
Distributor Ignition	DI	- Capacitive Discharge Ignition (CDI) - Closed Bowl Distributor - Electronic Ignition (EI) (with Distributor) - Electronic Spark Advance Control (ESAC) - High Energy Ignition (HEI) - Remote Mount Thick Film Ignition (Remote Mount TFI) - Thick Film Ignition (TFI)
Distributor Ignition Capacitor	DI Capacitor	Condenser
Distributor Ignition Control Module	Distributor ICM	Electronic Distributor Ignition System Module (EDIS Module)
Distributor Ignition System	DI System	Electronic Distributor Ignition System (EDIS)
Early Fuel Evaporation	EFE	Early Fuel Evaporation (EFE)
Electrically Erasable Programmable Read Only Memory	EEPROM	Electrically Erasable Programmable Read Only Memory (E2PROM)
Electronic Continuous Fuel Injection System	Electronic CFI System	Continuous Injection System - Electronic (Continuous Injection System-E) (CIS-E)
Electronic engine Control	Electronic EC	Electronic Engine Control (EEC)
Electronic Ignition	EI	- Computer Controlled Coil Ignition (C3I) - Distributorless Ignition (DLI) - Electronic Ignition (EI) (without distributor) - Integrated Direct Ignition (IDI)
Electronic Ignition System	EI System	- Direct Ignition System (DIS) - Distributorless Ignition System (DIS) - Electronic Distributorless Ignition System (EDIS)
Engine Control	EC	Electronic Engine Control (EEC)
Engine Control Module	ECM	Engine Control Module (ECM)

New Term	New Acronym	Old Terms (Acronyms)
Engine Coolant Level	ECL	Engine Coolant Level (ECL)
Engine Coolant Level Indicator	ECL Indicator	Engine Coolant Level Indicator
Engine Coolant Temperature	ECT	Engine Coolant Temperature (ECT)
Engine Coolant Temperature Sensor	ECT Sensor	- Coolant Temperature Sensor (CTS) - Engine Coolant Temperature Sender (ECT Sender)
Engine Coolant Temperature Switch	ECT Switch	Coolant Temperature Switch (CTS)
Engine Speed	RPM	- Crankshaft Speed - Revolutions Per Minute (RPM)
Engine Speed Sensor	RPM Sensor	Crankshaft Speed Sensor
Erasable Programmable Read Only Memory	EPROM	Erasable Programmable Read Only Memory (EPROM)
Evaporative Emission	EVAP	Evaporative Emission (EVAP)
Evaporative Emission Canister	EVAP Canister	- Canister - Charcoal Canister
Evaporative Emission Canister Purge	EVAP Canister Purge	- EVAP CANP - Canister Purge (CANP)
Evaporative Emission Canister Purge Valve	EVAP Canister Purge Valve	- Canister Purge Valve - Canister Purge Vacuum Switching Valve (Canister Purge VSV) - Duty Solenoid for Purge Valve - Evaporative Emission Purge Valve (EVAP Purge Valve) - Vacuum Solenoid Valve (Canister) (VSV) - Vacuum Solenoid Valve (EVAP) (VSV)
Evaporative Emission System	EVAP System	Evaporation Emission Control System (EECS)
Exhaust Gas Recirculation	EGR	Digital Exhaust Gas Recirculation (Digital EGR)
Exhaust Gas Recirculation Backpressure Transducer	EGR Backpressure Transducer	Backpressure Transducer
Exhaust Gas Recirculation Diagnostic Valve	EGR Diagnostic	EGR Diagnostic Valve
Exhaust Gas Recirculation System	EGR System	EGR System
Exhaust Gas Recirculation Temperature	EGRT	EGR Temperature
Exhaust Gas Recirculation Temperature Sensor	EGRT Sensor	Recirculated Exhaust Gas Temperature Sensor (REGTS)
Exhaust Gas Recirculation Thermal Vacuum Valve	EGR TVV	EGR Thermal Vacuum Valve (EGR TVV)
Exhaust Gas Recirculation Vacuum Regulator Solenoid	EGR Vacuum Regulator Solenoid	EGR Vacuum Regulator Solenoid (EVR Solenoid)
Exhaust Gas Recirculation Vacuum Regulator Valve	EGR Vacuum Regulator Valve	EGR Vacuum Regulator Valve (EVRV)
Exhaust Gas Recirculation Valve	EGR Valve	EGR Valve (EGRV)
Exhaust Gas Recirculation Valve Control	EGR Valve Control	EGR Valve Control (EGRVC)
Exhaust Gas Recirculation Valve Position Sensor	EGR Valve Position Sensor	EGR Valve Position Sensor (EVP Sensor)
Fan Control	FC	- Electro-Drive Fan Control (EDF Control) - Engine Coolant Fan Control - High Electro-Drive Fan Control (HEDF Control) - Radiator Fan Control
Fan Control Module	FC Module	Fan Control Module

New Term	New Acronym	Old Terms (Acronyms)
Fan Control Relay	FC Relay	- Fan Motor Control Relay - Radiator Fan Relay
Feedback Pressure Exhaust Gas Recirculation	Feedback Pressure EGR	Pressure Feedback Exhaust Gas Recirculation
Feedback Pressure Exhaust Gas Recirculation Sensor	Feedback Pressure EGR Sensor	Pressure Feedback Exhaust Gas Recirculation (PFE) Sensor
Flash Electrically Erasable Programmable Read Only Memory	FEEPROM	Flash EEPROM
Flash Erasable Programmable Read Only Memory	FEPROM	Flash EPROM
Flexible Fuel	FF	Flexible Fuel (FF)
Flexible Fuel Sensor	FF Sensor	- Alcohol Concentration Sensor - Fuel Concentration Sensor - Fuel Quality Sensor - Percent Alcohol Sensor - Variable Fuel Sensor
Forth Gear	4GR	Fourth Gear (4GR)
Fuel Level Sensor	Fuel Level Sensor	Fuel Sensor
Fuel Pressure	Fuel Pressure	Fuel Pressure
Fuel Pressure Regulator	Fuel Pressure Regulator	Fuel Regulator
Fuel Pump	FP	Fuel Pump (FP)
Fuel Pump Module	FP Module	- Fuel Module - Fuel Sender - Fuel Tank Unit - In Tank Module
Fuel Pump Relay	FP Relay	Fuel Pump Relay
Fuel Trim	FT	Adaptive Fuel Strategy
Generator	GEN	Alternator (ALT)
Governor	Governor	Governor
Governor Control Module	GCM	Governor Electronic Module (GEM)
Ground	GND	Ground (GRD)
Heated Oxygen Sensor	HO2S	- Heated Exhaust Gas Oxygen Sensor (HEGO Sensor) - Heated Oxygen Sensor (HOS)
High Speed Fan Control Switch	High Speed FC Switch	High speed Fan Control Switch (High Speed FC Switch)
Idle Air Control	IAC	- Idle Air Bypass Control - Idle speed Control (ISC) - Idle Speed Control Bypass air (ISC BPA)
Idle Air Control Thermal Valve	IAC Thermal Valve	Fast Idle Thermo Valve
Idle Air Control Valve	IAC Valve	- Air Valve - Fast Idle Thermo Valve - Idle Air Control Valve (IACV)
Idle Speed Control	ISC	Throttle Opener
Idle Speed Control Actuator	ISC Actuator	Idle Speed Control Actuator (ISC Actuator)
Idle Speed Control Solenoid Vacuum	ISC Solenoid Vacuum Valve	- Throttle Opener Vacuum Switching Valve (Throttle Opener VSV) - Vacuum Solenoid Valve (Throttle) (VSV)

New Term	New Acronym	Old Terms (Acronyms)
Ignition Control	IC	- Electronic Spark Advance (ESA) - Electronic spark Timing (EST)
Ignition Control Module	ICM	- Distributorless Ignition System Module (DIS Module) - Thick Film Ignition Module (TFI Module)
Indirect Fuel Injection	IFI	- Fuel Injection (FI) - Indirect Fuel Injection (IDFI) - Indirect Diesel Injection (IDI)
Inertia Fuel Shutoff	IFS	Inertia Fuel Shutoff (IFS)
Inertia Fuel Shutoff Switch	IFS Switch	- Inertia Switch - Inertia Fuel - Shutoff Switch
Intake Air	IA	Intake Air
Intake Air Duct	IA Duct	Intake Air Duct
Intake Air System	IA System	Air Intake System
Intake Air Temperature	IAT	- Air Charge Temperature (ACT) - Manifold Air Temperature (MAT) - Throttle Body Temperature (TBT) - Vane Air Temperature (VAT)
Intake Air Temperature Sensor	IAT Sensor	- Air Temperature Sensor (ATS) - Intake Air Temperature Sensor (IATS) - Manifold Air Temperature Sensor (MATS)
Keep Alive Random Access Memory	Keep Alive RAM	Keep Alive memory (KAM)
Knock Sensor	KS	Detonation Sensor (DS)
Long Term Fuel Trim	Long Term FT	- Block Learn Matrix (BLM) - Block Learn Memory (BLM) - Block Learn Multiplier (BLM)
Low Speed Fan Control Switch	Low Speed FC Switch	Low Speed Fan Control Switch (Low Speed FC Switch)
Malfunction Indicator Lamp	MIL	- Check Engine - Service Engine Soon
Manifold Absolute Pressure	MAP	Manifold Absolute Pressure (MAP)
Manifold Absolute Pressure Sensor	MAP Sensor	- Intake Manifold Absolute Pressure Sensor - Manifold Absolute Pressure Sensor (MAPS) - Pressure Sensor (P-Sensor)
Manifold Differential Pressure	MDP	Manifold Differential Pressure (MDP)
Manifold Differential Pressure Sensor	MDP Sensor	Vacuum Sensor (VAC Sensor)
Manifold Surface Temperature	MST	Manifold Surface Temperature (MST)
Manifold Vacuum Zone	MVZ	Manifold Vacuum Zone (MVZ)
Manifold Vacuum Zone Switch	MVZ Switch	Vacuum Switches
Mass Air Flow	MAF	- Air Flow Control (AFC) - Air Flow Meter
Mass Air Flow Sensor	MAF Sensor	- Air Flow Meter - Air Flow Sensor (AFS) - Hot Wire Anemometer
Mixture Control	MC	- Feed Back Control (FBC) - Mixture Control (M/C)
Mixture Control Solenoid	MC Solenoid	Mixture Control Solenoid (MCS)

New Term	New Acronym	Old Terms (Acronyms)
Multiport Fuel Injection	MFI	- D-Jetronic - Digital Fuel Injection (EFI) - Electronic Fuel Injection (EFI) - Fuel Injection (FI) - L-Jetronic - LH-Jetronic - Motronic - Multipoint Injection (MPI) - Multiport Injection (MPI) - Port Fuel Injection (PFI) - Programmed Fuel Injection (PGM-FI) - Tuned Port Injection (TPI)
Nonvolatile Random Access Memory	NVRAM	- Keep Alive Memory (KAM) - Nonvolatile Memory (NVM)
Oil Pressure Sensor	Oil Pressure Sensor	Oil Pressure Sender
Oil Pressure Switch	Oil Pressure Switch	Oil Pressure Switch
On-Board Diagnostic	OBD	Self Test
Open Loop	OL	Open Loop (OL)
Oxidation Catalytic Converter	OC	- Continuous Oxidation Catalyst (COC) - Oxidation Catalyst (OC)
Oxygen Sensor	O2S	- Exhaust Gas Oxygen Sensor (EGO Sensor, EGOS) - Exhaust Gas Sensor (EGS) - Exhaust Oxygen Sensor (EOS) - Lambda - Oxygen Sensor (O2 Sensor, OS)
Park/Neutral Position	PNP	Park/Neutral (P/N)
Park/Neutral Position Switch	PNP Switch	- Neutral Drive Switch (NDS) - Neutral Gear Switch (NGS) - Neutral Position Switch (NPS) - Neutral Safety Switch
Periodic Trap Oxidizer	PTOX	Trap Oxidizer - Periodic (TOP)
Positive Crankcase Ventilation	PCV	Positive Crankcase Ventilation (PCV)
Positive Crankcase Ventilation (Valve)	PCV Valve	Positive Crankcase Ventilation (PCV valve)
Power Steering Pressure	PSP	Power Steering Pressure (PSP)
Power Steering Pressure Switch	PSP Switch	Power Steering Pressure Switch (P/S Pressure Switch, PSPS)
Powertrain Control Module	PCM	- Electronic Control Assembly (ECA) - Electronic Control Unit 4 (ECU4) - Electronic Engine Control Processor (EEC Processor) - Microprocessor Control Unit (MCU) - Single Board Engine Control (SBEC) - Single Module Engine Control (SMEC)
Pressure Transducer Exhaust Gas Recirculation System	Pressure Transducer EGR System	Pressure Transducer EGR System
Programmable Read Only Memory	PROM	Programmable Read Only memory (PROM)
Pulsed Secondary Air Injection	PAIR	- Air Injection Reactor (AIR) - Air Injection Valve (AIV) - Pulsair - Thermactor II
Pulsed Secondary Air Injection Valve	PAIR Valve	Reed Valve
Random Access Memory	RAM	Random Access Memory (RAM)
Read Only memory	ROM	Read Only Memory (ROM)

New Term	New Acronym	Old Terms (Acronyms)
Relay Module	RM	Integrated Relay Module
Scan Tool	ST	Scan Tool
Secondary Air Injection	AIR	- Air Injection (AI) - Air Injection Reactor (AIR) - Thermac - Thermactor
Secondary Air Injection Bypass	AIR Bypass	- Air Management 1 (AM1) - Secondary Air Injection Bypass (AIRB) - Thermactor Air Bypass (TAB)
Secondary Air Injection Bypass Valve	AIR Bypass Valve	Secondary Air Bypass Valve (SABV)
Secondary Air Injection Check Valve	AIR Check Valve	Secondary Air Check Valve
Secondary Air Injection Control Valve	AIR Control Valve	- Air Control Valve - Secondary Air Check Valve (SACV)
Secondary Air Injection Diverter	AIR Diverter	- Air Management2 (AM2) - Secondary Air Injection Diverter (AIRD) - Thermactor Air Diverter (TAD)
Secondary Air Injection Pump	AIR Pump	Air Injection Pump (AIP)
Secondary Air Injection Switching Valve	AIR Switching Valve	Secondary Air Switching Valve (SASV)
Sequential Multiport Fuel Injection	SFI	- Fuel Injection (FI) - Sequential Electronic Fuel Injection (SEFI) - Sequential Fuel Injection (SFI)
Service Reminder Indicator	SRI	- Check Engine - Engine Maintenance Reminder (EMR) - Oxygen Sensor Indicator (OXS) - Service Engine Soon
Short Term Fuel Trim	Short Term FT	Integrator (INT)
Smoke Puff Limiter	SPL	Smoke Puff Limiter (SPL)
Supercharger	SC	Supercharger (SC)
Supercharger Bypass	SCB	Supercharger Bypass (SCB)
Supercharger Bypass Solenoid	SCB Solenoid	Supercharger Bypass Solenoid (SBS)
System Readiness Test	SRT	System Readiness Test (SRT)
Thermal Vacuum Valve	TVV	Thermal Vacuum Switch (TVS)
Third Gear	3GR	Third Gear (3GR)
Three Way Catalytic Converter	TWC	Three Way Catalytic Converter (TWC)
Three Way + Oxidation Catalytic Converter	TWC + OC	Dual Bed
Throttle Body	TB	Fuel Charging Station
Throttle Body Fuel Injection	TBI	- Central Fuel Injection (CFI) - Electronic Fuel Injection (EFI) - Fuel Injection (FI) - Monotronic - Single Point Injection (SPI)
Throttle Position	TP	Throttle Position (TP)
Throttle Position Sensor	TP Sensor	- Throttle Position Sensor (TP) - Throttle Potentiometer
Throttle Position Switch	TP Switch	Throttle Position Switch (TPS)
Torque Converter Clutch	TCC	- Converter Clutch Control (CCC) - Converter Clutch Override (CCO) - Viscous Converter Clutch (VCC)

New Term	New Acronym	Old Terms (Acronyms)
Torque Converter Clutch Relay	TCC Relay	Lock Up Relay
Torque Converter Clutch Solenoid Valve	TCC Solenoid Valve	Lock Up Solenoid Valve (LUS)
Transmission Control Module	TCM	Transmission Control Module
Transmission Range	TR	- Park, Reverse, Neutral, Drive, Low (PRNDL) - Selection Lever Position (SLP) - Transmission Range Selection (TRS)
Transmission Range Sensor	TR Sensor	Manual Lever Position Sensor (MLP Sensor)
Transmission Range Switch	TR Switch	- Manual Range Position Switch (MRPS) - Transmission Position Switch - Transmission Range Selection Switch (TRSS)
Turbocharger	TC	Turbo
Vehicle Speed Sensor	VSS	- Distance Sensor - Pulse Generator (PG)
Voltage Regulator	VR	voltage Regulator (VR)
Volume Air Flow	VAF	- Air Flow Control (AFC) - Air Flow Meter - Vane Air Flow
Volume Air Flow Sensor	VAF Sensor	- Air Flow Meter - Air Flow Sensor (AFS)
Warm Up Oxidation Catalytic Converter	WU-OC	Light Off Catalyst
Warm Up Three Way Catalytic Converter	WU-TWC	Light Off Catalyst
Wide Open Throttle	WOT	Full Throttle
Wide Open Throttle Switch	WOT Switch	Wide Open Throttle Switch (WOTS)

EDI DISTRIBUTORS

North America - Canada

ONTARIO, QUEBEC, MONITOBA	M-K Power Products Corp.	5641 McAdam Road Mississauga, Ontario, Canada, L4Z-1N9	905-890-5323
ALBERTA, SASKATCHEWAN	Industrial Engines, Ltd.	14355 120th Avenue Edmonton, Alberta Canada, T5L 2R8	780-484-6213

North America - United States

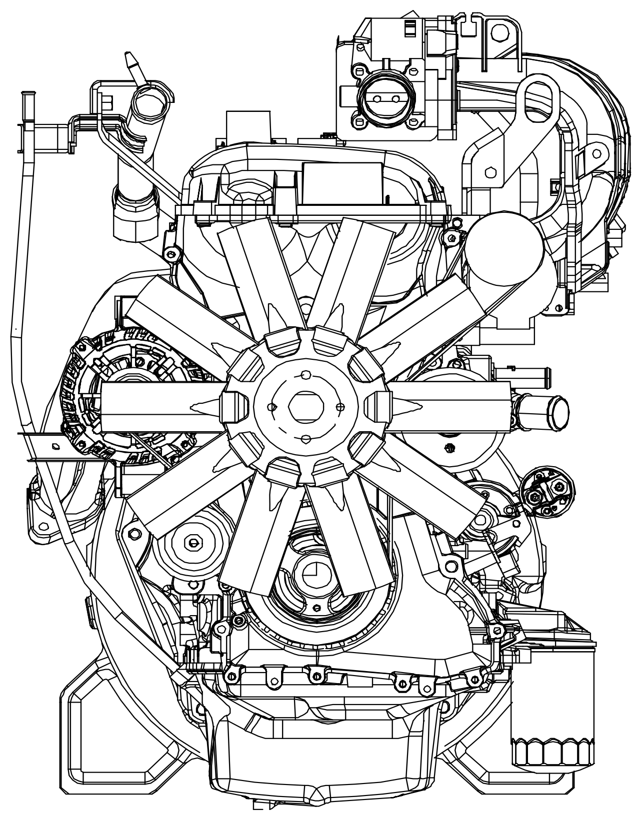
ALABAMA	M&I Ford	30762 State Highway 181 Daphne, AL 36526	800-633-1834
CALIFORNIA	Powertech Engines Inc.	2933 E. Hamilton Avenue Fresno, CA 93721	559-264-1776
FLORIDA	Engine Distributors, Inc.	259 Ellis Rd South Jacksonville, FL 32254	800-342-3576
	Engine Distributors, Inc.	2917 S. W. Second Ave. Fort Lauderdale, FL 33315	800-257-6605
MICHIGAN	Engine Center, Inc.	2351 Hilton Road Ferndale, MI 48220	800-726-8870
MISSOURI	C K Power Products	1100 Research Blvd. St. Louis, MO 63132	314-868-8620
NEBRASKA	Anderson Industrial Engines Co.	5532 Center Street Omaha, NE 68106	402-558-8700
NEW JERSEY	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	800-220-2700
NORTH CAROLINA	Engine Distributors, Inc.	303 Interstate Drive Archdale, NC 27263 3148	800-220-7080
OHIO	Graham Ford Inc.	707 W. Broad St. Columbus, OH 43222	614-464-6000
	North Coast Ford Industrial	11885 Bellaire Road Cleveland, OH 44135	216-251-5800
PENNSYLVANIA	Pitt Auto Electric	1241 Freedom Road Cranberry Twp., PA 16066	724-778-8200
WASHINGTON	Pacific Torque	18060 Des Moines Memorial Drive, Burien, WA 98148	206-241-8300

EDI Worldwide Service
Engine Distributors Inc
400 University Court
Blackwood NJ 08012
Service/Warranty
1-800-220-2700
1-856-228-7298
1-856-228-5657(fax parts & service)
1-856-228-5531(fax sales)

ENGINE DISTRIBUTORS INC.

DSG-423

SERVICE PARTS MANUAL



Ford Power Products

Powertrain Assemblies & Components
Provided By Ford Component Sales

EDI 1060030
June, 2007

GENERAL INFORMATION

This catalog has been prepared to assist you, the owner, in identifying the correct replacement parts for your Ford EDI Industrial Engine.

ILLUSTRATIONS

The illustrations depict mainly typical assemblies but may not in all cases show the exact shape or details of parts required. However, the purpose of the illustrations is to identify parts through visual and descriptive assistance. Illustrations are located immediately adjacent to the applicable text. Parts are identified in each illustration by Ford base numbers. Find the base number of the part desired and match it with the base number in the parts list column. When ordering replacement parts for your engine it will be necessary to contact your local EDI Distributor.

PARTS INFORMATION

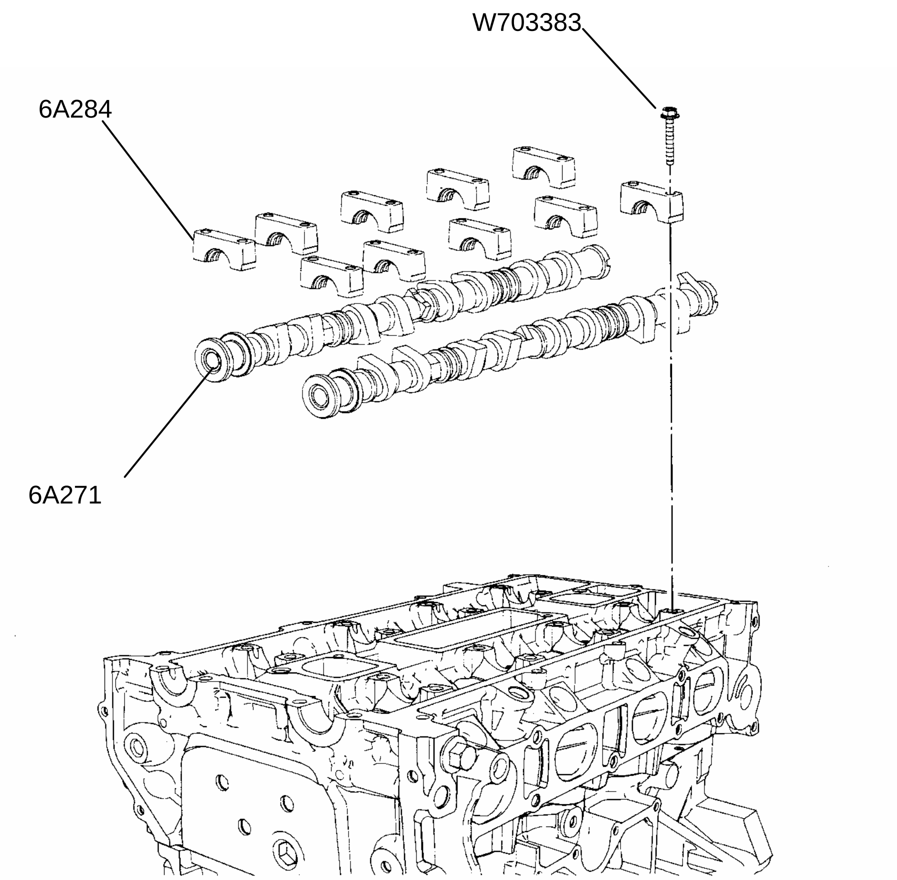
Each listing contains illustrations, base part number, part description and the quantity required to assist in identifying and ordering the correct part.

NOTE: The descriptions and specifications contained in this manual were in effect at the time the book was released for printing. Engine Distributors, Inc. (EDI) reserves the right to discontinue models at any time, or change specifications or design, without notice and without incurring obligation.

Engine Distributors, Inc.
400 University Ct.
Blackwood NJ 08012
800-220-2700

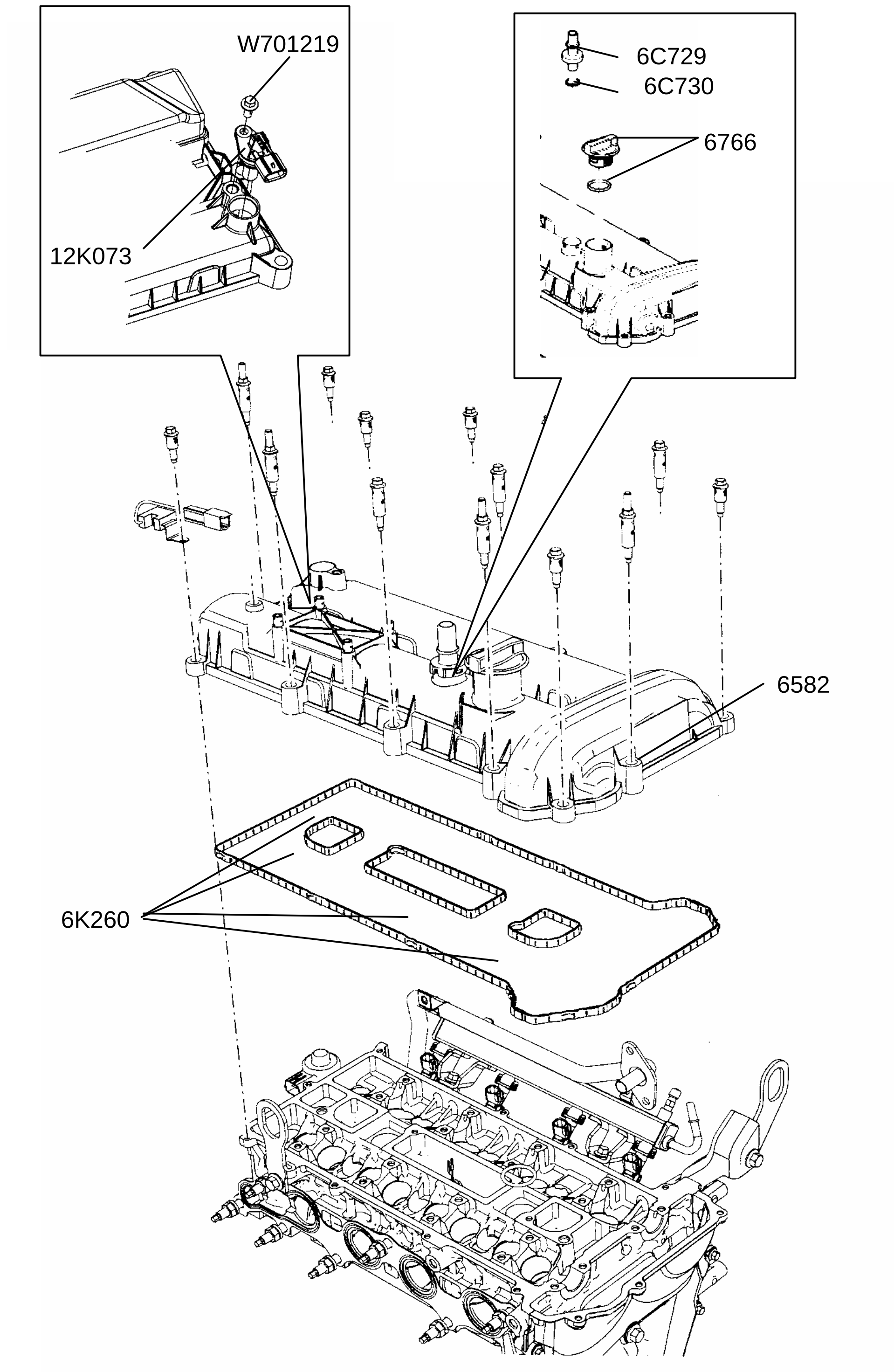
INDEX

CAMSHAFT & BEARINGS



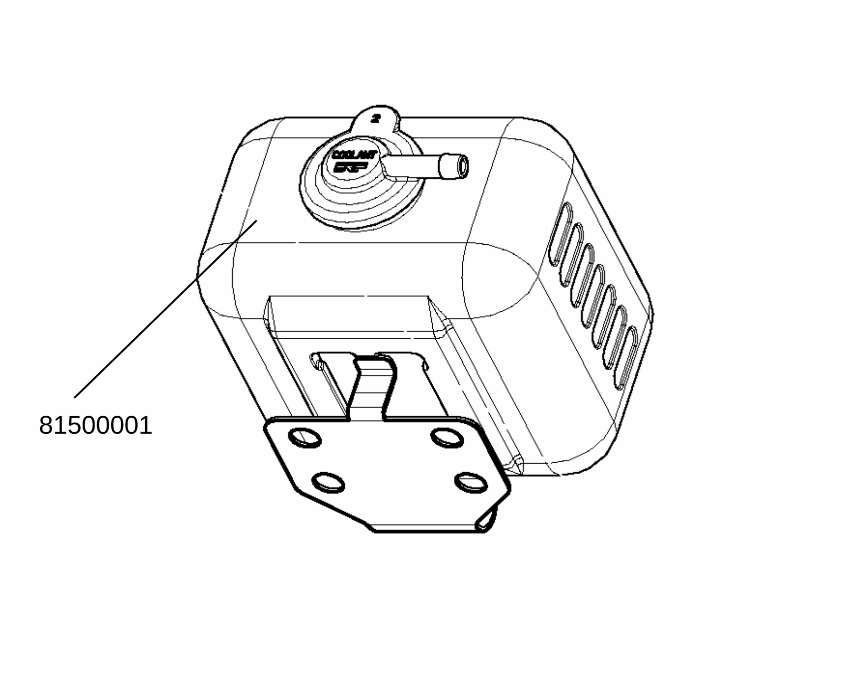
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Camshaft & Bearings**	
	6A284		CAP - CAMSHAFT BEARING (NOT SERVICED SEPARATELY - PART OF CYLINDER HEAD 6049)	8
	6A258		CAP - CAMSHAFT BEARING (NOT SERVICED SEPARATELY - PART OF CYLINDER HEAD 6049)	1
W	703383		BOLT - CAMSHAFT BEARING CAP	20
1S7Z	6250	JA	CAMSHAFT	2

CAMSHAFT COVER & RELATED PARTS



SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Camshaft Cover & Related Parts	
1S7Z	6B288	AA	SENSOR - CAMSHAFT POSITION	1
W	701219	S309	BOLT - CAMSHAFT POSITION SENSOR	2
4L5Z	6582	DA	COVER - CAMSHAFT (INCLUDES BOLTS)	1
1S7G	6K260	AA	GASKET - CAMSHAFT COVER	
YS4G	6766	AA	CAP - OIL FILLER - 1/4 TURN CLICK TYPE	1
4L5Z	6C729	AA	TUBE - VENTILATION	1
4M5Z	6C730	AA	O-RING - VENTILATION TUBE	1
4L5Z	6C519	DA	GROMMET	4

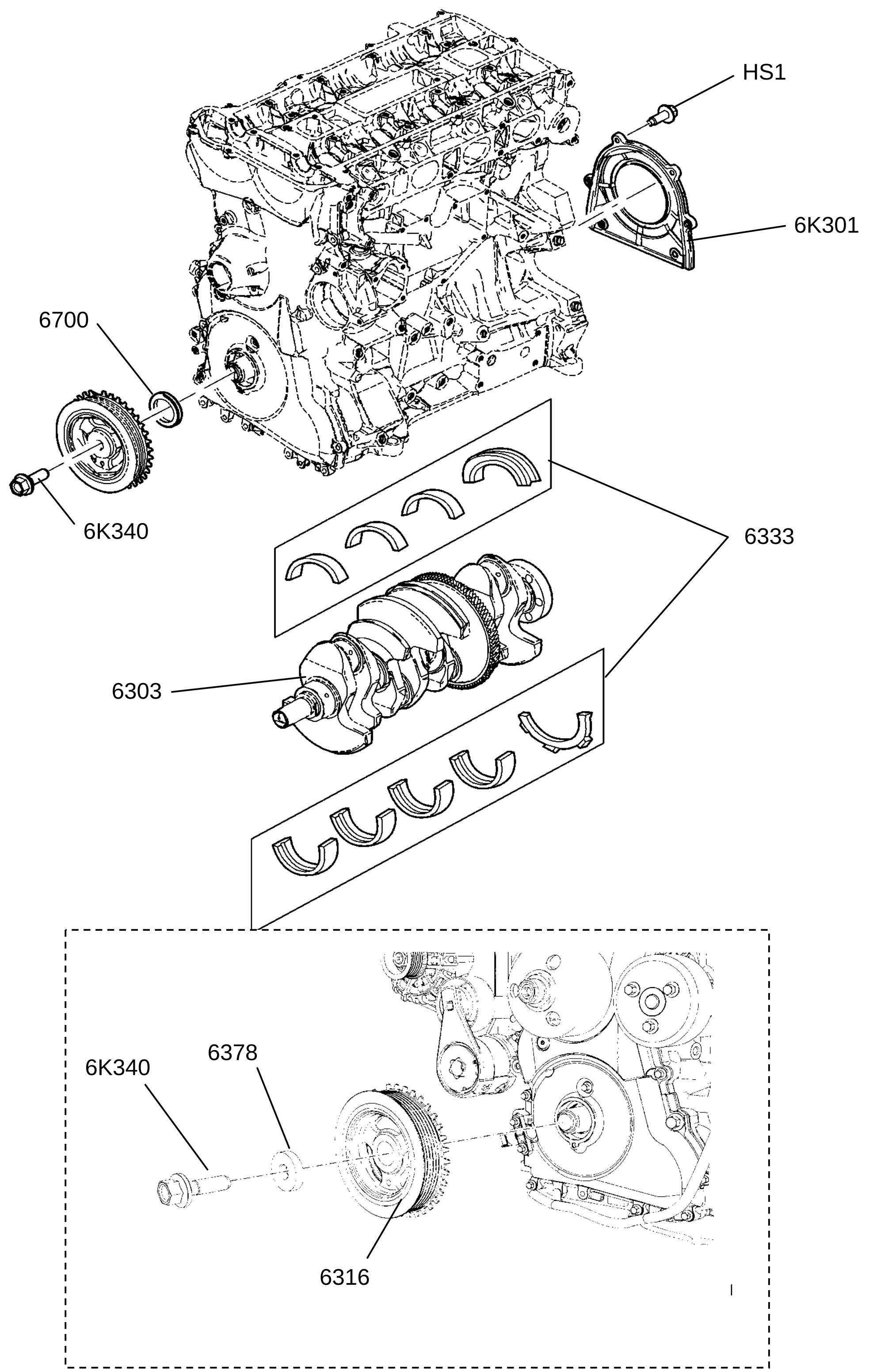
COOLANT RECOVERY SYSTEM



FPP00252

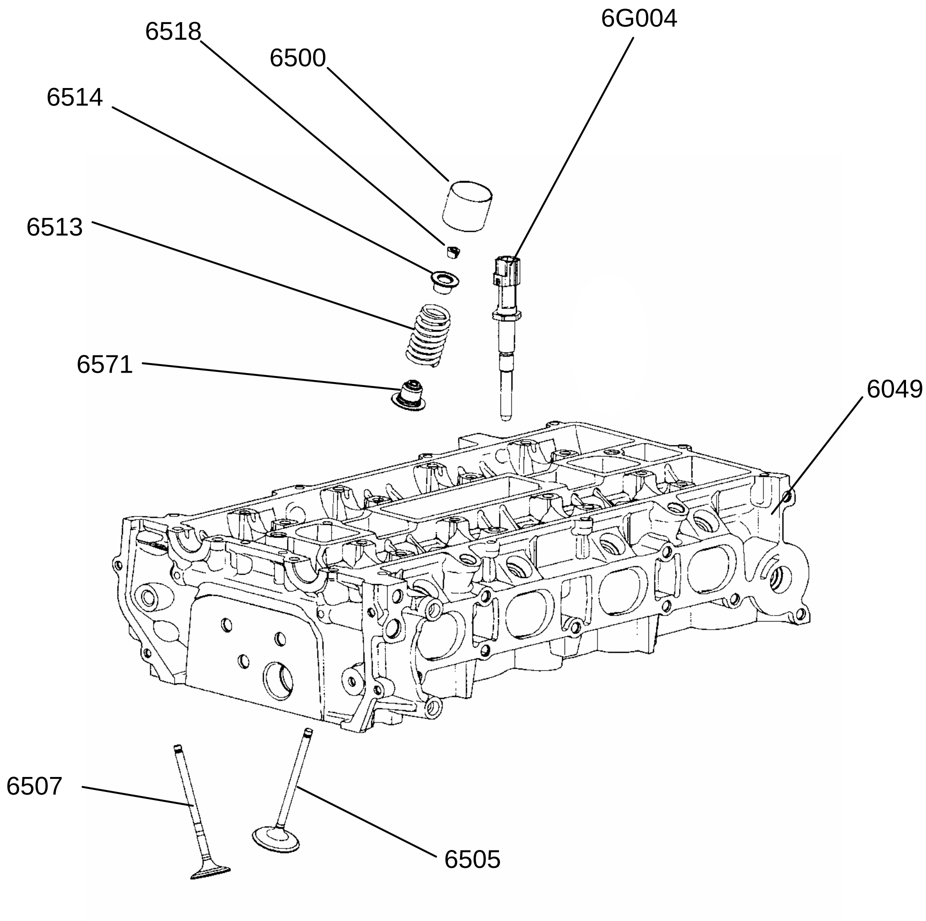
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Coolant Recovery System**	
	81500	001	RESERVOIR ASSY - RADIATOR - COOLANT RECOVERY	1

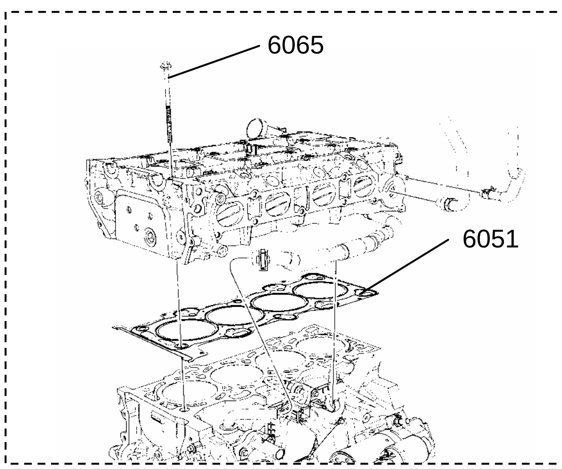
CRANKSHAFT & BEARINGS



SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Crankshaft & Bearings**	
	TBD		CRANKSHAFT - P150	1
	TBD		GEAR - CRANKSHAFT	1
	TBD		BEARING - CRANKSHAFT Main - FRONT	
	TBD		BEARING - CRANKSHAFT Main - FRONT	
	TBD		BEARING - CRANKSHAFT Main - FRONT	
	TBD		BEARING - CRANKSHAFT Main - UPPER	
	TBD		BEARING - CRANKSHAFT Main - UPPER	
	TBD		BEARING - CRANKSHAFT Main - UPPER	
	TBD		BEARING - CRANKSHAFT Main - UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		BEARING - CRANKSHAFT Main - TR UPPER	
	TBD		CAP - CRANKSHAFT BEARING	4
	TBD		BOLT CRANKSHAFT MAIN BEARING CAP	10
7U7Z	6312	A	DAMPER - CRANKSHAFT VIBRATION	1
	TBD		WASHER - CRANKSHAFT DAMPER	
	TBD		BOLT - CRANKSHAFT DAMPER	1
	TBD		SEAL - CRANKSHAFT OIL - FRONT	1
	TBD		RETAINER - CRANKSHAFT OIL SEAL - REAR	1

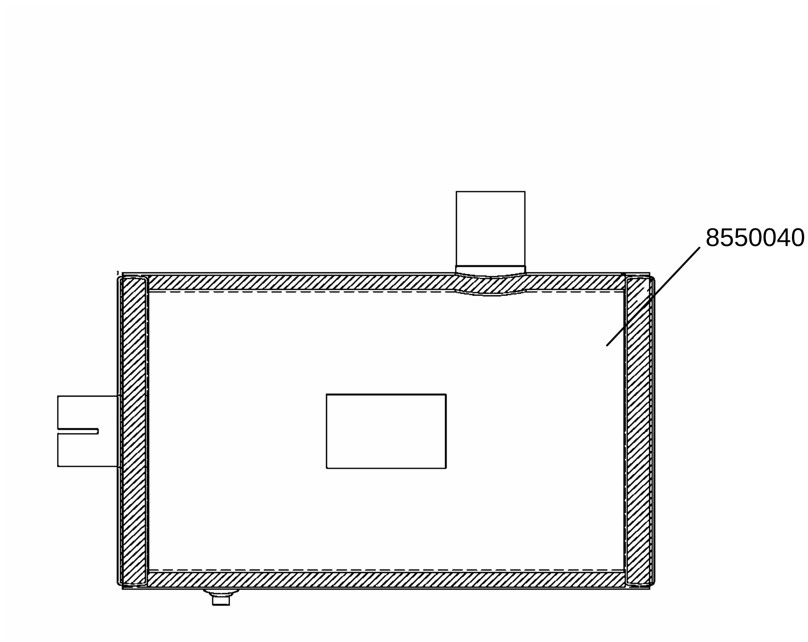
CYLINDER HEAD & VALVES





SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Cylinder Head & Valves**	
1S7Z	6518	AA	COLLET - VALVE SPRING RETAINER	32
1S7Z	6514	AA	RETAINER - VALVE SPRING	16
3M4Z	6513	BA	SPRING - VALVE	16
1S7Z	6065	CA	BOLT - CYLINDER HEAD	10
1S7Z	6571	EA	SEAL - VALVE STEM - EXHAUST	8
3S4Z	6571	AA	SEAL - VALVE STEM - INTAKE	8
	TBD		VALVE - EXHAUST	8
	TBD		VALVE - INTAKE	8
6C1G	6C032	AA	CYLINDER HEAD ASSEMBLY - WITH VALVES, LESS CAMSHAFTS (INCLUDES CAMSHAFT BEARING CAPS)	1
1S7Z	6051	AA	GASKET - CYLINDER HEAD	1
1S7Z	6G004	AA	SENSOR - CYLINDER HEAD TEMPERATURE	1
1S7Z	6500	AA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.0 MM	
1S7Z	6500	BA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.050 MM	
1S7Z	6500	CA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.10 MM	
1S7Z	6500	DA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.14 MM	
1S7Z	6500	EA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.18 MM	
1S7Z	6500	FA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.225 MM	
1S7Z	6500	GA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.26 MM	
1S7Z	6500	HA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.30 MM	
1S7Z	6500	JA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.35 MM	
1S7Z	6500	KA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.38 MM	
1S7Z	6500	LA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.42 MM	
1S7Z	6500	MA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.45 MM	
1S7Z	6500	NA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.50 MM	
1S7Z	6500	PA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.54 MM	
1S7Z	6500	QA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.59 MM	
1S7Z	6500	RA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.62 MM	
1S7Z	6500	SA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.67 MM	
1S7Z	6500	TA	TAPPET ASSEMBLY - VALVE HYDRAULIC - 3.71 MM	

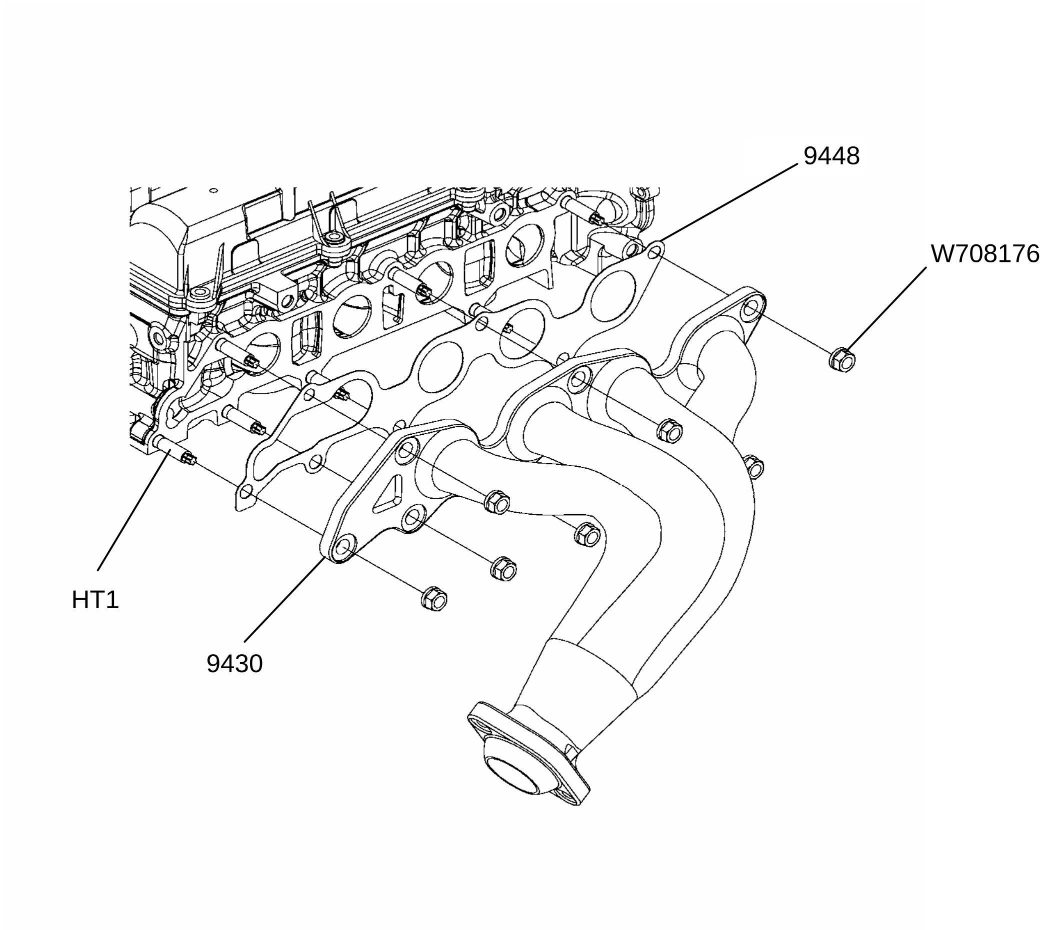
EXHAUST CATALYST

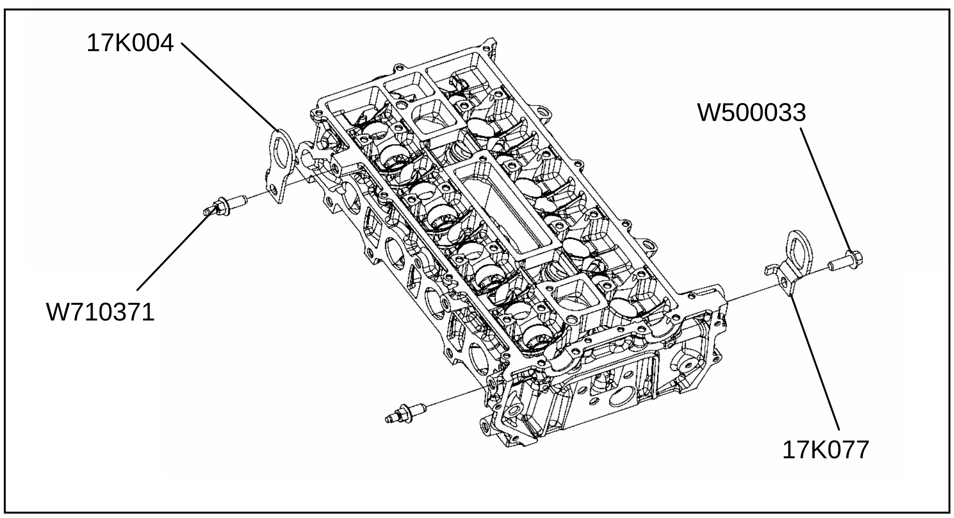


FPP00235

SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Exhaust Catalyst**	
	8550040		Catalyst-Muffler	1

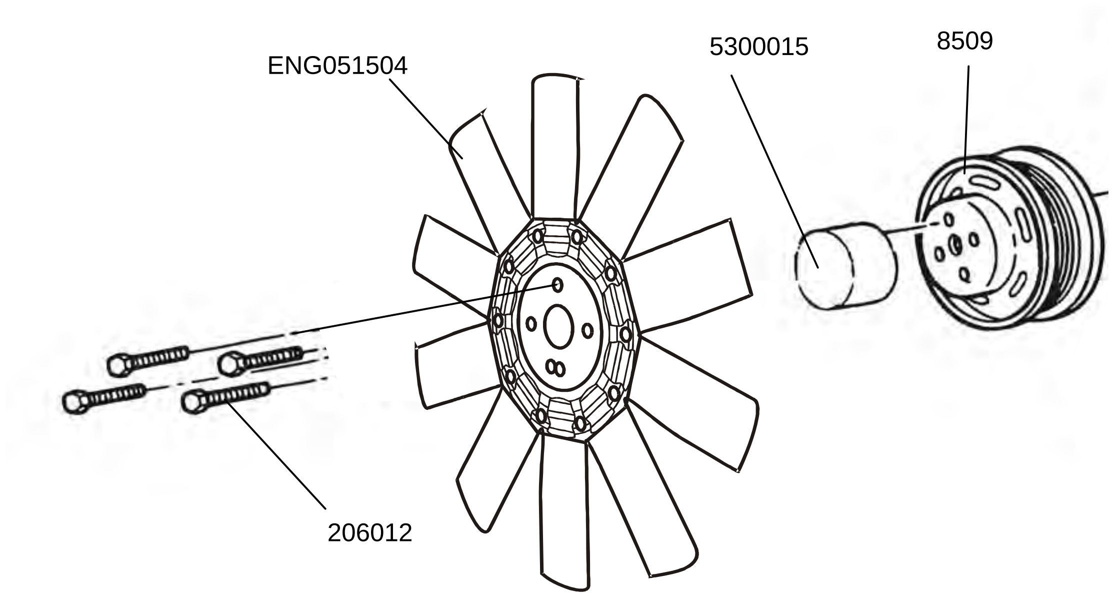
EXHAUST MANIFOLDS & LIFTING EYES





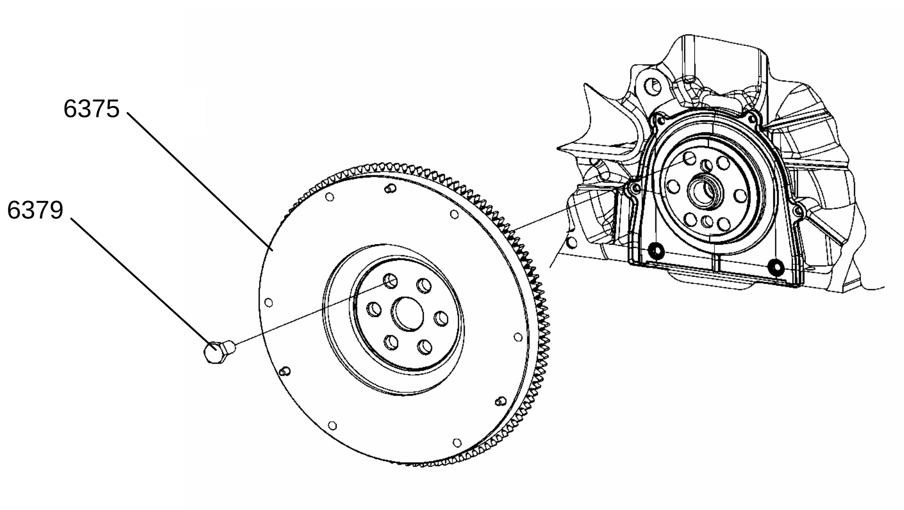
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Exhaust Manifolds & Lifting Eyes**	
1L5Z	9448	AB	GASKET - EXHAUST MANIFOLD	1
W	703662	S309	NUT - EXHAUST MANIFOLD M10	7
1L5Z	9430	BF	MANIFOLD - EXHAUST	1
W	704474	S309	STUD - M10 X 22 X 32 MM	
	TBD		LIFTING EYE - FRONT	1
			BOLT - LIFTING EYE	1
	TBD		LIFTING EYE - REAR	1
	TBD		STUD/BOLT - LIFTING EYE	1

FAN BLADE & PULLEYS



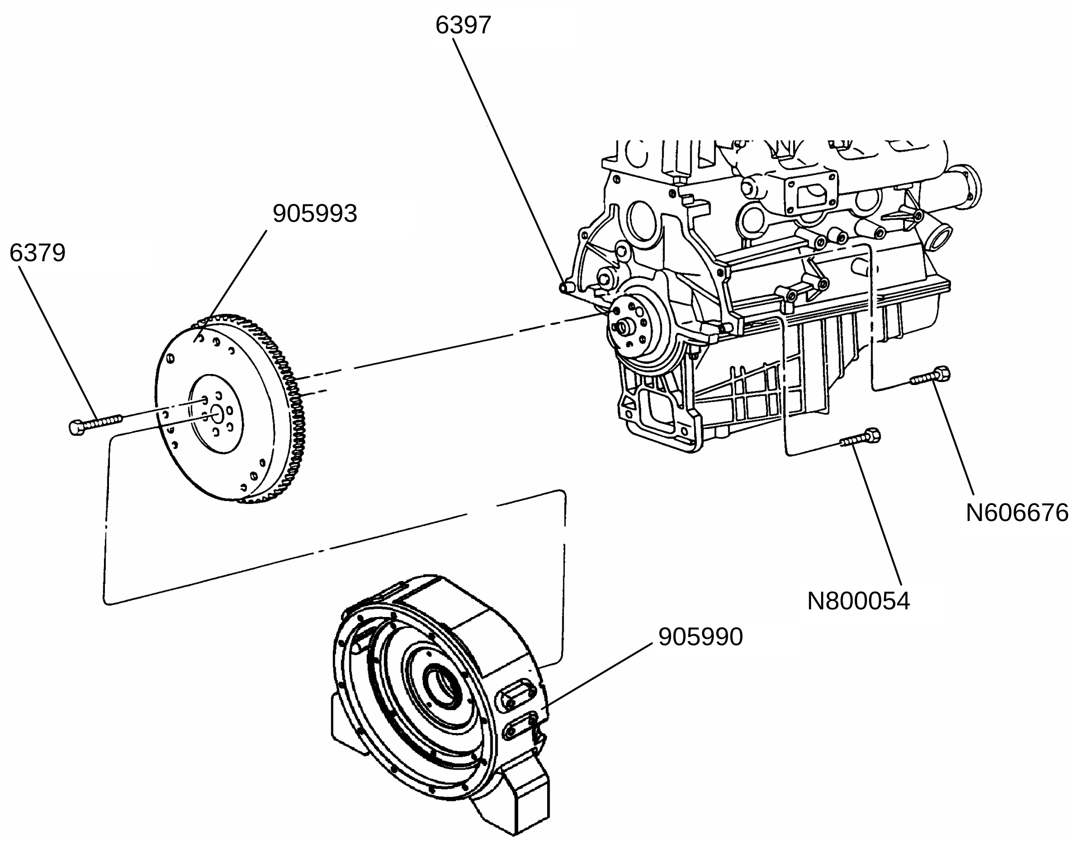
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Fan Blade & Pulleys**	
ENG	051504		FAN ASSEMBLY / SUCTION	1
ENG	051505		FAN ASSEMBLY / PUSHER	1
	5300015		FAN SPACER	1
	206012		FAN BOLTS	4

FLYWHEEL



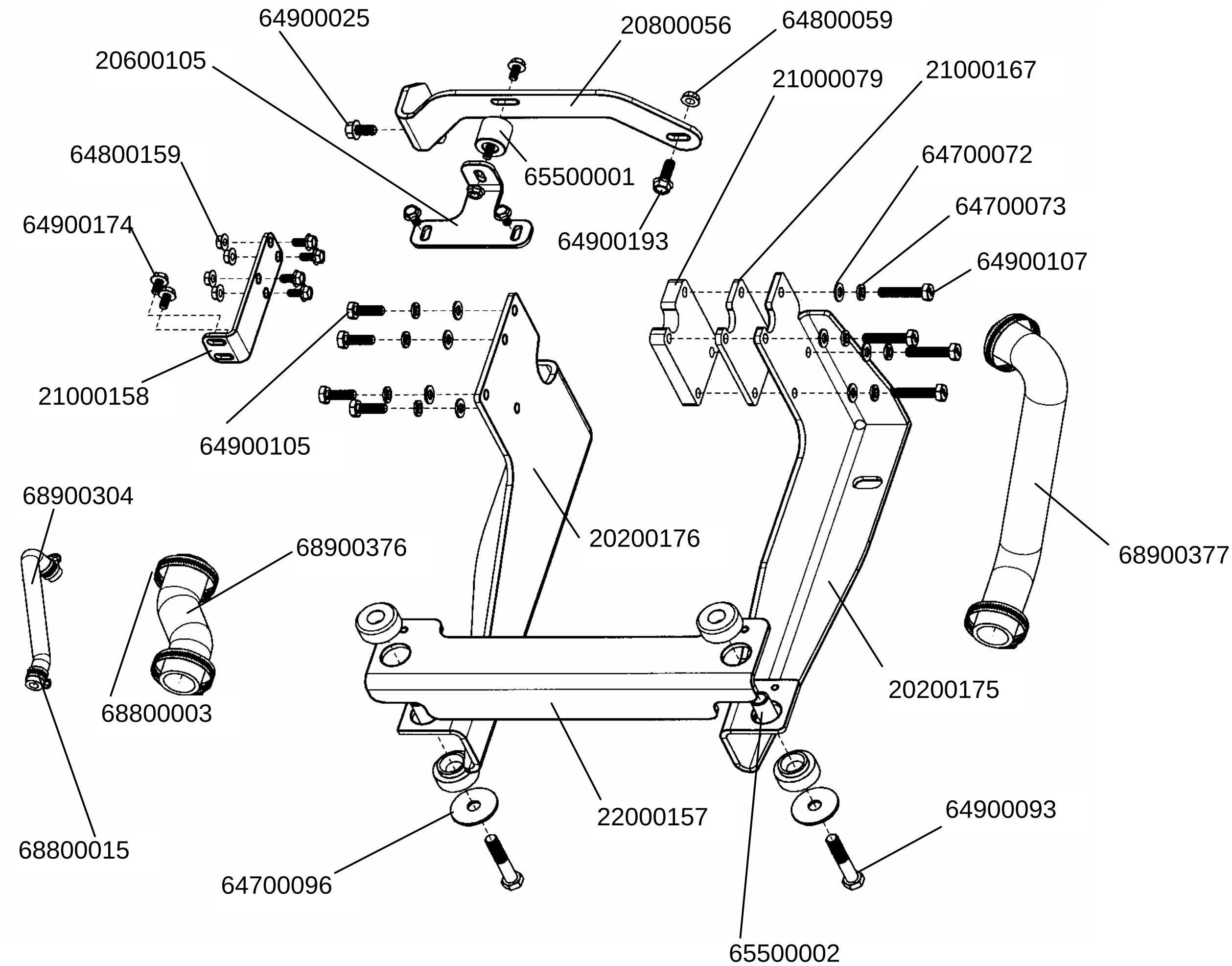
SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Flywheel	
1L5Z	6375	BA	FLYWHEEL - ENGINE	1
1S7Z	6379	AA	BOLT - ENGINE FLYWHEEL	6

FLYWHEEL HOUSING



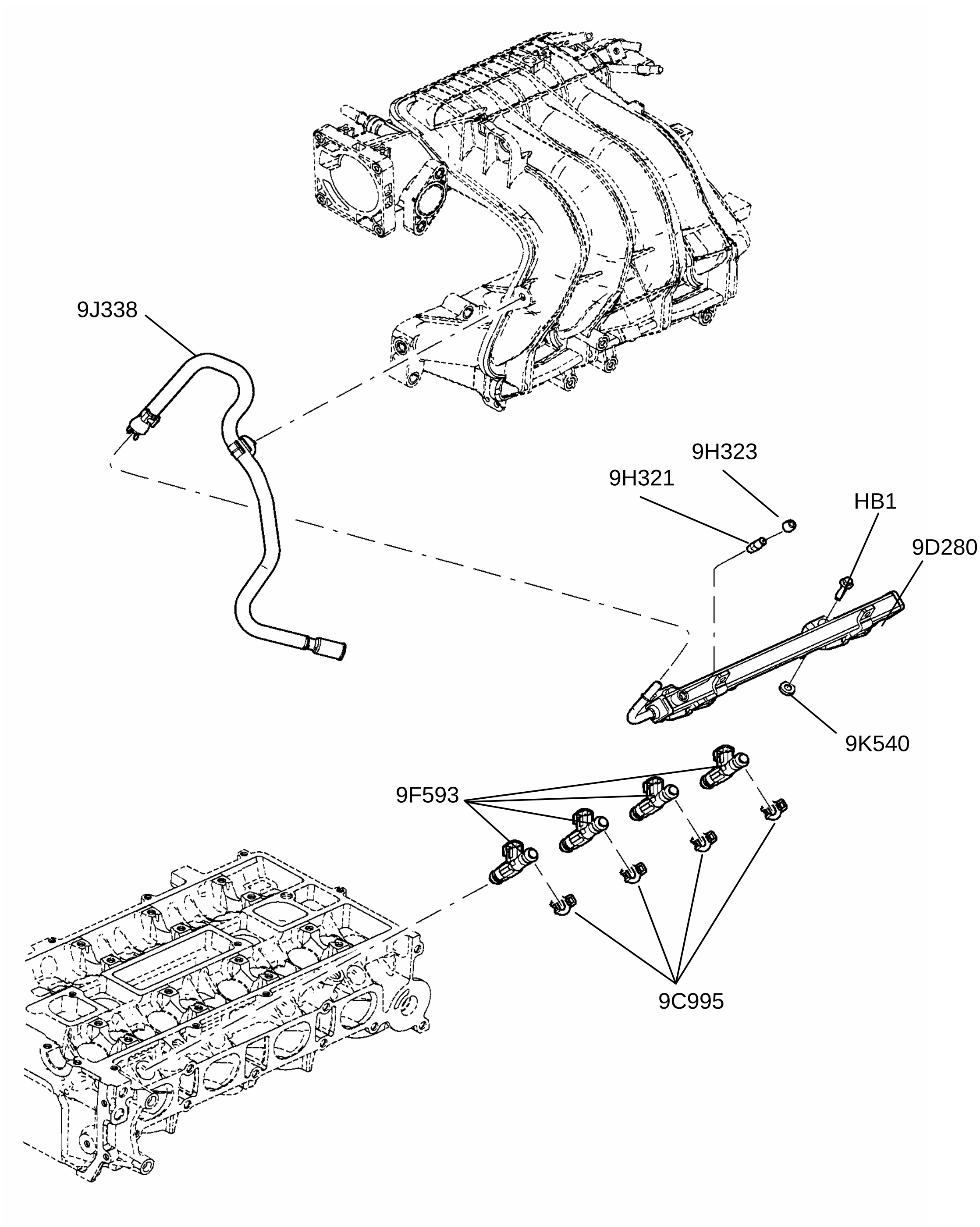
SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Flywheel Housing	
1S7Z	6379	AA	BOLTS	6
	905	990	HOUSING W/FEET	1
	905	993	SAE FLYWHEEL	1

FRONT ENGINE SUPPORT



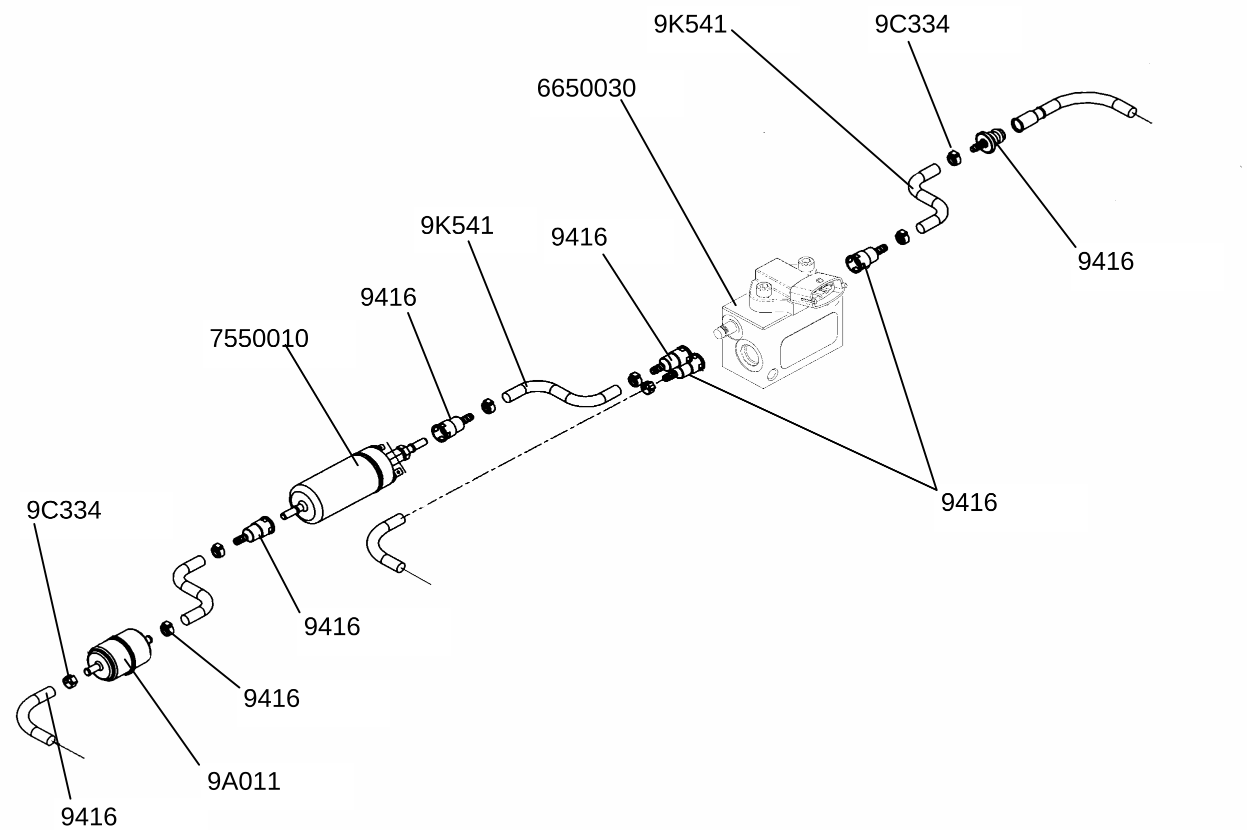
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Front Engine Support**	
202	001	75	LEG, LEFT FRONT	1
202	001	76	LEG, RIGHT FRONT	1
206	001	05	SUPPORT, UPPER	1
208	000	56	MOUNT, UPPER	1
210	000	79	BRACKET, MISC. SPACER - 121.0 X 89.0 X 6.35	1
210	001	58	BRACKET, OVERFLOW BOTTLE	1
210	001	67	BRACKET, MISC. SPACER	1
220	001	57	BRACKET, ASSEMBLY, CROSS	1
647	000	72	PLAIN WASHER, 10MM, REGULAR	8
647	000	73	HELICAL SPRING LOCK WASHER, 10MM	8
647	000	96	LARGE OD PLAIN WASHER, 0.500 X 2.00 X 0.125	2
648	000	59	M10 - 1.5, HEX SERRATED FLANGE NUT	1
648	001	59	M8 - 1.25, HEX SERRATED FLANGE NUT	5
649	000	25	M10 - 1.5 X 20, HEX SERRATED FLANGE CAP SCREW, CLASS 90	1
649	000	93	1/2 - 13 X 2 3/4, HEX CAP SCREW	2
649	001	05	M10 - 1.5 X 30, HEX CAP SCREW	4
649	001	07	M10 - 1.5 X 50, HEX CAP SCREW	4
649	001	74	M8 - 1.25 X 16, HEX SERRATED FLANGE CAP SCREW, CLASS 90	9
649	001	93	M10 - 1.5 X 30, HEX SERRATED FLANGE CAP SCREW	1
655	000	01	ISOLATOR, 32 X 32, M8 - 1.25	1
655	000	02	ISOLATOR, 46.4MM, 51.21MM, 1/2 - 13	2
688	000	03	CLAMP, HOSE, WORM - DRIVE, 40-64 OD	4
688	000	15	CLAMP, HOSE, WORM - DRIVE, 11-20 OD	2
689	003	04	HOSE, 20R4, VENT, ENGINE TO RADIATOR	1
689	003	76	HOSE, 33.0 ID	1
689	003	77	HOSE, 33.0 ID. 20R4	1

FUEL INJECTOR & RAIL



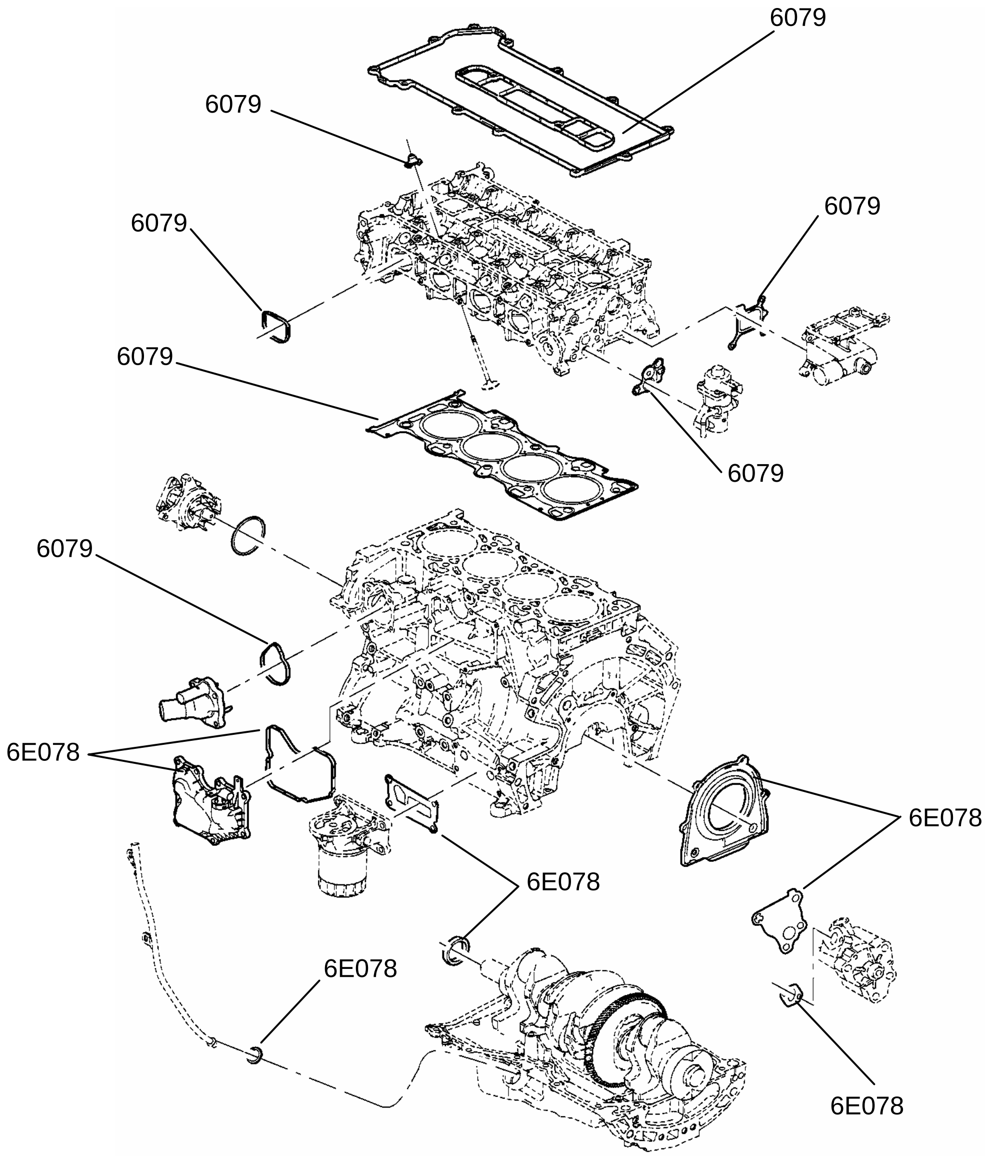
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Fuel Injector & Rail - EFI**	
4L5Z	9J338	BA	TUBE	1
928Z	9H323	AB	CAP	1
EOAY	9H321	A	VALVE ASSEMBLY - PRESSURE RELIEF	1
W	500225	S309	BOLT - M8 X 30 MM	1
4L5Z	9D280	AE	MANIFOLD ASSEMBLY - FUEL SUPPLY	1
4L5Z	9F593	AA	INJECTOR ASSEMBLY	4
1S7Z	9C995	CA	RETAINER - INJECTOR VALVE	4
5L8Z	9K540	AA	SEAL	1

FUEL PUMP - ELECTRIC



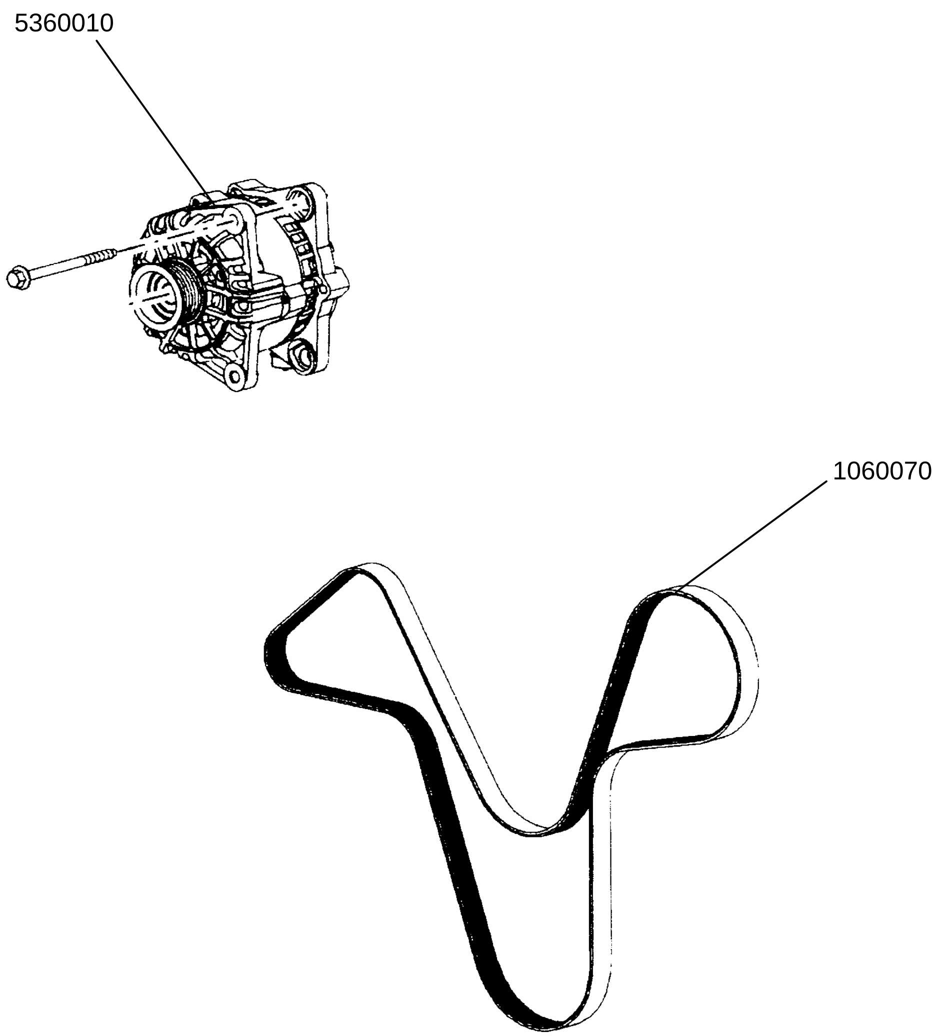
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Fuel Pump - Electric**	
	7550010		FUEL PUMP	1
	6650030		FUEL SENSOR ASSEMBLY	1
205	0040		FUEL SENSOR FITTINGS	2
205	0050		FUEL SENSOR FITTINGS	1
526	0010		FUEL SENSOR HARNESS	1
F89Z	9155	A	FILTER - FUEL TANK - 2007 AND LATER	1
F8JL	9A011	AA	FILTER - FUEL TANK - PRE 2007	1
F8JL	9K541	AA	TUBE - FUEL SUPPLY (cut to required length)	1
	N806207	S190	CONNECTOR BODY 6.35HOSE X 14.1	1
	N806188	S190	CONNECTOR ASY 9.52TUBEXB.35HOSE	2
F68A	9416	BA	ADAPTOR FUEL PUMP	8
F8JL	9C334	AA	CLAMP - FUEL TUBE	8
XU1L	9288	AA	HOSE – LOW PRESSURE FUEL	1
E3EE	9155	F4A	FILTER ASSY - FUEL	1

GASKET SETS


6079
6079
6079
6079
6079
6079
6079
6E078
6E078
6E078
6E078
6E078

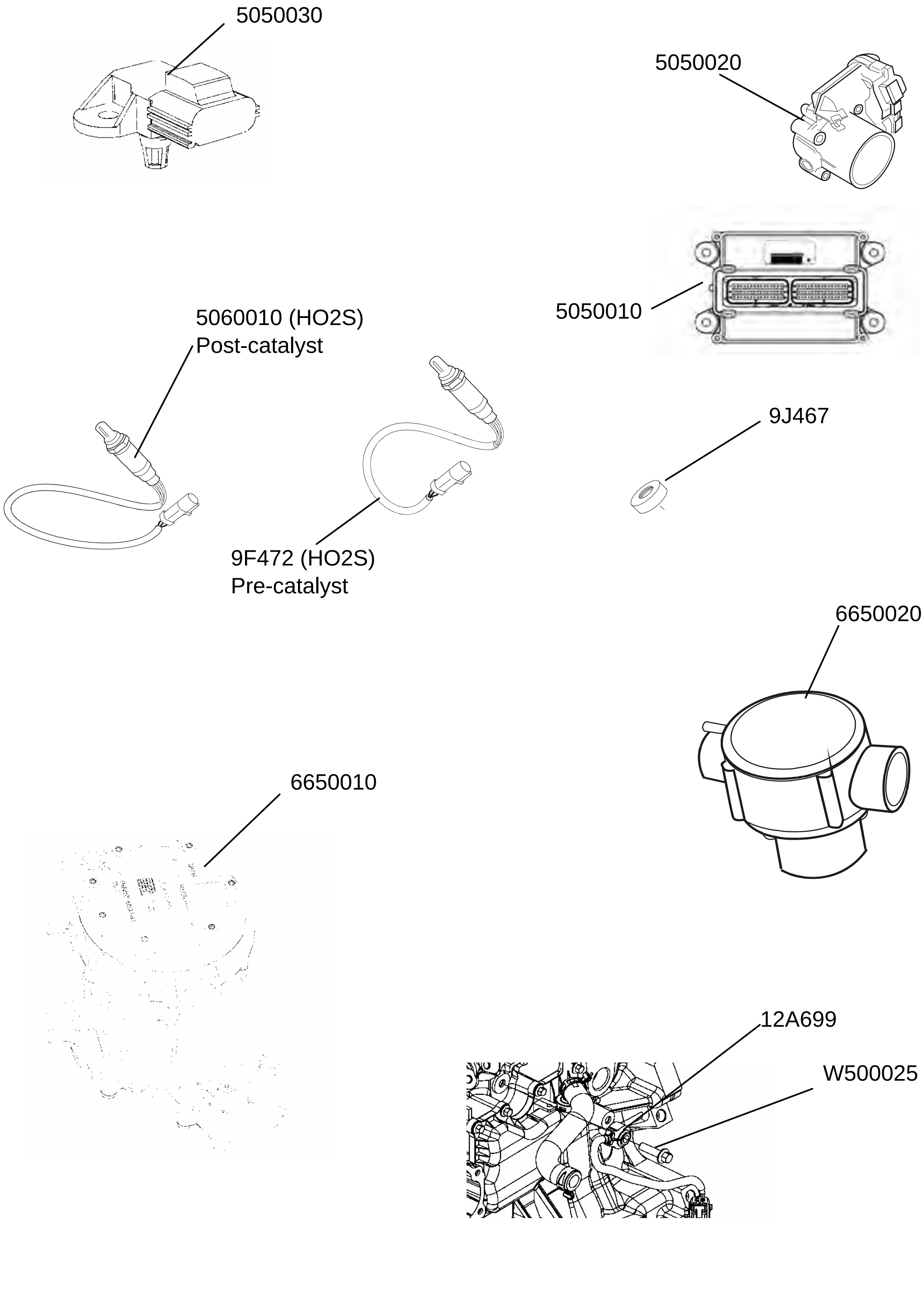
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Gasket Sets**	
1L5Z	6E078	AA	KIT - GASKET	1
			CONTENTS:	
			O-RING SEAL - OIL LEVEL INDICATOR TUBE	1
			GASKET - ENGINE VENT COVER	1
			GASKET - OIL FILTER ADAPTOR	1
			SEAL - CRANKSHAFT FRONT	1
			GASKET - CRANKSHAFT REAR SEAL RETAINER	1
			O-RING SEAL - COOLANT PUMP	1
1L5Z	6079	AA	KIT - GASKET	1
			CONTENTS:	
			GASKETS - CAMSHAFT COVER	1
			SEAL - VALVE	16
			GASKET - THERMOSTAT HOUSING	1
			GASKET - CYLINDER HEAD	1

GENERATOR



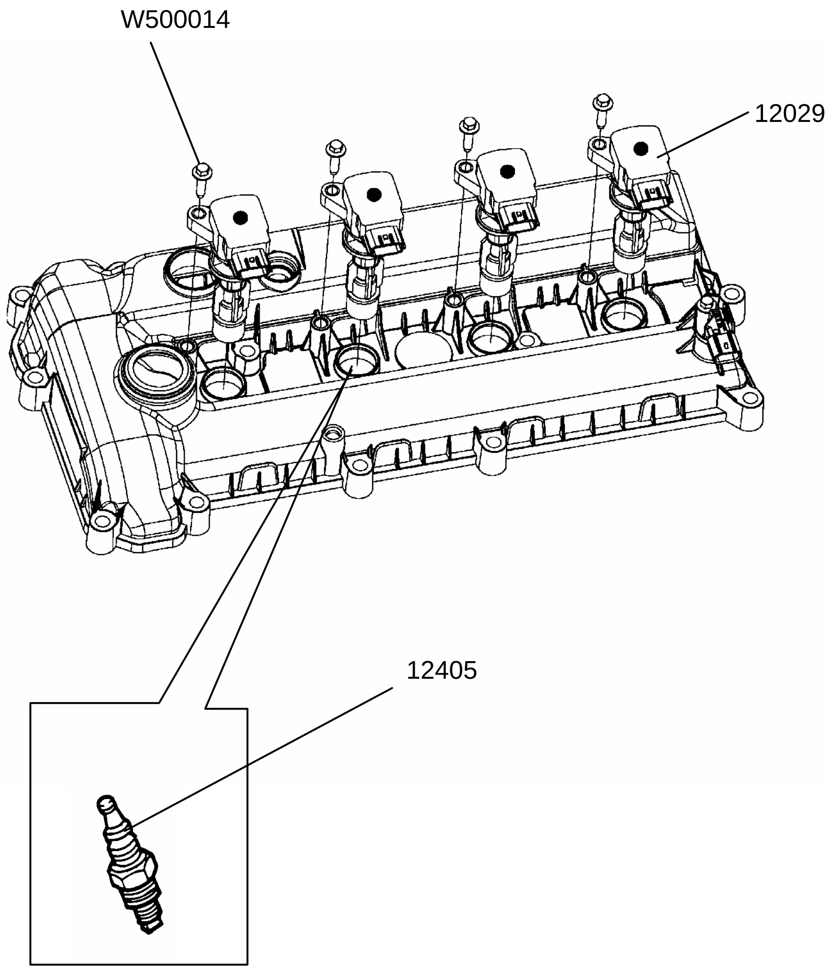
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Generator**	
	5360	010	GENERATOR ASSEMBLY	1
			BOLT - GENERATOR	
			MOUNT - GENERATOR ASSEMBLY	1
			BOLT - GENERATOR MOUNT	
	1060	070	BELT - FRONT END ACCESSORY DRIVE	1

GCP SYSTEM


5050030
5050020
5050010
5060010 (HO2S)
Post-catalyst
9J467
9F472 (HO2S)
Pre-catalyst
6650020
6650010
12A699
W500025

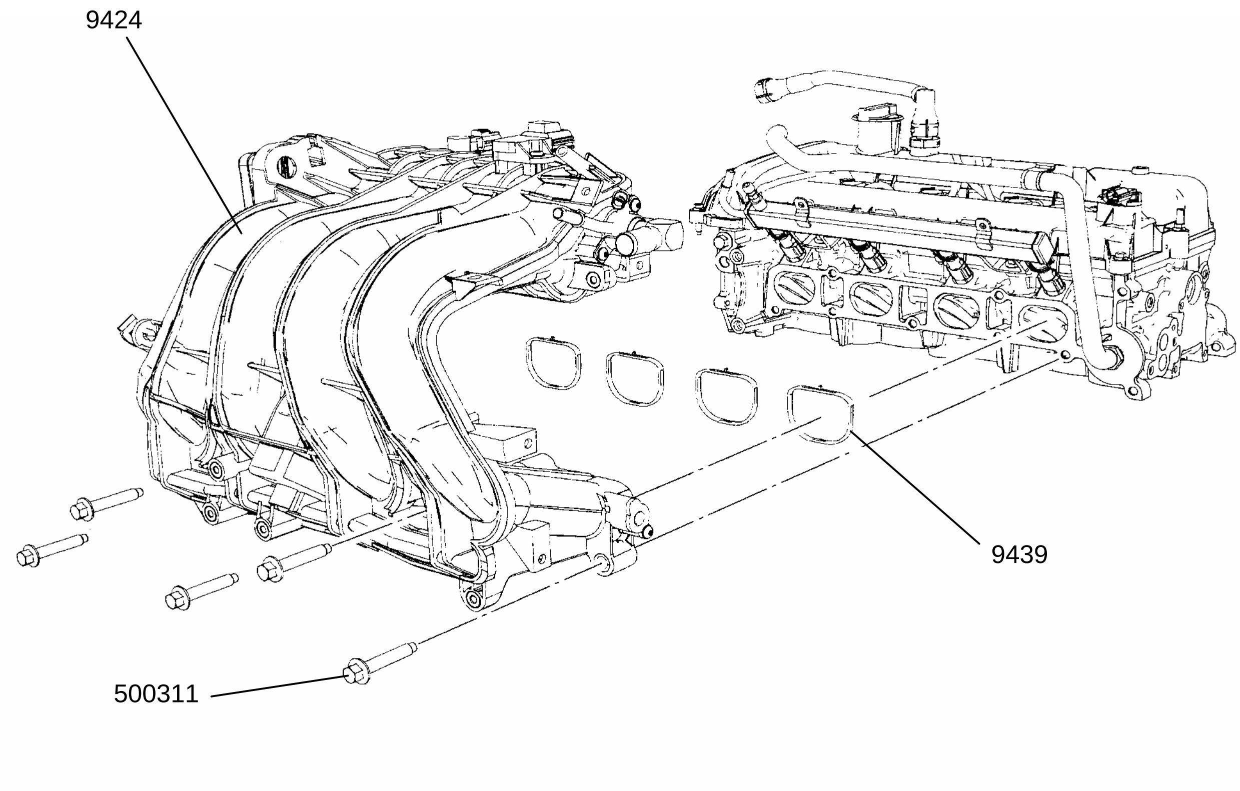
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**GCP SYSTEM**	
F5AC	9J467	CA	INSERT	1
506	0010		SENSOR - POST CATALYST	1
505	0010		GCP	1
F8JL	10A979	AA	LIGHT - MALFUNCTION INDICATOR	1
665	0010		EPR	1
W	500205		BOLT - M5 - TMAP SENSOR	1
505	0030		SENSOR - TEMPERATURE MANIFOLD ABSOLUTE PRESSURE (TMAP)	1
505	0020		THROTTLE BODY - ACTUATOR	1
W	500214		BOLT - M6 - AIR INTAKE CHARGE THROTTLE BODY	4
665	0020		MIXER	1
W	500025	S309	BOLT - M8 - KNOCK SENSOR	1
1S7Z	12A699	BB	SENSOR - KNOCK (KS)	1

IGNITION SYSTEM



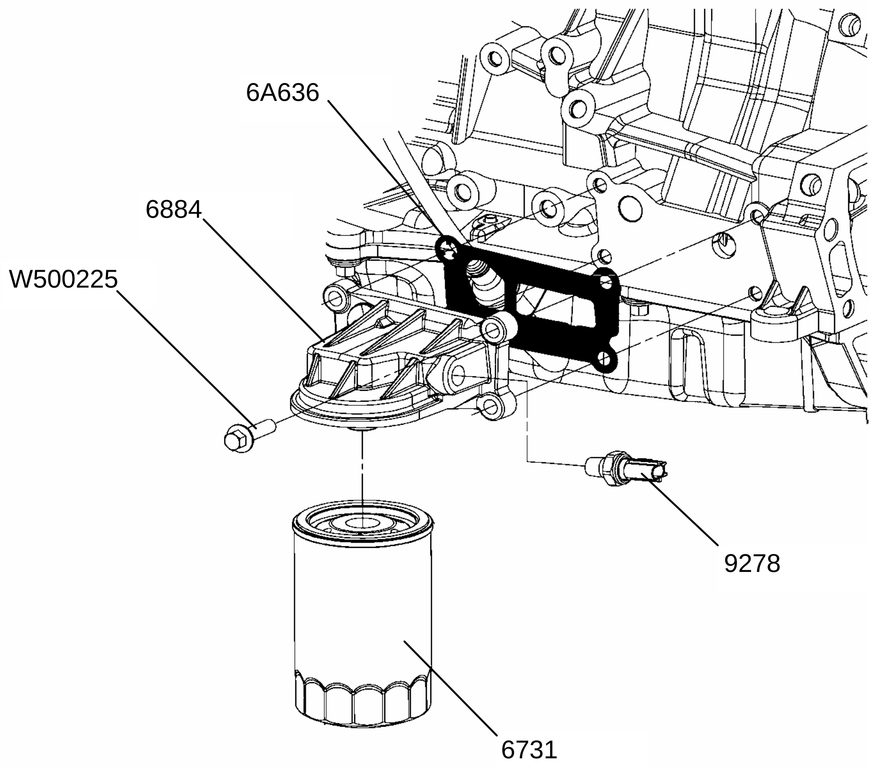
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Ignition System**	
4M5Z	12029	BC	IGNITION COIL	4
A6SF	32YPC		SPARK PLUG	4
W	500014	S309	BOLT - M6	4

INTAKE MANIFOLD



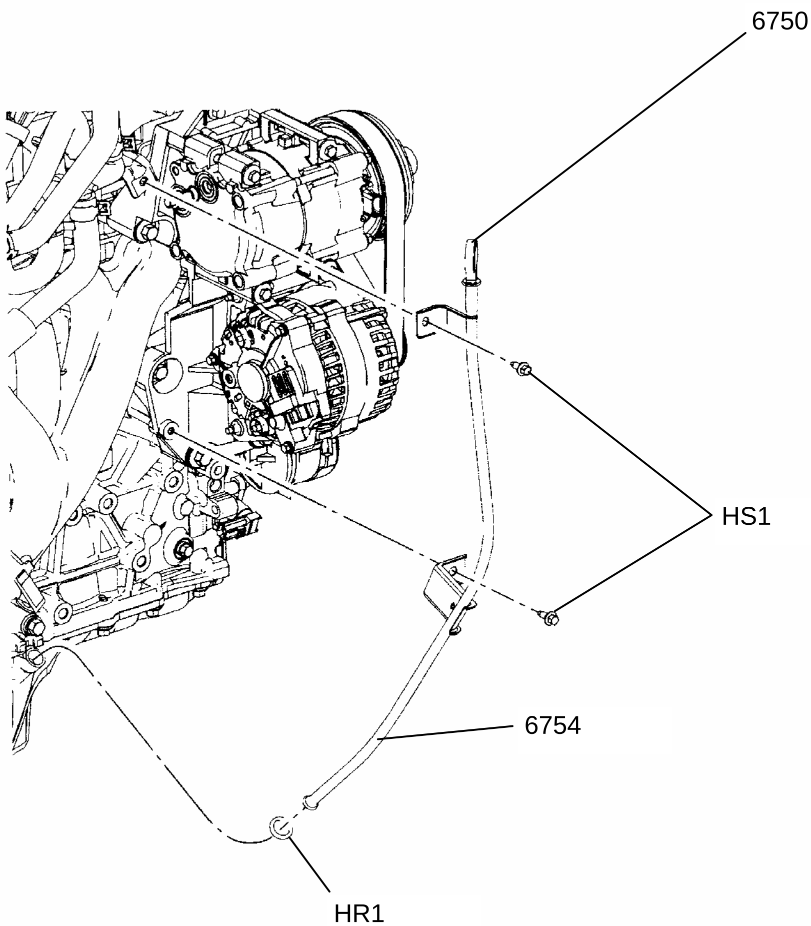
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Intake Manifold**	
4L5Z	9424	AA	INTAKE MANIFOLD	1
1S7Z	9439	AA	GASKET - INTAKE MANIFOLD	1
W	500311	S437	BOLT - INTAKE MANIFOLD - M8 X 40 MM	5

OIL FILTER & ADAPTOR



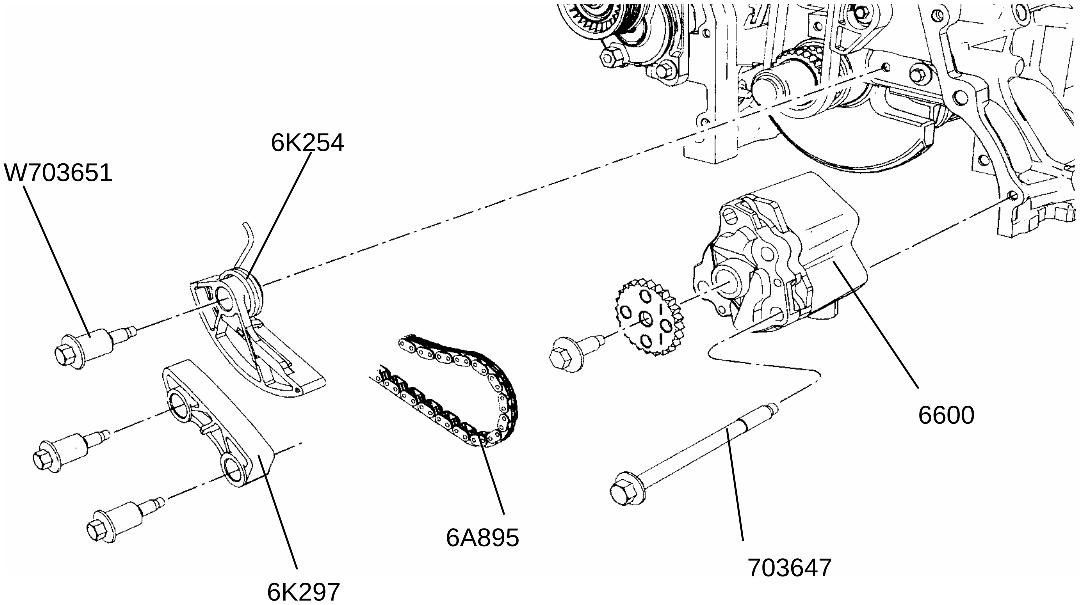
SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Oil Filter & Adaptor	
1L5Z	6881	AA	ADAPTOR - OIL FILTER	1
1S7Z	6840	AA	GASKET- OIL FILTER ADAPTOR TO CYLINDER BLOCK	1
6U5Z	9278	G	SWITCH ASSEMBLY - OIL PRESSURE - 1/4" NPTF	1
1S7Z	6731	DA	FILTER ASSEMBLY - OIL	1
W	500225	S309	BOLT - M8 X 30 MM	1

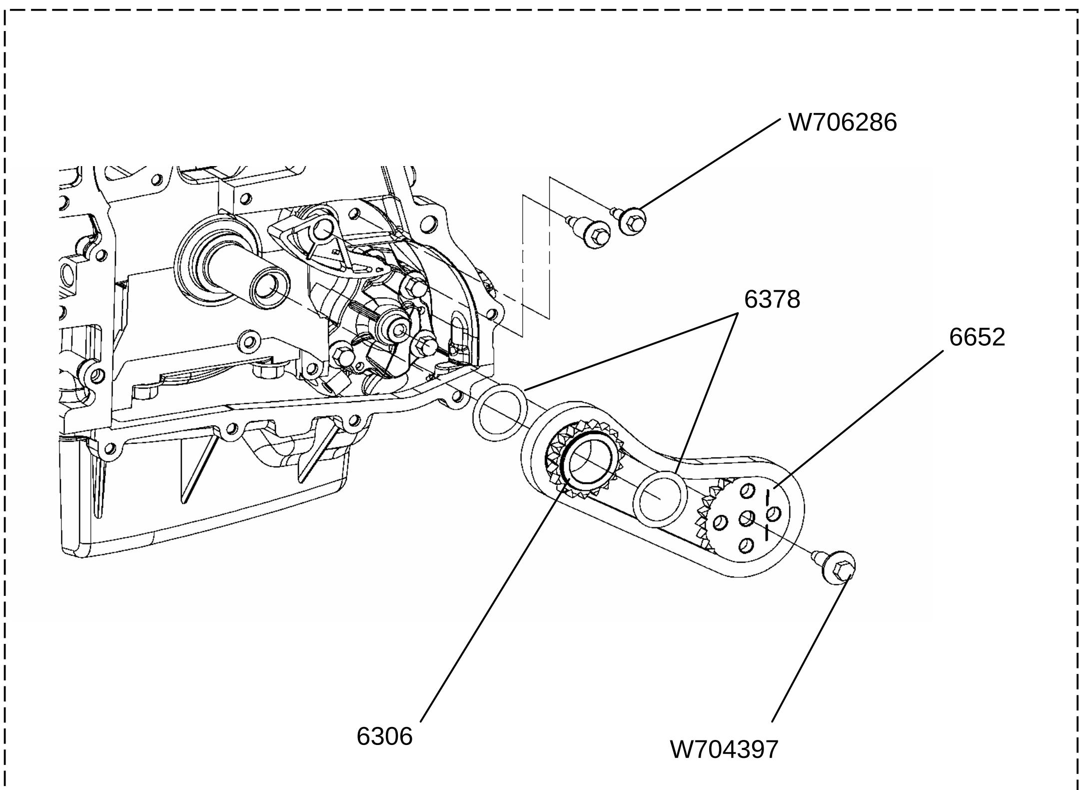
OIL LEVEL INDICATOR & TUBE



SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Oil Level Indicator & Tube	
1L5Z	6750	AA	INDICATOR ASSEMBLY - OIL LEVEL	1
1L5Z	6754	AA	TUBE ASSEMBLY - OIL LEVEL INDICATOR	1
W	500211	S309	SCREW - M6 X 12 MM	1
W	701261	S300	O-RING - OIL LEVEL INDICATOR TUBE - 9.5MM	1
6149	9710		SHORT TUBE & DIPSTICK	

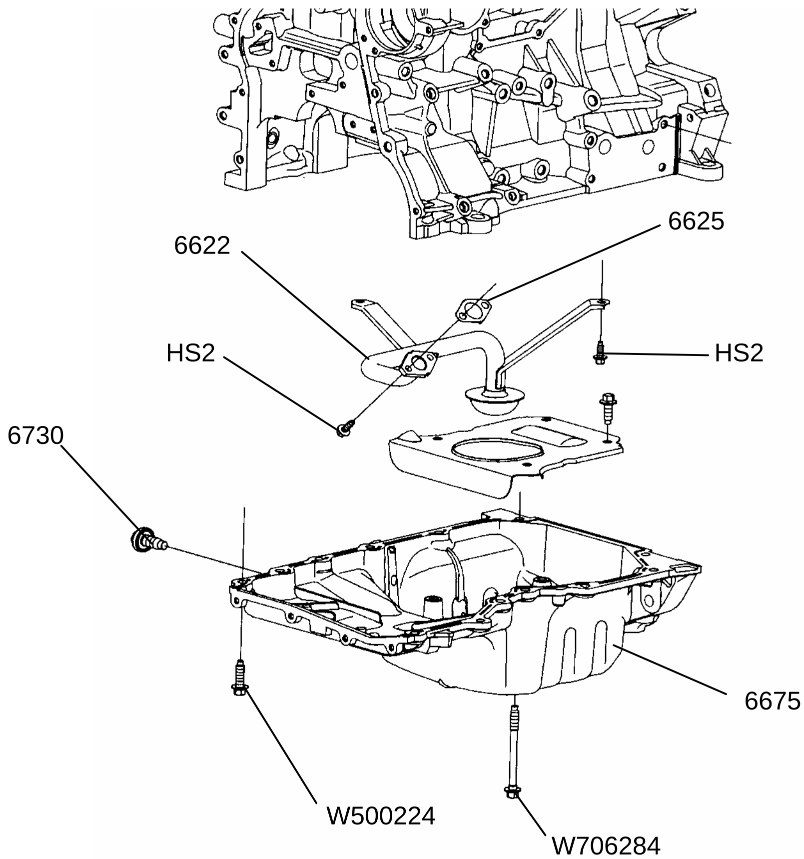
OIL PUMP, CHAIN & SPROKETS





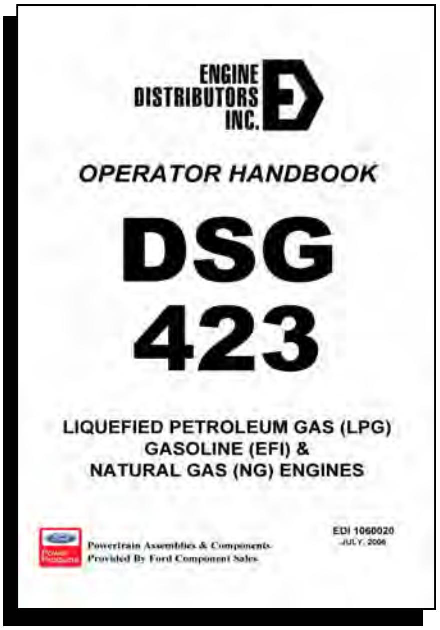
SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Oil Pump, Chain & Sprockets	
1S7Z	6M256	CA	GUIDE ASSEMBLY	1
1S7Z	6700	AA	SEAL ASSEMBLY - CRANKSHAFT OIL - FRONT	1
W	706286	S309	BOLT - M6 X 17 MM	1
1S7Z	6600	AA	PUMP ASSEMBLY - OIL	1
W	703647	S309	SCREW - M8 X 130MMM M8 X 103MM	1
6M8Z	6K297	BA	DISC - TIMING CHAIN GUIDE	1
1S7Z	6652	AA	GEAR	1
W	704397	S309	BOLT - M8 X 20 MM	1
1S7Z	6K254	CA	TENSIONER - TIMING BELT	1
W	703651	S309	BOLT - M6 X 27 MM	1
1S7Z	6A895	AA	CHAIN ASSEMBLY - OIL PUMP DRIVE	1

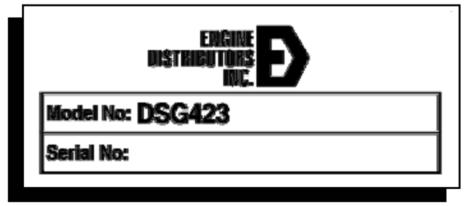
OIL PAN & RELATED PARTS

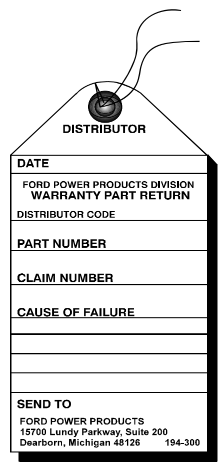


SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Oil Pan & Related Parts**	
1L5Z	6675	BA	PAN ASSEMBLY - ENGINE OIL	1
W	500224	S437	SCREW - M8 X 25MM	11
W	706284	S309	BOLT - M8 X 90 MM	2
XW4Z	6730	BA	PLUG - OIL PAN DRAIN	1
1L5Z	6622	AA	TUBE ASSEMBLY - OIL PUMP INLET	1
W	500212	S437	SCREW - M6 X 14	2
1L5Z	6625	AA	GASKET - OIL PUMP INLET TUBE	1
			BAFFLE - OIL PAN	1
			BOLT - OIL PAN BAFFLE	

OWNER'S LITERATURE

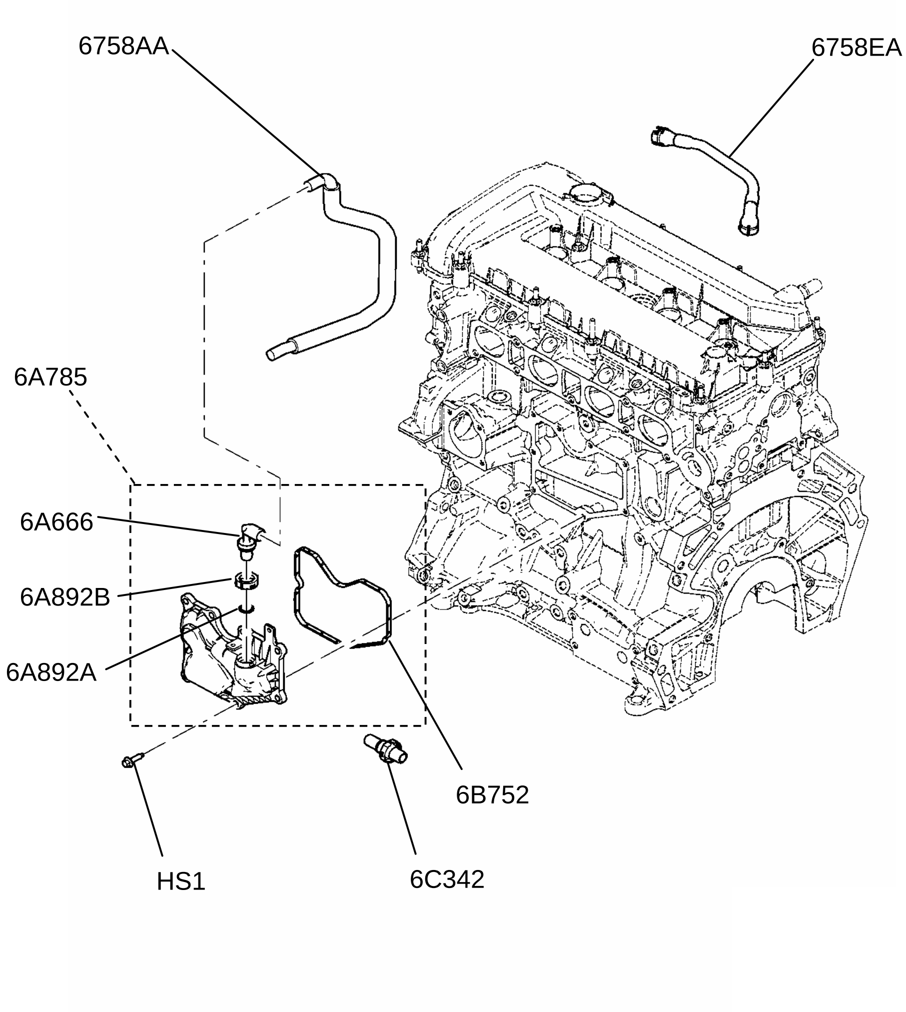






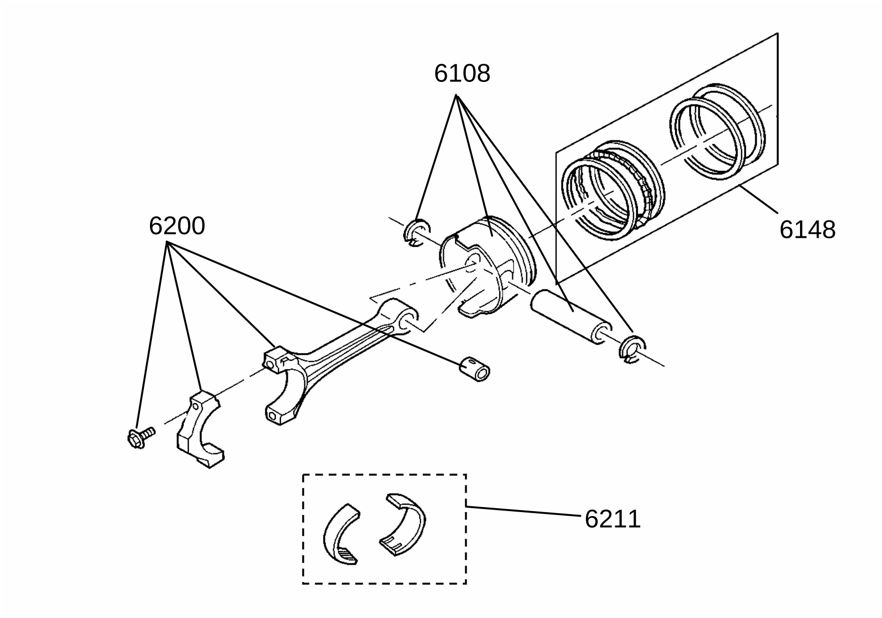
SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Owner's Literature	
EDI	106	0020	Operator Handbook	1
EDI	106	0030	Service Parts Manual	1
EDI	106	0040	Industrial Engine Service Manual	1

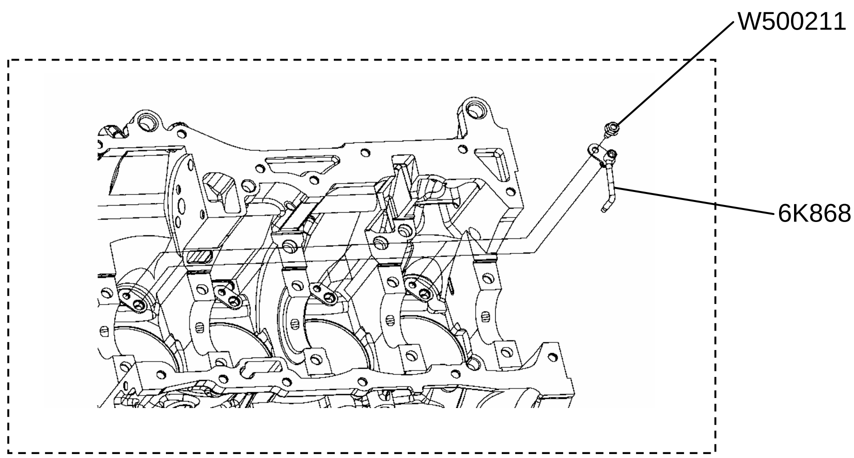
PCV VALVE & HOSE



SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**PCV Valve & Hose**	
4L5Z	6758	AA	TUBE - ATTACHES 6A785 (PCV) TO INTAKE MANIFOLD	1
4L5Z	6758	EA	TUBE - CLOSURE HOSE - INTAKE MANIFOLD TO ZIP TUBE	1
3S4Z	6B752	AA	GASKET	1
4L5Z	6A666	BA	VALV E ASSEMBLY - REGULATING	1
3S4Z	6A892	AA	RETAINER - O-RING	1
1S7Z	6A892	AAA	RETAINER - RETAINER	1
4L5Z	6B670	AA	HOSE - CONNECTING	1
W	500214	S300	SCREW - M6 X 1.0 X 22.5	1

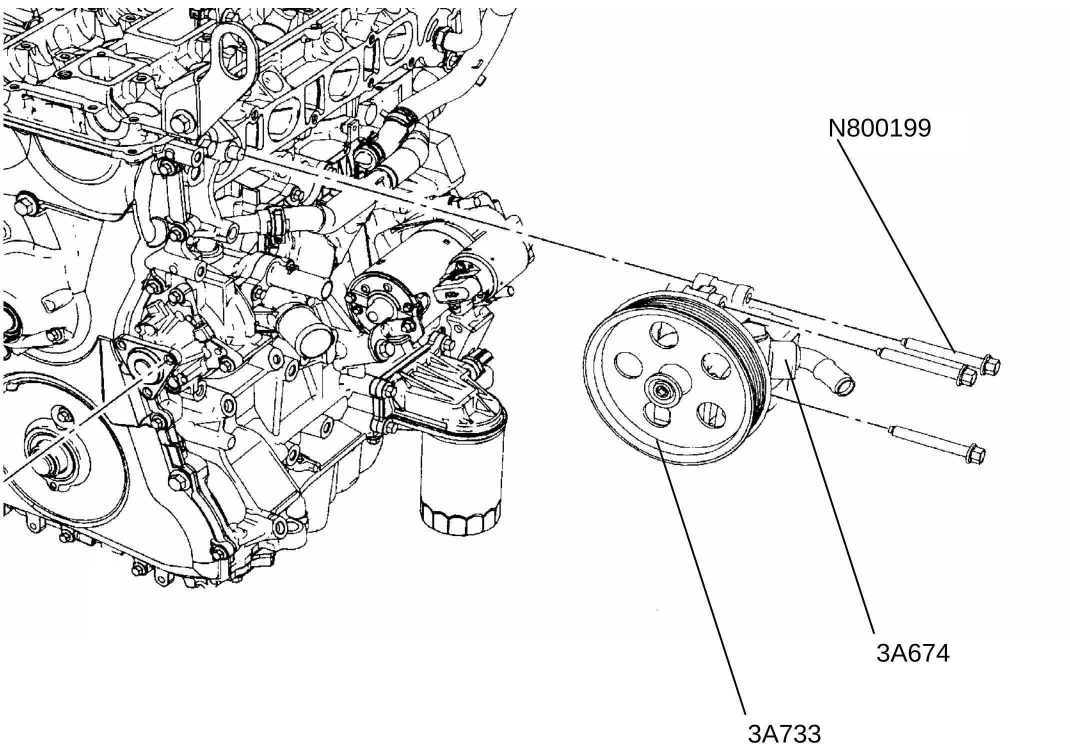
PISTON ASSEMBLY





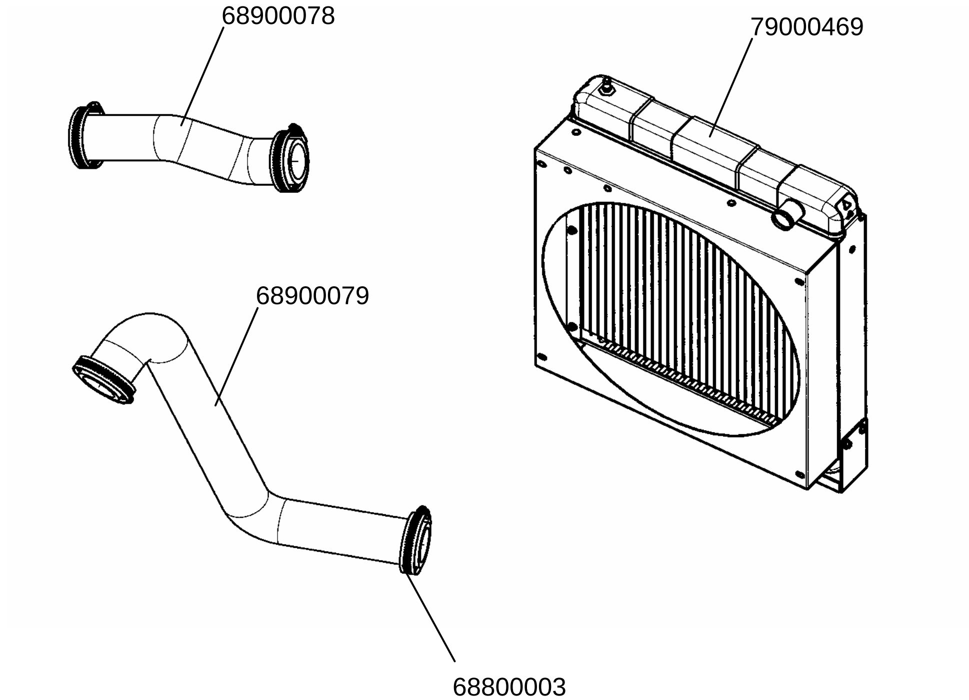
SERVICE PART NUMBER	DESCRIPTION	QTY.
BASE NO.	**Piston Assembly**	
TBD	Piston & Pin & Rod Subassembly	4
TBD	Piston Pin & Ring Kit - 0.050	
TBD	Piston Pin & Ring Kit - 0.100	
TBD	Piston Pin & Ring Kit - 0.850	
TBD	Bearing - Connecting Rod - 0.000	
TBD	Bearing - Connecting Rod - 6.500	
TBD	Bearing - Connecting Rod - 1.500	
TBD	NOZZLE - PISTON COOLING	4
TBD	BOLT - FLANGE TYPE - COOLER VALVE	4
TBD	Rod – Connecting, Assembly	1
TBD	Rod – Connecting, OP10	1
TBD	Rod – Connecting, Rough P150	1
TBD	Bolt - Connecting Rod	2
TBD	SKIRT - PISTON ASSEMBLY	
TBD	KIT - PISTON RING	

POWER STEERING



SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Power Steering	
4L5Z	3A674	AA	PUMP ASY. – POWER STEERING	1
1S7Z	3A733	A	PULLEY – POWER STEERING PUMP	1
	N800199	S437	SCREW	3

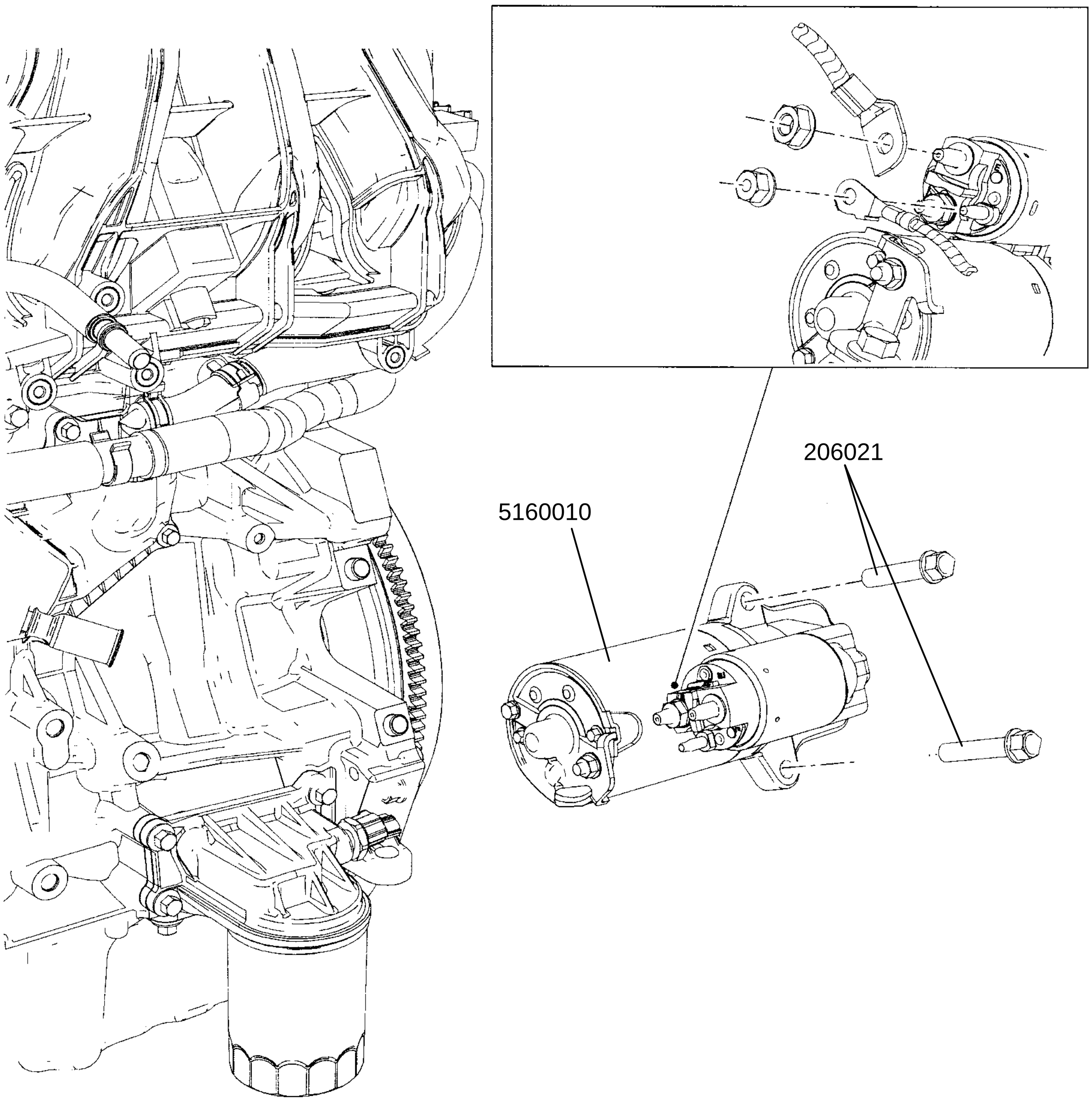
RADIATOR, HOSES & SHROUD



SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Radiator, Hoses & Shroud**	
	79000	469	RADIATOR	1
	68900	078	HOSE - RADIATOR UPPER	1
	68900	079	HOSE - RADIATOR LOWER	1
	68800	003	CLAMPS	4
			SHROUD - RADIATOR	1

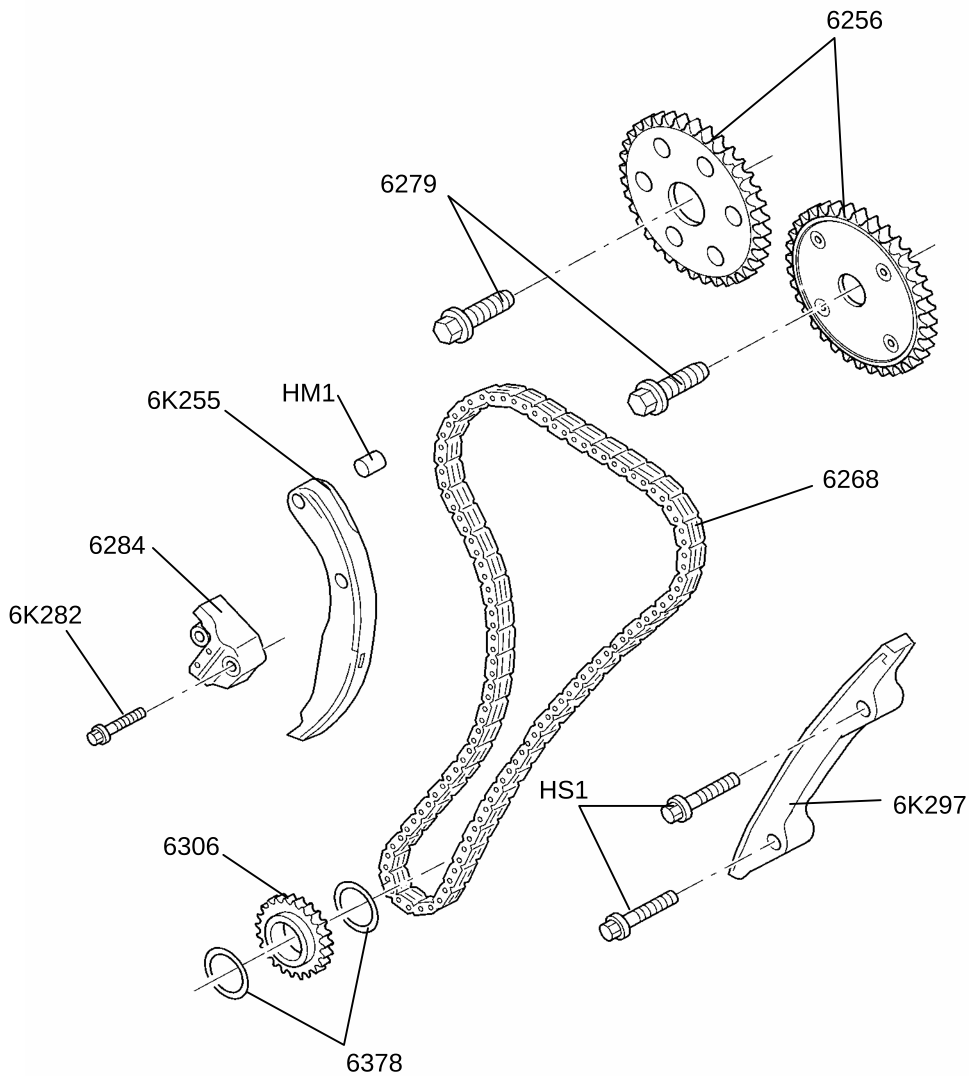
NOTE: For information on Heater Hoses, refer to "**Water By-Pass System**"

STARTER MOTOR



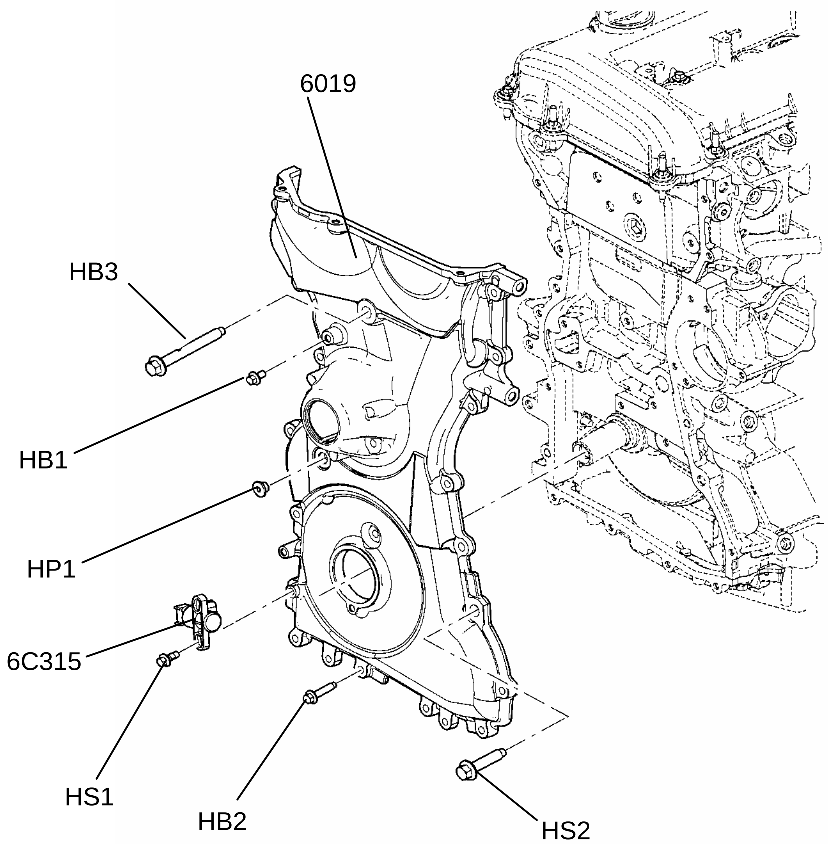
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Starter Motor**	
	5160	010	STARTER MOTOR	1
	206	021	BOLTS	2

TIMING CHAIN & GEARS



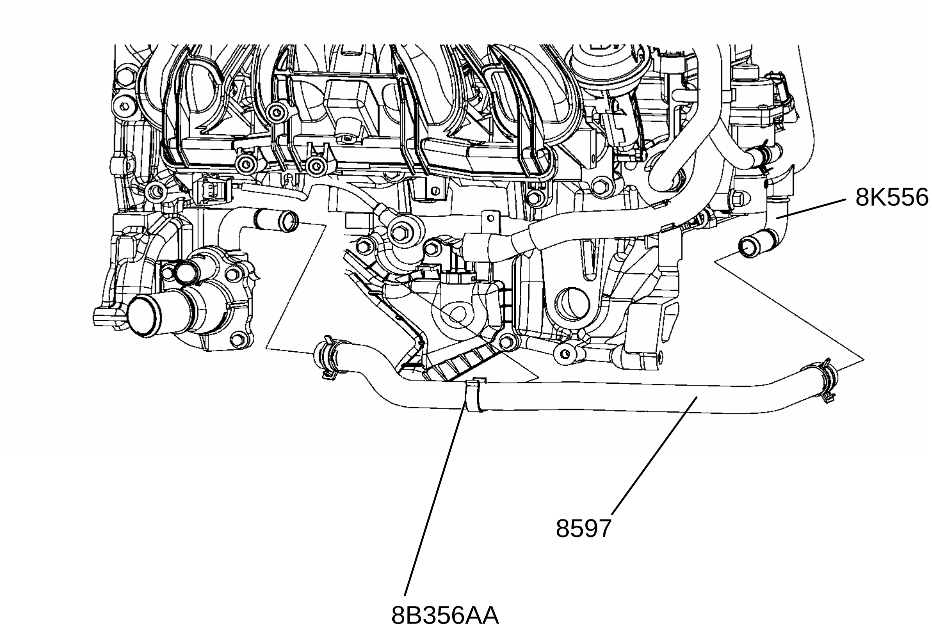
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Timing Chain & Gears**	
1S7Z	6256	AA	SPROCKET - CRANKSHAFT - RH/LH	1
3M4Z	6279	AA	BOLT - HEX HEAD FLANGED	1
1L5Z	6268	AA	CHAIN - TIMING	1
W	703549	S300	HARDWARE - MISC. PIN	1
1L5Z	6K255	AA	ARM - TIMING CHAIN TENSIONER	1
1S7Z	6K254	AA	TENSIONER - TIMING CHAIN	1
W	703643	S309	SCREW - M6 X 23.0	1
1L5Z	6K297	AA	MISC - TIMING BELT GUIDE	1
1S7Z	6K282	AA	BOLT	1
1S7Z	6378	AA	WASHER	1
1S7Z	6306	DA	GEAR - CRANKSHAFT	1
3L8Z	6256	AA	GEAR - CAMSHAFT	2

TIMING CHAIN COVER



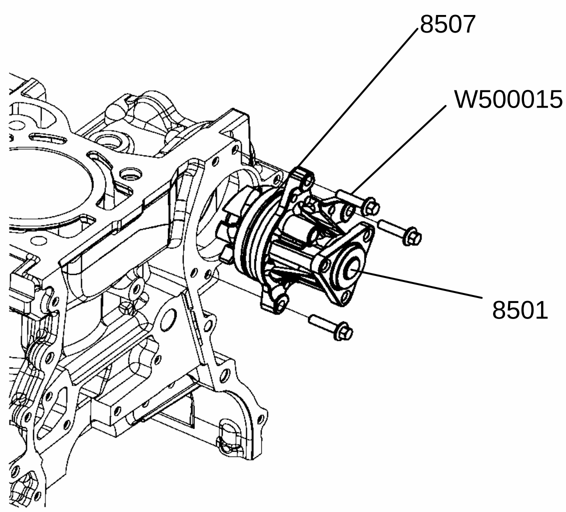
SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Timing Chain Cover**	
1L5G	6019	AA	COVER ASSEMBLY - ENGINE FRONT	1
W	500322	S301	BOLT - M10 X 50	3
W	500011	S439	BOLT - M6 X 12MM	1
W	500215	S437	BOLT - M6 X 1.00 X 25	1
W	500233	S309	SCREW M10 X 25MM	1
	W705310		STUD M6 1.0 X 25	1
1S7Z	6C315	AAA	SENSOR ASSEMBLY - CRANKSHAFT TIMING	1

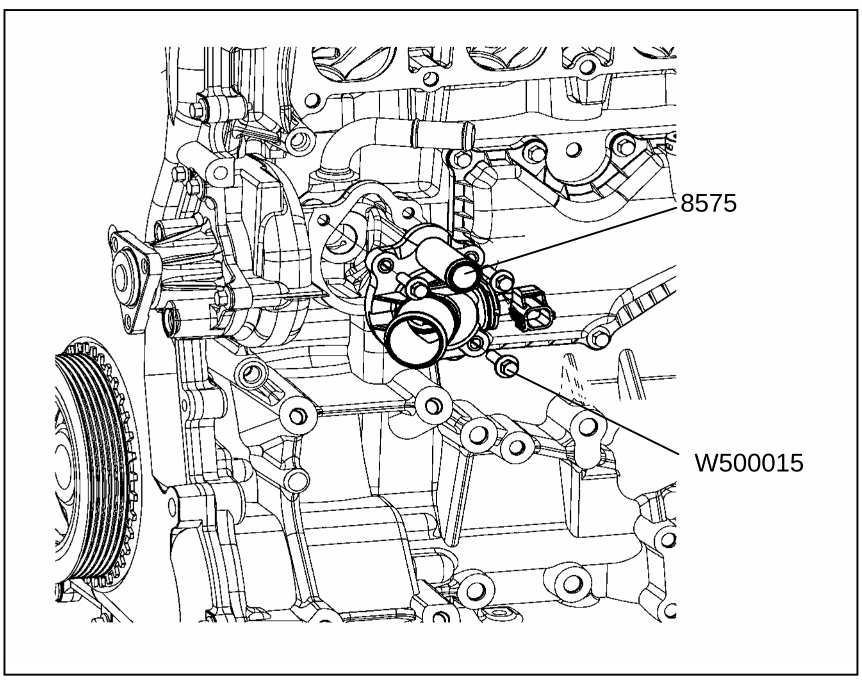
WATER BYPASS SYSTEM



SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Water Bypass System	
	8A582		HOSE & CLAMP ASSEMBLY - WATER BYPASS	
1S7Z	8597	AK	CONNECTOR - WATER BYPASS	
7L5Z	8K556	A	WATER OUTLET CONNECTOR	1
4M5Z	8B356	AA		2

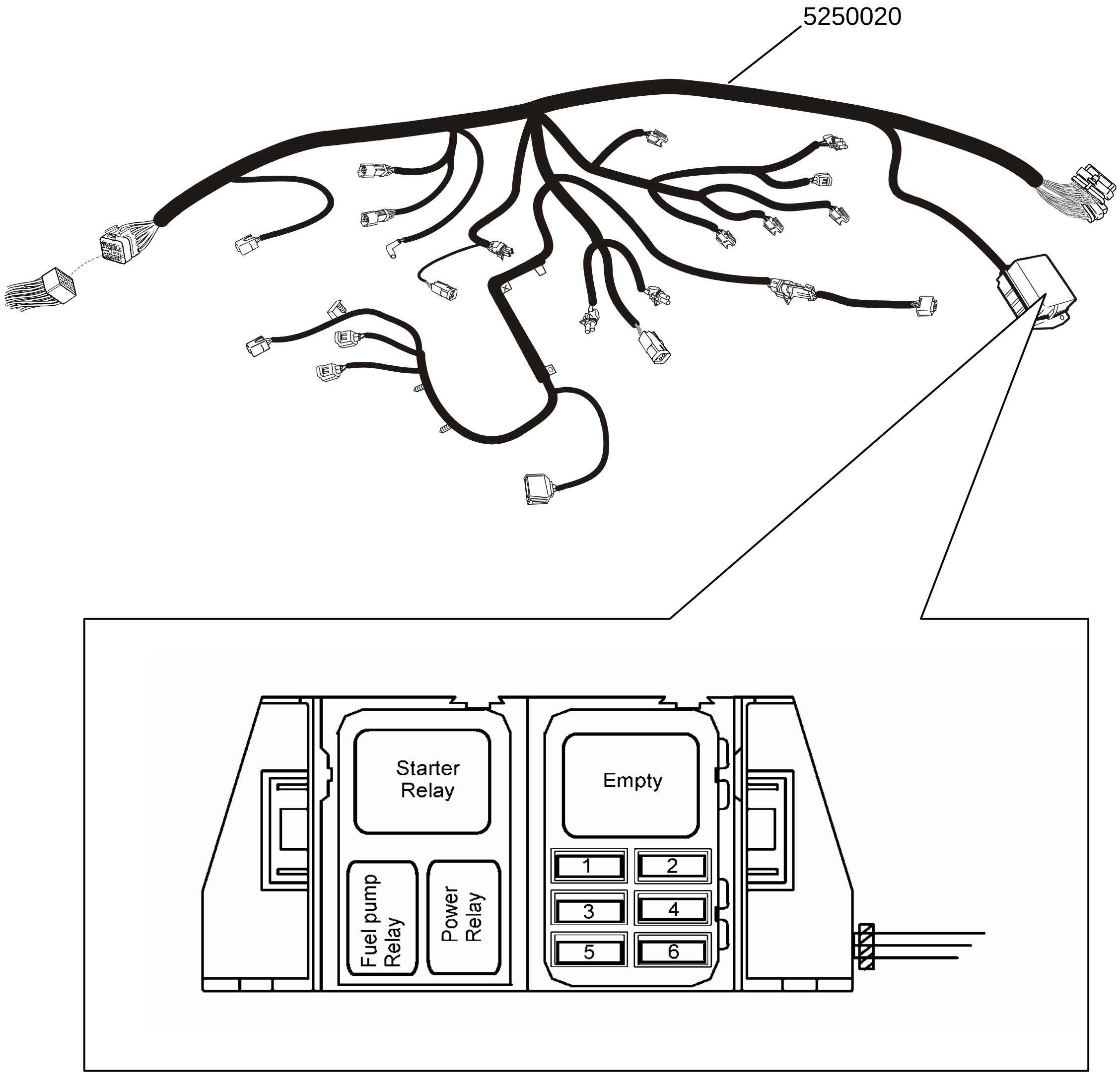
WATER PUMP & THERMOSTAT





SERVICE PART NUMBER	BASE NO.		DESCRIPTION	QTY.
			Water Pump & Thermostat	
4S4Z	8501	AA	WATER PUMP ASSEMBLY	1
W	500015	S309	BOLT - FLANGE HEAD TYPE - WATER PUMP	3
1S7Z	8507	AE	O-RING - WATER PUMP	1
W	500015	S309	BOLT - FLANGE HEAD TYPE - THERMOSTAT	3
4L5Z	8575	AD	THERMOSTAT ASSEMBLY	1
			.	

WIRING HARNESS, FUSES & RELAYS



SERVICE PART NUMBER			DESCRIPTION	QTY.
	BASE NO.		**Wiring Harness, Fuses & Relays**	
	5250	020	ENGINE HARNESS	1
	5060	030	F/P, POWER RELAY	
	5060	040	STARTER RELAY	

SAE J1701 (Issued 7/96)

Torque – Tension Relationships for SAE Grades 2,5 and 8

Diameter x Threads/in.	Stress Area	Grade 2			Grade 5			Grade 8		
	in2	Clamp load lb	Torque Dry k = 0.2	Torque Lub k = 0.15	Clamp load lb	Torque Dry k = 0.2	Torque Lub k = 0.15	Clamp load lb	Torque Dry k = 0.2	Torque Lub k = 0.15
1/4/2028	0.03637	1500	75 in-lb	56 in-lb	2319	116 in-lb	87 in-lb	3273	164 in-lb	123 in-lb
1/4/2020	0.03182	1313	66 in-lb	49 in-lb	2029	101 in-lb	76 in-lb	2864	143 in-lb	107 in-lb
5/16/2024	0.05806	2395	150 in-lb	112 in-lb	3700	230 in-lb	173 in-lb	5225	327 in-lb	245 in-lb
5/16/2018	0.05243	2163	135 in-lb	101 in-lb	3342	209 in-lb	157 in-lb	4719	295 in-lb	221 in-lb
3/8/2024	0.08783	3623	272 in-lb	204 in-lb	5600	420 in-lb	315 in-lb	7905	593 in-lb	445 in-lb
3/8/2016	0.07749	3196	240 in-lb	180 in-lb	4940	370 in-lb	278 in-lb	6974	523 in-lb	392 in-lb
7/16/2020	0.1187	4896	428 in-lb	321 in-lb	7567	662 in-lb	496 in-lb	10683	935 in-lb	700 in-lb
7/16/2014	0.1063	4385	384 in-lb	288 in-lb	6777	593 in-lb	445 in-lb	9567	837 in-lb	628 in-lb
1/2/2020	0.15995	6598	660 in-lb	495 in-lb	10197	1020 in-lb	764 in-lb	14396	1440 in-lb	1080 in-lb
1/2/2013	0.1419	5853	585 in-lb	439 in-lb	9046	904 in-lb	678 in-lb	12771	1277 in-lb	958 in-lb
9/16/2018	0.20298	8373	78 ft-lb	59 ft-lb	12940	121 ft-lb	91 ft-lb	18268	171 ft-lb	128 ft-lb
9/16/2012	0.18195	7505	70 ft-lb	53 ft-lb	11600	109 ft-lb	82 ft-lb	16376	154 ft-lb	115 ft-lb
5/8/2018	0.25595	10558	110 ft-lb	82 ft-lb	16317	170 ft-lb	127 ft-lb	23036	240 ft-lb	180 ft-lb
5/8/2011	0.226	9322	97 ft-lb	73 ft-lb	14407	150 ft-lb	113 ft-lb	20340	212 ft-lb	159 ft-lb
3/4/2016	0.37296	15385	192 ft-lb	144 ft-lb	23776	297 ft-lb	223 ft-lb	33566	420 ft-lb	315 ft-lb
3/4/2010	0.33446	13796	172 ft-lb	129 ft-lb	21532	269 ft-lb	201 ft-lb	30101	376 ft-lb	282 ft-lb
12-Jan	0.66304				42289	704 ft-lb	528 ft-lb	59674	995 ft-lb	746 ft-lb
8-Jan	0.60574				38616	644 ft-lb	483 ft-lb	54517	909 ft-lb	681 ft-lb
Tensile Strength					12,000 psi			150,000 psi		
Proof Load Stress		55,000 psi			85,000 psi			120,000 psi		

CAUTION: The previously listed torque and resulting tension are provided as an advisory guide. Individual application discretion is recommended. The content has been presented as accurately as possible but responsibility for its application lies

NOTE: The stress area of threaded senes not included may be computed from the equation $A_s = 0.7854\ (D-0.9743/n)^2$

Where: A_s=Stress area in inches^2

D=Diameter in inches

P=Threads per inch

Torque – Tension Relationships for Metric Property Classes

Diameter x Pitch	Stress Area mm^2	Class 4.6			Class 4.8			Class 5.8		
		Clamp load kN	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**	**Clamp load kN**	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**	**Clamp load kN**	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**
3.0 x 0.5	5.03	0.85	0.5	0.4	1.17	0.7	0.5			
3.5 x 0.6	6.78	1.14	0.8	0.6	1.58	1.1	0.8			
4.0 x 0.7	8.78	1.48	1.2	0.9	2.04	1.6	1.2			
5.0 x 0.8	14.2	2.4	2.4	1.8	3.3	3.3	2.5	4.05	4	3
6.0 x 1.0	20.1	3.4	4	3	4.67	5.66	4.2	5.73	6.9	5.2
8.0 x 1.25	36.6	6.18	9.9	7.4	8.51	13.6	10.2	10.4	16.7	12.5
10.0 x 1.50	58	9.79	19.6	14.7	13.48	27	20	16.5	33.1	24.8
12.0 x 1.75	84.3	14.22	34.1	25.6	19.6	47	35	24	58	43
14.0 x 2.00	115	19.41	54.3	40.8	26.74	75	56	32.8	92	69
16.0 x 2.00	157									
20.0 x 2.50	245									
24.0 x 3.00	353									
30.0 x 3.50	561									
36.0 x 4.00	817									
Tensile Strength		400 MPa			420 MPa			520 MPa		
Proof Load Stress		225 MPa			310 MPa			380 MPa		

Diameter x Pitch	Stress Area mm^2	Class 8.8			Class 9.8			Class 10.9		
		Clamp load kN	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**	**Clamp load kN**	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**	**Clamp load kN**	**Torque Dry k = 0.2 Nm**	**Torque Lub k = 0.15 Nm**
3.0 x 0.5	5.03									
3.5 x 0.6	6.78									
4.0 x 0.7	8.78									
5.0 x 0.8	14.2									
6.0 x 1.0	20.1									
8.0 x 1.25	36.6	16.5	26.4	19.8	17.8	28.5	21.4	22.8	36.5	27.3
10.0 x 1.50	58	26.1	52.2	39.2	28.3	56.6	42.4	36.1	72.2	54.2
12.0 x 1.75		37.9	91	68	41.1	99	74	52.5	126	94
14.0 x 2.00	115	51.8	145	109	56.1	157	118	71.6		150
16.0 x 2.00	157	70.6	226	170	76.5	245	184	97.7	313	235
20.0 x 2.50	245	110.2	441	331	119.4	478	358	152.5	610	458
24.0 x 3.00	353	158.9	762	572	172.1	826	620	220	1055	791
30.0 x 3.50	561	252.4	1515	1136	273.5	1641	1231	349	2095	1572
36.0 x 4.00	817	367.6	2647	1985	398.3	2868	2151	509	3662	2746
Tensile Strength		830 MPa			900 MPa			1040 MPa		
Proof Load Stress		600 MPa			650 MPa			830 MPa		

CAUTION: The previously listed torque and resulting tension are provided as an advisory guide. Individual application discretion is recommended. The content has been presented as accurately as possible but responsibility for its application lies

NOTE: The stress area of threaded senes not included may be computed from the equation $A_s=0.7854\ (D-0.9382\ P)^2$

Where: A_s=Stress area in mm^2

D=Diameter in mm

P=Pitch in mm

EDI DISTRIBUTORS

North America - Canada

ONTARIO, QUEBEC, MONITOBA	M-K Power Products Corp.	5641 McAdam Road Mississauga, Ontario, Canada, L4Z-1N9	905-890-5323
ALBERTA, SASKATCHEWAN	Industrial Engines, Ltd.	14355 120th Avenue Edmonton, Alberta Canada, T5L 2R8	780-484-6213

North America - United States

ALABAMA	M&I Ford	30762 State Highway 181 Daphne, AL 36526	800-633-1834
CALIFORNIA	Powertech Engines Inc.	2933 E. Hamilton Avenue Fresno, CA 93721	559-264-1776
FLORIDA	Engine Distributors, Inc.	259 Ellis Rd South Jacksonville, FL 32254	800-342-3576
	Engine Distributors, Inc.	2917 S. W. Second Ave. Fort Lauderdale, FL 33315	800-257-6605
MICHIGAN	Engine Center, Inc.	2351 Hilton Road Ferndale, MI 48220	800-726-8870
MISSOURI	C K Power Products	1100 Research Blvd. St. Louis, MO 63132	314-868-8620
NEBRASKA	Anderson Industrial Engines Co.	5532 Center Street Omaha, NE 68106	402-558-8700
NEW JERSEY	Engine Distributors, Inc.	400 University Court Blackwood, NJ 08012	800-220-2700
NORTH CAROLINA	Engine Distributors, Inc.	303 Interstate Drive Archdale, NC 27263 3148	800-220-7080
OHIO	Graham Ford Inc.	707 W. Broad St. Columbus, OH 43222	614-464-6000
	North Coast Ford Industrial	11885 Bellaire Road Cleveland, OH 44135	216-251-5800
PENNSYLVANIA	Pitt Auto Electric	1241 Freedom Road Cranberry Twp., PA 16066	724-778-8200
WASHINGTON	Pacific Torque	18060 Des Moines Memorial Drive, Burien, WA 98148	206-241-8300

EDI Worldwide Service
Engine Distributors Inc
400 University Court
Blackwood NJ 08012
Service/Warranty
1-800-220-2700
1-856-228-7298
1-856-228-5657(fax parts & service)
1-856-228-5531(fax sales)

Engine Distributors, Inc.
400 University Court
Blackwood, NJ 08012
1-856-228-7298
1-800-220-2700
1-856-228-5657(fax parts)
1-856-228-5531(fax sales)

ROCKWELL TA TYPE AXLE

MAINTENANCE INSTRUCTIONS

ROCKWELL TA TYPE AXLE

AXLE SHAFT REMOVAL

1. Place a drip pan under the end of the axle.

2. Remove seal and bearing retainer (item 34) from the end of the axle housing.

3. Pull the axle shaft (item 26 or 27) straight out and the tapered roller bearings will come with it.

4. Remove bearing cup from the housing if new bearings are to be installed.

AXLE WHEEL BEARINGS REPLACEMENT

1. Using a suitable press and puller, press the tapered roller bearing cones off the axle shaft.

2. Press the new bearings onto the axle shaft with the larger diameters toward each other.

3. Thoroughly grease the bearing cones with wheel bearing grease.

4. Insert and seat a new bearing cup into the housing recess and grease.

AXLE SHAFT REPLACEMENT

1. Check that the inner bearing cup is installed and seated in the housing and greased.

2. Insert the axle shaft into the housing.

3. Grease and install the outer-bearing cup.

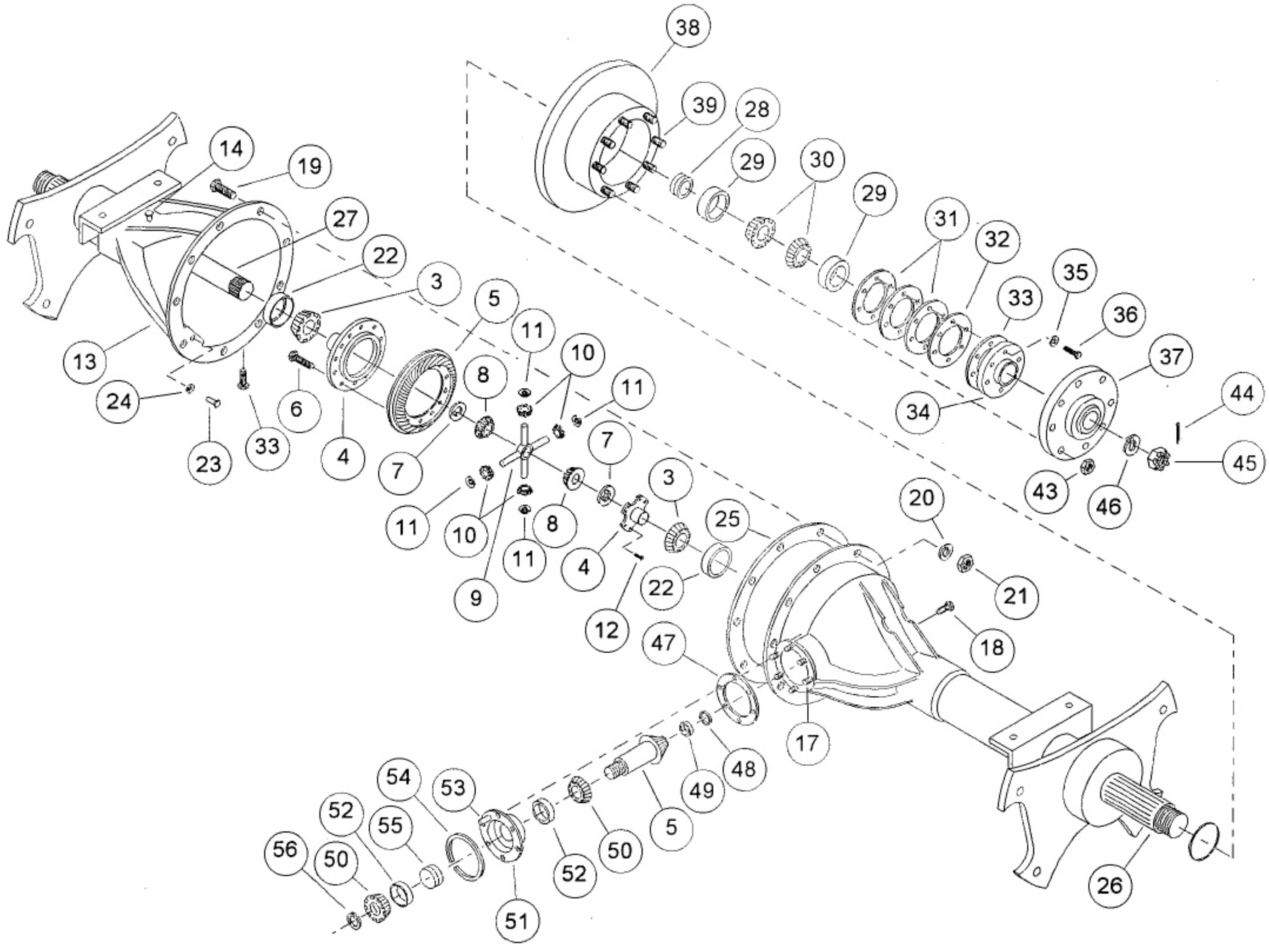
4. Install shim pack and retainer, secure with screws (item 36), torque to 50 ft. lbs.

5. Check for end play. Add or-remove shims until there is no or "0" end play. Then remove a .003" shim to obtain .003" preload.

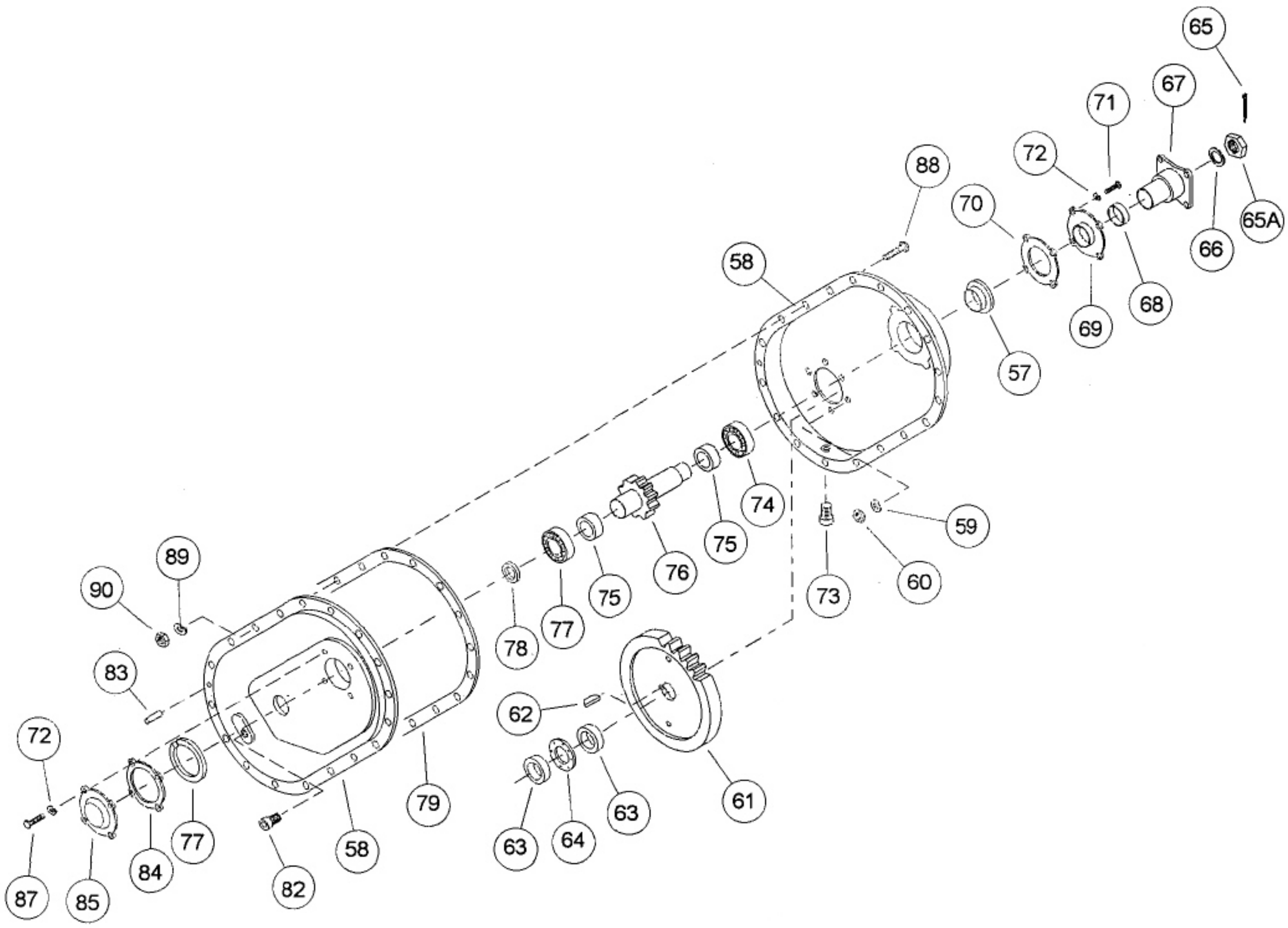
6. Apply sealer to inside of retainer after final shim pack has been determined. Assembly retainer to housing and install screws. Torque screws at 50 ft. lbs.

ROCKWELL TA TYPE AXLE

REAR DRIVE AXLE ASSEMBLY



REDUCTION GEAR BOX - REAR AXLE



DROP BOX REDUCTION GEAR REPLACEMENT

1. Place drain pan under the axle and drain the lube oil from both the center housing and the drop box housing.

2. Remove input flange (item 67) retain nut cotter key (item 65), nut (item 65A), washer (item 66) and input flange (item 67).

3. Remove back side bearing retainer (item 85) and screws (item 87).

4. Remove snap ring from outer bearing diameter (item 77).

5. Remove reduction gear box cover bolts (items 88, 89 & 90) and cover (item 58).

6. Remove input shaft with gear (item 76), and bearings.

7. From the large gear shaft, bend up tabs on lock washer (item 64), remove the locknut (item 63), lock washer, (item 64) and nut, (item 63).

8. Remove the gear (item 61). If it will not slide off, use (2) jack screws, 1/2-13 x 1 1/4" long into the two tapped holes in the gear to remove the gear with a gear puller.

9. Clean the drop box housing and replace the drain plugs

10. Place the new large gear (item 61) on the shaft and tap on to seat.

11. Install nut (item 63) and torque to 500 ft. lbs. Install lock washer (item 64).

12. Install locknut (item 63) and torque to 500 ft. lbs. Bend over tabs to lock both nuts.

13. Install new bearings (items 75 & 77), as required on the input shaft with gear (item 76).

14. Install new input shaft and bearing assembly. Remove snap ring from the bearing, (item 77) if the bearing was changed.

15. Assemble cover (item 58) with new gasket (item 79), screws (item 88), lock washers (item 89), nuts (item 90). Torque. bolts to 50 ft. lbs.

16. Install snap ring (item-78) on the end of the input shaft with gear (item 76) if the snap ring was removed to replace the bearing, (item 77).

17 Install the snap ring into the bearing (item 77).

18. Using a new gasket (item 84), install the rear bearing retainer (item 85), with the four. screws and lock washers (items 87 & 72). Torque to 50 ft. lbs.

19. Install the input flange (item 67), lock washer (item 66) and nut (item 65A). Torque to 200 ft. lbs.

20. Refill with oil to the bottom of the carrier fill plug and drop box fill plug. Refer to the Lubrication section for oil specifications.

DIFFERENTIAL REPAIR, PINION AND RING GEAR REPLACEMENT

1. Jack up the vehicle at both ends and put on secure jack stands.

2. Remove the rear wheels and tires.

3. Drain the rear axle lube oil.

4. Remove the 4 bolts securing-the drive shaft to the axle input flange and move drive shaft away.

5. Disconnect the 2 brake lines at the brake tees.

6. Place a secure jack under the axle and chain it to the jack for your safety.

7. Remove bolts or "U" bolts securing the axle to the spring or mount bars.

8. Lower the axle and move out from under the vehicle.

9. Place the axle in a clean work area on a bench or clean floor. Break brake line at tee for separating axle halves.

10. Remove back side bearing retainer (item 85) and screws (item 87)

11. Remove snap ring from outer bearing diameter (item 77).

12. Remove reduction gear box cover bolts (items 88, 89 & 90) and cover (item 58).

13. From the large gear shaft, bend up tabs on lock washer (item 64), remove the locknut (item 63), lock washer (item 64), and nut (item 6 3).

14. Remove the gear (item 61). If it will not slide off, use (2) screws 1/2-13 x 1 1/4" long into the two tapped holes in the gear to remove the gear with a gear puller.

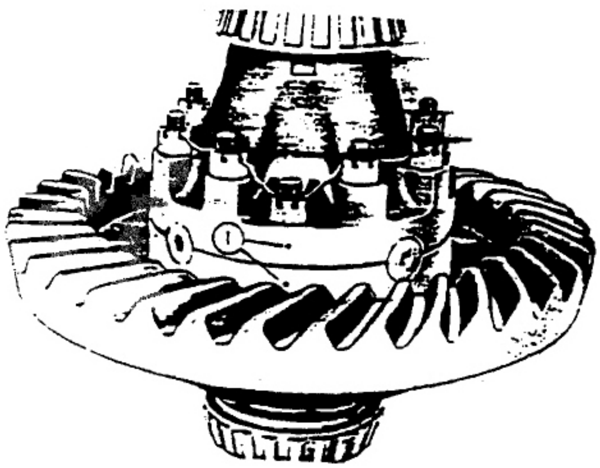
15. Remove nuts (item 60) and lock washers (item S9) securing the case half (item 58) to the axle carrier.

16. Remove bolts (items 19, 20 & 21) securing the two housings (items 13 & 16) together and separate.

17. Remove the differential and gear assembly.
18. Remove bearing retainer (item 51) .
19. Remove pinion shaft (item 5), with bearings.

DISASSEMBLE DRIVE UNIT

DISASSEMBLE DIFFERENTIAL AND GEAR ASSEMBLY



A. If original identification marks are not clear, mark differential case halves with a punch or chisel (as shown in photograph above) before disassembling, for correct alignment when reassembling.

B. Cut lock wire, remove bolts or cap screws and separate case halves.

C. Remove spider, pinions, side gears and thrust washers.

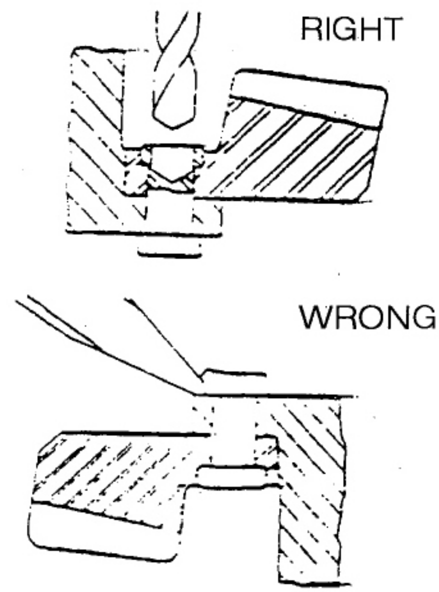
D. Remove rivets and separate gear and case if required.

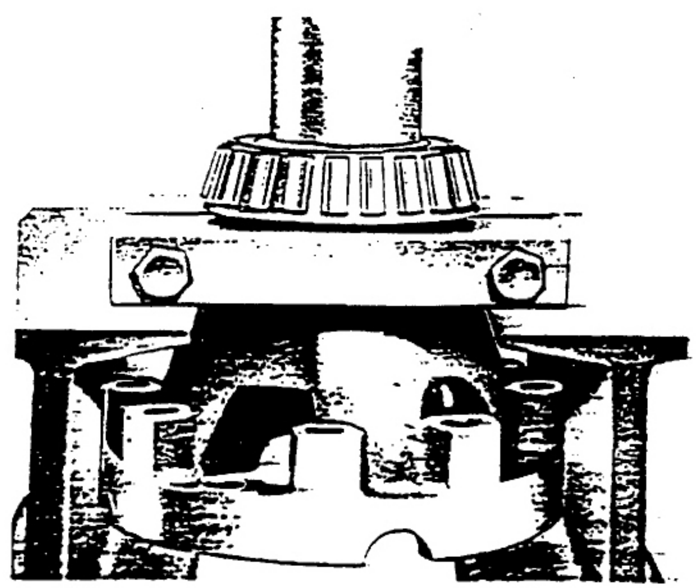
1. Carefully centerpunch rivets in center of head.

2. Use drill 1/32" smaller than body of rivet to drill through head.

3. Press out rivets.

REMOVE GEAR RIVETS:





E. Remove differential bearings with bearing puller if necessary to replace.

CLEAN

Parts having ground and polished surfaces such as gears, bearings, shafts and collars, should be cleaned in a suitable solvent such as kerosene or diesel fuel oil.

GASOLINE SHOULD BE AVOIDED.

Do NOT clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthosilicates or phosphates.

We do NOT recommend steam cleaning assembled drive units after they have been removed from the housing. When this method of cleaning is used, water is trapped in the cored passage of the castings and in the close clearance between parts as well as on the parts. This can lead to corrosion (rust) of critical parts of the assembly and the possibility of circulating rust particles in the lubricant. Premature failure of bearings, gears and other parts can be caused by this practice. Assembled drive units cannot be properly cleaned by steam cleaning, dipping or slushing. Complete drive unit disassembly is a necessary requisite to thorough cleaning.

ROUGH PARTS

Rough parts-such as differential carrier castings, cast brackets and some brake parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts are not ground or polished. The-parts should remain in the tank long enough to be thoroughly cleaned and heated through. This will aid the evaporation of the rinse water. The parts should be thoroughly rinsed after cleaning to remove all traces of alkali.

CAUTION: Exercise care to avoid skin rashes and inhalation of vapors when using alkali cleaners.

COMPLETE ASSEMBLIES

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all, openings are used. Breathers, vented shift units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

DRYING

Parts should be thoroughly dried immediately after cleaning. Use soft, clean, lintless absorbent paper towels or wiping rags free of abrasive material, such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.

CORROSION PREVENTION

Parts that have been cleaned, dried, inspected and are to be immediately reassembled should be coated with light oil to prevent corrosion. If these parts are to be stored for any length of time they should be treated with a good RUST PREVENTIVE COATING and wrapped in a special paper or other material designed to prevent corrosion.

INSPECT

It is impossible to overstress the importance of carefull and thorough inspection of drive unit parts prior to reassembly. Thorough visual inspection for indications of wear or stress, and the replacement of such parts as are necessary will eliminate costly and avoidable drive unit failure.

A. Inspect all bearings cups and cones, including those not removed from parts of the drive unit and replace if rollers or cups are pitted or damaged in any way. Remove parts needing replacement with a suitable puller or in a press with sleeves.

Avoid the use of drifts and hammers. They may easily mutilate or distort component parts.

B. Inspect first reduction bevel or hypoid and second reduction spur gears for wear or damage. Gears which are pitted, galled or worn or broken through case hardening should be replaced.

When necessary to replace the pinion or gear of a spiral bevel or hypoid gear set, the entire gear set should be replaced. We assume no responsibility for gears of these types when replaced in any other manner.

C. Inspect the differential assembly for the following:

1. Pitted, scored or worn thrust surfaces of differential case halves, thrust washers, spider trunnions and differential gears.

   Thrust washers must be replaced in sets. The use of a combination of old and new washers will result in premature failure.

2. Wear or damage to the differential pinion and side gear teeth. Always replace differential pinions and side gears in-sets.

D. Spur pinions for wear or damage to teeth.

E. Check end of pinion or indications of brinelling caused by worn splines. Replace the parts if the splines of the pinion and or thru shaft are worn, permitting movement of the pinion on the thru-shaft.

F. Axle shafts for indications of torsionaL fractures and runout Axle shafts should be inspected between centers to ascertain the amount of runout of the ground surface. Runout at the shaft flange and splines should not exceed .005" total indicator reading.

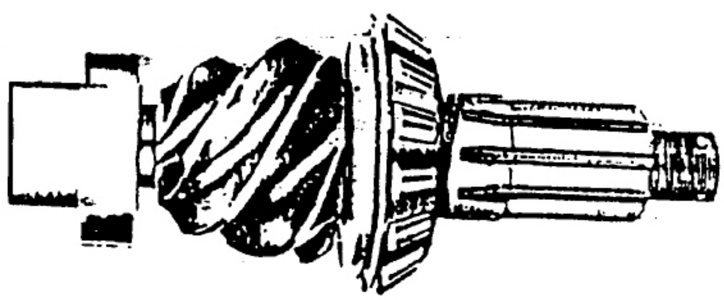
REPAIR

A. Replace all worn or damaged parts. Hex nuts with rounded corners, all lock-washers, oil seals and gaskets should be replaced at the time of overhaul.

Use only genuine Rockwell-Standard parts for satisfactory service. For example, using gaskets of foreign material generally leads to mechanical trouble due to variations in thickness and the inability of certain materials to withstand compression, oil, etc.

B. Remove nicks, mars and burrs from machined or ground surfaces. Threads must be clean and free to obtain accurate adjustment and correct torque. A fine mill or India stone is suitable for this purpose. Studs must be tight prior to reassembling the parts.

REASSEMBLE AXLE



Spiral Bevel

A. Press rear thrust and radial bearings firmly against the pinion shaft shoulder.

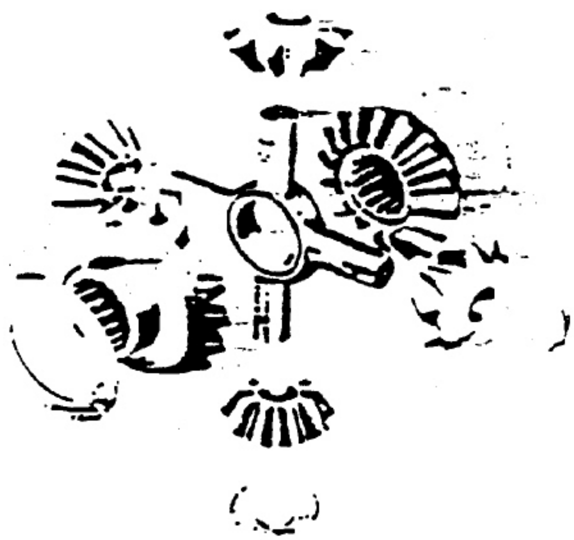
B. Install radial bearing lock ring and squeeze ring into pinion shaft groove with pliers.

C. If new cups are to be installed, press firmly against pinion cage shoulders.

D. Lubricate bearings and cups with light machine oil

ASSEMBLE DIFFERENTIAL AND BEVEL GEAR

A. Bolt bevel gear to case half with new bolts. Nuts away from the gear. Torque to 70 ft. lbs. If a new gear or differential case is to be used in the assembly, the bolt holes in the gear and case should be checked for alignment and line reamed if necessary. The gear must be tight on the case pilot.



B. Lubricate differential case inner walls and all component parts with axle lubricant.

C. Position thrust washer and side gear in bevel gear and case half assembly.

D. Place spider with pinions and thrust washers in position.

E. Install component side gear and thrust washer.

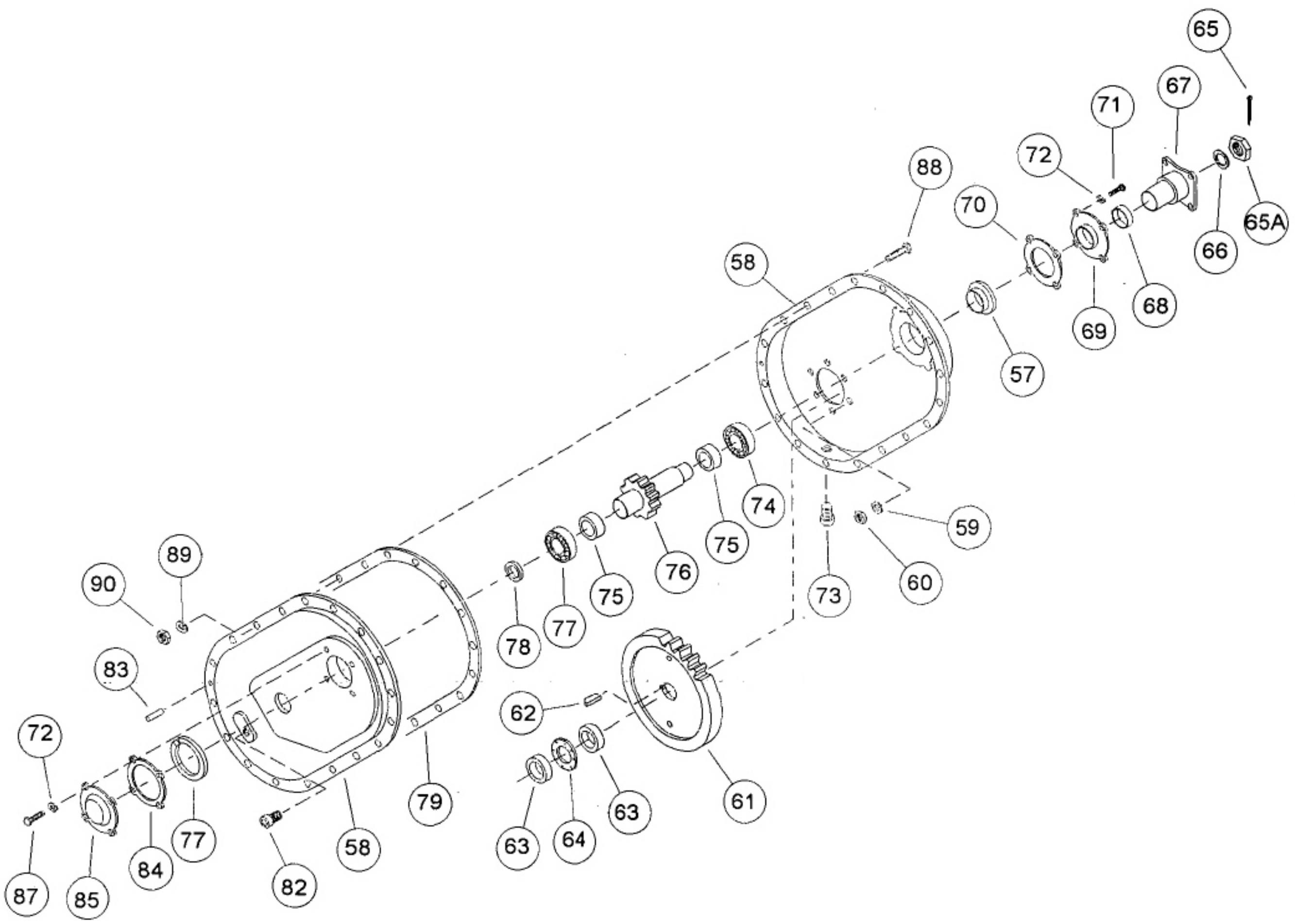
F. Align mating marks, position component case half and draw assembly together with four bolts or cap screws equally spaced.

G. Check assembly for free rotation of differential gears and correct if necessary.

H. Install remaining bolts or cap screws, tighten to 100 ft. lbs.

I. If bearings are to be replaced, press squarely and firmly on differential case halves.

REDUCTION GEAR BOX-REAR AXLE



TO INSTALL INPUT PINION WITH BEARINGS AND CHECK PRELOAD

1. Insert the pinion input shaft assembly (items 5, 48, 49, 50, 51, 52, 53, 54, 55 & 56) into the carrier hoiusing)item 16) with a new gasket, (item 47) over the studs.

2 Install the reduction box case half (item 58), to the carrier. Secure with lock washers and nuts (items 59 & 60). Torque nuts to 150 ft. lbs.

3. Install the large reduction gear (item 61) on the pinion shaft and tap on to seat.

4. Install nut (item 63) and torque to 450 - 550 ft. lbs. Use a block of hardwood between the pinion gear teeth housing to lock the pinion shaft so that it can be torqued. After torquing, remove wood block and wood splinters from the housing and pinion teeth.

5. Check pinion bearings preload by rotating the pinion and gear with an inch pound torque wrench. Should be 5-15 inch pounds required to rotate the pinion and gear assembly.

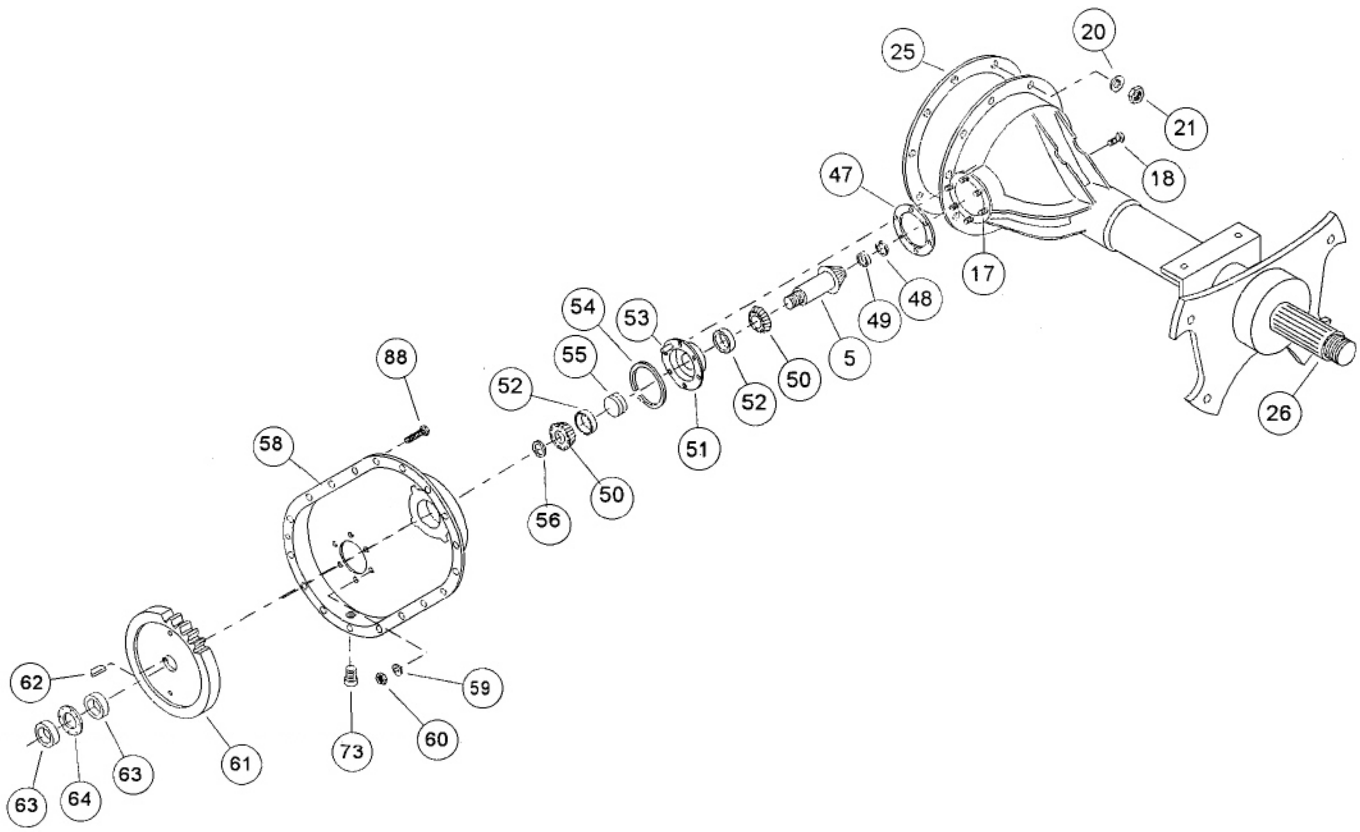
   Preload is adjusted by using different thicknesses of spacer, (item 55). Grind the spacer down to increase preload, cut a shim and add to the spacer to decrease preload. Different spacers are available as a kit when ordering a new ring and pinion gear set.

6. Adjust preload as required and torque according to step #4 above.

7. Install lockwasher, (item 64).

8. Install locknut (item 63) and torque to 450-550 ft. lbs. Bend over tabs to lock both nuts.

REAR DRIVE AXLE ASSEMBLY



1. Insert differential case with gear over the axle shaft end and into the housing half. No shims are required.

2. Using a new gasket (item 25), assemble the other case half together and secure with screws (item 19), lock washers, nuts (item 20 & 21), torque to 50 ft. lbs. Make sure the mounting pads are in the same position and level with each other.

ASSEMBLE DROP BOX

1. Install new bearings (items 75 & 77), as required on the input shaft with gear (item 76).

2. Install input shaft and bearing assembly. If a new bearing (item 77) was installed, remove the snap ring from (item 77).

3. Assemble cover (item 58) with new gasket (item 79), screws (item 88), lock washers (item 89), nuts (item 90). Torque bolts to 50 ft. lbs.

4. Install the snap ring (item 78), on to the end of the input gear and shaft with bearings (item 76) if the snap ring was removed to replace the bearing (item 77).

5. Install the snap ring into the bearing (item 77).

6. Using a new gasket (item 84), install the rear bearing retainer (item 85), with the four screws and lock washers (items 87 & 72). Torque to 50 ft. lbs.

7. Install the input flange (item 67), lock washer (item 66) and nut (item 65A). Torque to 200 ft. lbs.

8. Refill with oil to the bottom of the carrier fill plug and drop box fill plug. Refer to the Lubrication section for oil specifications.

TOROUE SPECIFICATIONS

AREA	TORQUE Foot Pounds (Newton Meters)
Axle Shaft to Hub Nut Tighten to assemble cotter key	400 (542)
Differential Case Screws	100 (136)
Differential Input Pinion Nuts	450-550 (610-745)
Drop Box Case Halves Screws	50 (68)
Drop Box Case to Carrier Nuts	150-190 (203-258)
Input Flange Bearing Retainer Screws	50 (68)
Input Flange Nut	200 (271)
Lugnuts	100 (136)
Ring Gear to Differential Case	70 (95)
Wheel Bearing Retainer Screws	50 (68)

TAYLOR-DUNN®
MANUFACTURING

Notes:

Green Since 1949

Appendixes

Contents

APPENDIX A: SUGGESTED TORQUE LIMITS FOR STANDARD HARDWARE

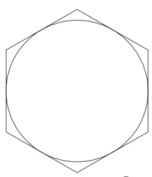
HARDWARE IDENTIFICATION

Standard Head Markings

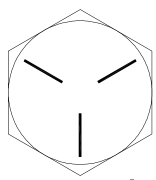
NOTE: Torque value used should be for lowest grade of hardware used. If a grade 2 nut is used on a grade 8 bolt, use grade 2 torque value.

NOTE: Toque values specified are for clean dry threads.

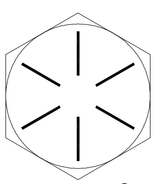
Hex Bolts



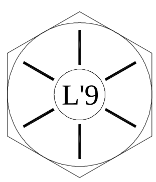
S.A.E. Grade 2



S.A.E. Grade 5



S.A.E. Grade 8



L'9

The grade of a metric bolt is cast directctly on the head. Below is an example of a 10.9. the location and style of the text will vary.

Other Bolts

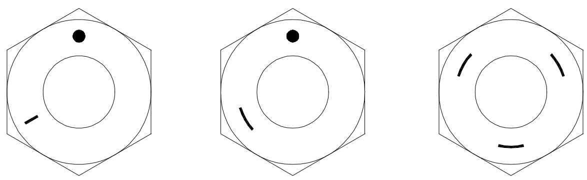
Truss Head, grade 2

Carriage Bolt, grade 2
(unless marked as above)

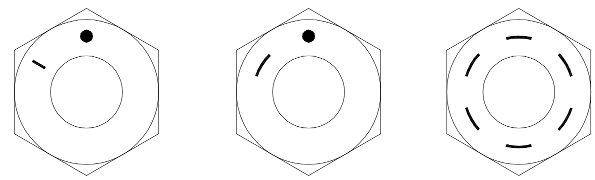
*Not available at time of printing

Hex Nuts

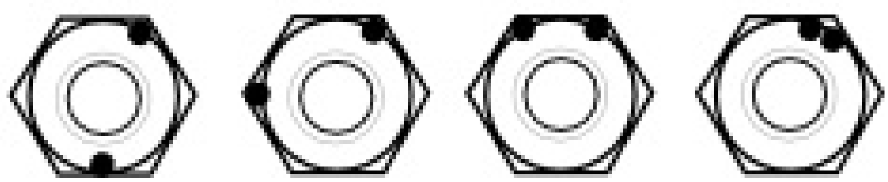
Nuts with no markings are to be treated as S.A.E. Grade 2



S.A.E. Grade 5



S.A.E. Grade 8



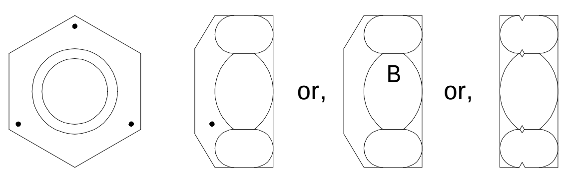
5.8 8.8 10.9 12.9

Metric Nuts

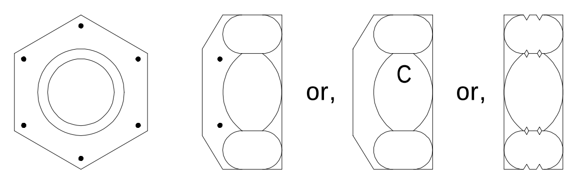
Hex Lock Nuts (stover)

Lock nuts use a letter to indicate the grade of the nut. Grade A' locknuts would be the equivelent of Grade '2' hex nuts, Grade 'B' as Grade '5' and Grade 'C' as Grade '8'.

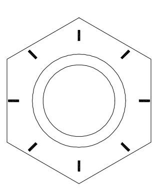
NOTE: Nuts with no markings are to be treated as S.A.E. Grade A



S.A.E. Grade B



S.A.E. Grade C



Grade L'9

Other Nuts

Other nuts used by Taylor-Dunn® should be treated as S.A.E. grade A

*Not available at time of printing

Generic Torque Values

All torque values are for clean dry zinc plated threads in noncritical steel assemblies of the same hardess specification. Reduce torque approximately 10-15% for lubricated threads.

Refer to the service section assembly procedure for critical torque values.

Imperial (inch), Foot Pounds

		Grade, SAE			
Dia.	Pitch	2	5	8	L9
#4	40	*	*	*	*
#6	32	*	*	*	*
#8	32	*	*	*	*
#10	32	*	*	*	*
#12	32	*	*	*	*
1/4	20	5.5	8.5	12.5	11
	28	6.5	10.5		
5/16	18	12.0	17.5	24.5	22
	24	12.5	19.0	*	*
3/8	16	20	30	43	40
	24	22.5	33	50	45
7/16	14	27	50	70	65
	20	36	55	77	70
1/2	13	49	75	106	95
	20	55	85	120	110
9/16	12	70	109	153	140
	18	78	121	171	160
5/8	11	97	150	212	195
	18	110	170	240	225
3/4	10	172	275	376	350
	16	192	297	420	390
7/8	9	278	429	593	565
	14	306	473	818	625
1	8	416	644	909	850
	14	466	721	1018	930
1-1/8	7	590	794	1287	1700
	12	662	891	1444	1850
1-1/4	7	832	1120	1817	2950
	12	922	1241	2012	3330

Imperial (inch), Newton Meters

		Grade, SAE			
Dia.	Pitch	2	5	8	L9
#4	40	*	*	*	*
#6	32	*	*	*	*
#8	32	*	*	*	*
#10	32	*	*	*	*
#12	32	*	*	*	*
1/4	20	7.4	11.5	16.9	14.9
	28	8.8	14.2		
5/16	18	16.2	23.7	33.2	29.8
	24	16.9	25.8	*	*
3/8	16	27.1	41	58	54
	24	30.5	45	68	61
7/16	14	37	68	95	88
	20	49	75	104	95
1/2	13	66	102	144	129
	20	75	115	163	149
9/16	12	95	148	614	190
	18	106	164	232	217
5/8	11	132	203	287	264
	18	149	230	325	305
3/4	10	233	373	510	475
	16	260	403	569	529
7/8	9	377	582	804	766
	14	415	641	1109	847
1	8	564	873	1232	1152
	14	632	978	1380	1261
1-1/8	7	800	1076	1744	2304
	12	897	1208	2364	2508
1-1/4	7	1128	1518	2463	4000
	12	1250	1682	2727	4514

Conversion Formulas:

Foot Pounds = Newton Meters x 0.737562149
Newton meters = Foot Pounds x 1.355817948

*Not available at time of printing

All torque values are for clean dry zinc plated threads in noncritical steel assemblies of the same hardess specification. Reduce torque approximately 10-15% for lubricated threads.

Refer to the service section assembly procedure for critical torque values.

Metric, Newton Meters

			Grade, N-m		
Dia.	Pitch	4.6	8.8	10.9	12.9
3	0.50	0.51	*	*	*
4	0.70	0.95	3.1	*	*
5	0.80	2.28	6.1	*	*
6	1.00	3.92	10.4	15.5	*
8	1.00	*	27.0	*	*
	1.25	9.48	25.0	37.0	*
10	1.00	*	57.0	*	*
	1.25	*	54.0	*	*
	1.50	19.1	51.0	75.0	*
12	1.25	*	96.0	*	*
	1.50	*	92.0	*	*
	1.75	32.6	87.0	160	*
14	1.50	*	150	*	*
	2.00	51.9	140	205	*
16	1.50	*	*	*	*
	2.00	79.9	215	310	*
18	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	110	300	*	*
20	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	156	430	*	*
22	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	211	580	*	*
24	2.00	*	*	*	*
	3.00	270	740	*	*
27	3.00	*	*	*	*
	3.00	398	*	*	*
30	2.00	*	*	*	*
	3.50	540	*	*	*

Metric, Foot Pounds

			Grade, N-m		
Dia.	Pitch	4.6	8.8	10.9	12.9
3	0.50	0.38	*	*	*
4	0.70	0.7	2.3	*	*
5	0.80	1.7	4.5	*	*
6	1.00	2.9	7.7	11.4	*
8	1.00	*	19.9	*	*
	1.25	7	18.4	27.3	*
10	1.00	*	42	*	*
	1.25	*	40	*	*
	1.50	14.1	38	55	*
12	1.25	*	71	*	*
	1.50	*	68	*	*
	1.75	24	64	118	*
14	1.50	*	111	*	*
	2.00	38	103	151	*
16	1.50	*	*	*	*
	2.00	60	158	229	*
18	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	81	221	*	*
20	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	115	317	*	*
22	1.50	*	*	*	*
	2.00	*	*	*	*
	2.50	156	428	*	*
24	2.00	*	*	*	*
	3.00	199	524	*	*
27	3.00	*	*	*	*
	3.00	293	*	*	*
30	2.00	*	*	*	*
	3.50	398	*	*	*

*Not available at time of printing

APPENDIX B: BRAKE LINING HANDLING PRECAUTIONS

⚠WARNING

Taylor-Dunn does not currently supply asbestos fiber-brake pads/shoes with any vehicle. However, there is the possibility that the original brake pads/shoes were replaced with aftermarket pads/shoes containing asbestos. Since this possibility does exist, the brake pads/shoes should be handled as if they do contain asbestos.

Never use compressed air or dry brush to clean the brake assemblies. Use an OSHA approved vacuum cleaner or any alternate method approved by OSHA to minimize the hazard caused by airborne asbestos fibers and brake dust.

Do not grind, sand, break, or chisel the brake pads/shoes, as this will cause unnecessary dust, possibly releasing asbestos fibers in the air.

Always wear protective clothing and a respirator when working on the brake pads/shoes or their associated components.

Inhaled asbestos fibers have been found to cause cancer and respiratory diseases.

Do not drive the vehicle if any worn or broken part is detected in any part of the brake system. The cause of the damage must be repaired immediately.

APPENDIX C: MANUFACTURER PART NUMBER CROSS REFERENCE

Component:	Description:	Part Number:	Vendor Name:
05-211-05	FILTER5/16"FUEL LINE,50 MICRON	G115	ONE STOP PARTS SOURCE
18-000-10	TIE ROD END, HEAVY DUTY,RH >	NCP 2692065	ORANGE COUNTY AUTO PARTS/ NAPA
18-000-11	TIE ROD END, HEAVY DUTY,LH >	NCP 2692064	ORANGE COUNTY AUTO PARTS/ NAPA
201030A	CYLINDER, STEERING, HYDRAULIC	3869	CARLSON HYDRAULICS INC
201032	JAM NUT, 11/16-18 RH	201032	EXCELL ENG INC
201037	STEERING COLUMN	204-1042-006/C	MIDWEST DIRECTIONAL SERV
201038	STEERING VALVE	211-1001-002CHARLYNN	SPENCER FLUID POWER INC
201039	STEERING WHEEL	143538P	VEHICLE IMPROVEMENT PRODUCTS
201134	FILTER ASSY, HYD	201134	ENGINEERED SALES
201283	JAM NUT 13/16-20	DORMAN 615-074	ORANGE AUTO PARTS/NAPA
4-2778901	MOUNT-ENGINE (65 DURO)	10-00547-01	TRELLEBORG INDUSTRIAL AVS INC
500055	U-BOLT REAR DRIVE AXLE LARGE	500055	BTM INC
500059	U-BOLT REAR DRIVE AXLE SMALL	500059	EXCELL ENG INC
500103-V6	RADIATOR, INLET @ RT	RS-5768	JB RADIATOR SPECIALITIES
500105-A	SOLENOID	120-902	WHITE RODGERS/EMERSON
500111-A	MOUNT/RADIATOR/ H.D.	3254-070-F6	EBCO INC
500117	BATTERY, GROUP 31 HEAVY DUTY	VMF31S-5 POWER VOLT	INTERSTATE BATTERIES OF CALIF
500128	SWITCH,IGNITION,KEYLESS	956-3124	COLE HERSEE CO
500130	COOLANT RECOVERY KIT	BVR-4 222	ATLANTIC PACIFIC AUTOMOTIVE
500140	HINGE \ HOOD (1)	500140 PER PRINT	S & D PRODUCTS INC
500145	LINE\STEEL\REAR BRAKES\FRONT	500145	RIGHT STUFF DETAILING
500146	LINE\STEEL\REAR BRAKES\REAR	500146	RIGHT STUFF DETAILING
500147	LINE\STEEL\BRAKE\SHORT	500147	RIGHT STUFF DETAILING
500148A	LINE\STEEL\BRAKE\LONG (1)	500148A	RIGHT STUFF DETAILING
500159	ADPTR UNION 1/4 INV >	302X4 (10PK)	EATON AEROQUIP
500185	SHOULDER BOLT \ BRAKE PEDAL (	26254	EXCELL ENG INC
500195	ADPTR INV FLARE 9/16 M-1/4 F >	7908 (2 PER PK)	EATON AEROQUIP
500201	FTG, 5/16 INV FL - 1/4 MPT	202X5X4	EATON AEROQUIP
500220-G	GROMMET STD - HALF	127P-5B	DFCI SOLUTIONS INC
500220-R	RECEPTACLE - SLIP ON	1219-L5-25305-Z3CT	DFCI SOLUTIONS INC
500220-WS	WING STUD STD	121J-W570-Z3CT	DFCI SOLUTIONS INC
500232-C	WIRE ROPE \ 1/8 VINYL COATED	45513	FASTENAL COMPANY
500233	DECAL \ WARNING (OPERATION)	500233	WILLINGTON NAME PLATES
500235	DECAL, UNLEADED FUEL ONLY,	500235	WILLINGTON NAME PLATES
500235-W	DECAL, UNLEADED FUEL ONLY, WHT	500235-W	WILLINGTON NAME PLATES
500237	DECAL \ CAUTION FAN	500237	WILLINGTON NAME PLATES
500243	CLAMP, HOSE, #72	B72H (10 PER PKG)	ATLANTIC PACIFIC AUTOMOTIVE
500249	HOSE 3/8 FUEL/VACUUM	EATON H05706-50R	EATON AEROQUIP
500262	CAP, RADIATOR 13 PSI	10229	ONE STOP PARTS SOURCE
500263	GROUND STRAP, ENG TO CHASSIS	148014/20314	TAYLOR CABLE PRODUCTS INC
500284-B	SEAT BUCKET WITH RAILS	WM917A	WISE COMPANY
500298-A	RUBBER BOOT1/8"X4"X7"\P.BRAKE	48150-1 PRINT	METRO INDUSTRIES INC
500362	LIFT SPRING \ HOOD	C16-11253	SUSPA INC
500363	BALL STUD \ LIFT SPRING >	P67-00001F	SUSPA INC
500364	BOOT \INSULATING \BATTERY CABL	23517	WAYTEK INC
500529	ROD END \ SHIFTER	CL-1301361	SUPERIOR SIGNALS INC
500539	BRACKET \ SHIFTER MOUNTING	1758867	HARLAN GLOBAL MFG
500543	LEVER \ PARKING BRAKE	02182900	ORSCHELN CO
500546	GAUGE, FUEL LEVEL, 240 OHM>	06339-01	MAXIMA TECHNOLOGIES
500547	FUEL SENDER (13 GAL TANK)	100438	MAXIMA TECHNOLOGIES

Component:	Description:	Part Number:	Vendor Name:
500552	SWITCH\HYD PRESS\MC	8626	COLE HERSEE CO
500555	CLAMP\MUFFLER\2"	4200	ONE STOP PARTS SOURCE
500557	BUMPER, HOOD	020110251/	EBCO INC
500558-A	RELAY \ HORN (4 PIN)	87106B	BARKER ENTERPRISES INC
500560	HOUR METER SWITCH	CL-909518/HOBBS76575	SUPERIOR SIGNALS INC
500563	COTTER PIN \ 1/8 X 1 3/4	0165345	FASTENAL COMPANY
500571	GREASE ZERK 1/8NPT STR	60102	FASTENAL COMPANY
500574	LATCH ASSY. \ HOOD	AH 35R	AUSTIN HARDWARE & SUPPLY
500576	WASHER\CU\BRAKE LINE	20600	B & W BRAKE INC
500581	COLLAR \ FUEL POCKET	95327/02050-0072	HARLAN GLOBAL MFG
500583	BUSHING, SPRING EYE	NB 311	SECURITY STEEL SUPPLY CO
500586	HORN \ W/BRACKET	7224921 /30 PER PACK	FIAMM TECHNOLOGIES INC
500589	HANDLE \ HOOD	9611	AUSTIN HARDWARE & SUPPLY
500591	BRAKE LINE/AT MC	97027	RIGHT STUFF DETAILING
500624	TRIM SEAL \ FRNT CAB & LOW >	SD-170	AUSTIN HARDWARE & SUPPLY
500673	CALIPER/FRONT BRAKES >>>>	07860300	TOL-O-MATIC INC
500759-0250	WIRE LOOM NYLON 1/4	LCN-250-500	WAYTEK INC
500759-0350	WIRE LOOM \ 3/8" \ NYLON	LCN-350-500	ANAHEIM WIRE PRODUCTS
500759-0500	WIRE LOOM \ 1/2" \ NYLON	LCN-500-250	WAYTEK INC
500759-0750	LOOM, NYLON 3/4"	LCN-750-550	ANAHEIM WIRE PRODUCTS
500781	CIRCUIT BREAKER \ 10A	46410	WAYTEK INC
500782	CIRCUIT BREAKER \ 50A	46350	WAYTEK INC
500787	CIRCUIT BREAKER \ 15A	46415	WAYTEK INC
500788	BRACKET \ 4-CIRCUIT BREAKER	46464	WAYTEK INC
500789	BUSS BAR \ 4 GANG	46564	WAYTEK INC
500790	BUSS BAR \ 3 GANG	46563	WAYTEK INC
500791	BUSS BAR \ 2 GANG	46562	WAYTEK INC
500805-7-A	AIR CLEANER ASSEMBLY	FPG-070020-1	FILTER-TEK INC
500805-7-B	BRACKET \ AIR CLEANER MOUNTING	AAH-002070-3	FILTER-TEK INC
500810	FLEX PLATE	F207	AUTOCRAFT MFG CO INC
500811	RING/FLEX PLATE/USE W/500810	C20Z-6A366A	POWERTECH ENGINES INC
500838	KEY 1/4 SQ X 3/4	0953159	EXCELL ENG INC
500840	NUT \ STEER ARM STOP	36208	FASTENAL COMPANY
500842	NUT, BEARING ADJUST	1227L636/SEE EXTEND	TAIYUAN CHENKE MANF CO LTD
500844	GASKET, HUB	95362	METRO INDUSTRIES INC
500846	HUB >	TIG-3001-153 (95010)	TAIYUAN CHENKE MANF CO LTD
500849	CONE, BEARING, HD AXLE	18590	TIMKEN CORP
500850	CUP \ BEARING \ HD AXLE	18520	TIMKEN CORP
500851	SEAL, INNER GREASE, HD AXLE	CL103964	SUPERIOR SIGNALS INC
500857	KIT, KING PIN, R&LH, HD AXL	TK476B	TRAYER PRODUCTS INC
500864	SPRING \ ACCEL. RETURN \ F300	CL-2352605	INDUSTRIAL SPRING CORP
500898	STUD FRONT WHEEL 1/2-20X1-7/8	P151421	GKN AMRSTRONG WHEELS INC
500975	TRIM SEAL	SD-168	AUSTIN HARDWARE & SUPPLY
501040-7	DECAL, SHIFT	DIE #2957	WILLINGTON NAME PLATES
501273	CALIPER & FASTENERS / CARLISLE	419-9017	CARLISLE INDUSTRIAL BRAKE
502013	TEE, 1/4 INVERTED FLARE	702X4	EATON AEROQUIP
502131	CLAMP, HOSE, #48	0427619	FASTENAL COMPANY
502134	BOOT, RUBBER, STEERING	CB4-B	T-H MARINE SUPPLIES INC
502136	SWITCH, FOOT/HORN	FCS-1	T-H MARINE SUPPLIES INC
502142	REFLECTOR, RED	B491R	PETERSON MANUFACTURING CO
502143	REFLECTOR, AMBER	B491A	PETERSON MANUFACTURING CO

Component:	Description:	Number:	Vendor Name:
502177	DECAL FEDEX LOGO HOOD	0025	CALAWAY SYSTEMS INC
502198	ADPTR INV FLARE 5/16M X 1/4F >	7829 (5 PER PK)	EATON AEROQUIP
502246	TRANS MOUNT \ ISOLATOR	2448	ANCHOR INDUSTRIES INC
502321	BULB, LIGHT #53	CLB 53 PREMIUM	ATLANTIC PACIFIC AUTOMOTIVE
502324	DIPSTICK TUBE FORD C6	E5TZ7A228H	POWERTECH ENGINES INC
502427	BOLT/SPECIAL FLEXPLATE C6	378171-S100	POWERTECH ENGINES INC
502496	RELAY\ACCESSORY	TYCO 75551/SEE QUOTE	WAYTEK INC
502518	TEE/BRAKE LINE/.250	7898	EATON AEROQUIP
502533	CIRCUIT BREAKER BOOT	23540	WAYTEK INC
502556A	BOOT \ TOP POST \ POSITIVE	23503	WAYTEK INC
502587	SHIFT INHIBITOR	C6CA-ES-HPS-00	SAFETY SYSTEMS & CONTROLS INC
502737	COLLAR, LOCKING 1/2 ID	33374	EXCELL ENG INC
502758	WHL TIRE ASSY, 225/75R16	502758 (75 R 16)	PETE’S ROAD SERVICE INC
503056	CLAMP, U-BOLT, 3/16	43422	FASTENAL COMPANY
503191	BSHG .75 OD X.50 ID X1.25 BRZ	EP081220	PRECISION INDUSTRIES INC
503415	LT TAIL/STOP/GROM/HARN 44030R>	44030R	TRUCK-LITE CO INC
503800	HOSE RDTR 1.5X1.75DIA 90 6.5LG	7631/20904	ORANGE AUTO PARTS/NAPA
503829	FTG 45DEG 1/8NPT - 5/16 INV FL	352X5	EATON AEROQUIP
503954	MUFFLER WRAP 2"	11002	THERMO TEC INC
504084	FTG BRS 1/4 F INV - 1/8 FPT	652X4 (5 PER PK)	EATON AEROQUIP
504087	FTG BRS 3/8MPT - 1/4FPT	3220X6X4	ORANGE COUNTY AUTO PARTS/NAPA
504121	FTG 90 MALE ELBOW 3/8 TO 3/8	2501-6-6 / C5405X6X6	EATON AEROQUIP
504124	FTG STR THD O-RING CONN TO MAL	C5315X6 10PK	EATON AEROQUIP
504125	FTG 90 STR THD O-RING TO MALE	C5515X6	EATON AEROQUIP
504420	REFLECTOR, RND YEL, 2"	B477A	PETERSON MANUFACTURING CO
504595	AXLE 20:1 TA267	TA267HDB200 667	AXLETECH INTERNATIONAL
504596	CLAMP, HOSE, 3/4, STEPLESS EAR	0427991	FASTENAL COMPANY
504938	DECAL / CHECK ENGINE	.75 X1 3M7941	WILLINGTON NAME PLATES
504942	FTG, 5/16 HB X 1/4 MPT BARB	41040504	KR JOHNSON
504998	FTG, 90D FUEL, 7.9 MM (5/16)	F78A-9416-DA	POWERTECH ENGINES INC
505461	FUEL CAP W/SCR 2" NPT RED/EPA>	1273EPA/10	PROTECTOSEAL CO
505502	HYDROBOOST	02040A2880	ROBERT BOSCH CORP
505735	CLAMP, MUFFLER, 1 3/4"	H134	ATLANTIC PACIFIC AUTOMOTIVE
505787	ELBOW, AIR INLET, 2"	P105529	FILTER-TEK INC
505879	WIRE, SAFETY, 0.032 DIA	8905K31	MCMASTER-CARR
505893	ENGINE, FORD 2.3L GAS LRG	DSG423I-6005-A	POWERTECH ENGINES INC
506201	BACK-UP LAMP ASSY, LED	44180C	TRUCK-LITE CO INC
506304	PS RESERVOIR, 2.3L / 4.2L FORD	3L3Z-3A697AA	POWERTECH ENGINES INC
506334	HOSE, RAD 1-1/2 - 1-1/4 90 DEG	7564/20801	ORANGE AUTO PARTS/NAPA
66-000-40	CAP, COOLANT, 5/16	7151841	ORANGE COUNTY AUTO PARTS/NAPA
66-400-08	HANGER, EXHAUST, RUBBER	255217	ORANGE COUNTY AUTO PARTS/NAPA
66-400-60	HOSE, RADIATOR, UPPER, 2.3	NBHFF194	ORANGE COUNTY AUTO PARTS/NAPA
71-100-00	SW,TOGGLE,15A,125V W/HDWE	CA204-78XTA1	ELECTRIC SWITCHES INC
72-028-41	LAMP, AMBER PILOT	PL-20-AC	CARLTON BATES CO INC
72-028-42	LAMP, GREEN PILOT	PL-20-GC	COLE HERSEE CO
74-000-00	HOUR-METER,12 TO 48 VOLTS	109218	MAXIMA TECHNOLOGIES
76744	FTG, 3/8 JIC - 1/2 MPT - 90DEG	25016-8/C5405X6X8	TOMPKINS INDUSTRIES INC
86-510-00	ASSY,BALL JT CLAMP#25469-H	C5469-H	MASON FORGE & DIE INC
90536	BUSHING, 3/4"M X 1/2"F	3220X12X8	EATON AEROQUIP
94-318-80	DECAL,ASSET NUMBER,5-DIGIT	0061L SPECIFY #	CALAWAY SYSTEMS INC
96-762-00	3/8 IN.CLEVIS CAST	B27084AZ	EXCELL ENG INC
99-525-25	FTG, 1/4 - 1/8 45 DEG ELBOW	352X4 (10 PER PK)	EATON AEROQUIP
A10621	SHIM, 1.75 OD X 1.16 ID X 0.01	SM-37	TRAYER PRODUCTS INC

APPENDIX D: SUGGESTED SPARE PARTS LIST

Component	Description	*Qty
05-211-05	FILTER5/16"FUEL LINE,50 MICRON	1
18-000-10	TIE ROD END, HEAVY DUTY,RH >	3
18-000-11	TIE ROD END, HEAVY DUTY,LH >	1
500105-A	SOLENOID	1
500117	BATTERY, GROUP 31 HEAVY DUTY	1
500128	SWITCH,IGNITION,KEYLESS	1
500362	LIFT SPRING \ HOOD	2
500552	SWITCH\HYD PRESS\MC	1
500560	HOUR METER SWITCH	1
500582	LEAF SPRING, FRONT AXLE	2
500844	GASKET, HUB	2
500849	CONE, BEARING, HD AXLE	4
500851	SEAL, INNER GREASE, HD AXLE	2
500864	SPRING \ ACCEL. RETURN \ F300	1
502142	REFLECTOR, RED	2
502143	REFLECTOR, AMBER	2
502321	BULB, LIGHT #53	2
502758	WHL TIRE ASSY, 225/75R16	2
503343	WHL/TIRE 6.50X10 PNEUMATIC	2
503415	LT TAIL/STOP/GROM/HARN 44030R>	2
504420	REFLECTOR, RND YEL, 2"	2
505999	ASSY,HEADLAMP, HALOGEN	2
506201	BACK-UP LAMP ASSY, LED	2
67-500-01	Air Filter	1
67-500-14	Oil filter	1
67-500-15	Fuel lFilter	1
71-100-00	SW,TOGGLE,15A,125V W/HDWE	1
71-503-01	HORN BUTTON, BLACK	1
85-000-10	ASSY, SPRING & BRONZE BUSHING	2
99-528-00	Filter, Steering Hydraulic	1
99-528-00	Filter, Transmission Hydraulic	1

***** - Quantity indicated is what is used on one vehicle. Quantity to be kept on hand as spare parts to be determined by the end user taking into account the total number of vehicles in service.***

***** - Quantity required varies or is not defined.***

APPENDIX E: REVISION HISTORY

10/18/2010: Published