

Atlas Copco Drilling Solutions



Operating, Safety and Maintenance Manual DM45/DM50/DML

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Read this manual before operating or servicing this equipment.



This manual contains important safety information.

Do not destroy this manual.

This manual must be available to personnel who operate and maintain this machine.

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SECTION 1

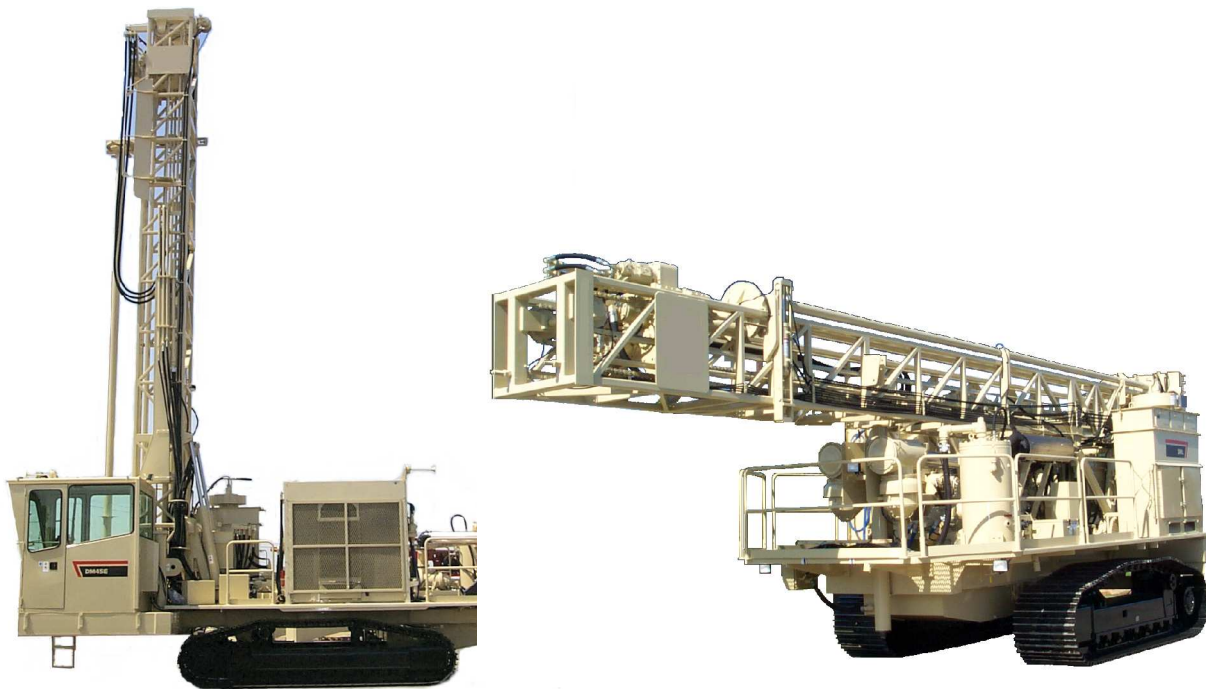
INTRODUCTION

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1.1 - INTRODUCTION

This Safety, Operation and Maintenance Manual has been developed to present the safety, operations and preventive maintenance requirements for safe, effective operation of the Drilling Solutions Mid-Range Blasthole Drills. The Drilling Solutions Mid-Range Blasthole Drills are: DM45/LP (Low Pressure), DM45/HP (High Pressure), DM50/LP (Low Pressure), DML/LP (Low Pressure) and DML/HP (High Pressure).

The purpose of this manual is to provide the operator and site maintenance personnel with the knowledge of the fundamental rules and criteria to be followed for on-site use and maintenance of a DM45, DM50 and DML Series Blasthole Drill Rig.



DM45 SERIES

DM50 SERIES

Figure 1.1 – 1

DML SERIES

The operator and site maintenance personnel must read and fully understand this Safety, Operation and Maintenance Manual before operating or servicing the drill. This manual has been organized to present the safety precautions, operation requirements and appropriate information needed to:

1. Safely operate the Blasthole Drill while achieving optimum production.
2. Understand the operating principle of each system associated with the Blasthole Drill.
3. React effectively and safely to emergency and alarm conditions.
4. Perform the necessary pre-operational and post-operational checks on the drill.

Always keep the “Safety, Operation and Maintenance” manual on the drill and available to the operator and helper.

1.1 - INTRODUCTION

HOW IS THIS MANUAL ORGANIZED

Although there is a substantial amount of information contained in the manual, it has been organized so that the reader can easily find the specific information needed.

The manual is divided into sections by information based on answers to the following questions:

1. What are the specific operator safety responsibilities? (Section 2.0)
2. What are the specifications of the drill itself? (Section 3.0)
3. What instruments and controls are used by the operator to operate and monitor the drill? (Section 4.0)
4. What are the operating capabilities and limitations of the equipment? (Section 5.0)
5. What inspections are the responsibility of the operator, and when must they be made? (Section 6.0)
6. What should the operator do when problems arise? What are the types of hydraulic, electrical and compressor systems? What is the correct operator troubleshooting response? (Section 7.0)
7. What the various terms mean that are used in this manual? (Section 8.0)

Where To Find Information

Each manual has a table of contents. If you are uncertain which section contains the information or where the information is located within a particular section, the first step is to consult the table of contents.

This Instruction manual consists of eight (8) sections:

- Section 1 --- Introduction describing the drill
- Section 2 --- Safety
- Section 3 --- Technical Specifications
- Section 4 --- Operating controls and instruments
- Section 5 --- Operating Instructions
- Section 6 --- Maintenance instructions
- Section 7 --- Systems/Troubleshooting
- Section 8 --- Glossary

If any part of this manual cannot be understood, contact your supervisor or local Drilling Solutions Distributor. This is an essential condition for working safely with the drill.

The correct drill operation, use and regular maintenance are also essential elements to provide the highest performance and safety.

NOTE:

The present manual is accompanied with an engine instruction manual. You are therefore advised to follow the operation and maintenance instructions as specified in both the engine and drill instruction manuals.

1.1 - INTRODUCTION

These symbols call your attention to a safety precaution. They mean:

**WARNING!
BE CAREFUL!
IT CONCERNS YOUR SAFETY!**



PROCEDURE WHEN RECEIVING THE DRILL

Your drill has been tested, accurately checked, and prepared for shipment. Every part of the drill, including the detached parts, has been accurately checked before being shipped from the factory.

When you receive the drill, and before unpacking the equipment, check if damage has occurred during transport and if any parts are missing.

Check the equipment by consulting the shipment documents.

If the goods are damaged, or if parts are missing, inform the freight agent as soon as possible. He will inform you regarding how to proceed in order to make a complaint.

IDENTIFICATION DATA

An exact description of the model type and the serial number of your drill will facilitate fast and efficient response from our parts and service support operations.

Always provide the model of your drill and it's serial number when you contact the local Drilling Solutions service or parts office.

We advise you to enter your drill data in the following lines to maintain drill and engine information:

Model _____

Drill Serial Number _____

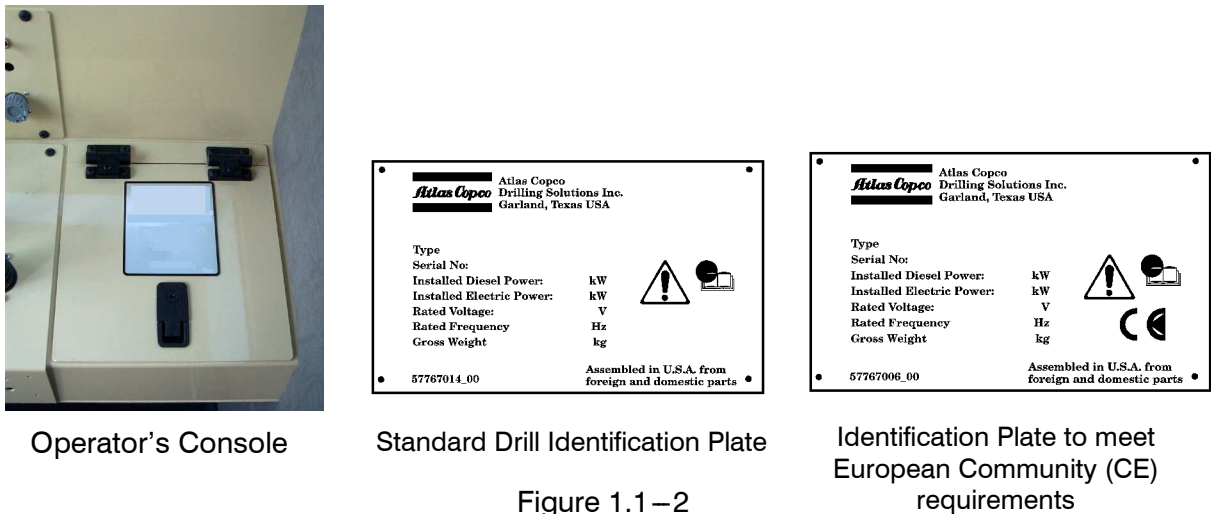
Year of Manufacture _____

Engine (Mfg. and Type of Engine) _____

Deck Engine Serial Number _____

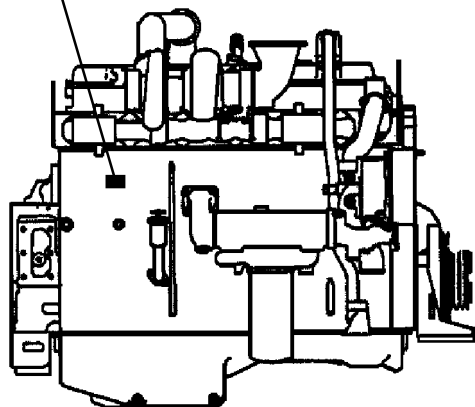
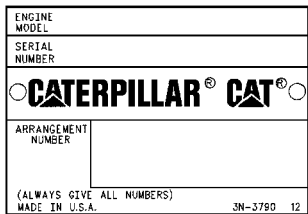
1.1 - INTRODUCTION

Drill Identification



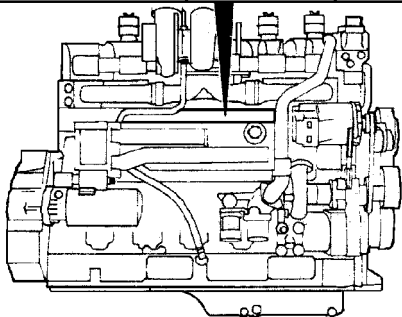
Engine Identification

The Cat engine number can be found on the identification plate



The Cummins engine number can be found on the identification plate

Engine No.	S.O. No.	E.C.S.	
Model	Alt. No.	Inspection/Service Center	
Adapted HP	at RPM	Engine Code	Family
Cont. No.	Warranty start date	Value (add code)	Part
Date of sale			
Manufactured by Cummins Engine Company, Inc. U.S.A. 3027/293			



Refer to the engine operator's instruction manual for further information on identification information.

Figure 1.1–3

1.1 - INTRODUCTION

Instruction Manual Storage

The instruction manuals are located within easy reach of the operator. A storage compartment in the operator's console provides space for the drill manuals. Also located in the cab, next to the operator's console, is the Laminated Safety Manual.

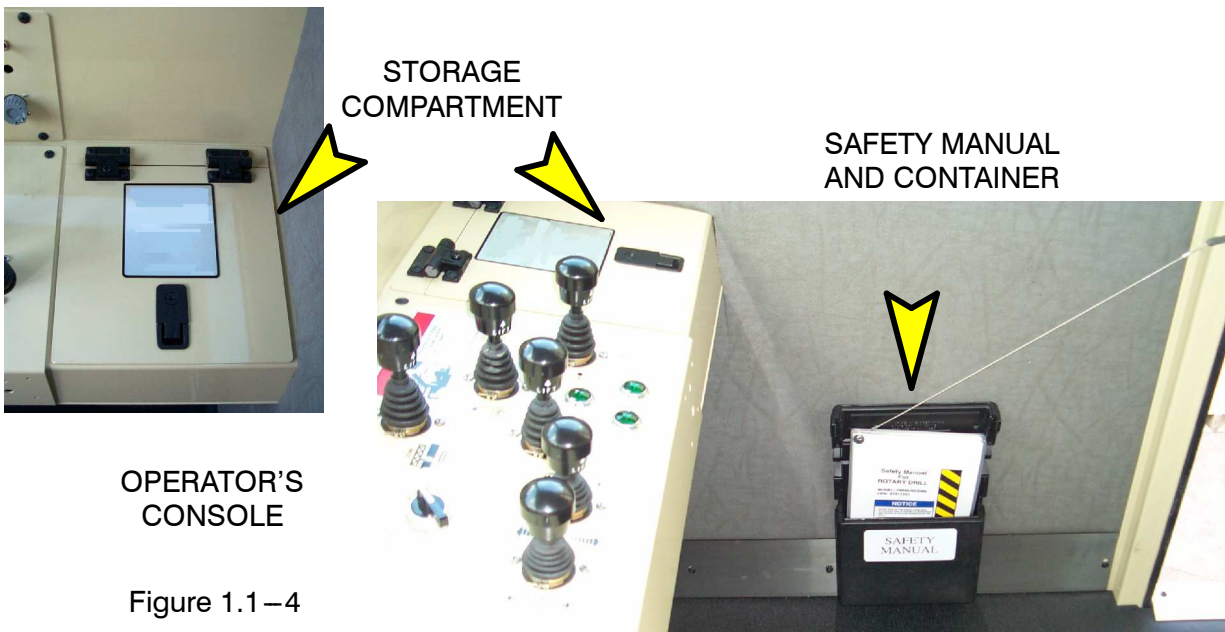


Figure 1.1-4

GENERAL INFORMATION

All safety rules in Section 2 must be observed.

If further information is required concerning the recommended blasthole drilling applications, contact your local Drilling Solutions distributor.

Drilling Solutions

Garland, Texas U.S.A.

Telephone: 972-496-7400

Customer Service Parts: 972-496-7382

Fax: 972-496-7427 (Customer Service Parts)

Fax: 972-496-7425 (Customer Service Warranty)

Drilling Solutions reserves the right to make any changes or modifications without prior notice and without incurring any liability to retrofit machines previously shipped from the factory.

1.1 - INTRODUCTION

DRILL DESCRIPTION

The DM45/LP (Low Pressure) is a crawler mounted, hydraulic tophead drive, multi-pass rotary drilling rig specifically designed for rotary action drilling of blastholes up to a maximum depth of 180 ft. (54.9 meters) and a maximum hole diameter of from 5 in. to 9 in. (127 mm to 228 mm). The standard DM45/LP utilizes a diesel engine to drive the air compressor and hydraulic system. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling. The DM45/LP comes equipped with an asymmetrical rotary screw air compressor.

The DM45/HP (High Pressure) is a crawler mounted, hydraulic tophead drive, multi-pass rotary drilling rig specifically designed for rotary/percussive action drilling of blastholes up to a maximum depth of 180 ft. (54.9 meters) and a maximum hole diameter of from 5 in. to 7 in. (127 mm to 203 mm) for DHD (down the hole hammer) drilling using high pressure compressed air. The standard DM45/HP utilizes a diesel engine to drive the air compressor and hydraulic system. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling. The DM45/HP comes equipped with an asymmetrical rotary screw air compressor.

The DM50/LP (Low Pressure) is a crawler mounted, hydraulic tophead drive, multi-pass rotary drilling rig specifically designed for rotary action drilling of blastholes up to a maximum depth of 180 ft. (54.9 meters) and a maximum hole diameter of from 7-7/8 in. to 9-7/8 in. (200 mm to 251 mm). The standard DM50/LP utilizes a diesel engine to drive the air compressor and hydraulic system. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling. The DM50/LP comes equipped with an asymmetrical rotary screw air compressor.

The DML is a crawler mounted, hydraulic tophead drive, multi-pass rotary drilling rig specifically designed for production blasthole drilling to depths of 180 ft. (54.9m) with a 30 ft. (9.1m) drill pipe change. A 35 ft. (10.7m) steel change is also available to handle single pass drilling requirements to 35 ft. (10.7m). Various carousel capacities are also available for the 35 ft., (10.7m) option. Hole size range for rotary drilling applications is nominally 6 in. to 10-5/8 in. (152mm to 270 mm). For DHD drilling with the high pressure air option, nominal hole size range is 6 in. to 9-7/8 in. (152 mm to 250 mm). Feed pressure generates a bit load force of up to 60,000 lb. (27,216 kg). The standard DML utilizes a diesel engine to drive the air compressor and hydraulic system. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling. The DML comes equipped with an asymmetrical rotary screw air compressor.

1.1 - INTRODUCTION

MACHINE DESCRIPTION (continued)

To permit optimum performance on a wide range of applications, and site requirements, the machine is equipped with:

- a.) Low pressure compressor installation (DM45LP, DM50LP, DML/LP)
- b.) High pressure compressor installation (DM45HP, DML/HP)
- c.) Dust suppression equipment
- d.) Standard 5 drill rod carousel
- e.) Operational controls in a sound proofed cab
- f.) High gradeability

The propulsion system features independent hydrostatic drive/service braking of each track, allowing steering by differential operation of the tramming control levers.

Engine

The Mid-Range series blasthole drill rigs use water cooled engines, with direct injection and turbo chargers.

Electric starting and belt driven alternator battery charging is standard on all drill models.

The drills are equipped with dual system air filtration. Dry type 2-stage air cleaners, with optional pre-cleaner, respectively provide clean air to the engine and the compressor.

The engine power / rpm is controlled by the engine speed control switch. The engine is shutdown either by the removable key "ON/OFF" switch or the emergency stop switch.

Main Frame

The drill main frame consists of a track frame which supports the power pack assembly (engine/compressor/hydraulic pumps), the combined engine radiator/hydraulic oil cooler, drill tower assembly and three leveling jacks.

Drill Tower

The drill tower assembly features the hydro-static driven rotary head and the hydraulic drill feed systems. A standard 5 drill rod carousel can be controlled from the operators console to provide safe and easy multi-pass drilling.

By using the angle drilling accessories, hole can be drilled at 5 degree increments from vertical up to 30 degrees from the vertical.

1.1 - INTRODUCTION

Controls

All of the controls are positioned for operator convenience in the operator's cab. Full details are provided in section 4.

Tramming (Propelling)

Each track is provided with direction (Forward and Reverse) speed control levers which control the tramming speed. This system also provides service braking by moving the respective levers towards the 'STOP' position.

Steering

The drill can be steered by adjusting the speed of one track relative to the other.

Braking

Service braking is effected by moving the tramming control lever towards the "STOP" position. Because the LH and RH track systems are independently controlled, one track acts as secondary braking for the other.

Parking brakes are incorporated into each track motor assembly and are fail-safe, hydraulically released, spring applied. These brakes will therefore be applied in the event of loss of brake release hydraulic pressure due to:

- a.) Pressing a RED emergency stop switch
- b.) Turning the main key operated "ON/OFF" switch to OFF position.
- c.) Hose failure resulting in loss of charge pressure, when the main pumps will cut off the flow to the tracks.

Operator's Cab

The operator's FOPS cab is designed for convenience, ease of control, comfort and safety while providing maximum visibility to the work area. The operator's station is sound insulated. A fully adjustable suspension-mounted seat is standard. Remote Tramming Control is available at Cab location.

Gradeability

Superior gradeability is the result of a powerful torque-balanced hydrostatic system with independent drive to both tracks.

1.1 - INTRODUCTION

Serviceability

The engine / compressor and hydraulic pumps power pack is accessible from the walk round operators deck. All daily checkpoints are positioned to encourage preventive maintenance. Color coded service charts show checkpoint locations, service intervals and proper lubricants. All grease points can be serviced from the two banks of grease nipples from which hoses provide grease to the respective components.



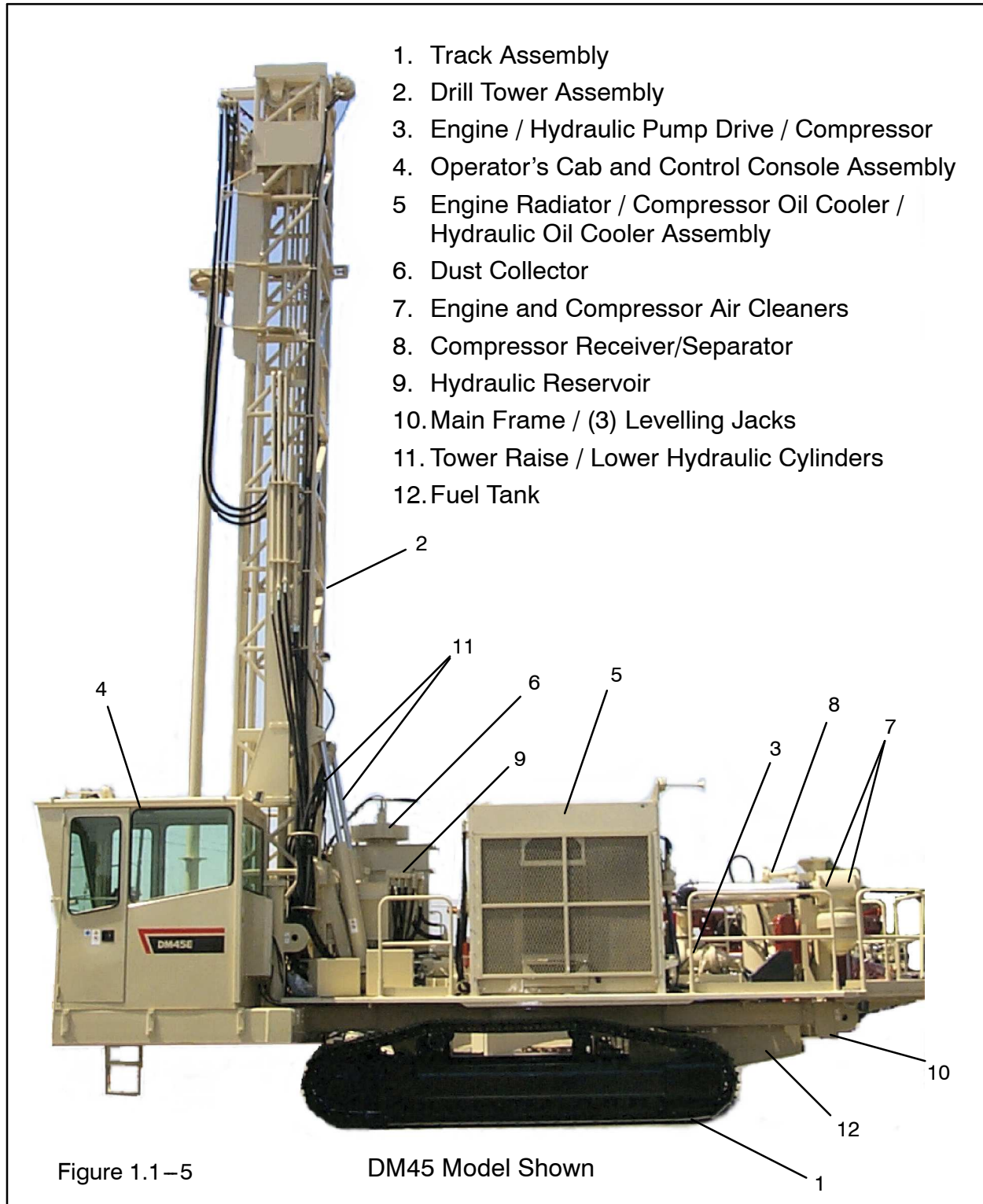
Your life may be endangered if the following is not complied with.

DO NOT add attachments to the machine that intrude into operator's protective area, reduce visibility, restrict emergency exits or add weight exceeding certification weight.

See the operator's manual or contact your dealer for complete inspection requirements and maintenance instructions.

1.1 - INTRODUCTION

IDENTIFICATION OF MAJOR COMPONENTS



SECTION 2

SAFETY

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2.1 - SAFETY

GENERAL SAFETY AND HEALTH

This book has been published to alert operators, helpers and mechanics to the possible physical dangers that are present in all phases of operation of this drill.

Anyone working around this drill must read and thoroughly understand the precautions outlined in this book before attempting to operate or perform work on the drill. In addition, “SAFETY FIRST” must always be the primary consideration of all personnel when working around this drill under normal or unusual conditions.

Since this book cannot cover every possible situation, all personnel are expected to exercise good judgement and common sense when operating, servicing or working near this drill.

If there is any doubt about the safe operating procedure of the drill, **STOP !!** Review the information supplied with the drill, ask your supervisor or contact your nearest Drilling Solution Representative for assistance.

Make sure all new employees read and understand the decals in Decal Safety Manual, mounted on drill. Never remove the Decal Safety Manual. Replace manual if it becomes lost or illegible.

2.1 - SAFETY

Safety And Health Statement

Every employer should have a safety and health philosophy based on the following statements.

- We are committed to providing a safe and healthy workplace for all our employees.
- We believe that injuries and accidents are preventable and that the well being of all our employees can be protected in the work environment.
- We believe that safety is number one. Safety will not be sacrificed for production.
- We believe that housekeeping is an integral part of our safety program and the protection of our employee's health.
- We believe that all of our employees are responsible for the safety of their coworkers. Each of us has the duty to listen, watch, and act upon hazards that might injure another.
- We believe that good safety training is necessary to assist employees in completing their assigned tasks in a safe manner.
- We believe that safety is a team effort.

Safety is an integral part of every individual's job responsibility. Every employee must be committed to these beliefs and must work in a manner that demonstrates that commitment.

Emergencies

Emergencies are situations where there is personal injury or property damage, or when there is imminent threat of personal injury or property damage. It is important for everyone to know how to respond to emergency situations in order to minimize injury and damage. Each operator must have a plan to be able to contact 911 or some other form of help immediately. These plans must be known to everyone around the drill in case someone is injured.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

OVERVIEW

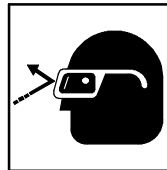
Before you operate, maintain, work around or in any other way use this drill: READ and STUDY this manual. KNOW how to safely use the drill controls and what you must do for safe maintenance. Failure to follow instructions or heed warnings could result in injury or death. Ensure that the drill is in correct condition before operating.

WEAR PROTECTIVE CLOTHING

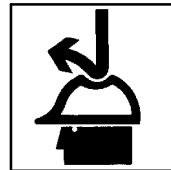
Anyone working around the drill **must** wear APPROVED safety equipment (safety shoes or protective footwear, safety glasses, hearing protection, hard hat, gloves, respirator, etc.) when operating or maintaining the machine.

Wear close fitting clothing and confine long hair.

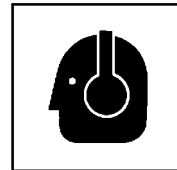
Operating equipment requires the full attention of the operator. Do not wear radio or music headphones while operating the machine.



Safety Glasses



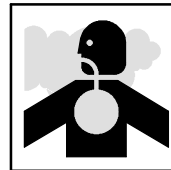
Hard Hat



Ear Protection



Electrically
Insulated Gloves



Respirator



Electrically
Insulated Boots

If you have ANY QUESTIONS about the safe use or maintenance of this drill, ask your supervisor or contact your nearest Drilling Solution Distributor for assistance. NEVER GUESS-ALWAYS CHECK!

Safety must always be the most important concern. Do not operate the drill when conditions are unsafe and consult your supervisor when safety is in doubt.

You must be alert, physically fit, and free from the influences of alcohol, drugs, or medications that might affect your thinking ability, judgement, sight, hearing, or reactions.

Signals must be given by the operator prior to starting or operating the drill.

Make sure all new employees read and understand the decals in the Decal Safety Manual, mounted on drill. Never remove the Decal Safety Manual. Replace manual if it becomes lost or illegible.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

WARNINGS

Throughout the manual, ***Dangers, Cautions, Warnings, Notices*** and ***Notes*** are used to designate instructions of particular importance.

In this manual, these terms have the following significance:



DANGER Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.



WARNING Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.



CAUTION Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.



NOTICE Notice is used to notify people of any or all installation, operation, or maintenance information which is important but not hazard-related. Hazard warnings should never be included under the Notice signal word.

NOTE: Note is used for any or all supplementary information not directly effecting safety or damage to equipment.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

DRILL APPLICATIONS

The Mid-Range drills are built in accordance with state of-the-art standards and recognized safety rules. Nevertheless, misuse may constitute a risk to the life and limb of the user or third parties, and may cause damage to the drill or other material property.

The Mid-Range drill must be used in accordance with its designated use as described in the operating manual. The drill must only be operated by safety-conscious persons who are fully aware of the risks involved in operating the drill. Any functional disorders, especially those affecting the safety of the drill, must be corrected immediately.

Designated Applications

The DM45/LP is designed exclusively for production blasthole drilling by rotary action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 5 in. (127mm) to 9 in. (228mm) for rotary bit applications.

The DM45/HP is designed exclusively for production blasthole drilling by rotary/percussive action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 5 in. (127mm) to 9 in. (228mm) for rotary bit applications and 5 in. (127mm) to 8 in. (203mm) for DHD (down the hole) drilling applications using a high pressure compressor.

The DM50/LP is designed exclusively for production blasthole drilling by rotary action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 7-7/8 in. (200mm) to 9-7/8 in. (251 mm) for rotary bit applications.

The DML is specifically designed for production blasthole drilling by rotary/percussive action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 6 in. (152mm) to 10-5/8 in. (270mm) for rotary bit applications and 6 in. (152mm) to 9-7/8 in. (250mm) for DHD (down the hole) drilling applications using a high pressure compressor.

Non Designated Applications

The Mid-Range series drills are not designed for pioneering/earth moving applications. The Mid-Range series drills are not designed for use on inclined surfaces greater than those defined in Section 3 or on soft and unstable ground. Use of the drills for purposes other than that mentioned (such as for towing other vehicles or equipment) is considered contrary to its designated use. The manufacturer/supplier cannot be held liable for any damage resulting from such use. The risk of such misuse lies entirely with the user.

Special order drills are designed and equipped with a remote tramming control console which must be used when tramming over unstable ground conditions or when loading the drill up ramps onto a trailer. The remote control enables the operator to control and move the drill from a vantage point outside the drill.

Operating the drill within the limits of its designated use also involves compliance with the inspection and maintenance directives contained in the operating manual.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

SELECTION AND QUALIFICATION OF PERSONNEL

Work on and with the drill must only be performed by qualified personnel. Statutory minimum age limits must be observed.

Those who operate, maintain and work on rotary drill rigs must be **competent**:

Physically -----To react correctly and quickly to avoid accidents.

Mentally -----To understand and apply all of the established rules, regulations and safe practices. To concentrate on the job to be done.

Emotionally-----To withstand stress and prevent mistakes.

Those who operate, maintain and work on rotary drill rigs must be **experienced**:

Trained In the operation and maintenance of the drill.

- a.). They should have read and understood the Manufacturer's Instruction Manual and know the ratings and capabilities of the drill they are using.
- b.). They must understand hand signals.
- c.). They must understand the meaning of various symbols on instruments, controls and specific parts of the drill rig.

Licensed -- If required by law.

1. The individual responsibilities of the personnel responsible for operation, setup, maintenance and repair of the drill should be stated clearly.
2. Define the drill operator's responsibility with regard to observing site traffic regulations.
3. The operator should have the authority to refuse instructions by third parties that are contrary to safety.
4. Do not allow persons being trained or instructed in the operation or maintenance of the drill to work without permanent supervision by an experienced person.
5. Work performed on the electrical system and/or equipment on the drill must be done only by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician and must be in accordance with electrical engineering rules and regulations.
6. Work on the mainframe and drill tower, brake, air and hydraulic systems must be performed by skilled personnel with special knowledge and training for such work.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

ORGANIZATIONAL MEASURES

1. **STOW** manuals in the manual compartment provided in the operator's cab. Manuals must always be available at the site where the drill is used. The operator's instruction manual shall be within easy reach of the operator's station.
2. **OBSERVE** and **INSTRUCT** the users in all other generally applicable legal and mandatory regulations relevant to accident prevention and environmental protection. These compulsory regulations may also deal with the handling of hazardous substances, issuing and/or wearing of personal protective equipment, and traffic regulations.
3. **SUPPLEMENT** all of the operating instructions with detailed working instructions covering the methodology of working sequences, individual job responsibilities, and overall supervisory responsibility.
4. **ALWAYS** be sure that all personnel entrusted with work on the drill have read the operating instructions and in particular the chapter on safety before any beginning work. Reading the instructions after work has begun is too late. This is especially important for persons who work only occasionally on the machine, e.g. during setup or maintenance.
5. **MAKE CERTAIN** personnel are working in compliance with the operating instructions and are alert to risks and safety factors.
6. **ALWAYS** tie back or secure long hair. Wear close-fitting garments and avoid wearing jewelry such as rings. Injury may result from clothing, hair, or jewelry being caught up in the machinery.
7. **USE** protective equipment wherever required by the circumstances or by the law. Always wear approved safety equipment while working around the drill. This includes an approved hard hat, safety glasses, protective footwear, gloves, respirator and ear protection.
8. **OBSERVE** all safety instructions and warnings attached to the drill.
9. **BE SURE** all safety instructions and warnings attached to the drill are complete and perfectly legible.
10. **STOP** the drill immediately in the event of safety relevant malfunctions or change in the drill behavior during operation. **REPORT** the malfunction to the proper authority/person.
11. **NEVER** provide service or maintenance to the drill unless both tracks are on firm, level ground.
12. **NEVER** make any modifications to drill which might affect safety without the manufacturer's approval. This applies to the installation and adjustment of safety devices and valves as well as to welding work on load bearing elements.
13. **ALWAYS ADHERE** to prescribed intervals or those specified in the operating instructions for routine checks and inspections.
14. Ensure that people, equipment and material not required for the correct operation of the drill are removed and kept out of the work area. The operator must never drill while people are around the drill platform. Alert personnel and crew to stay clear of the hole while drilling is in progress.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

ORGANIZATIONAL MEASURES (continued)

15. All crew members must ensure that unsafe conditions and practices are corrected or reported to the drill operator and supervisor.
16. All crew members who work around the drill, including support and maintenance people, must obey all warning signs and must ensure their own safety and the safety of others.
17. With careful planning, most accidents can be avoided.
 - a.) Have a clear understanding of the work to be done
 - b.) Consider potential dangers or hazards
 - c.) Develop a plan to do the job safely
 - d.) Explain the plan to all personnel concerned

GENERAL RULES FOR MID-RANGE DRILLS

Before starting or working around the drill, read and understand the safety manual, decal safety manual and labels located on the drill. Follow all directions on the labels. Do not remove or deface the labels. Replace them if they become damaged or lost.

1. All personnel working around this drill must wear approved safety equipment. This includes an approved hard hat, safety glasses, safety shoes and ear protection. They must not wear loose clothing that can get caught in moving parts. They should wear gloves when handling heavy parts and tools or any objects that are sharp or pointed. A respirator may be required in dusty conditions.
2. Keep work areas clean and free from grease, oil and other items or tools that could cause a slip or fall.
3. Keep all warning and information labels clean and readable. Replace labels if they become damaged, torn, painted over or removed.
4. Keep all controls and gauges in good working order. If they become damaged or broken, replace them before operating the drill.
5. Make a complete walk-around inspection of the drill before starting. During operation, make periodic checks to be sure the drill is operating properly.
6. Watch for leaking or broken hydraulic or air hoses. Replace them before they cause damage or a fire.
7. Do NOT operate the drill with excessively worn or broken parts.
8. Tighten or replace any loose or broken fittings, bolts or other connections before operating drill.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

GENERAL RULES FOR MID-RANGE DRILLS (continued)

9. Check the batteries and connections before starting the drill. Tighten terminal clamps and be sure all batteries have caps. Loose wires can cause fires and shocks. Spilled fluid can cause burns. Make sure all batteries are charged properly with correct fluids.
10. Use extreme caution whenever handling, cleaning, wiring or recharging batteries. They can explode and spray acid. Keep battery covers in place all the time.
11. Keep cabs clean. Mud, cans, bottles, tools and other debris can jam pedals and other controls and cause falls.
12. Make sure all controls are in neutral before starting the drill.
13. Make sure all guards are in place on the drill. Replace them if they have been removed for maintenance. DO NOT operate the drill if guards are not in place.
14. Know where your helper or oiler is at all times. DO NOT move the drill if they are not in sight.
15. Before moving the drill, make sure there is nothing in the way of travel. Make sure all the drill pipe is out of the ground and secured before moving.
16. Locate drill on level ground, if possible. Install cribbing (blocking) under each jack to insure a stable lifting platform in case ground is broken or soft.
17. Before raising the tower, make sure it is clear of tools or objects that could fall. Check to see that all hydraulic and air hoses do not become snagged during raising. Watch all hoist cables and keep them clear or spooled properly while raising tower.
18. When working on any air compressor hose or receiver tank, relieve all pressure in the system before removing any cap, plug or hose connection.
19. Never move the drill with the tower partially raised, unless it is an angle drill with the proper locking pins in place.
20. Never move the drill with the tower locking pins removed or the tower locking pins unpinned. The tower is not designed to be held up by the tower raising cylinders alone.
21. Keep work area clear of cuttings, tools and other objects.

PRE-START INSPECTION

1. **INSPECT** your drill rig daily. Ensure that the routine maintenance and lubrication are being dutifully performed. Have any malfunctioning, broken or missing parts repaired or replaced before use.
2. **VERIFY** that all instruction and safety labels are in place and readable. These are as important as any other equipment on the drill rig.
3. **NEVER** fill the fuel tank with the engine running, while near an open flame, or while smoking. **ALWAYS** wipe up any spilled fuel.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

PRE-START INSPECTION (continued)

4. **CHECK** for WARNING or lockout tags placed on the drill rig. **DO NOT** operate the drill rig until repairs have been made and the WARNING or lockout tags have been removed by authorized personnel.
5. **CLEAN** any foreign material from the operator's platform to reduce the danger of slipping.
6. **KNOW** the location of the Emergency Shut Down Control if the drill rig is so equipped.
7. **ALWAYS** know the capabilities and limitations of your drill: speed, gradeability, steering and braking.
8. **BE AWARE** of the dimensions of your drill rig's height, width and weight when moving the drill.
9. **CHECK** any conditions that could be dangerous: unstable ground condition or overhanging rock face.

SAFETY INSTRUCTIONS GOVERNING OPERATION

1. **OBSERVE** position of fire extinguishers, if so equipped, and ensure they are fully charged and inspected regularly.
2. **AVOID** any operational mode that might sacrifice safety.
3. **TAKE** all necessary precautions to ensure that the drill is used only when in a safe and reliable condition.
4. **OPERATE** the drill only if all protective and safety oriented devices, such as removable safety devices, emergency shut off equipment, sound proofing elements and exhausts, are in place and fully functional.
5. **START** drill from the drivers seat only. If the drill is equipped with an optional remote tramming control console, always use the remote control unit from a safe location when tramming over unstable ground conditions, loading the drill on ramps for trailer transport or when there is a risk of a roll over condition.
6. **WATCH** the indicators during startup and shutdown procedures in accordance with operating instructions.
7. **MAKE SURE** no one is at danger or risk before starting up or setting the drill in motion.
8. Personnel can be pinched, entangled or crushed by moving machinery. While the drill is in operation, crew members must never place any part of their bodies or clothing on or near any rotating machinery, gears, pinions, ropes, cables, chains or wrenches.
9. **CHECK** that the braking, steering, signaling and lighting systems are fully functional before starting work or traveling with the drill.
10. **CHECK** that all the accessories have been safely stowed away and that all levelling jacks are retracted fully before moving the drill.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

SAFETY INSTRUCTIONS GOVERNING OPERATION (continued)

11. **ALWAYS SWITCH ON** the lighting system in conditions of poor visibility and after dark.
12. **MAKE SURE** there is sufficient clearance when crossing underpasses, bridges and tunnels, or when operating under overhead lines.
13. **ALWAYS KEEP** at a safe distance from the edges of quarry face, pits and slopes.
14. **AVOID** any operation that might be a risk to drill stability.
15. **ALWAYS SECURE** drill against inadvertent movement and unauthorized use before leaving the operator's cab.

Starting

1. **ALWAYS USE** the handrails and steps to get on and off the drill rig. **ALWAYS MAINTAIN** a three-point contact when climbing onto or off of drill rig. Watch for slippery surfaces when mounting.
2. **READ** and **FOLLOW ALL** instruction decals.
3. **BEFORE** starting engine or beginning to move, check inside, outside and underneath drill for people or obstructions.
4. **BEFORE** starting the engine, **ENSURE** that the propel/drill mode selector is in the "DRILL" position and all tramming and drilling control levers are in the "STOP" position.
5. **BEFORE** starting engine, **ENSURE** that the parking brake control is in the "Applied" position.
6. **CHECK** for warnings or Lockout tags on the controls. If there is a tag attached to the switch, do not start the engine until the warning tag has been removed by the person who installed it.
7. **START** the engine from the operator's position only.
8. **ALWAYS USE EXTREME CAUTION** if you have to jump-start the engine.
9. **CHECK** all gauges and controls for correct operation. Stop the drill immediately and replace any that are defective.
10. **CHECK** all safety devices. Report any defects immediately.
11. **MAKE SURE** you are on solid, level ground before raising the tower. Use cribbing (blocking) if you are not sure.
12. When raising tower, **MAKE CERTAIN** there are no electrical power lines within the operating area of the drill.
13. **LISTEN** for unusual noises.
14. **ENGAGE** hydraulic controls slowly in cold weather to avoid shock loading.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Operating



Contacting power lines with any part of the drill will cause Death! Keep at least 3 meters (10 feet) away from power lines. If there appears any danger of wind or other obstruction closing the distance, do not drill in that area.

1. **ALWAYS** make sure that no person or obstruction is in your line of travel before tramming the drill rig.
2. **NEVER CLIMB** on or off the drill rig while it is in motion.
3. If drill is equipped with an optional remote tramming control console, always use the remote control unit from a safe location when tramming over unstable ground conditions, loading the drill on ramps for trailer transport or when there is a risk of a roll over condition.
4. **ALWAYS USE EXTREME CAUTION** and be very observant when operating in close quarters or congested areas.
5. **NEVER** carry passengers.
6. **KNOW** the area in which you are working. Familiarize yourself with work site obstructions and any other potential hazards in the area.
7. **KNOW** and **USE** hand signals required for particular jobs and know who has the responsibility for signaling.
8. **DO NOT** work in the vicinity of overhanging banks or on grades that could cause the drill rig to slide or roll over.
9. **AVOID** side hill travel. **ALWAYS** operate up and down slopes. **ALWAYS** keep the propulsion (travel) control lever in low speed close to the “STOP” position when climbing or descending hills.
10. **NEVER** allow bystanders, other than authorized persons, to stand within the drill rigs danger (working) area when the engine is running.
11. **ALWAYS LOOK** in all directions **BEFORE** changing your direction of travel and sound horn prior to moving.
12. **DO NOT** attempt to control drill rig travel speed with the throttle control. When operating the drill rig, maintain the engine speed at full “Operating” rpm.
13. **DO NOT** run the engine in a closed building for an extended length of time. **EXHAUST FUMES CAN KILL.**

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Drilling

1. All Drilling Solution Drills are equipped with an overpressure control system which vents feed pressure if the drill end leveling jacks are not supporting the weight of the drill. To ensure that someone has not disabled the system, each operator **must** perform the overpressure control system operational check procedure daily as described in section 6.5 of this manual.
2. Use the proper tools for the job. Do not attempt to lift pipe, subs, stabilizers or bits without the proper lifting devices.
3. Use the proper technique in loading and unloading drill pipe. If a lifting bail is used, make sure it can be detached by a helper while standing on the ground. Use the pipe handling tool if the carousel needs to be filled. Make sure the safety clip is in place. **NEVER RIDE THE ROTARY HEAD FOR ANY REASON!!!**
4. Do not attempt any repairs to the drill while it is running. Stop the drill to make repairs.
5. Do not allow anyone to climb the tower. If repairs must be made, lower tower or use a manlift to reach the repair area.
6. Do not ride the rotary head for any reason. It is not meant to be an elevator.
7. Do not use the hoist cable as a manlift.
8. Do not operate the drill except from the operator's station. Trying to operate from any other position is a safety hazard and can cause serious injury.
9. If drill is equipped with an optional remote tramming control console, always use the remote control unit from a safe location when tramming over unstable ground conditions, loading the drill on ramps for trailer transport or when there is a risk of a roll over condition.
10. Do not hoist or brake too sharply. This can cause premature failure of equipment and can be dangerous.
11. Know the limitations of your drill and don't exceed the design limits.
12. Don't retract the hoist so far that it slams into the crown block. Continuous pull on the wire rope can break it and drop the load.

Propelling (Tramming)

1. Make sure all drill pipe is out of the hole before moving.
2. Do not get on or off the drill when it is moving.
3. Lower tower if moving a long distance.
4. Secure all drill pipe and tools before moving the drill.
5. Know the drill's height, width, weight and length before moving.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Propelling (Tramming) - continued

6. Check brakes on tracks, before leaving job site.
7. Use the main pumps to control speed and direction. If a problem with tramming arises and the pumps don't respond to controls, shift the Drill/Propel Valve back to DRILL. This will set the parking brakes and stop the drill.
8. Use caution when loading a drill onto a trailer. Make sure the ramp will hold the weight of the drill.
9. If tramming with the tower raised, make sure all locking pins are in place and the ground is level and solid.
10. On deephole drills, be careful cornering to allow for tower overhang.
11. Know where your helpers are at all times. Do not move the drill if they are not in view.
12. Know and use proper signals when moving the drill.

Stopping And Shutdown

1. Move drill away from highwall or face before shutting the drill down for the day.
2. Don't park drill under an overhang or where a bank can cave in.
3. **ALWAYS** park the drill rig on solid, level ground. If this is not possible, always park the drill at a right angle to the slope and chock the tracks.
4. If drill is left over a hole, lower jacks so tracks touch the ground.
5. Be sure to relieve all pressures in the systems before leaving the drill.
6. Place all controls in neutral or park position before leaving the drill.
7. **ALWAYS** move the tram/drill mode selector to "DRILL" and make sure the tramming and drill control levers are all in the STOP positions.
8. **AVOID** leaving the controls with the engine running. NEVER leave the operator's cab while the engine is running.
9. Position the engine speed control to "LOW IDLE" and turn key switch to OFF.
10. Lock the ignition and remove the keys before leaving the operator's cab.
11. Lock all lockable compartments.
12. **USE** proper flags, barriers and warning devices, especially when parking in areas of heavy traffic.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

MAINTENANCE

In any work concerning the operation, conversion or adjustment of the drill and its safety oriented devices or any work related to maintenance, inspection and repair, always observe the startup and shut down procedures set out in the operating instructions and the information on maintenance work.

1. All personnel involved in setting up machines or handling maintenance or repairs must know and practice proper procedures, including lockout and tag out practices.
2. Ensure that the maintenance area is adequately secured.
3. If the drill is completely shut down for maintenance and repair work, it must be secured against inadvertent starting by:
 - a.) Locking the principal control elements and removing the ignition key
 - b.) Attaching a warning sign to the main starter key switch.
4. Carry out maintenance and repair work only if the drill is positioned on stable and level ground and has been secured against inadvertent movement.
5. **USE CARE** when attaching and securing lifting tackle to individual parts and large assemblies being moved for replacement purposes to avoid the risk of accidents. USE lifting gear that is in perfect condition and with adequate lifting capacity. NEVER work or stand under suspended loads.
6. **ALWAYS USE** the correct tools and workshop equipment when performing maintenance to the drill.
7. **ALWAYS USE** specially designed or otherwise safety oriented ladders and working platforms when doing overhead assembly work. Never use drill parts as a climbing aid and never climb the tower.
8. **KEEP** all handles, steps, handrails, platforms, landings and ladders free from mud, dirt, snow and ice.
9. **CLEAN** the drill, especially connections and threaded unions, of any traces of oil, fuel or any preservatives before carrying out maintenance or repair. **NEVER** use aggressive detergents. Use lint free cleaning rags.
10. Before cleaning the drill with water, steam jet (high pressure cleaning) or detergents, **COVER OR TAPE** up all openings which, for safety and functional reasons, must be protected against water, steam or detergent penetration. Special care must be taken with electric motors and switch gear cabinets.
11. **ENSURE** during cleaning of the drill that temperature sensors do not come into contact with hot cleaning agents.
12. **REMOVE** all covers and tapes applied for that purpose after cleaning the drill.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

MAINTENANCE (continued)

13. After cleaning, **EXAMINE** all of the fuel, lubricant and hydraulic fluid lines for leaks or loose connections, chafe marks and damage. **REPAIR** or **REPLACE** defective parts immediately.
14. **ALWAYS TIGHTEN** screwed connections that have been loosened during maintenance and repair.
15. Any safety devices removed for setup, maintenance or repair purposes must be refitted and checked immediately upon completion of the maintenance and repair work.
16. **ENSURE** that all consumables and replaced parts are disposed of safely and with minimum environmental impact.
17. **AVOID**, whenever possible: servicing, cleaning or examining the drill rig with engine running.
18. **AVOID**, whenever possible: servicing or providing maintenance to the drill rig unless tracks are adequately chocked and the parking brake is applied.
19. **DO NOT** alter the engine governor settings from those indicated in the engine manual and the engine option plate.
20. **ALWAYS** replace damaged or lost decals. Refer to the parts manual for the proper location and part number for all decals.
21. Use only original circuit breakers with the specified current rating. Shut down drill immediately if trouble occurs in the electric system.
22. Work on the electrical system or equipment may only be carried out by a skilled electrician or by specially instructed personnel under the control and supervision of an electrician and in accordance with the applicable electrical engineering.
23. If provided for in the regulations, the power supply to parts of the drill on which the inspection, maintenance and repair work is to be carried out, must be cut off.
24. Before starting any work, check the de-energized parts for the presence of power and ground or short circuit them in addition to insulating adjacent live parts and elements.
25. The electrical equipment of drill is to be inspected and checked at regular intervals. Defects such as loose connections or scorched cables must be rectified immediately.
26. Welding, flame cutting and grinding work on drill should only be done if expressly authorized, as there may be a risk of explosion and fire.
27. Before beginning any welding, flame cutting and grinding operations, clean the drill and its surroundings from dust and other flammable substances and make sure that the premises are adequately ventilated (risk of explosion).
28. Check all the lines, hoses and screwed connections regularly for leaks and obvious damage. Repair damage immediately. Splashed oil may cause injury and fire.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

MAINTENANCE (continued)

29. Depressurize all system sections and pressure pipes (hydraulic system and compressed air system) to be removed in accordance with specific instructions for the drill concerned before carrying out any repair work.
30. Hydraulic lines must be laid and fitted properly. Ensure that no connections are interchanged. The fittings, lengths and quality of the hoses must comply with the technical requirements.
31. When handling oil, grease and other chemical substances, observe the product related safety regulations.
32. Be careful when handling hot consumables (risk of burning or scalding).

Fueling

1. **NEVER** fill the fuel tank with the engine running, while near an open flame or while smoking. **ALWAYS** wipe up any spilled fuel.
2. Do not spill fuel on hot surfaces.
3. Refuel in a well ventilated area.
4. Keep open lights, lighted smoking materials, flames and spark-producing devices at a safe distance when refueling.
5. Keep fuel nozzle in contact with tank being filled, or provide a ground to prevent static sparks from igniting fuel.
6. Turn off cab and fuel heaters.
7. Never mix any other fuel with diesel oil. An explosion can occur.

Batteries

1. **DISCONNECT** battery cables when working on the electrical system or when welding on the drill rig.
2. **BE SURE** the battery area is well ventilated (clear of fumes) should it be necessary to connect a jump battery or battery charger. Fumes from the battery can ignite by a spark and explode.
3. **BE SURE** battery charger is “OFF” when making connections if battery charging is required.
4. Always wear safety glasses when servicing batteries.
5. Connect the ground cable last when installing a battery.
6. Battery acid will burn skin, eat holes in clothing and cause blindness if splashed into the eyes.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Batteries (continued)

7. Batteries generate a highly explosive mixture. A spark could ignite these gases.
8. Do not short across batteries. The spark could ignite the gases.
9. Keep battery covers in place at all times. Be sure there is no connection between the battery terminals and the cover.

Wire Rope & Cable

1. Winch ropes and cables must be inspected frequently for unforeseeable wear patterns, and discarded according to certain criteria (refer ISO 4305).
2. Wire rope running over drums and through sheaves creates pinch points. Do not use hands or bars to guide wire rope onto drums; instead, use rope guides. Keep clothing and all parts of the body away from running rope and from the machinery that moves the rope.
3. Replace wire rope when it is worn to the following:
 - a.) Six (6) randomly distributed broken wires are found in one lay.
 - b.) Wear of one-third (1/3) the original diameter of outside wires.
 - c.) Evidence of any heat damage from any cause.
 - d.) Any kinking or cracking occurs.
4. Make sure all hooks are connected properly.
 - a.) Saddle and nuts must be around lifting side of cable.
 - b.) Always use a thimble when installing a hook.
 - c.) Always use the correct number of clamps for cable size.
 - d.) All hooks must have lock type dogs to prevent cable from jumping out of the hook throat.
5. Do not allow cable to backlash on hoist or drum.
 - a.) Make sure cable spools properly on hoist drum.
 - b.) Do not overload the hoist or wire rope.

The normal operating temperature of hydraulic oil is hot enough to cause serious burns. Use precautions when working on any hot fluid lines or changing filters.

Cylinder Repairs Or Replacement

1. When repairing cylinders, be sure to block them up to prevent dropping or rolling off the drill.
2. After repairing or replacing cylinders, especially the feed or tower raising ones, purge all air out of each end of the cylinder before connecting it to the drill. Air in one end can cause the tower or rotary head to fall and cause an accident.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Cylinder Repairs Or Replacement (continued)

3. Loosen feed cables or chains before trying to remove feed cylinders.
4. Plug all hoses as soon as they are removed from the cylinders to prevent oil spills and slippery conditions.
5. Use a hoist to lift the larger cylinders.

Pumps And Motors

1. Make sure hoses are plugged when replacing pumps and motors.
2. Always replace pumps and motors with the same size and type.
3. Use the correct adapters when installing pump or motor.

Valves

1. When working on valves, keep area clean to prevent contamination from getting inside valve.
2. Be sure the valve being installed is the same type as the one removed. Motor and cylinder spools are interchangeable and may cause an accident or a failure of a component if used incorrectly.

Hoses

1. Do not replace a hose with a hose of lesser strength or capacity. Breakage or leakage could result.
2. Do not use a "will-fit" hose as it may fail and cause an accident before it can be replaced by the correct type.

Coolers And Fans

1. Never remove the fan guard unless the drill is shut down and locked out.
2. When testing fan speed, do so with the guard in place.
3. Do not try to remove debris from inside the fan guard. Stop the drill and lockout the switch before removing.
4. Be careful while washing out coolers with pressure washers. Spray can injure eyes.
5. Coolers are heavy. Obtain a suitable hoist capable of lifting and moving the coolers and the radiators before replacing them.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

Guards

1. If any guards must be removed from the drill to perform service, always replace them before drill is started.
2. If a guard becomes damaged or lost, replace or repair it before starting drill.
3. Do not cut out or modify a guard. It was designed to protect people from getting injured.

Tracks

1. Use the correct procedure for adjusting the track tension.
2. Never release all the pressure from the track tensioning spring. It can cause an accident.
3. Always raise the drill on the jacks before replacing idlers or track pads.

Lubrication

1. Never attempt to lubricate the drill while it is running, unless drill is fitted with automatic lube injection system. Stop drill for all maintenance.
2. To lubricate fittings on the tower, lay the tower down or use a man lift to access hard to reach and inaccessible places. Do NOT climb the tower for ANY reason.
3. To lubricate drive lines, reach through the guards. Do not remove them.

NOTE: If a lube point will not take grease, report it immediately. A bearing can get hot and cause a fire if not lubricated properly.

Compressor

The normal operating temperature of compressor oil is hot enough to cause serious burns. Use precautions when working on any hot fluid lines or changing filters.

1. Relieve all pressure in the receiver tank and lines before working on the compressor system.
2. Do not allow tools or air-powered equipment to be connected to the drill hoses. They must be attached to the service regulator and the pressure adjusted to the working capacity of the tool being used.
3. Do not remove any regulation or control hoses while the drill is running or pressure is still in the system. High pressure air can cause serious injuries.
4. Be careful when using service air to clean off the working area. High pressure air can be very dangerous.
5. Turn off drill air and exhaust drill string before unscrewing drill pipe at the table.
6. Do not turn on high pressure air too quickly when the air hoses are in the vicinity of people. Hoses can jump and injure people, especially if there is water or oil inside them.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

WARNING OF SPECIAL DANGERS

When working with the drill, maintain a safe distance from overhead electric lines. If work is to be carried out close to overhead electric lines, the working equipment must be kept well away from them. **CAUTION! DANGER!** Check out the prescribed safety distances.



If your **DRILL** comes into contact with a live wire:

1. Do not leave the drill.
 2. Tram the drill out of the hazard zone.
 3. Warn others against approaching and touching the drill.
 4. Have the live wire de-energized.
 5. Do not leave drill until the damaged line has been safely repaired or de-energized.
-

Operate internal combustion engines and fuel operated heating systems only in adequately ventilated premises. Before starting the drill in enclosed premises, make sure that there is sufficient ventilation.

Exceeding the slope or grade limitations of the drill and its configuration can cause the drill to tip over. Prior to moving the drill into position, always determine the safe operating grade of the drill with tower up and down. Do not move the drill with tower up unless the ground is firm and level and no obstructions will cause the drill to tip.

TRANSPORTING AND TOWING

1. Drill must be towed, loaded and transported only in accordance with operating instructions.
2. For towing the drill, observe the prescribed transport position, admissible speed and itinerary.
3. Use only appropriate means of transport and lifting gear of adequate capacity.
4. Fastening of loads and the instructing of crane operators should be entrusted to experienced persons only. Personnel giving the instructions must be within sight or sound of the operator.
5. **DO NOT** attempt to load the drill on the transport vehicle without knowledge and experience with the operation of the drill rig.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

TRANSPORTING AND TOWING (continued)

6. Always use a ramp when loading the drill rig on a transport vehicle. Be sure the ramps are of adequate strength, low angle, and proper height.
7. Use proper chock blocks in front and rear of the wheels of the transport vehicle when loading the drill rig.
8. Be sure trailer is on level ground and approach the transport vehicle loading ramps squarely to make sure the drill rig does not drop off the side of the ramp.
9. Keep trailer deck clean of clay, oil, mud, ice, frost and other material that can become slippery.
10. Use proper chock blocks in front and rear of the tracks once loaded on the trailer.
11. Move the tram/drill mode selector to “DRILL” and make sure the tramming and drill control levers are all in the STOP positions.
12. Position the engine speed control to “LOW IDLE” and turn key switch to OFF.
13. Lock all lockable compartments.
14. Always know the overall height, weight, width and length of the drill rig and hauling vehicle. **MAKE SURE** there is sufficient clearance when crossing underpasses, bridges and tunnels or when passing under overhead lines.
15. When moving the drill rig on public access roads, obey all traffic regulations and be sure that proper clearance flags, lights and warning signs, including the “Slow Moving Vehicle” emblem, are properly displayed. Know your approximate stopping distance at any given speed. Never turn corners at excessive speeds. Look in all directions before reversing direction of travel.
16. Position the drill rig on the transport vehicle centered from side to side and use proper chock blocks in front and rear of the tracks .
17. Secure the drill rig to the deck of the transport vehicle with adequate chains, cables and blocks to meet local regulations.

2.3 - SAFETY DECALS & NAMEPLATES



Before you operate , maintain, work around or in any other way use this drill, read and understand the safety decals and safety labels located on the drill. Follow all directions on the labels. Do not remove or deface the labels. Replace them if they become damaged or lost.

DECALS LIST

Ref.	Decal	Qty.	Location
1	---Warning: Falling Derrick -----	2	---- Bottom of Tower Raising Cylinders
2	---Caution: Excessive Oil -----	1	---- Backside of Hydraulic Reservoir
3	---Warning: Rotating Parts -----	2	---- Both Sides of Power Pack Base
4	---Warning: Rotating Shaft -----	2	---- Both Sides of Power Pack Base
5	---Warning: Rotating Fan Blade -----	2	---- Cooler Housing
6	---Notice: Engine Failure -----	1	---- Cooler Housing
7	---Warning: Radiator Heat/Pressure ----	1	---- Cooler Housing
8	---Warning: High Pressure -----	2	---- Top of Receiver Tank & Tank End Plate
9	---Warning: Service Tools Connection --	1	---- Horizontal Receiver Tank End Plate
		1	---- Side of Vertical Tank
10	--Warning: Combustible Gas-----	1	---- Battery Box
11	--Warning: Rotary Head -----	1	---- Face of Rotary Head
12	--Warning: Falling Rotary Head -----	2	---- Bottom of Tower
13	--Warning: Falling Carousel -----	1	---- Rod Changer Swing Cylinder
14	--Warning: Falling Drill Pipe -----	1	---- Helper Side Leveling Jack
15	--Warning: Hoist (1250 lbs. Winch) ----	1	---- Helper Side Leveling Jack
	Warning: Hoist (2500 lbs. Winch) ----	1	---- Helper Side Leveling Jack
16	--Notice: Hydraulic Failure-----	1	---- Top or side of Hydraulic Tank
17	--Warning: Do Not Modify or Alter ----	1	---- Operator's Console
18	--Danger: Hazardous Voltage -----	1	---- Operator's Console
19	--Warning: Flying Fanblades-----	1	---- Dust Collector Fan Wheel
20	--Notice: Dust Discharge -----	1	---- Front of Dust Collector
21	--Warning: No Climbing -----	2	---- Both Sides of Tower by Tower Pivot
22	--Notice: Avoid Electrical Damage ----	1	---- Front or Top of Battery Box
23	--Safety Manual -----	1	---- Inside Operator's Cab

CONSOLE NAMEPLATES

Nameplate, Engine Functions -----	1	---- See Partsbook for Part Number
Nameplate, Tram (Propel) Functions -----	1	---- See Partsbook for Part Number
Nameplate, Compressor Functions -----	1	---- See Partsbook for Part Number
Nameplate, Drill Functions -----	1	---- See Partsbook for Part Number
Nameplate, Gauges -----	1	---- See Partsbook for Part Number
Nameplate, Feed Functions (HP Only) ----	1	---- See Partsbook for Part Number
Nameplate, Air Conditioner/Heater-----	1	---- See Partsbook for Part Number



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals

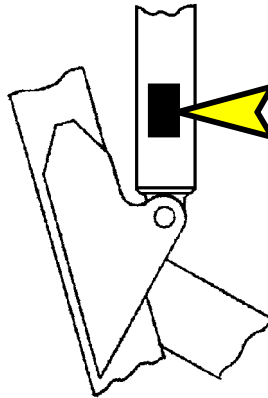
1.

**Decal, Warning:
Falling Derrick
Can Cause Severe
Injury or Death**

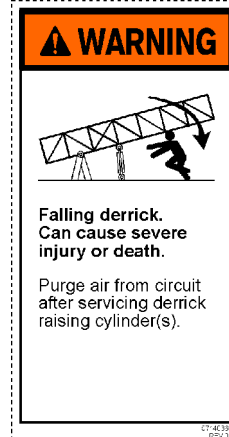
Purge air from circuit
after servicing tower
raising cylinder(s)

Quantity of 2

**Located at the bottom
of each tower raising
cylinder**



57140360



2.

**Decal, Caution:
Excessive Oil**

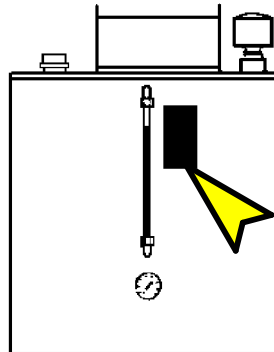
**Excessive Hydraulic Oil Can Rupture
Hydraulic Tank and Cause Injury or
Property Damage.**

Do not fill hydraulic tank with cylinders
extended.

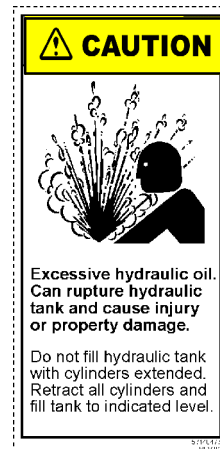
Retract all cylinders and fill tank to
indicated level.

Quantity of 1

**Located on the backside
of the hydraulic reservoir**



57140477



3.

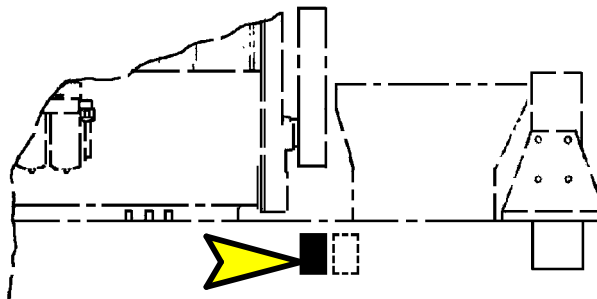
**Decal, Warning:
Rotating Parts**

**Rotating Parts Can
Cause Severe Injury**

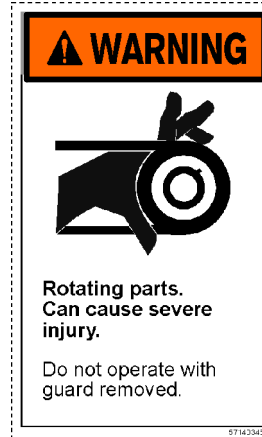
Do not operate with
guard removed.

Quantity of 2

**One on each side of
the power pack base**



57140345



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

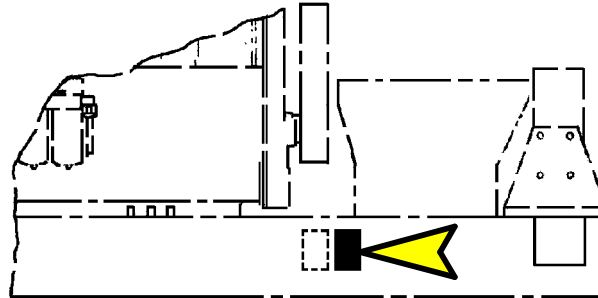
4.

Decal, Warning: Rotating Shaft

Rotating Shaft Can
Cause Severe Injury
or Death

Do not operate with
guard removed.

Quantity of 2
One on each side of
the power pack base



57140337



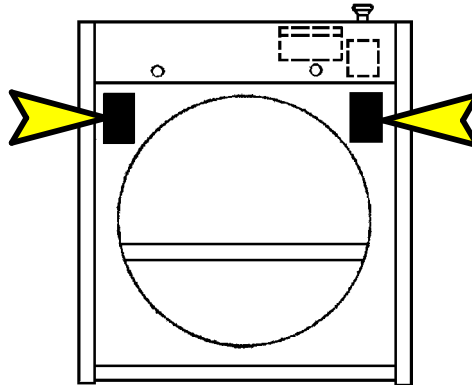
5.

Decal, Warning: Rotating Fan Blade

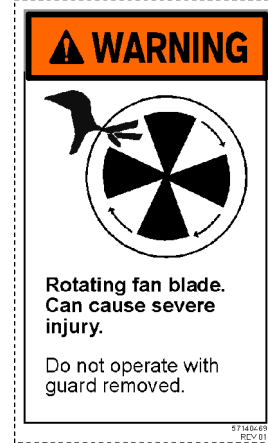
Rotating Blade Can
Cause Severe Injury

Do not operate with
guard removed.

Quantity of 1
Located on cooler
housing



57140469



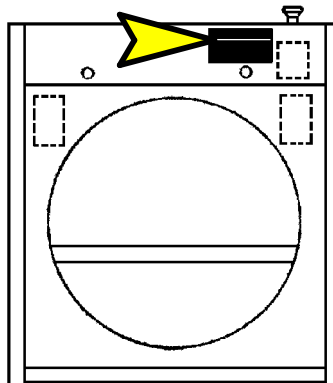
6.

Decal, Notice: Engine Failure

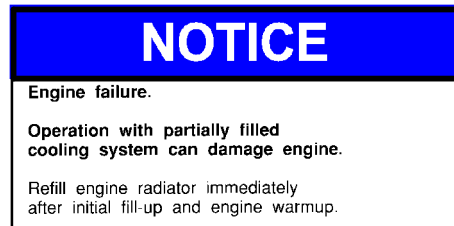
Operation with Partially Filled
Cooling System Can Damage
Engine

Refill engine radiator immediately
after initial fill up and engine
warmup

Quantity of 1
Located on cooler
housing



57140444



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

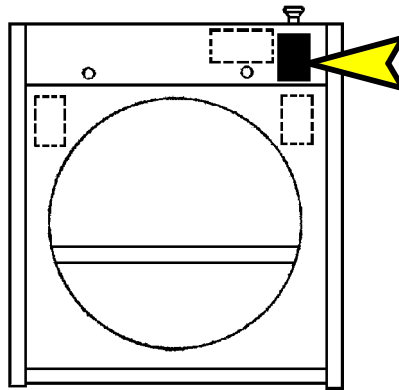
7.

Decal, Warning: Radiator Heat/Pressure

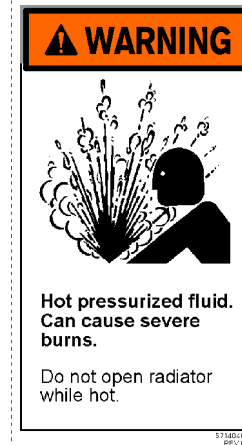
**Hot Pressurized Fluid
Can Cause Severe Burns**

Do not open radiator
when hot.

**Quantity of 1
Located on cooler
housing**



57140402



8.

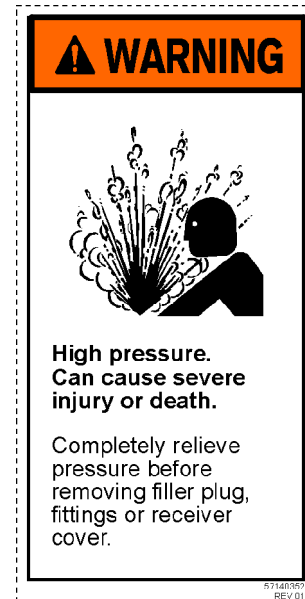
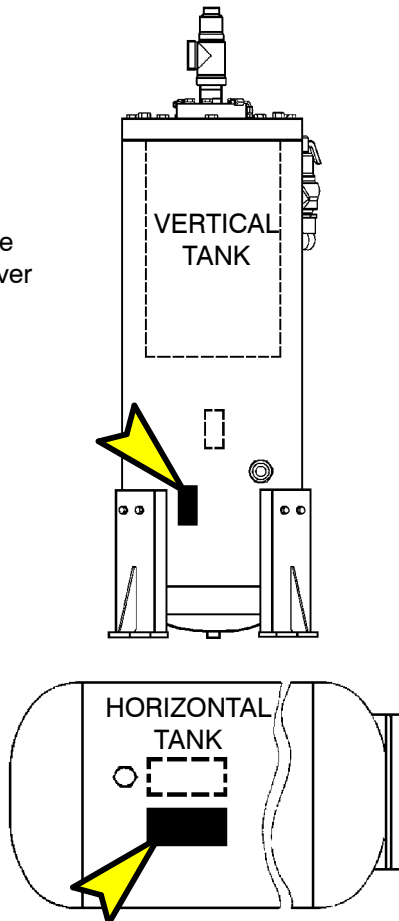
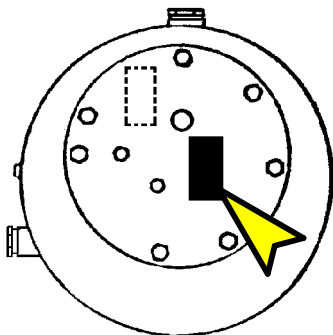
Decal, Warning: High Pressure

**High Pressure Can Cause
Severe Injury or Death**

Completely relieve pressure before
removing filler plug, fittings or receiver
cover.

**Quantity of 2
Located on side of vertical
receiver tank**

**Located on top of horizontal
receiver tank and on receiver
tank end plate cover**



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2.3 - SAFETY DECALS & NAMEPLATES



Safety Decals (continued)

9.

Decal, Warning: Service Tools Connection

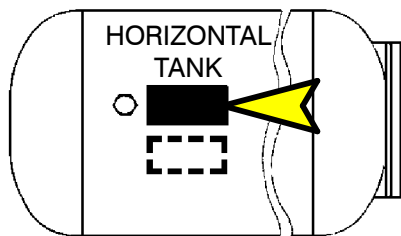
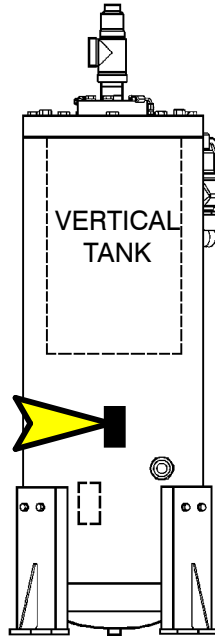
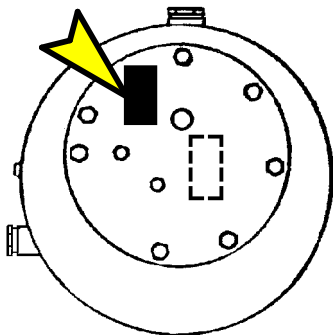
**High Pressure Air Can
Cause Severe Injury or
Death.**

*Reduce regulator pressure to
meet service requirements.*

Quantity of 1

**Located on side of vertical
receiver tank**

**Located on horizontal receiver
tank end plate cover**



57140428

10.

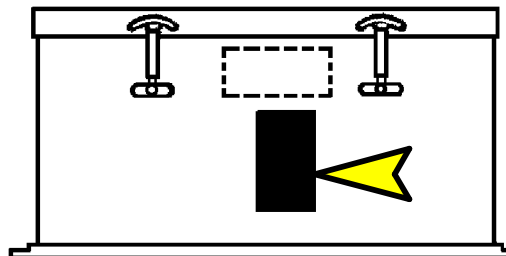
Decal, Warning: Combustible Gas

**Combustible Gas Can
Cause Severe Burns,
Blindness or Death**

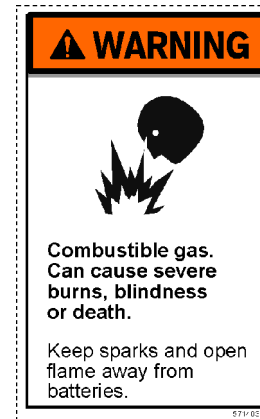
*Keep sparks and
open flame away
from batteries.*

Quantity of 1

**One located on the
battery box.**



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2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

11.

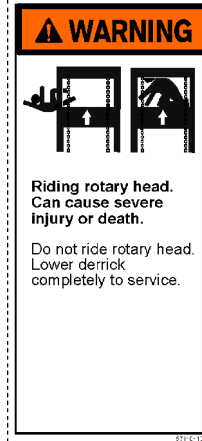
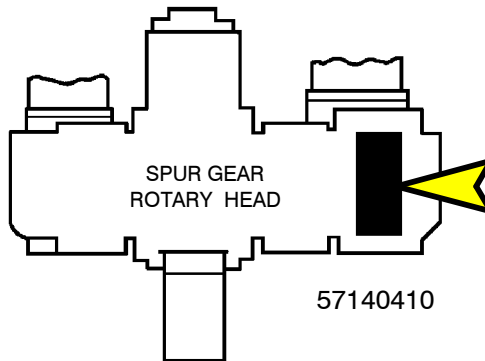
Decal, Warning: Rotary Head

**Riding Rotary Head Can
Cause Severe Injury or
Death.**

Do not ride rotary head.
Lower derrick completely
to service.

Quantity of 1

**Located on face of
rotary head**



12.

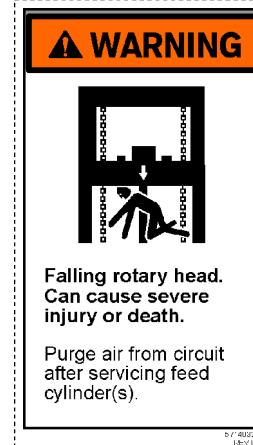
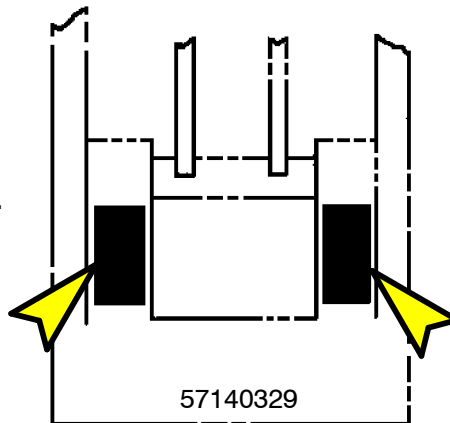
Decal, Warning: Falling Rotary Head

**Falling Rotary Head Can
Cause Severe Injury or Death.**

Purge air from circuit after
servicing feed cylinder(s).

Quantity of 2

**Located on the
bottom of the tower.**



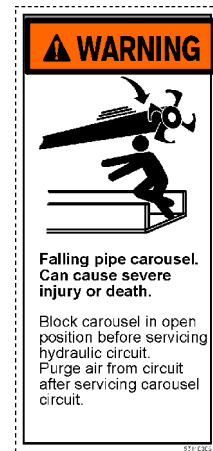
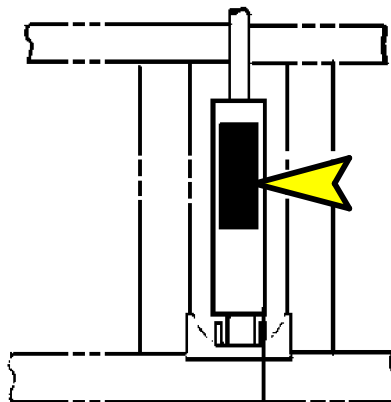
Decal, Warning: Falling Carousel

**Falling Pipe Carousel Can
Cause Severe Injury or Death.**

Block carousel in open position
before servicing hydraulic circuit.
Purge air from circuit after
servicing carousel circuit.

Quantity of 2

**Located on the rod
changer swing cylinder.**



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

14.

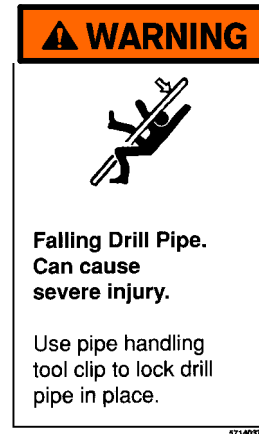
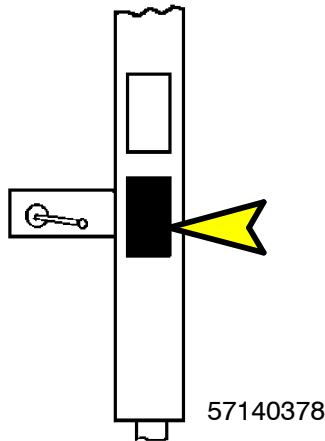
Decal, Warning: Falling Drill Pipe

**Falling Drill Pipe Can
Cause Severe Injury.**

Use pipe handling tool
clip to lock drill pipe in
place.

Quantity of 1

**Located on the helper
side leveling jack**



Decal, Warning: Hoist

15. **Falling Objects Can Cause
Severe Injury or Death.**

Do not lift more than
rated capacity of
1250 lbs. (568 kg)
with this hoist.

Do not use damaged cable.

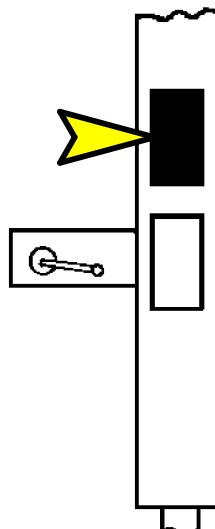
57297350

**Falling Objects Can Cause
Severe Injury or Death.**

Do not lift more than
rated capacity of
2500 lbs. (1136 kg)
with this hoist.

Do not use damaged cable.

57297368



Quantity of 1
**Located on the helper
side leveling jack**

2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

16.

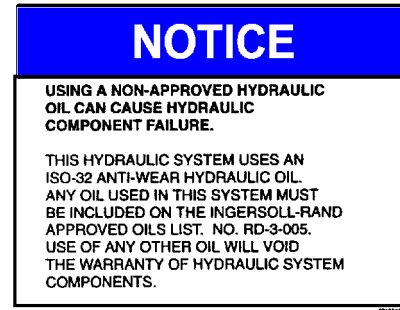
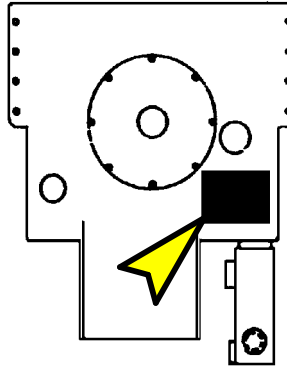
Decal, Notice: Hydraulic Failure

Using a Non-Approved Hydraulic Oil Can Cause Hydraulic Component Failure.

This hydraulic system uses an ISO-32 anti-wear hydraulic oil. Any oil used in this system must be included on the approved oils list. Use of any other oil will void the warranty of hydraulic system components.

Quantity of 1

Located on top of the hydraulic tank.



57146465

17.

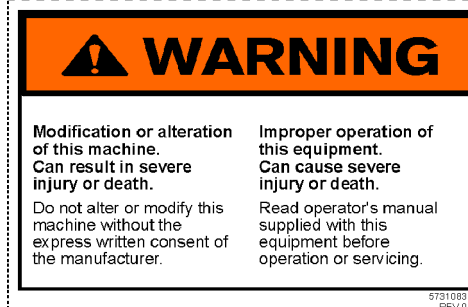
Decal, Warning: Do Not Modify or Alter

Modification or alteration of this machine can result in severe injury or death.

Do not alter or modify this machine without the express written consent of the manufacturer.

**Improper operation of
this equipment can cause
severe injury or death.**

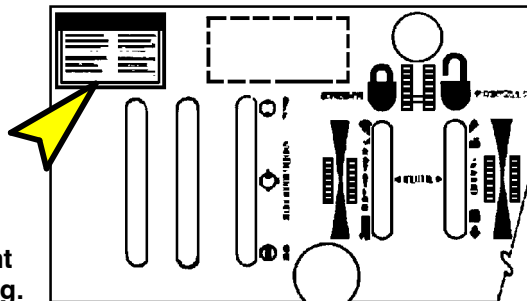
**Read the operator's manual
supplied with this equipment
before operation or servicing.**



Quantity of 1

**Located on the
operator's console**

57310831



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

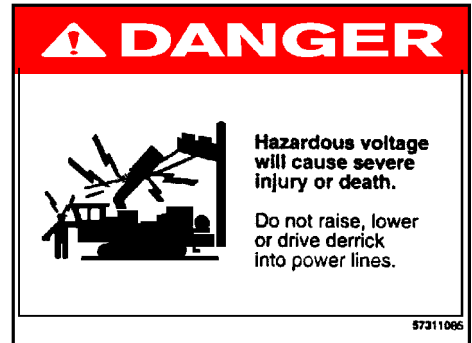
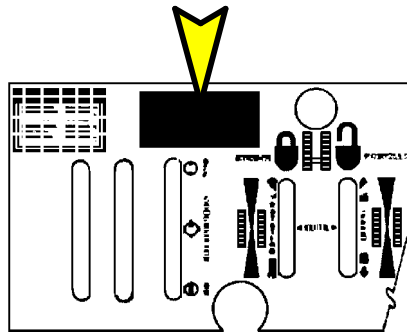
18.

Decal, Danger: Hazardous Voltage

**Hazardous Voltage
Will Cause Severe
Injury or Death.**

Do not raise, lower or
drive tower into power
lines.

**Quantity of 1
Located on the
operator's console.**



57311086

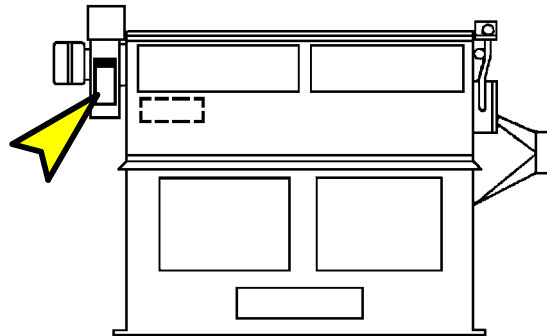
19.

Decal, Danger: Flying Fanblades

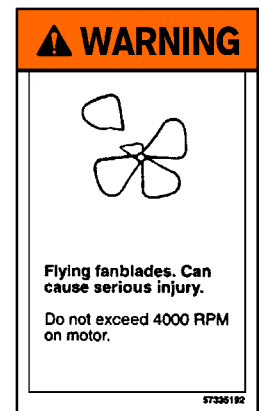
**Flying Fanblades Can
Cause Severe Injury.**

Do not exceed 4000 RPM
on motor.

**Quantity of 1
Located on the dust
collector by fan wheel.**



57335192

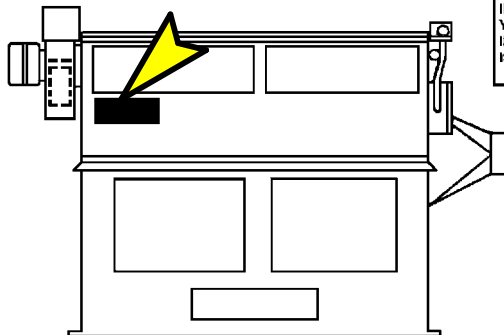


20.

Decal, Notice: Dust Discharge

If dust is being discharged
through fan, you must check
filters and correct problem. If
fan wheel is damaged by
dirty air there is no warranty
claim.

**Quantity of 1
Located on front of the
dust collector.**



57335200



2.3 - SAFETY DECALS & NAMEPLATES

Safety Decals (continued)

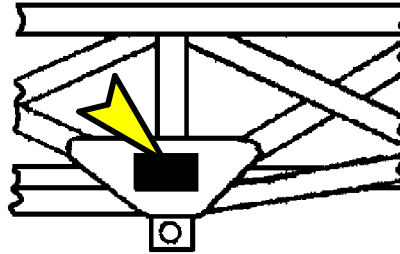
21.

Decal, Warning: No Climbing

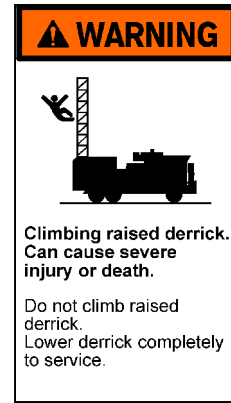
**Climbing Raised Derrick
Can Cause Severe Injury
or Death**

Do not climb raised derrick.
Lower derrick completely to
service.

Quantity of 2
**Located on the back of the
tower on a cross beam.**

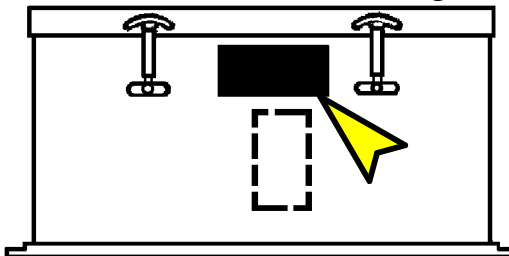


57318040



22.

Decal, Notice: To Avoid Electrical Damage



Quantity of 1 57345878

Located on front of the battery box

NOTICE

To avoid damage to the rig's electronic components, disconnect both battery positive (+) and negative (-) cables prior to welding. Attach the welding ground cable as close as possible to the part being welded. If necessary to weld close to an electronic component, it is recommended that the electronic component be temporarily removed.

57345878

23.

Safety Manual

Quantity of 1
**Located inside the
operator's cab.**

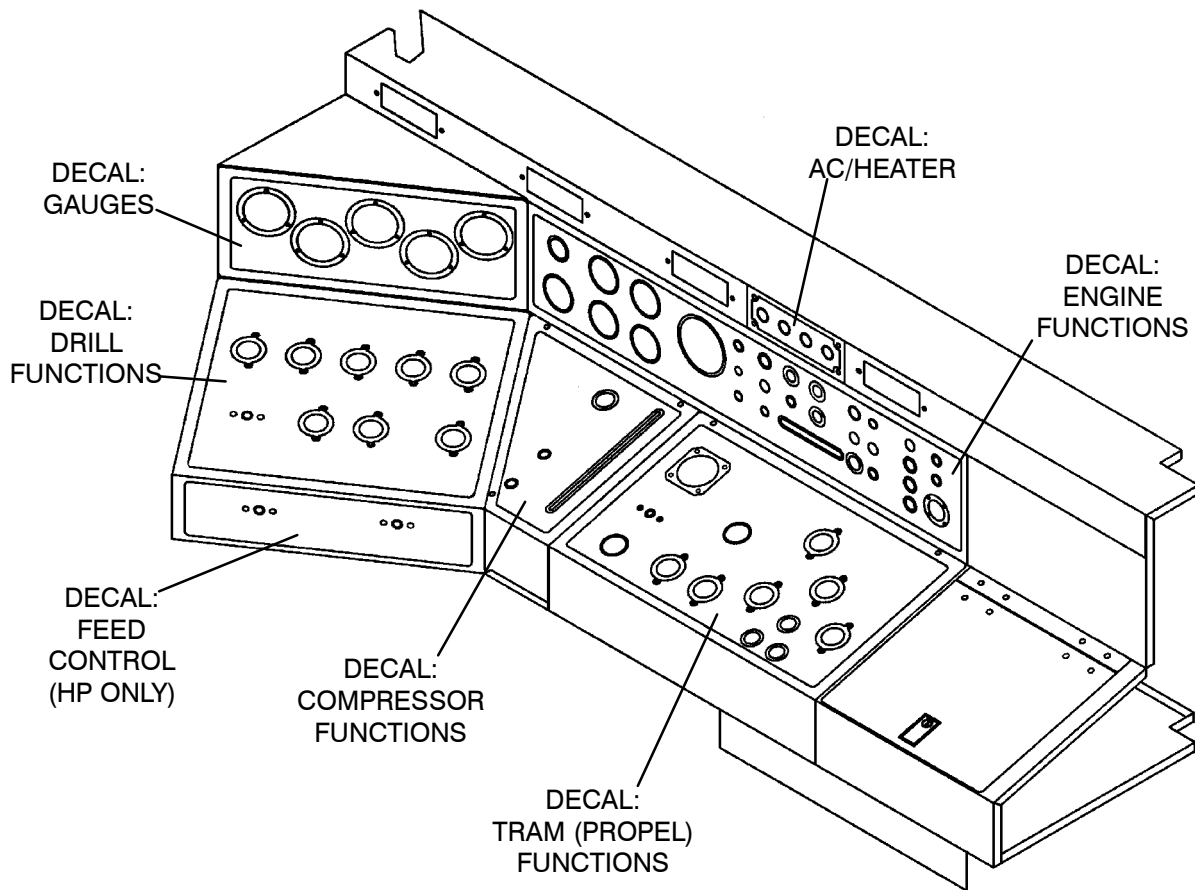
57311151



2.3 - SAFETY DECALS & NAMEPLATES



Console Nameplates



2.3 - SAFETY DECALS & NAMEPLATES

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2.4 - HAZARDOUS SUBSTANCE PRECAUTION



The following information is provided to assist the owners and operators of Drilling Solutions Equipment. Further information may be obtained by contacting your Drilling Solutions Equipment Distributor.

The following substances are used in the manufacturing of this machine and may be hazardous to health if used incorrectly.

SUBSTANCE

PRECAUTION

1. Anti Freeze ----- Avoid ingestion, skin contact and breathing fumes.
2. Hydraulic Oil ----- Avoid ingestion, skin contact and breathing fumes.
3. Engine Lubricating Oil --- Avoid ingestion, skin contact and breathing fumes.
4. Compressor Oil ----- Avoid ingestion, skin contact and breathing fumes.
5. Preservative Grease ---- Avoid ingestion, skin contact and breathing fumes.
6. Rust Preventative ----- Avoid ingestion, skin contact and breathing fumes.
7. Engine Fuel ----- Avoid ingestion, skin contact and breathing fumes.
8. Battery ----- Avoid ingestion, skin contact and breathing fumes.
9. SAE Gear Oil ----- Avoid ingestion, skin contact and breathing fumes.

The following substances may be produced during the operation of this machine and may be hazardous to health.

SUBSTANCE

PRECAUTION

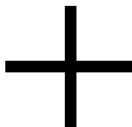
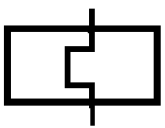
1. Engine Exhaust Fumes -- Avoid breathing fumes.
2. Engine Exhaust Fumes -- Avoid buildup of fumes in confined spaces.
3. Engine Exhaust Fumes -- Avoid buildup of fumes in confined spaces.
4. Electric Motor Dust ----- Avoid breathing in dust during maintenance.
(Brushes/Insulation)
5. Brake Lining Dust ----- Avoid breathing in dust during maintenance.

2.4 - HAZARDOUS SUBSTANCE PRECAUTION

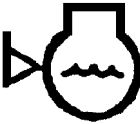
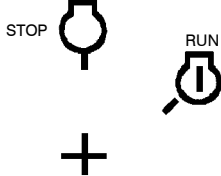
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2.5 - SYMBOL IDENTIFICATION

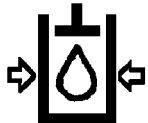
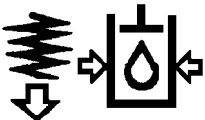
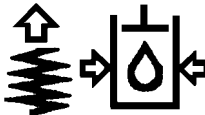
The following drill symbol information is provided to assist the owners and operators of Drilling Solutions Equipment. Further information may be obtained by contacting your Drilling Solutions Equipment Distributor.

Caution 	Read Operator's Manual 	Inspect/Test/Check 	On/Start 
Off/Stop 	On/Off 	Battery Condition 	Plus/Positive 
Minus/Negative 	Horn 	Hourmeter 	Seat (Lap) Belt 
Volume Empty 	Volume Half– Full 	Volume Full 	Circuit Breaker(s) 
Work Light 	Tram (Propel) Light 	Primer (Start Aid) 	Gas Inject (Cold Start) 

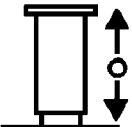
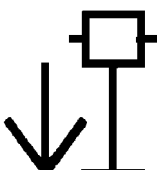
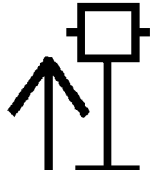
2.5 - SYMBOL IDENTIFICATION

Engine Electric Preheat 	Engine Bypass 	Start Switch (Crank Engine) 	Engine Start 
Engine On/Run 	Engine Rotations (RPM) 	Engine Oil 	Engine Oil Level 
Engine Oil Pressure 	Engine Oil Pressure—Failure 	Engine Oil Temperature 	Engine Oil Filter 
Engine Air Filter 	Engine Coolant 	Engine Coolant Level 	Coolant Temperature 
Emergency Engine Stop 	Engine STOP and Electrics ON/OFF 	Engine Datalink Test Point 	Engine Fault Warning (Diagnostic) 

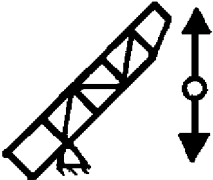
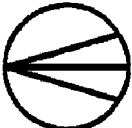
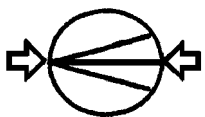
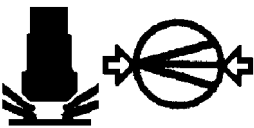
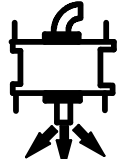
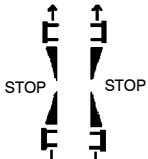
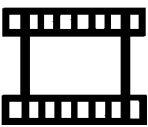
2.5 - SYMBOL IDENTIFICATION

Increase/Decrease Adjustment 	Incremental Increase/Decrease 	Filling – Emptying 	Fuel (Diesel) 
Fuel Level 	Fuel Filter 	Hydraulic Oil 	Hydraulic Oil Level 
Hydraulic Oil Pressure 	Hydraulic Oil Temperature 	Hydraulic Oil Filter 	Main Pump Supercharge Hydraulic Pressure 
Drill Rotation Hydraulic Pressure 	Drill Pulldown Hydraulic Pressure 	Drill Pullback Hydraulic Pressure 	Drill Feed Speed/Direction UP/STOP/DOWN 
Drill Feed Speed/Direction CW/STOP/CCW 	Drill Feed Pulldown Force 	Drill Feed Pullback Force 	Main Pump 

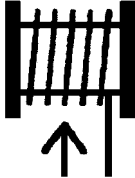
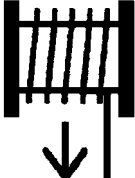
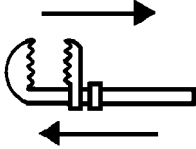
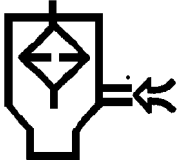
2.5 - SYMBOL IDENTIFICATION

Control Lever – Dual Direction 	Clockwise Rotation 	Counter Clockwise Rotation 	Drill Mode 
Drill Rotation (Clockwise) 	Drill Rotation (Counter Clockwise) 	Carousel – Rotate Counterclockwise 	Carousel – Rotate Clockwise 
Rod Indexer 	Rod Changer Swing 	Rod Changer – Swing into Load Position 	Rod Changer – Swing into Stowed Position 
Jack or Support Point 	Leveling Jack 	To Lower Leveling Jack 	To Raise Leveling Jack 
Rear Jack Indicator Light 	D.C. Side Jack Indicator Light 	Cab Side Jack Indicator Light 	 Angle Drill Rod Support

2.5 - SYMBOL IDENTIFICATION

Extend Hydraulic Cylinder 	Retract Hydraulic Cylinder 	Tower Locking Pin Engaged 	Tower Locking Pin Disengaged 
Tower Locking Pin Disengaged Warning Light 	Tower Raise/Lower 	Lower Derrick 	Raise Derrick 
Pneumatic Energy 	Compressed Air Pressure 	Compressor Intake Closed (Cold Start Position) 	Compressor Intake Open (Run Position) 
Drill Air Flow Adjustment (Zero to Maximum) 	Drilling Air Pressure 	Drill Air Throttle Valve 	Tram Speed and Direction REVERSE/STOP/FORWARD 
Crawler Tramming (Propelling) 	Transverse Angle 	Longitudinal Angle 	Linear Increase 

2.5 - SYMBOL IDENTIFICATION

Rotational Increase 	Parking Brake 	Brake On 	Brake Off 
Winch Lower (Spool Out) 	Winch Raise (Spool In) 	Breakout Wrench Disengage 	Breakout Wrench Engage 
Chain Wrench 	Pipe Wrench 	Water Injection Dust Collector 	Fluid Flushing (Water Injection) 
Dust Collection 	Lower Dust Suction Hood 	Raise Dust Suction Hood 	Dust Flap Up 
Dust Flap Down 	Telescopic Dust Curtain Up 	Telescopic Dust Curtain Down 	Heat ON 

2.5 - SYMBOL IDENTIFICATION

Air Lubrication (Air Flushing with Oil) 	Lubrication Oil Injection Indicator Light 	Rear Window Wiper 	Front Window Wiper 
Grease Point 	Oil Lubrication Point 	Lift Point 	Tie-Down Points 

2.5 - SYMBOL IDENTIFICATION

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SECTION 3 SPECIFICATIONS & SYSTEMS

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3.1 - SPECIFICATIONS

DRILL APPLICATIONS

The DM45, DM50 and DML series drills are the Drilling Solution Mid-Range Drill Product Line.

The Mid-Range drills are built in accordance with state-of-the-art standards and recognized safety rules. Nevertheless, their misuse may constitute a risk to the life and limb of the user or third parties and may cause damage to the drills or other material property.

The Mid-Range drill must be used in accordance with its designated use as described in the operating section of this manual (See Section 5). The Mid-Range drill must only be operated by safety-conscious persons who are fully aware of the risks involved in operating the drill. Any functional disorders, especially those affecting the safety of the drill, must be corrected immediately.

Designated Applications

The **DM45/LP** is designed exclusively for production blasthole drilling by rotary action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 5 in. (127mm) to 9 in. (228mm) for rotary bit applications.

The **DM45/HP** is designed exclusively for production blasthole drilling by rotary/percussive action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 5 in. (127mm) to 9 in. (228mm) for rotary bit applications and 5 in. (127mm) to 8 in. (203mm) for DHD (down the hole) drilling applications using a high pressure compressor.

The **DM50/LP** is designed exclusively for production blasthole drilling by rotary action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 7-7/8 in. (200mm) to 9-7/8 in. (251mm) for rotary bit applications.

The **DML/LP** is designed exclusively for production blasthole drilling by rotary action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 6 in. (152mm) to 10-5/8 in. (270mm) for rotary bit applications.

The **DML/HP** is designed exclusively for production blasthole drilling by rotary/percussive action, to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change, on prepared benches which are flat and firm. The nominal hole size diameter ranges from 6 in. (152mm) to 10-5/8 in. (270mm) for rotary bit applications and 6 in. (152mm) to 9-7/8 in. (250mm) for DHD (down the hole) drilling applications using a high pressure compressor.

3.1 - SPECIFICATIONS

Non Designated Applications

The Mid-Range drills are not designed for pioneering/earthmoving applications. The Mid-Range drills are not designed for use on inclined surfaces greater than those defined in the Mid-Range Blasthole Stability / Gradeability Chart or on soft and unstable ground. Use of the drills for purposes other than that mentioned (such as for towing other vehicles or equipment) is considered contrary to its designated use. The manufacturer/supplier cannot be held liable for any damage resulting from such use. The risk of such misuse lies entirely with the user.

Special order drills are designed and equipped with a remote tramming control console which must be used when tramming over unstable ground conditions or when loading the drill up ramps onto a trailer. The remote control enables the operator to control and move the drill from a vantage point outside the drill.

Operating the drill within the limits of its designated use also involves compliance with the inspection and maintenance directives contained in the operating manual.

GENERAL SPECIFICATIONS

The Drilling Solution **DM45/LP** is a crawler mounted, hydraulic tophead drive, multi-pass rotary drill rig specifically designed for production blasthole drilling to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change. Nominal hole size is 5 in. (127 mm) to 9 in. (228 mm) for rotary bit applications. Feed pressure generates a bit load force of up to 45,000 lb. (20,412 kg). The standard DM45/LP utilizes a diesel engine to drive the air compressor and hydraulic systems. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling.

The DM45/LP comes equipped with an asymmetrical rotary screw air compressor.

Technical Specifications are for the standard DM45/50 configuration. Your specific drill may or may not have all Options available.

3.1 - SPECIFICATIONS

GENERAL SPECIFICATIONS (continued)

The Drilling Solution **DM45/HP** is a crawler mounted, hydraulic tophead drive, multi-pass rotary drill rig specifically designed for production blasthole drilling to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change. Nominal hole size is 5 in. (127 mm) to 9 in. (228 mm) for rotary bit applications and 5 in. (127 mm) to 8 in. (203 mm) for DHD drilling with a high pressure air compressor. Feed pressure generates a bit load force of up to 45,000 lb. (20,412 kg). The standard DM45/HP utilizes a diesel engine to drive the air compressor and hydraulic systems. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling.

The DM45/HP comes equipped with an asymmetrical rotary screw air compressor. Various high pressure capacities are available. Technical Specifications are for the standard DM45/50 configuration. Your specific drill may or may not have all Options available.

The Drilling Solution **DM50/LP** is a crawler mounted, hydraulic tophead drive, multi-pass rotary drill rig specifically designed for production blasthole drilling to depths of 180 ft. (54.9 m) with a 30 ft. (9.1 m) drill pipe change. Nominal hole size is 7-7/8 in. (200 mm) to 9-7/8 in. (251 mm) for rotary bit applications. Feed pressure generates a bit load force of up to 50,000 lb. (22,680 kg). The standard DM50/LP utilizes a diesel engine to drive the air compressor and hydraulic systems. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling.

The DM50/LP comes equipped with an asymmetrical rotary screw air compressor. Technical Specifications are for the standard DM45/50 configuration. Your specific drill may or may not have all Options available.

The **DML** is a crawler mounted, hydraulic tophead drive, multi-pass rotary drilling rig specifically designed for production blasthole drilling to depths of 180 ft. (54.9m) with a 30 ft. (9.1m) drill pipe change. A 35 ft. (10.7m) steel change is also available to handle single pass drilling requirements to 35 ft. (10.7m). Various carousel capacities are also available for the 35 ft., (10.7m) option. Hole size range for rotary drilling applications is nominally 6 in. to 10-5/8 in. (152mm to 270 mm). For DHD drilling with the high pressure air option, nominal hole size range is 6 in. to 9-7/8 in. (152 mm to 250 mm). Feed pressure generates a bit load force of up to 60,000 lb. (27,216 kg). The standard DML utilizes a diesel engine to drive the air compressor and hydraulic system. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling. The DML comes equipped with an asymmetrical rotary screw air compressor.

3.1 - SPECIFICATIONS

OPERATIONAL LIMITATIONS

Ambient Temperature Range:

The drills come equipped for an ambient temperature working range between limits of 125°F (52°C) Maximum and 15°F (-9°C) Minimum.

Ground Pressure:

The DM45/50 utilizes an excavator type undercarriage with design ground pressure limit of 10.66 psi (73.5 kPa).

The DML utilizes an excavator type undercarriage with design ground pressure limit of 10.52 psi (72.5 kPa).

Maximum Allowable Slope Angle:

The drills come equipped for operation on slopes **not exceeding 20 degrees inclination**.

Operating Conditions For Stability:

*Note: Stability is affected by the tower position and orientation of the drill on the slope, the surface stability (bearing strength), and wind conditions. Refer to the Blasthole Drill Stability/Gradeability Chart for further guidance. **Note: Drilling Solution does not authorize use on slopes exceeding 20°.***

Sound Pressure Limitations (EEC Requirement):

Operator Exposure to Noise Emission – In accordance with the requirements of clauses 1.75f of Annex I of the Machinery Directive 89/392/EEC and Directive 91/368/EEC, EN791 Annex A Cl. 4.1, the drill has been tested at normal engine operating speed at the following maximum values: At Operators Station (in closed cab, seated/standing positions = less than 85 dBA. Tests were conducted with machine running at operating engine speed. Machine was in an open field with no structural objects reflecting sound.

Vibration Exposure Limitations (EEC Requirement):

Operator Exposure to Vibration – In accordance with the requirements of clauses 22.2 of Annex I of the Machinery Directive 89/392/EEC and Directive 91/368/EEC, EN791 Annex A Cl. 4.1, the drill has been tested and the weighted root mean square acceleration value to which arms are subjected does not exceed 2.5 m/s². Weighted root mean square acceleration to which body (feet and posterior) is subjected does not exceed 0.5 m/s². Tests were conducted with machine running at operating engine speed. The drill was in an open field with no structural objects reflecting sound.

3.1 - SPECIFICATIONS

STANDARD EQUIPMENT AND SPECIFICATIONS

1. Insulated Cab With FOPS And Noise Abated Less Than 80 dBa
2. Cab Pressurizer / Ventilator / Heater
3. "No Visible Emission" Dust Collector
4. Nine Quartz Halogen Night Lighting Package
5. Dust Hood With Curtains And Hydraulically Raising Dust Flap
6. Auxiliary Hoist For Drill Pipe And Accessory Handling
7. Side By Side Cooling Package Rated To 125°F (52°C) Ambient
8. Heavy Duty Engine Silencer / Muffler
9. Separate Air Intake Filters With Quick Release Dust Drop Covers For The Engine And Air Compressor
10. Gear Indexing Carousel For Five 4.5 In. (114 mm) X 30 Ft. (9.1 m) Pipe **(DM45)**
Gear Indexing Carousel For Five 5.5 In. (140 mm) X 30 Ft. (9.1 m) Pipe **(DM50/DML)**
11. Sliding Hydraulic Fork Wrench For Drill Pipe Breakout
12. Hydraulically Powered Auxiliary Chain Wrench
13. 380 Gallon (1,438 L) Fuel Tank
14. **DM45/50** -- 4SV-2-10 Two Motor High Speed Rotary Head, 0 to 200 RPM, Max. Torque of 6,200 ft/lb. (8,407 N-m)
DML ----- 4SV-2-10 Two Motor High Speed Rotary Head, 0 to 160 RPM, Max. Torque of 9,000 ft/lb. (6,600 N-m) @ 95 rpm/5,400 ft/lb. (3996 N-m) @ 160 rpm
15. 30 ft. Drill Pipe Change
16. No-Bump Rod Changer
17. Ether Injection
18. Jacks Indicator Lights
19. Three 48 in. (1,219 mm) Stroke Leveling Jacks
20. **DM45/50** -- 80,000 lb. (36,288 kg) GVW Rated Excavator Type Undercarriage
DML ----- 100,000 lb. (45,360 kg) GVW Rated Excavator Type Undercarriage
21. **DM45/50** -- 23.6 in. (600 mm) Wide Triple Bar Grousers
DML ----- 33.5 in. (850 mm) Wide Triple Bar Grousers
22. Reinforced Rectangular Steel Track Frame with Oscillation Yoke
23. Walkways and Railings Designed For Superb Maintenance Access
24. Remote Tower Pinning
25. Backup Alarm

Note: Specifications represented are calculated values at 100% efficiency.

3.1 - SPECIFICATIONS

MAIN FRAME

The DM45/DM50 main frame is designed and weld fabricated for Drilling Solution of 10 in. x 10 in. (254 mm x 254 mm) structural steel tubing for both rails and crossbeams.

The DML main frame is designed and weld fabricated for Drilling Solution of 10 in. x 14 in. (254 mm x 356 mm) structural steel tubing for both rails and crossbeams.

LEVELING JACK SPECIFICATIONS

Type:	Hydraulic cylinder with lock check
Number:	Three
Bore x Stroke/Rod Diameter	
(Two) Drill Side:	5 in. x 48 in. / 4 in. (127 mm x 1,219 mm / 102 mm)
(One) Non–Drill Side:	5 in. x 48 in. / 4 in. (127 mm x 1,219 mm / 102 mm)
Lift Capacity:	58,900 lb. (26,717 kg) each
Jack Pad Diameter:	30 in. (762 mm)
Jack Pad Area:	706.8 in. ² (4,560 cm ²) each
Jack Indicator Lights:	Three lights on the cab console illuminate when the jacks are fully retracted.

UNDERCARRIAGE AND PROPEL SYSTEM

The Drill utilizes an excavator type undercarriage, built to Drilling Solution specifications. The undercarriage is driven directly by a planetary gear system and two hydraulic motors.

A “walking beam” oscillation yoke allows the drill to propel over uneven ground without imposing excessive torsional stress on the main frame.

Both tracks are individually controlled with each track acting as an independent unit for steering purposes.

The tracks are hydraulically adjustable with a spring recoil system and are equipped with replaceable triple bar grouser pads.

Safety, Operation and Maintenance
DM45/DM50/DML
SECTION 3 – SPECIFICATIONS & SYSTEMS

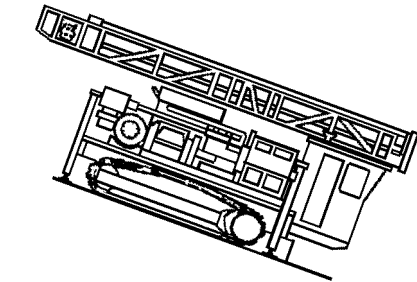
3.1 - SPECIFICATIONS

Undercarriage And Propel Specifications

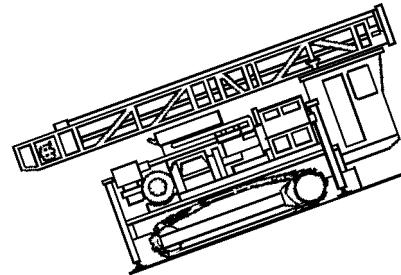
Description	DM45 / DM50	DML
Type:	Excavator (Caterpillar 325L or equivalent)	Excavator (Caterpillar 330S or equivalent)
Frame Construction:	Reinforced rectangular steel frame	
Rated GVW:	80,000 lb. (36,288 kg)	100,000 lb. (45,360 kg)
Mounting:	Oscillating walking beam (5° each side; total 10°)	
Total Crawler Length:	184 in. (4,674 mm)	180 in. (4,585 mm)
Crawler Ground Contact Length:	149 in. (3,785 mm)	141.9 in. (3,605 mm)
Take–Up Adjustment:	Hydraulic (grease) slack adjustment, spring recoil	
Rollers:	10 Lower / 2 Upper	7 Lower / 2 Upper
Location:	Strategically located for load distribution relative to the tower position (vertical or horizontal)	
Roller Size:	6.3 in. (160 mm)	6.6 in. (168 mm)
Roller Bearings:	Sealed –for–life	
Track Pads:		
Width:	Standard 23.6 in. (600 mm)	Standard 33.5 in. (850 mm)
Type:	Triple Bar Grouser	
Ground Pressure:	10.66 psi (73.5 kPa)	10.52 psi (72.5 kPa)
Rock Guards:	Full length rock guards/track guides are standard	
Brakes:	Plate type, spring applied, hydraulically released	
Tow Release:	Track drive manually releases for emergency towing	
Drive:	Hydraulic motors through planetary reduction	
Propel Motors:	Two	
Type:	Hydraulic, axial piston, fixed displacement	
Rating:	165 hp (123 kW) each	175 hp (130.5 kW) each
Propel Speed Range:	0 to 1.9 MPH (0 to 3.1 km/hr.)	0 to 1.7 MPH (0 to 2.7 km/hr.)

3.1 - SPECIFICATIONS

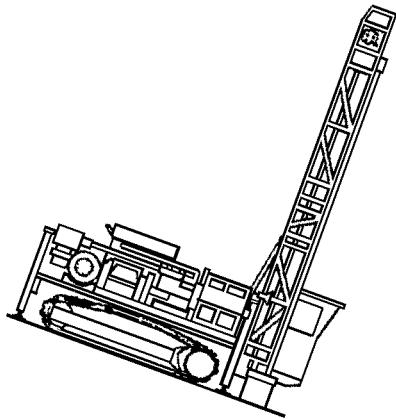
Mid-Range Blasthole Stability / Gradeability Chart



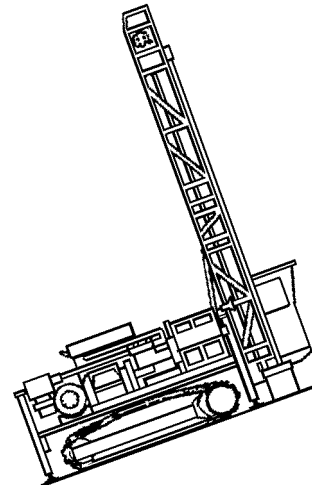
TOWER DOWN / DOWN HILL
PERMISSIBLE SLOPE ANGLE: 20°



TOWER DOWN / UP HILL
PERMISSIBLE SLOPE ANGLE: 20°

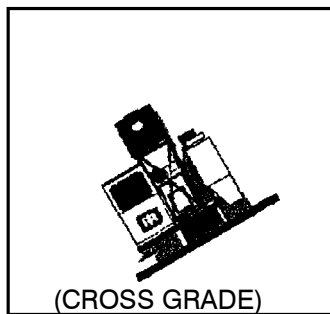


TOWER UP / DOWN HILL
PERMISSIBLE SLOPE ANGLE: 17°

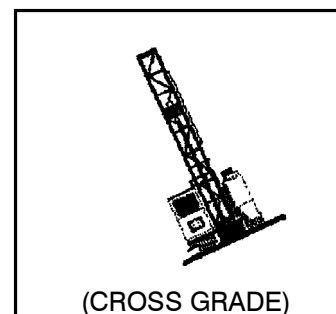
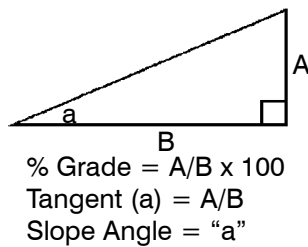


TOWER UP / UP HILL
PERMISSIBLE SLOPE ANGLE: 20°

Figure 3.1 – 1
DRAWINGS
NOT TO SCALE



TOWER DOWN / SIDE HILL
PERMISSIBLE SLOPE ANGLE: 20°



TOWER UP / SIDE HILL
PERMISSIBLE SLOPE ANGLE: 14°

Note: Maximum slope values are based upon calculations and testing and include certain options. Actual values for maximum slope may vary, depending upon similarity with rig considering smoothness of slope, ground condition, operator skill and experience, wind, speed of movement and acceleration. These values are STATIC limits of stability and are not intended as a recommendation for acceptable operation.

3.1 - SPECIFICATIONS

TOWER, CAROUSEL AND DRILL PIPE HANDLING

The tower is constructed of welded rectangular steel tubing. The fabrication is constructed by Drilling Solution in a special roll-over fixture that helps provide optimum welds.

The Drill is a multi-pass drill. A carousel type drill pipe changer is part of the tower assembly and is located on the outside of the tower frame.

The tower is raised and lowered by two hydraulic cylinders. Raising the tower to the vertical position with a full complement of drill pipe in the carousel can be accomplished in less than one minute. Tower pinning is performed from within the operator's cab.

An angle drilling option is also available.

Tower Specifications

Tower	25 ft. (7.6 m)	30 ft. (9.1 m)	35 ft. (10.7 m)
Tower Construction:	Four main member, open front, ASTM A500 rectangular steel tubing. All welded.		
Tower Raising Cylinders:	Two (2) hydraulic cylinders		
Bore:	5 in. (127 mm)	5.5 in. (140 mm)	
Rod:	3 in. (76.2 mm)		
Stroke:	48 in. (1,219 mm)		
Overall Tower Length:	35 ft.—3 in. (10.7 m)	40 ft.—3 in. (12.3 m)	45 ft.—3 in. (13.8 m)
Tower Weight:	Approximately 5,000 lbs. (2,268 kg.)	Approximately 5,500 lbs. (2,268 kg.)	
Rotary Head Travel:	27 ft.—8 in. (8.4 m)	33 ft.—6 in. (10.2 m)	38 ft.—6 in. (11.7 m)
Tubing Size			
Front:	4 in. x 6 in. x3/8 in. (102 mm x 152 mm x 9.5 mm)		5 in. x 3 in. x 3/8 in. (127mm x 76.2mm x 9.5mm)
Rear:	4 in. x 4 in. x1/4 in. (102 mm x 102 mm x 6.4 mm)		3 in. x 3 in. x 5/16 in. (76.2mm x 76.2mm x 7.9mm)
Diagonal Cross Members:	4 in. x 4 in. x3/16 in. (102 mm x 102 mm x 4.8 mm)		3 in. x 2 in. x 1/4 in. (76.2mm x 50.8mm x 6.4mm)
Vertical Cross Members:	4 in. x 4 in. x1/4 in. (102 mm x 102 mm x 6.4 mm)		3 in. x 2 in. x 1/4 in. (76.2mm x 50.8mm x 6.4mm)

3.1 - SPECIFICATIONS

DRILL PIPE CHANGE

Drill pipe changing is accomplished from the operator's console. A hydraulic positioned sliding fork wrench is used to break the joint with limited impact that minimizes shock loads on the tower, carousel, rotary head and feed components. Up to seven drill pipe are stored in the carousel, contingent upon pipe size and option selections. Two hydraulic cylinders swing the carousel into and out from the loading position under the rotary head. A hydraulic motor rotates the carousel to index the drill pipe under the rotary head for changing. An exclusive "keylock" carousel design securely locks the drill pipe at both the bottom and the top of the carousel to insure maximum safety for drill pipe storage and changing. An auxiliary hoist is provided as standard for drill pipe and accessory handling. A no-bump drill pipe changer, which limits the feed force of the rotary head until the carousel is moved into the complete out position and prohibits movement of the carousel if the head is not at the top of the tower, is provided as standard.

DRILL PIPE HANDLING SPECIFICATIONS

Standard 25 Ft. Tower

Drill Pipe Length = 25 ft. (7.6 m)

Auxiliary Hoist = 4,000 lb. (1,800 kg) capacity, mounted on top of the tower

Breakout System = Limited impact (sliding hydraulic fork chuck)

Auxiliary Breakout = Hydraulic powered chain wrench

Standard 30 Ft. Tower

Drill Pipe Length = 30 ft. (9.1 m)

Auxiliary Hoist = 4,000 lb. (1,800 kg) capacity, mounted on top of the tower

Breakout System = Limited impact (sliding hydraulic fork chuck)

Auxiliary Breakout = Hydraulic powered chain wrench

Option 35 Ft. Tower

Drill Pipe Length = 35 ft. (10.7 m)

Auxiliary Hoist = 4,000 lb. (1,800 kg) capacity, mounted on top of the tower

Breakout System = Limited impact (sliding hydraulic fork chuck)

Auxiliary Breakout = Hydraulic powered chain wrench

3.1 - SPECIFICATIONS

CAROUSEL SPECIFICATIONS

Carousel For 25 Ft. (7.6 M) Drill Pipe

Pipe Diameter (inches)	Pipe Diameter (millimeters)	Total Number *	Hole Depth (feet)	Hole Depth (Meters)
4	102	6	150	45.7
4–1/2	114	6	150	45.7
5	127	6	150	45.7
5–1/2	140	6	150	45.7
6–1/4	159	6	125	38.1

* Pipe capacity includes one pipe in rotary head.

Carousel For 30 Ft. (9.1 M) Drill Pipe

Pipe Diameter (inches)	Total Number of Drill Pipe *	Hole Depth (On–Board)	Remarks
4 in. (102 mm)	6	180 (54.9 m)	Standard Tower
	8	240 ft. (73.2 m)	Optional Carousel
4.5 in. (114 mm)	6	180 ft. (54.9 m)	Standard Tower
	8	240 ft. (73.2 m)	Optional Carousel
5 in. (127 mm)	6	180 ft. (54.9 m)	Standard Tower
5.5 in. (140 mm)	6	180 ft. (54.9 m)	Standard Tower
6.25 in. (159 mm)	5	150 ft. (45.7 m)	Standard Tower
7 in. (178 mm)	4	150 ft. (45.7 m)	Standard Tower
7.625 in. (194mm)	4	150 ft. (45.7 m)	Standard Tower

* Pipe capacity includes one pipe in rotary head.

Carousel For 35 Ft. (10.7 M) Drill Pipe

Pipe Diameter (inches)	Total Number of Drill Pipe *	Hole Depth (On–Board)	Remarks
4.5 in. (114 mm)	5	175 ft. (53.3 m)	Optional Extended Tower
5 in. (127 mm)	5	175 ft. (53.3 m)	Optional Extended Tower
5.5 in. (140 mm)	5	175 ft. (53.3 m)	Optional Tower and .415 in. (10.5 mm) pipe wall thickness
	4	140 ft. (42.7 m)	Optional Tower and .750 in. (19.1 mm) pipe wall thickness

3.1 - SPECIFICATIONS

CAROUSEL SPECIFICATIONS (continued)

Carousel For 35 Ft. (10.7 M) Drill Pipe (continued)

Pipe Diameter (inches)	Total Number of Drill Pipe *	Hole Depth (On–Board)	Remarks
6.25 in. (159mm)	5	170 ft. (53.3 m)	Optional Tower and .500 in. (12.7 mm) pipe wall thickness
	3	105 ft. (32.0 m)	Optional Tower and .750 in. (19.1 mm) pipe wall thickness
7 in. (178 mm)	4	140 ft. (42.7 m)	Optional Tower and .500 in. (12.7 mm) pipe wall thickness
	3	105 ft. (32.0 m)	Optional Tower and .750 in. (19.1 mm) pipe wall thickness
7.625in.(194mm)	3	105 ft. (32.0 m)	Optional Extended Tower

* Pipe capacity includes one pipe in rotary head.

DRILL PIPE SPECIFICATIONS

25 Ft. (7.6 M) Drill Pipe

Pipe Diameter	Length	Wall Thickness	Approximate Weight	Thread Size and Type
4 in. (102 mm)	25 ft. (7.6 m)	.337in.(8.6mm)	400 lb (181kg)	2–7/8 in. Reg API
4.5 in. (114mm)	25 ft. (7.6 m)	.337in.(8.6mm)	429 lb. (195 kg)	3–1/2 in. Reg API
		.674 in (17.1mm)	630 lb. (286 kg)	
5 in. (127 mm)	25 ft. (7.6 m)	.375in. (9.5mm)	488 lb. (221 kg)	3–1/2 in. Reg API
5.5 in. (140mm)	25 ft. (7.6 m)	.415in. (10.5mm)	625 lb. (284 kg)	3–1/2 in. BECO
6.25in.(159mm)	25 ft. (7.6 m)	.500in. (12.7mm)	775 lb. (325 kg)	4 in. BECO

3.1 - SPECIFICATIONS

DRILL PIPE SPECIFICATIONS (continued)

30 Ft. (9.1 M) Drill Pipe

Pipe Diameter	Length	Wall Thickness	Approximate Weight	Thread Size and Type
4 in. (102 mm)	30 ft. (9.1 m)	.337 in. (8.6mm)	435 lb. (197kg)	2–7/8 in. Reg API
	30 ft. (9.1 m)	.337 in. (8.6mm)	515 lb. (234kg)	3.5 in. Reg API
4.5 in. (114mm)	30 ft. (9.1 m)	.337 in. (8.6mm)	550 lb. (249 kg)	3–1/2 in. Reg API or BECO
	30 ft. (9.1 m)	.750 in. (19.1mm)	900 lb. (408 kg)	3–1/2 in. Reg API
5 in. (127 mm)	30 ft. (9.1 m)	.500 in. (12.7 mm)	721 lb. (327 kg)	3–1/2 in. Reg API or BECO
5.5 in. (140mm)	30 ft. (9.1 m)	.415 in. (10.5 mm)	750 lb. (340 kg)	3–1/2 in. BECO
6.25in.(159mm)	30 ft. (9.1 m)	.500 in. (12.7 mm)	930 lb. (422 kg)	4 in. BECO
7.in (178mm)	30 ft. (9.1 m)	.500 in. (12.7 mm)	1050 lb. (476 kg)	4.5 in. BECO
7.625 in. (194mm)	30 ft. (9.1 m)	.750 in. (19.1 mm)	1678 lb. (762 kg)	5.25 in. BECO

35 Ft. (10.7 M) Drill Pipe

Pipe Diameter	Length	Wall Thickness	Approximate Weight	Thread Size and Type
4.5 in. (114 mm)	35 ft. (10.7 m)	.750 in. (19.1 mm)	1050 lb. (476 kg)	3–1/2 in. Reg API
5 in. (127 mm)	35 ft. (10.7 m)	.750 in. (19.1 mm)	1190 lb. (540 kg)	3–1/2 in. Reg API or BECO
5.5 in. (140 mm)	35 ft. (10.7 m)	.415 in. (10.5 mm)	875 lb. (397 kg)	3–1/2 in. BECO
	35 ft. (10.7 m)	.750 in. (19.1 mm)	1330 lb. (603 kg)	3–1/2 in. BECO
6.25 in. (159 mm)	35 ft. (10.7 m)	.500 in. (12.7 mm)	1085 lb. (492 kg)	4 in. BECO
	35 ft. (10.7 m)	.750 in. (19.1 mm)	1540 lb. (699 kg)	4 in. BECO
7 in. (178 mm)	35 ft. (10.7 m)	.500 in. (12.7 mm)	1225 lb. (556 kg)	4.5 in. BECO
	35 ft. (10.7 m)	.750 in. (19.1 mm)	1750 lb. (794 kg)	4.5 in. BECO
7.625 in. (194 mm)	35 ft. (10.7 m)	.750 in. (19.1 mm)	1960 lb. (889 kg)	5.25 in. BECO

3.1 - SPECIFICATIONS

ROTARY HEAD

Standard rotation on the Drill is supplied by a rotary tophead (also called Rotary Head, Power Head or Tophead). Two hydraulic motors power the rotation of the rotary head. The Rotation Pressure Gauge (item 15 in Section 4 *Operating Controls and Instruments*), located on the control console, shows the amount of hydraulic pressure being applied to the rotary head motors.

A replaceable 29 in. (73.6 cm) spindle adapter between the rotary head spindle and the drill pipe is furnished as standard equipment, along with replaceable head guides.

Pulldown cables and pullback chains are attached to mounting plates which are attached to the rotary head housing.

Rotary Head Specifications

	Standard	Optional
Model	4SV-2-10.0	4SF-2-8
Speed Range:	Variable, 0 to 160 RPM	Variable, 0 to 120 RPM
Maximum Torque:	9,000 ft/lb. @ 95 RPM 5,400 ft/lb. @ 160 RPM	7,200 ft/lb. (9,763 N-m)
Rotary Head Motors:	Two	
Type:	One-Variable Displacement	Two – Fixed Displacement
	One-Fixed Displacement	
Reduction:	15:1	
Main Gear Face Width:	2.5 in. (63.5 mm)	
Rotary Head Weight:	2600 lb. (1179 kg)	
Head Guides:	Replaceable, Nylatron	

3.1 - SPECIFICATIONS

FEED SYSTEM

The closed-loop hydrostatic feed system is powered by two hydraulic feed cylinders that raise and lower the rotary head smoothly and positively by way of cable for pulldown and heavy duty feed chain for pullback.

The Pulldown Pressure Gauge (item 16 in Section 4 *Operating Controls*), located on the control console, shows the amount of hydraulic down pressure being exerted on the bit by the feed (cylinders) system.

NOTE:

The Feed Holdback Pressure Gauge **Option for HP drills only** (item 17 in Section 4 *Operating Controls*), located on the control console, shows the hydraulic pressure in the feed cylinders when drill holdback pressure is applied to prevent excessive down pressure on the drill bit.

The single Drill Feed controller (item 8 in Section 4 *Operating Controls*) for operation of direction and rate of drill feed allows the operator greater ease of operation while providing faster down feed and retract speeds.

This system operates more efficiently than other designs due to lower flows and the resulting reduced pressure drop. This enables the hydraulic pumps to operate in the more efficient portion of their performance curves.

Feed System Specifications

	Standard	Optional (35 ft)
Pulldown Force (less drill string):	Variable, 0 to 45,000 lb. (0 to 20,412 kg)	Variable, 0 to 60,000 lb. (0 to 27,216 kg)
Mechanism Type:	Two Hydraulic Cylinders and Feed Chain/Cable	
Cylinder Bore:	4–1/4 in. (108 mm)	4–3/4 in. (121 mm)
Rod Diameter:	3–1/4 in. (83 mm)	3–3/4 in. (95 mm)
Stroke:	196 in. (4,978 mm)	226 in. (5,760 mm)
Pulldown Cable Diameter:	1 in. (25.4 mm)	
Pullback Chain:	160H	
Fast Feed Speed:	146 ft/min. (44.5 m/min.)	109 ft/min. (33.2 m/min.)
Retract Speed:	205 ft/min. (62.5 m/min.)	181 ft/min. (55.2 m/min.)
Pullback Capacity:	0 to 22,000 lb. (0 to 9,979 kg)	

3.1 - SPECIFICATIONS

POWER PACK

The power pack (or power train) consists of a diesel engine directly coupled to an air compressor on one end and a hydraulic pump drive on the other end. This complete power pack assembly is mounted on its own sub base, which in turn is mounted to the rig frame. The in-line drive train configuration maximizes mechanical efficiency. The separate “floating” sub base isolates the components from drilling and propel shock loads and helps to maintain alignment between them.

A heavy duty engine silencer/muffler is provided to reduce engine noise emission. Separate engine and air compressor air cleaners have quick release dust drop covers, as standard, for easy maintenance.

Cooler

Currently, a single side-by-side-by-side coolers package is provided for the hydraulic oil, compressor oil and diesel engine coolant. All coolers are mounted side by side in one package and each section can be individually removed for easy maintenance. This package provides 125°F (52°C) ambient cooling with a single motor assembly and large fan rotating at relatively low speeds. This design is more efficient and produces less noise than dual cooler arrangements.

Cooling Package Specifications	
Type:	Side by side cooler package (engine compressor, hydraulic)
Fan Drive:	Axial Piston hydraulic motor
Rating:	125°F (52°C) ambient at sea level
Fan Blade:	54 in. (137.16 cm), 8 blade fan
Function:	Cools hydraulic oil, compressor oil and diesel engine coolant.

3.1 - SPECIFICATIONS

AIR COMPRESSOR

All air compressors used are of the oil flooded asymmetrical rotary screw design. Tapered roller bearings are used to handle thrust and radial loads. The receiver capacity is 38 gallon (144 liter). The compressor is directly driven by the diesel engine.

Regulation of the low pressure compressor is controlled by an “ON-OFF” type system. When the drilling operation does not demand air, the air compressor load can be removed, thereby conserving engine horsepower, extending compressor life and providing ease of starting, particularly under cold weather conditions. A standard oil pump is available to maintain continuous oil flow when the compressor inlet is closed.

Standard equipment for the air compressor includes a separate two-stage air cleaner and full instrumentation and controls. The lubrication system includes an oil cooler, bypass valve, oil filter, oil pump, and combination air receiver and oil separator tank. A safety shut down system is provided for high discharge air temperature.

The oil pump allows the operator to close the intake valve when no air is required. This greatly reduces the engine load which saves fuel and facilitates cold weather starting.

Low Pressure Air Compressor

Low pressure compressors are the single stage asymmetrical rotary screw type with tapered roller bearings and lubricated by a positive, gear oil pump.

Capacities and Pressures Available		
Size	Compressor CFM @ psi	(m³/min. @ kPa)
XL900 Series:	900 CFM @ 110 psi	(25.5 m ³ /min. @ 758 kPa)
XL1050 Series:	1050 CFM @ 110 psi	(29.7 m ³ /min. @ 758 kPa)
XL1200 Series:	1200 CFM @ 110 psi	(34.0 m ³ /min. @ 758 kPa)
XL1600 Series:	1600 CFM @ 110 psi	(45.3 m ³ /min. @ 758 kPa)
XL1900 Series:	1900 CFM @ 110 psi	(53.8 m ³ /min. @ 758 kPa)

High Pressure Air Compressor

High pressure compressors are the HR2 and HR2.5 two stage, over-and-under, oil flooded asymmetrical rotary screw type with tapered roller bearings and lubricated by a positive, gear oil pump.

Capacities and Pressures Available		
Size	Compressor CFM @ psi	(m³/min. @ kPa)
HP900 Series:	900 CFM @ 350 psi	(25.5 m ³ /min. @ 2,413 kPa)
HP1070 Series:	1070 CFM @ 350 psi	(30.3 m ³ /min. @ 2,413 kPa)
HP1250 Series:	1250 CFM @ 350 psi	(35.4 m ³ /min. @ 2,413 kPa)

3.1 - SPECIFICATIONS

ENGINE

Manufacturer	Model	hp (kW) @ RPM	Compressor CFM @ psi (m ³ /min. @ kPa)
Caterpillar	3406C	460 (342kW) @ 2100 rpm	XL900 @ 110 (25.5 @ 758)
		460 (342kW) @ 2100 rpm	XL1050 @ 110 (29.7 @ 758)
	3408C	525 (390kW) @ 2100 rpm	XL1200 @ 110 (34.0 @ 758)
	3412C	700 (521kW) @ 2100 rpm	XL1900 @ 110 (53.8 @ 758)
	3408C	525 (390kW) @ 2100 rpm	HP900 @ 350 (25.5 @ 2413)
	3412C	600 (447kW) @ 2100 rpm	HP1070 @ 350 (30.3 @ 2413)
		700 (521kW) @ 2100 rpm	HP1250 @ 350 (35.4 @ 2413)
	C15	425 (317kW) @ 1800 rpm	XL900 @ 110 (25.5 @ 758)
		475 (354kW) @ 1800 rpm	XL1050 @ 110 (29.7 @ 758)
		525 (390kW) @ 1800 rpm	XL1200 @ 110 (34.0 @ 758)
	C16	600 (447kW) @ 1800 rpm	XL1600 @ 110 (45.3 @ 758)
	C15	525 (390kW) @ 1800 rpm	HP900 @ 350 (25.5 @ 2413)
	C16	600 (447kW) @ 1800 rpm	HP1070 @ 350 (30.3 @ 2413)
	C18	630 (469kW) @ 1800 rpm	HP1070 @ 350 (30.3 @ 2413)
	3412E	760 (566kW) @ 2100 rpm	HP1250 @ 350 (35.4 @ 2413)

Manufacturer	Model	hp (kW)/RPM	Compressor CFM @ psi (m ³ /min. @ kPa)
Cummins	N14	400(298kW) / 2100 rpm	XL900 @ 110 (25.5 @ 758)
		460(342kW) / 2100 rpm	XL1050 @ 110 (29.7 @ 758)
		525(390kW) / 2100 rpm	XL1200 @ 110 (34.0 @ 758)
	QSK19C	700(521kW) / 2100 rpm	XL1900 @ 110 (53.8 @ 758)
	N14	525(391kW) / 2100 rpm	HP900 @ 350 (25.5 @ 2413)
	QSK19C	600(447kW) / 2100 rpm	HP1070 @ 350 (30.3 @ 2413)
		700(521kW) / 2100 rpm	HP1250 @ 350 (35.4 @ 2413)
	QSX15	425 (317kW) @ 1800 rpm	XL900 @ 110 (25.5 @ 758)
		475 (354kW) @ 1800 rpm	XL1050 @ 110 (29.7 @ 758)
		525 (390kW) @ 1800 rpm	XL1200 @ 110 (34.0 @ 758)
		600 (447kW) @ 1800 rpm	XL1600 @ 110 (45.3 @ 758)
	QSK19	760 (566kW) @ 2100 rpm	XL1900 @ 110 (45.3 @ 758)
	QSX15	525 (390kW) @ 1800 rpm	HP900 @ 350 (25.5 @ 2413)
		600 (447kW) @ 1800 rpm	HP1070 @ 350 (30.3 @ 2413)
	QSK19	760 (566kW) @ 2100 rpm	HP1250 @ 350 (35.4 @ 2413)

3.1 - SPECIFICATIONS

HYDRAULIC SYSTEM

All drilling and propel functions are hydraulically powered. The hydraulic system consists of a 82 gallon (310 Liter) hydraulic reservoir with 10 micron filtration, hydraulic pumps mounted on a three hole drive gearbox and various motors, valves, cylinders, pipes, hoses, filters and gauges. A hydraulic oil cooler assures cool oil temperatures to maximize system efficiency and component life.

The three hydraulic pumps are mounted for convenient service access on a single three-hole gear box driven off the engine through a drive shaft.

The two main pumps supply hydraulic power to either drilling functions (Drill Feed and Rotation) or Tram (Propel) functions. The auxiliary circuits double pump supplies oil for all other functions other than tramming, drill feed/rotation.

Hydraulic System Specifications

Feed System:	
25 ft. (7.6 m):	4,500 psi (31,028 kPa) pulldown and pullback
30 ft. (9.1 m):	4,500 psi (31,028 kPa) pulldown and pullback
35 ft. (10.7 m):	3,500 psi (24,133 kPa) pulldown
	4,500 psi (31,028 kPa) pullback
Rotation System:	4,500 psi (31,028 kPa)
Auxiliary Circuits:	2,750 psi (18,961 kPa)

Main Pumps:	
Number:	Two
Type:	Pressure compensated, variable displacement, axial piston
Capacity:	0 to 62.8 GPM (0 to 238 L/min.) @ 2,003 RPM each
Function:	Feed, rotation and propel (one pump per track)

Double Pump(s)	
Number:	One
Type:	2–section, vane, fixed displacement
Capacity:	Small Section: 24 gpm(91 L/min.) @ 2750 psi (18961 kPa)
	Large Section: 42 gpm(159 L/min.)@ 2750 psi (18961 kPa)
Function:	Small Section: 3 and 9–spool valve (dust collector, leveling jacks, drill pipe changer,hydraulic wrench, drill pipe indexer, drill pipe support, auxiliary hoist)
Function:	Large Section: Cooler package fan motor

3.1 - SPECIFICATIONS

Hydraulic System Specifications (continued)

Rotation Motors – Standard Rotary Head	
Speed Range:	Variable, 0–160 RPM
Maximum Torque:	9,000 ft/lb. @ 95 RPM
	5,400 ft/lb. @ 160 RPM
Number:	Two
Type:	One Variable Displacement One Fixed Displacement
Function:	Drill Rotation

Rotation Motors – High Torque Rotary Head	
Speed Range:	Variable, 0–120 RPM
Maximum Torque:	7,200 ft/lb. (9,763 N–m)
Number:	Two
Type:	Fixed Displacement
Function:	Drill Rotation

Propel Motors:	DM45 / DM50	DML
Number:	Two	
Type:	Hydraulic, axial piston, fixed displacement	
Rating:	165 hp (123 kW) each	175 hp (130.5 kW) each
Propel Speed Range:	0 to 1.9 MPH (0 to 3.1 km/hr.)	0 to 1.7 MPH (0 to 2.7 km/hr.)
Function:	Left Hand Track Drive and Right Hand Track Drive	

Fan Motor	
Number:	One
Type:	Variable Displacement, 7.25 in. ³ /rev.
	Variable Displacement, 8.0 in. ³ /rev. (for 700hp engines with XL1900,HP1250)
Function:	Cooler Package Fan Motor

3.1 - SPECIFICATIONS

Hydraulic System Specifications (continued)

Auxiliary Hoist Motor	
Number:	One
Type:	Fixed Displacement
Function:	Facilitates Drill Pipe Handling

Dust Collector Fan Motor	
Number:	One
Type:	Fixed Displacement, Hydraulic Vane Motor
Operating Pressure:	3,000 psi (20,685 kPa)
Function:	Drives Dust Collector Fan

Water Injection Pump Motor (Option)	
Number:	One
Type:	Fixed Displacement
Function:	Drives Water Injection Pump

Hydraulic Reservoir	
Capacity:	82 gallons (310 L)
Location:	Within Tower Support Structure
Standard Equipment:	Oil Level Indicator and Oil Temperature Gauge

CYLINDERS

Leveling Jack Cylinders

Description	DM45/50	DML
Type:	Hydraulic cylinder with double holding valves (Set @ 4500–5000 PSI)	
Quantity:	Three	
(Two) Drill Side:	5 in. bore x 48 in. stroke / 4 in. rod diameter (127 mm x 1,219 mm / 102 mm)	
(One) Non Drill End:	5 in. bore x 48 in. stroke / 4 in. rod diameter (127 mm x 1,219 mm / 102 mm)	
Jack Pad Diameter:	26 in. (660 mm) drilling end (side jacks)	
Jack Pad Diameter:	30 in. (762 mm) non–drilling end	
Function:	Raise and level the drill off the ground	

3.1 - SPECIFICATIONS

CYLINDERS (continued)

Tower Raising Cylinders

The tower is raised and lowered by two hydraulic cylinders. Raising the tower to the vertical position can be accomplished in less than one minute.

Type:	Hydraulic Cylinder
Quantity:	Two
Bore x Stroke/Rod Diameter	
25 Foot Tower:	5 in. x 48 in. x 3 in. (127 mm x1,219.2 mm x 76.2 mm)
30 Foot Tower:	5.5 in. x 48 in. x 3 in. (139.7 mm x1,219.2 mm x 76.2 mm)
35 Foot Tower	5.5 in. x 48 in. x 3 in. (139.7 mm x1,219.2 mm x 76.2 mm)
Function:	Raise and lower the tower

Tower Pinning Cylinder

Hydraulic operated tower pinning is performed remotely from the operator's console.

Type:	Hydraulic Cylinder
Quantity:	One
Bore x Stroke/Rod Diameter	2.5 in. x 20 in. x 1.13 in. (63.5 mm x 508 mm x 28.7 mm)
Function:	Automatic tower pinning

Feed Cylinder Specifications

The feed system is powered by two hydraulic feed cylinders that raise and lower the rotary head smoothly and positively.

Type:	Hydraulic Cylinder
Quantity:	Two
BorexStroke/Rod Diameter:	
25 Foot Tower:	4.25 in. x 166 in. x 3.25 in. (107.9 mm x4216.4 mm x 82.5 mm)
30 Foot Tower:	4.25 in. x 196 in. x 3.25 in. (107.9 mm x 4978.4 mm x 82.5 mm)
35 Foot Tower	4.75 in. x 226 in. x 3.75 in. (120.6 mm x 5740.4 mm x 95.25mm)
Function:	Move drill string up and down during drilling operations

3.1 - SPECIFICATIONS

CYLINDERS (continued)

Rod Changer (Carousel) Cylinder Specifications

Hydraulic cylinders swing the rod changer (carousel) into and out from the loading position under the rotary head.

Type:	Hydraulic Cylinder
Quantity:	Two
BoreStroke/Rod Diameter:	3.5 in. x 10 in. x 1.75 in. (88.9 mm x 254 mm x 44.45 mm)
Function:	Swings rod changer into and out from loading position

Rod Support Cylinder Specifications

The rod support cylinder positions the rod support during drill rod changes.

Type:	Hydraulic Cylinder
Quantity:	One
BoreStroke/Rod Diameter:	2.5 in. x 2 in. x 1.25 in. (63.5 mm x 50.8 mm x 31.75 mm)
Function:	Positions the rod support during drill rod change.

Chain Wrench Cylinder Specifications

The breakout chain wrench is a hydraulic cylinder powered chain wrench. The breakout chain wrench is clamped around the box end of the drill pipe above the table. By operating the breakout cylinder, the pipe joint can be broken and the drill rod set in the carousel.

Type:	Hydraulic Cylinder
Quantity:	One
Bore x Stroke/Rod Diameter	
Size:	3.5 in. x 9 in. x 1.5 in. (88.9 mm x 228.6 mm x 38.1 mm)
Function:	Used for breaking drill rod joints.

Sliding Breakout Fork Cylinder Specifications:

The sliding breakout fork cylinder extends and retracts the sliding breakout fork, located on the table, onto the flats on a drill rod during drill rod change.

Type:	Hydraulic cylinder
Quantity:	One (1)
BoreStroke/Rod Diameter:	
Size	1.5 in. x 8 in. x 1 in. (3.81 cm x 203.2 mm x 25.4 mm)
Function:	Holds drill rod at table level for breakout procedure

3.1 - SPECIFICATIONS

CYLINDERS (continued)

Dust Flap Cylinder Option:

The dust flap option is used on angle drill packages. The dust flap cylinder raises and lowers the dust flap.

Type:	Hydraulic cylinder
Quantity:	One
BorexStroke/Rod Diameter:	
Size:	3.5 in. x 10 in. x 1.75 in. (8.89 cm x 254 mm x 44.45 mm)
Function:	Raise and lower the dust flap

Telescopic Dust Curtain Cylinders Option:

The telescopic dust curtain cylinders option is used to raise and lower the dust curtain.

Dust Curtain Cylinder Specifications:	
Type:	Hydraulic cylinder
Quantity:	Two (2)
BorexStroke/Rod Diameter:	
Size:	2 in. x 16 in. x 1 in. rod (50.8 mm x 406.4 mm x 25.4 mm)
Function:	Raise and lower the telescopic dust curtain

Air Throttle Cylinder

The drill air throttle controls the air flow to the drill string and allows air flow down the hole.

Air Throttle Cylinder Specifications	
Type:	Hydraulic Cylinder
Quantity:	One
Bore x Stroke/Rod Diameter	
Size:	2.5 in. x 5 in. x 1.5 in. (63.5 mm x 127 mm x 38.1 mm)
Function:	Used for opening and closing the air throttle.

3.1 - SPECIFICATIONS

DUST COLLECTOR

A “No Visible Emission” dry dust collector is standard equipment on the drill. It is a pleated paper element type fan/filter unit. Interval flushing is controlled by an electronic timer. A vacuum hose allows the fan/filter unit to draw the dust out of the collection area. The dust is removed from the air stream as the air flows through the pleated paper filter elements. Heavy cuttings are contained around the hole.

Type: ----- “No visible Emission” pleated paper element with pneumatic flushing

Model: ----- Model and capacity are dependent on size of air compressor.

Dust Collector Specifications

	3600 CFM	4500 CFM	7E
Capacity:	3,600 CFM (102 m3/min.)	4,500 CFM (127 m3/min.)	7,000 CFM (198 m3/min.)
Mounting:	Fender Mounted		Top of Jack
Configuration:	Rectangular		Cyclone
Dimensions:			
Length:	52.0 in. (1,321 mm)	72 in. (1,829 mm)	61 in. (1,549 mm)
Height:	88.5 in. (2,248 mm)	72 in. (1,829 mm)	
Width (Diameter):	25 in. (635 mm)	24 in. (610 mm)	53.5 in. (1,359 mm)
Number of Filter Elements:	Four (4)	Six (6)	Nine (9)
Inlet Diameter:	8 in. (203 mm)	10 in. (254 mm)	12 in. (305 mm)
Compressors Used With:	XL1200 HP1250	Optional	XL1900
Dust Hood Connection:	8 in. (203mm) O.D. Suction Hose	10 in. (203mm) O.D. Suction Hose	12 in. (305mm) O.D. Suction Hose
Fan Motor:	Hydraulic Vane Motor, Fixed Displacement		
Motor Operating Pressure:	3,000 psi (20,685 kPa)		
Flow Control Valve:	Yes		
Internal Baffle:	Internal Baffle between Collector Intake Duct and Filters		
Dust Hood:	Rectangular with Split Curtains and Hydraulically Retractable Front Curtain		

3.1 - SPECIFICATIONS

OPERATOR'S CAB AND CONSOLE

All operational functions can be controlled from the driller's console within the cab of the drill. The cab is thermally insulated, heated, and ventilated. The cab is equipped with tinted safety glass windows, kick plates, an adjustable swivel seat and two lockable doors. There is an internal 40-watt light for cab interior illumination. Night Lights are operated from a 24-volt electrical system.

See Section 4 *Operating Controls & Instruments* for further information on the driller's console.

Operator's Cab Specifications

Thermal/Sound Insulation:	Noise abated (Less than 80 dBa)
Dimension:	Width: 64 in. (1.63 m) Length: 76 in. (1.93 m) Height: 86 in. (2.18 m)
Number of Doors:	Two • One hinged on drill deck side • One hinged on outboard side
Control Console Serviceability:	All controls are electric over hydraulic. The console is hinged for simplified access to the controllers. A wiring harness leads from the controllers to the spool valves and main pump controllers.
Heater/Ventilator:	42,330 Btu, 400 CFM
Ventilators:	Louver style vents are provided to direct the air flow for optimal comfort.
Cab Glass:	Tinted Safety Glass
Kick Plates:	Yes
Operator Seat:	One swivel type, adjustable, high back with arm rests.
Design:	1 piece construction and FOPS certified.
Isolation:	Isolation mounted

NIGHT LIGHTING SPECIFICATIONS

A nine-light halogen night lighting system is provided as standard for operator visibility under low light operating conditions.

- One Hole Collar Area Illumination
- One Power Pack Illumination
- Two Tower Illumination
- Five Trimming Illumination

One internal 40-watt for cab interior illumination

3.1 - SPECIFICATIONS

STANDARD TOOLS MANUALS

1. Hoist Plug for Drill Pipe
2. Spindle Sub
3. Blow Gun with Hose
4. Maintenance and Parts Manuals (1 set)
5. CD ROM Serial Parts Manual (2 Worldview)

DIMENSIONS AND WEIGHTS

Dimensions shown below are for a standard 30 ft. (9.1 m) tower, excluding drill pipe and accessories.

Weights and Dimensions	DM45 / DM50		DML	
	Tower Up	Tower Down	Tower Up	Tower Down
Length:	31 ft.—10 in. (9.7m)	43 ft.—7 in. (13.28m)	31 ft.—10 in. (9.70 m)	43 ft.—7 in. (13.28m)
Shipping Height:		14 ft.—0 in. (4.26m)		14 ft.—8 in. (4.5m)
Working Height:	43 ft.—0 in. (13.11m)	17 ft. 0 in. (5.18m)	43 ft.—8 in. (13.3m)	17 ft.—8 in. (5.4m)
Shipping Width:	13 ft.—4 in. (4.06m)		13 ft.—11 in. (4.02m)	
Working Width:	12 ft.—10 in. (3.9m)		16 ft.—6 in. (5.0 m)	
Width between Track Pads:	6 ft.—8 in. (2.03m)			
Distance between Jack Center at Drill End:	9 ft.—8 in. (2.95m)		12 ft.—3 in. (3.7 m)	
Distance between Jack Centers Front to Rear:	20 ft. 7 in. (6.27m)			
Shipping Weight:	72,000 – 78,000 lb. (32,700 – 35,400 kg)		82,000 – 88,000 lb. (37,000 – 40,000 kg)	
Working Weight:	77,000 – 85,000 lb. (34,900 – 38,600 kg)		87,000 – 95,000 lb. (39,500 – 43,000 kg)	

3.1 - SPECIFICATIONS

OPTIONAL EQUIPMENT

Air Conditioner Option

The operator can control the blower speed to regulate flow through the air conditioner evaporator. He also has the capability of directing the air flow with the use of vents and louvers placed above and below the control panel. A heater / ventilator is standard equipment and is enclosed in the same package. Air Conditioner Specifications are:

Air Conditioner: -- 36,770 Btu/hr.
Coolant: ---- R-134A

Angle Drilling Package Option

All controls for positioning angle drilling are located at the operator's control console inside the cab. The angle drill package includes the drill pipe support and angle drill tie bar. There are two angle drill packages available:

a. Package One:

Allows the tower to be positioned up to a maximum of 20° from the vertical in increments of 5°.

b. Package Two:

Allows the tower to be positioned up to a maximum of 30° from the vertical in increments of 5°.

Central Lubrication Option

a. Manual:

The Centralized Manual Lubrication Manifold allows lubricating of all non-traveling grease points from a single station.

b. Automatic:

The Automatic Central Machine Lube System has an air pump and timer and provides lubrication to all non-traveling grease points on the drill through metered injectors.

Cold Weather Starting Option

This option consists of an engine preheater. Either Gasoline or diesel preheaters are available.

3.1 - SPECIFICATIONS

Cold Weather Package Options

These options are custom designed to meet customer ambient operating conditions. The lowest operational temperature must be advised.

Some systems require electric power (110-V or 220-V). Other Systems require coolant re-circulation. The Cold Weather Package may include:

- a.) Engine Preheater -----• Fuel Tank Heater
- b.) Ether Starting Aid -----• Engine Block Heater
- c.) Oil Pan Heater -----• Water Tank Heater
- d.) Battery Heater -----• Hydraulic Tank Heater
- e.) Variable 2-Speed Fan Control -----• DHD Lube Tank Heater
- f.) Diesel Generator -----• Additional Cab Insulation
- g.) In-Line Fuel Heater -----• Additional Cab Heaters

Dust Control, Water Injection Option

The Water Injection System injects a regulated quantity of water into the air flow to the drill pipe. The water content suppresses the dust created by the drilling operation.

The Water Injection system has a hydraulic motor drive, 0 to 8 GPM (0 to 30 L/min.) pump. Water Injection Systems are available with a 300 gallon (1,136 L) water tank or a 500 gallon (1,893 L) water tank.

Moveable Dust Curtain

An optional hydraulically moveable dust curtain frame for vertical drilling brings the curtains to the ground. This is primarily designed for vertical drilling, but can assist with dust collection when angle drilling.

High Torque Rotary Head Option

The 4SF-2-8.0 Rotary Head is recommended for extreme high torque applications. Maximum torque to 7,200 ft/lbs (9,763 N-m) is available throughout the 0 to 120 RPM capability. This is a 2-motor head with 4 in.³/rev. (65.6 cm³/rev.) fixed displacement motors.

Torque Limit Control Option

The Rotation Torque Limit Control Option controls the amount of pressure being applied to the rotary head rotation motors. It can be adjusted to aid in connecting pipe joints or to limit torque on the bit during difficult drilling conditions.

3.1 - SPECIFICATIONS

35 Ft. (10.7 M) Drill Pipe Package

This tower option provides an extended tower capable of single pass drilling up to 35 feet (10.7 m). This tower can be supplied with or without a carousel.

Dhd Injection Lube Option For Hp Drills

The DHD Lubricator pump forces Rock Drill Oil down the drill string to the DHD for lubricating purposes. You must use a DHD Lubricator when using a DHD drill.

An optional 60 gallon (227L) injection lube system for DHD drilling is available.

NOTE: Follow Actual Manufacturer's Lubrication Instructions when using DHD Hammers. Rock Drill Oil is only used on Ingersoll-Rand DHD's (Down the Hole Drill).

Central Service System Option

The Central Service System allows for replenishment of all operating fluids from a centralized location. The operating fluids include: Engine Coolant, Compressor Oil, Hydraulic Oil, Diesel Fuel and Engine Crankcase Oil.

Also available is a fast fuel fill only service location.

Fire Suppression System Option

The Fire Suppression System remotely activates fire extinguishers from the operator's cab and ground level.

Language Nameplates Option

Language Nameplates are provided on request for non-english speaking destinations.

SECTION 4 OPERATING CONTROLS

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4.1 - OPERATING CONTROLS

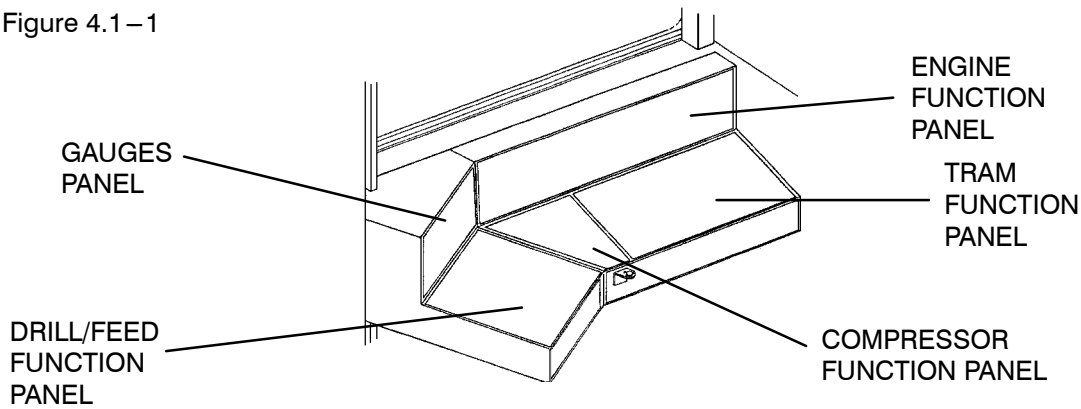
OPERATOR'S CONSOLE

The operating controls section provides basic information about the operating controls, instruments and indicators located on the control panel and the drill, that are used when operating the drill.

All operating functions can be controlled from the driller's console within the cab of the drill. Operation of the drill is performed using electric over hydraulic controllers ergonomically located so that the operator faces the drill centralizer while drilling.

The controls on the console are arranged in operating "function" panels.

Figure 4.1-1



4.1 - OPERATING CONTROLS

DRILL/FEED FUNCTIONS PANEL

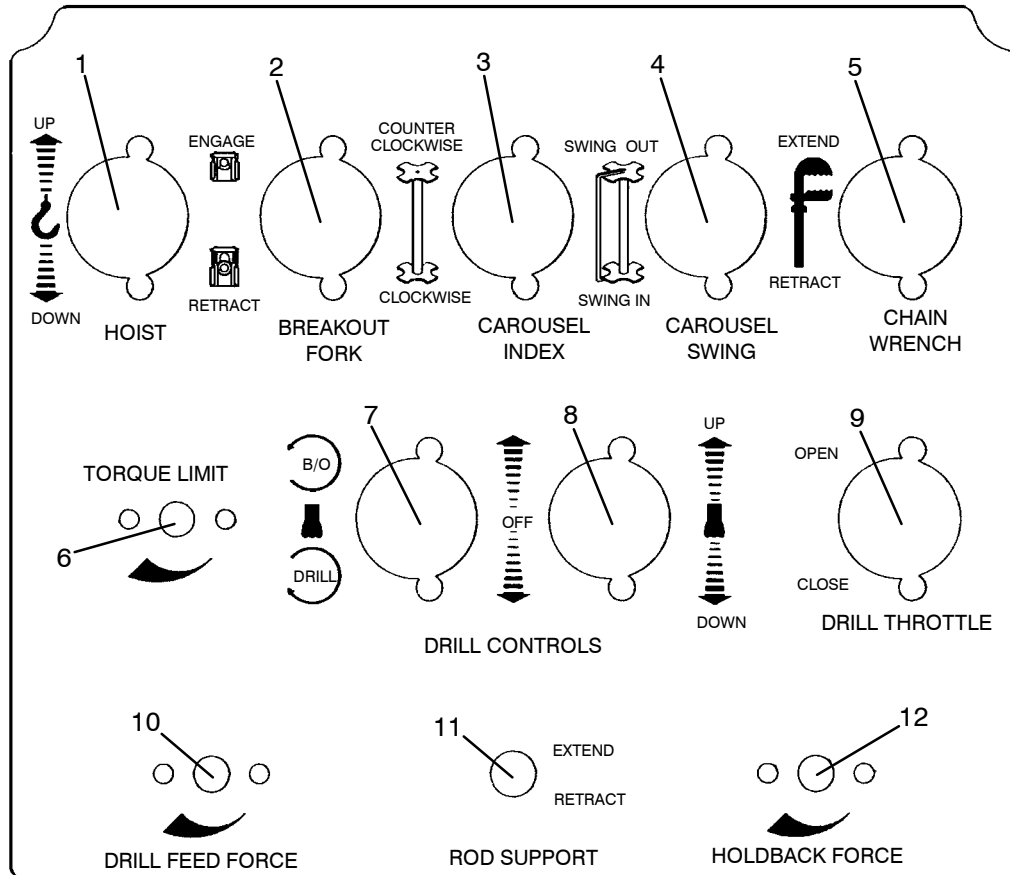


Figure 4.1–2

(1) Controller - Hoist

The Hoist Controller controls the hoist's direction and speed when raising or lowering drill pipe during loading into or unloading from the carousel (see figure 4.1–2).

To use the hoist in either Raise or Lower operations, gradually move the control in the required direction.

To slow and stop the hoist, move the control slowly to the STOP position and release the handle. A spring applied brake will automatically apply when the control is released in the STOP position.

(2) Controller - Breakout Wrench

Place the Sliding Breakout Wrench Controller in the engaged position and the sliding breakout wrench will slide forward and engage the flats on the drill rod or DHD. Moving the controller to the disengaged position will retract the sliding breakout fork wrench.

4.1 - OPERATING CONTROLS

DRILL/FEED FUNCTIONS PANEL (continued)

(3) Controller - Carousel Index

The Carousel Index Controller (see figure 4.1-2) controls the rotation of the carousel between indexing positions when multipass drilling is required.

Placing the controller into forward position will rotate the carousel clockwise to the next indexing position. Placing the controller into reverse position will rotate the carousel counterclockwise to the next indexing position.

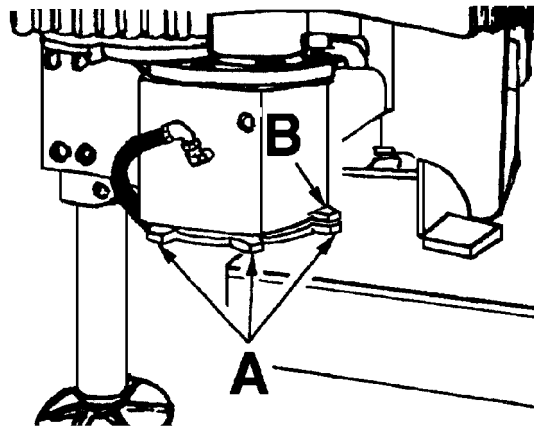


Figure 4.1-3

By controlling the rotation of the carousel, the index projections “A” can be aligned with the indexing pointer “B” (see figure 4.1-3). When correctly aligned, the drill rod will have been positioned with its axis aligned to the axis of the rotary head spindle. The loading or unloading process can then be completed.

(4) Controller - Carousel Swing

The Carousel Swing Controller (see figure 4.1-2) controls the carousel swing cylinders causing the swing between the stowed and drill rod load positions.

Pushing the controller will move the carousel to the stowed position, while pulling the controller will move the carousel under the rotary head to add and remove drill pipe.

(5) Controller - Chain Wrench

The Chain Wrench Controller (see figure 4.1-2) controls the hydraulic cylinder used with the chain wrench when loosening the threaded joints between the drill rod and the downhole drill, and also during bit replacement.

Placing the controller in the extend position will extend the cylinder. Placing the controller into the retract position will retract the cylinder.

4.1 - OPERATING CONTROLS

DRILL/FEED FUNCTIONS PANEL (continued)

(6) Control - Torque Limit

The Rotation Torque Limit Control Knob and Gauge (see figure 4.1-2) controls the amount of pressure being applied to the rotary head rotation motors. It can be adjusted to limit torque on the bit during difficult drilling conditions. **This is an option for high pressure drills only.**

(7) Controller - Rotation

The Drill Rotation Controller (see figure 4.1-2) controls the direction and speed of drill rotation. To rotate the drill in either the clockwise or counterclockwise direction, gradually move the controller in the required direction and speed of rotation will progressively increase. To stop rotation, move the controller into the STOP position where the indent should click into place.

Note: Rotation is only possible when the Mode Selector valve is in the Drill mode position.

(8) Controller - Drill Feed

The Drill Feed Controller (see figure 4.1-2) controls the direction and rate of drill feed.

To feed the drill in either the UP or Down direction, gradually move the controller in the required direction. The feed rate will progressively increase. To stop feed, move the controller into the OFF position. The indent should click into place.

Note: Rotation is only possible when the Mode Selector valve is in the Drill mode position.

(9) Controller - Drill Throttle

The Drill Air Throttle Controller (see figure 4.1-2) controls the air flow to the drill string and allows air flow down the hole to operate the DHD (Down Hole Drill) and clean the hole. It is used to turn ON/OFF the drilling air during drill rod or hammer changes. It can be adjusted to a lower setting while collaring the hole. **This is an option for high pressure drills only.**

(10) Rotary Switch - Drill Feed Force Control

The Drill Feed Pressure Control Rotary Switch (see figure 4.1-2) controls the down feed pressure to the feed cylinders while doing actual drilling.

Turning the control clockwise will increase feed pressure. Turning the control counterclockwise will reduce the feed pressure.

Note: When using downhole hammer drilling, use only sufficient feed pressure to match the rate of penetration.

4.1 - OPERATING CONTROLS

DRILL/FEED FUNCTIONS PANEL (continued)

(11) Toggle Switch - Rod Support

The Rod Support device is used when using the Angle Drilling Option.

Move the Rod Support Manual Override Switch (see figure 4.1-2) into EXTEND position to extend the rod support. Moving the Rod Support Manual Override Switch into RETRACT position will retract the rod support.

(12) Rotary Switch - Holdback Force

The Drill Holdback Pressure Control Rotary Switch (see figure 4.1-2) is provided to avoid excessive down feed pressure on the drill bit. **This is an option for high pressure drills only.**

On deep holes, the weight of the drill string may become excessive and overload the drilling system. To avoid this problem, drill holdback pressure can be varied so that the downhole drill bit is not overloaded.

Turning the control clockwise will increase and counterclockwise will reduce the holdback pressure.

4.1 - OPERATING CONTROLS

GAUGES PANEL

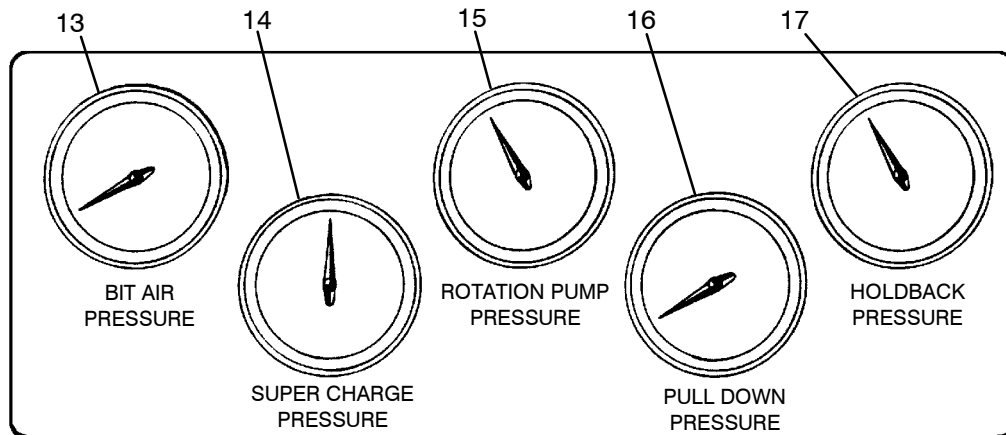


Figure 4.1–4

(13) Gauge - Bit Air Pressure

The (Drilling) Bit Air Pressure Gauge (figure 4.1–4) monitors the air pressure available for drilling. This pressure is adjusted by turning the Air Pressure Regulator (figure 4.1–6, item 50) adjustment knob clockwise to increase and counterclockwise to decrease the compressor discharge air pressure.

Note: Ensure that the pressure is adjusted to the type of downhole hammer being used. Do not operate 250 psi hammers on 350 psi.

(14) Gauge - Supercharge Pressure

The Supercharge Pressure Gauge (figure 4.1–4) monitors the main pump supercharge pressure. It shows the operator how much pressure is being delivered to the main pump inlet.

Note: It is essential that the supercharge pressure gauge reads not less than 65 psi during normal operation. Shutdown the machine to avoid serious damage to the main hydraulic system components. Call for service assistance to detect cause of the low pressure reading.

(15) Gauge - Rotation Pump Pressure

The Rotation Pressure Gauge (figure 4.1–4) shows the amount of hydraulic pressure being applied to the rotary head motor(s). It corresponds to the amount of torque developed by the rotary head during operation.

The *Rotation Torque Limit Control Option* (figure 4.1–2, item 6) can restrict the torque value.

4.1 - OPERATING CONTROLS

GAUGES PANEL (continued)

(16) Gauge - Pulldown Pressure

The Pulldown Pressure Gauge (figure 4.1-4) shows the amount of hydraulic down pressure being exerted on the bit by the feed (cylinder) system.

Pressure can be increased or decreased by turning the *Drill Feed Force Control* (figure 4.1-2, item 10).

(17) Gauge - Holdback Pressure

The Feed Holdback Pressure Gauge (figure 4.1-4) shows the hydraulic pressure in the feed cylinder when drill holdback pressure is applied to prevent excessive down pressure on the drill bit. **This is an option for high pressure drills only.**

Pressure can be increased or decreased by turning the *Feed Holdback Pressure Rotary Switch Option* (figure 4.1-2, item 12).

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL

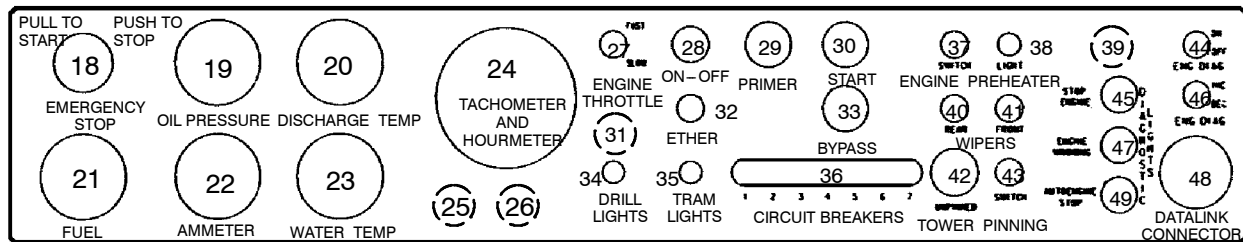


Figure 4.1 –5

(18) Button Switch - Emergency Stop

The RED emergency stop button switch (figure 4.1-5) shuts off power to the fuel valve and stops the engine when it is pushed. A red light inside the button switch is lit if the button switch is in “run” position. An optional second switch is located on the cab facing the drilling platform.

After depressing the switch, it is necessary to reset the switch before the machine can be restarted. To reset, pull the switch out into its active position.

Note: This switch has the same effect as turning the ON/OFF key switch fully to the STOP position.

(19) Gauge - Engine Oil Pressure

The engine oil pressure gauge (figure 4.1-5) indicates the engine oil pressure. This gauge should not read less than 10 psi on LOW idle nor less than 27 psi on HIGH idle.

Note: There is a pressure monitoring system on the engine that will shut down the engine immediately in the event that the oil pressure drops below 10 psi on LOW idle or less than 27 psi on HIGH idle; otherwise the engine could be severely damaged. Check the oil level according to the instructions provided in Section 6 - Maintenance Instructions.

Note: Refer to engine diagnostics section for checking engine problems in Section 7 - Trouble Shooting.

(20) Gauge - Discharge Temperature

The Compressor Discharge Air Temperature Gauge (figure 4.1-5) shows the temperature of the oil and air leaving the air end.

Normal operating temperatures are 180°-230°F(82°-110°C). This gauge also contains a switch that will stop the engine if the oil temperature in the compressor exceeds 248°F (120°C).

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(21) Gauge - Fuel Level

The fuel gauge (figure 4.1-5) monitors the level of fuel in the fuel tank. The tank should be refilled when the indicator needle moves to below 1/4 tank.

(22) Gauge - Ammeter

The Ammeter (figure 4.1-5) shows the rate of charge or discharge of the batteries when the Key Switch (item 28) is in the "ON" position. There is current present at the ammeter at all times. The ammeter should show (+) charge whenever the engine is running. The normal operating range is 25 to 28 volts.

(23) Gauge - Engine Coolant Temperature

The Engine Coolant Temperature Gauge (figure 4.1-5) shows the temperature of the engine coolant system. Normal operating temperature is from 150°-208°F (65°-98°C). The system will shut down if the temperature exceeds 210°F (99°C).

(24) Gauge - Tachometer/Hourmeter

The Tachometer / Elapsed Hour Meter Gauge (figure 4.1-5) shows the RPM of the engine while the engine is running and the number of hours and partial hours that the engine has been run. The tachometer is calibrated in RPM x 100 with a range of 0 to 30.

The tachometer is driven by the magnetic pickup which receives its signal from the engine flywheel. The pickup is a solid state device that counts teeth on the flywheel and sends a signal to the tachometer. The wires between the pickup and tachometer are specially shielded wires to prevent interference from outside signals. The elapsed time meter records the number of hours the engine has operated. It only works when the key is turned on.

(25) Indicator Light - Parking Brake Warning (Option)

The Parking Brake Warning Light (figure 4.1-5) indicates whether parking brakes are APPLIED or OFF. **This is an option.**

Note: Should the brake indicator light illuminate during tramming, call for service assistance to rectify the cause.

Do not attempt to tram the machine when the RED light remains illuminated. In tramming mode, moving the tram control levers from the STOP position should result in the Brake light extinguishing as the brakes automatically release.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(26) Toggle Switch - Parking Brake “ON-OFF” (Option)

The Parking Brake “ON/OFF” Switch (figure 4.1-5) is used when testing the brakes prior to tramping the drill. Apply the switch with the brakes on (applied) and the Parking Brake Warning Light (item 25) will illuminate RED. Release the Parking Brake Switch to release the brakes and the RED Parking Brake Warning Light should extinguish. **This is an option.**

NOTICE

Do not apply parking brake when the drill is in motion. Severe wear/damage to the brake could occur.

Note: This drill rig is equipped with spring applied disc brakes which are automatically applied in the event of an engine shutdown or hose failure causing loss of brake release pressure.

(27) Switch - Engine Speed Selector

The Engine Throttle Selector switch (figure 4.1-5) is used to select engine speed (rpm).

CAT engines use a ramp up/ramp down switch. From the middle position, the operator can ramp down to low idle (1200 RPM) or ramp up to operating speed (2100 RPM).

Low Idle = 1200 RPM
High Idle = 2100 RPM

CUMMINS engines use a three position switch. The three positions are:

Low Idle = 1200 RPM
High Idle = 1800 RPM
Operating = 2100 RPM

NOTE: Always ensure that the engine speed is at Operating RPM before tramping or drilling. Full Power is necessary to obtain the proper component operation and maximum rpm for greatest efficiency

WARNING

A Runaway drill can cause injury or death.

Do not attempt to control drill travel speed with the engine speed control.

Use the tram control (F-STOP- R) to control travel speed. Maintain engine speed at operating RPM for all drill operations.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(28) Key Switch - Electrical System “ON/OFF”

The electrical system “ON/OFF” Key Switch (figure 4.1-5) turns on all electrical power to the engine and controls stopping and run operations.

On Cummins engines, the electrical system “ON/OFF” Key Switch also activates the ECM (Electronic Control Module) that controls all aspects of the engine, including most shutdown devices.

Note: Always stop the engine and remove the key when leaving the drill unattended and/or performing certain maintenance procedures.

(29) Button Switch - Engine Fuel Primer

The Engine Fuel Primer Button Switch (figure 4.1-5) permits the priming of the engine fuel system after the drill has been standing idle for an extended period of time or after fuel filter replacement.

It is used to pump diesel fuel from the fuel tank to the engine. It can also be used to fill fuel filters after a filter change.

(30) Button Switch - Engine Starter

The Engine Starter Button Switch (figure 4.1-5) energizes the starter motor and engages the starter motor solenoid to crank the engine for startup. Press the Engine Starter Button Switch and the Engine Bypass Button Switch (figure 4.1-5, item 33) together to start the engine. Once the engine starts, release the Engine Starter Button Switch immediately.

NOTICE

Do not engage the starter motor solenoid longer than 30 seconds at a time or it will overheat and burn up the starter motor.

If the engine does not start, WAIT 3 minutes to allow the starter to cool before trying again.

(31) Button Switch - Horn (Option)

Pressing the Horn Button Switch (figure 4.1-5) will sound the horn and is used for a number of warnings. **This is an option.**

The Horn Button Switch activates the horn to alert anyone near the drill that the engine is about to be started.

The Horn button Switch activates the horn to alert personnel in the work zone that the drill is about to be moved.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(32) Button Switch - Ether (Option)

The Engine Ether Cold Start Button Switch (figure 4.1-5) controls the cold starting aid system. **This is an option.**

While cranking the engine with the Engine Starter Button Switch, press the Engine Ether Cold Start Button Switch to inject ether into the engine intake. Releasing pressure on the switch will automatically cut off the starting aid operation.

Note:

Starting aid may be required when temperature is below 32 degrees F (0 degrees C) and will be required when temperature is below 10 degrees F (-12 degrees C).

 WARNING

Starting aids are extremely flammable and can explode.

Overloading the engine air intake system could result in an explosion.

Avoid overloading the engine air intake when starting.

(33) Button Switch - Engine Bypass

The Engine Bypass Button Switch (figure 4.1-5) is used to allow the engine to start and build oil pressure by temporarily disengaging the engine oil pressure switchgauge from the circuit.

Once oil pressure is above 10psi, release the Engine Bypass Button Switch to allow the switchgauge to become operational.

(34) Toggle Switch - Drill Lights

The Drill Lights Control Switch (figure 4.1-5) is an "ON/OFF" switch that controls all the work lights. Move the switch to the ON position to turn on the lights and illuminate the working area.

(35) Toggle Switch - Tram Lights

The Tram (Propel) Lights Control Switch (figure 4.1-5) is an "ON/OFF" switch that controls all the tramming lights. Move the switch to the ON position to turn on the lights and illuminate the area ahead of the direction of travel.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(36) Circuit Breakers

The bank of seven (7) Circuit Breakers (figure 4.1-5) protect the drill's electrical circuits. The Circuit Breakers are mounted between the current producer, batteries or alternator and the devices they are protecting. In the event of an overload of a circuit, press in the tripped circuit breaker.

Note:

If there is a reoccurrence, call for service assistance to correct the cause of the overload in the circuit.

The Circuit Breaker identification is as follows:

1. 5 amp ---Engine Shutdown
2. 15 amp --Windshield Wiper System
3. 20 amp --Power Distribution for OEM Controllers
4. 15 amp --Compressed Air System
5. 15 amp --Power Distribution for Engine
6. 15 amp --Drill Working Lights
7. 20 amp --Tram (Propel) Lights

(37) Toggle Switch - Engine Preheater (Option)

The Engine Preheater Switch (figure 4.1-5) controls the preheater system. Turn switch "ON" to energize the engine preheater system. The unit will start below 140°F coolant temperature and cuts "OFF" automatically at 160°F. To turn the unit off, put the switch in the "OFF" position. (Refer to engine preheater manual for more information.) **This is an option.**

(38) Indicator Light - Engine Preheater (Option)

The Engine Preheater Indicator Light (figure 4.1-5) indicates whether the Engine Preheater System is energized or "OFF". **This is an option.**

(39) Button Switch - Warning Lights Test (Option)

Pressing the Warning Lights Test Button (figure 4.1-5) will cause all warning lights on the control panel to illuminate and confirm all warning lights are in service. **This is an option.**

Note: If any Warning Lights fail to illuminate when the button is depressed, call for service assistance to rectify the cause.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(40) Switch - Rear Windshield Wiper Selector (Option)

The Rear Windshield Wiper Switch (figure 4.1-5) activates the the rear windshield wiper and has three positions: High Speed, Low Speed and Off. **This is an option.**

(41) Switch - Front Windshield Wiper Selector (Option)

The Front Windshield Wiper Switch (figure 4.1-5) activates the the front windshield wiper and has three positions: High Speed, Low Speed and Off. **This is an option.**

(42) Indicator Light - Tower Unpinned Warning

The Tower Inpinned Warning Light (figure 4.1-5) illuminates when the locking pin is **not** engaged and the drill tower is **not locked** in the working position.

This Warning Light is also effective when using the Angle Drilling Option.

Note: It is unsafe to operate the drill with the raised tower in an unlocked position. If the locking pin will not engage, notify your supervisorService to correct the fault.

(43) Toggle Switch - Tower Locking Pin

The Tower Locking Pin Switch (figure 4.1-5) activates the hydraulic tower pinning cylinder and controls the locked or unlocked position of the tower locking pin.

Note: It is unsafe to operate the drill with the raised tower in an unlocked position. If the locking pin will not engage, notify your supervisor and call Service to correct the fault.

(44) Switch - Diagnostics Selector (Drills with ECM)

The Engine Diagnostic Selector Switch (figure 4.1-5) is used to turn on the Engine Diagnostic System and start the sequence of Fault Code Lights flashing. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

(45) Indicator Light - Engine Fault Diagnostic I (Drills with ECM)

The Bright Red Engine Diagnostic Indicator Light I (figure 4.1-5) illuminates in the event of an engine related fault. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

Note: Should this light come on during normal operating conditions, call for Service assistance to correct fault.

4.1 - OPERATING CONTROLS

ENGINE FUNCTIONS PANEL (continued)

(46) Switch - Diagnostics Increment/Decrement Selector

The Diagnostics Incremental/Decremental Selector Switch (figure 4.1-5) is used to detect the type of engine fault. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

(47) Indicator Light - Engine Fault Diagnostic II (Drills with ECM)

The Yellow Indicator Light II (figure 4.1-5) signals In-Range Failures of the Engine Protection System, plus battery voltage above or below normal. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

Note: Should this light come on during normal operating conditions, call for Service assistance to correct fault.

(48) Data Link Socket (Drills with ECM)

The Data Link Socket (figure 4.1-5) provides attachment of computerized engine test equipment when troubleshooting engine problems. Provided for use by engine service personnel. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

(49) Indicator Light - Engine Fault Diagnostic III (Drills with ECM)

The Red Engine Diagnostic Indicator Light III (figure 4.1-5) shows fault codes in the Engine Electronic Fuel System. Diagnostic Lights and Toggle Switches will be explained further in the Electrical Section of TROUBLESHOOTING.

Note: Should this light come on during normal operating conditions, call for Service assistance to correct fault.

4.1 - OPERATING CONTROLS

COMPRESSOR FUNCTIONS PANEL

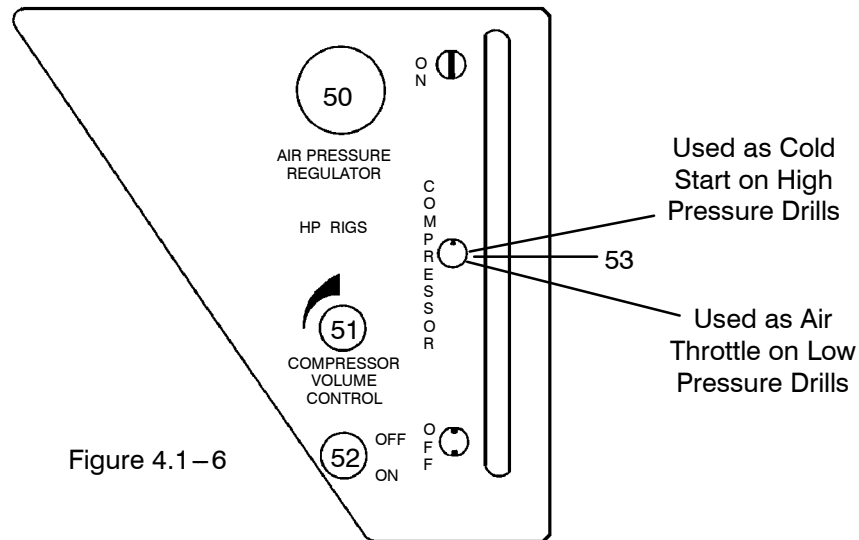


Figure 4.1-6

(50) Regulator - Air Pressure (HP Only)

The Compressor Air Pressure Regulator (figure 4.1-6) regulates the pressure to the compressor receiver/separator tank. **This is for high pressure drills only.**

Rotate the adjustment knob clockwise to increase the operating air pressure to the pressure required for the particular model of downhole drill being used. Refer to the Bit Air Pressure Gauge (see figure 4.1-4, item 13) while adjusting pressure.

(51) Regulator - Compressor Volume Control (HP Only)

The Compressor Volume Control (figure 4.1-6) is used to change the angle of the butterfly valve to decrease the volume (cfm) of air being allowed into the air end. It can be adjusted to match the volume being used by various downhole drills. Clockwise rotation increases compressor volume. Counterclockwise rotation decreases compressor volume. It should be screwed in clockwise for normal drilling. **This is for high pressure drills only.**

(52) Toggle Switch - Compressor ON/OFF (HP Only)

The Compressor ON/OFF Switch (figure 4.1-6) opens and closes the inlet valve to allow the compressor to build pressure or shut off. It makes air when it is in the “ON” position and closes the air inlet when it is in the “OFF” position. **This is for high pressure drills only.**

4.1 - OPERATING CONTROLS

COMPRESSOR FUNCTIONS PANEL (continued)

(53) Control Lever - Compressor Cold Start (HP Only)

This is for high pressure drills only. The Compressor Cold Start Control Lever (figure 4.1-6) is used to close the air inlet to the compressor when starting a cold engine. Closing the air intake prevents build up of pressure within the compressor rotors and thereby reduces startup torque load on the cold engine allowing the starter motor to spin the engine at a higher rpm.

(53) Low Pressure Compressor Control Lever (LP Only)

This is for low pressure drills only. On Low Pressure drills, the Compressor Control Lever (figure 4.1-6) is used as an Air Throttle that turns on the compressed air to power the Downhole Drill (DHD) and cleans the cuttings out of the hole for both rotary and Downhole drilling.

4.1 - OPERATING CONTROLS

TRAM FUNCTIONS PANEL

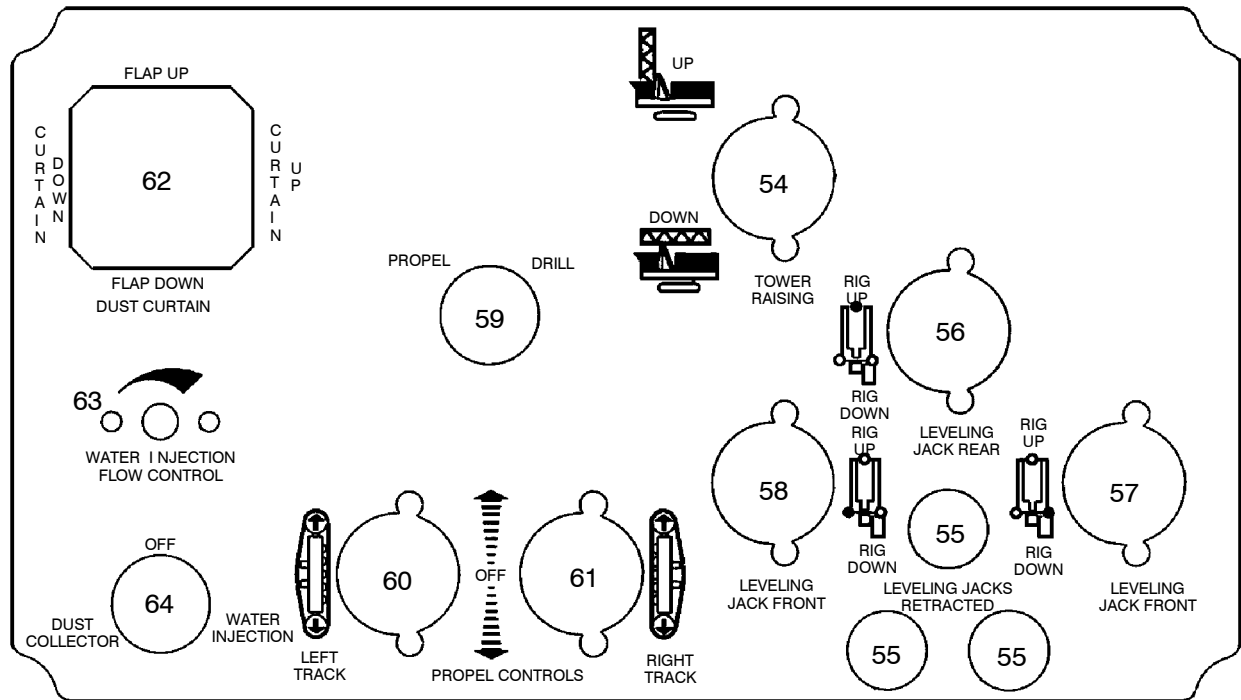


Figure 4.1 – 7

(54) Controller - Tower Raise/Lower

The Tower Raise/Lower Controller (figure 4.1-7) activates the tower raising cylinders which extend or retract for raising and lowering of the tower during drill setup.

Note: When raising or lowering the tower always control the movement to avoid impact as the tower is brought into final vertical or horizontal positions.

(55) Indicator Lights - Leveling Jacks Retracted

The three Leveling Jack “UP” Indicator Lights (figure 4.1-7) illuminate when the leveling jacks are up (retracted) and the drill is safe to tram (propel).

NOTICE

When operating the leveling jack controls, observe the Bubble Level (item 65) and both Inclinometers (item 69).

Ensure all three levelling jacks are operated and adjusted to level the drill in both directions and center the bubble in the Level gauge.

Do not exceed 20 degrees inclination on either inclinometer.

4.1 - OPERATING CONTROLS

TRAM FUNCTIONS PANEL (continued)

(56) Controller - Rear Leveling Jack

The Rear Jack Controller (figure 4.1-7) extends and retracts the leveling jack cylinder on the non-drilling end of the drill to raise or lower the drill.

(57) Controller - Cab Side Leveling Jack

The Cab Side Jack Controller (figure 4.1-7) extends and retracts the leveling jack cylinder on the cab side drilling end of the drill to raise or lower the drill.

(58) Controller - Dust Collector (DC) Side Leveling Jack

The Dust Collector Side Jack Controller (figure 4.1-7) extends and retracts the leveling jack cylinder on the DC side drilling end of the drill to raise or lower the drill.

(59) Rotary Switch - Propel/Drill Mode Selector

The Propel or Drill Selector Switch (figure 4.1-7) is a rotary switch used to select either Propel (Tram) Mode or Drill mode operations.

In the Propel position, the main pump flow is diverted to the Propel (Tram) controls (see items 60 and 61). The drill may be moved and the brakes automatically released as hydraulic flow to the propel motors increases.

In the Drill position, the main pump flow is diverted to the Drill Feed (figure 4.1-2, item 8) and Drill Rotation (figure 4.1-2, item 7) controls and the parking brakes are automatically applied in this position.

(59) Rotary Switch - Remote Tram/Propel/Drill Selector (Option)

The Remote Tram, Propel or Drill Selector Switch (figure 4.1-7) is a rotary switch used to select either Tramming Mode, Drilling Mode or Remote Tram Mode operations. **This is an option.**

In the Propel position, the main pump flow is diverted to the Propel (Tram) controls (see items 60 and 61). The drill may be moved and the brakes will automatically release as hydraulic flow to the propel motors increases.

In the **Remote Tram position**, tramming control is transferred to the remote tramming control console (see item 72).

In the Drill position, the main pump flow is diverted to the Drill Feed (figure 4.1-2, item 8) and Drill Rotation (figure 4.1-2, item 7) controls and the parking brakes are automatically applied in this position.

4.1 - OPERATING CONTROLS

TRAM FUNCTIONS PANEL (continued)

(59) Rotary Switch - Remote Tram/Propel/Drill Mode Selector Option (continued)

WARNING

LOSS OF MACHINE CONTROL

Moving the Tram (Propel) control (F-STOP-R) quickly may cause loss of drill control, lurching or serious injury. Move the Tram (Propel) control slowly.

Note:

The drilling end is considered the front end of the drill and F & R symbols relate to the respective directions of travel.

Note:

*There is also an electrical interlock switch in the propel control which only permits engine starting when the control is in the **STOP** position.*

(60) Controller - Left Track Propel (Tram)

The Left Track Propel Controller (figure 4.1-7) regulates the left hand side track direction, speed of travel, and service braking function. To propel the drill in either Forward or Reverse direction, gradually move the controller in the desired direction until the required propel speed and direction are effected. To slow and stop drill propel, move controller slowly towards the STOP position. Positioning the controller in the STOP position will halt drill propel movement and apply the brakes.

(61) Controller - Right Track Propel (Tram)

The Right Track Propel Controller (figure 4.1-7) regulates the right hand side track direction, speed of travel, and service braking function. To propel the drill in either Forward or Reverse direction, gradually move the controller in the desired direction until the required propel speed and direction are effected. To slow and stop drill propel, move controller slowly towards the STOP position. Positioning the controller in the STOP position will halt drill propel movement and apply the brakes.

(62) Controller -Dust Curtain UP/DOWN

The Dust Curtain Controller (figure 4.1-7) energizes the hydraulic cylinder that raises or lowers the dust curtain to ensure maximum collection of ejected dust. The arrow indicates direction of movement.

Note:

Always check that the dust curtain is clear of the ground when tramming the drill to avoid damage to the components.

4.1 - OPERATING CONTROLS

TRAM FUNCTIONS PANEL (continued)

(63) Rotary Switch - Water Injection Flow Control (Option)

The Water Injection Flow Control Rotary Switch (figure 4.1-7) adjusts the flow rate of water into the air stream to keep down dust and prevent collaring in the hole when the water injection pump is running. Rotate the switch clockwise to increase or counterclockwise to decrease the water flow rate. **This is an option.**

(64) Rotary Switch - Water Injection/Dust Collector Selector

The 3-position Water Injection/Dust Collector Selector Switch (figure 4.1-7) is used to select Water Injection operation, OFF (neither operation) or Dust Collector operation.

The Water Injection operation mode activates the hydraulic motor that engages the water injection pump which injects a regulated quantity of water into the drill air stream to suppress dust created by the drilling operation.

The Center position disengages both systems.

The Dust Collector operation mode activates the hydraulic motor that engages the dust collector fan, causing a vacuum around the hole inside the dust curtain. Small cuttings and dust ejected from the hole are deposited in the hopper or against the filters.

4.1 - OPERATING CONTROLS

OPERATOR'S CONSOLE

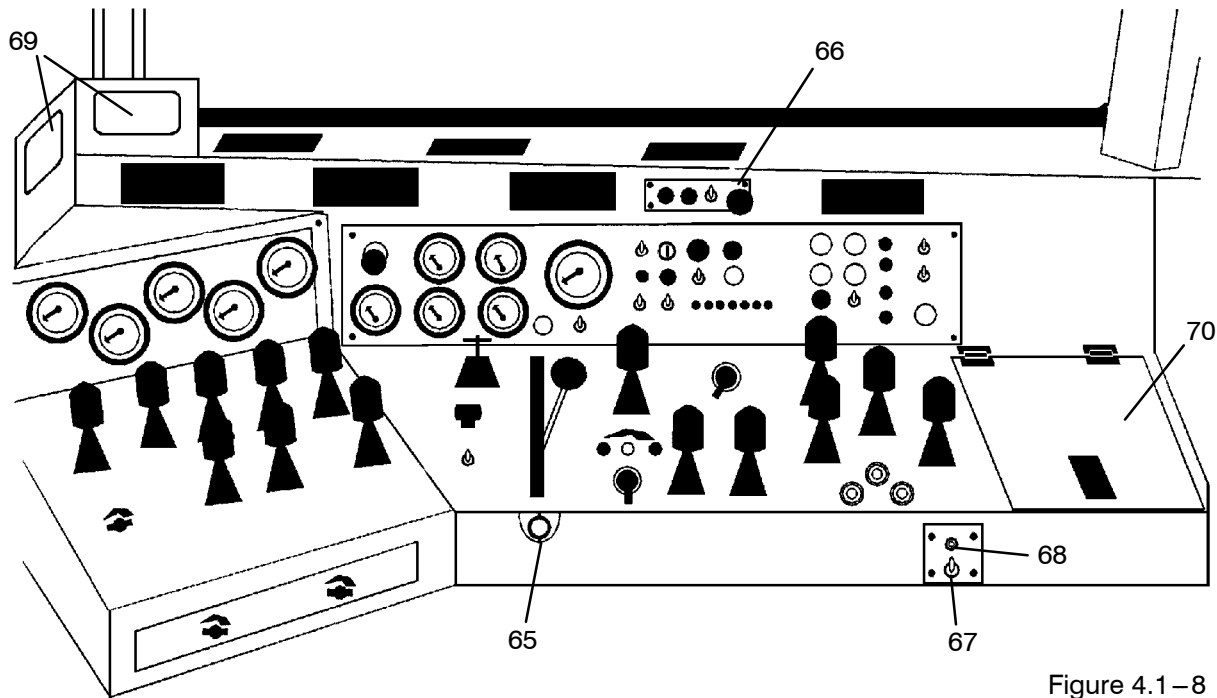


Figure 4.1 – 8

(65) Bubble Level

The Air Bubble Level Gauge (figure 4.1 – 8) is used when leveling the drill in both directions. The tower is designed to be vertical when the bubble is centered. The bubble **must be centered** before drilling begins.

(66) Control - Heat/Air Conditioning

The Heat/Air Control (figure 4.1 – 8) includes the “ON/OFF” switch, heat regulator control knob and an air regulator control knob.

(67) Toggle Switch - DHD Lubricator (HP Only)

The DHD Lubricator Switch (figure 4.1 – 8) is an “ON/OFF” switch for the DHD lubrication system. **This is for high pressure drills only.**

(68) Indicator Light - DHD Lubricator (HP Only)

The DHD Lubricator Indicator Light (figure 4.1 – 8) will illuminate to confirm that the lubrication system is in service. **This is for high pressure drills only.**

4.1 - OPERATING CONTROLS

OPERATOR'S CONSOLE (continued)

(69) Inclinometers (Option)

The Inclinometers (figure 4.1–8), one measuring the transverse angle (cross gradient) and one measuring the longitudinal angle, are provided to guide the operator when tramming on inclines where excessive gradients may create an overturning hazard. **This is an option.**

The longitudinal angle inclinometer registers the inclination in direction of travel while the other transverse angle inclinometer measures the inclination at 90 degrees to the direction of travel. Lower the tower when tramming over unstable surfaces.

Note:

Do not exceed the regulation 20 degree inclination reading on either inclinometer.

Note:

If you are equipped with the Optional Remote Tramming Control, lower the tower when tramming over unstable surfaces and use the Remote Control Console from a safe working area.

(70) Compartment - Instruction Manual Storage

The Instruction Manual Storage Compartment (figure 4.1–8) provides a secure, dry location within easy reach of the operator. Safety and operator instruction manuals must be available to the operator at all times.

(71) Seat - Operator's



Figure 4.1–9

The REAR facing Operator's Seat shown in figure 4.1–9) is equipped with adjustments for seat position and angle. Seat position rotation permits the operator a view of the control console and also the drill platform areas.

4.1 - OPERATING CONTROLS

NON-CAB CONTROLS & INSTRUMENTS

(72) Control Unit - Remote Propel (Option)

The Remote Tram (Propel) Control Unit (figure 4.1-10) permits the operator to tram the drill from a remote place of safety on occasions where there could be a risk of overturning due to unstable ground surface conditions or loading onto a trailer. **This is an option.**

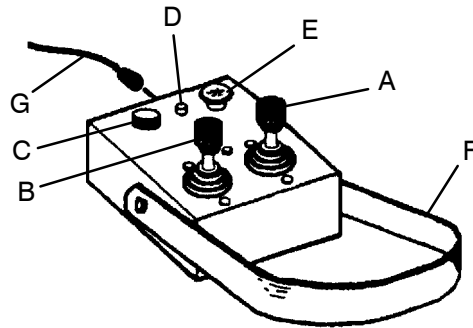


Figure 4.1 – 10

The panel controls are defined as:

- A = L.H. Side Track Tram Controller
- B = R.H Side Track Tram Controller
- C = Horn Button Switch
- D = GREEN Indicator Light
- E = Emergency Stop Button Switch
- F = Waist Harness
- G = Umbilical Cable

To use the Remote Tram (Propel) Control Unit:

1. Turn the Drill / Tram / Remote Tram Mode Selector Switch Option (see figure 4.1-7, item 59) into the Remote Tram Mode position.
2. Plug the Remote Control Umbilical Cable (G) into the socket on the Remote Control Unit. Secure the Waist Harness (F). When the remote control unit is plugged in to the cab the GREEN Indicator Light (D) should illuminate to indicate the controls are active.

With the engine running at 2100 rpm (see figure 4.1-5, item 27) and the tram/drill/remote tram mode switch (figure 4.1-7, item 59) in remote tram mode, take a position in a safe zone away from the high wall and out of the line of travel. Use the Remote Control Tram controllers to tram the drill or load the drill onto a trailer. When the risk of overturning no longer exists, remove the Umbilical Cable (G) and resume control from the main control console.

4.1 - OPERATING CONTROLS

NON-CAB CONTROLS & INSTRUMENTS (continued)

(73) Gauge - Hydraulic Oil Level

The Hydraulic Oil Level Gauge (figure 4.1-11) is located on the face of the hydraulic tank.

The hydraulic oil level should be monitored and the level maintained using respective symbol marks as reference.

Refer to the Maintenance Instructions for detailed information.

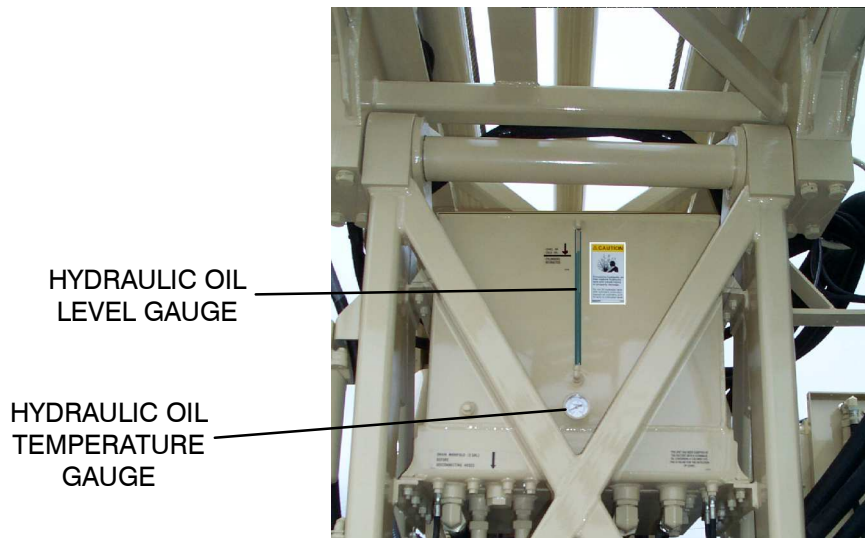


Figure 4.1-11

(74) Gauge - Hydraulic Oil Temperature

The Hydraulic Oil Temperature Gauge (figure 4.1-11) is located on the face of the hydraulic tank and indicates the operating hydraulic oil temperature.

Note:

If the indicated temperature exceeds 220 degrees F (104 degrees C), shut down the engine and call for service assistance to correct the problem.

4.1 - OPERATING CONTROLS

NON-CAB CONTROLS & INSTRUMENTS (continued)

(75) Isolation Switch - Battery

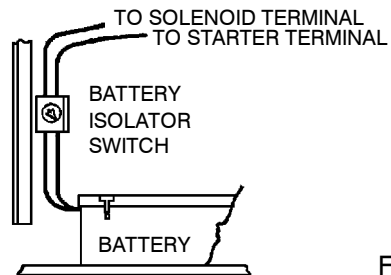


Figure 4.1 – 12

The Battery Isolator Switch (figure 4.1-12) is a heavy duty rotary switch that enables the battery to be isolated from the drill's electrical circuit.

This Battery Isolator Switch should be used whenever maintenance work is carried out on the drill.

SECTION 5 OPERATING INSTRUCTIONS

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5.1 - OPERATING SAFETY

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramping the drill.
7. If your drill is equipped with remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

5.1 - OPERATING SAFETY

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5.2 - WALK AROUND INSPECTION

WALK AROUND INSPECTION

Before every shift and prior to starting the drill, a walk around inspection of the overall drill should be performed. This is in addition to the 10 hour daily routine maintenance procedures. Performance of this inspection can result in longer life and maximum productivity from the drill.

Check for Hydraulic System Oil Leaks

A careful inspection of all hydraulic components (pumps, motors, valves, hoses, etc.) should be made to detect possible leaks or any irregularities. This is particularly important when the drill is new. Drills have been equipped at the factory with a hydraulic oil containing a blue colored dye which will aid in early detection of leaks.



Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Check for Compressor System Oil Leaks

A careful inspection of all compressor components (air end, air end pump, valves, hoses, fittings and filters) should be made to insure there are no compressor oil leaks or any irregularities. This is particularly important when the drill is new.



High Pressure can cause severe injury or death. Completely relieve pressure before removing filler plug, fittings or receiver cover.

Check for Coolant System Leaks

Power pack engine radiators should be checked for leaks. Failure to cool the engine properly can result in engine failure or severely reduce engine life.



Injury can occur when removing the radiator cap. Steam or fluid escaping from the radiator can burn. Inhibitor contains alkali. Avoid contact with skin and eyes.

Always shut down the engine and allow it to cool down before removing the radiator cap. Remove cap slowly to relieve pressure. Avoid contact with steam or escaping fluid.

5.2 - WALK AROUND INSPECTION

WALK AROUND INSPECTION (continued)

Check for Fuel System Leaks

Maintain fuel tanks at a high level to minimize water condensation inside the tank. This is best accomplished by filling fuel tanks at the end of each day. Check fuel tanks and fuel lines for possible leaks. Because of the potential fire hazard, leaks must be corrected as soon as they are spotted. Select the proper grade of fuel oil in accordance with the instructions given in the *Fuel Specifications* section of Section 7 MAINTENANCE.



Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames, and do not smoke while filling tank or draining fuel filters. Always wipe up any spilled fuel.

General Checks

Other general checks should be made at this time for any wear and tear on the drill. Check for broken or cracked welds, loose or missing bolts, broken or inoperative gauges, or any other irregularities which could lead to more costly breakdowns.

Frequently walk around the drill and inspect for leaks, loose or missing parts, damaged parts or parts out of adjustment. Perform all recommended daily maintenance.

5.3 - PRELIMINARY START INSPECTION

PRE-START INSPECTION

Before starting the DM45/50, a pre-operation inspection of the overall drill is very important. This inspection should be performed before each shift and at every startup. These are in addition to the 10 hour daily routine maintenance. Performance of this inspection can result in longer life and maximum productivity from the drill.

The following are checks and verifications of the overall drill that should be performed prior to starting. Refer to the *Maintenance Procedures* section of Section 6 MAINTENANCE.

Check Engine Lubricating Oil Level

Check the engine oil level by viewing the dipstick. The drill **must** be level when checking the oil level to be sure the measurement is correct. Wait at least 5 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan. If oil level is low, refer to the instructions given in the *Maintenance Procedures* section of Section 6 MAINTENANCE.



Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Check Engine Coolant Level

Check engine coolant level, on low pressure drills, at the radiator cap when the radiator is cool to the touch. The level should be maintained up to the neck of the filler.

Check engine coolant level, on high pressure drills, on the radiator sight glass. The level should be maintained so fluid can be seen in the sight glass.

If the coolant level is low, refer to the instructions given in the *Maintenance Procedures* section of Section 6 MAINTENANCE.



Injury can occur when removing the radiator cap. Steam or fluid escaping from the radiator can burn. Inhibitor contains alkali. Avoid contact with skin and eyes.

Always shut down the engine and allow to cool before removing the radiator cap. Remove cap slowly to relieve pressure. Avoid contact with steam or escaping fluid.

5.3 - PRELIMINARY START INSPECTION

PRE-START INSPECTION (continued)

Check Fuel Level

Check fuel level gauge. The tank should be refilled when the indicator needle moves to below 1/4 tank. Refer to the *Maintenance Procedures* section of Section 7 MAINTENANCE. Select the proper grade of fuel oil in accordance with the instructions given in the *Fuel Specifications* section of Section 7 MAINTENANCE.



Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames, and do not smoke while filling tank. Always wipe up any spilled fuel.

Drain Fuel Filter / Water Separator

The fuel filter / water separator should be monitored daily for signs of water and sediment. If water is present, drain the water and sediment from the filters / separators. Refer to the instructions given in the *Maintenance Procedures* section of Section 7 MAINTENANCE.



Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames, and do not smoke while draining fuel / water filters. Always wipe up any spilled fuel.

Check Compressor Oil Level

Check the compressor oil level. With the drill in a level position, the oil level should be in the middle of the sight gauge. If oil is required, follow the instructions in the *Maintenance Procedures* section of Section 7 MAINTENANCE.



High Pressure can cause severe injury or death.

Completely relieve pressure before removing filler plug, fittings or receiver cover.

Hot oil or components can burn. Avoid contact with hot oil or components.

5.3 - PRELIMINARY START INSPECTION

PRE-START INSPECTION (continued)

Drain Water from Receiver Tank

When compressing air, water will condense in the receiver tank and mix with the compressor oil. If allowed to accumulate, the water will significantly reduce bearing life. Follow the instructions in the *Maintenance Procedures* section of Section 7 MAINTENANCE and relieve water from the system.



High Pressure can cause severe injury or death.

Do not attempt to remove any plugs or open the drain valve before making sure all air pressure has been relieved from the system.

Hot oil or components can burn. Avoid contact with hot oil or components.

Check the Batteries

Check the battery posts and cables for corrosion. Check and keep the electrolyte levels above the battery plates or to the bottom of the fill holes. Refer to the *Maintenance Procedures* section of Section 7 MAINTENANCE.



Batteries contain an acid and can cause injury.

Battery fumes can ignite and explode. Do not smoke when observing battery fluid level.

Skin and eye contact with battery fluid can cause injury. Avoid skin and eye contact with battery fluid. If contact occurs, flush area immediately with water.

Check Pump Drive Gearbox Oil Level

Check the oil level in the Pump Drive Gearbox and maintain it to the “FULL” level indicated on the dipstick. Refer to the *Maintenance Procedures* section of Section 7 MAINTENANCE.



Rotating Shaft can cause severe injury or death. Do not operate with guard removed.

Hot oil or components can burn. Avoid contact with hot oil or components.

5.3 - PRELIMINARY START INSPECTION

PRE-START INSPECTION (continued)

Check the Hydraulic Oil Level

The hydraulic oil level should be checked by the sight gauge on the hydraulic tank.

The oil level in the hydraulic tank depends on the extended or retracted positions of the hydraulic cylinders. It is important to follow the directions in the *Maintenance Procedures* section of Section 6 MAINTENANCE when reading the level gauge:

1. The oil level *with all hydraulic cylinders retracted, tower down, jacks up and rotary head at the top of the tower* should be between the FULL mark and the MINIMUM mark on the sight gauge.
2. The top of the oil level **MUST** be visible when the engine is running **AND** when the engine is stopped. There must be oil showing on the gauge at all times.

Add oil to bring to levels defined above by following directions in the *Maintenance Procedures* section of Section 6 MAINTENANCE.

Select the proper grade of oil in accordance with the information given in the *Lube Specifications* section of Section 6 MAINTENANCE.



Excessive hydraulic oil can rupture the sealed hydraulic tank and cause injury or property damage.

Do not fill hydraulic tank with hydraulic cylinders extended. Retract all cylinders and fill tank to indicated level.



Dirt in the hydraulic system will lead to premature component failure. A clean, contaminant free system is extremely important to the drill's proper function. Take extra care when working around or on the hydraulic system to ensure its complete cleanliness.

When operating, the oil level must be between the maximum and minimum.

Keep Operator's Areas Clean

Clean windshields, mirrors and all lights. Check that all lights function.

Make sure the operator's areas, steps and grab rails are clean. Oil, grease, snow, ice or mud in these areas can cause you to slip and fall. Clean your boots of excess mud before getting on the drill.

Remove all personal items or other objects from the floor of the operator's area. Secure these items in a tool box or remove them from the drill.

5.3 - PRELIMINARY START INSPECTION

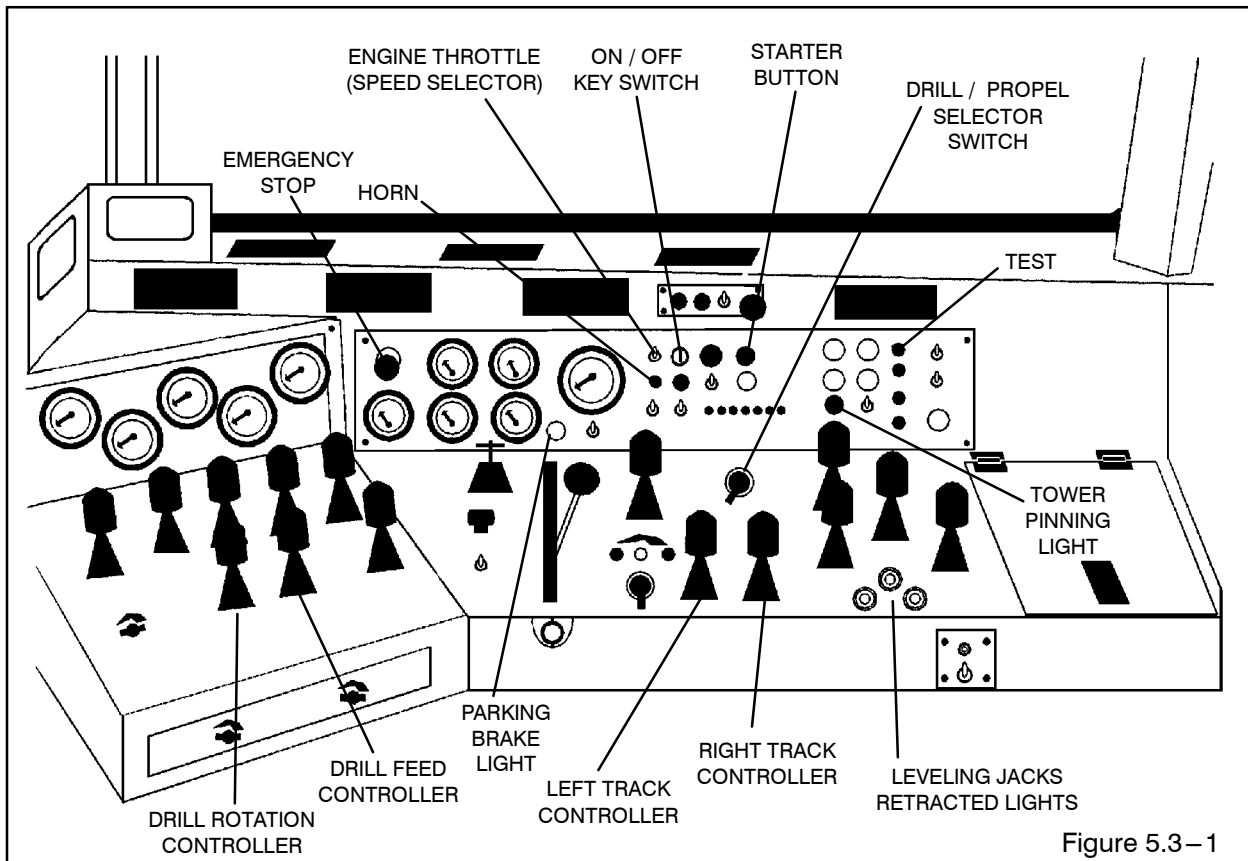
PRE-OPERATION CONTROLS INSPECTION

Before starting the drill, a check to verify that the Warning Lights, Backup Alarm, Horn and Emergency Stop controls are functioning properly is very important. This inspection should be performed before each shift and at every startup.



Any drill defects should be reported to the proper personnel. Defects must be corrected before starting and operating the drill.

The following are checks and verifications of the drill controls that should be performed prior to starting. Refer to Section 4 OPERATING CONTROLS.



5.3 - PRELIMINARY START INSPECTION

PRE-OPERATION CONTROLS INSPECTION (continued)

Warning Controls Check

1. Turn the DRILL / PROPEL selector switch (figure 5-1) to the DRILL mode position.
2. Be sure both the LEFT TRACK controller and RIGHT TRACK controller are in the STOP positions. The controllers are spring centered to the STOP position when released.

NOTE:

If the levers do not return to STOP when released, have the defect rectified immediately.

3. Put both the DRILL ROTATION controller and the DRILL FEED controller in their STOP positions.
4. Set the ENGINE THROTTLE (Speed) switch to LOW IDLE position (1200 rpm).
5. Turn the ON/OFF key switch to the “ON” position. The BACKUP ALARM should emit an intermittent beeping sound when the DRILL / PROPEL selector switch is in the PROPEL mode. Turn DRILL / PROPEL selector switch to DRILL mode and the BACKUP ALARM should stop.
6. With the ON/OFF key switch in the “ON” position, press the TEST button switch. All the following warning lights should illuminate on the console to verify that following warning lights and audible alarms are functioning.
 - a. The Red PARKING BRAKE “ON” indicator light should be on. **This is an option.**
 - b. The Red TOWER PINNING indicator light should be on.
 - c. All three (3) of the Green LEVELING JACKS RETRACTED indicator lights should be on.
 - d. The BACKUP ALARM should emit an intermittent beeping sound.

NOTE:

If any lights do not illuminate, notify service personnel to rectify the defect.

7. Turn the ON/OFF key switch to “OFF” position.
8. Press the HORN button to confirm that the horn is functioning properly.
9. Put the DRILL / PROPEL selector switch into PROPEL mode position. Move the Right Track controller in either direction away from STOP. Turn the ON/OFF key switch to the “ON” position and press the STARTER BUTTON. **The engine should not start.**
10. Put the DRILL / PROPEL selector switch into DRILL mode position. Move the Left Track controller in either direction away from STOP. Turn the ON/OFF key switch to the “ON” position and press the STARTER BUTTON. **The engine should not start.**

5.3 - PRELIMINARY START INSPECTION

PRE-OPERATION CONTROLS INSPECTION (continued)

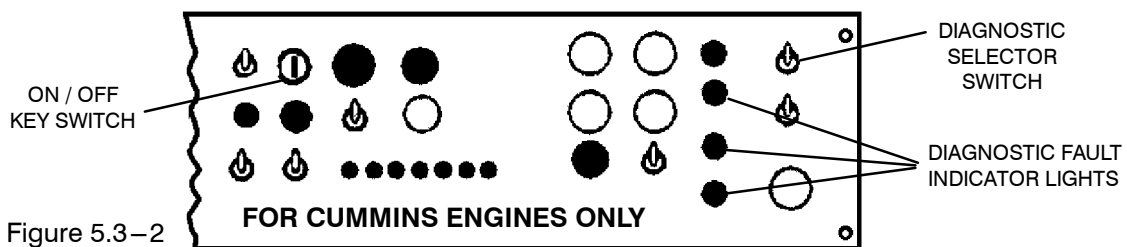
Warning Controls Check (continued)

11. With the DRILL / PROPEL selector switch in DRILL mode position, move the DRILL FEED controller in either direction away from STOP. Turn the ON/OFF key switch to the “ON” position and press the STARTER BUTTON. **The engine should not start.**
12. With DRILL / PROPEL selector switch in DRILL mode position, move DRILL ROTATION controller in either direction away from STOP. Turn the ON/OFF key switch to the “ON” position and press the STARTER BUTTON. **The engine should not start.**
13. Pull the EMERGENCY STOP button switch out. Turn the ON/OFF key switch to the “ON” position. The Red light inside the EMERGENCY STOP button switch should come on and stay lit when the switch is pulled out in the “RUN” position.
14. Check the EMERGENCY STOP by starting the engine (See the Instructions for Starting Engine). Then push IN the Emergency Stop Switch. The engine must immediately stop and the parking brake light should illuminate, indicating that the brakes are applied.

NOTE:

Before the engine can restart after being shut down with the emergency stop switch, the switch will first need to be reset. Pulling out the red button resets the switch.

15. Cummins Engines Only



With the ON/OFF Key Switch “OFF”, set the DIAGNOSTIC SELECTOR SWITCH to “ON”. Turn the ON/OFF Key Switch to “ON”, but **do not start the engine**. The three diagnostic lights will come on and stay on.

NOTE:

If all three lights come on only momentarily, then there is a fault code. Check the engine manufacturers Operation and Maintenance manual for full trouble shooting instructions.



If any controls, instruments or devices do not function correctly, refer to Section 8 TROUBLE SHOOTING or report any drill defects to the proper personnel. Defects must be corrected before starting and operating the drill.

5.3 - PRELIMINARY START INSPECTION

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5.4 - ENGINE OPERATION

STARTING ENGINE



Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Before starting engine or beginning to move drill, check inside, outside and underneath drill for people or obstructions.

Check for warnings or Lockout tags on the controls. If there is a tag attached to the switch, do not start the engine until the warning tag has been removed by the person who installed it.

START the engine from the operator's position only.

AVOID leaving the controls with the engine running. NEVER leave the operator's cab while the engine is running.

Engine Starting Procedure

Always sound the horn (Option) before starting the drill to alert everyone in the area.

1. Make sure all controls are in neutral or OFF positions.
2. Make sure the DRILL / PROPEL selector switch is in the DRILL mode position.
3. Make sure the LEFT TRACK controller and RIGHT TRACK controller are in the STOP positions.
4. Make sure that the DRILL ROTATION controller and the DRILL FEED controller are at the STOP positions.
5. Make sure the EMERGENCY STOP button switch is pulled out (reset).
6. Make sure ENGINE THROTTLE (Speed) switch is set at LOW IDLE position (1200 rpm).
7. MAKE SURE no one is at danger or risk before starting the engine.

5.4 - ENGINE OPERATION

STARTING ENGINE (continued)

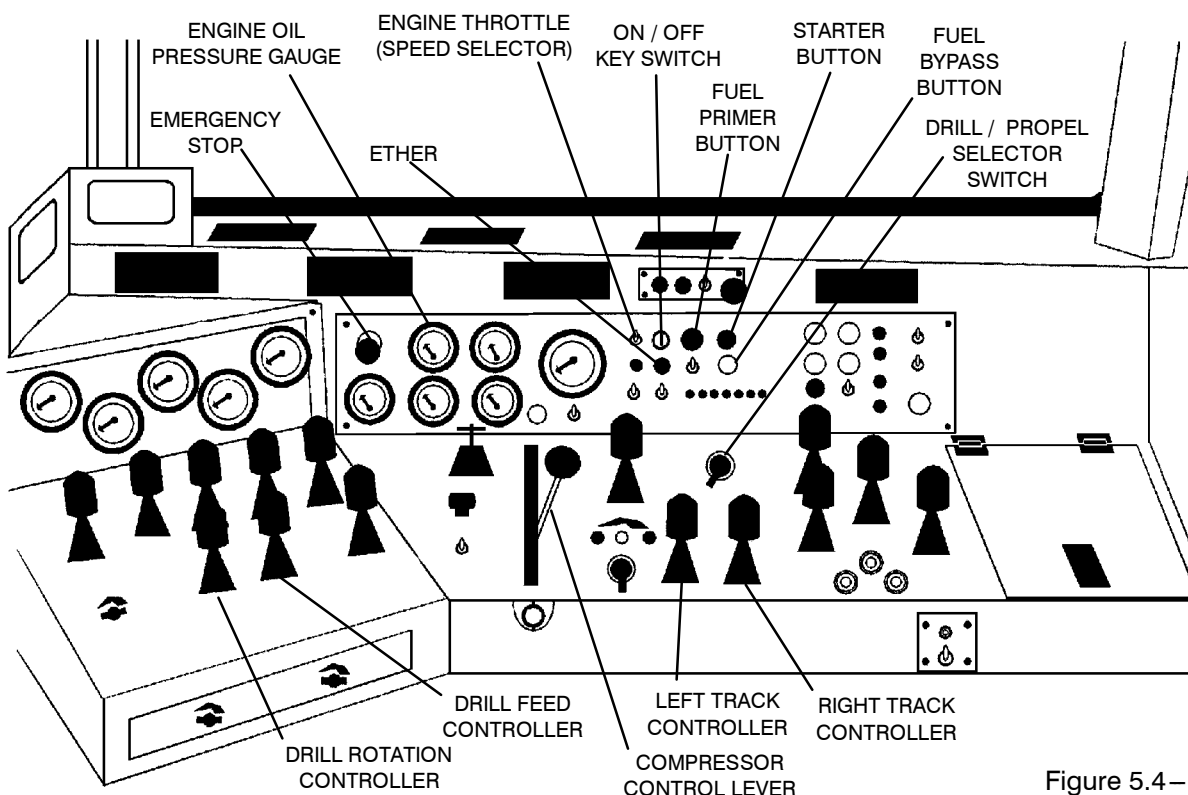


Figure 5.4–1

Start Engine

1. Turn Ignition KEY SWITCH to ON.
2. Press and hold in the Fuel PRIMER button switch and listen. Primer pumping action will slow down as fuel pressure builds up. Release the button when the pump slows down.
3. Move the COMPRESSOR CONTROL Lever to closed position and hold the lever there.
4. There is no Fuel BYPASS button on electronic engines. If you have a Fuel Bypass Button, hold it in while pushing the STARTER BUTTON. If you do not have a Fuel BYPASS button, Push the STARTER BUTTON.

NOTICE

The Starter may overheat if operated longer than 30 seconds. If the engine fails to start, allow the starter to cool 2 to 3 minutes before trying again.

5.4 - ENGINE OPERATION

STARTING ENGINE (continued)

Start Engine (continued)

5. When the engine starts, release the STARTER BUTTON.
6. Hold the Fuel BYPASS button in until the oil pressure gauge shows at least 25 psi. (This applies to non-electronic engines).
7. Slowly release the COMPRESSOR CONTROL Lever once the engine is running evenly.

 WARNING

Do not let the engine run for more than 20 seconds with the Compressor Control (HP Cold Start) Lever in the closed position (See Compressor Operation). Damage to the compressor can result.

NOTE:

Run the engine for a short time to warm up the engine and hydraulic systems.

NOTE: Electronic Engines

Once the engine is running with the ON/OFF Key Switch in the “ON” position, the Fault Indicator Warning Lights should only light up to indicate a fault. If any light illuminates and stays lit, contact proper service personnel.

Ether Cold Start Option

The Ether Cold Starting Air Option (figure 5.4-1) is available for starting engines when ambient temperature is below 50°F (10°C).

To use this option for starting, press and release the ETHER Injection button while pressing the starter button switch. (Ether is only injected when the starter button is operated).

 WARNING

Starting aids are extremely flammable and can explode.

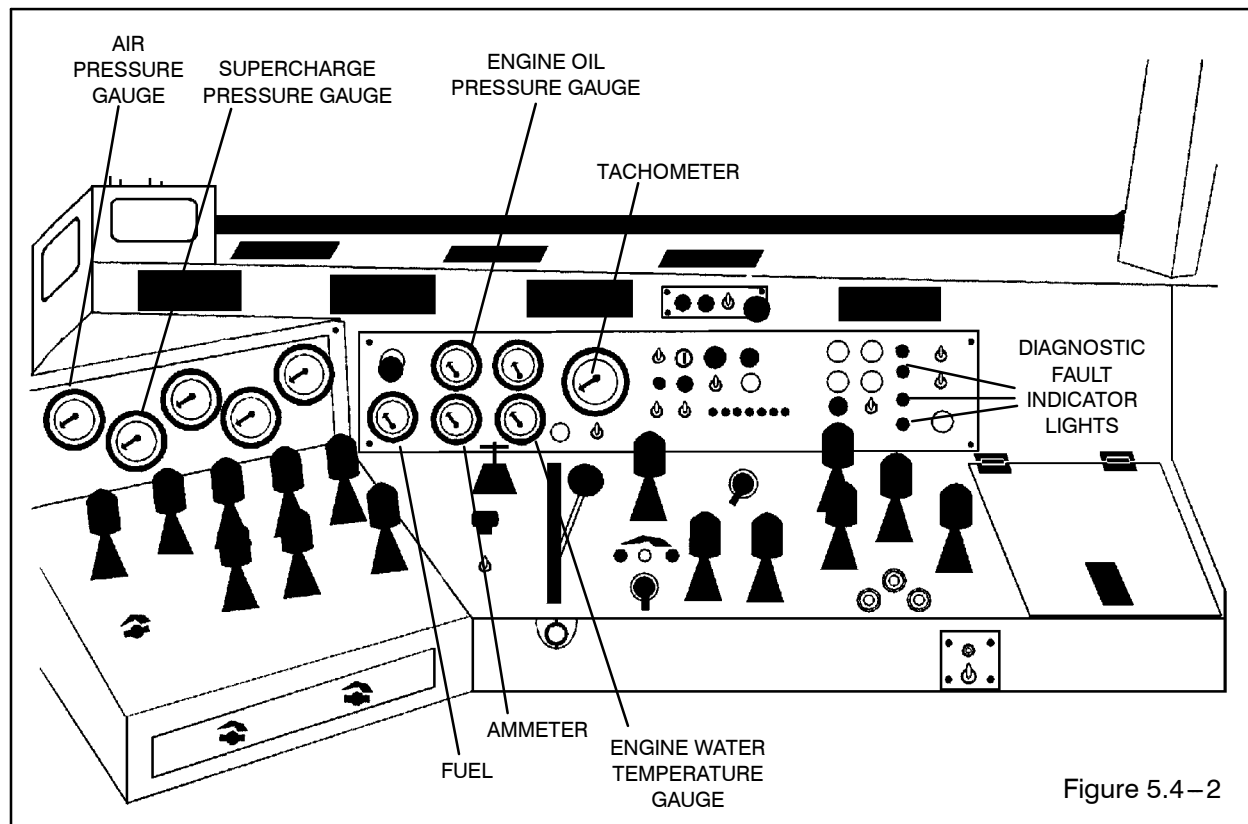
Overloading the engine air intake system could result in an explosion.

Avoid overloading the engine air intake system with starting aids.

5.4 - ENGINE OPERATION

VERIFY GAUGES & CONTROLS

After starting the drill, a check to verify that the Gauges and Engine Diagnostic Lights (Cummins Electronic Engine) are functioning properly is very important. This inspection should be performed before each shift and at every startup.



With the engine running, verify that:

1. Engine Diagnostic Lights (Cummins Engines only) temporarily light up and then go out.
2. The engine Tachometer should read 1200 rpm on LOW idle.
3. The engine Oil Pressure Gauge must be above 10 psi at LOW idle.
4. The Ammeter should show a (+) charge whenever the engine is running. If the Ammeter shows a discharge (-), stop the engine and determine the reason before proceeding.
5. The Supercharge Pressure Gauge must be above 65 psi.
6. The engine Water Temperature Gauge indicator shows a reading as the engine warms up.
7. With the air compressor turned off, the Air Pressure Gauge (HP only) should show about 125 psi.
8. The Hydraulic Oil Temperature Gauge, located on the back of the hydraulic tank, should indicate 100°F (38°C) before starting any operation of the drill.

5.4 - ENGINE OPERATION

OPERATING ENGINE

NOTE:

Always ensure that the engine speed is at Operating RPM before tramming or drilling. Full engine power is necessary to obtain the proper component operation and maximum rpm for greatest efficiency



Figure 5.4-3

The **Engine Speed (Throttle) Selector switch** is used to select engine speed (rpm).

CAT engines use a ramp up/ramp down switch. From the middle position, the operator can ramp down to low idle (1200 RPM) or ramp up to operating speed (2100 RPM).

Low Idle = 1200 RPM
High Idle = 2100 RPM

CUMMINS engines use a three position switch. The three positions are:

Low Idle = 1200 RPM
High Idle = 1800 RPM
Operating = 2100 RPM

NOTE:

Always ensure that the engine speed is at Operating RPM before tramming or drilling. Full Power is necessary to obtain the proper component operation and maximum rpm for greatest efficiency



A Runaway drill can cause injury or death.

Do not attempt to control drill travel speed with the engine speed control. Use the tram control (F-STOP- R) to control travel speed. Maintain engine speed at operating RPM for all drill operations.

The **Engine Oil Pressure Gauge** should not read less than 10 psi on LOW idle nor less than 27 psi on HIGH idle.

Note:

There is a pressure monitoring system on the engine that will shut down the engine immediately in the event that the oil pressure drops below 10 psi on LOW idle or less than 27 psi on HIGH idle; otherwise the engine could be severely damaged.

The Water Temperature Gauge shows the temperature of the engine coolant system. Normal operating temperature is from 150°-208°F (65°-98°C). The system will shut down if the temperature exceeds 210°F (99°C).

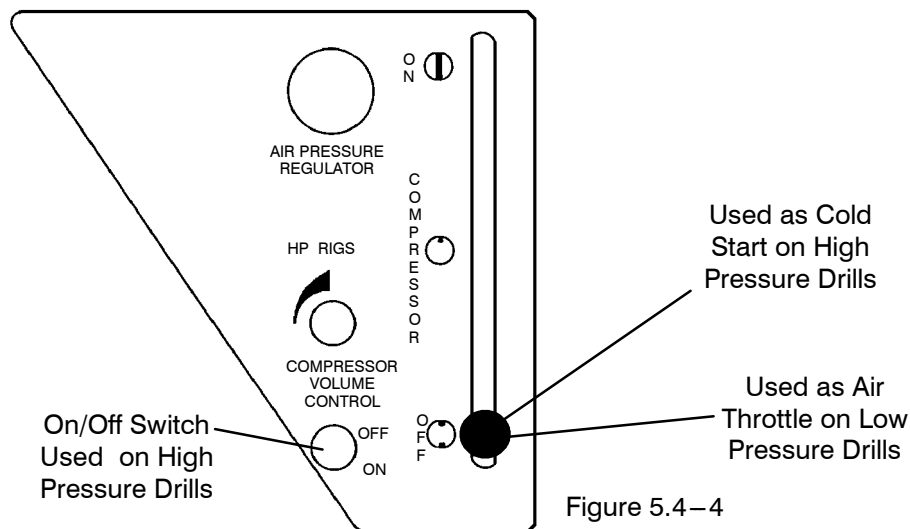
5.4 - ENGINE OPERATION

STOPPING ENGINE



Never shut down the drill with the Drill/Propel Selector Switch in the Propel Mode or with the Left Track Controller and Right Track Controller in any position but OFF. When the drill is started the next time, the drill could move and run over a helper or go over a high wall before the operator can react.

The following procedure is to inform the operator or service personnel how to turn off the engine. The procedure is part of the *Normal Drill Shutdown* shown in the STOPPING, PARKING & SHUTDOWN section.



1. Turn off the compressor and allow the receiver to blow down to minimum pressure.

Low Pressure Drills

On low pressure drills, the compressor is turned on and off with the use a manual inlet control. This is a lever and cable arrangement. Pull the lever towards the operator to close the inlet.

High Pressure Drills

On high-pressure drills, the Compressor On/Off Switch is used to turn the compressor on and off. This is a two position, pneumatic switch. It is used to open and close the compressor inlet valve.

2. Move the Engine Throttle (speed selector) switch to LOW idle (1200 rpm) position for about 5 minutes to allow the engine to cool down.
3. Turn the key switch to the OFF position.
4. After the engine has stopped, make sure the compressor blowdown valve opens and blows all the air out of the receiver tank.
5. Remove the key when you leave the operator's cab.

5.4 - ENGINE OPERATION

EMERGENCY SHUTDOWN

The Emergency stopping procedure for the drill may be very abrupt. This abrupt stop may damage the drill due to potentially high stress loading on its components. There are two types of emergency shutdowns. One is by the operator pushing the Emergency Stop button and the other is when one of the shutdown devices on the drill has registered an out of limit condition.



Figure 5.4–5

If the operator or other personnel are in immediate danger or if an emergency arises that is not under the protection of the shutdown devices, such as fire or other outside problem, initiate an emergency stop with the following procedure:

1. Push in the **Emergency Stop Button** and exit the drill.

If the operator or other personnel are not in immediate danger and the preservation of the drill equipment is the primary concern, proceed as follows:

1. All of the drill shutdown devices have gauges that show the operating temperature or pressure of the system they monitor. The operator should be able to avoid a shutdown condition if he checks the gauges frequently.

When one of the emergency stop or shutdown devices is energized, it immediately shuts off fuel to the engine. All engines are “energize to run”, which means there must be power to the fuel valve to allow fuel to flow. If power is lost, the fuel valve closes and stops the engine.

Every attempt should be made by the operator to shut the drill down under normal conditions to prevent damage to the drill. When a high pressure compressor is shut down at high pressure, the regulation system causes the air end to become a pressure vessel that will force compressor oil back up into the intake filters when the inlet butterfly valve opens. The element will have to be replaced and the tubes cleaned before the drill can be put back into service.

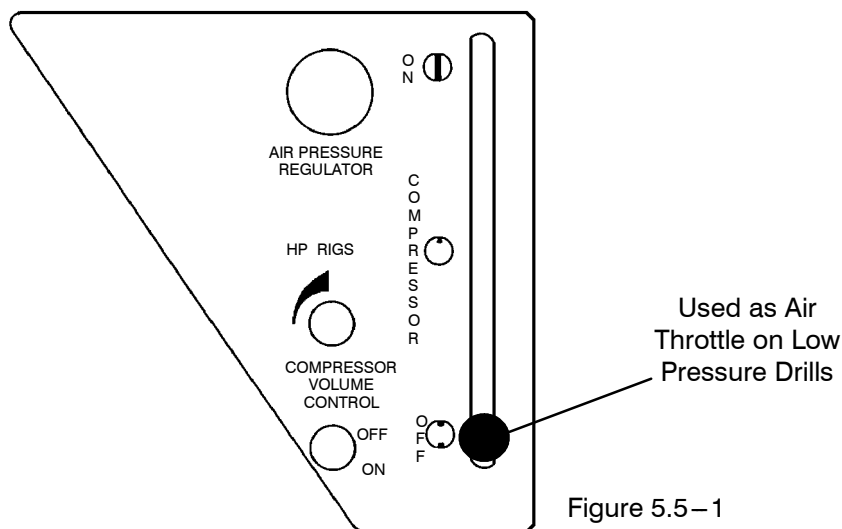
5.4 - ENGINE OPERATION

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5.5 - COMPRESSOR OPERATION

LOW PRESSURE OPERATION

The following procedure is to inform the operator or service personnel how to turn on, operate and turn off the Low Pressure compressor. On **low pressure** drills, the compressor is turned on and off with the use of a manual inlet control. This is a lever and cable arrangement. Refer to *Low Pressure Compressor* section of Section 3-SPECIFICATIONS & SYSTEMS.



Start Position

When the drill is first started, the *Control Handle* in the operator's cab is in the "OFF" position. The Inlet Butterfly Valve is closed. The only air entering the compressor is through the Orifice in the Inlet Butterfly Valve. Air pressure in the Receiver Tank is maintained at a minimum until the Inlet Butterfly Valve is opened.

Run Position

1. The compressor should not be turned on until the engine is running at 2100 rpm.
2. When the operator wishes to drill, he pushes the Control Handle to the ON position which opens the Inlet Butterfly Valve and allows the compressor to compress air.

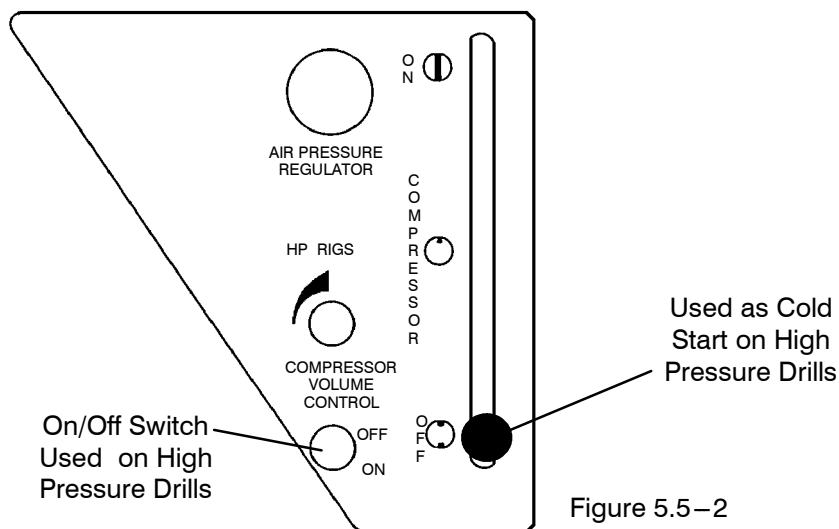
To Stop Compressor

1. Pull the lever towards the operator to close the Butterfly Inlet valve.
2. Move Engine Throttle (speed selector) switch to LOW idle (1200 rpm) position for about 5 minutes to allow the engine to cool down.

5.5 - COMPRESSOR OPERATION

HIGH PRESSURE OPERATION

The following procedure is to inform the operator or service personnel how to turn on, operate and turn off the High Pressure compressor. On **high pressure** drills, the Compressor On/Off Switch is used to turn the compressor on and off. Refer to *High Pressure Compressor* section of Section 3-SPECIFICATIONS & SYSTEMS.



Start Position

When the drill is first started, the compressor ON/OFF switch should be in the OFF position. The Inlet Butterfly Valve is closed. The only air entering the compressor is through the Orifice in the Inlet Butterfly Valve.

Run Position

1. The compressor should not be turned on until the engine is running at 2100 rpm.
2. Move the compressor ON/OFF switch to ON position. The ON position opens the Butterfly Inlet Valve and allows the compressor to compress air.

To Stop Compressor

1. Move the compressor ON/OFF switch to the OFF position. The OFF position closes the Butterfly Inlet Valve and stops the compressor from compressing air.
2. Move Engine Throttle (speed selector) switch to LOW idle (1200 rpm) position for about 5 minutes to allow the engine to cool down.

5.6 -PROPEL OPERATION

RECOMMENDATIONS AND CHECKS

1. Before starting engine or beginning to move drill, check inside, outside and underneath drill for people or obstructions. Check the work area for obstacles and personnel.
2. Make sure the horn and backup alarm are working properly. Refer to *Backup Alarm Check Procedure* shown below.
3. Check all instruments and warning lights. If instruments and lights indicate a fault or a problem, contact the appropriate personnel to correct them.
4. Make sure that all drill lights are working and provide good illumination of the working area.
5. Always be aware of the risk of overturning when propelling on ramps which are unstable or have steep slopes. Maintain a safe distance between edge of the ramp and the outer edges of the tracks.
6. Always sound the horn before moving the drill in either direction to alert persons in the area. Allow sufficient time before putting the drill into motion

Backup Alarm Check Procedure

After starting the drill, a check to verify that the Backup Alarm is functioning properly is very important. This inspection should be performed before each shift and at every startup.

1. Start engine (Refer to starting procedure in shown in *Engine Operation*).



Figure 5.6–1

2. To check that the Backup Alarm is functioning properly, move Propel/Drill Mode Selector to Propel (Figure 5.6–1). An intermittent alarm should sound immediately. If there is no alarm sound, contact the proper service personnel and correct the problem before operating the drill.

After starting the drill, a check to verify that the Hydrostatic Brakes are functioning properly is very important. This inspection should be performed before each shift and at every startup.

5.6 -PROPEL OPERATION

RECOMMENDATIONS AND CHECKS (continued)

Parking Brake Check Procedure (Option)

The Parking Brake “ON/OFF” Switch is used when testing the brakes prior to tramping the drill. Apply the switch with the brakes on (applied) and the Parking Brake Warning Light will illuminate RED. Release the Parking Brake Switch to release the brakes and the RED Parking Brake Warning Light should extinguish. **This is an option.**

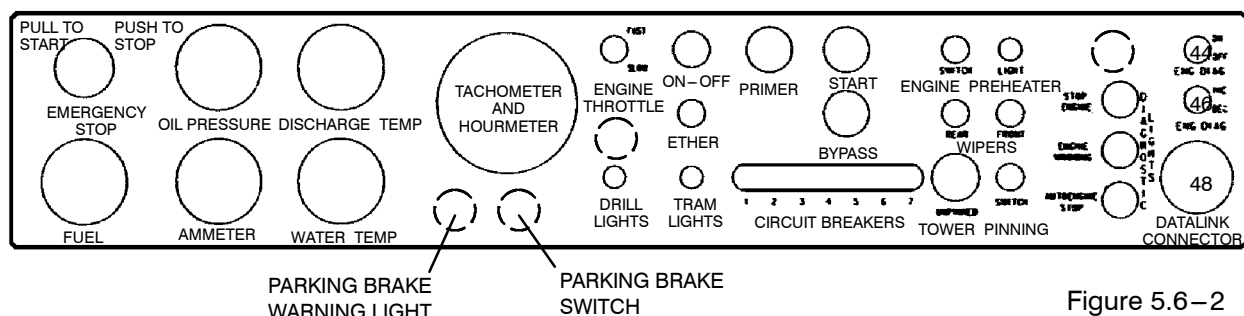


Figure 5.6–2

To test the parking brake effectiveness, attempt to tram the drill from a stationary position with the parking brake switch in the ON position. This test will indicate the condition of the brakes. The brakes are satisfactory if the drill cannot be moved.

NOTE:

Should the brake indicator light illuminate during tramping, call for service assistance to rectify the cause. Do not attempt to move the machine when the RED light remains illuminated. In the Propel mode, moving the Propel Controller levers from the STOP position should result in the Brake light extinguishing as the brakes automatically release.

NOTE:

Do not apply the parking brake when the drill is in motion. Severe wear and damage to the brake could occur.

Hydrostatic Brake System Check Procedure

1. Observe the area around the drill for personnel and obstructions.
2. Check for correct operation of the hydrostatic service brake system by tramping the drill in forward and reverse directions using the Propel Controllers to alternately accelerate and brake the drill movement.

NOTE:

Braking should be smooth and capable of bringing drill to a complete stop when Propel Controllers are placed in the STOP position. If not, you must contact service personnel immediately.

NOTICE

NOTE:

This drill rig is equipped with spring applied disc brakes which are automatically applied in the event of an engine shutdown or hose failure causing loss of brake release pressure.

5.6 -PROPEL OPERATION

RECOMMENDATIONS AND CHECKS (continued)

Propel (Tramming) the Drill

Check travel and work area for personnel and obstructions.

1. Make sure that all the controls are in the **neutral, stop** or **OFF** position. The Drill/Propel Selector should be in the **drill** mode position.
2. Start the engine (Refer to starting procedure in shown in *Engine Operation*).
3. When the engine, hydraulic and compressor oils have **all** reached 100°F (38°C), the drill can be operated.
4. Raise the Engine Throttle switch to full "operating" position.

NOTE: *Never use engine speed control to control the speed of travel.*

5. Move Propel/Drill Mode Selector to Propel. The main pump flow is diverted to the propel controllers. The drill may be moved. The brakes will automatically release as hydraulic flow to the propel motors increases.

NOTE:

The drilling end is considered the front end of the drill and F & R symbols relate to the respective directions of travel.

6. The Track Propel Controllers regulate the track direction, speed of travel, and the service braking function. To propel the drill in either Forward or Reverse direction, gradually move controller in the desired direction until the required propel speed and direction are effected. To slow and stop drill tramming, move the controller slowly towards the STOP position. Positioning the controller in the STOP position will halt drill propel movement and apply the brakes.



Figure 5.6–3

5.6 -PROPEL OPERATION

RECOMMENDATIONS AND CHECKS (continued)

Propel (Tramming) the Drill (continued)



LOSS OF MACHINE CONTROL

Moving the Propel Controllers (F-STOP-R) quickly may cause loss of drill control, lurching or serious injury. Move the Tram (Propel) control slowly.

7. Each Propel Track motor is operated independent from the other. Steer drill by moving the Propel Controllers (figure 5.6-3) and control the direction of track rotation of the respective Left Hand and Right Hand track. This way, the drill can be counter rotated when operating in a close area.



If the drill is moving and something causes the drill to start to run away, immediately move the Drill/Propel Selector to DRILL mode. This will shift the diverter valves to Drill and stop any more oil from passing through the propel motors. It will stop the drill.

8. During tramming, monitor the inclinometers (**option**) to ensure that drill does not exceed slopes of 20° in either direction of travel or at 90° to the line of travel. Refer to *Blasthole Stability/Gradeability Chart* in Section 3-SPECIFICATIONS & SYSTEMS.

Stopping Drill Propel

1. For normal braking, move Propel Controllers (figure 5.6-3) towards the **OFF** position.
2. To completely stop drill movement, position the Propel Controllers in the **OFF** position. The parking brake warning light (**option**) should illuminate.
3. Unless you are intending to move the drill immediately, move Drill/Propel mode selector switch to DRILL position. This action sets the brakes on the propel motors and keeps the tracks from moving.

5.7 - DRILL SETUP

LEVELING THE DRILL

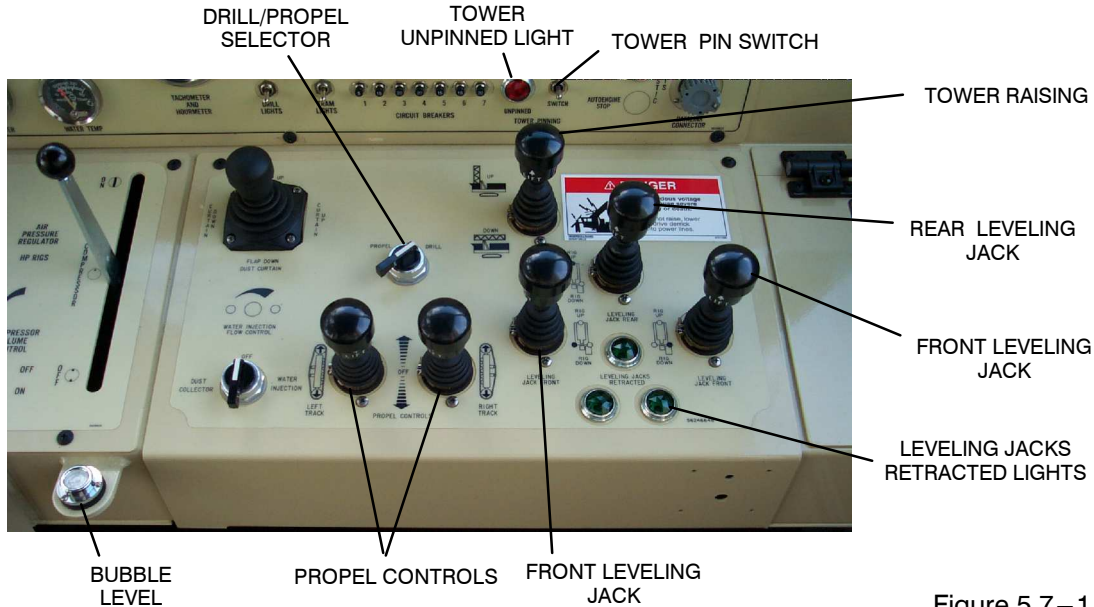


Figure 5.7-1

⚠ WARNING

Be sure the ground is level and solid before lowering jacks. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.

1. On arrival at the hole location, position the drill with the centralizer on the location of the hole.
2. Always check to see that the drill/propel mode selector is in the drill position and both propel controllers and the drill feed controller are at **stop** position.
3. Increase engine speed to 2100 rpm with the Engine Throttle Selector switch.
4. Evenly extend the three leveling jacks. Keep the drill level as indicated by the bubble in the level gauge.
 - a. First extend the two front (side) leveling jacks on the drilling end and level the drill side to side by adjusting the Front Levelling Jack Controllers (figure 5.7-1).
 - b. Extend the rear (non-drilling) end leveling jack with the Rear Leveling Jack Controller (see figure 5.7-1) and level the drill front to back until the level bubble is centered.

⚠ WARNING

Use adequate cribbing (blocking) under each jack to prevent the jacks from sinking into the ground and causing the drill to tip over. It is solely the operator's responsibility to ensure the drill does not turn over.

5.7 – DRILL SETUP

RAISING THE TOWER

Use the Tower Raise/Lower Controller (see Figure 5.7-1) to raise the tower. As the tower approaches a vertical position, slowly move the controller to its center position to allow the tower to position without impact. Never slam the tower into the vertical position.

TOWER PINNING

Position the Tower Pinning switch (see Figure 5.7-1) into the locked position and check that the tower Unpinned Warning Light is not illuminated. When the pin is fully engaged, the light should extinguish.

Check the level bubble (see Figure 5.7-1) and adjust leveling jacks as necessary to center the bubble. The tower is vertical when the bubble is centered.

NOTE: When the drill is being used with the Angle Drilling option, it is still necessary to level the drill before raising the tower to the required angle.

OVER PRESSURE CONTROL SYSTEM



Figure 5.7-2

Every drill is equipped with an Over Pressure Control System to help prevent tipping of the drill by over feeding during the drilling process. A pilot valve, mounted under each drilling end jack cylinder nipple, is closed as long as the jack is extended with the jack pad firmly on the ground. If the jack pad is raised off the ground, or the ground gives way under the pad, the nipple will push the pilot valve plunger down and open the compensator vent line on the main feed pump. This action reduces the feed pressure to zero (0) psi and prevents the drill rod from extending further. Both jack pads must be firmly on the ground so the pilot valve plungers extend and close. Pressure is then returned to the feed system.

5.7 – DRILL SETUP

Over Pressure Control Test

This Test Must Be Performed At The Start Of Each Shift.

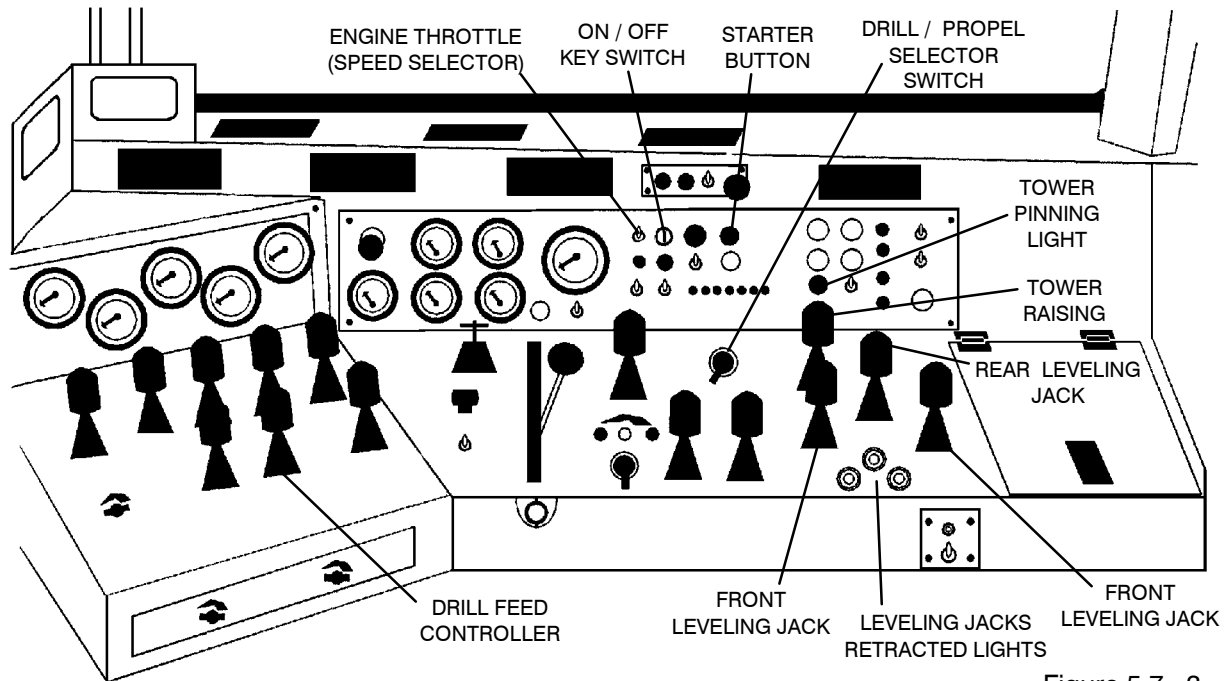


Figure 5.7–3

1. Raise the tower by following instructions in *Raising / Lowering the Tower Procedure*.
2. Retract both drilling end jacks off the ground (refer to *Leveling the Drill Procedure*)
3. Move the Drill Feed Controller to Pulldown.
4. There **Must Not Be Any Movement** of the feed system.
5. Move the Drill Feed Controller to the STOP position.
6. Extend one of the front (side) leveling jacks until it is firmly on the ground.
7. Move the Drill Feed Controller to Pulldown.
8. There **Must Not Be Any Movement** of the feed system.
9. Move the Drill Feed Controller to the STOP position.
10. Retract the jack and extend the other front (side) leveling jack until it is firmly on the ground.
11. Move the Drill Feed Controller to Pulldown.
12. There **Must Not Be Any Movement** of the feed system.
13. Move the Drill Feed Controller to the STOP position.

5.7 - DRILL SETUP

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5.8 - CAROUSEL

CAROUSEL

The Carousel (or Rod Holder) is used to transfer drill rod from the ground or another vehicle to the rotary head when adding or removing drill rod from the drill string.

After the carousel has been initially loaded with drill rod, it becomes a rod holder and is used to add and remove drill rod from the drill string.

The carousel is mounted on the Rod Changer and can be hydraulically positioned under the rotary head for loading drill rod from the carousel to the rotary head or unloading drill rod from the rotary head to the carousel..

The drill may be delivered to the worksite with or without drill rods loaded into the Rod Changer Carousel. Before tramping the drill to the hole location worksite, it is recommended that the carousel be loaded with a quantity of drill rods required up to a maximum of six (1 drill rod attached to the rotary head and 5 drill rods in the carousel). Refer to *Drill Pipe Change* in Section 3 - SPECIFICATIONS & SYSTEMS for more detailed information on the Rod Changer and Carousel.

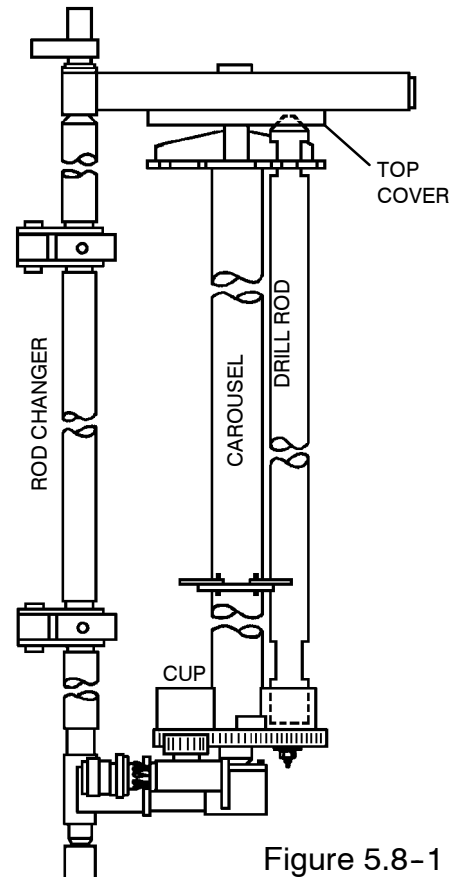


Figure 5.8-1

Jib Boom Position

When the drill is shipped from the factory, the Jib Boom is moved into the shipping position and bolted down for safe transportation.

Before attempting to load drill rod, the Jib Boom must be unbolted from the shipping position, moved to the operating position, and securely bolted down.

The Jib Boom is positioned with the pulley on the Boom in line with the opening on the carousel top cover plate

Figure 5.8-2

5.8 – CAROUSEL

Setup for Initial Carousel Loading

The following carousel loading procedure is recommended. Follow the operating instructions previously mentioned and:

1. Position the drill on a level, firm surface.
2. Move the propel/drill mode selector to DRILL.
3. Increase engine speed to 2100 rpm.
4. Evenly extend the three leveling jacks to maintain the level of the drill as indicated by the bubble in the level gauge.
 - a. First adjust the front jacks until the bubble is centered.
 - b. Adjust the rear jack until the bubble is centered.
5. Use the tower raise/lower control to raise the tower. As the tower approaches a vertical position, slowly move the control to its center position to allow the tower to position without impact.
6. Position the drill tower locking pin switch into the locked position and check that the drill tower locking pin disengaged warning light is not illuminated. When pin is fully engaged the light should extinguish.
7. Check the level bubble and adjust leveling jacks as necessary to center the bubble. The tower is vertical when the bubble is centered.

5.8 - CAROUSEL

Carousel Operating Procedure

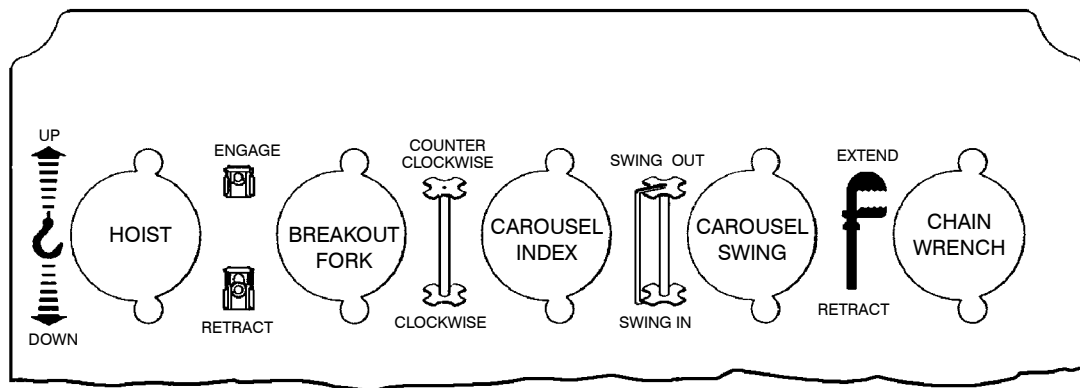


Figure 5.8-3

The instructions below are for operating the carousel prior to loading.

1. With the tower in the vertical position, use the Carousel Swing Controller to swing the carousel open all the way.
2. With the Carousel Index Controller, rotate the carousel so an empty drill pipe holding slot is in line with the opening on the carousel top cover.

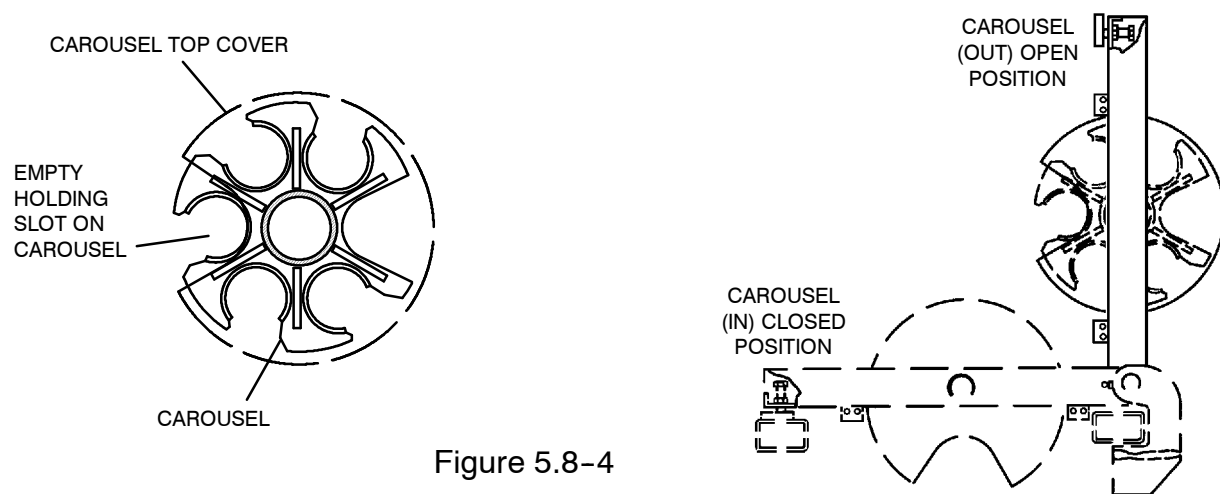


Figure 5.8-4

3. The Carousel Rod Holder is in position to accept the loading of drill rod from an external source.

5.8 - CAROUSEL

Initial Carousel Loading

The instructions below are for loading drill rod into the carousel. The drill rod may be from another vehicle or from on the ground.

1. With the tower in vertical position, use the hoist controller and lower the cable hook.
2. Connect the lifting bail to auxiliary hoist cable by inserting the cable hook into the eye at the top of the lifting bail. Be sure the hook locking device is working.
3. Extend the auxiliary hoist cable and attach the lifting bail to the drill rod to be picked up.

⚠ WARNING

Drill rod being pulled from a vehicle or the ground can become dangerous if not handled properly. Keep drill rod under control at all times.

4. If the drill rod is on a trailer or flatbed truck, a “tag” line should be employed to restrain the box end as the drill rod is lifted by the hoist. The drill rod must be prevented from sliding off the trailer or stack and causing harm.

⚠ WARNING

The Lifting Bail must be securely connected to the Drill Rod before any movement of the drill rod is attempted.

Failure to do so may result in the drill rod falling and causing injury.

5. Raise the lifting bail and drill rod while a helper controls the movement of the drill rod until it is hanging from the jib hoist next to the carousel.
6. A means of controlling the box end of the drill rod must be utilized, such as a second man to guide the box end or by using a Tag line that plays out as the drill rod is lifted.

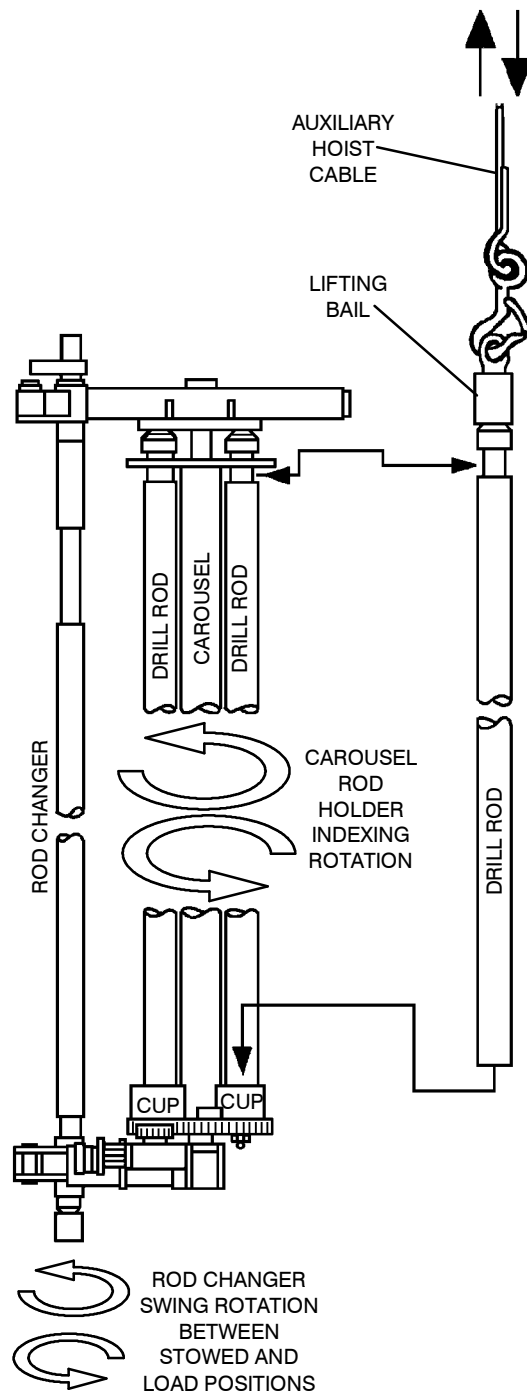


Figure 5.8-5

5.8 - CAROUSEL

Initial Carousel Loading (continued)

7. With the Carousel Swing Controller, swing the rod changer into position to align the drill rod with the cup on the bottom of the carousel.
8. Raise or lower drill rod and adjust the carousel swing until the necked down section at the upper pin end fits into the upper slotted area of the carousel. Align the hex sides of the box end of the drill rod with the hex sides of the cup (sometimes called hex chuck) on the bottom of the carousel rod holder.
9. Lower the drill rod into cup until the weight is off the lifting bail.
10. Lower the tower to horizontal position. Using 3 point contact, use the drill tower structure to access and detach the lifting bail from the drill rod.

WARNING

Make sure the drill rod is secured in both upper and lower sections of the carousel before removing the lifting bail. The drill rod may fall off if not held securely.

11. Raise the tower to the vertical position.
12. Rotate carousel so an empty drill pipe holding slot is in line with the opening on the carousel top cover.
13. Use the Carousel Swing Controller to swing the rod changer open all the way.
14. Using the hoist controller, lower and attach the lifting bail to the next drill rod that will be loaded from the truck or ground.
15. Repeat above procedure until the carousel rod holder is loaded.

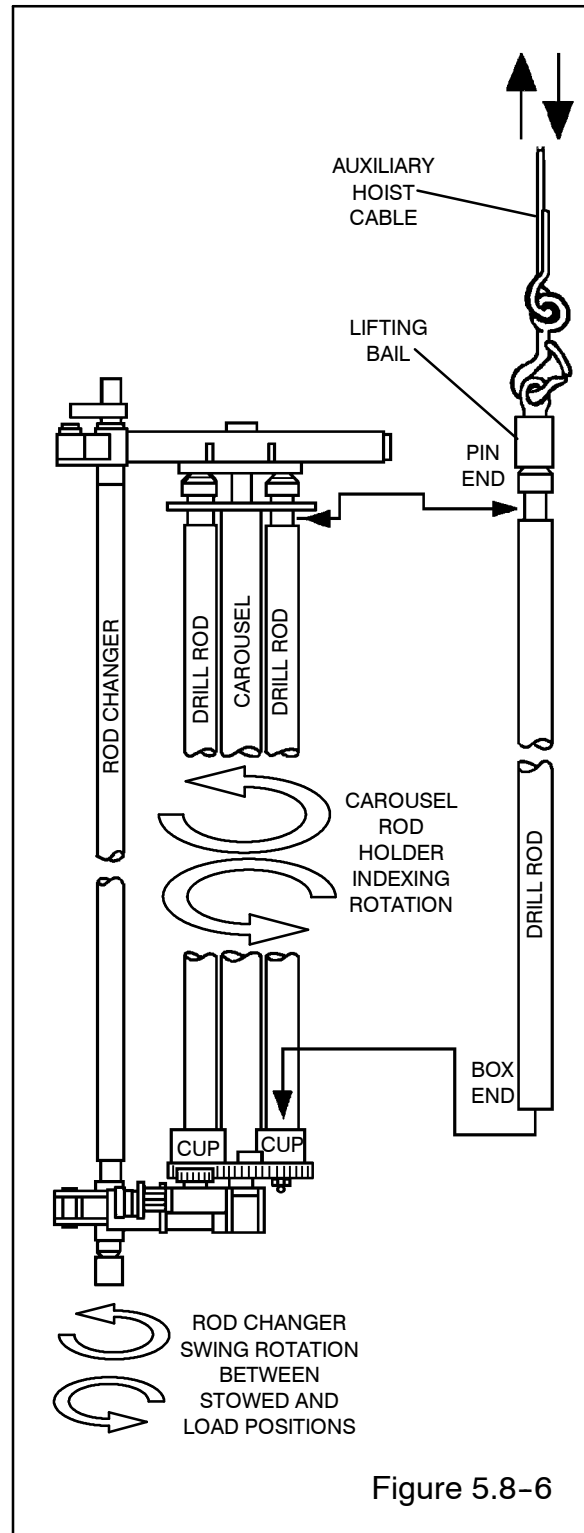


Figure 5.8-6

5.8 - CAROUSEL

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5.9 - DRILL ROD HANDLING

ADDING DRILL ROD PROCEDURE

Drill rod is stored in the carousel rod holder and is indexed (rotated) into position to connect to the rotary head. The following procedure applies to all Mid-Range drills. Follow the operating instructions previously mentioned and:

1. Position the drill on a level, firm surface.
2. Move the propel/drill mode selector to DRILL.
3. Increase engine speed to 2100 rpm.
4. Evenly extend the three leveling jacks to maintain the drill level as indicated by the bubble in the level gauge.
 - a.) First adjust the front jacks until the bubble is centered.
 - b.) Adjust the rear jack until the bubble is centered.
5. Use the tower raise/lower control to raise the tower. As the tower approaches a vertical position, slowly move the control to its center position to allow the tower to position without impact.
6. Position the drill tower locking pin switch into the locked position and check that the drill tower locking pin disengaged warning light is not illuminated. When pin is fully engaged the light should extinguish.
7. Check the level bubble and adjust leveling jacks as necessary to center the bubble. The tower is vertical when the bubble is centered.
8. Raise rotary head to top of tower using fast feed.
9. Make sure drill rod is in the correct position on the carousel.
10. Swing the carousel into loading position with drill rod under rotary head.
11. Engage clockwise rotation slowly.
12. Using the drill feed, lower the rotary head slowly until the threads are engaged. Watch the carousel for an indication of extra loading and listen to the threads making contact.
13. Continue rotating until drill rod revolves in the bottom cup against stop on carousel. Stop rotation.
14. If drill rod rotation is forcing cup against the stop, move the drill rod in a counter clockwise rotation slightly to free the rod.
15. Raise drill rod out of carousel cup and swing the carousel all the way into the open position.



Be sure a good joint has been made by looking up at the connection between the spindle adapter and the upper pipe joint before moving the drill rod.

5.9 - DRILL ROD HANDLING

ADDING DRILL ROD PROCEDURE (continued)

16. Using drill feed, lower the drill rod onto the next joint after lubricating the threads properly.
17. Engage clockwise rotation slowly.
18. Tighten joint securely. Raise drill string slightly to allow removal of the sliding fork wrench or J-Wrench if it was used.

Add Drill Rod to Drill String

Follow the procedure below to add drill rod to the drill string. Follow the operating instructions previously mentioned and:

1. Using proper drilling technique, drill down until the flats on the pin end of the drill rod pass below the drill table. Reverse feed and bring flats on drill rod above the table.
2. Stop rotation. Switch off lubricator if it is being used. Turn off the water pump if it is being used. Turn off drill air.

3. **Low Pressure Drills** – Turn off drill air by moving the Compressor Control Lever (LP Only) to OFF. The air in the drill string will vent and be relieved from drill string.

High Pressure Drills – Use the Drill Air Throttle (HP Only) to turn off drilling air during drill rod or hammer changes. The air in drill string will vent and be relieved from the drill string.



HIGH PRESSURE
DRILL AIR THROTTLE

LOW PRESSURE
CONTROL LEVER

Figure 5.9–1

4. Engage the sliding fork wrench (drill rod retainer) controller and insert sliding breakout wrench on to the flats of the drill rod.
5. Use full counter clockwise rotation power to break the joint. As threads disengage, use drill feed in the UP position to allow threads to separate. When joints are separated, stop rotation. Stop Feed.
6. Use fast feed to raise rotary head to top of tower.
7. Position the drill rod in carousel. Swing carousel in under the rotary head. Using drill feed, lower the rotary head.
8. Start slow clockwise rotation. Continue to lower the rotary head until the spindle adapter makes contact with the pin end of the drill rod.
9. Tighten joint threads until the drill rod cup at the bottom of the carousel rotates.

5.9 – DRILL ROD HANDLING

ADDING DRILL ROD PROCEDURE (continued)

Adding Drill Rod to Drill String (continued)

WARNING

Be sure a good joint has been made by looking up at the connection between the spindle adapter and the upper pipe joint before moving the drill rod.

10. Stop rotation. Raise drill rod out of the carousel.
11. Swing the carousel out of the way.
12. Lubricate the drill rod threads.
13. Use drill feed to lower the drill rod onto threads of the drill rod in the table.
14. Start slow rotation until joint is tight.
15. Stop feed and rotation.
16. Raise the drill string with drill feed only high enough to relieve pressure on the sliding fork wrench (drill rod retainer). Disengage the sliding fork wrench (drill rod retainer) from the drill string. Resume drilling.
17. Refer to *Rotary Drilling Procedures* or *DHD Drilling Procedures* for information on drilling procedures.

Remove Drill Rod From Drill String

1. Raise the rotary head, with drill string, to top of tower until the upper flats on the bottom drill rod line up with the sliding fork wrench on the drill table.
2. Stop feed and rotation. Engage the sliding fork wrench on the upper flats of bottom drill rod.
3. Use counter clockwise rotation to break the joint at the table. **Watch upper joint between the drill rod and spindle sub when breaking the joint.**

WARNING

If upper joint comes loose instead of lower one, stop rotation immediately. The drill rod can come loose and fall.

4. If the upper joint breaks loose first, tighten the joint up with clockwise rotation.
5. Use the chain wrench on side of tower to break the lower joint. Retract and extend the chain wrench cylinder back and forth until the joint breaks.
6. Remove and move chain (breakout) wrench and cylinder out of the way.
7. Use reverse rotation and feed to finish unscrewing the drill rod.

5.9 – DRILL ROD HANDLING

ADDING DRILL ROD PROCEDURE (continued)

Remove Drill Rod From Drill String (continued)

8. Raise the rotary head and drill rod to the top of the tower.
9. Make sure the carousel is indexed properly (See *Carousel Operating Procedure* in the CAROUSEL Section) . Swing the carousel in line with the drill rod.
10. Feed the rotary head down until the hex area on box end of the drill rod is in the lower carousel cup. The upper pin end of drill rod must be seated in the upper carousel holding slot. Refer to *Carousel Operating Procedure* in CAROUSEL Section
11. Use full counter clockwise rotation to break the joint between the spindle adapter and the drill rod. Use drill feed in up position to detach threads.
12. Index the carousel into position to accept the next drill rod and swing the carousel out of the way into the open position.
13. Fast feed rotary head to the bottom of the tower until the spindle is just above the threads of the drill rod in the table. Stop the rotary head.
14. Lubricate the threads on the drill rod.
15. Feed down the rotary head until the spindle threads contact the drill rod threads.
16. Start slow forward rotation until the connection is tight. Stop feed and rotation.
17. Raise drill string slightly to remove pressure on the sliding fork wrench.
18. Disengage the sliding fork wrench.
19. Start forward rotation and drill feed. Raise the rotary head, and one drill rod, to the top of tower until the upper flats on the bottom drill rod line up with the sliding fork wrench on the drill table.
20. Repeat the process for each drill rod in hole.

5.10 - ROTARY DRILLING PROCEDURES

DESCRIPTION

Rotary drilling methods use the combination of raw weight and rotation to chip and carve rock from a hole. The rotary method works fine in soft formations where adequate weight and stress can be applied to the rock to initiate fracture and chipping.

Rotary drilling is done by rotating a Tricone bit against the rock while using down pressure to crush the rock. A stabilizer is normally used to keep the hole straight and to prevent the bit from becoming stuck.

After the drill has been set up for drilling, there are a number of operations which involve handling heavy drill rods, drill bits and other components used for various drill rod and drill bit changing procedures.



Heavy components must be handled with care using appropriate lifting aids provided to facilitate heavy component lifting operations.

Rotary Drill String Tools and Accessories

The following are drill string tools and accessories used in rotary drilling for installing or changing the Tricone drill bit and breaking tight threaded joints between drill rods, rotary head, spindle or bits.

1. Rotary Head	10. Rotary Head Spindle
2. Auxiliary Hoist (Tower Mounted)	11. Auxiliary Hoist Cable
3. Lifting Bail	12. Spindle Sub
4. Chain Wrench	13. J-Wrench
5. Drill Pipe	14. Angle Drill Support (Option)
6. Drill Pipe Centralizer Bushing	15. Table Centralizer Bushing
7. Drill Split Bushing	16. Drill Bit Sub
8. Optional Stabilizer	17. Sliding Fork Wrench (Drill Rod Retainer)
9. Tricone Bit	18. Bit Basket

5.10 – ROTARY DRILLING PROCEDURES

Rotary Drill String Tools and Accessories (continued)

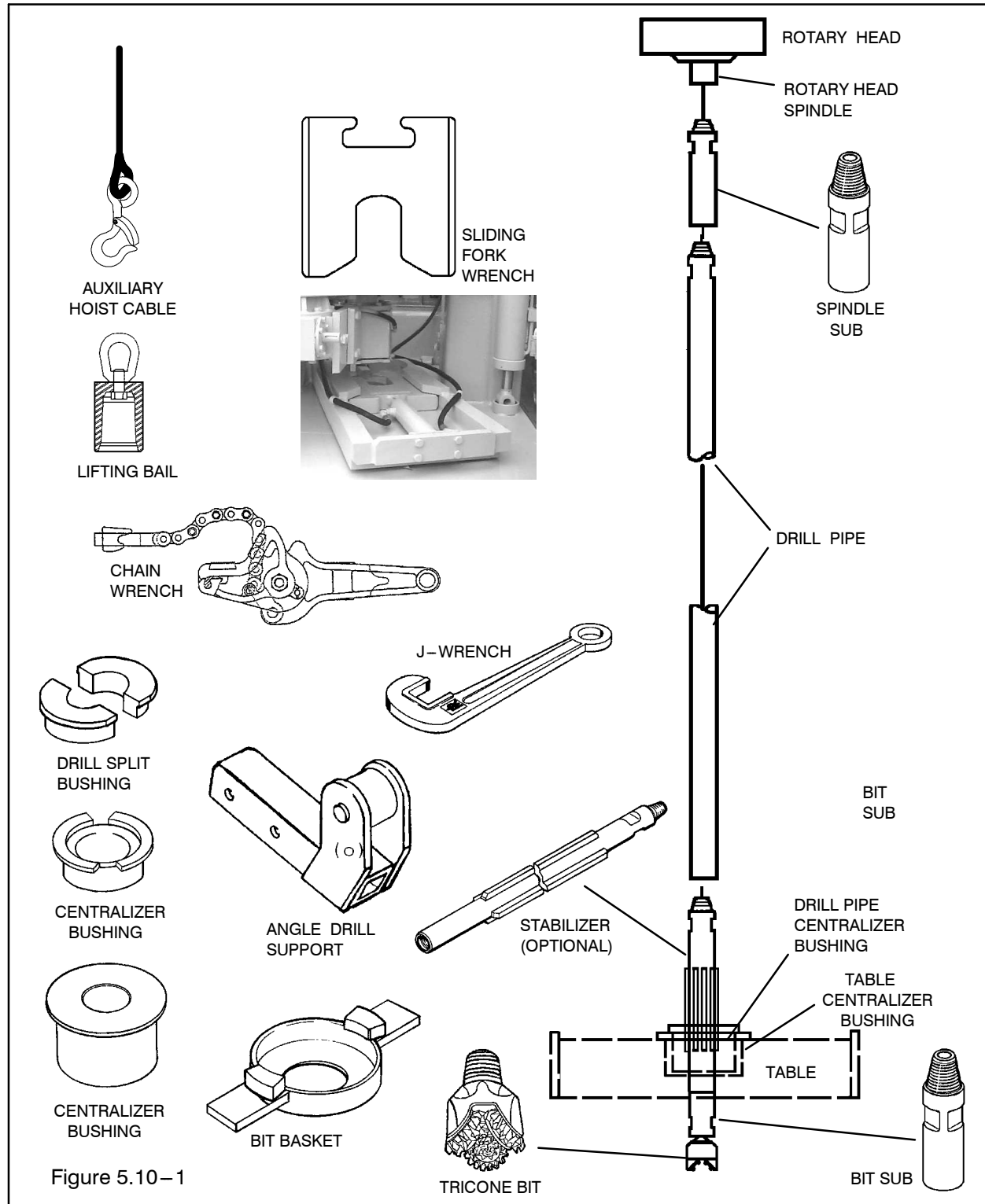
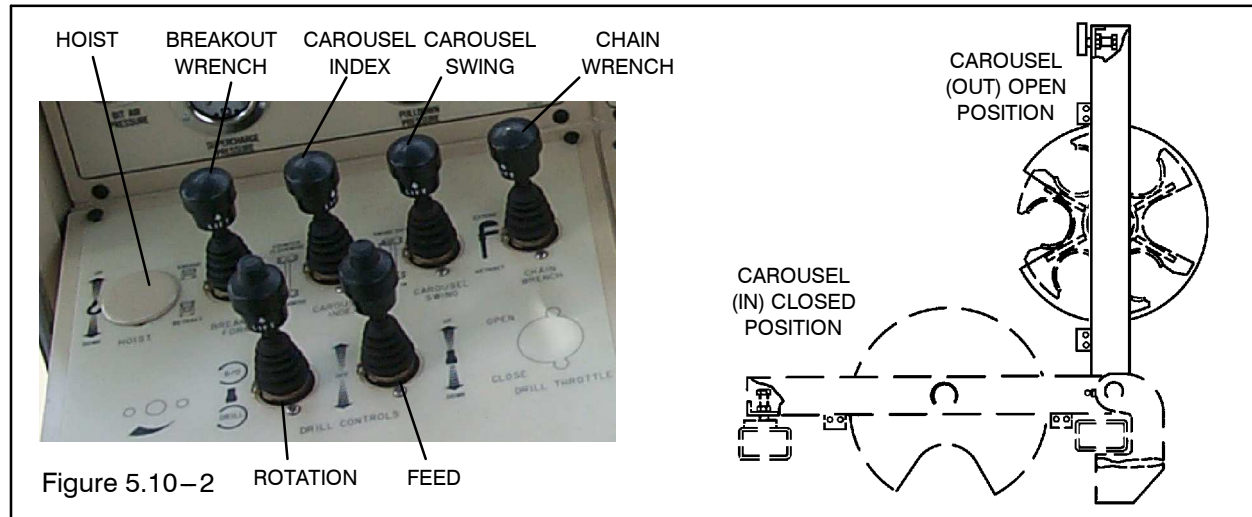


Figure 5.10–1

5.10 - ROTARY DRILLING PROCEDURES

Stabilizer Installation Procedure

The procedure below is for installing the Stabilizer (option) or Starter Rod. Before starting, be sure the rotary head is at the top of the tower and the rod changer/carousel is in the open (out) position.



1. Install the correct lifting bail on the pin end of the stabilizer. Use the auxiliary hoist to raise the stabilizer and line it up over the table.

⚠ WARNING

Be sure a good joint has been made by looking at the connection between the lifting bail and the stabilizer pin end threads before moving the stabilizer.

2. Put a block of wood or metal on the ground under the drill table so the stabilizer can rest on the ground while making connections. For short stabilizers, secure upper section in sliding fork wrench so rotary head can be threaded to it.
3. Lower stabilizer through table and onto the block of wood or plate on ground.
4. Remove lifting bail and move the auxiliary hoist cable out of the way.
5. Lubricate thread joints properly.
6. Install stabilizer bushings around the stabilizer.
7. Feed rotary head down to engage threads on pin end of stabilizer. Using slow forward rotation, tighten the stabilizer securely.
8. Raise stabilizer above table.

5.10 – ROTARY DRILLING PROCEDURES

Tricone Bit Installation Procedure

The procedure below is for installing the Tricone drill bit on the stabilizer (option) or Starter Rod. Note that the procedure is the same if you are installing the Tricone bit directly onto the drill rod.

1. With the stabilizer above table, remove the stabilizer bushings.
2. Install the rotary (Tricone) bit basket and the appropriate insert in the drill table.
3. Insert the Tricone bit into the insert in the bit basket.
4. Lubricate the threads on tricone bit.
5. Using the rotary head feed controller, lower the stabilizer (or drill rod) down onto the threads on the bit and tighten securely by using slow forward rotation.



Be sure a good joint has been made by looking at the connection between the lifting bail and the stabilizer pin end threads before moving the stabilizer.

6. Raise rotary head up until the Tricone bit clears the bit basket.
7. Remove the bit basket and store it out of the way.
8. Lower the stabilizer until the bit is below the table.
9. Install centralizer bushing.
10. Turn compressor on.
11. Turn on the drill air throttle (HP Only).
12. Turn on forward rotation and adjust speed.
13. Use drill feed in the down position to start drilling. Adjust down pressure with the drill feed pressure control (sometimes called remote relief valve).
14. Adjust rotation speed as required.

5.10 – ROTARY DRILLING PROCEDURES

Rotary Drilling Procedure

1. Make sure the stabilizer or bit sub, rotary bit and drill rod are installed correctly.
2. The engine speed should be 2100 RPM.
3. Turn on the drill air throttle (HP drills only) or Compressor ON (LP drills only). Refer to the instructions in the *COMPRESSOR OPERATION* section.
4. Push drill rotation controller to clockwise (forward) position. With the controller, adjust to slow rotation speed for starting the hole.

NOTE:

Rotation is only possible when the Drill / Propel Mode Selector is in the DRILL mode position.

5. Turn on the dust collector if necessary. Turn on the water pump if water injection is required at startup
6. Use drill feed controller in the DOWN position until the bit contacts the ground.
7. The first several feet or meters of drilling is called “overburden”. It usually consists of soft soil, broken rock, gravel or clay. When drilling through this mixture, care must be taken to prevent excessive cuttings from being blown out of the hole and causing a washout.
8. Adjust the rotation and feed speed to fit the type of overburden being drilled.
9. Use the drill feed controller in the DOWN position to start drilling. Adjust down pressure with the drill feed pressure control.
10. Adjust the rotation and the feed speed (down pressure) as required by checking the rotation and pulldown gauges.
11. Watch the cuttings coming from the hole to determine what type formation you are drilling through.
12. Using proper drilling technique, drill down until the flats on the pin end of the drill rod pass below the drill table. Reverse feed and bring flats on drill rod above the table.
13. Stop rotation. Switch off dust collector if it is being used. Turn off water pump if it is being used. Turn off drill air.
14. Follow the procedures in *Adding Drill Rod to Drill String* and resume drilling.
15. Follow the procedures in *Removing Drill Rod from Drill String*.

5.10 – ROTARY DRILLING PROCEDURES

Rotary Bit Changing Procedure

The procedure below is used when changing or replacing a rotary bit during the rotary drilling process.

1. Feed the drill rod up until the rotary bit is just below the table and raise the centralizer bushing.
2. Feed the drill rod up until the bit is above the table.
3. Install the bit basket.
4. Lower the bit into the bit basket.
5. Install the chain wrench onto the chain wrench hydraulic cylinder.
6. Connect the the chain wrench onto the drill rod.
7. Extend the chain wrench.
8. Retract the chain wrench to break the bit loose from the drill rod.
9. When the bit is loose, remove and move the chain wrench out of the way.
10. Use reverse rotation to unscrew the bit from the drill rod.
11. Use slow feed up to allow the bit threads to unscrew. Raise the drill rod above the bit.
12. Remove the old bit from the bit basket and replace it with the new bit.
13. Lubricate the threads on the new bit.
14. Lower drill rod onto bit.
15. Use slow forward rotation to tighten bit into drill rod.
16. Tighten securely.
17. Raise drill rod assembly above table.
18. Remove bit basket.
19. Lower drill rod until bit is below table.
20. Install centralizer bushing.
21. Turn on drill air throttle (HP drills only) or Compressor ON (LP drills only).
22. Engage drill rotation controller in the forward position and adjust rotation speed.
23. Use drill feed in the down position to start drilling. Adjust down pressure with the feed pressure control rotary switch.
24. Adjust rotation speed as required.

5.11 - DHD DRILLING PROCEDURES

DESCRIPTION

DHD's achieve high productivity in hard rock applications by adding percussion to the drilling process. In harder rock, the rotary method cannot supply sufficient load on the bit inserts to crack the rock and produce a chip.

Percussion drills overcome the rotary bit load limitation by producing a very high load during impact on the hammer. This load is sufficient to drive the cutting inserts into the rock to produce chips.

DHD's operate by using the position of a piston to direct supply and exhaust air to and from drive and return volumes. The drive volume "drives" the piston toward impact and the return volume "returns" the piston in preparation for another impact stroke.

Refer to *Ingersoll-Rand Technical Manual for "Quantum Leap" Downhole Drills , TM6121 (Part Number 52117397)* for detailed information on Model QL Series Downhole Drills.

After the drill has been set up for drilling, there are a number of operations which involve handling heavy drill rods, downhole hammers, drill bits and other components used for various drill rod and drill bit changing procedures.



Heavy components must be handled with care using appropriate lifting aids provided to facilitate heavy component lifting operations.

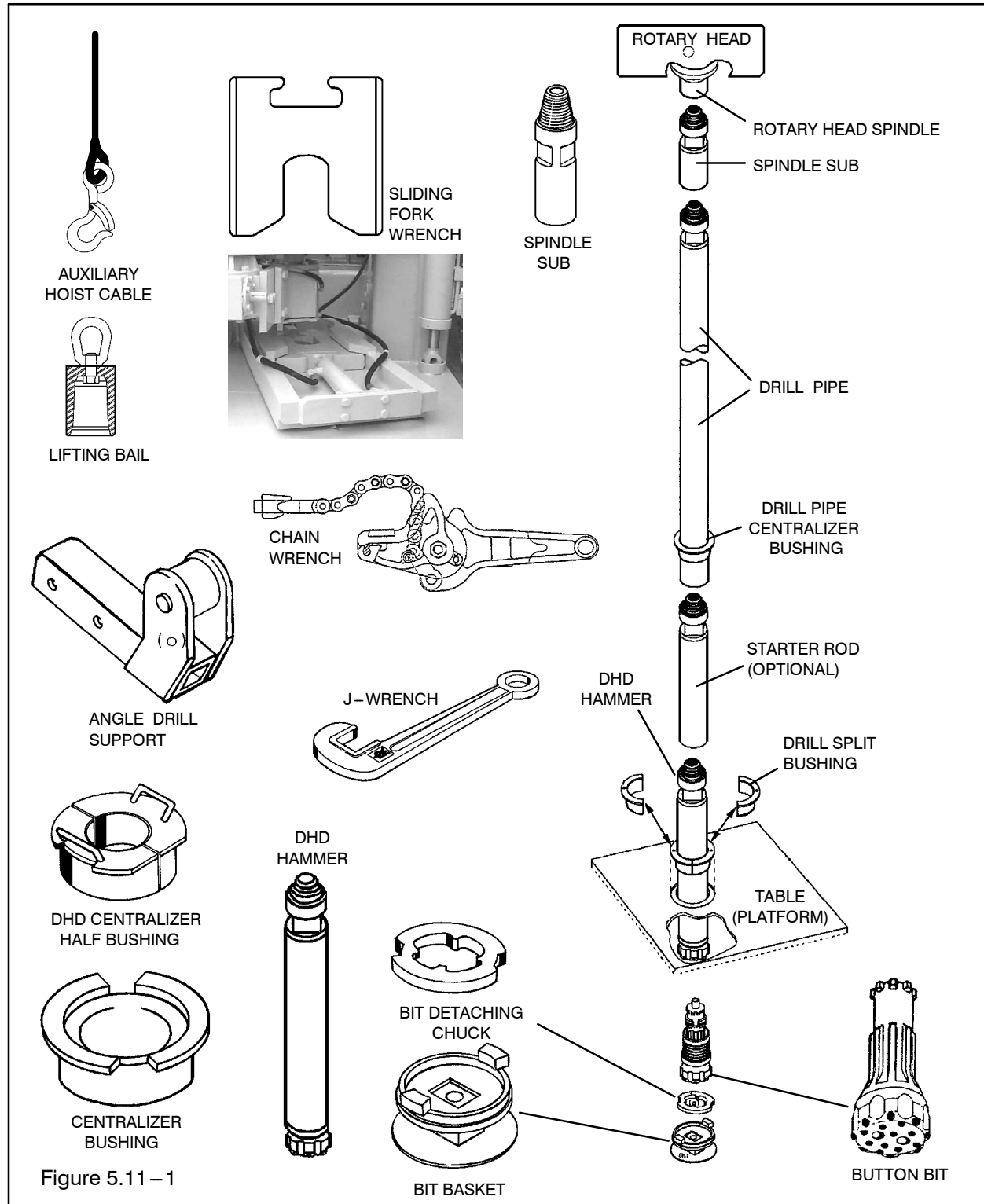
Downhole Drill String Tools and Accessories

The following are drill string tools, accessories and items involved with respect to loading the carousel, changing drill rod, installing and removing the DHD hammer, bit changing and releasing tight threaded joints between drill rods, DHD, DHD chuck, and rotary head spindle.

1. Rotary Head	10. Rotary Head Spindle
2. Auxiliary Hoist (Tower Mounted)	11. Auxiliary Hoist Cable
3. Lifting Bail	12. Spindle Sub
4. Chain Wrench	13. J-Wrench
5. Drill Pipe	14. Angle Drill Support (Option)
6. Drill Pipe Centralizer Bushing	15. DHD Centralizer Half Bushings
7. DHD Hammer	16. Button Bit
8. Starter Rod	17. Sliding Fork Wrench (Drill Rod Retainer)
9. Bit Basket	18. Bit Detaching Chuck (to fit button bit)

5.11 – DHD DRILLING PROCEDURES

Downhole Drill String Tools and Accessories (continued)



5.11 – DHD DRILLING PROCEDURES

DHD PROCESSES

Downhole drilling with a DHD consists of several processes. There is an order that should be followed to maximize performance. To downhole drill, an operator must: Install the DHD on the rotary head, Install a Button Bit on the DHD, Install a Starter Rod to the DHD, Start the Compressor, Starting the hole with the DHD, Add Drill Rod to the Drill String, Follow DHD Drilling Procedures, Remove the Drill Rod, Remove the DHD from Drill String, Remove the Bit from DHD and follow some General Hints.

DHD Installation

The Downhole Hammer Drill must be connected to the rotary head and be lifted so the Button Bit can be installed.

1. Remove the Drill Bushing from the table (tower bottom).
2. Attach the lifting bail to the backhead of the DHD.
3. Lower hoist cable until the cable hook can be installed into lifting bail.
4. Lift the DHD above the table and lower it through the hole in the drill table until the wear sleeve is about halfway below the table.
5. Install DHD centralizer half bushings around the DHD to secure it. Lower the DHD until the flats on the backhead are just above the split bushings. Stop lowering.
6. Install J-Wrench over flats on the backhead with long handle wrench against the derrick.
7. Lower the cable until the DHD hangs on the J-Wrench.
8. Remove lifting bail and secure the hoist cable.
9. Use the fast drill feed control to lower the rotary head until the spindle is just above the DHD backhead threads and stop.
10. Lubricate the threads on the backhead of the DHD with the correct thread grease. Select the proper grade of grease in accordance with instructions given in the *Lubricant Specifications* section of Section 6 MAINTENANCE.
11. Lower the rotary head until the spindle threads contact the threads on the DHD .
12. Start slow forward (clockwise) rotation and lower the rotary head until the connection is tight and the J-Wrench starts to move.

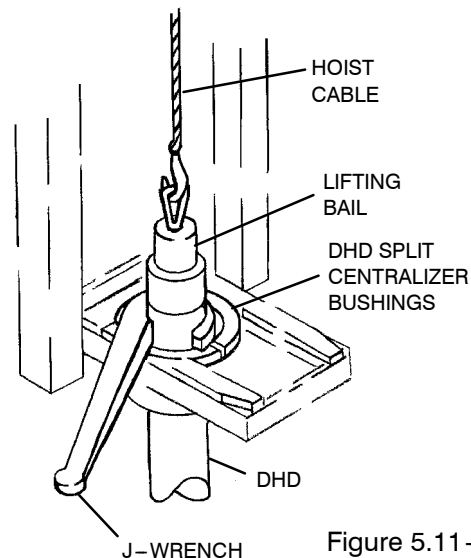


Figure 5.11–2

5.11 – DHD DRILLING PROCEDURES

DHD Installation (continued)

13. Stop rotation. Move rotary head up slowly to free the DHD from the J-Wrench. If the wrench is dragging against the tower, reverse rotation slightly until the wrench is free.
14. Remove the J-Wrench.
15. Using the Drill Feed Controller to regulate the speed, raise the DHD up out of the table.

DHD Button Bit Installation

The Button Bit must be installed on the Downhole Hammer Drill.

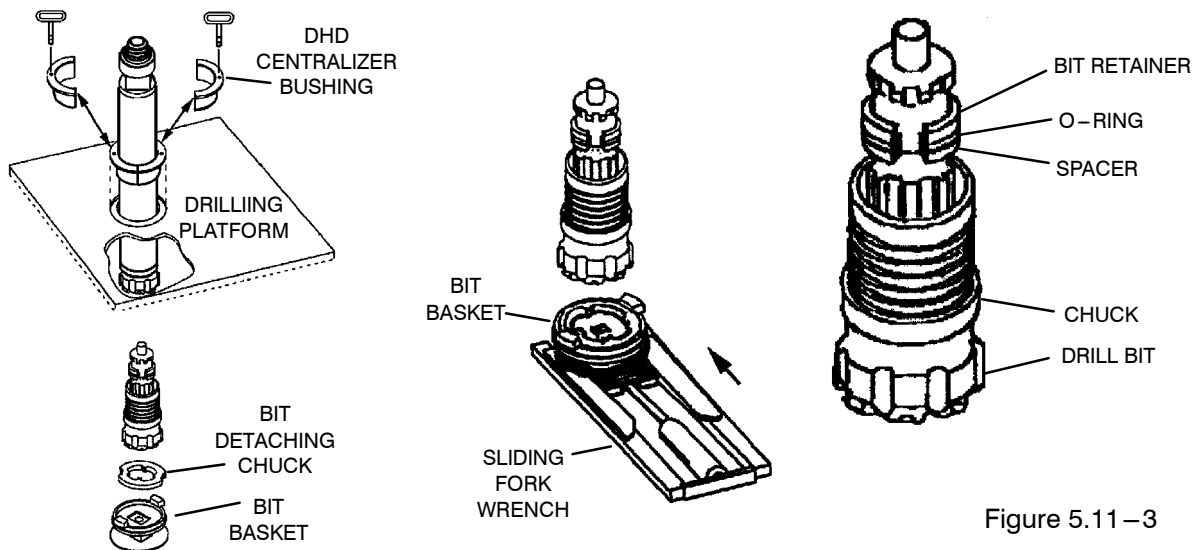


Figure 5.11–3

1. Remove the Drill Bushings from table and install the correct size Bit Basket and Bit Detaching Chuck for the size bit to be used into the drilling platform recess.
2. To prevent rotation of the Bit Basket, slide the Sliding Fork Wrench forward to engage the flats of the bit basket.
3. Manually insert the Button Bit into Bit Basket, being careful not to damage inserts.

NOTE:

*The Button inserts on a DHD bit are made to take a large force in one direction only and that is straight up. If a button receives a blow from any other direction, it may break. **Handle bits with care.***

4. Feed rotary head down until DHD is about 10 inches (25 cm) from the top of the bit. Stop feed.
5. Remove DHD bit chuck and retainers from DHD by unscrewing them.

5.11 – DHD DRILLING PROCEDURES

DHD Button Bit Installation (continued)

6. Install DHD BIT chuck and retainers on button bit and lubricate threads on chuck.

NOTE:

Bit Splines should be well lubricated with Rock Drill Oil or thread grease before the chuck is installed over the splines. Additionally, the threads on the chuck should be well coated with thread grease before threading the chuck into the DHD. Remember to install the bit retaining ring halves before threading the chuck into the DHD.

NOTE:

Follow Actual Manufacturer's Lubrication Instructions when using DHD Hammers. Rock Drill Oil is only used on Ingersoll-Rand DHD's..

7. Slowly feed the rotary head down until the DHD is over the top of the bit. Stop feed.
8. Slide the chuck and retainers up to make contact with the threads on the DHD.
9. Engage forward rotation slowly and hold the chuck in position so it threads up on the DHD. Tighten securely.
10. Stop rotation. Feed DHD with bit up to clear the bit basket and remove the basket.
11. Feed the DHD and bit down through the table until the bit and bit chuck are below the table top.
12. Install DHD split bushings.

NOTE:

The table may be close enough to the ground to prevent hanging the DHD and bit on the backhead. If this is the case, a shallow hole can be drilled, with the DHD connected to the rotary head, to allow it to be left in the table while loading a piece of drill pipe in the rotary head.

Installing Starter Rod to DHD

The starter rod (or drill rod) must be connected to the DHD and the rotary head.

1. Connect DHD and Bit assembly to the rotary head and drill down until DHD can be removed at the table.
2. Remove DHD from rotary head by inserting the J-Wrench on backhead flats of the DHD and using reverse rotary head rotation.
3. After DHD is unthreaded, use reverse rotary head rotation and raise the rotary head to the top of the tower. The DHD will be hanging off of the J-Wrench.

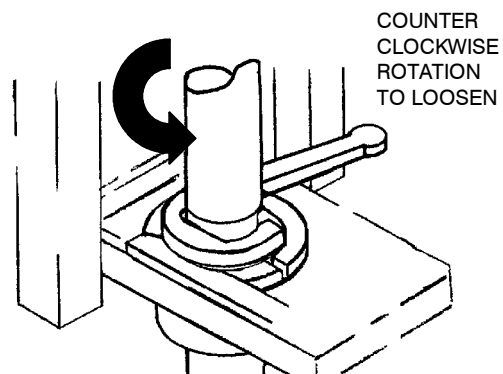


Figure 5.11–4

5.11 - DHD DRILLING PROCEDURES

Installing Starter Rod to DHD (continued)

4. Install a drill rod from the carousel onto the rotary head. (*See Adding Drill Rod Procedure*).
5. Lower rotary head and drill rod, stopping to place the drill rod centralizer bushing on the drill rod.
6. Lubricate the threads on the backhead of the DHD with the correct thread grease. Select the proper grade of grease in accordance with instructions given in the *Lubricant Specifications* section of Section 6 MAINTENANCE.
7. Slowly lower rotary head and drill rod, which should be slowly rotating clockwise, and tighten on to the DHD.
8. Stop feed and rotation when drill rod is tightened on to the DHD.
9. Raise the rotary head until the DHD is high enough above the table to allow removal of the J-Wrench and remove the J-Wrench.
10. Down feed, allowing the drill rod centralizer bushing to seat in the table centralizer.
11. Turn on the compressor (Follow the instructions in the *High Pressure Compressor* section of Section 3-SPECIFICATIONS & SYSTEMS).
12. Using the compressor and DHD, drill a hole the length of the drill pipe (*See DHD Drilling Procedures*).
13. Raise the rotary head and drill rod to top of tower.
14. Stop feed and rotation. Shut off the drill air throttle. Turn off the lubricator.
15. Remove the DHD from the drill rod using the J-Wrench. (*See Removing DHD from the Drill String Procedure*).
16. Remove the drill rod and load it into the carousel (*See Removing Drill Rod from Drill String Procedure*).
17. Use the lifting bail and the auxiliary hoist cable to lift the starter rod and hang it over the DHD.
18. Install the drill rod centralizer over the starter rod before manually connecting the starter rod to the DHD. It will hang on top of the DHD backhead.
19. Lubricate the threads on the backhead of the DHD with the correct thread grease.
20. Slowly lower the starter rod until the threads make contact with the DHD. Manually tighten the connection.

5.11 - DHD DRILLING PROCEDURES

Installing Starter Rod to DHD (continued)

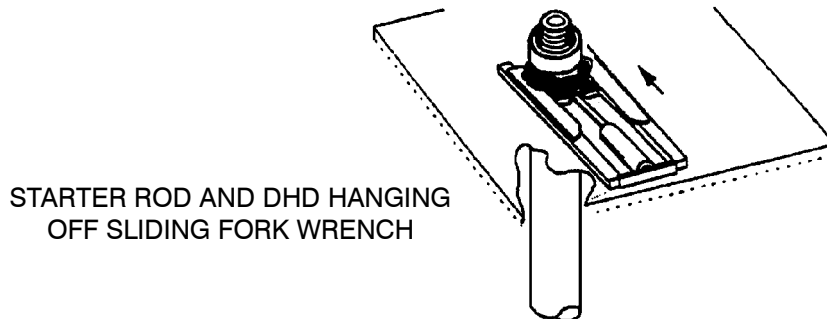


Figure 5.11–5

21. Using the hoist, raise the DHD and starter rod until the J-Wrench can be removed.
22. Lower the DHD and the starter rod into the hole until the fork wrench can be installed on the flats of the starter rod.
23. Remove the lifting bail and secure the hoist cable out of the way.
24. Bring the rotary head down close to the pin end of the starter rod. Stop feed.
25. Lubricate the threads of the starter rod.
26. Slowly lower the rotary head, which should be slowly rotating clockwise, to tighten on to the starter rod.

NOTE:

An alternative method is to use the lifting bail to pick up the starter rod until the DHD can be attached manually. Raise the DHD and starter rod and then carefully lower through the centralizer in the table and set it on the ground. A **manlift** must be used to remove the lifting bail and guide the rotary head on to the pin end of the rod.

5.11 - DHD DRILLING PROCEDURES

Starting the Hole with a DHD

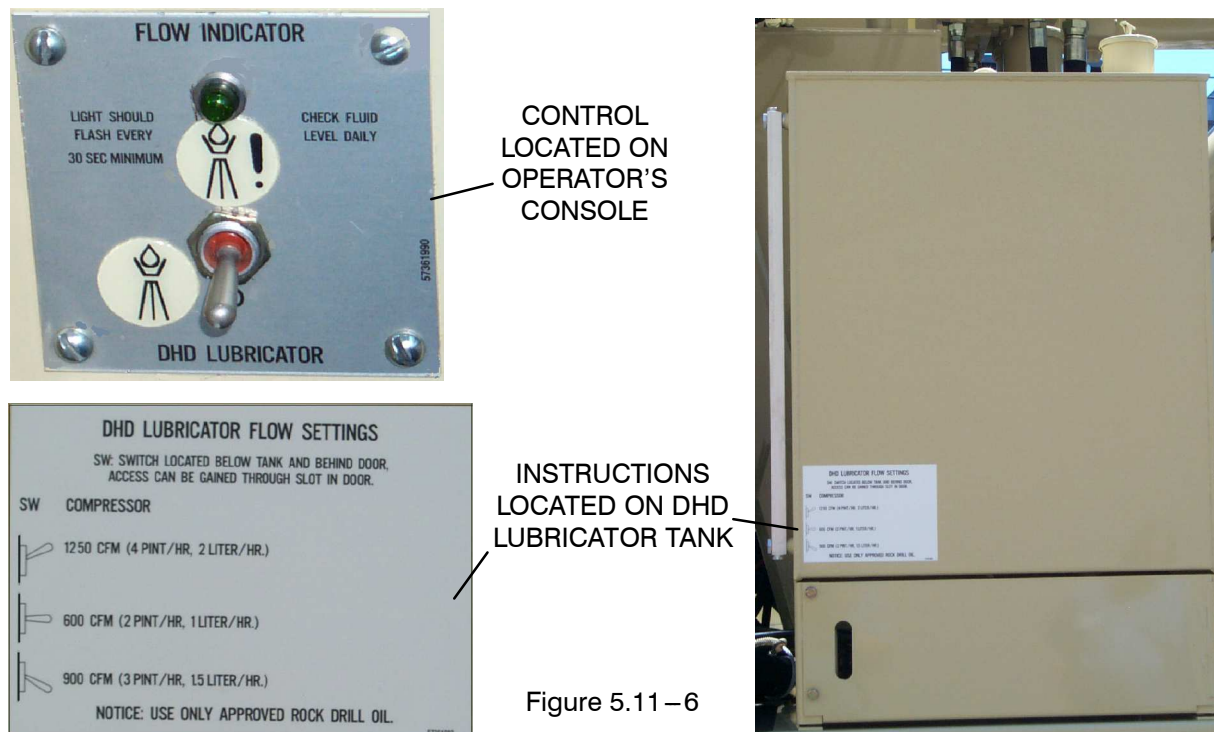


Figure 5.11 –6

When using the Ingersoll-Rand DHD for the first time, pour one cup (8 oz./230 ml) of Rock Drill Oil into the drill backhead to lubricate it before starting the DHD.

NOTE:

Follow Actual Manufacturer's Lubrication Instructions when using DHD Hammers. Rock Drill Oil is only used on Ingersoll-Rand DHD's.

1. The DHD should be connected to the starter rod to drill the hole.
2. The engine speed should be 2100 RPM.
3. Turn on the compressor. Adjust the pressure regulator to the desired setting. Refer to *High Pressure Operation* instructions in the COMPRESSOR OPERATION section.
4. Turn on the DHD lubricator switch on the console.
5. The DHD lubricator indicator light will light up to confirm the lubrication system is in service.
6. Regulate the flow if necessary. Read the instructions on the side of the lubricator to regulate for the compressor size of the drill.

5.11 - DHD DRILLING PROCEDURES

Starting the Hole with a DHD (continued)

7. Start the forward (clockwise) rotation using the Drill Rotation Controller. Regulate speed as needed with the Drill Rotation Controller.

NOTE:

Rotation is only possible when the Drill / Propel Mode Selector is in the DRILL mode position.

8. Make sure the dust aprons are in place.
9. Open the Drill Air Throttle slowly and allow air flow to operate the DHD.
10. Move the Drill Feed Controller to the DOWN position and adjust the feed speed for drilling conditions.
11. The first several feet or meters of drilling is called “overburden”. It usually consists of soft soil, broken rock, gravel or clay. When drilling through this mixture, care must be taken to prevent excessive cuttings from being blown out of the hole and causing a washout.
12. When the DHD has drilled below the drill table, it should be withdrawn from the hole. Move the Drill Feed controller to UP position and raise the DHD up out of the table until the split DHD bushings can be removed.
13. Stop Rotation. Shut off Drill Air Throttle. Turn off oiler.
14. Slowly lower the drill string down until the drill rod centralizer bushing can be inserted into the drill table. This bushing should be sitting on the backhead of the DHD around the drill rod. Drilling can now be resumed.

5.11 - DHD DRILLING PROCEDURES

Removing DHD from Drill String

1. Using drill feed, move the drill string so the backhead on the DHD is slightly above the table.
2. The centralizer bushing must be held up out of the way so the J-Wrench can be inserted on the backhead.
3. Install the split bushings around the DHD. Lower the DHD until the flats on the backhead are just above the table.

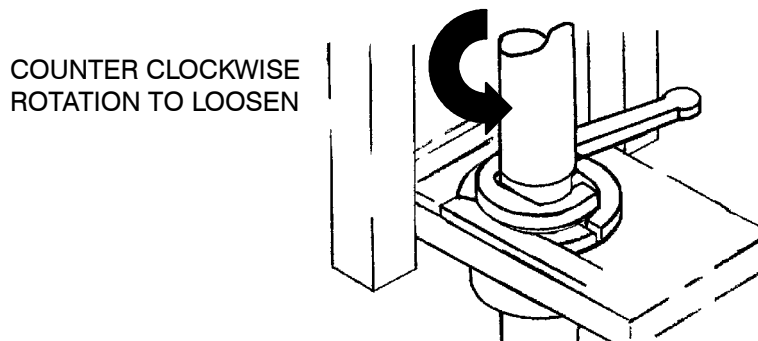


Figure 5.11 –7

4. Use the J-Wrench to secure the backhead on the table. Use drill feed to move DHD down until J-Wrench rests on table.
5. Slowly reverse rotation until the J-Wrench is almost touching a vertical tower member.
6. Using full rotation speed with drill rotation controller, reverse rotation and impact the J-Wrench against the tower member.
7. When the joint is loose, reduce speed on the drill rotation controller and slowly raise the rotary head until connection is separated.
8. Remove the drill rod from rotary head and store in the carousel.
9. If you are not going to remove the bit from the DHD, connect the lifting bail to backhead and lift the DHD out of the table. Store the split bushings.

5.11 - DHD DRILLING PROCEDURES

Bit Removal

Bit removal can be one of the most dangerous and frustrating tasks associated with the drilling operation. However, with the proper tools and techniques it should require no more than a few minutes to remove a bit. The following lists pointers which will be beneficial in helping you remove a bit quickly, safely and with reduced risk to damaging DHD parts and components:

1. Use sharp tong jaws. Worn or rolled over tong jaws increase the jaw pressure and make the wrench more prone to damaging the hammer case. Many hammer cases are case hardened which means sharp jaws are needed to grip through the hardened case.
2. Grip the casing in the proper location. Gripping over threads can make thread loosening extremely difficult. Example; as the wrench tightens it exerts an inward force which can pinch the threads if they are under the wrench jaw. This only increases the torque that is needed to uncouple the thread. Also, do not grip the casing in an area where the bore is not supported by either the piston or bearing. Gripping over an unsupported area can distort the bore.
3. Insure the bit fits properly within the bit basket. An improper fit may result in the bit slipping from the basket.
4. Never weld or hammer on the casing to loosen it. All casings except the QL200 are case hardened for extended service life. The hard casing surface can be cracked by welding or impacting with a sledge hammer.



Be sure chain wrenches or tongs are rated for the torque applied. The flying parts of chain wrenches can cause injury or death when they break.

Removing Bit from DHD

1. With the DHD hanging off of the J-Wrench, lower and connect rotary head to DHD.
2. Using drill feed, raise the rotary head until the DHD is high enough above the table to allow removal of the J-Wrench and remove the J-Wrench.
3. Using drill feed, raise DHD up until the bit basket can be installed into table recess.
4. Insert bit basket and bit detaching chuck into table recess and lower the bit into basket.
5. Attach chain wrench to lower section of DHD. **Do not allow chain wrench to contact DHD chuck.**
6. Use the Chain Wrench Controller to extend and retract the chain wrench cylinder. Loosen the bit chuck from DHD wear sleeve.

5.11 - DHD DRILLING PROCEDURES

Removing Bit from DHD (continued)

7. Remove the chain wrench and feed the rotary head up slowly. Simultaneously reverse the rotary head rotation and unscrew the bit chuck completely from the DHD wear sleeve. Stop feed and rotation.
8. Lift the bit chuck and retainers from the drill bit and remove the drill bit from bit basket.
9. Replace the old bit with new one and manually install bit chuck and retainers on new bit **or** manually install bit chuck and retainers back on DHD for storage.

DHD Drilling Procedures

1. Make sure the DHD, button bit and drill rod are installed correctly.
2. Turn on the drill air throttle controller slowly. Turn on the DHD lubricator. Turn on the water pump or dust collector if necessary.
3. Push the drill rotation controller to clockwise (forward) position. Adjust rotation speed with controller.

NOTE:

Rotation is only possible when the Drill/Propel Mode Selector is in the DRILL mode position.

4. Use drill feed controller in the DOWN position while starting a hole.
5. Regulate the drill feed by using the feed pressure control on the console.

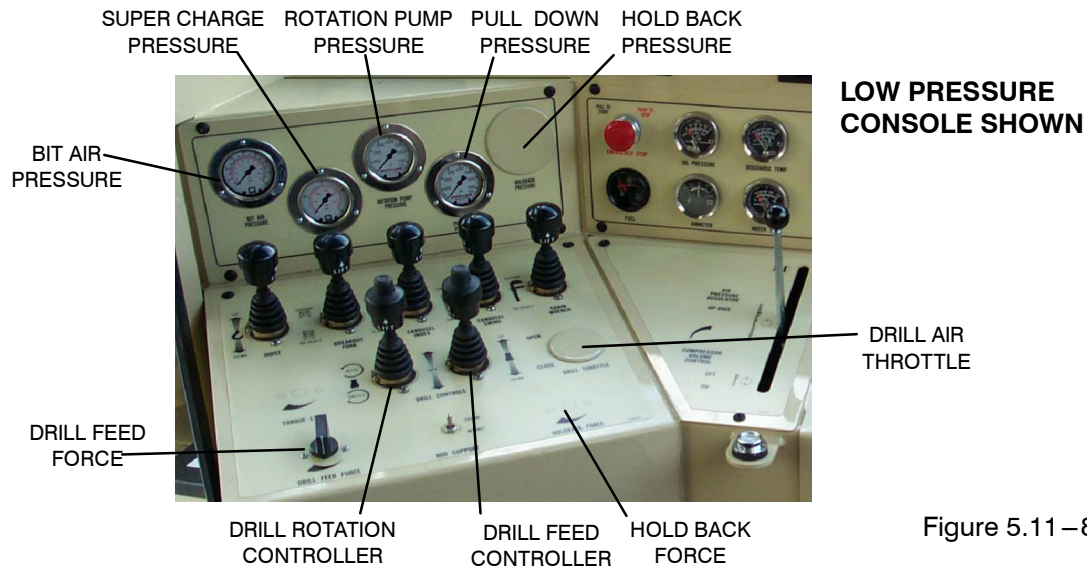


Figure 5.11 –8

6. Adjust the rotation and feed speed (down pressure) by checking the rotation and pulldown gauges. Pulldown pressure can be turned to holdback pressure when there is enough weight on the drill string to pull the drill string downward.
7. Watch the cuttings coming from the hole to determine what type formation you are drilling through.

5.11 - DHD DRILLING PROCEDURES

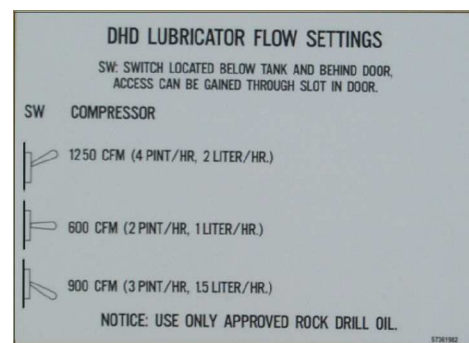
General Drilling Hints

1. The DHD lubricator must always be used whenever the DHD is being operated. Use the correct oil for the DHD and the season.

The amount of oil required varies with the size of the air compressor, not the DHD. Select the compressor size on the three position Lubricator Air Flow Selector. On 1050 cfm compressors, the setting is 900 cfm.



CONTROL LOCATED ON
OPERATOR'S CONSOLE



INSTRUCTIONS LOCATED ON
DHD LUBRICATOR TANK

Figure 5.11–9

Follow Actual Manufacturer's Lubrication Instructions when using DHD Hammers. Rock Drill Oil is only used on I-R DHD's.

2. The Water Injection Option should be used to contain dust and must be used whenever water is encountered in the hole to prevent collaring.
3. Do not operate the water pump if no circulation is being observed (i.e. bit is stuck in the hole). Water will fill up the air supply lines and flow back into the receiver tank of the compressor.
4. Do not open the drill air throttle flow control suddenly. It may cause a collapse of the separator element over a period of time.

5.11 - DHD DRILLING PROCEDURES

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5.12 - STOPPING, PARKING & SHUTDOWN

STOPPING, PARKING & SHUTDOWN

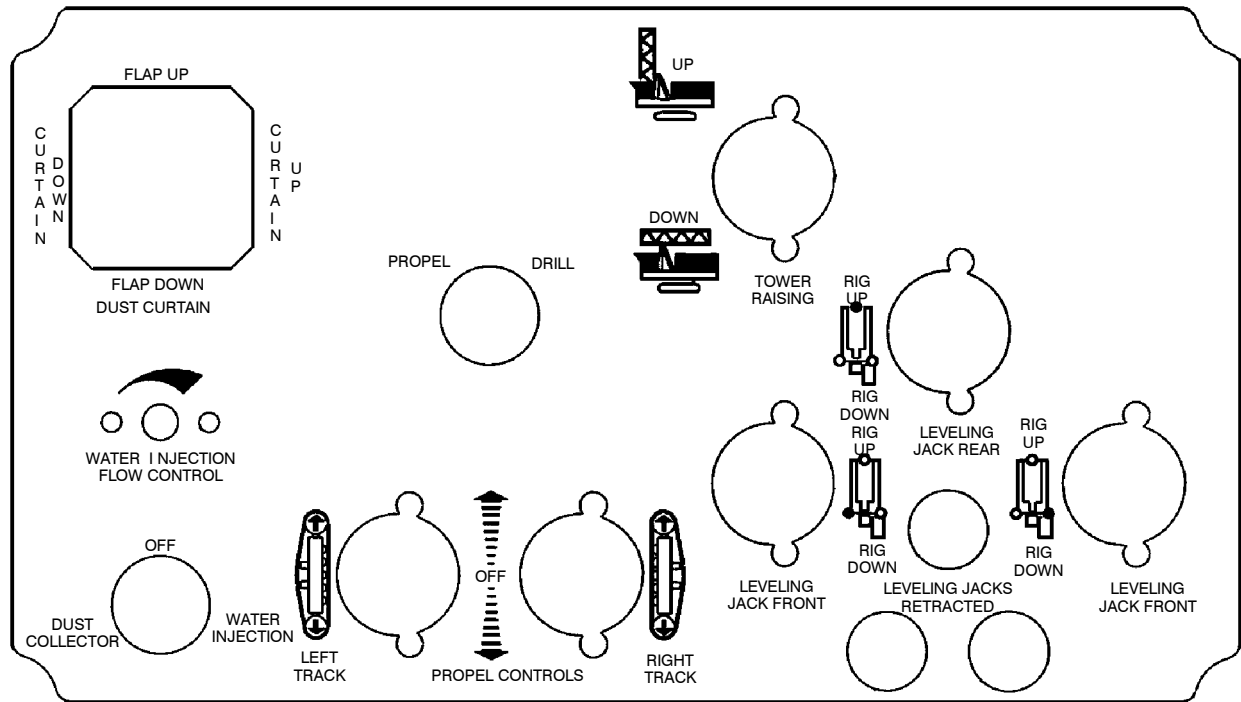


Figure 5.12–1

Stopping the Drill

1. For normal braking, move the Propel Controllers towards the **OFF** position.
2. To completely stop the movement, position the Propel Controllers in the **OFF** position and the parking brake warning light should illuminate.
3. Unless intending to move the drill immediately, move the Propel/Drill Mode Selector switch to the DRILL position.

Parking the Drill

1. Move drill away from the highwall or face before shutting the drill down for the day.
2. Don't park the drill under an overhang or where a bank can cave in.
3. ALWAYS park the drill on solid, level ground. If this is not possible, always park the drill at a right angle to the slope and chock the tracks.
4. If the drill is left over a hole, lower the jacks so the tracks touch the ground.
5. To park the drill, move it to firm, level ground. Bring the drill to a complete stop as mentioned above.
6. USE proper flags, barriers and warning devices, especially when parking in areas of heavy traffic.

5.12 - STOPPING, PARKING & SHUTDOWN

Normal Shut Down

Normal Shutdown describes how the drill is to be shutdown following a drilling operation or work shift. See “*Emergency Shutdown*” subsection which is part of the ENGINE OPERATION section for shutdown emergency conditions.

1. Raise the drill string out of the hole to clear the cuttings. Keep the string rotating and be sure air is flowing while withdrawing the bit.
2. Stop feed and rotation when the bit enters the table dust seal
3. Turn off the compressor and allow the receiver to blow down to minimum pressure.

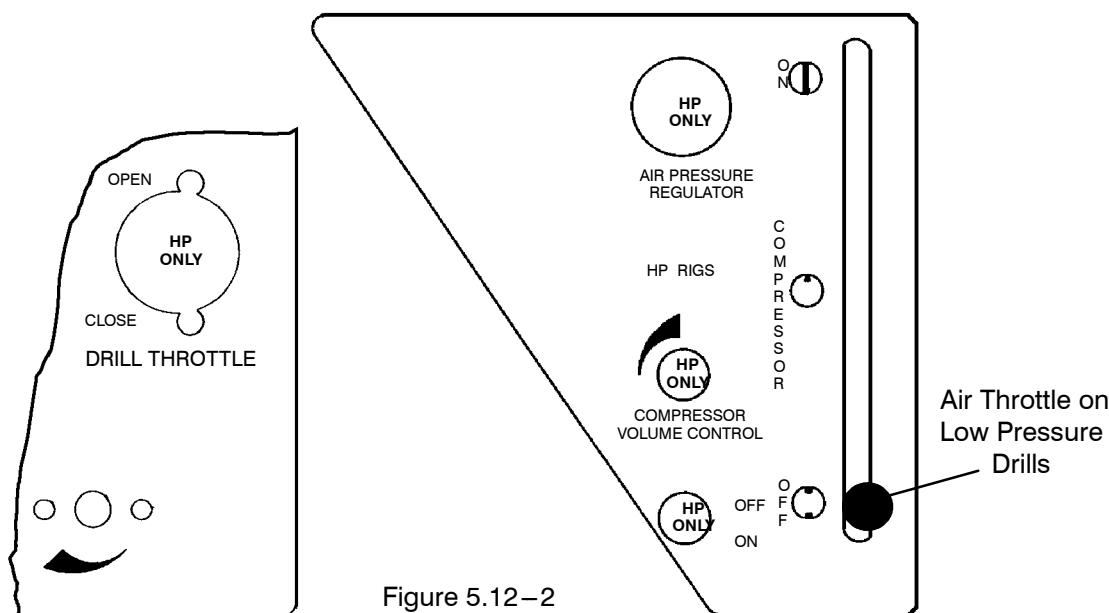


Figure 5.12–2

Low Pressure Drills

On low pressure drills, the compressor is turned on and off with the use of a manual inlet control. This is a lever and cable arrangement. Pull the lever towards the operator to close the inlet.

High Pressure Drills

On high-pressure drills, the Compressor On/Off Switch is used to turn the compressor on and off. This is a two position, pneumatic switch. It is used to open and close the compressor inlet valve. (See Section 5.5 Compressor Operation).

4. Open the Drill Air Throttle controller (HP Only) to lower air in the standpipe.
5. Pressure in the receiver tank **must never be over 150 psi when the engine is stopped. This applies to high pressure compressors (350 psi) only.**

5.12 - STOPPING, PARKING & SHUTDOWN

Normal Shut Down (continued)

6. If the hole is completed, lower the tower:
 - a. Position the Tower Pinning switch into the unlocked position. Check the tower Unpinned Warning Light is illuminated when the pin is fully disengaged.
 - b. Use the Tower Raise/Lower Controller to lower the tower. As the tower approaches the horizontal position, slowly move the controller to its center position to allow the tower to position without impact. Never slam the tower into the horizontal position.
7. Retract the leveling jacks, starting with the single jack on the non-drilling end. Raise them all the way up so they do not interfere with the movement of the drill.
8. Disconnect any piping, ropes or cables from the drill and store them properly.
9. Move the Engine Throttle (speed selector) switch to LOW idle (1200 rpm) position for about 5 minutes to allow the engine to cool down.
10. Be sure to relieve all pressures in the systems before leaving the drill.
11. Place all controls in neutral or park position before leaving the drill.
12. ALWAYS move the propel/drill mode selector to the “DRILL” position and make sure the propel and drill controllers are all in the STOP positions.
13. AVOID leaving the controls with the engine running. NEVER leave the operator’s cab while the engine is running.
14. Turn the key switch to the OFF position.
15. After the engine has stopped, make sure the compressor blowdown valve opens and blows all the air out of the receiver tank.

NOTICE

*If the blowdown valve opens for a few seconds and then closes, there was excessive pressure in the tank when the drill was stopped or a malfunction of a component in the regulation system. It will leak for several minutes and then the butterfly valve will open and allow air and oil to flow back up the intake tubes and into the air cleaners. **Repair the problem before using the drill again.***

16. Lock the ignition and remove the keys before leaving the operator’s cab.
17. Lock all lockable compartments.

5.12 - STOPPING, PARKING & SHUTDOWN

Daily Precautions After Work

Perform the following precautions each day after work in addition to the daily routine maintenance on the lubrication chart.

1. Fill the fuel tank to prevent condensation problems.
2. Clean the drill of accumulated material.
3. Lock all vandal protection devices on the drill.

Mounting and Dismounting of Equipment and Attachments

NOTE:

All optional equipment mounting and dismounting on the drill must be performed by authorized, trained personnel only.

5.13 - TRANSPORTING THE DRILL

TRANSPORTATION PROCEDURES

Safety Precautions

The drill must be towed, loaded and transported only in accordance with the following operating instructions.

1. When towing the drill, observe the prescribed transport position, admissible speed and the itinerary.
2. **DO NOT** attempt to load the drill rig on the transport vehicle without the knowledge and the experience with the operation of the drill rig.
3. Keep the trailer deck clean of clay, oil, mud, ice, frost and other material that can become slippery.
4. Always know the overall height, weight, width and length of the drill rig and hauling vehicle. **MAKE SURE** there is sufficient clearance when crossing underpasses, bridges and tunnels or when passing under overhead lines.
5. When moving the drill rig on public access roads, obey all traffic regulations and be sure that proper clearance flags, lights and warning signs, including the "Slow Moving Vehicle" emblem, are properly displayed. Know your approximate stopping distance at any given speed. Never turn corners at excessive speeds and look in all directions before reversing your direction of travel.

Drill Preparation

1. Remove all loose tools, material and accessories from the drill.
2. Raise the rotary head to the top of the tower.
3. Rotate the carousel so the empty area is in line with the drill rod in the head. Swing the carousel into the stowed position (closed).
4. Lower the tower. Feather the controller as the tower approaches the tower rest so it doesn't impact with excessive force.
5. Retract leveling jacks, starting with the single rear leveling jack. Retract the other two leveling jacks.
6. Make sure all controls are in neutral and any water lines and other connections are removed and stored.
7. Idle the engine at LOW idle (1200 rpm) position for five (5) minutes to cool all fluids down. Stop the engine and be sure the compressor blows down.

5.13 – TRANSPORTING THE DRILL

TRANSPORTATION PROCEDURES (continued)

Drill Preparation (continued)



Transferring the drill and equipment between work sites is potentially hazardous.

Before transporting the drill on public roads, check with your supervisor for instructions and information in respect to traffic regulations regarding construction machinery.

NOTE:

For more information on transporting, refer to the *Transporting and Towing* section of Section 2.2 – Safety Precautions and Guidelines.

Loading Drill by Drive On

The following information is for loading the drill under its own power (drive-on) for transporting.

1. Choose level ground which will solidly support the vehicle.
2. Always use a ramp when loading the drill rig on a transport vehicle. Be sure the ramps are of adequate strength, low angle, and proper height.
3. Clean the trailer surface and loading ramps.
4. Use the proper chock blocks in the front and rear of the wheels of the transport vehicle when loading the drill rig.
5. A signalman must assist the operator with any necessary warnings.
6. Use the Remote Propel (Option) Control Unit during loading the drill and control the loading procedure from a safe vantage point.

NOTE:

For more information on the Remote Propel Control Unit Option, refer to *Item 72 –Control Unit* in Section 4 – Operating Controls.

7. Approach the transporter loading ramps squarely to make sure the drill does not drop off side of ramp.
8. Propel the Drill onto the transporter vehicle trailer.
9. Position the drill rig on the transport vehicle centered from side to side and use proper chock blocks in front and rear of the tracks .
10. Move the propel/drill mode selector to the “DRILL” position and make sure the propel and drill controllers are all in the STOP positions.
11. Idle the engine at LOW idle (1200 rpm) position for five (5) minutes to cool all fluids down.

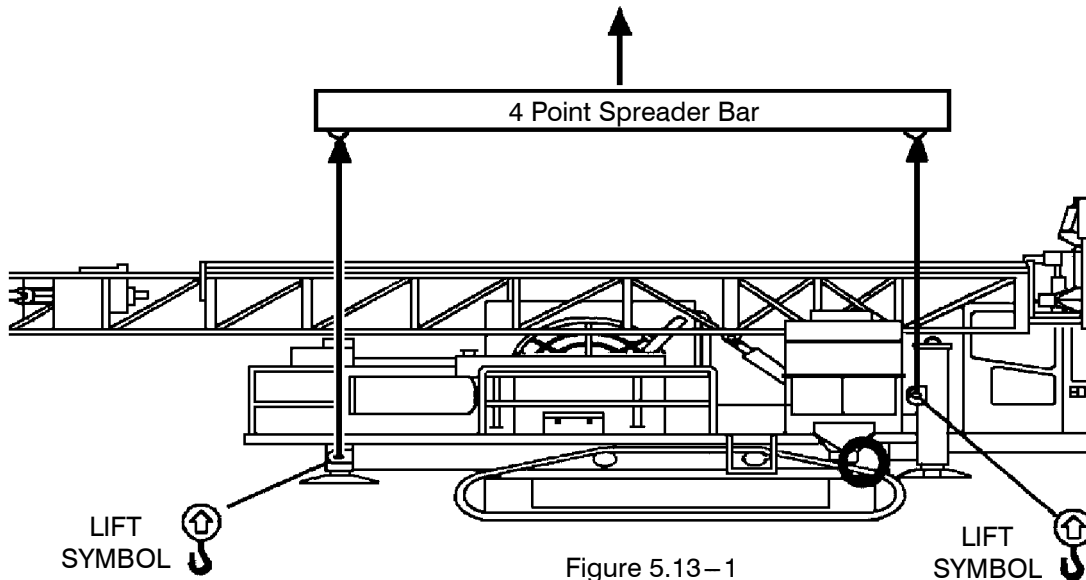
5.13– STOPPING, PARKING & SHUTDOWN

TRANSPORTATION PROCEDURES (continued)

Loading Drill by Drive On (continued)

12. Shut engine down, apply the parking brake switch (option) and be sure the compressor blows down.
13. Lock all lockable compartments and vandal protection devices on the drill.

Loading Drill with Lifting Equipment



The following information is for loading the drill, by lifting equipment, for transporting.

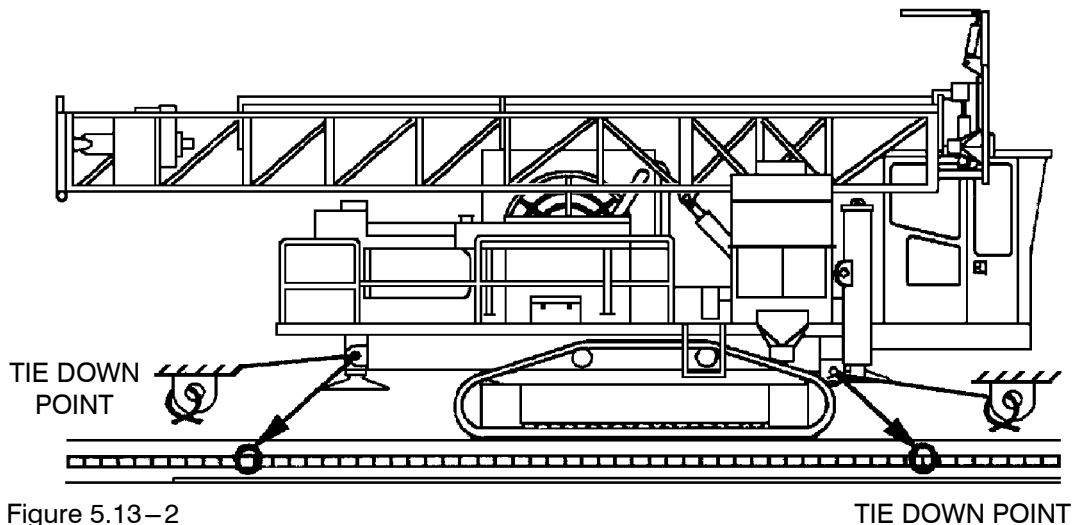
1. Use only appropriate means of transport and lifting gear of adequate capacity.
2. The fastening of loads and instructing of crane operators should be entrusted to experienced personnel only. The personnel giving the instructions must be within the sight or sound of the operator.
3. Always use the four lift points and proper lifting tackle. Refer to weight distribution in Section 3 Specifications & Systems.
4. Attach the lifting frame to drill using the four lift points marked with “lift symbol” as reference.
5. Ensure that the appropriate lifting equipment is rated to the drill’s weight before lifting.
6. Position the drill rig on the transport vehicle centered from side to side and use proper chock blocks in front and rear of the tracks .

5.13 – TRANSPORTING THE DRILL

TRANSPORTATION PROCEDURES (continued)

Tie Down Drill

1. After loading the drill on the transporter, ensure that all pivoting assemblies are in the locked positions and there are no unsecured or loose items which could dislodge during transport.
2. Ensure that the propel/drill mode selector is in the “DRILL” position and make sure the propel and drill controllers are all in the STOP positions.
3. If the engine has been running, idle the engine at LOW idle (1200 rpm) position for five (5) minutes to cool all fluids down.
4. Shut down engine and remove ON/OFF switch key.
5. Lock all lockable compartments and vandal protection devices on the drill.



6. Use proper chock blocks in front and rear of the tracks once loaded on the trailer.
7. Secure the drill rig to the deck of the transport vehicle with adequate chains, cables, tensioning devices, blocks or other appropriate equipment to the four tie down points in accordance with local regulations.
8. The driver of the transport vehicle must be aware of the total weight load on the axles and the overall dimensions of the drill. For further information, refer to the Dimensions and *Weights* in Section 3 – Specifications & Systems.

5.14 - TOWING THE DRILL

WARNING

Personal injury or death could result when towing a disabled drill incorrectly. Follow the recommendations below to properly perform the towing procedure.

1. You **MUST** block the tracks to prevent any movement before releasing the brakes or before disconnecting the final gear train. The drill can roll free if it is not blocked.
2. Relieve hydraulic tank and hydraulic line pressure before any disassembly. Operate the track propel controllers in both directions, with engine stopped, to relieve pressure.
3. Even after the drill has been turned off, the hydraulic oil can still be hot enough to burn. Allow the hydraulic oil to cool before draining.

NOTICE

To tow the drill, both final drives must be disengaged. Do not operate the travel motors with the final drives disengaged. Damage could result.

Clean the final drive covers and the nearby areas before disengaging the drives. Dirt can contaminate and damage the propel motors, reduce propel performance and cause drill malfunctions.

CAUTION

Use only drawbars for the towing requirement.

Maximum towing speed = 2.0 km/h (1.2 mph).

Maximum towing distance = 300 meters (984 feet).

5.14 - TOWING THE DRILL

GENERAL TOWING INFORMATION

These towing instructions are for moving a disabled drill a short distance, only a few meters (feet) at a low speed not faster than 2 km/h (1.2 mph), to a convenient repair location. These instructions are for emergencies only. Always haul the drill on a transporter if long distance moving is required.

Shielding must be provided on the towing machine to protect the operator if the tow line or bar should break.

Do not allow the operator, or any other personnel, on the drill when it is being towed.

Before towing, make sure the tow line or bar is in good condition and has sufficient strength for the towing situation involved. Use a towing line or bar with a strength of at least 1.5 times the gross weight of the towing machine for towing a disabled drill stuck in mud or when towing on a grade.

Attach cable to front end (cab end) tie down points if pulling forward, or attach to the rear end tie down points if pulling in reverse.

Do not use a chain for towing. A chain link can break, causing possible personal injury. Use a wire rope cable with loop or ring ends. Use an observer in a safe position to stop the towing procedure if the cable starts to break or unravel. Stop towing whenever the pulling machine moves without moving the towed drill.

Keep the tow line angle to a minimum. Do not exceed 30° angle from the straight ahead line of travel.

Sudden machine movement could overload the tow line or bar and cause premature breakage. Gradual and smooth acceleration will minimize breakages of towing components.

Normally, the towing machine should be as large as the disabled drill and have sufficient braking capacity, weight and power to control both the machine and the disabled drill for the grade and distance involved. To provide sufficient control and braking when moving the disabled drill downhill, a larger towing machine or additional tandem connected machines could be required. This will prevent a runaway or uncontrolled towing operation.

All the different situation requirements cannot be given here. Capacities range from minimal towing machine capacity required on smooth, level surfaces and increases to maximum capacity required on inclines and poor surface conditions.

5.14 - TOWING THE DRILL

Towing Procedure

To tow the drill a maximum of 300 meters (984 feet), use the following procedure:

1. Attach the drill to an appropriate towing vehicle using appropriate cable and drawbar which can be secured in position at the selected tie-down points on the drill. Remove the chocks.
2. Locate the final drive engagement mechanism.

WARNING

Only disengage final drives when machine is **NOT** moving.

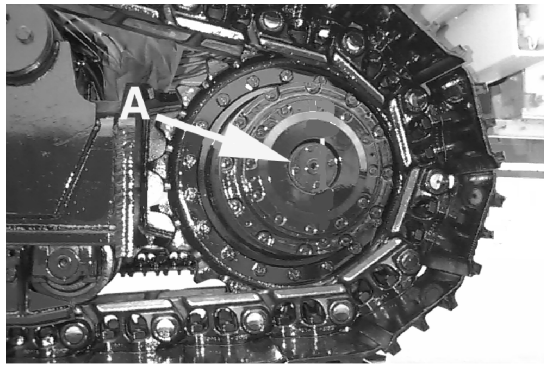
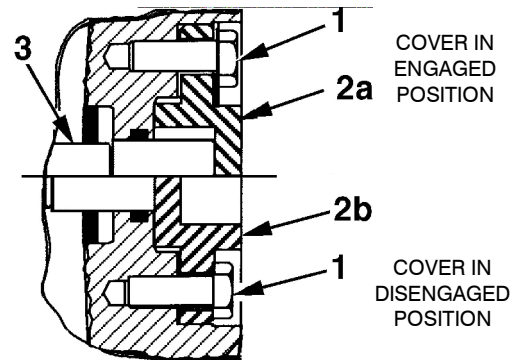


Figure 5.14–1



3. Thoroughly clean the area around the disconnect cover (item A).
4. Remove both screws (item 1).
5. Remove the disconnect cover from the engaged position (item 2a). The spring loaded input shaft (item 3) should move into its disengaged position when cover is removed.
6. Reinstall the disconnect cover in its disengaged position (item 2b). The spring loaded input shaft will disengage and allow the tracks to free wheel.
7. Repeat procedure for the other track drive.
8. When required, reverse the procedure to reengage the input shaft.

NOTICE

Do not allow oil temperature to exceed 194°F (90°C) while towing.

WARNING

The brakes are ineffective when the input shaft is disengaged. Provide other methods to control movement of the drill.

5.14 - TOWING THE DRILL

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5.15 - SPECIAL CONDITIONS OF USE

SPECIAL CONDITIONS

Cold Weather Conditions

1. Refer to the *Lubricant, Fuel and Cooling Sytem Specifications* that are found in Section 6 – MAINTENANCE regarding cold weather lubricants, hydraulic fluids, coolants, etc.
2. Use winter grade diesel fuel for operation at subzero temperatures.
3. Be extremely careful when using cold weather starting aids. The Starting aids are very flammable and should only be used if needed.
4. Remove batteries and store in a warm area to about 68°F (20°C).

Hot Weather Conditions

1. Monitor temperature gauges.
2. Keep cooling fins on radiator and oil cooler clean and free of accumulated dirt.

Water and Muddy Conditions

1. Clean the drill of accumulated material and thoroughly grease all lubrication points. Refer to *Lubricant Specifications* in Section 6 – MAINTENANCE.

Dusty Conditions

1. Keep air cleaner elements clean and free of accumulation of dirt.
2. Wear protective mask.

High Altitude Conditions

1. Be aware that engine power will be reduced.
2. Keep cooling fins on radiator and oil cooler clean and free of accumulated dirt.

Preservation & Storage

Observe the following when storing the drill for short periods of time.

1. Replace and secure all weatherproof covers.
2. Change all lubricants and fluids that may have deteriorated with use. Refer to *Lubricant Specifications* in Section 6 – MAINTENANCE.
3. Check that the storage site is not subject to flooding or other natural hazards.
4. Wherever practical, run the engine and operate all drill functions at regular intervals.

5.15 - SPECIAL CONDITIONS OF USE

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SECTION 6

MAINTENANCE

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6.1 - MAINTENANCE SAFETY

GENERAL MAINTENANCE SAFETY AND HEALTH

This manual has been published to alert operators, helpers and mechanics to the possible physical dangers that are present in all phases of operation and maintenance of this drill.

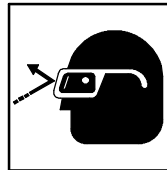
Anyone working around this drill must read and thoroughly understand the precautions outlined in this manual before attempting to operate or perform work on the drill. In addition, “SAFETY ALWAYS” must always be the primary consideration of all personnel when working around this drill under normal or unusual conditions.

WEAR PROTECTIVE CLOTHING

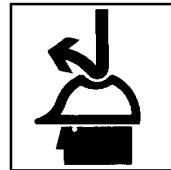
Anyone working around the drill **must** wear APPROVED safety equipment (safety shoes or protective footwear, safety glasses, hearing protection, hard hat, gloves, respirator, etc.) when operating or maintaining the machine.

Wear close fitting clothing and confine long hair.

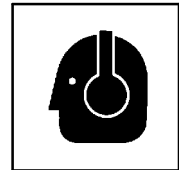
Operating equipment requires the full attention of the operator. Do not wear radio or music headphones while operating the machine.



Safety Glasses



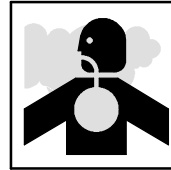
Hard Hat



Ear Protection



Electrically
Insulated Gloves



Respirator



Electrically
Insulated Boots

Since this manual cannot cover every possible situation, all personnel are expected to exercise good judgement and common sense when operating, servicing or working near this drill.

If there is any doubt about the safe operating procedure of the drill, **STOP !!** Review the information supplied with the drill, ask your supervisor or contact your nearest Drilling Solution Representative for assistance.

Make sure all new employees read and understand the decals in Decal Safety Manual, mounted on drill. Never remove the Decal Safety Manual. Replace manual if it becomes lost or illegible.

WARNING

Improper maintenance can cause severe injury or death. Read and understand the SAFETY PRECAUTIONS AND GUIDELINES section of this manual before you operate or perform any maintenance, service or repairs.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand the OPERATING CONTROLS & INSTRUMENTS section of this manual.

6.1 – MAINTENANCE SAFETY

WARNING

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working on the drill.

SAFETY PRECAUTIONS

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially dangerous situations before trouble occurs. Some of the potential problems and ways to prevent them are shown below.

WARNING

Fluid Penetration

1. Always use a wooden board or cardboard when checking for leaks.
 2. Leaking fluid under pressure can cause serious injury or death.
 3. If fluid is injected into the skin, see a physician immediately.
-

WARNING

Lines, Tubes and Hoses

1. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires.
2. Inspect all lines, tubes and hoses carefully. Do **not** use your bare hands to check for leaks.
3. Tighten all connections to the recommended torque.
4. Make sure all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.
5. Check for the following:
 - a. End fittings damaged, leaking or displaced.
 - b. Outer covering chafed or cut and wire reinforcing exposed.
 - c. Outer covering ballooning locally.
 - d. Evidence of kinking or crushing of the flexible part of the hose.
 - e. Armoring embedded in the outer cover.

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)

WARNING

Burn Prevention

1. Do not touch any part of an operating engine or its components.
 2. Allow the engine to cool before any repair or maintenance is performed.
 3. Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.
-

WARNING

Coolant

1. Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs.

At engine operating temperature, engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water. When pressure is relieved rapidly, this hot water can turn into steam. Always allow the hot cooling system components to cool before draining. Any contact with hot water or steam can cause severe burns. Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

2. Hold a rag over the cap or the plug to prevent being sprayed or splashed by liquids under pressure.
 3. Remove the cooling system filler cap slowly to relieve pressure.
 4. Cooling system additive (conditioner) contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.
-

WARNING

Oils

1. Hot oil and components can cause personal injury. Do not allow hot oil or any components to contact the skin.
 2. Keep all exhaust manifold and turbocharger shields in place to protect hot exhaust from oil spray in case of a line, tube or seal failure.
-

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)

WARNING

Batteries

1. Battery electrolyte contains acid and can cause injury. Avoid contact with skin and eyes. Wash hands after touching batteries and connectors. The use of gloves is recommended. Batteries give off flammable fumes, which can explode. Ensure there is proper ventilation for batteries, which are located in an enclosure.
 2. Always thaw a frozen battery before jump starting. Frozen batteries can explode.
 3. Do not smoke when observing the battery electrolyte levels.
 4. Always wear protective glasses when working with batteries.
 5. Never disconnect any charging unit circuit or battery circuit cable from the battery when charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.
-

WARNING

Fire or Explosion Prevention

1. Fire may result from lubricating oil or fuel sprayed on hot surfaces causing personal injury and property damage. Inspect all lines and tubes for wear or deterioration. They must be routed, supported or clamped securely. Tighten all connections to recommended torque. Leaks can cause fires.
2. Determine whether engine will be operated in an environment in which combustible gases could be drawn through the air inlet system. These gases could cause the engine to overspeed, which in turn could seriously damage the engine and result in bodily injury or property damage.
3. All fuels, most lubricants and some coolant mixtures are flammable.
4. Diesel fuel is flammable. Gasoline is flammable. The mixtures of diesel and gasoline fumes are extremely explosive.
5. Do not smoke while refueling or in a refueling area. Do not smoke in areas where batteries are charged, or where flammable materials are stored.
6. Batteries give off flammable fumes which can explode. Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons. Store all oily rags or other flammable material in a protective container, in a safe place.

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)

Fire or Explosion Prevention (continued)

WARNING

7. Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with a nonflammable solvent before welding or flame cutting on them. Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine. Do not expose the engine to flames, burning brush, etc., if possible.
8. Shields (if equipped), which protect hot exhaust components from oil or fuel spray in the event of a line, tube or seal failure, must be installed correctly.
9. Provide adequate and proper waste oil disposal. Oil filters and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.
10. All Batteries must be kept clean with covers kept on all cells, recommended cables and connections used and battery box covers kept in place when operating.
11. When starting from an external source, always connect the positive (+) jumper cable to the POSITIVE (+) terminal of the battery of the engine to be started. To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (—) boost ground cable last, to the starter NEGATIVE (—) terminal (if equipped) or to the engine block. See the Operation Section of this manual for specific starting instructions.
12. Clean and tighten all electrical connections. Check regularly for loose or frayed electrical wires. Refer to maintenance schedules for interval. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.
13. All wiring must be kept in good condition, properly routed and firmly attached. Routinely inspect wiring for wear or deterioration. Loose, unattached, extra or unnecessary wiring must be eliminated. All wires and cables must conform to the recommended gauge and be fused if necessary. Do not use smaller gauge wire or bypass fuses. Tight connections, recommended wiring and cables properly cared for will help prevent arcing or sparking which could cause a fire.

WARNING

Fire Extinguisher

1. Have a fire extinguisher available and know how to use it.
2. Inspect fire extinguisher and have it serviced as recommended on its instruction plate.

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)

WARNING

Crushing or Cutting Prevention

1. Support equipment and attachments properly when working beneath them.
 2. Never attempt adjustments while the engine is running unless otherwise specified in this manual.
 3. Stay clear of all rotating and moving parts. Guards should be in place when maintenance is not being performed.
 4. Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.
 5. Wear protective glasses when striking objects to avoid injury to your eyes.
 6. Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.
-

WARNING

Mounting and Dismounting

1. Clean steps, handholds and areas of the drill you will be working on or around.
 2. Always use the steps and handholds when mounting and dismounting with a three point stance.
 3. Do not climb on, or jump off, the drill or stand on components that cannot support your weight. Use an adequate ladder.
-

WARNING

Before Starting the Engine

1. Inspect the drill for potential hazards.
 2. Be sure all protective guards and covers are installed if the drill must be started to make adjustments or checks. To help prevent an accident caused by rotating parts, work very carefully around them.
 3. Do not disable or bypass automatic shutoff circuits. They are provided to prevent personal injury and drill damage.
 4. Never start an engine with the governor linkage disconnected.
 5. Make provisions for shutting off air or fuel supply to stop engine if there is an overspeed condition on start-up after performing repair or maintenance to the engine.
-

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)

WARNING

Engine Starting

1. DO NOT start the engine or move any of the controls if there is a warning tag attached to the controls. Check with the person who attached the tag before starting.
2. Make sure no one is working on, or close to the engine or engine driven components before starting it. Always inspect the engine before and after starting.
3. Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.
4. Always start the engine according to the required Engine Starting procedure described in this manual to prevent major engine component damage and personal injury.
5. Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.
6. Only use the Emergency Stop button in an emergency. DO NOT start the engine until the problem causing the emergency stop has been located and corrected.
7. On initial startup or overhaul, be prepared to STOP the drill should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.
8. Check the jacket water and oil temperature gauges frequently during operation of jacket water and/or lube oil heaters to ensure proper operation.
9. The diesel engine exhaust contains products of combustion that may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

WARNING

Starting Aids

1. Ether and other starting aids are poisonous and flammable. Do not smoke while changing ether cylinders.
2. Use ether only in well ventilated places.
3. Keep ether cylinders out of the reach of unauthorized persons.
4. Do not store replacement ether cylinders in living areas, the storage compartment or the cab.
5. Do not store ether cylinders in the direct sunlight or at temperatures above 102°F (39° C). Discard cylinders in a safe place. Do not puncture or burn cylinders.

6.1 – MAINTENANCE SAFETY

SAFETY PRECAUTIONS (continued)



Engine Stopping

1. Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.
 2. Only use the Emergency Stop button in an emergency. DO NOT start the drill until the problem is resolved.
 3. On initial startup or overhaul, be prepared to STOP engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.
-

GENERAL MAINTENANCE INFORMATION

To prevent minor irregularities from developing into serious conditions, several services or checks are recommended for the same intervals as the periodic lubrication. The purpose of these services or checks is to ensure the uninterrupted and safe operation of the unit by revealing the need for adjustment caused by normal wear.

Prior to conducting any maintenance work, ensure that the following instructions are observed:

1. The drill should be parked on a firm, level surface.
2. Ensure the engine is shut down and allowed to cool.
3. Disconnect the battery cables and cover exposed terminals before working on the drill's electrical system.
4. Stop the engine and allow the hydraulic oil pressure to fall before working on the hydraulic hose installations or connections.
5. Stop the engine and allow compressor air pressure to completely relieve from the receiver separator tank before working on the compressor, receiver tank and hose installations or connections.
6. Thoroughly wash fittings, caps, plugs, etc. with nonflammable, nontoxic cleaning solution before servicing to prevent dirt from entering while performing the service.

6.1 – MAINTENANCE SAFETY

GENERAL MAINTENANCE INFORMATION (continued)

When there is a need for an operator to work on the drill in the working area or the danger zone and this involves activation of one or several drill functions, such work shall only be done under the following conditions:

1. There shall always be two people present: both being fully instructed on the safety issues. One of them, from the main operator's position, shall supervise the safety of the service man doing the work.
2. The supervisor shall have immediate access to the emergency stop in all situations.
3. The area where the service work is to be performed shall be properly illuminated.
4. Communication between the service man and supervisor at the main operator's position shall be established in a reliable manner.
5. Only when drill is shut down completely and the means of starting are isolated is a person allowed to perform repair and maintenance work alone on the drill.

Handling Fluids, Oil and Fuel Filters

1. When draining fluids, ensure that adequate sealable containers are available and every care is taken to prevent spillage.
2. Always ensure waste fluids are disposed of in an environmentally safe manner.
3. Always ensure that used filters are stored in secure containers and are disposed of in an environmentally safe manner.

The maintenance schedule in this section shows those items requiring regular service and the interval at which they should be performed. A regular service program should be geared to the items listed under each interval. These intervals are based on average operating conditions. In the event of extremely severe, dusty or wet operating conditions, more frequent maintenance than specified may be necessary.

NOTE:

Refer to the Actual Manufacturer's Operation and Maintenance Manual for the Maintenance Schedules and procedures for the Deck Engine.

NOTE:

Refer to the Actual Manufacturer's Service Maintenance Manual for Maintenance Schedule and procedures for the Deck Engine.

6.1 – MAINTENANCE SAFETY

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6.2 - MAINTENANCE SCHEDULE

MAINTENANCE SCHEDULE

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed. **Note:** If the drill is operating under very severe conditions (such as very dusty air), the scheduled maintenance intervals should be reduced.

MAINTENANCE SCHEDULE		
DESCRIPTION	ACTION	LUBRICATION
AS REQUIRED		
Air Cleaners	Check-Service Indicators	See Parts Manual
	Check-Connections and Ducts for leaks	
	Empty-Dust Cups	
	Clean-Pre Cleaner	
	Check-Rain Guard	
	Change-Elements only as required	
Clean the Drill	Clean the Drill	
Loose Bolted Connections	Check-Tighten to proper torque	See Torque Specifications
Feed Chains	Check-Feed Chain sag and adjustment	
Wire Rope	Check-Wear and stretch conditions	
Grease Drum Option	Change Grease Drum	See Parts Book
Compressor Air Hose/Clamps	Inspect, Retighten Clamp Bolts	See Section 7
EVERY 8-10 HOURS OR DAILY		
Air Cleaners	Check-Service Indicators	See Parts Manual
	Check-Connections and Ducts for leaks	
	Empty-Dust Cups	
Engine	Check- Crankcase Oil Level. Add if low.	API CG4, 15W40
	Check-Engine Belts & Tensioner	
Engine Fuel Filter	Drain-water from Fuel/Water Separators	
Cooling System (Radiator, HOC, COC)	Check- Radiator Coolant Level	50/50-H2O & Coolant
	Clean-Cooling Fins	
Fuel Tank	Check-Fuel Level, fill to neck on tank	#2 Diesel fuel
Receiver Separator Tank	Check Compressor Oil Level	IR PROTEC (low pressure)
		XHP605 (high pressure)
	Drain-Water from Receiver Tank	
Hydraulic Reservoir	Check-Oil level on Tank Sight Gauge	ISO AW32
Hydraulic Oil Filters	Check-Main Return Oil Filters Restriction Indicator(s)	
	Check-Case Drain Oil Filter Restriction Indicator	
Rotary Head	Check-Rotary Head Oil Level	SAE 90W Gear Oil
	Grease-Upper Rotary Head Bearing	Exxon Mobil Ronex Extra Heavy Duty Moly 2

6.2 - MAINTENANCE SCHEDULE

MAINTENANCE SCHEDULE (continued)

MAINTENANCE SCHEDULE (continued)		
DESCRIPTION	ACTION	LUBRICATION
EVERY 8-10 HOURS OR DAILY (continued)		
Grease Points:		MPG-EP1 Grease
Tower Central Bank	5 shots of grease into each fitting	
Frame Central Bank	5 shots of grease into each fitting	
Sheaves and Sprockets	5 shots of grease into each fitting	
Carousel and Cups	5 shots of grease into each fitting	
Gearbox Driveshaft	5 shots of grease into each fitting	
Dust Collector	Check-Dropout and Suction Hoses, Rod Seal and Blower Discharge	See Parts Manual
	Check-Impulse Air and Filters	
Housekeeping	Clean the Drill	
EVERY 50 HOURS		
Batteries	Check-Electrolyte Level	Distilled Water
	Check-Keep terminals cleaned and tight	
Pump Drive Gearbox	Check for Oil Leaks	80W90 Gear Oil
	Check-Oil Level	
Track Planetary Gearbox	Check-Oil Level	ISO VG220 (Required Lubricant)
	Check for Oil Leaks	
	Check-for unusual noises	
Track Tension	Refer to Manufacturers Service Manual.	
Auxiliary Hoist	Periodic Inspection	
EVERY 100 HOURS		
Auxiliary Hoist	Change the Initial Oil	TEXACO MEROPA 150 OR EQUIVALENT API GL-2/3
EVERY 250 HOURS		
Engine	Change-Engine Oil	API CG4, 15W40
	Change-Engine Oil Filter(s)	See Parts Manual
	Replace-Engine Fuel Filter(s)	
	Replace-Engine Coolant Filter	
	Check-Engine DCA/SCA Level	Refer to Manufacturers Service Manual.
	CAT Engine Valve Lash Adjustment	
Track Planetary Gearbox	Check-torque tightness of bolts/nuts	
	Change the Initial Oil	ISO VG220 (Required Lubricant)
Jib Hoist	Check- Cable Condition	

6.2 – MAINTENANCE SCHEDULE

MAINTENANCE SCHEDULE (continued)

MAINTENANCE SCHEDULE (continued)		
DESCRIPTION	ACTION	LUBRICATION
EVERY 500 HOURS		
CAT Engine	Change-Primary Fuel/Water Separator(s)	See Parts Manual
Batteries	Clean-Batteries, Clamps & Cables	
Fuel Tank	Clean-Fuel Priming Pump	
	Replace-Fuel Tank Breather	See Parts Manual
Hydraulic Reservoir	Change-Hydraulic Tank Breather	See Parts Manual
Compressor	Clean-Compressor Oil Strainer	
	Change-Compressor Oil Filters	See Parts Manual
Pump Drive Gearbox	Change the Initial Oil	80W90 Gear Oil
Water Injection Pump	Change-Crankcase Oil	SAE40 (anti rust)
Auxiliary Hoist	Check-Oil Level	TEXACO MEROPA 150 OR EQUIVALENT API GL-2/3
Feed Cable & Wire Rope	Clean and Lubricate Cable/Rope	See Instructions
Compressor Air Hose/Clamps	Inspect Air Hose, Retighten Clamp Bolts	See Section 7
EVERY 1000 HOURS		
Receiver Separator Tank	Change-Compressor Oil	IR PROTEC (low pressure)
		XHP605 (high pressure)
Hydraulic Oil Filters	Replace Main Return Oil Filters	See Parts Manual
	Replace Case Drain Oil Filter	
Rotary Head	Change-Rotary Head Oil	SAE 90W Gear Oil
Pump Drive Gearbox	Change Oil	80W90 Gear Oil
Rod Changer	Change Gear Reducer Oil	140W Gear Oil
Auxiliary Hoist	Change Oil	TEXACO MEROPA 150 OR EQUIVALENT API GL-2/3

6.2 – MAINTENANCE SCHEDULE

MAINTENANCE SCHEDULE (continued)

MAINTENANCE SCHEDULE (continued)		
DESCRIPTION	ACTION	LUBRICATION
EVERY 2000 HOURS		
Air Cleaners	Replace-Primary/Safety Elements	See Parts Manual
Track Planetary Gearbox	Drain & Refill Gearbox	ISO VG220 (Required Lubricant)
Engine Valve Clearance	See Actual Manufacturer's Service Manual	
Engine Belts & Tensioner	See Actual Manufacturer's Service Manual	
EVERY 5000 HOURS		
Hydraulic Reservoir	Drain, Clean and Refill Hydraulic Tank	ISO AW32
EVERY 6000 HOURS		
Engine Coolant	Drain and Flush Engine Cooling System. Replenish Coolant. See Manufacturer's Service Manual.	50/50-H2O & Coolant

6.3 - FILL CAPACITIES/LUBRICANTS/FUEL

HAZARDOUS SUBSTANCE PRECAUTION



HAZARDOUS SUBSTANCE PRECAUTION

The following information is provided to assist the owners and operators of Drilling Solutions Equipment. Further information may be obtained by contacting your Drilling Solutions Equipment Distributor.

The following substances are used in the manufacturing of this Drill and may be hazardous to health if used incorrectly.

SUBSTANCE	PRECAUTION
Anti Freeze -----	Avoid ingestion, skin contact and breathing fumes.
Hydraulic Oil -----	Avoid ingestion, skin contact and breathing fumes.
Engine Lubricating Oil-----	Avoid ingestion, skin contact and breathing fumes.
Compressor Oil -----	Avoid ingestion, skin contact and breathing fumes.
Preservative Grease -----	Avoid ingestion, skin contact and breathing fumes.
Rust Preventative -----	Avoid ingestion, skin contact and breathing fumes.
Engine Fuel -----	Avoid ingestion, skin contact and breathing fumes.
Battery -----	Avoid ingestion, skin contact and breathing fumes.
SAE Gear Oil -----	Avoid ingestion, skin contact and breathing fumes.

The following substances may be produced during the operation of this Drill and may be hazardous to health.

SUBSTANCE	PRECAUTION
Engine Exhaust Fumes -----	Avoid breathing fumes.
Engine Exhaust Fumes -----	Avoid buildup of fumes in confined spaces.
Electric Motor Dust ----- (Brushes/Insulation)	Avoid breathing in during maintenance.
Brake Lining Dust -----	Avoid breathing in during maintenance.

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

GENERAL INFORMATION

Lubrication is an essential part of preventive maintenance, affecting to a great extent the useful life of the unit. Periodic lubrication of the moving parts reduces to a minimum the possibility of mechanical failures. Different lubricants are needed and some components in the unit require more frequent lubricant than others. Therefore, it is important that the instructions regarding types of frequency of the application be explicitly followed.

The lubrication Chart that follows in this section shows those items requiring regular service and the interval at which they should be performed. Details concerning fuel, oil and other lubricants follow the lubrication chart. A regular service program should be geared to the items listed under each interval. These intervals are based on average operating conditions. In the event of extremely severe, dusty or wet operating conditions, more frequent lubrication than specified may be necessary.

1. Specific recommendations of the brand and grade of lubricants are not made here due to regional availability, operating conditions and also the continual development of improved products. Where questions arise, refer to component manufacturer's manual and a reliable supplier.
2. All oil levels are to be checked with the drill parked on a level surface and while the oil is cold, unless otherwise specified.
3. On plug type check points, the oil levels are to be at the bottom edge of the check port.
4. All grease fittings are SAE STANDARD unless otherwise indicated. Grease the non sealed fittings until grease is seen extruding from the fitting. One ounce (28 grams) of EP-MPG equals one pump on a standard one pound (0.45 kg) grease gun.
5. Over lubrication on non sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.
6. Unless otherwise indicated, items not equipped with grease fittings (linkages, pins, levers, etc.) should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An anti-seize compound may be used if rust has not formed. Otherwise, the component must be cleaned first.
7. Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

To prevent minor irregularities from developing into serious conditions, several other services or checks are recommended for the same intervals as the periodic lubrication.

1. Thoroughly wash all fittings, caps, plugs, etc. with a non-flammable, non-toxic cleaning solution before servicing to prevent dirt from entering while performing the service.
2. Lubricants must be at operating temperature when draining.
3. During regular lubrication service, visually check the entire unit with regard to cap screws, nuts and bolts being properly secured.
4. Spot check several capscrews and nuts for proper torque. If any are found loose, a more thorough investigation must be made.
5. If a defect is detected which requires special maintenance service, stop the drill operation until the defect has been corrected. If necessary, contact the local Atlas Copco distributor for help.

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

LUBRICATION TABLE

Periodic lubrication requirements are listed in the following Lubrication Chart. These requirements include lubricant checks and greasing designated areas of the drill.

LUBRICATION CHART				
SERVICE INTERVAL	DESCRIPTION	SERVICE	REMARKS	QUANTITY
10 HOURS OR DAILY	ENGINE OIL	ADD	API CG4, SAE 15W40	FILL TO DIPSTICK FULL
	HYDRAULIC OIL	ADD	ISOAW32	FILL TO FULL MARK
	COMPRESSOR OIL	ADD AS NEEDED	IR PROTEC (LP) XHP605 (HP)	FILL TO FULL MARK
	ENGINE COOLANT	ADD	WATER–ANTIFREEZE	AR
	FUEL TANK	FILL	#2 DIESEL FUEL	FILL TO NECK
	ROTARY HEAD OIL	ADD	SAE 90W GEAR OIL	FILL TO FULL MARK
		GREASE	EXXON MOBIL RONEX EXTRA HD MOLY 2	UNTIL RELIEF VALVE POPS OUT
	SHEAVES AND SPROCKETS	GREASE	MPG–EP1 GREASE	5 SHOTS EACH GREASE POINT
	ROD CHANGER	GREASE	MPG–EP1 GREASE	
	CAROUSEL AND CUPS	GREASE	MPG–EP1 GREASE	
	GEARBOX DRIVE SHAFT	GREASE	MPG–EP1 GREASE	
	CYLINDERS (ALL)	GREASE	MPG–EP1 GREASE	
50 HOURS	BATTERIES	ADD	DISTILLED WATER	AR
	PUMP DRIVE GEARBOX	ADD	80W90 GEAR OIL	FILL TO DIPSTICK FULL
	TRACK PLANETARY GEARBOX	ADD	ISO VG220 (REQUIRED LUBRICANT)	FILL TO LEVEL HOLE
100 HOURS	AUXILIARY HOIST	CHANGE	TEXACO MEROPA 150 OR EQUIVALENT 90W GL2/GL3	FILL TO LEVEL HOLE
250 HOURS	ENGINE OIL	CHANGE	API CG4, SAE 15W40	CAT 3406–36 quart (34 liters) CAT 3408–48 quarts (45 liters) CAT C15 – 36 quarts (34 liters) CAT C16 – 36 quarts (34 liters) CAT C18–40 quarts (38 liters) CAT 3412–72 quarts (68 liters) CUMMINS N14–36 quart (34 liters) QSX15 – 48 quarts (45 liters) QSK19–72 quarts (68 liters)
	TRACK PLANETARY GEARBOX	CHANGE	ISO VG220 (REQUIRED LUBRICANT)	FILL TO LEVEL HOLE
500 HOURS	PUMP DRIVE GEARBOX	CHANGE	80W90 GEAR OIL	4.5 QUART (4.2 LITER)
	WATER INJECTION PUMP OIL	CHANGE	SAE40 (ANTI RUST)	10 OUNCES (295 MILLILITER)
	AUXILIARY HOIST OIL	ADD	TEXACO MEROPA 150 OR EQUIVALENT 90W GL2/GL3	4000 lb. HOIST=2 PINTS (1 LITER) 8000 lb. HOIST=4 PINTS (1.9 L)

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

Service Function (continued)

LUBRICATION CHART				
SERVICE INTERVAL	DESCRIPTION	SERVICE	REMARKS	QUANTITY
1000 HOURS	COMPRESSOR OIL	CHANGE	IR PROTEC (LP) XHP605 (HP)	38 GALLON (144 LITER)
	ROTARY HEAD OIL	CHANGE	SAE 90W GEAR OIL	44 QUART (42 LITER)
	PUMP DRIVE GEARBOX	CHANGE	80W90 GEAR OIL	4.5 QUART (4.2 LITER)
	ROD CHANGER GEARBOX OIL	CHANGE	140W GEAR OIL	3 PINT (1.41 LITER)
	AUXILIARY HOIST OIL	CHANGE	TEXACO MEROPA 150 OR EQUIVALENT 90W GL2/GL3	4000 lb. HOIST=2 PINTS (1 LITER) 8000 lb. HOIST=4 PINTS (1.9 LITER)
2000 HOURS	TRACK PLANETARY GEARBOX	CHANGE	ISO VG220 (REQUIRED LUBRICANT)	FILL TO LEVEL HOLE
5000 HOURS	HYDRAULIC OIL	CHECK	HYDRAULIC OIL ANALYSIS	150 GALLON (567 LITER)
6000 HOURS	ENGINE COOLANT	CHANGE	WATER–ANTIFREEZE	44 GALLON (166.54 LITER)

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

FILL CAPACITIES

The following fluid capacities are provided for servicing personnel who must perform drill maintenance in remote locations where complete shop facilities and resources are not available. These capacities will give the servicing personnel an approximation of the fluid capacities of the components to be serviced. Always ensure that the specified method of checking for accurate fluid levels is used.

APPROXIMATE CAPACITIES	
COMPONENT	APPROXIMATE QUANTITY
SYSTEMS	
Hydraulic Tank (ISO AW32):	82 gallon (310 liter)
Hydraulic Oil (entire system):	150 gallon (567 liter)
Receiver Tank Oil: IR PROTEC - Low Pressure XHP605 High Pressure)	38 gallon (143 liters)
Rotary Head Oil (SAE 90W Gear Oil):	11 gallon (42 liter)
Pump Drive Gearbox (80W90 Gear Oil):	4.44 qt. (4.2 liter)
Rod Changer Gearbox (140W Gear Oil):	3 pint (1.41 liter)
Auxiliary Winch (TEXACO MEROPA 150):	2 Pints (1 liter)
Track Final Drive (ISO VG 220 is Required Lubricant):	
DM45SP 325L Final Drive Gearbox:	1.85 gallon (7 liters)
DMLSP 330S/330L Final Drive Gearbox:	2.1 gallon (8 liters)
DECK ENGINE	
Engine Coolant (50-50 Water / Anti-Freeze):	44 gallon (166.54liter)
Engine Oil (SAE 15W40):	
CAT 3406 Series:	36 quarts (34.1 liters)
CAT 3408 Series:	48 quarts (45 liters)
CAT C-15/C-16 Series:	36 quarts (34 liters)
CAT C18 Series:	40 quarts (38 liters)
CAT 3412 Series:	72 quarts (68 liters)
CUMMINS N14 Series:	36 quarts (34.1 liters)
CUMMINS QSX15 Series:	48 quarts (45 liters)
CUMMINS QSK19C Series:	72 quarts (68 liters)
Fuel Tank (#2 ASTMD-975-60T):	380 gallon (1438 liter)
WATER INJECTION PUMP	
PUMP DRIVE (SAE40W Anti Rust)	10 ounce (295 milliliter)

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

AW32 HYDRAULIC OIL

Hydraulic Oil Specifications

The quality of the hydraulic oil is important to the satisfactory performance of any hydraulic system. The oil serves as the power transmission medium, system coolant and lubricant. Selection of the proper oil is essential to ensure proper system performance and life.

The drill left the factory filled with **HUMBLE HYDRAULIC H** oil. The following shows the specifications.

EXXON HUMBLE HYDRAULIC H 32					
ISO Viscosity Grade	Flash °C (°F)	Pour °C (°F)	Viscosity		Viscosity Index
			cSt at 40°C	cSt at 100°C	
32	206 (403)	-18 (0)	32	5.4	95

Grade AW32 is a general specification. Grade ISOAW32 is a general specification. Hydraulic oil must conform to Parker Hydraulics Pump Division HF-O Standards (4-11-78) and ISO Viscosity Grade 32. The following are approved oils for Parker Hydraulics Pump Division HF-O Standard.

Manufacturer	Specifications
AMOCO	AMOLITE: HF OIL NO. 32
EXXON	NUTO-H 32
GULF	HARMONY AW32
ILLINOIS OIL PRODUCTS	SUPREME R&O ANTIWEAR HYD. OIL
SUN OIL	SUNVIS 816 WR (32)
TEXACO	RANDO OIL NC 32
PENNZOIL	AWX (WITH EC HI TEC ADD PACKS)
ATLANTIC RICHFIELD CO. (ARCO)	DURO AW-32

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

LUBE VISCOSITY GRADE COMPARISONS

For use as a General Guide Only. Viscosities are based on a 95 VI oil.

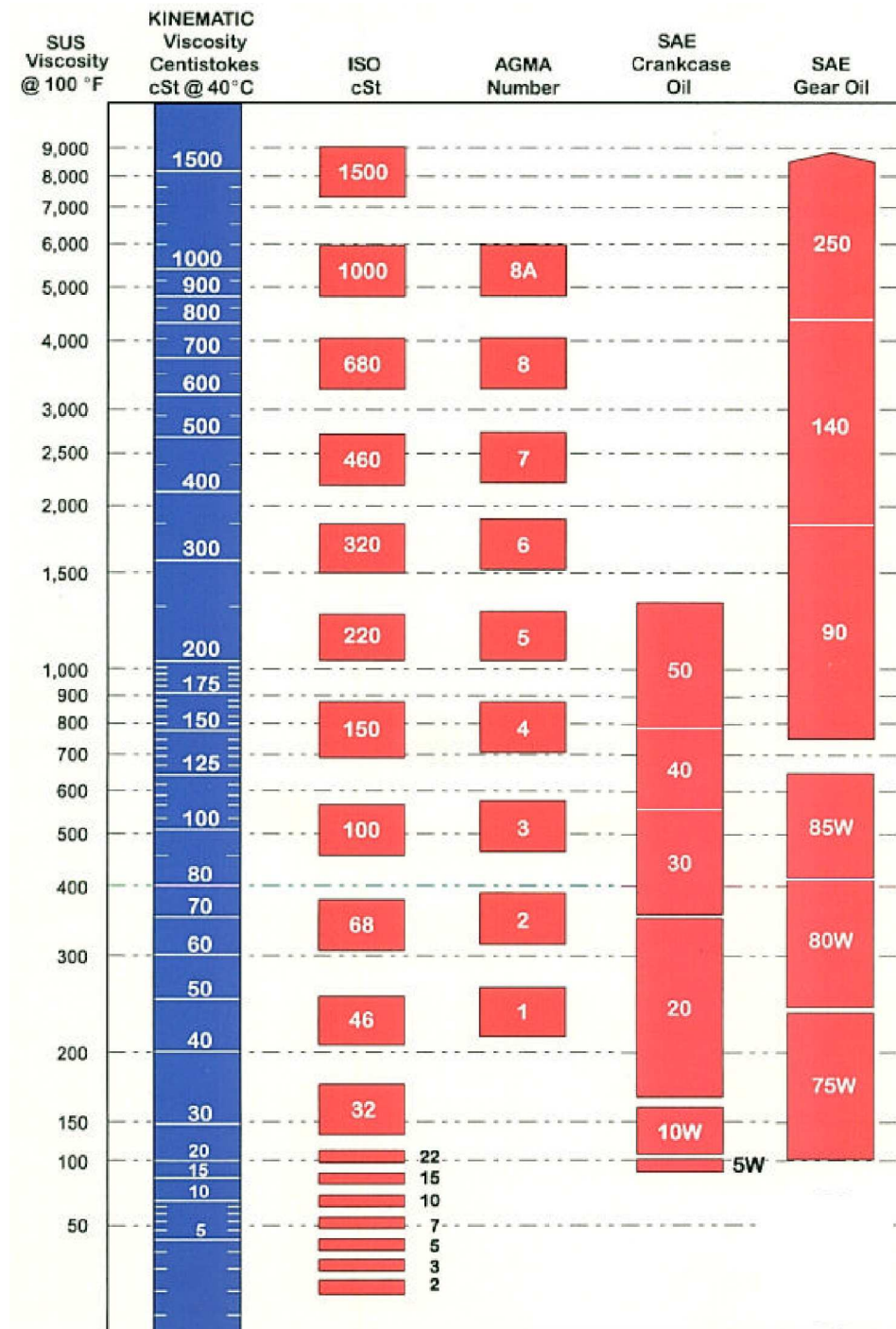


Figure 6.3–1

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

COMPRESSOR FLUIDS

COMPRESSOR FLUIDS		
Design Operating Pressure	Ambient Temperature	Specification
100 psi to 300 psi	-10°F to 125°F (-23°C to 52°C)	Preferred: IR Pro-Tec™ Alternate: ISO Viscosity Grade 46 with rust and oxidation inhibitors, designed for air compressor service.
350 psi	-10°F to 125°F (-23°C to 52°C)	Preferred: IR XHP 605 Alternate: IR XHP405 ISO Viscosity Grade 68 Group 3 or Group 5 with rust inhibitors designed for air compressor service.

Note: Compressor oil carryover (oil consumption) may be greater with the use of alternate fluids.

LUBRICANT OIL

Rotary Head Oil

ROTARY HEAD OIL		
Model	Quantity	Type
DM45, DM50, DML	44 Quart (11 Gallon) 41.6 Liter	S.A.E. 90W Gear Oil

Pump Drive Oil

PUMP DRIVE OIL		
Model	Quantity	Type
DM45, DM50, DML	6 Quart (1.5 Gallon) 5.67 Liter	80W90 Gear Oil

This gear lubricant is compounded to achieve high load carrying capacity and meet the requirements of either API-GL-5 or MIL-L-2105C. Unless otherwise specified, SAE-90 viscosity oil may be used for year round service. Low temperature usage is restricted as follows:

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

Pump Drive Oil (continued)

PUMP DRIVE EXTREME PRESSURE GEAR OIL	
SAE Viscosity Number	Minimum Ambient Temp. F° (C°)
75W	-40°F (-40°C)
80W	-15°F (-26°C)
85W	+10°F (-12°C)
90W	+20°F (-7°C)
140W	+40°F (+5°C)
250W	+50°F (+10°C)

FINAL DRIVE LUBRICATING OIL

Normal Operating Conditions

The actual manufacturer recommends only using lubricants that fulfill necessary viscosity requirements for lubricating the final drives.

The viscosity rating on the rating plate on the final drive and the following requirements must be observed: Use only lubricants with viscosity ratings for ISO VG150 and ISO VG220 for normal operating conditions from 50°F to 86°F (+10°C to +30°C).

Severe Operating Conditions

Under severe operating conditions, e.g. in an ambient temperature range between -22°F and 122°F (-30°C and +50°C), the actual manufacturer recommends using transmission oil with appropriate viscosity or a fully synthetic lubricant.

For lower operating temperatures, use oil with a lower viscosity (**SAE 80W-90**) and for higher temperatures, use oil with a higher viscosity (**SAE 85-140**).

Oil Recommendation

1. For lubrication of planetary gears (transmissions), use only the below listed or evident related type of oil!
2. The noted class of viscosity on the gearbox label is to be observed, respectively the following instructions are to be regarded.
3. Usually the noted viscosity of ISO-VG150 and ISO-VG220 is only given for normal operation temperature 50°F to 30°F (10°C to 30°C).

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

Oil Recommendation (continued)

Note: Choose by working temperature of 14°F to 50°F (±10°C) one viscosity class lower and at a range of 86°F to 122°F (30°C to 50°C) one grade higher as the necessary oil quality.

FINAL DRIVE OIL RECOMMENDATION	
Brand	Name / Designation
ARAL	DEGOL BG 150, BG 220
AVIA	AVILUB RSX 150
BP	ENERGOL GR-XP 150, GR-XP 220
CASTROL	ALPHA SP 150, ALPHA SP 220
CHEVRON	NL GEAR COMPOUND 150 220
DEUTSCHE SHELL	OMALA EP 150, EP220
ESSO	SPARTON EP 150, EP220
FINA	GIRAN 150, GIRAN 220
FUCHS	RENAP COMPOUND 104
GULF	EP LUBRICANT OIL HP 150, HP220
MOBIL	(MOBILGEAR) GF 629, GF30
TEXACO	MEROPA 150
TOTAL	CARTER EP 150, CARTER EP 220

HOIST/WINCH LUBRICANT

Required lubricant:

HOIST/WINCH LUBRICANT RECOMMENDATION	
Temperature Range	Required Lubricant
-30°F to 80°F (-34.47°C to 26.69°C)	Mobil SHC629 or Texaco Pinnacle 150
-10°F to 80°F (-23.35°C to 26.69°C)	Texaco Meropa 150 or equivalent AGMA #4EP
50°F to 130°F (10°C to 54.49°C)	Texaco Meropa 220 or equivalent AGMA #5EP

WATER INJECTION PUMP LUBRICANT

Required lubricant:

WATER INJECTION PUMP LUBRICANT RECOMMENDATION		
Component	Quantity	Type
Water Injection Pump Drive	10 ounce (295 milliliter)	SAE 40W(anti rust)

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

EXTREME PRESSURE MULTIPURPOSE GREASE

Under normal operating conditions, the following consistency grades are recommended:

CONSISTANCY GRADES	
Grade	Temperature Range
NLGI No. 0	Subzero Fahrenheit temperatures
NLGI No.1 or No. 2	Ambient temperatures 0–100°F (–17.8°C–38°C)
NLGI No. 2 or No. 3	Temperatures over 100°F (38°C)

Central Lube System Grease

When the Central Lube system is used, the drill leaves the factory with following grease. The following shows the specifications.

AUTOMATIC CENTRAL LUBE SYSTEM GREASE SPECIFICATION	
Descriptions	Specifications
Manufacturer:	Texaco, Inc.
Type:	Multi-Purpose Lithium Grease, Multipak EP0
Quantity:	120 lb. Drum (54.4 kg)
Soap, Lithium:	2.8%
Lead:	0.3%
Penetration, ASTM at 77°F (25°C)	
Unworked:	398
Worked:	378
Dropping Point:	367°F (186°C)
Oil Viscosity,	
SUS at 100°F (38°C)	960
(cSt)	(207)
SUS at 210°F (99°C)	81.0
(cSt)	(15.8)
Guide to Maximum Usable Temperature:	350°F (177°C)
Continuous Usable Temperature:	250°F (121°C)
Minimum Usable Temperature:	–30°F (–34°C)
Color:	Dark Green

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

Multi-Purpose Grease

With the exception of the Central Automatic Lube system and the Rotary Head, the following grease can be used:

MULTI-PURPOSE GREASE SPECIFICATION	
Descriptions	Specifications
Manufacturer:	Amalie Oil Company
Type:	Multi-Purpose Grease, EP1 (#673-6819)
Quantity:	120 lb. Drum (54.4 kg)
Soap Type:	LI-12-OH
Color:	Light Brown
NLG1 Grade:	2
Work Penetration D17 77°F (25°C)	265-295
Dropping Point:	
0-2265°C	177
0-2265°F	350
Rust, D-1743 (max):	1
Timken, D-2905, OK Load:	
Filler, WT.	-
Oxidation, D-942 (100 hrs):	7
Base Oil Properties:	
VIS @ 100°C (212°F) cSt	15.5
VIS @ 210°F (99°C) SUS	82
Pour Point:	
Degree Celsius:	-15°C
Degree Fahrenheit:	+5°F
Product Number:	5819

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

Rotary Head Grease

Atlas Copco recommends using Exxon Mobil Ronex Extra Heavy Duty Moly 2 grease in the rotary head. The following shows the specifications.

ROTARY HEAD GREASE SPECIFICATION	
Descriptions	Specifications
Manufacturer:	Exxon Mobil
Type:	Ronex Extra Heavy Duty Moly 2
Quantity:	1 lb. (.45 kg)
Thickener Type:	Lithium Complex
Pumpable Down To:	-10°C (14°F)
NLGL Grade:	2
Color:	Gray-Black
Base Oil Viscosity , ASTM D CST @ 40°C SUS @ 100°F	460 2500
Dropping Point, ASTM D 225:	250+ °C (480+ °F)
Rust Protection, ASTM D 1743:	Pass
Texture:	Smooth
Moly Percentage:	3
Note 1:	MOLY 2 is a compound with special extreme pressure and anti-wear additives to protect bearing surfaces at high load-carrying capability.
Note 2:	For applications requiring lower pumpable temperatures, contact engineering.

ENGINE LUBRICATING OIL

For latest applicable engine lubricating oil specifications, contact the engine manufacturer, your distributor or your local Drilling Solutions distributor. Drills leave the factory with API CG4, SAE 15W40 OIL. The following shows the specifications.

ENGINE LUBRICATING OIL SPECIFICATION	
Descriptions	Specifications
Manufacturer and Type:	AMOCO 300
SAE Viscosity Grade:	15W-40
API Service Category:	CG4, MIL-L-2104C
Approved Oils:	Pennzoil Long Life 15W-40 Texaco Ursa Super Plus 15W-40

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

ENGINE COOLANT SPECIFICATIONS

Coolant is normally composed of three elements: water, additives and glycol.

Water

Water is used in the cooling system to transfer heat. Distilled or deionized water is recommended for use in the engine cooling systems. DO NOT use the following types of water in cooling systems: hard water, softened water that has been conditioned with salt, and sea water. If distilled water or deionized water is not available, use water with the properties that are listed in the following table.

MINIMUM ACCEPTABLE WATER REQUIREMENTS	
Property	Maximum Limit
Chloride (Cl):	40 mg/L (2.4 grains/US gallon)
Sulfate (SO ₄):	100 mg/L (5.9 grains/US gallon)
Total Hardness:	170 mg/L (10 grains/US gallon)
Total Solids:	340 mg/L (20 grain/US gallon)
Acidity:	pH of 5.5 to 9.0

Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur: corrosion, formation of mineral deposits, rust, scale, pitting and erosion from cavitation of the cylinder liner and foaming of the coolant. Additives must be added at the proper concentration. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

1. Formation of gel compounds
2. Reduction of heat transfer
3. Leakage of the water pump seal
4. Plugging of radiators, coolers and small passages.

Glycol

Glycol in the coolant helps to provide protection against the following conditions: Boiling, Freezing and Cavitation of the water pump and the cylinder liner. For optimum performance, use a 1:1 mixture of a water/glycol solution.

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

FUEL OIL

Cummins Fuel Oil

 WARNING

Do not mix gasoline, alcohol or gasohol with diesel fuel. This mixture can cause an explosion.

Cummins Engine Company recommends the use of ASTM No. 2D fuel. The use of No. 2 diesel fuel will result in optimum engine performance. At operating temperatures below 32°F (0°C), acceptable performance can be obtained by using blends of No. 2D and No. 1D. The use of lighter fuels can reduce fuel economy.

The viscosity of the fuel **must** be kept above 1.3 cSt at 212°F (100°C) to provide adequate fuel system lubrication.

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

CUMMINS FUEL OIL SPECIFICATION TABLE	
Viscosity (ASTM D–445)	1.3 to 5.8 centistokes per second at 104°F (1.3 to 5.8 mm per second at 40°C)
Cetane Number (ASTM D–613)	40 minimum (exception: in cold weather or in service with prolonged idle, a higher cetane number is desirable)
Sulfur Content (ASTM D–129 or 1552)	Not to exceed 1 percent by weight
Water and Sediment (ASTM D–1796)	Not to exceed 0.1 percent by volume
Carbon Residue (Ramsbottom, ASTM–D–524 or Conradson, ASTM D–189)	Not to exceed 0.25 percent by weight on 10 percent volume residue
Flash Point	At least 125°F (52°C) or legal temperature if higher than 125°F (52°)
Density (ASTM D–287)	30 to 42°F (–1 to 6°C) API gravity at 60°F (16°C) (0.816 to 0.876 Sp. Gr.)
Cloud Point (ASTM D–97)	10°F (6°C) below lowest ambient temperature at which the fuel is expected to operate
Active Sulfur	Copper strip corrosion not to exceed No. 2 rating after 3 hours at 122°F (49°C)
Ash (ASTM D–482)	Not to exceed 0.02 percent by weight
Distillation (ASTM D–86)	The distillation curve must be smooth and continuous. At least 90 percent of the fuel must evaporate at less than 725°F (385°C).

6.3 – FILL CAPACITIES/LUBRICANTS/FUEL

CAT Fuel Oil

Diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into two general groups. The two groups are called the preferred fuels and the permissible fuels. The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel, furnace fuel, gas oil or kerosene. The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and in reduced engine service life. Diesel fuels that meet the specifications in the following table will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No.1-D or No. 2-D in “ASTM D975” generally meet the specifications. Specifications and requirements shown in the table are for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Caterpillar Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Aromatics	35% maximum	“D1319”
Ash	0.02% maximum (weight)	“D482”
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	“D524”
Cetane Number	40 minimum (DI engines)	“D613”
	35 minimum (PC engines)	
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature	
Copper Strip Corrosion	No. 3 maximum	“D130”
Distillation	10% at 282°C (540°F) maximum	“D86”
	90% at 360°C (680°F) maximum	
Flash Point	legal limit	“D93”
API Gravity	30 minimum	“D287”
	45 maximum	
Pour Point	6°C (10°F) minimum below ambient temperature	“D97”
Sulfur	3% maximum	“D3605” or “D1552”
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum at 40°C (104°F)	“D445”
Water and Sediment	0.1% maximum	“D1796”
Water	0.1% maximum	“D1744”
Sediment	0.05% maximum (weight)	“D473”
Gums and Resins	10 mg per 100 mL maximum	“D381”
Lubricity	3100 g minimum	“D6078”
	0.45 mm (0.018 inch) maximum at 60°C (140°F)	“D6079”
	0.38 mm (0.015 inch) maximum at 25°C (77°F)	

6.4 - MAINTENANCE AS REQUIRED

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.4 – MAINTENANCE AS REQUIRED

INITIAL BREAK-IN MAINTENANCE

New equipment requires the following initial one time break-in maintenance after 50 to 100 hours of operation. After this initial phase, the regular intervals listed in the maintenance schedule should be followed.

Check Wheel Nuts Adjustment

The following maintenance must be carried out after 50–100 hours:

1. Check that the wheel nuts (C) are torqued to the correct value of 420 ft/lbs (571 Nm).

NOTE:

If new wheel nuts have been recently installed, they may require frequent checks until they seat properly.

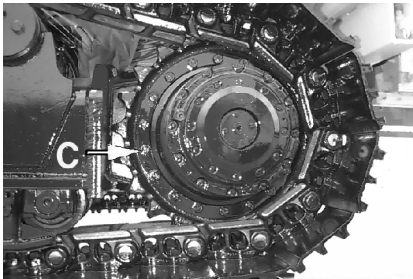


Figure 6.4–1

2. Repeat same procedure for the other track drive.

SERVICE AS REQUIRED

The following maintenance in this MAINTENANCE AS REQUIRED section requires attention on an as needed basis before, during and after the drill operation shift. This is in addition to the 10 hour daily routine maintenance procedures. Performance of this inspection can result in longer life and maximum productivity from the drill.

AIR CLEANERS

The following are detailed instructions for performing routine maintenance procedures on engine air cleaners and compressor air cleaners.



Engine and Air Compressor Damage. Raw, unfiltered air can cause engine and compressor damage. Never service the air cleaners while the engine is running.

6.4 – MAINTENANCE AS REQUIRED

Air Cleaner Indicators

Check the Air Cleaner Visual Restriction Indicators (see figure 6-2) before every shift, during every shift and after every shift.

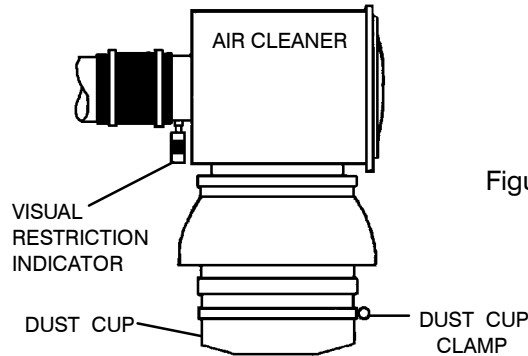


Figure 6.4-2

Clean and inspect both engine and compressor air cleaner visual restriction indicators. They should be GREEN. If RED, clean or replace the filter elements.

After servicing the element, reset the restriction indicator to GREEN when the element is replaced in the air cleaner housing.

The engine and compressor air cleaners must be checked to verify the restriction indicators are not sticking. Check by pressing in the rubber boot. The internal green/red indicator should move freely.

Connections and Ducts

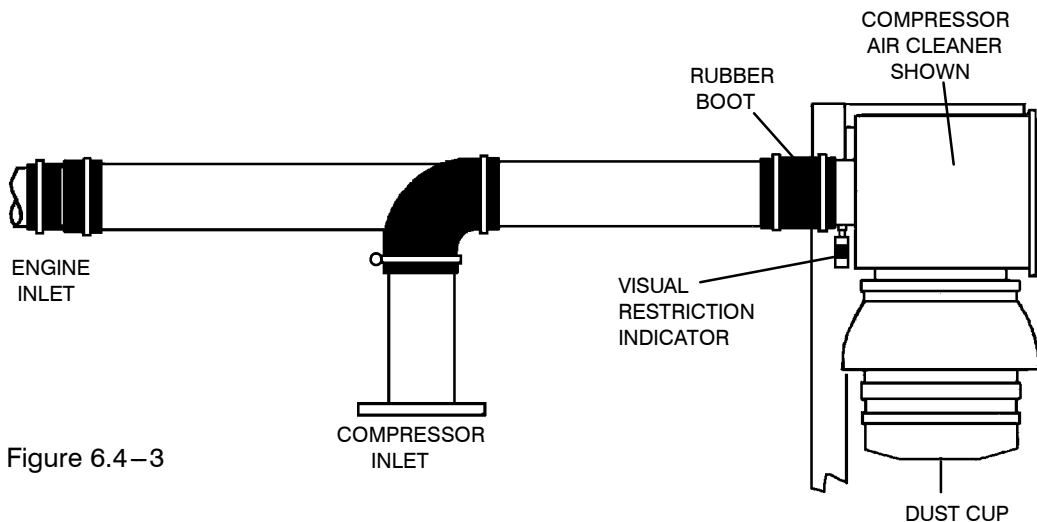


Figure 6.4-3

Check Air Cleaner connections and ducts for leaks before every shift, during every shift and after every shift. Ensure all connections between the air cleaner and engine are tight and sealed. Ensure all connections between the air cleaner and air compressor are tight and sealed.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

6.4 – MAINTENANCE AS REQUIRED

Empty Dust Cups

As daily routine maintenance, and as required in extremely dusty conditions, the dust cups on each of the air cleaners must be emptied of accumulations.

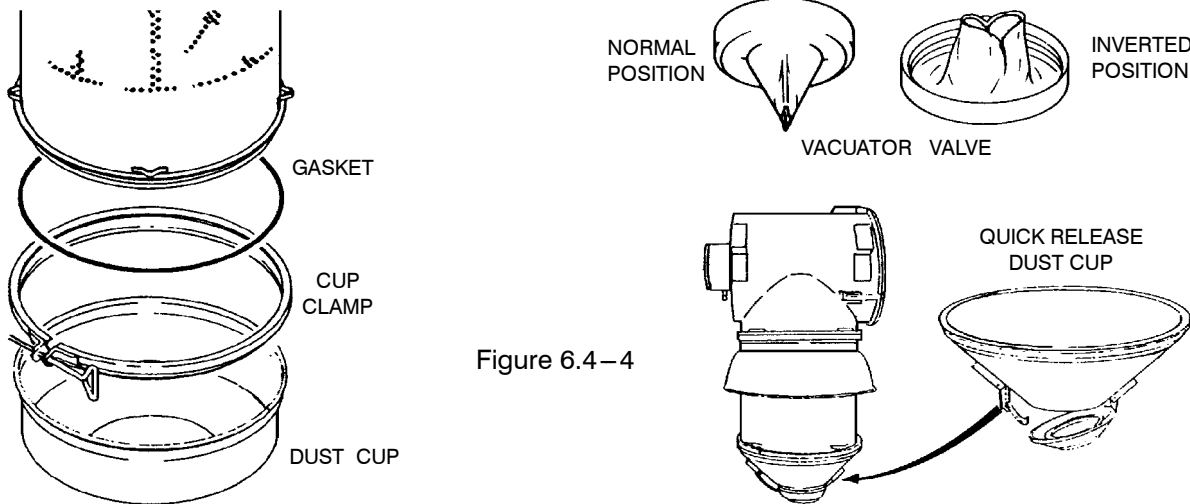


Figure 6.4-4

On filters equipped with dust cups (See Figure 6.4-4), the cup must be emptied when it becomes 2/3 full. The frequency of dust cup servicing varies with the operating conditions. It may be necessary to empty the dust cup daily.

1. Loosen the dust cup clamps and remove dust cups from both the compressor and engine air cleaners.
2. Empty any accumulations of dust and dirt and replace the dust cup. Secure the dust cup clamps.
3. When reinstalling the dust cup, make sure it seals all the way around the air cleaner body.
4. Inspect the o-ring between the dust cup and the air cleaner body. If it is damaged in any way, it must be replaced.

On filters equipped with a quick release dust cup (See Figure 6.4-4), simply release the latch on the dust cup and allow it to swing down and empty. When it is empty, close the dust cup and lock it in place with the latch.

On filters equipped with vacuator valves (See Figure 6.4-4), the dust cup service is cut to a minimum. A quick check to see that the vacuator valve is not inverted, damaged or plugged is all that is necessary.

6.4 – MAINTENANCE AS REQUIRED

Air Cleaner Pre-Cleaner

The Donaclone tubes in the filter pre-cleaner may become lightly plugged with dust which can be removed with a stiff fiber brush (See Figure 6.4-5). If heavy plugging is evident, remove the lower body section and clean with compressed air or water not to exceed 160°F (71 °C).



Never clean Donaclone tubes with compressed air unless both the safety and primary elements are installed in the air cleaner. Do not steam clean the tubes in the pre-cleaner.

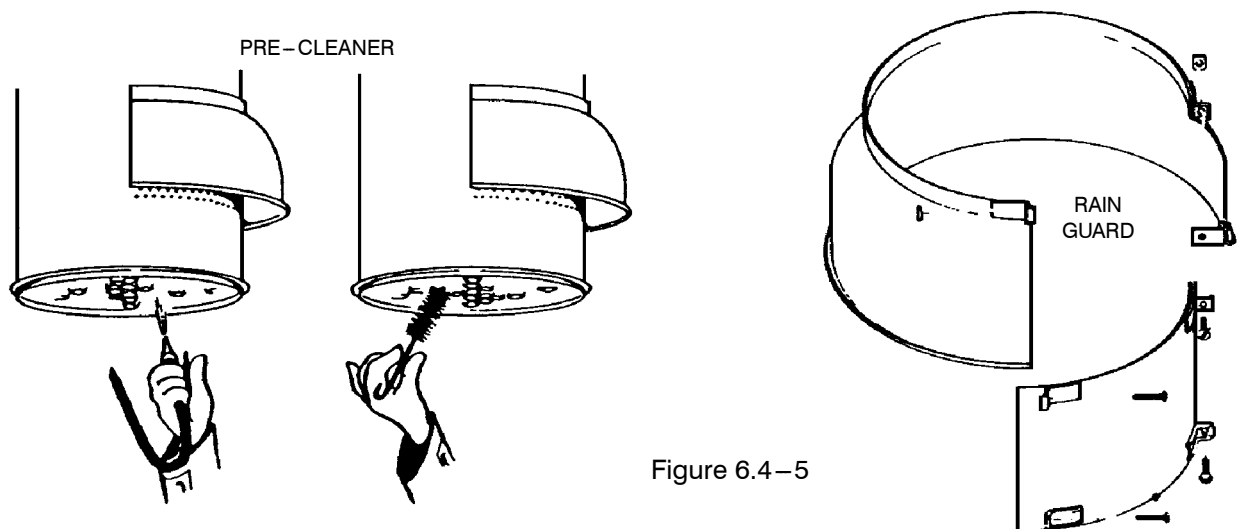


Figure 6.4-5

Check Cleaner Rain Guard

Check the bolts fastening the rain guard around the pre-cleaner body and make sure they are secure (See Figure 6.4-5).

If the bolts become loose, it will allow the rain guard to fall down over the openings in the pre-cleaner and restrict the flow of air into the air cleaner.

6.4 – MAINTENANCE AS REQUIRED

Air Cleaner Elements

The air cleaner is the dry type with two elements: A **primary element** that is replaceable and can be cleaned, and a **safety element** that should only be replaced and never cleaned.

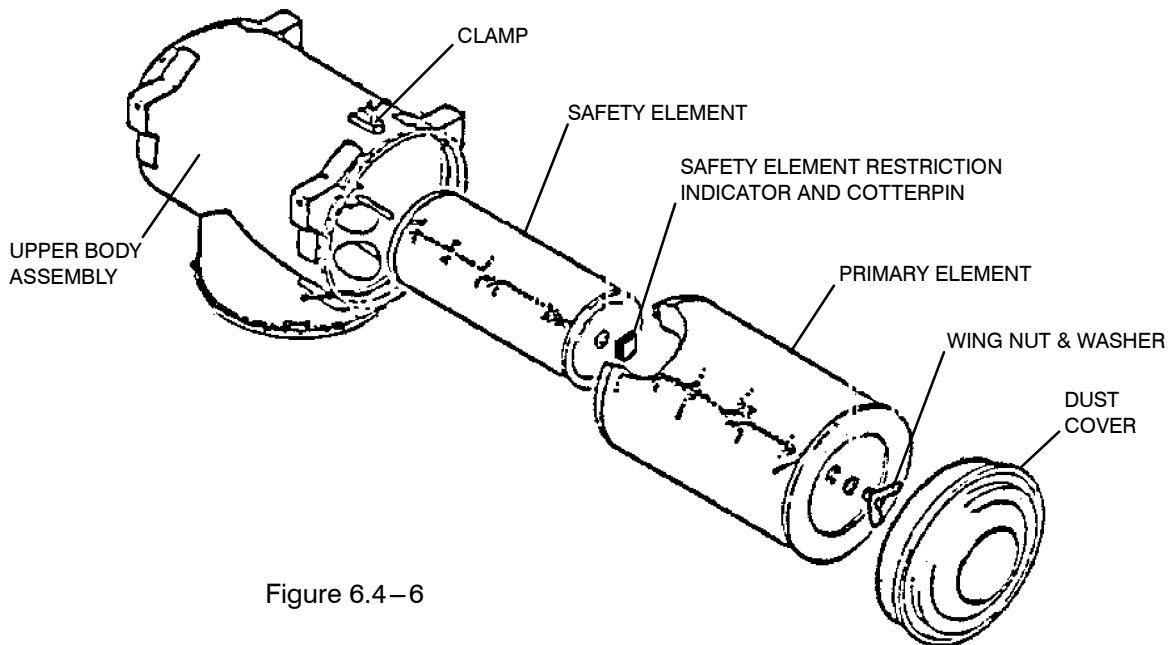


Figure 6.4–6

When the Visual Restriction Indicator is RED, clean and replace the air cleaner elements. The following maintenance procedure must be carried out.

1. Unclip the three clamps holding the dust cover.
2. Remove dust cover.
3. Remove wing nut and washer. Carefully withdraw the primary air cleaner element.
4. Inspect the safety element restriction indicator (Safety Signal). If the indicator is RED, replace the safety element.

NOTE:

*Make sure the safety element wing nut is tight. **Never attempt to clean a safety element.** You must change the safety element after three primary element changes or as indicated by the Safety Service Indicator.*

5. Clean the inside of the cover and the housing with a clean, damp cloth.

6.4 – MAINTENANCE AS REQUIRED

Air Cleaner Elements (continued)

6. To clean the primary element, perform the following:

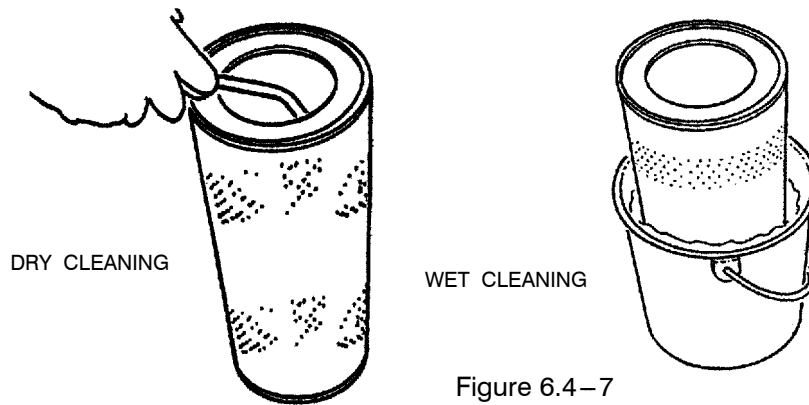


Figure 6.4-7

- a. To **dry clean** the element, carefully direct compressed air (not to exceed 100 psi or 5 bar pressure) at an angle onto the inside surface of the element from no closer than 1 inch (25.4mm) from the filter.
- b. To **wet clean** the element, soak for 15 minutes in lukewarm water, not exceeding 160°F (71°C), mixed with a commercially available detergent. Rinse till water runs clear (40 psi maximum).

After cleaning, the element must be thoroughly dry before using. Do not use compressed air to dry element.

NOTE:

Replace the primary element after six cleanings or annually, whichever comes first.

7. Examine new or newly cleaned primary element for torn or damaged pleats, bent end covers, liners and gaskets.
8. Ensure that the primary element wing nut and washer are not cracked or damaged. Replace if necessary.
9. The safety element should be replaced at this time if:
 - a.) Examination of the removed primary element reveals a torn or perforated element.
 - b.) Change safety element after three primary element changes or 1 year duration.
 - c.) Change safety element as indicated by the Safety Element Restriction Indicator.
 - d.) Change safety element if the air cleaner visual restriction indicator is RED after servicing the primary element.
10. Clean the inside of the air cleaner housing before removing safety element.
11. To replace the safety element, remove the cotterpin and restriction indicator. Carefully remove the safety element. Dispose of the used element properly.

6.4 – MAINTENANCE AS REQUIRED

Air Cleaner Elements (continued)

12. Install new safety element and secure it with the restriction indicator and cotterpin.
13. Carefully install the cleaned or new primary element and secure it with wing nut and washer.
14. Install the dust cover.
15. Inspect all air intake piping and joints between the air cleaners and engine air and compressor air inlets to ensure that no dusty air can enter.
16. Ensure all clamps are tight.

Air Cleaner Service Tips

Follow these simple service tips. You'll keep your air cleaners working at their best to protect your engines and compressor continuously.

1. To begin with, let restriction levels be your guide. Use a Restriction Indicator.
2. Service elements only when the restriction reaches the service level recommended by the engine or equipment manufacturer. It's only above that point that air cleaner restriction begins to reduce performance levels.
3. If engine or compressor performance is poor, but restriction is still within limits, ***do not change that element!*** The air cleaner is probably not at fault.
4. To get extra service hours out of each filter element, make sure the air inlet is away from any heavy dust clouds caused by operation. And make sure exhaust carbon cannot enter the air cleaner.
5. Check to see that all connections are tight and leak-free and that breakaway joints, both intake and exhaust, are aligned and sealing.
6. Make sure that the vacuator valve, on air cleaners so equipped, is not plugged. Is the cup joint sealing? This should take care of most of the air cleaner related performance problems.
7. When restriction readings finally indicate a change, remove primary element very carefully. Use a *damp* cloth to wipe out all the excess dust in the air cleaner.
8. If you reuse the elements, clean them with care. Rapping, tapping or pounding dust out of them is dangerous. Severe damage to the filter will result.
9. A thorough cleaning with air or water is recommended in many cases. But be careful. Too much pressure can break the filter paper and destroy the element.
10. Carefully check new or properly cleaned elements for damage before installing.
11. Never attempt to clean a safety element. Change safety elements only after three primary element changes or as indicated by a SafetySignal™ Service Indicator.
12. Make it a habit ***not*** to disturb the element until restriction again reaches the service limit.

6.4 – MAINTENANCE AS REQUIRED

CLEAN THE DRILL

The complete drill must be given a weekly cleaning. Daily cleaning will be required if material is adhering to the tower or track working parts.

1. Make sure the inside of the operator's cab, decking, steps and grab rails are clean. Oil, grease, snow, ice or mud in these areas can cause you to slip and fall. Clean your boots of excess mud before getting on the drill.
1. Check that no material or debris is jammed between track sprockets and track tensioners.
2. Check the tower feed installation for debris buildup around the sheaves.
3. Thoroughly wash all fittings, caps, plugs, etc. with a nonflammable, nontoxic cleaning solution before servicing to prevent dirt from entering while performing the service.

NOTE:

Protect all electric components and control panels against entry of water or steam when using high pressure cleaning methods. Cover the fuel and hydraulic fill cap breathers located on each tank.

4. After cleaning, check for defects in the air cleaner ducts.
 - a.) Check intake for accumulation of debris that could restrict air flow.
 - b.) Check air cleaner mounting hardware for security.
 - c.) Check all hoses for cracks, chafing or deterioration and replace them at the first sign of probable failure.

LOOSE BOLTED CONNECTIONS

If any loose nuts or bolts are found during the frequent walk around and the daily inspections, ensure they are properly torqued. Refer to 6-14 *Torque Specifications* for required torque on bolt sizes and grades.

Always replace self-locking nuts if they have been loosened.

6.4 - MAINTENANCE AS REQUIRED

DRILL FEED CHAINS

Check all chains periodically for signs of deterioration and wear.

Adjust Drill Feed Chains

1. With the tower down and the rotary head at the top of the tower but not touching the stops, measure the top feed chain sag from under the front tower member to the center of the feed chain (see Figure 6.4-8). The sag should not be more than three inches (7.6 cm).

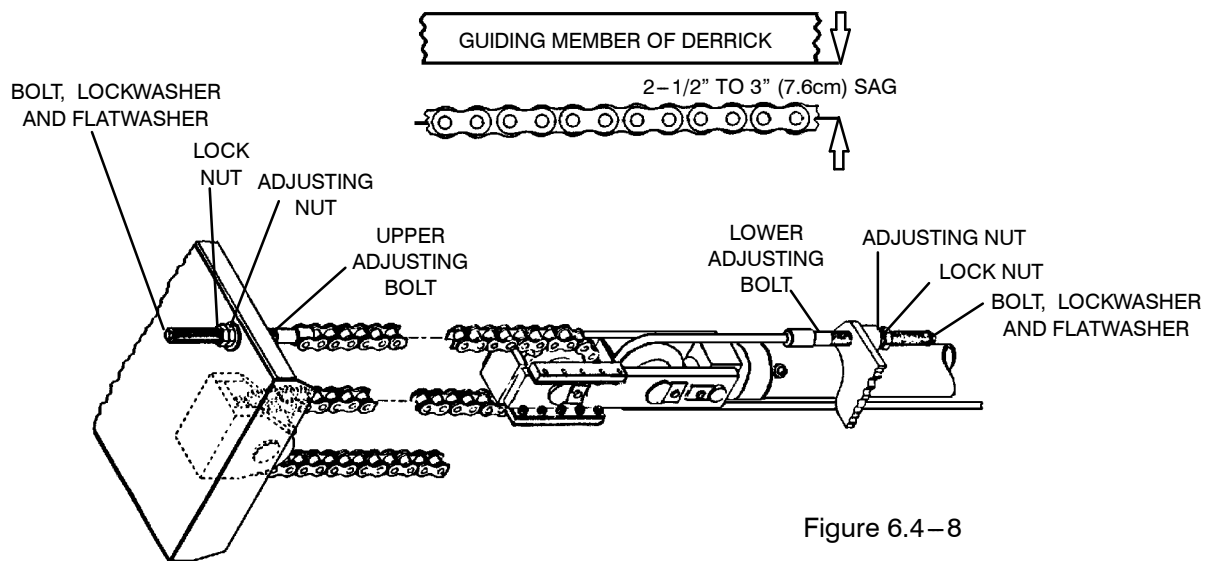


Figure 6.4-8

2. If the chain sag is more than three inches (7.6 cm), tighten the adjusting nuts at the top of the tower. Take up the sag in both feed chains until it measures between 2.5 (6.35 cm) and 3 inches (7.6 cm).
3. If one side of the feed system leads the other when raising and lowering the rotary head, tighten the top adjusting nut of the leading feed chain side.

NOTE:

Tighten until the other side begins to lead, then loosen until both sides move together. This adjustment may result in the tension on one side of the feed system to be more than the other, which is acceptable as long as neither feed chain sags more than three inches (7.6cm).

4. Raise the tower and lower the rotary head until the spindle contacts the centralizer. Check to see if the spindle is exactly in line with the centralizer.

6.4 - MAINTENANCE AS REQUIRED

Adjust Drill Feed Chains (continued)

5. If the spindle is not in line with the centralizer, it can be corrected by adjusting either side of the feed system.
 - a. Lower the tower and loosen the upper adjusting nut and tighten the lower adjusting nut to move the spindle away from the chain being worked on.
 - b. Loosen the lower adjusting nut and tighten the upper adjusting nut to move the spindle toward the chain being worked on.
 - c. The adjusting nut on one end of the feed chain must be tightened the same number of turns (including fractional turns) that were loosened on the other end so the chain tension is not changed.
6. Raise the rotary head to the top of the tower. If the feed cylinders are fully retracted before the rotary head reaches the stops at top of the tower, the lower adjusting nuts must be loosened and the upper nuts tightened.
7. Lower the rotary head to the bottom of the tower. If the feed cylinders are fully extended before the rotary head reaches the stops at the bottom of the tower, the upper adjusting nuts must be loosened and the lower nuts tightened.

NOTE:

Tighten the lower (or upper) adjusting nuts the same number of turns that the upper (or lower) nuts were loosened.

8. Install a locknut to each adjusting bolt, and as an added precaution install a bolt, lockwasher and flatwasher to the end of each adjusting bolt.
9. Raise the rotary head to top of the tower until the top of the rotary head just comes in contact with the stops. If the rotary head only contacts one stop, the gap between the other stop and the rotary head must be filled with shims.
10. Lower the rotary head to the bottom of the tower until it just comes in contact with the stops. Add shims if necessary.

6.4 - MAINTENANCE AS REQUIRED

FEED CABLE & WIRE ROPE

The wire rope industry recognizes the ASME (American Society for Mechanical Engineers) standards for the criteria to set the end of the service life of wire ropes on cranes and towers, based on visible indicators of wire rope deterioration.

Replacement Guideline

The standards for cranes and towers allow 6 broken wires in a rope lay length, or 3 broken wires in one strand, in a rope lay. The lay length is 5.5 times the rope diameter (B30.4–B30.8).

The overhead hoist standard criteria is 12 broken wires in a rope lay length, or 4 broken wires in one strand per lay length (B30.2 and 30.16).

There is no industry wide recognized standard for wire rope on drills, but the above standards can be used as a guide to determine a safe practical point for wire rope replacement. Cable feed on the pullback side on a drill is similar to a drilling derrick, as the cables support the drill pipe string and the rotary transmission device. The cable feed on the pulldown side of the drill does not reflect any of the ASME standard conditions. The only load these cables see is the hydraulically applied loads. There is no dead weight being supported and no component free fall will occur due to complete failure of the wire rope. However, a tensioned rope failure is possible, so replacement should not be delayed beyond the above determined replacement point.

Also, note that any broken wires protruding from the rope create a snagging hazard. These wires should be trimmed flush to the rope diameter. These trimmed broken wires need to be recorded and logged as to their exact locations, as part of the broken wire count criteria for determining rope replacement.

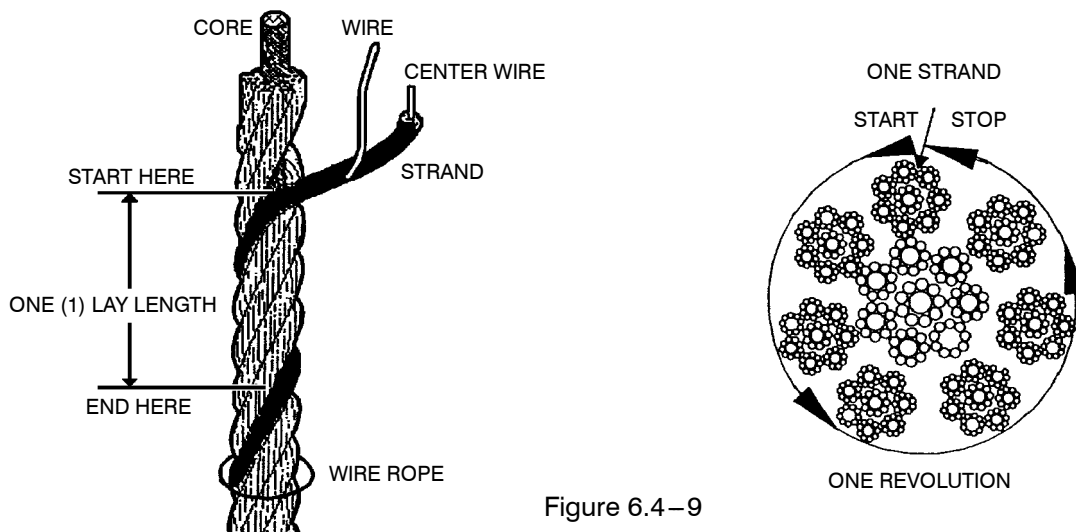


Figure 6.4–9

6.4 - MAINTENANCE AS REQUIRED

Replacement Guideline (continued)

The drawing in Figure 6.4–9 shows the wire rope broken down. The wire rope is made up of strands woven around a core. Each strand is made up of individual wires. If a rope breaks four (4) wires from the same strand within the lay length, it should be replaced according to ASME standards.

One lay length is the distance along the rope that it takes one strand to make one revolution. The diameter of a wire rope is taken at the highest points. It is NOT taken across the flats of the strands.

Feed Cable Adjustments

To prevent cables from “unwinding” while the cable is being adjusted, install a 1–1/2” open end wrench on the stud end of the cable to prevent it from turning. If the cable is allowed to unwind, it will require frequent adjustments that will use up all the adjusting threads. Holding the cable while tightening will insure proper adjustment and a longer cable life.

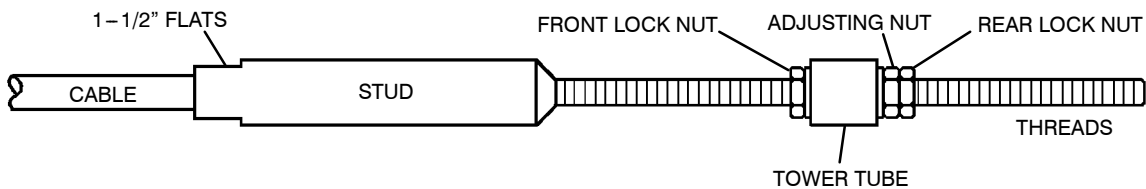


Figure 6.4–10

1. Move the rotary head to the top of the tower.
2. There are two lock nuts on the front end of the stud and one lock nut on the rear. The proper procedure for adjusting the cable is to loosen the front lock nut several turns to allow the cable to be tightened. Next, loosen the outside rear lock nut to allow the adjusting nut to be able to rotate. Holding the stud end with a wrench, tighten the adjusting nut against the support. This action pulls the cable and shortens its length. When the sag in the center of the cable is about 1/2", move the rear locking nut up behind the adjusting nut and tighten them together. Next, move the front locking nut up until it is touching the support and tighten securely.
3. The cable should NOT rotate as the rotary head travels up and down the tower. When the adjustment threads are all used up, the cable needs to be replaced.

6.4 - MAINTENANCE AS REQUIRED

Cable Lubrication

Lubrication of the feed cables should be included in the maintenance schedule. Cables should be cleaned with a wire brush and solvent and lubricated approximately every 500 hours with one of the following or equivalent:

1. Texaco Crater A
2. Brooks Klingfast 85 (Brooks Oil Co.)
3. Gulf Seneca 39
4. Whitmore's Wire Rope Lubricant (Whitmore Manufacturing Co.)

The lubricant can be applied with either a spray or a brush and is recommended for protection against corrosion only.

Wire Rope

Winch ropes, including their anchorage and other load carrying components of the travelling block and winch system, e.g. sheave bearings, rope sheaves and drill hooks, shall be checked at least once a week.

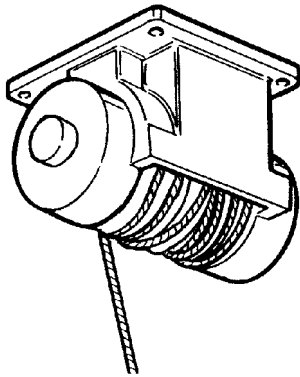


Figure 6.4–11

Wire ropes shall be examined and discarded in accordance with 3.5 of ISO 4309:1990. In table 3.5 of ISO 4309:1990, classification groups M1 and M2 shall be used. On drill rigs with normal hook load of more than 1000KN, the winch rope shall be regularly paid out and shortened according to a plan laid down by the manufacturer on basis of experience.

Wire rope used in drilling operations becomes unusable because of wear and wire breakage and should be discarded according to certain criteria (See Figure 6.4–9).

1. Replace when four (4) randomly distributed broken wires are found in one lay.
2. Replace when wire rope shows wear of one third (1/3) the original diameter of the outside wire.
3. Replace when evidence of any heat damage from any cause is found.
4. Replace when any kinking or cracking occurs.

6.4 - MAINTENANCE AS REQUIRED

Wire Rope Clamps

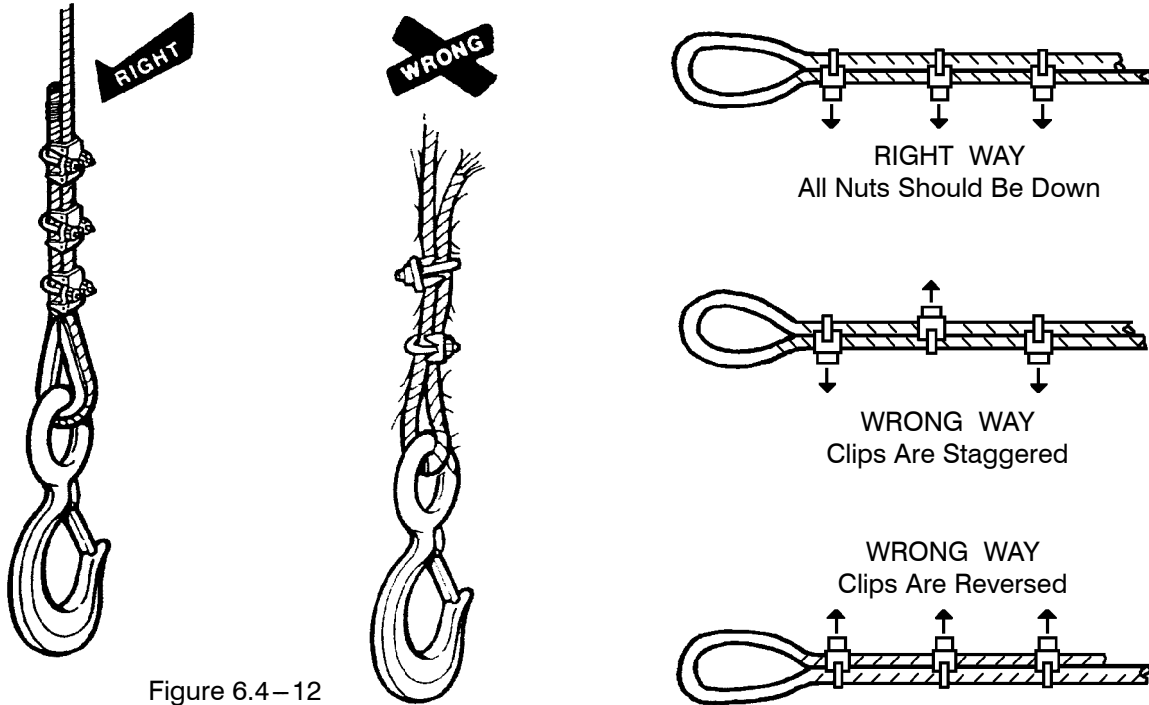


Figure 6.4-12

Incorrect installation of the rope clamps can cause premature rope failure and/or possible bodily injury.

Nuts should always be retightened after the initial load has been applied.

A termination made in accordance with the following instructions and using the number of clips shown has an approximate 80% efficiency rating. This rating is based upon the catalog breaking strength of wire rope. If a pulley is used in place of a thimble for turning back the rope, add one additional clip.

The number of clips shown is based upon using right regular or Lang lay wire rope, 6 X 19 Class or 6 X 37 Class, fibre core or IWRC, IPS or XIPS.

The number of clips shown also applies to right lay wire rope, 8 X 19 Class, fibre core, IPS, sizes 1-1/2 inch and smaller; and right regular lay wire rope, 18 X 7 Class, fibre core, IPS and XIPS, sizes 1-3/4 inch and smaller.

The important things are using proper thimble size, number of clamps and size, and installing them properly. Refer to drawing Figure 6.4-12 and Wire Rope Clamp chart.

6.4 - MAINTENANCE AS REQUIRED

Wire Rope Clamps (continued)

Correct Usage of Wire Rope Clips			
Dimensions are in inches and approximate			
Clip Size Inches	Minimum Number of Clips	Amount of Rope to Turn Back in Inches	Torque in Foot Pounds
1/8	2	3–1/4	–
3/16	2	3–3/4	–
1/4	2	4–3/4	15
5/16	2	5–1/2	30
3/8	2	6–1/2	45
7/16	2	7	65
1/2	3	11–1/2	65
9/16	3	12	95
5/8	3	12	95
3/4	4	18	130
7/8	4	19	225
1	5	26	225
1–1/8	6	34	225
1–1/4	6	37	360
1–3/8	7	44	360
1–1/2	7	48	360
1–5/8	7	51	430
1–3/4	7	53	590
2	8	71	750
2–1/4	8	73	750
2–1/2	9	84	750
2–3/4	10	100	750
3	10	106	1200

6.4 - MAINTENANCE AS REQUIRED

Wire Rope Installation

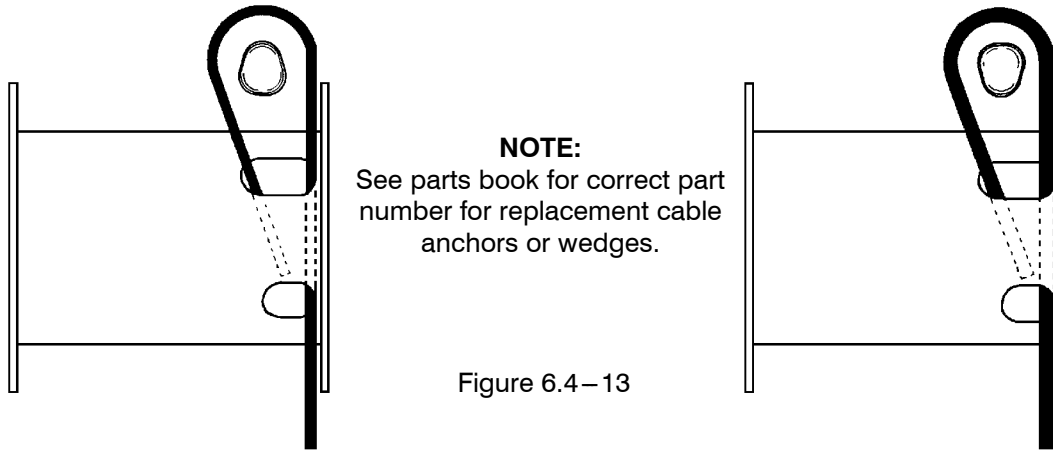
WARNING

The cable clamp is not designed to hold the full load alone. NEVER attempt to lift a load with less than 5 wraps of cable on the drum.

Unless a revolving stand is available, we recommend unwinding the cable coil prior to installing on winch drum. This prevents the cable from becoming twisted during the winding operation.

Insert large end first for 3/8 in. and 7/16 in.
(10mm And 11mm) wire rope.

Insert small end first for 1/2 in. and 9/16 in.
(13 mm and 14 mm) wire rope.



Take the free end of the wire rope and insert it through the small opening of the anchor pocket (see Figure 6.4-13). Loop the wire rope and push the free end about 3/4 of the way back through the pocket. Install the wedge, then pull the slack out of the wire rope. The wedge will slip into the pocket and secure the wire rope into the drum. The anchor is designed to accommodate several sizes of wire rope. You may anchor 3/8 in. and 7/16 in. (10 and 11 mm) wire rope by inserting the wedge, large end first. 1/2 in. and 9/16 in. (13 and 14 mm) wire rope may be anchored by inserting the wedge, small end first.

1. Wind cable onto the drum.
 - a. Leather gloves should be used when handling winch cable.
 - b. The cable winds in on **TOP** of the winch drum. Care should be taken to wind the cable on the winch drum as evenly and as tightly as possible.
2. Always use two persons when winding the cable onto the winch drum: one person to operate the controls and the other to guide the cable *from a safe distance* to obtain as level a winding job as possible.
3. When winding winch cable on the winch drum, never attempt to maintain tension by allowing winch cable to slip through hands. Always use “hand-over-hand” technique.

6.4 - MAINTENANCE AS REQUIRED

GREASE DRUM OPTION

On drills equipped with a central lubrication system option, changing the 55 gallon (208.45 liter) grease drum is an “As Required” maintenance item. The Timer/Controller is located inside the cab, on the wall by the tower side door. See Figure 6.4–14. A flashing light will signal when the grease drum is empty and needs to be replaced.

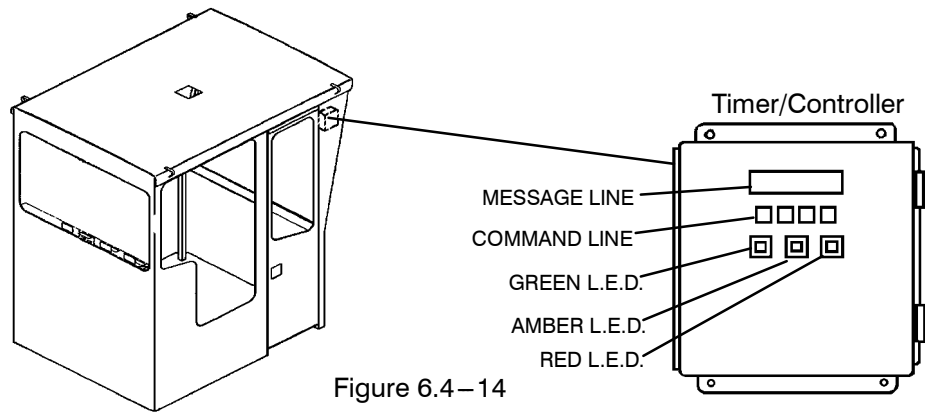


Figure 6.4–14

⚠ WARNING

Electrical shock hazard. Turn off and lock out power before opening enclosure. Do not subject sensor bodies to pressure greater than 6000 PSIG.

Change Grease Drum

⚠ WARNING

Do not attempt to service the lubrication system when the drill is running. Shut off the engine and relieve air pressure.

1. Undo the drum tie downs.
2. Remove the pump and cover.
3. Replace the used grease drum with a new grease drum. Dispose of the used grease drum in accordance with local guidelines and regulations.
4. Reattach the drum cover and pump.
5. Start the engine. When the compressor is turned on, the lube cycle will begin.

COMPRESSOR AIR HOSES AND CLAMPS

1. Periodic clamping bolts re-tightening is necessary due to “Cold-Flow” present in all rubber hoses. Tighten to recommended torque value listed on “BOSS CLAMPS” chart in Section 7 “SYSTEMS & TROUBLESHOOTING”.
2. Examine for and change out worn hoses and weakened Boss clamps. If the hoses are to be changed out, change the Boss clamps also. These Boss clamps hold the hose connections under a large amount of pressure. Remember, Boss clamps (including the nuts and bolts) are for **single use only. Do not reuse!** Once removed, discard.
3. Refer to the “Dixon Boss Clamp Selection and Installation” instructions shown in Section 7 “SYSTEMS & TROUBLESHOOTING” for the proper way to select and install Dixon Boss Clamps.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)



**THE OPERATOR IS RESPONSIBLE FOR THE SAFE
OPERATION OF THE DRILL.**

Over Pressure System Test

Do not test the Overpressure Control System with drill pipe or drill bit against the ground. Only test the system with the rotary head against the lower tower stops.

Step One:

Level the drill with the tracks about 1–2 inches (50.8mm) off the ground. The drill weight must be fully supported by the leveling jacks.

Step Two:

Raise the tower and pin it in the vertical position.

Step Three:

Feed the rotary head down against the bottom stops of the tower.

Step Four:

Slowly increase pulldown pressure to maximum down pressure.

Step Five:

Slowly lift the cab side leveling jack off the ground. Feed pressure must vent immediately when the jack pad is lifted. The rotary head will normally travel upwards slightly when pressure vents. If pressure vents immediately, go on to step six.

If feed pressure does not vent, reduce system pressure with the feed controls, re-level the drill and contact your supervisor for system repairs immediately.

Step Six:

Repeat steps 4 and 5, this time raising the dust collector side jack slightly. If pressure vents when the jack pad is lifted slightly off the ground, the system is working.

If it does not vent pulldown pressure, shut down the drill immediately and report any problems encountered to your supervisor.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

AIR CLEANERS

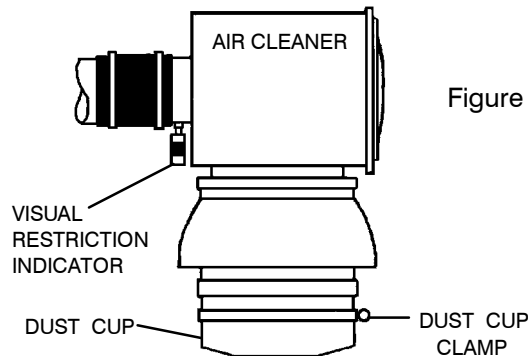
The following are detailed instructions for performing routine maintenance procedures on engine air cleaners and compressor air cleaners.



Engine and Air Compressor Damage. Raw, unfiltered air can cause engine and compressor damage. Never service the air cleaners while the engine is running.

Air Cleaner Indicators

Check the Air Cleaner Visual Restriction Indicators (see figure 6–2) before every shift, during every shift and after every shift.



Clean and inspect both engine and compressor air cleaner visual restriction indicators. They should be GREEN. If RED, clean or replace the filter elements.

After servicing the element, reset the restriction indicator to GREEN when the element is replaced in the air cleaner housing.

The engine and compressor air cleaners must be checked to verify the restriction indicators are not sticking. Check by pressing in the rubber boot. The internal green/red indicator should move freely.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

Connections and Ducts

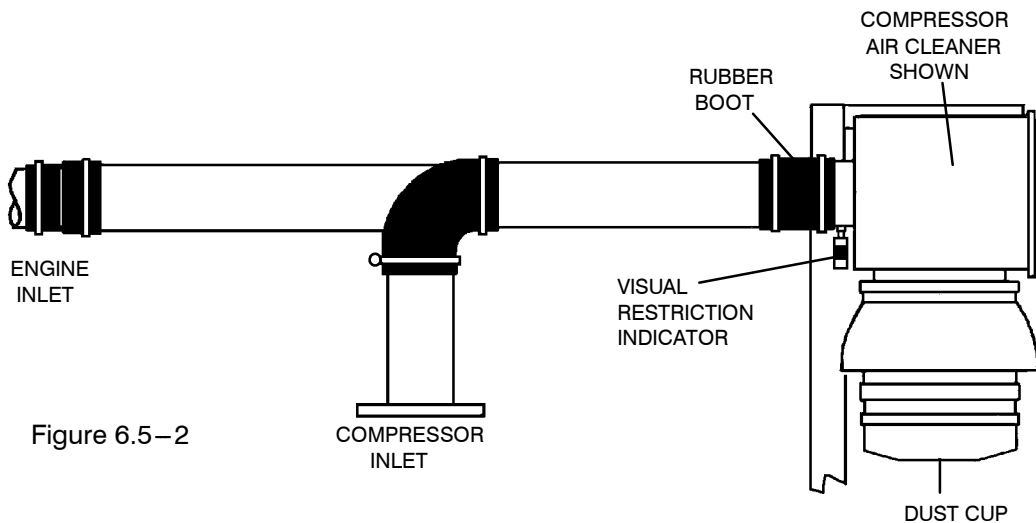


Figure 6.5–2

Check Air Cleaner connections and ducts for leaks before every shift, during every shift and after every shift. Ensure all connections between the air cleaner and engine are tight and sealed. Ensure all connections between the air cleaner and air compressor are tight and sealed.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

Empty Dust Cups

As daily routine maintenance, and as required in extremely dusty conditions, the dust cups on each of the air cleaners must be emptied of accumulations.

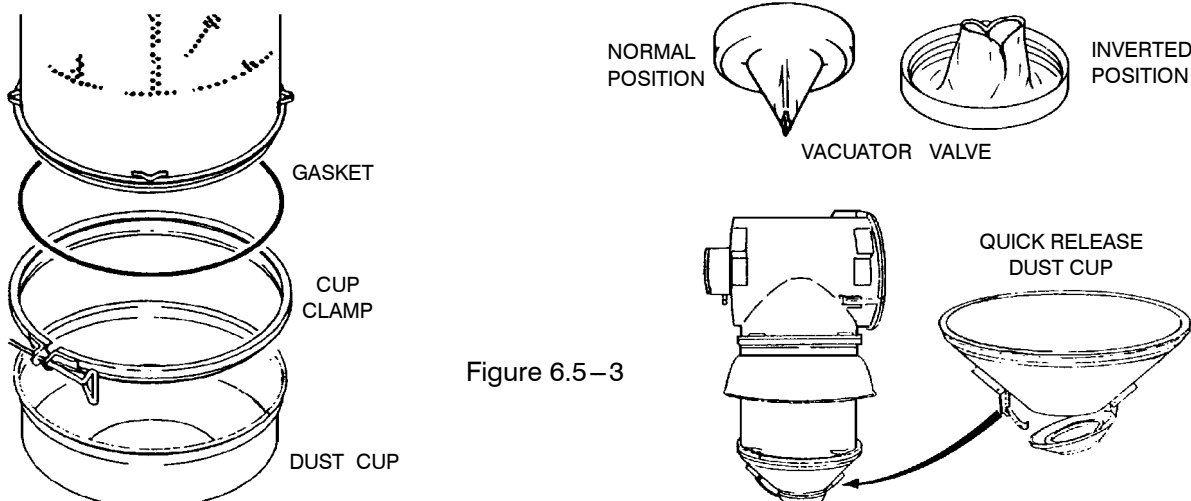


Figure 6.5–3

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

Empty Dust Cups (continued)

On filters equipped with dust cups (See Figure 6.5–3), the cup must be emptied when it becomes 2/3 full. The frequency of dust cup servicing varies with the operating conditions. It may be necessary to empty the dust cup daily.

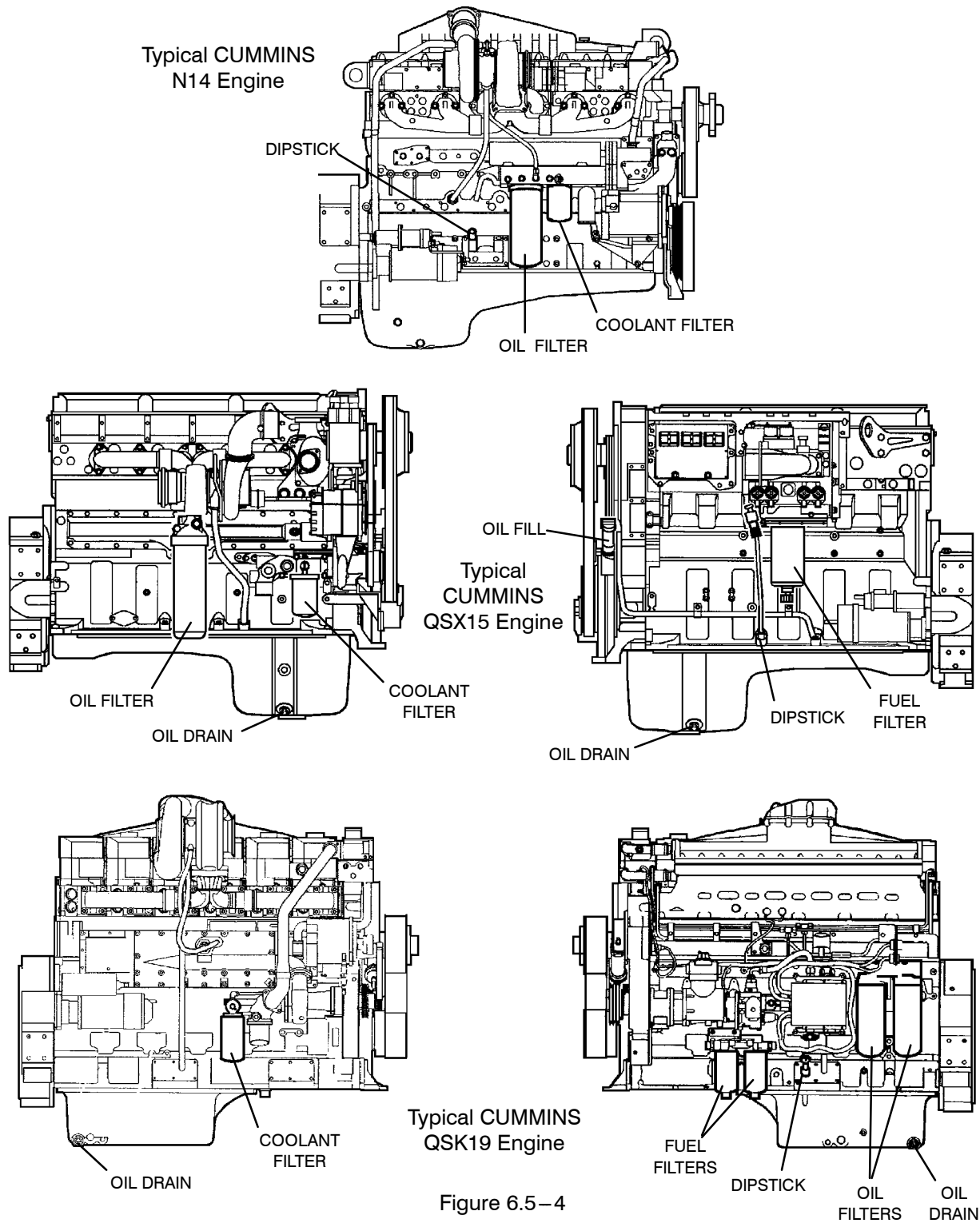
1. Loosen dust cup clamps and remove the dust cups on both the compressor and engine air cleaners.
2. Empty any accumulations of dust and dirt and replace the dust cup. Secure the dust cup clamps.
3. When reinstalling the dust cup, make sure it seals all the way around the air cleaner body.
4. Inspect the o-ring between the dust cup and the air cleaner body. If it is damaged in any way, it must be replaced.

On filters equipped with a quick release dust cup (See Figure 6.5–3), simply release the latch on the dust cup and allow it to swing down and empty. When it is empty, close the dust cup and lock it in place with the latch.

On filters equipped with vacuator valves (See Figure 6.5–3), the dust cup service is cut to a minimum. A quick check to see that the vacuator valve is not inverted, damaged or plugged is all that is necessary.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CUMMINS ENGINE



6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CUMMINS Engine Oil Level



Hot oil or components can burn. Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

The drawings in Figure 6.5–4 show typical CUMMINS Engines. Due to individual applications, your engine may appear different from the drawing.

Check the engine oil level **daily** by viewing the dipstick. Perform this maintenance with the engine shut off.

1. The drill **must** be on a level, stable surface when checking the oil level to be sure that the measurement is correct.

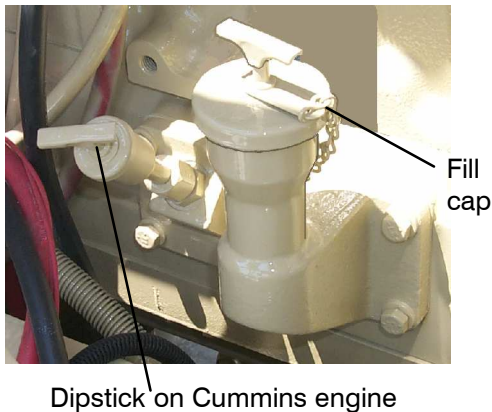


Figure 6.5–5

2. Wait at least 5 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan.
3. Pull out the dipstick (oil level gauge), wipe it clean with a lint free dry cloth and push the dipstick back in.
4. Pull out the dipstick again and check the oil level on the dipstick.
5. Maintain the oil level between the “L” (low) mark and “H” (high) mark on the oil level gauge (dipstick). Do not fill the crankcase above “HIGH” mark.



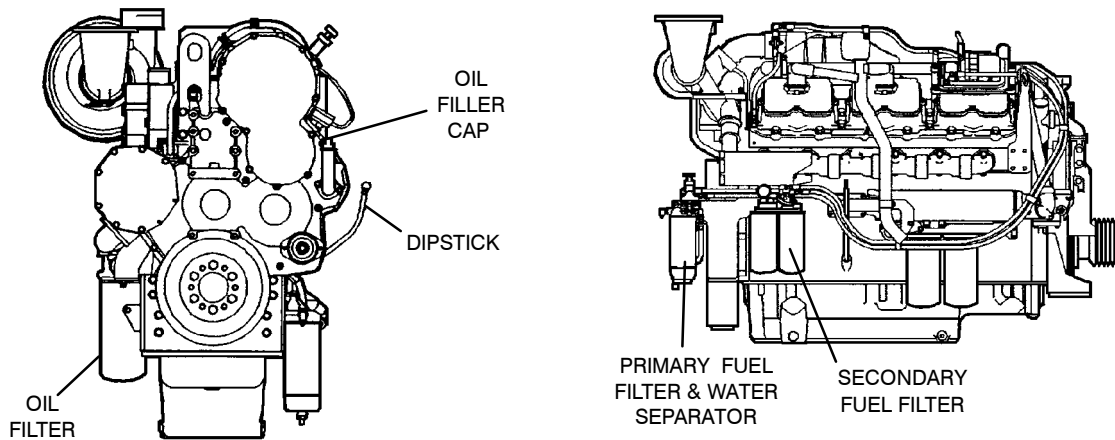
Never operate the engine with the oil level below the “L” (low) mark or above the “H” (high) mark.

6. Remove the oil filler cap and add oil, if necessary. (Refer to 6.3 *Lube Specifications* in this section for details on engine oil.)
7. Clean the oil filler cap and reinstall.
8. Repeat process and check oil level again after engine has run for about 1 minute.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CAT ENGINE

Typical CAT 3406E Engine Features



Typical CAT 3408E and 3412E Engine Features

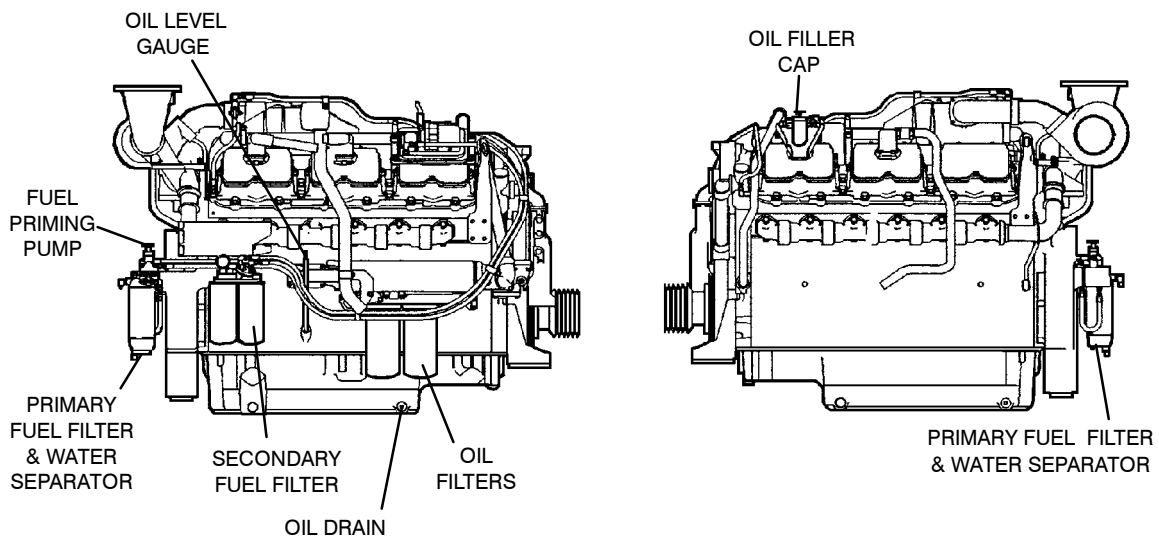
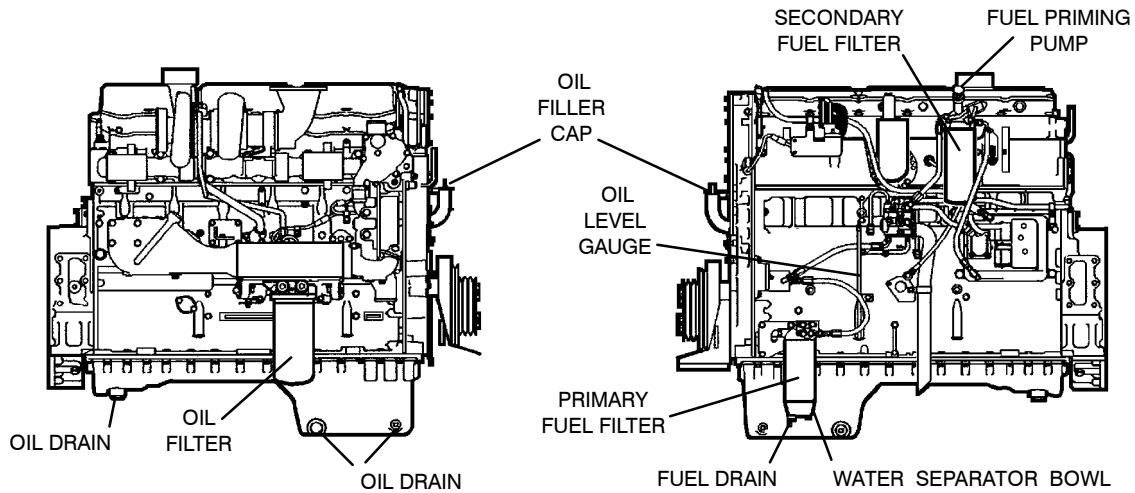


Figure 6.5–6

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CAT ENGINE (continued)

Typical CAT C–15 and C–16 Engine Features



Typical CAT C18 Engine Features

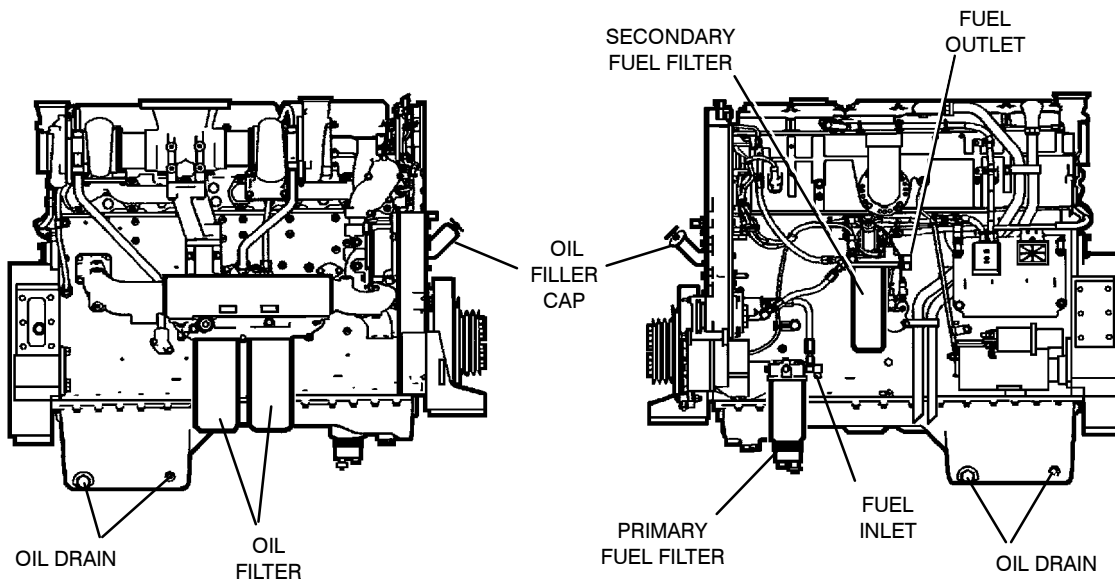


Figure 6.5–7

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CAT Engine Oil Level

WARNING

Hot oil or components can burn. Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

The drawings in Figure 6.5-6 and Figure 6.5-7 show typical CAT Engines. Due to individual applications, your engine may appear different from the drawing.

Check the engine oil level **daily** by viewing the dipstick. Perform this maintenance with the engine shut off.

1. The drill **must** be on a level, stable surface when checking the oil level to be sure that the measurement is correct.

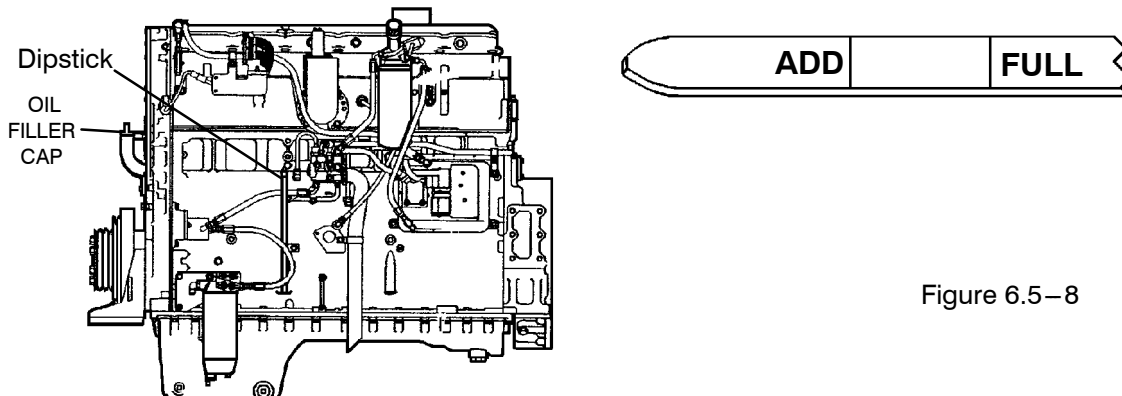


Figure 6.5–8

2. Wait at least 5 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan.
3. Pull out the dipstick (oil level gauge), wipe it clean with a lint free dry cloth and push the dipstick back in.
4. Pull out the dipstick again and check the oil level on the dipstick.
5. Maintain the oil level between the “L” (low) mark and “H” (high) mark on the oil level gauge (dipstick). Do not fill the crankcase above “HIGH” mark. Refer to *Lubricant Specifications* in this section for details on engine oil.

NOTICE

Operating engine when the oil level is above the “FULL” mark could cause the crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil’s lubricating characteristics and could result in the loss of power.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CAT Engine Oil Level (continued)

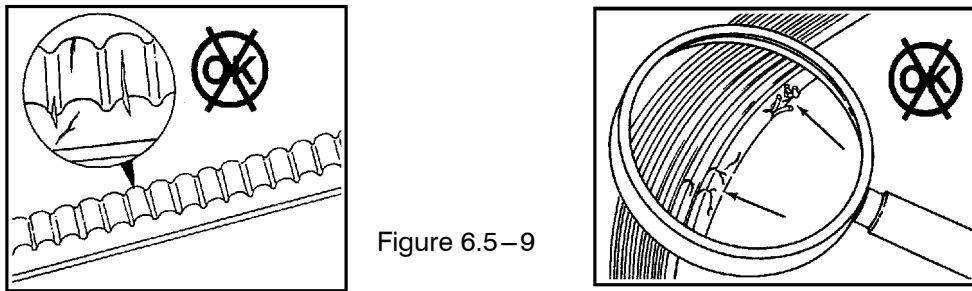
6. Remove the oil filler cap and add oil, if necessary. (Refer to 6.3 *Lubricant Specifications* in this section for details on engine oil.)
7. Clean the oil filler cap and reinstall.
8. Repeat process and check oil level again after engine has run for about 1 minute.

ENGINE BELTS & TENSIONER

Under normal operating conditions, the engine drive belts should be inspected **daily**. Belt damage can be caused by: Incorrect tension, Incorrect size or length, Pulley misalignment, Incorrect installation, Severe operating environment and Oil or grease on the belts.

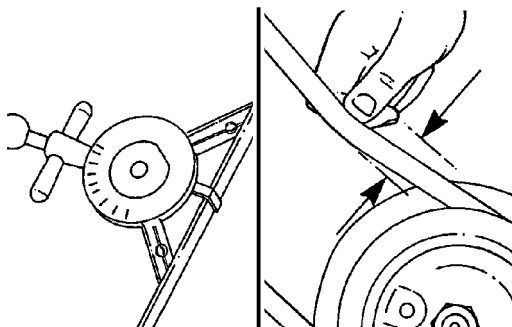
Adjust the belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belts. If the belts are too loose, the belts will vibrate. This vibration is enough to cause unnecessary wear on the belts and on the pulleys. If the belts are too tight, unnecessary stresses are placed upon the pulley bearings and upon the belts. These stresses will shorten the life of the belts and of the pulley bearings.

Drive Belts Inspection



To maximize the engine performance, visually inspect the belts for tension, wear, breaks, cracks or other damage. Replace belts that are cracked or frayed. Adjust belts that have a glazed or shiny surface which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear.

1. Remove the belt guard to check the belt tension or to replace belts.



6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

Drive Belts Inspection (continued)

2. Measure the belt tension in the center span of the pulleys (see Figure 6.5–10).

Note:

Refer to the Belt Tension Chart in the OEM Engine Operation and Maintenance Manual for the correct gauge and tension value for the belt width used.

3. An alternate method (deflection method) can be used to check belt tension by applying 25 lbs (110 N) force midway between the pulleys on v-belts. If the deflection is more than one (1) belt thickness per foot of pulley center distance, the belt **must** be adjusted. As a general rule, a correctly adjusted belt will deflect 1/2" to 3/4" (13mm to 19mm).

CUMMINS N14 Engine Alternator Drive Belt

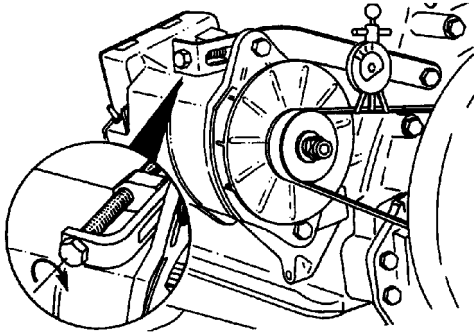


Figure 6.5–11

1. Loosen up the adjustment link locking cap screw and alternator pivot bolt.
2. Turn the adjusting screw to adjust the belt tensioner. *Refer to the Belt Tension Chart in the OEM Engine Operation and Maintenance Manual for the correct tension value.*
3. Tighten up the adjustment link locking cap screw and alternator pivot bolt to a torque value of 60 ft/lbs. (80Nm).

CUMMINS QSK19 Engine Alternator Drive Belt

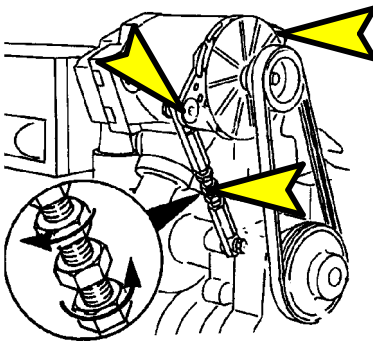


Figure 6.5–12

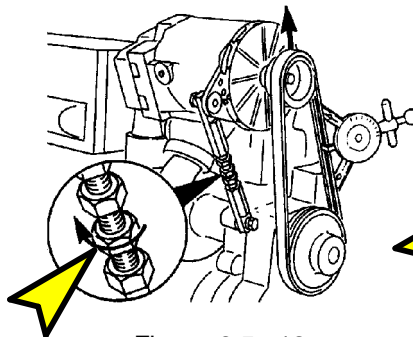


Figure 6.5–13

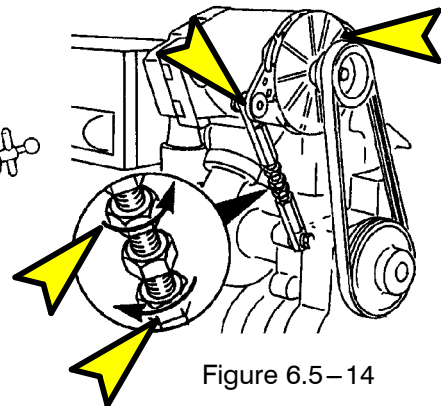


Figure 6.5–14

1. Loosen up the alternator and adjusting link mounting capscrews (See Figure 6.5–12).
Note: The lower jam nut has **left-hand** threads.

6.5 – MAINTENANCE (8–10 HOURS OR DAILY)

CUMMINS QSK19 Engine Alternator Drive Belt (continued)

2. Loosen up the jam nuts on the adjusting screw (See Figure 6.5-12).
3. Turn adjusting screw **clockwise** to tighten the belt tension (See Figure 6.5-13).
4. Tighten jam nuts on the adjusting screw (See Figure 6.5-13).

Note:

The lower jam nut has **left-hand** threads.

5. Tighten up the adjusting link and the alternator mounting capscrews to a torque value of 40 ft/lbs. (55Nm) as shown in Figure 6.5-14.

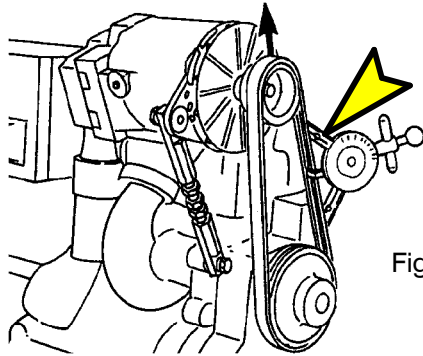


Figure 6.5–15

6. Check belt tension again to be sure it is correct. **Note:** Belt tension **must** be 150 ft/lb (670Nm).

CAT Engine Belts & Tensioner

Under normal operating conditions, the engine drive belts should be inspected **daily**. Belt damage can be caused by: Incorrect tension, Incorrect size or length, Pulley misalignment, Incorrect installation, Severe operating environment and Oil or grease on the belts.

Belt Inspection

To maximize the engine performance, inspect the belts for tension, wear, breaks, cracks or other damage. Replace belts if necessary.

1. Remove the belt guard to check the belt tension or to replace belts.
2. Check the belt tension. Adjust belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belts.
3. To check belt tension, apply 25 lbs (110 N) of force midway between pulleys. A correctly adjusted belt will deflect 1/2" to 3/4" (13mm to 19mm).

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Belt Adjustment

Adjust the belt tension in order to minimize belt slippage. Belt slippage will decrease the life of the belts.

If the belts are too loose, the belts will vibrate. This vibration is enough to cause unnecessary wear on the belts and on the pulleys. If the belts are too tight, unnecessary stresses are placed upon the pulley bearings and upon the belts. These stresses will shorten the life of the belts and of the pulley bearings.

If new belts are installed, check the tension again after 30 minutes of engine operation at the rated rpm.

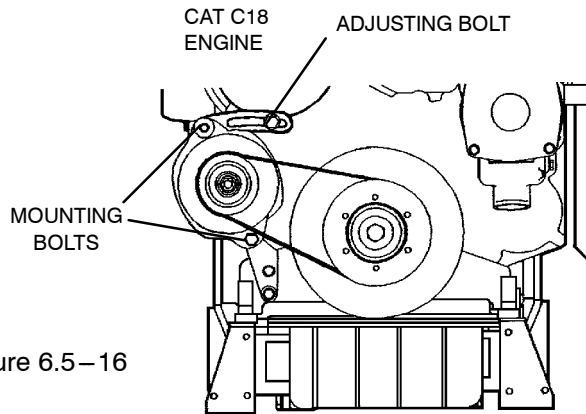
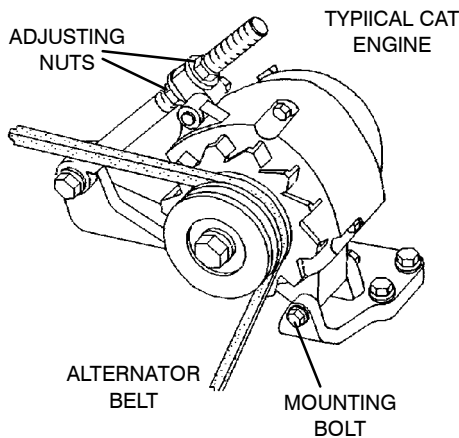


Figure 6.5–16

1. Remove the belt guard to adjust belt tension.
2. Manually adjust the compressor drive belt tension by loosening clamp screws and turning the tension adjustment screw (See Figure 6.5–16).
3. **Cat 3406 Engines**
Manually adjust alternator drive belt tension by loosening the clamp screws and turning the tension adjustment turnbuckle.

Cat 3408 and Cat 3412 Engines

Loosen The mounting bolt and adjusting nuts. Turn the adjusting nuts in order to increase or decrease the belt tension. Tighten adjusting nuts. Tighten mounting bolt. Refer to the *Torque Specifications* in this section for proper torques.

Cat C-15 and Cat C-16 Engines

Slightly loosen mounting bolt and adjusting nut. Move the pulley in order to adjust the belt tension. Tighten adjusting nuts and mounting bolts. Refer to the *Torque Specifications* in this section for proper torques.

Cat C18 Engine

Loosen the mounting bolts and adjusting bolt. Move the assembly in order to increase or decrease the belt tension. Tighten adjusting bolt. Tighten mounting bolts.

4. 1/2" (13mm) deflection with thumb pressure on the midspan position is the recommended tension indicator.
5. Ensure that the belt guard is replaced and secured.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Belt Replacement

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

Water Pump Drive Belt

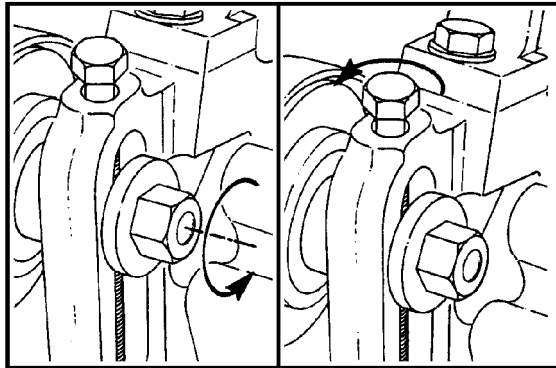


Figure 6.5-17

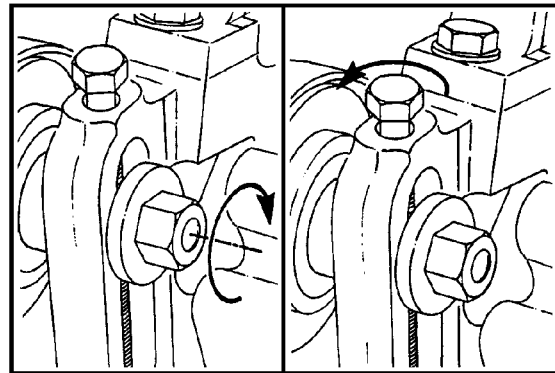


Figure 6.5-18

1. Loosen the locknut which secures the idler pulley to the water pump (Figure 6.5-17).
2. Turn the adjusting screw to adjust the belt tension (Figure 6.5-17).

Note:

Do **not** adjust belt tension to full value with the adjusting screw. Belt tension can increase when the lock nut is tightened and, therefore, reduce belt and bearing life.

3. Secure the idler pulley in position by tightening the lock nut to 50 ft/lb (70Nm) as shown in Figure 6.5-18.
4. Loosen up the adjusting screw 1/2 turn to prevent breakage (Figure 6.5-18).
5. Measure the belt tension again. Adjust if necessary.
6. Ensure that the belt guard is replaced and secured properly.

Fan Drive Belts Replacement

Note:

When a drive uses two or more belts, replace the belts as a complete set (See Figure 6.5-19).

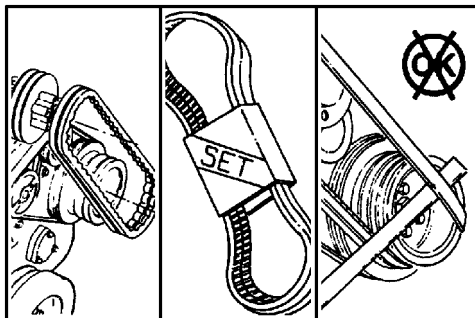


Figure 6.5-19

1. Loosen up the adjusting mechanism and move the pulley centers as close together as possible. The belts can then be installed without excessive force.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Drive Belts Replacement (continued)

- To prevent damage, do **not** roll a belt over the pulley or pry it on with a tool.

Note:

Refer to the Belt Tension Chart in your OEM Engine Operation and Maintenance Manual for the correct gauge and tension value for the belt width.

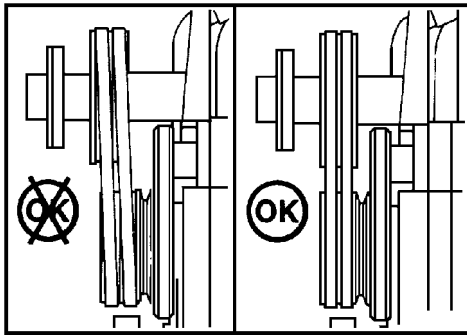


Figure 6.5-20

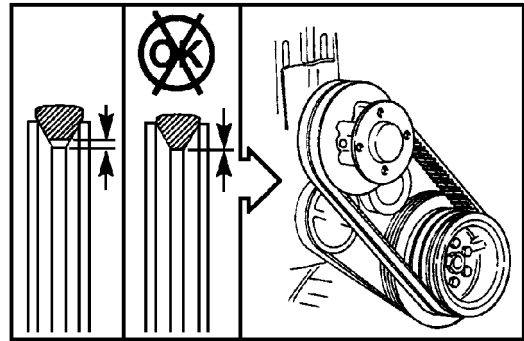


Figure 6.5-21

- Pulley misalignment **must not** exceed 1/16 inch for each 12 inches (6mm for each meter) of distance between pulley centers (Figure 6.5-20).
- Belts **must not** touch the bottom of pulley grooves. They **must not** protrude over 3/32 inch (3mm) above the top edge of the groove.
- When a drive uses two or more belts, the belt riding depth **must not** vary over 1/16 inch (2mm) between the belts (Figure 6.5-21).
- Ensure that the belt guard is replaced and secured properly.
- If new belts are installed, check the tension again after 30 minutes of engine operation at the rated rpm.

ENGINE FUEL/WATER SEPARATORS

Water in the fuel can cause the engine to run rough. If the fuel has been contaminated with water, the fuel/water separator element should be changed before the regularly scheduled interval of 500 hours. (See 6.9 Maintenance 250 Hours).

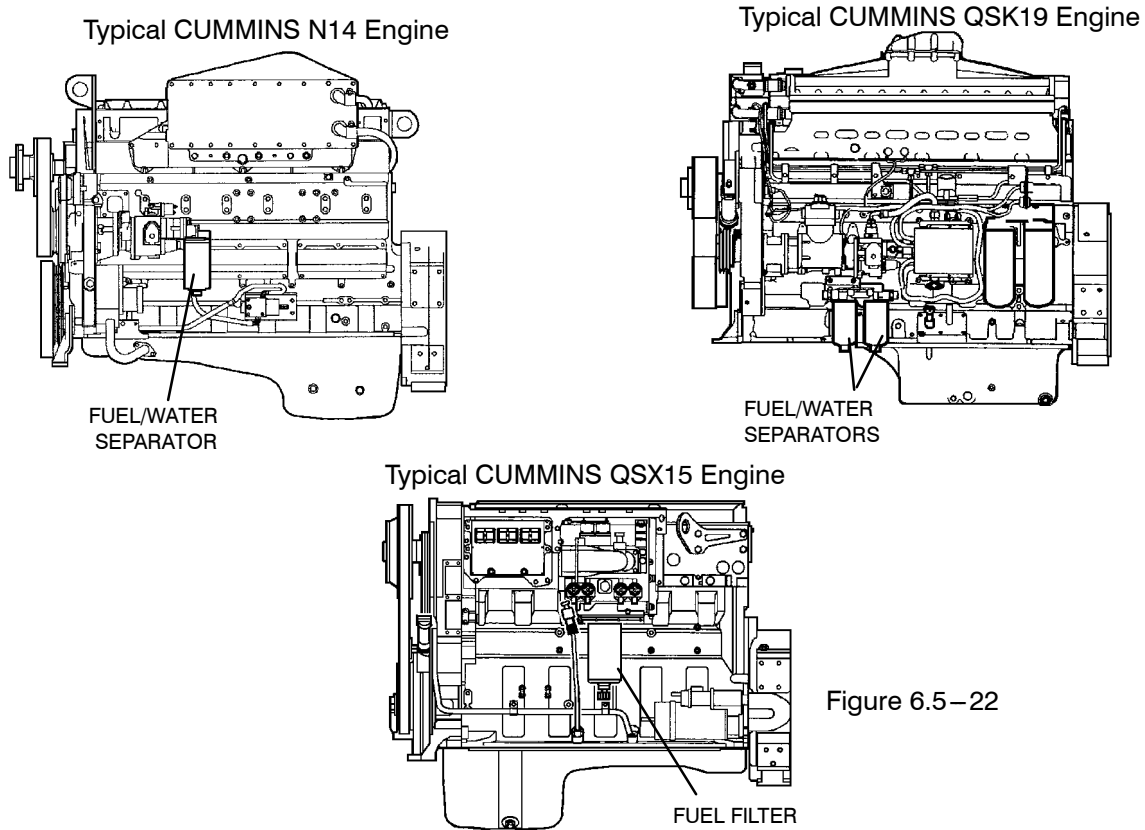
WARNING

Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames and do not smoke while draining fuel filters. Always wipe up any spilled fuel immediately.

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

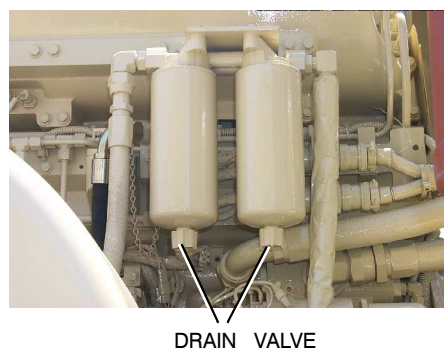
Cummins Fuel/Water Separator



Cummins requires that a fuel–water separator or fuel filter and water separator be installed in the fuel supply system. Drain the water and sediment from the separator **daily**.

NOTE:

The water and sediment may contain petroleum products. Please consult the local environmental agency for recommended disposal guidelines.



CUMMINS QSK ENGINE SHOWN

Figure 6.5–23

1. Shut off the engine.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Cummins Fuel/Water Separator (continued)

2. Use your hand to open drain valve. Turn the valve **counterclockwise** about 2-1/2 turns until draining occurs. Drain the filter sump of water and any sediment until the clear fuel is visible (about 1 cup).
3. Turn the valve **clockwise** approximately 2-1/2 turns to close the drain valve.



Do not overtighten the valve. It can damage the threads.

CAT Fuel/Water Separator

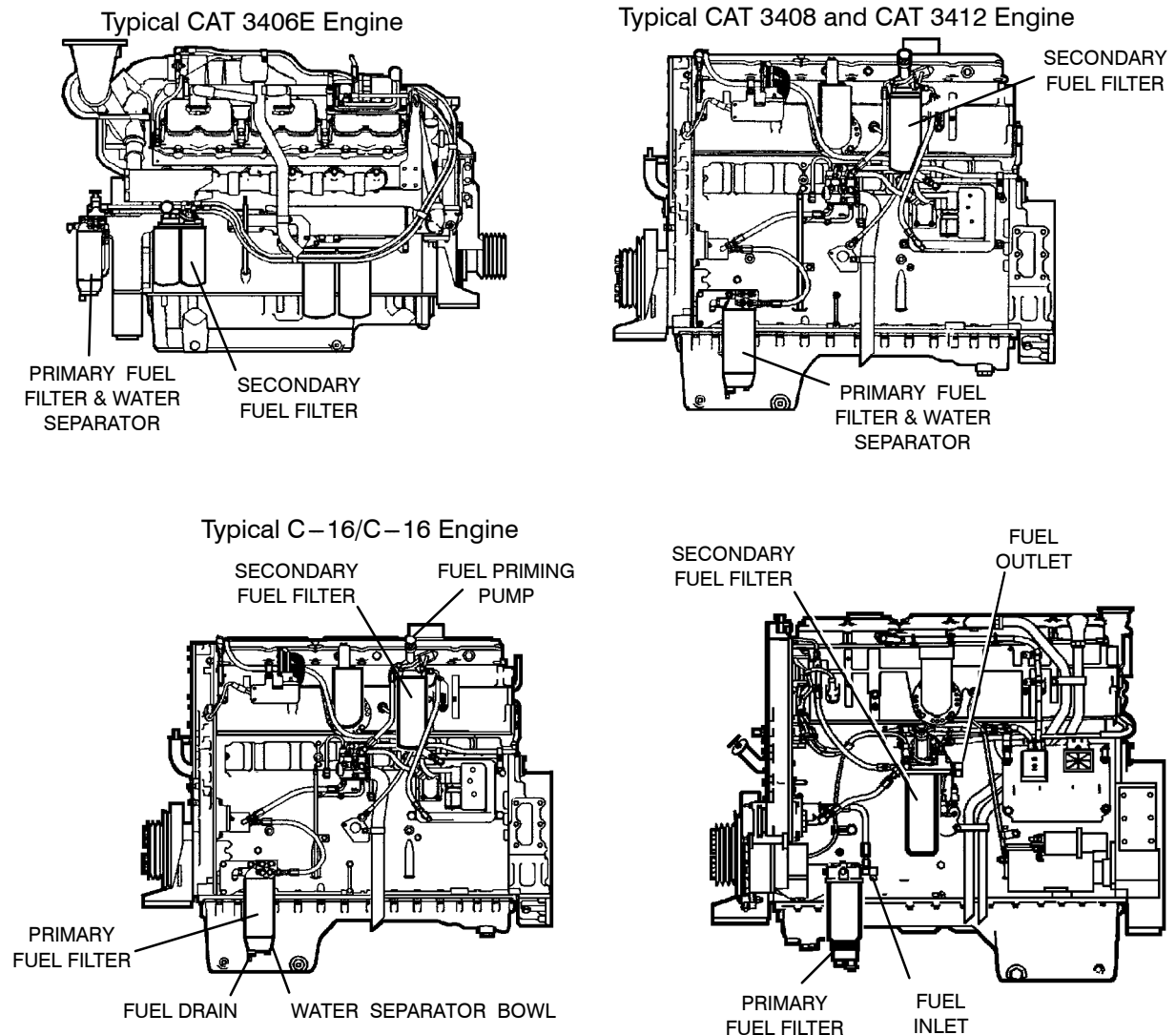


Figure 6.5-24

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

CAT Fuel/Water Separator (continued)

Water in the fuel can cause the engine to run rough. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval of 500 hours.

The primary filter/water separator also provides filtration to help extend the life of the secondary fuel filter. The element should be changed as part of the 500 hour routine maintenance schedule. If a vacuum gauge is installed, the primary filter/water separator should be changed at 50 to 70 kPa (15 to 20 inches of Hg.)

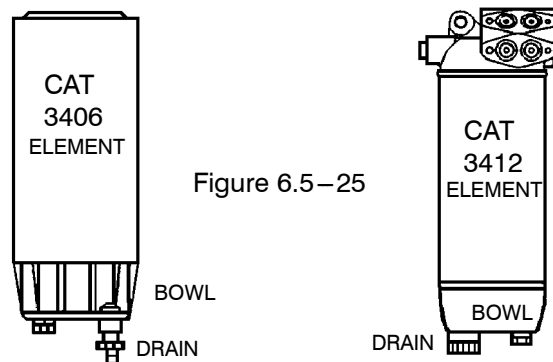
WARNING

Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames and do not smoke while draining fuel filters. Always wipe up any spilled fuel immediately.

If the engine is equipped with a fuel-water separator, drain the water and sediment from the separator daily.

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements.



The bowl should be monitored **daily** for signs of water. If water is present, drain the water from the bowl.

1. Shut off the engine.
2. Open the self-ventilated drain. Catch draining water in a suitable container and dispose of the water properly.
3. Close the drain.

NOTICE

The Water Separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

COOLING SYSTEM MAINTENANCE

Radiator Coolant Level

The coolant level must be checked **daily** as part of the **10 hour** routine maintenance procedure. Ensure the coolers are not too hot to touch.

WARNING

Do not remove the radiator cap from the cooler(s) while the engine is hot. Wait until the temperature is below 120°F (50°C) before removing the pressure cap. Failure to do so can result in personal injury from heated coolant spray or steam. Remove the filler cap slowly to relieve coolant system pressure.

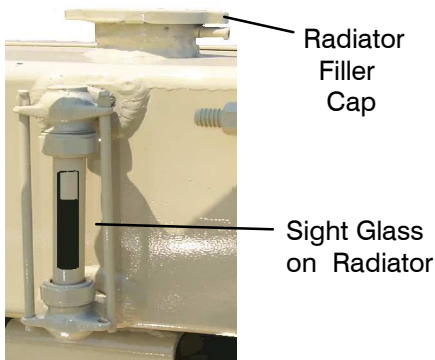
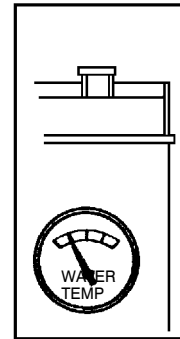
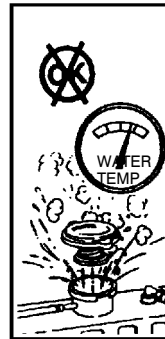


Figure 6.5–26



1. Check engine coolant level. The coolant level should be maintained so fluid can be seen in the sight glass. If coolant is low, add through filler cap.

NOTE:

If the coolant level is below the minimum level, the low level probe will activate the engine shutdown. In the case of repeated low level shutdowns, call for service to investigate cause of coolant loss.

2. Makeup coolant added to engine **must** be mixed with the correct proportions of antifreeze, supplemental coolant additive (SCA), and water to avoid engine damage. It must be used year round in all climates.

NOTE:

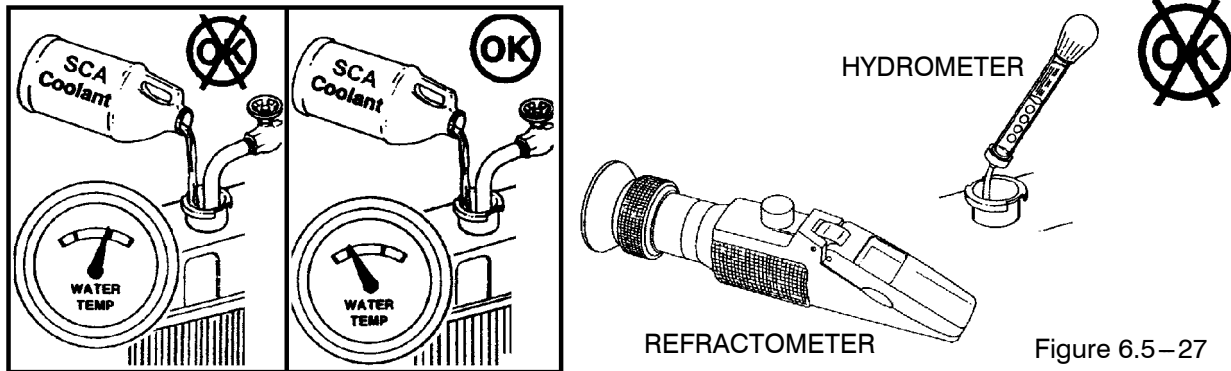
Refer to the *Cooling Recommendations and Specifications* in this section for more details on coolant. Also refer to engine manual.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Radiator Coolant Level (continued)

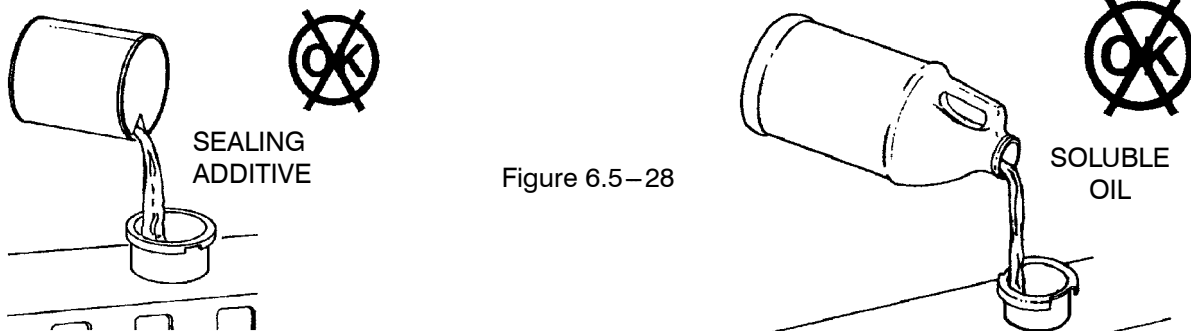


Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool to below 120°F (50°C) before adding coolant.



3. A refractometer **must** be used to **accurately** measure the freeze point of the coolant.
4. Do **not** use a floating ball hydrometer. Floating ball hydrometers can give an incorrect reading.

Cooling System Sealing Additives



Never use a sealing additive to stop leaks in the coolant system. The use of sealing additives will: (a) Build up in coolant low flow areas, (b) Clog coolant filters, (c) Plug radiator and oil cooler. This can result in coolant system plugging and inadequate coolant flow causing the engine to overheat.

Cooling System Soluble Oils

Do **not** use soluble oils in the cooling system. The use of soluble oils will: (a) Allow cylinder liner pitting, (b) Corrode brass and copper, (c) damage heat transfer surfaces, (d) damage seals and hoses.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Clean Radiator & Oil Cooler(s)

Check every **10 hours or daily** for signs of clogging on the exposed cooling fins on the combined radiator, compressor oil and hydraulic oil coolers as part of the routine maintenance procedure.

NOTE:

Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the radiator for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil and other debris. Clean the radiator if necessary.

NOTE:

If the drill has suffered leaks of oil or fuel, dirt will tend to adhere to the cooling fins of the radiator and hydraulic oil cooler. This accumulation of dirt will reduce the cooling efficiency. Therefore, any leaks of oil or fuel should be immediately repaired and cooling surfaces given a thorough cleaning.



Figure 6.5–29

⚠ WARNING

When using compressed air, water jets or steam cleaning methods, ensure that appropriate protective clothing is worn to protect eyes and exposed parts of the body.

Maximum air pressure at the nozzle must be less than 30 psi (205 kPa) for cleaning purposes.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Clean Radiator & Oil Coolers (continued)

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 0.25 inch (6 mm) away from fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 40 psi (275 kPa). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps and seals. Make repairs if necessary.

1. If clogging is dried on dirt, use liquid or dry air to remove from the cooling fins. If dry dust is present, use low pressure compressed air to clean.
2. In case of severe clogging due to fluid leaks, apply diesel fuel or a commercial cleaning detergent. Let it soak in and then wash off with water jet.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

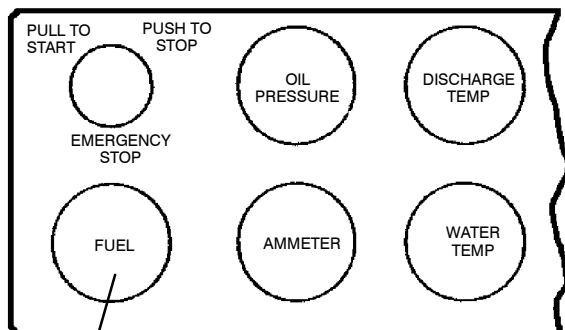
FUEL TANK



Fuel is flammable. May cause serious injury or death. Shut down engine, extinguish all open flames, and do not smoke while filling the fuel tank. Always wipe up any spilled fuel immediately.

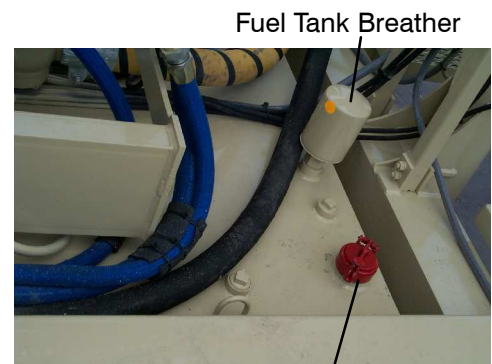
Check Fuel Level

Maintain fuel tank(s) at a high level to minimize water condensation inside the tank. This is best accomplished by filling the fuel tanks **at the end of each shift or day**. Check fuel tanks and fuel lines for possible leaks. Because of the potential fire hazard, leaks must be corrected as soon as they are spotted. Select the proper grade of fuel in accordance with the instructions given in 6.3 *Fuel Specifications* in this section.



Fuel Level Gauge

Figure 6.5–30



Fuel Tank Filler Cap

1. Check the fuel level by reading the fuel level gauge on the operator's console.
2. Never allow fuel tank(s) to completely empty, otherwise the entire fuel system will require bleeding.
3. When fuel is added, open the filler cap and clean the fill cap area.
4. Fill tank with correct grade of fuel. Refer to 6.3 *Fuel Specifications* in this section for more fuel details.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

RECEIVER SEPARATOR

Water condenses and must be drained **daily** from the bottom of the separator tank. If water is allowed to condense into the compressor oil, the bearing life will be considerably reduced.

Drain Water from Receiver Tank



High Pressure can cause severe injury or death. Completely relieve pressure before removing filler plug, drain valve, fittings or receiver cover.

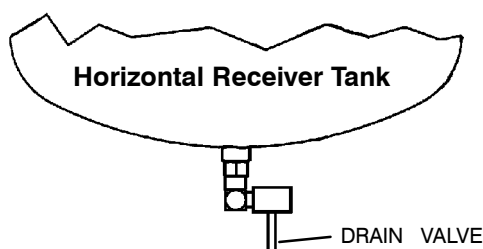
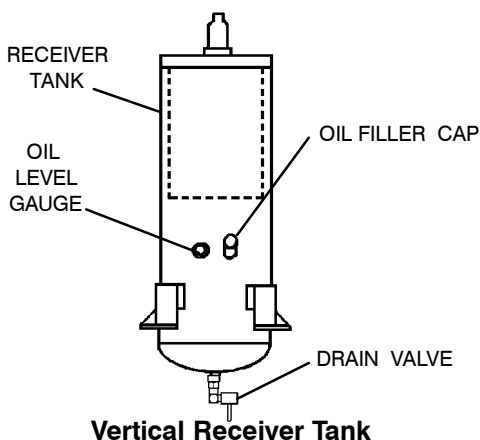


Figure 6.5–31

1. Locate and open the drain valve and allow any of the accumulated water to drain into a container.
2. When oil starts to flow, close drain valve.
3. Dispose of all accumulation in accordance with local regulations.

Check Compressor Oil Level

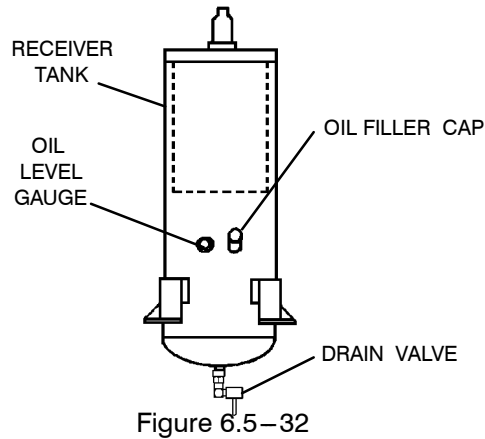
Periodically check the compressor oil level in the receiver tank. A loss of compressor oil could be an indication of excess oil carryover with the compressed air and would require a separator element change.



Do not attempt to open the filler plug, any drain plugs or the drain valve before making sure all air pressure has been relieved from the system. High Pressure can cause severe injury or death

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Check Compressor Oil Level (continued)



1. Check the oil level with the level gauge on the receiver separator tank
2. If necessary, add fresh, clean synthetic oil (filtered through a 10 micron filter) through the fill cap area to bring level to FULL.

Note:

Low Pressure compressors (110psi) use **IR-PROTEC Oil**.

High Pressure compressors (350 psi) use **XHP605 Oil**.

Refer to 6.3 Compressor Oil Specifications in this section for details on compressor oil.

Receiver Separator Element

Maintenance on the Receiver Separator Element is on an “**as required**” basis. A change of the receiver separator element is required when there is excessive oil carry over with the compressed air.

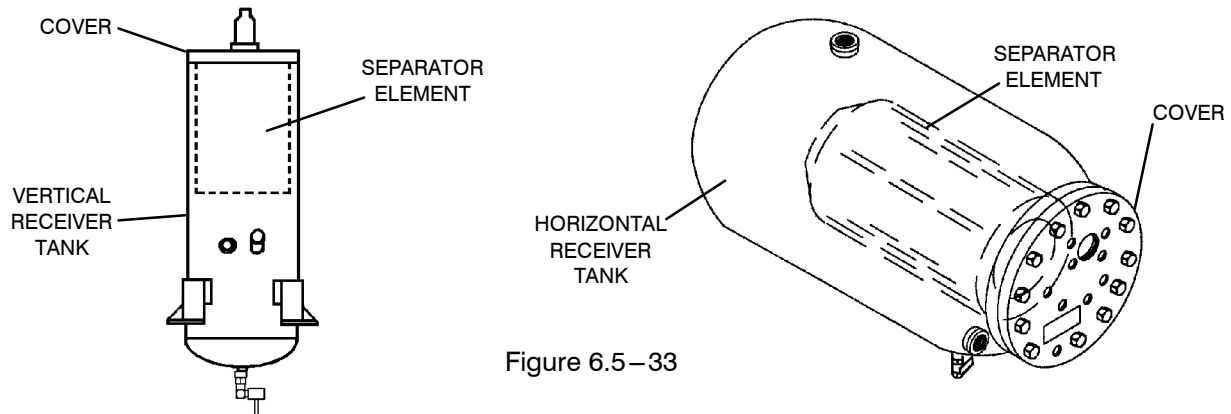
1. Park the drill on stable, level surface and shut down engine. Allow time for the drill to cool.



Do not attempt to remove any plugs or open the the drain valve before making sure all air pressure has been relieved from the system. High Pressure can cause severe injury or death. Hot oil or components can burn. Avoid contact with hot oil or components.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Receiver Separator Element (continued)



2. Remove the receiver cover and remove the separator element.
3. Discard the used element in accordance with local guidelines.
4. When installing the new element, make sure that the gasket is equipped with a staple. Also, install the element with the two drain holes located at the bottom.
5. Reattach the front cover and tighten bolts.
6. After startup, check the drill for any leaks at operating temperatures.

HYDRAULIC RESERVOIR

The hydraulic reservoir oil level must be checked **daily** as part of the **10 hour** routine maintenance procedure.

NOTICE

Dirt in the hydraulic system will lead to premature component failure. A clean, contaminant free system is extremely important to the drill's proper function.

Take extra care when working around or on the hydraulic system to ensure its complete cleanliness. When operating, the oil level must be between the maximum and minimum.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Hydraulic Reservoir Oil Level



Figure 6.5-34

1. Check the reservoir oil level by viewing the sight gauge (See Figure 6.5-34).
2. The oil level in the hydraulic tank depends on the extended or retracted positions of the hydraulic cylinders. It is important to observe and note the following information when reading the level gauge:
 - a. The oil level *with all hydraulic cylinders retracted* (tower down and leveling jacks up) should be even with the mark on the hydraulic reservoir next to the sight gauge.
 - b. The top of the oil level **MUST** be visible when the engine is running **AND** also when the engine is stopped. There must be oil showing on the gauge at all times. Add oil to bring to levels defined above.

NOTE:

*If no oil is showing on gauge, stop engine immediately and **call for service assistance** to investigate the cause of oil loss.*



Excessive hydraulic oil can rupture the sealed hydraulic tank and cause injury or property damage. Do not fill hydraulic tank with hydraulic cylinders extended. Retract all cylinders and fill tank to indicated level.

3. If necessary, add fresh, clean anti-wear (filtered through a 5 micron filter) hydraulic oil through the fill cap to bring tank level to FULL (See Figure 6.5-34). **Do not add oil through the suction manifold plug.** Refer to *Lubricant Specifications* for details on oil.
4. During operation, monitor the hydraulic oil temperature gauge.

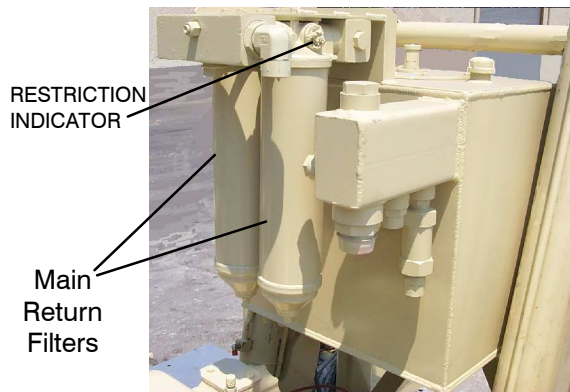
6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

HYDRAULIC OIL FILTERS

There are two system return hydraulic oil filters and one case drain filter on the drill.

The system main return filters are located on the rear face of the hydraulic tank. The main return flow to the tank passes through these filters and into the hydraulic oil tank's internal supercharge manifold. The supercharge of 65 psi provides supply to the piston pumps and minimizes cavitation problems.

The case drain filter is located on the drill tower support and filters case drain oil prior to return into the hydraulic tank.



RETURN FILTERS



CASE DRAIN FILTER

Figure 6.5-35

It is important to monitor the filter's restriction indicator sight glass during the **routine 10 hour walk around inspection** by the operator. If the indicator window shows RED, then the filter elements require replacement. If the window shows GREEN, the filters are satisfactory. When restriction indicates that element servicing is required, follow the instructions shown in 6.10 *Maintenance (1000 Hours)*. Under normal operating conditions, these filters are replaced at the regular **1000 Hour** service interval.

ROTARY HEAD

Check the rotary head oil level **daily**. Perform this maintenance with the tower up and the rotary head at the bottom of the tower.



Figure 6.5-36

- 1 Check the rotary head oil level. Oil must be showing in the sight glass.
2. If low, add oil through fill port until level is visible in sight glass. The rotary head is filled with SAE 90W Gear Oil. Refer to *Lubricant Specifications* within this section for recommended oil details.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

MANUAL LUBRICATION

The following grease procedures must be carried out as part of the **10 hour or daily** routine maintenance schedule.



**DRILL TOWER
BANK 1**

- PIVOT-TOWER
- PIVOT TOWER
- SHEAVE PIN TOP
- WINCH
- SHEAVE PIN TOP
- PIVOT BLOCK TOP-CAROUSEL
- INDEXER BUSHING TOP – CAROUSEL
- TOWER RAISING CYLINDER
- TOWER RAISING CYLINDER
- PIVOT BLOCK BOTTOM – CAROUSEL
- SWING CYLINDER BOTTOM- CAROUSEL
- SWING CYLINDER TOP – CAROUSEL
- PIVOT BLOCK TOP- CAROUSEL
- SWING CYLINDER TOP- CAROUSEL
- SWING CYLINDER BOTTOM- CAROUSEL
- INDEX BUSHING BOTTOM- CAROUSEL
- PIVOT BLOCK BOTTOM- CAROUSEL
- SHEAVE PIN BOTTOM
- SHEAVE PIN BOTTOM



**MAIN FRAME
BANK 2**

- FRONT JACK-CAB SIDE
- FRONT JACK-CAB SIDE
- FRONT JACK-D.C. SIDE
- FRONT JACK-D.C. SIDE
- TOWER RAISING CYLINDER-CAB SIDE
- TOWER RAISING CYLINDER-D.C. SIDE
- MAIN SHAFT-CAB SIDE
- MAIN SHAFT-D.C. SIDE
- OSC. YOKE-CAB SIDE
- OSC. YOKE-D.C. SIDE
- YOKE PIVOT
- REAR JACK-CAB SIDE
- REAR JACK-D.C. SIDE
- MAIN SHAFT-CAB SIDE
- MAIN SHAFT-D.C. SIDE

Figure 6.5-37

Drill Tower Central Grease

1. If necessary, raise the drill tower and lock in the vertical position.
2. Shut down the engine.
3. Clean all grease nipples.
4. Inject 5 shots of MPG-EP1 grease into each grease nipple on Bank 1 (See Figure 6.5-37).
5. Wipe off excess grease.

Main Frame Central Grease

1. If necessary, lower the drill tower into the horizontal position.
2. Shut down the engine.
3. Clean all grease nipples.
4. Inject 5 shots of MPG-EP1 grease into each grease nipple on Bank 2 (See Figure 6.5-37).
5. Wipe off excess grease.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Grease Sheaves & Sprockets



Figure 6.5-38

1. If necessary, lower the drill tower.
2. Shut down the engine.
3. Clean all grease nipples.
4. Inject 5 shots of MPG-EP1 grease into each sheave and sprocket grease nipple (See Figure 6.5-38).
5. Wipe off excess grease.

Grease Carousel Cups

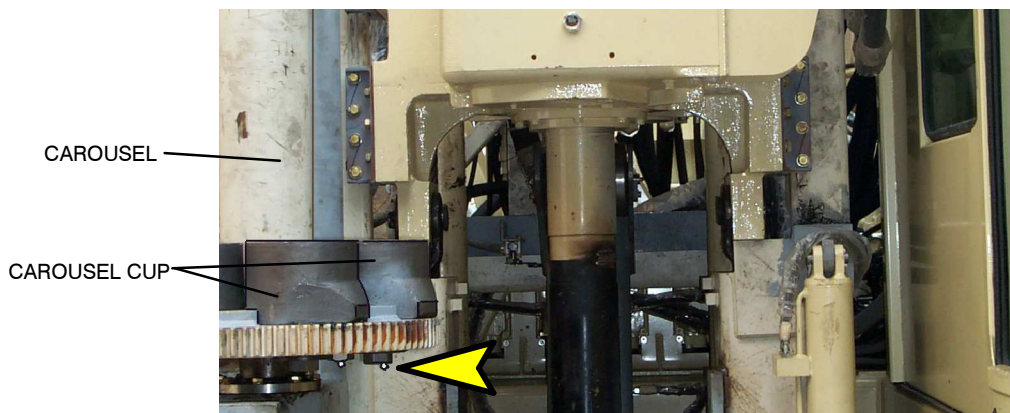


Figure 6.5-39

1. If necessary, raise the derrick and lock it in the vertical position.
2. Shut down the engine.
3. Clean all grease nipples.
3. Clean all grease nipples.
4. Inject 5 shots of MPG-EP1 grease into each drill rod carousel cup grease nipple (See Figure 6.5-39).
5. Wipe off excessive grease.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Grease Gearbox Drive Shaft Universal Joints

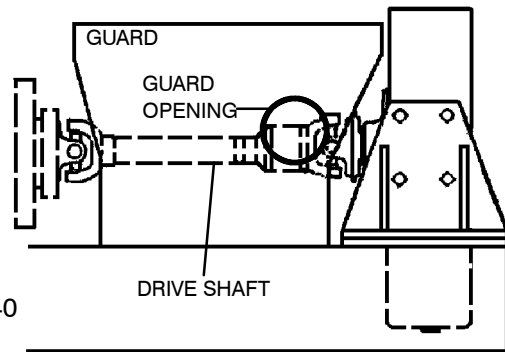
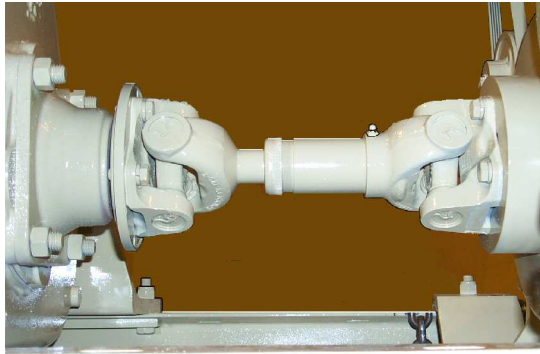


Figure 6.5–40

WARNING

Rotating Shaft can cause severe injury or death. Do not operate with guard removed.

1. Shut down engine.
2. Leave guard in place.
3. Reach in through opening in guard to clean the drive shaft u-joint grease nipples (See Figure 6.5-40).
4. If necessary, momentarily press the starter button (**with the key ON/OFF switch in OFF position**), to line up access to the grease nipples.
5. Inject 5 shots of MPG-EP1 grease into the drive shaft grease nipple. Wipe off all of the excessive grease.

Grease Rotary Head Upper Bearing

Grease the rotary head upper bearing daily at the grease point on the top of the rotary head.

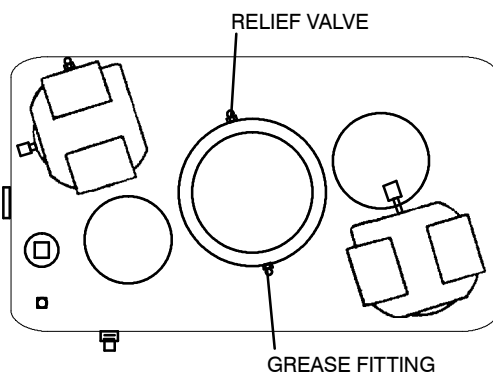


Figure 6.5–41

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Grease Rotary Head Upper Bearing (continued)

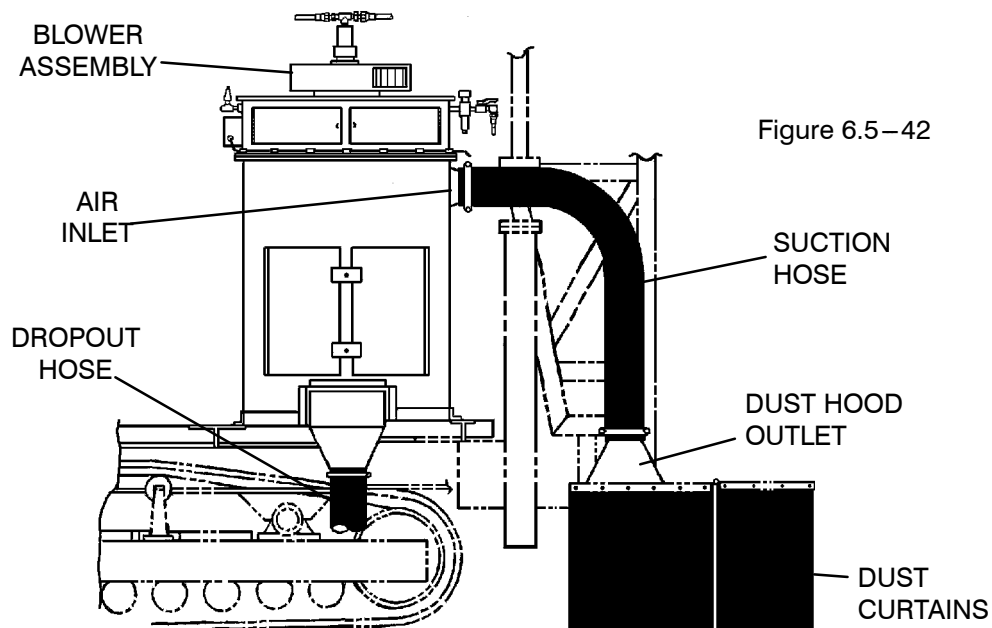
Make sure the grease at the relief valve is free to move and the port is not plugged. Remove the relief fitting to perform this task. Then, add grease slowly until it is coming out the open port. Make sure the relief fitting is operational. Replace the relief fitting and continue to add grease until the relief indicator pops out. In a short period of time, if the relief has not popped out, stop and determine where the grease is going. Exxon Mobil Ronex Extra Heavy Duty Moly 2 (PN/57818221) is recommended.

DUST COLLECTOR

In order to insure that the dust collector system is operating to its design specifications, the following visual inspections should be performed on a periodic basis.

Dropout Hose

Verify that the dropout hose located at the bottom of the dust collector is securely fastened to the dropout cone (See Figure 6.5-42). This hose should be free of any holes and should form a tight seal during the period when the collector is pulling a vacuum. The hose will open momentarily during each back-pulse of compressed air when the filter elements are being cleaned.



Suction Hose

The suction hose (See Figure 6.5-42) leading from the dust hood outlet to the dust collector inlet should be clear of obstructions such as a build-up of dirt or mud. There should be no kinks or extremely sharp bends in the suction hose.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

Blower Assembly

Observe the discharge of the blower assembly (See Figure 6.5-42). There should be no visible dust emerging from the outlet of the blower housing. If there is, the filter elements and/or filter gaskets should be **replaced immediately to avoid damage to the blower wheel**.

Rod Seal

Inspect the integrity of the rod seal attached to the bottom of the tower (See Figure 6.5-43). Also give attention to the dust curtains surrounding the hole (See Figure 6.5-42).



ROD SEAL ASSEMBLY



FILTER ELEMENTS

Figure 6.5-43

Filter Elements

Listen to the back-pulsing of the filter elements. There should be a sharp pulse of air every 2-3 seconds. If a pressure gauge is installed in the air supply line to the dust collector, verify that the air is pulsed at a peak pressure of approximately 40 psi.

The filters should be cleaned whenever possible by pulsing the elements with the blower system **turned off**. This can be done at the end of any drilling cycle, while changing drill rod and possibly between each hole.

Remove the dropout cone and inspect the filters. Replace them if they are worn, torn or shredded. Remove the wing nut and the filter should drop out.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

CLEAN THE DRILL

The complete drill must be given a weekly cleaning. Daily cleaning will be required if material is adhering to the tower or truck working parts.

1. Make sure the inside of the operator's cab is clean. Make sure the operator's areas, steps and grab rails are clean. Oil, grease, snow, ice or mud in these areas can cause you to slip and fall. Clean your boots of excess mud before getting in the cab or on the drill.
2. Check the tracks. Make sure that no material is jammed between the track sprockets and the track tensioners.
3. Check the tower feed installation for debris buildup around the sheaves.
4. Thoroughly wash all fittings, caps, plugs, etc. with a nonflammable, nontoxic cleaning solution before servicing to prevent dirt from entering while performing the service.

NOTE:

Protect all electric components and control panels against entry of water or steam when using high pressure cleaning methods. Cover the fuel and hydraulic fill cap breathers located on each tank.

5. After cleaning, check for defects in the air cleaner ducts.
 - a. Check intake for accumulation of debris that could restrict air flow.
 - b. Check air cleaner mounting hardware for security.
 - c. Check all hoses for cracks, chafing or deterioration and replace them at the first sign of probable failure.

6.5 - MAINTENANCE (8-10 HOURS OR DAILY)

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6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

BATTERIES

The following battery maintenance must be carried out as part of the **50 hour** routine maintenance schedule.



Batteries contain an acid and can cause injury. Battery fumes can ignite and explode. Skin and eye contact with battery fluid can cause injury.

Do not smoke when observing battery fluid level. Avoid skin and eye contact with battery fluid. If contact occurs, flush area immediately with water.

Electrolyte Level

1. Check the electrolyte level and keep the electrolyte level above the plates.
2. Refill with distilled water if necessary.

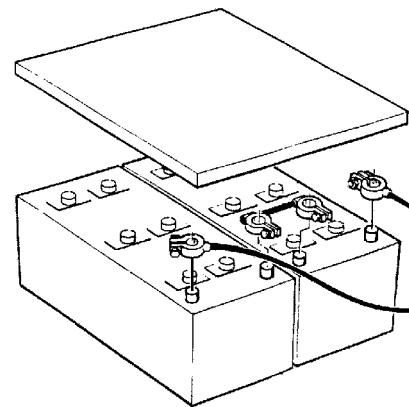


Over filling can cause poor performance or early failure.



BATTERIES

Figure 6.6–1



Battery Terminals

Keep the battery terminals clean and the connections tight.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

PUMP DRIVE GEARBOX



Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

Check Oil Level

The type of service and the operating conditions will determine the maintenance interval. However, it is recommended that the oil level be checked as part of the **50 hour** routine maintenance schedule. At the same time, check for oil leaks. Because the lubricant system is the heart of the unit, it is especially important that the oil be kept clean.

NOTE:

The oil in the pump drive gearbox should be changed whenever the oil shows traces of dirt or the effects of high temperature, evidenced by discoloration or strong odor.

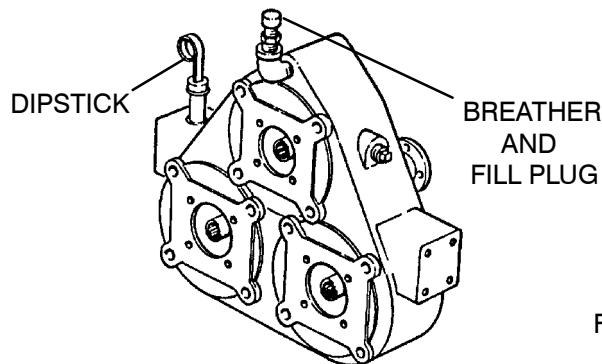


Figure 6.6–2

1. Move the drill to a level surface.
2. Stop engine before checking or adding oil.
3. Clean around the oil level dipstick and the oil fill plug before checking or adding oil.
4. Check the oil level within the gearbox with the dipstick. Remove the dipstick and wipe it clean. Reinsert and withdraw the dipstick to read the oil level within the gearbox.
5. If necessary, add 80W90 Gear Oil and fill to the correct level. Always use clean oil from clean containers. Do **not** overfill. This will cause in overheating.

Refer to *6.3 Lubricant Specifications* for the recommended required oil specifications.

6. Check and clean the gearbox breather.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

TRACK GEARBOX

The following gearbox maintenance must be carried out as part of the **50 hour** routine maintenance schedule.



Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

Check Oil Level

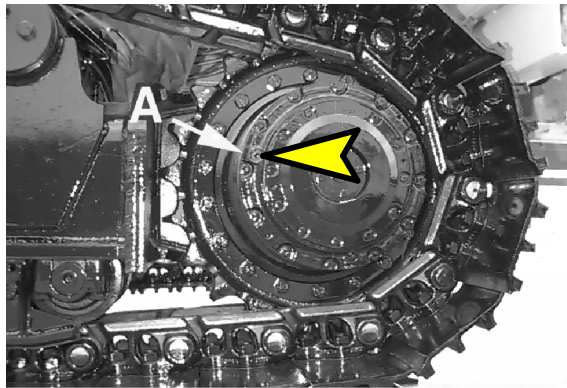


Figure 6.6–3

1. Move the drill to a level surface and shut off the engine.
2. Be sure that the planetary housings are not too hot to touch. If they are hot, give them time to cool down before proceeding.
3. Clean around the fill/level plug before it is removed. Remove the fill/level plug (A).
4. The oil should be level up to the bottom of the fill/level plug hole. If required, add oil through this port.
5. Required lubricant for the final drive gearboxes is ISO VG220. Refer to the 6.3 *Lubricant Specifications* for oil details.
6. Allow oil to stop flowing from the port.
7. Clean, install and tighten the plug.
8. Check for leaks.
9. Repeat same procedure for the other track drive.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

TRACKS

The following track maintenance must be carried out as part of the **50 hour** routine maintenance schedule.

One of the more critical factors in undercarriage wear is proper track adjustment.

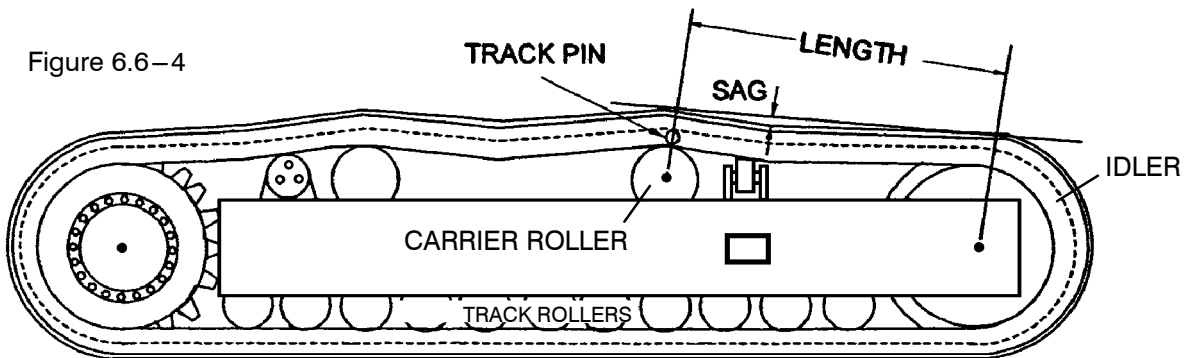
- a. Tracks that are **too tight** will put extra stress on both the undercarriage and the drive train components, while wasting horsepower.
- b. Tracks that are **too loose** create too much back bending, snaking and poor footing which causes needless wear on roller flanges, sprocket teeth and track guides.

Proper track adjustment will vary with soil conditions and drill application. For example, packing takes up slack, thus creating tight track. With excavator type chain, internal pin and bushing wear causes track to loosen and offset the tight track caused by packing. Proper track adjustment is important if long life and full track value are to be received.

Check Track Tension

1. The drill should be in it's working environment. Propel the drill through mud and allow dirt to pack the tracks.
2. Propel the drill in the direction of the idlers. Stop with one track pin directly over the front carrier roller (the one closest to the idler).

Figure 6.6–4



3. Place a straight edge on top of the shoe grousers between the front carrier roller and the idler.

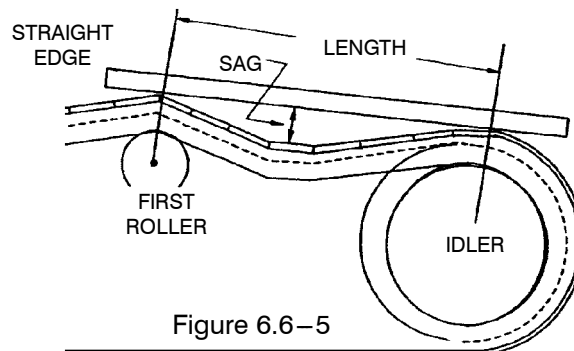


Figure 6.6–5

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

TRACKS (continued)

4. The correct **SAG** (distance from the bottom of the straight edge to top of the track shoe) is 3–4% of the distance between the top of the idler and the carrier roller.
5. Track requires retensioning when the top of the track sag between the top carrier rollers exceeds 1-1/2" (38 mm).

Track Adjustment

If the track is **too loose**, the track must be tightened by adding grease to the track adjuster. If the track is **too tight**, grease must be removed from the track adjuster.

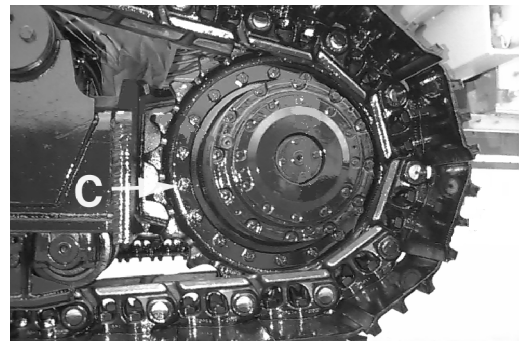
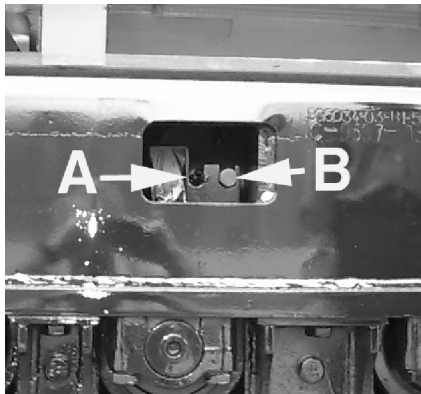


Figure 6.6–6

1. Clean the single grease fitting (A), shown in Figure 6.6–6.
2. Inject MPG-EP2 grease, with a high pressure grease gun, until the required track tension is obtained. Refer to 6.3 *Lubricant Specifications* for recommended grease requirements.
3. To reduce track tension, slightly unscrew the cover plug (B). The internal buffer spring will relax and grease will be ejected.
4. To readjust, secure cover (B) and inject grease at grease point (A) until the correct track tension is effected.
5. Repeat the same procedure for the other track drive.

Check Wheel Nuts Adjustment

The following track maintenance must be carried out as part of the **50 hour** routine maintenance schedule.

1. Check that the wheel nuts (C) are torqued to the correct value of 420 ft/lbs (571 Nm).

NOTE:

If new wheel nuts have been recently installed, they may require frequent checks until they seat properly.

2. Repeat same procedure for the other track drive.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

AUXILIARY HOIST

WARNING

Do not climb a raised tower. Climbing a raised tower can cause severe injury or death. Lower the tower to the horizontal position to service the winch.

WARNING

Never lift or transport personnel with the winch. Do not use the winch in any manner of operation which may endanger any individual.

CAUTION

Stay at least 10 feet (304.80 cm) away from cable while it is under tension. Cable should be inspected whenever unwound and replaced when broken strands are noted.

WARNING

Cable clamps are not designed to hold rated winch load. At least 5 wraps of cable must remain on the drum at all times.

Periodic Inspection

1. Inspect rigging, winch and hydraulic hoses at the beginning of each work shift. Defects should be corrected immediately.
2. Be certain that at least 5 full wraps of cable remain on the drum at all times; otherwise, the cable clamps may not hold the load.
3. Replace cable that has been kinked or has broken strands because it may fail without warning at low loads.
4. Inspect drive lugs on clutch and drum for rounding or cracking.
5. Inspect gear teeth for excessive wear. Wear should not exceed 1/16".

Refer to **Wire Rope** information in Section 6.4 *FEED CABLE & WIRE ROPE Maintenance As Required* for additional information on wire rope and wire rope clamps.

6.6 - MAINTENANCE (50 HOURS OR WEEKLY)

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6.7 - MAINTENANCE (100 HOURS)

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.



If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.7 – MAINTENANCE (100 HOURS)

AUXILIARY HOIST

Oil Change

The gear oil should be changed after the first one hundred (100) hours of operation, then every 1,000 operating hours or six (6) months, whichever occurs first. The gear oil must be changed to remove wear particles that impede the reliable and safe operation of the brake clutch and erode bearings, gears and seals. Failure to change gear oil at these suggested minimum intervals may contribute to intermittent brake slippage which could result in property damage, severe personal injury or death.

The gear oil should also be changed whenever the ambient temperature changes significantly and an oil from a different temperature range would be more appropriate. Oil viscosity with regard to ambient temperature is critical to reliable brake operation. Make certain that the gear oil viscosity used in your winch is correct for your prevailing ambient temperature. Failure to use the proper type and viscosity of planetary gear oil may contribute to brake slippage which could result in property damage, severe personal injury or death.

Required lubricant: For temperatures between –30 to 80°F use Mobil SHC629 or Texaco Pinnacle 150. For temperatures between –10 to 80°F use Texaco Meropa 150 or equivalent AGMA # 4EP. For temperatures between 50 to 130°F use Texaco Meropa 220 or equivalent AGMA # 5EP.

Capacity: 2 pints (.94 L)



Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

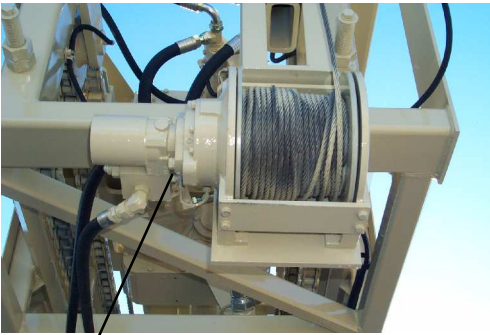


Do not climb a raised tower. Climbing a raised tower can cause severe injury or death. Lower the tower to the horizontal position to service the winch.

6.7 - MAINTENANCE (100 HOURS)

Oil Change (continued)

The gear oil should be changed after the first **one hundred (100) hours** of operation, then at every **1000 operating hours**



DRAIN PLUG



OIL LEVEL PLUG

Figure 6.7–1

1. Move the drill to a stable, level surface and shut off the engine.
2. Lower the tower to the horizontal position.
3. Place a container, with a capacity of at least 2 pints (.94 liters), under the drain point to collect the used oil.
4. Remove the oil level plug to allow the oil to drain smoothly (See Figure 6.7–1).
5. To drain the gear oil, remove the small drain plug.

WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

6. Drain the oil into a suitable container.
7. Clean and install the drain plug securely.
8. Remove the container and dispose of the used oil in accordance with local guidelines.
9. Refill housing with gear oil. Planetary winches are factory filled with Texaco Meropa 150 gear oil or equivalent industrial grade lubricant meeting AGMA 4EP or API GL-2 with ISO viscosity grade 150, for temperatures between $-10^{\circ}\text{F}(-25^{\circ}\text{C})$ to $80^{\circ}\text{F}(26^{\circ}\text{C})$.

For temperatures between $50^{\circ}\text{F}(10^{\circ}\text{C})$ and $130^{\circ}\text{F}(55^{\circ}\text{C})$, use Texaco Meropa 220 or equivalent AGMA 5EP. Planetary capacity is 2 U.S. pints (.94 liters). Refer to section 6.3 *Lubricant Specifications* for further recommended oil specifications.

10. Clean and install level plug.
11. Whenever the gear oil is changed, remove the vent plug (located in the drum support), clean in solvent and reinstall. *Do not paint over the vent or replace with a solid plug.*
12. Raise the tower, operate the auxiliary hoist and check for any leaks.

6.7 - MAINTENANCE (100 HOURS)

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6.8 - MAINTENANCE (250 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.8 – MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE

The following drawing shows a typical CAT 3406E, CAT 3408E and CAT 3412E Engine. Due to individual applications, your engine may appear different from the drawing.

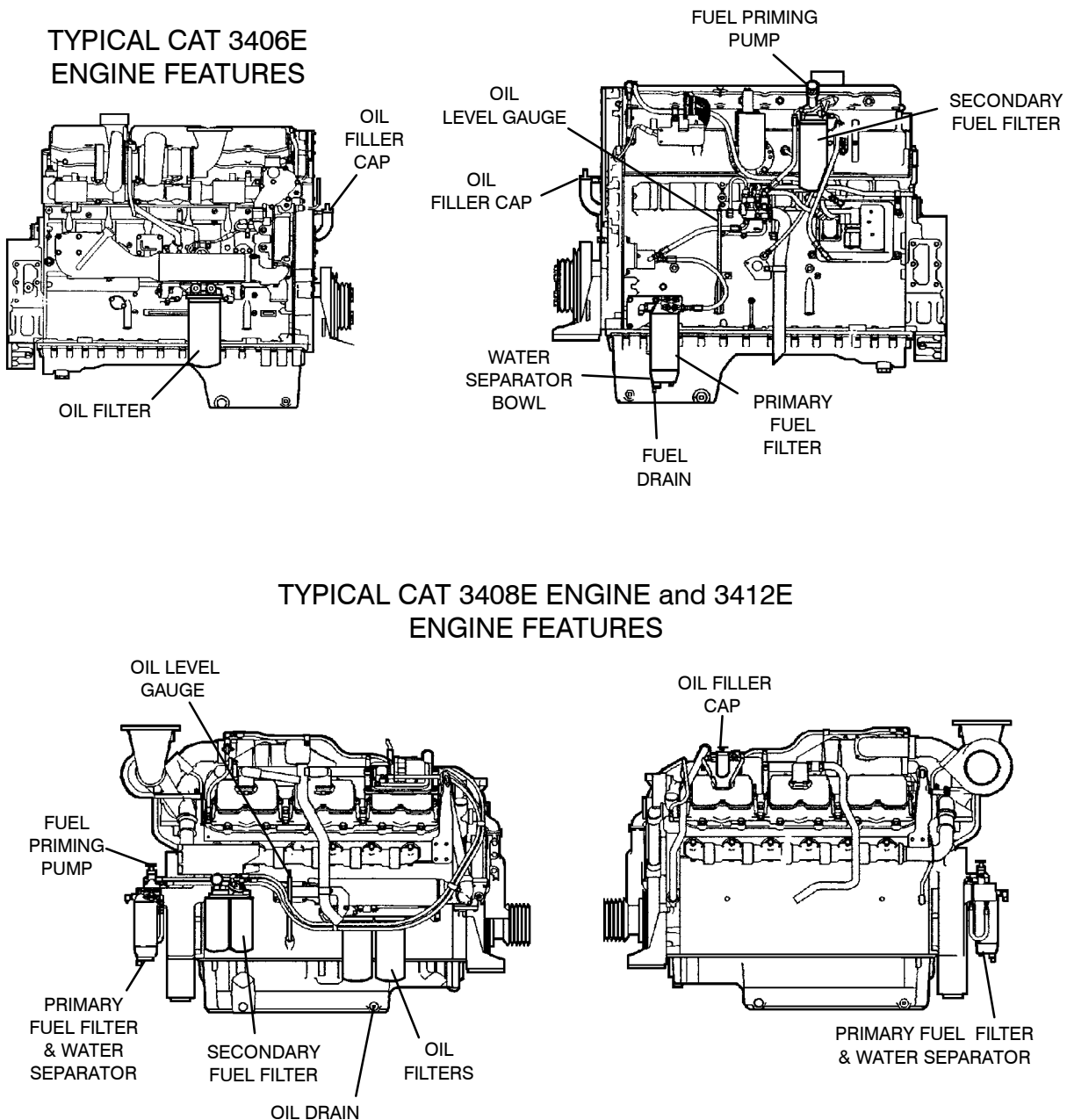


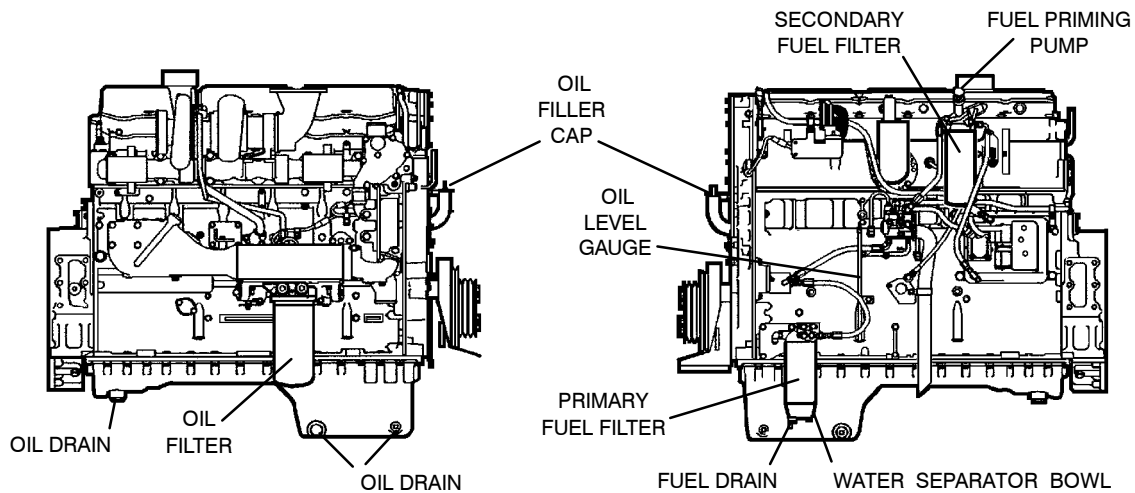
Figure 6.8–1

6.8 – MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

The following drawing shows a typical CAT C-15 and C-16 Engine. Due to individual applications, your engine may appear different from the drawing.

TYPICAL CAT C-15 ENGINE and C-16
ENGINE FEATURES



TYPICAL CAT C18 ENGINE FEATURES

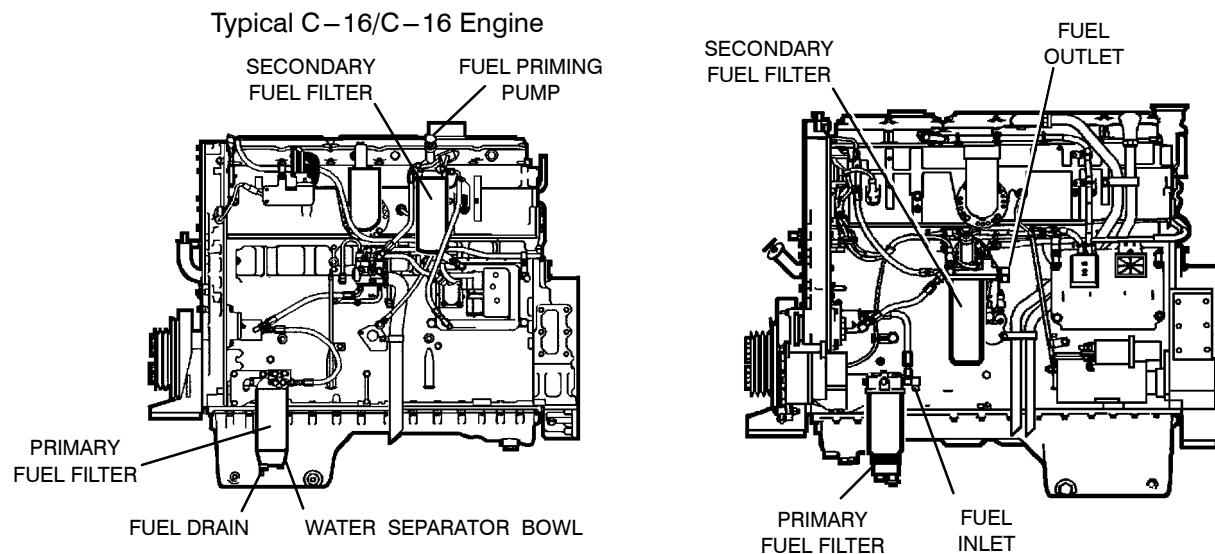


Figure 6.8-2

6.8 – MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

Cat Engine Oil and Filter

Change the Engine Oil and Oil Filter as part of the **250 Hour Routine Maintenance** Schedule.

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin. Oil must be at normal operating temperatures when draining. Do not allow used oil to drain into the ground. Dispose of properly.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed when draining cold oil. Drain the crankcase with the engine stopped. Drain the crankcase with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Cat Engine Oil

1. Position the drill on a stable, level surface and shut off engine. Wait at least 5 minutes after shutting off engine to drain the oil. This allows time for the oil to drain into the oil pan.
2. Ensure oil is warm by viewing the water temperature gauge. The temperature should not exceed 140°F. (60°C.) before draining oil.

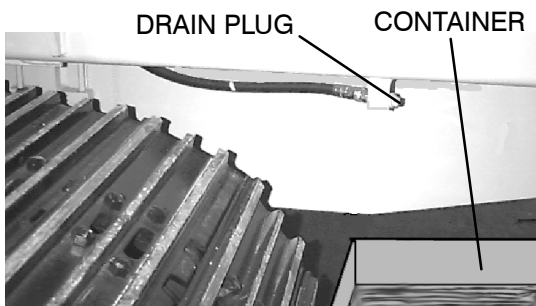


Figure 6.8–3

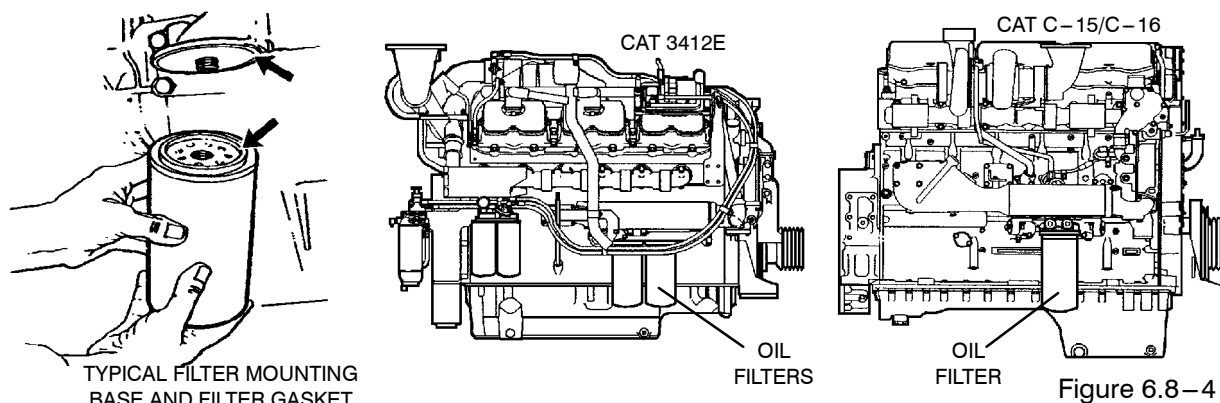
3. Place container, with a capacity of at least 20 gallon (70 liter), under the drain point.
4. Remove the drain plug and allow the oil to drain from the drain hose into a container.
5. After the oil has completely drained, clean the drain plug and install securely.
6. Dispose of used oil properly.

6.8 – MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

Replace the Cat Engine Oil Filter(s)

Change the engine oil filter(s) at the same time the engine oil is changed.



WARNING

Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

Place a container with a capacity of at least 2 quarts (2 liter) under the engine oil filter(s).

1. Clean around the head of the filter and then remove filter with an Oil Filter Strap Wrench Assembly.
2. Cut the filter open with an Oil Filter Cutter. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Cat dealer to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

3. Clean the sealing surface of the filter mounting base. Ensure that all of the old gasket is removed before installing the new filter.
4. Apply a film of clean engine oil to the seal of the new oil filter gasket before installing.

NOTE:

Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated and contaminated oil can cause accelerated wear to the engine components.

5. Install filter as specified by the filter manufacturer. Most filters have instructions printed on side of filter. Tighten the oil filter until the oil filter gasket contacts the base. Tighten the oil filter by hand according to instructions that are shown on the oil filter. **Do not overtighten the oil filter.**
6. Dispose of the used filters in compliance with local regulations.

6.8 – MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

Fill the Cat Engine Crankcase

The refill capacities for the Cat engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil.

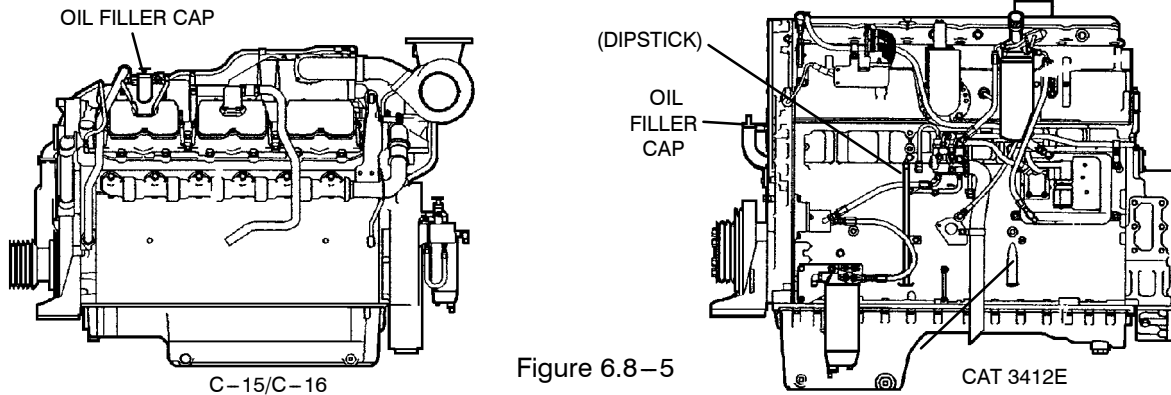


Figure 6.8-5

1. Remove the oil filler cap and fill the crankcase with the proper amount of oil.

CAT Engine Series	Oil Specification	Approximate Refill Capacities	
		Quarts	Liters
CAT 3406 Series	API CG-4 15W40 (All drills leave the factory filled with Amalie 15W40)	36	34
CAT 3408 Series		48	45
CAT 3412 Series		72	68
CAT C-15 Series		36	34
CAT C-16 Series		36	34
CAT C18 Series		40	38

Refer to 6.3 *Lubrication Specifications and Refill Capacities* for more detailed information.

NOTICE

If equipped with an auxiliary oil filter or remote oil filter system, follow the OEM or filter manufacturer's recommendations. Under filling or over filling the crankcase with oil can cause engine damage.

NOTICE

To prevent crankshaft bearing damage, crank the engine with the fuel OFF. This will fill the oil filter(s) before starting the engine. Do not crank the engine for more than 30 seconds.

2. Start the engine and run at "LOW IDLE" for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filter(s) are filled. Inspect the oil filter for oil leaks.
3. Stop engine and allow oil to drain back to the crankcase for a minimum of ten minutes.
4. Remove the oil level gauge in order to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

6.8 - MAINTENANCE (250 HOURS)

Cat Secondary Fuel Filter(s)

Under normal operating conditions, the secondary fuel filter(s) should be replaced every 250 hours as part of routine maintenance.

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up any spilled fuel immediately.

NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

NOTICE

Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

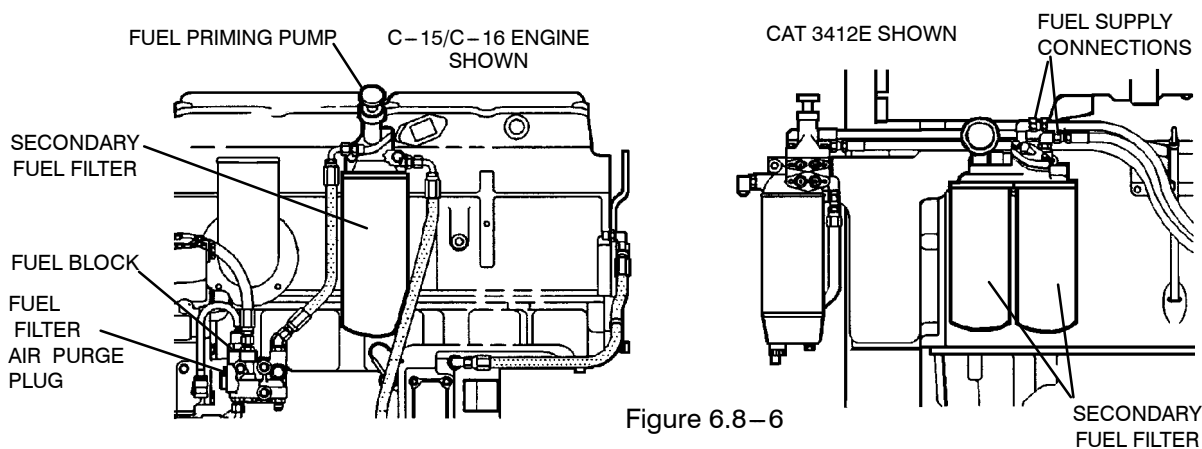


Figure 6.8-6

1. It may be necessary to relieve any residual fuel pressure from fuel system before removing the fuel filter.

CAT 3406, CAT C-15 and CAT C-16 Engines

Loosen the fuel filter air purge plug in order to purge any residual pressure (See Figure 6.8-6).

CAT 3408 Engines and CAT 3412 Engines

Loosen one of the fuel supply connections in order to purge any residual pressure (See Figure 6.8-6).

6.8 - MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

Cat Secondary Fuel Filter(s) (continued)

NOTICE

Do not loosen fuel lines or fittings at the fuel manifold or ECM. The engine components may be damaged.

2. Remove and discard the used fuel filter(s) in compliance with any local regulations.
3. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
4. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE

*In order to maximize fuel system life and prevent premature wear out from abrasive particles in the fuel, **use the correct filters.***

NOTICE

Do not fill the secondary fuel filter with fuel before installing. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

5. Install the new filter as specified by the filter manufacturer. Most filters have instructions printed on side of the filter. Spin fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filter(s) as a guide for proper tightening. Tighten the filter for an additional 3/4 turn by hand. **Do not overtighten the filter.**
6. With **CAT3406E, CAT C-15/C-16** engines, open the fuel tank supply valve and prime the fuel system. Refer to the engine manufacturer's manual for the information on priming the system.

When restarting the **CAT 3408E and CAT 3412** engines after replacing the fuel filters, it is necessary to prime the fuel system using the primer button switch on the console.

When restarting the **CAT C-18** engine after replacing the fuel filters, prime the fuel system with the priming valve (if equipped) and open the air purge screws. Refer to the engine manufacturer's manual for the information on priming the system.

7. If fuel filters are changed according to these instructions, no manual bleeding of fuel lines should be required. If necessary, refer to engine manufacturer's manual for the information on bleeding the system.
8. Check the fuel system for any leaks.

6.8 - MAINTENANCE (250 HOURS)

Replace CAT Coolant Filter



Figure 6.8–7

If your engine is equipped with an engine coolant filter, it must be replaced at every engine oil and oil filter change interval as part of the 250 Hour routine maintenance. Refer to CAT Engine Operator's Instruction manual for details.

1. Clean area around water cooler filter.
2. Place a container under filter to collect any escaping coolant during removal.
3. Close coolant additive element inlet and outlet valve.
4. Unscrew and discard the used filter in full compliance with local guidelines.
5. Clean the sealing surface of filter head.
6. If necessary, replace O-ring on the filter head.
7. Lubricate O-ring seal with clean oil.
8. Install new filter as specified in parts manual.
9. Check for leaks when engine is running at working temperature.

Engine SCA Level

Caterpillar engine cooling systems should be tested at 250 Hour intervals for the concentration of Supplemental Coolant Additives (SCA).

NOTICE

Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperature. Water alone does not provide adequate protection against boiling or freezing.

NOTE:

The engine is protected against corrosion of the cooling system by adding corrosion inhibitor to the coolant. If engine radiator has been topped off using only water, the additive content will become diluted and the risk of corrosion will increase.

Refer to engine instruction manual for further information and procedures on this important maintenance item.

6.8 - MAINTENANCE (250 HOURS)

CAT ENGINE MAINTENANCE (continued)

Engine Valve Lash

The initial valve lash adjustment on new engines is recommended at the first scheduled oil change (250 Hour Routine Maintenance). The initial adjustment is necessary due to initial wear of the valve train components and seating of the valve train components. Thereafter, inspect and adjust engine valve lash every 3000 Service Hours.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

WARNING

Ensure that the engine can not be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

NOTICE

Only qualified service personnel should perform this maintenance. Refer to your Caterpillar dealer for the complete valve lash adjustment procedure.

NOTICE

Operation of Caterpillar engines with improper valve adjustments can reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

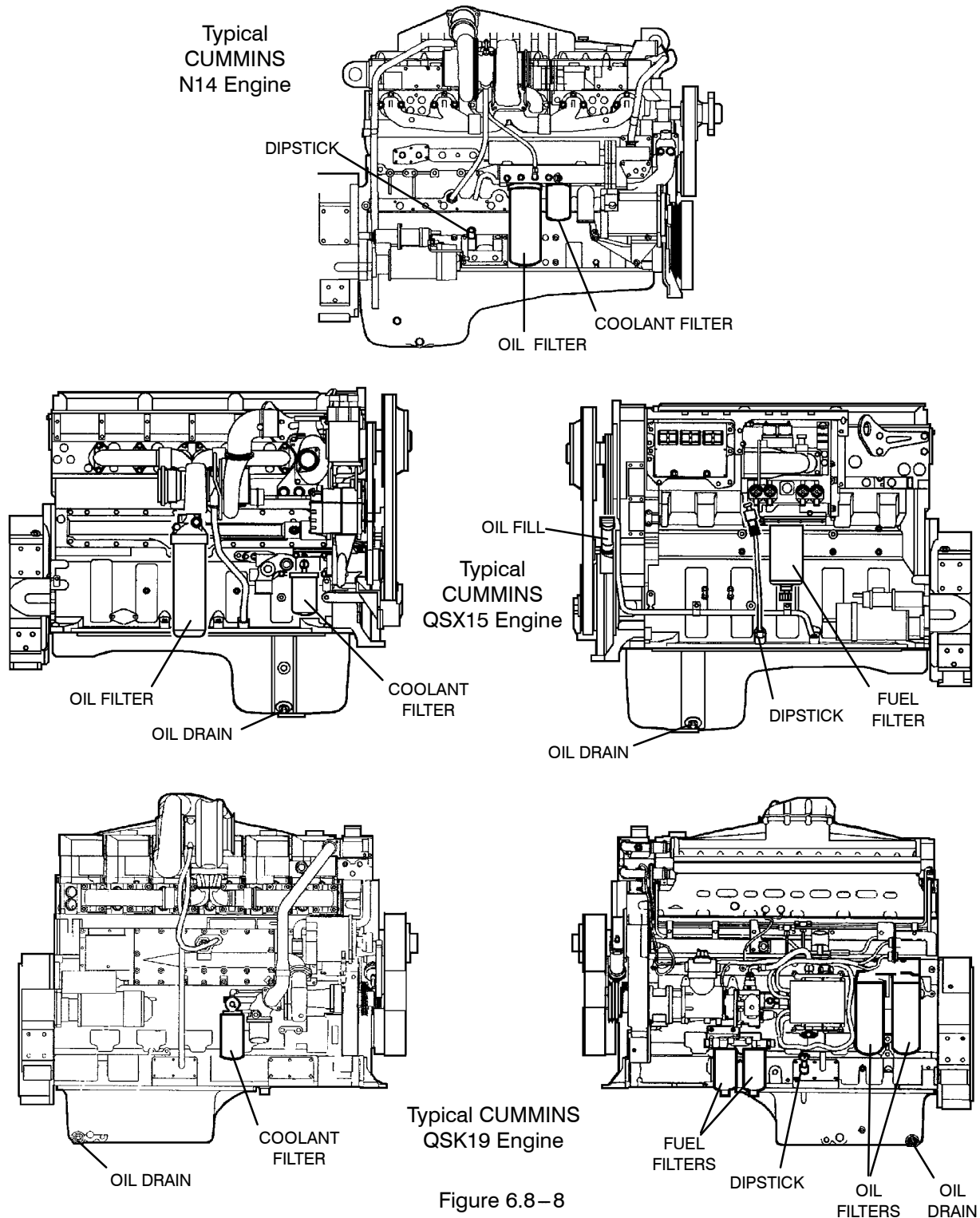
NOTICE

Refer to your Caterpillar Operation and Maintenance Manual for specific engine Maintenance Interval Schedule requirements.

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE

The following drawing shows a typical CUMMINS N14, QSX15 and QSK19 Engine. Due to individual applications, your engine may appear different from the drawing.



6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Change Engine Oil and Oil Filters

Change the Engine Oil and Oil Filter as part of the **250 Hour Routine Maintenance** Schedule.

WARNING

Avoid direct contact of hot oil with your skin. Hot oil can cause personal injury.

WARNING

Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, injection and common prolonged contact with used engine oil.

Do not allow used oil to drain into the ground. Dispose of properly.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the crankcase with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained properly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

1. Position the drill on a stable, level surface and shut off engine. Wait at least 5 minutes after shutting off engine to drain the oil. This allows time for the oil to drain into the oil pan.
2. Ensure oil is warm by viewing the water temperature gauge. The temperature should not exceed 140°F. (60°C.) before draining oil.

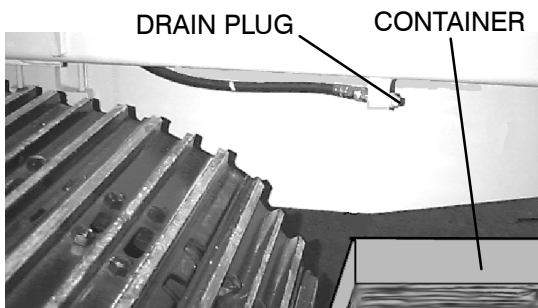


Figure 6.8-9

3. Place container, with a capacity of at least 20 gallon (70 liter), under the drain point.
4. Remove the drain plug and allow the oil to drain from the drain hose into a container.
5. After the oil has completely drained, clean the drain plug and install securely.
6. Dispose of used oil properly.

6.8 - MAINTENANCE (250 HOURS)

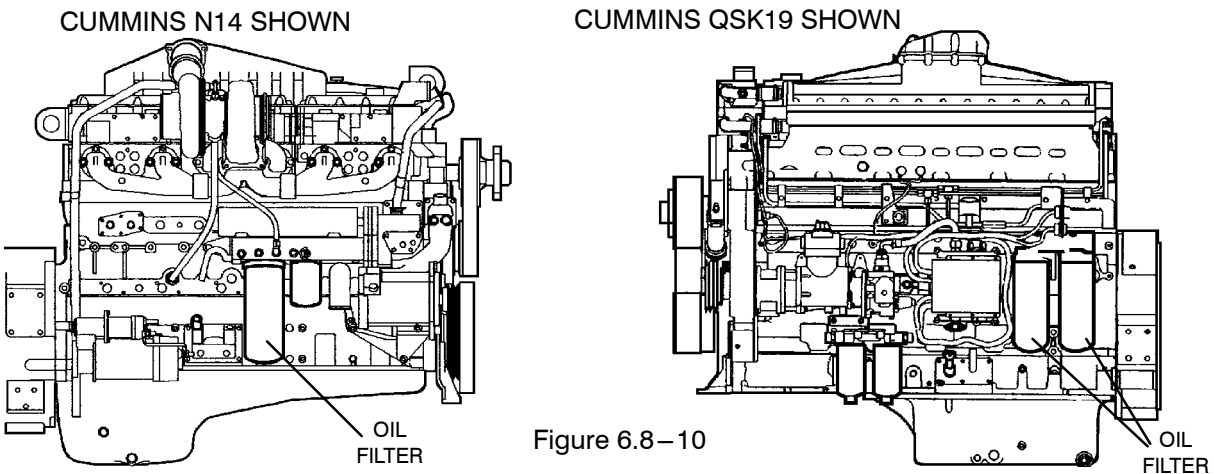
CUMMINS ENGINE MAINTENANCE (continued)

Replace the Engine Oil Filter(s)

Change the engine oil filter(s) at the same time the engine oil is changed.



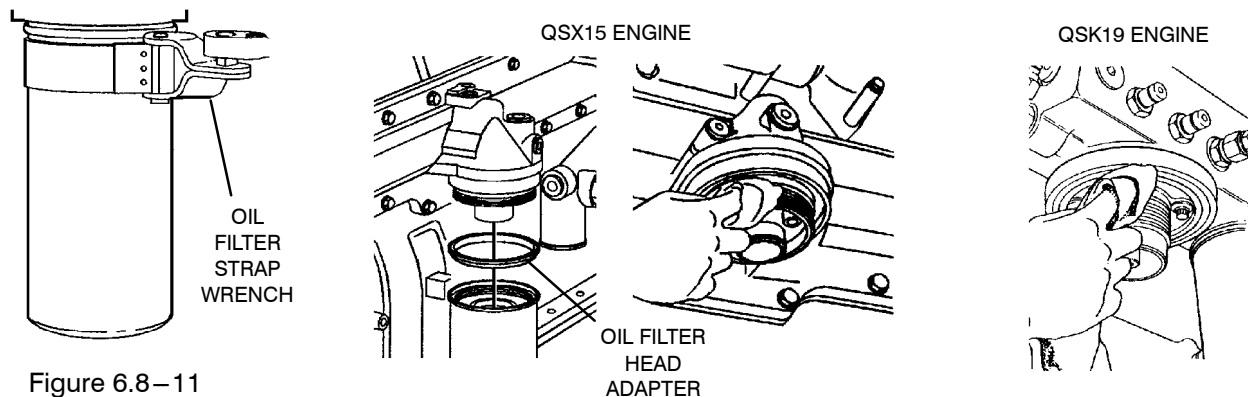
Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.



Place a container with a capacity of at least 3 quarts (2.84 liter) under the engine oil filter(s).

1. Clean the area around the lubricating oil filter head. Remove the filter(s) with an Oil Filter strap wrench assembly (see figure 6.8-11). **Note:** The O-ring can stick on the filter head. Make sure it is removed.

Note: If the lubricating oil filter head adapter comes off during the removal of the oil filter, reinstall oil filter head adapter (see figure 6.8-11). Use a small amount of loctite on the threads of the oil filter head adapter and tighten to 150 ft/lb (203 N•m).



6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Replace the Engine Oil Filter(s) - continued

2. Discard the filter(s) if they are not needed for a failure analysis. Dispose of the used filters in compliance with local regulations.
3. Cut all the way around the top of the oil filter(s) using a pipe cutter or hack saw. Inspect the pleated paper element for metal debris. Metal debris in filter can reveal an impending engine failure. If debris is found, find the reason for the debris and perform the needed repairs.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Cummins dealer in order to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

4. Clean around the sealing surface of the filter mounting base. Ensure that all of the old gasket is removed before installing the new filter (See Figure 6.8-11).



Fill the oil filter(s) with clean lubricating oil. The lack of lubrication during the delay until the filters are pumped full of oil is harmful to the engine.

5. Apply a film of clean engine oil to the seal of the new oil filter gasket before installing the new oil filter (See Figure 6.8-12).
6. Install the filter(s) as specified by the filter manufacturer.

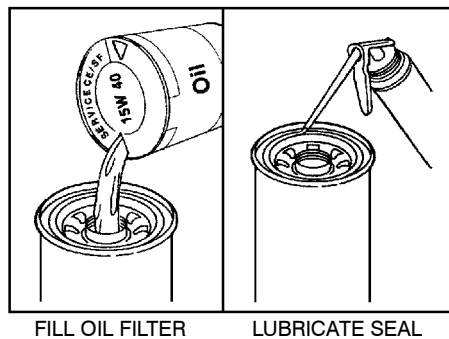
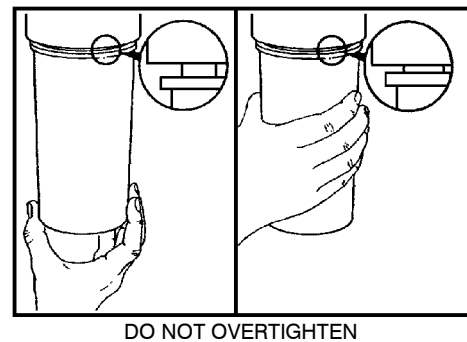


Figure 6.8-12



Mechanical overtightening can distort the threads or damage the filter element seal.

7. Most filters have their instructions printed on the side of the filter. Tighten the oil filter until the oil filter gasket contacts the base (See Figure 6.8-12). Tighten the oil filter by hand according to the instructions that are shown on the oil filter. **Do not overtighten the oil filter.**

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Replace the Engine Oil Filter(s) - continued

8. After oil has completely drained and the filter(s) have been replaced, clean the drain plug (see figure 6.8–9) and install securely.
9. Dispose of used oil properly and in accordance with local regulations.

Fill the Engine Crankcase

The refill capacities for the Cummins engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil.

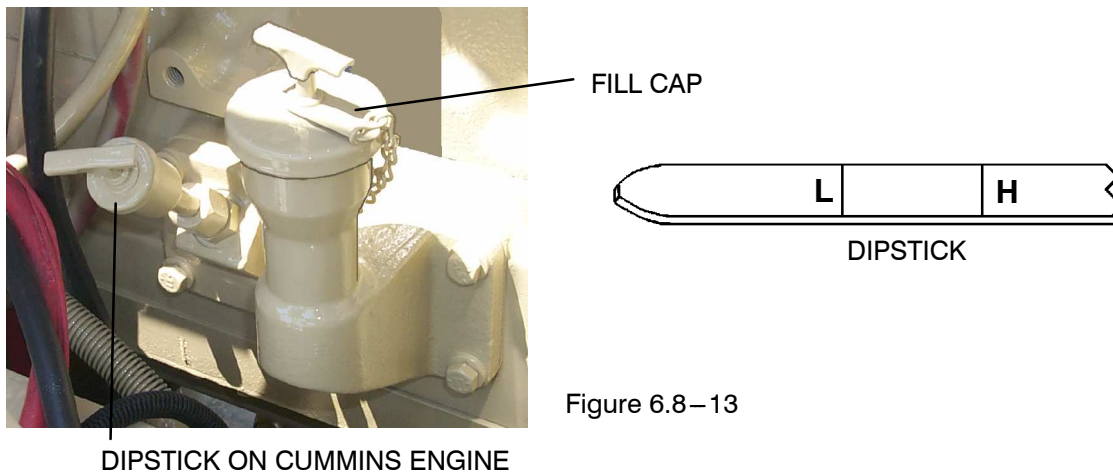


Figure 6.8–13

Cummins Engine Series	Oil Specification	Approximate Refill Capacities	
		Quarts	Liters
N14 Series	API CG–4 15W40 (All drills leave the factory filled with Amalie 15W40)	36	34.1
QSX15 Series		48	45
QSK19 Series		72	68

Refer to the *Lubrication Specifications* and *Refill Capacities* in this section for more detailed information.

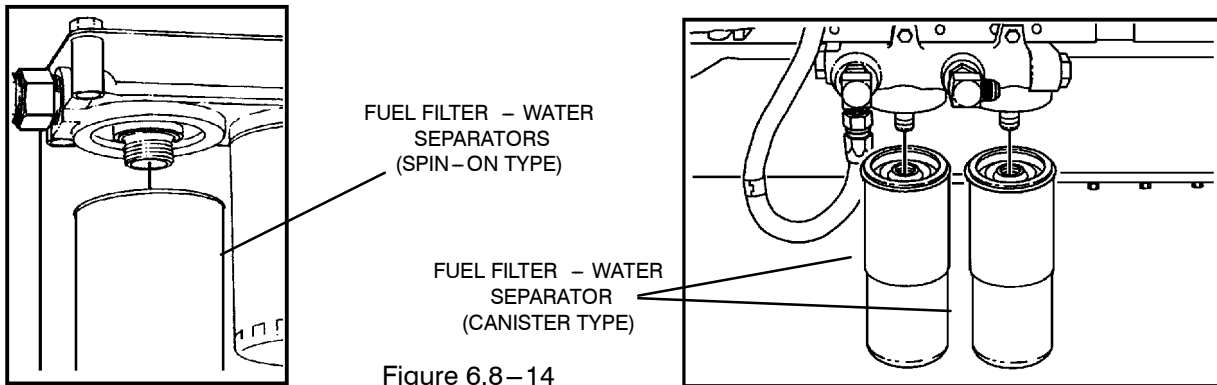
1. Remove the oil filler cap and fill the crankcase with the proper amount of oil.
2. Operate engine at idle speed to inspect for leaks at the oil filter(s) and the drain plug.
3. Shut off the engine. Wait approximately 5 minutes to let the oil drain from the upper parts of the engine.
4. Check the oil level again. Add oil as necessary to bring the oil level to the “H” (High) mark on the dipstick.

6.8 - MAINTENANCE (250 HOURS)

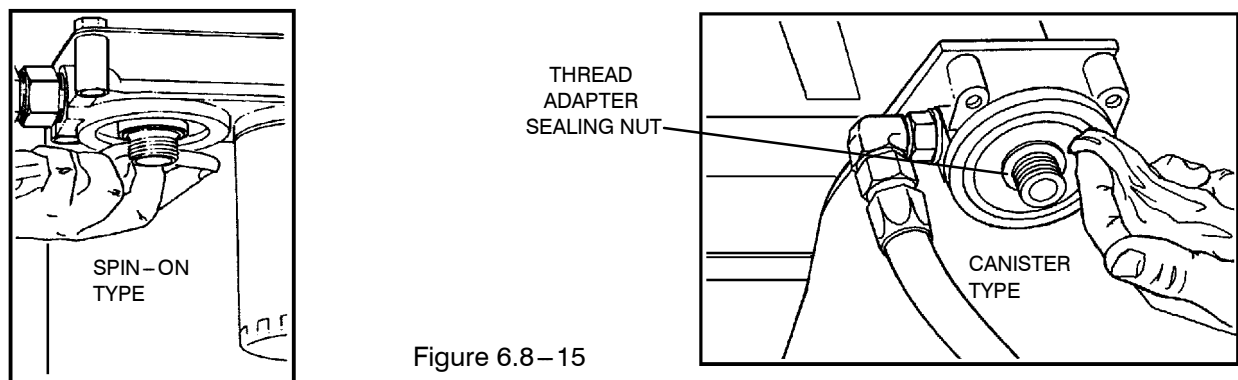
CUMMINS ENGINE MAINTENANCE (continued)

Replace Fuel Filter(s)

Every 250 hours or 6 months (whichever occurs first), replace the fuel filter(s).



1. Clean the area around the fuel filter head.
2. **QSK19 Engine** - Close the fuel line shutoff valve before changing the fuel filter(s), or the overhead tank can drain, causing a fuel leak.
3. Place a container under the fuel filter(s) to collect any escaping fuel when removing them.
4. Unscrew the used fuel filter(s) using 75-80mm and 90-95mm filter wrenches. Discard the used filter(s) in accordance with local guidelines.



5. **QSK19 Engine** - Remove the thread adapter sealing nut.
6. Use a clean, lint-free towel to clean the surface of the filter head gasket.
7. If necessary, replace the O-ring in the filter head.

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Replace Fuel Filter(s) (continued)

NOTE:

Use the correct filter(s) for your engine. Cummins requires that a fuel-water separator or a fuel filter and water separator be installed in the fuel supply system.

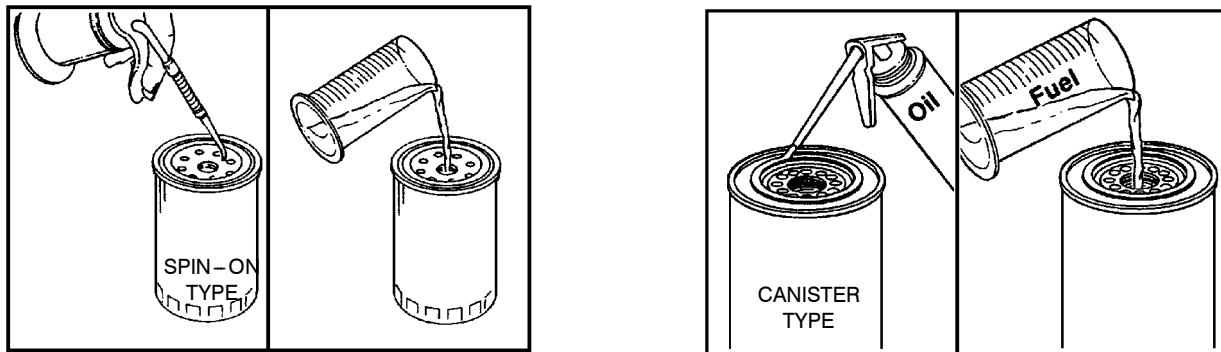


Figure 6.8-16

8. **QSK19 Engine** – Install a new thread adapter sealing ring supplied with the new filter.
9. Apply a light coating of clean engine oil to the surface of the filter gasket.
10. Fill new filter(s) with clean fuel.
11. Install the new filter(s) as specified by the manufacturer. The tightening instructions are normally printed on the outside of the filter.
12. Install the filter on the filter head. Turn the filter until the gasket touches the surface of the filter head.
13. Tighten the filter an additional 1/2 to 3/4 of a turn after the gasket touches the filter head surface. **Do not overtighten the filter.**
14. **QSK19 Engine** – Open the fuel line shutoff valve and check for leaks.
15. Check the engine and connections for leaks.
16. If fuel filters are changed according to these instructions, no manual bleeding of fuel lines should be required. If necessary, refer to engine manufacturer's manual for information on bleeding the system.

Note:

When restarting the engine after replacing the fuel filters, it is necessary to prime the fuel system using the primer button switch on the operator's console.

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Engine Coolant Filter

Replace the engine coolant filter at every engine oil and filter change interval as part of the 250 Hour routine maintenance schedule.

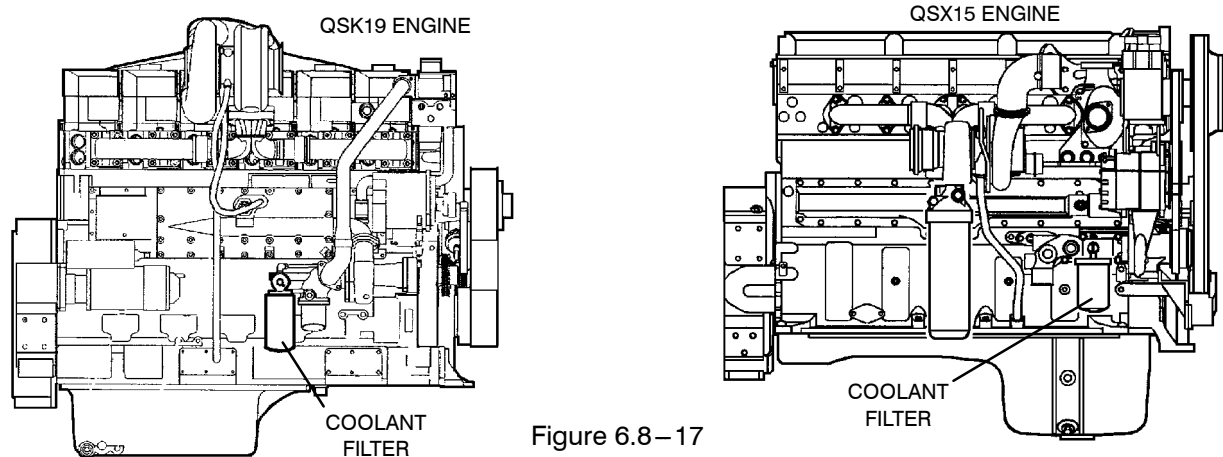


Figure 6.8-17

NOTE:

Use the correct engine coolant filter to maintain correct SCA (Supplemental Coolant Additive) concentration in the system. Maintain the correct concentration by changing the service filter at each oil drain interval. Refer to *Coolers Maintenance Procedures* for further SCA information.

Remove Engine Coolant Filter

Remove the coolant system pressure cap.

WARNING

Do not remove the pressure cap from a hot engine. Hot steam will cause serious personal injury. Remove the coolant system pressure cap and close the shutoff valve(s), if so equipped, before removing the coolant filter. Failure to do so can result in personal injury from heated coolant spray.

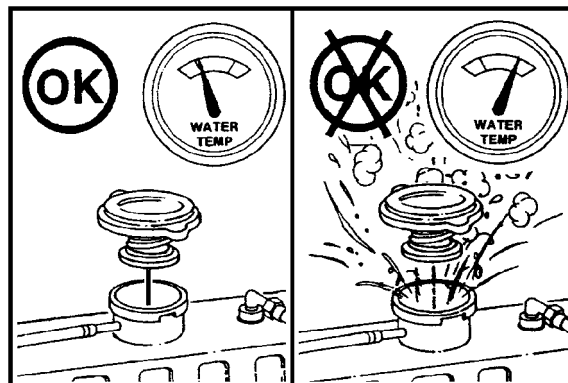


Figure 6.8-18

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Remove Engine Coolant Filter (continued)

A manual shutoff valve is provided to prevent coolant leakage while changing the coolant filter. With the valve in the vertical position, the coolant flows to and from the coolant filter. In the horizontal position, the coolant flow is cut off to and from the coolant filter.

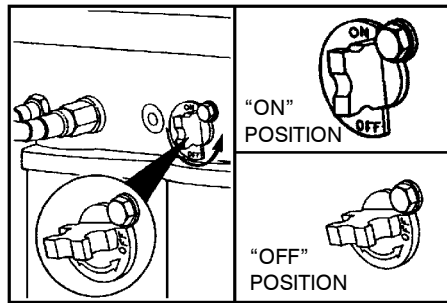
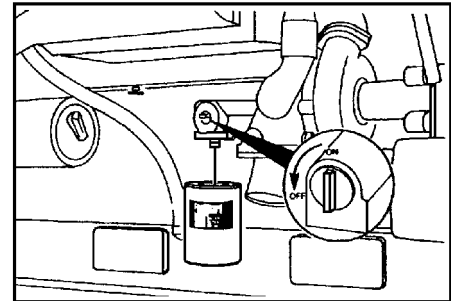


Figure 6.8–19



1. Turn the coolant shutoff valve to the "OFF" position (see figure 6.8–19).
2. Clean the area around water cooler filter (see figure 6.8–20).

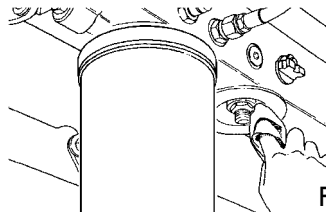


Figure 6.8–20

3. Place a container under filter to collect any escaping coolant during removal.
4. Unscrew and discard the used filter in full compliance with local guidelines.

Install Engine Coolant Filter

1. Clean the sealing surface of filter head.
2. If necessary, replace O-ring on filter head.

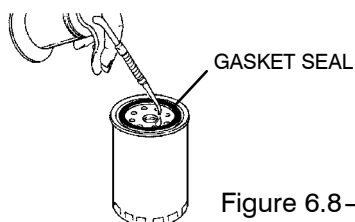


Figure 6.8–21

3. Apply a light film of engine oil to the gasket seal before installing the new coolant filter.

NOTE: Do **not** allow oil to get in the filter. It will break down the SCA.

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Install Engine Coolant Filter (continued)

4. Install the new filter as specified by the filter manufacturer. Turn filter until the seal touches the filter head. Turn an additional 1/2 to 3/4 of a turn after contact.

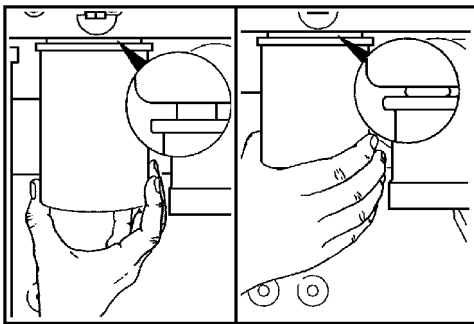
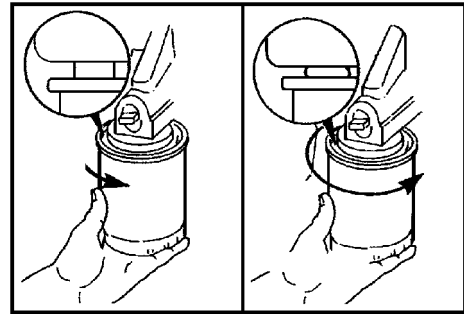


Figure 6.8-22



CAUTION

Mechanical over tightening can distort the threads or damage the filter head.

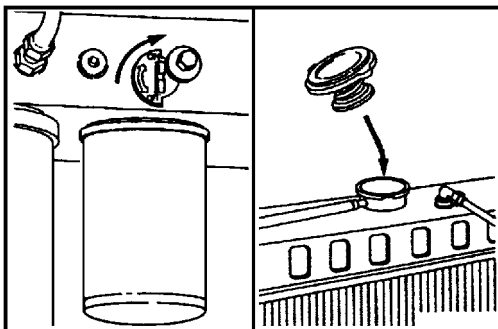
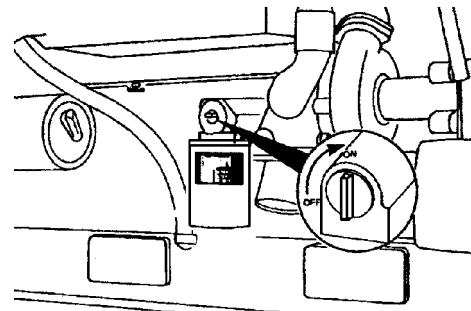


Figure 6.8-23



5. Open the shut-off valve.

CAUTION

Engine damage will result if the shut-off valve is left closed.

6. Install the coolant system pressure cap.
7. Operate the engine and check for coolant leaks.
8. After the air has been purged from coolant system, check the coolant level again.

6.8 - MAINTENANCE (250 HOURS)

CUMMINS ENGINE MAINTENANCE (continued)

Check Engine SCA Level

Cummins engine cooling systems should be tested at 250 Hour intervals for the concentration of Supplemental Coolant Additives (SCA).

NOTICE

Never use water alone without Supplemental Coolant Additives (SCA) or without inhibited coolant. Water alone is corrosive at engine operating temperature. Water alone does not provide adequate protection against boiling or freezing.

Note: *Engine is protected against corrosion of the cooling system by adding corrosion inhibitor to the coolant. If the engine radiator has been topped off using only water, the additive content will become diluted and the risk of corrosion will increase.*

Refer to engine instruction manual for further information and procedures on this important maintenance item.

The engine manual gives full details of the procedures for checking and servicing the engine cooling system.

TRACK PLANETARY GEARBOX

Check Wheel Nuts Adjustment

The following maintenance must be carried out every 250 hours or monthly:

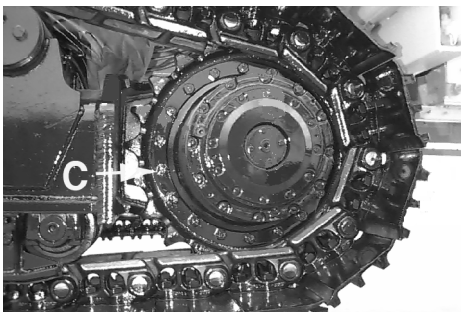


Figure 6.8–24

1. Check that the wheel nuts (C) are torqued to the correct value of 420 ft/lbs (571 Nm).

Note:

If new wheel nuts have been recently installed, they may require frequent checks until they seat properly.

2. Repeat same procedure for the other track drive.

6.8 - MAINTENANCE (250 HOURS)

WARNING

Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components.

Do not allow used oil to drain into the ground. Dispose of properly.

Change Initial Track Planetary Oil

The gear oil should be changed after the first **two hundred fifty (250) hours** of operation, then at every **2000 operating hours**

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum planetary gearbox life.

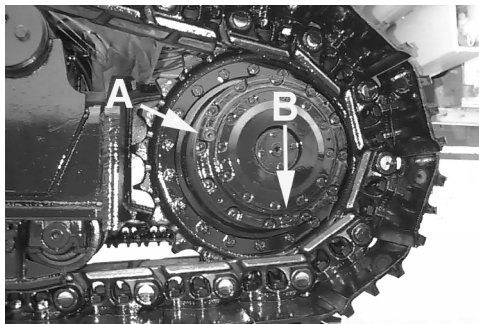


Figure 6.8–25

1. Move the drill to a level surface and shut off the engine.
2. Be sure oil is warm before draining oil.
3. Place container with a capacity of at least 25 quart (24 liter) under the track drive drain point (B).
4. Remove the drain plug (B) and the fill/level plug (A). Allow oil to drain from the drain port into the container.
5. Clean drain plug and install.
6. **DM45/DM50 Drills** – Refill the planetary through the oil filler plug hole (A) with about 7.4 quarts (7 liters) of ISO VG220 oil until planetary is full and oil overflows. Allow the surplus oil to drain out until the oil level is up to the bottom of the fill port (A).

DML Drills – Refill the planetary through the oil filler plug hole (A) with about 8.4 quarts (8 liters) of ISO VG220 oil until the planetary is full and oil overflows. Allow the surplus oil to drain out until the oil level is up to the bottom of the fill port (A).

Refer to *6.3 Lubricant Specifications* for the recommended required oil specifications.

7. Clean fill plug and install.
8. After start-up, check the planetary track drive for leaks at operating temperatures.
9. Repeat same procedure for the other track drive.

6.8 - MAINTENANCE (250 HOURS)

AUXILIARY HOIST

Wire Rope

Winch ropes, including their anchorage and other load carrying components of the travelling block and winch system, e.g. sheave bearings, rope sheaves and drill hooks, shall be checked at least once a week.

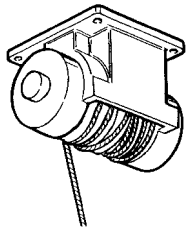


Figure 6.8–26

Wire ropes shall be examined and discarded in accordance with 3.5 of ISO 4309:1990. In table 3.5 of ISO 4309:1990, classification groups M1 and M2 shall be used. On drill rigs with normal hook load of more than 1000KN, the winch rope shall be regularly paid out and shortened according to a plan laid down by the manufacturer on basis of experience.

Wire rope used in drilling operations becomes unusable because of wear and wire breakage and should be discarded according to certain criteria (See FEED CABLE & WIRE ROPE shown in 6.4 *Maintenance As Required*).

1. Replace when four (4) randomly distributed broken wires are found in one lay.
2. Replace when wire rope shows wear of one third (1/3) the original diameter of the outside wire.
3. Replace when evidence of any heat damage from any cause is found.
4. Replace when any kinking or cracking occurs.

6.8 - MAINTENANCE (250 HOURS)

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6.9 - MAINTENANCE (500 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

6.9 - MAINTENANCE (500 HOURS)

CAT ENGINE

Primary Fuel Filter/Water Separator

Water in the fuel can cause the engine to run rough. If the fuel has been contaminated with water, the element should be changed before the regularly scheduled interval of 500 hours.

The primary filter/water separator also provides filtration to help extend the life of the secondary fuel filter. The element should be changed as part of the 500 hour routine maintenance schedule. If a vacuum gauge is installed, the primary filter/water separator should be changed if the pressure is at 50 to 70 kPa (15 to 20 inches of Hg.)

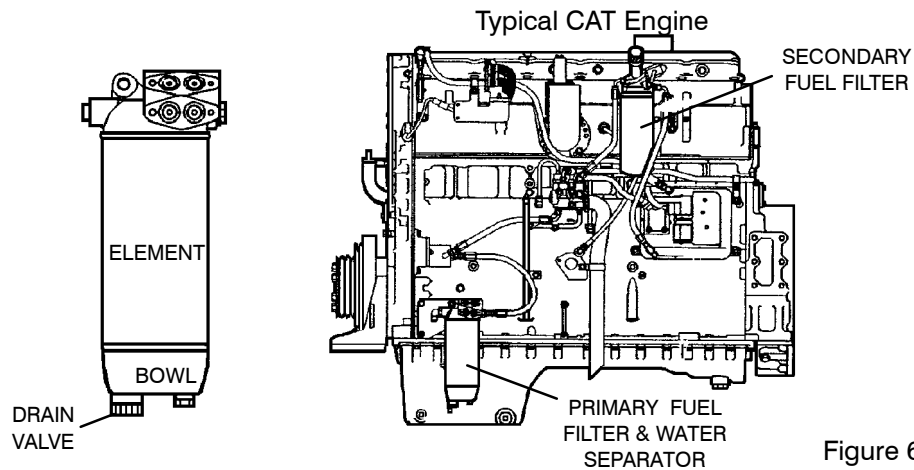


Figure 6.9–1

The bowl should be monitored **daily** for signs of water. If water is present, drain the water from the bowl.

1. Shut off the engine.
2. Open the self-ventilated drain (see Figure 6.9–1). Catch the draining water in a suitable container and dispose of the water properly.
3. Close the drain.

NOTICE

The Water Separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

Under normal operating conditions, the CAT engine primary filter/water separator element should be replaced every **500 hours** as part of routine maintenance.

6.9 - MAINTENANCE (500 HOURS)

Replace the Element

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up any spilled fuel immediately.

1. Stop the engine.
2. Turn the start switch to the “OFF” position. Disconnect the battery.
3. Shut off the fuel tank supply valve to the engine.
4. If the primary fuel filter is equipped with a drain valve, open the drain valve in order to drain any fuel from the filter case. Close the drain valve (see Figure 6.9-1)

NOTICE

Use a suitable container to catch any fuel that might spill. Clean up spilled fuel immediately.

5. Remove the fuel filter bowl and wash the fuel filter bowl with clean diesel fuel.
6. Remove the fuel filter.
7. Clean the gasket sealing surface of the fuel filter base. Ensure that all of the old gasket is removed.
8. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE

In order to maximize fuel system life and prevent premature wear out from the abrasive particles in the fuel, use the correct fuel filters.

9. Install the new filter. Spin the fuel filter onto the fuel filter base until the gasket contacts the base. Use the rotation index marks on the filters as a guide for proper tightening. Tighten the filter for an additional 3/4 turn by hand. **Do not overtighten the filter.**

NOTICE

Do not fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to the fuel system parts.

10. Install the clean fuel filter bowl on the new fuel filter.

NOTICE

The Water Separator is under suction during normal engine operation. Ensure the drain valve is tightened securely to help prevent air from entering the fuel system.

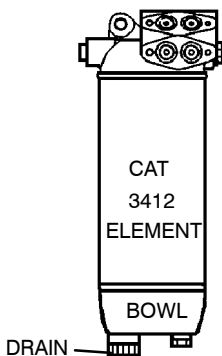
6.9 - MAINTENANCE (500 HOURS)

Replace the Element (continued)

11. Open the fuel tank supply valve.
12. Start the engine and check for leaks. Run the engine for one minute. Stop the engine and check for leaks again.

Leaks are difficult to detect while the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, check the components for overtightening or undertightening.

Cat 3412E



PRIMARY FUEL
FILTER/WATER
SEPARATOR

The following instructions are
specific to a **CAT 3412E** engine

Figure 6.9–2

1. Close the main fuel supply.
2. Remove element from element mounting base while bowl is attached.
3. Dispose of the filter contents. Remove the bowl from element. The bowl is reusable. Do not discard the bowl. Dispose of the used element in accordance with any local regulations.
4. Remove the O-ring from the gland of the bowl. Clean the bowl, O-ring and mounting base. Inspect the O-ring for damage and for deterioration. Replace the O-ring, if necessary.
5. Lubricate the O-ring with clean diesel fuel.
6. Install bowl on a new element. Tighten the bowl by hand. Do not use tools to tighten the bowl.

NOTICE

The primary filter/water separator may be prefilled with fuel to avoid rough running/stalling of the engine due to air. Do not fill the secondary filter with fuel before installation. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

6.9 - MAINTENANCE (500 HOURS)

Cat 3412 Primary Filter (continued)

7. Lubricate the top seal of element with clean diesel fuel. The element may be prefilled with fuel at this time. Install the new element on the mounting base. Tighten by hand.

NOTICE

The water separator is under suction during normal engine operation. Ensure that the vent plug is tightened securely to help prevent air from entering the fuel system.

8. Open the main fuel supply valve.
9. Start the engine and check for leaks. Run the engine for one minute. Stop the engine and check for leaks again.

Leaks are difficult to detect while the engine is running. The primary filter/water separator is under suction. A leak will allow air to enter the fuel. The air in the fuel can cause low power due to aeration of the fuel. If air enters the fuel, check the components for overtightening or undertightening.

BATTERIES

The following battery maintenance must be carried out as part of the **500 hour** routine maintenance schedule.

WARNING

Batteries contain an acid and can cause injury. Skin and eye contact with battery fluid can cause injury. Avoid skin and eye contact with battery fluid. If contact occurs, flush area immediately with water.

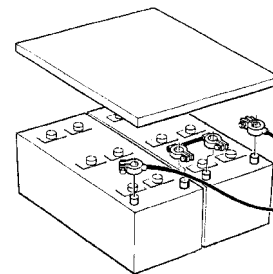


Figure 6.9–3

Batteries, Clamps & Cables

The standard batteries supplied are heavy duty lead acid type, requiring the following maintenance.

1. Keep the top of the batteries clean.
2. Clean the terminals.
3. Keep battery connections tight.
4. Apply a small amount of grease to the terminal connections to prevent corrosion.
5. Inspect the cables, clamps and hold down brackets. Replace if necessary.

6.9 - MAINTENANCE (500 HOURS)

BATTERIES (continued)

Electrolyte Level

1. Check the electrolyte level and keep the electrolyte level above the plates.
2. Refill with distilled water if necessary.



Over filling can cause poor performance or early failure.

FUEL TANK

Fuel Tank Breather

The fuel tank breather should be replaced as part of the **500 hour** routine maintenance procedure.

1. Thoroughly clean the area around the fuel tank breather (see Figure 6.9-4).
2. Remove the breather.
3. Until the new breather is installed, cover the breather port to ensure that nothing can get into the housing.
4. Install the new breather.

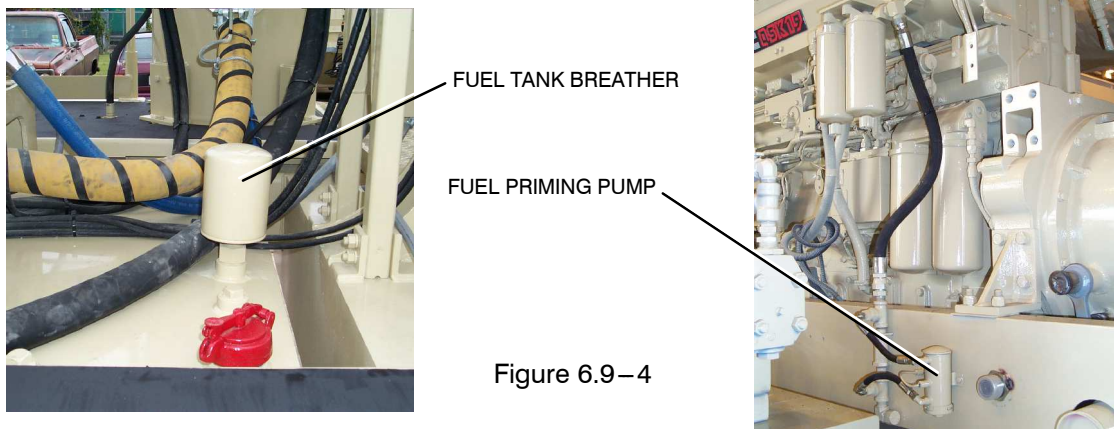


Figure 6.9-4

Fuel Priming Pump

Clean the fuel priming pump during the **500 hour** routine maintenance procedure.

1. Thoroughly clean the area around the fuel priming pump (See Figure 6.9-4).
2. Carefully remove the spring loaded cover and remove the strainer.
3. Clean the strainer.
4. Replace the strainer and secure the cover.

6.9 - MAINTENANCE (500 HOURS)

HYDRAULIC RESERVOIR

Hydraulic Tank Breather

The hydraulic tank breather should be replaced as part of the **500 hour** routine maintenance procedure.

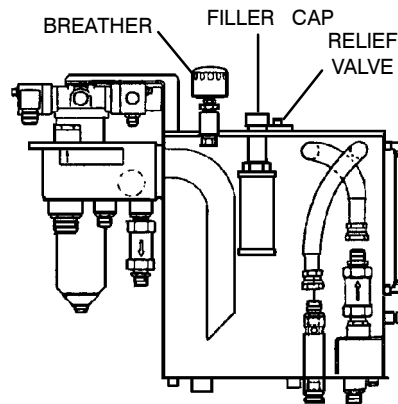


Figure 6.9–5

1. Thoroughly clean the area around the hydraulic tank breather.
2. Remove the breather.
3. Until the new breather is installed, cover the breather port to ensure that nothing can get into the tank housing.
4. Install the new breather.

COMPRESSOR

WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

WARNING

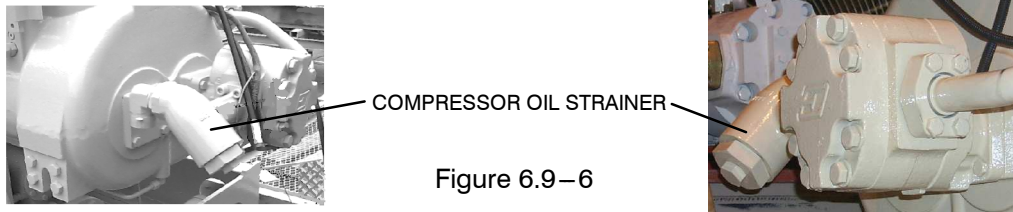
Do not attempt to remove any plugs or open the drain valve before making sure all air pressure has been relieved from the system.

Compressor Oil Strainer

A 40 mesh, (150 μ micron) strainer is mounted just before the inlet to the oil pump (see figure 6.9–6). It protects the pump and catches any foreign debris, such as hose pieces and parts of the thermostat that could damage the pump. The metal strainer should be removed, cleaned and re-installed every **500 hours**.

6.9 - MAINTENANCE (500 HOURS)

Compressor Oil Strainer (continued)



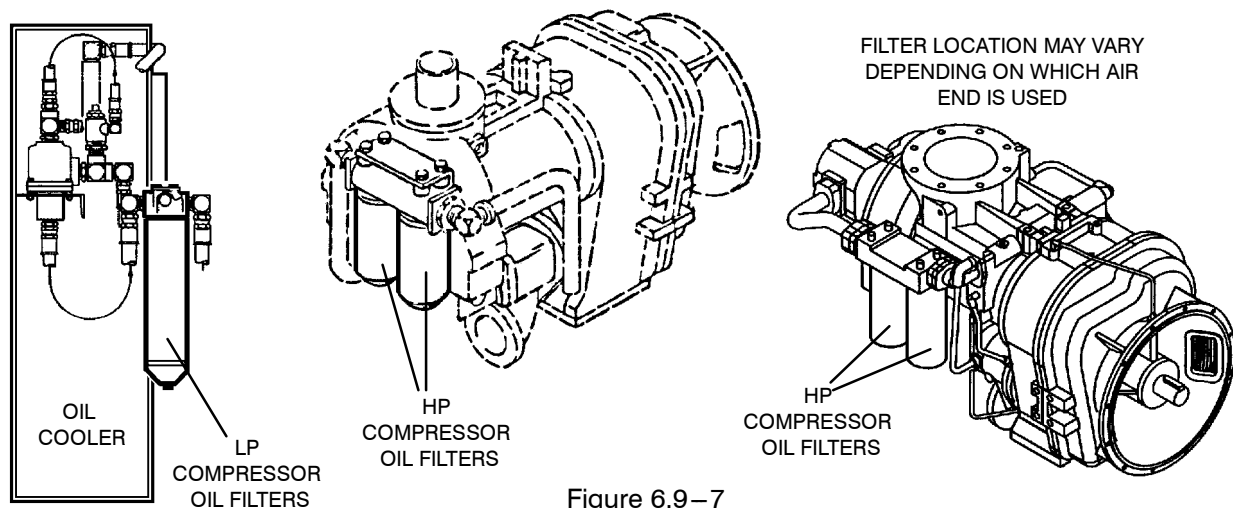
1. Thoroughly clean the entire area around the compressor oil strainer.
2. Remove the cover and remove the strainer element.
3. Clean the strainer and the magnetic plug.
4. Re-install the strainer element.
5. Replace and secure the cover.

Change Compressor Oil Filters

The following compressor oil filter maintenance must be carried out as part of the **500 hour** routine maintenance schedule.

⚠ WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.



1. Thoroughly clean and wipe all the external dirt and oil from the filter housing and the head area to minimize contamination from entering the system.

6.9 - MAINTENANCE (500 HOURS)

Change Compressor Oil Filters (continued)

2. Place a container under the oil filters to collect any oil escaping during removal and prevent any oil spill from contaminating the ground.
3. Unscrew the used filters using 90–95mm wrenches. Discard used filters in accordance with local guidelines.
4. Clean the sealing surface of dual filler head.
5. If necessary, replace the O-ring seals of the dual filter head.
6. Fill the new filters with clean compressor oil and lubricate the O-ring seal with clean oil.
7. Install new filters as specified in the parts manual. Most filters have instructions included.
8. After startup, check the oil filters for any leaks at operating temperatures.

PUMP DRIVE GEARBOX

The type of service and the operating conditions will determine the maintenance interval. However, it is recommended that the pump drive gearbox oil be changed after the first **five hundred (500) hours** of operation, then at every **1000 operating hours**. Because the lubricant system is the heart of the unit, it is especially important that the oil be kept clean.

NOTE: The oil in the pump drive gearbox should be changed whenever the oil shows traces of dirt or the effects of high temperature, evidenced by discoloration or strong odor.

Change Oil

WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Oil must be at normal operating temperature when draining. Do not allow used oil to drain into the ground. Dispose of properly.

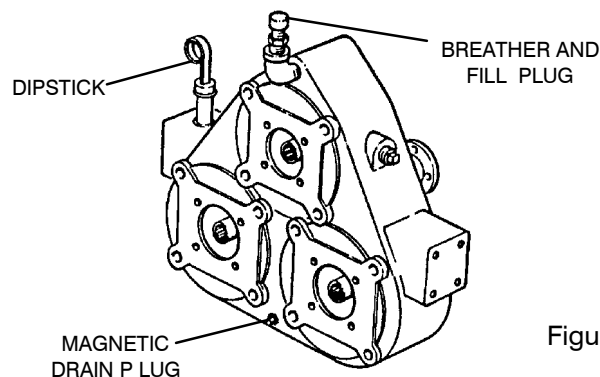


Figure 6.9–8

1. Move the drill to a stable, level surface and shut off the engine.

6.9 - MAINTENANCE (500 HOURS)

Change Oil (continued)

2. Place a container with a capacity of at least 4–1/2 quarts (4.02 liters) under the drain point.
3. Clean around oil fill, dipstick and drain plug areas.
4. Remove the drain plug and the breather.
5. Drain oil while the pump drive is still warm.
6. Examine oil for any contamination or metal particles. Metal debris can reveal an impending pump drive gearbox failure. If debris is found, find the reason for the debris and perform the needed repairs. Allow the oil to drain from the drain into a container.
7. Clean magnetic drain plug before installing.
8. Refill the pump drive gearbox through the breather port with 4–1/2 quarts (4.02 liters) of 80W90 Gear Oil **or** until the pump drive gearbox oil level reaches the FULL level on the dipstick. Refer to *6.3 Refill Capacities/Lubricants/Fuel Specifications* for recommended required oil specifications. **Do not overfill. This will result in over heating and possible malfunction of the gearbox.**
9. Clean the breather and install securely.
10. After startup, check the pump drive for any leaks at operating temperatures.

WATER INJECTION PUMP

Change Oil



The oil is to be at operating temperature for draining. Be careful. Hot oil and components can burn.

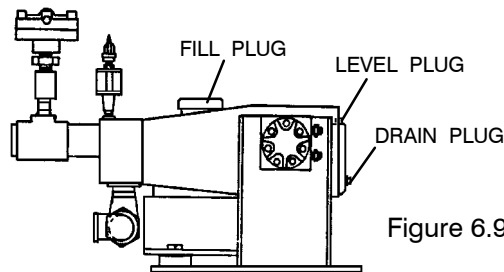


Figure 6.9–9

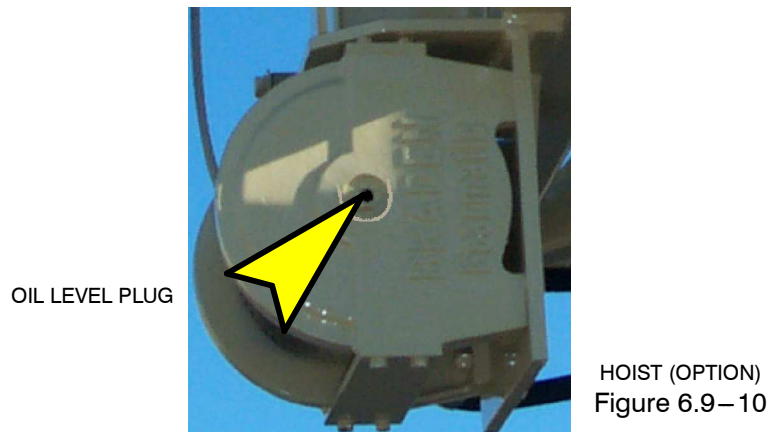
1. Position drill on stable, level surface.
2. Place a container at drain point to collect used oil.
3. Remove both fill plug and drain plug (Figure 6.9–9). Allow oil to drain completely.
4. After oil has drained, clean and replace drain plug.
5. Clean and remove the level plug.
6. Refill the oil through fill port until oil appears at level plug port. Refer to *6.3 Fill Capacities / Lubricants/Fuel Specifications* for oil details.
7. Clean and install fill plug and level plug.
8. Operate drill and water injection and check for any leaks.

6.9 - MAINTENANCE (500 HOURS)

AUXILIARY HOIST

Jib Hoist Oil Level

The gear oil level should be checked every **five hundred (500) hours** of operation.



1. Move the drill to a stable, level surface and lower the tower to the horizontal position.
2. Shut off the engine.
3. To check the oil level, remove the oil level plug shown in Figure 6.9-10. The oil should be level with the bottom of this opening.
4. If additional oil is needed, refill the housing to the bottom of the filler/sight plug. Planetary winches are factory filled with Texaco Meropa 150 gear oil or an equivalent industrial grade lubricant meeting AGMA 4EP or API GL-2 with ISO viscosity grade 150, for temperatures between -10°F (-25°C) to 80°F (26°C). For temperatures between 50°F (10°C) and 130°F (55°C), use Texaco Meropa 220 or equivalent AGMA 5EP. Planetary capacity is 2 U.S. pints (.94 liters). Refer to 6.3 *Lubricant Specifications* for further recommended oil specifications.
5. Drain and refill the housing if the oil shows signs of moisture or other contamination.
6. Lubricate drum shaft bracket and clutch (if so equipped) with grease.
7. Oil the connections of operating linkages using SAE 30 oil.

6.9 - MAINTENANCE (500 HOURS)

AUXILIARY HOIST

Cable/Rope Lubrication

Lubrication of the wire rope should be included in the maintenance schedule. Cables should be cleaned with a wire brush and solvent and lubricated approximately every **500 hours** with one of the following or equivalent:

1. Texaco Crater A
2. Brooks Klingfast 85 (Brooks Oil Co.)
3. Gulf Seneca 39
4. Whitmore's Wire Rope Lubricant (Whitmore Manufacturing Co.)

The lubricant can be applied with either a spray or a brush and is recommended for protection against corrosion only.

COMPRESSOR AIR HOSES AND CLAMPS

1. Periodic clamping bolts re-tightening is necessary due to "Cold-Flow" present in all rubber hoses. Tighten to recommended torque value listed on "BOSS CLAMPS" chart in Section 7 "SYSTEMS & TROUBLESHOOTING".
2. Examine for and change out worn hoses and weakened Boss clamps. If the hoses are to be changed out, change the Boss clamps also. These Boss clamps hold the hose connections under a large amount of pressure. Remember, Boss clamps (including the nuts and bolts) are for **single use only. Do not reuse!** Once removed, discard.
3. Refer to the "Dixon Boss Clamp Selection and Installation" instructions shown in Section 7 "SYSTEMS & TROUBLESHOOTING" for the proper way to select and install Dixon Boss Clamps.

6.10 - MAINTENANCE (1000 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and to allow sufficient time before putting the drill in motion.

6.10 - MAINTENANCE (1000 HOURS)

COMPRESSOR OIL

Under normal operating conditions, the compressor oil must be changed every **1000 hours** as part of a routine maintenance program.

⚠ WARNING

Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

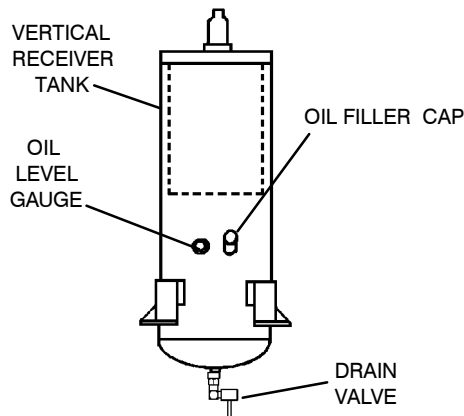
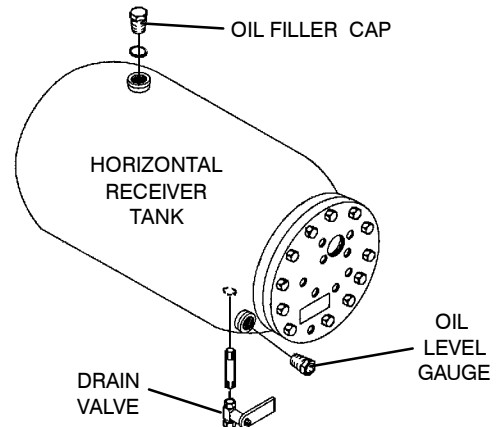


Figure 6.10–1



1. Position drill on stable, level surface and shutdown engine.
2. The best time to drain the receiver separator tank oil is when the oil is warm. At that time the sediment in the receiver separator is in suspension and will drain with the old oil. The temperature should not exceed 140°F (60°C) before draining oil.
3. Place a container with a capacity of at least 38 gallon (144 liter) under the drain point.

⚠ WARNING

Do not attempt to remove any plugs or open the drain valve before making sure all air pressure has been relieved from the system.

4. Open the drain valve and allow the compressor oil to drain into a container.
5. Dispose of the used oil in accordance with local guidelines.
6. Close the drain valve and refill the receiver tank, through the oil filler, with compressor oil to the full mark on the level gauge. See the *Compressor Oil Specifications* in this section for details on the compressor oil.) Replace the fill plug.

Note: *Low Pressure* compressors(110psi) use **IR-PROTEC Oil**.
High Pressure compressors (350 psi) use **XHP605 Oil**.

6.10 - MAINTENANCE (1000 HOURS)

HYDRAULIC OIL FILTERS

There are two system return hydraulic oil filters and one case drain filter on the drill.

The system main return filters are located on the rear face of the hydraulic tank. The main return flow to the tank passes through these filters and into the hydraulic oil tank's internal supercharge manifold. The supercharge of 65 psi provides supply to the piston pumps and minimizes cavitation problems.

The case drain filter is located on the drill tower support and filters case drain oil prior to return into the hydraulic tank.

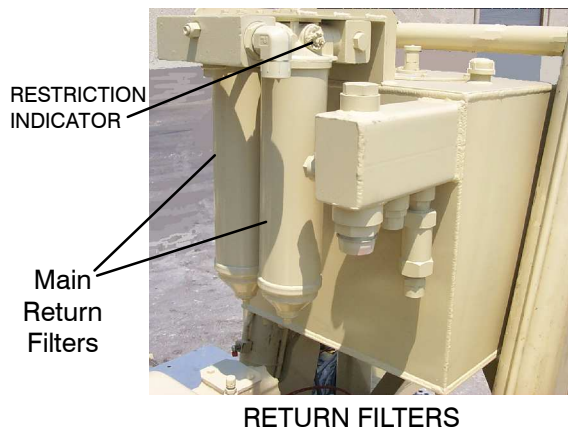


Figure 6.10-2



It is important to monitor the filter's restriction indicator sight glass during the routine 10 hour walk around inspection by the operator. If the indicator window shows RED, then the filter elements require replacement. If the window shows GREEN, the filters are satisfactory.

When restriction indicates that element servicing is required, proceed in the following manner. Under normal operating conditions, these filters are replaced at the regular **1000 Hour** service interval.

Main Return Filters

NOTICE

Dirt in the hydraulic system will lead to premature component failure. A clean, contaminant free system is extremely important to the drill's proper function. Take extra care when working around or on the hydraulic system to ensure its complete cleanliness.

WARNING

Do not attempt to service the filters before making sure all the hydraulic pressure has been relieved from the system.

6.10 - MAINTENANCE (1000 HOURS)

HYDRAULIC OIL FILTERS (continued)

Main Return Filters (continued)

When restriction indicates that element servicing is required, or the regular **1000 Hour** service interval is reached, proceed in the following manner for these filters:

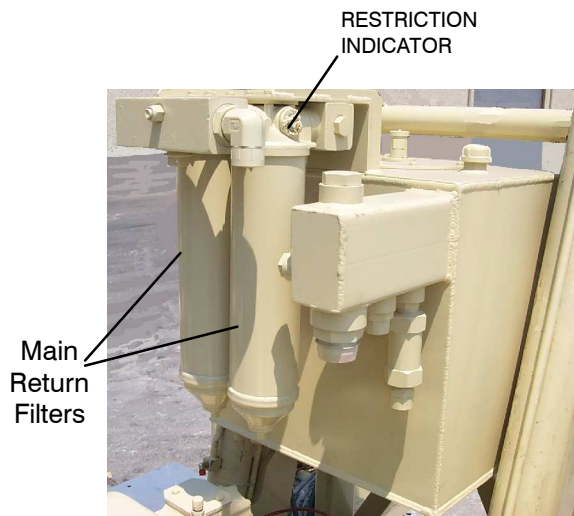
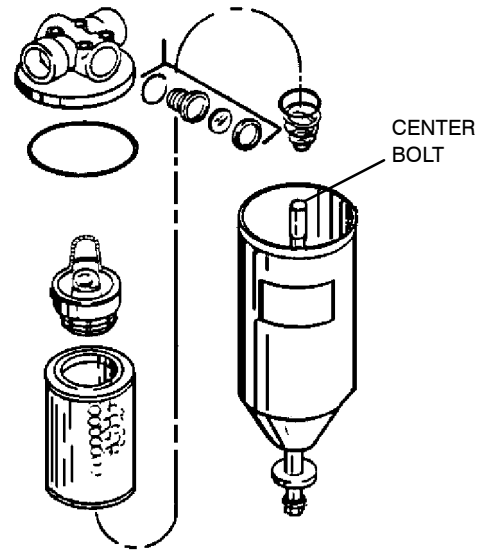


Figure 6.10–3



1. Wipe all external dirt and oil from filter housing and head area to minimize contamination from entering the system.
2. Place a container under the oil filters to prevent any oil spill from contaminating the ground.
3. Loosen the bolt at filter housing base and remove the housing, elements and the indicator as an assembly.
4. Remove the indicator from the element by twisting slightly with a side loading force. Do not pull the indicator straight out or pry loose. If the indicator comes out too easily, the snap in lugs are probably worn and the indicator should be replaced.
5. Discard the old elements in accordance with local guidelines.
6. Inspect the indicator and O-ring seal.
7. Snap indicator onto the new element, making sure the part number on the new element is the same as that on the element removed.
8. Clean the housing center bolt and spring in an approved cleaning solvent and allow to dry.
9. Inspect the O-ring washer on the center bolt and replace if damaged.
10. Install the center bolt through the bottom of the housing and slide the spring (small end first) down over the center bolt.

6.10 - MAINTENANCE (1000 HOURS)

HYDRAULIC OIL FILTERS (continued)

Main Return Filters (continued)

11. Place the element and indicator assembly into the housing and bolt the assembly, making sure the center bolt passes through the indicator centering hole.
12. Inspect the O-ring in the filter head and replace if damaged.



Over torquing the bolt will cause damage to the housing and/or O-ring washer seal.

13. Install the housing assembly onto the filter head making sure the indicator ears appear in the window and tighten the center bolt to 10–20 ft/lbs (13.55–27.11 Nm) torque.
14. After tightening, start engine and check for leaks. Correct if necessary.

Case Drain Filter

When restriction indicates that element servicing is required, or the regular **1000 Hour** service interval is reached, proceed in the following manner for this filter:

NOTICE

Dirt in the hydraulic system will lead to premature component failure. A clean, contaminant free system is extremely important to the drill's proper function. Take extra care when working around or on the hydraulic system to ensure its complete cleanliness.

WARNING

Do not attempt to service the filters before making sure all the hydraulic pressure has been relieved from the system.

1. Wipe all external dirt and oil from filter housing and head area to minimize contamination from entering the system.
2. Place a container under the oil filters to prevent any oil spill from contaminating the ground.
3. Carefully remove the 4 bolts that secure the retaining ring to the filter head.
4. Remove element(s) from the filter housing.
5. Save the element connector(s) located between the element(s) and discard old elements in accordance with any local guidelines.

6.10 - MAINTENANCE (1000 HOURS)

HYDRAULIC OIL FILTERS (continued)

Case Drain Filter (continued)

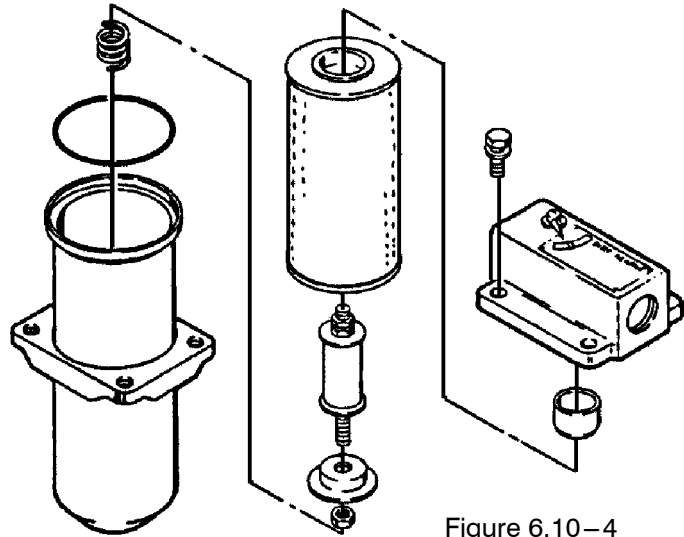


Figure 6.10-4

6. Clean the filter housing and filter head with an approved cleaning solvent.
7. Lubricate the grommets in the filter element(s) and install the compression spring and the spring plate into the bottom of the element before inserting element into the housing. On filters that use two elements or more, install the element connector between the elements.
8. Attach the housing to the filter head and tighten the 4 bolts evenly and in sequence. Care must be taken not to damage the O-ring.
9. Pressurize the hydraulic system and check for leaks.

ROTARY HEAD

Change the rotary head oil as part of the **1000** operating **Hour Routine Maintenance** Schedule.

Rotary Head Oil



Figure 6.10-5

1. Position the drill on a stable, level surface and raise the tower.

6.10 - MAINTENANCE (1000 HOURS)

ROTARY HEAD (continued)

Rotary Head Oil (continued)

2. If necessary, remove the drill rod and lower the rotary head to the bottom of the tower.
3. Shut off the engine.
4. Ensure oil is warm before draining oil.
5. Place a container with a capacity of at least 44 quart (42 liter) under the rotary head drain point.
6. Clean around the fill port area to prevent debris from entering during oil change.
7. Remove the fill plug and drain plug. Allow oil to drain into a container. Dispose of the used oil in accordance with local guidelines.

Note: Take care to prevent any contamination from entering the fill ports.

8. Clean drain plug and install. Using a 17mm wrench, torque to 60 ft/lbs (81 Nm).
9. Refill the rotary head gearbox, through the fill port, with SAE 90W Gear Oil to the full mark on the level gauge. The rotary head gearbox holds approximately 11 gallon (42 liter) of gear oil. (Refer to 6.3 *Lubricant Specifications* for oil details.
10. Install the fill plug.
11. After startup, check the rotary head for any leaks while at operating temperatures.
12. Raise rotary head to top of tower and reload the drill rod.

PUMP DRIVE GEARBOX

It is recommended that the pump drive gearbox oil be changed as part of the **1000 hour** routine maintenance schedule. Because the lubricant system is the heart of the unit, it is especially important that the oil be kept clean. **NOTE:** *The oil in the pump drive gearbox should be changed whenever the oil shows traces of dirt or the effects of high temperature, evidenced by discoloration or strong odor.*



Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

Change Oil

1. Move the drill to a stable, level surface and shut off the engine.
2. Place a container with a capacity of at least 4-1/2 quarts (4.02 liters) under the drain point.

6.10 - MAINTENANCE (1000 HOURS)

Change Oil (continued)

3. Clean around oil fill, dipstick and drain plug areas.
4. Remove the drain plug and the breather.

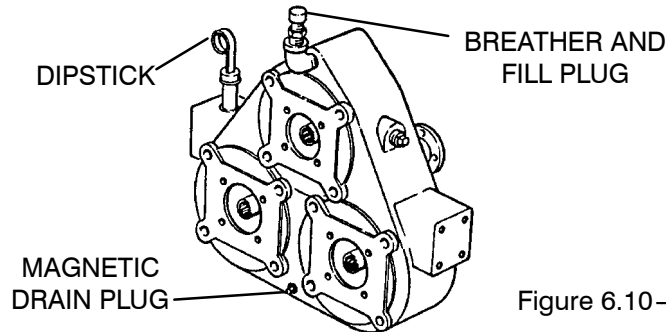


Figure 6.10–6

5. Drain oil while the pump drive is still warm.
6. Examine oil for any contamination or metal particles. Metal debris can reveal an impending pump drive gearbox failure. If debris is found, find the reason for the debris and perform the needed repairs. Allow the oil to drain from the drain into a container.
7. Clean magnetic drain plug before installing.
8. Refill the pump drive gearbox through the breather port with 4-1/2 quarts (4.02 liters) of 80W90 Gear Oil **or** until the pump drive gearbox oil level reaches the FULL level on the dipstick. **Do not overfill. This will result in over heating and possible malfunction of the gearbox.**
9. Clean the breather and install securely.
10. After startup, check the pump drive for any leaks at operating temperatures.

ROD CHANGER

The gear reducer oil should be changed after every **one thousand (1000) hours** of operation.



The oil is to be at operating temperature for draining. Be careful. Hot oil and components can burn.

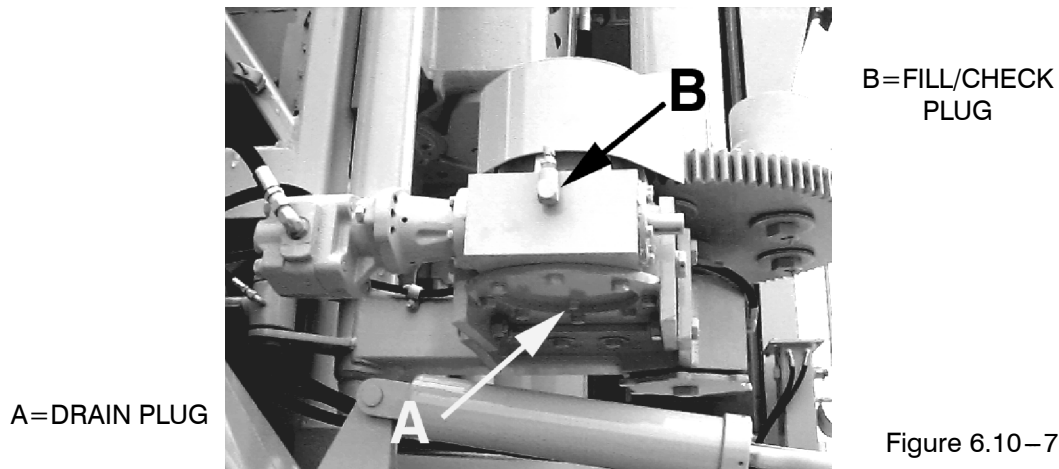
Gear Reducer Oil

1. Position the machine on stable, level surface.
2. Raise tower and swing the rod changer into drill rod change position.
3. Place container under drain point (A, Figure 6.10–7) to collect used oil.

6.10 - MAINTENANCE (1000 HOURS)

Gear Reducer Oil (continued)

4. Clean around fill/check plug (B, Figure 6.10-7) and remove it.
5. Clean around drain plug (A, Figure 6.10-7) and remove it.



6. Allow all oil to drain completely from the housing. Dispose of used oil in accordance with local guidelines.
7. Clean and replace the drain plug (A, Figure 6.10-7).
8. Refill the gearbox through fill port (B, Figure 6.10-7) until the oil is level with bottom of the fill/level port. Refer to Section 6.3 *Fuel and Lubricant* Instructions for oil details.
9. Clean and install the fill/level plug (B, Figure 6.10-7).
10. Swing the rod changer into the stowed position.
11. Operate the drill and check for any leaks.

6.10 - MAINTENANCE (1000 HOURS)

AUXILIARY HOIST

Oil Change

The gear oil should be changed every **1,000 operating hours or six (6) months**, whichever occurs first. The gear oil must be changed to remove wear particles that impede the reliable and safe operation of the brake clutch and erode bearings, gears and seals. Failure to change gear oil at these suggested minimum intervals may contribute to intermittent brake slippage which could result in property damage, severe personal injury or death.

The gear oil should also be changed whenever the ambient temperature changes significantly and an oil from a different temperature range would be more appropriate. Oil viscosity with regard to ambient temperature is critical to reliable brake operation. Make certain that the gear oil viscosity used in your winch is correct for your prevailing ambient temperature. Failure to use the proper type and viscosity of planetary gear oil may contribute to brake slippage which could result in property damage, severe personal injury or death.

Required lubricant: For temperatures between –30 to 80°F use Mobil SHC629 or Texaco Pinnacle 150. For temperatures between –10 to 80°F use Texaco Meropa 150 or equivalent AGMA # 4EP. For temperatures between 50 to 130°F use Texaco Meropa 220 or equivalent AGMA # 5EP.

Capacity: 2 pints (.94 L)

WARNING

Hot oil or components can burn. Avoid contact with hot oil or components.

Do not allow used oil to drain into the ground. Dispose of properly.

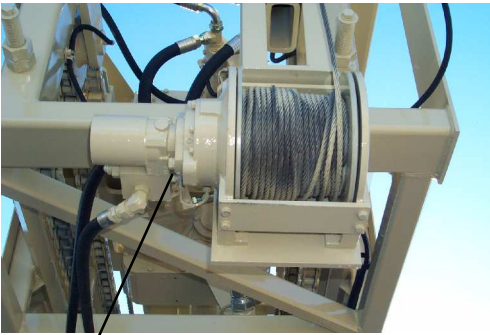
WARNING

Do not climb a raised tower. Climbing a raised tower can cause severe injury or death. Lower the tower to the horizontal position to service the winch.

6.10 - MAINTENANCE (1000 HOURS)

Oil Change (continued)

The gear oil should be changed after the first one hundred (100) hours of operation, then at every **1000 operating hours**



DRAIN PLUG

Figure 6.10–8



OIL LEVEL PLUG

1. Move the drill to a stable, level surface and shut off the engine.
2. Lower the tower to the horizontal position.
3. Place a container with a capacity of at least 2 pints (.94 liters) under drain point to collect the used oil.
4. Remove the oil level plug to allow the oil to drain smoothly (See Figure 6.10–8).
5. To drain the gear oil, remove small the drain plug.

WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of properly.

6. Drain the oil into a suitable container.
7. Clean and install the drain plug securely.
8. Remove the container and dispose of the used oil in accordance with local guidelines.
9. Refill housing with gear oil. Planetary winches are factory filled with Texaco Meropa 150 gear oil or equivalent industrial grade lubricant meeting AGMA 4EP or API GL-2 with ISO viscosity grade 150, for temperatures between -10°F(-25°C) to 80°F(26°C).

For temperatures between 50°F(10°C) and 130°F(55°C), use Texaco Meropa 220 or an equivalent AGMA 5EP. Planetary capacity is 2 U.S. pints (.94 liters). Refer to section 6.3 *Lubricant Specifications* for further recommended oil specifications.

10. Clean and install level plug.
11. Whenever the gear oil is changed, remove the vent plug (located in the drum support), clean in solvent and reinstall. *Do not paint over the vent or replace with a solid plug.*
12. Raise the tower, operate the auxiliary hoist and check for any leaks.

6.10 - MAINTENANCE (1000 HOURS)

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6.11 - MAINTENANCE (2000 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and to allow sufficient time before putting the drill in motion.

6.11 - MAINTENANCE (2000 HOURS)

Primary and Safety Elements

The primary and safety element must be replaced as part of the **2000 hour** routine maintenance schedule.

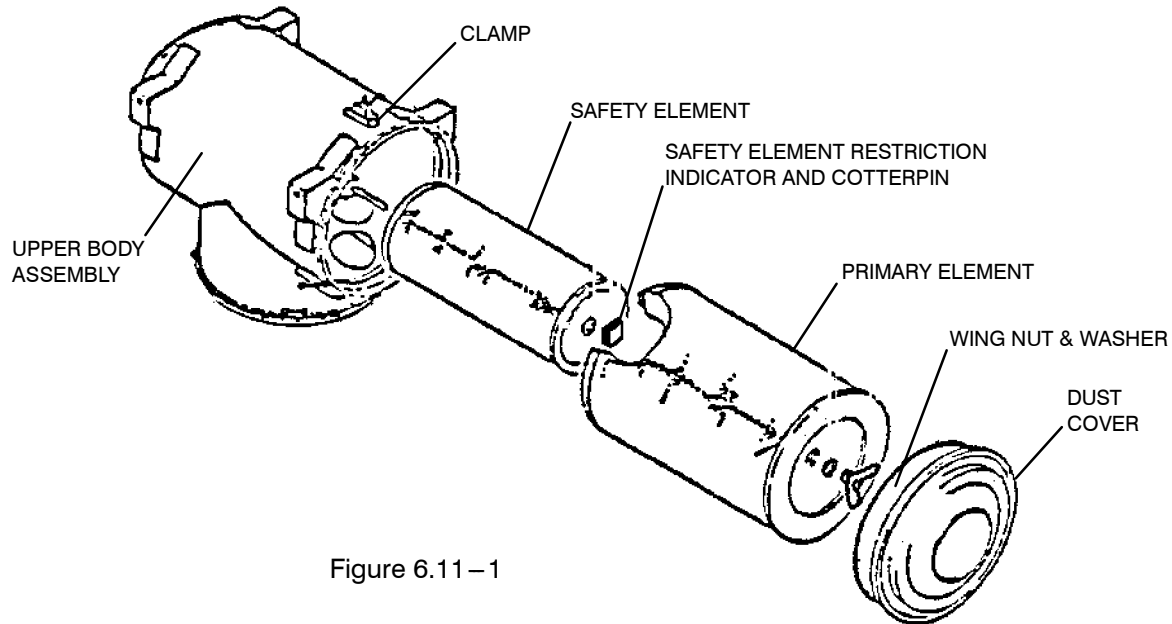


Figure 6.11 – 1

1. Unclip the three clamps holding the dust cover.
2. Remove dust cover.
3. Remove wing nut and washer. Carefully withdraw the primary air cleaner element.
4. To replace the safety element, remove the cotterpin and restriction indicator. Carefully remove the safety element. Dispose of the used element properly.
5. Clean the inside of the cover and the housing with a clean, damp cloth.
6. Install new safety element and secure it with the restriction indicator and cotterpin.
7. Examine the new primary element for torn or damaged pleats, bent end covers, liners and gaskets.
8. Ensure the primary element wing nut and washer are not cracked or damaged. Replace if necessary.
9. Carefully install the new primary element and secure it with the wing nut and washer.
10. Install the dust cover.
11. Inspect all air intake piping and joints between the air cleaners and the engine air and the compressor air inlets to ensure that no dusty air can enter.
12. Ensure all clamps are tight.

6.11 - MAINTENANCE (2000 HOURS)

TRACKS



Hot oil or components can burn. Oil must be at normal operating temperature when draining. Avoid contact with hot oil or components.

Change Track Planetary Oil

The gear oil should be changed after the first two hundred fifty (250) hours of operation, then at every **2000 operating hours**. This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule in order to help provide maximum planetary gearbox life.

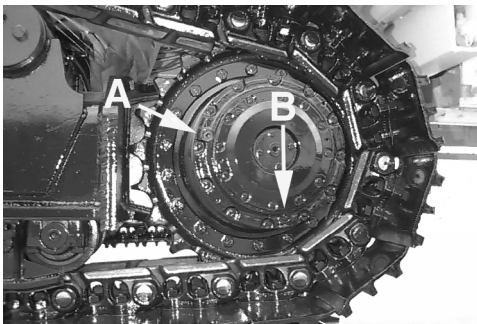


Figure 6.11 –2

1. Move the drill to a level surface and shut off the engine.
2. Be sure oil is warm before draining oil.
3. Place container with a capacity of at least 25 quart (24 liter) under the track drive drain point (B) as shown in Figure 6.11-2.
4. Remove the drain plug (B) and the fill/level plug (A). Allow oil to drain from the drain port into the container. Do not allow used oil to drain into the ground. Dispose of the used oil properly.
5. Clean drain plug and install.
6. **DM45/DM50 Drills** – Refill the planetary through the oil filler plug hole (A) with about 7.4 quarts (7 liters) of ISO VG220 oil until planetary is full and oil overflows. Allow the surplus oil to drain out until the oil level is up to the bottom of the fill port (A).

DML Drills – Refill the planetary through the oil filler plug hole (A) with about 8.4 quarts (8 liters) of ISO VG220 oil until the planetary is full and oil overflows. Allow the surplus oil to drain out until the oil level is up to the bottom of the fill port (A).

Refer to 6.3 *Lubricant Specifications* for the recommended required oil specifications.

7. Clean fill plug and install.
8. After start-up, check the planetary track drive for leaks at operating temperatures.
9. Repeat same procedure for the other track drive.

6.11 - MAINTENANCE (2000 HOURS)

ENGINE VALVES

Refer to actual manufacturer's manual for maintenance instructions concerning valve clearance, adjusters and injectors. This operation requires a trained service engineer.

ENGINE BELTS AND TENSIONER

Refer to 6.5 Engine Belts and Tensioner in *Maintenance (8-10 Hours or Daily)*. Also refer to actual manufacturer's manual for maintenance instructions.

6.12 - MAINTENANCE (5000 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and to allow sufficient time before putting the drill in motion.

6.12 - MAINTENANCE (5000 HOURS)

HYDRAULIC RESERVOIR

NOTICE

Dirt in the hydraulic system will lead to premature component failure. A clean, contaminant free system is extremely important to the machine's proper function. Take extra care when working around or on the hydraulic system to ensure its complete cleanliness.

Change Hydraulic Oil

Change the hydraulic tank oil (and filters) after any major hydraulic system repair and during the normal **5000 hour** routine maintenance.

⚠ WARNING

Oil must be at normal operating temperature when draining. Hot oil or components can burn. Avoid contact with hot oil or components.

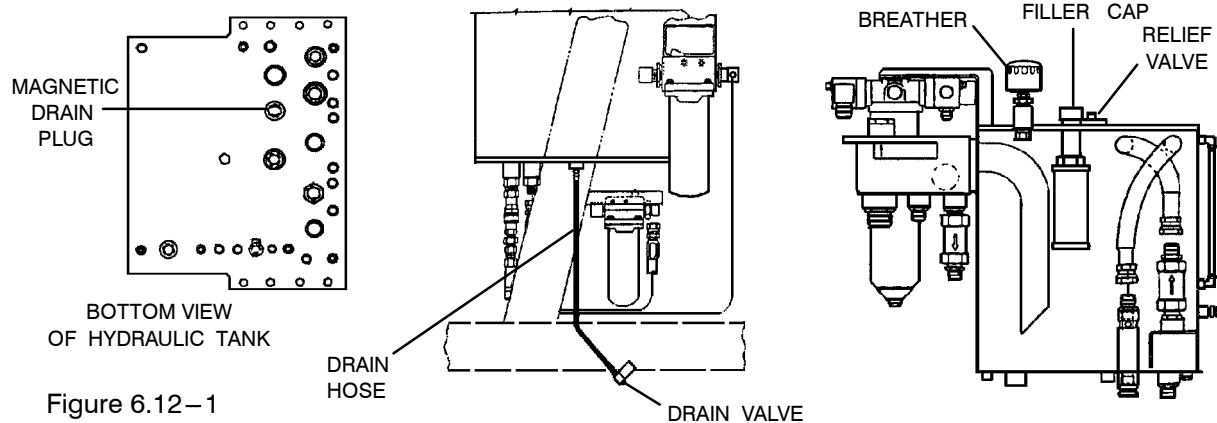


Figure 6.12-1

1. Position drill on stable, level surface and **retract** all hydraulic cylinders.
2. Ensure that a container with a capacity of at least 100 gallon (400 liter) is placed under the drain point to collect used oil. **Do not allow used oil to drain into the ground.**
3. Removing drain plug and attach a length of hose to facilitate draining the oil into containers (See Figure 6.12-1).

6.12 - MAINTENANCE (5000 HOURS)

HYDRAULIC RESERVOIR (continued)

Change Hydraulic Oil (continued)

4. Open the drain valve.
5. Allow the oil to drain and close the drain valve.
6. Remove the drain hose.
7. Clean and install the drain plug.
8. Dispose of the used oil in accordance with local guidelines.

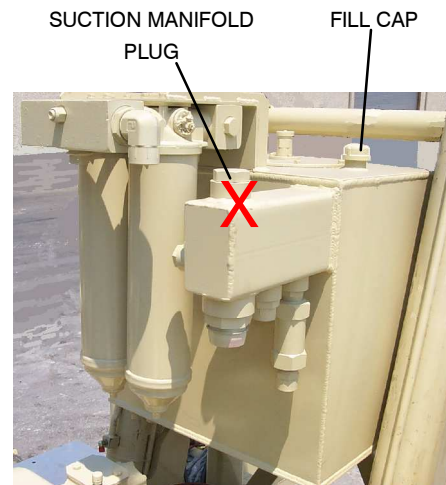
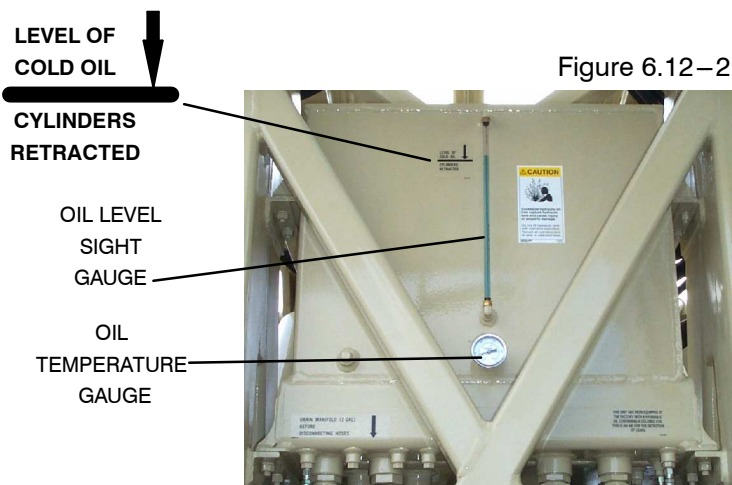
WARNING

Excessive hydraulic oil can rupture the sealed hydraulic tank and cause injury or property damage. Do not fill hydraulic tank with hydraulic cylinders extended. Retract all cylinders and fill tank to indicated level.

9. Clean the oil filler area and remove the filler cap. Refill the tank with clean, filtered hydraulic oil, from unopened containers, to the full level. **Do not add oil through the suction manifold plug.** Refer to 6.3 *Lubricant Specifications* for oil details.

Note:

Any contamination entering the hydraulic tank during filling will seriously risk damage to the pumps and motors. The system uses filtration only on the return oil and therefore oil in the tank must be free of contamination.



10. Check the reservoir oil level by viewing the sight gauge (See Figure 6.12-2).

6.12 - MAINTENANCE (5000 HOURS)

HYDRAULIC RESERVOIR (continued)

Change Hydraulic Oil (continued)

11. The oil level in the hydraulic tank depends on the extended or retracted positions of the hydraulic cylinders. It is important to observe and note the following information when reading the level gauge:
 - a. The oil level *with all hydraulic cylinders retracted* (tower down and leveling jacks up) should be even with the mark on hydraulic reservoir next to sight gauge (See Figure 6.12-2).
 - b. The top of the oil level **MUST** be visible when the engine is running **AND** also when the engine is stopped. There must be oil showing on the gauge at all times. Add oil to bring to levels defined above.

Note:

*If no oil is showing on the gauge, stop engine immediately and **call for service assistance** to investigate the cause of oil loss.*

12. During operation, monitor the hydraulic oil temperature gauge (See Figure 6.12-2).
13. Replace all hydraulic oil filters every time the hydraulic oil is changed. Refer to *Main Return Filters and Case Drain Filter*.

6.13 - MAINTENANCE (6000 HOURS)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and to allow sufficient time before putting the drill in motion.

6.13 - MAINTENANCE (6000 HOURS)

ENGINE COOLANT

The coolant system of any engine should be drained and flushed out after **6000 hours, or 2 years of service**. Unless the coolant has a corrosion preventive in it, rust and scale will eventually clog up the system. Any effective, commercial flushing agent should be used at least once or twice a year to ensure against buildup.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

1. The engine overheats frequently
2. Foaming is observed
3. The oil has entered the cooling system and the coolant is contaminated
4. The fuel has entered the cooling system and the coolant is contaminated.

NOTICE

Use of commercially available cooling system cleaners may cause damage to cooling system components. Therefore:

Caterpillar Engines - Use only cooling system cleaners that are approved for Caterpillar engines. Contact your nearest CAT dealer or refer to your CAT Operation and Maintenance Manual for specifics.

Cummins Engines - Use only cooling system cleaners that are approved for Cummins engines. Contact your nearest Cummins dealer or refer to your Cummins Operation and Maintenance Manual for specifics.

NOTE:

Inspect the water pump and the water temperature regulator after the cooling system has been drained. This is a good opportunity to replace the water pump, the water temperature regulator and the hoses, if necessary.

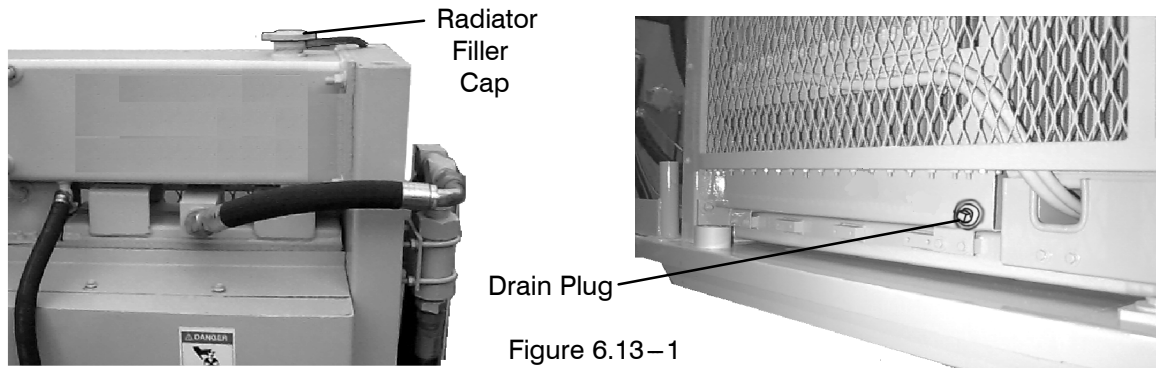
WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

Injury can occur when removing the radiator cap. Steam or fluid escaping from the radiator can burn. Inhibitor contains alkali. Avoid contact with skin and eyes. Avoid all contact with steam or escaping fluid.

6.13 - MAINTENANCE (6000 HOURS)

Drain Cooling System



1. Stop the engine and allow the engine to cool.
2. Place a container under the drain points to collect used coolant.
3. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
4. Remove the drain plug located at base of the radiator. At the same time, drain the engine block. Allow coolant to drain. (Refer to engine manufacturers manual for recommended procedure.)

NOTICE

*Engine coolant **must** be disposed of in a responsible manner. Please consult the local environmental agency for recommended disposal guidelines.*

Flush Cooling System

1. Flush the cooling system with clean water in order to remove any debris.
2. Close the drain valve (if equipped). Clean and install the drain plugs. Refer to 6.14 “Torque Specifications” for proper torque information.

NOTICE

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

6.13 - MAINTENANCE (6000 HOURS)

Flush Cooling System (continued)

3. Fill the cooling system with a mixture of clean water and cooling system cleaner.
Caterpillar Engines - Use a mixture of clean water and Cat Fast Acting Cooling System Cleaner. Add 1 pint (0.5 L) of cleaner per 4 US gallon (15 L) of the cooling system capacity.
Cummins Engines - Use a mixture of 1 US gallon (3.8 liters) of Fleetguard RESTORE, RESTORE PLUS (or equivalent) for each 10 to 15 gallons (38–57 liters) of cooling system capacity and fill the system with water.
4. Turn on the heater temperature switch to high to allow maximum coolant flow through the heater core. The blower does **not** have to be on.
5. Operate engine at low idle and normal operating temperatures of at least 185°F (85°C) for 1 to 1-1/2 hours.
6. Shut the engine off and drain the cooling system.
7. Fill the cooling system with clean water to flush the cooling system.
8. Operate engine at high idle for 5 minutes with coolant temperature above 185°F (85°C).
9. Shut off the engine and drain the cooling system.

Note:

*If the water being drained is still dirty, the system **must** be flushed again until the water is clean.*

10. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Remove the drain plugs located at the base of the radiator and the engine block. Allow the coolant to drain. Flush the cooling system with clean water. Close the drain valve (if equipped). Clean and install the drain plugs.

Fill the Cooling System

1. Refill radiator with a 50–50 mixture of the engine manufacturer's recommended antifreeze and good quality water. Install correct (SCA) Filter. Do **not** use any lubricant or corrosion inhibitor.

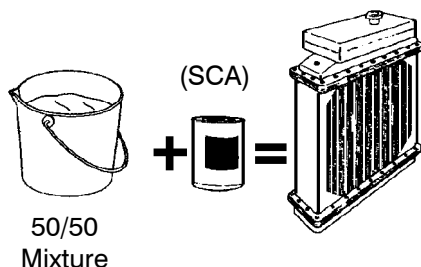


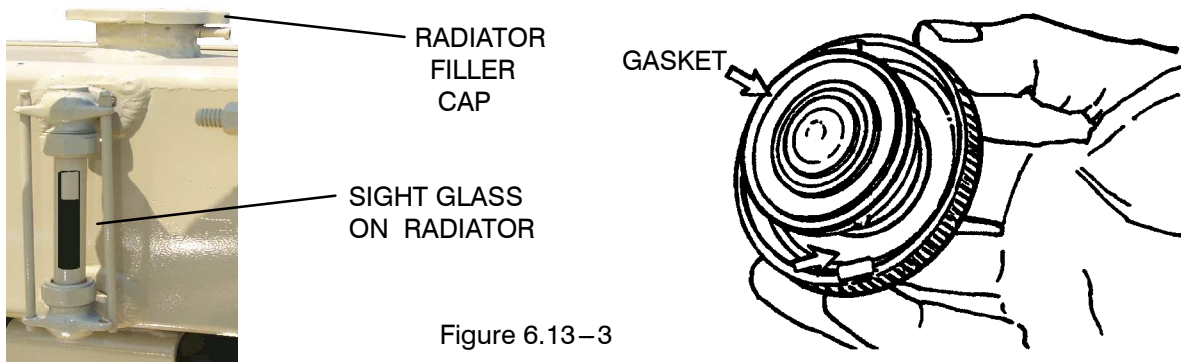
Figure 6.13–2

Fill the cooling system no faster than 19 L (5 US gallon) per minute to avoid air locks.

6.13 - MAINTENANCE (6000 HOURS)

Fill the Cooling System (continued)

2. When refilling cooling system, refer to engine manufacturer's Operation and Maintenance Instruction manual where full information is given on how obtain and to check the correct SCA level in the engine and on cooling system specifications. Do not install the cooling system filler cap.
3. Start and run the engine at low idle. Increase the engine rpm to 1500 rpm. Run the engine at high idle for one minute in order to purge the air from the cavities of the engine block. Stop the engine.
4. Check engine coolant level on the radiator. (See Figure 6.13-3). The coolant level should be maintained so fluid can be seen in the sight glass. If the coolant level is low, add more coolant through the filler cap.
5. Clean the cooling system filler cap. Check the condition of the filler cap gaskets. Replace the cooling system filler cap if the filler cap gaskets are damaged. Reinstall the cooling system filler cap.



6. Start engine. Inspect the cooling system for leaks and for proper operating temperature.

6.13 - MAINTENANCE (6000 HOURS)

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6.14 - TORQUE SPECIFICATIONS

STANDARD TORQUE VALUES



Use only the proper tools (inch or metric) on hardware. Other tools may not fit properly. They may slip and cause injury.

Head Markings

Fasteners should be replaced with the same or higher grade. If higher grade fasteners are used, these should only be tightened to the strength of the original.

GRADE 5 CAP SCREW HEAD MARKING

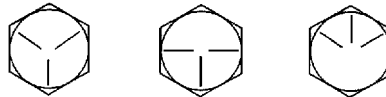
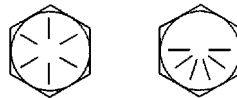


Figure 6.14–1



GRADE 8 CAP SCREW HEAD MARKING

Do not use these values if a different torque value or tightening procedure is listed for a specific application. Torque values listed are for general use only. All values are suggested maximum with dry plated hardware.

Make sure fastener threads are clean and you properly start thread engagement. This will prevent them from falling when tightening.

The following pages list the recommended tightening torques for the various size bolts used by Drilling Solutions. Proper Torque specifications should be used at all times.

The head of grade five (5) is marked with three (3) short lines. The head of grade eight (8) is marked with five (5) short lines.

In the following tables DRY means "clean dry" threads and LUBE means a "light film" of oil. Excess oil in a threaded dead end hole can create a hydraulic lock giving a false torque reading.

6.14 - TORQUE SPECIFICATIONS

Recommended Torques in Ft/Lbs.

This page lists the recommended tightening torques, in foot pounds (ft/lbs), for the various size bolts and nuts that are used. Proper torque specifications should be used at all times. The head of a grade five (5) bolt is marked with three (3) short lines. The head of a grade eight (8) bolt is marked with five (5) short lines. DRY means “clean dry threads” and LUBE means a “light film” of oil. Excess oil in a threaded dead end hole can create a hydraulic lock giving false torque readings.

SIZE	SAE GRADE 5 TIGHTENING TORQUE		SAE GRADE 8 TIGHTENING TORQUE	
	DRY	LUBE	DRY	LUBE
5/16 – 18 NC	16 – 17	12 – 13	23 – 25	17 – 18
5/16 – 24 NF	18 – 19	13 – 14	23 – 25	19 – 20
3/8 – 16 NC	28 – 30	21 – 23	42 – 45	33 – 35
3/8 – 24 NF	33 – 35	23 – 25	47 – 50	33 – 35
7/16 – 14 NC	47 – 50	33 – 35	65 – 70	51 – 55
7/16 – 20 NF	51 – 55	37 – 40	74 – 80	56 – 60
1/2 – 13 NC	70 – 75	51 – 55	102 – 110	74 – 80
1/2 – 20 NF	84 – 90	61 – 65	112 – 120	84 – 90
9/16 – 12 NC	102 – 110	74 – 80	140 – 150	102 – 110
9/16 – 18 NF	112 – 120	84 – 90	158 – 170	121 – 130
5/8 – 11 NC	140 – 150	102 – 110	205 – 220	158 – 170
5/8 – 18NF	158 – 170	121 – 130	223 – 240	167 – 180
3/4 – 10 NC	242 – 260	186 – 200	353 – 380	260 – 280
3/4 – 16 NF	279 – 300	205 – 220	391 – 420	298 – 320
7/8 – 9 NC	400 – 430	298 – 320	558 – 600	428 – 460
7/8 – 14 NF	437 – 470	326 – 350	614 – 660	465 – 500
1 – 8 NC	595 – 640	446 – 480	837 – 900	632 – 680
1 – 12 NF	651 – 700	493 – 530	930 – 1000	688 – 740
1 1/8 – 7 NC	744 – 800	558 – 600	1190 – 1280	893 – 960
1 1/8 – 12 NF	818 – 880	614 – 660	1339 – 1440	1004 – 1080
1 1/4 – 7 NC	1042 – 1120	781 – 840	1693 – 1820	1655 – 1360
1 1/4 – 12 NF	1153 – 1240	856 – 920	1860 – 2000	1395 – 1500
1 3/8 – 6 NC	1358 – 1460	1023 – 1100	2213 – 2380	1655 – 1780
1 3/8 – 12 NF	1562 – 1680	1172 – 1260	2530 – 2720	1897 – 2040
1 1/2 – 6 NC	1804 – 1940	1358 – 1460	2939 – 3160	2195 – 2360

6.14 - TORQUE SPECIFICATIONS

Recommended Torques in N-m

This page lists the recommended tightening torques, in N-m, for the various size bolts and nuts that are used. Proper torque specifications should be used at all times. The head of a grade five (5) bolt is marked with three (3) short lines. The head of a grade eight (8) bolt is marked with five (5) short lines. DRY means “clean dry threads” and LUBE means a “light film” of oil. Excess oil in a threaded dead end hole can create a hydraulic lock giving false torque readings.

SIZE	SAE GRADE 5 TIGHTENING TORQUE		SAE GRADE 8 TIGHTENING TORQUE	
	DRY	LUBE	DRY	LUBE
5/16 – 18 NC	22 – 27	16 – 17	31 – 33	23 – 24
5/16 – 24 NF	24 – 26	17 – 19	31 – 33	26 – 27
3/8 – 16 NC	37 – 40	28 – 31	56 – 60	44 – 47
3/8 – 24 NF	44 – 47	31 – 33	63 – 67	44 – 47
7/16 – 14 NC	63 – 67	44 – 47	87 – 93	68 – 73
7/16 – 20 NF	68 – 73	49 – 53	97 – 107	75 – 80
1/2 – 13 NC	93 – 100	68 – 73	136 – 147	99 – 107
1/2 – 20 NF	112 – 120	81 – 87	149 – 160	112 – 120
9/16 – 12 NC	136 – 147	99 – 107	187 – 200	136 – 147
9/16 – 18 NF	149 – 160	112 – 120	211 – 227	161 – 173
5/8 – 11 NC	187 – 200	136 – 147	273 – 293	281 – 227
5/8 – 18NF	211 – 227	161 – 173	297 – 320	223 – 240
3/4 – 10 NC	323 – 347	248 – 267	471 – 507	347 – 373
3/4 – 16 NF	372 – 400	273 – 293	521 – 560	397 – 427
7/8 – 9 NC	533 – 573	397 – 427	744 – 800	571 – 613
7/8 – 14 NF	583 – 627	435 – 467	819 – 880	620 – 667
1 – 8 NC	793 – 853	595 – 640	1116 – 1200	843 – 907
1 – 12 NF	868 – 933	657 – 707	1240 – 1333	917 – 987
1 1/8 – 7 NC	992 – 1067	744 – 800	1587 – 1707	1191 – 1280
1 1/8 – 12 NF	1090 – 1173	819 – 880	1785 – 1920	1339 – 1440
1 1/4 – 7 NC	1389 – 1493	1041 – 1120	2257 – 2427	1687 – 1813
1 1/4 – 12 NF	1537 – 1653	1141 – 1227	2480 – 2667	1860 – 2000
1 3/8 – 6 NC	1811 – 1947	1364 – 1467	2951 – 3173	2207 – 2373
1 3/8 – 12 NF	2083 – 2240	1563 – 1680	3373 – 3627	2529 – 2720
1 1/2 – 6 NC	2405 – 2587	1811 – 1947	3917 – 4213	2927 – 3147

6.14 - TORQUE SPECIFICATIONS

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SECTION 7

TROUBLESHOOTING

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7.1 - TROUBLESHOOTING (GENERAL)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control lever.
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If your drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel control levers and drill feed are at **stop** position and that the track brakes are applied.
11. Always sound horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

7.1 – TROUBLESHOOTING (GENERAL)

GENERAL



When carrying out trouble shooting procedures, it is important to strictly observe the safety precautions and guidelines in Section 1 of this manual.

Improper operation and maintenance is the most frequent cause of drill failures and problems. In the event of a failure, it is recommended that you read through this manual. Problems will be related to defects occurring in the following areas:

Electrical Controls

These are problems related to the electrical systems which control the engine, hydraulically operated controls, and the compressor controls. Refer to 7.2 *Electrical System DM45* for further information on the electrical systems used on this drill.

A bank of seven (7) circuit breakers protect the machines electrical circuits. In the event of overload of a circuit, it is necessary to press in the tripped circuit breaker.



Figure 7.1 – 1

NOTE:

If there is a recurrence, call for service assistance to correct the cause of the overload in the circuit.

The following is the identification of the circuit breakers on the console:

1. 5 amp = Engine Shutdown
2. 15 amp = Windscreen Wipers
3. 20 amp = Power Distribution Control
4. 15 amp = Compressed Air System
5. 15 amp = Power Distribution Engine
6. 15 amp = Drill Lights
7. 20 amp = Tram Lights

7.1 – TROUBLESHOOTING (GENERAL)

GENERAL (continued)

Mechanical Hydraulic Components

Trouble shooting and repairs of defects in the mechanical functioning of the hydraulic systems requires specialist knowledge. All mechanical problems should be referred to your local service support for assistance and are not considered part of operator maintenance covered in this manual. If you are unable to determine the cause of the problem, contact your local Drilling Solutions service office.

Mechanical Engine

Trouble shooting and repairs of defects in the mechanical functioning of the engine systems requires specialist knowledge and test equipment. All engine problems should be referred to your local service support for assistance and are not considered part of operator maintenance covered in this manual.

If you are unable to determine the cause of the problem or are unable to find a solution when following the trouble shooting chart, contact your local Drilling Solutions service office.

Operator Observed Problems

During operations, the operator may observe some problems which may be defined in 7.3 *Operator Observed Problems Trouble Shooting Chart*.

The trouble shooting chart is limited to machine control operational problems which will guide the operator to rectify the cause of the failure.

Air Compressor

Trouble shooting and repairs of defects in the mechanical functioning of the compressor systems requires specialist knowledge. All compressor related problems should be referred to your local service support for assistance and are not considered part of operator maintenance covered in this manual. If you are unable to determine the cause of the problem, contact your local Drilling Solutions service office.

7.1 - TROUBLESHOOTING (GENERAL)

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7.2 - TROUBLESHOOTING (ELECTRICAL)

WARNING

Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

GENERAL INFORMATION

The following operational hints should be observed:

1. Do not speed the engine when it is cold
2. Always chock the tracks if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Do not control propel speed using the engine speed control (throttle).
6. Always operate the drill at full engine power when drilling or tramming the drill.
7. If drill is equipped with the remote control system option, always use it from a safe location when propelling on unstable surfaces where there may be a risk of overturning and when loading onto a transporter where there is a risk of overturning.
8. Never propel or stop the drill on a slope or surface that is liable to collapse.
9. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
10. Before starting engine, always check to see that the drill/propel mode selector is in the drill position and both propel controllers and drill feed controller are at **stop** position and that the track brakes are applied.
11. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRICAL SYSTEM INFORMATION

The following information is provided to give an understanding of the electrical system and the relation to the operator’s control console described in Section 4 *Operating Controls*. **Note:** There are wiring schematics shown at the end of this section which also relate to the information provided here.

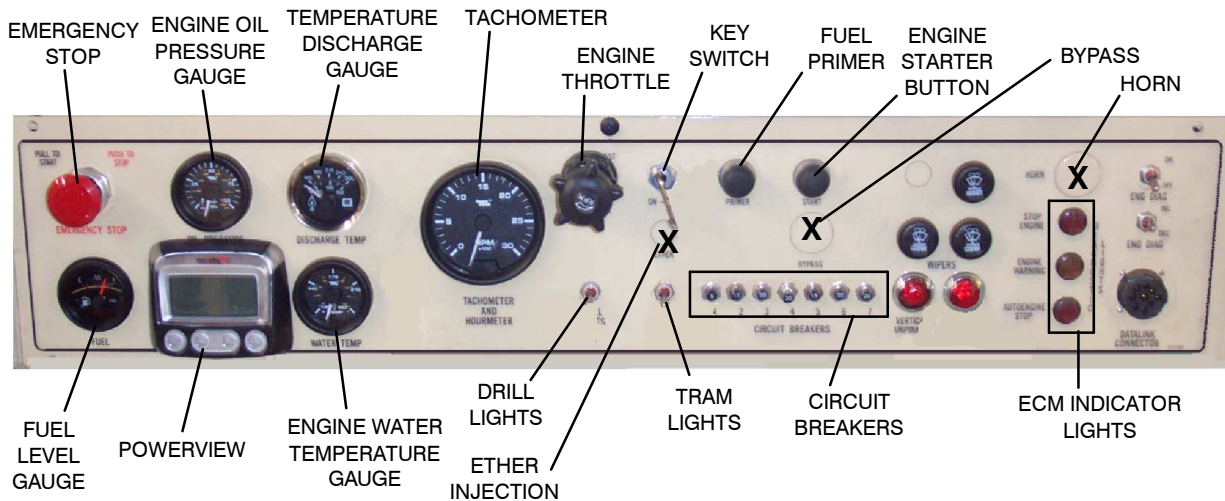


Engine Functions Panel for Engines with ECM Module

ECM INDICATOR
LIGHTS



Engine Functions Panel for Engines with MDDM Module



Engine Functions Panel for Engines with Powerview Module

Figure 7.2–1

7.2 - TROUBLESHOOTING (ELECTRICAL)

Cummins Engines

Drills equipped with Cummins engines have an electrical system with computer controls for all engine functions. The engine protection system will be explained in detail to give the operator an understanding of the system and to emphasize the need to call for specialist assistance in the event the engine system warning lights signal problems during operation.

Note that on a Cummins QSK19C/755HP engine, there are two starter motors used. Each starter motor uses two 12 volt batteries, connected in series, that provide 24 volt direct current (DC) to the system. The batteries use a machine ground to complete the circuit. The battery and starter ground cables are size 2/0. They are protected by four sections of fusible link. One is attached to each starter and the other to the alternator. Current flows through the ammeter to the number 2, 6 & 7 wires. Number 7 wire is the hot or (+) wire for the engine controls. Number 2 wire is the hot or (+) wire for the drill lighting system. Number 6 wire supplies current to the engine ECM.

When the engine is started, battery current is supplied to the starter motor through the starter solenoid (S2) contacts on one starter motor and the starter solenoid (S3) contacts on the other starter motor when they are closed. To close the contacts, the key switch must be turned to the "ON" position and the starter button depressed. This activates the (S1) coil which, in turn, closes contact (S1). Coil (S2) and coil (S3) are then powered and, in turn, activate (S2) and (S3) contacts. This is what actually makes contact with the motor starter. **NOTE:** Relay S3 is built into the second starter.

Note: Reference the wiring schematics at the end of this section which relate to the information provided here.

CAT Engines

Drills equipped with Caterpillar engines have an electrical system with computer controls for all engine functions. The Engine Monitoring System will be explained to give the operator an understanding of the system and to emphasize the need to call for specialist assistance in the event engine system warning lights signal problems during operation.

Note that on a Cat 3412E/760HP engine, there are two starter motors used. Each starter motor uses two 12 volt batteries, connected in series, that provide 24 volt direct current (DC) to the system. The batteries use a machine ground to complete the circuit. The battery and starter ground cables are size 2/0. They are protected by four sections of fusible link. One is attached to each starter and the other to the alternator. Current flows through the ammeter to the number 2, 6 & 7 wires. Number 7 wire is the hot or (+) wire for the engine controls. Number 2 wire is the hot or (+) wire for the drill lighting system. Number 6 wire supplies current to the engine ECM.

When the engine is started, battery current is supplied to the starter motor through the starter solenoid (S2) contacts on one starter motor and the starter solenoid (S3) contacts on the other starter motor when they are closed. To close the contacts, the key switch must be turned to the "ON" position and the starter button depressed. This activates the (S1) coil which, in turn, closes contact (S1). Coil (S2) and coil (S3) are then powered and, in turn, activate (S2) and (S3) contacts. This is what actually makes contact with the motor starter. **NOTE:** Relay S3 is built into the second starter.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Starting Engines

Before the engine can start, the emergency stop button must be pulled out or disengaged. This allows current to flow through relay R1B and the emergency stop button to the fuel solenoid. This solenoid allows the flow of fuel into the engine. If power is cut off to the fuel solenoid, engine fuel flow will cease and the engine will stop. This is why it is called an “Energize To Run” system.

For the engine to start, the bypass button must also be depressed. Depressing the bypass button allows the oil pressure switches and the engine speed switch to be taken out of the system until the engine is started and has built up sufficient oil pressure. Once engine oil pressure has reached 10 psi at an idle speed of 1200 RPM, the bypass button can be released. The starter button should be released as soon as the engine starts. With the throttle control at low idle, the engine will continue to run at 1200 RPM.

NOTICE

Do not operate the starter motor for more than 30 seconds at a time. Let the starter motor cool for at least 2 minutes before attempting to start again. Overheating, caused by excessive cranking, will seriously damage the starter motor.

Ether Injection is recommended by all engine manufacturers during cold weather starts and in ambient temperatures below 50°F (10°C). To activate Ether Injection, simply push the Button marked “ETHER”. It must be pushed each time you wish to inject ether into the engine. You cannot over inject ether into the engine with the injection system supplied. It should be used, as needed, until the engine temperature has reached 70°F (21°C).

Another device helpful in starting is the Fuel Primer Pump. It pumps fuel from the fuel tank into the fuel filters or fills the fuel line with fuel after a fuel filter change. It is activated by pushing the “PRIMER” button on the console. This supplies current to the primer motor that operates the pump.

ELECTRICAL SYSTEM COMPONENTS

Batteries

Each starter motor uses two 8D type batteries rated at 12 volts each, connected in series, that provide 24 volt direct current (DC) to the system (see figure 7.2-2). They should be checked every 50 operating hours as part of routine maintenance. Refer to *6.6-Maintenance (50 Hours or Weekly)*.



Figure 7.2-2

Note that on CAT3412E/760HP and Cummins QSX15/600HP Tier 2 engines, four 8D type batteries rated at 12 volts each are used in order to handle the two starter motors.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Fusible Links

Fusible links are used on all Atlas Copco drills to prevent a short circuit from causing a fire or burning someone. They are connected between the starter and the batteries and the alternator and the batteries. They are located at the starter and the alternator to prevent any damage to adjacent components or other circuits.

A fusible link is a lead in an electrical wiring system designed to open the circuit when subjected to an extreme current overload. By opening the circuit in the presence of a current overload, no damage will occur to the wiring system protected by the fusible link.

Physically, the fusible link is a tinned, stranded conductor that is 9 inches (228.6 mm) long and insulated with a thermosetting material and enclosed in a blue cover. There should be no burning of the insulation in the first five seconds of current application and no secondary arcing after the conductor has separated.

A four gauge size differential is maintained between the fusible link and the smallest gauge size in the wiring it protects. A number 12 gauge wire link is used on Atlas Copco products. Because of this differential, the resistance per unit length will be larger in the fusible link and the heat dissipated along the link will be greater than in the other section of cable. The heat generated starts to melt the core at a location in the link. The copper core becomes fused and molten. Capillary action draws the copper away from the hot spot that causes the ream to neck. This action continues until the core is completely separated.

The links should never be removed unless they have burned out doing their job. Then they should be replaced immediately. They should **not** be replaced with the regular #1 or #2 wires since there will be no protection for the electrical system.

Bulk fusible link material is listed under CPN 56987795 and the individual 9 inch length is CPN 56999360. A spare set should be attached to every drill so it is available in case of a short circuit. If it is not replaced immediately, there is a tendency to forget it completely over a short period of time. Every mechanic should carry several pieces with them at all times.

The fusible links used on the drill are blue and are 9 inches (23cm) long. There is a ring connector on one end of each link. Fasten one fusible link end ring connector to the starter and fasten the other fusible link end ring connector to the alternator. The other end of each fusible link is connected to the main hot wire #1 by a wire nut. The main hot wire (#1) is a red, 8 gauge wire.

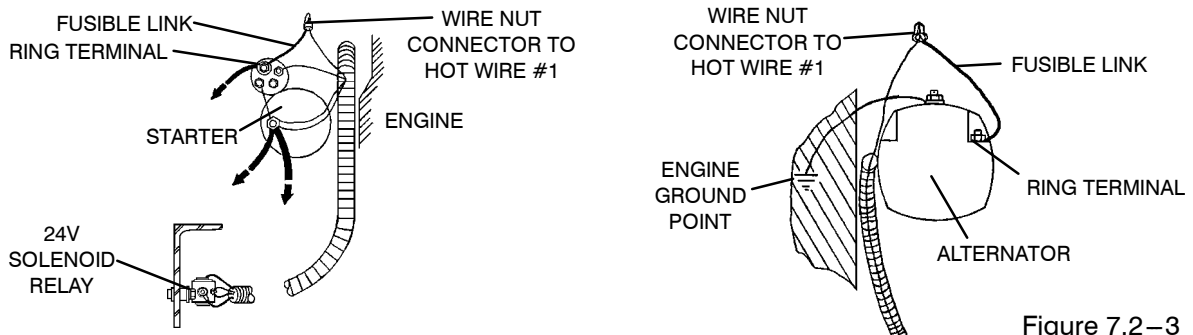


Figure 7.2-3

7.2 - TROUBLESHOOTING (ELECTRICAL)

Fusible Links (continued)

NOTICE

Fusible Links must be in place to operate the drill. If a short circuit destroys a fusible link, it **MUST** be replaced before the drill goes back in service.

Starter Motor

The starter motor contains the built in starter relay (Relay S2). The second starter motor used on the engine contains the built in starter relay (Relay S3).

Alternator

The alternator is a 24v, 100 amp model. It is used to charge the batteries and provide current to the electrical system and the night lights.

Key Switch

The key switch controls current to all functions but the night lights. The electrical system “ON-OFF” key switch turns on all electrical power to the engine and controls stopping and run operations. When it is turned on it supplies power through wire number 7 to the starter button, primer motor, tachometer and the compressor shutdown switch.

The electrical system “ON-OFF” key switch also activates the ECM (Electronic Control Module) that controls all aspects of the engine, including most shutdown devices. Refer to the electrical schematics for engine water temperature switch, fuel gauge and throttle switch.

Note: Always stop the engine and remove the key when leaving the drill unattended or while performing certain maintenance procedures.

Circuit Breakers

The bank of seven (7) circuit breakers, located on the control console, protect the drill's electrical circuits. The circuit breakers are mounted between the current producer, batteries or alternator and the devices they are protecting. In the event of an overload of a circuit, it is necessary to press in the tripped circuit breaker. **Note:** If there is a recurrence, call for service assistance to correct the cause of the overload in the circuit.

The following is the identification of the circuit breakers on the console:

- 1.) 5 amp= Engine Shutdown
- 2.) 15 amp = Windshield Wipers and Washers
- 3.) 20 amp = Power Distribution for OEM Controllers
- 4.) 20 amp = Air Conditioner/Pressurizer System
- 5.) 15 amp = Power Distribution for Engine
- 6.) 20 amp = Drill Working Lights
- 7.) 20 amp = Tram (Propel) Lights

7.2 - TROUBLESHOOTING (ELECTRICAL)

Push Buttons

The push buttons on the operator's console enable the operator to:

- a. Start the engine
- b. Pump fuel from the fuel tank to prime the engine fuel system (QSK).
- c. Sound an audible warning (horn)
- d. Inject ether into the engine intake (option)
- e. Bypass the oil pressure switches and engine speed switch (throttle) until the engine has started and built up sufficient oil pressure.

These push buttons are spring loaded to disconnect power when they are released.

Tachometer / Magnetic Pickup

The tachometer is driven by the magnetic pickup which receives its signal from the engine flywheel. The pickup is a solid state device that counts the teeth on the flywheel and sends a signal to the tachometer.

The wires between the pickup and tachometer are specially shielded wires to prevent interference from outside signals.

The elapsed time meter records the number of hours the engine has operated. It only works when the key is turned on.

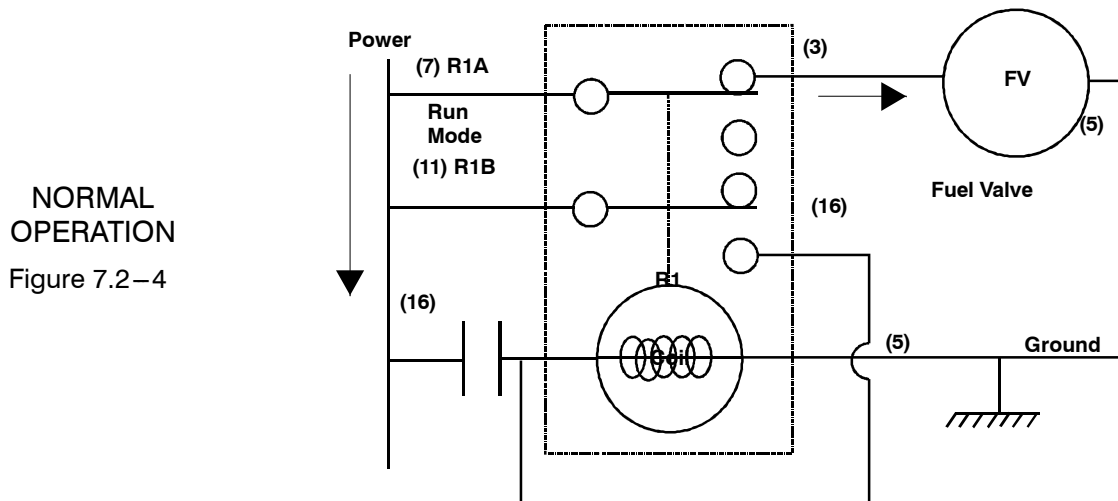
7.2 - TROUBLESHOOTING (ELECTRICAL)

Relays

A starter relay is connected between the starter button and the starter motor that energizes the starter solenoid switch. The starter relay actually engages the starter motor. There are two parts to any relay; a coil and at least one set of contacts (points). The coil physically changes the condition of the contacts from normally open to closed or vice versa. There can be several sets of contacts for one coil.

Relays are used in several circuits on the drills and the schematics do not always show how they interact with each other.

A relay consists of a coil connected to one or more sets of contacts. When the coil is energized, the solenoid pulls the other contacts downward. In some cases, this disconnects a circuit while in others it makes a new circuit. For example, the shutdown relay R1 has a coil marked R1. This coil is connected physically to R1A, a normally closed contact. R1B is a normally open contact, connected physically, that becomes energized when R1 is energized. Even though the schematic shows the elements in different places, they are actually made up of a single device.



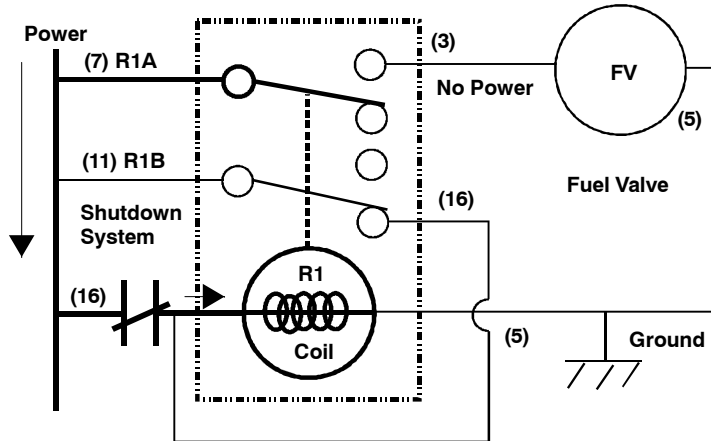
All shutdown devices are in the open mode during normal running conditions and are connected to the R1 Relay coil.

Should an abnormal condition occur in any of these circuits, the appropriate monitoring device will close and cause R1 relay coil to become energized.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Relays (continued)

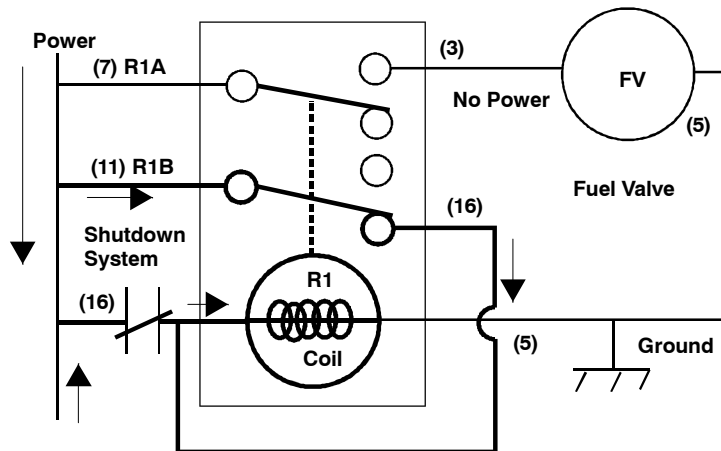
SHUTDOWN
OCCURS
Figure 7.2–5



When R1 coil is energized, it moves the R1A contacts from a normally closed position to an open position. This interrupts the flow to the fuel solenoid and shuts down the engine. It also cuts off current to the red light in the emergency stop button.

If the engine was at high idle (1800 RPM) when the shutdown occurred, the high pressure oil switch may shut the engine down.

R1B HOLDS
POWER OFF
Figure 7.2–6



If the oil pressure remained higher than 10 psi, but lower than 27 psi, the engine would try to restart at low idle. For this reason we added R1B. When current is interrupted to the fuel solenoid, it must remain off until the engine stops. To insure this happens, R1B supplies current to R1 coil continuously to keep it from cycling.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Diodes

Diodes are used in many areas of the electrical system. Their function is to allow current to flow in one direction but not in the other.

One of the locations a diode is used in is the fuel relay coil circuit. When the coil is energized, it builds up a charge internally as it operates the magnet within the coil. When the current is removed from the coil, a “residual” charge is left in the coil. This must have a path to dissipate. That path is provided by the diode. It allows current to flow through itself and discharge without causing any damage to the rest of the circuit. It is shown in Figure 7.2-7.

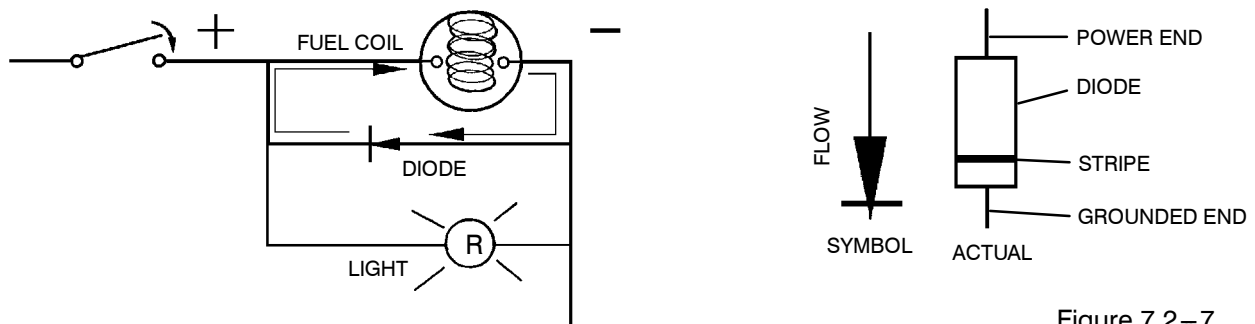


Figure 7.2-7

Other areas where diodes are used are in test circuits on larger drills. They provide a means of testing light bulbs without activating the shutdown devices. They can be recognized by the wire at each end and a stripe around one end as shown in Figure 7.2-7.

ENGINE SHUTDOWN DEVICES

The drill is equipped with several shutdown devices to prevent harm to the engine or compressor in case of loss of fluids or other related problems. It has a compressor discharge temperature switch, an engine coolant temperature switch and two engine oil pressure shutdown switches.

Compressor Discharge Temperature Switch

This Murphy Switchgauge has a gauge on the operator's console and a sensor located on the compressor discharge piping of the compressor. It monitors the temperature coming out of the compressor. When the temperature increases to 248°F (120°C), a contact inside the gauge makes electrical contact with relay R1. This cuts the power to the engine.

Engine Water Temperature Switch

This switchgauge is also mounted in the console and the coolant temperature sensor, located at the water manifold of most engines, monitors engine coolant temperature. Activation temperature for the high coolant temperature fault is 224°F (107°C).

7.2 - TROUBLESHOOTING (ELECTRICAL)

Engine Oil Pressure Switch

This switchgauge, mounted in the console, has two pressure limit switches that close when the pressure falls below 27 psi and 10 psi. It does not have a capillary tube but uses a hose connected to the engine to supply pressure to the switchgauge. Both gages are normally closed and rely on engine oil pressure to open them. They both work through the engine speed switch and close when oil pressure falls below 27 psi or 10 psi, depending on the engine speed.

Engine Speed Switch

This device is a heavy-duty speed switch set to trigger from one input signal when a pre-determined speed is reached. Engines that have a maximum RPM of 2100 are switched at 1750 RPM. This means that when the engine is at an idle speed of 1200 RPM, the speed switch is on the normally closed side and connects to the 10 psi switch. When the engine speeds up past 1750 RPM, the speed switch changes to the normally open side where the 27-psi switch takes over. As long as the pressure does not fall below either setting, depending on the speed, the system will not be activated. If the pressure does fall below the setting, current will flow through the switchgauge and the speed switch to energize R1 coil and shut the drill down.

The input signal supply source is a magnetic sensor that utilizes an electro-magnetic effect to produce an output signal of electric pulses. The frequency of the electric pulse is determined by the number of flywheel gear teeth passing in front of the sensor in a given time. The pulse frequency is representative of engine speed and therefore is used to cause the speed switch to change states at different speeds. The magnetic sensor is also used to operate the engine tachometer and elapsed time meter.

Emergency Engine Shutdown

The emergency engine shut down switch has a red light that comes on when the fuel system is energized. If the light goes out, it normally means that the engine fuel system is not operating. Pushing the emergency engine shut down switch shuts off power to the fuel valve which stops fuel flow and shuts the engine down. Turning the key switch does the same thing. All engines are “energized to run”, which means the fuel system must be energized in order to pump fuel.

ELECTRICAL CONTROLLED DEVICES

There are three Solenoid Control Valves offered as options.

One is a single solenoid valve that controls the carousel “NO BUMP”. The purpose of this device is to prevent the rotary head from pressing down on the carousel when the carousel is not in the fully closed position. It consists of a Normally Open (NO) Limit Switch mounted on the back of the Swing Cylinder of the carousel. As long as the carousel is in the fully stored position, the switch is closed and the solenoid is energized. This moves the two position, two-way valve to the closed position and no oil is allowed to escape to the remote relief valve from the pump compensator.

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRICAL CONTROLLED DEVICES (continued)

If the carousel is swung in slightly, the switch is de-energized and the spring opens the two-way valve. This vents the pump compensator down to the remote relief setting of 900 psi to prevent any damage to the carousel if the rotary head jams it downward.

The **second** solenoid valve in the “NO BUMP” circuit is the switch controlling the movement of the carousel while the rotary head is in motion. A limit switch is located about three feet down from the top of the tower on the right hand side. As long as the rotary head is in the uppermost location, the switch is energized and the two-way valve is closed.

This allows the carousel to be moved in or out as needed to load or unload drill pipe. If the rotary head is moved downward, the switch opens and allows the spring on the two-way valve to open and direct oil flow back to the return manifold, thus stopping the movement of the carousel inward. It can be closed at any time. When it is in the fully stowed position, the other limit switch is closed thus allowing full pressure on the down feed.

The **third** electric device is the ROD SUPPORT switch. It is a double solenoid operated, two position, four way valve. The limit switch that controls the valve is located on the back of the tower, about four feet down from the top on the same side as the “NO BUMP”. The solenoid operated valve is located under the drill cab.

When the rotary head is all the way to the top, the limit switch is in the closed position, thus energizing the solenoid on one side of the valve. This allows flow from the P1 section of the double pump to enter the cylinder connected to the pipe support and move it out to hold the next piece of the drill pipe.

As the rotary head moves down past the limit switch, the switch changes position and the other solenoid is energized. This action shifts the valve and directs flow to the other end of the cylinder, closing the pipe support and getting it out of the way of the rotary head.

CAT 3412E ELECTRONIC ENGINE

The Caterpillar 3412E Engine is designed with electronic controls. The integral onboard computer controls the operation of the engine. Current operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. For more information on electronic engine features, refer to the Caterpillar Operation and Maintenance Manual, “Engine Features and Controls” topic (Operation Section).

Engine Electronics



Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ELECTRONIC ENGINE (continued)

Engine Electronics (continued)

The engine has a monitoring system with the following modes: OFF, WARNING, DERATE and SHUTDOWN. Under the following operating conditions, the engine power and/or the engine speed may be limited.

- a.) Very low oil pressure
- b.) High coolant temperature
- c.) Very high coolant temperature
- d.) Very low coolant level

CAT 3412E MONITORING SYSTEM

WARNING

If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury. The engine can be restarted following shutdown for emergency maneuvers, if necessary.

NOTICE

The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and derate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

“Warning/Derate/Shutdown”

WARNING

If the Shutdown mode has been selected and the warning indicator activates, bring the engine to a stop whenever possible. Depending on the application, special precautions should be taken to avoid personal injury.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E MONITORING SYSTEM (continued)

“Warning/Derate/Shutdown” (continued)

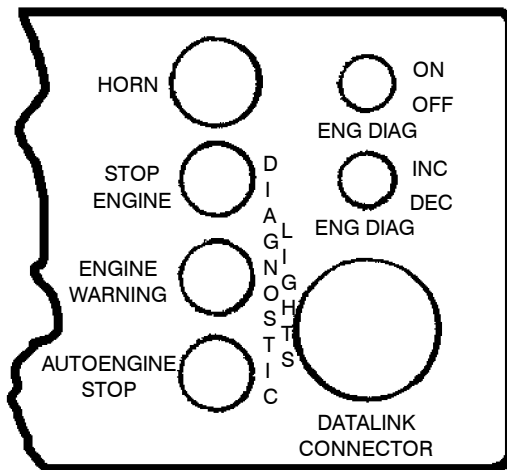


Figure 7.2–8



The “Diagnostic” lamp turns “ON” and the warning signal (red lamp) on the console (Figure 7.2–8) is activated. After the warning, the engine power will be derated. The engine will continue to derate rpm until a shutdown of the engine occurs. The engine can be restarted after a shutdown for use in an emergency.

A shutdown of the engine may occur in as little as 20 seconds. The engine can be restarted after a shutdown for use in an emergency. However, the cause of the initial shutdown may still exist. The engine may shut down again in as little as 20 seconds.

If there is a signal for coolant loss, there will be a 10 second delay in order to verify the condition. The system will derate the engine power for 40 seconds before the engine will shut down if the engine has been programmed to shut down.

If there is a signal for low oil pressure or for coolant temperature, there will be a two second delay in order to verify the condition. The system will derate the engine power for 30 seconds before the engine will shut down if the engine has been programmed to shutdown.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS

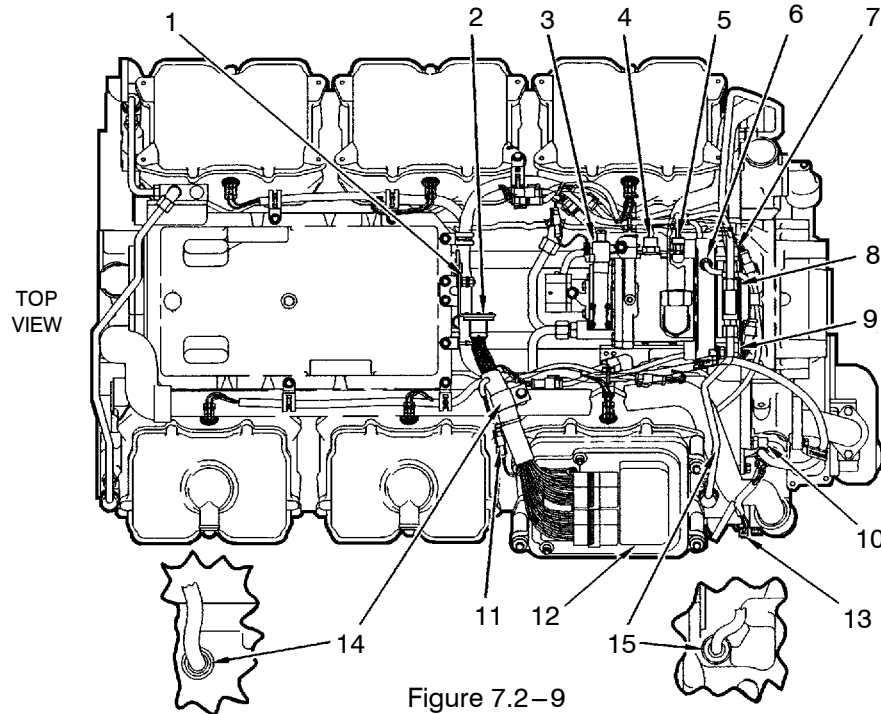


Figure 7.2–9

Sensor Locations

1. Cylinder head grounding stud
2. Forty (40) pin connector
3. Injection actuation pressure control valve
4. Oil temperature sensor
5. Oil pressure sensor
6. Atmospheric pressure sensor
7. Secondary speed/timing sensor
8. Fuel temperature sensor
9. Primary speed/timing sensor
10. Coolant temperature sensor
11. TC probe connector
12. Electronic Control Module
13. Coolant flow switch connector
14. Injection actuation pressure sensor (hidden view)
15. Turbocharger outlet pressure sensor (hidden view)

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

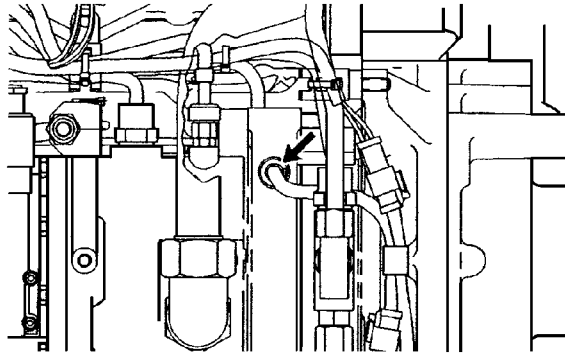
Failure of Sensors

A failure of any of the sensors may be caused by one of the following malfunctions:

- a.) Sensor output is open
- b.) Sensor output is shorted to “- battery” or “+ battery”.
- c.) Measured reading of the sensor is out of specification.

Atmospheric Pressure Sensor

ATMOSPHERIC
PRESSURE SENSOR
Figure 7.2–10



The atmospheric pressure sensor measures the atmospheric pressure in the crankcase. A signal is sent to the Electronic Control Module (ECM).

Warning Signals

Engines may be equipped with warning signals in order to alert the operator when undesirable operating conditions occur. When a warning signal is activated, corrective measures must be made before the situation becomes an emergency.

Warning signals are electrically operated. The operation of all electric warning signals utilize components that actuate switches in a sensing unit. Warning signals are set for the following parameters:

- a.) critical operating temperatures
- b.) operating pressures
- c.) operating levels
- d.) operating speeds

A history of all of the engine faults is maintained in the Electronic Control Module (ECM). These faults can be either Active Codes or Logged Codes.

System diagnostics can be connected to a warning signal (red lamp). The signal will continue until the condition is corrected.

A switch may be installed in the warning signal circuit in order to disable the warning signal while the engine is stopped for repairs. Ensure that the warning switch is reset after repairs have been made.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Cold Start Strategy

The cold start strategy utilizes the input from the oil temperature sensor to improve starting in low temperatures. The cold start strategy helps to provide the following features:

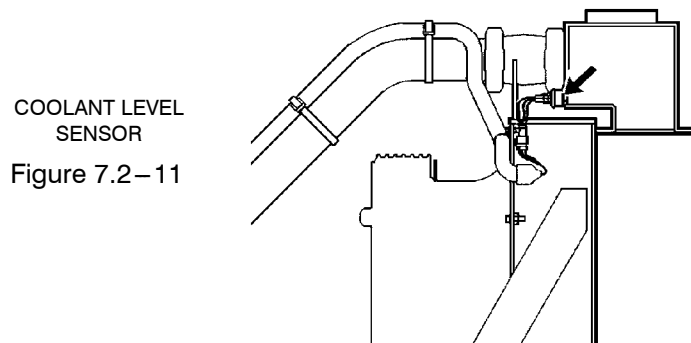
- a.) Quicker cold starts
- 2.) White smoke cleanup
- c.) Decreased deep cycling of the battery
- d.) Extended engine life

When the oil temperature is below 140°F (60°C), the cold start strategy is activated. The cold start strategy deactivates under any of the following conditions:

- a.) The oil temperature reaches 140°F (60°C).
- b.) The engine has run for 14 minutes.

Coolant Level Sensor

The coolant level sensor is used to detect a condition when the coolant level is low. The coolant level sensor provides information to the ECM. The output from the ECM can indicate a low coolant level through a relay or a lamp. Coolant must be added to the cooling system in order to correct the condition. **Note:** The coolant level sensor is an optional feature.



The electrical control system can be programmed with one of the following options:

“Enabled” The system will monitor the input from the coolant level sensor.

“Disabled” The system will not monitor the input from the coolant level sensor and all of the diagnostics that are associated with the coolant level sensor will be disabled.

Failure of the Coolant Level Sensor

A failure of the coolant level sensor will not cause a shutdown of the engine or any horsepower change.

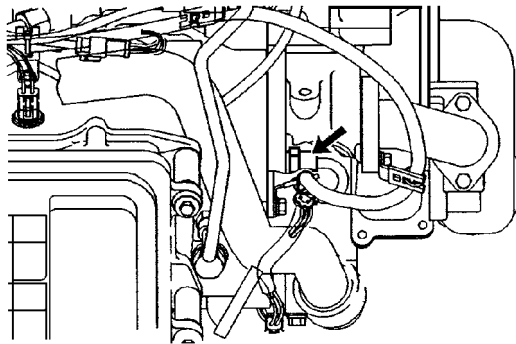
7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Coolant Temperature Sensor

The coolant temperature sensor monitors engine coolant temperature. This feature is used for engine system diagnostics with an output from the ECM. The output of the ECM can indicate a high coolant temperature through a relay or a lamp. Activation temperature for the high coolant temperature fault is 224°F (107°C).

COOLANT
TEMPERATURE
SENSOR (TOP VIEW)
Figure 7.2–12



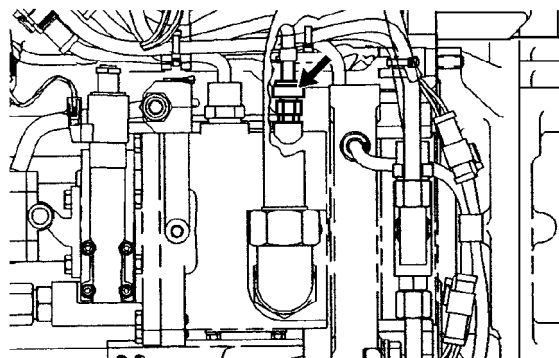
Failure of the Coolant Temperature Sensor

The ECM will detect a failure of the coolant temperature sensor. The diagnostic lamp will warn the operator about the status of the coolant temperature sensor. Coolant temperature related strategies will be disabled if a failure occurs. A failure of the coolant temperature sensor will not cause a shutdown of the engine or any horsepower change.

Engine Oil Pressure Sensor

The engine oil pressure sensor is an absolute pressure sensor that measures the engine oil pressure in the main oil gallery. The engine oil pressure sensor detects engine oil pressure for diagnostic purposes. The engine oil pressure sensor sends a signal to the ECM.

ENGINE OIL
PRESSURE SENSOR
(TOP VIEW)
Figure 7.2–13



Low Oil Pressure Warning

The setpoint is dependent upon the engine speed. The fault will be active and logged only if the engine has been running for more than 15 seconds.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Very Low Oil Pressure Warning

The very low oil pressure setpoint is dependent upon the engine speed. If the DERATE mode of the engine monitoring system is selected, the ECM will derate the engine power. The engine horsepower will be limited.

Failure of the Engine Oil Pressure Sensor

The ECM will detect failure of the engine oil pressure sensor. The diagnostic lamp warns the user about the status of the engine oil pressure sensor. The engine oil pressure related strategies will be disabled in the event of a failure of the engine oil pressure sensor. A failure of the engine oil pressure sensor will not cause a shutdown of the engine or any horsepower change.

Engine Oil Temperature Sensor

The engine oil temperature sensor monitors the temperature of the engine oil. The ECM uses the information from the engine oil temperature sensor in order to adjust the timing of the fuel injection and the pressure of the fuel injection. The engine oil temperature sensor is also used by the ECM in order to determine initiation of Cold Start Strategy.

Engine Shutoff Controls

Secondary shutoff controls are electrically operated. Know the types and the locations of the shutoff controls, the conditions which cause each control to function, and the resetting procedure that is required to start the engine. Always determine the cause of the shutdown. Before the engine is restarted, make the necessary repairs.

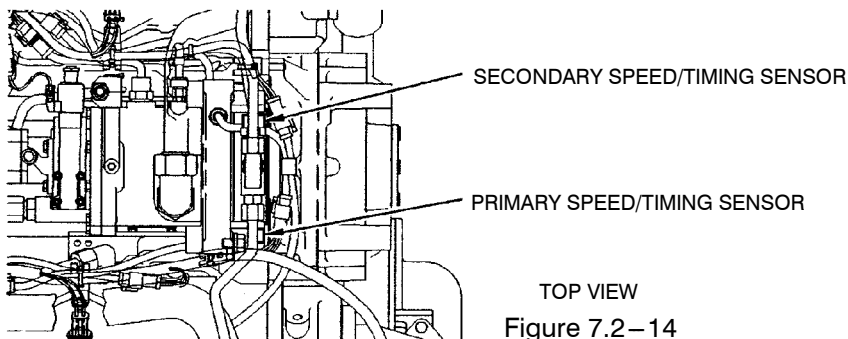
Engine Speed Governing

The engine speed governor monitors the throttle position and the actual engine speed (rpm) in order to help control the following items: engine rpm, response, torque output, and smoke limiting. The engine speed governor also helps to maintain constant engine rpm.

The engine rpm is controlled by governing the duration of the fuel injection to the cylinders. The electronic unit injectors control the duration of the fuel injection. The throttle input signal is used to calculate the desired engine rpm.

Engine Speed/Timing Sensor

If the primary speed/timing sensor (1) cannot sense engine speed, the "DIAGNOSTIC" lamp will indicate a diagnostic fault code which will be logged in the ECM memory.



7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Engine Speed/Timing Sensor (continued)

If the primary speed/timing sensor (see Figure 7.2-14) cannot sense engine speed, the automatic default will use secondary speed/timing sensor. The secondary speed/timing sensor will be used until the primary speed/timing sensor is replaced.

Failure of the Speed/Timing Sensor

If any of the following conditions are present, a failure of the speed/timing sensor may have occurred:

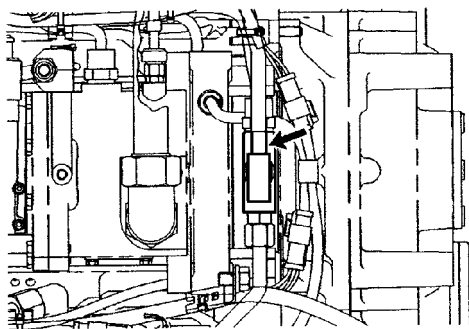
- a.) The speed/timing sensor is missing pulses.
- b.) The speed/timing sensor has extra pulses.

Intermittent failure causes erratic engine control. The electronic control system will detect a failure of the primary speed/timing sensor. The operator will be warned through the diagnostic lamp. If both of the speed/timing sensors fail, the engine will shut down.

Fuel Pressure Sensor

The fuel pressure sensor monitors the fuel filter outlet pressure. Low fuel pressure or high fuel pressure will not cause a shutdown of the engine. Low fuel pressure can result in low power. Fuel pressure that is outside of the normal range will affect the engine performance. If the fuel filter outlet pressure is low, the fuel filter may need to be replaced.

Fuel Temperature Sensor



FUEL TEMPERATURE
SENSOR (TOP VIEW)

Figure 7.2–15

The fuel temperature sensor monitors the fuel temperature. Fuel temperature is monitored in order to adjust the fuel rate so that the engine will deliver consistent power. The fuel temperature sensor can also be used to warn the operator of excessive fuel temperature. A high fuel temperature can adversely affect the engine performance.

Injection Actuation Pressure Sensor

The injection actuation pressure sensor provides a signal of the injection pressure to the ECM. The ECM modifies the current to the injection actuation pressure control valve in order to control the injection actuation pressure. The desired actuation pressure is based on the following engine parameters: quantity of fuel, injection timing, engine speed, and engine operating mode.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Inlet Manifold Air Temperature

The inlet manifold air temperature sensor measures the temperature of the air in the inlet manifold. The ECM monitors the signal from the inlet manifold air temperature sensor. The output of the ECM can indicate high inlet manifold air temperature through a relay or a lamp. The inlet manifold air temperature sensor will not cause a shutdown of the engine or any horsepower change.

Note:

The inlet manifold air temperature sensor will be affected by the temperature of the inlet manifold. This is noticeable when the engine is idling and after the engine is shut off. This warm-up is due to the lack of coolant circulation through the engine. The reading from the inlet manifold air temperature sensor may be significantly higher than the actual temperature of the air inside the inlet manifold until the inlet manifold cools.

Overspeed

An overspeed condition is detected by the primary speed/timing sensor. If the engine rpm speed exceeds 2500 rpm, the Electronic Control Module (ECM) will shut off the electronic unit injectors. The electronic unit injectors will be shut off until the engine speed drops below 2500 rpm. A diagnostic fault code will be logged into the ECM memory and the "DIAGNOSTIC" lamp will indicate a diagnostic fault code.

Throttle Position Sensor

The Throttle Position Sensor (TPS) sends a signal to the ECM. The signal from the TPS is required in order to govern engine speed. The TPS signal is used by the ECM in order to calculate the desired engine speed. The TPS is calibrated during the initial installation of the engine. **Note:** Some installations of the TPS do not need calibration.

Failure of the Throttle Position Sensor

An intermittent failure in the TPS causes the engine speed to vary erratically. The ECM will perform the following process:

- a.) The ECM will detect the failure of the TPS.
- b.) The ECM will warn the operator of the failure through the diagnostic lamp.
- c.) The ECM will set the desired engine speed to low idle.

Turbocharger Outlet Pressure Sensor

The turbocharger outlet pressure sensor provides a signal which corresponds to boost to the ECM. The injection of fuel that is limited by the ECM is based on the boost pressure and the fuel ratio control limit. This feature is called the FRC Fuel Limit on the Electronic Service Tool.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E SENSORS AND ELECTRICAL COMPONENTS (continued)

Turbocharger Outlet Pressure Sensor (continued)

The ECM performs an automatic calibration of the turbocharger outlet pressure sensor whenever the ECM is powered and the engine is off for at least five (5) seconds. During an automatic calibration, the ECM calibrates the turbocharger outlet pressure sensor against the atmospheric pressure sensor and an acceptable offset pressure range. If the FRC offset value is not in the range, the previous calibration value is used. A manual calibration should be performed if the turbocharger outlet pressure sensor is replaced.

Failure of the Turbocharger Outlet Pressure Sensor

The ECM will detect failure of the turbocharger outlet pressure sensor. The operator will be warned of the problem through the diagnostic lamp. The strategies that are related to the boost will be disabled. A failure of the turbocharger outlet pressure sensor will not cause a shutdown of the engine.

CAT 3412E ENGINE DIAGNOSTICS

Caterpillar Electronic Engines have the capability to perform a self-diagnostics test. When the system detects a problem, the “DIAGNOSTIC” lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the following components:

- a.) Caterpillar electronic service tools
- b.) “DIAGNOSTIC” lamp

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes.

Active codes represent problems that currently exist. These problems should be investigated first. If a code is active, the “DIAGNOSTIC” lamp will flash the flash code at five (5) second intervals.

Logged codes represent the following items:

- a.) Intermittent problems
- b.) Recorded events
- c.) Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE DIAGNOSTICS (continued)

Diagnostic Lamp

The “DIAGNOSTIC” lamp is used to indicate the existence of an active fault by flashing codes.



Figure 7.2–16

When the ignition switch is first turned on, the “DIAGNOSTIC” lamp will go through the following procedure:

1. The “DIAGNOSTIC” lamp will come on and the “DIAGNOSTIC” lamp will remain on for five (5) seconds.
2. The “DIAGNOSTIC” lamp will turn off.
3. The “DIAGNOSTIC” lamp will come on again and the “DIAGNOSTIC” lamp will flash codes for any active diagnostic codes.
4. The “DIAGNOSTIC” lamp will turn off for five (5) seconds.
5. The “DIAGNOSTIC” lamp repeats all active diagnostic codes.

A fault diagnostic code will remain active until the problem is repaired. The electronic control module will continue flashing the flash code at five (5) second intervals until the problem is repaired.

Diagnostic Flash Code Retrieval

Use the “DIAGNOSTIC” lamp or a Caterpillar electronic service tool to determine the diagnostic flash code. Use the following procedure to retrieve the diagnostic codes if the engine is equipped with a “DIAGNOSTIC” lamp:

1. Turn the ignition key to the ON position. The engine does not need to be started in order to view codes. The engine does not need to be running while the ignition switch is in the ON position.
 - a.) The “DIAGNOSTIC” lamp blinks on and off at five (5) second intervals.
 - b.) When the ignition key is in the ON position, the lamp is checked for proper operation. If there are any active codes except for Code 34, the codes are displayed at this time.

Note: The “DIAGNOSTIC” lamp will illuminate for five (5) seconds. The lamp will stay on if there is an active diagnostic code.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE DIAGNOSTICS (continued)

Diagnostic Flash Code Retrieval (continued)

2. The diagnostic codes will always be flashed. There is no toggle switch that will shut off the lamp.
3. The “DIAGNOSTIC” lamp will flash in order to indicate a two-digit code. The sequence of flashes represents the system diagnostic message. Each digit of the two-digit code is determined by counting the number of flashes. The lamp flashes at a rate of two times per second. The lamp will pause for two seconds between codes.

Diagnostic Flash Codes

The table below indicates the potential effect on the engine performance with active flash codes. The table also forms a list of electronic diagnostic codes and descriptions.

DIAGNOSTIC FLASH CODE OR ENGINE PERFORMANCE RELATIONSHIP FOR CATERPILLAR 3412E ENGINES							
DIAGNOSTIC FLASH CODE		EFFECT ON ENGINE PERFORMANCE			SUGGESTED OPERATOR ACTION		
		ENGINE MISFIRE	LOW POWER	REDUCED ENGINE SPEED	SHUT DOWN ENGINE	SERVICE	SCHEDULE SERVICE
14	INJECTION ACTUATION PRESSURE CONTROL VALVE OPEN CIRCUIT	X	X	X	X		X
14	INJECTION ACTUATION PRESSURE CONTROL VALVE SHORT TO GROUND	X	X	X	X		X
21	ANALOG SUPPLY OPEN/SHORT TO “+” BATTERY		X				X
21	ANALOG SUPPLY SHORT TO GROUND		X				X
21	DIGITAL SUPPLY SHORT TO “+” BATTERY		X				X
21	DIGITAL SUPPLY SHORT TO GROUND		X				X
22	INJECTION ACTUATION PRESSURE SIGNAL OPEN/SHORT TO “+” BATTERY		X	X	X		X
22	INJECTION ACTUATION PRESSURE SIGNAL SHORT TO GROUND		X	X	X		X
24	OIL PRESSURE SIGNAL OPEN/SHORT TO “+” BATTERY		X		X		X (1)
24	OIL PRESSURE SIGNAL SHORT TO GROUND		X		X		X (1)
25	TURBOCHARGER COMPRESSOR OUTLET PRESSURE SIGNAL ABOVE NORMAL		X				X
25	TURBOCHARGER COMPRESSOR OUTLET PRESSURE SIGNAL OPEN/SHORT TO “+” BATTERY		X				X
25	TURBOCHARGER COMPRESSOR OUTLET PRESSURE SIGNAL SHORT TO GROUND		X				X

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE DIAGNOSTICS (continued)

Diagnostic Flash Codes (continued)

DIAGNOSTIC FLASH CODE OR ENGINE PERFORMANCE RELATIONSHIP FOR CATERPILLAR 3412E ENGINES							
DIAGNOSTIC FLASH CODE		EFFECT ON ENGINE PERFORMANCE			SUGGESTED OPERATOR ACTION		
		ENGINE MISFIRE	LOW POWER	REDUCED ENGINE SPEED	SHUT DOWN ENGINE	SERVICE	SCHEDULE SERVICE
26	ATMOSPHERIC PRESSURE SIGNAL OPEN/SHORT TO "+" BATTERY		X	X	X		X
26	PRIMARY SPEED/TIMING SIGNAL ABNORMAL		X	X	X		X
27	COOLANT TEMPERATURE SIGNAL OPEN/SHORT TO "+" BATTERY	X	X		X		X
27	COOLANT TEMPERATURE SIGNAL SHORT TO GROUND	X	X		X		X
27	FUEL TEMPERATURE SIGNAL OPEN/SHORT TO "+" BATTERY		X				X
27	FUEL TEMPERATURE SIGNAL SHORT TO GROUND		X				X
27	OIL TEMPERATURE SIGNAL OPEN/SHORT TO "+" BATTERY		X				X
27	OIL TEMPERATURE SIGNAL SHORT TO GROUND		X				X
32	THROTTLE POSITION SIGNAL ABNORMAL				X		X
34	LOSS OF PRIMARY SPEED/TIMING SIGNAL	X				X (2)	X
34	PRIMARY SPEED/TIMING SIGNAL OPEN/SHORT TO "+" BATTERY			X		X (2)	X
34	PRIMARY SPEED/TIMING SIGNAL ABNORMAL	X				X (2)	X
34	LOSS OF SECONDARY SPEED/TIMING SIGNAL	X				X (2)	X
34	SECONDARY SPEED/TIMING SIGNAL OPEN/SHORT TO "+" BATTERY			X		X (2)	X
34	SECONDARY SPEED/TIMING SIGNAL ABNORMAL	X				X (2)	X
37	FUEL PRESSURE SIGNAL OPEN/SHORT TO "+" BATTERY						X
37	FUEL PRESSURE SIGNAL SHORT TO GROUND						X
38	INLET AIR MANIFOLD TEMPERATURE SIGNAL OPEN/SHORT TO "+" BATTERY						X
38	INLET AIR MANIFOLD TEMPERATURE SIGNAL SHORT TO GROUND						X
42	ATMOSPHERIC PRESSURE SENSOR CALIBRATION		X				X
42	TURBOCHARGER COMPRESSOR OUTLET PRESSURE SENSOR CALIBRATION		X				X
42	SPEED/TIMING SENSOR CALIBRATION	X	X				X

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE DIAGNOSTICS (continued)

Diagnostic Flash Codes (continued)

DIAGNOSTIC FLASH CODE OR ENGINE PERFORMANCE RELATIONSHIP FOR CATERPILLAR 3412E ENGINES							
DIAGNOSTIC FLASH CODE		EFFECT ON ENGINE PERFORMANCE			SUGGESTED OPERATOR ACTION		
		ENGINE MISFIRE	LOW POWER	REDUCED ENGINE SPEED	SHUT DOWN ENGINE	SERVICE	SCHEDULE SERVICE
53	INTERNAL ECM PROBLEM	X	X	X	X		X
56	PERSONALITY MODULE MISMATCH				X		X
56	CHECK PROGRAMMABLE PARAMETERS				X		X
71	CYLINDER 1 FAULT	X	X			X	
72	CYLINDER 2 FAULT	X	X			X	
73	CYLINDER 3 FAULT	X	X			X	
74	CYLINDER 4 FAULT	X	X			X	
75	CYLINDER 5 FAULT	X	X			X	
76	CYLINDER 6 FAULT	X	X			X	
77	CYLINDER 7 FAULT	X	X			X	
78	CYLINDER 8 FAULT	X	X			X	
81	CYLINDER 9 FAULT	X	X			X	
82	CYLINDER 10 FAULT	X	X			X	
83	CYLINDER 11 FAULT	X	X			X	
84	CYLINDER 12 FAULT	X	X			X	

(1) Engine Monitoring must be programmed to Derate or Shutdown before the power and engine rpm are reduced. Engine Monitoring must be programmed to Shutdown before the engine will shutdown.

(2) If both the primary speed/timing sensor and the backup speed/timing sensor fail, a shutdown will occur.

For further information or assistance for repairs, consult your local Drilling Solutions distributor or an authorized Caterpillar dealer.

Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates a diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved with Caterpillar electronic service tools. The codes that have been logged can be cleared with Caterpillar electronic service tools. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure and high engine coolant temperature.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE DIAGNOSTICS (continued)

Engine Operation With Active Diagnostic Codes

If the diagnostic lamp starts to flash codes during normal engine operation, the system has identified a situation that is not within the specification. Use Caterpillar electronic service tools to check the active diagnostic codes.

Note: If the customer has selected “DERATE” and if there is a low pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible. Refer to “Diagnostic Flash Code Retrieval” for more information on flash codes.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the “Diagnostic Flash Codes” for more information on the relationship between these active diagnostic codes and engine performance.

Engine Operation With Intermittent Diagnostic Codes

If the diagnostic lamp starts to flash codes during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should note the circumstances that are involved during the time that the lamp was on:

- a.) Low Power
- b.) Limits of the engine speed
- c.) Excessive smoke, etc.

This information can be useful to help troubleshoot the situation. The information can also be used for future reference.

CAT ENGINE PROTECTION

Troubleshooting a failure on an engine can be a difficult procedure. See the CAT Service Manual for troubleshooting information. All repairs should be made by a properly trained mechanic. Your Caterpillar dealer has the personnel and special tools needed to troubleshoot and make repairs to your engine.

See the Troubleshooting Manual within the CAT Service Manual. The list of problems, causes and corrections given in the CAT Service Manual will only give an indication of where a possible problem can be, and what repairs may be needed. Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT 3412E ENGINE PROTECTION (continued)

The CAT Service Manual can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs. Your Caterpillar dealer is equipped with the necessary tools and personnel to provide assistance when necessary.

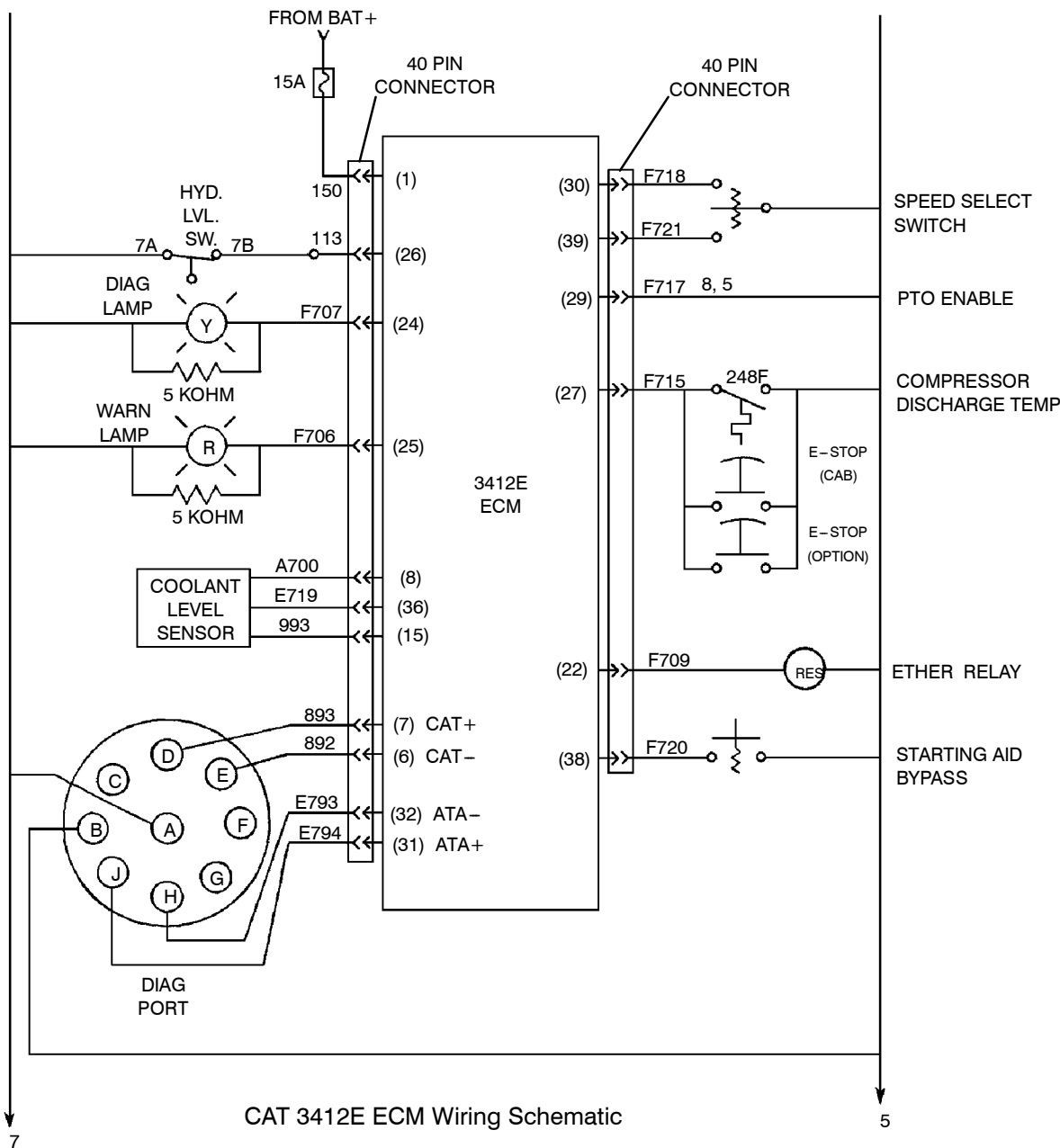


Figure 7.2–17

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE ELECTRONICS

Caterpillar engines (Electronic and Tier II) have a comprehensive, programmable Engine Monitoring System. The Engine Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control: WARNING, DERATE and SHUTDOWN. These engine monitoring modes have the ability to limit engine speed and/or the engine power.

Many of the parameters that are monitored by the ECM can be programmed for the engine monitoring functions. The following parameters can be monitored as a part of the Engine Monitoring System: Operating Altitude, Engine Coolant Level, Engine Coolant Temperature, Engine Oil Pressure, Engine Speed, Fuel Temperature, Intake Manifold Air Temperature and System Voltage.

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Caterpillar Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to Engine Monitoring System for more information.

CAT MONITORING SYSTEM



If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury.

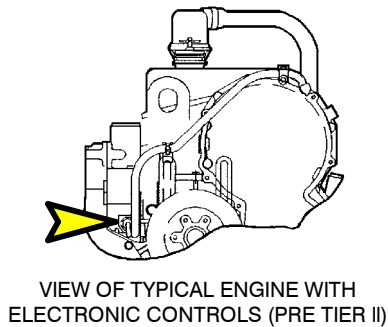


The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and derate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

7.2 - TROUBLESHOOTING (ELECTRICAL)

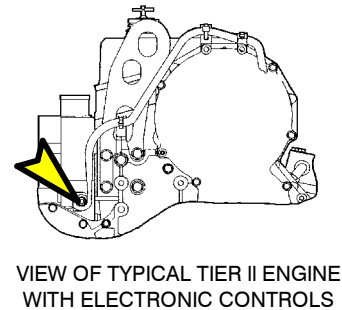
CAT SENSORS AND ELECTRICAL COMPONENTS

Coolant Temperature Sensor



LOCATION OF COOLANT
TEMPERATURE SENSOR

Figure 7.2–18



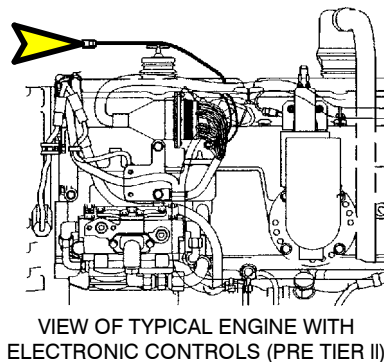
The engine coolant temperature sensor monitors the temperature of the engine coolant. The coolant temperature signal is sent to the Electronic Control Module (ECM) for engine monitoring and for improved engine control. The signal is used by the ECM for all of the following engine functions: engine timing control, engine operating mode and engine protection.

The ECM is capable of adjusting the engine timing relative to the engine operating temperature. The concept of dynamic timing provides the engine with the ability to control exhaust emissions. Timing control also aids in white smoke cleanup during cold engine operation.

The ECM also uses the signal from the engine coolant temperature sensor to determine the mode of operation for the engine. Several aspects of engine operation are affected by the engine operating mode: acceleration ramp rates, engine timing and fuel injector timing.

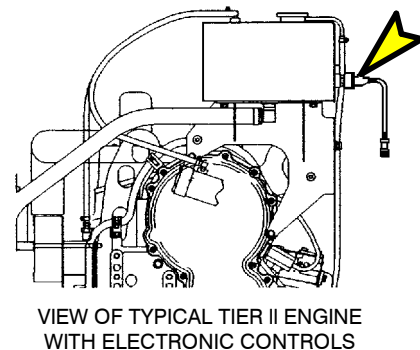
Coolant Temperature Protection

Excessive engine coolant temperature is an undesirable operating condition. Serious damage to the engine can result if the coolant level is too low or too high and the engine is allowed to overheat. If the engine coolant temperature increases to excessive levels, the engine monitoring system will initiate actions that will protect the engine from damage.



LOCATION OF COOLANT
LEVEL SENSOR

Figure 7.2–19



7.2 - TROUBLESHOOTING (ELECTRICAL)

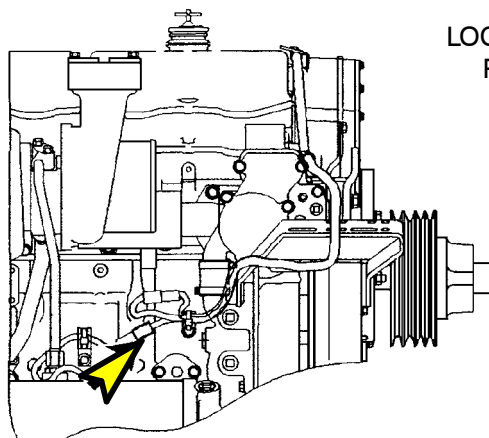
CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

Coolant Level Sensor

The coolant level sensor is an optional sensor. This sensor monitors the engine coolant in the cooling system expansion tank. The coolant level sensor signal is sent to the ECM for the purpose of engine monitoring.

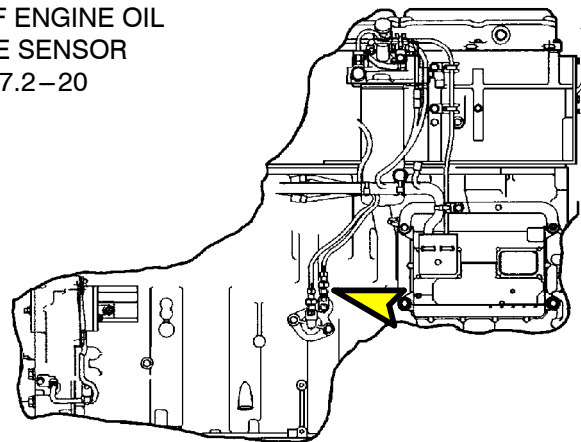
Engine Oil Pressure Sensor

The engine oil pressure sensor provides an oil pressure signal to the Electronic Control Module (ECM) for the purpose of engine monitoring. The electronic signal is compared to an Oil Pressure Map that is stored in ECM memory. The Oil Pressure Map is derived from a direct relationship between engine speed and the oil pressure that is expected at that speed. The engine monitoring system records a low engine oil pressure condition in ECM memory if the sensor value is not within the proper range. The monitoring system then initiates protective measures.



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)

LOCATION OF ENGINE OIL
PRESSURE SENSOR
Figure 7.2–20



VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

⚠ WARNING

Low engine oil pressure is an undesirable operating condition. When a low oil pressure condition exists in the engine, there is a possibility of damage to major engine components. Low oil pressure protection is a safety feature that will take the necessary measures in order to initiate an engine shutdown in the event of a low oil pressure condition.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

Fuel Temperature Sensor

The fuel temperature sensor monitors the inlet fuel temperature. The Electronic Control Module (ECM) utilizes the signal from the fuel temperature sensor to provide fuel temperature compensation for the engine fuel control system. Fuel temperature compensation provides the following benefits:

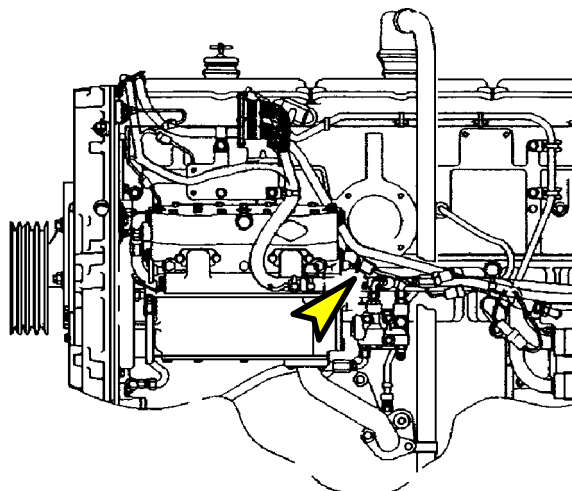
- a.) Rated engine horsepower regardless of fuel temperature.
- b.) Highly accurate fuel rates and fuel consumption rates.
- c.) Optimum fuel economy

Changes in the temperature of the fuel affects the power output of the engine. The ECM adjusts the engine fuel rate according to the temperature of the fuel. This feature allows full engine power to be realized by the operator at any fuel temperature.

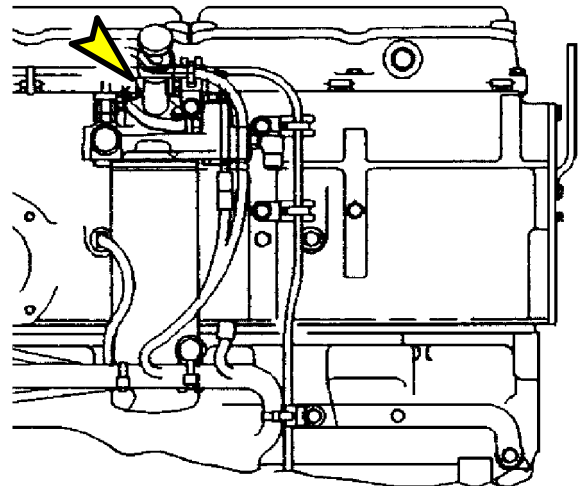


High Fuel Temperature is an undesirable operating condition.

LOCATION OF FUEL TEMPERATURE SENSOR



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)



VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

Figure 7.2–21

Fuel temperature will also affect the calculation of fuel consumption rate that is performed by the ECM. The ECM utilizes the fuel temperature signal to provide an adjusted value for these calculations.

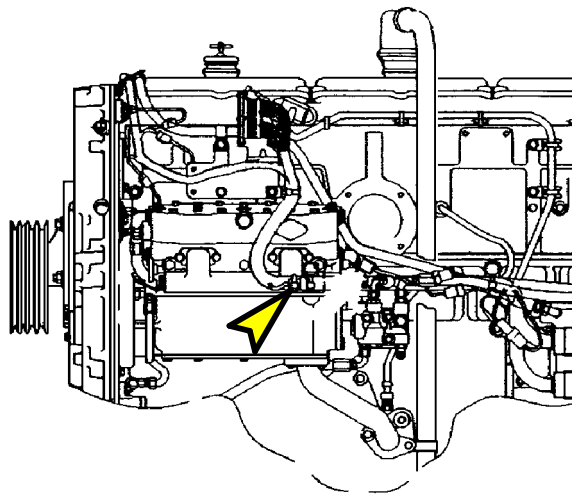
7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

Fuel Pressure Sensor

The fuel pressure sensor monitors filtered fuel pressure. Although fuel pressures that are outside the normal operating range may adversely affect engine performance, there should not be any noticeable reduction in the engine horsepower. Abnormal fuel pressure will not cause an engine shutdown. A low filtered fuel pressure may indicate that the low pressure fuel system requires maintenance.

LOCATION OF FUEL PRESSURE SENSOR



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)

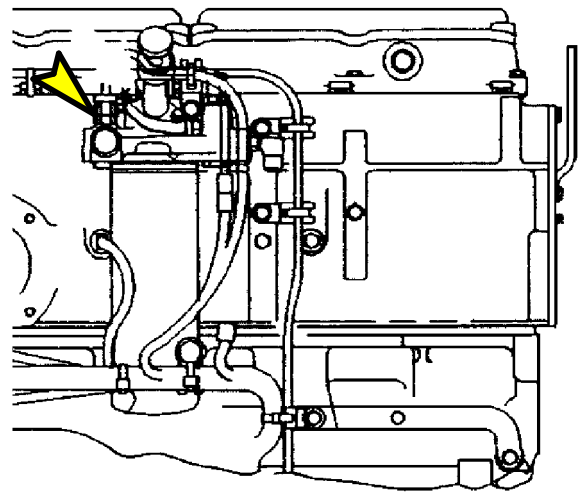


Figure 7.2–22

VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

The fuel pressure sensor measures the fuel pressure after the fuel has been filtered. The sensor connector for the fuel pressure sending unit is located on the machine side of the machine connector. For more information, refer to the actual manufacturer Troubleshooting Guide for this engine.

For more information on fuel system maintenance, refer to the maintenance section in the actual manufacturer Operation and Maintenance Manual.

Air Inlet Temperature Sensor



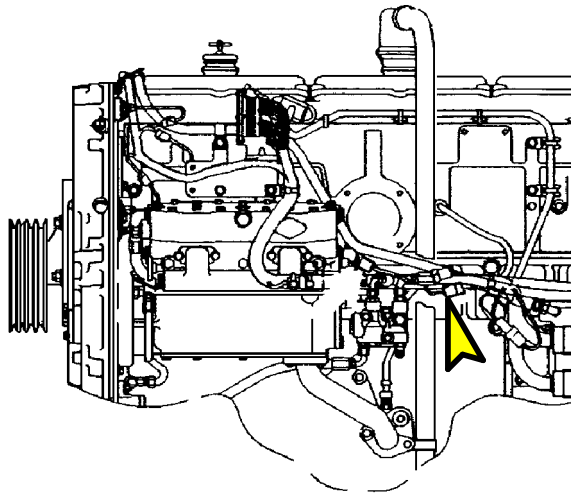
Excessive inlet air temperature is an undesirable operating condition.

The air inlet temperature sensor detects the temperature of the air that is passing through the inlet manifold. A signal is sent to the Electronic Control Module (ECM) for interpretation.

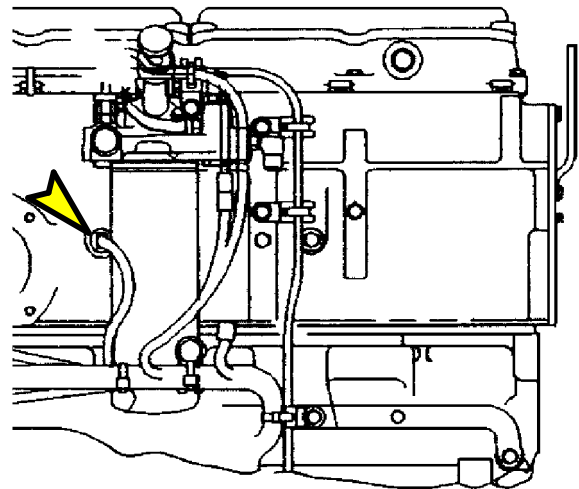
7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

LOCATION OF AIR INLET TEMPERATURE SENSOR



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)



VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

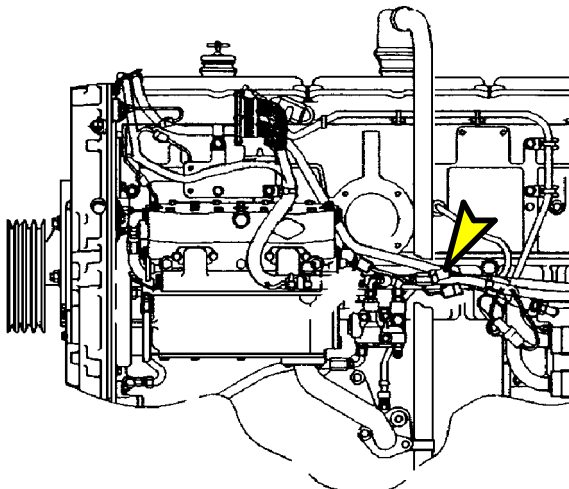
Figure 7.2–23

The ECM uses the information from the inlet air temperature sensor in order to accurately control the emissions levels of the engine. As the inlet air temperature changes, the fuel injection timing is advanced. This is done in order to maintain the exhaust emission standards.

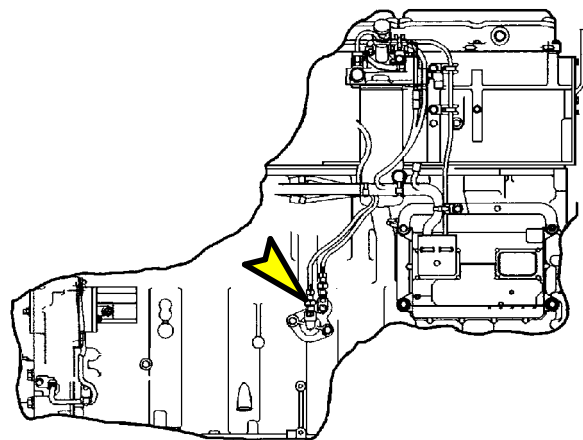
Atmospheric Pressure Sensor

The atmospheric pressure sensor measures the pressure in the crankcase. This sensor assumes that crankcase pressure is a representation of atmospheric pressure. A signal is sent to the Electronic Control Module (ECM).

LOCATION OF ATMOSPHERIC PRESSURE SENSOR



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)



VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

Figure 7.2–24

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

Atmospheric Pressure Sensor (continued)

The ECM utilizes the value that is read by the atmospheric pressure sensor for the following functions:

1. Reference source for pressure sensor calibrations
 - a.) Calculating the operating altitude
 - b.) Calculating boost pressure
 - c.) Checking for air inlet restriction

When the ECM is powered, all of the pressure sensors that are used for engine monitoring receive an automatic calibration. The ECM uses the value that is received from the atmospheric pressure sensor to calculate the pressure offset value.

The ECM also utilizes atmospheric pressure to determine the active engine derate during high elevation operation. The engine monitoring system compares the current atmospheric pressure value to the programmed derate setpoint. The engine is derated by limiting the fuel delivery at a rate of approximately 3 percent for each 1000 ft. (304 m) of elevation.

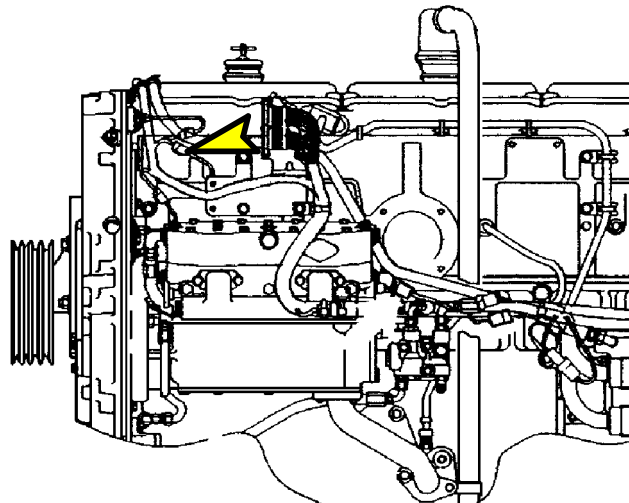
Actual boost pressure is calculated by the ECM. The difference between the turbocharger outlet pressure and the atmospheric pressure is equal to the actual boost pressure. Boost pressure is used for calculating fuel system adjustments.

Turbocharger Outlet Pressure Sensor

LOCATION OF TURBOCHARGER
OUTLET PRESSURE SENSOR

Figure 7.2–25

VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)



The turbocharger outlet pressure sensor measures the pressure of the turbocharged aftercooled air from a port in the air inlet manifold. The sensor provides a signal to the Electronic Control Module (ECM) that is used to calculate turbocharger boost pressure. The ECM derives boost pressure by taking the difference between the turbocharger outlet pressure and the atmospheric pressure.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

Turbocharger Outlet Pressure Sensor (continued)

Engine boost and actual engine speed are used by the ECM to govern the fuel air ratio control and the fuel rack limiting functions. During a change in speed or a change in load, the ECM adjusts the fuel injector delivery and the engine timing in order to provide maximum engine response while minimizing the transient smoke levels.

Engine Monitoring and Protection

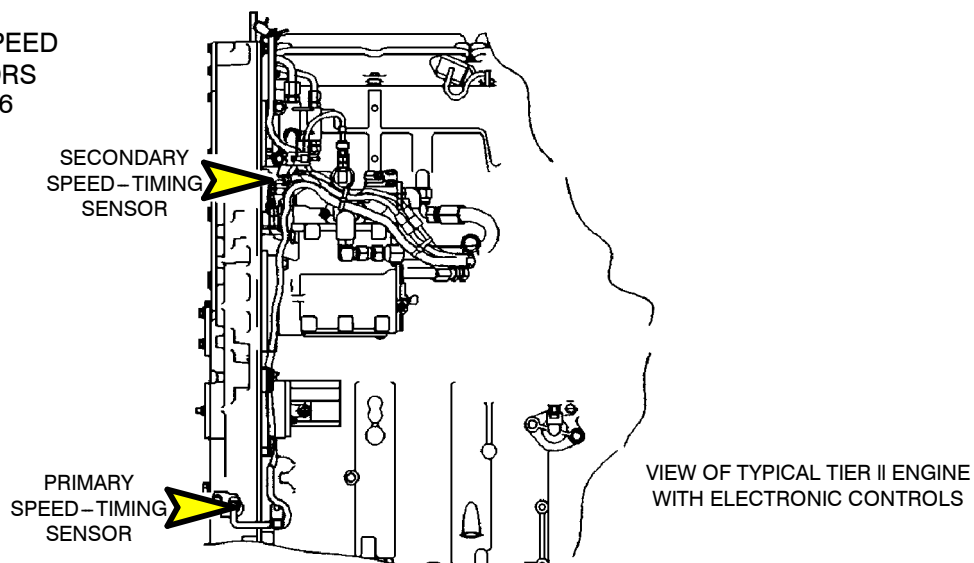
Pre Tier II Engines: The system operation that is described above outlines the importance of a valid signal from the turbocharger outlet pressure sensor. If this signal becomes suspect, erratic operation of the engine could result. The ECM will compensate by applying a default signal to all control functions that utilize the signal. The ECM will use the default signal while the diagnostic code remains in the ACTIVE state. The diagnostic condition will be displayed for the operator and the engine will continue to operate.

Note: ACTIVE diagnostic codes indicate that a problem with the engine electronics system is suspected. The engine should be serviced by a qualified technician immediately.

Speed Timing Sensor

If primary speed-timing sensor cannot sense engine speed, the “DIAGNOSTIC” lamp will indicate a diagnostic fault code. The diagnostic fault code will be logged into the memory of the Electronic Control Module (ECM).

LOCATION OF SPEED
TIMING SENSORS
Figure 7.2–26



7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT SENSORS AND ELECTRICAL COMPONENTS (continued)

If primary speed-timing sensor cannot sense engine speed, the automatic default will use secondary speed-timing sensor. The secondary speed-timing sensor will be used until the primary speed-timing sensor is replaced. The engine will shut down if both speed-timing sensors fail.

Failure of the Speed-Timing Sensor

If any of the following conditions are present, a failure of the speed-timing sensor may have occurred:

- a.) The speed-timing sensor output has opened.
- b.) The speed-timing sensor is shorted to ground.
- c.) The speed-timing sensor is shorted to supply.
- d.) The speed-timing sensor is missing pulses.
- e.) The speed-timing sensor has extra pulses.

Intermittent failure causes erratic engine control. The electronic control system will detect a failure of the primary speed-timing sensor. The operator will be warned through the “DIAGNOSTIC” lamp.

Engine Speed Governing

The engine speed governor monitors the throttle position and actual engine speed (rpm) in order to help control the following items: engine speed, response, torque output and smoke limiting. The engine speed governor also helps to maintain constant engine speed.

The engine speed is controlled by the governing of the fuel injection duration of the electronic unit injectors. Throttle input is used to calculate the desired engine speed.

ENGINE DIAGNOSTICS

Self-Diagnostics

Caterpillar Electronic Engines have the capability to perform a self-diagnostic test. When the system detects an active problem, the “DIAGNOSTIC” lights are activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the the “DIAGNOSTIC” lights or Caterpillar electronic service tools.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to diagnostic code retrieval and the diagnostic code charts for more information on retrieving engine diagnostic codes.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Self-Diagnostics (continued)

Active codes represent problems that currently exist. These problems should be investigated first. If a code is active, the “DIAGNOSTIC” lamp will flash the flash code at five second intervals.

Logged codes may represent intermittent problems, recorded problems or performance history.

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

Scroll Toggle

The Scroll Toggle is a spring centered switch that moves the ECM “UP” one fault code every time it is toggled upward and it moves the ECM “DOWN” one fault code every time it is pushed downward. When it is released, it moves back to the neutral position.

Diagnostic Lamp

The “DIAGNOSTIC” lamp is used to indicate the existence of an active fault by flashing codes. When the ignition switch is first turned on, the “DIAGNOSTIC” lamp will go through the following procedure:

1. The “DIAGNOSTIC” lamp will come on and will remain on for five seconds. This checks the operation of the lamp.
2. The “DIAGNOSTIC” lamp will turn off.
3. The “DIAGNOSTIC” lamp will come on again and the lamp will flash codes for any active diagnostic codes. Not all diagnostic codes have a unique flash code.
4. The “DIAGNOSTIC” lamp will turn off for five seconds.
5. The “DIAGNOSTIC” lamp repeats all active diagnostic codes.

A fault diagnostic code will remain active until the problem is repaired. The electronic control module will continue flashing the flash code at five second intervals until the problem is repaired.

Diagnostic Flash Code Retrieval

You can use the “DIAGNOSTIC” lamp to determine the diagnostic flash code. Not all diagnostic codes have a unique flash code.

Note: Flash codes should only be used to indicate the nature of a diagnostic condition. Do not use flash codes to perform detailed troubleshooting.

Use the following procedure to retrieve the diagnostic codes with the engine DIAGNOSTIC lamp:

1. The “DIAGNOSTIC” lamp will flash to indicate a two-digit code. The sequence of flashes represents the system diagnostic message. Each digit of the two-digit code is determined by counting the number of flashes. The lamp flashes at a rate of two times per second. The lamp will pause for one second between digits. The lamp will pause for two seconds between codes.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Diagnostic Flash Code Retrieval (continued)

2. Turn the ignition key (start/run key) to the ON position. The engine does not need to be started in order to view codes. The engine does not need to be running while the ignition switch (start/run switch) is in the ON position. The “DIAGNOSTIC” lamp blinks on and off at five second intervals.
 - a). When the ignition key (start/run key) is in the ON position, the lamp is checked for proper operation. If there are any active codes, except for Code 34, the codes are displayed at this time.

Note: The “DIAGNOSTIC” lamp will illuminate for five seconds. The lamp will stay on if there is an active diagnostic code.

3. Active diagnostic codes will always be flashed. There is no toggle switch that will shut off the lamp.

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
00	545-05	545-05	Ether Start Relay open/short to +batt				
	545-06	545-06	Ether Start Relay short to ground				
12	266-02	266-02	Incorrect Crank-without-inject inputs				
13	174-03	174-03	Fuel Temperature open/short to +batt				
	174-04	174-04	Fuel Temperature short to ground				
21	262-03	620-03	5 Volt Sensor DC Power Supply short to +batt				
	262-04	620-04	5 Volt Sensor DC Power Supply short to ground				
	263-03	678-03	Digital Sensor Supply short to +batt				
	263-04	678-04	Digital Sensor Supply short to ground				
24	100-03	100-03	Engine Oil Pressure open/short to +batt				
	100-04	100-04	Engine Oil Pressure short to ground				

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Performance Effect Of Active Diagnostic Codes (continued)

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
26	274-03	108-03	Atmospheric Pressure open/short to +batt				
	274-04	108-04	Atmospheric Pressure short to ground				
27	110-03	110-03	Engine Coolant Temperature open/short to +batt	X	X	X	
	110-04	110-04	Engine Coolant Temperature short to ground	X	X	X	
28	91-13	91-13	Throttle Position calibration required		X	X	
32	91-08	91-08	Throttle Position signal abnormal		X	X	
34	320-02	190-02	Speed/Timing Sensor Loss of Signal	X			X (1)
	320-11	190-11	Speed/Timing Sensor mechanical failure	X			X (1)
	342-02	723-02	Loss of Secondary Engine Speed Signal	X			X (1)
	342-11	723-11	Secondary Engine Speed Sensor mechanical failure	X			X (1)
37	94-03	94-03	Fuel Pressure open/short to +batt				
	94-04	94-04	Fuel Pressure short to ground				
	175-03	175-03	Engine Oil Temperature open/short to +batt				
	175-04	175-04	Engine Oil Temperature short to ground				
38	172-03	172-03	Intake Manifold Air Temperature open/short to +batt	X	X	X	
	172-04	172-04	Intake Manifold Air Temperature short to ground	X	X	X	

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Performance Effect Of Active Diagnostic Codes (continued)

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
42	261-13	228-13	Engine Timing calibration required	X	X	X	X
51	168-02	168-02	System Voltage intermittent/erratic	X	X		X
53	254-12		Electronic Control Module Error	X	X	X	X
56	253-02	234-02	Personality Module mismatch				X ⁽²⁾
	268-02	1111-02	Check Programmable Parameters		X	X	
58	247-09	639-09	J1939 Data Link communications				
72	1-11	651-11	Injector Cylinder #1 fault	X	X		
	2-11	652-11	Injector Cylinder #2 fault	X	X		
73	3-11	653-11	Injector Cylinder #3 fault	X	X		
	4-11	654-11	Injector Cylinder #4 fault	X	X		
74	5-11	655-11	Injector Cylinder #5 fault	X	X		
	6-11	656-11	Injector Cylinder #6 fault	X	X		

(1) The engine will shut down if both speed/timing sensors are lost.

(2) Fuel injection will not occur and the engine will not start

Event Codes

The ECM can log events. Events refer to engine operating conditions such as low oil pressure or high coolant temperature. The following table is a cross reference for event codes. Logged events usually indicate a mechanical problem instead of an electronic system problem

Cross-Reference for Event Codes			
Flash Codes	EID Codes	SPN-FMI Codes	Description of Code
35	004	0190-16	Engine Overspeed Shutdown
63	005	0094-15	Fuel Filter Restriction Derate

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Event Codes (continued)

Cross-Reference for Event Codes			
Flash Codes	EID Codes	SPN-FMI Codes	Description of Code
63	006	0094-16	Fuel Filter Restriction Shutdown
61	015	0110-16	High Engine Coolant Temperature Derate
61	016	0110-00	High Engine Coolant Temperature Shutdown
61	017	0110-15	High Engine Coolant Temperature
64	025	0172-16	High Inlet Air Temperature Derate
64	027	0172-15	High Inlet Air Temperature Warning
46	039	0100-18	Low Engine Oil Pressure Derate
46	040	0100-01	Low Engine Oil Pressure Shutdown
65	054	0174-16	High Fuel Temperature Derate
65	055	0174-00	High Fuel Temperature Shutdown
65	056	0174-15	High Fuel Temperature Warning
62	057	0111-18	Low Engine Coolant Level Derate
62	058	0111-01	Low Engine Coolant Level Shutdown
62	059	0111-17	Low Engine Coolant Level Warning
63	095	0094-00	Fuel Filter Restriction Warning
63	096	0094-00	High Fuel Pressure
46	100	0100-17	Low Engine Oil Pressure Warning
35	190	0190-00	Engine Overspeed Warning

Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved and cleared. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure and high engine coolant temperature.

Engine Operation with Active Diagnostic Codes

If the diagnostic lamp starts to flash codes during normal engine operation, the system has identified a situation that is not within the specification. Check the flash code or digital display, if equipped, to check the active diagnostic codes.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTICS (continued)

Engine Operation with Active Diagnostic Codes (continued)

Note: If the flash code shows “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the OEM Operation and Maintenance Manual for more information on the relationship between these active diagnostic codes and engine performance.

Engine Operation with Intermittent Diagnostic Codes

If the diagnostic lamp starts to flash codes during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light, such as: Low power, Limits of the engine speed or Excessive smoke, etc.

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 ENGINE

Drills equipped with **QSK19** engines are equipped with several shutdown devices to prevent harm to the engine or compressor in case of loss of fluids or other related problems. There is a Compressor Discharge Temperature Switch, an Engine coolant Temperature Switch and an Engine Oil Pressure Shutdown switch.



Figure 7.2-27

Compressor Discharge Temperature Switchgag

The discharge temperature switchgag (also called compressor shutdown switch) is a Murphy Switchgag consisting of a gauge on the operator's console and a capillary tube that runs to the discharge piping of the compressor. When the temperature increases to 248°F (120°C), a contact inside the gauge makes electrical contact with relay R1. This cuts the power to the engine. The temperature dial range is 140-300°F (60-149°C).

NOTICE: The temperature sensing bulb must be immersed in coolant or some other medium to send temperature changes to the switchgag. Loss of coolant will leave the bulb dry, which prevents the switchgag from responding quickly to increasing temperatures, making it useless. An engine can be destroyed from loss of coolant.

Water Temperature Switch

This switchgag is also mounted on the operator's control panel while the probe connected to the capillary tube is connected at the water manifold of most engines. It is a normally open switch that closes when the engine water temperature reaches 210°F (99°C). It functions the same as the compressor discharge temperature switchgag. The temperature dial range is 130-250°F (54-121°C).

NOTICE: The temperature sensing bulb must be immersed in coolant or some other medium to send temperature changes to the switchgag. Loss of coolant will leave the bulb dry, which prevents the switchgag from responding quickly to increasing temperatures, making it useless. An engine can be destroyed from loss of coolant.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 ENGINE (continued)

Engine Oil Pressure Switch

This switchgauge, mounted on the operator's control console, has two pressure limit contacts that close when the pressure falls below 27 psi and 10 psi respectively. It does not have a capillary tube but uses a hose connected to the engine to supply pressure to the switchgauge. Both contacts are normally closed and rely on engine oil pressure to open them. They both work through the Engine Speed Switch and close when oil pressure falls below 27 psi or 10 psi, depending on the engine speed. The temperature dial range is 0-100°F (-18.8°C thru 37.8°C). Also used in conjunction with the oil pressure switchgauge is an engine speed switch. This device is an electronic heavy-duty speed switch set at the factory to trigger from one input signal when a pre-determined speed of 1750 RPM is encountered. This means that when the engine is at an idle speed of 1200 RPM, the speed switch is on the normally closed side and connects to the 10 psi switch.

When the engine is speeded up past 1750 RPM, the speed switch changes to the normally open side where the 27-psi switch takes over. As long as the pressure does not fall below either setting, depending on the speed, the system will not be activated. If the pressure does fall below the setting, current will flow through the switchgauge and the speed switch to energize R1 coil and shut the drill down. The input signal supply source is a magnetic sensor that utilizes an electro-magnetic effect to produce an output signal of electric pulses. The frequency of the electric pulse is determined by the number of flywheel gear teeth passing in front of the sensor in a given time. The pulse frequency is representative of engine speed and therefore is used to cause the speed switch to change states at a frequency equal to 1750 RPM. The magnetic sensor is also used to source the engine tachometer and elapsed time meter.

QSK19 ENGINE PROTECTION SYSTEM

The Cummins Quantum™ fuel system uses an ECM (Electronic Control Module) to operate the devices needed to monitor and vary the operation of the QSK19 engine. It is equipped with an engine protection fault code system and an electronic fuel system fault code system. The system monitors critical engine temperatures, fluid levels, oil and fuel pressures. It will log diagnostic faults when an over, or under, normal operating range condition occurs. If an out-of-range condition exists, engine derate action will be initiated. The operator will be alerted by the illumination of the "Bright Red" light. The warning lamp will start to flash as the out-of-range condition gets worse and engine shut down will occur shortly thereafter (see Figure 7.2-28).

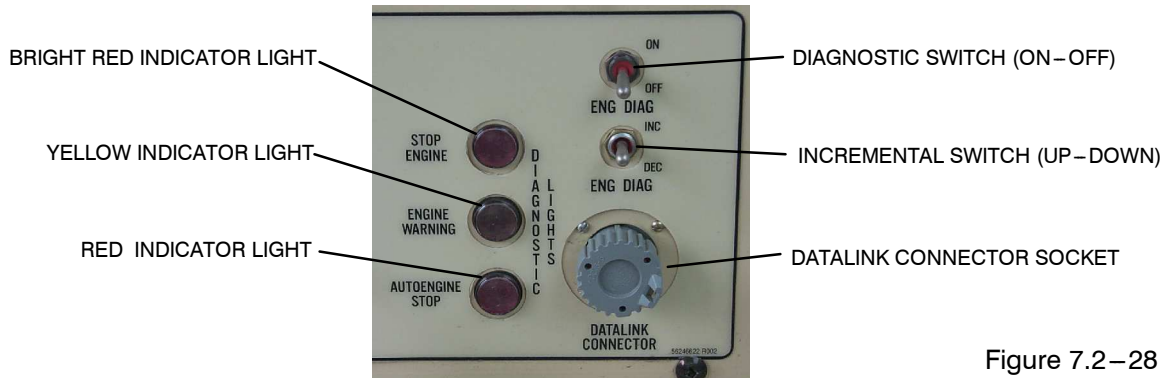


Figure 7.2-28

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSK19 INDICATOR LIGHT SYSTEM

There are three different colored indicator lights on the operator's console (see figure 7.2-28). Each light has its own function:

Bright Red Indicator Light

The Bright Red Indicator Light (see figure 7.2-28) shows fault codes in the Engine Protection System. The Bright Red light signals problems in the Engine Protection System. The Bright Red light will come on when an out-of-range condition occurs. These include:

- a. Coolant Temperature
- b. Coolant Level
- c. Intake Manifold Temperature
- d. Low or Very Low Oil Pressure

The Bright Red light will come on steady when the condition first appears but will change to a blinking light if the condition continues. If the problem is not resolved, the engine will shut down when the condition reaches the preset limit.

Yellow Indicator Light

The Yellow Indicator Light (see figure 7.2-28) signals In-Range Failures of the Engine Protection System, plus battery voltage above or below normal. In the diagnostic mode, the Yellow Light flashes to indicate a fault code is about to be flashed by the Red Light. The Yellow Light blinks before each fault code is signaled by the Red Light.

Red Indicator Light

The Red Indicator Light (see figure 7.2-28) shows fault codes in the Engine Electronic Fuel System. The Red Light signals problems with the ECM, such as a short circuit or lost signals from or to the ECM. It will shut the engine down if any of the fault codes are activated, since the ECM will be unable to control the engine correctly. The Red Light blinks the actual fault code when the diagnostic switch is in the "ON" position.

DIAGNOSTIC FAULT CODES

If you have a laptop computer and the software program "INSITE", you can plug into the console Data Link socket (see figure 7.2-28) and diagnose all the fault codes residing in the ECM. Every code is recorded in the ECM until it is removed by the computer.

There are two types of fault codes: Active and Inactive.

Active fault code means the code is presently active on the engine, i.e., high engine temperature.

Inactive fault code means the code was active at one time but is not active now. An example would be: low coolant level fault code that the operator filled. It is no longer an active code but it will be retained in the ECM.

7.2 - TROUBLESHOOTING (ELECTRICAL)

DIAGNOSTIC FAULT CODES (continued)

Diagnostic Switch

The Diagnostic Switch (see figure 7.2-28) must be in the “OFF” position for normal operation. It will not show fault codes if it is left in the “ON” position.

Incremental Switch

The Incremental Switch (see figure 7.2-28) is a spring centered switch that moves the ECM “UP” one fault code every time it is toggled upward and it moves the ECM “DOWN” one fault code every time it is pushed downward. When it is released, it moves back to the neutral position.

Finding Fault Codes

If you do not have a computer, you may check for active fault codes by using the following steps:

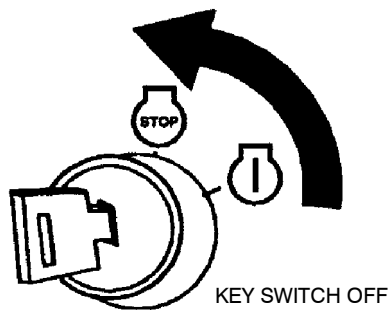
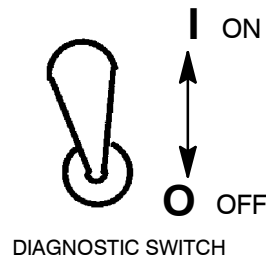


Figure 7.2-29



1. Turn the key switch to the “OFF” position (see figure 7.2-29).
2. Move the diagnostic switch (see figure 7.2-29) to the “ON” position.

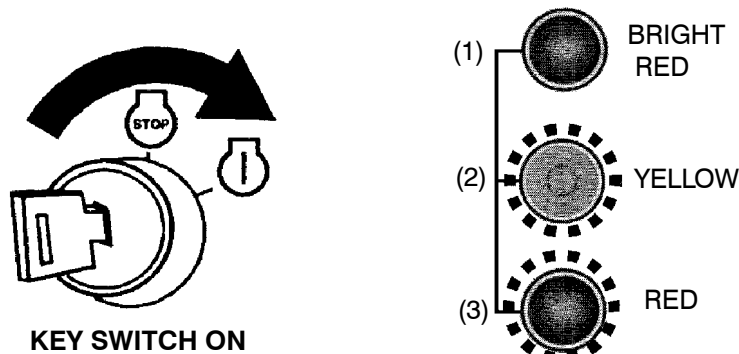


Figure 7.2-30

3. Turn the key switch to the “ON” position (see figure 7.2-30).
4. If no fault codes are recorded, all three lights will come on and stay on.

If fault codes are recorded, all three lights will come on momentarily. The yellow (2) warning and red (3) stop lights will begin to flash the code of the recorded fault. The Bright Red (1) light will not flash.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Engine Protection System Fault Codes

The engine protection system records separate codes when an out-of-range condition is found for any of the sensors in the engine protection system. Engine protection is **only** available when the engine protection feature is enabled.

- a.) Coolant Temperature
- b.) Coolant Level
- c.) Intake Manifold Temperature
- d.) Low or Very Low Oil Pressure

The engine protection system will light the maintenance (yellow) lamp when an out-of-range condition occurs. **Note:** Lamp colors and labels will vary by OEM.

If the engine protection maintenance lamp comes on while the engine is running, it means that a fault code has been recorded. The light will remain on as long as the fault is occurring.

The light will begin to flash if the condition continues to get worse. The engine power and/or speed will be gradually reduced. If the engine protection shutdown feature is enabled, the engine will shut down to prevent engine damage.

READING QSK19 FAULT CODES

The fault code will flash in the following sequence. First, the yellow warning lamp will flash. Then there will be a short 1-second pause when both the yellow and red lights are off. Then the numbers of the recorded fault code will flash in red. There will be a 1-second pause between each number. When the number has stopped flashing, the yellow light will appear again. The number will repeat in the same sequence.

The lights will continue to flash the same fault code until the system has advanced to the next active fault code. To go to the second fault code, move the incremental switch to "+", then release it (figure 7.2–31). You can also go back to the previous fault code by moving the switch to "-", then releasing it. To check the third or fourth fault code, move the switch to "+", then release it when all active codes have been viewed. Moving the switch to "+" will go back to the first fault code.

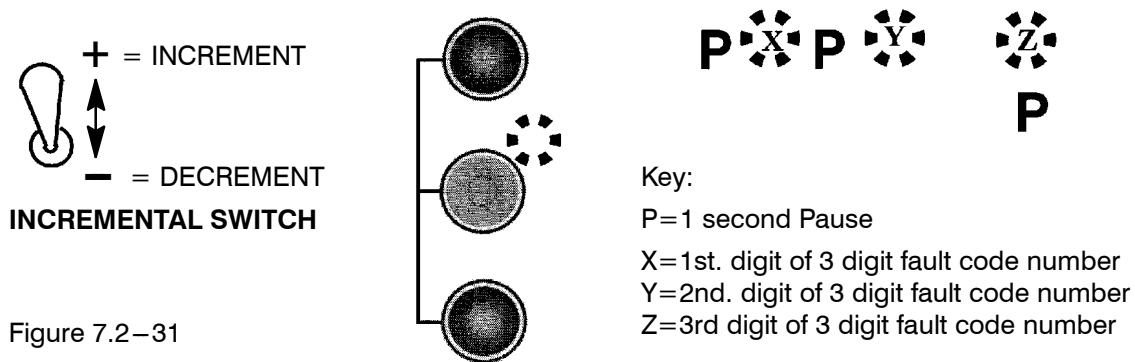


Figure 7.2–31

There is a one second pause between each digit of the 3-digit code number. When all three digits of the number have been signalled, the yellow light will flash again.

7.2 - TROUBLESHOOTING (ELECTRICAL)

READING QSK19 FAULT CODES (continued)

Fault Code Example

To show exactly what a sequence would look like, let's suppose that a Bright Red light comes on and after a few minutes, starts to blink. The operator should stop the engine as soon as possible and determine the cause. He turns the key switch "OFF" and turns the diagnostic switch "ON". This starts the sequence of fault code lights flashing. The sequence for a Fault Code 235 would look like the sequence shown in the table below.

The yellow light comes on and flashes once. The red light flashes the first number, in this case a two (2). Then the red light goes out for one second and starts the next number, a three (3). Again a one second pause, then the final number five (5). The fault code is 235, or low coolant level (see Fault Code Tables for a description of the fault codes).

Since the fault code started as a Bright Red light, the problem was an out-of-range condition, i.e., low oil pressure, low coolant level, high temperature or high manifold temperature.

Example of Sequence for a Fault Code							
Yellow Light	Pause	Red Light 1st Digit X=blink count	Pause	Red Light 1st Digit X=blink count	Pause	Red Light 1st Digit X=blink count	Fault Code= XYZ
Flash = 1 Blink	1 sec.	X	1 sec.	Y	1 sec.	Z	XYZ
1		2		3		5	235

To stop the diagnostic system, move the diagnostic switch to the OFF position. Turn the engine key switch to the OFF position.

QSK19 The explanation and correction of all fault codes is in the troubleshooting charts of the QSK19 Operation and Maintenance manual, available from Cummins.

QSX15 The explanation and correction of all fault codes is in the troubleshooting charts of the QSX15 fuel manual, available from Cummins. Refer to the Troubleshooting and Repair Manual, Electronic Control System, Signature, ISX and QSX15 Engines, and Bulletin No. 3666259.

Electronic fault code troubleshooting trees are in ascending numerical order.

When a diagnostic fault code is recorded in the ECM, ECM input and output data are recorded from all sensors and switches. Snapshot data allow the relationships between ECM inputs and outputs to be viewed and used during troubleshooting.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 FAULT CODE TABLES

The fault codes for the Bright Red light, which are the most common, are shown in the *Bright Red Light (Engine Protection)* Table. With the exception of code 432, most other codes can be acted on by the operator.

Bright Red Light (Engine Protection) Fault Codes

Bright Red Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
143	Oil Pressure Sensor–Data Below Normal Range	1
151	Engine Coolant Temperature Sensor–Data above Normal Range	0
155	Intake Manifold Temperature Sensor–Data Above Normal Range	0
219	Oil Level Low	1
233	Coolant Pressure Level Low	1
235	Engine Coolant Level–Data above Normal Range	1
253	Oil Level Sensor–Low Oil Level Detected	1
261	Fuel Temperature High	0
292	OEM Temperature Out of Range	14
296	OEM Pressure Sensor Out of Range	14
415	Oil Pressure Sensor–Very Low Oil Pressure	1
432	Throttle Position Idle Validation Switch–Switch Position and Throttle Percent Mismatch Failure	13
471	Very Low Oil Level Detected	1
555	High Blowby Pressure Detected	0
649	Maintenance Monitor Interval Warning Level Has Been Reached	0

Yellow Light Fault Codes

The failures caused by yellow (and red) lights indicate wiring problems or internal ECM malfunctions that the operator cannot repair. Call your local dealer if a yellow (or red) light comes on. Examples of the fault codes are shown tabulated in tables.

Yellow Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
113	Timing Actuator–Component Shorted High	3
114	Timing Actuator–Component Shorted Low	4
118	Fuel Pump Pressure Sensor–Failed High	3
119	Fuel Pump Pressure Sensor–Failed Low	4

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 FAULT CODE TABLES (continued)

Yellow Light Fault Codes (continued)

Yellow Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
121	Engine Speed Sensor (ESS) – One Lost Signal	10
122	Boost Pressure Sensor – Component Shorted High	3
123	Boost Pressure Sensor – Component Shorted Low	4
135	Oil Pressure Sensor – Component Shorted High	3
141	Oil Pressure Sensor – Component Shorted Low	4
144	Engine Coolant Temperature Sensor – Component Shorted High	3
145	Engine Coolant Temperature Sensor – Component Shorted Low	4
153	Intake Manifold Temperature Sensor – Component Shorted High	3
154	Intake Manifold Temperature Sensor – Component Shorted Low	4
221	Ambient Air Pressure Sensor – Component Shorted High	3
222	Ambient Air Pressure Sensor – Component Shorted Low	4
223	Burn Valve Solenoid – Shorted Low	4
225	Makeup Valve Solenoid – Shorted Low	4
231	Coolant Pressure Sensor – Failed High	3
232	Coolant Pressure Sensor – Failed Low	1
237	Input Throttle Signal – Data Above or Below Normal Range	2
252	Oil Level Sensor Error	2
263	Fuel Temperature Sensor – Failed High	3
265	Fuel Temperature Sensor – Failed Low	4
293	OEM Temperature Sensor – Failed High	3
294	OEM Temperature Sensor – Failed Low	4
297	OEM Pressure Sensor – Failed High	3
298	OEM Pressure Sensor – Failed Low	4
316	Fuel Pump Actuator Is Open	3
318	Actual and Desired Fuel Pump Pressures Are Out of Range	7
343	Electronic Control Module (ECM) – Internal Communication Error	12
346	Electronic Control Module (ECM) – Powerdown Error	12
349	Tailshaft Governor at Greater Frequency than Threshold	0
384	Ether Injection Solenoid – Open or Shorted	11
422	Engine Coolant Level Sensors Signals – Data Invalid	2
423	Fuel Timing Pressure Sensor – In Range Failure	2

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 FAULT CODE TABLES (continued)

Yellow Light Fault Codes (continued)

Yellow Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
426	ECM Can Not Transmit On J1939 Datalink	3
427	ECM Can Not Transmit On J1939 Datalink at Acceptable Rate	9
431	Throttle Position Idle Validation Switch – Invalid	2
441	Battery Voltage, Unswitched – Data Below Normal Engine Range	1
442	Battery Voltage, Unswitched – Data Above Normal Engine Range	0
467	Error Between Desired Timing Fueling and Commanded Timing Fueling Exceeds Normal Limit	2
468	Error Between Desired Rail Fueling and Commanded Timing Fueling Exceeds Normal Limit	2
473	Remote Oil Level Sensor Error	2
487	Ether bottle Empty	1
489	Auxiliary Speed Frequency – Below Threshold	1
497	Multiple Unit Synchronization Switch Error	2
524	Alternator Droop Switch Fault	2
527	Dual – Output A Signal – Open or Short Circuit	3
529	Dual – Output B Signal – Open or Short Circuit	3
554	Fuel Pressure Sensor – In Range Failure	2
719	Crankcase Blowby Pressure – Failed High	3
729	Crankcase Blowby Pressure – Failed Low	4
777	Calculated Turbine Inlet Temperature or Calculated Compressor Discharge Temperature Has Exceeded Calibrated Limit	0

Red Light Fault Codes

The failures caused by red (and yellow) lights indicate wiring problems or internal ECM malfunctions that the operator cannot repair. Call your local dealer if a red (or yellow) light comes on. Examples of the fault codes are shown tabulated in tables.

Red Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
111	Electronic Control Module (ECM) – Memory Failure	12
112	Timing Actuator – Fueling Flow Mismatch	7
115	Engine Speed Sensor (ESS) – Both Signals Lost	2
116	Fuel Timing Pressure Sensor – Component Shorted High	3
117	Fuel Timing Pressure Sensor – Component Shorted Low	4

7.2 - TROUBLESHOOTING (ELECTRICAL)

CUMMINS QSK19 FAULT CODE TABLES (continued)

Red Light Fault Codes (continued)

Red Light illuminates = ON		
Fault Code	Description of Problem	Failure Mode Indicator
131	Throttle Position Sensor–Component Shorted High	3
132	Throttle Position Sensor–Component Shorted Low	4
133	Remote Throttle Position Sensor–Failed High	3
134	Remote Throttle Position Sensor–Failed Low	3
147	Frequency Throttle Signal–Less than 100 Hz	8
148	Frequency Throttle Signal–More than 1500 Hz	8
234	Engine Speed–Data Above Normal Range	0
254	Fuel Shutoff Valve–Component Shorted Low	4
259	Fuel Shutoff Valve–Component Stuck Open	7
451	Fuel Pressure Sensor–Component Shorted High	3
452	Fuel Pressure Sensor–Component Shorted Low	4
455	Rail Actuator–Component Shorted High or Open	3
511	Rail Actuator–Component Shorted Low	4
514	Rail Actuator–Fueling Flow Mismatch	7
551	No Voltage Detected on Both of the Idle Validation Off–Idle and Idle–Signal Pins	4
553	Engine Fueling Pressure Exceeded–Data Above Normal Range	0

No Fault Lamp

Fault Code	Description of Problem	Failure Mode Indicator
299	Engine Shutdown without Key Before Proper Cool down	31
611	Engine Shutdown by Operator Before Proper Cool down	31
753	Engine Position Sensor Signals Do Not Match	2

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 SENSORS AND ELECTRICAL COMPONENTS

Drills equipped with **QSX15** engines are equipped with several shutdown devices to prevent harm to the engine or compressor in case of loss of fluids or other related problems. There is a Compressor Discharge Temperature Switch, an Engine coolant Temperature Switch and an Engine Oil Pressure Shutdown switch.

Compressor Discharge Temperature Switch

The discharge temperature gauge is on the operator's console. The discharge air temperature gauge shows the temperature of the oil and air leaving the air end. The temperature dial range is 140–300°F (60–149°C). Normal operating temperatures are 180°–230°F (82°–110°C).

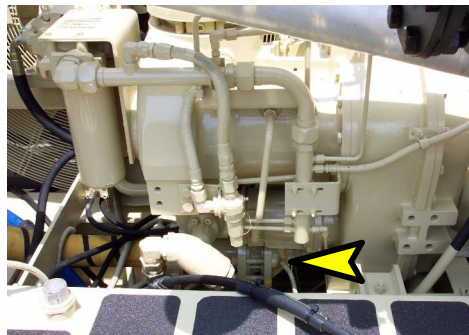


Figure 7.2–32

COMPRESSOR SHUTOFF SWITCH

In a **QSX15** engine, the temperature shutdown switch is located on the compressor as shown in (figure 7.2–32) and spliced into engine start wire #38. When the temperature increases to 248°F (120°C), the switch cuts the power to the engine.

NOTICE: The temperature sensing bulb must be immersed in coolant or some other medium to send temperature changes to the switch. Loss of coolant will leave the bulb dry, which prevents the switch from responding quickly to increasing temperatures, making it useless.

Engine Oil Pressure/Temperature Sensor

The engine oil pressure gauge, mounted on the operator's control panel, shows the pressure that is required to circulate oil inside the engine. The oil pressure/temperature sensor, located on the fuel pump side of the engine (see figure 7.2–33), monitors lubricating oil pressure and temperature for the engine protection system. The temperature dial range is 0–100°F (–18.8°C thru 37.8°C).

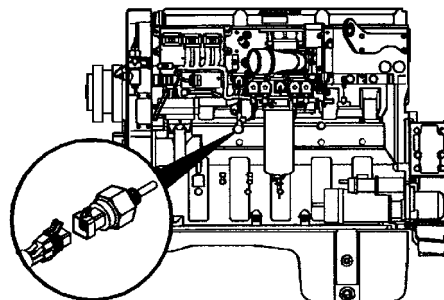


Figure 7.2–33

OIL PRESSURE / TEMPERATURE SENSOR

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 SENSORS AND ELECTRICAL COMPONENTS (continued)

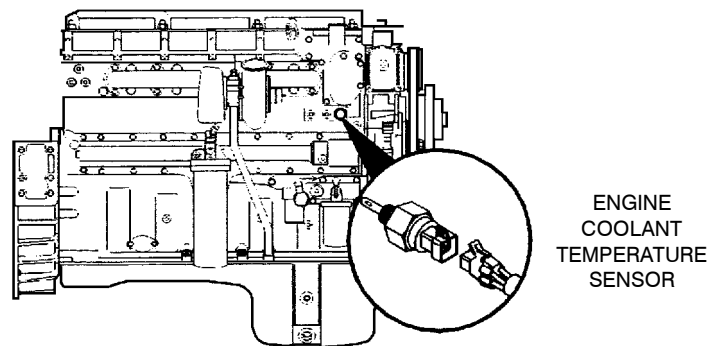
Engine Oil Pressure/Temperature Sensor (continued)

⚠ WARNING

Low engine oil pressure is an undesirable operating condition. When a low oil pressure condition exists in the engine, there is a possibility of damage to major engine components. Low oil pressure protection is a safety feature that will take the necessary measures in order to initiate an engine shutdown in the event of a low oil pressure condition.

Engine Coolant Temperature Sensor

The water temperature gauge is mounted on the operator's control panel. The temperature dial range is 130–250°F (54–121°C). The engine coolant temperature sensor, located in the thermostat housing (see figure 7.2–34), monitors engine coolant temperature used in the fuel control function and engine protection system. When the temperature increases to 210°F (99°C), the sensor cuts the power to the engine.



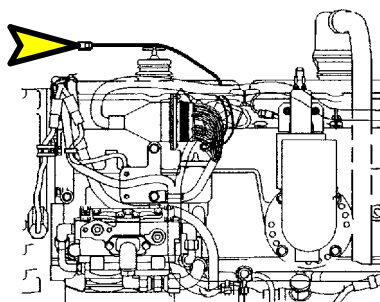
ENGINE
COOLANT
TEMPERATURE
SENSOR

Figure 7.2–34

NOTICE: The temperature sensing bulb must be immersed in coolant or some other medium to send temperature changes to the switchgauge. Loss of coolant will leave the bulb dry, which prevents the switchgauge from responding quickly to increasing temperatures, making it useless. An engine can be destroyed from loss of coolant.

Engine Coolant Level Sensor

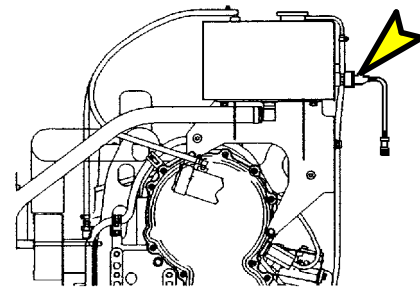
The coolant level sensor is an optional sensor, mounted in the radiator top tank or surge tank, depending on the OEM. It is a fluid level actuated switch required for the engine protection system. This sensor monitors the engine coolant in the cooling system expansion tank. The coolant level sensor signal is sent to the ECM for the purpose of engine monitoring.



VIEW OF TYPICAL ENGINE WITH
ELECTRONIC CONTROLS (PRE TIER II)

LOCATION OF COOLANT
LEVEL SENSOR

Figure 7.2–35



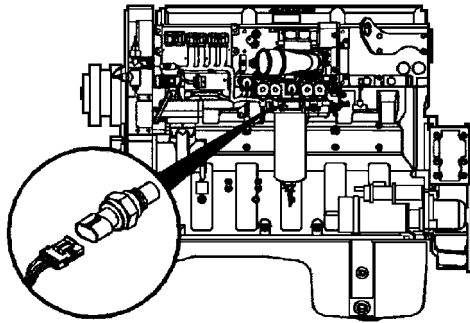
VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 CUMMINS SENSORS AND ELECTRICAL COMPONENTS (continued)

Fuel Pressure Sensor

The fuel pressure sensor, located on the integrated fuel system module, monitors actuator supply rail pressure. For more information, refer to the actual manufacturer Troubleshooting Guide for this engine.



LOCATION OF FUEL PRESSURE SENSOR

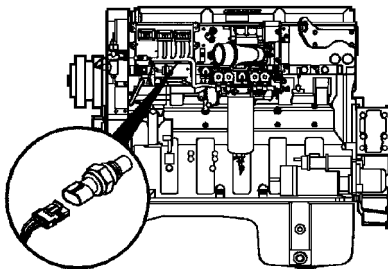
VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

Figure 7.2–36

For more information on fuel system maintenance, refer to the maintenance section in the actual manufacturer Operation and Maintenance Manual.

Ambient Air Pressure Sensor

The ambient air pressure sensor is located on the fuel pump side of the engine, just below the ECM. It is used to control fueling.



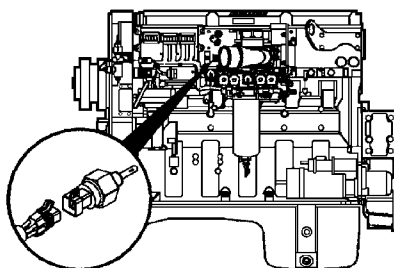
LOCATION OF AMBIENT AIR PRESSURE
SENSOR

VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

Figure 7.2–37

Intake Air Pressure/Temperature Sensor

The intake air pressure/temperature sensor, located in the front of the intake air connection, monitors positive manifold pressure and turbocharged intake air temperature. Both are used in the fuel control function. The intake air pressure/temperature sensor is also used in the engine protection system.



LOCATION OF INTAKE AIR
PRESSURE/TEMPERATURE SENSOR

VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

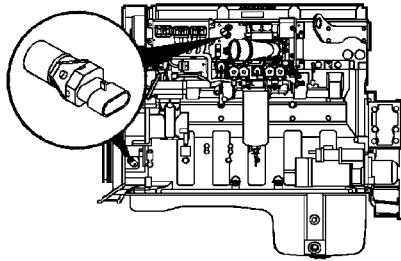
Figure 7.2–38

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 CUMMINS SENSORS AND ELECTRICAL COMPONENTS (continued)

Engine Cam and Crank Position Sensors

The engine cam and crank position sensors provide engine speed and position information. The cam position sensor is located between the ECM and fuel pump. The crank position sensor is located below the air compressor drive or the barring device.



LOCATION OF ENGINE CAM AND
CRANK POSITION SENSORS

VIEW OF TYPICAL TIER II ENGINE
WITH ELECTRONIC CONTROLS

Figure 7.2–39

QSX15 ENGINE DIAGNOSTICS

Self-Diagnostics

Tier II Electronic Engines have the capability to perform a self-diagnostic test. When the system detects an active problem, the “DIAGNOSTIC” lights on the Murphy Display and Diagnostic Module (MDDM) are activated (see Figure 7.2–40). Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the the MDDM diagnostic lights or OEM engine electronic service tools.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to diagnostic code retrieval and the diagnostic code charts for more information on retrieving engine diagnostic codes.

Active codes represent problems that currently exist. These problems should be investigated first. If a code is active, the “DIAGNOSTIC” lamp will flash the flash code at five second intervals.

Logged codes may represent intermittent problems, recorded problems or performance history.

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

Scroll Toggle

The Scroll Up button on the MDDM moves the ECM “UP” one fault code every time it is pushed. The Scroll Down button on the MDDM moves the ECM “DOWN” one fault code every time it is pushed.

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 ENGINE DIAGNOSTICS (continued)

Diagnostic Lights

The diagnostic LED is used to indicate the existence of an active fault by flashing codes. When a fault occurs, the amber LED will be illuminated during Active Service Code warning faults, and the red LED will be illuminated during shutdown faults.

1. The LED lamp will come on and will remain on for five seconds. This checks the operation of the lamp.
2. The LED lamp will turn off.
3. The LED lamp will come on again and the lamp will flash codes for any active diagnostic codes. Not all diagnostic codes have a unique flash code.
4. The LED lamp will turn off for five seconds.
5. The LED lamp repeats all active diagnostic codes.

A fault diagnostic code will remain active until the problem is repaired. The electronic control module will continue flashing the flash code at five second intervals until the problem is repaired.

Diagnostic Flash Code Retrieval

You can use the LED lamps to determine the diagnostic flash code. Not all diagnostic codes have a unique flash code. **Note:** Flash codes should only be used to indicate the nature of a diagnostic condition. Do not use flash codes to perform detailed troubleshooting.

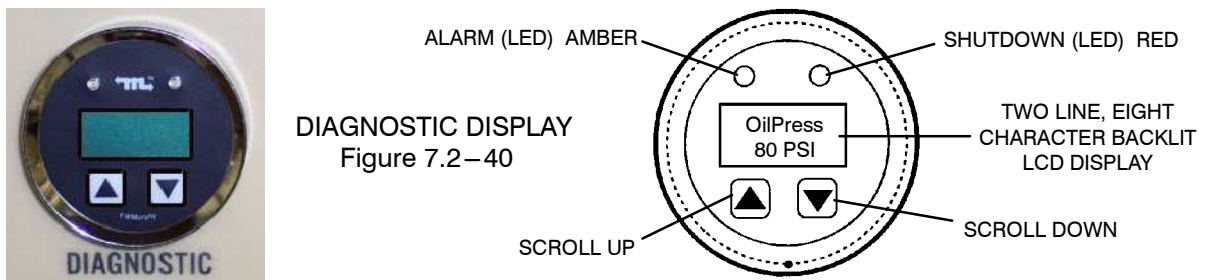
Use the following procedure to retrieve the diagnostic codes with the engine DIAGNOSTIC lamp:

1. The LED lamp will flash to indicate a code (two-digit code for Cat engines or a three digit code for Cummins engines). The sequence of flashes represents the system diagnostic message. Each digit of the code can be determined by counting the number of flashes. The lamp flashes at a rate of two times per second. The lamp will pause for one second between digits. The lamp will pause for two seconds between codes.
2. Turn the ignition key (start/run key) to the ON position. The engine does not need to be started in order to view codes. The engine does not need to be running while the ignition switch (start/run switch) is in the ON position. The LED lamp blinks on and off at five second intervals.
 - a). When the ignition key (start/run key) is in ON position, the lamp is checked for proper operation. If there are any active codes, except for Code 34, the codes are displayed at this time. **Note:** The LED lamp will illuminate for five seconds. The lamp will stay on if there is an active diagnostic code.
3. Active diagnostic codes will always be flashed. There is no toggle switch that will shut off the lamp.

7.2 - TROUBLESHOOTING (ELECTRICAL)

TIER II ENGINE DIAGNOSTIC MODULE

QSX15 engines use the Murphy Display and Diagnostic Module (MDDM) for instrumentation and control for Tier II electronically controlled engines communicating using the SAE J1939 Controller Area Network (CAN).



Description

The MDDM is a powerful, easy to use multifunction tool that enables the operator to view many different engine parameters in English or Metric units (when applicable) and engine service codes. The MDDM includes a two line, eight character backlit LCD display. The top line displays data labels, i.e. "OilPress". The bottom line displays appropriate units information i.e. "80 psi" for oil pressure (see Figure 7.2-40).

The MDDM has two push buttons (UP and DOWN) for scrolling through the parameter list and viewing the menu list. Two LED's (amber and red) are used to signal active fault messages received by the MDDM.

Other components in the system are microprocessor-based analog gauges for displaying critical engine data broadcast by the ECM: engine RPM, oil pressure, coolant temperature, interstage pressure and discharge temperature.

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS

The MDDM is simple to use and allows quick and easy navigation through the menu structure to find the information needed. The MDDM Main Menu Tree (below) first displays engine data parameters, followed by the sub-menu entry points. **Note:** When first powered up, some unused parameters may be displayed by the MDDM. The parameters will be automatically removed from the display after the initialization cycle is complete.

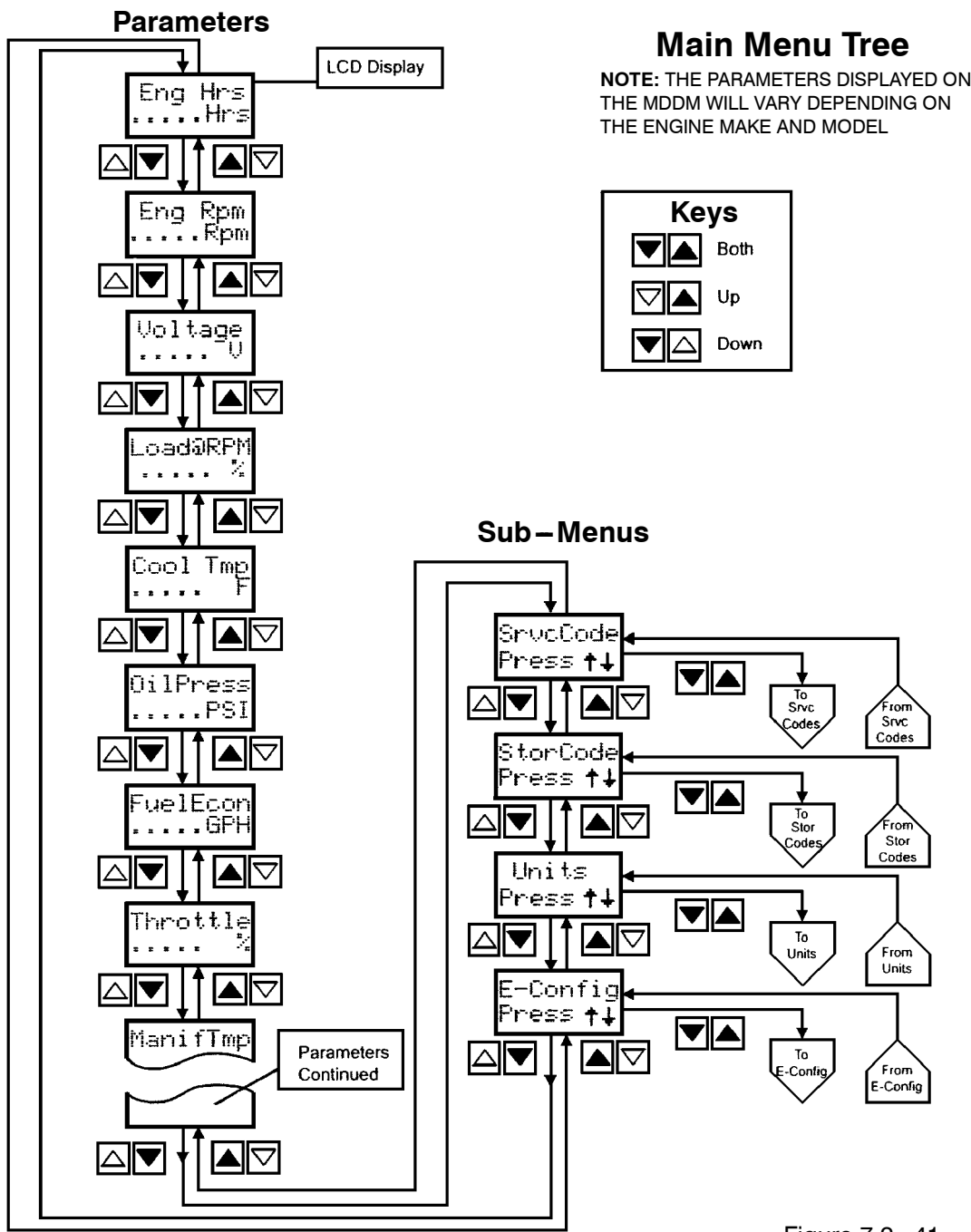


Figure 7.2–41

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS (continued)

The following two rules are used for accessing the various items on the main menus:

1. To scroll through the parameter list, press either the UP or DOWN push buttons.
2. To select or exit from a sub-menu, SIMULTANEOUSLY press the UP and DOWN push buttons.

Selecting Engine Data Parameters

To read any of the engine parameters, press either the UP or DOWN button until the top line of the display shows the desired information.

Selecting Sub-Menus

Press either the UP or DOWN button until the top line of the display shows the label of the desired Sub-Menu. Then press BOTH the UP and DOWN buttons SIMULTANEOUSLY. This action will select the Sub-Menu and the next screen on the display will list the Sub-Menu items.

Changing Units of Measure

The MDDM can display engine data in either English or Metric units. To select English or Metric, the Units Sub-Menu must be selected. To select the Units Sub-Menu, press the UP or DOWN button until the display shows the following label:

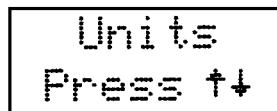


Figure 7.2–42

Press BOTH the UP and DOWN buttons SIMULTANEOUSLY to select the Units Sub-Menu. The Units Sub-Menu Figure (below) shows the steps for selecting the desired units of measure. Two options are available:

1. Press BOTH buttons to retain the current units designation.
2. Press either UP or DOWN button to toggle the units selection, then press BOTH buttons to select the desired measure.

See Units Sub-Menu flow chart on next page.

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS (continued)

Changing Units of Measure (continued)

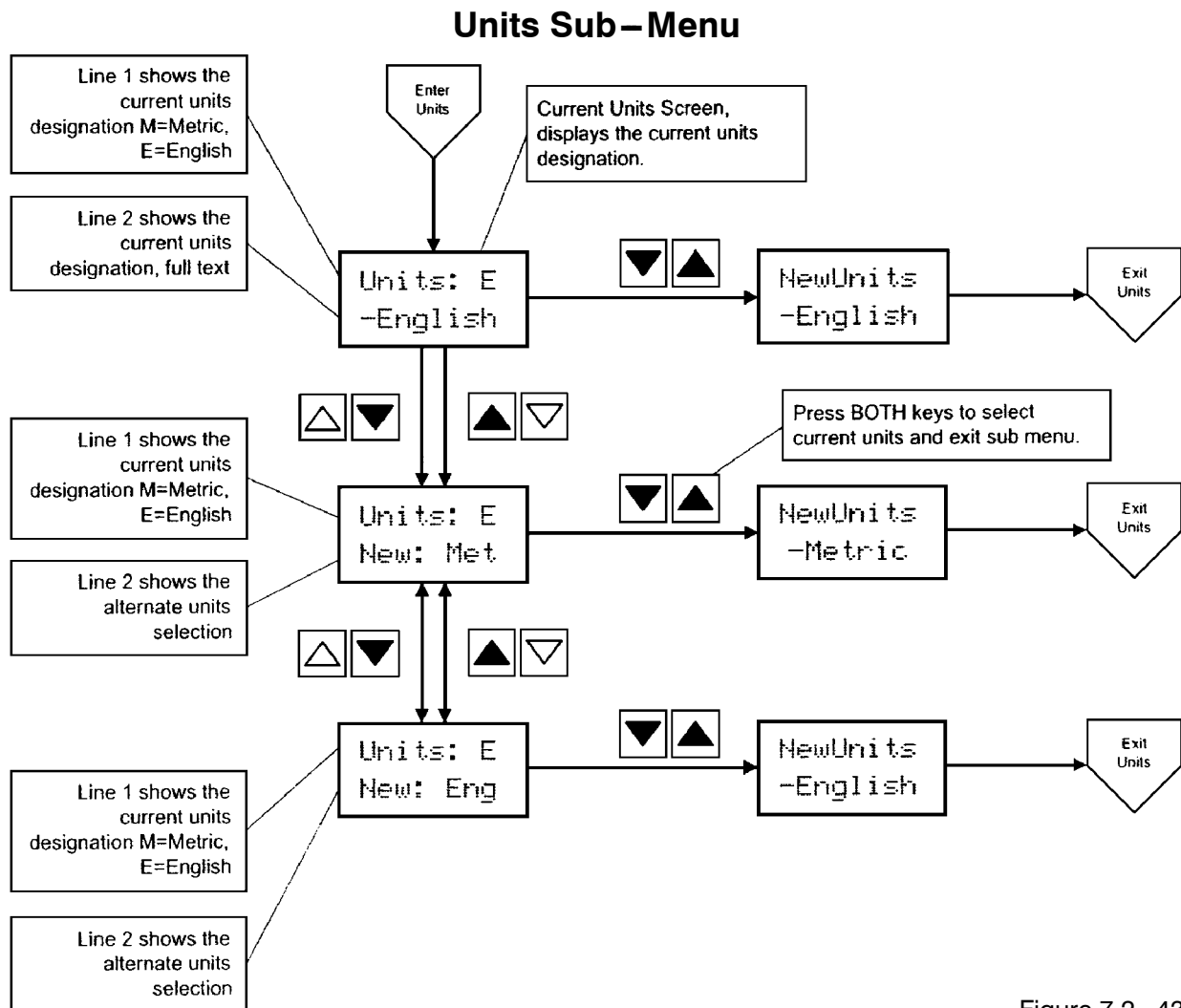
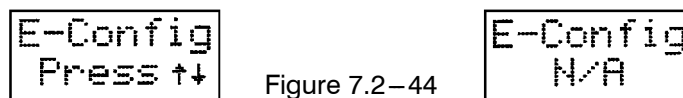


Figure 7.2–43

Viewing Engine Configuration Data

The MDDM can display the engine configuration data stored in the engine ECM. To select the Engine Configuration Sub-Menu (shown on next page), press the UP or DOWN button until the display shows the following label:



Press **BOTH** the UP and DOWN buttons **SIMULTANEOUSLY** to select the engine configuration Sub-Menu. The MDDM will display the engine configuration data as shown in Engine Configuration Sub-Menu. If the Engine Configuration is not available, the display will show (see above right side).

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS (continued)

Viewing Engine Configuration Data (continued)

NOTE: The parameters displayed on the MDDM will vary depending on the engine make and model

Engine Configuration Sub-Menu

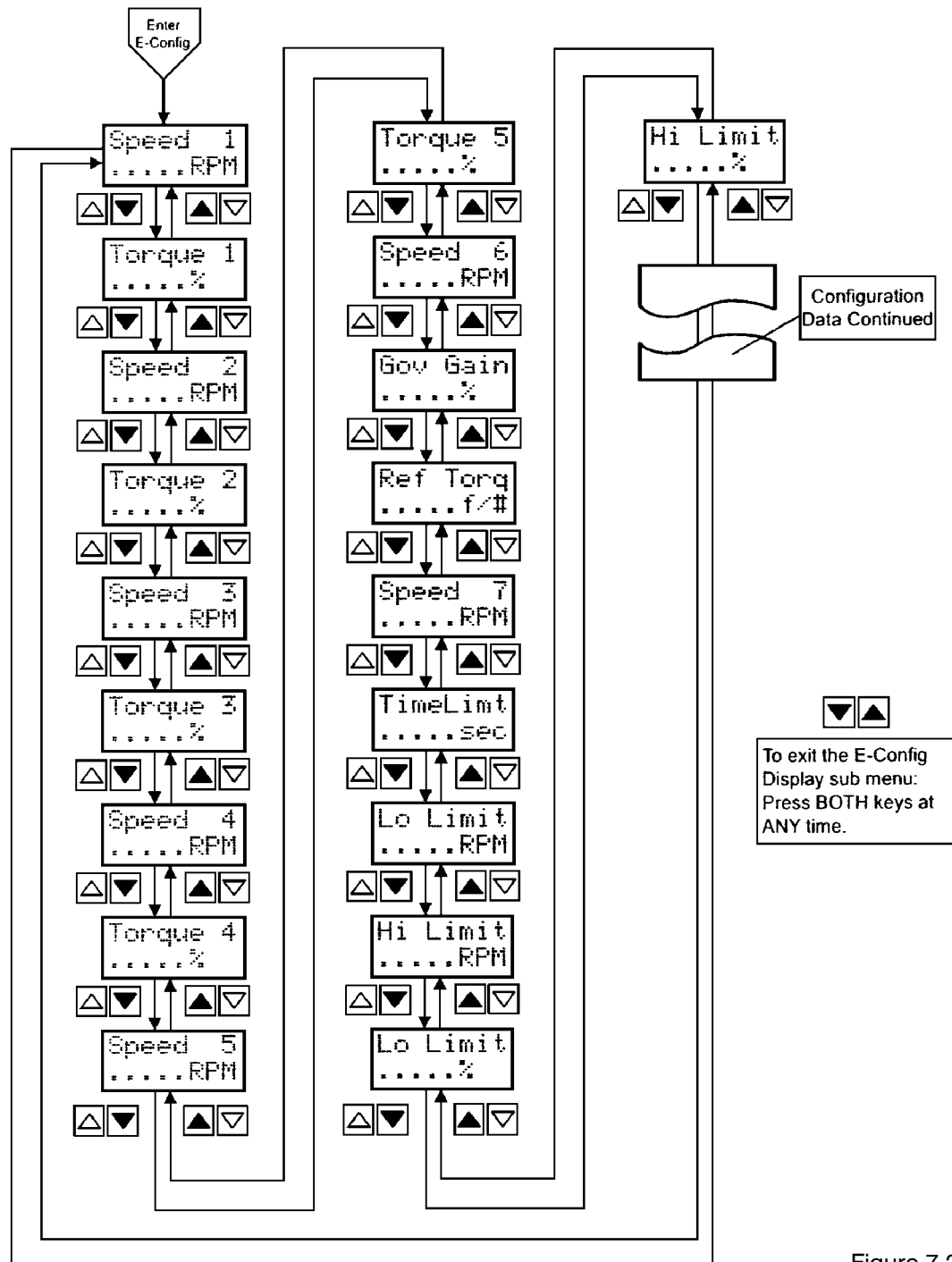


Figure 7.2–45

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS (continued)

Viewing Active Engine Service Codes

The MDDM continuously monitors all messages broadcast over the SAE J1939 Control Area Network (CAN) and displays all Active Service Codes at the time the message is broadcast. When a fault occurs the display will show the message “SrvcCode” every five seconds interrupting the currently displayed parameter. **In addition, the amber LED will be illuminating during Active Service Code warning faults, and the red LED will be illuminated during shutdown faults.** These warnings will continue until the fault clears.

To view the Active Service Codes, select the Service Code Sub-Menu by pressing the UP or DOWN button until the display shows the label shown below on the left.

SrvcCode
Press ↑↓

Figure 7.2–46

SrvcCode
No Codes

Press both the UP and DOWN buttons SIMULTANEOUSLY to select the Service Code Sub-Menu. The MDDM will display all Active Service Codes as shown in the Service Codes Menu schematic (below). If Service Codes are not available, the display will show “SrvcCode No Codes” as shown above.

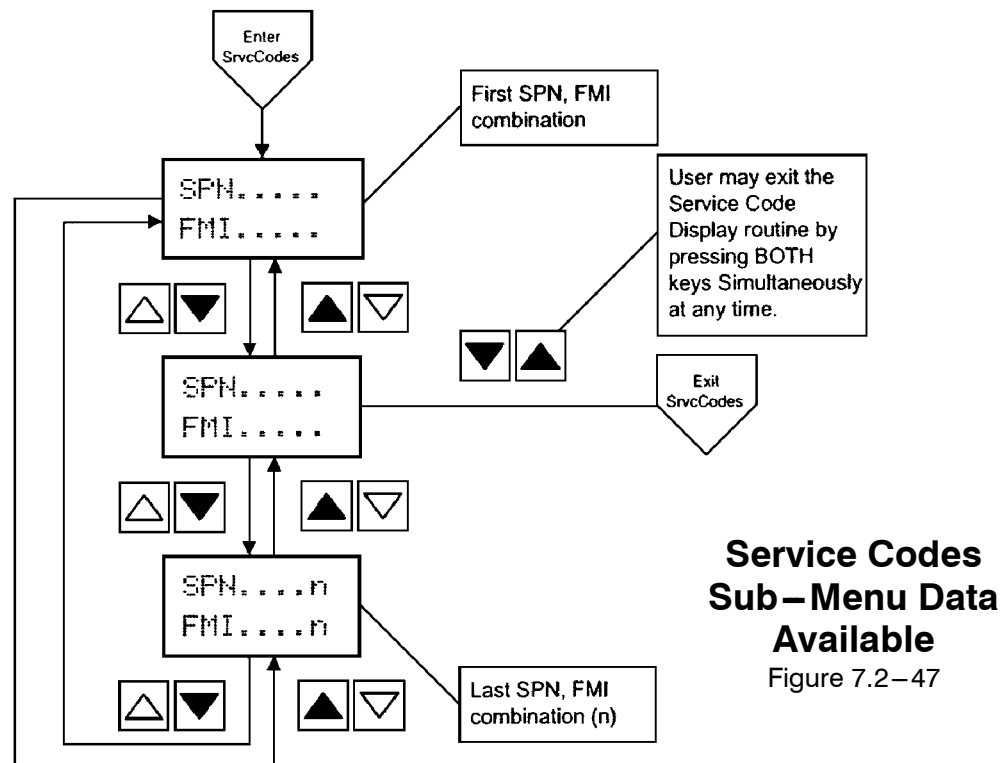


Figure 7.2–47

Explanation of SPN & FMI Diagnostic Codes

SPN refers to Suspect Parameter Number and FMI refers to Failure Mode Identifier. Both the SPN and FMI are used in the J1939 standard for identification of faults and conditions.

7.2 - TROUBLESHOOTING (ELECTRICAL)

MDDM OPERATING INSTRUCTIONS (continued)

Viewing Service Codes in the Engine Control Module (ECM)

The MDDM can request Stored Service Codes (DM2) from the engine. The Stored Service Codes may be used for diagnostic and service needs. To view the Stored Service Codes it is necessary to select the “StorCode” Sub-Menu by pressing the UP or DOWN button until the display shows the following label.

StorCode
Press ↑↓

Figure 7.2–48

StorCode
No Data

Press both the UP and DOWN buttons SIMULTANEOUSLY to select the StorCodes Sub-Menu. The MDDM will display the Stored Service Codes according to the menus shown in the schematic below. If Stored Service Codes are not available, the display will show “StorCode No Data” as shown above.

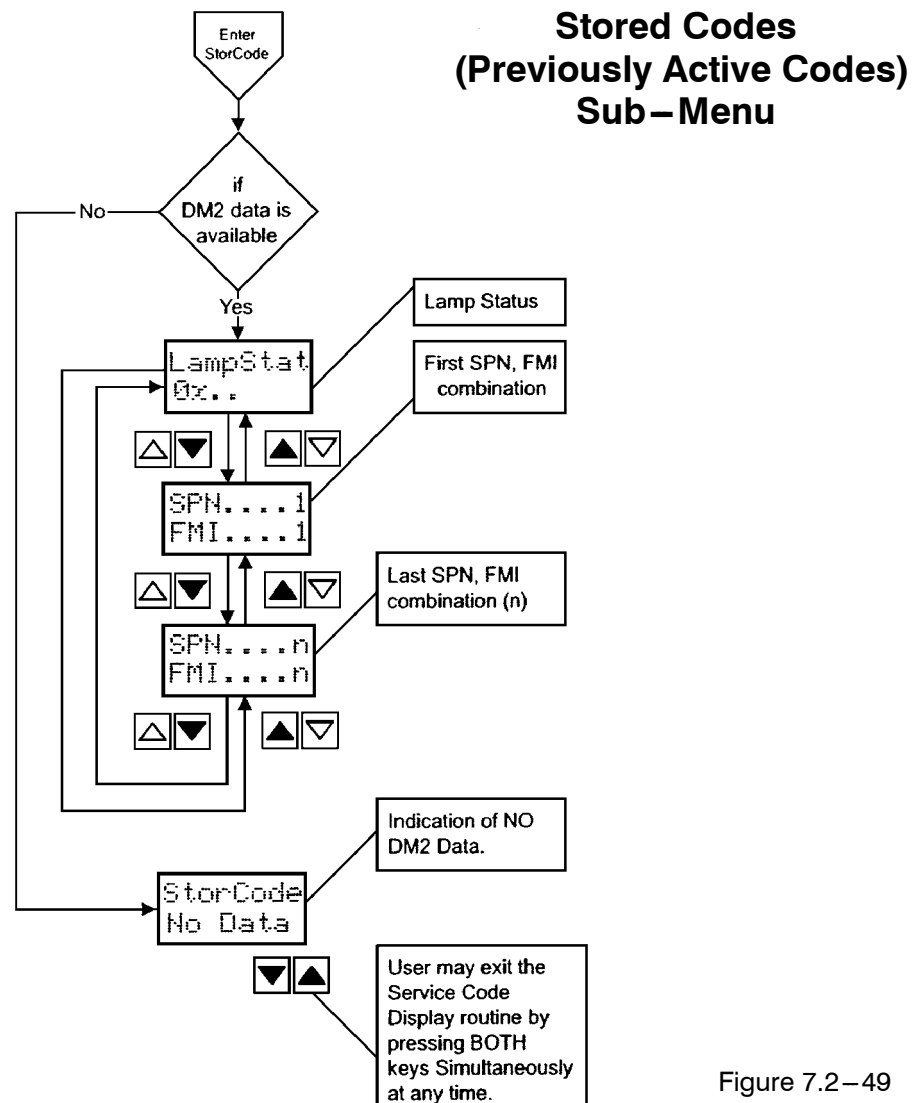


Figure 7.2–49

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTIC CODES

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
00	545-05	545-05	Ether Start Relay open/short to +batt				
	545-06	545-06	Ether Start Relay short to ground				
12	266-02	266-02	Incorrect Crank-without-inject inputs				
13	174-03	174-03	Fuel Temperature open/short to +batt				
	174-04	174-04	Fuel Temperature short to ground				
21	262-03	620-03	5 Volt Sensor DC Power Supply short to +batt				
	262-04	620-04	5 Volt Sensor DC Power Supply short to ground				
	263-03	678-03	Digital Sensor Supply short to +batt				
	263-04	678-04	Digital Sensor Supply short to ground				
24	100-03	100-03	Engine Oil Pressure open/short to +batt				
	100-04	100-04	Engine Oil Pressure short to ground				
26	274-03	108-03	Atmospheric Pressure open/short to +batt				
	274-04	108-04	Atmospheric Pressure short to ground				
27	110-03	110-03	Engine Coolant Temperature open/short to +batt	X	X	X	
	110-04	110-04	Engine Coolant Temperature short to ground	X	X	X	
28	91-13	91-13	Throttle Position calibration required		X	X	
32	91-08	91-08	Throttle Position signal abnormal		X	X	

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTIC CODES (continued)

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
34	320-02	190-02	Speed/Timing Sensor Loss of Signal	X			X (1)
	320-11	190-11	Speed/Timing Sensor mechanical failure	X			X (1)
	342-02	723-02	Loss of Secondary Engine Speed Signal	X			X (1)
	342-11	723-11	Secondary Engine Speed Sensor mechanical failure	X			X (1)
37	94-03	94-03	Fuel Pressure open/short to +batt				
	94-04	94-04	Fuel Pressure short to ground				
	175-03	175-03	Engine Oil Temperature open/short to +batt				
	175-04	175-04	Engine Oil Temperature short to ground				
38	172-03	172-03	Intake Manifold Air Temperature open/short to +batt	X	X	X	
	172-04	172-04	Intake Manifold Air Temperature short to ground	X	X	X	
42	261-13	228-13	Engine Timing calibration required	X	X	X	X
51	168-02	168-02	System Voltage intermittent/erratic	X	X		X
53	254-12		Electronic Control Module Error	X	X	X	X
56	253-02	234-02	Personality Module mismatch				X(2)
	268-02	1111-02	Check Programmable Parameters		X	X	
58	247-09	639-09	J1939 Data Link communications				
72	1-11	651-11	Injector Cylinder #1 fault	X	X		
	2-11	652-11	Injector Cylinder #2 fault	X	X		

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTIC CODES (continued)

Possible Performance Effect of Active Diagnostic Codes							
Flash Code	CID-FMI Code	SPN-FMI Code	Description of Code	Engine Misfires	Low Power	Reduced Engine Speed	Engine Shutdown
73	3-11	653-11	Injector Cylinder #3 fault	X	X		
	4-11	654-11	Injector Cylinder #4 fault	X	X		
74	5-11	655-11	Injector Cylinder #5 fault	X	X		
	6-11	656-11	Injector Cylinder #6 fault	X	X		

- (1) The engine will shut down if both speed/timing sensors are lost.
 (2) Fuel injection will not occur and the engine will not start

Event Codes

The ECM can log events. Events refer to engine operating conditions such as low oil pressure or high coolant temperature. The following table is a cross reference for event codes. Logged events usually indicate a mechanical problem instead of an electronic system problem

Cross-Reference for Event Codes			
Flash Codes	EID Codes	SPN-FMI Codes	Description of Code
35	004	0190-16	Engine Overspeed Shutdown
63	005	0094-15	Fuel Filter Restriction Derate
63	006	0094-16	Fuel Filter Restriction Shutdown
61	015	0110-16	High Engine Coolant Temperature Derate
61	016	0110-00	High Engine Coolant Temperature Shutdown
61	017	0110-15	High Engine Coolant Temperature
64	025	0172-16	High Inlet Air Temperature Derate
64	027	0172-15	High Inlet Air Temperature Warning
46	039	0100-18	Low Engine Oil Pressure Derate
46	040	0100-01	Low Engine Oil Pressure Shutdown
65	054	0174-16	High Fuel Temperature Derate
65	055	0174-00	High Fuel Temperature Shutdown
65	056	0174-15	High Fuel Temperature Warning

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTIC CODES (continued)

Event Codes (continued)

Cross-Reference for Event Codes			
Flash Codes	EID Codes	SPN-FMI Codes	Description of Code
62	057	0111-18	Low Engine Coolant Level Derate
62	058	0111-01	Low Engine Coolant Level Shutdown
62	059	0111-17	Low Engine Coolant Level Warning
63	095	0094-00	Fuel Filter Restriction Warning
63	096	0094-00	High Fuel Pressure
46	100	0100-17	Low Engine Oil Pressure Warning
35	190	0190-00	Engine Overspeed Warning

Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged in the memory of the ECM can be retrieved and cleared. The codes that have been logged in the memory of the ECM will be automatically cleared from the memory after 100 hours. The following faults can not be cleared from the memory of the ECM without using a factory password: overspeed, low engine oil pressure and high engine coolant temperature.

Engine Operation with Active Diagnostic Codes

If the LED lamp starts to flash codes during normal engine operation, the system has identified a situation that is not within the specification. Check the flash code or digital display, if equipped, to check the active diagnostic codes.

Note: If the flash code shows “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the LED lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the OEM Operation and Maintenance Manual for more information on the relationship between these active diagnostic codes and engine performance.

7.2 - TROUBLESHOOTING (ELECTRICAL)

CAT ENGINE DIAGNOSTIC CODES (continued)

Engine Operation with Intermittent Diagnostic Codes

If the LED lamp starts to flash codes during normal engine operation and the LED lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light, such as: Low power, Limits of the engine speed or Excessive smoke, etc.

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

QSX15 ENGINE PROTECTION SYSTEM

QSX15 engines are equipped with an engine protection system. The system monitors critical engine temperatures and pressures and will log diagnostic faults when an abnormal operating condition occurs. If an out-of-range condition exists and engine derate action is to be initiated, the operator will be alerted by the illumination of the LED. The warning light will blink or flash when out-of-range conditions continue to worsen. Refer to “Cummins Operation and Maintenance Manual for Industrial and Power Generation QSX15 Engines”, Bulletin No. 3666423-00, for detailed information about the QSX15 protection system.

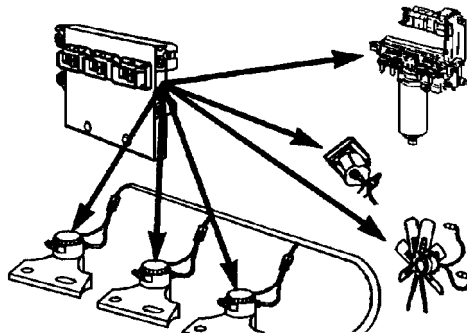


Figure 7.2–50

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 ENGINE PROTECTION SYSTEM (continued)

The QSX15 fuel system is an electronically controlled system designed to optimize engine control and reduce exhaust emissions. The QSX15 fuel system controls engine speed and fuel pressure based on input from the electric throttle and other equipment-specific and/or model-specific features. Refer to “Cummins Operation and Maintenance Manual for Industrial and Power Generation QSX15 Engines”, Bulletin No. 3666423-00, for detailed information about the QSX fuel system.

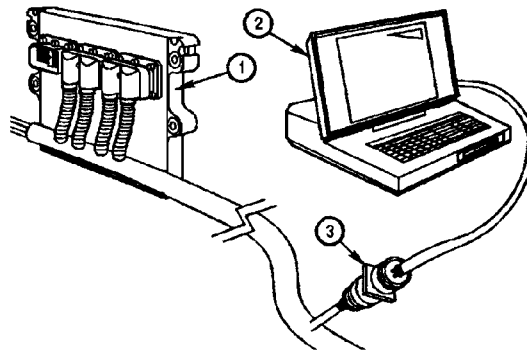


Figure 7.2–51

The ECM (1) has a datalink (2) for electronic service tools (3) shown in figure 7.2–51. Electronic service tools can be used to read and program owner-specified information into the ECM by a Cummins Authorized Repair Location. The electronic service tools can also be used to aid in troubleshooting the engine, in the event of a failure, by reading and displaying fault codes.

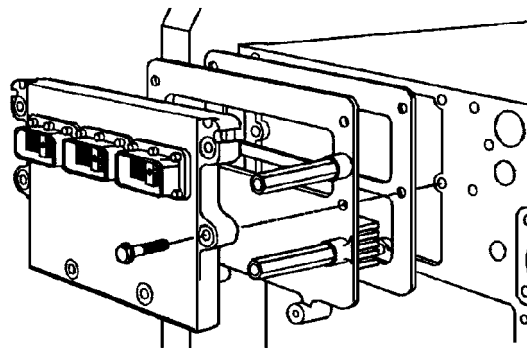


Figure 7.2–52

The engine has a cooling plate that is mounted to the cooler head within the air intake port. The ECM is mounted to the cooling plate. The intake air flows over the cooling plate and cools the electronics in the ECM.

The system monitors critical engine temperatures, fluid levels, oil and fuel pressures. It will log diagnostic faults when an over, or under, normal operating range condition occurs.

If an out-of-range condition exists, engine derate action will be initiated. The operator will be alerted by the illumination of the LED light on the MDDM. The warning lamp will start to flash as the out-of-range condition gets worse and engine shut down will occur shortly thereafter.

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 ENGINE DIAGNOSTIC CODES

Cummins QSX15 Fault Listing				
Cummins Fault Code	J1939 SPN	J1939 FMI	Abbreviated Fault Description	Lamp
111	629	12	Electronic control module failure – call Cummins Service	Red
112	635	7	Timing fueling flow error – call Cummins Service	Red
113	635	3	Timing actuator circuit failed high – return to shop	Yellow
115	190	2	Engine speed and/or position signal error – call Cummins Service	Red
116	156	3	Fuel timing sensor shorted high – call Cummins Service	Red
117	156	4	Fuel timing sensor shorted low – call Cummins Service	Red
118	135	3	Fuel pump pressure sensor shorted high – ok to complete shift	Yellow
119	135	4	Fuel pump pressure sensor shorted low – ok to complete shift	Yellow
121	190	10	One engine speed signal missing – ok to complete shift	Yellow
122	102	3	Left bank intake manifold pressure sensor circuit failure, component shorted high – ok to complete shift	None
123	102	4	Left bank intake manifold pressure sensor circuit failure, component shorted low – ok to complete shift	None
131	91	3	Throttle position sensor shorted high – call Cummins Service	Red
132	91	4	Throttle position sensor shorted low – call Cummins Service	Red
133	29	3	Remote throttle position sensor shorted high – call Cummins Service	Red
134	29	4	Remote throttle position sensor shorted low – call Cummins Service	Red
135	100	3	Oil pressure sensor shorted high – call Cummins Service	Yellow
141	100	4	Oil pressure sensor shorted low – call Cummins Service	Yellow
143	100	1	Oil pressure sensor data shorted low – call Cummins Service	EP
144	110	3	Coolant Temperature sensor shorted high – call Cummins Service	Yellow
145	110	4	Coolant Temperature sensor shorted low – call Cummins Service	Yellow
147	91	8	Frequency Throttle signal failure – call Cummins Service	Red
151	110	0	High coolant temp., engine will shutdown – call Cummins Service	EP
153	105	3	Intake manifold temp sensor shorted high – ok to complete shift	Yellow
154	105	4	Intake manifold temp sensor shorted low – ok to complete shift	Yellow
155	105	0	High intake manifold temperature sensor, engine will shut down call Cummins Service	EP
219	1380	1	Remote oil level low – return to shop	Yellow
221	108	3	Ambient air pressure sensor shorted high – ok to complete shift	Yellow
222	108	4	Ambient air pressure sensor shorted low – ok to complete shift	Yellow
223	1265	4	Burn valve solenoid open or shorted – return to shop	Yellow
225	1266	4	Makeup valve solenoid open or shorted – return to shop	Yellow

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 ENGINE DIAGNOSTIC CODES (continued)

Cummins QSX15 Fault Listing				
Cummins Fault Code	J1939 SPN	J1939 FMI	Abbreviated Fault Description	Lamp
231	109	3	Coolant pressure sensor shorted high - ok to complete shift	Yellow
232	109	4	Coolant pressure sensor shorted low - ok to complete shift	Yellow
233	109	1	Low Coolant Pressure, engine will shutdown - call Cummins Service	EP
234	190	0	Engine overspeed - call Cummins Service	Red
235	111	1	Low coolant level - call Cummins Service	EP
237	644	2	Multiple unit synchronization error - call Cummins Service	Yellow
252	98	2	Oil level signal error - return to shop	Yellow
253	98	1	Oil level low, engine will shut down - call Cummins Service	EP
254	632	4	Fuel shutoff valve shorted low - ok to complete shift	NONE
259	632	7	Fuel shutoff valve failure - call Cummins Service	Red
261	174	0	High fuel temperature, engine will shutdown - call Cummins Service	EP
263	174	3	Fuel temperature sensor shorted high - ok to complete shift	Yellow
265	174	4	Fuel temperature sensor shorted low - ok to complete shift	Yellow
292	1083	14	OEM temp sensor outside normal range, engine will shut down call Cummins Service	EP
293	1083	3	OEM temperature sensor shorted high - call IR Service	Yellow
294	1083	4	OEM temperature sensor shorted low - call IR Service	Yellow
296	1084	14	OEM pressure sensor outside normal range, engine will shut down call Cummins Service	EP
297	1084	3	OEM pressure sensor shorted high - call IR Service	Yellow
298	1084	4	OEM pressure sensor shorted low - call IR Service	Yellow
299	1384	31	ECM initiated hot shutdown error - ok to complete shift	NONE
316	931	3	Fuel pump actuator shorted high - ok to complete shift	Yellow
318	931	7	Fuel pump actuator failure- call Cummins Service	Yellow
343	629	12	ECM software error- call Cummins Service	Yellow
346	630	12	ECM software/hardware failure - call Cummins Service	Yellow
349	191	0	Output shaft (tailshaft) speed above normal operational range call IR Service	Yellow
384	626	11	Ether solenoid circuit failure - ok to complete shift	Yellow
422	111	2	Coolant level signal invalid - ok to complete shift	Yellow
423	156	2	Fuel timing pressure failurer - return to shop	Yellow

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 ENGINE DIAGNOSTIC CODES (continued)

Cummins QSX15 Fault Listing				
Cummins Fault Code	J1939 SPN	J1939 FMI	Abbreviated Fault Description	Lamp
426	639	3	J1939 data cannot transmit, voltage above normal or shorted high	Yellow
427	639	9	J1939 data cannot transmit, abnormal update rate	NONE
431	91	2	Throttle position idle validation invalid – ok to complete shift	NONE
432	91	13	Throttle position out of calibration – ok to complete shift	Red
441	168	1	Battery Voltage low – return to shop	NONE
442	168	0	Battery voltage high – call Cummins Service	Yellow
451	157	3	Fueling rail pressure sensor shorted high – call Cummins Service	Red
452	157	4	Fueling rail pressure sensor shorted low – call Cummins Service	Red
455	633	3	Fuel control valve failure – call Cummins Service	Red
467	635	2	Timing rail actuator data out of range – ok to complete shift	Yellow
468	633	2	Fuel rail actuator data out of range – ok to complete shift	Yellow
473	1380	2	Remote oil level sensor signal invalid – return to shop	Yellow
487	626	1	Ether bottle empty	NONE
489	191	1	Auxiliary speed frequency low error – call Cummins Service	Yellow
497	1377	2	Multiple unit synchronization switch circuit data error call Cummins Service	Yellow
514	633	7	Fuel Control Valve Failure – call Cummins Service	Red
524	113	2	OEM alternator droop switch validation fault	NONE
527	702	3	Dual output “A” shorted high or open circuit – ok to complete shift	Yellow
528	93	2	Alternate torque curve switch circuit error – ok to complete shift	NONE
529	703	3	Dual output “B” shorted high or open circuit – ok to complete shift	Yellow
553	157	0	Fuel rail pressure over limits – call Cummins Service	Red
554	157	2	Fuel rail pressure sensor circuit failure – call Cummins Service	Yellow
555	1264	0	High blowby pressure, Engine will shut down – call Cummins Service	EP
611	1383	31	Engine hot shutdown	NONE
649	1144	0	Change lubricating oil and filter – ok to complete shift	NONE
719	1264	3	Blowby pressure sensor circuit failure high – ok to complete shift	Yellow
729	1264	4	Blowby pressure sensor circuit failure low – ok to complete shift	Yellow
777	1180	0	Ambient derate error – ok to complete shift	Yellow

7.2 - TROUBLESHOOTING (ELECTRICAL)

MurphyLink™ POWERVIEW SYSTEM

Description

The PowerView has been developed to meet the needs for instrumentation and control on electronically controlled engines communicating using the SAE J1939 Controller Area Network (CAN).



POWERVERVIEW

Figure 7.2–53

The PowerView is a multifunctional tool that enables operators to view many different engine or transmission parameters and service codes. The PowerView includes a graphical backlit LCD screen. The display can show either a single parameter or a quadrant display showing four parameters simultaneously (figure 7.2–53). Diagnostic capabilities include fault codes with text translation for the most common fault conditions. The PowerView has four buttons using self-calibrating charge transfer activation technology, which eliminates the concern for pushbutton wear and failure.

The enhanced alarm indication has ultra bright alarm and shutdown LRDs (amber & red). It has a wide temperature range of -40°F to $+185^{\circ}\text{F}$ (-40°C to $+85^{\circ}\text{C}$), display viewing -40°F to $+167^{\circ}\text{F}$ (-40°C to $+75^{\circ}\text{C}$), and increased environmental sealing to ± 5 PSI ($\pm 35\text{kPa}$).

Other components in the system are microprocessor PowerView Gages for displaying critical engine data broadcast by an electronic engine or transmission's Engine Control Unit (ECU): engine RPM, oil pressure, coolant temperature, system voltage, etc. and a combination audible alarm and relay unit for warning and shutdown annunciation.

Faceplate Features and Keypad Functions

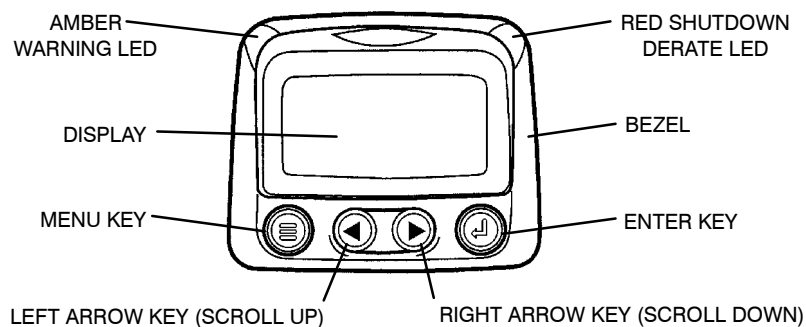


Figure 7.2–54

7.2 - TROUBLESHOOTING (ELECTRICAL)

The keypad on the PowerView is a capacitive *touch* sensing system. There are no mechanical switches to wear or stick. It operates in extreme temperatures; with gloves, through ice, snow, mud, grease, etc., and it allows complete sealing of the front of the PowerView. The “key is touched” feedback is provided by the flashing screen. The keys on the keypad (figure 7.2–54) perform the following:

Menu Key:

The menu key (figure 7.2–54) is touched to either enter or exit the menu screens.

Left Arrow Key:

The left arrow key (figure 7.2–54) is touched to scroll through the screen either moving the parameter selection toward the left or upward.

Right Arrow Key:

The right arrow key (figure 7.2–54) is touched to scroll through the screen either moving the parameter selection toward the right or downward.

Enter Key:

The enter key, also known as Enter Button, (figure 7.2–54) is touched to select the parameter that is highlighted on the screen.

MECHANICAL INSTALLATION

Typical Quick-Connect Diagram

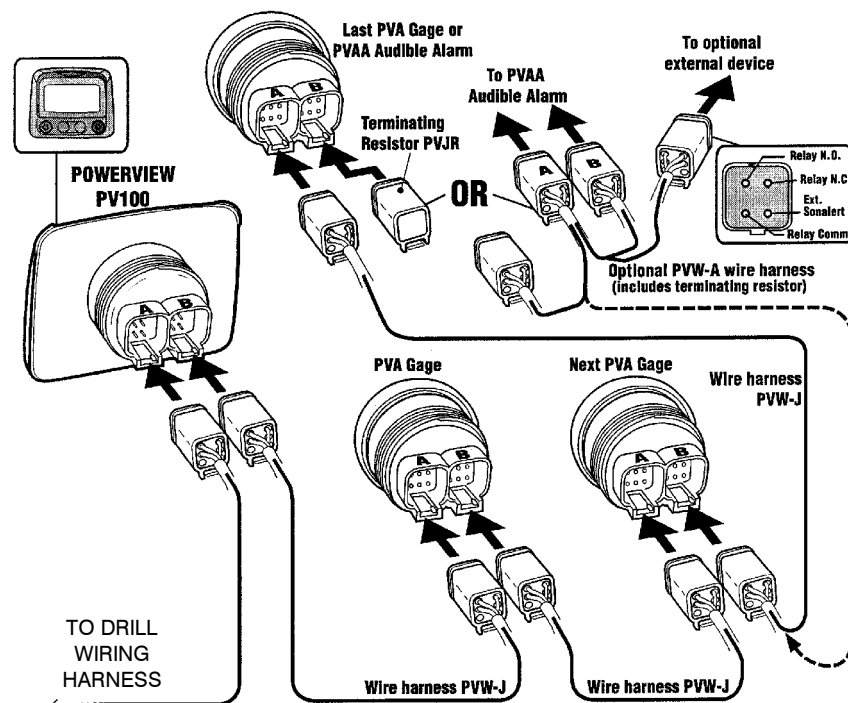


Figure 7.2–55

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRICAL INSTALLATION

PowerView Unit Back View

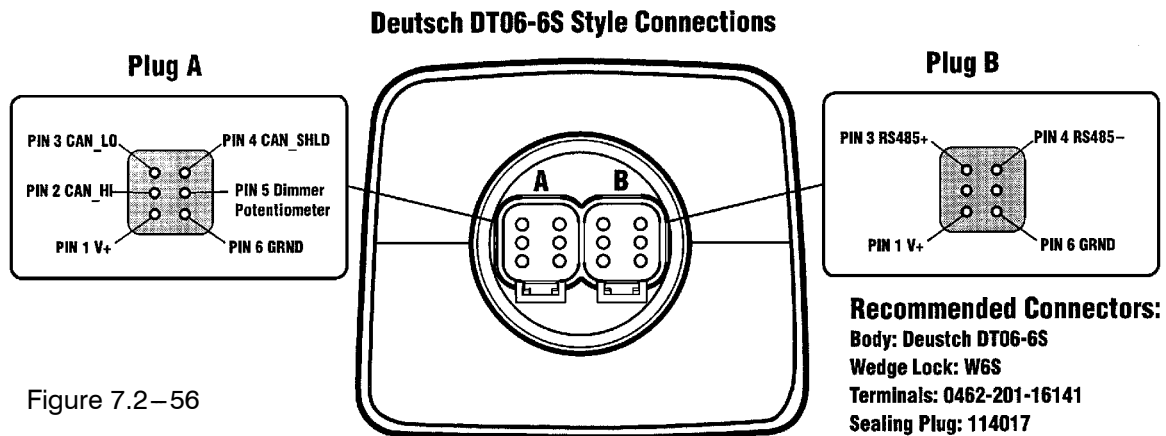


Figure 7.2–56

POWERVERVIEW OPERATION

1. When power is first applied to the PowerView, the “Logo” is displayed.
2. The “Wait to Start” message will be displayed for engines with a pre-startup sequence. Once the “Wait to Start” message is no longer displayed the operator may start the engine. **Note:** Displays only when SAE J1939 message is supported by engine manufacturer.
3. Once the engine has started the single engine parameter is displayed.

Main Menu Navigation

1. Starting at the single or four engine parameter display, touch “Menu”.

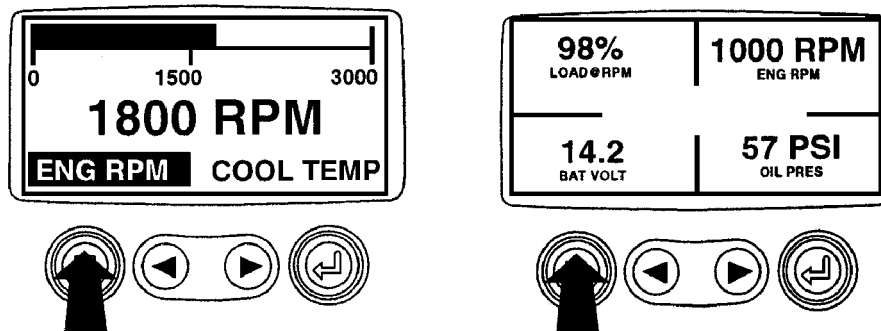


Figure 7.2–57

7.2 - TROUBLESHOOTING (ELECTRICAL)

Main Menu Navigation (continued)

- The first seven items of the “Main Menu” will be displayed. Touching the “Arrow Buttons” will scroll through the menu selection.

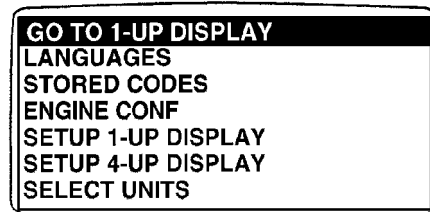


Figure 7.2–58



- Touching the right arrow button will scroll down to reveal the last items of “Main Menu” screen highlighting the next item down.

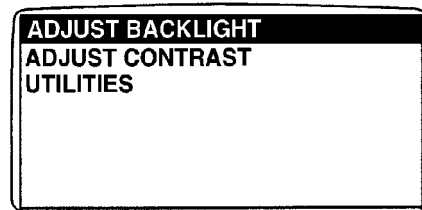


Figure 7.2–59



- Touch the “Arrows” to scroll to the desired menu item or touch “Menu” to exit the Main menu and return to the engine parameter display.

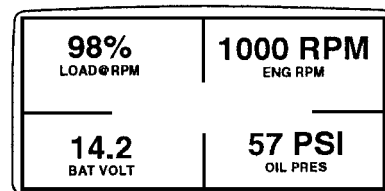
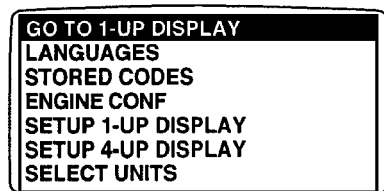


Figure 7.2–60

7.2 - TROUBLESHOOTING (ELECTRICAL)

Selecting a Language

1. Starting at the main menu display use the “Arrows” to scroll to the “Language” menu and once highlighted touch the “Enter” button.

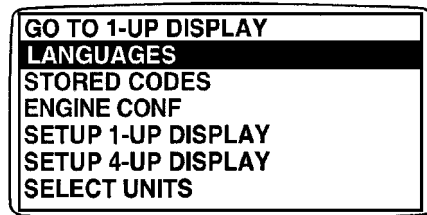


Figure 7.2–61



2. Language choices will be displayed. Use the “Arrow” buttons to scroll through selections and touch “Enter” to make a selection.
3. Now that you have selected the language, touch the “Menu” button to return to the main menu display.

Stored Fault Codes

1. Starting at the single or the four engine parameter display touch the “Menu button”.

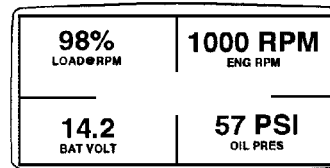
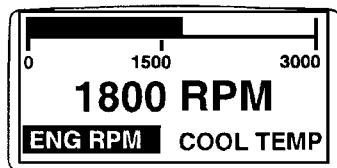


Figure 7.2–62

2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until the Stored Fault Codes is highlighted.

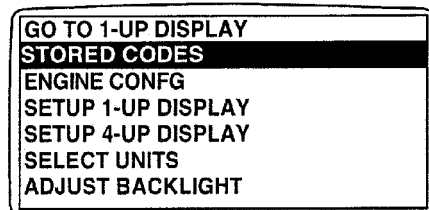


Figure 7.2–63



7.2 - TROUBLESHOOTING (ELECTRICAL)

Stored Fault Codes (continued)

- Once the “Stored Fault Codes” menu item has been highlighted touch the “Enter Button” to view the “Stored Fault Codes” (when applicable, consult engine manufacturer for the SAE J1939 supported parameters).

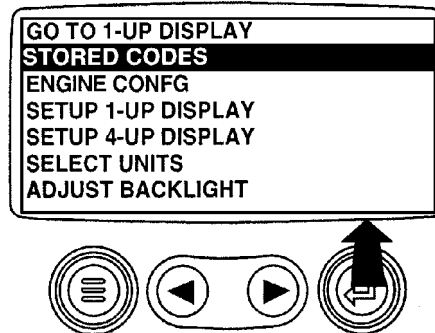


Figure 7.2–64

- If the word “MORE” appears above the “Arrow Buttons” there are more stored fault codes that may be viewed. Use the “Arrow Buttons” to scroll to the next Stored Diagnostic Code.

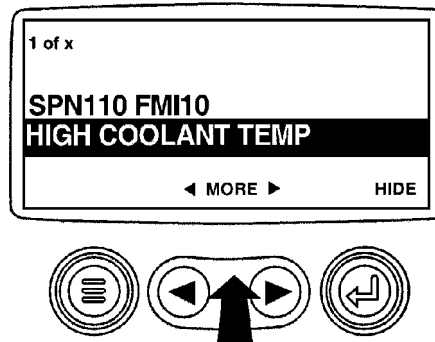


Figure 7.2–65

- Touch the “Menu Button” to return to the main menu.
- Touch the “Menu Button” to exit the Main menu and return to the engine parameter display.

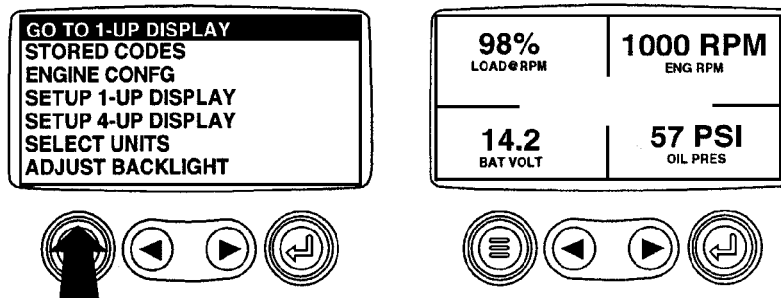
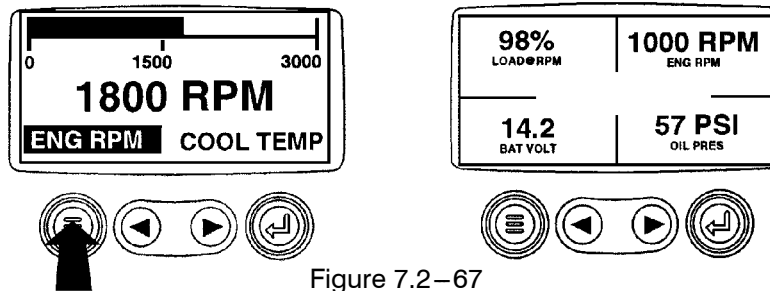


Figure 7.2–66

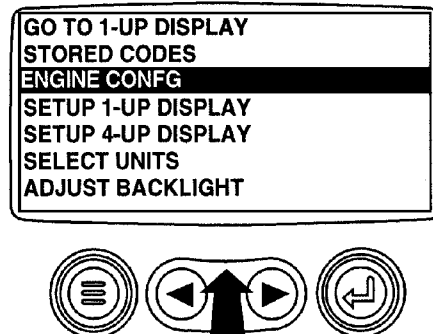
7.2 - TROUBLESHOOTING (ELECTRICAL)

Engine Configuration Data

1. Starting at the single or the four engine parameter display touch the “Menu button”.



2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until the “Engine Configuration” is highlighted.



3. Once the “Engine Configuration” menu has been highlighted touch the “Enter Button” to view the engine configuration data.
4. Use the “Arrow Buttons” to scroll through the engine configuration data.
5. Touch the “Menu Button” to return to the main menu.
6. Touch the “Menu Button” to exit the Main menu and return to the engine parameter display.

FAULTS AND WARNINGS

Auxiliary Gage Fault

1. During normal operation the single or four parameter screen will be displayed.
2. The PVA Series auxiliary gages can be attached to the PowerView. These auxiliary gages communicate with the Modbus master PowerView via a daisy-chained RS-485 port. If at any time during system initialization or normal operation an auxiliary gage should fail, the single or four parameter screen will be replaced with the “MLink Gauge Fault” message.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Auxiliary Gage Fault (continued)

3. To acknowledge and “Hide” the fault and return to the single or the four parameter display, touch the “Enter Button”.
4. The display will return to the single or four parameter screen.

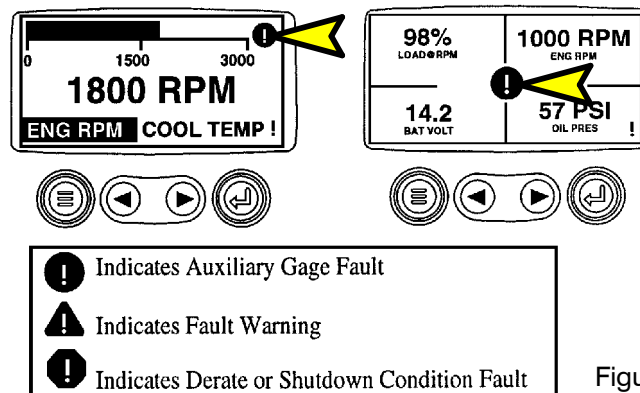


Figure 7.2–69

5. Touching the “Enter Button” will redisplay the hidden fault. Touching the “Enter Button” once again will hide the fault and return the screen to the single or four parameter display. **Note:** The fault can only be cleared by correcting the cause of the fault condition.

Active Fault Codes

1. During normal operation the single or four parameter screen will be displayed.
2. When the PowerView receives a fault code from an engine control unit the single or four parameter screen will be replaced with the “Active Fault Codes” message.

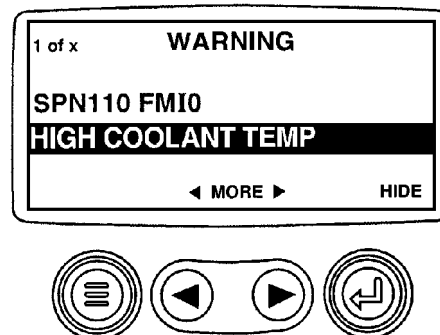


Figure 7.2–70

3. If the word “MORE” appears above the “Arrow Buttons” there are more active fault codes that may be reviewed. Use the “Arrow Buttons” to scroll to the next “Active Fault Code”.
4. To acknowledge and “Hide” the fault and return to the single or four parameter display touch the “Enter Button”

7.2 - TROUBLESHOOTING (ELECTRICAL)

Active Fault Codes (continued)

- The display will return to the single or four parameter display, but the display will contain the “Active Fault” warning icon. Touching the “Enter Button” will redisplay the hidden fault.

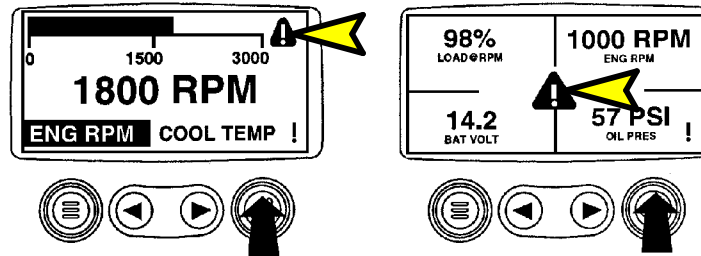


Figure 7.2-71

- Touching the “Enter Button” once again will hide the fault and return the screen to the single or four parameter display.
- The single or four the parameter screen will display the fault icon until the fault condition is corrected. **Note:** Ignoring active fault codes could result in severe engine damage.

Shutdown Codes

- During normal operation the single or four parameter screen will be displayed.
- When the PowerView receives a severe fault code from an engine control unit the single or four parameter screen will be replaced with the “Shutdown” message.

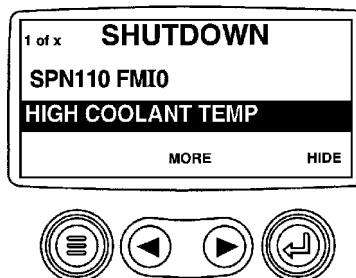


Figure 7.2-72

- To acknowledge and “Hide” the fault and return to the single or the four parameter display, touch the “Enter Button”.
- The display will return to the single or four parameter display, but the display will contain the “Shut Down” icon. Touching the “Enter Button” will redisplay the hidden fault.

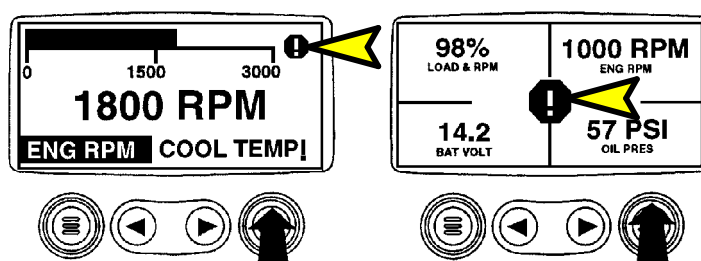


Figure 7.2-73

7.2 - TROUBLESHOOTING (ELECTRICAL)

Shutdown Codes (continued)

5. Touching the “Enter Button” once again will hide the fault and return the screen to the single or four parameter display.
6. The single or four the parameter screen will display the fault icon until the fault condition is corrected. **Note:** Ignoring active fault codes could result in severe engine damage.

Back Light Adjustment

1. Starting at the single or four engine parameter display touch the “Menu Button”.
2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until the “Adjust Backlight” is highlighted.

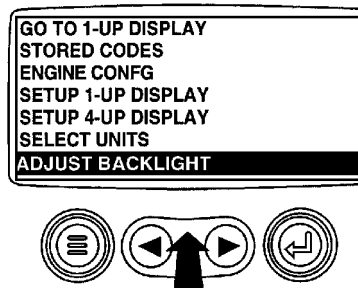


Figure 7.2–74

3. Once the “Adjust Backlight” menu has been highlighted touch the “Enter Button” to activate the “Adjust Backlight” function.
4. Use the “Arrow Buttons” to select the desired backlight intensity.
5. Touch the “Menu Button” to return to the main menu.
6. Touch the “Menu Button” to exit the main menu and return to the engine parameter display.

Contrast Adjustment

1. Starting at the single or four engine parameter display touch the “Menu Button”.
2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until “Adjust Contrast” is highlighted.
3. Once the “Adjust Contrast” menu has been highlighted touch the “Enter Button” to activate the “Adjust Contrast” function.
4. Use the “Arrow Buttons” to select the desired contrast intensity.
5. Touch the “Menu Button” to return to the main menu.
6. Touch the “Menu Button” to exit the main menu and return to the engine parameter display.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Select Units

1. Starting at the single or four engine parameter display touch the “Menu Button”.
2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until “Select Units” is highlighted.
3. Once the “Select Units” menu has been highlighted touch the “Enter Button” to access the “Select Units” function.
4. Use the arrows to highlight desired units. “English” for Imperial units i.e. PSI, ° F or Metric kPa, Metric Bar for IS units i.e. kPa, Bar, °C.

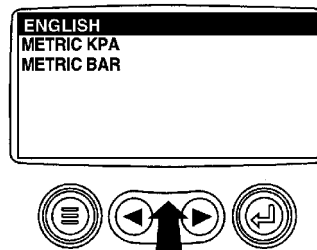


Figure 7.2–75

5. Touch the “Enter Button” to select the highlighted units.
6. Touch the “Menu Button” to return to the main menu.
7. Touch the “Menu Button” to exit the main menu and return to the engine parameter display.

Setup 1-Up Display

1. Starting at the single engine parameter display, touch the “Menu Button”.
2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until “Setup 1-Up Display” is highlighted.
3. Once the “Setup 1-Up Display” menu item has been highlighted touch the “Enter Button” to access the “Setup 1-Up Display” function.
4. Three options are available for modification of the 1-Up display.
 - a.) **Use Defaults** – This option contains a set of engine parameters: Engine Hours, Engine RPM, System Voltage, Battery Voltage, % Engine Load at Current RPM, Coolant Temp., Oil Pressure.
 - b.) **Custom Setup** – This option allows for the modification of what parameter, the number of parameters, and the order in which the parameters are being displayed.
 - c.) **Automatic Scan** – Selecting the scan function will cause the 1-Up Display to scroll through the selected set of parameters one at a time, momentarily pausing at each.
5. **Use Defaults** – To select “Use Defaults” use the arrow buttons to scroll to and highlight “Use Defaults” in the menu display.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Setup 1-Up Display (continued)

6. Touch the “Enter Button” to activate the “Use Defaults” function.
7. A message indicating the “Single Engine” parameter display parameters are reset to the factory defaults will be displayed, then the display will return to the “Custom Setup” menu.
8. **Custom Setup** – To perform a custom setup of the 1-Up Display, use the arrow buttons to scroll to and highlight “Custom Setup” on the display.
9. Touching the “Enter Button” will display a list of engine parameters.
10. Use the “Arrow Buttons” to scroll to and highlight a selected parameter (parameter with a # symbol to the right of it).
11. Touch the “Enter Button” to deselect the selected parameter, removing it from the list of parameters being displayed on the 1-Up display.
12. Use the “Arrow Buttons” to scroll and highlight the desired parameter that has not been selected for display.
13. Touch the “Enter Button” to select the highlighted parameter for inclusion in the Single Engine Parameter Display.
14. Continue to scroll and select additional parameters for the custom 1-Up Display. Touch the “Menu Button” at any time to return to the “Custom Setup” menu.
15. **Automatic Scan** – Selecting scan function will cause the 1-Up Display to scroll through the selected set of parameters one at a time. Use the “Arrow Buttons” to scroll to the “Automatic Scan” function.
16. Touching the “Enter Button” toggles the “Automatic Scan” function on.
17. Touching the “Enter Button” again toggles the “Automatic Scan” function off.
18. Once the “Use Defaults”, “Custom Setup” and “Automatic Scan” functions have been set, touch the “Menu Button” to return to the main menu.
19. Touch the “Menu Button” to exit the main menu and return to engine parameter display.

Setup 4-Up Display

1. From the single or four engine parameter display touch the “Menu Button”.
2. The main menu will pop up on the display. Use the “Arrow Buttons” to scroll through the menu until “Setup 4-Up Display” is highlighted.
3. Once the “Setup 4-Up Display” menu item has been highlighted touch the “Enter Button” to activate the “Setup 4-Up Display” menu.
4. Touch the “Enter Button” to deactivate the “Use Defaults” function. This action will reset the unit to the factory default.

7.2 - TROUBLESHOOTING (ELECTRICAL)

Setup 4-Up Display (continued)

5. "Use Defaults" screen will be displayed during the resetting period then will automatically return to the "Setup 4-Up Display" menu.
6. Select the "4-Up Custom Setup" from the "4-Up Setup" menu.
7. The quadrant with the backlit parameter value is the current selected parameter. Use the "Arrow Buttons" to highlight the parameter value in the quadrant you wish to place a new parameter.
8. Touch the "Enter Button" and a list of parameters will appear.
9. The quadrant that is highlighted is the selected parameter for the screen. Use the "Arrow Buttons" to highlight the new parameter to be placed in the quadrant that was selected in the previous screen. **Note:** The number to the right of the parameter indicates the quadrant in which it is displayed (1 = Upper Left Quadrant, 2 = Lower Left Quadrant, 3 = Upper Right Quadrant, 4 = Lower Right Quadrant).
10. Touch the "Enter Button" to change the selected parameter in the quadrant to the new parameter.
11. Use the "Menu Button" to return to the "4-Up Custom Setup" screen.
12. The parameter in the selected quadrant has changed to the parameter that was selected in the previous screen.
13. Repeat the parameter selection process until all spaces are filled.
14. Touch the "Menu Button" to return to the main menu.
15. Touch the "Menu Button" to exit the main menu and return to engine parameter display.

UTILITIES (Information and Troubleshooting)

1. Starting at the single or four engine parameter display, touch the "Menu Button".
2. The main menu will be displayed. Use the "Arrow Buttons" to scroll through the menu until the "Utilities" is highlighted.
3. Once the "Utilities" menu item has been highlighted touch the "Enter Button" to activate the "Utilities" functions.
4. Touch "Select" to enter "Gage Data" display. When "Gage Data" is selected the PowerView will communicate with the analog gages at a fixed rate of 38.4 k Baud, 8 data bits, no parity check, 1 stop bits, half duplex.
5. Use the "Arrow Buttons" to scroll through the items or touch "Menu" to return to the "Utilities" menu.
6. Touch the "Menu Button" to return to the "Utilities" menu.

7.2 - TROUBLESHOOTING (ELECTRICAL)

UTILITIES (Information and Troubleshooting) continued

7. Use the “Arrows” to highlight “Remove All Gages”. Touch “Select” to clear gage data from memory. It takes a moment to clear all gages.
8. When the gage data has cleared, the display automatically returns to the “Utilities” menu. Scroll to “Software Version”. Touch “Select” to view the software version currently in the PowerView.
9. Touch “Menu” to return to “Utilities”. Highlight “Fault Conversion” using the “Arrows”. Touch “Select” to enter the Fault conversion menu.
10. Use the “Arrows” to scroll and highlight the version, then touch “Select” and an asterisk appears to the right of the selection.

Note: There are four (4) different methods for converting fault codes. The PowerView always looks for J1939 Version 4 and can be set to use one of the 3 other J1939 versions. Most engine ECU's use Version 4, therefore in most cases adjustment of this menu option will not be required.

Upon receiving an unrecognizable fault, change to a different J1939 Version. If the fault SPN does not change when the version is changed, the ECU generating the fault is using Fault Conversion method 4. If the SPN number does change but is still unrecognizable, try changing to another J1939 Version not yet used and continue to check the SPN number.

11. Touch the “Menu” button to return to “Utilities” menu. Touch the “Menu” button again to return to the “Main” menu.

MODBUS Setup

1. Starting at the single or four engine parameter display, touch the “Menu Button”.
2. The main menu will be displayed. Use the “Arrow Buttons” to scroll through the menu until the “Utilities” is highlighted, then touch “Enter”.
3. Once in the “Utilities” menu use the “Arrows” to scroll through the menu until the “Modbus Setup” menu is highlighted, then touch “Enter”.
4. Use the “Arrows” to scroll down to and highlight either the “Slave Active or Master Active” modes. Touch the “Enter” button to toggle between master and slave.
5. Use the “Arrows” to scroll to the “Serial Port” menu to highlight it, then touch “Enter”.
6. Use the “Arrows” button to scroll to each selection to configure the MODBUS values for your application.
7. When finished, touch “Menu” to return to the previous screen.

7.2 - TROUBLESHOOTING (ELECTRICAL)

J1939 PARAMETERS

SAE J1939 MURPHYLINK SYSTEM IMPLEMENTATION OF J1939 PARAMETERS				
SOURCE: SAEJ1939-71 SURFACE VEHICLE RECOMMENDED PRACTICE				
SAE J1939 SECTION	DESCRIPTION	PGN	PARAMETER	DISPLAY VALUE
5.3.6	ELEC ENG CONT #2 - EEC2	61443	ACCELERATOR PEDAL POSITION	THROTTLE
			PERCENT LOAD AT CURRENT RPM	LOAD@RPM
5.3.7	ELEC ENG CONT #1 - EEC1	61444	ACTUAL ENGINE % TORQUE	ENG TORQ
			ENGINE SPEED	ENG RPM
5.3.14	VEHICLE DISTANCE	65248	TRIP DISTANCE	TRIP DIST
			TOTAL VEHICLE DISTANCE	VEH DIST
5.3.19	ENGINE HOURS, REVOLUTIONS	65253	TOTAL ENGINE HOURS	ENG HRS
5.3.23	FUEL CONSUMPTION	65257	TRIP FUEL	TRIP FUEL
			TOTAL FUEL USED	FUEL USED
5.3.28	ENGINE TEMPERATURE	65262	ENGINE COOLANT TEMP	COOL TEMP
			FUEL TEMPERATURE	FUEL TEMP
			ENGINE OIL TEMPERATURE	OIL TEMP
			ENGINE INTERCOOLER TEMP	INTC TEMP
5.3.29	ENGINE FLUID LEVEL/PRESSURE	65263	FUEL DELIVERY PRESSURE	FUEL PRES
			ENGINE OIL LEVEL	OIL LVL
			ENGINE OIL PRESSURE	OIL PRES
			COOLANT PRESSURE	COOL PRES
			COOLANT LEVEL	COOL LVL
5.3.31	CRUISE CONT/VEHICLE SPEED	65265	WHEEL BASED VEHICLE SPEED	VEH SPD
5.3.32	FUEL ECONOMY	65266	FUEL RATE	FUEL RATE
			INSTANTANEOUS FUEL ECONOMY	FUEL ECON
			AVERAGE FUEL ECONOMY	AVG ECON
5.3.35	AMBIENT CONDITIONS	65269	BAROMETRIC PRESSURE	BARO PRES
			AIR INLET TEMPERATURE	AIR IN TP
5.3.36	INLET/EXHAUST CONDITIONS	65270	BOOST PRESSURE	BST PRES
			INTAKE MANIFOLD TEMP	MANI TEMP
			AIR FILTER DIFFERENTIAL PRESS	AIR DIF PR
			EXHAUST GAS TEMPERATURE	EXH TEMP
5.3.37	VEHICLE ELECTRICAL POWER	65271	ALTERNATOR VOLTAGE	ALT VOLT
			ELECTRICAL POTENTIAL (Voltage)	SYS VOLT
			BATTERY POT. VOLTAGE (switched)	BAT VOLT
5.3.8	ELECTRONIC TRANSMISSION CONTROLLER #2	61445	SELECTED GEAR	SLECT GEAR
			CURRENT GEAR	CURNT GEAR
5.3.38	TRANSMISSION FLUIDS	65272	TRANSMISSION OIL PRESSURE	TRAN PRES
			TRANSMISSION OIL TEMP	TRAN TEMP
5.3.46	ENG FLUID LEVEL/PRESSURE #2	65243	INJECTOR METERING RAIL 1 PRES	INJ PRES1
			INJECTOR METERING RAIL 2 PRES	INJ PRES2

7.2 - TROUBLESHOOTING (ELECTRICAL)

J1939 PARAMETERS (continued)

SAE J1939 MURPHYLINK SYSTEM IMPLEMENTATION OF J1939 PARAMETERS				
SOURCE: SAEJ1939-71 SURFACE VEHICLE RECOMMENDED PRACTICE				
SAE J1939 SECTION	DESCRIPTION	PGN	PARAMETER	DISPLAY VALUE
5.3.58	FAN DRIVE	65213		FAN SPD
5.3.111	AUXILIARY PRESSURES & TEMPERATURES	65164	AUXILIARY TEMPERATURE	AUX TEMP
			AUXILIARY PRESSURE	AUX PRES
	DIAGNOSTIC MESSAGES	65226	DM1 - ACTIVE DIAGNOSTIC	SRVCCODE
		65227	DM2 - PREVIOUSLY ACTIVE DIAGNOSTIC CODE	STORCODE
		65228	DM3 - DIAGNOSTIC CLEAR	
J1939 N/A	MACHINE HOURS (PowerView Calculated)	N/A	MACHINE HOURS	MACH HRS
5.3.17	ENGINE CONFIGURATION	65251	ENGINE CONFIGURATION	ENG CONF
5.3.5	ELECTRONIC TRANSMISSION CONTROLLER #1	61442	OUTPUT SHAFT SPEED	OUT SFT SP
			INPUT SHAFT SPEED	IN SFT SP
			TORQUE CONVERTER LOCKUP ENGAGED	TORQ LOCK

GLOSSARY

CANBUS FAILURE

PowerView has not received any CAN messages for at least 30 seconds.

NO DATA

PowerView has not received the particular message being displayed for at least 5 seconds.

NOT SUPPORTED

PowerView has received a message from the ECU stating the displayed message is not supported.

DATA ERROR

PowerView has received an error message from the ECU for the displayed message.

EMPTY

No parameter selected for this 4-UP quadrant.

WAIT TO START PREHEATING

This is a message from the engine indicating it is in a preheating cycle. Wait until this message clears before starting the engine.

TIMEOUT ECU NOT RESPONDING

The ECU did not respond to the PowerView request.

NO GAGE DATA

The PowerView has no record of connected gages to the RS485 bus.

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRIC LADDER

The electric ladder schematic is a logical way to show how the current flows in the various parts of the electrical circuits on a drill. The schematic is broken into seven (7) parts that are different and serve different purposes.



Figure 7.2–76

The first part is the Power Supply. These are the Batteries that supply all the power to the system. They are indicated by the two battery symbols (figure 7.2–76).

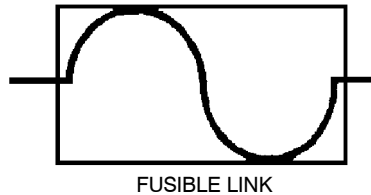


Figure 7.2–77

The second part is the Fusible Link (figure 7.2–77) that protects against massive short circuit and fire. It is always located in the main wiring just beyond the batteries. It is located beyond the batteries and between the alternator and the batteries so any high flow of electricity is prohibited or stopped from getting to the batteries and causing a fire. Remember that electricity flows out of the batteries but back from the alternator to the batteries. Fuse links are blue colored and are 9 inches (23 cm) long. They have a ring connector on one end and use a wire nut to connect to the main hot wire.

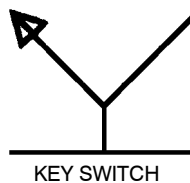
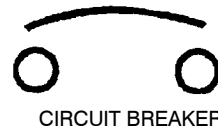


Figure 7.2–78



The third part is the Key Switch and the Circuit Breakers (figure 7.2–78) that protect each separate circuit and control the power to the whole system.

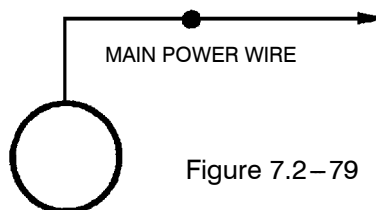


Figure 7.2–79

The fourth part is the Main Power Wire or Wires (figure 7.2–79). These are the positive or plus (+) wires that carry the current to each area. They are usually larger in size than the others so they can carry more current without getting hot.

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRIC LADDER (continued)

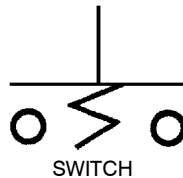


Figure 7.2–80

The fifth part is the Switch or Controller that allows current or disconnects it from the operating system (figure 7.2–80). These may be push button switches or remotely controlled switches that cause a change in the system.

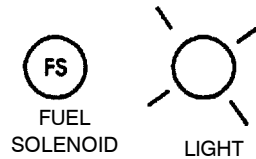


Figure 7.2–81

The sixth part is the actual Solenoid, Relay, Light or other device that is activated by supplying power to it or removing power from it (see figure 7.2–81).

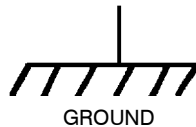


Figure 7.2–82

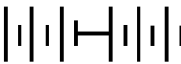
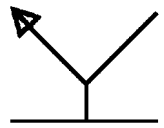
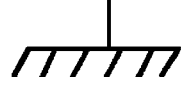
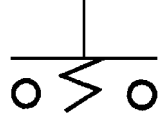
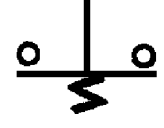
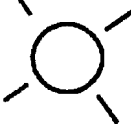
The last part is the Return or Ground Wire that makes a complete circuit and allows the system to be a system (see figure 7.2–82). These wires don't always seem significant but without a good ground wire the system will not function.

Remember that all power flows from the batteries to the main power line, usually through the ammeter. You will notice several diodes in the circuits. The symbol is an arrow with a bar across the end. These act the same as check valves in a hydraulic circuit. They allow current to flow in one direction but not backwards.

24 volt battery power means that both 12 volt batteries add together to produce 24 volts. Batteries in series produce whatever their voltages add up to. Thus, two 12 volt batteries will produce 24 volts.

7.2 - TROUBLESHOOTING (ELECTRICAL)

ELECTRICAL SYMBOLS

				
BATTERY	FUSE LINK	AMMETER	KEY SWITCH	CIRCUIT BREAKER
				
GROUND	PRESSURE SWITCH	PUSH BUTTON	BYPASS BUTTON	EMERGENCY STOP
				
COIL (RELAY)	*N O SECTION of RELAY	**N C SECTION of RELAY	LIMIT SWITCH	TEMPERATURE SWITCH
				
FLOAT SWITCH	ENCLOSURE	MOTOR	ALTERNATOR	FUEL SOLENOID
				
LIGHT	SWITCH	RESISTOR	DIODE	SHUNT

* N O = Normally Open
** N C = Normally Closed

Figure 7.2–83

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with Cummins QSK19 Engine

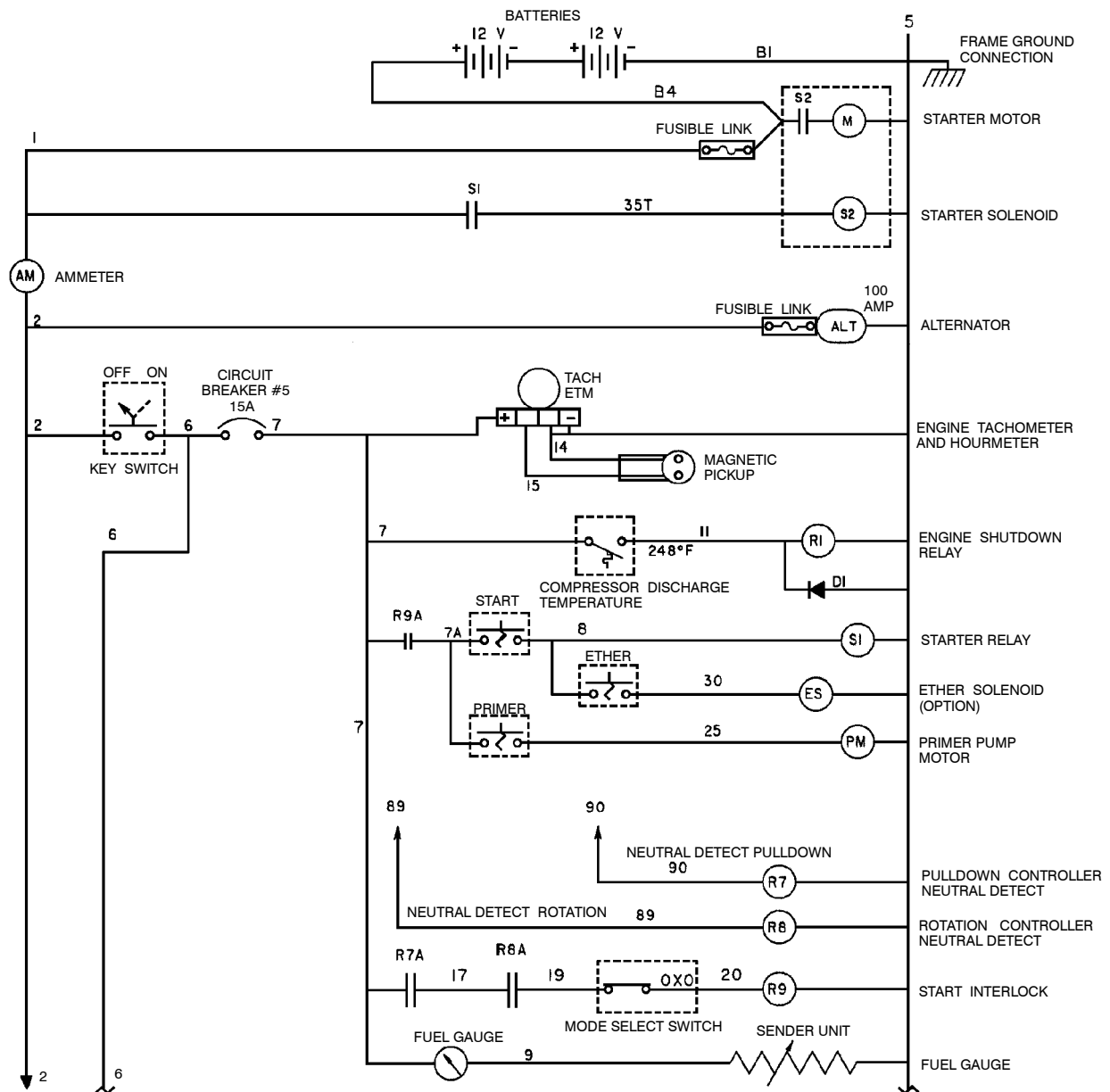


Figure 7.2–84

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with Cummins QSK19 Engine

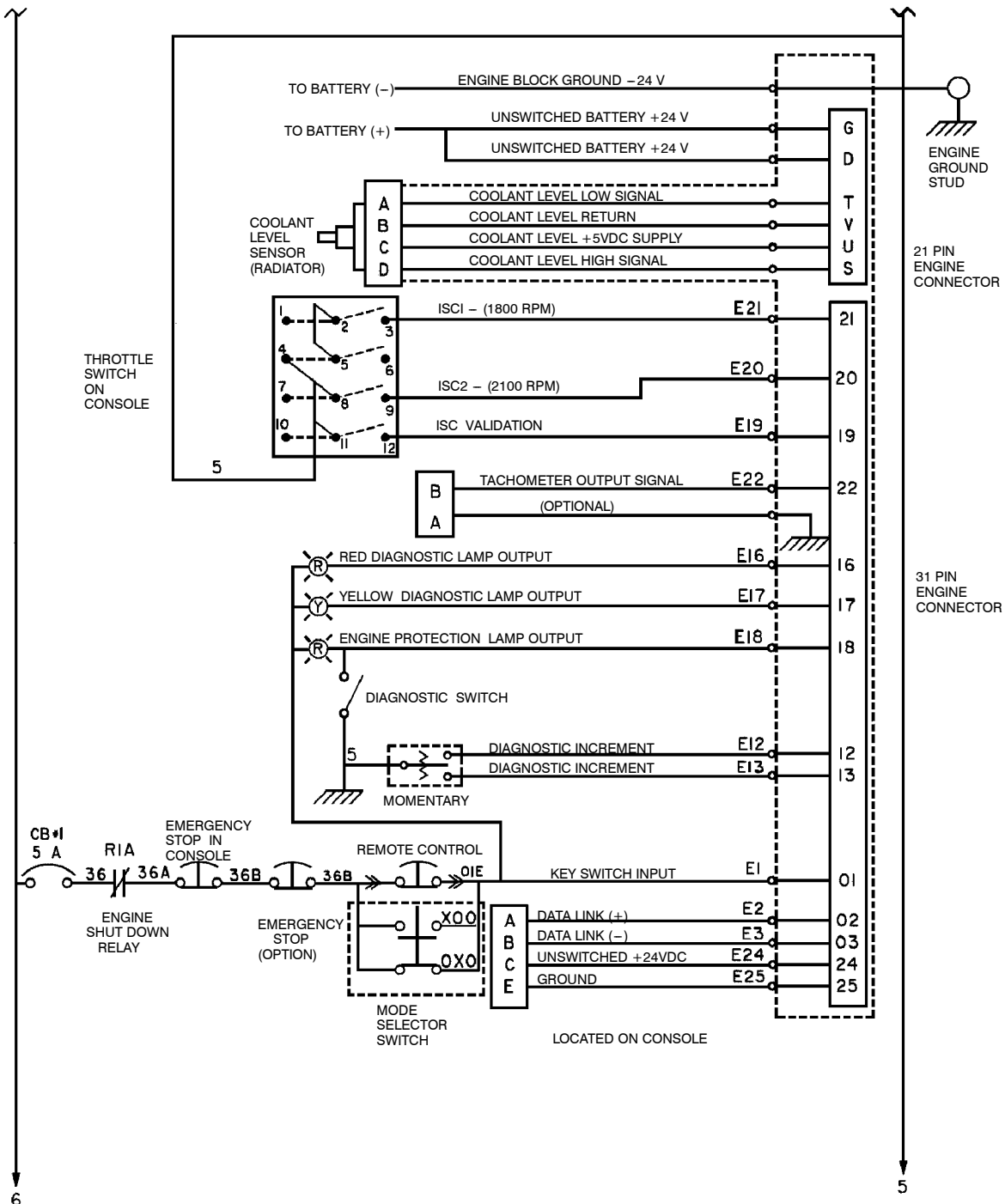


Figure 7.2-85

7.2 - TROUBLESHOOTING (ELECTRICAL)

QSX15 WIRING SCHEMATIC

Drills equipped with the Cummins QSX15 engines have an electrical system with computer controls for all engine functions as defined in the Cummins QSX15 Wiring Schematic.

WIRING SCHEMATIC – Drills with Cummins QSX15 Engine

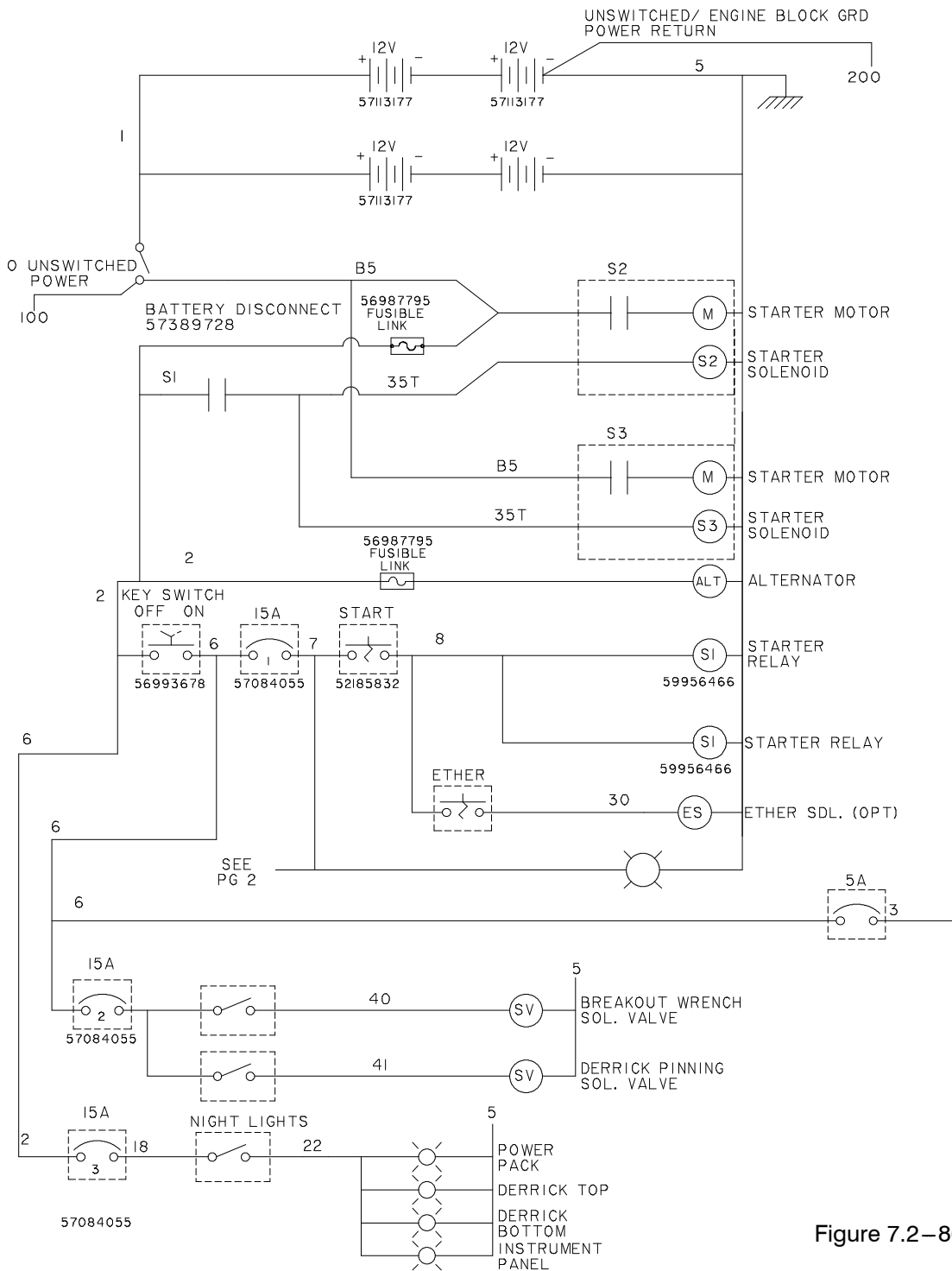


Figure 7.2–86

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with Cummins QSX15 Engine

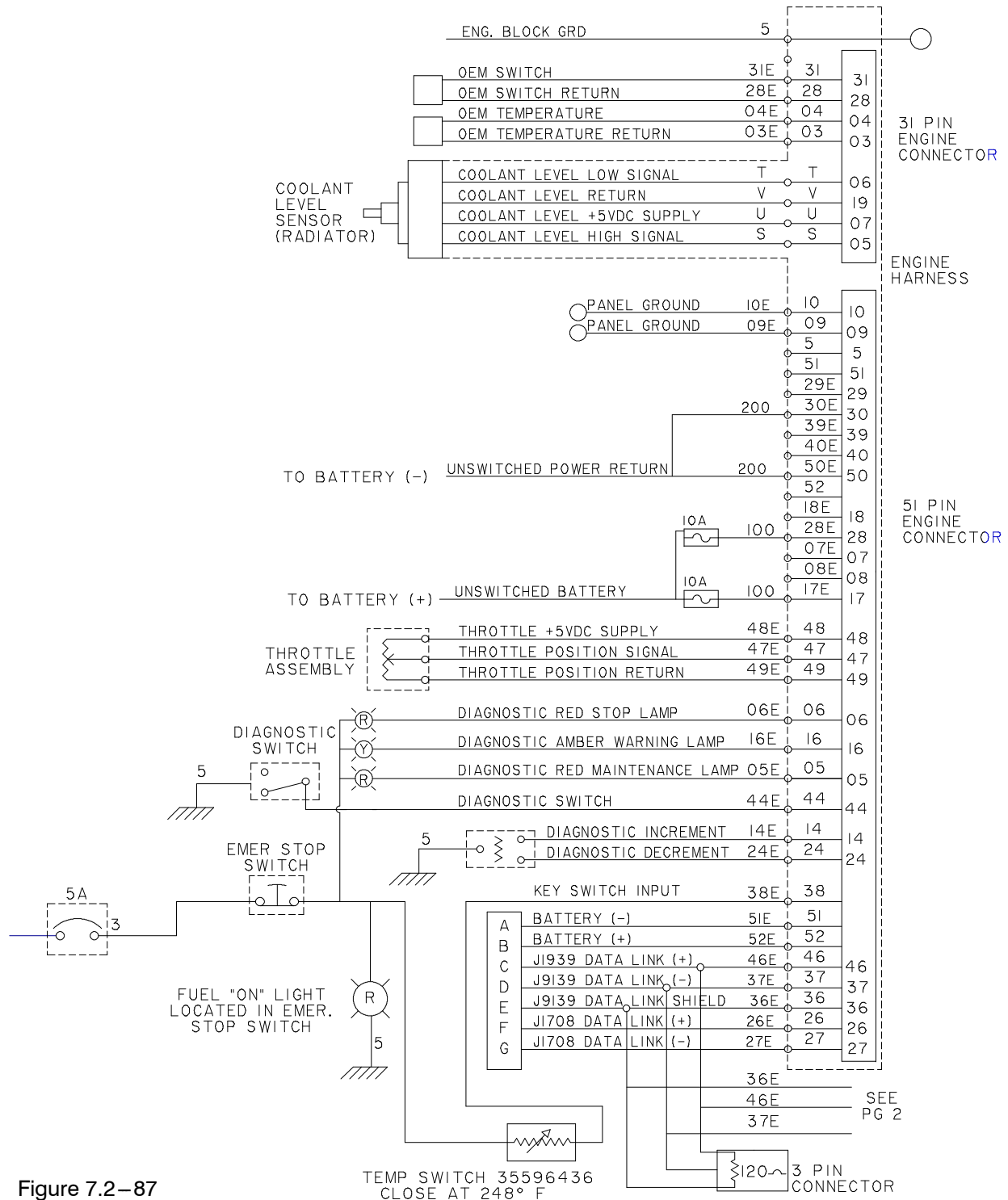


Figure 7.2–87

7.2 - TROUBLESHOOTING (ELECTRICAL)

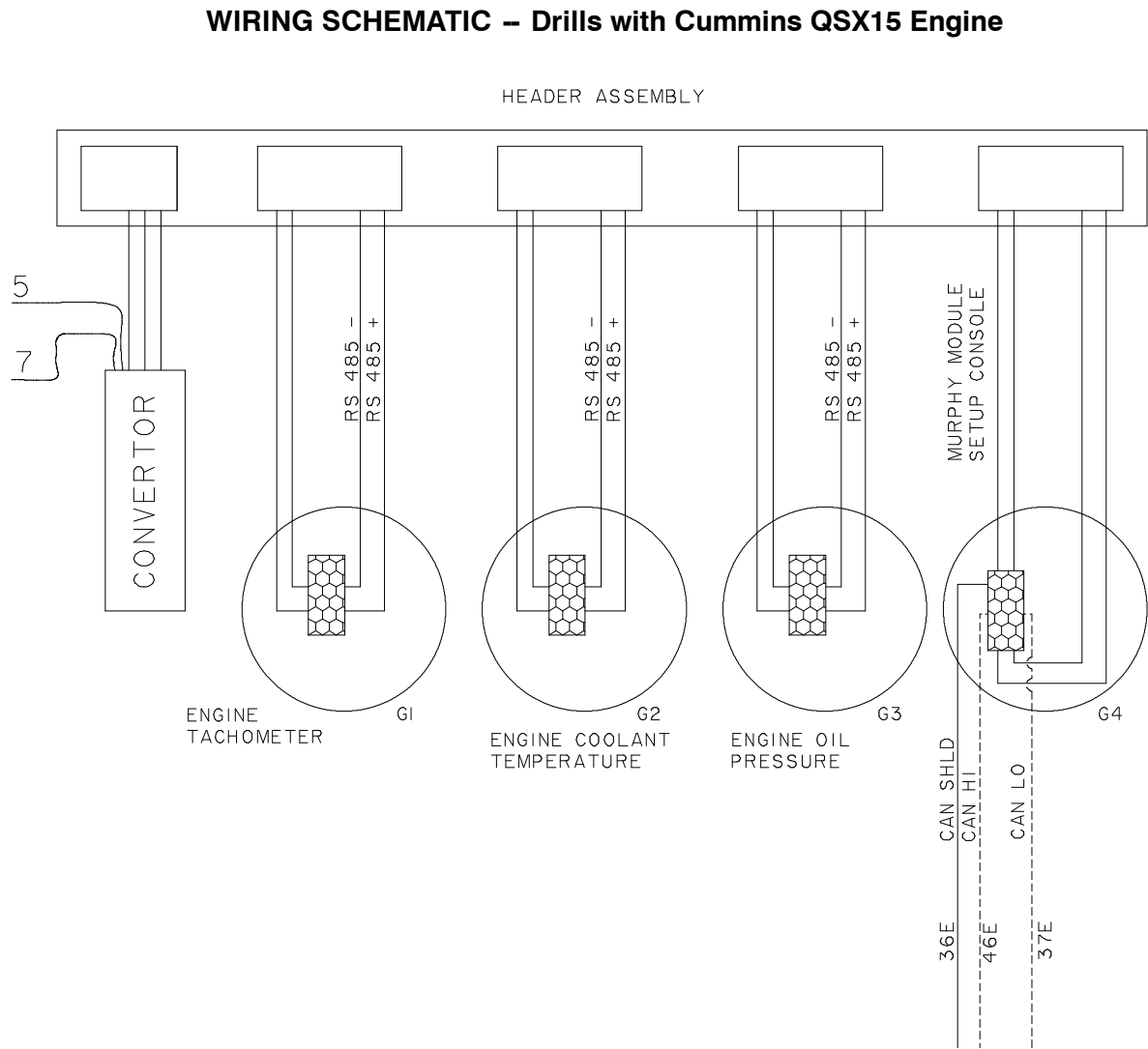


Figure 7.2–88

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with Cummins QSX15 Engine

COLOR		WIRE DESCRIPTION	
	GAGE	NUMBER	CIRCUIT
RED	8	1,	+ POSITIVE FEEDER
GREEN	14	3,4,7,8,16,25,30	START,STOP,ETHER
BLUE	14	10,40,41	BREAKOUT WRENCH, PINNING
VIOLET	14	18,22	LIGHTS
BLACK	10,14	5,09E,10E	GROUND
WHT	14	28E,18E,07E,08E,17E	UNSWITCHED POWER
RED	10	6,35	JUMPER WIRE OR BUSS BAR
		29E,30E,39E,40E,50E	UNSWITCHED POWER RETURN
GRAY	14	T,V,U,S,38E,14E, 24E,44E,05E,16E, 06E,31E,28E,04E,03E	ENGINE HARNESS
GRAY	14/3	(48E,47E,49E) (46E,37E)(26E,27E)	QSX HARNESS

EXCEPTIONS : BATTERY & STARTER GROUND CABLES,
ARE BLACK 2/0.

NOTES :

1. SYMBOLS IN () ARE TERMINAL MARKINGS ON DEVICES.
2. LAMP LOCATED IN AMP-METER.

Figure 7.2–89

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with CAT Engine

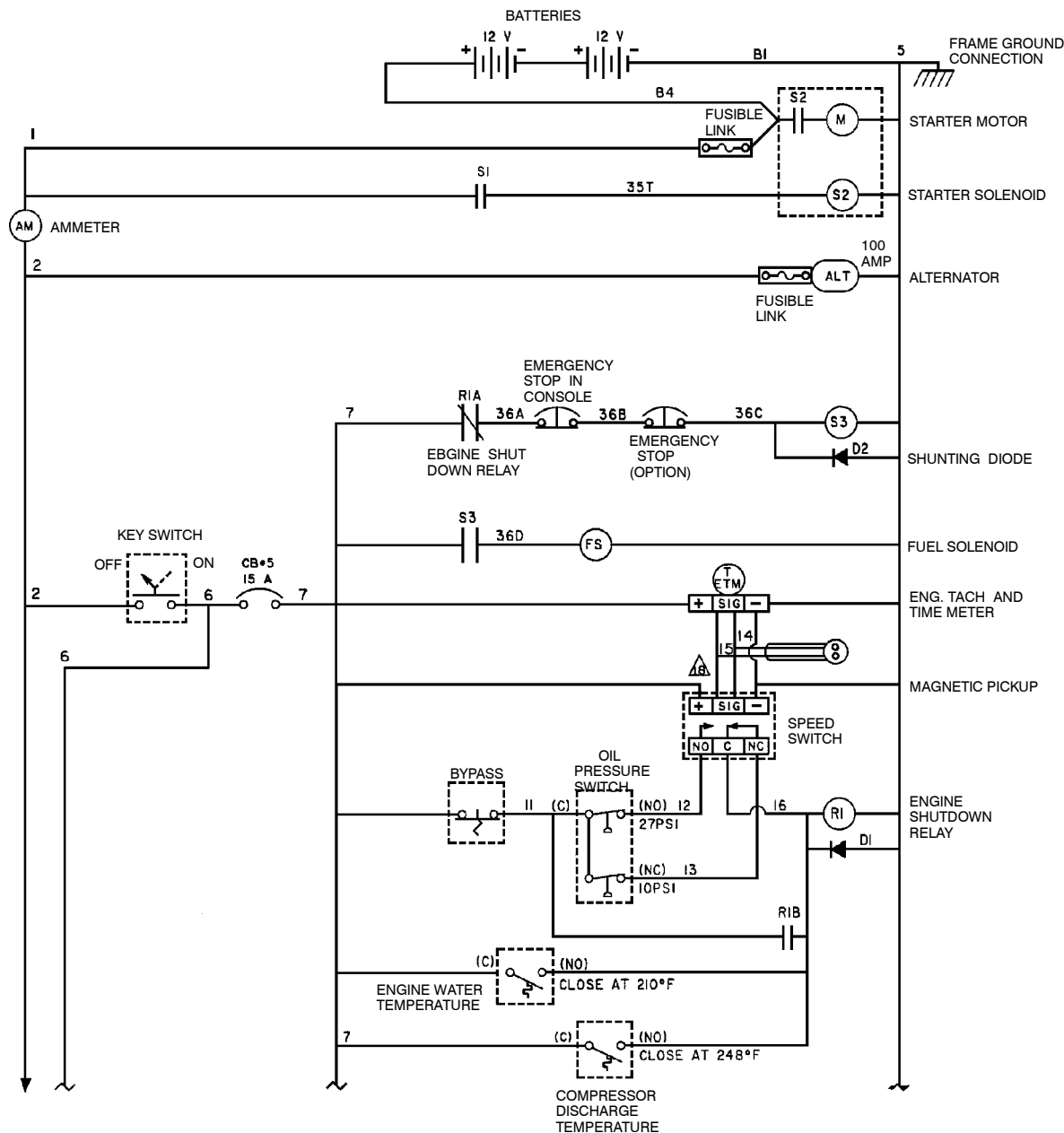


Figure 7.2–90

7.2 - TROUBLESHOOTING (ELECTRICAL)

WIRING SCHEMATIC – Drills with CAT ENGINE

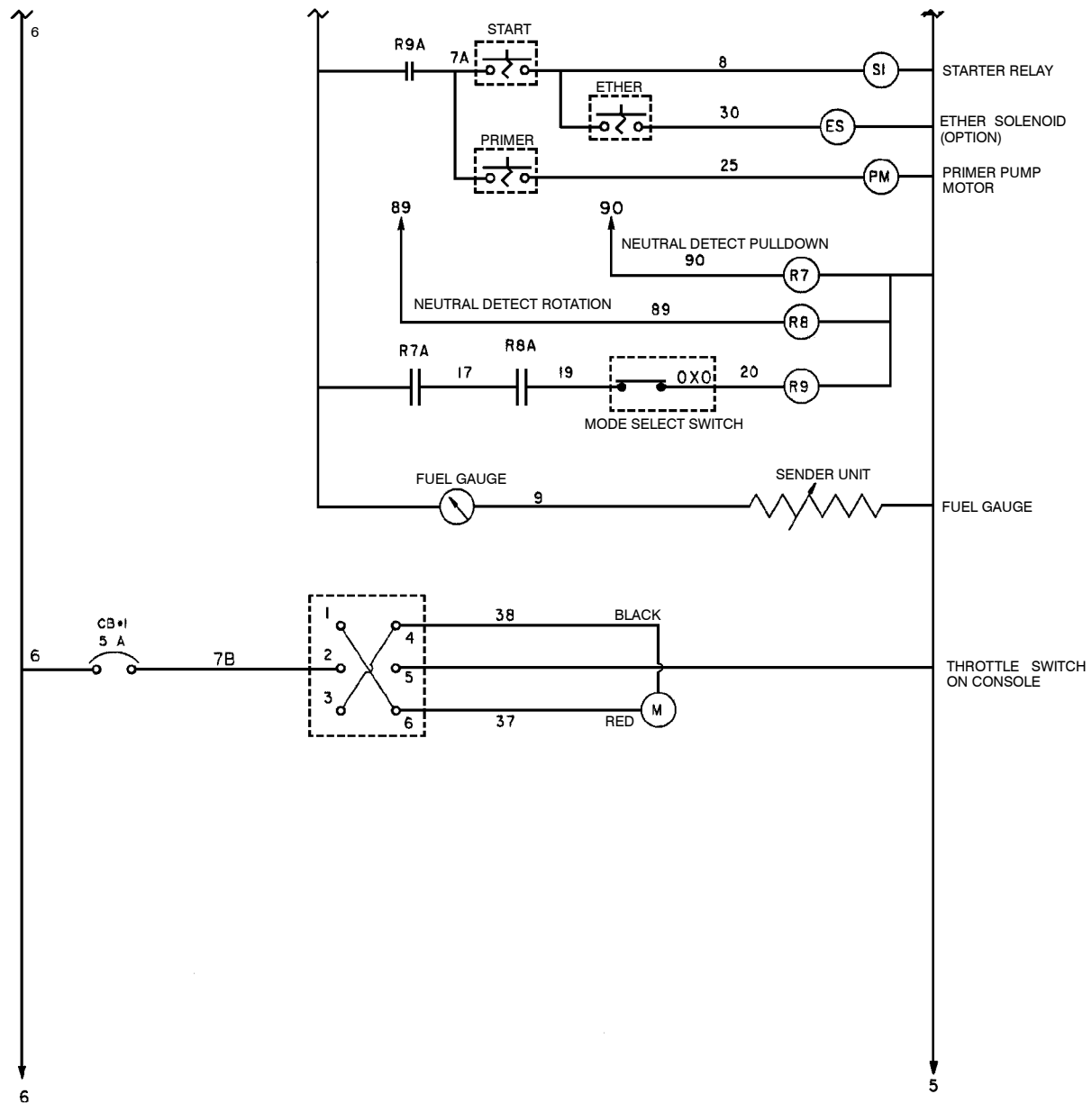


Figure 7.2–91

7.2 - TROUBLESHOOTING (ELECTRICAL)

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7.3 - TROUBLESHOOTING (OPERATOR OBSERVED PROBLEMS)

OPERATOR OBSERVED PROBLEMS

During operations, the operator may observe some problems which may be defined in the following *Operator Observed Problems Trouble Shooting Chart*.

The trouble shooting chart is limited to machine control operational problems which will guide the operator to rectify the cause of the failure.

Operator Observed Problems Trouble Shooting Chart		
Problem	Cause	Correction
ENGINE WILL NOT START (Starter does not rotate)	Circuit breaker "5" tripped	Reset Circuit Breaker "5"
	Emergency Stop switch requires resetting	Check Emergency Stop switch and reset if required
	Drill Propel Control in Propel Mode	Move to Drill Mode
	Track controllers not in STOP position	Move to STOP position
	Batteries disconnected at Isolator Switch	Turn battery isolator switch to ON
	Batteries discharged	Check batteries. Recharge if required
	Battery cable connections loose or disconnected	Clean and tighten terminals
	a). Fusible link to starter motor fused	Call for service to correct fault
	b). Starter relay fault	
	c). Starter switch defective	
	d). Starter solenoid or starter defective	
	Compressor Switchgauge defective	Replace Switchgauge
	Shutdown Relay defective	Replace Relay
	Empty Fuel Tank	Fill tank
	Fuel solenoid at fuel pump defective	Call for service
	Defective Wiring	Check with test lamp

7.3 – TROUBLESHOOTING (OPERATOR OBSERVED PROBLEMS)

OPERATOR OBSERVED PROBLEMS (continued)

Operator Observed Problems Trouble Shooting Chart		
Problem	Cause	Correction
ENGINE DIFFICULT TO START AND HAS POOR AND IRREGULAR PERFORMANCE	Compressor butterfly inlet valve open while starting	Close butterfly inlet valve when starting
	Low battery power	Check battery
	Batteries discharged	Charge batteries if necessary
	Battery cable connections loose or corroded causing starter to turn too slowly	Clean and tighten terminal connections, cover connections with acid free grease
	Using too high viscosity oils in low ambient temperature	Use appropriate oil grade in winter
	Fuel line blockage due to wax separation in winter	Change fuel filters, bleed fuel system, check for fuel leaks and loose connections
	Incorrect valve clearances	Call for service to adjust
	a). Defective fuel injectors	Call for specialist service
	b). Defective turbo charger	
	Blocked air cleaner element	Clean or replace element
	Loose or badly adjusted engine speed control linkage	Call for specialist service to make adjustments
ENGINE SHUTS DOWN	Engine fault	Check Engine Diagnostics
ENGINE MAKING EXCESSIVE FUMES	Engine oil level too high	Drain engine oil to correct level on the dipstick
	Blocked air cleaner element	Clean or replace element
	Low compression due to poor condition of valves or incorrect valve clearances	Call for specialist service
ENGINE OVERHEATS !! STOP ENGINE IMMEDIATELY!!	Excessive dirt on cooling system blocking air flow	Clean cooling fins on radiator / oil coolers
	Engine coolant loss. Low coolant level in engine.	Call for service to correct defects
	Defective injector nozzles	
	Incorrect fuel pump calibration	
	Cooling system fan not rotating or rotating at reduced rpm.	
LOW ENGINE OIL PRESSURE	Low engine oil will activate engine diagnostic ECM system	Refer to 7.2 QSK ENGINE PROTECTION SYSTEM.
BATTERY STATE AMMETER INDICATES LOW OR NEGATIVE VALUE	Speed of alternator too low	Check drive belt tension
	Not changing due to defective alternator or regulator	Call for service to correct defects
GENERAL DEFECTS ON ELECTRICAL EQUIPMENT	Circuit breaker open	Reset respective circuit breaker
	Defective parts or wiring	Call for service to correct defects

7.4 – LOW PRESSURE COMPRESSOR

PNEUMATIC SYSTEM INFORMATION

All air compressors used on the Mid-Range drills are of the oil flooded asymmetrical rotary screw design. Tapered roller bearings are used to handle thrust and radial loads.

Standard equipment for the air compressor includes a separate three stage inlet air cleaner and full instrumentation and controls. The lubrication system includes an oil cooler, bypass valve, oil filter, oil pump, and combination receiver and oil separator tank. A safety shutdown system is also provided for high discharge air temperature.

The oil pump allows the operator to close the intake valve when no air is required. This greatly reduces the engine load which saves fuel and facilitates cold weather starting.

Low Pressure compressors are those with discharge pressures of 100 to 150 psi. A compressor is considered high pressure if the discharge pressure is 250 psi or greater. All of the **High Pressure** compressors have discharge pressures of 350 psi. See *Low Pressure Compressor* or *High Pressure Compressor* sections for specific detailed information.

There are three systems on a rotary screw compressor:

1. **Lubrication System**
2. **Separation System**
3. **Regulation System**

Each system is critical to the operation of the air end and the systems are all interrelated. These systems will be described further in the appropriate areas of *Low Pressure Compressor* or *High Pressure Compressor* sections

7.4 – LOW PRESSURE COMPRESSOR

COMPRESSOR FIRE PREVENTION

A fiber gasket is installed between the outside cover of the receiver and the metal tube holding the separator element in place. This gasket prevents oil from leaking around the metal tube and down the hole.

When air and oil flow through the filter media, static electric charges are created. If these charges are allowed to build up, a spark similar to a lightning flash will occur. This will set the oil and the media on fire. The fire will burn from the inside of the element through the standpipe hose and will follow the air flow until it burns through the air hose. This is **NOT** a fire caused by the compressor flashing.

To prevent this from happening, several metal staples have been installed THROUGH the gasket so each side comes in contact with the metal. This bridge serves to allow the static charge to drain off outside the receiver tank and not cause a static buildup.



When replacing separator element, be sure there is at least one staple that shows through on both sides of the gasket and is not covered with glue.

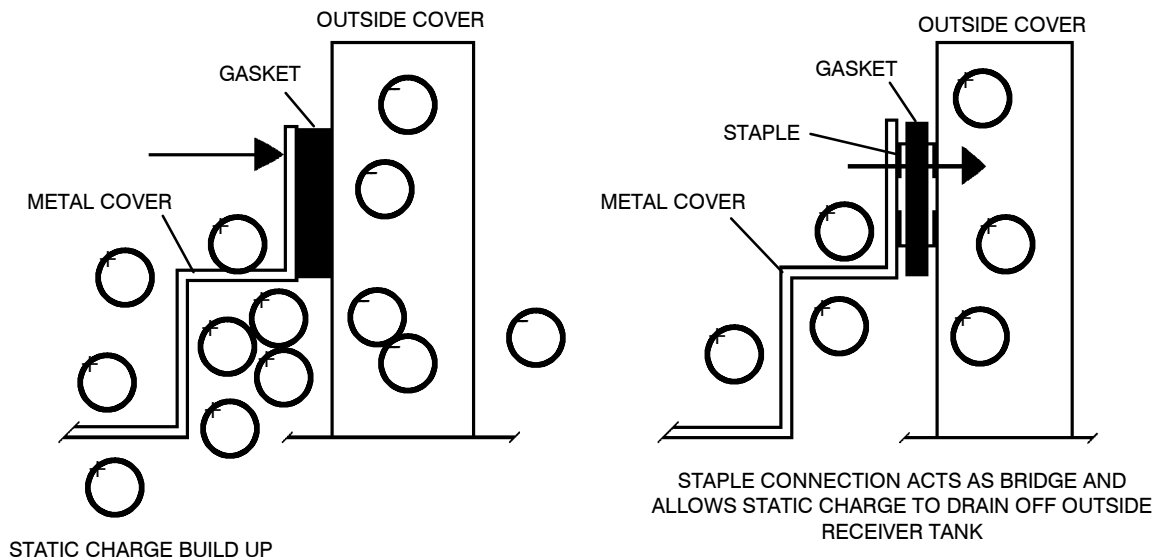


Figure 7.4–1

7.4 – LOW PRESSURE COMPRESSOR

LUBRICATION SYSTEM

Low Pressure compressors are those with discharge pressures of 100 to 150 psi. These compressors are of the single stage, oil flooded, asymmetrical screw design. They are listed by the metric diameter of the rotors. The Low Pressure Drills use a 226mm air end or a 285mm air end.

The **Lubrication System** consists of the receiver, an oil pump, cooler, mixing valve, filters and a manifold. When the compressor is compressing air, a minimum pressure valve in the discharge line holds a certain pressure in the receiver tank to assist in pushing the oil through the system. The minimum pressure valve is set at 20–60 psi.

COMPONENTS

Receiver - Separator Tank

The receiver tank (Figure 7.4-2) contains the compressed air and the lubricating oil for the compressor. The oil is removed from the air by centrifugal force, gravity and velocity. The receiver tank has an oil sight glass that shows the oil level at all times. The oil level must be visible in the sight glass whether the drill is running or shut down.

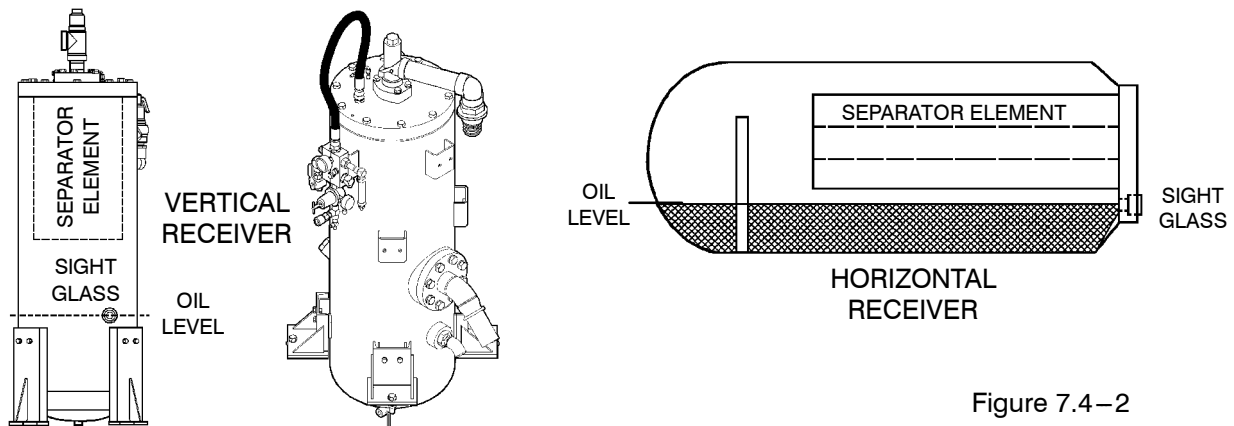


Figure 7.4-2

Oil Pump

The oil pump (Figure 7.4-3) is a gear type pump, driven from the rear of one of the compressor rotors. It operates as long as the compressor is turning. It is speed sensitive and pumps at rated volume when the compressor is at full RPM.

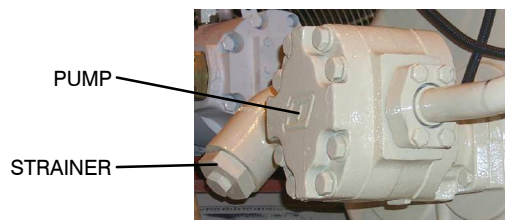
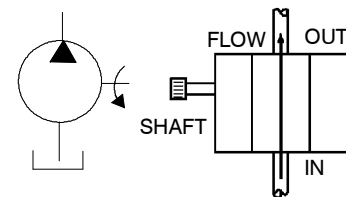


Figure 7.4-3



It acts as a normal pump when the oil is cold and becomes a restriction to hold back pressure on the receiver tank when the compressor is operating at normal pressure and temperature. This prevents all the oil from being forced out of the receiver tank at once and flooding the compressor.

7.4 – LOW PRESSURE COMPRESSOR

LUBRICATION SYSTEM COMPONENTS (continued)

Strainer

A 40 mesh (150 micron) strainer is mounted just before the inlet to the oil pump as shown in figure 7.4–3. It protects the pump and catches any foreign debris such as hose pieces and parts of the thermostat that could damage the pump. The metal strainer should be removed, cleaned and reinstalled every 500 hours.

Compressor Oil

The low pressure (XL series/110 psi) air ends require a special oil. This oil is **not** compatible with certain types of O-rings. Therefore, we use “Viton” type O-rings in the air end fittings and filters. The oil is also **not** compatible with other oils and should never be mixed with other oil. **Low pressure compressors use I-R PROTEC oil.** Be sure to change the filters every 500 hours.

Mixing Valve

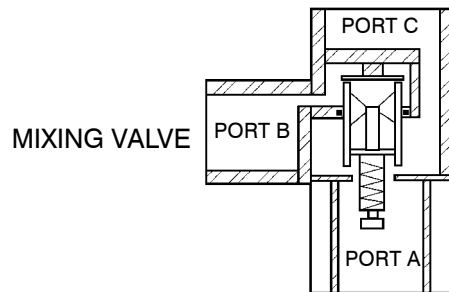


Figure 7.4–4

The Mixing Valve (Figure 7.4–4) contains a thermostat that stops oil flow in one direction when it is cold and allows oil to flow from another direction when it reaches operating temperature. When the temperature is below 140°F (63°C), oil flows from port “B” to port “A”, thus bypassing the oil cooler altogether. When the temperature increases to 160°F (71°C), the thermostat is completely opened and all the oil flows from from port “C” to “A” and shuts off all flow to “B”. At temperatures in between 140°F (63°C) and 160°F (71°C), some oil flows through port “B” to “A” and some oil flows through the cooler and from “C” to “A”. Under normal operation, some oil is flowing through both “B” and “C”. The normal discharge temperature of the oil leaving the air end should be between 180°F (83°C) and 220°F (104°C).

Oil Cooler

The Compressor Oil Cooler (Figure 7.4–5) is a single pass unit. Hot oil enters from the bottom of the cooler and cool oil exits out the top. This prevents any air bubbles that may have been carried along with the oil from being trapped in the top and creating a vapor barrier.

7.4 – LOW PRESSURE COMPRESSOR

Oil Cooler (continued)

The cooler is made up of three sections. The larger section cools the compressor oil, the middle section cools the engine coolant and the smaller section cools the hydraulic oil.

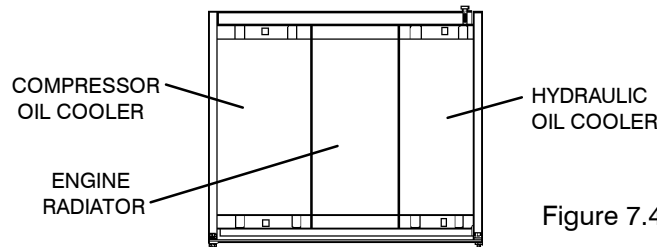


Figure 7.4–5

Relief Valve

A 50 psi Relief Valve (Figure 7.4–6) is connected between the inlet and outlet of the oil cooler.

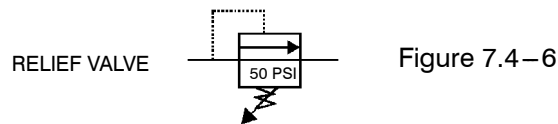


Figure 7.4–6

If the cooler becomes plugged and the inlet pressure becomes 50 psi higher than the outlet pressure, the relief valve opens and allows oil to bypass the cooler. When the differential pressure is reduced below 50 psi, the valve will close and normal flow resumes.

Oil Filter

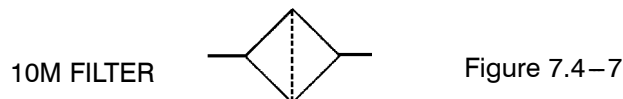


Figure 7.4–7

A 10 micron filter (Figure 7.4–7) is installed at the outlet of the cooler before the oil reaches the compressor. It catches any contaminants that may have been picked up in the circuit and prevents them from plugging the orifices at the inlets to the bearings.

Discharge Check Valve

The Discharge Check Valve serves one purpose for two mediums, air and oil. It prevents air and oil, under pressure, from backing up into the air end. When the drill is stopped, pressure in the compressor drops to zero. There is still pressure in the receiver tank until it completely blows down. If the check valve was not there, air pressure would force air and oil back through the compressor housing and out the inlet valve, thus flooding the air cleaners.

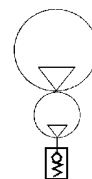


Figure 7.4–8

Figure 7.4–8 shows the valve being held open. It has a single spring. The hinge must be mounted on top to prevent the valve from staying open when the drill is shut down. Notice the white nylon ring that forms a tight seal to prevent back flow when the drill is stopped.

7.4 – LOW PRESSURE COMPRESSOR

Oil Flow

The layout for the lubrication system is shown below in. Oil is stored in the receiver tank. At startup, the pump must pull the oil from the tank. When air pressure rises in the receiver, oil is pushed by air pressure from the tank to the oil pump. The pump then moves the oil to the mixing valve and/or the cooler. Depending on the oil temperature, it either flows through the mixing valve, filter and into the compressor oil manifold or through the oil cooler and then the mixing valve, filter and to the compressor oil manifold.

From the compressor manifold, oil passes into the air end. Oil is pumped to each bearing and rotor and into the cavity of the air end to mix with the air being compressed. This controls the temperature of the discharge air. When the air has been compressed, the oil/air mixture passes into the receiver tank to be separated.

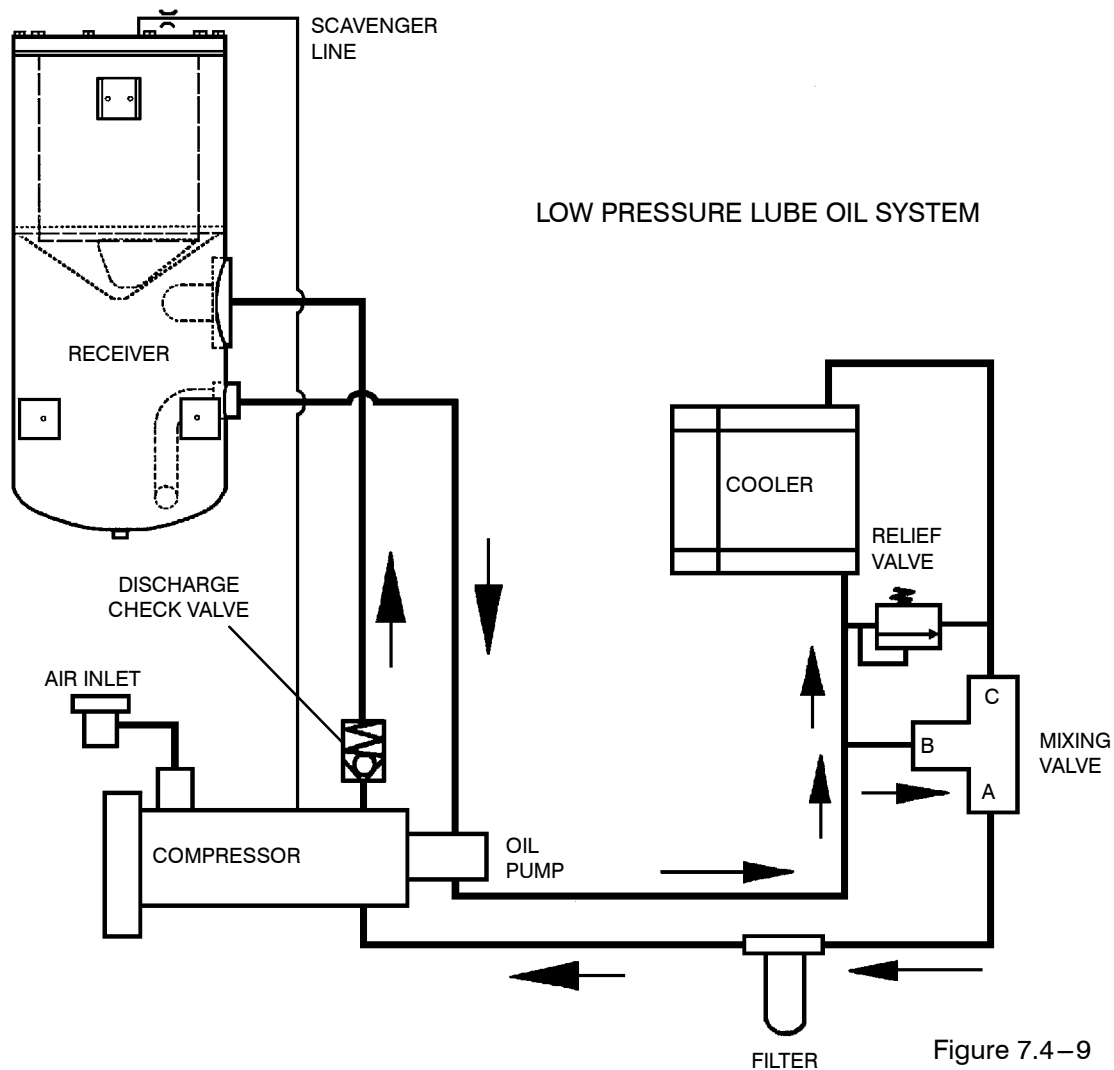


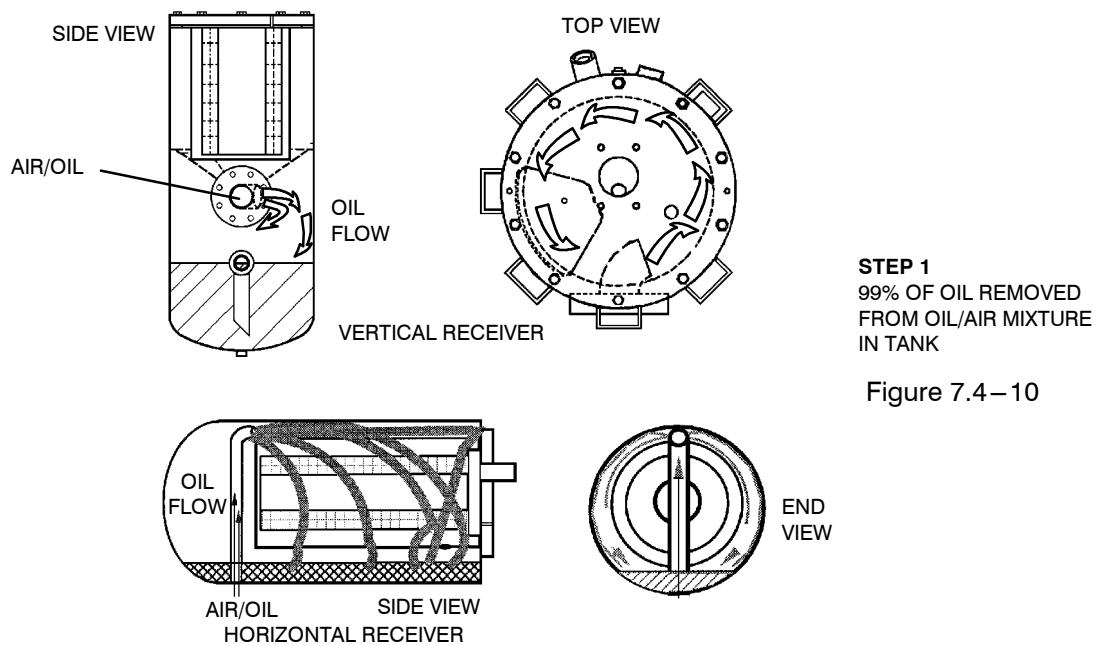
Figure 7.4–9

7.4 – LOW PRESSURE COMPRESSOR

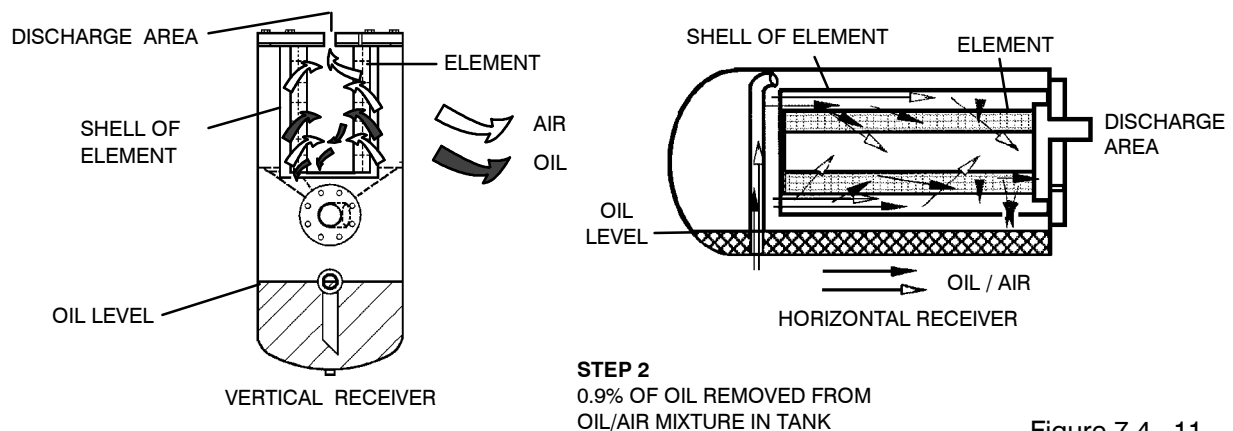
SEPARATION SYSTEM

Lubricating oil is forced through the air end to **cool, seal and lubricate** the rotors. When the oil is pumped into the receiver-separator tank, it must be separated from the air going down the hole. This is accomplished in three steps.

1. The Air/Oil mixture enters the receiver through the inlet pipe and splashes against the inner walls. This forces the majority of oil to fall to the bottom of the tank and remain there.



2. When the down stream air line is opened and air flows down the hole, some of the remaining oil is carried along with it into the filter area. A metal canister prevents oil from flowing through the filter directly. The air/oil mixture enters the outer edge of the element and moves towards the center. As the oil travels through the element, it is slowed down by friction and gravity pulls it downward. Most of the oil drops out the bottom of the element and falls into the reservoir.



7.4 – LOW PRESSURE COMPRESSOR

SEPARATION SYSTEM (continued)

- The final step in the separation process is removing any remaining oil from the element so it is not carried over into the down hole air stream (see Figure 7.4–12). When enough excess oil is carried into the center of the element, a series of holes in the end of the filter element allows oil to fill an area between the flange and the element. The scavenger line is connected between the flange and the inlet of the compressor. Since there is a differential pressure between the receiver tank and the low pressure area of the compressor, oil and air are forced through the scavenger line into the inlet area of the air end, thus removing the last of the oil carryover. A 0.94" orifice in the line prevents excessive amounts of air loss.

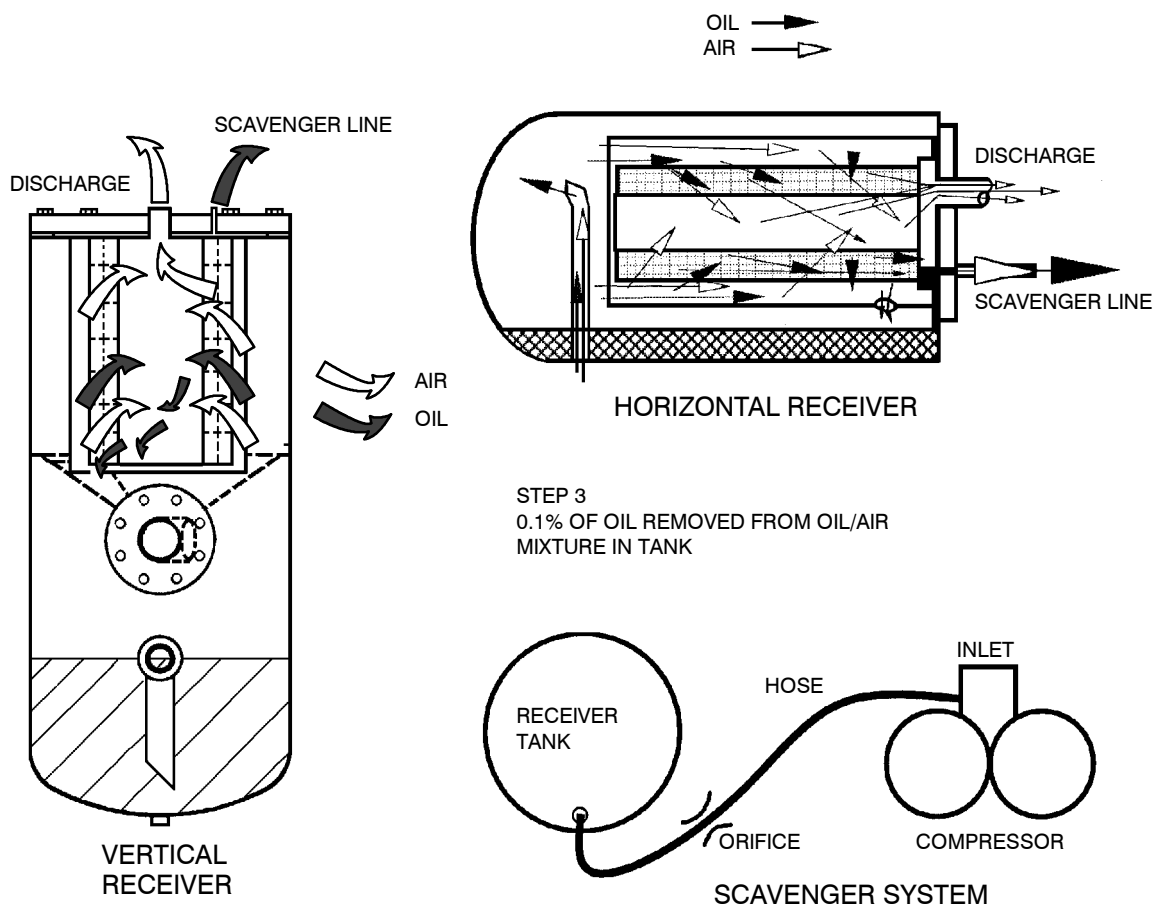


Figure 7.4–12

7.4 – LOW PRESSURE COMPRESSOR

SEPARATION SYSTEM (continued)

It is important to note when changing separator elements that the element be installed correctly. The word “TOP” should always be on top to insure that the drain holes are at the bottom (see Figure 7.4–13). This prevents excessive buildup in the scavenger area.

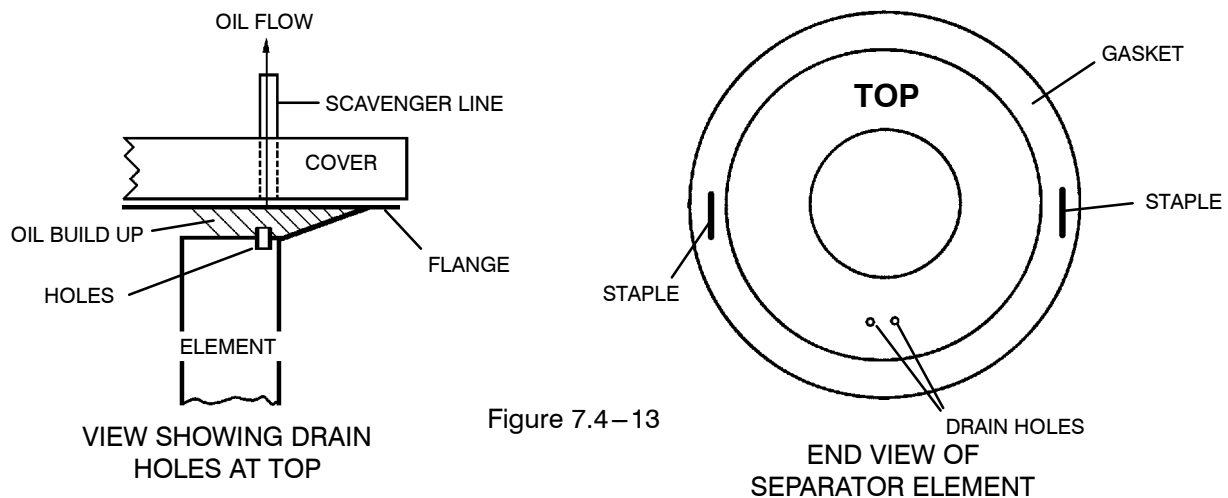


Figure 7.4–13

Another item to watch when changing elements is to be sure that the staples in the gaskets are left there to prevent a static electric charge from building up and causing a fire.

7.4 – LOW PRESSURE COMPRESSOR

REGULATION SYSTEM

The regulation system controls the pressure and volume of the air going down the hole to the bit. The *Butterfly Valve* (also called the “*Inlet Valve*”) is manually opened and closed by the compressor control handle in the operator’s control console in the cab (see Figure 7.4–14). Normal drilling is performed when the operator pulls the handle toward him to open the *Inlet Valve* while the engine is at full RPM. This allows air into the compressor inlet and it is compressed as it goes through the air end. The compressed air is forced into the *Receiver Tank* and as long as the pressure is greater than 20 psi, air will flow to the bit through the standpipe. A *Minimum Pressure Valve* is mounted between the receiver tank and the standpipe to insure there is always 20 psi in the tank. This pressure forces oil into the *Oil Pump* to insure a positive flow to the lubrication system at all times.

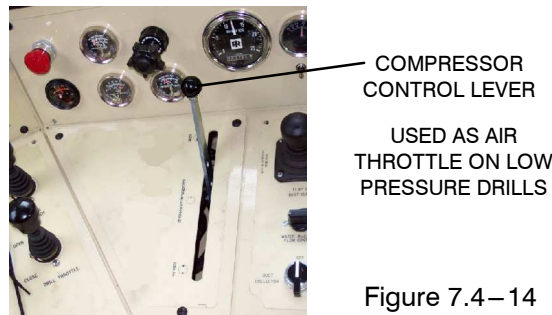


Figure 7.4–14

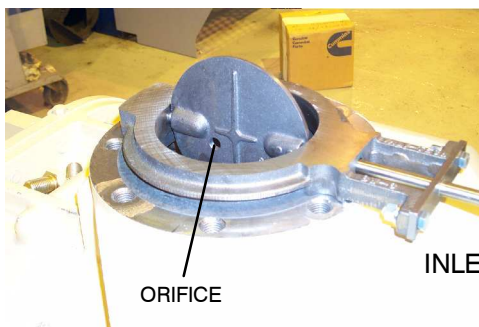
A *Discharge Check Valve* is located at the discharge of the air end to prevent any pressure from returning to the air end when the drill is stopped. While the drill is running, there is a flow of oil being pumped into the air end whether air is being compressed or not. This oil is forced out of the air end into the *Receiver Tank* through the *Check Valve*.

There is a scavenger line connected from the base of the *Separator Element* to the inlet area on the air end. This line removes the excess oil from the element and returns it to the air end. Refer to the previous SEPARATION SYSTEM Section for more information.

REGULATION SYSTEM COMPONENTS

The 226mm and 285mm air end regulation system has one manual control to open and close the inlet valve and several other automatic devices to operate the system.

Inlet “Butterfly” Valve



INLET “BUTTERFLY” VALVE

Figure 7.4–15



The Inlet Butterfly Valve is a round, wafer valve that sits on top of the compressor. It has a shaft that is connected to the center of the valve. This is where the linkage for the Control Cable and the Air Cylinder are attached.

7.4 – LOW PRESSURE COMPRESSOR

REGULATION SYSTEM (continued)

Orifice in Inlet Valve

There is an orifice drilled in the Inlet Butterfly Valve (Figure 7.4–15) to allow outside air to enter the compressor at all times. This opening allows enough air into the compressor to provide pressure to the auxiliary functions such as the air pulse on the dust collector.

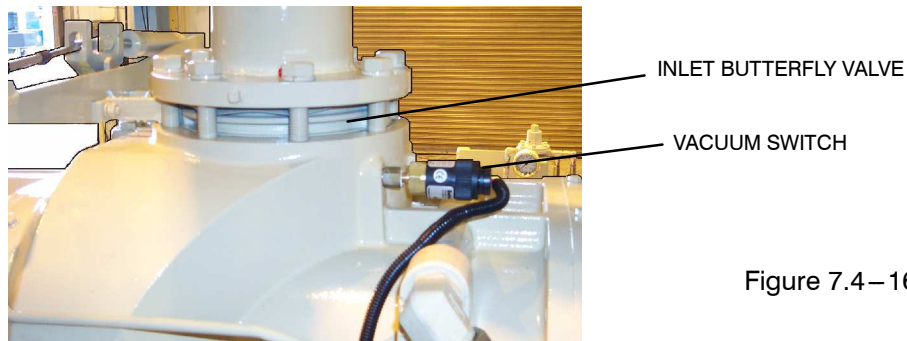


Figure 7.4–16

A Vacuum Switch (Figure 7.4–16) is attached to the compressor housing just under the *Inlet Butterfly Valve*.

When the Inlet Butterfly Valve is closed, a vacuum is developed in this area that closes a 24 VDC switch when it reaches 15 in. Hg.

When the Inlet Butterfly Valve is opened, vacuum is lost and the switch opens, releasing the solenoid in the Control Valve.

Control Valve



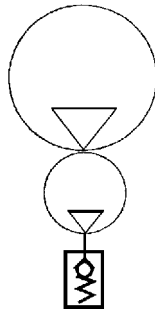
Figure 7.4–17

The Control Valve is a two position, three way valve that connects the Blowdown Valve with both the suction and discharge sides of the compressor. It is operated by a 24 VDC Solenoid Switch on one end and a spring on the other. If the solenoid is not activated, the spring will move it to the default or pressure setting. This allows pressure from the compressor to pilot the Blowdown Valve closed.

7.4 – LOW PRESSURE COMPRESSOR

REGULATION SYSTEM (continued)

Discharge Check Valve



DISCHARGE
CHECK VALVE

Figure 7.4–18

The Discharge Check Valve is located at the outlet of the compressor and prevents any oil or air, under pressure, from backing up into the compressor housing. While the compressor is running, oil and air are being forced out of the compressor housing and this keeps the Discharge Check Valve open. When the compressor is stopped nothing is coming from the compressor side, but pressure is built up in the receiver. This would pressurize the compressor housing if the Discharge check Valve were not there.

Figure 7.4–18 shows the valve being held open. It has a single spring. The hinge must be mounted on top to prevent the valve from staying open when the drill is shut down. Notice the white nylon ring that forms a tight seal to prevent back flow when the drill is stopped.

Blowdown Valve



SILENCER

RECEIVER
TANK

BLOWDOWN
VALVE

LOCATED UNDER THE DECKING
NEXT TO THE RECEIVER TANK



Figure 7.4–19

The Blowdown Valve (Figure 7.4–19) maintains the balance of pressure between the air entering through the orifice and escaping through the Minimum Pressure Valve. When the Inlet Butterfly Valve is closed, air is still being compressed and the pressure in the Receiver Tank would build until the *Safety Valve* opened. Whenever the vacuum switch closes, the Control Valve is positioned to allow pilot pressure to bleed off from the Blowdown Valve and it opens, allowing pressure to bleed through the silencer and maintain the same pressure in the Receiver Tank.

7.4 – LOW PRESSURE COMPRESSOR

REGULATION SYSTEM (continued)

Receiver Tank

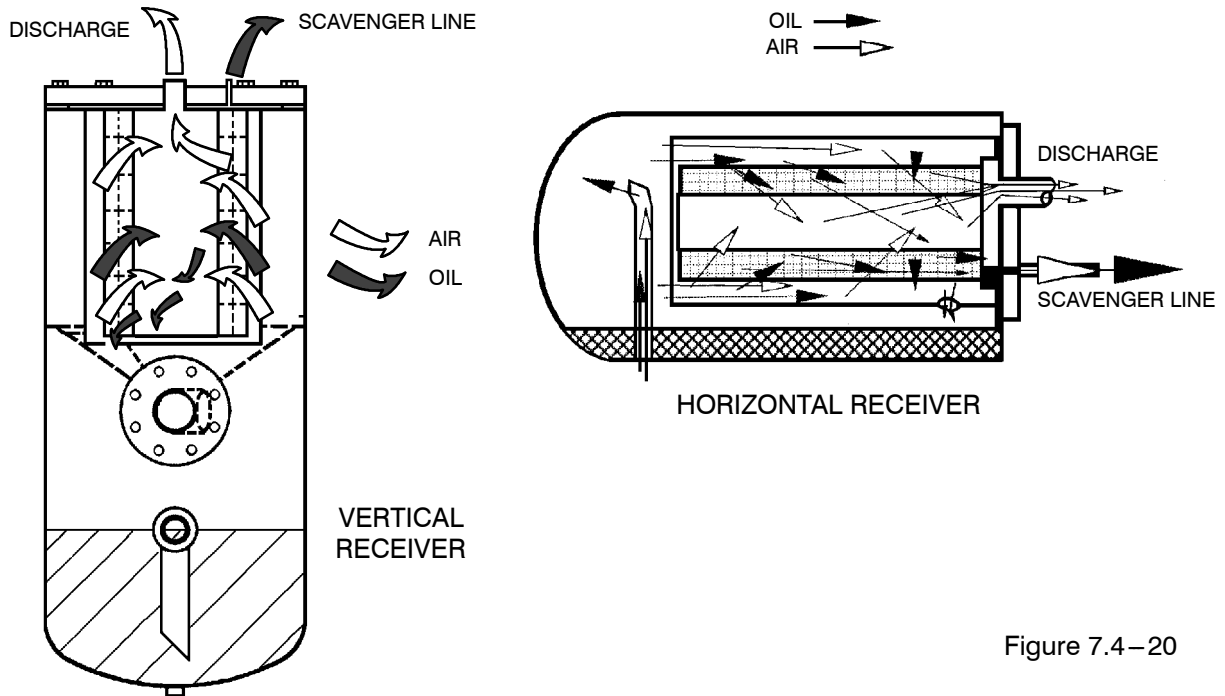


Figure 7.4–20

The Receiver Tank serves several purposes. It contains the lubricating oil that is used to cool and lubricate the compressor. It serves as a reservoir for the compressed air. Also, the Separator Element helps to separate the oil from the air.

Minimum Pressure Valve



MINIMUM PRESSURE VALVE



SAFETY RELIEF VALVE

The minimum pressure relief valve (Figure 7.4–21) opens when the pressure in the Receiver Tank reaches 20 psi. It maintains a back-pressure in the Receiver to force oil out of the tank into the lubricating system. If this valve were not present, the air pressure would drop to 0 psi and the lubricating system would not get enough oil to keep the compressor cool.

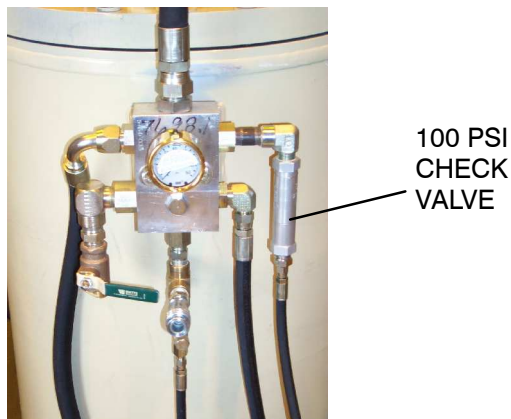
7.4 – LOW PRESSURE COMPRESSOR

REGULATION SYSTEM (continued)

Safety Relief Valve

All drills are equipped with safety valves (Figure 7.4-21). The setting on these valves is 25–50 psi higher than the maximum working pressure. The **only** function of a safety valve is to prevent damage to the receiver tank in case of other failures. It should never be used as a high pressure relief valve for two reasons. One, the pressure setting is above the allowable working pressure of the compressor. Two, the safety valve loses a small amount of spring tension every time it is opened. Therefore, the pop off pressure will be reduced each time it is opened and will shortly open below the normal operating pressure and will have to be replaced.

100 psi Check Valve



AIR CYLINDER

Figure 7.4–22

A 100 psi Check Valve (Figure 7.4-22) is attached to the discharge area of the compressor. In the event that the bit becomes plugged down the hole, air pressure would build up and normally open the safety valves. An automatic shut off system using the check valve and an air cylinder prevents this from happening.

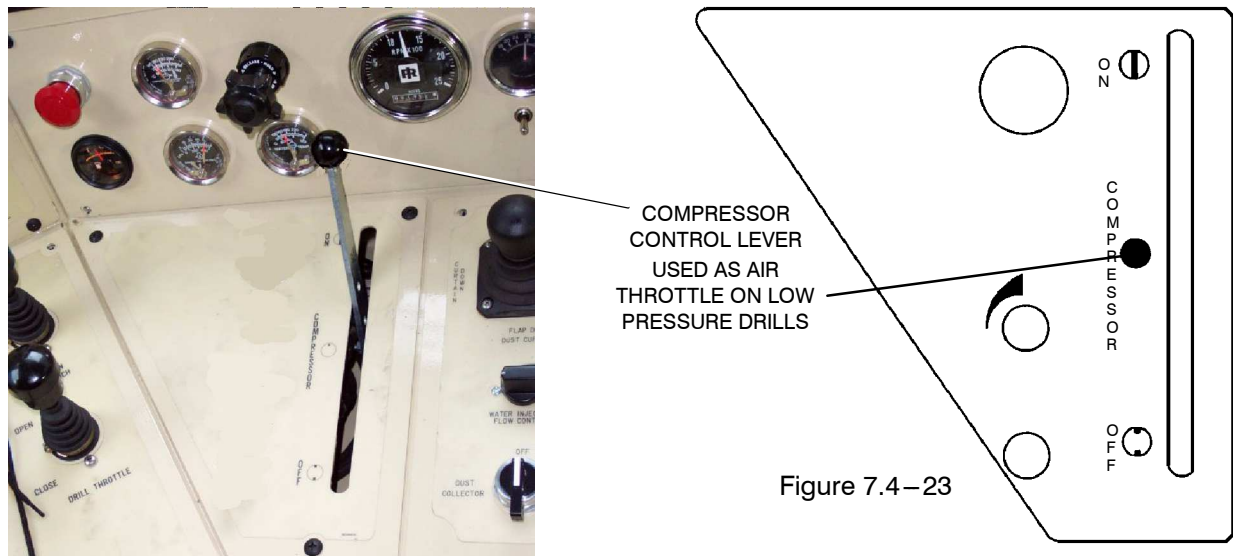
Air Cylinder

A single acting Air Cylinder (Figure 7.4-22) with a spring return is attached to the Butterfly Valve opposite the control Cable. Whenever air pressure exceeds 100 psi, the Check Valve opens and allows excess pressure to enter the back of the cylinder. When the pressure overcomes the spring pressure (about 35 psi), the cylinder will extend and close the Butterfly Valve regardless of the Control Cable position. This will alert the operator that there is a problem downstream. A small (0.06") hole is drilled in the inlet fitting of the air line to relieve the pressure in the cylinder when the check valve closes.

7.4 – LOW PRESSURE COMPRESSOR

OPERATION

When the drill is first started, the *Control Handle* in the operator's cab is in the "OFF" position and pushed forward. The *Inlet Butterfly Valve* is closed and the only air entering the compressor is through the *Orifice* in the *Inlet Butterfly Valve*. The closed inlet causes a high vacuum under the *Inlet Butterfly Valve* and almost immediately closes the *Vacuum Switch*. This activates the solenoid that shifts the *Control Valve*.



When the *Control Valve* is shifted, it connects the pilot section of the *Blowdown Valve* to the vacuum side of the compressor. The vacuum assists the spring on the *Blowdown Valve* in shifting the *Control Valve* and allows some air from the *Receiver Tank* to discharge through the silencer.

When the operator pulls the *Control Handle* and opens the *Inlet Butterfly Valve*, vacuum is lost at the *Vacuum Switch*. The *Control Valve* changes position to allow pressure from the compressor discharge to pilot the *Blowdown Valve* closed and stop all flow from the *Receiver Tank*. This is the normal "RUN" position.

LP Compressor Control Lever

This is for low pressure drills only. On Low Pressure drills, the Compressor Control Lever (figure 7.4-23) is used as an Air Throttle that turns on the compressed air to power the Downhole Drill (DHD) and cleans the cuttings out of the hole for both rotary and Downhole drilling.

7.4 – LOW PRESSURE COMPRESSOR

Start Position

The Control Handle is forward in the “OFF” position. The Inlet Butterfly Valve is closed. When the compressor starts, some air is allowed to enter through the orifice but the vacuum increases until it activates the solenoid in the Control Valve. When the Control Valve opens, it reduces pilot pressure to the Blowdown Valve and the spring shifts the valve to open position. Pressure in the Receiver Tank is allowed to escape through the Blowdown Valve. Air pressure in the Receiver Tank is maintained at a minimum until the Inlet Butterfly Valve is opened. Refer to START OR OFF MODE Schematic below.



Figure 7.4–24

7.4 – LOW PRESSURE COMPRESSOR

Run Position

When the operator wishes to drill, he pulls the Control Handle and opens the Inlet Butterfly Valve. This action causes the Vacuum Switch to open and the Control Valve shifts by spring pressure to the open position. This action pilots the Blowdown Valve closed and stops all air from escaping through the Blowdown Valve. All air pressure is then directed down the hole through the Minimum Pressure Valve. Refer to RUN MODE Schematic below.

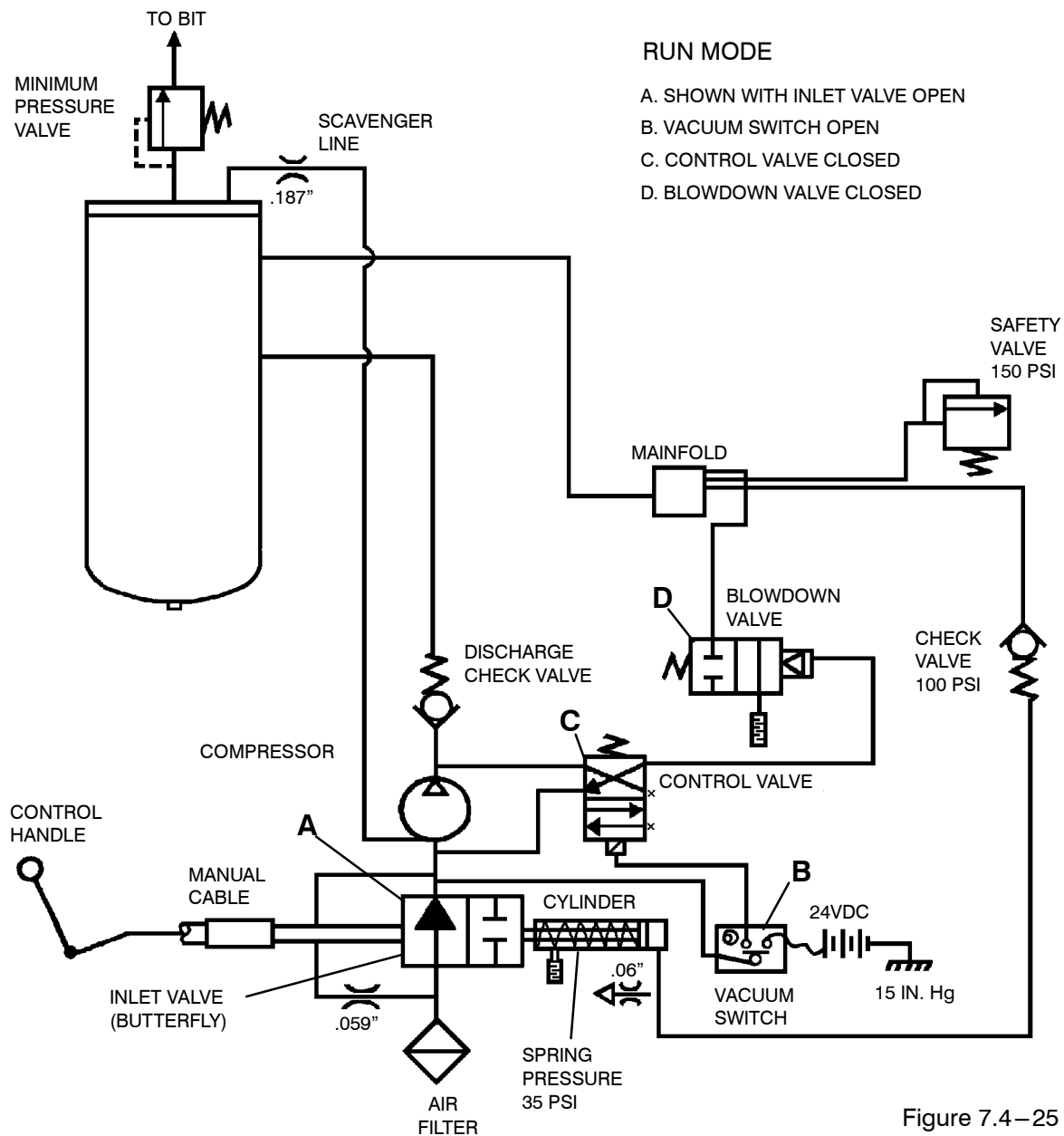


Figure 7.4–25

7.4 – LOW PRESSURE COMPRESSOR

Stuck Bit Position

In the event the drill bit becomes plugged, pressure in the system would build up until it blew the Safety Valves. To prevent this, a Check Valve and Air Cylinder are installed in the system. Whenever the receiver pressure approaches the safety setting, the Check Valve opens and allows pressure to flow to the Air Cylinder. The Air Cylinder is directly connected to the Inlet Butterfly Valve and closes it when air pressure overcomes the Check Valve setting and the spring in the Air

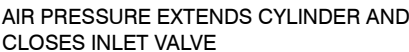


Figure 7.4–26

7.4 – LOW PRESSURE COMPRESSOR

COMPRESSOR RELATED PROBLEMS

Trouble shooting and repairs of defects in the mechanical functioning of the compressor systems requires specialist knowledge. All compressor related problems should be referred to your local service support for assistance and are not considered part of operator maintenance covered in this manual. If you are unable to determine the cause of the problem, contact your local Drilling Solutions service office.

Compressor Related Problems Trouble Shooting Chart		
Problem	Cause	Correction
Drill Shuts Down After A Short Running Time	High discharge temperature	a). Check for low oil level
		b). Check for obstructions in oil cooler
		c). Check fan speed
Excessive Oil Consumption	Oil carryover through discharge air hose	a). Check for high oil level in separator
		b). Check for plugged orifice in scavenger line
Compressor Makes Air But Volume Is Low	Volume control adjusted to lower setting	Close volume control
	Butterfly valve not completely open	Adjust UL88 and/or linkage
	Clogged air inlet filter	Clean or replace filter elements
	Broken butterfly valve	Replace valve

7.4 – LOW PRESSURE COMPRESSOR

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7.5 – HIGH PRESSURE COMPRESSOR

PNEUMATIC SYSTEM INFORMATION

All air compressors used on the Mid-Range drills are of the oil flooded asymmetrical rotary screw design. Tapered roller bearings are used to handle thrust and radial loads.

Standard equipment for the air compressor includes a separate three stage inlet air cleaner and full instrumentation and controls. The lubrication system includes an oil cooler, bypass valve, oil filter, oil pump, and combination receiver and oil separator tank. A safety shutdown system is also provided for high discharge air temperature.

The oil pump allows the operator to close the intake valve when no air is required. This greatly reduces the engine load which saves fuel and facilitates cold weather starting.

Low Pressure compressors are those with discharge pressures of 100 to 150 psi. A compressor is considered high pressure if the discharge pressure is 250 psi or greater. All of the **High Pressure** compressors have discharge pressures of 350 psi. See *Low Pressure Compressor* or *High Pressure Compressor* sections for specific detailed information.

There are three systems on a rotary screw compressor:

1. **Lubrication System**
2. **Separation System**
3. **Regulation System**

Each system is critical to the operation of the air end and the systems are all interrelated. These systems will be described further in the appropriate areas of *Low Pressure Compressor* or *High Pressure Compressor* sections

7.5 – HIGH PRESSURE COMPRESSOR

COMPRESSOR FIRE PREVENTION

A fiber gasket is installed between the outside cover of the receiver and the metal tube holding the separator element in place. This gasket prevents oil from leaking around the metal tube and down the hole.

When air and oil flow through the filter media, static electric charges are created. If these charges are allowed to build up, a spark similar to a lightning flash will occur. This will set the oil and the media on fire. The fire will burn from the inside of the element through the standpipe hose and will follow the air flow until it burns through the air hose. This is **NOT** a fire caused by the compressor flashing.

To prevent this from happening, several metal staples have been installed THROUGH the gasket so each side comes in contact with the metal. This bridge serves to allow the static charge to drain off outside the receiver tank and not cause a static buildup.



When replacing separator element, be sure there is at least one staple that shows through on both sides of the gasket and is not covered with glue.

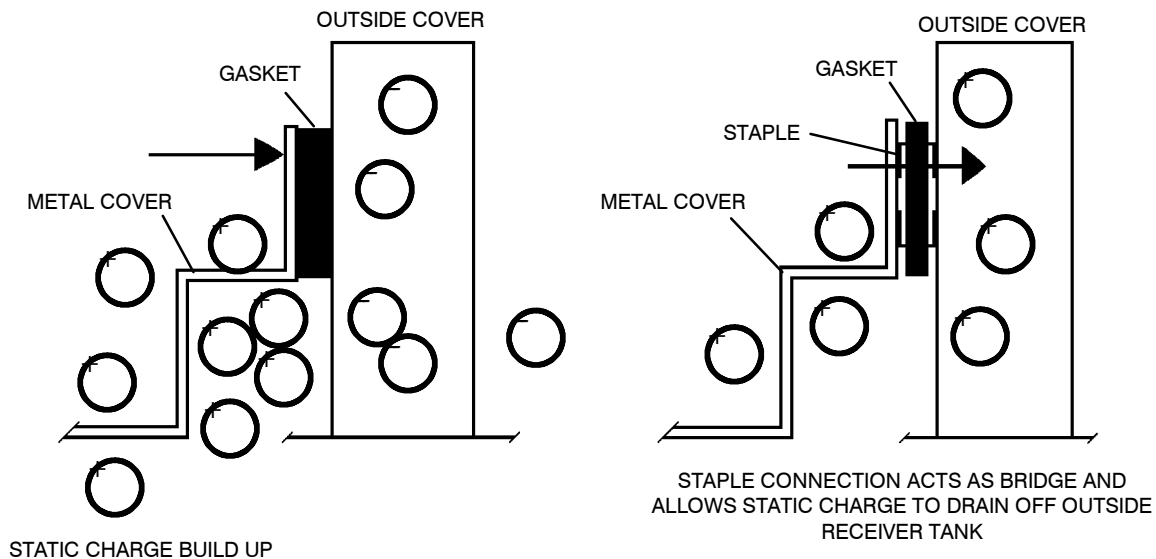


Figure 7.5–1

7.5 – HIGH PRESSURE COMPRESSOR

OVERVIEW

A compressor is considered high pressure if the discharge pressure is 250 psi or greater. All high pressure compressors have discharge pressures of 350 psi. They are designated either HR2 or HR2.5. These models describe the rotor sizes. For example, the HR2 has two sets of rotors; a 226mm size and a 127.5mm size. The HR2.5 has two sets of rotors; 226mm x 2\127.5mm. The size of the rotors and their speed determine the inlet volume of the air end. There are three sizes; 900,cfm, 1050 cfm and 1250 cfm.

There are three systems on a rotary screw compressor: the lubrication system, the separation system and the regulation system. Each system is critical to the operation of the air end and the systems are all interrelated.

LUBRICATION SYSTEM

COMPONENTS

The equipment used in the lubrication section includes the Receiver Tank, Mixing Valve, Oil Cooler, Bypass Valve, Strainer, Filters, Oil Pump, Relief Valve, Discharge Check Valve and special oil.

Receiver - Separator Tank

The receiver tank (Figure 7.5–2) contains the lubricating oil for the compressor. The oil is removed from the air by centrifugal force, gravity, velocity and filtration. The receiver tank has an oil level sight glass that shows the oil level at all times. The oil level glass should be at least half full when the drill is shut down and oil must show in the glass when the drill is running.

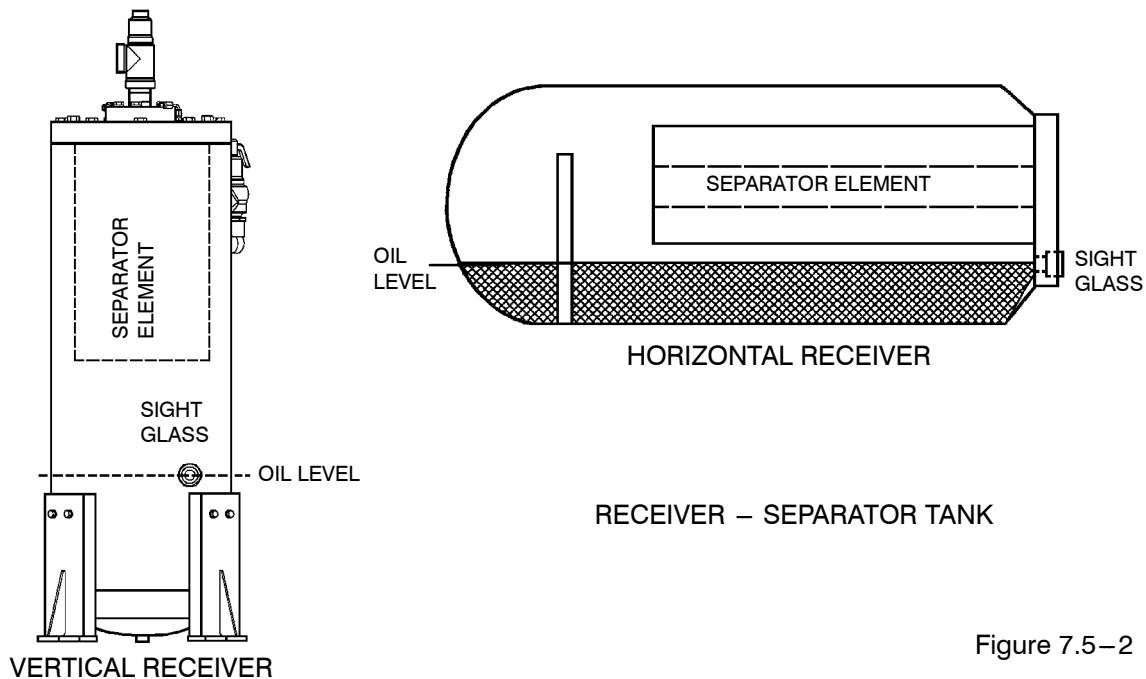


Figure 7.5–2

7.5 – HIGH PRESSURE COMPRESSOR

LUBRICATION SYSTEM (continued)

Oil Pump

The oil pump (Figure 7.5–3) is a gear type pump, driven from the rear of one of the compressor rotors. It operates whenever the compressor is turning. It is speed sensitive and pumps at rated volume only when the compressor is at full RPM.

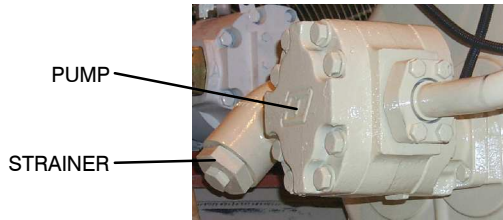
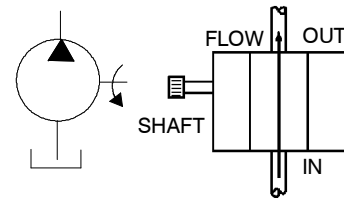


Figure 7.5–3



Strainer

A 40 mesh (150 micron) strainer is mounted just before the inlet to the oil pump as shown in Figure 7.5–3. It protects the pump and catches any foreign debris such as hose pieces and parts of the thermostat that could damage the pump. The metal strainer should be removed, cleaned and reinstalled every 500 hours.

Oil Cooler

The cooler package is made up of three sections. The larger section cools the compressor oil, the middle section cools the engine coolant and the smaller section cools the hydraulic oil.

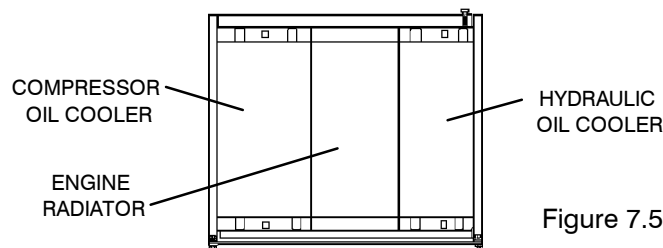


Figure 7.5–4

The Compressor Oil Cooler (Figure 7.5–4) is a single pass unit. Hot oil enters from the bottom of the cooler and cool oil exits out the top. This prevents any air bubbles that may have been carried along with the oil from being trapped in the top and creating a vapor barrier.

Compressor Oil

The very high pressure created in these air ends requires a special oil. This oil is **not** compatible with certain types of O-rings. Therefore, we use “Viton” type O-rings in the air end fittings and filters. The oil is also **not** compatible with other oils and should never be mixed with other oil. **High Pressure compressors use I-R XHP605 oil.** Be sure to change the filters every 500 hours.

7.5 – HIGH PRESSURE COMPRESSOR

LUBRICATION SYSTEM (continued)

Mixing Valve

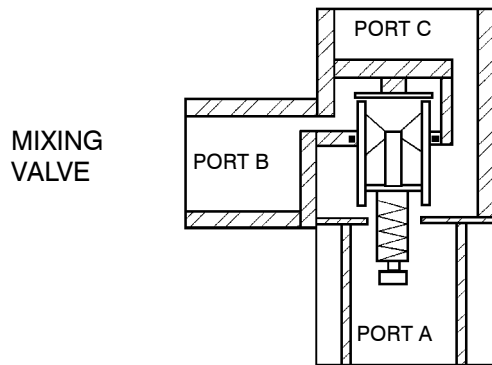


Figure 7.5–5

The Mixing Valve (Figure 7.5–5) contains a thermostat that stops oil flow in one direction when it is cold and allows oil to flow from another direction when it reaches operating temperature. When the temperature is below 140°F (63°C), oil flows from port “B” to port “A”, thus bypassing the oil cooler altogether. When the temperature increases to 160°F (71°C), the thermostat is completely opened and all the oil flows from from port “C” to “A” and shuts off all flow to “B”. At temperatures in between 140°F (63°C) and 160°F (71°C), some oil flows through port “B” to “A” and some oil flows through the cooler and from “C” to “A”. Under normal operation, some oil is flowing through both “B” and “C”. The normal discharge temperature of the oil leaving the air end should be between 180°F (83°C) and 220°F (104°C).

Relief Valve / Check Valve

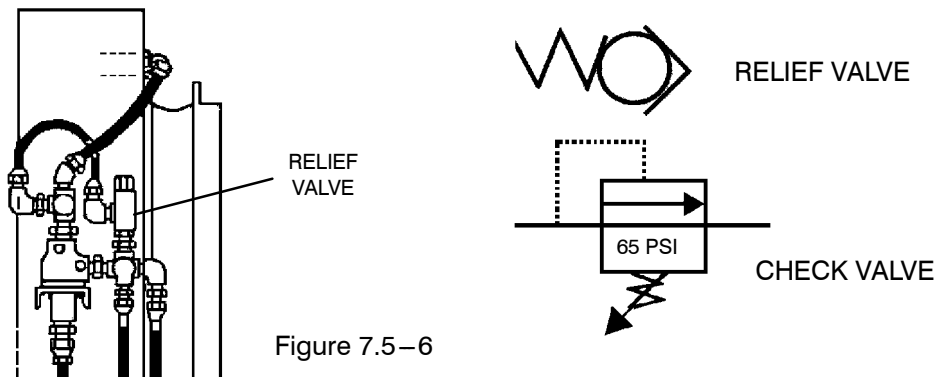


Figure 7.5–6

A 65 psi relief valve (Figure 7.5–6), which replaces the 50 psi relief valve (HR2) and 75 psi relief valve (HR2.5), is connected between the inlet and outlet of the oil cooler. If the cooler becomes plugged and the inlet pressure becomes 65 psi higher than the outlet pressure, the relief valve opens and allows oil to bypass the cooler. When the differential pressure is reduced below 65 psi, the valve will close and normal flow resumes. The new 65 psi relief valve allows the new, larger oil cooler system to function properly.

7.5 – HIGH PRESSURE COMPRESSOR

LUBRICATION SYSTEM (continued)

Oil Filter

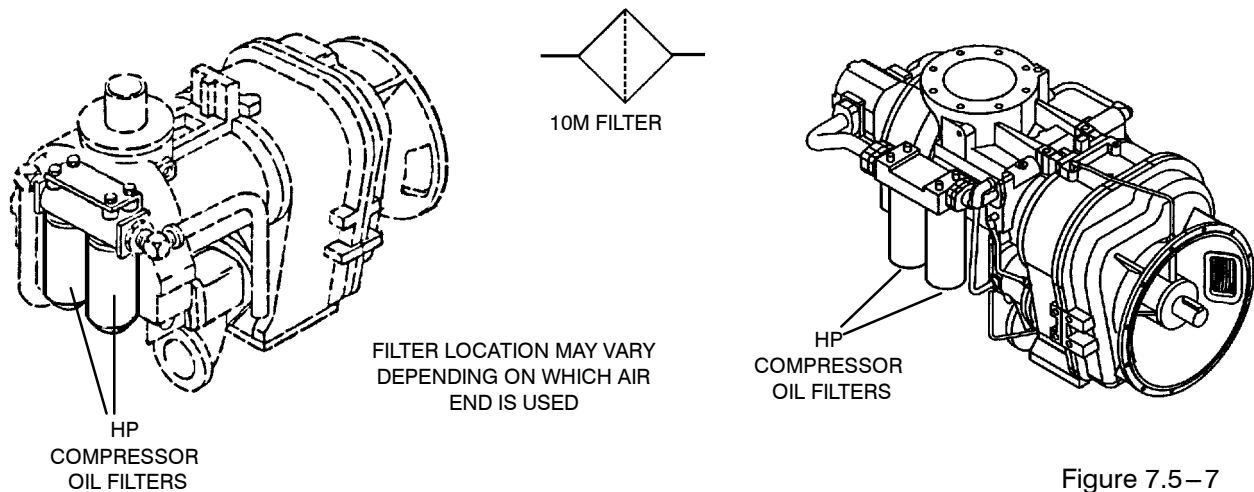


Figure 7.5–7

Two 10 micron filters are installed at the outlet of the pump before the oil reaches the compressor bearings. It catches any contaminants that may have been picked up in the circuit and prevents them from plugging the orifices at the inlets to the bearings.

Discharge Check Valve

DISCHARGE
CHECK VALVE

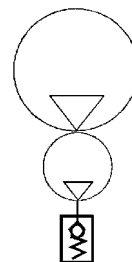


Figure 7.5–8

The Discharge Check Valve is located at the outlet of the compressor and prevents any oil or air, under pressure, from backing up into the compressor housing. While the compressor is running, oil and air are being forced out of the compressor housing and this keeps the Discharge Check Valve open. When the compressor is stopped nothing is coming from the compressor side, but pressure is built up in the receiver. This would pressurize the compressor housing if the Discharge check Valve were not there.

Figure 7.5–8 shows the valve being held open. It has a single spring. The hinge must be mounted on top to prevent the valve from staying open when the drill is shut down. Notice the white nylon ring that forms a tight seal to prevent back flow when the drill is stopped.

7.5 – HIGH PRESSURE COMPRESSOR

LUBRICATING SYSTEM OPERATION

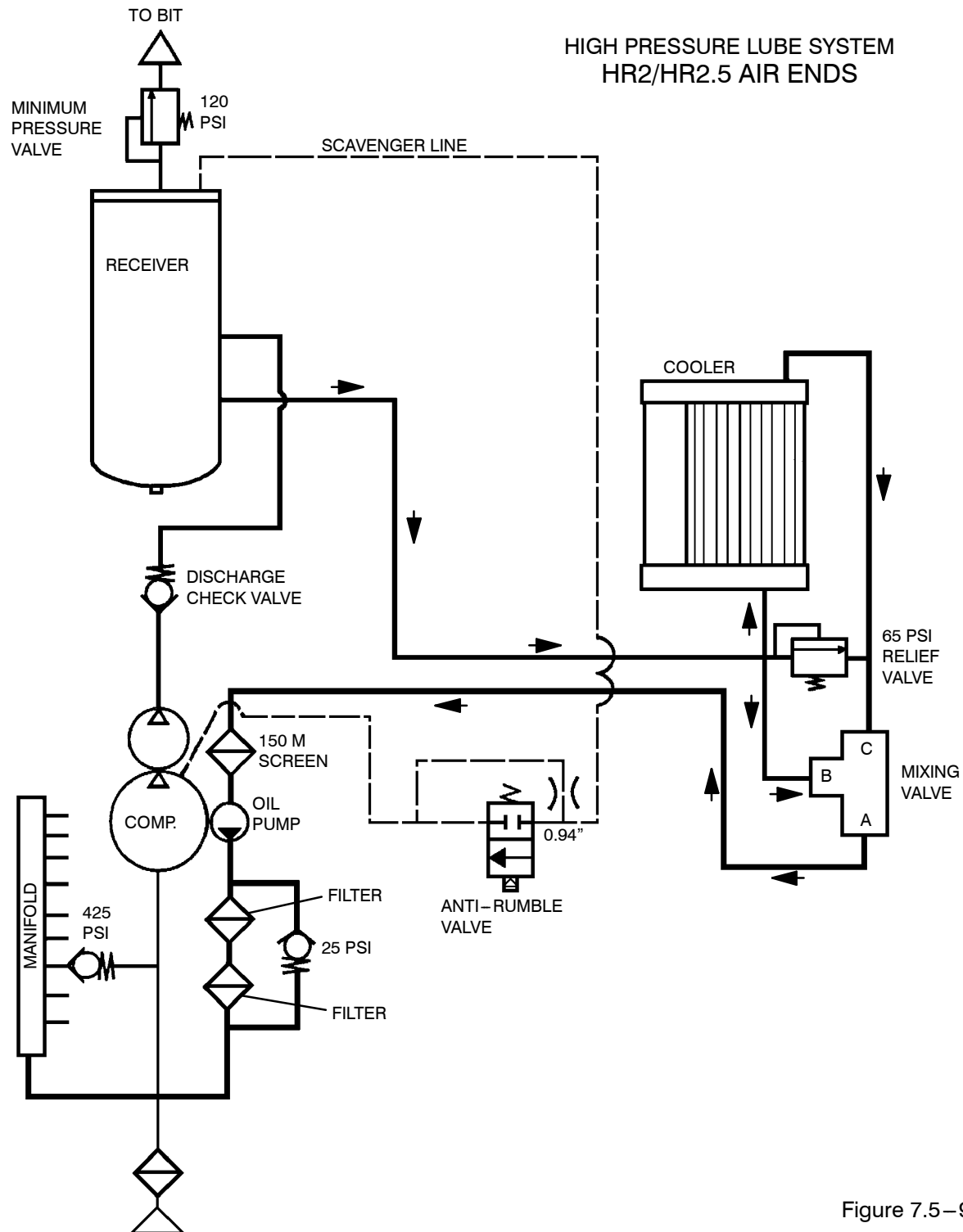


Figure 7.5–9

7.5 – HIGH PRESSURE COMPRESSOR

LUBRICATING SYSTEM OPERATION (continued)

Use Figure 7.5–9 *High Pressure Lube System* schematic to follow the oil flow in the Lubricating and Cooling system.

Oil is injected into the air end under pressure. The oil serves three purposes:

1. It **cools** the air end bearings and rotors.
2. It **lubricates** the moving parts
3. It **seals** the clearances between the male and female rotors, and between the rotors and the housings and end plates.

The discharge check valve prevents air pressure and oil from reentering the compressor when the drill is stopped.

The receiver–separator serves two purposes:

1. It stores compressed air for future use.
2. It separates the oil from the air.

Oil is forced from the receiver by air pressure flowing through the piping towards the oil cooler. The oil has three paths it can follow at this point.

1. When the oil is cold, the **mixing valve** allows oil to bypass the cooler and go directly to the oil pump (“B” to “A”).
2. As the oil warms up to 140°F (63°C), the **thermostat** in the mixing valve starts to open and some oil flows up through the cooler. Most of the oil still flows through the bypass (“B” to “A” and some “C” to “A”).
3. When the oil temperature reaches 160°F (71°C), the valve is closed completely and all oil flows through the **cooler** (“C” to “A”). The valve stays partially open during normal operation and the discharge temperature of the oil stays between 140°F (63°C) and 160°F (71°C).

If the **oil cooler** becomes plugged and the differential pressure across the cooler builds up to 65 psi, the **relief valve** opens and allows oil to bypass the cooler. It still flows from (“C” to “A”) in the **mixing valve**.

When the oil exits the **mixing valve**, it passes through a 40 mesh (150:) **screen** into the inlet of the **oil pump**. When the oil is cold or the receiver is operating at low pressure, the pump performs as a regular pump by forcing oil into the compressor. But as the temperature and pressure increase, the **pump** acts to prevent excess oil from getting into the compressor and flooding it.

Before the oil reaches the pump, it passes through a 40 mesh **150 micron strainer** that keeps larger debris from reaching the pump.

After the oil passes the pump and before it gets to the compressor bearings, it passes through two (2) **10 micron filters** and then flows through a metal **manifold** that sends oil to all areas of the compressor. Each bearing has its own supply line. The balance of the oil goes into the low pressure area of the rotors.

A **425 psi relief valve** is located between the oil pump and the compressor and bearings that prevents damage to the system in case of a high pressure surge during cold starts and/or blockage in the bearing lines. When the temperature of the oil warms up, the relief valve will close.

7.5 – HIGH PRESSURE COMPRESSOR

SEPARATION SYSTEM

Lubricating oil is forced through the air end to **cool, seal and lubricate** the rotors. When the oil is pumped into the receiver-separator tank, it must be separated from the air going down the hole. This is accomplished in three steps.

1. The Air/Oil mixture enters the receiver through the inlet pipe and splashes against the inner walls. This forces the majority of oil to fall to the bottom of the tank and remain there.

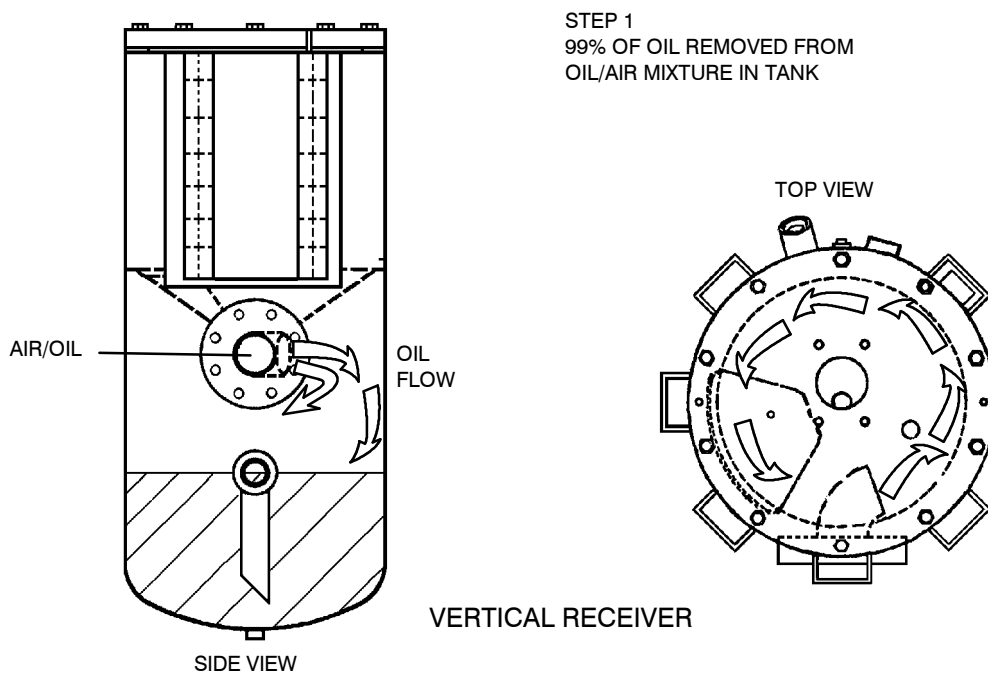
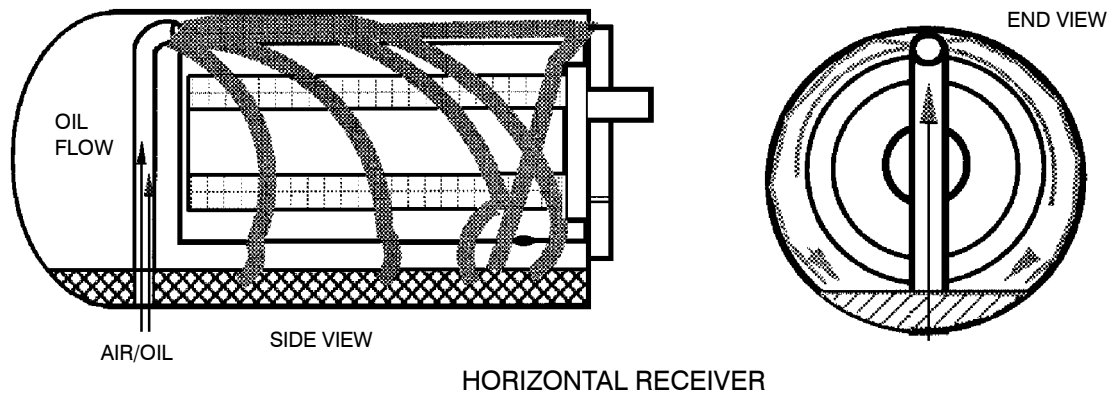
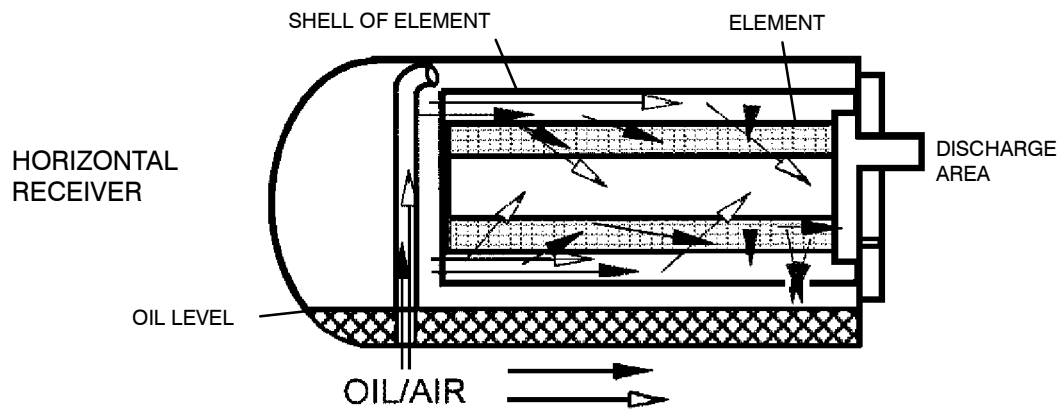


Figure 7.5–10

7.5 – HIGH PRESSURE COMPRESSOR

SEPARATION SYSTEM (continued)

- When the down stream air line is opened and air flows down the hole, some of the remaining oil is carried along with it into the filter area. A metal canister prevents oil from flowing through the filter directly. The air/oil mixture enters the outer edge of the element and moves towards the center. As the oil travels through the element, it is slowed down by friction and gravity pulls it downward. Most of the oil drops out the bottom of the element and falls into the reservoir.



STEP 2
0.9% OF OIL REMOVED FROM OIL/AIR
MIXTURE IN TANK

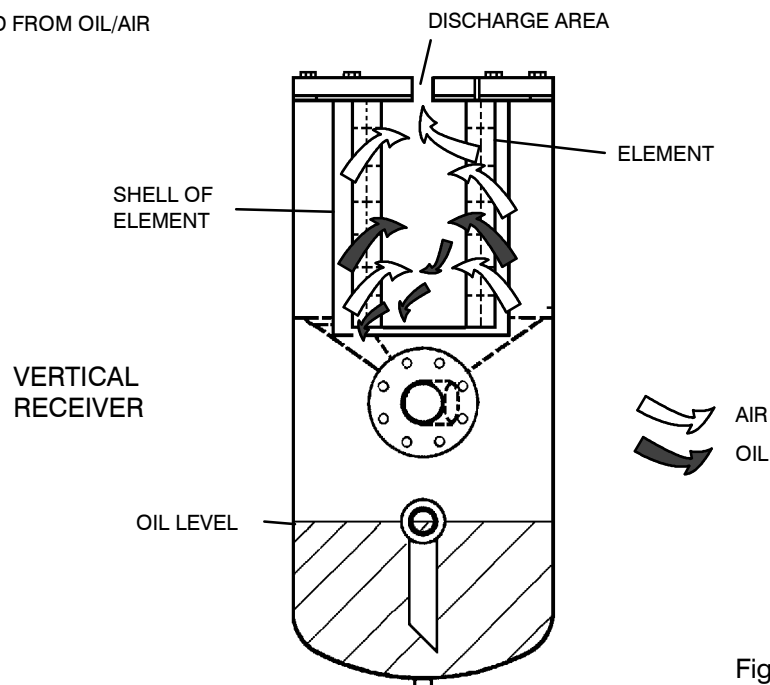


Figure 7.5–11

7.5 – HIGH PRESSURE COMPRESSOR

SEPARATION SYSTEM (continued)

- The final step in the separation process is removing any remaining oil from the element so it is not carried over into the down hole air stream. When enough excess oil is carried into the center of the element, a series of holes in the end of the filter element allow the oil to fill an area between the flange and the element. The scavenger line is connected between the flange and the inlet of the compressor. Since there is a differential pressure between the receiver tank and the low pressure area of the compressor, oil and air are forced through the scavenger line into the inlet area of the air end, thus removing the last of the oil carryover. A 0.94" orifice in the line prevents excessive amounts of air loss.

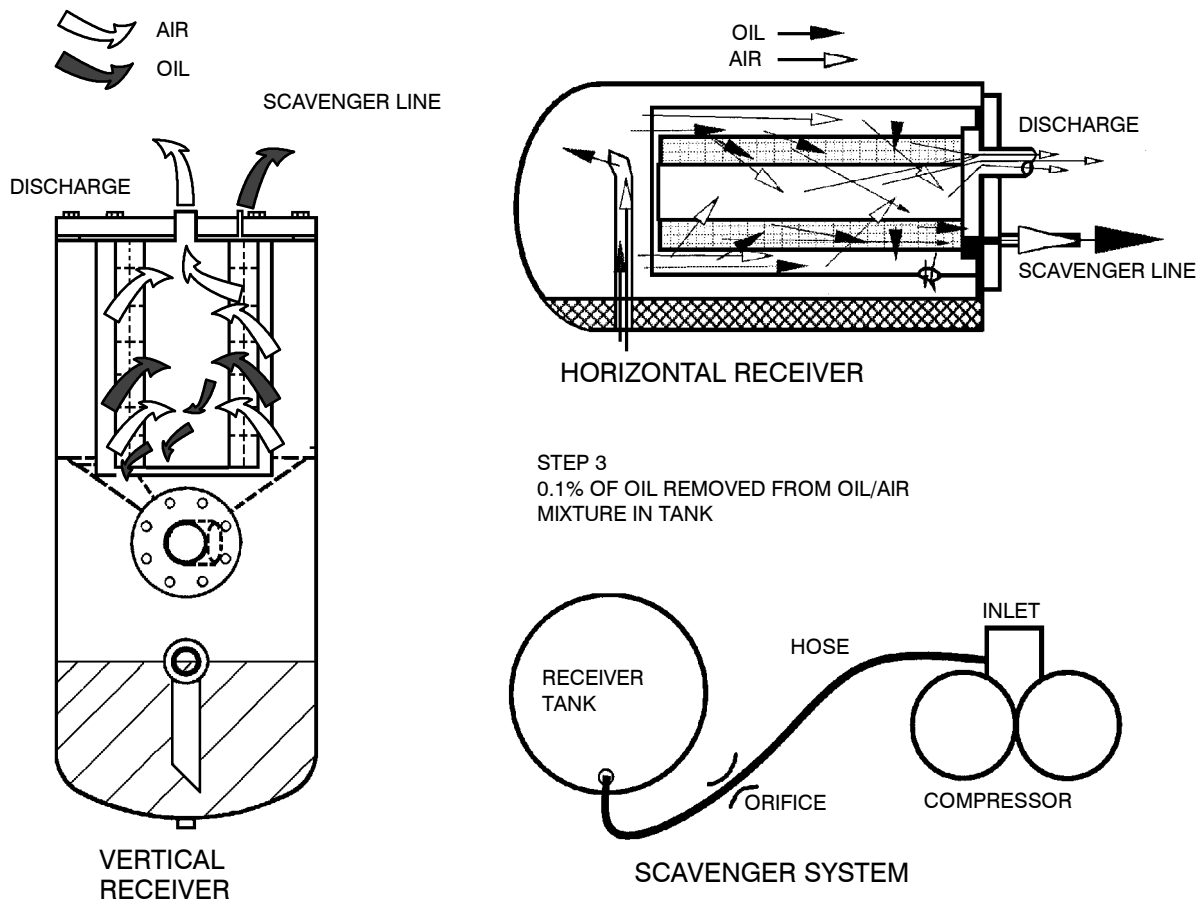


Figure 7.5–12

The HR2/HR2.5 air ends all have an “anti-rumble” valve connected in parallel with the scavenger orifice. The “anti-rumble” valve is a pilot operated valve that opens when the compressor is not making air. It allows a large volume of compressed air from the receiver back into the air end to mix with the oil already being pumped into it. The air acts as a cushion to prevent the “rumbling” sound caused by oil, in a vacuum, being forced through the rotors. When the compressor inlet is opened, the “anti-rumble” valve closes and the scavenger orifice operates in the normal fashion.

7.5 – HIGH PRESSURE COMPRESSOR

SEPARATION SYSTEM (continued)

It is important to note when changing separator elements that the element be installed correctly. The word “TOP” should always be on top to insure that the drain holes are at the bottom. This prevents excessive buildup in the scavenger area.

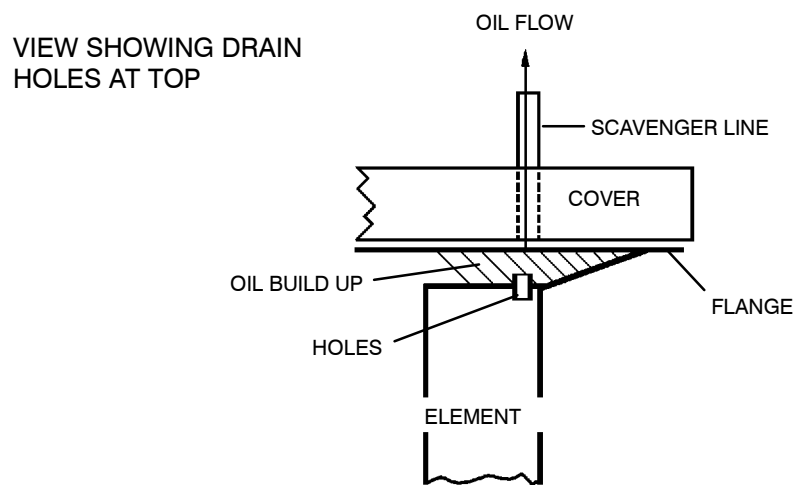


Figure 7.5–13

Another item to watch when changing elements is to be sure that the staples in the gaskets are left there to prevent a static electric charge from building up and causing a fire.

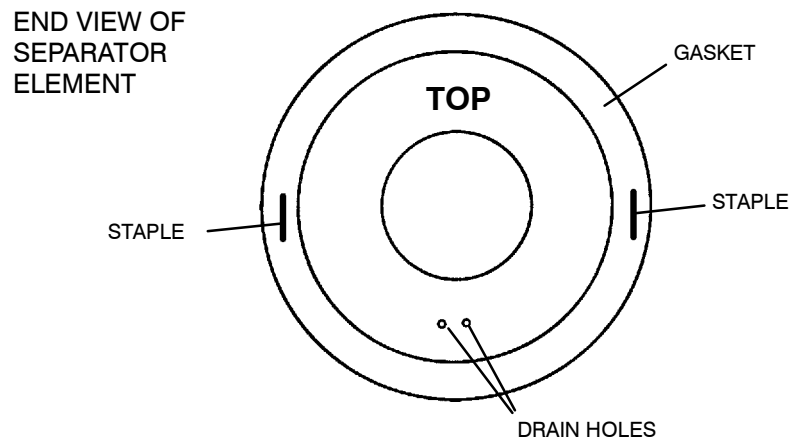


Figure 7.5–14

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE

The regulation system controls the pressure and volume of the air going down the hole to the bit. All I-R high pressure compressors have discharge pressures of 350 psi. I-R uses the UL88 unloader valve to control the discharge pressure and volume.

COMPONENTS

The regulation system on high pressure compressors is designed around the UL88 modulating valve and includes several other automatic devices to operate the system.

Inlet “Butterfly” Valve

The Inlet Butterfly Valve is a round, wafer valve that sits on top of the compressor. It has a shaft that is connected to the center of the valve. This is where the linkage for the UL88 Unloader Valve is attached.

INLET “BUTTERFLY” VALVE
Figure 7.5–15



UL88 Unloader Valve

The regulation system on high pressure compressors is designed around the UL88 modulating valve. It controls the pressure and volume in the receiver by opening and closing the inlet (butterfly) valve according to the discharge pressure in the receiver.

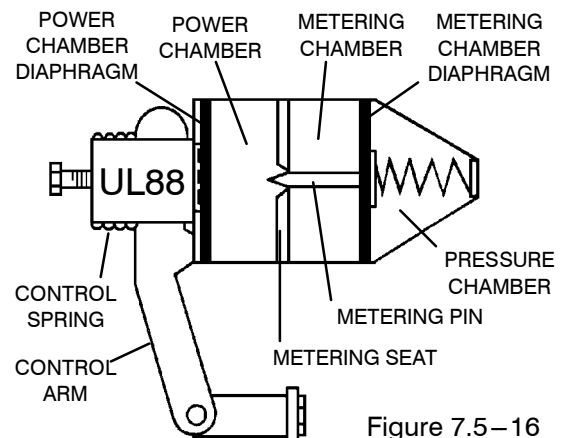
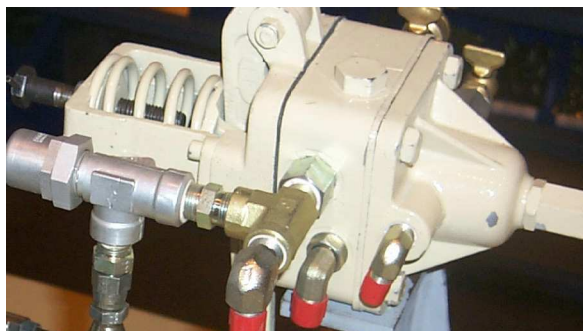


Figure 7.5–16

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

UL88 Unloader Valve (continued)

The UL88 consists of three chambers; the Power Chamber, the Metering Chamber and the Pressure Chamber (Figure 7.5-16).

There are two diaphragms in the UL88. One is the Power diaphragm and the other is the Metering diaphragm (Figure 7.5-16). Air pressure works on the Metering diaphragm to open it against spring pressure in the Pressure Chamber and allow air to flow through the metering seat into the Power Chamber.

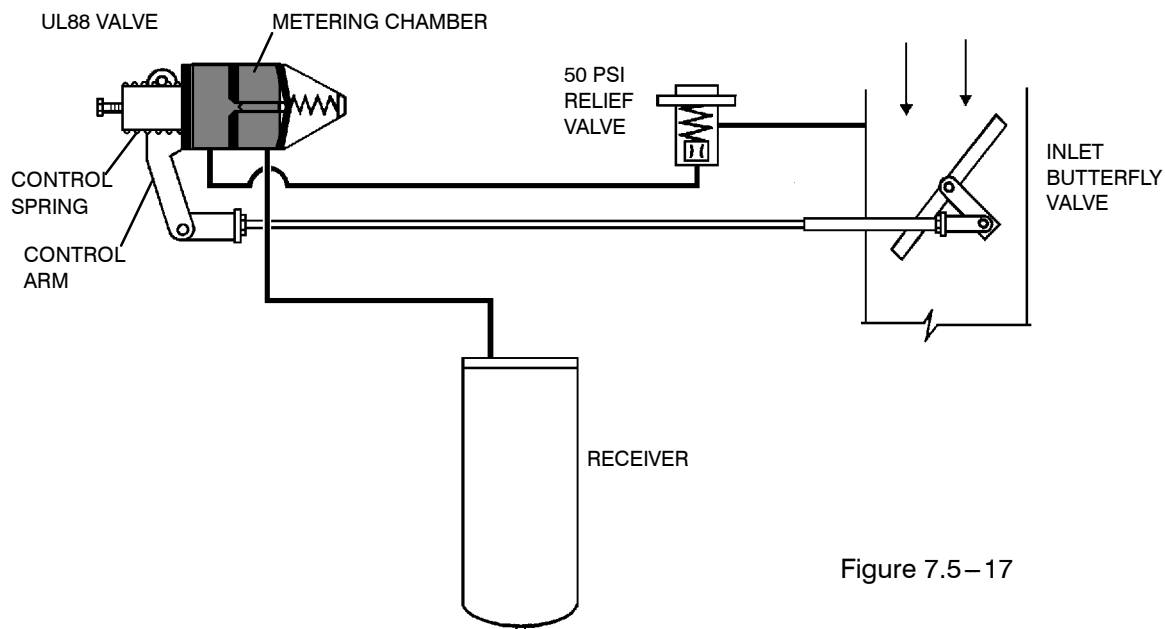


Figure 7.5-17

When the air pressure becomes high enough in the Power Chamber, the diaphragm pushes against the control arm which is held in place by the control spring. This pulls the linkage connected to the inlet (butterfly) valve and closes it. This cuts off intake to the compressor. When there is no pressure in the Power Chamber, control spring force holds the inlet valve open (See Figure 7.5-17). There must be air pressure in the Power Chamber to close the inlet valve.

There are several components needed to operate this system correctly. They include an ON-OFF switch, a linkage control arm, inlet butterfly valve, receiver tank, 100 psi check valve and a 50 psi relief valve.

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

ON-OFF Switch

This switch is located in the operator's console (Figure 7.5-18) and allows air pressure to flow into the Power Chamber or it can stop the flow. When the ON-OFF switch is turned "OFF", air flows through it and pressurizes the Power Chamber Diaphragm. This pushes the control arm back and closes the inlet valve. Thus when the ON-OFF switch is "OFF", it is "ON" or actually flowing.

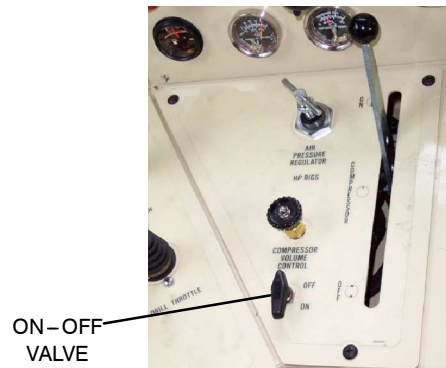


Figure 7.5-18

When the ON-OFF switch is turned "ON", air is prevented from getting into the Power Chamber and the inlet valve stays open making air. On older drills, there is a port in the ON-OFF switch for exhaust. It must be plugged to operate correctly. On newer drills, there is a ball type valve without the exhaust. Air bleeds out through the orifice in the 50 psi relief valve.

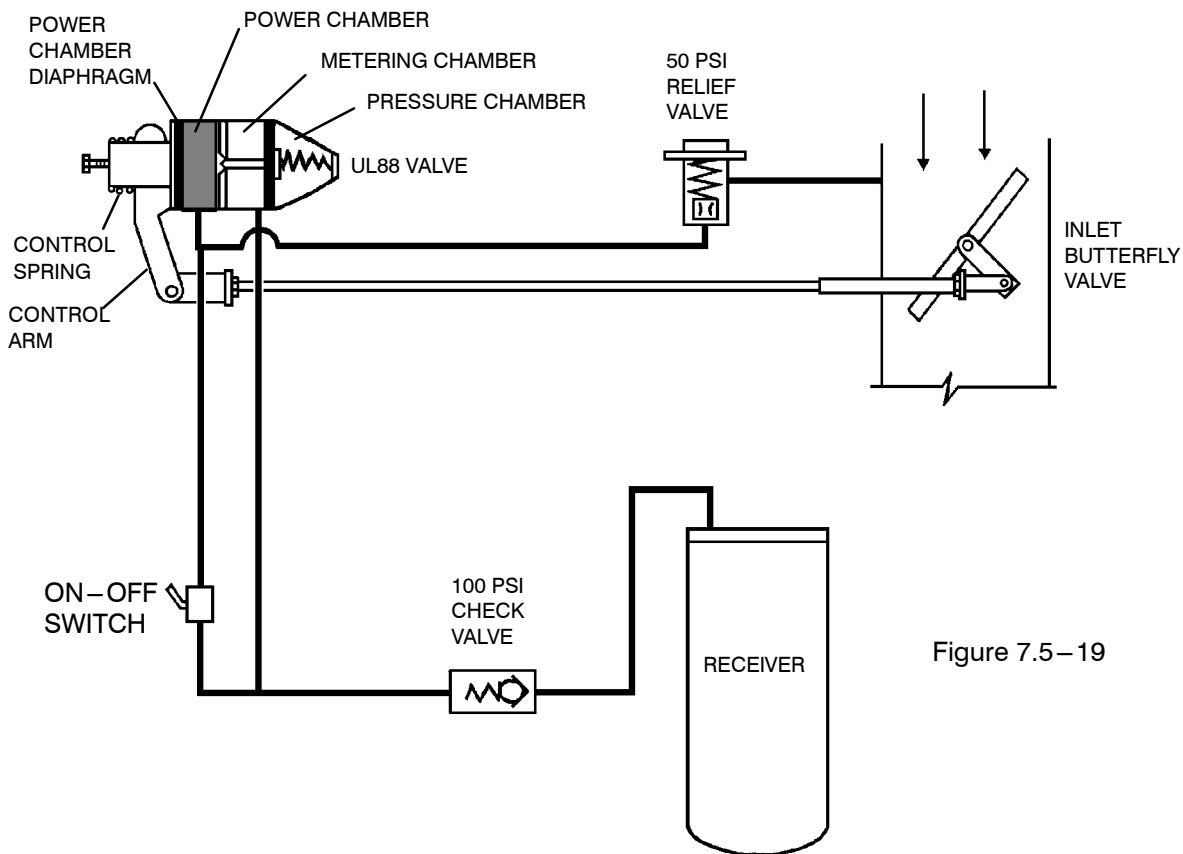
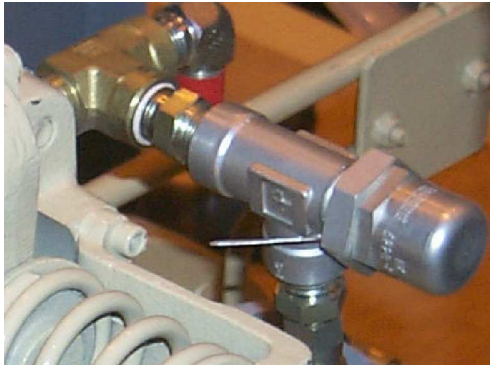


Figure 7.5-19

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

50 psi Relief Valve / Orifice



50 PSI RELIEF
VALVE / ORIFICE

Figure 7.5–20

A 50 psi relief valve is located in the line between the ON-OFF switch and the UL88 Power Chamber (Figure 7.5-20). There is a small orifice in the valve that allows a certain amount of air to continuously blow through it. This relieves the pressure in the Power Chamber when the switch is turned “ON” and lets the Power Chamber diaphragm return to its normal position. The relief valve works only when a high pressure surge would damage the UL88.

100 psi Check Valve



100 PSI CHECK
(CIGAR) VALVE

Figure 7.5–21

The UL88 and the pressure regulator were designed to operate at **250 psi maximum pressure**, so a 100 psi check (cigar) valve, shown in Figure 7.5-21, was installed in line from the receiver tank to reduce the final discharge pressure from the check (cigar) valve from 350 psi to 250 psi. When a drill is first started, air pressure in the receiver tank must increase above 100 psi before the check valve opens and allows any air to the UL88.

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Volume Control Valve

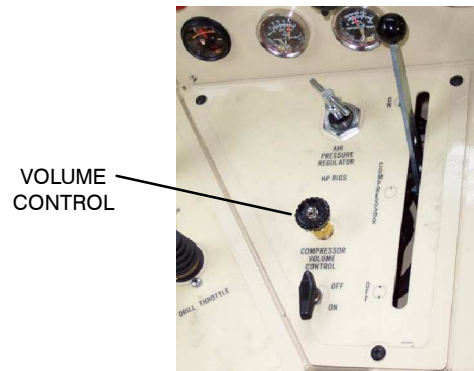


Figure 7.5–22

There may be times when the operator wishes to use a down hole device that uses less air volume than the compressor is rated for. To prevent the compressor from “hunting” (opening and closing the inlet valve rapidly), a volume control (Figure 7.5–22) was added. It consists of a needle valve that can be opened to allow a certain volume of air into the Power Chamber to assist in modulating the UL88. It should be closed tight for full volume.

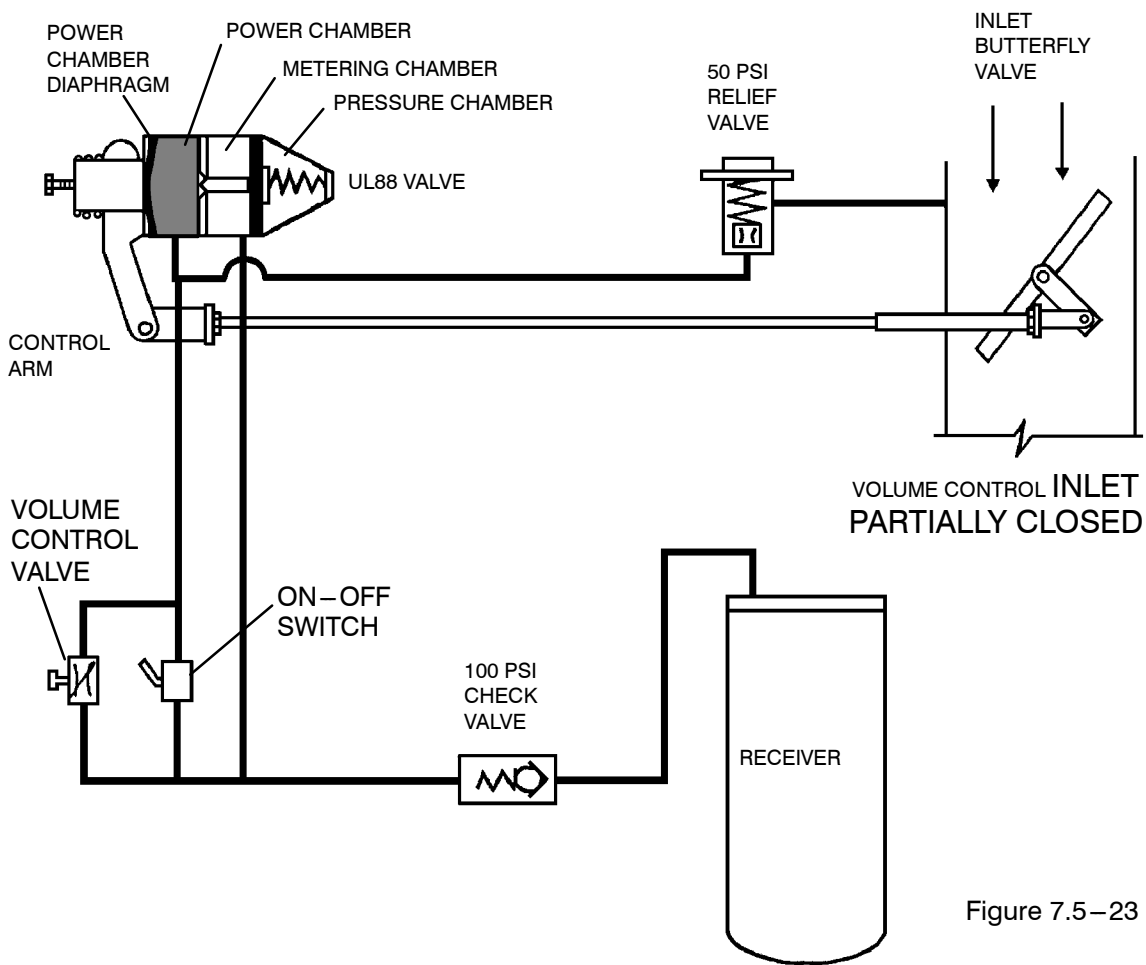


Figure 7.5–23

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Pressure Regulator

Discharge pressure is set by the Pressure Regulator mounted on the control console (Figure 7.5–24). It can be increased or decreased as the situation demands. A spring inside the pressure chamber puts a minimum amount of pressure on the metering chamber diaphragm. The pressure regulator increases that pressure up to the maximum psi allowed by the system.

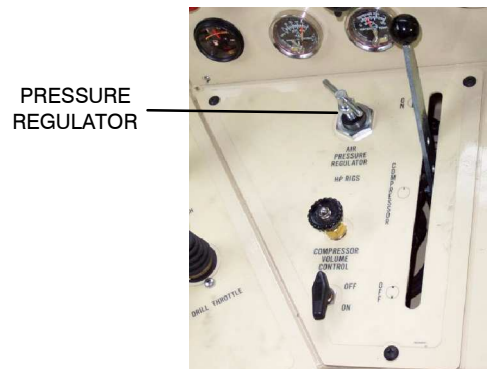


Figure 7.5–24

NOTE: The regulator should **not** be decreased while the compressor is turned ON. Turn the compressor OFF and bleed the system down, then back the regulator off. Otherwise, the regulator diaphragm will be destroyed by excess pressure.

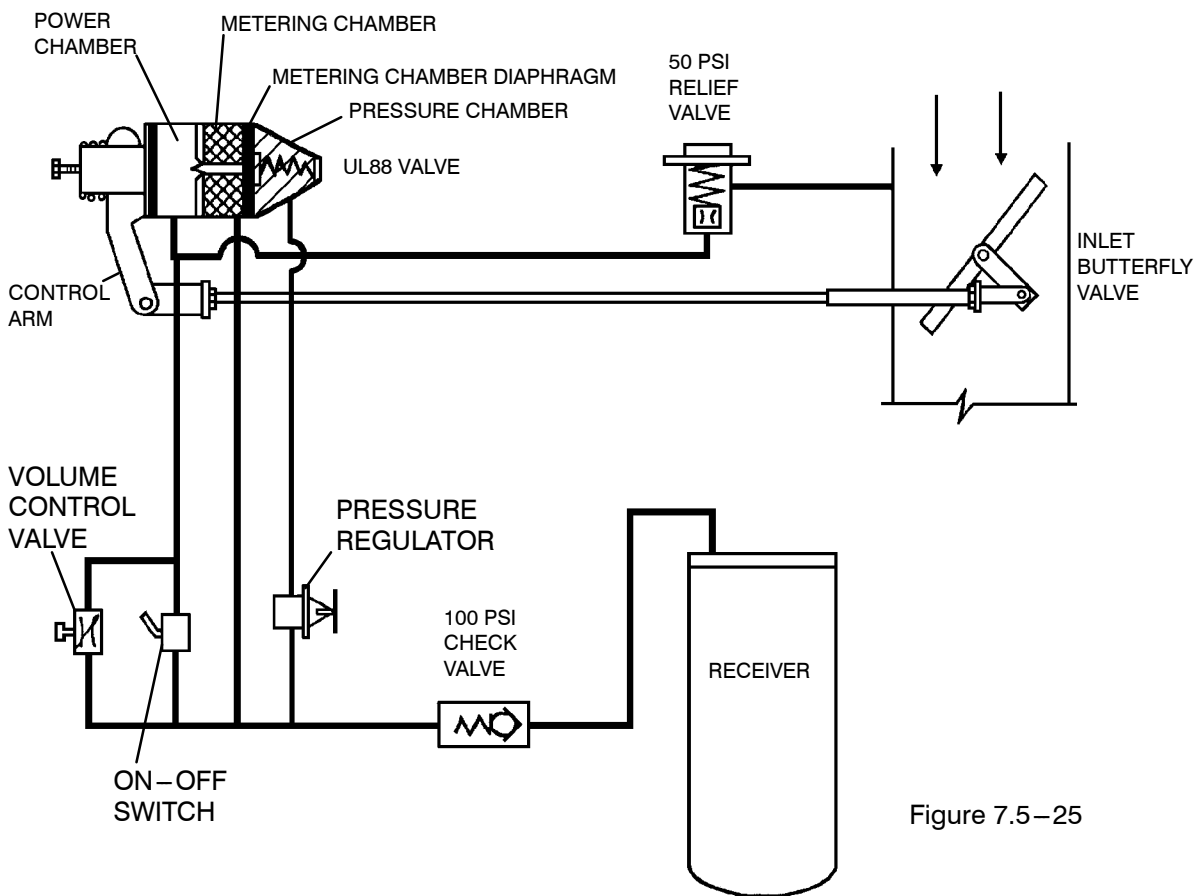


Figure 7.5–25

7.5 – HIGH PRESSURE COMPRESSOR

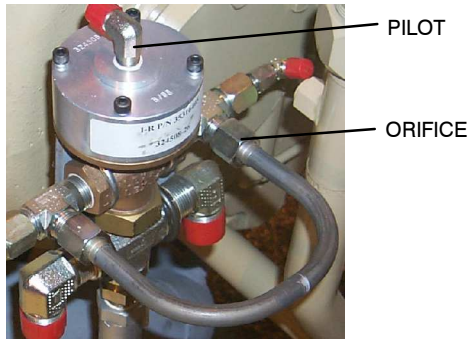
REGULATION SYSTEM-HIGH PRESSURE (continued)

Anti-Rumble Valve

When the compressor inlet is closed, no air is flowing through the rotors but the oil pump is still pumping the same volume of oil. This causes the rotors to try to compress oil. The result is backlash by the rotors that causes a loud “**rumbling**” sound. To prevent this from doing any damage to the air end, an anti-rumble valve has been installed (Figure 7.5–26).

ANTI-RUMBLE
VALVE

Figure 7.5–26



This valve allows a measured volume of compressed air from the receiver tank back into the rotor housing whenever the inlet valve is closed. This air mixes with the oil and cushions the rotors. The valve is automatically turned off when the inlet valve is opened and all of the air goes down the hole. The scavenger line is the tube that goes from the inlet to the outlet. An orifice is mounted in the fitting. This carries the oil/air mixture back to the air end inlet.

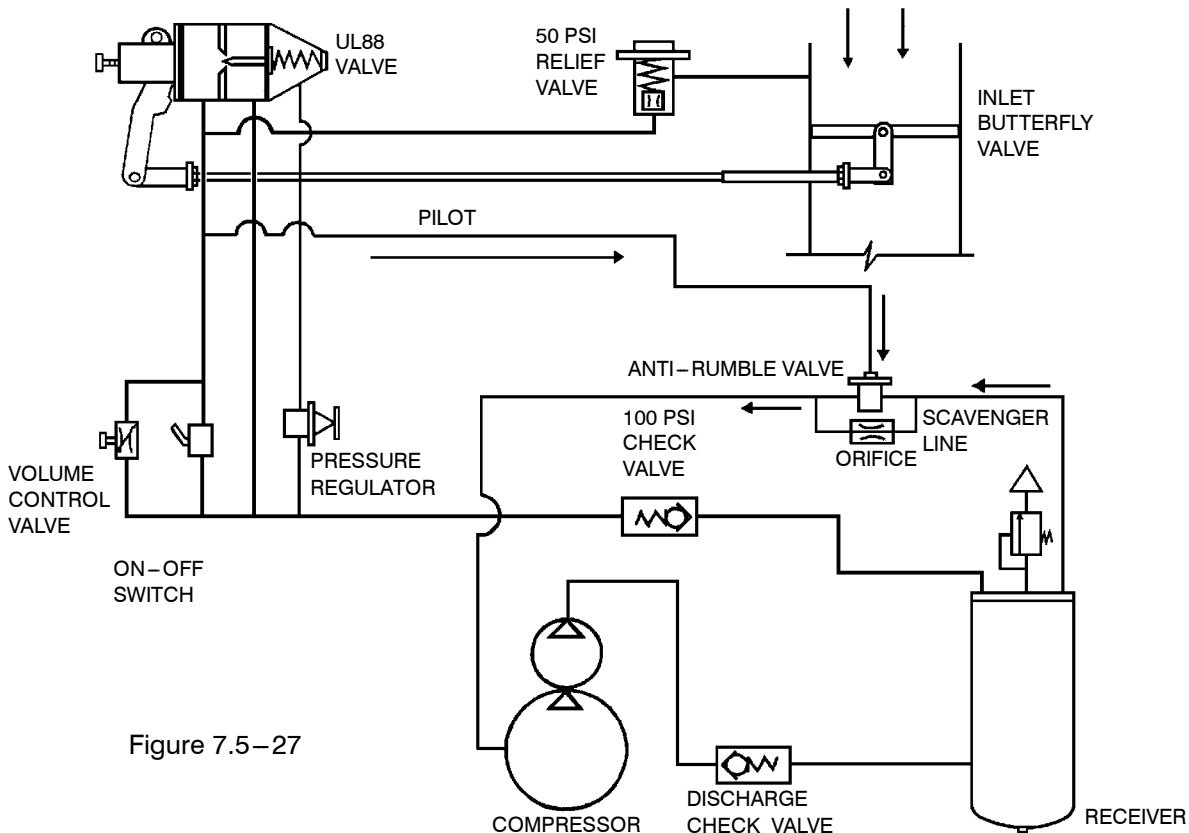


Figure 7.5–27

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Blow Down Valve

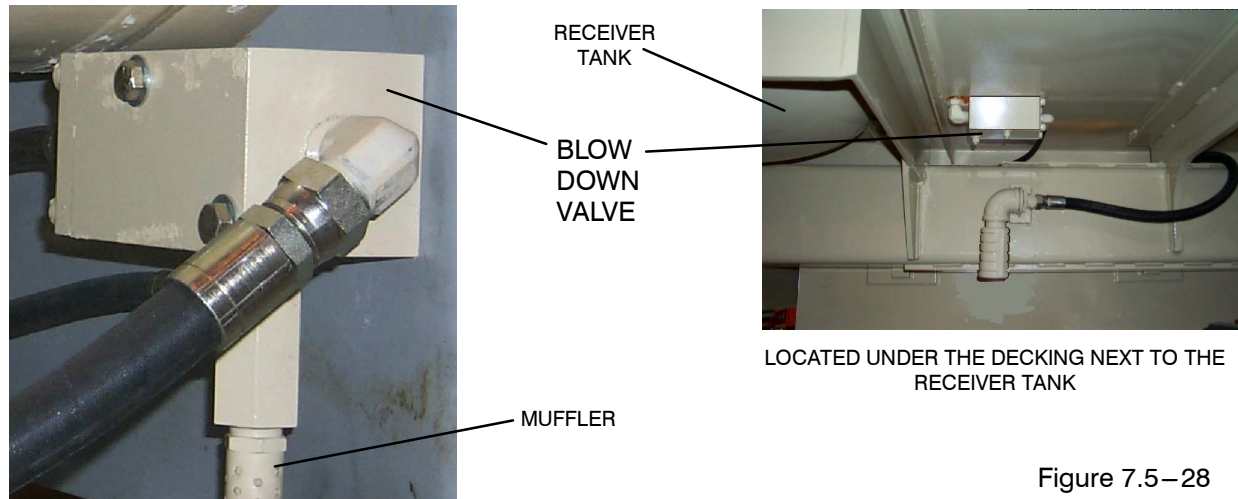


Figure 7.5–28

Without a shut off valve, there is still pressurized air trapped in the receiver tank when the drill is stopped. This air must be exhausted before the drill is started again. An **automatic blow down valve** (Figure 7.5–28) is connected to the receiver tank, on the dry side of the separator element, to relieve the pressure in the tank. A pilot line has been installed between the discharge of the compressor and the discharge check valve. As long as the compressor is running, pilot pressure prevents the valve from opening. When the compressor is stopped, there is no pilot pressure available to keep the valve closed and the spring pressure opens the valve and allows tank air pressure to escape.

On the outlet side of the valve is an orifice and a silencer. The silencer is there to muffle the noise of the escaping air. The orifice is there to provide enough back pressure to pilot the shut off valve or exhaust valve closed.

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Shutoff Valve

When the drill is stopped, air pressure from the receiver can still flow through the lines and pressurize the power chamber. This would close the inlet valve and trap air pressure inside the air end, since the discharge check valve would prevent any air/oil from getting out of the air end. This would cause a back pressure on the inlet valve and keep it closed. Oil and air would still be entering the air end through the scavenger line and when the inlet valve finally opens, oil under pressure will blow through the intake tubes and soak the air cleaners. Therefore, a shut off valve (Figure 7.5-29) is installed in line between the ON-OFF switch and the volume control to shut off any air pressure from reaching the power chamber. The shutoff valve is piloted by the back pressure caused by the orifice downstream from the blow down valve.

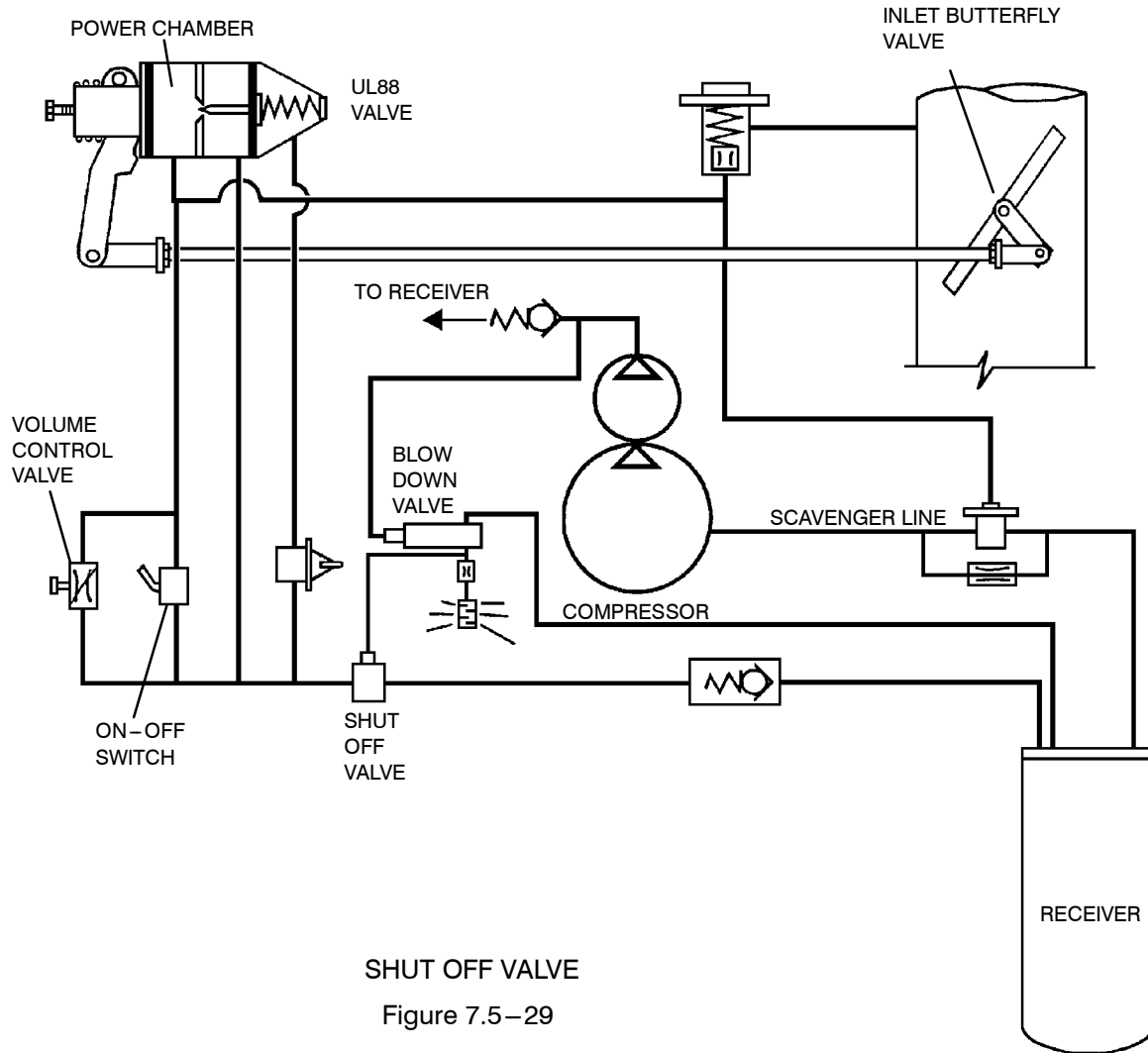


Figure 7.5-29

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

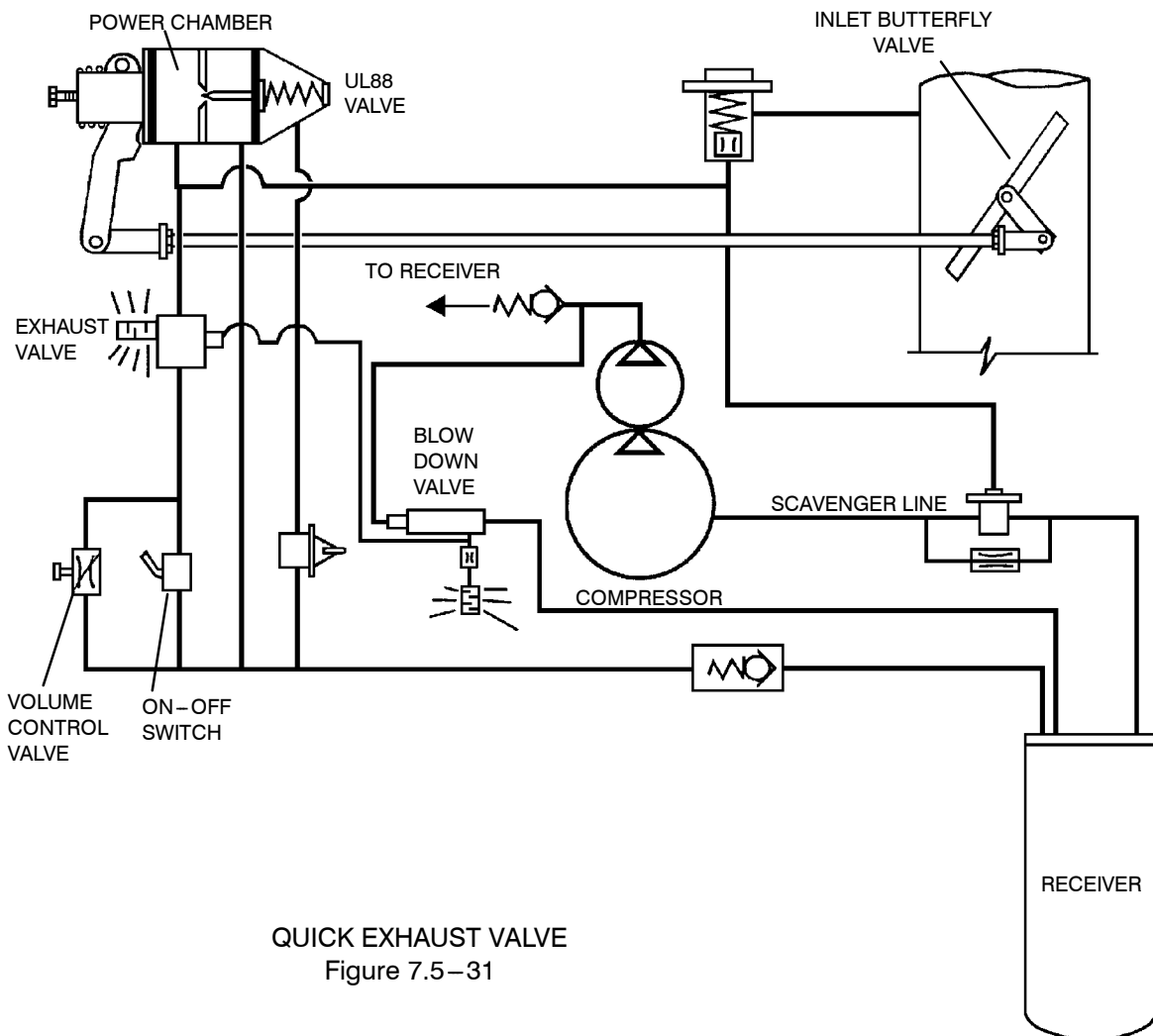
Quick Exhaust Valve

Some drills are equipped with a Quick Exhaust valve (Figure 7.5–30) instead of a Shut Off valve. The difference is that the shut off valve stops the flow of air to the UL88 and the exhaust valve exhausts any air in the lines leading to the UL88.



Figure 7.5–30

Either system will prevent air from reaching the Power Chamber. The quick exhaust valve is piloted from the same connection on the Blowdown Valve. When it receives pilot pressure, it opens and exhausts all the pressure in the line leading to the Power Chamber, thus preventing the inlet valve from closing.



QUICK EXHAUST VALVE
Figure 7.5–31

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Minimum Pressure Valve

A minimum pressure valve (Figure 7.5–32) is installed between the receiver and the main air hose which goes to the tower air hard piping. Its only purpose is to maintain a minimum amount of pressure in the receiver tank to force the oil into the lubrication system. On most high pressure drills, the valve is set at 120 psi (140 psi on HR2.5 compressors). This means that the down hole pressure may be 50 psi or 350 psi but the receiver tank never sees a pressure less than 120 (140) psi. It does not control the volume of air in CFM. It only restricts the outlet pressure. It has nothing to do with the pressure shown on the pressure gauge at startup.

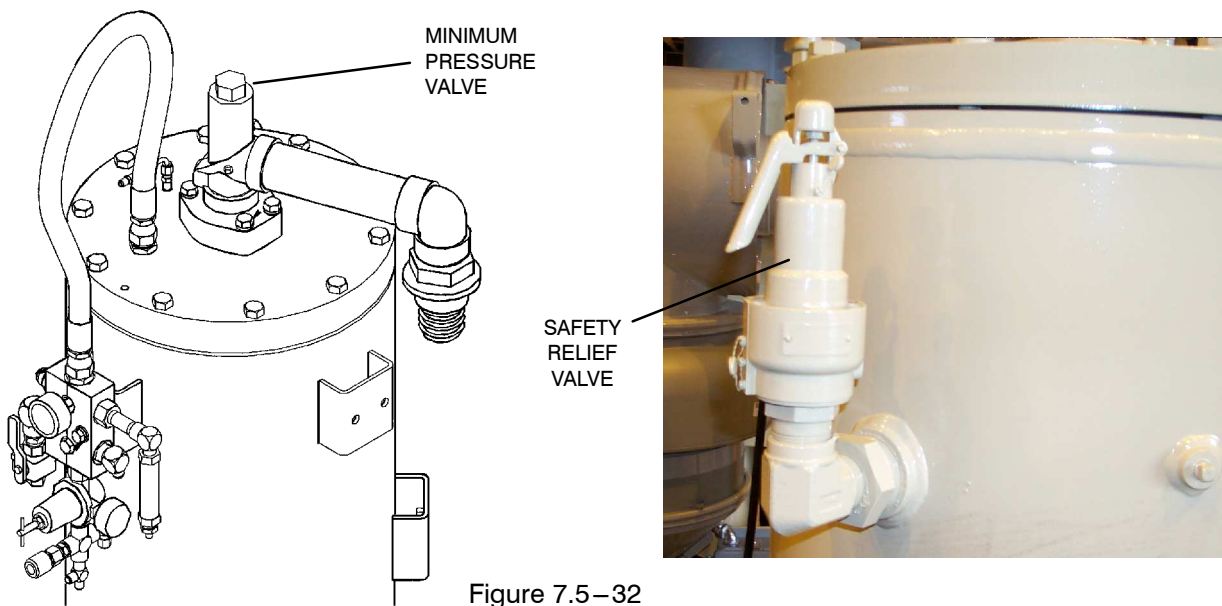


Figure 7.5–32

Safety Relief Valves

All drills are equipped with safety valves (Figure 7.5–32). The setting on these valves is 25–50 psi higher than the maximum working pressure. The **only** function of a safety valve is to prevent damage to the receiver tank in case of other failures. It should never be used as a high pressure relief valve for two reasons. One, the pressure setting is above the allowable working pressure of the compressor. Two, the safety valve loses a small amount of spring tension every time it is opened. Therefore, the pop off pressure will be reduced each time it is opened and will shortly open below the normal operating pressure and will have to be replaced.

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Drill Air Throttle Valve

All high pressure drills are equipped with a drill air throttle valve (Figure 7.5–33) to control the air flow down the hole. These valves can be metered to prevent excess air flow from disturbing the formation. The throttle valve is connected downstream from the minimum pressure valve. **The throttle valve should always be opened slowly to prevent premature damage to the separator element.**



DRILL AIR
THROTTLE
CONTROLLER

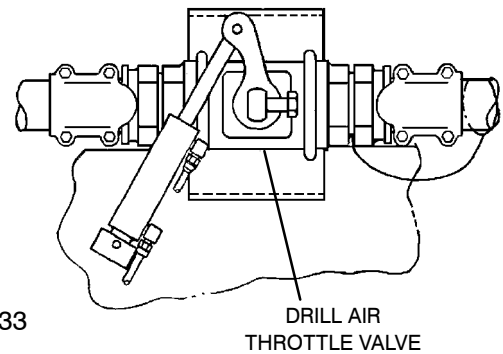


Figure 7.5–33

DRILL AIR
THROTTLE VALVE

The Drill Air Throttle Controller (Figure 7.5–33) controls the drill air throttle valve which allows air flow to the drill string and allows air flow down the hole to operate the DHD (Down Hole Drill) and clean the hole. It is used to turn ON/OFF the drilling air during drill rod or hammer changes. It can be adjusted to a lower setting while collaring the hole. **This is an option for high pressure drills only.**

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Service Connection

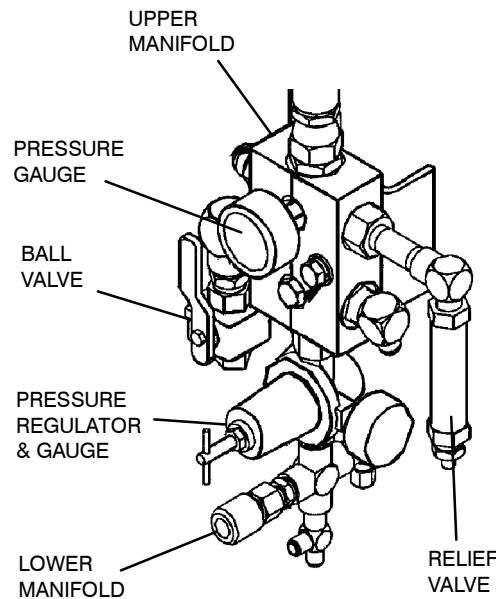


Figure 7.5–34

A ball valve and a pressure regulator (Figure 7.5–34) are connected to the main discharge piping to accommodate tools and equipment that use air power. The pressure regulator is used to lower the high operating pressure to the tool operating pressure, usually around 100 psi. The ball valve is there to reduce the load on the regulator when it is not being used.

Note: Do not operate the service air pressure at normal discharge pressure, since most air tools are rated for no more than 100 psi.

Pressure Gauge

A pressure gauge (Figure 7.5–34) is connected to the upper manifold on the receiver tank before the minimum pressure valve. It reads tank pressure at all times. If a rotary bit or other device is being used down hole that requires less than minimum pressure setting, the gauge will read only minimum pressure. A second gauge must be installed in the standpipe to read actual down hole pressure if you are operating below minimum pressure.

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Regulation System Schematic

The drawing in Figure 7.5–35 shows the basic layout of the regulation system for high pressure drills. Air pressure is pumped into the receiver tank from the compressor. As the pressure reaches 100 psi, the check valve opens and allows air to flow through the metering line into the Metering Chamber. At the same time, air flows through the ON-OFF switch into the Power Chamber. When the pressure builds up past 100 psi enough to overcome the control spring (45 psi), the inlet butterfly valve will close and the compressor will stop making air. This is why the compressor inlet butterfly valve closes at 145 psi on start up.

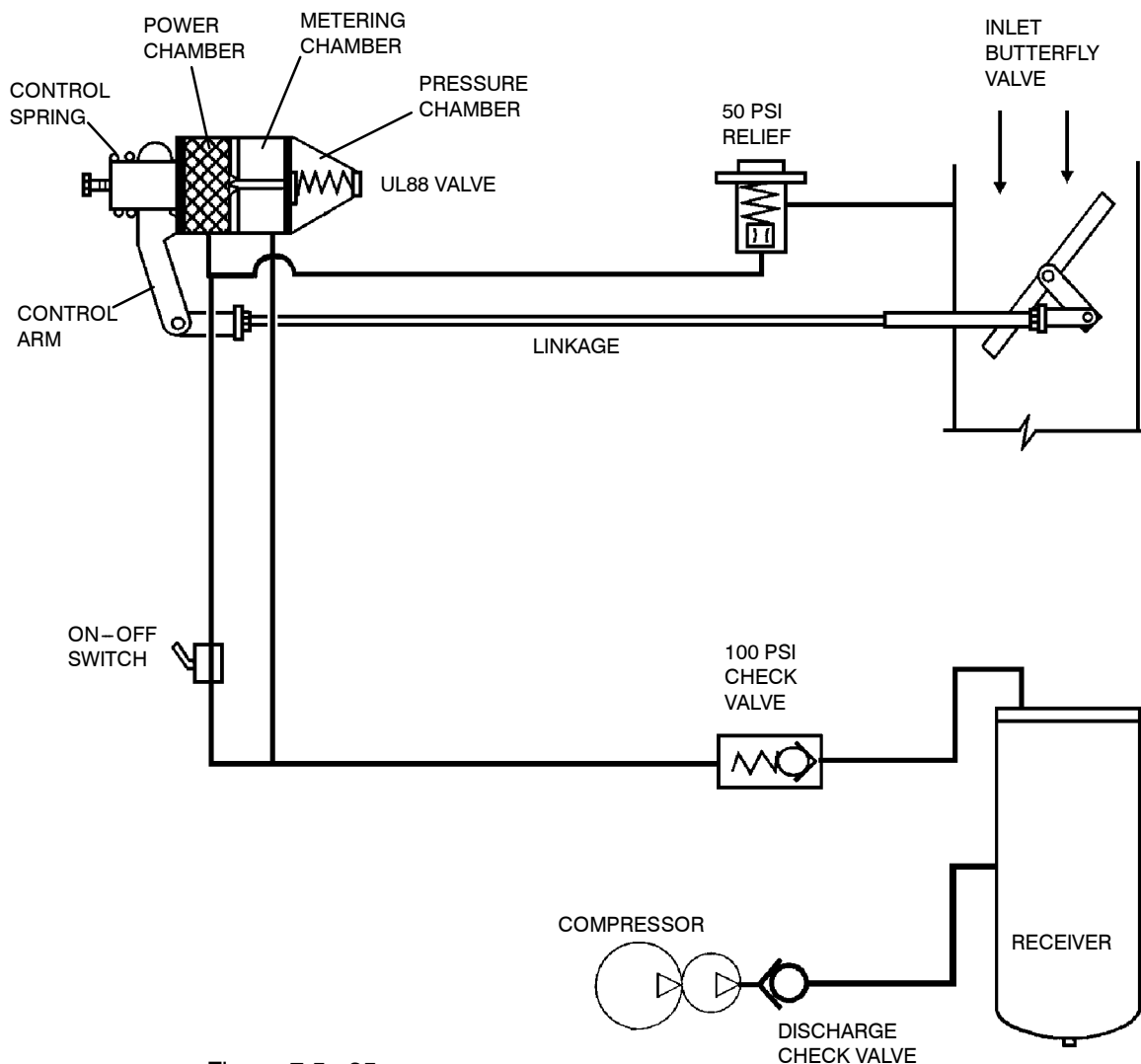


Figure 7.5–35

7.5 – HIGH PRESSURE COMPRESSOR

REGULATION SYSTEM-HIGH PRESSURE (continued)

Regulation System Schematic (continued)

The drawing in Figure 7.5–36 shows the volume control and the pressure regulator. It also shows the scavenger line and orifice between the receiver and the compressor low pressure area.

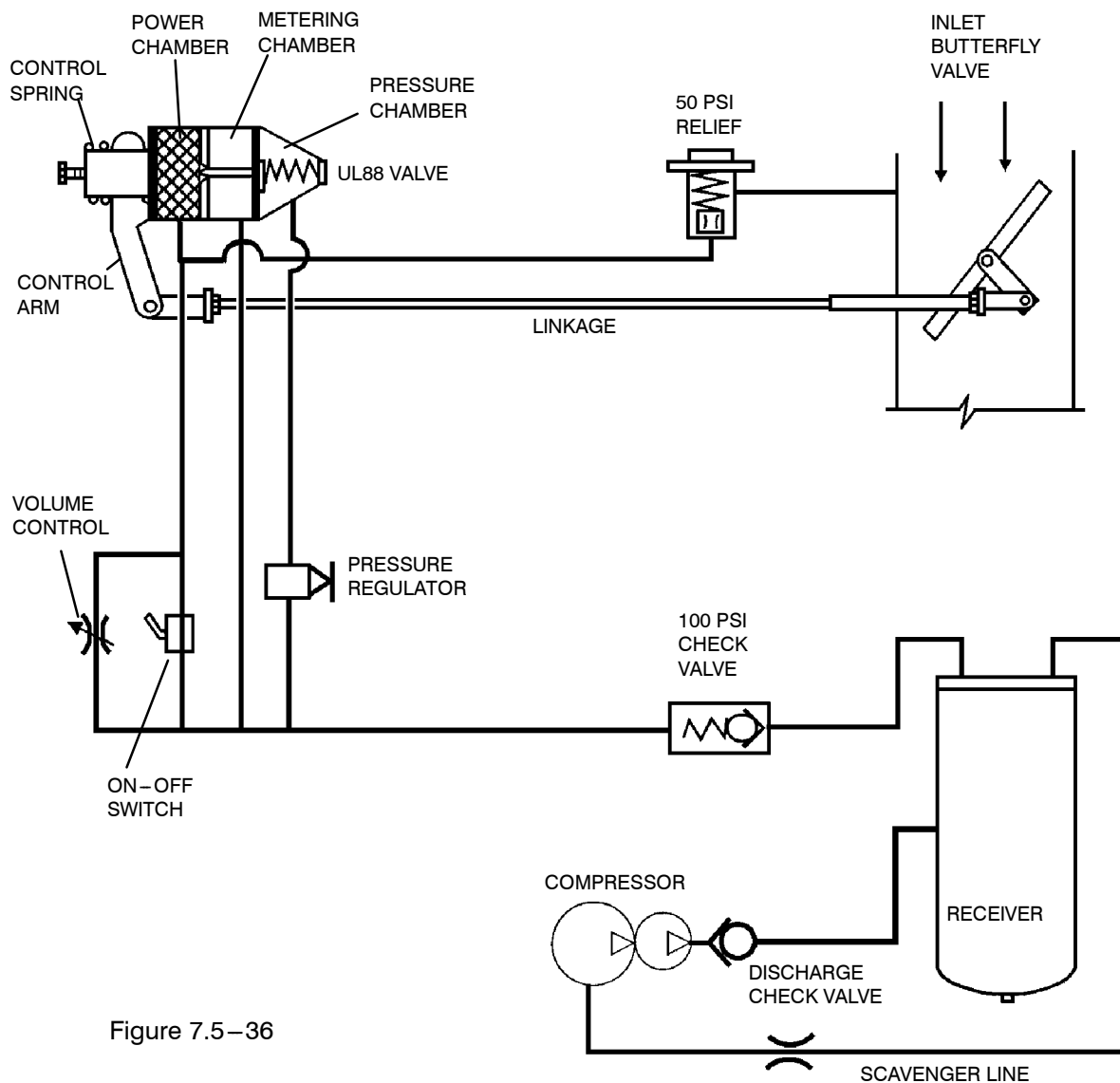


Figure 7.5–36

7.5 – HIGH PRESSURE COMPRESSOR

SHUTDOWN SYSTEM

The shutdown system, shown in Figure 7.5–37, consists of a pilot operated blowdown valve and a shut off valve or a quick exhaust valve. When the drill is stopped, pilot pressure is lost to the blowdown valve and the spring opens the valve so the receiver tank blows down. There is an orifice between the blowdown valve and the muffler that causes enough back pressure to activate the pilot on the shut off or quick exhaust valve. This will either stop all flow to the Power Chamber of the UL88 or exhaust the pressure coming to the Power Chamber, thus preventing the inlet butterfly valve from closing. At the same time, pilot pressure to the anti-rumble valve is lost and it closes. This allows only scavenger air to enter the compressor cavity.

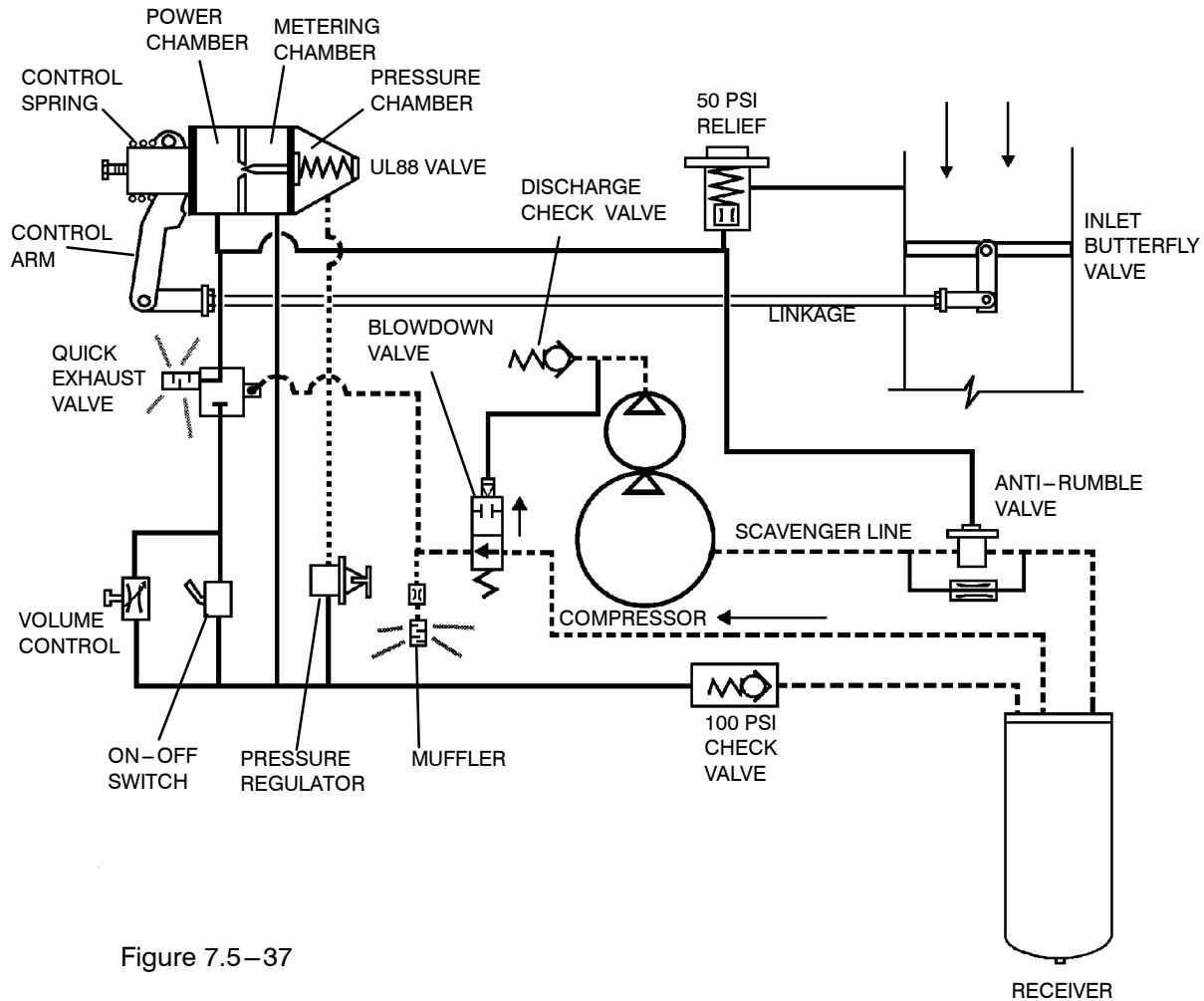


Figure 7.5–37

7.5 – HIGH PRESSURE COMPRESSOR

OPERATION

Starting

Before starting the drill, make sure the compressor ON-OFF Switch is OFF, the Drill Air Throttle is closed and the Pressure Regulator is set properly (See Figure 7.5-38). Once the drill has started and all fluids are at operating temperatures, check the discharge pressure gauge on the operator's console. It should be about 140–145 psi. Next, turn the ON-OFF Switch to the ON position. This action cuts off the flow to the Power Chamber. Now all the pressure is passing through the 100 psi check valve and into the Metering Chamber.

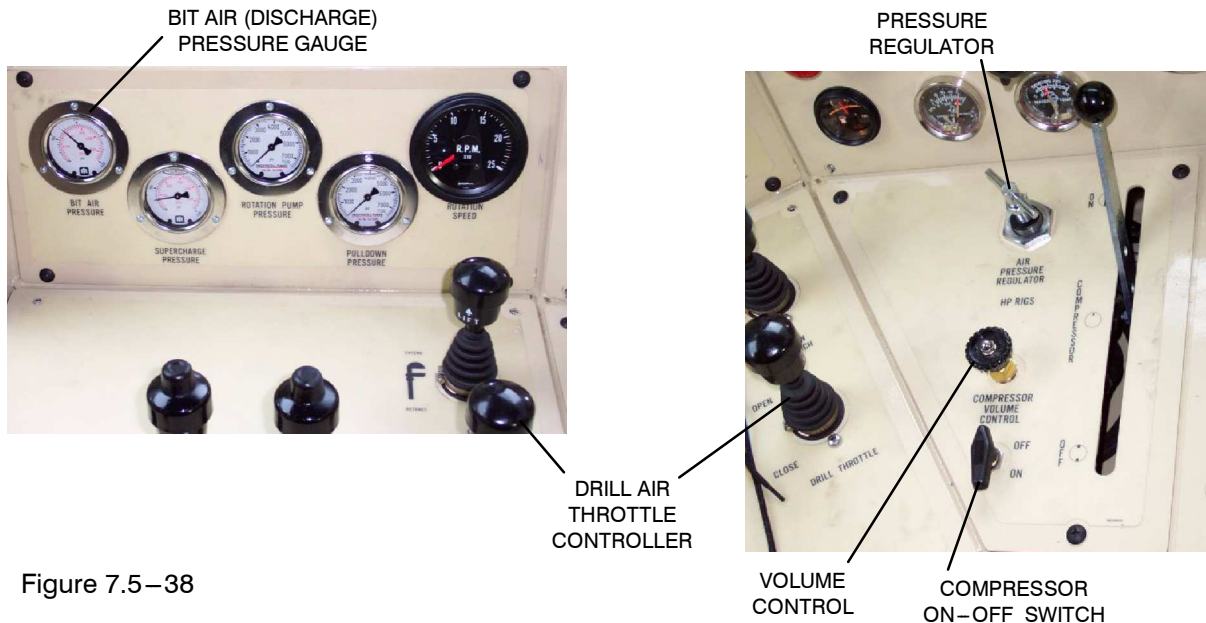


Figure 7.5-38

When the pressure pushing on the Metering diaphragm overcomes the spring pressure in the Pressure Chamber, the metering pin will be pulled out of its seat and allow air pressure into the Power Chamber. Pressure will increase in the Power Chamber until pressure against that diaphragm overcomes the control spring and pushes the control arm back which closes the inlet butterfly valve.

Drill pressure is adjusted by increasing or decreasing the pressure on the regulator on the console. To increase pressure, simply turn the “T” handle clockwise while watching the pressure gauge on the panel. Once it has reached the proper pressure, release the handle. **To reduce pressure on the system, refer to the procedure at the end of this section. Do not simply unscrew the handle.**

7.5 – HIGH PRESSURE COMPRESSOR

OPERATION (continued)

Drilling

When the operator is ready to start a DHD (Down Hole Drill), **slowly** open the air throttle (See Figure 7.5–38). This will allow the pressure in the receiver tank to escape down the hole without damaging the separator element. Sudden release of pressure will shorten the life of the element.

When the hole is completed or the operator wants to add another drill pipe, he simply closes the Drill Air Throttle. Pressure increases in the receiver and control lines until the inlet butterfly valve is closed by pressure in the Power Chamber. The operator does **not** have to turn the ON–OFF switch to the OFF position unless air is not going to be needed for a time. Pressure will stay at the setting of the regulator until the Drill Air Throttle is opened again.

Shutting Down

Before stopping the engine, the operator must release high pressure air from the receiver tank.

1. Turn the ON–OFF Switch to OFF (See Figure 7.5–38).
2. Open the Drill Air Throttle slowly, and allow as much pressure as possible to escape from the receiver tank.
3. The tank pressure should read **no higher** than 140–150 psi.
4. When the pressure gauge shows 140–150 psi, stop the engine.
5. The automatic blowdown valve should open and exhaust **all** the air pressure from the tank.
6. If the blowdown stops blowing before all the air is out of the tank, physically check to see if the inlet butterfly valve is open. If it is not, manually open the valve.

If the drill is shut down under high pressure, the anti-rumble valve will still be open because there is pressure in the Power Chamber to pilot it open. The line from the UL88 inlet valve is still seeing pressure because the 100 psi check valve is open. This pressure causes the inlet butterfly valve to stay closed. The discharge check valve is also closed from tank pressure so the air end becomes a pressure vessel. Now, pressure on both sides of the inlet butterfly valve are trying to push it up evenly and it cannot open.

If the blowdown valve does not start to blow down, it will very quickly be piloted closed from pressure in the air end. Now oil and air are being forced into the air end and will continue to do so until tank pressure bleeds down low enough to allow the 100 psi check valve to close, cutting off flow to the UL88.

When the inlet butterfly valve finally opens, the air and oil mixture will escape with high velocity through the inlet and up through the inlet tubes to the air cleaners. Enough oil will be present to saturate the primary cleaner and render it useless.

This is why the **compressor should never be shut down intentionally under high pressure**. If there is a shutdown switch triggered by low oil or engine problems, there is nothing one can do but clean up the mess and replace the air cleaner element.

7.5 – HIGH PRESSURE COMPRESSOR

AIR PRESSURE REGULATOR

Theory of Operation

The Air Pressure Regulator (See Figure 7.5–39) used on all high pressure drills is a pressure reducing valve that can handle inlet pressures up to 300 psi and reduce the output pressure to a range of 10 psi to 250 psi. It will operate within a temperature range of 0°F (–17.8°C) to 175°F (79.4°C).

When the drill is first started, there is no air pressure in the regulator or the pressure chamber of the UL88. Air pressure builds up in the metering chamber as the compressor develops air pressure.

At the same time, pressure is allowed into the power chamber and when receiver pressure overcomes the 100 psi check valve and the control spring on the UL88, the inlet valve closes. This condition is static until the compressor ON–OFF switch is turned “ON”.

Once the compressor is loaded by turning the ON–OFF switch to “ON”, pressure builds in the metering chamber until it overcomes the spring setting in the pressure chamber. Then the metering pin pulls away from the seat and lets pressure escape into the power chamber.

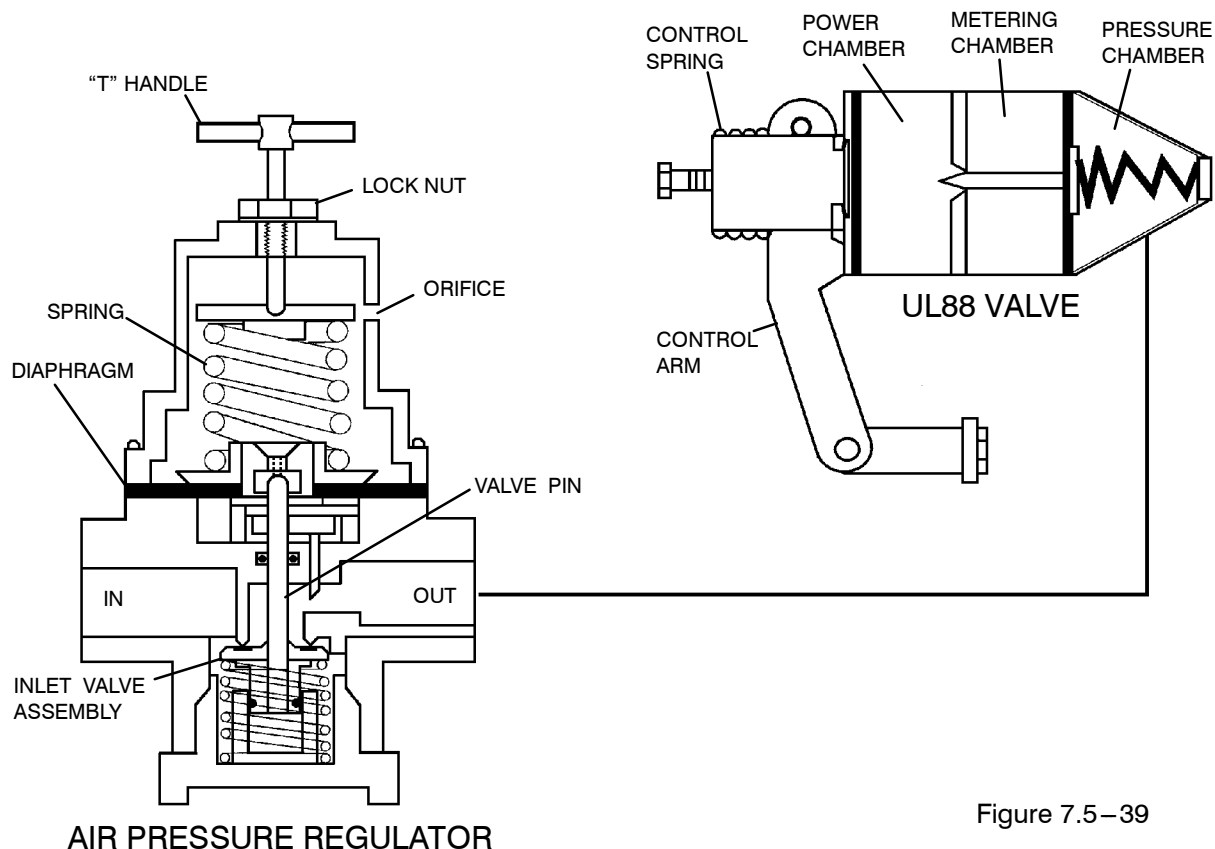


Figure 7.5–39

7.5 – HIGH PRESSURE COMPRESSOR

AIR PRESSURE REGULATOR (continued)

Increasing Pressure

To increase the discharge pressure down the hole, the air regulator pressure must be increased. This is done by screwing the “T” handle clockwise. Each full turn increases the discharge pressure by about 60 psi. As the “T” handle is screwed in, the cone in the diaphragm forces the small pin against the inlet valve assembly and opens the valve. Inlet pressure is allowed to flow through the valve and into the pressure chamber of the UL88. At the same time, pressure is ported to the base of the diaphragm. As air pressure in the system increases, the force working on the area of the diaphragm increases until it overcomes the spring setting on top of the diaphragm. This action relieves pressure on the inlet valve spring assembly and cuts off flow to the UL88. When the correct discharge pressure is obtained, the handle is set by tightening the lock nut on the handle.

As air pressure varies down the hole, the metering chamber pressure varies with it. When receiver pressure builds up enough to overcome the spring and regulator pressure in the pressure chamber, the metering pin comes off the seat and air flows into the power chamber, closing the inlet valve.

Increasing discharge pressure causes no problem for the air pressure regulator or the UL88. However, reducing pressure by using the improper procedure can damage both the regulator diaphragm and the metering chamber diaphragm.

The air pressure on the downstream side of the air regulator and in the pressure chamber of the UL88 is trapped by the pressure on the inlet side of the air regulator. If the spring pressure on top of the diaphragm is released by unscrewing the “T” handle without lowering the inlet pressure, air pressure acting on the bottom of the diaphragm will rupture it after several improper uses.

Decreasing Pressure

The proper procedure is to turn OFF the Compressor On-Off Switch, BLOW the receiver pressure down to minimum using the DRILL AIR VALVE and **then UNSCREW the “T” handle to minimum**. This action relieves the high pressure on the valve assembly and lets the higher pressure in the downstream side open the valve assembly, thus pulling the valve pin away from the diaphragm cone. The air trapped in the diaphragm will exhaust through the center port of the diaphragm and relieve all pressure in the UL88 and under the diaphragm. There is a port on the side of the air regulator cap that allows air pressure out of the system.

Damage to the metering chamber diaphragm can be caused by relieving spring pressure in the air regulator while under high pressure in the system. This will leave high pressure in the metering chamber and no pressure in the pressure chamber. The uneven pressure will rupture the diaphragm prematurely.

Relieving the high pressure in the system while there is still pressure in the pressure chamber will not cause the same problem to the metering chamber diaphragm since the metering pin prevents the diaphragm from collapsing excessively. As soon as the pressure is relieved in the system, the “T” handle can be unscrewed and the pressure will relieve in the regulator system.

7.5 – HIGH PRESSURE COMPRESSOR

COMPRESSOR RELATED PROBLEMS

Trouble shooting and repairs of defects in the mechanical functioning of the compressor systems requires specialist knowledge. All compressor related problems should be referred to your local service support for assistance and are not considered part of operator maintenance covered in this manual. If you are unable to determine the cause of the problem, contact your local Drilling Solutions service office.

Compressor Related Problems Trouble Shooting Chart		
Problem	Cause	Correction
Drill Shuts Down After A Short Running Time	High discharge temperature	• Check for low oil level
		• Check for obstructions in oil cooler
		• Check fan speed
Compressor Is Turned On, But Does Not Produce Compressed Air	Butterfly valve stuck in closed position	Adjust linkage and/or stop on UL88 regulator
	UL88 has hole in diaphragm	Replace diaphragm
	Pressure switch adjusted too low	Adjust pressure switch to required pressure setting
Excessive Oil Consumption	Oil carryover through discharge air hose	• Check for high oil level in separator
		• Check for plugged orifice in scavenger line
Compressor Makes Air But Volume Is Low	Volume control adjusted to lower setting	Close volume control
	Butterfly valve not completely open	Adjust UL88 and/or linkage
	Clogged air inlet filter	Clean or replace filter elements
	Broken butterfly valve	Replace valve
1. Excessive foaming of compressor fluid. 2. Excessive oil carryover into service air. 3. Oil or foam out of the blowdown valve during shutdown.	Foam and air release characteristics of oil are insufficient to remedy the symptoms (problem). Products previously used were Mobil 626 and IR XHP505.	IR XHP605 replaces XHP505 as the standard factory fill for XHP compressors above 300 psi.

7.5 – HIGH PRESSURE COMPRESSOR

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7.6 - HYDRAULIC SYSTEM

HYDRAULIC SYSTEM INTRODUCTION

The **DM45/DM50/DML** Drills are hydraulically driven blast hole drills. Power to drive the hydraulic systems is supplied by a diesel engine which drives a gearbox (Figure 7.6-1), which in turn drives three hydraulic pumps (Figure 7.6-2). The three hydraulic pumps convert the mechanical rotary energy from the engine to hydraulic energy which can be used by the various motors and cylinders to perform the necessary drilling and propelling tasks. The result is a simple and flexible drilling system.

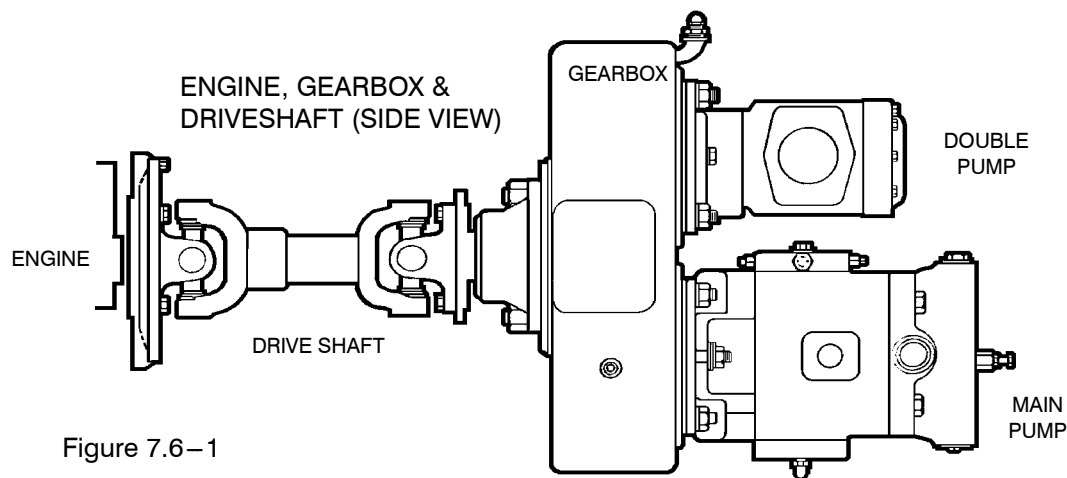


Figure 7.6-1

The hydraulic system consists of several circuits. Each circuit includes one or more pumps which supply pressurized streams of hydraulic fluid to hydraulic cylinders and motors. The main hydraulic circuits are the **Propel Circuit**, **Feed and Rotation Circuit**, and **Auxiliary Functions Circuit**. Also included in this section is the **cooling circuit**.

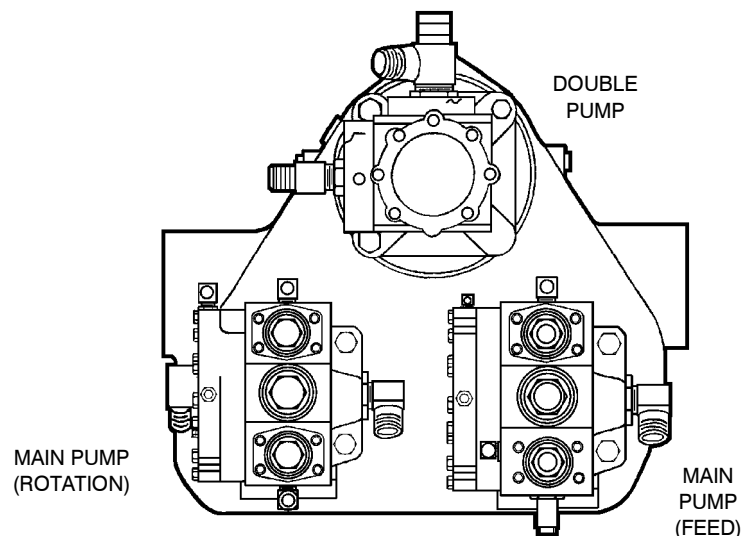


Figure 7.6-2

7.6 - HYDRAULIC SYSTEM

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7-165

7.7 - HYDRAULIC SYMBOLS

Joining Line Symbols

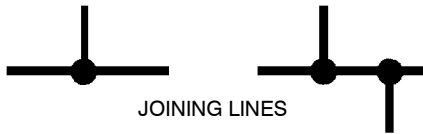
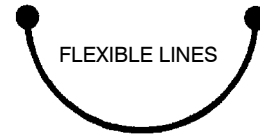


Figure 7.7–4



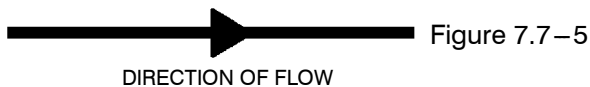
The symbols for joining lines is shown in Figure 7.7–4. They show us that the fluid paths are connected.

Flexible Line Symbols

The symbol for a flexible line or hose is also shown in Figure 7.7–4. The curve in the line illustrates the flexible hose and the two heavy dots represent terminal points.

Arrow Symbols

Next is the arrow (Figure 7.7–5) which will appear in the working line. This arrow shows the direction of flow of the fluid.



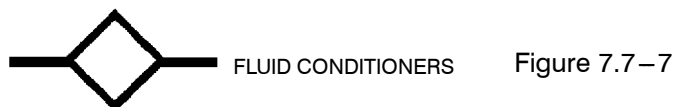
Tank or Reservoir Symbols

The tank or reservoir symbols are shown in Figure 7.7–6. They appear on hydraulic diagrams as the vented tank or the pressurized tank. It is important to note that even though these symbols may appear in many different places on a hydraulic diagram, there is usually only one centralized tank.



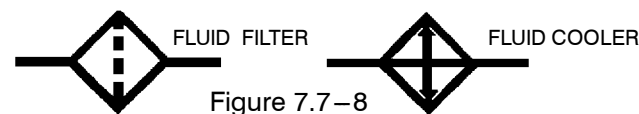
Fluid Container Symbol

The symbol for fluid conditioners is shown in Figure 7.7–7.



Oil Filter / Oil Cooler Symbols

The symbol with a dotted line drawn from top to bottom represents an oil filter. The same symbol with arrows at the top and bottom of it represents an oil cooler. Refer to Figure 7.7–8.



7.7 - HYDRAULIC SYMBOLS

Accumulator Symbols

Accumulator symbols are shown in Figure 7.7-9. On the left is the spring loaded type, in the center is the gas loaded type, and on the right we have the weighted type accumulator.

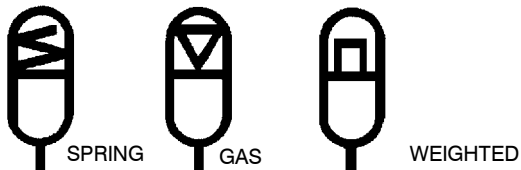


Figure 7.7-9

Restrictor Symbol

The restrictor symbol is shown in Figure 7.7-10. This symbol is usually shown on a working line and indicates an orifice type restriction.



Figure 7.7-10

Cylinders Symbol

There are two commonly used symbols for cylinders. There is the double acting single end rod symbol and the double acting double end rod symbol. Both symbols are shown in Figure 7.7-11. Notice the difference. The left cylinder has only one rod. The right cylinder has two rods.

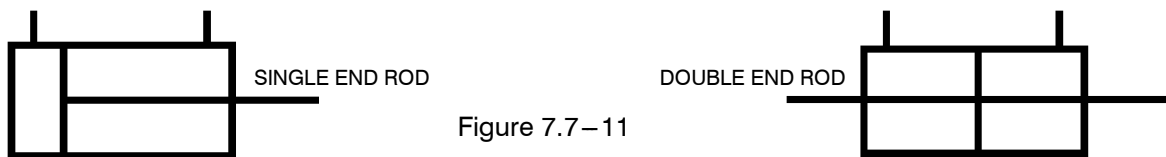


Figure 7.7-11

Activating Device Symbol

Let's go on to activating device symbols. There are ten basic arrangements that will appear from time to time on hydraulic diagrams. These symbols show how a pump, motor or valve is actuated. They are shown in Figure 7.7-12.

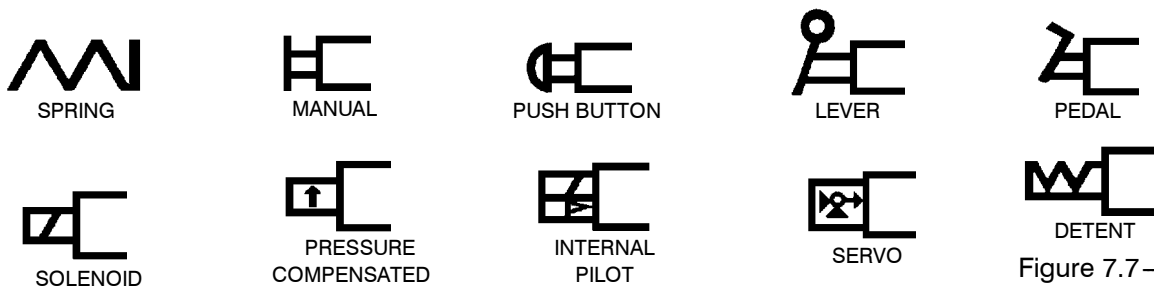


Figure 7.7-12

7.7 - HYDRAULIC SYMBOLS

Pump and Motor

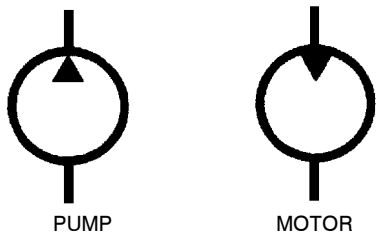


Figure 7.7-13

It is important to note that the only difference in the pump and motor symbols is the direction of the energy triangle. Remember that in the pump symbol the energy triangle is pointed outward toward the working line. In the motor symbol the energy triangle is pointed in toward the center of the circle, away from the working line. Refer to Figure 7.7-13.

Pump Symbols

Now let's go on to the **Pump** symbols. There are four basic configurations that we should be concerned with.

1. **Unidirectional Configuration**
2. **Bidirectional Configuration**
3. **Fixed Displacement Configuration**
4. **Variable Displacement Configuration**

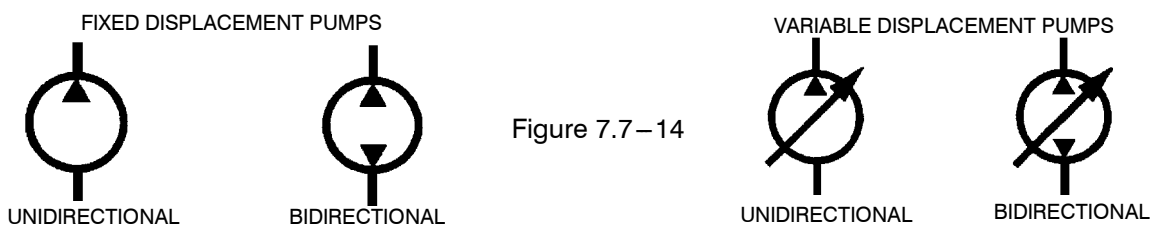


Figure 7.7-14

Fixed Displacement Unidirectional Pump Symbol

The Fixed Displacement Unidirectional pump symbol, which means one direction of fluid flow, is denoted by a circle with an energy triangle pointed out toward the working line.

Fixed Displacement Bidirectional Pump Symbol

The next symbol is for the Fixed Displacement Bidirectional pump, which has two directions of fluid flow. The energy triangles point out towards the working lines, one triangle at the top and the other triangle at the bottom of the circle.

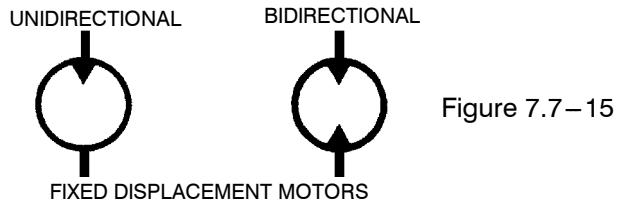
Variable Displacement Pump Symbols

Both the Unidirectional and Bidirectional pumps may be Variable Output pumps. Symbols for the pumps which are variable output have a 45° arrow drawn in them.

7.7 - HYDRAULIC SYMBOLS

Hydraulic Motor Symbols

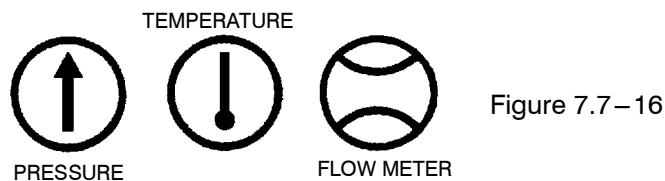
Next are the the **Hydraulic Motor** symbols.



Motor Symbols are represented by a circle with the energy triangle pointed inward from the working line. Refer to Figure 7.7-15. There are two basic types: fixed displacement unidirectional and fixed displacement bidirectional

Instrument Symbols

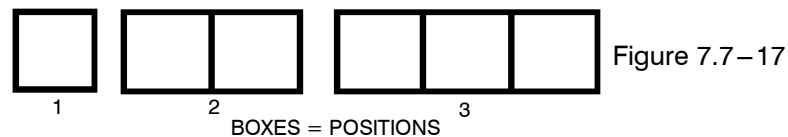
There are three types of instrument symbols which you should know and they are shown in Figure 7.7-16.



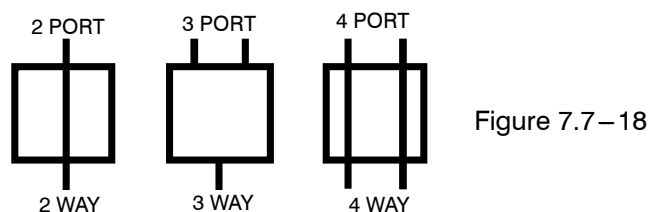
1. The pressure gauge symbol is shown on the left side.
2. The temperature gauge symbol is shown in the center.
3. The flow meter symbol is shown at the right.

Valve Symbols

The next area to cover is valve symbols. Begin with some of the basic symbols shown in figure 7.7-17.



Most valves are depicted by using a box as a symbol. Pressure and flow control valves usually use one box. Directional control valves use two or more boxes. The number of boxes indicates the number of valve positions.



Notice that the box symbols shown in Figure 7.7-18 have lines drawn to them. These are referred to as ports. At the left is a two port valve, commonly called a “2 way” valve. In the center is a three port, or “3 way” valve. On the right is a four port or “4 way” valve.

7.7 - HYDRAULIC SYMBOLS

Three Position “4 Way” Valve

Let us examine the most common of all control valves, the three position “4 way” valve (see figure 7.7-19).

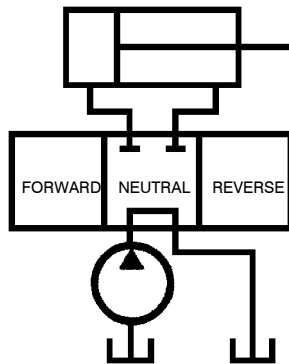


Figure 7.7-19

This control valve directs fluid or oil flow to a forward position, a neutral position, or a reverse position. This illustration shows the fluid or oil flow path when the valve is in neutral position. In neutral, oil flows from the pump into the valve and back to the tank.

Arrows

Arrows in the adjoining squares (Figure 7.7-20) show the fluid flow path when the valve is shifted to the other positions.

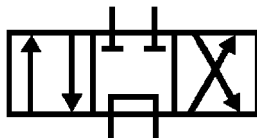
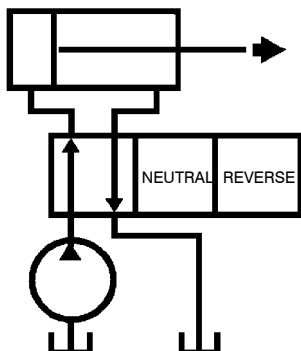


Figure 7.7-20

Forward Position

With the forward position activated, the fluid or oil flows from the pump through the valve and onto the left side of the cylinder. Return oil from the cylinder is released through the valve and back to the tank. Refer to Figure 7.7-21.

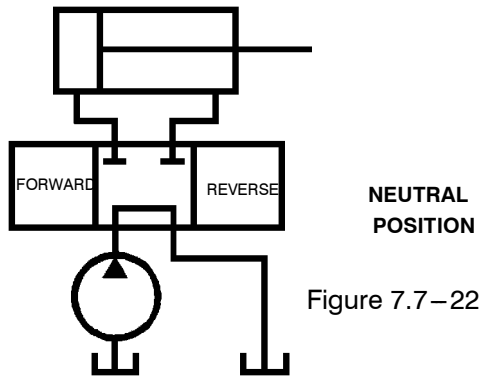


FORWARD POSITION
Figure 7.7-21

7.7 - HYDRAULIC SYMBOLS

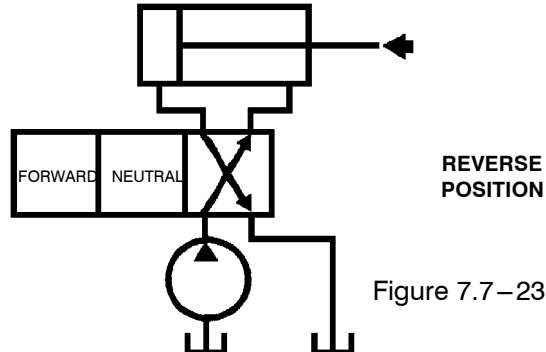
Neutral Position

With the valve in the neutral position, fluid or oil is allowed to flow from the pump through the valve body and back to the tank. Refer to Figure 7.7-22.

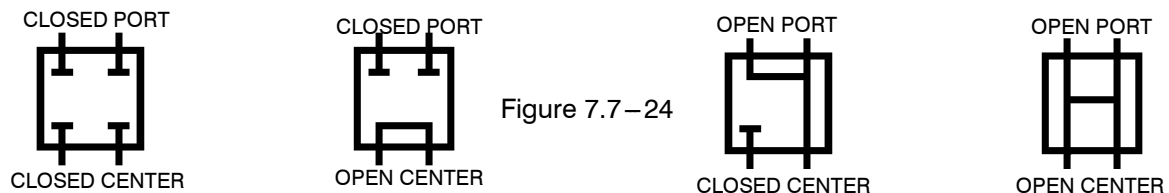


Reverse Position

With the reverse position activated, fluid or oil flows from the pump through the valve and into the right side of the cylinder. Return oil from the left side of the cylinder is released back through the valve and returned to the tank. Refer to Figure 7.7-23.



Valve Centers



Let's look at valve centers now. There are four main center valve configuration symbols.

1. Closed Port – Closed Center
2. Closed Port – Opened Center
3. Open Port – Closed Center
4. Open Port – Open Center

7.7 - HYDRAULIC SYMBOLS

Series Parallel Valve

Now that we have seen our directional control valves at work, let's see how we bank two or more valves together. In this diagram, one pump is supplying oil to two valves for control of two different actuators. The valves are connected together by a parallel passage which allows simultaneous operation of both functions.

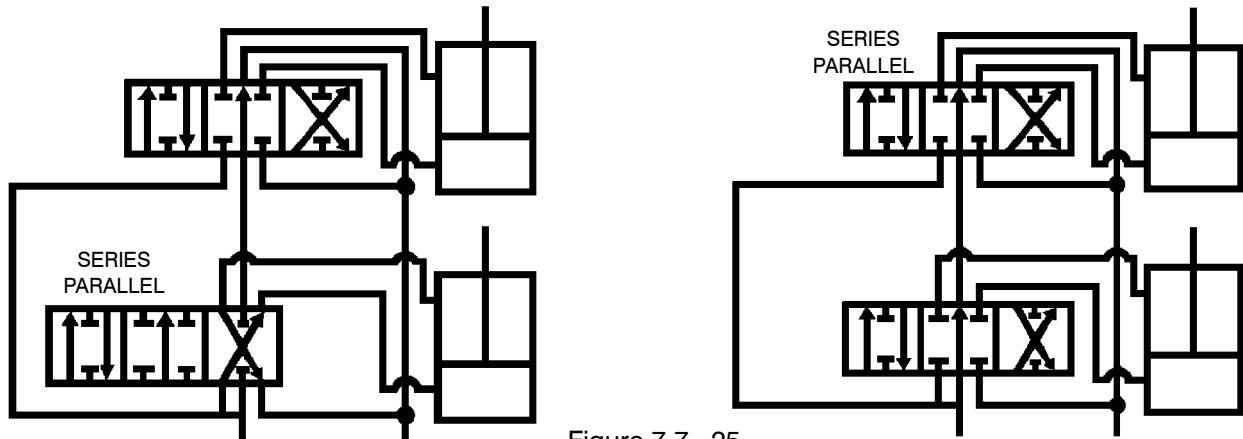


Figure 7.7-25

When the bottom valve is shifted to the reverse position, oil is still available for the other spool through the parallel passage. This is called a series parallel valve.

There are several other symbols which will often appear on a hydraulic diagram.

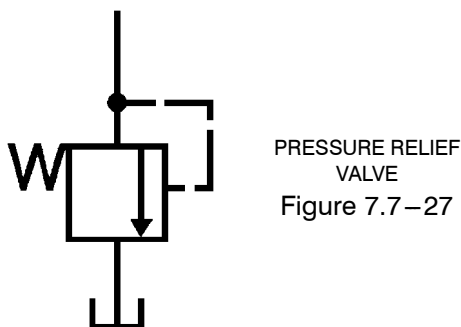
Manual On-Off Valve

The symbol for a manual on-off valve is shown in Figure 7.6-26.



Pressure Relief Valve

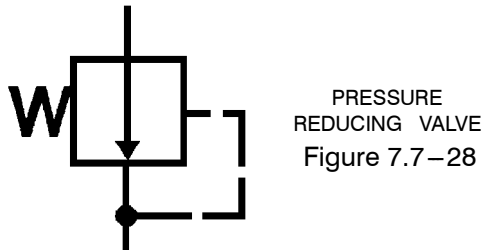
This is the symbol for a pressure relief valve (See Figure 7.7-27), shown here in its normal position. Notice that the arrow is being held to the far right by the spring. The pilot line is connected to the upstream side of the valve. When upstream pressure exceeds the spring setting the arrow shifts, dumping oil to the tank.



7.7 - HYDRAULIC SYMBOLS

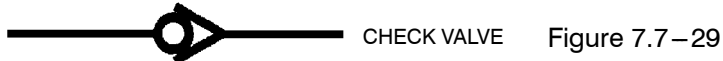
Pressure Reducing Valve

The symbol for a pressure reducing valve is shown in Figure 7.7–28. It is shown in its normal position. Note that the pilot line is connected to the working line downstream of the arrow. This will be your clue to whether or not it is a pressure reducing or pressure relieving type valve.



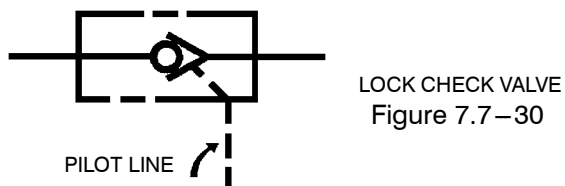
Check Valve

Another important valve symbol is the check valve. In Figure 7.7–29, the check valve is shown with the direction of the free flow to the left. Fluid cannot flow to the right because the ball will seat.



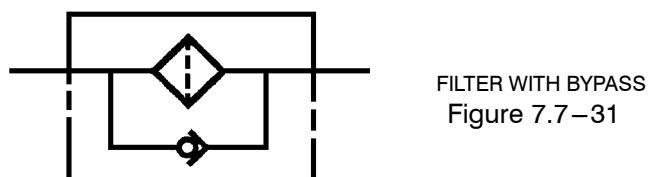
Pilot Operated Lock Check Valve

The pilot line symbol indicates a pilot operated lock check valve. This valve will allow reverse flow when pilot pressure is present.



Bypass Valve

The check valve symbol is also used to show a bypass valve. In this application, the ball is held seated by spring pressure and the valve opens when pressure drop across the filter becomes too great.



7.7 - HYDRAULIC SYMBOLS

Overcenter Valve

The overcenter valve shown in Figure 7.7–32 throttles return oil to prevent a runaway condition on a heavily loaded cylinder or motor. If the cylinder should try to collapse faster than the pump is supplying oil, the pilot pressure will drop and the overcenter valve will throttle the exhaust oil leaving the cylinder.

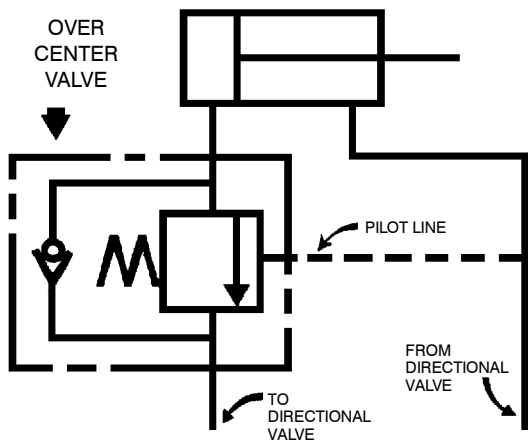
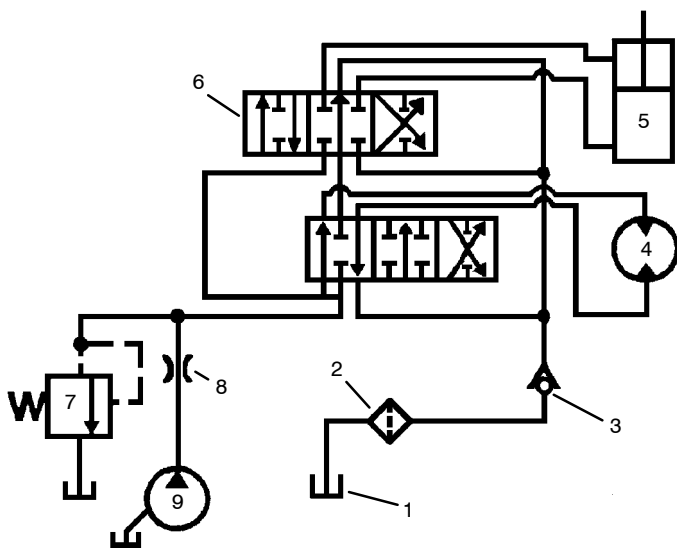


Figure 7.7–32

Let's review. A typical hydraulic diagram is shown in Figure 7.7–33. Can you name all the components?



- 1 _____
- 2 _____
- 3 _____
- 4 _____
- 5 _____
- 6 _____
- 7 _____
- 8 _____
- 9 _____

Figure 7.7–33

7.8 - PROPEL SYSTEM

PROPEL CIRCUIT

The **DM45/DM50/DML** drill is mounted on two crawler type tracks, each powered by a fixed displacement hydraulic motor, operating through a planetary gear set to a final drive which turns the drive sprocket. The hydraulic motors are bent axis types, each driven by one main pump using a closed loop circuit.

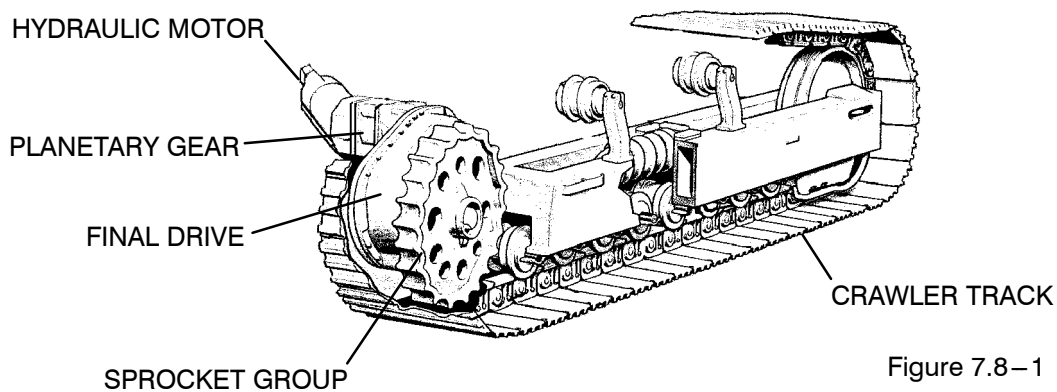


Figure 7.8–1

Components

The primary components of the propel circuit are the hydraulic pumps, propel motors, filters, valves and controls. Hydraulic pumps are used to provide oil flow to the various cylinders and motors connected to different devices. They do not cause pressure in themselves but react to forces on each system.

Main Pumps

The main pumps are closed-loop hydrostatic transmission piston type package pumps. The main pump symbol is shown in Figure 7.8-2. The entire pump is depicted as a “package”.

Loop basically means the complete path of hoses, fittings, valves, motors and other components the oil flows through on its way from and back to the pump. *Closed-Loop* means that oil entering the main pumping element comes directly back from the system without first passing through the system reservoir. Oil is used repeatedly in a continuous loop. *Hydrostatic Transmission* means that the pump is designed for use in a system in which power is transmitted by the pressure of a fluid. It is designed to work with very little slippage and leakage. *Package* means that the pump unit contains not only the main pumping element but also the controls, valves and auxiliary pump needed for proper interface with the hydraulic system. The displacement of these pumps can also be changed (variable displacement). The main pump schematic is shown in figure 7.8-2.

7.8 - PROPEL SYSTEM

Main Pumps (continued)

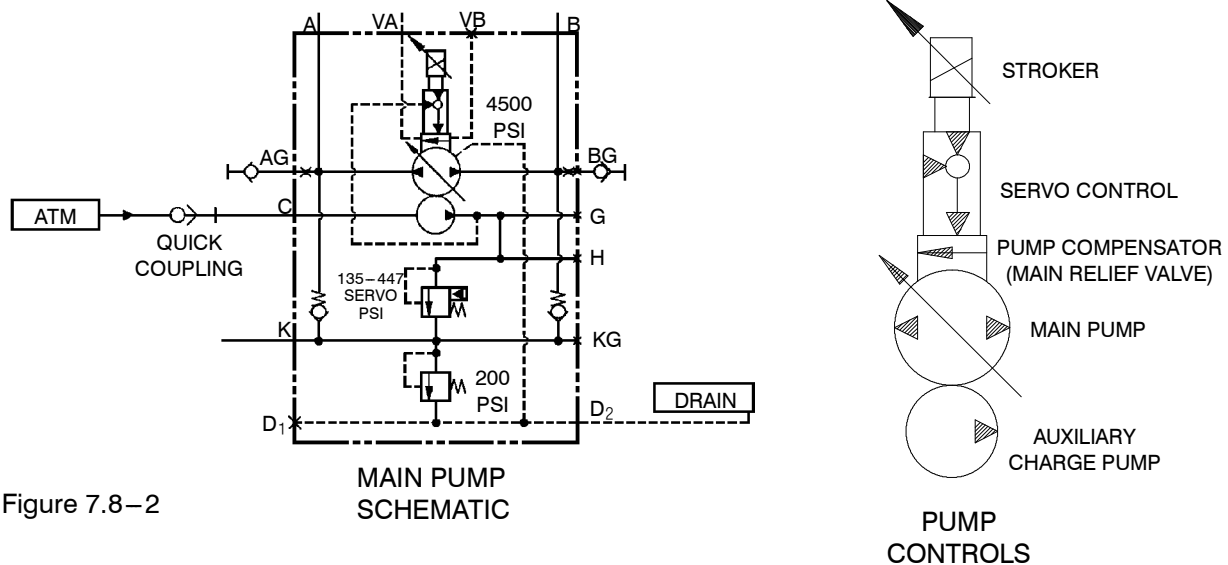


Figure 7.8-2

The main rotating group is depicted in Figure 7.8-2 as a large circle with two triangles pointing towards the work port lines. It has a displacement of 7.25 cu.in./rev. when adjusted to achieve full volume output. A long arrow through the circle means the pump displacement is variable. The two main work ports are the “A” and “B” ports. Either port can discharge oil depending on the position of the pump displacement controls. Which ever port is not discharging oil is receiving oil. In other words, if oil is leaving port “A”, practically the same amount of oil is being returned to port “B”.

Two ports that are connected to ports “A” and “B” are “AG” and “BG” respectively. These ports provide a place to attach a pressure gauge. On the DM45/DM50 DML series, these ports are used to interface with the hot oil shuttle (See Figure 7.8-9).

An auxiliary charge pump, housed within the pump package, is driven off the main pump shaft. This is represented schematically by a circle with one triangle pointed toward the work port (See Figure 7.8-2). The purpose of this small pump is to provide oil to work the pump controls and to charge the main pump loop so that it never runs out of oil.

Oil is supplied to the charge pump through port “C” (See Figure 7.8-2). Oil leaving the charge pump is directed to the swashplate control system. Any oil that is not used for swashplate control passes over the servo relief into the loop replenishment circuit.

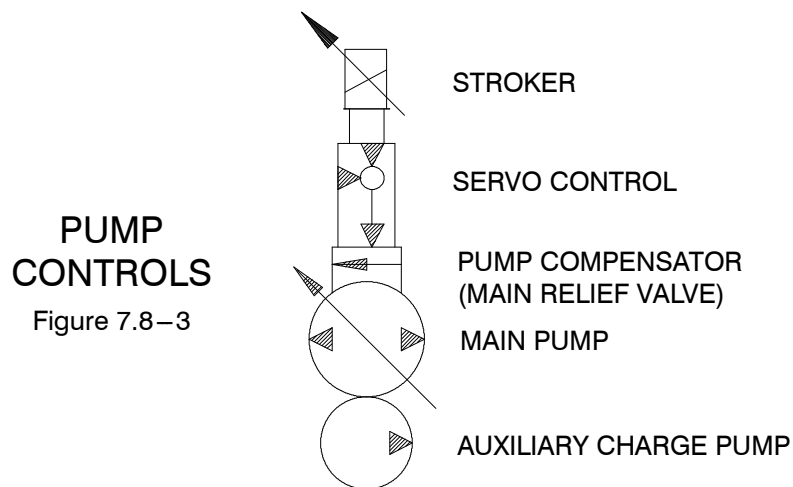
Replenishment oil can flow through the check valves that correspond to the “A” and “B” ports or it can flow over the 200 psi charge relief valve to the pump case. As long as pressure on either side of the loop does not exceed 200 psi, the relief valve will not open. Any excess oil which does dump over the relief valve mixes with leakage oil already in the pump case and leaves the package pump through port “D1” or port “D2” (See Figure 7.8-2).

7.8 - PROPEL SYSTEM

Main Pumps (continued)

Pump controls used with the main pump are proportional. Operator input is supplied electrically to the pump through the electric stroker via a proportional electric controller. When the operator moves the control handle, the electric input is converted to a hydraulic input (top triangle). Here it is amplified (left triangle) and the resulting output (lower triangle) drives the pump swashplate positioning system.

Pump controls used with this pump are the electric stroker, rotary servo control and the pressure compensator (See Figure 7.8-3). The electric stroker is represented schematically by the box with the diagonal arrow that indicates variability. The rotary servo is represented schematically by the box containing three triangles and a circle. The pump compensator (main relief valve) is represented schematically by the box containing an arrow (between the servo control and the main pump symbols).



The Pressure Compensator can override the swashplate controls whenever its pressure setting is reached. The compensator can be remotely set by regulating the pressure at port “VA” or port “VB” (See Figure 7.8-2). If ports “VA” and “VB” are plugged, the compensator will limit the pressure in either “A” port or “B” port to 4500 PSI.

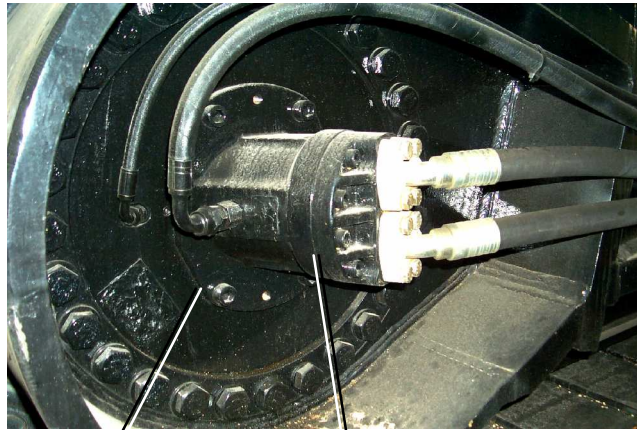
If port “VA” is remotely relieved to a lower pressure, (i.e. torque limit control) pump port “A” pressure will be limited to the remote pressure instead of the higher internal setting. The same principal governs the operation of the “VB” port.

The Main Pump Compensator adjustments should not normally change. If it becomes necessary to replace a pump, a trained factory service representative should be called.

7.8 - PROPEL SYSTEM

Propel Motors

Propel motors rotate the final drive mechanism in the undercarriage system to make the tracks move forward or backward. The more flow provided to a motor, the faster it turns.



BRAKE

PROPEL MOTOR

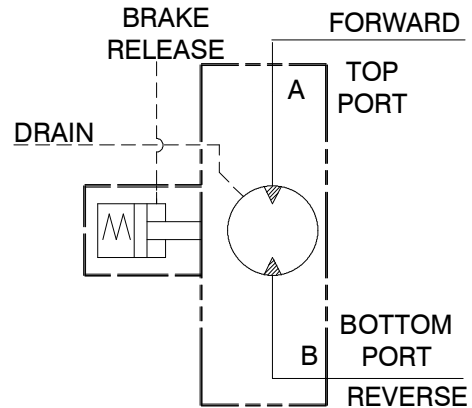


Figure 7.8-4

The Propel Motors are closed-loop, axial piston, fixed displacement hydrostatic transmission motors. Oil is supplied to the basic motor through either the “A” port or the “B” port (Figure 7.8-4). Supplying oil to the “A” port will cause the motor to rotate in one direction. After the oil is used to rotate the motor it leaves through port “B”. Oil supplied to port “B” will cause the motor to rotate in the opposite direction and will leave through port “A”.

Propel motors all have case drain lines that must be connected to prevent pressure buildup in the motor housing.

Propel Motor Brake

Since there is no dynamic friction brake system on a hydraulically operated drill, the braking ability is provided by a brake mechanism that prevents the hydraulic motor from turning. This locks up the final drive and prevents the track from moving.

The motor brake is a spring actuated, hydraulically released, multiple disc, static brake unit. It is a bolt on unit that fits between the propel motor and the track drive final gearbox (Figure 7.8-4). In normal operation, springs load the brake discs to keep the motor shaft from turning. This fail-safe operation ensures that the brake will apply automatically if oil is not supplied to the brake oil port.

The brake is released by supplying oil to its oil port. Pressure pushes on the springs to release the load on the brake discs. This allows the motor shaft to turn. The brake will remain released as long as pressure is being supplied.

7.8 - PROPEL SYSTEM

PROPEL CIRCUIT (continued)

Diverter Valve Assembly

The purpose of the diverter valves is to shift the flow of a pump from one actuator to another. For example, the propel system is not needed while in the drilling mode, so the diverter valve shifts the flow from the propel circuit to the rotation circuit. Thus, one pump is used for two functions.

The Diverter Valves are two-position, hydraulically shifted, three way valves. The valve is represented schematically in Figure 7.8-5. The spring on the left side of the valve requires the valve to be shifted so that “P” is connected to “B” and “T” is connected to “A” when no hydraulic shift signal is present. The shift operators are represented by a triangle in a box on each end of the valve. Hydraulic pressure applied to either operator will cause the valve spool to shift to the position corresponding to the signal. In other words, pressure applied to the right end of the spool will cause the valve to shift to the “P” to “A”, “B” to “T” position. Approximately 100 psi is needed to override the spring and shift the valve. Note that the “T” ports are plugged.

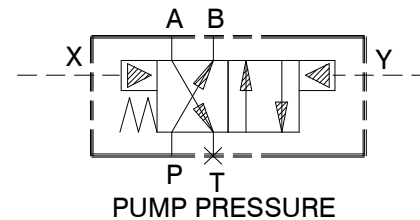


Figure 7.8-5

The main part of the valve consists of a housing with a sliding spool and spool operators. The valve is bolted to a subplate with six sockethead capscrews. The subplate provides threaded ports to interface with the rest of the system. The two pilot ports are represented by “X” and “Y”.

There is a spring installed within the valve body to actuate the spool on the “X” end. This is to assist in moving the diverter valve to the “Drill” position. In the event of a loss of hydraulic pressure, the spring will shift the valve into the “Drill” mode position. This position vents hydraulic brake pressure to tank and prevents the drill from moving. Refer to the *Oil Path Selection* information shown with Figure 7.8-11.

Diverter Valves Location

The diverter valves and sub-plates are mounted directly under the hydraulic tank, facing the drilling end of the drill (See Figure 7.8-5). They can be replaced by simply unbolting the valve and installing a new one. No hoses have to be removed.

7.8 - PROPEL SYSTEM

PROPEL CIRCUIT (continued)

Propel/Drill Mode Selector

The mode of operation (Drill or Propel) is determined by the operator of the drill. This is done with the use of the Mode Selector switch, commonly called the Drill/Propel switch on the operator's console (See Figure 7.8-6). There are two positions for proper operation, DRILL and PROPEL. The mode selector switch is a two position *electric* switch. The switch is energized whenever the ignition key switch is in the "ON" position. When the operator moves the mode selector switch from one position to the other, electric power is diverted from one circuit to another. The two circuits control the mode of operation in which the drill can be used. When the drill mode is selected, only controllers used for drilling are energized. When propel mode is selected, only the controllers for propel are energized.

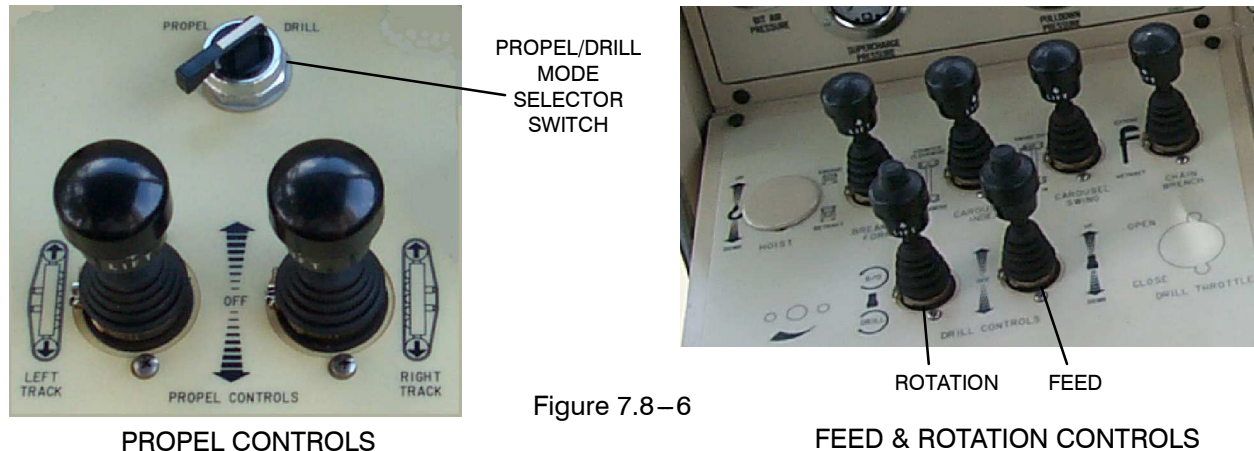


Figure 7.8-6

At the same time the propel mode is selected, the drill/propel switch energizes the solenoid operated drill/propel valve (See Figure 7.8-7). When this solenoid is energized, the valve is shifted to divert pilot pressure to the "Y" ports of the main diverter valves (See Figure 7.8-5) and at the same time to release the track brakes. The internal, normally open pilot operated check valves are piloted closed. This effectively isolates the pump compensator, allowing it to control the maximum system pressure. The drill/propel hydraulic valve and the schematic representation are shown below in Figure 7.8-7.

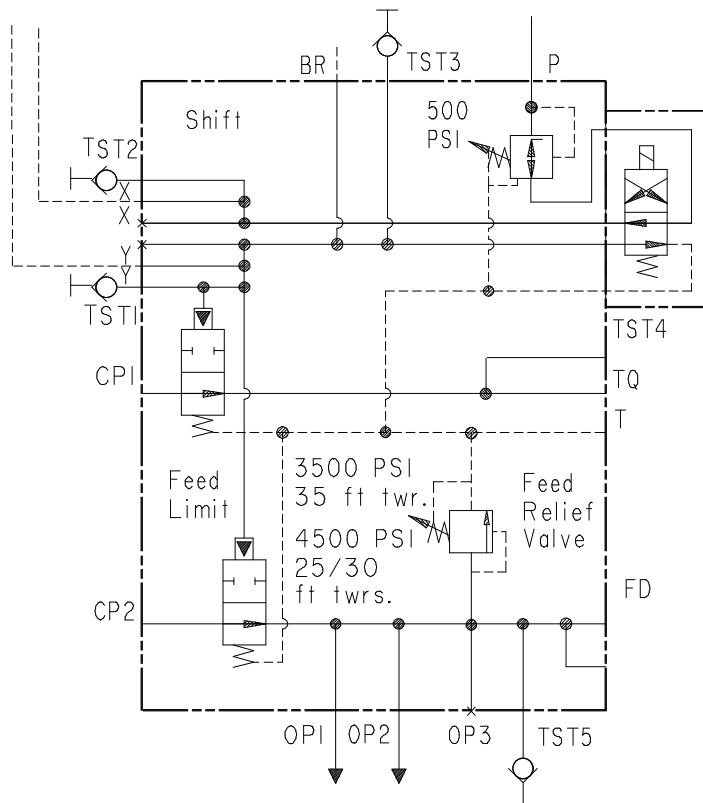
Drill/Propel Control Valve

The Drill/Propel valve (Figure 7.8-7) is a manifold and valve assembly that contains all the components required to: 1) control diverter valve shifting from the drill mode to propel position and vice versa, 2) control propel brake operation, 3) limit torque of the drill rotation circuit and 4) limit drill feed force. The valve assembly consists of a steel manifold with 4 cartridge valves and an electrically operated two-position four way valve. The drill operator selects the mode of operation by the use of an electric mode selector switch on the operator's panel (Figure 7.8-6). The drill/propel valve is located on the dust collector side decking beside the tower support (Figure 7.8-7).

7.8 - PROPEL SYSTEM

PROPEL CIRCUIT (continued)

Drill/Propel Control Valve (continued)



DRILL PROPEL VALVE SCHEMATIC



DRILL PROPEL VALVE

Figure 7.8–7

Hydraulic pilot pressure is provided by the fan circuit to the “P” port of the drill / propel valve. When propel mode is selected, the electric coil on the solenoid operated valve is energized, the valve shifts and flow is directed from the “P” port of the drill/propel valve through the 4-way valve to the “Y” ports. At the same time, the pilot operated two way valves are piloted to the closed position. Oil at the manifold “Y” port is also available to the brake pressure reducing cartridge. Oil crossing this cartridge is reduced to 500 psi. The check valve in parallel with the reducing valve allows rapid return of oil at the “BR” port to the drill/propel control valve to allow monitoring of function pressure as well as diagnosis of problems.

Within the “CP1” and “CP2” ports are “**normally open**” pilot operated check valves. These valves allow communication between the pump compensator and the remotely operated device for controlling pump pressure. When the operator selects propel mode, pilot pressure closes these two pilot operated check valves, isolating the pump compensator. Therefore, in propel mode the pump compensator determines the maximum pressure limit, not the operator.

7.8 - PROPEL SYSTEM

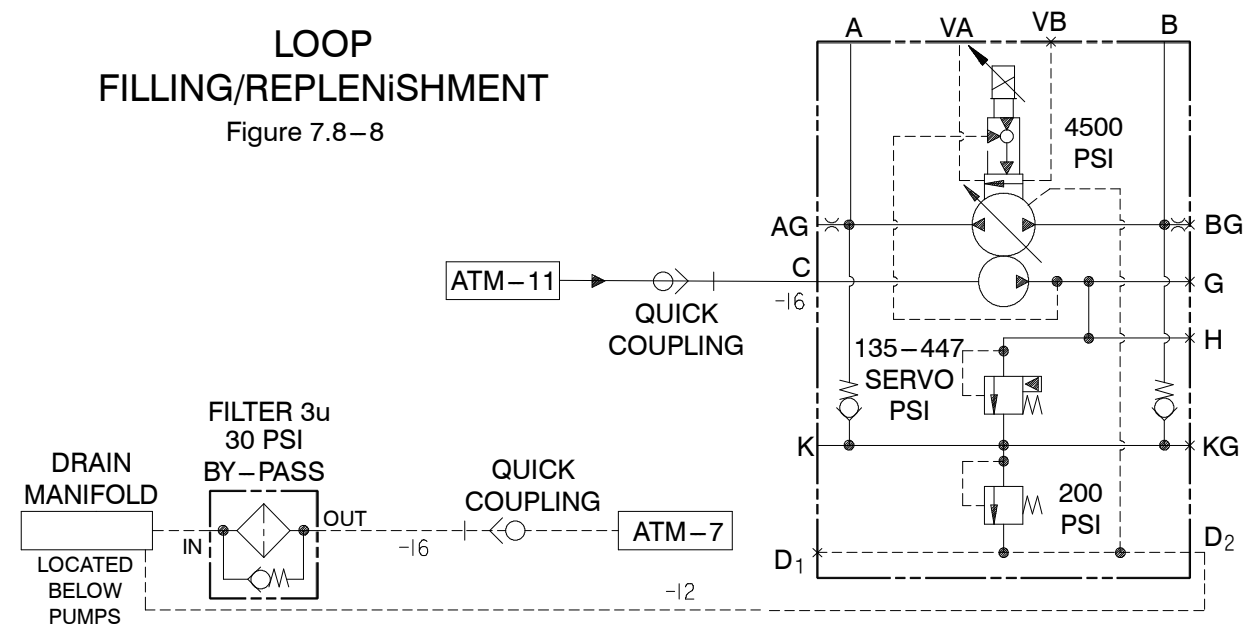
PROPEL CIRCUIT (continued)

Loop Filling/Replenishment

The oil needed to initially charge the main loop, and keep it full, is picked up by the charge pump at port “C”. Port “C” connects to the reservoir through the suction hoses. Oil is continuously injected into the main loop to make up for normal leakage in the pump, motor and diverter valves, and to make up for the oil being stripped out of the loop by the hot oil shuttle in the loop flushing circuit.

Leakage from the main pump is collected in the pump case and returned to the main hydraulic reservoir by way of the pump “D” port. Leakage oil, combined with hot oil shuttle flow also returns to the system reservoir through the case drain manifold included in another circuit.

When the pump is in neutral, the leakage flow from the pump is supplemented by charge flow that comes from the charge relief valve in the pump. Propel motor leakage is collected in the motor case and it is also returned to the drain manifold.

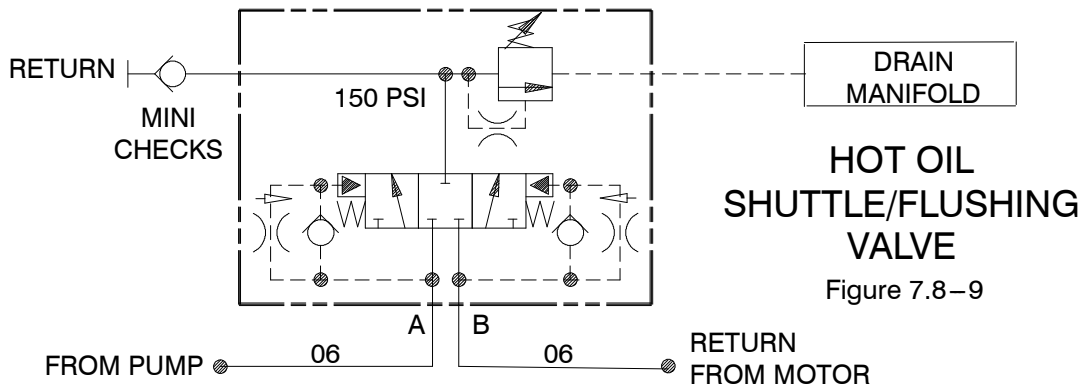


7.8 - PROPEL SYSTEM

PROPEL CIRCUIT (continued)

Loop Flushing Circuit

The Loop Flushing Circuit removes a small portion of the total oil available in the transmission loop. This oil, leaving the loop, carries with it some heat and contamination that may be present in the system.

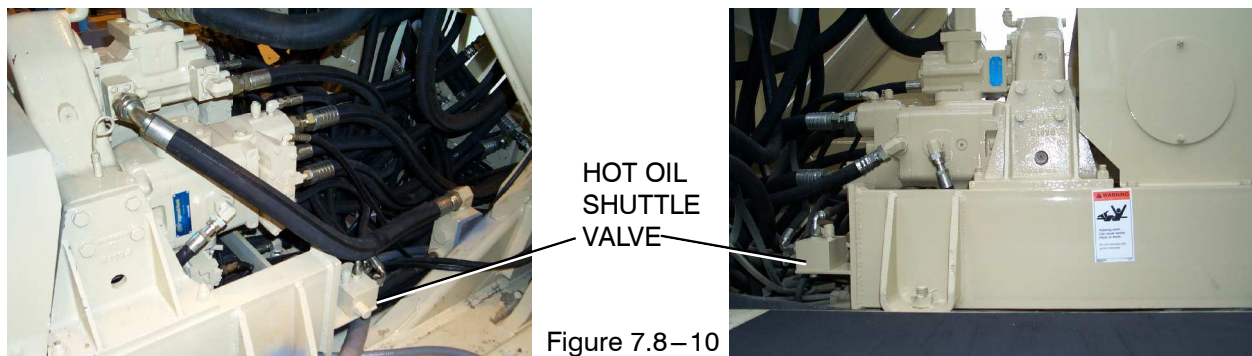


The valve circuit, commonly called the **hot oil shuttle valve**, is represented schematically by a three position directional valve and relief valve (Figure 7.8-8). The three position directional valve is normally centered by its springs. In this position, no oil flows out of either the “A” side or the “B” side of the loop. The valve shifts whenever there is an unbalance of pressures across the circuit. For example, if the “A” side of the loop is at a higher pressure than the “B” side, the shuttle valve shifts to allow “B” side oil (low pressure oil) to leave the loop.

The relief valve guarantees that the minimum desired loop pressure will always be maintained. In other words, the shuttle can’t cause the main loop to run out of oil. The relief valve is set at 150 psi.

There is one loop flushing circuit for each main pump. The circuits work with their respective pump whatever the mode of operation (drilling or propelling).

LOCATION

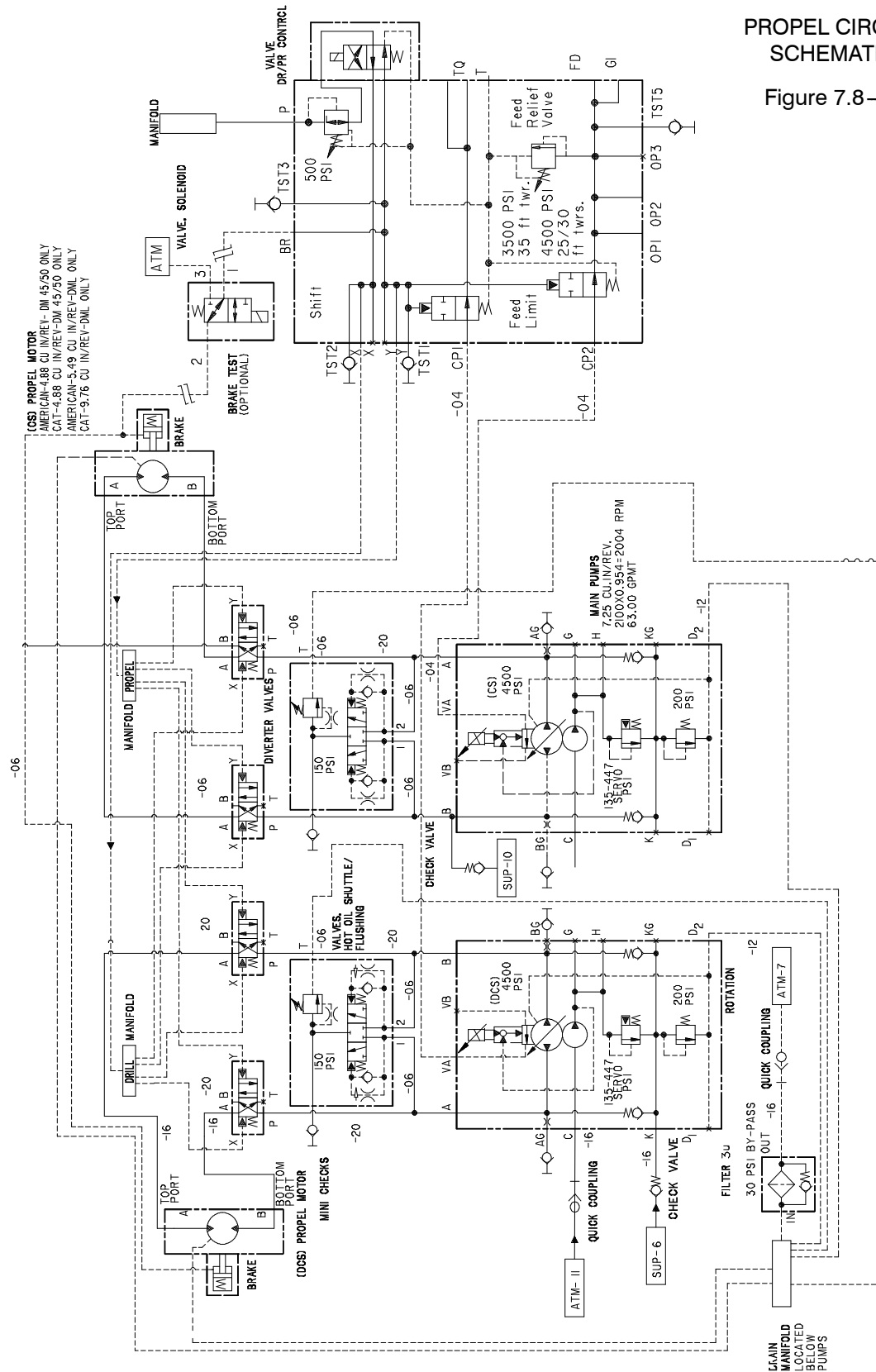


Each hot oil shuttle valve is mounted on the inside of the power pack base in front of, and below, each main pump (Figure 7.8-1).

7.8 - PROPEL SYSTEM

PROPEL CIRCUIT
SCHEMATIC

Figure 7.8–11



7.8 - PROPEL SYSTEM

PROPEL CIRCUIT (continued)

Circuit Operation

The primary oil path in the propel circuit are the closed hydrostatic loops indicated by the solid lines connecting the main pumps to the propel motors on the schematic below (Refer to Figure 7.8-11 and Figure 7.8-12).

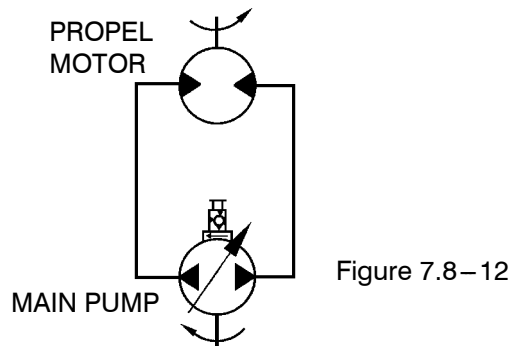


Figure 7.8-12

There is a transmission system to drive each track. The main pump swashplate controls are moved by an electrical input via a proportional electric controller. There is a controller for each of the two main pumps corresponding to the left and right track drive systems.

Whenever the main pump is “destroyed” (swashplate in neutral), oil does not flow in the loop and the propel motor does not rotate. Moving the swashplate control out of its neutral position in one direction causes oil to flow counter clockwise in the loop. The oil flow causes the propel motor to rotate. Moving the swashplate control out of its neutral position in the other direction causes oil to flow clockwise in the loop. The propel motor now turns in the opposite direction. The speed of the motor in either direction is governed by the amount of pump swashplate control movement.

The two transmission systems (two pumps and two motors) allow each drill track to operate independently of each other. The tracks can turn at different speeds or even in different directions to provide maximum drive and steering flexibility.

Oil Path Selection

The only interruptions in the main loops are the four Diverter Valves (See Figure 7.8-11). The diverter valves are shifted to connect the main pumps to the propel motors whenever the propel circuit is energized. These valves are shifted to connect “P” to “A” and “B” to “T” whenever the propel circuit is energized. The propel circuit uses the “P” and “A” ports on all four valves. The valves are all shifted by supplying oil to the “X” or “Y” ports. This is done by shifting the Drill/Propel valve. Oil for this purpose is supplied by the auxiliary circuit manifold through the drill/propel control valve assembly.

In the Propel Mode, the Drill/Propel Selector Valve directs oil to the Diverter valve “Y” ports and drains the “X” ports. At the same time, oil is also directed to release both motor brakes and to energize the propel alarm switch. A point to remember is that with the drill off, the control system defaults to the Drill Mode. This is why the spring in the Diverter is on the “X” port side.

7.8 - PROPEL SYSTEM

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7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT

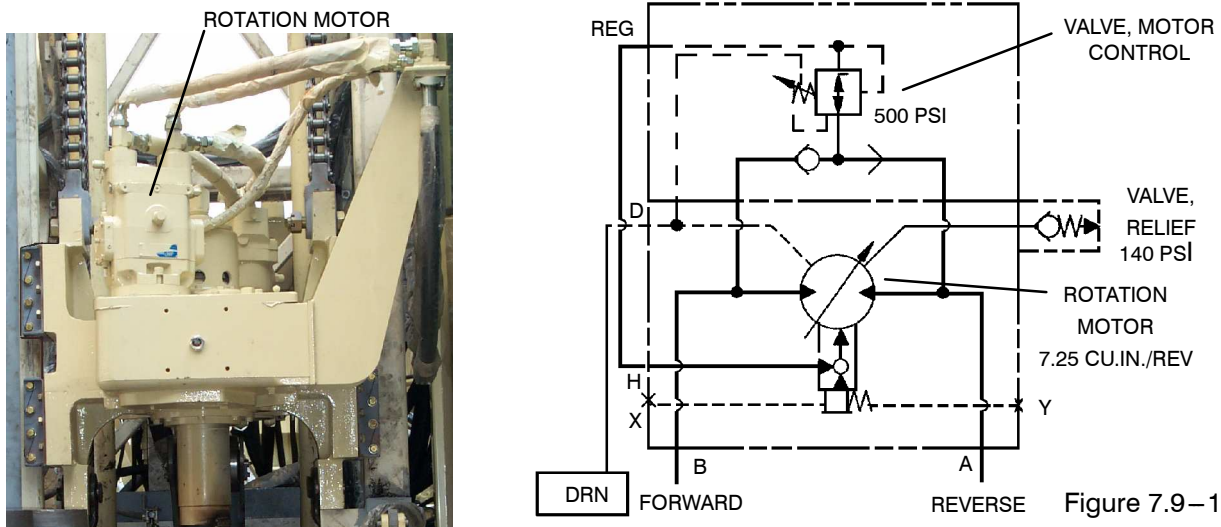
The primary components of the Drill Feed and Rotation Circuits are the Main Pumps, Rotation Motors, Pulldown Cylinders, Filters, Valves and Controls.

Main Pumps

The Main Pumps used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of their characteristics and schematic can be found in the Propel Circuit Section of this manual.

Rotation Motors

Depending on the type of rotary head used, the rotation motor on the single motor head is a closed-loop, variable displacement, hydrostatic transmission motor. The two motor head uses two fixed displacement closed-loop motors.



Closed loop, as previously mentioned, means that the reservoir is not included in the pump/motor circuit. Hydrostatic Transmission means that the motor is designed for use in a system in which power is transmitted by the pressure of a fluid. The schematic for the rotation motors is shown in Figure 7.9-1. The main motor section is shown by the circle with two triangles pointed inward from the two main ports. The long arrow through the circle means that the motor displacement can be changed to give different speed and torque levels.

The motor displacement is controlled by the swashplate servo system shown on the schematic as a box sitting on the motor. Inside the box are three triangles and a circle which represent the servo input, summing and output functions. The servo receives oil to power its systems from the motor “H” port. It also receives an input from a mechanical arrangement of springs and pistons indicated by the hat and spring on top of the servo envelope. The displacement of the motor can be set at its maximum level or its minimum level by energizing the “X” port or the “Y” port, respectively, on the motor.

7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Rotation Motor Adjustment

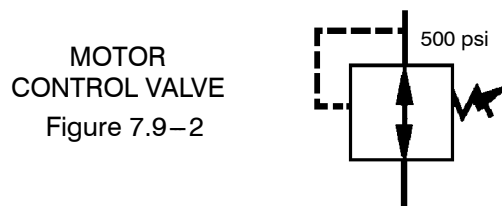
The displacement of the pump can be set by turning the Motor Volume stop screws clockwise or counter clockwise.

Turning the screw clockwise decreases the motor swashplate angle. This causes the motor to turn faster, trying to displace the flow from the rotation pump. Turning the screw counter clockwise increases the motor swashplate angle. This causes the motor to turn slower due to the increase in oil volume displaced per revolution. The Main Pump must be at full volume in order to set the motor speed correctly.

Rotation Motor Control Valve

Oil must be supplied to the motor “H” ports to drive the swashplate positioning servo system. Oil for this purpose must be at a lower pressure than that normally found in the loop. A pressure reducing valve (motor control valve) externally mounted on one motor provides this oil (See Figure 7.9-1).

The motor control valve (Figure 7.9-2) is an assembly that bolts to the top of one of the rotation motors. The assembly contains a shuttle valve and a pressure reducing valve. The shuttle valve receives oil from both sides of the motor into its two ends. If the pressure available at one end is higher than the pressure at the other end, the shuttle ball shifts toward the low pressure and seals off that port. The higher pressure is then free to flow to the pressure reducing valve.



The pressure reducing valve is responsible for reducing the pressure of the oil to a lower pressure so that it can be used in the rotation motor server system (about 500 psi). The pressure reducing valve will open, close or even take oil in reverse to keep the “REG” port pressure at the value set by the spring adjustment. Any oil that the valve takes back from the “REG” port flows to the valve drain port where it can be passed back to the motor case.

The motor control valve must be replaced as a complete unit. There are no adjustments required.

Check Valves

The rotation motor allows normal leakage within the rotation motor case. Oil pressure in the case drain must exceed 15 psi to open the check valve in the case drain line. (Refer to the Rotation Circuit schematic Figure 7.9-13). After the valve has opened, oil can flow back to the system reservoir. The check valve is there to prevent the rotary head gearbox oil from draining back through the motor case when the tower is in the horizontal position.

7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Check Valves (continued)

The main function of the check valve is to keep the motor cases full of oil in all positions of the drill tower. On the variable displacement motor, there is a 140 psi relief valve mounted on the side of the case to serve as a safety backup for the case drain line in the event that the line becomes plugged or kinked. (Refer to Figure 7.9-1).

Diverter Valve Assembly

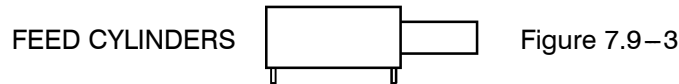
The diverter valve assemblies used for the drill feed and rotation circuits are also used for the propel circuit. A description of their characteristics and schematic can be found in the propel circuit section of this manual.

Drill/Propel Control Valve

The Drill/Propel Control Valve used for the drill feed and rotation circuits is also used for the propel circuit. A description of their characteristics and schematic can be found in the propel section of this manual.

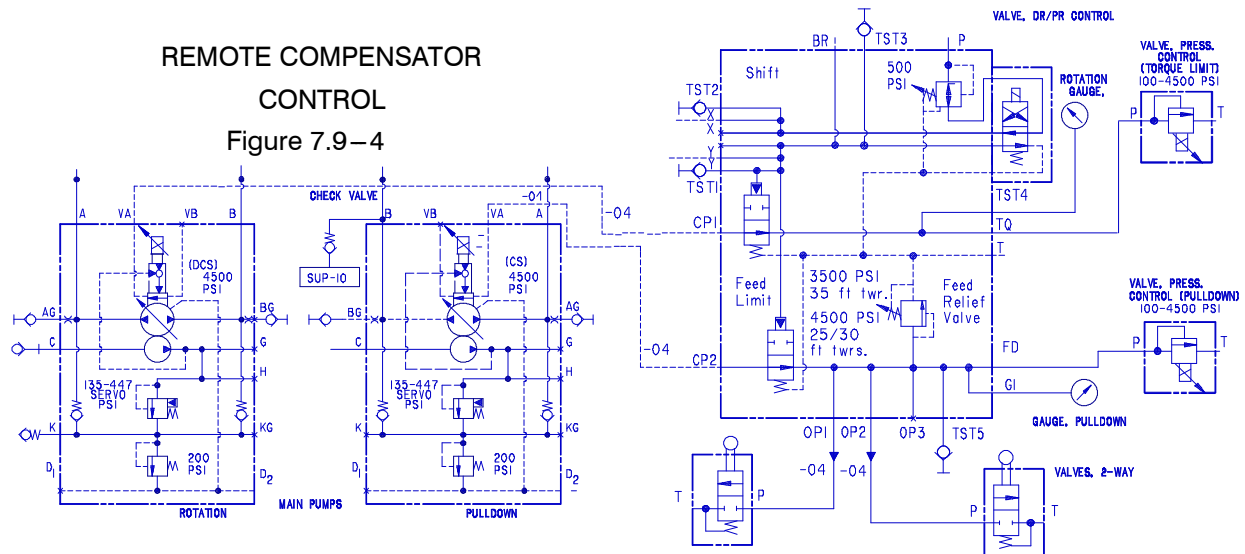
Feed Cylinders

The feed cylinders (also called pull-down cylinders) are mounted inside the tower. The feed cylinder and cylinder schematic symbol are shown in Figure 7.9-3.



The Feed Cylinders are double acting, single rod cylinders. “Double Acting” means that the cylinder can be powered by the hydraulic system to extend and to retract. “Single Rod” means that the cylinder only has one rod extending from one end of the cylinder tube.

Remote Compensator Control



7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Remote Compensator Control (continued)

In the drill mode, the compensator vent connections are utilized to provide interface with remote pressure control devices.

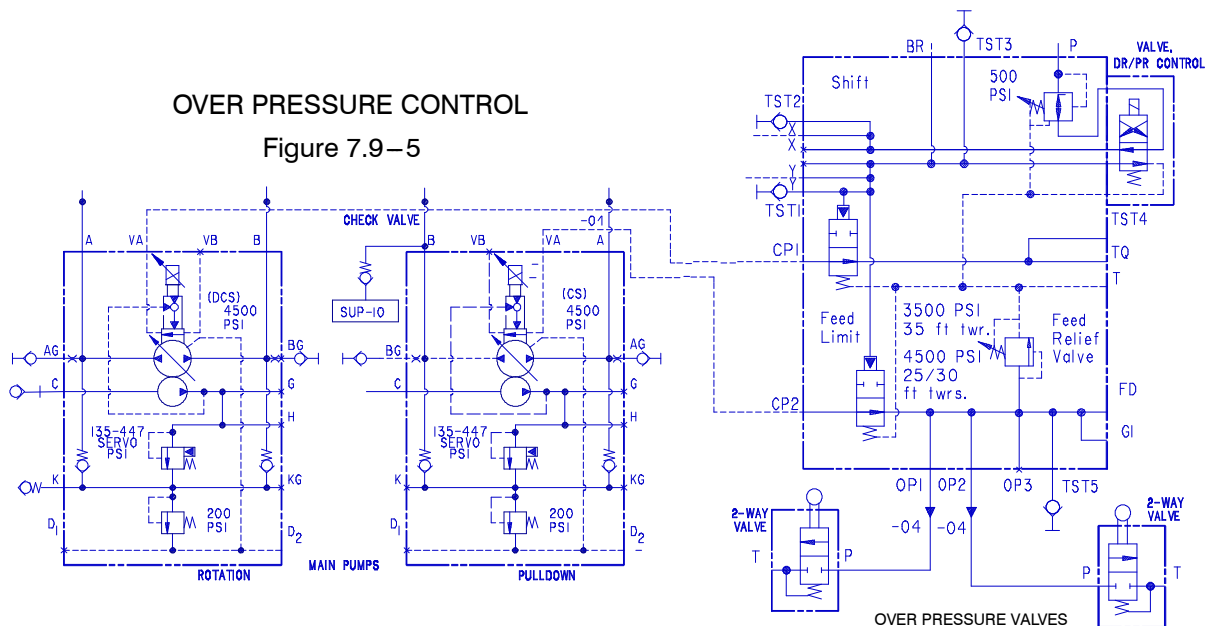
This allows for the main pumps to be remotely controlled by the operator and gives variability and infinite control of actuator speeds and pressures. The -4 line in Figure 7.9-4 shows the connection at the pump for remote control of the compensator. The other end of this hose connects to the drill/propel valve at the “CP1” port (compensator pressure). The cab side main pump provides flow for the feed system. A hose from the “VA” port connects to the “CP2” port. When in drill mode, the oil from the “VB” port flows through the drill/propel valve to an electrically operated, proportional control valve called the FEMA control valve.

Increasing the electrical power to the FEMA valve coil proportionally blocks off the path from “VB” to tank. The more current the higher the pressure rises. The less flow through the valve, the higher the pump pressure potential. When the path is fully blocked, the pump can generate full compensator pressure.

NOTE: De-energizing the coil opens the valve fully. Therefore, if the electrical circuit is open to the FEMA valve, no feed pressure or rotation torque pressure will develop (If torque limit is on the drill).

Over Pressure Control

The connections for the over pressure controls are part of the drill/propel valve. When in the drill mode, the drill has the capacity to apply forty five thousand pounds of force on the bit. The drill is designed to vent pulldown force if the ground gives way beneath the jacks or for some other reason the drill is unsupported.



7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Over Pressure Control (continued)

The ports labeled “OP1” and “OP2” are common to the feed pump “VA” port and are connected by hoses to the overpressure control valves. These valves are mounted, one on each of the front (side) drilling end leveling jacks (See Figure 7.9-6). If for any reason the drill is unsupported by the leveling jack, the pipe nipple will drop to gravity and mash the button as shown. This opens the path to tank, venting the feed pump compensator “VA” port.

OVERPRESSURE
CONTROL VALVE
Figure 7.9-6



Note:

The Over Pressure control system should be tested daily to insure proper functionality. If the system does not function properly, the drill should be shut down immediately. The drill must remain shut down and not used until the Over Pressure control system is repaired.

**THE OPERATOR IS RESPONSIBLE FOR THE SAFE
OPERATION OF THE DRILL.**

7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Over Pressure System Test

Do not test the Overpressure Control System with drill pipe or drill bit against the ground. Only test the system with the rotary head against the lower tower stops.

Step One:

Level the drill with the tracks about 1–2 inches (50.8mm) off the ground. The drill weight must be fully supported by the leveling jacks.

Step Two:

Raise the tower and pin it in the vertical position.

Step Three:

Feed the rotary head down against the bottom stops of the tower.

Step Four:

Slowly increase pulldown pressure to maximum down pressure.

Step Five:

Slowly lift the cab side leveling jack off the ground. Feed pressure must vent immediately when the jack pad is lifted. The rotary head will normally travel upwards slightly when pressure vents. If pressure vents immediately, go on to step six.

If feed pressure does not vent, reduce system pressure with the feed controls, re-level the drill and contact your supervisor for system repairs immediately.

Step Six:

Repeat steps 4 and 5, this time raising the dust collector side jack slightly. If pressure vents when the jack pad is lifted slightly off the ground, the system is working.

If it does not vent pulldown pressure, shut down the drill immediately and report any problems encountered to your supervisor.

7.9 - FEED AND ROTATION SYSTEM

FEED & ROTATION CIRCUIT (continued)

Regen Valve

The Regen valve in the Drill Feed loop performs three functions in the feed circuit (See Figure 7.9–7).

First, it acts as a regenerative valve when the load is not too great, allowing oil from the rod end to add to the pump flow into the base end and increase the head speed downward. Second, it prevents the head and drill pipe from coming down the tower too quickly. Third, it allows excess oil from the base end to return to the tank when the pump is supplying oil to the rod ends, even though it is a closed loop system.

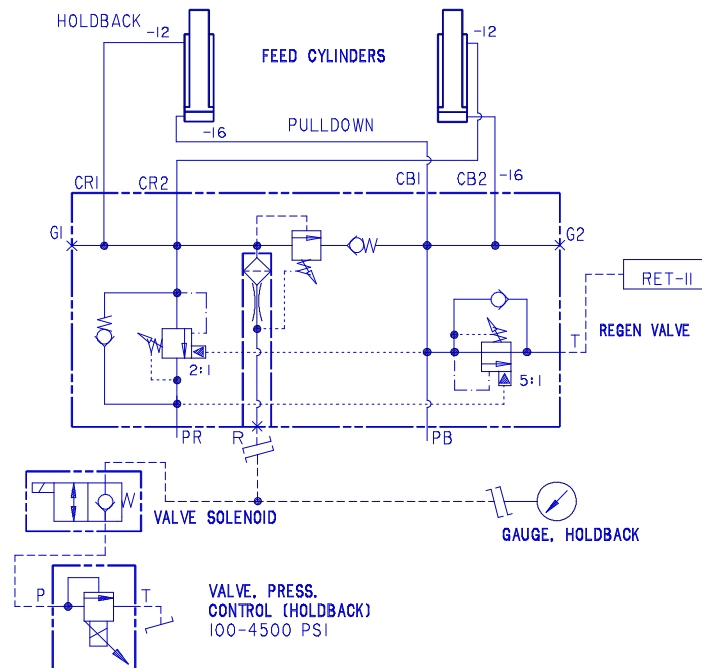


Figure 7.9–7

The assembly contains an overcenter or holding circuit to hold back pressure at the “CR” ports, and another overcenter circuit to control oil flow from the “PB” port.

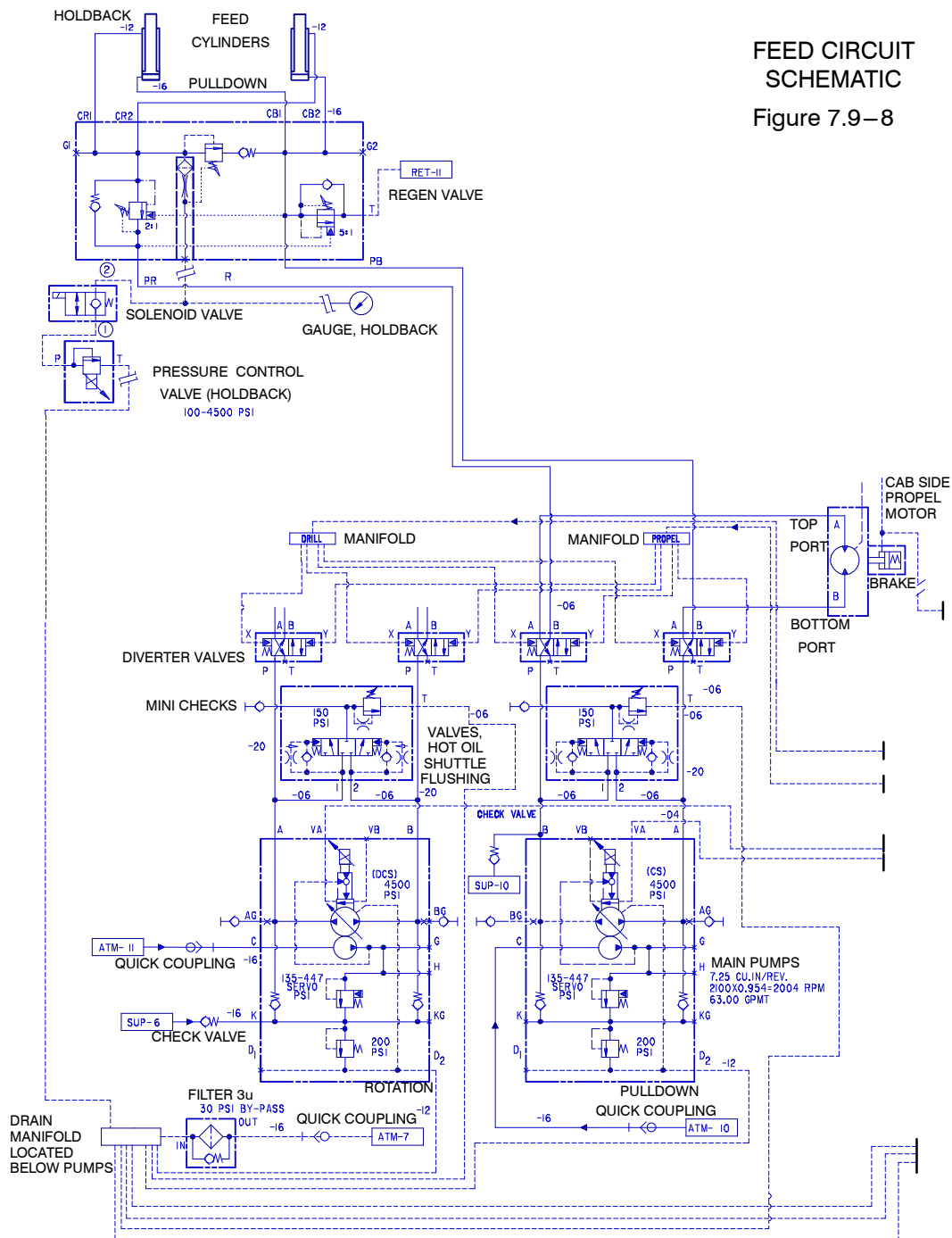
The overcenter circuit that controls pressure at the “CR” ports is illustrated on the left half of the schematic in Figure 7.9–7. When oil flows from the “PR” port to the “CR” ports, the check valve opens and the oil goes around the overcenter valve. When oil is flowing from the “CR” ports to the “PR” port, the overcenter valve provides a flow resistance. The overcenter valve resistance is influenced by the spring setting, the “CR” pressure and the “PB” pressure. The spring setting is always fixed for a particular application, but the “CR” and “PB” pressures change due to influences outside the valve.

The overcenter circuit that controls flow from the “PB” port is represented on the right half of the schematic in Figure 7.9–7. The overcenter valve opening is influenced by its spring setting and by pressures at “PR” and “PB”. The valve is set so that pressure at “PB” alone is not sufficient to cause valve opening. Pressure applied at the “PR” port will open the valve, however, since this pressure acts on a larger area within the valve.

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT

The drill feed circuit is shown in Figure 7.9-8 and continues into Figure 7.9-9. The feed circuit, in conjunction with the overpressure control, contains all pumps, motors, valves, feed cylinders and components needed to form a safe, highly efficient drilling system. See Figure 7.9-5 for the overpressure system.



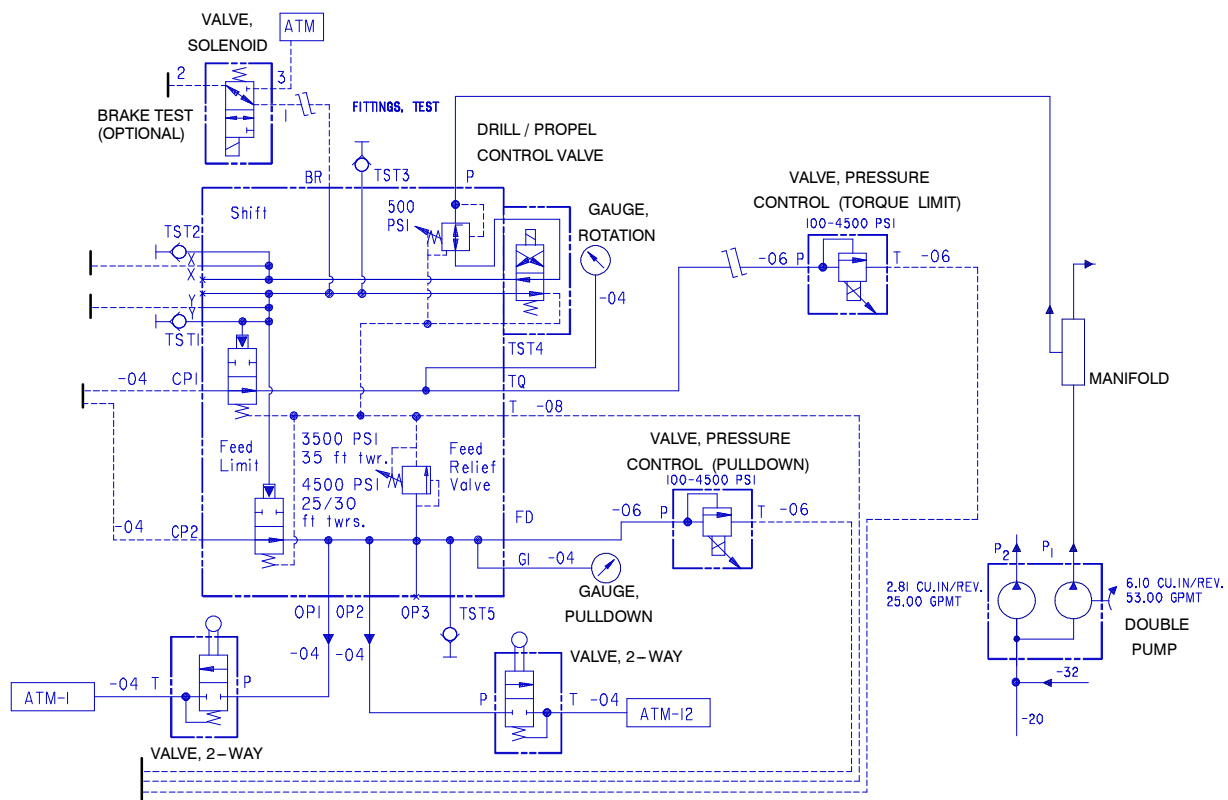
**FEED CIRCUIT
SCHEMATIC**

Figure 7.9-8

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT (continued)

FEED CIRCUIT
SCHEMATIC
Figure 7.9–9



Feed

The Drill Feed circuit uses the cab side Right Pump and the Pulldown Cylinders in a closed-loop circuit. This pump is controlled by moving a proportional electric controller located on the operator's console in the operator's cab. The controller operates the pump stroker to control oil flow. When the pump is destroked (controller in center/off position), no oil flows in the transmission loop and the feed cylinders do not move. If the pump is stroked (either forward or reverse), the cylinder rod moves up or down correspondingly. The speed of cylinder travel is proportional to the amount of main pump flow (amount of controller lever movement).

The main components of the feed system are the main pumps, diverter valves, feed system control valve and feed cylinders. Let's start with the main pumps.

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT (continued)

Main Pumps

The Main Pumps used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of their characteristics and schematic can be found in the Propel Circuit Section of this manual.

Diverter Valve Assembly

The Diverter Valves used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of their characteristics and schematic can be found in the Propel Circuit Section of this manual.

Drill/Propel Mode Selector

The Drill/Propel Mode Selector Switch used for the Drill Feed and Rotation Circuits is also used for the Propel Circuit. A description of it's characteristics and schematic can be found in the Propel Circuit Section of this manual.

Drill/Propel Control Valve

The Drill/Propel Valve used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of it's characteristics and schematic can be found in the Propel Circuit Section of this manual.

Feed Cylinders

The Feed Cylinder and cylinder schematic symbol are shown in Figure 7.9-3.

Closed Loop Feed Control

The use of closed loop hydraulics, in conjunction with typical double acting cylinders, is unique to Drilling Solution products. This is accomplished with the use of the feed system control valve, commonly called the Regen Valve (See Figure 7.9-10).



FEED SYSTEM CONTROL VALVE
"REGEN VALVE"
Figure 7.9-10

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT (continued)

Closed Loop Feed Control (continued)

High pressure drills utilize Regen Valve #57448144. Low pressure drills use #57448136. See *Feed System Control Valves*, in this manual, for a technical explanation of the valves, including their differences and functions.

When drilling with a down hole drill, commonly called “Hammer Drilling”, keeping the correct weight on the bit is critical. Too much weight can cause bit or hammer damage, and poor penetration rate. Too little weight is not good either. It is necessary for the driller to be able to easily control the weight on the bit as the hole depth increases. This is accomplished by the use of a “Holdback” system. This feed system balances the pressures within the feed cylinders to counteract gravity, string weight and pulldown force.

The holdback system allows the driller to control the rod end oil path remotely. This is accomplished by connecting remote controls to the “R” port of the regen valve. See Figure 7.9-11 for “R” port location.

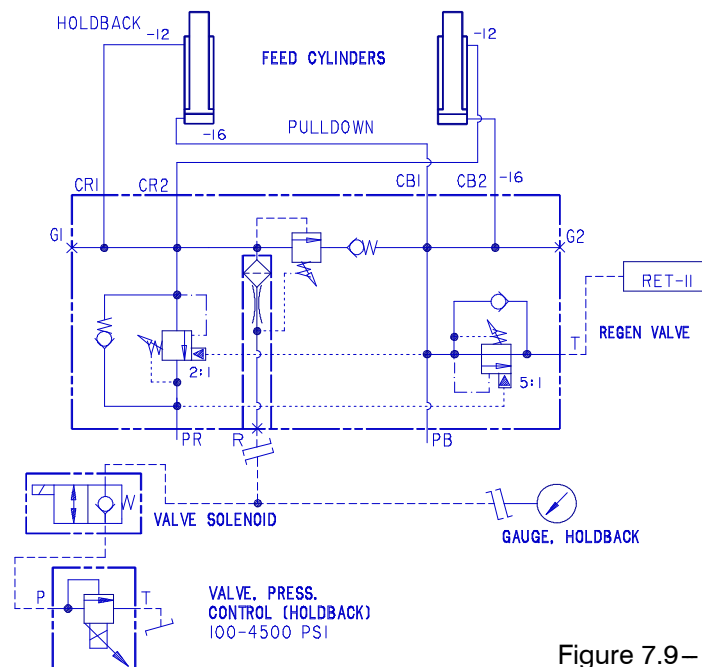


Figure 7.9-11

Much like the pulldown FEMA control system, the operator controls the oil from the feed cylinder through a solenoid operated proportional control valve. As the current to the coil increases, the path is restricted. As the valve closes off the pathway, oil is trapped within the rod end of the feed system. Pressure in the rod end of the cylinder counteracts the string weight. The holdback FEMA control is located on the back of the tower beside the regen valve (**HP drills only**).

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT (continued)

Closed Loop Feed Control (continued)

Note:

Holdback on the drill will not lift the drill string off the bottom of the hole.

It only counteracts gravity and string weight. Adding slight pulldown will overcome the holdback system. This is done in some cases to prevent the bit from bouncing. Do not add too much weight. Weight/100PSI is explained in the *Feed System Control Valves* Section of this manual.

Loop Flushing Circuit

There is a loop flushing circuit in the Drill Feed circuit even though make up oil is allowed into the system via the supercharge inlet on port “B” and excess oil is removed from the system via the regen valve reliefs. When the cylinders are extended, extra make up oil is supplied to the base end by the supercharge system. When the cylinders are retracted, there is less oil required to fill the rod end than coming out of the base end, so the excess oil is diverted to the Return by the two relief valves in the Regen Valve in Figure 7.9–11.

Relief Valves

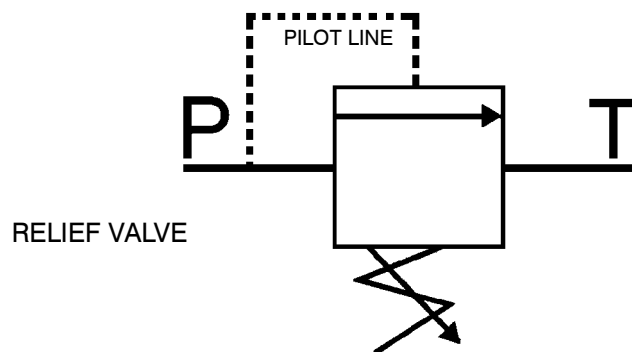


Figure 7.9–12

Two Relief Valves are used in the Drill Feed Circuit together with other controls (See Figure 7–9–8 and Figure 7.9–9). The Relief Valves are the Pulldown and Pullback Reliefs (**High Pressure models only**). The same type valve is used on the Torque Limit Control.

They are schematically shown in Figure 7.9–12. Oil flows from the “P” port to the “T” port when the valve is open. Oil cannot flow from the “T” port to the “P” port. The basic valve symbol is a box with an arrow showing no cross connection of the “P” and “T” ports (normally closed). The symbol arrow (representing the valve spool) is held in the closed position by an adjustable length spring. Inlet oil pressure (dashed pilot line) will open the valve whenever oil force exceeds the spring force.

7.9 - FEED AND ROTATION SYSTEM

FEED CIRCUIT (continued)

Pulldown Relief Valve Adjustment

This valve is frequently adjusted during daily drilling operations. The adjustment is on the operator's console.

If replacement of the Pulldown Relief becomes necessary, set the pressure range of the valve as follows:

1. Position the rotary head at the bottom of the tower against the lower stops.
2. Remove the knob from the adjustment screw.
3. Turn in on the adjustment screw until the pulldown system pressure reaches 4500 psi.
4. Lock the valve adjustment screw jam nut against the valve body.
5. Reinstall the adjustment knob, screwing it completely down against the jam nut.
6. Tighten the knob set screw to hold the knob in place.
7. Screw out on the knob to reduce system pressure.
8. Re-check the pressure setting.

7.9 - FEED AND ROTATION SYSTEM

FEED SYSTEM CONTROL VALVE

The Feed System Control Valve, used on Mid-Range Blasthole drills, controls the operation of a single rod cylinder in a closed hydraulic circuit. It automatically directs oil flow in response to system pressures to allow the feed cylinders to retract and extend in a conventional mode and to extend in a regeneration mode.

The Feed System Control Valve controls 3 feed system functions. The first of these functions is **load holding** (offsetting the weight of the rotary head and the first drill rod). The second function is the **regeneration** of the feed cylinder (to make the cylinder extend quickly). The third function is **removing excess oil** from the base end of the cylinder circuit (when the cylinder is retracting). Each of these functions is explained in detail below.

LOAD HOLDING

Load holding is needed in this application because the system is biased by the weight of the rotary head and drill rod. The holding circuit provides a resistance (hydraulically) to the tendency of the rotary head to fall. Although there is only one valve in the assembly that is called a holding valve, load holding is accomplished by both the “**holding valve**” and the “**sequence valve**”.

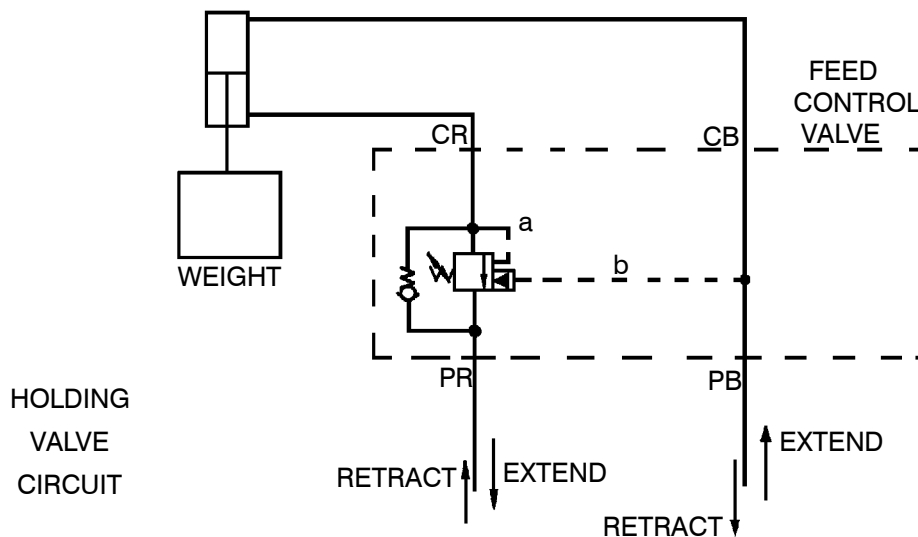


Figure 7.9–13

Holding Valve Circuit

The “holding valve” circuit is shown in Figure 7.9–13. Note that there are two parts to this valve circuit; a check valve (illustrated by the ball and seat symbol) and a counterbalance valve (illustrated by the box and associated spring and pilot symbols).

7.9 - FEED AND ROTATION SYSTEM

Holding Valve Circuit (continued)

During cylinder retract, oil is directed by the pump directly to the PR port in the **feed system control valve** assembly. Oil flows through the check valve to the rod end of the hydraulic cylinder, causing the cylinder to retract.

When the cylinder is not being directed by the pump to move, there is no oil being directed to either side of the circuit. There is, however, a pressure at the CR port. This pressure is generated by the tendency of the hydraulic cylinder to extend under the influence of the external weight as mentioned above. The check valve reacts to this pressure by closing, thus blocking the path for oil to escape in this way. The pressure also acts on the counterbalance section through the pilot line "a". Note that the pressure tries to open the valve and the spring tries to keep the valve closed. If the spring setting exceeds the pressure at "a", the valve will stay closed and the cylinder will not move.

When the cylinder is being directed by the pump to extend, the pilot section of the counterbalance valve (represented by a box and a triangle) influences the opening of the valve. Pressure to the pilot comes from the cylinder side of the circuit through the line marked "b". This pressure works with a 2:1 mechanical advantage against the valve spring. The extend pressure needed to open the valve is:

$$[\text{Spring Setting (psi)} - \text{CR pressure (psi)}] / 2$$

So if the spring setting is 6000 psi and the CR pressure is 1250 psi, the valve will open and the cylinder will begin to move when the extend pressure reaches 2375 psi.

$$[6000 - 1250] / 2 = 2375$$

It is important to keep in mind that this is a simplified example and that actually there are endless combinations of extend and CR pressure that will cause the valve to open. If you were to work out all these possible combinations and plot them all on a graph of extended pressure vs. cylinder force, the results would look like those in Figure 7.9-14. Note that there is no cylinder force (no cylinder movement) until the extend pressure reaches a certain level.

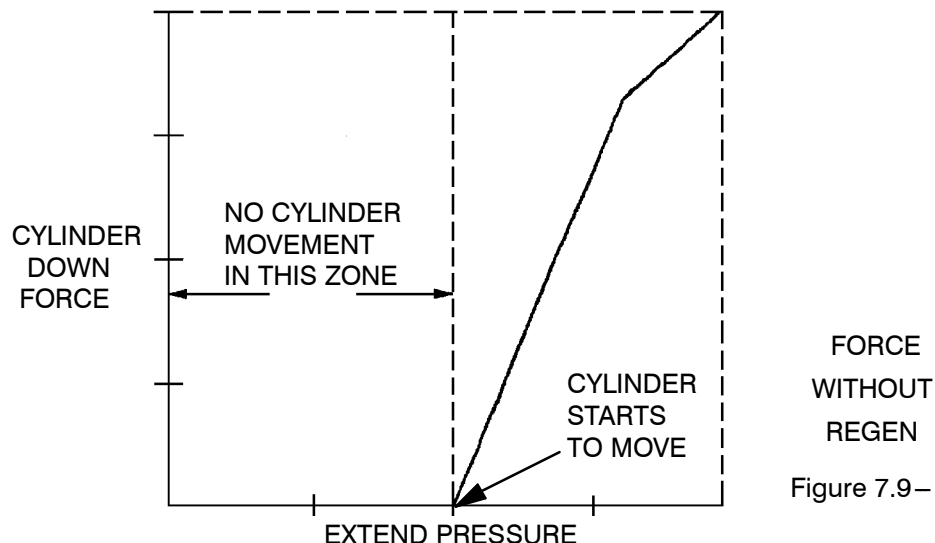
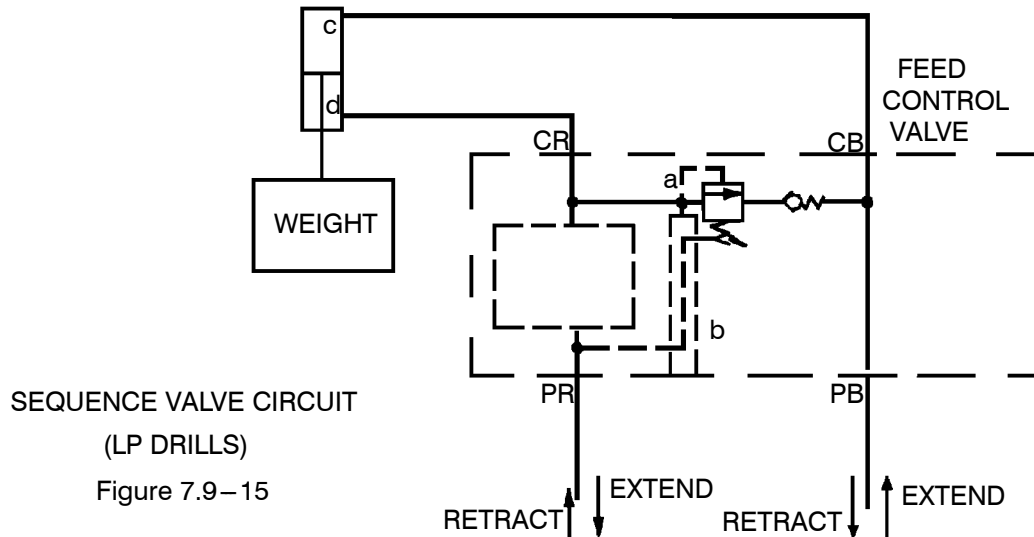


Figure 7.9-14

7.9 - FEED AND ROTATION SYSTEM

Sequence Valve Circuit (LP Drills)



The “sequence valve” circuit for LP (low pressure) drills is shown in Figure 7.9–15. One of the valve parts shown is actually called a sequence valve (the box with associated parts). A check valve is also included in this circuit.

During cylinder retract, oil is directed by the pump to the rod end of the cylinder as explained earlier. The oil acts on the sequence valve in 2 ways: 1) retract pressure at PR port passes through the pilot line “b” to the spring chamber, and 2) retract pressure at the CR port passes through another pilot line “a” and tries to open the valve. During retract, PR pressure is always higher than CR pressure so the spring and pressure difference keeps the sequence valve closed.

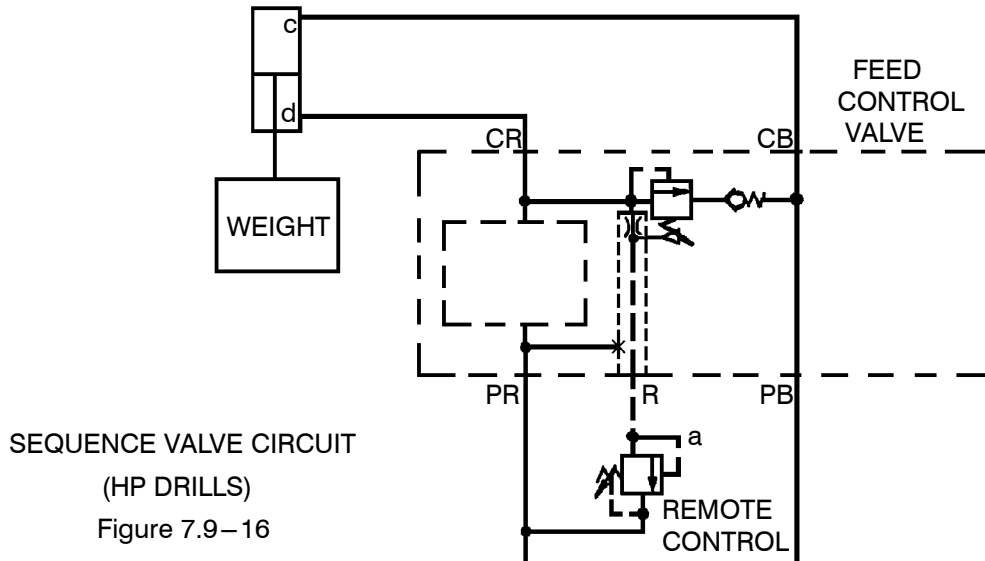
When the cylinder is not being directed to move, there is still pressure at port CR as explained in the previous section. This pressure acts on the sequence valve (through the pilot line “a”) to try to open it. In this case, there is no pressure at PR to help keep the valve closed but as long as the CR pressure does not exceed the spring setting, the valve will stay closed anyway and the cylinder will not move.

When the cylinder is being directed by the pump to extend, the pressure on the cylinder piston “c” begins to increase. The increase in pressure on the cylinder piston causes movement and a corresponding proportional pressure increase in the pressure at “d” and CR. When the pressure at CR has been forced to increase to a level that exceeds the valve spring setting, the valve will open and there will be controlled, continuous movement of the cylinder. The valve will always open at the same extend pressure unless the load changes. Remember that adding or subtracting a drill rod changes weight and therefore changes the extend pressure at which cylinder movement begins.

Beyond the point at which the valve opens, cylinder force is proportional to extend pressure. If this relationship is plotted like the holding valve plot, the results look like those in Figure 7.9–17.

7.9 - FEED AND ROTATION SYSTEM

Sequence Valve Circuit (HP Drills)



The “sequence valve” circuit for HP (high pressure) drills is shown in Figure 7.9-16. Removing a configuration plug from the LP valve assembly and replacing it with a different configuration plug makes the changes required to add remote control capability to the sequence valve. The HP configuration plug makes the following changes to the sequence circuit:

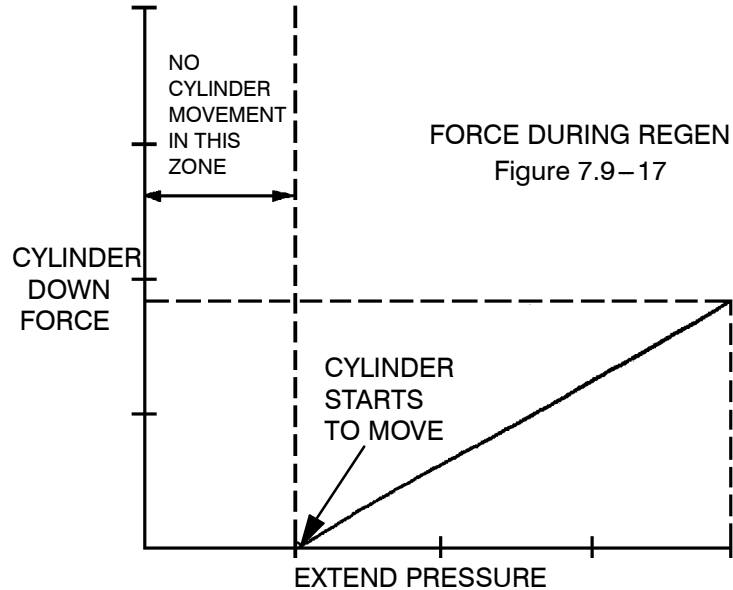
1. Disconnects the sequence valve spring chamber from the assembly PR port.
2. Connects the spring sequence spring chamber to the assembly CR port through an orifice.
3. Provides a remote control port R.

The complete remote control circuit includes a relief valve that is attached between the assembly R port and the PR side of the feed control circuit as shown. The relief valve is mounted in the operator’s cab so that the operator has control over its adjustment.

Oil at the assembly CR port is available to both ends of the sequence valve spool. The oil provided to the spring end of the sequence flows through an orifice and fills the spring chamber and the remote control line all the way to the remote relief valve. As long as the pressure at the inlet of the relief valve is below the relief valve spring setting, the oil in the sequence spring chamber cannot escape. The pressure acting to open the sequence is the same as the pressure acting to close the sequence (in the spring chamber) and the sequence spring keeps the valve closed. If the pressure at the remote relief inlet exceeds the setting of the relief valve, the relief opens and begins to flow oil. The oil flow out of the sequence spring area causes a pressure drop across the orifice. The pressure to open the sequence valve exceeds the closing pressure and the spring force and the sequence opens to allow regen flow.

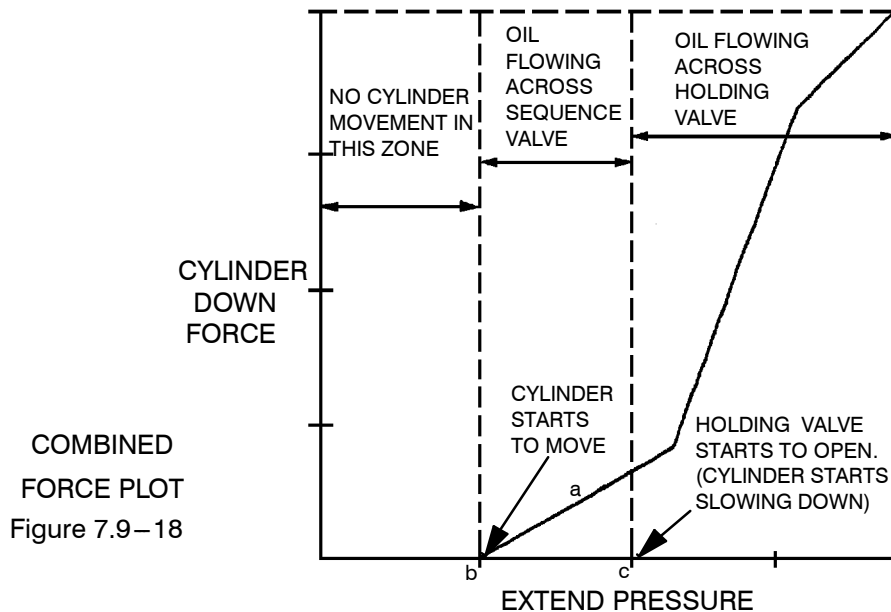
Varying the relief valve setting causes a corresponding change in the pressure at which regen starts and therefore varies the amount of holdback.

7.9 - FEED AND ROTATION SYSTEM



Automatic Holding Selection

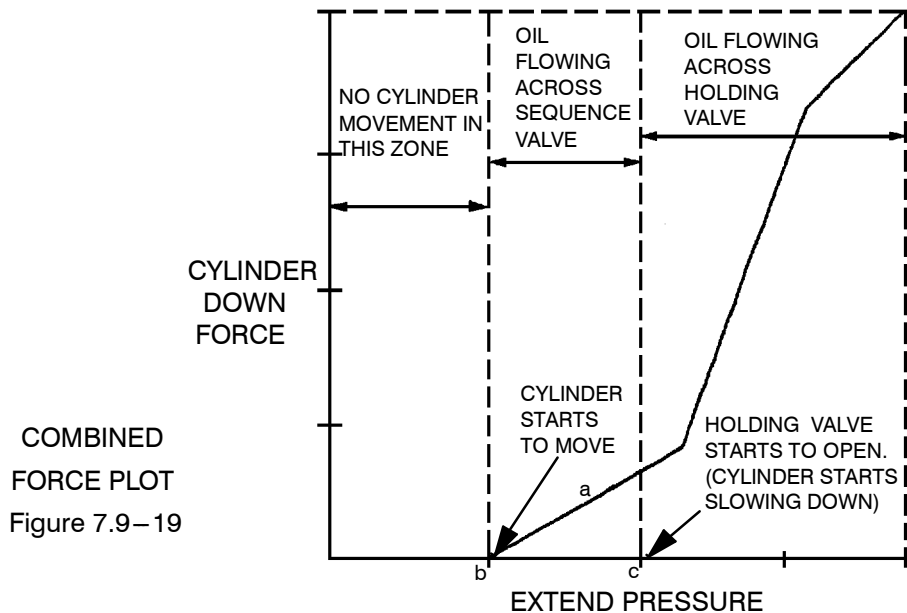
Figure 7.9-18 shows what happens if Figure 7.9-14 and Figure 7.9-17 are combined. The first section “a” of the resulting curve belongs to the sequence valve. The extend pressure at which cylinder movement begins is identified by the “b”. When movement does begin, oil is flowing through the sequence valve, not the holding valve. If feed pressure increases to “c”, some of the oil at CR begins to flow through the holding valve. Note that when the extend pressure is less than “b”, there is no cylinder force and no cylinder movement.



7.9 - FEED AND ROTATION SYSTEM

REGENERATION

Regeneration is a redirection of oil from the cylinder rod end back to the cylinder base end to increase the cylinder extend speed. When the cylinder is in “regen”, the extend speed does increase but the available cylinder force decreases. It is therefore desirable to keep the cylinder out of regen when high forces are needed.



Referring to figure 7.9–19 (Combined Force Plot), it can be seen that there is a certain range of feed pressures that cause oil to flow across the sequence valve. When oil is flowing through this path, the cylinder is in regen. Rod oil is being forced back to the cylinder extend side where it combines with pump flow and causes the cylinder speed to increase.

There is also a certain range of extend pressures that cause oil to flow across the holding valve. Any oil that flows across the holding valve is not available for regen and therefore not available to help the cylinder reach its maximum possible speed. In the case where all the rod end oil is flowing across the holding valve, the cylinder is not in regen.

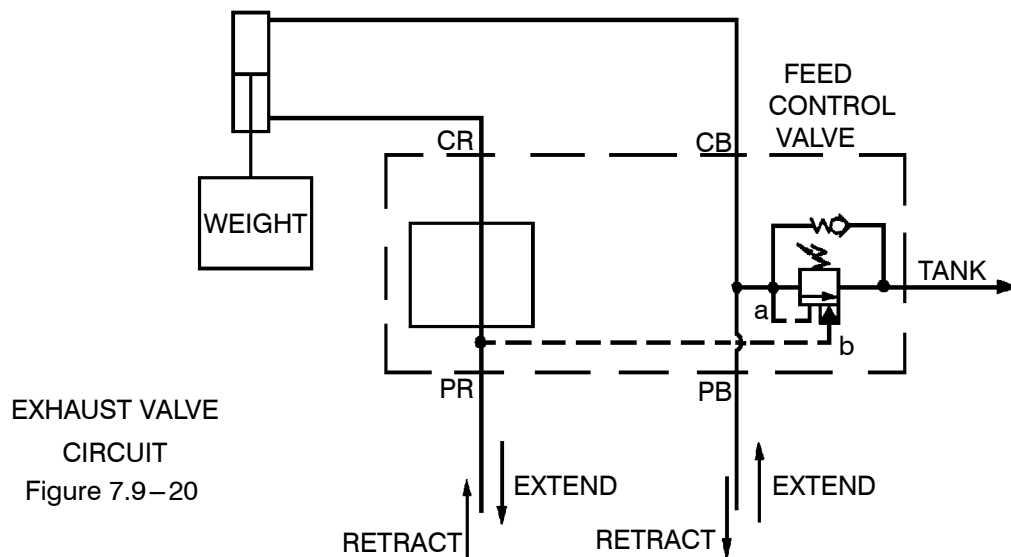
Automatic Regen Selection

The cylinder extend pressure automatically controls the mode of cylinder operation. If there is not much resistance to cylinder movement (generally during rod handling), the extend pressure is low and the cylinder is allowed to be in regen. Maximum extend speed can be reached in this mode. On the other hand, if there is resistance to cylinder movement (as during drilling for example), the valves direct oil out of the regen path and the cylinder speed goes down as the force goes up.

7.9 - FEED AND ROTATION SYSTEM

REMOVING EXCESS OIL

The remaining section of the Feed System Control Valve is the exhaust valve which removes oil from the cylinder extend side when the cylinder is retracting. The excess oil is present during retract because the cylinder extend side holds more oil than the retract side. Refer to Figure 7.9–20 for this circuit.



EXHAUST VALVE
CIRCUIT
Figure 7.9–20

During cylinder extend, oil is directed by the pump to the extend side of the cylinder. Oil is also available to one end of the exhaust valve through the pilot line “a”. Pilot line “b” is connected to the opposite side of the circuit at PR. Because the cylinder is in the extend mode, there is no pressure at PR and therefore no pressure available to “b”. As long as the extend pressure at “a” is less than the spring setting, the valve will remain closed so that oil needed to develop maximum extend force is not lost to tank.

During cylinder retract, oil is directed to the rod end of the cylinder and to the pilot side of the exhaust valve through “b”. The pressure acting on the pilot acts with a 3:1 mechanical advantage against the valve spring.

In addition to this opening influence, there is also an influence at “a” from the pressure in the extend side of the circuit (caused by the oil surplus and the retracting cylinder). When the combination of pressures acting to open the valve (at “a” and “b”) exceeds the spring setting, the valve opens and allows excess oil to bypass the pump and return to the system tank.

7.9 - FEED AND ROTATION SYSTEM

ADJUSTMENT PROCEDURE

1. Install a test gauge in the **Cylinder Feed Pressure Test Port**. Refer to Figure 7.9-21.

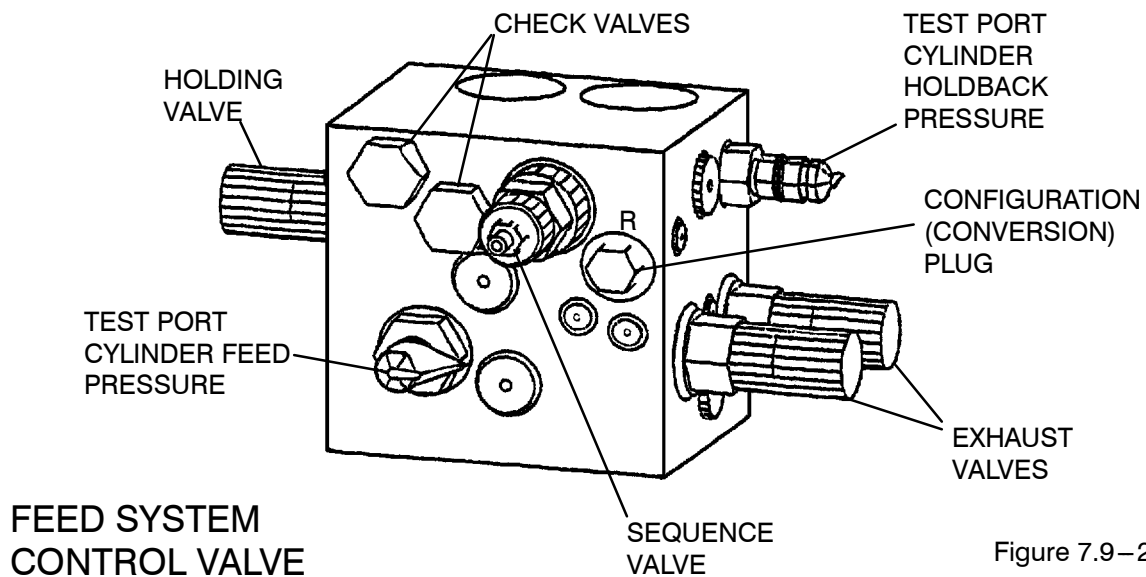


Figure 7.9-21

Low Pressure Drills

2. With the rotary head moving slowly down the tower, adjust the **Sequence Valve** until the test gauge reads 700 psi. Lock the adjustment in place. Adjustment is complete.

High Pressure Drills

For drills equipped with a remote control sequence valve (holdback control).

2. With the engine off and the rotary head at the bottom of tower, screw in the holdback remote control (on the operator's console).
3. Turn the **Sequence Valve** adjustment all the way out (ccw) and lock in place.
4. Turn engine on and move the rotary head to the top of the tower. Then move the feed control lever slightly forward from neutral so the rotary head is moving slowly (between 2 and 10 feet per minute) down the tower. Set the holdback remote control to 700 psi feed pressure. The adjustment is complete.

7.9 - FEED AND ROTATION SYSTEM

ADJUSTMENT CHECK

Low Pressure Drills

With the rotary head moving slowly down the tower (2 to 10 feet per minute), the feed down gauge should read about 700 psi.

High Pressure Drills

High pressure drills are provided with a remote sequence valve adjustment (holdback control) the operator can set from the operator's console. While moving the rotary head slowly down the tower, verify that the feed down gauge reading can be influenced by screwing in and out on the holdback control. Readings between 500 and 1800 psi are typical (depending on the feed down pressure setting).

CONVERSION PROCEDURE

Low pressure and high pressure feed control valve assemblies are alike except for the removeable conversion plug (see Figure 7.9-21) and the sequence cartridge. The conversion plug for an HP assembly has an SAE port "R" in the hex end of the cartridge. A fitting, hose and relief valve attached to this port will allow remote control of the adjustment of the sequence cartridge. The conversion plug for an LP assembly does not have an external "R" port.

To convert an LP assembly to a HP assembly, remove the non-ported conversion plug and replace it with a ported conversion plug. The sequence cartridge must also be changed to the HP version which has a lower adjustment range. Install the assembly on the drill, connect the "R" port and adjust the Sequence Cartridge according to the adjustment procedure in this manual.

To convert an HP assembly to a LP assembly, remove the ported conversion plug and replace it with a non-ported conversion plug. The sequence cartridge must also be changed to the LP version which has a higher adjustment range. LP drills do not have the "R" port control piping. Hook up the other connections and adjust the Sequence Cartridge according to the adjustment procedure in this manual.

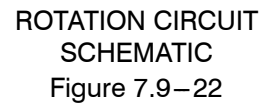
SERVICE PROCEDURE

The feed control valve assembly is designed with replaceable cartridges in a steel manifold. The cartridges can be quickly replaced (in less than 10 minutes) using conventional tools if failures occur. The manifold remains connected to the system so that contamination can be minimized. Complete replacement of the feed control valve assembly is not required or recommended. See the troubleshooting section of this manual for cartridge failure diagnosis help.

7.9 - FEED AND ROTATION SYSTEM

ROTATION CIRCUIT

The primary components of the Rotation Circuit are the Main Pumps, Rotation Motors, Filters, Valves and Controls.



7.9 - FEED AND ROTATION SYSTEM

ROTATION CIRCUIT (continued)

Rotation

The non-cab side main pump (rotation) is controlled by moving a proportional electric controller located on the operator's console in the operator's cab. The controller operates the pump stroker to control oil flow. When the pump is de-stroked (controller in center/off position), no oil flows in the transmission loop and the rotation motors do not turn. If the pump is stroked (either forward or reverse), the rotation motors will turn in one direction or the other. Rotation motor speed is proportional to the amount of main pump flow (amount of controller lever movement).

Motor Displacement Control

Oil must be supplied to the "H" ports on the rotation motors to drive the motor swashplate positioning servo system. Oil for this purpose must be at a lower pressure than that normally found in the loop. The valve that supplies this pressure is the motor control valve.

Oil available at the motor control "REG" port is supplied to the "H" ports on both rotation motors. The oil pressure moves the motor swashplates to the position called for by the mechanical displacement adjustments on each motor. Adjusting the motors for smaller displacements results in higher speed and lower torque.

Main Pumps

The Main Pumps used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of their characteristics and schematic can be found in the Propel Circuit Section of this manual (See Figure 7.8-2).

Diverter Valve Assembly

The Diverter Valves used for the Drill Feed and Rotation Circuits are also used for the Propel Circuit. A description of their characteristics and schematic can be found in the Propel Circuit Section of this manual (See Figure 7.8-5).

Drill/Propel Mode Selector

The Drill/Propel Mode Selector Switch used for the Drill Feed and Rotation Circuits is also used for the Propel Circuit. A description of its characteristics and schematic can be found in the Propel Circuit Section of this manual (See Figure 7.8-6).

Regen/Feed Valve

A description of the characteristics and schematic for the Regenerative Valve can be found under Drill Feed System in this section of this manual.

7.9 - FEED AND ROTATION SYSTEM

ROTATION CIRCUIT (continued)

Drill/Propel Control Valve

Shifting the Drill/Propel Valve to “Drill” drains oil from the Propel Alarm and the “Y” ports of the Diverter valves. This action also pressurizes the “X” ports of the Diverter valves and shifts them into the Drill Mode.

Since both pumps will be operating at different pressures in Drill and Propel, a means of changing the Relief settings had to be found. This was done with the “Pilot-to-Open” Check valves. By allowing flow through the Check valve in the Drill Mode, the Compensator can be adjusted with a remote Relief valve for both Feed and Rotation. Thus, when the Drill/Propel valve is shifted, pilot pressure is applied to the back side of the two Check valves and they are held open. This allows each Compensator to be regulated by the Pulldown Relief valve or the Torque Relief valve, both on the operator’s panel.

Oil Path Selection

The only interruptions in the main loops are the four Diverter Valves (See Figure 7.8-11). The diverter valves are shifted to connect the dist collector side (non cab side) main pump to the rotation motors whenever “Drill” mode is selected. This is done by supplying oil to the “X” ports and venting the “Y” ports on the diverter manifolds. Oil for this purpose is supplied by the fan circuit manifold through the drill/propel control valve assembly.

In the Drill Mode, the Drill/Propel Selector Valve directs oil to the Diverter manifold “X” ports and drains the “Y” ports. At the same time, oil is drained from the propel brakes so that they will lock. In this mode, the Drill/Propel valve also connects the main pump compensator to the rotation gauge and, in some applications, a pressure control valve (**Torque Limit valve for High Pressure drills only**). A point to remember is that with the drill off, the control system defaults to the Drill Mode. This is why the spring in the Diverter is on the “X” port side.

Loop Filling / Replenishment

The oil needed to initially charge each main loop and keep it full is picked up by the main pump charge pump at port “C”. Port “C” connects to the drill suction manifold. The charge pump continuously injects oil into the main loop to make up for normal leakage in the pump, motor and valves, and to make up for the oil being stripped out of the loop by the flushing circuit in the diverter manifold.

Leakage from the main pump is collected in the pump case and returned to the drain manifold by way of the pump “D” port. When the pump is in neutral, the leakage flow from the pump is supplemented by charge flow that comes from the charge relief valve in the pump. Rotation motor leakage is collected in the motor case and it also returns to the drain manifold. Oil pressure in the case must exceed 30 psi to open a check valve in the drain manifold. The purpose of the check valve is to keep the motor cases full of oil at all times.

7.9 - FEED AND ROTATION SYSTEM

ROTATION CIRCUIT (continued)

Torque Limit Control (optional)

To prevent the over-torque of joints and to limit rotational pressure while drilling, a Torque Limit Control Option can be installed. This remote relief valve can limit rotational pressure from maximum down to 100 psi. It is adjustable by the operator.

Drill Feed Pressure

A Remote Relief valve is installed downstream from the Check Valve, on the other pump, so the operator can control the Down Feed pressure on the bit. This Relief valve is adjustable between 100–4500 psi.

Over-Pressure Control

Allowing flow through the Check valve in the Feed Circuit also brings the Over-Pressure Control system into play and reduces the pressure to the Feed Pump to 0 psi if the drilling end Leveling Jacks are not set properly. Either one of the Two-Way Valves can be opened and vent all pressure from the Main Pump to 0 psi. The Leveling Jacks must be set firmly on the ground before the Main Pump comes back on line with operating pressure.

7.9 - FEED AND ROTATION SYSTEM

TROUBLE SHOOTING FEED SYSTEM

Feed System Drifts Down

Is the feed down pressure indicated on the pulldown gauge above 700 psi with the engine on and the pump stroke control in neutral?

Yes

- | The pump is not centering properly or it is not nulled properly. If the pump has mechanical controls, check the linkages and cable for binding. Re-null the pump if required.

No

Is it a High Pressure (HP) drill?

Yes

- | Turn the remote holdback control in the console all the way in. Does it still drift?

| **Yes**

- | | Vent the feed control assembly. Disconnect the remote control hose attached to the feed valve assembly "R" port. Plug the hose and cap the fitting. Start the engine and raise the head slightly off the stops. Does the head still drift?

| | **Yes**

- | | | Vent the feed control assembly. Reconnect the remote control hose. Go to **leak checks**.

| | **No**

- | | Vent the feed control valve assembly. Reconnect the remote control hose. Does the drill console have a separate holdback gauge (in addition to the pulldown pressure gauge)?

| | **Yes**

- | | | Replace the relief cartridge in the holdback remote control valve in the console. Make sure the sealing washer under the nose of the cartridge is in good condition and that it fits properly in the bottom of the cavity. Make sure the cartridge is screwed tightly into the cavity.

| | **No**

- | | If console has only one gauge used for pulldown and holdback, there is a shuttle valve inside console that connects the feed control valve "R" port to the gauge.

- | | Replace this shuttle valve. If head still drifts, replace the relief cartridge in the holdback remote control valve in the console. Make sure the sealing washer under the nose of the cartridge is in good condition and that it fits properly in the bottom of the cavity. Make sure that the cartridge is screwed tightly into the cavity.

7.9 - FEED AND ROTATION SYSTEM

Problem: Feed System Drifts Down (continued)

I **No**

I The setting of the remote holdback in the console is not high enough.
I Increase the holdback setting by screwing in on the adjustment.

No

Turn the sequence valve cartridge adjustment (on feed control valve assembly) all the way in. Count the turns so you can return to the original adjustment later. Does the feed system still drift?

Yes

I Go to leak checks.

No

The setting of the sequence cartridge in feed control valve assembly was not high enough. Return to original setting. Increase the setting in 1/2 turn increments. Check the drift after each adjustment until the drift stops.

Vent Feed Control Valve

The feed control valve assembly is able to hold back drill string and rotary head weight because it traps pressure in the feed cylinder rod end.

Before opening any feed circuit connections, vent any trapped pressure with the following procedure:

Rest the rotary head on the lower tower stops, or rest the drill pipe on the ground or lay the tower down flat. Turn the engine off and vent pressure from the feed control valve assembly "G1" port. Vent by connecting port "G1" to port "G2" with a small jumper hose that fits the test ports. Do not tighten the ends of the hose onto either test fitting until both ends of the looped hose are connected. Give the oil in port "G1" time to drain and then remove the jumper hose and check the pressure at port "G1" with a gauge. When the pressure has drained, re-install the jumper hose. The valve assembly can now be safely serviced.

Leak Checks

Lay the tower down and vent the feed control valve assembly. Disconnect the feed cylinder rod end hoses at the feed control valve and cap off the open fittings on the valve. Plug one of the cylinder hoses and leave the other one open. Slowly raise the tower and watch for feed system drift. Does the head drift?

Yes

I The plugged cylinder is leaking internally. Replace or repair.

No

Lay the tower down and vent the feed control valve assembly. Move the hose plug from the previous cylinder rod end hose to the other cylinder rod end hose. Leave the previous hose open. Raise the tower and watch for feed system drift. Does the head drift?

7.9 - FEED AND ROTATION SYSTEM

Problem: Feed System Drifts Down (continued)

Leak Checks (continued)

Yes

- I The plugged cylinder is leaking internally. Replace or repair.

No

The Sequence Valve, the Isolation Plug or the Counterbalance Valve is leaking. Vent the feed control valve assembly. Remove each of these valve cartridges and check the o-ring seals. Repair or replace any damaged o-rings. (Some cutting or fraying of the backup rings is normal and will not cause leakage). If the head still drifts, replace all three cartridges and readjust the sequence valve according to the adjustment procedure. The cartridges that were removed can be reinserted one at a time into assembly to identify the actual failed cartridge.

Down Feed Pressure

Problem: Feed Down Is Too Slow

Is cab-first propel speed also too slow?

Yes

- I Check the mechanical or electric stroke control to pump. Repair or readjust as required.

No

Check the indicator on the side of the pump opposite the input control. Does the indicator move to the full stroke position when the input control is stroked fully and the rotary head is moving down the tower?

Yes

- I When the pump is at full stroke (down) and the pressure regulator is screwed all the way in, is feed pressure high (greater than 1800 psi)?

I Yes

- I I The sequence valve setting is too high and the oil needed for regen is escaping across the overcenter cartridge. For HP drills (with a remote control in the console), decrease the holdback setting. For LP drills, screw out on the sequence valve adjustment until feed down pressure is about 700–900 psi when the head is feeding slowly down the tower.

I No

- I I The overcenter cartridge is leaking oil needed for regen. Replace the overcenter cartridge.

No

Increase the feed down pressure setting. Does the pump stroke fully now?

7.9 - FEED AND ROTATION SYSTEM

Down Feed Pressure (continued)

Problem: Feed Down Is Too Slow (continued)

Yes

- I Try running with a higher pulldown pressure setting.

No

The pump is de-stroking because a pressure limit has been reached. Check the feed down pressure regulator, no-bump controls and any maximum pressure limiting controls in the console.

Down Feed Pressure Won't Go Up To Maximum Limit

Is pressure during cab-first propel OK?

Yes

- I When in Drill Mode with the pump feed control in the fully stroked (down) position, does the indicator on the other side of the pump indicate that the pump is stroking?

I Yes

- I I Replace the Exhaust Valves (2) in the feed control valve assembly.

I No

- I Check all of the parts attached to the "VA" port of the pump. These include the feed down pressure regulator, the overpressure control valves on the leveling jacks and on some drills a maximum pressure limiting relief valve under console.
- I The pump compensator is being vented by one of these parts.

No

The pump or pump compensator has failed. Repair or replace.

7.10 - AUXILIARY FUNCTION CIRCUIT

AUXILIARY FUNCTIONS

The Auxiliary Function Circuit performs all of the tasks associated with the actual drilling process except Rotation and Drill Feed. Some of these tasks are Tower Raising, Leveling Jack Operation, Water Injection, Dust Collection, Hoisting, Breakout, Oil and Air Cooling.

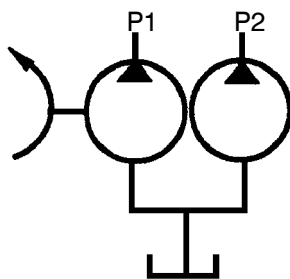
The double pump supplies two valve assemblies: a six (6) spool valve and a nine (9) spool valve. Each section of these valve assemblies control a specific auxiliary function. An explanation of the auxiliary functions is divided into two sections, each corresponding to the valve assemblies and each assembly divided into the valve sections (or spools) and the functions each section of each valve assembly controls. The examination of these circuits will follow a brief discussion of the components found in the Auxiliary Functions Circuit.

Components

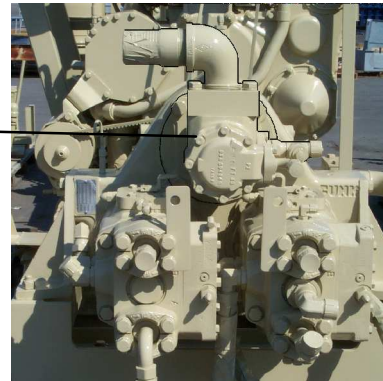
The components of the auxiliary function circuit are the double pump, motors, cylinders, valves, coolers and filters that are required to perform the drilling functions. A review of these components and how they are represented schematically will help to give a clear view of the auxiliary functions.

Double Pump

The double pump is a two section, fixed displacement, vane type pump. The two pumping elements inside the housing have a common inlet and two separate outlets as shown in the schematic in Figure 7.10-1.



DOUBLE PUMP
Figure 7.10-1



The circle contains one triangle, signifying one direction of flow. The first section (Section 1) on each pump is designated schematically as “P1” and the second section (Section 2) of each pump is designated as “P2”. Pump section 1 is capable of delivering more oil than section 2 for a given input shaft speed. The suction for the pump is designated as “S”.

Double Pump Location

The double pump is located in the top position of the three hole pump drive gearbox, above the feed/rotation and propel main pumps.

7.10 - AUXILIARY FUNCTION CIRCUIT

AUXILIARY FUNCTIONS (continued)

P1 Pump Circuit

Oil supply for all of the hydraulic circuits comes from the Hydraulic Reservoir through a Strainer, a Shut-Off Valve and the Suction Pipe. The two sections of the Double Pump pick up oil from a Suction Pipe. Each section of the Double pump supplies a different set of functions.

The P1 section of the Double Pump drives the Oil Cooler Fan Motor and the Engine Radiator Fan Motor. This section also supplies pilot oil for use in the Propel, Drill Feed and Rotation Circuits, and the Rod Support function.

After P1 oil has been used to drive the motors, it passes through the Oil Cooler and the system filters and is then supplied to the Supercharge Manifold for use in other circuits.

P2 Pump Circuit

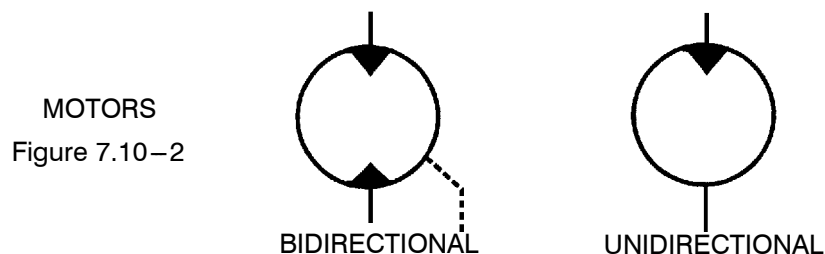
The P2 section of the Double Pump supplies the flow requirements for the rest of the drill systems. Oil flow from the pump is fed into the Six-Spool Valve (See Schematic in Figure 7.10–10 for more information).

P2 Circuit oil, when not used by the Six-Spool Valve, is supplied to the Nine-Spool Valve through the Six-Spool Valve. (See 9-Spool Valve Schematic in Figure 7.10–15).

All of the oil in the P2 circuit mixes with Return Manifold oil and enters the system Main Filters, where it is directed to the Supercharge Circuit for use in the Drill Feed, Rotation and Propel circuits.

Motors

Representative Motor symbols are shown in Figure 7.10–2. The circle may contain one triangle pointed inward from one work port (unidirectional) or a triangle pointed inward from both ports (bidirectional). Both motors shown are fixed displacement.



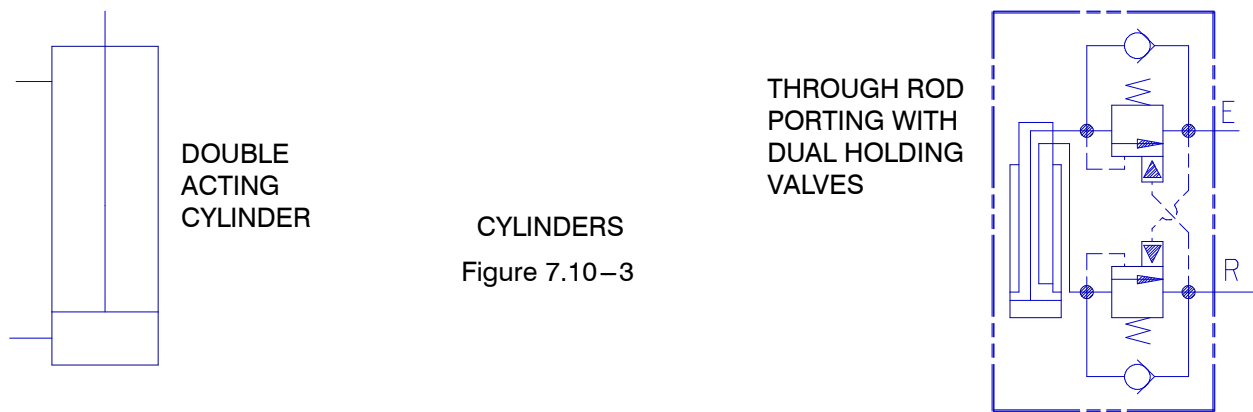
This means that speed may only be changed by changing the motor supply flow. Dotted lines leaving the circle show that the motor case leakage is taken away from the motor externally.

7.10 - AUXILIARY FUNCTION CIRCUIT

AUXILIARY FUNCTIONS (continued)

Cylinders

Representative Cylinder symbols are shown in Figure 7.10-3. These are all double acting, single rod cylinders. “Double-Acting” means that the cylinder can be powered by the hydraulic system to extend and to retract. “Single-Rod” means that the cylinder only has one rod extending out of one end of the cylinder tube.



The Cylinder symbol on the right (Figure 7.10-3) shows a different porting arrangement (through the rod porting) and an integral valve arrangement. The valve section is a dual Overcenter Valve circuit which effectively locks the cylinder. (See Figure 7.9-6 in the Feed and Rotation Circuit section of this manual for the description of the operation of an Overcenter Valve). The valves are preset at the factory to open at 4000 psi relief pressure.

Relief Valves

Relief Valves are used in many locations in the Auxiliary function Circuit. A representative Relief Valve symbol is shown in figure 7.10-4.

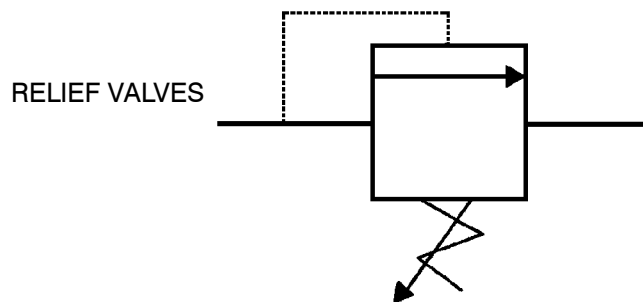


Figure 7.10-4

The basic valve envelope (box) contains an arrow in the normally closed position. The adjustable length spring holds the valve spool in the closed position until inlet pressure overcomes the spring force. The valve opens and closes as required to limit the maximum pressure at its inlet.

7.10 - AUXILIARY FUNCTION CIRCUIT

AUXILIARY FUNCTIONS (continued)

Restrictor Valves

Bypass type Restrictor Valves allow a restricted flow to the work load and divert any excess oil to the valve bypass port.

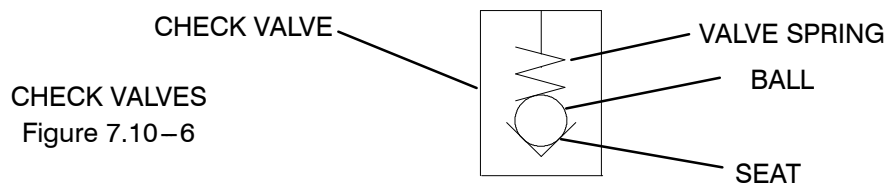


Figure 7.10–5

The Water Injection Regulator is an example of this type of valve. The Restrictor Valve symbol is shown in Figure 7.10–5.

Check Valves

The Check Valve (Figure 7.10–6) is a one-way valve of the hydraulic circuit. Flow into the spring end of the valve forces the ball into its seat to block fluid flow (blocked flow direction). Flow into the seat end of the valve pushes the ball out of its seat to permit fluid flow (free flow direction). The check valve spring is typically preloaded at the factory to provide a preset, nonadjustable valve opening pressure in the free flow direction.



Two Way Valve

The Two Way Valve (Figure 7.10–7) has a closed position and an open position that can be activated by a plunger.

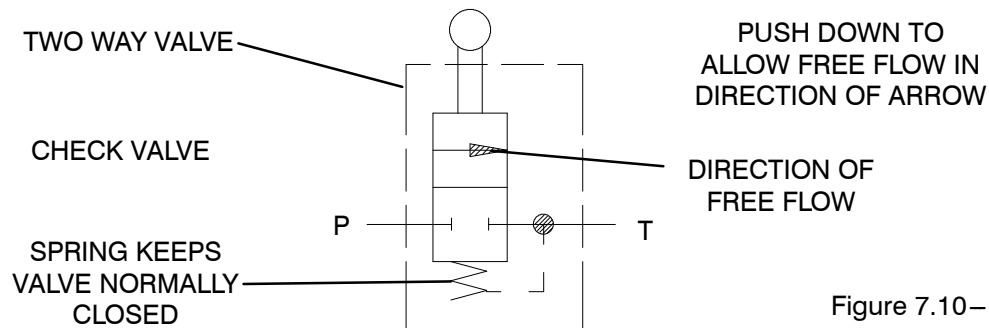


Figure 7.10–7

In the normal position, the valve spring holds the valve closed so that oil cannot flow from the “P” to the “T” port. When the plunger is pressed, however, the valve shifts and free flow is allowed.

7.10 - AUXILIARY FUNCTION CIRCUIT

AUXILIARY FUNCTIONS (continued)

Holding Valves

Holding Valves are used throughout the auxiliary functions circuit to keep motors and cylinders locked and to provide smooth load movement. Holding Valves are represented schematically below in Figure 7.10-8.

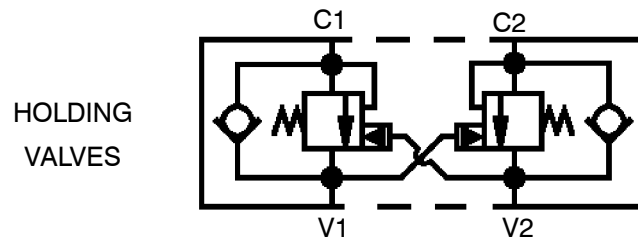


Figure 7.10-8

The Holding Valve is a pressure control device that receives pilot signals from the actuation pressure as well as the return pressure. When the influence of both signals is sufficient to overcome the valve spring setting, the valve opens to allow controlled flow. The valve is also capable of providing protection against accidentally dropping a load. The valve is usually set for an opening pressure higher than that which can be generated by the load alone so that, if actuation pressure is lost, the valve closes.

Pilot Check Valves

The Pilot Check Valve is shown schematically below in Figure 7.10-9.

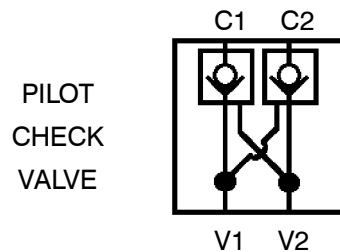
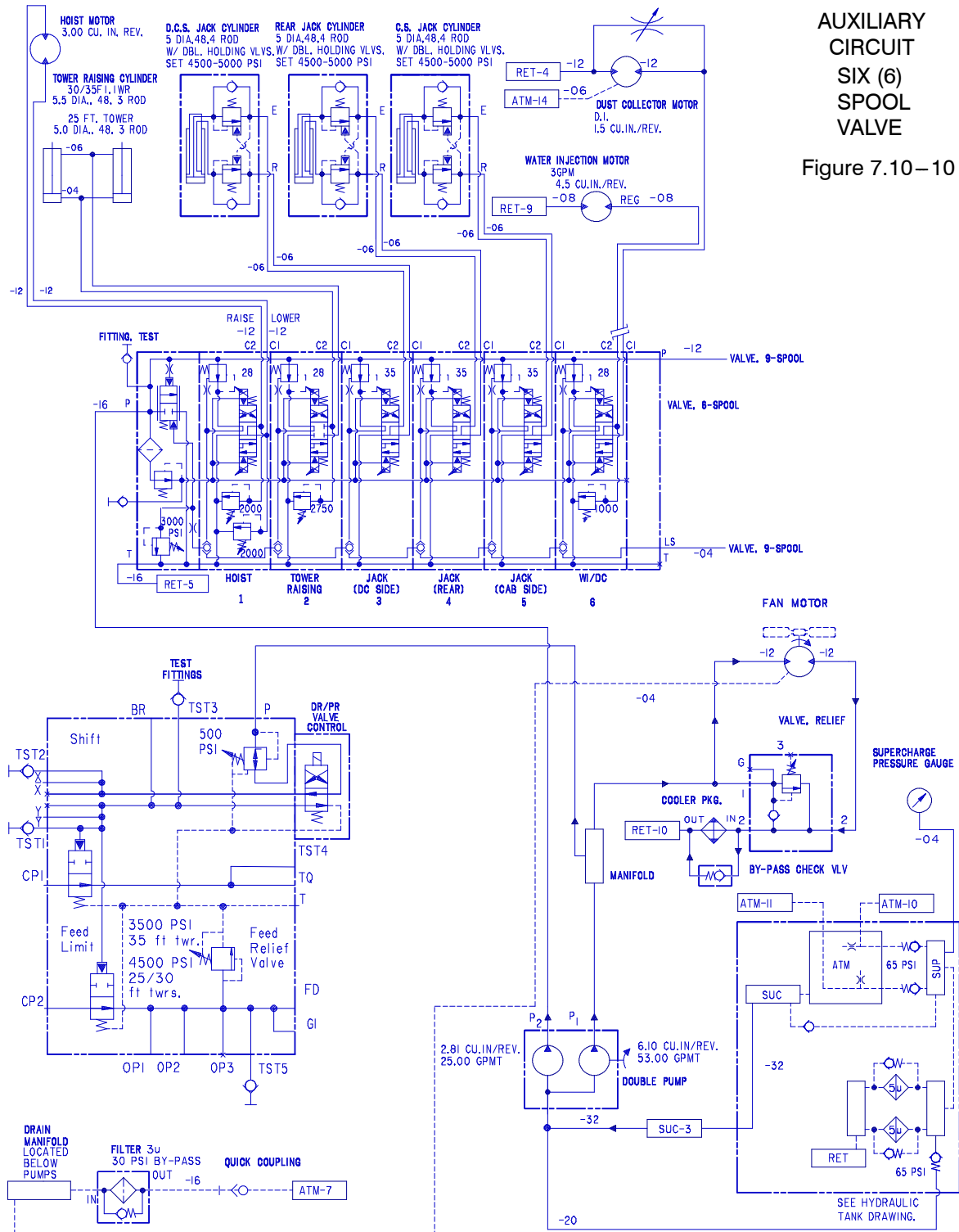


Figure 7.10-9

The Pilot Check Valve is another type of holding valve used for locking hydraulic components in place. The valve works like a check valve in one flow direction and locks in the reverse flow direction. In the reverse flow direction, the valve can be piloted open to allow reverse flow. Once the valve has been piloted opened, oil flows with very little restriction.

7.10 - AUXILIARY FUNCTION CIRCUIT

6-SPOOL VALVE



7.10 - AUXILIARY FUNCTION CIRCUIT

6-SPOOL VALVE (continued)

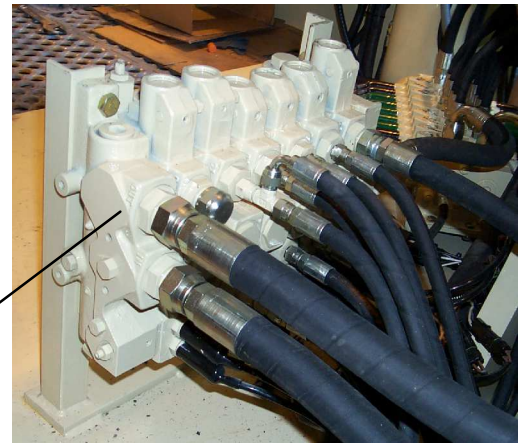
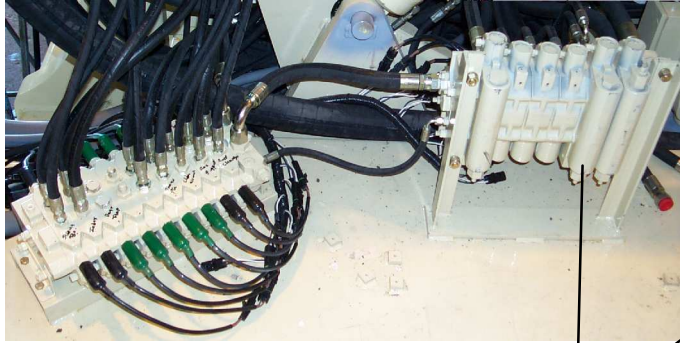


Figure 7.10–11

SIX-SPOOL
VALVE

The 6-Spool Valve is an assembly made up of six individual 4-way valves with a common inlet and outlet. The 4-way valves are electrically operated, closed centered, proportional valves with load sensing capabilities and pressure compensation. Three of the sections have individual port relief valves. The inlet section for the valve assembly contains an unloading valve, a relief valve, and a reducing valve and filter for supplying pilot oil to the 4-way valve sections. The 6-Spool Valve assembly is shown schematically below (Figure 7.10–12).

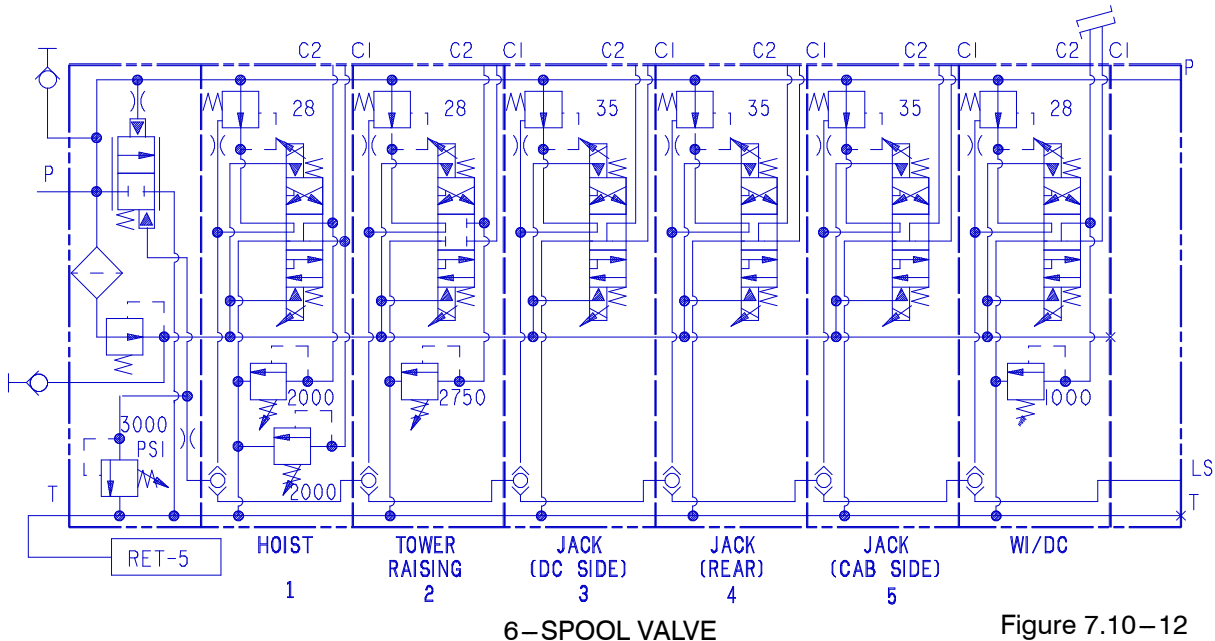


Figure 7.10–12

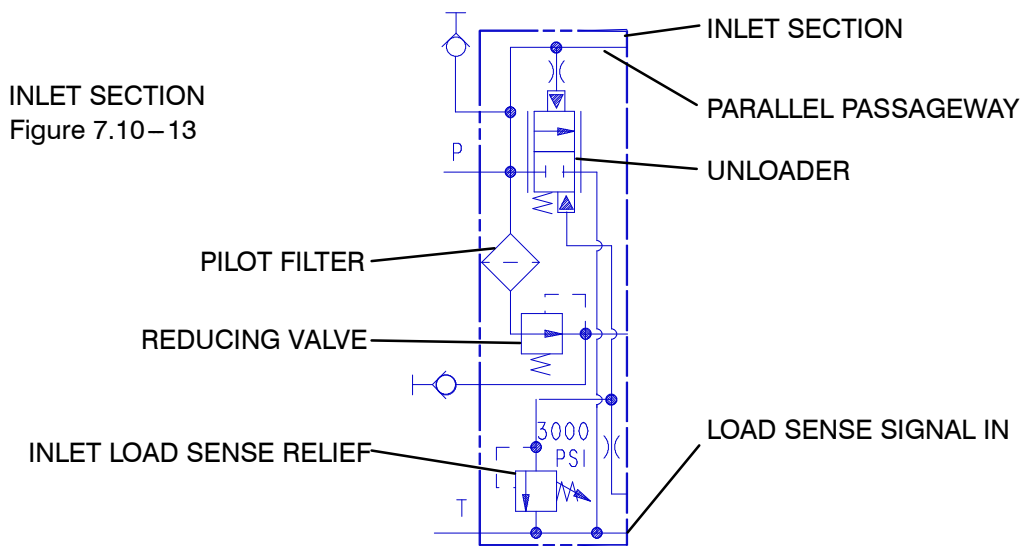
Oil enters the inlet section (shown schematically in Figure 7.10–13) at the “P” port. Oil can exit the section through the “parallel” passageway at the top right corner of the section schematic or through the “unloader” to the section “T” port. When the parallel passageway is blocked, all of the oil flow must exit through the unloader. The total oil flow can also be proportioned by the unloader so that some flow goes in each direction.

7.10 - AUXILIARY FUNCTION CIRCUIT

6-SPOOL VALVE (continued)

The inlet section unloader (Figure 7.10–13) receives signals from the parallel passageway and from a “load sense” signal from the 4-way valves. The pressure in the “parallel” passageway must be 200 psi higher than the “load sense” pressure in order to open the unloader. With no “load sense” pressure, the unloader closes and routes oil to the “parallel” passageway where it can be used by the 4-way valve sections. When a “load sense” signal is received back from the valve sections, the unloader will throttle the oil flow between the two exits to keep the “parallel” passageway pressure 200 psi higher than the pressure being called for by the valve sections.

The inlet relief provides a way to control the maximum allowed “load sense” signal and therefore the maximum valve working pressure. When the “load sense” signal rises to the relief setting, the relief opens to keep the signal from going any higher. The unloader will allow the “parallel” passageway pressure to exceed this setting by 200 psi.



The pilot filter and reducing valve in the inlet section provide a reduced working pressure for the proportional electric controls on the individual 4-way valve sections. The operating pressure provided by the reducing valve is 200–220 psi.

The 6-Spool Valve 4-way valve sections are all similar and are represented schematically in Figure 7.10–14.

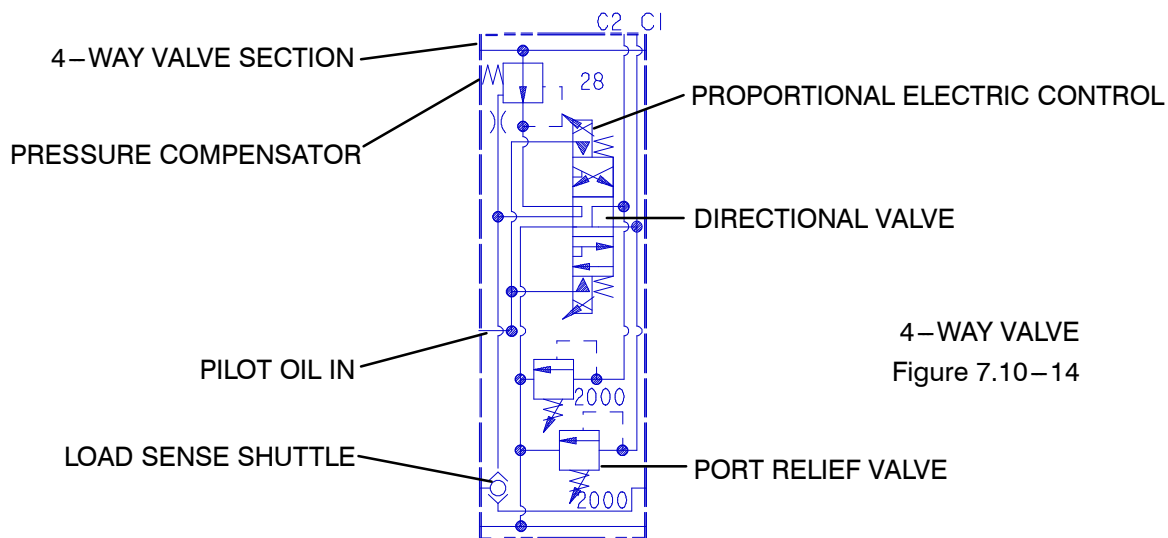
The parts of the 4-way valve are the pressure compensator (represented by the box symbol at the top left corner), the directional valve (represented as a 3-position closed-center 4-way valve), the individual port relief valves, and the “load sense” shuttle valve (Refer to Figure 7.10–14).

7.10 - AUXILIARY FUNCTION CIRCUIT

6-SPOOL VALVE (continued)

The pressure compensator (Figure 7.10-14) is the device that determines how much oil the directional valve will get. The compensator receives one pressure signal from the oil that it discharges. This signal attempts to keep the compensator open so that oil can flow freely. When the directional valve is shifted, the compensator receives a second signal from whichever work port is receiving the flow. This signal indicates the working pressure needed to move the working load and this pressure (and a spring) try to close the compensator. The compensator will throttle the oil flow in response to the two pressure signals to supply precisely the amount of oil the directional valve needs to operate. If the pressure in the parallel passageway happens to be higher than what the load requires, the compensator will maintain whatever pressure drop is required to keep the directional valve at the proper operating pressure.

The directional valve (Figure 7.10-14) is normally held in its center (closed) position by springs. It is shifted by applying electric current signals to proportional electro-hydraulic pressure controls on the ends of the valve. The pressure controls receive pilot oil from the inlet section. When the pressure control receives an electric signal, it proportions pilot pressure to a level proportional to the electric signal. The resulting pressure pushes the valve spool against its centering springs. The amount of movement, and therefore the amount of flow, is proportional to the positioning pressure.



The maximum flow available from a particular directional valve section is indicated by a number near the pressure compensator symbol (Figure 7.10-14). Each spool is intended for a particular function and maximum flow needed is selected accordingly. Each spool is also equipped with flow limiters which are used only on the dust collector section. The port relief valves are responsible for limiting work port operating pressure at design levels. When work port pressure reaches the valve setting, the valve opens and oil flows to the valve section return passageway.

7.10 - AUXILIARY FUNCTION CIRCUIT

6-SPOOL VALVE (continued)

A “load sense” shuttle is in each of the valve sections (Figure 7.10-14). The shuttle determines whether or not the highest pressure from downstream is higher than the pressure within its section. It passes its selection to the next section upstream. Ultimately the highest working pressure (the “load sense” pressure) reaches the 6-Spool Valve inlet where it can be used by the inlet unloader. Oil that is returned from the individual valve sections leaves the 6-Spool Valve through the “T” port and returns to the return manifold.

6-Spool Valve Sections

1. First Valve Section

The first valve section controls the Hoist Motor

2. Second Valve Section

The second valve section controls the Tower Raising Cylinders.

3. Third Valve Section

The third valve section controls the Leveling Jack on the Dust Collector Side of the drill.

4. Fourth Valve Section

The fourth valve section controls the Rear Leveling Jack on the Non-Drilling End of the drill.

5. Fifth Valve Section

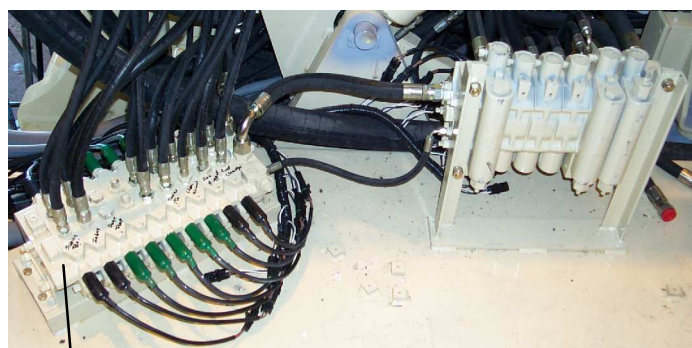
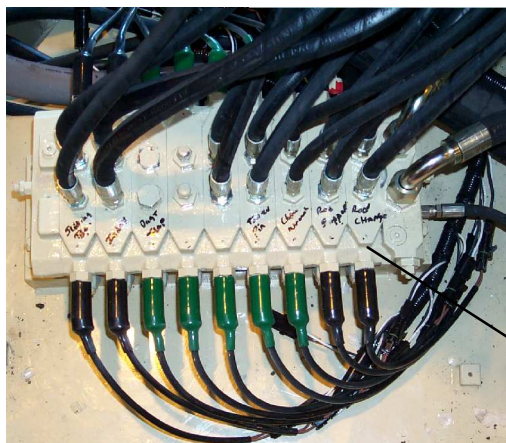
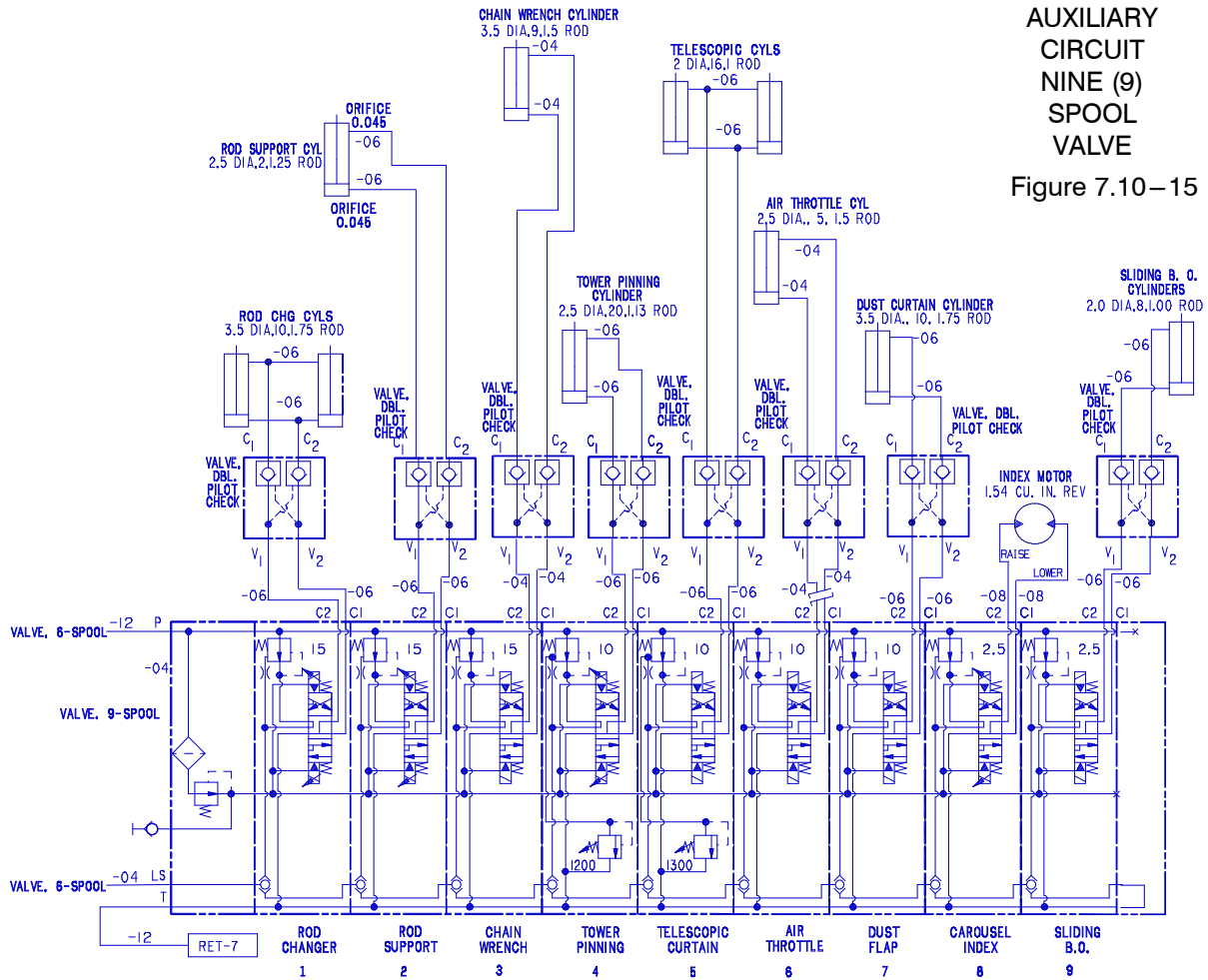
The fifth valve section controls the Leveling Jack on the Cab Side of the drill.

6. Sixth Valve Section

The sixth valve section controls the Dust Collector Motor and the Water Injection Motor. These circuits are plumbed differently in that the return oil from both motors does not return to the valve “T” port. This allows one motor to be controlled by feeding oil to the “A” port and the other motor to be controlled by feeding oil to the “B” port. Return oil from both motors is routed back to the Return Manifold.

7.10 - AUXILIARY FUNCTION CIRCUIT

9-SPOOL VALVE



NINE-SPOOL
VALVE

Figure 7.10–16

7.10 - AUXILIARY FUNCTION CIRCUIT

9-SPOOL VALVE (continued)

The 9-Spool Valve schematic is shown in Figure 7.10-15. The 9-Spool Valve operates like the 6-Spool, but it does not have an inlet unloader or an inlet relief valve. The highest load sense signal within the assembly is used by the 6-Spool Valve unloader which keeps operating pressure within both assemblies below 3000 psi. Another difference is that the pressure limiting components in the 9-Spool Valve sections are not port reliefs. The “common pressure limiters” in some of the 9-Spool Valve sections regulate the section “load sense” pressure and a single device controls both work ports within a section. Like the 6-Spool Valve, the 9-Spool Valve inlet has a pilot filter and reducing valve to supply its electro-hydraulic controls.

P2 Pump Circuit

The P2 section of the Double Pump supplies the flow requirements for the rest of the drill systems. Oil flow from the pump is fed into the Six-Spool Valve (See Schematic in Figure 7.10-10 for more information).

P2 Circuit oil, when not used by the Six-Spool Valve, is supplied to the Nine-Spool Valve through the Six-Spool Valve. (See 9-Spool Valve Schematic in Figure 7.10-15).

All of the oil in the P2 circuit mixes with Return Manifold oil and enters the system Main Filters, where it is directed to the Supercharge Circuit for use in the Drill Feed, Rotation and Propel circuits.

Circuit Operation

The oil supplied to the 6-Spool and 9-Spool valves is used by the valve circuits to do cylinder and motor operation functions.

The spool valves are pressure compensated, load-sense components. They operate differently from conventional spool valves in that the working pressure for the pumps is not determined by the lowest load. In a conventional system, oil flow to a highly loaded motor or cylinder can be interrupted by operating another spool that has a lower flow resistance. The load sense valves, on the other hand, will attempt to satisfy the requirements of both heavy loads and light loads at the same time. It does this by restricting flow to the light load, with a spool pressure compensator, to make up the difference in working pressures. The only time the valve assembly fails to satisfy all loads is when the total flow being demanded by all actuated spools exceeds the available pump flow.

Oil is used in the valves and returned to the return manifold. The individual valve spools are actuated by proportional or on/off electric controls controlled by the operator. The proportional controls allow precise positioning of the valve spools and they also allow the maximum flow from the individual spools to be limited with a maximum current adjustment.

7.10 - AUXILIARY FUNCTION CIRCUIT

9-SPOOL VALVE (continued)

9-Spool Valve Sections

1. First Valve Section

The first valve section controls the Rod Changer Cylinders.

2. Second Valve Section

The second valve section controls the Rod Support Cylinder.

3. Third Valve Section

The Chain Wrench Cylinder is supplied by the third valve section.

4. Fourth Valve Section

The fourth valve section controls the Tower Pinning Cylinder.

5. Fifth Valve Section

The fifth valve section controls the Telescopic Dust Curtain Cylinders.

6. Sixth Valve Section

The sixth valve section controls the Air Throttle Cylinder.

7. Seventh Valve Section

The seventh valve section controls the Dust Flap (Curtain) Cylinder.

8. Eighth Valve Section

The eighth valve section controls the Carousel Index Motor.

9. Ninth Valve Section

The ninth valve section controls the Sliding Breakout Cylinder.

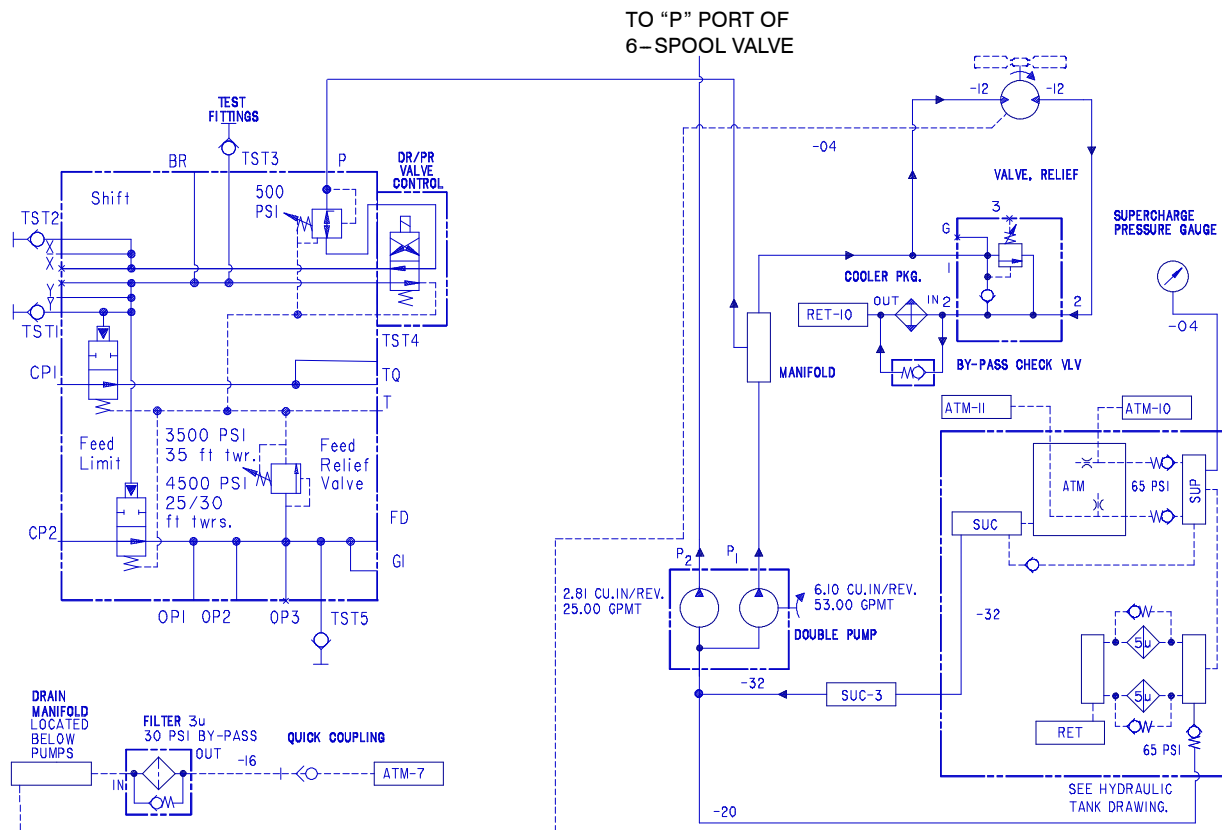
7.10 - AUXILIARY FUNCTION CIRCUIT

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7.11 - COOLING CIRCUIT

COOLING CIRCUIT

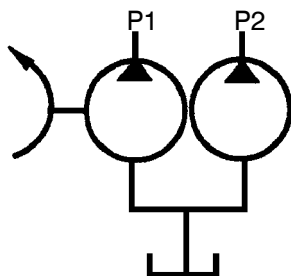
The purpose of the cooling circuit is to remove heat from the hydraulic and engine coolant circuits on the drill. The cooling circuit accomplishes this with a set of fin and tube heat exchangers, also called radiators. Heat is transferred from the liquids in the tube side to the fins, and on to the atmosphere.



COOLING CIRCUIT

Figure 7.11 – 1

Oil supply for all of the DM45/50 hydraulic circuits comes from the Hydraulic Reservoir through a Strainer, a Shut-Off Valve and the Suction Pipe. The two sections of the Double Pump pick up oil from a Suction Pipe. Each section of the Double pump supplies a different set of functions.



DOUBLE PUMP

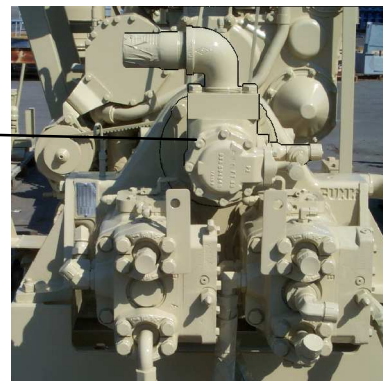


Figure 7.11 – 2

7.11 - COOLING CIRCUIT

COOLING CIRCUIT (continued)

Double Pump

The double pump is a two section, fixed displacement, vane type pump. The two pumping elements inside the housing have a common inlet and two separate outlets as shown in the schematic in Figure 7.11-2.

The circle contains one triangle, signifying one direction of flow. The first section (Section 1) on each pump is designated schematically as “P1” and the second section (Section 2) of each pump is designated as “P2”. Pump section 1 is capable of delivering more oil than section 2 for a given input shaft speed. The suction for the pump is designated as “S”.

The Auxiliary Function Circuit performs all of the tasks associated with the actual drilling process except Rotation and Drill Feed. These tasks include Oil and Air Cooling.

P1 Pump Circuit

The P1 section of the Double Pump drives the Oil Cooler Fan Motor and the Engine Radiator Fan Motor. This section also supplies pilot oil for use in the Propel, Drill Feed and Rotation Circuits, and the Rod Support function. The maximum working pressure of these circuits is determined by Fan Speed. A Relief Valve mounted on the side of the Cooler is used to regulate the Fan Speed. Oil that is bypassed by this valve is directed through the Main Filters to the Supercharge Manifold.

After P1 oil has been used to drive the motors, it passes through the Oil Cooler and the system filters and is then supplied to the Supercharge Manifold for use in other circuits.

P2 Pump Circuit

The P2 section of the Double Pump supplies the flow requirements for the rest of the drill systems. Oil that does occasionally flow over the Relief Valve mixes with oil being returned from any of the extending or retracting cylinders and is returned to a return manifold.

Fans

All new Drills have 54 inch (1372 mm) Fan Blades with the new style cooler. This allows slower Fan Speeds with a resulting decrease in noise. New Drills have been modified to use a 65 psi Check Valve in place of the Amot valve. Some oil can pass through the cooler at startup, allowing a faster warmup time. The Fan Speed Relief valve has been changed to incorporate a coast down check valve within the valve. This means the motors will not cavitate during shutdown.

7.11 - COOLING CIRCUIT

COOLING CIRCUIT (continued)

Cooling Package

STACKED COOLER PACKAGE



(CURRENT PRODUCTION)
SIDE-BY-SIDE COOLER PACKAGE



COOLER PACKAGE

Figure 7.11-3

The standard cooling package used on the mid-range drills is the side-by-side cooler package. The cooling package is determined by the size of the engine and compressor that is used (See Figure 7.11-3).

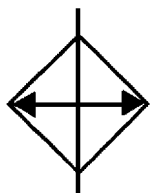
A side-by-side cooler package can have an engine water cooler, engine aftercooler, compressor oil cooler, hydraulic oil cooler and an air conditioner core.

As a comparison, a stacked cooler package will have the radiator, compressor oil cooler and hydraulic oil cooler “stacked” in a row, with the possible addition of an air conditioner core added on.

Fan Motor Relief Valve

The Fan Motor Relief Valve is adjusted to control fan speed. To adjust, measure the fan speed with an appropriate photo or strobe tach. Screw in on the adjustment to increase speed. Screw out on the adjustment to decrease motor speed. (Make adjustments with system oil at normal operating temperature).

Hydraulic Oil Cooler



HYDRAULIC OIL COOLER

Figure 7.11-4

The Hydraulic Oil Cooler, which is part of the cooler package, can be found on the cooling circuit schematic is shown in Figure 7.11-1. The cooler is equipped with a bypass valve to divert oil around the core when the oil is cold. The oil pressure in this condition will be higher than normal. As oil temperature reaches its normal operating range, the bypass valve closes and forces oil to go through the core.

7.11 - COOLING CIRCUIT

COOLING CIRCUIT (continued)

Filters

There are two system return hydraulic oil filters and one case drain filter on the drill.

The system main return filters are located on the rear face of the hydraulic tank (See Figure 7.11–5). All oil from the return manifold is directed through these filters before it is returned to the system reservoir supercharge manifold. The supercharge of 65 psi provides supply to the piston pumps and minimizes cavitation problems.

The case drain filter is located on the drill tower support and filters case drain oil prior to return into the hydraulic tank (See Figure 7.11–5).

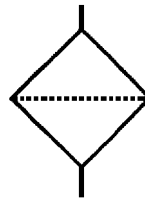
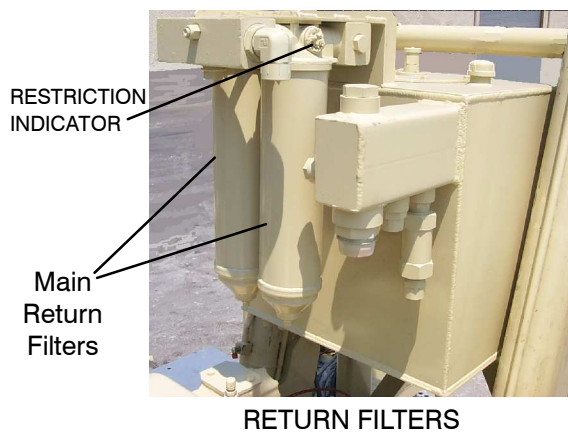


Figure 7.11–5



The Oil Filters clean the oil used by the Main Pumps and Motors. Each filter incorporates a Bypass Check Valve to protect against rupturing the element or housing if the filter becomes plugged.

The Filter is represented schematically by a square, tipped on one corner with the inlet and outlet connected to the two opposite corners and a dashed line connecting the two remaining corners (See Figure 7.11–5). Oil flows into the filter through the inlet port and leaves through the outlet port. Contamination is captured by the porous element within the housing. An additional feature is the Visual Indicator used to signal a “clogged” element.

Supercharge Circuit

The Supercharge circuit gets its oil from the P1 and P2 sections of the Double Pump, the Water Injection Motor Return and Regulator Valve bypass port.

7.12 - ELECTRO•HYDRAULIC SYSTEM

OVERVIEW

The primary function of the Electro-Hydraulic Controls (EHC's) used on the Mid-Range Series Drills is to provide a link between operator command and valve or pump operation. The EHC's are like the manual controls used on other machines in that they translate commands from the machine operator into movement of the valve spools or pump swashplates. They differ from manual controls however, in that the link is not direct. Before the operator commands reach the valve spool or pump servo, they have been:

- a.) Translated into an electrical signal
- b.) Transmitted through a wire
- c.) Translated into a hydraulic pressure.

It is the hydraulic pressure acting on the valve spool or pump servo control which actually causes the final spool or swashplate movement.

There are two basic components to each Electro-Hydraulic Control as indicated by the name. The electric part consists of the electronic or electrical remote controller (RC) mounted in the control console, the associated wiring parts, and in some cases, additional relays and switches that modify the electric signal in some way. The electrical part also includes the coil at the valve or pump that helps to convert the electric signal back to the mechanical movement required to develop hydraulic pressure. The second basic component of the EHC is the hydraulic part. This part is simply an arrangement of fixed or variable orifices that oil flows through. The adjustment of the variable orifice by the electric coil determines the amount of pressure and the corresponding amount of valve spool movement.

From the operator's point of view the EHC link will not be that much different from a direct mechanical link. Movement of the RC in the console will still result in the corresponding movement of the appropriate drilling function. The RC will be easier to operate and will provide no feedback (feel) through the control handle. The operator will also find that there are some operation sequences that the control will not allow (such as powering the rotary head into the rod support).

From a technical point of view however, the EHC link has some distinct differences from the direct link. The most obvious of these differences is that the EHC link is more complex. The operator's command is translated twice before reaching the end of the link. The second primary difference is that all safety interrupts are included in the link. If the operator attempts an illegal operation in a protected link, the electrical command that actually reaches the valve or pump will be altered and in some cases interrupted. If however, the electrical signal actually reaches the device coil and a pressure signal is generated, the function connected to that device will move.

7.12 - ELECTRO•HYDRAULIC SYSTEM

OVERVIEW (continued)

All the EHC links can be further classified as either proportional or on/off. The proportional links provide precise movement of the valve spool that corresponds directly to movement of the RC handle. The proportional links operate with either DC output or a Pulse Width Modulated (PWM) current output depending on the device being controlled. The signals for pump control for example, are 0 to 300 milliamp, DC current signal. The On/Off links provide a DC current output which causes full travel of the valve spool whenever the RC handle moves past the threshold position.

GENERAL CONCEPTS AND TERMINOLOGY

The following pages provide a discussion of the general circuit concepts, as well as a detailed description of each type of EHC and associated parts.

Current Control

The proportional RC's used for the Drillmaster Series are current control devices. The RC's that drive Denison coils supply a current signal in the range of 60 to 300 milliamps depending on handle position. The Rotary RC's which drive the FEMA valve coils supply a current signal from 100 to 500 milliamp range proportional to the position of the handle.

Current control devices operate differently from voltage control devices in that their output voltage is not always useful as an indicator of valve operation or position. It is the current, not the voltage, that is the same for a given handle or knob position. The only reliable check of the RC output is to measure the current flowing from the device. A simple example demonstrates this fact:

Suppose a 24 ohm coil is supplied with a 24 volt DC input. The current that will flow through the coil is $V/R = 1.00$ Amp. If the voltage to the coil is reduced by half, the current will be cut by half. If the coil fails open the current will be 0. If the coil shorts, the current will most likely be high enough to melt the insulation from the wires.

On the other hand, suppose the same coil is supplied with a regulated current signal (1 Amp). The voltage across the coil will be $1 \text{ Amp} \times 24 \text{ Ohms} = 24 \text{ volts}$. If the current is cut by half, the voltage will be cut by half. If the coil fails open when a 1/2 Amp regulated current is called for, the voltage goes to battery voltage, 24 volts, to try to hold up the current signal. If the coil shorts, voltage drops to zero to try to maintain the current at 1/2 Amp.

This illustrates that the voltage on a RC output can be zero if the coil is shorted. Likewise the voltage reading can be 24 volts if the output is open regardless of the handle position. Output voltage is not necessarily a good indicator of circuit operation unless the circuit resistance is known.

7.12 - ELECTRO•HYDRAULIC SYSTEM

GENERAL CONCEPTS AND TERMINOLOGY (continued)

Pulse Width Modulation

Pulse Width Modulation (PWM) is the name given to a particular kind of electrical signal used for some hydraulic control applications. The signal results from high speed electronic switching of supply voltage to create a string of pulses all having the same height and varying width.

The PWM frequency for a given application is constant. That means that the amount of time that elapses between the start of a pulse and the start of the next pulse (the period “P”) is always the same. In the case of the Drillmaster Series PWM signals, that time is 1/33 HZ = .03 seconds. The time during every period “P” of the wave form when the voltage is switched on is the “on time” or “pulse width”. Likewise the time during every period when the voltage is switched off is the “off time”. The variation of the pulse width, or on time vs. off time, is what gives the signal proportionality.

Threshold

The threshold is the minimum output level from an RC. The current ranges for the controllers described above start at some level other than zero. In the case of the Denison RC, for example, the current output starts at 60 milliamps. By starting at this minimum level, current values that are too low to cause any resulting movement of the pump servo can be tuned out. As soon as the RC handle moves off center, the current level jumps up to the minimum level required to cause something to happen.

Maximum Out

Maximum Out is the maximum current level delivered by an RC when the handle or knob is at full stroke. For example, the normal maximum out for the Denison RC is 300 milliamps. The maximum out adjustment is preset but adjusting a potentiometer on the RC circuit board can change the level.

7.12 - ELECTRO•HYDRAULIC SYSTEM

CONTROLLERS

Dual Range

A Dual Range RC has two maximum output levels; a low range level, and a high range level. These controllers can be identified by the “R” terminal on the main terminal strip. When the “R” terminal is supplied with a 24 VDC signal, the controller is in high range and the corresponding current range will be from the threshold setting to the normal maximum out setting. The high range value is set by the maximum out pot described above. When the voltage signal to the “R” terminal is interrupted, the controller is in the low range. In this range, the current output will be from threshold to the low range setting. The low range setting is adjustable with the low range pot on the RC circuit board.

Single Coil Controllers

The Denison RC can be further classified as single coil controllers. In these circuits, there is 1 coil connected between the “A” and “B” terminal on the RC terminal strip. When the handle is moved toward the “A” terminal, current flows out “A”, through the coil winding in the pump stroker, and back to the RC “B” terminal. When the handle moves toward the “B” terminal, current flows out “B”, through the coil winding and back to the RC “A” terminal. The pump stroker interprets the direction of the current as well as the magnitude of the current.

Dual Coil Controllers

The Apitech and Fema valve coils interpret only the magnitude of the current signal, not the direction of the current flow. In the case of the Apitech valves, there is one coil that moves the spool in one direction and another coil moves the spool in the other direction. In these “dual coil” circuits, the “A” terminal is connected to either of two wires on a valve coil. The remaining coil wire is connected to ground. The “B” terminal of the RC is connected to either of the two wires on the second coil. The remaining coil wire is connected to ground. When the handle is moved toward the “A” terminal, current flows through the first coil, and then to ground. When the handle is moved toward the “B” terminal, current flows through the second coil to ground.

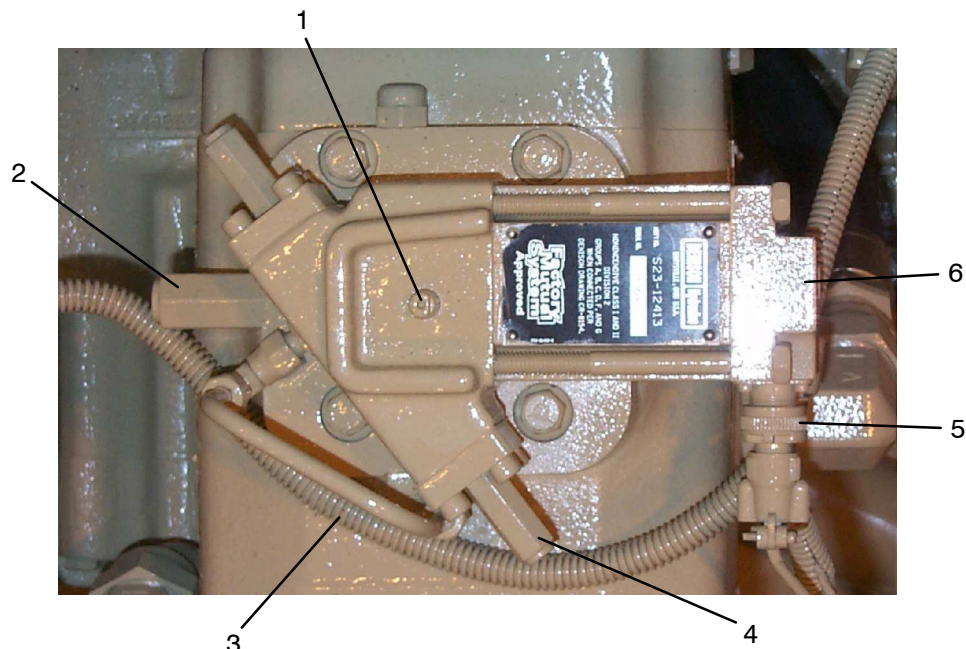
7.12 - ELECTRO•HYDRAULIC SYSTEM

DENISON 500 STROKER

The DENISON 500 Electro-Hydraulic Stroker (Illustrated in Figure 7.12-1) provides a modulating servo position proportional to input current. It does not require electrical displacement.

The electro-hydraulics stroker, consisting of a voice coil, jet pipe and piston, positions the rotary servo shaft, which controls the pump rocker cam position. With zero current input, the voice coil exerts no force, and the two springs center the jet pipe between the receivers, the jet stream splits evenly to produce the same pressure in each receiver. These pressures are connected to corresponding ends of the piston and being equal create no motion.

If current is applied to the voice coil, it exerts a force on the armature in proportion to the magnitude and polarity of the current. This causes the jet pipe to deflect so that it is aimed more directly at one receiver pipe. The pressure in that pipe rises and the pressure in the other pipe falls, causing the pressure on the ends of the piston to change accordingly. The piston then moves, rotating the servo shaft and either compressing or relaxing the feedback spring, depending on the direction of motion. When the piston moves far enough that the change in feedback spring force equals the voice coil force, the jet pipe re-centers and the piston stops at that position.



DENISON STROKER

Figure 7.12-1

7.12 - ELECTRO•HYDRAULIC SYSTEM

DENISON 500 STROKER (continued)

The numbers in Figure 7.12-1 correspond to the numbers below. Each number below precedes a description of the component it represents.

1. Manual Override Shaft – Used to manually stroke the pump.
2. Mechanical Null Adjustment – Used to mechanically center the pump swashplate in the neutral position.
3. Servo Supply Tube – Tube which carries pump servo pressure to the Denison Stroker from the main body of the pump.
4. Mechanical Volume Stop Adjustment – Used to mechanically set the pump volume.
5. Two Pin Electrical Connector – Military style connector which receives electrical signals.
6. Electrical Null Adjustment – Used to fine tune the main pump after the initial mechanical adjustment has been done.

Denison 500 Stroker Adjustment

There are two styles of electric input controls used on Denison pumps. One control style has an “acorn nut” type mechanical null adjustment assembly. The other has an enclosed style mechanical null adjustment assembly like those shown in Figure 7.12-1. Tools needed for “Null” adjustment are:

Acorn Type

- a.) 2 x 3/4” open end wrenches
- b.) 1 x rod to fit through a 1/8” hole in the null adjustment shaft
- c.) 2 x 7/16” open end wrench (for electrical null steps)
- d.) 2 x –4 (1/4”) JIC capnuts
- e.) 1 x 3/32” Allen Wrench

Enclosed Mechanical Type

- a.) 1 x 3/4” open end wrench
- b.) 2 x 7/16” open end wrench (for electrical null steps)
- c.) 1 x 3/16” Allen wrench
- d.) 1 x 1/4” Allen wrench
- e.) 1 x 3/32” Allen wrench

7.12 - ELECTRO•HYDRAULIC SYSTEM

DENISON 500 STROKER (continued)

Adjustment Steps

1. Track mounted drills should be in the propel mode with the machine raised on jacks until the tracks clear the ground.
2. With the drill turned off, disconnect the electric wires from the two pin connector on the pump input control.
3. Start the drill. If the tracks creep, the pump null is out of adjustment.
4. With the drill turned off, remove the servo supply tube (See Figure 7.12-1) and cap the two open ports with the -4 JIC capnuts.
5. **A. For acorn nut style adjustments**, remove the acorn nut from the mechanical null adjust screw using a 3/4" wrench. Hold the null adjust screw with a rod inserted through the 1/8" hole in the side of the screw. Loosen the lock nut.
B. If the adjustment is the enclosed type, remove the plug from the end of the 3/4" hex barrel using a 3/16" Allen wrench. Insert a 1/4" Allen into the end of the barrel to hold the internal screw stem. Loosen the 3/4" hex barrel.
6. Turn the null adjust screw in one direction until the track starts creeping. Note the position of the null adjust screw.
NOTE: The nulls adjust screw has a mechanical stop that limits its rotation in both directions. Do not force the screw past its stops.
7. Now turn the null adjust screw in the other direction until the track starts creeping in the other direction. Again, note the position of the adjust screw.
8. Position the null adjust screw halfway between the two positions found in steps 6 and 7 and then lock the adjustment screw in place by tightening the locknut (acorn style control) or hex barrel (within 100 psi). This can be verified by measuring the pressures at the pump A and B ports.
9. Replace the acorn nut (acorn nut style control) or the barrel nut plug (enclosed style control). The pump is now mechanically nulled.
10. With the drill turned off, remove the -4 JIC capnuts from the input control and re-install the servo supply tube. Restart the engine.

NOTE: When the engine is started, the tracks may creep even though the pump has been mechanically nulled. The electric part of the adjustment will correct the creeping.

7.12 - ELECTRO•HYDRAULIC SYSTEM

DENISON 500 STROKER (continued)

Adjustment Steps (continued)

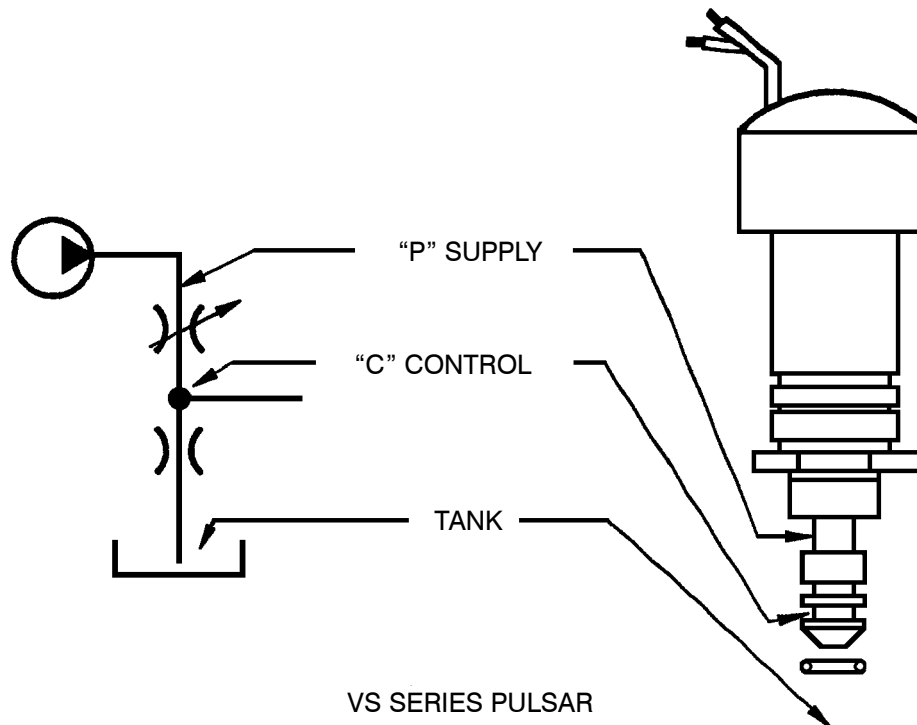
11. The electric null adjust screw is an Allen screw located under the capnut shown in Figure 7.12-1. Remove capnut from electric null adjust screw using two 7/16" open end wrenches. Hold the internal Allen screw with a 3/32" Allen Wrench and loosen the jam nut.
12. Turn electric null adjust screw in one direction until the track starts to creep. Note the position of the screw.
13. Turn the electric null adjust screw in the other direction until the track starts to creep in the other direction. Again, note the position of the null adjust screw.
14. Position electric null adjust screw half way between the two positions found in steps 12 and 13, and then lock the adjustment screw in place by tightening the jam nut. Pump A and B side pressures should now be equal (within 100 psi). This can be verified if desired by measuring the pressures at the pump A and B ports.
15. Replace the capnut and reconnect the electric wires to the two-pin connector. The pump null adjustment is now complete.

7.12 - ELECTRO•HYDRAULIC SYSTEM

VALVES

Apitech Pulsars

The PULSAR VS Series pressure control valve is a normally closed, spring biased, solenoid actuated, high speed, digital (on/off) valve. It consists of a removable, replaceable cartridge assembly specifically matched with a separate orifice plate and O-ring seal. To generate a proportional control pressure, the coil is energized 33 times per second with a pulse width modulated (PWM) electrical signal. The resulting control pressure is directly proportional to the duty cycle or “On” time per cycle of this excitation. Oil exiting the cartridge is restricted by the 0.024” fixed orifice plate; the resulting backpressure is proportional to the operator-regulated duty cycle. This pressure is then routed within the working section to the end of the main spool to furnish the control pressure.



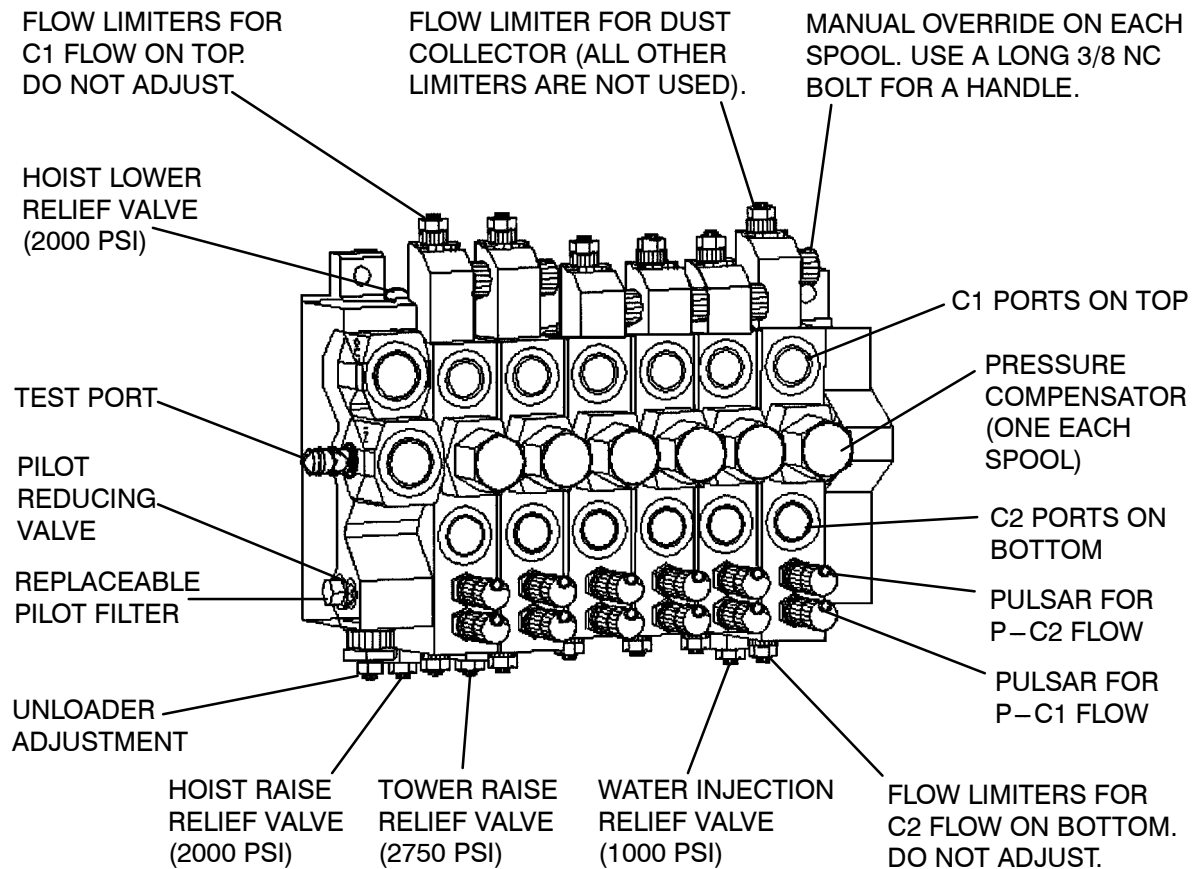
VS SERIES PULSAR
Figure 7.12–2

7.12 - ELECTRO•HYDRAULIC SYSTEM

VALVES (continued)

6-Spool Valve

The 6-Spool Valve assembly is an electrically operated, proportional, load sensing 4-way valve stack. The individual parts and features are shown in Figure 7.12-3.



6-SPOOL VALVE
Figure 7.12-3

The inlet section of the assembly contains the pilot pressure reducing valve and filter for the 6 spools. It also contains the unloader valve for setting the maximum working pressure for all spool valve functions on the machine. The unloader is adjusted to 3000 psi working pressure at the factory and should not require readjustment in the field.

The inlet section, pilot pressure reducing valve and filter are serviceable items. The valve can be replaced by screwing the old one out of the inlet housing and screwing in a new one.

7.12 - ELECTRO•HYDRAULIC SYSTEM

VALVES (continued)

6-Spool Valve (continued)

There are 4 work port relief valves in the 6-Spool Valve assembly. The first spool section has a port relief on both C1 and C2 ports to control hoist pressures. These pressures are set for 2000 psi pressure reading at the 6-Spool Valve test port (with C1 and C2 ports blocked). The second spool section has a port relief on the C2 port to control tower raising pressure. This valve is set for 2750 psi pressure reading at the 6-Spool Valve test port (with the Tower Raising Cylinders fully stroked). The sixth spool section has a port relief on the C2 port to control maximum Water Injection Motor pressure. This valve is set for 1000 psi pressure reading at the 6-Spool Valve test port (with C2 port blocked). All of these pressures are adjusted at the factory. No adjustment should be required in the field unless an entire assembly is being replaced.

Each spool section has two Pulsar coils for shifting the spool (one for each direction). The coils and the respective ports they control are shown in Figure 7.12-3. The coils can be replaced by screwing the old part out and inserting a new one in its place. When removing a coil, the o-ring inside the coil cavity must also be replaced. Remove the o-ring with an o-ring pick. Insert the new o-ring into the coil cavity and be sure it is fully seated before screwing in the new Pulsar. If the o-ring has not been inserted properly, a resistance will be felt as the Pulsar is being screwed in place and the valve will not operate properly.

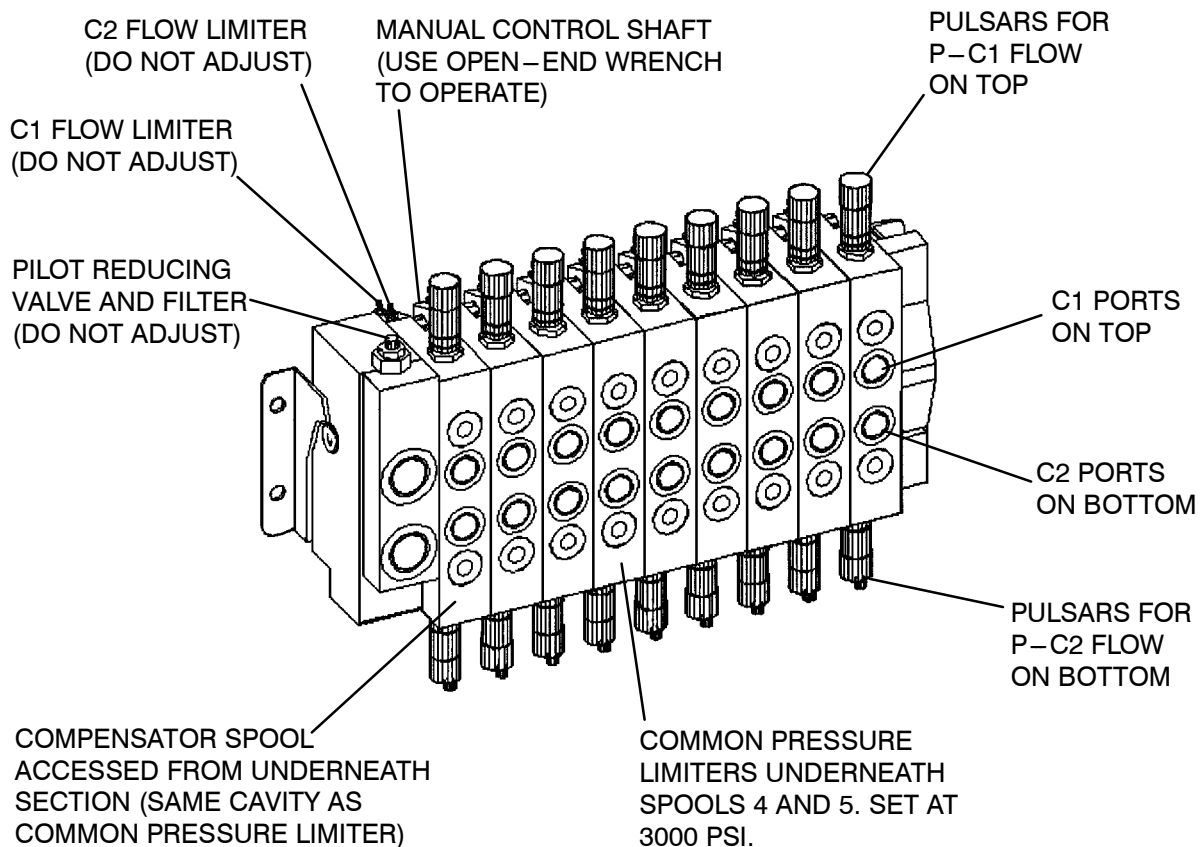
NOTE: Speed control of some of the valve functions is done with current adjustments to the valve coils. See the electrical EHC section for more details.

7.12 - ELECTRO•HYDRAULIC SYSTEM

VALVES (continued)

9-Spool Valve

The 9-Spool Valve assembly is an electrically operated, proportional, load sensing 4-way valve stack. The individual parts and features are shown in Figure 7.12-4.



9-SPOOL VALVE
Figure 7.12-4

The inlet section of the assembly contains the pilot pressure reducing valve and filter for the 9 spools. The inlet does not have an unloader. This stack sends a signal to the 6-Spool Valve unloader that controls the maximum working pressure for both assemblies.

The inlet section, pilot pressure reducing valve and filter are serviceable items. The valve can be replaced by screwing the old one out of the inlet housing and screwing in a new one.

7.12 - ELECTRO•HYDRAULIC SYSTEM

VALVES (continued)

9-Spool Valve (continued)

There are 2 "common pressure limiters" in the 9-Spool Valve assembly. The common pressure limiter controls the maximum spool compensator pressure to limit working pressure at both C1 and C2 ports. The limiter in the fourth spool section provides a means to limit pressure in the breakout fork circuit. However, this limiter is set to allow maximum (3000 psi) pressure in the Mid-Range drill series application. The same is true for the limiter in the fifth spool section which controls rod support maximum pressure. All of these pressures are adjusted at the factory. No adjustment should be required in the field unless an entire assembly is being replaced.

Extending or retracting the cylinder all the way and reading the pressure at the test port on the 6-Spool Valve inlet (with the spool actuated) can check the maximum pressure in any cylinder circuit. The maximum pressure in a motor circuit can be checked by plugging the valve work ports and reading the pressure at 6-Spool Valve test port (with the spool actuated).

Each spool section has two Pulsar coils for shifting the spool (one for each direction). The coils and the respective ports they control are shown in Figure 7.12-4. The coils can be replaced by screwing the old part out and inserting a new one in its place. When removing a coil, the o-ring inside the coil cavity must also be replaced. Remove the o-ring with an o-ring pick. Insert the new o-ring into the coil cavity and be sure it is fully seated before screwing in the new Pulsar. If the o-ring has not been inserted properly, a resistance will be felt as the Pulsar is being screwed in place and the valve will not operate properly.

NOTE: Speed control of some of the valve functions is done with current adjustments to the valve coils. See the electrical EHC section for more details.

7.12 - ELECTRO•HYDRAULIC SYSTEM

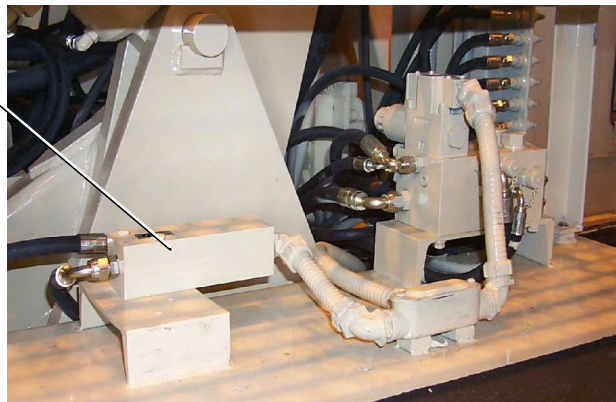
VALVES (continued)

FEMA Pulldown / Holdback Control Valves

On the Mid-Range drill series, the FEMA Pressure controller (Illustrated in Figure 7.12-5) is used in the drill feed system. On **low-pressure drills** it is used only in the Pulldown circuit. On **high pressure drills** there are two used. One is used in Pulldown and one in the Holdback circuits (Illustrated in Figure 7.12-6). The FEMA Pressure controller is a proportional pressure controller which consists of a coil, armature, poppet, nozzle, filter and housing. The FEMA valve is used as part of the main pump compensator control circuit in the Drill mode of operation. It is hydraulically isolated from the pump by a pilot operated check valve when the machine is in the propel mode. The FEMA valves are located between dust collector and the tower support on the service decking.

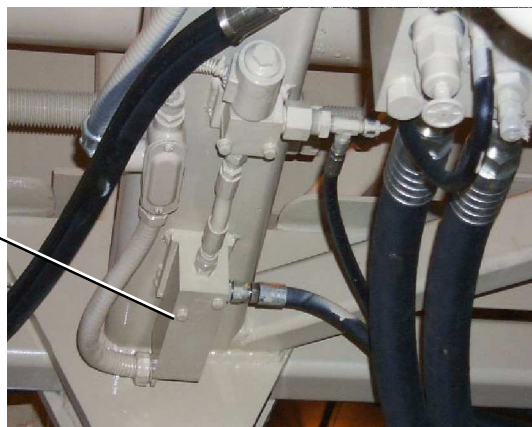
**FEMA PULLDOWN
CONTROL VALVE
(DUST COLLECTOR
SIDE DECKING)**

**FEMA PULLDOWN
CONTROL**
Figure 7.12-5



**FEMA HOLDBACK
CONTROL VALVE
(BACK OF TOWER)**

**FEMA HOLDBACK
CONTROL (HP)**
Figure 7.12-6



7.12 - ELECTRO•HYDRAULIC SYSTEM

CONTROLLERS

Pulldown Controller

As the operator turns the Pulldown or Holdback controller to the right, the DC electrical current signal to the FEMA controller is increased. As current is increased to the valve coil, the internal poppet is pushed closer to the nozzle. This poppet movement causes a restriction to oil flow that in turn builds pressure proportionally at the valves “C” port. This valve adjustment is made by the drill operator when there is a requirement for feed pressure increase or decrease.

The Pulldown force rotary controller is energized (wire # 82) when the Drill/Propel switch is in the Drill mode. The electrical current output of the controller is a direct current proportional signal from 0–12 VDC w/24 Ohm Coil. When the operator turns the control knob to the right, current signal is supplied to the FEMA valve coil. The farther the knob is turned the higher the current signal output will be.

When the Feed control lever is in the feed down position, the feed system hydraulic pressure can be controlled remotely by turning the Pulldown force knob. The pressure is variable from zero to maximum Pulldown pressure.

NOTE: Maximum Pulldown pressure developed while drilling is dependent on force controller output and ground (rock) formation conditions. While drilling in soft ground formations, it may be impossible to reach the maximum hydraulic pressure relief setting.

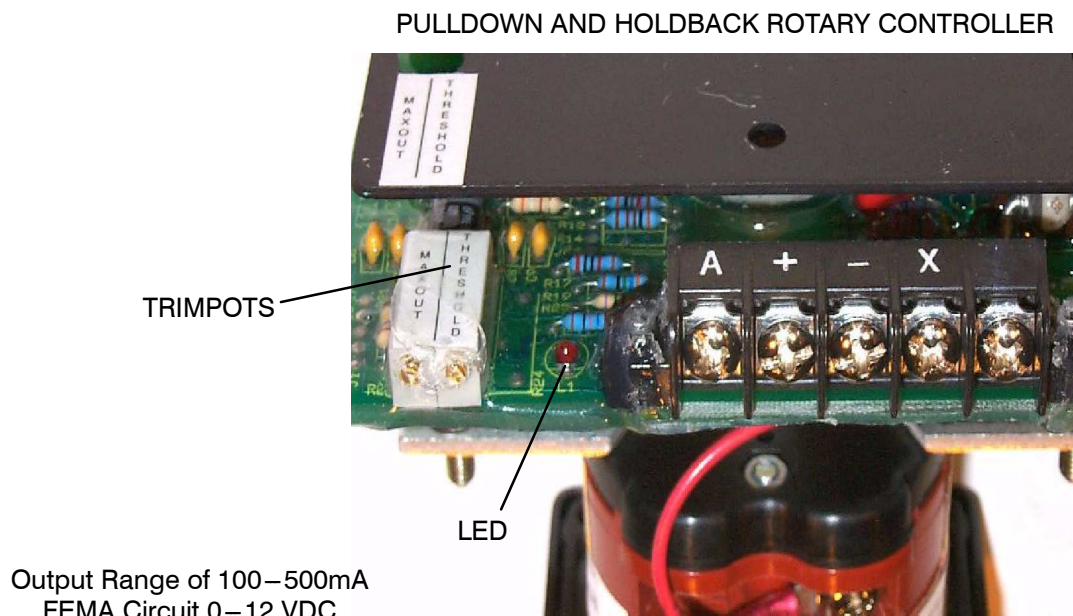


Figure 7.12–7

7.12 - ELECTRO•HYDRAULIC SYSTEM

CONTROLLERS (continued)

Water Injection Rotary Activated Controller

The water injection remote controller provides a proportional signal that is actuated by the drill operator through a rotary control knob. The output it provides is the same 33 Hz PWM signal as the other controllers associated with Apitech valves.

The water injection controller electrical power is provided from wire number 80 on the electrical circuit through the three position Dust Control Switch. The rotary controller is energized when the switch is turned to the water injection position. As the knob is turned from its off position, it supplies a proportional current signal to the upper coil on the sixth spool of the 6-spool valve stack. This shifts the spool to allow oil to flow out the “C2” port to the water injection motor. The oil flow, and therefore the motor speed, is determined by the position of the rotary remote controller knob.

WATER INJECTION
ROTARY ACTUATED CONTROLLER

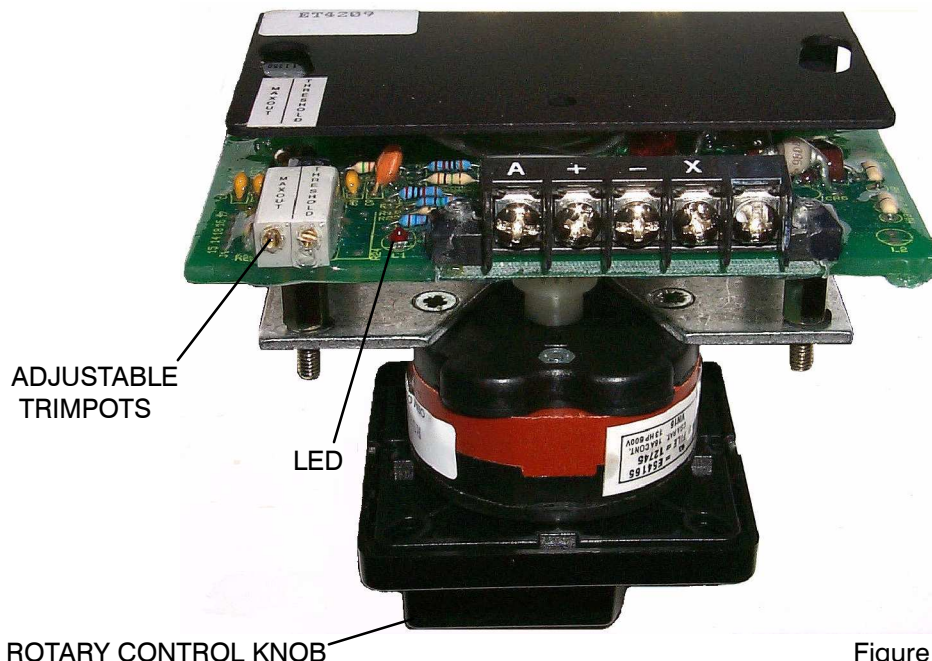


Figure 7.12–8

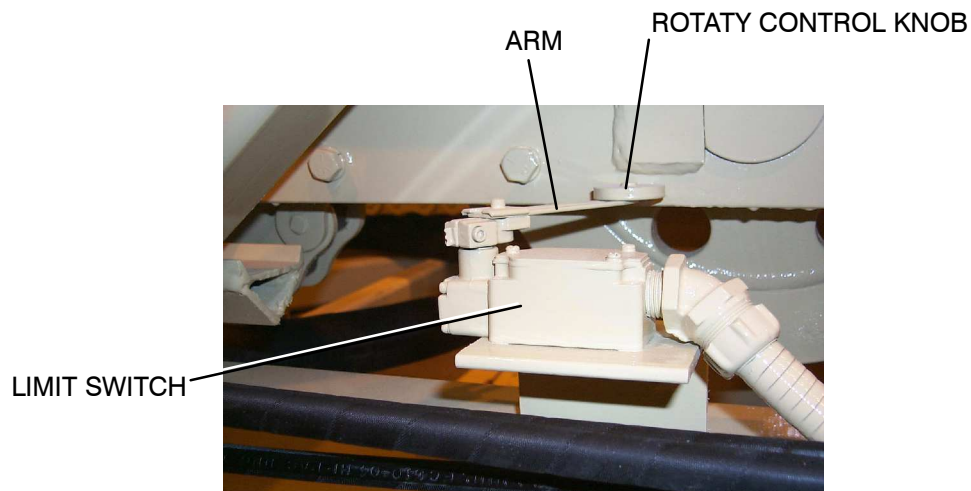
7.12 - ELECTRO•HYDRAULIC SYSTEM

LIMIT SWITCHES

In some cases, an EHC link must receive information about the position of drill components so that drilling operations can be sequenced or protected against movement that would cause damage. On the Mid-Range Drill Series electrical circuit, limit switches mounted at appropriate locations in the tower assembly provide this information.

The limit switches all have two sets of contacts (four terminals). One set of contacts is normally open (NO) and the other is normally closed (NC). Whenever the lever is in its normal (un-actuated) position, a circuit attached to the NO contacts will be interrupted so that no current can flow. If the switch arm is rotated either clockwise or counter-clockwise, the contacts change state. The NO contacts will close to enable their circuit and the NC contacts will open to interrupt their circuit.

On the Mid-Range Drill Series drills with standard equipment, there is only one limit switch (LS5 on the electrical schematic) used for this purpose. It is located at the upper end of the feed cylinder on the dust collector side. The limit switch is mounted along the path of the traveling sheave cage such that the lever is actuated as the sheave cage passes (See Figure 7.12-9). This switch provides information about rotary head position for feed deceleration and optional tram interlock circuits.



LIMIT SWITCH
Figure 7.12-9

On drills equipped with additional options (Rod Support LS-6, No Bump Rod Changer LS-4), there will be additional switches of this type in the tower.

7.12 - ELECTRO•HYDRAULIC SYSTEM

RELAYS

DPDT 24 VDC Relay

There are several relays that are used on the Mid-Range drill Series in various electrical circuits. The relay illustrated in Figure 7.12-10 is typical of the relays used. This is a double pole, double throw, 24 VDC relay. Each relay includes a 24 VDC coil and two sets of contacts. Each set of contacts (“A” and “B”) has a normally open pair and a normally closed pair. When the coil of the relay is energized, the electro-magnetic energy causes the internal contact pairs to change state. The normally open pairs will close, and the normally closed pairs will open.

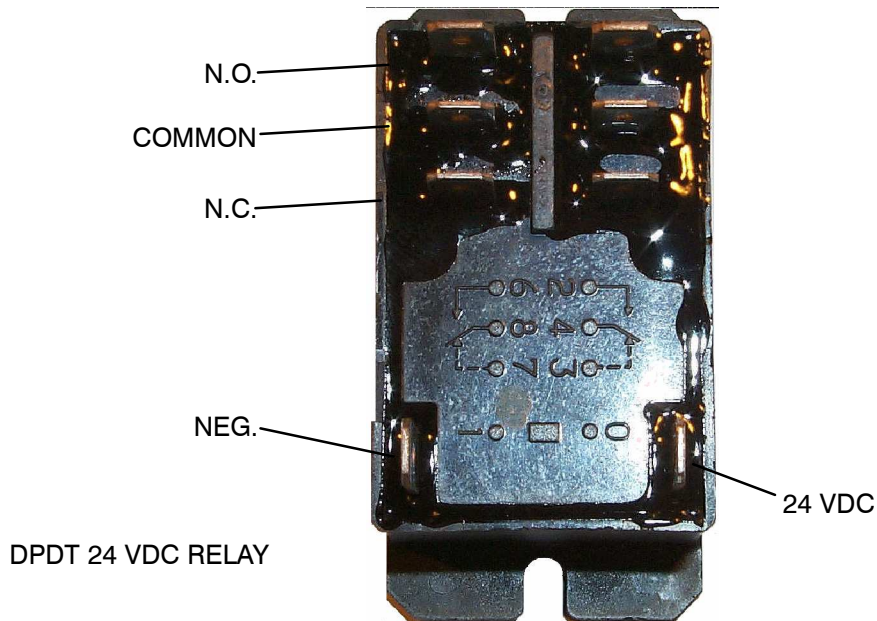


Figure 7.12-10

Figure 7.12-11 shows Relays located behind the Engine Functions Panel of the operators console (See Section 4 *Operating Controls* For Panel Location).

RELAYS
BEHIND
PANEL



Figure 7.12-11

7.12 - ELECTRO•HYDRAULIC SYSTEM

TYPICAL COIL RESISTANCE

The resistance of a coil on an Apitech valve, Fema valve or a Denison stroker can be checked from the cab console. Use the following procedure for the coil being checked.

Denison Stroker Coil

When checking the Denison coil, it is recommended to switch the drill propel selector switch to the propel position. Remove the wires from the “A” and “B” terminals of the propel controller. Measure the resistance between the two open wires. The resistance should be 24 to 30 ohms.

If checked in the drill mode, the feed circuit resistance can be greater than 30 ohms (Denison coil resistance) due to the possibility of the deceleration resistor being in the circuit. If checked in the drill mode, with the rotary head at the top of the tower, the resistance between the “A” and “B” wires should be about 420 ohms. The additional resistance will come from a 390-ohm resistor in the feed deceleration circuit.

ADJUSTMENTS

Apitech Coils

There are two coils on each Apitech valve section. To check the coil attached to the controller “A” terminal, remove the wire from the “A” terminal and read the resistance between the open wire and ground. The resistance should be about 65 ohms. The “B” side coil resistance can be checked the same way.

Fema Coils

The Pulldown FEMA coil resistance can be checked only if the carousel is in the stowed (open) position. Remove the wires from the controller “A” and “B” terminals. Measure the resistance between the two open wires. The resistance should be about 24 ohms.

PROPORTIONAL REMOTE CONTROL OUTPUT

OEM or remote controllers can be checked for proper output with a voltmeter. To check an RC with a voltmeter follow the procedure below.

1. Check for 24 VDC input voltage. Read from terminal “+” to ground “-”.
2. Check for good ground. Power off, read resistance from terminal “-” to ground. Resistance should be zero.
3. Check the coil resistance for the particular circuit as explained in the section above.
4. With the resistance known and the “A” and “B” wires connected back up, the voltage from “A” to “-” or from “B” to “-” can be measured. Voltage should be in the following ranges:
 - a.) Apitech Circuits: Variable 0 – 24 VDC w/65 Ohm coil
 - b.) FEMA Circuit: Variable 0 – 12 VDC w/24 Ohm coil
 - c.) Denison Circuits: Variable 0 – 10 VDC w/27 Ohm coil

7.12 - ELECTRO•HYDRAULIC SYSTEM

CHECKING RELAY

The easiest way to do a quick check on a relay is to listen to or feel the relay. If the relay is being actuated by a switch signal, it will click when the connection is made. A more reliable check requires the use of a voltmeter. Check the coil terminals. One coil terminal should be grounded and one should receive a voltage signal when appropriate. If the relay is switching, check the individual contact pairs next. Check the resistance across the contact pairs (both open and closed) with the wires disconnected or the relay pulled from its socket. Open contacts read infinite resistance. Closed contacts read zero resistance. Make sure the contacts are not welded together by switching the relay with 24 volts and repeating the resistance check.

CHECKING LIMIT SWITCH

The easiest way to check the function of a limit switch is to rotate the arm and listen for the click of the switch. A more reliable check requires the use of a voltmeter. Open up the cover and check the resistance across the contact pairs (open and closed) with the wires disconnected. Also make sure the contact pairs change from open to closed or closed to open when the arm is switched back and forth.

CHECKING DIODE

To check a diode, remove it from the circuit. The diode is a uni-directional device (like a check valve) so be sure to remember exactly what end was connected to what terminal so that it can be put back in the same orientation. One end of the diode has a line printed around it. The line is on the end that BLOCKS current flow. Set the voltmeter to read resistance (ohms). Connect the red lead to the end with the line. Connect the black lead to the end away from the line. The resistance indicated should be infinite (open circuit). Now switch the meter leads black on line and red away from the line). Resistance should be zero (closed circuit). If either test fails, the diode is no good.

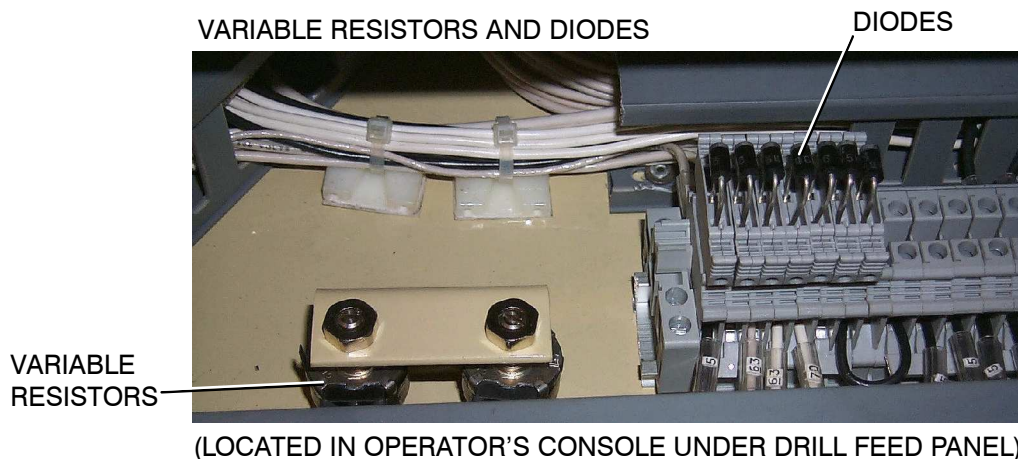


Figure 7.12–12

7.13 - EHC OPERATION

OPERATION

Jack Controllers

The controllers used in conjunction with the Apitech hydraulic valves are Pulse Width Modulated (PWM) controllers. The controllers shown in Figure 7.13-1 are representations of the typical controllers used.

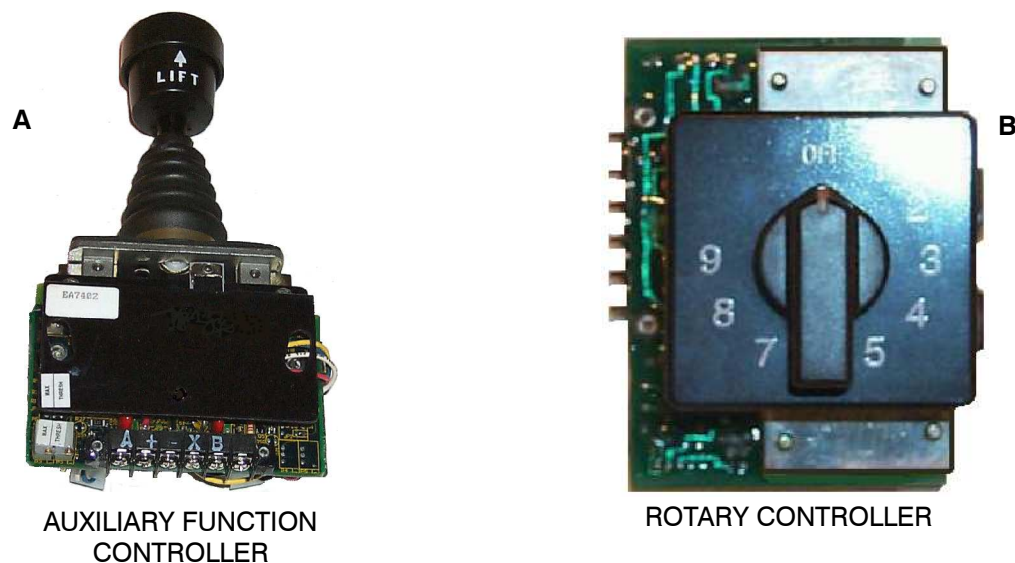


Figure 7.13-1

The Jack Control (A) EHC's are only energized when the Drill/Propel switch is in the "DRILL" mode. The EHC links that operate the 3 jack spools are pulse width modulated (PWM) links. These links control spools number three, four and five in the six-spool valve stack. The RC's (Remote Controllers) are set up to drive dual coils as described in *VALVES, Apitech Pulsars* (See Figure 7.12-2).

The Jack remote controls (RC's) have a neutral lock that must be lifted by the operator before the lever can be taken off center. The neutral locks are intended to prevent unintentional movement of the handle.

Whenever a RC handle is moved away from the operator, the "A" terminal delivers a PWM current signal to the upper Pulsar on the appropriate valve spool. (The current level coming from the RC is proportional to the handle position). The upper Pulsar converts the current signal to the proportional pressure signal required to position the valve spool and oil flows out the valve "C1" port to retract the jack cylinder. When the RC handle is moved toward the operator, the "B" terminal on the RC board delivers a proportional PWM current signal to the wire connected to the lower Pulsar. The Pulsar converts the current signal to a pressure signal that acts on the valve spool to shift in the other direction. Oil flows out port "C2" to extend the jack cylinder.

7.13 - EHC OPERATION

OPERATION (continued)

Hoist Controller

The Hoist Control RC (Figure 7.13-1,A) is the same type with the same PWM output as the jacks RC. When the control handle is moved away from the operator, the “A” terminal and the circuit attached to it is powered with a proportional PWM current signal. This raises the hoist cable. When the handle is moved in the “B” direction, current flows through the lower valve coil on the hoist spool (6 spool) and oil flows out the “C2” valve port to lower the hoist cable.

Tower Raising Controller

The Tower Raising Control RC (Figure 7.13-1,A) is the same type controller as the jacks and hoist. It is a PWM control with a neutral lock. Current from the “B” terminal powers the upper Pulsar on the second spool of the six-spool valve stack. This causes oil to flow from the “C2” port to extend the tower raise cylinders and raise the tower. The “A” terminal is connected to the lower Pulsar that controls oil flow out the spool valves “C1” port to retract the cylinders and lower the tower.

Rod Indexer Controller

The Rod Indexer RC (Figure 7.13-1,A) is the same type as the tower raise, hoist and jack controls. PWM proportional current from “B” causes oil to flow from port “C2” to the rod changer to index clockwise. Current from “A” causes the rod changer to index counter-clockwise.

Breakout Wrench Controller

The Breakout Wrench RC (Figure 7.13-1,A) is the same as the tower raise, hoist, rod index and jack controls. A proportional current signal from “B” powers the upper Pulsar on the fourth section of the nine-spool valve stack. This causes oil to flow from the “C1” port to retract the breakout fork cylinders. The lower Pulsar is powered by a proportional current signal from the “A” terminal on the RC when the handle is moved in that direction. This causes oil to flow out port “C2” that extends the breakout fork cylinders to engage the fork.

7.13 - EHC OPERATION

OPERATION (continued)

Carousel Swing Controller

The Carousel Swing RC (Figure 7.13-1,A) is the same as the controllers for the jacks, hoist, tower raise, rod index, and the breakout fork. When the handle is moved in the direction of the “B” terminal, a proportional PWM signal is available at the “B” terminal. Current flows from the terminal to the lower Pulsar on the first spool in the nine spool valve bank. The Pulsar positions the spool so that oil flows out the “C1” port and causes the carousel swing cylinders to extend and swing the carousel toward the load position.

NOTE: Drills with No Bump rod changer protection. This complete EHC link differs because it is protected against swinging the carousel in if the rotary head is in the way. An electrical limit switch (LS7) protects the carousel by interrupting the current to the Pulsar. The switch is normally open, held closed by the rotary head. If the rotary head is not at the top of the tower, current to the Pulsar is interrupted due to the open contacts in the limit switch (LS7).

There are no interrupts in the circuit for opening the carousel. When the operator moves the RC handle away toward the “A” terminal, current is supplied to the upper Pulsar on the first nine spool section. This causes the spool to shift to flow oil out of the “C2” port to retract the carousel swing cylinders and move the carousel to the open or “Stowed” position.

Chain Wrench Controller

The Chain Wrench RC (Figure 7.13-1,A) is the same as the controllers for the jacks, hoist, breakout fork, tower raise, rod indexer. Moving the handle toward the “B” terminal enables a PWM signal to flow to the Pulsar on the “C2” side of the spool valve. This signal causes the spool to shift directing oil flow from the “C2” port to the base end or extend port of the chain wrench cylinder. Moving the handle toward the “A” terminal causes the spool to shift the other direction, sending oil flow from the “C1” port to the retract or rod end of the chain wrench hydraulic cylinder.

Water Injection Controller

The Water Injection RC (Figure 7.13-1,B) is a proportional control with a rotary knob. The output it provides is the same 33 Hz PWM signal that the above RC’s use.

The Water Injection RC power is provided from wire number eighty (80) in the electrical circuit through a three-position switch. The RC is turned on when the Water Injection/Dust Collector switch is turned to the Water Injection position. As the RC knob is turned away from its off position, it supplies a proportional PWM current signal to the upper coil of the six-spool valve stack. This shifts the spool to allow oil flow out the “C2” port to the water injection motor. The oil flow and therefore the motor speed is determined by the position of the RC knob.

7.13 - EHC OPERATION

OPERATION (continued)

Dust Collector

The EHC link for the Dust Collector is significantly less complicated than those described in the previous discussions. This link is an on/off control that powers up the lower Pulsar on the sixth spool in the six-spool valve stack. The 24 VDC signal comes from the dust collector/water injection selector switch when it is shifted to the DC/PULSE position. The 24 VDC signal causes the valve spool to shift all the way to its spool stop to flow oil out the “C1” port to turn the dust collector motor.

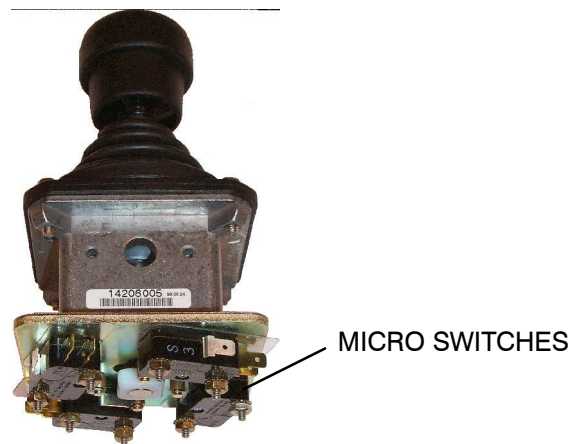
Dust Hood Controller

The Dust Hood controller is a dual axis controller (Figure 7.13-2). This controller is used to control both raising and lowering of the dust hood and raising and lowering of the front and rear dust curtains. Moving the handle left and right lowers and raises the front and rear curtains. Moving the handle fore and aft raises and lowers the dust hood.

This controller is not a PWM controller. It is a dual axis, On/Off, spring to neutral type and supplies 24 VDC from the micro switch to the Pulsar that corresponds to the direction of handle movement. There are four micro switches located at the bottom of the controller that are actuated by the handle when moved.

DUAL ACTION
CONTROLLER

Figure 7.13-2



Tower Pinning

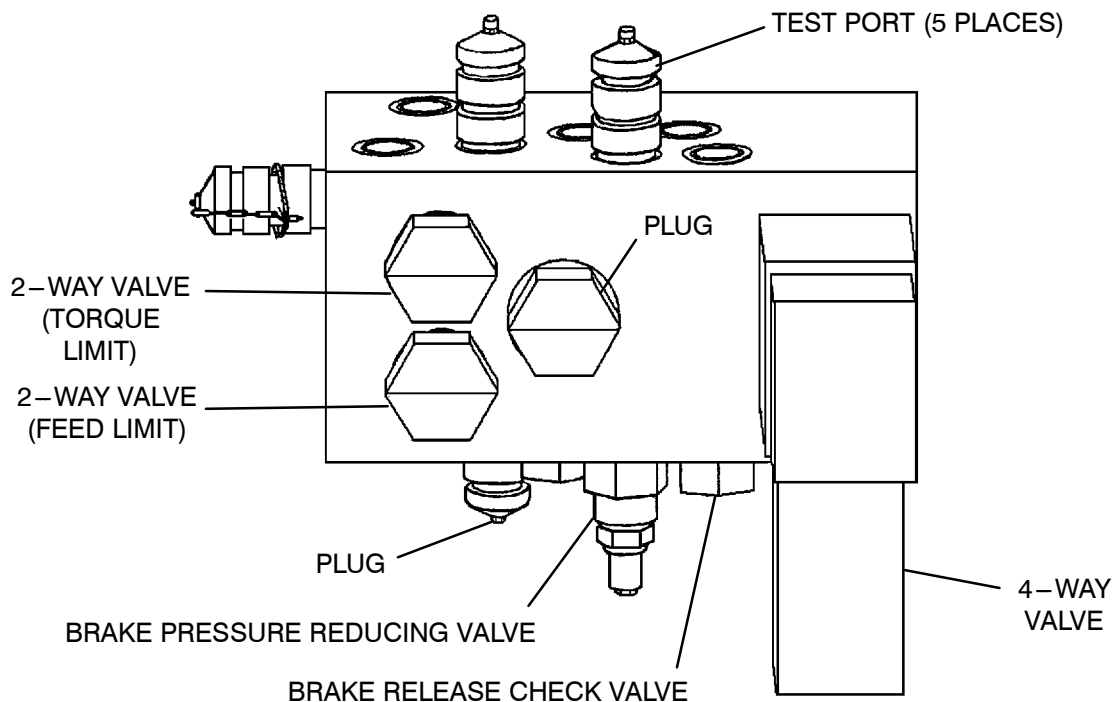
The Tower Pinning is controlled by a spring-centered toggle switch. The switch supplies 24 VDC to the Pulsars on section four of the nine-spool valve stack. Pushing the switch up energizes the Pulsar corresponding to the “C1” port diverting oil to extend the pinning cylinder. Pushing the switch down energizes the Pulsar corresponding to the “C2” port of the valve section. This disengages (retracts) the pinning cylinder, unpinning the tower from the pinning clevis.

NOTE: Do not operate the machine in “DRILL” mode with the tower unpinned. This can result in excessive loading of the tower support pivot area and the tower raising cylinders. Improper operation of the machine can cause severe damage or injury.

7.13 - EHC OPERATION

DRILL PROPEL VALVE

The Drill/Propel Mode Control Valve manages all of the mode selection, brake and pump compensator enabling tasks for the drill. It is a ductile iron manifold into which 4 valve cartridges are inserted (See Figure 7.13-3). A solenoid operated 4-way valve, bolted to one side of the manifold, selects the drill mode or the propel mode for the drill. The solenoid is energized when the propel mode is selected and de-energized when in the Drill mode.



DRILL / PROPEL CONTROL VALVE ASSEMBLY

Figure 7.13-3

The valve assembly can be completely rebuilt by replacing the 4 valve cartridges and the solenoid operated 4-way valve bolted to the side of the manifold. The assembly should never be serviced as a complete unit.

The only adjustment on the assembly is a pressure adjustment for the propel Brakes. The Brake pressure is set at 500 psi by turning the adjustment until this pressure is indicated at the Brake Pressure test port. The engine should be running (at high idle) and Propel mode should be selected when the pressure is being adjusted. The drill does not have to be propelling.

7.13 - EHC OPERATION

DRILL FEED CIRCUIT

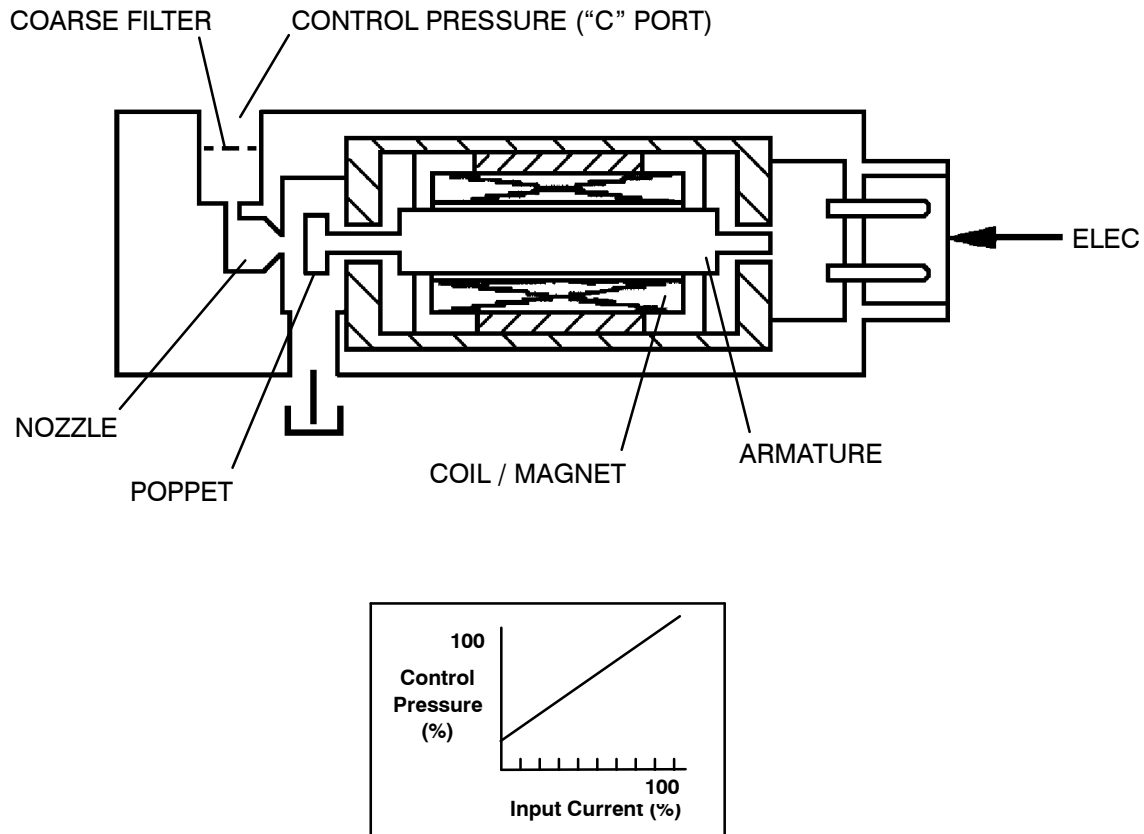
With the Drill/Propel selector in the Drill position, electrical power transfers from wire number 80 to wire number 82 (See Figure 7.13-5). This supplies power to the Feed, Rotation and Auxiliary function controllers. These controllers are used in conjunction with the Drilling process.

To start the rotary head moving down the tower, the operator pulls the Feed lever forward. This sends a proportional electrical current from the controller to the cab side Denison main pump stroker (See *CONTROLLERS, Denison 500 Stroker, Figure 7.12-1*). The electrical signal to the stroker results in changing the main pump swashplate angle. The farther the lever is moved, the farther the swashplate will come on stroke, increasing the pump displacement from zero displacement up to the full displacement setting of the pump. Reducing the lever movement, (reducing the current output to the stroker) reduces the swashplate angle. Therefore, rotary head speed is affected by the amount of Feed lever movement.

The Drill/Propel control valve and the FEMA actuator also affect the movement of the rotary head. When the Drill /Propel switch is in the “DRILL” mode, power is supplied to the Feed control lever, Pulldown Force controller and to the solenoid operated four way valve portion of the Drill/Propel control valve. Energizing the solenoid shifts the valve, enabling communication (hydraulically) between the main pump compensator “VA” port and the drain manifold through the Drill/Propel control valve and the FEMA actuator.

7.13 - EHC OPERATION

DRILL FEED CIRCUIT (continued)



PROPORTIONAL PRESSURE CONTROLLER (PPC TWO PORT DESIGN)

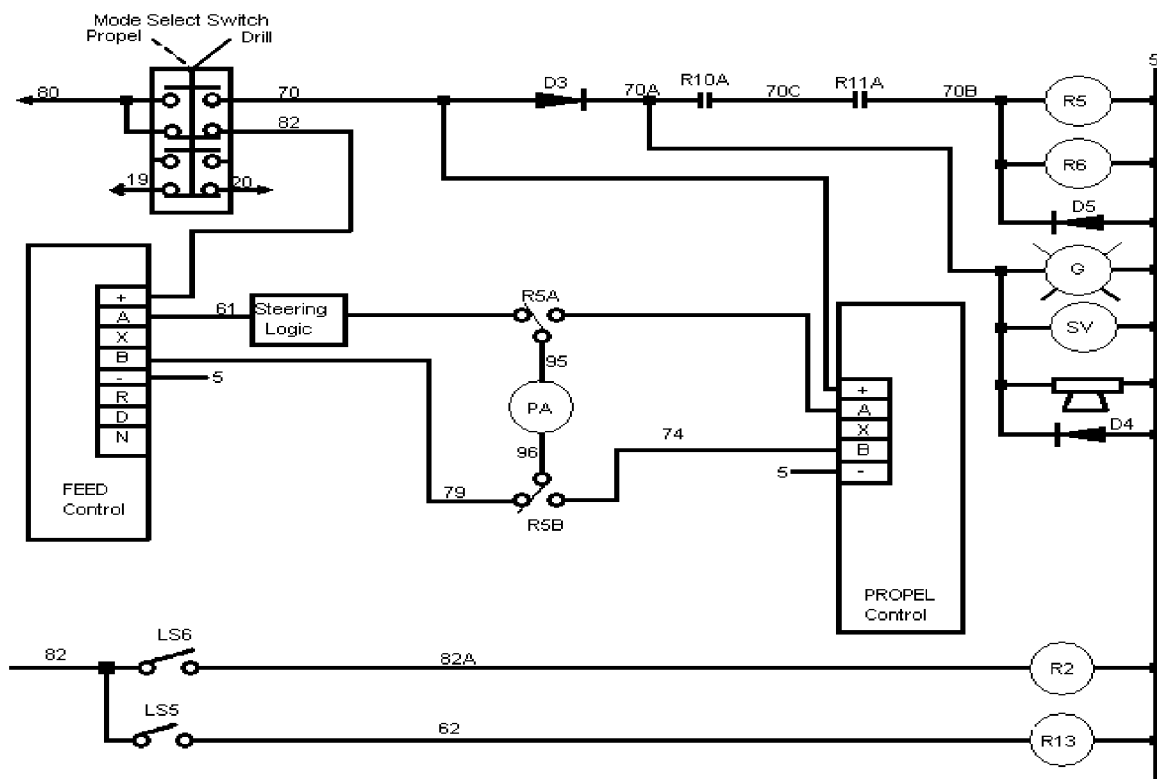
Figure 7.13-4

The FEMA actuator is a normally open electrically controlled hydraulic valve (See Figure 7.13-4). It receives electrical signal from the Pulldown Force rotary controller. The Pulldown force controller sends 24 VDC electrical signal to the FEMA valve. If the FEMA valve is receiving no current signal, it will be in the normally open condition. In the open condition, the "VA" line of the main pump compensator is open or "Vented" to tank. Electrical signal to the FEMA coil causes the FEMA valve to close off the communication path of the "VA" port to the tank. Increasing the current signal closes off the FEMA valve, allowing a rise of the Feed circuit hydraulic pressure. Feed pressure is proportional to the amount of Pulldown Force control knob movement. Turning the knob to the right increases system pressure and turning to the left lowers system pressure.

7.13 - EHC OPERATION

DRILL FEED CIRCUIT (continued)

Figure 7.13-5 contains a simplified sketch of schematic #56243579. Only the essential components for controlling the feed on the drill are shown. The other components and circuit interlocks have been left off to simplify the discussion of the operation of the feed circuit.



PARTIAL SCHEMATIC FOR FEED CIRCUIT

Figure 7.13–5

Relay R10 and R11 are optional interlocks to the propel circuit. Relay R10 allows the rig to propel only when all of the jacks are fully retracted. Relay R11 allows the rig to propel only when the Rotary head is fully raised in the tower.

Terminals R, D and N on the Feed Electro-Hydraulic Controller (EHC) are used for different applications and will be discussed in further detail in other sections of this manual.

The circuit indicated in “steering Logic” box provides safety overrides to keep the rotary head from ramming into the top of the tower, the carousel or the rod support. An in depth discussion of this circuit is provided.

7.13 - EHC OPERATION

DRILL FEED CIRCUIT (continued)

There are 6 electrical components involved in controlling the Feed circuit: Limit Switches LS5, LS6, Diodes D6, D7, Relays R2 and R13. Relays R2 and R13 provide interlocks to prevent the rotary head from damaging the carousel or the rod support. Components D3, D4, D5, R5, R6, R10, R11 are used for propelling the rig.

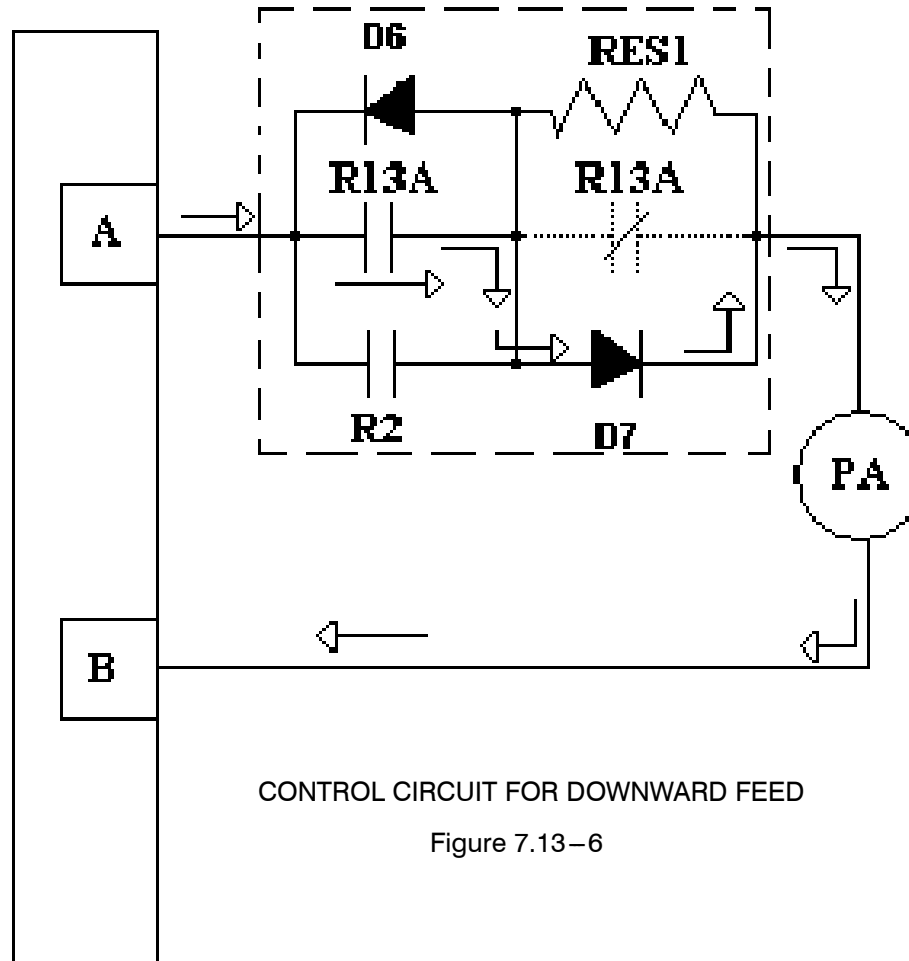
When the Propel/Drill Selector switch is in the “DRILL” position, Wire 82 provides electrical power to the Pull Down (Feed) EHC, the Rotation EHC, the Rod Support Extend/Retract switch, and the other electro-hydraulic controls (See Figure 7.13-5).

Note that relays R5 & R6 are DE-ENERGIZED whenever the Mode Selector switch is in the DRILL position. This prevents the Drill from shifting into Propel mode in the event that electrical power is lost. As a further safety measure, only those electro-hydraulic controllers (EHC) necessary for drilling operations are energized.

Pulling the handle of the Feed EHC toward the operator will cause the rotary head to move down the tower at speeds depending on the displacement of the handle from the neutral position. Similarly, pushing the handle away from the operator will cause the power head to move up the tower.

7.13 - EHC OPERATION

UPPER TOWER DECEL WITH ROD SUPPORT INTERLOCK



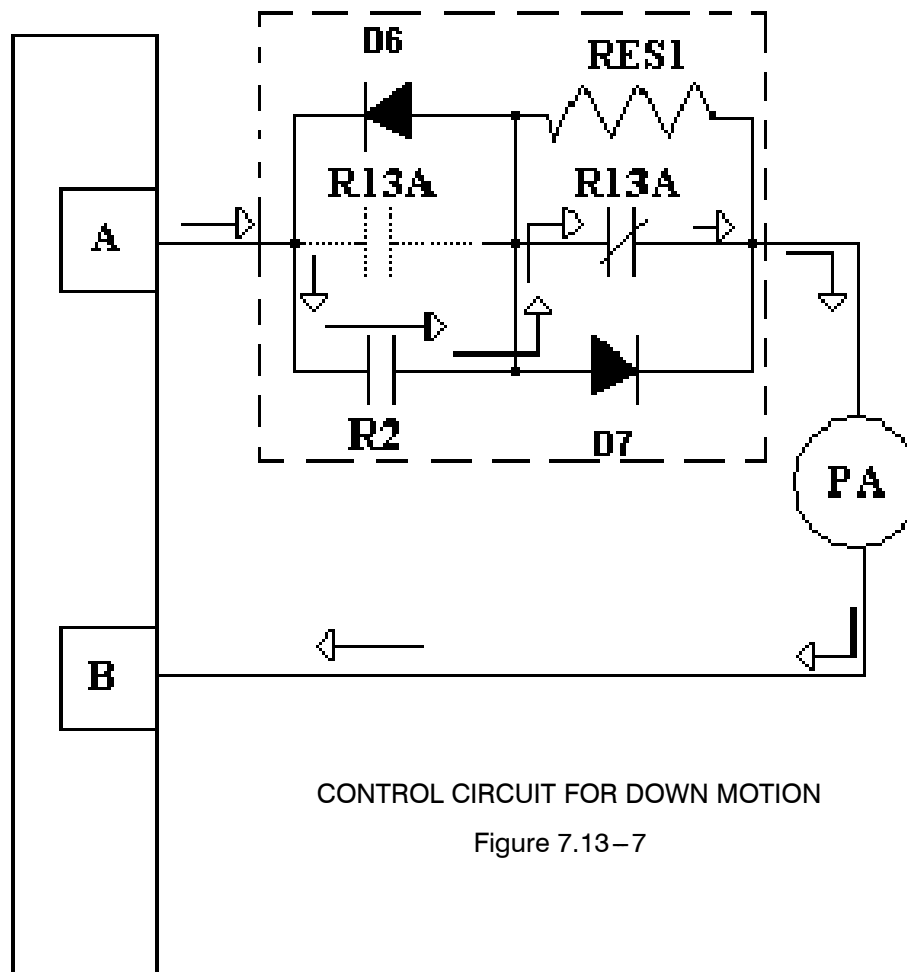
CONTROL CIRCUIT FOR DOWNWARD FEED

Figure 7.13–6

For Downward motion of the rotary head, electrical current flows from terminal “A” of the Feed RC, through the closed contact of R13A, through diode D7 to the proportional actuator PA and back to terminal B of the EHC, as indicated by the arrows in Figure 7.13–6. The rotary head will proceed at full speed in the downward direction because diode D7 bypasses resistor RES1 and the N.C. contact of R13.

7.13 - EHC OPERATION

UPPER TOWER DECEL WITH ROD SUPPORT INTERLOCK (continued)



CONTROL CIRCUIT FOR DOWN MOTION

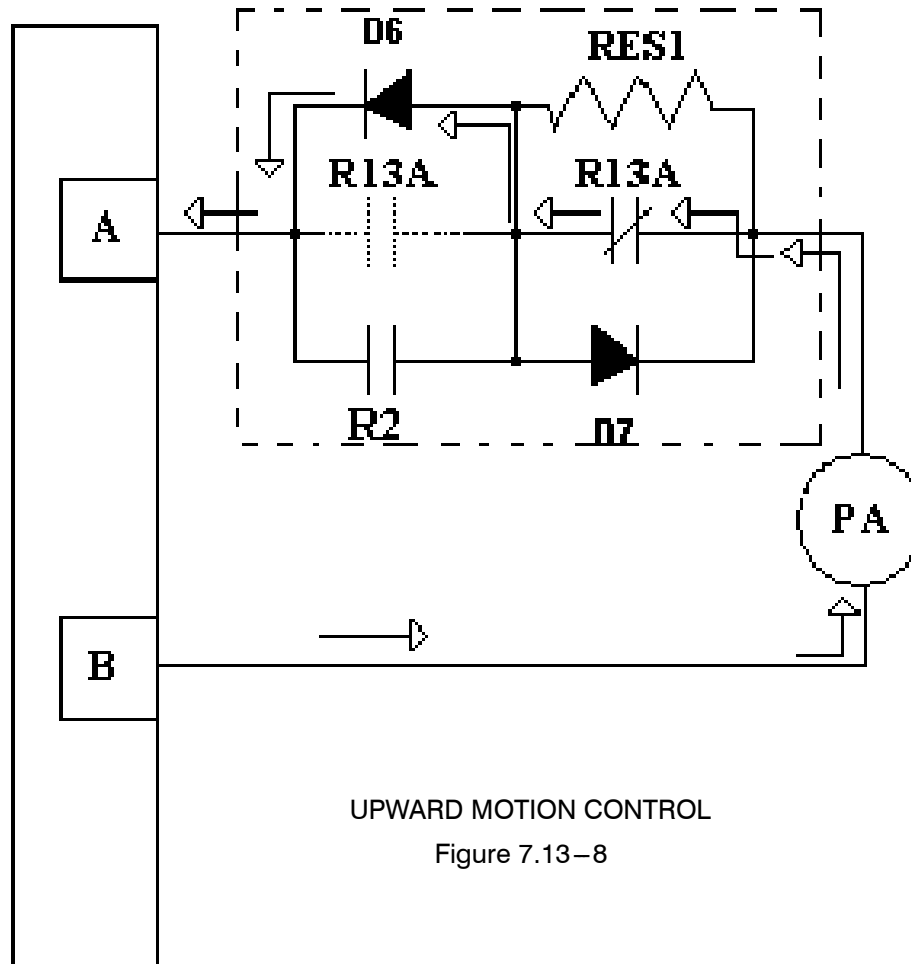
Figure 7.13–7

With the rotary head positioned at the top of the tower, limit switch LS-5 is closed, and relay R13 is energized. With the rod support arm fully retracted, limit switch LS-6 is closed and relay R2 is energized. The Normally Open (NO) contact of R13 is closed and the Normally Closed (NC) contact of R13 will be Open (NC). Also, the N.O. contact of R2 will be closed.

Once the rotary head moves down far enough to release limit LS-5, relay R13 de-energizes, the N.O. contact opens, and the N.C. contact closes. There should be no change in the speed of the rotary head, as shown in Figure 7.13-7.

7.13 - EHC OPERATION

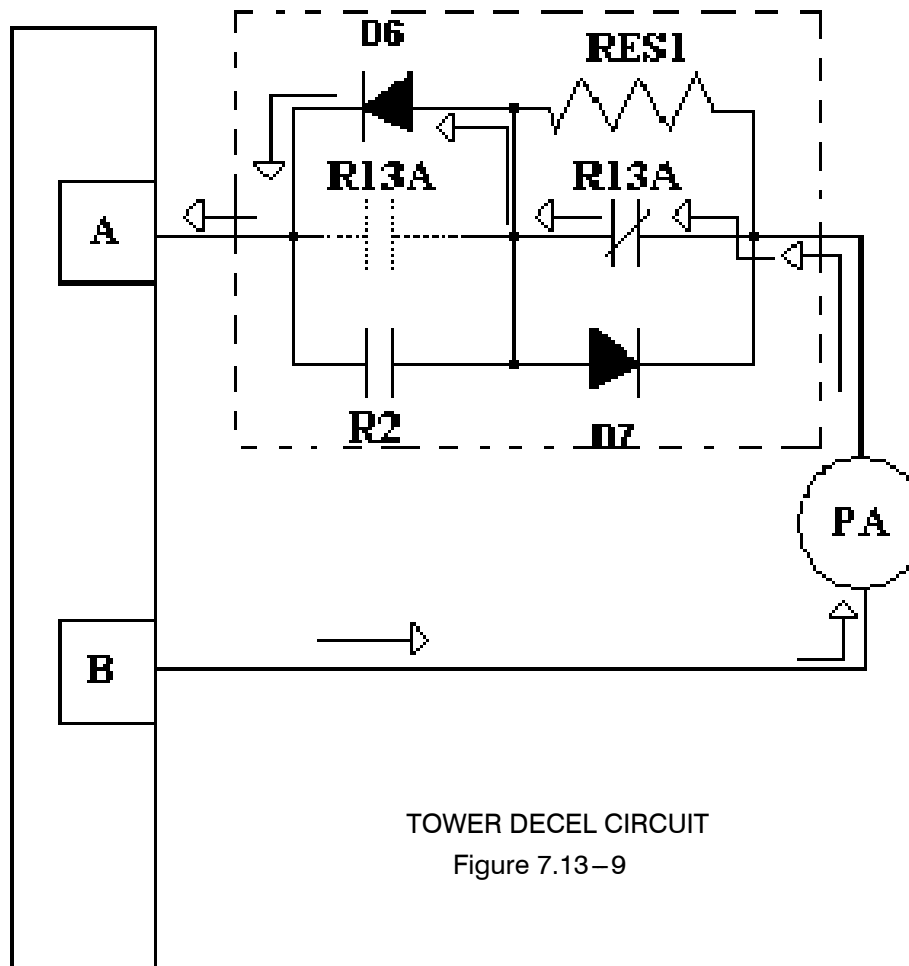
UPPER TOWER DECEL WITH ROD SUPPORT INTERLOCK (continued)



Reversing the motion of the rotary head, electrical current flows from terminal “B” of the RC, through the PA, through the normally closed contact R13A and through diode D6, as shown in Figure 7.13–8.

7.13 - EHC OPERATION

UPPER TOWER DECEL WITH ROD SUPPORT INTERLOCK (continued)



The rotary head will rise at full speed until limit LS-5 is activated, at that time relay R13 energizes, rerouting the electrical current through resistor RES1.

The resistor reduces the amount of electrical energy available to the PA, slowing the upward speed of the rotary head and preventing the rotary head from slamming into the top of the tower, as shown in Figure 7.13-9.

7.13 - EHC OPERATION

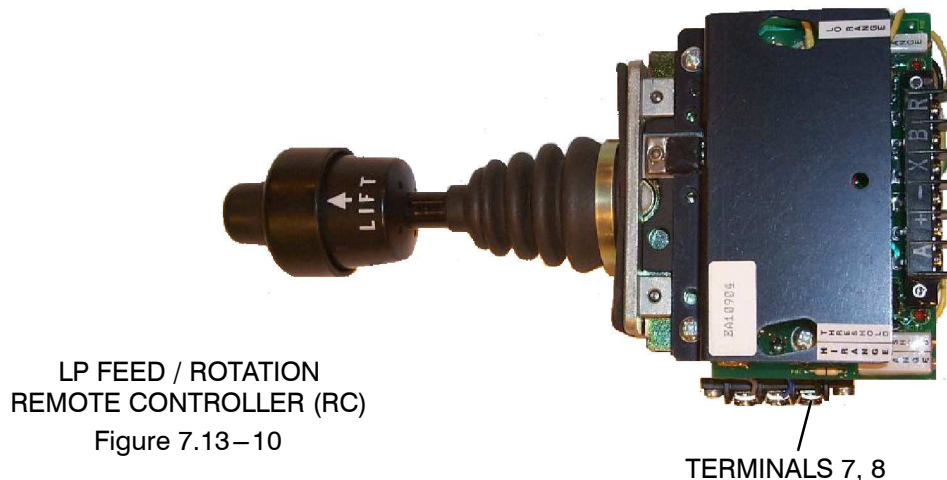
ROTATION CONTROL

When the Drill/Propel switch is in the Drill mode, the main pump controller on the Dust Collector side is used to control the drill pipe rotation. It controls both speed and direction of rotation. Pushing the controller away from the operator makes the drill pipe turn counterclockwise or reverse for breakout. This direction of rotation is used to uncouple drill pipes from one another.

Pulling the control lever forward starts the drill pipe turning clockwise. This direction of rotation is used for normal drilling and for connecting pipes together. The Rotation controller is shown in Figure 7.13–10. For Torque control information, see Torque Limit section.

LP Drill Feed and Rotation Controller

The EHC link for Feed pump control uses a proportional, single coil RC with a neutral safety lock and dual range control switch. The RC output is a proportional DC current signal, not a PWM current signal (See Figure 7.13–10). The Mode selector switch must be set to the “DRILL MODE” before the Drill Feed and Rotation controllers will function.



The Feed and Rotation controllers are identical on XL machines. The RC's each have two terminal strips. The first strip provides access to the “+”, “-”, “A”, “X”, “B”, “R”, and “N” terminals (“N” is spade connection on micro switch opposite side). The second strip is mounted on the side of the RC and it provides access to terminals 7, 8, and 9. These connect to a micro switch that is switched by a button in the end of the RC handle. Terminals 7 and 9 are a (NC) normally closed pair. Terminals 7 and 8 are a (NO) normally open contact pair.

7.13 - EHC OPERATION

LP Drill Feed and Rotation Controller (continued)

The normal mode for the Feed and Rotation RC's is high range mode. The NC contacts 7 and 9 switch 24 VDC from the RC "+" terminal to the "R" terminal to shift the control into high range. If the button on the end of the handle is pressed, the NC contacts 7 and 9 open and interrupt the power to the "R" terminal. This shifts the control into low range mode.

The high range mode allows a proportional DC current signal from about 60 mA to 300 mA (no pump stroke to full pump stroke). The low range allows a proportional DC current signal from about 60 mA to 100 mA (no pump stroke to 1/16 stroke).

In the low range, full RC handle movement corresponds to a change of only 40 mA that gives a finer control for more precise alignment of the drill steel flats with the breakout fork. The actual maximum low range speed can be adjusted with the "low range" pot on the RC circuit board.

When the RC handle (feed or rotation) is pulled toward the operator, a proportional DC current signal is supplied from the "B" terminal to the corresponding main pump stoker. This causes the pump swashplate to position to allow flow from the pump "A" port. If this controller is used for control of the rotation pump, the rotation motors will turn the drill pipe clockwise. The amount of oil the pump supplies and therefore the forward rotation speed is proportional to the handle position.

When the RC handle is pushed away from the operator, the proportional current signal from the RD "A" terminal flows through the stoker coil in the other direction. This causes the pump swashplate to position to allow flow from the pump "B" port and the drill pipe turns counter-clockwise. The reverse rotation speed is proportional to handle position.

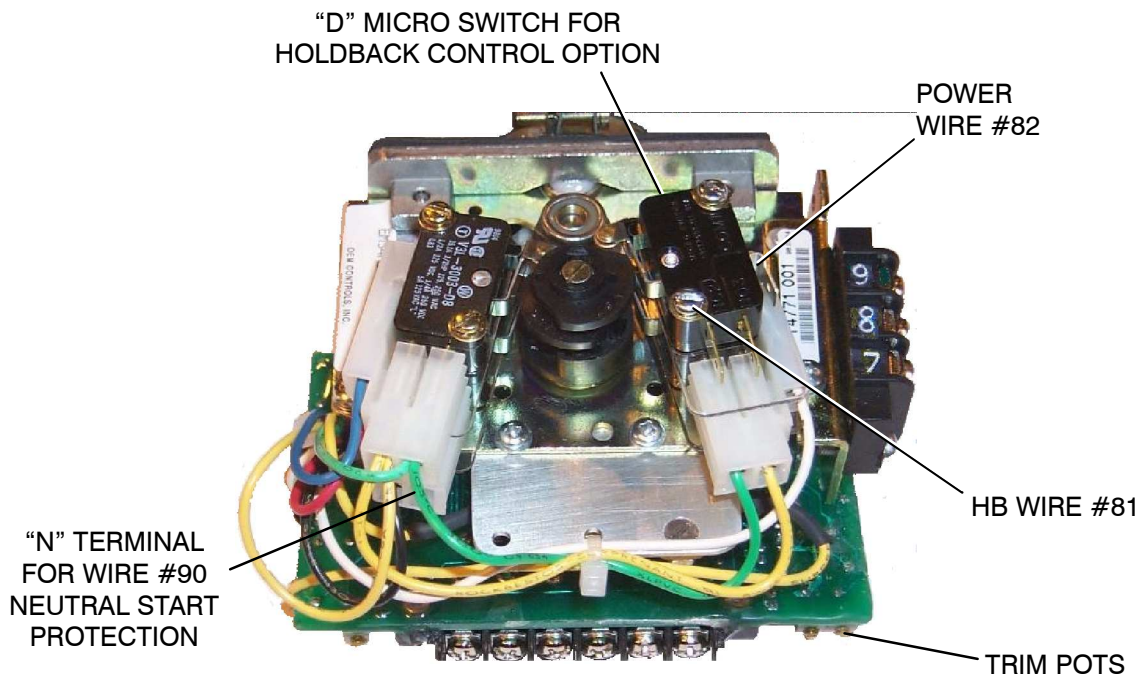
The EHC link for the feed pump control uses the same RC as for the rotation speed control (Low Pressure Drills machines only). The RC output is a proportional DC current signal, not a PWM current signal. This RC uses the dual range selection circuit described in the discussion above. (The low range mode is particularly useful for precise positioning of the drill pipe.) This link is different, however, in that both control directions have protection circuits.

When the feed RC handle is pulled toward the operator, a proportional DC current signal is supplied from the RC "B" terminal to the feed pump stoker coil. The other side of the stoker coil is connected to the circuit components (Limit Switches) that provide feed down interrupt control and feed up deceleration control. If the action of any of these components closes a direct path to RC terminal "A", the pump will stroke to allow oil flow from pump port "A" and the rotary head will feed down. If the action of any of the components adds resistance before closing a path to RC terminal "A", the pump will stroke slightly to allow very slow feed down speed. If the action of any of the components interrupts the path to RC "A" terminal, the pump will not stroke and the rotary head will not feed down.

7.13 - EHC OPERATION

Feed Controller (HP)

The Feed Controller is different on High Pressure drills than from those on low-pressure drills. Like the LP controller, the HP feed controller also has two terminal strips. It is different, however, in that it has an additional micro switch connected to the circuit board. (See Figure 7.13–11)



FEED CONTROLLER With HOLDBACK FEATURES

Figure 7.13– 11

The first terminal strip provides access to the “+”, “–”, “A”, “X”, “B”, and “R” terminals. The “N” and “D” terminals indicated on the schematic are actually micro switches located on the circuit board side of the controller. The “D” micro switch makes it different from the ones in the previous discussion. When the handle is moved toward the operator, NO contact “D” within the micro switch is actuated. This energizes wire number 81. When terminal “D” is energized, 24 VDC current flows through wire # 81 to the coil of the holdback solenoid operated control valve. When the solenoid operated valve coil is energized, the hydraulic Holdback circuit is functional.

The second terminal strip is mounted on the side of the RC and it provides access to terminals 7, 8, and 9. These connect to a micro switch that is switched by a button in the end of the RC handle. Terminals 7 and 9 are a (NC) normally closed pair. Terminals 7 and 8 are a (NO) normally open contact pair.

On high-pressure drills used for “DHD” drilling, the feed system requirements are different than those of an LP low pressure “Rotary” drill. The additional terminal and switches interact with the “Holdback” control circuit. These controls will be discussed in the “Holdback Control” section.

7.13 - EHC OPERATION

Drill Feed Force / No Bump Rod Changer (Option)

The EHC link for feed force control uses a rotary RC with a proportional DC output. The output range is from 100 to 500 mA.

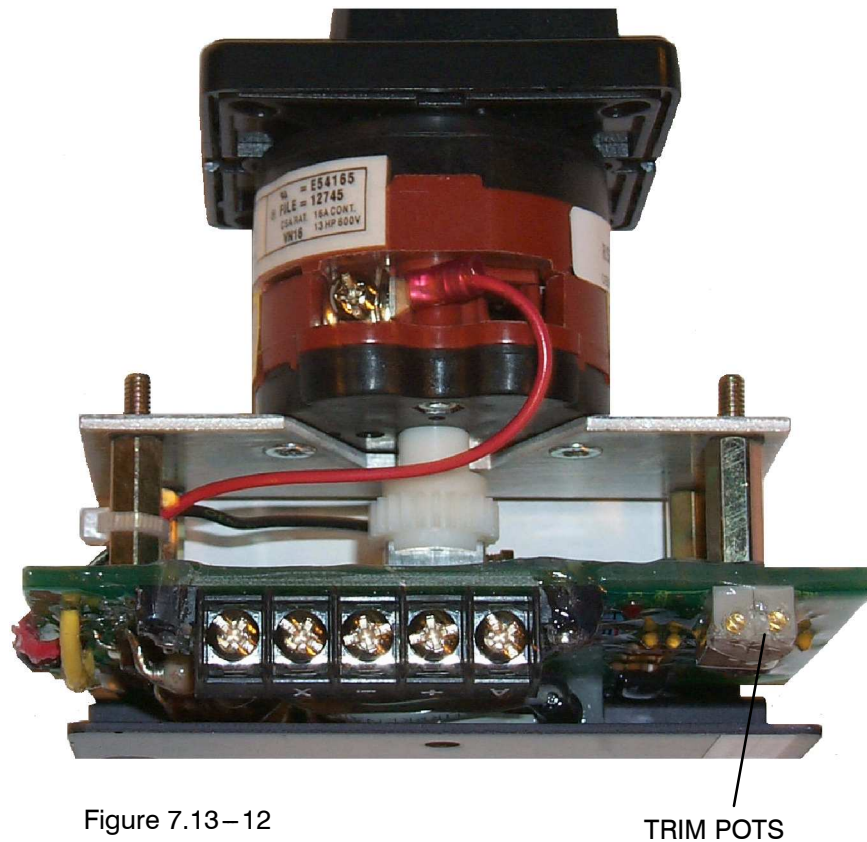
The RC receives 24 VDC from wire number 82. When the knob is turned from its off position, a proportional current flows from terminal “A” to the normally open contacts of (LS6) the Rod Support limit switch. If the Rod Support is stowed out of the way of the rotary head, the NO switch contacts close and allow RC output to drive the FEMA valve coil. Pressures from 400 to 4500 psi can now be commanded by the RC. (3500 psi maximum for 35 foot tower drills).

On Mid-Range Drill Series drills that are equipped with the No Bump Rod Changer option, the NC contacts on the carousel limit switch (LS4) are connected between the NO BUMP resistor (located in operators console) and the FEMA valve coil. The other end of the resistor is connected to 24 VDC from wire 82. If the carousel is loading a rod, the switch is in the “normal” position and current from the resistor is supplied to the FEMA coil. The resistor can be adjusted to limit maximum feed down pressure. This prevents the rotary head from feeding down with enough force to damage the carousel. If the carousel is out of the way of the rotary head, the NC contacts open and the current path through the resistor is disconnected from the FEMA coil.

7.13 - EHC OPERATION

Holdback Control (HP)

The EHC link for Holdback force control uses a rotary RC with a proportional DC output. The output range is from 100 to 500 mA. Also included in the Holdback circuit is a solenoid operated, two way valve. The two way valve ((See *FEMA PULLDOWN CONTROL*, Figure 7.12-5). is energized by a limit switch (terminal “D”, see electrical schematic Figure 7.13-5) on the feed controller. When the feed lever is moved in the feed down direction, the normally open limit switch immediately closes energizing wire #81. Wire 81 is connected to the solenoid operated two-way valve. When energized, the valve opens and the holdback function is enabled.



The Holdback rotary controller receives 24 VDC from wire number 82. When the knob is turned from its off position, a proportional current flows from terminal “A” to the FEMA valve coil in the “Holdback” circuit. As long as the Feed control lever is actuated in the feed down direction (toward the operator), the Holdback rotary controller can be used to affect the feed system bit loading.

As weight is added to the drill string, the operator must increase the holdback pressure to take weight off the bit.

7.13 - EHC OPERATION

Rotation Control

The EHC link for Rotation Pump Control uses a proportional, single coil RC with a neutral safety lock and dual range control switch. (See Figure 7.13-13). The RC output is a proportional DC current signal, not a PWM current signal. The Drill/Propel selector switch must be set to the “DRILL MODE” before the rotation controller will function.



Figure 7.13-13

TERMINALS 7, 8, 9

The rotation control RC has two terminal strips. The first strip provides access to the “+”, “-”, “A”, “X”, “B”, “R” terminals. Terminal “N” is located on a micro switch located on the circuit board side of the controller. It is used for neutral start protection and is a spade connection on the circuit board.

The second strip is mounted on the side of the RC and it provides access to terminals 7, 8, and 9. These connect to a micro switch that is switched by a button in the end of the RC handle. Terminals 7 and 9 are a (NC) normally closed pair. Terminals 7 and 8 are a (NO) normally open contact pair.

The normal mode for the rotation speed RC is the high range mode. The NC contacts 7 and 9 switch 24 VDC from the RC “+” terminal to the “R” terminal to shift the control into high range. If the button on the end of the controller is pressed, the NC contacts 7 and 9 open and interrupt power to the “R” terminal. This shifts the control into low range mode. The high range mode allows a proportional DC current signal from about 60 milliamps to 300 milliamps (no pump stroke to full pump stroke). The low range allows a proportional DC current signal from about 60 milliamps to about 100 milliamps (no pump stroke to about 1/16 pump stroke). In the low range, full RC handle movement corresponds to a change of only 40 mA that gives a finer control for more precise alignment of the drill steel flats with the breakout fork. The actual maximum low range speed can be adjusted with the “low range” pot on the RC circuit board.

7.13 - EHC OPERATION

Torque Limit Control (Option)

The EHC link for Torque Limit Control uses a rotary RC with a proportional DC output. The output range is from 100 to 500 mA (Same part # as Pulldown and Holdback).

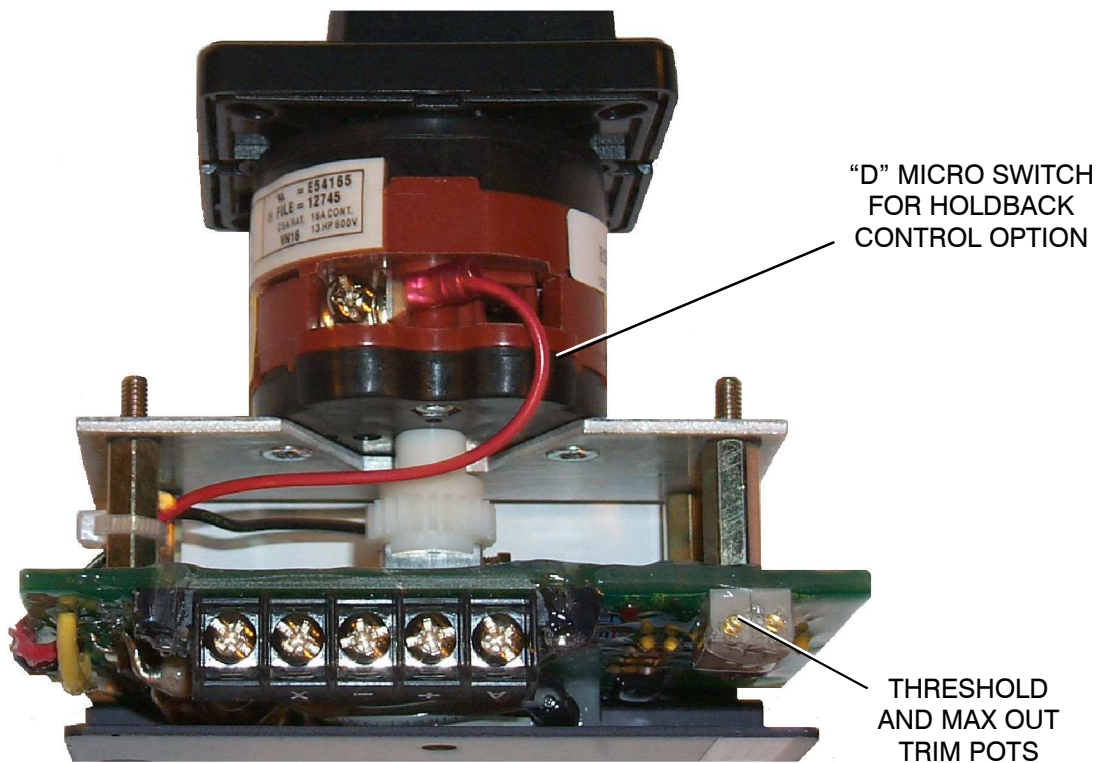


Figure 7.13–14

The RC receives 24 VDC from wire number 82. When the knob is turned from its off position, a proportional 24 VDC signal flows from terminal "A" to the FEMA valve coil in the "Torque Limit" circuit. As long as the Rotation lever is actuated in the forward rotation direction (toward the operator), the torque limit rotary controller can be used to affect (raise or lower) the rotation system torque force. Turning the knob to the right increases the torque force available in the rotation circuit.

7.14 - EHC ADJUSTMENTS

EHC ADJUSTMENTS

Feed and Rotation Controllers

The Mid-Range Series drills with (low-pressure) LP compressors used for rotary drilling use the same type controller for both the “Feed” and “Rotation” functions. The feed and rotation controllers are only energized when the machine is in the “DRILL” mode. The feed and rotation controller is shown in Figure 7.14-1. These controllers are located on the Drill Functions Panel of the operators console (See Section 4 *Operating Controls* For Panel Location) and are used to control the main pumps during the drilling operations.

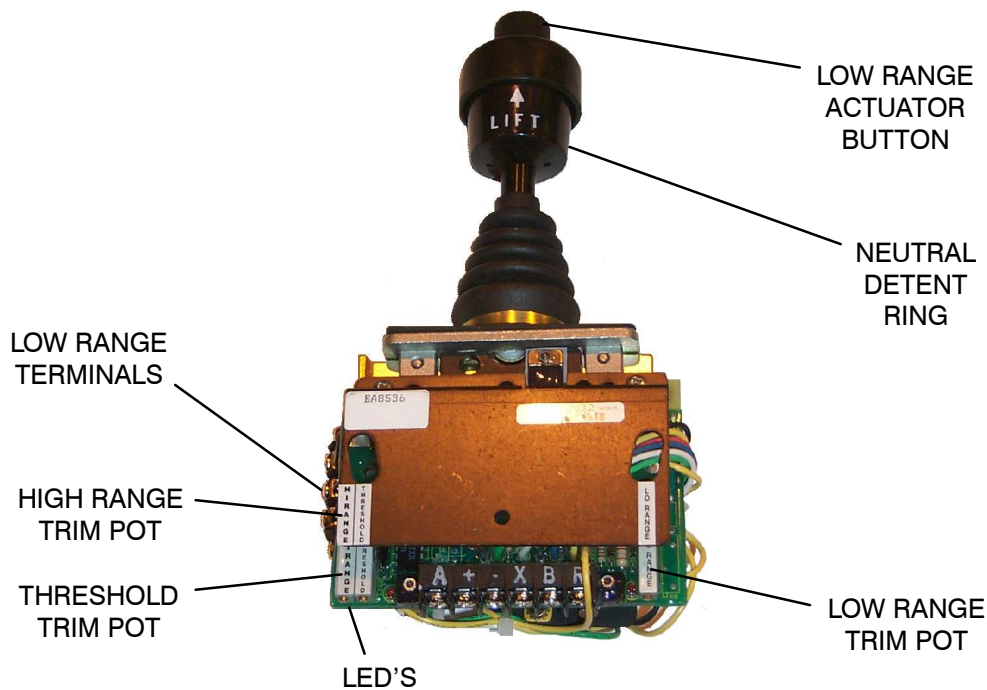


Figure 7.14-1

On HP (High-Pressure) drills, the “Feed” controller has an additional micro-switch for “Holdback” functions, and it works in conjunction with the “Holdback” regulator.

These controllers are electrical devices that send an output current of 60-300 milliamps to the Denison 500 stroker. The electrical output current is proportional to the degree of movement of the control lever. The farther the lever is pushed in either direction, the higher the current signal to the pump stroker. The result is a machine that operates smoothly while providing the operator with proportional actuation of the hydraulic functions used for drilling.

7.14 - EHC ADJUSTMENTS

Feed and Rotation Controllers (continued)

The Feed and Rotation controllers must be adjusted at installation.

Tools required:

- a.) 1 Phillips screwdriver for opening control panel
- b.) 1 Slotted screwdriver for removal of wires from terminal strip
- c.) 1 Ammeter with milliamp readings
- d.) 1 Trim Pot screwdriver

On the Mid-Range Drill Series, two identical controllers are used for controlling the track functions while in the tramming mode. The controller used is shown in Figure 7.14-2.

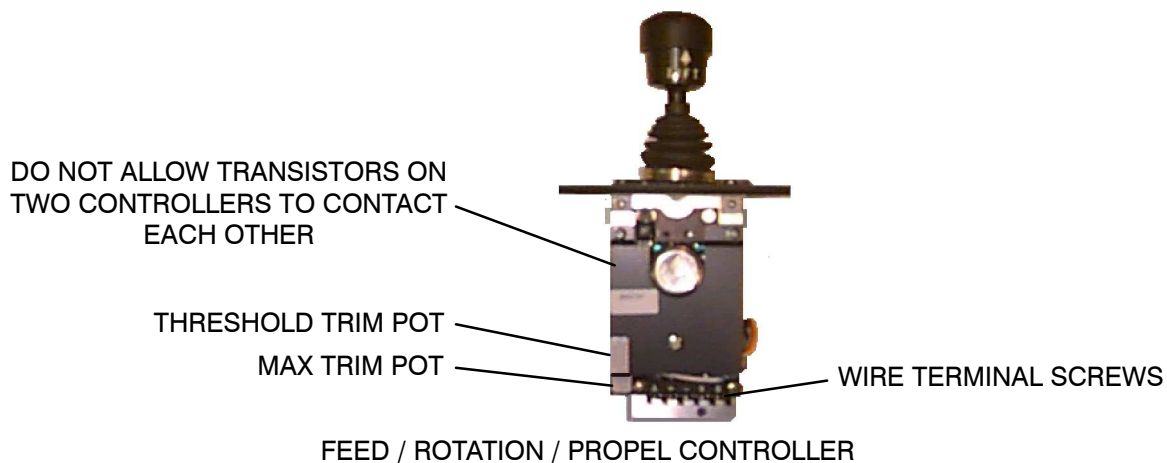


Figure 7.14-2

The instructions for adjustment of the "Feed" and "Rotation" controllers are as follows:

1. Start the procedure with the engine "OFF", key switch "ON", and the Drill/Propel selector in "DRILL" position.
2. Remove "B" wire from controller terminal strip and splice an ammeter between the controller and the "B" wire (red lead to "B" and black lead to open wire).
3. Pull remote control handle slightly on stroke (until a faint click is heard). Set "Threshold" pot to 60 milliamps. Friction hold should keep the controller on stroke.
4. Pull remote control handle fully on stroke and set the "Hi range" pot to 300 Milliamps.
5. With remote control handle still fully on stroke, push and hold the "Low Range Actuator Button" (See Figure 7.14-1). Set the Low Range pot to 100 milliamps.
6. Remove the meter and reconnect the wire to the "B" terminal.

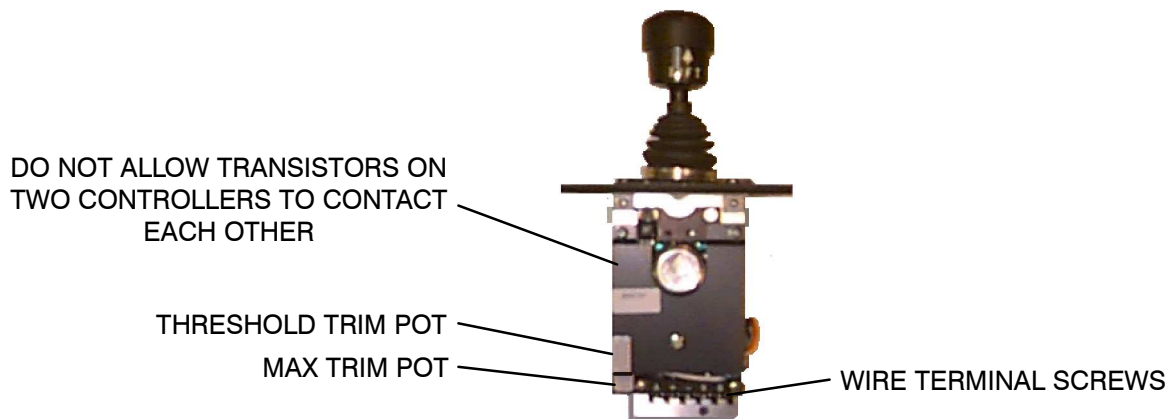
7.14 - EHC ADJUSTMENTS

Propel Controller Adjustment

Adjustment of the Propel Controllers is described in the following steps:

1. Start with engine "Off", Key switch in the "On" position and Drill/Propel selector in "PROPEL" mode.
2. Remove "B" wire from controller terminal strip and splice an ammeter between the controller and the "B" wire (red lead to "B" terminal and black lead to the open wire).
3. Pull remote control handle slightly on stroke (until a faint click is heard). Set "Threshold" pot to 60 milliamps. Lever will have to be held on stroke because the controller is spring returned to center.
4. Pull remote control handle fully on stroke, hold and set "Max" pot to 300 Milli-amps.
5. Remove the ammeter and reconnect the wire to the "B" terminal.

NOTE: These controllers are mounted very near to one another. When installing, care should be taken to ensure that the two controllers cannot make contact with each other. If they contact each other they will not function, or may be sporadically inoperative.



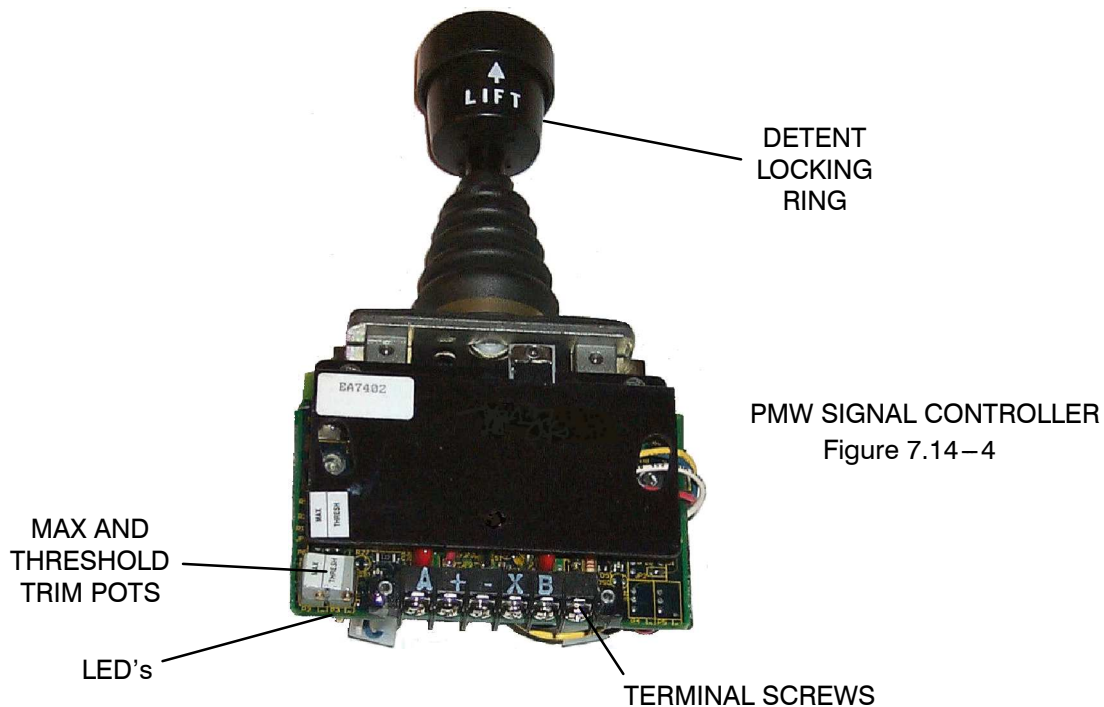
FEED / ROTATION / PROPEL CONTROLLER

Figure 7.14–3

7.14 - EHC ADJUSTMENTS

Auxiliary Function Controllers

On the Mid-Range Drill Series, there are up to fifteen auxiliary functions that are powered by the Apitech Electro-hydraulic control valve. The Apitech valve is actuated by the drill operator through the use of electrical controllers. The Apitech Pulsar is not designed for use with a constant 24 VDC current signal. Therefore, the controllers used on the Mid-Range Drill Series are either Pulse Width Modulated (PWM) current signal, or spring returned to neutral ON/OFF controllers. The controller shown in Figure 7.14-4 is a PWM signal controller. It also is spring returned to neutral and has a locking detent to prevent unintentional actuation.



The controllers must be adjusted at installation. This adjustment is accomplished by setting the “Threshold” and “Max” voltage pots. Adjust the pots as follows:

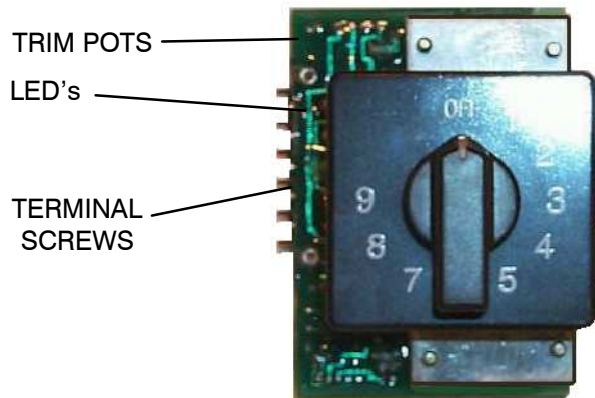
1. Slightly pull the lever on stroke in either direction, until a faint click is heard and hold.
2. Adjust the “Threshold” pot until the function being actuated just begins to move (i.e. Chain Wrench cylinder just starts to move). LED on the card should be just flickering. This is an indicator of the “On Time” and “Off Time” of the PWM signal.
3. Pull handle to full stroke. Adjust the “Max” pot until the LED is constantly “On”.

The controller voltage output should now be proportional to the lever movement, from the “Threshold” to “Max”. The speed and some characteristics of each function can be adjusted in this manner to suit the preferences of the operator.

7.14 - EHC ADJUSTMENTS

Auxiliary Function Controllers (continurd)

Figure 7.14-5 shows one rotary controller (Water Injection) on the console that controls an Apitech valve section. While it looks virtually the same, this controller is electronically different from the rotary type controllers that control the feed system.



WATER INJECTION
ROTARY CONTROLLER
Figure 7.14-5

The Water Injection controller uses a PWM signal to proportionally control the water injection pump. This gives the drill operator the ability to control the speed and flow volume of the water injection pump. This RC is adjusted in the same manner as the lever operated RC's only it is operated with a rotary knob rather than a lever. Turn the RC on till a faint click is heard and set the "Threshold" to approximately 60 mA. Then turn the knob to "Full On" position and adjust the "Max" pot to the point where the LED is constant and bright. This provides the proportional control desired. Minimum output can be adjusted to suit the operator or drilling condition.

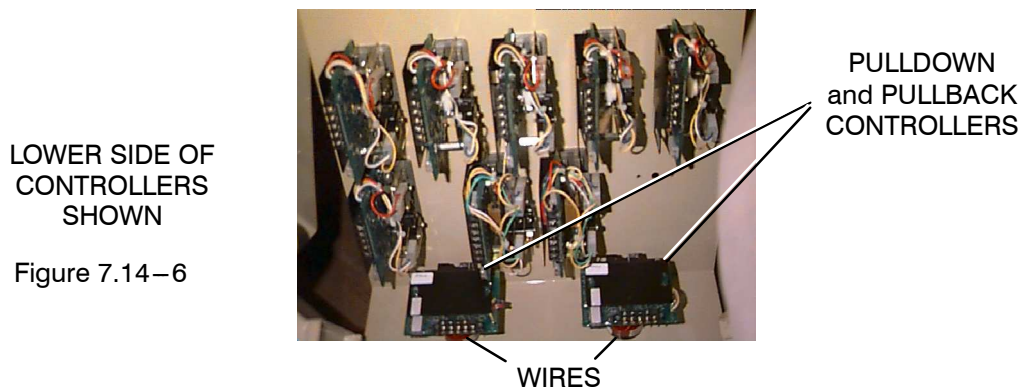


Figure 7.14-6

The Feed system rotary type controllers (Pulldown and Holdback) are 24 VDC proportional controllers. The Feed system controllers, shown in Figure 7.14-6, can be visually differentiated from the Water injection controller by the presence of a red and black wire that runs from the circuit board to the mount (knob) end of the controller. The Water Injection RC has no wire.

7.14 - EHC ADJUSTMENTS

Pulldown Force Rotary Controller

Machines used for rotary drilling have one rotary type controller in the feed system. It is used by the operator, in conjunction with the Feed lever, to adjust the Pulldown force or weight on the bit while drilling. Turning the knob to the right increases feed force. When replacement is required, the controller current output will require adjustment.

Tools needed for adjustments:

- a.) 1 (one) 24 VDC Voltmeter (can be used if desired)
- b.) 1 Phillips screwdriver to open console
- c.) 1 Slotted screwdriver to remove wires from terminal (for controller replacement)
- d.) 1 trim pot screwdriver

Adjustment of the Pulldown Force rotary controller is done as follows:

1. Start the adjustment with the engine running at high idle, machine in the “Drill Mode”, and the rotary head against the lower feed stops.
2. With the Pulldown rotary controller in the “OFF” position, pull the Feed system Main pump controller downward.
3. Turn the Pulldown Force rotary controller to the “ON” position until a faint click is heard.
4. Turn the “Threshold” trim pot until the Pulldown gauge reads 400 psi maximum. If the minimum Pulldown pressure is higher than 400 psi, back out on the “Threshold” trim pot until it reads 400 psi.
5. Turn rotary controller knob to its maximum position. If Max prescribed Pulldown pressure is not reached, adjust the “Max” pot clockwise until the proper maximum pressure is reached.
6. If the Pulldown pressure control is proportional to the knob movement, the adjustment is complete.

Drills equipped with (HP) high-pressure compressors for DHD drilling will have two rotary type controllers in the feed system. One is the Pulldown controller, as described above, and the other is a Holdback rotary controller.

7.14 - EHC ADJUSTMENTS

Holdback Rotary Controller

DHD operations require operating the drill with a limited and specific amount of weight on the bit. Holdback control allows the drill operator to control the amount of weight on the bit as more pipe is added to the drill string. When a drill pipe is added, the operator can offset the weight of the new pipe by increasing the Holdback setting. The Holdback rotary controllers should be checked for proper operation at installation.

To Verify Holdback Function:

1. Turn the "Pulldown" rotary controller "Off".
2. Turn the "Holdback" controller "On".
3. Start the engine.
4. Pull the Feed lever to the down direction.
5. The rotary head may begin to move downward due to the main pump charge pressure. (Approximately 250 psi.)
6. Turn the Holdback regulator to the right to increase the setting until the head stops moving downward.
7. Refer to the Holdback gauge to see if Holdback pressure rises as the knob is turned to the right and as the head slows to a stop. Pressure seen on the Holdback gauge will show the weight of the rotary head, drill pipe, subs and bit. Once the rotary head stops, turning the regulator more will not increase the pressure. Reducing the Holdback setting allows the operator to apply more weight on the bit while drilling.

7.14 - EHC ADJUSTMENTS

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7.15 - TROUBLESHOOTING (DUST COLLECTOR)

DUST COLLECTOR

If, upon inspection of your dust control system, it is obvious that the unit is not operating properly, the following discussion should help you to troubleshoot the problem.

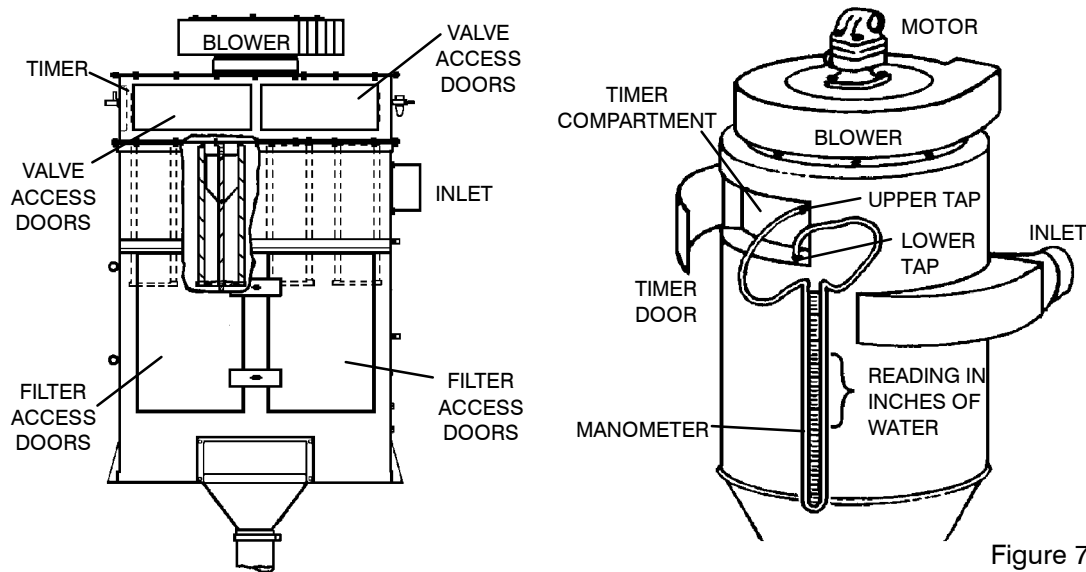


Figure 7.15-1

All problems with the dust collector system can be isolated through the use of a water manometer. Measurements should be made separately on the upper and lower vacuum taps located on the dust collector housing. Depending on whether your readings are higher or lower than the normal values, the following explanations will apply.

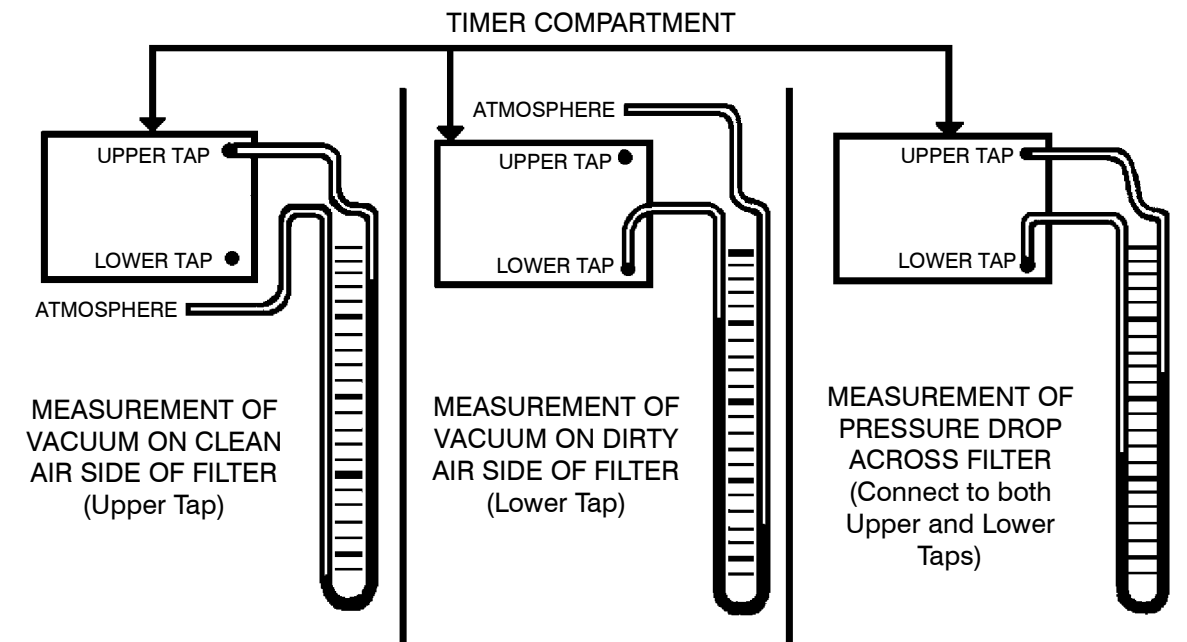


Figure 7.15-2

7.15 - TROUBLESHOOTING (DUST COLLECTOR)

Upper Tap HIGH - Lower Tap LOW

This situation indicates that the blower assembly is being “choked off”, causing the vacuum in the clean air section to go up. The fact that the area around the filter elements (lower tap) is low indicates that air is not moving through the filters (i.e. plugged filter elements). The main reason that this occurs is failure of the back-pulsing system of pulsed air. Three probable causes are:

1. The incoming air pressure is too low. This pressure should be maintained at about 40 psi. Insert a gauge at the point where air enters the dust collector to make your measurement.
2. The pneumatic or electric timer could be malfunctioning. Check the timer to see that each station is being fired at a timer interval of about 2-3 seconds between stations.
3. Impulse valves over the filter elements may themselves be faulty. If one of the diaphragms of the impulse valves develops a hole or a rock becomes lodged in the valve causing the diaphragm to seat improperly, the compressed air may never be allowed to build up to the required 40 psi pressure and/or the valve may not fire properly. Also, for electric systems, the electric-air solenoid valve operating the impulse valve may be faulty.

Upper Tap HIGH - Lower Tap HIGH

This situation indicates that the system is being “choked off” prior to the filter elements. This generally results from a plugged suction hose due to the build-up of dirt and mud or obstruction by a foreign obstacle such as a shot-sack.

Upper Tap LOW - Lower Tap LOW

This condition points to a loss in suction capacity. The primary concern here is fan speed. The fan may be turning below the suggested 3000 rpm because of a problem in hydraulic oil supply (or the air supply in the case of an air motor). Another situation often occurs when the motor is changed out or repaired. The motor may be reconnected incorrectly to cause the blower wheel to turn in a reverse direction. When this happens, a vacuum will be produced and some air flow will occur. The best way to verify proper rotation of the wheel is to observe it visually upon startup or shut down. The blower wheel should turn clockwise when viewed from the top looking down at the dust collector.

As a final comment, one should note that the dust collector fan should be run as close to 3000 rpm as possible. Although the fan can easily tolerate higher speeds and the system will indeed pull more air at higher speeds, operating the system at such speeds can cause unnecessary wear of filter elements, dust collector housing and suction hose.

7.15 - TROUBLESHOOTING (DUST COLLECTOR)

Dust Collector Trouble Shooting Guide

Dust Collector Trouble Shooting Guide				
Manometer Reading		Indication	Cause	Cure
Upper	Lower			
HIGH	LOW	Loss of suction. High reading across filter.	Plugged Filter	Check Pulse Air (Faulty timer, impulse valves or low pressure)
HIGH	HIGH	Loss of suction. Reading of zero across filter.	Plugged Hose	Clear air path
LOW	LOW	Loss of suction	Low fan speed. Fan runs backwards. Dump hose missing.	Adjust hydraulic flow. Check hydraulic hookups. Replace dump hose.
HIGH	HIGH	Poor Filter Life	Fan speed too high	Reduce hydraulic flow to fan motor.

Excess Dust

Dust Escaping Around Dust Collector		
Problem	Action	Correction
Damaged Dust Skirt	Visual Check	Repair or Replace Dust Skirt
Rod Seal Missing or Damaged	Visual Check	Replace Rod Seal
Suction Dust from Dust Collector Plugged	Visual Check for Dust Buildup in Duct	Check Fan Speed. Low Air Volume Will Not Carry Dust. Clean Duct.
Suction Dust From Drill To Dust Collector Leaking	Visual Check For Holes In Duct Work Or Leaking Joints	Repair Or Replace As Required
Dust Skirt Not Touching Ground To Form Seal	Visual Check	Dust Skirt Should Be Modified To Seal On All Sides
Dust Discharge Box Plugged	Remove Dust Discharge Box	Clean Out Dust Discharge Box
Dust Discharge Flap Damaged	Remove Dust Discharge Box And Inspect	Repair Or Replace Dust Discharge Box
Dust Collector Hopper Plugged	Open Door	Clean Out
Filters Dirty	Remove Filters And Inspect For Dirt Inside Of Cartridge	Clean With Compressed Air Or Replace With New Filters
Top Of Dust Collector Full Of Dust	Visual Check	Clean Out. Check Filters For Holes. Check To See That Filters Are Properly Installed And Wing Nuts Are Tight.

7.15 - TROUBLESHOOTING (DUST COLLECTOR)

Fan Dust

Dust Discharging From Fan		
Problem	Action	Correction
Filter Leaking	Remove Filter. Check For Holes With A Light.	Replace Filters And Clean Out Top Section.
Filter Seal Leaking	Check Seal On Filter	Clean Seal and Tighten Wing Not

Pulse

Pulse Not Functioning Properly		
Problem	Action	Correction
Air Bleeding From Solenoid	Check Solenoid Exhaust Port	Check That Timer Is Sequencing Properly. Repair If Necessary. Replace Solenoid.
Pulse Valve Blowing Continuously	Check Solenoid Exhaust Port	Same As Above
No Pulse	Check Power To Timer	Repair Power Source. Replace Timer.

Setting the Electric Timer

There are three (3) switches on the DET-9000 timer that control the “First Out” and “Last Out”. A flathead screwdriver can be used to set each switch to a digital value from 0 to 9. The procedure is as follows:

1. The “OFF TIME” switch controls the amount of time between pulses. A value of 0 represents On/Off time of 0.5 seconds. Each step after adds 0.5 seconds, with step 9 representing the maximum value of five (5) seconds.
2. The “FIRST OUT” switch should be set to the station number of the first solenoid that is to be activated. A value of 0 is not allowed and will cause the yellow error lamp to blink on and off.
3. The “LAST OUT” switch should likewise be set to the last station number to be activated. If there are four filter elements in the dust collector and the first solenoid is connected to station 1, then the “LAST OUT” switch should be set to 4. Once again, 0 is not allowed.
4. If power is on when any adjustments to the above switches are made, then the reset push button must be pushed before the adjustments will take place.

7.16 - TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

GENERAL INFORMATION

Retain this information for reference. If additional information is needed, supply model and serial numbers stamped on the nameplate.

1. The pump should be located where there is sufficient space around and above the unit for raising pump to change lubricant drum or to make adjustments.
2. The time controller should be located adjacent to the pump and it should be accessible for adjustments. The length of connecting air and lubricant hoses limits the spacing between the pump and the time controller.
3. Connect air supply line to the 3/8" NPT female inlet of the solenoid air valve. Connect air hose from pump to the 3/8" NPT elbow at the back side of solenoid air valve. Connect the lubricant delivery hose from pump to the 3/4" NPT female inlet at the bottom of the junction block.
4. Install lubricant supply line to system into the 3/4" NPT female outlet of the junction block.
5. Finally, install electric power supply to time controller.

Principle of Operation

The pump is operated by the time controller (see figure 7.16-1). The timer closes the electric circuit to the solenoid air valve. The solenoid air valve opens and permits air to pass through the air hose, operating the pump and closing the vent valve.

The pump continues to operate until the lubricant pressure in the supply lines is sufficient to operate the injectors. After the injectors operate (discharge lubricant to bearings), the pump continues to build up pressure in the supply lines until there is sufficient pressure to open the pressure switch.

The opening of the pressure switch breaks the electric circuit to the solenoid air valve, which shuts off air supply to the pump. At the same time the lubricant pressure opens the vent valve and allows the supply line pressure to vent back into the lubricant drum. The injectors automatically reload and the system is ready for next lubrication period.

7.16 – TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

Typical System Drawing

The drawing shown below is the actual manufacturer's drawing used for descriptive purposes.

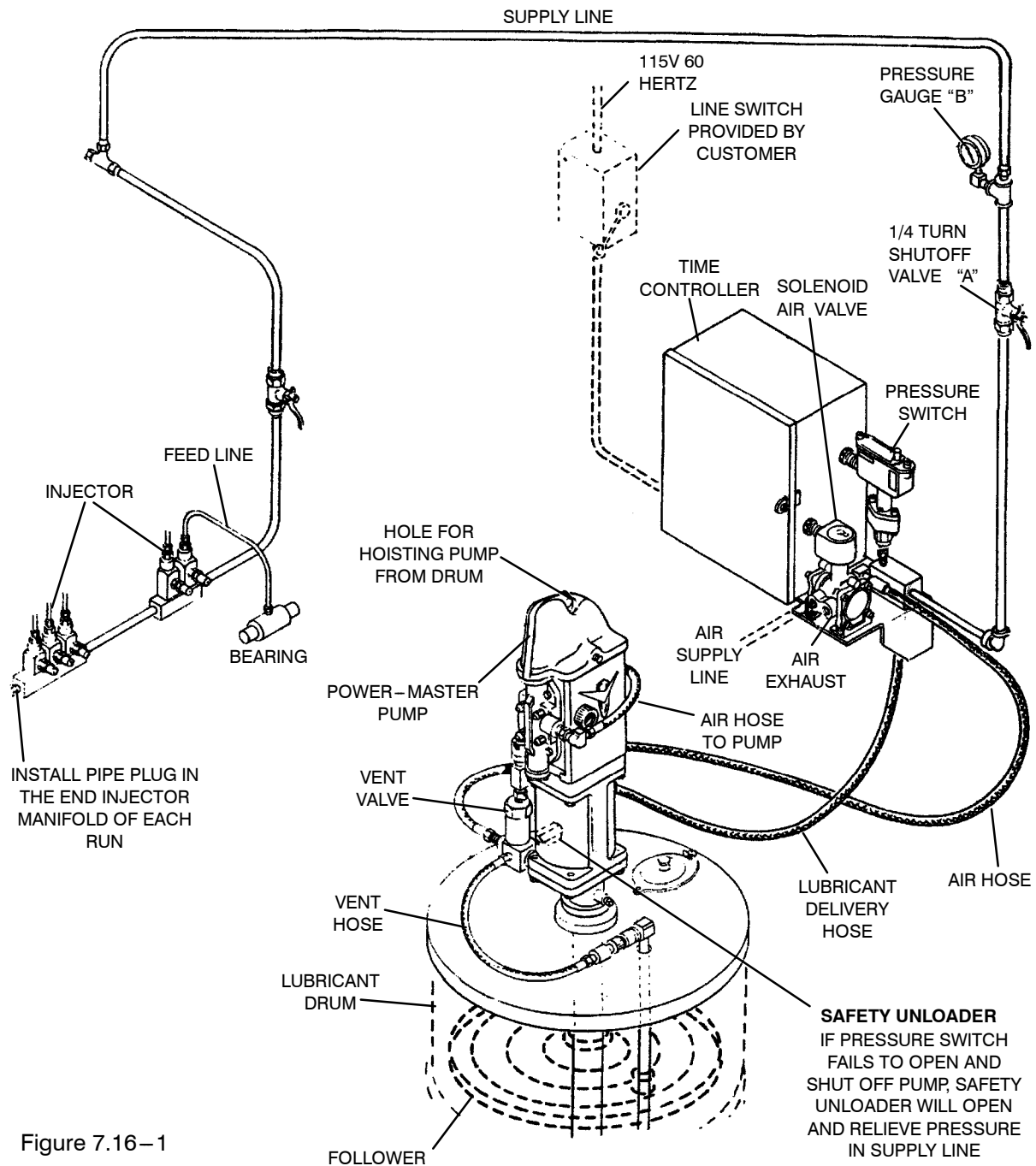


Figure 7.16-1

7.16 – TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

Fill Supply Line

Refer to Figure 7.16-1 for additional information.

1. Remove pipe plugs from the injector manifold at the end of each run.
2. Set time delay relay to maximum position.
3. Place timer toggle switch in “A” position.
4. Close line switch to start pump.
5. Pump in operation will charge supply line with lubricant.
6. When lubricant begins to flow from the open end of injector manifold (injector farthest from pump), open line switch to shut off pump.
7. Replace pipe plugs in all injector manifolds.
8. Re-adjust time delay relay to desired delay interval.

Prime Feed Lines

Operate the pump by rotating program disc clockwise by hand through one clip. Repeat several times to be sure each injector is operating.

Operation Check

1. Open shut-off valve “A” which should be installed in the supply line adjacent to the pressure gauge and pump as illustrated in Figure 7.16-1. Start pump as above. Allow the pump to operate until the supply line pressure builds up to about 2500 PSIG (for high pressure units) as indicated on the pressure gauge “B ” or 850 PSIG (for low pressure units).
2. Close the shut-off valve “A” and this will trap the lubricant pressure in the supply line. Each individual injector can now be inspected for the correct discharge position of the indicator stem.

Note:

Pressure reading on the pressure gauge should remain constant after the shut-off valve is closed. A pressure decline on the pressure gauge indicates a leak in the supply line. After the system has been checked, open the shut-off valve and the system is ready for the desired lubrication cycles.

Set timer to program the lubrication cycle frequency.

7.16 - TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

Attach Air Motor to Pump Tube

1. Tightly connect air motor coupling nut to the pump plunger.
2. Attach the air motor to the pump outlet body flange with the four bolts & nuts (hand tight) supplied with air motor.
3. Slowly cycle the pump several times by using just enough air pressure to operate the pump without stalling.
4. Stop the pump on an “up” stroke and tighten the four bolts & nuts to securely fasten the air motor to the pump tube.

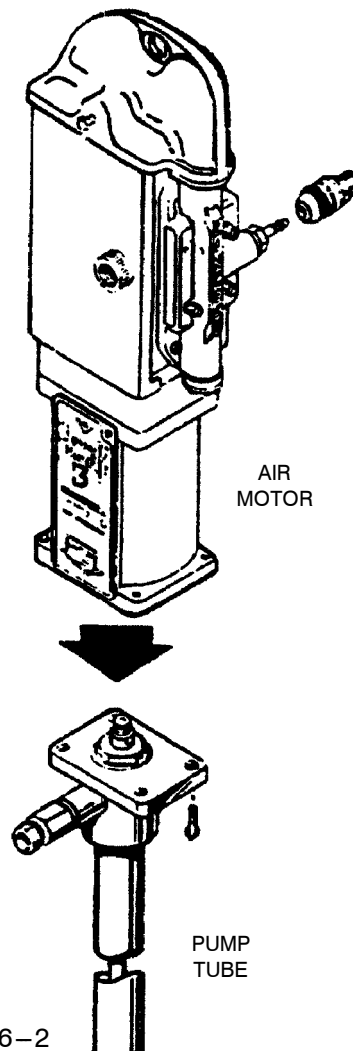


Figure 7.16–2

7.16 - TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

Failures without Alarm Systems

TIME CONTROL FAILURES (for systems WITHOUT an alarm system)	
System Failure Symptoms	Possible Cause
Pump does not start with selector switch in position "A" or "B".	1. Faulty Control Relay. 2. Faulty Time Delay Relay. 3. Switch Arm held down at all times. 4. Faulty "A" – "B" Selector Switch. 5. Faulty Timer Switch. 6. Faulty Pressure Switch.
Pre-lube cycle normal with selector switch in position "A" but no timed function occurs with selector switch in either position.	1. Faulty Timer Motor. 2. Switch Arm is not fully depressed. 3. Faulty Timer Switch. 4. Dial clips not positioned in inner groove.
No operation with selector switch in position "A", normal operation with selector switch in position "B".	1. Jumper wire at terminals 5 and 6 removed. 2. Faulty Control Relay. 3. Faulty Selector Switch.
No operation with selector switch in position "B", normal operation with selector switch in position "A".	1. Faulty Control Relay. 2. Faulty Pressure Switch. 3. Faulty Selector Switch.
Repeat cycle with selector switch in either position.	1. Faulty Control Relay.
Repeat cycle with selector switch in position "A" only or in position "B" only.	1. Faulty Pressure Switch. 2. Faulty Control Relay.

SYSTEM FAILURES (for systems WITHOUT an alarm system)	
System Failure Symptoms	Possible Cause
Pump fails to start.	1. System pressure does not vent.
System does not reach full pressure.	1. Pressure Switch set too low. 2. Faulty Pressure Switch.

Failures with Alarm Systems

TIME CONTROL FAILURES (for systems WITH an alarm system)	
System Failure Symptoms	Possible Cause
Pump fails to start.	1. Faulty Time Delay Relay.
System does not reach full pressure.	1. Faulty Time Delay Relay. 2. Time Delay Relay set too fast.

7.16 - TROUBLESHOOTING (CENTROMATIC LUBE OPTION)

Failures with Alarm Systems (continued)

SYSTEM FAILURES (for systems WITH an alarm system)	
System Failure Symptoms	Possible Cause
Pump fails to start.	1. Faulty Air Solenoid Valve. 2. Insufficient air pressure. 3. Faulty pump motor.
System does not reach full pressure.	1. Faulty pump. 2. Insufficient air pressure. 3. Pump has lost its prime. 4. Open Safety Unloader. 5. Broken or leaking lube supply line. 6. Pressure Switch set too high or faulty Pressure Switch.

7.17 - ENGINE HEATER

INTRODUCTION

This section is provided to present an overview of the engine block heater system currently used.

The preheater will preheat an engine block to ensure reliable starting in cold weather. At the same time it may be used throughout the year to reduce the wear associated with cold starts.

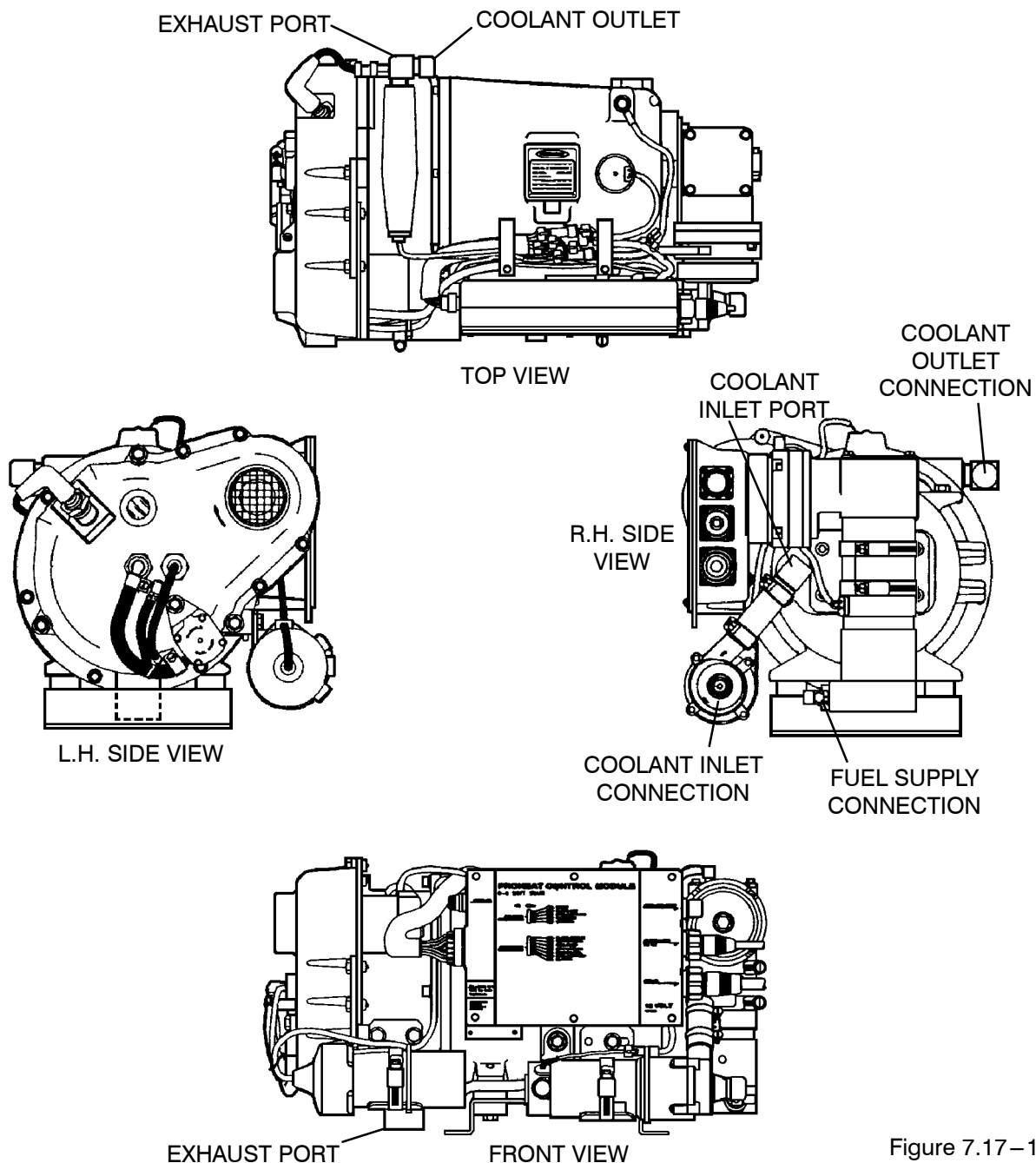


Figure 7.17–1

7.17 - ENGINE HEATER

TECHNICAL SPECIFICATIONS

Model	Heat Rating BTU/hr. (kw)	Volts Nominal (range)	Current Amps	Fuel Rate Gal/hr (l/hr)	Coolant Flow Gal/min (l/min)
X45-12	45,000 (13.0)	12 (10.0-15)	7.5	.32 (1.2)	8.0 (30)
X45-24		24 (20-30)	3.75		

⚠ WARNING

DO NOT use gasoline

Ignition Type: ----- Electronic spark ignition

Fuel Types: ----- Diesel #1, #2, Kerosine

Coolant Temperature:----- 150° to 185°F (65° to 85°C) @ heater

Enclosure Dimensions: ----- 12.5W x 11H x 20.5L inches
(318W x 280H x 521L mm)

Weight, Heater only----- 40 lbs. (18 kg)

Weight, with Enclosure: ----- 55 lbs. (25 kg)

Operating Temperature Range: ----- -40° to 122°F (-40° to 50°C)

Heat Exchanger Capacity: ----- 1 quart U.S. (0.97 liter)

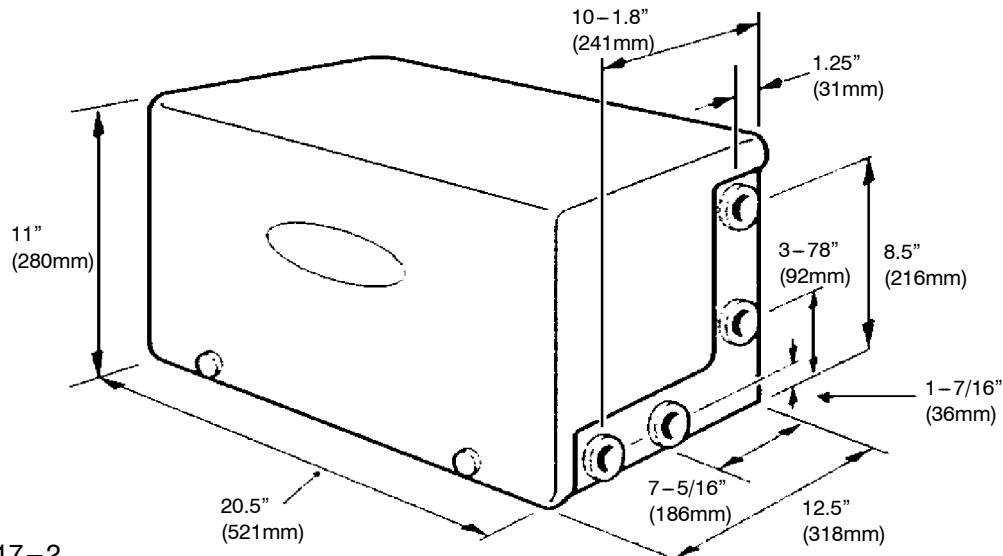
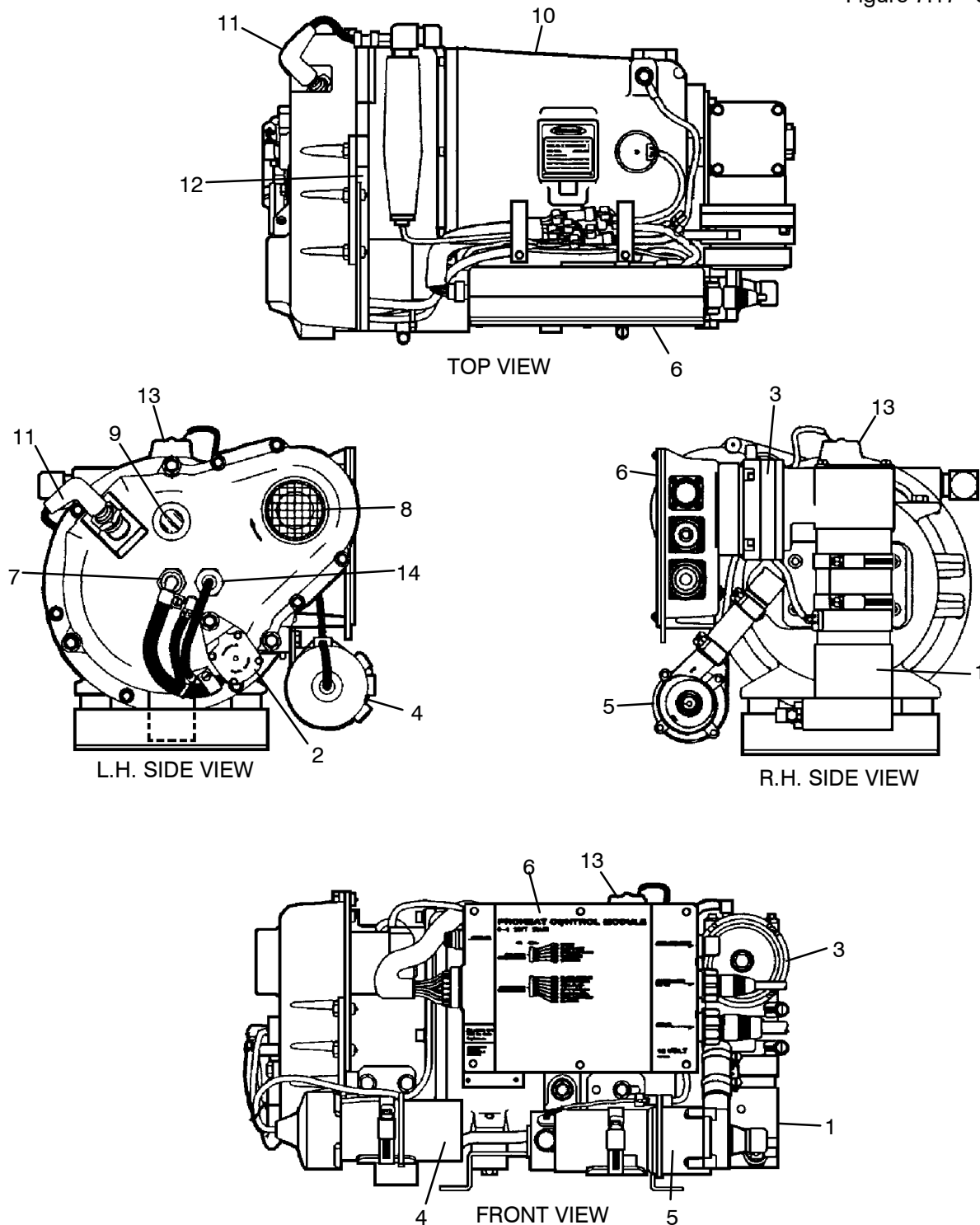


Figure 7.17-2

7.17 - ENGINE HEATER

PRINCIPAL OF OPERATION

Figure 7.17–3



7.17 - ENGINE HEATER

PRINCIPAL OF OPERATION (continued)

1. Fuel Pump

A gear pump driven from the same motor as the compressor pulls fuel from the tank. The fuel is filtered at the fuel pump inlet. The gear pump will develop a maximum pressure of 10 psi on the outlet side of the pump (figure 7.17-3).

2. Fuel Regulator

Reduces fuel to atmospheric pressure. Siphoning action from the nozzle draws fuel from the regulator. Without this siphoning there is no fuel flow.

3. Air Compressor

A diaphragm type compressor supplies air to the fuel nozzle.

4. Ignition Coil

An automotive type ignition coil supplies high voltage to the ignition electrode, sparking to the combustion tube.

5. Coolant Pump

Circulates the engine coolant. An impeller style pump is used because of its low current draw and free flow during engine operation. **It is not self priming.** The pump must be flooded and the system must be purged of all air for it to operate. **(DO NOT run dry).**

6. PROHEAT Control Module (PMC)

Utilizes a microprocessor to monitor conditions and control outputs to the motors and sensors. It has powerful diagnostics to assist in troubleshooting. One of the key features is the diagnostic display on the front of the PMC which has LEDs to indicate function or component problems.

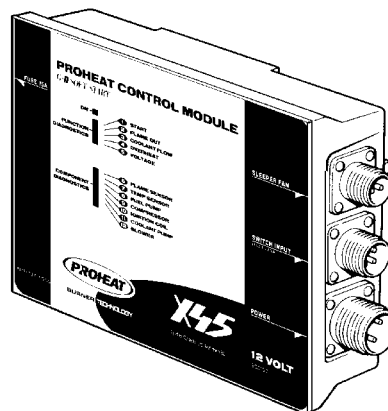


Figure 7.17-4

Note: The PCM is unique in that it uses “ground side” switching for the blower, compressor, coolant pump and ignition coil. The positive wire to the motors and ignition coil will show voltage even when the heater is switched “OFF”.

7.17 - ENGINE HEATER

PRINCIPAL OF OPERATION (continued)

7. Nozzle

An air/fuel aspirating type spray nozzle is located inside the housing. The compressed air flows through the nozzle at high speed creating a venturi effect. This siphons fuel from the regulator and combines it with the air, creating an extremely fine mist which is sprayed out of the nozzle into the combustion chamber. The nozzle determines the air/fuel ratio.

8. Blower

The blower uses an impeller type fan to supply approximately 90% of the combustion air at low pressure. It is also used to cool and purge the combustion chamber during the 3 minute shutdown sequence.

9. Inspection Port

The inspection port allows for visual inspection of the combustion process and is invaluable for reducing time spent on troubleshooting and servicing the heater.

10. Heat Exchanger

The heat exchanger is a two part cast aluminum housing. Coolant will typically rise 10° to 15°F (6°-8°C) in temperature as it passes through the heat exchanger, depending on the flow rate.

11. Ignition Electrode

The electrode is located near the nozzle just out of the air/fuel mixture path. During the ignition sequence the spark jumps the gap between the electrode and the combustion tube, igniting the air/fuel mixture. Spark duration is 60 seconds.

12. Coolant Temperature Sensor

The coolant temperature sensor measures coolant temperature at the outlet port of the heat exchanger.

13. Overheat Breaker Sensor

The overheat breaker sensor protects the heater from damage should it be operated without coolant. The overheat breaker monitors the surface temperature of the heat exchanger casting. When the temperature reaches 286°F (141°C) the breaker “trips out”. This shuts off the power to the air compressor, extinguishing the flame. The breaker can be reset by pushing down on the red button located under the rubber cap.

7.17 - ENGINE HEATER

PRINCIPAL OF OPERATION (continued)

14. Flame Sensor

The flame sensor photo-electronically measures the intensity of the flame. It is the flame sensor that signals to the PCM that the air/fuel mixture is burning properly.

15. On/Off Switch

The on/off switch is used to switch the heater “on” and “off”. It has an indicator lamp that displays a red light when switched “on”. A flashing red light indicates a heater diagnostic code and one of the LEDs on the PCM diagnostic display will be lit. **The “on/off” switch is not used on Drilling Solutions drills. A timer is used on Drilling Solutions drills.**

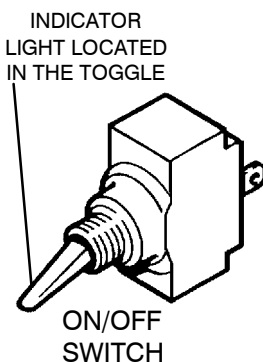
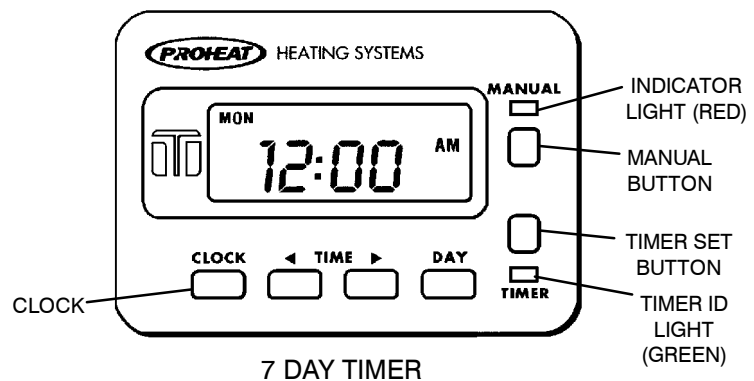


Figure 7.17–5



16. Seven (7) Day Timer

The 7 day timer is used to switch the heater “on” and “off” (figure 7.17–5). This can be done manually or by a preset time and day. It has an indicator lamp that displays a red light when switched or timed “ON”. A flashing red light indicates a heater diagnostic code and one of the LEDs on the PCM diagnostic display will be lit (See *Normal Operating Sequence* for details).

7.17 - ENGINE HEATER

NORMAL OPERATING SEQUENCE

1. Switch “ON”

The timer lamp (or the on/off switch if used) and the PCM “ON” LED will light. The heater goes to “Precheck”.

2. Precheck

The PCM performs a short diagnostic cycle. This takes several seconds, checking components for proper ranges, short circuits and open circuits. If there are no errors indicated, the heater goes to “ignition”.

3. Ignition

The blower starts first, followed by the coolant pump, ignition spark, air compressor and fuel pump. The ignition electrode sparks, 60 seconds maximum, until the flame sensor “sees” a flame. Once the flame sensor “sees” a flame, the heater goes to “full output”.

4. Full Output

The heater runs at full output until the coolant temperature reaches 185°F (85°C) at the heater outlet. At this time, the heater shuts the flame off and goes to “purge”.

5. Purge

The air compressor and fuel pump shut off immediately. The blower and coolant pump continue to run. After 3 minutes, the blower stops and the heater goes to “Standby”.

6. Standby

The coolant pump circulates the coolant through the system until the temperature drops to 150°F (65°C) at the heater outlet; then it will enter Precheck and repeat steps 2-6. The heater will continue to repeat steps 2-5 until it is turned “OFF”.

7. Switch “OFF”

If the heater is in Full Output, it will purge first and then shut “OFF”. If the heater is in Standby, it will shut “OFF” immediately. **Note:** The heater will purge for three reasons:

- a.) The coolant reaches 185°F (85°C)
- b.) There is a function or component problem (*see Troubleshooting & Repair*)
- c.) The heater is operating at Full Output when it is shut “OFF”.

7.17 - ENGINE HEATER

NORMAL OPERATING SEQUENCE (continued)

Function and Component Diagnostics

The microprocessor in the PCM continually monitors all the heater systems. If the internal diagnostics discover a problem, a diagnostic code will be displayed on the PCM function display. The Timer red “ON” light will also flash the diagnostic code followed by a pause and then repeated, the number of flashes correspond to the numbered diagnostic code; eg. 5 flashes indicate a VOLTAGE ERROR. (See *Diagnostic Code Description* below for a complete list of error flash codes). If this occurs, refer to the troubleshooting section to assist in problem diagnosis.

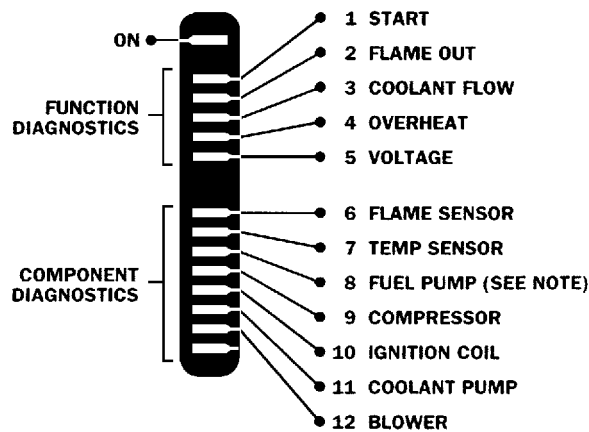


Figure 7.17–6

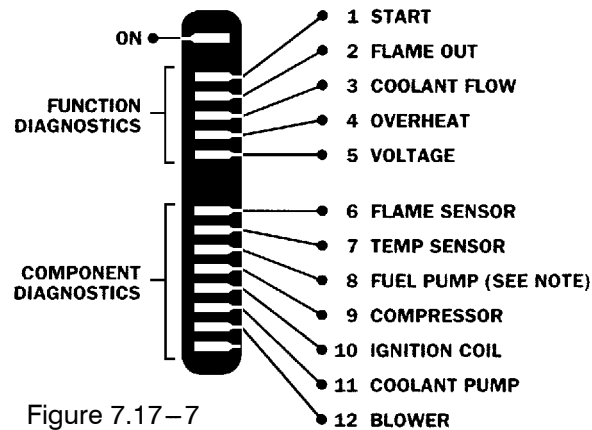
CODE No.	Description of Diagnostic Code	No. of Flashes
1	Start	1
2	Flame Out	2
3	Coolant Flow	3
4	Coolant Overheat	4
5	Voltage (High/Low)	5
6	Flame Sensor	6
7	Temperature Sensor	7
8	Fuel Pump *	8
9	Compressor	9
10	Ignition Coil	10
11	Coolant Pump	11
12	Blower (Combustion)	12
13	not used	13

* The fuel pump is a gear pump driven by the compressor motor. The fuel pump is NOT being monitored electrically. Should this component diagnostic code appear, there is a fault in the main wire harness connector or in the PCM. All mechanical problems with the fuel pump will be indicated as either a (1) START or a (2) FLAME OUT diagnostic code.

7.17 - ENGINE HEATER

TROUBLESHOOTING & REPAIR

The Troubleshooting & Repair Guide is divided into four sections:



Function Errors:

Errors displayed on the PCM diagnostic panel will cause the heater to shut down. These diagnostic codes are usually the result of a system problem.

It is possible to have two or more diagnostic codes displayed at the same time. A function diagnostic code may be displayed in conjunction with a component diagnostic code.

Component Faults:

This section covers the individual heater components. In many cases there is a corresponding indicator light on the PCM function display. The indicator light only indicates an electrical problem, NOT a mechanical failure. Component problems can also cause Function diagnostic codes.

Component:

This section includes the electrode gap, fuse, nozzle and fuel regulator.

Operational Problems:

These are problems that are not specifically described in the Function or Component diagnostic sections.

Note: Always let the heater run through two cycles when troubleshooting. The heater will attempt one restart after any function or component diagnostic code. The heater will not start if it is in a purge cycle or if the coolant temperature is above 150°F (65°C).

7.17 - ENGINE HEATER

TROUBLESHOOTING & REPAIR (continued)

On

A continuously flashing “ON” indicator indicates a problem in the PCM.



Figure 7.17–8

Check: Heater PCM function

- a) Turn the heater switch located on the timer to “OFF”. Reset the PCM by removing the power connection for 10 seconds, then reconnecting it. If the “ON” light continues to flash, replace the PCM.

Function Diagnostic

(1) Start

A START diagnostic code indicates that the flame sensor did not see a flame during the 60 second ignition period.

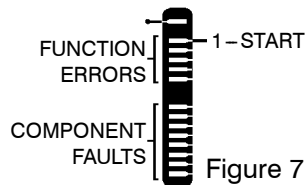


Figure 7.17–9

If the START diagnostic code is displayed, turn the heater “OFF” and then “ON” to restart. Observe the heater operation through the inspection window.

Symptom: Flame visible

The heater shuts down after 60 second ignition period.

Check: Flame Sensor

- a) Inspect for open circuit in the wiring.
- b) Inspect the lens for cleanliness.

Check: Fuel System

- c) Is there restriction in the fuel system?
- d) Is the nozzle plugged?
- e) Is the fuel pump operating?
- f) For a defective pressure regulator.
- g) Is the compressor functioning?
- h) What type of fuel is being used?

7.17 - ENGINE HEATER

Function Diagnostic (continued)

(1) Start (continued)

Symptom: No Flame visible

The spark continues for the 60 second ignition period. The heater shuts down after the 60 second ignition period.

Check: Fuel System

- a) Is there a restriction in the fuel system?
- b) Is the nozzle plugged?
- c) Is the fuel pump operating?
- d) For a defective pressure regulator.
- e) Is the compressor functioning?

Note: A spark should be visible across the gap between the ignition electrode and the combustion tube.

Symptom: Heater is Backfiring

Backfiring is usually caused by a severe restriction of combustion air or air in the fuel line.

Check: Inlet Air Flow

- a) Is the blower error displayed?
- b) Blower Operation:
 - 1. Is the blower turning?
 - 2. Is the blower turning slowly?
- c) For restrictions at the fan inlet port and in the exhaust system.
- d) For carbon build up in the combustion chamber.

Check: Fuel System

- a) Is fuel level low?
- b) Air leaking into fuel system?

7.17 - ENGINE HEATER

Function Diagnostic (continued)

(1) Start (continued)

Symptom: No Flame visible

No spark

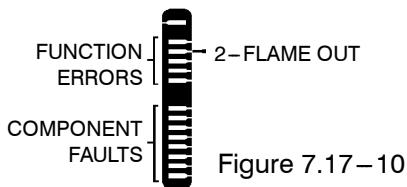
The heater shuts down after the 60 second ignition period

Check: Ignition System

- a) Check for a poor electrical connection between the ignition coil and the high tension lead.
- b) Check for a poor electrical connection between the electrode and the high tension lead.
- c) Inspect the electrode gap. Check for carbon bridging from the ignition electrode to the combustion tube.
- d) Inspect the primary electrical connections to the ignition coil and coil function.
- e) Is the heater chassis ground wire attached? The ground is connected to the boss located near the fuel pump.

(2) Flame Out

A Flame Out diagnostic code occurs when the heater has started successfully but is unable to maintain a steady flame.



If during ignition the flame sensor does not see a flame, the ignition electrode is switched on immediately. If the flame is not reestablished within 10 seconds the heater will shut down and the FLAME OUT diagnostic code will be displayed. The heater will go into the Purge mode and attempt to restart in 3 minutes, depending on the coolant temperature.

If the flame fails to re-ignite on the second attempt, a START diagnostic code will be displayed on the function control panel. If, however, the flame sensor senses enough of a flame during Ignition, it will enter the Full Output mode. During Full Output, if the flame sensor fails to see a flame then the FLAME OUT diagnostic code will be displayed.

7.17 - ENGINE HEATER

Function Diagnostic (continued)

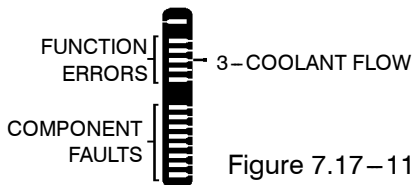
(2) Flame Out (continued)

Check: Fuel System

- a) Is there restriction in the fuel system?
- b) Is the nozzle plugged?
- c) Is the fuel pump operating?
- d) For a defective pressure regulator.
- e) Is the compressor functioning?
- f) What type of fuel is being used?

(3) Coolant Flow

A COOLANT FLOW diagnostic code is displayed when the coolant temperature reaches 185°F (85°C) in less than one minute after ignition. This indicates that the coolant flow is severely restricted or blocked. This feature aids in detecting coolant flow problems that can degrade the heater performance.



An in-line flow indicator is a valuable troubleshooting tool used to: a) Check the coolant flow and direction, b) Check for air in the system, c) Check for restrictions caused by the drill systems ie. Shuttle valves, manual valves, air operated valves.

Check: Coolant Flow

- a) **Coolant Lines:** For restrictions and blockages. Are Clamps tight?
- b) **Shutoff Valves:** Ensure that shutoff valves are open and functioning properly.
- c) **Fittings:** Fittings must be at least 1/2"NPT or larger. Avoid using 90° fittings where possible.
- d) **Coolant Flow Direction:** The heater **must** be plumbed so the coolant pump is pumping the coolant in the same direction as engine coolant pump. The heater can be used when the engine is running.
- e) **Coolant Pump:** Does the pump function properly?
- f) **Coolant System Capacity:** The coolant system must contain at least 3 gallons (11 liters) of coolant. If the system contains less the coolant may reach 185°F (85°C) in less than 1 minute causing a COOLANT FLOW diagnostic code.

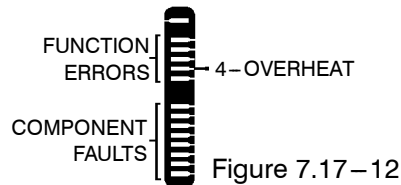
NOTE: If the coolant system is contaminated with magnetic material, it may cause the impeller to seize.

7.17 - ENGINE HEATER

Function Diagnostic (continued)

(4) Overheat

An OVERHEAT diagnostic code is displayed when the overheat breaker has tripped, shutting the heater down. This occurs if the heater has been started with little or no coolant in the heat exchanger.



Check: Coolant Flow

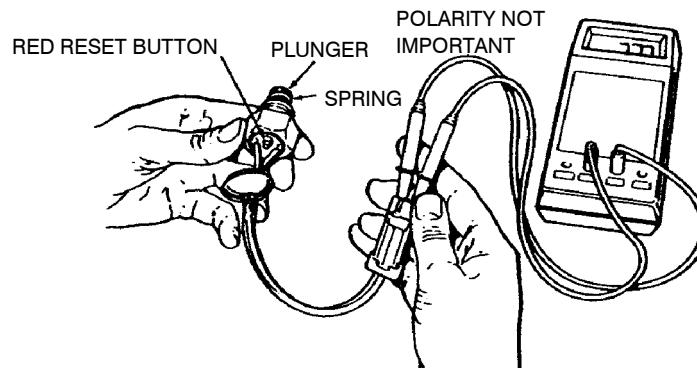
- Is there coolant in the system?
- Determine if there is a blockage or air in the plumbing.

The compressor motor is wired in series with the overheat breaker. The breaker contains a normally closed thermo switch. When the thermostat reaches the preset temperature of 286°F (141°C), the contacts OPEN shutting the compressor and fuel pump OFF, instantly shutting the heater down. It cannot be restarted until the breaker is manually reset.

To reset the breaker, remove the rubber cap covering the top of the overheat breaker and press the red reset button on top. If the breaker will not reset, allow the heater to cool.

Test Procedure:

Connect a multimeter (adjusted to measure resistance) to the overheat breaker connector (figure 7.17-13). The sensor should be normally closed. If the sensor has tripped, the circuit should be open.



Do not reset the Overheat breaker until the cause of the overheat condition has been determined.

7.17 - ENGINE HEATER

Function Diagnostic (continued)

(5) Voltage

A VOLTAGE diagnostic code indicates that the supply voltage to the heater is out of the normal range.

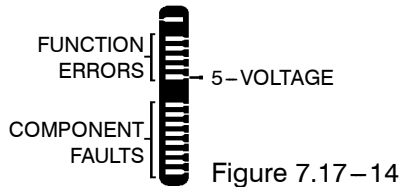


Figure 7.17-14

Voltage ranges:

12 Volt heater - 10.0 to 15.0 Volts

24 Volt heater - 20.0 to 30.0 Volts

Check: Vehicle Voltage

- a) Heater voltage must be within the specified range. See *Heater Voltage Measurement* for procedure to measure heater voltage.

NOTE: Bad connections may show good voltage under no load conditions but not under full load. With the heater "OFF", measure the voltage. Then turn the heater "ON" and measure the voltage again. If the voltage drop is more than one Volt, check the deck engine battery connections and the power connection at the PCM.

- b) If the measured voltage is higher than the specified range then check the voltage regulator.

NOTE: If the engine batteries are marginal, starting the engine while the heater is running may:

- a) Drop the voltage enough to cause a voltage error.
- b) Cause random component errors (brown out).

To reset the PCM, turn the heater "OFF" and then back "ON" at the timer. If the problem continues, load test the batteries to confirm their condition. Each battery should be independently tested.

Current: Checking current draw is done at the power harness connections on the batteries.

- 1) Check the current draw on the red POSITIVE wire with the heater NOT running. Should read 80 to 100 mA.
- 2) Check current draw on the red POSITIVE wire with the heater running in full output, ignition "OFF". Should read 6.5 to 7.5 Amps.
- 3) Check current draw on the black NEGATIVE wire with the heater NOT running and the red POSITIVE wire disconnected. Should read 0 mA. This test is to confirm whether or not there is a power leakage from the drill through the heater.

7.17 - ENGINE HEATER

Function Diagnostic (continued)

(5) Voltage (continued)

Heater Voltage Measurement

The positive terminal of the ignition coil is always hot relative to the heater chassis ground as long as power is connected to the heater. This is the supply voltage to the heater.

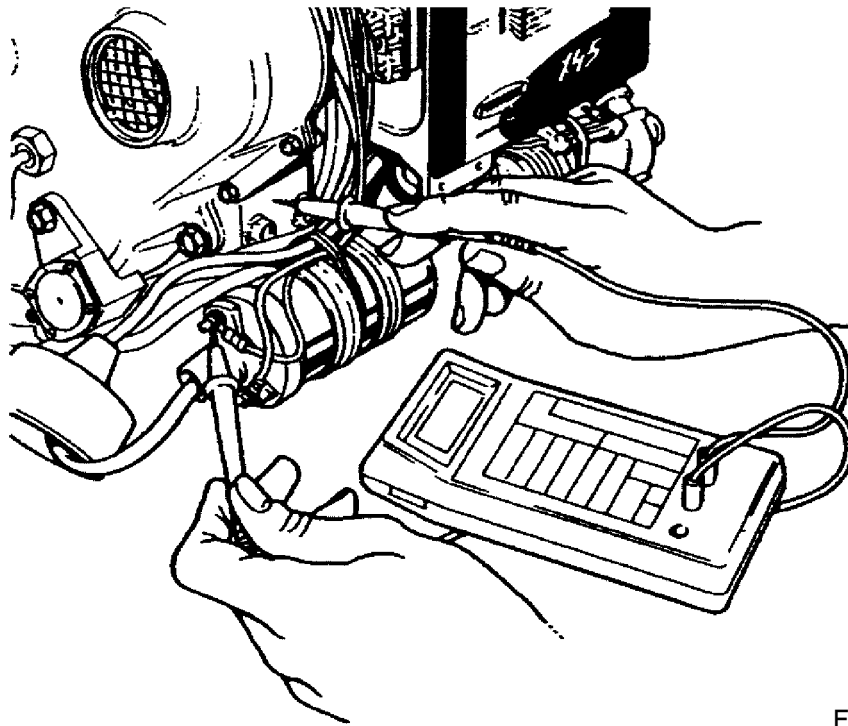


Figure 7.17–15

Test Procedure:

- Locate the rubber boot on the end of the ignition coil and peel it back to expose the positive and negative terminals.
- Select the DC Volts range of a multimeter and connect as shown in figure 7.17–15. The positive lead of the multimeter should be attached to the positive coil lead. The negative lead of the multimeter should be attached to the heater chassis at the heater ground boss (see figure 7.17–30).
- Read the voltage with the heater running or trying to run.

Normal Voltage ranges:

12 Volt heater – 10.0 to 15.0 Volts

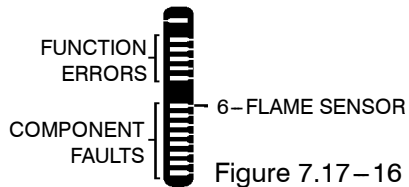
24 Volt heater – 20.0 to 30.0 Volts

7.17 - ENGINE HEATER

Component Diagnostic

(6) Flame Sensor

A FLAME SENSOR diagnostic code indicates an electrical short circuit in the flame sensor wiring or a flame sensor failure. It will not indicate an open circuit. The flame sensor is an optical device which “sees” the flame. If the sensor lens is dirty or has an open circuit, it cannot “see” the flame and results in either a START or a FLAME OUT diagnostic code to display.



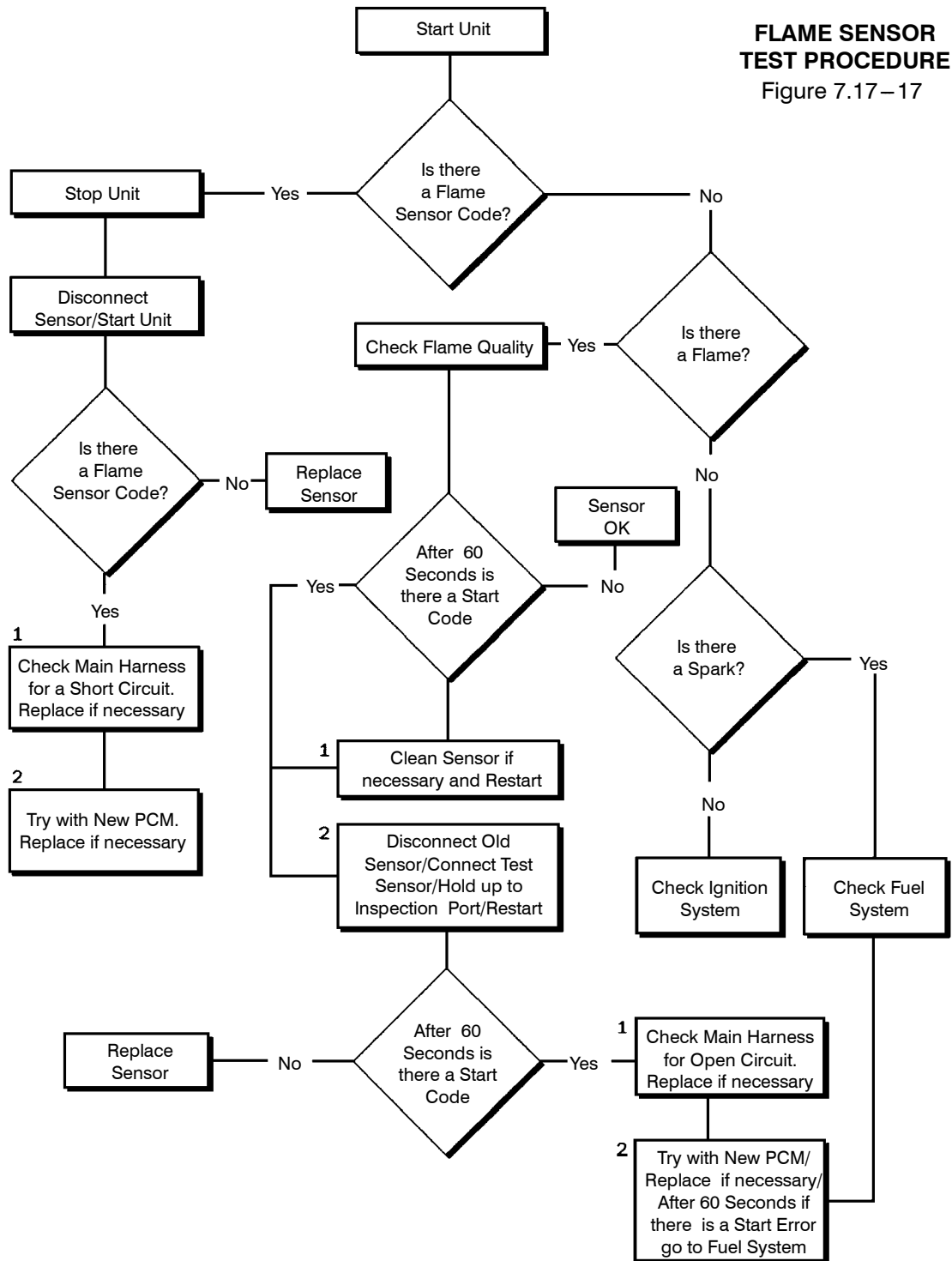
Check: Flame Sensor

- Inspect the flame sensor wiring for a short circuit.
- Inspect the flame sensor lens for cleanliness.
- Test the flame sensor (*See Flame Sensor Test Procedure*).

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(6) Flame Sensor (continued)

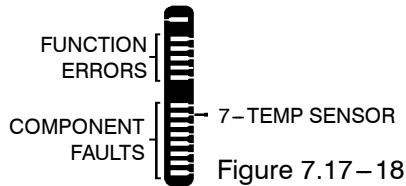


7.17 - ENGINE HEATER

Component Diagnostic (continued)

(7) Temp Sensor

A TEMP SENSOR diagnostic code indicates a short or open circuit in the temperature sensor wiring or the coolant temperature is out of range, below -58°F (-50°C) or above 266°F (130°C). The resistance of the temperature sensor is proportional to temperature.



Check: Temperature Sensor (CODE indicated)

- Inspect wiring for short or open circuits.
- Test the sensor.

Test Procedure:

- Connect multimeter (adjusted to measure resistance) to temperature sensor as shown in figure 7.17-19. Polarity of the sensor connections to the multimeter is not important.
- Measure the sensor resistance versus temperature under following conditions:
 - at room temperature
 - in a freezer
 - in boiling water
- Compare the measured values against the graph in figure 7.17-20. If values do not approximately match, then the sensor is defective and must be replaced.

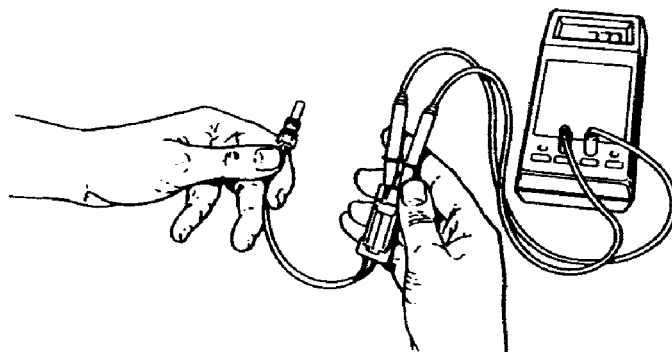


Figure 7.17-19

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(7) Temp Sensor (continued)

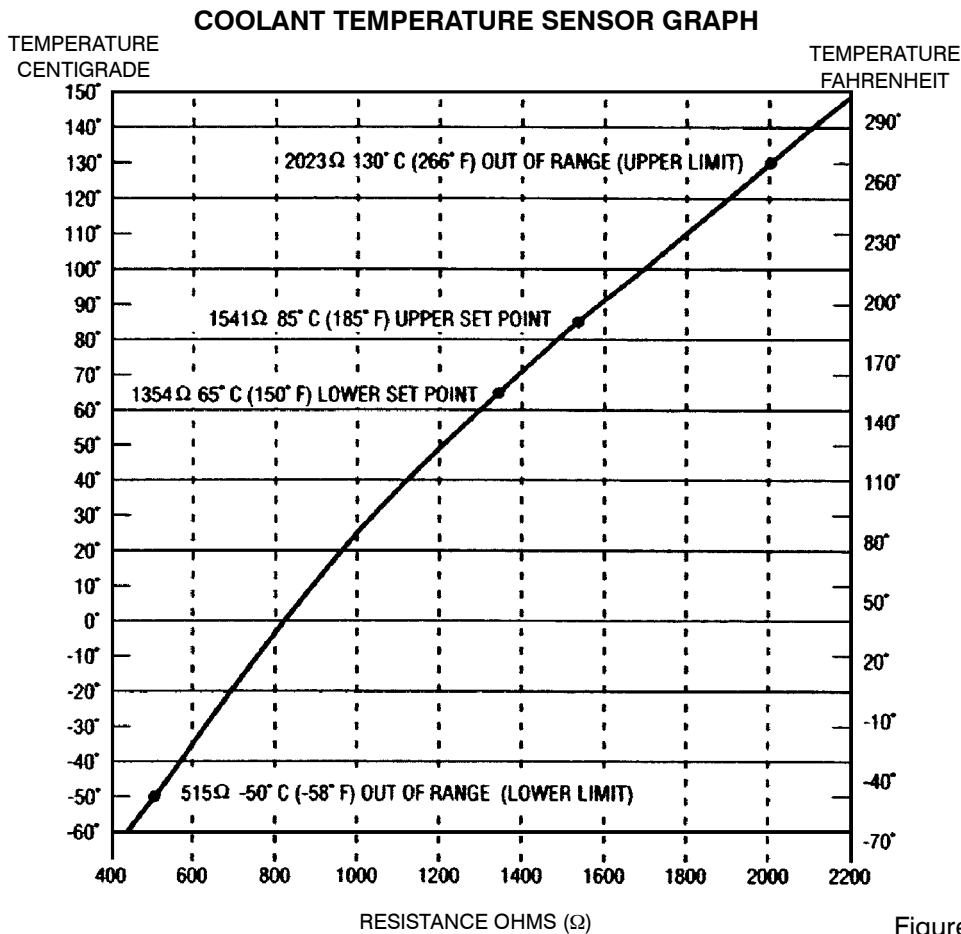


Figure 7.17–20

NOTE: Room Temperature 70°F (20°C) Resistance 950Ω
Boiling Water 212°F (100°C) . . Resistance 1700Ω

(8) Fuel Pump

The fuel gear pump is driven by the same motor as the compressor. Therefore, there is NO fuel pump electrical diagnostic code. A FUEL PUMP diagnostic code would indicate a fault in the PCM **only**.

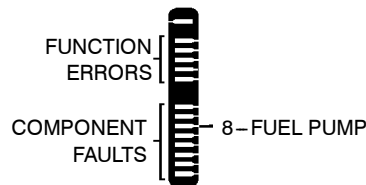


Figure 7.17–21

A short or open circuit fault in the motor that drives the fuel pump will be indicated by a COMPRESSOR diagnostic code.

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(8) Fuel Pump (continued)

A mechanical fault within the fuel pump such as stripped drive couplings, jammed gears or a faulty pressure relief valve, would be indicated by:

- START diagnostic code
- FLAME OUT diagnostic code
- Blown fuse in the PCM. Indicates that the pump is seized.

Check: Fuel Pump

- Fuel pump as per procedure (*See Fuel System*).
- Relief valve for contamination
- Filter for contamination
- Drive couplings

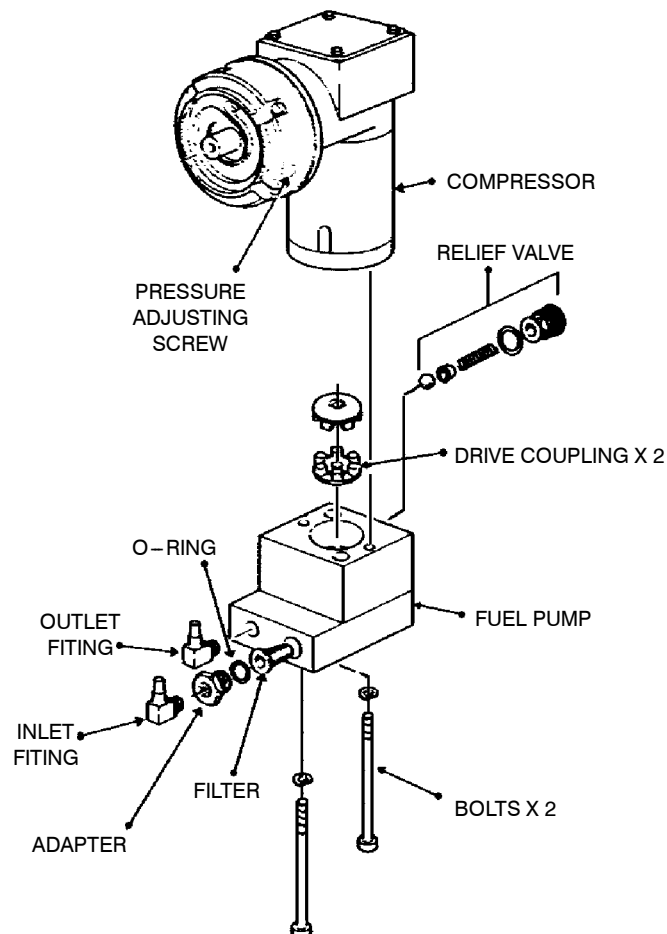


Figure 7.17–22

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(9) Compressor

A COMPRESSOR diagnostic code indicates an open circuit in the wire harness, a short in the wire harness between the positive and negative leads or an internal short in the motor. This component is ground side switched in the PCM.

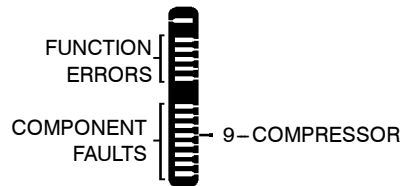


Figure 7.17–23

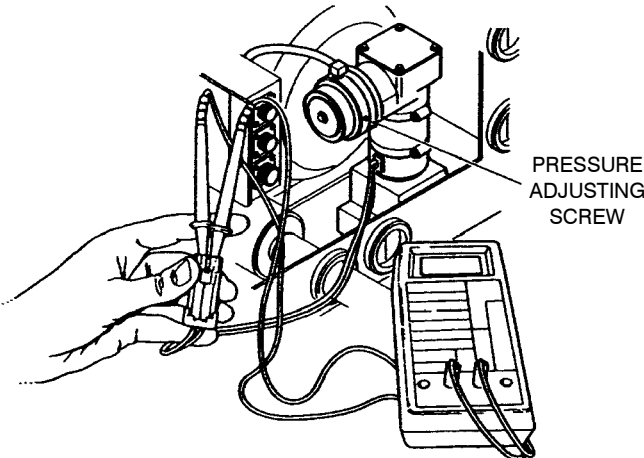
Symptom: Air Compressor not running (code indicated)

Check: Air Compressor wiring & function

- a) That compressor is connected to harness correctly.
- b) The connector pins for damage or corrosion.
- c) Harness for pinched or abraded wires.
- d) Test compressor. If it tests OK replace PCM.

Test Procedure:

- a) Connect air compressor directly to a power source of the rated voltage (12/24 Volts) and see if the motor runs. If not, replace the compressor.
- b) Measure air compressor motor resistance by using a multimeter and measure resistance across compressor connector pins. If resistance shows an open or short circuit, replace the compressor assembly.
- c) Measure air compressor current. Use a test lead as described in the Service Bulletin in Appendix.



<u>MODEL</u>	<u>CURRENT DRAW (AMPS)</u>
X45–12	3.50–5.00 @ 12 Volts
X45–24	1.50–3.00 @ 24 Volts

Figure 7.17–24

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(9) Compressor (continued)

Symptom: Air Compressor running (NO CODE indicated)
No or low air flow

Check: Air flow using pressure gauge. Ensure gauge is accurate (0-15 psi)

Procedure: Install the pressure gauge as shown in figure 7.17-25. The Pressure Reading for X45: 6.5 psi @ 12/24 Volts.

High pressure reading indicates:

- Blocked Nozzle. Air passage only (*See Nozzle-figure 7.17-39*).
- Compressor is out of adjustment. Re-adjust the compressor using the adjustment screw as indicated in figure 7.17-26.

Low pressure reading indicates:

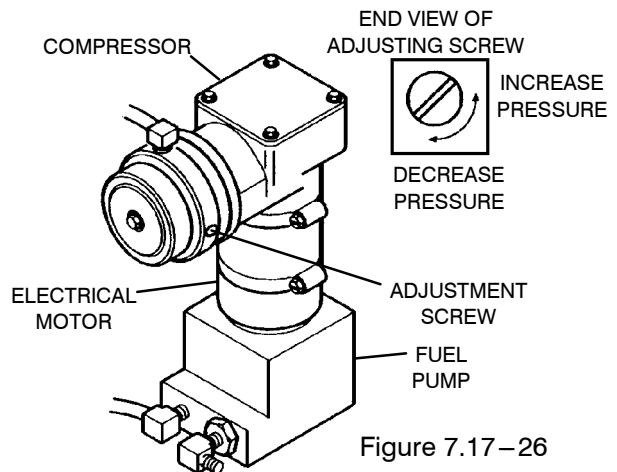
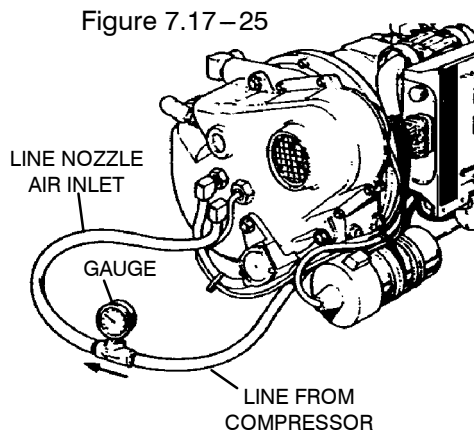
- Pinched or leaking air line from the compressor outlet fitting to the fan end inlet.
- Plugged compressor inlet filter. Retest with the filter removed.

Normal reading but a rich or lean flame:

- Check for contaminated nozzle, fuel passage (*See Nozzle*).
- Check the blower.
- Check the fuel regulator.
- Check fuel system.

Pressure Adjustment:

- Locate adjusting screw on the compressor head (figure 7.17-26).
- Adjust as necessary. Ensure that voltage is nominally 12 or 24 Volts.



7.17 - ENGINE HEATER

Component Diagnostic (continued)

(9) Compressor (continued)

Symptom: Air Compressor running (NO CODE indicated)
Fuse blown in PCM

Check: Air Compressor operation

- a) Harness for pinched or abraded wires. The positive wire must not short to ground.
- b) Motor for internal short.
- c) Check for seized motor or fuel pump.



Disconnect the PCM electrical power prior to trying to turn the compressor counterweight by hand.

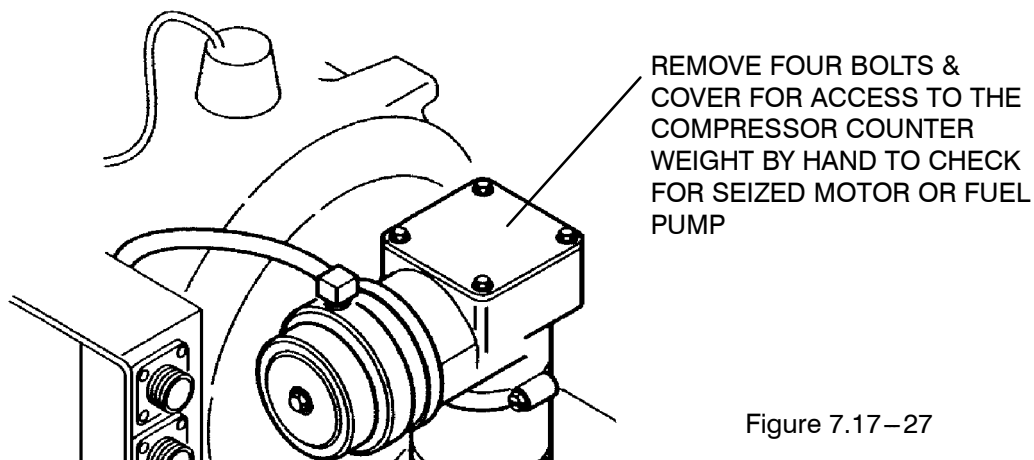


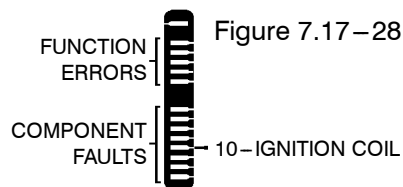
Figure 7.17–27

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(10) Ignition Coil

An IGNITION COIL diagnostic code indicates an open circuit in the wire harness, a short in the wire harness between the positive and negative leads or an internal short in the coil. The fuse will blow if there is a short to ground in the positive lead or the coil. The ignition coil is the easiest place to measure the voltage on the heater. This component is ground side switched in the PCM.



WARNING

The heater chassis is grounded from the PCM as shown in figure 7.17-30. Ensure the ground is securely connected. Failure to ensure a proper ground may result in electric shock.

Symptom: No spark at the electrode (code indicated)

Check: Coil wiring

- a) Inspect the wiring harness to ensure the ring terminals are secured to the coil. Make sure the polarity is correct.
- b) Inspect for broken or abraded wires in the wire harness.
- c) Test coil (see figure 7.17-29).
- d) If an IGNITION COIL diagnostic code occurs and no fault is found in the coil and wiring, then the PCM must be checked.

Symptom: No spark at the electrode (NO code indicated)

Check: High tension wires and electrode

- a) Inspect the high tension lead between the coil and the electrode.
- b) Inspect the ground lead between the second electrode and the heater chassis.
- c) Is the electrode gap adjusted correctly? (*See Electrode Gap figure 7.17-35*).

7.17 - ENGINE HEATER

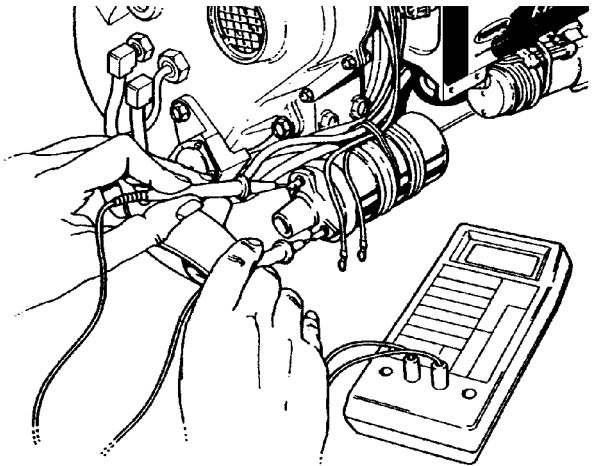
Component Diagnostic (continued)

(10) Ignition Coil (continued)

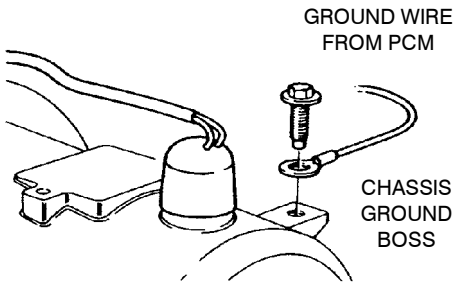
Test Procedure:

- a) Measure the ignition coil resistance. Use a multimeter to measure the resistance across the positive and negative terminals. The resistance should be less than 1 ohm. If the resistance is “open circuit” or 0 ohms (short circuit) then replace the ignition coil.

NOTE: Remove positive and negative wires from the coil when testing.



IGNITION COIL TEST
Figure 7.17–29



GROUND BOSS
Figure 7.17–30

(11) Coolant Pump

A COOLANT PUMP diagnostic code indicates an open circuit in the wire harness, a short in the wire harness between the positive and negative leads or an internal short in the motor. This component is ground side switched in the PCM.

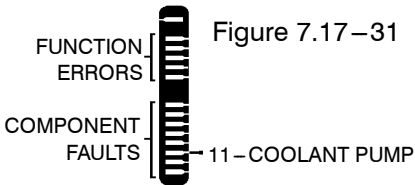


Figure 7.17–31

The coolant pump is not self priming. Ensure that the coolant system has been purged of air by running the deck engine for at least ten minutes following installation or service (DO NOT run dry).

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(11) Coolant Pump (continued)

Symptom: Coolant Pump not running (code indicated)

Check: Coolant Pump wiring & function

- a) That the coolant pump is connected to harness correctly. (*See Heater Wiring Diagram*).
 - b) The connector pins for damage or corrosion.
 - c) Harness for pinched or abraded wires.
 - d) Test pump. If it tests OK replace PCM (*See Test Procedure and figure 7.17-32*).
-

Symptom: Coolant Pump not running (no code indicated)

Fuse blown in PCM

Check: Coolant Pump function

- a) Harness for pinched or abraded wires. Positive lead must not short to ground.
 - b) Check motor for internal short (*figure 7.17-32 and Test Procedure*).
-

Symptom: Coolant Pump not pumping (no code indicated)

Check: Coolant Pump function

- a) If the impeller is turning freely. If not, replace pump.
-

Symptom: Coolant Pump leaking

Check: Leak location

- a) Hose clamps. Tighten if necessary.
 - b) Pump housing seal. Replace pump if required.
-

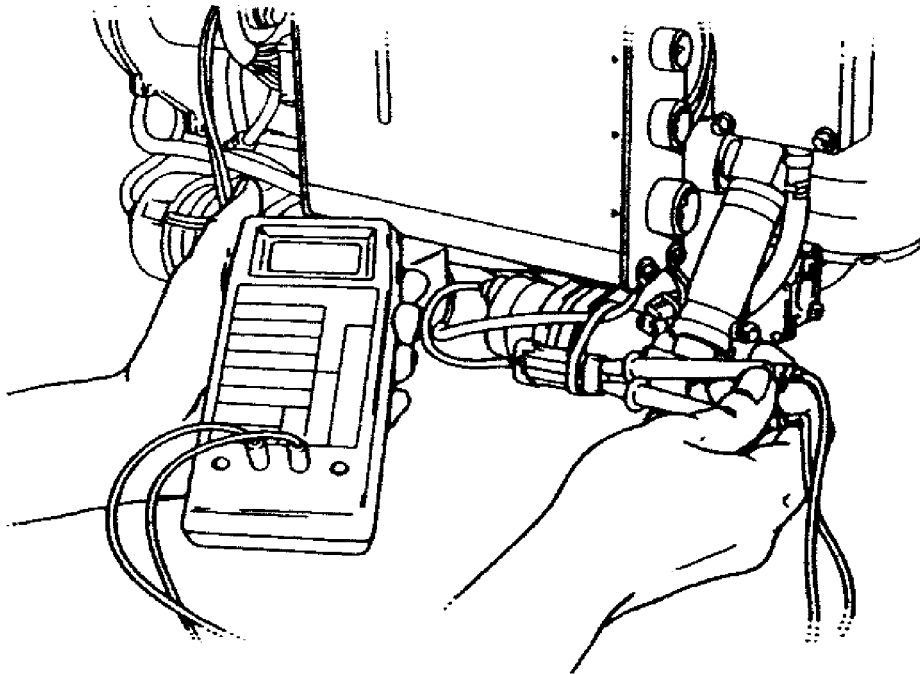
7.17 - ENGINE HEATER

Component Diagnostic (continued)

(11) Coolant Pump (continued)

Test Procedure:

- Connect coolant pump directly to the rated voltage (12/24 Volts) and see if it runs. If not, replace the pump.
- Measure coolant pump motor resistance. With a multimeter, measure the resistance across the coolant pump connector pins. If resistance shows an open circuit or an internal short circuit, replace the coolant pump.
- Measure the coolant pump current. Use a test lead as described in the Service Bulletin in Appendix.



COOLANT PUMP TEST

<u>MODEL</u>	<u>CURRENT DRAW (AMPS)</u>
X45–12	1.50–4.00 @ 12 Volts
X45–24	0.75–2.00 @ 24 Volts

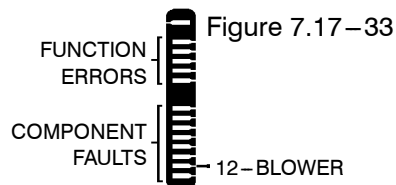
Figure 7.17–32

7.17 - ENGINE HEATER

Component Diagnostic (continued)

(12) Blower

A BLOWER diagnostic code indicates an open circuit in the wire harness, a short in the wire harness between the positive and negative leads or an internal short in the motor. This component is ground side switched in the PCM.



NOTE: An RPM check was added to the PCM. This feature measures the blower RPM and will give an error should it fall below the necessary RPM to maintain sufficient combustion air.



When a blower fails, the combustion chamber must be checked for carbon buildup and cleaned as necessary.

Symptom: Blower not running (code indicated)

Check: Blower wiring & function

- That blower is connected to harness correctly (*See Wiring Diagram*).
- The connector pins for damage or corrosion.
- Harness for pinched or abraded wires.
- Test blower. If it tests OK replace PCM (*See Test Procedure and figure 7.17-34*).

Symptom: Blower not running (no code indicated) Fuse blown in PCM

Check: Blower function

- Harness for pinched or abraded wires. Positive lead must not short to ground.
- Check motor for internal short (*See Test Procedure and fig. 7.17-34*).

Symptom: Blower turning slowly (no code indicated)

Check: Blower function

- For fan blade rubbing on housing.
- For fan blade slipping on motor shaft.

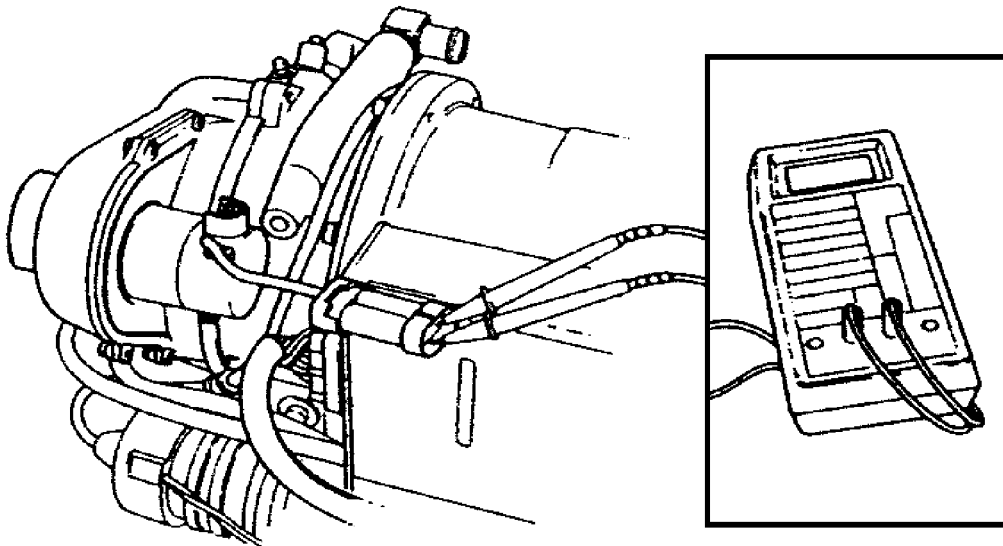
7.17 - ENGINE HEATER

Component Diagnostic (continued)

(12) Blower (continued)

Test Procedure:

- Connect the blower to a power supply of the rated voltage. Does the blower turn? If not, replace the blower.
- Measure the blower motor resistance. Using a multimeter, measure the resistance across the blower connector pins. If resistance shows an open circuit or an internal short circuit, replace the blower assembly.
- Measure blower current. Use a test lead as described on the Service Bulletin in Appendix.



BLOWER TEST

<u>MODEL</u>	<u>CURRENT DRAW (AMPS)</u>
X45–12	.75–1.5 @ 12 Volts
X45–24	.5–1.0 @ 24 Volts

Figure 7.17–34

7.17 - ENGINE HEATER

Components

Electrode Gap

The electrode gap is factory set and should not require adjustment.

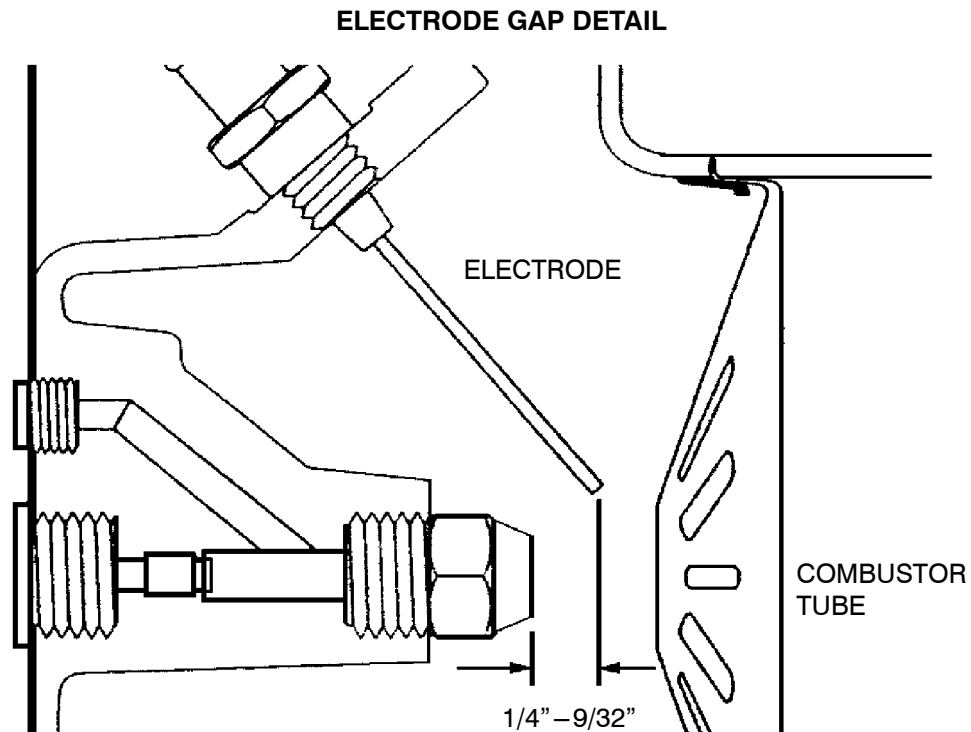


Figure 7.17–35

NOTE: Ensure that the electrode is not bent during servicing. To readjust the electrode, bend it to the correct setting.

7.17 - ENGINE HEATER

Components (continued)

Fuse

If, when the heater is turned “ON”, the heater does not run and the “ON” light does not light, check the fuse in the PCM. The fuse will blow if there is a short to ground in a positive lead or internally for the following components: ON/OFF Switch, Air Compressor, Ignition Coil, Coolant Pump and Blower.

Reversing polarity at the battery will also cause the fuse to blow. This will not harm the PCM.



Repeated replacement of the fuse or using incorrectly rated fuses without correcting the problem can damage the PCM.

Check: Heater wiring

- a) Check polarity of battery connections
- b) Test the internal wire harness for short circuits.

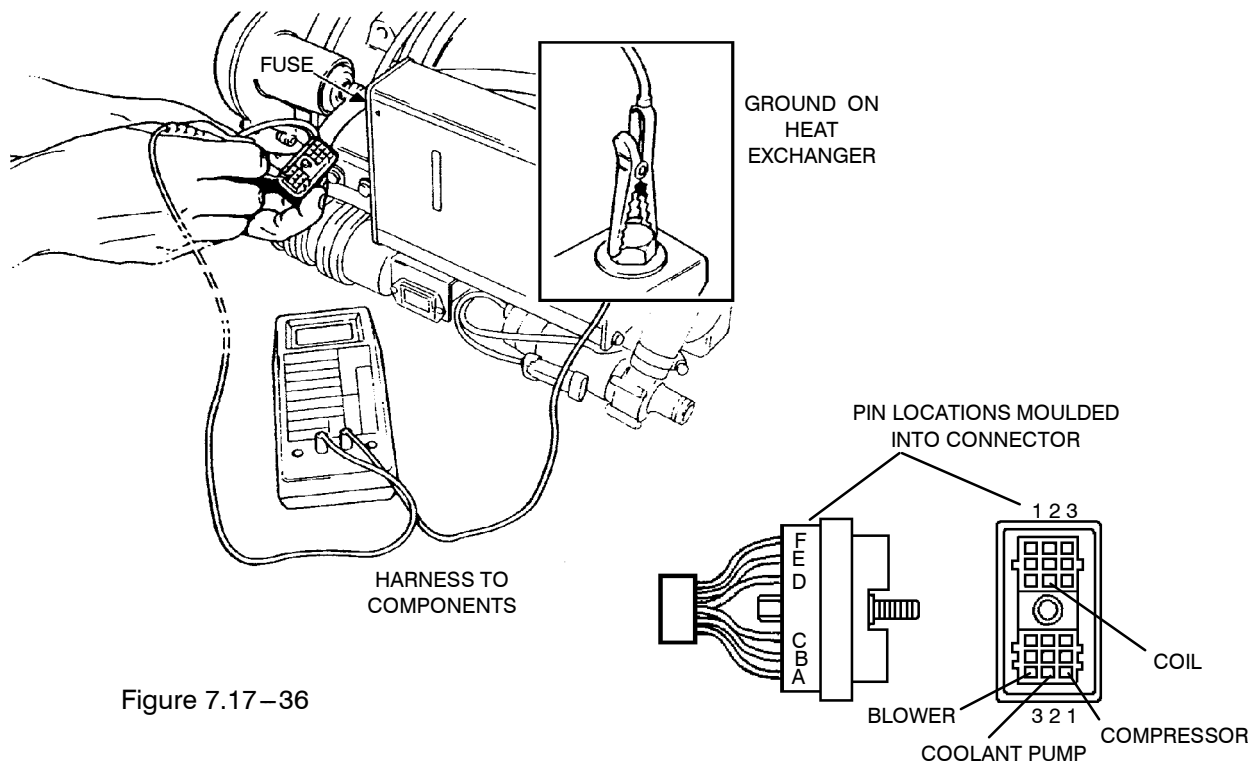


Figure 7.17–36

The following page describes the test procedure for a blown fuse with power connected and the heater switched off.

7.17 - ENGINE HEATER

Components (continued)

Fuse (continued)

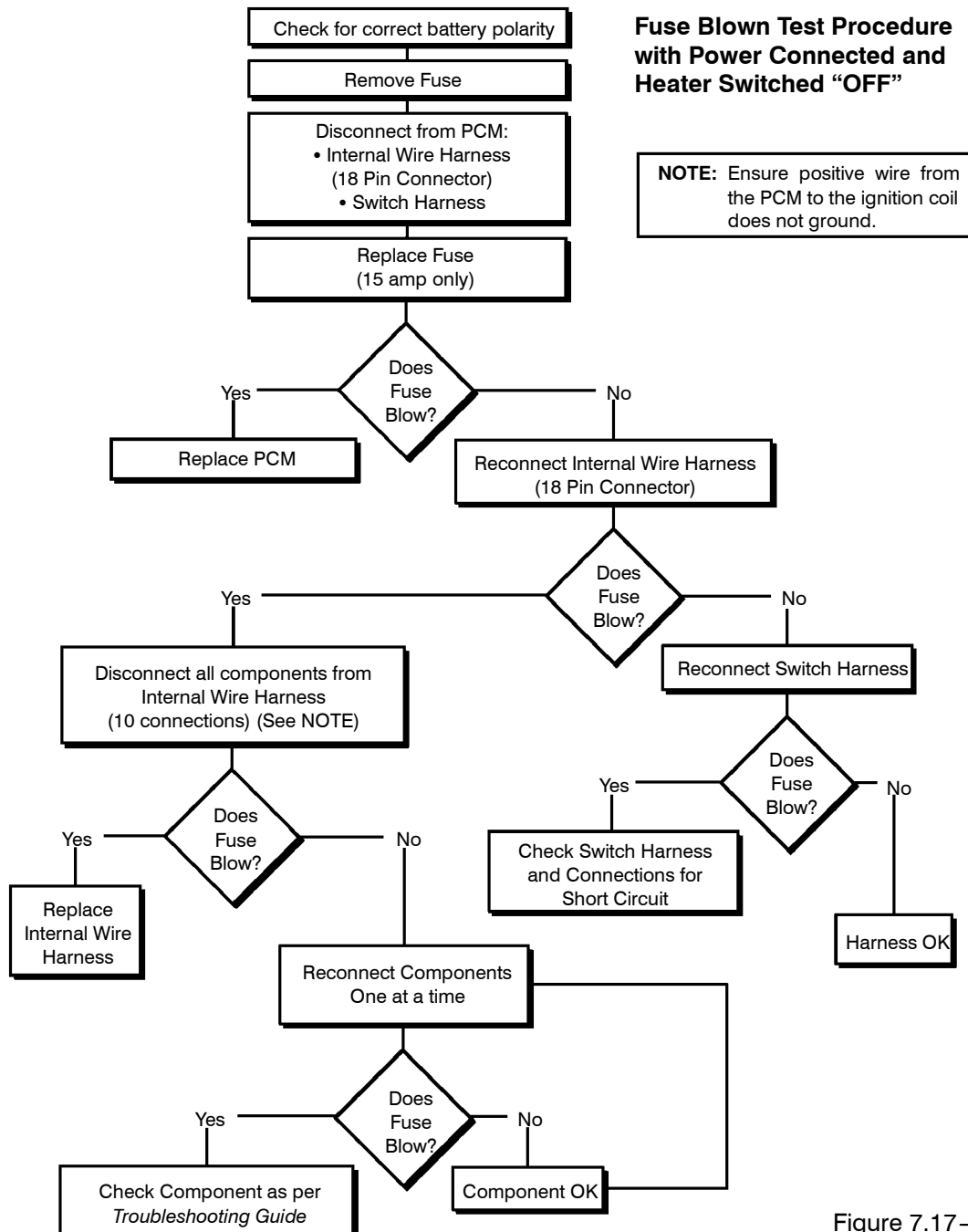


Figure 7.17–37

7.17 - ENGINE HEATER

Components (continued)

Nozzle

The nozzle (and the compressor) regulate the fuel air mixture. A set orifice size allows a certain amount of fuel and air to flow through the distributor (see figure 7.17-38). Problems in the nozzle can cause poor burning. This will be indicated by a START or FLAME OUT diagnostic code on the PCM function display.

Check: Nozzle

- Inspect the nozzle for blockage.
- Clean or replace nozzle as necessary.
- Check and clean fuel passage in the fan end.

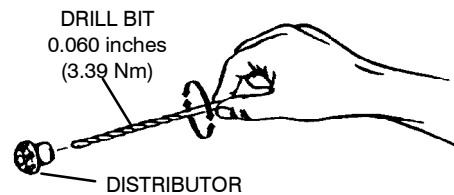
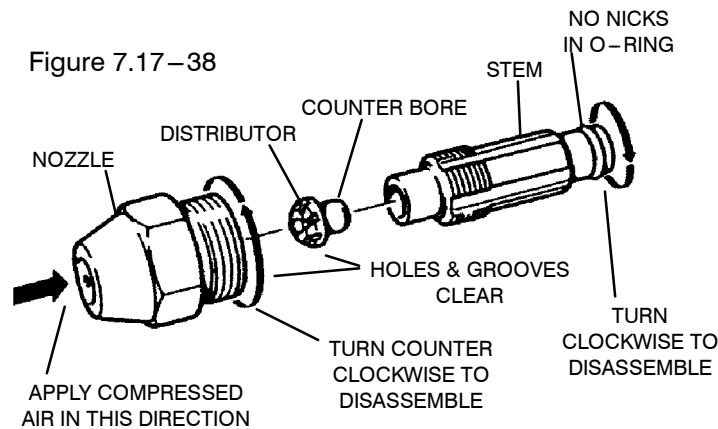


Figure 7.17-39

Nozzle Cleaning Procedure:

- Remove nozzle from fan end.
- Disassemble nozzle as shown in figure 7.17-38.
- Use a cleaner/degreaser to thoroughly wash the separate parts.
- Dislodging contaminants in the distributor counterbore can be done by lightly hand spinning a drill bit (0.060" dia.) and then washing (figure 7-17-39). Do not use a tip cleaner in the fuel orifice.
- Reassemble nozzle and torque to 30 inch pounds (3.39 Nm).
- Use compressed air for cleaning **only** in the direction indicated by the arrow in figure 7.17-38.
- Lubricate the O-ring with diesel fuel and reinstall nozzle in fan end.

NOTE: See Step 6 of *Fuel System Troubleshooting* section to confirm that nozzle is functioning correctly. All of the nozzles' parts are matched parts. **Do not interchange.**

7.17 - ENGINE HEATER

Components (continued)

Fuel Regulator

The fuel regulator reduces the fuel pressure supplied by the fuel pump from 5 psi (0.34 Bar) down to atmospheric pressure. Compressed air flowing through the nozzle creates a venturi effect which siphons fuel from the regulator. If the compressed air flow through the nozzle stops, the regulator closes, shutting off the fuel flow.

Check: Fuel Regulator

- a) Ensure that the vent hole in the regulator is not plugged.
- b) Ensure that all fuel line connections are tight. Check the clamps.

Test Procedure:

- a) Disconnect the fuel line at the nozzle fuel inlet fitting and place it in a container.
- b) Start the heater. Insert a small blunt pin in the regulator vent hole and **gently** depress the diaphragm.
- c) Fuel should flow out of the fuel line. If there is no fuel flow, the regulator is plugged.

NOTE: Should a fuel regulator fail, the combustion chamber must be checked for carbon build up and cleaned as necessary.

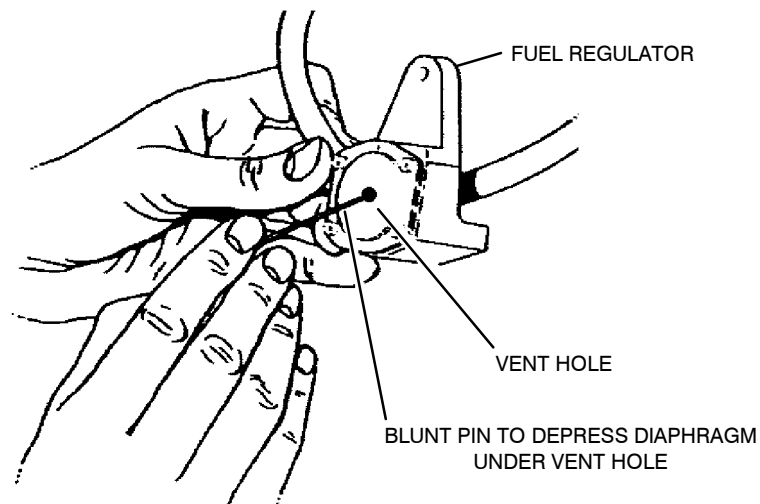
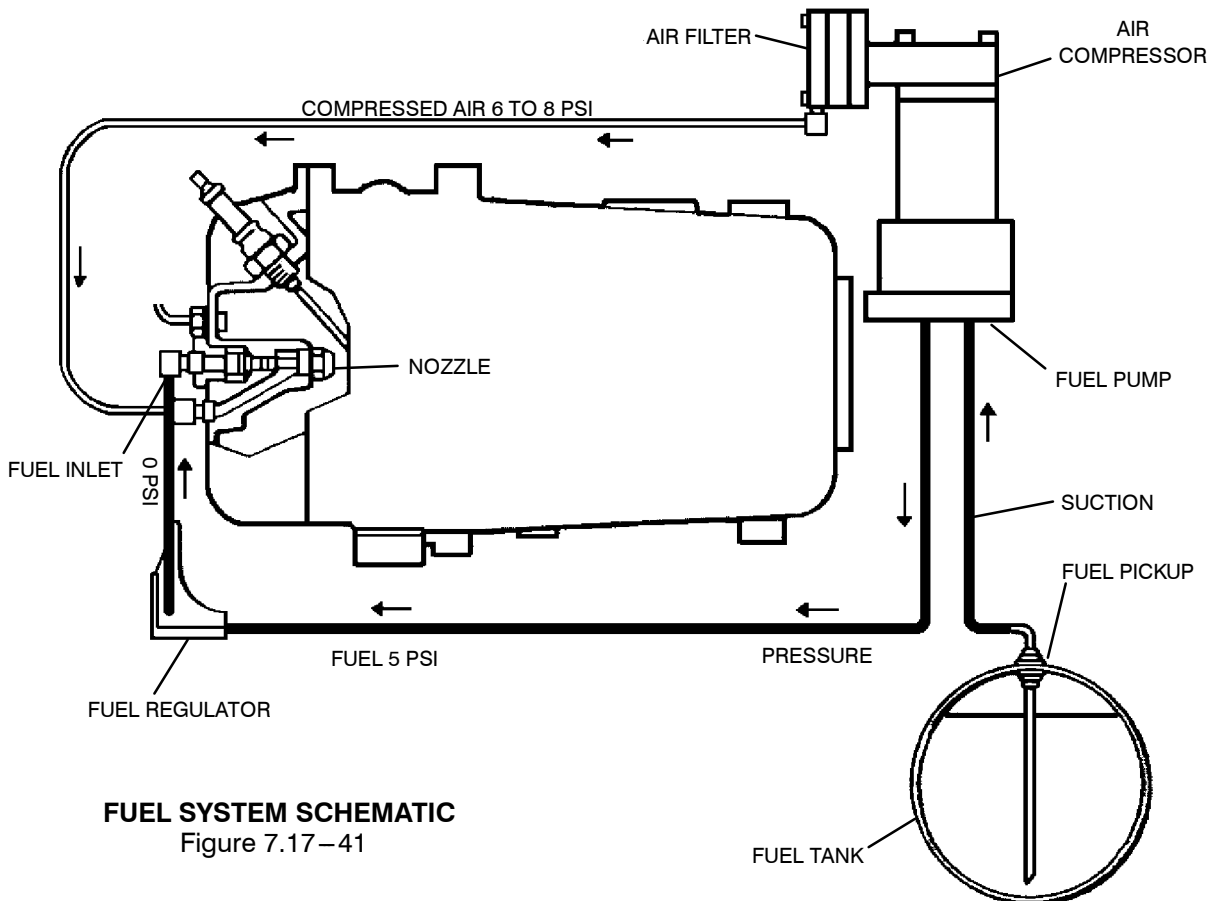


Figure 7.17 – 40

7.17 - ENGINE HEATER

Fuel System



Step 1 **Is there fuel in the tank?**

Step 2 Start the heater. The heater will try to start twice. Wait until it has gone through two cycles (approximately 10 minutes). The heater diagnostic system will tell you what it thinks is wrong. While it is running, observe for:

Is there flame?

yes, means there is ignition and fuel. Refer to “Is the ignition spark turning “OFF”?

No, go to step 3.

b.) **Is the ignition spark turning “OFF”?**

yes, then the Flame Sensor sees a flame.

No, then the flame is either too weak or the Flame Sensor and/or circuit is faulty. See Flame Sensor (figure 7.17–16)

7.17 - ENGINE HEATER

Fuel System (continued)

Step 3 Does the Fuel Pump work?

This component must be tested before proceeding with troubleshooting.

- a.) Disconnect the fuel line at the inlet to the regulator. Start the heater. Check fuel flow, approximately 1 pint (1/2 liter) in 60 seconds.
- b.) Run the fuel pump by connecting remote power to the compressor motor and checking for fuel flow.

Step 4 Does the Regulator work?

- a.) Disconnect the fuel line at the fuel inlet fitting. Hold the line at the same level as the inlet. Start the heater. There should be no fuel flow. This indicates that the regulator is holding the fuel pressure.
- b.) Lightly push on the regulator diaphragm (use a blunt tool). Fuel should flow from the line (see figure 7.17-40).

NOTE: A regulator that is stuck open will produce a rich flame, and blockage in the regulator needle valve seat will produce a lean flame.

Step 5 Does the Compressor work?

- a.) Check the pressure output (see figure 7.17-24 and 7.17-25).

Step 6 Isolate the Nozzle and Compressor

- a.) Split the fuel system by drawing fuel from a remote source. Disconnect the fuel line at the outlet of the fuel regulator. Put this end into a small container of fuel that is about the same level as the center of the regulator (refer to figure 7.17-42). This will eliminate the fuel pump and regulator from the system. Start the heater. If there is still a fuel problem, it must be in the Compressor or Nozzle.

ELIMINATING FUEL PUMP AND REGULATOR FROM SYSTEM

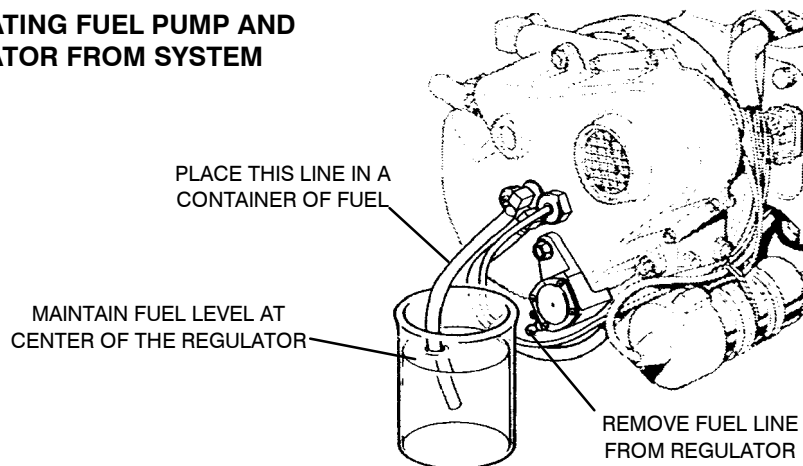


Figure 7.17-42

Step 7 Is the Fuel Nozzle contaminated?

- a.) Clean the nozzle with a cleaner/degreaser, which will wash contamination out the back end of the nozzle.

7.17 - ENGINE HEATER

Operational Problems

Heater Operational Problems that are not specifically described in the function or component diagnostic section are shown below.

Smoking exhaust and smelly exhaust fumes

These symptoms are usually an indication of an extremely rich air/fuel mixture.

Check:

- a) Is the heater connected to the correct voltage?. (Refer to 7.17-15).
- b) Is the blower functioning? Is the air inlet restricted?
- c) Is the compressor functioning? (Refer to 7.17-24).
- d) Is the exhaust restricted?
- e) Is it a new heater? New heaters may smoke for 15 minutes as oil is burned off the exhaust pipe. This is normal.

Low heat output

If the heater appears to be functioning properly but the driver complains of low heat, this is often indicative of a coolant flow restriction. (Refer to 7.17-11).

Engine temperature gauge reads low

Depending on its location, the engine temperature sensor may not be directly in the path of coolant flow from the heater. In these cases the gauge may read significantly lower than actual coolant temperature.

Backfiring

Backfiring occurs when there is air in the fuel supply lines.

Check:

- a) Fuel level in tank. Is the pickup submerged?
- b) Air leaks. Are all the fuel line clamps tight?
- c) For severely restricted combustion air blockage at the blower inlet, combustion chamber, or in the exhaust system.

7.17 - ENGINE HEATER

MAINTENANCE

WEEKLY MAINTENANCE

Run the heater a minimum once a week to keep new fuel in the heater's critical components.

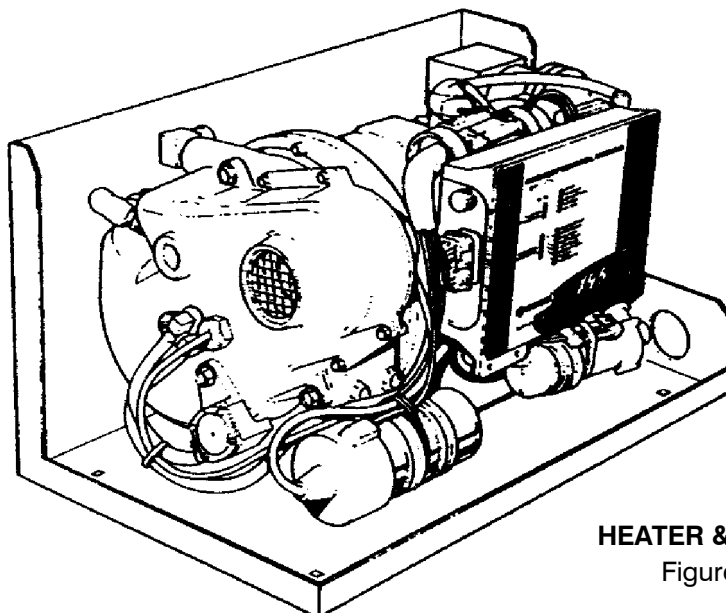
ANNUAL MAINTENANCE

Check the system annually before each heating season. There are several maintenance procedures you can perform to keep your heater in service. Read this maintenance section carefully.

Always return to your authorized Drilling Solutions dealer or distributor for major maintenance.

Clean Heater Enclosure

Remove the heater enclosure cover and blow out the compartment with compressed air. Clean any accumulated debris or dust from the components. Make sure the opening around the exhaust pipe is clear. Visually inspect all the components for wear or damage.



HEATER & ENCLOSURE

Figure 7.17–43

7.17 - ENGINE HEATER

MAINTENANCE (continued)

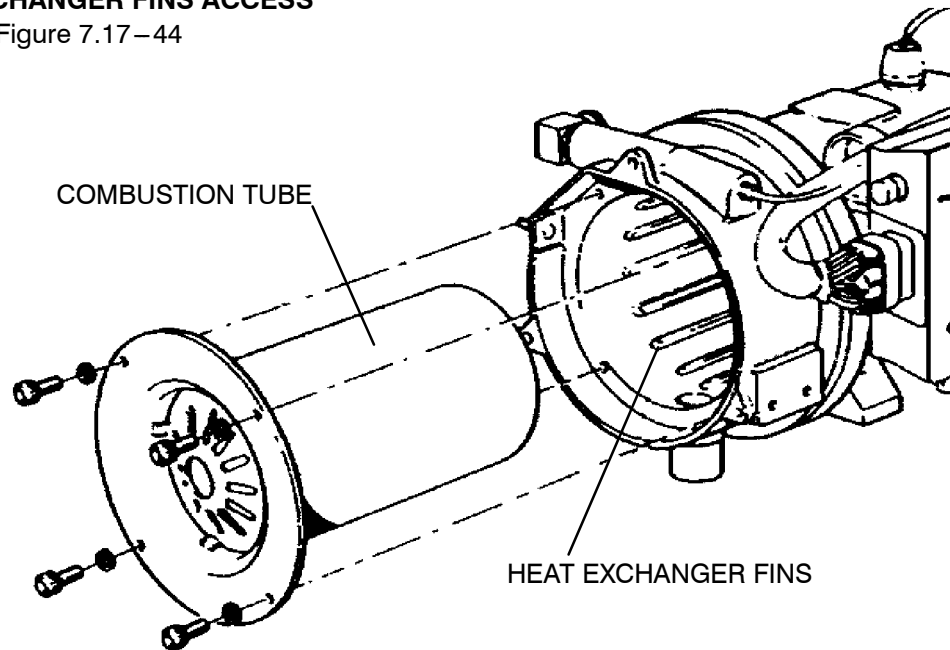
Heat Exchanger

To maintain optimum heat output, clean any combustion deposits that may have accumulated on the heat exchanger fins.

- a.) Remove ignition lead from ignition electrode.
- b.) Remove blower connector
- c.) Remove the 3 bolts securing the fan end assembly.
- d.) Remove the fan end assembly and combustion tube to access the inside of the heat exchanger. Use a wire brush to loosen the deposits and an air hose to blow them out.

HEAT EXCHANGER FINS ACCESS

Figure 7.17 – 44



Exhaust System

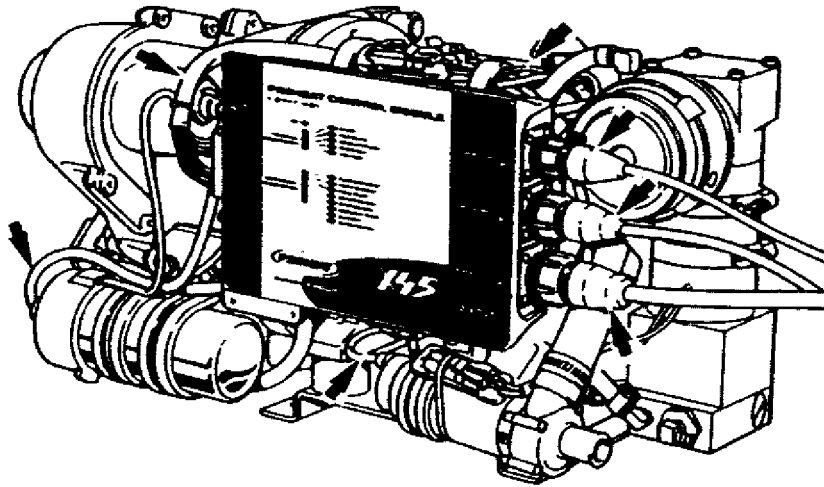
Check the exhaust system carefully. Make sure the exhaust pipe is vented safely away from the vehicle cab. Check the pipe for dents, restrictions or severely corroded areas. Replace the exhaust pipe and clamps if necessary. Ensure the exhaust pipe clamp is tight.

7.17 - ENGINE HEATER

MAINTENANCE (continued)

Electrical System

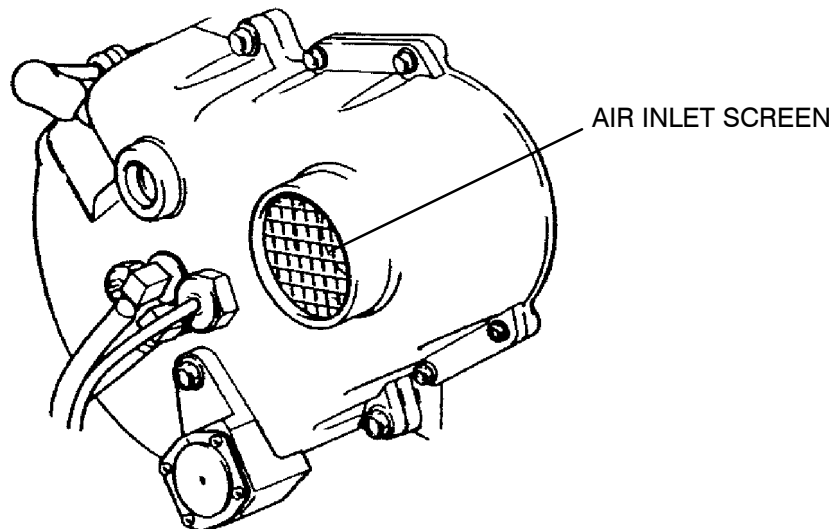
Check the internal and the external wire harnesses for damage. Replace if required.



WIRE HARNESS
Figure 7.17–45

Clean Air Intake

Check the combustion air inlet screen for restrictions. Clean as required.



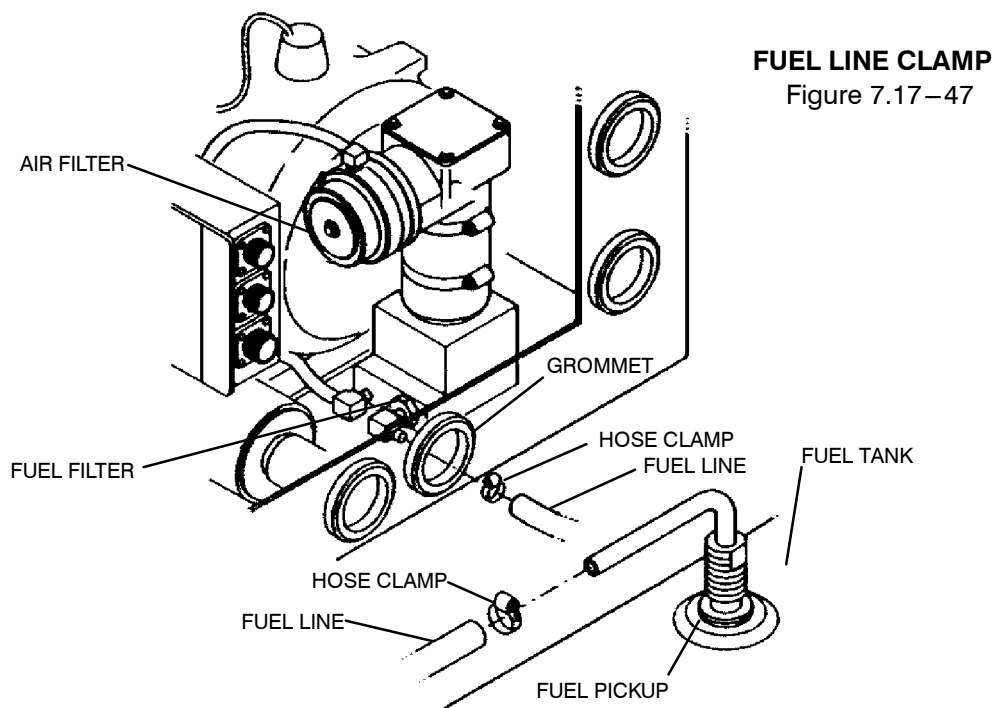
AIR INTAKE
Figure 7.17–46

7.17 - ENGINE HEATER

MAINTENANCE (continued)

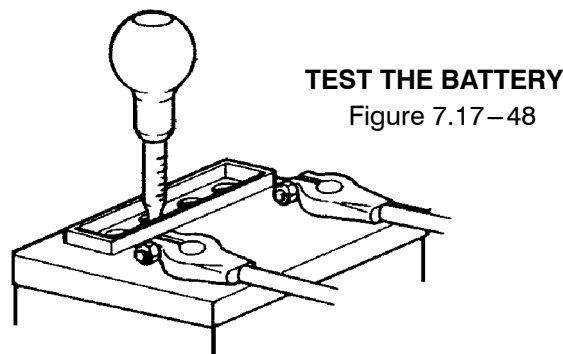
Fuel System

Check the fuel system for damaged fuel lines or leakage. Make sure the clamps on the fuel lines are secure.



Engine Batteries

Check the condition of the batteries and the power connections. The heater will not function properly with weak batteries or corroded connections. If you are unsure of their condition, load test each battery separately and replace as required. Clean terminals to remove all corrosion.

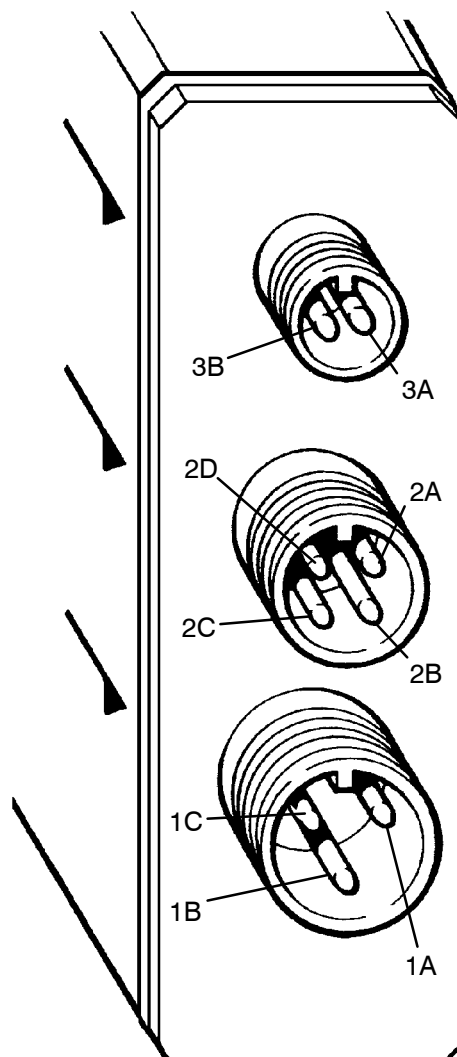


7.17 - ENGINE HEATER

MAINTENANCE (continued)

Operation Test

Run the system for at least 15 minutes or until the heater cycles “OFF” and then “ON” again.



PCM: PIN-OUT DIAGRAM

Figure 7.17-49

3-A	POWER +12V/+24V (3 AMP LIMIT)
3-B	GROUND (-)
2-A	POWER +12V/+24V (OUTPUT)
2-B	GROUND (-)
2-C	“ON” SIGNAL (TO HEATER)
2-D	INDICATOR +12V/+24VOLTS
1-A	POWER +12V/+24V (INPUT)
1-B	GROUND (-)
1-C	NOT USED

7.17 - ENGINE HEATER

MAINTENANCE (continued)
Heater Wiring Diagram

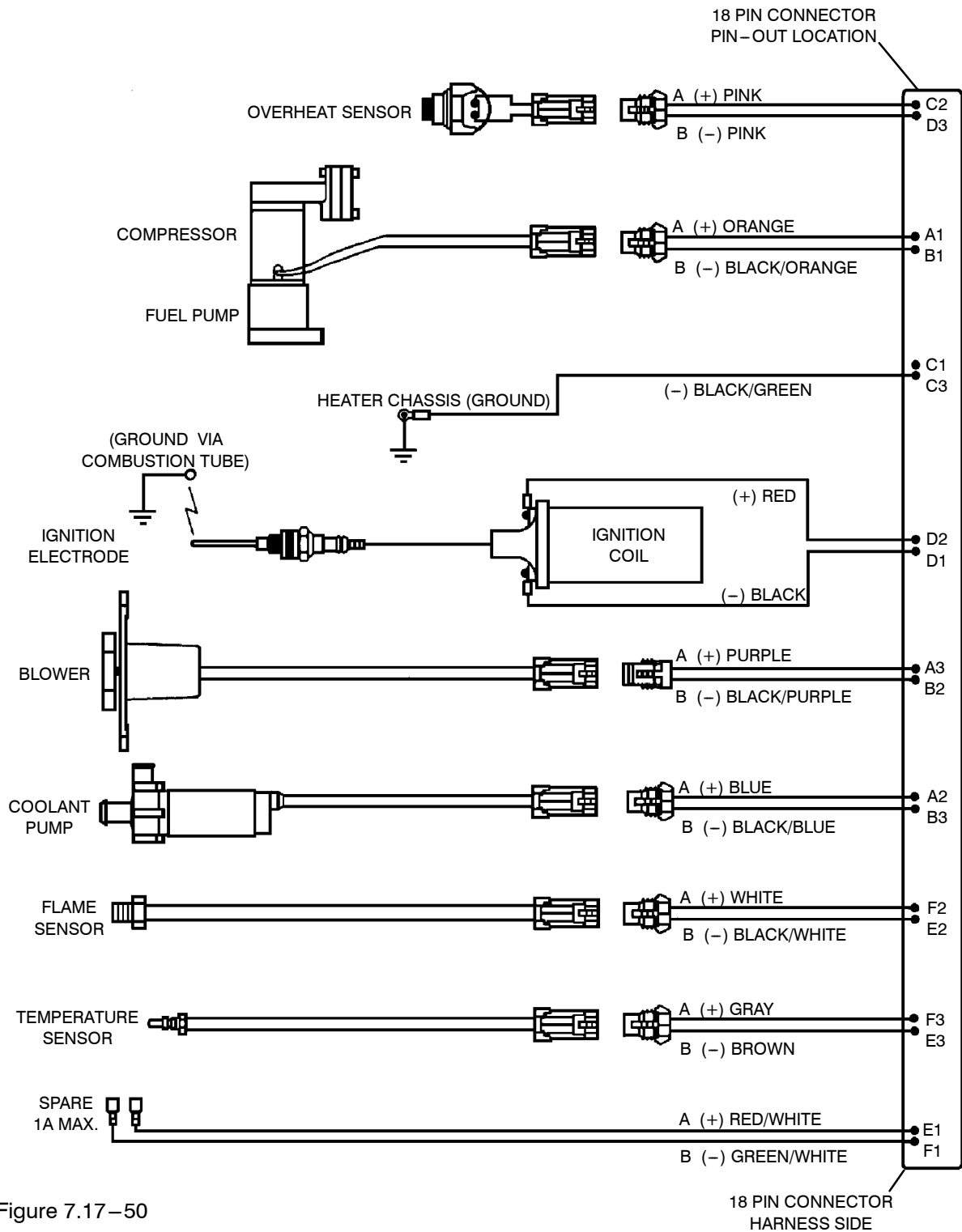
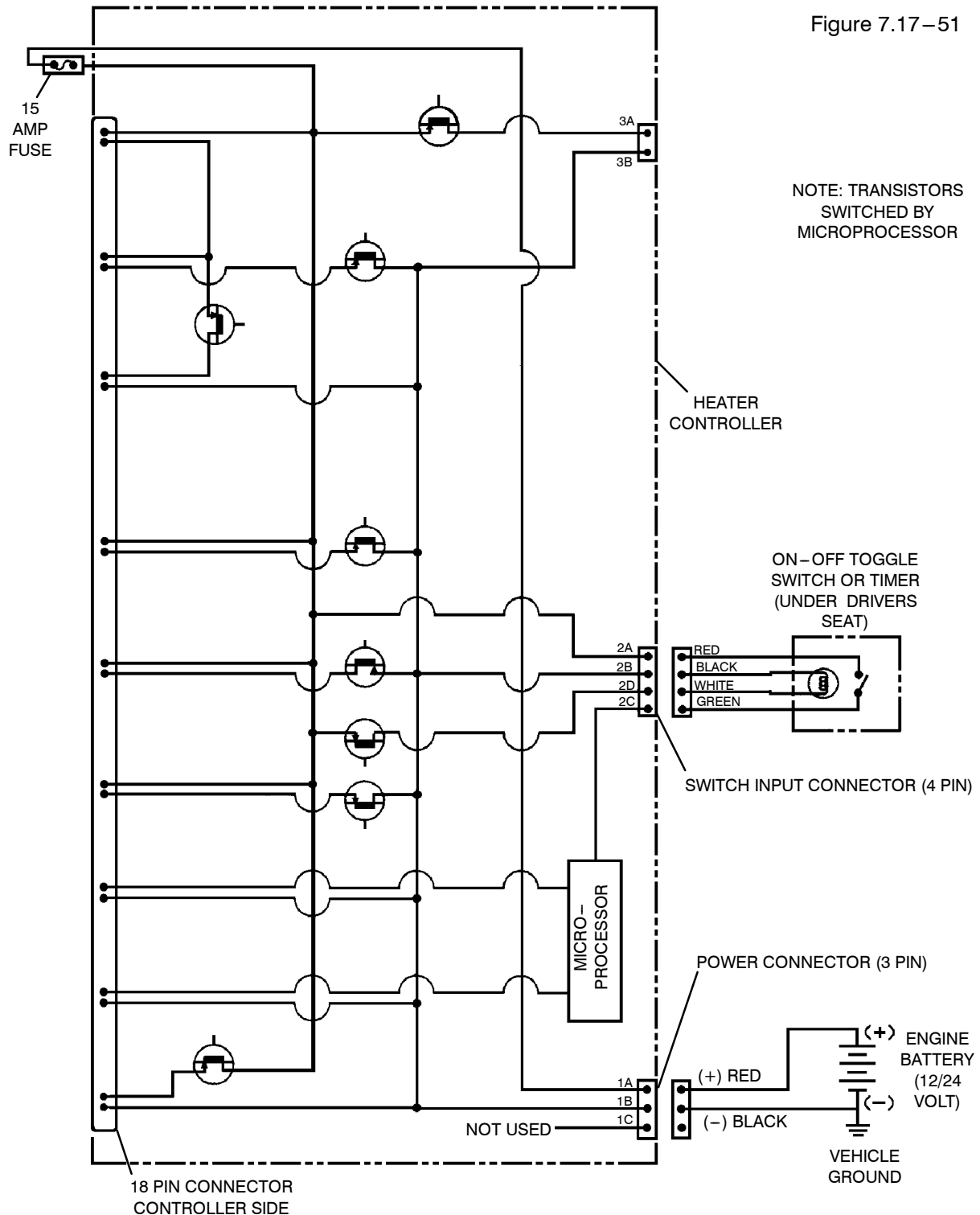


Figure 7.17–50

7.17 - ENGINE HEATER

MAINTENANCE (continued)

Heater Wiring Diagram (continued)



7.17 - ENGINE HEATER

TIMER

General Description

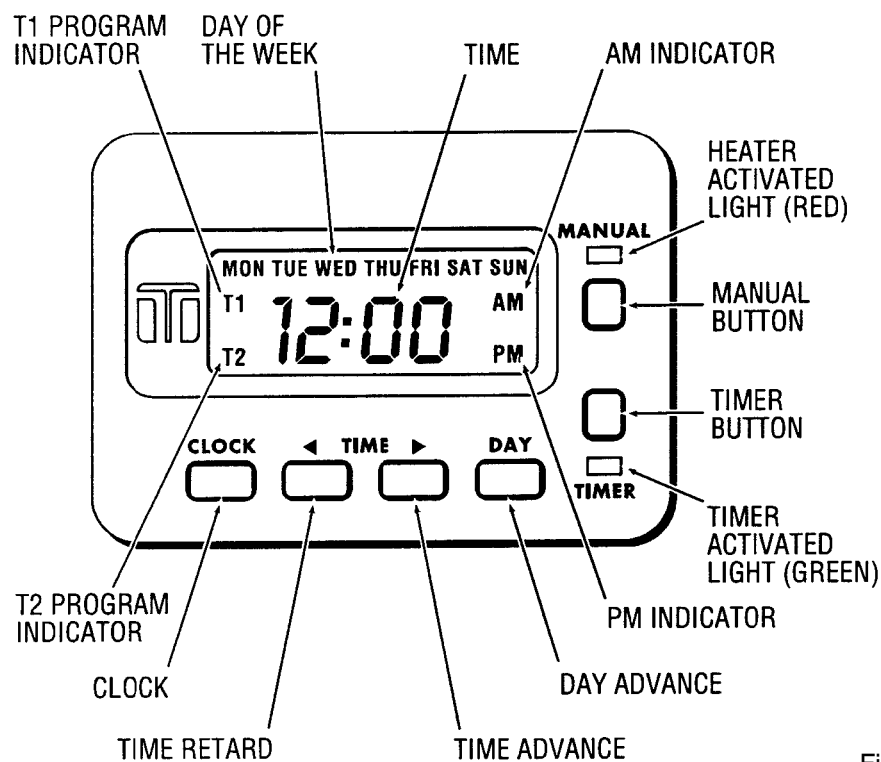


Figure 7.17–52

The 7 day timer can be preset for a single start time, one day at a time or programmed start times per day constantly activated for multiple days of the week. The clock can be preset for 12 or 24 hour time display. The heater run time duration can be preset for 1 or 3 hours. The manual button can be used to override the program and run the heater indefinitely until it is switched off.

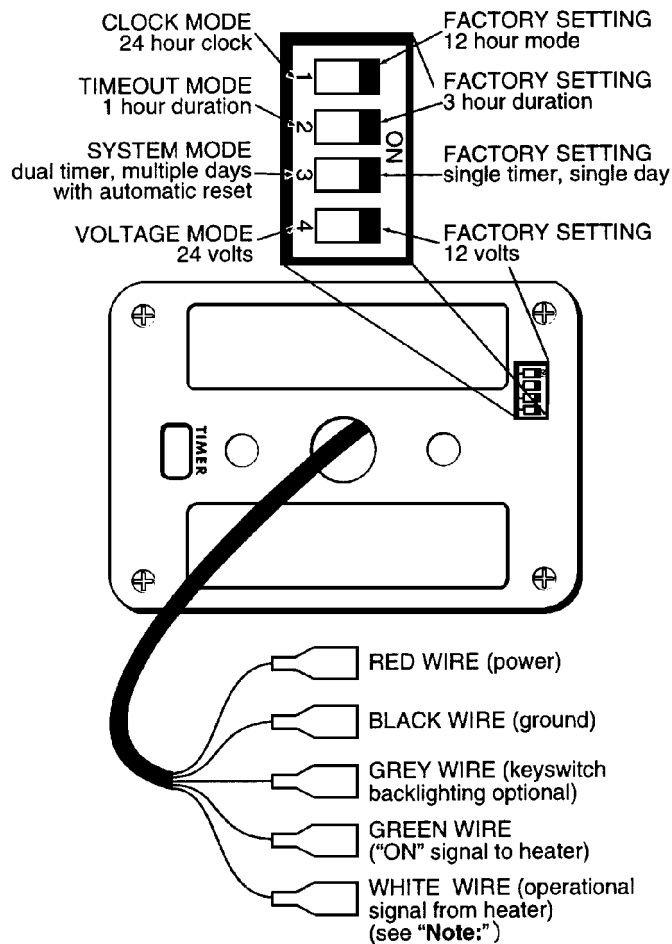
NOTE: The time must be set for the drill system voltage.

If power to the timer is interrupted, the display will flash “12:00 am MON.” in 12 hour format or “00:00 MON.” on 24 hour format. Stored programmed times will remain set in memory.

7.17 - ENGINE HEATER

TIMER (continued)

Wiring & Switch Settings



NOTE: BEFORE USING TIMER, SET THE DIP SWITCH SETTINGS FOR YOUR APPLICATION.

Figure 7.17–53

NOTE: IF THE TIMER IS CONNECTED TO A HEATER WHICH DOES NOT HAVE AN OPERATIONAL SIGNAL WIRE, THEN THE WHITE TIMER WIRE MUST BE JUMPERED TO THE GREEN "ON SIGNAL" WIRE IN ORDER FOR THE TIMER'S RED "ON" INDICATOR TO LIGHT.

Heater Connection

CAUTION

Power to the controller must be disconnected before connecting the timer.

Connect the heater switch harness wires to the timer as follows:

- Black to Black
- Green to Green
- White to White
- Red to Red

CAUTION

Mis-wiring the timer connections may result in timer damage.

7.17 - ENGINE HEATER

TIMER (continued)

To Set Clock - Time & Day

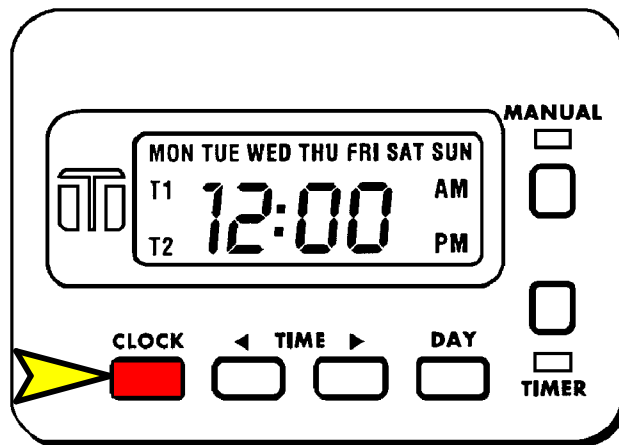


Figure 7.17–54

Step 1

Press and hold **"Clock"**.

Step 2

Press "**◀**" or "**▶**" to set time.

Step 3

Press **"Day"** to set day

Step 4

Release **"Clock"**.

NOTE:

The 12 or 24 hour option is set using Dip Switch No. 1 on back of timer.

ON = 12 hour mode

OFF = 24 hour mode

(factory preset: 12 hour mode)

7.17 - ENGINE HEATER

TIMER (continued)

To Set Single Timer Mode

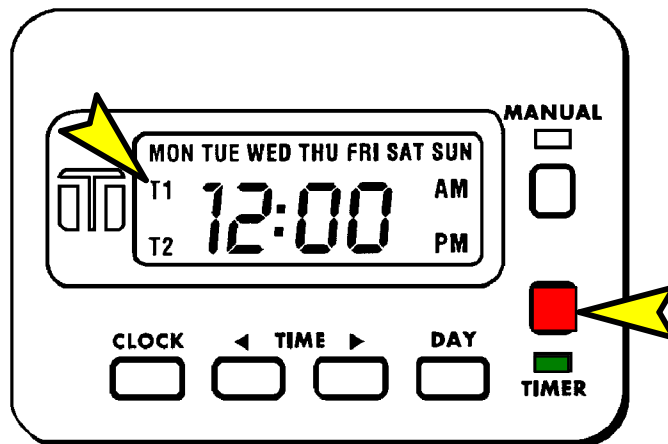


Figure 7.17–55

Step 1

Press and hold **“Timer”**. (Green light will go on and “T1” will flash.)

Step 2

Press “◀” or “▶” to set “ON” time.

Step 3

Press **“Day”** to set day

Step 4

Release **“Timer”**. (Green light and “T1” will remain lit to indicate active Timer.)

Timer set in the single timer mode only will allow you to set one “ON” time. With the T1 time activated, the Timer will go “ON” at the preset time and will be deactivated at the end of its duration time. To reactivate the Timer, press **“Timer”**.

NOTE:

When set time is reached, the heater switches on. Red and green lights are on.

The 1 or 3 hour duration option is set using Dip Switch No. 2 on back of timer.

ON = 3 hour duration

OFF = 1 hour duration

(factory preset: 3 hour duration)

7.17 - ENGINE HEATER

TIMER (continued)

To Set Dual Timer Mode

In the dual timer mode setting you can program your timer to come “ON” daily, Monday thru Friday, Monday thru Saturday or Monday thru Sunday. It also has a built in repeat function so that you do not have to reactivate the timer after every duration time.

NOTE:

In dual timer mode you can set T1, T2 or both T1 & T2. Timer mode option is set using Dip Switch No. 3 on back of timer.

ON = single timer (T1 only)

OFF = dual timer (T1 and T2)

(factory preset: T1 only)

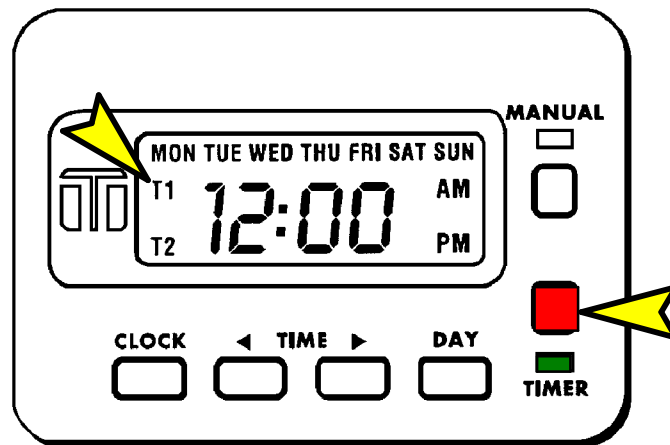


Figure 7.17–56

Step 1

Press and hold “**Timer**”. (Green light will go on and “T1” will flash.)

Step 2

Press “◀” or “▶” to set “ON” time.

Step 3

Press “**Day**” to set day(s).

Step 4

Release “**Timer**”. (Green light and “T1” will remain lit to indicate active T1 program.)

T1 program is now activated. Follow steps 5 thru 8 for T2 program.

7.17 - ENGINE HEATER

TIMER (continued)

To Set Dual Timer Mode (continued)

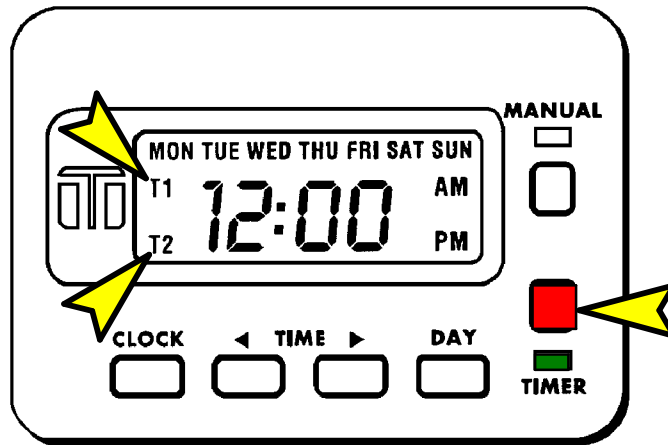


Figure 7.17–57

Step 5

Press and hold **“Timer”**. (Green light will remain on and “T2” will flash.)

Step 6

Press “◀” or “▶” to set “ON” time.

Step 7

Press **“Day”** to set day(s).

Step 8

Release **“Timer”**. (Green light and “T2” will remain lit to indicate active T2 program.)

Step 9

Press **“Timer”** once more to activate both “T1” and “T2”. (“T1” and “T2” will remain lit to indicate active “T1” and “T2” program.)

NOTE:

Timer will repeat each set day until switched off.

Example:

Drill timer set T1 at 6:00 a.m. Monday thru Friday. Set T2 at 2:00 p.m. Monday thru Friday.

Timer will repeat each cycle each week until it is switched off.

7.17 - ENGINE HEATER

TIMER (continued)

Manual & Timed Heater Operation

The **“Manual”** button is used to turn the heater on and off when desired.

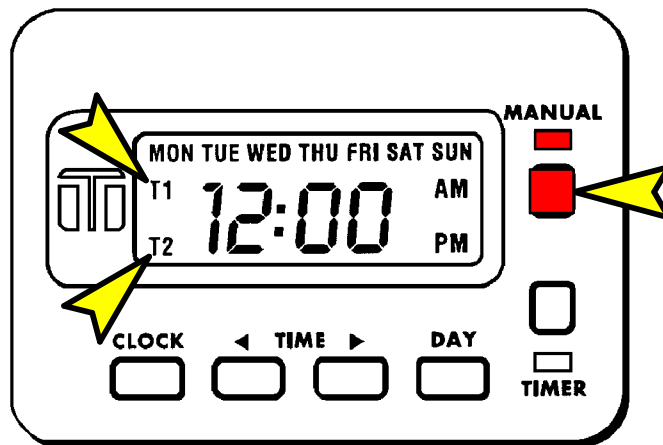


Figure 7.17–58

Step 1

Press **“Manual”** to activate the heater. (Red light will go on and the heater will operate indefinitely.)

Step 2

Press **“Manual”** again to deactivate the heater. (Red light will go out and the heater will turn off.)

NOTE:

“Manual” and “Timer” cannot be active at the same time. If “Manual” is active and “Timer” is pressed, the heater will turn off and the red light goes out.

If “Timer” is active and “Manual” is pressed, “Timer” is deactivated and the green light goes out.

When the heater has been turned on by the “T1 Timer” in a single timer mode, the heater can be turned off by pressing either “Manual” or “Timer”. Both red and green lights will go out.

If the heater has been turned on by the “T1 or T2 Timer” in dual mode, pressing “Manual” will turn the heater off but leaves the timer(s) activated. Pressing “Timer” will turn off the heater and deactivate the timer(s).

7.17 - ENGINE HEATER

Diagnostics

When the timer is installed on a heater, the timer's red "Heater Activated Light" will be lit constantly while the heater is running normally. In the case of a heater error, the timer's red light will flash an error code followed by a pause.

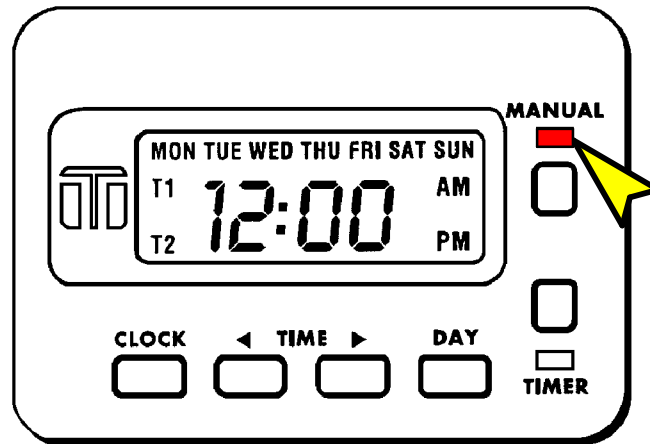


Figure 7.17–59

Example:

Repeatedly flashing five pulses separated by a pause indicates a heater voltage error.

The heater error codes are as follows:

- 1 Flash ----- Start Error
- 2 Flashes ----- Flame Out
- 3 Flashed ----- Coolant Flow
- 4 Flashes ----- Overheat
- 5 Flashes ----- Voltage
- 6 Flashes ----- Flame Sensor
- 7 Flashes ----- Temperature Sensor
- 8 Flashes ----- Fuel Pump
- 9 Flashes ----- Compressor
- 10 Flashes ----- Ignition Coil
- 11 Flashes ----- Coolant Pump
- 12 Flashes ----- Blower
- 13 Not Used ----- Not Used

These errors correspond to those displayed on the Control Module diagnostic panel shown in figure 7.17-6.

7.17 - ENGINE HEATER

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7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Dixon Boss Clamp Selection and Installation

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

SAFETY INFORMATION

MSHA (Mine Safety and Health Administration) Regulations

30 CFR Sections 56.13021 and 57.13021

Except where automatic shutoff valves are used, safety chains or other suitable locking devices shall be used at connections to machines of high pressure hose line of 3/4" inside diameter or larger, and between high pressure hose lines of 3/4" inside diameter or larger, where a connection failure would create a hazard.

30 CFR Section 75.1730

(e) Safety chains, suitable locking devices, or automatic cut-off valves shall be used at connections to machines of high pressure hose lines of 3/4 of an inch inside diameter or larger, and between high pressure hose lines of 3/4 of an inch inside diameter or larger, where a connection failure would create a hazard. For purposes of this paragraph, high pressure means pressure of 100 PSI (6.9 bar) or more.

30 CFR Section 77.412

(d) Safety chains or suitable locking devices shall be used at connections to machines of high pressure hose line of 1 -inch inside diameter or larger, and between high pressure hose line of 1 -inch inside diameter or larger, where a connection failure would create a hazard.

S.T.A.M.P.E.D.

When fabricating and specifying hose assemblies, ask the following questions:

Size:

What is the I.D. (Inside Diameter) of the hose? What is the O.D. (Outside Diameter) of both ends of the hose? What is the overall length of the assembly required?

Temperature:

What is the temperature range of the media (product) that is flowing through the hose assembly? What is the temperature range of the environment that surrounds the outside of the hose assembly?

Application:

How is the hose assembly actually being used? Is it a pressure application? Is it a vacuum (suction) application? Is it a gravity flow application? Are there any special requirements that the hose assembly is expected to perform? Is the hose being used in a horizontal or vertical position? Are there any pulsations or vibrations acting on the hose assembly?

Media:

What is the media/material that is flowing through the hose assembly? Being specific is critical. Check for: Abrasive materials, chemical compatibility, etc.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

S.T.A.M.P.E.D. (continued)

Pressure:

What is the maximum pressure including surges (or, maximum vacuum) that this hose assembly will be subjected to? Always rate the maximum working pressure of your hose assembly by the lowest rated component in the system.

Ends:

What couplings have been requested by the user? Are they the proper fittings for the application and hose selected.

Dixon:

Dixon recommends that, based on the hose, fittings and attachment method used, all assemblies be permanently marked with the designed working pressure and intended media. Do not use other manufacturer's fittings or ferrules with Dixon products due to the differences in dimensions and tolerances. We also recommend that all hose assemblies be tested frequently. *Be Safe: Any questions on application, use or assembly contact your local Atlas Copco dealer or distributor.*

Force Chart

Force (In Pounds)										
Hose I.D.	25 PSI	50 PSI	75 PSI	100 PSI	150 PSI	200 PSI	250 PSI	300 PSI	500 PSI	1000 PSI
1/4"	1	2	4	5	7	10	12	15	25	49
3/8"	3	6	8	11	17	22	28	33	55	110
1/2"	5	10	15	20	29	39	49	59	98	196
3/4"	11	22	33	44	66	88	110	133	221	442
1"	20	39	59	79	118	157	196	236	393	785
1-1/4"	31	61	92	123	184	245	307	368	614	1227
1-1/2"	44	88	133	177	265	353	442	530	884	1767
2"	79	157	236	314	471	628	785	942	1471	3142
2-1/2"	123	245	368	491	736	982	1227	1473	2454	4909
3"	177	353	530	707	1060	1414	1767	2121	3534	7069
4"	314	628	942	1257	1885	2513	3142	3770	6283	12566
5"	491	982	1473	1964	2945	3927	4909	5891	9818	19635
6"	707	1414	2121	2827	4241	5655	7069	8482	14137	28274
8"	1257	2513	3770	5027	7540	10053	12566	15080	25133	50266
10"	1964	3927	5891	7854	11781	15708	19635	23562	39270	78540
12"	2827	5655	8482	11310	16965	22620	28274	33929	46549	113098

Note: For hose I.D.'s from 1-1/4" to 12" the force in pounds is greater than the PSI.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Force Chart (continued)

- 1.) *Force is the dynamic power which is exported longitudinally through a hose, towards the ends. To arrive at the number of pounds of force exerted, you merely multiply the area of the I.D. times the working pressure being used.*
- 2.) Area of a circle: $\Pi \times r^2$ ($\Pi[3.1416]$ times radius squared)
- 3.) Force = Area x Pressure

GENERAL PREPARATION INSTRUCTIONS

The following contains general procedures that relate to all assemblies in terms of preparation.

1. **Cutting the Hose** - Two terms are used:
 - a.) **Cut to length** means cut the hose to the length requested excluding the length of the fitting(s).
 - b.) **Overall Length (O.A.L.)** refers to the overall length of the assembly including fittings.

Example: The hose has to be cut to a certain length so that when couplings are installed the length of entire assembly is the required overall length. The calculation below describes the steps to determine hose length to be cut to obtain the required overall length.

O.A.L = requirement is 50 ft. (This is the total length of the assembly).

Fitting Length = 7 inches (This is the overall length of the fitting).

Shank Length = 4 inches (This is length of the fitting that is inserted into the hose).

A.	Fitting Length	7 inches
B.	Shank Length	<u>4 inches</u>
C.	Subtract A from B	3 inches
D.	Multiply C by 2	<u>x2</u>
E.	Total Coupling Length	6 inches
F.	Overall Length Required	50 foot
G.	Subtract E from F	<u>6 inches</u>
	Cut Hose Length	49 foot - 6 inches (49'-6")

2. **Cut Ends Square** - Hose ends must be cut square (90° to the length of the hose) for proper coupling insertion. Improper insertion can reduce coupling retention.
3. **Clean Hose Ends** - Debris left inside the hose from the cutting process must be removed prior to coupling insertion. This is especially important when an abrasive wheel or "chop saw" is used to make a cut. Debris will reduce coupling retention.
4. **Determine number of clamps required**

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

GENERAL PREPARATION INSTRUCTIONS (continued)

5. **Mark Hose for Proper Clamp Placement** - The Boss Clamps and Air King Clamps do not require a hose marking for placement. because the clamp's gripping finger positions the clamp automatically.
6. **Static Grounding** - When static grounding is required it's essential that it be done properly. Typically, it is accomplished by bending the built-in static wire or the helical wire (or wires) in to the hose I.D. (Inside Diameter) so that the wire or the wires make contact with the metal coupling. Bend in no more wire than necessary. One half inch is usually sufficient. Other methods of static grounding may be required due to hose type, hose manufacturer or style of coupling being installed. **Always** contact the hose manufacturer to verify proper static grounding techniques for that particular hose. Improper static grounding can lead to fire, explosions reduced assembly life, damage to property and injury or death to personnel.
7. **Hoses with Helical Wire** - Determine which direction the helical wire is pointing. Proper installation of pre-formed band clamps or bands and buckles relies upon proper orientation of the clamp tail with the helical wire. **Note:** If helical wire is not used for static grounding, trim the wire flush with the hose. This will prevent operator injuries during the assembly.
8. **Seal the Hose Ends** - At each end of the hose, the reinforcement is exposed to the outside elements. This exposure can lead to premature assembly failure especially if the end of the assembly is laying in a puddle of water or puddle of product. If assembly is to be subjected to these conditions, the hose ends must be sealed. Typically, rubber cement or shellac can be used. Wire reinforce hoses can corrode to the point of failure near the clamp. Textile or fabric reinforced hoses can "wick" water or product to anywhere in the length of the hose and exit the cover at the weakest spot.
9. **Apply Coupling Lubricant** - Lubricate the coupling shank and hose inside diameter prior to the coupling insertion. Dixon recommends using Dixon Coupling Lubricant (DCL10 pint, DCL80 gallon). **Do not** use hand soap, oil, grease, WD40, Silicon Spray or other similar substances that may attack the hose tube material and / or reduce coupling retention.

DIXON DIAMETER TAPE PROCEDURE

All Dixon clamping devices ("Boss" Clamps, Double Bolt Clamps, Single Bolt Clamps, "T" Bolt Clamps, Holedall Ferrules, etc.) have a minimum and maximum hose O.D. (Outside Diameter) range. To ensure proper coupling performance, it is imperative that the clamping device selected be the correct size for the hose O.D. being used.

Accurate hose O.D. measurement is achieved by using a Diameter Tape. Both ends of the hose **must** be measured due to the variances allowed by the hose manufacturers in their production tolerances. In addition, the hose manufacturers change dimensional specifications on their products without prior notification.

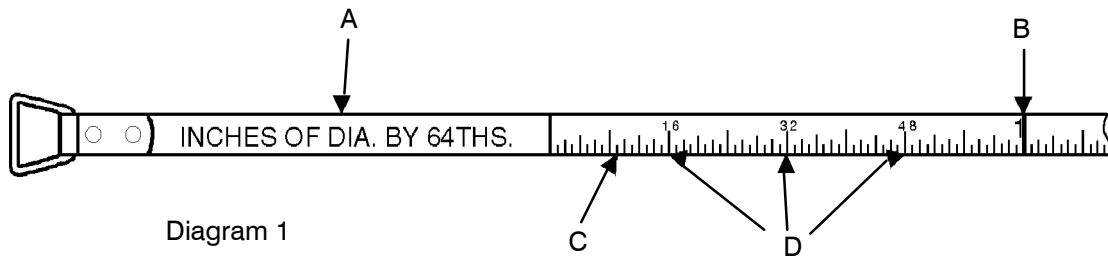
Procedure

1. Grasping the tape buckle, pull several inches of tape from the case.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Procedure (continued)

2. One side of the tape is a regular ruler. The other side of the tape is marked "INCHES OF DIA. BY 64THS. (See "A" on Diagram 1). This is the side of the tape used to measure hose O.D.



3. To understand how the diameter tape works, do the following:
 - a.) Locate the numbers (1,2,3,etc.) with a line the width of the tape to the right of it (See "B" in Diagram 1). These represent inches of diameter.
 - b.) The numbers "16", "32", and "48" are reference numbers (See "D" in Diagram 1). They represent 16/64ths, 32/64ths and 48/64ths of an inch respectively.
 - c.) Each hash marks between these two numbers represents 1/64th of an inch (See "C" in Diagram 1).

These numbers, when combined as outlined below, convert the hose circumference into inches of diameter.

4. To measure the hose O.D. with the diameter tape, do the following:
 - a.) With the diameter side of the tape facing up, loop the tape around the end of the hose to be measured keeping the loop two to three inches from the hose end.
 - b.) While the tape is being looped around the hose, keep the buckle to the bottom of the loop.
 - c.) Making sure that the tape is as flat on the hose as possible, pull the tape tight.
 - d.) The line to the right of "INCHES OF DIA. BY 64THS." should line up with one of the inches of diameter marks, reference number marks or hash marks above it.
5. To read the hose O.D. just measured in step 4, do the following:
 - a.) Determine the inches of diameter number. If the line from Step 4d above lines up with one of these numbers, this is your outside diameter (See Diagram 2). If line from Step 4d above lines up with a reference the number to the LEFT of an inches of diameter number, see step 5b below.
 - b.) Locate the reference number (if needed) to the LEFT of inches of diameter number determined by the line from Step 4d above. The outside diameter will be the inches of diameter number from Step 5a above PLUS the 64ths represented by the reference number (See Diagram 3). If the line from Step 4d above is to the left of a reference number, see Step 5c.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Procedure (continued)

- c. Locate the hash mark (if needed) to the LEFT of the reference number determined by the line from Step 4d. The outside diameter will be the inches of diameter from Step 5a PLUS the 64ths represented by reference number from Step 5b PLUS the number of hash marks from the reference number including the one above the line from Step 4d (See Diagram 4).

Note: It is a good practice to measure each hose end twice to ensure an accurate measurement.

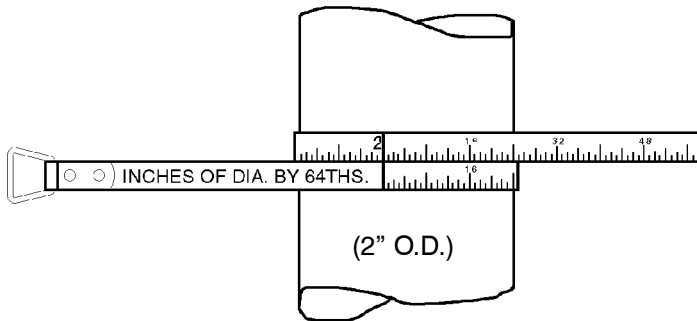


Diagram 2

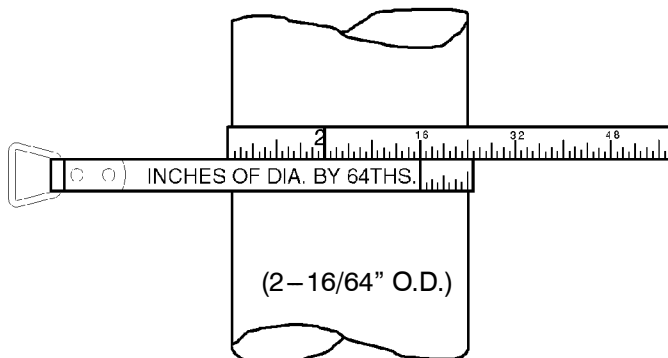


Diagram 3

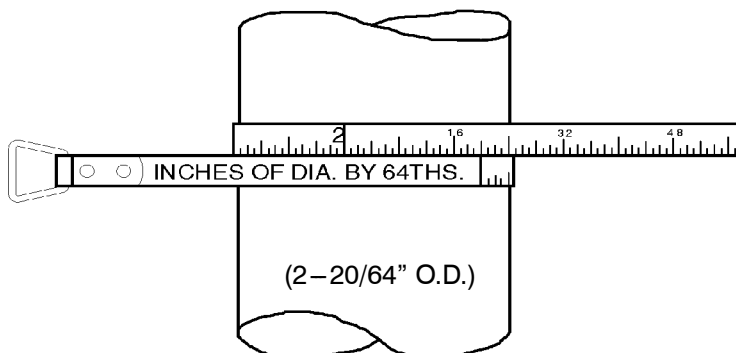


Diagram 4

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

BOSS CLAMPS

HOSE I.D.	HOSE O.D.		TORQUE	TYPE
	FROM:	TO:		
1/4"	36/64"	42/64"	6 ft/lbs	2-BOLT TYPE
3/8"	44/64"	56/64"	6 ft/lbs	
1/2"	52/64"	60/64"	6 ft/lbs	
1/2"	60/64"	1-4/64"	12 ft/lbs	
1/2"	1-12/64"	1-12/64"	12 ft/lbs	
3/4"	1-10/64"	1-18/64"	21 ft/lbs	
3/4"	1-12/64"	1-20/64"	21 ft/lbs	
3/4"	1-20/64"	1-32/64"	21 ft/lbs	
3/4"	1-32/64"	1-44/64"	21 ft/lbs	
1/2"	58/64"	1-2/64	6 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
1"	1-26/64"	1-36/64"	21 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
1"	1-34/64"	1-46/64"	21 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
1"	1-44/64"	1-60/64"	21 ft/lbs	
1"	1-60/64"	2-8/64"	21 ft/lbs	
1-1/4"	1-32/64"	1-50/64"	40 ft/lbs	
1-1/4"	1-44/64"	1-56/64"	21 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
1-1/4"	1-50/64"	2-6/64"	40 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
1-1/4"	1-56/64"	2-4/64"	21 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
1-1/4"	2-8/64"	2-24/64"	40 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
1-1/2"	1-52/64"	2"	40 ft/lbs	
1-1/2"	2"	2-14/64"	40 ft/lbs	
1-1/2"	2"	2-8/64"	21 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
1-1/2"	2-4/64"	2-16/64"	40 ft/lbs	
1-1/2"	2-12/64"	2-24/64"	40 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
1-1/2"	2-24/64"	2-36/64"	40 ft/lbs	
1-1/2"	2-36/64"	2-48/64"	40 ft/lbs	

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

BOSS CLAMPS (continued)

HOSE I.D.	HOSE O.D.		TORQUE	TYPE
	FROM:	TO:		
2"	2-16/64"	2-32/64"	40 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
2"	2-22/64"	2-34/64"	60 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
2"	2-32/64"	2-48/64"	40 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
2"	2-32/64"	2-50/64"	60 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
2"	2-48/64"	3-4/64"	60 ft/lbs	
2"	2-48/64"	3-4/64"	60 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
2"	3-6/64"	3-28/64"	60 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
2-1/2"	3-4/64"	3-32/64"	60 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
2-1/2"	3-6/64"	3-28/64"	60 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
2-1/2"	3-32/64"	3-60/64"	150 ft/lbs	
3"	3-32/64"	3-48/64"	60 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
3"	3-32/64"	3-60/64"	150 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
3"	3-48/64"	4"	150 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
3"	3-52/64"	4-4/64"	150 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
3"	4"	4-12/64"	200 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS
3"	4-4/64"	4-28/64"	200 ft/lbs	4-BOLT TYPE 2 GRIPPING FINGERS
3"	4-12/64"	4-32/64"	200 ft/lbs	4-BOLT TYPE 4 GRIPPING FINGERS

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

BOSS CLAMPS (continued)

HOSE I.D.	HOSE O.D.		TORQUE	TYPE
	FROM:	TO:		
3"	4 – 16/64"	4 – 52/64"	150 ft/lbs	THREE PIECE 6 – BOLT TYPE
4"	4 – 40/64"	5"	150 ft/lbs.	
4"	4 – 56/64"	5 – 16/64"	200 ft/lbs.	
4"	5 – 16/64"	5 – 38/64"	200 ft/lbs.	
4"	5 – 34/64"	5 – 60/64"	200 ft/lbs.	
6"	6 – 56/64"	7 – 24/64"	200 ft/lbs.	
6"	7 – 32/64"	8"	200 ft/lbs.	

Note:

1. The bolts used in the Boss interlocking clamps are **not** standard bolts. They vary from standard bolts in their length, diameter, overall thread length and material hardness. These bolts can be re-torqued, but it is **not** recommended that they be reused, as they are designed for a single bend only. Dixon recommends using only factory supplied replacement bolts.
2. Torque values for clamps are based on dry bolts. The use of lubricant on bolts will adversely effect clamp performance.
3. Do not lubricate bolts.
4. Recommended torque rating is in ft./lbs.

“Boss” Clamp Selection

1. Measure the hose “Free” O.D. (Outside Diameter) with a diameter tape. “Free” O.D. is the outside diameter **before** the stem is inserted.
2. Determine the hose I.D. (Inside Diameter).
3. On the Boss Clamp Chart, locate the “Hose I.D.” column.
4. Locate the section of clamps in that column that correspond with the hose I.D.
5. From that section of the clamps, find the clamp that has an O.D. range in the “Hose O.D. From / To” column that best fits the hose O.D. just measured.

Additional Information

1. For steam hose, select the clamp that has a maximum range as close to (but not smaller than) the measured hose O.D. This will allow the clamp to be re-tightened many times to adjust for “Cold-Flow” which speeds up with increased temperature and /or hot/cold cycles.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Additional Information (continued)

2. For hard wall constructed hose (wire present) with an O.D. at or near the clamp's maximum range, use of the next largest clamp may be required. See "Criteria For Sufficient Fit of a Boss Clamp" to determine proper clamp fit.
3. For soft wall constructed hose (no wire present) having an O.D. at or near clamp's minimum range, use of the next smallest clamp may be required. See "Criteria For Sufficient Fit of a Boss Clamp" to determine proper clamp fit.

Notes

1. Use of an incorrectly sized "Boss" clamp can result in damage to property and serious injury to personnel.
2. Refer to the "DIXON DIAMETER TAPE PROCEDURE" for instructions on how to read a diameter tape.
3. Refer to "INSTALLATION OF BOSS 2 BOLT CLAMP" for assembly techniques when using a two bolt "Boss" clamp.
4. Refer to "INSTALLATION OF BOSS 4 BOLT CLAMP" for assembly techniques when using a four bolt "Boss" clamp.
5. Refer to "INSTALLATION OF BOSS 6 BOLT CLAMP" for assembly techniques when using a six bolt "Boss" clamp.

Criteria For Sufficient Fit of a Boss Clamp

Notes

1. Sufficient fit criteria provides inspection guidelines when the clamp has been assembled in accordance with prescribed Procedure and all of the bolts are tightened to 150 FT/LBS. FOR 3 INCH CLAMP, 60 FT/LBS FOR THE 2-1/2 AND 2 INCH CLAMPS.
2. The failure to adhere to these guidelines could produce poor clamp performance, leaking assemblies or even separation of hose and coupling that may cause property damage and / or serious injury to personnel.

Minimum Range

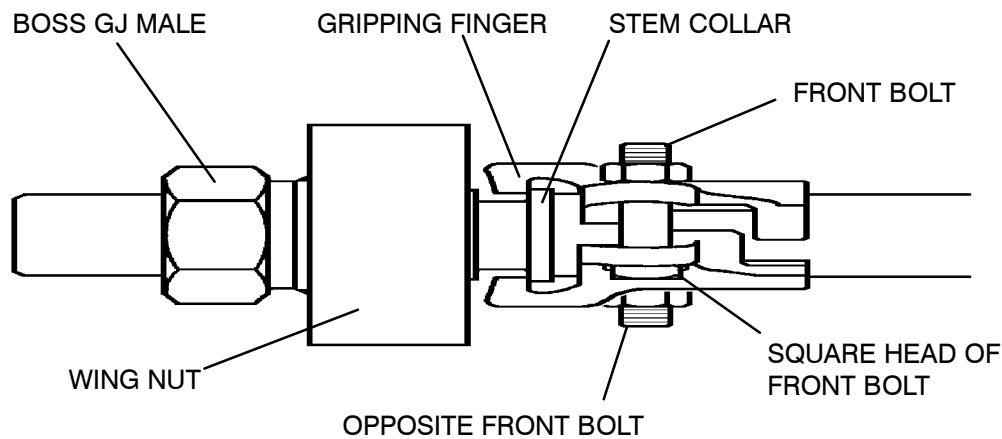
1. 1/32" clearance between clamp halves (both sides) for clamps that are designed to fit 1/4" I.D. through 2" I.D. hose.
2. 1/16" clearance between clamp halves (both sides for 4 bolt clamps) or all segments (6 bolt clamps) for clamps designed to fit 2-1/2" I.D. through 6" I.D. hose.
3. 1/32" clearance between clamp gripping fingers (all gripping fingers) and stem groove for all sizes.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Maximum Range

1. 1/32" interlock between the clamp gripping finger and stem collar (all gripping fingers) for clamps designed to fit 1/4" I.D. through 2" I.D.
2. 1/16" interlock between the clamp gripping finger and stem collar (all gripping fingers) for clamps designed to fit 2-1/2" I.D. through 6" I.D.
3. 1/32" interlock between dovetail extensions (both sides) for clamps designed to fit 1/4" I.D. through 2" I.D. hose.
4. 1/16" interlock between dovetail extensions on both sides (4 bolt clamps) or all segments (6 bolt clamps) for clamps designed to fit 2-1/2" I.D. through 6" I.D. hose.

INSTALLATION OF BOSS 2 BOLT CLAMP



Procedure

1. Prepare the hose. Refer to "GENERAL PREPARATION INSTRUCTIONS".
2. Place the stem in a vise.
 - a.) For male stems, tighten the vise on the hex.
 - b.) For female stems (wing nut), place a spud in the vice, tighten and then thread the wing nut onto the spud.
3. Select the proper Boss Clamp. Refer to "Boss Clamp Selection".
4. Position the clamp gripping fingers behind the stem collar as illustrated above.
5. Tighten the bolts by hand until there is equal thread engagement. **Note:** When hose O.D. is at or near clamp maximum range, starting of nuts on bolts may require squeezing clamp halves in a vise.
6. Bolt tightening sequence is as follows:
 - a.) Front bolt, 1 full turn.
 - b.) Opposite side front bolt, 1 full turn.
 - c.) Repeat "1" and "2" until all bolts are tightened to recommended torque value listed on "BOSS CLAMPS" chart. Torque values are based upon "dry bolts". Lubricant on bolts will adversely effect clamp performance. **Use a torque wrench.**
 - d.) Remove assembly from vise.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

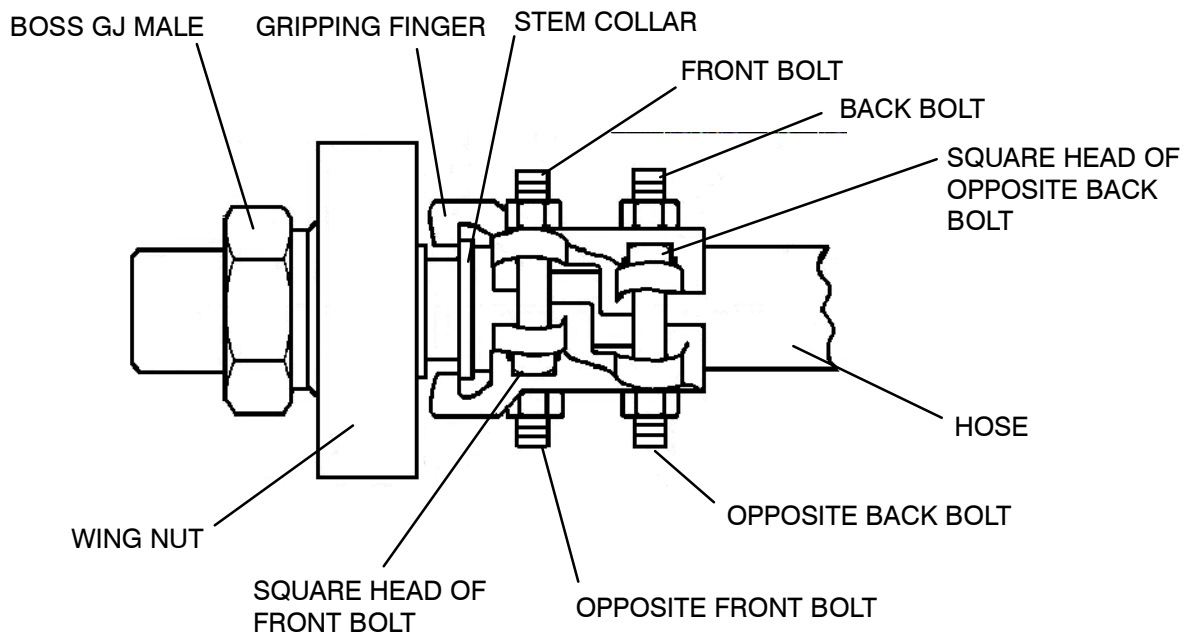
Procedure (continued)

7. Test assembly if required. Refer to “TESTING”.

Notes:

1. Clamp bolts are designed to bend during tightening. This “bending” allows the clamp to conform to the hose circumference.
2. Periodic bolt re-tightening is necessary due to “Cold-Flow” present in all rubber hoses.
3. Boss clamps (including the nuts and bolts) are for **single use only**. **Do not reuse**. Once removed, discard.
4. Refer to “Criteria For Sufficient Fit of a Boss Clamp” to determine proper assembly.

INSTALLATION OF BOSS 4 BOLT CLAMP



Notes:

1. Periodic bolt re-tightening is necessary due to “Cold-Flow” present in all rubber hoses.
2. Boss clamps (including the nuts and bolts) are for **single use only**! **Once removed, discard**.

Process

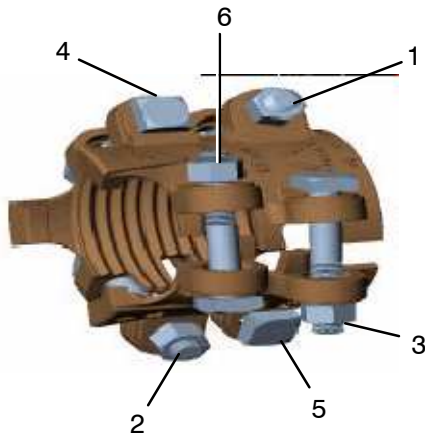
1. Prepare the hose. Refer to “GENERAL PREPARATION INSTRUCTIONS”.
2. Place the stem in a vise.
 - a.) For male stems, tighten the vise on the hex.
 - b.) For female stems (wing nut), place a spud in the vice, tighten and then thread the wing nut onto the spud.
3. Select the proper Boss Clamp. Refer to “Boss Clamp Selection”.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Process (continued)

4. Position the clamp gripping fingers behind the stem collar as illustrated above.
5. Tighten the bolts by hand until there is equal thread engagement. **Note:** When hose O.D. is at or near clamp maximum range, starting of nuts on bolts may require squeezing clamp halves.
6. Using a torque wrench, tighten bolts to the recommended torque **of 150 ft-lbs for the 3 inch clamp and 60 ft-lbs for the 2-12 inch and 2 inch clamps**. Torque values are based upon “dry bolts”. Lubricant on bolts will adversely effect clamp performance. Bolt tightening sequence is as follows:
 - a.) Back bolt, 1 full turn.
 - b.) Front bolt, 1 full turn.
 - c.) Snug by hand, nuts on opposite side of bolts just tightened.
 - d.) Opposite side back bolt, 1 full turn.
 - e.) Opposite side front bolt, 1 full turn.
 - f.) Snug by hand, nuts on opposite side of bolts just tightened.
 - g.) Repeat “a” to “f” until all bolts are tightened to recommended torque. Clamp bolts are designed to bend during tightening. This “bending” allows the clamp to conform to the hose circumference.
7. Test assembly if required. Refer to “TESTING”.
8. Refer to “Criteria For Sufficient Fit of a Boss Clamp” to determine proper assembly.

INSTALLATION OF BOSS 6 BOLT CLAMP



Procedure

1. Prepare the hose. Refer to “GENERAL PREPARATION INSTRUCTIONS”.
2. Place the stem in a vise.
 - a.) For male stems, tighten the vise on the hex.
 - b.) For female stems (wing nut), place a spud in the vice, tighten and then thread the wing nut onto the spud.
3. Select the proper Boss Clamp. Refer to “Boss Clamp Selection”.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

Procedure (continued)

4. Position the clamp gripping fingers behind the stem collar.
5. Tighten the bolts by hand until there is equal thread engagement on all six nuts.
6. Tighten nuts on bolts in the following sequence. See Boss 6 Bolt Clamp illustration.
 - a.) Bolt “1” – one full turn. Before tightening each bolt in sequence, snug the nut by hand if loose.
 - b.) Bolt “2” – one full turn.
 - c.) Bolt “3” – one full turn.
 - d.) Bolt “4” – one full turn.
 - e.) Bolt “5” – one full turn.
 - f.) Bolt “6” – one full turn.
 - g.) Repeat “1” to “6” until all bolts are tightened to recommended torque value listed on “BOSS CLAMPS” chart. Torque values are based upon “dry bolts”. Lubricant on bolts will adversely effect clamp performance. **Use a torque wrench.**
 - h.) Remove assembly from vice.
7. Test assembly if required. Refer to “TESTING”.

Notes:

1. Clamp bolts are designed to bend during tightening. This “bending” allows the clamp to conform to the hose circumference.
2. Periodic bolt re-tightening is necessary due to “Cold-Flow” present in all rubber hoses.
3. Boss clamps (including the nuts and bolts) are for **single use only. Do not reuse.** Once removed, discard.
4. Refer to the “Criteria For Sufficient Fit of a Boss Clamp” for guidelines to determine proper assembly.

TESTING

The following is for general hydrostatic testing and electrical continuity testing. Other procedures may need to be employed. Follow the RMA (Rubber Manufacturers Association) hydrostatic test procedures IP-11-1 through IP-11-8 or ASTM D-380 (latest revision). Consult the hose manufacturer if questions arise. If an assembly requires both hydrostatic and electrical continuity testing, perform the electrical continuity test first.

7.18 - AIR HOSE CLAMP SELECTION AND INSTALLATION

TESTING (continued)

Hydrostatic Testing

1. Determine the assembly working pressure. The assembly working pressure is the *lesser* pressure rating of either the hose or the couplings.
2. Determine the test pressure. Test pressure is 1 – 1/2 times the assembly working pressure.
3. Lay the assembly in a straight line.
4. Install test caps or test plugs to both ends.
5. Connect bleed-off valve to one end and test pump intermediate hose to other end of test sample.
6. Position test pump (or test sample) to that test pump and test sample are at a 90° angle to each other.
7. Fill test sample with water. Elevate end with bleed-off valve to purge air from sample. Make certain that all air is removed.
8. Bulwark ends of test sample to prevent damage from accidental coupling separation.
9. Activate pump until test pressure is achieved.
10. Hold test pressure for 15 minutes.
11. Turn off pump and relieve pressure from test sample.
12. Remove test fixtures from test sample.
13. Drain water from test sample.
14. Complete test report for sample just tested.



No one is to stand near ends of test samples while under pressure for any reason.

Electrical Continuity Testing

No standard exists for testing electrical continuity. Generally speaking, this type of testing is done with either a continuity meter or a multimeter.

The continuity meter simply has a light that goes on when each coupling is simultaneously touched with a probe. A multimeter registers electricity in ohms (Ω).

Always contact the hose manufacturer for instructions on the proper method and criteria for electrical continuity testing.

SECTION 8

GLOSSARY

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8.1 - GLOSSARY OF DRILLING TERMS

~A~

Actuator

A motor or cylinder that is being put into motion by the flow of a hydraulic pump.

Adapter-Adaptor (both spellings are accepted).

A device used to connect two different sizes or types of threads. It is used to connect rotary head spindles to drill pipe, drill pipe to stabilizers and stabilizers to drill bits.

ANFO

Ammonium Nitrate Fuel Oil mixture: explosive most commonly used in blastholes.

Annulus

The space between the drill pipe and the outer diameter of the hole made by the bit.

Annunciator

An electrical signaling device on a switchboard.

API

American Petroleum Institute.

ASME

American Society of Mechanical Engineers.

ASTM

American Society of Testing Materials.

Auto Lube System

An air powered pump that provides grease to various components of the drill through hoses. It can be manual or computer controlled.

Axle (Main Shaft)

The tube connecting the tracks of a Blasthole drill to the main frame.

~B~

Bank

Vertical surface of an elevation; also called face.

Beco Thread

A coarse type of thread used on drill pipe for blastholes.

Bench

Work area on top edge of an elevation. The work area for blasthole drills.

8.1 - GLOSSARY OF DRILLING TERMS

Bit, Auger

A type of bit used to drill soft formations. It usually has a series of flutes on the outside.

Bit, Claw

A wing-type bit that has multiple flukes. Sometimes called a Drag Bit.

Bit Breaker

A device installed in the centralizer table to hold a bit stationary while the drill pipe is being removed from the bit by reversing the rotation. Also called **Bit Basket**.

Bit, DHD

A solid, one piece bit, with shaped tungsten carbide inserts in the face. Used in percussion drilling.

Bit, Roller

Also called a Tricone bit. It usually has three conical rollers fitted with steel or tungsten carbide teeth that rip the rock loose using down pressure.

Bits

Tools that pulverize formations so that material can be removed from the hole. Generally 3-blade, 3-cone or percussion.

Blasthole

A drilled hole used for purposes of excavation rather than exploration, geological information or water wells. Usually limited to 200 feet.

Blasting

The act of igniting explosives in a borehole to produce broken rock.

Blowdown

Term used when releasing compressed air from the receiver tank on a compressor when the drill is stopped.

Blowdown Valve

The valve that opens when the drill is stopped and releases all the air pressure in the receiver tank.

Bore

To make a hole in the ground with a drill.

Borehole

The hole made by a bit.

Box End

Fitting on the female end of a drill pipe. See Pin End.

8.1 - GLOSSARY OF DRILLING TERMS

Breakout

Refers to the act of loosening threaded pipe joints; and of unscrewing one section of pipe from another, while coming out of the hole.

Breakout Wrench

A wrench, connected to a hydraulic cylinder, used to turn the upper piece of pipe while the lower pipe is being held by the Fork Chuck or Sliding Wrench.

Bridge

An obstruction in the hole. Usually caused by a caving formation or something falling in the hole.

Burden

Distance from the blasthole to the nearest face. Distance measured from face to a row of holes.

Buttons

Short, rounded teeth of sintered tungsten carbide inserts which serve as teeth in drill bits used for drilling very hard rock.

Butterfly Valve

The inlet valve of the air compressor.

Burden

Distance between a blasthole and the nearest free or open face; the material to be displaced.

~C~

Cable

A strong, heavy steel, wire rope. Also known as **Wire Rope**. Used for pulldown and pullback in the derrick. Also used in hoisting. May be rotating or rotation resistant.

Cable Reel

A device that holds the electrical power cable on electric driven blasthole drills.

Carousel

A rotating device that holds extra drill pipe. It can be moved under the rotary head to add and remove drill pipe from the string, or the rotary head moves over it.

Carbide, Tungsten

W₂C. A very hard compound used in inserts in rock bits. It has a very high melting point. It is very strong in one direction but very brittle in another.

Casing

Special pipe used to hold the overburden back in water wells. May be steel or plastic.

8.1 - GLOSSARY OF DRILLING TERMS

Casing, Drive Shoe

Coupling of forged steel to protect lower end of casing in overburden.

Cathead

Rotating drum used to spool hemp rope to pick up tools manually.

Catwalks

Walkways around a working area of a drill.

Cavitation

The pitting of a solid surface by the formation of low pressure bubbles formed in the fluid. Air being allowed into the inlet of pumps.

Centralizer Bushing

A circular ring installed around the drill pipe in the drill table to keep the pipe aligned properly with the rotary head. It usually has a replaceable insert in the center.

Chain Wrench

A special wrench, consisting of a chain section and a metal vee section, with jaws, that grips the drill pipe and/or the DHD to tighten or loosen the connections.

Clinometer

A device for measuring the angle of the drill pipe with the ground. Also referred to as an **Inclinometer**.

Collar the Hole

Opening at the top of the blasthole; the mouth where rock has been broken by blasting. Usually the first few feet of the blasthole that are cracked and broken.

Compressor

An asymmetrical rotary screw driven device for compressing air. May be single or two stages, depending on the discharge pressure.

Console

The panel that contains most of the drill's controls. Also called the Operator's Panel.

Conventional Mud

A drilling fluid containing essentially bentonite clay and water.

Conveyor

Equipment used to carry material to crushers and screens for reduction and separation.

Cooler (HOC, COC)

Most drills have two coolers; one for the hydraulic fluid and the other for the compressor oil. The engine radiator is sometimes referred to as an engine cooler.

8.1 - GLOSSARY OF DRILLING TERMS

Coring

The act of procuring a sample of the formation being drilled for geological information purposes.

Coupling

A connector for drill rods, pipe or casing with identical threads, male or female, at each end.

Cribbing

A set of wooden ties or metal plates used to add surface area to the jack pads to prevent the pad from sinking into the ground. Also called blocking.

Crown Sheaves

The upper sheaves in a derrick that supports the cable that connects to the rotary head.

Crosshead

The outer metal can surrounding the leveling jack cylinders. The **crosshead slide** is the lower portion that connects to the bottom of the cylinders and the **crosshead cap** is the flanged piece on top of the crosshead.

Crusher

Device used to reduce broken rock to a smaller fragment size.

Cut (verb)

Process of excavating material to lower the level of part of an elevation.

Cut (noun)

Part of an excavation of a specified depth and width.

Cuttings

Particles of formation obtained from the hole during drilling operations.

~D~

Decking

Process of alternating explosives with inert material in a blasthole to properly distribute explosives or reduce vibrations. Also refers to the metal catwalks around the outside of the drill.

Deephole

Rotary drills used to drill water wells, exploration holes and monitoring holes.

Delay Interval

Elapsed time between detonation of individual blastholes in a multiple hole blast.

8.1 - GLOSSARY OF DRILLING TERMS

Derrick

A tall framework over a drilled hole used to support drilling equipment. The part of the drill that contains the feed system and the rotary head. See Tower and Mast.

DHD

Down Hole Drill. An air driven, piston powered device for drilling hard rock. It is also called a Hammer.

DHD Bushings

The split bushings used to maintain alignment of the DHD while passing through the drill table. See Split Bushings.

Differential Pressure

The difference in pressure between the inlet and outlet of a component, i.e., a cooler.

Dip

The angle between a horizontal plane and the plane of the ore vein, measured at right angles to the Strike.

Diverter Valve

A two position, three way, valve that allows one hydraulic pump to perform two separate functions.

Dressing a Bit

Sharpening DHD drill bits with a grinder to shape the carbides.

Drifter

An out-of-the-hole drill that rotates the drill rod and provides a percussive force, by means of a striking bar, through the rod to the bit.

Drill

A machine for drilling rock, or unconsolidated formations. Also called a Rotary Drill. The act of boring a hole in the ground.

Drill Collar

A heavy, thick-walled section of pipe used to add drilling weight to the bit and stabilize the drill string.

Drill Rod

See Drill Pipe. Hollow, flush-jointed, coupled rods used on small percussion type rock drills. Used with drifters mostly.

Drill Pipe

Hollow tubing, specially welded to tool joints, used in drilling larger holes than drill rods.

Drill/Propel Valve

A switch that shifts the diverter valves to allow pump flow to go from drill functions to propel motors.

8.1 - GLOSSARY OF DRILLING TERMS

Drill String

The string of pipe, including subs, stabilizers, collars and bit, extending from the bit to the rotary head, that carries the air or mud down to the bit and provides rotation to the bit.

Driller (Operator)

The employee directly in charge of a drill. Operation of the drill is their main duty.

Drill Table

The area at the bottom of the derrick that contains the centralizer bushing or master bushing that the drill pipe travels through.

Dust Collector

A vacuum device with a hose attached to the dust hood that pulls cuttings away from the hole and deposits them to the side of the drill.

~F~

Face

Vertical surface on an elevation. Also called bank.

Feed Cable

Cables, anchored on the top and the bottom of the derrick, that pass through the traveling sheave block and connect to the top and bottom of the rotary head. They are adjusted by tightening the threaded rods on each end.

Feed Chain

Heavy duty chain links connected to the rotary head through upper and lower sprockets and the traveling sheave block. They are adjusted similar to cable.

Fill

Process of moving material into a depression to raise its level; often follows the cut process.

Fish

An object accidentally lost in the hole.

Fishing

Operations on the drill for the purpose of retrieving the fish from the hole.

Fishing Magnet

Run in the hole on non-metallic line, to pick up any small pieces of metal.

Fishing Tools

Tools of various kinds run in the hole to assist in retrieving a fish from the hole. **Overshots** fit over the pipe while **Taps** fit inside the pipe.

8.1 - GLOSSARY OF DRILLING TERMS

Flats

Machined areas on the side of drill pipe or other components where wrenches can be installed to hold or break the joints. Some pipe has two flats, others have four flats.

Floor

Level area at the base of a bank or face.

Fork Chuck

The hand held or “flop-down” wrench used to hold the top of the pipe in the Drill Table while adding or removing other pipe.

~G~

Grouting

To fill the hole or annulus with grout, i.e., cement and water.

~H~

Hammer

A different name for a Down Hole Drill.

Hammer Bushing

Split bushings installed in the drill table to allow the DHD to start the hole in a straight line. It is removed once the DHD is below the table. Also called DHD Bushings.

Haul Distance

Distance material has to be moved, such as from a *cut* to a *fill*.

Hauling Equipment

Trucks and other conveyances for moving material. Also called Haul Trucks.

Hazard

Any condition of the drilling equipment or the environment that might tend to cause accidents or fire.

Hoist

Windlass used to pick up drill pipe and other heavy objects. See Winch.

Hoist Plug

A lifting device installed in the box end of a tool. Opposite of **Lifting Bail**.

Hole

A bore made by rotating a bit into the ground.

8.1 - GLOSSARY OF DRILLING TERMS

Hole Openers

Large bit with pilot used to increase the diameter of a hole.

Hose, Drilling

Connects rotary head to top of hard piping to allow movement of rotary head. Also called **Standpipe Hose**.

Hose, Suction

Attaches to mud pump inlet with other end submerged in mud pit.

Hydraulic Cylinders

Double acting cylinders that are extended and retracted to perform various functions on a drill. They are powered by hydraulic fluid from a pump.

Hydraulic Motors

Piston or vane type motors, driven by hydraulic pumps, that rotate various devices on a drill.

Hydraulic Pumps

Piston, vane and gear type hydraulic pumps that provide flow for the various actuators on the drill.

Hydrostatic Head

The pressure exerted by a column of fluid, usually expressed in pounds per square inch.

~|~

Inclinometer

An instrument for measuring the angle to the horizontal or vertical of a drill hole or vein.

I.W.R.C.

Abbreviation for *Independent Wire Rope Center*. This refers to type of construction of wire rope. This wire rope center is in effect a separate wire rope in itself that provides a core for the line and prevents it from crushing.

Interstage Pressure

The air pressure present between stages of a two-stage compressor while the compressor is making air.

~J~

J Wrench

Specially shaped wrench to fit the backhead of a DHD. Used to hold DHD in the table or to remove the backhead from the wear sleeve.

8.1 - GLOSSARY OF DRILLING TERMS

~K~

Kelly Bar

A fluted or square drill pipe that is turned by a rotary table using a set of pins.

~L~

Leveling Jacks

Hydraulic cylinders mounted in a crosshead that raise and lower the drill.
Also referred to as Outriggers or Stabilizers.

Lifting Bail

A threaded cap for picking up pipe, bits, DHDs and stabilizers. It screws on the pin end.
Some bails have a swivel hook while others have solid tops. See **Hoist Plug**.

Loaders

Large, front end bucket equipment used to pick up material for loading in various types of hauling equipment.

~M~

Main Frame

The welded component of a track mounted drill. The truck frame on a wheeled drill.

Makeup

The act of tightening threaded joints. Making a connection.

Making Hole

The act of drilling.

Making Up a Joint

The act of screwing a joint of pipe into another joint or section of pipe.

Manifold

A pipe or chamber that has several openings for hose connections.

Mast

A vertical pole. See Derrick.

Micron - :- Mu

A unit of length equal to one millionth part of a meter, or one thousandth part of a millimeter. About 4/100,000th inch.

8.1 - GLOSSARY OF DRILLING TERMS

Mid-Inlet Swivel

Device for removing cuttings from the hole while drilling with Reverse Circulation Equipment.

Mine Plan

Plan for making cuts and creating elevations, benches for efficient removal of material. The mine plan considers a variety of factors, including: the type and location of material, the size and number of shovels, loaders, and hauling equipment, haul distances, blasthole patterns, etc.

Mist Drilling

A method of rotary drilling where water is dispersed in the air as the drilling fluid.

Mud

A water or oil –base drilling fluid whose properties have been altered by solids. Mud is a term commonly given to drilling fluids. It is used in place of air when drilling unconsolidated formations.

Mud Drilling

Using a bentonite clay and water as the drilling fluid.

Mud Pit

A hole dug in the ground or a steel pit to hold the drilling mud as it is being circulated in the hole.

Mud Pump

Pumps that are used to circulate the drilling mud.

~O~

Oscillation Yoke

The beam connecting each track of a blasthole track drill with the main frame that allows the tracks to move independently up and down.

Open Hole

Any uncased portion of a hole.

Operator

The person who performs the drilling operation with the drill. See Driller.

Overburden

Any unconsolidated material lying on top of the bedrock or the coal seam.

8.1 - GLOSSARY OF DRILLING TERMS

~P~

Parasitic Load

The load imposed on the engine by the direct connection of the compressor and main pump drive during starting.

Pattern

Layout and distances between blastholes, specifically including burden and spacing.

Penetration Rate

Speed at which a bit advances while drilling, measured in feet per hour.

Percussion Drill

Drill that chips and penetrates rock with repeated blows.

Pin End

Fitting on male end of drill pipe. See **Box End**.

Pioneer Work

Drilling in rough, broken or inclined areas. Removing the original layers of dirt and rock.

Pipe Dope

Special lubricant used to protect the threads on pipe joints. See **Thread Lube**.

Pipe Support

A device that holds the lower section of pipe in place while connecting to the next joint with the rotary head when angle drilling. Also called **Rod Support**.

Pit

An excavation in the ground for the removal of mineral deposits.

PLC

Programmable Logic Controller. A device that monitors many aspects of a drill's operation.

Potable Water

Water that is safe to drink.

Powder Factor/Specific Charge

Relationship between the weight of explosives in a blasthole and the volume of materials to be displaced. It is measured in pounds per cubic yard or kilograms per cubic meter.

Power Pack Base

The welded channel frame that contains the prime mover, the compressor and the hydraulic pumps and gearbox.

8.1 - GLOSSARY OF DRILLING TERMS

Power Pack

The complete sub-assembly of base, engine, compressor, and hydraulic drive.

Presplitting

Process of drilling a line of small diameter holes spaced relatively close together, generally before drilling a production blast and loaded with light explosive charges to create a clean, unbroken rock face.

Production Rate

penetration during a given reporting period. This rate includes all lost time, including maintenance, breakdowns, long moves, inclement weather, etc.

Propel

To cause to move forward or onward. To drive or tram.

Protectors, Thread

Steel or plastic covers to cover the box and pin ends of drill pipe when they are not being used.

Pump, Water Injection

Pump used to pump water into the drill air stream to keep the dust settled and to assist in flushing the hole.

Pullback

The force available to remove the drill string from the hole.

Pulldown

Force exerted on the drill bit by the thrust of the drill rig and from the weight of the drill string.

~R~

Raise

A mine opening, like a shaft, driven upward from the back of a level to a level above, or to the surface.

Rate Of Penetration

The rate in which the drill proceeds in the deepening of the hole. It is usually expressed in feet per hour.

Reamer

Bit-like tool, generally run directly above the bit to enlarge and maintain a straight hole.

Reservoir

The tank used for storing the hydraulic oil used in the hydraulic system.

8.1 - GLOSSARY OF DRILLING TERMS

Reverse Circulation Drilling

Using a double wall pipe to force air/water down the hole and removing the cuttings between the two pipes. See Mid-Inlet Swivel.

Rod Changer

See Carousel. A device that holds extra drill rod (pipe).

Rotary Drilling

The method of drilling that depends on the rotation of a column of pipe to the bottom of which is attached a bit. Air or fluid is circulated to remove the cuttings.

Rotary Head

A movable gearbox used to provide rotation to the drill string. It is connected to the feed chains or cables on each end and to the drill string through the spindle.

~S~

Safety Hook

Attached to end of hoist line to secure hoist plug or lifting bail. Has a safety latch to prevent load from slipping off hook.

Scales

Equipment used to determine the weight and *value* of material being transported from a quarry.

Screens

Devices used to separate broken material into groups of similar size.

Shock Sub

A device used to isolate the shock of drilling from the rotary head. It is made of hard rubber layers mounted inside of steel outer rings.

Shooting

Exploding high explosives in a hole to shatter the rock. See Blasting.

Single Pass Drill

Drill rig with a long tower that permits drilling a blasthole without stopping to add drill pipe (rod). Uses a Kelly in place of regular pipe.

Uses a rotary table to turn the Kelly instead of a rotary head.

Stemming

Material of a specified depth added on top of a powder column to confine the blasthole and make the explosion more efficient.

Strip Mine

A large section of land used to remove coal deposits.

8.1 - GLOSSARY OF DRILLING TERMS

Shot

A charge of high explosives deposited in a series of holes to shatter the rock.

Shutdown

A term that can mean the end of the shift or workday or an unplanned stopping of the drill due to a system failure.

Sliding Fork

A wrench that slides around the flats of the drill pipe to hold lower section. Controlled by hydraulic cylinder(s). Used in place of **Fork Chuck**.

Slips

Used in the rotary table to hold and break out drill pipe. Also used to hold casing in the table.

Spacing

Distance between blastholes measured parallel with the face.

Spear

Tools of various design that are screwed or wedged inside of bits, pipe, etc., that are lodged in the hole. See Fishing Tools.

Spindle

The short section of pipe that rotates within the rotary head and protrudes out each end.

Speed Switch

An electronic device that changes states when the engine reaches a certain speed. Used to control dual oil pressure switches.

Split Bushings

The removable bushings that allow the DHD or Stabilizer to pass through the drill table while drilling a straight hole. See DHD Bushings.

Stabilizer, Drill Pipe

Heavy -walled pipe having special spiral or fluted ribs extending around the diameter, within 1/8 "to 1/4" of hole size. Most stabilizers are fitted just above the bit, while in-line stabilizers keep the hole straight.

Standpipe

Part of the circulating system. The hard and flexible piping from the main valve to the flexible hosing leading to the rotary head. Water injection, DHD oil and foam are injected into this line.

Static Water Level

The distance from the top of ground down to the standing water level.

8.1 - GLOSSARY OF DRILLING TERMS

Strike

The bearing of the outcrop of an inclined bed or structure on a level surface. See Dip.

Stuck In The Hole

Refers to drill pipe inadvertently becoming fastened in the hole.

Subdrilling

Bottom portion of a blasthole drilled below the floor level to permit upward displacement of material and thereby prevent a toe at the bottom of a face.

Substitute (Sub)

A coupling with different type or diameter of threads at either end. The term pin denotes a male thread, and box, a female thread. To connect two components with different threads. See Adapter.

Supercharge Pressure

Inlet oil pressure to the main pump(s) that has been pressurized to prevent cavitation.

Swivel

A coupling on top of the rotary head to allow the spindle to rotate while the main hose remains stationary.

~T~

Table Drive

Drill design that locates the drill pipe rotation mechanism on the drill deck in a stationary position instead of using the rotary head.

Threaded and Coupled Casing (T&C)

Steel casing using a coupling between each section of pipe. Thread style is right hand, fine thread.

Thread Lube

A special compound used to lubricate the threads of drill pipe. See Pipe Dope.

Tongs

A type of wrench used to make up and break out drill pipe using external forces, such as hydraulic cylinders or cables.

Tool Joint

A drill pipe coupler consisting of a pin and box of various designs and sizes. Deephole drills normally use API style threads, while Blasthole drills use Beco style threads.

Top Head Drill

Drill design that locates the drill pipe rotation head in the drill tower and it moves up and down with the drill string. See Rotary Head.

8.1 - GLOSSARY OF DRILLING TERMS

Torque

A turning or twisting force. A moment caused by force acting on an arm. A one pound force acting on a one foot arm would produce one lb-ft of torque.

Tower

A tall, slender structure used for observation, signaling or pumping. See Derrick and Mast. Term used to indicate the derrick on a blasthole drill.

Turning To The Right

Slang term for making hole.

Tram

A cable car or a four-wheeled open box in a coal mine. See **Propel**.

Trammed

To move in a tram.

Tramming

Process of moving a drill with the tower up from a completed blasthole to the location of the next. See propelling.

Traveling Sheave Block

A series of sheaves, connected to the feed chains or cables, that are moved up and down the derrick by the feed cylinders.

Twist Off

To twist a joint of pipe in two by excessive torque applied by the rotary head or rotary table.

~U~

UL88

The unloader valve that controls pressure and volume on a high-pressure compressor system.

Undercarriage

The means of moving a track type vehicle. It contains the track frame, rollers, grousers, rock guards, drive sprocket, propel motors and planetary drive.

Uphole Velocity

The speed (in feet per minute) that the cuttings travel out of the hole.
This is dependent on the bit size, the compressor size and the pipe size.

8.1 - GLOSSARY OF DRILLING TERMS

~W~

Washpipe

Hard surfaced steel tubes inserted in swivels to allow rotation of drill string and prolong life of packing. They are replaceable in most swivels.

Water Table

The underground level at which water is found. See Static Level.

Water Well

A hole drilled for the purpose of obtaining potable water.

Weight On Bit

In rotary drilling, a specified weight is required on the bit for maximum performance. A gauge on the console is calibrated to correspond to the drill string weight.

Whipstock

A device inserted in the well used for deflecting or directional drilling.

Wiggins Quick Fill

A Centralized Service Station that connects to various systems on the drill to allow remote filling of engine oil, compressor oil and hydraulic oil.

Winch

A stationary hoisting machine having a drum around which is wound a rope.

Wiper, Pipe

An annular rubber disk for wiping drill pipe clean of cuttings when it is being withdrawn from the hole.

Wire Rope

Rope made of twisted strands of steel wire. Also called Cable.



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