OPERATING, SAFETY
AND MAINTENANCE MANUAL

TH60

Read this instruction manual before operating this equipment.

This manual contains important safety information.
Do not destroy this manual.
This manual must be available to the personnel who operate and maintain this machine.

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Section 1 - Introduction

INTRODUCTION

General Information

This Safety, Operation and Maintenance Manual has been developed to present the safety, operations and preventive maintenance requirements for safe, effective operation and maintenance of the Atlas Copco Drilling Solutions TH60 Waterwell Drill.

The primary 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 aTH60 Waterwell Drill.

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 TH60 Waterwell drill while achieving optimum production.
2. Understand the operating principal of each system associated with the TH60 Waterwell drill.
3. React effectively and safely to emergency and alarm conditions.
4. Perform the necessary pre-operational and post-operational checks on the drill.

If any part of this manual cannot be understood, contact your supervisor or local Atlas Copco Distributor. This is an essential condition for working safely with the TH60 Waterwell drill. The correct Th60 operation, use and regular maintenance are also essential elements to provide the highest performance and safety.

NOTE: Always keep the “Safety, Operation and Maintenance” manual on the drill and available to the operator and helper. The present manual is accompanied with an engine instruction manual and a carrier instruction manual. Always provide the model of your drill and it’s serial number when you contact the local Atlas Copco service or parts office.

How this manual is organized

Although there is a substantial amount of information contained in the manual, it has been organized so the reader can easily find the specific information needed. The present manual is accompanied with a carrier instruction manual. You are therefore advised to follow the operation and maintenance instructions as specified in both the carrier and drill instruction manuals. The manual is divided into sections by information based on answers to the following questions:

1. What are the specific operator responsibilities? (See Section 2)
2. What are the specifications of the drill itself? (See Section 3)
3. What instruments and controls are used by the operator to operate and monitor the drill? (See Section 4)
4. What are the proper operating procedures for the equipment? (See Section 5)
5. What are the maintenance schedules? When and how is maintenance to be performed? (See Section 6)
6. What should the operator do when problems arise. What are the types of hydraulic, electric and compressor systems? What is the correct operator troubleshooting response? (See Section 7)
7. What do the various terms mean that are used in this manual? (See Section 8)

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 the eight (8) sections shown below:

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 necessary to provide the highest performance and safety.

Throughout the manual, ***Dangers, Cautions, Warnings, Notices*** and ***Notes*** are used to provide the reader with special noteworthy information. 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 indicates 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 installation, operation or maintenance information which is important but is not hazard related. The hazard warnings should never be included under the Notice signal word.

Procedure when receiving the TH60 drill

Your TH60 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 TH60 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 TH60 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 on the following lines to maintain drill and engine information necessary to facilitate fast and efficient response from our parts and service support operations.:

Model

____

Drill Serial Number

____

Chassis VIN Number

____

Year of Manufacture

____

Truck Engine and Serial Number:

Engine (Mfg. and Type of Engine)

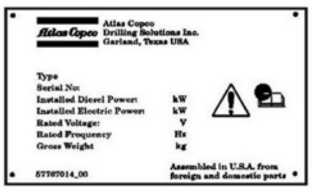
____

Engine Serial Number

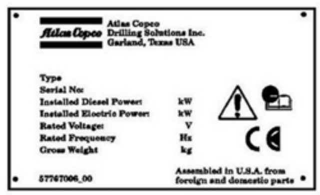
____

Drill Identification

The TH60 Identification Plate is located on the driller’s console as shown below.

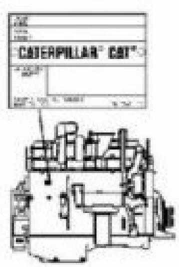


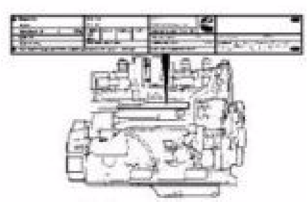
Standard Drill Identification Plate



Identification Plate to meet European Community (CE) requirements

Engine Identification





The engine identification number can be found on the engine identification plate. The engine data plate, as shown above, provides the model identification and other important data about the engine. Refer to the engine operator’s instruction manual for further information on the identification information. Have the following engine data available when communicating with an Authorized Repair Location. The data on the data plate is mandatory when sourcing service parts:

1. Engine Serial Number (ESN)
2. Control Parts List
3. Model
4. Advertised Horsepower and RPM

Carrier Vehicle Identification

The carrier vehicle identification number can be found on the identification plate located on the inside of the carrier cab door.

Instruction Manual Location

The instruction manuals are located within easy reach of the operator. A tool cabinet located beneath the oil cooler provides space for the drill manuals.

General Information

All safety rules in section 2 must be observed. If further information is required concerning recommended water well drilling applications, contact your local Atlas Copco Drilling Solutions distributor.

Atlas Copco 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)

Atlas Copco 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.

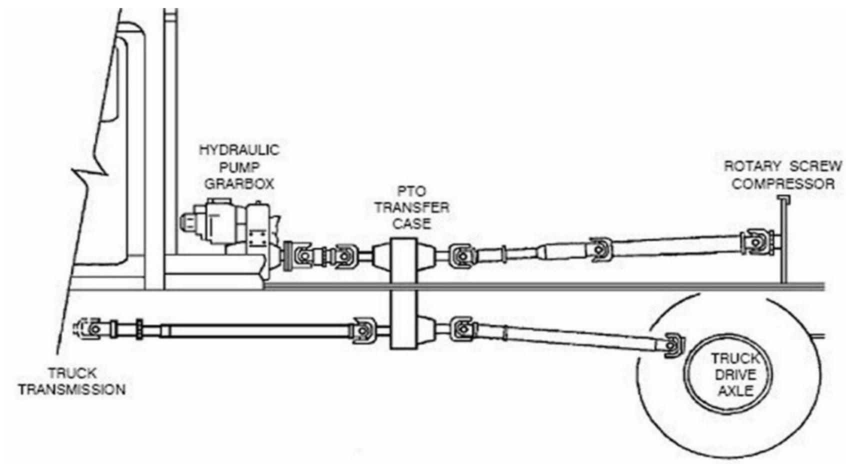
Drill Description

TH60 Waterwell Drill Description

The TH60 is a mid-weight, truck powered, tophead drive drill for water well applications using rotary air, mud or DHD (down-hole-drill) techniques. The drill is set up to handle 3-1/2 in. x 20 ft. (89mm x 6.1m) or 4-1/2 in. x 20 ft. (14 mm x 6.1 m) drill pipe. The rear half of the drilling table retracts hydraulically while the front half swings away from either side of the table to accommodate up to 14 in. (355.6 mm) casing.

Currently, the standard chassis used on a TH60 water well drill is the Peterbuilt Model 357. It incorporates four (4) frame mounted leveling jacks to keep the drill level and stable while drilling. The mid jacks behind the truck cab provide optimum stability and more balanced drill and truck frame load distribution.

The standard TH60 uses a diesel engine connected directly to a heavy duty transfer case. The transfer case has four driveshaft connections:



1. Truck transmission to lower transfer case, as mentioned above.
2. Lower transfer case to rear axles.
3. Upper transfer case to hydraulic pump drive gearbox.
4. Upper transfer case to air compressor.

The derrick is constructed of welded steel tubing. An internal carousel type drill pipe changer is mounted inside the derrick and holds either seven (7) or nine (9) drill pipes, depending on the O.D. of the pipe. A pipe rack is mounted on the left side of the drill and holds 15 or 24 extra pieces of pipe, depending on the O.D. The derrick is raised and lowered by two hydraulic cylinders.

Drill pipe changing is done by emptying the carousel first, then pulling pipe from the pipe rack. Pulling pipe out of the hole is done just the opposite, after replacing one piece of pipe in the carousel to stow the rotary head.

All drilling functions are controlled from the operator’s console adjacent to the drill table. The operating controls and gauges are positioned within easy reach of the operator.

To permit optimum performance on a wide range of applications and site requirements, the TH60 Waterwell Drill is equipped with:

1. 850CFM/HR2 or 900CFM/HR2.5 & 1800 rpm over/under screw air compressor
2. Cummins ISX, 575HP carrier engine
3. Peterbuilt 357 Carrier
4. Hydraulic cylinder driven cable feed system
5. Hydraulic driven four motor spur gear rotary tophead
6. Seven (7) or nine (9) drill pipe carousel
7. Easily accessed operator’s console and platform
8. Drill pipe rack
9. Hydraulic cylinder operated breakout wrench
10. Retractable table with an air operated bottom holding wrench
11. Four (4) leveling jacks

Carrier

With the Peterbuilt chassis, the TH60 has the power to move effortlessly from job to job and drill under the toughest conditions. The special truck frame supports the compressor assembly, the hydraulic pump drive assembly, the combined hydraulic oil cooler and compressor oil cooler assembly, derrick assembly and four leveling jacks.

Derrick

The derrick is constructed of welded tubular steel with cross bracing on both sides and the back. A set of sheaves at the top and bottom of the derrick support the feed cables. The derrick assembly features the hydraulically driven rotary tophead and the hydraulic drill feed systems. The feed system consists of the rotary tophead, the hydraulic feed cylinder and a set of cables connected to the top and bottom of the rotary head assembly.

Drill pipe changing is done by emptying the carousel first, then pulling pipe from the pipe rack. Pulling pipe out of the hole is done just the opposite, after replacing one piece of pipe in the carousel to stow the rotary tophead.

Controls

All operational functions can be controlled from the driller’s console. All of the controls, with the exception of the helper’s jib boom and jib hoist control located on the helper’s side of the drill table, are positioned for operator convenience on the operator’s console. The operator’s console has been designed for convenience, ease of control and safety while providing maximum visibility to the work area. Full details are provided in Section 4 (Operator Controls).

Serviceability

The compressor and hydraulic pump drive are accessible from either side of the drill. All daily check points are positioned to encourage preventive maintenance.

⚠ DANGER

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

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

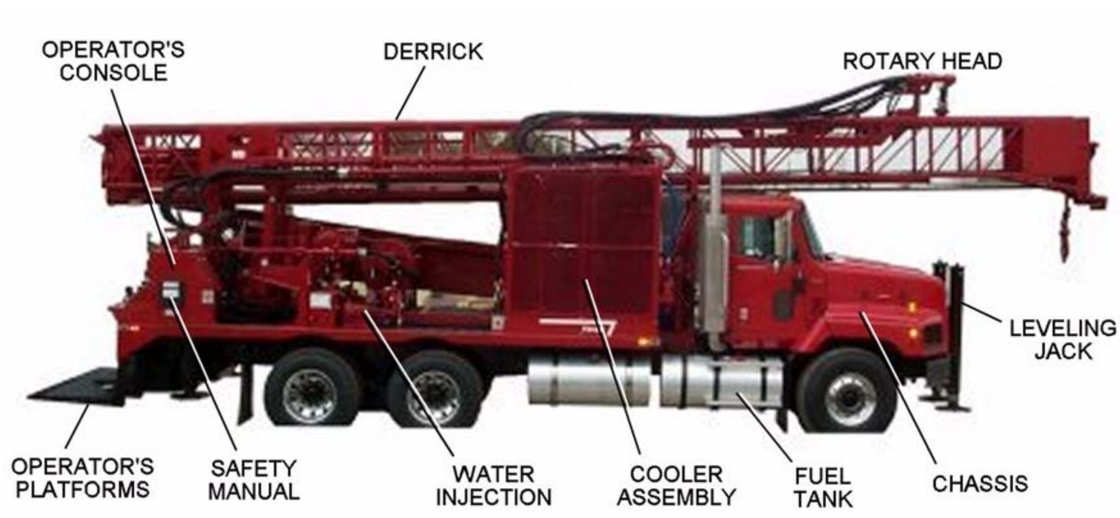
See the operator's manual or contact your dealer for complete inspection requirements and maintenance instructions.

Standard Features on TH60 Waterwell Drill

1. Easily accessed hydraulic controls
2. Operator's console mounted to the deck to operate engine and leveling jacks
3. Auxiliary hoist for drill rod and accessories handling
4. Cooling package rated to 125°F (52°C) ambient temperature
5. Improved breakout wrench
6. Hydraulic powered table slide
7. Jib Hoist
8. Spur Gear hydraulic powered rotary tophead
9. Four leveling jacks
10. Deck mounted rod box
11. Custom designed two (2) rear axle, diesel driven carrier with a 13-speed transmission.
12. Under cooler storage box

Identification of Major Components

The pictures shown are for reference only.



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Section 2 - Safety

2.1 - SAFETY AND HEALTH

General 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.

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 procedures of the drill, **STOP!** Review the information supplied with the drill, ask your supervisor or contact your nearest Atlas Coped Drilling Solutions representative for assistance.

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

Safety and Health Statement

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

1. We are committed to providing a safe and healthy workplace for all our employees.
2. We believe that injuries and accidents are preventable and that the well being of all our employees can be protected in the work environment.
3. We believe that safety is number one. Safety will not be sacrificed for production.
4. We believe that housekeeping is an integral part of our safety program and the protection of our employee's health.
5. We believe that all of our employees are responsible for the safety of their co-workers. Each of us has the duty to listen, watch and act upon hazards that might injure another.
6. We believe that good safety training is necessary to assist employees in completing their assigned tasks in a safe manner.
7. 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, such as Fire or Medical Emergency Services, immediately. These plans must be known to everyone around the drill in case someone is injured.

Important Safety Instructions

Personal safety is of prime importance at all times when performing any operations or maintenance on a drill. While we have no direct control over the way the drill is operated or maintained, we wish to call your attention to those procedures which are potentially hazardous. Knowing the guidelines shown in section 2.2 will help provide for your safety, for the safety of those around you and for proper operation and maintenance of the drill.

2.2 - SAFETY PRECAUTIONS AND GUIDELINES

OVERVIEW

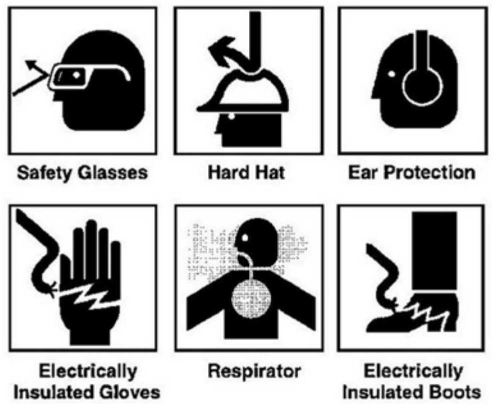
Before you operate, maintain, work around or in any other way use this drill: READ and STUDY this manual. KNOW how to safely use the drill controls and what you must do for safe maintenance. Failure to follow instructions or heed warnings could result in injury or death. Ensure that the drill is in good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



If you have ANY QUESTIONS about the safe use or maintenance of this drill, ask your supervisor or contact your nearest Drilling Solutions 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 that is mounted on the drill. Never remove the Decal Safety manual. Replace the Decal Safety manual if it becomes lost, damaged or illegible.

Warnings

Throughout the manual, ***Notes, Notices, Cautions, Warnings*** and ***Danger*** symbols are used to designate instructions of particular importance. Look for these symbols which point out items of extreme importance to you and your co-workers' safety. Read and understand thoroughly. Heed the warning and follow the associated instructions. In this manual, these terms have the following significance:

NOTE: Note is used for supplementary information not directly effecting safety or damage to equipment. Note can also refer to special information on the efficient use of the drill.

NOTICE

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

CAUTION

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.

WARNING

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

DANGER

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.

Drill Applications

The TH60 Watewell drill is 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 TH60 Waterwell drill must be used in accordance with its designated use as described in this Safety, Operation and Maintenance 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 Drilling Solutions TH60 Waterwell drill is a mid-weight, truck powered, hydraulic tophead drive drill designed primarily for water well applications.

Non-Designated Applications

The Drilling Solutions TH60 Waterwell drills are not designed for use on inclined surfaces or on soft and unstable surfaces. Use of the Th60 Waterwell 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.

WARNING

Set up the Th60 Waterwell drill on a level surface. If this is not available, the site should be adequately prepared prior to drill setup.

Operating the Th60 waterwell drill within the limits of its designated use also involves compliance with the inspection and maintenance directives contained in the operating manual.

Safety Reminder

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

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 the drill. If there is any doubt about the safe operating procedure of the drill, ***stop*** and review the information supplied with the drill or contact your nearest Drilling Solutions representative for assistance.

Personnel Requirements

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 TH60 Waterwell drill must be **competent:**

Physically - To react correctly and quickly to avoid accidents.

Mentally - To understand and apply all 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 TH60 Waterwell drill must be ***experienced:***

Trained - In the operation and maintenance of the TH60 Waterwell drill.

1. They should have read and understood the Manufacturer’s Instruction Manuals and know the ratings and capabilities of the drill they are using.
2. They must understand hand signals.
3. They must understand the meaning of various symbols on instruments, controls and specific parts of the drill.

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 on the electrical system and equipment of 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 truck chassis, derrick, brake and hydraulic systems must be performed by skilled personnel with special knowledge and training for such work.

General Guidelines

1. STOW the instruction manuals within easy reach of the operator. Manuals must always be available at the site where the drill is being used. A tool cabinet, located beneath the oil cooler, provides space for the drill manuals.
2. OBSERVE and INSTRUCT the user in all other generally applicable mandatory and legal regulations relevant to accident prevention and environmental protection. These compulsory regulations may also deal with the handling of any hazardous substances, issuing and/or wearing personal protective equipment, and traffic regulations.
3. SUPPLEMENT operating instructions with detailed working instructions covering the methodology of the working sequences, all individual job responsibilities and overall supervisory responsibility.
4. ALWAYS be sure that persons entrusted with work on the drill have read the operating instructions and in particular the chapter on safety before beginning work. Reading the instructions after work has begun is too late. This is especially important for persons who work only occasionally on the drill, e.g. during setup or maintenance.
5. MAKE CERTAIN all personnel are working in compliance with the operating instructions and are alert to risks and safety factors.
6. ALWAYS tie back or otherwise 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.
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 drill behavior during operation. REPORT the malfunction to the proper authority/person.
11. NEVER provide service or maintenance to the drill unless all of the truck wheels are on firm, level ground.
12. DO NOT make any modifications to the drill which might affect safety without having the manufacturer’s approval. This applies to the installation and adjustment of safety devices as well as to welding work on load bearing elements.
13. ALWAYS ADHERE to the prescribed intervals and/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 table. Alert people and crew to stay clear of the hole while drilling is in process.

15. ALL PERSONNEL who work around the drill must ensure that any unsafe conditions and practices are corrected or reported to the drill operator and supervisor.
16. ALL PERSONNEL who work around the drill, including the 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 Atlas Copco 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 the drill ***must*** wear safety equipment (safety shoes or protective footwear, safety glasses, hearing protection, approved hard hat, gloves, respirator, etc.) when operating or maintaining the drill. Tie back or otherwise secure long hair. Do ***not*** wear loose clothing which can become caught up in moving parts.
2. Keep the operator’s platform and work areas clean and free from grease, oil and other items or tools that could cause a slip or fall.
3. Keep the truck cab and all operator platforms clean. Mud, cans, bottles, tools and other debris can jam pedals and other controls and cause falls.
4. Keep the work site area clear of cuttings, tools, and other objects.
5. Keep all warning and information labels clean and readable. Replace labels if they become damaged, torn, painted over or removed.
6. Keep all controls and gauges in good working order. If they become damaged or broken, replace them before operating the drill.
7. Make a complete walk-around inspection of the drill before starting. During operation, make periodic checks to be sure the drill is operating properly.
8. Watch for leaking or broken hydraulic or air hoses. Replace them before they cause damage or a fire.
9. Do ***NOT*** operate the drill with excessively worn or broken parts.
10. Tighten or replace any loose or broken fittings, bolts or other connections before operating the drill.

11. 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.
12. Use extreme caution when handling, cleaning, wiring, or recharging batteries. They can explode and spray acid. Keep battery covers in place all the time.
13. Make sure all controls are in neutral before starting the drill.
14. 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.
15. Know where your helper or oiler is at all times. ***DO NOT*** move the drill if they are not in sight.
16. 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.
17. Locate the drill on level ground, if possible. Install cribbing (blocking) under each jack to insure a stable lifting platform in case the ground is broken or soft.
18. Before raising the derrick, 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 the derrick.
19. When working on any air compressor hose or receiver tank, relieve all pressure in the system before removing any cap, plug or hose connection.
20. Never move the drill with the derrick partially raised, unless it is an angle drill with the proper locking pins in place.
21. Never move the drill with the derrick locking pins removed or unpinned. The derrick is not designed to be held up by the derrick raising cylinders alone.

Pre-Start Inspection

1. ***INSPECT*** your drill 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.
3. ***NEVER*** fill the fuel tank with the engine running, while near an open flame, or while smoking. ***ALWAYS*** wipe up any spilled fuel.
4. ***CHECK*** for ***WARNING*** or lockout tags placed on the drill. ***DO NOT*** operate the drill until repairs have been made and all 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 a slip or a fall.

6. ***KNOW*** the location of the Emergency Shut Down control if the drill is so equipped.
7. ***ALWAYS*** know the capabilities and limitations of your drill equipment: speed, gradient, steering and braking.
8. ***BE AWARE*** of the dimensions of your drill's height, width and weight when moving the drill.
9. ***CHECK*** for any conditions that could be dangerous: unstable ground condition, tree limbs, low hanging wires or an overhanging rock face.

Operation Safety

General Information

1. OBSERVE the position of fire extinguishers, if so equipped, and ensure that 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 the drill from the operator's console only.
6. WATCH the indicators during startup and shutdown procedures in accordance with the operating instructions.
7. MAKE SURE no one is at danger or risk before starting up or setting the drill in motion. 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.
8. CHECK to see that braking, steering, signaling and lighting systems are fully functional before starting work or traveling with the drill.
9. CHECK that accessories have been safely stowed away and that all leveling jacks are retracted fully before moving the drill.
10. ALWAYS SWITCH ON the lighting system in conditions of poor visibility and after dark.
11. MAKE SURE there is sufficient clearance when crossing underpasses, bridges and tunnels, or when operating under overhead lines.
12. ALWAYS KEEP at a safe distance from the edges of steep slopes.
13. AVOID any operation that might be a risk to drill stability.

14. ALWAYS SECURE the drill against inadvertent movement by putting the truck in gear and engaging the parking brake before leaving the truck cab.
15. ALWAYS SECURE the drill against all unauthorized use before leaving the operator’s cab.

Starting Safety

1. ALWAYS USE handrails and steps to get on and off the drill. ALWAYS MAINTAIN a three point contact when climbing onto or off the drill. 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 the drill for people or obstructions.
4. BEFORE starting the engine, ENSURE that the carrier parking brake is in the “APPLIED” position.
5. BEFORE starting the engine, check that all operating controls are in the stop or neutral position and the emergency stop button is pulled out.
6. CHECK for Warning or Lockout tags on the controls. If there is a tag attached to the start switch, do not start the engine until the warning tag has been removed by the person who installed it.
7. ALWAYS sound the horn before starting the drill to alert everyone in the area.
8. START the engine from the truck cab only.
9. ALWAYS USE EXTREME CAUTION if you have to jump start the engine.
10. CHECK all the gauges and controls for correct operation. Stop the drill immediately and replace any that are defective.
11. CHECK all safety devices. Report any defects immediately.
12. MAKE SURE the drill is on solid, level ground before lowering the jacks and raising the derrick. Use cribbing (blocking) if you are not sure.
13. WHEN raising the derrick, make certain there are no electrical power lines within the operating area of the drill.
14. LISTEN for unusual noises.
15. ENGAGE hydraulic controls slowly in cold weather to avoid shock loading.

Electrical Power Line Safety

⚠ DANGER

Do not raise the derrick or operate this drill in the vicinity of electrical power lines. Operating too close or contacting a power line with any part of the drill can result in electrocution.

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

1. Place the drill as far as possible from electrical power lines and never work inside the minimum specified distance set by local, state or federal regulations.
2. Treat all electrical lines as live power lines.
3. Clear the area. Slowly raise and lower the derrick. If the distance to the line has been misjudged, your reaction time might be too slow.
4. A signal person must be used to guide the drill in the vicinity of power lines. The signal person and drill operator must be in direct visual contact at all times.

Operating Safely

1. ALWAYS make sure that no person or obstruction is in your line of travel before moving the drill.
2. NEVER CLIMB on or off the drill while it is in motion.
3. USE EXTREME CAUTION and be very observant when operating in close quarters or congested areas.
4. NEVER carry passengers.
5. KNOW the area in which you are working. Familiarize yourself with any and all work site obstructions and any other potential hazards in the area.
6. KNOW and USE the hand signals required for particular jobs and know who has the responsibility for signaling.
7. DO NOT work in the vicinity of overhanging banks or on grades that could cause the drill to slide or roll over.
8. AVOID side hill travel. ALWAYS operate up and down slopes.
9. NEVER allow bystanders, other than authorized persons, to stand within the drill's danger (working) area when the engine is running.

10. ALWAYS LOOK in all directions BEFORE changing your direction of travel and sound the horn prior to moving.
11. DO NOT run the engine in a closed building for an extended length of time. EXHAUST FUMES CAN KILL.

Drilling

All Atlas Copco Drilling Solutions drills are equipped with an overpressure control system which will vent feed pressure if the drill end leveling jacks are not supporting the weight of the drill. To ensure someone has not disabled the system, each operator **must** perform the overpressure control system operational check procedure daily as described in sections 5.6 and 6.5 of this manual.

1. Use the proper tools for the job. Do not attempt to lift drill pipe, subs, stabilizers or bits without the proper lifting devices.
2. 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 a 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!!!**
3. Do not attempt any repairs to the drill while it is running. Stop the drill to make repairs.
4. Do not allow anyone to climb the derrick. If repairs must be made, lower the derrick or use a manlift to reach the repair area.
5. **Do not ride the rotary head for any reason.** It is not meant to be an elevator.
6. Do not use the hoist cable as a manlift.
7. 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.
8. Do not hoist or brake too sharply. This can cause premature failure of equipment and can be dangerous.
9. 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.
10. Know the limitations of your drill and don’t exceed the design limits.

Moving the Drill

1. Make sure all drill pipe is out of the hole before moving the drill.
2. Do not get on or off the drill when it is moving.
3. Lower the derrick 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 the drill.
6. Check the carrier brakes before leaving the job site.

7. If moving with the derrick raised, make sure all locking pins are in place and the ground is level and solid.
8. Be careful cornering to allow for derrick overhang.
9. Know where your helpers are at all times. Do not move the drill if they are not in view.
10. Know and use proper signals when moving the drill.

Stopping and Shutdown

1. 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 wheels.
2. If the drill is left over the hole, lower the jacks so the wheels touch the ground.
3. Be sure to relieve all pressures in the systems before leaving the drill.
4. Place all controls in neutral or park position before leaving the drill.
5. Move the engine throttle to low idle position for approximately 5 minutes to allow the engine to cool down before turning the key switch to OFF.
6. Turn off the air transfer valve located behind the truck cab. ***Note:*** This valve must be off when moving over public roads to comply with federal laws.
7. Shift from PTO to driving position.
8. Shut off the engine and remove the keys before leaving the truck cab.
9. Install the operator’s panel cover on the operator’s console and lock it.
10. Raise the folding operator’s platform and fasten it.
11. Lock all lockable compartments.
12. USE proper flags, barriers and warning devices, especially when parking in areas of heavy traffic.

Maintenance Safety

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 shutdown procedures set out in the operating instructions and the information on maintenance work.

All personnel involved in setting up drills or handling maintenance and repairs must know and practice proper procedures, including lockout and tagout practices.

1. Ensure that the maintenance area is adequately secured.

2. When 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.

3. Carry out maintenance and repair work only if the drill is positioned on stable and level ground and has been secured against inadvertent movement.
4. USE CARE when attaching and securing lifting tackle to individual parts and to 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.
5. ALWAYS USE the correct tools and workshop equipment when performing maintenance to the drill.
6. 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 derrick.
7. KEEP all handles, steps, handrails, platforms, landings and ladders free from mud, dirt, snow and ice.
8. CLEAN the drill, especially connections and threaded unions, of any traces of oil, fuel or preservatives before carrying out maintenance or repair. NEVER use aggressive detergents. Use lint free cleaning rags.
9. 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 components.
10. ENSURE during cleaning of the drill that temperature sensors do not come into contact with hot cleaning agents.
11. REMOVE all covers and tapes applied for that purpose after cleaning the drill.
12. After cleaning the drill, EXAMINE all fuel, lubricant and hydraulic fluid lines for leaks, loose connections, chafe marks and damage. REPAIR or REPLACE defective parts immediately.
13. Always TIGHTEN any and all screwed connections that have been loosened during maintenance and repair.
14. Any safety devices that were removed for setup, maintenance or repair purposes must be refitted and checked immediately upon completion of the maintenance and repair work.
15. ENSURE that all the consumable and replaced parts are disposed of safely and with minimum environmental impact.
16. AVOID, whenever possible, the servicing, cleaning or examining the drill with the engine running.

17. AVOID whenever possible; servicing or providing maintenance to the drill unless the wheels are adequately chocked and the parking brake is applied.
18. DO NOT alter the engine governor settings from those indicated in the engine manual and the engine option plate.
19. ALWAYS replace damaged or lost decals. Refer to the parts manual for proper location and part number for all decals.
20. Use only original circuit breakers with the specified current rating. Shut down the drill immediately if trouble occurs in the electrical system.
21. Work on the electrical system or on electrical equipment may only be carried out by a skilled electrician or by specially instructed personnel under the direct supervision and control of an electrician and in accordance with the applicable electrical engineering.
22. If provided for in the regulations, power supply to parts of the drill on which inspection, maintenance and repair work is to be carried out, must be cut off.
23. 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.
24. The electrical equipment of the drill is to be inspected and checked at regular intervals. Defects such as loose connections or scorched cables must be rectified immediately.
25. Welding, flame cutting and grinding work on the drill should only be done if expressly authorized, as there may be a risk of explosion and fire.
26. Winches and ropes must be inspected frequently for unforeseen wear patterns and discarded according to certain criteria (refer to ISO 4305).
27. Before beginning welding, flame cutting and grinding operations, clean the drill and surrounding area from dust and other flammable substances and make sure that the premises are adequately ventilated (risk of explosion).
28. Check all lines, hoses and screwed connections regularly for any leaks and for obvious damage. Repair damage immediately. Splashed oil may cause injury and fire.
29. Depressurize all system sections and pressure pipes (hydraulic, compressed air) that are to be removed in accordance with the specific instructions before carrying out any repair work.
30. Hydraulic lines must be laid and fitted properly and correctly. Ensure that there are no connections that are interchanged. The fittings, lengths and quality of the hoses must comply with the technical requirements.
31. Observe all of the product related safety regulations when handling oil, grease and other chemical substances.
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 or 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.
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 the 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.
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. Winches and ropes must be inspected frequently for unforeseen 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 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) of the original diameter of the 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 the 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 the cable spools properly on hoist or drum.

   b. Do not overload the hoist or wire rope.

Hot Oil and Components

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.

⚠ 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 used oil properly and in accordance with local guidelines.

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 derrick raising cylinders, purge all air out of each end of the cylinder before connecting it to the drill. Air in one end can cause the derrick or rotary head to fall and cause an accident.
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 pumps or motors.

Valves

1. When working on valves, keep area clean to prevent contamination from getting inside the valves.
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 one 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 key 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 coolers and/or radiators before replacing.

Guards

1. If any guards must be removed from the drill to perform service, always replace them before the 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.

Lubrication

1. Never attempt to lubricate the drill while it is running, unless the drill is fitted with an automatic lube injection system. Stop the drill for all maintenance.
2. To lubricate fittings on the derrick, lay the derrick down and use a manlift to access hard to reach and inaccessible places. Do ***NOT*** climb the derrick 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.

Receiver Tank

⚠ WARNING

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.

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

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 dangerous.
5. Turn off drill air and exhaust the 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 the hose.

Warning of Special Dangers

Overhead Electric Wires

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.

DANGER

If your drill comes into contact with a live wire, DO NOT step off the operator's platform. DO NOT leave the drill.

If the driver is in the truck cab, drive the drill out of the hazard zone.

Warn others against approaching and touching the drill. Have the live wire de-energized. DO NOT leave the drill until the damaged line has been safely de-energized.

Ventilation

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.

Grade Limitations

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 the derrick up and down. Do not move the drill with the derrick up.

2.3 - SAFETY DECALS & NAMEPLATES

Pre-Operation

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.

Table 1: Decals List

Ref.	Decal	Qty.	Location
1	Caution: Excessive Oil	1	On Side of Hydraulic Reservoir
2	Warning: Falling Drill Pipe	1	Next to Sliding Breakout Wrench
		1	At Base Bottom of Rod Rack
3	Warning: Rotating Fan Blade	2	Cooler Housing
4	Warning: High Pressure	2	Top of Receiver & On Receiver End Plate
5	Warning: Service Tools Connection	1	On Mud Pump Standpipe Bracket
6	Warning: Combustible Gas	1	Carrier Battery Box
7	Warning: Falling Derrick	2	Bottom of Derrick Raising Cylinders
8	Warning: Powerhead	1	Face of Rotary Head
9	Danger: Hazardous Voltage	1	Operator’s Control Console
10	Warning: Falling Rotary Head	1	Bottom of Feed Cylinder
11	Notice: Hydraulic Failure	1	Top or Side of Hydraulic Tank
12	Warning: Do Not Modify or Alter	1	Operator’s Control Console
13	Warning: No Climbing	2	Both Sides of Derrick on Crossbeams
14	Notice: Avoid Electrical Damage	1	Side of Battery Box
15	Warning: Rotating Shaft	2	Both Sides of Driveline Guard
16	Warning: Rotating Parts	2	Both Sides of Driveline Guard
17	Laminated Safety Manual	1	Side of Operator’s Console

Safety Decals

1\.

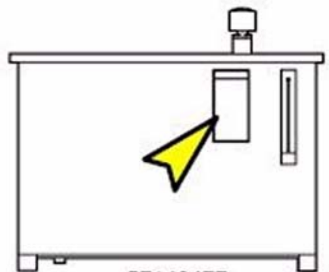
Decal, Caution: Excessive Oil

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 side of the hydraulic reservoir



57140477

2\.

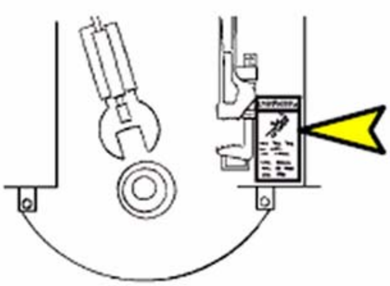
Decal, Warning: Falling Drill Pipe

Falling Drill Pipe Can Cause Severe Injury.

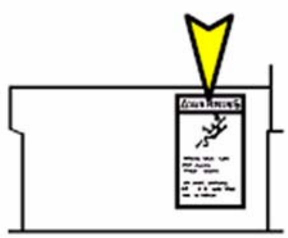
Use pipe handling tool clip to lock drill pipe in place.

Quantity of 2

57156333



One located next to sliding breakout wrench



One located at bottom of Rod Rack

3.

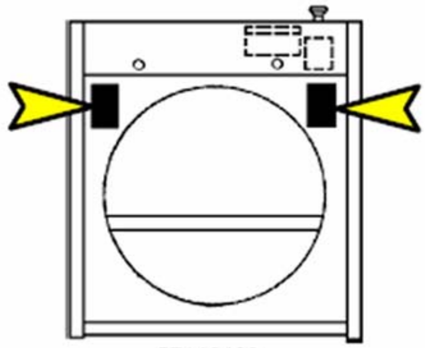
Decal, Warning: Rotating Fan Blade

Rotating Blade Can Cause Severe Injury

Do not operate with guard removed.

Quantity of 2

Located on cooler housing



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4.

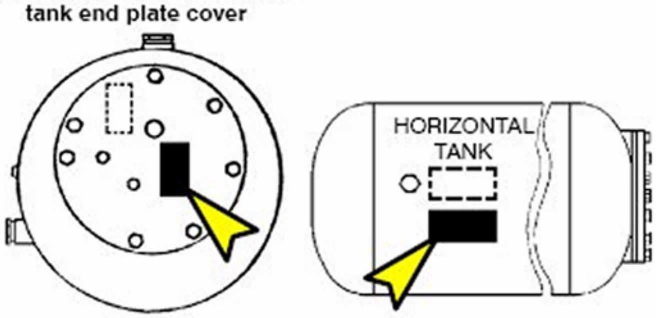
Decal, Warning: High Pressure

High Pressure Can Cause Severe Injury or Death

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

Quantity of 2

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



57140352

5.

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 mud pump standpipe bracket

57140428

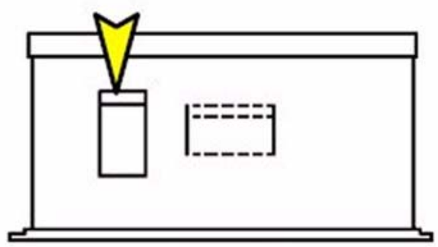
6. **Decal, Warning: Combustible Gas**

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 on passenger side under the seat



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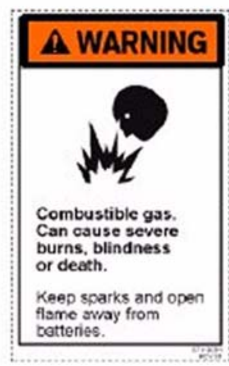


7.

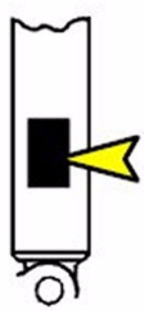
Decal, Warning: Falling Derrick

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 derrick raising cylinder



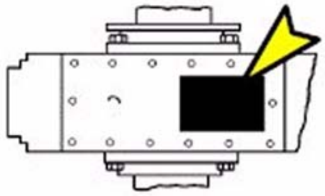
57140360

8.

Decal, Warning: Powerhead

Falling or crushing hazard. Severe injury or death can occur from falling from derrick or be crushed between rotary head and derrick.

Do not ride rotary head or climb derrick. Lower derrick to service.



Quantity of 1

Located on face of rotary head

57155517

9.

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.

57348112

10.

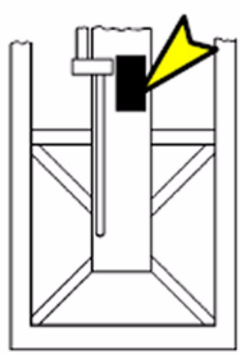
Decal, Warning: Falling Rotary Head

Falling Rotary Head Can Cause Severe Injury or Death.

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

Quantity of 1

Located on the bottom of the feed cylinder.



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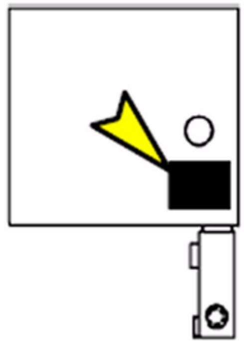
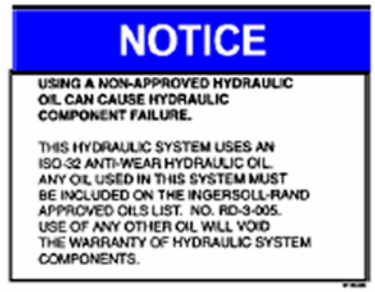
11. **Decal, Notice: Hydraulic Failure**

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.





57156465

Quantity of 1

Located on top of the hydraulic tank.

12. **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.

57310831

Quantity of 1

Located on the operator's console

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

13. **Decal, Warning: No Climbing**

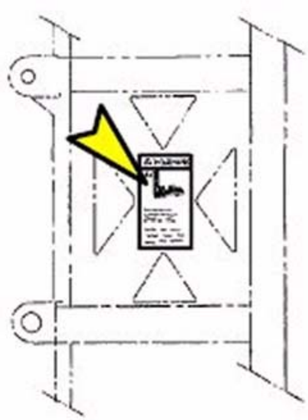
Climbing Raised Derrick Can Cause Severe Injury or Death

Do not climb raised derrick.

Lower derrick completely to service.

Quantity of 2

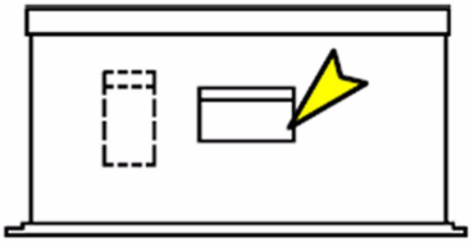
Located on both sides of the derrick on a cross beam.



57318040

14.

**Decal, Notice:
To Avoid Electrical Damage**



Quantity of 1 57345878

Located on side of the battery box

15.

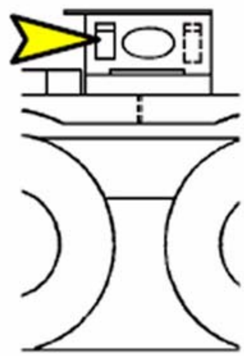
**Decal, Warning:
Rotating Shaft**

Rotating Shaft Can Cause Severe Injury or Death.

Do not operate with guard removed.

Quantity of 2

One on each side of the drive line guard



57140337

16.

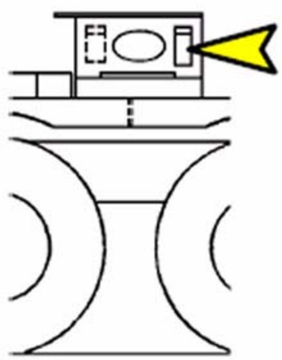
**Decal, Warning:
Rotating Parts**

Rotating Parts Can Cause Severe Injury

Do not operate with guard removed.

Quantity of 2

One on each side of the drive line guard



57140345

17.

Safety Manual

Located on side of operator's console

57313983

2.4 - HAZARDOUS SUBSTANCE PRECAUTION

General Information

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

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

Table 2: Hazardous Substance Precaution

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

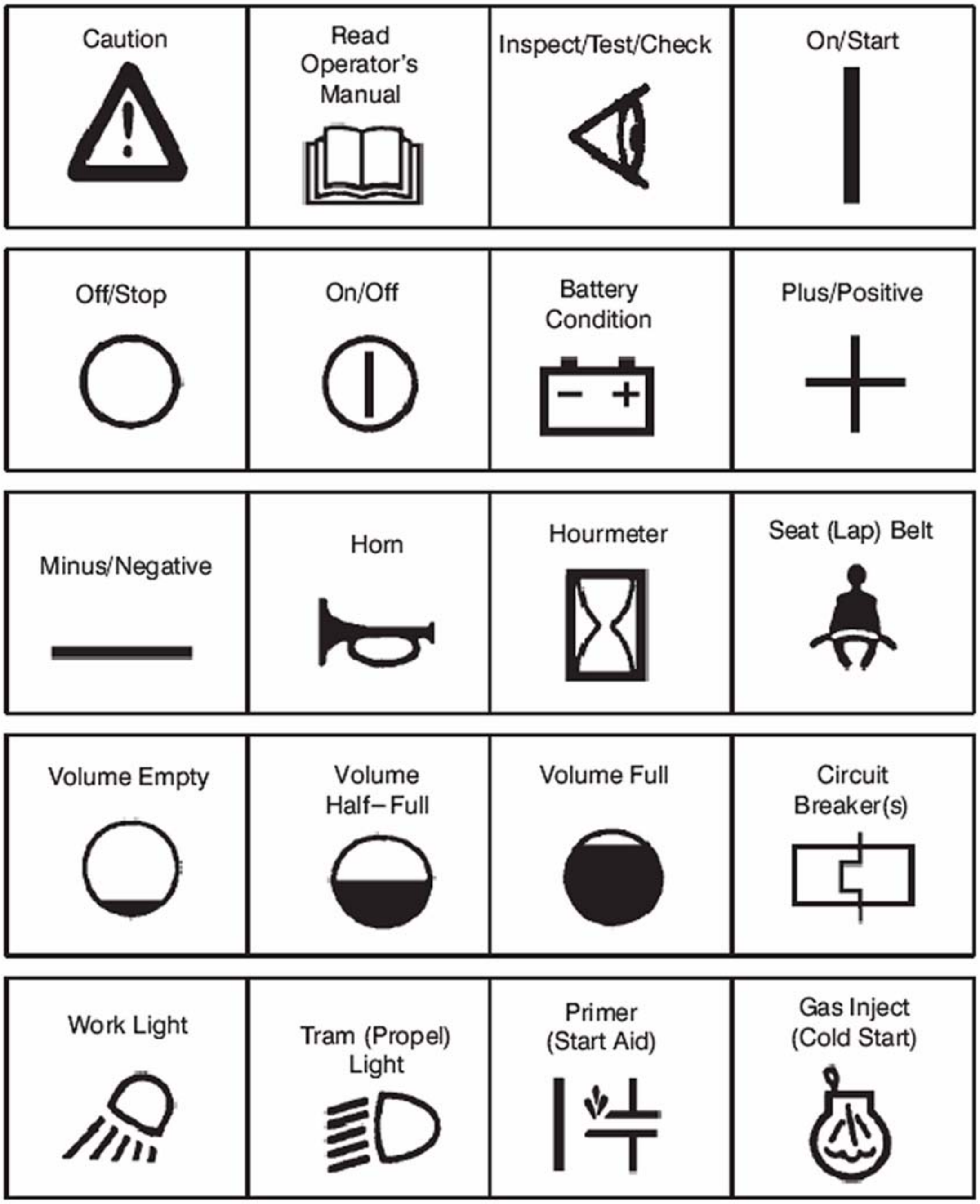
The following substances may be produced during the operation of this machine and may be hazardous to health.

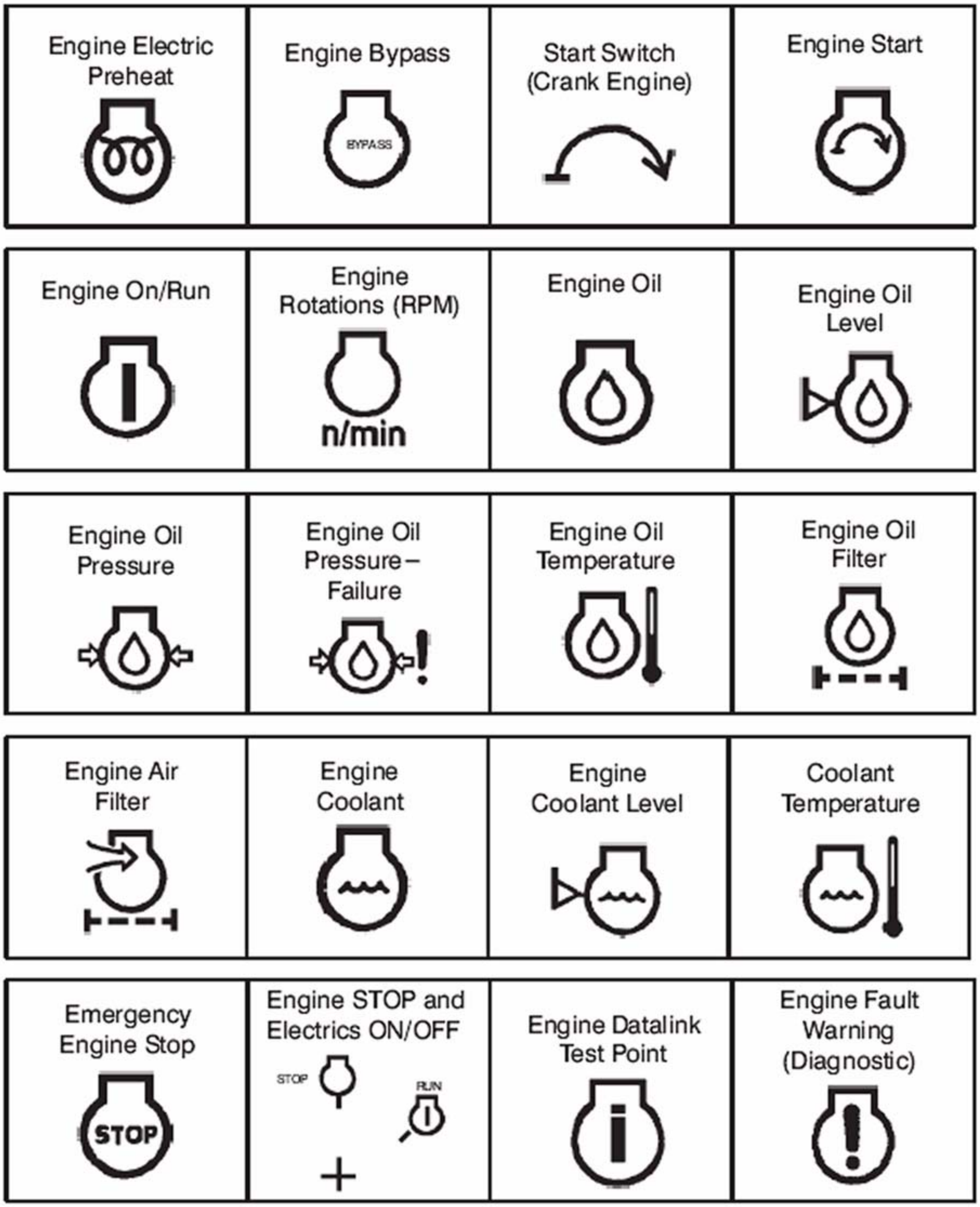
Table 3: Hazardous Substance Precaution

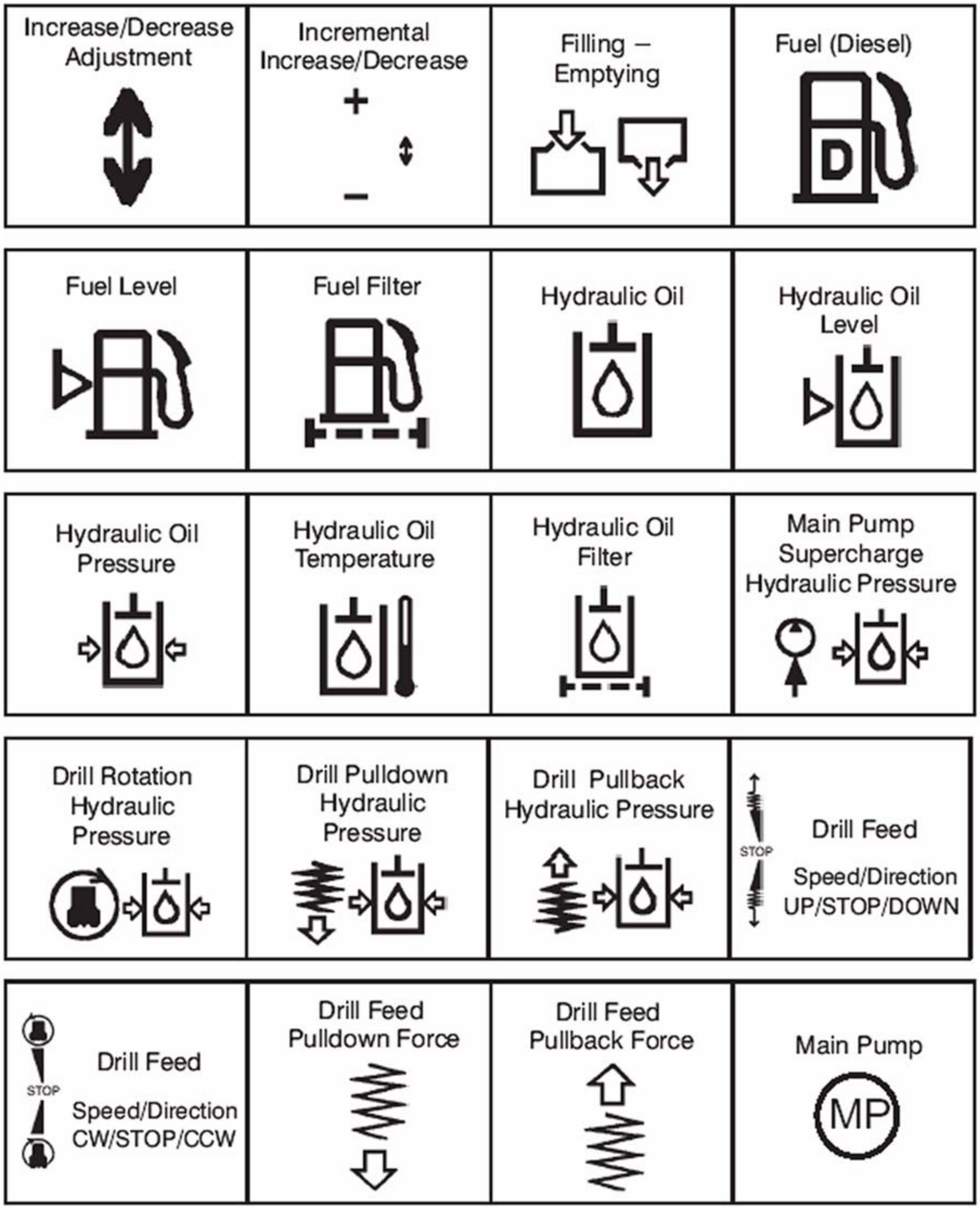
Substance	Precaution
Engine Exhaust Fumes	Avoid breathing fumes
Engine Exhaust Fumes	Avoid buildup of fumes in confined spaces
Electric Motor Dust (Brushes/Insulation)	Avoid breathing in dust during maintenance
Brake Lining Dust	Avoid breathing in dust during maintenance

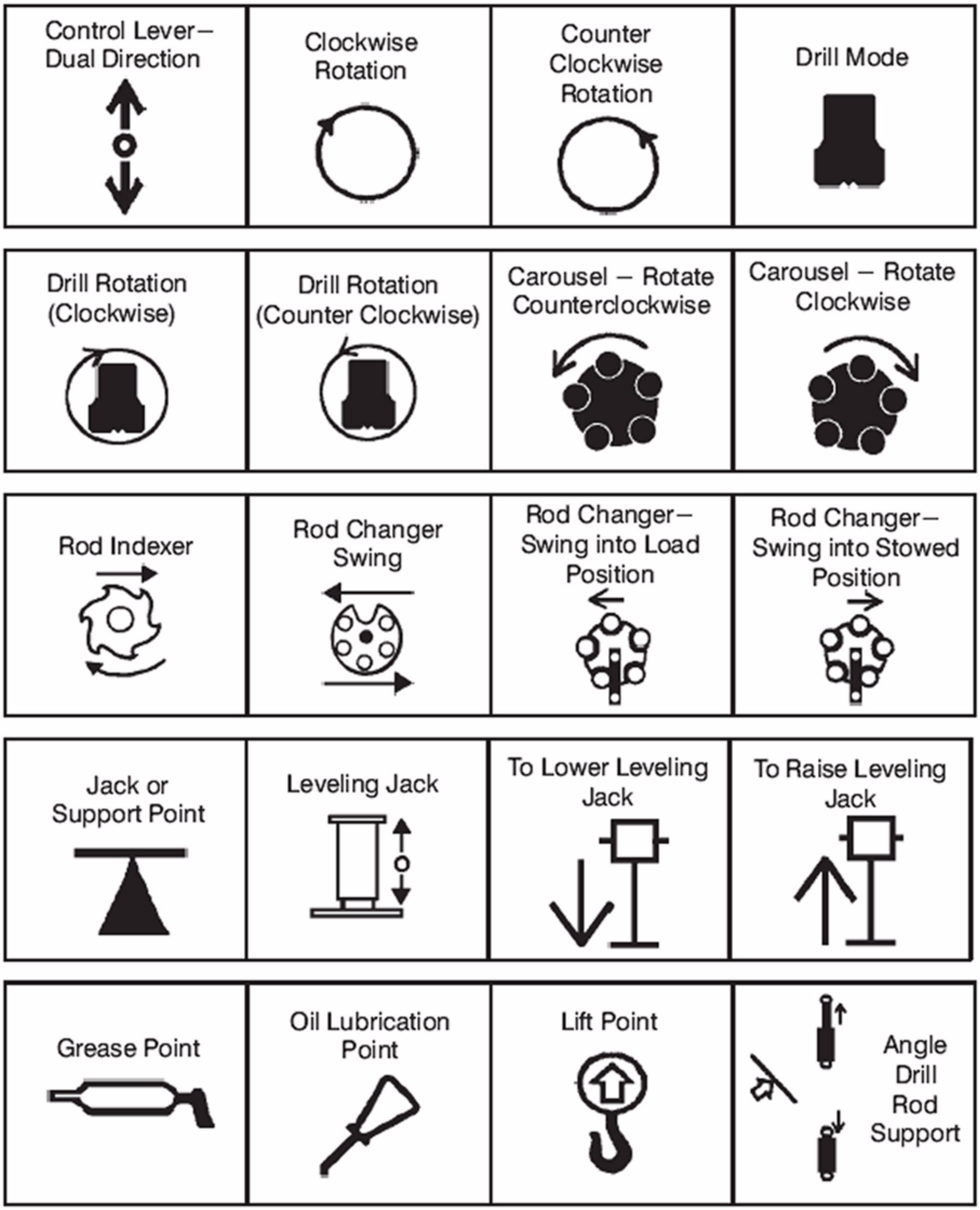
2.5 - SYMBOL IDENTIFICATION

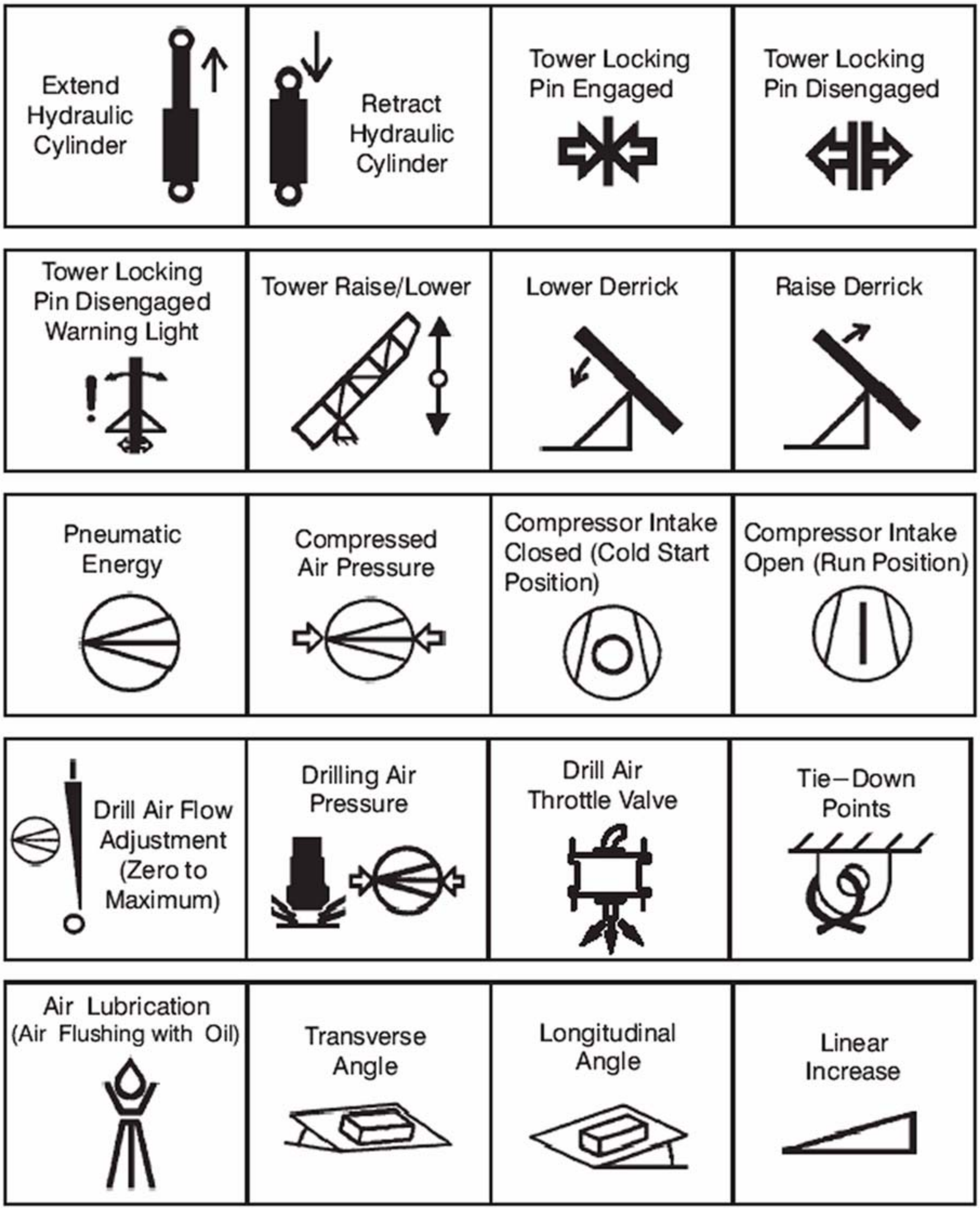
The following drill symbol information is provided to assist the owners and operators of Atlas Copco Drilling Solutions Equipment. Further information may be obtained by contacting your Atlas Copco Drilling Solutions Equipment Distributor.

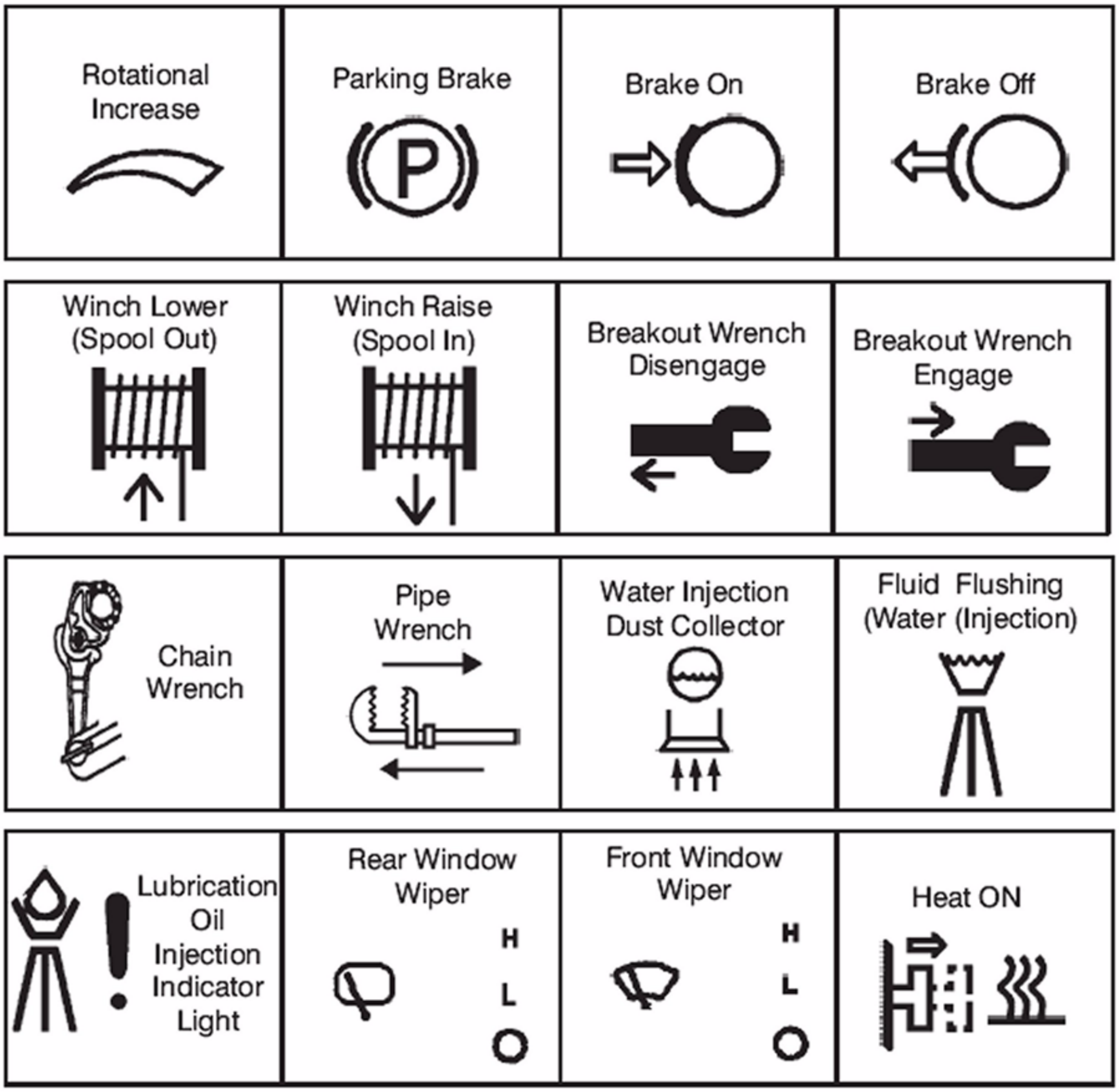



Engine Electric Preheat
Engine Bypass
BYPASS
Start Switch (Crank Engine)
Engine Start
Engine On/Run
Engine Rotations (RPM)
n/min
Engine Oil
Engine Oil Level
Engine Oil Pressure
Engine Oil Pressure – Failure
Engine Oil Temperature
Engine Oil Filter
Engine Air Filter
Engine Coolant
Engine Coolant Level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


Increase/Decrease Adjustment
Incremental Increase/Decrease
+
–
Filling – Emptying
Fuel (Diesel)
D
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
STOP
Drill Feed
Speed/Direction UP/STOP/DOWN
STOP
Drill Feed
Speed/Direction CW/STOP/CCW
Drill Feed Pulldown Force
Drill Feed Pullback Force
Main Pump
MP


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
Grease Point
Oil Lubrication Point
Lift Point
Angle Drill Rod Support


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
Tie–Down Points
Air Lubrication (Air Flushing with Oil)
Transverse Angle
Longitudinal Angle
Linear Increase


Rotational Increase
Parking Brake
P
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)
Lubrication Oil Injection Indicator Light
Rear Window Wiper
H
L
Front Window Wiper
H
L
Heat ON

Section 3 - Specifications

SPECIFICATIONS

General Description

The TH60 is a mid-weight, truck powered, tophead drive drill for water well applications using either rotary or DHD (down-hole-hammer) drilling as well as mud drilling methods on prepared (if necessary) ground that is flat and firm. The TH60 handles up to 14 in. (355.6 mm) casing.

The standard carrier used on a TH60 water well drill is a Peterbilt Model 357, powered by a Cummins ISX 565 HP diesel engine.

The standard TH60 uses a diesel engine connected directly to a heavy duty transfer case. The transfer case has four driveshaft connections:

1. Truck transmission to lower transfer case.
2. Lower transfer case to rear axles.
3. Upper transfer case to hydraulic pump drive gearbox.
4. Upper transfer case to air compressor.

The TH60 is equipped with a high pressure asymmetrical over/under compressor, available in two sizes (825/350 and 900/350), for high performance downhole (DHD) drilling.

The TH60 incorporates four (4) frame mounted leveling jacks to keep the drill level and stable while drilling. The derrick is constructed of welded steel tubing. The mid jacks behind the truck cab provide optimum stability and more balanced drill and truck frame load distribution. The derrick is raised and lowered by two hydraulic cylinders.

The drill pipe carousel is contained in the derrick in a fixed position and indexed in both directions from the console by the hydraulic motor. The carousel holds nine 3.5” x 20’ (89 mm x 6.1m) drill pipe or seven 4.5” x 20’ (114mm x 6.1 m) drill pipe. The rear half of the drilling table retracts hydraulically while the front half swings away from either side of the table to accommodate up to 14 in. (355.6mm) casing.

The TH60 rotary head can be retracted and positioned over either the center of the hole or the internal carousel. Retracting the head allows drill pipe to be loaded out of the carousel and allows casing to be handled more easily inside the derrick.

In conjunction with the retractable rotary head, an 18,000 (8,165 kg) drawworks is available. The jib boom swings and extends to position drill pipe, tools and casing directly over the hole, reducing the amount of labor required.

Drill pipe changing is done by moving drill pipe in and out of the carousel and rotary head. The rotary head is used to move all drill pipe in and out of the hole. All drilling functions are controlled from the operator’s console adjacent to the drill table. The operating controls and gauges are positioned within easy reach of the operator.

Built to last, the structural components and integrity of the TH60 separate this drilling rig from all of its competitors. This truck powered, tophead drive drill for water well applications provides a pullback force of up to 26,500 lb. (12,020 kg). The spur gear drive tophead provides 5,000 ft-lb. (6,780 N-m) of torque.

The TH60 Waterwell 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 TH60 Waterwell drill must be used in accordance with its designated use as described in the operating section of this manual (See Section 5). The TH60 Waterwell 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 TH60 Waterwell drills are truck powered, hydraulic tophead drive, multi--pass rotary drills specifically designed for drilling water wells using either rotary, mud drilling techniques or downhole drilling methods using a high pressure compressor on prepared (if necessary) ground that is flat and firm. The standard TH60 has a pullback capacity of 26,500 lbs. (12,020 kg.) The carousel holds seven (7) pieces of 4.5 in. (11.4 cm.) O.D. x 20 ft. (6.1 m) long drill pipe or nine (9) pieces of 3.5 in. (89mm) O.D. x 20 ft (6.1m) long drill pipe. The table opening is hinged to swing out 160° to enable handling of 14” (114 mm) casing.

Non Designated Applications

The TH60 Waterwell drills are not designed for pioneering/earth moving applications. The TH60 Waterwell drills are not designed for use on inclined surfaces or on soft and unstable ground. Use of the TH60 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.

⚠ WARNING

Set up the TH60 Waterwell Drill on a level surface. If this is not available, the site and the way to the site should be adequately prepared prior to drill setup.

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

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.

Operating Conditions For Stability

Stability is affected by the derrick position and orientation of the drill, surface stability (bearing strength), and wind conditions.

⚠ WARNING

Set up the TH60 Waterwell drill on a level surface. If this is not available, prepare the site and the way to the site before set up and drilling with the TH60.

⚠ WARNING

Do not move or transport the TH60 Waterwell drill with the derrick in the raised (up) position.

⚠ WARNING

Travel at a safe speed relevant to surrounding conditions.

Contact your local Drilling Solutions distributor, dealer or service office for further information.

Standard Equipment

1. Retractable Table
2. Top and bottom air actuated breakout wrenches
3. Hydraulic draw works for drill pipe and accessory handling
4. Lockable Steel Tool Cabinet
5. Cooling package rated to 125°F (52°C) ambient temperature
6. Carousel for Seven 4.5” (114 mm) x 20 ft. (6.1 m) or Nine 3.5” (89 mm) x 20 ft (6.1 m) Pipe
7. Drill Pipe Rack for (24) 3.5 in. (89mm) or (15) 4.5 in. (114mm) drill pipe
8. Hydraulic Powered Pipe Wrench
9. Four Leveling Jacks provide optimum stability
10. Backup alarm

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

⚠ DANGER

Your life may be endangered if the following is not complied with. DO NOT add attachments to the drill 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.

Specifications

General Information

The TH60 is a mid-weight, truck powered, tophead drive drill for waterwell applications. The drill is set up to handle 4.5 in. x 20 ft. (114mmx 6.1m) or 3.5 in. x 20 ft. (89mmx 6.1m) drill pipe. The rear half of the drilling table retracts hydraulically while the front half swings away from either side of the table to accommodate up to 14 in. (355.6 mm) casing.

Carrier

The current production TH60 Waterwell drill is mounted on a Peterbilt Model 357, powered by a Cummins ISX 565 diesel engine. **You must look at your carrier manuals,** located in the driver's door storage pocket on the drill, to determine the exact configuration of your chassis.

Table 1: TH60 Water Well Drill

TH60 Water Well Drill Specifications		
Carrier:	Peterbilt 357	
	Cummins ISX, 565 HP	
	247 inch Wheelbase	
	66,000 GVWR	
Powerpack:	Cummins ISX, 565 HP	
	Transfer Case from Peterbilt Chassis	
Derrick:	Capacity:	49,000 lb. (22,270 kg)
	Size:	32'L x 36"W x 28'D (9.8mL x 914mmW x 711mmD)
	Retract Channels:	Foot Pedal Control
	Table:	Retractable Table with Swing out Front

TH60 Water Well Drill Specifications		
Feed System:	Type:	Single Cylinder, Cable Feed
	Retract Channels:	Foot Pedal Control
	Pulldown:	30,000 lb. (13,608 kg)
	Pullback:	25,000 lb. (12,020 kg)
	Feed Rate:	24 FPM (7.3 MPM)
	Fast Feed Rate Up:	125 FPM (38.1 MPM)
	Fast Feed Rate Down:	220 FPM (67.1 MPM)
Rotary Head:	Type:	Spur Gear
	Rotation:	0-160 RPM
	Torque:	5000 ft/lb. (6780 Nm)
	Swivel/Piping	2.5” (64mm) swivel and air piping
Hydraulic Drawworks with Jib Boom:	Type:	Hydraulic
	Drum Size:	14.5 inch (368 mm)
	Spooling Capacity:	436 ft. (133m) of 5/8” Cable
	Speed Up/Down:	Variable, 0-130 FPM (39.6 MPM) first wrap
	Lifting Capacity:	18,000 lb. single line, first wrap (8164 kg) bare drum
	Jib Boom:	Swing and Extend
Options:	38 ft. (11.6m) Casing Driver Hammer, 38 ft. (11.6m) Dual Wall/Casing Hammer Derrick, Water Injection, Mud Pump Packages, 32,000 lb. Deephole Package, 2-Speed High Torque Head, Rod Spinner, Aluminum Platforms.	

Table 2: Peterbilt Truck Specifications

Peterbilt Vehicle Summary		
Unit:	Model & Type:	Model 357, Full Truck
Body:	Type:	Platform w/Devices
	Length:	20 ft. (6.1 m)
	Height:	13.5 ft. (4.1 m)
	Max. Laden Weight:	1000 lbs. (453.6 kg)

Peterbilt Vehicle Summary		
Chassis:	Front Axle Load:	20000 lbs.(9071.8 kg)
	Rear Axle Load:	46000 lbs. (20865 kg)
	Gross Carrier Weight:	66000 lbs. (29937 kg)
	Wheelbase:	247 in. (6273.8 mm)
	Front Axle to BOC:	72.5 in. (1841.5 mm)
	Cab to Axle:	174.5 in. (4432.3 mm)
	Cab to EOF:	288.5 in. (7327.9 mm)
Frame & Equipment:	11.5” Steel Rails, Steel Xmbrs, To 444”, 3/8” Rail Thickness. 4-Piece Nylon Insert Frame Fasteners, Class 10.9 Bolts. 3-Piece C-Channel Xmbr w/Cast Gussets. Chassis Hose and Wiring Bundles Conviently Routed Through Gussets.	
	10-3/4” x 3/8” Full Steel Liner, Huck Bolt All Accessible Frame Components, EOF Square w/o Xmbr, Peterbilt Front Wheel Mudflaps.	
Front Axles & Equipment:	Dana Spicer EFA20F4 18-20,000 lb. Standard Track. Dana Spicer ES cam brakes, 11-1/4” bolt circle. Factory Front Axle Alignment. Outboard Mounted Brake Drums.Zerk Fittings on Tie Rod Ends, King Pins and Draglink Ball Joints.	
	Taper Leaf Springs with Shocks 23,000 lbs SBFA	
	Power Steering Sheppard M100 Dual. 16,000-21,000 lb. SBFA. Glidekote Splines on Steering Shaft. Power Steering Reservoir Frame Mounted for use with Dual Steering Gears.	
	PHP10 Iron Hubs, Cast Drums, 16.5 x 6 Cam Brakes. 18,000 to 20,000 lb. front axles. Includes Dana Spicer EES1200/410 brake linings, non-asbestos.	
	Standard Oil Seals	
	Haldex/Dana Auto Slack Adjusters.	
Rear Axle & Equipment:	Dana Spicer DS463P 46,000 lb. Laser Factory Axle Alignment Accurate to .030 of an inch. Magnetic Rear Axle Oil Drain Plug. Outboard Mounted Brake Drums.	
	PHP10 Alum LMS Hubs, Cast Drums, 16.5 x 7 Brakes. 46,000 lb. maximum, tandem axle, Dana Spicer ES brakes.	

Peterbilt Vehicle Summary	
Rear Axle & Equipment:	MGM TR 3030 in. Parking Brakes, Both Axles.
	Haldex/Dana Auto Slack Adjusters, Tandem Axles.
	Chicago Rawhide Scotseal Plus XL Oil Seals, Tandem. Brake Dust Shields, Tandem Axles.
	Dana Spicer Full Lock Diff Lock, Both Axles (46,000 to 58,000 lbs. Separate Dash Cntrl-Full Lock/Main Diff/Cont Trac. Dana Spicer or Meritor Tandem/TriDrive Axles.
	Gusseted Cam Brackets Dana spicer 16.5 x 7 Cam Brake. Tandem Axles, 48,000 lb. Max GAWR, Welded Gusset Cam Bracket.
	Meritor Wabco 4S4M ABS, SBM Valve. Synthetic Axle Lubricant, All Axles. Ratio, 4.88 Rear Axle. Hendrickson RT-463 46,000 lb., 54 in. Axle Spacing.
Engine & Engine Equipment:	ISX 565/2000 587 @1700 1850 @ 1200, Includes alum flywheel housing. Chevron Delo Multigrade engine Oil, SAE 15W40. Magnetic Engine Oil Drain Plug.
	Delco Remy 130 Amp alternator 22 SI. Immersion Type Pre-heater 110-120V 1500 Watts Phillips.
	Delco Remy 12V Starter. Key Ingition/Push Button Start Switch. Weather Pack Silicone Sealed Electrical Chassis Connectors. 12 Volt System w/Circuit Protection Wires Numbered Every 4 inches or less.
	4 Champ PC31MC12V Batteries 2600 CCA Threaded Stu Type Terminal. Maintenance Free 12V Batteries, Stranded Copper Battery Cables, Double Aught (00) Or Larger.
	Horton Fan Clutch ISX/Signature (Furnished on Signature Engine) DriveMaster. Cummins 18.7 CFM Air Compressor (Furnished On Engine).
	Spin-on Fuel Filter Frame Mounted. Spin-on Water Filter Engine Mounted ISM/ISX.
	Cummins Engine Protection Shutdown (Includes oil pressure, oil temperature, coolant temperature and intake manifold temperature.
	High Capacity Cooling System (1440 Radiator)
	Silicone Radiator Hoses Includes Constant Torque Clamps.

Peterbilt Vehicle Summary	
Engine & Engine Equipment:	2 Dnldsn 13 in. Painted Clnrs Cowl Mtd w/Painted Cap. Includes stainless steel brackets and straps.
	Constant Torq Hose Clamps on Air Intake Hoses for Donaldson Air Cleaners. Stainless Steel Air Cleaner Straps, Brackets and Fasteners. Moulded Rubber Air Intake Connections with Lined Stainless Steel Clamps.
	Dual 5 in. Exhaust Vert Resilient Cab Mounted Stainless Steel Flex Tubing & Clamps. High Mount Exhaust Routing Dual. Dual Exhaust Guards Stainless Steel. Dual Curved Chromed Standpipes. Dual 36 in. Standpipes.
Transmission & Clutch:	Fuller RTLO18913A 13 Speed Includes Iron Bell Housing, oil-to-water cooler, Internal oil pump, rear transmission support and direct shift pattern. Magnetic Transmission Oil Drain Plug.
	1810 HD Driveline With Single Midship Bearing w/4.5 in. x .180 Wall Tubing. Half Round End Yokes w/Zerk Fittings. Coated Driveshaft Splines.
	1810 HD Driveshaft. Half Round End Yokes w/Zerk Fittings. Coated Driveshaft Splines.
	Young F301HY1P Oil Cooler Water-Oil.
	Synthetic Lubricant-Manual Transmission
	Eaton Fuller 15.5 in. Clutch Easy Pedal VCTplus. Ceramic/4000# Plate/1860 Torque/Vibration Control Technology.
	Manual Adjust Clutch with Grease Bearing.
	Fabco PTO170 Transfer Case (Split Box) 873-052-13
Air & Trailer Equipment:	Bendix AD-IS Dryer with Heater. An integrated system air dryer that incorporates the functions of the air dryer, purge reservoir (which increases the drying capacity), wet air tank, pressure relief valve, single check valves, and pressure protection valve for air susp and other air accessories. Includes easy-to- service spin-on dessicant cartrige.
	Wire Braid Chassis Hose. Braided Chassis Harness Cover. Rubber Lined Clamps along Frame Rail. Teflon Lined, Stainless Steel Braided compressor Discharge Hose.

Peterbilt Vehicle Summary	
Air & Trailer Equipment:	Air Tanks Mounted Inside Frame Rail Flanges.
	(3) Steel Painted Air Tanks.
Tires & Wheels:	FF: BR 20 Ply 425/65R22.5 M844F
	RR: BR 14 Ply 11R22.5 M711
	Code-Rear Tire Qty 08
	FF: Accur 29807 Pit 22.5 x 12.25 Stl Whl
	RR: Accur 28408 Pit 22.5 x 8.25 Stl Whl. Pilot Mt, Two Hand Holes.
	Code-Rear Rim Qty 08.
Fuel Tanks:	26 in. Aluminum 100 Gallon Fuel Tank RH U/C
	26 in. Aluminum 100 Gallon Fuel Tank LH U/C Additio. Paddle Handle Filler Cap with Threadless Filler Neck Wire Braid Fuel Line.
	(1) Non-Slip Fuel Tank Step RH U/C. (1) Non-Slip Fuel Tank Step LH U/C. Center Fuel Tank Fill.
	Fuel Cooler.
	Dual Draw, Dual Return, w/o Xover Or Guard. Top Draw, without Shut-Off Valves.
Battery Box & Bumper:	Alum Bumper Swept Back Polished w/o FEPTO with center tow hook and step plates on top of bumper.
	Heavy Duty External Tow Eye.
Cab & Equipment:	Aluminum Cab 119” Vocational Fiberglass. Hood SBFA. Ignition and Doors Keyed Alike. Stainless Steel Grille. Full Length Piano Type Stainless Steel Door Hinges and Pins. Three Point Resilient Cab Mounting. One Piece Roof. Aircraft Grade Huckbolt Fasteners. Tinted Safety Glass. Separate Vent Window in the Doors. Interior Noise Reduction Package. Rubber Fender Lips 2.25 inch Wide.
	UltraRide LowBack Vinyl Air Driver Seat. UltraRide LowBack Vinyl Passenger Seat Non-Susp Mounted on in-Cab Battery Box. Seat Cushion Bolted to Battery Box Cover. Includes Two Battery Disconnect Switches. 3-Point Safety Belt (Driver & Passenger). 18 in. (4) Spoke Foam Steering Wheel, Soft Touch.

Peterbilt Vehicle Summary	
Cab & Equipment:	Adjustable Steering Column, Tilt Telescope. Accent Interior Grey. Includes vinyl padded interior panels, door pads with carpet insert, driver door map pocket, (2) inside sunvisors with map strap, (2) coat hooks, cup holder and map bin in dash, (2) inside entry grab handles, (2) dome/reading lights, and black extruded rubber floor covering.
	Large Fixed Rear Window BOC Standard Tint. View Window in RH Door. Combo Fresh Air Heater/Air Conditioner with radiator mounted condenser. 54,500 BTU/HR Heater/Air Conditioner. Bi-Level Heater and Defroster Controls. Silicone Heater Hoses.
	Outside Sunvisor Stainless Steel. Stainless Steel Mirrors 7 x 16 inch (Prutsman MP716S). Convex Mirror Over RH Door. (2) Convex Prutsman 8 inch SS Mirror Center mounted under mirror bracket. Stainless Steel Mirror Fasteners. Brackets Optimized for 102 inch Width.
	(1) Air Horn 24.5 inch Chrome, Round w/Horn Shield. Mount Air Horn Logger Style-LH Single Electric Horn. Delphi AM/FM/WB W/2 Speakers. Plug-in Auto Reset Circuit Breaker in place of fuses in junction box. Removable Bugscreen Behind Grille. Peterbilt Electric Windshield Wipers w/Intermittent Feature. 5 Lb. 3a:40bc Fire Extinguisher mounted behind driver seat.
	Triangle Reflector Kit Shipped Loose.
	Instrument Package #5. Includes Peterbilt electric speedometer w/trip odometer, tachometer, voltmeter, dual air pressure, engine oil pressure, engine oil temperature, water temperature, (2) axle oil temperature (tandem axle), main transmission oil temperature, air application, air filter restriction, manifold pressure, Peterbilt pyrometer (2 inch), clock and fuel level gauge.
	Standard Warning Light Package. Includes high water temperature, low oil pressure, and low air pressure warning lights w/buzzers, high beam and turn signal indicators. Interaxle differential lockout warning light without buzzer (not included in the Medium Duty model). Inlet air heater and alternator charging system warning lights without buzzers (only included in the Medium Duty model). Warning light bar located in top center of the instrument panel.

<table>
<tr><th colspan="3">Peterbilt Vehicle Summary</th></tr>
<tr><td>Cab & Equipment:</td><td colspan="2">Speed/Odometer Disconnect when PTO is Engaged. Headlights Single Rect Pod Mounted w/Halogen hi beam with integral turn signals. Marker Lights (5) Rect ICC. Daytime Running Lights (required on Canadian units). Moveable EOF Xmbr For Mounting Tail Light square EOF with or without EOF xmbr. RR Combination Stop, Turn & Tail Lights.</td></tr>
<tr><td rowspan="4">Paint:</td><td colspan="2">(1) Color Dupont Two Stage-Cab/Hood Base Coat/Clear Coat.</td></tr>
<tr><td rowspan="3">(1) Color Dupont Two Stage-Cab/Hood Base Coat/Clear Coat</td><td>N85020 1 - L0506EB RED</td></tr>
<tr><td>N85200 FRAME N0001EA BLACK</td></tr>
<tr><td>N85300 WHEEL N0006EA WHITE</td></tr>
<tr><td colspan="3">Specifications Subject to Change Without Notice.</td></tr>
</table>

Powerpack

The power pack (or power train) consists of the truck diesel engine connected directly to a heavy duty transfer case. The power source is the truck engine through a full power transfer case.The transfer case has four driveshaft connections:

1. Truck transmission to lower transfer case connection
2. Lower transfer case to rear axles connection
3. Upper transfer case to hydraulic pump drive gearbox connection
4. Upper transfer case to air compressor connection

Table 3: Standard Power Pack Selections

Engine	Model	HP (kW) RPM	Compressor CFM @ psi (m^3/min. @ kPa)
Cummins	ISX	565hp (421kW) / 1806 rpm	HP825 @ 350 (25.5@2413)
			HP900 @ 350 (25.5@2413)

Truck Engine

The Cummins ISX engine provides electronically controlled fuel injection plus many additional features that enhance engine and vehicle performance. The control center of the ISX system is the electronic control module (ECM). The ECM regulates fuel injection quantity and timing. The ECM also processes switch and sensor inputs from the cab, chassis and engine and communicates with the driver using warning lights on the dash panel. Additional features of the ISX system include an engine protection system.

Engine Specifications

Table 4: Truck Engine Specifications

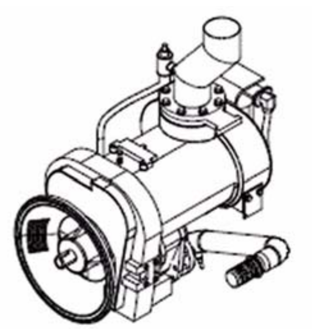
Make / Model:	**Cummins ISX**, 565HP (421 kW) @ 1806 RPM
Engine Cooling Package:	Rated at 12°5F (52°C) ambient at sea level
Exhaust System:	Silenced for reduced noise levels
Fuel Capacity:	200 gallons (757 liters)
Electrical System:	24 Volt
Auto Shutdown:	Low oil pressure, low coolant level, high water temperature, high compressor temperature

Transfer Case

Power is supplied from the truck engine through the full power transfer case. The transfer case has three output shafts. One shaft powers the rear wheels for road travel, one shaft powers a pump drive gear box for the hydraulic pumps, and one shaft powers the air compressor. Power to drill or transport the rig is engaged or disengaged with air shifters which are controlled from the truck cab. The air compressor engage/disengage control is located on the operator's control panel. The transfer case is equipped with a lubricant oil cooler.

Air Compressor

Air compressors used on the TH60 Waterwell drills are of the oil flooded asymmetrical rotary screw design. Tapered roller bearings are used to handle thrust and radial loads. The compressor is directly driven by the drive shaft connection from the heavy duty transfer case, which is directly driven by the drive shaft connection to the truck diesel engine.



Standard equipment for the air compressor includes a separate three-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 shutdown 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.

Table 5: Compressor Specifications

Capacities and Pressures Available	
Make/Model:	825HR2 @ 350 psi
	900HR2 @ 350 psi
Type:	High pressure two stage, over/under, oil flooded asymmetrical rotary screw
Volume:	825 cfm @ 350 psi, (23.4 m^3/min. @ 2413 kPa)
	900 cfm @ 350 psi, (25.5 m^3/min. @ 2413 kPa)
Pressure Range:	120 psi to 350 psi (827 kPa to 2413 kPa)
Operational RPM:	2100 RPM
Receiver Capacity:	25 gallon (95 liter)
Power Source:	From diesel engine through transfer case to airend

Cooling Package

A single side-by-side cooling package is provided for the hydraulic oil and compressor oil. The 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.

Table 6: Cooling Package Specifications

Type:	Air to oil heat exchanger. Side-by-side cooler package (compressor oil and hydraulic oil)
Fan Drive:	Spring Vane hydraulic motor
Rating:	125°F (52°C) ambient at sea level
Fan Blade:	6-blade fan with 2-speed selector
Function:	Cools hydraulic oil and compressor oil

Hydraulics

General Information

All drilling functions on the TH60 are hydraulically powered. The system consists of an 85 gallon (322 liter) hydraulic reservoir with 10-micron filtration, hydraulic pumps mounted on a three hole gearbox and various valves, cylinders, pipes, hoses, filters and gauges. A hydraulic oil cooler assures cool oil temperatures to maximize system deficiency and component life.

The hydraulic pumps are mounted for convenient service access on a single three-hole gearbox. Power to operate the hydraulic pumps is supplied by the truck engine, through the truck transmission and transfer case, via a driveline to the gearbox. Pumps are powered by a triple pump drive; input @ 2100 RPM.

Hydraulic Reservoir

Table 7: Hydraulic Reservoir Specifications

System Capacity:	85 gallon (322 liter)
Filtration:	All filters are equipped with 10 micron elements
Quantity/Location:	Located in center of truck frame behind cooler package
Standard Equipment:	Oil level sight gauge and oil temperature gauge, two in-tank return filters, one oil strainer and one tank breather

Gear Pump

Table 8: Gear Pump Specifications

Quantity:	One
Type:	Four (4) Stage Gear Pump
Capacity:	P1 Section: 6.37 in^3/rev., 55 gpmt (208 lpm) @ 2000 rpm
	P2 Section: 3.19 in^3/rev., 27.6 gpmt (104.5 lpm) @ 2000 rpm
	P3 Section: 1.91in^3/rev., 16.5 gpmt (62.5 lpm) @ 2000 rpm
	P4 Section: 1.91in^3/rev., 16.5gpmt (62.5 lpm) @ 2000 rpm
Function:	P1 Section: Feed Cylinder, 18K Main Hoist
	P2 Section: Cooling Fan Motor
	P3 Section: Jib Boom, Carousel Motor, Breakout Wrench, Derrick Raising Cylinders, Retract Table, Sand Reel Motor, Leveling Jacks, Water Injection Motor
	P4 Section: Drill Feed Control

Rotation Pump

Table 9: Rotation Pump Specifications

Quantity/Location:	One, mounted on 3-hole pump drive gearbox
Type:	Axial Piston Pump
Capacity:	7.93 in^3/rev. (130cc), 91.5 GPM (346 lpm)
Function:	Rotary Tophead Rotation

Mud Pump (Option)

A third hydraulic pump will be included when one of the optional mud pumps is ordered. The size of the hydraulic pump will be determined by the size of the mud pump.

Table 10: Hydraulic Pump Specifications

Quantity/Location:	One, mounted on back of 3-hole pump drive gearbox
Type:	Axial Piston Pump
Capacity:	
5 x 6 Mud Pump	4.57 in^3/rev. (75 cc)
4x5x14 Mud Pump	6.10 in^3/rev (100 cc).
3 x 4 Mud Pump:	6.10 in^3/rev. (100 cc)
Function:	Power the Hydraulic Mud Pump

Rotation Motor

Table 11: Rotation Motor Specifications

Single Speed Rotation Motor Specifications	
Quantity:	Four
Type:	Standard Hydraulic Motor, Bi-Directional
Displacement:	9.9 in^3/rev. (162.3 cm^3/rev.)
Rotation:	0 to 160 RPM
Torque:	5000 ft/lbs. (6780 Nm)
Function:	Drill Rotation

Mid Torque, Two Speed Rotation Motor Specifications	
Quantity:	Four
Type:	Two Speed: Hydraulic Motor, Bi-Directional
Displacement:	12.5 in^3/rev. (204.9 cm^3/rev.)
Rotation:	High Range: 0 to 170 RPM
	Low Range: 0 to 125 RPM

Mid Torque, Two Speed Rotation Motor Specifications	
Torque:	High Range: 4650 ft/lbs. (6305 Nm)
	Low Range: 6250 ft/lbs. (8475 Nm)
Function:	Drill Rotation

High Torque, Two Speed Rotation Motor Specifications	
Quantity:	Four
Type:	Two Speed: Hydraulic Motor, Bi-Directional
Displacement:	15 in^3/rev. (254 cm^3/rev.)
Rotation:	High Range: 0 to 140 RPM
	Low Range: 0 to 105 RPM
Torque:	High Range: 6000 ft/lbs. (8136 Nm)
	Low Range: 8000 ft/lbs. (10,848 Nm)
Function:	Drill Rotation

Fan Motor

Table 12: Fan Motor Specifications

Quantity/Location:	One
Type:	Hydraulic Spring Vane Motor
Displacement:	Fixed displacement, 3.59 in^3/rev. (1300 rpm)
Torque:	57 in/lbs. (6.4 Nm)
Function:	Cooler Package Fan Motor

Carousel Motor

Table 13: Carousel Motor Specification

Quantity:	One
Type:	Hydraulic Motor, Bi-Directional
Displacement:	22.5 in^3/rev
Function:	Rotates the carousel to index drill pipe under rotary tophead

Sand Reel Motor

Table 14: Sand Reel Motor Specifications

Quantity:	One
Type:	Hydraulic Motor, Bi-Directional
Displacement:	1.01 in^3/rev.
Function:	Facilitates Casing Handling

Water Injection Motor

Table 15: Water Injection Motor Specifications

8 GPM Water Injection Motor Specification	
Quantity:	One
Type:	8 GPM: Fixed Displacement 10.3 in^3/rev.
Capacity:	0 to 9 GPMT (0 to 34 LPM)
Pressure:	550 psi (3792 kPa) maximum
Function:	Drives Water Injection Pump

12 GPM Water Injection Motor Specification	
Quantity:	One
Type:	12 GPM: Fixed Displacement 6.1 in^3/rev.
Capacity:	0 to 12 GPMT (0 to 45 LPM)
Pressure:	550 psi (3792 kPa) maximum
Function:	Drives Water Injection Pump

25 GPM Water Injection Motor Specification	
Quantity:	One
Type:	25 GPM: Fixed Displacement 6.1 in^3/rev.
Capacity:	0 to 25 GPMT (0 to 95 LPM)
Pressure:	550 psi (3792 kPa) maximum
Function:	Drives Water Injection Pump

Mud Pump Option Motor

Table 16: Mud Pump Option Motor Specifications

Quantity/Location:	One, mounted on the mud pump gear reducer
Type:	Axial Piston
Capacity:	3 x 4 Mud Option: 2.03 in^3/rev.
	5 x 6 Mud Option: 2.03in^3/rev.
Function:	Operates the Mud Pump

Leveling Jack Cylinders

The TH60 Waterwell drill utilizes a four-point hydraulic leveling jack system with 18 inch (45.7 cm) O.D. jack pads. The mid jacks behind the truck cab provide optimum stability and more balanced drill and truck frame load distribution.

Table 17: Hydraulic Leveling Jacks Specifications

Type:	Hydraulic cylinder with single pilot holding valve
Quantity:	**Four (4)**
Bore x Stroke x Rod Diameter	
Non-Drilling End:	**Two** - 5.75 in. x 48 in. stroke / 4.5 in. (146mm x 1219mm x 114mm)
Drilling End:	**Two** - 5.75 in. x 36 in. stroke / 4.5 in. (146mm x 914mm x 114mm)
Jack Pad Diameter:	18 inches (457 mm)
Function:	Raise and level the drill off the ground

Derrick Raising Cylinders

The derrick is raised and lowered by two hydraulic cylinders. Raising the derrick to the vertical position can be accomplished in less than one minute. Derrick pinning is a manual operation.

Table 18: Derrick Raising Cylinders Specifications

Quantity/Type:	Two Hydraulic Cylinder
Bore x Stroke x Diameter	5 in. x 36 in. x 3 in. (127mm x 914.4mm x 76mm
Function:	Raise and lower the derrick

Feed Cylinder

The TH60 Water Well drill uses a single hydraulic cylinder cable feed system.

Table 19: Feed Cylinder Specifications

Type:	Hydraulic Cylinder
Quantity:	One
Bore x Stroke x Diameter:	6 in. x 156 in. x 3 in. (164mm x 3962mm x 76mm)
	6.5 in. x 156 in. x 3 in. (165mm x 3962mm x 76mm)
	6.5 in. x 180 in. x 3.5 in. (165mm x 4572mm x 89mm)
Function:	Raise and lower the rotary tophead

Retract Table Cylinder

The retract table is retracted by a hydraulic cylinder.

Table 20: Retract Table Cylinder Specifications

Quantity/Type:	One, Hydraulic Cylinder
Bore x Stroke x Diameter:	3.5 in. x 10 in. x 1.75 in. (89mm x 254mm x 44.5mm)
Function:	Retracts table to provide working space for casing and tools.

Breakout Wrench Cylinder

The breakout wrench uses a hydraulic cylinder to operate the chain or pipe breakout wrench.

Table 21: Breakout Wrench Cylinder Specifications

Quantity/Type:	One, Hydraulic Cylinder
Bore x Stroke x Diameter:	3.5 in. x 10 in x 1.5 in. (89mm x 254mm x 38mm)
Function:	Used for breaking drill pipe joints

Jib Boom Swing Cylinder

The jib boom swing cylinder controls the movement of the boom arm to position the cable directly over the rod loader/carousel to load and unload drill pipe.

Table 22: Jib Boom Swing Cylinder Specifications

Quantity/Type:	One, Hydraulic
Bore x Stroke x Diameter:	3 in. x 14.125 in. x 1.5 in. (76.2mm x 358.7mm x 38mm)
Function:	Swings drill pipe over carousel when loading/unloading pipe

Jib Arm Extend Cylinder

Table 23: Jib Boom Extend Cylinder Specifications

Quantity/Type:	One, Hydraulic
Bore x Stroke x Diameter:	3 in. x 14.125 in. x 1.5 in. (76.2mm x 358.7mm x 38mm)
Function:	Extends jib arm when loading pipe from rod rack

Bottom Holding Wrench Air Cylinder

The bottom holding wrench, also called the sliding breakout wrench, is used to hold the drill pipe flats at the table when breaking joints.

Table 24: Bottom Holding Wrench Air Cylinder Specifications

Quantity/Type:	One, Air Cylinder
Size:	2 in. x 5 in. x 1.0625 in. (50.8mm x 203mm x 27mm)
Function:	Slides forward on drill table to engage the flats on the drill pipe.

Upper Holding Wrench Air Cylinder

The upper holding wrench is used when breaking joints at the rotary tophead when loading and unloading the carousel.

Table 25: Upper Holding Wrench Air Cylinder Specifications

Quantity/Type:	One, Air Cylinder
Size:	4 in. x 6 in. x 1.75 in. (101.6mm x 152mm x 44.45mm)
Function:	Engages drill pipe flats when loading and unloading carousel.

Derrick

General Information

The derrick is constructed of welded tubular steel with cross bracing on both sides and the back. The fabrication is constructed by Drilling Solutions in a special roll-over fixture that helps provide optimum welds. A set of sheaves at the top and bottom of the derrick support the feed cables. The derrick assembly features the hydrostatic driven rotary head and the hydraulic drill feed systems. The feed system consists of the rotary head, hydraulic feed cylinder and cable connected to the top and bottom of the rotary head.

The derrick is designed to hold the rotary head as it goes up and down carrying the drill string. It is built to withstand the torque exerted by the rotary head during the drilling operation.

Table 26: Derrick Specifications

Derrick Construction:	Welded cold finished steel tubing.
Rated Working Capacity:	49,000 lbs. (22,226 kg) rating
Dimensions:	32 ft. long (9.8 m)
	36 inch wide (914 mm)
	28 inch depth (711 mm)
Maximum Working Clearance:	30 ft.-11.5 inches (9.4 m) from hoist line hook at top of derrick to table
Spindle Sub to Table:	The standard (32 ft.) derrick clearance is 23 ft.-3 inches (7.1 m)
Retract Channels:	Pneumatic foot pedal control at platform
Table:	Retractable table with swing out front

Spur Gear Rotary Head

The standard tophead drive (also called rotary head) is used to rotate the drill bit and to add and remove drill pipe from the drill string. The drill string is connected to the tophead and all rotation and feed pressure is exerted through the rotary head.

Four hydraulic motors power the tophead. The rotation pressure gauge, located on the control console, shows the amount of hydraulic pressure being applied to the tophead motors. Speeds varying from 0-160 RPM can be obtained using this tophead. The standard tophead drive has 2.5” (63.5 mm) swivel and air piping.

Drill Pipe Carousel

The drill pipe carousel is contained in the derrick in a fixed position and indexed in both directions from the console by a hydraulic motor.

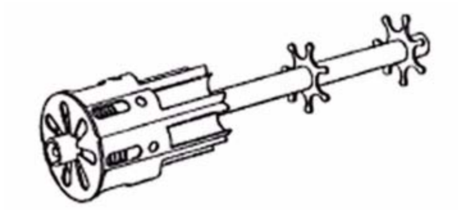


Table 27: Carousel Specifications

Location:	Fixed position inside derrick
Carousel Indexing:	Hydraulic, forward and reverse
Capacity:	Nine (9) 3.5” x 20’ (89mm x 6.1m) drill pipe
	Seven (7) 4.5” x 20’ (114mm x 6.1m) drill pipe
Function:	Positions drill pipe under the rotary head for drill pipe loading and unloading

Retract Table

The TH60 table is designed to open and retract to provide a clear working space for large casing and tools. The rear half of the drilling table retracts hydraulically while the front half swings away from either side of the table to accommodate up to 14” (355.6 mm) casing.

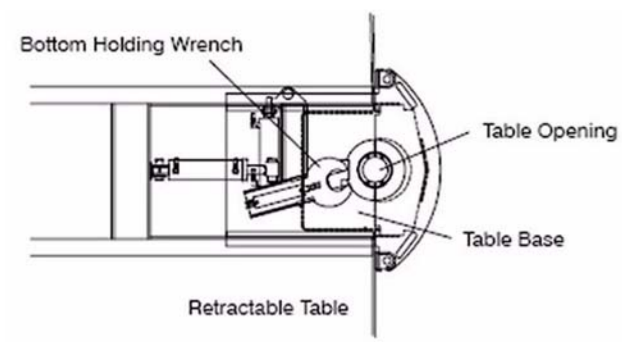


Table 28: Retract Table Specifications

Retract:	Hydraulic Cylinder: 3.5”x10”x1.75” (89mm x 254mm x 44.5mm)
Table Base:	Two half plates. Rear half retracts and front half is hinged to swing out 160° to enable handling of 14” (355.6 mm) casing.
Bottom Holding Wrench:	An air operated wrench fits either 3.5” (89mm) or 4.5” (114mm) drill pipe flats.

Pneumatic Breakout (Holding) Wrenches

Drill pipe breakout is accomplished by upper and lower air actuated holding wrenches, coupled with the rotation power of the rotary tophead. In addition, a hydraulic cylinder operates a self adjusting pipe wrench which develops up to 6250 ft/lbs. (8474 Nm) of breakout torque.

Feed System

The TH60 Water Well drill is powered by a single cylinder that raises and lowers the rotary tophead smoothly and positively by way of single cable for pulldown and pullback. The feed pressure gauge located on the operator's console shows the amount of hydraulic down pressure being exerted on the bit by the feed (cylinder) system.

Table 29: Feed Specifications

Feed System Specifications	
Mechanism Type:	Single Hydraulic Cylinder
Hydraulic Cylinders:	6 in. x 156 in. x 3 in. (164 mm x 3962 mm x 76 mm)
	6.5 in. x 156 in. x 3 in. (165mm x 3962 mm x 76 mm)
	6.5 in. x 180 in. x 3.5 in. (165mm x 4572mm x 89mm)
Pulldown:	30,000 lbs. (13,608 kg)
Pullback:	26,500 lbs. (12,020 kg)
Drill Feed Rate:	24 fpm (7.3 mpm) maximum
Fast Feed Rate Down:	220 fpm (67.1 mpm)
Fast Feed Rate Up:	125 fpm (38.1 mpm)
Function:	Raises and lowers the rotary tophead (drill string)

Hydraulic Drawworks

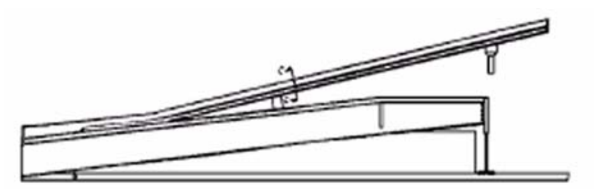
The hydraulic drawworks is pedestal mounted on the drill deck just behind the derrick. Controls for the drawworks are located on the control panel and helper's side drill deck.

A pivoting and telescoping jib boom is controlled hydraulically from the helper's platform. The swing is from the centerline of the borehole to a position over the pipe rack.

Table 30: Hydraulic Drawworks

Hydraulic Drawworks Specifications	
Type:	Hydraulic
Drum Size:	14.5 inches (368 mm)
Spooling Capacity:	436 ft. (132.9 m) of 5/8 in. rotation resistant cable
Speed Up/Down:	Variable, 0 to 130 fpm (39.6 mpm) first wrap.
Lifting Capacity:	18,000 lb. (8164 kg) single line, first wrap, bare drum
Jib Boom:	Swing and Extend

Drill Pipe Rack



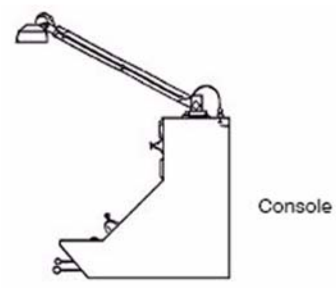
Tool Box

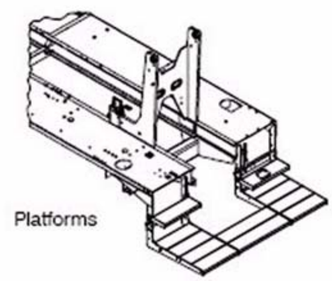
The tool box is mounted on the driller's side, behind the truck cab and below the deck. Construction is all steel with locking hatches.

Table 31: Tool Box Specifications

Width:	24 inches (610 mm) wide
Height:	58 inches (1473 mm) high
Depth:	26 inches (660 mm) deep

Operator’s Console





Drill operations are controlled from the control panel located at the right rear side of the drill. The operator and helper are provided with folding working platforms on each side of the table area. Three pneumatic foot pedals are mounted in the operator’s platform to operate retract gates, upper breakout (holding) wrench and full speed engine throttle. An aluminum platform option between the operator’s platform is available.

Sand Reel

The sand reel is used to handle large, heavy objects like casing, stabilizers, drill collars etc.

Table 32: Sand Reel Option

Sand Reel Specification	
Type:	Hydraulic powered (available with or without clutch)
Drum Size:	5-9/16 inch (141 mm) diameter
Drum Capacity:	1000 ft. (304.8 m) of 3/8 in. (9.5 mm) diameter cable
Line Speed Up/Down:	160 fpm (48.8 mpm) bare drum
	490 fpm (167.6 mpm) full drum
Bare Drum Line Pull:	2000 lb. (907 kg)

Injection Line Oiler Option

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. ***Note:*** *Follow actual manufacturer’s lubrication instructions when using DHD hammers.*

Table 33: DHD Lubricator Specifications

Type	Capacity	Flow Adjustment
Injection Line Oiler with Electric Pump	7 gallon (26.5 L) reservoir	Manually adjustable (4) four positions

Deephole Package Option

The Deephole Package is available on the 32 foot (9.8 m) derrick only.

Table 34: Deephole Package

Deephole Package Specifications	
Hydraulic Cylinder:	6.5” x 156” x 3” (165mm x 3962mm x 76mm)
Pulldown:	30,000 lb. (13,608 kg)
Pullback:	32,500 lb. (14,742 kg)

Extended Derrick

The extended derrick option gives you an additional 6 ft. (1829mm) of derrick length to handle longer casing or to add a casing hammer. A second set of retract gates allow the rotary head to be retracted at two different locations within the derrick.

Table 35: Extended Derrick Option

38 ft. (11.6 m) Casing Driver Derrick Option	
Maximum Pullback:	30,000 lbs. (13,608 kg)
Spindle Sub to Table:	29ft.-3 inches (8.9 m)

38 ft. (11.6 m) Dual Wall/Casing Hammer Derrick Option	
Minimum pullback:	30,000 lbs. (13,608 kg)

Water Injection

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.

Table 36: Water Injection Specifications

Type	Size	Capacity	Pressure	Foam
John Bean	9 GPM	0-9 gpm (0-34 L/min.)	550 PSI (3792 kPa) maximum	Optional foam injection pump available
Cat	12 GPM	0-12gpm (0-45 L/min.)		
John Bean	18 GPM	0-18 gpm (0-68 L/min.)		
Cat	25 GPM	0-25 gpm (0-95 L/min.)		

Mud Pump

Mud pump packages are available on the TH60 Waterwell drill. All Mud Pump packages are supplied with suction hose and foot valve/strainer.

Table 37: Mud Pump Specifications

Type:	Capacity:
3 x 4 Centrifugal. Mounted horizontally under driller’s console.	300 gpmt (1136 lpm) @ 145 psi (1000 kPa)
5 x 6 Piston. Mounted on deck between the hydraulic tank and compressor.	150 gpmt (568 lpm) @ 310 psi (2137 kPa)

Hub Odometer Option

The hub odometer attaches to a truck wheel hub and is used to record road miles.

Drill Pipe

Table 38: Drill Pipe Selection

Drill Pipe Specification		
Size:	Connections:	Flats:
3.5” (89 mm) OD x 20 ft. (6.1 m) long external flush: approx. 240 lb (109 kg).	2-3/8 inch (60 mm) IF box up/pin down connections.	2-3/4 inch (70 mm) wrench flats on box end of drill pipe
4.5” (114 mm) OD x 20 ft. (6.1 m) long external flush: approx. 345 lb (156 kg).	2-7/8 inch (73mm) IF box up/pin down connections.	3-1/5 inch (89 mm) wrench flats on box end of drill pipe

Standard Tools & Accessories

1. Hoist Plug for drill pipe
2. Drill pipe centralizer bushings
3. Breakout Wrench
4. Feed Cable Socket Wrench
5. Fire Extinguisher
6. Road Hazard Kit
7. Rod Handling Sling
8. Three CD ROM serial Parts manual and Safety, Operation and Maintenance manual; Three serial number paper Parts manuals and three paper Safety, Operation and Maintenance Manuals.

Weights and Dimensions

Table 39: Weight and Dimension Specifications

Dimensions and Weights for Shipping	
Width:	8 feet (2.4 m)
Length (Derrick down):	36 feet (11 m)
Height (Derrick down):	13 feet - 6 inches (4.1 m) depending on options
Height (Derrick up):	40 feet - 6 inches (12.3 m)
Derrick:	32 feet L x 36 inches W x 28 inches D
	(9.8 m L x 914 mm W x 711 mm D
Gross Weight (less drill pipe and mud pump):	66,000 lbs (29,937 kg) GVWR

Performance specifications are based on maximum computed values and are subject to revision without notification. Nothing in this manual is intended to extend any warranty or representation, expressed or implied, regarding the products described herein. Any such warranties or other terms and conditions shall be in accordance with Drilling Solutions standard terms and conditions of sale for such products, which are available upon request.

These machine specifications are those in effect at the time of this printing. However, Atlas Copco is constantly striving for product improvements and enhancements. Accordingly, the right is reserved to make such changes in specifications and design that the Company considers in conformity with this policy or are due to unavailability of materials or assemblies. Final confirmation of current specifications should be made by contacting Atlas Copco Drilling Solutions, Garland, Texas, USA.

Section 4 - Controls

Operating Controls

GENERAL INFORMATION

⚠ 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 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.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the tires 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting the engine, make sure all operator console controls are either in "OFF" or "NEUTRAL" positions and that the parking brake is applied.
9. 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.

TH60 INSTRUMENTS AND CONTROLS

Introduction

The instruments and controls section of this manual provides basic information about the operating controls, instruments and indicators located on the consoles and around the drill.

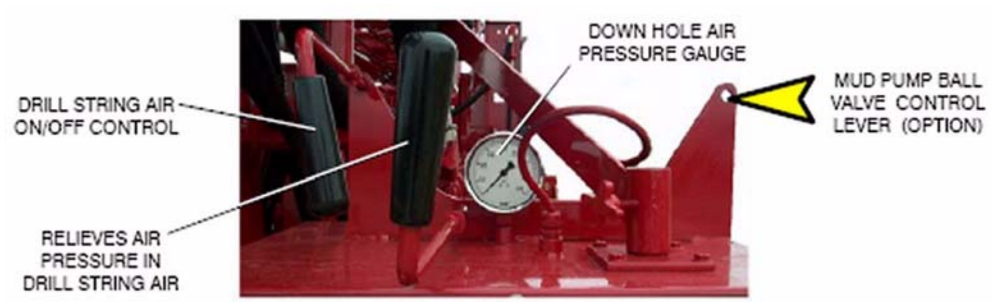
All drilling operations are controlled from the operator's console located at the right rear side of the rig. The slim profile and quick opening side panels provide easy access for maintenance and service.

TH60 Console

The following pages will describe the controls on the console.

TOP OF CONSOLE

The TH60 Water Well drill has control levers and a gauge on top of the operator's console.



Top of Console

Drill String Air On/Off Control

The left hand ball valve lever (sometimes called Drill Air Throttle) controls the air flow from the rotary screw compressor. The ball valve must be closed (pulled out) before starting the compressor. Push in (open) the ball valve lever after the compressor has built up air pressure to put air into and through the drill string.

Center Ball Valve Lever

When the drill is stopped, there is still air under pressure trapped in the drill string. The center ball valve lever is used to relieve air pressure in the drill string. Push in to close the ball valve. Pull out to open the ball valve.

Down Hole Air Pressure Gauge

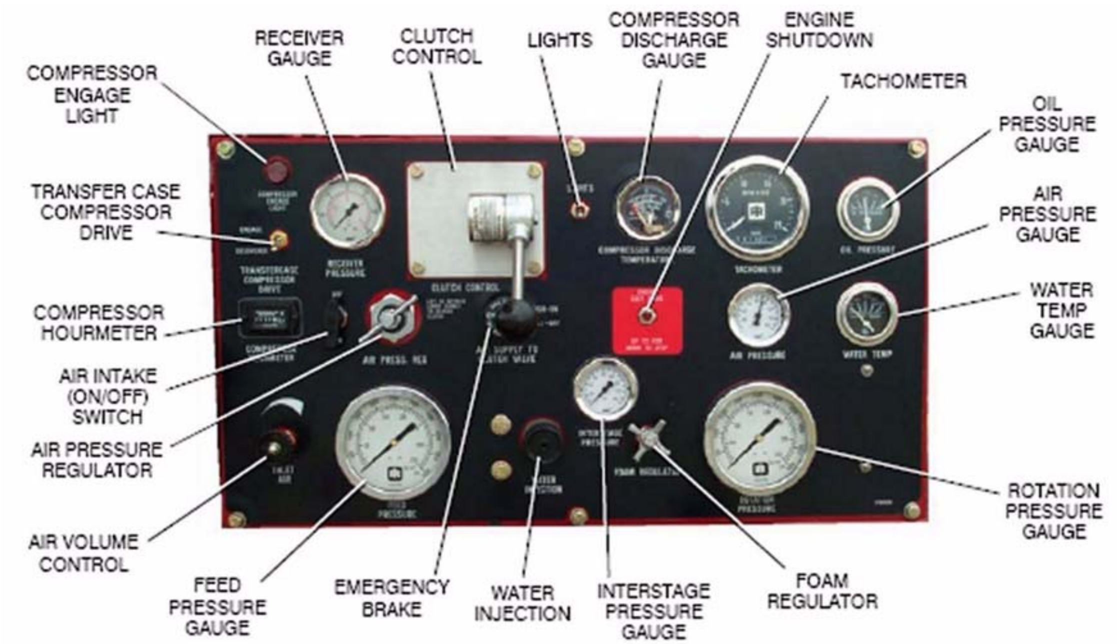
The Down Hole Air Pressure Gauge indicates down hole air pressure supplied to bit.

Mud Pump Ball Valve Lever (Option)

The mud pump ball valve controls the off/on mud flow from the standpipe to the drill bit. Push in to open the mud flow. Pull out to stop the mud flow. Note: Always shut off the mud pump before closing the mud pump ball valve.

UPPER CONSOLE

The controls on the upper operator's panel are identified below reading clockwise from the Compressor Engage Light.



Compressor Engage Light

When the Transfer Case Compressor Drive is engaged, the Compressor Engage Light will illuminate to notify the driller that the Transfer Case Compressor Drive is engaged.

Receiver Pressure Gauge

The Receiver Pressure Gauge (also called discharge pressure or bit air pressure gauge) shows the amount of pressure being discharged from the compressor and available to the drill bit on high pressure drills. Drill pressure depends on the size DHD (down hole drill) being used, drill bit size and the choke size inside the DHD.

This pressure is adjusted by turning the air pressure regulator control adjustment knob clockwise to increase and counterclockwise to decrease the compressor discharge air pressure.

NOTICE

Ensure that the pressure is adjusted to the type of downhole hammer being used.

Clutch Control

The Air Compressor Drive Clutch Control is the control for the air clutch to engage the rotary screw compressor drive shaft and the hydraulic drive. Lift the lever slowly to depress the clutch. Lower the lever slowly to release clutch.

Drill Lights

The drill lights control switch is an “ON/OFF” toggle switch that controls all the drill work lights, including the operator’s control panel light located above the control panel. Move the switch to the ON position to turn on all the lights and illuminate the working area.

Discharge Temperature Gauge

While compressing air, heat is formed. Oil is pumped into the air end to cool this air. The Discharge Temperature Gauge (sometimes called the air receiver temperature gauge) shows the temperature of the oil and air leaving the air end. Normal operating temperatures are 180° to 220°F (82° to 104°C). This gauge also contains a switch that will stop the engine if the oil temperature in the compressor exceeds 248°F (120°C).

Engine Shut Down Switch

Pushing the Engine Shut Down Switch down shuts off power to the fuel valve which stops fuel flow and shuts the engine down. The Shut Down Switch must be pushed up for the engine to start and run. Turning the key switch in the truck cab does the same thing. All engines are “energized to run”, which means the fuel system must be energized in order to pump fuel.

Engine Tachometer

The Tachometer/Elapsed Hour Meter gauge 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 25.

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.

Since engine speed controls pump speed, it is important to maintain certain rpm speeds when performing various functions.

Engine Oil Pressure Gauge

The Engine Oil Pressure Gauge shows the pressure that is required to circulate oil inside the engine. This gauge should not read less than 10 psi on LOW idle nor less than 27 psi on HIGH idle.

NOTICE

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 that 27 psi on HIGH idle; otherwise the engine could be severely damaged. Check the oil level according to the instructions provided in the Maintenance Instructions.

Air Pressure Gauge

The Air Pressure Gauge measures the amount of the truck engine compressor air received at the console. All of the air controlled functions operate from the truck engine compressor. The air pressure gauge should read between 120-125 psi. (8-8.6 bar). ***Note:*** The console air valves will not operate when air pressure drops below 65-70 psi. (4.5-4.8 bar).

Water Temperature Gauge

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

Rotation Pressure Gauge

The Rotation Pressure Gauge shows the amount of hydraulic pressure being applied to the rotary head motors. It corresponds to the amount of torque developed by the rotary head during operation.

It is used in conjunction with the feed rotation pressure control to obtain the best penetration rate.

Foam Control Option

The Foam Control is used to adjust the amount of drill foam added to the water injection flow. Foam volume is increased by turning the control to the left. Foam volume is decreased by turning the control to the right.

Interstage Pressure Gauge

High pressure compressors use two stages to obtain the 350 psi discharge pressure. Interstage pressure is the pressure developed by the first stage as it goes to the second stage.

The Compressor Interstage Gauge shows the pressure between the first and second stages of the air end when the compressor is working. It normally operates between 80 to 120 psi. (5.52 to 8.16 bar).

Water Injection Flow Control (Option)

The Water Injection Flow Control 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.

Emergency Brake

The Emergency Brake air supply is also the air supply to the clutch valve. When the air supply is transferred from the truck cab to the operator's console, the emergency brake automatically pops out. The emergency brake button must be pushed IN to enable air flow to the Clutch Control to operate the compressor (and hydraulic drive).

Feed Pressure Gauge

The Feed Pressure Gauge (sometimes called pulldown pressure) shows the amount of hydraulic down pressure being exerted on the bit by the feed (cylinder) system. Increase or decrease the pulldown pressure in the feed cylinder with the Feed Pressure Regulator. ***Note:*** Adjustments with the Feed Pressure Regulator (also called pulldown regulator) have a direct affect on the readings of both the Feed Pressure Gauge and the Rotation Pressure Gauge.

⚠ WARNING

Do not exceed 1500 psi (103.4 bar) on the Feed Pressure Gauge. There is sufficient overpressure to raise the TH60 off the leveling jacks. Stay Alert

Air Volume Control

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 was added. It consists of a needle valve that can be opened to allow a certain volume of air into the power chamber of the UL88 regulator to assist in modulating the UL88. It should be closed tight for full volume.

The compressor Air Volume Control 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.

Air Pressure Regulator

The Air Pressure (air intake) Regulator is used primarily when hammer drilling to increase air pressure down in the hole when it is needed. Discharge pressure to the receiver tank is set by the Air Pressure Regulator Valve mounted on the control console. It can be increased or decreased as the situation demands from 140 psi (9.66 bar) to 375 psi (25.9 bar). 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.

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 receiver pressure gauge while adjusting pressure.

NOTICE

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.

Compressor On/Off Switch

The Air Compressor On/Off Switch is used to control the UL--88 regulator which regulates the compressor air inlet (butterfly) valve. With the switch in ON position, the air inlet opens to atmosphere, allowing the rotary screw compressor to build air.With the switch in OFF position, the air inlet valve closes and prevents atmosphere air flow into the rotary screw compressor. The Compressor will unload at about 125 to 140 psi (8.63 to 9.66 bar) after the engine starts. The operator uses the compressor ON/OFF switch to build air to go down the hole.

Compressor Hourmeter

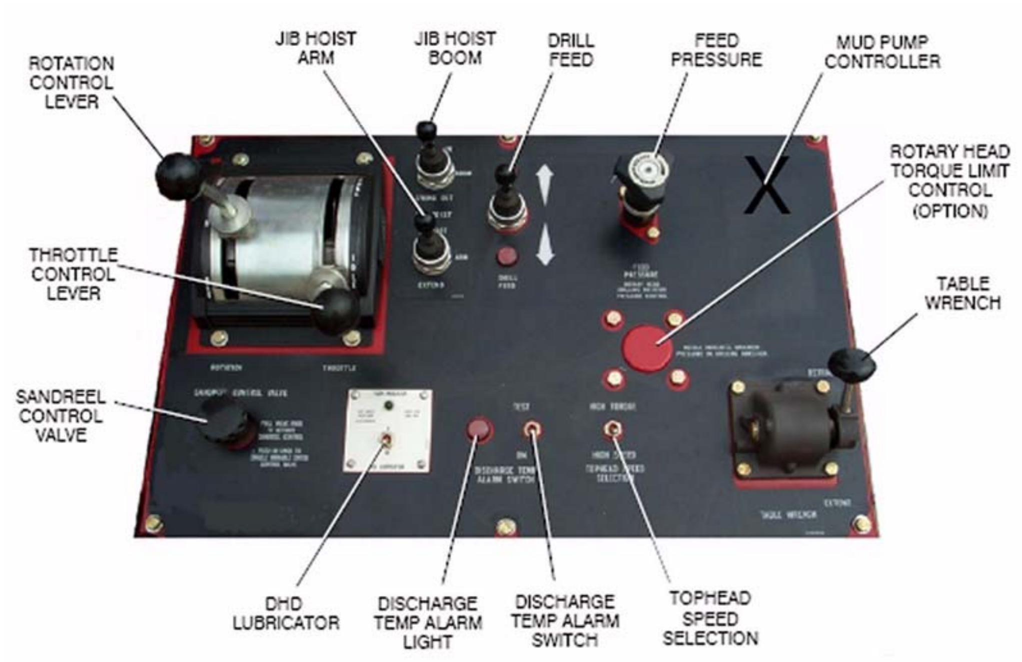
The Compressor Hourmeter is located on the upper console. The Compressor Hourmeter records and displays the number of hours the compressor has run and is used for preventive maintenance purposes.

Transfer Case Drive Engage

The Transfer Case Drive Engage and Disengage switch is used to engage the driveshaft from the transfer case to the screw compressor. When the air compressor drive shaft is engaged, the Compressor Engage Light will light up.

MIDDLE CONSOLE

The Middle Console contains the controls for the feed and rotation of the tophead as well as controls for most options. The controls on the middle operator's panel are identified below reading clockwise from the Rotation Control Lever.



Rotation Control

The Rotation Control controls the direction and speed of the drill pipe rotation. To rotate the drill pipe in either the clockwise or counterclockwise direction, gradually move the control lever in the required direction and speed of rotation will progressively increase. To stop rotation, move the control lever into the center position.

Jib Hoist Arm Extend

The Jib Extend Control extends and retracts the jib boom arm.

Jib Boom Swing

The Jib Boom Swing Control moves the jib boom to the side and back to aid in loading drill rod.

Drill Feed Selector

The Drill Feed Selector is used to engage pulldown and pullback modes while drilling. A red light indicates the selected mode. Push the lever away from operator for pullback mode. Pull the lever toward the operator for pulldown mode.

Feed Pressure Control

The Drill Feed Pressure Control Valve controls the pressure to the feed cylinder while doing actual drilling.

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

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

Mud Pump Controller (Option)

The Mud Pump Controller Option is used to increase or decrease mud pump flow. Push lever away to increase mud pump volume. Pull lever forward to decrease mud pump volume. The lever remains in the position that it is moved to.

Torque Limit Control (Option)

The Torque Limit Control knob and gauge controls the amount of pressure being applied to the rotary head rotation motors. It can be adjusted to aid in connecting steel threaded casing or to limit torque on the bit during difficult drilling conditions.

Rotation Pressure is increased by turning the control to the right. Rotation Pressure is decreased by turning the control to the left.

Table Wrench Control

The Table Wrench Controller is used to retract or extend the table wrench and to hold the drill string in the table. Retract the wrench by pushing the lever away from the operator. Extend the wrench by pulling the lever toward the operator.

Tophead Speed Selection (Option)

The High Speed High Torque Switch changes the flow from all four motors (High torque) to three motors (High speed) to provide higher rotation speed or the highest torque.

Discharge Temperature Alarm Switch

The Discharge Temp Alarm Switch is used to test the discharge temperature alarm to make sure it is operational. The Discharge Temperature Alarm consists of a red warning light and an alarm bell.

DHD Lubricator

The DHD Lubricator Switch is an “ON/OFF” switch for the DHD lubrication system. The DHD Lubricator Indicator Light will illuminate to confirm that the lubrication system is in service.

Sand Reel Control Valve

The Sand Reel Control Valve has two purposes. With the control pulled out, the sand reel cable moves up and down at a steady rate of travel using the Sand Reel controller. With the control pushed in, the cable is in free fall mode and the Sand Reel Clutch/Brake must be used to control the free fall.

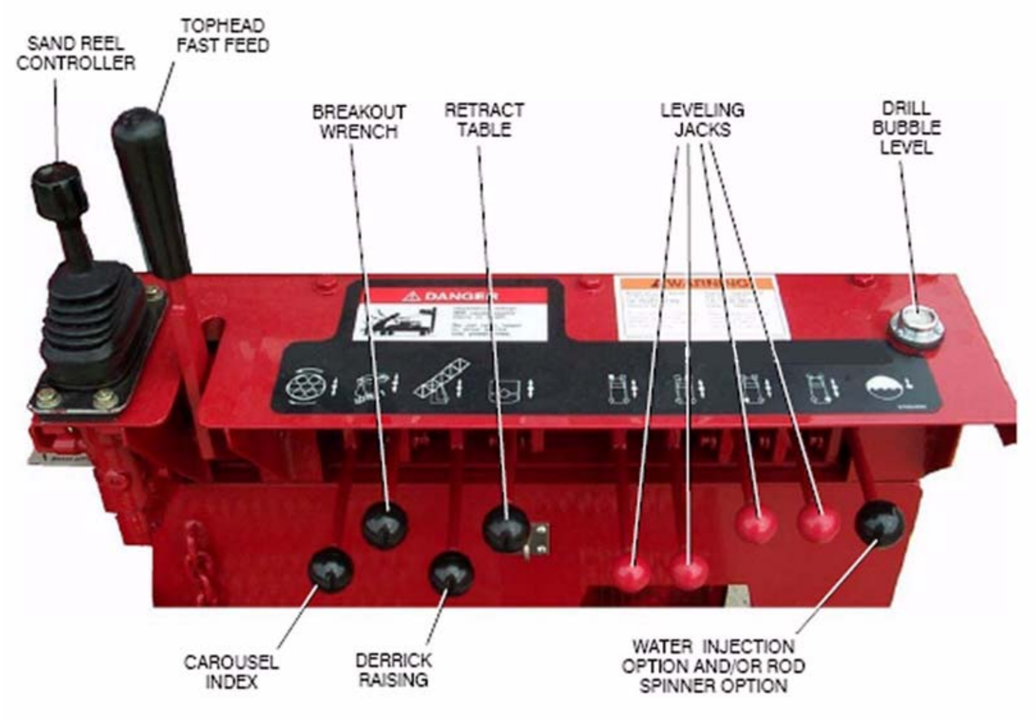
Hand Throttle Control

The Throttle Control regulates the speed (RPM) of the engine. In road driving mode, the engine has an idle speed of 600 rpm and a full throttle of 1800 rpm. In drilling mode, the engine should have an idle speed of 850 rpm. The engine should always be run at low idle for 5 minutes before shutdown.

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

LOWER CONSOLE

The Lower Console Controls functions are from left to right: Sand Reel Control, Tophead Fast Feed Control, Carousel Index Control, Breakout Wrench Control, Derrick Raising Control, Retract Table Control, Leveling Jack Controls, Water Injection Control, and the Drill Bubble Level.



Sand Reel Control (Option)

The Sand Reel Hoist Control is used to raise and lower sand reel hoist. Raise the hoist cable by pushing the control lever. Lower the hoist cable by pulling the control.

Fast Feed Control

The Fast Feed Control is used to raise and lower the rotary tophead by directing the hydraulic oil flow from the fast feed pump to the feed cylinder.

Fast feed is used to move the tophead up and down quickly during non-drilling functions, such as adding or removing drill pipe. It is not used for actual drilling. Drilling is done with the drill feed circuit.

NOTICE

Fast Feed is used for non-drilling functions only.

Carousel Index

The Carousel Index controls the rotation of the carousel to move drill rod under the drill string when drill pipe needs to be added to the string. Also the carousel can be indexed to load drill pipe onto the carousel when pulling pipe out of the hole.

Raise the control for Counterclockwise rotation. Lower the control for Clockwise rotation.

Breakout Wrench Control

The Breakout Wrench is used for removing drill pipe from the rotary tophead and/or other drill pipe at the table. Raise the control to unscrew pipe. Lower the control to reset wrench.

Derrick Raising Control

The Derrick Raising Control is used to raise and lower derrick. Raise the derrick by pulling the control up. Lower the derrick by pushing the control down.

NOTICE: Feather the Derrick Raising Control handle when derrick approaches vertical position. Do not slam derrick against stops.

Retract Table Control

The Retract Table Control is used to retract the table to allow bushings to be changed or to install large casing. Retract the table by lifting the control and Close the table by lowering control.

Leveling Jacks Controls

The Jack Controls control the two drilling end jacks and the two non-drilling end jacks. These handles are used in conjunction with the bubble level on the console to level the drill. Raise the jacks by lowering the control handles. Lower the jacks by lifting the control handles. Lift and lower the jacks a little at a time to keep the drill as level as possible at all times.

Water Injection Control (Option)

The Water Injection Control is used to activate/deactivate the water injection pump. Activate the water injection pump by lifting the control lever. Deactivate the water injection pump by lowering the control lever to the neutral position.

NOTICE: As the Water Injection will only use one side of the valve, another hydraulically driven option may be used by the same control valve. Be aware that lifting the control handle away from the neutral position will activate the Water Injection and lowering the control handle away from the neutral position will activate the added hydraulically driven option.

Rod Spinner Control (Option)

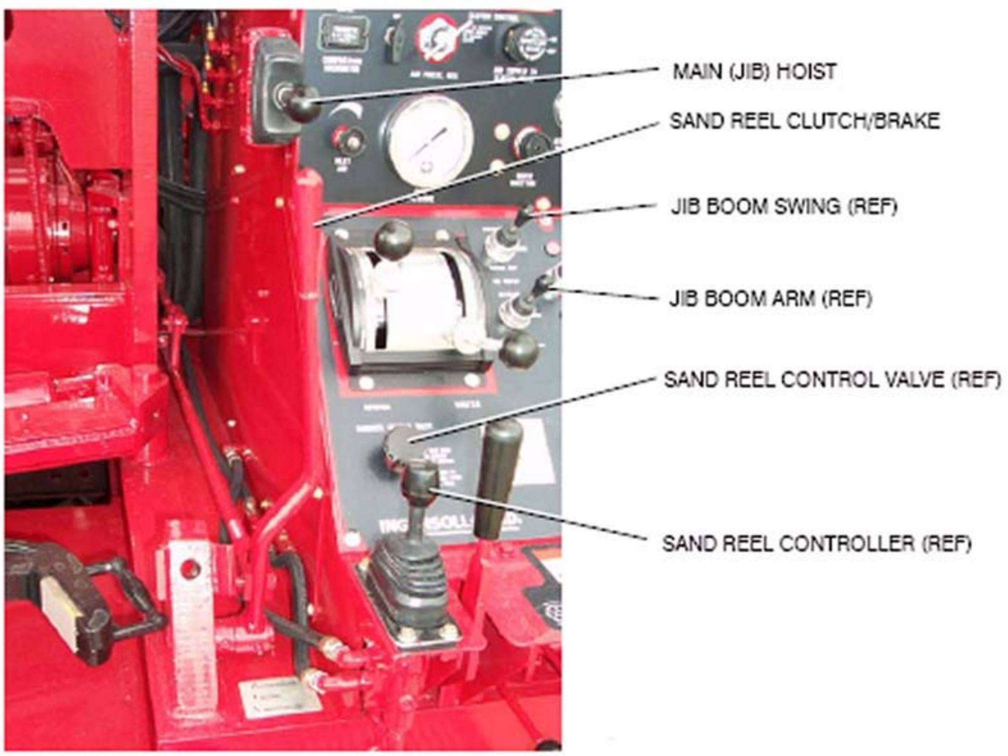
The Rod Spinner (option) is used to attach or detach drill pipe to or from the drill string. The Rod Spinner Control must be pushed down (away from the neutral position) to turn on the Rod Spinner. Raise the control to the neutral position to turn off the Rod Spinner.

Drill Bubble Level

The Drill Bubble Level gauge is used when leveling the drill in both directions. The derrick is designed to be vertical when the bubble is centered. The bubble must be centered before drilling begins.

SIDE OF CONSOLE

The Main (Jib) Hoist and Sand Reel Controls are located on the side of the operator's console.



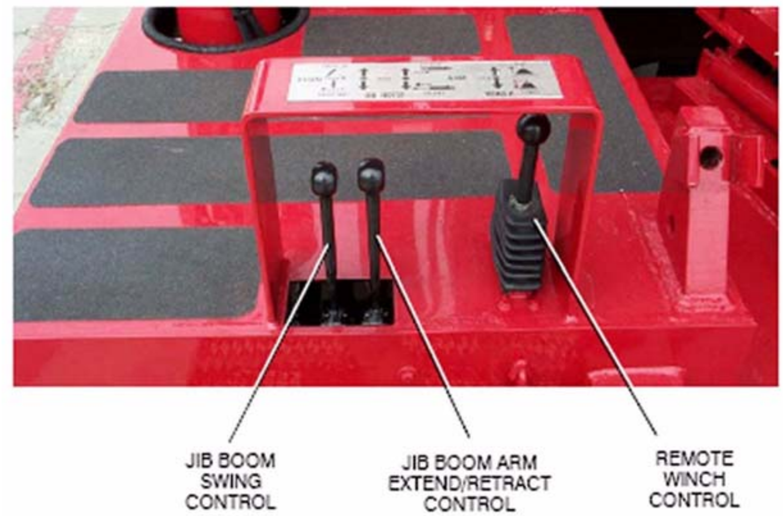
Main (Jib) Hoist Controller

The Main (Jib) Hoist Controller is used to raise and lower the hoist cable. Raise the cable by lifting the lever up. Lower the cable by pulling the lever down. A Remote Winch Control is also located on the helper's side and will be discussed later.

Sand Reel Clutch/Brake Lever

The Sand Reel Clutch Lever must be moved forward (away from the operator) to operate the sandreel. The clutch lever pulled towards the operator stops the sandreel by disengaging the clutch and also acts as a brake for the sandreel.

HELPER’S CONTROLS



Jib Boom Swing Control

The Jib Boom Swing Control is used to swing the jib boom, mounted on top of derrick, from side to front for adding and removing drill pipe. Push the control away to move the boom. Pull the control forward to move the boom.

Jib Boom Extend and Retract Control

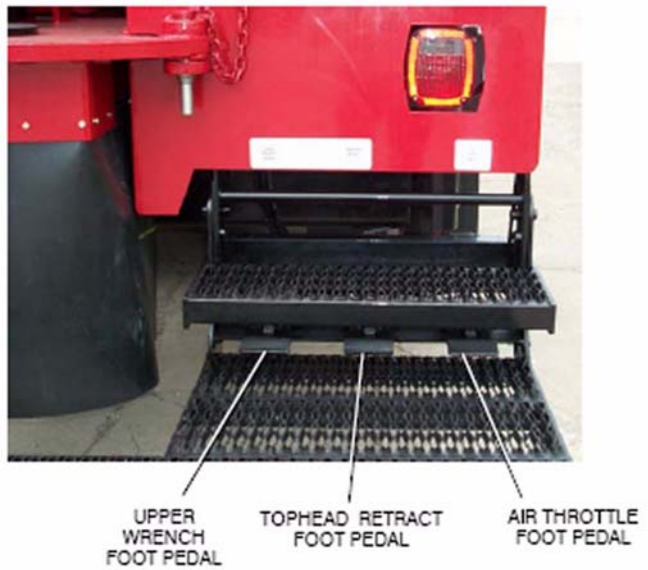
The Jib Boom Extend/Retract Control is used to extend/retract Jib Boom for adding and removing drill pipe. Push the control away to extend the jib boom in. Pull the control forward to retract the jib boom out.

Remote Jib Winch (Hoist) Control

The Jib Hoist Control controls the hoist’s direction and speed when raising or lowering the cable that picks up the drill pipe during loading into or unloading from the carousel and when handling DHD’s. 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. A spring applied brake will automatically apply when the control is released in the STOP position.

UNDER CONSOLE

Below the console are three foot controls. The left foot control is the Upper Wrench Foot Pedal. The center foot control is the Rotary Head Retract Foot Pedal. The right foot control is the foot operated Air Throttle Pedal. These under console controls are shown below.



Upper Wrench Foot Pedal

The foot operated Upper Wrench Foot Pedal controls the air operated top holding wrench (on the top plate above the carousel). Stepping on the foot pedal (out position) moves the top holding wrench out and onto the drill rod flats when breaking a joint between the tophead spindle and the drill pipe. Releasing the left foot pedal disengages the wrench.

Tophead Retract Foot Pedal

The foot operated Tophead Drive Retract Pedal opens the retract gates on the derrick retract channels when bringing the tophead into retract position. The Tophead Retract Foot Pedal is used to assist in loading/unloading of drill pipe. Springs return the gates to their normal position when the pedal is released. Depressing the center foot pedal opens the gates to allow loading/unloading of drill pipe. The Tophead must be raised into the retracted position. Releasing the center foot pedal returns gates to normal position. ***Note:*** The Tophead is also retracted when loading casing into well, and for transport.

Foot Operated Air Throttle Pedal

The Foot Operated Air Throttle Pedal can be used to give a quick boost to engine rpm. ***Note:*** Boosting the engine rpm ALSO boosts the pump speeds.

AUXILIARY CONTROLS AND INDICATORS

The following controls, instruments and gauges are not located on the control console. They are located at various places on the drill. Auxiliary Controls are not used to do actual drilling, but are needed to perform functions that aid in the drilling procedures.

Service Pressure Regulator

A pressure regulator and a ball valve are connected to the main air discharge pipe 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.

NOTICE: Do not operate the service air pressure at normal discharge pressure, since most air tools are rated for no more than 100 psi.

Manual Blowdown Valve

The Manual Blowdown Valve is a ball valve used to empty pressurized air from the receiver tank.

When fluid is added to the receiver or when the separator element must be changed, the air pressure inside the receiver tank must be relieved.

⚠ WARNING

Pressurized air will escape when the manual blowdown valve is opened. DO NOT allow any part of body under opening as air escapes. Wear safety glasses when relieving the air.

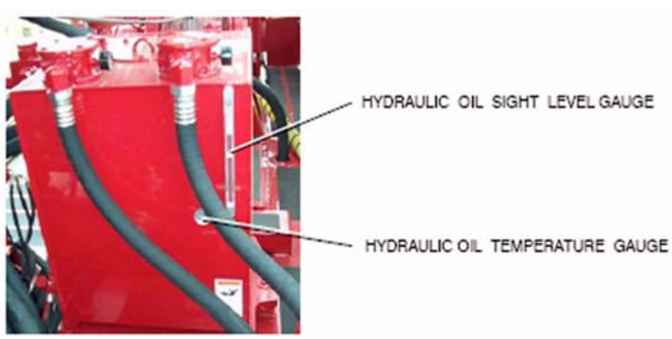
Receiver Tank Oil Level Gauge

The receiver tank 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. The sight 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.

Hydraulic Oil Level Gauge

The Hydraulic Oil Level Gauge is located on the face of the hydraulic tank. The hydraulic oil level should be monitored with the hydraulic oil level gauge and the level maintained at the proper level. Failure to maintain this level will result in the malfunction of the hydraulic system, overheating of circuit components and the destruction of hydraulic pumps and motors.



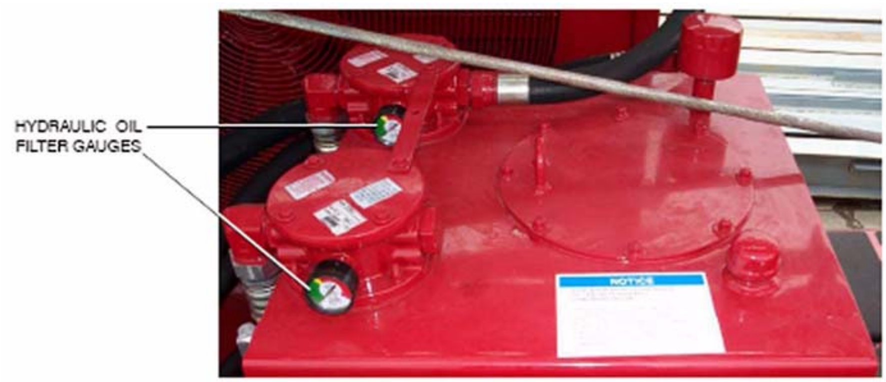
Hydraulic Oil Temperature Gauge

The Hydraulic Oil Temperature Gauge is located on the face of the hydraulic tank and indicates the operating hydraulic oil temperature.

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

Hydraulic Oil Filter Gauges

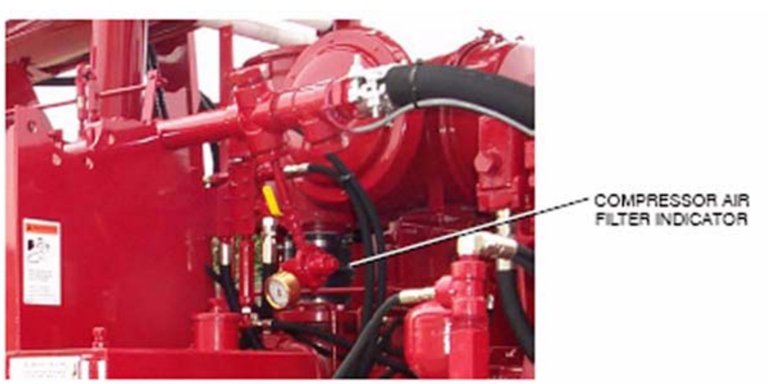
The in-tank hydraulic oil filters have a sight glass indicator located in the head of the filter.



The filter element should be replaced when the top half of the sight glass shows red.

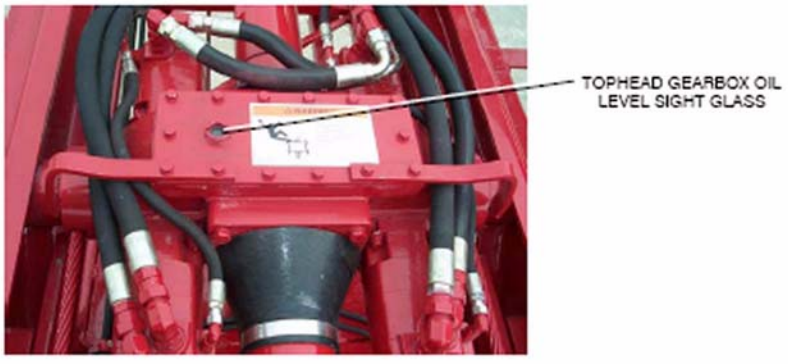
Compressor Air Filter Indicator

The Air Filter Indicator measures the restriction of the air cleaner and alerts the operator when filter replacement is required.



Rotary Tophead Gearbox

The Tophead Drive Gearbox lube level should be checked daily. When the derrick is raised (vertical position), the lube level should be halfway on the sight gauge in the front gearbox cover.



CAB INSTRUMENTS AND CONTROLS

The following explains the location of the various features on your vehicle and describes their function. For information on using these features in driving, see the paragraphs that follow. Each truck is custom built, therefore your instrument panel may not look exactly like the one in the pictures that follow.

Left Side of Truck Dashboard

The controls on the left side of the truck dashboard are identified below. The drawing under the photograph identifies the gauges and controls. ***Note:*** Location of controls and gauges may vary from layout shown below.

Note: Typical Panel Shown. Your Panel may not look exactly like the one shown.

Engine Oil Pressure Gauge

It is important to maintain oil pressure within acceptable limits. Your engine manual will give normal operating pressures for your engine.

⚠ CAUTION

Continuing to operate your engine with insufficient oil pressure will cause serious engine damage.

1. If your oil pressure fails to rise within 10 seconds after your engine starts, stop the engine and determine the cause.
2. If your oil pressure suddenly drops while you are driving, bring the vehicle to a stop as soon as possible in a safe location off the road and turn off the engine.Wait a few minutes to allow oil to drain into the oil pan and then check the oil level. Add oil if necessary. If the problem persists, contact an authorized service center.

Check the engine manufacturer’s manual for the correct oil pressure ranges for your engine.

The Engine Oil Pressure Gauge shows the pressure that is required to circulate oil inside the engine. This gauge should not read less than 10 psi on LOW idle nor less than 27 psi on HIGH idle.

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 that 27 psi on HIGH idle; otherwise the engine could be severely damaged. Check the oil level according to the instructions provided in the Maintenance Instructions. Refer to engine diagnostics section for checking engine problems in the Trouble Shooting section.

Engine Water Temperature Gauge

The water temperature gauge shows the temperature of the engine coolant. Under normal operating conditions the water temperature gauge should register between 165°F and 205°F (74°C and 90°C). Under certain conditions, somewhat higher temperatures may be acceptable. But the maximum allowable temperature is 210°F (99°C) with the cooling system pressurized, except for certain special engines. Check your engine manual to be sure.

⚠ WARNING

Do not remove the radiator fill cap while the engine is hot. Scalding steam and fluid under pressure may escape and cause serious personal injuries. You could be badly burned.

1. Wait until the coolant temperature is below 122°F (50°C).
2. Protect face, hands and arms by covering the cap with a large, thick rag to protect against escaping fluid and steam.
3. Carefully and slowly turn the cap one-quarter (1/4) of a turn or until it reaches the first stop. Allow excess pressure to escape. Push down and turn for final removal.

The cooling system may overheat if the coolant level is below normal or if there is a sudden loss of coolant (such as a hose splitting). It may also temporarily overheat during severe operating conditions such as climbing a long hill on a hot day or stopping after high speed driving.

If the “Engine Coolant Temperature” warning light comes on, or you have any other reason to suspect the engine may be overheating:

1. Stop the vehicle, but DON’T TURN OFF THE ENGINE unless a low water warning device indicates a loss of coolant.
2. With the transmission in neutral, check to be certain the oil pressure gauge reads normal. Increase the engine speed to about 1100-1200 RPM maximum. Return the idle speed to normal after 2 or 3 minutes. If the warning light doesn’t go off or the temperature gauge doesn’t begin to drop, then turn the engine off.
3. If the overheating came from severe operating conditions, the temperature should have cooled by this time. If it has not, stop the engine and let it cool before checking to see if the coolant is low.

Voltmeter

The voltmeter displays the voltage at which the batteries are being charged while the engine is running.

Fuel Gauge

⚠ WARNING

Do not remove a fuel tank cap near an open flame. Hot fuel vapors are combustible and can cause an explosion or fire resulting in injury or death.

The fuel gauge shows the approximate amount of fuel in the fuel tanks. Besides empty and full, the gauge also indicates 1/4, 1/2, 3/4 of total capacity. Keep the fuel tanks at least half full to reduce condensation of moisture in the tanks. This moisture can damage the engine.

⚠ WARNING

Carrying additional fuel containers in the vehicle is dangerous. Full or empty, they may leak, explode and cause or feed a fire. Don't carry extra fuel containers, even empty ones.

Primary & Secondary Air Pressure Gauges

The air reservoir primary and secondary air pressure gauges indicate the amount of air pressure in the brake system in pounds per square inch (psi).

1. The Primary gauge shows front reservoir air pressure.
2. The Secondary gauge shows the pressure in the rear reservoir.

Ensure the air pressure registers more than 100 psi (689.5 kPa) in both service systems before you move the vehicle. If the pressure in either or both circuits is too low for normal brake operation (the pointer of one gauge is in the red sector), a warning light in the panel will glow and the audible alarm will sound.

⚠ WARNING

The air pressure warning light and the audible alarm indicate a dangerous situation. There is not enough air pressure in the reservoirs for repeated braking and the brake system has failed. If air pressure falls below 60 psi (414 kPa) the spring brakes could suddenly apply, causing a wheel lockup, loss of control or your vehicle to be overtaken by following vehicles. You could be in an accident and severely injured. If these alarms come on while you are driving, bring the vehicle to a stop right away. If the light and alarm do not turn off at startup, do not try to drive the vehicle until the problem is found and fixed.

Tachometer

The tachometer measures the engine speed in revolutions-per-minute (RPM). The tachometer also includes an engine hour meter and outside air temperature display.

Watching the tachometer is important to driving efficiently. It will let you match driving speed and gear selection to the operating range of your engine. If your engine speed gets too high, you can select a higher gear to lower the RPM. If your engine speed drops too low, you can select a lower gear to raise the RPM.

Engine Hours / Outside Air Temperature

The LCD display in the lower part of the tachometer contains the engine hour meter and the outside air temperature display.

The engine hour meter will display the total number of hours the engine has been running. The maximum hours that can be shown are “99999.9” before the meter rolls over to zero.

The outside air temperature (OAT) will display the temperature outside the vehicle. The temperature can be displayed from -40°F to 158°F in Fahrenheit or -40°C to 70°C Celsius. The display will also alert the driver when the outside temperature approaches freezing (32°F or 0°C) by displaying a snowflake symbol. The symbol will turn on when the temperature drops below 34°F (11°C) and flash for the first 3 seconds, then stay on until the temperature goes above 37°F (28°C).

The OAT’s scale units (Fahrenheit or Celsius) can be changed by pressing the trip reset button on the speedometer 4 times in less than 4 seconds.

Notes:

1. The OAT display will come on when the door is open and the key switch is in the accessory or ignition position. The OAT display will turn off when the ignition switch is turned off.
2. The OAT display uses a sensor (located at the bottom of the driver’s side mirror assembly) to measure outside air temperature only. It is not capable of displaying the temperature of the road surface on either the temperature display or the snowflake icon.

Speedometer

The speedometer indicates the vehicle’s speed in miles per hour (mph) and in kilometers per hour (km/h). The speedometer also includes an odometer, trip meter and trip reset button.

Odometer / Trip Meter

The LCD display in the lower part of the speedometer contains the odometer and trip meter.

The odometer displays the total distance your vehicle has traveled. It will display in miles on an English speedometer or in kilometers on a metric speedometer. The maximum distance that can be shown on the odometer is “1 999 999” before it rolls over to zero.

The trip odometer displays how far the vehicle has gone on a particular trip. The trip odometer will display in miles on an English speedometer or in kilometers on a metric speedometer, in one tenth divisions. The maximum distance that can be shown on the trip odometer is “9999.9” before it rolls over to zero.

To reset the trip odometer, press and hold the trip reset button on the speedometer. The numbers will reset to **0** and begin to count new miles/km traveled.

The trip reset button also toggles outside air temperature (OAT) scale units that are shown in the tachometer LCD display.

Note: *The Odometer / Trip Meter comes on when the door is opened and the key switch is in the accessory or ignition position. The Odometer / Trip Meter will remain on for 3 seconds after the door is closed or the ignition is turned off. This allows driver and service personnel to read the odometer without ignition switch being turned on.*

Standard Warning Lights and Buzzers

The warning lights and buzzer may indicate something is wrong with one of the vital systems on the vehicle. Check the lights frequently, and respond properly as soon as you see one go on. These lights could save you from a serious accident.

⚠ WARNING

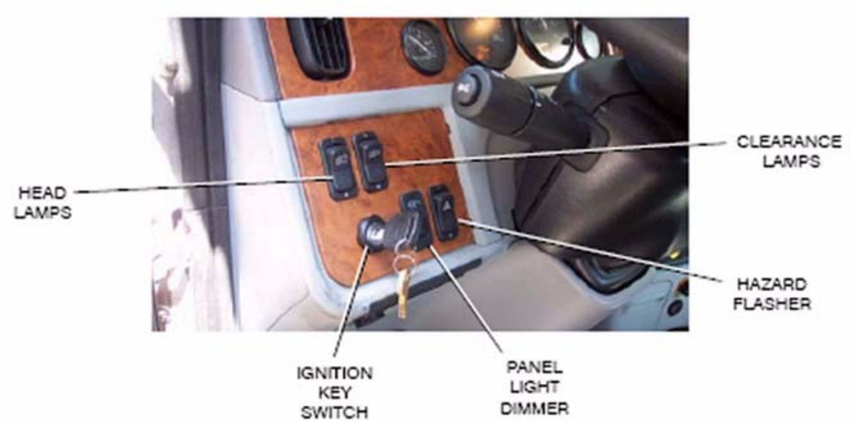
Ignoring a warning light or buzzer could lead to an accident. These signals tell you something is wrong with the vehicle. It could be a failure in an important system, such as the brakes. Never ignore a warning signal. Have the appropriate system checked right away.

When you turn on the ignition, the following will turn on for 3 to 5 seconds, as a test to let you know they are working.

Buzzer

The warning buzzer sounds to let you know some of the systems are working.

Lower Left Side of Truck Dashboard



Headlamps

The headlights are controlled by the control panel switch. When the headlights are ON, the dash lights, side and tail lamps are also on.

⚠ WARNING

Do not use daytime running lights (DRL) during periods of darkness or reduced visibility. Do not use DRL as a substitute for headlamps or other lights during operations that require lighting of your vehicle. Doing so could lead to an injury accident.

⚠ CAUTION

On vehicles equipped with daytime running lights (DRL), the high beam headlights go on automatically at reduced brightness if the engine is running and the headlamp switch is turned off. The daytime running lights are turned off automatically while the parking brake is engaged. If the headlamp switch is turned on, the DRL system is overridden and headlamps operate normally.

ID and Clearance Light Switch

These are the amber lights on top of the cab, the lights on the front and sides of the truck and the red lights on the rear of the truck. They are controlled by the control panel switch labelled CL LPS.

Ignition Switch

The ignition switch has four positions:

1. ACC (Accessory): With the key in this position you can play the radio or use other accessories, but the engine won't start.
2. OFF: In this position all systems are off and you can remove the key.
3. IGN & ACC: This position allows you to turn on the engine and all accessory power.
4. START: Starter activation to start engine.

Keys and Locks

The same key fits the ignition and doors. Frame mounted tool box locks and locking fuel tank caps each have individual keys.

Panel Light Dimmer

The Panel Light Dimmer lets you vary the brightness of your instrument panel lights.

Hazard Flasher

The four-way Emergency Flasher switch is located to the right of the ignition switch. With the switch in the ON position, the emergency flasher makes all four turn signals (front and rear) flash simultaneously. The flasher works independently of the ignition switch. Always use the flasher if the vehicle is disabled or parked under emergency conditions.

⚠ WARNING

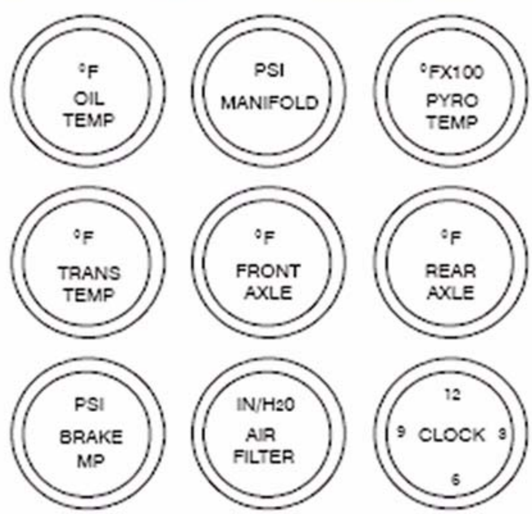
Use the Hazard Flasher Warning System any time you have to stop off the road or on the side of the road, day or night. A hard- to- see vehicle can result in an injury accident. Another vehicle could run into you if you do not set the flashers. Always move the vehicle a safe distance off the road when stalled or stopped for repairs. A disabled vehicle can be dangerous for you and others. The hot exhaust system could ignite dry grass, spilled fuel or other substances. Do not park or operate the vehicle where exhaust system could contact dry grass, brush, spilled fuel or any other material that could cause a fire.

Dome Light

The dome light (not shown) is operated by gently pushing on the lens until a click is heard. The same action turns the light on or off, depending on its previous state.

Right Side of Truck Dashboard

The gauges and controls on the right side of the truck dashboard are identified below. The drawing under the photograph identifies the gauges. ***Note:*** Location of controls and gauges may vary from layout shown below.



Engine Oil Temperature Gauge

The Engine Oil Temperature gauge monitors lubricating oil temperature for the engine.

Manifold Pressure Gauge

The Manifold Pressure gauge indicates the power the engine is putting out by showing the amount of turbo boost. If the pressure indicated by the manifold pressure gauge goes down, there may be something wrong with the engine. Have it checked by a qualified service person.

Pyrometer

The Pyrometer gauge indicates engine exhaust gas temperature. Since it responds almost immediately to changes in exhaust gas temperature, the pyrometer is an excellent indicator of engine output. Monitor it in conjunction with the tachometer and manifold pressure gauge. The pyrometer can be a useful aid to operating the truck more efficiently and avoiding sudden changes in engine operating temperature. See the engine owner's manual for maximum temperature recommendations.

Transmission Temperature Gauge

The Transmission Temperature gauge indicates the temperature of the oil in the transmission. Watch this gauge to know when the transmission is overheating. If it is, have it checked by an authorized service representative. Maximum transmission temperature may vary, depending upon the transmission and type of lubricant. Check the transmission's owner's manual.

Forward/Rear Drive Axle Temperature Gauge

These gauges indicate the temperature of the lubricant in the vehicle's axle(s). These temperatures will vary with the kind of load and driving conditions encountered. Maximum axle temperature may vary, depending upon the axle and type of lubricant. Very high temperatures signal a need to have the axle(s) lubrication checked.

⚠ CAUTION

Driving with very hot temperatures in the rear drive axles can cause serious damage to axle bearings and seals. Have your axle lubrication checked if you notice a sign of overheating.

Brake

This air application gauge shows how much air pressure is being applied from the foot brake valve.

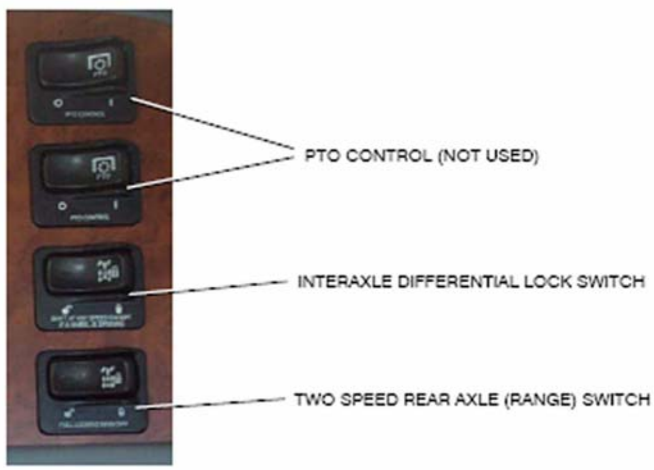
Air Filter Restriction Gauge

These gauges indicates the condition of the engine air cleaner and is measured by inches of water (H2O). A clean filter should register 7” H2O (may vary with system design) and a filter whose life is over will register approximately 25” H2O.

⚠ CAUTION

Continued operation with the Air Filter Restriction Gauge reading 25” H2O may cause damage to the engine. Inspect the filter and replace if necessary. Holes in the paper element render an air cleaner useless and may cause the Air Filter Restriction Gauge to give false reading, even if the element is clogged. Replace the element if it is damaged.

Upper Right Side of Truck Dashboard



Interaxle Differential Lock Switch

The Interaxle Differential Lock Switch allows differential action between the forward rear and the rear rear driving axles. The interaxle differential lock switch allows the operator to LOCK or UNLOCK the differential. The guard over this switch prevents you from accidentally activating the lock.

⚠ WARNING

Placing the differential lock in the “LOCK” position while the wheels are spinning could cause loss of control or axle damage. You could be hurt. Switch to “LOCK” only when the wheels are not spinning.

On vehicles with tandem rear axles, the interaxle differential allows each axle to turn independently. Differential action between the tandems relieves stress on the rear axles and tires and provides better performance. When operating normally on paved, dry surfaces, keep the truck’s interaxle differential in the UNLOCK position.

In the LOCK position, continuous operation on a paved, dry surface stresses the tandem axles, possibly causing internal damage to them.

1. Shift into the LOCK position to operate on slippery surfaces like:
   a. Ice or snow, with or without tire chains
   b. Dirt roads
   c. Loose sand, mud or other off-road conditions
2. Switch into LOCK when checking performance on a chassis dynamometer.

⚠ WARNING

Do not put the differential lock in LOCK position while the wheels are spinning freely (slipping). You could lose control of the vehicle or cause axle damage. You could be injured. Switch to LOCK only when the wheels are not spinning.

1. Do not operate the vehicle on dry pavement with the differential locked; it could lead to an injury accident. On dry pavement, you will not be able to steer well with the differential locked. Lock differential only when operating on surfaces with poor traction, such as wet, slippery roads or loose gravel.
2. Do not use the differential lock during downhill operation or at speeds above 25 mph (40 km/h). When engaged under these conditions, the vehicle will exhibit “understeer” handling characteristics. This “understeer” condition will cause the vehicle to not turn as quickly and more steering effort will be required, which can cause an injury accident.

To reduce load on the drive train, ease up on the throttle pedal whenever you shift into LOCK or UNLOCK.

Two Speed Rear Axle (Range) Switch

If the vehicle is equipped with a two-speed rear axle, you can select the axle range by the dash mounted switch. The low range provides maximum torque for operating off-highway. The high range is a faster ratio for highway speeds.

⚠ WARNING

Never shift the axle when moving downhill. Engine driveline disengagement may occur, eliminating engine retardation and allowing the wheels to spin faster than the current speed of the engine. This may require severe braking to slow the vehicle down and can result in an injury accident.

1. Unlock the interaxle differential before starting.
2. Put the Range Selector in the LOW range. Shift the transmission to start the truck moving.
3. Off Highway: When you are driving on rough terrain and secondary roads, keep the axle in the LOW range. Shift the transmission to maintain the road speed you want.
4. When you go from off highway to highway driving, shift the axle to the HIGH range this way:
   a. Be sure the differential is UNLOCKED.
   b. Keep the accelerator down and move the Range Selector to HIGH.
   c. Keep driving with the accelerator down until you want the axle to shift.
   d. Then release the accelerator until the axle has shifted.
   e. You are now in HIGH axle range on the highway. Shift the transmission normally to reach your desired cruising speed.
5. If you need to downshift the axle for more power:
   a. Keep the accelerator down and move the Range Selector to LOW.
   b. Keep driving with the accelerator down until you want to downshift the axle.
   c. Then release and depress the accelerator pedal quickly to increase the engine RPM.
   d. The axle will shift to the LOW range.

Important Tips on Operating the Dual Range Axle

NOTICE: If the vehicle has an automatic transmission, it may be necessary to shift it to the Neutral position momentarily to allow the main differential lock splines to fully engage or disengage.

1. To avoid damaging the vehicle, shift the axle at a slower speed until you are used to driving the dual range axle.

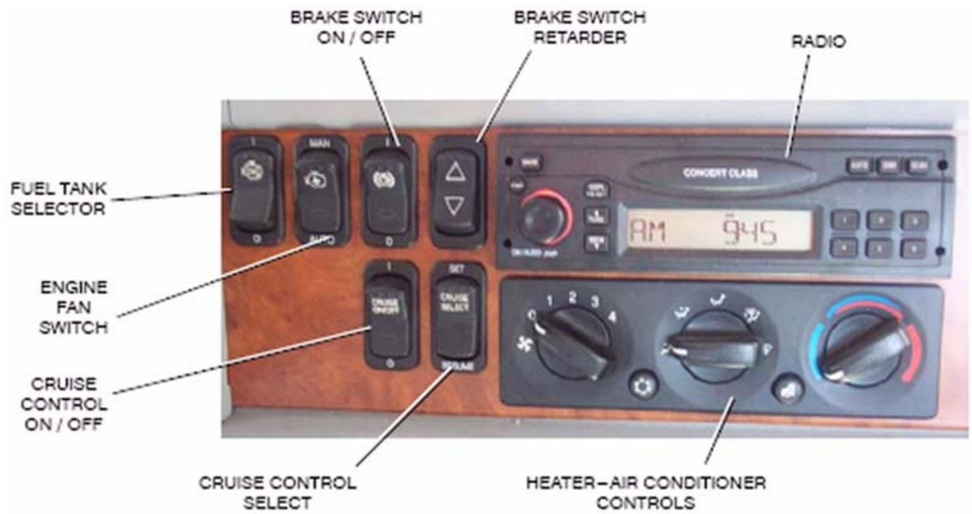
2. When driving on a surface with good traction, keep the interaxle differential unlocked. You can drive with the axle in LOW or HIGH range.
3. Always UNLOCK the interaxle differential before shifting the axle speed range.

CAUTION

If you shift the axle range with the interaxle differential in LOCK, you could do serious damage to the axles. Never shift the axle range with the differential locked.

4. Park the truck with the Range Selector in LOW.

Lower Right Side of Truck Dashboard



Fuel Tank Selector

The Fuel Tank Selector is used to access the left and right fuel tanks.

Engine Fan Switch

The Engine Fan Switch allows you to control the engine fan manually or automatically. With the ignition key switch ON and the fan switch in the ON position, the engine fan will be on regardless of engine temperature. With the engine fan switch in the AUTOMATIC position, the engine fan will automatically turn on when the engine coolant reaches a temperature of about 200°F (93.3°C).

⚠ WARNING

Do not work on the fan with the engine running. Anyone near the engine fan when it turns on could be badly injured. If it is set at ON, it will turn on any time the ignition key switch is turned to the ON position. In AUTOMATIC, it could engage suddenly without warning. Before turning on the ignition or switching from AUTOMATIC to ON, be sure no one is near the fan.

⚠ CAUTION

1. The fan or equipment near it could be damaged if the fan turns on suddenly when you don't expect it. Keep all tools and equipment such as rags away from the fan and take care no one turns on the ignition when someone is working near the fan.

2. Do not operate the fan in the manual (ON) position for extended periods of time. The fan hub was designed for intermittent operation. Sustained operation will shorten the fan hub's service life as well as reduce fuel economy.

Engine Brake ON/OFF Switch and Retarder Switch

The ON/OFF switch turns the system ON or OFF. The Brake Retarder switch performs the progressive braking function that controls the amount of retarding.

1. If you have the two mode system, select HIGH or LOW.
2. If you have the three mode system, select low, medium or high retarding.

In conventional models with Eaton transmissions, the engine brake switch may be located on the shift control knob. For more information on when and how to use the engine brake in the vehicle, see the engine brake manufacturer's owner's manual that is included with the vehicle.

Engine Brake

Refer to the instructions provided in the Vehicle Maintenance Instructions. Refer to engine owners manual for further information on engine brakes.

The Engine Brakes use the energy of engine compression to provide vehicle retardation by converting the engine to an energy absorbing device to reduce vehicle speed. This is accomplished by a hydraulic circuit that opens the exhaust valves near the end of the compression stroke.

⚠ WARNING

In an emergency, the engine brake might not stop you fast enough to prevent an accident. You could be badly hurt if you relied only on your engine brake. Use the service brakes for quick stops. The engine brake is not an emergency brake.

⚠ WARNING

The engine brake is NOT intended as the primary brake for the vehicle, nor is it an emergency brake. The engine brake only helps the service brakes by using pressure to slow the drive train. Use the service brakes for quick stops.

⚠ WARNING

The service brakes must be used in an emergency. The engine brake alone might not stop you fast enough to prevent an accident. You could be badly hurt if you relied only on the engine brake.

⚠ WARNING

Do not use the engine brake when operating on road surfaces with poor traction (wet, icy or snow covered roads) or in heavy traffic. The engine brake can cause the wheels to skid on a slippery surface. You could lose control of the vehicle if the wheels begin to skid, resulting in an accident.

Cruise Control Switch

The Cruise Control Master Switch turns the cruise control ON or OFF. The second switch allows you to SET the desired speed or RESUME the desired speed after the cruise control function has been interrupted.

⚠ WARNING

Do not operate the cruise control when operating on road surfaces with poor traction (wet, icy or snow covered roads) or in heavy traffic. Accelerations caused by the normal operation of the cruise control could cause you to lose control of the vehicle resulting in an injury accident.

NOTICE: Cruise control functions and features may vary depending upon which engine you have. For specific explanation of your cruise control, see the cruise control or engine manual included with the vehicle.

In conventional models with Eaton transmissions, the cruise control switches may be located on the shift control knob.

Heater / Air Conditioning Controls

The heat and air conditioning controls are mounted below the right hand instrument panel.

⚠ WARNING

Exhaust fumes from the engine contain carbon monoxide, a colorless and odorless gas. Do not breath the engine exhaust gas. A poorly maintained, damaged or corroded exhaust system can allow carbon monoxide to enter the cab. Entry of carbon monoxide into the cab is also possible from other vehicles nearby. Failure to properly maintain the vehicle could cause carbon monoxide to enter the cab and cause serious illness.

⚠ CAUTION

Never idle the vehicle for prolonged periods of time if you sense that exhaust fumes are entering the cab. Investigate the cause of the fumes and correct it as soon as possible. If the vehicle must be driven under these conditions, drive only with the windows slightly open. Failure to repair the source of the exhaust fumes may lead to personal harm.

NOTICE:

1. Keep engine exhaust system and the vehicle's cab ventilation system properly maintained. It is recommended that the vehicle's exhaust system and cab be inspected:

a. By a competent technician every 15,000 miles (24,140 km).

b. Whenever a change is noticed in the sound of the exhaust system.

c. Whenever the exhaust system underbody or cab is damaged.

2. To allow for proper operation of the vehicle ventilation system, keep the inlet grille at the base of the windshield clear of snow, ice leaves and other obstructions at all times.
3. Do not stay in the vehicle with the engine running or idling for more than 10 minutes with the vehicle's Heater and A/C ventilation system in RECIRC or at LOW FAN SPEED. Even with the ventilation system ON, running engine while parked or stopped for prolonged periods of time is not recommended.
4. If you are required to idle the vehicle for long periods of time, install an auxiliary heater or automatic idle control. These auxiliary devices can reduce fuel consumption and save you money.
5. If other vehicles are parked next to you idling, move the vehicle or do not stay in your vehicle for prolonged periods of time.
6. When idling for short periods of time:

   a. Set the heating or cooling system to Heat or A/C

   b. Set the fan to Medium or High speed

   c. Set the controls to FRESH AIR

The cab's control panel has five (5) controls, which are listed below.

1. A rotary knob (BLOWER SPEED) in the upper left portion controlling the blower speed with four settings.
2. A rotary knob (AIR MOVEMENT) in the upper center portion controlling the movement of air within the cab. This control is continuously variable through five (5) modes (clockwise from left):

   a. Panel

   b. Panel / Floor

   c. Floor

   d. Defrost / Floor

   e. Defrost

3. A rotary knob (AIR TEMP) in the upper right portion controlling the air temperature.
4. A rocker switch (A/C ON/OFF) in lower left portion to engage air conditioner compressor (only vehicles with air conditioning).
5. A rocker switch (FRESH AIR) in the lower center portion to select either fresh or recirculated air mode.

⚠ WARNING

Do not drive with visibility reduced by fog, condensation or frost on the windshield. Your view may be obscured, which could cause an injury accident. For clear visibility and safe driving it is extremely important for you to follow the instructions pertaining to the function and use of the ventilation / heating and defogging / defrosting system. If in doubt, consult your dealer. Maximum heating output and fast defrosting can be obtained only after the engine has reached operating temperature.

⚠ CAUTION

During extreme cold weather, do not blow hot defroster air onto cold windshields. This could crack the glass. Turn the air flow control to DEFROST and adjust the fan speed accordingly while the engine warms. If the engine is already warm, move the temperature selector to COOL, then gradually increase the temperature when you see that the windshield is starting to warm up.

To defog the windshield, select the DEFROST mode and turn the blower speed to high. Set the temperature knob to hot. The air conditioner is automatically activated to remove moisture from the cab. After the windshield is clear, adjust the mode, blower speed and temperature to your comfort.

To cool the cab, turn on the A/C switch and set the temperature knob to cool and the blower to high until the cab becomes cool. Then turn down the blower if you wish.

For Efficient Cooling:

1. Be sure all heater and air conditioner controls are off.
2. Start the engine. Allow time for warm up.

⚠ CAUTION

A cold compressor can cause refrigerant to liquefy and warp the valve plates or cause a hydraulic lock. Warm the engine before starting the air conditioner.

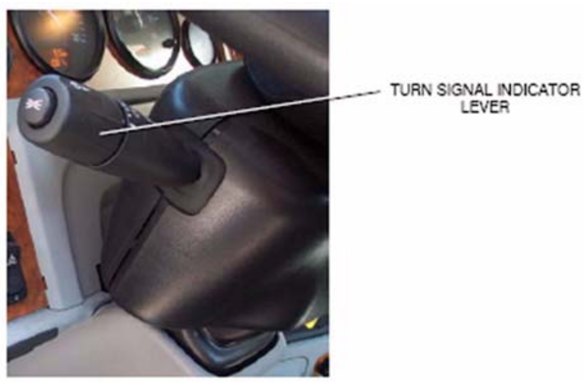
To avoid damage to the compressor and blower motors, turn off all controls when a system is not in use.

3. Set the air control in the RECIRC mode.

4. Close all windows.
5. Idle the engine between 1000 and 1500 RPM and turn the blower speed control to HIGH.
6. After the cab temperature cools to a comfortable level, adjust blower speed and controls to keep the desired condition.

NOTICE: *When the air conditioner isn't in regular use, operate it for at least 15 minutes at least once a month or every 5000 miles (8046 km), whichever comes first. This will lubricate the seals in the air conditioning system. The air conditioning system is active when the DEFROST mode is selected.*

Steering Column Mounted Controls



NOTICE: *The ignition key must be turned ON for the signal/switch to operate.*

Turn Signal and Indicator Lights

The turn signal lever is mounted on the left side of the steering column below the steering wheel. Green directional indicator lights appear on the instrument panel. To operate the signal, move the lever in the direction of the turn. Each time the turn indicator is activated the buzzer emits a short beep.

⚠ WARNING

After you complete a turn, shut the system off by returning the lever to the "OFF" (center) position. The switch's lever action is NOT self-canceling. Failure to shut off a turn signal could confuse other drivers and result in an injury accident. An indicator light in the instrument panel will flash until the turn signal is turned off.

High Beam Headlights

NOTICE: *The headlamps must be "ON" for the high beam switch to operate*.

1. To switch the headlamps to lower or higher beam, gently pull the turn signal lever towards the steering wheel, until you hear the switch click and the beam changes. The blue indicator light in the instrument panel will be "ON" when the high beam is being used.
2. To return to the previous beam, pull the lever towards the steering wheel again.

Headlamp Flash

To activate headlamp flash, gently push the turn signal lever away from the steering wheel, until you hear and feel the switch click. Release lever to deactivate.

1. If headlamps are off, low beams will flash on.
2. If headlamps are on, they will dim. Maximum duration of dimming is 3 seconds. When the function ends, the headlamps will return to low beams.

ID and Clearance Lights Flash

To flash, press the button on the end of the turn signal lever and hold. To cancel the flash, release the button. If the ID and Clearance lights are on, they will flash off.

Windshield Wipers / Washers

The vehicle is equipped with a two-speed, intermittent windshield wiper system. A seven position rotary wiper switch located on the turn signal lever operates the windshield wipers and washer. Rotate the end of the turn signal lever to change wiper mode.

Table 1: Wiper Switch Settings

Wiper SWitch Position:	***Wiper Speed:***
Off	Off
Intermittent #1	20 Second Delay
Intermittent #2	17 Second Delay
Intermittent #3	7 Second Delay
Intermittent #4	4 Second Delay
Low	Low Speed
High	High Speed

NOTE: *The ignition key must be turned to ON or ACC for the wiper / washer switches to operate.*

The first position after OFF is the intermittent #1 cycle. The next positions are intermittent #2, #3 and #4. The last two positions are wiper low speed and wiper high speed. See the wiper switch settings table above for intermittent delay times.

To Wash Windshield

Push the rotary wash/wipe knob in towards steering column, hold for more than 0.8 seconds and then release. Hold the knob in to extend the washing cycle. After the lever is released, the wipers will shut off automatically or resume the wiper's setting speed.

To activate the wipers for one swipe without activating the washer ("mist" function), push the turn signal lever in (towards the steering column) and release in less than 0.5 seconds. The wipers will perform a single swipe and then resume the wiper's setting speed.

⚠ WARNING

Do not drive with worn or dirty wiper blades. They can reduce visibility, making driving hazardous. Clean blades regularly to remove road film and wax build- up. Use an alcohol based cleaning solution and a lint free cloth and wipe along the blades.

⚠ CAUTION

Do not use antifreeze or engine coolant in the windshield washer reservoir. Damage to seals and other components will result.

If the electric pump is operated for a long period (more than 15 seconds) with a dry reservoir, the pump motor may be damaged.

Check the windshield washing fluid daily. If necessary, fill to top. Keep the fluid container filled with a non-freezing solvent mixture during cold weather. Plain water with a little liquid detergent added may be satisfactory during warm weather. In cold weather, warm the windshield with the defrosters before using the washer to help prevent icing that may block the driver's vision. Run the blower on "high" for a few moments before driving off. This helps clear the intake ducts of snow and further lessens the chance of fogging on the inside of the windshield.

Clean all inside and outside windows regularly. Use an alcohol--based cleaning solution and wipe dry with either a lint free or a chamois cloth. Avoid running the wiper blades over a dry windshield to prevent scratching the glass. Spray on washer fluid first. A scratched windshield will reduce visibility.

Horns

The Peterbuilt truck has an electric horn. To operate, press on the horn symbol near the center of the steering wheel. The Peterbuilt truck has an air horn in addition to an electric horn. Control the air horn by pulling on the lanyard extending from the overhead panel.

Tilt-Telescoping Steering Wheel

Depending on the vehicle’s configuration, you may have either a Tilt/Telescoping or a fixed steering column.

1. The tilt feature allows forward and rearward movement of the wheel.
2. The telescoping feature allows you to move the steering wheel up and down.

To activate these features, locate the Tilt/Telescoping pedal shown above.

⚠ WARNING

Adjusting the Tilt-Telescoping Steering Wheel while the vehicle is in motion could cause loss of control. You wouldn’t be able to steer properly and could have an accident. Make all adjustments to the steering mechanism while the vehicle is stopped.

To adjust the steering wheel, PUSH and HOLD the pedal down fully. Push or pull the wheel to the desired height and angle, then RELEASE the pedal to lock the wheel at the correct position.

Under Right Console

Cigarette Lighter

To operate your lighter, push the knob in. After a few moments the lighter will automatically pop out, ready to use. After use, insert the knob, but don't push it in. The lighter circuit is protected by a 20 ampere fuse to prevent damage should the lighter get stuck in the IN position. If this fuse needs replacement, check to ensure that the lighter is not stuck before replacing the fuse.

⚠ WARNING

Do not exceed the voltage/amperage capacity of the cigarette lighter. It could result in a fire. Follow all warnings and instructions in the operator's manual for the appliance you are using.

The lighter receptacle may be used to power auxiliary equipment that does not draw more than 20 amperes maximum.

Ashtray

⚠ WARNING

Paper or other combustible substances in an ashtray could cause a fire. Keep all burnable materials besides smoking materials out of the ashtray.

Parking Brake Valve

The yellow diamond shaped knob located on the right hand control panel controls the parking brakes. These are spring brakes which are activated by releasing air pressure from their chambers.

When they are not in use, air pressure compresses the springs and releases the brakes. But putting the valve in the PARK position exhausts air from the chambers and allows the springs to extend and apply the brakes. Also, if the system air drops below the safe operating level, the spring brakes will apply automatically, bringing the vehicle to a stop

⚠ WARNING

Do not leave the cab without applying the parking brake. The truck could roll and cause an injury accident. Always apply the parking brake before you leave the cab.

⚠ WARNING

Stopping with the parking brake controls can cause a sudden wheel lock-up, loss of control or can cause you to be overtaken by following vehicles. You could be severely injured. Never pull out the parking brake valve while the vehicle is moving.

⚠ WARNING

Do not use service brakes to park and hold an unattended vehicle - use the parking brakes. Because service brakes work with air pressure, these brakes could slowly release. The vehicle could roll, causing a serious accident. Someone could be hurt or killed. Never rely on the service brakes to hold a parked vehicle.

⚠ WARNING

Never drive the vehicle with the parking brake applied. Always release the parking brakes prior to moving the vehicle. Failure to disengage the parking brakes prior to moving the vehicle could result in excessive heat build-up in the brake system, resulting in a fire.

NOTICE: *Today's diesel electronic engines have significant torque and startability power at low RPM. Combinations of engine speed and available torque may overpower the vehicle's parking brakes.*

1. ***To apply the parking brakes***, pull the yellow knob out. The parking brakes will set.

⚠ CAUTION

Do not try to put the vehicle in motion before pressure in the system reaches 100 psi (689 kPa) because the wheels are locked by the spring brake action. Unnecessary stress and possible brake malfunction could occur if the vehicle is forced to move before the air system reaches 100 psi (689 kPa).

2. To release the truck parking brakes, push in the yellow knob.

Pedals on Floor

There are three pedals on the floor of the operator's cab as shown above.

1. Clutch Pedal
2. Service Brake Pedal
3. Accelerator Pedal

Riding the Clutch

The clutch pedal is not a footrest. Driving with your foot on the clutch pedal will allow the clutch to slip, causing excessive heat and wear. You can damage the vehicle this way.

Clutch Travel

⚠ CAUTION

***Always use first gear or low speed range to start the vehicle in motion. The use of a higher gear or speed range forces undue strain on engine, clutch, other transmission components and may cause damage*.**

1. To put the vehicle into motion, push down until the clutch pedal makes contact. This contact will occur at about 1/2 to 1 inch (12.7mmto 25.4mm) from the end of pedal stroke. Select a gear low enough to let the vehicle start forward with the throttle at idle until the clutch is fully engaged.
2. The total stroke of the clutch pedal is about 10 inches (254mm). The first 1-3/4 to 2 inches (44.45 to 50.8mm) is free travel. After that is the release stroke, the part that fully releases the clutch. The last 1/2 to 1 inch (12.7 mm to 25.4 mm) engages the clutch brake. If the vehicle is new, watch the free travel in the clutch carefully for the first few hundred miles. As the clutch lining wears and high spots get worn smooth, you will get less free travel.
3. Always start out in a low gear with a ceramic faced clutch. Starting in higher gears, even with a light load, will cause a very jumpy start and excessive wear.
4. And don’t allow the vehicle to roll in the opposite direction at all during clutch engagement. If you need to start up on an incline, apply the service brakes before you release the parking brake. Then release the service brakes as you engage the clutch and apply throttle.

Release Bearing Wear

When you must idle the engine for any period of time, shift the transmission to neutral and engage the clutch (take your foot off the pedal). This helps prevent unnecessary wear of the clutch release bearing. And it is less tiring for you, too.

Clutch Adjustment

Inspect manual and self-adjusting clutches regularly to maintain correct clutch adjustment. Have your dealer’s service department perform any adjustments necessary. Do not adjust the clutch by adjusting the external linkage without first checking (and correcting if necessary) the internal clutch adjustment. Using only the external linkage adjustment could damage the clutch.

Clutch Brake

1. The clutch brake is used for stopping gear rotation to let you shift into first gear or reverse when the vehicle is at a standstill.
2. About the last 1/2 to 1 inch (12.7mm to 25.4mm) of clutch pedal travel activates the clutch brake. So if you are stopped and want to shift directly into 1st or reverse, depress the clutch pedal until contact with the clutch brake is made to stop transmission gear rotation.
3. If you have a butt-tooth condition and can’t shift the transmission, gradually release the clutch. The drive gear can roll enough to allow the teeth to line up properly and complete the shift.

⚠ CAUTION

Be careful not to apply the clutch brake while the vehicle is moving. The purpose of the clutch brake is to stop the transmission so that you can shift into a starting gear without grinding. Applying the clutch brake when the vehicle is moving causes a braking effect on the entire vehicle. This wear naturally shortens the service life of the clutch brake.

Double Clutching

Whether you are upshifting or downshifting, it is best to double clutch. Double clutching is easier on the transmission and on the engine, helping the vehicle match engine speed with driveline speed and achieving clash free shifts. To double clutch:

1. Push down the clutch pedal to disengage the clutch.
2. Move the gear shift lever to neutral.
3. Release clutch pedal to engage the clutch. This lets you control the RPM of the main shaft gears. Thus you can match the RPM of the main shaft gears to those of the output shaft.
   a. ***Up Shifts***: Let the engine and gears slow down to the RPM required for the next gear. Use the tachometer to determine optimum RPM for gear engagement.
   b. ***Down Shifts:*** Press accelerator to increase engine and gear speed to the RPM required in the lower gear. Use the tachometer to determine optimum RPM for gear engagement.
4. Now quickly press the pedal to disengage the clutch. Move the gear shift lever to the next gear speed position.
5. Release the pedal to engage the clutch.

Brake Safety and Emergency

To stop the vehicle in an emergency, vary the service brake application pressure to provide maximum braking force without locking the wheels. Use engine compression to assist the service brakes; i.e., don’t depress the clutch pedal until the engine reaches idle speed.

⚠ WARNING

Do not operate the vehicle in the event of a malfunction in any air circuit. The vehicle should not be operated until the system is repaired and braking circuits, including all pneumatic and mechanical components, are working properly. Loss of system air can cause the service brakes not to function, resulting in the sudden application of the spring brakes causing wheel lockup, loss of control or overtake by following vehicles. You could be in an accident and severely injured.

⚠ WARNING

Unless you have an anti- lock braking system, always avoid completely depressing the service brake pedal, if possible, even during emergency braking. Depressing the brake pedal too aggressively can cause the wheels to lock, which can lead to an uncontrolled skid and could cause an accident.

Overheated Brakes

Under normal braking conditions, the energy generated will bring the internal brake drum temperature to about 500°F (260°C). This is well within the safe zone: The maximum safe temperature of linings for drum type brakes is usually about 800°F (427°C).

But if service brakes are used improperly or for prolonged periods, internal brake drum temperatures may commonly exceed 800°F (427°C). Such brake overheating may be detected by a burning smell or smoke coming from a drum. If this occurs, you should immediately stop and check for cracked brake drums or lining fires. If neither exists, get back behind the wheel and resume a slow speed as soon as possible to cool the brakes.

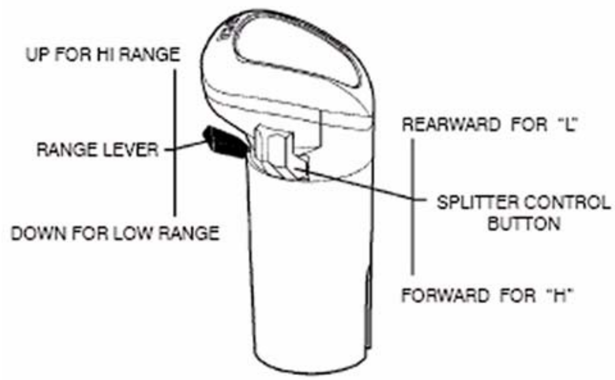
TRANSMISION

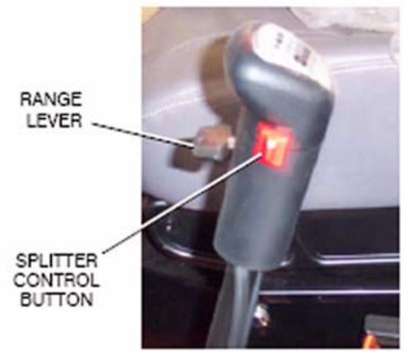
General Information

Models in this series provide thirteen (13) forward speeds and two (2) reverse, consisting of a five (5) speed front section and a three (3) speed auxiliary section. The auxiliary section contains LO and HI range ratios, plus the L H splitter gear ratios. The gear shift lever mechanically engages and disengages the gears.

1. The LO position in the front section is used only as a starting gear. The other four ratios are used once in LO range and again in HI range. Each of the four ratios, when used in the HI range, can be split with the splitter control button.

2. After shifting out of the LO position, use the Roadranger repeat “H” shift pattern. LO range and HI range are selected with the range lever. It is used once during the upshift and once during the downshift sequence.





3. Always preselect the range shift. After preselection, the transmission will automatically make the synchronizer range shift as the shift lever passes through neutral.
4. When in HI range, the gear ratios can be split by using the Splitter Control Button. The “L”/Rearward position gives 5th, 6th, 7th and 8th speed ratios; the “H”/Forward position splits each of the HI range speed ratios. Therefore, all eight progressive HI range ratios can be obtained.

Table 2: Gear Ratios

Range	Gear	RTLO-14613B		RTLO-XX713A	
		Ratios	% Steps	Ratios	% Steps
HI	8th H	.85: 1	18	.73: 1	17
	8th L	1.00	18	.86	17
	7th H	1.18	18	1.00	17
	7th L	1.39	18	1.17	18
	6th H	1.64	18	1.38	17
	6th L	1.94	18	1.62	21
	5th H	2.28	18	1.95	17
	5th L	2.70	40	2.29	41

LO	4th	3.78	39	3.23	37
	3rd	5.26	40	4.43	38
	2nd	7.34	39	6.11	42
	1st	10.20	44	8.64	42
	LO	14.71		12.31	
HI	Reverse-HI	3.89		3.50	
LO	Reverse-LO	14.71		13.22	

Range Shift

The range lever selects LO or HI range. It is used once during an upshift sequence and once during a downshift sequence.

Preselect

NOTICE: *Always preselect all range and splitter shifts when upshifting or downshifting. Preselection requires that the range lever and/or splitter button are moved to the needed position before starting the shift.*

1. Preselected range shifts are completed automatically as the lever is moved through neutral and into the next gear. Preselecting all range shifts prevents damage to the transmission and provides for smoother shifts.
2. Preselected splitter shifts allow smooth and faster shifts. However, do not delay. Start and complete the shift immediately after preselecting the splitter to avoid unnecessary wear on internal transmission parts.

Splitter Shift

The splitter control button selects LO split “L” or high split “H”. It is used in each HI range speed ratio.

Optional Equipment

For easier and faster gear engagement while the vehicle is standing still, some Eaton Fuller transmissions may be equipped with a Clutch Brake.

Clutch Brake

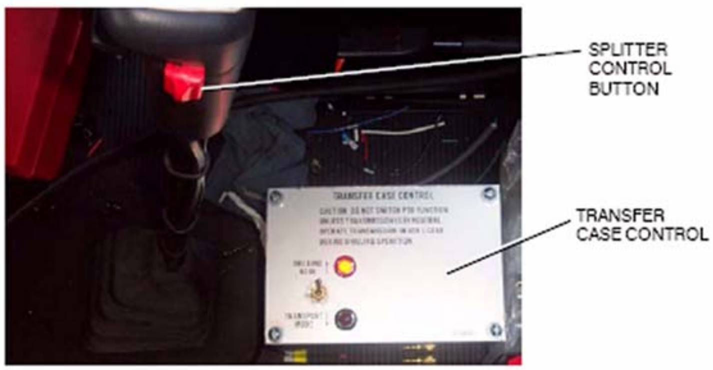
(Used with pull--type clutches) - The clutch brake is applied by fully depressing the clutch pedal to the floor board. When applied, the brake slows down and can stop the transmission front box gearing. It is a disc type brake incorporated into the clutch and transmission drive gear assemblies.

⚠ CAUTION

Never use the Clutch Brake when upshifting or downshifting. Use ONLY for initial gear engagement when the vehicle is standing still.

TRANSFER CASE CONTROL

The standard TH60 has a 13 speed transmission. The drilling gear is 8th L gear direct drive. Shift into 8th L gear and leave the clutch depressed when making the PTO/DIRECT DRIVE changes.



1. Move the transfer case control switch to “Drilling Mode”. The drilling mode light will come on when is engaged.
2. The transfer case control switch ***must*** be returned to “Transport Mode” before attempting to drive or move the drill. The transport mode light will come on when is engaged.

⚠ CAUTION

Do not switch PTO function unless transmission is in neutral. Operate transmission in 8th L gear during drilling operation.

Drilling Mode Indicator Light

The Drilling Mode Indicator Light is on when the transfer case has been shifted to operate the PTO function.

Transport Mode Indicator Light

The Transport Mode Indicator Light is on when the transfer case has been shifted to drive the rear axles.

Air Transfer Valve

The air transfer valve allows air to move from the truck engine compressor to the operator's console, thus isolating the truck chassis air brake system. This allows the truck to be driven if an air leak occurs in the drilling rig air control system.

The air transfer valve is mounted on the side of the truck deck between the back of the cab and the deck. It must be turned to a horizontal position, as shown above, for air to transfer back to the operator's console.

⚠ WARNING

The air transfer valve must be in the vertical (off) position when driving the TH60 on the road to meet with federal regulations.

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Section 5 - OPERATING

OPERATING SAFETY

Safe Operations

Introduction

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.

⚠ WARNING

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

⚠ WARNING

Always wear the 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 and instruments before you operate or perform any maintenance, service or repairs on the drill.

⚠ WARNING

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

General Information

The following operational hints should be observed:

1. Do not increase the engine speed to high idle the engine has been warmed up.
2. Always chock the wheels if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill with the engine running.
4. Always perform safety checks prior to starting, operating or maintaining the drill.
5. Always sound the horn before moving the drill in either direction to alert personnel and to allow sufficient time before putting the drill into motion.
6. Always use safe judgement when driving on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning. Always use a spotter.
7. Always use approved protective clothing such as gloves, steel toe shoes, goggles, ear protection and safety helmet when performing service maintenance. Do not wear oil stained or damaged garments.
8. Always operate the drill at full engine power when drilling.
9. Never drive or stop the drill on a slope or surface that is liable to collapse.
10. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
11. Before starting engine, always check to see that the control levers and drill feed are at stop, neutral or off position and that the parking brakes are applied.

DAILY INSPECTION

Walk Around Inspection

FYI (For Your Information)

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 8 hour daily routine maintenance procedures. Performance of this inspection can result in longer life and maximum productivity from the drill.

Hydraulic System

A careful inspection of all hydraulic components (hydraulic oil cooler, pumps, motors, valves, hoses, fittings, etc.) should be made to detect any signs of oil, possible oil 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.

⚠ WARNING

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

Compressor System

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

⚠ WARNING

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

Coolant System

The carrier engine radiator should be checked for leaks daily. Failure to cool the carrier engine properly can result in engine failure or severely reduce engine life.

⚠ WARNING

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 the radiator cap slowly to relieve pressure. Avoid contact with steam or escaping fluid.

Air Hose Leaks

Inspect the flexible air hoses for wear/tear conditions. Check the air system connections for loose connections. Make sure the air hose safety chains are secure.

Wheels and Tires

Check the tires for damage or unusual wear. Check and maintain tire pressure. Check the wheel nuts and retighten them after the first 100 miles (161 km) and every 200 miles (322 km) thereafter.

Fuel Systems

The fuel systems should be checked on a daily basis for possible leaks. Maintain the fuel tanks 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 day. 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 information in the 6.3 *"Refill Capacities/Lubricants/Fuel"* section of this manual.

⚠ WARNING

Fuel is flammable. May cause serious injury or death. Shut down the engine, extinguish all open flames and do not smoke while filling fuel tanks 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.

Check all bolted assemblies for tightness. Inspect the entire drill for any loose, worn or missing parts and replace them as needed. Inspect fluid lines, hoses, filler openings, drain plugs, pressure caps, tires, derrick cables, hoist wire cables, muffler, engine, safety shrouds and the area under the drill for signs of leakage.

Pay attention to the U-joint and flange bolts, rotary tophead mounting bolts, retract table mounting bolts, air compressor mounting bolts, transfer case mounting bolts, mud pump gear box bolts, leveling jack bolts and cable sheave pin locks.

NOTICE: *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.*

Operator’s Areas

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 carrier cab and the operator’s platform area. Secure these items in the tool box, tool cabinet or remove them from the drill.

PRELIMINARY START INSPECTION

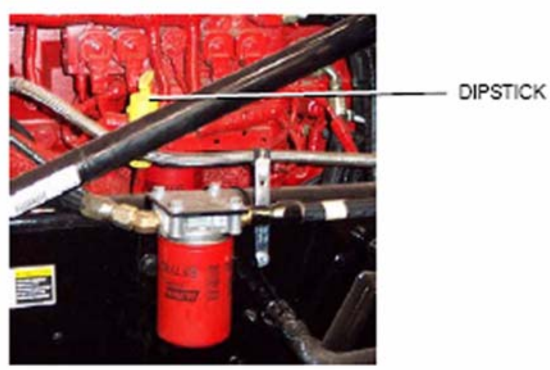
Pre-Start Inspection

FYI (For Your Information)

Before starting the drill, 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 8 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 the drill. Refer to the instructions given in Section 6 *“Maintenance Procedures”* for the correct maintenance procedures and oil specifications.

Engine Oil Level

Check the engine oil level by viewing the engine 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 the oil level is low, add oil through the fill cap to the full mark on the dipstick.



⚠ WARNING

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

⚠ CAUTION

Never operate the engine with the oil level below the “L” (low) mark or above the “H” (high) mark.

Engine Coolant Level

⚠ CAUTION

Engine coolant must be properly maintained to protect against engine damage. Coolant must be tested at regular intervals to ensure it can provide adequate protection against freezing, boiling and corrosion. It is the owner's responsibility to know the type of coolant used and to maintain it properly.

⚠ WARNING

Removing the radiator cap on a hot engine can cause scalding coolant to spray out and burn you badly. If the engine has been in operation within the previous 30 minutes, be very careful in removing the radiator cap. Protect face, hands and arms against escaping fluid and steam by covering the cap with a large, thick rag. If you see any steam or coolant escaping, don't try to remove it until the radiator cools down. If you see nothing escaping, still remove the cap very slowly and be careful. Be ready to back off if any steam or coolant begins to escape. Inhibitor contains alkali. Avoid contact with skin and eyes**.**

⚠ WARNING

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**.**

Top off a cooling system when coolant is no longer visible in the sight glass of a surge tank (if equipped) on a cold engine. With the engine cold, top up with premixed coolant of the desired freeze protection concentration. Add coolant through the pressure cap neck of the surge tank. Pressure cap = 7 psi (.48 bar) for CAT engines, 15 psi (1.03 bar) for Cummins engines.

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 the cause of coolant loss.***

If coolant must be added, use a reliable brand of permanent antifreeze in a 50-50 mixture. It must be used year round in all climates. Refer to instructions in Section 6 *"Maintenance Procedures"* for the correct procedures.

Fuel Level

Check fuel level gauge on the truck dashboard. The tanks should be refilled when the indicator needle moves to below 1/4 tank. Refer to the Maintenance Procedures section of Section 6 MAINTENANCE. Select the proper grade of fuel oil in accordance with the instructions given in the Fuel Specifications section of Section 6 MAINTENANCE.

Maintain fuel tank(s) at a high level to minimize water condensation inside the tank(s). 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.

⚠ WARNING

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

1. Check the fuel level by reading the fuel level gauge.
2. Never allow the fuel tank to completely empty, otherwise the entire fuel system will require bleeding.
3. If the fuel level is low, add clean, filtered fuel.
4. Fill tanks with the correct grade of fuel. Refer to Section 6.3 *Fuel Specifications* for more fuel details.

Fuel Filter/Water Separator

The fuel filter/water separator (if equipped) 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 instructions given in 6.5 *Maintenance Procedures* for further information.

⚠ WARNING

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

Compressor Oil Level

Check the compressor oil level in the receiver tank. With the drill in a level position, the oil level should be in the middle of the sight gauge.

⚠ WARNING

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.

If necessary, add fresh, clean (filtered through a 10 micron filter) XHP605 synthetic oil through the fill cap to bring the oil level to the middle of the sight gauge. If oil is required, follow the instructions in Section 6.5 *Maintenance Procedures* for the correct procedures. Refer to Section 6.3 *Refill Capacities/Lubricants/Fuel* for oil details.

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 Section 6 *Maintenance Procedures* for the correct procedure to relieve water from the system.

⚠ WARNING

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.

Batteries

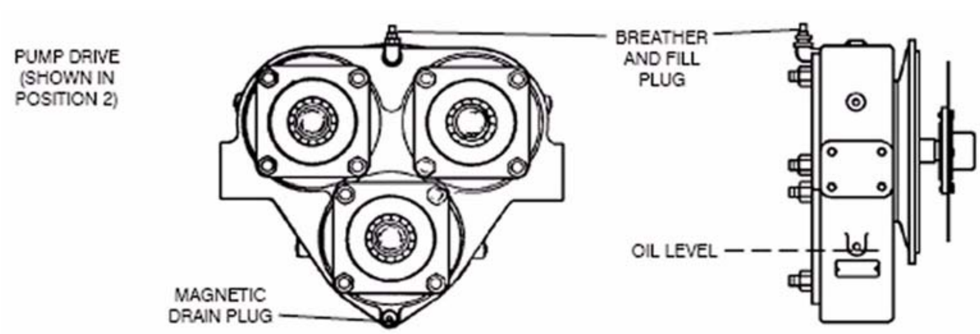
Check the battery posts and cables for corrosion. Check and keep the electrolyte levels above the battery plates or to the bottom of the fill holes. See Section 6 *Maintenance* for the correct procedures.

⚠ WARNING

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.

Pump Drive Gearbox

Check the oil level in the Pump Drive Gearbox. The oil level must be level with the oil level plug opening shown in the drawing below. Refer to Maintenance Procedures section of Section 6 MAINTENANCE.



⚠ WARNING

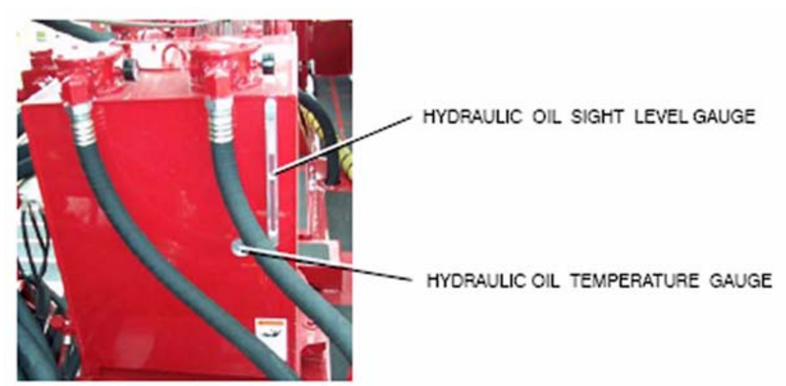
Rotating shaft can cause severe injury or death. Do not operate with guard removed. Hot oil or components can burn. Avoid contact with hot oil or components.

1. Move the drill to a level surface.
2. Stop the engine before checking oil level or adding oil.
3. Clean around the breather and oil fill plug before adding oil.
4. Check the oil level within the gearbox.

If it is necessary to add oil, refer to Section 6 *Maintenance* for the correct procedures.

Hydraulic Reservoir 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 instructions in Section 6 *Maintenance* for the correct procedures when reading the oil sight level gauge.



1. The oil level *with all hydraulic cylinders retracted, derrick down, jacks up and rotary tophead in retract position* should be 1 inch (25.4 mm) from the top of the oil level sight gauge.
2. The top of the oil level MUST be visible when the engine is running AND when the engine is not running. There must be oil showing on the gauge at all times.

NOTE: ***If no oil is showing on the sight gauge, stop the engine immediately. Call for service assistance to investigate the cause of oil loss.***

Add oil to bring oil to the level defined above by following the directions in the Section 6 *Maintenance* Section. Select the proper grade of oil in accordance with the information given in the Section 6 *Lube Specifications Section.*

⚠ CAUTION

Excessive hydraulic oil can rupture the sealed hydraulic tank and cause injury or property damage. Do not fill the hydraulic tank with hydraulic cylinders extended. Retract all cylinders and fill tank to indicated level.

⚠ CAUTION

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

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.

Drain Hydraulic Tank Moisture

Some hydraulic tanks have a moisture bleeder valve underneath the hydraulic tank. Push this bleeder up to drain moisture from the tank. Release the bleeder when the moisture has been drained.

Operator's Areas

1. Clean windshields, mirrors and all lights. Check that all of the lights function.
2. Make sure the operator's areas, steps and grab rails are clean. Oil, grease, snow, ice, clay or mud in these areas can cause you to slip and fall. Clean your boots of excess mud before getting on the drill.
3. Remove all personal items or other objects from the floor of the carrier cab and operator's platform area. Secure these items in a tool box, tool cabinet or remove them from the drill.

Verify Controls

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.

⚠ CAUTION

If any controls, instruments or devices do not function correctly, refer to Section 7 TROUBLE SHOOTING or report any drill defects to the proper personnel. Defects must be corrected before starting and operating the drill.

Driver's Checklist

Safe Vehicle Operation

To keep your vehicle in top shape and to maintain its high level of safety for you and the drill, make a thorough inspection every day before you drive. You'll save maintenance time later and the safety checks could help prevent a serious accident. Please remember, too, that Federal law requires a pre-trip inspection.

You aren't expected to become a professional mechanic. The purpose of your inspections is to find anything that might interfere with the safe and efficient transportation of yourself and your drill. If you do find something wrong and can't fix it yourself, please have a qualified mechanic fix it right away.

For your safety, as well as those around you, be a responsible driver:

1. If you drink, ***do not drive***.
2. Do not drive if you are tired, ill or under emotional stress.

Much has gone into the manufacturing of your Peterbilt, including advanced engineering techniques, rigid quality control and demanding inspections. These manufacturing processes will be enhanced by you, the safe driver, who observes the following:

1. Knows and understands how to operate a vehicle and all of its controls.
2. Maintains the vehicle properly.
3. Uses driving skills wisely.

⚠ WARNING

Do not drink and drive. Your reflexes, perceptions and judgement can be affected by even a small amount of alcohol. You could have a serious, or even fatal accident, if you drive after drinking. The use of alcohol, drugs and certain medications will seriously impair perception, reactions and driving ability. These circumstances can substantially increase the risk of an accident and personal injury.

The daily checks listed below are the foundation of your overall preventive maintenance program.

Approaching the Vehicle

1. Check the overall appearance and condition. Are windows, mirrors and lights clean and unobstructed?
2. Check beneath the vehicle. Are there signs of fuel, oil or water leaks?
3. Check for damaged, loose or missing parts. Are there parts showing signs of excessive wear or lack of lubrication? Have a qualified mechanic examine any questionable items and repair them without delay.

Check Under Truck Hood and Cab

With the engine stopped:

1. Check the engine oil level; top up as necessary. Refer to your engine's operating manual for the type of oil to use.
2. Check the engine coolant level while the engine is cold. Top off as necessary with premixed coolant. Refer to instructions for adding coolant to the proper level.
3. Check the engine belts. Refer to the instructions to check belt condition and adjust tension.
4. Check brake lines and hoses.
5. Check all other accessories, controls, belts, hose and wiring for condition and adjustment.
6. Check the windshield washer fluid level; top up if necessary.
7. Check the power steering fluid reservoir; top off if necessary.
8. Check the steering components (pitman arm, draglink, power steering hoses, etc.)
9. Drain the fuel/water separator.
10. Check the fire extinguisher charge.
11. Check the road emergency kit. Is it complete?
12. Check the windshield washer fluid level; Top off if necessary.

Check Outside the Vehicle

⚠ WARNING

Diesel fuel in the presence of an ignition source (such as a cigarette) could cause an explosion. You could be seriously injured. A mixture of gasoline or alcohol with diesel fuel increases this risk of explosion. Use only the fuel recommended for your engine.

⚠ WARNING

Hot fuel vapors are combustible and can cause an explosion or fire resulting in injury or death. Do not remove a fuel tank cap near an open flame.

1. Be sure all wheel nuts and cap nuts are secure. Check wheel cap nut torque weekly; refer to the instructions.
2. Check tires for condition and proper inflation.
3. Check the front wheel bearing lube level.
4. Check the parking (spring) brakes as to the condition and tightness of air lines, breathers, clamp rings & bolts, mounting studs and release bolts.
5. Check turn signal operation.
6. Check emergency flashers and exterior lamps.
7. Check the fuel tanks. Is there enough fuel? Are the tank caps secure?
8. Visually inspect the fuel tank mounting hardware. Are the tank straps tight? Is the webbing in place?
9. If equipped with fuel tank mounting steps: are they damaged or broken? Is the grommet / windlace in place between the tank and side plate? Are bolts missing or loose?
10. Check the air cleaner(s) and muffler(s). Are they tight and secure?
11. Check for loose or missing suspension fasteners.
12. Check springs or other suspension parts for damage such as cracks, gouges, distortions, bulges or chafing.
13. Check the air system. Are there leaks?

14. Drain excess moisture from all air supply tanks. Make sure the drain cocks are closed. This procedure is also required for air supply tanks equipped with automatic drain valves.
15. Check that cab latch or hood holddowns are hooked.

In-Cab Check

⚠ CAUTION

To avoid injury while entering or leaving the cab, keep your feet in contact with the steps and your hands on the handhold. Always have three points of contact as you enter or exit a cab.

1. Adjust the seats.
2. Fasten and adjust safety restraint belts.
3. Adjust the steering column.
4. Check mirror adjustment.
5. Operate air powered devices to circulate lubricants.

STARTING TRUCK ENGINE

Starting Engine

1. Before moving the drill, check inside, outside and underneath the drill for people or obstructions.
2. Before starting the engine and beginning to drill, check inside, outside and underneath the drill for people or obstructions.
3. 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.
4. START the engine from the operator's position only.
5. AVOID leaving the controls with the engine running. NEVER leave the operator's drill platform while the drill is running.

⚠ CAUTION

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

Starting & Operating Truck Engine

Since each vehicle is custom equipped, all engine operation instructions in this manual are general. You will want to consult the manual for your engine to find out details about your specific engine's needs. You may need to use a slightly different procedure from the one outlined here.

Also check the ATA Truck Driver's Handbook in your glove box. It will give you tips on starting, shifting and driving a truck.

⚠ WARNING

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

⚠ WARNING

If you are not experienced with the drill's controls and instruments, read and understand Section 4 "Controls" before you operate or perform any maintenance, service or repairs on the drill.

1. Before starting the engine and beginning to drill, check inside, outside and underneath drill for people or obstructions.
2. 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.
3. START the engine from the operator's position in the truck cab.

Below are instructions for both normal temperature starting and cold weather starting.

Normal Temperature Start Procedure

When the outside temperature is about 50°F (10°C), you can use the following procedure.

1. Make sure all operator drill console controls are either in "OFF" or "NEUTRAL" positions.

⚠ WARNING

The pulldown low speed valve lever must be in the "CENTER" (neutral) position before starting the engine. If accidentally bumped into an operating position, it will cause serious damage when air is transferred back to the operator's console.

2. Set the Parking Brake.
3. Put your main transmission in Neutral.
4. Disengage (depress) the clutch (manual transmission).
5. Turn the key switch to START (starter activation to start engine).

⚠ WARNING

Do not depress the accelerator pedal or move the accelerator lever from the idle position while cranking the engine. This can result in engine overspeed and severe damage to the engine.

⚠ CAUTION

To prevent damage to the starting motor, do not engage the starting motor for more than thirty seconds. Wait 2 minutes between each attempt to start).

⚠ CAUTION

Never operate the starter motor while the engine is running. The starter and flywheel gears could clash and jam, severely damaging them.

6. If engine does not start within 30 seconds, release the starter switch. To avoid overtaxing the starter motor or the batteries, don't use the starter for more than 30 seconds. Let the starter motor cool and the batteries recover for two minutes before trying again. If the engine still won't start after a couple of tries, check the manual override shutdown valve and fuel lines for possible fuel starvation or air leaks. Starting failure may mean fuel isn't reaching the injectors. The absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.
7. As soon as the engine starts, begin to watch the oil pressure gauge. Check your engine manufacturer's manual for the right pressure for your engine. If the oil pressure doesn't rise within a few seconds, stop the engine. Find out what is wrong before starting the engine.

⚠ CAUTION

The engine must have adequate oil pressure within 15 seconds after starting. If the WARNING lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut off the engine immediately to avoid engine damage. The low oil trouble shooting procedure is located in Troubleshooting Symptoms (Section TS) of the Owners Manual ISX Engine and the Troubleshooting Section of this manual.

8. Slowly engage (release) the clutch after the engine has started.
9. Idle the engine 3 to 5 minutes before operating with a load. Wait until normal engine oil pressure registers on the gauge before idling or accelerating engine beyond 1000 RPM.

Cold Temperature Start Procedure

In cold weather, fast engine starting helps relieve the loads on the electrical system and cranking motor. Using the special cold starting equipment will help starting. If you follow a few simple guidelines, you will extend the service life of your engine.

1. Keep the electrical system in top condition.
2. Use the best quality fuel of the recommended lubricating oil.
3. Use recommended engine lubricating oil.

⚠ WARNING

The fluid in ether starting systems is extremely flammable and poisonous. If you swallow it, it can be harmful or fatal.

1. ***Do not smoke when testing, installing or servicing an ether starting unit. Service it in a well ventilated area away from heat, open flames or sparks.***
2. ***If swallowed, do not induce vomiting, Call a physician immediately.***
3. ***Wear goggles to avoid getting fluid in your eyes. Avoid getting it on your skin and avoid breathing the fumes. If fluid does get in your eyes or fumes irritate your eyes, flush for 15 minutes with large amounts of clean water. Contact an eye specialist.***
4. ***Do not move or relocate the ether cylinder or tubing from its original installation. It must be mounted to protect it from engine exhaust heat and also from moving parts which could damage it.***
5. ***Do not store the spare cylinder in the cab.***
6. ***In warm weather, when you will not need the ether starting system, remove the ether bottle from the truck and store it safely. Also, return the protective cap to the bottle mounting connector.***

In cold weather the engine will start faster and the starter motor will work more easily if ether is injected into the engine cylinder while the engine is being cranked.

Automatic System

When you turn the ignition key to “START”, the cranking motor and the ether system are engaged. When needed, starting fluid is released from a pressurized cylinder, flows through a valve and tubing and sprays from a nozzle in the engine’s air intake system. For more helpful starting information, refer to the engine manual that came with your vehicle.

Engine Warm-up

The purpose of engine warm-up is to allow oil film to be established between pistons and liners, shafts and bearings while the engine gradually reaches operating temperature. After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

⚠ CAUTION

Do not operate engine at low idle for long periods with engine coolant temperature below the minimum specifications (Section V of the Owners Manual ISX Engine). This can result in the following:

1. a.) Fuel Dilution of the lubrication oil
2. Carbon build up in the cylinder
3. Cylinder head valve sticking
4. Reduced performance

Warm-up Procedure

1. After you've started the engine, idle it at approximately 600 PRM while you check:
   a. Oil Pressure
   b. Air Pressure
   c. Alternator Output
2. After a few minutes of idling at 600 RPM, increase the idle speed up to 900 or 1000 RPM. Continue your warm-up. This procedure allows oil to warm and flow freely while pistons, liners, shafts and bearings expand slowly and evenly. In extremely cold temperatures, you may have to increase idle speed.

***NOTE:** In colder climates where the temperature is often below freezing, the warm-up for turbocharged engines is especially important. Chilled external oil lines that lead to the turbocharger will slow the oil flow until the oil warms, reducing oil available for the bearings. Watch the engine oil temperature or pressure gauge for a warming trend before increasing engine idle speed (RPM).*

3. Continue the engine warm-up until the coolant temperature reaches 130°F (54°C). At this temperature, you can use partial throttle. Wait until the coolant temperature is at least 160°F (71°C) before operating at full throttle.

⚠ WARNING

Exhaust fumes from the engine contain carbon monoxide, a colorless and odorless gas. Do not breath the engine exhaust gas. A poorly maintained, damaged or corroded exhaust system can allow carbon monoxide to enter the cab. Entry of carbon monoxide into the cab is also possible from other vehicles nearby. Failure to properly maintain your vehicle could cause carbon monoxide to enter the cab and cause serious illness.

⚠ WARNING

DO NOT OPERATE A DIESEL ENGINE WHERE THERE ARE OR CAN BE COMBUSTIBLE VAPORS. The vapors can be sucked through the air intake system and cause engine acceleration and overspeeding that can result in a fire, an explosion and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of overspeeding. Remember, Cummins has no way of knowing the use you have for the engine. THE EQUIPMENT OWNER AND OPERATOR ARE RESPONSIBLE FOR SAFE OPERATION IN A HOSTILE ENVIRONMENT. CONSULT YOUR CUMMINS AUTHORIZED REPAIR LOCATION FOR FURTHER INFORMATION.

⚠ CAUTION

Do not expose the engine to corrosive chemicals. Corrosive chemicals can damage the engine.

⚠ CAUTION

Never idle the vehicle for prolonged periods of time if you sense that exhaust fumes are entering the cab. Investigate the cause of the fumes and correct it as soon as possible. If the vehicle must be driven under these conditions, drive only with the windows slightly open. Failure to repair the source of the exhaust fumes may lead to personal harm.

Winterfronts and shutters can be used on a vehicle or equipment to reduce air flow through the radiator core into the engine compartment. This can reduce the time required to warm the engine and help maintain the engine coolant temperature.

CAUTION

The use of a winterfront can result in excessive engine coolant, oil and charge air (intake) temperatures, which can lead to overheating and possible engine damage.

Use only a winterfront available from the Peterbilt (or OEM) dealer that is compatible with a 2002 EPA-compliant engine cooling system. These winterfronts are specifically designed for use with new grill snap patterns.

NOTICE:

1. Keep the engine exhaust system and the cab ventilation system properly maintained. It is recommended that the vehicle's exhaust system be inspected:
   a. By a competent technician every 15,000 miles
   b. Whenever a change is noticed in the sound of the exhaust system
   c. Whenever the exhaust system, underbody or cab is damaged.
2. Do not stay in the vehicle with the engine running or idling more than 10 minutes with the vehicle's Heater and A/C ventilation system in the RECIRC or at LOW FAN SPEED. Even with the ventilation system ON, running the engine while parked or stopped for prolonged periods of time is not recommended.
3. If other vehicles are parked next to you idling, move your vehicle or do not stay in the vehicle for prolonged periods of time.

Operating the Engine (Normal)

If equipped, monitor the oil pressure and coolant temperature gauges frequently. Refer to Section 6 *Refill Capacities/Lubricants/Fuel* for recommended specifications. Continuous operation with engine coolant temperature above or below the engine coolant temperature specifications can damage the engine.

If an overheating condition starts to occur, reduce the power output of the engine by releasing the accelerator pedal or lever or shifting the transmission to a lower gear (when in driving mode), or both, until the temperature returns to the normal operating range. If the temperature does not return to normal, shut off the engine and refer to Trouble shooting or contact a local Authorized Engine Repair Location.

Most failures give an early warning. Look and listen for changes in performance, sound or engine appearance that can indicate service or engine repair is needed. Some changes to look for are:

1. Engine misfires
2. Vibration

3. Unusual engine noises
4. Sudden changes in engine operating temperatures or pressures
5. Excessive smoke
6. Loss of power
7. An increase in oil consumption
8. An increase in fuel consumption
9. Fuel, oil or coolant leaks

Operating the Engine (Cold Weather)

It is possible to operate engines in extremely cold environments if they are properly prepared and maintained. Satisfactory performance of an engine in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures.

The correct engine coolant, lubricating oil and fuels must be used for the cold weather range in which the engine is being operated. Below are the recommendations for these critical engine fluids:

Ambient Temperature of 0° to 32°C (32° to - 25°F)

1. Use 50% ethylene glycol antifreeze and 50% water for the engine coolant mixture.
2. Refer to Maintenance Specifications (Section 6) Oil recommendations for the correct specifications.
3. Diesel fuel must have maximum cloud and pour points 6°C (10°F) lower than the ambient temperature in which the engine operates.

Ambient Temperature of -32° to 54°C (-25° to -65°F)

1. Use 60% ethylene glycol antifreeze and 40% water for the engine coolant mixture.
2. Refer to Maintenance Specifications (Section 6) Oil recommendations for the correct specifications.
3. Diesel fuel must have maximum cloud and pour points 6°C (10°F) lower than the ambient temperature in which the engine operates.

Winterfronts and shutters can be used on a vehicle or equipment to reduce air flow through the radiator core into the engine compartment. This can reduce the time required to warm the engine and help maintain the engine coolant temperature. *Use only a winterfront available from Peterbilt (or OEM) dealer that is compatible with a 2002 EPA compliant engine cooling system*. ***Refer to the engine manual for additional information on cold weather operating aids***.

OPERATING

General Information

⚠ 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.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels if there is a possibility of uncontrolled movement.
3. Always perform safety checks prior to starting and using the drill.
4. Always operate the drill at full engine power when drilling.
5. Always use safe judgement when driving on unstable surfaces where there may be a risk of overturning or when loading onto a transporter where there is a risk of overturning. Always use a spotter.
6. Never drive or stop the drill on a slope or surface that is liable to collapse.
7. Before starting engine, always check to see that the control levers and drill feed are at stop, neutral or off position and that the parking brakes are applied.
8. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.

Operation

1. Before the drill startup, a pre-operational general inspection of the TH60 Waterwell drill should be performed in accordance with those instructions previously mentioned and in the instructions found in the Maintenance Section (Section 6).
2. Lower the driller platforms from road (driving) position to drilling position. Unbolt the bottom bolt and push the platforms down to a horizontal position as shown below.

3. Make sure all operator console controls are either "OFF" or in the "NEUTRAL" position and all control console gauges read zero.

4. The Engine Shutdown toggle switch must be in the UP (RUN) position.
5. The Emergency Brake Stop button is in the extended position (pulled out).

⚠ WARNING

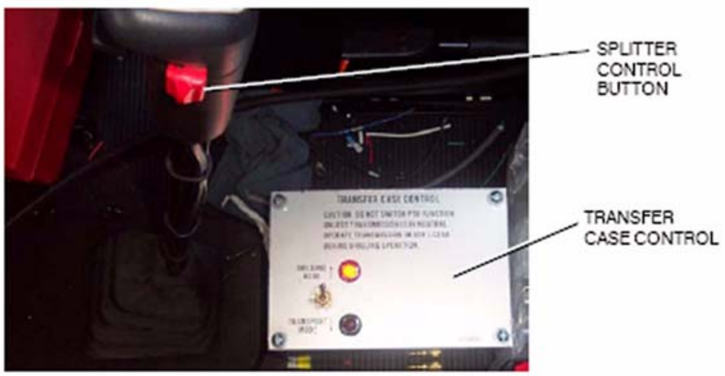
The Drill Feed (pulldown/pullback) valve lever must be in the "center" (neutral) position before starting the engine. If accidentally bumped into an operating position, it will cause serious damage when air is transferred back to the operator's control.

6. Start the engine from the truck cab. Turn the ignition switch to the "START" position. When the engine starts, release the key. Refer to "Starting Truck Engine" instructions.

NOTICE: *As a general rule, DO NOT operate the starter motor more than 30 seconds at a time without pausing to allow the starter motor to cool for at least 2 minutes. Overheating, caused by excessive cranking, will seriously damage the starter motor.*

7. Allow the engine to warm up at idle speed (1200 RPM) for a minimum of 5 minutes. Warm up time should be extended when extremely low ambient conditions (cold weather) occur or when battery power is depleted during initial start up.
8. Check the Engine and Compressor Air Cleaner indicators to determine if those elements require servicing.
9. Check the hydraulic system filter indicators to determine if those elements require servicing.
10. Check the panel gauges to insure all readings (pressures and temperatures) are within specifications:
    a. Tachometer: Idle Speed = 1200RPM
    b. Ammeter: Positive (Charging)
    c. Engine Water Temperature Gauge: 125°F to 165°F (51°C to 74°C)
11. Make sure the parking brake is in the extended position, i.e. pulled out.

12. Shift from the truck direct drive to PTO. The standard TH60 has a 13 speed transmission. The drilling gear is 8th L gear direct drive. Shift the transmission into 8th L gear and leave the clutch depressed when making the PTO/DIRECT DRIVE changes.



    a. Move the transfer case control switch to “Drilling Mode”. The drilling mode light will come on when it is engaged

    b. The transfer case control switch must be returned to “Transport Mode” position before attempting to drive or move the drill. The transport mode light will come on when it is engaged.

⚠ CAUTION

Do not switch PTO function unless transmission is in neutral. Operate transmission in 8th L gear during drilling operation.

13. Transfer the air pressure from the truck engine compressor to the operator’s console by turning the air transfer valve to a horizontal position.

Leveling the Drill

⚠ WARNING

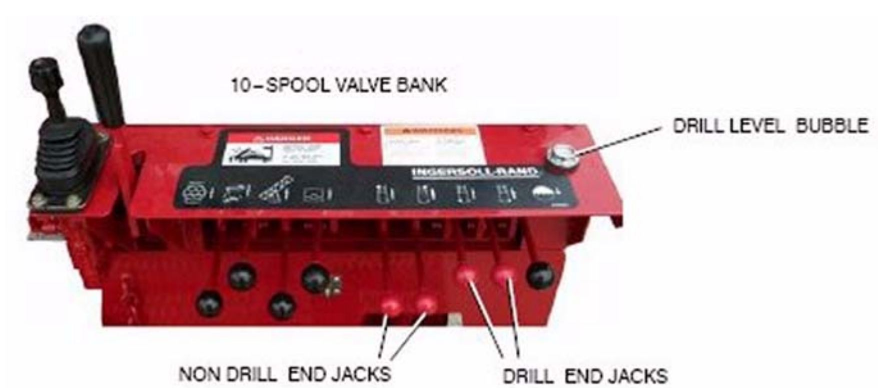
***Be sure the ground is level and solid before lowering the jacks. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk*.**

⚠ WARNING

Remember, in the level position, the jacks alone must carry the entire weight of the drill. It is imperative that adequate cribbing be used. THE LIABILITY FOR TIPPING A DRILL OVER LIES SOLELY WITH THE DRILLER.

1. Check ground conditions under the drill. Make sure it will support the weight of the drill.
2. Install suitable Cribbing (Blocking) under all jacks as required for ground conditions. The purpose of cribbing is to increase the area of jack pad.
3. Increase engine speed to 1800 RPM maximum with throttle control lever.

4. Raise the leveling jacks valve levers to extend the jacks and raise the drill. Methods may vary, but one way would be to extend the two rear jacks at the same time and then the two front (mid) jacks. Raise the drill evenly (front to rear and side to side) until the desired level is reached.



⚠ WARNING

***Raise the drill evenly to avoid inducing a twist into the truck frame*.**

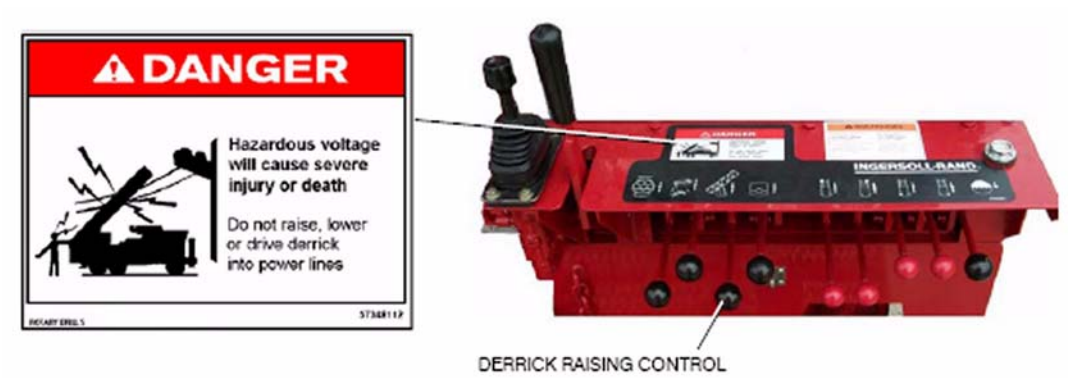
5. Keep the drill as low to ground as possible to lower the risk of rollover if ground gives away under one jack.
6. Level the drill to the drill level bubble.

NOTICE: *The derrick is plumb when the drill level bubble is centered*.

Raising the Derrick

⚠ DANGER

Before raising the derrick, make sure there are no overhead electrical power lines in the immediate vicinity.



⚠ WARNING

Check all hoses and cables to be sure they are free and clear. Check the derrick for any tools or loose objects before raising.

1. Ensure the drill is level.

NOTICE: *Check the blocking and cribbing before raising the derrick*.

2. The engine speed should be full speed.
3. The drill should be on its jacks and level at its lowest possible position.
4. Add slack to the main hoist cable if the cable is tied off. Check all hoses and cables to make sure they are clear and free and remain so during raising.

5. Remove the derrick anchor bolts from the derrick foot rests located on the main frame and store them in the table as shown below.

6. Locate the derrick raising control lever. (Raise the derrick by pulling the control lever up. Lower the derrick by pushing the control lever down.)

NOTICE: *Recheck hoses and cables making sure they do not snag or bind during raising.*

7. Raise the derrick until it is in the vertical position. Before the derrick approaches the vertical position, slowly move the control to its center position (or "feather" the control) to allow the derrick to position without impact.

8. When the derrick is raised, ***bolt it down*** to the derrick foot rests with the bolts removed in step 5. If not bolted down, ***any*** stress or pressure will warp the derrick and cause severe damage.

⚠ CAUTION

Never drill with anchor bolts unfastened.

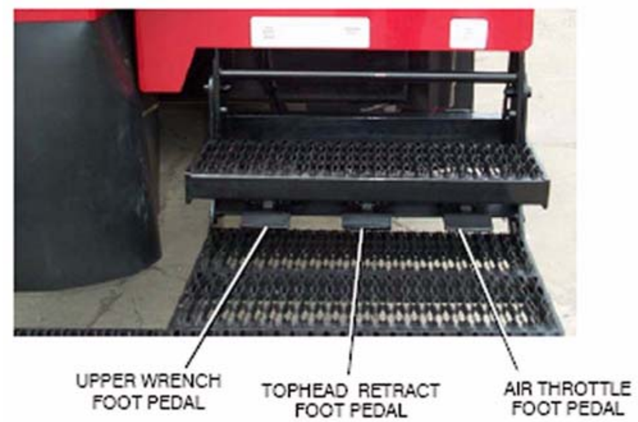
9. The rotary head should be in the retract (inner track) position.

10. Recheck to make sure the drill is still level.

Drill Setup

1. Move the drill feed control to UP position until the rotary head moves up and out of the retract position. The retract gates will open and close automatically when going out of retract.

2. Move the tophead fast feed control to DOWN position and bring the rotary tophead to the bottom of the derrick.
3. Grease the rotary head spindle sub threads.
4. Move the tophead fast feed control to UP position and raise the rotary tophead above the retract gates.
5. Follow these steps to bring the rotary head into retract position:



   a. Step on the tophead retract foot pedal to open the retract gates on the guide channel.
   b. While holding the tophead retract foot pedal down, move the drill feed control to DOWN position to start the rotary head moving into retract.
   c. Once the rotary tophead starts moving into retract position, ***release the tophead retract foot pedal*** or damage to the main air hose and tophead hoses will occur.
   d. Move the drill feed control to “CENTER” (neutral/stop) position when the rotary tophead is fully into retract.

Over Pressure Control

The TH60 feed system provides more than enough feed capability to “lift” the unit by overfeeding the bit. To reduce the possibility of tipping the drill over due to operator error in overfeeding, the “Over Pressure Control” has been added to the feed circuits.

⚠ WARNING

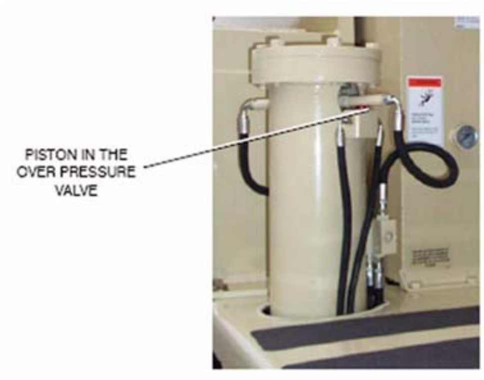
The Over Pressure Control does not relieve the operator from the responsibility of having control of the drill at all times. While the Over Pressure Control reduces the chances of a tipover, the operator must see that he does not overfeed the drill to this extent.

NOTICE: *The operator must ensure the jacks are located on firm ground. Nothing can prevent the drill from upsetting if the ground or shoring under the jacks gives way*.

NOTICE

LIABILITY FOR TIPPING A DRILL OVER LIES SOLELY WITH THE DRILLER.

To ensure the over pressure control is operational and working properly, the following procedure should be performed daily or before each drilling shift:



1. Locate the drill on a level, graded surface. Raise and level the drill just high enough so that the pistons in the over pressure valves on the drilling end jacks are no longer depressed. The tires should be on the ground, partially supporting the drill.
2. Remove all drill rod, stabilizers, hammers, etc. from the rotary head.
3. Raise and lock the derrick.
4. Move the empty rotary tophead to the bottom of the derrick using slow feed.
5. Turn the feed regulator to the maximum pulldown pressure of 2500 PSI.
6. Raise the leveling jack on the drilling end rod box side enough to depress the over pressure piston.
7. Read the feed pressure gauge and verify the feed pressure drops below 750 psi.

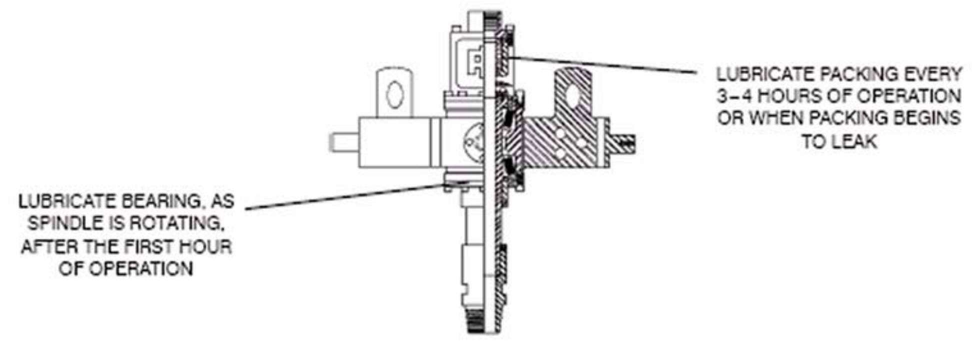
NOTICE: *If the feed pressure does not drop below 750 psi, troubleshoot and repair the circuit*.

8. Repeat the above for the drilling end console side leveling jack.
9. Repeat the above process using the fast feed controls.

If all checks are met, the over pressure control is functional and drilling can proceed.

Rotary Tophead Swivel

After the Over Pressure Control check and with the rotary tophead still at the bottom of the derrick, lubricate the packing and bearings before rotating the swivel, especially if the drill has not been operated over a period of time. Slowly rotate the spindle/swivel to unstick the packing from the washtube.



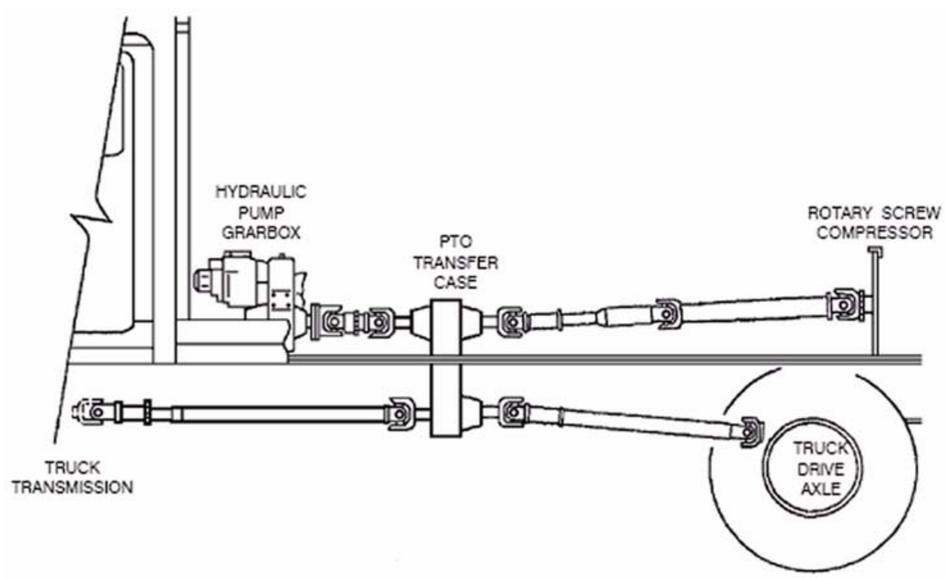
ROTARY HEAD SWIVEL

NOTICE: *Lubricate the bearings, with the spindle rotating, after the first hour of operation. Lubricate the packing every 3 - 4 hours of operation or when it begins to leak.*

Compressors

Air to operate drilling functions (sliding breakout wrench, upper holding wrench, retract cylinders) originates from the truck engine compressor and is transferred to the drill console through the air transfer valve.

Compressed air for down hole air and DHD air originates from a high pressure two stage, over/ under, oil flooded asymmetrical rotary screw compressor driven by the truck engine through a PTO Transfer Case.

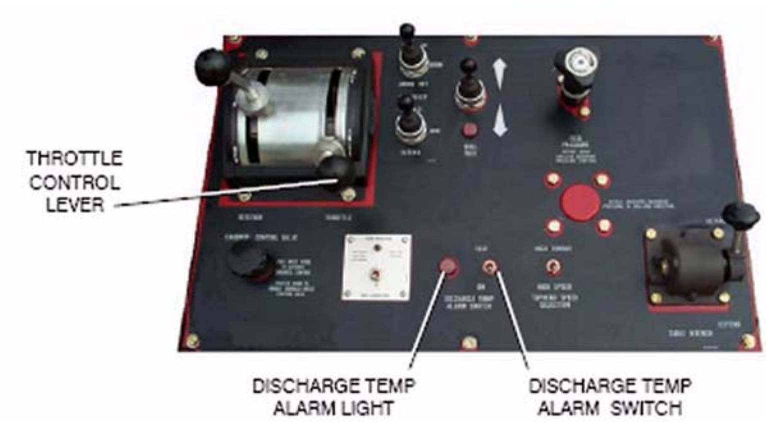


1. The Transfer Case Drive Engage and Disengage switch is used to engage the driveshaft from the transfer case to the screw compressor. When the air compressor drive shaft is engaged, the Compressor Engage Light will light up.

2. The Air Compressor Drive Clutch Control is the control for the air clutch to engage the rotary screw compressor drive shaft and the hydraulic drive. Lift the lever slowly to depress the clutch. Lower the lever slowly to release clutch.

NOTICE: *Warm the compressor oil for 15-20 minutes before making air*.

3. Turn on the air intake (On/Off) switch to build air. The Air Compressor On/Off Switch is used to control the UL-88 regulator which regulates the compressor air inlet (butterfly) valve. With the switch in the ON position, the air inlet opens to atmosphere, allowing the rotary screw compressor to build air. With the switch in the OFF position, the air inlet valve closes and prevents atmosphere air flow into the rotary screw compressor. The Compressor will unload at about 125-140 psi (8.63-9.66 bar) after the engine starts. The operator uses the compressor ON/OFF switch to build air to go down the hole.
4. With the air standpipe ball valve partially closed, the receiver air pressure gauge should read 75-80 psi (5-5.5 bar).
5. Increase engine speed to 1800 rpm.
6. Test the discharge temperature alarm switch to see if it is operational (red warning light ***and*** alarm bell.



Rotary Drill

Rotary Drill String

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 applying sufficient down pressure onto the bit 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.

⚠ WARNING

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

⚠ 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.

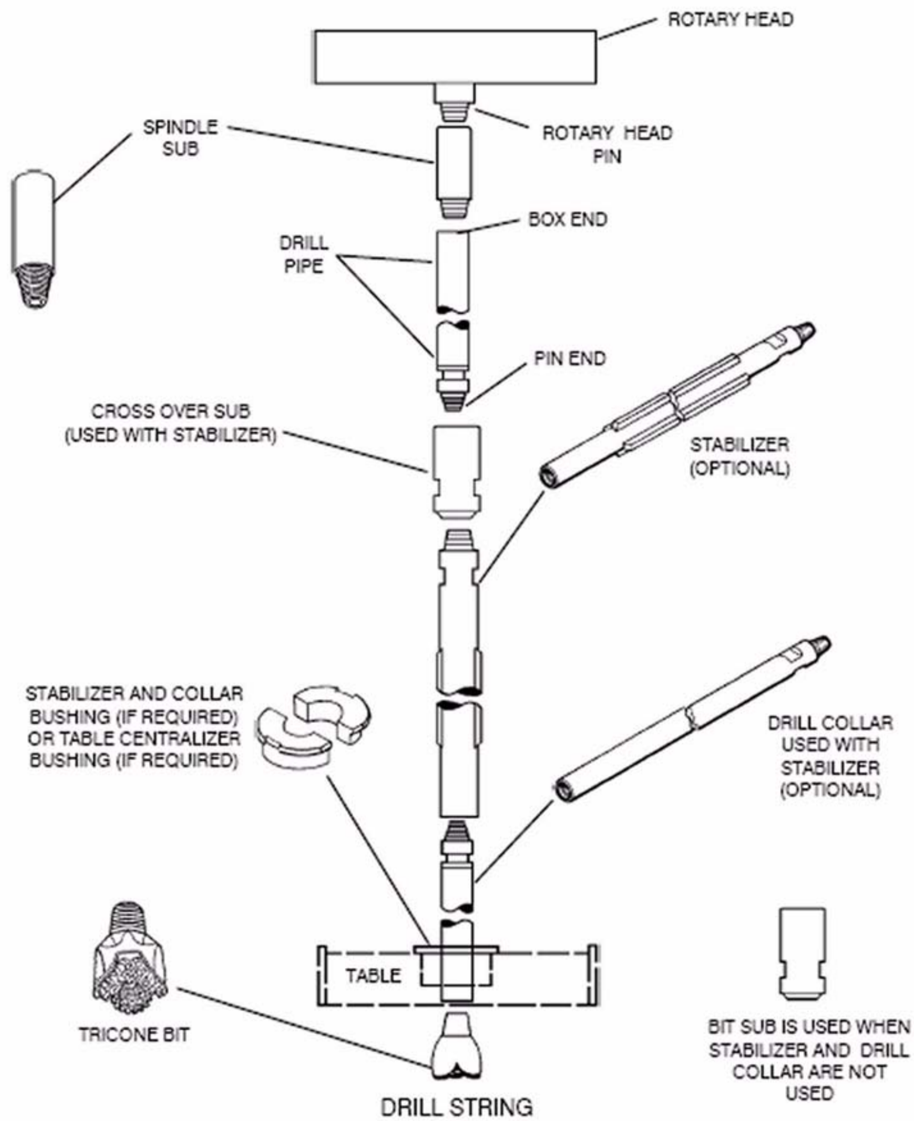
Always wear correct safety gear while working on or around the drill. This includes an Approved Hard Hat, Safety Glasses, Steel Toe Shoes, Gloves, Respirator and Ear Protection. Do not wear loose fitting clothing that can become caught in rotating components.

⚠ WARNING

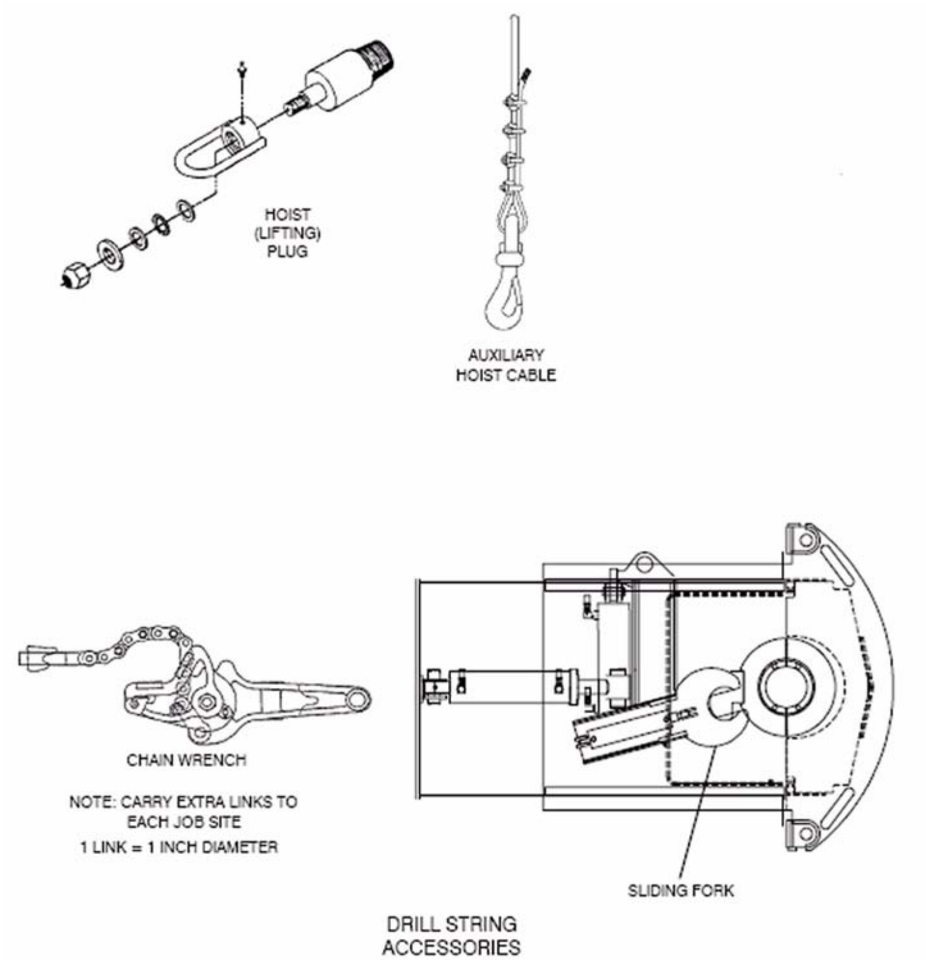
If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

Rotary Drill String Assembly

Illustrated below are the drill string and the accessories and tools needed to install and change drill pipe, bits and spindles



Rotary Drill String Assembly (Continued)



The process for building the Rotary Drill String assembly starts with loading the stabilizer and the spindle sub and crossover sub, if required. Next the tricone bit is mounted, then the drill pipe is added. In some cases, a stabilizer is not needed and the tricone bit is mounted onto a bit sub installed in place of the stabilizer assembly.

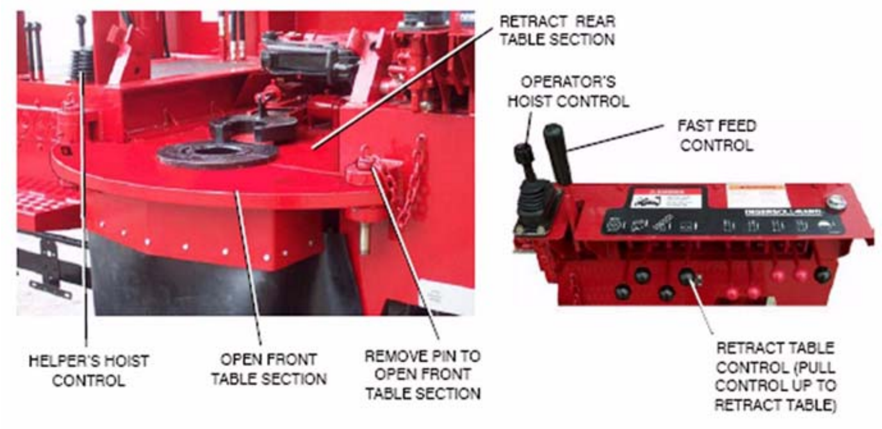
Loading Stabilizer, Tricone Bit and Stabilizer Bushings

The TH60 is designed to drill a variety of holes. Some holes will require a stabilizer at the bottom of the drill string. Follow the process below to mount the stabilizer, bit and bushings.

1. Select the stabilizer and manually screw on the crossover sub, if needed.
2. Install hoist (lifting) plug onto sub/stabilizer and connect main hoist cable.

⚠ 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.

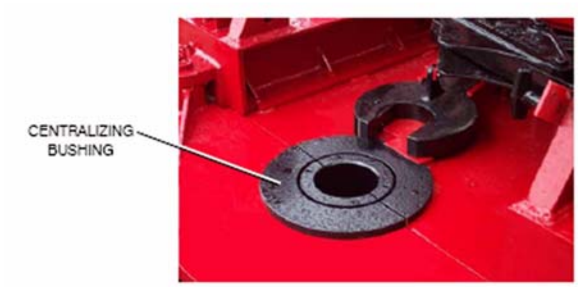


3. Retract the table. Then open front table section and lower the stabilizer through opening.
4. Raise hoist until stabilizer is above centralizer table. The hoist can be raised from one of two controls. One is located on the operator's console and the other is at the helper's controls. Push the control away from the operator to raise the hoist.

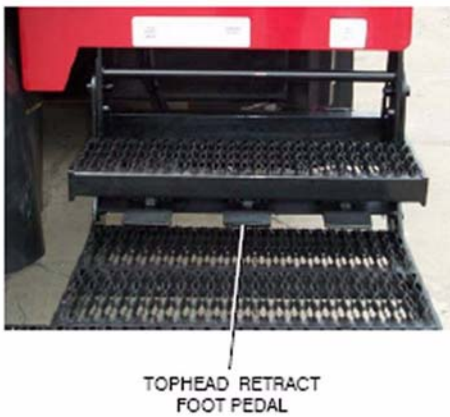
⚠ WARNING

***Do not let the centralizer bushing drop into the drilled hole*.**

5. Put a block of wood or metal on the ground, underneath the drill table, so the stabilizer or starter pipe can rest on the ground while making connections. For short stabilizers, secure the upper section on the drill table with a fork chuck wrench so rotary top head can be threaded to it.



6. Install the centralizer bushing.
7. Lower stabilizer or starter pipe through table and onto the block of wood or metal plate on the ground. Close the front table section, then close the back table section.
8. Remove hoist plug and move hoist cable out of the way.
9. Lubricate threads of sub/stabilizer with tool joint compound.



10. Bring rotary tophead out of retract and feed down the derrick until it is just above stabilizer. To feed the rotary head down the derrick, pull the drill feed control toward the operator.
11. Align tool joints and feed the rotary tophead down while using slow forward rotation to make a connection. Forward rotation is achieved by pushing the rotation control away from the operator.
12. Once the connection is made, feed the tophead up until stabilizer is above the table.
13. Remove the stabilizer bushings.
14. Use this same process to add the drill collar that will be used with the stabilizer. Raise this assembly above the table.
15. Install the rotary (or tricone) bit basket and the appropriate bit basket insert into the drill table.
16. Place the tricone bit into the bit basket.
17. Lubricate the threads on the bit.
18. Feed the rotary tophead and the stabilizer (or drill rod) down and engage the threads on the tricone bit. Tighten securely by using slow forward rotation.
19. Use slow forward rotation to tighten the bit onto the stabilizer. Tighten securely.
20. Raise the stabilizer assembly above the table.
21. Remove the bit basket and bit basket insert.
22. Lower the stabilizer until the bit is below the table.
23. Install stabilizer bushings in table.

Pipe Handling Procedures

Prepare to Add Drill Pipe to Drill String

Once the string is drilled down to the flats level with the table and the stabilizer, bit and bushings are in place, it is time to add the drill pipe. The drill string must be separated below the spindle sub. The general procedure for adding drill pipe uses the following steps, regardless of location.

WARNING

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

WARNING

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

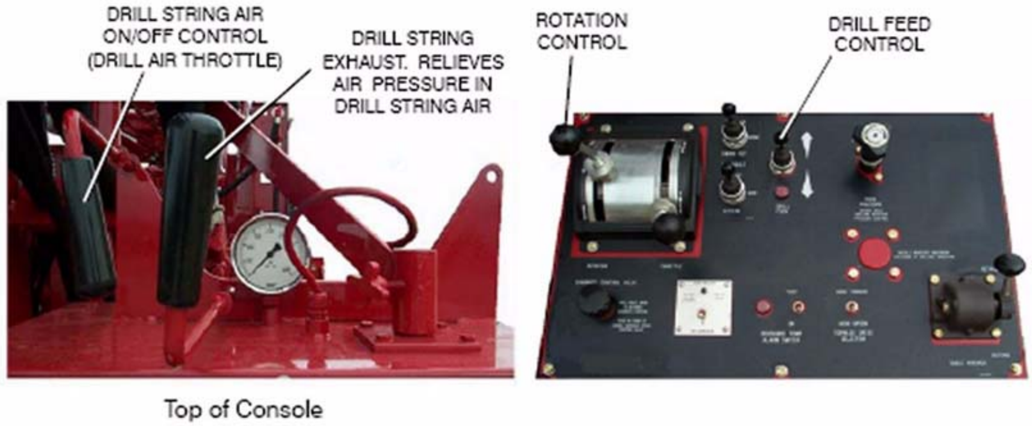
Safety should be the main concern for anyone working on or around the drill. Do not perform any function that could put someone in danger.

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.

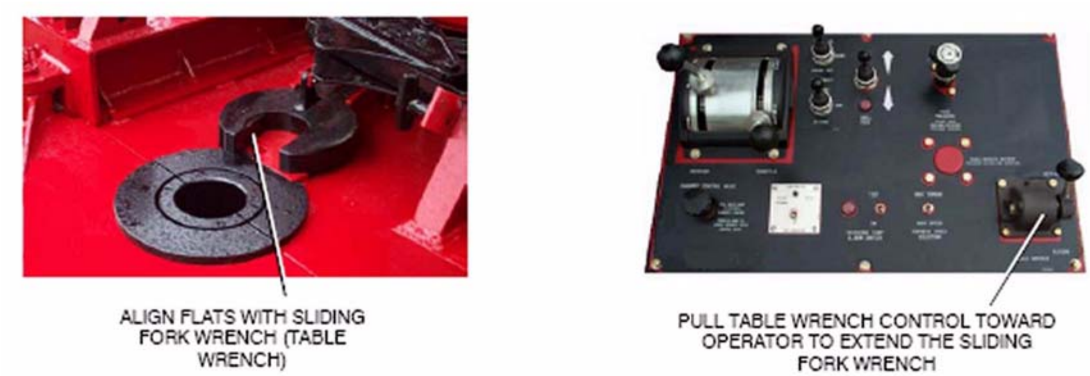
WARNING

Unexpected drill motion or moving parts can cut or crush. If you are not experienced with the drill's controls and instruments, read and understand Section 4 - Operating Controls & Instruments.

1. Drill down until the box end of the pipe flats or crossover sub flats pass below the drill table.



2. Stop rotation and feed.
3. Turn off the drill string air by pulling the drill throttle control out.
4. Open the table and remove the stabilizer or DHD bushing, then mount drill pipe centralizer bushing and close table.



5. Reverse feed and raise the pipe flats or crossover sub flats above the table. Rotate the drill string slowly until the sliding fork wrench (table wrench) aligns with the flats.
6. Extend the table wrench onto the flats. Extend the table wrench by pulling the table wrench control towards the operator.

7. Turn off the water injection, if equipped. Push the control down to neutral (or center) position to turn off the water injection.
8. Turn off the DHD lubricator, if equipped.
9. Open the drill string exhaust. Allow all air pressure to escape the drill string. Close the drill string vent.

10. Loosen the threaded joint by pulling the rotation control toward the operator.
11. As soon as the threads loosen, gently push the drill feed control away from the operator to feed the rotary tophead up until the joint has separated, then return the drill feed control to the center position.
12. Once the joint is separated, push the fast feed control away from the operator to feed the rotary tophead to the top of the derrick.

Adding Drill Pipe to the Drill String

Drill pipe is stored in the carousel, the pipe rack or on a separate service vehicle and is hoisted into position to connect to the rotary tophead. When a hole is started, pipe is added to the drill string from the carousel first. When all of the pipe is removed from the carousel, pipe is then taken from the pipe rack on the side of the drill. If more pipe is needed to complete the hole, it must be taken from the ground or another vehicle.

⚠ WARNING

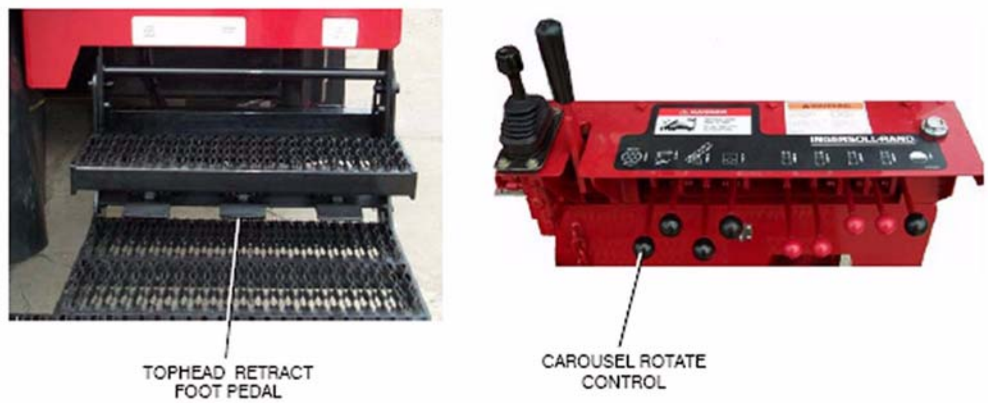
Heavy components must be handled with care using appropriate lifting aids provided to facilitate component lifting operations.

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.

Adding Drill Pipe from the Carousel

1. To add drill pipe from the carousel, open the retract gates using the rotary tophead retract foot pedal. Hold the retract gates open and move the rotary tophead down slowly. The moment the upper rollers are in the retract gate channels, close the retract gate by releasing the rotary tophead retract foot pedal.



2. Rotate the carousel with the carousel rotation control until the drill pipe is directly under the rotary tophead spindle.
3. Start slow forward rotation with the feed rotation control. Continue to lower the rotary tophead until the spindle sub makes contact with the drill pipe in the carousel.
4. Increase forward rotation at a medium speed as the drill pipe rises onto the threads.
5. Tighten the joint until the pipe rotates in the carousel cup. Look up at the joint and ensure the joint is made.
6. Stop rotation.
7. Raise the drill pipe out of the carousel. Continue to raise the rotary tophead out of the retract track and onto the main track. The retract gates will open and close again without operator assistance when the rotary tophead is moved up out of retract.
8. Listen for both retract gates to close, then lower the drill pipe to a position immediately above the drill string assembly held by the sliding fork wrench. Lubricate the threads.
9. Lower the drill pipe until the pin makes contact with the drill string assembly in the table.
10. Start forward rotation and feed down slightly until the joint is made. Make sure the joint is tight.

11. Stop feed and rotation. Release torque on the sliding fork wrench by reversing the rotation by 1/4 inch (6.35 mm).
12. Raise the drill string slightly until the sliding fork wrench can be retracted away from the drill pipe.
13. Begin drilling.

Adding Drill Pipe from the Pipe Rack

In order to add drill pipe to the drill string from the pipe rack, one joint of pipe must be placed in the carousel. Therefore, when drilling a deep hole, one section of the carousel must be left open to receive the extra joint of pipe. The technique is similar to a table drive operation in that the extra joint must be drilled in and then removed in order to add a section of pipe from the pipe rack.

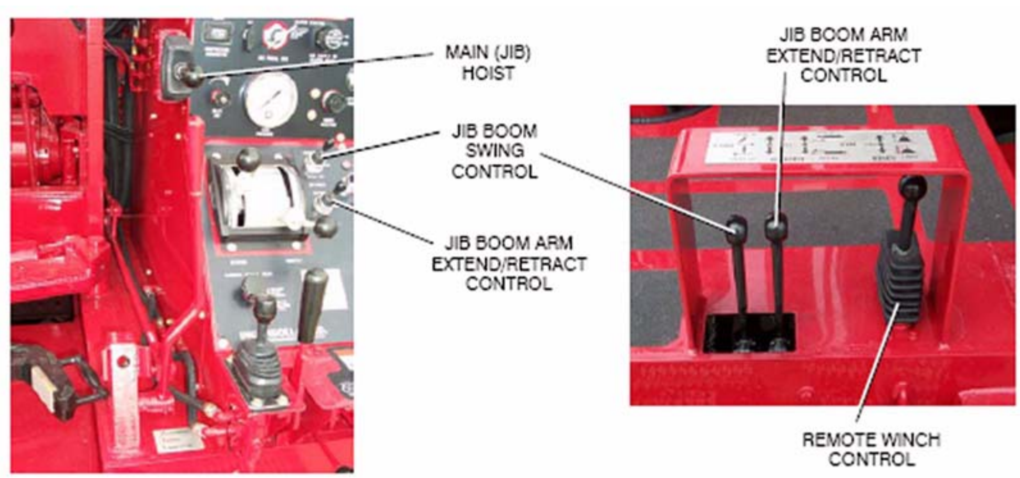
1. Raise the rotary head and one drill pipe out of the hole.
2. Extend the sliding fork wrench (table wrench) onto the flats of the lower drill pipe.
3. Break the joint at the table. If the upper pipe comes loose first, go to the next step. If not, raise the rotary tophead and pipe to the top of the derrick and into the retract channels. Open the retract gates using the rotary tophead retract foot pedal. Hold the retract gates open and move the rotary tophead down slowly. The moment the upper rollers are in the retract channels, close the retract gates by releasing the rotary tophead retract foot pedal.

4. If the upper pipe does not come loose first, then, using the hydraulic breakout wrench, break the joint at the table and place the pipe into the carousel. Make sure the pipe is secure to the rotary tophead.
5. Attach the hoist plug to the box end of the pipe in the pipe rack. Extend the jib arm and swing the jib over the pipe rack.
6. Connect the hoist jib line to the hoist plug.
7. Carefully lift the drill pipe until it hangs vertical.
8. Swing the jib back to the center of the derrick and retract the jib into position over the drill string.

9. Lubricate the pin end tool joint and lower the pipe until it engages the pipe in the table.
10. Screw the pipe hanging on the hoist into the pipe in the table by hand or use a small chain wrench.
11. Raise the hoist slightly, lifting the entire drill string and retract sliding fork wrench.
12. Lower the drill string into the hole until the sliding fork wrench can be engaged at the box end of the added drill pipe.
13. Align flats and engage the sliding fork wrench to secure the string to the table.
14. Remove the hoist plug.
15. Bring the rotary tophead and the drill pipe still attached up and out of the retract channels, then lower to connect to the pipe in the table. Lubricate threads before connecting.
16. Resume drilling.

Adding Drill Pipe from Single Pipe Loader

The single pipe loader is used to load drill pipe when the carousel is not used. Pipe must be loaded into the single pipe loader from the pipe rack or from a service vehicle.



1. Attach the pipe handling tool (sling) to the hook on the jib hoist.
2. Lower the pipe handling tool until it can be installed onto a joint of pipe.
3. Connect the pipe handling tool (sling) to a joint of pipe. The top (spring loaded end) of the pipe handling tool is first inserted into the box end of the drill pipe. Then, by compressing the spring, the bottom hook can be inserted into the pin end of the pipe.

⚠ WARNING

Drill pipe must be kept under control at all times. Serious injury or death can result if pipe falls or rolls. The pipe must be prevented from sliding off of the trailer of rack and hitting the hoist operator.

4. Raise the pipe until it is hanging beside the single pipe loader.
5. Use the jib swing control to move the pipe in line with the loader.
6. Lift the drill pipe up and carefully position the lower end of the drill pipe into the single pipe loader boot. Then lower it all the way to the bottom of the boot.
7. Apply slack to the hoist line slightly.
8. Pull the hook down and out of the pin end of the pipe.
9. Raise the hoist and remove the pipe handling tool from the drill pipe.
10. Swing the pipe handling tool out of the way.
11. Swing the single pipe loader under the rotary tophead.
12. Feed rotary tophead down and start forward rotation until the spindle adapter makes contact with the box end of the pipe standing in the single pipe loader.
13. Tighten the joint until the pipe rotates in the bottom of the loader boot.
14. Stop feed and rotation.
15. Raise the drill pipe out of the loader.
16. Lubricate the pipe threads.
17. Start a slow forward rotation and feed down to connect the joint. Continue until the joint is tight.
18. Stop the feed and rotation. Release the torque on the sliding fork wrench by reversing the rotation by 1/4 inch.
19. Raise the drill string slightly until the sliding fork wrench can be retracted away from the pipe.
20. Resume drilling.

Changing the DHD Bit

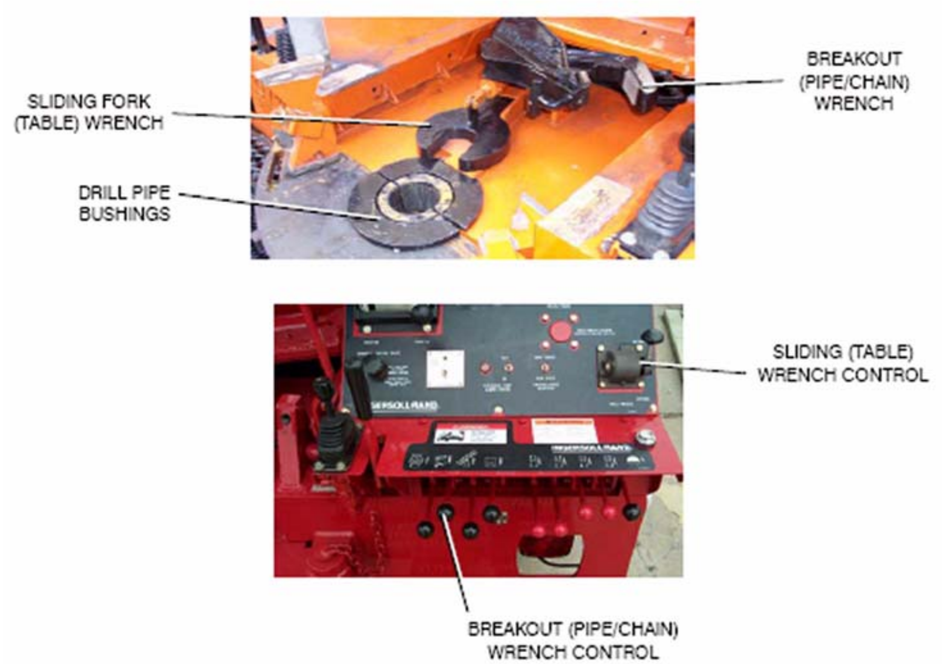
1. Remove all drill pipe from the drill string and store. Connect the rotary tophead to the DHD.
2. Feed the rotary tophead up until the DHD is just below the table.
3. Remove the drill pipe bushings.
4. Feed the DHD up until it is above the table.

5. Install the bit basket and the appropriate insert.
6. Lower the bit into the basket.

⚠ WARNING

Do not force chuck into the bit.

7. Retract the breakout wrench cylinder and position the wrench onto the chuck.



8. Extend the breakout cylinder to loosen the chuck.
9. When the chuck is loose, remove the breakout chain wrench.
10. Use reverse rotation and slowly feed up to unscrew the chuck from the wear sleeve.
11. Feed the DHD up until the retaining rings and the chuck can be removed from the bit.
12. Replace the bit with a new bit.
13. Install the chuck and retaining rings on the new bit.
14. Lubricate the threads with tool joint compound.
15. Slowly feed wear sleeve over bit while holding chuck up.
16. Use slow forward rotation to connect the chuck to the wear sleeve. Tighten securely to the proper torque.
17. Feed the DHD assembly up and remove the bit basket and the bit insert.

Changing Rotary Bit

1. Remove all drill pipe from the drill string and store. Do not remove the stabilizer.
2. Feed the stabilizer up until it is just below the table.
3. Remove the drill pipe bushings.
4. Feed the stabilizer up until the bit is above the table.
5. Mount the bit basket and the appropriate insert into the table.
6. Lower the bit into the basket.

⚠ WARNING

Do not force the bit into the basket.

7. Retract the pipe/chain wrench cylinder and position the wrench onto the bit.
8. Extend the pipe/chain wrench cylinder to loosen the bit.
9. When the bit is loose, remove the pipe/chain wrench.
10. Use reverse rotation and slowly feed up to unscrew the button bit from the stabilizer.
11. Remove the old bit and place the new bit into the insert in the bit basket.
12. Lubricate the threads on the new bit.
13. Using the rotary tophead, feed the stabilizer down onto the threads of the bit and tighten using forward rotation.
14. Raise the rotary tophead and remove the bit basket.
15. Resume drilling.

Removing Drill Pipe and Drilling Tools

When the hole is finished and the drill pipe and drilling tools must be put up, it is important to remember to load the drill pipe into the carousel before reloading the pipe rack and any service vehicle.

Reloading Pipe Into Carousel

1. Raise the rotary tophead and one drill pipe out of the hole.
2. Bring the joint between the top drill pipe and the next drill pipe above the table and extend the sliding fork wrench on the flats of the lower pipe.
3. Reverse the rotation of the rotary tophead at full pump volume and break the joint at the table. If the upper joint breaks first, stop rotation. Break the joint by using the breakout wrench and hydraulic breakout cylinder.

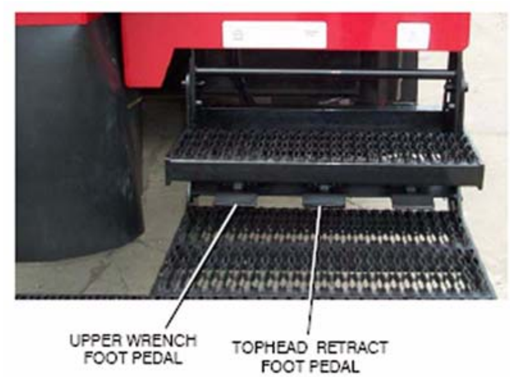
CAUTION

Watch the upper tool joint when breaking out.

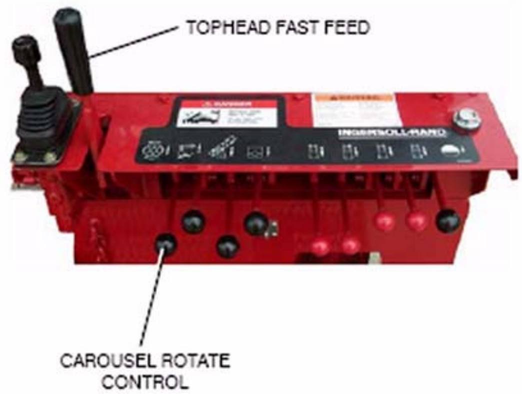
WARNING

***If the upper joint comes loose before the lower joint, stop rotation immediately*.**

4. Work the breakout wrench back and forth until the shoulders are loose.
5. Once the lower shoulder is loose, remove the breakout pipe/chain wrench and the breakout hydraulic cylinder.
6. Use reverse rotation to finish unscrewing the lower section.
7. Once the joint is apart, raise the rotary tophead with drill pipe to the top of the derrick and lower into the retract channels.
8. Lower the drill pipe into the tube in the carousel. Lower the drill pipe (pulldown low speed) until the bottom drill rod shoulder touches the top of the carousel spring. This places the drill pipe flats in the correct position to engage the upper breakout wrench.



9. Engage the upper breakout wrench and use reverse rotation to break the tool joint.
10. Once the joint is broken, stop rotation and disengage the upper breakout wrench.
11. Lower the drill pipe to the bottom of the carousel cup and then continue reverse rotation to complete breaking the joint.
12. Raise the rotary tophead and rotate the carousel to ready it for the next drill pipe.



13. Bring the rotary tophead out of the retract channels.
14. Fast feed the rotary tophead to the bottom of the derrick to pick up another joint.
15. Repeat this process until all but one of the carousel cups are full. Always leave one cup open in case of trouble.

Reloading Pipe Into Pipe Rack

1. Lower the rotary tophead and drill string to the table.
2. Engage the sliding fork wrench onto the flats of the drill pipe.
3. Reverse the rotary tophead rotation and break the joint at the table.
4. Once the joint is broken, raise the rotary tophead to the top of the derrick and move it into the retract channels.
5. Thread the hoist plug into the box end of the drill pipe in the table.
6. Connect the jib hoist hook to the hoist plug.
7. Raise the drill string with the jib hoist until the next pipe joint can be engaged with the sliding fork wrench.
8. Use the breakout wrench and the breakout hydraulic cylinder to loosen the pipe joint at the table. Complete unscrewing the joint by hand.
9. Use the jib hoist to raise the drill pipe and move it into the side of the pipe rack. Then lower it into the pipe rack.
10. Remove the hoist plug and attach it to the next pipe in the table.
11. Repeat this process until the pipe rack is full.

Reloading Pipe to Service Vehicle

1. Bring the rotary tophead out of the retract channels.

2. Fast feed the rotary tophead down to the table and connect to the drill pipe at the table. Do not torque the connection.
3. Raise the rotary tophead and drill string until the next pipe joint is at the table. Break the joint.
4. Raise the rotary tophead and the one drill pipe to the top of the derrick.
5. Move the single pipe loader under the drill.
6. Lower the rotary tophead and drill pipe to the bottom of the cup of the single pipe loader.
7. Use reverse rotation to finish disconnecting the rotary tophead from the drill pipe. Raise the rotary tophead up and out of the way.
8. Mount the pipe handling tool (sling) onto the jib hoist hook. Raise the pipe handling tool and install the top of the tool into the pipe in the loader.
9. Mount the bottom of the tool to the bottom of the pipe.
10. Mount a “tag” line to the drill pipe.
11. Raise the jib hoist until the pipe is just above the cup of the single pipe loader.
12. Swing the jib hoist to the service vehicle (or laydown area) and align the pipe to be laid down.
13. Slowly lower the jib hoist and pull the box end of the pipe away from the drill as it is being lowered.
14. When the pipe is safely down and is prevented from rolling, remove the pipe handling tool.
15. Continue this process until all the drill pipe has been relocated.

Loading Drill Pipe Storage Rack

1. The drill pipe storage rack has a capacity for nine 3-1/2 inch x 20 foot (89 mm x 6.1 m) or seven 4-1/2 inch x 20 foot (114 mm x 6.1 m) drill pipe.
2. To load the rack, thread the hoist plug into the box end of the drill pipe.
3. Raise the pipe to the height required to clear the end of the rack.
4. Lower the pipe with the hoist while guiding the pipe in the rack.
5. Remove the hoist plug.
6. Repeat the procedure until the rack is full as described in step 1 above.

Down Hole Drill

DHD Drill String

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.

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

WARNING

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

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

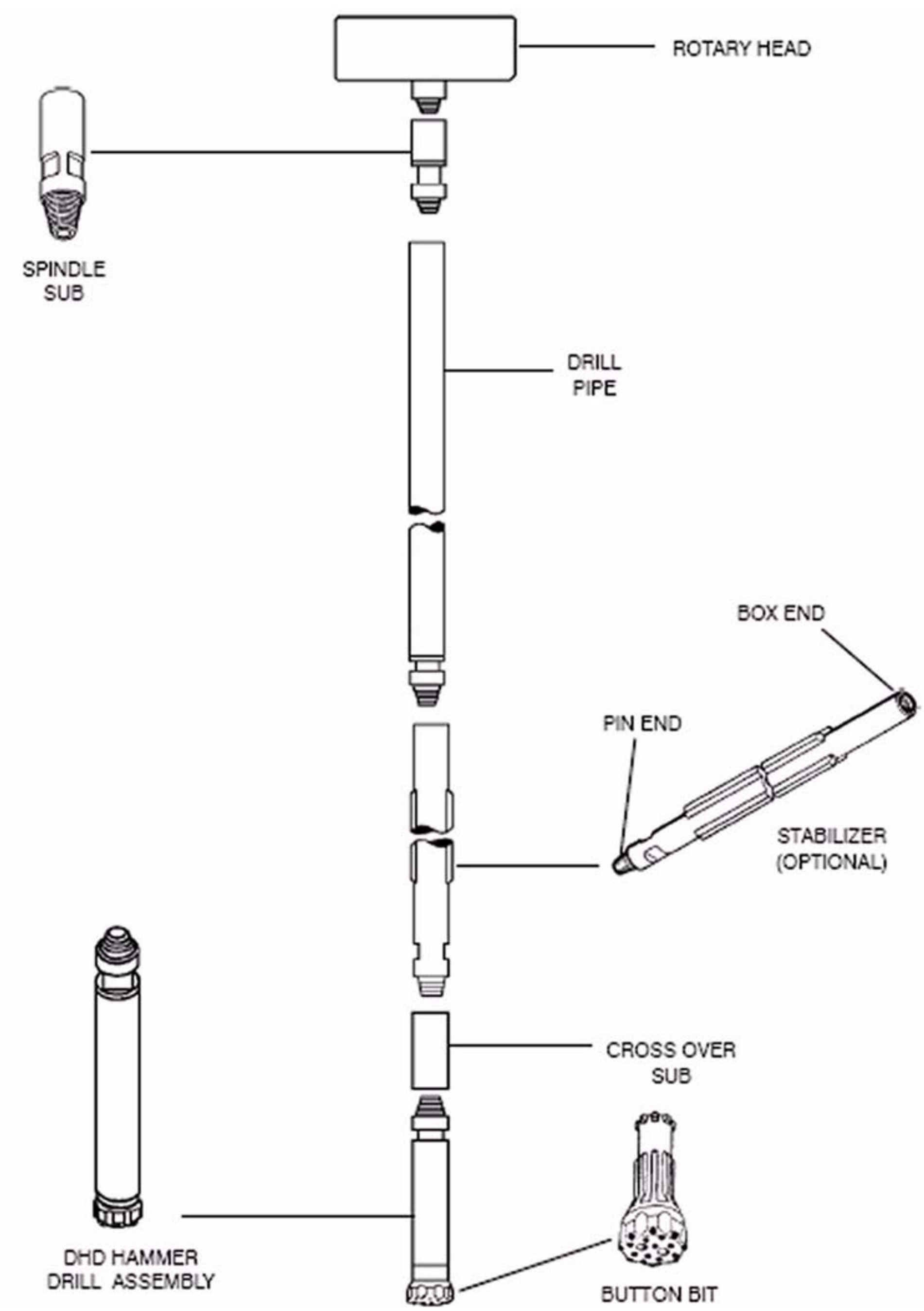
Unexpected drill motion or moving parts can cut or crush. Shut down engine before working on the drill.

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

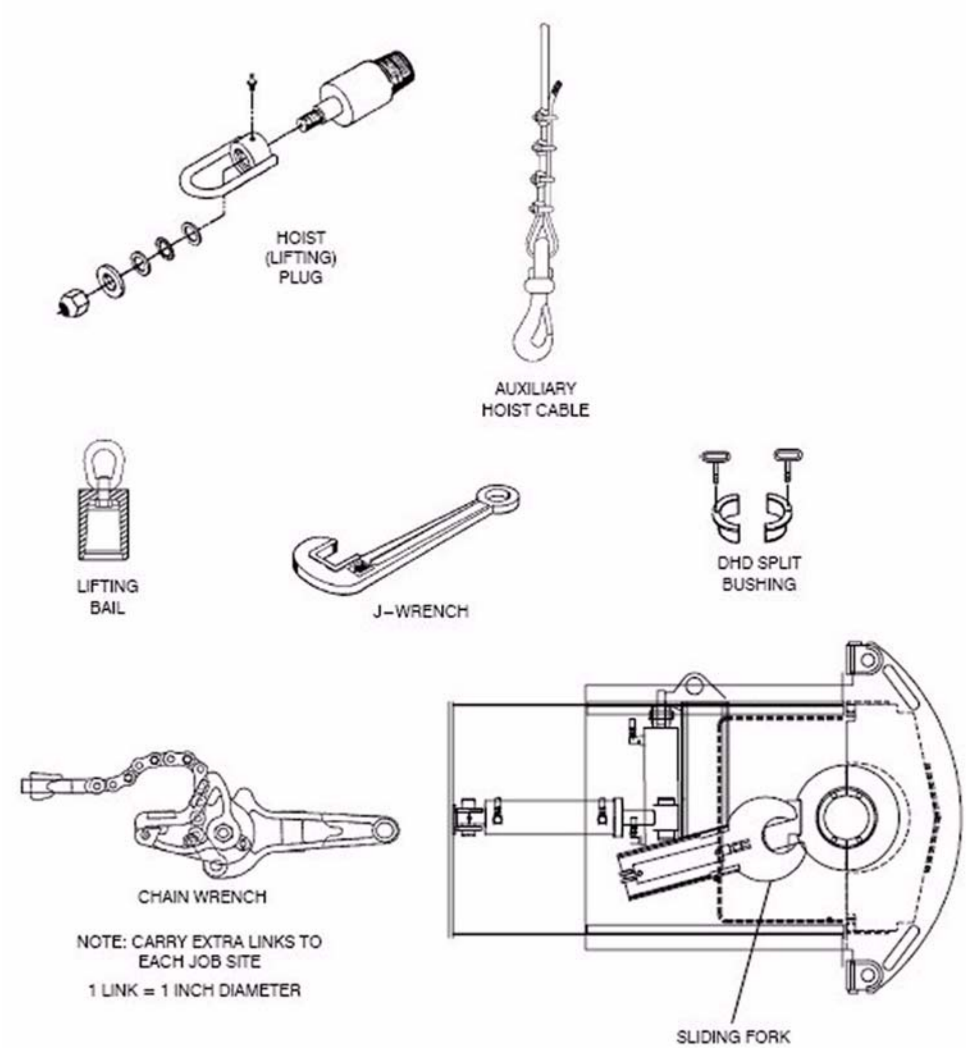
Read and understand Section 2 - Safety Precautions and Guidelines before you operate or perform any maintenance, service or repairs on the drill.

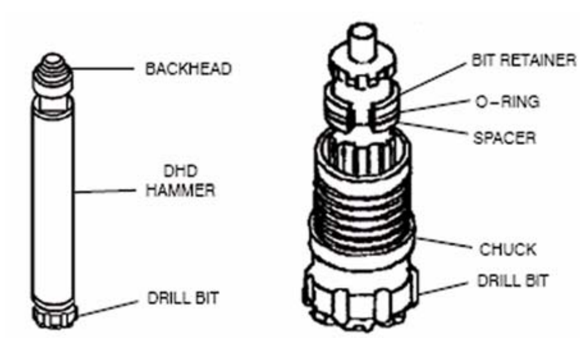
DHD Drill String Assembly

Illustrated below are the drill string and the accessories and tools needed to install and change drill pipe, bits and spindles.



DHD Drill String Assembly (continued)



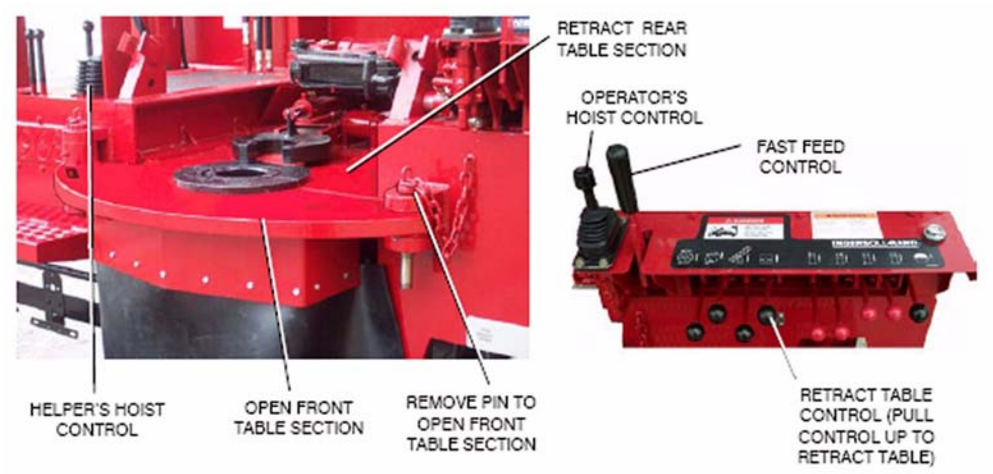


The DHD (Down Hole Drill) can be used to drill overburden and rock. Casing bits and reamers are used to drill the initial holes to install casing and to provide an annulus for grouting. The following instructions are for a stabilizer to be used. If a stabilizer is not required, use a drill pipe from the carousel in its place.

1. Select the stabilizer and manually screw on the crossover sub, if needed.
2. Install hoist (lifting) plug onto stabilizer/sub and connect main hoist cable.

⚠ 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.



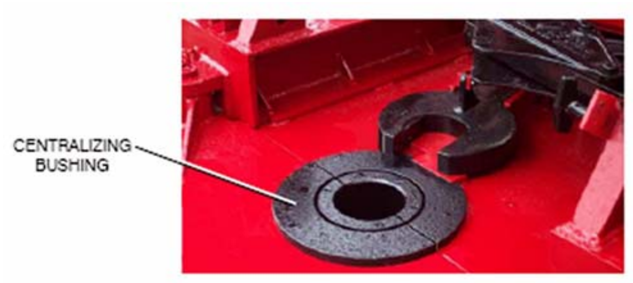
3. Raise hoist until stabilizer is above centralizer table. The hoist can be raised from one of two controls. One is located on the operator's console and the other is at the helper's controls. Push the control away from the operator to raise the hoist.
4. Retract the table. Open the front table section and lower the stabilizer through opening.

⚠ WARNING

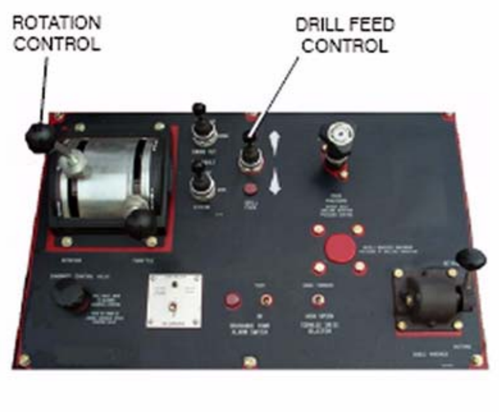
Do not let centralizer bushing drop into drilled hole.

5. Place a block of wood or metal on the ground underneath the drill table so the stabilizer or starter pipe can rest on the ground while making connections. For short stabilizers, secure the upper section on the drill table with a fork chuck wrench so rotary tophead can be threaded to it.

6. Install the centralizer bushing.



7. Lower stabilizer or starter pipe through table and onto the block of wood or metal plate on the ground. Close the front table section and then close the back table section.
8. Remove the hoist plug and move hoist cable out of the way.
9. Lubricate threads of sub/stabilizer with tool joint compound.



10. Bring rotary tophead out of retract and feed down the derrick until it is just above stabilizer. To feed the rotary tophead down the derrick, pull the drill feed control toward the operator.
11. Manually align tool joints and feed rotary tophead down while using slow forward rotation to make connection. Forward rotation is achieved by pushing the rotation control away from the operator.
12. Once connection is made, feed the tophead up until stabilizer is above the table.
13. Remove the stabilizer bushings.
14. Mount the lifting bail to the backhead of the DHD.

⚠ WARNING

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

15. Connect the hoist cable to the lifting bail and raise DHD until it hangs over centralizer table. The hoist can be raised from one of two controls. One is located on the operator's console and the other is at the helper's controls. Push the control away from the operator to raise the hoist.
16. Install the DHD table bushings and lower the DHD into the hole in the table.
17. Mount the J-Wrench onto the flats at the backhead with the handle against the derrick.
18. Lower the DHD until it hangs on the J-Wrench.
19. Remove the lifting bail and secure the hoist cable out of the way.

NOTICE: *When using the DHD for the first time, pour one cup (8 oz./230ml) of Rock Drill Oil into the drill backhead to lubricate it before starting the DHD.* ***Follow actual manufacturer's lubrication instructions when using DHD hammers***.

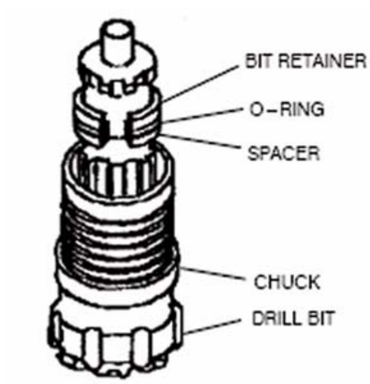
20. Use the fast feed drill control to lower the rotary tophead until the stabilizer is just above the DHD backhead and stop.
21. Lubricate the threads with tool joint compound.
22. Slowly feed the stabilizer and crossover sub assembly onto the DHD backhead and slowly rotate until the J-Wrench starts to rotate.

⚠ CAUTION

Keep away from the J-Wrench while tightening the connection.

23. Stop rotation and feed. Release the torque on the J-Wrench by reversing the rotation by 1/4 inch (6.35mm).

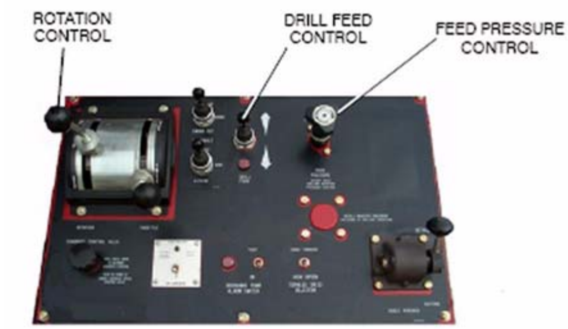
24. Cover the drilled hole so that parts and components used do not fall into the hole.
25. Remove the J-Wrench and the DHD table bushings.
26. Break the DHD chuck loose.
27. Feed the rotary head up until the DHD chuck is about two feet above the table.
28. Manually unscrew the chuck and remove the bit retaining rings.
29. Install the bit basket into the table and secure it.
30. Install the appropriate sized insert into the basket.
31. Manually install the button bit into the insert. Be careful not to damage the carbide buttons.
32. Install the DHD chuck over the splines of the bit. Install the bit retaining rings onto the bit.
33. Lubricate the threads of the chuck with tool joint compound.
34. Slowly feed the wear sleeve over the bit while holding the chuck up.
35. Use slow forward rotation to connect the chuck to the wear sleeve. Tighten securely using proper torque.
36. Feed the DHD assembly up and remove the bit basket and insert.
37. Feed the bit below the table and install the DHD table bushings.



Drilling With Air

Drilling operations are similar whether drilling with straight air rotary, down--hole hammer, straight mud or mud/air etc.

This text explains the operation procedure for straight air rotary drilling. The procedure differences for water injection drilling, DHD hammer drilling and mud drilling are explained after the straight air rotary drilling procedure.



1. Make sure the feed pressure control is turned out, but not completely.
2. Lower the drill pipe, with drill feed low speed, until the rotary bit is approximately 4 to 6 inches (101.6 to 152.4 mm) above ground.
3. Start spindle rotation by moving the rotation control lever to full “DRILL” position and start drilling. ***Always*** drill with pulldown low speed.
4. A driller can tell what is happening down hole by watching three key gauges and the cuttings that are coming out of the hole. The further down the hole, the more important these gauges become because depth increases the pressure readings.

   a. ***Rotation Pressure Gauge*** - Measures the amount of torque being demanded from the rotary tophead (or amount of hydraulic pressure being demanded by the rotary tophead motors). Depending on ground conditions, pulldown pressure might be increased by using the feed pressure regulator. This affects the reading on the rotation pressure gauge.

⚠ WARNING

***Do not drill if the indicator moves into the red area. This indicates the hydraulic system is overloaded, which causes overheating and serious damage. When the indicator moves into the red area, reduce the (pulldown) feed pressure setting. This will move the indicator back to the green (safe) area. If the rotary head stalls; raise the drill rod, reset the feed pressure regulator and resume drilling*.**

b. ***Feed Pressure Gauge*** - Measures the amount of hydraulic pulldown pressure in the hydraulic pulldown cylinder. Increase or decrease feed pressure with the feed pressure regulator. ***Note:*** *Adjustments with the feed pressure regulator have a direct affect on the readings of both the feed pressure gauge* **and** *rotation pressure gauge.*

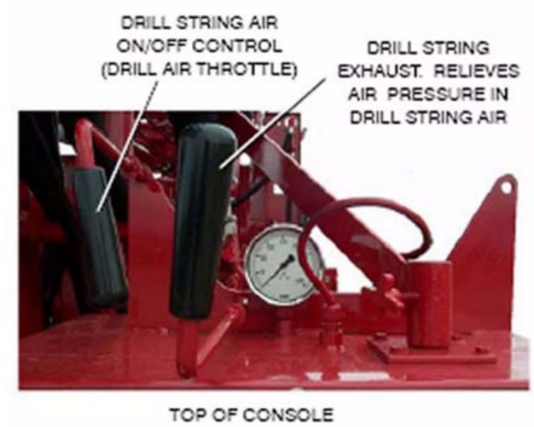
⚠ WARNING

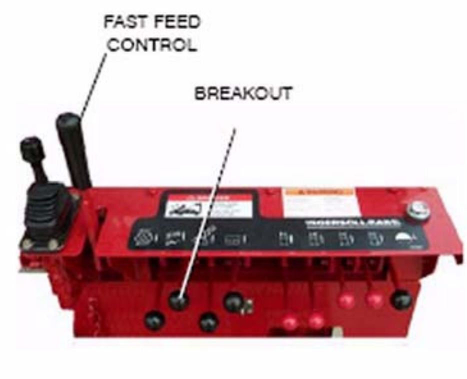
Do not exceed 1500 psi (103 bar) on the feed pressure gauge. There is sufficient overpressure capability to raise the drill off the jacks. STAY ALERT!

c. ***Receiver Pressure Gauge*** - Measures how much air pressure is in the receiver tank. The gauge should register between 75 psi (when not in use) and 250 psi. It will fluctuate when drilling. A sudden high pressure reading, when drilling, indicates the drill bit is plugged. Stop the low speed feed and raise the bit 4-6 inches (101.6-152.4 mm) off the bottom of the hole, allowing air pressure to build up and blow out the dirt/cuttings. ***Do not*** stop spindle rotation when moving a drill rod up/down the hole. Resume drilling when the pressure drops back to normal on the gauge.

5. Drill down until the rotary tophead hits the stop on the derrick and move the drill feed lever to neutral “CENTER” position.
6. Raise the drill pipe with the drill feed control until the drill pipe flats are in position to be held with the sliding fork (table) wrench.
7. Turn off spindle rotation when the drill pipe flats line up with the bottom holding wrench.
8. Bring the sliding fork (table) wrench out onto the drill pipe flats
9. Shut off the rotary screw compressor air intake switch.

10. Slow engine speed down to 1200 rpm.





11. Open the center drill string exhaust ball valve to relieve any down hole air pressure. When the standpipe air pressure gauge reaches 0 psi, all air pressure is relieved (except minimum pressure in the receiver tank).
12. Move the hydraulic breakout wrench lever to “OUT” position. Manually put it on the tophead spindle sub and tighten.

⚠ CAUTION

Be sure the hydraulic breakout wrench is ONLY attached to the rotary head spindle sub.

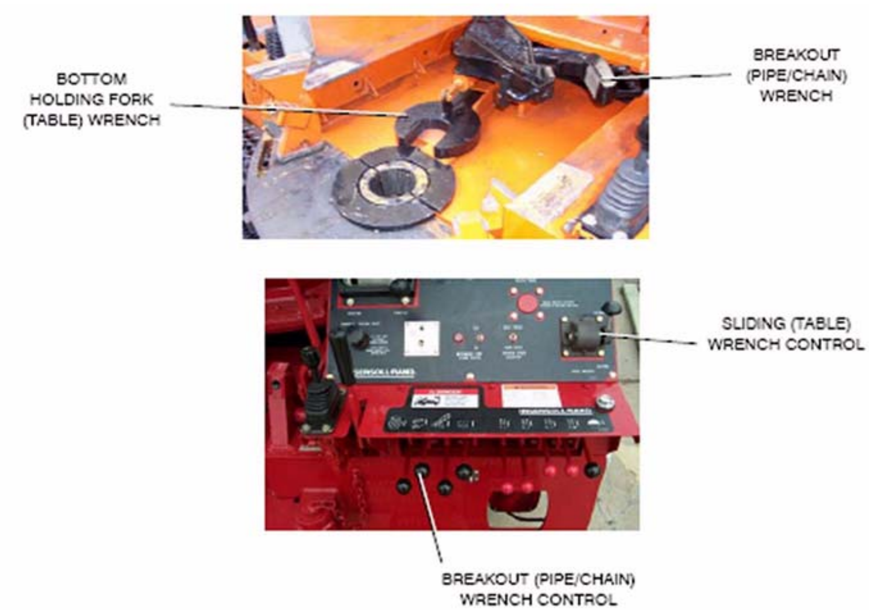
13. Move the hydraulic breakout wrench lever to the “IN” position to break the joint. Manually remove the hydraulic breakout joint.
14. Move the rotary head rotation control lever to a low speed “BREAKOUT” position while moving the drill feed low speed lever to “UP” position. This dual action will unthread the joint.
15. When the joint is unthreaded, stop drill feed low speed and rotary tophead spindle rotation.

16. Grease the rotary tophead spindle sub threads.
17. Raise the rotary tophead and put it into retract.
18. Load the next drill pipe from the carousel, make the joint with the lower drill pipe, increase engine rpm, turn on the compressor air intake switch and continue drilling.

Carousel Reloading

1. Turn off the air compressor air intake switch and relieve the air pressure.

2. Move the air compressor drive clutch lever to “OFF” position to disengage the air compressor drive clutch.
3. With the rotary tophead spindle rotation in “DRILL” position, raise the drill string one complete pipe length with fast feed until the bottom pipe flats are level with the bottom holding wrench (sliding table fork wrench).
4. Turn off the spindle rotation when the bottom drill pipe flats line up with the table wrench.



5. Bring the bottom holding fork wrench out onto the bottom drill pipe flats.
6. Move the hydraulic pipe/chain wrench lever to the “OUT” position. Manually put it on the upper drill pipe and tighten.

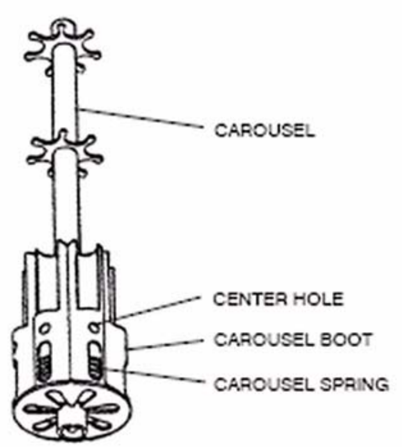
⚠ CAUTION

The hydraulic breakout wrench MUST be attached to the upper drill pipe ONLY.

7. Move the hydraulic breakout pipe/chain wrench lever to the “IN” position to break the joint. Manually disconnect the hydraulic pipe/chain wrench and push it back out of the way.
8. At the same time, put the rotation control in slow speed “BREAKOUT” position and move the drill feed control to “UP” position to unthread the pipe joint.

NOTICE: *Make sure that the drill pipe does not unthread from the rotary top head sub.*

9. When the joint is unthreaded, stop the rotary tophead breakout spindle rotation. Raise the drill pipe until the rotary tophead is above the retract gates.
10. Put the rotary tophead (and drill pipe) into retract.
11. Using drill feed low speed, lower the drill pipe into the carousel until the bottom shoulder is in the center of the hole in the middle of the carousel.



12. Step on the upper holding wrench foot pedal to move the air operated upper breakout wrench out to the drill pipe. Keep the upper holding wrench pedal down. Move the rotary tophead rotation control lever slowly to “BREAKOUT” position. This will turn the drill pipe and enable the upper breakout wrench to engage with the pipe upper flats.

13. Use the rotary tophead spindle rotation in “BREAKOUT” position to break the joint between the rotary tophead spindle sub and drill rod. Do not completely unthread the joint. When the joint is loosened, return the rotation control lever to “NEUTRAL” position
14. Release the upper holding wrench foot pedal.
15. Lower the drill pipe (drill feed) until the bottom drill pipe shoulder touches the top of the carousel spring.
16. Move the rotary tophead spindle rotation lever to the “BREAKOUT” position and unthread the joint. The drill pipe will drop to the bottom of the carousel when unthreaded.
17. Raise the rotary tophead out of retract position. Go back down for the next drill pipe. Repeat the process until the carousel is loaded.

Water Injection

1. The water injection pump injects water into the air stream. This serves a number of purposes.

    a. A small amount of water subdues the drilling dust, reduces wear on the equipment and prolongs truck, engine and compressor filter life.

    b. When small quantities of water are encountered in rock, dust will stick to the walls of the hole and drill pipe making a mud collar which prevents the pulling of the drill pipe and bit. The water pump supplies adequate water to flush the hole clean.

    c. When drilling with a DHD, the water pump serves the same purpose as above, plus the water cools the air which improves the lubrication of the hammer and prolongs its life. Water also serves as a seal between hammer piston and cylinder walls, giving better compression on worn hammers.

    d. The water injection system affords an excellent method of injecting drilling chemicals down the hole. There has been much progress in drilling chemicals and, when used, these chemicals are added through the water injection pump or the pulse pump.

    e. The water injection system can be used as a wash down system for the drilling rig and other equipment by using the blowdown line as a spray hose.

2. Connect the water suction line to the quick disconnect on the water injection pump suction and place the line in a clean water source.

    NOTE: ***Be sure that the blowdown valve on the water injection pump is closed and that the discharge valve has been opened.***

3. The air compressor must be running before the water injection system is turned on.

⚠ WARNING

Water entering the air line when the bit is plugged can cause severe damage to the compressor.

4. The water injection control is used to activate and deactivate the water injection pump. Activate the water injection pump by lifting the control lever. Deactivate the water injection pump by lowering the control lever to the neutral position.

   NOTE: ***The Cat pump rod lubricator valves should be adjusted before starting the pump.***

NOTICE: Because the Water Injection option will only use one side of the valve, another hydraulically driven option may be used by the same control valve. Be aware that lifting the control handle away from the neutral position will activate Water Injection and lowering the control handle away from the neutral position will activate the added hydraulically driven option.

5. The Water Injection Flow Control 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.
6. Move the water injection pump control lever to off position when adding drill pipe or unloading drill pipe.

7. The Cat pump lubricators should be checked periodically during operation for proper drip rate

   NOTE: ***The drip valves should be closed when the pump is not in use.***

Foam Injection Operation

The foam control is used to adjust the amount of drill foam added to the water injection flow. Foam volume is increased by turning the foam volume control to the left. Foam volume is decreased by turning the foam volume control to the right.

1. Follow the above water injection procedures #2 through #5.
2. Connect the pulse pump suction hose to the chemical tank.
3. After water flow has been established, open the pump needle valve about one (1) turn. This will purge air from the pulse pump and at the same time prime it.

⚠ CAUTION

Do not operate the pulse pump dry. This could damage the diaphragm. Make sure that the metering valve is tightened after all the air has been purged.

4. Then set the water injection system for the proper discharge rate and adjust the foam system metering valve to obtain the desired water/chemical ratio.

   NOTE: ***Check chemical output by measuring the chemical tank*.**

NOTICE: *Before shutting the pump down, flush out the pulse pump's system with water by placing the suction line in a clean water source. Failure to clean system could cause loss of drill time.*

DHD Hammer Drilling

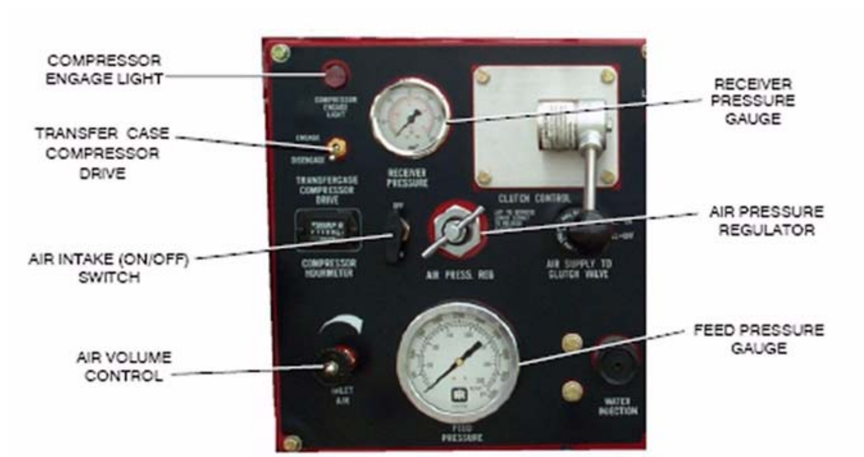
Hammer drilling uses a percussion type bit, a DHD lubricator and DHD air pressure regulator.

The DHD lubricator control controls the pump that forces DHD oil down the drill string to the DHD for lubricating purposes. When the toggle switch is turned ON, a pump under the lubricating tank starts pumping. The flow indicator light blinks every time oil is injected into the air stream. Instructions for flow settings are located on the face of the DHD lubricator tank. Note that flow settings are set for air compressor size.

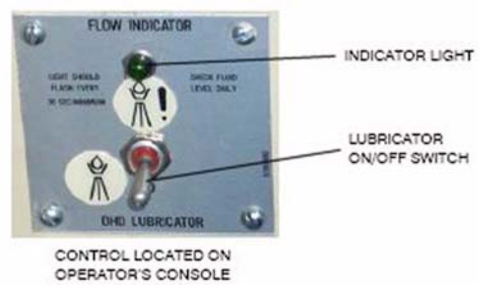
When using the DHD for the first time, pour one cup (8 oz./230ml.) of Rock Drill Oil into the drill backhead to lubricate it before starting the DHD.

NOTICE: *Follow Actual Manufacturer's Lubrication Instructions when using DHD hammers*.

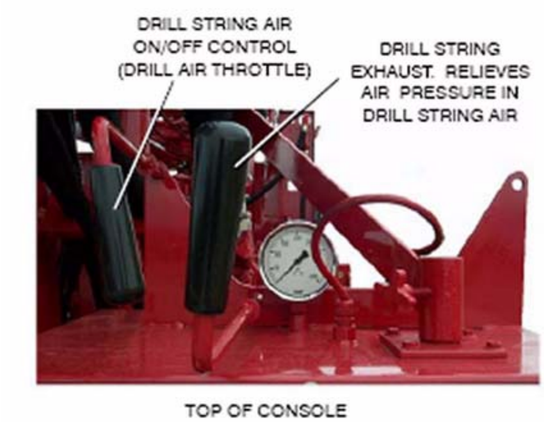
1. The DHD should be connected to the starter rod to drill the hole.
2. The engine speed should be 1800 RPM.
3. Turn on the compressor. Adjust pressure regulator to the desired setting.



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 to the compressor size of the drill.
7. Start slow forward (clockwise) rotation using the rotation control. Rotation speed can be adjusted with the rotation control.
8. Make sure the dust aprons are in place.
9. Open the drill air throttle valve slowly and allow air flow to operate the DHD.



10. Move the drill feed control handle to the DOWN position while starting a hole and adjust the drill feed pressure valve to set the speed for the 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 drill feed handle 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 DHD lubricator.

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 DHD backhead around the drill rod. Drilling can now be resumed.
15. Start forward (clockwise) rotation using the rotation control valve.
16. Move the drill feed control to the DOWN position while starting a hole. It can be turned to the UP position (holdback position) when there is enough weight on the drill string to pull the drill string downward. Adjust the drill feed pressure valve to set the speed for the drilling conditions.
17. Turn on the compressor. Adjust pressure regulator to the desired setting.
18. Open the drill air throttle valve slowly and allow air flow to operate the DHD.
19. Adjust the rotation and feed speed (down pressure) by checking the rotation and pulldown gauges. The pulldown pressure can be turned to holdback pressure when there is enough weight on the drill string to pull the drill string downward.
20. Watch the cuttings coming from the hole to determine what type formation you are drilling through. Continue drilling.
21. A driller will listen for different “sounds” when hammer drilling.

    a. A rapid “high pitch” sound means that air pressure is keeping the hammer too far off the bottom of the hole to drill. Increase the feed pressure with the feed pressure regulator.

    b. A rhythmic “medium-low pitch” sound indicates the hammer is drilling correctly. Look for cuttings coming out of the hole.

    c. A very erratic “low-deep pitch” sound means there is too much down pressure on the hammer. The drill rod will “jerk” instead of rotating evenly. When the spindle rotation pressure gauge needle jumps erratically from high-to-low, it also indicates too much down pressure. When there is too much down pressure, cut back on the feed regulator.

22. After reaching a certain depth, the weight of the drill string steel will force the hammer to the bottom of the hole. Use the air pressure regulator to overcome the steel weight and keep the hammer up off the bottom of the hole.
23. Maintain the receiver pressure gauge reading between 300-600 psi, by using the drill feed control and air pressure regulator, for better efficiency when hammer drilling.

General Drilling Hints

1. The DHD lubricator must always be used whenever a DHD is being operated. Use the correct oil for the DHD and the season. The amount of oil varies with the air compressor size, not the DHD. Select the compressor size on the three position lubricator air flow selector.

NOTICE: *Follow Actual Manufacturer's Lubrication Instructions when using DHD hammers*.

2. Water injection should be used to contain dust and 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., the bit is stuck in the hole). Water will fill up the air supply lines and flow back into the receiver separator 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.

Mud Drilling

Description

When drilling in unstable formations, a mud "mix" is necessary to stabilize the hole wall and prevent cave ins. A mud pump forces mud mix down the hole through a circulating mud system and applies the mud mix directly to the hole wall, thereby reinforcing and stabilizing it.

While drilling, make sure the mud mix circulates. Samples of mud circulation cuttings will indicate what type of soil conditions exist.

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

⚠ WARNING

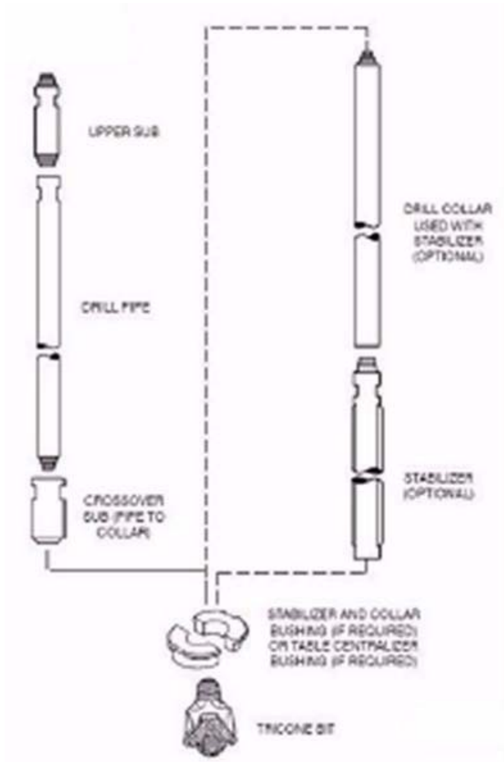
Heavy components must be handled with care using appropriate lifting aids provided to facilitate heavy component lifting operations.

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 rotation components.

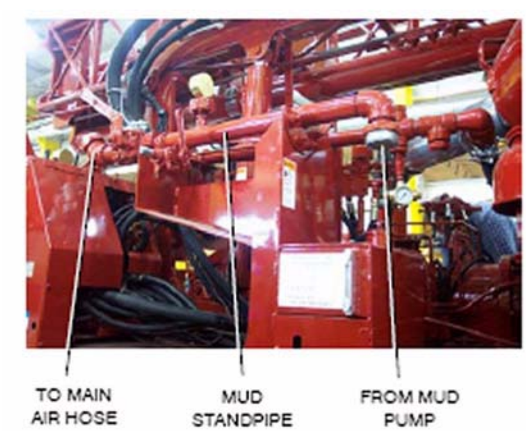
Mud/Rotary Drill String Tools & Accessories

The following illustration shows a typical drill string suited for mud/rotary drilling.



Mud Drilling Procedures

Preparation of the drilling site includes preparing the mud source, checking the mud pump before starting and mixing the mud according to the specifications of the manufacturer and requirement of the hole.



1. Change the main derrick air hose from the air standpipe over to the mud standpipe.

⚠ WARNING

Shut down the air compressor and relieve all air pressure before disconnecting the air hose from the air standpipe.

2. Attach a bypass hose to the bypass valve outlet on the mud standpipe and position the remaining end of bypass hose in mixing area of the mud source.
3. Connect the mud pump suction hose to the mud pump inlet and place the free end into the suction side of the mud source.
4. Fill the mud source with water.

⚠ CAUTION

The mud pump suction inlet must always be completely under water. DO NOT allow pump to draw air. Severe pump damage may result.

5. Open mud injection bypass valve (located on mud standpipe).
6. Close the mud pump ball valve lever (located on top of console).
7. Set the engine speed at high speed.
8. Push the mud pump controller on the console to start water flow through the bypass hose.

⚠ CAUTION

In freezing weather, the mud pump gear end oil must be warmed before starting mud pump. It is recommended that a cold pump be brought up to speed gradually.

9. Mix desired type of mud at end of mud source farthest away from pump suction inlet.
10. Arrange a return line from drill hole to mud source. The return line must enter the mud source area furthest from pump suction inlet area.
11. Open mud pump ball valve lever (top of console) and then close bypass valve (under mud manifold) to start mud injection.

⚠ WARNING

***DO NOT EXCEED 400 PSI (27.57 bar) mud injection pressure*!**

12. Mud flow is controlled by adjusting the speed of the mud pump. Pull the mud pump controller on the console down to increase pump speed.

⚠ CAUTION

In freezing weather, the mud pump gear end oil must be warmed before starting the pump. It is recommended that a cold pump be brought up to speed gradually.

13. Use the bypass valve as a relief to regulate mud injection pressure so as not to exceed 400 psi (27.57 bar).
14. Turn on forward rotation and adjust speed with the rotation control.
15. Use drill feed in the down position to start drilling.
16. Monitor the mud pump pressure gauge. By watching the pressure gauge, located on the mud pump standpipe, an operator can decide what flow of mud mix is needed to meet the drilling requirements and adjust the mud pump speed controller speed accordingly.

    NOTE: ***Adjust the mud pump speed control to select a flow that will not allow the bit to plug or the pump to lose prime. This is directly affected by the formation in which you are drilling.***

17. While drilling, make sure the mud mix circulates. Samples of circulation cuttings will indicate what type of soil conditions exist.
18. ***When adding drill pipe to the drill string***: Move the mud pump speed controller to the center or "OFF" position. Close the mud pump ball valve on the drain line. Then open the blowdown valve lever (on top of the console) and relieve the down hole pressure.
19. Add drill pipe per previous instructions.

20. Open the ball valve on the drain line, turn on the ON/OFF valve and continue drilling.
21. Drill down to desired depth.

NOTE: ***When mud drilling, there are three additional steps that must be followed when coming out of the hole. (Be sure to add the mud wiper before starting out of the hole).***

a. After each joint is separated, raise the drill pipe about one foot from the separated joint.

b. Place the mud suction hose into a clean water source.

c. Using the mud pump, flush the drill pipe (this serves to flush the mud pump also).

NOTE: ***Flush, wash and clean the mud mix from all drill pipe prior to loading them into the rod box or transport vehicle. The bit should also be free of any mud mix residue.***

22. When drilling is completed, flush and clean the mud mix from the mud pump.
23. Open bypass valve completely and close the mud pump ball valve lever (top of console).
24. Slow mud pump down to a stop.
25. Disconnect the main air hose from the mud standpipe and connect it to the air standpipe.
26. Wash and clean the mud mix from the drill pipe before loading in the carousel and/or storing the drill pipe.
27. Drain the mud pump and mud pump standpipe if the temperature is below freezing.

⚠ WARNING

This procedure must be followed or severe damage will occur to both the mud pump and all associated piping. This could lead to an extended down time maintenance requirement.

Casing

The following information is related to setting casing and flushing the hole wall.

Setting Casing

1. Raise the rotary tophead to the top of the derrick and put the rotary tophead into the retract position.
2. Un-pin and swing out the clamping bar. Then retract the table.
3. Remove the split centralizer bushings in the table and clamping bar. Replace them with the required size casing clamps.
4. Connect a choker sling onto the first piece of casing.
5. Attach the hoist cable to the choker sling and raise the casing above the hole. Lower the casing down into the hole until the casing is about one foot above table level. ***WARNING: Do not use free fall for lowering casing down the hole.***
6. Move the table out to drilling position. Close the clamping bar and pin it shut.
7. Remove the choker sling and attach it to the next piece of casing.

   NOTE: A choker sling cannot be used on a plain end pipe.

8. Lift the casing, with the hoist, above the first casing.
   a. If “plastic casing” is used: put on the casing collar and cement the joint.
   b. If “weld type casing” is used: join the casing shoulders and weld.
   c. If “threaded casing” is used: clean and grease the threads of each piece of casing before making the joint. Use a manual casing chain wrench or the breakout wrench to tighten the joints.
9. Using this procedure, set the screen and remainder of the casing.
10. When the casing and the screen are set, unpin and swing out the clamping bar (centralizer half of the driller’s table). Retract the table to make working room above the hole.
11. Add the required grouting around the casing.

Flushing the Hole Wall

After mud drilling, mud mix is usually blocking the watershed around the screen. Use the following procedure to flush the mud mix from the hole wall and to open well to water flow.

1. Attach a spray nozzle on the end of a drill pipe and run the drill string back down the hole inside the casing.

2. Use the mud pump and a clean water source to flush the casing and the screen.
3. With the pulldown in slow feed and the rotary head spindle in drill rotation, stroke the drill string up and down in the area of the screen several times to remove the mud mix wall.
4. When the watershed is flowing, raise the drill string and disassemble the drill string.
5. Set the water pump in the well.

SHUT DOWN & DRIVE AWAY

Shutdown Procedures

NOTE: ***See section 4 "Operating Controls" for a more complete description of all the operating controls, instruments and indicators that are used when operating the drill.***

The following procedures are related to the drill functions. Do not confuse them with the truck (carrier) functions, which are moving, transporting and parking the drill.

Normal shutdown describes how the drill is to be shutdown following a drilling operation or work shift.

1. Raise the drill string out of the hole to clear the cuttings. Keep the drill 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. Switch off lubricator if it is being used. Turn off water injection pump if it is being used. Turn off drill air with the drill air throttle. (The drill air throttle should be opened slowly in order to prevent premature failure of the receiver separator element. To open, pull the lever out). To close, push the lever in.
4. Exhaust the air from drill string by opening the air exhaust (blow off) valve (located above the console). Close the valve when all pressure is exhausted.
5. Turn off the compressor and allow the receiver to blow down to minimum pressure.
6. If the hole is completed, remove all drill pipe from the derrick. Remove all loose tools, material and accessories from the drill and stow in their proper place.
7. Remove the centralizer half (clamping bar) of the driller's table and store it securely.
8. Prior to lowering the derrick, inspect for proper overhead clearance and for any obstruction or tool left on the drill or derrick.
9. Lowering the Derrick.
10. Raise the leveling jacks until they are fully retracted.

    NOTE: ***Any material used for cribbing or blocking the drill should be removed and stored in the support vehicle.***

11. Lower the hoist and position the arm for proper storage or shipment. Anchor the hoist cable.
12. Make sure all controls are in "OFF" or "NEUTRAL" positions and all water lines and other connections are removed and stored. BE SURE THE DRILL FEED SELECTOR IS IN THE "CENTER" POSITION.

13. Disconnect the mud pump suction hose (if used) and store it out of the way.
14. Be sure that the mud pump ball valve lever and the blowdown valve lever have been pushed in to the closed position.
15. Turn off the air transfer valve behind the truck cab.

    NOTE: ***This valve must be shut off when moving over public roads to comply with federal laws*.**

16. Install the console cover. Lock all lockable compartments.
17. Clean off all transport lights so they can be seen from behind.
18. Shift from PTO to Driving position.

Moving the Drill

The following procedures are related to the truck (carrier) moving functions. Do not confuse them with the truck (carrier) parking or transporting the drill procedures.

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 the derrick before moving the drill.
4. Secure all drill pipe and tools before moving the drill.
5. Know the drill's height, width, weight and length before moving.
6. Check the brakes on the truck before leaving the job site.
7. Be careful cornering to allow for derrick overhang.
8. Know where your helpers are at all times. Do not move the drill if they are not in view.
9. Know and use proper signals when moving the drill.

Parking the Drill

1. Always use the steps and hand holds when mounting and dismounting by using a three point stance.
2. Release the parking brake, located on the truck dashboard, before moving the drill. To release parking brake, push knob in. The parking brake is to be used for parking the vehicle only. See actual manufacturer's parts and service manuals for more complete carrier information.
3. Move the drill away from the highwall or face before shutting the drill down for the day.
4. Don't park the drill under an overhang or where a bank can cave in.

5. 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 wheels.
6. If the drill is left over a hole, lower the jacks so the wheels touch the ground.
7. To park the drill, move it to firm, level ground and bring the drill to a complete stop as mentioned above.
8. USE proper flags, barriers and warning devices, especially when parking in areas of heavy traffic.
9. Apply the parking brake as mentioned above.
10. Shut off carrier engine per carrier instructions.
11. Lock the ignition and remove the key before leaving the carrier cab.
12. Lock the carrier cab if the drill is to be left unattended.

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 tanks to prevent condensation problems.
2. Clean the drill of accumulated material.
3. Lock all vandal protection devices on the drill.

Equipment and Attachments

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

TRANSPORTING THE DRILL

Transportation Procedures

Safety Precautions

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

⚠ WARNING

Driving the drill and moving equipment between work sites is potentially hazardous.

⚠ WARNING

Drill rig cannot be transported with drill pipe in the carousel.

The drill must be driven and transported only in accordance with the operating instructions.

1. When driving the drill, observe the prescribed transport position, admissible speed and itinerary.
2. ***Do not*** attempt to drive unless knowledgeable and experienced.
3. Keep the carrier cab and carrier entry steps 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. MAKE SURE there is sufficient clearance when crossing underpasses, bridges and tunnels or when passing under overhead lines.
5. When moving the drill 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 your direction of travel.

Drill Preparation

1. Remove all loose tools, materials and accessories from the drill and store in the tool compartment or other proper place.
2. Raise the rotary tophead to the top of the derrick and place in retract position.

3. Swing the pipe holder option (if used) into the closed position.
4. Remove the derrick and table locking pins and store them.
5. Remove the drillers platform bracket bolt from table support post.
6. Check again for overhead clearance. Lower the derrick onto the derrick rest. Feather the derrick raise/lower control lever as the derrick approaches the derrick rest so it doesn't hit with excessive force. Never slam the derrick into the horizontal position.
7. Retract the jacks, starting with the mid jacks on the non-drilling end of the truck. Retract the other jacks. Store any cribbing that was used.
8. Anchor the Hoist cable.
9. Make sure all controls are in neutral or off positions and all water lines and other connections are removed and stored.
10. Raise the driller's platform and bolt them in the upright (road) position.
11. Install the console cover. Lock all lockable compartments.
12. Clean off all transport lights so they can be seen from behind.

Driver Checklist

1. Be sure you know your vehicle and its equipment and how to use it safely.
2. See that windows, mirrors, lights and the truck cab are clean and unobstructed.
3. Check tires for proper pressure and inspect for damage.
4. Check to be sure that all lug (wheel) nuts are in place.
5. Check for fluid leaks.
6. Listen for air leaks.
7. Drain moisture from air tanks daily.
8. Check lights and reflectors.
9. Check oil and coolant levels.

Start Up

1. Before starting the engine, check inside, outside and underneath the drill for people or obstructions.
2. ALWAYS sound the horn before starting the truck to alert everyone in the area.
3. Check to be sure that the warning lights work as the key is turned on.
4. Check all gauges (including fuel).
5. Start engine.
6. Check for excessive noise or vibration.

Final Walk Around Check

1. Look for leaks, now that the engine is running.
2. Check to see that all the lights work.
3. Check to see that doors, covers and emergency equipment (and contents) are in place.
4. Be sure everything is properly stowed.
5. Before beginning to move, check inside, outside and underneath the drill for people or obstructions.
6. Check area behind the drill before backing up.

Before Driving

1. Fasten seat belts.
2. Adjust each mirror so you can just see the side of the vehicle in the side of the mirror closest to the vehicle. This helps you determine the relation to objects seen in the mirror.
3. Release the parking brake.

   NOTE: ***Air pressure must be high enough to release the spring loaded parking brakes before moving the drill (75 psi).***

TOWING THE DRILL

Towing Information

Be Safety Conscious

Proper equipment must be used to prevent damage to the vehicle and the drill during any tow. State and local laws which apply to vehicles in tow must be followed.

If the vehicle is to be towed by a wrecker, use only equipment designed for this purpose, following the instructions of the wrecker manufacturer. A safety chain system must be used.

⚠ WARNING

Personal injury or death could result when towing a disabled drill incorrectly.

⚠ WARNING

Block the wheels of the drill to prevent movement before releasing the emergency brake system or disconnecting the propeller shaft at axle pinion or removing axle shafts. The drill can roll free if it is not blocked.

⚠ WARNING

Use the following recommendations to properly perform the towing procedure.

⚠ WARNING

Be sure to block the wheels of the drill and reapply the emergency brake system before disconnecting from the towing vehicle.

⚠ CAUTION

Maximum towing speed = 35 mph (60 km/h)

⚠ WARNING

Drill rig cannot be transported with drill pipe in the rod box.

1. All state and local laws regarding such items as warning signals, night lighting, speed, etc. must be followed.
2. No vehicle should ever be towed over 35 mph (56.33 km/hr).
3. Loose or protruding parts of the drill should be secured prior to moving.
4. A safety chain system that is completely independent of the primary lifting and towing attachment must be used.
5. Operators should refrain from going under a vehicle which is being lifted by the towing equipment unless the vehicle is adequately supported by safety stands.
6. No towing operation which for any reason jeopardizes the safety of the wrecker or any bystanders or other motorists should be attempted.
7. Do not allow the operator, or any other personnel, on the drill when it is being towed.
8. The driver of the towing vehicle must be aware of the total weight load on the axles and the overall dimensions of the drill. For further information, refer to *Weights and Dimensions* in the Technical Specifications section of this manual.
9. Sudden machine movement could cause premature breakage. Gradual and smooth acceleration will minimize breakages of towing components.
10. Normally, the towing vehicle should be as large as the disabled drill and have sufficient braking capacity, weight and power to control both the towing vehicle and the disabled drill for the grade and distance involved.
11. To provide sufficient control and braking when moving the disabled drill downhill, a larger towing vehicle or additional tandem connected vehicle could be required. This will prevent a runaway or uncontrolled towing operation.
12. All the different situation requirements cannot be given here. Capacities range from minimal towing vehicle capacity required on smooth, level surfaces and increases to maximum capacity required on inclines and on poor surface conditions.

Towing Procedures

Proper equipment must be used to prevent damage to the towing vehicle and the drill during any tow. State and local laws which apply to vehicles in tow must be followed.

If the vehicle is to be towed by a wrecker, use only equipment designed for this purpose, following the instructions of the wrecker manufacturer. A safety chain system must be used. The procedures below must be followed when towing for extended distances to prevent possible damage to the transmission.

SPECIAL CONDITIONS OF USE

Special Conditions

Cold Weather Conditions

1. Refer to Section 6 - *Refill Capacities / Lubricants / Fuel* in the maintenance section for information regarding cold weather lubricants, hydraulic fluids, coolants. fuel etc.
2. Use winter grade diesel fuel for operation at subzero temperatures.
3. Be extremely careful when using cold weather starting aids. 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 Section 6 - *Refill Capacities / Lubricants / Fuel* in the maintenance section for information regarding lubricants, hydraulic fluids, coolants, fuel, etc.

Dusty Conditions

1. Keep air cleaner elements clean and free of accumulation of dirt.
2. Wear a 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 Section 6 - *Refill Capacities / Lubricants / Fuel* in the maintenance section for information regarding lubricants, hydraulic fluids, coolants, fuel, etc.
3. Check that the storage site is not subject to flooding or other natural hazards.
4. Wherever practical, run the engine and operate all the drill functions at regular intervals.

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Section 6 - Maintenance

6-1 MAINTENANCE SAFETY

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.

⚠ 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.

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.

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.

⚠ WARNING

If you are not experienced with the drill’s controls and instruments, read and understand the OPERATING CONTROLS & INSTRUMENTS section of this manual.

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 Solutions representative for assistance.

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

⚠ WARNING

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

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.

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.

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 that 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.

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.

Coolant

1. Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs.

    a. At engine operating temperature, the 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 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.

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.

Batteries

1. Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes. Wash hands after touching batteries and connectors. 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 the charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

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 the recommended torque. Leaks can cause fires,
2. Determine whether the 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.
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 and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.
10. Batteries must be kept clean, 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 intervals. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.
13. All of the 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.

Fire Extinguisher

1. Have a fire extinguisher available and know how to use it.
2. Inspect the fire extinguisher and have it serviced as recommended on its instruction plate.

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 whenever 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.

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. Do not stand on components that cannot support your weight. Use an adequate ladder.

Engine Pre-Start

1. Inspect the drill for potential hazards.

2. Be sure all protective guards and covers are installed if a drill must be started to make adjustments or checks. To help prevent an accident caused by rotating parts, work 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 the air or fuel supply to stop the engine if there is an overspeed condition on start-up after performing repair or maintenance to the engine.

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 the engine, or close to the engine or the engine driven components before starting the engine. Always inspect the engine before and after starting.
3. Start the engine only from the truck cab. 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. Shutdown the engine according to *"Engine Shutdown 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 the operation of jacket water and/or lube oil heaters to ensure proper operation.
9. 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.

Starting Aids

⚠ WARNING

Explosion Hazard. Do not use volatile starting aids such as ether, propane or gasoline in the engine air intake system. Glow plugs and/or grid heater will ignite vapors, which can cause severe engine damage, personal injury or death.

Engine Stopping

1. Stop the engine 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*** the engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.

Maintenance Information

To prevent minor irregularities from developing into serious conditions, several other 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 drill 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 tank before working on the compressor, receiver tank and hose installations or connections.
6. Thoroughly wash all fittings, caps, plugs, etc. with nonflammable, nontoxic cleaning solution before servicing to prevent dirt from entering while performing the service.

When there is a need for service personnel to work on the drill in the working area or 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 station, 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 the supervisor at the main operator's station shall be established in a reliable manner.
5. Only when the 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.

Fluids, Oil and Fuel Filters

1. When draining fluids, ensure that adequate sealable containers are available and that 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 disposed of in an environmentally safe manner.

6-2 MAINTENANCE SCHEDULE

Schedule Information

The maintenance schedule 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 Carrier Vehicle.***

> **NOTE:** ***Refer to the Actual Manufacturer's Service Manual for the service maintenance procedures for the Carrier Vehicle.***

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

Table 1: Maintenance as Required

Description	Action	Lubrication
Compressor Air Cleaner	Check - Air Cleaner Indicator	See Parts Manual
	Check - Connections and Ducts for leaks	
	Empty - Dust Cup	
	Clean - Pre Cleaner	
	Check - Rain Guard	
	Change - Elements only as required	
Cleanliness	Clean the Drill	
Loose Bolted Connections	Check - Tighten to proper torque	See Torque specifications
Feed Cable	Check - Feed Cable sag and adjustment	
Wire Rope	Check - Wear and stretch conditions	
Receiver Separator Tank	Replace Separator Element	

Description	Action	Lubrication
Compressor Air Hose and Clamps	Inspect Hoses, Retighten Clamp Bolts	See Section 7

Table 2: Maintenance at 8 Hours or Daily

Description	Action	Lubrication
Overpressure Control	Check - Overpressure System	
Compressor Air Cleaner	Check - Air Cleaner Indicator	
	Check - Connections and Ducts for leaks	
	Empty - Dust Cup	
Cooling System (HOC and COC)	Clean - Cooling Fins	
Fuel Tank	Check - Fuel Level, Fill	#2 Diesel Fuel
Receiver Separator Tank	Check - Compressor Oil Level	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 Filter Restriction Indicator	
	Check - Case Drain Oil Filter Restriction Indicator	
Rotary Tophead	Check - Rotary Tophead Oil Level	SAE 80W90
	Grease Rotary Tophead Swivel 3Yoke Assembly	MPG-EPS Grease

Description	Action	Lubrication
Derrick Pivot Pins:	5 shots of grease into each grease fitting	MPG-EPS Grease See Actual Manufacturer
Carousel Bearings		
Sheaves		
Cylinders		
Tophead Swivel Yoke		
Tophead Guide Rollers		
Holding Wrenches		
Chain/Pipe Wrench		
Drive Lines and U-Joints		
Retract Gates		
Mud Pump Grease Points		
Rod Holder (Option)		
Jib Hoist/Boom		
Sandreel Shaft Bearing		
DHD Lubricator	Check Oil Level. Add if Low	Rock Drill Oil
Truck Engine	Check - Engine Oil Level. Add if low.	API CG4, 15W40
Truck Transmission	Check - Transmission Oil Level	SAE 50
Truck Power Steering	Check - Oil Level	SAE 10W40
Truck Cooling System	Check - Radiator coolant Level. Clean Cooling Fins.	50/50 Mix - H_2O/Coolant
Housekeeping	Clean the Drill	

Table 3: Maintenance at 50 Hours or Weekly

Description	Action	Lubrication
Batteries	Check - Electrolyte Level	Distilled Water (H_2O)
	Check - Keep Terminals cleaned and tight	

Description	Action	Lubrication
Winch/Sand Reel Cable and Wire Rope	Periodic Inspection	
Water Injection Pump	Change Crankcase Oil	SAE40 (anti rust)
Pump Drive Gearbox	Inspect for Oil Leaks. Clean Breather	
	Check - Oil Level	80W90 Gear Oil

Table 4: Maintenance at 100 Hours

Description	Action	Lubrication
Winch	Change the Initial Oil	TEXACO MEROPA 150 or equivalent API GL-2/3
	Tighten Winch Mounting Bolts	
Sand Reel	Change the Initial Oil	
	Tighten Winch Mounting Bolts	

Table 5: Maintenance at 250 Hours (Carrier)

Description	Action	Lubrication
Engine (Truck)	Change - Engine Oil	API CG4, 15W40
	Change - Engine Oil Filters	
	Replace - Fuel Filter(s)	
	Replace - Coolant Filter	
	Check - Engine SCA Level	Refer to Engine Manual
	Check - Belt Tension	
Truck Transmission	Check Transmission Oil	SAE50
Truck Power Steering	Check Power Steering Oil	SAE 10W40
Truck Differentials	Check Differential Oil	SAE 80W90

Table 6: Maintenance at 500 Hours

Description	Action	Lubrication
Batteries	Clean - Batteries, Clamps and Cables	
Hydraulic Reservoir	Change - Hydraulic Tank Breather	See Parts Manual
Compressor	Clean - Compressor Oil Strainer	
	Change - Compressor Oil Filters	
Pump Drive Gearbox	Change - Initial Oil	80W90 Gear Oil
Water Injection Pump	Change - Crankcase Oil	SAE40 (anti rust)
Winch & Sand Reel	Check - Winch Oil Level, and Sand Reel Gearbox Oil Level	TEXACO MEROPA 150 or equivalent API GL-2/3
	Tighten - Winch Mounting Bolts	
	Clean and Lubricate Cable and Rope	See Instructions
Compressor Air Hose and Clamps	Inspect Hose, Retighten Clamp Bolts	See Section 7

Table 7: Maintenance at 1000 Hours

Description	Action	Lubrication
Receiver Tank	Change Compressor Oil	XHP605 (high Pressure)
Hydraulics	Change Hydraulic Oil	ISO AW32
	Replace Main Return Oil Filter	See Parts Manual
	Replace Case Drain Oil Filter	
	Replace Charge Oil Filter	
Rotary Head	Change - Rotary Head Oil	SAE 80W90
Pump Drive Gearbox	Change - Gearbox Oil	80W90 Gear Oil

Description	Action	Lubrication
Winch & Sand Reel	Change - Winch Oil and Sand Reel Oil	TEXACO MEROPA 150 or equivalent API GL-2/3
	Tighten - Winch Mounting Bolts	
Water Injection Pump	Change - Crankcase Oil	SAE40 (anti rust)
Carousel	Change Gearbox Oil	80W90 Gear Oil

Table 8: Maintenance at 2000 Hours

Description	Action	Lubrication
Air Cleaners	Replace Primary and Safety Elements	See Parts Manual
Engine	Check Engine Valve Clearance	See Actual Manufacturer’s Service Manual
Compressor	Replace Discharge Hose	See Parts Manual

Table 9: Maintenance at 2500 Hours

Description	Action	Lubrication
Receiver Tank	Change Receiver Separator Element	See Parts Manual

Table 10: Maintenance at 4000 Hours

Description	Action	Lubrication
Engine	Drain and Flush Engine Cooling System. Replenish Coolant. See Actual Manufacturer’s Service Manual	50/50 Mix - H_2O/Coolant

Engine Maintenance

The following maintenance information shows those items on the truck engine requiring regular service and the interval at which they should be performed

> **NOTE:** ***Refer to the Actual Manufacturer's Operation and Maintenance manuals for the maintenance schedules and procedures for the Carrier Engine and Carrier Vehicle.***

> **NOTE:** ***Refer to the Actual Manufacturer's Carrier manual for the service procedures for the Carrier Engine and Carrier Vehicle.***

Maintenance Interval Schedule

Ensure that all safety information, warnings and instructions are read and understood before any operation or any maintenance procedures are performed.

The user is responsible for the performance of maintenance, including all adjustments, the use of proper lubricants, fluids, filters and the replacement of components due to normal wear and aging. The performance of this product may be diminished if proper maintenance intervals and procedures are not followed. Components may experience accelerated wear if proper maintenance intervals and procedures are not followed.

Use fuel consumption, service hours or calendar time, WHICH EVER OCCURS FIRST, in order to determine the maintenance intervals. Products that operate in severe operating conditions may require more frequent maintenance.

> **NOTE:** ***Before each consecutive interval is performed, all maintenance from the previous interval must be performed.***

Table 11: Engine Maintenance Interval Schedule

Description	***Action***
When Required:	
Battery:	Replace
Battery or Battery Cable:	Disconnect
Engine Air Cleaner (Dual) Element:	Clean / Replace
Engine Storage Procedure:	Check
Fuel System:	Prime
Severe Service Application:	Check
Daily:	
Cooling System Coolant Level:	Check

Description	*Action*
Engine Air Cleaner Service Indicator:	Inspect
Engine Oil Level:	Check
(Fuel) Primary Filter/Water Separator:	Drain
Power Take-Off Clutch:	Check/Adjust/Lubricate
Walk Around Inspection:	Walk Around Inspection
Every Week:	
Fuel Tank Water and Sediment:	Drain
Jacket Water Heater:	Check
Every 250 Service Hours:	
Cooling System Supplemental Coolant Additive (SCA):	Test / Add
Engine Oil and Filter:	Change
Fuel Tank Water and Sediment:	Drain
Initial 500 Hours (for New Systems, Refilled Systems and Converted Systems:	
Cooling System Coolant Sample (Level 2)	Obtain
Every 500 Service Hours:	
Belts:	Inspect / Adjust / Replace
Coolant System Coolant Sample (Level 1)	Obtain
Starting Motor:	Inspect
Turbocharger:	Inspect
Water Pump:	Inspect
Every 500 Service Hours or 6 Months:	
Engine Devices:	Check
Every 2000 Hours or 1 Year:	
Alternator:	Inspect
Every Year:	
Cooling System Coolant Sample (Level 2)	Obtain
Every 3000 Service Hours or 3 Years:	
Cooling System Coolant (DEAC):	Change
Cooling System Coolant Extender (ELC)	Add

Description	***Action***
Cooling System Water Temp. Regulator:	Replace
Every 8000 Service Hours or 3 Years:	
Driven Equipment:	Check
Every 12,000 Service Hours or 6 Years:	
Coolant System Coolant (ELC):	Change
Every 14,000 L (3750 US gal) of Fuel or 250 Service Hours or 1 Year:	
Battery Electrolyte Level:	Check
Electronics Grounding Stud:	Inspect / Clean / Tighten
Engine Crankcase Breather:	Clean
Engine Oil Sample:	Obtain
Fuel System Primary Filter (Water Separator) Element:	Replace
Hoses and Clamps:	Inspect / Replace
Radiator:	Clean
Every 28,500 L (7500 US gal) of Fuel or 500 Service Hours or 1 Year:	
Engine Oil and Filter:	Change
Every 114,000 L (30,000 US gal) of Fuel or 3000 Service Hours:	
After Cooler Core:	Clean / Test
Every 170,400 L (45,000 US gal) of Fuel or 3000 Service Hours:	
Crankshaft Vibration Damper:	Inspect
Electronic Unit Injector:	Inspect / Adjust
Engine:	Clean
Engine Mounts:	Inspect:
Engine Speed / Timing Sensors:	Check / Clean / Calibrate
Engine Valve Lash:	Inspect / Adjust
Engine Valve Rotators:	Inspect
Fan Drive Bearing:	Lubricate
Every 380,000 L (100,000 US gal) of Fuel or 10,000 Service Hours:	
Overhaul Considerations:	Overhaul Consideration
Fan Drive Bearing (During Overhaul):	Replace

6-3 REFILL 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 distributor.

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

Table 12:

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 Preventive	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
Rock Drill 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.

Table 13:

Substance	Precaution
Engine Exhaust Fumes	Avoid breathing fumes
Engine Exhaust Fumes	Avoid buildup of fumes in confined spaces

Substance	Precaution
Electric Motor Dust (Brushes/Insulation)	Avoid breathing in during maintenance
Brake Lining Dust	Avoid breathing in during maintenance

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 lube 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.

Specific recommendations of brand and grade of lubricants are not made here due to regional availability, operating conditions and the continual development of improved products. Where questions arise, refer to the component manufacturer’s manual and a reliable supplier.

All oil levels are to be checked with the drill parked on a level surface and while the oil is cold, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the check port.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease 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.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

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.

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 capscrews, 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 Drilling Solutions distributor for assistance.

Lubrication Table

Periodic lubrication requirements are listed in the following Lubrication Chart. These requirements include lubricant checks and greasing designated areas of the drill.

Table 14:

Description	Fluid	Remarks
8 Hours or Daily		
Truck Engine Oil	API CG4, SAE 15W40	Check dipstick. Fill to “FULL”.
Truck Engine Coolant	50/50 Mixture of Water & Antifreeze	Check at radiator cap with radiator cool to touch. Fill to “full” level.
Compressor Oil	XHP605 (HP)	Check at receiver tank sight gauge. Fill to “full” level.
Hydraulic Oil	ISO AW32	Check at sight gauge on reservoir. Fill to “full” level.
Compressor Oil	XHP605 (HP)	Check at receiver tank sight gauge. Fill to “full” level.
Fuel/Water Separator		Drain collected water.
Fuel Tanks	#2 Diesel Fuel	Fill to fill cap of (each) tank
Rotary Tophead Oil	SAE 80W90 Gear Oil	Check at sight gauge on rotary tophead. Fill to “full” level.
Derrick Pivot Pin	MPG-EP2 Grease	5 shots at each grease point
Rod Holder Option	MPG-EP2 Grease	5 shots at each grease point
Carousel Bearings	MPG-EP2 Grease	5 shots at each grease point
Sheaves & Sprockets	MPG-EP2 Grease	5 shots at each grease point
Cylinders (All)	MPG-EP2 Grease	5 shots at each grease point
Jib Hoist & Boom	MPG-EP2 Grease	5 shots at each grease point

Description	Fluid	Remarks
8 Hours or Daily (continued)		
Gearbox Driveshaft	MPG-EP2 Grease	5 shots at each grease point
Breakout Wrench	MPG-EP2 Grease	5 shots at each grease point
Leveling Jacks Sliding Surface	MPG-EP2 Grease	5 shots at each grease point
Mud Pump Shaft Seal	MPG-EP2 Grease	5 shots at each grease point
Drive Lines & U-Joints	MPG-EP2 Grease	5 shots at each grease point
Retract Gate Arms	MPG-EP2 Grease	5 shots at each grease point
50 Hours		
Batteries	Distilled Water	Check fluid levels in each battery.Fill cells as required.
Pump Drive Gearbox	SAE 80W90	Check at gearbox oil level port.
Transmission Oil	MIL-L-2104B SAE 50	Check dipstick. Fill to “FULL”.
Truck Power Steering	SAE10W40	Check dipstick. Fill to “FULL”.
100 Hours		
Jib Hoist	Texaco Meropa 150 or equivalent GL2/GL3	Drain, then refill jib hoist with 2 pints (1 liter) of oil.
Casing Hoist		Drain, then refill casing hoist with 4 pints (1.9 liter) of oil.
250 Hours		
Cummins ISX565 Engine	API CG4, SAE 15W40	Drain used oil, replace oil filter(s), refill engine with 48 qt. (45.4 liter) of oil.
Engine SCA Level	SCA	See Actual Mfg. Manual
Truck Differentials	SAE 80W90	Change truck axle(s) oil. Refer to actual manufacturer’s manuals.
Rotary Tophead and Swivel	MPG-EP2 Grease	Apply until relief fitting shows grease leak.
500 Hours		
Pump Drive Gearbox	SAE 80W90 Gear Oil	Drain, then refill gearbox to oil level port.
Water Injection Pump	SAE40 (anti-rust)	Drain, then refill to oil level port.

Description	Fluid	Remarks
Jib Hoist	Texaco Meropa 150 or equivalent GL2/GL3	Check oil level at oil level fill port. Add oil if necessary.
Casing Hoist	Texaco Meropa 150 or equivalent GL2/GL3	Check oil level at oil level fill port. Add oil if necessary.
Carrier Engine Oil	API CG4, SAE 15W40	Drain used oil, replace oil filter(s), refill engine per engine manufacturer's instructions.
Carrier Engine Cooling System.	50/50 Mixture of Water & Antifreeze	Drain and flush engine cooling system. Refill per engine manufacturer's instructions.
Carrier Drivelines and U-Joints	MPG-EP2 Grease	5 shots at each grease point on drivelines and u-joints.
1000 Hours		
Truck Transmission Oil	SAE 50	Change transmission filter and oil. Refer to actual manufacturer's manuals.
Compressor Oil	XHP605 (HP)	Drain, then refill receiver tank with approximately 25 gallon (94.6 liter) of fluid.
Hydraulic Oil	ISO AW32	Drain, clean and then refill hydraulic tank with approximately 88 gallon (333 liter) of oil.
Rotary Tophead Oil	SAE 80W90 Gear Oil	Drain, then refill rotary head with 4 quarts (3.78 liter) of oil.
Pump Drive Gearbox	SAE 80W90 Gear Oil	Drain, then refill gearbox with 4.5 quarts (4.25 liter) of oil.
Jib Hoist	Texaco Meropa 150 or equivalent GL2/GL3	Drain, then refill jib hoist with 2 pints (1 liter) of oil.
Casing Hoist		Drain, then refill casing hoist with 4 pints (1.9 liter) of oil.
Water Injection Pump	SAE40 (anti-rust)	Drain, then refill with 10 ounces (295 ml) of oil.
4000 Hours		
Engine Coolant	50/50 Mixture of Water & Antifreeze	Drain and flush engine cooling system. Replenish coolant. See Actual Manufacturer's Service Manual.

Refill 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.

Table 15: Approximate Refill Capacities

Component	Approximate Quantity
Systems	
Hydraulic Tank (ISO AW32)	88 gallon (333 liter)
Compressor Oil (receiver tank)	25 gallon (94.6 liters) XHP605
Rotary Tophead Oil (SAE 80W90)	1 gallon (3.78 liter)
Pump Drive Gearbox (SAE 80W90)	4.5 quart (4.25 liter)
Winch (Meropa 150)	4 quart (4 liter)
Sand Reel (Meropa 150)	2 pints (1 liter)
Water Injection Pump (SAE 40W anti-rust)	10 ounce (295 milliliter)
DHD Lubricator (Rock Drill Oil)	7 gallon (26.5 liter)
Carrier Engine	
Cummins ISX565 Engine (SAE 15W40)	48 quart (45.4 liter)
Engine Coolant (50/50 water/antifreeze)	28 quart (26.5 liter)
Fuel Tank (#2 ASTMD-975-60T)	Two (2) 100 gallon (378.5 liter) tanks

Hydraulic Oil

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:

Table 16: Hydraulic Oil Specification

EXXON HUMBLE HYDRAULIC H 32					
ISO Viscosity Grade	**Flash °C (°F)**	**Pour °C (°F)**	**Viscosity**		**Viscosity Index**
			cSt at 40°C	cSt -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.

Table 17: Approved Oils

The following are approved oils for Parker Hydraulics Pump Division HF-O Standard.	
AMOCO	AMOLITE: HF OIL NO. 21
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 NO. 32
TEXACO	AWX (WITH EC HI TEC ADD PACKS)
ATLANTIC RICHFIELD CO. (ARCO)	DURO AW-32

Lubricant Oil & Grease

Extreme Pressure Multipurpose Lubricant

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.

Table 18: Extreme Purpose Multipurpose Lubricant

Application	Quantity	Type
Rotary Tophead	1 gallon (3.78 liter)	S.A.E. 90W Gear Oil
Planetary Drive Gearbox	4.5 quart (4.24 liter)	80W90 Gear Oil

Low temperature usage is restricted as follows:

Table 19: Low Temperature Usage

EP Multipurpose Lubricant	
SAE Viscosity Number	**Ambient Temperature 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)

Hoist/Winch Lubricant

The following table represents the lubricant used in the Jib Hoist and the Casing Hoist.

Table 20: Hoist/Winch Lubricant Specifications

Temperature Range	*Required Lubricant*
-30°F to 80°F (-34.47°C to 26.69°C)	Texaco Pinnacle 150
-10°F to 80°F (-23.35°C to 26.69°C)	Texaco Meropa 150 or an equivalent AGMA #4EP
50°F to 130°F (10°C to 54.49°C)	Texaco Meropa 220 or an equivalent AGMA #5EP

Water Injection Pump Lubricant

The required lubricating oil for the 25 gallon Cat water injection pump is as follows:

Table 21: Water Injection Pump Lubricant Recommendation

Component	*Quantity*	*Type*
Water Injection Pump	84 ounces (2.48 liters)	SAE40W (anti-rust)

Compressor Fluids

The TH60 Waterwell Drill is available as a high pressure drill only. Therefore, use only **XHP605** compressor oil.

Table 22: Compressor Fluids

Design Operating Pressure	Ambient Temperature	Specification
350 psi	-10°F to 125°F (-23°C to 52°C)	IR XHP605. ISO viscosity grade 68, group 3 or 4 with rust inhibitors designed for air compressor service.

NOTE: Compressor oil carryover (oil consumption) may be greater with the use of alternate fluids.

Engine Lubricating Oil

The use of quality engine lubricating oils, combined with appropriate oil drain and filter change intervals, is a critical factor in maintaining engine performance and durability.

For the latest applicable engine lubricating oil specifications, contact the engine manufacturer, your dealer or your local Drilling Solutions distributor. Drills leave the factory with API CG4, SAE 15W40 oil, as shown below.

Table 23: Engine Lubricating Oil Specification (from factory)

Description	Specification
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

Extreme Pressure Multipurpose Grease

This is a lithium soap base grease with a high load carrying capacity. The following properties are recommended:

Table 24: High Load Properties

EP Multipurpose Grease	
Timkin OK Load	40 lb. (18.14 kg) minimum
Dropping Point	350°F (177°C) minimum
Oil Viscosity	75 SUS minimum at 210°F (99°C)
Water Resistance	Excellent

Under normal operating conditions, the following consistency grades are recommended:

Table 25: Normal Operating Properties

Normal Operating Condition Consistency Grades	
NLGI Number 0	Subzero fahrenheit temperatures
NLGI Number 1 or Number 2	Ambient temperatures of 0°F to100°F or (-17.8°C - 38°C)
NLGI Number 2 or Number 3	Temperatures over 100°F (38°C)

Multi-Purpose Grease

With the exception of the rotary head, the following grease can be used:

Table 26: Multi-Purpose Grease Specfication

Description	Specifications
Manufacturer:	Amalie Oil Company
Type:	Multi-Purpose Grease, EP1 (#673-6819)
Quantity:	120 lb. Drum (54.4 kg)
Soap Type & Color:	LI-12-OH, Light Brown
NLG1 Grade:	2
Work Penetration, D17, 77°F (25°C):	265 - 295
Dropping Point, 0-2265°C (0-2265°F):	177 (350)
Rust, D-1743 (max):	1
Timken, D-2905, OK Load:	-
Filler, WT.:	-
Oxidation, D-942 (100 hrs):	7
VIS @ 100°C (212°F) cSt:	15.5
VIS @ 210°F (99°C) SUS:	82
Pour Point Degree Celsius:	-15°C
Pour Point Degree Fahrenheit:	+5°F
Product Number:	5819

Rotary Tophead Grease

Atlas Copco recommends using Exxon Mobil Ronex Extra Heavy Duty Moly 2 grease for the rotary tophead grease points. The following shows the specifications:

Table 27: Rotary Tophead Grease Specification

Description	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:	460
SUS @ 100°F:	2500
Dropping Point, ASTM D 225:	250+°C (380+°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.

Coolant Specifications

Coolant

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.

Table 28: 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.

General Information

Cummins **strongly** recommends the use of fully formulated antifreeze or coolant containing a precharge of supplemental additive (SCA). The antifreeze or coolant **must** meet the specifications outlined in The Maintenance Council (TMC) Recommended Practice (RP) 329 (ethylene glycol) or RP 330 (propylene glycol). The use of fully formulated antifreeze or coolant significantly simplifies cooling system maintenance.

Fully formulated **antifreeze** contains balanced amounts of antifreeze, DCA and buffering compounds, but does **not** contain 50 percent water.

Fully formulated **coolant** contains balanced amounts of antifreeze, SCA and buffering compounds already pre-mixed 50/50 with deionized water.

Fully Formulated Coolant/Antifreeze

Cummins Engine Company, Inc. recommends using either a 50/50 mixture of good quality water and fully formulated antifreeze, or fully formulated coolant when filling the coolant system. The fully formulated antifreeze or coolant **must** meet TMC RP329 or TMC RP330 specifications.

NOTE: ***Use of products meeting TMC RP329 or TMC RP330 is necessary for 1500 hour and 6000 hour service intervals.***

NOTE: ***Low silicate antifreeze meeting ASTM D4985 is inadequate for these extended service intervals.***

Table 29: Coolant / Antifreeze

Water Quality	
Calcium Magnesium (Hardness)	Maximum 170 ppm as ($CaCO_3$ + $MgCO_3$)
Chloride	40ppm as (Cl)
Sulfur	100 ppm as (SO_4)

Good quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.

Fully formulated antifreeze **must** be mixed with quality water at a 50/50 ratio (40 percent to 60 percent working range). A 50/50 mixture of antifreeze and water gives a -34°F (-36°C) freezing point and a 228°F (110°C) boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze is 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.

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 the following table.

Table 30: Cummins Specification for Distillate Diesel Fuel

Specifications	Requirements	ASTM Test
Viscosity	1.3 TO 5.8 Centistokes per second at 104°F (1.3 to 5.8 mm per second at 40°C)	D-445
Cetane Number	40 minimum (exception: in cold weather or in service with prolonged idle, a higher cetane number is desirable)	D-613
Sulfur Content	Not to exceed 1 percent by weight	D-129 OR D-1552
Water and Sediment	Not to exceed 0.1 percent by volume	D-1796

Specifications	Requirements	ASTM Test
Carbon Residue	Not to exceed 0.25 percent by weight on 10 percent volume residue.	Ramsbottom D-524 or Conradson D-189
Flash Point	At least 125°F (52°C) or legal temperature if higher than 125°F (52°C)	D-93
Density	30°F to 40°F (-1°C to 6°C) API gravity at 60°F (16°C). (0.816 to o.876 Sp. Gr.	D-287
Cloud Point	10°F (6°C) below lowest ambient temp at which the fuel is expected to operate	D-97
Active Sulfur	Copper strip corrosion not to exceed No. 2 rating after 3hours at122°F (49°C)	
Ash	Not to exceed 0.02 percent by weight	D-482
Distillation	The distillation curve must be smooth and continuous. At least 90 percent of the fuel must evaporate at less than 725°F (385°C)	D-86

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 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.

Table 31: 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

Specifications	Requirements	ASTM Test
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 540°F (282°C) maximum	D86
	90% at 680°F (360°C) maximum	
Flash Point	legal limit	D93
API Gravity	30 minimum	D287
	45 maximum	
Pour Point	10°F (6°C) minimum below ambient temp	D97
Sulfur	3% maximum	D3605 or D1552
Kinematic Viscosity	1.4 cSt minimum and 20.0 cSt maximum at 104°F (40°C)	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	3100g minimum	D6078
	0.018 inch (0.45mm) maximum at 140°F (60°C)	
	o.015 inch (0.38mm) maximum at 77°F (25°C)	

6-4 MAINTENANCE AS REQUIRED

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do not wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. **Always** apply the parking brake before leaving the truck cab.

Maintenance As Required

The following preventive maintenance and service 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 8 hour daily maintenance procedures. Performance of this inspection can result in longer life and maximum productivity from the drill. Refer to the actual manufacturer’s service manuals for “As Required” maintenance and service on the carrier.

Air Cleaners

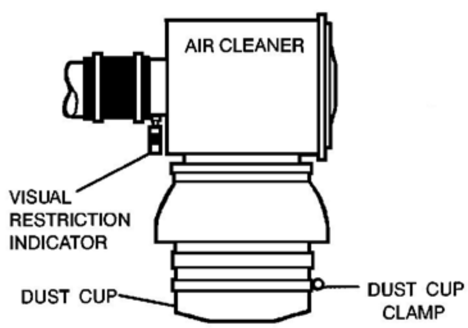
The following are detailed instructions for performing routine maintenance procedures on the compressor air cleaner.

⚠ CAUTION

Raw, unfiltered air can cause compressor damage. Never service the air cleaner while the drill is running.

Air Cleaner Indicators

Check the air cleaner visual restriction indicator before every shift, during every shift and after every shift.



Clean and inspect the compressor air cleaner visual restriction indicator. It should be GREEN. If the indicator shows RED, indicating a plugged air cleaner, 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 compressor air cleaner must be checked to verify the restriction indicator is not sticking. Check by pressing in the rubber boot. The internal green/red indicator should move freely.

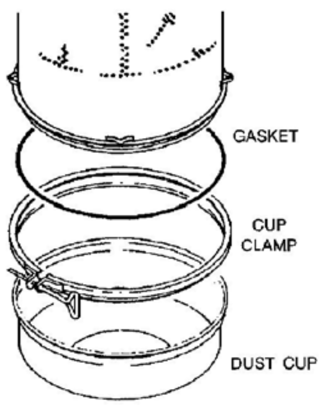
Connections and Ducts

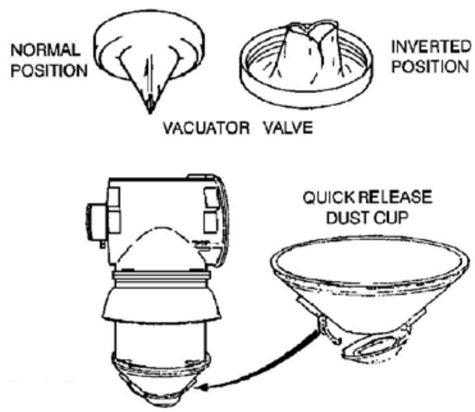
Check air cleaner and ducts for leaks before every shift, during every shift and after every shift. Ensure all connections between the air cleaner and air compressor are tight and sealed.

> **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 cup on the air cleaner must be emptied of accumulations.





On air cleaners equipped with dust cups, 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 the dust cups on the compressor air cleaner.
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.

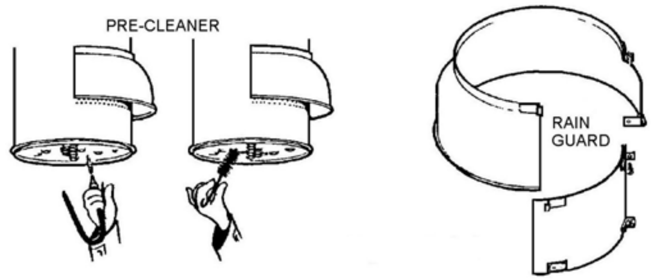
On air cleaners equipped with a quick release dust cup, simply release the latch on the dust cup and allow it to swing down and empty. When it is empty, close the dust cup and lock it in place with the latch.

On air cleaners equipped with vacuator valves, 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.

Most carrier engine air cleaners use a vacuator valve on the air cleaner that is mounted outside on the back side of the carrier cab. See the carrier actual manufacturer's service manual for information on the carrier air cleaner.

Air Cleaner Pre-Cleaner

The Donoclone tubes in the air cleaner pre-cleaner may become lightly plugged with dust which can be removed with a stiff fiber brush. If heavy plugging is evident, remove the lower body section and clean with compressed air or water not to exceed 160°F (71°C).



CAUTION

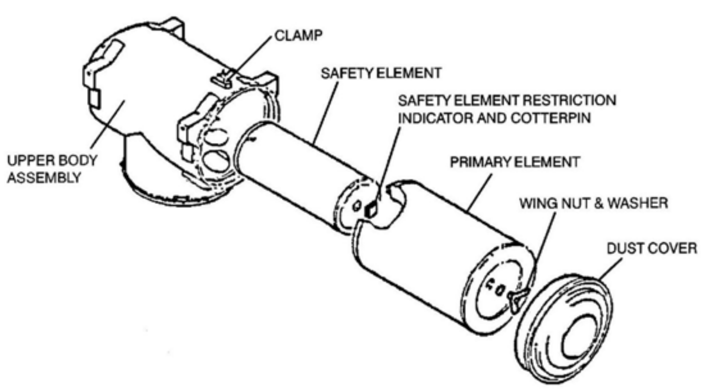
Never clean Donoclone tubes with compressed air unless both the safety and primary elements are installed in the air cleaner. Do not steam clean the tubes in the pre-cleaner.

Air Cleaner Rain Guard

Check the bolts fastening the rain guard around the pre-cleaner body and make sure they are secure. 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.

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.

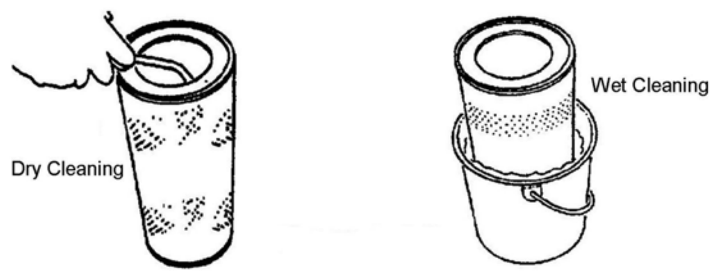


When the visual restriction indicator is RED, clean and replace the air cleaner elements. The following maintenance procedure must be followed.

1. Unclip the three clamps holding the dust cover.
2. Remove the dust cover.
3. Remove the 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 that 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. To clean the primary element, perform the following:



   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 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 until water runs clear (40 psi maximum).

   c. After the cleaning, the element must be thoroughly dry before using. Do not use compressed air to dry the element.

   NOTE: ***Replace the primary element after six cleanings or annually, whichever comes first.***

7. Examine the new or newly cleaned 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. The safety element should be replaced at this time if:

   a. Examination of the 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.
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 the wing nut and washer.
14. Install the dust cover.
15. Inspect all air intake piping and joints between the air cleaner and inspect the compressor air inlet 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 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 compressor or equipment manufacturer. It's only above that point that air cleaner restriction begins to reduce performance levels.
3. If the 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 the primary element very carefully. Use a *damp* cloth to wipe out all 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$_{TM}$ Service indicator.
12. Make it a habit **not** to disturb the element until restriction again reaches the service limit.

Clean the Drill

The complete drill must be given a weekly cleaning. Daily cleaning will be required if material is adhering to the derrick or truck working parts.

1. Make sure the inside of the truck cab and access to the truck 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 derrick 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.***

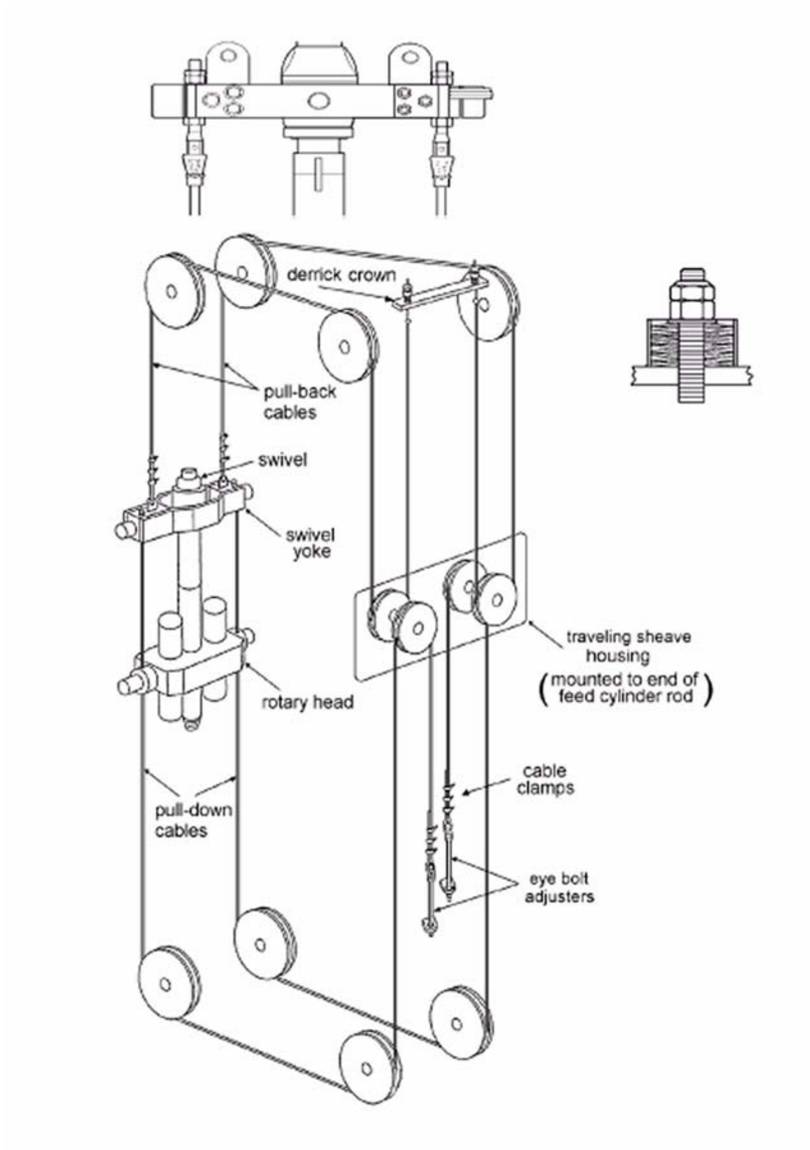
4. After cleaning, check for defects in the air cleaner ducts.
   a. Check intake for accumulation of debris that could restrict air flow.
   b. Check air cleaner mounting hardware for security.
   c. Check all hoses for cracks, chafing or deterioration and replace at the first sign of probable failure.

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 *“Torque Specifications”* for the required torque for all bolt sizes and grades. Always replace self-locking nuts if they have been loosened.

Feed Cable

Two feed cable (pull back) connections are provided on the top of the tophead swivel yoke and two (pull down) on the bottom of the tophead swivel yoke to attach the feed cables. The feed cables are adjustable for wear and stretch. The lower feed (pull down) cables are adjusted from the eye bolt adjusters, which are mounted on the derrick, and the upper feed (pull back) cables are adjusted from the upper connections mounted on the derrick crown. Check all cable periodically for signs of wear and deterioration.



Adjust Feed Cable

1. Back off the jam nuts on the cable anchors. Hold each feed cable stationary with a large pipe wrench so the cable will not turn while adjusting.
2. Start with the pullback (upper feed) cables. They run from the swivel yoke housing to the derrick crown. Turn anchor adjusting nut until the total amount

of deflection at mid span of the cable is 1/4 inch (6.35mm). Both upper feed cables are to be adjusted equally.

3. After the pullback cables are adjusted properly, adjust the pulldown (lower feed) cables in the same manner. Total deflection in the cable should be 1/4 inch (6.35mm) at midspan.
4. Re-check deflection of the pullback cables (upper feed cables) and readjust if necessary.
5. Tighten jam nuts against the anchor nuts.
6. If one side of the feed system leads the other when raising and lowering the tophead, tighten the top adjusting nut of the leading feed cable 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 cable sags more than 1/4 inch (6.39mm).*
7. Raise the derrick and lower the tophead until the spindle contacts the centralizer. Check to see if the spindle is exactly in line with the centralizer.
8. 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 derrick. Loosen the upper adjusting nut and tighten the lower adjusting nut to move the spindle away from the cable being worked on figure 6-4-8).

    b. Loosen the lower adjusting nut and tighten the upper adjusting nut to move the spindle toward the cable being worked on.

    c. The adjusting nut on one end of the cable anchor assembly must be tightened the same number of turns (including fractional turns) that were loosened on the other end of the cable anchor assembly so the cable tension is not changed.

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.

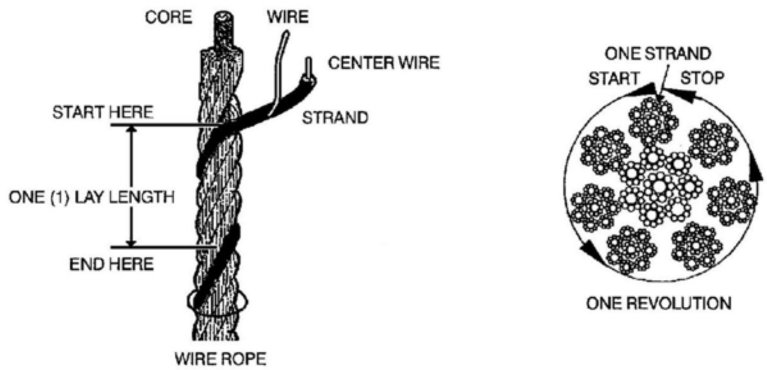
Replacement Guideline

The standards for cranes and towers allow six (6) broken wires in a wire rope lay length, or three (3) broken wires in one strand, in a wire rope lay. The lay length is 5.5 times the wire rope diameter (B30.4-B30.8).

The overhead hoist standard criteria is twelve (12) broken wires in a wire rope lay length, or four (4) broken wires in one strand per lay length (B30.2 and B30.16).

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.

Also, note that any broken wires protruding from the wire rope create a snagging hazard. These wires should be trimmed flush to the wire 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 wire rope replacement.



The drawing above 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 wire 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 wire 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.

Cable Lubrication

Lubrication of the wire ropes and cables should be included in the maintenance schedule. Wire ropes and cables should be cleaned with a wire brush and solvent and lubricated about 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 winch system, e.g. sheave bearings, rope sheaves and drill hooks, shall be checked at least once a week.

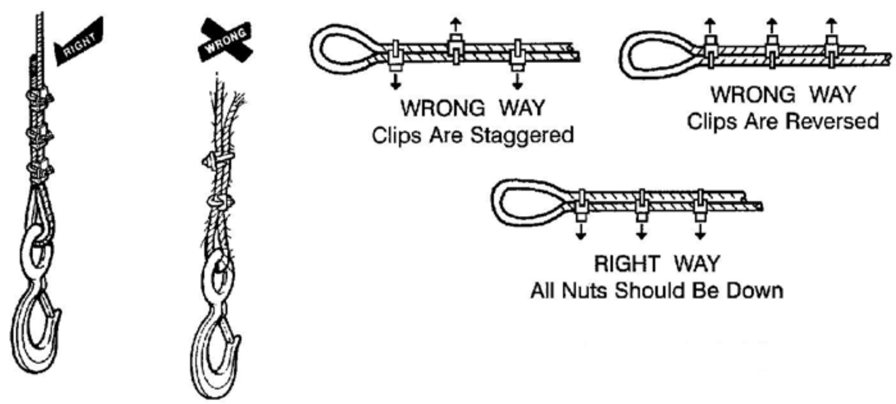
Wire ropes shall be examined and discarded in accordance with 3.5 of ISO 4309:1990. In table 3.5 of ISO 4309:1990, classification groups M1 and M2 shall be used. On drill rigs with normal hook load of more than 1000KN, the winch rope shall be regularly paid out and shortened according to a plan laid 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.

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) of 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.

Wire Rope Clamps

Incorrect installation of the rope clamps can cause premature rope failure and/or possible bodily injury.



1. Nuts should always be retightened after the initial load has been applied.
2. 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.
3. 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.
4. 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.
5. The important things are using proper thimble size, number of clamps and size, and installing them properly. See Wire Rope Clamp chart.

Table 32: Correct Usage of Wire Rope Clips

Clip Size Inches	Minimum Number of Clips	Amount of Rope to Turn Back in Inches	Torque in Foot Pounds
Dimensions are in inches and are approximate			
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	260
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

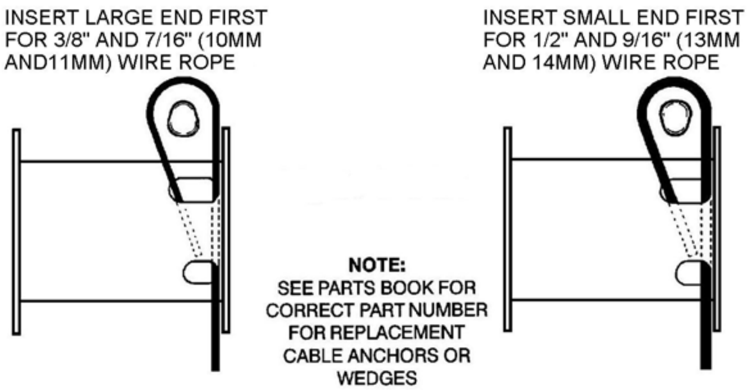
Wire Rope Installation

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.

⚠ WARNING

The cable clamp is not designed to hold the full load alone. NEVER attempt to lift a load with less than five (5) wraps of cable on the drum.

Take the free end of the wire rope and insert it through the small opening of the anchor pocket. 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 inch and 7/16 inch (10mm and 11mm) wire rope by inserting the wedge large end first. You may anchor 1/2 inch and 9/16 inch (13mm and 14mm) wire rope 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 tight 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.

Receiver Separator Element

Maintenance on the receiver separator element is on an **“as required”** basis. A change of the separator element is required when there is excessive oil carryover with the compressed air.

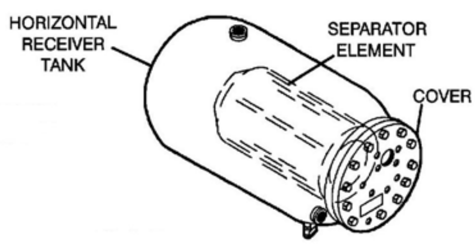
⚠ WARNING

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

⚠ WARNING

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

1. Park the drill on a stable, level surface and shut down the engine. Allow time for the drill to cool down.



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 the bolts.
6. After startup, check for any leaks at operating temperatures.

Compressor Air Hose and Clamps

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.

Air Hose & 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 and change out worn hoses and weakened Boss clamps. If hoses are to be changed out, change the Boss clams also. Boss clamps hold the hose connections under a large amount of pressure. Boss clamps (including nuts and bolts) are for **single use only. Do not reuse.** Once removed, discard.

6-5 MAINTENANCE (8-10 Hours)

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do not wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Overpressure Control System Test

To reduce the possibility of tipping the drill over due to operator error from overfeeding, the Overpressure Control has been added to the feed circuits. The Overpressure Control system test must be performed at the start of each shift.

1. Raise the drill on all jacks until the tires are about one inch (25.4mm) off the ground.
2. Stall fast feed at the bottom of the derrick. Raise the left rear jack off the ground and verify that feed pressure drops below 600 psi. Read pressure from the feed gauge on the console.
3. Repeat step 2 using the right rear jack.
4. Repeat steps 2 and 3 using slow feed.

Air Cleaners

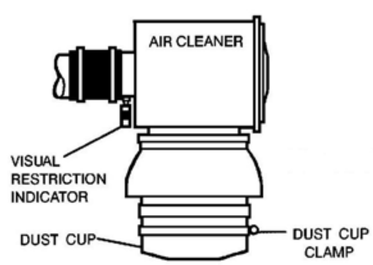
The following are detailed instructions for performing routine maintenance procedures on the compressor air cleaner. Note: See actual manufacturer's service and maintenance manuals for maintenance information on the carrier air cleaner.

⚠ CAUTION

Raw, unfiltered air can cause engine and compressor damage. Never service the air cleaners while the engine is running.

Air Cleaner Indicators

1. Check the air cleaner visual restriction indicator before every shift, during every shift and after every shift.



2. Clean and inspect the compressor air cleaner visual restriction indicator. It should be GREEN. If the indicator shows RED, indicating a plugged air cleaner, clean or replace the filter elements.
3. After servicing the element, reset the restriction indicator to GREEN when the element is replaced in the air cleaner housing.

4. The compressor air cleaner must be checked to verify the restriction indicator is not sticking. Check by pressing in the rubber boot. The internal green/red indicator should move freely.

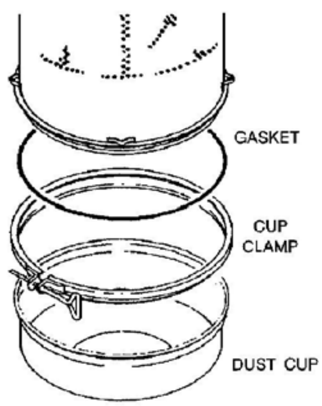
Connections and Ducts

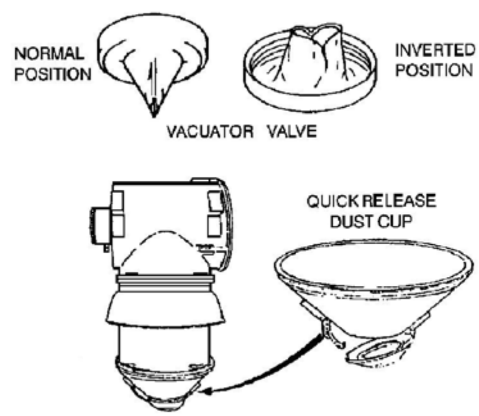
Check air cleaner connections and ducts for leaks before every shift, during every shift and after every shift. Ensure all connections between the air cleaner and air compressor are tight and sealed.

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 cup on the air cleaner must be emptied of accumulations.





On air cleaners equipped with a dust cup, 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 clamp and remove the dust cup on the compressor air cleaner.
2. Empty any accumulations of dust and dirt and replace the dust cup. Secure the dust cup clamp.
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 air cleaners equipped with a quick release dust cup, 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 air cleaners equipped with vacuator valves, 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.

Most carrier engine air cleaners use a vacuator valve on the air cleaner that is mounted outside on the back side of the carrier cab. See the carrier actual manufacturer's service manual for information on the carrier air cleaner.

Cooling System

Radiator Coolant Level

The coolant level must be checked **daily** as part of the **8 hour** routine maintenance procedure. Ensure the coolers are not too hot to touch.

⚠ WARNING

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 the cap slowly to relieve pressure. Avoid contact with steam or escaping fluid.

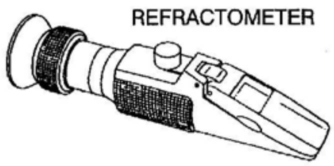
⚠ WARNING

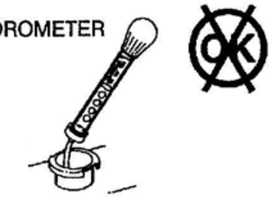
Do not remove the radiator cap from the cooler(s) while the engine is hot. Wait until the temperature is below 120°F (50°C) before removing the pressure cap. Failure to do so can result in personal injury from heated coolant spray or steam. Remove the filler cap slowly to relieve coolant system pressure.

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.***

⚠ CAUTION

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.





1. A refractometer ***must*** be used to accurately measure the freeze point of the coolant.
2. Do ***not*** use a floating ball hydrometer. Floating ball hydrometers can give an incorrect reading.

Clean Radiator(s) and Oil Coolers

If the drill has suffered leaks of oil or fuel, dirt will tend to adhere to the cooling fins of the radiator and oil coolers. 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.

Check every **8 hours or daily** for signs of clogging on the exposed cooling fins on the radiator, compressor oil cooler and hydraulic oil cooler 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.

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 (6mm) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.

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.

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 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.

Fuel Tanks

Care and maintenance of the fuel system is important to the proper operation of any diesel engine. Some of the more critical items which can cause poor operating efficiency, malfunction or damage to the engine and fuel system are listed below:

Dirt

Dirt can only enter the fuel system through the filler cap opening of the fuel tank by the tank being filled with dirty fuel, dirt from the hose nozzle or by failing to clean the area around the tank cap before opening.

The fuel system is equipped with filters that will handle the dirt up to a point. These filters must be replaced on a periodic basis in a preventive maintenance program, as previously mentioned

Water

Water may enter the fuel tank either by purchasing fuel which contains water, or water may contaminate the fuel in storage at the service location. Another source of water in the fuel is from condensation from air entering the tank cap breather hole. To prevent condensation, it is recommended that all fuel tanks be filled when a vehicle returns from a run and not let the tank sit overnight with less than a full tank.

The filters can handle some water, but when water goes beyond them, the water will gall the injector body and score the fuel pump body and gears.

Water is an additional problem when in the fuel in cold weather since it can freeze and stop the flow of fuel to the engine. There are commercial additives available that can be put into the fuel to prevent the water from freezing. Enough fuel must be drained from the water separator daily to remove all water that may have collected in it.

Air

A loose suction line in the fuel system will permit air to enter the system, causing the engine to idle roughly and not function properly under a load.

Fuel System Maintenance

The fuel system hoses and fittings must have their tightness checked on a regular basis. The following steps will help keep the fuel system functioning satisfactorily:

1. Let no contamination (dirt or water) enter the tank filler opening.
2. The fuel for the diesel engine must be of good quality (Grade 2) and should be obtained from a reliable supplier.
3. Have a clean fuel nozzle and loading area where vehicle fuel tank is filled.
4. Have fuel tanks filled at the end of each shift before parking. Be sure the vent in the fuel cap is open. Do not fill fuel tank above bottom of the filler neck.
5. Replace filters on a regular basis.
6. Keep all fuel system hoses and fittings tight.

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 information in 6.3 *Refill Capacities/Lubricants/Fuel.*

⚠ WARNING

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

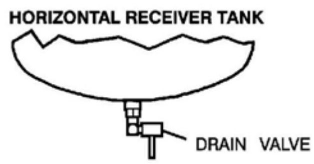
1. Check the fuel level by reading the fuel level gauge located on the cab dashboard.
2. Never allow fuel tanks to completely empty, otherwise the entire fuel system will require bleeding.
3. When fuel is added, clean the fill cap area and open the fuel filler cap.
4. Fill tank with the correct grade of fuel. Refer to 6.3 Refill Capacities/Lubricants/Fuel for more details.

Receiver Separator

The receiver tank 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 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.

Drain Water from Receiver Tank

Water condenses and must be drained ***daily*** from the bottom of the receiver tank. If water is allowed to condense into the compressor oil, the bearing life will be considerably reduced.



⚠ WARNING

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

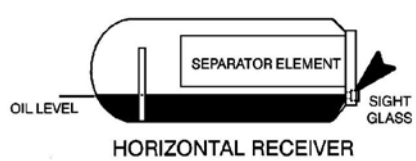
1. Locate and open the receiver tank drain valve and allow any of the accumulated water to drain into a container.
2. When oil starts to flow, close the drain valve.
3. Dispose of all accumulation in accordance with local regulations.

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.

⚠ WARNING

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.



Check the receiver separator oil level at the sight glass oil level gauge on the receiver as shown above. The procedure to check the fluid level is as follows.

1. The engine must not be running

2. The fluid must be in the center of the oil level sight glass on the receiver tank.
3. If necessary, add fresh, clean synthetic oil (filtered through a 10 micron filter) through the fill cap area to bring the oil level to FULL.
4. ***High pressure*** compressors (350 psi) must use ***XHP605 Oil***. For details on compressor oil, refer to "Compressor Fluids" in section 6-3 *Refill Capacities/ Lubricants/Fuel Specifications*.

Receiver Separator Element

Maintenance on the receiver separator element is on an **"*as required*"** basis. A change of the separator element is required when there is excessive oil carryover with the compressed air.

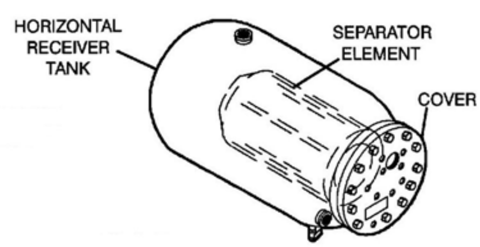
⚠ WARNING

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

⚠ WARNING

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

1. Park the drill on a stable, level surface and shut down the engine. Allow time for the drill to cool down.



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 the bolts.
6. After startup, check for any leaks at operating temperatures.

Hydraulic Reservoir

The hydraulic reservoir oil level must be checked **daily** as part of the **8 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 levels.

Hydraulic Oil Level

The following procedure is proper for checking the hydraulic oil level in the reservoir. If the hydraulic oil level is low, add hydraulic oil.

⚠ CAUTION

Excessive hydraulic oil can rupture the 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.

1. The drill must be level.

2. Check the reservoir oil level by viewing the sight gauge.

3. 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 (derrick down and leveling jacks up should be even with the mark on the oil level 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 the gauge, stop the engine immediately and call for service assistance to investigate the cause of oil loss.***

4. If necessary, add fresh, clean (filtered through a 5 micron filter) anti-wear hydraulic oil through the fill cap to bring tank level to the FULL level on the sight gauge. ***Do not add oil through the suction manifold plug*****.** Refer to 6.3 *Refill Capacities/Lubricants/Fuel* for details on hydraulic oil.

5. During operation, monitor the hydraulic oil temperature gauge located on the operator's control panel.

Hydraulic Oil Filters

It is important to monitor the filters' restriction indicator sight glass during the ***routine 8 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.

There are two hydraulic return oil filters, one hydraulic case drain oil filter and one hydraulic pump charge filter on the drill.

The system ***main return filters*** are in-tank filters located in the hydraulic tank and available for servicing at the top of the tank. The main return flow to the tank passes through these filters and into the hydraulic tank.

The ***case drain filter*** is located on the side of the derrick rest behind the truck cab and filters case drain oil prior to return into the hydraulic tank.

The ***pump charge filter*** is located on the derrick rest, behind the truck cab, near and above the main hydraulic drive gearbox and filter oil to the rotation pump and pulldown pump.

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.

⚠ WARNING

Do not attempt to service the filters before making sure all the hydraulic pressure has been relieved from the system.

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.

NOTICE

Care must be taken to ensure that fluids are contained during any inspection or work that is performed on this component. Follow all local and federal regulations concerning the handling of hydraulic fluid.

Rotary Tophead

Check the rotary tophead ***daily***. Perform this maintenance with the derrick up and the rotary head at the bottom of the derrick.

⚠ WARNING

Riding the rotary head can cause severe injury or death. Do not ride the rotary head.

⚠ WARNING

Climbing a raised derrick can cause severe injury or death. Do not climb a raised derrick.

⚠ WARNING

Falling derrick can cause severe injury or death. Ensure all locking pins are in locked position.

⚠ WARNING

Rotating shafts or drill string can cause severe injury or death. Do not service the rotary head with the drill string in motion.

1. Move the drill to a stable, level surface and raise the derrick.
2. If necessary, remove the drill pipe in the rotary tophead and lower the rotary tophead to the bottom of the derrick.
3. Inspect the rotary tophead housing for leaks.
4. Inspect the fluid level sight glass for damage
5. Check the rotary tophead oil level. Oil must be showing in the sight glass located on the side of the rotary tophead.

If the fluid level is low, add fluid using the following procedure:

1. The drill must be level. The derrick must be raised and the rotary tophead must be at the bottom of the derrick.
2. Clean the area around the fill plug and remove the fill plug.
3. Add SAE 80W90 oil through the fill port until the oil level is visible in the center of the sight glass. Refer to 6.3 *Refill Capacities/Lubricants/Fuel* for details on hydraulic oil.
4. Once the proper oil level is reached, replace the fill plug and tighten.

Swivel-Yoke

With a grease gun, lubricate all lube points on the swivel-yoke assembly, including the roller assembly.

Lubrication

The following grease procedures must be carried out as part of the ***8 hour or daily*** routine maintenance schedule.

Derrick Pivot Pins

1. Shut down engine.
2. Apply grease gun pressure to the derrick pivot pin lube points (both sides) until all of the old grease has been purged out and new grease appears.
3. Wipe off all excess grease.

Carousel Bearings

The carousel contains bearings at the upper and lower ends of the carousel main shaft.

1. The upper and lower bearings on the carousel main shaft require 5 pumps of grease daily, at shift change, or every 8 hours of drill operation. Wipe off excess grease.

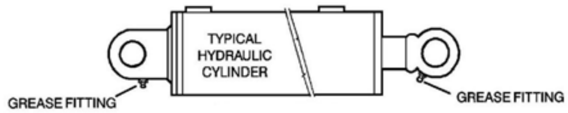
Sheaves

There are four feed cable sheaves on the traveling sheave cage. There are four feed cable sheaves at the top of the derrick and four more feed cable sheaves at the bottom of the derrick. In addition, there are two draw works sheaves located at the top of the derrick.

1. Lower the derrick to the horizontal position.
2. Shut down the engine.
3. Using a manlift, clean the grease nipples on the sheave.
4. Inject five shots of MPG-EP2 grease into each grease nipple or until all of the old grease has been purged out and new grease appears.
5. Wipe off excess grease.
6. It is particularly important that the lower feed cable sheaves at the bottom of the derrick be kept clean. Allowing cuttings to build up on these sheaves could result in a failure of the sheave itself or in the cable.

Cylinders

Grease the cylinders on the drill daily. A typical cylinder will have a grease fitting at both the rod end and the cylinder end of the cylinder. Both need lubricated. A typical TH60 will have two (2) derrick raise cylinders, four (4) leveling jacks cylinders, one (1) jib boom swing cylinder, one (1) jib boom extend cylinder, one (1) feed cylinder, one (1) table retract cylinder, one (1) breakout wrench cylinder, one (1) upper breakout (air) wrench and one (1) table (sliding) wrench air cylinder.



1. Lower the derrick into the horizontal position.
2. Shut down the engine.
3. Use a manlift, if necessary. ***Do not*** climb on derrick.
4. Clean all grease nipples on the cylinders.
5. Inject five shots of MPG-EP2 grease into each grease nipple.
6. Wipe off excess grease.

Rotary Tophead, Swivel and Rollers

Visually inspect the unit for leakage, damage or wear daily, at shift change or every 8 hours of operation.

NOTICE

If a problem is found during a visual inspection, DO NOT RUN THE ROTARY TOPHEAD until the problem is fixed.

1. Move the drill to a stable, level surface and raise the derrick.
2. If necessary, remove the drill pipe in the rotary tophead and lower the rotary tophead and swivel yoke to the bottom of the derrick.
3. Clean all the grease nipples on the swivel yoke assembly and guide rollers.
4. Inject five shots of MPG-EP2 grease into each grease nipple.
5. Wipe off excess grease.

Breakout (Holding) Wrenches

The upper and lower breakout (holding) wrench grease points require 5 pumps of grease daily, at shift change, or every 8 hours of drill operation.

1. The lower breakout holding wrench has two grease points in the sliding portion of the wrench and two grease points at the pivot points of the wrench.
2. The upper breakout holding wrench has only one grease point at its pivot.

Chain/Pipe Wrench

1. Clean all the grease nipples on the chain/pipe wrench assembly.
2. Inject five shots of MPG-EP2 grease into each grease nipple.
3. Wipe off excess grease.

Drive Lines and U-Joints

There are four (4) drivelines on the standard TH60.

1. Truck transmission to PTO
2. PTO to Truck Axle (s)
3. PTO to Main Hydraulic Drive Gearbox
4. PTO to Airend

To insure proper lubrication of all bearing assemblies on the truck universal joints, it is essential that the lubricant be added until it appears at all journal cross bearing seals.

NOTE: ***Do not assume that the bearing cavities have been filled with lubricant unless flow is noticed around all bearing seals.***

⚠ WARNING

Shut down engine and remove ignition key from ignition switch. Rotating shaft can cause severe injury or death. Do not operate with the guard removed.

1. Apply grease gun pressure to lubrication fitting until fresh grease appears at the pressure relief hole in the welch plug at the sleeve end of the spline. When grease appears, cover the pressure relief hole with finger and continue to apply pressure until fresh grease appears at the sleeve yoke seal.

Retract Gate Arms

The retract gate arms are located at the top of the derrick.

1. Lower the derrick into the horizontal position.
2. Shut down the engine.
3. Use a manlift, if necessary. ***Do not*** climb on derrick.
4. Clean all grease nipples on the retract gate arms.

5. Pump 5 shots of grease into the grease fitting on each of the 4 retract gates daily, at shift change, or every 8 hours of drill operation.
6. Wipe off excess grease.
7. Verify the locking collar on each retract gate is tight. A loose locking collar will allow the retract gate to move into the path of the rotary tophead and cause extensive damage to the feed system.

Mud Pump Grease Points

The number of grease points will vary depending on which mud pump is installed on the drill. There are grease points on the mud piping valves, for the mud pump shaft seal, for the mud pump bull gear shaft and for the pump jack shaft (input shaft).

1. Clean all the grease nipples on the mud pump assembly.
2. Pump 5 shots of grease into the grease fittings.
3. Wipe off excess grease.

Rod Holder Option

If necessary, raise the derrick and lock the derrick in the vertical position.

1. Shut down engine.
2. Clean all the grease nipples on the rod holder.
3. Pump 5 shots of grease into each grease fitting on the rod holder.
4. Wipe off excess grease.

Jib Hoist/Boom

The jib hoist/jib boom grease points require 5 pumps of grease daily, at shift change, or every 8 hours of drill operation. ***Note***: Use a manlift to grease the fittings located at the top of the derrick crown. The jib boom grease points are:

1. The rod end of the boom swing cylinder.
2. The boom swing cylinder pivot.
3. Both ends of the boom extend cylinder.
4. The boom extend cylinder pivot.
5. The jib boom arm pivot.
6. Four places on the jib boom arm slide (two on top, two on bottom).
7. Front and rear cable sheave pins.

Sandreel

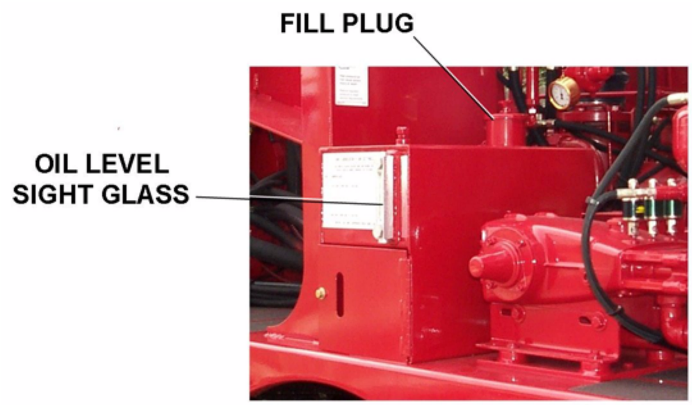
The sandreel grease points require 5 pumps of grease daily, at shift change, or every 8 hours of drill operation. There are five grease points located on the sandreel, shafts and levers. In addition, there are two (one each) grease points on the sandreel sheaves at the top of the derrick.

1. Clean all the grease nipples.
2. Pump 5 shots of grease into the grease fittings.
3. Wipe off excess grease.
4. ***Note:*** Lower the derrick to horizontal position and use a manlift to grease the sandreel sheaves at the top of the derrick.

DHD Lubricator

DHD's (Down Hole Drill) 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.

The DHD lubricator must always be used whenever the DHD is being operated. Use the correct oil for the DHD and the season. Make sure there is sufficient Rock Drill Oil in the lubricator to lubricate the DHD during each shift.



1. A sight glass on the side of the lubricator shows the amount of oil left.

NOTICE: Use approved rock drill oil only to obtain maximum life from your DHD.

2. Add approved Rock Drill Oil through the fill plug on top of the container. Oil can be added while the drill is running, if necessary.

NOTICE: Make sure all dirt and cuttings are removed around fill cap.

Carrier

Refer to the actual manufacturer’s service and maintenance manuals for specific information on maintenance for the truck transmission and the carrier cooling system.

Truck Engine

Maintain the engine oil level between the “ADD” and “FULL” marks on the dipstick. Refer to the actual manufacturer’s service and maintenance manuals for specific information on Engine Lubricating Oil.

Truck Transmission

Refer to the actual manufacturer’s service and maintenance manuals for specific information on maintenance for the truck transmission.

Truck Power Steering

Refer to the actual manufacturer’s service and maintenance manuals for specific information on maintenance for the truck power steering unit.

Truck Cooling System

Refer to the actual manufacturer’s service and maintenance manuals for specific information on maintenance for the truck cooling system.

Housekeeping

The complete drill must be given a weekly cleaning. Daily cleaning will be required if material is adhering to the derrick or truck working parts.

1. Make sure the inside of the carrier 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 operator’s platform.
2. Check the derrick 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 electrical 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 at the first sign of probable failure.

6-6 MAINTENANCE (50 Hours or Weekly)

General Information

WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Batteries

The following battery maintenance must be carried out as part of the **50 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.

⚠ WARNING

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

Electrolyte Level

1. Check the electrolyte level and keep the electrolyte level above the plates.
2. Refill with distilled water if necessary.
3. ***Do not over fill***. Over filling can cause poor performance or early failure.

Battery Terminals

Keep the battery terminals clean and the connections tight.

Winch/Sand Reel Cable

The following must be carried out as part of the **50 hour** routine maintenance schedule.

⚠ WARNING

Do not climb a raised derrick. Climbing a raised derrick can cause severe injury or death. Lower the derrick to the horizontal position to service the jib hoist and sand reel.

⚠ WARNING

Never lift or transport personnel with the winches. Do not use the winch in any manner of operation which may endanger any individual.

⚠ CAUTION

Stay at least 10 feet (304.8 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 five (5) wraps of cable must remain on the drum at all times*.**

Wire Rope

Wire ropes, including their anchorage and other load carrying components of the traveling block and winch system, e.g. sheave bearings, rope sheaves and drill hooks shall be checked at least ***once a week***.

Wire rope used in drilling operations becomes unusable because of wear and wire breakage and should be 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 drills 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 the basis of experience.

1. Replace when four (4) randomly distributed broken wires are found in one lay.
2. Replace when the 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.

Refer to ***Cable & Wire Rope*** information in 6.4 *Maintenance As Required* for additional information on wire rope and wire rope clamps.

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 five (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”.

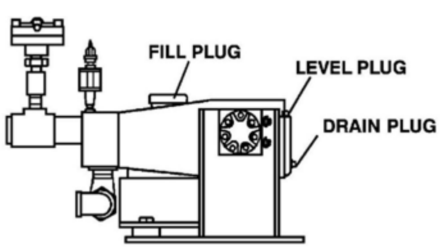
Water Injection Pump

Change the initial water injection pump oil after the first 50 hours of operation. Thereafter, water injection pump oil change maintenance must be carried out as part of the 500 hour routine maintenance schedule and every 500 hours thereafter.

⚠ WARNING

The water injection pump oil should be at operating temperature for draining. Be careful. Hot oil and components can burn.

Change Initial Oil



1. Position the drill on stable, level surface.

2. Place a container with a capacity of at least 12 ounces (295 ml) under the drain point to collect the used oil.
3. Remove both fill plug and drain plug. 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 the fill port until oil appears at level plug. Refill with SAE40 (anti rust) oil.
7. Clean and install fill plug and level plug.
8. Operate the drill and water injection and check for any leaks.

Pump Drive Gearbox

Oil Leaks

Inspect the hydraulic pump drive gearbox for leaks as part of the ***50 hour*** maintenance schedule. Follow the steps shown below.

1. Look for signs of oil on the case and around the bottom of the case.
2. If there are signs of oil leakage, clean the outside of the case and around the bottom. Verify signs of oil are from the case and not another source.
3. If a leak is verified, contact maintenance and take corrective action.

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 any traces of dirt or the effects of high temperature, evidenced by discoloration or strong odor.***

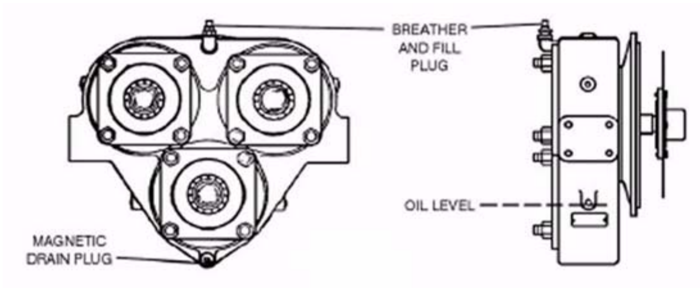
⚠ WARNING

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.

⚠ CAUTION

Do not add or check the oil level with the engine running.

1. Move the drill to a level surface.
2. Stop engine before checking or adding oil.



3. Clean around the oil level plug and the oil fill plug before checking or adding oil.
4. Check the oil level within the gearbox. The oil should be level with the oil level plug.
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 overheating. Refer to Sec. 6-3 Refill Capacities/Lubricants/Fuel for recommended oil specifications.
6. Check and clean the gearbox breather.

6-7 MAINTENANCE (100 Hours)

General Information

WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Winch

A regular program of preventive maintenance for the winch will minimize the need for emergency servicing and insure long life and trouble free service. All service intervals are specified for operating hours of the drill.

> **NOTE:** ***The service intervals that are suggested will optimize component service life. The intervals may be gradually increased or decreased after gaining experience with a particular lubricant and the recommendations of an independent oil analysis.***

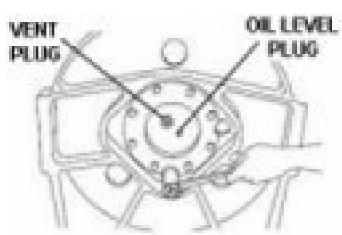
The gear oil should be changed after the first one hundred (100) hours of operation, then every 1000 operating hours or six (6) months, whichever occurs first. The gear oil must be changed to remove wear particles that impede the reliable and safe operation of the brake clutch and erode bearings, gears 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 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 -10°F to 80°F (-23.3°C to 26.6°C) use Texaco Meropa 150 or equivalent API GL-2/3. For temperatures between 50°F to 130°F (10°C to 54.4°C) use Texaco Meropa 220 or equivalent API GL-2/3.

Oil Change

1. Move the drill to a stable, level surface.
2. Shut off the engine.
3. Place a container with a capacity of at least 4 quarts (4 liters) under the drain point to collect the used oil.
4. Clean around the fill/oil level plug.



5. To drain the oil, screw a short piece of 1” pipe into the larger threads of the drain hole.
6. Use a 3/8” drive extension to remove the drain plug through the pipe.
7. Remove the drain plug, insert a suction drain tube and allow the oil to drain smoothly into the suitable container.
8. Clean and install the drain plug.
9. Using a suitable hose or funnel, refill the housing with Texaco Meropa or equivalent API GL-2/3, through the fill hole, until oil is level with the bottom of the fill/level hole. Winches which are being serviced may not require as much oil due to incomplete draining of the original winch oil. The approximate capacity is 4 quarts (4 liter). Refer to section 6.3 *Refill Capacities/Lubricants/ Fuel* for further recommended oil specifications.
10. Clean and install the fill/level plug.
11. Remove the container and dispose of the used oil in accordance with local guidelines.
12. Whenever the gear oil is changed, remove the vent plug, clean in solvent and reinstall. ***Do not*** paint over the vent plug or replace it with a solid plug.

Mounting Bolts

Tighten all winch base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every five hundred (500) operating hours or six (6) months, whichever occurs first.

Sand Reel

A regular program of preventive maintenance for the casing hoist will minimize the need for emergency servicing and insure long life and trouble free service. All service intervals are specified for operating hours of the drill.

> **NOTE:** ***The service intervals that are suggested will optimize component service life. The intervals may be gradually increased or decreased after gaining experience with a particular lubricant and the recommendations of an independent oil analysis.***

Oil Change

The gear oil should be changed after the ***first one hundred (100) hours*** of operation, then ***every 1000 operating hours or six (6) months,*** whichever occurs first. 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. Make certain that the gear viscosity used in your winch is correct for your prevailing ambient temperature.

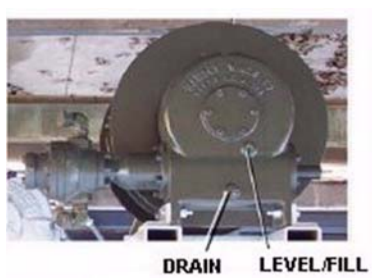
⚠ WARNING

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.

Required lubricant: For temperatures between -10°F to 80°F (-23.3°C to 26.6°C) use Texaco Meropa 150 or equivalent API GL-2/3. For temperatures between 50°F to 130°F (10°C to 54.4°C) use Texaco Meropa 220 or equivalent API GL-2/3.

Replace the lubricant using the following steps:

1. Move the drill to a stable, level surface.
2. Shut off the engine.
3. Place a container with a capacity of at least 4 quarts (4 liters) under the drain point to collect the used oil.
4. Clean around the oil level plug (fill plug) and remove the oil level plug.



5. Clean and remove the drain plug. Allow the oil to drain smoothly into a suitable container. Install the drain plug.
6. Refill the housing with Texaco Meropa or equivalent API GL-2/3, through the fill hole, until oil is level with the bottom of the fill/level hole. Sand reels which are being serviced may not require as much oil due to incomplete draining of the original sand reel oil. The approximate capacity is 4 quart (3.78 liter).
7. Clean and install the fill/oil level plug.
8. Remove the container and dispose of the used oil in accordance with local guidelines.
9. Raise the derrick, operate the sand reel and check for leaks.

Mounting Bolts

Tighten all sand reel base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every five hundred (500) operating hours or six (6) months, whichever occurs first.

6-8 MAINTENANCE (250 Hours)

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Truck Maintenance

Truck Engine

Refer to the actual manufacturer's service and maintenance manuals for specific information on maintenance for the truck engine.

1. Change the engine oil after 250 hours of operation. Use an API CG4, 15W40 lubricating oil. Refer to the engine manufacturer's manual for the correct procedure to perform this maintenance.
2. Change the engine oil filter(s) when changing the engine oil. Follow engine manufacturer's recommendations.
3. Change the fuel filter(s) when changing the engine oil. Follow engine manufacturer's recommendations.
4. Change the coolant filter when changing the engine oil. Follow engine manufacturer's recommendations.
5. Check the engine SCA level at this time. Refer to the engine manual.
6. Check the engine belt(s) tension at this time. Refer to the engine manual.

Truck Transmission

Refer to the actual manufacturer's service and maintenance manuals for specific information on maintenance for the truck transmission.

1. Check the truck transmission oil level every 250 operating hours. Add oil if necessary. Refer to the actual manufacturer's service manual for the procedure and for the type of transmission fluid used in your vehicle.

Truck Power Steering

Refer to the actual manufacturer's service and maintenance manuals for specific information on maintenance for the truck power steering system.

1. Check the truck power steering fluid level every 250 operating hours. Add oil id necessary. Refer to the actual manufacturer's service manual for the procedure and for the type of power steering fluid used in your vehicle.

Truck Differentials

Refer to the actual manufacturer's service and maintenance manuals for specific information on maintenance for the truck differentials.

1. Check the gear oil level in the truck differentials every 250 operating hours. Fill to oil level plug if needed. Refer to the actual manufacturer's service manual for the procedure and for the type of gear oil used in the differentials.

6-9 MAINTENANCE (500 Hours)

General Information

WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

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.

⚠ WARNING

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

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.

Electrolyte Level

1. Check the electrolyte level and keep the electrolyte level above the plates.
2. Refill with distilled water if necessary.

⚠ CAUTION

Over filling can cause poor performance or early failure.

Hydraulic Reservoir

The following hydraulic reservoir maintenance must be carried out as part of the ***500 hour*** routine maintenance schedule.

Hydraulic Tank Breather

The hydraulic tank breather should be replaced as part of the **500 hour** routine maintenance procedure.

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

The following compressor system maintenance must be carried out as part of the ***500 hour*** routine maintenance schedule.

⚠ WARNING

Hot compressor oil or components can burn. Avoid contact with hot oil or components. Do not allow used compressor oil to drain into the ground. Dispose of used compressor oil properly.

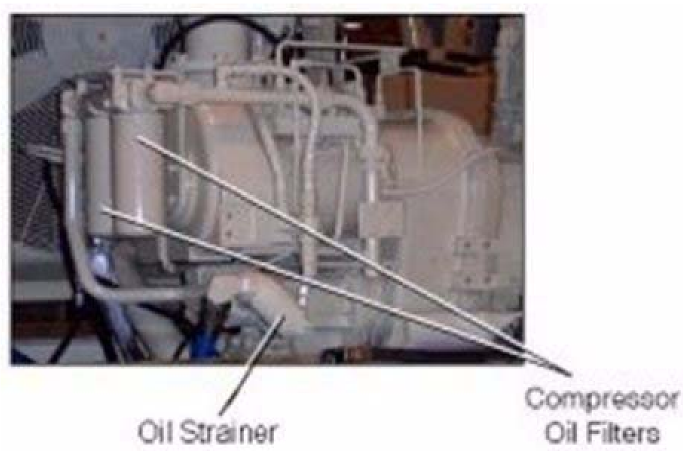
⚠ WARNING

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

Compressor Oil Strainer

A 40 mesh (150 micron) strainer is mounted just before the inlet to the oil pump. 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***.

1. Thoroughly clean the entire area around the compressor oil strainer.
2. Remove the plug from the end of the strainer.
3. Pull the strainer out of the body and wipe clean. Remove any debris from the strainer before replacing.
4. Insert the strainer back into the body.
5. Install the Plug. Tighten securely.
6. Check for leaks.



Compressor Oil Filters

The following compressor oil filter maintenance must be carried out as part of the ***500 hour*** routine maintenance schedule.

⚠ WARNING

Hot compressor oil or components can burn. Avoid contact with hot compressor oil or components. Do not let used oil 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.

2. Place a container under the oil filters to collect any oil escaping during filter removal and to prevent any oil spill from contaminating the ground.
3. Unscrew the used filters using a filter wrench. Discard the used filters in accordance with local guidelines.
4. Clean the sealing surface of the filter mounting base. Make sure the entire old gasket is removed.
5. Fill the new filters with clean compressor oil and lubricate the o-ring seal with clean oil.
6. Screw the new oil filters on until the gasket contacts the base. Tighten the filters 3/4 of a turn more by hand. Do not over tighten. Use the rotation index marks, on the filters, as a guide for proper tightening.
7. After startup, check the oil filters for any leaks at operating temperatures.

Pump Drive Gearbox

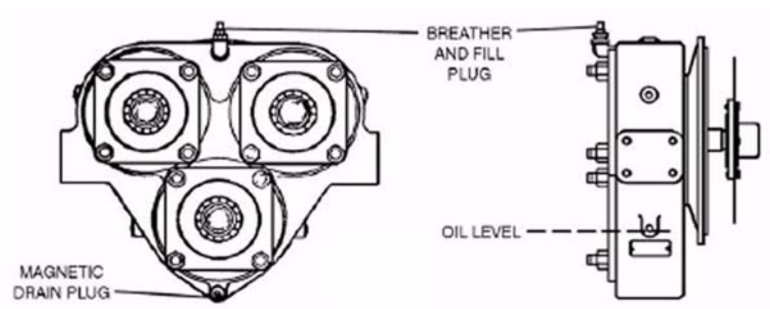
The type of service and the operating conditions will determine the maintenance interval. However, it is recommended that the pump drive gearbox oil be changed after the first five hundred (500) hours of operation, then at every 1000 operating hours. Because the lubricant system is the heart of the unit, 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.*

⚠ 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.

Change Pump Drive Gearbox 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 liter) under the drain point.
3. Clean around the drain plug, oil fill plug, breather and oil level plug areas.
4. Remove the drain plug and the breather.
5. Drain the oil while the pump drive is still warm. At this time, most of the sediment in the gearbox will be in suspension and will drain with the old oil.
6. Examine the 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 the magnetic drain plug before installing. Install the drain plug.
8. Refill the pump drive gearbox through the breather/fill port with 80W90 gear oil until the oil level reaches the oil level port on the gearbox. ***Do not overfill. This will result in the overheating and possible malfunction of the gearbox.***
9. Clean the breather and install securely.
10. After startup, check the pump drive gearbox for any leaks at operating temperature.

Water Injection Pump

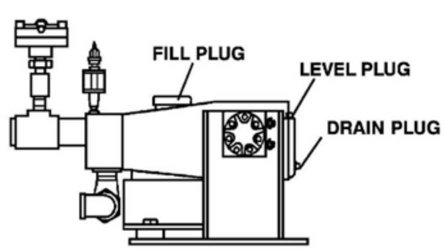
The following water injection pump maintenance must be carried out as part of the ***500 hour*** routine maintenance schedule and every 500 hours thereafter.

⚠ WARNING

The water injection pump oil should be at operating temperature for draining. Be careful. Hot oil and components can burn.

Change Oil

1. Position the drill on stable, level surface.
2. Place a container with a capacity of at least 12 ounces (295 ml) under the drain point to collect the used oil.



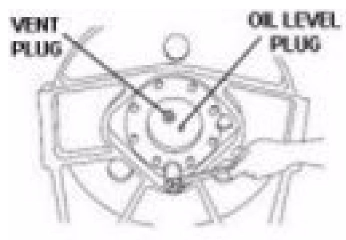
3. Remove both fill plug and drain plug. Allow oil to drain completely.
4. After oil has drained, clean and replace drain plug.
5. Clean and remove the level plug.
6. Refill the oil through the fill port until oil appears at level plug. Refer to 6.3 *Refill Capacities/Lubricants/Fuel Specifications* for oil details.
7. Clean and install fill plug and level plug.
8. Operate the drill and water injection and check for any leaks.

Winch/Sand Reel

The winch and sand reel oil levels should be checked every ***five hundred (500) hours*** or three (3) months of operation, whichever comes first.

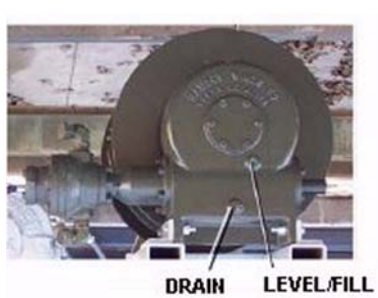
Winch Oil Level

1. Move the drill to a stable, level surface.
2. Shut off the engine.



3. To check the oil level, remove the oil level plug located in the center of the drum support. Maintain the lubricant level in the gear housing level with the bottom of this opening. Drain and refill the housing if the oil shows signs of moisture or other contamination. If additional oil is needed, refer to 6.3 Refill Capacities/ Lubricants/Fuel Specifications for oil recommendations.

Sand Reel Oil Level



1. Move the drill to a stable, level surface.

2. Shut off the engine.
3. To check the oil level, remove the oil level plug located on the side of the gearbox. Maintain the lubricant level in the gear housing level with the bottom of this opening.
4. Drain and refill the housing if the oil shows signs of moisture or other contamination.

Mounting Bolts

Tighten all winch and sand reel base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every ***five hundred (500) operating hours*** or three (3) months of operation, whichever comes first. Refer to 6-14 *Torque Specifications.*

Cable/Rope Lubrication.

Lubrication of the wire rope and cable should be included in the maintenance schedule. Cables should be cleaned with a wire brush and solvent and lubricated every ***500 hours*** with one of the following or equivalent:

1. Texaco Crater A
2. Brooks Klingfast 85 (Brooks Oil Company)
3. Gulf Senaca 39
4. Whitmore's Wire Rope Lubricant (Whitmore Manufacturing Company)

The lubricant can be applied with either a spray or a brush and is recommended for protection against corrosion only.

Compressor Air Hose and Clamps

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.

Air Hose & 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 and change out worn hoses and weakened Boss clamps. If hoses are to be changed out, change the Boss clamps also. 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 them.

6-10 MAINTENANCE (1000 Hours)

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Receiver Tank

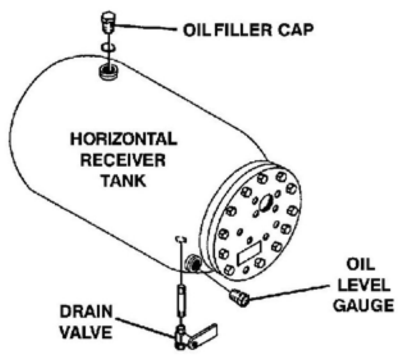
Under normal operating conditions, the compressor oil must be changed every 1000 hours as part of a routine maintenance program.

DANGER

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

WARNING

Oil must be at normal temperature when draining. 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.



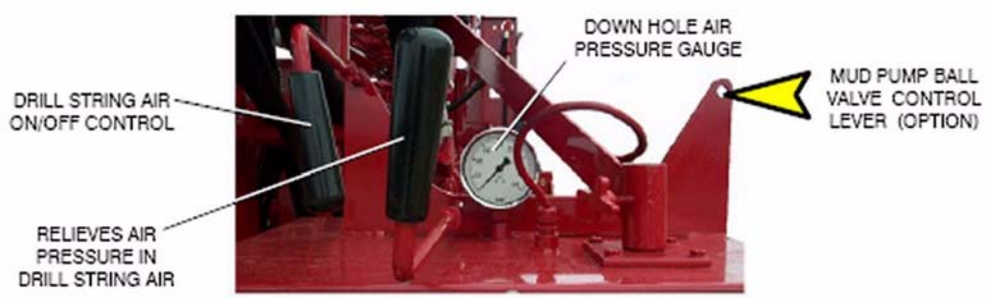
Change Compressor Oil

1. Park the drill on a stable, level surface and shutdown the engine.
2. The best time to drain the compressor oil in the receiver tank 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. Temperature should not exceed 140°F (60°C) before draining oil.
3. Place a container with a capacity of at least 40 gallon (151 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. The engine must not be running and all pressure relieved from the receiver tank.



Top of Console

5. Open the drain valve and allow the compressor oil to drain into the container. ***Do not allow used oil to drain into the ground. Dispose of the used oil in accordance with local guidelines.***
6. Close the drain valve and refill the receiver tank through the oil filler. Fill with **XHP605** oil to the center of the oil level sight gauge on the receiver tank. See Section 6-3 *"Refill Capacities/Lubricants/Fuel Specifications*" for details on the compressor oil. ***Note: High pressure compressors use XHP605 oil.***
7. Clean and replace the oil filler cap.

Hydraulic Reservoir

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. For the specifications and requirements that the hydraulic oil used in this drill should meet, refer to the information below and to 6-3 *Refill Capacities/Lubricants/Fuel Specifications.*

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

The hydraulic oil reservoir (and filters) should be changed after any major hydraulic system repair and every ***1000 operating hours or six (6) months***, whichever occurs first. Replace all hydraulic oil filters every time the hydraulic oil is changed.

1. Position the drill on a stable, level surface and ***retract*** all hydraulic cylinders.
2. Shut off the engine and allow the hydraulic oil to cool.

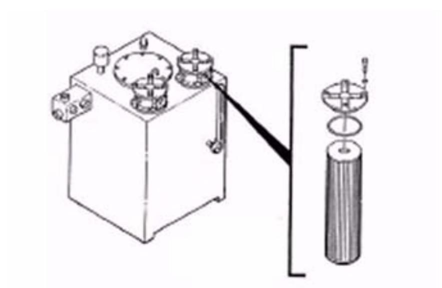
⚠ WARNING

***Hydraulic oil must be at normal operating temperature when draining. Hot oil or components can burn. Avoid contact with hot oil or components*.**

3. Ensure that a container with a capacity of at least 100 gallon (378.5 liters) is placed under the drain point to collect used oil. ***Do not allow used oil to drain into the ground.***

NOTICE

***Remove the old return filters before adding clean oil*.**



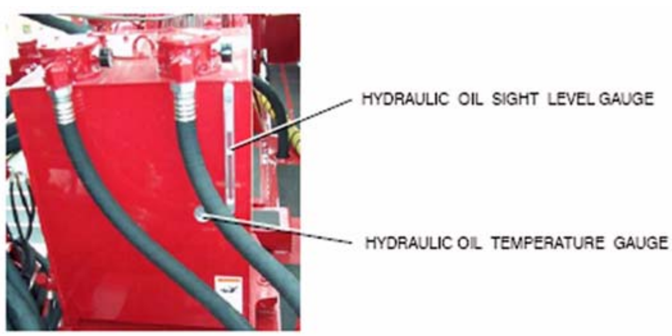
4. Remove the four bolts and lock washers from the return filters' top covers and carefully remove the covers. There is a spring inside the cover.
5. Lift out the spring and bypass valve, noting the order and orientation of these components.
6. Lift the elements out and away from the housing quickly. Do not allow dirty oil from the filter elements to drain from the element into the housing.
7. Make sure all of the old gasket seal is retained in the element and removed from the filter housing.

8. Now open the drain valve and allow the oil to drain from the hydraulic tank.

9. Close the drain valve.
10. Dispose of the used oil in accordance with local guidelines.
11. Inspect the filter and gaskets for damage. ***Do not use a damaged filter***. Inspect o-rings for serviceable condition. If damaged, replace o-rings.
12. Install new filter elements, bypass valves and springs in correct order.
13. Replace the covers and install the bolts.
14. Clean the oil filler area and remove the filler cap. Refill the tank with clean, filtered hydraulic oil from freshly opened containers to the full level on the oil level sight gauge.

    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.***

15. When adding oil, be sure to filter it through a 10 micron filter. Do not add oil through the suction manifold plug. Refer to 6-3 Refill Capacities/Lubricants/ Fuel for details.
16. Check the oil level in the reservoir by viewing the sight gauge. Make sure that all of the fittings are tight and secure.



17. 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 cylinders retracted* (derrick down and leveling jacks up) should be even with the mark on the hydraulic reservoir next to the oil level 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.

18. Clean and replace the filler cap.
19. After completing all scheduled service (hydraulic oil change and changing both in-tank return filters), start the engine and check for leaks.
20. During operation, monitor the hydraulic oil level sight gauge and hydraulic temperature gauge located on the side of the hydraulic oil reservoir.

    NOTE: ***If no oil is showing on the oil level gauge, stop the engine immediately and call for service assistance to investigate the cause of oil loss*.**

21. Replace all hydraulic oil filters every time the hydraulic oil is changed.
22. Operate the drill and check for leaks.

Hydraulic Oil Filters

It is important to monitor the filters' restriction indicator sight glass during the routine 8 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, use the following instructions to replace the filter elements. Under normal operating conditions, these filters are replaced at the regular 1000 hour service interval.

There are two hydraulic return oil filters, one hydraulic case drain oil filter and one hydraulic pump charge filter on the drill.

The system ***main return filters*** are in-tank filters located in the hydraulic tank and available for servicing at the top of the tank. The main return flow to the tank passes through these filters and into the hydraulic tank.

The ***case drain filter*** is located on the side of the derrick rest behind the truck cab and filters case drain oil prior to return into the hydraulic tank.

The ***pump charge filter*** is located on the tower rest, behind the truck cab, near and above the main hydraulic drive gearbox and filters oil to the rotation pump and pulldown pump.

⚠ WARNING

Do not attempt to service the filters before making sure all the hydraulic pressure has been relieved from the system.

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.

NOTICE

Care must be taken to ensure that fluids are contained during any inspection or work that is performed on these components. Follow all local and federal regulations concerning the handling of hydraulic fluid.

Main Return Filters

When restriction indicates that element servicing is required, or when the regular **1000 hour** service interval is reached, follow the instructions previously shown under ***Change Hydraulic Oil*** which includes changing the main return filters.

Case Drain Filter

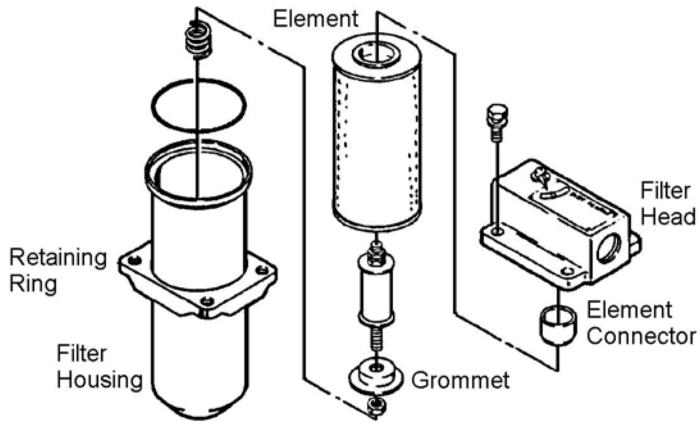
The case drain filter is located on the side of the derrick rest behind the truck cab. When restriction indicates that element servicing is required, or when the regular **1000 hour** service interval is reached, proceed in the following manner:

1. Stop the engine and allow the hydraulic oil to cool.

⚠ WARNING

Hot oil or components can burn. Oil must be at normal temperature when draining. Avoid contact with hot oil or components. Do not allow used oil to drain into the ground. Dispose of used oil properly.

2. Wipe all the external dirt and oil from the filter housing and the head area to minimize contamination from entering the system.
3. Place a container under the oil filter to prevent any oil spill from contaminating the ground.



4. Carefully remove the four (4) bolts that secure the retaining ring to the filter head.
5. Empty the oil from the filter housing into a drain container. Remove element(s) from the filter housing.
6. Save the element connectors located between the elements. Discard the old elements in accordance with any local guidelines.
7. Clean the filter housing and filter head with an approved cleaning solvent.
8. Lubricate the grommets in the filter elements 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 connectors between the elements.
9. Attach the housing to the filter head and tighten the four (4) bolts evenly and in sequence. Care must be taken not to damage the o-ring. ***Over torquing bolts will cause damage to the housing and/or o-ring washer seal.***
10. Pressurize the hydraulic system and check for leaks.
11. Check the oil level in the hydraulic reservoir and add oil if necessary following the procedures previously mentioned.

Pump Charge Filters

The hydraulic pump charge filters are located on the derrick support.

1. Stop engine and allow oil to cool.
2. Provide a suitable container to catch drained oil.

⚠ WARNING

Hot oil or components can burn. Avoid contact with hot oil or components. Do not allow used oil to drain onto the ground. Dispose of used oil properly.

3. Use a strap wrench and unscrew the spin-on filter.
4. Dispose of used oil and filters in accordance with local regulations.
5. Clean the base of the filter head, making sure all trace of the old seal is removed.
6. Apply a thin coat of oil to the seal on the new filter.
7. Fill the replacement filter with fresh, clean hydraulic oil.
8. Screw the new filter onto the base by hand. When the seal contacts the base, tighten 3/4 turn more.
9. Start the engine and check for leaks.

Rotary Tophead

Change the rotary tophead oil as part of the ***1000 hour*** routine maintenance schedule.

⚠ WARNING

Riding the rotary head can cause severe injury or death. Do not ride the rotary head.

⚠ WARNING

Climbing a raised derrick can cause severe injury or death. Do not climb raised derrick.

⚠ WARNING

A falling derrick can cause severe injury or death. Ensure all locking pins are in a locked position.

⚠ WARNING

Rotating shafts or a rotating drill string can cause severe injury or death. Do not service the rotary head with the drill string in motion.

Rotary Tophead Oil

To change the lubricant in the rotary head, follow the procedure below.

1. Move the drill to a stable, level surface and raise the derrick.
2. If necessary, remove the drill pipe in the rotary tophead and lower the rotary tophead to the bottom of the derrick.
3. Shut off the engine.
4. Ensure oil is warm before draining. At that time the sediment in the rotary tophead is in suspension and will drain with the old oil.
5. Place a container with a capacity of at least 3 gallon (11.35 liters) under the rotary tophead drain point.
6. Clean around the breather/fill port area to prevent debris from entering the rotary tophead housing during the oil change. ***Take care to prevent any contamination from entering the fill port.***
7. Remove the drain plug and allow the oil to drain.

NOTICE

Care must be taken to ensure fluids are contained during any inspection or maintenance on this component. Handle and dispose of fluids according to local regulations and mandates.

8. Remove the breather/fill plug to allow air into the housing during draining. Allow the oil to drain into a container. Dispose of the used oil in accordance with local guidelines.
9. After the rotary tophead case is drained, clean the drain plug and install it.
10. Refill the rotary head gearbox through the fill port with SAE 90W gear oil until the fluid is in the center of the fluid level sight glass.
11. Clean and install the fill plug.
12. After startup, check the rotary head for any leaks while at operating temperature.

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.*

Follow the instructions previously shown under ***Maintenance (500 Hours)***.

Winch & Sand Reel

A regular program of preventive maintenance for the winch and sand reel will minimize the need for emergency servicing and insure long life and trouble free service. All service intervals are specified for operating hours of the drill.

The gear oil should be changed after the ***first one hundred (100) hours*** of operation, then ***every 1000 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 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.

Refer to ***Maintenance (100 Hours)*** for the procedure and instructions to change oil in the winch and sand reel.

Mounting Bolts

Tighten all winch base mounting bolts to recommended torque after the first one hundred (100) hours of operation, then every ***1000 operating hours*** or six (6) months, whichever occurs first.

Table 33: Winch Mounting Bolt Torque

Thread Condition	Torque
Dry Thread	205 to 220 ft/lbs. (278 to 280 Nm)
Lubed Thread	158 to 170 ft/lbs. (214 to 230.5 Nm)

Water Injection Pump

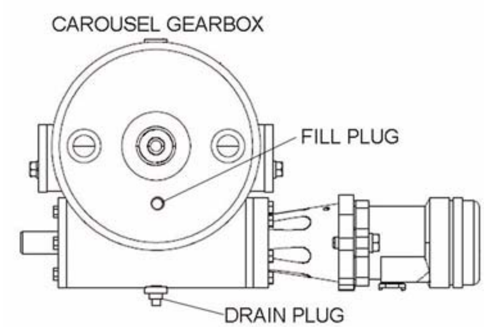
The following water injection pump maintenance must be carried out as part of the 500 hour routine maintenance schedule and every ***1000 hours*** thereafter.

Refer to ***Maintenance (500 Hours)*** for the procedure and instructions to change oil in the water injection pump.

Carousel

Carousel Gearbox

Change the carousel gearbox oil every ***1000*** operating hours. Follow the instructions shown below.



1. Move the drill to a stable, level surface. Raise the derrick and pin it in the vertical position.
2. Operate the carousel to warm the gearbox.
3. Lower the derrick to the horizontal position. Shut off the engine.
4. Place a container with a capacity of at least 4 pints (1.89 liters) under the drain plug to collect the used oil.
5. Remove the fill plug and the drain plug from the carousel gearbox and allow the oil to drain.
6. Properly dispose of the used oil.
7. Clean and install the drain plug.
8. Refill the gearbox with clean gear oil to the fill plug level.
9. Clean and install the fill plug.

6-11 MAINTENANCE (2000 Hours)

General Information

WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 the correct safety gear while working on or around the drill. This includes an approved hard hat, safety glasses, steel toe shoes/boots, gloves, respirator and ear protection. Do **not** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

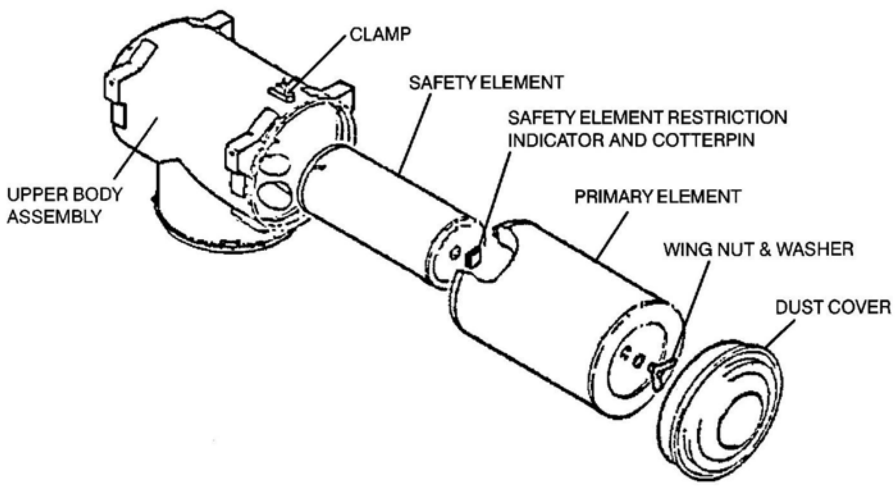
1. Do not speed engine when it is cold.
2. Always chock the wheels if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. **Always** apply the parking brake before leaving the truck cab.

Air Cleaners

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

Primary and Safety Elements

The primary and safety elements must be replaced as part of the ***2000 hour*** maintenance schedule. The following maintenance procedure must be followed:.



1. Unclip the three clamps holding the dust cover and remove the dust cover.
2. Remove the wing nut and washer. Carefully withdraw the primary air cleaner element.
3. To replace the safety element, remove the cotterpin and restriction indicator. Carefully remove the safety element. Dispose of the used elements properly.
4. Clean the inside of the cover and the housing with a clean, damp cloth.
5. Install new safety element and secure it with restriction indicator and cotterpin.
6. Examine the new primary element for torn or damaged pleats, bent end covers, liners and gaskets.
7. Ensure that the primary element wing nut and washer are not cracked or damaged. Replace if necessary.
8. Carefully install new primary element and secure it with wing nut and washer.
9. Install the dust cover.
10. Inspect all air intake piping and joints between air cleaner and compressor air inlets to ensure that no dusty air can enter.
11. Ensure all clamps are tight.

Engine Valves

Refer to the actual manufacturer's manual for maintenance instructions concerning valve clearance, adjusters and injectors. This operation requires a trained service engineer.

Compressor

The yellow and black striped air hose between the compressor and the receiver tank should be changed ***every two (2) compressor oil changes*** or once every ***2000 hours***, whichever occurs first,

Compressor Discharge Hose

This hose is subject to the highest temperatures in the compressor system and is in contact with synthetic oil at all times. If the hose is not replaced periodically, the inner lining will begin to break down. Lining material can clog the cooler and damage the compressor lubrication pump.

6-12 MAINTENANCE (2500 Hours)

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 the correct safety gear while working on or around the drill. This includes an approved hard hat, safety glasses, steel toe shoes/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Compressor

Compressor Fire Prevention

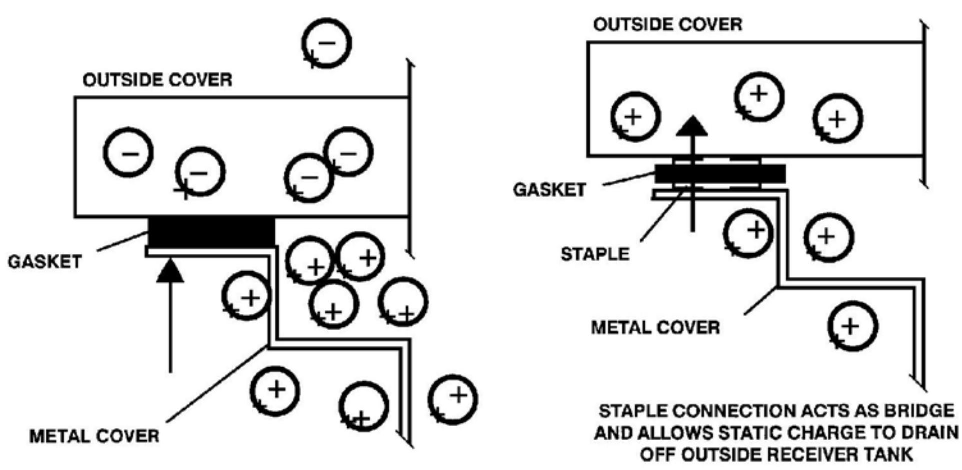
A fiber gasket is installed between the outside cover of the receiver tank and the metal tube holding the separator element in place. This gasket prevents oil from leaking around the metal tube and down the hole.

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.

⚠ CAUTION

When replacing the 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.



Receiver Separator Element

Maintenance on the receiver separator element is on an ***"as required"*** basis. A change of the separator element is required when there is excessive oil carryover with the compressed air. Otherwise, change the separator element at ***2500 hours***.

WARNING

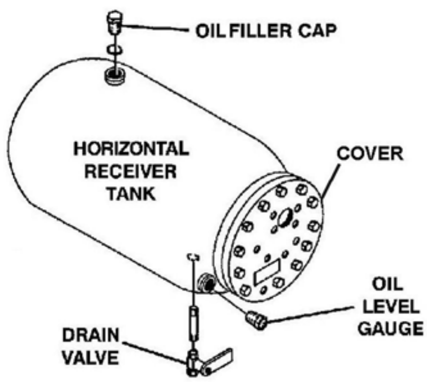
High pressure can cause severe injury or death. Do not attempt to remove any plugs or open the drain valve before making sure all air pressure has been relieved from the system. Completely relieve pressure before opening the drain valve or removing the filler plug, fittings or removing the receiver cover.

WARNING

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

The following maintenance procedure must be followed:

1. Park the drill on a stable, level surface and shut down the engine. Allow time for the drill to cool.



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. Re-attach the cover and tighten the bolts.
    a. Horizontal tank - torque bolts to 353-380 ft/lbs. dry (471-507Nm).
6. After startup, check the drill for any leaks at operating temperatures.

6-13 MAINTENANCE (4000 Hours)

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 the correct safety gear while working on or around the drill. This includes an approved hard hat, safety glasses, steel toe shoes/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Engine Coolant

The coolant system of any engine should be drained and flushed out after ***4000 hours or two (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. Oil has entered the cooling system and the coolant is contaminated.
4. 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:

1. ***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.
2. ***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

This is a 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*.**

Drain Cooling System

1. Stop the engine and allow the engine to cool.
2. Place a container under the drain valve to collect used coolant.
3. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap when draining the system to ensure proper draining.
4. Open the drain valve and allow the radiator coolant to drain into the container. At the same time, drain the engine block. ***Refer to the engine manufacturer's Service and Maintenance manuals for the recommended procedures***.

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. ***Refer to the engine manufacturer's Service and Maintenance manuals for the recommended procedures***

Fill the Cooling System

1. Refill the radiator with a 50-50 mixture of the engine manufacturer's recommended antifreeze and quality water. Install the correct coolant filter.
2. When refilling the cooling system, refer to the ***engine manufacturer's Operation and Maintenance instruction manual.***

6-14 Torque Specifications

Standard Torque Values

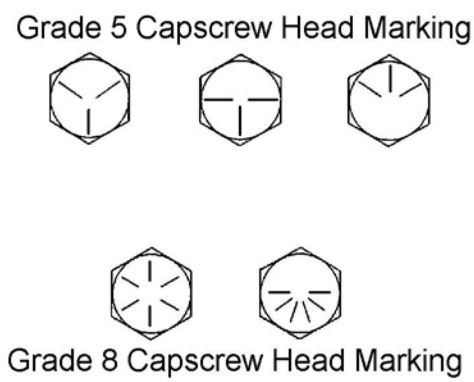
General Information

⚠ CAUTION

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 grade or a higher grade. If higher grade fasteners are used, these should only be tightened to the strength of the original grade fastener.



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 a 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.

Recommended Torques in Foot Pounds (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.

Table 34: ***Recommended Torques in Ft/Lbs*****.**

SIZE	SAE GRADE 5 TIGHTENING TORQUE		SAE GRADE 8 TIGHTENING TORQUE	
	DRY	LUBE	DRY	LUBE
5/16 - 18 NC 5/16 - 24 NF	16 - 17 18 - 19	12 - 13 13 - 14	23 - 25	17 - 18 19 - 20
3/8 - 16 NC 3/8 - 24 NF	28 - 30 33 - 35	21 - 23 23 - 25	42 - 45 47 - 50	33 - 35
7/16 - 14 NC 7/16 - 20 NF	47 - 50 51 - 55	33 - 35 37 - 40	65 - 70 74 - 80	51 - 55 56 - 60
1/2 - 13 NC 1/2 - 20 NF	70 - 75 84 - 90	51 - 55 61 - 65	102 - 110 112 - 120	74 - 80 84 - 90
9/16 - 12 NC 9/16 - 18 NF	102 - 110 112 - 120	74 - 80 84 - 90	140 - 150 158 - 170	102 - 110 121 - 130
5/8 - 11 NC 5/8 - 18 NF	140 - 150 158 - 170	102 - 110 121 - 130	205 - 220 223 - 240	158 - 170 167 - 180
3/4 - 10 NC 3/4 - 16 NF	242 - 260 279 - 300	186 - 200 205 - 220	353 - 380 391- 420	260 - 280 298 - 320
7/8 - 9 NC 7/8 - 14 NF	400 - 430 437 - 470	298 - 320 326 - 350	558 - 600 614 - 660	428 - 460 465 - 500
3/4 - 10 NC 3/4 - 16 NF	242 - 260 279 - 300	186 - 200 205 - 220	353 - 380 391 - 420	260 - 280 298 - 320
7/8 - 9 NC 7/8 - 14 NF	400 - 430 437 - 470	298 - 320 326 - 350	558 - 600 614 - 660	428 - 460 465 - 500
1 - 8 NC 1 - 12 NF	595 - 640 651 - 700	446 - 480 493 - 530	837 - 900 930 - 1000	632 - 680 688 - 740
1-1/8 - 7 NC 1-1/8 - 12 NF	744 - 800 818 - 880	558 - 600 614 - 660	1190 - 1280 1339 - 1440	893 - 960 1004 - 1080
1-1/4 - 6 NC 1-1/4 - 12 NF	1042 - 1120 1153 - 1240	781 - 840 856 - 920	1693 - 1820 1860 - 2000	1255 - 1360 1395 - 1500

SIZE	*SAE GRADE 5 TIGHTENING TORQUE*		*SAE GRADE 8 TIGHTENING TORQUE*	
	DRY	*LUBE*	*DRY*	*LUBE*
1-3/8 - 6 NC 1-3/8 - 12 NF	1358 - 1460 1562 - 1680	1023 - 1100 1172 - 1260	2213 - 2380 2530 - 2720	1655 - 1780 1897 - 2040
1-1/2 - 6 NC	1804 - 1940	1358 - 1460	2939 - 3160	2195 - 2360

Recommended Torques in Nm

This page lists the recommended tightening torques, in newton-meters (Nm), 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.

Table 35: ***Recommended Torques in Nm***

SIZE	SAE GRADE 5 TIGHTENING TORQUE		SAE GRADE 8 TIGHTENING TORQUE	
	DRY	LUBE	DRY	LUBE
5/16 - 18 NC 5/16 - 24 NF	22 - 27 24 - 26	16 - 17 17 - 19	31 - 33	23 - 24 26 - 27
3/8 - 16 NC 3/8 - 24 NF	37 - 40 44 - 47	28 - 31 31 - 33	56 - 60 63 - 67	44 - 47
7/16 - 14 NC 7/16 - 20 NF	63 - 67 68 - 73	44-47 49 - 53	87 - 93 97 - 107	68 - 73 75 - 80
1/2 - 13 NC 1/2 - 20 NF	93 - 100 112 - 120	68 - 73 81 - 87	136 - 147 149 - 160	99 - 107 112 - 120
9/16 - 12 NC 9/16 - 18 NF	136 - 147 149 - 160	99 - 107 112 - 120	187 - 200 211 - 227	136 - 147 161 - 173
5/8 - 11 NC 5/8 - 18 NF	187 - 200 211 - 227	136 - 147 161 - 173	273 - 293 297 - 320	281 - 227 223 - 240
3/4 - 10 NC 3/4 - 16 NF	323 - 347 372 - 400	248 - 267 273 - 293	471 - 507 521 - 560	347 - 373 397 - 427
7/8 - 9 NC 7/8 - 14 NF	533 - 573 583 - 627	397 - 427 435 - 467	744 - 800 819 - 880	571 - 613 620 - 667
1-8 NC 1-12 NF	793 - 853 868 - 933	595 - 640 657 - 707	1116 - 1200 1240 - 1333	843 - 907 917 - 987

SIZE	***SAE GRADE 5 TIGHTENING TORQUE***		***SAE GRADE 8 TIGHTENING TORQUE***	
	DRY	***LUBE***	***DRY***	***LUBE***
1-1/8 - 7 NC 1-1/8 - 12 NF	992 - 1067 1090 - 1173	774 - 800 819 - 880	1587 - 1707 1785 - 1920	1191 - 1280 1339 - 1440
1-1/4 - 7 NC 1-1/4 - 12 NF	1389 - 1493 1537 - 1653	1041 - 1120 1141 - 1227	2257 - 2427 2480 - 2667	1687 - 1813 1860 - 2000
1-3/8 - 6 NC 1-3/8 - 12 NF	1811 - 1947 2083 - 2240	1364 - 1467 1563 - 1680	2951 - 3173 3373 - 3627	2207 - 2373 2529 - 2720
1-1/2 - 6 NC	2405 - 2587	1811 - 1947	3917 - 4213	2927 - 3147

Section 7 - Troubleshooting

7-1 INTRODUCTION

General Information

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 toed shoes/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

Troubleshooting Information

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, operator observed problems, pneumatic and mechanical/hydraulic.

⚠ WARNING

When carrying out troubleshooting procedures, it is important to strictly observe the safety precautions and guidelines in section 2 of this manual.

Electrical

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* for further information on the electrical systems used on this drill.

Four (4) circuit breakers 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*.**

Operator Observed Problems

During operation, 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 failure control operational problems which will guide the operator to rectify the cause of the failure.

Pneumatics

During operations, the operator may observe some problems which may be defined in 7-4 *Compressor*.

Troubleshooting 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.

Mechanical Hydraulic Components

Troubleshooting 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

Troubleshooting and repairs of defects in the mechanical functioning of the engine systems requires specialist knowledge. 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 a troubleshooting chart, contact your local Drilling Solutions service office

7-2 ELECTRICAL

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 toed shoes/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. Always apply the parking brake before leaving the truck cab.

Electrical System Information

The following information is provided to give an understanding of the electrical system and the relation to the operator's control panel that is described in Section 4 - *Operating Controls*. ***Note*** that there are wiring schematics shown at the end of this section which also relate to the information provided here.

Cummins Engines

Drills equipped with Cummins engines have an electrical system with computer controls for all engine functions. Refer to the actual manufacturer's operator manuals for an explanation of the engine protection and monitoring system.

CAT Engines

Drills equipped with Caterpillar engines have an electrical system with computer controls for all engine functions. Refer to the actual manufacturer's operator manuals for an explanation of the engine protection and monitoring system.

Starting Engines

Before the engine can start, the emergency stop button must be pulled out or disengaged.

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.

Electrical System Components

Circuit Breakers

A bank of four (4) circuit breakers (figure 7-2-1), located on the operator's control panel, 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 table shows the identification of the circuit breakers located on the operator's control panel:

Table 1: Circuit Breakers

5 Amp	Engine Gauges and Optional Controls
15 Amp	Power Distribution
20 Amp	Lights (Derrick and Console)

Emergency Engine Shutdown

Pushing the emergency engine shutdown 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.

Compressor Discharge Temperature Switch

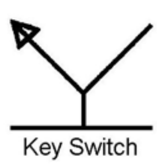
The discharge temperature switchgage (also called compressor shutdown switch) is a Murphy switchgage consisting of a gauge on the operator's control panel that shows the temperature of the oil and air leaving the air end. Normal operating temperatures are 180°F-220°F (82°C-104°C). This gauge also contains a switch that will stop the engine if the oil temperature in the compressor exceeds 248F° (120°C).

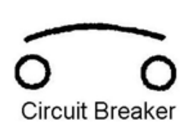
Electric Ladder

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 six (6) parts that are different and serve different purposes.

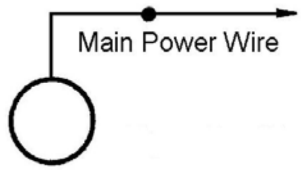
The first part is the Power Supply. These are the Batteries that supply all the power to the system. They are indicated by the two battery symbols.

The second part is the Key Switch and the Circuit Breakers that protect each separate circuit and control the power to the whole system.

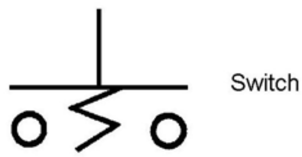




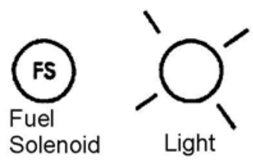
The third part is the Main Power Wire or Wires. These are the positive or plus (+) wires that carry the current to each area. They are usually larger in size than the others so they can carry more current without getting hot.



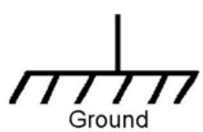
The fourth part is the switch or controller that allows current or disconnects current from the operating system. These may be push button switches or remotely controlled switches that cause a change in the system.



The fifth part is the actual Solenoid, Relay, Light or other device that is activated by supplying power to it or removing power from it.



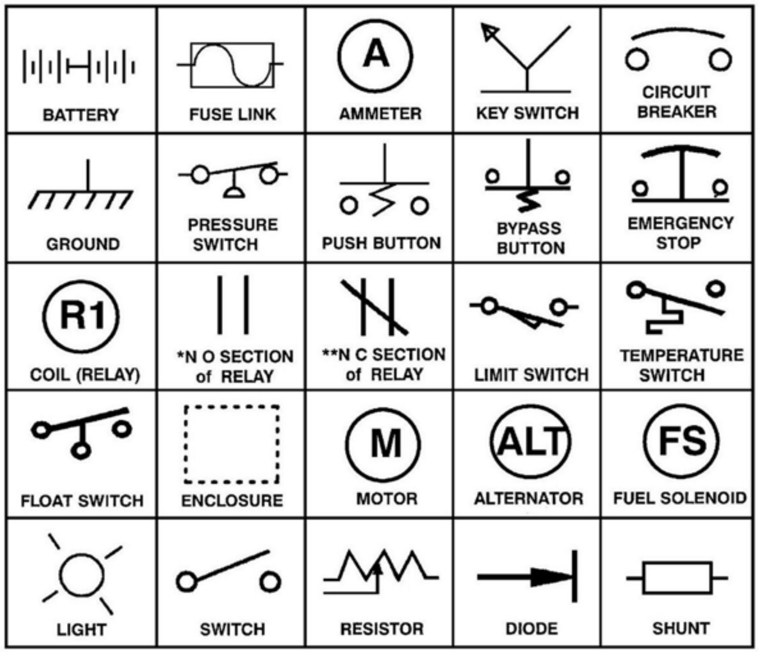
The last part is the Return or Ground Wire that makes a complete circuit and allows the system to be a system. These wires don't always seem significant but without a good ground wire the system will not function.



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.

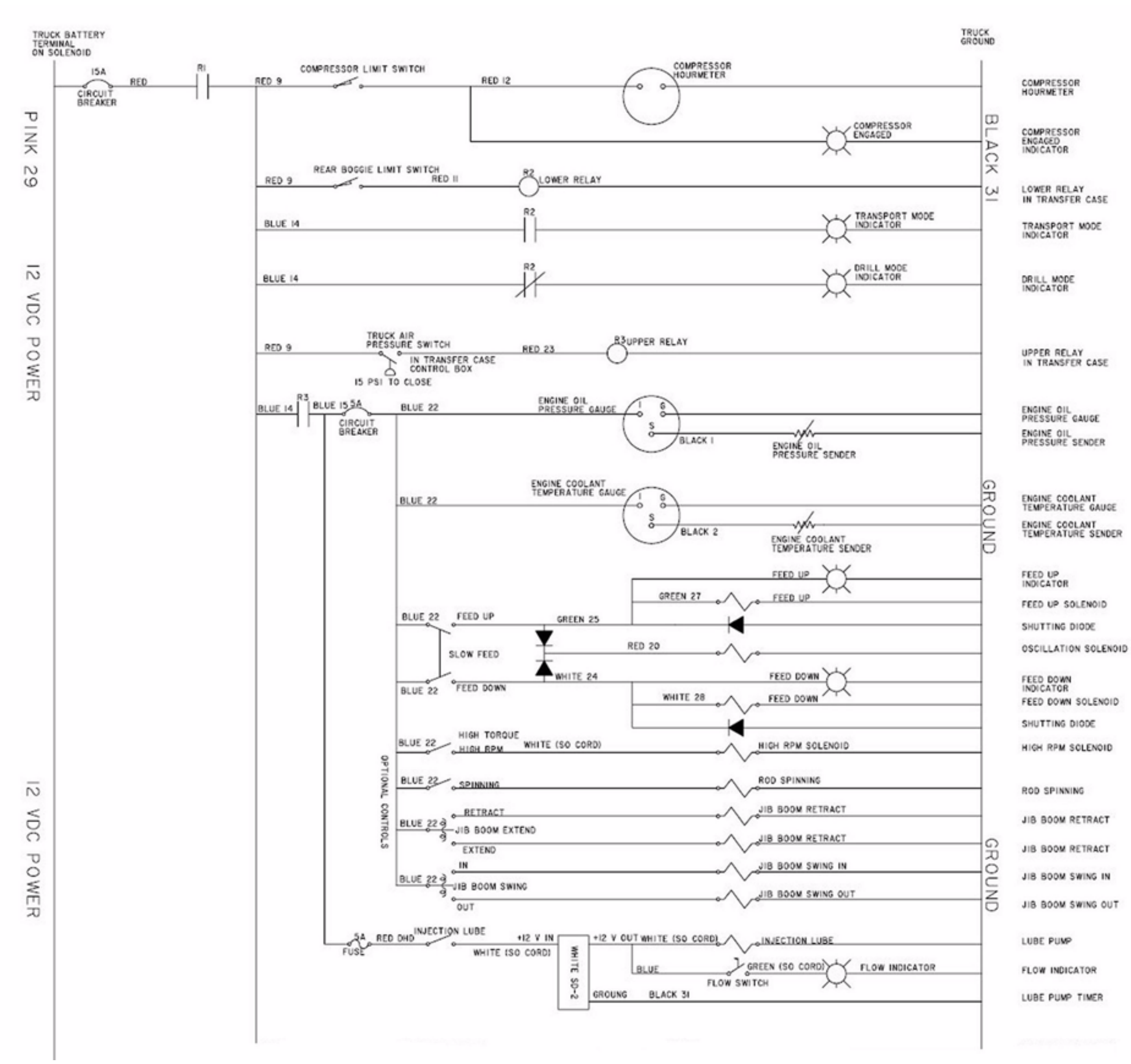
Electrical Symbols

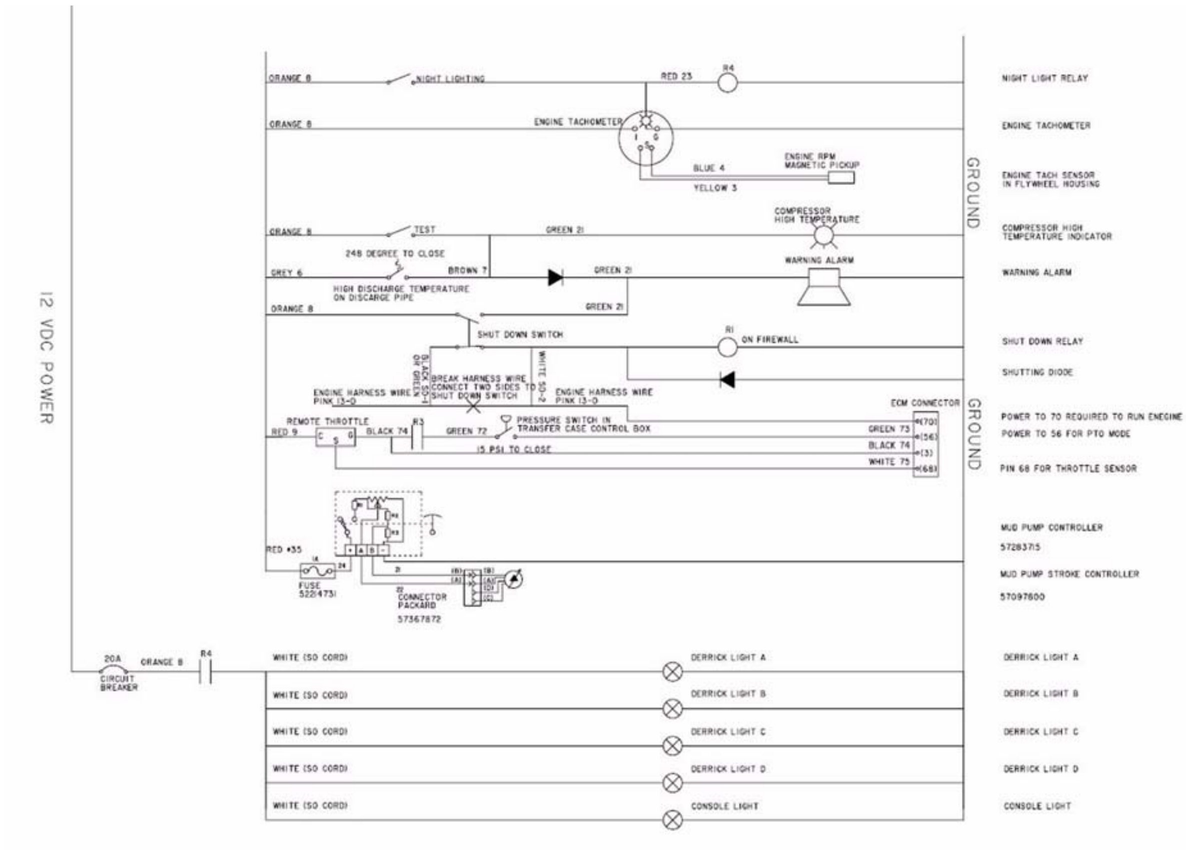


* N O = Normally Open
** N C = Normally Closed

Schematics

The following information is provided to give an understanding of the electrical system and the relation to the operator's control panel described in Section 4 - *Controls*.




12 VDC POWER
ORANGE 8
NIGHT LIGHTING
RED 23
R4
NIGHT LIGHT RELAY
ORANGE 8
ENGINE TACHOMETER
ENGINE TACHOMETER
BLUE 4
YELLOW 3
ENGINE RPM MAGNETIC PICKUP
ENGINE TACH SENSOR IN FLYWHEEL HOUSING
GROUND
ORANGE 8
TEST
GREEN 21
COMPRESSOR HIGH TEMPERATURE
COMPRESSOR HIGH TEMPERATURE INDICATOR
248 DEGREE TO CLOSE
GREY 6
BROWN 7
GREEN 21
WARNING ALARM
WARNING ALARM
HIGH DISCHARGE TEMPERATURE ON DISCARGE PIPE
ORANGE 8
GREEN 21
SHUT DOWN SWITCH
R1
ON FIREWALL
SHUT DOWN RELAY
SHUTTING DIODE
BLACK 50-1 OR GREEN
BREAK HARNESS WIRE CONNECT TWO SIDES TO SHUT DOWN SWITCH
WHITE 50-2
ENGINE HARNESS WIRE PINK 13-D
ENGINE HARNESS WIRE PINK 13-D
ECM CONNECTOR
REMOTE THROTTLE
RED 9
BLACK 74
R3
GREEN 72
PRESSURE SWITCH IN TRANSFER CASE CONTROL BOX
15 PSI TO CLOSE
GREEN 73
BLACK 74
WHITE 75
(70)
(56)
(3)
(68)
GROUND
POWER TO 70 REQUIRED TO RUN ENEGINE
POWER TO 56 FOR PTO MODE
PIN 68 FOR THROTTLE SENSOR
RED #35
FUSE 5221473l
CONNECTOR PACKARD
57367872
MUD PUMP CONTROLLER
57283715
MUD PUMP STROKE CONTROLLER
57097600
20A
CIRCUIT BREAKER
ORANGE 8
R4
WHITE (SO CORD)
DERRICK LIGHT A
DERRICK LIGHT A
WHITE (SO CORD)
DERRICK LIGHT B
DERRICK LIGHT B
WHITE (SO CORD)
DERRICK LIGHT C
DERRICK LIGHT C
WHITE (SO CORD)
DERRICK LIGHT D
DERRICK LIGHT D
WHITE (SO CORD)
CONSOLE LIGHT
CONSOLE LIGHT

7-3 OPERATOR OBSERVED PROBLEMS

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 toed shoes/boots, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. Always apply the parking brake before leaving the truck cab.

Operator Observed Problems

During operations, the operator may observe some problems which may be defined in the following *Operator Observed Problems Troubleshooting Chart*.

The troubleshooting chart is limited to machine control operational problems which will guide the operator to rectify the cause of the failure.

Table 2: Trouble Shooting Chart

Operator Observed Problems Trouble Shooting Chart		
Problem	***Cause***	***Correction***
Engine will not start. (Starter does not rotate)	Circuit Breaker Tripped	Reset Circuit Breaker
	Emergency Stop Switch requires resetting	Check Emergency Stop Switch and reset if required
	Batteries Discharged	Check Batteries. Recharge if required.
	Battery cable connections loose or disconnected.	Clean and tighten terminals
	Starter Relay fault	Call for service to correct fault.
	Starter Switch defective	
	Starter Solenoid or Starter defective.	
	Compressor Switchgage defective.	Replace Switchgage
	Shutdown Relay defective	Replace Relay
	Empty Fuel Tank	Fill Fuel Tank
	Defective Wiring	Check with test lamp.
Engine difficult to start. Engine 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.

Operator Observed Problems Trouble Shooting Chart		
Problem	***Cause***	***Correction***
(continued): Engine difficult to start. Engine has poor and irregular performance.	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.
	Defective Fuel Injectors	Call for specialist service
	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 and oil coolers.
	Engine coolant loss. Low coolant level in engine.	
	Defective injector nozzles.	
	Incorrect fuel pump calibration.	
	Cooling system fan not rotating or rotating at reduced RPM.	

Operator Observed Problems Trouble Shooting Chart		
Low engine oil pressure	Low engine oil will activate engine diagnostic ECM system	See Actual Manufacturer’s Operation Manual for correct engine diagnostics.
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 HIGH PRESSURE COMPRESSOR

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 toed shoes/boots, gloves, respirator and ear protection. Do **not** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

1. Do not speed engine when it is cold.
2. Always chock the wheels 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. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Compressor Fire Prevention

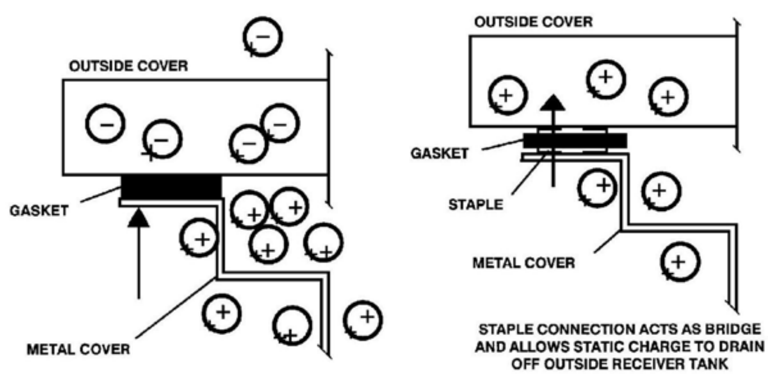
A fiber gasket is installed between the outside cover of the receiver and the metal tube holding the separator element in place. This gasket prevents oil from leaking around the metal tube and down the hole.

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.

⚠ CAUTION

***When replacing the separator element, be sure there is a least one staple that shows through on both sides of the gasket and is not covered with glue*.**



Pneumatic System Information

All air compressors used on TH60 Series 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 a combination receiver and oil separator tank. A safety shutdown system is also provided for high discharge air temperature.

The inlet butterfly valve 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.

A compressor is considered high pressure if the discharge pressure is 250 psi (17.25 bar) or greater. All TH60 ***high pressure*** compressors have discharge pressures of 350 psi (24.15 bar). 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 two sizes: 900 cfm and 1070 cfm.

There are three (3) systems on a rotary screw compressor. Each system is critical to the operation of the air end and the systems are all interrelated. These systems are:

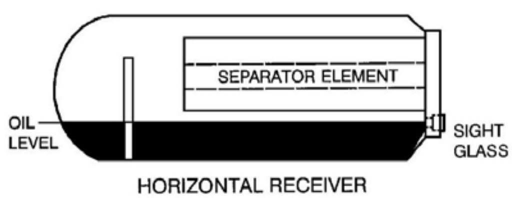
1. Lubrication System
2. Separation System
3. Regulation System

Lubrication System

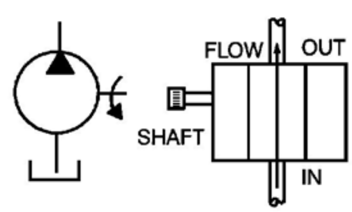
The equipment used in the lubrication section includes the receiver tank, mixing valve, oil cooler, bypass valve, strainer, filters, oil pump, relief valve, discharge check valve and special oil.

Receiver Separator Tank

The receiver tank contains the compressed air and 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 ***must be visible*** in the sight glass whether the drill is running or shut down.



Oil Pump



The oil pump 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.

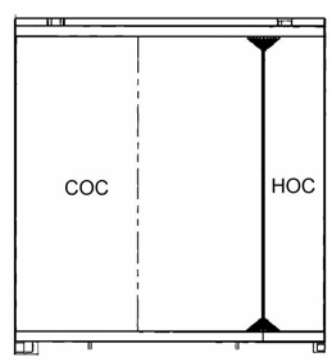
It acts as a normal pump when the oil is cold but becomes a restriction to maintain oil flow from the receiver tank when the compressor is operating at normal pressure and temperature. This prevents all the oil from being forced out of the receiver tank at once and flooding the compressor rotors. There is ***no*** shaft seal in this pump since it is being lubricated by the same oil it is pumping.

Strainer

A 40 mesh (150 micron) strainer is mounted just before the inlet to the oil pump as shown above. 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 Cooler

The cooler package is made up of two sections. The largest section is the compressor oil cooler and the other section is the hydraulic oil cooler.



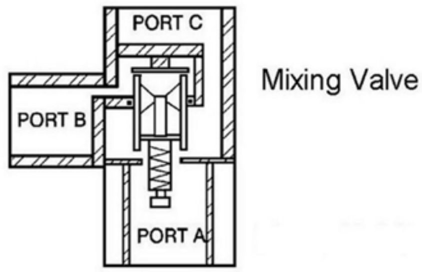
The compressor oil cooler is a single pass unit. Hot oil enters from the bottom of the cooler and cool oil exits out from the top. This prevents any air bubbles that may have been carried along with the oil from being trapped in the top and creating a vapor barrier.

Compressor Oil

The very high pressure created in high pressure air ends requires a special oil. This oil is ***not*** compatible with certain types of O-rings. Therefore, 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. ***These high pressure compressors use XHP605 oil.*** Be sure to change the filters every 500 hours.

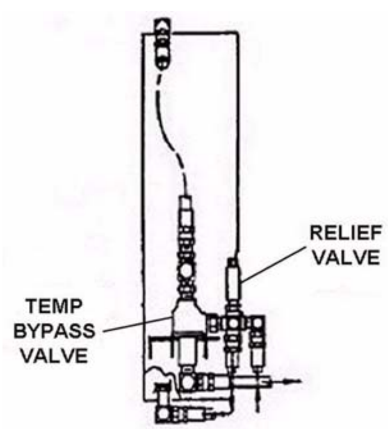
Mixing Valve

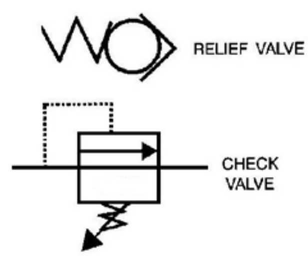
The mixing valve, also called the ***temperature bypass valve***, contains a thermostat that stops oil flow in one direction when it is cold and allows oil to flow from another direction when it reaches operating temperature.



When the temperature is below 140°F (63°C), oil flows from port “B” to port “A”, thus bypassing the cooler altogether. When the temperature increases to 160°F (71°C), the thermostat is completely opened and all the oil flows 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).

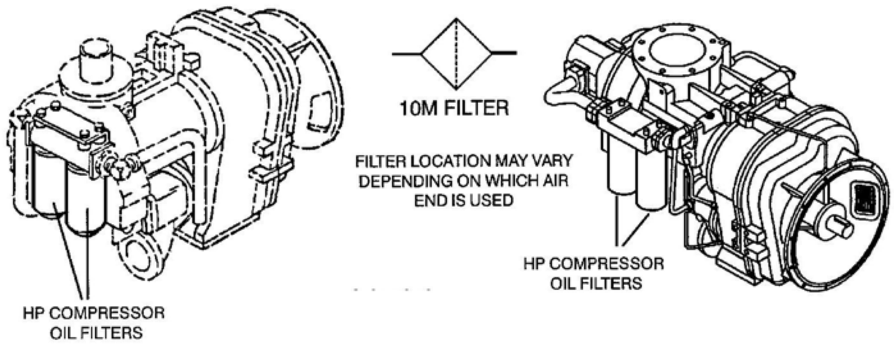
Relief Valve / Check Valve





A 50 psi (3.45 bar) relief valve is connected between the inlet and outlet of the oil cooler. If the cooler becomes plugged and the inlet pressure becomes 50 psi (3.45 bar) 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 (3.45 bar), the valve will close and normal flow resumes. This allows the oil cooler system to function properly.

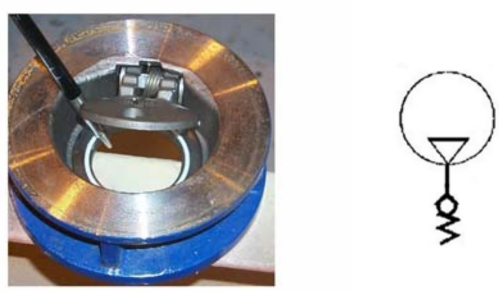
Oil Filter



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

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.



The previous picture shows the discharge check 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.

Lubrication System Operation

Oil is injected into the air end under pressure. The oil serves three purposes:

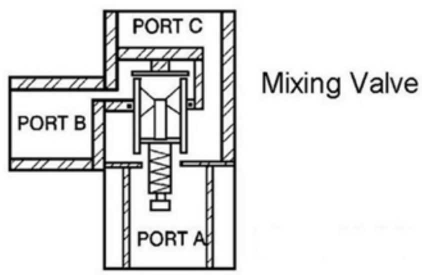
1. It ***cools*** the air end bearings and rotors
2. It ***lubricates*** the moving parts
3. It ***seals*** the clearances between the male and female rotors, and between the rotors and the housings and end plates.

The *Discharge Check Valve* prevents air pressure and oil from re entering 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 50 psi (3.45 bar), 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.

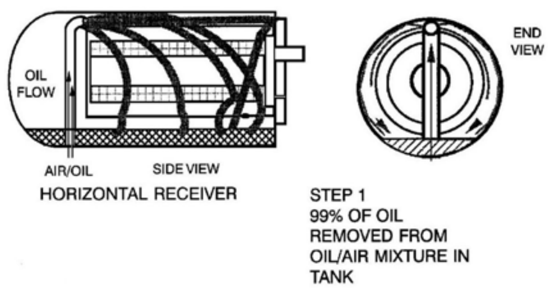
After the oil passes the pump and before it gets to the compressor bearings, it passes through two (2) **10 micron filters** and then flows through a metal **manifold** that sends oil to all areas of the compressor. Each bearing has its own supply line. The balance of the oil goes into the low pressure area of the rotors.

A **425 psi (29.33 bar) relief valve** is located between the oil pump and the compressor and bearing 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.

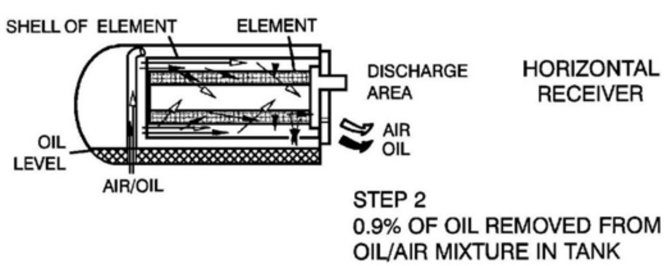
Separation System

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.

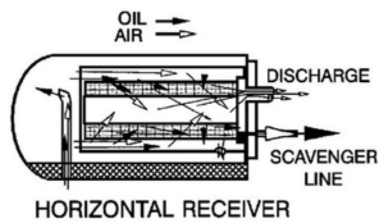
1. The air/oil mixture enters the receiver through the inlet pipe and splashes against the inner walls. This forces the majority of oil to fall to the bottom of the tank and remain there.



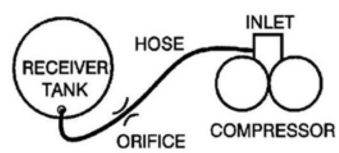
2. When the down stream air line is opened and air flows down the hole, some of the remaining oil is carried along with it into the filter area. A metal canister prevents oil from flowing through the filter directly. The air/oil mix enters the outer edge of the element and moves toward the center. As the oil travels through the element, it is slowed down by friction and gravity pulls it downward. Most of the oil drops out of the bottom of the element and falls into the reservoir.



3. 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.



STEP 3
0.1% OF OIL REMOVED FROM
OIL/AIR MIXTURE IN TANK

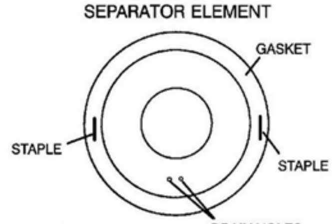


SCAVENGER SYSTEM

The HR2 and 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.

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.

END VIEW OF
SEPARATOR ELEMENT



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.

Regulation System Components

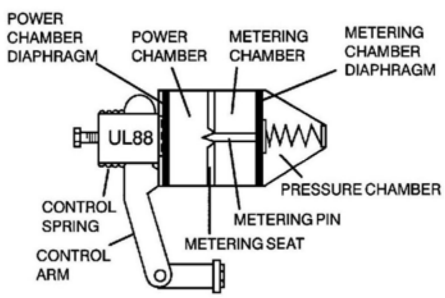
The regulation system controls the pressure and volume of the air going down the hole to the bit. All Drilling Solutions high pressure compressors have discharge pressures of 350 psi (24.15 bar). Drilling Solutions uses the UL88 unloader valve to control the discharge pressure and volume. The regulation 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.

UL88 Unloader Valve

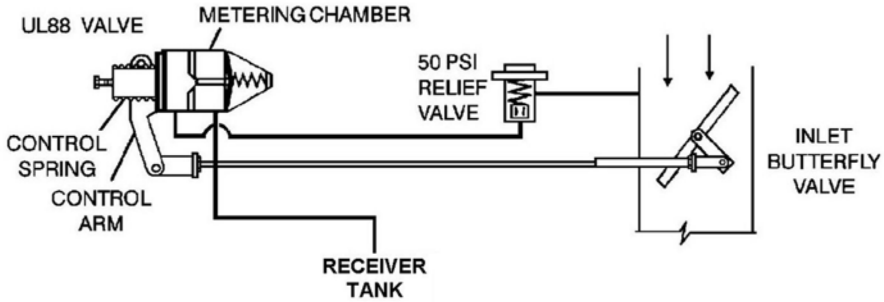
The regulation system on high pressure compressors is designed around the UL88 modulating valve. It controls the pressure and volume in the receiver by opening and closing the inlet (butterfly) valve according to the discharge pressure in the receiver.



The UL88 consists of three chambers: (1) the Power Chamber, (2) the Metering Chamber and (3) the Pressure Chamber.

There are two diaphragms in the UL88. One is the power diaphragm and the other is the metering diaphragm. 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.

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. There must be air pressure in the power chamber to close the inlet valve.

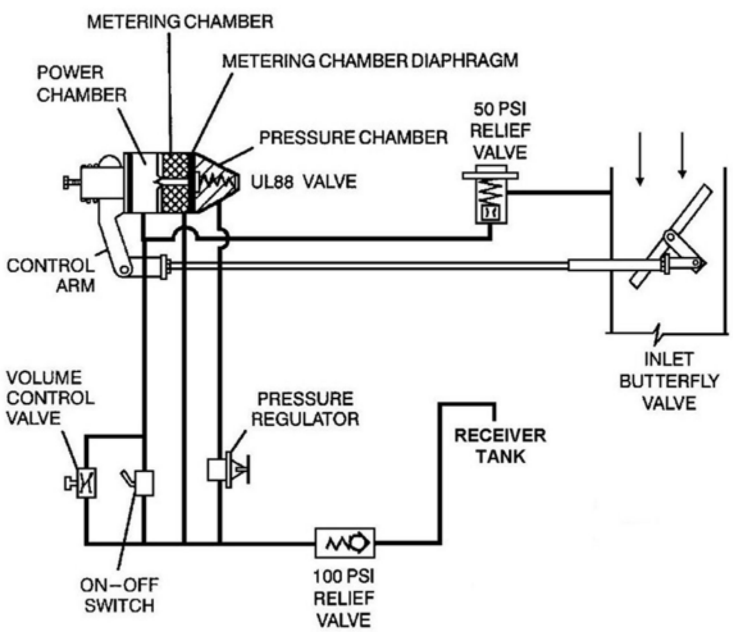


There are several components needed to operate the regulation system correctly. They include an ON-OFF switch, a linkage control arm, inlet butterfly valve, receiver tank, 100 psi (6.9 bar) check valve and a 50 psi (3.45 bar) relief valve.

ON/OFF Switch

The compressor ON/OFF switch is located on the operator’s control panel 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.

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 properly. On newer drills, there is a ball type valve without the exhaust. Air bleeds out through the orifice in the 50 psi (3.45 bar) relief valve.



50 psi (3.45 bar) Relief Valve / Orifice

A 50 psi (3.45 bar) relief valve is located in the line between the ON/OFF switch and the UL88 power chamber. 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 (6.9 bar) Check Valve

The UL88 and the pressure regulator were designed to operate at 250 psi (17.25 bar) maximum pressure, so a 100 psi (6.9 bar) check valve was installed in line from the receiver tank to reduce the final discharge pressure from 350 psi (24.15 bar) to 250 psi (17.25 bar). When a drill is first started, air pressure in the receiver tank must increase above 100 psi (6.9 bar) before the check valve opens and allows any air to the UL88.

Volume Control Valve

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 butterfly valve rapidly), an air volume control 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.

Air Pressure Regulator

Discharge pressure is set by the compressor Air Pressure Regulator mounted on the operator’s control panel. 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.

> **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*.**

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.

This valve allows a measured volume of compressed air from the receiver tank back into the rotor housing whenever the inlet butterfly 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 air/oil mixture back to the air end inlet.

Blow Down Valve

Without a shutoff 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 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 shutoff valve or exhaust valve closed.

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 and 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 shutoff valve 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.

Quick Exhaust Valve

Some drills are equipped with a quick exhaust valve instead of a shutoff valve. The difference is that the shutoff valve stops the flow of air to the UL88 and the exhaust valve exhausts any air in the lines leading to the UL88. Either system will prevent air from reaching the power chamber.

Quick Exhaust Valve

The quick exhaust valve is piloted from the same connection on the blow down 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 butterfly valve from closing.

Minimum Pressure Valve

A minimum pressure valve is installed between the receiver and the main air hose which goes to the derrick 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/8.28 bar (140 psi/9.6 bar on HR2.5 compressors). This means that the down hole pressure may be 50 psi/3.45 bar or 350 psi/24.15 bar but the receiver tank never sees a pressure less than 120 psi/8.28 bar (140 psi/9.6 bar). It does not control the volume of air in CDFM. It only restricts the outlet pressure. It has nothing to do with the pressure shown on the pressure gauge at startup.

Safety Relief Valves

All drills are equipped with safety valves. The setting on these valves is 25-50 psi (1.73-3.45 bar) 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:

1. The pressure setting is above the allowable working pressure of the compressor.
2. 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 normal operating pressure and will have to be replaced.

Drill Air Throttle Valve

All high pressure drills are equipped with a drill air throttle valve to control the air flow down the hole. These valves can be metered to prevent excess air flow from disturbing the formation. The main air throttle valve is connected downstream from the minimum pressure valve. ***The drill air throttle valve should always be opened slowly to prevent premature damage to the separator element*.**

Top of Console

The drill air throttle handle opens and closes the drill air throttle valve located on the air manifold. The air throttle controls air flow to the drill string and allows air flow down the hole to operate the DHD (down hole drill) and clean the cuttings out of the hole for both rotary and downhole drilling. It can be used to turn ON/OFF the drilling air during drill pipe or hammer changes. It can be adjusted to a lower setting while collaring the hole.

It can be adjusted for volume down the hole. It does ***not control pressure***. Push the handle to allow air to the drill string. Pull the handle to restrict air to the drill string. The Down Hole Air Pressure Gauge indicates down hole air pressure supplied to the drill bit or hammer.

Drill String Vent

When the drill is stopped, there is still air under pressure trapped in the drill string. The center ball valve lever is used to relieve air pressure in the drill string. Push in to close the ball valve. Pull out to open the ball valve.

Service Connection

A ball valve and a pressure regulator are connected to the drill air manifold 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 (6.9 bar). 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 (6.9 bar).***

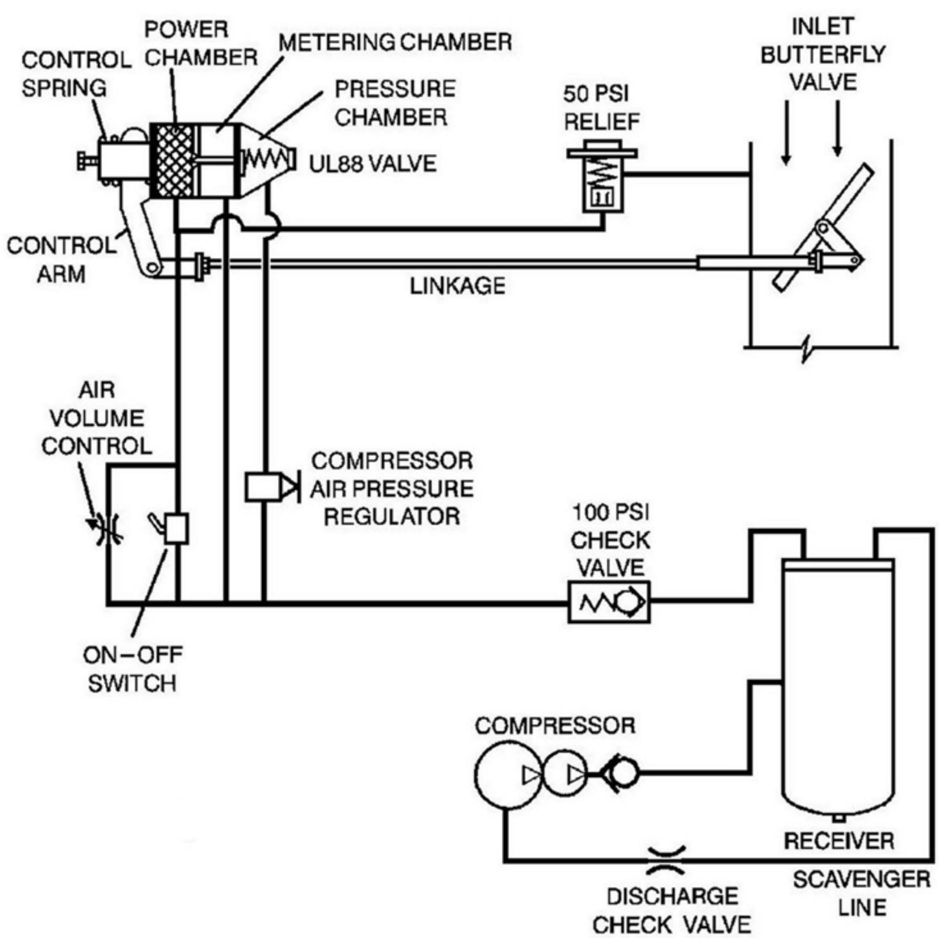
Manual Blowdown Valve

The Manual Blowdown Valve is a ball valve used to empty pressurized air from the receiver tank. When fluid is added to the receiver or when the separator element must be changed, the air pressure inside the receiver tank must be relieved.

⚠ WARNING

***Pressurized air will escape when the manual blowdown valve is opened. DO NOT allow any part of body under opening as air escapes. Wear safety glasses when relieving the air*.**

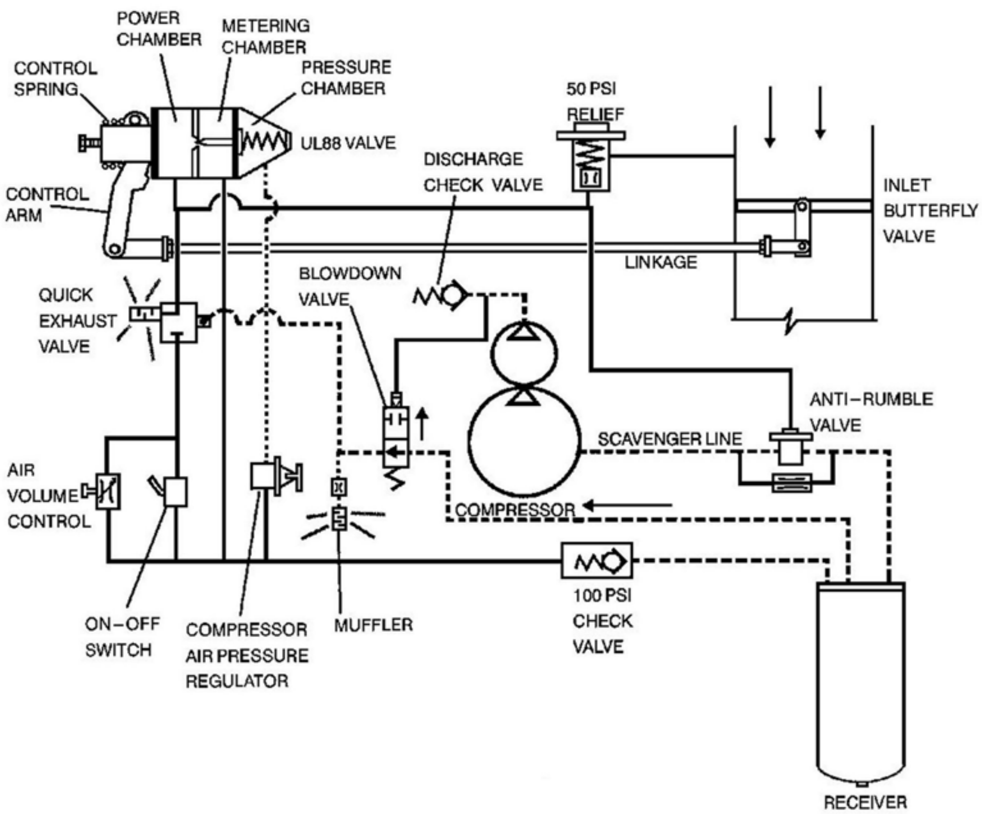
Typical Regulation System Schematic



The previous drawing shows the basic layout of a typical regulation system for high pressure drills. Air pressure is pumped into the receiver tank from the compressor. As the pressure reaches 100 psi (6.9 bar), 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 (6.9 bar) enough to overcome the control spring (45 psi / 3.11 bar), 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 (10.01 bar) on start up.

The drawing also shows the volume control, pressure regulator, scavenger line and the orifice between the receiver and the compressor low pressure area.

Typical Shutdown System



The typical shutdown system consists of a pilot operated blowdown valve and a shutoff 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 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.

Operation

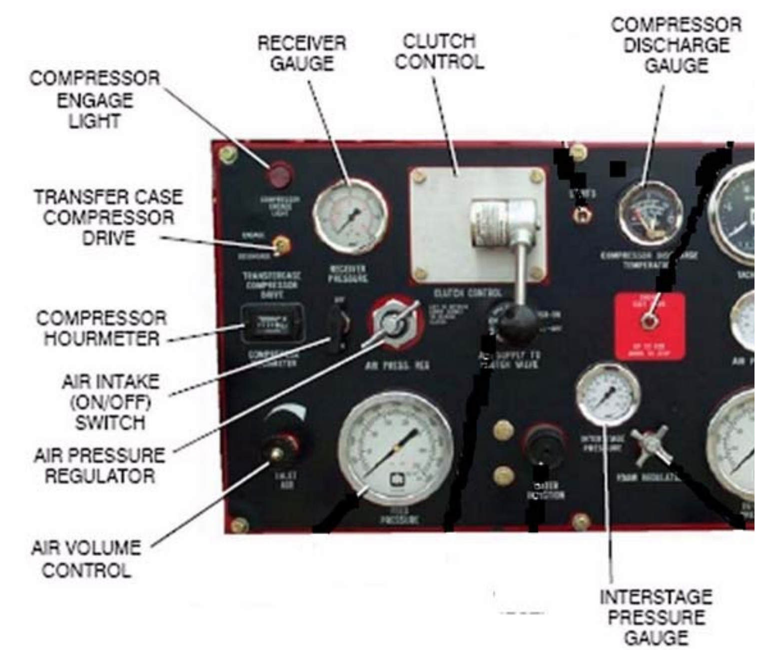
The Transfer Case Compressor Drive Engage and Disengage switch is used to engage the driveshaft from the transfer case to the screw compressor. When the air compressor drive shaft is engaged, the Compressor Engage Light will light up.

> **NOTE:** ***Before engaging the compressor drive shaft, make sure the Air Intake ON/OFF switch is OFF, the Drill Air Throttle is closed and the Air Pressure Regulator is set properly.***

The Air Compressor Drive Clutch Control is the control for the air clutch to engage the rotary screw compressor drive shaft and the hydraulic drive. Lower the lever slowly to release clutch.

> **NOTE:** ***Warm the compressor oil for 15-20 minutes before making air.***

Top of Console



Starting

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 (9.66-10.01 bar). Next, turn the compressor 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 (6.9 bar) check valve and into the metering chamber.

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 air pressure regulator on the control panel. 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*.**

Drilling

When the operator is ready to start a DHD (Down Hole Drill), slowly open the drill air throttle. 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.
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 (9.66-10.35 bar).
4. When the pressure gauge shows 140-150 psi (9.66-10.35 bar), 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 (6.9 bar) 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 (6.9 bar) check valve to close, cutting off flow to the UL88.

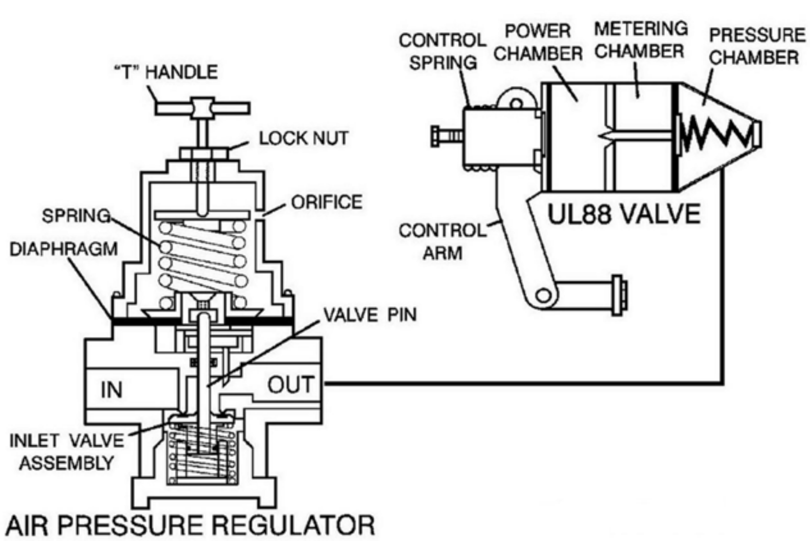
When the inlet butterfly valve finally opens, the air and oil mixture will escape with high velocity through the inlet and up through the inlet tubes to the air cleaners. Enough oil will be present to saturate the primary cleaner and render it useless.

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.

Air Pressure Regulator

Theory of Operation

The air pressure regulator used on all high pressure drills is a pressure reducing valve that can handle inlet pressures up to 300 psi (20.7 bar) and reduce the output pressure to a range of 10 psi (.69 bar) to 250 psi (17.25 bar). 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 (6.9 bar) 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.

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 (4.14 bar). 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 throttle valve and ***then unscrew the “T” handle to minimum***. This action relieves the high pressure on the valve assembly and lets 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 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 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.

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.

Table 3: Compressor Related Problems

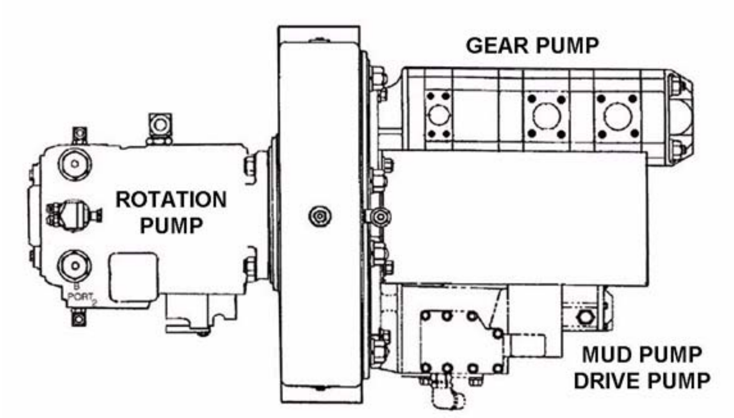
Problem	Cause	Correction
Drill Shuts Down After A Short Running Time	High discharge temperature	Check for low oil level
		Check for obstructions in oil cooler
		Check fan speed
Compressor Turned On, But Does Not Produce Compressed Air	Butterfly valve stuck in closed position	Adjust linkage and/or stop 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

Problem	Cause	Correction
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
Excessive Foaming Of Compressor Fluid	Foam and air release characteristics of oil are insufficient to remedy the symptoms (problem). Products previously used were Mobil 626 and XHP505.	XHP605 replaces XHP505 as the standard factory fill for XHP compressors above 300 psi (20.7 bar)
Excessive Oil Carryover Into Service Air		
Oil Or Foam Out Of The Blowdown Valve During Shutdown		

7-5 HYDRAULIC SYSTEM

Hydraulic System Introduction

Power to drive the hydraulic systems is supplied by the truck diesel engine with a drive shaft connection to a heavy duty transfer case with a drive shaft connection to a hydraulic pump drive, which in turn drives three (3) hydraulic pumps. The 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 tasks. The result is a simple and flexible drilling system.



The hydraulic system consists of several circuits. Each circuit includes one or more pumps which supply pressurized streams of fluid to hydraulic cylinders and motors.

1. The ***Rotation Pump*** is used to supply oil to the rotary head rotation motors in the ***Rotation Circuit.***
2. The ***Four (4) Section Gear Pump*** is used for the following circuits:
   a. The ***P1 Gear Pump Section***, along with the P4 Gear Pump Section, is used to supply oil to the ***Main Hoist Circuit*** and the ***Fast Feed Circuit***.
   b. The ***P2 Gear Pump Section*** supplies oil to the ***Cooler Fan Circuit***.
   c. The ***P3 Gear Pump Section*** supplies oil to the two-spool and 10-spool valves for the ***Auxiliary Functions Circuits***.
   d. The ***P4 Gear Pump Section***, along with the P1 Gear Pump Section, supplies oil to the ***Drill Feed Circuit***.
3. The ***Mud Pump Drive Pump*** supplies oil to power the ***Mud Pump Circuit.***

7-6 HYDRAULIC SYMBOLS

Fluid Power Symbols

Understanding and recognizing fluid power symbols is skill used in reading schematic drawings for trouble shooting. It will also aid in understanding the schematics used to describe the hydraulic systems used on Drilling Solutions drills.

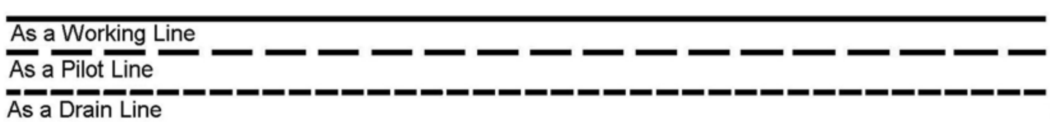
Symbols on schematics are pictographs (pictures of what the object does) and are used to represent the component. The following symbols are an international fluid power language designed by the American National Standard Institute.

You will remember fluid power symbols more easily if you learn the significance of these three shapes:

1. **Circle** = Pump, Motor or Gauge
2. **Square** = Valve of some sort
3. **Diamond** = Fluid Container

Line Symbols

Hydraulic lines, tubes and hoses that carry fluid between components are drawn as a line.

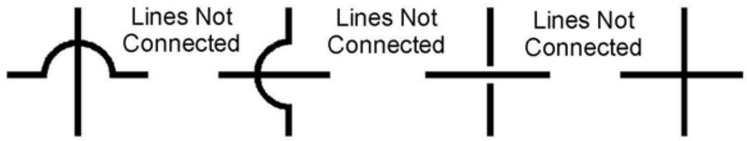


1. The ***Working Line*** is an unbroken line which connects symbols in the hydraulic diagram together.
2. The ***Pilot Line*** denotes pilot pressure.
3. The ***Drain Line*** denotes system drainage.

Connections for lines are shown below. Pay attention to the presence of a “dot” at the intersection of lines. If there is no “dot” and the lines cross, the lines **do not connect**. If the lines intersect but one line ends, then even without a “dot” the lines **do connect**.

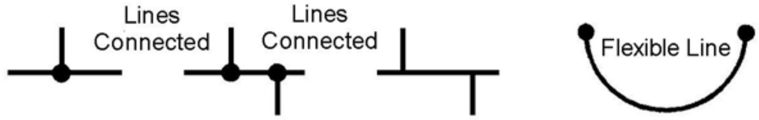
Crossing Line Symbols

Let's examine the crossing line symbols. These are fluid or lines that cross but do not join. They are independent and separate of each other.



Joining Line Symbol

The symbols for joining lines is shown in below. They show us that fluid paths are connected.



Pay attention to the presence of a "dot" at the intersection of lines. If lines intersect but one line ends, then even without a "dot" the lines do connect.

Flexible Line Symbol

The symbol for a flexible line or hose is also shown above. The curve in the line illustrates the flexible hose and the two heavy "dots" represent terminal points.

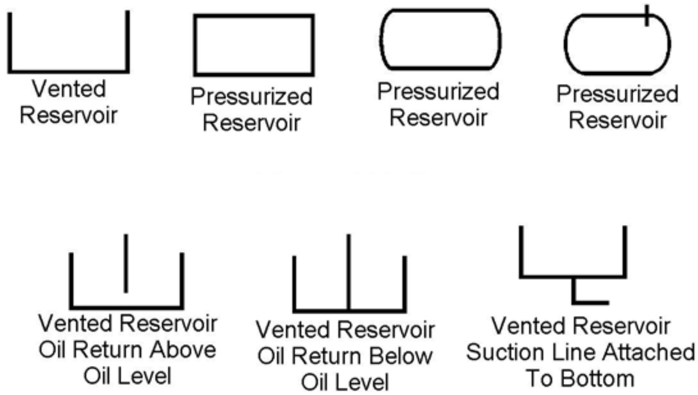
Arrow Symbols

The arrow symbol appears in the working line. The arrow shows the direction of flow of the fluid.

Reservoir or Tank Symbols

Reservoirs and tanks are used to contain fluids, provide cooling, separate air and oil, and provide pressure to the pump if the reservoir is pressurized.

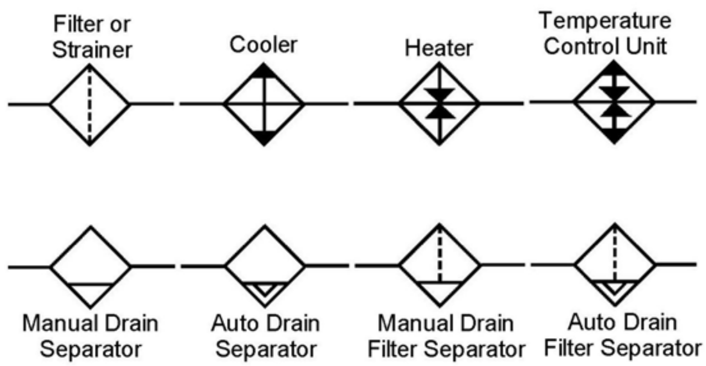
The tank and reservoir symbols are shown next. They appear on hydraulic diagrams as the vented tank or pressurized tank. It is important to note that even though these symbols may appear in many different places on a hydraulic diagram, there is usually only one centralized reservoir tank.



Reservoir symbols can also show the point of connection for suction and return lines as above.

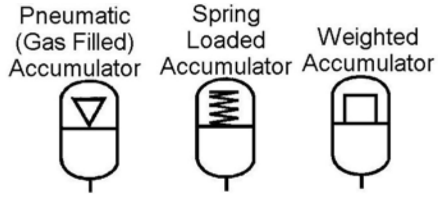
Fluid Container Symbols

The condition of the oil is changed from one state to another. Typical “conditioners” are filters, heaters and coolers which can contain drains of various sorts. Symbols for fluid conditioners are shown below. 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.



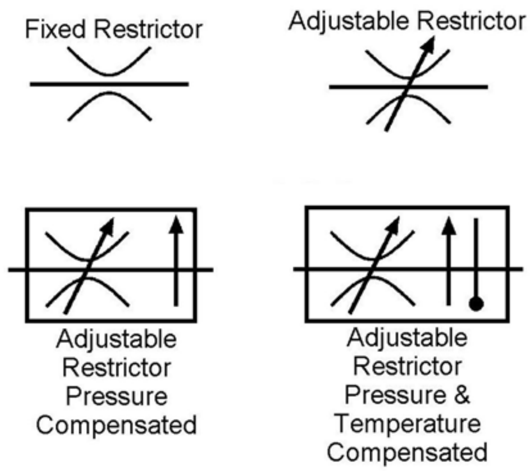
Accumulator Symbols

Hydraulic accumulators act as shock absorbers for the system. They are installed in parallel with the pump and do several things. They dampen out oscillations in pressure (keep pressure constant) and provide flow when components move and activate. The are drawn as ovals with a line in the center which represents the diaphragm or piston that separates the oil from the spring or gas. On the left is the gas loaded type, in the center is the spring loaded type and on the right is the weighted type.



Restrictor Symbols

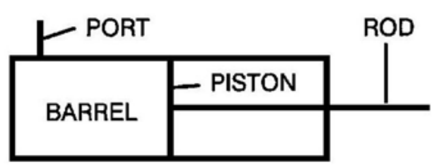
Sometimes it's necessary to slow down flow or to create a pressure drop at some point in the system.



Restrictors are drawn to represent a pinch in the line, and can either be fixed or variable and can be controlled by other systems as well, such as being temperature or pressure controlled.

Hydraulic Cylinders

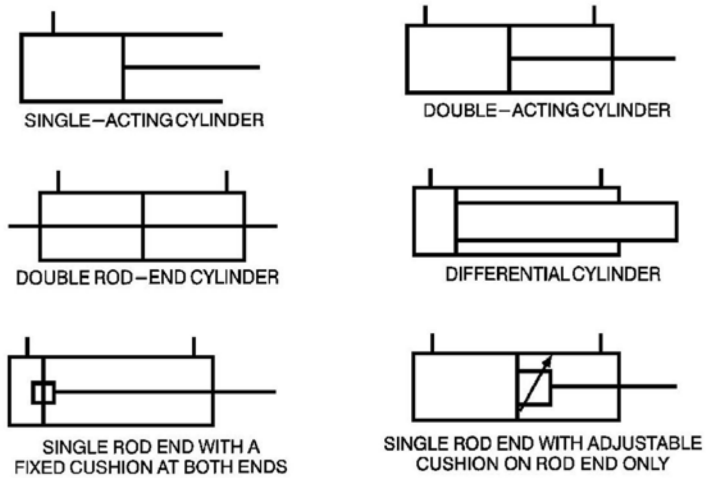
Hydraulic cylinders convert fluid power to linear mechanical power. Fluid under pressure pushes against the ends of the piston to move it in order to move some other mechanism. Cylinders are drawn as rectangles with lines in the center to represent the **piston**, and lines through the ends to represent the **rod**. **Fluid ports** are shown on the outer ends of the **cylinder barrel.**



TYPICAL HYDRAULIC CYLINDER

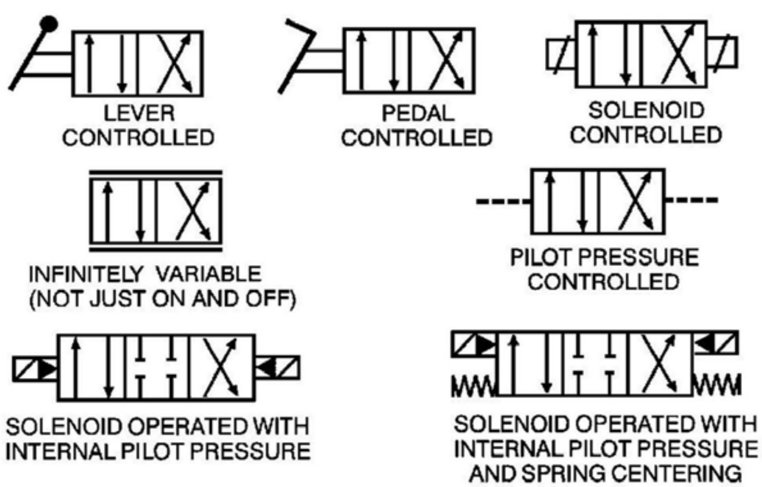
A **single-acting cylinder** has only one port so that fluid under pressure only enters one end and pushes only in one direction. The cylinder reverses by opening a valve to let gravity or a spring return the piston to the other end.

A **double-acting cylinder** has ports at each end so pressurized fluid will enter both ends and push against the piston in both directions.

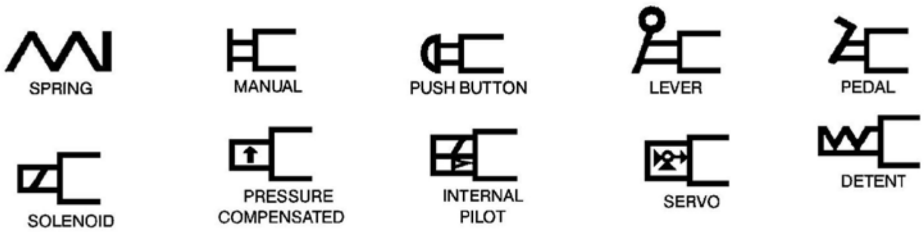


Activating Device Symbol

There are a variety of ways to actuate control valves. These include manually by hand with a lever, by foot with a pedal, with an electric solenoid (coil), using external pilot pressure, using a spring, using internal pilot pressure or using any combination of the above.

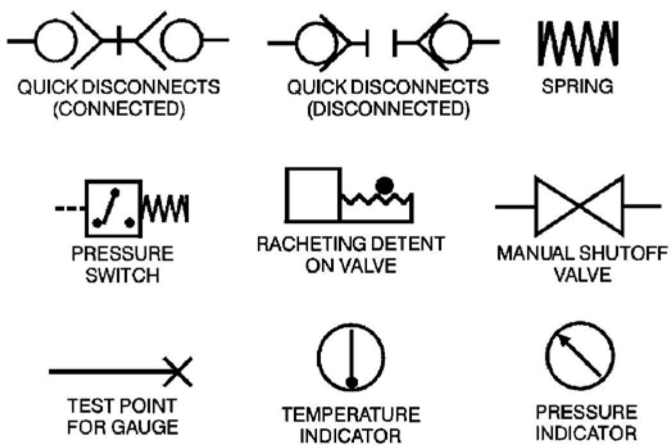


There are ten basic arrangements that will appear from time to time on hydraulic diagrams. These symbols show how a pump, motor or valve is actuated. They are shown below.



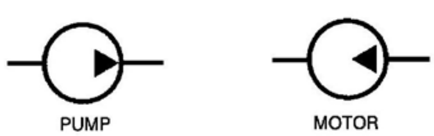
Miscellaneous Symbols

Miscellaneous symbols are shown below.



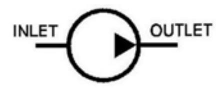
Pump and Motor

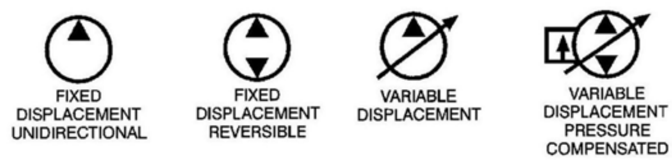
It is important to note that the only difference in the pump and motor symbols is the direction of the energy triangle. Remember that in the pump symbol the energy triangle is pointed outward toward the working line. In the motor symbol the energy triangle is pointed in toward the center of the circle, away from the working line.



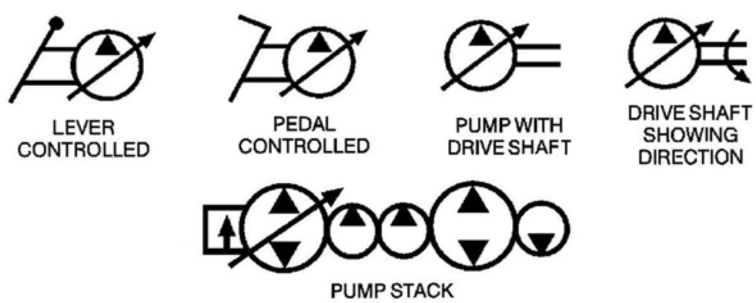
Pump Symbols

Pumps are drawn as circles with triangles pointing outward from the center. The triangle represents the direction that fluid flows out of the pump and should be viewed as an arrow. A single arrow shows a one-direction (unidirectional) pump, while two arrows indicate a reversible (bidirectional) pump. A diagonal arrow cutting across the pump body indicates the pump displacement (output flow and volume) can be adjusted. A small rectangle on the side of the pump with a small arrow inside indicates that the pump output is compensated (adjusted or controlled) by a pressure signal from a pilot line.



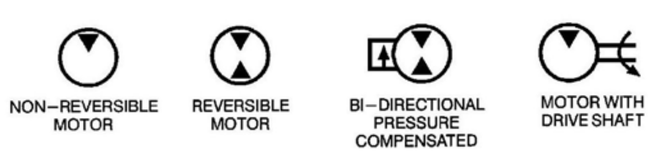


Pumps are also drawn to indicate how their output can be controlled. The attachments to the pumps look like the components they represent. The lever and pedal look like a lever and pedal. The drive shaft is shown as a pair of lines on the side of the pump, either with or without an arrow showing the direction of rotation. Pumps can also be drawn as stacks, which indicate that all pumps are driven by the same driveshaft.



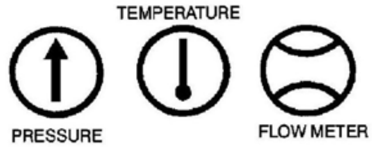
Hydraulic Motor symbols

Motors are drawn as circles with triangles pointing in toward the center of the circle. Hydraulic motors are actually hydraulic pumps that work in reverse. Except for a few differences, pumps and motors are identical. Use the same rules to interpret motor symbols as you would for pump symbols.



Instrument Symbols

There are three types of instrument symbols which you should know. The pressure gauge symbol is shown on the left side below. The temperature gauge is shown in the center and the flow meter symbol is shown at the right.



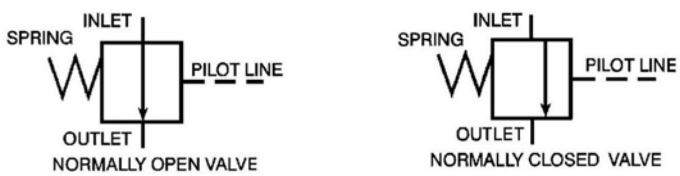
Valves

Hydraulic pressure is controlled through the use of valves that open and close at different times to allow fluid to be bypassed from points of high pressure to points of low pressure. The basic valve symbol is a square (box) which represents the valve body or spool. An arrow in the center represents the path oil takes through the valve.

Pressure control valves are typically pilot operated - that is, the valve is moved automatically by hydraulic pressure and not by a person. Pilot oil pressure is resisted by a spring, which can often be adjusted. The higher the spring tension, the more fluid pressure required to move the valve.

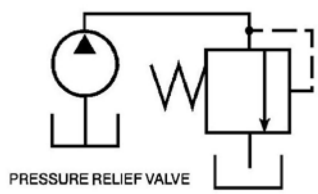
To visualize the operation of this type of valve, imagine that the entire square will move away from the pilot line and towards the spring. If the valve is normally open, fluid flow will be cut off by the pilot line. If the valve is normally closed, the pilot line will cause oil to start flowing.

Valves can either be ON/OFF valves with no flow in the middle, or infinitely variable, which means flow will gradually increase or decrease as pilot pressure increases and/or decreases.



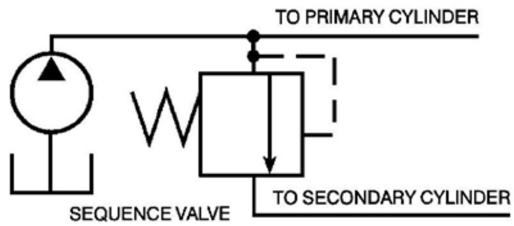
Pressure Relief Valve

A pressure relief valve is a normally closed valve that senses the high pressure at its inlet. As the pressure at the inlet increases, the pressure in the pilot line begins to push against the valve body (spool). As the valve body moves, the ports begin to line up and fluid will begin flowing through the relief valve. The relief valve typically dumps back into the reservoir. Most relief valves are infinitely variable.



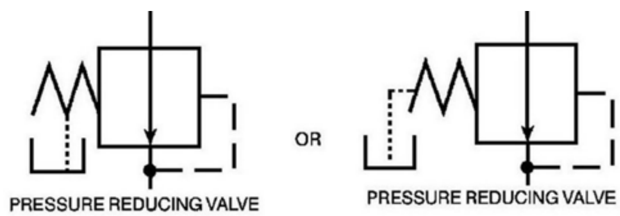
Sequence Valve

A sequence valve is a normally closed valve that opens once the inlet pressure reaches a preset point. This type of valve is designed to allow different components to act “sequentially”, meaning one after the other. Once the primary actuator reaches the limit of its travel, fluid pressure in the feed line will rise. This rising pressure opens the sequence valve which allows fluid to flow through it to the secondary cylinder.



Pressure Reducing Valve

A pressure reducing valve is a normally open valve that senses the outlet pressure going to an actuator. As the pressure in the outlet increases, pilot pressure increases which gradually closes the reducing valve. As the valve closes, oil from the high pressure side of the valve is directed back to the reservoir which dumps pressure at the outlet.

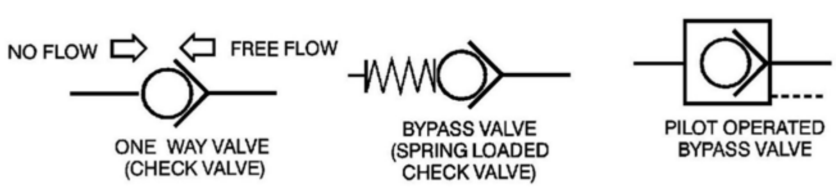


Directional Control Valves

The direction that fluid flows in a line can be controlled by using valves which allow flow in only one direction. These valves are typically referred to as “check valves” because they “check” the flow if it tries to reverse. These valves can have simple check balls or can have machined poppet type valves. They can also be more complex pilot operated valves that have spools.

In the case of a ball check valve, the allowed flow is opposite the arrow, or towards the ball. If the valve has no spring, the valve offers resistance to flow only in the “closed” direction; in the “open” direction the valve moves with any movement of fluid and does not have a pressure setting.

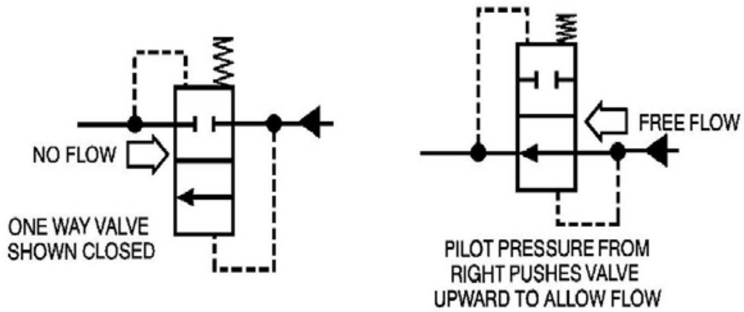
If the check valve has a spring it will oppose flow in the “open” direction up to the point where hydraulic pressure overcomes spring tension. Check valves can also be pilot operated.



Another method of drawing check valves (directional valves) is using composite symbols as in the previous sequence. This method contains a blocked path and a free path. The dashed lines represent pilot pressure lines. As pressure increases on the blocked side of the valve, the pilot line moves the valve to reduce or cut off supply, depending upon whether the valve is normally open or closed.

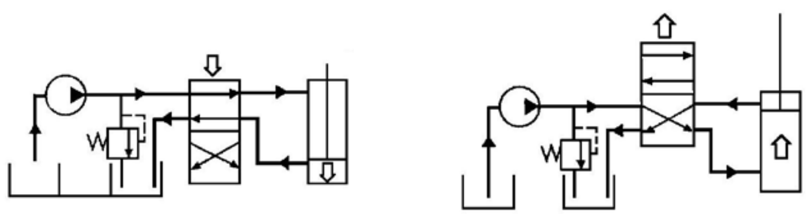
The spring keeps the valve in the normal position. If pressure builds up on the flow side of the valve, the pilot line pressurizes and moves the valve into the open position, compressing the spring in the process, and allowing oil to flow. If the flow attempts to reverse, the other pilot line pressurizes and adds to spring pressure to close the valve, cutting off flow.

These valves are commonly referred to as flow dividers or flow control valves. This type of valve can be a pressure relief valve or pressure reducing valve depending upon location of pilot source and spring setting.



Two Position Flow Control Valve

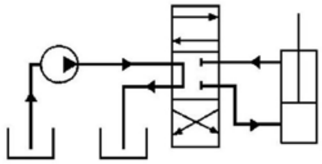
Two position flow control valves typically are used to make the flow reverse to an actuator in a simple system, although other arrangements are possible. The valve spool slides long-ways to allow one or the other valve position to direct flow. Because these valves have no center position they must be used with a pressure relief valve that opens to dump system pressure when the actuator bottoms out.

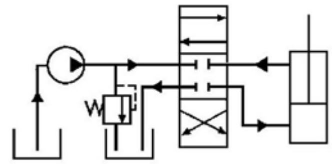


Note that the direction of oil flow does not change on the pump side of the valve. The direction changes only after the valve changes the flow to redirect pressure to the retracted side of the cylinder.

Three Position Flow Control Valves

Flow control valves are drawn as composite symbols using squares to represent the valve spool. To visualize the operation of these valves it’s necessary to imagine them moving long-ways with the spool sliding to move the different flow arrows into a position to allow oil to flow through them.





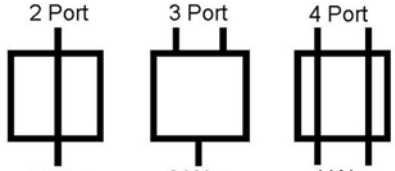
The centers of the valves determine what type of system is in use. An **open center** system uses valves that allow oil to flow through them at all times (out of the pump and back into the reservoir) when no actuators are in use. This system does not require a pressure relief valve.

A **closed center** system uses valves that block flow through them when no actuators are in use, thereby “liquid locking” the system. In this type of system a pressure relief valve is mandatory to prevent the system from destroying itself when the valves are in the center.

Valve Symbols

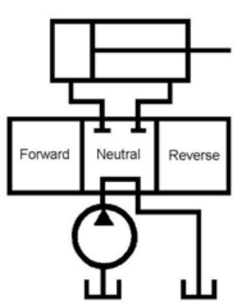
The next area to cover is valve symbols. Begin with some of the basic symbols shown below.

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 below 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 three port, or 3-way valve. On the right is a four port or 4-way valve.



Three Position “4-Way” Valve

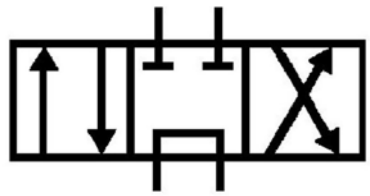
Let us examine the most common of all control valves, which is the “4-way” valve below.



This control valve directs fluid or oil flow to a forward position, a neutral position or a reverse position. The previous picture 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 reservoir.

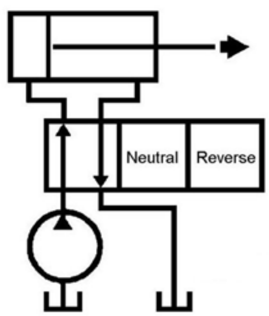
Arrows

Arrows in the adjoining squares show the fluid flow path when the valve is shifted to the other positions.



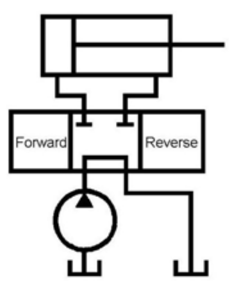
Forward Position

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.



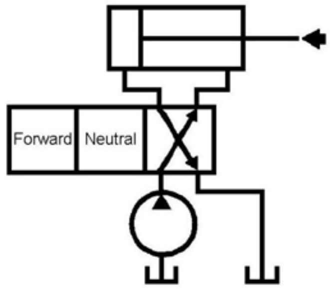
Neutral Position

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 picture below.



Reverse Position

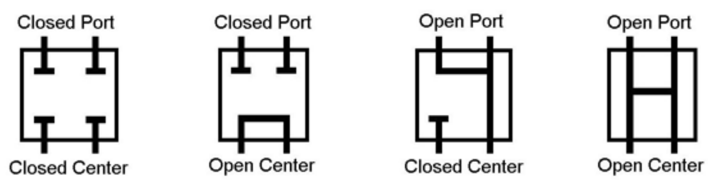
With the reverse position activated, fluid or oil flows from the pump through the valve and into the right side of the cylinder. Return oil from the left side of the cylinder is released back through the valve and returned to the tank.



Valve Centers

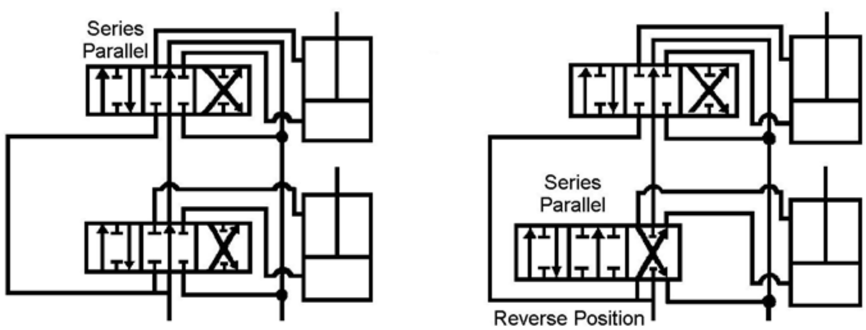
Let’s look at valve centers now. There are four main center valve configuration symbols:

1. Closed Port - Closed Center
2. Closed Port - Opened Center
3. Open Port - Closed Center
4. Open Port - Open Center



Series Parallel Valves

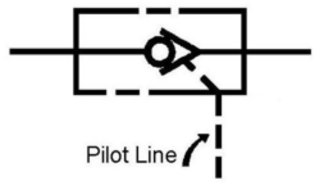
Now that we have seen our directional control valves at work, let’s see how we bank two or more valves together. As shown below, one pump is supplying oil to two valves for control of two different actuators. The valves are connected together by a parallel passage which allows simultaneous operation of both functions.



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.

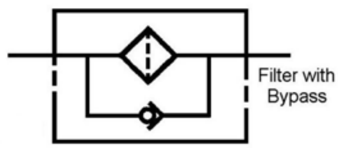
Pilot Operated Lock Check Valve

The pilot line symbol indicates a pilot operated lock check valve. This valve will allow reverse flow when pilot pressure is present.



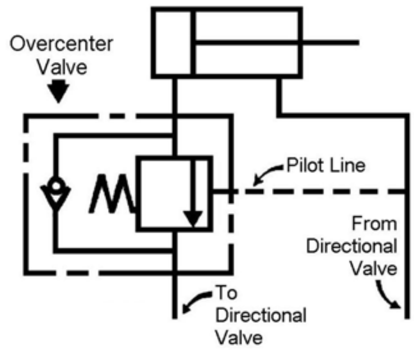
Bypass Valve

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.



Overcenter Valve

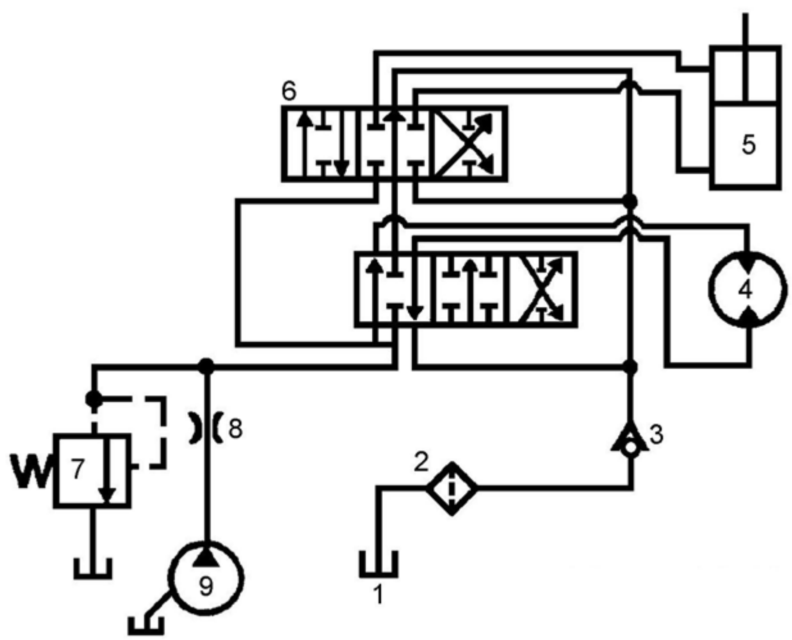
The overcenter valve shown below throttles return oil to prevent a runaway condition on a heavily loaded cylinder or motor. If the cylinder should try to collapse faster than the pump is supplying oil, the pilot pressure will drop and the overcenter valve will throttle the exhaust oil leaving the cylinder.



Review

Let's review. A typical hydraulic diagram (schematic) is shown below. Can you name all the components?

1.
2.
3.
4.
5.
6.
7.
8.
9.



7-7 ROTATION CIRCUIT

General Information

⚠ WARNING

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

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

Unexpected drill motion or moving parts can cut or crush. Shut down the engine before working 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 toed boots/shoes, gloves, respirator and ear protection. Do ***not*** wear loose fitting clothing that can become caught on rotating components.

The following operational hints should be observed:

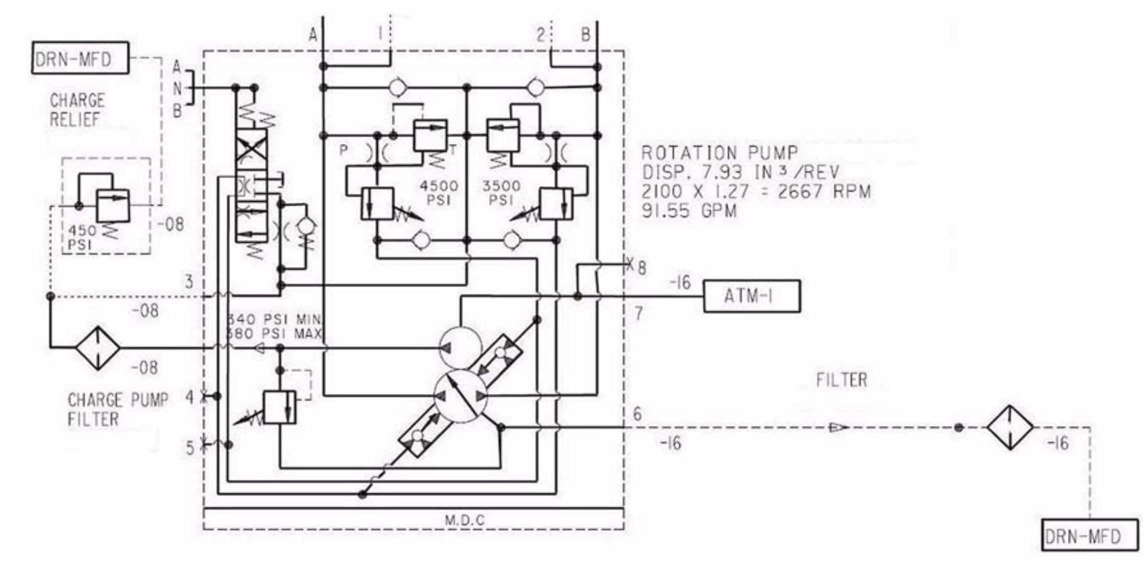
1. Do not speed engine when it is cold.
2. Always chock the wheels if there is a possibility of uncontrolled movement.
3. Do not lubricate the drill while the engine is running.
4. Always perform safety checks prior to starting and using the drill.
5. Always operate the drill at full engine power when drilling.
6. Never stop the drill on a slope or surface that is liable to collapse.
7. Never stop the drill against a high wall that is liable to collapse or cause a crushing risk.
8. Before starting engine, always check to see that the drill feed selector valve is in the stop position and all the controls are in the off or neutral position on the operator's control panel.
9. Always sound the horn before moving the drill in either direction to alert personnel and allow sufficient time before putting the drill in motion.
10. ***Always*** apply the parking brake before leaving the truck cab.

Rotation Circuit

The primary components of the rotation circuit are the rotation pump, charge pump, charge pump filter, charge pump relief valve, rotation motors, hot oil shuttle valve, torque limit control (option), filters, valves and controls. This system utilizes a closed loop system. The controls for the components are shown below.

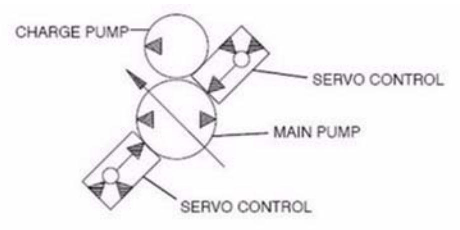
Rotation Pump

The rotation pump is a closed-loop hydrostatic transmission piston type package pump. The rotation pump symbol is shown in the schematic below. The circles with the two power triangles, pointing outward, show that the pump is bi-directional. The arrow through the middle at an angle means the pump has a variable flow control. 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. Hydraulic 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 rotating group is depicted as a large circle with two triangles pointing towards the work port lines. 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”.

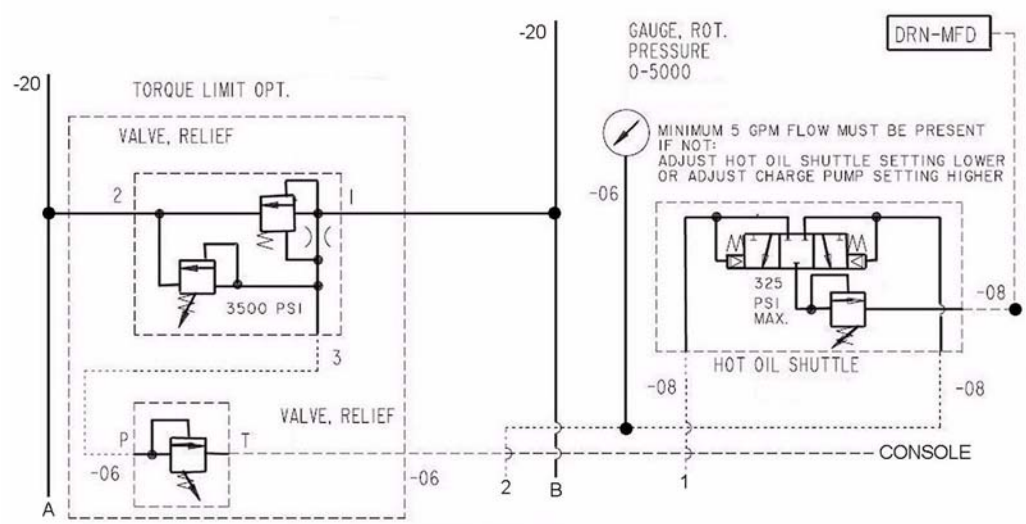


A charge pump built into the rotation pump provides hydraulic power to move the swash plate. This is represented schematically by a circle with one triangle pointed toward the work port. The purpose of this small pump is to provide oil to work the pump controls and to charge the main pump loop so that it never runs out of oil.

The first relief valve provides pressure to operate the swash plate. The second relief valve is used on closed loop systems only.

The rotation pump is used in the rotation circuit to control the speed and direction of the drill string. It is a variable displacement piston pump that operates on both sides of center. The pump output is controlled by the operator via the rotation controller located on the operator’s console.

The pump controller used with the rotation pump is proportional. Operator input is supplied electrically to the servo control on the pump 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. A small filter is provided in the servo circuit to keep the spool valve functioning properly.



Some hot, dirty oil must be drained from the circuit and clean, cool oil must be put back into the loop. This is done by the charge pump that is built into the rotation pump and a hot oil shuttle valve. Cool, clean oil is pumped through the charge pump and into the make-up oil. A relief valve in the charge pump outlet forces the clean oil into the make-up line and the same volume that is allowed in is returned through the hot oil shuttle. The hot oil shuttle will exhaust low pressure oil no matter which direction the rotation is in, and the charge pump will supply make-up oil from either side.

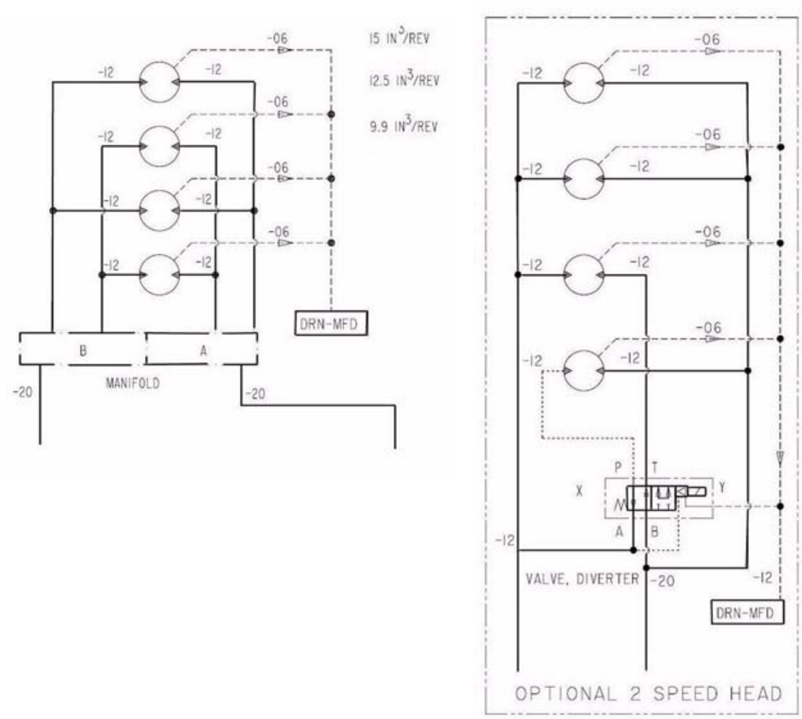
On drills with a torque limit control, a sequence valve is added to the forward rotation line to prevent the torque limit from dropping below 500 psi (3447 kPa).

Rotation Motors

There are two types of rotary heads used on the TH60 Waterwell drill. One is a four motor, single speed drive head and the other is a four motor, two speed drive head.

The four (4) rotary head motors are fixed displacement motors and are bi-directional and thus can be used either in forward or reverse rotation. Note that system pressure is limited to 3500 psi (24,132.5 kPa) in the forward direction and 4500 psi (31,027 kPa) in reverse, for breakout purposes.

The schematic for the rotation motors is shown below. The main motor section is shown by the circle with two triangles pointed inward from the two main ports. There are case drains on each since they are piston motors.



The single speed standard rotary head uses four 9.9 cu. in./rev hydraulic rotation motors with 5,000 ft/lbs (6,780 N-m) torque @ a rotation speed of 0-125 RPM.

The single speed high torque rotary head uses four 15 cu. in./rev hydraulic rotation motors with 8,000 ft/lbs (10,848 N-m) torque @ a rotation speed of 0-110 RPM.

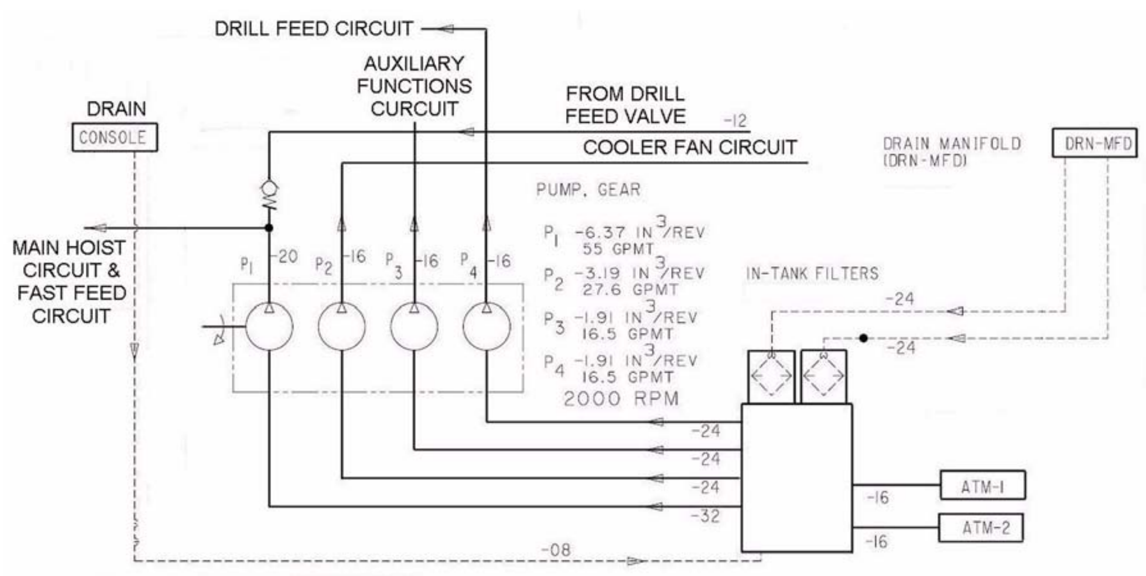
The optional two speed mid-range torque rotary head uses four 12.5 cu. in./rev hydraulic rotation motors with 6,250 ft/lbs (8,475 N-m) torque @ a rotation speed of 0-128 RPM or 4,650 ft/lbs (6,305 N-m) @ a rotation speed of 0-170 RPM.

The optional two speed high torque rotary head uses four 15 cu. in./rev hydraulic rotation motors with 8,000 ft/lbs (10,848 N-m) torque @ a rotation speed of 0-107 RPM or 6,000 ft/lbs (8,136 N-m) @ a rotation speed of 0-142 RPM.

Four Section Gear Pump

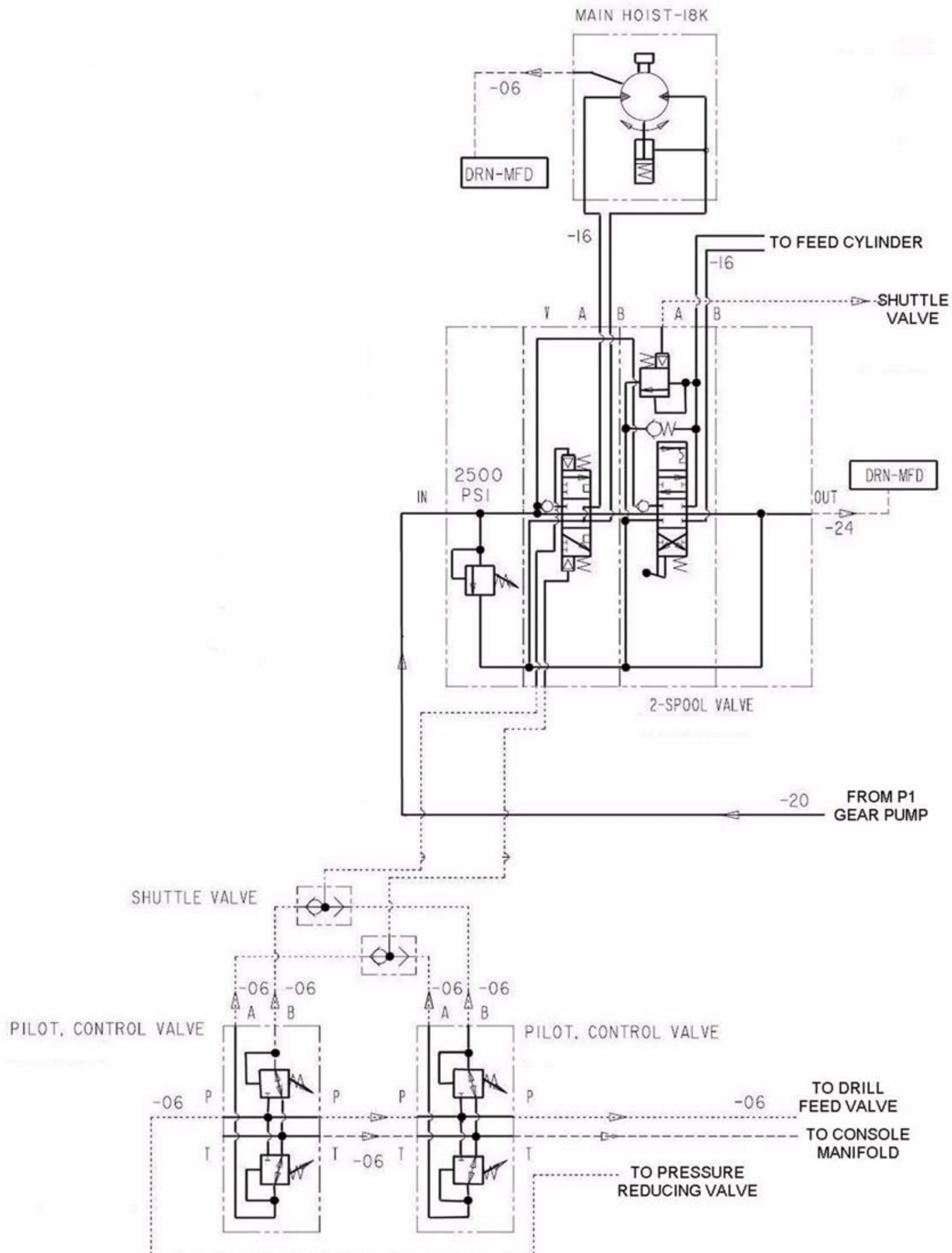
The ***Four Section Gear Pump*** is used to supply oil to the following circuits:

1. The ***P1 Gear Pump Section***, along with the P4 Gear Pump Section, is used to supply oil to the ***Main Hoist Circuit*** and the ***Fast Feed Circuit.***
2. The ***P2 Gear Pump Section*** supplies oil to the ***Cooler Fan Circuit***
3. The ***P3 Gear Pump Section*** supplies oil to the two-spool and 10-spool valves for the ***Auxiliary Functions Circuits***
4. The ***P4 Gear Pump Section***, along with the P1 Gear Pump Section, supplies oil to the ***Drill Feed Circuit***



Main Hoist, Drill Feed, Fast Feed, Pilot Valves Schematic

The hydraulic gear pump supplies oil to the electric over hydraulic, single spool drill feed valve located behind the control panel. The drill feed system has a separate pressure relief valve that keeps the drill feed relief from exceeding 2500 psi (172 bar).


MAIN HOIST-18K
-06
DRN-MFD
-16
TO FEED CYLINDER
-16
SHUTTLE
VALVE
V A B A B
2500
PSI
IN
OUT
-24
DRN-MFD
2-SPOOL VALVE
-20
FROM P1
GEAR PUMP
SHUTTLE VALVE
-06 -06
A B
-06 -06
A B
PILOT, CONTROL VALVE
PILOT, CONTROL VALVE
-06
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-06
TO DRILL
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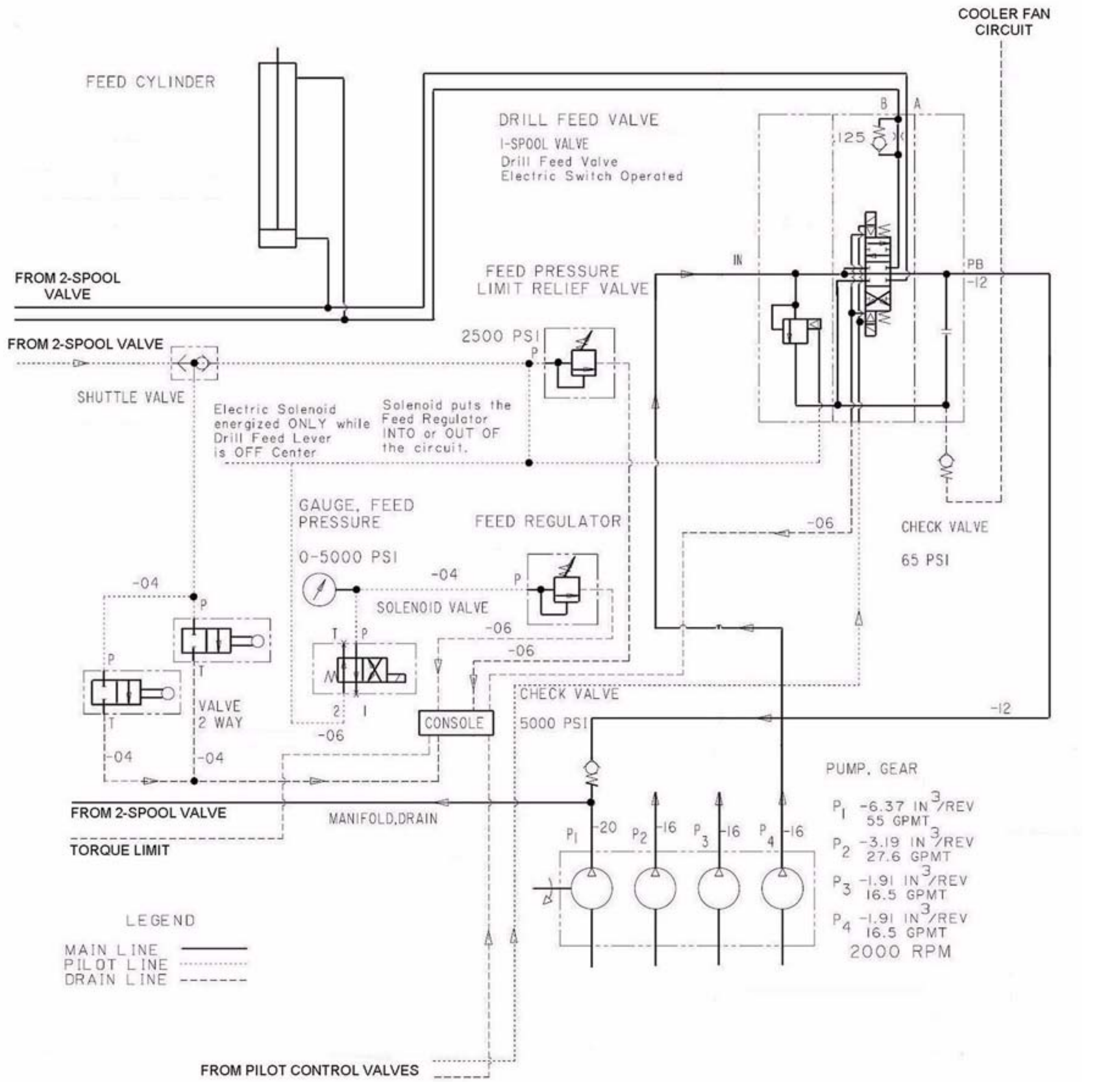
TO CONSOLE
MANIFOLD
TO PRESSURE
REDUCING VALVE



The TH60 has an electrically operated isolation valve that closes off the remote relief valve from the rest of the circuit when not in the drilling mode. The remote relief is located next to the drill feed controller on the console and can be adjusted to limit drill feed, either up or down, from 100-2500 psi (6.9-172 bar). The isolation valve is operated by an electric solenoid that is activated only when the drill feed control is activated. The up-down drill feed valve also lights red lights on the console when it is operated. The isolation valve is energized in both the up and down position. This isolation valve is in the circuit to prevent varying operational responses when the main hoist is operated. Without the isolation valve, the fast feed and main hoist would relieve at the same pressure as the remote relief setting and would result in sporadic operation.

The drill feed valve has a check valve and a 0.125" orifice in the "B" port outlet. This allows full flow to the feed cylinder in the down position, but prevents oil from back-feeding the drill feed valve when the fast feed (2-spool) valve is activated.

Overpressure Controls

These two valves, mounted on each of the drilling end jacks, are simply two position, two way valves that are opened by the jack nipples moving downward on the valve plunger. This allows flow to drain out of the two spool valve. Once the jack has been placed back on the ground, and the nipple is moved off the plunger, pressure is restored to the system.

To ensure the over pressure control is operational and working properly, the following procedure should be performed daily or before each drilling shift:

1. Locate the drill on a level, graded surface. Raise and level the drill just high enough so that the pistons in the overpressure valves on the drilling end jacks are no longer depressed. The tires should be on the ground, partially supporting the drill.
2. Remove all drill rod, stabilizers, hammers, etc. from the rotary tophead.
3. Raise and lock the derrick.
4. Move the empty rotary tophead to the bottom of the derrick using slow feed.
5. Turn the feed regulator to the maximum pulldown pressure of 2500 psi (172 bar.
6. Raise the jack on the drilling end, rod box side enough to depress the overpressure piston.
7. Read the feed pressure gauge and verify the feed pressure drops below 600 psi 41.3 bar).

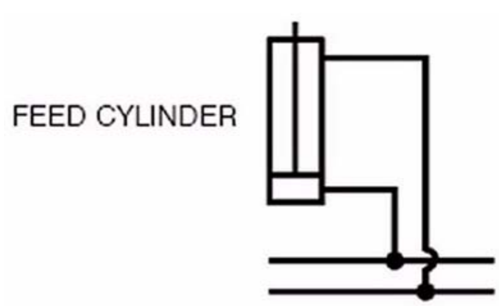
   NOTE: If the Feed Pressure does not drop below 600 psi (41.3 bar), troubleshoot and repair the circuit.

8. Repeat the above for the drilling end, console side jack.
9. Repeat the above process using the fast feed controls.

If all checks are met, the over pressure control is functional and drilling can proceed.

Feed Cylinders

The feed cylinders (also called pulldown cylinders) are double acting, single rod cylinders. The schematic symbol for the feed cylinder is shown below.



"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.

1. The standard 32 ft. derrick uses one 6 in. diameter x 156 in. x 3 in. diameter rod (152.4mm x 3962.4 mm x 76.2 mm) cylinder.
2. The deephole 32 ft. derrick uses one 6.5 in. diameter x 156 in. x 3 in. diameter rod (165.1 mm x 3962.4 mm x 76.2 mm) cylinder.
3. The 38 ft. derrick uses one 6.5 in. diameter x 180 in. x 3.5 in. diameter rod (165.1 mm x 4572 mm x 88.9 mm) cylinder.

Fast Feed

The feed system is made up of two sections of the hydraulic gear pump. The fast feed section (P1) of the four section pump supplies 55 GPMT and the drill feed section (P4) of the four section pump supplies 16.5 GPMT.

The fast feed section is operated through one of the spool valve sections of a 2 spool valve. It has a 2500 psi (172.3 bar) main relief and the spool has a regenerative section built in and initiated if the operator pushes the control all the way forward. This action allows oil, coming from the rod end, to mix with flow from the pump and increase the speed of the cylinder in the "down" position only.

The fast feed valve is operated by a hydraulic pilot valve mounted on the left side of the carousel.

The fast feed, hoist and the drill feed are all controlled by the overpressure valves on the two leveling jacks nearest to the drilling end of the drill. If either jack is off the ground or falls in a hole, the reliefs on the main two spool valve and the drill feed valve will vent and no pressure will be seen in either circuit until the overpressure valve is closed.

Pilot System

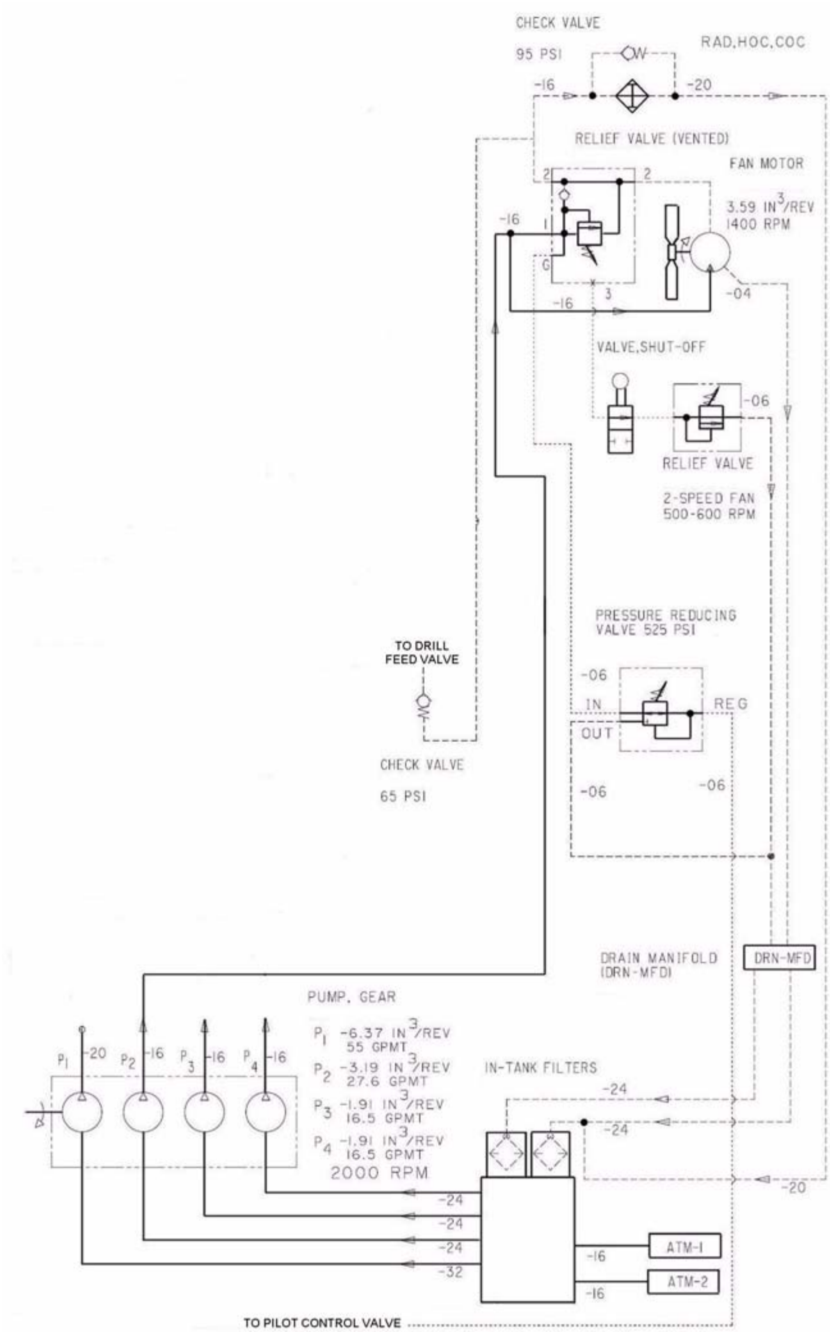
There are two pilot control valves for the main hoist; one on the operator's console and the other on the helper's side of the drill next to the jib arm swing and extend valves.

The main hoist operates through one of the spool valve sections of the main 2 spool valve that is mounted on the back of the derrick below the sand reel. Pressure to operate the main 2 spool valve comes from the P1 section of the hydraulic gear pump.

Pressure to operate the jib boom swing and extend comes from the P3 section of the hydraulic gear pump through the 2-spool jib valve.

Cooler Fan Circuit

The single fan motor is rotated by the P2 section of the hydraulic gear pump. The P2 section of the four section pump has a displacement of 3.19 in3/rev with a 27.6 GPMT flow.



Also teed into the line is a pressure reducing valve set at 525 psi that supplies the pilot pressure for the pilot system. Oil leaving the fan motor is directed to the hydraulic oil cooler. This is the only oil that is directly cooled in the system. A 95 psi check valve by-passes the hydraulic oil cooler during cold starts, or plugged tubes.

7-8 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 the jib arm extend, jib boom swing, carousel index, breakout wrench, derrick raise, table retract, sand reel motor (option), leveling jacks, water injection and/or rod spinner option.

The P3 section of the four section hydraulic gear pump supplies oil to the 2-spool jib valve and then on to the 10-spool valve. The P3 section of the four section hydraulic gear pump has a displacement of 1.91 in3/rev with a 16.5GPMT flow. The 10-spool valve has a 2500 psi main relief and there are two port relief valves on the carousel rotation section which are set at 500 psi each. This is necessary because of the large size of the motor used to rotate the carousel slowly.

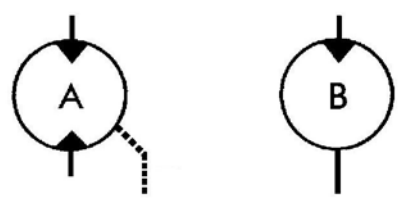
Each section of the 10-spool valve assembly controls a specific auxiliary function. An explanation of the auxiliary functions is divided into the valve sections (or spools) and the functions each section controls. The examination of these circuits will follow a brief explanation of the components found in the auxiliary functions circuit.

Components

The components of the auxiliary function circuit are the hydraulic gear pump, motors, cylinders, valves, 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.

Motors

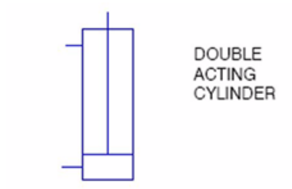
Representative motor symbols are shown below. The circle may contain one triangle pointed inward from one work port (unidirectional) or a triangle pointed inward from both ports (bidirectional).



Motor “B” is fixed displacement. This means that speed may only be changed by changing the motor supply flow. Motor “A” is bi-directional. Dotted lines leaving the circle show that the motor case leakage is taken away from the motor externally.

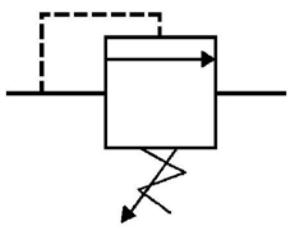
Cylinders

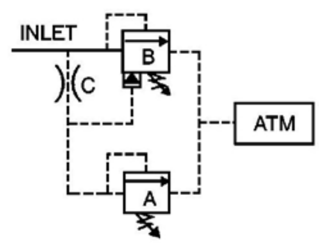
Representative cylinder symbols are shown below. These are all double acting, single rod cylinders. “Double-Acting” means that the cylinder can be powered by the hydraulic system to extend and to retract. “Single-Rod” means that the cylinder only has one rod extending out of one end of the cylinder tube.



Relief Valves

Relief valves are used in many locations in the auxiliary functions circuit. A representative relief valve symbol is shown below.



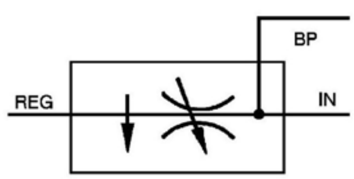


The basic valve envelope (box) contains an arrow in the normally closed position. The adjustable length spring holds the valve spool in the closed position until inlet pressure overcomes the spring force. The valve opens and closes as required to limit the maximum pressure at its inlet.

Valve “A” is the pilot section. If there is no flow, there is no pressure drop across the orifice “C”. Pressures from both pilots at “B” are equal and the spring is able to keep the valve closed. As the pressure increases, the pilot relief “A” opens at the set relief pressure. Thus, there is flow through the orifice and pilot pressure on the spring side of the main relief drops. This allows the upper pilot pressure to overcome the combination of spring and lower pilot pressure and the main relief opens, allowing full flow through the valve.

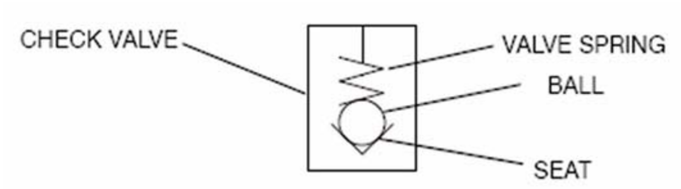
Restrictor Valves

Bypass type restrictor valves allow a restricted flow to the work load and divert any excess oil to the valve bypass port.The water injection regulator is an example of this type of valve.



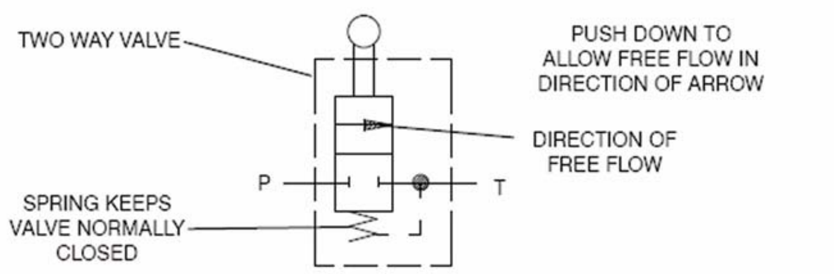
Check Valves

The check valve 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.



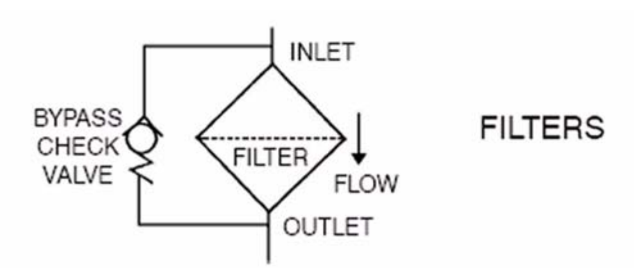
Two Way Valve

The two way valve has a closed position and an open position that can be activated by a plunger. 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.



Filters

The filter (shown below) is represented by a square, tipped on one corner with the inlet and outlet to two opposite corners and a dashed line connecting the two remaining corners. 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.‘



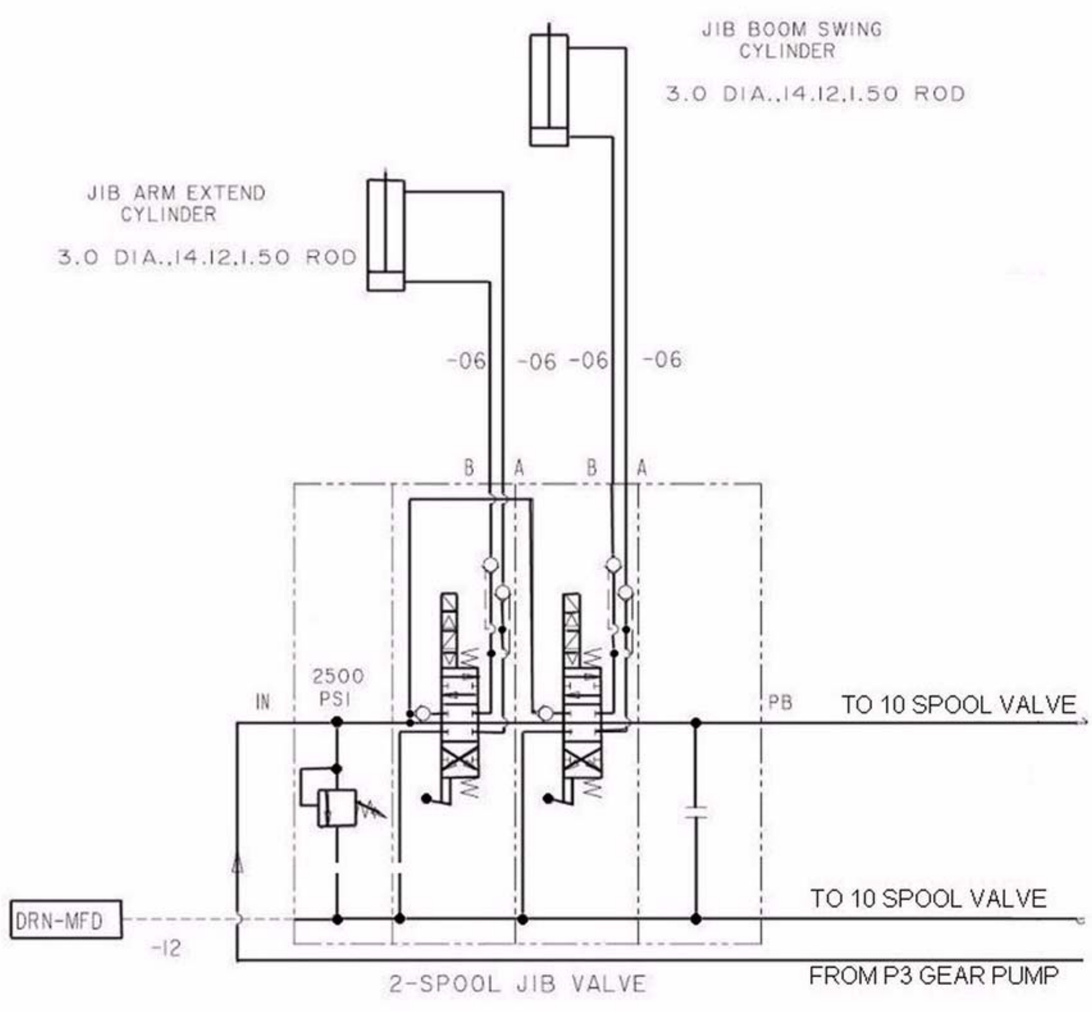
An additional feature in certain filters is the visual indicator used to signal a “clogged” element. A bypass check valve is installed in line with the flow. In case the filter becomes plugged or dirty, the check valve will open and allow oil to flow around the filter

There are two single element in-tank filters used to clean the hydraulic oil. They are 10 (micron) rated filters using the inside-out flow pattern. This means that if a filter is contaminated and has to be changed, the debris that normally would be on the outside of the element would fall into the hydraulic reservoir and contaminate the whole reservoir. With the inside-out type, all debris is trapped inside the filter element and can be removed safely, without getting any contamination in the reservoir. Using single elements also keeps debris from getting into the system since the elements don't come apart in the container.

There is a drain manifold mounted on the deck in front of the hydraulic reservoir. It has o-ring fittings that prevent leaks and all the oil from the system, except the pilot oil, is returned through this manifold.

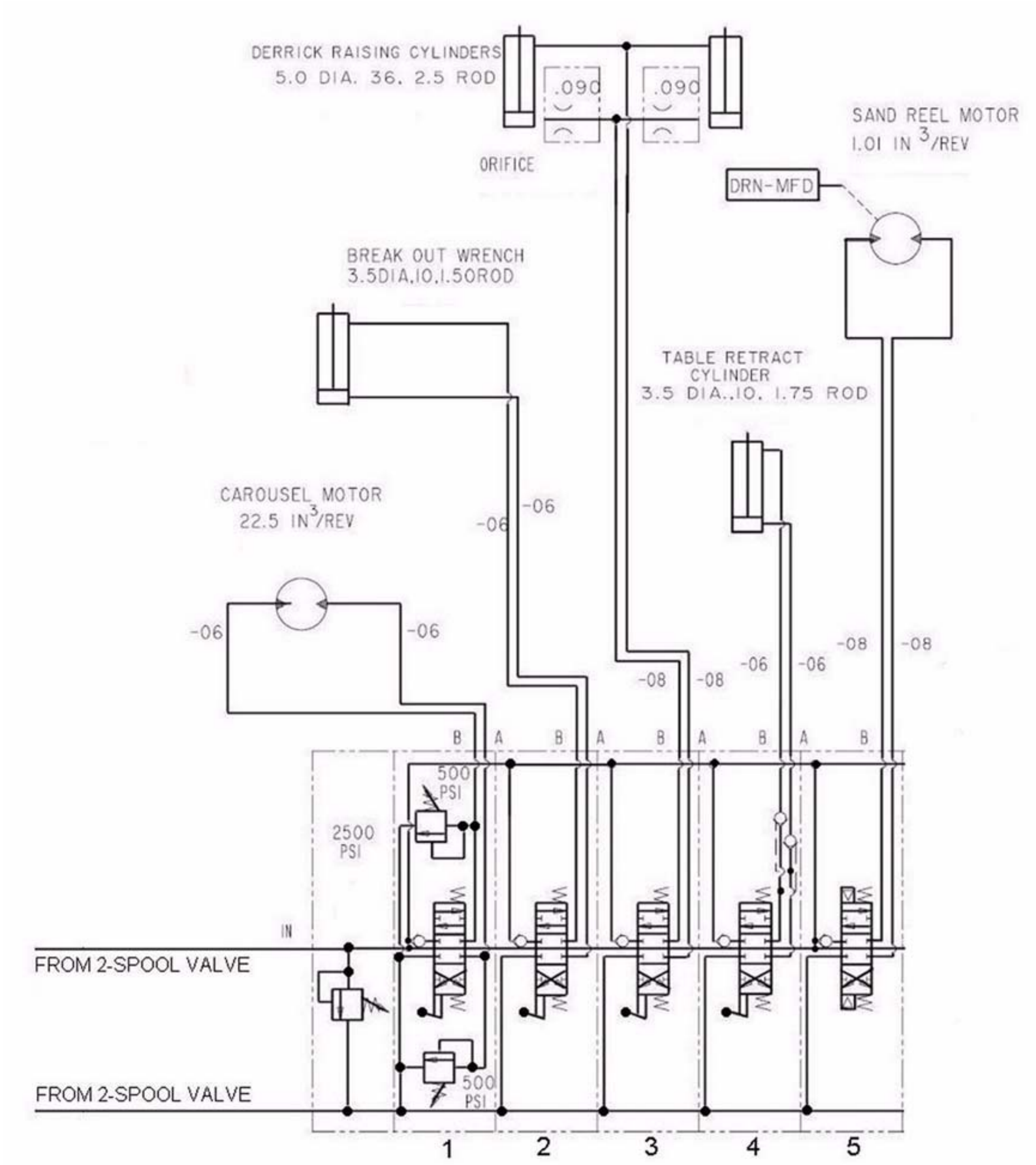
2-Spool Jib Valve

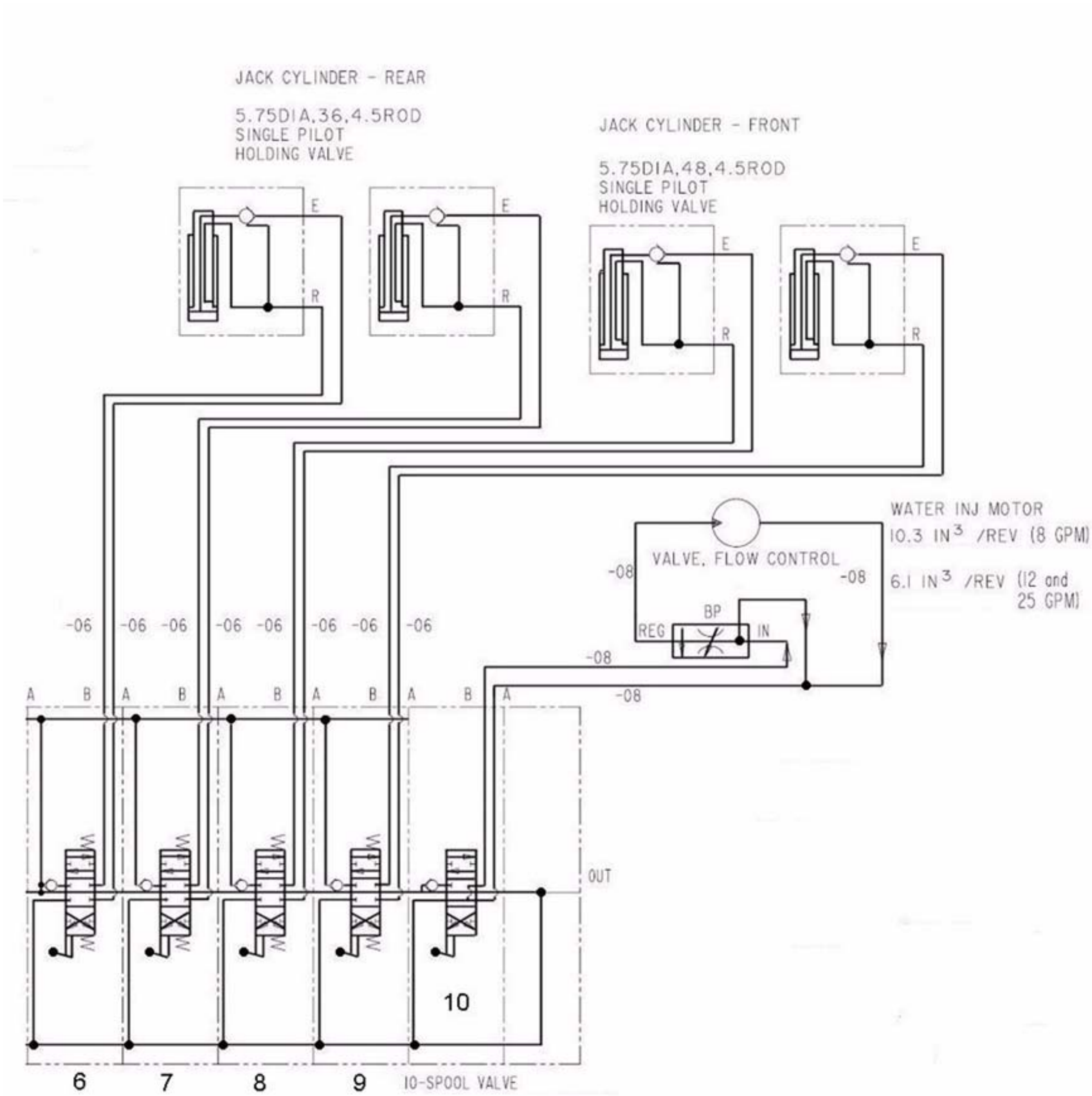
The P3 section of the four section gear pump supplies oil to the 2-spool jib valve and the 10-spool valve. The P3 section of the four section pump has a displacement of 1.91 in/rev with a 16.5 GPMT flow. The 2-spool valve has a 2500 psi main relief. The 2-spool jib valve allows the operator to operate the jib boom swing and extend cylinders.



10-Spool Valve

The P3 section of the four section pump supplies oil to the 10-spool valve through the 2-spool valve. The P3 section of the four section pump has a displacement of 1.91 in/rev with a 16.5 GPMT flow. The 10-spool valve has a 2500 psi main relief and there are two port relief valves on the carousel rotation section which are set at 500 psi each. This is necessary because of the large size of the motor used to rotate the carousel slowly.





Valve Section One (Carousel Index)

This is a motor spool, spring centered section that operates the carousel index motor. The carousel motor has a displacement of 22.5 in3/rev. The carousel index controls the rotation of the carousel when moving drill pipe under the drill string when adding pipe to the drill string or removing drill pipe from the drill string.

Valve Section Two (Breakout Wrench)

The cylinder spool section controls the breakout cylinder on standard drills. The breakout chain/pipe wrench is used for removing drill pipe from the rotary head or drill string at the table.

Valve Section Three (Derrick Raising Cylinders)

This section operates the derrick raising cylinders. ***Note:*** Each cylinder has a .090 orifice. Feather the derrick raising control when derrick approaches vertical position. ***Do not slam derrick against stops***.

Valve Section Four (Retract Table)

This section operates the retract table cylinder. Retract the table to change bushings or install large casing. Retract the table by lifting the control and close the table by lowering the control.

Valve Section Five (Sand Reel Hoist Option)

This is a motor spool, spring centered section that operates the sand reel motor. The sand reel motor has a displacement of 1.01 in3/rev. The sand reel hoist control is used to raise and lower the sand reel hoist. ***Note:*** If the sand reel is not ordered, this spool section is removed.

Valve Section Six (Leveling Jack)

This section operates the cab end, rod box side, leveling jack. The jack is mounted directly behind the truck cab. The standard jack has a 5.75 in. (146 mm) bore x 4.5 in. (114.3 mm) x 36 in. (914 mm) stroke with a single pilot holding valve and an 18 in. (457 mm) jack pad.

Note: On a Paystar 5600i heavy duty truck, the jack is part of the front bumper assembly. This option jack has a 5.75 in. (146mm) bore x 48 in. (1219mm) stroke with a single pilot holding valve and an 18 in. (457mm) jack pad.

Valve Section Seven (Leveling Jack)

This section operates the cab end, operator’s console side, leveling jack. The jack is mounted directly behind the truck cab. The standard jack has a 5.75 in. (146 mm) bore x 4.5 in. (114.3mm) x 36 in. (914mm) stroke with a single pilot holding valve and an 18 in. (457mm) jack pad.

Note: On a Paystar 5600i heavy duty truck, the jack is part of the front bumper assembly. This option jack has a 5.75 in. (146mm) bore x 48 in. (1219mm) stroke with a single pilot holding valve and an 18 in. (457mm) jack pad.

Valve Section Eight (Leveling Jack)

This section operates the drill end, rod box side, leveling jack. The jack is located on the side of the deck behind the rear wheel. The standard jack has a 5.75 in. (146 mm) bore x 4.5 in. (114.3 mm) x 48 in. (1219 mm) stroke with a single pilot holding valve and an 18 in. (457 mm) jack pad.

Valve Section Nine (Leveling Jack)

This section operates the drill end, operator's console side, leveling jack. The jack is located on the side of the deck behind the rear wheel. The standard jack has a 5.75 in. (146 mm) bore x 4.5 in. (114.3 mm) x 48 in. (1219 mm) stroke with a single pilot holding valve and an 18 in. (457 mm) jack pad.

Valve Section Ten (Water Injection/Rod Spinner Option)

This is a motor spool used to operate the water injection motor. A bypass flow control valve is located between the spool and the hydraulic motor. This allows the operator to divert some of the flow away from the motor and adjust the speed of the water pump. Different sized motors are furnished with different sized water pumps. One motor has a displacement of 6.1 in3/rev. with 12 or 25 GMP and the other motor has a displacement of 10.3 in3/rev. with 8 GMP.

Notice: As the water injection will only use one side of the valve, another hydraulically driven option may be used by the same control valve. Be aware that lifting the control away from the neutral position will activate the water injection and lowering the control handle away from the neutral position will activate the added hydraulically driven option.

An optional pipe spinner that attaches and detaches drill pipe can be mounted on the rear truck bumper. It is a hydraulic motor/pneumatic cylinder design. This option is not shown on the 10--spool circuit schematic.

Mud Pump Circuit (Option)

The mud pump drive is the same closed loop system as the rotation circuit. It utilizes two different pumps and motors, depending on the size and type of mud pump.The hydraulic pumps are both set at 3500 psi rotation pressure. A hot oil shuttle, set at 180 psi, removes a portion of the hot, dirty oil and the charge pump replaces what is removed with cool, clean oil because of the 350 psi setting.

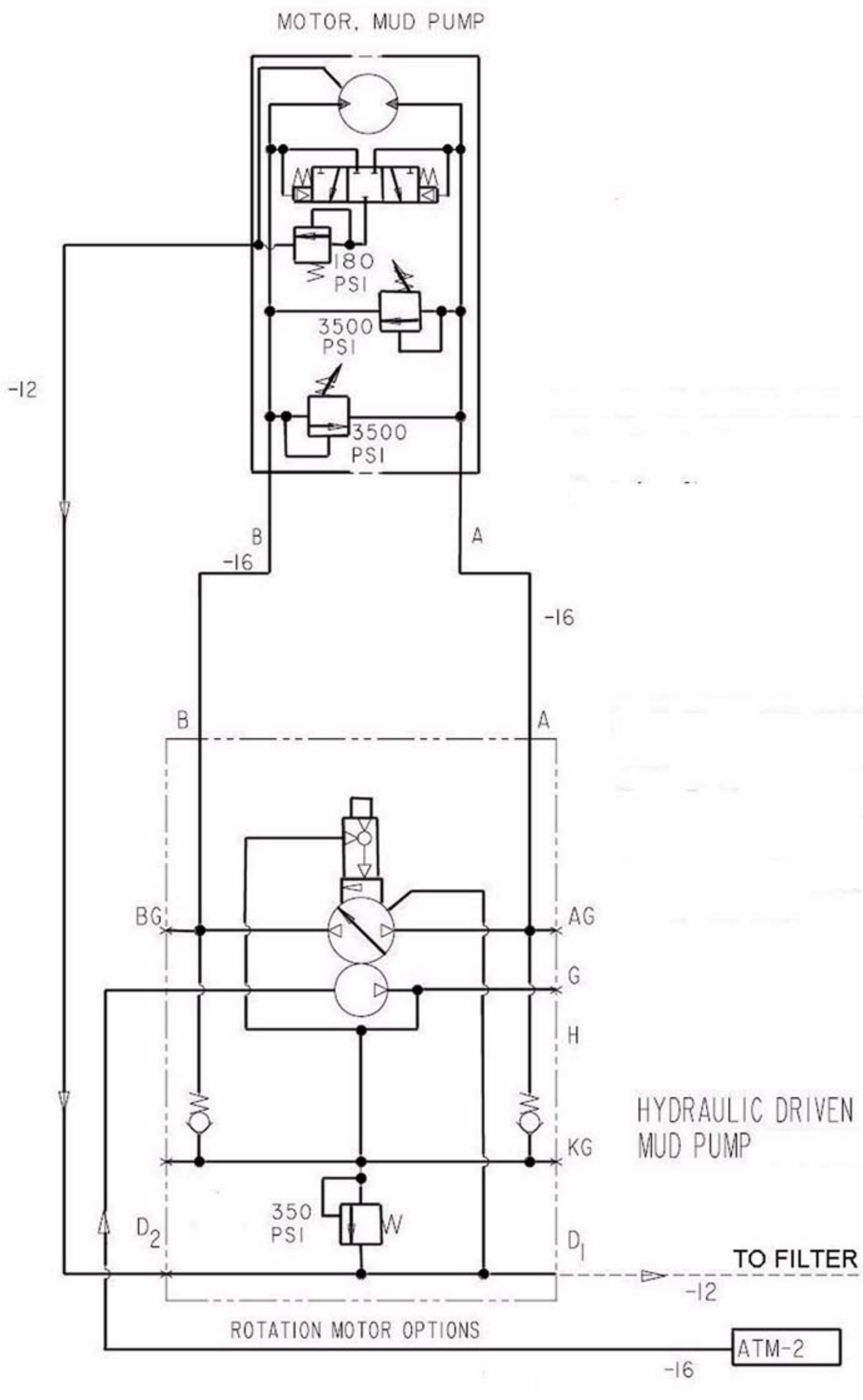
5 x 6 Mud Pump Option

1. The 5 x 6 duplex piston mud pump delivers 150 GPM (568 L/min @ 310 psi (2,137 kPa).
2. The hydraulic pump used with the 5 x 6 duplex piston mud pump option has a displacement of 4.57 in3/rev.
3. The hydraulic motor used with the 5 x 6 duplex piston mud pump has a displacement of 2.03 in3/rev.

3 x 4 Mud Pump Option

1. The 3 x 4 centrifugal mud pump, mounted in a vertical position adjacent to the rear jack on the helper's side, delivers 300 GPM (1135 L/min) @ 145 psi (999 kPa).

2. The hydraulic pump used with the 3 x 4 centrifugal mud pump option has a displacement of 6.10 in3/rev.
3. The hydraulic motor used with the 3 x 4 centrifugal mud pump has a displacement of 2.03 in3/rev.



7-9 WATER INJECTION

Cat Water Injection

CAUTION

CAT PUMPS are positive displacement pumps. Therefore, a properly designed pressure relief or safety valve must be installed in the discharge piping. Failure to install such a relief mechanism could result in personal injury or damage to the pump or system.

Installation and Startup

Optimum performance of the pump is dependent upon the entire fluid system and will be obtained only with the proper selection, installation of plumbing and operation of the pump and accessories.

Specifications

Maximum specifications refer to individual attributes. It is ***not*** implied that ***all maxims*** can be performed ***simultaneously***.

Lubrication

Before starting pump, fill crankcase to dot on oil dipstick per specification with ***Cat Pump Crankcase Oil, ISO-68 multi-viscosity petroleum based lubricating oil with anti-wear and rust inhibitor additives.*** Approximate amounts are shown below.

Table 4:

12 gpm size (45.42 liters)	40 oz. (1182.8 ml)
25 gpm size (94.63 liters)	84 oz. (2483.88 ml)

Change initial fill after 50 hours running period. Change oil every three months or at 500 hour intervals thereafter. If the pump is used in extremely dirty or humid conditions, it is strongly recommended pump be enclosed.

Oilers

Prior to initial operation, fill the three oilers with Cat Pump Oil. With the oiler shutoff lever in a vertical position, screw the dome down to seat the needle valve tightly (the shutoff valve becomes loose). Then back the needle off the valve seat slightly (approximately 1/8 turn) and tighten the lock nut. Prior to initial operation, saturate wicks. Then run pump one to two hours with three to four drops per hour from each oiler; thereafter, one drop per hour per oiler.

Flipping the shutoff lever to the horizontal position shuts off the oil flow. Additional lubrication may be required with increased hours of operation and temperature.

Inlet Conditions

Refer to the complete ***Inlet Condition Check List*** before starting your system. DO NOT RUN PUMP DRY.

Nozzles

A worn nozzle will result in loss of pressure. Do not adjust pressure regulating device to compensate. Replace nozzle and reset to system pressure.

Discharge Plumbing

1. OPEN ALL VALVES BEFORE STARTING SYSTEM to avoid deadhead overpressure condition and severe damage to the pump or system.
2. Install a ***pulsation dampening*** device mounted directly to the discharge line. Optimum precharge should be calibrated at 30-50% of the operating system.
3. A ***reliable pressure gauge*** should be installed near the discharge outlet of the high pressure manifold. This is extremely important for adjusting pressure regulating devices and also for proper sizing of the nozzle or restricting orifice. The pump is rated for a maximum pressure; this is the ***pressure*** which would be ***read at the discharge manifold of the pump***, NOT AT THE GUN OR NOZZLE end of a long hose.
4. ***A pressure regulator or unloader valve must be installed to prevent overpressure*** in the event the discharge or downstream plumbing becomes plugged or is turned off. Severe damage to the pump will result if this condition occurs without a relief valve in the line. Discharge regulating devices should be at minimum pressure setting at startup. START SYSTEM WITH ALL VALVES OPEN OR IN THE LOW PRESSURE SETTING.
5. ***Note:*** Use PTFE liquid (sparingly) or tape when connecting plumbing. Exercise caution not to wrap tape beyond the last thread to avoid tape from becoming lodged in the pump or accessories. This condition will cause a malfunction of the pump or system.

Pumped Fluids

Some fluids may require a ***flush between operations or before storing***. For extended storing or between use in cold climates, drain all pumped fluids from pump and ***flush with antifreeze solution to prevent freezing and damage*** to the pump. DO NOT RUN PUMP WITH FROZEN FLUID.

Inlet Condition Check List

Inadequate inlet conditions can cause serious malfunctions in the best designed pump.

Surprisingly, the simplest of things can cause the most severe problems or go unnoticed to the unfamiliar or untrained eye. REVIEW THIS CHECK LIST BEFORE OPERATION OF ANY SYSTEM. Remember, no two systems are alike, so there can be no ***one*** best way to set up a system. All factors must be carefully considered.

The ***inlet supply*** should be adequate to accommodate the maximum flow being delivered by the pump.

1. Open inlet shutoff valve and turn on water supply to avoid cavitating pump. ***Do not run pump dry***.
2. Avoid closed loop systems especially with high temperature, ultra-high pressure or large volumes. Conditions vary with regulating/unloader valve.
3. Low vapor pressure fluids, such as solvents, require a booster pump and a C.A.T. (Captive Acceleration Tube) to maintain adequate inlet supply.
4. Higher viscosity fluids require a positive head and a C.A.T. to assure adequate inlet supply.
5. Higher temperature fluids tend to vaporize and require positive heads and C.A.T. to assure adequate inlet supply.
6. When using an inlet supply reservoir, you must size it to provide adequate fluid to accommodate the maximum output of the pump, generally a minimum of 10 times the GPM (however, a combination of system factors can change this requirement); provide adequate baffling in the tank to eliminate air bubbles and turbulence; and install diffusers on all return lines to the tank.

The ***inlet line size*** should be adequate to avoid starving the pump.

1. Line size must be a minimum of one size larger than the pump inlet fitting. Avoid thick walled fittings, tees, 90 degree elbows or valves in the inlet line of the pump to reduce the risk of flow restriction and cavitation.
2. The line must be a flexible hose, not a rigid pipe, and reinforced on the suction systems to avoid collapsing.
3. The simpler the inlet plumbing, the less the potential for problems. Keep the length to a minimum, the number of elbows and joints to a minimum (ideally no elbows) and the inlet accessories to a minimum.
4. Use pipe sealant to assure air-tight, positive sealing pipe joints.

Inlet pressure should fall within the specifications of the pump.

1. Acceleration loss of fluids may be increased by high RPM, high temperatures, low vapor pressures or high viscosity and may require pressurized inlet and C.A.T. to maintain adequate inlet supply.
2. Optimum pump performance is obtained with +20 psi (1.4 bar) inlet pressure and a C.A.T. for certain applications. With an adequate inlet plumbing, most pumps will perform with a flooded suction. The maximum inlet pressure is 40 psi (2.8 bar). Negative suction up to -8.5 psi (-0.5 bar) can be reached with optimum plumbing conditions.

Inlet accessories are designed to protect against over pressurization, control inlet flow, contamination or temperature and provide ease of servicing.

1. A shutoff valve is recommended to facilitate maintenance.
2. Installation of a C.A.T (Captive Acceleration Tube) is essential in applications with stressful conditions such as high temperatures, a booster pump feed or long inlet lines. ***Do not use C.A.T. with negative inlet pressure.***
3. A stand pipe can be used in some applications to help maintain a positive head in the inlet line.
4. Inspect and clean inlet filters on a regular schedule.
5. A pressure gauge is recommended to monitor the inlet pressure and it should be mounted AS CLOSE TO THE PUMP INLET as possible. ***Short term, intermittent cavitation will not register on a standard gauge.***
6. All accessories should be sized to avoid restricting the inlet flow.
7. All accessories should be compatible with the solution being pumped in order to prevent premature failure or malfunction.

Bypass to inlet care should be exercised when deciding the method of bypass from control valves.

1. It is recommended the bypass be directed to a baffled reservoir tank, with at least one baffle between the bypass line and the inlet line to the pump.
2. Although not recommended, bypass fluid may be returned to the inlet line of the pump if the system is properly designed to protect your pump. When using this method, a *pressure reducing valve* should be installed onto the inlet line (***between*** the bypass connection and the inlet to the pump) to avoid excessive pressure to the inlet of the pump. It is also recommended that a *thermo valve* be used in the bypass line to monitor the temperature build-up in the bypass loop to avoid premature seal failure.
3. A low pressure, flexible cloth braid (not metal braid) hose should be used from the bypass connection to the inlet of the pump.
4. Caution should be taken. Do not undersize the bypass hose diameter and length. Typical length is 24 inches (609.6 mm).
5. Check the pressure in the bypass line to avoid over pressurizing the inlet.

Diagnosis & Maintenance

Table 5:

Problem	***Probable Cause***	***Solution***
Pulsation	Faulty Pulsation Dampener	Check precharge. If the precharge is low, recharge it or install a new one.

Problem	***Probable Cause***	***Solution***
Low Pressure	Worn Nozzle	Replace nozzle of proper size
	Belt Slippage	Tighten or replace. Use correct belt type and length
	Air leak in inlet plumbing	Disassemble, reseal and reassemble
	Pressure gauge inoperative or not registering accurately	Check with new gauge; replace worn or damaged gauge.
	Relief valve stuck, partially plugged or improperly adjusted; valve seat worn	Clean and adjust relief valve; check for worn or dirty valve seats. Repair with valve kit.
	Inlet suction strainer clogged or improper size	Clean. Use adequate size. Check more frequently.
	Worn piston assembly. Abrasives in pumped fluid or severe cavitation. Inadequate water supply.	Install proper filter. Suction at inlet manifold must be limited to lifting less than 20 feet of water or -8.5psi vacuum.
	Fouled or dirty inlet or discharge valves.	clean inlet and discharge valve assemblies
	Worn inlet or discharge valves	Replace worn valves, valve seats
	Leaky discharge hose	Replace discharge hose and check for air tight connections
Pump runs extremely rough, pressure very low	Restricted inlet or air entering the inlet plumbing	Proper size inlet plumbing; check for air tight seal
	Damaged cup or stuck inlet or discharge valve	Replace worn cups or valves; clean out foreign material.
(continued) Pump runs extremely rough, pressure very low	Worn inlet seals allowing air into system or leaking fluid	Install new inlet manifold seals and possibly seals

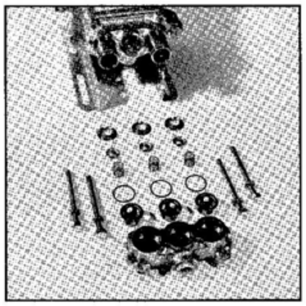
Problem	***Probable Cause***	***Solution***
Cylinder o-ring blown next to discharge manifold.	Pressures in excess of rated psi or distorted manifold from freezing damage.	Check for plugged nozzle, closed valves or for an improperly adjusted bypass valve. Replace defective manifold or o-ring. Protect from freezing.
Leakage at the cylinder o-rings, at the discharge manifold and black powdery substance in the area of the o-ring	Loose cylinders. Cylinder motion caused by improper shimming of the discharge manifold.	Remove spacer shims on manifold studs. Do not remove too many shims or the ears of the manifold will be bowed when the manifold is retightened, causing looseness in the center cylinder.
Water leakage from under the inlet manifold	Worn inlet manifold seals. Leaking sleeve o-ring.	Install new o-rings and seals as required. Replace scored sleeves.
Oil leak between crankcase and pumping section	Worn crankcase piston rod seals	Replace crankcase piston rod seals
	Excess oil from wicks	Reduce quantity of oil per oiling
Oil leaking in the area of the crankshaft	Worn crankshaft seal or improperly installed oil seal retaining packing	Remove oil seal retainer and replace damaged gasket and/or seals
	Bad bearing	Replace bearing.
Excessive play in the end of the crankshaft pulley	Worn main ball bearing from excessive tension on drive belt	Replace bearing. Properly tension belt. Use correct type and length.
Water in crankcase	May be caused by humid air condensing into water inside the crankcase.	Change oil every 3 months or 500 hour intervals using Premium 10W30 Grade non-detergent hydraulic oil (other approved oil every month or 200 hours)
	Leakage of manifold inlet seals and/or piston rod sleeve o-ring	Replace seals, sleeve and o-rings.
Oil leaking from side of crankcase	Worn crankshaft seals	Replace seals

Problem	***Probable Cause***	***Solution***
Oil leaking at the rear portion of the crankcase	Damaged or improperly installed oil gauge or worn crankcase rear cover o-ring, or drain plug o-ring	Replace oil gauge, cover o-ring, or drain plug o-ring as needed.
Oil leakage from drain plug	Loose drain plug or worn drain plug o-ring	Tighten drain plug or replace 0-ring
Loud knocking noise in pump	Pulley loose on crankshaft	Check key and tighten set screw
		Check alignment and belt position
	Broken or worn bearing	Replace bearing
Frequent or premature failure of the inlet manifold seals	Scored rods or sleeves	Replace rods and sleeves
	Overpressure to inlet manifold	Reduce inlet pressure per instructions.
	Stressful inlet conditions	Install C.A.T.
Short cup life	Abrasive material in the fluid being pumped	Install proper filtration on pump inlet plumbing.
	Excessive pressure and/or temperature of fluid being pumped	Check discharge pressure, fluid temperature or control valve bypass
	Running pump dry	***Do not run pump without water***
	Front edge of piston sharp	Replace with new piston
	Chrome plating of cylinders damaged causing excessive wear of cups. May be caused by pumping acid solution.	Install new cups and cylinders. Pump only fluid compatible with chrome.
	Short life on cups on cylinders.	Stressful inlet conditions. Install C.A.T.
Strong surging at the inlet and low pressure on the discharge side.	Foreign particles in the inlet or discharge valve or worn inlet and/or discharge valves.	Check for smooth mating surfaces on inlet valves and discharge valve seats. Flat valves and inlet valves may be lapped on a very fine oil stone; ***Quiet Valve parts must be replaced***.

Servicing the Valve Assemblies

Disassembly:

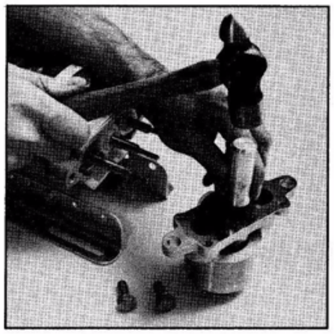
1. Remove the fasteners securing the discharge manifold to the crankcase of the pump.

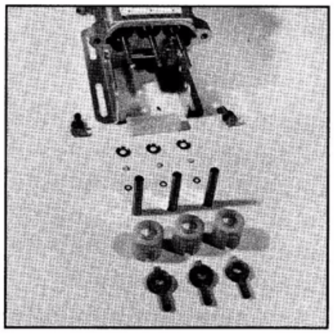


2. Support the discharge manifold and tap from the backside with a soft mallet. Gradually work free from cylinders.
3. Valve assemblies will remain in the manifold. Pump models with o-ring groove on the outside of the valve seat require the assistance of a Valve Seat Removal Tool to remove the valve seat. The valve, spring and retainer will fall out when the manifold is inverted. Pump models without the o-ring groove on the outside of the valve seat permit the seat, valve, spring and retainer all to fall out when the manifold is inverted.

Reassembly:

1. Examine the retainer for wear and replace as needed. Replace the retainer in manifold chamber with nylon tab down.
2. Examine spring for fatigue and replace as needed. Insert spring into center of retainer.
3. Inspect the valves for wear, ridges or pitting and replace as needed. ***Note:*** Seating side of ***flat valves*** may be lapped on flat surface using 240 grit paper. ***Quiet valves***, due to their shape, must be replaced. Insert valve over spring with ***dimpled side up*****.**





4. Examine all o-rings and backup rings on the valve seat. Replace them if they are used or worn. Always lubricate o-rings for ease of installation and to avoid damage. ***Note:*** First install o-ring in groove on seat towards seating surface, then backup ring. ***Note:*** Models without outer groove on seat require the o-ring to be placed on the lip of the retainer.
5. Examine valve seats for wear, pitting or grooves. Lap the ***Flat Valve*** seats with 240 grit paper or replace if there is evidence of excessive wear. ***Quiet Valve*** seats must be replaced if worn. Install seats with ***dish side down***.
6. Lubricate o-rings on exposed cylinder. Exercise caution when slipping manifold over cylinders to avoid damaging cylinder o-rings. Completely press manifold over cylinder.
7. Replace fasteners and torque per torque chart on following pages. ***Note:*** Replace all original shims if used. ***When new manifold is used, reshim pump*.** When starting the pump, check to see that there is no cylinder motion. This will cause premature failure of the cylinder o-rings. Center cylinder motion indicates improper shimming.

Servicing the Valve Pumping Section

Disassembly:

1. Remove the discharge manifold as previously explained.
2. Grasp cylinders by hand and with an up and down motion, pull the cylinders from inlet manifold.
3. Remove cotterpin, nut and washer from piston rod.
4. Next remove the retainer, spacer, piston-cup assembly and inlet valve.

Reassembly:

1. Examine inlet valve surface for pitting, scale or grooves. Reverse valve and sand inlet side of valve using 240 grit paper for clean surface or replace if evidence of excessive wear. Slip onto rod.
2. Examine piston seating surface and lightly sand on flat surface using 240 grit paper. If extreme pitting or sharp edges, replace piston.
3. Examine cup for wear, cracking, tearing or separation from the piston. If worn, replace and lubricate before installing on piston. ***Note-cup installation:*** Wipe cup inserter with oil. slip backup ring (when used) onto piston. Push cup over inserter and square with all surfaces. Faulty cup installation causes premature cup failure. Some models use a one piece piston assembly. The cup does not separate from the piston. Replace entire assembly. Lubricate piston assembly and slip piston-cup assembly onto the piston rod with ***lip facing discharge***.
4. Next, replace the piston spacer and retainer on rod.
5. Replace washer, thread on nut and torque per torque chart shown on following pages. ***Note:*** Always replace with ***new stainless steel cotterpin*** and turn

ends under.

6. Examine cylinder walls for scoring or etching which causes premature wear of cups and replace as needed.
7. Lubricate the cylinder and replace o-rings and/or backup rings if worn or damaged. ***Backup rings go to low pressure side of the o-rings.*** Carefully slip cylinder over rod ends and push into inlet manifold with the ***backup ring to the discharge, stroke marking on the inside of the cylinder to the crankcase,***
8. Position discharge manifold onto pumps as described. Replace fasteners and torque per specifications chart shown on following pages.

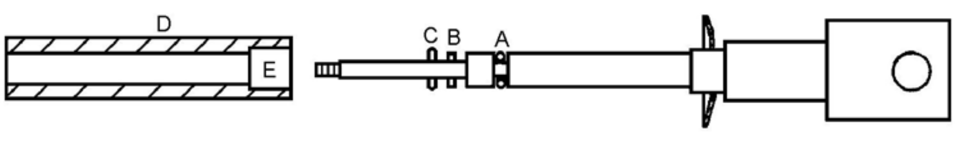
Servicing Sleeves and Seals

Disassembly:

1. Remove discharge manifold and piston assemblies as described.
2. Remove inlet manifold containing seals.
3. Grasp sleeves and with a pulling and twisting motion remove the sleeve from the piston rod. ***Note:*** Grasp sleeve with pliers only if replacing worn sleeves, as the procedure will mar the sleeves.
4. Next, remove the seal retainer.
5. Remove and examine o-rings and/or backup rings on piston rod for wear and replace as needed.

Reassembly:

1. Visually inspect that the barrier-slinger is in position.
2. Lubricate new o-rings and/or backup rings and slip onto piston rod. Install the first o-ring (A) in the groove on the piston rod. Next, position the backup ring (B) against the stepped shoulder. Then install the second o-ring (C). Exercise caution as you slip the o-ring over thread end of the piston rod.



3. Examine sleeves for scoring or etching and replace. ***Immerse sleeves (D) in oil and carefully twist and push sleeve onto rod with machined counter bore end (E) first.***
4. Next, install seal retainers. If wicks are used, replace wicks. Thoroughly saturate with oil, place in seal retainer and install retainer.
5. Place inlet manifold on pair of clearance blocks with ***crankcase side down*** and drive out old seals.

6. Invert inlet manifold with ***crankcase side up*** and install new seals. Lubricate O.D. of seal and install Prrrrm-A-Lube seal with ***garter spring down***. If using blue dot seal, install ***blue dot*** seal facing up. ***Note:*** The 25 gpm model does not have Prrrrm-A-Lube option. Install with ***spring down*.**
7. Slip lubricated seal inserters onto piston rod ends, position inlet manifold onto pump and remove seal inserters. Some models secure inlet manifold to crankcase. Replace fasteners and torque per specification chart shown on following pages.
8. Reassemble piston assemblies and discharge manifold as described.
9. Replace original quantity of shims on each stud before replacing discharge manifold.

Servicing Crankcase Section

1. While the inlet manifold, sleeves and seal retainers are removed, examine the seals in the crankcase for wear.
2. Check oil for proper level and for evidence of water in oil or other contaminants.
3. Rotate crankshaft by hand to feel for smooth bearing movement.
4. Examine crankshaft oil seal externally for drying, cracking or leaking.

Torque Chart

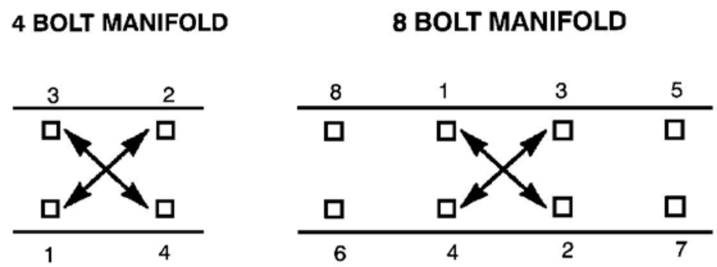
Table 6: Piston Rod Nut

Pump Model	Thread	Tool Size	Torque
12 gpm	M7 x 1.0	10mm Hex	70-120 in/lbs (8-13 Nm)
25 gpm	M8 x 1.25	13mm Hex	90-150 in/lbs (10-17 Nm)

Table 7: Manifold Stud/Nut and Cylinder Bolts

Pump Model	Thread	Tool Size	Torque
12 gpm	M10 x 1.5	17mm Hex	250 in/lbs (28 Nm)
25 gpm	M12 x 1.75	19mm Hex	370 in/lbs (42 Nm)

Manifold Torque Sequence



Pulse Pump Injection Head

The pulse pump is optional for high pressure Cat pumps only.

Operation

With gun open, start drive pump. After water starts to flow out the nozzle (minimum 200 psi/ 13.8 bar), open bleed valve one turn to purge air from pulse pump, thus priming the pulse pump. After all air is purged, torque valve 100 and 120 in/lbs (11.3 and 13.56 Nm). Then set drive pump for proper discharge pressure.

⚠ CAUTION

Pulse Pump will not operate with a pressurized inlet to the drive pump.

⚠ CAUTION

Do not operate the pulse pump dry. This could damage the diaphragm.

Performance

After the unit is operating, adjust metering valve to obtain desired water/chemical ratio. Check chemical output by measuring chemical supply tank. ***Note: A metering valve not supplied by Cat Pumps with pulse pump***.

Mixing Ratio varies with output of drive pump, the model pulse pump being used and whether a metering valve is used.

Maintenance

Before shutting system down, flush pulse pump by placing chemical supply line in water. If volume of chemical decreases, lap the discharge valve, suction valve seat and valve with 440 grit paper. Check diaphragm for leaks.

Trouble Shooting

No Chemical Supply From Pulse Pump

1. Failure of diaphragm or spring
2. Air in chemical supply line
3. Foreign material in inlet or discharge valves
4. Pressurized inlet to drive pump

Limited Chemical Supply From Pulse Pump

1. Air in chemical supply line
2. Clog in manifold port fitting
3. Loose lock nut of diaphragm spring
4. Worn inlet and discharge valves

Bean Water Injection

This section is designed to help with routine maintenance and do-it-yourself service that the John Bean pump or equipment may require.

Installation

Pump Location

1. Locate the pump as close to the source of supply as possible. It is desirable to set the pump in a clean and dry place with sufficient lighting and adequate space for inspection and maintenance.

Foundation

1. The pump should be mounted in a vertical position and securely fastened in order to maintain alignment and prevent vibration.

Suction Line

General

1. When installing pipe and fittings, be sure the inside of all parts are free from dirt, scale, burrs and other foreign material which might interfere with the pump operation. Make sure all joints are tight and free from air leaks which cause cavitation and loss of pump capacity.
2. Return the overflow from a relief valve or pressure regulator directly to the supply tank. Care must be taken not to locate return where it will cause excessive turbulence directly at the suction inlet.

Length and Size

1. The suction line from source to pump inlet should be as short and direct as possible, using either piping or durable non-collapsing hosing as circumstances warrant.
2. The suction pipe size should be at least the same as the pump inlet connection, or preferably larger to avoid limiting the pump capacity. The supply source should be located above the inlet connection for smoother operation of the pump and longer packing life. When a static lift is used, the lift should be kept as small as possible. Elbows, nipples and unions should be kept at an absolute minimum. To isolate mechanical and hydraulic vibrations, hose connections are recommended at the pump for both suction and discharge.
3. Install both the suction and discharge piping so it is supported independently, thus avoiding vibrations as well as strain on the pump.

Gate Valves

1. In order to cut off the supply of liquid during maintenance inspections, a gate valve is recommended as close as possible to the inlet side of the pump. The openings in the gate valve should not be smaller than the pump inlet openings.

Suction Dampener

1. Where long suction lines occur, it may be necessary to install a suction dampener to minimize vibration.

Drain Plugs

1. Drain plugs or drain cocks are advisable for use at low points in both the suction and discharge lines. This is especially true if temperature conditions drop to the freezing point or lower.

Strainer

1. Install a strainer in the suction line to remove particles which might interfere with the valves. Strainers may be of the open type at the end of the suction line or fully enclosed, having a removable cover for inspection. It is very important that strainers are cleaned periodically and sized properly so they do not restrict suction flow.

Pump Connections

1. Install unions as close as possible to the inlet and outlet openings of the pump to facilitate any future servicing, should the need arise.

Discharge Lines

Size and Length

1. Install the discharge piping as short and direct as possible, using the same size pipe as the pump outlet connection. When the discharge hose is extra long, use the next larger size diameter hose to minimize friction.

Relief Valve

1. Select a relief valve of adequate capacity and install in discharge line between the pump and check valve (if used) or the shutoff valve. Bean relief valves bypass excess liquids to prevent extreme pressures. They are easily adjusted for pressure control.

Pressure Gauge

1. A pressure gauge is recommended to aid in checking or adjusting pressures and it should be installed in the discharge line near the relief valve.

Discharge Dampener

1. Install a pulsation dampener of adequate size in the discharge line to ensure smooth delivery by dampening pulsations and minimizing surging.

Power Source

1. If the pump is driven by an electric motor, use wire of sufficient size to carry the load with the additional protection of fuses or thermal relays.
2. If the pump and motor are connected by a flexible coupling, be sure the two shafts are in good alignment with each other.

Direction of Rotation

1. The pump may be operated in either direction with satisfactory results.

Servicing Instructions

Safety First!

Disconnect the power source ***before*** performing ***any*** service on the pump

General Care of the Pump

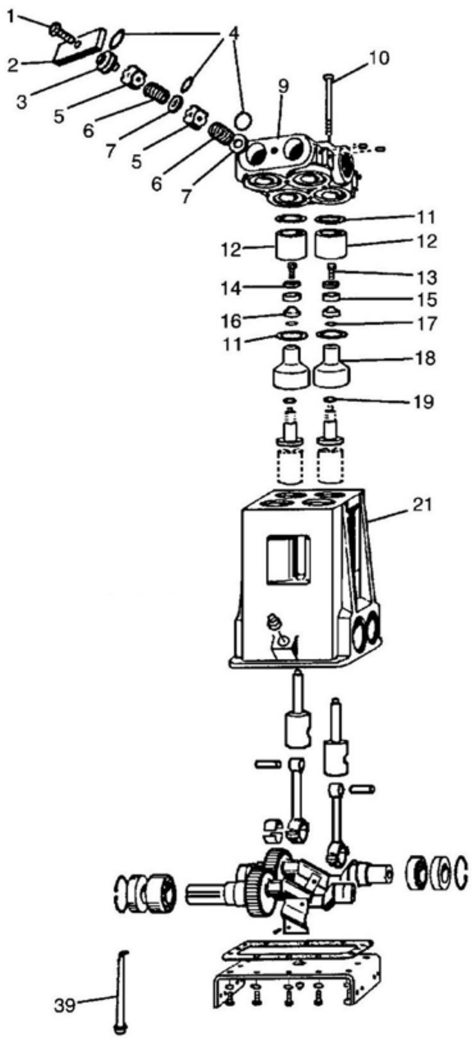
1. Drain and refill the pump crankcase with clean SAE30 API service clarification MM or better oil after the first 100 hours of operation. Following the first 100 hours of operation, for best results change the oil every 750 hours of operation.
2. Keep all piping and mounting bolts tight.
3. Replace all worn parts promptly with OEM replacement parts.

Care in Freezing Weather

⚠ CAUTION

Important - Precautions must be taken to avoid damage to the pump from

***liquid allowed to freeze in the valve chamber*.**



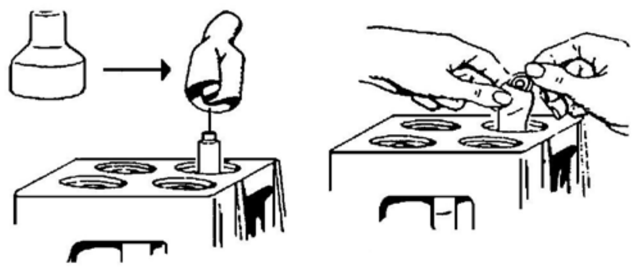
1. Drain all connecting piping.
2. Refer to above pump drawing. Remove capscrew (1), clamp(2), valve (3), valve disc and spring (5) to drain the valve chamber (9) when freezing temperatures are expected. Remove the “top” discharge valves or raise them to be sure that no liquid is trapped under the “inner” suction valves.

Servicing the Plunger Packings

1. Release valve chamber (9) from pump case by removing the four capscrews (10) shown above.
2. Lift the chamber free of the cylinders (12). Remove the cap screws (13), the cup washers (14) and plunger packings (15).
3. Lift the cylinders (12) from the pump case (21).
4. Inspect the o-rings (17) and the umbrellas (18). If either of these parts are worn

or damaged, they should be replaced. A pocket knife can be used for easiest removal of the umbrellas. Clean all parts thoroughly and replace the worn parts with exact OEM replacement parts.

5. When reassembling plunger packings, inspect the bottom gasket (11) and replace if necessary. ***Note:*** If it is necessary to replace one gasket at either top or bottom of the cylinders, then all bottom or top cylinder gaskets should be replaced. Torque capscrews to 8-10 ft/lbs (11-13.5 Nm). ***Note:*** For easier installation of the umbrella, soak in hot water for approximately two to three minutes to soften.
6. Fold the plastic umbrellas (18), as shown in below, to insert them through openings and over ends of crosshead rods.



7. Press tops of umbrellas to place pilot washers (19) over ends of rods ***with groove up***.
8. Place o-rings (17) and packing holders (16) in position on ends of crosshead rods.
9. Place cylinders (12) in position in the mounting plate recess.
10. Oil the plunger packings (15) and press them in the open end of the cylinders, with the cup “up”. Use the thumb to press the packings into each cylinder firmly and squarely on the plunger rod end.
11. Turn the pump by hand to raise each plunger rod to the top of the stroke, as needed.
12. Place the cup washers (14), with the ribbed side against the plunger packing, inside the cups of the packing.
13. Secure packing and washers to plunger rods with capscrews (13), tightening them until the washers and cups seat firmly on the plunger rods. Torque to 15-20 ft/lbs (20-27 Nm).
14. Inspect top cylinder gaskets (11) and replace all if any show defects, holding them in place in the valve chamber by using heavy oil or grease if necessary.
15. Return the valve chamber to position over the cylinder, making sure that gaskets (11) and cylinders (12) are properly positioned in the top and bottom recesses.
16. Tighten capscrews (10) alternately and evenly until the parts are snugly seated. Torque capscrews 20-25 ft/lbs (27-34 Nm).
17. ***Important*:** Clean buildup from cylinders. Submerge the cylinder in uncut

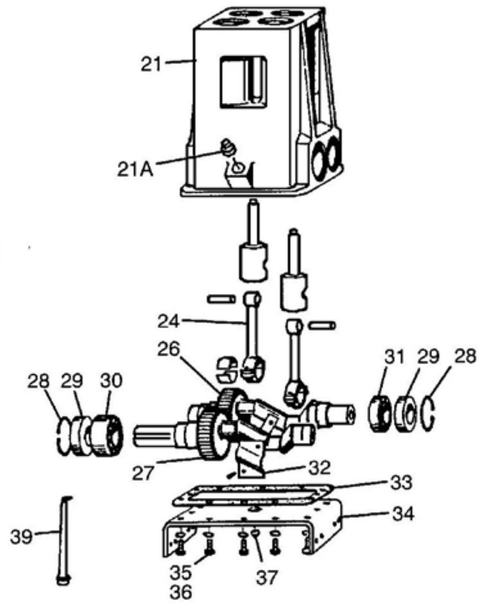
muriat acid (28% hydrochloric acid) for three (3) minutes, rinse in clear water, wash with strong soap, submerge in acid for two (2) more minutes, rinse in clear water and wipe off.

Servicing the Pump Valves

1. Remove the capscrew (1) and clamp bar (2) from the valve chamber (9) and lift out valve covers (3) with o-rings (4) attached.
2. Remove the discharge valve springs and disc assemblies (6) and valve cages (5).
3. Insert the round end of valve seat puller tool (39) through the opening at the center of the valve seats (7). Loosen the seats from the valve chamber (9) with a “rocking” motion of the tool.
4. Remove the valve seats from the recesses with the opposite end (curved end) of the puller tool (39).
5. Repeat the four preceding steps to remove the suction valve parts which are identical to the discharge valve parts and are located immediately “under” them in the valve chamber.
6. Clean ***all*** parts and ***inspect*** them. Replace all worn parts as needed. ***Note:*** Valve seats (7) may be used either side “up”, thus if one side shows wear, the opposite side may be used to provide a new seat.
7. With the o-ring (4) in place on each valve seat (7), place a few drops of light oil on the ring and seat and place each ***squarely*** in the bottom of the recess in the valve chamber.
8. Place the valve cages (5) on the valve seats (7) and the spring and disc assemblies (6) inside each cage.
9. Repeat steps (7) and (8) to install the “outer” discharge valve parts.
10. Place the valve covers (3), with o-rings on the ***bottom groove***, over each valve assembly.
11. Replace clamp bar (2) and capscrews (1), tightening capscrew (1) snugly only. ***Do not overtighten capscrew (1). Overtightening can damage valve parts***. Torque to 30 ft/lbs (40.6 Nm).

Servicing the Crankshaft

1. Remove pipe plug (37) and drain oil from pump case.



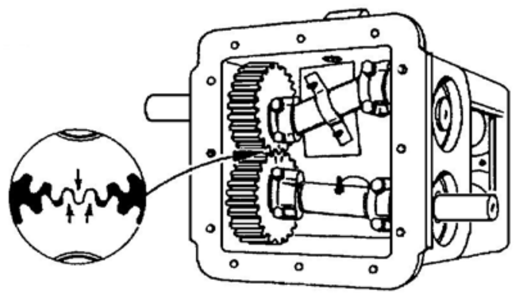
2. Disconnect piping and remove pump from mounting.
3. Remove capscrews (36), wave washers (35) and mounting base (34) carefully to protect the gasket (33).
4. Remove capscrews from the connecting rod assemblies (24). Use a center punch or other suitable instrument to mark caps and rods for proper rematching when they are reassembled.
5. Remove oil slingers (32) from the crankshafts (26) and (27).
6. Push the connecting rods and crosshead assemblies into the pump case to clear the crankshafts (26) and (27).
7. Remove the driven sheave from the crankshaft extension.
8. Remove the snap rings (28) from groove in pump case at outside of bearings (30 and 31).
9. Use a suitable wood block and hammer to tap against gear ends (outside) of each crankshaft to remove oil seals and bearings at opposite side of pump case. Crankshafts, with bearings at gear ends, may then be removed from bottom of case.

⚠ CAUTION

Never pound directly on bearings (31) when removing or replacing them

on the crankshaft.

10. A block of wood with a suitable sized opening or block supports to assure reasonable equal support around the bearing in a press is best for this important work.
11. After inspecting and replacing all the worn parts, press new bearings (if needed) against the shoulders on the crankshaft, then place the assembly through openings into the pump case.



12. ***Important: Timing the Pump*** - Arrows on gears must be located ***exactly*** as shown above to properly time the pump.
13. With the crankshaft and bearings assembly in place in the pump case, place the oil seals (29) carefully over the ends of the crankshaft with the “lip” of the seals facing the inside of the pump case. ***Care should be taken*** when passing seals over the crankcase to avoid folding the lip of the seal under or damaging the lip.
14. Set the snap rings (28) in the grooves in the bearing housings against the oil seals and tap the crankcase to allow a ***slight*** end play in the crankshaft.
15. Assemble the connecting rods and crossheads, being sure to rematch the rod and cap properly as marked when disassembled. Use 6-8 ft/lbs (8-11 Nm) torque on capscrews.
16. Complete the assembly by reversing steps (1) through (8), being sure to replace the drain plug (37).
17. Remove plug (21A) and fill the crankcase with clean SAE30 non detergent motor oil to the filler plug level. Clean and replace the filler plug.

Turn the pump a few revolutions by hand to be sure all parts are running freely before using the pump.

Servicing the Crossheads

1. Remove the valve chamber, the cylinders and the plunger packings as described in paragraph (1) and (2) of ***Servicing the Plunger Packings***.
2. Remove o-ring seal (17), backup washer (19) and the crosshead umbrellas (18) that are shown in figure 7-9-5.
3. Remove the mounting base and the connecting rods as described in paragraphs (1) through (4) of ***Servicing the Crankshaft***.

4. Turn the crankshaft by hand to allow removal of the crossheads through the pump case opening.
5. Reverse paragraphs (1) through (3) when reassembling the crossheads. Be sure that all parts are reassembled in their ***exact*** former positions.

Operation

1. Check the drain plug located on the bottom of the base to ensure that it is properly tightened.
2. Add clean SAE30 API service classification MM or better oil to the pump crankcase. Maintain oil at the filler plug level.
3. Inspect the pump to see that all nuts and screws are tight.
4. Turn the pump sheave by hand a few times to make sure the pump operates freely.
5. Start the pump and check its speed. After liquid transfer has been made, set the pressure gauge to the desired reading.
6. Since the power required to drive the pump varies directly with the pressure and the amount of fluid handled, it is recommended that the unit be operated according to specifications.

If the speed is increased excessively, there is danger of either overheating the bearings or causing cavitation in the fluid end of the pump.

If pressure is increased excessively, bearing life will be drastically reduced in addition to breakage of other parts.

Exceeding pump specification limits for either pressure or speed results in overloading the power source.

DIXON Boss 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:

1. ***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?

2. ***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?

3. ***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?

4. ***Media:***

   What is the media/material that is flowing through the hose assembly? Being specific is critical. Check for: Abrasive materials, chemical compatibility, etc.

5. ***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.

6. ***Ends:***

   What couplings have been requested by the user? Are they the proper fittings for the application and hose selected.

7. ***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.

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[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 (4 INCHES)

A - B = C C = 3 INCHES

TWO HOSE ENDS MEANS C X 2 = TOTAL COUPLING LENGTH

THEREFORE C X 2 = 6 INCHES OF TOTAL COUPLING LENGTH

LET E REPRESENT C X 2. THEN E = 6 INCHES (.5 FEET)

ALLOW F TO REPRESENT THE OVERALL LENGTH OF THE HOSE. THEN F = 50 FEET

SUBTRACT E FROM F TO GET THE OVERALL CUT LENGTH OF THE HOSE.

(50 FEET) - (.5 FEET) = 49.5 FEET CUT HOSE LENGTH

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

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) into 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 devises (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 devise 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.
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.

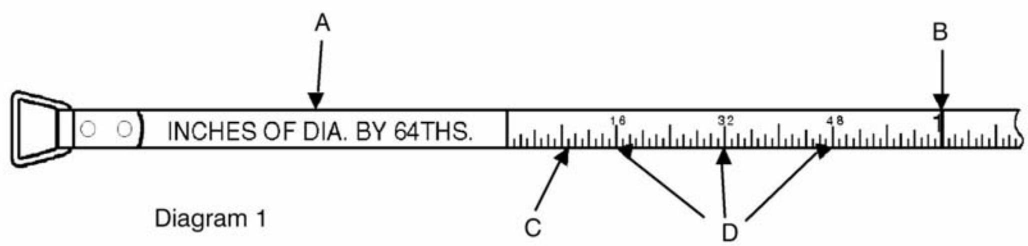


Diagram 1

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 mark* 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.

   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).

Diagram 2

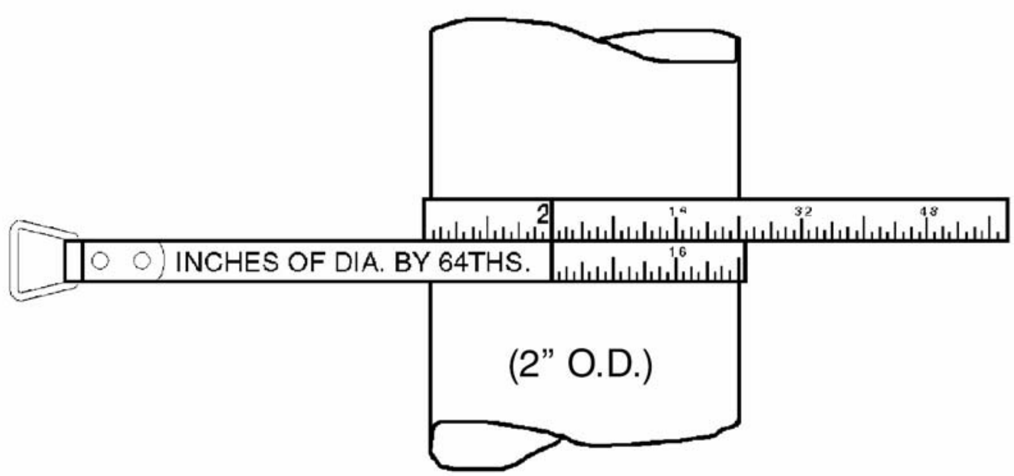


Diagram 3:

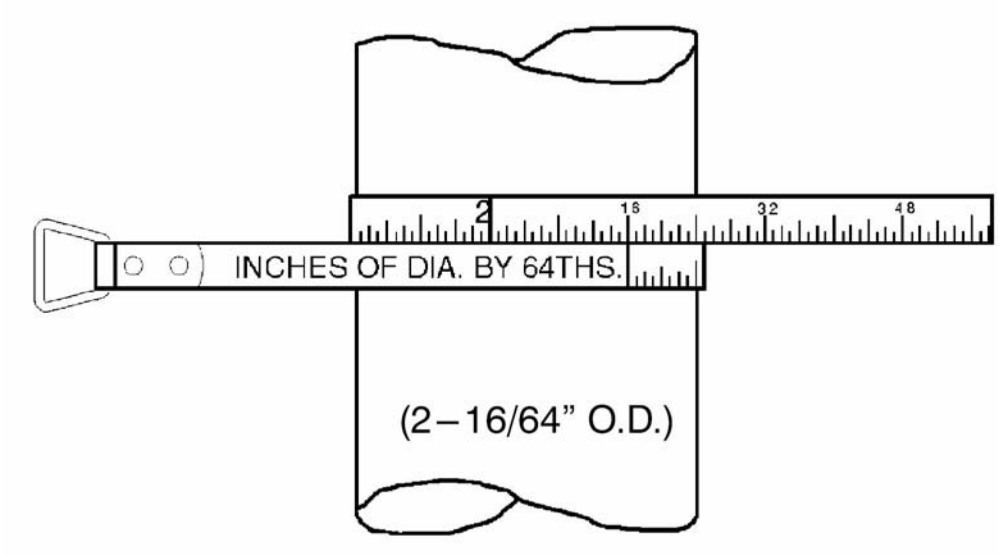
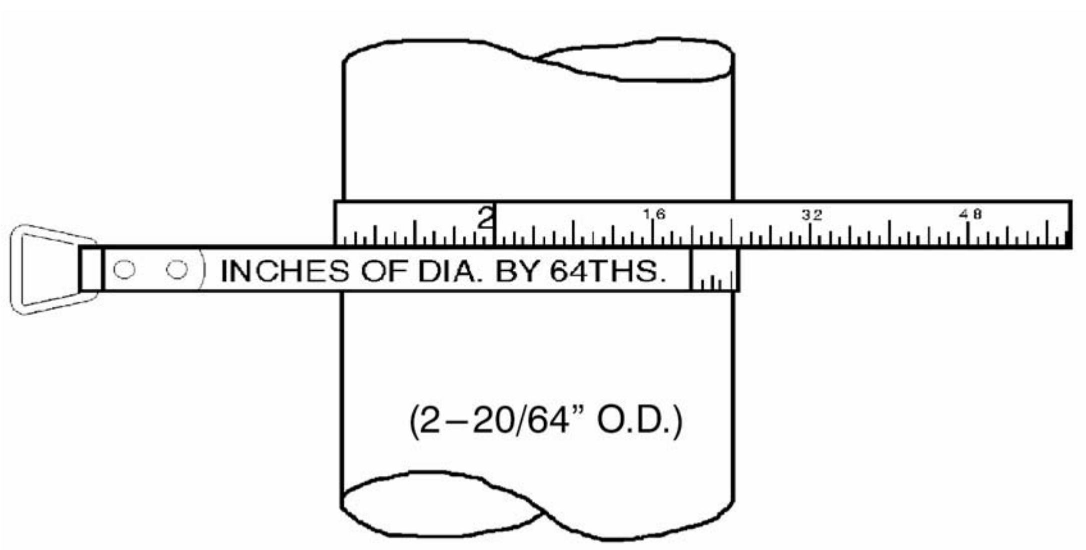


Diagram 4:



Note: It is a good practice to measure each hose end twice to ensure an accurate measurement.

BOSS CLAMPS

HOSE I.D.	HOSE O.D. FROM:	HOSE O.D. TO:	TORQUE	TYPE
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	

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

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 and cold cycles.
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 clam 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 procedures 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.

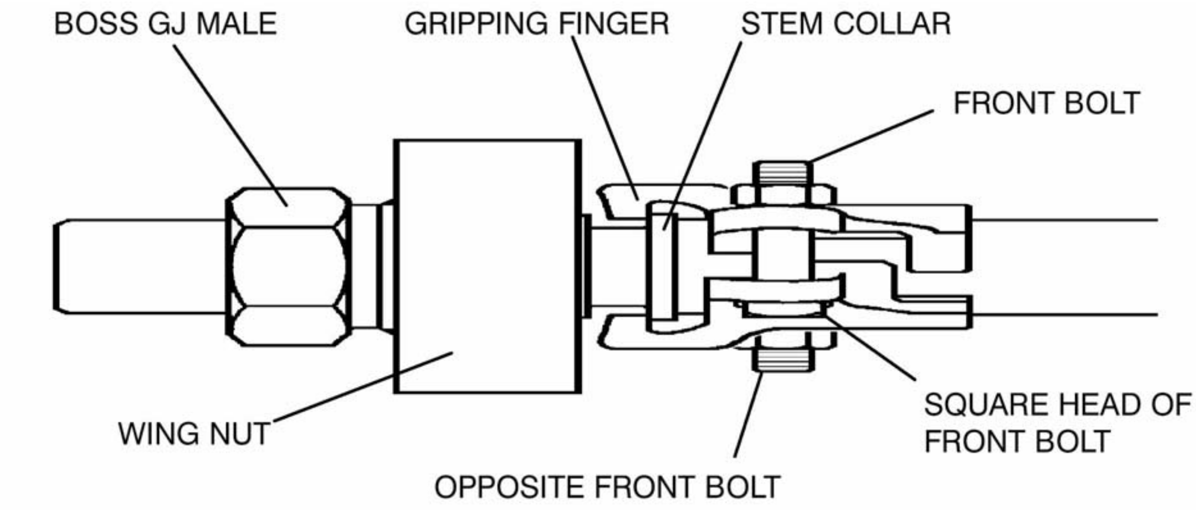
Minimum Range

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.

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

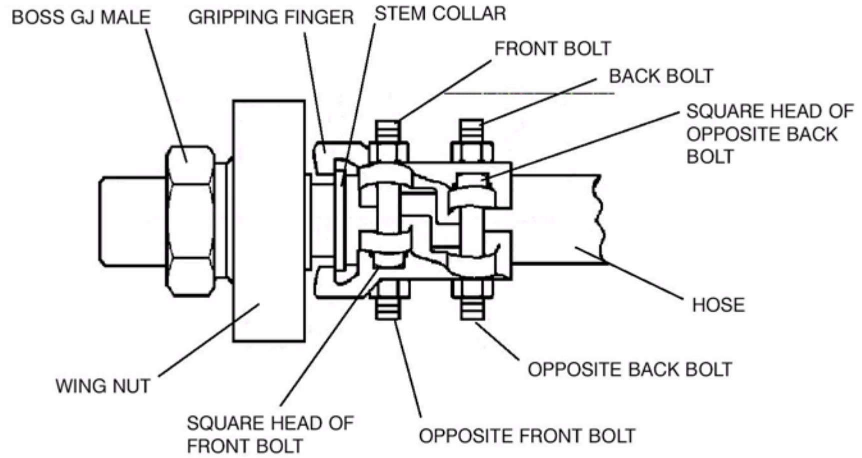
1. Prepare the hose. Refer to *GENERAL PREPARATION INSTRUCTIONS.*
2. Place the stem in a vise.
   a. For male stems, tighten the vise on the hex.
   b. For female stems (wing nut), place a spud in the vice, tighten and then thread the wing nut onto the spud.
3. Select the proper Boss Clamp. Refer to *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. 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 nuts and bolts) are for ***single use only! Once removed, discard.***

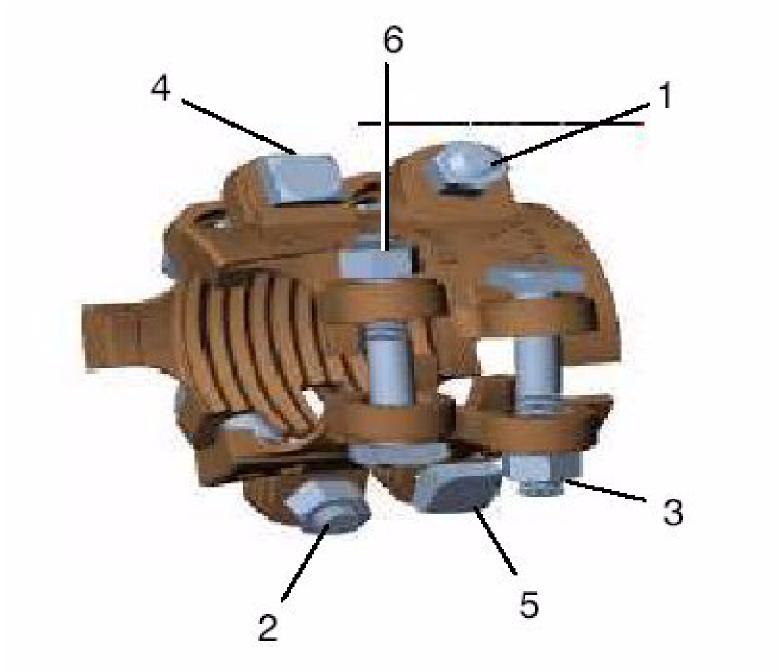
Process

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*.
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 steps **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*.
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.

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.

⚠ CAUTION

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 (W).

Always contact the hose manufacturer for instructions on the proper method and criteria for electrical continuity testing.

SECTION 8 - GLOSSARY

GLOSSARY OF 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.

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.

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

W_2C. 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.

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.

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 an 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.

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.

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.

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.

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.

~I~

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.

~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.

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.

~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.

Power Pack

he 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.

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.

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.

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.

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.

~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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