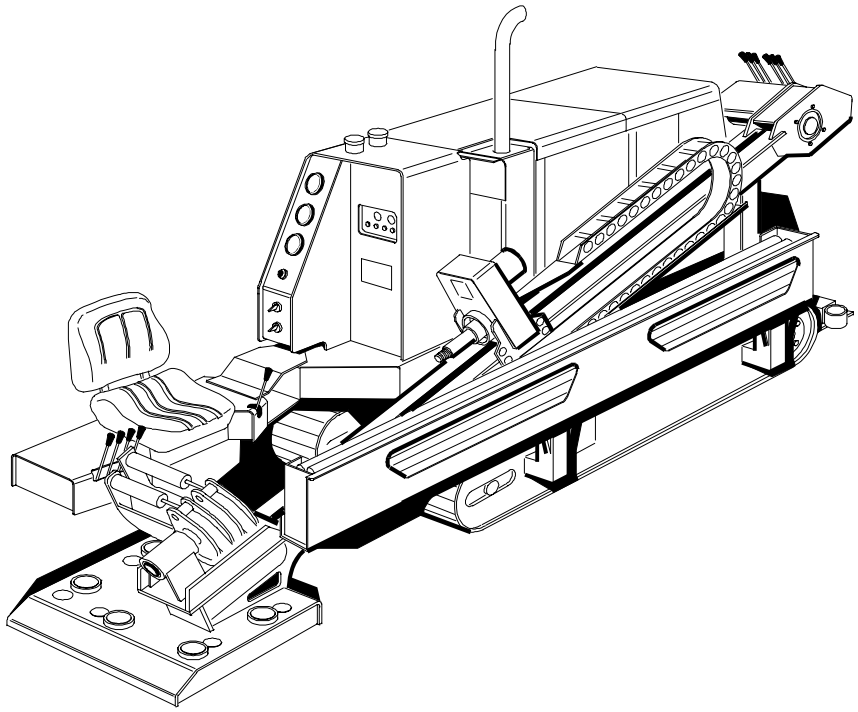
STRAIGHTLINE ®

1450 South Spencer Road • P.O. Box 388 • Newton, Kansas 67114
Phone: (316)-238-5511 • (800) 654-3484 • Fax: (316) 283-2738



StraightLine Horizontal Directional Drill

Model 910

Operator Manual

Table of Contents

Glossary

Anchor: System of plates, stakes, and pins that secures the drill rack to the ground.

Auger: Anchor pins which are screwed into the ground through holes in anchor plates.

Antifreeze System: Reservoir, plumbing, and control valves to allow antifreeze to be introduced to the fluid system when the boring system is idle during cold temperatures.

Backreamer: Tool used during pullback for enlarging pilot bore.

Bar: Measurement of pressure (metric).

Bentonite: Finely ground clay commonly mixed with water for drilling solution.

Bore Log: Drawing of the proposed bore path in plan view and side view showing entry, exit, depth, existing hazards, steering areas including curve radii, and other information.

Bore Path: Planned or actually traveled location of the drill head/string through the earth.

Breakout: Loosening a section of drill pipe prior to removing it from the drill string.

Breakout Wrenches: System of manually held or hydraulically powered friction wrenches for holding drill pipe from rotating when adding drill pipe. It is also used for loosening drill pipe joints when removing drill pipe.

Breakout Wrench: The rear most built-in drill pipe wrench which is hydraulically rotated and used when removing drill pipe sections when pulling back.

Carriage: Traveling unit which pushes and rotates the drill pipe.

Chain Bed: Wide surface on top of the drill frame on which the carriage travels.

Chocks: Wedges used to block wheels and tires so as to hold them into position.

Control Panel: Panel containing all gauges, hydraulic valves, switches and buttons required to operate the drill rack, and or power unit.

Cuttings: See **Returns**.

Cutting Teeth: Hardened cutting burrs, usually carbide, on drill heads and backreamers.

Down-Hole Equipment: Same as tooling.

Drive Chain: Large, heavy chain which drives carriage up and down chain bed.

Drill Head: Assembly of cutting bit, steering shoe, and transmitter housing.

Drill Pipe: Sections of high-strength steel pipe with threaded tool joints attached. Drill pipe is sized for length, diameter, and thread size for each model of Drill Rack.

Drill Pipe Cart: Two-wheeled cart used to store and transport drill pipe from trailer to drill rack.

Drill Rack: The mobile portion of the drilling system capable of rotating and pushing drill pipe into the soil.

Drilling Solution: The fluid mixture which is pumped out of the drill head to facilitate boring.

Drill String: Assembly of drill head and all attached drill pipe..

Equal Potential Mat: Large metal mesh mat on which operators stand during operation to give grounding protection in case of an electrical hit.

Filter Sub: Device between the drill head and the drill pipe which contains a mesh strainer to prevent lumps of material in the drilling fluid from clogging fluid jets.

Feathering: To meter or regulate the speed of a function by precisely controlling the movement of the control valve lever.

GPM: Abbreviation of gallons per minute, a measure of liquid flow rate.

Ground Rod: Copper/Brass rod which is hand driven into the ground to give grounding protection in case of electrical hit.

Ground Rod/Mat Cables: Cables which attach drill rack main frame to equal potential mats and rod.

Jets: Replaceable fluid outlets found in both drill heads and backreamers.

kPA: Abbreviation of Kilopascals, a measure of pressure.

Locate: 1) The operation of using the locator to determine drill head position. 2) The identification of existing underground utilities and hazards done by the utility service company. 3) The hazards identified are commonly referred to as “Locates” and the process of marking the hazards is commonly referred to as “Doing locates”.

Locator: 1) The hand-held receiving portion of the radio detection equipment. 2) The person using the locator equipment.

LPM: Abbreviation of liters per minute, a measure of liquid flow rate.

Makeup: Adding a new section of drill pipe to the in-use drill string.

Makeup Wrench: The forward-most built-in drill pipe wrench on the drill rack used in both adding and removing drill pipe sections.

Marsh Funnel: A viscosity measuring device used to evaluate drilling fluid.

Meggar: Instrument which measures the conductivity of the grounding system.

Mud Mixer: Gasoline engine, or hydraulic, powered recirculation pump which allows drilling fluid additives to be added and thoroughly mixed.

Packed Off: Underground condition in which the material being pulled back becomes jammed due to the tunnel collapsing or the insufficient flow of the drilling fluid/cuttings packing the returns between the material and the tunnel wall.

pH Scale: Index which indicates acidity of a liquid.

Pilot Bore: Process of guiding the drill string to a specific location, according to the planned bore path.

Polymer: Chemical added to water or bentonite mixture used as drilling solution.

Pull Back: Operation of pulling the material being installed into the finished bore path, usually combined with the backreaming operation.

PSI: Abbreviation of pounds per square inch, a measure of pressure.

Pushing: Thrusting the drill string without rotation to change the direction of the pilot bore.

Ramp: Moveable tailgate which lowers to provide an inclined ramp for loading and unloading drill rack.

Returns: The loose material dislodged when boring or backreaming, usually mixed with drilling solution. Sometimes known as cuttings.

Rotation: Rotating the drill string to give a straight pilot bore.

Rotation Motor: Hydraulic motor located in the carriage which rotates the drill string.

Sonde: See Transmitter.

Stake: Headed steel pins which are driven into the ground through holes in anchor plates.

Stakedown Plates: Earth contact plates through which the anchors are driven.

Steering Shoe: Replaceable shoe on the drill head, mounted at an angle which causes the drill string to veer when being pushed without being rotated.

Strike Alert: Alarm system which indicates the presence of electrical current in the drill string.

Sub saver: Replaceable connector through which the drill pipe is attached to the carriage.

Swivel: Device at the end of the drill string during backreaming/pullback operations which prevents material being installed from twisting.

Thrust: Force used in moving the carriage and drill string linearly, measured in pounds.

Thrust Motor: Hydraulic motor located at the back of the main frame which powers the chain that draws the carriage up or down the chain bed.

Tooling: Drill string, boring, backreaming, and pulling equipment.

Torque: Force used in rotating the drill string, measured in ft.-lbs.

Tracking: Marking the path of the drill head as it advances down the bore path.

Tramming: Using the tracks to move the drill rack**.**

Transmitter: Radio transmitting device which is placed inside drill head necessary for accurate locating.

Umbilical: Hydraulic hoses and Electrical cables connecting the drill rack to the trailer.

Utility: 1) The existing electrical, gas, water, etc. service at the bore site and the company that either owns or operates them as in: "Utility hit" or "Having the utility company do the 'Locates'". 2) The material which is being pulled into the backreamed, pilot bored tunnel, as in: "Installing or pulling the utility".

Viscosity: Measure of fluid thickness, measured in seconds. Sometimes expressed as weight.

Water Swivel: Fluid elbow at of the carriage which connects the drilling fluid to the drill pipe.

Water Pump: Hydraulically driven high-pressure pump which pumps the drilling fluid.

Water Tank: Large reservoir which holds the fluids used in drilling.

Wiper: Flexible device mounted on the front of the main frame, installed around the drill pipe as it is being pulled back to help remove mud and debris.

Yield: Change in physical properties of bentonite clay when added to water which allows the particles to remain suspended in solution.

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Chapter 1

Safety

The StraightLine 910 is a powerful tool. Use and maintain it with respect and caution. Your safety and the safety of other persons in the work area are dependent on the proper operation of this machine. The information in this manual is intended to assist you in operating this machine according to established procedures but does not replace any safety rules and laws used in your area.

This safety alert symbol means SAFETY ALERT! This symbol is used both on the machine and in this manual to alert the operator that the message following the symbol concerns safety. Carefully read the message and make sure you understand the causes of possible injury or death.

The safety alert symbol will be used with these words:

⚠ **DANGER** Indicates an imminently hazardous situation which will result in death or serious injury unless avoided.

⚠ **WARNING** Indicates a potentially hazardous situation which could result in death or serious injury unless avoided.

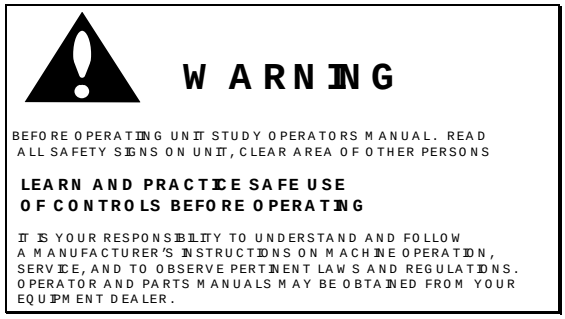
⚠ **CAUTION** Indicates a potential hazardous situation which may result in minor or moderate injury if not avoided.

Other important information which can help you do a better job, simplify maintenance, or prevent an unsafe situation will be emphasized by the word **IMPORTANT:** followed by an instruction or information.

Operator Qualifications and Training

⚠ **WARNING**

Read this manual carefully before using the Boring System. Consult your StraightLine Dealer or Factory Representative for field instruction advice.



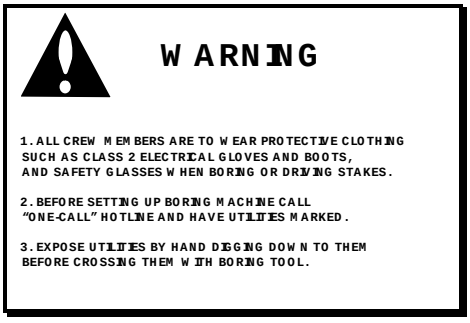
Initial training shall be done at a non-hazardous site such as an open field, free of utility easements. Training shall include the proper use of safety, protective, and locating equipment.

Operator Safety

⚠ **WARNING** Always wear O.S.H.A. approved head gear (not provided) when operating at or near drill rack.

Always wear safety glasses (provided) O.S.H.A. approved safety goggles (not provided) to prevent eye injury.

Always wear the three (3) glove protection system (provided) to guard against electrical shock. Always wear the electrical protection boots (provided) to guard against the possibility of electrical shock caused by the drill pipe contacting an underground utility.



Machine Safety

⚠ **DANGER** Turning shaft can crush arms or legs. DO NOT TOUCH DRILL STEM WHILE ROTATING. Do not wear jewelry, rings, watches or loose clothing when operating drill rack as these items may catch resulting in possible serious injury or death.

⚠ **WARNING** Moving parts can cut off hands, feet, or fingers. DO NOT TOUCH MOVING PARTS.

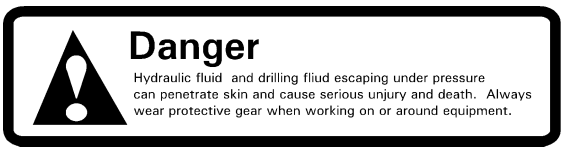
⚠ **WARNING** Pinch points can crush hands or fingers. KEEP YOUR HANDS AWAY FROM MOVING MACHINERY AND PINCH POINTS.

IMPORTANT Clear all persons and tools from around the drill pipe before starting power supply and then keep bystanders at least 10 ft (3 m) away from turning drill shaft. Do not stand over trench or drill pipe while boring.

IMPORTANT: During pullback operations, material being installed may rotate if swivel malfunctions. Keep all persons away from material being installed.

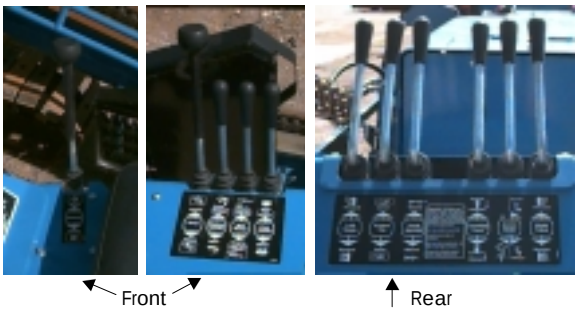
⚠ **DANGER** POISON! Hydraulic oil under pressure can penetrate the skin and burn or cause blood poisoning. Use a piece of cardboard to check for leaks, NOT YOUR HAND! Before disconnecting any lines, relieve system pressure. Before pressuring up system, be sure all connections are tight and lines, pipes and hoses are NOT damaged. Oil escaping from a very small hole can be almost invisible.

Wear protective clothing and eye protection. If you are injured by pressurized hydraulic fluid, get IMMEDIATE MEDICAL ATTENTION FROM A DOCTOR FAMILIAR WITH THIS TYPE OF INJURY.



Always make sure that any guards or safety plates are intact and installed properly to insure safe operation.

⚠ **WARNING DO NOT ALTER CONTROLS**! Do not tie down controls. If releasing a control lever does not cause the motion being controlled to stop, shut down power source using the EMERGENCY STOP button and get the unit repaired immediately.



⚠ **WARNING** Crushing weight. The boring machinery, tools and equipment are heavy and if moved or operated in an unsafe manner can tip over or fall, killing or crushing you.

IMPORTANT: Maintain control of Drill Rack at all times during transport. Have enough manpower or arrange mechanical means (such as a winch) available to prevent rollover and injury. Be particularly aware of tipover hazards when operating on slopes, curbs, uneven or soft ground.

⚠ **WARNING** Anchor drill rack properly before rotating drill pipe. Failure to properly stake down drill rack can result in drill rack tipover which can crush and kill the operator.

⚠ **WARNING** Fire or explosion possible. Fuel and fumes can catch fire or explode and cause serious burns or death.

⚠ **WARNING** Electrical shock possible. Do not operate the equipment when lightening is possible. Serious injury or death may result.

⚠ **CAUTION** Slips and falls possible. Do not step in any spilled material (drilling fluid, hydraulic oil, etc.). Falling on slippery surfaces may cause serious personal injury.

⚠ **CAUTION** Read and understand the Safety and Operation Manual for the Stake Driver. You must use proper safety equipment when operating the Driver. The BR 67 Driver vibration is rated at 20m/sec^2 with a noise rating level of 106 dB (A).

IMPORTANT: Adequate lighting must be provided when operation of this unit occurs beyond daylight hours.

Jobsite Safety

Place jobsite pedestrian and traffic warning barriers in accordance with Federal, State, and Local Regulations. If jobsite workers are exposed to traffic hazards, wear high-visibility safety vests and other protective clothing required by Federal, State and Local regulations.

⚠ **WARNING Call your one-call Hotline!** Know and comply with regulations covering One-Call service or utility notification before beginning any boring operation including drill rack stake-down. Notify any utilities "One-Call Hotline" does not represent in your area.

⚠ **DANGER** Always use the equal potential mats provided with your unit when setting up a jobsite, in preparation of a boring operation. Grid mats are subject to wear. Inspect them each time they are used and replace them as required.

⚠ **DANGER** Overhead lines. Contacting overhead lines while handling drill pipe may cause death. Know the location of overhead lines and use extreme caution if any are near!

⚠ **DANGER** Buried underground hazards:

- Electrical power
- Cables, fluid, and gas carrying pipes
- Fiber optic cables

Electrical hits can cause electrocution, pipe hits can cause fire, explosion, asphyxiation or toxic gas or liquid release, and fiber optic cables carry laser-light signals which can cause eye damage.

Jobsite Inspection And Briefing

Take the time to thoroughly check the entire work site yourself for indications of underground hazards. Be alert for "warning signs" such as:

- Notices of buried utilities
- Absence of overhead lines near facilities that logically use utilities
- Gas meters
- Water meters
- Junction boxes
- Manhole covers
- Evidence of previous excavation such as "settled" spots

Use utility locating devices throughout your bore area. Remember they are not perfect- even with an experienced operator. Before crossing an underground utility, carefully hand dig to expose it.

Hold a briefing for all authorized worksite personnel prior to beginning operations. The briefing should include:

- Who is in charge
- Location and type of buried obstructions, services
- Job site security, warning signs, barriers, identify authorized personnel
- Safety considerations associated with operation of the drilling unit, personal protective equipment, clothing, emergency procedures, and emergency telephone numbers

Operating Safety

Use 2-way radio contact between the drill rack operator and the locator to coordinate the boring operation. Have pre-arranged backup hand signals in case the radios fail or cannot be used.

⚠ **WARNING** **Do not** trust locating instruments when crossing or boring close to hazardous services. Expose hazardous utilities by careful hand-digging.

Do not trust locating done previously.

Do not hesitate to contact utilities to shut down services for the duration of the job if there is doubt to location of underground hazards.

Be alert to any change from normal during a boring job.

- **LOOK** for leaks, loose connectors, loosening anchors, changes to drilling fluids, problems with tools or drill pipe, or other equipment.

- **LISTEN** for unexpected engine lugging, bearing noises, high pressure squeals and any unexpected or unusual rattles, knocks, screeches, or any change to the normal operating noises.

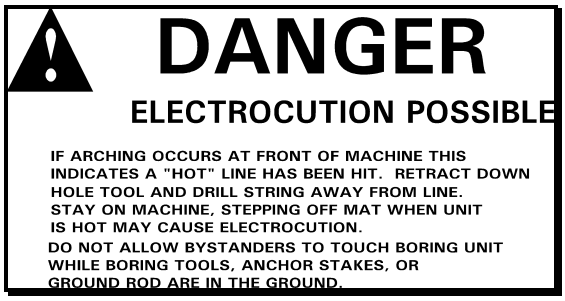
- **SMELL** for unusual odors such as hot oil, burning insulation, natural gas, etc.

- **FEEL** for changes in the resistance to thrust or rotation during boring or any changes to how the equipment is operating.

- **STOP** and correct anything you see, hear, smell, or feel that is potentially unsafe.

Emergency Procedures For Hits

⚠ **DANGER** Electrocution Possible.
Unprotected bystanders could be electrocuted if in contact with any part of the boring equipment, including the mudskid, if a “hot” line is hit.



Do not let anyone touch the unit while boring. All persons who come in contact with the boring equipment should always wear protective clothing such as Class 2 electrical gloves and boots while boring.

BE ALERT! Hitting a “hot” line may be indicated by arcing at the front of the drill rack; a warning on a strike alert device, nearby power outage; smoke, explosion, arcing, etc. on or around nearby electrical transformers and equipment; or nothing at all. Most electrical strikes are not immediately noticeable but are still potentially lethal.

Electrical Hits

If an electrical hit occurs, do not panic.

If you are on the machine, stay on the machine.

If you are standing on the ground, stay where you are and don’t touch any equipment.

Stepping off a well-grounded equal potential mat may cause electrocution. If you are off the equipment, remain still and stay off the equipment.

Warn everybody in the area that an electrical strike has occurred and to stay away from the mudskid, drill rack, or any other equipment in the area.

If the operator is on the mat or otherwise in contact with the drill rack, he should retract the downhole tool and drill pipe away from the line. Pull back the carriage to the top of the rack to attempt to disengage from the electrical contact.

⚠ **WARNING** Do not try to disconnect a drill pipe or joint until electrical power is shut down. Do not rely on electrical circuit breakers as power can be rerouted and circuit breakers can be reset.

Contact the utility company immediately so they can shut off power and arrange repairs.

Gas Or Liquid Line Hits

⚠ **DANGER Explosion Possible.** If a gas or volatile liquid line hit occurs, immediately shut down any power sources such as generators, hydraulic power packs, or vehicles and leave the area. If the power sources cannot readily be shut down, leave the area immediately!

Contact the utility company immediately and warn people in the area. Do not return to the area until given permission by the utility company.

Fiber Optic Cable Hits

⚠ **CAUTION Do not** look into the severed ends of the cable! Laser light will cause permanent eye damage or blindness. If you do not know what kind of cable you have cut, do not look into the ends in case it is a fiber optic cable.

Safety Summary

Be Aware

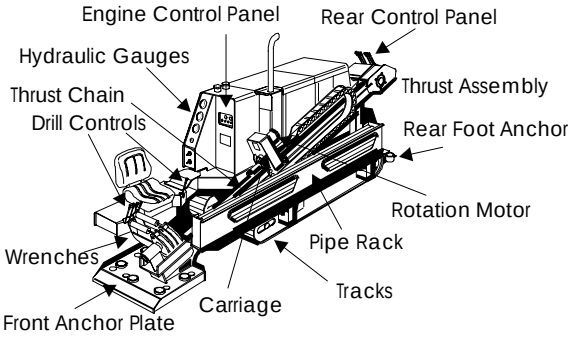
Safety is important. Safety precautions and safe operation habits must be the principal consideration before you begin work and continue throughout the job. You should be aware of all hazards overhead, on the surface, and underground before unloading the drill rack from the trailer.

Be Prepared

Take the necessary precautions to protect personnel and bystanders in case of an inadvertent utility hit before anything is driven into the ground. This includes wearing of personal protective equipment, proper jobsite security, and proper training of all jobsite workers.

The most important safety consideration is a well trained crew. Using the proper equipment, the proper tools, in the proper manner on a well planned and well prepared boring job is the best safety policy.

Equipment Information



This chapter describes the location, function, and operation of the 910 controls and components.

Read carefully and adhere to all notices, warnings, danger decals, and callouts. If you have any questions regarding this equipment or it's operation, contact your StraightLine Dealer or factory representative for further information.

Engine Control Panel

The Engine control panel located behind the operator's seat contains the controls and warning indicators for the Hatz engine. See the engine instruction book for complete safety and operation details of the engine.

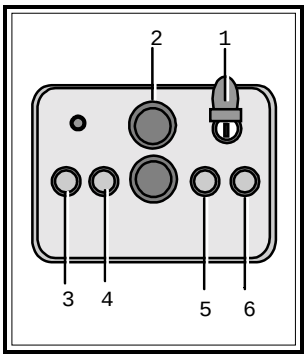
1. *Ignition Switch:* This switch has four positions to control the operation of the engine.

Off (O) In this position the unit is off, the fuel control solenoid is in the "Kill" position, the electrical system is disconnected and the key may be removed.

On (I) Rotate the key one position clockwise. The on position connects electrical system, the indicator lamps for charging control and oil pressure will light up.

Preheat (II) Rotate the key two positions past off and this connects the cold start preheat (glow plug) circuit. When the temperature is below 40° pre-glow approximately 1-2 min. the glow indicator should be visually red.

Start (III) Rotate the key three positions past off and this engages the starter. Do not crank the engine for longer than 20 seconds at a time.



2. Preheat Glow Indicator: This shows that the circuit is preheating properly.

3. Throttle Fuse: This is a 7.5 amp fuse used to protect the throttle circuit

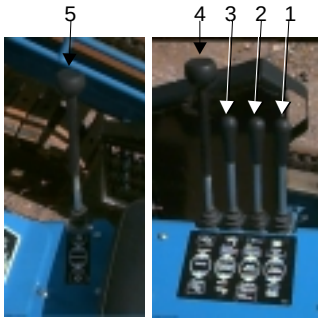
4. Oil Pressure Light: This light will turn on if the engine is not able to maintain proper oil pressure.

5. Alternator Charge Light: This light will turn on if the alternator is not able to maintain proper current output.

6. Air Filter Light: This light will turn on if the air filter becomes restricted.

Drill Controls

1. Makeup Wrench Lever: This lever controls the makeup (front) wrench.



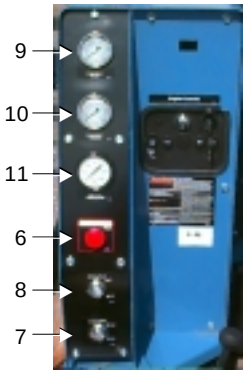
Push to extend the makeup wrench cylinder which will lock the drill string against reverse rotation.

2. Breakout Wrench Lever: **(rear wrench) Push to extend the breakout wrench cylinder which will lock the drill pipe against reverse rotation.**
Pull to retract the makeup wrench cylinder which will lock the drill string against forward rotation.

3. Breakout Cylinder Lever: Push to move Breakout Cylinder up (breakout). Pull to move Breakout Cylinder down (makeup)

4. Thrust Lever: **Push to move carriage to back (pullback) and pull to move carriage to front (thrust).**

5. Rotation Lever: Push to rotate saversub in reverse (counter-clockwise) and pull to rotate saver sub in forward (clockwise).



6. Emergency Shut Down Switch: Twist and pull out to run. Push in to stop.

7. Throttle Switch: Rotate up to run engine at high idle and Rotate down to run engine at low idle.

8. Drilling Fluid Switch: Toggle up to pump and Rotate down to stop pumping.

9. Thrust Gauge: Indicates hydraulic pressure in the circuit which is pressurized when in Thrust mode. Indicated pressure should never exceed 3,000 PSI (207 Bar).

10. Rotation Gauge: Indicates hydraulic pressure in the circuit which is pressurized when in the Forward Rotation mode. Indicated pressure should never exceed 2900 PSI (200 Bar).

11. Drilling Fluid Gauge: Indicates pressure of the drilling fluid in the drill string and drilling fluid umbilical hose. Indicated pressure should never exceed 950 PSI (65 Bar).

Strike Alert

The strike alert is designed with special electronic filters to sense 60 hertz AC electrical power. It uses a red light and siren to alert the operator of current flowing through the grounding cable. The strike alert consists of an enclosure containing the electronic sensing components, the controls mounted on the face of the enclosure, grounding cables, a six foot long ground rod, and an equal potential mat. The Strike Alert operates with 12VDC electrical power provided by the drilling unit.

Verify that the front panel switch is in the “armed” position and the green light is illuminated before driving anchor stakes or drilling. If an electrical utility hit is experienced, the red light and siren will activate and must be reset by switching the front panel switch to the “off” position then back to the “armed” position.

The current sensitivity selector has three positions.

- The .02A position is the most sensitive selection. This position begins sensing at .017A (17mA)
- The .2A position represents a reduction in current sensitivity which begins sensing at .17A (170mA)
- The .50 position is the least sensitive position and begins sensing a .47A (470mA)

IMPORTANT: The front panel switch must be returned to the “OFF” position prior to switching between the sensitivity levels to avoid possible false triggering.

Rear Controls

1. *Left Hand Track Lever:* Push lever forward to mobile left track forward and pull lever back to mobile left track in reverse.

2. *Tilt Lever:* Push lever forward to lower the angle of the drill frame Pull lever back to raise the angle of the drill frame.

3. *Track Spread Lever:* Push lever forward to move tracks to the narrow position, and pull lever back to move tracks to the wide position. Warning: Damage

will result if tracks are moved in or out while tracks are on the ground.

4. Rear Anchor Foot Lever: Pull up to extend leveling foot cylinder and raise the rear of the unit, push down to retract the leveling foot to lower the unit.

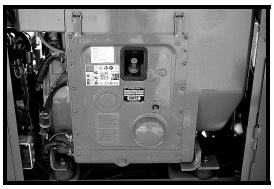
5. *Auxiliary Hydraulic Circuit Lever:* Pull to turn on power, push to turn off power to the auxiliary hydraulic circuit.

6. *Right Hand Track Lever:* Push lever forward to mobile right track forward and pull lever back to mobile right track in reverse.

Fluid Level/Condition Indicators

Hydraulic Fluid: Hydraulic oil level is shown by a sight glass on the side of the hydraulic oil reservoir located at the rear of the unit. The proper level is the mid point between high and low when the oil is cold.

Hydraulic Oil Sight Gauge



Engine Oil Dip Stick

Engine Oil: Engine oil level is shown by a dipstick located on the side of the engine behind the engine enclosure door. Check daily.

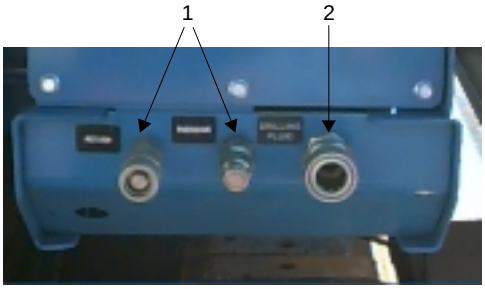
Engine Fuel: Diesel fuel tank level is shown by a gauge located in fuel tank at the rear of the unit.

Hydraulic Oil Filter Condition: The hydraulic filter in the oil reservoir is equipped with a filter condition gauge. If this gauge reads in the red when the engine is running at high speed and the oil temperature is above 70°F (21°C), the filter should be changed.

Umbilical Connections

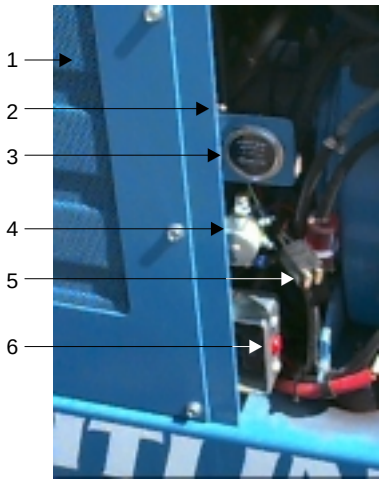
1. Auxiliary Hydraulic Circuit: Two non-spill quick couplers at the rear of the unit provide a hydraulic circuit for after market hydraulic equipment.

2. *Drilling Fluid:* The drilling fluid supply hose is connected to the drill rack with a brass quick coupler. It is not equipped with a check valve to simplify drainage and cleaning.



Engine Compartment

1. *Hydraulic Oil Cooler:* This unit is equipped with an electrically powered and controlled oil cooler. This is an automatic system, the thermostat is set to turn on the cooling system when the oil temperature reaches 120°F (49°C).



2. *Override Switch:* This switch will override the automatic thermostat on the oil cooler. Toggle this switch up to manually turn on the cooler fans. Toggle this switch down for automatic operation.

3. *Hour meter:* This indicates the run time on the unit.

4. *Relay:* This relay controls the power to the cooler fan motors.

5. *25 Amp Fuses:* Each fan motor is protected by a 25 Amp fuse.

6. *40 Amp Circuit Breaker*: This Breaker protects the power circuit to the cooling fan motors.

Important: The Hatz engine is air cooled. Do not run the engine unless all engine cowling is in place.

Battery

The unit is equipped with a 12v 700 cold cranking amp battery.

Anchor Driver

This device is a hydraulically driven component to drive the anchor stakes. It connects to the unit through umbilical connections at the rear of the unit. When properly connected, squeeze the trigger to start the Driver, release the trigger to stop.

Stake Puller

This device is used in conjunction with the anchor driver/puller lever located at the rear control panel. It connects to the unit through the same umbilical connections as the driver at the rear of the unit. When properly connected, push the valve lever to extend the anchor puller and pull the valve lever to retract the anchor puller.

Chapter 3

Planning the Bore

Information

Successful bores begin well before the first pipe goes in the ground. Find and review any existing information already available about the job and jobsite. The basics include length, depth, and obstacles for the planned bore.

♦Job Plan: Check for information on existing or planned structures, and their elevations. Check for any proposed work that may be taking place. If possible, review their plans or documentation of the jobsite. Contact local authorities about safety procedures and regulations.

♦Pullback Material: Verify the material you will be pulling back, its bend radius, weight and stiffness.

♦One-Call Services: Call area One-Call or similar services and have existing lines located and marked. Call any utilities in your area that do not subscribe to One-Call.

♦Traffic Control: Contact local authorities about safety procedures and regulations, when working near a road or other traffic area.

♦Emergency Services: Find the telephone numbers for local emergency and medical facilities at hand. Develop an emergency action plan including telephone locations and backup.

Site Inspection

Inspect jobsite before transporting equipment**.** Check for the following**:**

- Identify Hazards

⚠ **Warning:** Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.

- Signs of Utilities (See “Safety” section)
- Observe and comply with any jobsite notices
- Survey the job site for changes in elevation
- Identify obstacles such as buildings, roads, streams, railroads tracks, and the like.
- Access
- Traffic
- Soil type and condition
- Water supply
- Sources of locator interference power lines, railroad tracks, etc.)

Plan the Bore Path

The bore path must be planned before boring begins, from entry to exit. The bore path can be marked on the ground with spray paint or flags, or written on paper for operator reference.

The lay out of the bore path must consider depth of the bore, recommended steering limits, entry grade, and set-back distance. The entry and exit points can be marked once the desired depth and set back distances are determined.

Depth: Generally, the conditions found on the jobsite will determine the depth of the bore**.** To reduce depth, reduce entry angle. To increase depth, increase entry angle and set-back. Also consider the selection of the transmitter.

Steering limits: The 910 has a minimum bend radius of 113 feet. This translates to no more that a 4.5% change in grade in one length of drill pipe on a vertical steer, or 113 feet of forward distance (not 113 feet of pipe) to make a 90 degree turn.

Important: “Over-steering” or bending the pipe more sharply than recommended limits will damage and shorten the life of the pipe. This damage is not always visible. Repeated abuse of the steering limits will result in bent or broken pipe that may make recovery of the drill head, transmitter, backreamer or utility difficult or impossible.

Entry Angle: This is angle of the boring unit as compared to the angle of ground A shallow entry angle allows you to reach horizontal sooner and with less bending. Increasing entry angle makes bore path longer and deeper.

Set-back distance: This is the distance from entry to where the pipe will run horizontal. If set-back distance is too is too short, the steering limits will be exceeded and pipe can be damaged.

Traffic: Vehicle and pedestrian traffic must be a safe distance from boring equipment. Allow at least 10' (3m) buffer zone around equipment.

Slope: Fluid system should be parked on a level site. Consider how slope will affect boring unit set-up, bending pipe and fluid flow out of hole.

Evaluate The Soil Conditions

Soil conditions include (but not limited to) compactability, moisture content, porosity, stickiness, presence of rocks, and underground water formations. These conditions can be determined by several methods. These methods escalate in complexity ranging from simply inquiring about underground experience in the area, to inspection of local open-cut excavations, to hand digging, and ultimately to core sample drilling with geologic evaluation.

Select the Tooling

The selection of tooling depends on the soil conditions at the job site and the material to be installed.

Select The Drilling Fluid

The selection and mixture of drilling fluid also depends on the soil at the job site and the material to be installed.

CheckList

Use the check list on the following page as a guide to plan your bore.

Planning the Bore Checklist

Brief the Crew

- ❑ Survey the job site, locate and mark all underground utilities
- ❑ Brief the crew on all known hazards
- ❑ Expose all proposed crossings
- ❑ Plan the pilot bore, confirm that a bore log is at hand, and mark the proposed bore path
- ❑ Assign adequate manpower where needed
- ❑ Confirm emergency procedures, and access to emergency phones and numbers
- ❑ Location of all safety barriers and the appropriate precautions to secure the jobsite and equipment.
- ❑ Confirm that the crew has and wears appropriate safety gear.

Supplies:

- ❑ Receiver/locator with charged batteries
- ❑ Transmitter and spare batteries
- ❑ Two way radios and spare batteries
- ❑ Wrenches and spare cogs
- ❑ Anchoring equipment and accessories
- ❑ Allen bolts and wrenches
- ❑ Bits, filters, jets
- ❑ Adapters, pipe, transmitter head
- ❑ Marking flags, paint
- ❑ Water and additional hoses
- ❑ Bentonite/polymer
- ❑ Spare Fuses
- ❑ Keys
- ❑ Tooling, Backreamers, swivels, pulling devices
- ❑ Wash wand and hose
- ❑ Duct tape
- ❑ Spray lubricant
- ❑ Joint compound and brush
- ❑ Notepad and pencil

Equipment

- ❑ Fuel
- ❑ Hydraulic fluid
- ❑ Engine oil
- ❑ Battery
- ❑ Lube points
- ❑ Thrust chain
- ❑ Filters (air, oil, hydraulic)
- ❑ Fluid pump
- ❑ Couplers
- ❑ Tracks
- ❑ Mud mixer
- ❑ Hoses and valves
- ❑ Fluid solenoid
- ❑ Water tanks
- ❑ Wrenches/cogs
- ❑ Equal potential mats and cables in good condition

Chapter 4

Setup at the Job Site

Upon arrival at the job site, park the trailer on a level area that is close enough to where the drill rack will be anchored to allow the umbilicals to be easily connected. Use wheel chocks and the tongue jack to prevent the trailer from unexpectedly moving before starting to unload the drill rack. When the trailer has been securely parked, then the safety barriers, traffic cones, hazard lights, etc. around the trailer should be erected and activated to prevent non-authorized personnel from coming in contact with the equipment.

Unload The Drill Rack

⚠ **WARNING** Crushing Weight, if moved or operated in an unsafe manner this equipment can crush operators or bystanders.

Refer to the equipment information (Chapter 2) to identify and operate the controls of the unit. If the ramp on your trailer is wide enough, spread the tracks before you unload the unit. Start the engine, raise the rear of the unit with rear foot control and raise the front of the unit with the tilt control then spread the tracks with the Track Spread control valve. Carefully tram the drill rack off the trailer and to the bore entry location. Maintain control of the drill rack at all times.

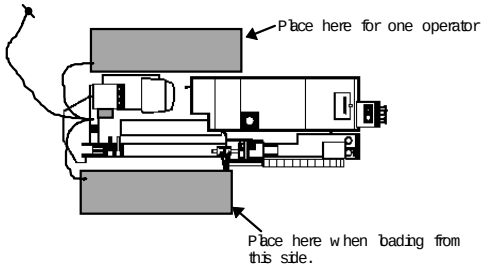
Position The Drill Rack

If drill rack must be moved across or along a slope, always lift the unit off the ground and spread the tracks to prevent accidental rollover of the unit. If the drill rack position is on uneven terrain, such as an embankment, the setback between the drill rack and the entry point should be adjusted to compensate for the change in the geometry. If set up on an incline is unavoidable, do not exceed a maximum incline of 30º to maintain proper engine lubrication. If necessary, start the engine and position the drill rack for the desired drill pipe entry angle with the level foot and the tilt control. When finished shut the engine off.

Setup the Strike Alert

⚠ **WARNING** The Strike Alert system indicates only that the drill has come into contact with electrical power, you must wear the proper protective clothing for recommended protection.

When the drill rack is in position, unroll the equal potential mat and position it with the ground cable socket towards the front and close to the center of the anchor site. Position the mat on the side of the unit that will provide the most protection for the crew while drill pipe is in the ground. If the operator will be loading drill stem, then place on the left hand side. If another crew member will be loading drill stem, place it on the right hand side.



Equal Potential Mat Placement

⚠ **DANGER** Electric Shock Put on electrical insulating boots and gloves, then anchor the mat in position using the mat stakes provided, making sure that the mat and stakes are flush with the ground to prevent a tripping hazard.

Auger the ground stake into the ground until no more than 1 foot is left exposed. If the ground is extremely dry, pour water down and around the ground rod to help with a proper ground. The earth ground should be tested with a device such as a Megger to determine the resistance to ground.

Make the cable connections to the equal potential mat, Strike Alert, the drill rack, and the

ground rod. Now connect the ground umbilical between the mud skid and the drill rack. Arrange the path of the umbilical so as to avoid having to walk on or over the umbilical which can cause premature wear and damage.

Check the Strike Alert system before driving the anchors. Place the front panel switch in the “test” position and verify the operation of the red light and siren. If the red light and siren do not operate in the “test” position, verify that the key switch is turned on, the fuse in the front panel (or on the bottom) of the box is functional. Also check that the battery is charged and properly connected.

After the unit has operated with the switch in the “test” position, put the switch in the “armed” position and verify the green light is illuminated.

Anchor The Drill Rack

⚠ **WARNING** Anchor drill rack properly before rotating drill pipe. Failure to properly stake down drill rack can result in drill rack tip over which can crush you when the drill string is rotated.

⚠ **CAUTION** Read and understand the Safety and Operation Manual for the Stake Driver. Your must use proper safety equipment when operation the driver. The BR 67 Driver vibration is rate a 20m/sec2 with a noise rating level of 106dB(A).

⚠ **WARNING** Always wear O.S.H.A. approved head gear and hearing protection when operating the Stake Driver.

Always wear safety glasses or O.S.H.A approved safety goggles to prevent eye injury.

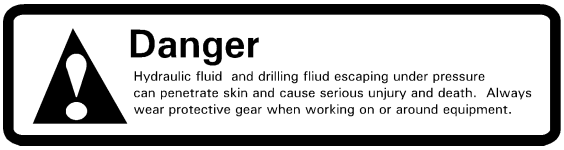
Always wear the three glove system to guard against electrical shock.

Always wear the electrical protection boots to guard against possible electrical shock.

IMPORTANT: Failure to securely anchor drill rack allows premature drill pipe and drill pipe guide wear. Premature drill pipe wear is usually discovered by drill pipe breakage under load, underground. Proper use of anchors could prevent future use of shovels (digging up drill head) or checkbook (buying new drill head, sonde, etc.) by keeping drill pipe centered in drill pipe guide. TIE IT DOWN TO THE GROUND!

Inspect the anchor driver hose ends for damage or dirt. Repair or clean off before connecting, the engine must not be running. Connect the stake driver to the quick disconnect couplings provided at the rear of the unit. It is a good practice to connect the return hose first and disconnect it last to minimize trapped pressure within the driver.

⚠ **Caution** Secure the hydraulic couplers by rotating the lock ring of the female coupler half to the lock position. Failure to secure the couplers could result in unexpected disconnect under pressure or restrict circuit fluid flow causing erratic performance.



If not already on, put on the electrical insulating boots and gloves. Start the engine activate the driver circuit by moving the anchor/puller control valve lever at the front control panel. Place the hammer end of the driver on a stake with the stake aligned through a hole in the stake plate, squeeze the trigger to start the driver, (adequate down pressure is very important). Continue driving until the stake collar is against the anchor plate. Repeat for each stake to be driven.

IMPORTANT: Do Not operate the driver without holding it against a work surface, this puts an excessive strain on the driver foot.

Disconnect The Driver

IMPORTANT: Any trapped pressure in the lines WILL make it difficult to connect the driver the next time. To avoid trapping pressure in the lines:

- Shut off the engine
- Operate the Anchor/Puller control valve lever through all positions a few times, with the trigger on the driver in the on position
- Disconnect the pressure line first, and then the return line
- Connect the driver hose ends together

Stow the anchor driver for the next use.

Prepare the Drilling Fluid

Mixing Bentonite

With water in the main tank, set the Selector Valve handle to mix and the drilling fluid switch off. Start the engine and set to high throttle. Slowly open the ball valve on the hopper to introduce the mix to the water. Follow all the supplier’s instructions for best results.

IMPORTANT: Do not allow too much material at once or the venturi will clog.

Mixing Polymers

With water in the main tank, set the Selector Valve handle to mix and the drilling fluid switch off. Start the engine and set to high throttle. Add the correct amount of polymers directly into the main tank, do not use the venturi system.

Connect the Mud Skid Umbilicals.

The operator at the drill rack should confirm that the mud skid umbilical connections are correct by momentary operation of the drilling fluid switch. Don't start to bore until the following items are also completed.

See the mud system operators manual for complete and detailed instructions.

SET UP CHECK LIST

- ❑ Brief the crew on all known hazards
- ❑ Survey the job site, locate and mark all underground utilities
- ❑ Expose all proposed crossings
- ❑ The proposed bore path is marked, and bore log at hand.
- ❑ Confirm that the crew is trained in emergency procedures, and has access to emergency phone numbers
- ❑ Secure and anchor the drill rack
- ❑ Connect the ground mats to a tested ground stake
- ❑ Erect all safety barriers and take the appropriate precautions to secure the job site and equipment.
- ❑ Check the tooling, is there an adequate amount of drill pipe, thread lube, and supplies to mix drilling fluid.
- ❑ Service the drill rack and mud skid including the fuel and oil levels
- ❑ Service any trailer mounted equipment
- ❑ Mix the drilling fluid thoroughly using suitable water and test the drilling fluid for viscosity, sand content, filter cake, or other factors as required
- ❑ Set the drilling fluid speed control valve lever on the mud skid and measure the flow rate
- ❑ Confirm that the crew has and wears appropriate safety gear
- ❑ Install fresh batteries in the transmitter, and confirm that a fully charged battery pack is in the locator receiver
- ❑ Calibrate the locator receiver
- ❑ Test the radio communications between the locator and the operator

Chapter 5

Starting the Pilot Bore

Thread Lube

Apply thread lubricant to the tool joint using the brush provided. The lubricant should coat the threads on both halves of the tool joint and should also coat the shoulder of the makeup pipe joint.

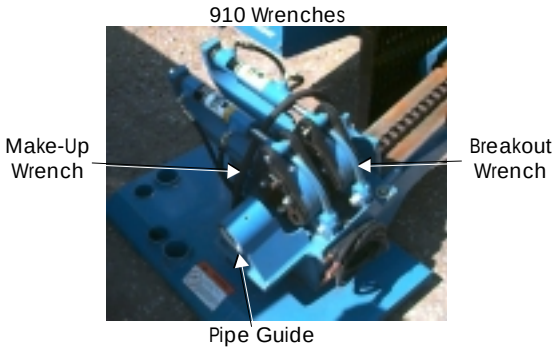
Important: For optimum operation and to prolong the life of the drill pipe, always use thread grease on every stem change beginning with the very first section installed.

If the drill pipe is new or has not been used in three or more days, apply a generous coating to the shoulder and threads of both the male and female ends. Otherwise, apply a generous coating to the shoulder and male threads before the tool joint is screwed together.

Tighten Joints At The Saver Sub.

Center both wrench cylinders. Move the first piece of pipe into position with the front (male) end inserted through the wrenches and the rear (female) end held directly in front of the saver sub. The 910 is equipped with a guide to aid in this operation.

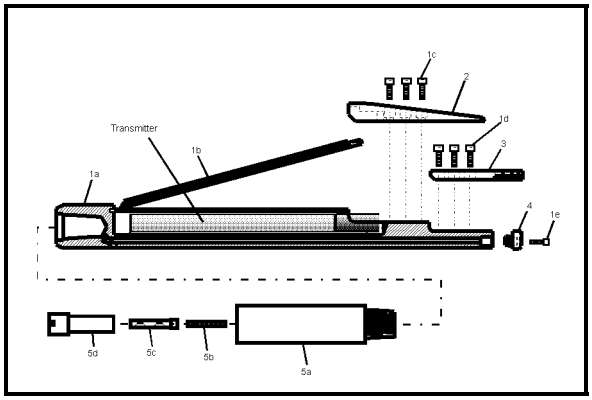
Tighten the section of drill pipe onto the saver sub by locking the makeup wrench for forward rotation (pull). Then advance the carriage (thrust forward) while slowly rotating the saver sub (forward) until it is tightened to full drill rotation torque.



Move (push) the makeup wrench back to neutral, the pin that connects the cylinder to the wrench body is even with the end of the rod shield. Momentarily (reverse) rotate to release the wrench. The drill pipe should be advanced (thrust forward) through the makeup wrench and the drill pipe guide to expose the male threads in front of the drill rack so that the drill head assembly may be attached.

Assemble the Drill Head

Assemble the drill head with the appropriate filter for the drilling fluid selected, Sonde, bit, and fluid jets. Use thread compound on all bolts.



Apply thread lube to the male end of the drill pipe. Attach the drill head assembly by screwing it on the drill pipe and tighten with hand wrenches.

⚠ **DANGER** Turning shaft can crush arms or legs Do not touch drill pipe while rotating. Do not wear jewelry, rings, watches, or loose clothing

when operating drill rack as these items may catch resulting in serious injury or death.

Check the Jets

Toggle the drilling fluid pump control switch to the on position and run fluid through the umbilical, swivel, drill pipe, filter, and jets. Observe the pattern of fluid spray from the jets to make sure that the system is operating properly.

Important: If there is any foreign material clogging the fluid jets, remove and clean the filter as well as the jets before re-testing. Checking the condition of the filter can be done more easily at this point than at any other time during the job. If any restrictions or other problems occur, solve them before continuing the bore.

Turn the drilling fluid pump control switch on and when the drilling fluid pressure gauge registers pressure, pull the rotation lever to the forward position and hold engaged.

Important: Whenever you are advancing the drill head, you must have fluid (under pressure) flowing through the drill head to insure the jets do not become clogged.

Important: The pressure will register on the drilling solution gauge even if the drill head jets have become clogged. There is an easy way to check for clogged jets. Turn the drilling fluid pump control switch on and watch the drilling fluid pressure gauge till it registers pressure. Turn the switch off and monitor the pressure reading on the gauge. If the pressure falls off quickly the jets are not clogged. If the pressure takes some time to drop off the jets are clogged.

Dig A Pilot Hole

Dig a starting hole to give the drill a flat surface into which the bore may begin with out deflection.

Being perfectly aligned when beginning the bore is absolutely necessary for fast easy drill pipe addition during the boring operation and easy stem removal during the pullback operation. An off-center entry hole causes unnecessary pressure on the tool joints, reducing the useful life of both the drill pipe and the tool joints. The increased side pressure caused by an off center entry hole increases the horsepower requirements for boring, steering, and pullback which reduces the capacity of the entire drilling system.

Advance (thrust forward) the drill head slowly by feathering the valve handle to control movement and rotating (forward) until the drill head is all the way to the front end of the drill rack with the back (female) tool joint of the drill pipe in the opening of the makeup wrench.

⚠ **DANGER** Do not touch the drill pipe while it is rotating. Do not wear jewelry, rings, watches, or loose clothing when operating drill rack as these items may catch, resulting in serious injury or death.

⚠ **WARNING** Do not wire, wedge, tape, or tie down controls in any way**.** Maintain personal control of the boring equipment at all times**.**

⚠ **DANGER** Electrical Shock. Know the location of all electrical lines and stay at least 10 feet (3m) away from all "**hot**" electrical lines, including overhead lines. Contacting electrical lines with drill pipe, whether drilling underground or handling pipe above ground, will cause serious injury or death.

Chapter 6

Completing the Pilot Bore

Adding Drill Pipe

To begin adding drill pipe, turn the drilling fluid pump off.

With the female tool joint in the jaws of the makeup wrench, extend the makeup wrench (push) locking the drill pipe against reverse rotation, apply reverse rotation to break the sub saver joint lose. Continue reverse rotation until the saver sub is completely disengaged from the drill pipe. The 910 is equipped with a floating carriage system that allows enough idle, linear movement to thread and unthread drill stem. Apply thread lube to the saver sub.

Retract the makeup wrench cylinder to neutral (pull) then thrust (reverse) to retract the carriage to the rear of the chain bed.

Move a new section of drill pipe in position between the exposed tool joint in the makeup wrench and the saver sub onto the guide that is provided. Apply thread lube to the male end of the drill pipe and saver sub.

Center the new section of drill pipe in the tool joint of the previous drill pipe and the saver sub. Slowly thrust (forward) and rotate (forward) to loosely engage both the threads in the tool joint of the previous drill pipe and the saver sub.

Retract the makeup wrench cylinder (pull) to lock the drill pipe against forward rotation, and slowly rotate (forward) to shoulder up the tool joint threads to full rotation torque.

Extend (push) the makeup wrench cylinder to the neutral position.

Note: You may have to rotate (reverse) slightly to disengage the cogs.

Important: Take special notice of the sequence in which functions and switches are turned on and off. Following them will reduce the possibility of clogging the fluid jets and spraying yourself with drilling fluid.

Turn the drilling fluid pump switch on, when the drilling fluid gauge registers pressure, rotate (forward) and thrust (forward) to bore, or thrust (forward) only to push or steer as required until the female tool joint reaches the inside of the makeup wrench.

Important: Do not rotate drill string in reverse, any time the drill string or pipe is in the ground. This can cause the drill pipe to loosen and come apart underground.

Check the fluid usage after the drill head has been advanced approximately 20 feet and adjust as required.

Guiding the Bore

Guiding the drill head through the planned bore path is accomplished by connecting straight runs of rotation with curved runs of steering. This process relies on the use of locating equipment and experienced operators.

Steering or “pushing” involves rotating the drill head to orient the steering shoe, and pushing the drill head without rotating to cause the head to veer in a controlled direction.

In order to bore (rotate) or steer (push) with accuracy, the direction and pitch and roll of the drill head must be known before thrust force is applied. Modern tracking and locating equipment provide that information and give precise position and depth information. Refer to the operator’s manual supplied with the tracking or locating equipment to learn how to most accurately guide the drill head.

Boring

When advancing the drill head without steering, the locator tells the operator to “rotate” and reports the distance to advance.

The operator turns the drilling fluid switch on, and waits until the pressure registers on the drilling fluid pressure gauge. Then engage, rotate (forward) and slowly advance thrust

(forward) until a new drill pipe must be added or the distance requested by the locator has been advanced.

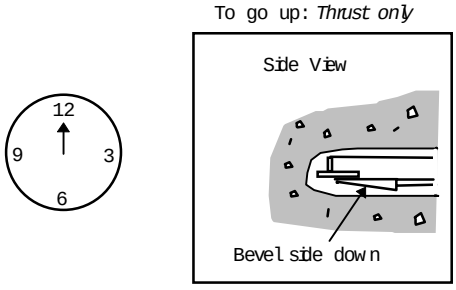
Advancing the drill head at the correct speed is critical when boring or steering. Monitor the thrust and rotation hydraulic pressure gauges, pressure readings will correspond to the amount of resistance in the respective functions. Learning to "read" the information these gauges furnish will help determine how fast you may safely advance the drill string.

At this point, the operator stops thrust first, then allows a few revolutions of rotation to release torque windup in the drill string, and then turns the drilling fluid switch off.

Steering

The first steer is usually performed to change the grade from the point of entry to the first level run. When the drill head is at the point of the bore path where the steering arc levels off and the desired depth is reached, the operator first stops the thrust. The drill head is then rotated a few revolutions to release windup and the drilling fluid switch is turned off. The locator marks the position of the drill head and reads the orientation of the steering shoe.

The drill head orientation and steering directions are given in terms of "clock" position with the clock face viewed from the operator position. The drill head will steer in the direction of its clock position with 12 o'clock being straight up, 3 o'clock being a level right turn, etc. Therefore to change from a downward entry bore path to level bore path, the drill head needs to steer to the 12 o'clock direction.



The locator using the locating device will analyze the stopped and the desired clock position of the drill head. He then must determine the desired drill head position and communicate this to the operator.

The operator notes the orientation of the exposed drill pipe or saver sub and rotates the appropriate number of "hours" in order to put the steering shoe in the correct position for the steer.

The locator confirms the new orientation of the drill head and tells the operator the distance to push at that clock position.

The operator turns the drilling fluid switch on, insures that there is pressure on the drilling fluid gauge, then engages thrust (forward) feathering the valve to control speed. The operator pushes the drill pipe ahead for the distance requested, then stops the thrust, and turns the drilling fluid switch off.

The locator marks the new position, notes the depth (and pitch if available) and determines the need for any additional steering requirements. If pitch information is not provided on the locator device, a short straight bore with precise depth reading will indicate whether or not the drill head is level.

The locator should mark the progress of the bore on the surface at least every 5 feet if possible, more often, if necessary. Keep track of the actual bore path in the bore log by recording the depths at each location point.

Finishing the Pilot Bore

The pilot bore can be guided to a pit but is usually accomplished by steering the drillhead up to the surface at the planned exit point. Make sure that the upward curve of the bore path at the exit does not exceed the bend radius of the drill pipe or the material to be installed. The last steering curve is the first pullback curve, so all installed material will bend around this curve. It is good practice to maintain as straight a bore path as possible.

When the locator can verify that the drill head is on an upward path and is about to emerge, secure the area around the exit point.

When the drill has emerged the operator should toggle the drilling fluid pump to OFF and advance the drill string until the drill head and filter sub are clear of the ground.

Shut down the power unit and remove the key from the ignition switch before starting the preparation for pullback operations.

Thoroughly clean and flush the drill head and filtersub. Inspect for damage and wear to the

cutting bit and the steering shoe. Open the transmitter housing cover and remove the transmitter. Clean off the transmitter, remove batteries, and return the transmitter and locator receiver to the transport/storage case. Return the drill head to its storage place on the trailer.

Chapter 7

Pullback Operations

Pullback operations involve two individual tasks that are usually done together: Backreaming, the process of enlarging the pilot bore; and pullback, the process of pulling the utility into the tunnel with a swivel.

Drilling fluid management and tooling selection are very important to successful pullbacks. The demand on horsepower can be greatly reduced, and the quality of the tunnel can be greatly improved through proper management and equipment.

Prereaming

Prereaming is backreaming before pulling back the utility. It is done for two reasons:

1. Larger bores can be accomplished using limited horsepower,
2. A tunnel can be positively established before introducing the utility to the tunnel.

Operations requiring prereaming are usually operations that also require careful attention to the drilling fluid and hole formation.

Pullback Safety

The pilot bore may have guided the drill string in near proximity to an unmarked hazard that went undetected. Backreaming enlarges the pilot bore, and may now bring the drill string in contact with that hazard . This contact has all the same consequences of a utility hit on the pilot bore. Observe all of the safety rules for the pull back as the pilot bore.

⚠ **DANGER** Electrocution Possible. If arching occurs at front of machine this indicates a “HOT” line has been hit. Anyone could be electrocuted from contact with any part of the boring equipment, including the mud skid.

⚠ **DANGER** Turning shaft can crush arms or legs Do not touch drill pipe while rotating. Do not wear jewelry, rings, watches, or loose clothing when operating drill rack as these items may catch resulting in serious injury or death.

⚠ **WARNING** Keep all persons away from material being installed during pullback operations. The material being installed may rotate unexpectedly if swivel malfunctions.

Assemble The Tooling

Apply a liberal amount of thread lube to the threads of all the tooling. Make sure the threads are fully seated and tightened. Check to see that the jets are properly sized and functioning. The swivel should be properly lubricated and in good condition.

With system shut off assemble the tooling to the drill pipe and attach the material being installed with the appropriate puller, adapters, or attaching hardware.

Start the Pullback

Position a crew member at the exit hole to communicate the status of the drilling fluid flow to the operator at the drill rack, and also to monitor the utility being installed

Communication of the fluid situation to the operator will help regulate the speed of the pullback to prevent “outrunning” the drilling fluid or allowing the returns to pack off and “stick” the installed material.

Start the engine of the drill rack and mud skid. Turn the drilling fluid switch on momentarily to check the jets.

Thrust as required to position the next tool joint between the wrenches and disconnect the saversub from the drill pipe following the procedure used in adding drill pipe.

Thrust (forward) to position the saversub through the breakout wrench and using the procedure used in adding drill pipe, connect the saversub to drill pipe.

Thrust (reverse) slowly to retract the drill string until the backreaming tool contacts the earth at the exit hole.

Important: Do Not rotate drill string in reverse (counter-clockwise) while drilling, backreaming, or anytime the drill string is in the ground. This may allow the drill pipe sections to loosen and come apart underground.

Rotate (forward) at full speed, turn the drilling fluid switch on and thrust (reverse) retracting the drill string, feathering the thrust valve as required to maintain a steady pull without overloading the drill rack, tooling, or material being installed.

Monitor the thrust and rotation hydraulic pressure gauges, pressure readings will correspond to the amount of resistance in the respective functions. Learning to "read" the information these gauges furnish will help determine how fast you may safely pullback.

NOTE: Drilling fluid management during pullback is critical to prevent excess drag and related problems. The amount of fluid being pumped around the backreamer and material being pulled back is controlled by the setting of the fluid pump speed control and the speed of the pullback. The proper speed of pullback and the proper flow rate is another "it depends" calculations. The locator who is at the exit hole (material entry point) should carefully monitor the exit hole for fluid which should be present but not in excess.

Removing Drill Pipe

Continue until the next drill pipe tool joint is positioned between the breakout wrench and the makeup wrench. Stop thrust, and rotation, turn the drilling fluid switch off.

Important: Some utility material is "elastic" and may pull the drill pipe back towards the tunnel when the saver sub is disconnected .

If you experience this:

1. Slow the speed of the pullback to allow the material to stay normalized
2. Increase fluid flow to better lubricate or "float:" the material being pulled
3. Pull the pipe joint a bit past the wrenches then push it back into the correct position to relieve the tension before breaking the drill pipe joint.
4. Use the make-up wrench to help hold string.

Breakout

Retract (pull) the breakout wrench cylinder to the right. Extend (push) the makeup wrench cylinder to the left and raise (push) the breakout cylinder to break the drill pipe loose from the drill string.

Important: Rotate (reverse) slowly as the tool joint loosens between the sections of drill pipe to prevent "backdrive" of the rotation motor. This action will prolong the life of the rotation drive components. Return the breakout wrench cylinder and the breakout cylinder to their neutral position. Slowly rotate (reverse) to release the threads in the tool joint. Stop movement when the threads clear but the tool joint remains in the jaws of the breakout wrench.

Extend (push) the breakout wrench cylinder to the right, rotate (reverse) to break the joint between the drill pipe and the saver sub. Retract (pull) the breakout wrench cylinder to its neutral position

Grasp the drill pipe and continue to rotate (reverse) until the drill pipe is completely disconnected from the saversub, then place the drill pipe in the storage rack.

Thrust (forward), and apply thread lube to the saver sub as it moves into position through the breakout wrench to align with the next tool joint.

Important: Always apply thread lube to the saversub on every joint for optimum operation and to prolong the life of the drill pipe.

Retract (pull) the makeup wrench cylinder, and then slowly rotate (forward) to connect the

saversub to the drill string continue to rotate (forward) to tighten the joint to full system torque.

Retract (pull) the Makeup Wrench cylinder to its neutral position.

NOTE: If the makeup wrench does not disengage, slowly rotate (reverse) just enough to loosen the wrench cogs.

Turn the drilling fluid switch on, when pressure registers, rotate (forward) and thrust (reverse) to carefully continue the pullback.

Repeat as necessary until the backreamer is about to emerge from the entry hole.

COMPLETING THE PULLBACK

Retract the carriage to the rear of the chain bed then forward to release the tension on the pulling swivel.

Shut down the drill rack and remove the key from the ignition switch.

Disconnect the now installed material from the swivel by removing the pulling connectors from the material and the swivel clevis.

Remove the swivel from the drill string, clean, and repack with water resistant grease. immediately.

Remove the backreamer and the filter sub from the drill pipe.

Cleaning the dirt and mud off the equipment will make the next setup easier. If clean water is available on site, it is a good idea to wash things off as they are loaded. If not, clean off when possible.

Restart the drill rack and position the front tool joint of the last section of drill pipe in the breakout wrench.

Extend (push) the breakout wrench cylinder and rotate (reverse) to break the saversub loose from the last remaining drill pipe and continue until the joint is almost apart.
Retract (pull) the breakout wrench cylinder to its neutral position, grasp the drill pipe and when it releases, place in the drill pipe storage rack.

Pullback operations are usually best done as a non-stop operation from start to finish. Before starting, complete this check list and maybe you won't have to shut-down halfway back.

Pullback Checklist

- ☐ Fuel and oil levels
- ☐ Drilling fluid and supplies
- ☐ Utility supplies and conditions
- ☐ Apply a liberal amount of "Taper-Lube" grease to the threads of all the tooling
- ☐ Check the swivel and lube with water-proof "Jet-Lube"
- ☐ Install the drill pipe wiper over the drill pipe at the front of the drill pipe guide
- ☐ Attach the backreamer(s) and pulling swivel to the drill string. Make sure the threads are fully seated and tightened
- ☐ Use the appropriate pullers, adapters and attaching hardware to connect the material to the swivel
- ☐ Check the condition of the drilling fluid filter in the filter sub (if one is being used) and insure that the jets are properly sized
- ☐ Reset the drilling fluid pump speed control on the mud skid to match the conditions for the pull back. This can be verified by doing a timed measurement at the tool.
- ☐ Test the radio communication between the observer and the operator.

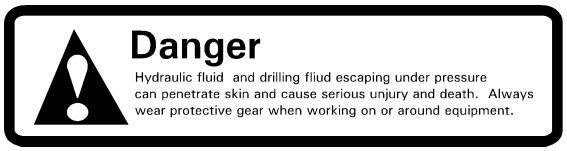
Chapter 8

Shutdown

Remove the Stakes

Inspect the stake puller hose ends for damage or dirt. Clean and repair as needed. The engine must not be running. Connect the stake puller to the quick disconnect couplings provided at the rear of the unit.

⚠ **Caution** Secure the hydraulic couplers by rotating the lock ring of the female coupler half to the lock position. Failure to secure the couplers could restrict circuit fluid flow causing erratic performance or unexpectedly disconnect under pressure.



Retract the puller and slide the foot over the top of the stake. Place the horseshoe shaped clip into the annular groove at the top of the stake to lock the puller onto the stake.

Position the puller foot so it will push against the anchor plate. A crew member holds the puller in position, as another actuates the puller by operating the anchor/puller lever at the rear control panel. If the stake gets cocked at an angle, it may be necessary to stop and reposition the puller so that the stake will more easily pull through the anchor plate.

⚠ **WARNING** Crushing power, if moved or operated in an unsafe manner this equipment can crush operators or bystanders.

Extensions are provided to fully retract the stake if necessary. When the stake is loosened to where it can be removed by hand, retract the puller. Remove the horseshoe clip and repeat this process on all the remaining anchor stakes.

Wash Down

Wash down the tooling and the unit.

Breakdown

Disconnect the umbilical connections from the drill rack and carefully recoil the hoses and electrical cable to prevent tangles.

Disconnect the grounding cables, recoil the ground mat and ground rod, and store.

Return the drill rack to the trailer.

⚠ **WARNING** Crushing Weight, if moved or operated in an unsafe manner this equipment can crush operators or bystanders.

Lift the rear ramp into the transport position

Roll up the ground mats and unscrew the ground rod from the earth, clean off the dirt and return to the trailer.

Fill in all potholes and excavations, erect any required barricades, and remove any barricades or other site safety equipment which is no longer required.

Remove the chocks holding the trailer wheels and you are now ready for the next setup.

Drilling Fluid

If the unit is not going to be used again the same day, the drilling fluid must be off-loaded and the entire fluid system flushed with clean water or antifreeze in freezing conditions.

IMPORTANT: Drilling Solution is a non-hazardous material but should be disposed of in a responsible manner. Obey all local regulations regarding disposal of drilling fluids.

Flushing the Drilling Fluid System

When pumping bentonite it is important to flush the entire water circuit at the end of each day with fresh water. An “RV” type (polypropylene glycol), anti-freeze solution may be necessary if conditions go below freezing.

See mud system operator manual for complete instruction on flushing and winterizing of both the mixing and drill fouid delivery systems.

Chapter 9

Maintenance

Engine

The 910 is equipped with a Hatz 2 cylinder air cooled diesel engine model number 2L40C. Refer to the engine manufacturer's Operation and Maintenance Manual for complete maintenance instructions and procedures.

Oil: Check the engine oil level daily. Use an oil that meets API classification SE. Change the engine oil every 100 hours. It requires 4.5 quarts (5 Liters) of oil with filter change. The oil must meet API classifications of CD / CE / CF4. Refer to the engine manual to determine the proper viscosity for your local conditions.

Oil Filter: Change the engine oil filter at every oil change.

Air Cleaner: Inspect the air cleaner every 250 hours and replace every 500 hours. Check all connections for mechanical tightness. In case of leakage, replace necessary parts or gaskets if adjustment does not correct the fault. Inspect for mud caking or signs of excessive wear or damage. There is a warning light in the engine control box that will turn on if the filter is plugged.

Fuel Filters: This unit is equipped with 2 fuel filters. The Pre-filter is located to the rear of the engine outside the cowling, and should be replaced every 500 hours. The main Fuel Filter is located inside the engine cowling and should be replaced every 1000 hours.

Fuel Tank: Check fuel level daily, the capacity of the tank is 15 Gallons (55 Liters). Fuel used in the unit should have a sulfur content of less than 0.5%

Throttle Solenoid: Engine rpm's are Low Idle 1100 rpm's, High Idle 3000 rpm's.

⚠ **Caution:** Do not exceed the maximum operating engine speed.

Hydraulics

Hydraulic Fluid: Check hydraulic fluid level daily. The level should be slightly above half full when the oil is cold to allow for normal expansion. Replace the hydraulic oil annually.The factory fill oil is mobil HP 10-30. Engine oil with an API classification of SE is recommended, see below for the proper weight.

Above 40°	use	30w
15-40°	use	20-20w
0 - 15°	use	10w
0° - Below	use	5w-20

Hydraulic Reservoir: The reservoir has an 18 gallon (68 Liters) capacity.

Hydraulic Filters: Replace the return filter in the 910 unit after the first 50 hours of operation, thereafter, check the filter condition indicator weekly and replace the filter element as required. To check the Indicator, run the engine at high Idle with the oil at operating temperature (70° or above). The replacement element for the 910 is Part Number 236-8210-02.

Flushing Water Circuit: When using Bentonite, it is important to flush the entire water circuit at the end of each day with fresh water. For procedure check Chapter 8, Shut down.

Water Pump Valves: The water pump has four suction valves and four discharge valves located in the head of the pump at the fluid end. The amount of wear and service required to maintain the valves varies with the amount of Bentonite being pumped, properly mixing the Bentonite, and the amount of care used in flushing the system clean at the end of each day. Using contaminated water with foreign matter in it or not flushing the circuit clean each day will cause the valves to fail prematurely. These failures are not covered under warranty.

When a valve is worn out, stuck open, or unseated there will be a noticeable hammering sound at the pump and the hoses will be cavitating. If the Bentonite is mixed to a good smooth consistency there will be less chance of plugging up the valves. If the pump sucks in a large clump of Bentonite, the valve can become

stuck open allowing the abrasive mixture to jet through the valve. This may cut the valve like a torch.

Another cause of hammering valves and cavitating is air in the circuit. Check all fittings on the suction side of the pump for cracks or looseness.

If the water has been drained from the pump, or the valves have recently been serviced, the pump may need to be primed to remove the air. Before priming the pump, try shutting off the flow to the pump at the ball valve for a second or two. Then open the ball valve fast. The quick suction may flush out the air. Use caution when doing this. Running the pump dry will ruin the valves.

To replace the valves follow the instructions in the manufacturer's manual. **Thrust Chain:** The thrust chain will begin to stretch and loosen up after it wears in. Visually inspect chain tightness during pull-back to monitor chain tension. An extremely loose chain may get bunched up at the sprocket during a tough pull-back breaking the chain or damaging the thrust motor, sprockets, and bearings.

Thrust Motor: The Thrust Motor is coupled directly to the Thrust Chain Drive Sprocket, there is no maintenance except for the lubrication of the Thrust bearings listed above.

Track Drive Motors: The Track Drive Motor is coupled directly to the Track Drive Sprocket, there is no maintenance except for the lubrication of the Track Drive bearings listed above.

Track Idler: The Track Idler is coupled directly to the Track Adjustment, there is no maintenance except for the lubrication of the bearings listed above.

Track Adjustment: The Tracks will begin to stretch and loosen up after they wear in. Visually inspect the Tracks for tightness. Loose Tracks may make popping noises, slip or stick, and possibly slip off the Drive sprocket.

Water Swivel Filter: The filter for the water swivel is located inside the steel pipe on the inlet to the Water Swivel, on the carriage. Use a suitable filter for the type of drilling fluid used. If using straight water a 100 mesh filter is sufficient. If the fluid is a very thick mixture of Bentonite use the largest mesh filter available (20 mesh). Check the filter at least on every bore and carry plenty of spares to replace as necessary.

Rotation Motor/Spindle: The rotation motor is coupled directly to the spindle shaft. maintenance for the lubrication of the spindle bearings is listed above.

Saver Sub: The purpose of the saver sub is to allow a replaceable tool joint for protecting drill stem and the carriage spindle. Always use plenty of thread lube on the threads every time you load another piece of drill stem. Constantly monitor the threads on the saver sub for wear. When the sharp edges of the threads begin to show rounding or, if the shoulders of the joint will not come together, completely bottoming out, it is time to replace the saver sub. Failure to maintain the saver sub will result in costly damage to the drill stem. Never run the drill stem directly to the carriage spindle shaft. Always carry an extra saver sub to allow servicing when needed. Try to replace the saver sub at the end of a day to allow ample curing time for the loctite. See Maintenance Procedures to replace the saver sub.

Carriage Roller Bearings: Maintain the carriage lubrication intervals as outlined above. Monitor the bearings for flat spots and check for free-play in the carriage daily. Failure to replace worn bearings may result in accelerated wear to the drill stem and saver sub.

Wrench Cogs: Wrench cogs have a varying life expectancy. Depending on the manner of operation and the amount of drilling time they encounter. When the cogs fail to grip they need to be replaced. When new cogs fail to grip the wrench bodies will probably need to be replaced. (It is recomended to carry extra cog springs.)

910 Maintenance Schedule

Daily

- ☑ Engine Oil Level
- ☑ Engine Fuel Level
- ☑ Engine & Hydraulics for Leaks
- ☑Hydraulic Oil level
- ☑ Drilling Fluid Pump Oil Level
- ☑ Drilling Fluid Filter

Weekly

- ☑Grease Lubrication Points
- ☑Inspect Wrench Cogs

- ☑ Hydraulic Filter Condition Indicator
  Replace Filter as needed
- ☑ Inspect Battery Fluid Level
- ☑ Inspect Thrust Chain
- ☑ Replace Hydraulic Filter elements after first 50 hours

Every 250 Hours

- ☑ Change Engine Oil & Filter
- ☑ Change/Clean Engine Air Filter
- ☑ Inspect & Clean Engine Cooling System
- ☑ Inspect & Clean Battery Cables
- ☑ Inspect & Adjust Engine Rpm's
- ☑ Change Fuel Pre-Filter

Annually

- ☑ Change Drilling Fluid Pump Oil
- ☑ Replace Hydraulic Oil

Hydraulic System Operation:

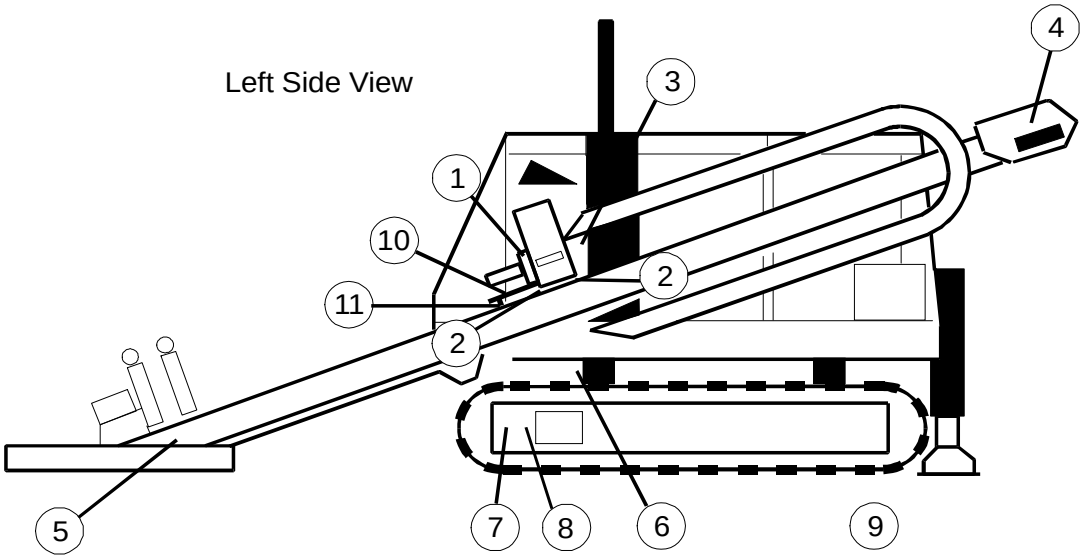
The 910 has an open center type hydraulic system. The primary components of the system consist of a main pump, rear control valve, front control valve, a leveling control valve, and the various cylinders and motors to make the unit function. The pump is mounted directly to the rear of the diesel engine. It is a fixed displacement pump (the type that produces flows anytime the engine is running). NOTE: DO NOT RUN THE ENGINE WITH THE HYDRAULIC FLOW BLOCKED. Always provide a flow path to the reservoir for the hydraulic fluid.

The front section (nearest the engine) of this tandem pump supplies a 12 GPM flow, first to the rear control valve and then to the front control valve. The pressure in this circuit is regulated by a relief valve cartridge mounted in the inlet of the rear control valve. The rear section of the tandem gear pump provides a 6 GPM flow directly to the Front control valve providing a total of 18 GPM to the valve. The pressure in this circuit is regulated by a relief valve cartridge mounted in the left inlet of the front fontrol valve. There are also work port relief valves in both the forward and reverse ports of the thrust and rotary control valve sections.

* JetLube is a water resistant grease, it may be used in all locations to simplify application

Lubrication

1	Spindle Bearing (1)	Multi-Lube	6 shots
2	Carriage Roller Bearings (8)	JetLube*	1 shot
3	Water Swivel Bearings (2)	JetLube	1 shot
4	Thrust Motor Bearings (2)	Multi-Lube	2 shots
5	Thrust Chain Sprocket Bearings (1)	JetLube	3 shots
6	Drill Rack Pivot (3)	Multi-Lube	1 shot
7	Track Adjustment (4)	JetLube	2 shots
8	Track Idler Bearings (2)	Multi-Lube	1 shot
9	Drive Motor Bearings (4)	Multi-Lube	2 shots
10	Drill Rod Support (1)	Multi-Lube	2 shots
11	Drill Rod Support Roller Bearings (2)	Multi-Lube	1 shot



Maintenance Procedures

Thrust Chain Adjustment
1. With no drill pipe on the carriage, start the unit and move the carriage to the front of the rack.

2. Apply full forward thrust and observe the thrust chain near the drive sprocket at the rear of the rack.

3. If the thrust chain droops below the top of the rack frame and causes the chain to bunch, the thrust chain should be tightened.

4. Shut off the unit. At the front of the drill frame loosen the jam nut on the idler sprocket. Tighten (clockwise) the adjusting nut to increase the tension on the thrust chain.

5. Repeat steps 1 - 4 until the chain droops but no longer bunches. Do not over-tighten the thrust chain, this will shorten the chain life.

Thrust Chain Installation
If the old chain is still in place:
1. Loosen the tension on the thrust idler at the front of the rack.

2. Connect new chain to old chain with connector link.

3. Start the unit and slowly apply thrust to pull the old chain out and the new chain in.

4. Disconnect the old chain and connect the new chain to the carriage.

5. Perform the adjustment procedure above.

If the old chain is not in place:
1. Position and secure the carriage in the middle of the drill frame.

2. Rotate break out wrenches out of the way and remove the cover to expose the front chain idler.

3. At the end of the drill frame, drop one end of the chain down through the center channel.

4. Fish the chain up and around the front idler to the top side and connect to the carriage.

5. Start the unit, slowly and carefully thrust forward to take the slack out of the chain.

6. Shut the unit off and connect the thrust chain to the carriage.

Saver Sub Replacement:
The saver sub should be changed before it becomes worn to the point that the tool joint will no longer shoulder up. If the saver sub continues to be used past this wear point, the drill pipe joints can become rounded and mushroomed making replacement of all tool joints or drill pipe necessary.
Saver Sub Replacement Procedure: Loctite adhesive is required in saver sub installation. Plan on allowing enough time for the adhesive to completely cure. It is best to replace a worn saver sub at the end of the day for overnight curing.
The proper Loctite retaining compound is 680 green. The time needed for a complete cure can be accelerated by using the proper primer.

Loctite 680 Green
Full Cure Without Primer = 8 hours
Full Cure With Primer “T” = 3 hours

1. Install a drill stem, attach it to the saver sub and run it through the pipe guide during this operation to prevent bending stress on carriage spindle.
2. The best method to break the adhesive seal is to heat the saver sub to approximately 300 degrees. At this temperature, the adhesive begins to liquefy and produce a very distinct bad odor.
Note: When applying heat to the saver sub, take care not to over heat it. This could transfer too much heat to the carriage spindle shaft and damage the lip seal at the carriage.

3. Lock the saver sub into the break out wrench and reverse rotate to loosen.
4. After allowing the carriage shaft to cool, install the new saver sub using the recommended Loctite and primer (mating surfaces must be perfectly clean).
5. Use the break out wrench to lock the new saver sub onto the carriage shaft.

Wrench Service

The makeup and breakout wrenches for the DL910 use replaceable cogs in a shaped body to safely and securely grip the drill pipe tool joints when adding or removing drill pipe sections from the drill string. The cogs must be replaced when they wear to the point that the tool joint can no longer be securely held against rotation.

1. Remove the wrench to be serviced from the drill rack. The breakout wrench is released by removing the lock pin and clevis pin from the breakout cylinder rod clevis. The makeup wrench is released by removing the lock pin from the mounting pin on the drill pipe guide assembly.
2. Clean the wrench assembly using a pressure washer or steam cleaner if necessary.
3. Carefully remove the centering springs from the wrench assembly and lay aside.
4. Remove the four Nylock nuts which retain the forward plate to the cog shafts.
5. Remove the forward plate and the worn wrench cogs.
7. Replace and tighten the four Nylock nuts. Use new Nylock nuts if the nuts have been reused three times.
8. Check the cogs for free rotation. If the cogs do not rotate remove the front cover, cogs, and the cog shafts by removing the Nylock nuts from the rear cover and reassemble using new cog shafts.
9. Reattach the centering springs to the wrench assemblies.
10. Reinstall the wrench assemblies to the drill rack by reinstalling the pins and lock pins as required.
11. If the wrench assembly with new cogs does not positively grip the drill pipe tool joints, the wrench body must be replaced. This requires doing steps 1 through 10 as well as removing the height adjusting bolt from the old wrench body and installing in the new wrench body.

910 Troubleshooting Charts

Engine Troubleshooting

Symptom	Cause	Remedy
Engine won't turn over	Weak Battery	Charge battery or replace if required.
	Defective ignition switch	Contact StraightLine Dealer
	Defective starter	Contact StraightLine Dealer
Engine turns but won't start	No fuel	Add fuel
	Wrong fuel	Replace with correct fuel
	Dirt or water in fuel	Drain, clean fuel system, replace fuel filter and fill with clean fuel
	Air in fuel system	Bleed air from fuel system
	Clogged air filter	Replace air filter
	Blower belt broken	Replace blower belt
	Emergency shut down in "stop" position	Put both shut down switches in "run" position
	Defective run solenoid	Contact StraightLine Dealer
Engine starts but won't run at high idle	Defective idle solenoid	Contact StraightLine Dealer
	Defective high idle switch	Contact StraightLine Dealer
	Blown throttle fuse	Replace 7.5 amp
Lack of engine power	Wrong fuel	Replace with correct fuel
	Dirt or water in fuel	Drain, clean fuel system, replace fuel filter and fill with clean fuel
	Air in fuel system	Bleed air from fuel system
	Clogged fuel filter	Replace fuel filter
	Clogged air filter	Replace air filter
	Wrong engine oil	Replace with correct oil
	Engine overheats	Check cooling air flow contact StraightLine Dealer if required
	Fuel system out of calibration	Contact StraightLine Dealer
	Internal engine wear	Contact StraightLine Dealer
Engine always at high idle	Throttle spring broken	Replace spring

Hydraulic Troubleshooting

Symptom	Cause	Remedy
No hydraulic function on any circuit	No hydraulic fluid	fill reservoir with proper fluid
	Clogged inlet strainer	Drain reservoir and clean strainer
	Pump drive sheared	Contact StraightLine Dealer
Thrust operates but rotation does not	Rear relief valve	Contact StraightLine Dealer
Rotation operates but thrust does not	Front relief valve stuck open	Contact StraightLine Dealer
	Port relief stuck open	Contact StraightLine Dealer
Slow or weak hydraulic operation in all functions	Low hydraulic fluid level	Add hydraulic fluid
	Clogged inlet strainer	Drain reservoir and clean strainer
	Clogged hydraulic filter	Replace filter
	Aerated hydraulic fluid	Contact StraightLine Dealer
	Worn pump	Contact StraightLine Dealer
	Worn hydraulic motor	Contact StraightLine Dealer
	Cold hydraulic fluid	Allow machine to warm up before operating hydraulics
	Engine RPMs set too low	Low 1100 High 3000 Contact StraightLine Dealer
	High operating temperature	Contact StraightLine Dealer
Slow or weak operation in either thrust or rotary	Worn hydraulic motor	Contact StraightLine Dealer
	Incorrectly adjusted	Contact StraightLine Dealer
	work port relief valve(s)	Contact StraightLine Dealer
Aerated hydraulic fluid	Low hydraulic fluid Incorrect hydraulic fluid	Add hydraulic fluid Replace with correct fluid
	Water in hydraulic fluid	Drain and replace fluid
	Air leak in pump suction line	Contact StraightLine Dealer
High hydraulic fluid temp	Defective fan controller relay	Replace relay
	Blown fan motor fuse	Replace25 Amp fuse
	Tripped circuit breaker	Reset 40 A CB
	Defective temperature sensor switch	Replace sensor switch
	Restricted air flow to oil cooler	Clean and remove obstructions from oil cooler
	Excess engine temperature	Contact StraightLine Dealer
	Low hydraulic fluid	Add hydraulic fluid
	Excess relief bypassed oil	Do Not hold functions at relief pressure for more than 2 minutes
	Worn hydraulic pump	Contact StraightLine Dealer
Noisy hydraulic system	Low hydraulic fluid	Add hydraulic fluid
	Incorrect hydraulic fluid	Replace with correct fluid
	Cold hydraulic fluid	Allow machine to warm up

Electrical Troubleshooting

Symptom	Cause	Remedy
Low battery voltage	Low water level	Add water
	Loose alternator belt	Tighten alternator belt
	Alternator not charging	Contact StraightLine Dealer
	Defective battery	Replace battery
	Defective battery cables	Inspect, clean, and tighten cables
	Continuous drain on battery	Find draining load and correct.
Drill rack controls do not operate the drill ing fluid pump	Umbilical disconnected	Connect umbilical
	Mud skid engine not running	Start engine
	Mud skid battery dead	Charge, or replace battery
	Defective solenoid valve	Contact StraightLine Dealer
	Defective solenoid valve	Contact StraightLine Dealer
	Defective solenoid switch	Contact StraightLine Dealer

Drilling Solution System Troubleshooting

Symptom	Cause	Remedy
Fluid pump will not run	Umbilical disconnected	Connect umbilical
	Blown fuse	Replace fuse
	Defective solenoid valve	Contact StraightLine Dealer
	Fluid umbilical disconnected	Connect fluid umbilical
Fluid pump runs but low or no flow	Worn or stuck pump valves	Replace pump valves
	Fluid pump relief valve set too low or stuck open	Contact StraightLine Dealer
	Clogged fluid filter	Clean and or replace filter screen
	Clogged jets	Clean jets and filter screens

Specifications

Thrust and Pullback	8200 lb.	3720 kg/
Maximum Spindle Torque	820 lb.	372 kg/m
Maximum Spindle Speed	100 RPM	
Length	13' 3""	4.03 m
Width	35"- 47"	119 cm
Height	58"	216 cm
Weight w / pipe	7,250 lb.	3,291 kg
Amount of Pipe Carried	21 (105')	26 m
Pilot Bore Diameter	3"	7.62 cm
Max. Backream Diameter	12"	30 cm
Maximum Bore Length	400'+	122 +m
Accuracy	3" window	7.62 cm
Mud Pump Max. pressure	950 psi	66 Bar
Drilling Fluid Flow Rate	0-6 gpm	0-23 1/min.
Ground Drive	Yes	
Type of Ground Drive	Steel Track	
Automated Wrenches	Yes	
Operator's Seat	Yes	
Stake Down	Yes	
Engine Type	Hatz Diesel	
Power Output	35 hp	26 kW
Low RPM	1100 RPM	
Hi RPM.	3000 RPM	
Engine Oil Capacity	4.5 qt.	5 liters
Fuel Capacity	15 gal	55 liters
Maximum Pressure	3000 psi	206 bar
Main Hydraulic Circuit	12 gpm	45 1/min.
Secondary Hydraulic circuit	6 gpm	22.5 1/min.
Hydraulic Fluid Capacity	18 gal	68liters
Cold Bypass Relief.	45 psi	3 bar
Drilling Fluid Pressure	950 psi	66 bar
Hydraulic Fluid Coolers	Yes	
Engine Cooling	Air	
Operator Noise Level	91.5 dB(A)	
Exterior Noise Level	92 dB(A)	

910
Mud Skid
Dealer Preparation Check-List

Delivery Date:	
Unit Model:	
Unit Serial No.	
Engine Serial No.	

Dealer:	
Address:	
City/State/Zip	

Inspected By:	
Date:	

Sold To:	
Address:	
City/State/Zip	

Inspection Procedure Codes

OK	No Service Required
0	Corrective Action Required
X	Corrected (Note Corrective action taken)
1	Weld Cracks, Dents &/or Rust
2	Installation

3	Leaks
4	Operation
5	Condition
6	Tightness

Drill Rack Inspection

Check	OK	O	X
Paint & General Appearance (5)			
Lubrication Points (5)			
Carriage Fit-up (2 5 6)			
Thrust Chain Tension (6)			
Track Chain tension (6)			
Rod Guide-Wrench Alignment (2 5)			
Ground Lug & cables (2 5 6)			
Hoses & Fittings (2 3 5 6)			
Hose Routings (2 5)			
Hour Meter Reading @			
Hydraulic Pump (2 5 6)			

Check	OK	X	O
Quick Disconnects (3)			
Engine Oil Level (2)			
Engine Cooling System (4)			
Hydraulic Oil Level (5)			
Hydraulic Oil Filter Contion (5)			
Fuel Tank Level (2)			
Battery (2 5 6)			
Charging System (4)			
Air Filter (2 3 5)			
Seat (4 5)			

Operational Check

Check	OK	O	X
Ignition Start/Stop			
Low Oil Pres. Warning Light			
Charge Warning Light			
Pre-Heat Circuit			
Engine RPM'S 100/3000			
Thrust forward			
Thrust Reverse			
Rotation Forward			
Rotation Reverse			
Breakout Wrench			
Make-up Wrench			
Breakout Cylinder			

Check	OK	O	X
Throttle Switch			
Emergency Stop Sw.(Front)			
Drilling Solution Switch			
Strike Alert			
Right Tram			
Left Tram			
Tilt			
Level			
Stake Driver/Puller			
Track Spread			
Emergency Stop Sw. (Rear)			
All Controls Operate Per Decals			

Cooling Fans				Cooling Fan Override Switch				

Standard Tooling Inventory

Check	Qty	OK	O	X	Check	Qty	OK	O	X
Drill rod 1 7/8" X 10'	40				Equal Potiental Mat	1			
4th Gen. Series II Drill Head	1				5' Ground Cable	1			
Pullback Swivel	1				100' Ground Cable	1			
Thread Lube 2.5 Gal.	1				20kv Rubber Gloves w/liner	2pr			
Thread Lube Brush	1				20 kv Rubber Safety boots	2pr			
Grounding rod	1				Safety Glasses	2pr			

Hydraulic System Pressures

Check	OK	O	X	Check	OK	X	O
Main Relief (thrust) 300 PSI				Make-up Wrench 1800 PSI			
Main Relief (Rotation) 3000 PSI				Breakout Wrench 1300PSI			
Rotation Port Releifs 2900 PSI				Breakout Sequence Valve 1300PSI			
Stake Driver/Puller 2000PSI							

Decal Inspection

NO	Description	Part Number	Qty	OK	O	X
	Full Decal Kit	100010				
	Operation Decal Kit	280085				
1	Decal, Operation - Mixer Control Valve	120270	1			
2	Decal, Operation - Mixng Valve	120271	1			
3	Decal, Operation - Mud Pump Flow Control	120272	1			
4	Decal, Operation - Mud Mixer Inlet	120273	1			
5	Decal, Operation - Mud Mixer Outlet	120274	1			
6	Decal, Operation - Mud Pump Inlet	120275	1			
7	Decal, Operation - Mud Pump Outlet	120276	1			
8	Decal, Operation - Hydraulic Oil Fill	120277	1			
9	Decal, Operation - Unleaded Gasoline	120278	1			
10	Decal, Operation - Check engine Oil level	120279	1			
11	Decal, Operation - Hydr. Pressure @ Mud Pump	120280	1			
12	Decal, Operation - Hydr. Pressure @ Mud Mixer	120281	1			
	Safety Decal Kit	280086				
1	Decal, safety - General Operating Instructions	220282	1			
2	Decal, Safety - Warning, Rotating Shaft	120283	2			
3	Decal, Safety - Warning, Hot Muffler	120284	2			
4	Decal, Safety - Danger, Avoid Fuel Fire	120285	1			
5	Decal, Safety - Warning, Avoid Breath. Mud Dust	120286	1			
6	Decal, Safety - Warning, Avoid crushed Fingers	120287	3			
7	Decal, Safety - Warning, Avoid Battery Explosion	120288	1			
8	Decal, Safety - Warning, Drill Fluid Under Pressure	120289	1			
	Image Decal Kit	280087				
1	Decal, identity - Straightline Logo 4" x 8.5"	236-9443-02	2			
2	Decal, Identity - Model 1415	120290	2			
3	Decal, Identity - Blue/White Stripe x 74" (purch. Roll no. 236-9465-02)	161225	2			
4	Decal, Identity - US Flag	750-114-02	1			