

JT1220 Mach 1

Operator's Manual



CE

CMW®

Issue 2.1



054- 114

Overview

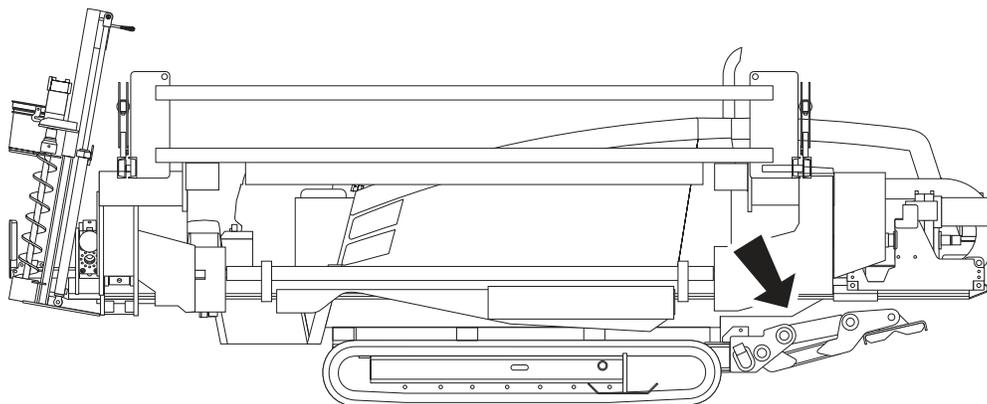


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Serial Number Location

Record serial numbers and date of purchase in spaces provided. Drilling unit serial number is located as shown.



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Item	
date of manufacture	
date of purchase	
drilling unit serial number	
trailer serial number	
engine serial number	

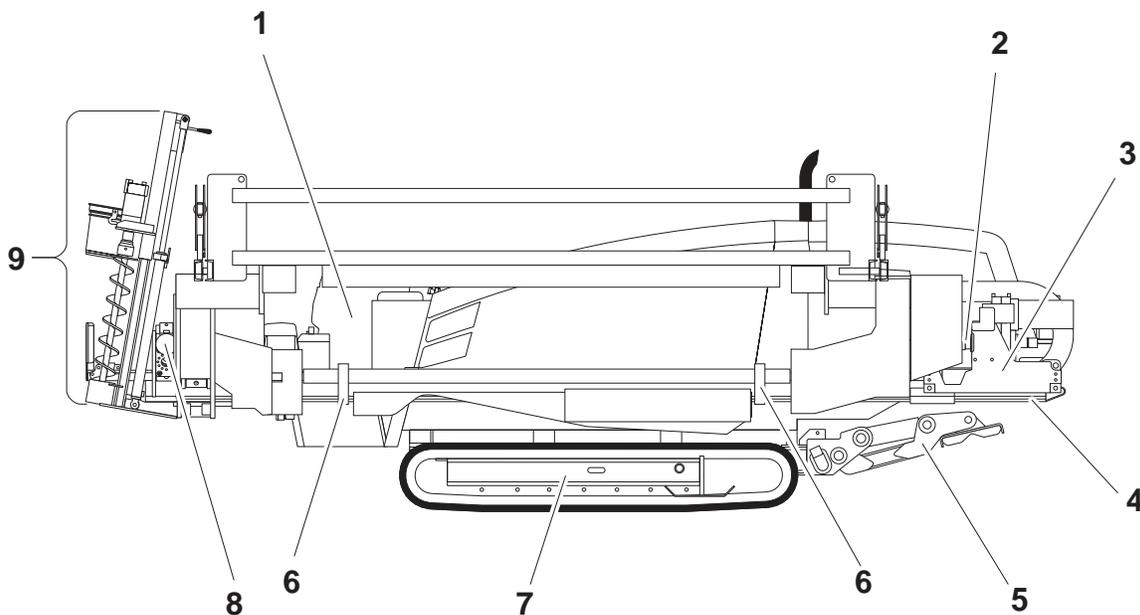
Intended Use



The JT1220 Mach 1 is a self-contained horizontal directional drilling unit designed to install buried cable and pipe at distances to 400' (122 m) depending on soil conditions and is intended for operation in ambient temperatures from 0° to 115°F (-18° to 46°C). Use in any other way is considered contrary to the intended use.

The JT1220 Mach 1 can be used with Ditch Witch drilling fluid units and Ditch Witch Subsite locating equipment. It should be operated, serviced, and repaired only by persons familiar with its particular characteristics and acquainted with the relevant safety procedures.

Unit Components



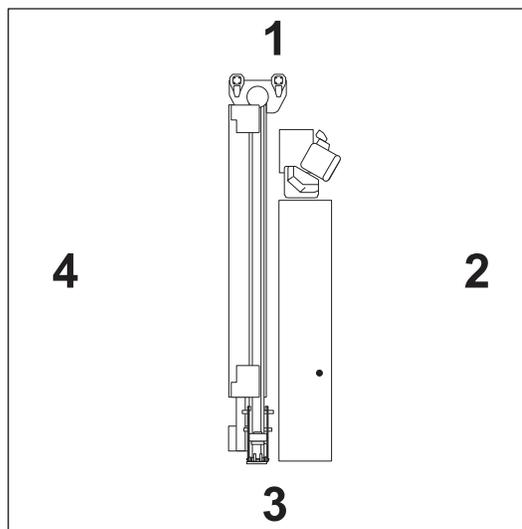
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- | | |
|-----------------------|---------------------|
| 1. Operator's station | 6. Pipeloader |
| 2. Spindle | 7. Tracks |
| 3. Carriage | 8. Vise wrenches |
| 4. Drill frame | 9. Anchoring system |
| 5. Stabilizer | |

Operator Orientation

IMPORTANT: Top view of unit is shown.

1. Front of unit
2. Right side of unit
3. Rear of unit
4. Left side of unit



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About This Manual

This manual contains information for the proper use of this machine. See the beige **Operation Overview** pages for basic operating procedures. Cross references such as “See page 50” will direct you to detailed procedures.

Bulleted Lists

Bulleted lists provide helpful or important information or contain procedures that do not have to be performed in a specific order.

Numbered Lists

Numbered lists contain illustration callouts or list steps that must be performed in order.

“Continued” Indicators



indicates that a procedure is continued on the next page.

Foreword



This manual is an important part of your equipment. It provides safety information and operation instructions to help you use and maintain your Ditch Witch equipment.

Read this manual before using your equipment. Keep it with the equipment at all times for future reference. If you sell your equipment, be sure to give this manual to the new owner.

If you need a replacement copy, contact your Ditch Witch dealer. If you need assistance in locating a dealer, visit our website at **www.ditchwitch.com** or write to the following address:

The Charles Machine Works, Inc.
Attn: Marketing Department
PO Box 66
Perry, OK 73077-0066
USA

The descriptions and specifications in this manual are subject to change without notice. The Charles Machine Works, Inc. reserves the right to improve equipment. Some product improvements may have taken place after this manual was published. For the latest information on Ditch Witch equipment, see your Ditch Witch dealer.

Thank you for buying and using Ditch Witch equipment.

JT1220 Mach 1 Operator's Manual

Issue number 2.1/OM-3/06

Part number 054-114

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This product is covered by one or more of the following patents:

U.S. B1 4,858,704; 4,953,638; 5,148,880; 5,242,026; 5,341,887; 5,490,569; 5,684,466; 5,713,423; 5,794,719; 5,880,680; 5,941,322; 6,085,852; 6,109,371; 6,179,065; 6,216,803; 6,250,403; 6,250,404; 6,290,606; 6,311,790; 6,411,094; 6,543,551; 6,550,547; 6,672,409; 6,739,413; 6,761,231; 6,776,246; 6,808,210; 6,827,158; 6,848,506; 6,871,712; RE37,450; RE37,923; RE37,975; RE38,418; **AU** 689,533; 706,544; 718,034; 755,862; **CA** 2,156,398; 2,217,899; **DE** 694 17 019; 695 29 634; 297 01 406; **EP** 0683845; 0674093; 0817901; 0846841; 0927892; **FR** 674,093; **GB** 2,309,239; 2,312,006; EP674,093; EP846,841; **JP** 3,458,247; other U.S. and foreign patents pending.

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Safety

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Guidelines

Follow these guidelines before operating any jobsite equipment:

- Complete proper training and read operator's manual before using equipment.
- Contact One-Call (888-258-0808) and any utility companies which do not subscribe to One-Call. Have all underground pipes and cables located and marked before operating equipment. If you damage a utility, contact utility company.
- Classify jobsite based on its hazards and use correct tools and machinery, safety equipment, and work methods for jobsite.
- Mark jobsite clearly and keep spectators away.
- Wear personal protective equipment.
- Review jobsite hazards, safety and emergency procedures, and individual responsibilities with all personnel before work begins. Safety videos are available from your Ditch Witch dealer.
- Replace missing or damaged safety shields and safety signs.
- Use equipment carefully. Stop operation and investigate anything that does not look or feel right.
- Do not operate unit where flammable gas is present.
- Contact your Ditch Witch dealer if you have any question about operation, maintenance, or equipment use.

Safety Alert Classifications

These classifications and the icons defined on the following pages work together to alert you to situations which could be harmful to you, jobsite bystanders or your equipment. When you see these words and icons in the book or on the machine, carefully read and follow all instructions. **YOUR SAFETY IS AT STAKE.**



Watch for the three safety alert levels: **DANGER**, **WARNING** and **CAUTION**. Learn what each level means.

 **DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

 **WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

 **CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Watch for two other words: **NOTICE** and **IMPORTANT**.

NOTICE can keep you from doing something that might damage the machine or someone's property. It can also alert you against unsafe practices.

IMPORTANT can help you do a better job or make your job easier in some way.

Safety Alerts



⚠ DANGER

Turning shaft will kill you or crush arm or leg. Stay away.



⚠ DANGER

Electric shock. Contacting electric lines will cause death or serious injury. Know location of lines and stay away.



⚠ DANGER

Deadly gases. Lack of oxygen or presence of gas will cause sickness or death. Provide ventilation.



⚠ DANGER

Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.



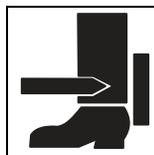
⚠ WARNING

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



⚠ WARNING

Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away.



⚠ WARNING

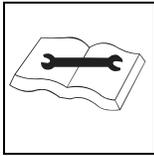
Moving parts could cut off hand or foot. Stay away.



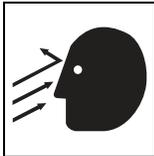
⚠ WARNING Explosion possible. Serious injury or equipment damage could occur. Follow directions carefully.



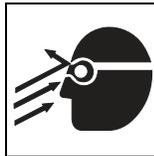
⚠ WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.



⚠ WARNING Improper control function could cause death or serious injury. If control does not work as described in instructions, stop machine and have it serviced.



⚠ WARNING Looking into fiber optic cable could result in permanent vision damage. Do not look into ends of fiber optic or unidentified cable.



⚠ WARNING Pressurized fluid or air could pierce skin and cause injury or death. Stay away.



⚠ WARNING Fire or explosion possible. Fumes could ignite and cause burns. No smoking, no flame, no spark.



⚠ WARNING Moving traffic - hazardous situation. Death or serious injury could result. Avoid moving vehicles, wear high visibility clothing, post appropriate warning signs.





⚠ WARNING Hot pressurized cooling system fluid could cause serious burns. Allow to cool before servicing.



⚠ CAUTION Flying objects may cause injury. Wear hard hat and safety glasses.



⚠ CAUTION Hot parts may cause burns. Do not touch until cool.



⚠ CAUTION Exposure to high noise levels may cause hearing loss. Wear hearing protection.



⚠ CAUTION Fall possible. Slips or trips may result in injury. Keep area clean.



⚠ CAUTION Battery acid may cause burns. Avoid contact.



⚠ CAUTION Improper handling or use of chemicals may result in illness, injury, or equipment damage. Follow instructions on labels and in material safety data sheets (MSDS).

Emergency Procedures

Before operating any equipment, review emergency procedures and check that all safety precautions have been taken.

EMERGENCY SHUTDOWN - Turn ignition switch to stop position or push remote engine stop button (if equipped).



Electric Strike Description

When working near electric cables, remember the following:

- Electricity follows all paths to ground, not just path of least resistance.
- Pipes, hoses, and cables will conduct electricity back to all equipment.
- Low voltage current can injure or kill. Almost one-third of work-related electrocutions result from contact with less than 440 volts.

Most electric strikes are not noticeable, but indications of a strike include:

- power outage
- smoke
- explosion
- popping noises
- arcing electricity

If any of these occur, or if strike alarm sounds or flashes, assume an electric strike has occurred.

If an Electric Line is Damaged

If you suspect an electric line has been damaged and you are **on drilling unit or bonded ground mats**, DO NOT MOVE. Remain on drilling machine or mats and take the following actions. The order and degree of action will depend on the situation.

- Warn people nearby that an electric strike has occurred.
- Have someone contact electric company.
- Reverse drilling direction and try to break contact. Do not touch drill pipe with hands or hand-held tools.
- Press electric strike system status button.
 - If alarm sounds again, stay where you are and wait for electric company to shut off power.
 - If alarm does not sound and there is no other indication of a strike, wait at least one full minute before moving away from equipment. Utility might use automatic reclosers which will restart current flow. If alarm sounds again while waiting, stay where you are until electric company shuts off power.
 - If alarm does not sound but all lights in strike indicator are on, assume strike is continuing and stay where you are until electric company shuts off power.
- Do not resume drilling or allow anyone into area until given permission by electric company.

If you suspect an electric line has been damaged and you are **off drilling unit or bonded ground mats**, DO NOT TOUCH ANY EQUIPMENT connected to drilling unit. Take the following actions. The order and degree of action will depend on the situation.

- Stay where you are unless you are wearing electric insulating boots. If you leave, do not return to area or allow anyone into area until given permission by electric company.

If a Gas Line is Damaged

If you suspect a gas line has been damaged, take the following actions. The order and degree of action will depend on the situation.

- Immediately shut off engine(s), if this can be done safely and quickly.
- Remove any ignition source(s), if this can be done safely and quickly.
- Warn others that a gas line has been cut and that they should leave the area.
- Leave jobsite as quickly as possible.
- Immediately call your local emergency phone number and utility company.
- If jobsite is along street, stop traffic from driving near jobsite.
- Do not return to jobsite until given permission by emergency personnel and utility company.



If a Fiber Optic Cable is Damaged

Do not look into cut ends of fiber optic or unidentified cable. Vision damage can occur.

If Machine Catches on Fire

Perform emergency shutdown procedure and then take the following actions. The order and degree of action will depend on the situation.

- Immediately move battery disconnect switch (if equipped) to disconnect position.
- If fire is small and fire extinguisher is available, attempt to extinguish fire.
- If fire cannot be extinguished, leave area as quickly as possible and contact emergency personnel.

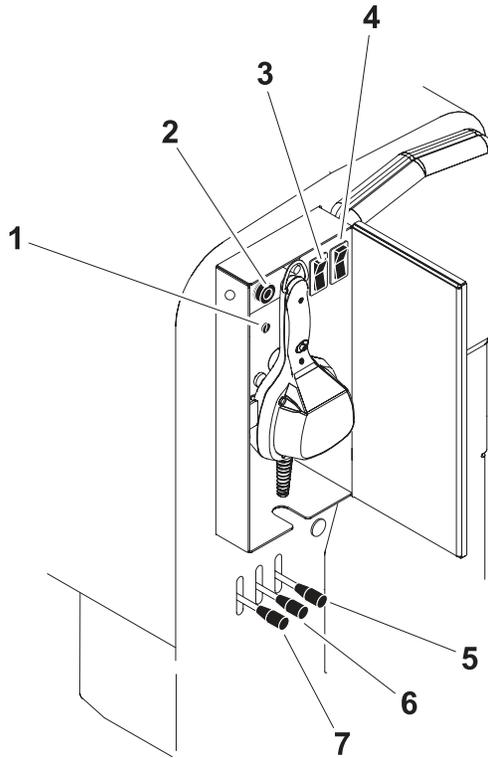
Controls

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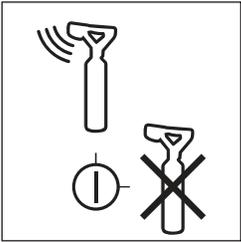


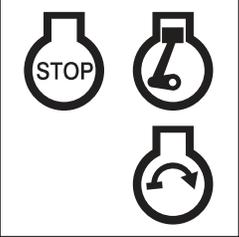
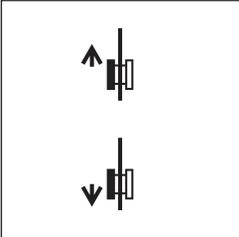
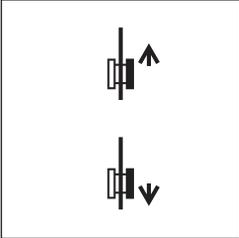
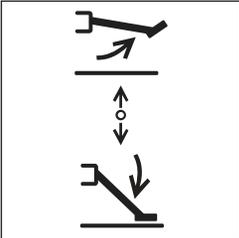
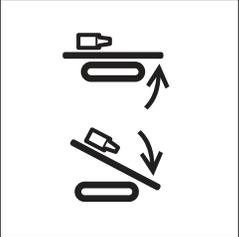
Set-Up Console



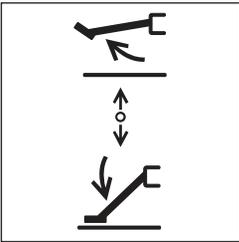
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|------------------------|-----------------------------|
| 1. Tracker control key | 5. Right stabilizer control |
| 2. Ignition switch | 6. Frame tilt control |
| 3. Left track switch | 7. Left stabilizer control |
| 4. Right track switch | |

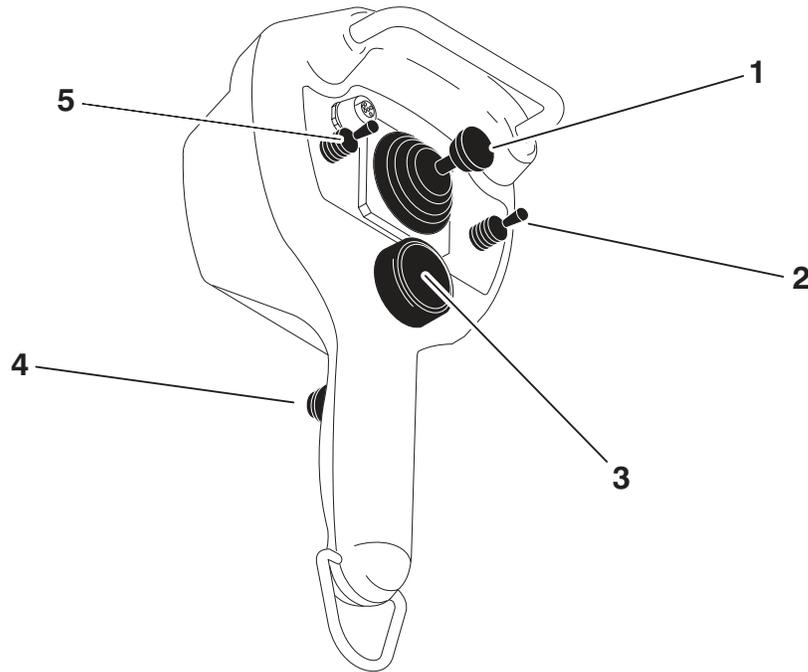
Item	Description	Notes
<p>1. Tracker control key</p>  <p>c00ic063h.eps</p>	<p>To allow tracker operator to stop thrust and rotation, move key to enable position (up).</p> <p>To override tracker control mode, move key to disable position (right).</p>	<p>IMPORTANT: Remove key and keep in tracker operator's possession.</p>

Item	Description	Notes
<p>2. Ignition switch</p>  <p>c00ic065h.eps</p>	<p>To start engine, insert key and turn clockwise.</p> <p>To stop engine, turn key counterclockwise.</p>	<p>IMPORTANT:</p> <ul style="list-style-type: none"> Restart engine with ignition switch after it has been turned off with remote engine stop switch. If wrenches are engaged when engine is stopped with ignition switch, wrenches will release and then engage when unit is started.
<p>3. Left track switch</p>  <p>c00ic147h.eps</p>	<p>To move forward, press top.</p> <p>To move backward, press bottom.</p>	<p>IMPORTANT: Use track switches only if tethered control is inoperable.</p>
<p>4. Right track switch</p>  <p>c00ic148h.eps</p>	<p>To move forward, press top.</p> <p>To move backward, press bottom.</p>	<p>IMPORTANT: Use track switches only if tethered control is inoperable.</p>
<p>5. Right stabilizer control</p>  <p>c00ic029h.eps</p>	<p>To raise, pull up.</p> <p>To lower, push down.</p>	<p>IMPORTANT: Lower left and right stabilizers to the ground to stabilize unit and then adjust for side-to-side stability. After unit is level, adjust for entry angle.</p> <p>NOTICE: Stand clear of right stabilizer to avoid crushing your foot.</p>
<p>6. Frame tilt control</p>  <p>c00ic026h.eps</p>	<p>To raise front end of drill frame, pull up.</p> <p>To lower front end of drill frame, push down.</p>	



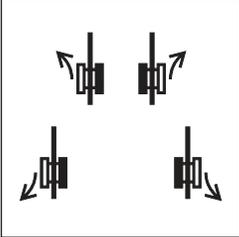
Item	Description	Notes
<p>7. Left stabilizer control</p>  <p>c00ic030h.eps</p>	<p>To raise, pull up.</p> <p>To lower, push down.</p>	<p>IMPORTANT: Lower left and right stabilizers to the ground to stabilize unit and then adjust for side-to-side stability. After unit is level, adjust for entry angle.</p>

Tethered Ground Drive Controller



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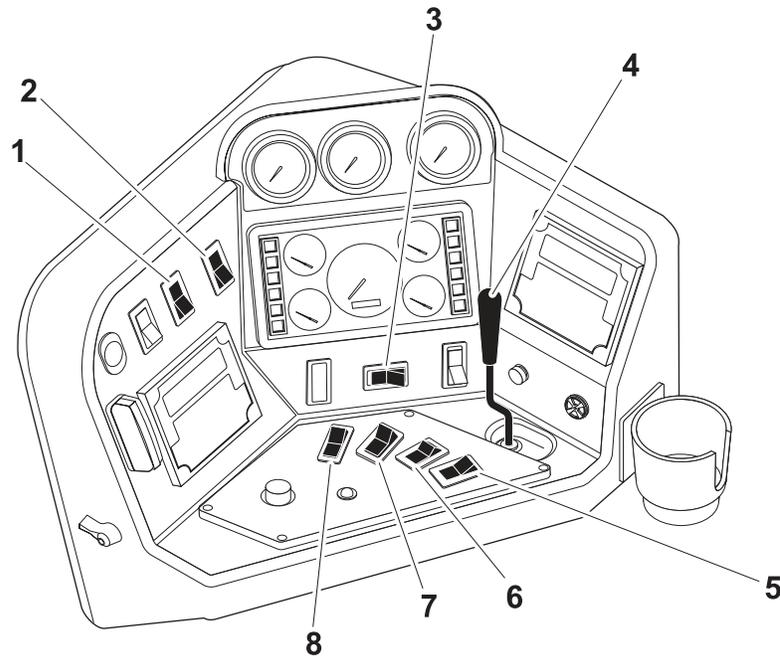
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|----------------------------|-----------------------------|
| 1. Speed/direction control | 4. Operator presence switch |
| 2. Power mode switch | 5. Throttle switch |
| 3. Remote engine stop | |

Item	Description	Notes
1. Speed/direction control  <small>c00ic145h.eps</small>	To move forward, push. To move backward, pull. To steer, move left or right.	IMPORTANT: <ul style="list-style-type: none"> Operator presence switch must be pressed and operator seat must be empty for control to work. See "Steer Unit" on page 76 for more information.

Item	Description	Notes
<p>2. Power mode switch</p> <div data-bbox="261 312 500 552" style="border: 1px solid black; padding: 10px; text-align: center;">  </div> <p><small>c00ic146h.eps</small></p>	<p>To select normal driving mode (high), push.</p> <p>To select loading and unloading mode (low), pull.</p> <p>To disable controller, return to center.</p>	
<p>3. Remote engine stop</p>	<p>To stop engine, press red button.</p>	<p>IMPORTANT: To restart engine, turn ignition switch off and then back on.</p>
<p>4. Operator presence switch</p>	<p>To operate ground drive with tethered controller, press.</p> <p>To disable controller, release.</p>	
<p>5. Throttle switch</p> <div data-bbox="261 865 500 1104" style="border: 1px solid black; padding: 10px; text-align: center;">  </div> <p><small>c00ic042h.eps</small></p>	<p>To increase engine speed, push.</p> <p>To decrease engine speed, pull.</p>	<p>IMPORTANT: Throttle switch at operator's station must be in center position for this switch to control speed.</p>

Left Control Console

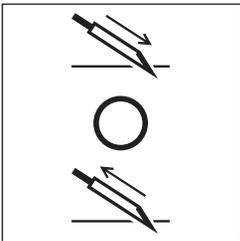
Pipeloding Controls



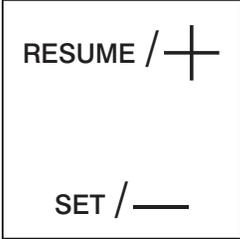
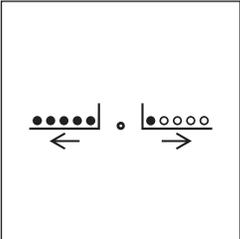
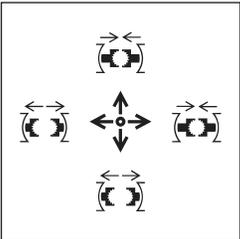
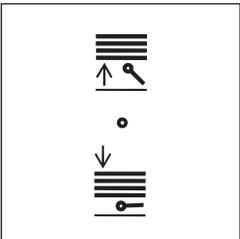
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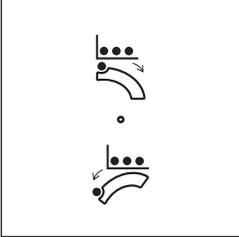
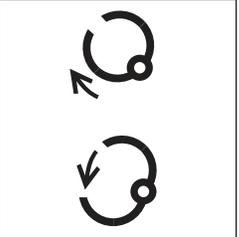
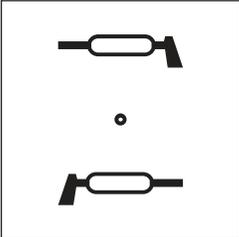
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|---------------------------------------|---------------------------|
| 1. Add pipe/manual/remove pipe switch | 5. Pipe lift switch |
| 2. Set/Resume switch | 6. Pipe shuttle switch |
| 3. Pipe box switch | 7. Pipe gripper switch |
| 4. Wrench control | 8. Pipe lubricator switch |

IMPORTANT: Switch 1 will not function unless unit is equipped with pipeloader automation option.

Item	Description	Notes
1. Add pipe/manual/remove pipe switch 	To select "add pipe" automated pipeloader function, press top. To use manual pipeloader controls, move to center. To select "remove pipe" automated pipeloader function, press bottom.	See "Add Pipe" on page 97. See "Remove Pipe" on page 103.

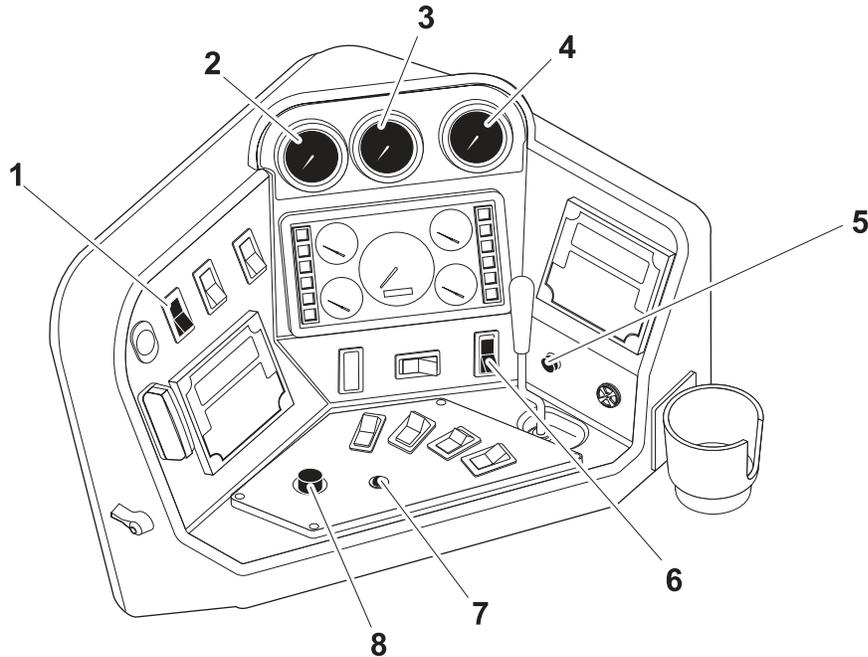
c00ic031h.eps

Item	Description	Notes
<p>2. Set/resume switch</p>  <p>c00ic113h.eps</p>	<p>To resume operation or increase operation levels, press top.</p> <p>To set operating conditions or reduce operation levels, press bottom.</p>	<p>See "Cruise Control" on page 140.</p>
<p>3. Pipe box switch</p>  <p>c00ic173h.eps</p>	<p>To shift pipe box toward operator, press left side.</p> <p>To shift pipe box away from operator, press right side.</p>	<p>IMPORTANT: See "Shift Pipe Box" on page 135.</p>
<p>4. Wrench control</p>  <p>c00ic149h.eps</p>	<p>To clamp front wrench, move to right.</p> <p>To unclamp front wrench, move to left.</p> <p>To clamp and rotate rear (rotating) wrench, push.</p> <p>To unclamp rear (rotating) wrench, pull.</p>	
<p>5. Pipe lift switch</p>  <p>c00ic171h.eps</p>	<p>To raise, press top.</p> <p>To lower, press bottom.</p>	

Item	Description	Notes
<p>6. Pipe shuttle switch</p>  <p>c00ic172h.eps</p>	<p>To move toward pipe box, press top.</p> <p>To move toward spindle, press bottom.</p>	
<p>7. Pipe gripper switch</p>  <p>c00ic035h.eps</p>	<p>To close, press top.</p> <p>To open, press bottom.</p>	
<p>8. Pipe lubricator switch</p>  <p>c00ic150h.eps</p>	<p>To fill applicator at back of pipeloader, press top.</p> <p>To apply joint compound to threads at wrenches, press bottom.</p>	

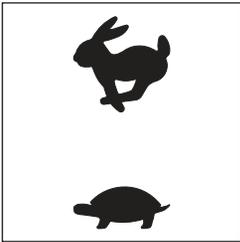


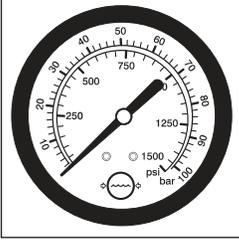
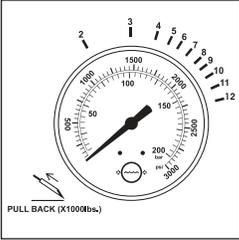
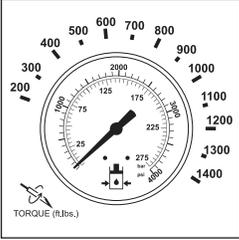
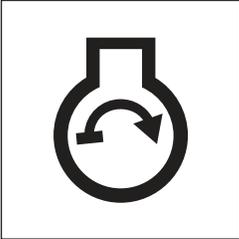
Drilling/Operation Controls



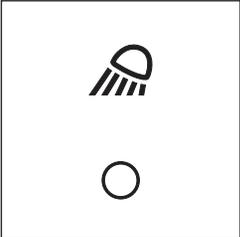
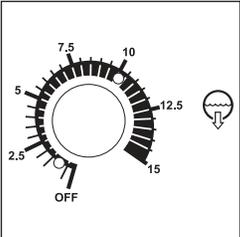
j10om006h.eps

- | | |
|----------------------------------|-------------------------------|
| 1. Engine throttle switch | 5. Remote engine start switch |
| 2. Drilling fluid pressure gauge | 6. Console/Work light switch |
| 3. Thrust pressure gauge | 7. Fluid pump indicator |
| 4. Rotation pressure gauge | 8. Fluid flow control |

Item	Description	Notes
<p>1. Engine throttle switch</p>  <p>c00ic042h.eps</p>	<p>To increase speed, press top. Return switch to center when desired speed is reached.</p> <p>To enable autothrottle mode, press top and leave switch in top position.</p> <p>To decrease speed, press bottom.</p> <p>To disable autothrottle mode, return switch to center after desired speed is reached.</p>	<p>Autothrottle mode slows the engine to low throttle after 15 seconds of inactivity involving thrust, rotation, drilling fluid flow, or pipeloader functions. To return to high speed, activate thrust, rotation, drilling fluid, or an add/remove cycle.</p>

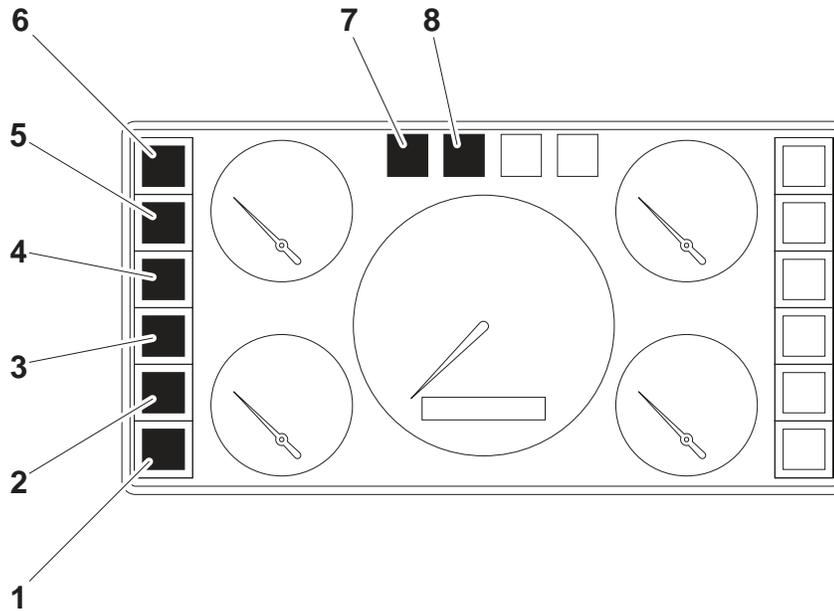
Item	Description	Notes
<p>2. Drilling fluid pressure gauge</p>  <p>c00ic157h.eps</p>	<p>Displays drilling fluid pressure supplied by drilling fluid pump.</p>	
<p>3. Thrust pressure gauge</p>  <p>c00ic155h.eps</p>	<p>Displays hydraulic fluid pressure to thrust motor during thrust and pullback.</p> <p>Estimates thrust and pullback force on lines outside gauge.</p>	
<p>4. Rotation pressure gauge</p>  <p>c00ic156h.eps</p>	<p>Displays hydraulic fluid pressure to rotation motor when spindle is turned clockwise.</p> <p>Estimates rotational torque on lines outside gauge.</p>	
<p>5. Remote engine start switch</p>  <p>c00ic152h.eps</p>	<p>To start engine from operator's station, push button.</p> <p>Release when engine starts.</p>	<p>IMPORTANT: This button works only when key on set-up console is on, operator is in seat, and battery disconnect switch is closed.</p>



Item	Description	Notes
<p>6. Console/Work light switch</p>  <p>c00ic151h.eps</p>	<p>To turn on, press top.</p> <p>To turn off, press bottom.</p>	
<p>7. Fluid pump indicator</p>	<p>If fluid pump is on, light should be on.</p> <p>If fluid pump is off, light should be off.</p>	
<p>8. Fluid flow control</p>  <p>c00ic168h.eps</p>	<p>To increase flow, turn clockwise.</p> <p>To decrease flow, turn counterclockwise.</p> <p>To stop flow, turn all the way counterclockwise.</p>	

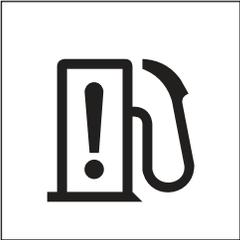
Gauge Cluster

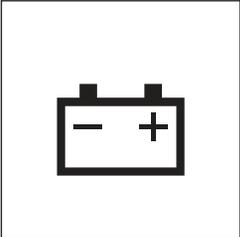
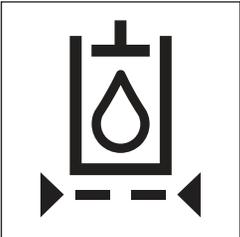
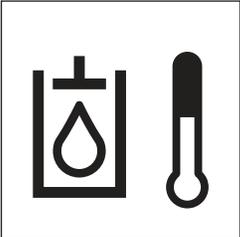
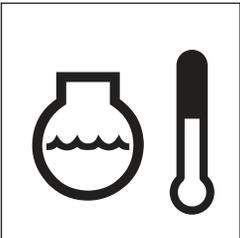
Unit Status Indicators

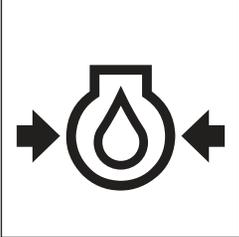


j10om010h.eps

- | | |
|---|---------------------------------------|
| 1. Water in fuel indicator | 5. Coolant high temperature indicator |
| 2. Battery charging indicator | 6. Engine oil pressure indicator |
| 3. Hydraulic filter service indicator | 7. Operator presence indicator |
| 4. Hydraulic oil high temperature indicator | 8. Diagnostic light (red) |

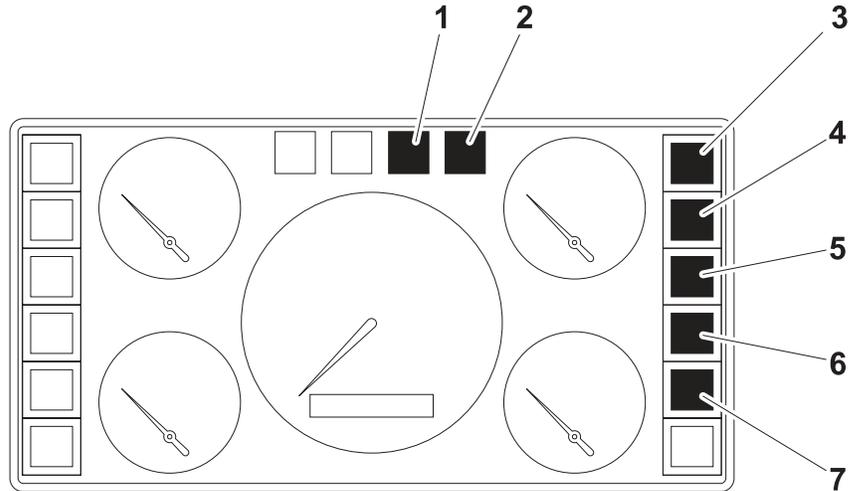
Item	Description	Notes
1. Water in fuel indicator  <p>c00ic160h.eps</p>	Indicates the presence of water in the fuel.	Drain water from fuel filter. See page 159.

Item	Description	Notes
<p>2. Battery charging indicator</p>  <p>c00ic081h.eps</p>	<p>Indicates battery is not charging.</p>	
<p>3. Hydraulic filter service indicator</p>  <p>c00ic024h.eps</p>	<p>Indicates hydraulic fluid filter needs replacing.</p>	<p>Change filter when indicator lights continuously and as indicated on page 168.</p>
<p>4. Hydraulic fluid temperature indicator</p>  <p>c00ic023h.eps</p>	<p>Indicates hydraulic fluid is overheating.</p>	<ul style="list-style-type: none"> • Check hydraulic fluid level. • Check cooler for debris. See page 168.
<p>5. Coolant high temperature indicator</p>  <p>c00ic120h.eps</p>	<p>Indicates coolant is overheating.</p>	<p>IMPORTANT: Alarms will sound when coolant overheats.</p> <p>Stop engine and let cool. Check coolant level.</p>

Item	Description	Notes
<p>6. Engine oil pressure indicator</p>  <p>c00ic119h.eps</p>	<p>Indicates engine oil pressure is too low.</p>	<p>IMPORTANT: Alarms will sound when engine oil pressure is too low.</p> <p>Stop engine and check oil level.</p>
<p>7. Operator presence indicator</p>  <p>c00ic161h.eps</p>	<p>Indicates operator is seated in operator's station.</p>	<p>Thrust and rotation will not operate unless light is on.</p>
<p>8. Diagnostic light (red)</p>  <p>c00ic051h.eps</p>	<p>If system is OK, light should be off.</p> <p>If system may not be getting power, light should be on.</p> <p>If a non-essential diagnostic code is recorded, light should flash on and off for 10 seconds.</p> <p>If an essential diagnostic code is recorded, light should flash on for three seconds and off for half a second.</p>	<p>See "Interpret Diagnostic Codes" on page 141.</p>

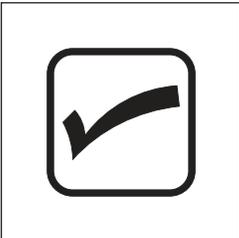


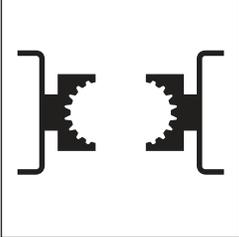
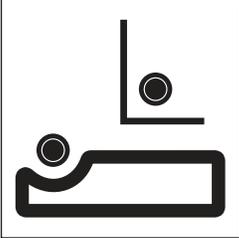
Pipeloding Status Indicators



j10om011h.eps

- | | |
|-----------------------------------|------------------------------------|
| 1. Control cycle light (green) | 5. Shuttle home status indicator |
| 2. Rear stop status indicator | 6. Front pipe box status indicator |
| 3. Carriage home status indicator | 7. Rear pipe box status indicator |
| 4. Front wrench status indicator | |

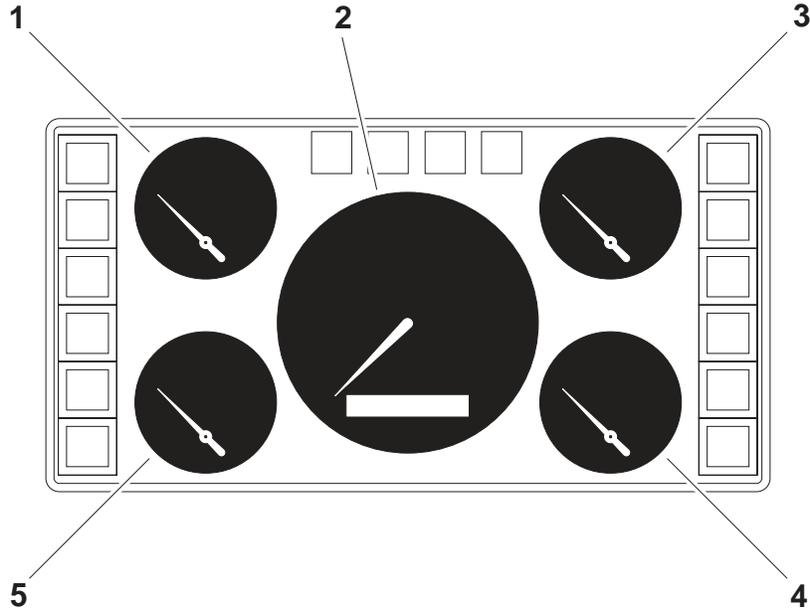
Item	Description	Notes
<p>1. Control cycle light (green)</p>  <p>c00ic056h.eps</p>	<p>If nothing is being controlled, light should be off.</p> <p>If system is waiting for an action before starting cycle, light should flash on and off.</p> <p>If something is being controlled, light should be on.</p> <p>If control cycle is interrupted, light should flash twice quickly.</p>	

Item	Description	Notes
<p>2. Rear stop status indicator</p>  <p>c00ic162h.eps</p>	<p>If carriage is at very back of drill frame, light should be on.</p> <p>If carriage is away from very back of drill frame, light should be off.</p>	
<p>3. Carriage home status indicator</p>  <p>c00ic163h.eps</p>	<p>If carriage is in the home zone at either end of drill frame, light should be on.</p> <p>If carriage is out of the home zone at either end of drill frame, light should be off.</p>	
<p>4. Front wrench status indicator</p>  <p>c00ic164h.eps</p>	<p>If front wrench is closed, light should be on.</p> <p>If front wrench is open, light should be off.</p>	
<p>5. Shuttle home status indicator</p>  <p>c00ic165h.eps</p>	<p>If shuttle is retracted, light should be on.</p> <p>If shuttle is not completely retracted, light should be off.</p>	



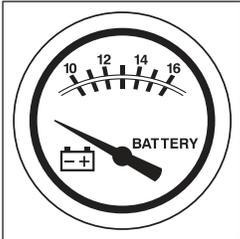
Item	Description	Notes
<p>6. Front pipe box status indicator</p>  <p>c00ic166h.eps</p>	<p>If active pipe column contains pipe, light should be on.</p> <p>If active pipe column does not contain pipe, light should be off.</p>	<p>IMPORTANT:</p> <ul style="list-style-type: none"> • Check pipe box status lights to see when active column of pipe box is empty. See “Shift Pipe Box” on page 135. • One light on and one light off indicates a jammed pipe. See “Correct Misaligned or Jammed Pipe” on page 136.
<p>7. Rear pipe box status indicator</p>  <p>c00ic167h.eps</p>	<p>If active pipe column contains pipe, light should be on.</p> <p>If active pipe column does not contain pipe, light should be off.</p>	<p>IMPORTANT:</p> <ul style="list-style-type: none"> • Check pipe box status lights to see when active column of pipe box is empty. See “Shift Pipe Box” on page 135. • One light on and one light off indicates a jammed pipe. See “Correct Misaligned or Jammed Pipe” on page 136..

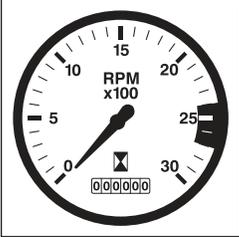
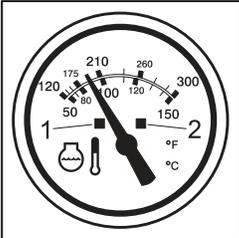
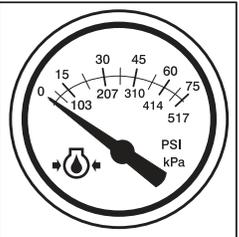
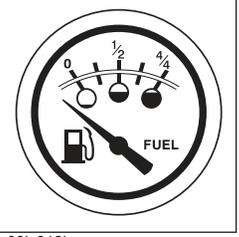
Gauges



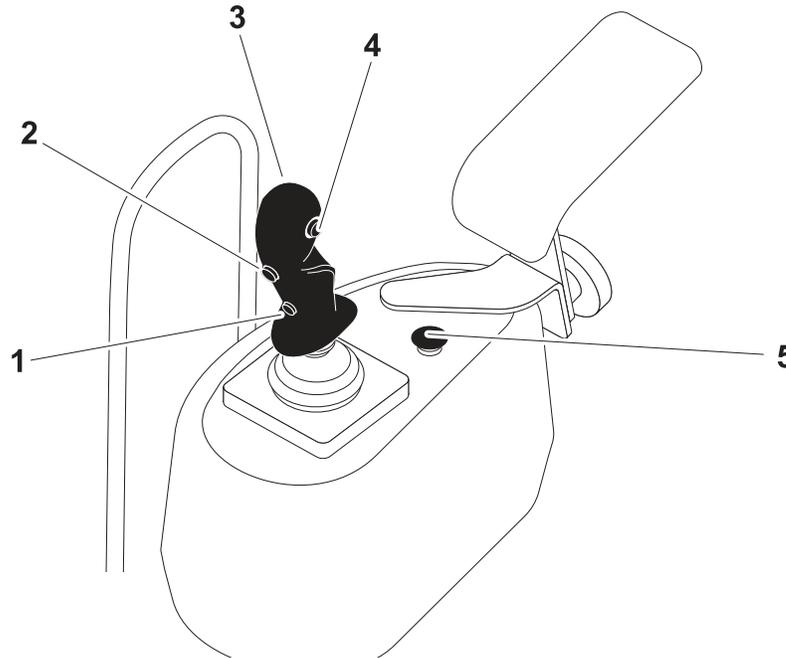
j10om009h.eps

- | | |
|-------------------------------------|------------------------------|
| 1. Voltmeter | 4. Engine oil pressure gauge |
| 2. Tachometer/Hourmeter | 5. Fuel gauge |
| 3. Engine coolant temperature gauge | |

Item	Description	Notes
<p>1. Voltmeter</p>  <p>c00ic093h.eps</p>	Displays system voltage.	Should show 13 to 14 volts with engine running.

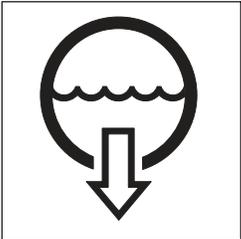
Item	Description	Notes
<p>2. Tachometer/Hourmeter</p>  <p>c00ic159h.eps</p>	<p>Displays engine rpm.</p> <p>Displays engine operating time.</p>	<p>Full load reading should be 2200 rpm.</p> <p>Use these times to schedule service.</p>
<p>3. Engine coolant temperature gauge</p>  <p>c00ic020h.eps</p>	<p>Displays engine coolant temperature.</p>	<p>Normal coolant temperature is 190°-212° F (88°-100° C).</p>
<p>4. Engine oil pressure gauge</p>  <p>c00ic021h.eps</p>	<p>Displays engine oil pressure.</p>	<p>Full load reading should be 35-65 psi (2.4-4.5 bar).</p> <p>At idle, reading should not drop below 12 psi (0.8 bar).</p>
<p>5. Fuel gauge</p>  <p>c00ic018h.eps</p>	<p>Displays fuel level in tank.</p>	<p>Use only #2 diesel fuel.</p> <p>Refer to engine operator's manual for cold weather fuel recommendations.</p> <p>Tank holds 19 gal (72 L).</p>

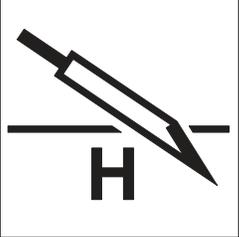
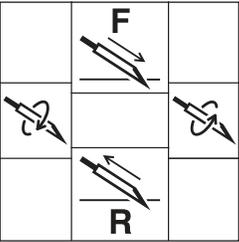
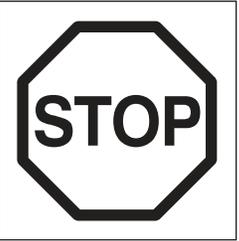
Right Control Console



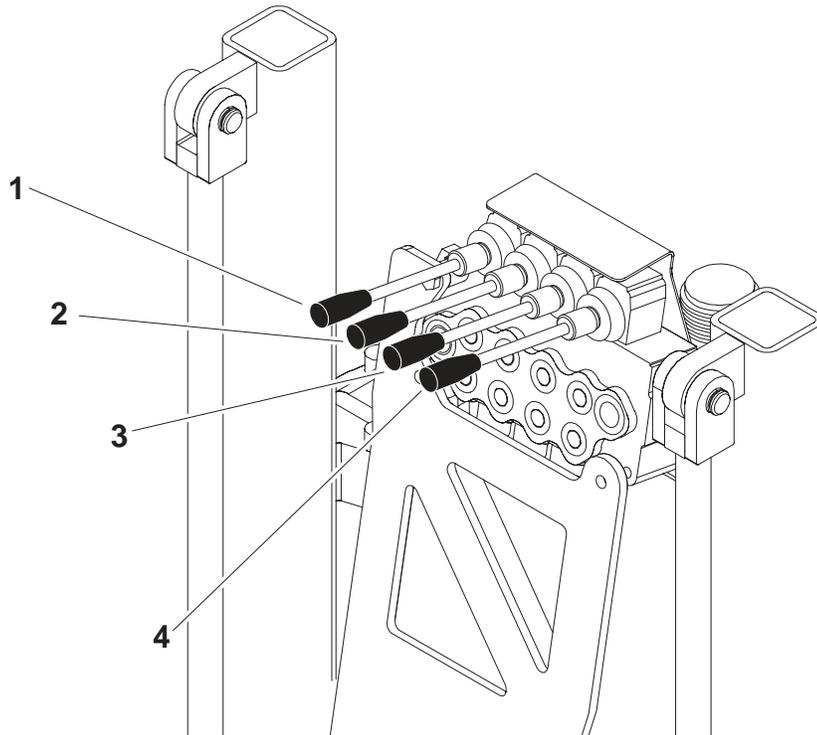
j10om007h.eps

- | | |
|--------------------------------|-------------------------------------|
| 1. Drilling fluid pump switch | 4. Drilling fluid quick fill switch |
| 2. Dual speed carriage control | 5. Remote engine stop switch |
| 3. Carriage control | |

Item	Description	Notes
1. Drilling fluid pump switch  <small>c00ic060h.eps</small>	To turn on, press once. To turn off, press once.	

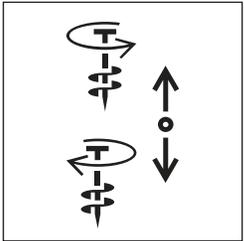
Item	Description	Notes
<p>2. Dual speed carriage control</p>  <p>c00ic058h.eps</p>	<p>To engage high carriage travel speed, push and hold.</p> <p>To return to normal carriage speed, release.</p> <p>To override assisted makeup mode, push and hold.</p>	<p>Use during bore or pullback when no pipe is in spindle to save time.</p> <p>Use during pipe makeup when pipe ends are misaligned.</p> <p>IMPORTANT: Overriding assisted makeup mode puts pipe threads in jeopardy. If frequent overriding is necessary, see your Ditch Witch dealer for pipeloader adjustment.</p>
<p>3. Carriage control</p>  <p>c00ic061h.eps</p>	<p>To move carriage forward, push.</p> <p>To move carriage backward, pull.</p> <p>To rotate spindle counterclockwise (breakout), move right.</p> <p>To rotate spindle clockwise (makeup), move left.</p>	<p>IMPORTANT: See "Operate Carriage Control" on page 91 for more information.</p>
<p>4. Drilling fluid quick fill switch</p>  <p>c00ic059h.eps</p>	<p>To override fluid control setting for full pump flow, press and hold.</p> <p>To return fluid flow to flow control setting, release.</p>	
<p>5. Remote engine stop switch</p>  <p>c00ic062h.eps</p>	<p>To stop engine, press.</p> <p>To restart engine, turn ignition off and then back to start.</p>	<p>IMPORTANT:</p> <ul style="list-style-type: none"> If this switch is used to stop drilling unit, be sure to turn ignition switch off if machine will be left unattended for long periods of time. Battery discharge can occur. If wrenches are engaged when remote stop is pressed, wrenches will remain engaged but could gradually open.

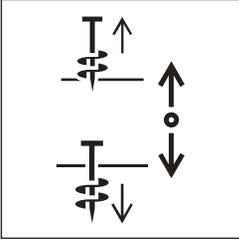
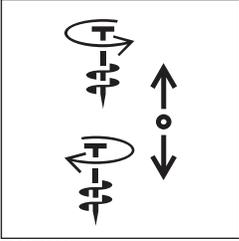
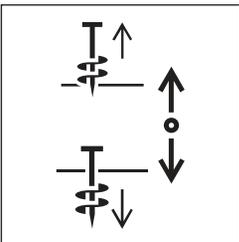
Anchoring System Console



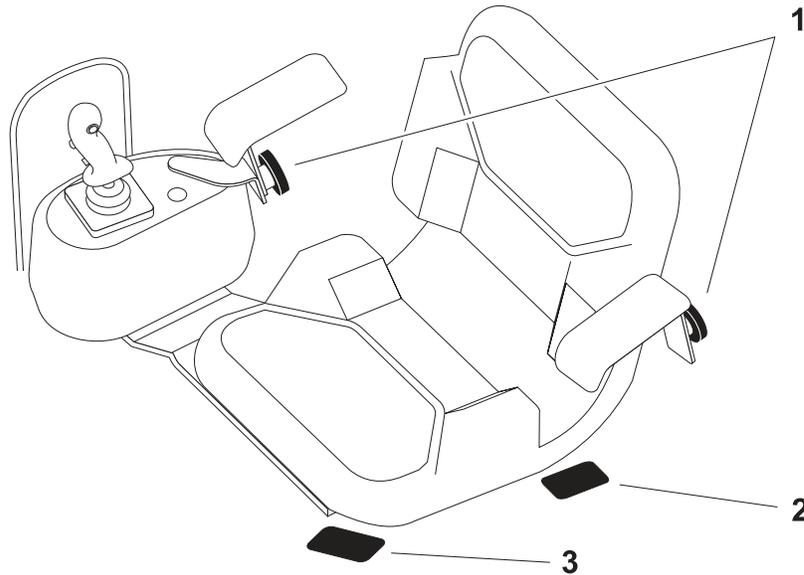
j10om015h.eps

- | | |
|--------------------------|---------------------------|
| 1. Left rotation control | 3. Right rotation control |
| 2. Left thrust control | 4. Right thrust control |

Item	Description	Notes
<p>1. Left rotation control</p>  <p>c00ic169h.eps</p>	<p>To drive anchor, push down.</p> <p>To remove anchor, pull up.</p>	<p>IMPORTANT: Stand on platform when operating anchor controls.</p>

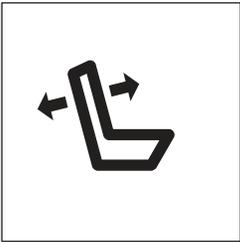
Item	Description	Notes
<p>2. Left thrust control</p>  <p>c00ic170h.eps</p>	<p>To move anchor down, push down.</p> <p>To move anchor up, pull up.</p>	<p>IMPORTANT: Stand on platform when operating anchor controls.</p>
<p>3. Right rotation control</p>  <p>c00ic169h.eps</p>	<p>To drive anchor, push down.</p> <p>To remove anchor, pull up.</p>	<p>IMPORTANT: Stand on platform when operating anchor controls.</p>
<p>4. Right thrust control</p>  <p>c00ic170h.eps</p>	<p>To move anchor down, push down.</p> <p>To move anchor up, pull up.</p>	<p>IMPORTANT: Stand on platform when operating anchor controls.</p>

Seat/Armrest



i10om008h.eps

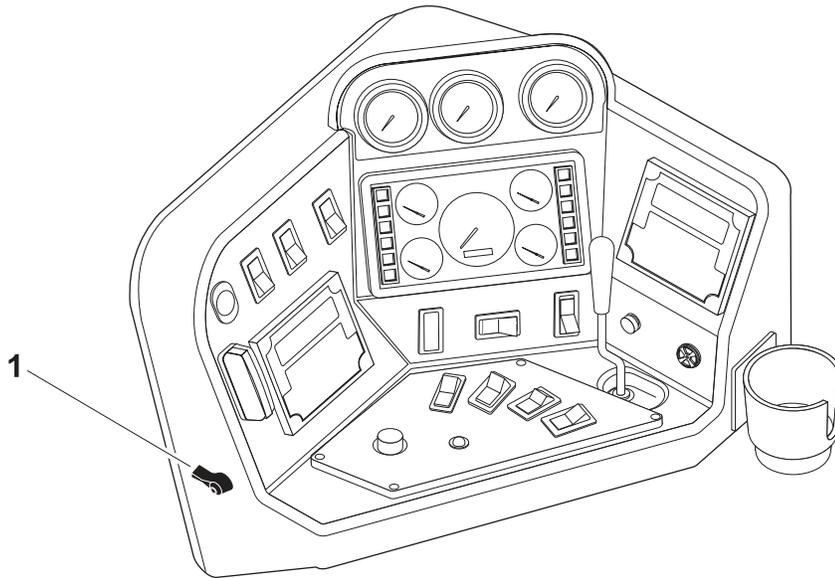
- 1. Armrest adjustment
- 2. Seat recline control
- 3. Seat slide control

Item	Description	Notes
1. Armrest adjustment	To adjust armrest position, unscrew knob, move armrest to new position, and screw knob in.	
2. Seat recline control 	To recline or raise seatback, lift. To lock seatback in position, release.	

c00ic096h.eps

Item	Description	Notes
<p>3. Seat slide control</p> <div data-bbox="261 317 501 558" style="border: 1px solid black; padding: 5px; text-align: center;">  </div> <p><small>c00ic095h.eps</small></p>	<p>To slide forward or backward, move left.</p> <p>To lock seat in position, move right.</p>	

Battery

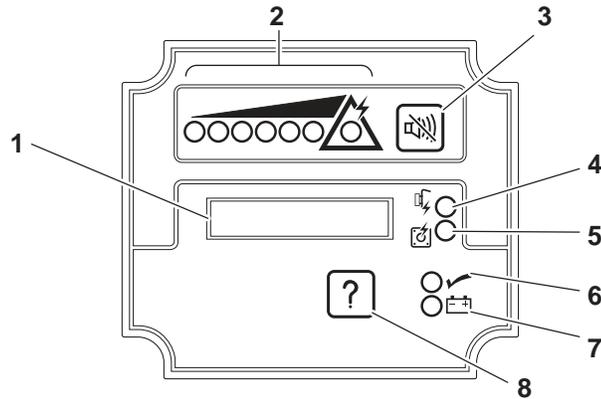


j10om012h.eps

1. Battery disconnect switch

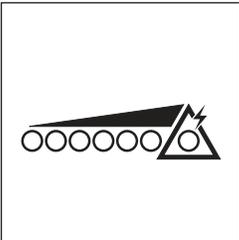
Item	Description	Notes
1. Battery disconnect switch	To connect, move left. To disconnect, move right.	

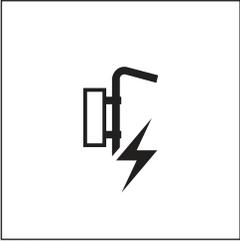
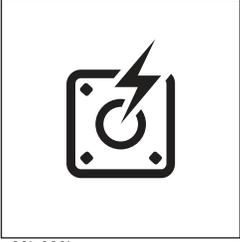
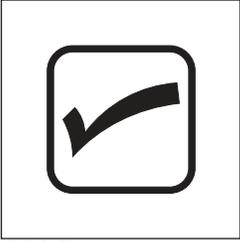
ESID



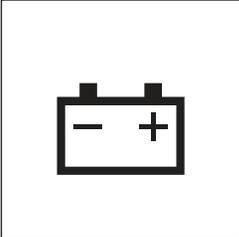
j07om042h.eps

- | | |
|------------------------------|--------------------------------------|
| 1. Alphanumeric display | 5. Current problem indicator |
| 2. Strike indicator | 6. OK indicator |
| 3. Alarm interrupt button | 7. Electrical power supply indicator |
| 4. Voltage problem indicator | 8. Self test button |

Item	Description	Notes
1. Alphanumeric display	Display amount of current and voltage being detected as a percentage of strike condition. The line with the "V" shows voltage reading and the line with the "A" shows current reading.	
2. Strike indicator  <p>c00ic077h.eps</p>	Red lights come on as values in display increase. Light in triangle represents strike warning condition and will trigger alarm(s) and strobe(s). Remember that system can go from one or two lights to an electric strike immediately.	NOTICE: The ESID does not indicate proximity to electric lines. System will activate only when voltage and/or amperage detected at the drilling unit are above threshold minimum limits.

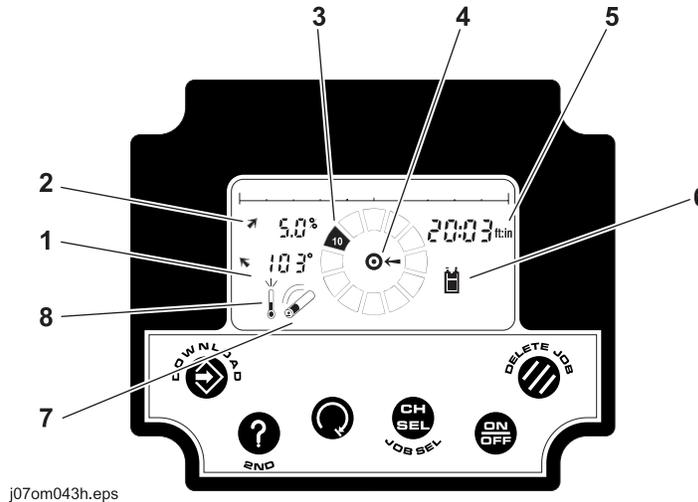
Item	Description	Notes
<p>3. Alarm interrupt button</p>  <p>c00ic078h.eps</p>	<p>To turn off strike alarm at drilling unit, press.</p>	
<p>4. Voltage problem indicator</p>  <p>c00ic078h.eps</p>	<p>Blinking red light indicates a voltage indicator problem.</p>	<p>See "Troubleshoot Strike System" on page 112.</p>
<p>5. Current problem indicator</p>  <p>c00ic080h.eps</p>	<p>Blinking red light indicates a current indicator problem.</p>	<p>See "Troubleshoot Strike System" on page 112.</p>
<p>6. OK indicator</p>  <p>c00ic056h.eps</p>	<p>Green light means system self test detected no problems.</p> <p>Strike system is ready to operate.</p>	



Item	Description	Notes
<p>7. Electrical power supply indicator</p>  <p>c00ic081h.eps</p>	<p>Green light means control box has sufficient electrical power for operation.</p> <p>Strike system is ready to operate if OK indicator is also on.</p>	
<p>8. Self test button</p>  <p>c00ic075h.eps</p>	<p>To start manual self test, press.</p> <p>To reset system after a strike has been detected, press.</p>	<p>Checks all systems and circuits.</p> <p>NOTICE: See "If an Electric Line is Damaged" on page 16.</p>

Ditch Witch Electronics 750/752 Display

Indicators

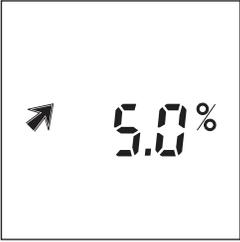
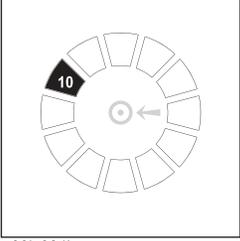
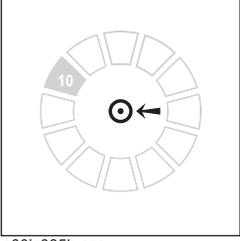


j07om043h.eps

- | | |
|---|-------------------------------------|
| 1. Beacon temperature display | 5. Depth estimate |
| 2. Pitch/slope indicator and percentage indicator | 6. Display battery status indicator |
| 3. Roll indicator | 7. Beacon battery status indicator |
| 4. Target identifier indicator | 8. Beacon temperature indicator |

IMPORTANT: Some items operate differently depending where data is being saved. **Internal** refers to pipe data being saved to 750 Display memory. **External** refers to pipe data being sent to a properly connected laptop computer running a version of Trac Management System software.

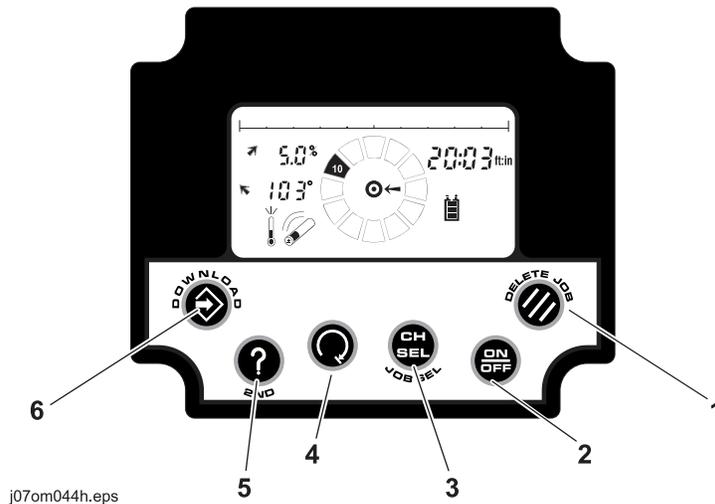
Item	Description	Notes
<p>1. Beacon temperature display</p>  <p>c00ic286h.eps</p>	Shows beacon temperature readings in degrees Fahrenheit and degrees Centigrade.	

Item	Description	Notes
<p>2. Pitch/slope indicator and percentage indicator</p>  <p>c00ic083h.eps</p>	<p>Indicates pitch beacon percent of grade.</p>	<p>Internal: shows pipe label and stored pitch.</p> <p>External: shows desired pitch.</p>
<p>3. Roll indicator</p>  <p>c00ic084h.eps</p>	<p>Indicates beacon roll angle.</p>	
<p>4. Target identifier indicator</p>  <p>c00ic085h.eps</p>	<p>Indicates approximate beacon location.</p>	<p>Only one set of arrows is active at a time.</p>
<p>5. Depth estimate</p>  <p>c00ic086h.eps</p>	<p>Indicates beacon depth estimate.</p>	<p>Internal: shows job number and stored depth.</p> <p>External: shows desired depth.</p>

Item	Description	Notes
<p>6. Display battery status indicator</p> <div data-bbox="261 359 501 600" style="text-align: center;">  </div> <p><small>c00ic087h.eps</small></p>	<p>Indicates display power from drilling unit.</p>	<p>If all five bars are not showing, check display power connections.</p>
<p>7. Beacon battery status indicator</p> <div data-bbox="261 737 501 978" style="text-align: center;">  </div> <p><small>c00ic088h.eps</small></p>	<p>Indicates beacon battery status.</p>	<p>See beacon instruction sheet.</p>
<p>8. Beacon temperature indicator</p> <div data-bbox="261 1115 501 1356" style="text-align: center;">  </div> <p><small>c00ic089h.eps</small></p>	<p>Indicates beacon temperature.</p>	<p>See beacon instruction sheet.</p>

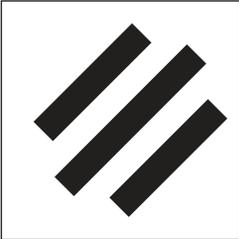


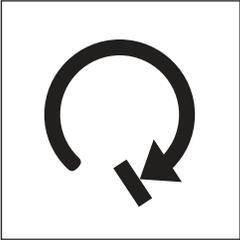
Controls



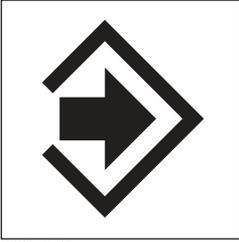
- 1. Delete button
- 2. On/Off button
- 3. Channel select button
- 4. Roll stop button
- 5. Recall button
- 6. Store button

IMPORTANT: Some items operate differently depending where data is being saved. **Internal** refers to pipe data being saved to 750 Display memory. **External** refers to pipe data being sent to a properly connected laptop computer running a version of Trac Management System software.

Item	Description	Notes
<p>1. Delete button</p>  <p>c00ic071h.eps</p>	<p>To delete current pipe, press.</p> <p>Second function:</p> <p>To delete all jobs in internal logging memory, press with Recall button.</p>	<p>Previous pipe number will appear in numeric display when data is deleted.</p>

Item	Description	Notes
<p>2. On/Off button</p>  <p>c00ic112h.eps</p>	<p>To turn on, press.</p> <p>To turn off, press again.</p>	
<p>3. Channel select button</p>  <p>c00ic073h.eps</p>	<p>To display current channel, press and release.</p> <p>To switch channels, press and hold.</p> <p>Second function:</p> <p>To start a new job, press with Recall button.</p> <p>"Init" and job number will be displayed.</p>	<p>Unit defaults to last channel used each time unit is turned on.</p> <p>IMPORTANT: Make sure display and tracker are set to the same channel.</p>
<p>4. Roll stop button</p>  <p>c00ic074h.eps</p>	<p>This feature is not yet available.</p>	
<p>5. Recall button</p>  <p>c00ic075h.eps</p>	<p>To see data about pipe, press and release.</p> <p>Second function:</p> <p>To access second functions, press with other buttons.</p>	<p>Internal: shows data about previous pipe.</p> <p>External: shows data about next pipe.</p>



Item	Description	Notes
<p>6. Store button</p>  <p>c00ic076h.eps</p>	<p>To display serial number, press and hold while pressing on/off button.</p> <p>To store current pipe data, press.</p> <p>Second function:</p> <p>To download all jobs stored in internal logging memory:</p> <ul style="list-style-type: none"> • Press with Recall button • Connect display to PC running Trac Management System software. 	<p>Pipe number will appear in numeric display when data is stored.</p> <p>IMPORTANT: Pipe data cannot be stored without a valid depth estimate.</p>

Operation Overview

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Backreaming	58
Leaving Jobsite	58
Storing Equipment	58



Planning

1. Gather information about jobsite. See page 61.
2. Inspect jobsite. See page 62.
3. Classify jobsite. See page 64.
4. Plan bore path. See page 66.
5. Check supplies and prepare equipment. See page 72.
6. Load equipment. See page 81.

Setting Up at Jobsite

1. Prepare jobsite. See page 71.
2. Unload drilling unit from trailer. See page 84.
3. Assemble drill string. See page 93.
4. Position drilling unit and frame. See page 89.
5. Assemble strike system. See page 110.
6. Anchor drilling unit. See page 109.
7. Connect fluid system. See page 89.
8. Calibrate tracker with beacon that will be installed in beacon housing. See tracker operator's manual.

Drilling

1. Start system. See page 90.
2. Prime drilling fluid pump. See page 90.
3. Engage tracker control if desired. See page 121.
4. Drill first pipe. See page 95.
5. Record bore path. See page 100.
6. Enable automated pipeloader system. See page 96.
7. Add pipe. See page 97.
8. Drill remaining pipes in pipe box.
 - Correct direction. See page 99.
 - Engage cruise control. See page 140.
 - Shift pipe box. See page 135.
9. Add up to a single column of drill pipe to empty box (see page 135) to complete bore.
10. Surface drill head. See page 101.



Backreaming

1. Assemble backream string. See page 102.
2. Start drilling unit and adjust throttle.
3. Set drilling fluid flow. Check that fluid flows through all nozzles. See page 116.
4. Remove pipe from bore. See page 103.
5. Remove up to a single column of drill pipe from full box (see page 131) to complete backream.
6. Remove pullback device. See page 105.

Backreaming Tips

- Plan backreaming job before drilling. Plan bore path as straight as possible. Check bend limits of pullback material. Check that appropriate pullback devices are on hand.
- Keep all bends as gradual as possible.
- Drilling fluid quality is a key factor in backreaming success. Contact your Ditch Witch dealer for information on testing water, selecting additives, and mixing drilling fluid.
- Backreaming requires more fluid than drilling. Make sure enough fluid is used.

Leaving Jobsite

1. Remove downhole tools. See page 105.
2. Remove anchors. See page 109.
3. Rinse unit and downhole tools. See page 150.
4. Disassemble strike system and disconnect from fluid system. See page 151.
5. Stow tools. See page 151.
6. Load unit onto trailer. See page 81.

Storing Equipment

1. For cold weather storage, antifreeze drilling unit. See page 148.
2. For long-term storage, disconnect battery disconnect switch.

Prepare

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- Notify One-Call Services61
- Examine Pullback Material61
- Arrange for Traffic Control61
- Plan for Emergency Services61

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- Minimum Depth70
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Gather Information

A successful job begins before the bore. The first step in planning is reviewing information already available about the job and jobsite.

Review Job Plan

Review blueprints or other plans and make sure you have taken bore enlargement during backreaming and pullback into account. Check for information about existing or planned structures, elevations, or proposed work that may be taking place at the same time.

Notify 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.

Examine Pullback Material

Ask for a sample of the material you will be pulling back. Check its weight and stiffness. Contact the manufacturer for bend radius information. Check that you have appropriate pullback devices.



Arrange for Traffic Control

If working near a road or other traffic area, contact local authorities about safety procedures and regulations.

Plan for Emergency Services

Have the telephone numbers for local emergency and medical facilities on hand. Check that you will have access to a telephone.

Inspect Site

Inspect jobsite before transporting equipment. Check for the following:

- overall grade or slope
- changes in elevation such as hills or open trenches
- obstacles such as buildings, railroad crossings, or streams
- signs of utilities (See "Inspect Jobsite" on page 64.)
- traffic
- access
- soil type and condition
- water supply
- sources of locator interference (rebar, railroad tracks, etc.)

Take soil samples from several locations along bore path to determine best bit and backreamer combinations.

Identify Hazards

Identify safety hazards and classify jobsite. See "Classify Jobsite" on page 64.

**WARNING**

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

NOTICE:

- Wear personal protective equipment including hard hat, safety eye wear, and hearing protection.
- Do not wear jewelry or loose clothing.
- Notify One-Call and companies which do not subscribe to One-Call.
- Comply with all utility notification regulations before digging or drilling.
- Verify location of previously marked underground hazards.
- Mark jobsite clearly and keep spectators away.

Remember, jobsite is classified by hazards in place -- not by line being installed.

Select Start and End Points

Select one end to use as a starting point. Consider the following when selecting a starting point:

Slope

Fluid system should be parked on a level site. Consider how slope will affect drilling unit setup, bending pipe, and fluid flow out of hole.

Traffic

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

Space

Check that starting and ending points allow enough space for gradual pipe bending. See "Minimum Setback" on page 69.

Check that there is enough space to work and to set up electric strike system.

Comfort

Consider shade, wind, fumes, and other site features.

Drill downhill when possible so fluid will flow away from drilling unit.



Classify Jobsite

Inspect Jobsite

- Follow U.S. Department of Labor regulations on excavating and trenching (Part 1926, Subpart P) and other similar regulations.
- Contact One-Call (888-258-0808) and any utility companies which do not subscribe to One-Call.
- Inspect jobsite and perimeter for evidence of underground hazards, such as:
 - “buried utility” notices
 - utility facilities without overhead lines
 - gas or water meters
 - junction boxes
 - drop boxes
 - light poles
 - manhole covers
 - sunken ground
- Have an experienced locating equipment operator sweep area within 20' (6 m) to each side of bore path. Verify previously marked line and cable locations.
- Mark location of all buried utilities and obstructions.
- Classify jobsite.

Select a Classification

Jobsites are classified according to underground hazards present.

If working . . .	then classify jobsite as . . .
within 10' (3 m) of a buried electric line	electric
within 10' (3 m) of a natural gas line	natural gas
in concrete, sand or granite which is capable of producing crystalline silica (quartz) dust	crystalline silica (quartz) dust
within 10' (3 m) of any other hazard	other

NOTICE: If you have any doubt about jobsite classification, or if jobsite might contain unmarked hazards, take steps outlined previously to identify hazards and classify jobsite before working.

Apply Precautions

Once classified, precautions appropriate for jobsite must be taken.

Electric Jobsite Precautions

In addition to using a directional drilling system with an electric strike system, use one or both of these methods.

- Expose line by careful hand digging or soft excavation. Use beacon to track bore path.
- Have service shut down while work is in progress. Have electric company test lines before returning them to service.

Natural Gas Jobsite Precautions

In addition to using a directional drilling system and positioning equipment upwind from gas lines, use one or both of these methods.

- Expose lines by careful hand digging or soft excavation. Use beacon to track bore path.
- Have gas shut off while work is in progress. Have gas company test lines before returning them to service.



Crystalline Silica (Quartz) Dust Precautions

Follow OSHA or other guidelines for exposure to crystalline silica when trenching, sawing or drilling through material that might produce dust containing crystalline silica (quartz).

Other Jobsite Precautions

You may need to use different methods to safely avoid other underground hazards. Talk with those knowledgeable about hazards present at each site to determine which precautions should be taken or if job should be attempted.

Plan Bore Path

Plan the bore path, from entry to end, before drilling begins. The Ditch Witch Subsite **Trac Management System Plus** is available for planning your bore path. This special software can be run in the field using a laptop computer equipped with Windows® 95 or higher operating system. See your Ditch Witch dealer for details.

If not using Trac Management System Plus, mark the bore path on the ground with spray paint or flags, or record it on paper for operator reference.

For complicated bores, consult an engineer. Have the jobsite surveyed and bore path calculated. Be sure the engineer knows minimum entry pitch, bend limits of drill pipe, bend and tension limits of pullback material, pipe lengths, and location of all underground utilities.

For less complicated bores, plan the bore based on four measurements:

- recommended bend limit
- entry pitch
- minimum setback
- minimum depth

IMPORTANT: See the following pages for more information about these measurements. If not using Trac Management System Plus, see "Bore Path Calculator" on page 70 and use these measurements to help plan your bore.

Recommended Bend Limits

Ditch Witch drill pipes are designed to bend slightly during operation. Slight bending allows for steering and correcting direction. Bending beyond recommended limits will cause damage that might not be visible. This damage adds up and will later lead to sudden drill pipe failure.

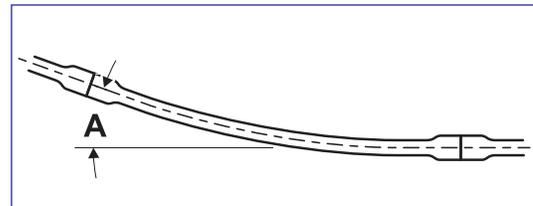
IMPORTANT: Consider recommended bend limits during any bend, not just during bore entry.

Pipe Pitch

Ditch Witch drill pipe is tested to bend at a maximum percent pitch. For JT1220 Mach 1 drill pipe, make sure pitch (A) changes no more than **9%** over the full length of each pipe.

NOTICE: Bending drill pipe more sharply than recommended will damage pipe and cause failure over time. Changes in pitch must be **equally distributed** over the length of a pipe. Maximum changes in pitch within 1-2' (300-600 mm) of pipe create sharp bends that will damage pipe.

Monitor the pitch of each pipe with the 750 Display on the operator's console. See page 49.



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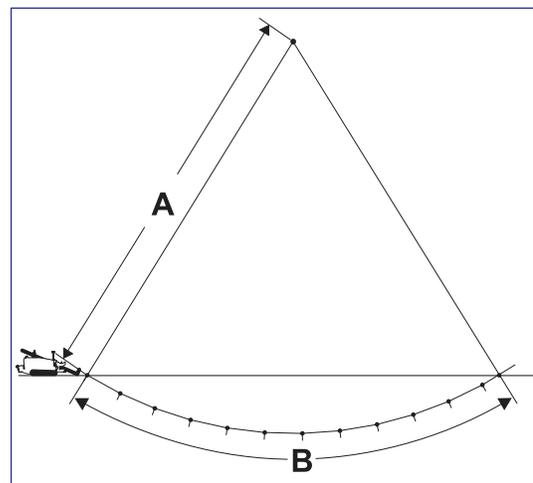
Bend Radius

JT1220 Mach 1 drill pipes have a tested minimum bend radius of 105' (32 m). This means that a 90-degree bend in the bore path:

- has a radius (A) of 105' (32 m)
- requires approximately 165' (50 m) of drill pipe (B).

NOTICE: Bending drill pipe more sharply than recommended will damage the pipe and cause failure over time.

- If bend radius is reduced, drill pipe life is reduced.
- If bend radius is increased, drill pipe life is increased.

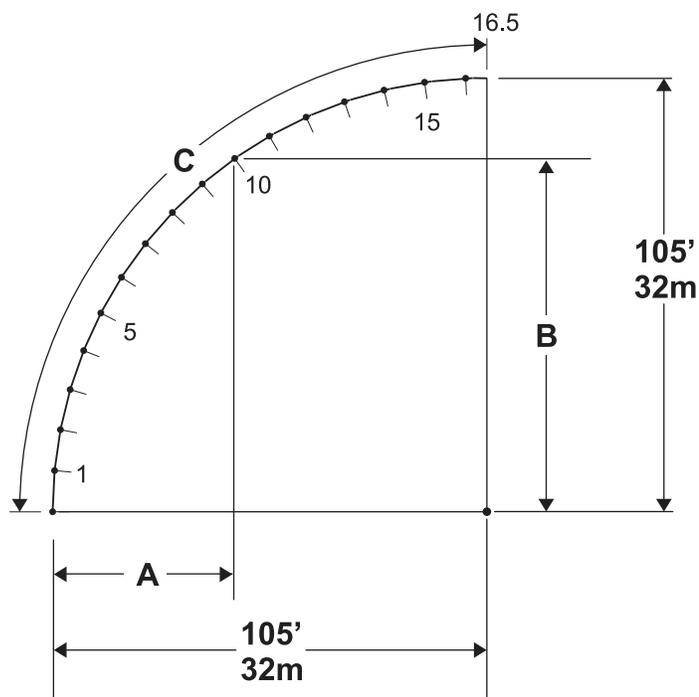


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IMPORTANT: Use the charts on the next page to keep bends within safe limits.

Pipe-By-Pipe Bend Limits

Pipe (C)	Forward (B)	Deflection (A)	Pipe (C)	Forward (B)	Deflection (A)
1	10 ft 0 in (3.0 m)	0 ft 6 in (0.1 m)	10	85 ft 6 in (26.1 m)	44 ft 1 in (13.4 m)
2	19 ft 10 in (6.1 m)	1 ft 11 in (0.6 m)	11	90 ft 11 in (27.7 m)	52 ft 6 in (16 m)
3	29 ft 7 in (9.0 m)	4 ft 3 in (1.3 m)	12	95 ft 6 in (29.1 m)	61 ft 5 in (18.7 m)
4	39 ft 0 in (11.9 m)	7 ft 6 in (2.3 m)	13	99 ft 3 in (30.3 m)	70 ft 8 in (21.5 m)
5	48 ft 1 in (14.6 m)	11 ft 8 in (3.6 m)	14	102 ft 0 in (31.1 m)	80 ft 3 in (24.5 m)
6	56 ft 9 in (17.3 m)	16 ft 8 in (5.1 m)	15	103 ft 11 in (31.7 m)	90 ft 1 in (27.5 m)
7	64 ft 11 in (19.8 m)	22 ft 5 in (6.8 m)	16	104 ft 10 in (31.9 m)	100 ft 0 in (30.5 m)
8	72 ft 5 in (22.1 m)	29 ft 0 in (8.8 m)	16.5	105 ft 0 in (32 m)	105 ft 0 in (32 m)
9	79 ft 4 in (24.2 m)	36 ft 3 in (11 m)			



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Pipe 10 is illustrated.

Entry Pitch

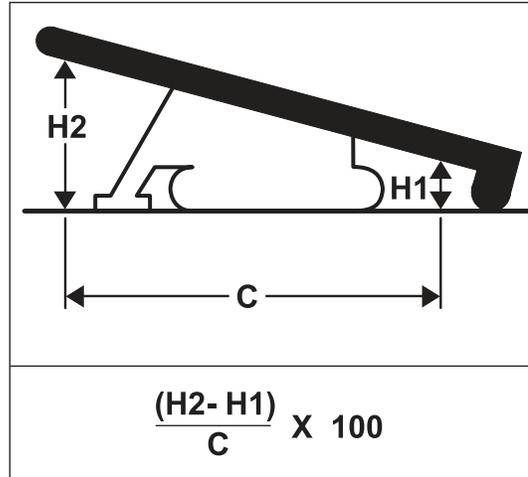
Entry pitch is the slope of the drill frame compared with the slope of the ground. Determine entry pitch one of two ways:

1. With Pitch Beacon

- Lay pitch beacon on the ground and read pitch.
- Lay pitch beacon on drill frame and read pitch.
- Subtract ground pitch from drilling unit pitch.

2. With Measurements

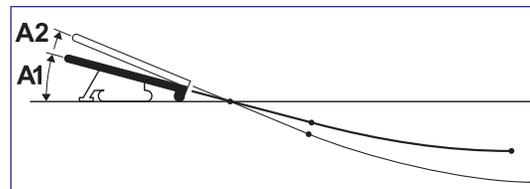
- Measure from the ground to front end of drill frame (H1).
- Measure from the ground to back end of frame (H2).
- Subtract (H1) from (H2). Record this number.
- Measure the distance between front and back points (C).
- Divide (H2-H1) by (C), then multiply by 100. This is your pitch.



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IMPORTANT: A shallow entry pitch (A1) allows you to reach horizontal sooner and with less bending. Increasing entry pitch (A2) makes bore path longer and deeper.

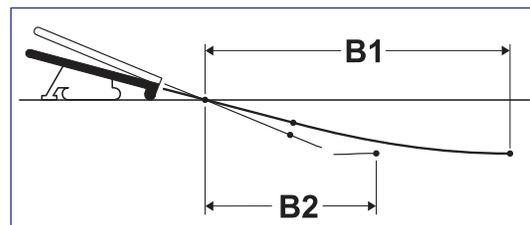


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Minimum Setback

Setback is the distance from the entry point to where pipe becomes horizontal (B1).

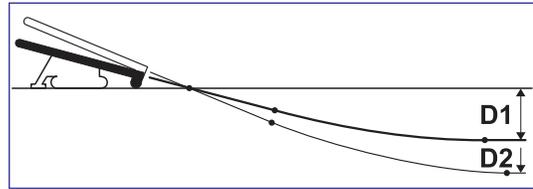
NOTICE: If setback is too small (B2), you will exceed bend limits and damage the pipe.



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Minimum Depth

Because you must bend pipe gradually, entry pitch and bend limits determine how deep the pipe will be when it becomes horizontal. This is called the **minimum depth**.

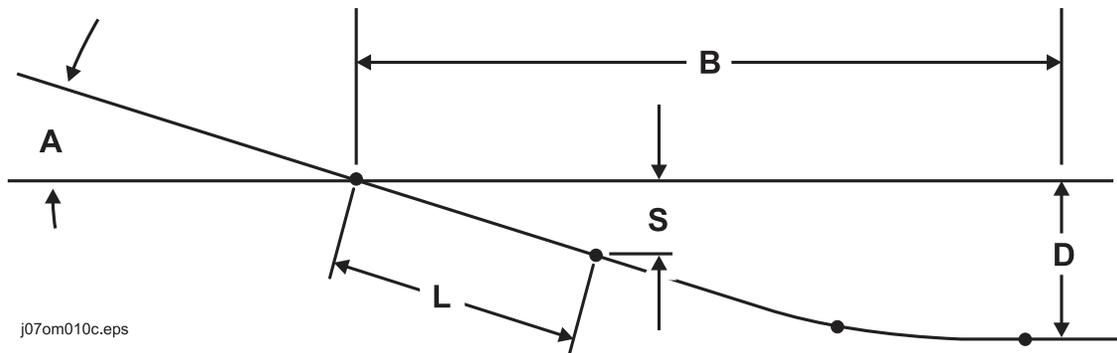


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- To reduce minimum depth (D1), reduce entry pitch. This also decreases setback.
- To increase minimum depth (D2), increase entry pitch. This also increases setback.

Bore Path Calculator

Entry pitch, setback, and minimum depth work together with bend limits to determine the bore path. To find the setback (B) and entry pitch (A) that will take you to the desired minimum depth (D), use the chart below.



j07om010c.eps

Minimum depth (D)	Entry pitch (A)	Setback (B)	Depth to begin steering (S)
3 ft 0 in (0.9 m)	-18%	26 ft 0 in (7.9 m)	1 ft 5 in (0.43 m)
3 ft 7 in (1.1 m)	-20%	28 ft 6 in (8.7 m)	1 ft 7 in (0.48 m)
4 ft 2 in (1.2 m)	-22%	30 ft 6 in (9.3 m)	1 ft 9 in (0.52 m)
4 ft 9 in (1.4 m)	-24%	32 ft 3 in (9.8 m)	1 ft 10 in (0.57 m)

IMPORTANT: Numbers in table based on **105' (32 m) minimum bend radius**, beacon housing, EZ-Connect, connector, transition sub, and 1/3 of first drill pipe (L, totaling 8' [2.4 m]) in the ground before steering.

Prepare Jobsite



WARNING

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

NOTICE:

- If jobsite classification is in question or if the possibility of unmarked electric utilities exists, classify jobsite as electric.
- Cutting high voltage cable can cause electrocution. Expose lines by hand before digging.
- All vegetation near operator's station must be removed. Contact with trees, shrubs, or weeds during electrical strike could result in electrocution.

Mark Bore Path



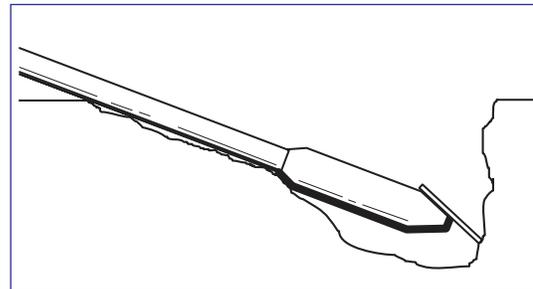
Mark your planned bore path and all located utility lines with flags or paint.

Prepare Entry Point

For bore to be successful, first pipe must be straight as it enters the ground.

To help ensure that the first pipe does not bend, dig a small starting hole so that the first pipe is drilled into a vertical surface.

To prevent bending or straining pipe, position drilling unit for straight entry.



j07om011c.eps

Check Supplies and Prepare Equipment

Check Supplies

- receiver/transmitter or tracker with spare batteries
- beacons with new and spare batteries
- two-way radios with new and spare batteries
- quick wrench (see page 129)
- transition sub
- anchoring equipment and accessories
- bits, screens, nozzles (see page 124)
- adapters, pipe, beacon housings
- marking flags or paint
- water and additional hoses
- fuel
- drilling fluid additives (see page 116)
- spare fuses
- keys
- backreamers, swivels, pulling devices (see page 124)
- wash down hose and spray gun
- duct tape
- spray lubricant
- tool joint compound (see page 157)
- electrically insulating boots and gloves
- personal protective equipment, such as hard hat and safety glasses
- notepad and pencil

Prepare Equipment

Fluid Levels

- fuel
- hydraulic fluid
- engine coolant
- battery charge
- engine oil

Condition and Function

- filters (air, oil, hydraulic)
- fluid pump
- couplers
- tires and tracks
- pumps and motors
- drilling fluid mixer
- hoses and valves
- water tanks



Assemble Accessories

Fire Extinguisher

If required, mount a fire extinguisher near the power unit but away from possible points of ignition. The fire extinguisher should always be classified for both oil and electric fires. It should meet legal and regulatory requirements.

Drive

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Start Unit

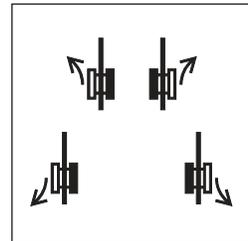
1. Insert key.
2. Turn key clockwise. See page 21 for more information.
3. Run engine at low throttle for 5 minutes.

Steer Unit

To steer drilling unit while using tethered ground drive controller, follow instructions for type of steering desired.

To steer while moving forward, push forward and then move to left or right. Drilling unit will gradually turn to left or right.

To steer while moving backward, pull back and then move to left or right. Drilling unit will gradually turn to left or right.



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For tight steering in low speed, move control to center position and then to a corner. Tracks will counter-rotate and turn drilling unit in a tight circle.

Shut Down Unit

1. Stop track movement.
2. Lower drill frame and stabilizers to the ground.

IMPORTANT: If frame and stabilizers cannot be lowered, use cylinder locks or other suitable material to block the tracks. Remove cylinder locks or chocks before driving unit.

3. Run engine at low throttle for 3 minutes to cool.
4. Turn key to STOP.
5. Remove key.

Transport

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- Unhitch Trailer84

Tow **85**



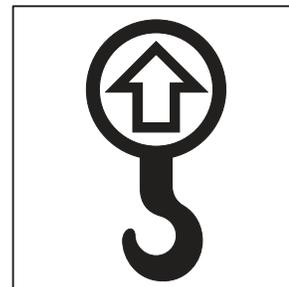
Lift



WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

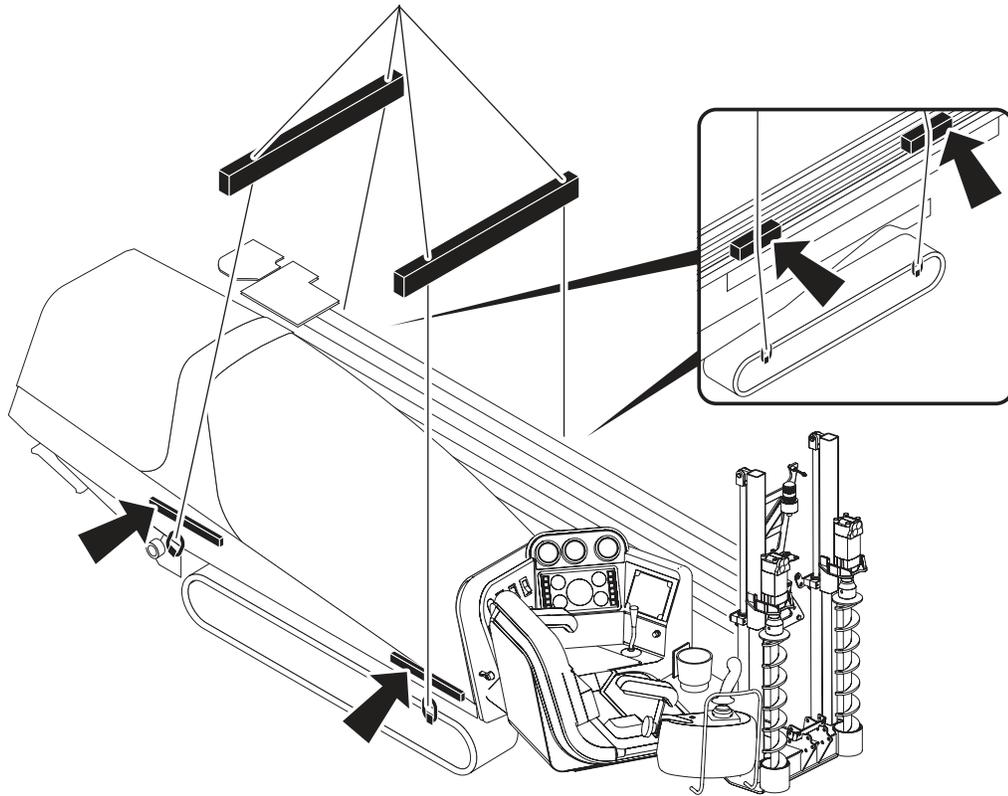
Points

Lifting points are identified by lifting decals. Lifting at other points is unsafe and can damage machinery.



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Procedure



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Use a crane capable of supporting the equipment's size and weight. See "Specifications" on page 185 or measure and weigh equipment before lifting.

1. Attach chains to four lift points (two on each side of drilling unit).
2. Install spacer blocks (shown) between the chain and the drilling unit as shown above.
3. Attach each chain securely to cross members.

IMPORTANT: Length of spreader bars should be equal to width of drilling unit.

4. Bring chains together to a central pull point.



Haul

Inspect Trailer

- Check hitch for wear and cracks. Lubricate if needed.
- Check u-bolts and axles for wear. Replace if needed.
- Check fasteners for wear and tightness. Replace or tighten if needed.
- Check battery for 12V charge.
- Inspect lights for cleanliness and correct operation. Inspect reflectors and replace if needed.
- Check tire pressure. Check lug nut tightness with a torque wrench. Adjust if needed.
- Ensure trailer brakes are adjusted to come on in synchronization with tow vehicle brakes.
- Check ramps and trailer bed for cracks.

Hitch Trailer

1. Back tow vehicle to trailer.
2. Put manual transmission into first or reverse gear or automatic transmission into park. Turn off ignition. Set parking brake.
3. Connect trailer drawbar, lunette or coupler to tow vehicle hitch and lock in place with lock pin. If needed, adjust drawbar, lunette or coupler height to level load.
4. Connect safety chains to tow vehicle.
5. Connect breakaway switch cable to tow vehicle. Do not connect to pintle hook or hitch ball.
6. Plug trailer electrical connector into tow vehicle connector.
7. Use jack crank to raise jack base and stow.
8. Remove wheel blocks.

Load



WARNING

Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

- Load and unload trailer on level ground.
- Verify that trailer wheels are blocked.
- Incorrect loading can cause trailer swaying.
- Attach trailer to vehicle before loading or unloading.
- Ten to fifteen percent of total vehicle weight (equipment plus trailer) must be on tongue to help prevent trailer sway.

With Tiedown Kit

1. Start drilling unit engine.
2. Move drilling unit to rear of trailer and align with ramps.
3. Slow engine to low throttle and slowly drive unit onto trailer until track reaches chock.
4. Lower drill frame to drill frame rest.
5. Back unit until front of drill frame is seated in rest.
6. Lower stabilizers to trailer floor.
7. Stop engine.
8. Attach tiedowns at rear of unit where indicated on page 82.



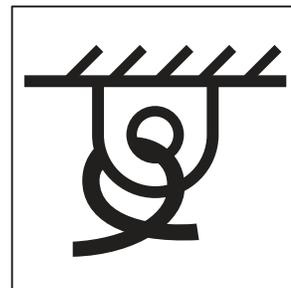
Without Tiedown Kit

1. Start drilling unit engine.
2. Move drilling unit to rear of trailer and align with ramps.
3. Slow engine to low throttle and slowly drive unit onto trailer.
4. Lower stabilizers to trailer floor.
5. Lower drill frame to trailer floor.
6. Stop engine when unit is safely positioned on trailer bed.
7. Attach tiedowns to drilling unit where indicated on page 82.

Tie Down

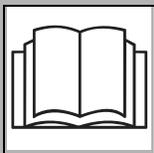
Points

Tiedown points are identified by tiedown decals. Securing to trailer at other points is unsafe and can damage machinery.



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Procedure

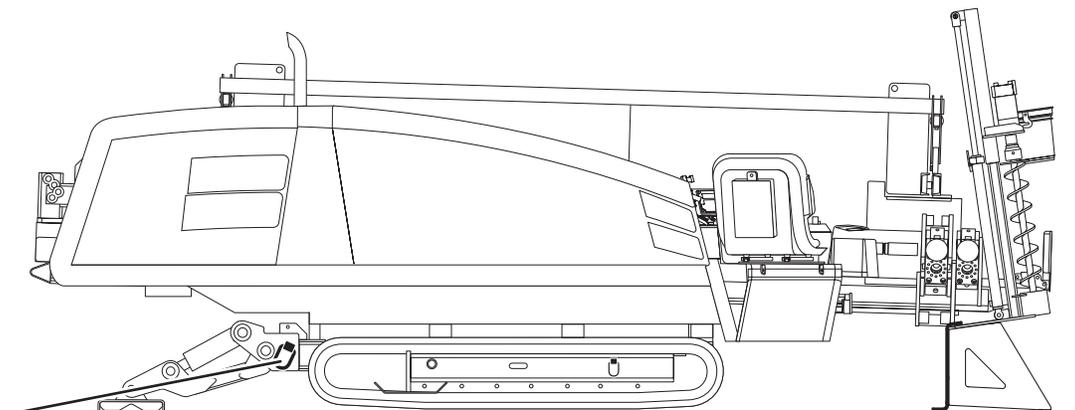


⚠ WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE: Wrenches can open after engine shutdown. Ensure that any downhole tool or pipe in tool joint vises is attached to spindle or removed before transport.

With Tiedown Kit

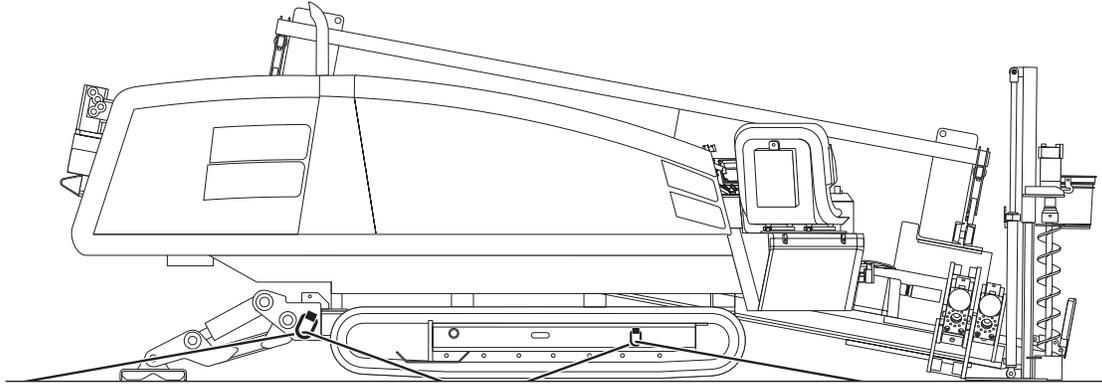
Loop tiedowns around rear tiedown points. Make sure tiedowns are tight before transporting.



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Without Tiedown Kit

Loop tiedowns around unit at tiedown points. Make sure tiedowns are tight before transporting.



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Unload



WARNING Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

NOTICE:

- Load and unload trailer on level ground.
- Ensure trailer wheels are blocked.
- Attach trailer to vehicle before loading or unloading.

With Tiedown Kit

1. Lower ramps.
2. Remove tiedowns.
3. Start drilling unit engine.
4. Raise stabilizers.
5. Move drilling unit forward until track meets chock.
6. Raise drill frame.
7. Slow engine to low throttle and slowly back unit down trailer or ramps.

Without Tiedown Kit

1. Lower ramps.
2. Remove tiedowns.
3. Start drilling unit engine.
4. Raise stabilizers.
5. Raise drill frame.
6. Slow engine to low throttle and slowly back unit down trailer or ramps.

Unhitch Trailer

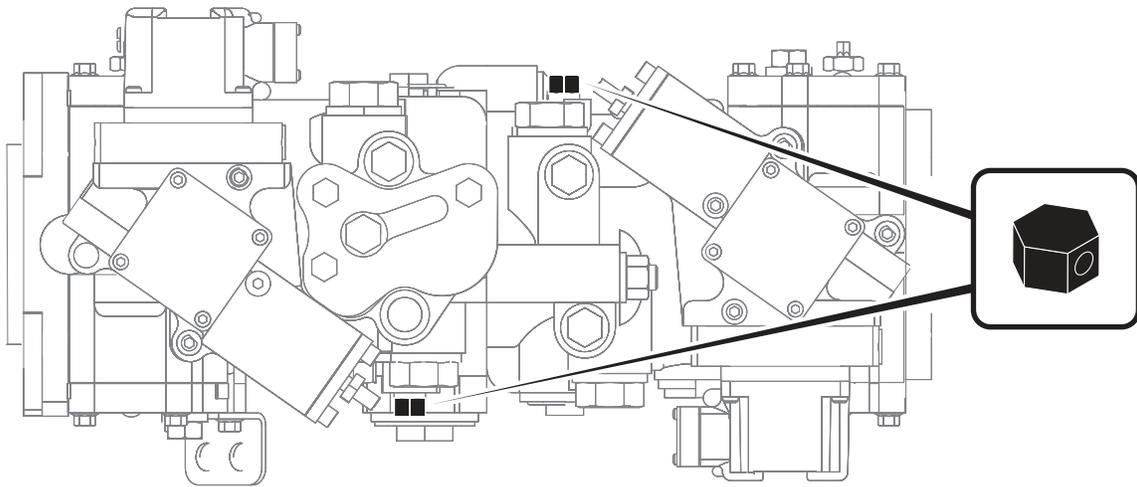
1. Stop tow vehicle and trailer on level ground.
2. Put manual transmission into first or reverse gear or automatic transmission into park. Turn off ignition. Set parking brake.
3. Block trailer wheels.
4. Reverse "Hitch Trailer " steps to unhitch trailer from tow vehicle.

Tow

Under normal conditions, drilling unit should not be towed. If unit breaks down and towing is necessary:

- Attach chains to indicated tow points facing towing vehicle.
- Open bypass valves.
- Open selector valves.
- Tow for short distances at less than 1 mph (1.6 km/h).
- Use maximum towing force of 1.5 times unit weight.

To open bypass valves for towing, rotate valve stems (shown) two full revolutions.



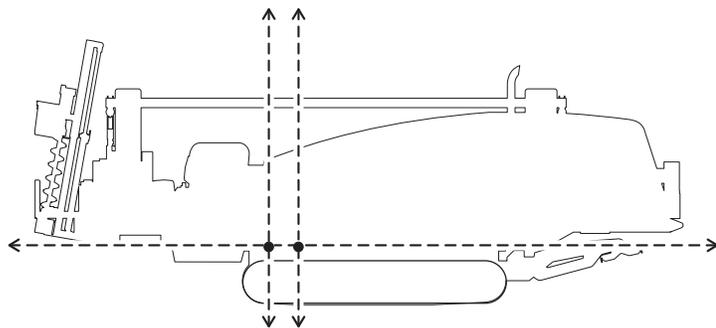
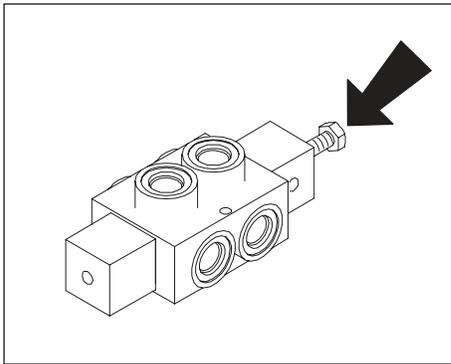
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NOTICE: Do not open valves more than two turns.

To close bypass valves and return to normal operation, torque valve stems (shown) to 7-10 ft•lb (9.5-14 N•m).

NOTICE: Do not over-tighten bypass valves.

To open selector valves for towing, loosen jam nut and tighten valve screw (shown) until it is fully threaded.

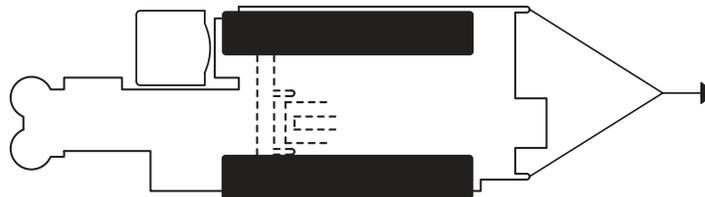


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To close selector valves and return to normal operation, unthread valve screw and tighten jam nut.

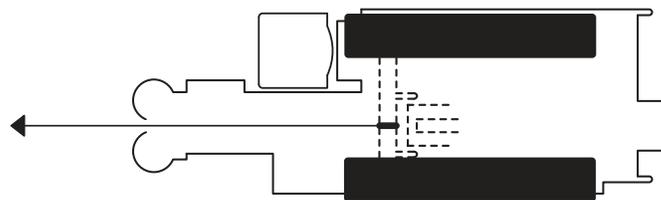
To attach chains to tow points, determine which points are facing towing vehicle.

If **back** tow points are facing towing vehicle, loop chains through each tow point and bring them together to a central pull point.



j10om077h.eps

If **front** tow points are facing towing vehicle, loop chain through tow point and pull straight forward.



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Conduct a Bore



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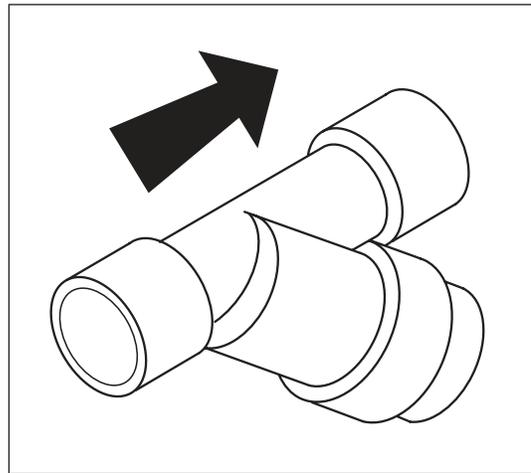
Position Equipment

1. Review bore plan and select drilling unit position and fluid unit position. See "Select Start and End Points" on page 63.
2. Move equipment into selected positions.

Connect Fluid System

1. Connect fluid hose from mixing system to drilling fluid pump. A 1.5" (38 mm) or larger, non-collapsible hose is required.
2. Install y-strainer between mixing unit and drilling fluid pump. Position strainer so that drilling fluid flows in the direction of the arrow. In most cases, positioning strainer at outlet of mixing unit gives best results.

IMPORTANT: Clean y-strainer regularly. See page 166.



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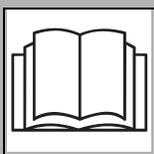
Start System

1. Start drilling unit and remote fluid unit. Allow both engines to warm up.

IMPORTANT: Ensure that mixture of drilling fluid matches drilling conditions.

2. Enable tracker control mode if desired. See "Tracker Control" on page 121.
3. Press top of drilling unit throttle switch until engine is at full throttle. If you do not want to use autothrottle mode, return switch to center position.
4. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.

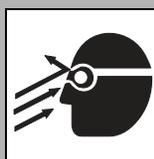
Prime Drilling Fluid Pump



WARNING

Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE: Failure to prime the drilling fluid pump will cause flow fluctuations, which will make it difficult to control the washwand.



WARNING

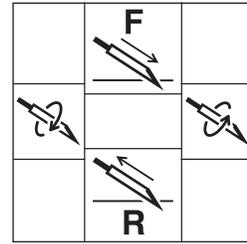
Pressurized fluid or air could pierce skin and cause injury or death. Stay away.

Prime drilling fluid pump each time tank is changed. To prime the pump:

1. Fill drilling fluid hose and connect hose to unit.
2. Operate mixing/transfer pump at full speed for 1 - 3 minutes to discharge air from system.
3. Return mixing/transfer pump to normal operating speed and continue the bore.
4. If drilling fluid pressure surges are observed, repeat step 2.

Operate Carriage Control

The thrust/rotation control has eight positions which allow the four basic functions to be combined. The chart below summarizes functions that occur when control is put at a combined position. Operator must be in seat for control to function.



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Carriage Movement	Rotation Direction	
forward	clockwise (makeup)	 ic1102a.eps
reverse	counterclockwise (breakout)	 ic1104a.eps

Clamp Pipe



⚠ DANGER

Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE: Clamping anywhere else on the pipe will weaken the pipe. Pipe can later break, even when operating under normal loads.

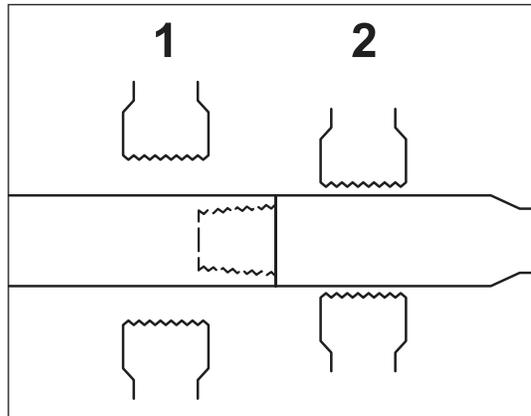


⚠ WARNING

Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

NOTICE: Wrenches can open after engine shutdown. Ensure that any downhole tool or pipe in tool joint vises is attached to spindle or removed before transport.

Clamp on pipe when joint is centered between wrenches (1 and 2). Always clamp on the larger diameter areas on either side of the tool joint face.



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Assemble Drill String

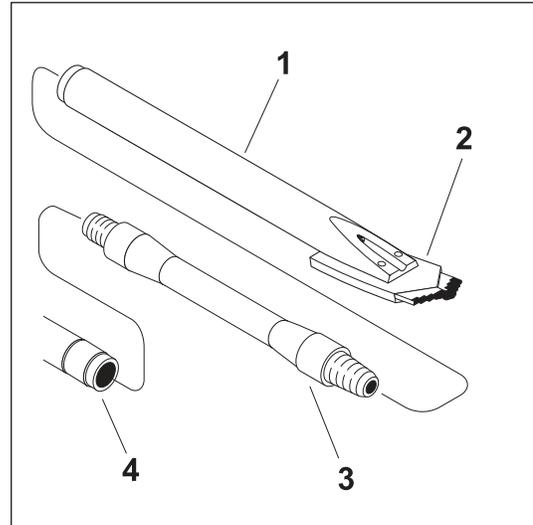


Prepare Beacon Housing

1. Select nozzles and bit.

IMPORTANT: A variety of nozzles and bits are available to suit your particular job conditions. See "Downhole Tools" on page 124 for more information, or contact your Ditch Witch dealer.

2. Insert nozzle into beacon housing.
3. Attach bit (2) to beacon housing (1).
4. Install beacon, following beacon instructions for:
 - battery replacement
 - beacon positioning
5. Install beacon housing lid. See "Beacon Housings" on page 125.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.



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Attach Transition Sub

Use either machine torque or quick wrench to attach transition sub (2) to beacon housing (1).

Machine Torque

1. Pull transition sub into front wrench.
2. Close wrench.
3. Lube joints.
4. Slowly make up joint.
5. Use full machine torque to tighten joint fully.

Quick Wrench

1. Lube joints with TJC.
2. Attach quick wrench to the joint in the join position and tighten joint. See "Quick Wrench" on page 129.

Connect Drill Pipe

1. Start drilling unit engine.
2. Align transition sub (3) in front wrench.
3. Clamp tool in front wrench. See "Clamp Pipe" on page 92.
4. Load pipe (4).
 - Make sure pipe box is positioned correctly.
 - Close grippers.
 - Lubricate upper pipe threads.
 - Move pipe to spindle. Verify that lower threads were lubricated as pipe moved to spindle.
 - Raise pipe in box.
5. Connect pipe.
 - Move carriage forward until saver sub nears male pipe thread.
 - Slowly rotate spindle clockwise. Carriage will move forward as threads screw together.
 - Slowly move carriage forward until pipe end touches end of transition sub.
 - To screw pipes together and fully torque joint, slowly rotate drill pipe until spindle stops turning.
 - Open wrench.
 - Open grippers.
 - Retract shuttles fully.
 - Lower pipe lifters.
6. Close guides.

Drill First Pipe



⚠ DANGER

Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE:

- Keep everyone at least 10' (3 m) away from turning drill string.
- Push rod or pipe slowly. Forcing can bend string. Do not use bent rod or pipe.



⚠ WARNING

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

1. Turn on drilling fluid.
2. Visually check for drilling fluid flow.
3. Turn drill bit to starting position. See "Prepare Entry Point" on page 71.
4. Slowly move carriage forward. Drill in downhole tools and 1/3 of first pipe before steering.
5. Monitor gauges.

Enable Automated Pipeloader System

Add Pipe	Remove Pipe
<ol style="list-style-type: none"> 1. Make sure pipe box is properly positioned. See "Shift Pipe Box" on page 135. 2. Open front wrench, retract shuttles, and grip pipe for add pipe function to work. 3. Press top of add pipe/manual/remove pipe switch. Green control cycle light will come on. 4. Grippers will open, pipe will be lowered, and then green control cycle light will flash. 	<ol style="list-style-type: none"> 1. Make sure pipe box is properly positioned. See "Shift Pipe Box" on page 135. 2. Open front wrench, retract shuttles, and grip pipe for remove pipe function to work. 3. Press bottom of add pipe/manual/remove pipe switch. Green control cycle light will come on. 4. Grippers will open, pipe will be lowered and lifted off shuttles, and then green control cycle light will flash.

IMPORTANT: If you leave the seat **during** an add or remove pipe cycle, switch to manual control and finish pipe cycle. Then switch back to add pipe or remove pipe. If you leave the seat **between** add or remove pipe cycles, re-enabling system is not needed.

IMPORTANT: If gripper switch is not in the grip position when using optional pipeloader automation, grippers will open when automation is stopped and gripped pipe could be dropped. To return a dropped pipe to the drill string, see "Correct Dropped Pipe" on page 135.



Add Pipe

IMPORTANT: If gripper switch is not in the grip position when using optional pipeloader automation, grippers will open when automation is stopped and gripped pipe could be dropped. To return a dropped pipe to the drill string, see "Correct Dropped Pipe" on page 135.

1. Press top of drilling unit throttle switch until engine is at full throttle.
2. Enable automated pipeloader system (automated pipeloader control only). See "Enable Automated Pipeloader System" on page 96.
3. Break joint at saver sub.

Manual Pipeloader Controls	Automated Pipeloader Control
<ul style="list-style-type: none"> • Clamp pipe joint. See "Clamp Pipe" on page 92. • Locate drill head. • Engage front wrench until pipe is clamped and pressure develops. • Slowly rotate spindle counterclockwise. Carriage will move back automatically as threads unscrew. • After threads are fully unscrewed, stop rotation and move carriage to back of frame. 	<ul style="list-style-type: none"> • Clamp pipe joint. See "Clamp Pipe" on page 92. • Locate drill head. • Engage front wrench until pipe is clamped and pressure develops. • Slowly rotate spindle counterclockwise. Carriage will move back automatically as threads unscrew. • After threads are fully unscrewed, stop rotation and move carriage to back of frame. • While carriage is moving, green control cycle light will come on. Grippers will grip, pipe will be lubed, and then green control cycle light will flash.

4. Load pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
<ul style="list-style-type: none"> • Make sure lift arms are completely lowered. • Close grippers. • Lube upper pipe threads. • Move pipe to spindle and lube lower threads. • Raise pipe in box. 	<ul style="list-style-type: none"> • When carriage is moved to back of drill frame, press resume switch. Green control cycle light will come on. • Pipe will be moved to spindle, front threads will be lubed, pipe in box will be lifted, and then green control cycle light will flash.



5. Connect pipe to saver sub.

IMPORTANT: Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will unscrew joints.

- Move carriage forward until saver sub meets pipe.
- Slowly rotate spindle clockwise. Carriage will move forward automatically as threads screw together.

6. Connect new pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
<ul style="list-style-type: none"> • Slowly move carriage forward until pipe ends touch. • To screw pipes together and fully torque joint, slowly rotate pipe until spindle stops turning and full pressure is developed. • Open wrench. • Open grippers. • Retract shuttles fully. • Lower pipe lifters. 	<ul style="list-style-type: none"> • Slowly move carriage forward and rotate spindle until pipe screws together. • To screw pipes together and fully torque joint, slowly rotate pipe until spindle stops turning and full pressure is developed. • Open wrench. • Press resume. Green control cycle light will come on. • Grippers will open, shuttles will retract, pipe lifters will lower, and then green control cycle light will flash.

7. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.
8. Rotate spindle.
9. Slowly move carriage forward. Adjust rotation speed control according to bit size and soil conditions.
10. Engage and set cruise control as desired. See "Cruise Control" on page 140.
11. Monitor gauges.
12. Locate drill head with tracker at least every half-length of pipe.

Correct Direction



Correcting direction is a skill operators gain with experience and knowledge of equipment and soil conditions. These instructions cover only basic procedures. For information about specific equipment or jobsites, contact your Ditch Witch dealer.

To track progress and make corrections, one crew member locates the drill head and sends instructions to the operator. Corrections are made by tracking the drill head, comparing current position to bore plan, and steering drill head as needed.

Basic Rules

- Steering ability depends on soil condition; bit, drill head, and nozzle used; roll of drill head; and distance pushed without outer rotation.
- All corrections should be made as gradually as possible. See “Recommended Bend Limits” on page 67.
- Over correcting will cause “snaking.” This can damage pipe and will make drilling and pullback more difficult. Begin to straighten out of each correction as early as possible.
- Do not push an entire piece of drill pipe into ground without rotation. This can exceed bend radius and cause pipe failure.

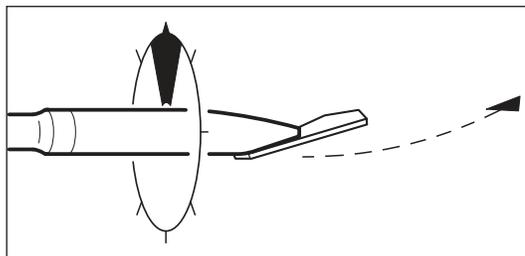
Procedure

1. Locate drill head. Take readings available with your beacon and locating equipment such as:
 - depth
 - pitch
 - left/right information
 - temperature
 - beacon roll
2. Compare position to bore plan. Determine direction drilling should go.
3. Position drill head.
4. Push in drill pipe as needed to change direction.
5. Rotate in remaining length of drill pipe.

Drill Head Position

The drill head position is determined by reading beacon roll. Roll is displayed as a clock face position.

1. Read beacon roll.
2. Slowly rotate pipe until locator displays desired beacon roll.



j07om048c.eps

To change direction:

1. Rotate pipe to clock position you intend to travel.
2. Push pipe into ground.

To move forward without changing direction:

Rotate pipe into ground.

Record Bore Path

Locate drill head every half-length of pipe. As the job is completed, record the actual data for each drill pipe. List pitch and depth of each joint and a brief description of the procedure. In addition, draw a simple sketch of the site and record depth and rough location of pullback.

The Trac Management System Plus is also available for plotting and tracking your bore path. It utilizes the Subsite 750 Tracker, 750 Display, a tracking beacon, and special software. The display can store jobs in its memory or the system can be run in the field using a laptop computer equipped with the Windows® 95 or higher operating system. See your Ditch Witch dealer for details.

Surface Drill Head



⚠ DANGER

Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

1. Guide drill head to target pit or up through surface. Make all bends gradual. See "Recommended Bend Limits" on page 67.
2. Clean area around exit point.
3. If using tracker control mode, tracker operator turns off tracker to disable drilling unit thrust/pullback and rotation hydraulics. Tracker operator waits for green light to enter pit and change tools.

If not using tracker control mode, tracker operator signals to drilling unit operator to stop engine before changing downhole tools.

4. Turn fluid flow control to off position as soon as drill head emerges.
5. Clean drill head especially around threads.
6. Disconnect EZ-Connect joint or use quick wrench to remove drill head. Keep threads clean. See "Quick Wrench" on page 129.

Assemble Backream String


⚠ DANGER

Turning shaft will kill you or crush arm or leg. Stay away.

NOTICE: Keep everyone away from material being installed.


⚠ DANGER

Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.


⚠ WARNING

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

NOTICE: Continue to use strike system during backreaming.

1. Select backreaming devices. See "Backreamers" on page 126.
2. Determine fluid rate requirements and install appropriate nozzles to provide sufficient flow. See "Backream Fluid Requirements" on page 127 and "Nozzles" on page 124.
3. Attach backreamer to backream beacon housing if tracking backream.
4. Install beacon, following beacon instructions for:
 - battery replacement
 - beacon positioning
5. Install beacon housing lid. See "Beacon Housings" on page 125.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.
8. Connect EZ-Connect joint or use quick wrench to attach backreamer/beacon housing assembly to transition sub. See "Quick Wrench" on page 129.
9. Attach additional pullback devices or product to end of backreamer/beacon housing assembly.

Remove Pipe



IMPORTANT: If gripper switch is not in the grip position when using optional pipeloader automation, grippers will open when automation is stopped and gripped pipe could be dropped. To return a dropped pipe to the drill string, see "Correct Dropped Pipe" on page 135.

NOTICE: If engine is shut off during backreaming, drill pipe clamped by wrenches but not connected to saver sub can be pulled downhole as vise wrenches loosen.

1. Enable automated pipeloader system (automated pipeloader control only). See page 96.
2. Stop carriage when pipes are aligned in wrenches.
3. Clamp pipe in front wrench. See page 92.
4. Clamp and rotate rear wrench to break front joint. See "Wrench control" on page 25.
5. Disengage rear wrench.
6. Grip pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
<ul style="list-style-type: none">• Open grippers.• Lift pipe off shuttles.• Extend shuttles to spindle position.• Close grippers.• Lower lifters.	<ul style="list-style-type: none">• Press resume. Green control cycle light will come on.• Shuttles will extend, grippers will grip, pipe lifters will lower, and then green control cycle light will flash.

7. Unscrew front joint.
 - Slowly rotate spindle counterclockwise to unscrew pipe. Carriage will move back automatically until threads unscrew.
 - Move carriage back until pipe is properly positioned in rear wrench.



8. Break rear joint.
 - Engage rear wrench.
 - Slowly rotate spindle counterclockwise until joint is loosened. **Do not** fully unscrew joint.
 - Disengage rear wrench.
 - Move carriage back until front end of pipe is positioned inside front end of pipe box.
 - Rotate spindle counterclockwise until saver sub is unscrewed from pipe.
 - Stop rotation and move carriage to back of frame.
9. Ensure pipe box is positioned correctly.
10. Load pipe into pipe box.

Manual Pipeloader Controls	Automated Pipeloader Control
<ul style="list-style-type: none"> • Move shuttle under pipe box. • Release grippers and raise lift arms to place pipe in box. • Lube front threads. 	<ul style="list-style-type: none"> • Press resume. Green control cycle light will come on. • Shuttles will retract, front threads will be lubed, grippers will release pipe, pipe lifters will raise until pipe is off shuttles, and then green control cycle light will flash.

11. Attach saver sub to next pipe.
 - Move carriage forward until saver sub touches pipe.
 - Rotate spindle to screw onto pipe. Slowly tighten joint to full machine torque.
12. Disengage front wrench to release pipe.

Remove Pullback Device



The pullback device can be removed when the last pipe is on the frame. It can also be removed when a target pit along the bore path has been reached. Remaining pipe is then pulled back and removed.



⚠ DANGER

Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.

1. Press bottom of drilling unit throttle switch until engine is at low throttle.
2. Turn off drilling fluid.
3. Turn drilling unit engine off.
4. Clean pullback device.
5. Use quick wrench to remove pullback device. See "Quick Wrench" on page 129.

Systems and Equipment

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Anchor System



WARNING

Crushing weight. If load falls or moves, it could kill or crush you. Use proper procedures and equipment or stay away.



NOTICE:

- Drive anchors properly before drilling.
- Stand on platform when operating anchor controls.
- Wear high-top protective boots with legs of pants completely tucked inside.
- Wear protective gloves.
- If you are not driving two anchors to full depth, drive optional ground rod into soil away from drilling unit and connect ground rod to drilling unit.



DANGER

Turning shaft can kill you or crush arm or leg. Stay away.

NOTICE: Do not replace anchor collar bolt with one longer than original. Clothing could catch on turning shaft.

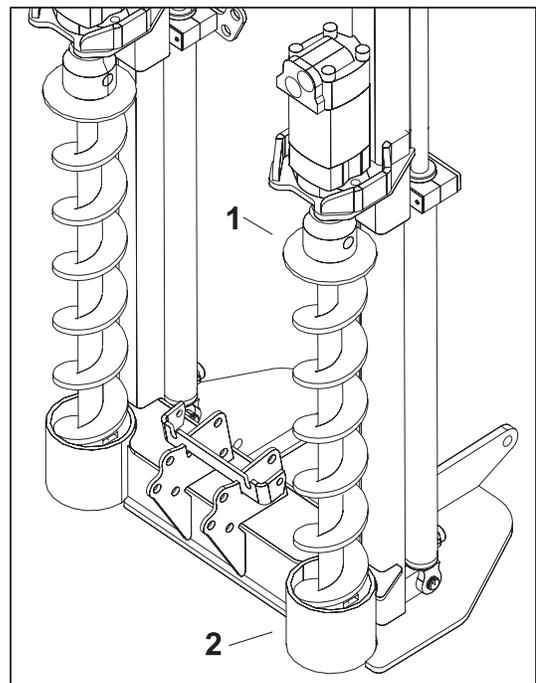
Drive Anchors

IMPORTANT: Carefully time anchor rotation with anchor movement. Properly driven anchors should not auger up soil.

1. Use anchor rotation and thrust controls to drive anchor into ground.
2. Anchor is set when cap (1) rests firmly on centering tube (2).
3. Repeat process for other anchor.

Remove Anchors

1. Use anchor rotation and thrust controls to slowly remove anchor shaft from ground.
2. Repeat process for other anchor.



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Electric Strike System

Any time you drill in an electric jobsite, electric strike system must be properly set up, tested, and used. You must wear protective boots and gloves meeting the following standards:

- Boots must have high tops and meet the electric hazard protection requirements of ANSI Z-41, 1991, when tested at 14,000 volts. Tuck legs of pants completely inside boots.
- Gloves must have 17,000 AC maximum use voltage, according to ASTM specification D120-87.

If working around higher voltage, use gloves and boots with appropriately higher ratings.

NOTICE: The strike system does not prevent electric strikes or detect strikes before they occur. **If alarms are activated, a strike has already occurred** and equipment is electrified.

Read and follow “Electric Jobsite Precautions” on page 65. Review safety procedures before each job.

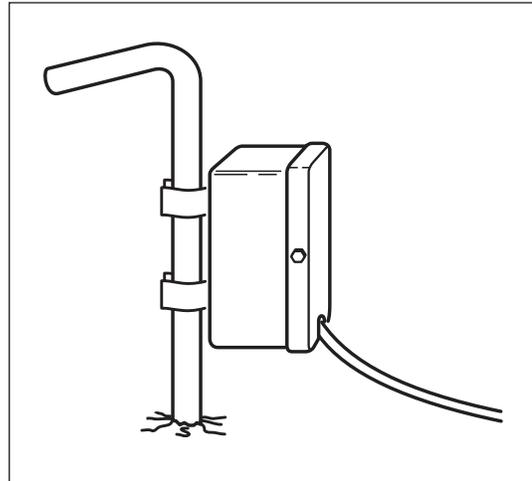
FCC Statement

The Electric Strike System has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, can cause harmful interference to radio communications. Operation of this equipment in a residential area could cause harmful interference which the user will be required to correct at his own expense.

Changes or modifications not expressly approved in writing by The Charles Machine Works, Inc. may void the user's authority to operate this equipment.

Assemble Voltage Detector

1. Drive voltage stake into ground at least 6' (2 m) away from any part of system.
2. Clip voltage limiter to voltage stake.



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Test Strike System

If system fails any part of this test, see "Troubleshoot Strike System" on page 112 on the following page. Do not drill until test is completed successfully.

1. Turn on drilling unit.
2. ESID control module will perform internal tests which check everything but alarms and strobe.
3. If green OK indicator and electrical power supply indicator lights remain on, press self test button to perform total test of strike system. During this test:
 - All lights should glow.
 - Alphanumeric readout should display numbers.
 - Alarms and strobes on all connected units should sound.
4. If this test is successful, OK indicator and electrical power supply indicator lights will remain on.
5. Use Electric Strike Simulator to test voltage and current sensors. See page 114.

Troubleshoot Strike System

When strike system detects a problem, an error code will be displayed. Anytime this happens, press self test button to retest. If error code is still displayed and does not appear in this chart, have control module checked or replaced.

Other problem situations and their possible causes and solutions are listed in the chart below.

Problem	Possible cause	Possible solution
No lights or readings showing after drilling unit key has been on at least one minute	Problems in startup	Push self test button. If problem goes away, retest strike system
	No power to strike system control module	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
	Check that cable from drilling unit carries more than 10V	
	Defective control module	Have control module checked or replaced
Screen is blank	Strike system is not getting adequate power from drilling unit	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
		Check that harness from drilling unit carries more than 10V
	Defective control module	Have control module checked or replaced
Information on screen is visible during self test but not after test is complete	LCD contrast is not set properly	Contact your Ditch Witch dealer to adjust contrast
OK indicator is on, but electrical power supply indicator is off	Strike system is not getting adequate power from drilling unit	Check drilling unit electric system
		Check that harness from drilling unit to control module is connected
		Check that harness from drilling unit carries more than 10V
	Defective control module	Have control module checked or replaced
Electrical power supply indicator is on, but OK indicator is off	Problem detected during test	Check for error code and have control module checked or replaced
	Defective control module	Have control module checked or replaced

Problem	Possible cause	Possible solution
Strobe light on drilling unit does not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective strobe light	1. Disconnect strobe and connect to external 12V power source. 2. If strobe does not work, replace it.
	Defective control module	Have control module checked or replaced
Alarm on drilling unit does not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective alarm	1. Disconnect strobe and connect to external 12V power source. 2. If strobe does not work, replace it.
	Defective control module	Have control module checked or replaced
Strobe light and alarm on drilling unit do not work during total test	Improper connections with control module	Check connections and wiring harness
	Defective control module	Have control module checked or replaced
EC2 code displays and current problem indicator is on	Improper connections with control module	Check cable connections on control module and current transformer
	Defective current transformer	1. Disconnect current transformer. 2. Check for 20-40 ohms from pin 1 to pin 4, 20-40 ohms from pin 1 to pin 2, and less than 1 ohm from pin 2 to pin 4.
	Defective current transformer cable	1. Disconnect cable from transformer and control module. 2. Check continuity of cable. 3. If continuity is zero or cable is damaged, replace.
	Defective control module	Have control module checked or replaced
EV1 code displays and voltage problem indicator is on	Improper connection of voltage limiter to ground stake	Check voltage limiter connection to ground stake and verify that ground stake is driven into the ground
	Defective voltage limiter	Have voltage limiter checked or replaced
	Defective control module	Have control module checked or replaced



Problem	Possible cause	Possible solution
EV2 code displays and voltage problem indicator is on	Improper connections with control module	Check cable connection on control module
	Defective voltage limiter	Have voltage limiter checked or replaced
	Defective control module	Have control module checked or replaced

Use Electric Strike Simulator

Use the Electric Strike Simulator (p/n 259-506) to test voltage and current sensors on ESID. If readings are less than indicated here, replace 9V battery in simulator and retest.

Current Test

To test for current at normal levels:

1. Thread one lead wire through current transformer.
2. Clip ends of lead wires together to make one loop.
3. Move simulator switch to "current" and press test button.
4. Watch screen and lights above display on strike system.
 - Three or four lights should turn on.
 - Current "A" should show 30-50% in display.

To test for current at strike levels:

1. Put two or three loops through current transformer.
2. Follow steps above to test.
3. Display should show the following:
 - All lights should turn on.
 - Alarm and strobe should turn on.

With two loops,

- Current "A" should be 80-110%.
- Strike indication might go on and off.

With three loops,

- Current should be 130-160%.
- Strike indication should be continuous.



Voltage Test

1. Place voltage limiter on something insulated from ground and drilling unit (such as dry board or tire), but near frame of drilling unit.
2. Clip one lead to frame.
3. Clip other lead to one voltage limiter mount.
4. Move simulator switch to "voltage" and press test button.
5. Watch screen and lights above display on strike system.
 - All lights should turn on.
 - Alarm and strobe should turn on.
 - Voltage "V" should show 90-110%.

It is normal for simulator voltage levels to drift below strike level. When this happens, light in triangle should go off and alarm and strobe should stop working. If the level drifts above strike level again, light, alarm, and strobe should be turned on again.

Drilling Fluid

For productive drilling and equipment protection, use these recommended Baroid® products, available from your Ditch Witch dealer.

- Soda ash
- Quik-Gel™ dry powder bentonite (p/n 259-804)
- E-Z Mud™ liquid polymer (p/n 259-805)
- Liqui-Trol™ liquid polymer suspension (p/n 259-808)
- Quik-Trol™ dry powder polymer (p/n 259-809)
- Bore-Gel™ drilling fluid (p/n 259-807)
- Con-Det™ water-soluble cleaning solution (p/n 259-810)

Guidelines

Match drilling fluid to soil type. This chart is meant as a guideline only. See your local Ditch Witch dealer for soil conditions and drilling fluid recommendations for your area. Also see our interactive Drilling Fluid Formulator at www.ditchwitch.com.

Soil type	Drilling fluid recommendation
smooth, flowing sand	bentonite or Bore-Gel + medium chain polymer
coarse sand or light soil	bentonite or Bore-Gel
heavy clay	long chain polymer + Con-Det
swelling clay	long chain polymer + Con-Det
rock	Bore-Gel

Polymer

This drilling fluid additive provides excellent lubrication and increases viscosity in average soils and heavy clay. In swelling clay, polymer can reduce swelling that traps pipe in the bore.

There are two types of polymer:

- long chain such as Baroid EZ-Mud
- medium chain such as Baroid Quik-Trol

Bentonite

Bentonite is a dry powder. When properly mixed with water, it forms a thin cake on bore walls, lubricating the bore, keeping it open, and holding fluid in the bore.

Some things to remember when mixing bentonite:

- Use clean water free of salt, calcium, or excessive chlorine.
- Use water with pH level between 9 and 10.
- Use water with hardness of less than 120 ppm.
- Do not use bentonite containing sand.
- Mix bentonite thoroughly or it will settle in tank.
- Do not mix bentonite to a funnel viscosity of over 50.

For information on measuring funnel viscosity, see "Funnel Viscosity" on page 120.

Mixtures

Bentonite does not mix well in water containing polymer. To use both, mix bentonite first, then add polymer. When adding other products follow the order listed below.

NOTICE:

- If chemicals are added in the wrong order, they will not mix properly and will form clumps.
- If tank contains bentonite/polymer mix and more drilling fluid is needed, completely empty tank and start with fresh water before mixing another batch.

General mixing order:

1. Soda ash
2. Bentonite
3. Polymer
4. Con-Det

Bore-Gel contains premixed bentonite, polymer, and soda ash. Use approximately 15 lb/100 gal (7 kg/380 L) in normal drilling conditions, up to 45 lb/100 gal (21 kg/380 L) in sand or gravel and up to 50 lb/100 gal (23 kg/380 L) in rock.



Basic Fluid Recipes

Soil type	Mixture/100 gal (378 L) of water	Notes
fine sand	35 lb (16 kg) Bore-Gel	
coarse sand	35 lb (16 kg) Bore-Gel .5 lb (225 g) No-Sag	Add .5 lb (225 g) of Quik-Trol for additional filtrate control
fine sand below water table	40 lb (18 kg) Bore-Gel .75 lb (340 g) Quik-Trol	Add .5 - 1 gal (2-4 L) of Dinomul in high torque situations
coarse sand below water table	40 lb (18 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 - 1 gal (2-4 L) of Dinomul in high torque situations
gravel	50 lb (23 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 lb (225 g) of Barolift to reduce loss of returns
cobble	50 lb (23 kg) Bore-Gel .75 lb (340 g) Quik-Trol .75 lb (340 g) No-Sag	Add .5 lb (225 g) of Barolift to reduce loss of returns
sand, gravel, clay or shale	35 - 40 lb (16-18 kg) Bore-Gel .5 pt (235 mL) EZ-Mud .5 gal (2 L) Con-Det	Vary mixture according to percentage of sand and clay
clay	.5 lb (225 g) Poly Bore .5 gal (2 L) Con-Det	Flow rate should be 3-5 parts fluid to 1 part soil. May use .25 - .5 gal (1-2 L) of Penetrol instead of Con-Det
swelling/sticky clay	.75 - 1 lb (340-450 g) Poly Bore .5 - 1 gal (2-4 L) Con-Det	Flow rate should be 3-5 parts fluid to 1 part soil. May use .25 - .5 gal (1-2 L) of Penetrol instead of Con-Det
solid rock (shale)	40 lb (18 kg) Bore-Gel	Use .5 pt (235 mL) of No Sag for large diameter or longer bores
solid rock (other than shale)	40 - 50 lb (18-23 kg) Bore-Gel	Use .5 pt (235 mL) of EZ-Mud in reactive shales
rock/clay mixture	40 - 50 lb (18-23 kg) Bore-Gel .5 pt (235 mL) EZ-Mud	
rock/sand mixture	40 - 50 lb (18-23 kg) Bore-Gel	Use .5 pt (235 mL) of No Sag for large diameter or longer bores
fractured rock	50 lb (23 kg) Bore-Gel .5 - 1lb (225-450 g) No-Sag	Use .5 lb (225 g) of Barolift to reduce fluid loss to formation

Drilling Fluid Requirements

1. Determine drilling conditions and choose appropriate drilling fluid mix.
2. Estimate amount of supplies needed and check availability.
 - Drilling fluid
 - Water supply. If more water than can be carried with the unit will be needed, arrange to transport additional water.
 - Bentonite and/or polymer
3. Check water quality.
 - Use meter or pH test strips to test pH of water. If pH is below 9.0, add 1 lb (454 g) soda ash per tank. Test and repeat until pH is between 9 and 10.
 - Check water hardness using hardness test strips. Treat with soda ash if hardness exceeds 125 ppm.



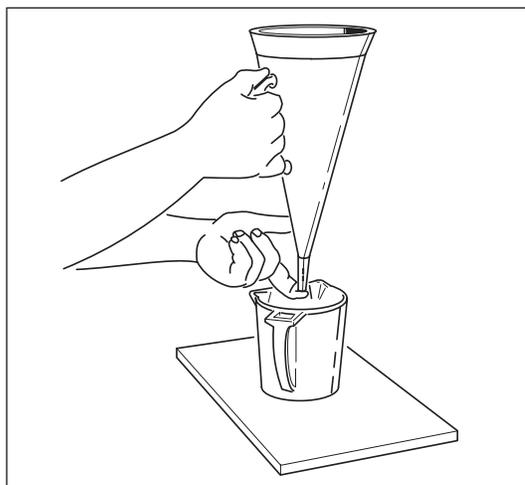
Funnel Viscosity

Viscosity is the measure of internal resistance of a fluid to flow; the greater the resistance, the higher the viscosity. Viscosity of drilling fluids must be controlled.

To determine viscosity, you will need a Marsh funnel (p/n 259-267) and a measuring cup, available from your Ditch Witch dealer.

IMPORTANT: Make sure Marsh funnel is clean and free of obstruction and that you have a stopwatch available for timing the viscosity.

1. Using wash hose and a clean container, take a fresh sample of drilling fluid. The sample must be at least 1.5 qt (1.4 L).
2. With finger over bottom of funnel, fill with fluid from the container through the screen until fluid reaches the bottom of the screen.
3. Move funnel over 1 qt (.95 L) container.
4. Remove finger from bottom of funnel and use the stopwatch to count the number of seconds it takes for 1 qt (.95 L) of fluid to pass through the funnel. The number of seconds is the viscosity.
5. Thoroughly rinse measuring cup and Marsh funnel.



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Tracker Control

Overview



WARNING

Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.



This mode allows the 750 Tracker operator to disable hydraulic power to drilling unit thrust and rotation.

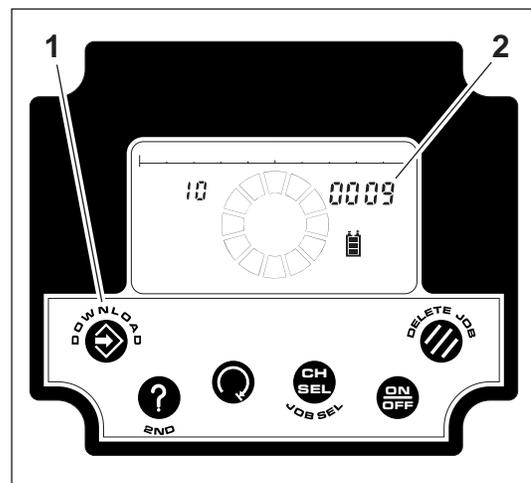
NOTICE: This mode does not disable thrust and rotation immediately. Functions are disabled within 16 seconds.

Use tracker control any time you change downhole tools or during other times when the drill string is exposed. Tracker control works by stopping communication between the tracker and the display. When this happens, the green tracker control light on the drilling unit comes on and thrust and rotation are disabled.

Operation

Enable Thrust and Rotation

1. Start drilling unit.
2. Turn off 750 Display.
3. Press and hold DOWNLOAD (1) while turning on 750 Display until a four-digit code (2) appears.



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4. Turn on 750 Tracker and check four-digit code.

If codes on tracker and display match, thrust and rotation hydraulics on the drilling unit are enabled.

If codes on tracker and display do not match, adjust tracker code:

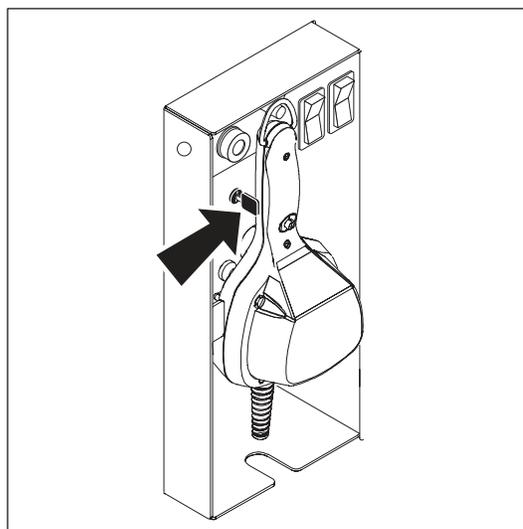
- Press and hold fore/aft/left/right button while making the following adjustments.
- Use ON/OFF to advance first two digits (1). Use DEPTH to lower first two digits.
- Use up arrow to advance last two digits (2). Use down arrow to lower last two digits.
- Press and hold each button to advance or lower value quickly.
- To start sending code from the tracker to the display, press and hold fore/aft/left/right button and press MODE. Thrust and rotation hydraulics on the drilling unit are now enabled.



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Troubleshooting Tip: If thrust and rotation are not enabled:

- Check whether the green tracker control light located on drilling unit anchoring console is on. If it is, communication has probably stopped between tracker and display, or tracker is set to incorrect code.
- If communication cannot be restored, install tracker control key (shown) in drilling unit. Green tracker control light located on anchoring console will go off. Thrust and rotation will function.



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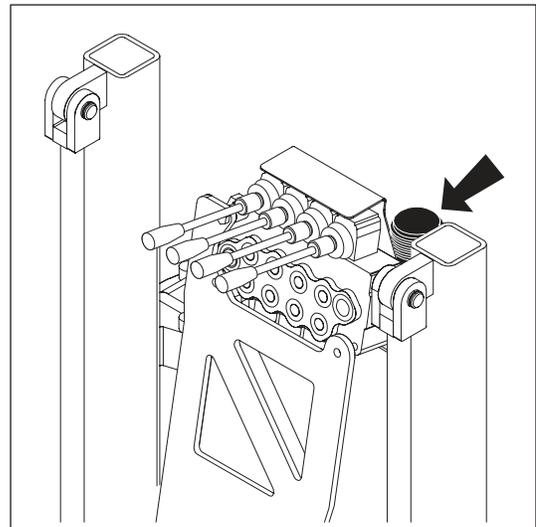
5. Remove tracker control key (shown) from set-up console at rear of drilling unit. Keep in tracker operator's possession.

6. Drill and track bore.

Disable Thrust and Rotation

1. When drill head enters target pit or exits the ground, turn off tracker.

After 8-16 seconds, green tracker control light (shown), located on drilling unit anchoring console, will come on. Hydraulic power to thrust and rotation will be disabled.



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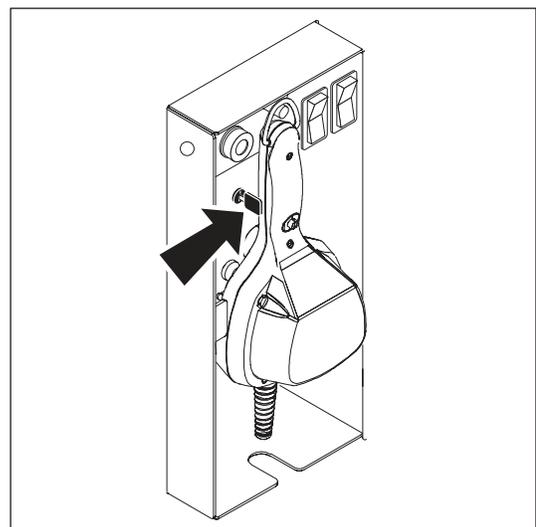


IMPORTANT: Tracker operator cannot disable thrust and rotation from tracker if tracker control key (shown) is installed in drilling unit and turned to the disable position. See "Tracker control key" on page 20 for more information.

NOTICE: If you are not using tracker control, turn off drilling unit before changing downhole tools.

2. Change downhole tools.
3. **If you are tracking backreamer's path**, turn on tracker and enable code transmission. After 8-16 seconds, green tracker control light on drilling unit anchoring console will go off and thrust and rotation will function.

If you are not tracking backreamer's path, install tracker control key (shown) on drilling unit. Green tracker control light on drilling unit anchoring console will go off and thrust and rotation will function.



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Downhole Tools

Nozzles

Nozzles control fluid flow from the pipe to the bore. Select nozzles that will supply **at least** the amount of fluid per minute needed for the flow and pressure you will be using. A nozzle that will supply more fluid per minute is recommended. See your Ditch Witch dealer for nozzle recommendations.

Bits

Selection

These charts are meant as a guideline only. No one bit works well in all conditions. See your Ditch Witch dealer for soil conditions and bit recommendations for your area. Also see our interactive Downhole Tool Selector at www.ditchwitch.com.

- 1 = best
- 2 = good
- 3 = fair
- 4 = not recommended

Bit	Sandy Soil	Soft Soil	Medium Soil	Hard Soil	Rocky Soil	Soft Rock	Hard Rock
Sand bit	1	2	4	4	4	4	4
Durabit	2	2	1	1	4	4	4
Tuff bit	2	1	1	1	2	3	4
Steep Taper Tuff bit	4	3	2	1	1	2	4
Barracuda bit	2	1	1	2	3	4	4
Steep Taper bit	4	3	2	1	1	2	4
Hard Surface bit	2	1	2	3	4	4	4
Glacier bit	4	4	4	3	1	2	4
Rhino bit	4	4	3	3	1	1	3
Jetting assembly	4	4	3	2	1	2	3
Rockmaster	4	4	3	2	1	1	1
Talon Rock bit	4	3	2	1	1	1	4

Soil	Description
sandy soil	sugar sand, blow sand, or other soils where sand is the predominant component
soft soil	sandy loam
medium soil	loams, loamy clays
hard soil	packed clays, gumbo, all compacted soils
rocky soil	chunk rock, glacial till, cobble, rip rap, gravel
soft rock	soft limestone, sandstone, shale, coral, caliche
hard rock	granite, schist, marble, hard limestone



Installation

Remove all paint from mating surfaces before attaching any bit to housing. Install screws (p/n 107-277) and torque bolts to 120 ft•lb (163 N•m).

Beacon Housings

Beacon Installation

To ensure beacon is installed correctly in rock housing, place battery end of beacon away from bit end of housing.

Backreamers

A backreamer enlarges the hole as pipe is pulled back through the bore. No one backreamer works well in all conditions. These charts are meant as a guideline only. See your local Ditch Witch dealer for soil conditions and backreamer recommendations for your area. Also see our interactive Downhole Tool Selector at www.ditchwitch.com.

- 1 = best
- 2 = good
- 3 = fair
- 4 = not recommended

Backreamer	Sandy Soil	Soft Soil	Medium Soil	Hard Soil	Rocky Soil	Soft Rock	Hard Rock
Beavertail	3	1	1	1	3	4	4
Three Wing	4	3	3	2	1	1	4
Water Wing	4	3	2	1	2	2	4
Compact Fluted	1	1	2	2	2	3	4
Kodiak	4	3	3	2	1	2	4
Rhino Rock	4	4	4	4	3	2	1
Rockmaster	4	4	4	4	3	1	1
Compaction Cone	1	2	3	4	4	4	4
HC Hard Condition	4	3	2	1	1	4	4
ST Saw Tooth	2	2	1	2	2	3	4
MX Mixer	2	2	3	4	4	4	4
CT Cutter	3	2	1	2	3	4	4
EX Expander	1	2	3	4	4	4	4
Fluted Cone	1	1	2	2	2	3	4

IMPORTANT: For soil definitions, see the chart on the previous page.

Backream Fluid Requirements

Backreaming is only successful when enough fluid reaches the bore. The amount of fluid needed depends on size of bore and soil condition.

Follow these steps to find the **minimum** amount of fluid needed in perfect conditions.



IMPORTANT: Use more fluid than recommended or the backream might be dry and unsuccessful.

Instructions	Example
1. Find amount of fluid needed for your size of backreamer. See the table on the next page.	U.S. A 6" backreamer requires at least 1.47 gal/ft.
	Metric A 152-mm backreamer requires at least 18.24 L/m.
2. Multiply this number by distance per minute you plan to backream. The answer is an estimate of amount of fluid you will need for each minute of backreaming.	U.S. 1.5 gal x 2 ft/min = 3 gal for each minute of backreaming.
	Metric 18 L x .5 m/min = 9 L for each minute of backreaming

IMPORTANT: After you have determined how much fluid you will need, see your Ditch Witch dealer for nozzle recommendations.

Backream Fluid Requirements

Backreamer/product diameter		Gal/ft	L/m	Backreamer/product diameter		Gal/ft	L/m
.5 in	13 mm	0.01	0.13	13.5 in	343 mm	7.44	92.35
1 in	25 mm	0.04	0.51	14 in	356 mm	8.00	99.31
1.5 in	38 mm	0.09	1.14	14.5 in	368 mm	8.58	106.54
2 in	51 mm	0.16	2.03	15 in	381 mm	9.18	114.01
2.5 in	64 mm	0.25	3.17	15.5 in	394 mm	9.80	121.74
3 in	76 mm	0.37	4.56	16 in	406 mm	10.44	129.72
3.5 in	89 mm	0.5	6.21	16.5 in	419 mm	11.11	137.95
4 in	102 mm	0.65	8.11	17 in	432 mm	11.79	146.44
4.5 in	114 mm	0.83	10.26	17.5 in	445 mm	12.49	155.18
5 in	127 mm	1.02	12.67	18 in	457 mm	13.22	164.17
5.5 in	139 mm	1.23	15.33	18.5 in	470 mm	13.96	173.42
6 in	152 mm	1.47	18.24	19 in	483 mm	14.73	182.92
6.5 in	165 mm	1.72	21.41	19.5 in	495 mm	15.51	192.68
7 in	178 mm	2.00	24.83	20 in	508 mm	16.32	202.68
7.5 in	190 mm	2.29	28.50	20.5 in	521 mm	17.15	212.94
8 in	203 mm	2.61	32.43	21 in	533 mm	17.99	223.46
8.5 in	216 mm	2.95	36.61	21.5 in	546 mm	18.86	234.23
9 in	229 mm	3.30	41.04	22 in	559 mm	19.75	245.25
9.5 in	241 mm	3.68	45.73	22.5 in	572 mm	20.65	256.52
10 in	254 mm	4.08	50.67	23 in	584 mm	21.58	268.05
10.5 in	267 mm	4.50	55.86	23.5 in	597 mm	22.53	279.83
11 in	289 mm	4.94	61.31	24 in	610 mm	23.50	291.86
11.5 in	292 mm	5.40	67.01	24.5 in	622 mm	24.49	304.15
12 in	305 mm	5.88	72.97	25 in	635 mm	25.50	316.69
12.5 in	318 mm	6.37	79.17	25.5 in	648 mm	26.53	329.49
13 in	330 mm	6.90	85.63	26 in	660 mm	27.58	342.53

Quick Wrench

To attach or remove downhole tools, use quick wrench to join or break the joint.

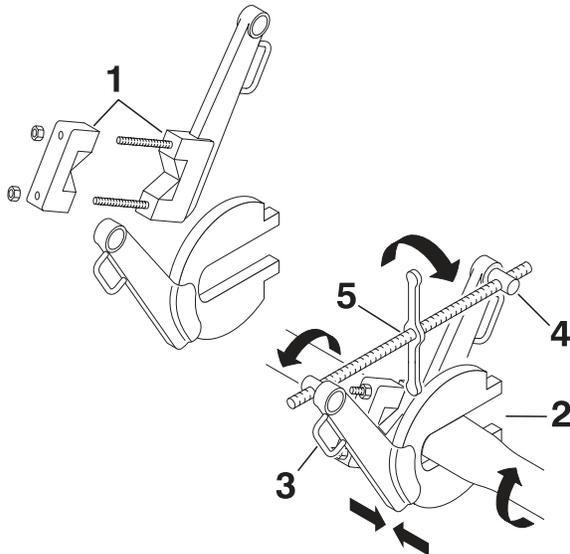


⚠ DANGER Moving tools will kill or injure. Shut off drill string power when anyone can be struck by moving or thrown tools. Never use pipe wrenches on drill string.



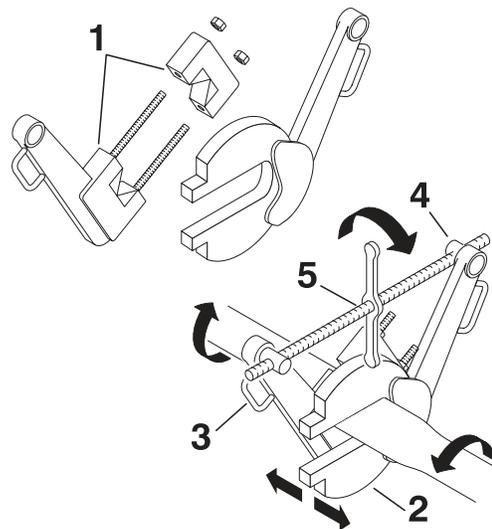
IMPORTANT: Apply TJC to threads and hand-tighten joint before attaching quick wrench components to tighten joint.

Attach quick wrench in either the join or break position.



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Join

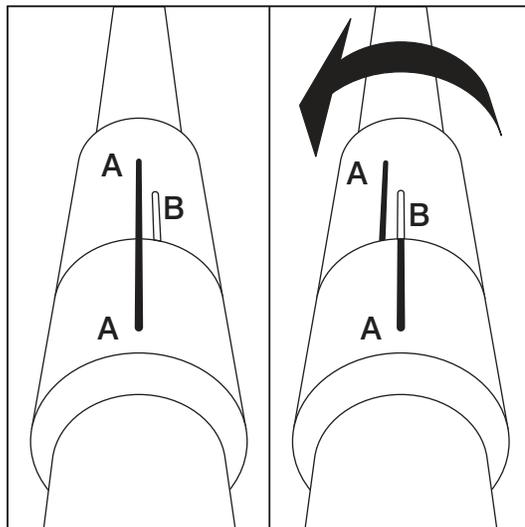


Break

- Unbolt vise (1) and place jaws around pipe.
- Bolt jaws of vise together.
- Place jaw (2) around pipe.
- Pin handles (3) to wrench jaws. Be sure handles are both up.
- Attach pivot nuts (4) to wrench handles so that screw drive handle (5) is over joint.

To Join

1. Scribe straight line across joint on both sides of separating line (A).
2. Scribe second line (B) on moveable side of joint in the opposite direction of tightening action .25" (6 mm) away from first line.
3. Turn handle until second line (B) meets first (A).
4. Turn handle opposite direction two turns to relieve pressure.
5. Remove quick wrench components.



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To Break

1. Turn handle until joint is broken.
2. Turn handle opposite direction two turns to relieve pressure.
3. Remove quick wrench components.

Drill Pipe

Perform Regular Drill Pipe Care

Precondition New Pipe



Repeat this procedure **three times** for each piece of pipe before it is used the first time:

1. **Hand-lubricate** entire surface of threads and shoulders of both ends of pipe with copper base tool joint compound. See page 157 for correct lubricant.
2. Join pipe and tighten joint.
3. Break joint.
4. Move pipe back to box.

NOTICE: Failure to follow this procedure could result in fused joints. Pipe will be damaged or destroyed.

Lubricate Joints Before Each Use

Lubricate threads and shoulders of male joints with copper base tool joint compound. This prevents rust and reduces wear on shoulders and threads. See page 157 for correct lubricant.

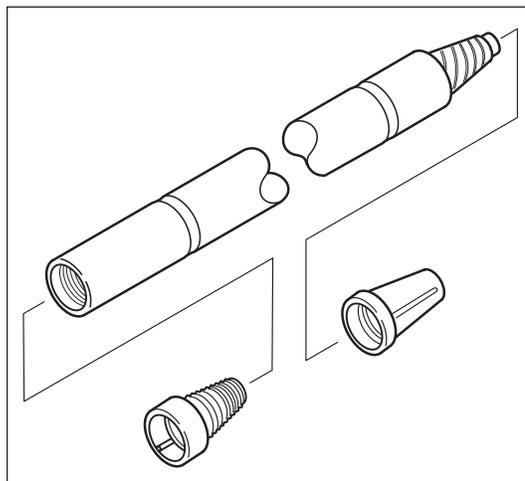
Clean the Threads

Clean the threads as needed with high-pressure water and detergent.

NOTICE: Do not use gasoline or other petroleum-based solvents. This prevents tool joint compound from sticking to the joints and will reduce thread life.

Use Caps and Plugs

Before transporting in dusty conditions or prolonged storage, install caps and plugs to male and female ends of pipe and to saver sub.



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Replace Worn Saver Sub

Because each pipe comes in contact with the saver sub, check saver sub regularly for wear. Replace it when it is worn, or it will damage your drill pipe. See page 184 for replacement procedure.

Precondition a new saver sub the same way you do new pipe. See "Precondition New Pipe" on page 131.

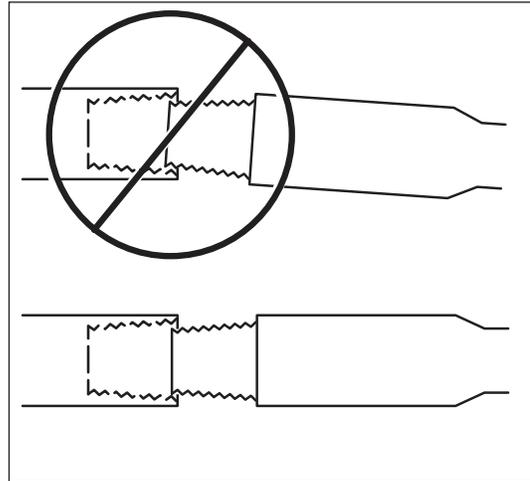
Rotate Pipe Order

Because the lead drill pipe is in the ground longer, it is subjected to higher shock loads and experiences more wear. To help spread this wear evenly over all pipe, move the lead pipe from the previous job out of the first position. See "Rotate Drill Pipe Order" on page 136.

Use Drill Pipe Correctly

Align the Joints

Always carefully align the male and female ends of pipe before screwing them together. Poor alignment can damage the threads and destroy the usefulness of the joint.

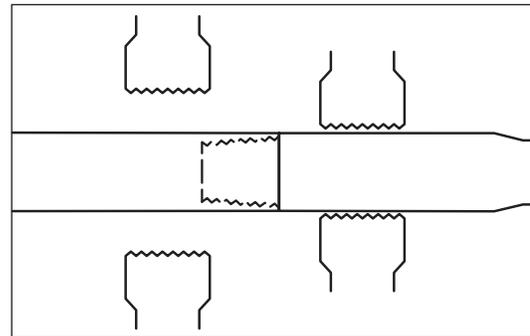


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Clamp Pipe Correctly

Clamp on pipe when joint is centered between wrenches. Clamp only on the tool joint of the drill pipe as shown. This portion of the drill pipe is designed for clamping and is considerably thicker and stronger than the rest of the pipe.

NOTICE: Clamping anywhere else on the pipe will weaken the pipe. Pipe can later break, even when operating under normal loads.



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See "Clamp Pipe" on page 92 for more information.



Make Up and Break Out Joints Correctly

Assisted Makeup protects threads by automatically matching carriage movement speed to rotation during makeup and breakout.

- To screw pipes together and fully torque joint, slowly rotate pipe until spindle stops turning and full pressure is developed. Improperly torqued joints will damage the shoulder faces and threads, and will cause joints to leak or break while drilling or backreaming.
- To unscrew pipes, slowly rotate spindle counterclockwise. Carriage will move back automatically until threads unscrew.

If assisted makeup is unavailable, follow these two steps:

- **Make up and break out joints slowly.** Do not ram pipes together during makeup or force them apart during breakout. Carefully time rotation with carriage travel speed, and always connect and disconnect joints slowly and deliberately. This will help prevent thread crossing, galling, and shoulder swelling.
- **Torque joints fully.** Once the joint is connected and the shoulder faces are touching, torque them to full machine torque. Improperly torqued joints will damage the shoulder faces and threads, and will cause joints to leak or break while drilling or backreaming.

Do not Overwork the Pipe

Never exceed the bend radius for your pipe. See “Recommended Bend Limits” on page 67. Do not oversteer.

NOTICE: Bending pipe more sharply than recommended will damage pipe and cause failure.

Pipeloader

Shift Pipe Box

IMPORTANT: Lift arms must be fully raised for pipe box to move.

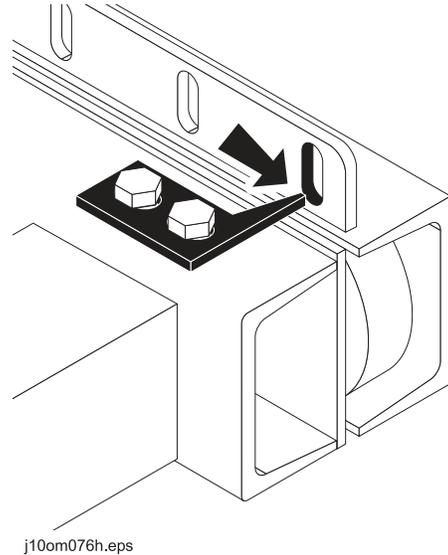


Drilling

1. Shift pipe box when both pipe box status lights are off.
2. Release pipe box switch when mechanical pointer is in center of cutout (shown) for new column.

Backreaming

1. Shift pipe box when active column is full (8 pipes).
2. Release pipe box switch when mechanical pointer is in center of cutout (shown) for new column.



Correct Dropped Pipe

When grippers are not closed before drill pipe automation is enabled, the pipel loader can drop a drill pipe when automation is turned off. To prevent this, always grip pipe before enabling pipel loader automation. See "Enable Automated Pipel loader System" on page 96.

To return a dropped pipe to the drill string, turn off engine and manually retrieve pipe. Return it to the pipe box by one of the following methods:

- To return the pipe to its original position in the drill string, load it as a single piece of pipe. See page 138.
- To return the pipe to a later position in the drill string, remove two pins over top of pipe box, manually place the pipe into top of the active column, and install two pins.

Correct Misaligned or Jammed Pipe

One pipe box status light on and one light off indicates a misaligned or jammed pipe. Turn off engine and inspect pipe in active column.

- If one end of a drill pipe is jammed and will not drop correctly from pipe box, inspect pipe box position. If pipe box appears to be improperly aligned with discharge chute, return to operator's station and move pipe box slightly until mechanical pointer is in center of cutout (shown) for active column.
- If drill pipe is bent, remove it from pipe box and discard.

NOTICE: If neither of the causes and solutions outlined above correct the misaligned or jammed pipe, contact your Ditch Witch dealer for assistance.

Rotate Drill Pipe Order

Rotating the lead pipe to the back of the string is a manual process. Rotate drill pipes in the drill string weekly.

Guidelines

- Rotate only as many columns as used on the longest bore of the week. For example, if the longest bore was 320' (97.5 m), then only rotate the four columns used.
- Plan to rotate the pipes during the longest bore of the week.
- The lead pipe can only be rotated to the very back of the drill string when a bore requires at least one pipe from last (inner) column.

Procedure

1. During pullback, move to next column when only seven pipes are in last column from which pipe was removed during drilling.
2. Follow regular pullback procedure to load pipe into all remaining columns.
3. When lead pipe is in grippers, disconnect from both ends of lead pipe and retract shuttles fully.
4. Follow procedure for removing a single pipe. See page 139.
5. Turn off engine.
6. Remove pins across top of pipe box.
7. Remove lead pipe from auxiliary shuttles and place into vacant slot in pipe box.
8. Install pins over drill pipe.
9. Close both auxiliary pipe loaders.

Add/Remove Single Pipe

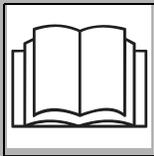
Load a single drill pipe or up to a whole column of drill pipe into an empty column of pipe box to finish bore without changing pipe boxes.



⚠ DANGER Electric shock. Contacting electric lines will cause death or serious injury. Know location of lines and stay away.

NOTICE:

- Do not attempt to load and unload pipe while drilling or backreaming. Unprotected worker can be injured by electric strike.
- On electrical jobsite, load and unload pipe only if grid mats are properly set up and connected to drilling unit and loader is wearing electrically insulating boots and gloves.



⚠ WARNING Incorrect procedures could result in death, injury, or property damage. Learn to use equipment correctly.

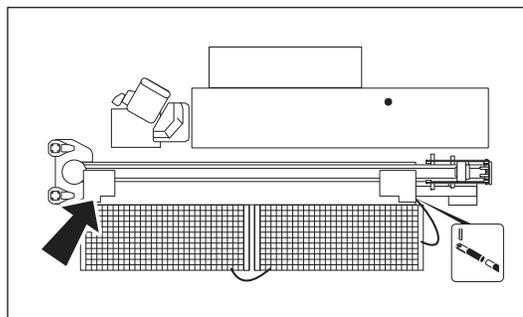
NOTICE:

- Open or close **both** auxiliary pipe loaders. Moving shuttles with one auxiliary pipe loader open and one closed will damage equipment and cause possible injury.
- Carriage must be in full back position to load and unload pipe.



Add Single Pipe

1. Place grid mats on the ground on pipe box side of drilling unit.
2. Connect mats.
3. Connect bonding cable to drilling unit (shown in inset).
4. Position entire drill pipe box on mat (shown).
5. Ensure pipe box is positioned properly. See "Shift Pipe Box" on page 135.
6. Move shuttles out fully.

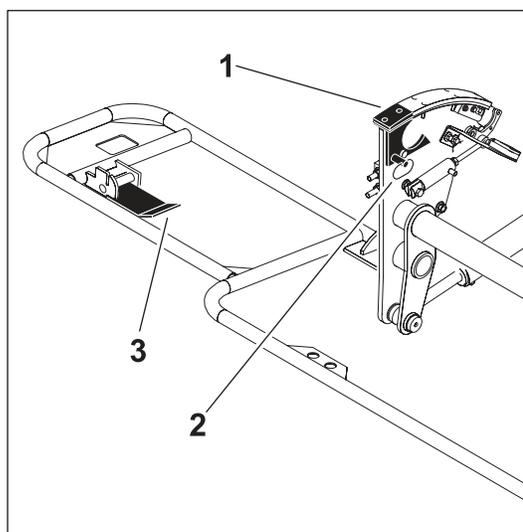


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**WARNING**

Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

7. Lift pipe positioning aid (3, located on lower end of pipel loader personnel restraint bar), rotate, and lock into slot.
8. Pull pin (2) on shuttle, rotate auxiliary pipe loader (1) down, and install pin.
9. Repeat process for other shuttle.
10. Lift pipe.
11. Load a pipe in auxiliary pipe loaders with lower end resting against pipe positioning aid.
12. Move auxiliary pipe loaders in fully.
13. Lower pipe.
14. Raise pipe into column.
15. Move shuttles all the way out.
16. Repeat steps 10-15 to load more pieces of pipe.
17. Move pipe to pipel loader grippers.
 - Raise last pipe.
 - Move shuttles out.
 - Lower pipe into front grippers.
18. Before operating pipel loader:
 - Close both auxiliary pipe loaders.
 - Step away from drilling unit.

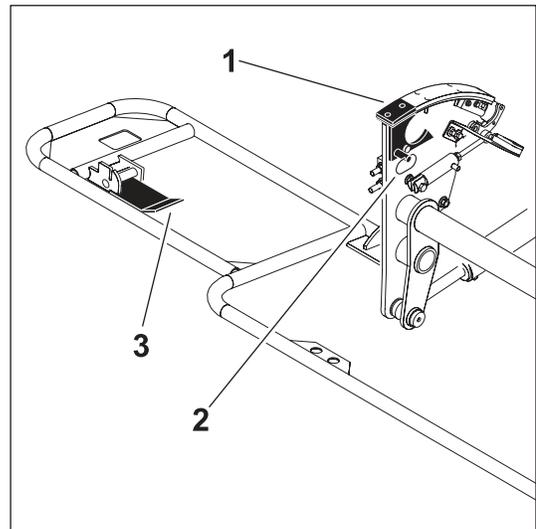


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Remove Single Pipe

Unload all drill pipe loaded with auxiliary pipe loaders.

1. Lift, rotate, and lock pipe positioning aid (3) into stowed position.
2. Ensure pipe box is positioned properly. See "Shift Pipe Box" on page 135.
3. Move shuttles out fully.
4. Pull pin (2) on shuttle, rotate auxiliary pipe loader (1) down, and install pin.
5. Repeat process for other shuttle.
6. Raise pipe.
7. Move pipe to auxiliary pipe loaders.
 - Move shuttles in.
 - Lower pipe into auxiliary pipe loaders.
8. Move shuttles out.



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WARNING

Crushing weight. If load falls or moves it could kill or crush you. Use proper procedures and equipment or stay away.

9. Remove pipe from auxiliary pipe loaders and store properly.
10. Repeat steps 5-8 to unload remaining added drill pipe.
11. After all added drill pipe is unloaded with auxiliary pipe loaders:
 - Close both auxiliary pipe loaders.
 - Step away from pipeloader.
 - Finish loading remaining drill pipe using standard procedure. See "Remove Pipe" on page 103.

Cruise Control

During the bore, you can set the desired thrust, pullback, and rotation speeds to match ground conditions. Cruise control enables the unit to maintain these settings hands-free. You can engage, disengage, override, and resume these settings at any time.

IMPORTANT: In order for cruise control to function, front wrench must be open and shuttles must be under pipe box.

Engage

Thrust/Pullback and Rotation Control	Thrust/Pullback Control Only
<ol style="list-style-type: none"> 1. Position joystick so that thrust or pullback and rotation are at desired speeds. 2. Press set. Green control cycle light will come on. 3. Release joystick. 	<ol style="list-style-type: none"> 1. Position joystick to desired thrust or pullback setting. 2. Press set. Green control cycle light will come on. 3. Release joystick. 4. Operator controls rotation with joystick.

Adjust Settings

Setting	Instructions
Thrust or Pullback	<ul style="list-style-type: none"> • To increase thrust or pullback speed while joystick is in neutral position, press resume. • To decrease thrust or pullback speed while joystick is in neutral position, press set.
Rotation	<ul style="list-style-type: none"> • To increase rotation speed, move joystick to left and press resume. • To decrease rotation speed, move joystick to left and press set.

Override

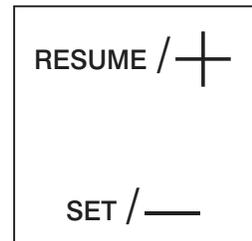
- To override settings, move joystick out of neutral and beyond current setting. Unit will increase to new setting.
- To return to previous setting, release joystick.

Disengage

To disengage cruise control, move joystick out of neutral and in opposite direction of carriage travel. Green control cycle light will go off.

Resume

1. Position joystick out of neutral in forward or backward direction.
2. Press resume. Green control cycle light will come on.



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Interpret Diagnostic Codes

Diagnostic Light

Use the red diagnostic light to learn the condition of the diagnostic system. Under normal operating conditions, the diagnostic light will light steadily for two seconds after ignition is turned on to indicate light is working. It will then go out and remain out unless a diagnostic code is recorded.

If diagnostic codes are detected, the diagnostic light will either flash on and off for 10 seconds to indicate a non-essential code or remain on for 3 seconds and off for half a second to indicate an essential code.

Code Severity Levels

Diagnostic codes are given one of two levels of severity.

- A **non-essential** code affects non-essential functions of the unit. If the system detects a non-essential problem, a diagnostic code will be recorded and the diagnostic light will flash for 10 seconds and then go out. Each time ignition is turned on, full operation will be available until the diagnostic system detects a problem.
- An **essential** code affects rotation, thrust, drilling fluid, or ground drive. If the system detects an essential problem, a diagnostic code will be recorded and the diagnostic light will cycle on for three seconds and off for 1/2 second. Some machine functions may not work until the problem is corrected. Each time ignition is turned on, full operation will be available until the diagnostic system detects a problem.



Review Modes

IMPORTANT: Do not turn off ignition. Diagnostic codes are cleared each time ignition is turned off.

View All Codes	View Codes Individually
<ol style="list-style-type: none"> 1. Ensure that engine is running and no one is sitting in operator's seat. 2. Press and hold the resume button for two seconds. 3. Diagnostic light will flash code 12 (flash, pause, flash, flash, longer pause) to indicate review mode is operational. 4. After flashing code 12, all diagnostic codes detected since the last time the ignition was turned on are flashed three times each. 5. To save diagnostic codes, continue normal operation. Do not turn ignition off. 6. Once the problem has been corrected, clear all codes by turning ignition off. 	<ol style="list-style-type: none"> 1. Ensure that engine is running and no one is sitting in operator's seat. 2. Press and hold the set button for two seconds. 3. Diagnostic light will flash code 12 (flash, pause, flash, flash, longer pause) to indicate review mode is operational. 4. After code 12 is flashed, press set button to see first code. <ul style="list-style-type: none"> • Press resume to see same code again or press set to see next code. • Continue pressing set until all diagnostic codes detected since the last time the ignition was turned on are flashed. 5. To save diagnostic codes, continue normal operation. Do not turn ignition off. 6. Once the problem has been corrected, clear all codes by turning ignition off.

Diagnostic Code Interpretation

Diagnostic codes are displayed through a series of light flashes and pauses. Count number of flashes and pauses to interpret code.

Example: "Flash, flash, flash, pause, flash, flash, longer pause" represents code 32.

Tips for interpreting codes:

- In View All Codes mode, the green control cycle light will come on the first time the red diagnostic light flashes a code. The green control cycle light will then go off and the red diagnostic light will flash the code two more times.
- Codes are displayed from lower to higher numbers.
- Code 11 is not used.
- Code 12 signals successful entry into and exit from review mode.

Diagnostic Codes

The following table lists the attributes of each diagnostic code. Information presented includes: code number, condition causing code to be sent, result, and level of severity.

Code	Condition	Result	Severity
12	normal review mode entry	code is not stored	n/a
13	no 12V power to controller	drill and drive are blocked	essential
14	no 5V power from controller	drill and drive are blocked	essential
15	unknown output driver continuity problem	code is stored	non-essential
32	no continuity to shuttle extend solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
33	no continuity to shuttle retract solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
34	no continuity to pipe lift solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
35	no continuity to pipe lower solenoid	add pipe or remove pipe is aborted and code is aborted	non-essential
42	no continuity to pipe release solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
43	no continuity to lube rear solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
44	no continuity to lube front solenoid	add pipe or remove pipe is aborted and code is stored	non-essential
45	no continuity to carriage two speed solenoid	code is stored	non-essential
51	no continuity to rotation cw solenoid	cruise control is blocked	essential
52	no continuity to rotation ccw solenoid	cruise control is blocked	essential
53	no continuity to thrust forward solenoid	cruise control is blocked	essential
54	no continuity to thrust backward solenoid	cruise control is blocked	essential
55	no continuity to left track forward solenoid	drive is blocked	essential
61	no continuity to pipe box in solenoid	code is stored	non-essential
62	no continuity to pipe box out solenoid	code is stored	non-essential



Code	Condition	Result	Severity
63	no continuity to auxiliary dump valve	add pipe or remove pipe aborted and code is stored	non-essential
65	no continuity to thrust/right track neutral valve	cruise control is blocked	essential
71	no continuity to drive selector valve	drive is blocked	essential
73	no continuity to throttle up solenoid	code is stored	non-essential
74	no continuity to throttle down solenoid	code is stored	non-essential
111	no continuity to left track reverse solenoid	drive is blocked	essential
112	no continuity to right track forward solenoid	drive is blocked	essential
113	no continuity to right track reverse solenoid	drive is blocked	essential
114	no continuity to drilling fluid pump solenoid	code is stored	essential
131	no continuity to thrust rear home switch	add pipe and remove pipe are blocked	non-essential
132	no continuity to thrust front home switch	add pipe and remove pipe are blocked	non-essential
133	no continuity to shuttle home switch	add pipe and remove pipe are blocked	non-essential
134	no continuity to front wrench switch	add pipe and remove pipe are blocked	non-essential
144	drive joystick left/right out of range	drive is blocked	essential
145	drive joystick forward/backward out of range	drive is blocked	essential
151	drill joystick left/right out of range	rotation and cruise control are blocked	essential
152	drill joystick forward/backward out of range	rotation and cruise control are blocked	essential
154	drilling fluid potentiometer out of range	code is stored	essential
161	no continuity to front pipe box switch	code is stored	non-essential
162	no continuity to rear pipe box switch	code is stored	non-essential

Code	Condition	Result	Severity
163	no continuity to pipe up switch	pipe box movement is blocked and code is stored	non-essential
164	no continuity to tracker control input	code is stored	non-essential
166	no continuity to thrust rear stop switch	code is stored	non-essential
171	no continuity to pipe grip rocker switch	code is stored	non-essential
172	no continuity to pipe shuttle rocker switch	code is stored	non-essential
173	no continuity to pipe lift rocker switch	code is stored	non-essential
174	no continuity to pipe box rocker switch	code is stored	non-essential
175	no continuity to pipe lube rocker switch	code is stored	non-essential
184	no continuity to throttle rocker switch	code is stored	non-essential
185	no continuity to set/resume rocker switch	code is stored	non-essential
191	no continuity to engine speed sensor	code is stored	non-essential
215	no continuity to float position sensor	assisted makeup is blocked and code is stored	non-essential
221	system voltage is below 12.5V	code is stored	non-essential
233	drill and drive inputs both on	drill and drive are blocked	essential
234	add pipe and remove pipe inputs both on	add pipe and remove pipe are blocked	non-essential
235	front home and rear home inputs both on	add pipe and remove pipe are blocked	non-essential
241	shuttles not responding correctly	add pipe or remove pipe is aborted and code is stored	non-essential
251	float sensor is reading out of range	assisted makeup is blocked and code is stored	non-essential
254	error reading setup table information	add pipe and remove pipe are blocked	essential



Code	Condition	Result	Severity
255	undefinable diagnostic code reported	code is stored	non-essential

Complete the Job

Chapter Contents

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• Reclaim Antifreeze	149
Rinse Equipment	150
Disconnect	151
Stow Tools	151

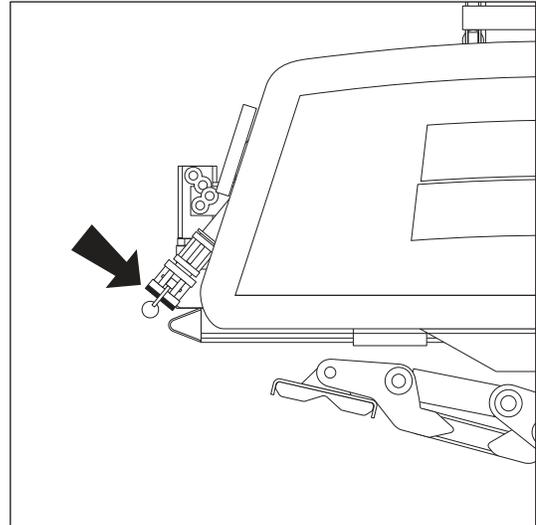


Antifreeze Drilling Unit

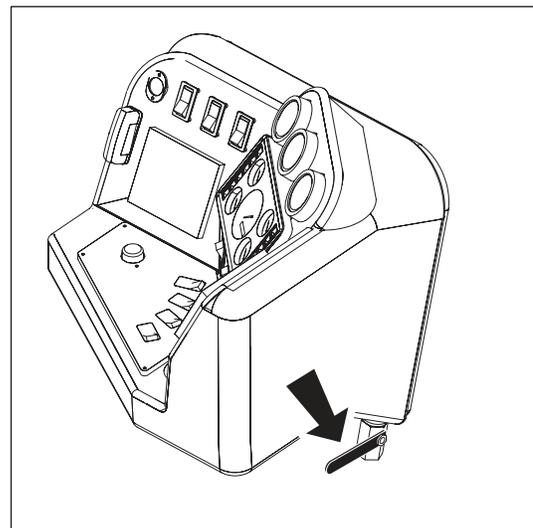
Your drilling unit can be left overnight in freezing conditions by circulating a polypropylene-based antifreeze (p/n 265-644) through optional antifreeze system before shutdown.

Add Antifreeze

1. Fill antifreeze tank with 3 gal (11 L) of approved antifreeze.
2. Move carriage to front of drill frame.
3. Position 3-gal (11-L) bucket under spindle.
4. Install plug at quick coupler for drilling fluid pump (shown).
5. Open valve between antifreeze tank and head of drilling fluid pump.
6. Turn drilling fluid potentiometer counterclockwise to zero position.
7. Start unit and set throttle to slow position.
8. Slowly turn drilling fluid potentiometer clockwise until indicator light comes on. If light does not come on, press drilling fluid pump switch.
9. Run drilling fluid pump until antifreeze comes out of spindle.
10. Turn drilling fluid potentiometer counterclockwise to zero position.
11. Open valve below operator's console (shown).
12. Slowly turn drilling fluid potentiometer clockwise until indicator light comes on.
13. Close valve below console when antifreeze runs out of valve below console.
14. Turn drilling fluid potentiometer counterclockwise to zero position.



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j10om067h.eps

Reclaim Antifreeze

1. Connect remote fluid system. See page 89.
2. Turn on remote fluid system engine.
3. Start drilling unit and run at low throttle.
4. Move carriage to front of drill frame.
5. Position 3-gal (11-L) bucket under spindle.
6. Turn drilling fluid pump on low speed.
7. Turn drilling fluid pump off when drilling fluid comes out of spindle.
8. Open hood and pour antifreeze into tank.



IMPORTANT: Antifreeze can be removed from antifreeze tank and disposed of properly or it can be reused until it is too diluted with drilling fluid to protect against freezing.