JT40/JT40 All Terrain

HRC and LRC

Operator's Manual

CE

Issue 1.0
Original Instruction

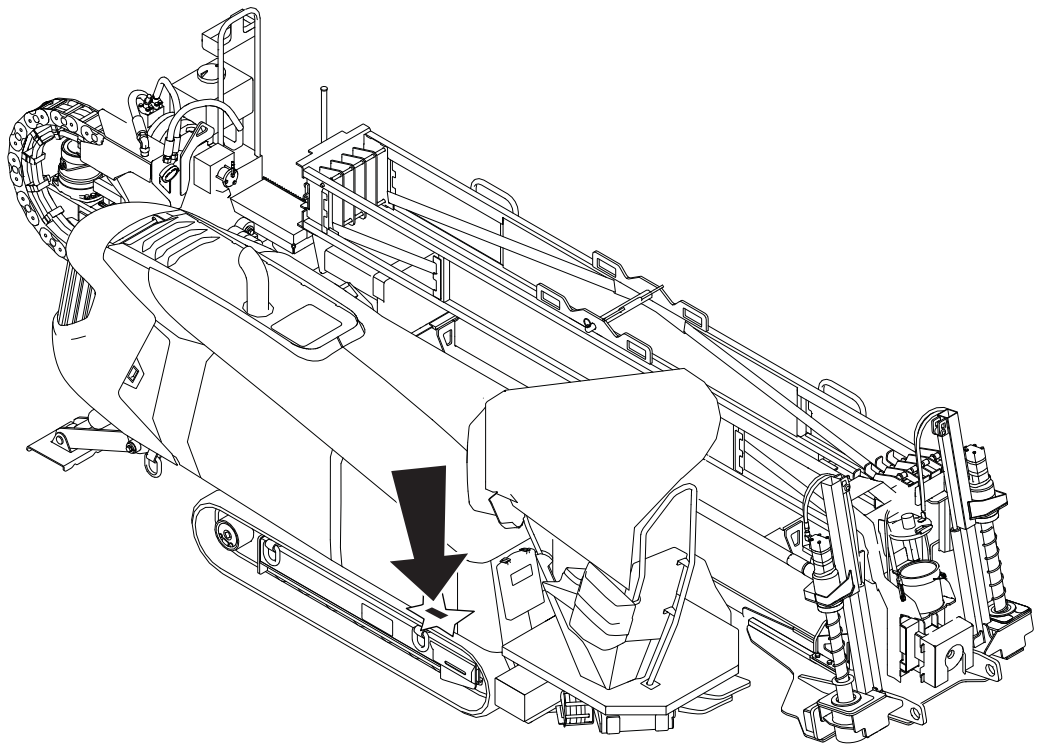
053-2966

Overview

Chapter Contents

Serial Number Location

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



j59om059w.eps

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

Intended Use

The JT40 is a self-contained horizontal directional drilling unit designed to install buried cable and pipe to distances of 600-1000' (183-305 m) depending on diameter of drill pipe and soil conditions. Its All Terrain version is designed to drill through rock, cobblestone, broken rock, gravel, and caliche.

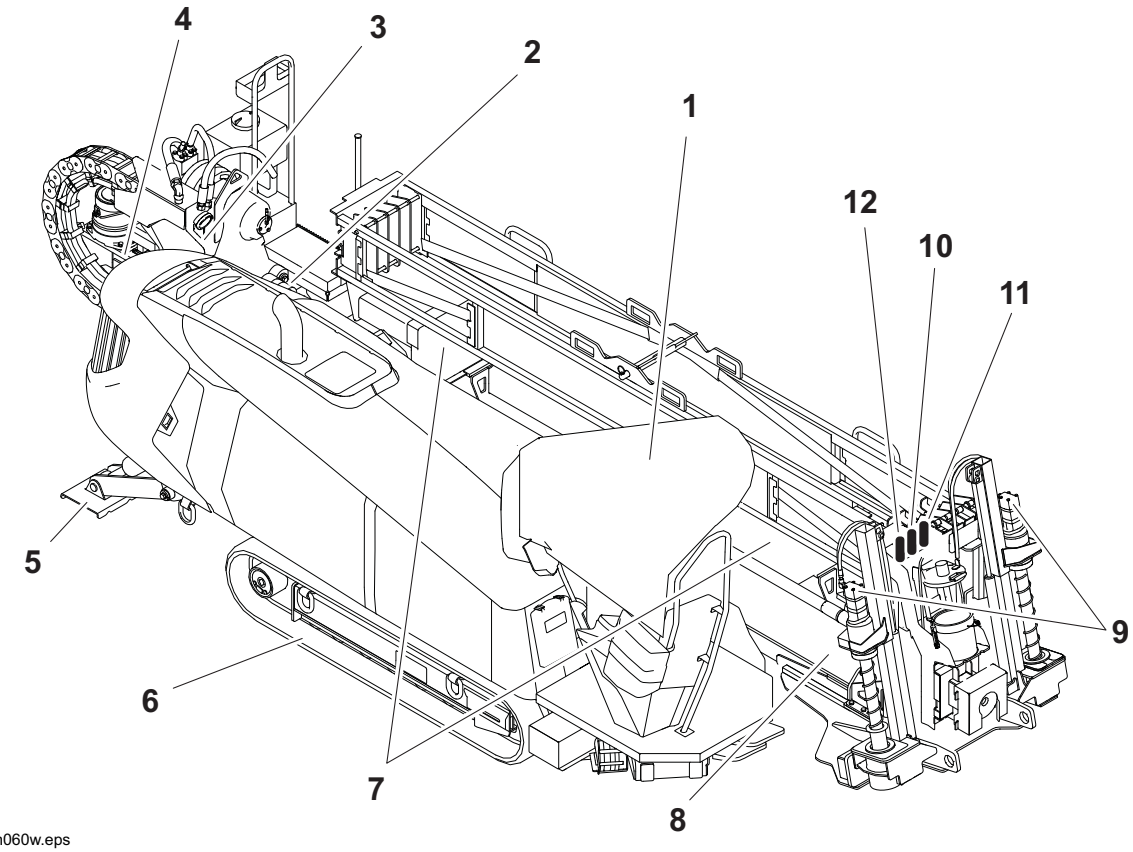
These units are intended for operation in ambient temperatures from -20° to 115°F (-29° to 46°C). Contact your Ditch Witch® dealer for provisions required for operating in extreme temperatures. Use in any other way is considered contrary to the intended use.

The JT40/JT40 All Terrain should be used with genuine Ditch Witch drilling fluid units and Subsite® Electronics tracking equipment. It should be operated, serviced, and repaired only by persons familiar with its particular characteristics and acquainted with the relevant safety procedures.

Equipment Modification

This equipment was designed and built in accordance with applicable standards and regulations. Modification of equipment could mean that it will no longer meet regulations and may not function properly or in accordance with the operating instructions. Modification of equipment should only be made by competent personnel possessing knowledge of applicable standards, regulations, equipment design functionality/requirements and any required specialized testing.

Unit Components



j59om060w.eps

1. Operator's station
2. Spindle
3. Carriage
4. Drill frame
5. Stabilizer
6. Tracks
7. Pipeloader
8. Vise wrenches
9. Anchoring system
10. DrillLok® light (green)
11. Wireless remote control light (clear)
12. ESID strobe light (amber)

FCC Statement - Internal Transmitter

U.S.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by **The Charles Machine Works, Inc.** could void the user's authority to operate the equipment.

Contains **FCC ID**: ITQ-TR2 & KQL-RM02410.

Canada

CAN ICES-2/NMB-2

This device complies with Industry Canada *license-exempt* RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Contains **IC**: 3598A-TR2I & 2268C-RM02410.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Contient **IC**: 3598A-TR2I & 2268C-RM02410.

RF Exposure Statement

In order to comply with RF exposure requirements during normal operation, this device must be held in front of the body horizontally. The antenna must be vertical in line with the body with at least 4" (100 mm) separation distance from the body.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

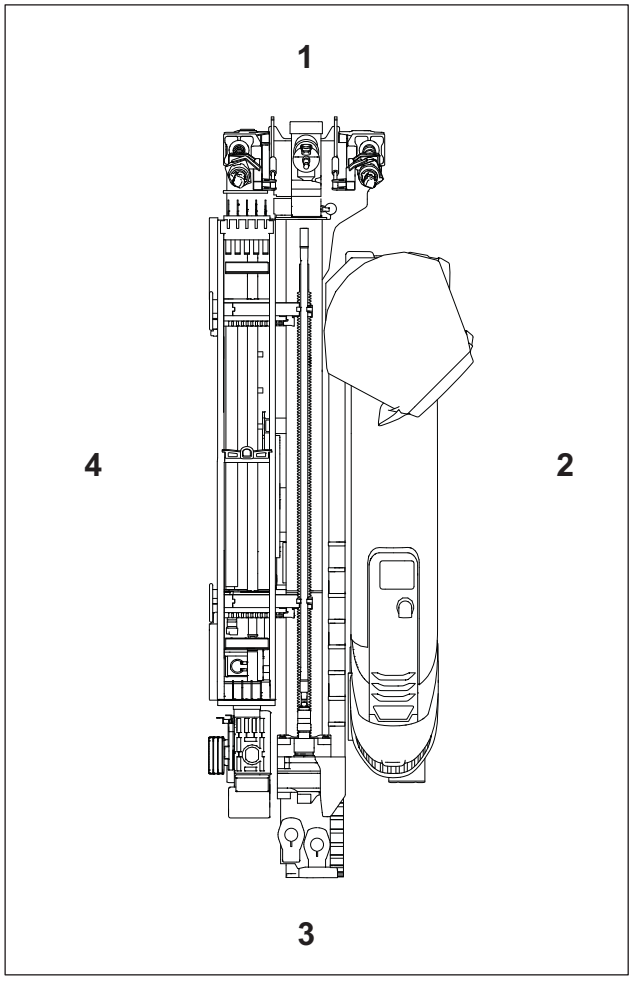
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Health Canada's Safety Code. The installer of this device should ensure that RF radiation is not emitted in excess of the Health Canada's requirement. Information can be obtained at http://hc-sc.qc.ca/ewh-sem/pub/radiation/radio_guide-lignes_direct-eng.php.

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.

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.

JT40/JT40 All Terrain
HRC & LRC
Operator's Manual

Issue number 1.0/OM-4/16
Part number 053-2966

Contents

Safety

Chapter Contents

Guidelines

When you see this safety alert sign, carefully read and follow all instructions.
YOUR SAFETY IS AT STAKE. Read this entire section before using your equipment.

Follow these guidelines before operating any jobsite equipment:

- Complete proper training and read operator's manual before using equipment.
- Mark proposed path with white paint and have underground utilities located before working. In the US or Canada, call 811 (US) or 888-258-0808 (US and Canada). Also contact any local utilities that do not participate in the One-Call service. In countries that do not have a One-Call service, contact all local utility companies to have underground utilities located.
- 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 or at www.ditchwitch.com/safe. Safety Data Sheets (SDS) are available at www.ditchwitch.com/support.
- Fully inspect equipment before operating. Repair or replace any worn or damaged parts. Replace missing or damaged safety shields and safety signs. Contact your Ditch Witch dealer for assistance.
- Use equipment carefully. Stop operation and investigate anything that does not look or feel right.
- Do not operate unit where flammable gas may be present.
- Only operate equipment in well-ventilated areas.
- Contact your Ditch Witch dealer if you have any question about operation, maintenance, or equipment use.
- Complete the equipment checklist located at www.ditchwitch.com/safe.

California Proposition 65 Warning

This product may contain chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

- battery posts, terminals and related accessories
- engine exhaust
- ethylene glycol

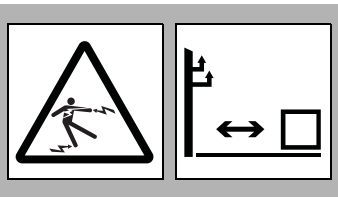
Emergency Procedures

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

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



DANGER Electric shock will cause death or serious injury. Stay away. 274-049

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. Many 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 equipment**, DO NOT MOVE. Remain on drilling machine and take the following actions. The order and degree of action will depend on the situation.

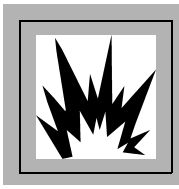
- Warn people nearby that an electric strike has occurred.
- Have someone contact electric company.
- Reverse drilling direction and try to break contact. Do not touch drill pipe with hands or hand-held tools.
- Press electric strike system self test button.
    - If alarm sounds again, stay where you 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 equipment**, 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


WARNING Fire or explosion possible. Fumes could ignite and cause burns. No smoking, no flame, no spark. 275-419 (2P)



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

If you suspect a gas line has been damaged, take the following actions. The orders 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. Contact utility company.

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 and accessible) 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.

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 a hazardous situation that, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

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

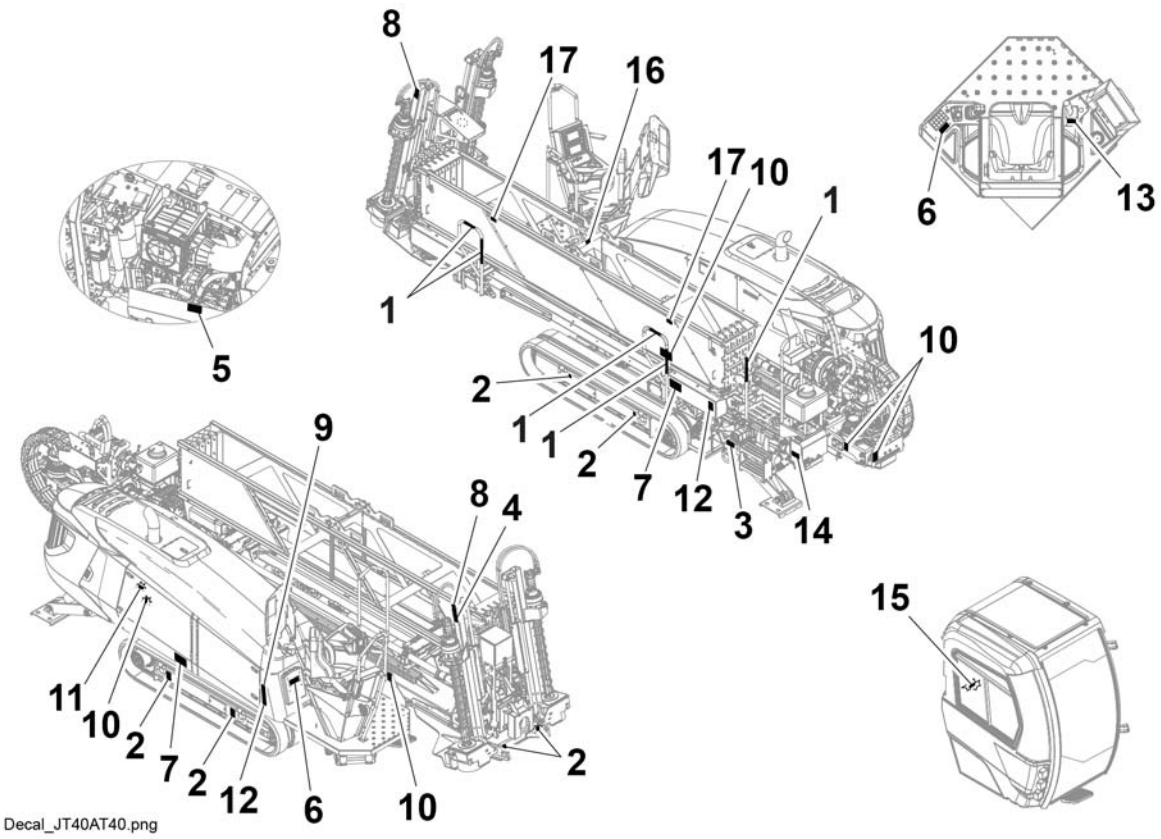
CAUTION indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

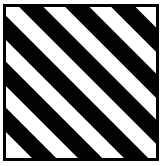
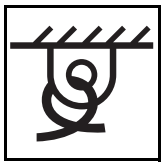
Watch for two other words: ***NOTICE*** and **IMPORTANT**.

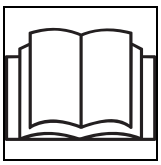
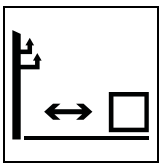
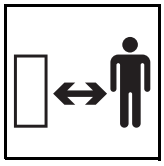
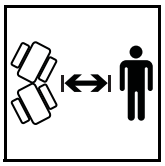
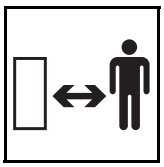
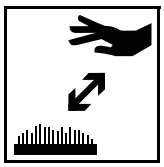
NOTICE indicates information considered important, but not hazard-related (e.g., messages relating to property damage).

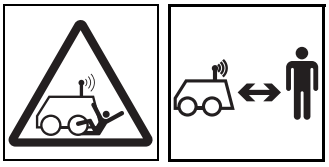
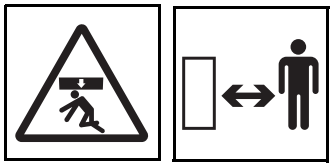
IMPORTANT can help you do a better job or make your job easier in some way.

Machine Safety Alerts



1		DANGER stripe decal. See Parts Manual for replacement part numbers.
2		Tiedown location. See Transport chapter for more information. 274-318
3		**⚠ WARNING** Crushing weight. Place cylinder lock on extended cylinder and secure. 273-231, 273-413

4	 	**DANGER** Moving tools will kill or injure. Never use pipe wrenches on drill string. 273-278
5	 	**WARNING** Fire or explosion possible. Do not use starter fluid. 273-459 (2P), 274-206 (2P), 700-206 (2P)
6	 	**WARNING** Read operator's manual. Follow safety rules and know how to use all controls. Your safety is at stake. 273-475
7	 	**DANGER** Electric shock will cause death or serious injury. Stay away. 274-049
8	 	**DANGER** Turning shaft will kill you or crush arm or leg. Stay away. 274-187
9	 	**WARNING** Moving parts. Crushing could cause death or severe injury. Use correct procedures and equipment. Stay away from moving parts and their range of movement. 274-204
10	 	**WARNING** Moving parts could cut off hand or foot. Stay away. 275-184, 273-546
11	 	**CAUTION** Hot parts may cause burns. Do not touch until cool or wear gloves. 275-355 (2-P), 273-423 (2-P)

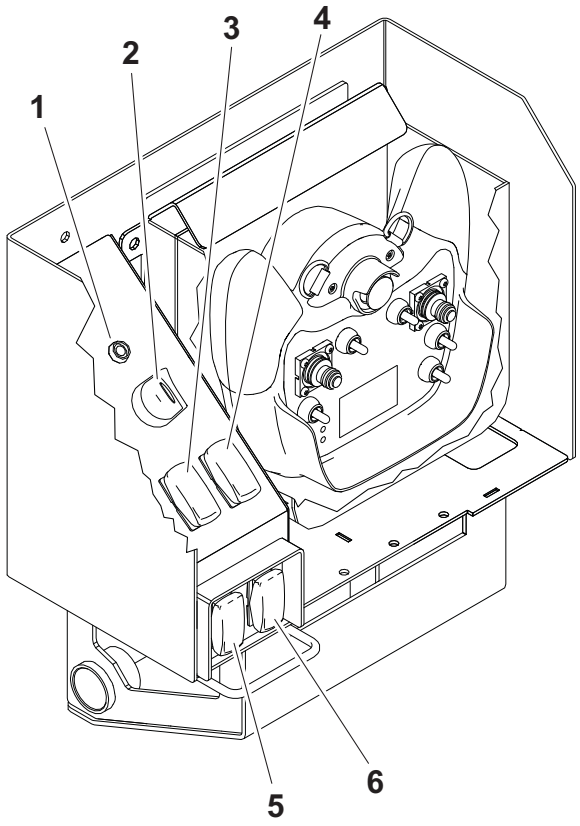
12		**CAUTION** Equipment can be operated by remote control. Stay away. 270-6035
13		**WARNING** Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment.
14		**WARNING** Pressurized fluid or air could pierce skin and cause severe injury. Refer to operator's manual for proper use. 270-6035
15		Emergency exit. Pull pin and lift rear window to exit cab in case of emergency. 270-6859
16		Lift point. See Transport chapter for more information. 274-442
17		**WARNING** Crushing weight could cause death or serious injury. Stay away. 275-326, 701-326

Controls

Chapter Contents

Set-Up Console

Controls



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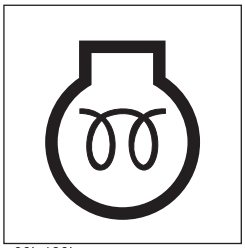
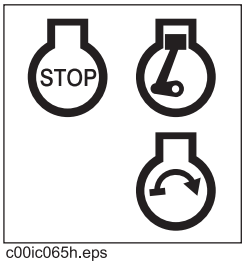
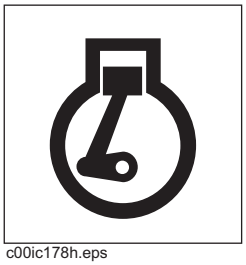
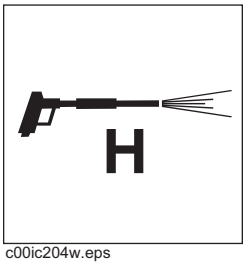
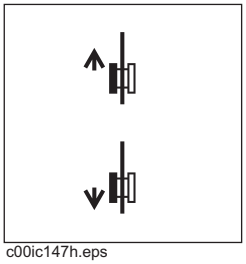
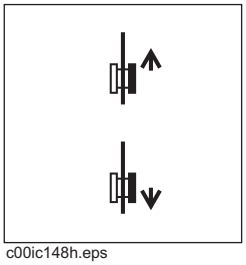
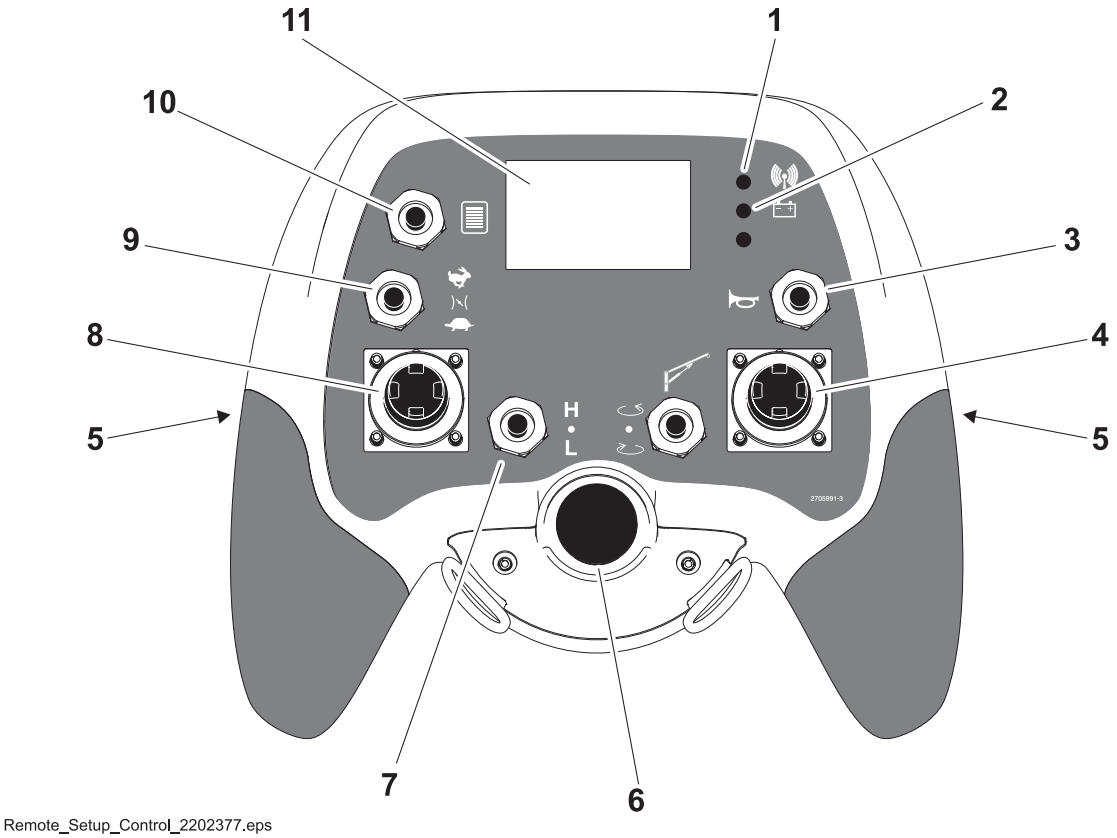
1. Cold start wait indicator
2. Ignition switch
3. Engine shutdown override switch
4. Wash wand switch
5. Left track switch
6. Right track switch

Item	Description	Notes
1. Cold start wait indicator  c00ic180h.eps	Lights when intake air pre-heater is operating.	***NOTICE:*** If indicator is on, wait until it goes out before starting engine.

Item	Description	Notes
2. Ignition switch  c00ic065h.eps	To start engine, insert key and turn clockwise. To stop engine, turn key counterclockwise.	**IMPORTANT:** • Restart engine with ignition switch after it has been turned off with any 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.
3. Engine shutdown override switch  c00ic178h.eps	If engine shutdown indicator comes on, press to delay engine shutdown for 30 seconds.	This control allows a temporary override of engine shutdown. ***NOTICE:*** After 30 seconds, engine will again shut down unless fault condition has been corrected. **IMPORTANT:** See "Electronic Controlled Engine Overview" on page 191.
4. Wash wand switch  c00ic204w.eps	To turn wash wand on, press top. To turn wash wand off, press bottom.	
5. Left track switch  c00ic147h.eps	To move forward, press top. To move backward, press bottom.	**IMPORTANT:** Use track switches only if wireless control is inoperable.
6. Right track switch  c00ic148h.eps	To move forward, press top. To move backward, press bottom.	**IMPORTANT:** Use track switches only if wireless control is inoperable.

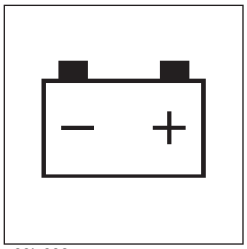
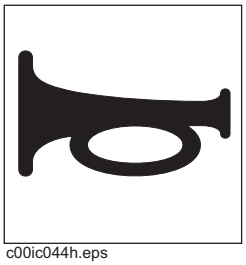
Wireless Remote Controller

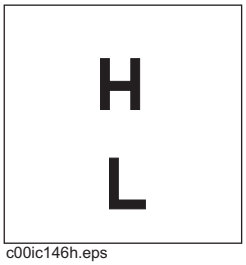
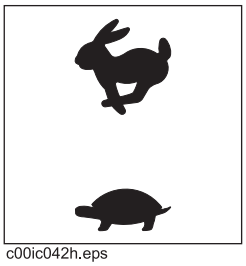


Remote_Setup_Control_2202377.eps

1. Communication link indicator
2. Power status indicator
3. Power/start/horn switch
4. Right multifunction joystick
5. Operator presence switches
6. Engine stop
7. Drive mode switch
8. Left multifunction joystick
9. Throttle switch
10. Menu select switch
11. LCD display

IMPORTANT: Operator station must be empty to operate wireless ground drive control.

Item	Description	Notes
1. Communication link indicator  c00ic713h.eps	Indicates the status of the transmitter and receiver link. • Blinking yellow indicates no communication link. • Blinking green indicates good communication link. • Steady red indicates an internal problem. Contact your Ditch Witch® dealer.	An active communication link is required for wireless control.
2. Power status indicator  c00ic008w.eps	Indicates battery status and cable connection. • Off indicates good battery level. • Blinking red indicates low battery level. • Solid green indicates transmitter is connected to machine.	
3. Power/start/horn switch  c00ic044h.eps	To turn power on, hold switch up until yellow LED indicator comes on and then blinks green. Release switch. Wireless remote control light (page 4) will shine. To start operation, hold switch up with joystick controls in neutral position until horn sounds. Release switch. To use horn, move switch up. Release switch to stop horn. To turn power off, hold switch down until LED indicators go off.	• Transmitter shuts off and yellow LED indicator blinks after 1 minute of inactivity. Hold switch up twice to restart. • Must be pushed to initialize the transmitter each time the menu selection changes.
4. Right multifunction joystick	Move joystick to control selected system.	See "Multifunction Joystick Control Modes" on page 27.
5. Operator presence switches	To operate wireless controller, press one or both switches. To disable controller, release.	**IMPORTANT:** Operator presence switches must be released and pressed again after changing modes to enable new function. See "Menu select switch" on page 24.

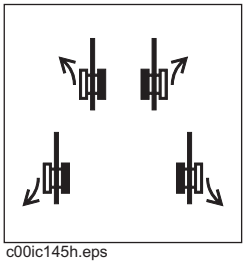
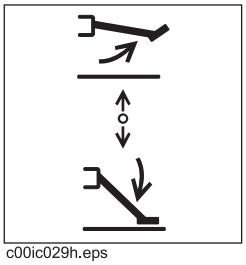
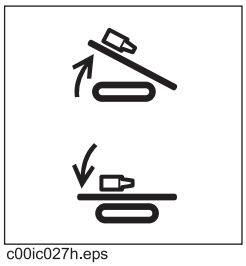
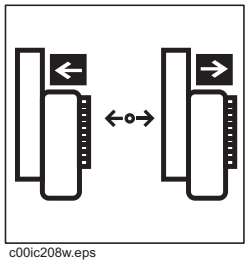
Item	Description	Notes
6. Engine stop	To stop engine, press red button.	**IMPORTANT:** To restart engine, turn ignition switch off and then back on.
7. Drive mode switch  c00ic146h.eps	To select normal driving mode (high), move up. To select loading and unloading mode (low), move down.	
8. Left multifunction joystick	Move joystick to control selected system.	See "Multifunction Joystick Control Modes" on page 27.
9. Throttle switch  c00ic042h.eps	To increase engine speed, move up. To decrease engine speed, move down. Release switch to stop speed adjustment.	**IMPORTANT:** Switch only works when controller is in the ready mode (green LED blinking) and at least one operator presence switch is pressed.
10. Menu select switch	To move up through the modes on the transmitter move up. To move down through the modes on the transmitter move down. Release switch to stop moving through modes.	**IMPORTANT:** Operator presence switches must be released and pressed again after changing modes to enable new function. See "Operator presence switches" on page 24.
11. LCD display	Indicates the selected mode of operation.	

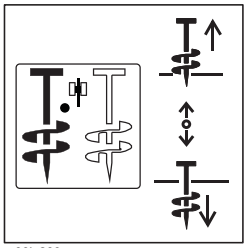
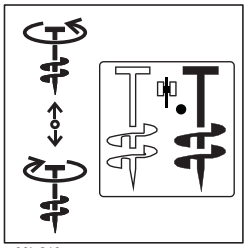
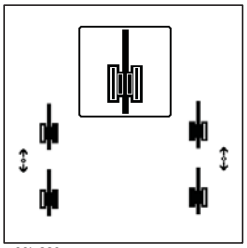
Multifunction Joystick Control Modes

The multifunction joystick controls are capable of controlling multiple systems by selecting various modes.

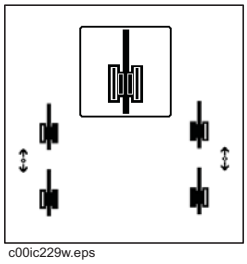
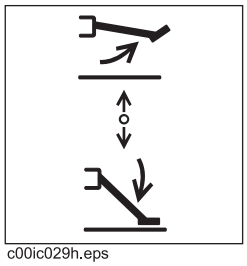
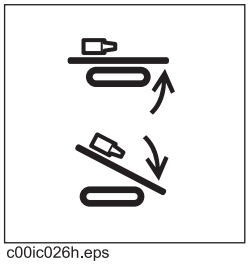
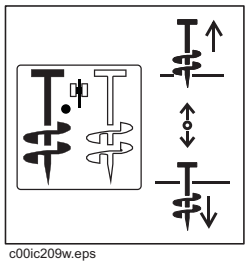
IMPORTANT: To switch between modes, see "Menu select switch" on page 26.

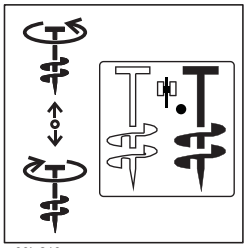
Multifunction Joystick (Right) Modes

Item	Description	Notes
1. Single joystick ground drive control  c00ic145h.eps	To move forward, move up. To move backward, move down. To steer, move left or right while moving forward or backward.	• Operator presence switch must be pressed and operator seat must be empty for control to work. • See "Steer Unit" on page 108 for more information.
2. Right stabilizer control  c00ic029h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** Lower left and right stabilizers to the ground together, then adjust individually.
3. Back frame tilt control  c00ic027h.eps	To raise, push up. To lower, push down.	**IMPORTANT:** To ensure a stable platform for drilling, use front and back tilt controls together to set frame at desired pitch without raising tracks off the ground.
4. Operator station slide control  c00ic208w.eps	To move toward drill, press left. To move away from drill, press right.	Drill icon will appear when operator station is in correct position for drilling.

Item	Description	Notes
5. Left anchor dual joystick control  c00ic209w.eps	To raise, push up. To lower, push down.	
6. Right anchor dual joystick control  c00ic210w.eps	To raise, push up. To lower, push down.	
7. Dual joystick ground drive control  c00ic229w.eps	To move right track forward, move lever forward. To move right track backward, move lever back.	• Operator presence switch must be pressed and operator seat must be empty for control to work. • See "Steer Unit" on page 108 for more information.

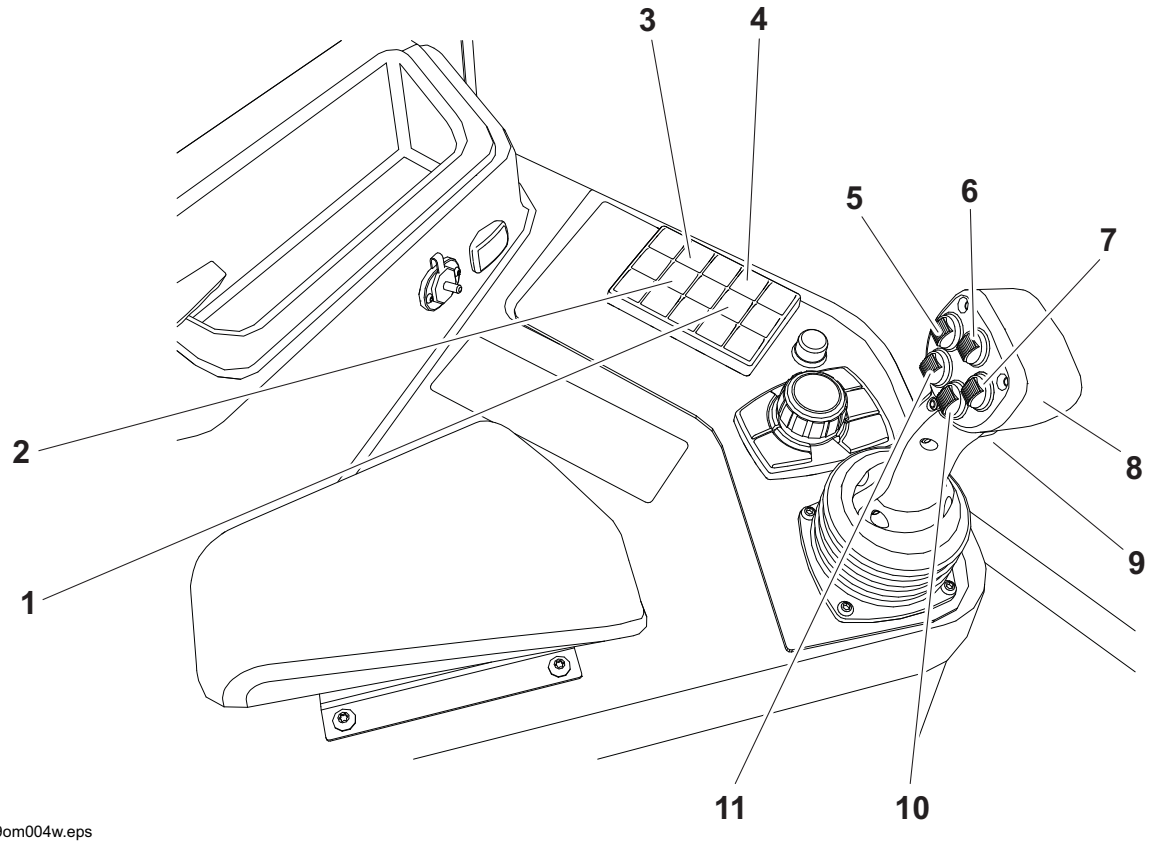
Multifunction Joystick (Left) Modes

Item	Description	Notes
1. Dual joystick ground drive control  c00ic229w.eps	To move right track forward, move lever forward. To move right track backward, move lever back.	• Operator presence switch must be pressed and operator seat must be empty for control to work. • See "Steer Unit" on page 108 for more information.
2. Left stabilizer control  c00ic029h.eps	To raise, push up. To lower, pull down.	**IMPORTANT:** Lower left and right stabilizers to the ground together, then adjust individually.
3. Front frame tilt control  c00ic026h.eps	To raise, push up. To lower, push down.	**IMPORTANT:** To ensure a stable platform for drilling, use front and back tilt controls together to set frame at desired pitch without raising tracks off the ground.
4. Left anchor dual joystick control  c00ic209w.eps	To rotate counterclockwise, push up. To rotate clockwise, push down.	

Item	Description	Notes
5. Right anchor dual joystick control  c00ic210w.eps	To rotate counterclockwise, push up. To rotate clockwise, push down.	

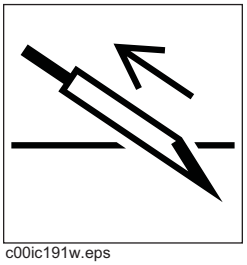
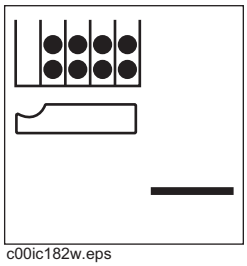
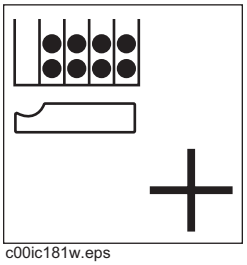
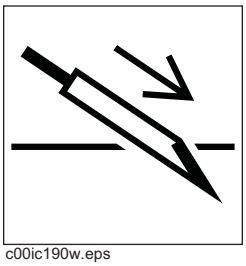
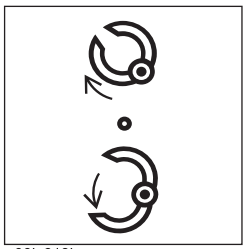
Left Control Console

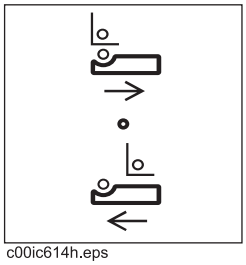
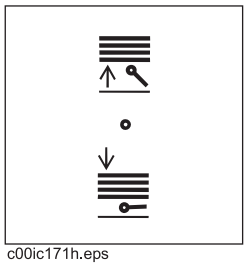
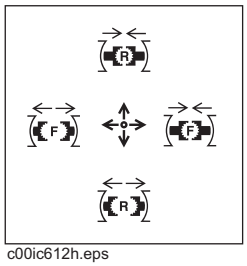
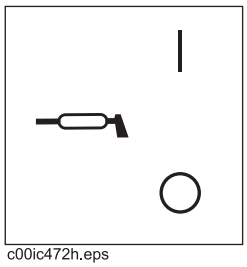
Pipeloading Controls

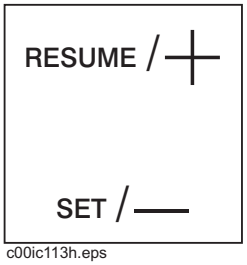
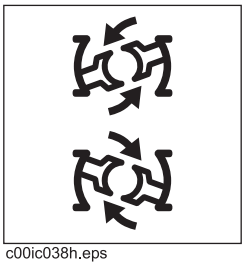


j59om004w.eps

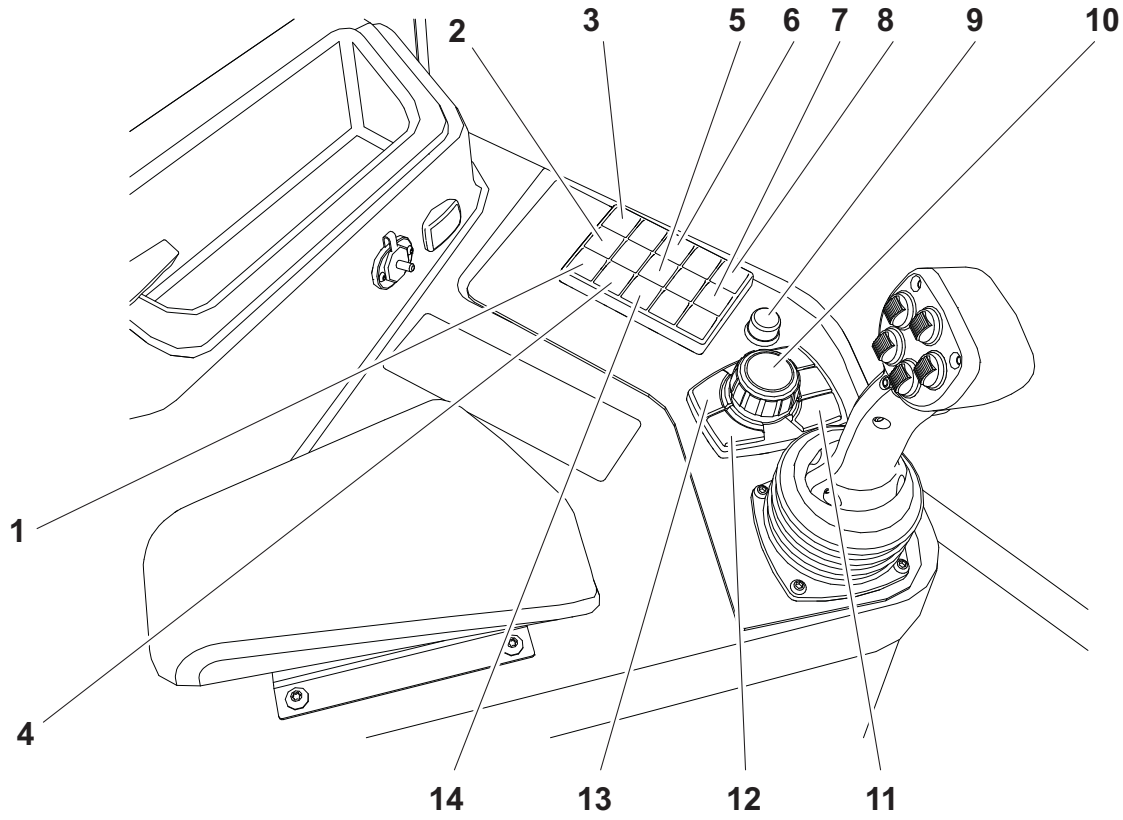
1. Remove pipe control
2. Select previous row control
3. Select next row control
4. Add pipe control
5. Pipe gripper switch
6. Pipe shuttle switch
7. Pipe lift switch
8. Wrench control
9. Pipe lubricator switch
10. Set/Resume switch
11. Rear wrench rotation switch

Item	Description	Notes
1. Remove pipe control  c00ic191w.eps	To select automated "remove pipe" pipeloader function, press. To use manual pipeloader controls, press again.	See "Enable Automated Pipeloader System" on page 130.
2. Select previous row control  c00ic182w.eps	To move shuttle to previous row in pipe box, press.	**IMPORTANT:** See "Row Select" on page 177.
3. Select next row control  c00ic181w.eps	To move shuttle to next row in pipe box, press.	**IMPORTANT:** See "Row Select" on page 177.
4. Add pipe control  c00ic190w.eps	To select automated "add pipe" pipeloader function, press. To use manual pipeloader controls, press again.	See "Enable Automated Pipeloader System" on page 130.
5. Pipe gripper switch  c00ic613h.eps	To close, press top. To open, press bottom. To stop grippers, release.	

Item	Description	Notes
6. Pipe shuttle switch  c00ic614h.eps	To move toward pipe box, press top. To move toward spindle, press bottom. To stop shuttles, release.	
7. Pipe lift switch  c00ic171h.eps	To raise, press top. To lower, press bottom. To stop, release.	
8. Wrench control  c00ic612h.eps	To clamp rear wrench, push forward. To unclamp rear wrench, pull back. To clamp front wrench, move to right. To unclamp front wrench, move to left.	
9. Pipe lubricator switch  c00ic472h.eps	To apply joint compound, press.	Applies joint compound to threads at wrenches.

Item	Description	Notes
10. Set/Resume switch  c00ic113h.eps	To resume operation or increase operation levels, press top. To set operating conditions or reduce operation levels, press bottom.	See "Cruise Control" on page 186. See "AutoCarve control" on page 37. See "Pipeloader" on page 175.
11. Rear wrench rotation switch  c00ic038h.eps	To rotate counterclockwise, press top. To rotate clockwise, press bottom. To stop rotation, release.	

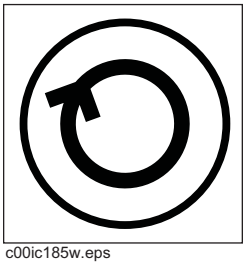
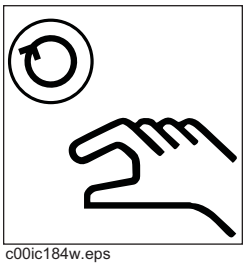
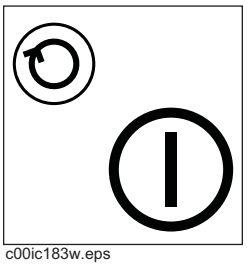
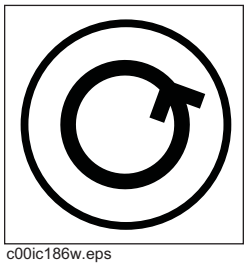
Drilling/Operation Controls

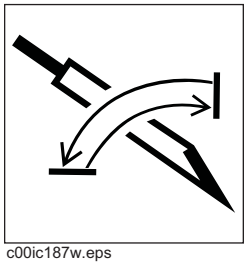
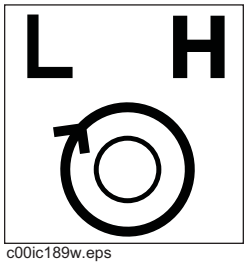
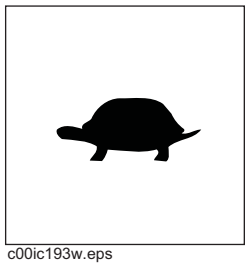


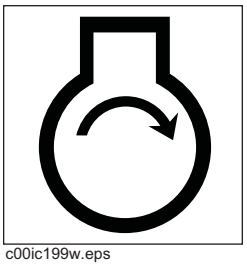
j59om005w.eps

1. Jog clockwise control (AT only)
2. Manual inner spindle control (AT only)
3. Automated inner spindle control (AT only)
4. Jog counterclockwise control (AT only)
5. AutoCarve control (JT and AT Dirt modes)
6. Two-speed rotation control
7. Engine throttle down control
8. Autothrottle control
9. Remote engine start control
10. Rotary operation control
11. Inner spindle selector (AT Rock mode)
12. Fluid flow selector
13. Carve window selector (JT and AT Dirt modes)
14. Outer spindle brake control (JT only*)

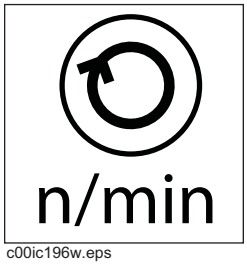
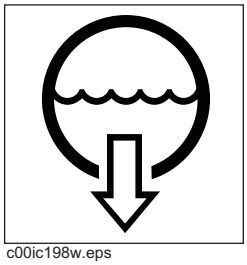
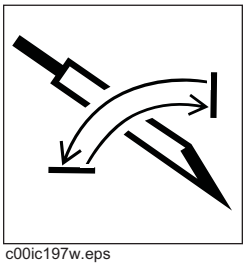
*Optional

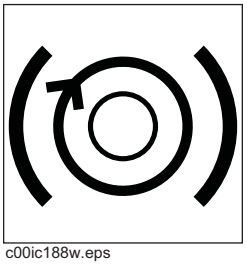
Item	Description	Notes
1. Jog clockwise control  c00ic185w.eps	To turn inner rod clockwise at a fixed speed, press. To stop, press again.	
2. Manual inner spindle control  c00ic184w.eps	To turn on, press. To return to automated inner spindle control, press again.	**IMPORTANT:** • To control inner spindle speed, drilling mode switch must be in AT position. See "Engine Compartment" on page 69. • Use rotary operation control to control inner rotation. See "Rotary operation control" on page 39. • Range of speed is reduced to allow easier manual control.
3. Automated inner spindle control  c00ic183w.eps	To turn on, press. To turn off to manually control inner rotation speed and direction, press again. Then use manual inner spindle control as needed. See "Manual inner spindle control" on page 36.	**IMPORTANT:** • To control inner spindle speed, drilling mode switch must be in AT position. See "Engine Compartment" on page 69. • Use rotary operation control to control inner rotation. See "Rotary operation control" on page 39. • Automated inner spindle control and inner spindle selector must be ON before using rotary operation control to control inner rotation. See "Automated inner spindle selector" on page 40.
4. Jog counterclockwise control  c00ic186w.eps	To turn inner rod counterclockwise at a fixed speed, press. To stop, press again.	

Item	Description	Notes
5. AutoCarve control  c00ic187w.eps	To enable autocarve, press. To disable autocarve, press again.	**IMPORTANT:** • Use rotary operation control to adjust carve window. See "Rotary operation control" on page 39. • AutoCarve control and carve window selector must be ON before using rotary operation control to adjust carve window. See "Carve window selector" on page 40. • Two-speed thrust is not allowed in autocarve mode. • Cruise control is not available in autocarve mode. • Autocarve is disabled while front wrench is closed.
6. Two-speed rotation control  c00ic189w.eps	To rotate in high speed, press. To rotate in low speed, press again.	
7. Engine throttle down control  c00ic193w.eps	To decrease engine speed, press.	Engine speed will be decreased incrementally each time the engine throttle down control is pressed.

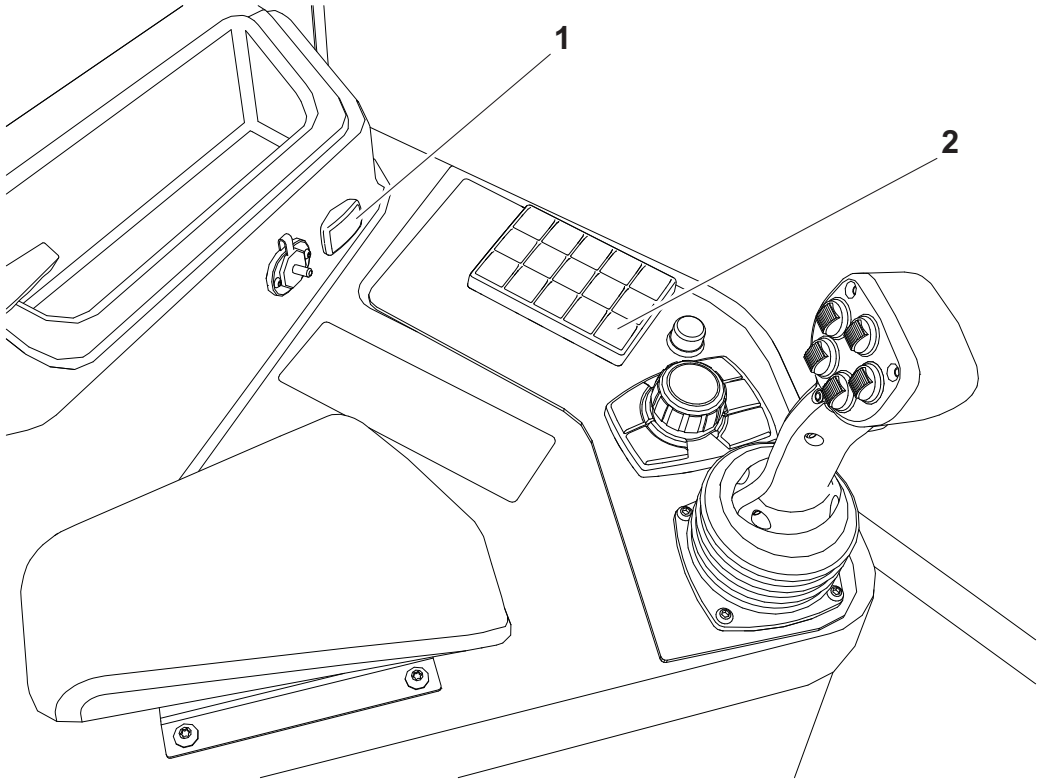
Item	Description	Notes
8. Autothrottle control  c00ic192w.eps	To enable autothrottle mode, press. To disable autothrottle mode, press again.	Autothrottle mode slows the engine to low throttle after 15 seconds of inactivity involving thrust, rotation, drilling fluid flow, or pipeloader functions. To return to high speed, activate thrust, rotation, drilling fluid, or an add/remove pipe cycle.
9. Remote engine start control  c00ic199w.eps	To start engine from operator's station, push button. Release when engine starts.	**IMPORTANT:** This button works only when key in set-up console is on, operator is in seat, and battery disconnect switch is closed.

Item	Description	Notes
10. Rotary operation control	Turn knob to control the following functions: Press and turn knob to allow finer control of the following functions.	
	Manual inner spindle speed control: To increase manual inner spindle speed, turn clockwise. To decrease manual inner spindle speed, turn counterclockwise.	See "Manual inner spindle control" on page 36.
	Automated inner spindle speed control: To increase rotation speed, turn clockwise. To decrease rotation speed, turn counterclockwise.	See "Automated inner spindle control" on page 36.
	Fluid flow control To increase flow, turn clockwise. To decrease flow, turn counterclockwise.	See "Drilling fluid pump switch" on page 45.
	Carve window control: To increase carve window range, turn clockwise. To decrease carve window range, turn counterclockwise	See "AutoCarve control" on page 37.

Item	Description	Notes
11. Automated inner spindle selector  c00ic196w.eps	To turn on, press. To turn off, press again.	**IMPORTANT:** • Drilling mode switch must be in AT position. See "Engine Compartment" on page 69. • To control inner spindle rotation speed, automated inner spindle control must be on. See "Automated inner spindle control" on page 36. • Use rotary operation control to adjust inner spindle speed. See "Rotary operation control" on page 39.
12. Fluid flow selector  c00ic198w.eps	To turn on, press. To turn off, press again.	**IMPORTANT:** • To control drilling fluid flow drilling fluid pump must be switched on. See "Right Control Console" on page 44. • Use rotary operation control to adjust fluid flow. See "Rotary operation control" on page 39.
13. Carve window selector  c00ic197w.eps	To turn on, press. To turn off, press again.	**IMPORTANT:** • To adjust carve window, AutoCarve control must be on. See "AutoCarve control" on page 37. • Use rotary operation control to adjust carve window. See "Rotary operation control" on page 39. • **For AT units:** To set carve window, autocarve mode must be enabled and drilling mode switch in **AT Dirt** position. See "Engine Compartment" on page 69.

Item	Description	Notes
14. Outer spindle brake control  c00ic188w.eps	To engage, press. To disengage, press again.	Prevents outer spindle from rotating when inner spindle or mud motor are in use. Brake is temporarily released when front wrench is closed to allow pipe change.

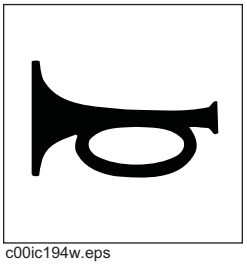
Miscellaneous Controls



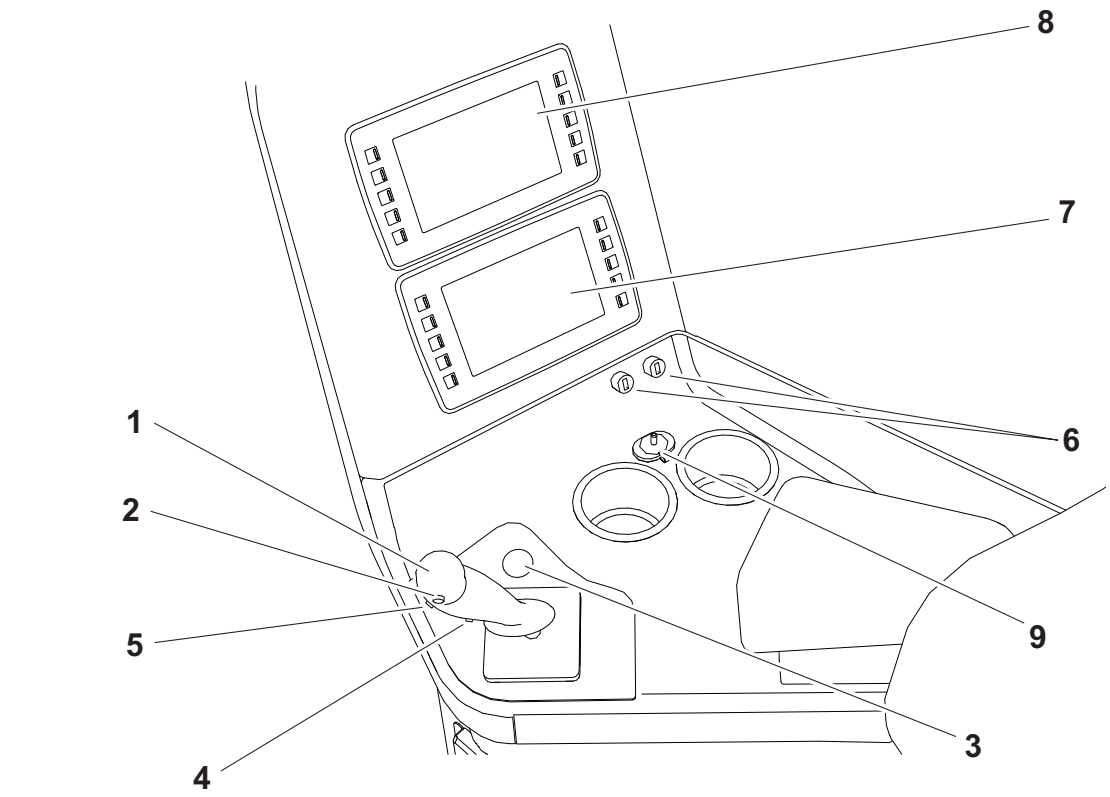
j59om076w.eps

1. ESID alarm interrupt/self-test switch
2. Horn

Item	Description	Notes
1. ESID alarm interrupt/ self-test switch  c00ic711h.eps	To turn off strike alarm at drilling unit, press top. To start manual self-test, press bottom. To reset system after a strike has been detected, press bottom.	**IMPORTANT:** • Self-test checks all systems and circuits except voltage limiter. See "Voltage Test" on page 157. • See "If an Electric Line is Damaged" on page 14.

Item	Description	Notes
2. Horn  c00ic194w.eps	Press and hold to sound horn.	

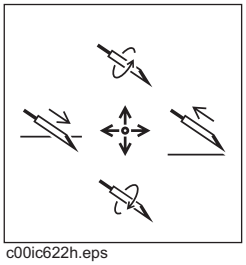
Right Control Console

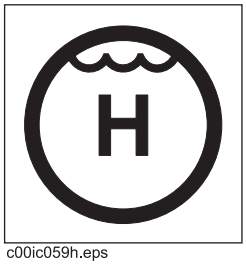
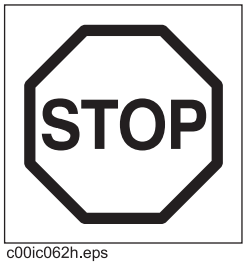
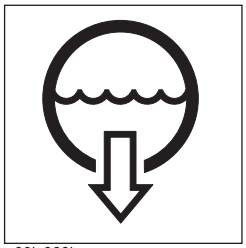


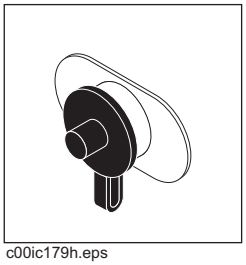
j59om003w.eps

1. Carriage control joystick
2. Drilling fluid quick fill switch
3. Remote engine stop switch
4. Drilling fluid pump switch
5. Multi-use button
6. USB port
7. Lower/Remote* display
8. Upper display
9. Auxiliary outlet

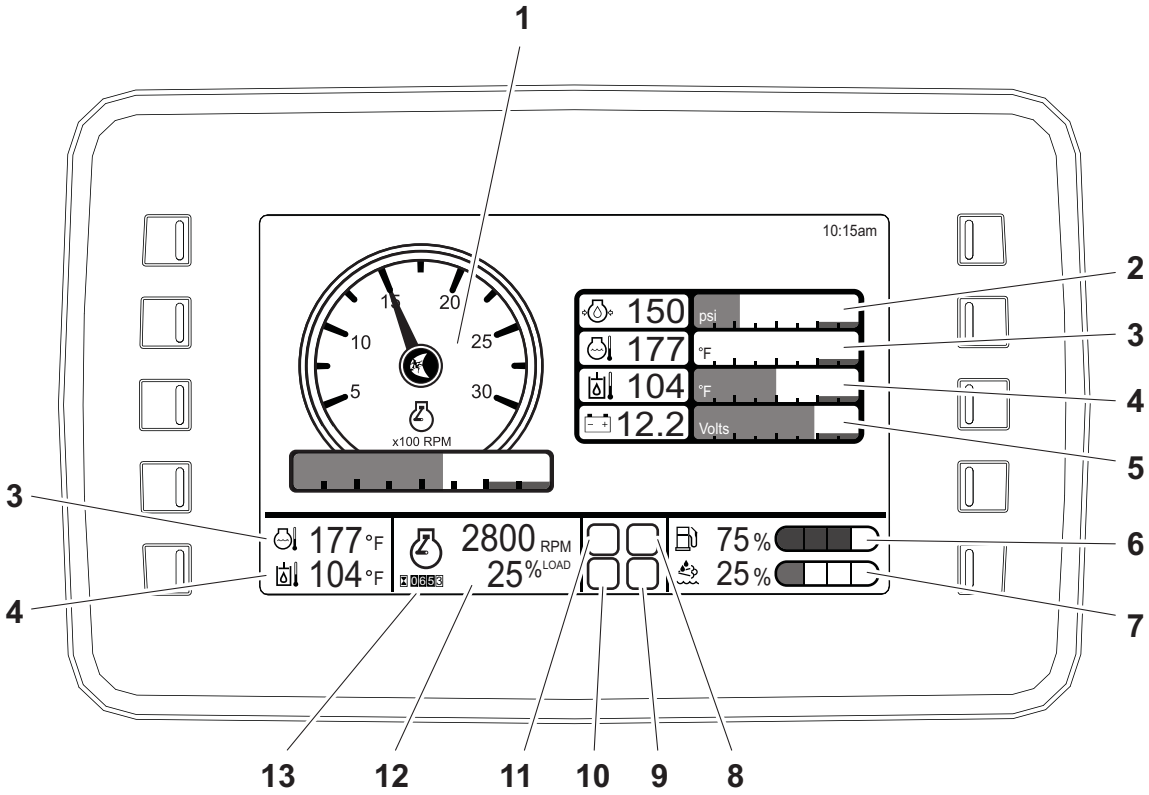
*See tracker manual

Item	Description	Notes
1. Carriage control joystick  c00ic622h.eps	To move carriage forward, push. To move carriage backward, pull. To rotate spindle counterclockwise (breakout), move right. To rotate spindle clockwise (makeup), move left.	**IMPORTANT:** See "Operate Carriage Control" on page 123 for more information.

Item	Description	Notes
2. Drilling fluid quick fill switch  c00ic059h.eps	For full pump flow to fill pipe with fluid, press and hold. To return fluid flow to flow control setting, release.	**IMPORTANT:** Overrides fluid control setting for full pump flow. Also overrides temporary fluid shutdown when front wrench is closed.
3. Remote engine stop switch  c00ic062h.eps	To stop engine, press. To restart engine, press remote engine start switch (page 35).	**IMPORTANT:** • 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.
4. Drilling fluid pump switch  c00ic060h.eps	To turn on, press once. To turn off, press once.	**IMPORTANT:** • Use rotary operation control to control drilling fluid flow. See "Rotary operation control" on page 39. • Drilling fluid pump switch and fluid flow selector must be ON before using rotary operation control to control drilling fluid flow. See "Fluid flow selector" on page 40.
5. Multi-use button	To engage a function, push and hold. To return to normal operation, release.	**Operation Options:** • Two-speed carriage control • Autocarve reaming and positioning functions • Interrupted makeup system override
6. USB port	Provides power for mobile devices.	DC5V, 1A (5W)

Item	Description	Notes
7. Lower/Remote display	Displays graphic symbols for indicators and conditions. If using a Subsite® Electronics tracking system, information from the tracker is also displayed.	For more information see "Lower Display" on page 47. See tracking system operator's manual for more information.
8. Upper display	Displays graphic symbols for indicators and conditions.	For more information see "Upper Display" on page 50.
9. Auxiliary outlet  c00ic179h.eps	Provides power for other equipment.	Power output is 12VDC, 5A.

Lower Display



j59om077w.eps

IMPORTANT: If unit is equipped with Subsite® Electronics COMMANDER™ 7 display, engine information will be displayed on screen in addition to tracker information.

1. Tachometer
2. Engine oil pressure indicator/numeric display
3. Engine coolant temperature indicator/numeric display
4. Hydraulic fluid temperature indicator/numeric display
5. Voltmeter display
6. Fuel gauge
7. DEF indicator/tank level percentage*
8. Exhaust cleaning indicator*
9. High exhaust temperature indicator*
10. Hydraulic fluid filter indicator/Hydraulic fluid temperature indicator
11. Engine warning/stop indicator
12. Engine load display
13. Hourmeter

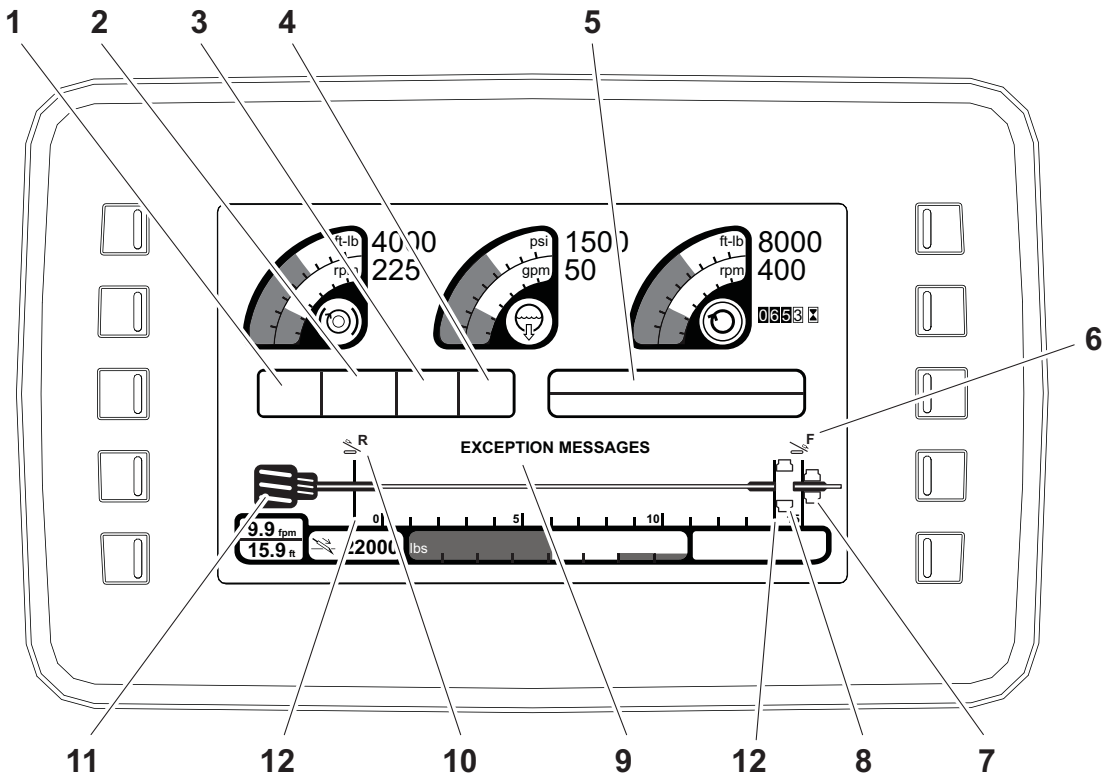
*HRC units only

Item	Description	Notes
1. Tachometer	Displays engine speed.	
2. Engine oil pressure indicator/numeric display	 Displays engine oil pressure.	Full load reading should be 60-80 psi (4.1-5.5 bar).
3. Engine coolant temperature indicator/ numeric display	 Displays engine coolant temperature.	Normal coolant temperature is 160°-225° F (71°-107° C).
4. Hydraulic fluid temperature indicator/ numeric display	 Displays hydraulic fluid temperature.	Normal hydraulic fluid temperature is less than 170° F (77° C).
5. Voltmeter display	 Shows system voltage.	Normal voltage is 13-14V with engine running.
6. Fuel gauge	 Displays amount of fuel remaining in tank.	Icon flashes yellow when fuel level reaches 10%. See "Approved Fuel" on page 204.
7. DEF indicator/tank level percentage	 Displays amount of diesel exhaust fluid (DEF) remaining in tank.	• Icon flashes yellow every one second if level is lower than 10% but higher than 2.5%. • Icon flashes yellow every half second if level is less than 2.5%. • Icon flashes yellow every two seconds if quality of DEF is poor. See "Diesel Exhaust Fluid (DEF) - HRC Only" on page 205.
8. Exhaust cleaning indicator	 Lights when a system cleaning is needed.  Lights when operator has disabled exhaust cleaning.	See "Diesel Exhaust Fluid (DEF) - HRC Only" on page 205.
9. High exhaust temperature indicator	 Lights when exhaust temperatures are high.	***NOTICE:*** May light when exhaust cleaning is occurring.
10. Hydraulic fluid filter indicator/Hydraulic fluid temperature indicator	 Lights when hydraulic filter is restricted.  Lights when hydraulic fluid temperature is too high.	

Item	Description	Notes
11. Engine warning/stop indicator	Lights when engine needs attention. Lights when operator needs to stop engine.	
12. Engine load display	Displays engine load.	
13. Hourmeter	Displays number of hours engine has been running.	

Upper Display

Status Indicators



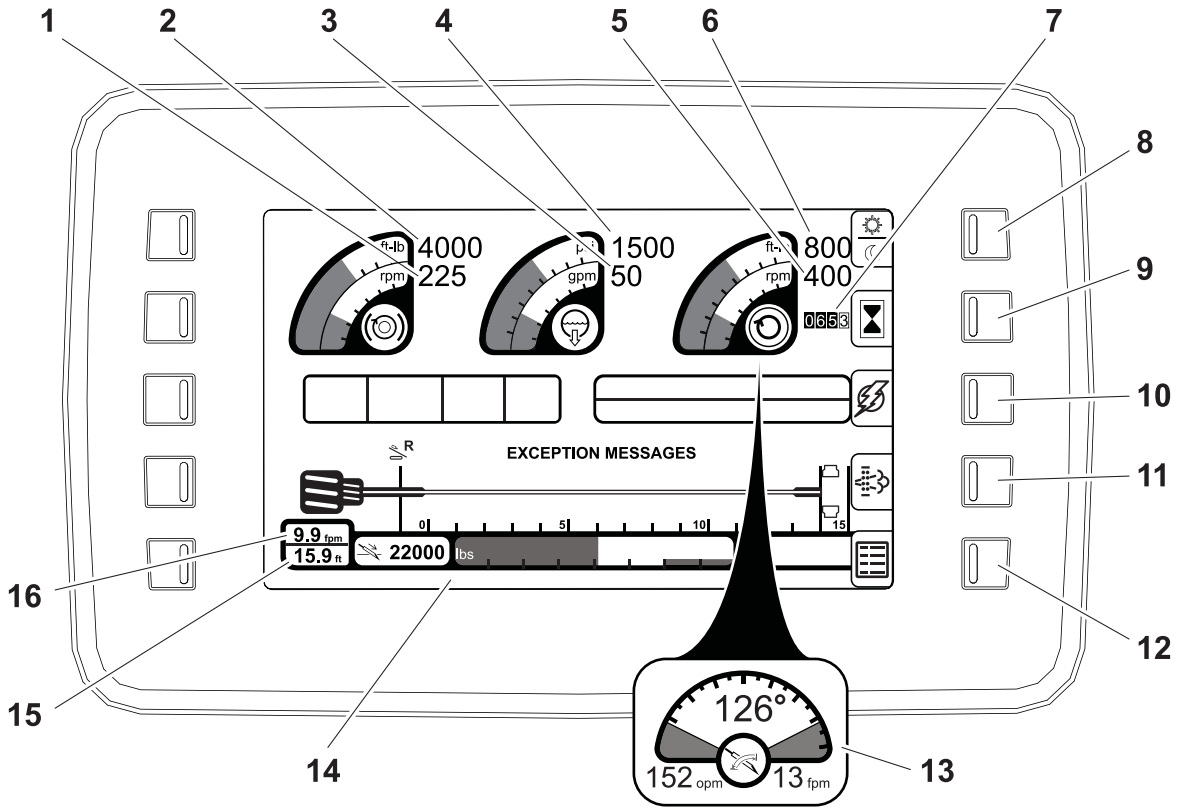
j59om063w.eps

1. ESID status indicator
2. Pipe row indicator
3. Drill/Drive indicator
4. Cruise mode indicator
5. Operation messages
6. Front home/stop indicator
7. Front wrench indicator
8. Rear wrench indicator
9. Exception messages
10. Rear home/stop indicator
11. Carriage indicator
12. Tool joint position indicator

Item	Description	Notes
1. ESID status indicator	 ESID OK  ESID voltage  ESID detected, not OK  ESID not detected  ESID current indicator	Green background Red background Yellow background Red background Red background
2. Pipe row indicator	 Indicates current row of pipe selected.	
3. Drill/Drive indicator	 AT rock drill mode  JT drill mode  AT dirt drill mode  Drive mode	
4. Cruise mode indicator	 Indicates when cruise mode is enabled.	
5. Operation messages	Displays messages for overall operation of the machine.	
6. Front home/stop indicator	 Indicates when the carriage has reached the rear home/stop indicator.	• **Yellow background:** Carriage is approaching the rear home position. • **Green background:** Carriage has reached the rear home position. • **Red background:** Carriage is in the rear stop position.
7. Front wrench indicator	 Wrenches closed Wrenches open	
8. Rear wrench indicator	 Wrenches closed Wrenches open	
9. Exception messages	Displays any cautionary or warning messages.	

Item	Description	Notes
10. Rear home/stop indicator	 Indicates when the carriage has reached the rear home/stop indicator.	• **Yellow background:** Carriage is approaching the rear home position. • **Green background:** Carriage has reached the rear home position. • **Red background:** Carriage is in the rear stop position.
11. Carriage indicator	Animated display of the movement of the carriage and outer and inner (AT only) pipe.	
12. Tool joint position indicator	Displays the current position of the SaverLok® and pipe tool joints.	

Gauges and Buttons



j59om066w.eps

1. Outer rotation speed gauge
2. Outer rotation pressure gauge
3. Drilling fluid rotation speed gauge
4. Drilling fluid rotation pressure gauge
5. Inner rotation speed gauge (AT only)
6. Inner rotation pressure gauge (AT only)
7. Inner rotation hour meter
8. Day/Night mode key
9. Inner rotation hour reset key (AT only)
10. ESID status display key
11. Force exhaust cleaning key (HRC only)
12. Main menu key
13. Carve window (JT and AT Dirt mode only)
14. Thrust pressure gauge
15. Carriage distance display
16. Carriage speed display

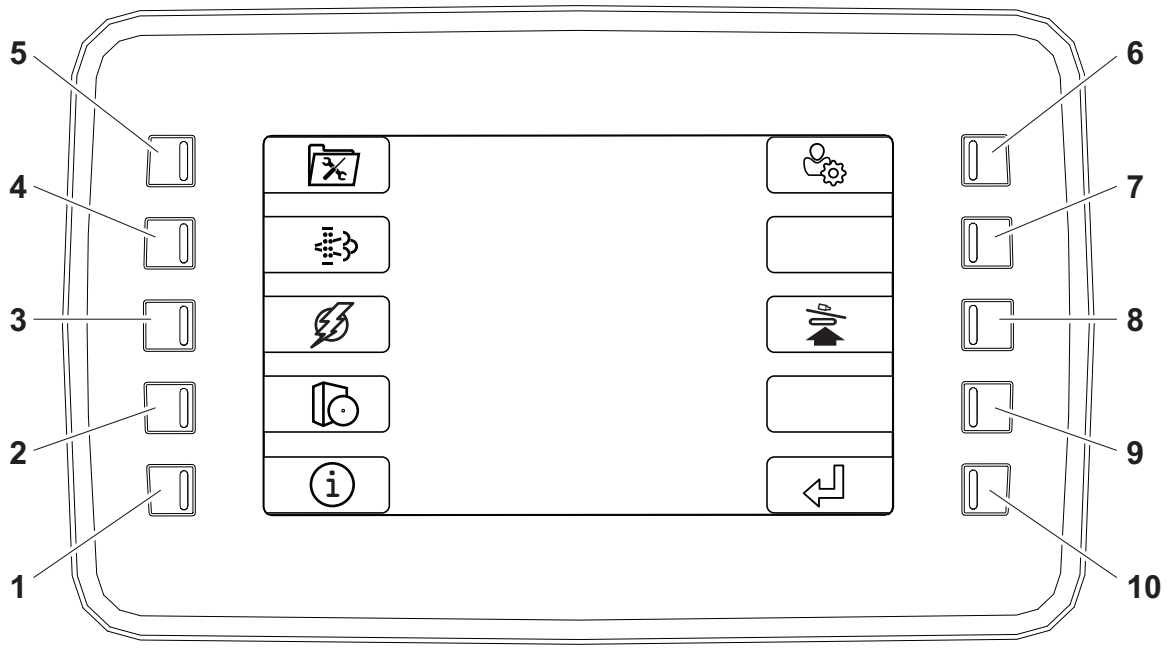
IMPORTANT: Press any key to activate menu buttons.

Item	Description	Notes
1. Outer rotation speed gauge	Displays outer rotation speed graphically and numerically.	

Item	Description	Notes
2. Outer rotation pressure gauge	Displays outer rotation pressure graphically and numerically.	
3. Drilling fluid rotation speed gauge	Displays drilling fluid rotation speed graphically and numerically.	
4. Drilling fluid rotation pressure gauge	Displays drilling fluid rotation pressure graphically and numerically.	
5. Inner rotation speed gauge	Displays inner rotation speed graphically and numerically.	
6. Inner rotation pressure gauge	Displays inner rotation pressure graphically and numerically.	
7. Inner rotation hour meter	Displays inner rotation hours since last manual reset.	See "Inner rotation hour reset key (AT only)" on page 53.
8. Day/Night mode key	Press from main screen to toggle between day and night modes.	
9. Inner rotation hour reset key	Press and hold for five seconds to reset inner rotation hours.	
10. ESID status display key	Displays when unit detects an error with ESID system.	
11. Stationary exhaust cleaning key	Press from main screen (gauges) to force stationary exhaust cleaning.	***NOTICE:*** • Failure to complete an exhaust cleaning when required can cause damage to the engine. • A typical exhaust cleaning cycle will take approximately 35 minutes. • Ensure machine is away from combustible material and engine is set at low throttle before initiating exhaust cleaning. • A pop-up message will appear when exhaust cleaning is selected. Follow on-screen prompts to complete the process.

Item	Description	Notes
12. Main menu key	Press from main screen (gauges) to select main menu.	See "Main Menu" on page 56.
13. Carve window	Displays the carve window, set by operator.	**IMPORTANT:** This gauge replaces the inner rotation speed/pressure gauge when the carve function is selected. See "Use AutoCarve" on page 138.
14. Thrust pressure gauge	Numerically and graphically displays thrust pressure.	
15. Carriage distance display	Numerically displays distance of the carriage.	
16. Carriage speed display	Numerically displays speed of the carriage.	

Main Menu



j59om067w.eps

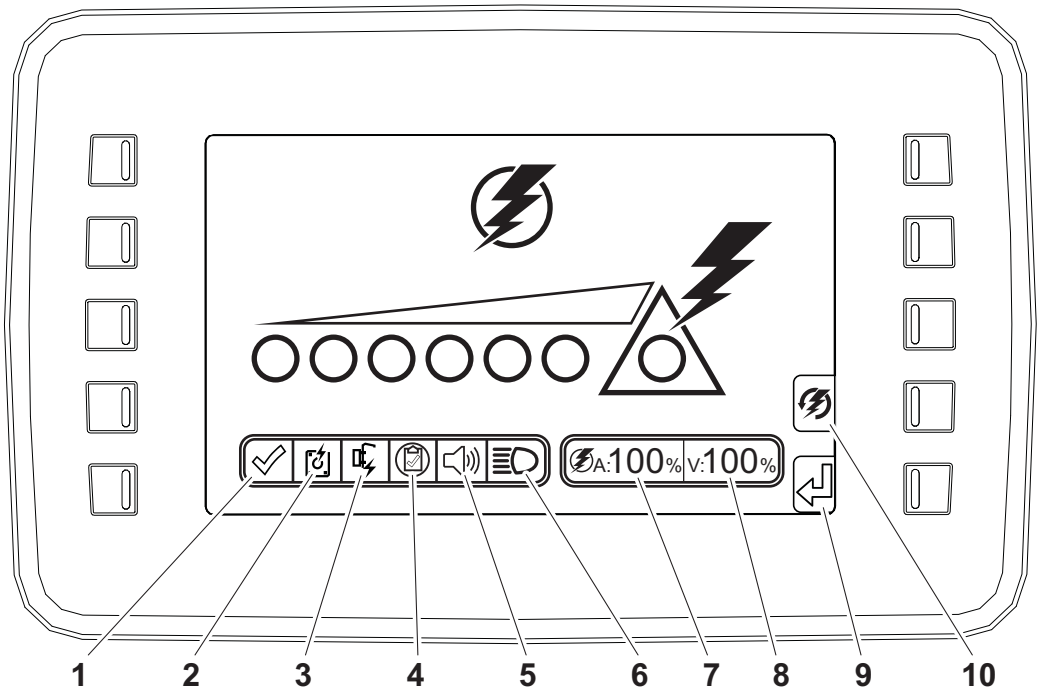
IMPORTANT: Soft key commands change with each menu screen and are displayed next to the key.

1. Information menu key
2. System settings key
3. ESID history menu key
4. Exhaust cleaning activation key (HRC only)
5. Engine diagnostics key
6. User settings key
7. Not used
8. Drill set-up menu key
9. Not used
10. Return key

Item	Description	Notes
1. Information menu key	Press to display information about raw values and rotation hours.	
2. System settings key	Press to display software version information.	
3. ESID history menu key	Press to select the ESID history menu.	Displays past ESID codes.

Item	Description	Notes
4. Exhaust cleaning activation key	Press to activate exhaust cleaning.	***NOTICE:*** • Failure to complete an exhaust cleaning when required can cause damage to the engine. • Ensure machine is away from combustible material and engine is set at low throttle before initiating exhaust cleaning. • A pop-up message will appear when exhaust cleaning is selected. Follow on-screen prompts to complete the process.
5. Engine diagnostics key	Press to display engine diagnostic codes, if any.	**IMPORTANT:** If diagnostic codes are displayed, contact your Ditch Witch® dealer.
6. User settings key	Press to customize settings.	Real time clock, brightness, and language can be adjusted in this screen.
7. Not used		
8. Drill set-up menu key	Press to access menu used to adjust cab, anchors, stabilizers, and frame tilt using the carriage control joystick.	See "Drill Set-Up Menu" on page 61. All drill set-up functions are also possible using the wireless remote controller also. See "Wireless Remote Controller" on page 24.
9. Not used		
10. Return key	Press to return to main screen (gauges).	

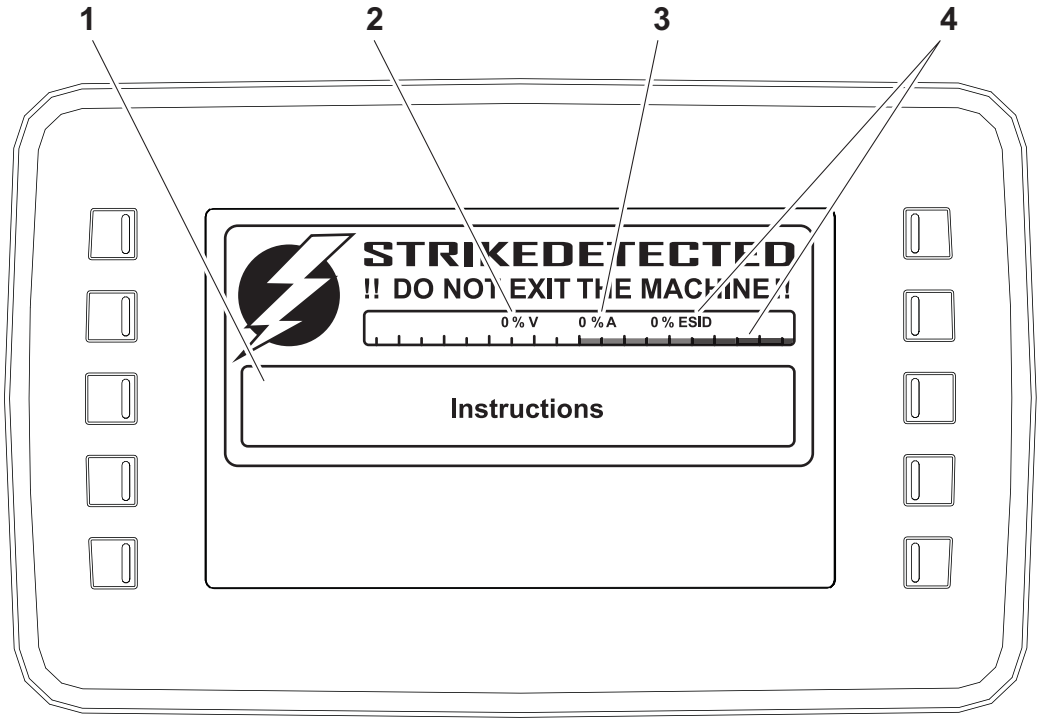
ESID Status Display



j59om073w.eps

Item	Description
1. ESID okay (check) indicator	ESID self test reports no problems.
2. ESID amperage indicator	ESID has detected a non-specific problem with current coil circuit.
3. ESID voltage indicator	ESID has detected a non-specific problem with voltage limiter circuit.
4. ESID test indicator	Self test is being conducted.
5. ESID horn active indicator	
6. ESID strobe active indicator	
7. ESID coil strike percentage	
8. ESID volt strike percentage	
9. Return key	Press to return to main screen (gauges).
10. ESID history menu key	Displays past ESID codes.

ESID Strike Display

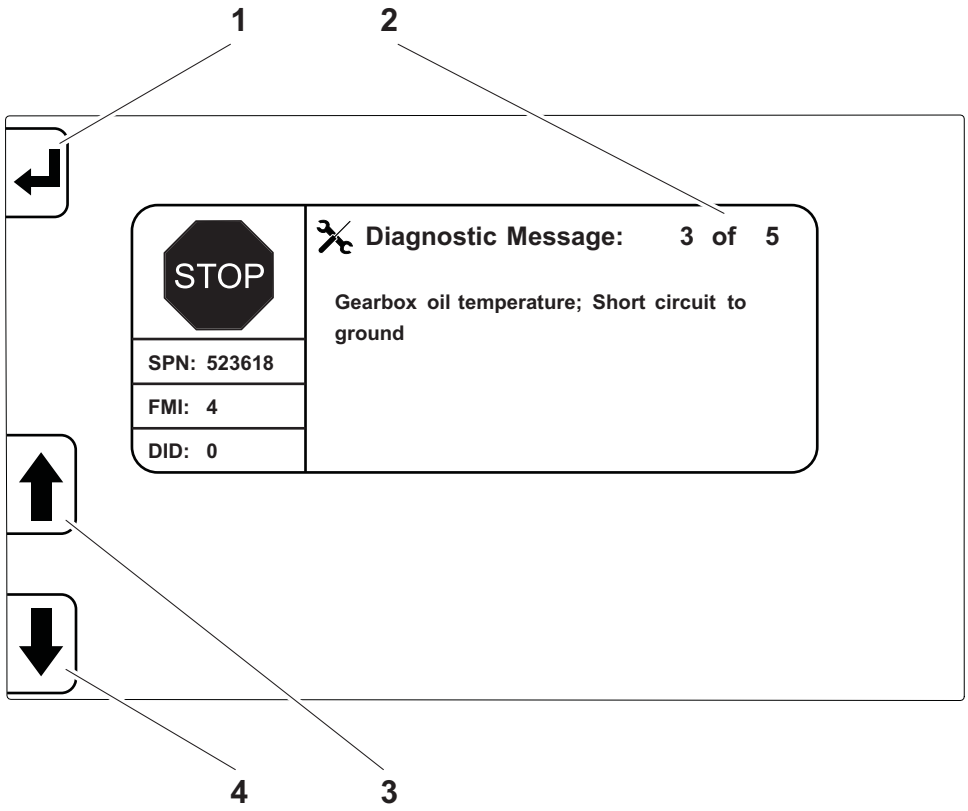


Item	Description
1. Instruction display	Follow the instructions on the screen when a strike is detected.
2. Voltage indicator	Indicates percentage of voltage difference detected between voltage limiter and unit. 30 volts will display as 100%.
3. Current indicator	Indicates percentage of current being detected at the current transformer. 300 milliamps will display as 100%.
4. Strike condition indicator	Indicates the total combined percentage of detected voltage and current and displays it graphically. An alarm condition occurs when the total combined percentage is equal to or greater than 100%.

The above screen is displayed when an electrical strike is detected. For more information, See "Electric Strike System" on page 152.

IMPORTANT: 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.

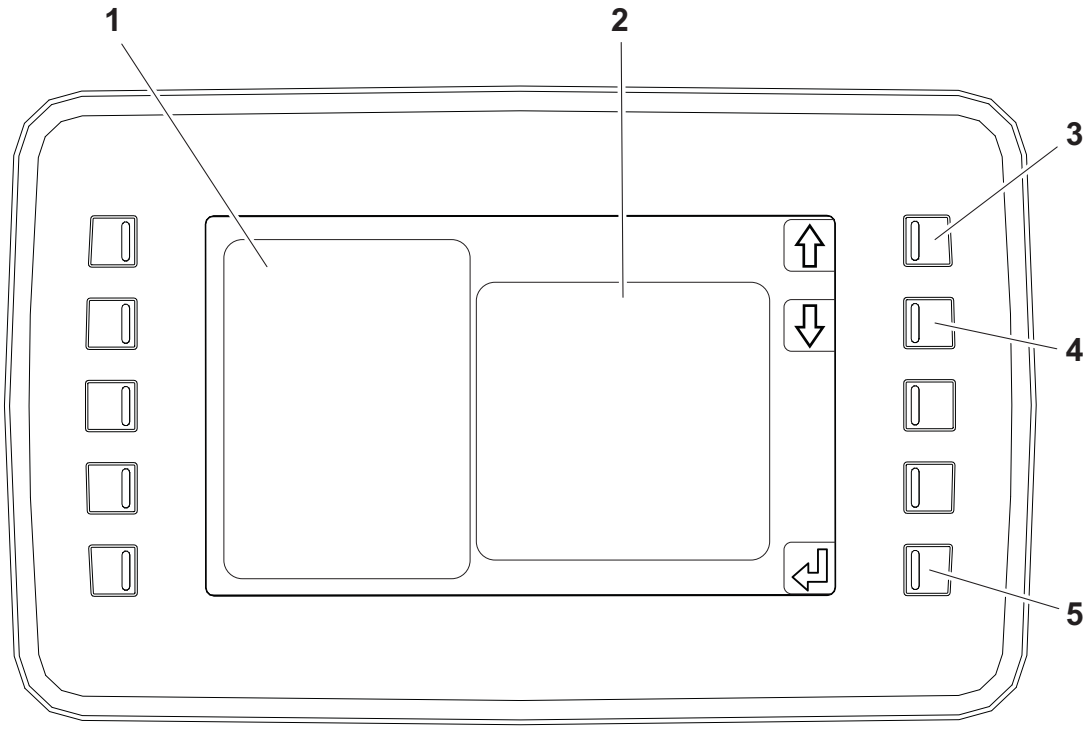
Diagnostic Messages



j59om075w.eps

Item	Description
1. Hide/Recall key	Press to hide/recall active error messages.
2. Diagnostics error message information display	Displays detailed information about the error messages.
3. Next error message key	Press to display next active error message in list.
4. Previous error message key	Press to display previous active error message in list.

Drill Set-Up Menu



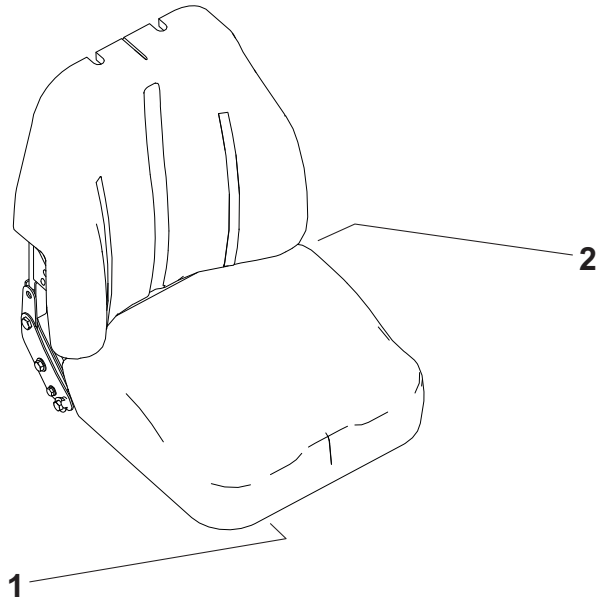
j59om120w.eps

1. System set-up indicator
2. Set-up controls
3. Previous system set-up display key
4. Next system set-up display key
5. Return key

Item	Description
1. System set-up indicator	Visually indicates which system is being set up. Adjust cab, anchors, stabilizers, and frame tilt using the carriage control joystick.

Item	Description
2. Set-up controls	 To move cab toward drill, press joystick left.  To move cab away from drill, press joystick right.  To move anchor clockwise, press joystick right.  To move anchor counterclockwise, press joystick left.  To raise anchor, move joystick backward.  To lower anchor, move joystick forward.  To raise back frame tilt, move joystick forward and to the right.  To lower back frame tilt, move joystick backward and to the right.  To raise front frame tilt, move joystick backward and to the left.  To lower front frame tilt, move joystick backward and to the left.  To raise left stabilizer, move joystick forward and to the left.  To lower left stabilizer, move joystick backward and to the left.  To raise right stabilizer, move joystick forward and to the right.  To lower right stabilizer, move joystick backward and to the right. *Functions can be combined while setting up anchors, frame tilt, or stabilizers.
3. Previous system set-up display key	Press to display previous system set-up display.
4. Next system set-up display key	Press to display next system set-up display.
5. Return key	Press to return to main screen (gauges).

Open Station Seat



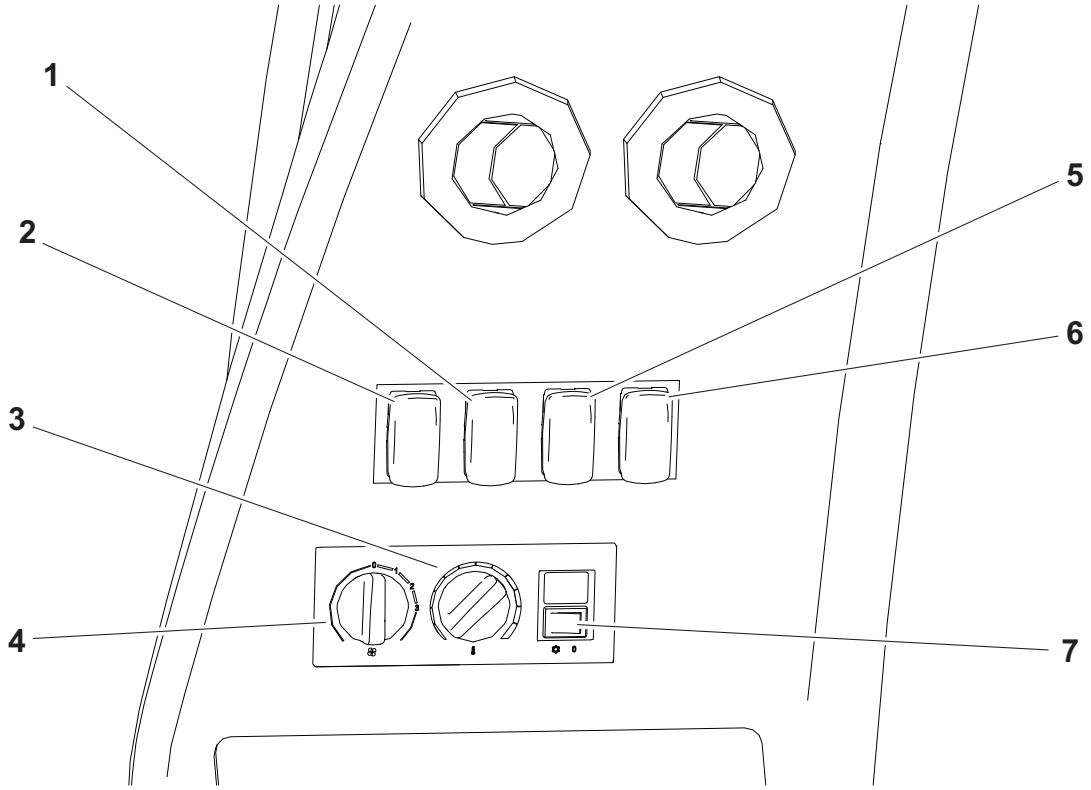
j59om085w.eps

1. Slide control
2. Recline control

Item	Description	Notes
1. Slide control	To slide forward or backward, pull then adjust seat. To lock seat in position, release.	
2. Recline control	To recline seatback, rotate backward. To raise seatback, rotate forward.	

Cab (Optional)

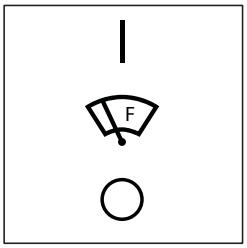
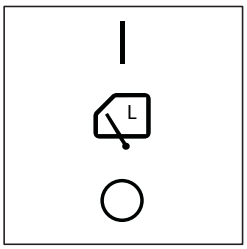
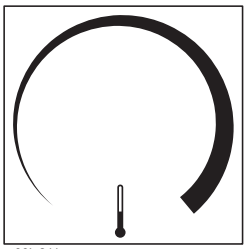
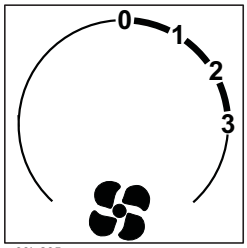
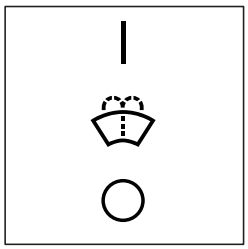
Controls

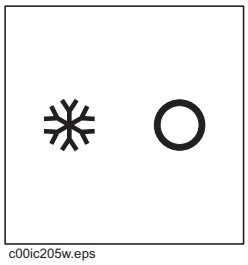


j59om007w.eps

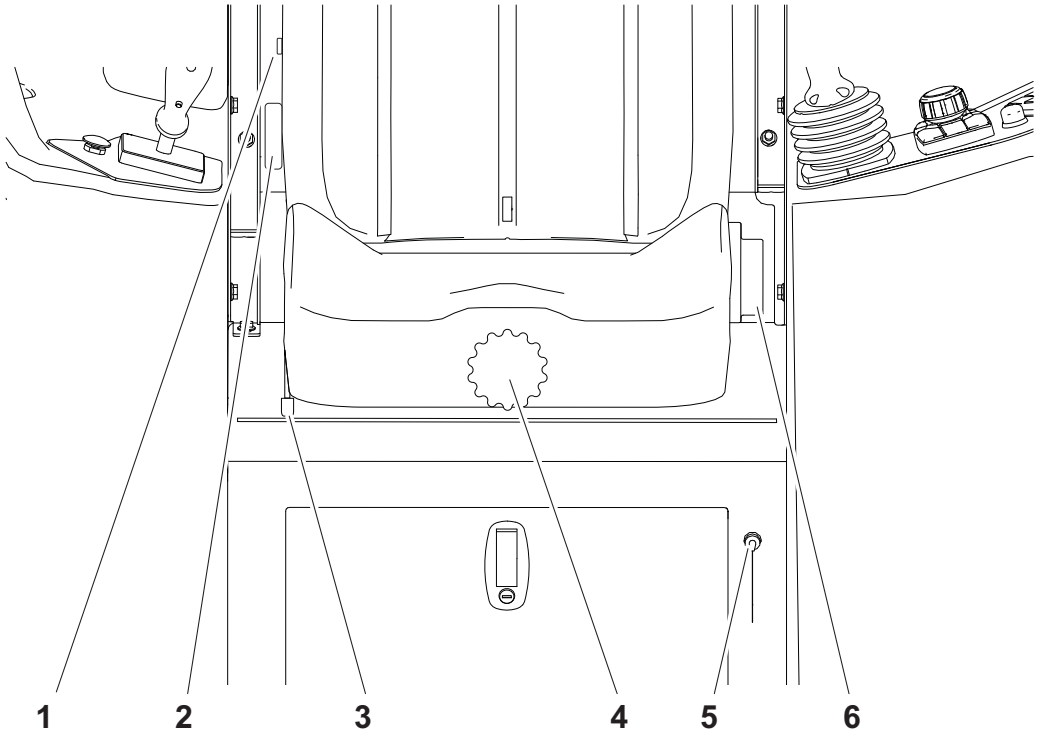
EMERGENCY EXIT: Pull pin and lift rear window to exit cab in case of emergency.

1. Door wiper switch
2. Left wiper switch
3. Air temperature dial
4. Fan speed dial
5. Washer fluid switch
6. Work light switch
7. Air conditioner on/off switch

Item	Description	Notes
1. Door wiper switch  c00ic214w.eps	To turn on, press top. To turn off, press bottom.	
2. Left wiper switch  c00ic212w.eps	To turn on, press top. To turn off, press bottom.	
3. Air temperature dial  c00ic211w.eps	To adjust air temperature, turn dial.	
4. Fan speed dial  c00ic205w.eps	To adjust fan speed, turn dial.	
5. Washer fluid switch  c00ic213w.eps	To turn on, press top. To turn off, press bottom.	

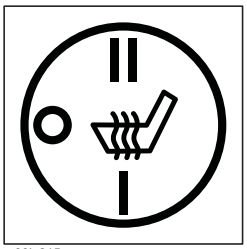
Item	Description	Notes
6. Work light switch  c00ic048w.eps	To turn on, press top. To turn off, press bottom.	
7. Air conditioner on/off switch  c00ic205w.eps	To turn air conditioner on, press left. To turn air conditioner off, press right.	

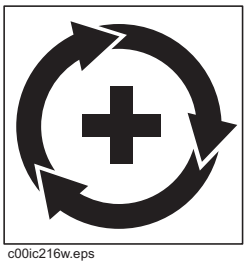
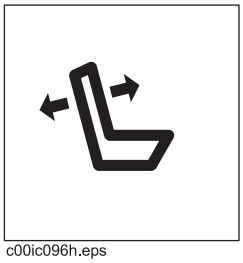
Seat



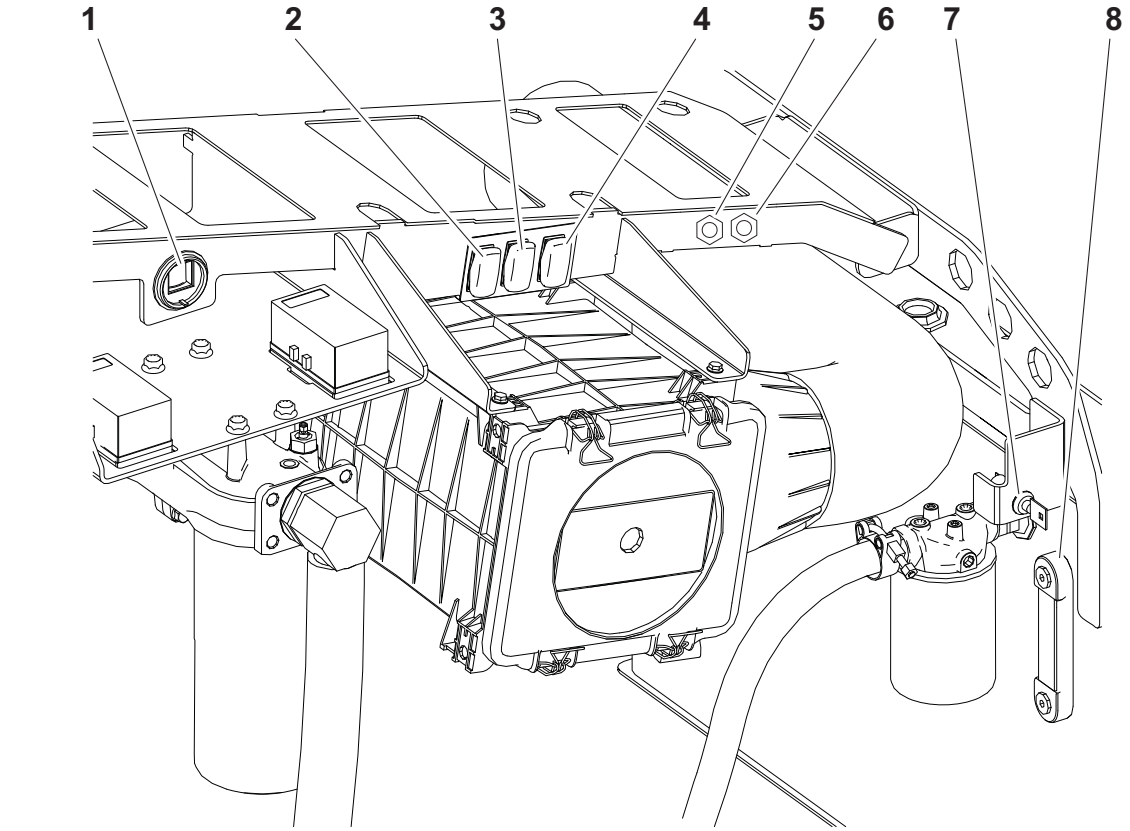
j59om006w.eps

1. Heat switch
2. Lumbar lever
3. Slide control
4. Suspension control
5. EDT diagnostic port, cab controller
6. Recline control

Item	Description	Notes
1. Heat switch  c00ic215w.eps	To turn seat heat on high, press top. To turn lumbar heat off, press middle. To turn seat heat on low, press bottom.	
2. Lumbar lever	Push lever down to engage lumbar support. Push lever up to disengage lumbar support.	

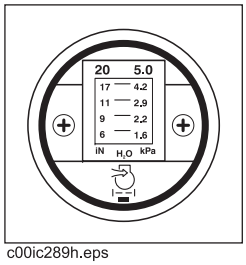
Item	Description	Notes
3. Slide control  c00ic095h.eps	To slide forward or backward, move right. To lock seat in position, release.	
4. Suspension control  c00ic216w.eps	Adjust dial to approximate body weight for additional comfort.	
5. EDT diagnostic port, cab controller	For use only by qualified Ditch Witch® technicians.	
6. Recline control  c00ic096h.eps	To recline seatback, rotate backward. To raise seatback, rotate forward.	

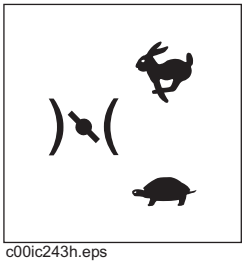
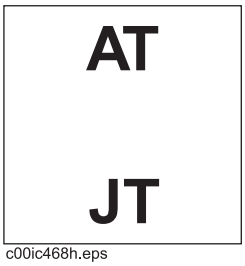
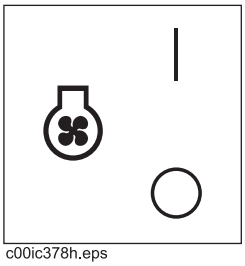
Engine Compartment

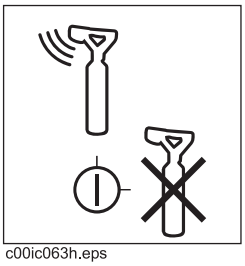
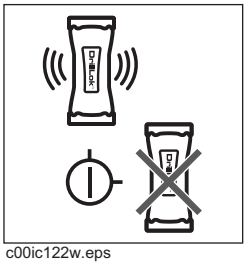


j59om008w.eps

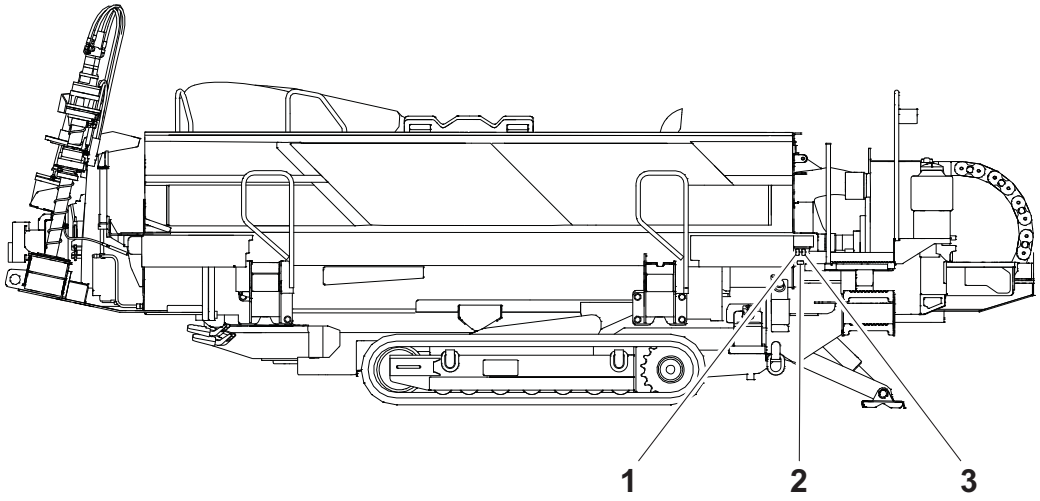
1. Air intake restriction indicator (LRC only)
2. Throttle switch
3. Drilling mode switch (AT units only)
4. Fan speed switch
5. EDT diagnostic port, remote control receiver
6. EDT diagnostic port, main controller
7. DrillLok® key
8. Hydraulic fluid and temperature sightglass

Item	Description	Notes
1. Air intake restriction indicator  c00ic289h.eps	Shows air intake restriction on LRC units only.	Replace the air filter elements when the indicator reaches the red zone. See "Change Air Filter" on page 233.

Item	Description	Notes
2. Throttle switch  c00ic243h.eps	To increase engine speed, press top. To decrease engine speed, press bottom. To further increase or decrease speed, press additional times (or hold until desired speed is reached).	Use this switch only if throttle switch on console does not work.
3. Drilling mode switch (AT only)  c00ic468h.eps	To select **AT Rock** mode, press top. To select **AT Dirt** mode, move to middle. To select **JT** mode, press bottom.	Use **AT Rock** mode when using AT pipe with inner rod and rock drilling bits. Use **AT Dirt** mode when using AT pipe with inner rod and adapter to use dirt tool head. Use **JT** drilling mode when using JT pipe without inner rod.
4. Fan speed switch  c00ic378h.eps	For high speed, press top. For automatic speed, press bottom.	**IMPORTANT:** If switch is on high speed, fan will run at full speed all the time. If switch is on auto speed, fan speed will vary in relation to engine temperature.
5. EDT diagnostic port, remote control receiver	For use only by qualified Ditch Witch® technicians.	
6. EDT diagnostic port, main controller	For use only by qualified Ditch Witch® technicians.	

Item	Description	Notes
7. DrillLok® key  c00ic063h.eps  c00ic122w.eps	To allow tracker operator to stop thrust and rotation, move key to enable position (up). To override DrillLok mode, move key to override position (right).	**IMPORTANT:** Remove key and keep in tracker operator's possession. • Top icon is shown when operating with Subsite® Electronics tracker. • Bottom icon is shown when operating without Subsite Electronics tracker.
8. Hydraulic fluid and temperature sightglass	Displays hydraulic fluid level and temperature.	Normal coolant temperature is less than 175° F (79° C).

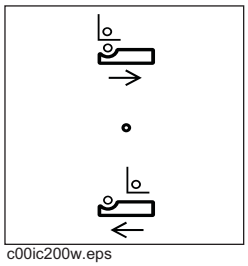
Auxiliary Pipeloading

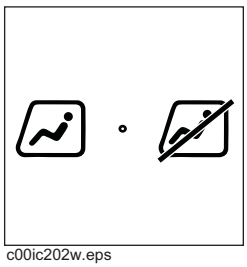
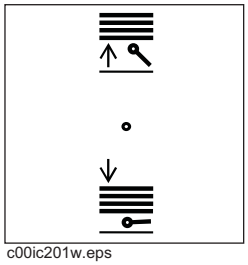


j59om009w.eps

NOTICE: See "Add/Remove Single Pipe" on page 179.

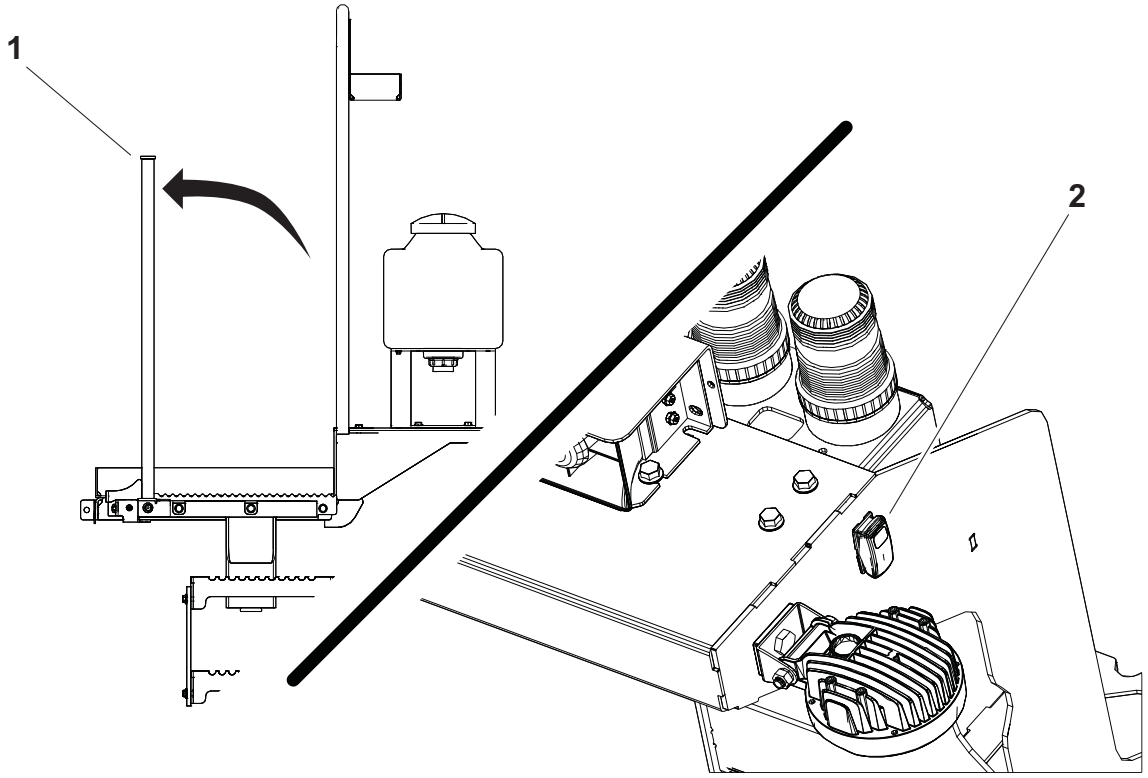
1. Auxiliary pipe shuttle switch
2. Auxiliary pipe load restricted operating mode switch
3. Auxiliary pipe lifter switch

Item	Description	Notes
1. Auxiliary pipe shuttle switch  c00ic200w.eps	To move toward pipe box, press top. To move toward spindle, press bottom. To stop shuttles, release.	

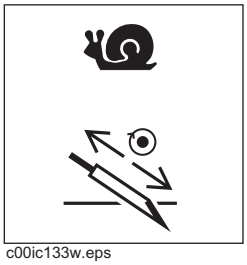
Item	Description	Notes
2. Auxiliary pipe load restricted operating mode switch  c00ic202w.eps	To override drill operator control of shuttles and lifters, press right. To enable drill operator control of shuttles and lifter, press left.	
3. Auxiliary pipe lifter switch  c00ic201w.eps	To raise, press top. To lower, press bottom. To stop, release.	

Wireline (Optional)

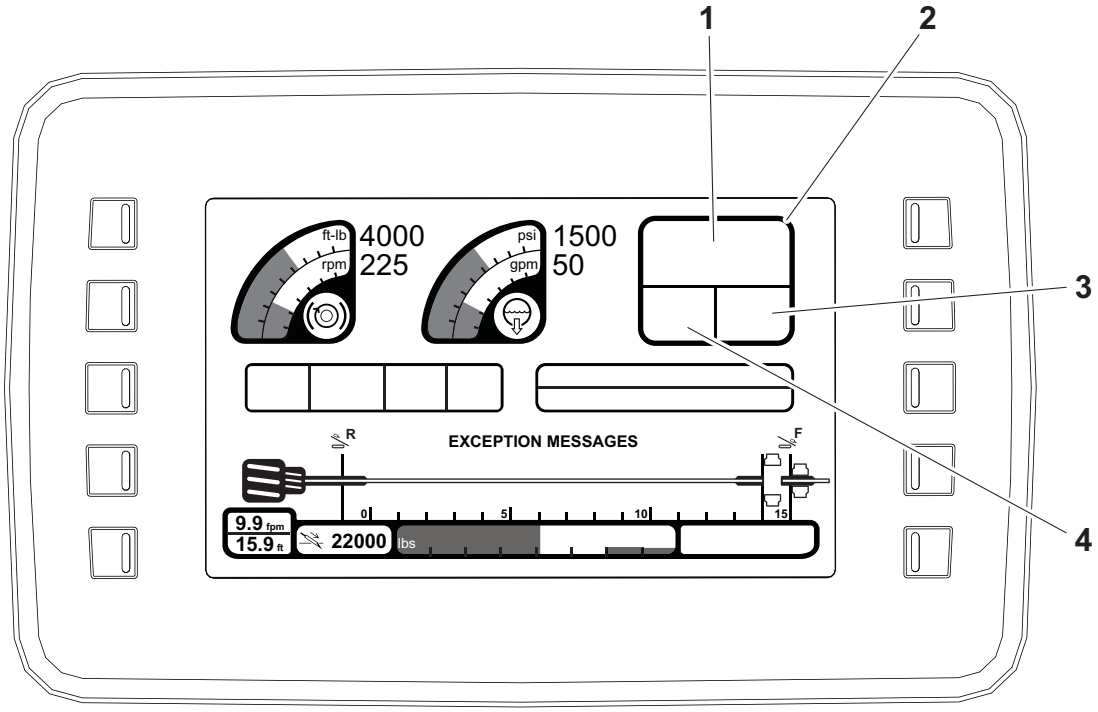
Controls



1. Wireline restricted operating mode platform switch
2. Wireline restricted operating mode switch

Item	Description	Notes
Wireline restricted operating mode switch  c00ic133w.eps	To enable wireline restricted operating mode, move wireline restricted operating mode platform switch (1) to the upright position or press top of wireline restricted operating mode switch (2). To disable wireline restricted operating mode, move wireline restricted operating mode platform switch to the downright position or press bottom of wireline restricted operating mode switch.	Green light will indicate when wireline restricted operating mode is active. **IMPORTANT:** Wireline restricted operating mode is enabled after wireline restricted operating mode switch is turned ON or wireline operator mode platform switch is in the upright position. For more information, see "Wireline Operation" on page 188

Wireline Restricted Operating Mode (ROM)



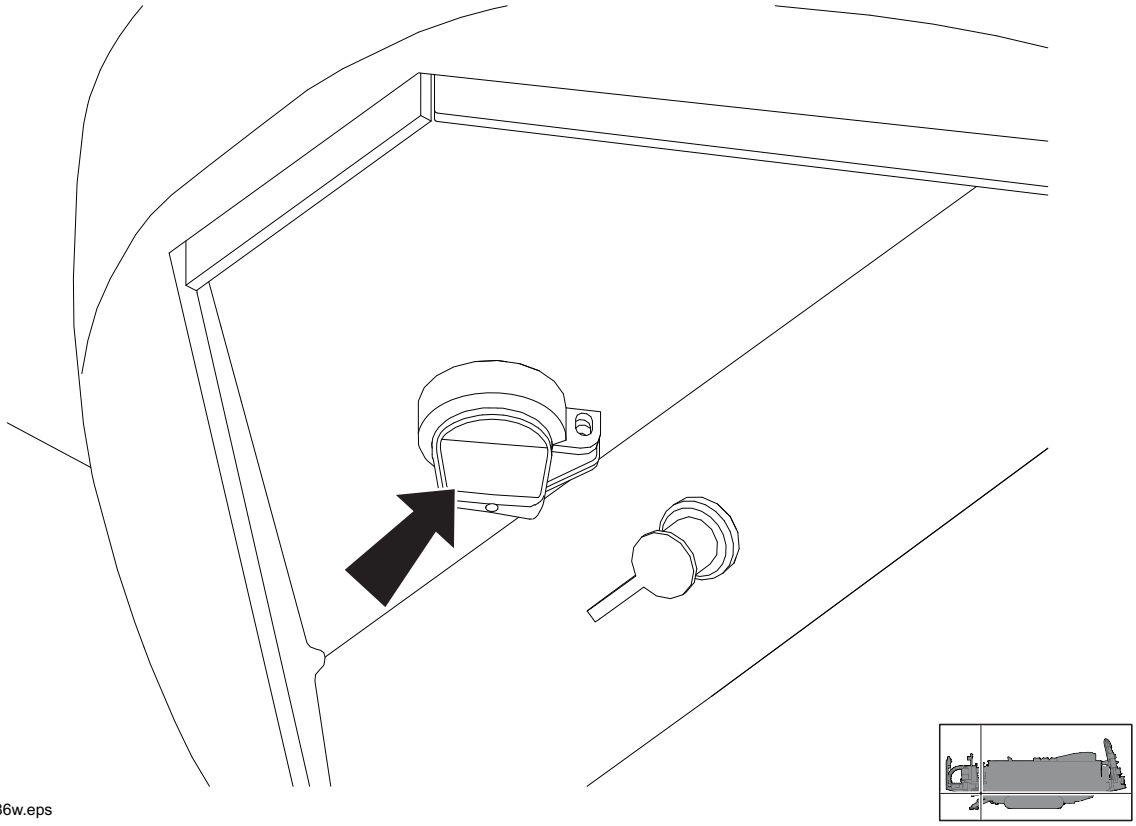
j59om064w.eps

IMPORTANT: Wireline restricted operating mode gauge replaces the inner rotation speed/pressure gauge when the unit is equipped with wireline option.

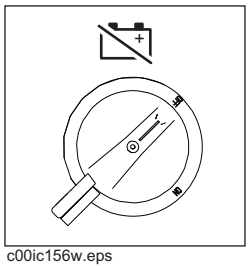
Item	Description	Notes
1. ROM status indicator	Indicates ROM is on. Indicates ROM error. See your Ditch Witch® dealer.	
2. ROM message boundary	Green boundary indicates ROM mode is on. Yellow and red boundary indicate error conditions. See your Ditch Witch dealer.	Turn off wireline ROM switch (page 74). Do not use ROM until error is fixed.
3. ROM switch status indicator	F ON Indicates switch is on. F Indicates an error.	See "Wireline restricted operating mode switch" on page 74.

Item	Description	Notes
4. ROM platform switch status indicator	 Indicates switch is on.  Indicates an error.	See "Wireline restricted operating mode platform switch" on page 74.

Battery Disconnect



Battery disconnect switch

Item	Description	Notes
Battery disconnect switch  c00ic156w.eps	To connect, move right. To disconnect, move left.	***NOTICE:*** • Do not operate battery switch with engine running. • To avoid equipment damage, wait two minutes after turning engine off before disconnecting battery.

Operation Overview

Chapter Contents

Planning

1. Gather information about jobsite. See page 85.
2. Inspect jobsite. See page 86.
3. Classify jobsite. See page 88.
4. Plan bore path. See page 91.
5. Check supplies and prepare equipment. See page 101.
6. Load equipment. See page 114.

Setting Up at Jobsite

1. Prepare jobsite. See page 100.
2. Mix drilling fluid. See page 158.
3. Unload drilling unit from trailer. See page 116.
4. Assemble drill string. See page 125.
5. Position drilling unit and drill frame. See page 121.
6. Assemble strike system. See page 152.
7. Anchor drilling unit. See page 149.
8. Connect fluid system. See page 121.
9. Calibrate tracker with beacon that will be installed in beacon housing. See tracker operator's manual.

Drilling

1. Start system. See page 122.
2. Engage DrillLok® if desired. See page 162.
3. Drill first pipe. See page 129.
4. Record bore path. See page 139.
5. Enable automated pipeloader system. See page 130.
6. Add pipe. See page 131.
7. Drill remaining pipes in pipe box.
   - Correct direction. See page 136.
   - Engage cruise control. See page 186.
   - Shift pipe box. See page 177.
8. Add additional drill pipe to empty box (see page 179) to complete bore.
9. Surface drill head. See page 140.
   - Remove drill head.
   - Grease downhole tool (AT mode).

Backreaming

1. Assemble backream string. See page 142.
2. Start drilling unit and adjust throttle.
3. Set drilling fluid flow. Check that fluid flows through all nozzles.
4. Remove extra drill pipe from pipe box (see page 182) to complete backream.
5. Remove remaining pipe to complete backream.
6. Remove pullback device. See page 145.

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.
2. Remove anchors. See page 150.
3. Rinse unit and downhole tools. See page 196.
4. Disassemble strike system and disconnect from fluid system. See page 152.
5. Stow tools. See page 197.
6. Load unit onto trailer. See page 114.

Storing Equipment

1. For cold weather storage, antifreeze drilling unit see page 194.
2. For long-term storage, disconnect battery disconnect switch.

Prepare

Chapter Contents

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

Mark proposed path with white paint and have underground utilities located before working.

- In the US or Canada, call 811 (US) or 888-258-0808 (US and Canada). Also contact any local utilities that do not participate in the One-Call service.
- In countries that do not have a One-Call service, contact all local utility companies to have underground utilities located.

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

Identify Hazards

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
  - "buried utility" notices
  - utility facilities without overhead lines
  - gas or water meters
  - junction boxes
  - drop boxes
  - light poles
  - manhole covers
  - sunken ground
- traffic
- access
- soil type and condition
- water supply
- sources of locator interference (rebar, railroad tracks, etc.)

Have an experienced locating equipment operator sweep area within 20' (6 m) to each side of bore path to verify previously marked line and cable locations. Mark location of all buried utilities and obstructions.

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

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. Assess the risks on each slope to determine if factors affecting risks create an unsafe condition for drilling.

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 96.

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

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment. 274-050; 274-724 (2P)

To help avoid injury:

- Wear personal protective equipment including hard hat, safety eye wear, and hearing protection.
- Do not wear jewelry or loose clothing.
- Mark proposed path with white paint and have underground utilities located before working.
- 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 a Classification

Jobsites are classified according to underground hazards present.

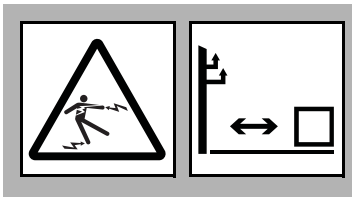
If working . . .	then classify jobsite as . . .
within 10' (3 m) of a buried electric line	electric
within 10' (3 m) of a natural gas line	natural gas
in concrete, sand, or granite which is capable of producing crystalline silica (quartz) dust	crystalline silica (quartz) dust
within 10' (3 m) of any 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. Follow U.S. Department of Labor regulations on excavating and trenching (Part 1926, Subpart P) and other similar regulations.

Electric Jobsite Precautions

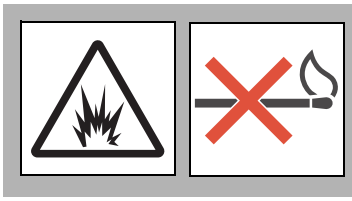


DANGER Electric shock will cause death or serious injury. Stay away. 274-049

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. If utility must be crossed, tracker operator must watch the drill head during drilling and backreaming. The tracker operator must have communication with the drill operator or DrillLok® system must be enabled with the DrillLok key in the tracker operator's possession.
- Have service shut down while work is in progress. Have electric company test lines before returning them to service.

Natural Gas Jobsite Precautions

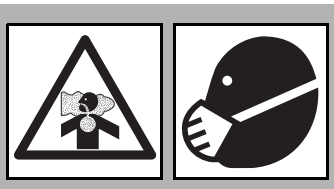


WARNING Fire or explosion possible. Fumes could ignite and cause burns. No smoking, no flame, no spark. 275-419 (2P)

Position equipment upwind from gas lines and use one or both of these methods.

- Expose lines by careful hand digging or soft excavation. Use beacon to track bore path. If utility must be crossed, tracker operator must watch the drill head during drilling and backreaming. The tracker operator must have communication with the drill operator or DrillLok system must be enabled with the DrillLok key in the tracker operator's possession.
- Have gas shut off while work is in progress. Have gas company test lines before returning them to service.

Crystalline Silica (Quartz) Dust Precautions



CAUTION Breathing crystalline silica dust may cause lung disease. Cutting, drilling, or working materials such as concrete, sand, or rock containing quartz may result in exposure to silica dust. Use dust control methods or appropriate breathing protection when exposed to silica dust.

To help avoid injury:

- Use water spray or other means to control dust.
- Refer to U.S. Department of Labor Occupational Safety and Health Administration guidelines to learn more about appropriate breathing protection and permissible exposure limits.

Crystalline silica dust is a naturally occurring substance found in soil, sand, concrete, granite, and quartz. Breathing silica dust particles while cutting, drilling, or working materials may cause lung disease or cancer. To reduce exposure:

- Use water spray or other means to control dust.
- Refer to U.S. Department of Labor Occupational Safety and Health Administration guidelines to learn more about appropriate breathing protection and permissible exposure limits.

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. Subsite® Electronics bore planning software is available for planning your bore path. This special software can be run in the field using a laptop computer. See your Ditch Witch® dealer for details.

If not using bore planning software, 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 bore planning software, see "Bore Path Calculator" on page 97 and use these measurements to help plan your bore.

Recommended Bend Limits

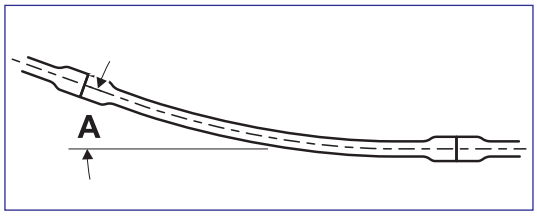
Ditch Witch® drill pipes are designed to bend slightly during operation. Slight bending allows for steering and correcting direction. Bending beyond recommended limits will cause damage that might not be visible. This damage adds up and will later lead to sudden drill pipe failure.

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.

Make sure pitch (A) changes no more than the following percentages over the full length of each pipe.



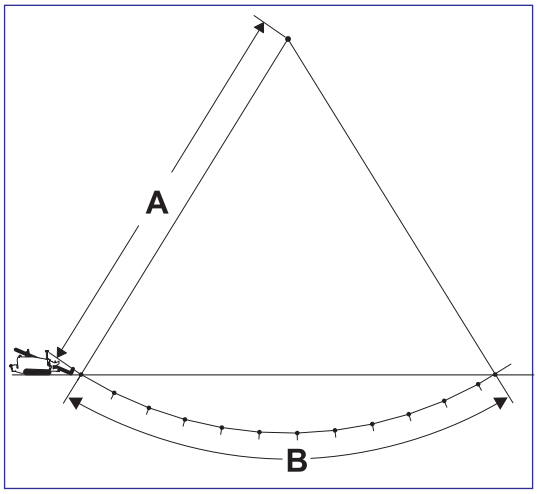
j07om003c.eps

JT Power Pipe® HD	JT HIWS1	AT pipe
10.3%	10.4%	8.9%

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 tracker remote display on the operator's console. (See tracking system operation instructions.)

Bend Radius



j07om078h.eps

JT40 Power Pipe® HD drill pipes have a tested minimum bend radius of 146' (44.5 m). This means that a 90-degree bend in the bore path:

- has a radius (A) of 146' (44.5 m)
- requires approximately 229' (69.8 m) of drill pipe (B).

JT40 HIWS1 drill pipes have a tested minimum bend radius of 145' (44.2 m). This means that a 90-degree bend in the bore path:

- has a radius (A) of 145' (44.2 m)
- requires approximately 228' (69.5 m) of drill pipe (B).

AT

JT40 All Terrain drill pipes have a tested minimum bend radius of 170' (51.8 m). This means that a 90-degree bend in the bore path:

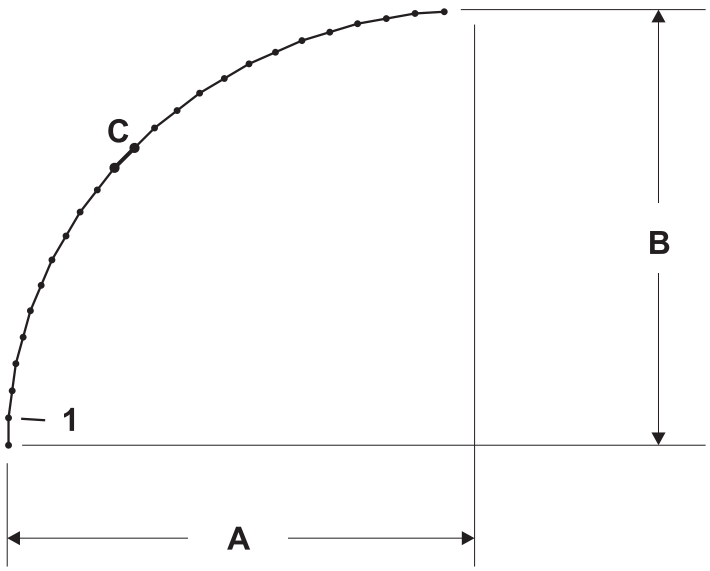
- has a radius (A) of 170' (51.8 m)
- requires approximately 267' (81.4 m) of drill pipe (B).

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.

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

Pipe-By-Pipe Bend Limits



th.eps

JT40 Power Pipe® HD

Pipe (C)	Forward (B)	Deflection (A)	Pipe (C)	Forward (B)	Deflection (A)
1	14’ 11.7” (4.56 m)	0’ 9.2” (0.23 m)	**9**	116’ 6.7” (35.53 m)	58’ 1.2” (17.71 m)
2	29’ 9.5” (9.08 m)	3’ 0.9” (0.94 m)	**10**	124’ 11.5” (38.10 m)	70’ 6.3” (21.50 m)
3	44’ 3.5” (13.50 m)	6’ 10.6” (2.10 m)	**11**	132’ 0.5” (40.25 m)	83’ 8.8” (25.52 m)
4	58’ 3.9” (17.78 m)	12’ 1.9” (3.71 m)	**12**	137’ 8.8” (30.72 m)	97’ 9.3” (29.80 m)
5	71’ 8.9” (21.87 m)	18’ 10.2” (5.75 m)	**13**	141’ 11.6” (41.98 m)	111’ 11.9” (34.14 m)
6	84’ 4.9” (25.73 m)	26’ 10.5” (8.19 m)	**14**	144’ 8.4” (44.10 m)	126’ 8.8” (38.63 m)
7	96’ 2.1” (29.31 m)	36’ 2.0” (11.02 m)	**15**	145’ 10.9” (44.47 m)	141’ 8.2” (43.19 m)
8	106’ 11.2” (32.59 m)	46’ 7.3” (14.21 m)	**16**	146’ 0.0” (44.50 m)	146’ 0.0” (44.50 m)

JT40 HIWS1 Pipe

Pipe (C)	Forward (B)	Deflection (A)	Pipe (C)	Forward (B)	Deflection (A)
1	14' 11.7" (4.56 m)	0' 9.2" (0.23 m)	**9**	116' 6.7" (35.53 m)	58' 1.2" (17.71 m)
2	29' 9.5" (9.08 m)	3' 0.9" (0.94 m)	**10**	124' 11.5" (38.10 m)	70' 6.3" (21.50 m)
3	44' 3.5" (13.50 m)	6' 10.6" (2.10 m)	**11**	132' 0.5" (40.25 m)	83' 8.8" (25.52 m)
4	58' 3.9" (17.78 m)	12' 1.9" (3.71 m)	**12**	137' 8.8" (30.72 m)	97' 9.3" (29.80 m)
5	71' 8.9" (21.87 m)	18' 10.2" (5.75 m)	**13**	141' 11.6" (41.98 m)	111' 11.9" (34.14 m)
6	84' 4.9" (25.73 m)	26' 10.5" (8.19 m)	**14**	144' 8.4" (44.10 m)	126' 8.8" (38.63 m)
7	96' 2.1" (29.31 m)	36' 2.0" (11.02 m)	**15**	145' 10.9" (44.47 m)	141' 8.2" (43.19 m)
8	106' 11.2" (32.59 m)	46' 7.3" (14.21 m)	**16**	146' 0.0" (44.50 m)	146' 0.0" (44.50 m)

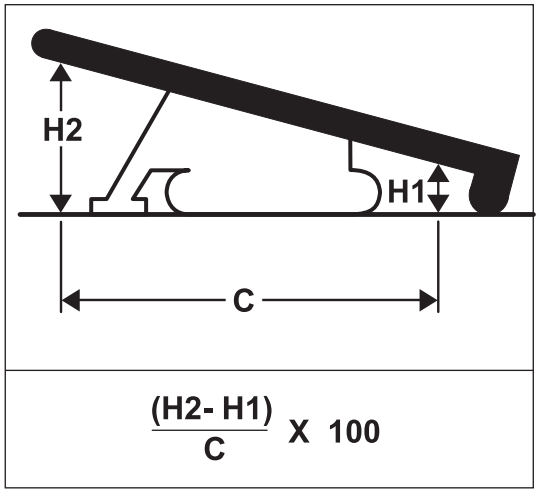
AT40 Power Pipe® HD

Pipe (C)	Forward (B)	Deflection (A)	Pipe (C)	Forward (B)	Deflection (A)
1	14' 11.8" (4.57 m)	0' 7.9" (0.20 m)	**10**	131' 3.4" (40.02 m)	61' 11.9" (15.85 m)
2	29' 10.1" (9.10 m)	2' 7.7" (0.81 m)	**11**	140' 3.4" (34.8 m)	73' 11.8" (22.55 m)
3	44' 5.7" (13.56 m)	5' 11.1" (1.81 m)	**12**	148' 2.4" (45.17 m)	86' 8.6" (26.43 m)
4	58' 9.1" (17.91 m)	10' 5.7" (3.19 m)	**13**	154' 11.6" (47.23 m)	100' 1.2" (30.51 m)
5	72' 7.1" (22.13 m)	16' 3.3" (4.96 m)	**14**	160' 6.3" (48.93 m)	114' 0.3" (34.75 m)
6	85' 10.3" (26.17 m)	23' 3.3" (7.09 m)	**15**	164' 10.0" (50.24 m)	128' 4.7" (39.13 m)
7	98' 5.4" (30.01 m)	31' 4.9" (9.57 m)	**16**	167' 10.3" (51.16 m)	143' 0.9" (43.61 m)
8	110' 3.4" (33.61 m)	40' 7.5" (12.38 m)	**17**	169' 6.9" (51.69 m)	157' 11.7" (48.15 m)
9	121' 3.0" (36.96 m)	50' 10.1" (15.50 m)	**18**	170' 0.0" (51.82 m)	170' 0.0" (51.82 m)

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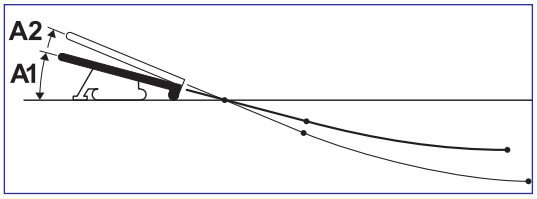
IMPORTANT: A shallow entry pitch (A1) allows you to reach horizontal sooner and with less bending. Increasing entry pitch (A2) makes minimum setback longer and deeper.



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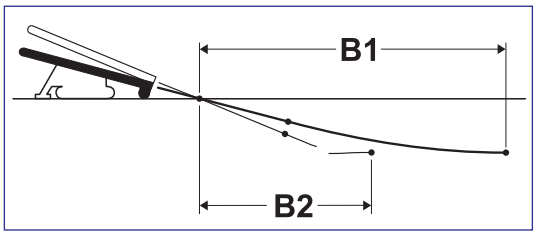
Minimum Setback

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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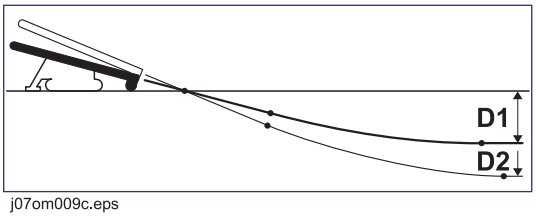
Minimum Depth



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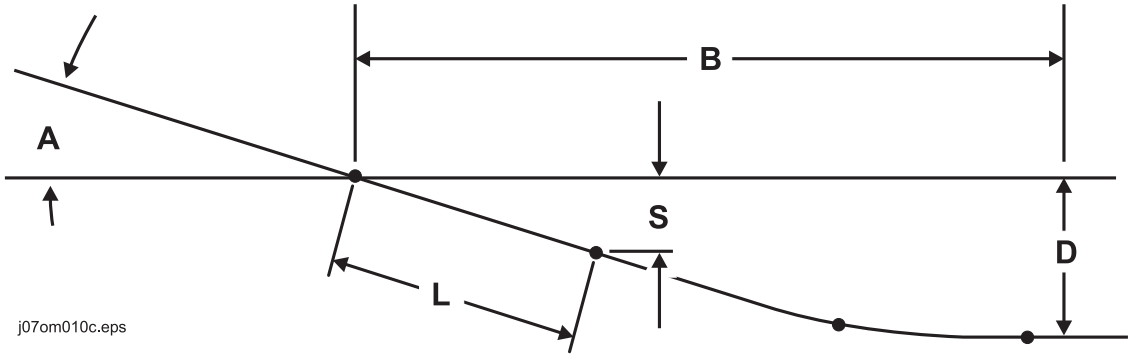
Because you must bend pipe gradually, entry pitch and bend limits determine how deep the pipe will be when it becomes horizontal. This is called the **minimum depth**.

- 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.

JT40 Power Pipe® HD



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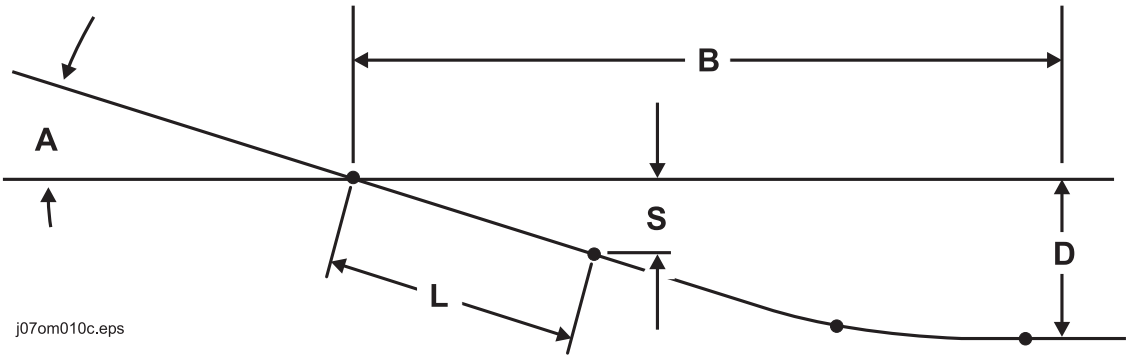
Minimum depth (D)	Entry pitch (A)	Setback (B)	Depth to begin steering (S)
4’ 4” (1.32 m)	18% / 10.0°	37’ 3” (11.35 m)	2’ 2” (0.66 m)
5’ 5” (1.65 m)	21% / 11.6°	41’ 2” (12.55 m)	2’ 6” (0.76 m)
6’ 8” (2.03 m)	23% / 13.2°	45’ 1” (13.74 m)	2’ 9” (0.84 m)
7’ 11” (2.41 m)	26% / 14.8°	49’ 0” (14.94 m)	3’ 1” (0.94 m)
9’ 5” (2.87 m)	29% / 16.4°	52’ 10” (16.10 m)	3’ 5” (1.04 m)
10’ 11” (3.33 m)	32% / 18.0°	56’ 7” (17.25 m)	3’ 9” (1.14 m)

IMPORTANT: Numbers in table based on **146’ (44.5 m) minimum bend radius** and beacon housing, EZ-Connect connector, transition sub, and 1/3 of first drill pipe (L, totaling 12’ 1” [3.68 m]) in the ground before steering.

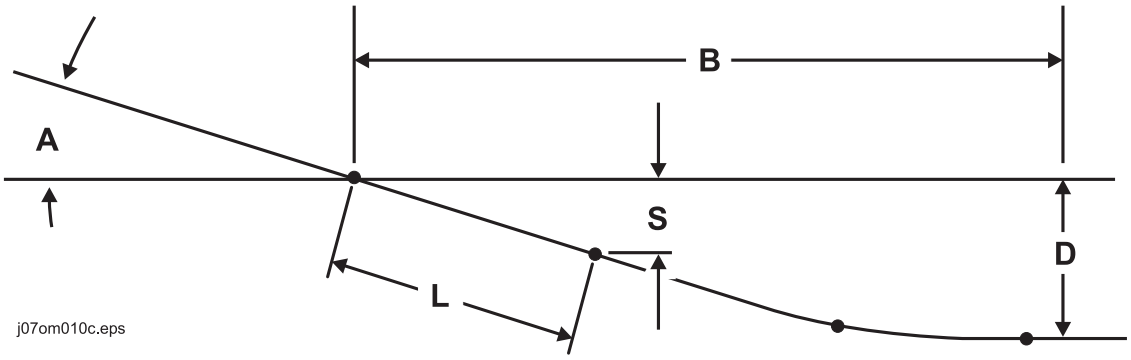
JT40 HIWS1 Pipe



Minimum depth (D)	Entry pitch (A)	Setback (B)	Depth to begin steering (S)
4' 4" (1.32 m)	18% / 10.0°	37' 3" (11.35 m)	2' 2" (0.66 m)
5' 4" (1.63 m)	21% / 11.6°	41' 2" (12.55 m)	2' 6" (0.76 m)
6' 8" (2.03 m)	23% / 13.2°	45' 1" (13.74 m)	2' 9" (0.84 m)
8' 0"(2.44 m)	26% / 14.8°	49' 0" (14.94 m)	3' 1" (0.94 m)
9' 4" (2.84 m)	29% / 16.4°	52' 10" (16.10 m)	3' 5" (1.04 m)
10' 11" (3.33 m)	32% / 18.0°	56' 7" (17.25 m)	3' 9" (1.14 m)

IMPORTANT: Numbers in table based on **145' (44.2 m) minimum bend radius** and beacon housing, EZ-Connect connector, transition sub, and 1/3 of first drill pipe (L, totaling 12' 1" [3.68 m]) in the ground before steering.

AT40 Pipe



Minimum depth (D)	Entry pitch (A)	Setback (B)	Depth to begin steering (S)
4' 3" (1.30 m)	18% / 10.0°	38' 7" (11.76 m)	1' 8" (0.51 m)
5' 4" (1.63 m)	21% / 11.6°	43' 3" (13.18 m)	1' 11" (0.58 m)
6' 8" (2.03 m)	23% / 13.2°	47' 10" (14.58 m)	2' 2" (0.66 m)
7' 11"(2.41 m)	26% / 14.8°	52' 4" (15.95 m)	2' 5" (0.74 m)
9' 7" (2.92 m)	29% / 16.4°	56' 10" (17.32 m)	2' 8" (0.81 m)
11' 2" (3.40 m)	32% / 18.0°	61' 4" (18.69 m)	2' 11" (0.89 m)

IMPORTANT: Numbers in table based on **170' (51.8 m) minimum bend radius** and beacon housing and 1/3 of first drill pipe (L, totaling 9' 2" [2.79 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. 274-050; 274-724 (2P)

To help avoid injury:

- If jobsite classification is in question or is the possibility of unmarked electric utilities exists, classify jobsite as electric.
- Expose lines by hand before digging. Cutting high voltage cable can cause electrocution.
- 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

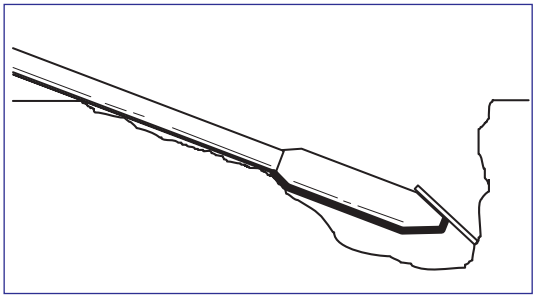
Mark your planned bore path and all located utility lines with flags or paint.

Prepare Entry Point

For bore to be successful, first pipe must be straight as it enters the ground. See "Align the Joints" on page 173.

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. Steer down as required at start. Drill head will tend to move in easiest direction (toward surface) when rotated near the surface.

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



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Check Supplies and Prepare Equipment

Check Supplies

- receiver/transmitter or tracker with spare batteries, if needed
- extra batteries for DrillLok® remote, if equipped
- extra batteries for wireless remote controller
- beacons with new and spare batteries
- two-way radios with new and spare batteries
- quick wrench (see page 169)
- transition sub
- anchoring equipment and accessories
- bits, screens, nozzles (see page 163)
- adapters, pipe, beacon housings
- marking flags or paint
- water and additional hoses
- fuel
- drilling fluid additives (see page 161)
- spare fuses
- keys
- backreamers, swivels, pulling devices (see page 166)
- wash down hose and spray gun
- duct tape
- spray lubricant
- tool joint compound (see page 202)
- electrically insulating boots and gloves. Boots must have high tops and meet the electric hazard protection requirements of ASTM F2413 when tested at 18,000 volts. Tuck legs of pants completely inside boots.
- personal protective equipment, such as hard hat and safety glasses
- notepad and pencil

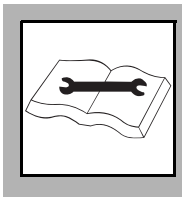
Prepare Equipment

Fluid Levels

- fuel
- diesel exhaust fluid (DEF)
- hydraulic fluid
- engine coolant
- battery charge
- engine oil

Condition and Function

- all controls



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.

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

Select Drilling Mode

Three drilling setups are available with this unit:

- AT mode
- AT dirt mode
- JT mode

Select the best setup based on jobsite conditions.

Mode	Situation used	Downhole tools	Capabilities
AT	Rock, soft rock, other non-compressible soils. Any other situation with difficult steering because of hard soil conditions.	• All Terrain drill pipe • Rockmaster® tool	• 40,000 lb (178 kN) of thrust • inner rotation
AT dirt	When one bore out of several can be better or more quickly done with conventional downhole tools. This bore is such that changing to JT pipe is not practical.	• All Terrain drill pipe • beacon housing • transition sub (p/n 400-1383) • standard JT tools	• 40,000 lb (178 kN) of thrust • no inner rotation
JT	Soft or intermittent soft rock or other compressible soils.	• JT drill pipe • standard JT tools	• 40,000 lb (178 kN) of thrust • no inner rotation

Once drilling mode has been selected, configure drilling unit to match mode.

Prepare Drilling Unit

AT Mode

- Verify unit has not been converted to JT mode. Install SaverLok® body, pipe loader accessories, pipe guides, and wrench inserts for AT pipe.
- Inspect Rockmaster® tool and select bit based on jobsite conditions.
- Use appropriate anchors for jobsite conditions.
- Load All Terrain pipe and pipe box onto unit.
- Move mode selector switch to AT position.

AT Dirt Mode

- Verify unit has not been converted to JT mode. Install SaverLok® body, pipe loader accessories, pipe guides, and wrench inserts for AT pipe.
- Use transition sub between All Terrain pipe and beacon housing. Select soil bit based on jobsite conditions.
- Use appropriate anchors for jobsite conditions.
- Load All Terrain pipe and pipe box onto unit.
- Move mode selector switch to AT DIRT position.

JT Mode

IMPORTANT: Use conversion kit (p/n 190-2715).

- Install SaverLok® body, pipe loader accessories, pipe guides, and wrench inserts for JT pipe.
- Use standard transition sub and beacon housing. Select soil bit based on jobsite conditions.
- Use auger type anchors.
- Load JT pipe and pipe box onto unit.

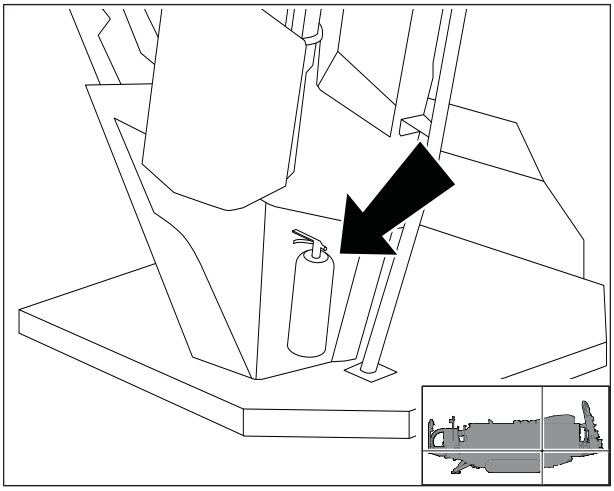
IMPORTANT: Do not put JT pipe into a large All Terrain pipe box. Pipe can jam and box can be damaged. Use JT pipe box.

- Move mode selector switch to JT position.

Assemble Accessories

Fire Extinguisher

Identify location (shown) for fire extinguisher. 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.



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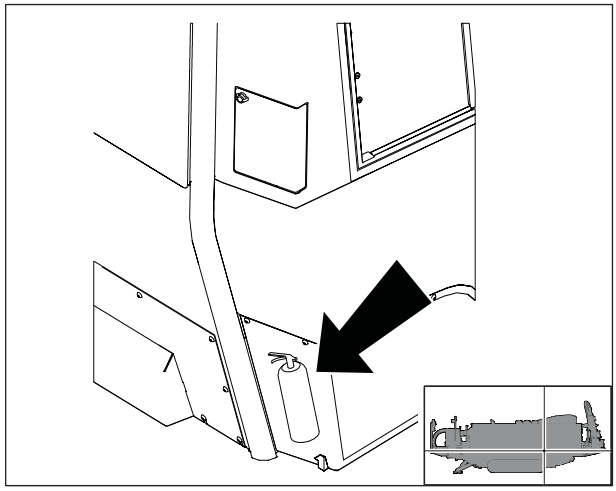

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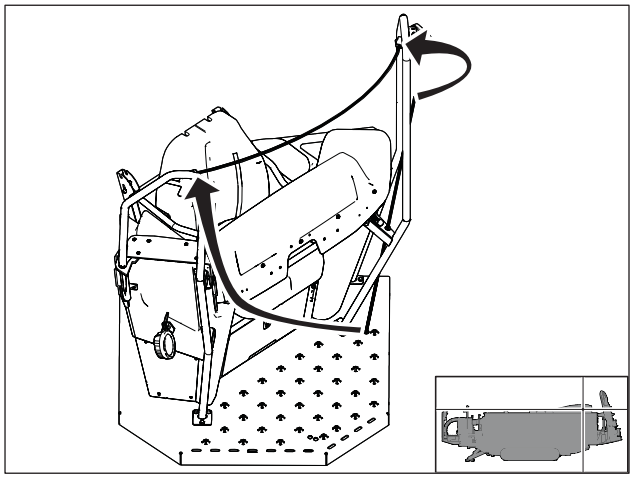
Covers and Canopy (Open Station Only)

1. Remove canopy from storage position under console cover.
2. Remove fiberglass rod from storage position and slide through front pocket of canopy.
3. Insert fiberglass rod into top of operator station grab rails (shown).



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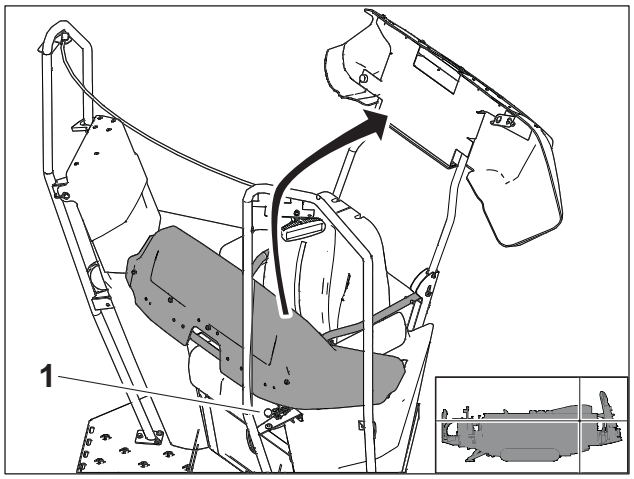
4. Unlatch console cover (1) and lift and press into locking position as shown.



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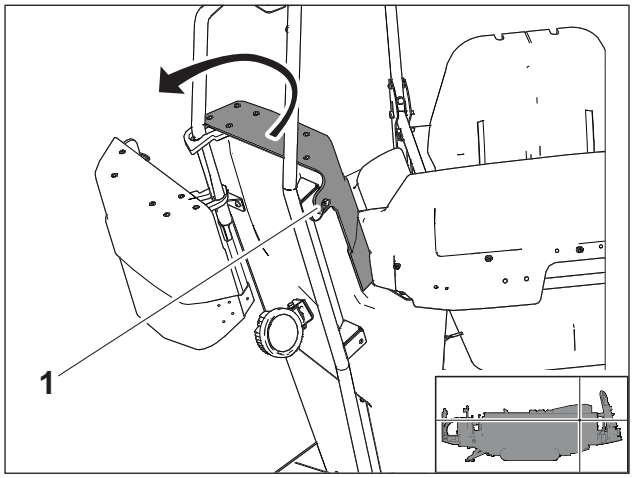
5. Remove pin (1) and lift and lower display cover as shown.



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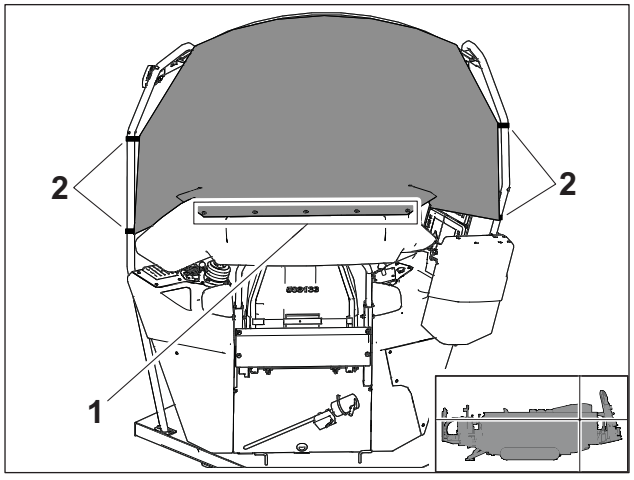
6. Secure canopy to operator station grab rails with snaps (1) and buckles (2).

   IMPORTANT: Optional canopy has buckles that connect at the bottom of the operator station instead of snaps.

7. To disassemble repeat steps in reverse order.



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Drive

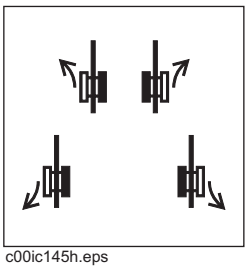
Chapter Contents

Start Unit

1. Insert key.
2. Turn key clockwise. See page 23 for more information.
3. Run engine at low throttle for 5 minutes.

Steer Unit

To steer drilling unit, follow instructions for type of steering desired. See "Wireless Remote Controller" on page 184.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IMPORTANT: Operator station must be empty to operate wireless ground drive control.

Single Joystick Ground Drive

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.

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.

Dual Joystick Ground Drive

To steer while moving forward, move one control slightly more than the other to turn in the desired direction. Drilling unit will gradually turn to left or right.

To steer while moving backward, move one control slightly more than the other to turn in the desired direction. Drilling unit will gradually turn to left or right.

For tight steering at low speed, one control to reverse and one control to forward to turn in the desired direction. Drilling unit will counter-rotate and turn drilling unit in a tight circle.

Tips to Reduce Track Wear

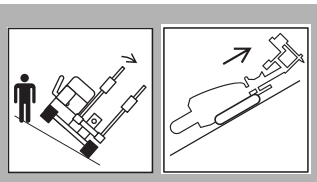
Rubber tracks are best suited at soil-based job sites with minimal rock and debris. Sharp objects such as gravel, steel shards, and broken concrete will damage rubber tracks and undercarriage components. Excessive operation on concrete or asphalt will shorten track life. When storing your machine, keep tracks away from rain and direct sunlight.

Wash tracks daily to remove foreign objects and abrasive soil from sprockets and idler rollers. Drive slowly and make wide turns when possible. Regularly check undercarriage components (sprocket, rollers, idler) for wear and damage. Maintain proper track tension. (See "Check Track Tension and Condition" on page 208.)

To prevent premature wear, avoid the following:

- Spinning tracks under heavy load.
- Turning on sharp objects such as stones, stumps and debris.
- Quick turns or "spin" turns on asphalt or concrete.
- Driving over curbs, ledges, and sharp objects.
- Driving with track edges pressed against hard walls, curbs or other objects.
- Driving on slopes.
- Operating on corrosive materials such as salt or fertilizer. Wash immediately.

Safe Slope Operation



WARNING Tipover possible. Machine can tip over and crush you.

To help avoid injury:

- Always operate from the uphill side of the unit.
- Drive cautiously at all times.
- Never jerk control levers. Use a steady even motion.

Operating safely on a slope depends upon many factors including:

- Distribution of machine weight (weight of machine may change due to configuration)
- Even or rough ground conditions
- Potential for ground giving way causing unplanned tilt forward, reverse or sideways
- Nearness of ditches, ruts, stumps or other obstructions and sudden changes in slope
- Speed
- Turning
- Operator skill

These varying factors make it impractical to specify a maximum safe operating angle in this manual. It is therefore important for the operator to be aware of these conditions and adjust operation accordingly. Maximum engine angle and braking performance are two absolute limits which must never be exceeded. These maximums are stated below since they are design limits. These design limits usually exceed the operating limits and must never be used alone to establish safe operating angle for variable conditions.

HRC: Maximum engine lubrication angle – 45°

LRC: Maximum engine lubrication angle – 45°

Maximum engine operation angle – 38°

Maximum service brake retarding force – equal to traction of both tracks.

Maximum secondary brake retarding force – equal to traction of one track.

Maximum park brake holding force – equal to traction of both tracks.

Shut Down Unit

1. Stop track movement.
2. Lower drill frame and stabilizers to the ground.
3. Run engine at high throttle with no load for one minute, then low throttle with no load for two minutes to cool.
4. Turn ignition switch to STOP.
5. Remove key.

Transport

Chapter Contents

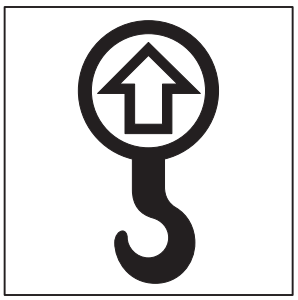
Lift

This machine is not configured for lifting. If the machine must be lifted, load machine into a container or onto a platform appropriate for lifting. See "Specifications" for weight of machine.

Pipe Box Lifting Procedure

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

See "Remove/Install Pipe Box" on page 175.



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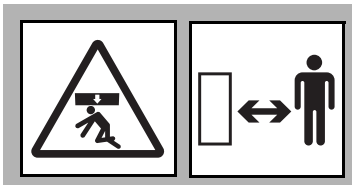
Load

NOTICE: Machine should be loaded using wireless remote controller. See "Wireless Remote Controller" on page 24.



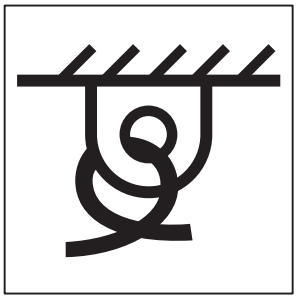
WARNING Crushing weight could cause death or serious injury. Stay away. 275-326

To help avoid injury:

- Attach trailer to tow vehicle before loading or unloading.
- Load and unload trailer on level ground.
- Block trailer wheels.
- Prevent trailer sway by loading ten to fifteen percent of total vehicle weight (equipment plus trailer) on tongue.

1. Start drilling unit engine.
2. Select "loading and unloading mode (low)."
3. Move drilling unit to rear of trailer and align with ramps.
4. Slowly drive unit onto trailer.
5. Lower stabilizers to trailer floor.
6. Lower drill frame to trailer floor.
7. Stop engine when unit is safely positioned on trailer bed for proper tongue weight.
8. Attach tiedowns to drilling unit where indicated on page 115.
9. Ensure that all covers are properly secured.

Tie Down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Points

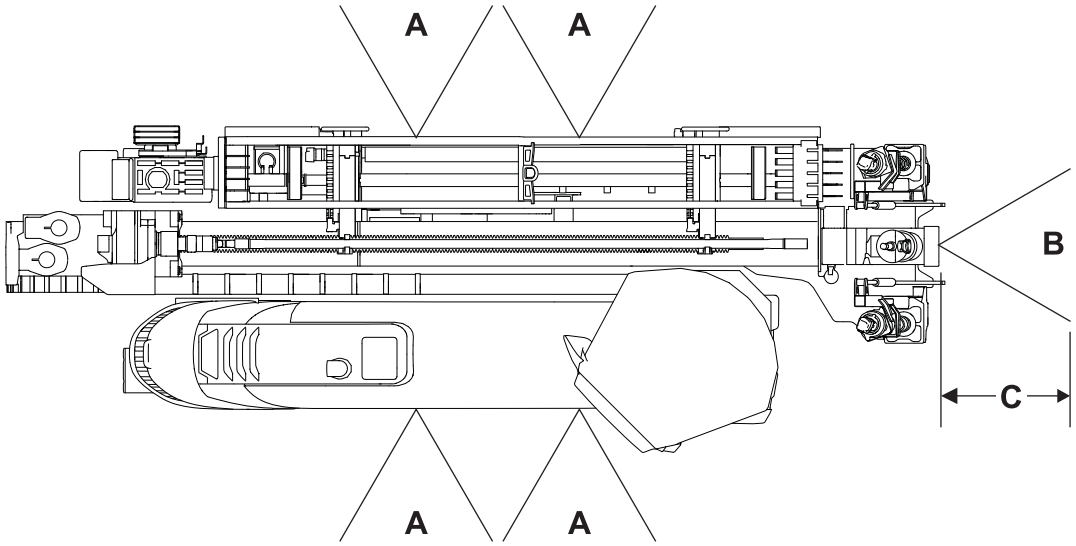
Tiedown points are identified by tiedown decals. Securing to trailer at other points can damage machinery.

Procedure

NOTICE:

- Wrenches can open after engine shutdown. Ensure that any downhole tool or pipe in wrenches is attached to spindle or removed before transport.
- Use Grade 7-3/8" (18.7 cm) transport chain to secure drilling unit.

Loop a transport chain around each tie down point. See chart below for correct distances between tiedown ends. Make sure tiedowns are tight before transporting.



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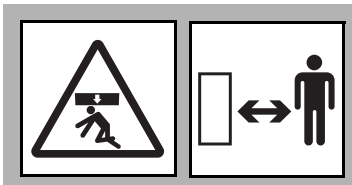
IMPORTANT: If hauling unit without pipe box, remove remaining pipe in drill frame chute.

Distance	U.S.	Metric
A	greater than 18"	greater than 45.72 cm
B	less than 50"	less than 127 cm
C	greater than 10"	greater than 25.4 cm

Unload

NOTICE: Machine should be unloaded using wireless remote controller. See "Wireless Remote Controller" on page 24.



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

To help avoid injury:

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

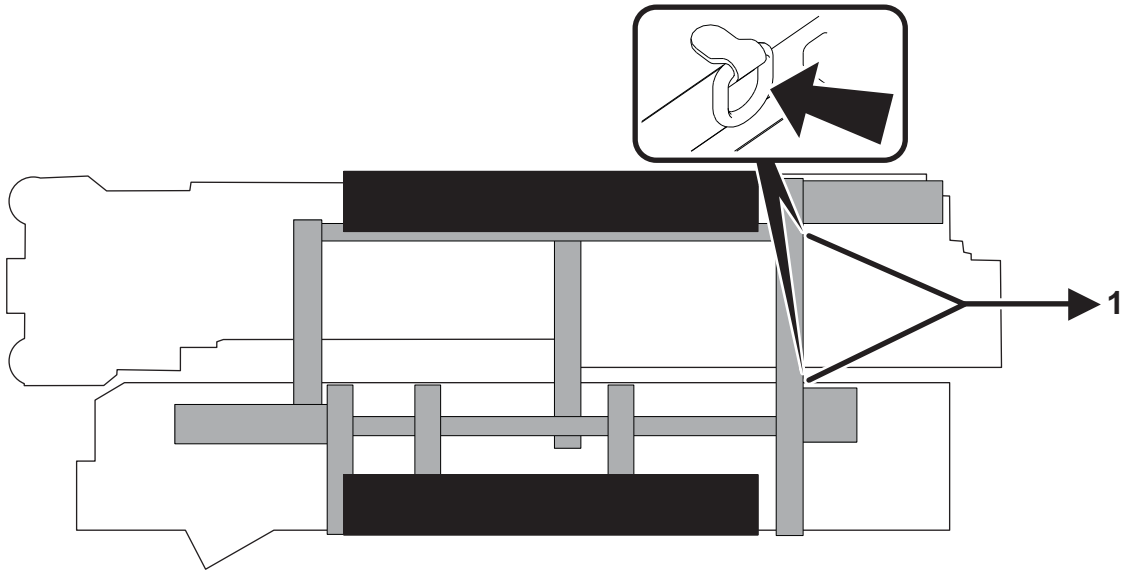
1. Lower trailer or ramps.
2. Remove tiedowns.
3. Start drilling unit engine.
4. Raise stabilizers.
5. Raise drill frame.
6. Slow engine to low throttle and slowly back unit down trailer or ramps.

Retrieve

Under normal conditions, drilling unit should not be towed. If unit becomes disabled and retrieval is necessary:

- tow for short distances at less than 1 mph (1.6 km/h),
- use maximum towing force of 1.5 times unit weight,
- use towing chains appropriately rated for maximum towing force,
- attach chains to indicated tow points facing towing vehicle (shown),
- disengage track planetaries.

Loop chain (1) through each tow point and bring them together to a central pull point. Arrange chains so that angle A is always less than 120°.



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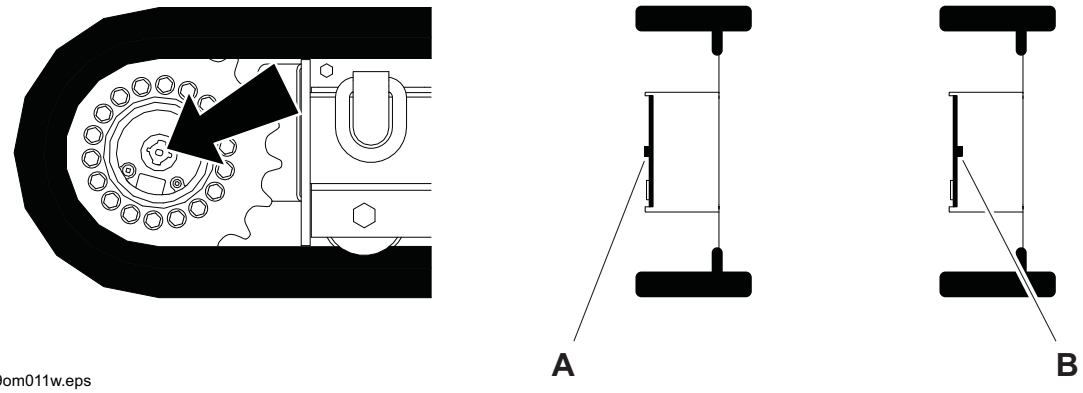
To disengage track planetaries, reverse small cover plate in center of planetary on each track drive.

IMPORTANT: When planetaries are disengaged, unit has no brakes.



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A. Normal operation B. Towing

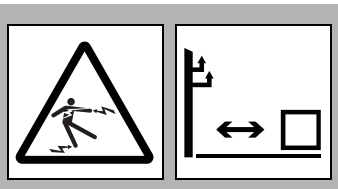
Conduct a Bore

Chapter Contents

Position Equipment

1. Review bore plan and select drilling unit position and fluid unit position. See "Select Start and End Points" on page 87.
2. Move equipment into selected positions.
3. Drive anchors. (See "Anchor System" on page 149.)
4. Connect and test electric strike system. (See "Electric Strike System" on page 152.)

Connect Fluid System

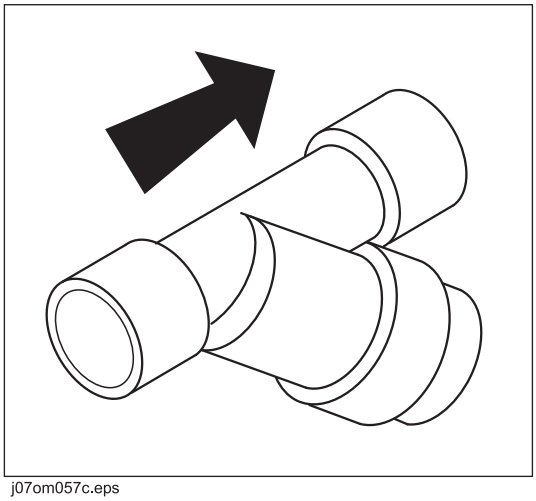


DANGER Electric shock will cause death or serious injury. Stay away. 274-049

To help avoid injury: Do not connect drilling unit to a public or private (business or home) water supply. If an electrical strike occurs while drilling unit is connected to a fluid system, the fluid system will also become electrified.

1. Connect fluid hose from mixing system to drilling fluid pump. A 2.0" (50.8 mm) or larger, non-collable 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 213.



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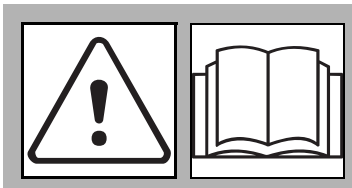
Start System

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

   IMPORTANT: Ensure that mixture of drilling fluid matches drilling conditions. See "Drilling Fluid" on page 158.

2. Enable DrillLok® mode if desired. See "DrillLok® System" on page 162.
3. Increase engine to full throttle. See "Autothrottle control" on page 38.
4. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.

Prime Drilling Fluid Pump



WARNING Read operator's manual. Know how to use all controls. Your safety is at stake. 273-475.

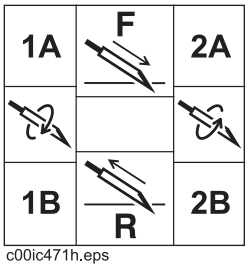
To help avoid injury: Failure to prime the drilling fluid pump will cause flow fluctuations, which will make it difficult to control the washwand.

WARNING Pressurized fluid or air could pierce skin and cause severe injury. Refer to operator's manual for proper use. 270-6035

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



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Drilling

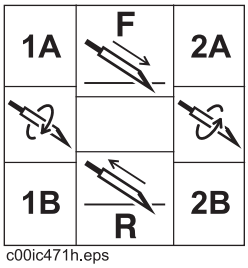
During normal drilling operation, the thrust/rotation joystick controls both operations and allows any combination of the two based on the position of the joystick:

- Push joystick toward 1A for forward thrust with clockwise rotation.

NOTICE: Counterclockwise rotation can unthread pipe in the ground.

- Push joystick toward 2A for forward thrust with counterclockwise rotation.
- Pull joystick toward 2B for reverse thrust, with counterclockwise rotation.
- Pull joystick toward 1B reverse thrust, with clockwise rotation.

Assisted Makeup



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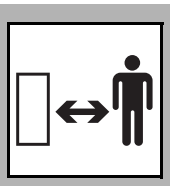
During pipe change operations when front wrench is closed and carriage is on front or rear home, the thrust/rotation joystick only controls the speed and direction of rotation. The machine controller manages thrust and matches the speed and direction of rotation to smoothly thread or unthread pipe sections.

Push joystick toward 1A or 1B for clockwise rotation (machine controlled forward thrust).

Push joystick toward 2A or 2B for counterclockwise rotation (machine controlled reverse thrust).

If the thrust/rotation joystick is moved straight forward or backward so there is no rotation, only thrust is controlled.

Clamp Pipe



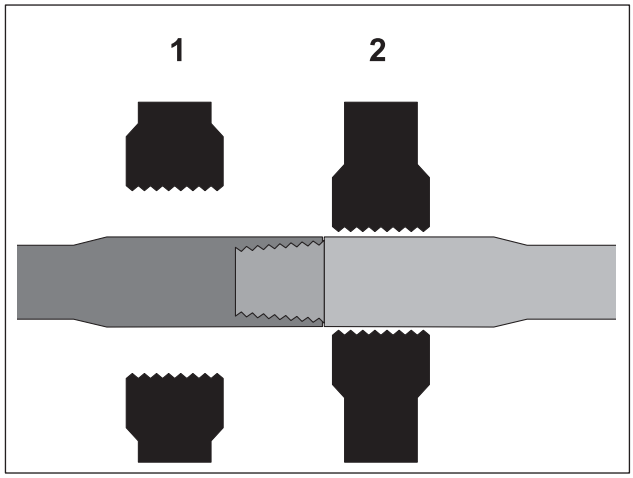
DANGER Turning shaft will kill you or crush arm or leg. Stay away.

To help avoid injury: Only clamp pipe at reinforced end. Clamping anywhere else on the pipe will weaken the pipe. Pipe can later break, even when operating under normal loads.

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

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

NOTICE: Clamping pipes on top of female end threads can damage threads. Only clamp female pipe ends behind the threads.

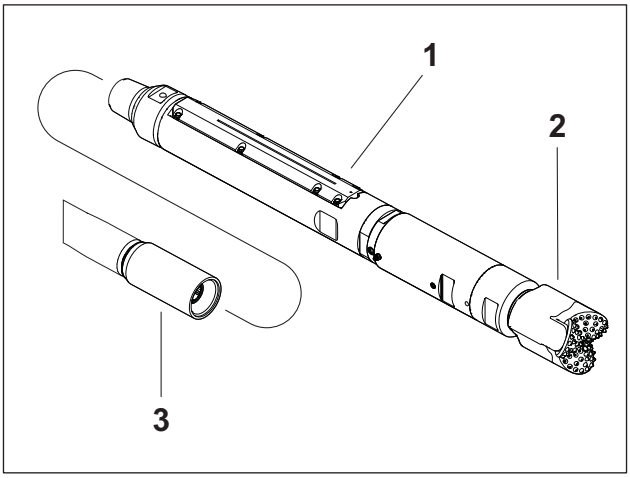


DrillPipe_Clamp.eps

Assemble Drill String

AT Mode (AT Pipe)

1. Rockmaster® tool
2. bit
3. JT40 AT drill pipe



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Prepare Rockmaster® Tool

1. Select bit. Ensure that bit and housing have suitable number of nozzles for jobsite conditions. See page 163.
2. Install bit onto Rockmaster tool using the wrench set and scribe line technique. See page 169 for correct procedures.
3. Ensure that Rockmaster tool is properly lubricated (from last usage). If using Rockmaster tool for the first time, lubricate the tool:
   - Remove rear plug from tool.
   - Install zerk.
   - Remove front plug.
   - Rotate the tool by hand while pumping tool with WRG until grease comes out rear port.
   - Reinstall front plug and add 1-5 pumps WRG.
   - Remove zerk.
   - Reinstall rear plug.
4. Install beacon, following beacon instructions for:
   - battery replacement
   - beacon positioning
5. Install beacon housing lid.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.

Attach Downhole Tool

See "Hydratong Wrenches" on page 169.

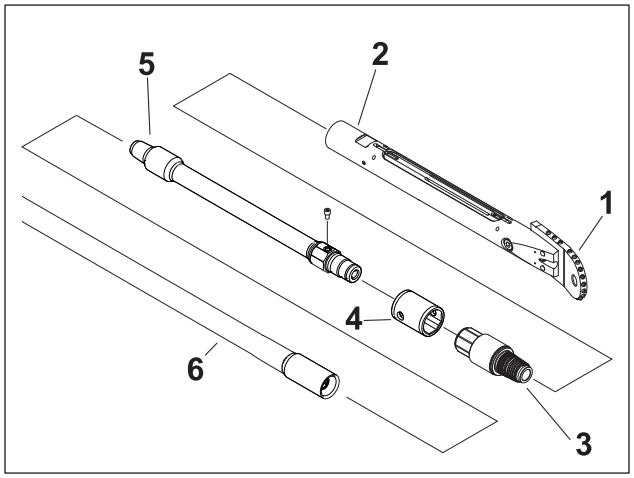
Machine Torque

1. Remove blocks from pipe guides.
2. Pull tool into lower wrench.
3. Close wrench.
4. Use machine torque to tighten joint fully.

Quick Wrenches

1. Lube joints with TJC (tool joint compound).
2. Attach quick wrenches to the joint in the join position and tighten joint.

AT Dirt Mode (AT Pipe)



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1. bit
2. beacon housing
3. adapter
4. collar
5. transition sub
6. JT40 AT drill pipe

JT Mode

1. bit
2. beacon housing
3. adapter
4. collar
5. transition sub
6. JT40 drill pipe (Power Pipe® HD or HIWS1 Pipe)

Prepare Beacon Housing

1. Select nozzles and bit.

IMPORTANT: A variety of nozzles and bits are available to suit your particular job conditions. See page 163 for more information, or contact your Ditch Witch® dealer.

2. Insert nozzle into beacon housing.
3. Attach bit to beacon housing.
4. Install beacon, following beacon instructions for:
   - battery replacement
   - beacon positioning.
5. Install beacon housing lid.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.

Attach Transition Sub

1. Remove blocks from pipe guides.
2. Pull transition sub into front wrench.
3. Close wrench.
4. Lube joints.
5. Use machine torque to tighten joint fully.

Attach Beacon Housing

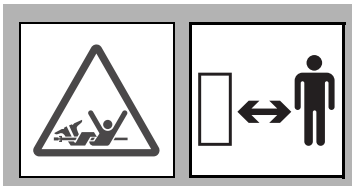
Use machine torque to attach beacon housing.

1. Pull beacon housing into front wrench.
2. Close wrench.
3. Use machine torque to tighten joint fully.

Connect Drill Pipe

4. Start drilling unit engine.
5. Align drill pipe in front wrench.
6. Clamp tool joint in front wrench. See "Clamp Pipe" on page 124.
7. Disconnect from pipe:
   - Rotate spindle counterclockwise until threads on pipe segments are disengaged from each other. Carriage will move backward as pipe rotates counterclockwise.
   - Stop rotation and move carriage backward until it stops on the rear stop switch.
8. Load pipe:
   - Ensure shuttle stop is positioned correctly.
   - Open grippers or make sure they are open.
   - Grippers open as pipe is lowered.
   - Close grippers around pipe.
   - Lubricate pipe threads at front wrench.
   - Move pipe to spindle.
   - Raise pipe lifters.
9. Connect pipe:
   - Move carriage forward until spindle meets back end of pipe joint. Rotate spindle clockwise until pipe begins to spin. Relax grippers slightly.
   - Move carriage forward until pipe joints meet at front wrench.
   - Rotate spindle clockwise. Carriage will move forward as pipe threads tighten.
   - Rotate clockwise until spindle stops turning, and joint is fully tightened.
   - Open grippers.
   - Retract shuttles fully.
   - Open front wrench.

Drill First Pipe



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

To help avoid injury:

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

WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment. 274-050; 274-724 (2P).

AT Mode

1. Turn on drilling fluid.
2. Visually check for drilling fluid flow.
3. Turn drill outer pipe to starting position.
4. Rotate inner spindle clockwise.
5. Slowly move carriage forward. Drill first pipe as straight as possible.
6. Monitor gauges.
   - If inner rotation torque approaches 800 ft•lb (1080 N•m), slow carriage travel.
   - If inner rotation stalls, stop carriage thrust. If inner rotation does not resume, pull pipe back.

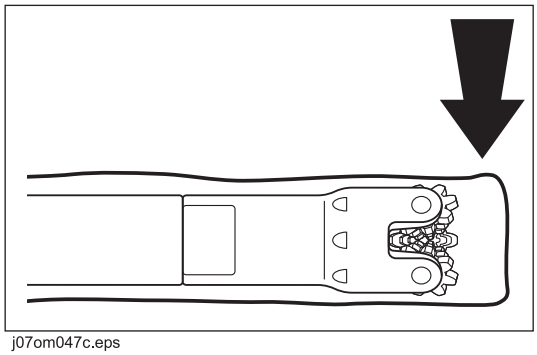
AT Dirt/JT Mode

1. Turn on drilling fluid.
2. Visually check for drilling fluid flow.
3. Turn drill bit to starting position.
4. Slowly move carriage forward. Drill first pipe as straight as possible.
5. Monitor gauges.

Swab the Hole

IMPORTANT: Swab hole after each pipe is drilled to remove cuttings and keep the hole clear (AT Mode). Some conditions may require more frequent swabbing.

1. Move carriage forward until carriage touches rear wrench.
2. Move carriage to rear of drill frame with drilling fluid and inner rotation on.
3. Move carriage forward until pipe joint is properly located between wrenches for joint breakout.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Enable Automated Pipeloader System

Add Pipe	Remove Pipe
1. Ensure pipe box is properly positioned.	1. Ensure pipe box is properly positioned.
2. Open front wrench.	2. Open front wrench.
3. Retract shuttles.	3. Retract shuttles.
4. Adjust engine to full throttle for add pipe function to work.	4. Adjust engine to full throttle for remove pipe function to work.
5. Press top of add pipe control. If any steps are skipped, the upper display will inform the operator which steps to take to continue operation.	5. Press bottom of remove pipe control. If any steps are skipped, the upper display will inform the operator which steps to take to continue operation.
6. Grippers will open, pipe will be lifted, pipe box checked (pipe available), then lowered into shuttles. If no pipe is detected, the operator is instructed to move the pipe box before continuing.	6. Grippers will open, pipe will be lowered and lifted out of shuttles. 7. Ensure pipe box column is not full. If pipe box column is full, shift pipe box to the next empty column.

IMPORTANT: If operator leaves the seat **during** an add or remove pipe cycle when the upper display shows "Adding (or removing) pipe", the pipe cycle will pause and the display will show "PIPE paused in <pipe state>". When returning to the seat, the display will show three cycling messages that prompt you to re-enable the system: "PIPE LOADER paused"; "to continue..."; "press RESUME switch." If you leave the seat while the display shows the pipe cycle is "ready" or "waiting", it is not necessary to re-enable the system.

Add Pipe

AT Mode

1. Press drilling unit autothrottle control. See "Autothrottle control" on page 38. Engine will increase to full throttle.
2. Enable automated pipeloader system if desired. See "Enable Automated Pipeloader System" on page 130.
3. Break joint at SaverLok® body.

Manual Pipeloader Controls	Automated Pipeloader Control
• Turn inner rotation off and position pipe between wrenches. See "Clamp Pipe" on page 124. • If spindle brake is set, disengage it, rotate outer pipe to 3 o'clock, and close front wrench. • Locate drill head. • Rotate spindle counterclockwise. • Carriage moves back slowly as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame until rear stop indicator is lit on upper display.	• Turn inner rotation off and position pipe between wrenches. See "Clamp Pipe" on page 124. • If spindle brake is set, disengage it, rotate outer pipe to 3 o'clock, and close front wrench. • Locate drill head. • Rotate spindle counterclockwise. • Carriage moves back slowly as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame until rear stop indicator is lit in right console. • While carriage is moving, grippers will grip, pipe is lubed, and upper display shows corresponding messages.

4. Load pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Ensure that lift arms are completely lowered. • Close grippers. • Move pipe in shuttles to spindle and lube threads at wrench. • Raise pipe in box.	• With carriage at rear stop position at back of drill frame as indicated by upper display, press RESUME. Display changes to "Adding Pipe". Pipe is moved to spindle, pipe in box is lifted. **IMPORTANT:** If a row of pipes is empty and RESUME is pressed, "Row Empty, Select New Row" will appear on display. Use row select buttons (page 32) to select new row and press RESUME. Shuttle will move to new row. • Display reads "ADD PIPE waiting".

5. Connect pipe to SaverLok® body.

Manual Pipeloader Controls	Automated Pipeloader Control
IMPORTANT: Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints.	**IMPORTANT:** Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints.
• Move carriage forward until SaverLok meets pipe. • Rotate spindle clockwise until SaverLok threads onto pipe. • Relax grippers.	• Move carriage forward until SaverLok meets pipe. • Rotate spindle clockwise until SaverLok threads onto pipe. • Press RESUME. Grippers will relax.

6. Connect new pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Slowly move carriage forward to allow inner rod to match up and rotate spindle clockwise until pipe threads together. • To fully tighten joint, slowly rotate pipe until spindle stops turning. • Open wrench. • Open grippers fully. • Retract shuttles. • Lower pipe lifters.	• Slowly move carriage forward to allow inner rod to match up and rotate spindle clockwise until pipe threads together. • Press RESUME. Display changes to "Retracting Shuttles." Grippers open, shuttles retract, pipe lifters lower and display reads "Lowering Pipe." Display changes to "Open Front Wrench." • To fully tighten joint, slowly rotate pipe until spindle stops turning. • Open wrench. If wrench will not open, look at upper display for operation messages.

7. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.
8. Adjust fluid flow control to set flow to appropriate level.
9. Set clock position for steering or rotate spindle.
10. Turn inner rotation on.
11. Slowly move carriage forward. Adjust rotation speed control according to bit size and soil conditions.
12. Engage and set cruise control as desired. See "Cruise Control" on page 186.
13. Monitor gauges. If inner rotation stalls, stop carriage travel. If inner rotation does not resume, pull pipe back.
14. Locate drill head with tracker at least every half-length of pipe.

IMPORTANT: To improve accuracy of depth estimate, turn inner rotation off, disengage spindle brake, and rotate outer pipe to 3 o'clock.

15. Engage spindle brake, if desired, and drill rest of pipe.

IMPORTANT: If steering, rotate to desired clock position, engage spindle brake and drill.

JT Mode

1. Press drilling unit autothrottle control. See "Autothrottle control" on page 38. Engine will increase to full throttle.
2. Enable automated pipeloader system if desired. See "Enable Automated Pipeloader System" on page 130.
3. Break joint at saver sub.

Manual Pipeloader Controls	Automated Pipeloader Control
• Position pipe in wrenches. See "Clamp Pipe" on page 124. • Locate drill head. • Rotate pipe to 12 o'clock position. • Close front wrench. • Rotate spindle counterclockwise. • Carriage moves back slowly as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame until rear stop indicator is lit in right console.	• With pipe loader enabled, see "Enable Automated Pipeloader System" on page 130. Position pipe in wrenches. See "Clamp Pipe" on page 124. • Locate drill head. • Rotate pipe to 12 o'clock position. • Close front wrench. • Rotate spindle counterclockwise. • Carriage moves back slowly, as threads separate. • After threads are fully separated, stop rotation and move carriage to back of frame until rear stop indicator is lit in right console. • While carriage is moving, grippers will grip, pipe is lubed, and upper display shows corresponding messages.

4. Load pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Ensure that lift arms are completely lowered. • Close grippers. • Move pipe in shuttles to spindle and lube front threads at wrench. • Raise pipe in box.	• With carriage at rear stop position at back of drill frame as indicated by upper display, press RESUME. Display changes to "Adding Pipe". Pipe is moved to spindle. Pipe in box is lifted. **IMPORTANT:** If a row of pipes is empty and RESUME is pressed, "Row Empty, Select New Row" will appear on display. Use row select buttons (page 32) to select new row and press RESUME. Shuttle will move to new row. • Display reads "ADD PIPE waiting".

5. Connect pipe to saver sub.

Manual Pipeloader Controls	Automated Pipeloader Control
IMPORTANT: Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints.	**IMPORTANT:** Always rotate clockwise unless breaking pipe joint. Rotating counterclockwise will separate joints.
• Move carriage forward until saver sub meets pipe. • Rotate spindle clockwise until saver sub threads onto pipe. • Relax grippers.	• Move carriage forward until saver sub meets pipe. • Rotate spindle clockwise until saver sub threads onto pipe. • Press RESUME. Grippers will relax.

6. Connect new pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Slowly move carriage forward until new pipe meets pipe in wrench. • Rotate spindle clockwise until pipes thread together. • To fully tighten joint, slowly rotate pipe until spindle stops turning. • Open wrench. • Open grippers fully. • Retract shuttles. • Lower pipe lifters.	• Slowly move carriage forward until new pipe meets pipe in wrench. • Rotate spindle clockwise until pipes thread together. • Press RESUME. Display changes to "Retracting Shuttles." Grippers open, shuttles retract, pipe lifters lower and display reads "Lowering Pipe." Display changes to "Open Front Wrench." • To fully tighten joint, slowly rotate pipe until spindle stops turning. • Open wrench. If wrench will not open, look at upper display for operation messages.

7. Press and hold quick fill fluid pump switch until pipe fills and fluid pressure begins to rise.
8. Adjust fluid flow control to set flow to appropriate level.
9. Rotate spindle.
10. Slowly move carriage forward. Adjust rotation speed control according to bit size and soil conditions.
11. Engage and set cruise control as desired. See "Cruise Control" on page 186.
12. Monitor gauges.
13. 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

General

- 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 92.
- 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.

JT Mode

- Do not push an entire piece of drill pipe into ground without rotation. This can exceed bend radius and cause pipe failure.

AT Mode

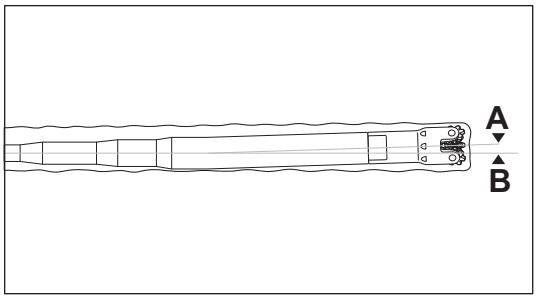
- Steering in rock is slower than steering in other soil conditions. Be patient.
- Inner rod is rotating at all times when AT mode is selected and inner rotation switch is on.
- Stop outer rotation and engage spindle brake when making directional changes.
- Depth estimate and pitch accuracy improve if drill head is at 3 o'clock when reading is taken.
- Pull back 6" (152 mm) of pipe before checking pitch.

Procedure

1. Locate drill head. Take readings available with your beacon and tracking equipment such as:
   - depth

     IMPORTANT: In AT mode, depth estimate improves if drill head is at 3 o'clock position (A) rather than horizontal (B).

   - pitch
   - left/right information
   - temperature
   - beacon roll



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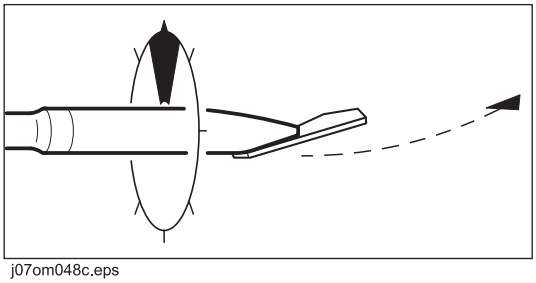
2. Compare position to bore plan. Determine direction drilling should go.
3. Position drill head.
4. Drill in pipe.

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 tracking equipment displays desired beacon roll.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To change direction:

JT mode	AT mode
1. Rotate pipe to clock position you intend to travel. 2. Push pipe into ground.	1. Rotate outer pipe to clock position you intend to travel. 2. Engage spindle brake. 3. Engage inner rotation and push pipe into ground.

To move forward without changing direction:

JT mode	AT mode
1. Rotate pipe. 2. Push pipe into ground.	1. Rotate outer pipe. 2. Engage inner rotation and push pipe into ground.

Use AutoCarve

AutoCarve helps the operator change direction when thrust stalls in difficult soil conditions while drilling in JT or AT dirt mode. AutoCarve rotates the bit clockwise and counterclockwise to grind away soil, clearing a path to improve steering through tough formations. AutoCarve does not replace AT drill mode.

Movement	Description
alternating clockwise and counterclockwise rotation	Enables the downhole tool to carve tough soil formations. Rotation speed can be adjusted during autocarving. ***NOTICE:*** To reduce the chance of unthreading pipe sections downhole, rotation pressure is limited during counterclockwise rotation; however, the operator should monitor carve operation and adjust thrust and rotation to prevent unthreading.
carve window	The range of alternating rotation.
thrust	In autocarve mode, initial thrust speed is very slow or fully stopped. Adjust speed anytime during carving.
pullback	Thrust and rotation operate normally when joystick is pulled rearward. High-speed pullback is not available in autocarve mode.

Operation

IMPORTANT:

- 2-speed thrust is not allowed in AutoCarve mode.
- AutoCarve mode is disabled while front wrench is closed.
- Adding or removing pipe does not affect AutoCarve position.

1. **Position downhole tool for carving.** Rotate the toolhead to the desired position.
2. **Turn on AutoCarve mode.** Press top of AutoCarve switch.
3. **Begin carving.** Move thrust control to full forward and then release to neutral to start alternating rotation. Adjust thrust and rotation speed as needed during carving.
4. **Adjust thrust speed.** Press and hold the Resume switch until carriage begins to move forward, then release switch. Press Resume repeatedly to increase thrust speed to desired setting. To reduce thrust speed, press Set switch.
5. **Set carve window.** Use the Carve Window Potentiometer to set the desired range of travel. Adjust as needed while carving.
6. **Adjust rotation speed**. Move rotation control to full clockwise rotation. Press the Set/Resume switch to decrease/increase rotation speed. Adjust as needed while carving.

IMPORTANT: For finer adjustment, press the multi-use button while adjusting thrust or rotation. Be aware, however, this also activates the reaming function and will change steering direction unless the tool is stopped at the original position before releasing multi-use button.

7. **Pause carving.** Move thrust control back from neutral.
8. **Resume carving.** Move thrust control to full forward and then release to neutral to start alternating rotation.
9. **Ream a newly carved section.** After carving a few inches, press and hold the 2-Speed button and m**o**ve rotation control to full clockwise rotation for maximum rotation. When tool rotates freely, reduce rotation speed and stop at desired carve position. Release 2-Speed button and resume carving.

   IMPORTANT: If full rotation seems restricted and insufficient to ream the hole, move carriage back slightly until full rotation is possible, then move carriage forward while rotating.

10. **Exit carve mode.** Press bottom of AutoCarve switch. Carriage movement and rotation will stop. Continue normal drilling.

    Note: For quicker setup during a long bore, autocarve thrust and rotation settings are retained until the unit is shut down.

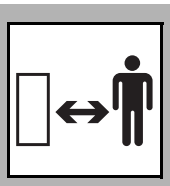
Record Bore Path

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.

Subsite® Electronics bore tracking software is also available for plotting and tracking your bore path.It utilizes a Subsite Electronics tracking system, including a tracker, display, and 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. See your Ditch Witch® dealer for details.

Surface Drill Head


DANGER Moving tools will kill or injure. Never use pipe wrenches on drill string. 273-278

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

To help avoid injury:

- Tracker operator and drill operator should maintain two-way communication.
- Keep everyone clear of the exposed drill string.
- No one should enter pit until clear communication is given by the drill operator that the drill unit is shut down. Do not enter pit until green light DrillLok® system light on unit is lit. See "DrillLok® System" on page 162.
- Drill operator should be instructed to discontinue drill string rotation as soon as drill bit exits the bore. Use thrust only to extend drill string beyond exit hole.

1. Guide drill head to target pit or up through surface. Make all bends gradual. See "Recommended Bend Limits" on page 92.
2. Clean area around exit point.
3. Turn fluid flow control to off position as soon as drill head emerges.
4. Allow tracker operator to turn off tracker or use DrillLok® system to disable drilling unit thrust/pullback and rotation hydraulics. Tracker operator waits at least 16 seconds for green light to enter pit and change tools.
5. Clean drill head especially around threads.
6. Disconnect EZ-Connect joint or use quick wrench to remove drill head. Keep threads clean. See "Hydratong Wrenches" on page 169.

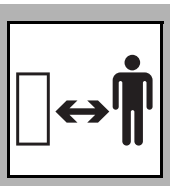
Backream

Sometimes it is necessary to drill a pilot hole first, then enlarge the hole to accommodate larger product. As a general rule, the final hole should be 1.5 times larger than the diameter of the product being installed. The number of passes needed depends on soil conditions. Do not try to increase hole size too much in one pass. Several passes using successively larger reamers will save wear on machine.


DANGER Moving tools will kill or injure. Never use pipe wrenches on drill string. 273-278


WARNING Jobsite hazards could cause death or serious injury. Use correct equipment and work methods. Use and maintain proper safety equipment. 274-050; 274-724 (2P)

To help avoid injury: Continue to use strike system during backreaming.

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

To help avoid injury:

- Maintain two-way communication with tracker operator.
- Begin backream only when tracker operator has communicated that everyone is clear of the exposed backream string.
- Do not allow anyone to stand to the side of the exposed drill string. Drill string and backreamer can move sideways suddenly if rotated while away from the exit hole.

Assemble Backream String

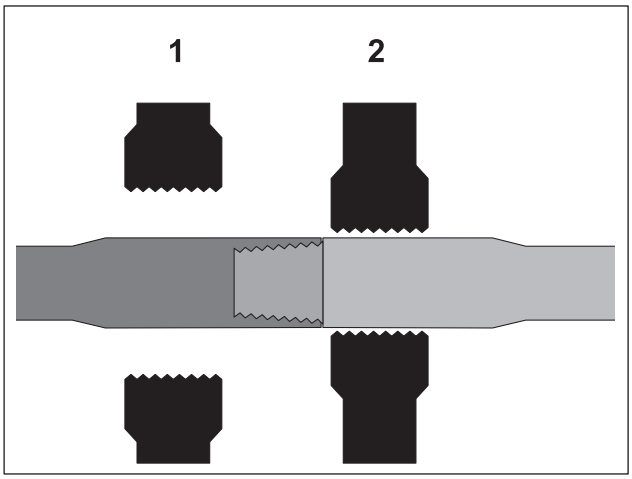
1. Select backreaming devices. See "Backreamers" on page 166.
2. Determine fluid rate requirements and install appropriate nozzles to provide sufficient flow. See "Backream Fluid Requirements" on page 167 and "Nozzles" on page 163.
3. Attach backreamer to beacon housing if tracking backream.
4. Install beacon, following beacon instructions for:
   - battery replacement
   - beacon positioning
5. Install beacon housing lid. See page 164.
6. Follow beacon instructions to check beacon operation.
7. Follow tracker instructions to calibrate beacon.
8. Use quick wrenches to attach transition sub to drill pipe string.
9. Use quick wrenches to attach backreamer/beacon housing assembly to transition sub.
10. Attach additional pullback devices or product to end of backreamer/beacon housing assembly.

Begin Backream

1. After backream assembly is attached to pipe, tracker operator should:
   - leave pit and stand away from the exposed drill string.
   - if using DrillLok® system, turn on tracker to enable drilling unit thrust/pullback and rotation.
   - if not using DrillLok system, communicate to drill operator that backream string is clear.
2. Turn on drill fluid and pressurize drill pipe. Verify that jets are open.
3. Without rotating, slowly pull back until reamer contacts bore hole opening. Do not lodge reamer in hole.
4. Begin slow rotation and pullback.
5. Increase drilling fluid flow and rotation as the backream string enters the ground.
6. If tracking backream, tracker operator may continue tracking when the backream string is no longer visible.

Remove Pipe

1. Enable automated pipeloader system if desired. See "Enable Automated Pipeloader System" on page 130.
2. Position pipe joint between wrenches.
3. Clamp pipes with both wrenches (1,2). Always clamp on the large diameter areas of either side of the tool joint face. See "Clamp Pipe" on page 124.



DrillPipe_Clamp.eps

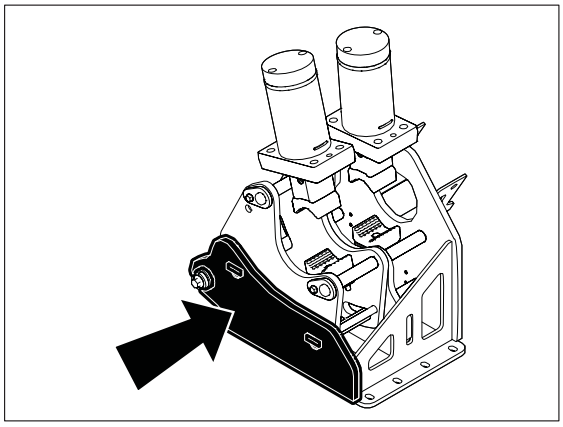
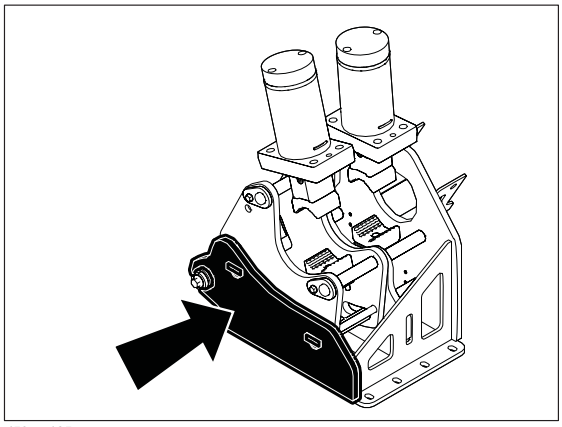
4. Break front joint.
   - Turn rear wrench counterclockwise to break joint.
   - Open rear wrench and rotate wrench clockwise to original position.
5. Grip pipe.

Manual Pipeloader Controls	Automated Pipeloader Control
• Lift pipe out of shuttles. Grippers will open as pipe is lifted. • Extend shuttles to spindle position. • Close grippers. Relax grippers to allow pipe to rotate. • Lower lifters.	• Press RESUME. Display reads "Extending Shuttles" and shuttles extend, grippers grip fully then relax open, and pipe lifters lower. • Display reads "Resume to Close Gripper."

6. Separate front joint.

Manual Pipeloader Controls	Automated Pipeloader Control
• Rotate spindle counterclockwise to separate pipe. • Continue to rotate until joint is fully separated.	• Rotate spindle counterclockwise to separate pipe. • Continue to rotate until joint is fully separated.

7. Break rear joint.

Manual Pipeloader Controls	Automated Pipeloader Control
• Close rear wrench. • Rotate spindle counterclockwise until joint is loosened at saver sub. **Do not** fully unthread joint. • Open rear wrench. • Move carriage back until the front end of the pipe clears the front face of the wrench mount plate (shown).	• Close rear wrench. • Rotate spindle counterclockwise until joint is loosened at saver sub. **Do not** fully unthread joint. • Open rear wrench. • Move carriage back until the front end of the pipe clears the front face of the wrench mount plate (shown).
 j59om105w.eps	 j59om105w.eps
• Close grippers. • Rotate spindle counterclockwise until saver sub is separated from pipe. • Move carriage to back of frame until rear stop indicator is lit in right console.	• Press RESUME. Grippers close. • Rotate spindle counterclockwise until saver sub is separated from pipe. • Move carriage to back of frame until rear stop indicator is lit in right console.

8. Load pipe into pipe box.

Manual Pipeloader Controls	Automated Pipeloader Control
• Retract shuttles to delivery chute. • Release grippers and raise lift arms to place pipe in box. • Lube front threads.	• Press RESUME. Display reads "Retracting Shuttles," shuttles will retract to delivery chute, threads are lubed, grippers release pipe, and pipe lifters raise to place pipe in box. • Display reads "Remove Pipe Waiting".

9. Attach saver sub to next pipe.

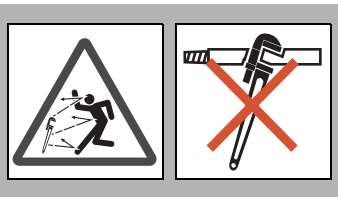
Manual Pipeloader Controls	Automated Pipeloader Control
• Move carriage forward until saver sub touches pipe. • Rotate spindle to thread saver sub onto pipe. Carriage moves forward slowly as pipe threads together. Slowly tighten joint to full machine torque.	• Move carriage forward until saver sub touches pipe. • Rotate spindle to thread saver sub onto pipe. Carriage moves forward slowly as pipe threads together. Slowly tighten joint to full machine torque.

10. Open front wrench to release pipe.
11. Check pipe box to see if row is full. If so, select next empty row.

NOTICE: Damage can occur when lifting with too many pipes in a column. Be aware of the number of pipes in the column and check indicator flags as column is filled.

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. Never use pipe wrenches on drill string. 273-278

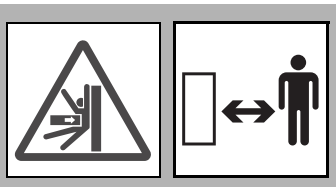
1. Press bottom of drilling unit throttle switch until engine is at low throttle.
2. Turn off drilling fluid.
3. Turn drilling unit engine off.
4. Clean pullback device.
5. Disconnect pullback material.
6. Use quick wrenches to remove pullback device.

Systems and Equipment

Chapter Contents

Anchor System

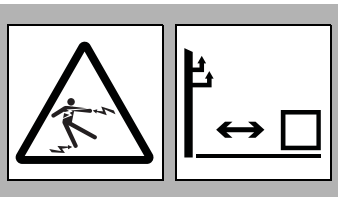
The methods for anchoring this unit are available: anchors, alternate anchors, and a combination of both. Choose the correct method based on jobsite conditions.



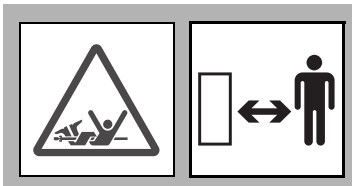
WARNING Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away 274-204.

To help avoid injury:

- Set stabilizers prior to driving anchors.
- Drive anchors properly and/or tie off unit before drilling.
- Stand on platform when operating anchor controls.
- Wear high-top protective boots with legs of pants completely tucked inside.
- Wear protective gloves.
- Only swing cab after setup is complete.
- 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 Electric shock will cause death or serious injury. Stay away. 274-049



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

To help avoid injury: Do not replace anchor collar bolt with one longer than original. Clothing could catch on turning shaft.

Select Anchor

Two anchor types are available. Choose the correct anchor type based on jobsite conditions.

Anchor type	Situation used
rock bit	hard/soft rock, asphalt, concrete, cobble
auger bit	soft soil to hard soil, soft rock

IMPORTANT: Do not attempt to operate anchor controls while drill fluid is on. Drill fluid operation may divert power from anchor system so that anchor controls perform poorly.

Drive Anchors

1. Install centering cap.

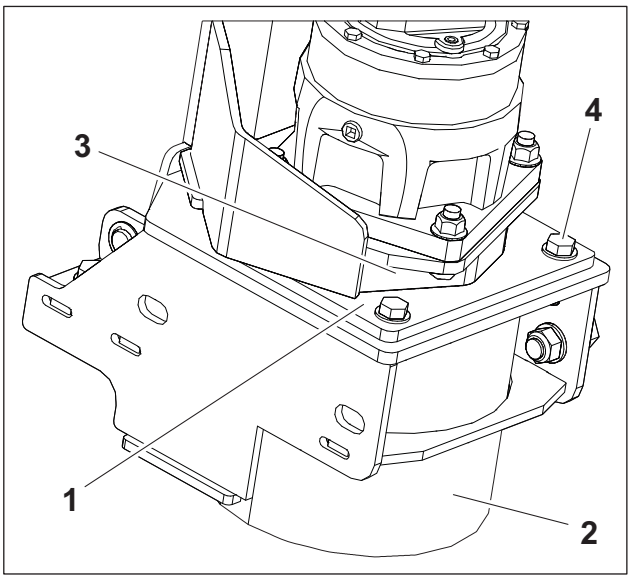
   NOTICE: Centering cap must be properly installed to prevent damage to anchor.

Centering cap is installed properly when:

- Bolt/washer/nut assemblies (4) are secure but not over-tightened.
- Centering cap (1) is free to slide back and forth inside centering tube (2) under normal loading.

2. Use high speed rotation and low thrust to drive anchor into the ground.

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



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3. Anchor is set when auger shaft flange (3) rests firmly on centering cap (1).
4. 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.

Alternate Anchors

Use tie-off points on machine in situations where anchors cannot be used or in combination with the anchors in situations where additional anchoring is needed. Contact a rigging specialist for assistance with this process to ensure the rigging can withstand potential forces.

NOTICE:

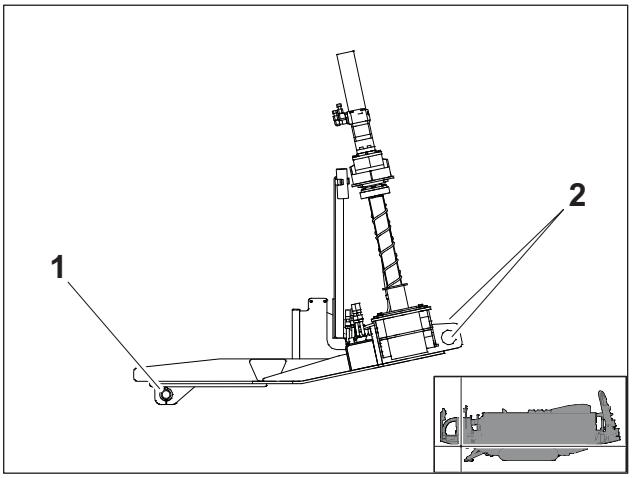
- If using remote tie-offs instead of anchors, additional grounding of the machine will need to be done using kit 100-794.
- Avoid drill string when implementing remote tie-off option.
- Rigging must be able to withstand forces of up to 40,000 lb (178 kN).

1. Use alternate anchoring option (1) when backreaming. Connect chain to pin and run straight back from machine.

   NOTICE: Ensure that pin is secure before attaching chain to it.

2. Use rings located on front of anchor frame (2) to anchor machine when drilling out. Connect a chain to each ear and run straight forward from machine.

   NOTICE: Looping the chain through the ears will case damage to the frame.



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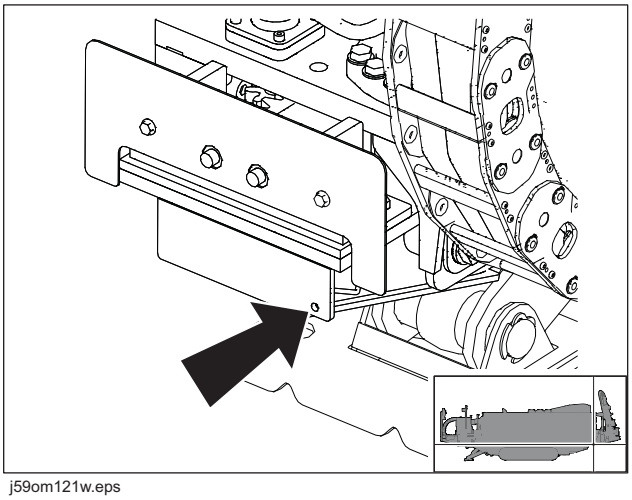
3. Connect ground rod included in grounding kit to drill frame as shown.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Electric Strike System

Any time you drill in an electric jobsite, electric strike system must be properly set up, tested, and used. Drill operator and tracker operator must wear protective boots, and the drill operator must have protective gloves within reach, all meeting the following standards:

- Boots must have high tops and meet the electric hazard protection requirements of ASTM F2413 or ASTM F1117 when tested at 18,000 volts. Tuck legs of pants completely inside boots.
- Gloves must have 17,000 AC maximum use voltage, according to ASTM specification D120.

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 89. Review safety procedures before each job.

If an electric strike occurs, immediately contact your local Ditch Witch® dealer to have the electric strike system tested.

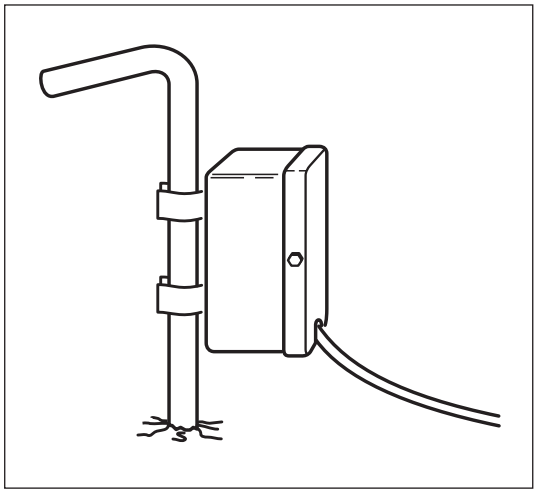
FCC Statement

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 the following page. Do not drill until test is completed successfully.

1. Turn on drilling unit.
2. To test alarms and strobe, press the test button on the left console. See "ESID alarm interrupt/self-test switch" on page 42.
3. Press the ESID soft key to view test results and historical data stored in the upper display. This data includes:
   - ESID bar graph
   - alphanumeric readout showing volts and amps
   - current diagnostic codes, or diagnostic codes detected during previous tests
4. Use Electric Strike Simulator to test voltage and current sensors. See page 156.

Troubleshoot Strike System

When strike system detects a problem, a diagnostic code will be displayed. Anytime this happens, press self-test function to retest. If an 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 communication with ESID. Red icon  shown on upper display.	Problems in startup	Go to ESID menu and select test function. If problem goes away, retest strike system
	No power to strike system control module	Check drilling unit electrical system
		Check that harness from drilling unit to control module is connected
	Defective control module	Have control module checked or replaced
	Defective CAN bus connection	Ensure CAN cable from drilling unit to ESID control module is connected
SPN521513 FMI31 DID224 shows on upper display	Test wire not connected	Check that test wire is connected to ESID control module
		Check that test wire is connected to upper display
		Have ESID control module checked or replaced
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 alarm and connect to external 12V power source. 2. If alarm does not work, replace it.
	Defective control module	Have control module checked or replaced

Problem	Possible cause	Possible solution
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
SPN523518 FMI31 DID224 and red ESID current indicator icon shows on upper display. 	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
Red ESID voltage icon shows on upper display. No code is displayed. 	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
	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. If readings are still less than indicated, contact your Ditch Witch® dealer to have ESID repaired before drilling.

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. Select ESID menu on upper display.
4. Move simulator switch to "current" and press test button.
5. Watch display on upper display.
   - ESID bar graph should show 1/2 scale on display.
   - ESID % and Current "AMPS" should show 30% or higher 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:

   With two loops,
   - Current "AMPS" should be 80% or higher.
   - Strike indication might go on and off.

   With three loops,
   - Current should be 130% or higher.
   - 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 display screen:
    - Alarm and strobe should turn on.
    - ESID% and voltage "volts" should show 90% or higher.

It is normal for simulator voltage levels to drift below strike level. When this happens, ESID bar should show less than full and alarm and strobe should stop working. If the level drifts above strike level again, light, ESID bar, and strobe should be turned on again.

Drilling Fluid

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).

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)
- EZ-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 dealer for soil conditions and drilling fluid recommendations for your area.

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 161.

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.

IMPORTANT:

- 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®

The **Bore-Gel**® system 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.

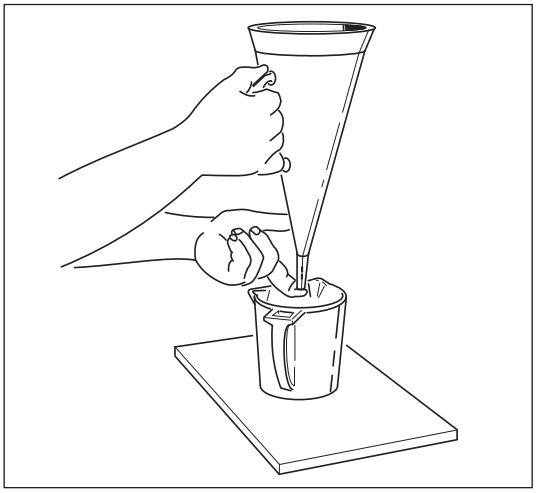
Funnel Viscosity

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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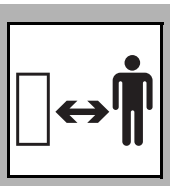
DrillLok® System



DANGER Rotating shaft will cause death or serious injury. Stay away.

To help avoid injury:

- Use DrillLok system any time you change downhole tools or during other times when the drill string is exposed.
- If you are not using DrillLok system, turn off drilling unit and keep key in tracker operator's possession before changing downhole tools.

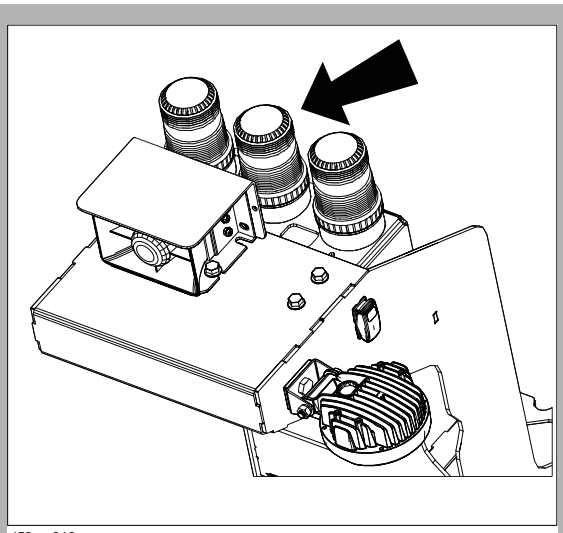
This mode allows the tracker operator to disable hydraulic power to drilling unit thrust and rotation.

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

If thrust and rotation are not enabled check whether the green DrillLok light (shown), located on front of drilling unit, is on. If it is, thrust and rotation have been disabled by DrillLok.system.

NOTICE: Tracker operator cannot disable thrust and rotation from tracker if DrillLok key is installed in drilling unit and turned to the deactivated position.

See "DrillLok® key" on page 71.



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Operation with Subsite® Electronics Tracking Equipment: See tracker manual.

Operation without Subsite Electronics Tracking Equipment: Only available on units with DrillLok system. See DrillLok operation sheet.

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 dealer for soil conditions and bit recommendations for your area.

- 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	3	4	4	4	4
Tornado bit	2	2	2	1	1	3	4
Tuff bit	3	2	1	1	3	1	4
Steep Taper Tuff bit	2	2	1	1	2	1	4
Barracuda bit	2	1	1	2	3	4	4
Steep Taper bit	2	2	1	2	2	3	4
Hard Surface bit	3	1	2	3	4	4	4
Glacier bit	4	4	4	3	1	2	4
Rhino bit	4	4	3	3	1	1	3
Rockmaster®	4	4	3	2	1	1	1
Talon bit	3	3	2	1	1	2	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
cobble rock	chunk rock, glacial till, cobble, gravel
soft rock	sandstone, shale, coral, caliche, chaulk
medium rock	limestone, caliche, sandstone, shale
hard rock	granite, schist, marble, hard limestone

Installation

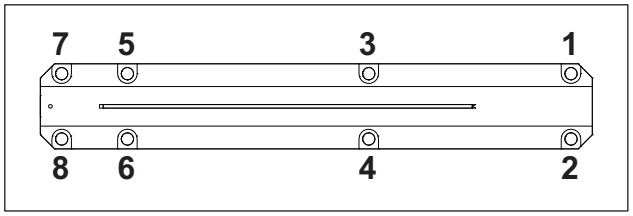
Remove all paint from mating surfaces before attaching any bit to housing. Install screws (p/n 107-277) and tighten bolts to 120 ft•lb (163 N•m).

Beacon Housings

Rockmaster® Lid Installation

IMPORTANT: Lid bolts are one-time-use parts. Install new bolts each time lid is installed.

1. Clean all threads, bolt holes and mating surfaces.
2. Follow tightening sequence (shown).
3. Tighten bolts to 60-70 ft•lb (81-95 N•m).
4. Repeat tightening sequence.



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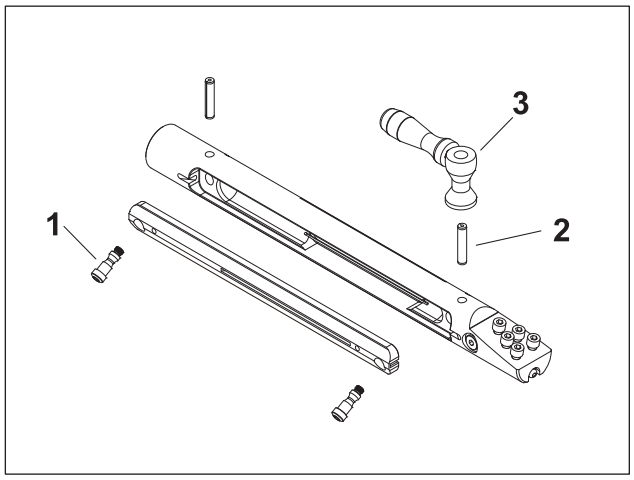
Dirt Housing Lid Installation

Lid Installation

1. Clean all threads, bolt holes and mating surfaces.
2. Use removable thread locker (Loctite® 242 or equivalent), if desired.
3. Place lid on trough and install bolts (1).
4. Use punch holder (3) to drive roll pins (2) from direction shown.



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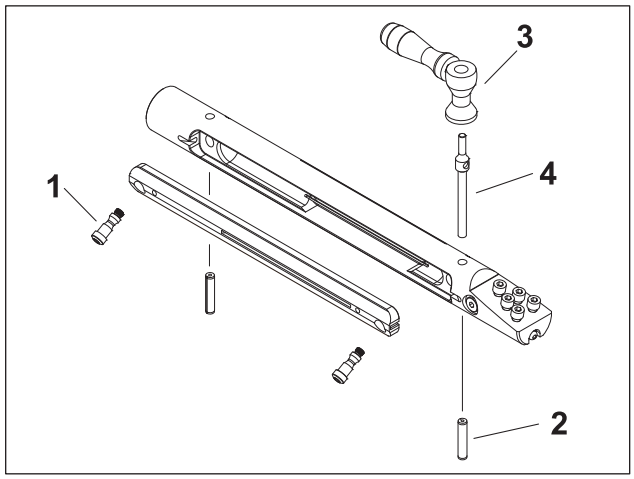
Lid Removal

1. Use punch holder (3) with bolt pin driver (4) to drive out pins (2).
2. Remove bolts.
3. Remove lid.



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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.

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

Backreamer	Sandy Soil	Soft Soil	Medium Soil	Hard Soil	Rocky Soil	Soft Rock	Hard Rock
Compact Fluted HD	3	3	1	2			
Kodiak TM HD			3	2	1	2	
Beavertail HD	2	1	1	1			
WarthogTM HD							
Rockmaster®	4	4	4	4	3	1	1

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

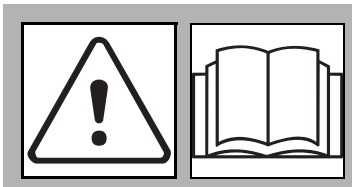
IMPORTANT: After you have determined how much fluid you will need, see your Ditch Witch® dealer for nozzle recommendations.

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	140 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	191 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	279 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

Hydratong Wrenches

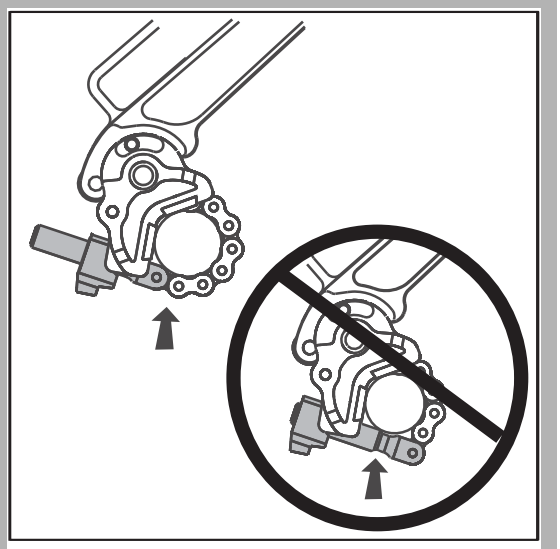
To attach or remove downhole tools, use the Hydratong wrenches to join or break the joint.



WARNING Read operator's manual. Know how to use all controls. Your safety is at stake. 273-475

To help avoid injury:

- Ensure only chain tongs and chain are in contact with pipe (shown) and that chain is correctly wrapped. Do not use Hydratong with chain bushing pin touching pipe (shown).
- Stand away from the Hydratong when using it.



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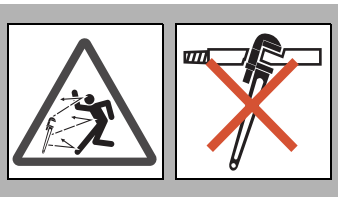
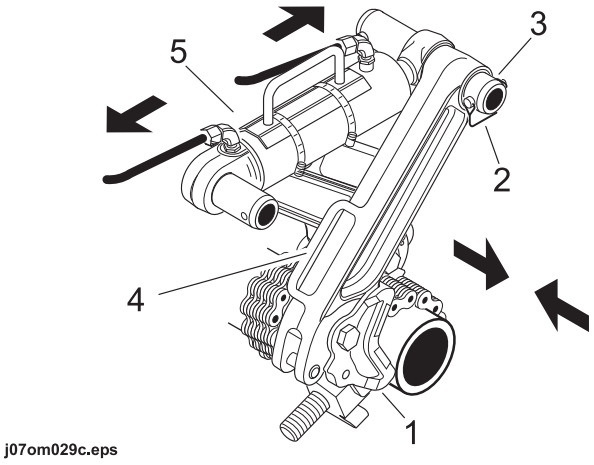


DANGER Moving tools will kill or injure. Never use pipe wrenches on drill string. 273-278

1. To join, apply TJC to threads and hand tighten joint.
2. Verify chain tong size is appropriate for pipe diameter. New chain tongs work with pipe diameter 4.5" to 5" (11.43 cm to 12.7 cm). To accommodate 3 5/8" to 4 3/8" (9.2 cm to 11.1 cm) pipe, remove one chain link.

3. Attach Hydratong in either the join or break position.



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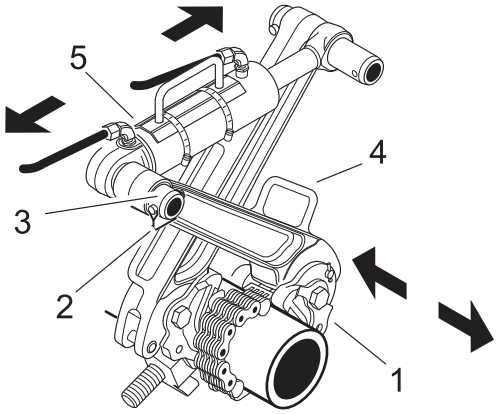
Join

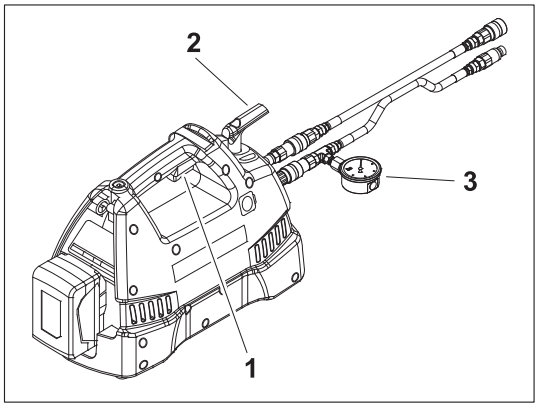


Break

IMPORTANT: Ensure arms are crossed before using wrench.

- Attach chain tongs (1) to both sides of joint. Place tongs as close to joint as possible.
- Remove snapper pins (2) from slide pins (3), and insert slide pins into wrench handles (4).
- Attach each end of hydraulic cylinder (5) to slide pins and insert snapper pins.

4. Remove all slack from wrench and joint.
5. To join, use the scribe line method to prepare joints for proper tightening. See "Scribe Line Method" on page 171.
6. Connect Hydratong power pack to cylinder..
7. To tighten or loosen joint, move shuttle valve handle (2, shown) toward the A position on pump and press power switch (1, shown) to extend cylinder.
8. To reposition chain tongs and continue tightening or loosening joint, move handle to the B position and then press power switch to retract cylinder.
9. Monitor gauge (3, shown) and refer to decal on pump to achieve the approximate torque value.



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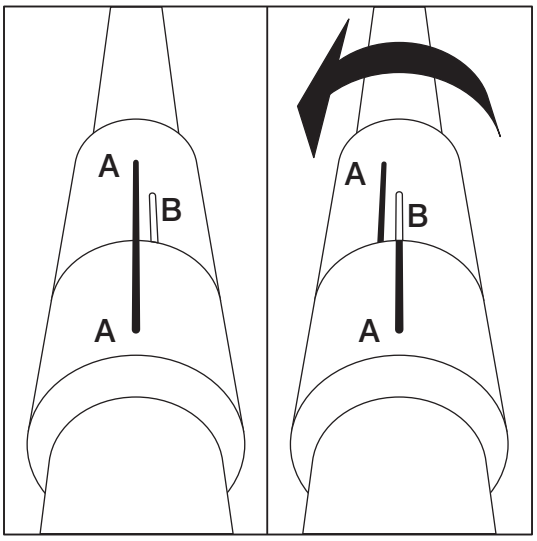
IMPORTANT: Gauge gives an estimate of torque. Use scribe line method to verify proper make-up torque.

10. Move handle to center (neutral) position to relieve pressure.
11. Disconnect hoses and remove Hydratong components.

Scribe Line Method

1. To join, scribe straight line across joint on both sides of separating line (A).
2. To join, scribe second line (B) on movable side of joint in the opposite direction of tightening action. Refer to table for correct dimension.

Connection	Dimension
transition sub to JT40 Power Pipe® HD	5/16" (8.0 mm)
transition sub to beacon housing	1/2" (13 mm)
transition sub to All Terrain pipe	1/4" (6.4 mm)
transition sub to JT40 HIWS1 pipe	5/16" (8.0 mm)



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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 202 for recommended 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 202 for recommended 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.

Replace Worn SaverLok® Body

Because each pipe comes in contact with the SaverLok body, check SaverLok body regularly for wear. Compare condition of SaverLok body threads to condition of your drill pipe threads. Replace SaverLok body any time when its thread condition is not better than thread condition of your drill pipe. Failing to replace SaverLok body will result in damaged drill pipe. See page 235 for replacement procedure.

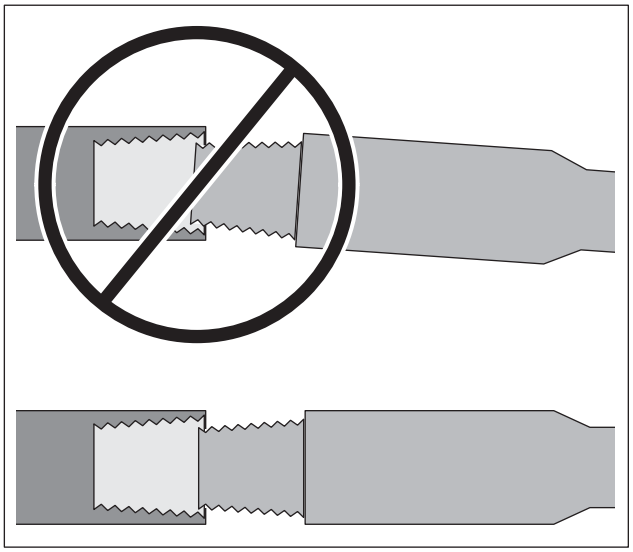
Precondition a new SaverLok body the same way you do new pipe.

Use Drill Pipe Correctly

Align the Joints

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

NOTICE: If joints get out of alignment during a bore, use frame tilt or rear stabilizers to adjust the unit.



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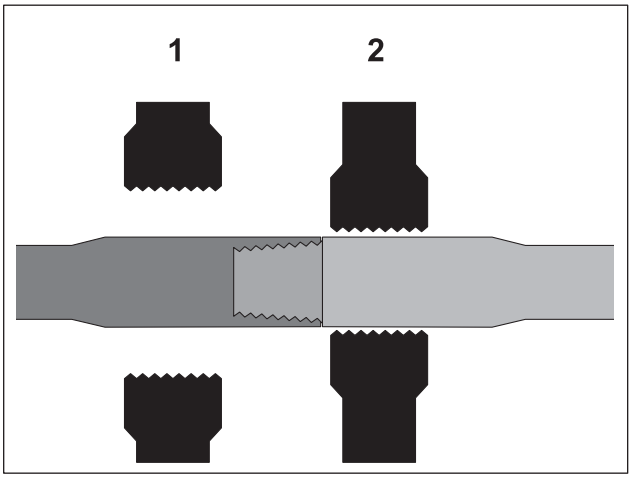
Clamp Pipe Correctly

Clamp on pipe when joint is 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.

See "Clamp Pipe" on page 124 for more information.



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Make Up and Break Out Joints Correctly

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

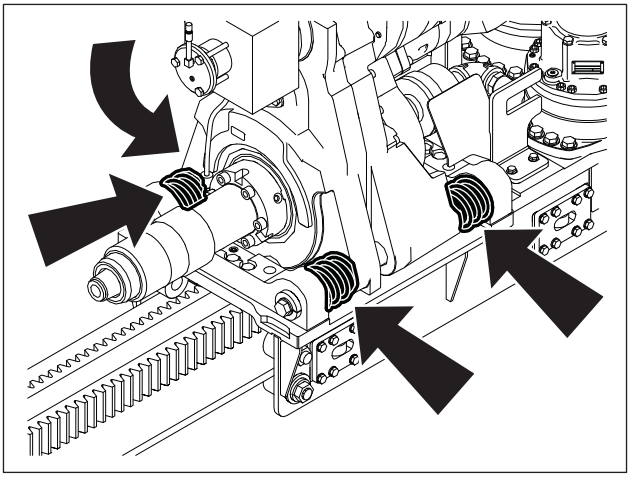
- To connect pipes together and fully tighten joint, slowly rotate pipe until spindle stops turning and full pressure is developed. Improperly tightened joints will damage the shoulder faces and threads, and will cause joints to leak or break while drilling or backreaming.
- To disconnect pipes, slowly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

IMPORTANT: If assisted makeup is not functioning, unit will not thrust or rotate while carriage is on front or rear home with front wrench closed. Press and hold multi-use button to operate thrust and rotation and follow these instructions.

Make up and break out joints slowly. Do not ram pipes together during makeup or force them apart during breakout. Carefully match carriage travel speed to rotation speed, and always connect and disconnect joints slowly and deliberately. This will help prevent thread crossing, galling, and shoulder swelling.

Makeup

- Carefully move carriage forward until spindle (or pipe) contacts threads of pipe in the wrench and begins to collapse spring on the side of the carriage (shown). Stop thrusting and rotate clockwise until spring is fully relaxed. Carefully move thrust forward as you spin the threads together, keeping the spring as relaxed as possible.
- **Tighten joints fully.** Once the joint is connected and the shoulder faces are touching, tighten to full machine torque. Improperly tightened joints will damage the shoulder faces and threads, and will cause joints to leak or break while drilling or backreaming.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Breakout

Carefully move the carriage backward until the spring on the side of the carriage is almost fully collapsed. Do not fully collapse the spring. Stop thrusting and rotate counterclockwise until spring is fully relaxed. Carefully move thrust backward and spin the threads apart, keeping the spring as relaxed as possible until the pipe joint is fully separated.

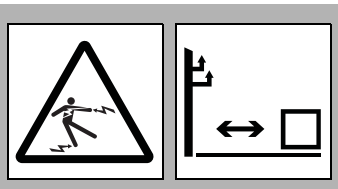
Do not Overwork the Pipe

Never exceed the bend radius for your pipe. See "Recommended Bend Limits" on page 92. Do not oversteer.

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

Pipeloader

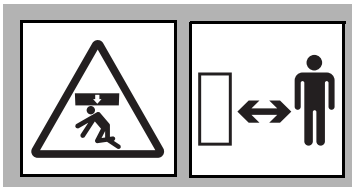
Remove/Install Pipe Box



DANGER Electric shock will cause death or serious injury. Stay away. 274-049

To help avoid injury:

- 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 loader is wearing electrically insulating boots and gloves.



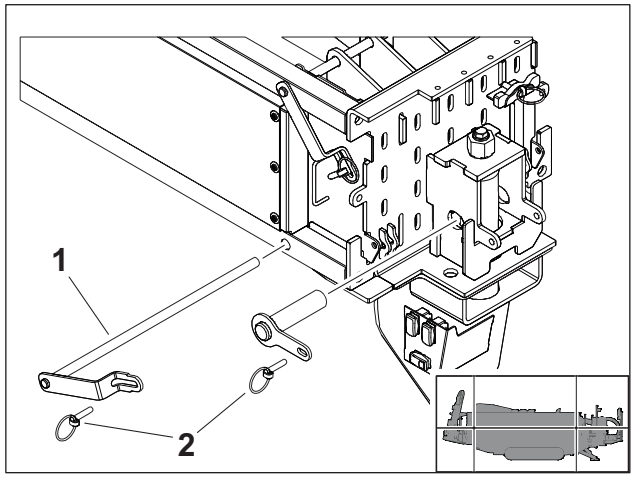
WARNING Crushing weight could cause death or serious injury. Stay away. 275-326.

To help avoid injury:

- Always walk around unit and check for obstructions before moving load.
- Use crane capable of supporting the equipment's size and weight. See page 241 or measure and weigh equipment before lifting.
- Never remove pins from ends of pipe box until you have attached lifting device. Box may fall if pipe lift switch is pressed without end pins in place.
- Lift only one box of pipe at a time.
- Do not take your eyes off moving load. Always look in the direction load is moving.
- Never swing a load over people.

Prepare

1. Lift pipe and remove pins (2) and support bars (1) from pipe box storage pockets.
2. Insert each support bar (1) into opening and retain with pin through tab.
3. Press pipe lower switch to lower pipes onto support bars.



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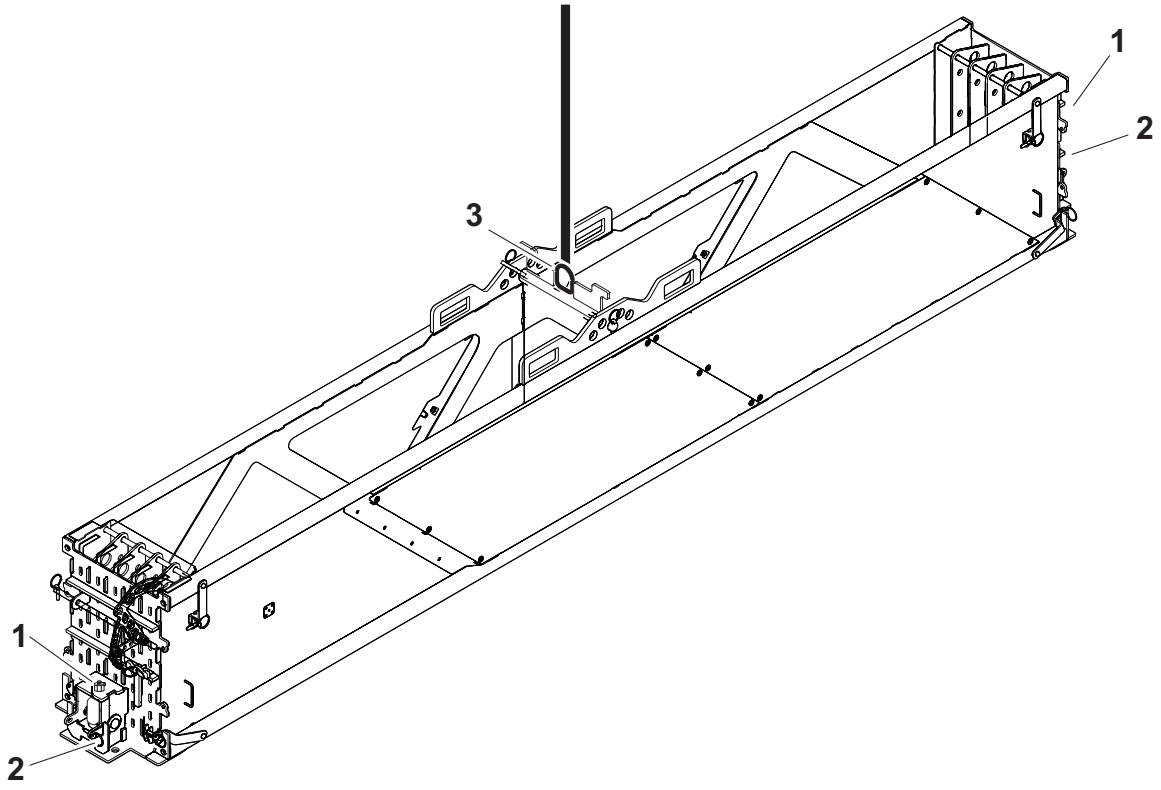
Remove Pipe Box



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1. Install lift block (4) and secure with lift block support bar and pins. Adjust to match drill frame angle.
2. Remove threaded caps (1) from pins.
3. Remove pins (2).
4. Move pipe box off of drill frame.

Install Pipe Box

NOTICE: Pipe box should only be installed onto pipeloader when pipe box shuttle is in first row position.

1. Move pipe box over front and rear locating pins and lower into position. Ensure pipe box is moved all the way to the front.
2. Install threaded caps onto pins.
3. Install pins.
4. Raise pipe with lifter on unit.
5. Remove bottom support pins from both ends of pipe box. Store support pins in pipe box storage pockets.

Row Select

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

Drilling

Change row when column is empty. If automated pipeloader is being used, the main display will inform you that it is time to select a new row. Use row select buttons to select new row. See "Select next row control" on page 32.

IMPORTANT: Shuttle must be extended from under pipe box when row is selected.

Backreaming

Select next row when active column is full.

NOTICE:

- Damage can occur when lifting with too many pipes in a column. Be aware of the number of pipes in the column.
- Shuttle must be extended from under pipe box when row is selected.

Correct Dropped Pipe

To return a dropped pipe to the drill string, turn off engine and manually retrieve pipe. Return it to the pipe box by loading it as a single piece of pipe. See "Add Single Pipe" on page 180.

Correct Misaligned or Jammed Pipe

A pop-up message on the upper display will indicate a misaligned or jammed pipe. Turn off engine and inspect pipe in active column. If drill pipe is bent, remove it from pipe box and discard.

NOTICE: If misaligned or jammed pipe cannot be corrected by removing bent pipe, contact your Ditch Witch® dealer for assistance.

Rotate Drill Pipe Order

Rotating the drill pipe is a manual process. Rotate drill pipes in the drill string weekly.

Guidelines

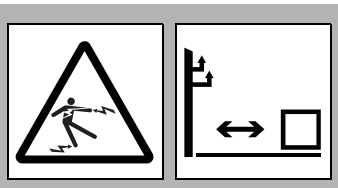
- Rotate only as many columns as used on the longest bore of the week. For example, if the longest bore was 320' (98 m), then only rotate the four columns used.
- Plan to rotate the pipes during the longest bore of the week.

Procedure

1. Remove rotate pipe retainers (301-8546) from stowed position.
2. Raise pipe until the center of the bottom row of pipe is centered in the bottom slots in the pipe box.
3. Insert rotate pipe retainers into the bottom slot on front and rear of pipe box on the first row of pipe.
4. Secure rotate pipe retainer with lynch pin (p/n 110-228).
5. Adjust row stop to second row of pipe.
6. Operate drill until only one row of pipe remains.
7. Set row stop to first row.
8. Raise pipe lifters to take weight off of rotate pipe retainers.
9. Remove rotate pipe retainers and secure in stowed position.
10. Operate drill until pipe box is empty.
11. Fill box using normal operating procedures.

Add/Remove Single Pipe

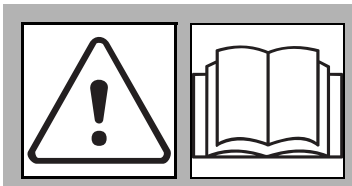
Load a single drill pipe or up to a whole row of drill pipe into last row of pipe box to finish bore without changing pipe boxes. Pipe can be added as soon as last row of pipe has been started and other rows are empty.



DANGER Electric shock will cause death or serious injury. Stay away. 274-049

To help avoid injury:

- 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 loader is wearing electrically insulating boots and gloves.



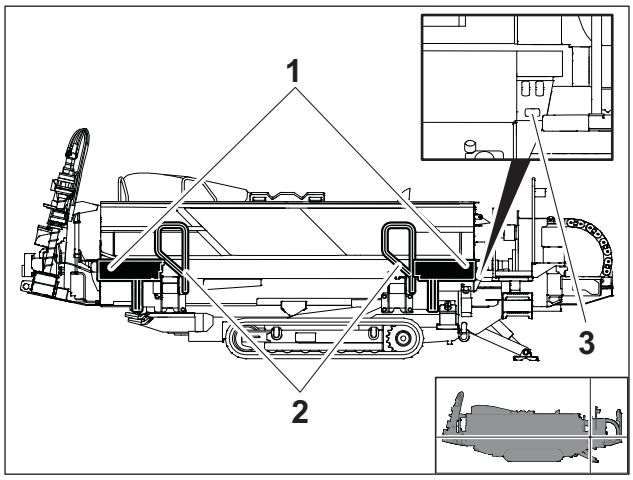
WARNING Read operator's manual. Know how to use all controls. Your safety is at stake. 273-475

To help avoid injury:

- 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.
- Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.

Add Single Pipe

1. Move row select to last row.
2. Lower shuttle covers (2).
3. Lower lifter covers (1).
4. Press right side of auxiliary pipe load restricted operating mode switch (3) to override drill operator control of shuttles and lifters and move control to single load switches. See "Auxiliary pipe load restricted operating mode switch" on page 73.
5. Move shuttles out fully.



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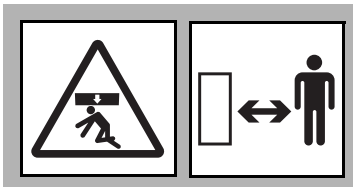
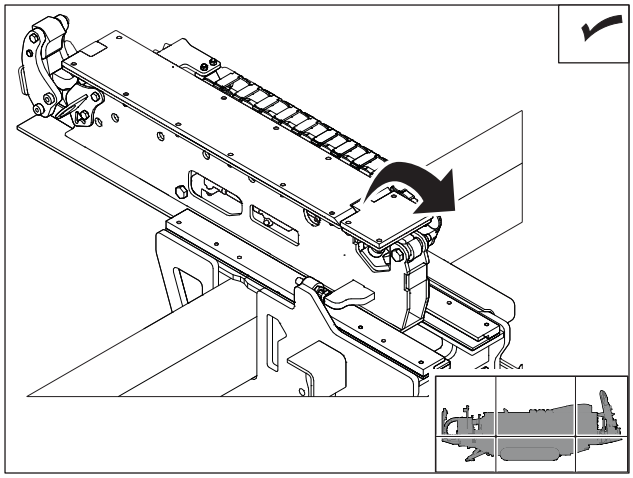


WARNING Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away.

To help avoid injury:

- Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.
- Do not attempt to move shuttles until everyone is at least 10 ft (3 m) away from machine.
- Ensure switch operator is standing clear of all moving parts while adding pipe.

6. Rotate auxiliary pipe loaders into position as shown.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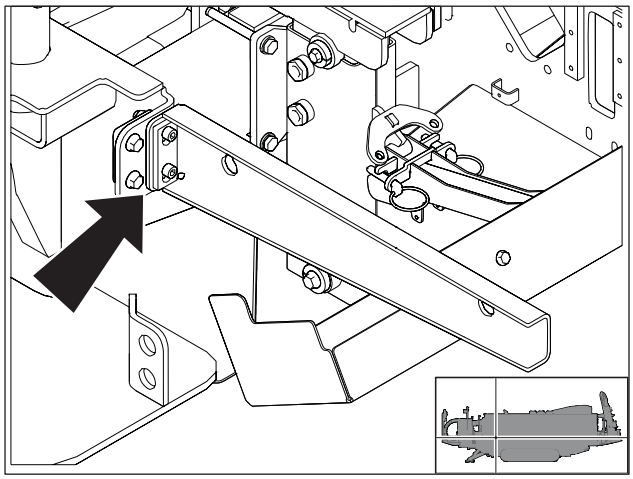
7. Remove pipe guide (stored on shuttle drive cover) and attach to front of pipe loader frame as shown.
8. Load a pipe in auxiliary pipe loaders and rest it against pipe guide.
9. Move auxiliary pipe loaders under last row.
10. Raise pipe into last row.
11. Move shuttles all the way out.
12. Repeat steps 8-11 to load more pieces of pipe into the last row.
13. Move pipe to pipeloader grippers.
    - Raise last pipe into last row.
    - Move shuttles out.
    - Lower pipe into front grippers.
14. Before moving pipe to carriage spindle:
    - Close both auxiliary pipe loaders.
    - Remove pipe guide and store it on shuttle drive cover.
    - Pin lifter covers back in upright position.
    - Press left side of auxiliary pipe load restricted operating mode switch to enable drill operator control of shuttles and lifter.
    - Step away from drilling unit.



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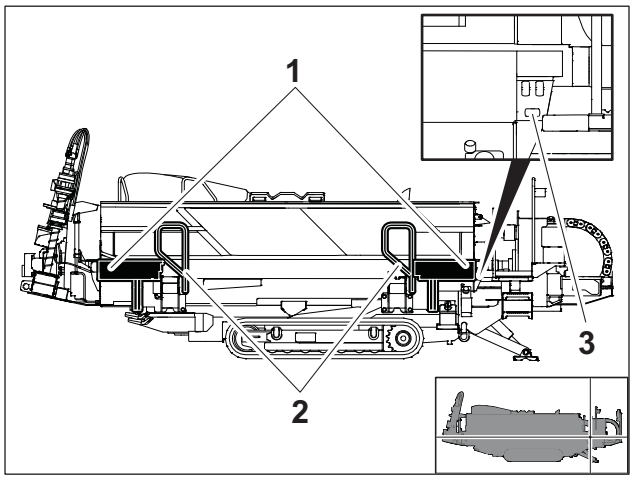
Remove Single Pipe

Unload drill pipe loaded with auxiliary pipe loaders. Pipe in last row of pipe box can be unloaded only when all other rows are empty.

1. Ensure last row is selected.
2. Lower shuttle covers (1).
3. Lower lifter covers (2).
4. Press right side of auxiliary pipe load restricted operating mode switch (3) to override drill operator control of shuttles and lifters and move control to single load switches. See "Auxiliary pipe load restricted operating mode switch" on page 73.
5. Move shuttles out fully.
6. Rotate auxiliary pipe loaders into position as shown.



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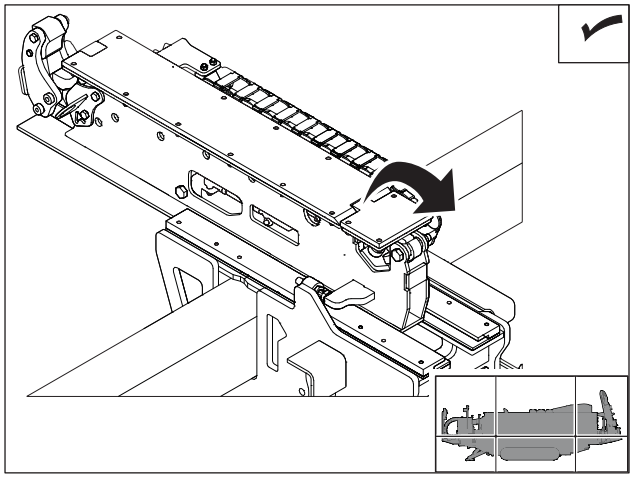
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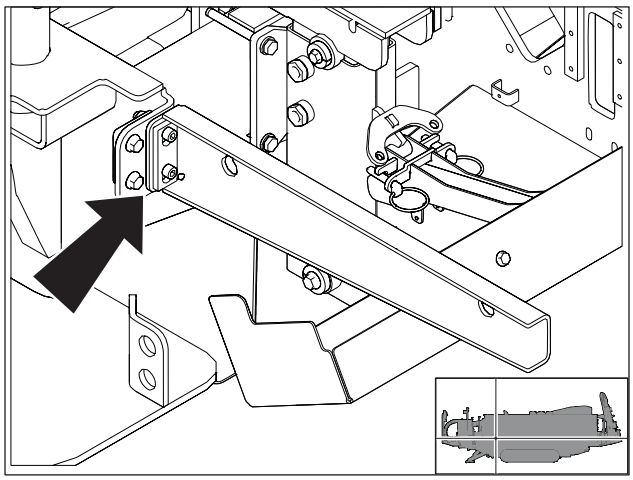
7. Remove pipe guide (stored on shuttle drive cover) and attach to front of pipe loader frame as shown.
8. Raise pipe in last row.
9. Move pipe to auxiliary pipe loaders.
   - Move shuttles in.
   - Lower pipe into auxiliary pipe loaders.
10. Move shuttles out.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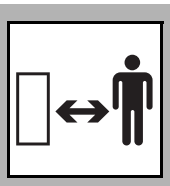


WARNING Crushing weight could cause death or serious injury. Use proper procedures and equipment or stay away.

To help avoid injury:

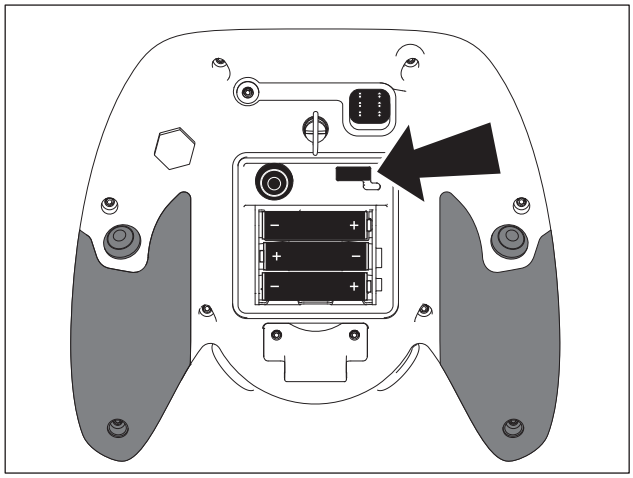
- Drill pipe is heavy. Have enough people on hand to manually add or remove single pipe to pipe box.
- Do not attempt to move shuttles until everyone is at least 10 ft (3 m) away from machine.
- Ensure switch operator is standing clear of all moving parts while removing pipe.

11. Remove pipe from auxiliary pipe loaders and store properly.
12. Repeat steps 8-10 to unload remaining added drill pipe.
13. After all added drill pipe is unloaded with auxiliary pipe loaders:
    - Close both auxiliary pipe loaders.
    - Remove pipe stop and store it on shuttle guard.
14. Press left side of auxiliary pipe load restricted operating mode switch to enable drill operator control of shuttles and lifter.
15. Finish loading remaining drill pipe into last row using standard procedure. See "Remove Pipe" on page 143.

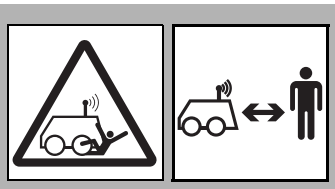
Wireless Remote Controller

Before each use

1. Check transmitter unit battery status. Replace batteries if necessary. See page 237.
2. Ensure USB key (shown) is installed. This key is a lockout feature to prevent unauthorized use.



Operation



CAUTION Equipment can be operated by remote control. Stay away.

270-6037

To help avoid injury:

- Keep drilling unit in sight at all times when using wireless remote controller.
- Keep a safe distance away from drilling unit when operating wireless remote controller.
- Ensure bystanders are not near the area the drilling unit will be driven.
- Remove strap from around neck when using wireless controller near moving parts. Place wireless controller in storage box after use. Take care not to store with neck strap on top of switches.

EMERGENCY STOP: Press engine stop on wireless remote or machine.

IMPORTANT: Operator station must be empty to operate wireless ground drive control.

1. Start the remote transmitter by moving the power/start/horn switch up until communication link indicator is steady yellow and then blinks green. Clear wireless remote control light (page 4) will shine on the machine being controlled.
2. Move power/start/horn switch up again with speed/direction control in neutral until horn sounds.

IMPORTANT: Wireless controller will shut down after one minute of inactivity. Move power/start/horn switch up to restart.

3. To drive machine, select the desired drive mode. Press one or both operator presence switches and then set throttle and use the joystick to steer.
4. Shut down the transmitter by moving power/start/horn switch down until LED indicators go off.

Troubleshooting

If drilling unit does not respond as expected when using wireless ground drive, turn transmitter off and use alternate ground drive controls.

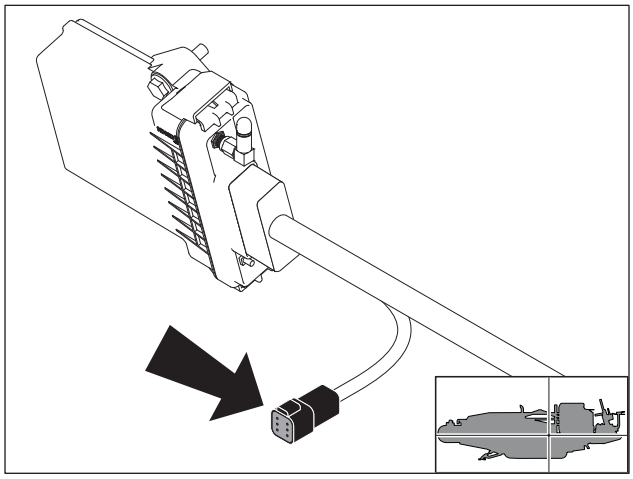
If communication link indicator is blinking yellow, communication between transmitter and receiver has stopped. Move wireless remote closer to machine while maintaining a safe distance. If in an area with interference, try changing the channel (see below).

If communication link indicator is red, communication has been lost. Shut down wireless remote and restart to try to enable communication. If that doesn't work, contact your Ditch Witch® dealer.

If battery and communication link indicators both display red for several seconds and then the wireless controller shuts off, USB key is not installed.

To change channels:

1. Turn machine ignition key on with engine off.
2. Connect harness (shown) to transmitter (2).
3. Ensure battery indicator is solid green.



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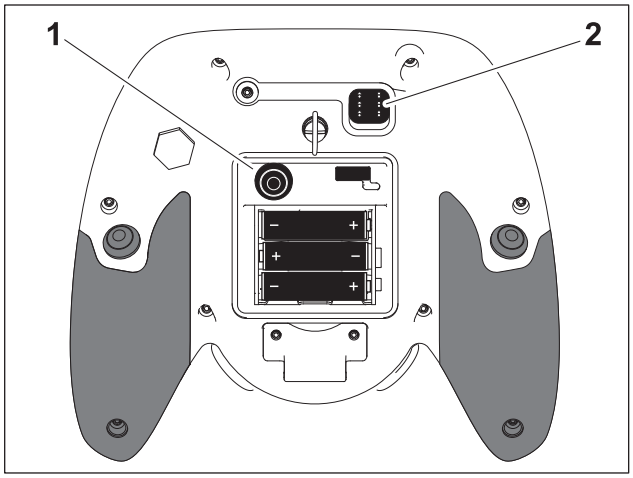
4. Press the channel switch (1) until communication link indicator begins to blink green/yellow and then release the channel switch.
   - Rapid blinking green indicator signals successful channel connection.
   - Blinking yellow indicator signals unsuccessful channel connection.



Remote_Channel.eps

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 delivery chute (fully retracted).

Engage

Thrust/Pullback and Rotation Cruise	Thrust/Pullback Cruise Only
1. Position joystick so that thrust or pullback and rotation are at desired speeds. 2. Press set. Cruise mode indicator will appear on upper display. See "Cruise mode indicator" on page 51. 3. Release joystick.	1. Position joystick to desired thrust or pullback setting. 2. Press set. Cruise mode indicator will appear on upper display. See "Cruise mode indicator" on page 51. 3. Release joystick. 4. Operator can control rotation with joystick. In JT or AT Dirt modes, there is only clockwise rotation. In AT mode, there is clockwise and counterclockwise rotation so the operator can "wiggle" through cobble rock. ***NOTICE:*** Counterclockwise rotation can "break out" pipe joints downhole and unthread the joint. Operator should not rotate counterclockwise long enough to unthread a joint.

Adjust Settings

Setting	Instructions
Thrust or Pullback	• To increase thrust or pullback speed, set joystick in neutral position and press resume. • To decrease thrust or pullback speed, set joystick in neutral position and press set.
Rotation	• To increase rotation speed, move joystick to left and press resume. • To decrease rotation speed, move joystick to left and press set.

Note: To obtain fine adjustments, press and hold the multi-use button while making the adjustment.

Override

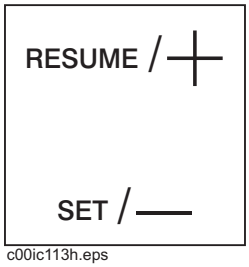
- To override thrust/pullback settings, move joystick out of neutral and beyond current setting. Unit will increase to joystick setting.
- To return to previous setting, release joystick.

Disengage

To disengage cruise control, move joystick out of neutral in opposite direction of carriage travel. Cruise mode indicator disappears from the upper display and carriage stops moving.

Resume

1. Position joystick out of neutral in direction to be resumed (forward or backward).
2. Press resume. Thrust and rotation resume at the previous settings and cruise mode indicator appears on upper display. See "Cruise mode indicator" on page 51.



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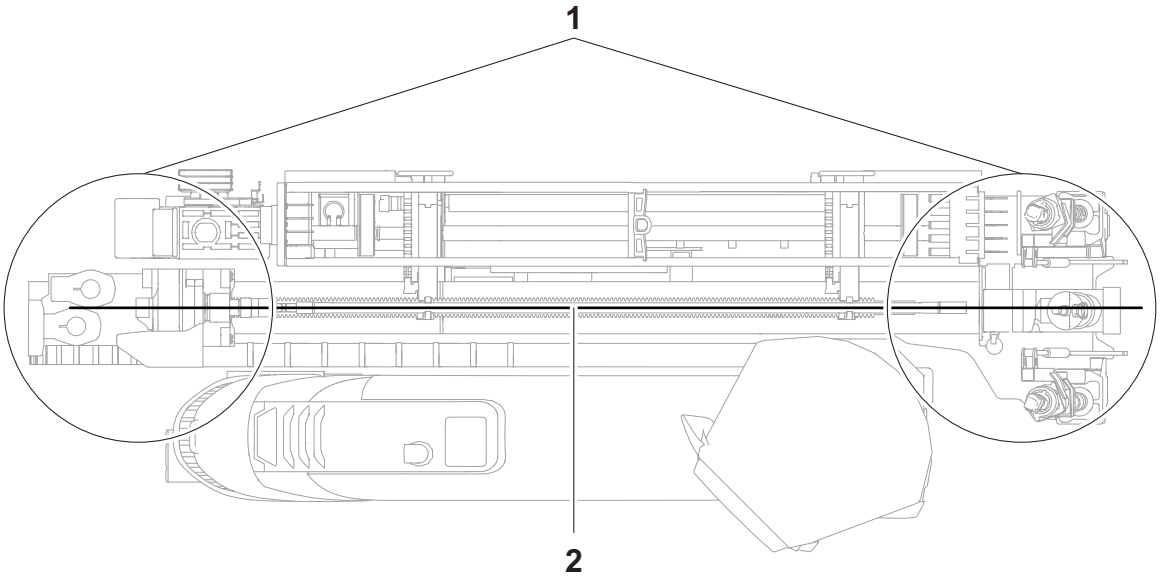
Wireline Operation

IMPORTANT: This section is intended as an overview for the JT40 drilling unit operator. During most bores, a wireline operation specialist is responsible for making wireline connections. For specific information about wireline operation, including system operation and safety precautions, consult your wireline operation equipment vendor.

The JT40 can be modified to operate a wireline operation system by installing kit 190-2518. Wireline operation uses a transmitter in the drilling head that is hard wired through the drill string to an offboard computer station at the rear of the unit. Each time pipe is added to the drill string, a new section of wireline is inserted through the new pipe, gearbox, and water swivel, then spliced to the tracking system. The operator must be aware of the wireline operation specialist's activity at the front and rear of the machine.



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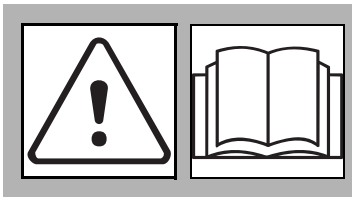
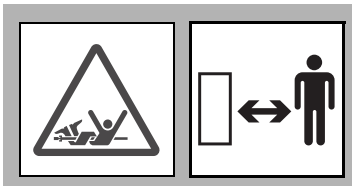
1. Operator awareness zones
2. Wireline

Operation



WARNING Read operator's manual. Know how to use all controls. Your safety is at stake. 273-475

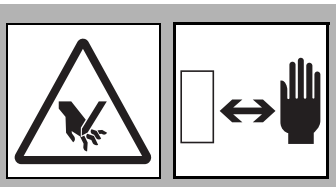


DANGER Turning shaft will kill you or crush arm or leg. Stay away.

To help avoid injury:

- Ensure that thrust and rotation are disabled or in restricted mode while wireline operation specialist is working at front and rear of machine.
- Do not drive unit from the wireline platform.

1. Connect drill head, transition sub, and wireline beacon housing.
2. Drill first pipe. After first pipe is downhole, clamp pipe in wrenches.
3. Position next pipe in shuttles.



WARNING Moving parts could cut off hand or foot. Stay away. 275-184, 273-437,

To help avoid injury:

- DO NOT operate pipe box, pipeloading, anchor, setup controls, or any other controls while tracking specialist is making wireline connections.
- Maintain constant two-way communication with tracking specialist.

4. The wireline operation specialist will:
    - Turn the wireline restricted operating mode (ROM) switch to the ON position to slow thrust and rotation. See "Wireline restricted operating mode switch" on page 74.
    - Insert a section of wireline through the pipe in the shuttles.
    - Splice one end of the new wire to the wireline in the clamped pipe.
    - Insert the other end (rear of machine) through the spindle, gearbox, and water swivel.
5. Use the pipeloading controls to move the new pipe into position and makeup the joint.

6. The wireline operation specialist will:
    - Remove slack in the wireline.
    - Secure the wireline at the spindle.
    - Connect the wireline to the offboard computer.
    - Turn the wireline ROM switch to the OFF position to enable unrestricted thrust and rotation.
7. Install next new section of pipe.
8. Continue process for duration of bore.

Diagnostic Codes

The JT40 / JT40 All Terrain is equipped with two diagnostic systems: engine and machine. The engine diagnostic system detects critical and non-critical errors within the engine operating system and communicates fault codes on the upper display. The machine diagnostic system detects errors within the automated machine control system. These error codes are also displayed on the upper display.

To hide/recall active codes: Press the soft key on the upper display for the diagnostic message center. Then press the soft key to hide/recall messages.

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

Electronic Controlled Engine Overview

This unit is equipped with a self-diagnostic computer-controlled engine management system. An ECU (Electronic Control Unit) monitors engine performance and makes adjustments to optimize that performance.

Indicators, plus diagnostic codes and messages, on the upper display tell the operator about potential engine problems and certain engine events. Depending on the severity of the problem, the ECU may reduce engine power or speed or may shut the engine down. The ECU also stores all diagnostic codes regardless of severity.

Reading Engine Diagnostic Codes

Engine diagnostic codes are shown in pop-up messages on the upper display. Amber or yellow messages indicate problems that should be addressed but do not need immediate attention. Red messages indicate problems that need immediate attention. Failure to address a problem indicated by a red message will generally result in the engine derating or shutting down.

Machine Diagnostic System Overview

Use the upper display to view condition of the machine automation diagnostic system. Under normal operating conditions, any diagnostic code that is recorded will be shown as a pop-up message on the upper display.

Diagnostic Codes

Note the SPN, FMI, and description of the diagnostic code for future reference, if needed. See “Appendix” on page 253.

Sensor Override

Automated functions of the JT40/JT40 All Terrain are made possible by communication between five electronic controllers onboard the unit. Sensor Override Mode permits limited operation without automated functions and standard equipment protections. In Sensor Override Mode, an operator can complete a bore and move the unit away from the jobsite so that proper repairs can be made at a Ditch Witch® dealership.

NOTICE: Some automated functions that protect components from damage are NOT available in Sensor Override Mode. **Use extreme caution when operating in Sensor Override Mode.**

IMPORTANT: Only a qualified Ditch Witch® service technician can return the unit to normal operation. Contact your Ditch Witch dealership.

If a sensor affected by Sensor Override Mode has an error and needs attention, a pop-up message will appear. Each pop-up message will give the operator the option to override the error. This table explains how automated functions are affected in Sensor Override Mode both if overridden by the operator and if not overridden.

Pop-up Message Displayed	Cause	With Override	Without Override
"Carriage Encoder Sensor Error. If you override the error, the carriage will be able to run into the stops and the shuttle. This may damage the machine."	1. No CAN communications. 2. Sensor shows the carriage is beyond the front or rear stop. 3. Sensor does not detect movement when the carriage should be moving.	• Two-speed thrust disabled • Pipeloader automation disabled • Distance drilled disabled	• Carriage unable to move • Shuttles unable to extend from under pipe box
"Shuttle Encoder Sensor Error. If you override the error, the carriage will be able to run into the shuttle. This may damage the machine."	1. No CAN communications. 2. Sensor shows the shuttle is beyond the spindle stop or the last row of pipe. 3. Sensor does not detect movement when shuttle should be moving.	• Pipeloader automation disabled	• Carriage unable to move • Shuttles unable to extend from under pipe box
"Shuttle Row Stop Error. If you override this error, the row stop must be manually moved to the correct location for each row."	1. Row select sensor reads out of range. 2. Row select motor pulling too much or too little current. 3. Row select sensor not detecting movement when row select should be moving.	• Pipeloader automation disabled • Automatic row change disabled	• Row stop will stay in current position

Complete the Job

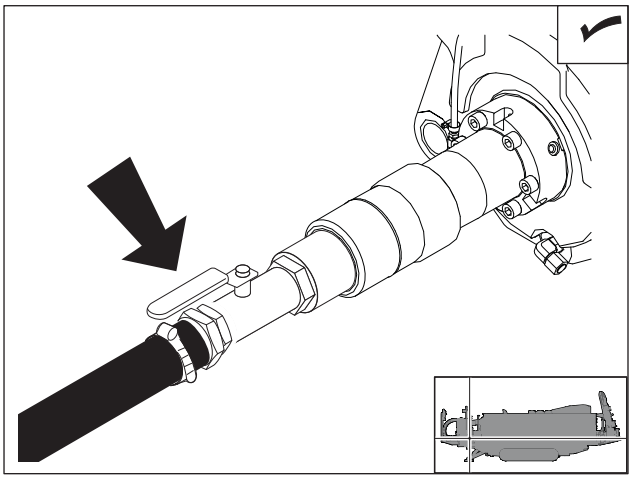
Chapter Contents

Antifreeze Drilling Unit

Your drilling unit can be left overnight in freezing conditions by filling fluid lines with a polyproplyene-based antifreeze (p/n 265-1055) with optional antifreeze system before shutdown.

Add Antifreeze

1. Fill antifreeze tank with 8 gal (30 L) of approved antifreeze.
2. Install plug on suction side of drilling fluid pump.
3. Open valve below antifreeze tank.
4. Install optional antifreeze reclaimer adapter in spindle. Ensure valve (shown) is open.
5. Turn drilling fluid potentiometer counterclockwise to zero position.
6. Start unit and set throttle to slow position.
7. Set drilling fluid pump switch to on 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 pump switch to off position. Close valve on antifreeze reclaimer adapter.



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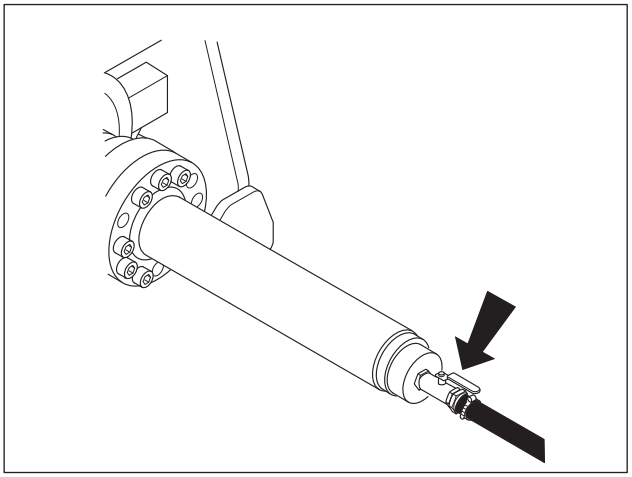
Reclaim Antifreeze

1. Hold hose on optional antifreeze reclaimer over top of antifreeze tank.
2. Open valve on reclaimer (shown).
3. Connect drilling fluid transfer hose from tanks to drilling fluid pump inlet.
4. Close valve below antifreeze tank.
5. Start unit and run at low throttle.
6. Turn drilling fluid pump on low speed.
7. Turn drilling fluid pump off when drilling fluid comes out of reclaimer hose.
8. Remove antifreeze reclaimer.



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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.

Rinse Equipment

Use Washwand

WARNING Pressurized fluid or air could pierce skin and cause severe injury. Refer to operator's manual for proper use. 270-6035

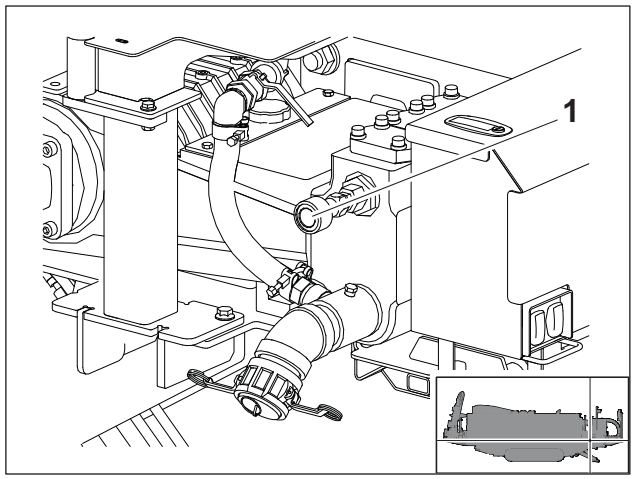
To help avoid injury:

- Wear protective eyewear and clothing.
- Never use high flow when using washwand.
- Never point or aim the wand at yourself or anyone else. Keep nozzle low to the ground.
- Prime the drilling fluid pump before operating washwand. Failure to prime the drilling fluid pump will cause flow fluctuations, which will make it difficult to control the washwand. For instructions, see "Connect Fluid System" on page 121.

NOTICE: Do not spray water onto operator's console. Do not spray water onto electrical center in engine compartment. Electrical components could be damaged. Wipe down instead.

1. Turn fluid flow control (page 40) to low setting.
2. Connect the wash wand at quick connect (2) at rear of unit.
3. Press wash wand switch to close discharge valve. See "Wash wand switch" on page 23.
4. Check surroundings before pressing handle to start pressurized fluid flow.
5. Spray water onto equipment to remove dirt and mud. Some pressure might be needed to remove dried mud from wrench area.

   IMPORTANT: If front wrench is closed, fluid will not flow to the wash wand.



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6. Release handle to stop flow.

Disconnect

Disconnect and store the following hoses and cables (if used):

- electric strike system voltage stake
- fluid hose

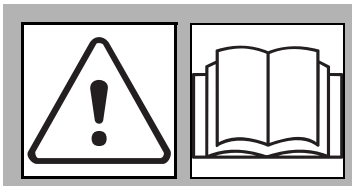
Stow Tools

Make sure all quick wrenches, bits, pullback devices, and other tools are loaded and properly secured on trailer or truck.

Service

Chapter Contents

Service Precautions



WARNING Read operator's manual. Know how to use all controls. Your safety is at stake. 273-475

To help avoid injury:

- Unless otherwise instructed, all service should be performed with engine off.
- Refer to engine manufacturer's manual for engine maintenance instructions.

Welding Precaution

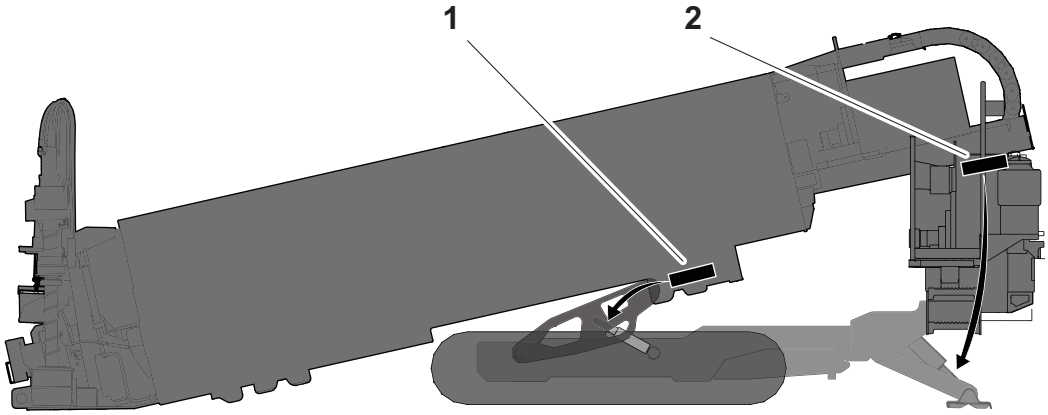
NOTICE: Welding can damage electronics.

- Welding currents can damage electronic components. Always disconnect the ECU ground connection from the frame, harness connections to the ECU, and other electronic components prior to welding on machine or attachments. Connect welder ground close to welding point and make sure no electronic components are in the ground path.
- Disconnect battery at battery disconnect switch before welding to prevent damage to battery. See "Check Battery" on page 237.
- Do not turn off battery disconnect switch with engine running, or alternator and other electronic devices may be damaged.

Washing Precaution

NOTICE: Water can damage electronics. When cleaning equipment, do not spray electrical components with water.

Working Under Drilling Unit



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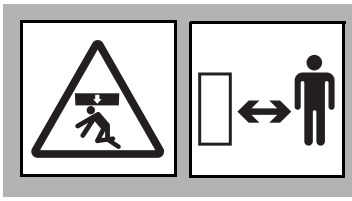


WARNING Crushing weight could cause death or serious injury. Stay away. 275-326

Before working under area of drilling unit supported by a stabilizer, make sure drilling unit is parked on hard surface.

1. Remove cylinder locks from storage at rear of pipe box (2) and place over extended cylinder rods (shown) with curved ends toward stabilizer shoes.
2. Lower unit until load is supported by cylinder locks.

Before working under area of drilling unit supported by **frame tilt cylinder**, make sure drilling unit is parked on hard surface.

1. Remove drill frame support stored under rear step (1) and place under drill frame (shown).
2. Lower drill frame until load is supported by drill frame support.

Replace cylinder locks or drill frame support if damaged.

Recommended Lubricants/Service Key

Item	Description
DEO	Diesel engine oil meeting or exceeding Cummins® 20081, API CJ-4, ACEA E9 • Engine must use low SAPS oil (ash will plug aftertreatment device.) • Use viscosity grade SAE 15W40 unless ambient temperatures below 5° F (-15° C) are expected. Lower viscosity oils must meet the performance specifications shown above. API American Petroleum Institute, ACEA European Automobile Manufacturer's Association.
LRC DEO	Diesel engine oil meeting or exceeding Cummins 20078, API CI-4, ACEA E7. ***NOTICE:*** Shipped from factory with CJ-4 DEO. Change oil initially at 250 hrs. Use viscosity grade SAE 15W40 unless ambient temperatures below 5° F (-15° C) are expected. Lower viscosity oils must meet the performance specifications shown above. API American Petroleum Institute, ACEA European Automobile Manufacturer's Association.
DEF	Diesel exhaust fluid (DEF) meeting ISO 22241-1 or DIN 70070
DEAC	Diesel engine antifreeze/coolant meeting CES 14603 See "Approved Coolant" on page 203.
MPG	Multipurpose grease. Use polyurea based NLGI GC-LB Grade 1.5 or lithium based NLGI GC-LB Grade 2
WRG	Multipurpose extreme pressure water resistant grease. Use polyurea based NLGI GC-LB Grade 2 (p/n 255-1019)
EPS	Extreme pressure spray lubricant, Lubriplate LO152-063 or equivalent (p/n 256-034)
MPL	Multipurpose gear oil meeting API service classification GL-5 (SAE 80W90)
THF	Tractor hydraulic fluid, similar to Phillips 66® PowerTran Fluid, Mobilfluid ®424, Chevron® Tractor Hydraulic Fluid, Texaco® TDH Oil, or equivalent
TJC	Tool joint compound: Ditch Witch® standard (p/n 259-858) or environmental (p/n 256-1005)

	Check level of fluid or lubricant		Check condition
	Filter		Change, replace, adjust, service or test

Proper lubrication and maintenance protects Ditch Witch® equipment from damage and failure. Service intervals listed are for minimum requirements. In extreme conditions, service machine more frequently. Use only genuine Ditch Witch parts, filters, approved lubricants, TJC, and approved coolants to maintain warranty. Fill to capacities listed in "Specifications" on page 241.

For more information on engine lubrication and maintenance, see your engine manual.

IMPORTANT: Use the "Service Record" on page 251 to record all required service to your machine.

Approved Coolant

This unit was filled with coolant meeting Cummins® CES 14603 (**blue** in color) before shipment from factory. Add or replace only with coolant meeting this specification, such as Fleetguard® ES Compleat™ coolant. This coolant is available, pre-diluted, from your Ditch Witch dealer as part number 255-1055. Contact your Cummins service partner for a full list of approved coolants meeting CES 14603. In an emergency, non-Cummins approved, heavy duty diesel engine coolant meeting ASTM D6210 may be used. Change to CES 14603 coolant as soon as practical.

NOTICE:

- Use only pre-diluted coolant or concentrated coolant mixed with distilled water. Do not use tap water.
- Do not use water or high-silicate automotive-type coolant. This will lead to engine damage or premature engine failure.
- Do not mix heavy-duty diesel engine coolant and automotive-type coolants. This will lead to coolant breakdown and engine damage.

Approved Fuel

HRC (Highly Regulated Countries)

⚠WARNING Avoid static electricity when fueling. Ultra Low Sulfur Diesel (ULSD) poses a greater static ignition hazard than earlier diesel formulations. Avoid death or serious injury from fire or explosion. Consult with your fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

This engine is designed to run on diesel fuel. Use only high quality fuel meeting ASTM D975 No. 2D, EN590, or equivalent. At temperatures below 32° F (0° C) winter fuel blends are acceptable. See the engine operation manual for more information.

NOTICE: Use only Ultra Low Sulfur Diesel (less than 15 ppm sulfur content in the US and Canada or 10 mg/kg in EU and Japan) in this unit. Operating with higher sulfur content will damage the engine and aftertreatment device.

Biodiesel blends up to 5% (B5) are approved for use in this unit. The fuel used must meet the specifications for diesel fuel shown above. In certain markets, higher blends may be used if certain steps are taken. Extra attention is needed when using biodiesel, especially when operating in cold weather or storing fuel. Contact your Ditch Witch® dealer or the engine manufacturer for more information.

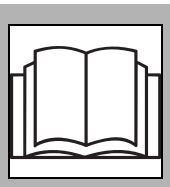
LRC Engine (Less Regulated Countries)

This engine is designed to run on diesel fuel. Use only high quality fuel meeting ASTM D975 No. 2D, EN590, or equivalent. At temperatures below 32° F (0° C) winter fuel blends are acceptable. See the engine operation manual for more information.

IMPORTANT: Worldwide, fuel sulfur regulations vary widely. Fuel used should always comply with local regulations. Prior to shipping, LRC units were filled with Tier 4i DEO. If operating fuel with sulfur content above 15 ppm (15 mg/kg), change oil initially at 250 hours.

Biodiesel blends up to 5% (B5) are approved for use in this unit. The fuel used must meet the specifications for diesel fuel shown above. In certain markets, higher blends may be used if certain steps are taken. Extra attention is needed when using biodiesel, especially when operating in cold weather or storing fuel. Contact your Ditch Witch dealer or the engine manufacturer for more information.

Diesel Exhaust Fluid (DEF) - HRC Only

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

To help avoid injury:

- Diesel exhaust fluid is corrosive. Avoid spills. If spill occurs wipe clean immediately.
- Avoid contact with skin. If contact occurs, rinse with water immediately.
- Avoid contact with eyes. If contact occurs, seek medical help immediately.
- Avoid ingestion. If ingested, seek medical help immediately.

This engine requires diesel exhaust fluid (DEF) to meet emission regulations. Use only high quality DEF meeting ISO 22241-1 or DIN 70070 requirements. Running this engine without DEF will increase exhaust emissions and cause engine to derate. Do not dilute or contaminate DEF or substitute other fluids. Tampering with the DEF system will increase exhaust emissions and cause the engine to derate.

DEF has other common names such as Urea, AUS 32, AdBlue, NOx Reduction Agent, and Catalyst Solution.

DEF freezes at 11.3°F (-11.5°C) but the system is designed to prevent freezing during normal operation. If DEF freezes in the tank when the engine is shut down, the system will quickly thaw DEF when engine is started.

DEF has a limited shelf life. In ideal conditions, minimum expected shelf life is 18 months. At temperatures higher than 90°F (32°C), DEF will degrade more rapidly. Do not store in direct sunlight.

Storage and transfer equipment must be compatible with DEF. Most materials (especially hoses) are not compatible and will degrade and contaminate DEF. Never use contaminated DEF. Containers made of polyethylene or polypropylene are recommended.

This machine will consume DEF at a rate between 2 and 3% of diesel consumption. Many factors affect consumption rate, but a good rule of thumb is to fill the DEF tank every other time the diesel tank is filled.

Exhaust Cleaning - HRC Only

This engine has a Selective Catalytic Reduction (SCR) system that uses a small amount of DEF to convert NOx emissions in the exhaust into nitrogen and water. The SCR system cleans itself automatically, unless it is manually inhibited by the operator.

Automatic exhaust cleaning happens during normal machine operation when sensors in the engine determine the need. During an engine exhaust cleaning cycle, engine exhaust can reach high temperatures. When this happens, the high exhaust temperature icon will light.

If the jobsite is in an area where high exhaust temperature might cause a problem, inhibit exhaust cleaning (see "Exhaust cleaning activation key" on page 57) for the duration of the job and return to automatic cleaning when the job is finished. The exhaust cleaning inhibited icon will light and remain on until the system is returned to automatic exhaust cleaning mode.

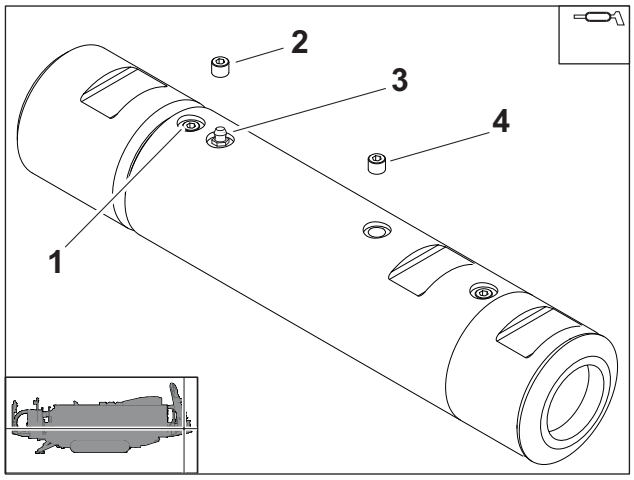
The exhaust cleaning icon will light when the system is inhibited and an exhaust cleaning cycle is needed.

- The icon will light when an automatic cleaning is needed. If the area will allow it, return the unit to automatic cleaning mode and let it run automatically.
- The icon will flash when a manual cleaning is needed. Set the engine to low throttle with no load and initiate the manual exhaust cleaning cycle. The light will continue to flash until the manual exhaust cleaning cycle is finished (approximately 30 minutes).
- A manual exhaust cleaning cycle is required after automatic exhaust cleaning has been inhibited multiple times. If manual cleaning is not done when indicated, the engine will derate.

Each Use

Location	Task	Notes
DOWNHOLE TOOL	AT Rockmaster® tool	AT only; WRG (p/n 255-1019)

Lube Rockmaster Tool



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1. Remove plugs (2,4) from tool body and install zerk (3).
2. Inject WRG into zerk. See "Recommended Lubricants/Service Key" on page 202.

   IMPORTANT: Do not use calcium-based grease. Use only Ditch Witch® recommended grease or equivalent.

3. Continue pumping until new, clean grease seeps into the open front port.
4. Replace plug (4).
5. Inject 1-5 pumps WRG into zerk.

   IMPORTANT: Discontinue lubing the Rockmaster tool when there is resistance to adding more grease.

6. Remove zerk and reinstall rear plug.

Startup/10 Hour

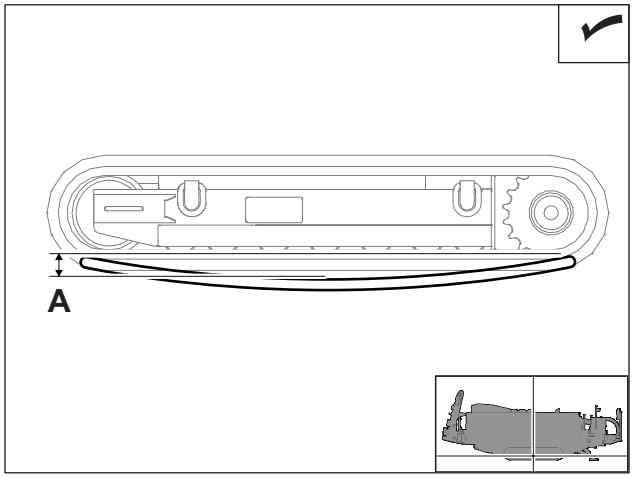
Location	Task	Notes
DRILLING UNIT	Check track tension and condition	
	Check fuel filter water separator	
	Check engine oil level	DEO
	Check fluid pump piston seals	
	Check engine coolant level	DEAC
	Check pipe auto lubricator spray nozzle	
	Check hydraulic hoses	
	Check hydraulic fluid level	THF
	Check fluid pump oil level	MPL
	Check pipe auto lubricator level	TJC
	Clean drilling fluid y-strainer	
	Inspect crankcase breather tube	HRC only
	Empty dust ejector valve	

Check Track Tension and Condition

Check track tension and condition before startup and every 10 hours of operation and adjust or replace as needed. See "Adjust Track Tension" on page 229.

To check:

1. Lift track.
2. Place straightedge across front track span from idler to sprocket as shown.
3. Distance from top edge of bottom of track to straightedge (A) should be 0.75" (19.05 mm).



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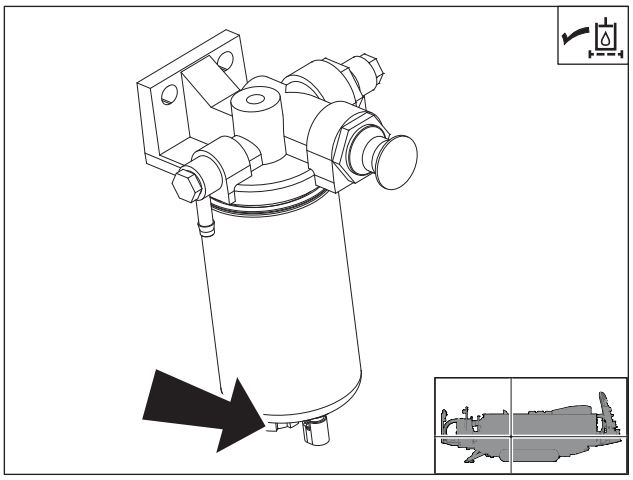
Check Fuel Filter Water Separator

Check fuel filter water separator before startup and every 10 hours of operation. Drain water at plug (shown) as needed.



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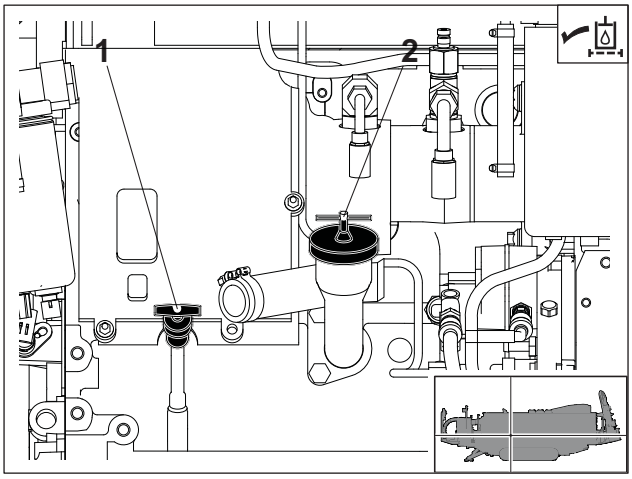
Check Engine Oil Level

Check engine oil at dipstick (1) before startup and every 10 hours of operation. Check with unit on level surface. Add DEO at fill (2) as necessary to keep oil level at highest line on dipstick.



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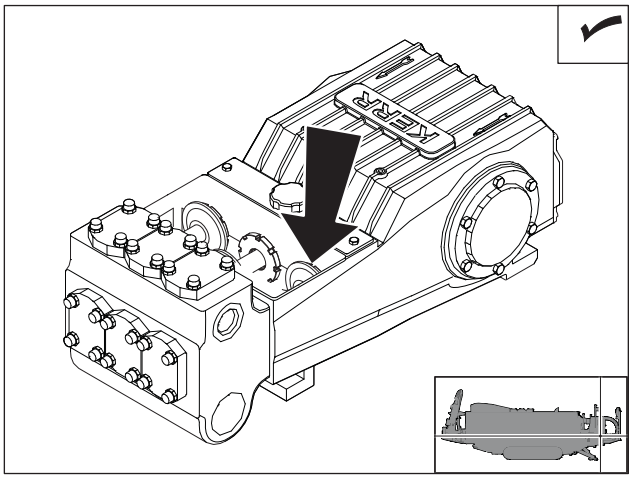
Check Fluid Pump Piston Seals

Check piston seals for signs of excessive leakage before startup and every 10 hours of operation. Replace if leakage becomes excessive.



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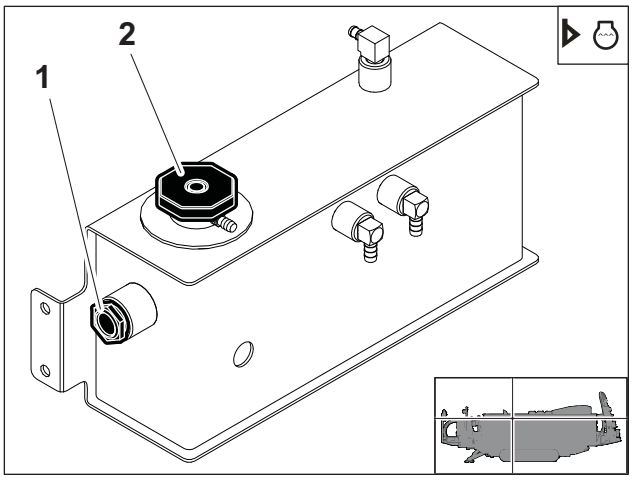
Check Engine Coolant Level

Check coolant level, with engine cool and unit on level ground at sight glass (1) of expansion tank before startup and every 10 hours of operation. Maintain coolant level at halfway point on sight glass. If low, add approved coolant at fill (2).

IMPORTANT: See "Approved Coolant" on page 203 for information on approved coolants.



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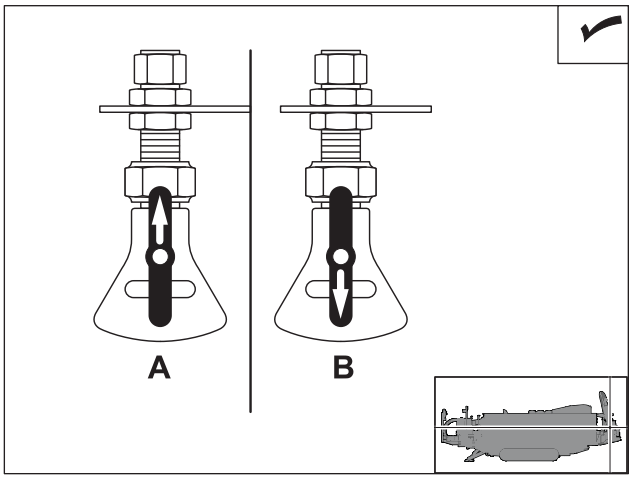
Check Pipe Auto Lubricator Spray Nozzle

Check pipe auto lubricator spray nozzle before startup and every 10 hours of operation. Ensure that nozzle is free of obstructions and operates properly. Clean as needed.

NOTICE: Ditch Witch® tool joint compound is specially formulated to work with Ditch Witch pipe lubrication system. Use of other tool joint compounds will clog system. See "Recommended Lubricants/Service Key" on page 202 for more information.



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To clean:

1. Rotate handle to the upward, or cleanout, position (A).
2. Operate pump until obstruction is flushed.

NOTICE: If neoprene washer comes out during flushing, entire nozzle must be replaced.

3. Rotate handle to the downward, or spray, position (B).
4. Clean nozzle guard. If necessary, pull handle/nozzle insert out of housing to clean with fine wire or solvent.

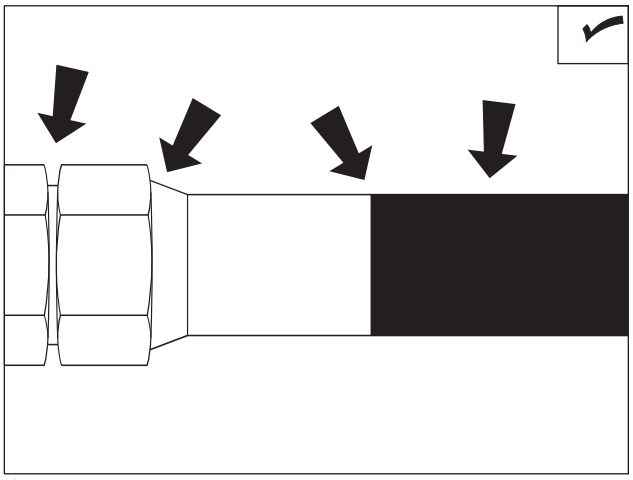
Check Hydraulic Hoses

WARNING Pressurized fluid or air could pierce skin and cause severe injury. Refer to operator's manual for proper use. 270-6035

To help avoid injury:

- Use a piece of cardboard or wood, rather than hands, to search for leaks.
- Wear protective clothing, including gloves and eye protection.
- Before disconnecting a hydraulic line, turn engine off and operate all controls to relieve pressure.
- Lower, block, or support any raised component with a hoist.
- Cover connection with heavy cloth and loosen connector nut slightly to relieve residual pressure. Catch all fluid in a container.
- Before using system, check that all connections are tight and all lines are undamaged.
- If you are injured, seek immediate medical attention from a doctor familiar with this type of injury.

Check hydraulic hoses for leaks before startup and every 10 hours of operation.

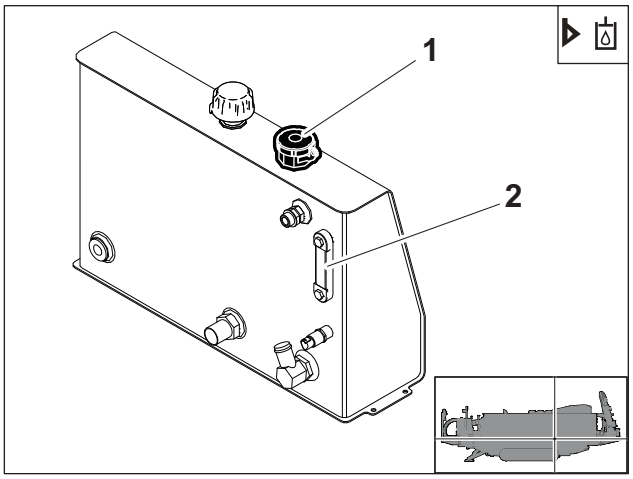


CheckHoses.eps

Check Hydraulic Fluid Level

Check hydraulic fluid level before startup and every 10 hours of operation. Maintain fluid level at halfway point on sight glass (2), when unit is on level ground, engine is off, and fluid is cool. Add THF at hydraulic fluid fill (1) as needed.

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 153-791) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with new filter. After 50 hours of normal operation, replace with new filter (p/n 153-792).



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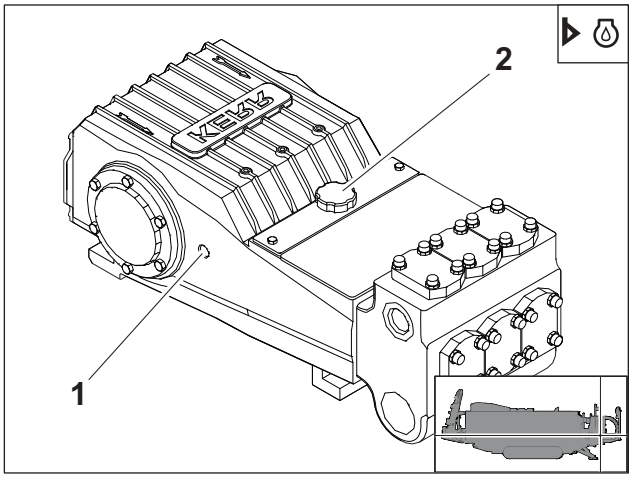
Check Fluid Pump Oil Level

Check fluid pump oil level at sight glass (1) before startup and every 10 hours of operation. Add MPL at fill (2) as needed.



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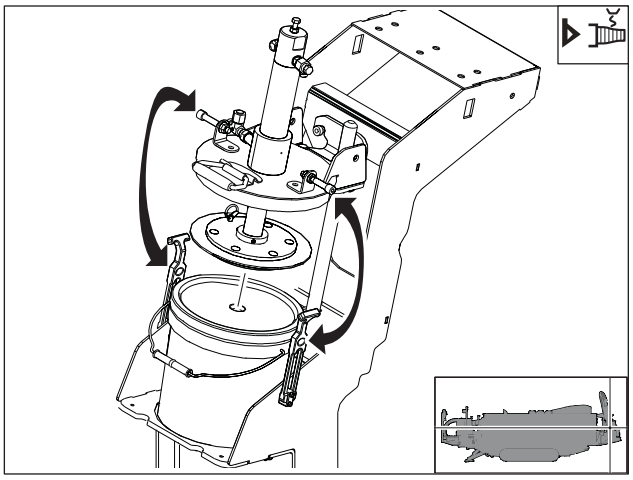
Check Pipe Auto Lubricator Level

Check pipe auto lubricator TJC level before startup and every 10 hours of operation. Change pail as needed. See "Change Auto Lubricator Pail" on page 230 for procedure.

NOTICE: Ditch Witch® tool joint compound is specially formulated to work with Ditch Witch pipe lubrication system. Use of other tool joint compounds will clog system. See "Recommended Lubricants/Service Key" on page 202 for more information.



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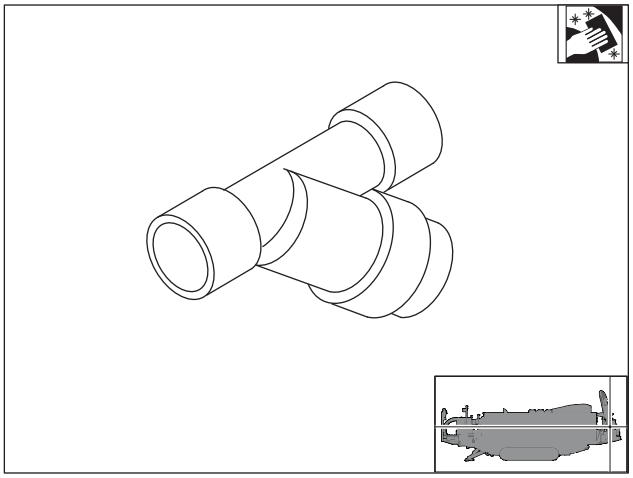
Clean Drilling Fluid Y-Strainer

Clean drilling fluid y-strainer before startup and every 10 hours of operation. Ensure that strainer is free of debris.



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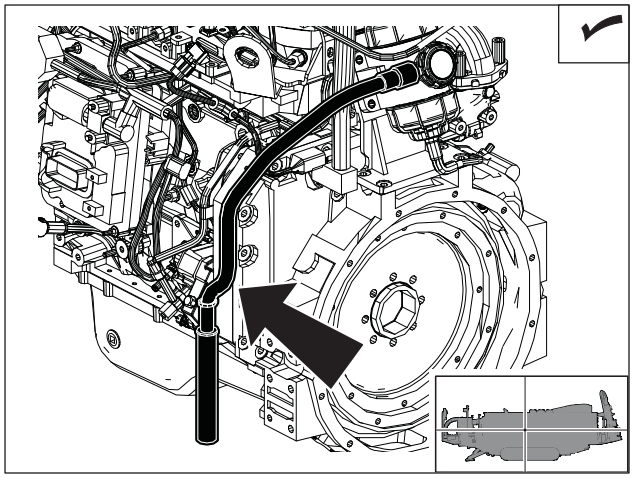
Inspect Crankcase Breather Tube (HRC only)

Inspect crankcase breather tube (shown) for debris before startup and every 10 hours of operation.



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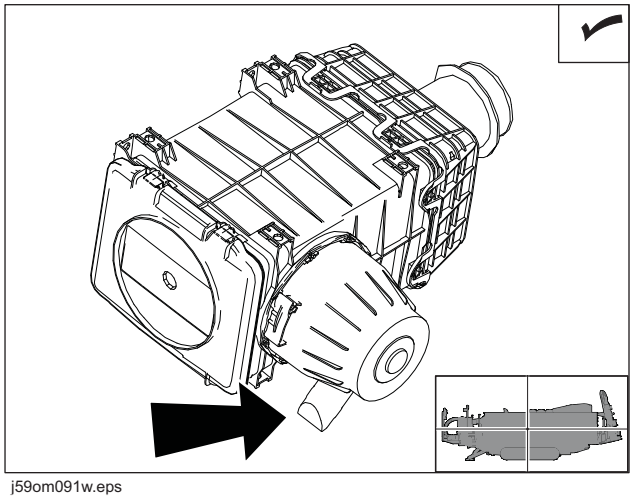
Empty Dust Ejector Valve

Check dust ejector valve (shown) before startup and every 10 hours of operation. Ensure that valve is not inverted, damaged, plugged, or cracked.



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50 Hour

Location	Task	Notes
DRILLING UNIT	Change fluid pump oil	Initial service, MPL
	Check radiator	
	Change hydraulic filters	Initial service
	Check ground drive gearbox oil level	2 gearboxes, MPL
	Check rotation gearbox oil level	MPL
	Inspect thrust rollers	
	Drain water from hydraulic tank	
	Check heavy duty anchor gearbox oil level	MPL
	Check SaverLok inner drive collar	AT only
	Check SaverLok® torque	
DOWNHOLE TOOL	Rebuild AT Rockmaster® housing	AT only; kit available

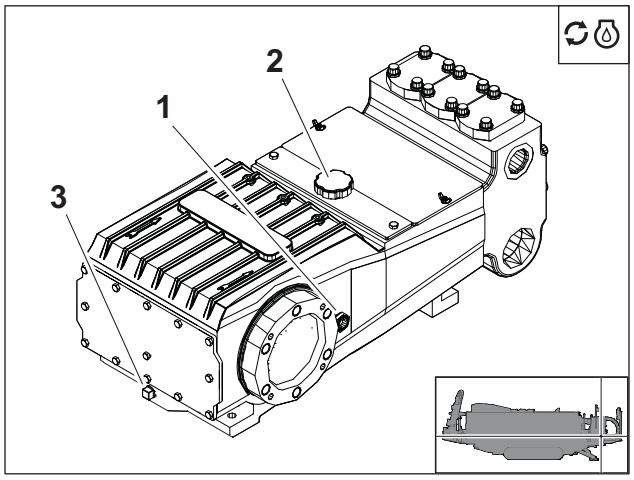
Drilling Unit

Change Fluid Pump Oil (Initial Service)

Change fluid pump oil at first 50 hours and every 2000 hours thereafter.

To change:

1. Drain at plug (3). Ensure that magnetic drain plug is cleaned of debris before reinstalling.
2. Add 2.8 qt (2.6 L) MPL at fill plug (2). Maintain fluid level at sight glass (1).



j59om092w.eps

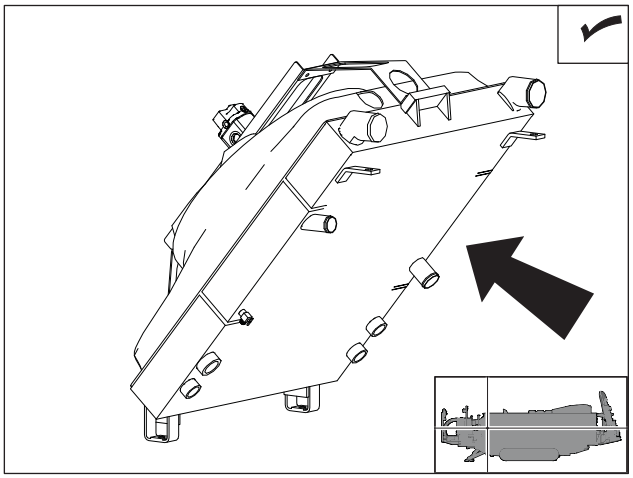
Check Radiator

Check radiator for dirt, grass, and other debris every 50 hours. Check more often if operating in dusty or grassy conditions. Clean as needed.

To clean:

- Clean fins with compressed air or spray wash.
- Open rear hood and spray through radiator toward engine.
- If grease and oil are present on radiator, spray with solvent and allow to soak overnight.

IMPORTANT: Be careful not to damage fins with high pressure air or water.

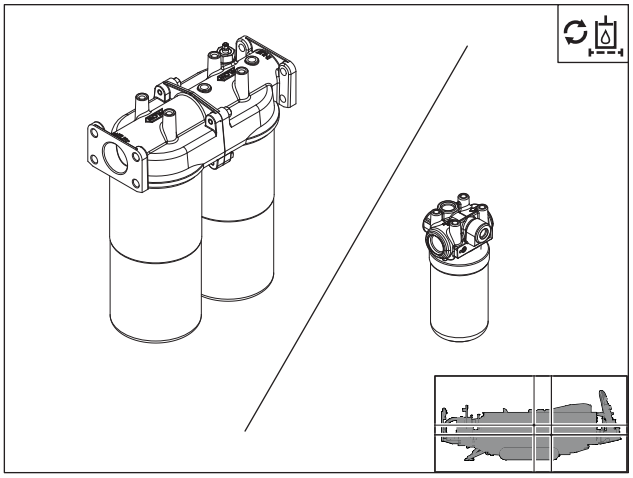


j59om028w.eps

Change Hydraulic Filters (Initial Service)

Change hydraulic filter after first 50 hours. Replace filter every 500 hours thereafter. Change filter more often if indicated by filter indicator.

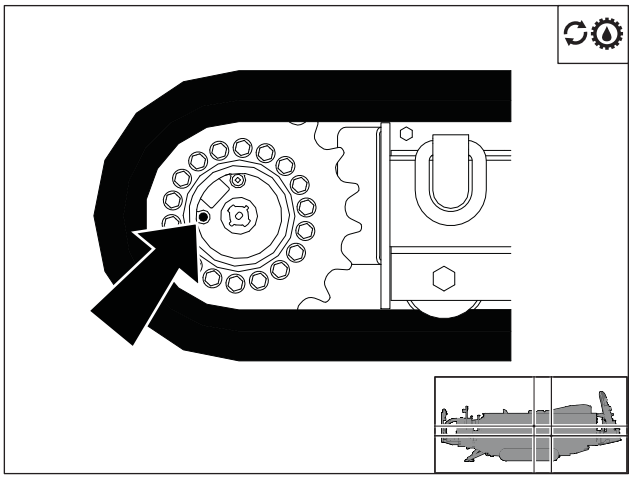
IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 153-791) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with new filter. After 50 hours of normal operation, replace with new filter (p/n 153-792).



j59om029w.eps

Check Ground Drive Gearbox Oil Level

Check oil level in both ground drive gearboxes every 50 hours. Rotate plug (shown) until level with center of gearbox. Open plug. If oil does not come out, add MPL as needed. Never fill more than halfway.

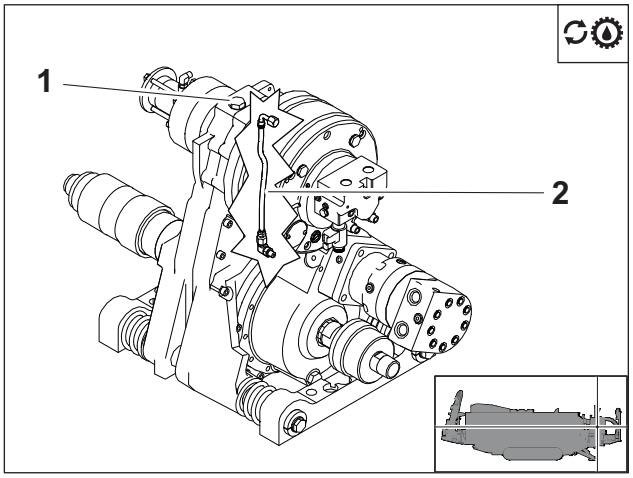


j59om030w.eps

Check Rotation Gearbox Oil Level

IMPORTANT: Drill frame must be level for accurate reading.

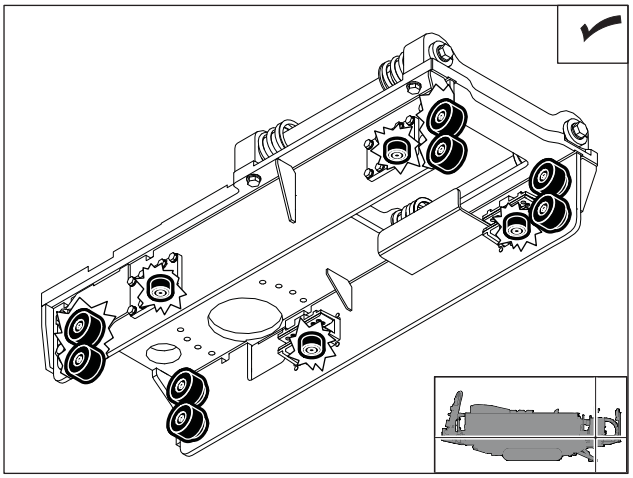
Check rotation gearbox oil level at sight tube (2) every 50 hours. Add MPL at fill (1) as needed.



j59om031w.eps

Inspect Thrust Rollers

Inspect thrust rollers (at each end of carriage, shown) every 50 hours. Clean or replace if they do not turn freely.



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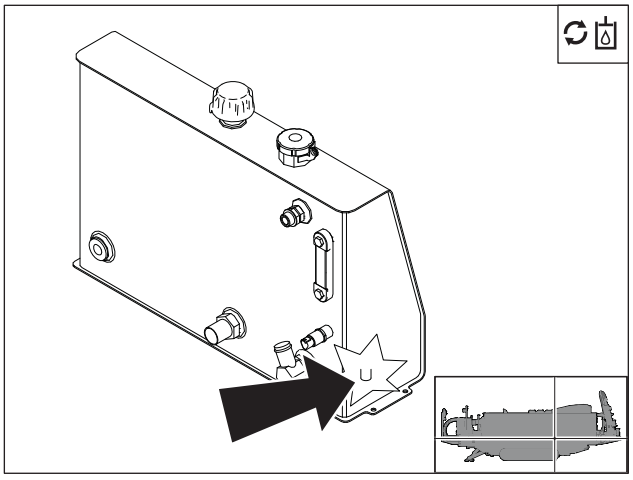
Drain Water from Hydraulic Tank

Drain water out of tank every 50 hours. To drain, turn plug slightly until water comes out. After all water has drained, tighten plug.

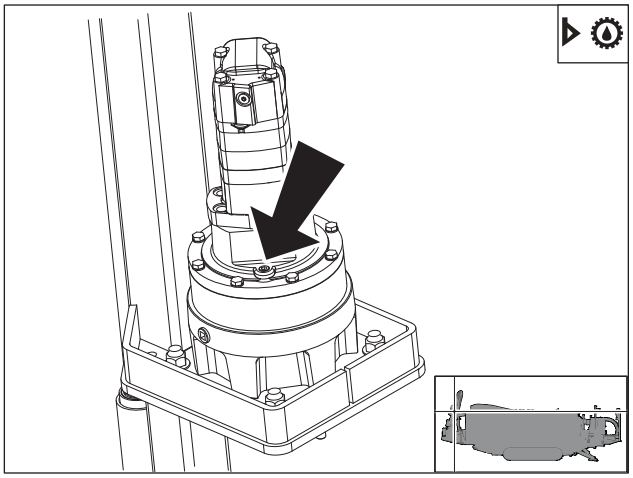


j59om035w.eps

Check Heavy Duty Anchor Gearbox Oil Level

Check standard duty anchor driver gearboxes oil level at fill plug (shown) every 50 hours. Add MPL at fill as needed.

IMPORTANT: Gearbox must be level for accurate reading.

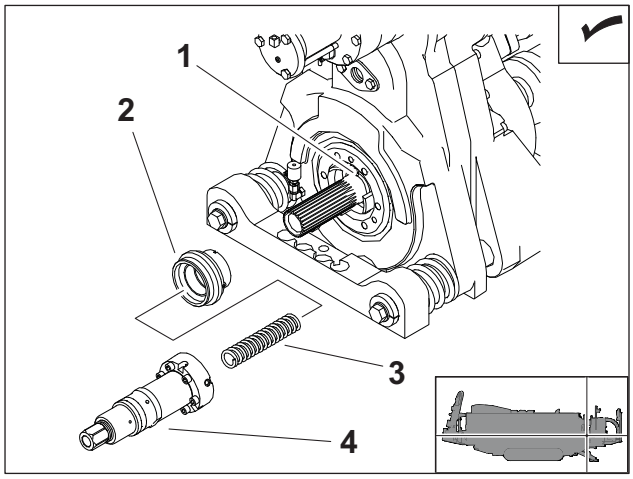

j59om037w.eps

Check SaverLok® Inner Drive Collar

Shine flashlight into spindle and check condition of hex stub (4) every 50 hours. Replace if rounded.

To replace:

1. Remove SaverLok® connection. Do not remove indexing dowels from spindle.
2. Slide hex stub (4) and spring (3) off of drive shaft.
3. Check condition of hex stub and replace if needed.
4. Check o-ring on inner water swivel (2, seal kit) and replace if needed.
5. Install new spring and hex stub.
6. Install saver sub. See "Change Inner Water Swivel (Seal Kit)" on page 232.



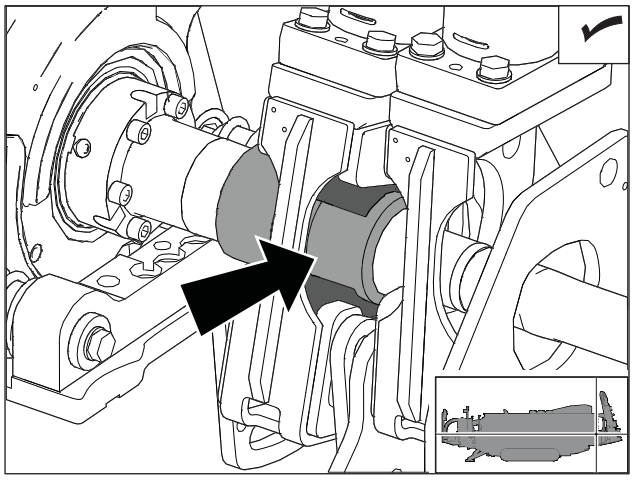
j59om034w.eps

Check SaverLok Torque

Check SaverLok torque every 50 hours.

To check:

1. Start unit and position carriage so that collar can be clamped in rear wrenches.
2. Clamp wrenches on collar and tighten SaverLok assembly until outer rotation pressure gauge reads 4500-5000 psi (310-345 bar) in low speed setting. See "Outer rotation pressure gauge" on page 53.



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Downhole Tool

Rebuild Rockmaster® Tool

Rebuild downhole tool every 50 hours as measured by inner rotation hourmeter. Use kits indicated by the chart below to rebuild downhole tool. Kits are available at your Ditch Witch® dealer.

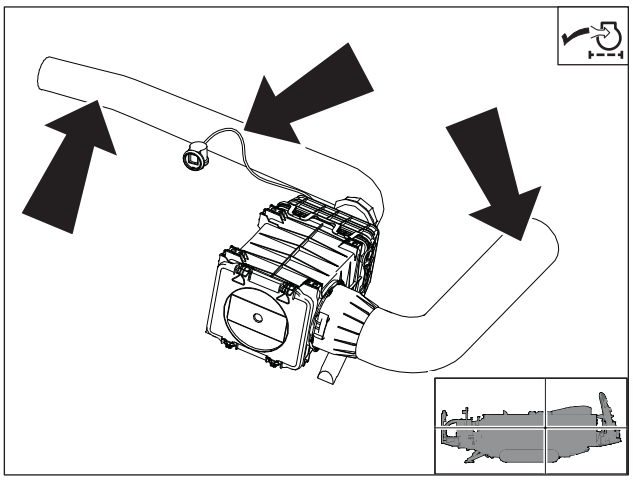
Rockmaster Tool	Rebuild Kit
400-2460	190-2679 (bearings and seals)
400-2630	400-2688 (bearings, seals, spindle, and hub)

250 Hour

Location	Task	Notes
DRILLING UNIT	Inspect air intake system (LRC only)	
	Change rotation gearbox oil	MPL

Inspect Air Intake System (LRC only)

Inspect intake piping for cracked hoses, loose clamps, or punctures. Tighten or replace parts as necessary.



j59om038w.eps

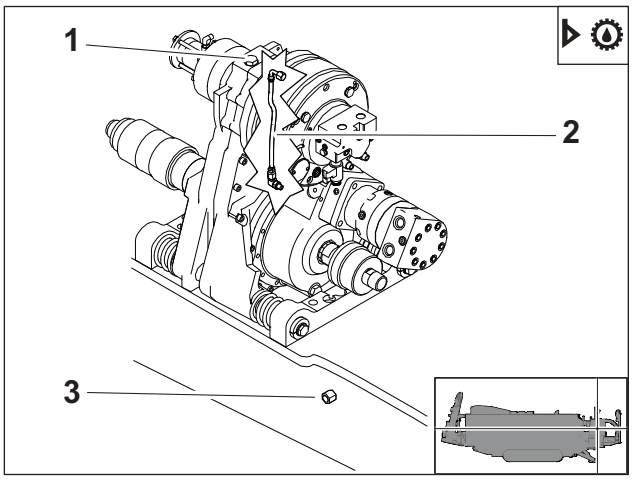
Change Rotation Gearbox Oil

IMPORTANT: Gearbox must be level for accurate reading.

Change rotation gearbox oil every 250 hours.

To change:

1. Drain oil at gearbox oil drain (3).
2. Replace drain plug.
3. Add MPL at fill (1).
4. Check level at sight tube (2).
5. Replace fill plug.



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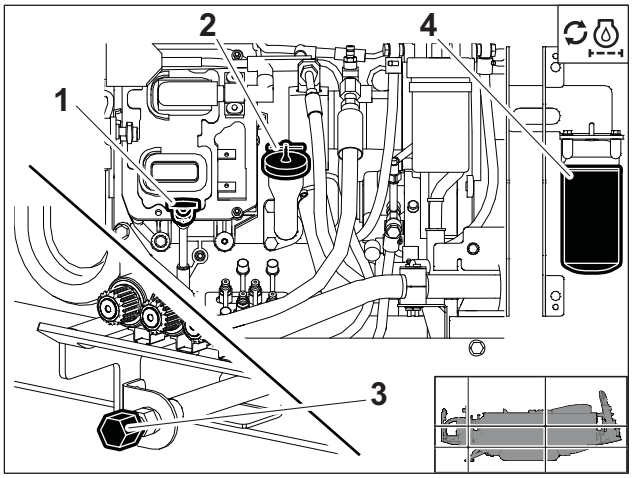
500 Hour

Location	Task	Notes
DRILLING UNIT	Change engine oil and filter	DEO
	Change hydraulic filters	Normal conditions
	Change hydraulic fluid	THF
	Change fuel filters	
	Inspect radiator cap	

Change Engine Oil and Filter

IMPORTANT: See "Recommended Lubricants/ Service Key" on page 202.

Change engine oil and filter every 500 hours. Drain oil (3), change filter (4), and add 11.5 qt (10.9 L) of DEO at fill (1). Run engine and check oil level at dipstick (2). Add oil to bring level to highest line on dipstick.



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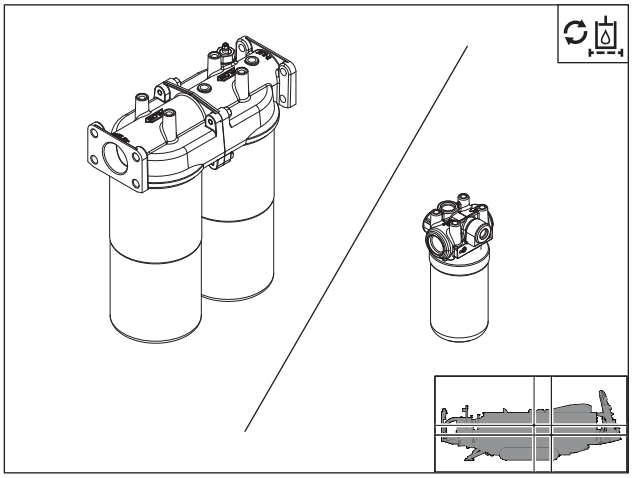
Change Hydraulic Filters (Normal Conditions)

Change hydraulic filter every 500 hours. Change filter more often if indicated by filter indicator.

IMPORTANT: If hydraulic system must be opened for repair, install new filter (p/n 153-791) for first 50 hours of operation. If this filter becomes plugged in fewer than 20 hours, replace with new filter. After 50 hours of normal operation, replace with new filter (p/n 153-792).


j59om029w.eps

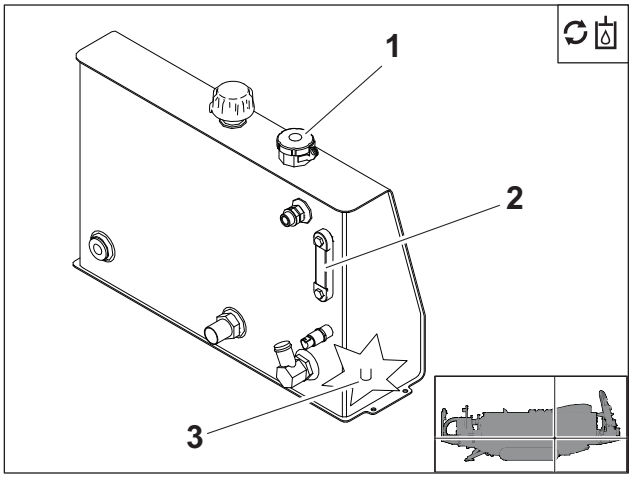
Change Hydraulic Fluid

Change hydraulic fluid every 1000 hours.

To change:

1. Drain hydraulic oil at drain (3).
2. Add THF at fill (1) until level is at halfway point on sight glass (2).

IMPORTANT: Change oil every 250 hours if jobsite temperature exceeds 100°F (38°C) more than 50% of the time.



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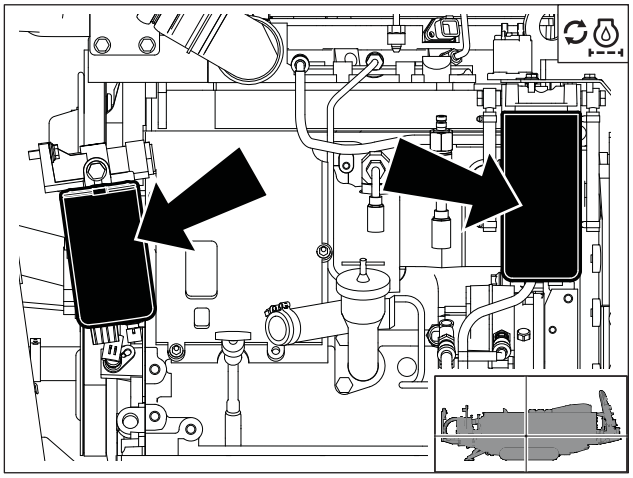
Change Fuel Filters

Replace fuel filters every 500 hours.



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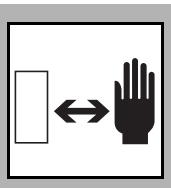
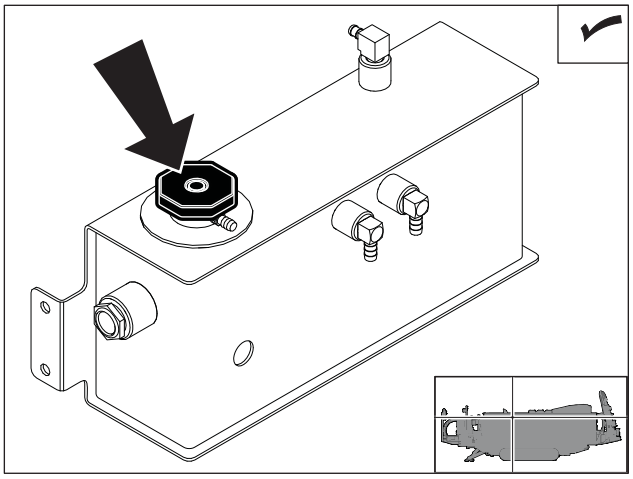
Inspect Radiator Cap



CAUTION Hot parts may cause burns. Do not touch until cool or wear gloves. 275-355 (2-P), 273-423 (2-P)

To help avoid injury: Wait for machine to cool before inspecting radiator cap.

Inspect radiator cap (shown) every 500 hours. Ensure rubber seal is not damaged.



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1000 Hour

Location	Task	Notes
DRILLING UNIT	Change heavy duty anchor gearbox oil	2 gearboxes, MPL
	Change standard duty anchor gearbox oil	2 gearboxes, MPL
	Change engine drive belt	
	Replace diesel exhaust fluid (DEF) tank filter	HRC only
	Change ground drive gearbox oil	2 gearboxes, MPL

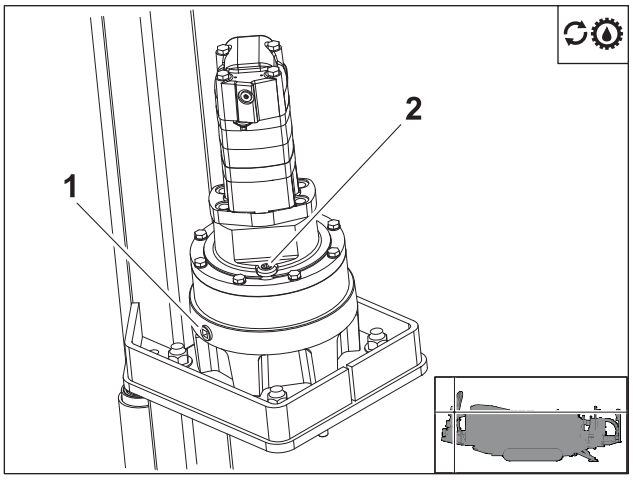
Change Heavy Duty Anchor Gearbox Oil

Change standard duty anchor gearbox oil every 1000 hours. Capacity is 26 oz (0.77 L) MPL per gearbox.

To change:

1. Ensure that gearbox is level.
2. Drain oil at gearbox oil drain (1). Replace drain plug.
3. Fill gearbox with MPL at fill plug (2).

IMPORTANT: Gearbox must be level for accurate reading.



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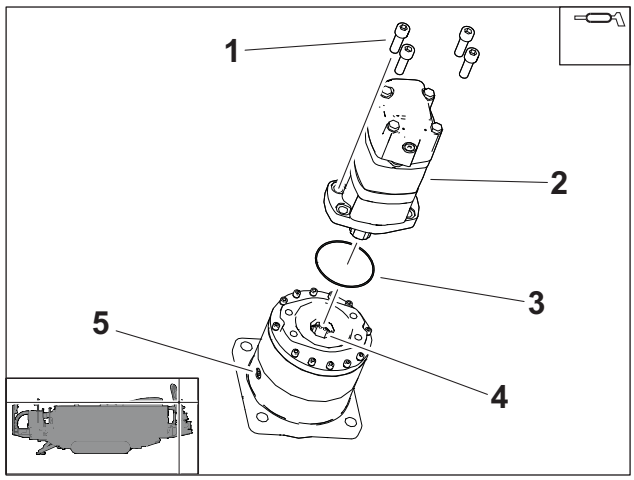
Change Standard Duty Anchor Gearbox Oil



j59om115w.eps

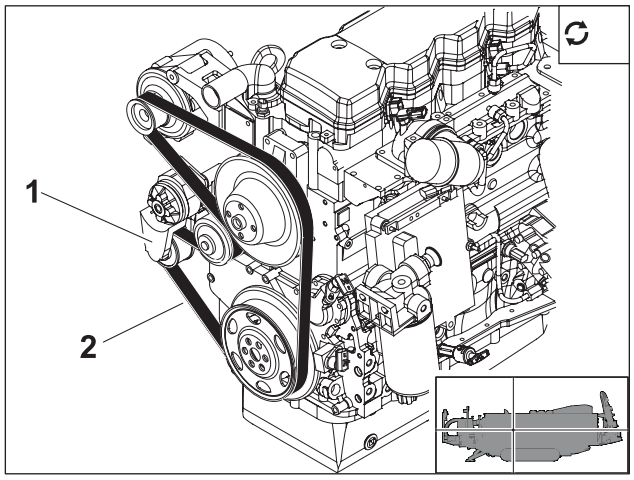
Change heavy duty anchor gearbox oil every 1000 hours. Capacity is 14 oz (0.41 L) MPL per gearbox.

To change:

1. Ensure that gearbox is level.
2. Drain oil at gearbox oil drain (5). Replace drain plug.
3. Remove four bolts (1) to remove hydraulic motor (2).
4. Remove o-ring (3). Replace if needed. Contact your Ditch Witch® dealer for replacement parts.
5. Fill gearbox with MPL at fill (shown).

IMPORTANT: Gearbox must be level for accurate reading.

Change Engine Drive Belt



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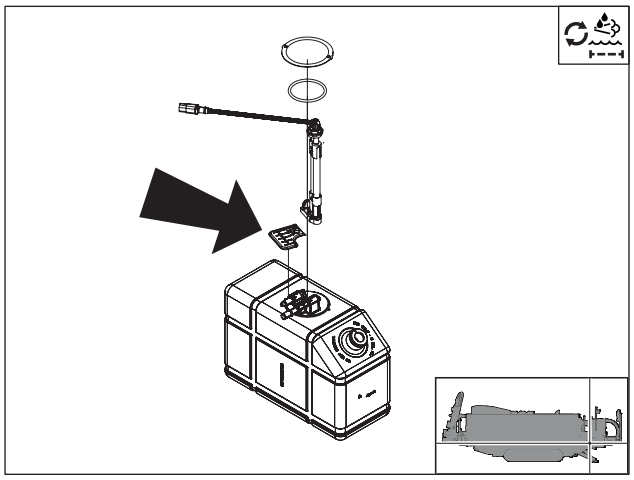
Change engine drive belt every 1000 hours.

1. Turn off engine and remove key.
2. Use a 1/2" drive rachet at pulley (1) to remove tension.
3. Remove belt (2).
4. Inspect engine belt tensioner (3) for damage and debris.
5. Install new belt.

Change Diesel Exhaust Fluid (DEF) Tank Filter (HRC Only)

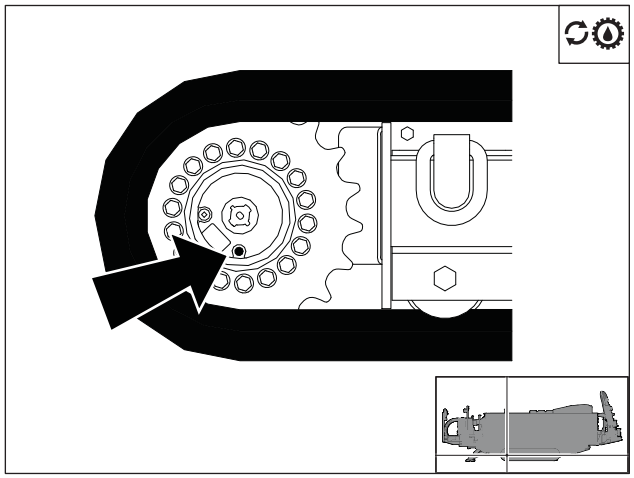

j59om095w.eps

Change DEF filter (shown) every 1000 hours.

Contact your Ditch Witch® dealer for more detailed information.

1. Remove multifunction head unit from DEF tank. Take care not to damage unit during removal.
2. Remove retention screw and discard.
3. Pull filter off suction tube and discard.
4. Position new filter suction tube housing onto the bottom of the suction tube and press flush against bottom of heater tube fin. Ensure filter retention screw aligns with retention screw housing.
5. Install new retention screw.
6. Install multifunction head unit into DEF tank. Take care not to damage unit during installation.

Change Ground Drive Gearbox Oil


j59om044w.eps

Change oil in both ground drive gearboxes every 1000 hours.

To change:

1. Drain oil at plug (shown).
2. Rotate gearbox 90° and add MPL at fill plug.

IMPORTANT:

- Drill frame must be parked on level surface for accurate reading.
- Use helper to assist in positioning gearbox plugs for checking and adding oil.
- Do not fill more than halfway.

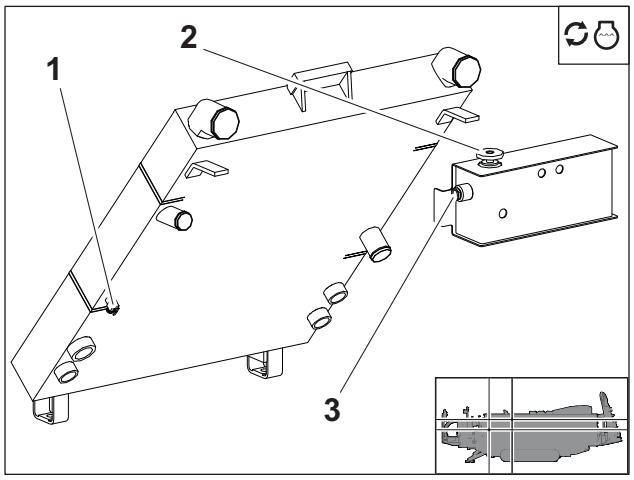
3. Replace fill plug.

2000 Hour

Location	Task	Notes
DRILLING UNIT	Change engine coolant	DEAC
	Change fluid pump oil	MPL
	Replace crankcase breather filter	HRC only

Change Engine Coolant

Drain cooling system at drain (1) every two years or 2000 hours. Add approved coolant according to instructions below. Refill capacity is 24 qt (22.7 L) for HRC units and 23 qt (21.8 L) for LRC (Tier 3) units.



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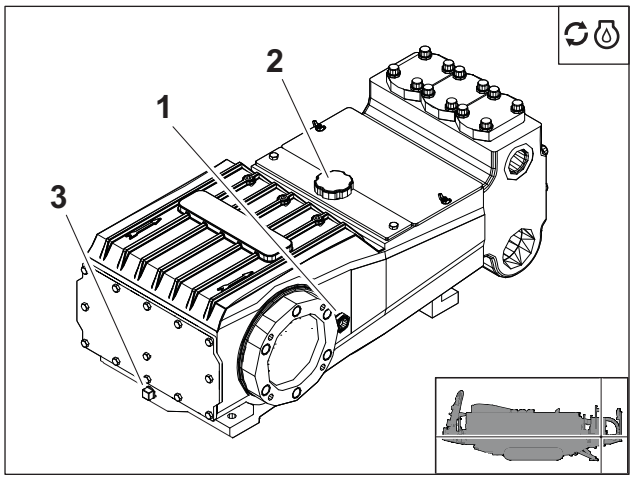
NOTICE:

- The use of non-approved coolant may lead to engine damage or premature engine failure and will void engine warranty.
- See "Approved Coolant" on page 203 for list of requirements.
- Use only distilled water for mixing coolants. Do not use tap water.

To fill:

1. Remove fill cap (2) on expansion tank.
2. Add coolant at radiator fill (2) at a rate of 3 gpm (11.4 L/min) or less until full.
3. Run engine with thermostat open (>195°F/90°C engine temperature) for several minutes.
4. Stop engine and let it cool.
5. Maintain coolant level at halfway point on sight glass (3).
6. Install fill cap on expansion tank.

Change Fluid Pump Oil



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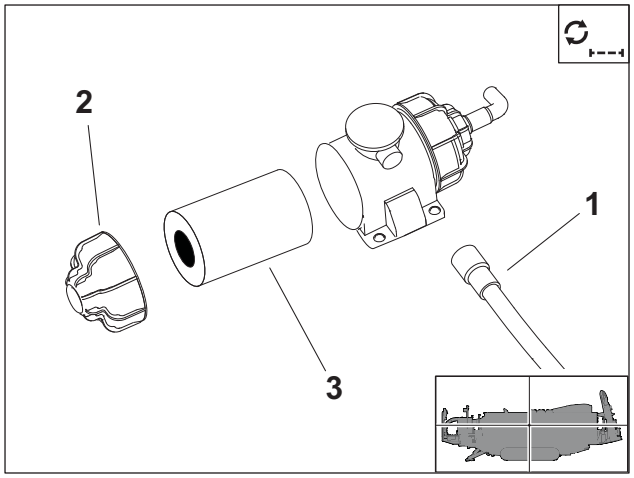
Change fluid pump oil every 2000 hours.

To change:

1. Drain at plug (3). Ensure that magnetic drain plug is cleaned of debris before reinstalling.
2. Add 2.8 qt (2.6 L) MPL at fill plug (2). Maintain fluid level at sight glass (1).

Replace Crankcase Breather Filter (HRC Only)



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Replace crankcase breather filter every 2000 hours.

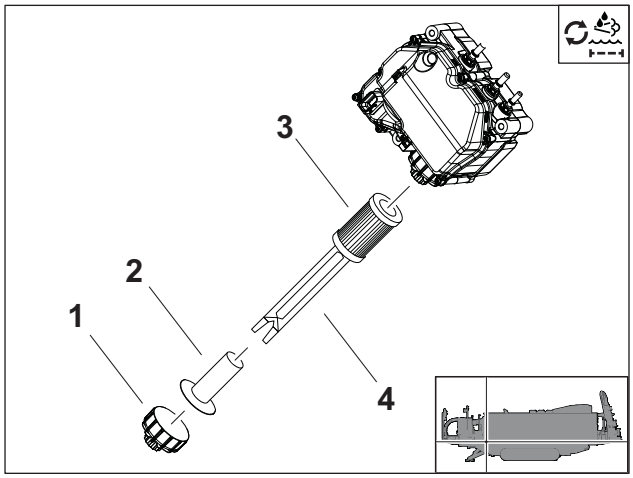
To replace:

1. Disconnect crankcase ventilation hose (1).
2. Turn breather housing cover (2) counterclockwise.
3. Remove filter element (3).
4. Install the new filter element either end up in the crankcase ventilation breather housing.
5. Install breather housing cover and turn clockwise.
6. Install crankcase ventilation hose.

4500 Hour (HRC Only)

Replace Diesel Exhaust Fluid (DEF) Pump Filter

Replace diesel exhaust fluid (DEF) pump filter every 4500 hours or every 3 years.



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To remove:

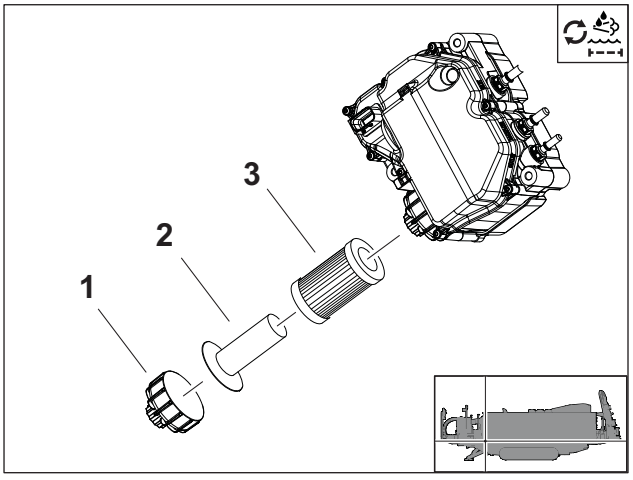
1. Unscrew DEF filter cap (1) and inspect threads for damage. Replace if needed.
2. Remove the DEF filter equalizing element (2).
3. Remove DEF dosing unit filter element (3) using disposable service tool (4).

IMPORTANT: A disposable service tool is included with the filter to aid in filter removal.

- Use the color of the plastic on the filter to determine which end of the tool to use.
- When inserting the tool, a "click" sound will indicate proper engagement with the filter.

To install:

1. Slide DEF filter equalizing element (2) into the DEF filter cartridge (3).
2. Insert filter equalizing element and filter cartridge assembly into the DEF dosing unit.
3. Install cap (1) and tighten to 177 in•lb (20 N•m).



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As Needed

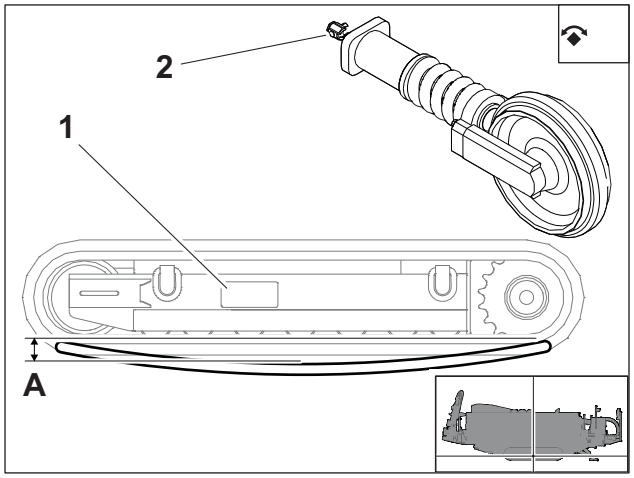
Location	Task	Notes
DRILLING UNIT	Adjust track tension	
	Change auto lubricator pail	TJC
	Check pipeloader inserts	
	Check pipe guide inserts	
	Check fluid pump ball valve	
	Check track support slide pads	
	Change inner water swivel (seal kit)	
	Change air filter	
	Clean crankcase breather tube	Anytime system is opened
	Check wrench jaw inserts	
	Change hydraulic filter	
	Replace SaverLok® body	
	Replace slide cartridge wear pads	
	Change wireless remote controller batteries	
	Check battery	
	Charge battery	

Adjust Track Tension

Check track tension and adjust or replace as needed.

To adjust:

1. Lift track.
2. Place straightedge across front track span from idler to sprocket as shown.
3. Remove cover (1).
4. Pump MPG into fitting (2) until distance between top edge of bottom of track and straightedge (A) is 0.75" (19.05 mm).



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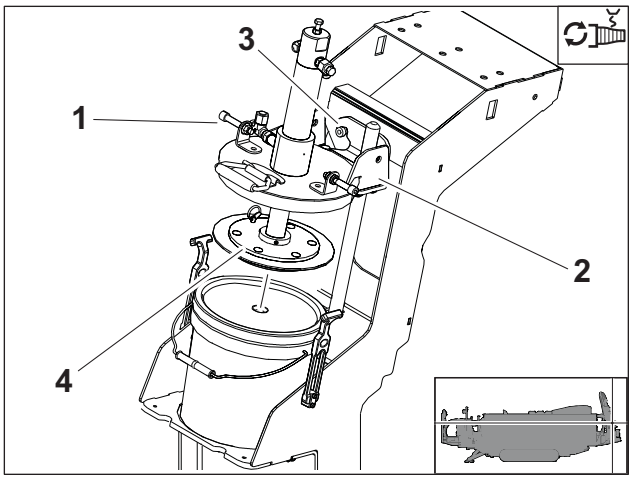
5. Drive straight forward one machine length and check tension again.

Change Auto Lubricator Pail



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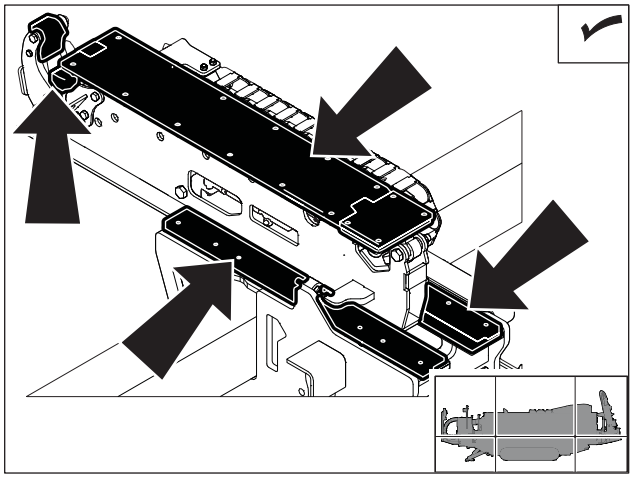
Check pipe auto lubricator TJC level and change pail as needed.

To change pail:

1. Unlatch auto lubricator pail from pump (1).
2. Lift pump and lid assembly (2) up guide pole and secure on shoulder bolt (3).
3. Remove follower plate (4) from existing pail.
4. Install follower plate into new pail. Press firmly onto follower plate until TJC comes up in center opening.
5. Remove pump and lid assembly from shoulder bolt and lower into pail, guiding pump into center hole of follower plate.
6. Relatch auto lubricator pail to pump.
7. Remove cap from discharge tee on pump. Operate pump until discharged TJC is free of air pockets. Replace cap.

NOTICE: Use only genuine Ditch Witch® tool joint compound to maintain warranty. See "Recommended Lubricants/Service Key" on page 202 for more information.

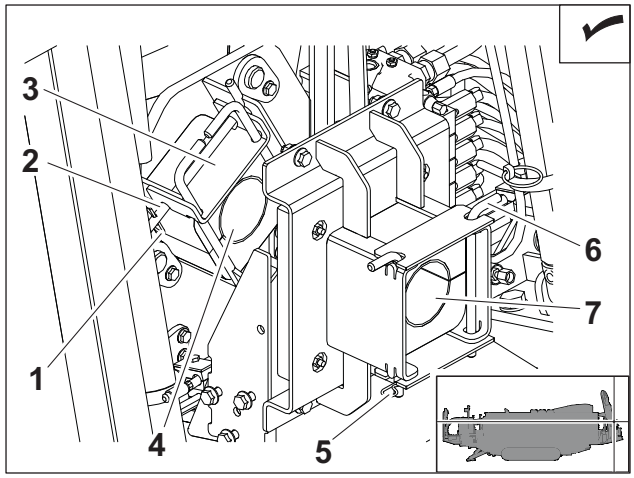
Check Pipeloader Inserts


j59om099w.eps

Check pipeloader inserts at indicated areas for wear. Flip gripper inserts for longer wear, or replace as needed.

IMPORTANT: Ensure bolts are tightened evenly to enable inserts to slide freely and wear evenly.

Check Pipe Guide Inserts



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Check pipe guide inserts for wear. Rotate inserts for longer wear, or replace as needed.

NOTICE: Failure to replace worn pipe guide inserts may cause damage to the machine.

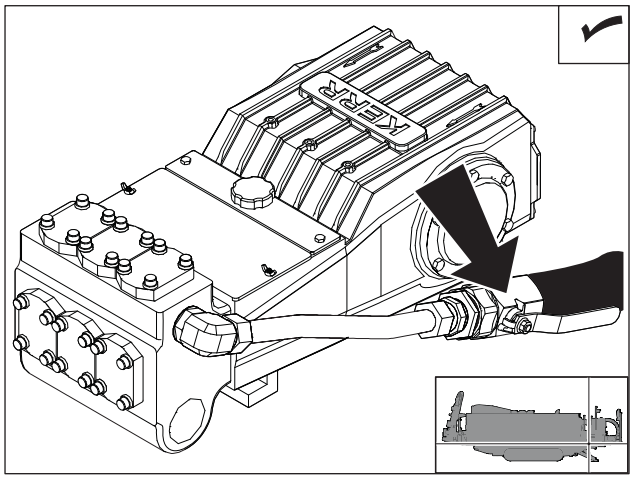
To replace front pipe guide inserts:

1. Remove lynch pins (5).
2. Remove pins (6) and open pipe guide.
3. Remove guide inserts.
4. Replace in reverse order.

To replace rear pipe guide inserts:

1. Remove pin (1) to remove pin (2).
2. Slide plate (3) up to remove guide inserts (4).
3. Replace in reverse order.

Check Fluid Pump Ball Valve



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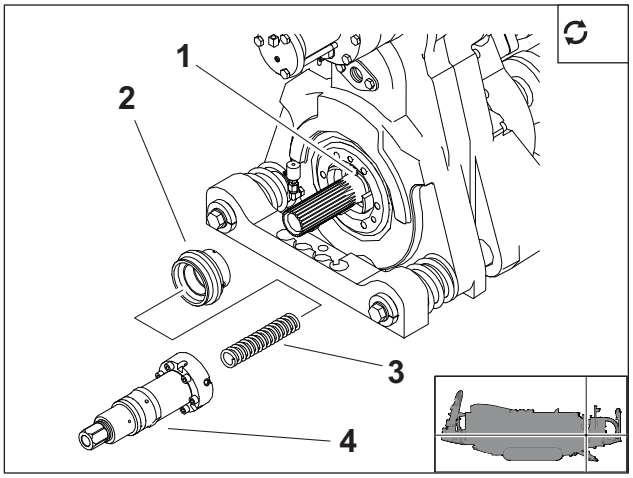
Check ball valve for leaks. Tighten stem packing as needed. Contact your Ditch Witch® dealer for replacement packing.

Change Inner Water Swivel (Seal Kit)



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Replace inner water swivel (seal kit) as needed. Contact your Ditch Witch® dealer for replacement parts.

To replace:

1. Remove SaverLok® and SaverLok connection. Do not remove indexing dowels from spindle.
2. Remove hex stub (4) and spring (3) from drive shaft.
3. Remove seal bodies (2).

> **IMPORTANT:** Use care when handling main body to avoid seal contamination. Do not allow grease to touch inner seals during installation.

4. Inspect set screw (1). To replace, thread new set screw fully into different hole using Loctite® 242 or equivalent.
5. Slide new small seal body onto drive shaft.
6. Lightly coat seal with SAE 30 engine oil and install large seal body.

> ***NOTICE:*** Do not run seals without lubrication. Damage will occur.

7. Install hex stub and spring.
8. Install SaverLok connection and SaverLok. See page 235.

Change Air Filter

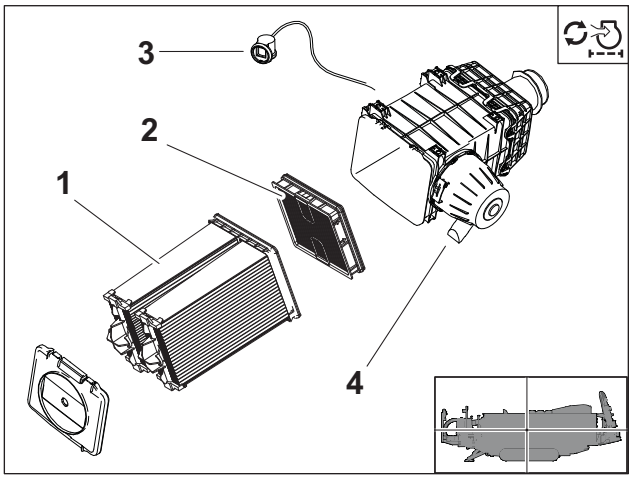
Change air filter when indicated on display (HRC units) or as indicated by air intake restriction indicator (LRC units).

NOTICE: Only open the air filter canister when air restriction is indicated. Change the elements, do not attempt to clean them.

- Compressed air or water may damage filter elements.
- Tapping filter elements to loosen dirt may damage the elements.

To change air filter:

1. Disengage clasps and remove cover.
2. Remove primary element (1) and secondary element (2). Be sure to position primary filter as shown.
3. Wipe inside of housing and wash cover and dust ejector valve (4).
4. Install new element(s).
5. Install cover and engage clasps.
6. **LRC only**: Reset air intake restriction indicator (3).



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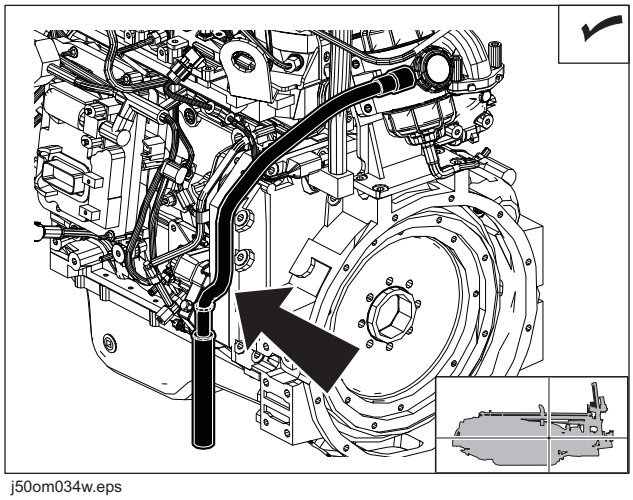
Clean Crankcase Breather Tube

IMPORTANT: HRC unit is shown.

Clean crankcase breather tube with detergent and warm water as needed.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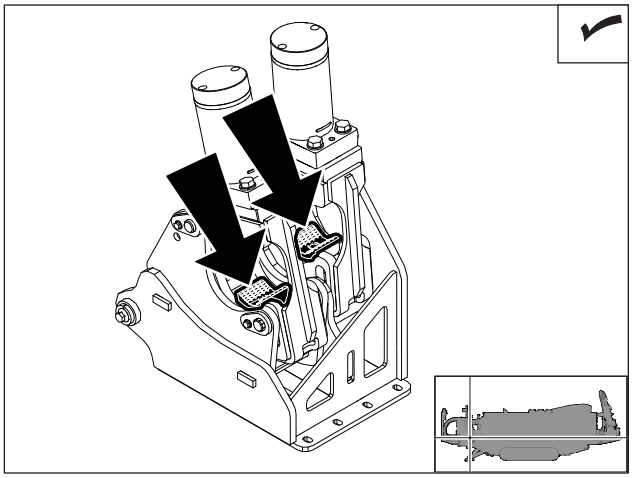
Check Wrench Jaw Inserts

Check wrench jaw inserts for wear and replace as needed.



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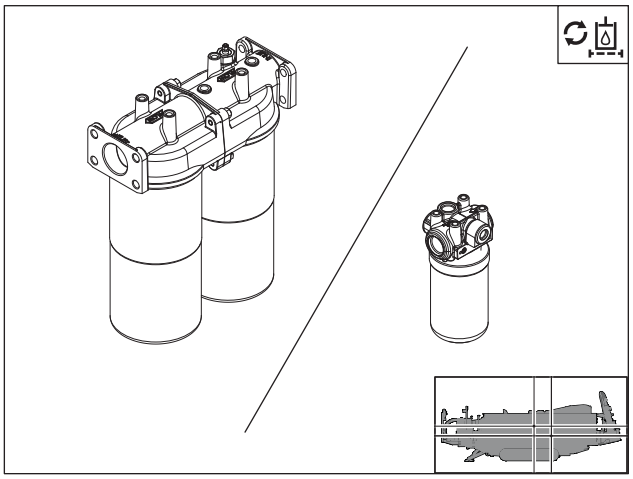
Change Hydraulic Filter (Anytime System Opened)

Change hydraulic filter anytime system is opened for repair. Change filter and add THF as needed at hydraulic fluid fill.



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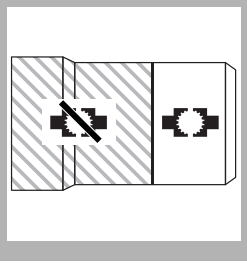
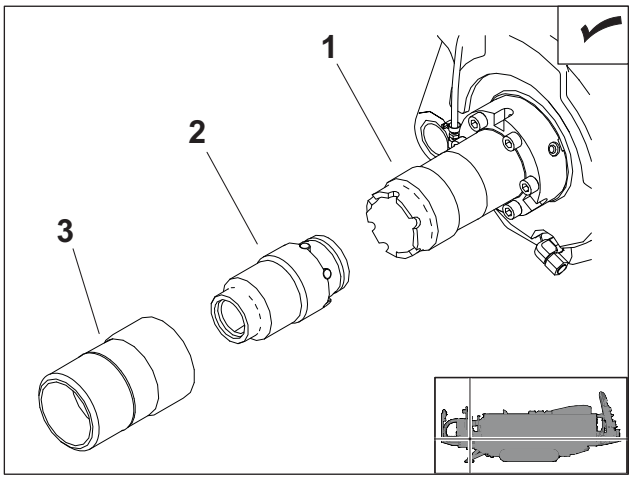
Replace SaverLok® Body

Replace SaverLok body (2) as needed.

NOTICE: Clamping front wrench on SaverLok nose will damage the threads and impede disassembly.





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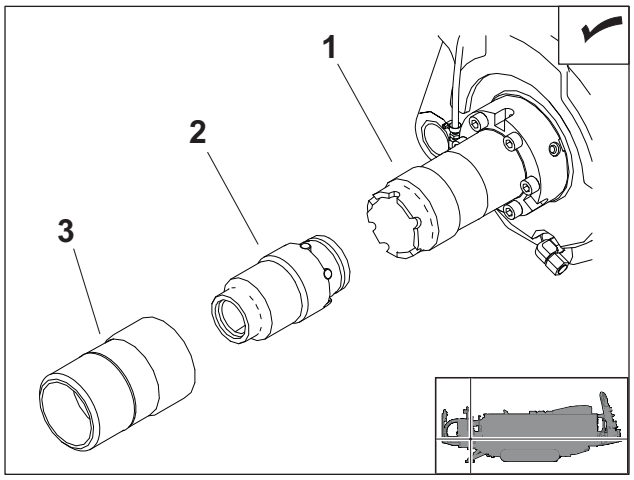
To remove:

1. Clean front wrench of all pipe and tooling.
2. Close front wrench.
3. Position the carriage so that the SaverLok collar (3) can be clamped into the rear wrenchClamp rear wrench on SaverLok collar.

IMPORTANT: Unit may not build enough torque to break out the SaverLok body unless both wrenches are closed.

4. Rotate spindle counterclockwise to unthread collar. Remove collar from system and set aside for later use.
5. Remove SaverLok body from SaverLok connection (1).
   - If parts are clean and dry, pull SaverLok body free of SaverLok connection by hand.
   - If the parts are not clean and dry, reposition carriage to clamp SaverLok body in rear wrench and thrust carriage back to pull SaverLok body free from connection.
6. Turn off engine.

To install:



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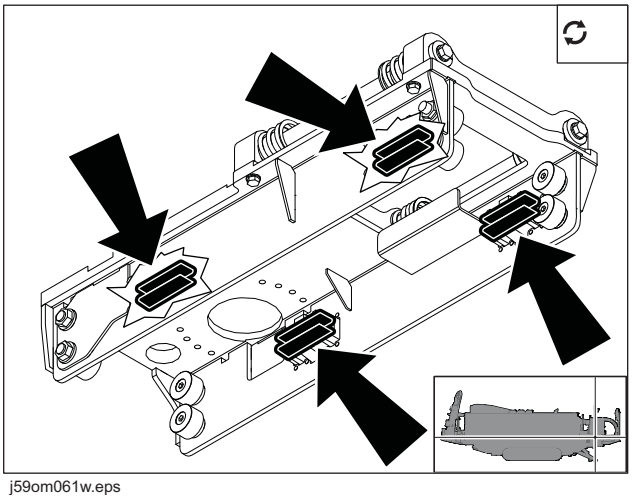
1. Inspect SaverLok® connection (1) for damage. Coat threads with clean TJC.
2. Coat SaverLok shoulder (2) and SaverLok collar (3) threads and shoulder with clean TJC.
3. Apply grease or lubricant to the SaverLok o-ring and insert SaverLok body into SaverLok connection. The connection will not lock fully into place.
4. Thread SaverLok body into connection until o-ring is fully engaged using one of the following methods:
   - Slide SaverLok collar over SaverLok body and engage threads by hand. Once the SaverLok collar is hand tight (bottomed out), remove collar.
   - Tap the SaverLok nose with a rubber mallet until the o-ring is fully engaged.
5. Position SaverLok body by hand for proper engagement of pins and grooves.
6. Slide SaverLok collar over SaverLok body and hand-tighten the threads (typically 3-4 turns).
7. Start unit and position carriage so that collar can be clamped in the rear wrenches.
8. Clamp wrench on collar and tighten SaverLok assembly to a rotation pressure gauge reading between 4500-5000 psi (310-345 bar). This is equivalent to 4500-5000 ft•lb (6101-6779 N•m) of torque.
9. Immediately loosen the collar and repeat the tighten/loosen process five times to break in the contact surfaces.
10. Tighten SaverLok assembly to a rotation pressure gauge reading between 4350-5800 psi (300-400 bar) to finish the installation.

Replace Slide Cartridge Wear Pads

IMPORTANT: Slide cartridge wear pads need to be replaced only if a roller has recently been replaced.

Check slide cartridge wear pads and replace as needed.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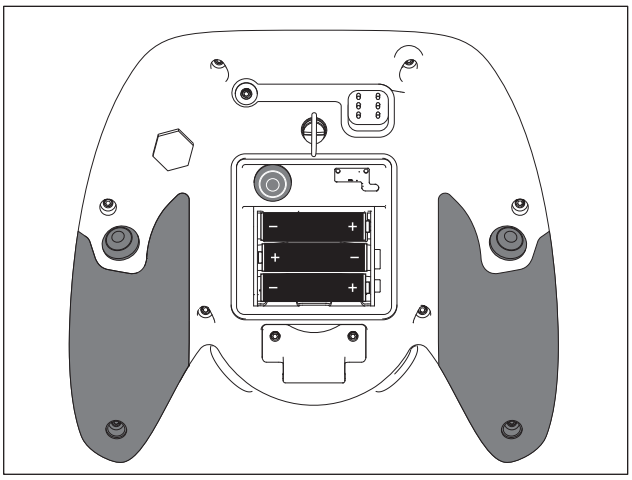
Change Wireless Remote Controller Batteries

Replace batteries when low battery indicator is displayed. Install 6 AA batteries as shown.



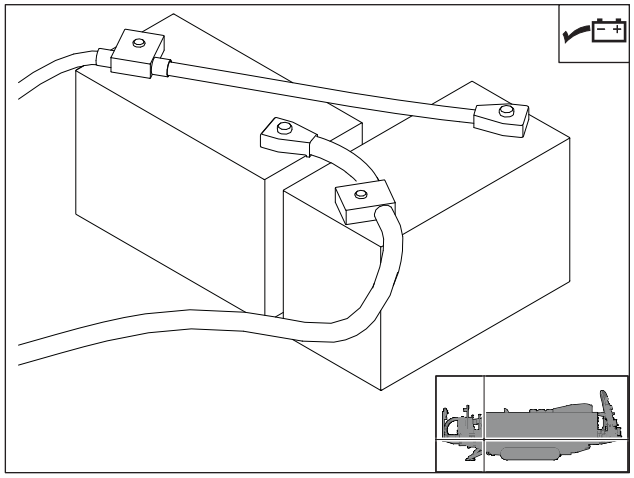
Remote_Battery.eps

Check Battery

Check batteries as needed. Keep batteries clean and terminals free of corrosion.

To clean:

1. Turn battery disconnect switch to the off position.
2. Ensure that no ignition sources are near batteries.
3. Loosen and remove battery cable clamps carefully, **negative (-)** cable first.
4. Clean cable clamps and terminals with wire brush or battery cleaning tool to remove dull glaze.
5. Check for signs of internal corrosion in cables.
6. Connect battery cable clamps, **positive (+)** cable first.
7. Tighten any loose connections.
8. Ensure that battery tiedowns are secure.
9. Turn battery disconnect switch to the on position.



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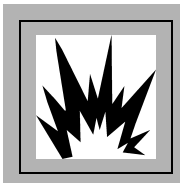
WARNING Explosion possible. Serious injury or equipment damage could occur. Follow directions carefully.

To help avoid injury: Do not create sparks and do not short across battery terminals for any reason.

Charge Battery



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

To help avoid injury:

- Use a single 12V maximum source for charging. Do not connect to rapid chargers or dual batteries.
- Use caution and wear personal protective equipment such as safety eyewear, when charging or cleaning battery.
- Keep sparks, flames, and any ignition source away from batteries at all times. Internal contents are extremely hazardous. Leaking fluid is corrosive. Battery may be explosive at higher temperatures.
- NEVER lean over battery when making connections.
- Do not allow vehicles to touch when charging.
- Do not attempt to charge a battery that is leaking, bulging, heavily corroded, frozen, or otherwise damaged.
- NEVER short-circuit battery terminals for any reason or strike battery posts or cable terminals.
- Refer to MSDS for additional information regarding this battery.

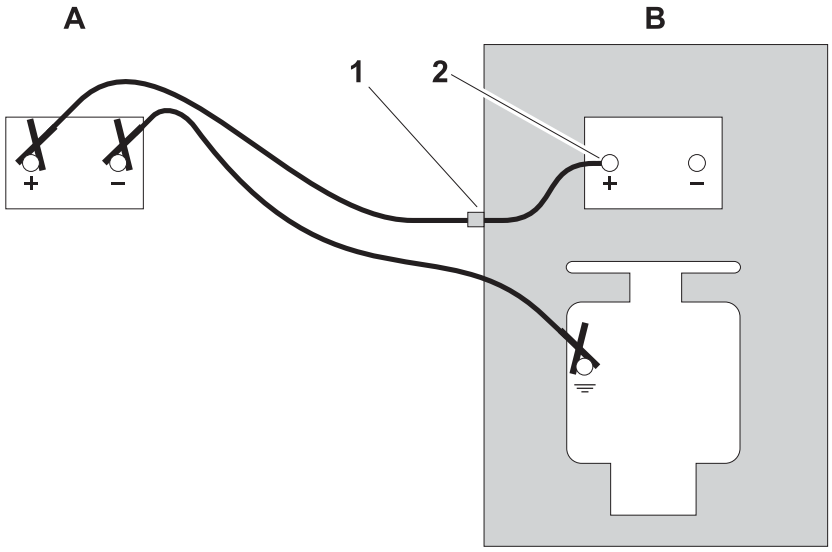
Before You Start

Electronic components can be easily damaged by electrical surges. Jump starting can damage electronics and electrical systems, and is not recommended. Try to charge the battery instead. Use quality large diameter jumper cables capable of carrying high currents (400 amps or more). Cheap cables may not allow enough current flow to charge a dead/discharged battery.

Read all steps thoroughly and review illustration before performing procedure.

Charging Procedure (Engine Off)

1. Park service vehicle close to disabled equipment but do not allow vehicles to touch. Engage parking brake in both vehicles.
2. Turn the ignition switch to the OFF position in both vehicles, and turn off all electrical loads. Disconnect the machine controller.



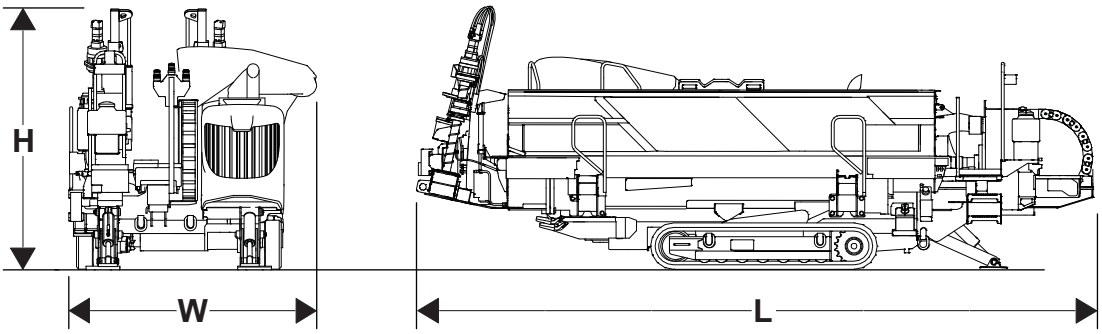
3. Inspect battery in disabled vehicle (B) for signs of cracking, bulging, leaking, or other damage. Connect red positive (+) jumper cable clamp to positive (+) post (2) of battery in disabled vehicle first.

IMPORTANT: Some equipment may have a positive jumper cable terminal (1) located externally. If so equipped, connect red positive (+) jumper cable clamp to terminal.

4. Connect the other red positive (+) jumper cable clamp to positive (+) post of battery (A) in the service vehicle.
5. Connect black negative (-) cable clamp to negative (-) post of battery (A) in service vehicle.
6. Connect the other black negative (-) cable clamp to the engine or frame ground on the disabled vehicle, at least 12" (305 mm) from the failed battery, as shown.
7. Operate service vehicle engine at 1500-2000 rpm for a few minutes to build an electrical charge in the failed battery.
8. Stop engine in service vehicle.
9. Remove jumper cables from the service vehicle, black negative (-) clamp first. Do not allow clamps to touch.
10. Remove black negative (-) cable clamp from the disabled engine or frame ground first.
11. Remove red positive (+) cable clamp from the disabled vehicle positive (+) battery post last.
12. Reconnect machine controller and try to start disabled vehicle.

If the disabled vehicle did not start, check for loose or corroded battery cable connections. Poor connections will prevent current from charging the failed battery. Clean terminals and posts if necessary and repeat steps above.

Specifications



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Dimensions		U.S.	Metric
L, overall machine length			
	driving (per SAE J2022)	295 in	7.50 m
	transport (per SAE J2022)	290 in	7.37 m
W, overall machine width			
	base width (per SAE J2022)	89 in	2.03 m
	width with cab (per SAE J2022)	108 in	2.74 m
	width with cab, support removed (per SAE J2022)	103 in	2.62 m
H, overall machine height			
	driving (per SAE J2022)	114 in	2.90 m
	transport (per SAE J2022)	97 in	2.46 m
	transport with cab (per SAE J2022)	97 in	2.46 m
Operating mass			
	T4 JT base unit, no pipe (per SAE J2022)	20,500 lb	9300 kg
	T4 AT base unit, no pipe (per SAE J2022)	21,600 lb	9800 kg
	LRC (T3) JT base unit, no pipe (per SAE J2022)	20,335 lb	9224 kg
	LRC (T3) AT base unit, no pipe (per SAE J2022)	21,435 lb	9723 kg
	Add cab option, heat and air (per SAE J2022)	690 lb	313 kg
Entry angle (per SAE J2022)		20-29%	20-29%
Angle of approach		17°	17°
Angle of approach (with cab)		17°	17°
Angle of departure		17°	17°

Dimensions	U.S.	Metric
T4 Ground bearing pressure, JT, pipe, w/cab (per ISO 16754)	12.5	0.88 kg/cm^2
T4 Ground bearing pressure, AT, pipe, w/cab (per ISO 16754)	12.7	0.89 kg/cm^2
Ground clearance (per ISO 16754)	7.0 in	178 mm

Power Pipe® HD	U.S.	Metric
Length (per SAE J2022), nominal	180 in	4.57 m
Joint diameter (per SAE J2022)	3.13 in	80 mm
Tubing diameter (per SAE J2022)	2.81 in	71 mm
Minimum bend radius (per SAE J2022)	146 ft	45 m
Weight, lined (per SAE J2022)	150 lb	68 kg
Weight of lined drill pipe and JT40 large box (40 pipe)	7140 lb	3240 kg
Weight of lined drill pipe and JT40 small box (20 pipe)	3797 lb	1720 kg

HIWS1 Pipe	U.S.	Metric
Length (per SAE J2022), nominal	180 in	4.57 m
Joint diameter (per SAE J2022)	3.10 in	79 mm
Tubing diameter (per SAE J2022)	2.63 in	67 mm
Minimum bend radius (per SAE J2022)	145 ft	44 m
Weight (per SAE J2022)	165 lb	75 kg
Weight of drill pipe and JT40 large box (35 pipe)	6915 lb	3140 kg
Weight of drill pipe and JT40 small box (15 pipe)	3287 lb	1490 kg

All Terrain Pipe	U.S.	Metric
Length (per SAE J2022), nominal	180 in	4.57 m
Joint diameter (per SAE J2022)	3.75 in	95 mm
Tubing diameter (per SAE J2022)	3.07 in	78 mm
Minimum bend radius (per SAE J2022)	170 ft	52 m
Weight (per SAE J2022), with inner rod	231 lb	105 kg
Weight of drill pipe and large box (24 pipe)	6350 lb	2880 kg
Weight of drill pipe and small box (12 pipe)	3450 lb	1560 kg

Operational	U.S.	Metric
Maximum spindle speed (per SAE J2022)	225 rpm	225 rpm
Maximum spindle speed (per SAE J2022) (AT inner spindle)	280 rpm	280 rpm
Maximum spindle torque	5500 ft•lb	7460 N•m
Maximum spindle torque (AT inner spindle)	2000 ft•lb	2710 N•m
Carriage thrust travel speed (per SAE J2022)	180 fpm	55 m/min
Carriage pullback travel speed (per SAE J2022)	180 fpm	55 m/min
Thrust force (per SAE J2022)	40,000 lb	178 kN
Thrust force (All Terrain mode) (per SAE J2022)	40,000 lb	178 kN
Pullback force (per SAE J2022)	40,000 lb	178 kN
Bore diameter	4.50 in	114 mm
Bore diameter (All Terrain)	5.50 in	140 mm
Backream diameter	soil dependent	
Ground travel speed, forward (per SAE J2022)	3.0 mph	4.8 km/h
Ground travel speed, reverse (per SAE J2022)	3.0 mph	4.8 km/h

Power		U.S.	Metric
Engine: Cummins® QSB4.5			
Fuel: diesel			
Cooling medium: liquid			
Injection: direct			
Aspiration: turbocharged and charge air cooled			
Cylinders: 4			
Displacement		275 in^3	4.5 L
Bore		4.21 in	107 mm
Stroke		4.88 in	124 mm
LRC (EPA Tier 3, EU Stage IIIA)			
	manufacturer's gross power rating (per SAE J1995)	148 hp	110 kW
	estimated net power rating (per SAE J1349)	143 hp	114 kW
	rated speed	2300 rpm	2300 rpm
	peak gross power @ 2000 rpm	156 hp	116 kW

Power		**U.S.**	**Metric**
HRC (EPA Tier 4 EU Stage IV)			
	manufacturer's gross power rating (per SAE J1995)	160 hp	119 kW
	estimated net power rating (per SAE J1349)	152 hp	113 kW
	rated speed	2300 rpm	2300 rpm
	peak gross power @ 2200 rpm	163 hp	122 kW

Drilling Fluid System (Onboard)	**U.S.**	**Metric**
Maximum drilling fluid pressure (per SAE J2022)	1000 psi	69 bar
Maximum drilling fluid flow (per SAE J2022)	70 gpm	265 L/min

Fluid Capacities	**U.S.**	**Metric**
Hydraulic reservoir	17 gal	64 L
Fuel tank	56 gal	212 L
Engine oil, including filter	14 qt	13.2 L
Cooling system	24 qt	22.7 L
Antifreeze tank	8 gal	30 L
Diesel exhaust fluid (DEF) tank (HRC only)	3.6 gal	13.6 L

Battery (2 used)
SAE reserve capacity 195 min, 12V, negative ground, SAE cold crank @ 0°F (-18°C), 950 amps.

Noise Levels
Operator ear sound pressure level is < or = 85 dBA sound pressure per ISO 6396 Operator ear sound pressure level (with cab) is < or = 73 dBA sound pressure per ISO 6396 Exterior sound power level is < or = 103 dBA per ISO 6395

Vibration Levels
Average vibration transmitted to the operator's hand and whole body during normal operation does not exceed 2.5 and 0.5 m/sec^2 respectively.

Specifications are called out according to SAE recommended practices where indicated. Specifications are general and subject to change without notice. If exact measurements are required, equipment should be weighed and measured. Due to selected options, delivered equipment may not necessarily match that shown.

Declaration of Conformity Information

Countries in the European Union should have received a Declaration of Conformity (DOC) with this machine similar to the example below.

The Charles Machine Works, Inc.
PO Box 66
1959 West Fir Avenue
Perry, Oklahoma, USA 73077-0066
Phone: 580 572 3784
FAX: 580 572 3525

Declares that the product:

Model: **Ditch Witch® XXXX**

Type: **(machine type)**

Engine Power: **xxx kW**

Serial Number: **CMWXXXXXXXXXXXXX**

Conforms to the requirements of:

2006/42/EC Machinery Directive

2014/30/EU Electromagnetic Compatibility Directive

2000/14/EC Noise Emission Directive

Measured sound power level (Annex V): **xxx dBA**
Guaranteed sound power level (Annex V): **xxx dBA**

The Technical Construction File is maintained at the manufacturer's location.

The manufacturer's European representative is:

Ditch Witch Barcelona
International Underground Systems, S.L.
C/EL PLA, 130 * Poligon Industrial El Pla
08980 Sant Feliu De Llobregat * Spain
Phone: +34 93 632 7344
FAX: +34 93 632 7343

Support

Procedure

Notify your dealer immediately of any malfunction or failure of Ditch Witch equipment.

Always give model, serial number, and approximate date of your equipment purchase. This information should be recorded and placed on file by the owner at the time of purchase.

Return damaged parts to dealer for inspection and warranty consideration if in warranty time frame.

Order genuine Ditch Witch replacement or repair parts from your authorized Ditch Witch dealer. Use of another manufacturer's parts may void warranty consideration.

Resources

Publications

Contact your Ditch Witch dealer for publications and videos covering safety, operation, service, and repair of your equipment.

Ditch Witch® Training

For information about on-site, individualized training, contact your Ditch Witch dealer.

Warranty

Ditch Witch® Equipment and Replacement Parts Limited Warranty Policy

Subject to the limitation and exclusions herein, free replacement parts will be provided at any authorized Ditch Witch dealership for any Ditch Witch equipment or parts manufactured by the Ditch Witch factory that fail due to a defect in material or workmanship within one (1) year of first commercial use. Free labor will be provided at any authorized Ditch Witch dealership for installation of parts under this warranty during the first year following "initial commercial" use of the serial-numbered Ditch Witch equipment on which it is installed. The customer is responsible for transporting their equipment to an authorized Ditch Witch dealership for all warranty work.

Exclusions from Product Warranty

- All incidental or consequential damages.
- All defects, damages, or injuries caused by misuse, abuse, improper installation, alteration, neglect, or uses other than those for which products were intended.
- All defects, damages, or injuries caused by improper training, operation, or servicing of products in a manner inconsistent with manufacturer's recommendations.
- All engines and engine accessories (these are covered by original manufacturer's warranty).
- Tires, belts, and other parts which may be subject to another manufacturer's warranty (such warranty will be available to purchaser).
- ALL IMPLIED WARRANTIES NOT EXPRESSLY STATED HEREIN, INCLUDING ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY.

IF THE PRODUCTS ARE PURCHASED FOR COMMERCIAL PURPOSES, AS DEFINED BY THE UNIFORM COMMERCIAL CODE, THEN THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE FACE HEREOF AND THERE ARE NO IMPLIED WARRANTIES OF ANY KIND WHICH EXTEND TO A COMMERCIAL BUYER. ALL OTHER PROVISIONS OF THIS LIMITED WARRANTY APPLY INCLUDING THE DUTIES IMPOSED.

Ditch Witch products have been tested to deliver acceptable performance in most conditions. This does not imply they will deliver acceptable performance in all conditions. Therefore, to assure suitability, products should be operated under anticipated working conditions prior to purchase.

Defects will be determined by an inspection within thirty (30) days of the date of failure of the product or part by Ditch Witch Product Support (DWPS) or its authorized dealer. DWPS will provide the location of its inspection facilities or its nearest authorized dealer upon inquiry. DWPS reserves the right to supply remanufactured replacements parts under this warranty as it deems appropriate.

Extended warranties are available upon request from your local Ditch Witch dealer or the Ditch Witch factory.

Some states do not allow exclusion or limitation of incidental or consequential damages, so above limitation of exclusion may not apply. Further, some states do not allow exclusion of or limitation of how long an implied warranty lasts, so the above limitation may not apply. This limited warranty gives product owner specific legal rights and the product owner may also have other rights which vary from state to state.

For information regarding this limited warranty, contact the DWPS department, P.O. Box 66, Perry, OK 73077-0066, or contact your local dealer.

First version: 1/91; Latest version: 8/16

A Note To Ditch Witch Equipment Owners:

If your equipment was purchased through a Ditch Witch dealer, there is no need to read further.

However, if you purchased from any other source, please fill out the form on the reverse side and return it to us.

This will enable you to receive updates on this equipment as well as information on new products of interest.

Thanks for using Ditch Witch equipment.

(Please Fold Along This Line And Seal At Bottom With Tape)

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO 23 PERRY OKLAHOMA

POSTAGE WILL BE PAID BY

The Charles Machine Works, Inc.
P.O. Box 66
Perry, Oklahoma 73077-9989

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BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO 23 PERRY OKLAHOMA

POSTAGE WILL BE PAID BY

The Charles Machine Works, Inc.
P.O. Box 66
Perry, Oklahoma 73077-9989

Ditch Witch® Registration Card

Please Type or Print All Information

Purchaser's Company Name

Attention

Street Address or P.O. Box

City County

State Zip Nation

( )

Phone Number With Area Code

Model Serial Number

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Name of Ditch Witch Dealership

Your Signature

Ditch Witch® Registration Card

Please Type or Print All Information

Purchaser's Company Name

Attention

Street Address or P.O. Box

City County

State Zip Nation

( )

Phone Number With Area Code

Model Serial Number

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Attachments/Accessories Serial Numbers

Name of Ditch Witch Dealership

Your Signature

Service Record

Service Performed	Date	Hours

Service Performed	Date	Hours

Appendix

Chapter Contents

Machine Diagnostic Codes

SPN	FMI	DID	Description	Triggering Condition
521356	1	219 - Main Controller	Thrust/Right Track Hydraulic Pressure Low	Pin B3 reads below 0.600V for more than 4 seconds while thrust is in operation.
521356	1	219 - Main Controller	Thrust/Right Track Hydraulic Pressure Low	Pin B3 reads below 0.600V for more than 4 seconds while right drive track is in operation.
521356	3	219 - Main Controller	Thrust Pressure Sensor Voltage High	Pin B3 reads above 4.80V for more than 1 second.
521356	3	49 - Cab Controller	Joystick X Axis Voltage High	Pin P2 reads above 4.75V for more than 1 second.
521356	4	219 - Main Controller	Thrust Pressure Sensor Voltage Low	Pin B3 reads below 0.250V for more than 1 second.
521356	4	220 - Pipe Controller	Front Wireline ROM Switch Voltage Low	Pin B3 reads below 2.4V for more than 1 second.
521356	4	49 - Cab Controller	Joystick X Axis Voltage Low	Pin P2 reads below 0.250V for more than 1 second.
521357	3	49 - Cab Controller	Joystick Y Axis Voltage High	Pin P3 reads above 4.75V for more than 1 second.
521357	4	219 - Main Controller	Machine Mode Switch Voltage Low	Pin C3 machine mode switch reads below 0.4V for more than 1 second.
521357	4	220 - Pipe Controller	Rear Wireline ROM Switch Voltage Low	Pin C3 reads below 2.4V for more than 1 second.
521357	4	49 - Cab Controller	Joystick Y Axis Voltage Low	Pin P3 reads below 0.250V for more than 1 second.
521358	1	219 - Main Controller	Rotation/Left Track Hydraulic Pressure Low	Pin D3 reads below 0.600V for more than 4 seconds while rotation is in operation.
521358	1	219 - Main Controller	Rotation/Left Track Hydraulic Pressure Low	Pin D3 reads below 0.600V for more than 4 seconds while left drive track is in operation.
521358	3	219 - Main Controller	Rotation Pressure Sensor Voltage High	Pin D3 reads above 4.80V for more than 1 second.
521358	4	219 - Main Controller	Rotation Pressure Sensor Voltage Low	Pin D3 reads below 0.250V for more than 1 second.
521359	1	219 - Main Controller	Inner Rotation Hydraulic Pressure Low	Pin E3 reads below 0.600V for more than 4 seconds while inner rotation is in operation.
521359	3	219 - Main Controller	Inner Rotation Pressure Sensor Voltage High	Pin E3 reads above 4.80V for more than 1 second (AT option must be on).
521359	4	219 - Main Controller	Inner Rotation Pressure Sensor Voltage Low	Pin E3 reads below 0.250V for more than 1 second (AT option must be on).
521360	1	219 - Main Controller	DWATS Hydraulic Pressure Low	Pin F3 reads below 0.55V for more than 4 seconds while DWATS pump is in operation.
521360	3	219 - Main Controller	DWATS Pressure Sensor Voltage High	Pin F3 reads above 4.80V for more than 1 second.
521360	4	219 - Main Controller	DWATS Pressure Sensor Voltage Low	Pin F3 reads below 0.250V for more than 1 second.
521361	0	219 - Main Controller	Hydraulic Temperature High	Pin G3 reads above 212°F(100°C) or 3.83V for more than 10 seconds.
521361	3	219 - Main Controller	Hydraulic Temperature Sensor Voltage High	Pin G3 reads above 4.80V for more than 1 second.
521361	3	220 - Pipe Controller	Row Select Position Sensor Voltage High	Pin G3 reads voltage above 4.8V for more than 1 second.
521361	4	219 - Main Controller	Hydraulic Temperature Sensor Voltage Low	Pin G3 reads below 0.250V for more than 1 second.
521361	4	220 - Pipe Controller	Row Select Position Sensor Voltage Low	Pin G3 reads voltage below 0.25V for more than 1 second.
521362	3	219 - Main Controller	Fuel Sender Voltage High	Pin H3 reads above 4.50V for more than 1 second.
521362	4	219 - Main Controller	Fuel Sender Voltage Low	Pin H3 reads below 0.75V for more than 1 second.
521363	0	219 - Main Controller	Outer Rotation Hydraulic Temperature High	Pin J3 reads above 250°F(121°C) or 4.4V for more than 10 seconds.
521363	3	219 - Main Controller	Outer Rotation Hyd Temp Sensor Voltage High	Pin J3 reads above 4.80V for more than 1 second.
521363	4	219 - Main Controller	Outer Rotation Hyd Temp Sensor Voltage Low	Pin J3 reads below 0.250V for more than 1 second.
521364	4	220 - Pipe Controller	Single Pipe Loader Lifter Switch Voltage Low	Pin K3 reads below 1V for more than 1 second.
521365	4	220 - Pipe Controller	Single Pipe Loader Shuttle Switch Voltage Low	Pin reads below 1V for more than 1 second.
521367	3	236 - Carriage Controlle	External 5 Volt Power Supply High	5V supply voltage reads high for more than 1 second.
521367	4	236 - Carriage Controlle	External 5 Volt Power Supply	5V supply voltage reads low for more than 1 second.
521371	0	236 - Carriage Controlle	Onboard Temperature Sensor	Temperature sensor reads too high.
521375	3	219 - Main Controller	Main Controller Internal 6V Supply Voltage High	Internal 6.3V power supply reads above 7V for more than 1 second.
521375	4	219 - Main Controller	Main Controller Internal 6V Supply Voltage Low	Internal 6.3V power supply reads below 5.5V for more than 1 second.
521376	3	219 - Main Controller	Main Controller 5 Volt Output Supply Voltage High	5V output reads above 5.5V for more than 1 second.
521376	3	220 - Pipe Controller	Pipe Controller 5 Volt Output Supply Voltage High	5V output reads above 5.5 volts.
521376	4	219 - Main Controller	Main Controller 5 Volt Output Supply Voltage Low	5V output reads below 4.5V for more than 1 second.
521376	4	220 - Pipe Controller	Pipe Controller 5 Volt Output Supply Voltage Low	5V output reads below 4.5V.
521377	3	219 - Main Controller	Main Controller Internal 5V Supply Voltage High	Internal 5V supply reads above 5.5V for more than 1 second.
521377	3	220 - Pipe Controller	Pipe Controller Internal 5V Supply Voltage High	Internal 5V supply reads above 5.5V.
521377	4	219 - Main Controller	Main Controller Internal 5V Supply Voltage Low	Internal 5V supply reads below 4.5V for more than 1 second.
521377	4	220 - Pipe Controller	Pipe Controller Internal 5V Supply Voltage Low	Internal 5V supply reads below 4.5V.
521378	3	219 - Main Controller	Main Controller 12 V Ignition Voltage High	12V battery reads above 15.5V for more than 1 second.
521378	3	220 - Pipe Controller	Pipe Controller 12 V Ignition Voltage High	Battery reads above 15.5V.
521378	4	219 - Main Controller	Main Controller 12 V Ignition Voltage Low	12V battery voltage reads below 9V for more than 1 second.
521378	4	220 - Pipe Controller	Pipe Controller 12 V Ignition Voltage Low	Battery reads below 9V.
521452	0	220 - Pipe Controller	Front Gripper Position Sensor Out Of Range High	Pin R2 PWM reads more than 16% duty cycle for more than 1 second.

521452	1	220 - Pipe Controller	Front Gripper Position Sensor Out Of Range Low	Pin R2 PWM reads less than 5% duty cycle for more than 1 second.
521453	0	220 - Pipe Controller	Rear Gripper Position Sensor Out Of Range High	Pin R3 PWM reads more than 16% duty cycle for more than 1 second.
521453	1	220 - Pipe Controller	Rear Gripper Position Sensor Out Of Range Low	Pin R3 PWM reads less than 5% duty cycle for more than 1 second.
521454	8	236 - Carriage Controlle	Float Sensor PPU Frequency Error	Float sensor frequency or duty cycle is out of range.
521456	0	220 - Pipe Controller	Pipe Controller Over Temperature	Pipe controller temperature above (100+40 °F) for more than 10 seconds.
521462	0	219 - Main Controller	Carriage Position Out of Range High	Carriage position reading out of range. Position extended beyond front stop.
521462	1	219 - Main Controller	Carriage Position Out of Range Low	Carriage position reading out of range. Position retracted further than rear stop.
521462	31	219 - Main Controller	Carriage Movement Not Detected	Carriage position not changing for 1 second when thrust command is >15% and carriage pressure is > 1000 psi (69 bar).
521463	0	219 - Main Controller	Shuttle Position Out of Range High	Shuttle position reading out of range. P{osition extended beyond last pipe.
521463	1	219 - Main Controller	Shuttle Position Out of Range Low	Shuttle position reading out of range. Position retracted further than spindle limit.
521472	0	219 - Main Controller	Main Controller Temperature High	Internal controller temperature reads higher than 212°F(100°C) for more then 10 seconds.
521504	31	224 - ESID	ESID error: Could not read the real-time clock	Error reading the real-time clock.
521505	31	224 - ESID	No display communications	New ESID has no LCD.
521510	31	224 - ESID	ESID strobe output error: The connection is open or shorte	H.S. driver current limit or over-temperature / output open (<0.21 / 10mA).
521511	31	224 - ESID	ESID horn output error: The connection is open or shorted	H.S. driver current limit or over-temperature / output open (<0.21 / 10mA).
521512	31	224 - ESID	ESID supply (battery) voltage is too low	Battery supply under-voltage (< 5.5V).
521513	31	224 - ESID	ESID wiring issue: BDTest is not connected	No high-side driver detected on the BDTest wire.
521515	31	224 - ESID	ESID error: The voltage limiter failed its self-test	Voltage probe failed self-test.
521516	31	224 - ESID	ESID error: The coil failed its self-test	Current probe failed self-test.
521517	31	224 - ESID	ESID error: The voltage limiter is outside of calibration	Reads peak values from self-test waveform.
521518	31	224 - ESID	ESID error: the coil is outside of calibration	Reads peak values from self-test waveform.
521519	31	224 - ESID	ESID connection error: The voltage limiter is not connected	Voltage limiter is not connected.
521520	31	224 - ESID	ESID connection error: The coil is not connected	Current coil is not connected.
521521	31	224 - ESID	ESID connection error: The voltage limiter is not grounded	EVOPEN (no ground stake detected).
521523	31	224 - ESID	ESID is above maximum operating temperature	Temperature > 185°F (85°C).
521524	31	224 - ESID	ESID is below minimum operating temperature	Temperature < 15°F (-9°C).
521580	5	219 - Main Controller	Track Brake Valve Open Circuit	While output is on: Status line for track brake valve is low and feedback is > 10V for more than 1 second.
521580	6	219 - Main Controller	Track Brake Valve Short Circuit	While output is on: Status line for rrack brake valve is low and feedback is < 10V for more than 1 second.
521580	11	223 - Wireless RX	Front Drill Frame Up Fault	While output is on: Front drill frame up valve open or short circuited.
521580	31	219 - Main Controller	Track Brake Valve Internal Error	An error occurred in the software or internal controller hardware.
521581	5	219 - Main Controller	Selector/Diverter (Drill/Drive) Valve Open Circuit	While output is on: Status line for drill/drive valve is low and feedback is > 10V for more than 1 second.
521581	6	219 - Main Controller	Selector/Diverter (Drill/Drive) Valve Short Circuit	While output is on: Status line for drill/drive valve is low and feedback is < 10V for more than 1 second.
521581	11	223 - Wireless RX	Front Drill Frame Down Fault	While output is on: Front drill frame down valve open or short circuited.
521581	31	219 - Main Controller	Selector/Diverter (Drill/Drive) Valve Internal Error	An error occurred in the software or internal controller hardware.
521582	5	219 - Main Controller	Auxiliary Dump Valve Open Circuit	While output is on: Status line for aux dump valve is low and feedback is > 10V for more than 1 second.
521582	5	220 - Pipe Controller	Remote Lockout Strobe Signal Open Circuit	Open circuit.
521582	6	219 - Main Controller	Auxiliary Dump Valve Short Circuit	While output is on: Status line for aux dump valve is low and feedback is < 10V for more than 1 second.
521582	6	220 - Pipe Controller	Remote Lockout Strobe Signal Short Circuit	Shorted to ground.
521582	11	223 - Wireless RX	Rear Drill Frame Up Fault	While output is on: Rear drill frame up valve open or short circuited.
521582	31	219 - Main Controller	Auxiliary Dump Valve Internal Error	An error occurred in the software or internal controller hardware.
521582	31	220 - Pipe Controller	Remote Lockout Strobe Internal Error	An error occurred in the software or internal controller hardware.
521583	5	219 - Main Controller	Lube Valve Open Circuit	While output is on: Status line for lube valve is low and feedback is > 10V for more than 1 second.
521583	5	220 - Pipe Controller	Rear Wrench CCW Valve Open Circuit	Open circuit.
521583	6	219 - Main Controller	Lube Valve Short Circuit	While output is on: Status line for lube valve is low and feedback is < 10V for more than 1 second.
521583	6	220 - Pipe Controller	Rear Wrench CCW Valve Short Circuit	Shorted to ground.
521583	11	223 - Wireless RX	Rear Drill Frame Down Fault	While output is on: Rear drill frame down valve open or short circuited.
521583	31	219 - Main Controller	Lube Valve Internal Error	An error occurred in the software or internal controller hardware.
521583	31	220 - Pipe Controller	Rear Wrench CCW Valve Internal Error	An error occurred in the software or internal controller hardware.
521584	5	219 - Main Controller	Cooling Fan Solenoid Open Circuit	While output is on: Status line for cooling fan solenoid is low and feedback is > 10V for more than 1 second.
521584	5	220 - Pipe Controller	Grippers Open Valve Open Circuit	Open circuit.
521584	6	219 - Main Controller	Cooling Fan Solenoid Short Circuit	While output is on: Status line for cooling fan solenoid is low and feedback is < 10V for more than 1 second.
521584	6	220 - Pipe Controller	Grippers Open Valve Short Circuit	Shorted to ground.
521584	31	219 - Main Controller	Cooling Fan Solenoid Internal Error	An error occurred in the software or internal controller hardware.

521584	31	220 - Pipe Controller	Grippers Open Valve Internal Error	An error occurred in the software or internal controller hardware.
521585	5	219 - Main Controller	Drill Fluid Hydraulic Enable Valve Open Circuit	While output is on: Status line for drill fluid hyd valve is low and feedback is > 10V for more than 1 second.
521585	5	220 - Pipe Controller	Grippers Close Valve Open Circuit	Open circuit.
521585	6	219 - Main Controller	Drill Fluid Hydraulic Enable Valve Short Circuit	While output is on: Status line for drill fluid hyd valve is low and feedback is < 10V for more than 1 second.
521585	6	220 - Pipe Controller	Grippers Close Valve Short Circuit	Shorted to ground.
521585	11	223 - Wireless RX	Drill Fluid Shut Off Fault	While output is on: Drill fluid shut-off valve open or short circuited.
521585	31	219 - Main Controller	Drill Fluid Hydraulic Enable Valve Internal Error	An error occurred in the software or internal controller hardware.
521585	31	220 - Pipe Controller	Grippers Close Valve Internal Error	An error occurred in the software or internal controller hardware.
521586	5	220 - Pipe Controller	Lifters Up Valve Open Circuit	Open circuit.
521586	6	220 - Pipe Controller	Lifters Up Valve Short Circuit	Shorted to ground.
521586	11	223 - Wireless RX	Horn Circuit Fault	While output is on: Horn circuit open or short circuited.
521586	31	220 - Pipe Controller	Lifters Up Valve Internal Error	An error occurred in the software or internal controller hardware.
521587	5	220 - Pipe Controller	Lifters Down Valve Open Circuit	Open circuit.
521587	6	219 - Main Controller	Ignition Alarm Short Circuit	While output is on: Status line for track brake valve is low and feedback is < 10V for more than 1 second.
521587	6	220 - Pipe Controller	Lifters Down Valve Short Circuit	Shorted to ground.
521587	11	223 - Wireless RX	Right Stabilizer Up Fault	While output is on: Right stabilizer up solenoid is open or short circuited.
521587	31	219 - Main Controller	Ignition Alarm Internal Error	An error occurred in the software or internal controller hardware.
521587	31	220 - Pipe Controller	Lifters Down Valve Internal Error	An error occurred in the software or internal controller hardware.
521587	31	236 - Carriage Controlle	Variable Rotation Solenoid	While output is on: Variable rotation solenoid is open or short circuited.
521588	5	219 - Main Controller	(ePOR) Thrust Fwd / Right Track Fwd Solenoid Open Circuit	While output is on: Current feedback < 100mA for more than 1 second.
521588	5	220 - Pipe Controller	Right Hand Anchor Up Solenoid Open Circuit	Open circuit.
521588	6	219 - Main Controller	(ePOR) Thrust Fwd / Right Track Fwd Solenoid Short Circuit	While output is on: Current reedback > 2A for more than 0.5 second.
521588	6	220 - Pipe Controller	Right Hand Anchor Up Solenoid Short Circuit	Shorted to ground.
521588	11	223 - Wireless RX	Right Stabilizer Down Fault	While output is on: Right stabilizer down solenoid is open or short circuited.
521588	31	219 - Main Controller	(ePOR) Thrust Fwd / Right Track Fwd Solenoid Internal Err	An error occurred in the software or internal controller hardware.
521588	31	220 - Pipe Controller	Right Hand Anchor Up Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521589	5	219 - Main Controller	(ePOR) Thrust Rev / Right Track Rev Solenoid Open Circuit	While output is on: Current feedback < 100mA for more than 1 second.
521589	5	220 - Pipe Controller	Left Hand Anchor Up Solenoid Open Circuit	Open circuit.
521589	6	219 - Main Controller	(ePOR) Thrust Rev / Right Track Rev Solenoid Short Circuit	While output is on: Current feedback > 2A for more than 0.5 second.
521589	6	220 - Pipe Controller	Left Hand Anchor Up Solenoid Short Circuit	Shorted to ground.
521589	11	223 - Wireless RX	Left Stabilizer Up Fault	While output is on: Left stabilizer up solenoid is open or short circuited.
521589	31	219 - Main Controller	(ePOR) Thrust Rev / Right Track Rev Solenoid Internal Err	An error occurred in the software or internal controller hardware.
521589	31	220 - Pipe Controller	Left Hand Anchor Up Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521589	31	236 - Carriage Controlle	Thrust Brake Valve	While output is on: Thrust brake valve is open or short circuited.
521590	5	219 - Main Controller	Outer Rotation CCW/Left Track Reverse Open Circuit	While output is on: Current feedback < 50mA for more than 1 second.
521590	5	220 - Pipe Controller	Right Hand Anchor Down Solenoid Open Circuit	Open circuit.
521590	6	219 - Main Controller	Outer Rotation CCW/Left Track Reverse Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.
521590	6	220 - Pipe Controller	Right Hand Anchor Down Solenoid Short Circuit	Shorted to ground.
521590	11	223 - Wireless RX	Left Stabilizer Down Fault	While output is on: Left stabilizer down solenoid is open or short circuited.
521590	31	219 - Main Controller	Outer Rotation CCW/Left Track Reverse Internal Error	An error occurred in the software or internal controller hardware.
521590	31	220 - Pipe Controller	Right Hand Anchor Down Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521590	31	236 - Carriage Controlle	Thrust 2-Speed Valve	While output is on: Thrust 2-speed valve is open or short circuited.
521591	5	219 - Main Controller	Outer Rotation CW/Left Track Forward Open Circuit	While output is on: Current feedback < 50mA for more than 1 second.
521591	5	220 - Pipe Controller	Left Hand Anchor Down Solenoid Open Circuit	Open circuit.
521591	6	219 - Main Controller	Outer Rotation CW/Left Track Forward Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.
521591	6	220 - Pipe Controller	Left Hand Anchor Down Solenoid Short Circuit	Shorted to ground.
521591	11	223 - Wireless RX	Strobe Fault	While output is on: Strobe line is open or short circuited.
521591	31	219 - Main Controller	Outer Rotation CW/Left Track Forward Internal Error	An error occurred in the software or internal controller hardware.
521591	31	220 - Pipe Controller	Left Hand Anchor Down Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521591	31	236 - Carriage Controlle	Rotation Brake Valve	While output is on: Rotation brake valve is open or short circuited.
521592	5	219 - Main Controller	Thrust Forward/Right Track Forward Open Circuit	While output is on: Current feedback < 50mA for more than 1 second.
521592	5	220 - Pipe Controller	Right Hand Anchor CW Solenoid Open Circuit	Open circuit.
521592	6	219 - Main Controller	Thrust Forward/Right Track Forward Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.

521592	6	220 - Pipe Controller	Right Hand Anchor CW Solenoid Short Circuit	Shorted to ground.
521592	31	219 - Main Controller	Thrust Forward/Right Track Forward Internal Error	An error occurred in the software or internal controller hardware.
521592	31	220 - Pipe Controller	Right Hand Anchor CW Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521593	5	219 - Main Controller	Thrust Reverse/Right Track Reverse Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521593	5	220 - Pipe Controller	Left Hand Anchor CW Solenoid Open Circuit	Open circuit.
521593	6	219 - Main Controller	Thrust Reverse/Right Track Reverse Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.
521593	6	220 - Pipe Controller	Left Hand Anchor CW Solenoid Short Circuit	Shorted to ground.
521593	31	219 - Main Controller	Thrust Reverse/Right Track Reverse Internal Error	An error occurred in the software or internal controller hardware.
521593	31	220 - Pipe Controller	Left Hand Anchor CW Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521594	5	219 - Main Controller	Inner Rotation CW Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521594	5	220 - Pipe Controller	Right Hand Anchor CCW Solenoid Open Circuit	Open circuit.
521594	6	219 - Main Controller	Inner Rotation CW Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.
521594	6	220 - Pipe Controller	Right Hand Anchor CCW Solenoid Short Circuit	Shorted to ground.
521594	31	219 - Main Controller	Inner Rotation CW Internal Error	An error occurred in the software or internal controller hardware.
521594	31	220 - Pipe Controller	Right Hand Anchor CCW Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521595	5	219 - Main Controller	Inner Rotation CCW Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521595	5	220 - Pipe Controller	Left Hand Anchor CCW Solenoid Open Circuit	Open circuit.
521595	6	219 - Main Controller	Inner Rotation CCW Short Circuit	While output is on: Current feedback > 300mA for more than 1 second.
521595	6	220 - Pipe Controller	Left Hand Anchor CCW Solenoid Short Circuit	Shorted to ground.
521595	31	219 - Main Controller	Inner Rotation CCW Internal Error	An error occurred in the software or internal controller hardware.
521595	31	220 - Pipe Controller	Left Hand Anchor CCW Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521596	5	219 - Main Controller	Outer Rotation Flushing Solenoid Open Circuit	While output is on: Current feedback < 200mA for more than 1 second.
521596	5	220 - Pipe Controller	Shuttle Extend Solenoid Open Circuit	Open circuit.
521596	6	219 - Main Controller	Outer Rotation Flushing Solenoid Short Circuit	While output is on: Current feedback > 2A for more than 1 second.
521596	6	220 - Pipe Controller	Shuttle Extend Solenoid Short Circuit	Shorted to ground.
521596	31	219 - Main Controller	(ePOR) Outer Rot CW / Left Track Rev Solenoid Internal Err	An error occurred in the software or internal controller hardware.
521596	31	220 - Pipe Controller	Shuttle Extend Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521597	5	219 - Main Controller	(ePOR) Outer Rot CCW / Left Track Fwd Solenoid Open Circ	While output is on: Current feedback < 30mA for more than 1 second.
521597	5	220 - Pipe Controller	Shuttle Retract Solenoid Open Circuit	Open circuit.
521597	6	219 - Main Controller	(ePOR) Outer Rot CCW / Left Track Fwd Solenoid Short Circ	While output is on: Current feedback > 2A for more than 1 second.
521597	6	220 - Pipe Controller	Shuttle Retract Solenoid Short Circuit	Shorted to ground.
521597	31	219 - Main Controller	(ePOR) Outer Rot CCW / Left Track Fwd Solenoid Internal E	An error occurred in the software or internal controller hardware.
521597	31	220 - Pipe Controller	Shuttle Retract Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521598	5	219 - Main Controller	Cab Position Extend Valve Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521598	5	220 - Pipe Controller	Row Select Motor Up Open Circuit	Open circuit.
521598	6	219 - Main Controller	Cab Position Extend Valve Short Circuit	While output is on: Current feedback > 2A for more than 1 second.
521598	6	220 - Pipe Controller	Row Select Motor Up Short Circuit	Shorted to ground.
521598	31	219 - Main Controller	Cab Position Extend Valve Internal Error	An error occurred in the software or internal controller hardware.
521598	31	220 - Pipe Controller	Row Select Motor Up Internal Error	An error occurred in the software or internal controller hardware.
521599	5	219 - Main Controller	Cab Position Retract Valve Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521599	5	220 - Pipe Controller	Row Select Motor Down Open Circuit	Open circuit.
521599	6	219 - Main Controller	Cab Position Retract Valve Short Circuit	While output is on: Current feedback > 2A for more than 1 second.
521599	6	220 - Pipe Controller	Row Select Motor Down Short Circuit	Shorted to ground.
521599	31	219 - Main Controller	Cab Position Retract Valve Internal Error	An error occurred in the software or internal controller hardware.
521599	31	220 - Pipe Controller	Row Select Motor Down Internal Error	An error occurred in the software or internal controller hardware.
521600	5	219 - Main Controller	DWATS Pressure Solenoid Open Circuit	While output is on: Current feedback < 30mA for more than 1 second.
521600	5	220 - Pipe Controller	Front Wrench Close Valve Open Circuit	Open circuit.
521600	6	219 - Main Controller	DWATS Pressure Solenoid Short Circuit	While output is on: Current feedback > 2A for more than 1 second.
521600	6	220 - Pipe Controller	Front Wrench Close Valve Short Circuit	Shorted to ground.
521600	31	219 - Main Controller	DWATS Pressure Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521600	31	220 - Pipe Controller	Front Wrench Close Valve Internal Error	An error occurred in the software or internal controller hardware.
521601	5	219 - Main Controller	DWATS Pump Solenoid Open Circuit	While output is on: Current feedback 200 < mA for more than 1 second.
521601	5	220 - Pipe Controller	Rear Wrench Close Valve Open Circuit	Open circuit.

521601	6	219 - Main Controller	DWATS Pump Solenoid Short Circuit	While output is on: Current feedback > 2A for more than 1 second.
521601	6	220 - Pipe Controller	Rear Wrench Close Valve Short Circuit	Shorted to ground.
521601	31	219 - Main Controller	DWATS Pump Solenoid Internal Error	An error occurred in the software or internal controller hardware.
521601	31	220 - Pipe Controller	Rear Wrench Close Valve Internal Error	An error occurred in the software or internal controller hardware.
521708	3	223 - Wireless RX	Right Joystick X Axis Voltage High	Remote transmitter ON : Right joystick X-axis voltage more than 4.75V.
521708	4	223 - Wireless RX	Right Joystick X Axis Voltage Low	Remote transmitter ON : Right joystick X-axis voltage less than 0.25V.
521709	3	223 - Wireless RX	Right Joystick Y Axis Voltage High	Remote transmitter ON : Right joystick Y-axis voltage more than 4.75V.
521709	4	223 - Wireless RX	Right Joystick Y Axis Voltage Low	Remote transmitter ON : Right joystick Y-axis voltage less than 0.25V.
521710	3	223 - Wireless RX	Left Joystick X Axis Voltage High	Remote transmitter ON : Left joystick X-axis voltage more than 4.75V.
521710	4	223 - Wireless RX	Left Joystick X Axis Voltage Low	Remote transmitter ON : Left joystick X-axis voltage less than 0.25V.
521711	3	223 - Wireless RX	Left Joystick Y Axis Voltage High	Remote transmitter ON : Left joystick Y-axis voltage more than 4.75V.
521711	4	223 - Wireless RX	Left Joystick Y Axis Voltage Low	Remote transmitter ON : Left joystick Y-axis voltage less than 0.25V.
521800	31	219 - Main Controller	Rotation Brake Engage Error	System is unable to engage rotation brake due to a failure during engagement process.
521901	31	219 - Main Controller	System Setting Check Sum Fail	A system setting had an invalid checksum.
521901	31	220 - Pipe Controller	System Setting Memory Write Fail	
521901	31	220 - Pipe Controller	System Setting Check Sum Fail	
521901	31	49 - Cab Controller	Switch Memory Write Fail	Internal memory error.
521902	31	219 - Main Controller	System Setting Memory Write Fail	A system setting was unable to be written to memory.
521902	31	220 - Pipe Controller	Row Stop Stuck	The row stop motor is on, but is not moving for more than 10 seconds.
521903	31	219 - Main Controller	Front Lifter High Rear Lifter Low	The front lifter is reading raised, the rear lifter is reading down.
521904	31	219 - Main Controller	Front Lifter Low Rear Lifter High	The front lifter is reading down, the rear lifter is reading raised.
521960	31	219 - Main Controller	Remove Pipe Shuttle Retract New Row Timeout	In automated remove pipe, the gripper relax function took longer than expected.
521961	31	219 - Main Controller	Add Pipe Shuttle Retract New Row Timeout	In automated remove pipe the row stop did not complete movement in the time required.
521962	31	219 - Main Controller	Remove Pipe Shuttle Bump Timeout	In automated remove pipe, the gripper relax function took longer than expected.
521963	31	219 - Main Controller	Add Pipe Shuttle Bump Timeout	In automated remove pipe the row stop did not complete movement in the time required.
521964	31	219 - Main Controller	Remove Pipe Gripper Relax Timeout	In automated remove pipe, the gripper relax function took longer than expected.
521965	31	219 - Main Controller	Remove Pipe Row Stop Movement Timeout	In automated remove pipe the row stop did not complete movement in the time required.
521966	31	219 - Main Controller	Remove Pipe Front Gripper Pipe Misfeed	In automated remove pipe no pipe was in the front gripper but there was a pipe in the rear gripper.
521967	31	219 - Main Controller	Remove Pipe Rear Gripper Pipe Misfeed	In automated remove pipe no pipe was in the rear gripper but there was a pipe in the front gripper.
521968	31	219 - Main Controller	Remove Pipe Shuttle Extend Timeout	Shuttles did not retract before the time out in automated remove pipe.
521969	31	219 - Main Controller	Remove Pipe Gripper Close Timeout	Grippers did not close before the time out in automated remove pipe.
521970	31	219 - Main Controller	Remove Pipe Lifter Down Timeout	Lifters did not move to the down position before the timeout in automated remove pipe.
521971	31	219 - Main Controller	Remove Pipe Retract To Shuttle Stop Timeout	Shuttles did not retract to shuttle stop when automated remove pipe is initializing.
521972	31	219 - Main Controller	Remove Pipe Shuttle Retract Timeout	Shuttles did not retract before the time out in automated remove pipe.
521973	31	219 - Main Controller	Remove Pipe Gripper Open Timeout	Grippers did not open before the time out in automated remove pipe.
521974	31	219 - Main Controller	Remove Pipe Lifter Up Timeout	Lifters did not move to the up position before the timeout in automated remove pipe.
521975	31	219 - Main Controller	Add Pipe Gripper Relax Timeout	In automated add pipe, the gripper relax function took longer than the expected amount of time.
521976	31	219 - Main Controller	Add Pipe Row Stop Movement Timeout	In automated add pipe the row stop did not complete movement in the time required.
521977	31	219 - Main Controller	Add Pipe Front Gripper Pipe Misfeed	In automated add pipe no pipe was in the front gripper but there was a pipe in the rear gripper.
521978	31	219 - Main Controller	Add Pipe Rear Gripper Pipe Misfeed	In automated add pipe no pipe was in the rear gripper but there was a pipe in the front gripper.
521979	31	219 - Main Controller	Add Pipe Shuttle Extend Timeout	Shuttles did not retract before the time out in automated add pipe.
521980	31	219 - Main Controller	Add Pipe Gripper Close Timeout	Grippers did not close before the time out in automated add pipe.
521981	31	219 - Main Controller	Add Pipe Lifter Down Timeout	Lifters did not move to the down position before the timeout in automated add pipe.
521982	31	219 - Main Controller	Add Pipe Retract To Shuttle Stop Timeout	Shuttles did not retract to shuttle stop when automated add pipe is initializing.
521983	31	219 - Main Controller	Add Pipe Shuttle Retract Timeout	Shuttles did not retract before the time out in automated add pipe.
521983	31	247 - Top Display	ESID Controller Communication Lost	Communication has been lost from this controller.
521984	31	219 - Main Controller	Add Pipe Gripper Open Timeout	Grippers did not open before the time out in automated add pipe.
521984	31	247 - Top Display	Supervisory Controller Communication Lost	Communication has been lost from this controller.
521985	31	219 - Main Controller	Add Pipe Lifter Up Timeout	Lifters did not move to the up position before the timeout in automated add pipe.
521985	31	247 - Top Display	Main Controller Communication Lost	Communication has been lost from this controller.
521986	31	219 - Main Controller	Engine Controller Communication Lost	One or more messages from the engine controller to the main controller are not received at the expected rate.
521986	31	247 - Top Display	Engine Controller Communication Lost	Communication has been lost from this controller.
521987	31	219 - Main Controller	Outer Rotation Encoder Communication Lost	One or more messages from the outer rotation encoder to the main controller are not received at the expected rate.

521988	31	219 - Main Controller	Shuttle Encoder Communication Lost	One or more messages from the shuttle encoder to the main controller are not received at the expected rate.
521989	31	219 - Main Controller	Carriage Encoder Communication Lost	One or more messages from the carriage encoder to the main controller are not received at the expected rate.
521990	31	219 - Main Controller	Remote RX Controller Communication Lost	One or more messages from the remote receiver to the main controller are not received at the expected rate.
521990	31	247 - Top Display	Remote RX Controller Communication Lost	Communication has been lost from this controller.
521991	31	219 - Main Controller	Carriage Controller Communication Lost	One or more messages from the carriage controller to the main controller are not received at the expected rate.
521991	31	247 - Top Display	Carriage Controller Communication Lost	Communication has been lost from this controller.
521992	31	219 - Main Controller	Cab Controller Communication Lost	One or more messages from the cab controller to the main controller are not received at the expected rate.
521992	31	247 - Top Display	Cab Controller Communication Lost	Communication has been lost from this controller.
521993	31	219 - Main Controller	Pipe Controller Communication Lost	One or more messages from the pipe controller to the main controller are not received at the expected rate.
521993	31	247 - Top Display	Pipe Controller Communication Lost	Communication has been lost from this controller.
521994	31	219 - Main Controller	J1939 Address Conflict	None.
521994	31	220 - Pipe Controller	J1939 Address Conflict	
521994	31	236 - Carriage Controlle	J1939 Address Conflict	Two devices on the CAN have the same source address.
521994	31	49 - Cab Controller	J1939 Address Conflict	Another CAN device is using the same source address as the cab controller.
521994	31	223 - Wireless RX	J1939 Address Conflict	Two devices of the CAN bus are having same source address.
521995	31	219 - Main Controller	Hardware Protection	None.
521995	31	220 - Pipe Controller	Hardware Protection	
521995	31	236 - Carriage Controlle	Hardware Protection	Internal controller hardware error.
521995	31	49 - Cab Controller	Hardware Protection	Internal controller hardware error.
521996	31	219 - Main Controller	Internal Hardware Error	None.
521996	31	220 - Pipe Controller	Internal Hardware Error	
521996	31	236 - Carriage Controlle	Internal Hardware Error	Internal controller hardware error.
521996	31	49 - Cab Controller	Internal Hardware Error	Internal controller hardware error.
521996	31	223 - Wireless RX	Internal Hardware Error	Internal controller hardware error.
521997	31	219 - Main Controller	Controller Internal System Error	Software errors such as memory allocation.
521997	31	220 - Pipe Controller	Controller Internal System Error	
521997	31	236 - Carriage Controlle	Controller Internal System Error	Internal controller hardware error.
521997	31	49 - Cab Controller	Controller Internal System Error	Internal controller hardware error.
521997	31	223 - Wireless RX	Controller Internal System Error	Internal controller hardware error.
521998	31	219 - Main Controller	Invalid Option Parameter Settings	Options are outside of the acceptable range of values.
521998	31	220 - Pipe Controller	Invalid Option Parameter Settings	Settings stored in non-volatile memory are outside of the expected range or there is a checksum error.
521998	31	236 - Carriage Controlle	Invalid Option Parameter Settings	Options are outside of the acceptable range of values, or the parameter checksum calculation has an error.
521998	31	49 - Cab Controller	Invalid Option Parameter Settings	Settings stored in non-volatile memory are outside of the expected range or there is a checksum error.
521998	31	223 - Wireless RX	Invalid Option Parameter Settings	Settings stored in non-volatile memory are outside of the expected range or there is a checksum error.
521999	31	219 - Main Controller	Invalid Parameters Error	Parameters are outside of the acceptable range of values, or the parameter checksum calculation has an error.
521999	31	220 - Pipe Controller	Invalid Parameters Error	Parameters stored in non-volatile memory are outside of the expected range or there is a checksum error.
521999	31	236 - Carriage Controlle	Invalid Parameters Error	Parameters are outside of the acceptable range of values, or the parameter checksum calculation has an error.
521999	31	49 - Cab Controller	Invalid Parameters Error	Parameters stored in non-volatile memory are outside of the expected range or there is a checksum error.
521999	31	223 - Wireless RX	Invalid Parameters Error	Parameters stored in non-volatile memory are outside of the expected range or there is a checksum error.

Engine Diagnostic Codes

J1939_SPN	J1939_FMI	Cummins' Fault Code	Circuit	Cummins Detailed Description	QSB4.5	QSB6.7
27	4	2272	EGR Valve Position Circuit	Voltage below normal, or shorted to low source	X	X
81	16	2754	Engine Diesel Particulate Filter Intake Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level		X
84	2	241	Wheel-Based Vehicle Speed	Data erratic, intermittent or incorrect	X	X
84	10	242	Wheel-Based Vehicle Speed	Sensor Circuit tampering has been detected , Abnormal rate of change		X
84	19	3525	Wheel-Based Vehicle Speed	Received Network Data In Error		X
91	0	148	Accelerator Pedal or Lever Position Sensor 1	Data valid but above normal operational range , Most Severe Level	X	X
91	1	147	Accelerator Pedal or Lever Position 1 Sensor Circuit Frequency	Data valid but below normal operating Range	X	X
91	2	1242	Accelerator Pedal or Lever Position Sensor 1	Data erratic, intermittent or incorrect	X	X
91	3	131	Accelerator Pedal or Lever Position Sensor 1 Circuit	Voltage above normal, or shorted to high source	X	X
91	4	132	Accelerator Pedal or Lever Position Sensor 1 Circuit	Voltage below normal, or shorted to low source	X	X
91	9	3326	SAE J1939 Multiplexed Accelerator Pedal or Lever Sensor System	Abnormal update rate	X	X
91	19	1515	SAE J1939 Multiplexed Accelerator Pedal or Lever Sensor System	Received Network Data In Error	X	X
94	3	546	Fuel Delivery Pressure Sensor Circuit	Voltage above normal, or shorted to high source	X	X
94	4	547	Fuel Delivery Pressure Sensor Circuit	Voltage below normal, or shorted to low source	X	X
95	16	2372	Fuel Filter Differential Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
97	3	428	Water in Fuel Indicator Sensor Circuit	Voltage above normal, or shorted to high source	X	X
97	4	429	Water in Fuel Indicator Sensor Circuit	Voltage below normal, or shorted to low source	X	X
97	15	418	Water in Fuel Indicator	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
97	16	1852	Water in Fuel Indicator	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
100	1	415	Engine Oil Rifle Pressure	Data valid but below normal operational range , Most Severe Level	X	X
100	2	435	Engine Oil Rifle Pressure	Data erratic, intermittent or incorrect	X	X
100	3	135	Engine Oil Rifle Pressure 1 Sensor Circuit	Voltage above normal, or shorted to high source	X	X
100	4	141	Engine Oil Rifle Pressure 1 Sensor Circuit	Voltage below normal, or shorted to low source	X	X
100	18	143	Engine Oil Rifle Pressure	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
101	0	556	Crankcase Pressure	Data valid but above normal operational range , Most Severe Level	X	X
101	2	1942	Crankcase Pressure	Data erratic, intermittent or incorrect	X	X
101	3	1843	Crankcase Pressure Circuit	Voltage above normal, or shorted to high source	X	X
101	4	1844	Crankcase Pressure Circuit	Voltage below normal, or shorted to low source	X	X
101	15	1974	Crankcase Pressure	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
101	16	555	Crankcase Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
102	3	122	Intake Manifold 1 Pressure Sensor Circuit	Voltage above normal, or shorted to high source	X	X
102	4	123	Intake Manifold 1 Pressure Sensor Circuit	Voltage below normal, or shorted to low source	X	X
102	16	124	Intake Manifold 1 Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level		X
103	15	2288	Turbocharger 1 Speed	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
103	16	595	Turbocharger 1 Speed	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
103	18	687	Turbocharger 1 Speed	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
105	0	155	Intake Manifold 1 Temperature	Data valid but above normal operational range , Most Severe Level	X	X
105	3	153	Intake Manifold 1 Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
105	4	154	Intake Manifold 1 Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
105	15	2964	Intake Manifold 1 Temperature	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
105	16	488	Intake Manifold 1 Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
107	15	5576	Engine Air Filter Differential Pressure	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
107	16	3341	Engine Air Filter Differential Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
108	3	221	Barometric Pressure Sensor Circuit	Voltage above normal, or shorted to high source		X
108	4	222	Barometric Pressure Sensor Circuit	Voltage above normal, or shorted to low source		X
110	0	151	Engine Coolant Temperature	Data valid but above normal operational range , Most Severe Level	X	X
110	3	144	Engine Coolant Temperature 1 Sensor Circuit	Voltage above normal, or shorted to high source	X	X
110	4	145	Engine Coolant Temperature 1 Sensor Circuit	Voltage below normal, or shorted to low source	X	X
110	16	146	Engine Coolant Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
110	31	2646	Engine Coolant Temperature	Condition Exists	X	X
110	31	2659	Engine Coolant Temperature	Condition Exists	X	X
111	1	235	Coolant Level	Data valid but below normal operational range , Most Severe Level	X	X
111	3	195	Coolant Level Sensor 1 Circuit	Voltage above normal, or shorted to high source	X	X
111	4	196	Coolant Level Sensor 1 Circuit	Voltage below normal, or shorted to low source	X	X
111	9	3613	SAE J1939 Multiplexing PGN Timeout Error	Abnormal update rate		X
111	17	2448	Coolant Level	Data Valid But Below Normal Operating Range , Least Severe Level	X	X
111	18	197	Coolant Level	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
111	19	3614	Coolant Level Sensor	Received Network Data in Error		X

J1939_SPN	J1939_FMI	Cummins' Fault Code	Circuit	Cummins Detailed Description	QSB4.5	QSB6.7
157	0	449	Injector Metering Rail 1 Pressure	Data valid but above normal operational range , Most Severe Level	X	X
157	3	451	Injector Metering Rail 1 Pressure Sensor Circuit	Voltage above normal, or shorted to high source	X	X
157	4	452	Injector Metering Rail 1 Pressure Sensor Circuit	Voltage below normal, or shorted to low source	X	X
157	16	553	Injector Metering Rail 1 Pressure	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
157	18	559	Injector Metering Rail 1 Pressure	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
168	16	442	Battery 1 Voltage	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
168	17	3724	Battery 1 Voltage	Data Valid But Below Normal Operating Range , Least Severe Level	X	X
168	18	441	Battery 1 Voltage	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
171	3	249	Ambient Air Temperature Sensor 1 Circuit	Voltage above normal, or shorted to high source		X
171	4	256	Ambient Air Temperature Sensor 1 Circuit	Voltage below normal, or shorted to low source		X
171	9	3531	Ambient Air Temperature	Abnormal update rate		X
190	0	234	Engine Crankshaft Speed/Position	Data valid but above normal operational range , Most Severe Level	X	X
190	2	689	Engine Crankshaft Speed/Position	Data erratic, intermittent or incorrect	X	X
190	2	2321	Engine Crankshaft Speed/Position	Data erratic, intermittent or incorrect	X	X
190	16	2468	Engine Crankshaft Speed/Position	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
191	9	3328	Transmission Output Shaft Speed	Abnormal update rate		X
191	16	349	Transmission Output Shaft Speed	Data Valid But Above Normal Operating Range , Moderately Severe Level		X
191	18	489	Transmission Output Shaft Speed	Data Valid But Below Normal Operating Range , Moderately Severe Level		X
191	19	3418	Transmission Output Shaft Speed	Received Network Data In Error		X
237	13	4517	Vehicle Identification Number	Out of Calibration	X	X
411	2	1866	Exhaust Gas Recirculation Differential Pressure	Data erratic, intermittent or incorrect	X	X
411	3	2273	Exhaust Gas Recirculation Differential Pressure Sensor Circuit	Voltage above normal, or shorted to high source	X	X
411	4	2274	Exhaust Gas Recirculation Differential Pressure Sensor Circuit	Voltage below normal, or shorted to low source	X	X
412	3	2375	Exhaust Gas Recirculation Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
412	4	2376	Exhaust Gas Recirculation Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
412	15	2961	Exhaust Gas Recirculation Temperature	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
412	16	2962	Exhaust Gas Recirculation Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
441	3	293	Auxiliary Temperature Sensor Input 1 Circuit	Voltage above normal, or shorted to high source		X
441	4	294	Auxiliary Temperature Sensor Input 1 Circuit	Voltage below normal, or shorted to low source		X
441	14	292	Auxiliary Temperature Sensor Input 1	Special Instructions		X
442	3	3765	Auxiliary Temperature Sensor Input 2 Circuit	Voltage above normal, or shorted to high source		X
442	4	3766	Auxiliary Temperature Sensor Input 2 Circuit	Voltage below normal, or shorted to low source		X
558	2	431	Accelerator Pedal or Lever Idle Validation Switch	Data erratic, intermittent or incorrect	X	X
558	13	432	Accelerator Pedal or Lever Idle Validation Switch Circuit	Out of Calibration	X	X
558	19	3527	Accelerator Pedal or Lever Idle Validation Switch	Received Network Data In Error	X	X
563	9	3488	Anti-Lock Braking (ABS) Active	Anti-Lock Braking (ABS) Controller , Abnormal update rate	X	X
563	31	4215	Anti-Lock Braking (ABS) Active	Condition Exists	X	X
611	2	523	Auxiliary Intermediate (PTO) Speed Switch Validation	Data erratic, intermittent or incorrect		X
612	2	115	Engine Magnetic Speed/Position Lost Both of Two Signals	Data erratic, intermittent or incorrect	X	X
625	9	291	Proprietary Datalink Error (OEM/Vehicle Datalink)	Abnormal update rate	X	X
629	12	111	Engine Control Module Critical Internal Failure	Bad intelligent device or component	X	X
629	12	343	Engine Control Module Warning Internal Hardware Failure	Bad intelligent device or component	X	X
630	12	3697	Engine Control Module Calibration Memory	Bad intelligent device or component	X	X
633	31	2311	Electronic Fuel Injection Control Valve Circuit	Condition Exists	X	X
639	9	285	SAE J1939 Multiplexing PGN Timeout Error	Abnormal update rate	X	X
639	13	286	SAE J1939 Multiplexing Configuration Error	Out of Calibration	X	X
640	14	599	Auxiliary Commanded Dual Output Shutdown	Special Instructions		X
641	7	2387	VGT Actuator Driver Circuit (Motor)	Mechanical system not responding or out of adjustment	X	X
641	9	2636	VGT Actuator Driver Circuit	Abnormal update rate	X	X
641	11	2198	VGT Actuator Driver Circuit	Root Cause Not Known	X	X
641	12	2634	VGT Actuator Controller	Bad intelligent device or component	X	X
641	13	1898	VGT Actuator Controller	Out of Calibration	X	X
641	13	2449	VGT Actuator Controller	Out of Calibration	X	X
641	15	1962	VGT Actuator Driver Over Temperature (Calculated)	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
641	31	2635	VGT Actuator Driver Circuit	Condition Exists	X	X
644	2	237	External Speed Command Input (Multiple Unit Synchronization)	Data erratic, intermittent or incorrect	X	
647	3	2377	Fan Control Circuit	Voltage above normal, or shorted to high source	X	X
647	4	245	Fan Control Circuit	Voltage below normal, or shorted to low source	X	X
651	5	322	Injector Solenoid Driver Cylinder 1 Circuit	Current below normal or open circuit	X	X

J1939_SPN	J1939_FMI	Cummins' Fault Code	Circuit	Cummins Detailed Description	QSB4.5	QSB6.7
652	5	331	Injector Solenoid Driver Cylinder 2 Circuit	Current below normal or open circuit	X	X
652	7	1141	Injector Solenoid Driver Cylinder 2	Mechanical system not responding or out of adjustment	X	X
653	5	324	Injector Solenoid Driver Cylinder 3 Circuit	Current below normal or open circuit	X	X
653	7	1142	Injector Solenoid Driver Cylinder 3	Mechanical system not responding or out of adjustment	X	X
654	5	332	Injector Solenoid Driver Cylinder 4 Circuit	Current below normal or open circuit	X	X
654	7	1143	Injector Solenoid Driver Cylinder 4	Mechanical system not responding or out of adjustment	X	X
655	5	323	Injector Solenoid Driver Cylinder 5 Circuit	Current below normal or open circuit	X	X
655	7	1144	Injector Solenoid Driver Cylinder 5	Mechanical system not responding or out of adjustment		X
656	5	325	Injector Solenoid Driver Cylinder 6 Circuit	Current below normal or open circuit	X	X
656	7	1145	Injector Solenoid Driver Cylinder 6	Mechanical system not responding or out of adjustment		X
677	3	584	Starter Relay Driver Circuit	Voltage above normal, or shorted to high source	X	X
677	4	585	Starter Relay Driver Circuit	Voltage below normal, or shorted to low source	X	X
697	3	2557	Auxiliary PWM Driver 1 Circuit	Voltage above normal, or shorted to high source	X	X
697	4	2558	Auxiliary PWM Driver 1 Circuit	Voltage below normal, or shorted to low source	X	X
701	14	4734	Auxiliary Input/Output 1	Special Instructions	X	X
702	3	527	Auxiliary Input/Output 2 Circuit	Voltage above normal, or shorted to high source		X
703	3	529	Auxiliary Input/Output 3 Circuit	Voltage above normal, or shorted to high source		X
723	2	778	Engine Camshaft Speed / Position Sensor	Data erratic, intermittent or incorrect	X	X
723	2	2322	Engine Camshaft Speed / Position Sensor	Data erratic, intermittent or incorrect	X	X
723	7	731	Engine Speed / Position Camshaft and Crankshaft Misalignment	Mechanical system not responding or out of adjustment	X	X
729	3	2555	Engine Intake Air Heater 1 Circuit	Voltage above normal, or shorted to high source	X	X
729	4	2556	Engine Intake Air Heater 1 Circuit	Voltage below normal, or shorted to low source	X	X
748	9	3641	Transmission Output Retarder	Abnormal update rate	X	X
974	3	133	Remote Accelerator Pedal or Lever Position Sensor 1 Circuit	Voltage above normal, or shorted to high source	X	X
974	4	134	Remote Accelerator Pedal or Lever Position Sensor 1 Circuit	Voltage below normal, or shorted to low source	X	X
974	19	288	SAE J1939 Multiplexing Remote Accelerator Pedal or Lever Position Sensor System	Received Network Data In Error	X	X
1073	3	2367	Engine Brake Actuator Driver Output 2 Circuit	Voltage above normal, or shorted to high source		X
1073	4	2363	Engine Brake Actuator Driver Output 2 Circuit	Voltage below normal, or shorted to low source		X
1081	9	3555	Engine Wait to Start Lamp	Abnormal update rate	X	X
1172	3	691	Turbocharger 1 Compressor Intake Temperature Circuit	Voltage above normal, or shorted to high source	X	X
1172	4	692	Turbocharger 1 Compressor Intake Temperature Circuit	Voltage below normal, or shorted to low source	X	X
1176	2	743	Turbocharger 1 Compressor Intake Pressure	Data erratic, intermittent or incorrect	X	X
1176	3	741	Turbocharger 1 Compressor Intake Pressure Circuit	Voltage above normal, or shorted to high source	X	X
1176	4	742	Turbocharger 1 Compressor Intake Pressure Circuit	Voltage below normal, or shorted to low source	X	X
1194	13	3298	Anti	theft Encryption Seed , Out of Calibration	X	X
1209	2	2554	Exhaust Gas Pressure 1	Data erratic, intermittent or incorrect	X	X
1209	3	2373	Exhaust Gas Pressure Sensor 1 Circuit	Voltage above normal, or shorted to high source	X	X
1209	4	2374	Exhaust Gas Pressure Sensor 1 Circuit	Voltage below normal, or shorted to low source	X	X
1231	2	3329	J1939 Network #2	Data erratic, intermittent or incorrect	X	X
1235	2	3331	J1939 Network #3	Data erratic, intermittent or incorrect	X	X
1267	3	338	Idle Shutdown Vehicle Accessories Relay Driver Circuit	Voltage above normal, or shorted to high source		X
1267	4	339	Idle Shutdown Vehicle Accessories Relay Driver Circuit	Voltage below normal, or shorted to low source		X
1323	31	1654	Engine Misfire Cylinder 1	Condition Exists	X	X
1324	31	1655	Engine Misfire Cylinder 2	Condition Exists	X	X
1325	31	1656	Engine Misfire Cylinder 3	Condition Exists	X	X
1326	31	1657	Engine Misfire Cylinder 4	Condition Exists	X	X
1327	31	1658	Engine Misfire Cylinder 5	Condition Exists		X
1328	31	1659	Engine Misfire Cylinder 6	Condition Exists		X
1347	3	272	Engine Fuel Pump Pressurizing Assembly 1 Circuit	Voltage above normal, or shorted to high source	X	X
1347	4	271	Engine Fuel Pump Pressurizing Assembly 1 Circuit	Voltage below normal, or shorted to low source	X	X
1347	7	281	Engine Fuel Pump Pressurizing Assembly 1	Mechanical system not responding or out of adjustment	X	X
1349	3	483	Injector Metering Rail 2 Pressure Sensor Circuit	Voltage above normal, or shorted to high source	X	X
1377	2	497	Multiple Unit Synchronization Switch	Data erratic, intermittent or incorrect		X
1378	31	649	Engine Oil Change Interval	Condition Exists	X	X
1387	3	1539	Auxiliary Pressure Sensor Input 1 Circuit	Voltage above normal, or shorted to high source		X
1387	4	1621	Auxiliary Pressure Sensor Input 1 Circuit	Voltage below normal, or shorted to low source		X
1388	3	297	Auxiliary Pressure Sensor Input 2 Circuit	Voltage above normal, or shorted to high source		X
1388	4	298	Auxiliary Pressure Sensor Input 2 Circuit	Voltage below normal, or shorted to low source		X
1388	14	296	Auxiliary Pressure Sensor Input 2	Special Instructions		X

J1939_SPN	J1939_FMI	Cummins' Fault Code	Circuit	Cummins Detailed Description	QSB4.5	QSB6.7
1569	31	3714	Engine Protection Torque Derate	Condition Exists	X	X
1623	9	3186	Tachograph Output Shaft Speed	Abnormal update rate		X
1623	13	5248	Tachograph Output Shaft Speed	Out of Calibration		X
1623	19	3213	Tachograph Output Shaft Speed	Received Network Data In Error		X
1632	14	2998	Engine Torque Limit Feature	Special Instructions		X
1639	0	4789	Fan Speed	Data Valid but Above Normal Operational Range , Most Severe Level	X	X
1639	1	4791	Fan Speed	Data Valid but Below Normal Operational Range , Most Severe Level	X	X
1668	2	4437	J1939 Network #4	Data erratic, intermittent or incorrect	X	X
1675	31	3737	Engine Starter Mode Overcrank Protection	Condition Exists	X	X
1761	1	1673	Aftertreatment 1 Diesel Exhaust Fluid Tank Level	Data valid but below normal operational range , Most Severe Level	X	X
1761	3	1669	Aftertreatment 1 Diesel Exhaust Fluid Tank Level Sensor Circuit	Voltage above normal, or shorted to high source	X	X
1761	4	1668	Aftertreatment 1 Diesel Exhaust Fluid Tank Level Sensor Circuit	Voltage below normal, or shorted to low source	X	X
1761	10	4769	Aftertreatment 1 Diesel Exhaust Fluid Tank Level Sensor	Abnormal Rate of Change	X	X
1761	11	4739	Aftertreatment 1 Diesel Exhaust Fluid Tank Level Sensor	Root Cause Not Known	X	X
1761	13	4732	Aftertreatment 1 Diesel Exhaust Fluid Tank Level Sensor	Out of Calibration		X
1761	17	3497	Aftertreatment 1 Diesel Exhaust Fluid Tank Level	Data Valid But Below Normal Operating Range , Least Severe Level	X	X
1761	18	3498	Aftertreatment 1 Diesel Exhaust Fluid Tank Level	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
2623	3	1239	Accelerator Pedal or Lever Position Sensor 2 Circuit	Voltage above normal, or shorted to high source	X	X
2623	4	1241	Accelerator Pedal or Lever Position Sensor 2 Circuit	Voltage below normal, or shorted to low source	X	X
2630	3	2571	Engine Charge Air Cooler Outlet Temperature	Voltage above normal, or shorted to high source		X
2630	4	2572	Engine Charge Air Cooler Outlet Temperature	Voltage below normal, or shorted to low source		X
2789	15	2346	Turbocharger Turbine Intake Temperature	Data Valid But Above Normal Operating Range , Least Severe	X	X
2791	5	2349	EGR Valve Control Circuit	Current below normal or open circuit	X	X
2791	6	2353	EGR Valve Control Circuit	Current above normal or grounded circuit	X	X
2791	7	2357	EGR Valve Control Circuit	Mechanical system not responding or out of adjustment	X	X
2791	13	1896	EGR Valve Controller	Out of Calibration	X	X
2791	15	1961	EGR Valve Control Circuit Over Temperature	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
3031	2	1679	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature	Data erratic, intermittent or incorrect	X	X
3031	3	1678	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature Sensor	Voltage above normal, or shorted to high source	X	X
3031	4	1677	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature Sensor	Voltage below normal, or shorted to low source	X	X
3031	9	4572	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature	Abnormal Update Rate	X	X
3031	11	4737	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature	Root Cause Not Known		X
3031	13	4731	Aftertreatment 1 Diesel Exhaust Fluid Tank Temperature Sensor	Out of Calibration		X
3216	2	3228	Aftertreatment 1 Intake NOx Sensor	Data erratic, intermittent or incorrect	X	X
3216	4	1885	Aftertreatment 1 Intake NOx Sensor Circuit	Voltage below normal, or shorted to low source	X	X
3216	9	3232	Aftertreatment 1 Intake NOx Sensor	Abnormal update rate	X	X
3216	10	3725	Aftertreatment 1 Intake NOx Sensor	Abnormal rate of change	X	X
3216	13	3718	Aftertreatment 1 Intake NOx	Out of Calibration	X	X
3216	16	3726	Aftertreatment 1 Intake NOx	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
3216	20	3748	Aftertreatment 1 Intake NOx Sensor	Data not Rational , Drifted High	X	X
3218	2	3682	Aftertreatment 1 Intake NOx Sensor Power Supply	Data erratic, intermittent or incorrect	X	X
3226	2	1694	Aftertreatment 1 Outlet NOx Sensor	Data erratic, intermittent or incorrect	X	X
3226	4	1887	Aftertreatment 1 Outlet NOx Sensor Circuit	Voltage below normal, or shorted to low source	X	X
3226	9	2771	Aftertreatment 1 Outlet NOx Sensor	Abnormal update rate	X	X
3226	10	3545	Aftertreatment 1 Outlet NOx Sensor	Abnormal rate of change	X	X
3226	13	3717	Aftertreatment 1 Outlet NOx Sensor	Out of Calibration	X	X
3226	20	3749	Aftertreatment 1 Outlet NOx Sensor	Data not Rational , Drifted High	X	X
3228	2	3681	Aftertreatment 1 Outlet NOx Sensor Power Supply	Data erratic, intermittent or incorrect	X	X
3246	3	3319	Aftertreatment 1 Diesel Particulate Filter Outlet Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
3361	2	2976	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Temperature	Data erratic, intermittent or incorrect	X	X
3361	3	3558	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit	Voltage above normal, or shorted to high source	X	X
3361	4	3559	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit	Voltage below normal, or shorted to low source	X	X
3362	31	1682	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Input Lines	Condition Exists	X	X
3363	3	1683	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	Voltage above normal, or shorted to high source	X	X
3363	4	1684	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	Voltage below normal, or shorted to low source	X	X
3363	7	3242	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	Mechanical system not responding or out of adjustment	X	X
3363	16	1713	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
3363	18	1712	Aftertreatment 1 Diesel Exhaust Fluid Tank Heater	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
3364	2	3878	Aftertreatment Diesel Exhaust Fluid Quality	Data erratic, intermittent or incorrect	X	X

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3364	3	1686	Aftertreatment Diesel Exhaust Fluid Quality Sensor Circuit	Voltage above normal, or shorted to high source	X	X
3364	4	1685	Aftertreatment Diesel Exhaust Fluid Quality Sensor Circuit	Voltage below normal, or shorted to low source	X	X
3364	5	4741	Aftertreatment Diesel Exhaust Fluid Quality Sensor Circuit	Current below normal or open circuit	X	X
3364	6	4742	Aftertreatment Diesel Exhaust Fluid Quality Sensor Circuit	Current above normal or grounded circuit	X	X
3364	7	3876	Aftertreatment Diesel Exhaust Fluid Quality Sensor	Mechanical system not responding or out of adjustment	X	X
3364	9	3868	Aftertreatment Diesel Exhaust Fluid Quality	Abnormal update rate	X	X
3364	10	4277	Aftertreatment Diesel Exhaust Fluid Quality	Abnormal Rate of Change	X	X
3364	11	1715	Aftertreatment Diesel Exhaust Fluid Quality	Root Cause Not Known	X	X
3364	12	3877	Aftertreatment Diesel Exhaust Fluid Quality Sensor	Bad intelligent device or component		X
3364	13	1714	Aftertreatment Diesel Exhaust Fluid Quality	Out of Calibration	X	X
3364	15	4842	Aftertreatment Diesel Exhaust Fluid Quality	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
3364	18	3867	Aftertreatment Diesel Exhaust Fluid Quality	Data Valid But Below Normal Operating Range , Moderate Severe Level	X	X
3364	19	4241	Aftertreatment Diesel Exhaust Fluid Quality	Received Network Data In Error	X	X
3509	3	386	Sensor Supply 1 Circuit	Voltage above normal, or shorted to high source	X	X
3509	4	352	Sensor Supply 1 Circuit	Voltage below normal, or shorted to low source	X	X
3510	3	227	Sensor Supply 2 Circuit	Voltage above normal, or shorted to high source	X	X
3510	4	187	Sensor Supply 2 Circuit	Voltage below normal, or shorted to low source	X	X
3511	3	239	Sensor Supply 3 Circuit	Voltage above normal, or shorted to high source	X	X
3511	4	238	Sensor Supply 3 Circuit	Voltage below normal, or shorted to low source	X	X
3512	3	2185	Sensor Supply 4 Circuit	Voltage above normal, or shorted to high source	X	X
3512	4	2186	Sensor Supply 4 Circuit	Voltage below normal, or shorted to low source	X	X
3513	3	1695	Sensor Supply 5	Voltage above normal, or shorted to high source	X	X
3513	4	1696	Sensor Supply 5	Voltage below normal, or shorted to low source	X	X
3514	3	515	Sensor Supply 6 Circuit	Voltage above normal, or shorted to high source	X	X
3514	4	516	Sensor Supply 6 Circuit	Voltage below normal, or shorted to low source	X	X
3515	5	4743	Aftertreatment 1 Diesel Exhaust Fluid Temperature 2 Sensor Circuit	Current below normal or open circuit	X	X
3515	6	4744	Aftertreatment 1 Diesel Exhaust Fluid Temperature 2 Sensor Circuit	Current above normal or grounded	X	X
3515	10	4243	Aftertreatment 1 Diesel Exhaust Fluid Temperature 2	Abnormal Rate of Change	X	X
3515	11	4745	Aftertreatment 1 Diesel Exhaust Fluid Temperature 2	Root Cause Not Known	X	X
3521	11	4768	Aftertreatment 1 Diesel Exhaust Fluid Property	Root Cause Not Known	X	X
3597	2	1117	Power Supply Lost With Ignition On	Data erratic, intermittent or incorrect	X	X
3597	12	351	Injector Power Supply	Bad intelligent device or component	X	X
3597	18	1938	ECU Power Output Supply Voltage 1	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
3667	2	5221	Engine Air Shutoff Status	Data erratic, intermittent or incorrect		X
3667	3	3139	Engine Air Shutoff Circuit	Voltage above normal, or shorted to high source		X
3667	4	3141	Engine Air Shutoff Circuit	Voltage below normal, or shorted to low source		X
3667	7	4484	Engine Air Shutoff	Mechanical System Not Responding or Out of Adjustment		X
3695	2	4213	Aftertreatment Regeneration Inhibit Switch	Data erratic, intermittent or incorrect	X	X
4094	31	3543	NOx limits exceeded due to Insufficient Reagent Quality	Condition Exists		X
4096	31	3547	Aftertreatment Diesel Exhaust Fluid Tank Empty	Condition Exists	X	X
4185	31	1427	Overspeed Shutdown Relay Driver Diagnostic has detected an error	Condition Exists	X	X
4186	31	1428	Low Oil Pressure (LOP) Shutdown Relay Driver Diagnostic has detected an error	Condition Exists	X	X
4187	31	1429	High Engine Temp. (HET) Shutdown Relay Driver Diagnostic has detected an error	Condition Exists	X	X
4188	31	1431	Pre-Low Oil Pressure Indicator Relay Driver	Pre-Low Oil Pressure Warning Relay Driver Diagnostic has detected an error , Condition Exists	X	X
4223	31	1432	Pre-High Engine Temperature Warning Relay Driver	Pre-High Engine Temp. Warning Relay Driver Diagnostic has detected an error , Condition Exists	X	X
4334	2	3596	Aftertreatment 1 Diesel Exhaust Fluid Pressure Sensor	Data erratic, intermittent or incorrect	X	X
4334	3	3571	Aftertreatment 1 Diesel Exhaust Fluid Pressure Sensor	Voltage above normal, or shorted to high source	X	X
4334	4	3572	Aftertreatment 1 Diesel Exhaust Fluid Pressure Sensor	Voltage below normal, or shorted to low source	X	X
4334	16	3575	Aftertreatment 1 Diesel Exhaust Fluid Pressure Sensor	Data Valid But Above Normal Operating Range	X	X
4334	18	3574	Aftertreatment 1 Diesel Exhaust Fluid Pressure Sensor	Data Valid But Below Normal Operating Range	X	X
4337	10	4249	Aftertreatment 1 Diesel Exhaust Fluid Dosing Temperature	Abnormal Rate of Change	X	X
4340	3	3237	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 1 Circuit	Voltage above normal, or shorted to high source	X	X
4340	4	3238	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 1 Circuit	Voltage below normal, or shorted to low source	X	X
4340	5	3258	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 1 Circuit	Current below normal or open circuit	X	X
4342	3	3239	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2 Circuit	Voltage above normal, or shorted to high source	X	X
4342	4	3241	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2 Circuit	Voltage below normal, or shorted to low source	X	X
4342	5	3261	Aftertreatment 1 Diesel Exhaust Fluid Line Heater 2 Circuit	Current below normal or open circuit	X	X
4344	3	3422	Aftertreatment Diesel Exhaust Fluid Line Heater 3 Circuit	Voltage above normal, or shorted to high source	X	X
4344	4	3423	Aftertreatment Diesel Exhaust Fluid Line Heater 3 Circuit	Voltage below normal, or shorted to low source	X	X

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4344	5	3425	Aftertreatment Diesel Exhaust Fluid Line Heater 3 Circuit	Current below normal or open circuit	X	X
4360	0	3229	Aftertreatment 1 SCR Intake Temperature	Data valid but above normal operational range , Most Severe Level	X	X
4360	2	3144	Aftertreatment 1 SCR Intake Temperature Sensor	Data erratic, intermittent or incorrect	X	X
4360	3	3142	Aftertreatment 1 SCR Intake Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
4360	4	3143	Aftertreatment 1 SCR Intake Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
4360	15	3164	Aftertreatment 1 SCR Intake Temperature	Data Valid But Above Normal Operating Range , Least Severe	X	X
4360	16	3231	Aftertreatment 1 SCR Intake Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
4363	0	3165	Aftertreatment 1 SCR Outlet Temperature	Data valid but above normal operational range , Most Severe	X	X
4363	2	3148	Aftertreatment 1 SCR Outlet Temperature Sensor	Data erratic, intermittent or incorrect	X	X
4363	3	3146	Aftertreatment 1 SCR Outlet Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
4363	4	3147	Aftertreatment 1 SCR Outlet Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
4363	16	3235	Aftertreatment 1 SCR Outlet Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
4364	18	3582	Aftertreatment SCR Catalyst Conversion Efficiency	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
4376	3	3577	Aftertreatment Diesel Exhaust Fluid Return Valve	Voltage above normal, or shorted to high source	X	X
4376	4	3578	Aftertreatment Diesel Exhaust Fluid Return Valve	Voltage below normal, or shorted to low source	X	X
4376	7	4157	Aftertreatment Diesel Exhaust Fluid Return Valve	Mechanical system not responding or out of adjust	X	X
4765	2	3315	Aftertreatment 1 Diesel Oxidation Catalyst Intake Temperature	Data erratic, intermittent or incorrect	X	X
4765	3	3314	Aftertreatment 1 Diesel Oxidation Catalyst Intake Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
4765	4	3313	Aftertreatment 1 Diesel Oxidation Catalyst Intake Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
4765	16	3251	Aftertreatment 1 Diesel Oxidation Catalyst Intake Temperature	Data Valid But Above Normal Operating Range	X	X
4766	0	5387	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature	Data Valid But Above Normal Operating Range , Most Severe Level	X	X
4766	2	5386	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature	Data Erratic, Intermittent, or Incorrect	X	X
4766	3	4533	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature Sensor Circuit	Voltage above normal, or shorted to high source	X	X
4766	4	4534	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature Sensor Circuit	Voltage below normal, or shorted to low source	X	X
4766	15	5389	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
4766	16	5388	Aftertreatment 1 Diesel Oxidation Catalyst Outlet Gas Temperature	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
4792	7	3751	Aftertreatment SCR Catalyst System	Mechanical system not responding or out of adjustment	X	X
4792	14	4585	Aftertreatment 1 SCR Catalyst System	Special Instructions		X
4794	31	3151	Aftertreatment 1 SCR Catalyst System Missing	Condition Exists	X	X
4796	31	1664	Aftertreatment 1 Diesel Oxidation Catalyst Missing	Condition Exists	X	X
5018	11	2637	Aftertreatment 1 Diesel Oxidation Catalyst Face Plugged	Root Cause Not Known	X	X
5018	14	5617	Aftertreatment 1 Diesel Oxidation Catalyst System	Special Instructions	X	X
5024	10	3649	Aftertreatment 1 Intake NOx Sensor Heater	Abnormal rate of change	X	X
5031	10	3583	Aftertreatment 1 Outlet NOx Sensor Heater	Abnormal rate of change	X	X
5125	3	3419	Sensor Supply 7 Circuit	Voltage above normal, or shorted to high source	X	X
5125	4	3421	Sensor Supply 7 Circuit	Voltage below normal, or shorted to low source	X	X
5245	31	4863	Aftertreatment SCR Operator Inducement Active	Condition Exists		X
5246	0	3712	Aftertreatment SCR Operator Inducement	Data valid but above normal operational range , Most Severe level	X	X
5298	18	1691	Aftertreatment 1 Diesel Oxidation Catalyst Conversion Efficiency	Data Valid But Below Normal Operating Range , Moderately Severe Level	X	X
5394	2	3755	Aftertreatment Diesel Exhaust Fluid Dosing Valve	Data erratic, intermittent or incorrect	X	X
5394	5	3567	Aftertreatment Diesel Exhaust Fluid Dosing Valve	Current below normal or open circuit	X	X
5394	7	3568	Aftertreatment Diesel Exhaust Fluid Dosing Valve	Mechanical system not responding or out of adjustment	X	X
5484	3	3633	Engine Fan Clutch 2 Control Circuit	Voltage above normal, or shorted to high source	X	X
5484	4	3634	Engine Fan Clutch 2 Control Circuit	Voltage below normal, or shorted to low source	X	X
5491	3	3562	Aftertreatment Diesel Exhaust Fluid Line Heater Relay	Voltage above normal, or shorted to high source	X	X
5491	4	3563	Aftertreatment Diesel Exhaust Fluid Line Heater Relay	Voltage below normal, or shorted to low source	X	X
5571	0	3741	High Pressure Common Rail Fuel Pressure Relief Valve	Data valid but above normal operational range	X	X
5571	3	4262	High Pressure Common Rail Fuel Pressure Relief Valve	Voltage Above Normal, or Shorted to High Source		X
5571	4	4263	High Pressure Common Rail Fuel Pressure Relief Valve	Voltage below normal, or shorted to low source		X
5571	7	3727	High Pressure Common Rail Fuel Pressure Relief Valve	Mechanical system not responding or out of adjustment	X	X
5571	15	5585	High Pressure Common Rail Fuel Pressure Relief Valve	Data Valid But Above Normal Operating Range , Least Severe Level	X	X
5571	31	4867	High Pressure Common Rail Fuel Pressure Relief Valve	Condition Exists		X
5603	9	3843	Cruise Control Disable Command	Abnormal update rate		X
5603	31	3845	Cruise Control Disable Command	Condition Exists		X
5605	31	3844	Cruise Control Pause Command	Condition Exists		X
5742	3	4161	Aftertreatment Diesel Particulate Filter Temperature Sensor Module	Voltage Above Normal, or Shorted to high source	X	X
5742	4	4162	Aftertreatment Diesel Particulate Filter Temperature Sensor Module	Voltage below normal, or shorted to low source	X	X
5742	9	4151	Aftertreatment Diesel Particulate Filter Temperature Sensor Module	Abnormal update rate	X	X
5742	12	4158	Aftertreatment Diesel Particulate Filter Temperature Sensor Module	Bad intelligent device or component	X	X

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5742	16	4163	Aftertreatment Diesel Particulate Filter Temperature Sensor Module	Data Valid But Above Normal Operating Range	X	X
5743	3	4164	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Voltage Above Normal, or Shorted to high source	X	X
5743	4	4165	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Voltage below normal, or Shorted to low source	X	X
5743	9	4152	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Abnormal update rate	X	X
5743	11	4261	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Root Cause Not Known	X	X
5743	12	4159	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Bad intelligent device or component	X	X
5743	16	4166	Aftertreatment Selective Catalytic Reduction Temperature Sensor Module	Data Valid But Above Normal	X	X
5745	3	4168	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater	Voltage Above Normal, or Shorted to High	X	X
5745	4	4169	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater	Voltage below normal, or shorted to low source	X	X
5745	18	4171	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater	Data Valid But Below Normal Operating Range	X	X
5746	3	4155	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater Relay	Voltage Above Normal, or Shorted to high source	X	X
5746	4	4156	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater Relay	Voltage below normal, or shorted to low source	X	X
5798	10	4251	Aftertreatment 1 Diesel Exhaust Fluid Dosing Unit Heater Temperature	Abnormal Rate of Change	X	X
6655	3	4951	Maintain ECU Power Lamp	Voltage Above Normal, or Shorted to High Source		X
6655	4	4952	Maintain ECU Power Lamp	Voltage Below Normal, or Shorted to Low Source		X
6713	9	5177	VGT Actuator Driver Circuit	Abnormal update rate		X
6713	13	4956	Variable Geometry Turbocharger Actuator Software	Out of Calibration		X
6713	31	4957	Variable Geometry Turbocharger Actuator Software	Condition Exists		X
6802	31	5278	Aftertreatment 1 Diesel Exhaust Fluid Dosing System Frozen	Condition Exists	X	X
6881	9	5653	SCR Operator Inducement Override Switch	Abnormal Update Rate	X	X
6881	13	5654	SCR Operator Inducement Override Switch	Out of Calibration	X	X
6882	3	5393	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Voltage Above Normal or Shorted to High Source	X	X
6882	4	5394	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Voltage Below Normal or Shorted to Low Source	X	X
6882	9	5391	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Abnormal Update Rate	X	X
6882	11	5395	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Root Cause Not Known	X	X
6882	12	5392	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Bad Intelligent Device or Component	X	X
6882	16	5396	Aftertreatment Diesel Oxidation Catalyst Temperature Sensor Module	Data Valid But Above Normal Operating Range , Moderately Severe Level	X	X
6918	31	5632	SCR System Cleaning Inhibited Due to Inhibit Switch	Condition Exists	X	X
6928	31	5631	SCR System Cleaning Inhibited Due to System Timeout	Condition Exists	X	X
520784	3	5183	Fan Blade Pitch Position Sensor Circuit	Voltage Above Normal, or Shorted to High Source	X	X
520784	4	5184	Fan Blade Pitch Position Sensor Circuit	Voltage Below Normal, or Shorted to Low Source	X	X
520784	5	5185	Fan Blade Pitch	Mechanical system not responding or out of adjustment	X	X
520808	31	5291	Engine Emergency Shutdown Switch Actived	Condition Exists		X
520809	31	5292	Excessive Time Since Last Engine Air Shutoff Maintenance Test	Condition Exists		X
524286	31	5617	Aftertreatment 1 Diesel Oxidation Catalyst System	Special Instruction	X	X