



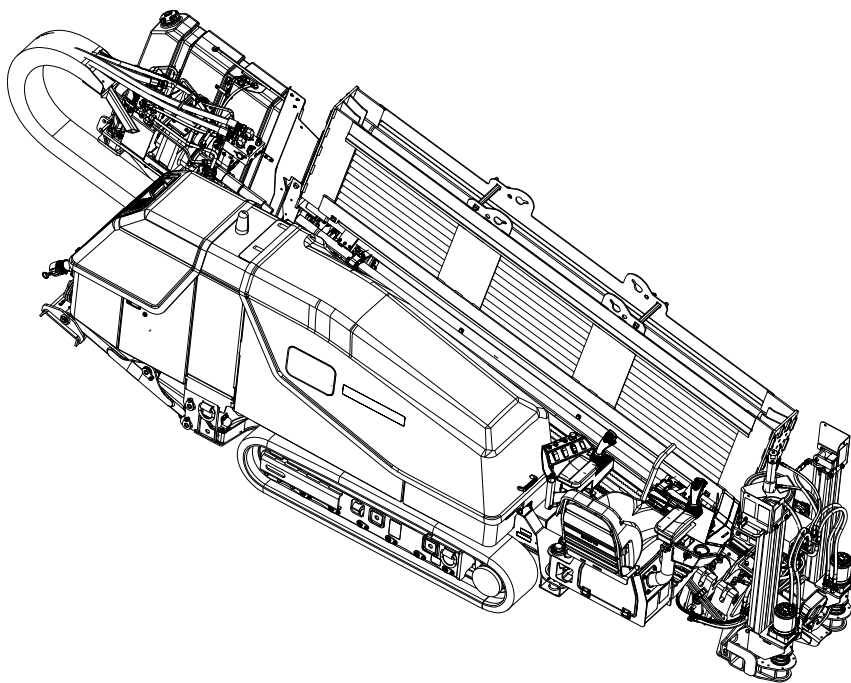
Form No. 3414-730 Rev A

Count on it.

Operator's Manual

2226 Directional Drill

Model No. 23803—Serial No. 400000000 and Up



⚠ WARNING

CALIFORNIA Proposition 65 Warning

This product contains a chemical or chemicals known to the State of California to cause cancer, birth defects, or reproductive harm.

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

It is a violation of California Public Resource Code Section 4442 or 4443 to use or operate the engine on any forest-covered, brush-covered, or grass-covered land unless the engine is equipped with a spark arrester, as defined in Section 4442, maintained in effective working order or the engine is constructed, equipped, and maintained for the prevention of fire.

Introduction

This machine is a directional drill intended for underground drilling and pullback operation for utility lines including: electrical, gas, communication, water, etc. It is designed to operate a wide variety of attachments each of which perform a specialized function. This machine is to be used in temperatures of 17 to 37°C (0 to 100°F).

Before starting or operating the machine, read this information carefully to learn how to operate and maintain your product properly and to avoid injury and product damage. You are responsible for operating the product properly and safely.

You may contact Toro directly at www.Toro.com for product safety and operation training materials, accessory information, help finding a dealer, or to register your product.

Whenever you need service, genuine Toro parts, or additional information, contact an Authorized Service Dealer or Toro Customer Service and have the model and serial numbers of your product ready. [Figure 1](#) identifies the location of the model and serial numbers on the product. Write the numbers in the space provided.

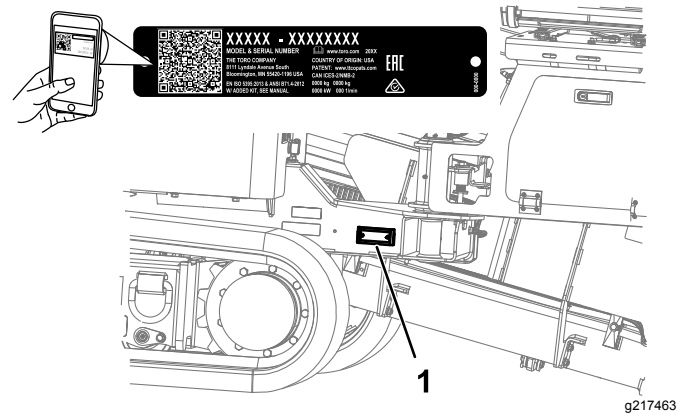


Figure 1

1. Model and serial number location

Model No. _____

Serial No. _____

This manual identifies potential hazards and has safety messages identified by the safety alert symbol ([Figure 2](#)), which signals a hazard that may cause serious injury or death if you do not follow the recommended precautions.



Figure 2

1. Safety alert symbol

This manual uses 2 words to highlight information. **Important** calls attention to special mechanical information and **Note** emphasizes general information worthy of special attention.

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Safety

Important: This machine was manufactured according to the appropriate regulatory standards. Modifying this machine in any way may cause it to be out of compliance with those standards and with the instructions in this *Operator’s Manual*. Modifications to this machine should only be made by only the manufacturer or an Authorized Service Dealer.

Important: Before operating in an area with high-voltage lines or cables, contact a “One-Call System Directory” service. In the USA, call 811 or your local utility company. If you do not know your local utility company’s phone number, call the national number (USA and Canada only) at 1-888-258-0808. In Australia, call 1100 for the nationwide marking service. Also, contact any utility companies that are not participants of the “One-Call System Directory” service. Please refer to [Drilling Near Utility Lines \(page 6\)](#) for more information.

General Safety

This product is capable of amputating hands and feet and of throwing objects. Always follow all safety instructions to avoid serious personal injury.

Using this product for purposes other than its intended use could prove dangerous to you and bystanders.

- Read and understand the contents of this *Operator’s Manual* before starting the engine.
- Do not put your hands or feet near moving components of the machine.
- Do not operate the machine without all guards and other safety protective devices in place and working on the machine.
- Keep bystanders and pets a safe distance away from the machine.
- Never allow children to operate the machine.
- Stop the machine and shut off the engine before servicing or fueling the machine.

Improperly using or maintaining this machine can result in injury. To reduce the potential for injury, comply with these safety instructions and always pay attention to the safety-alert symbol, which means Caution, Warning, or Danger—personal safety instruction. Failure to comply with these instructions may result in personal injury or death.

You can find additional safety information where needed throughout this *Operator’s Manual*.

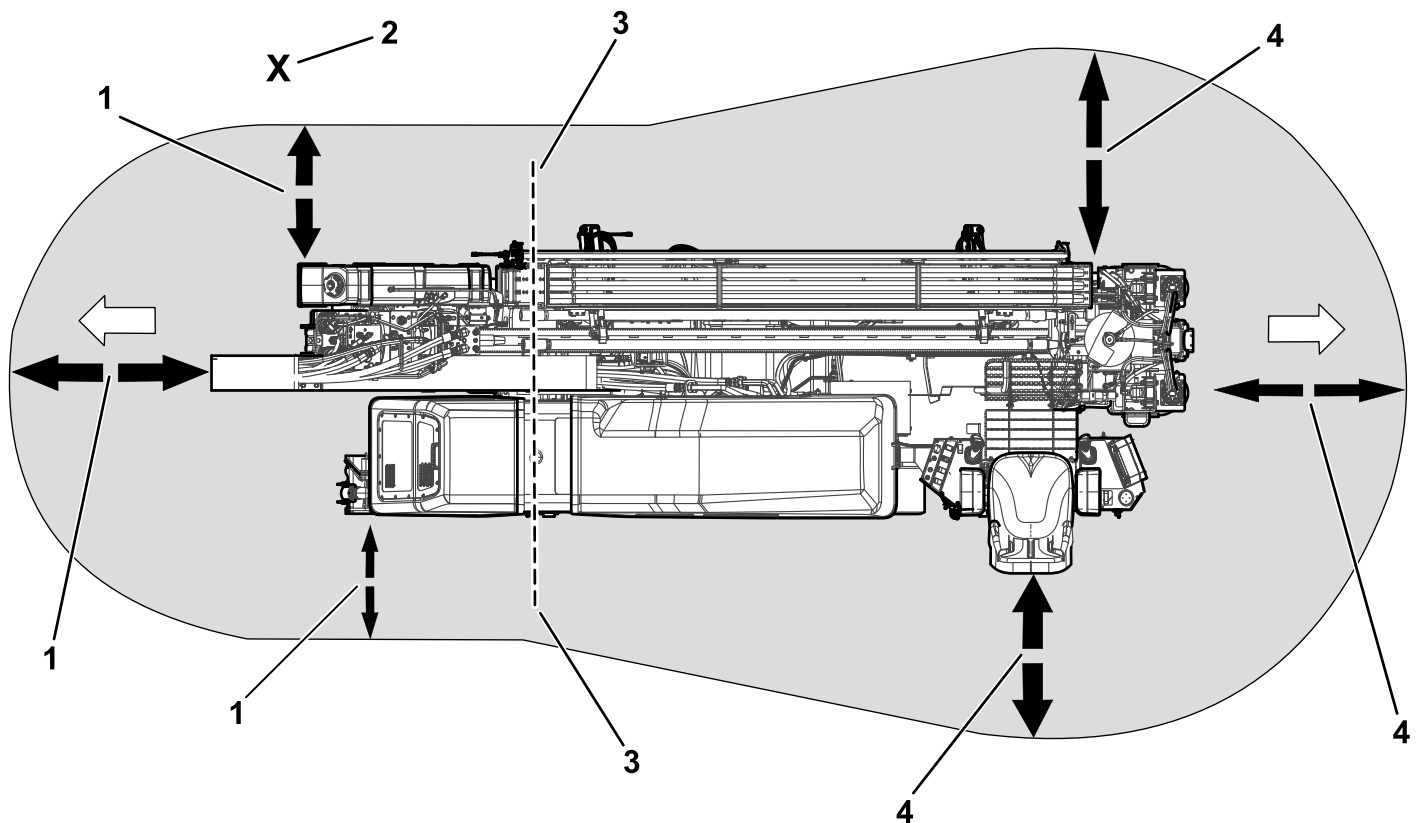
Tramming Safety

You move the machine to and from the work site with the use of a travel pendant. When tramming (moving the machine with the pendant), observe the following safety precautions:

- Operate the travel pendant alongside the machine outside of the danger zone (Figure 3).
- Keep all bystanders away while tramming the machine.
- Do not carry passengers on the machine.
- Watch for the turning-radius sweep of the drill frame, as the center of the turning radius is the end of the track.

- Move slowly when using the pendant for tramming.
- Use care when loading or unloading the machine onto a trailer.
- Watch for traffic when crossing roadways.
- Check for overhead clearances (i.e., doorways, branches, electrical wires) before tramming under any objects and do not contact them.
- When tramming on a slope, you should be uphill from the machine.

Use the following illustration to ensure that bystanders do not enter the danger zone while you are tramming the machine.



g217464

Figure 3
Driving Danger Zone

- | | |
|---------------------------------|---|
| 1. 1.8 m (6 ft) safety distance | 3. Turning-radius center (end of the track) |
| 2. Operator | 4. 2.4 m (8 ft) safety distance |

Drilling Safety

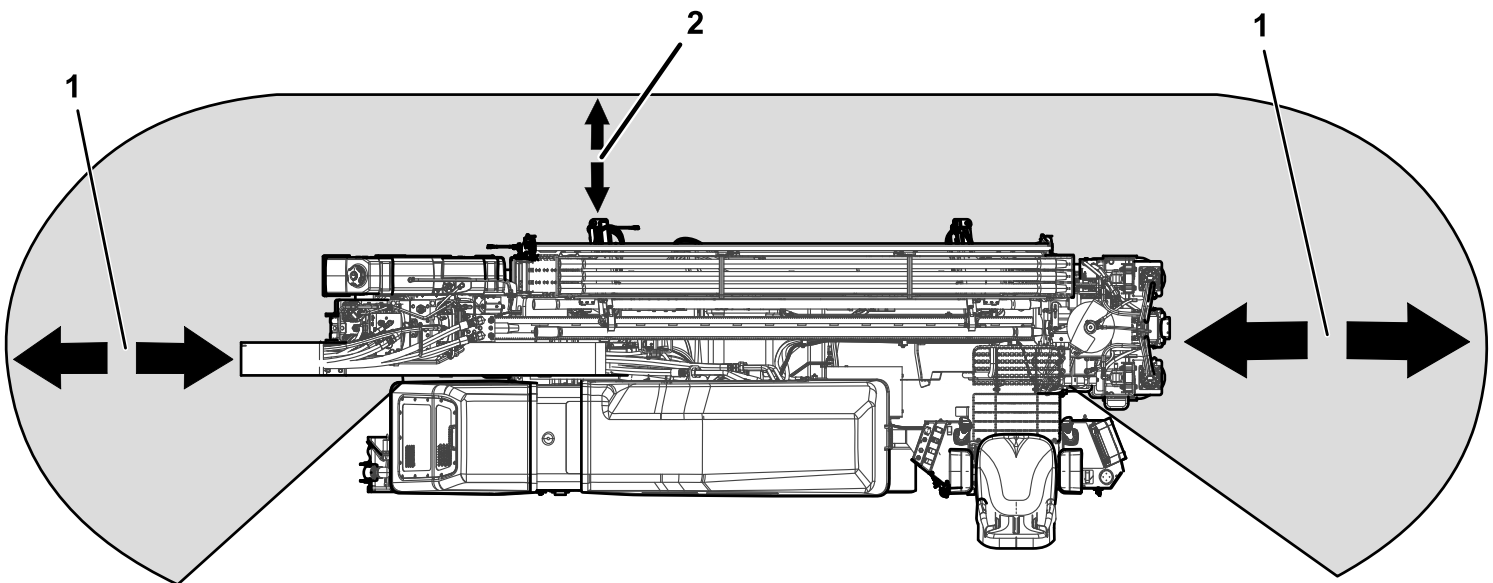
- Always lower the pipe loading guard before drilling (Figure 4).
- Always engage the exit side lockout before operating.
- Keep bystanders and pets a safe distance away from the machine.
- Stop operating the machine if anyone enters the drilling danger zone.
- Ensure that no one approaches a pipe while it is spinning.

Drilling Danger Zone

The danger zone is the area within and around the machine where a person is exposed to the risk of injury.

The danger zone defines the amount of space needed for safe drilling operation, including movement of the carriage.

Use the following illustration to ensure that bystanders do not enter the danger zone while you are drilling.



g217462

Figure 4
Drilling Danger Zone

1. 3 m (10 ft) safety distance

2. 1.8 m (6 ft) safety distance

Drilling Near Utility Lines

Important: Before operating in an area with high-voltage lines or cables, contact a “One-Call System Directory” service. In the USA, call 811 or your local utility company. If you do not know your local utility company’s phone number, call the national number (USA and Canada only) at 1-888-258-0808. In Australia, call 1100 for the nationwide marking service. Also, contact any utility companies that are not participants of the “One-Call System Directory” service.

Utility Line Color

Refer to the following table for the proper utility line and the corresponding utility line color (USA and Canada).

Utility Line	Utility Line Color
Electric	Red
Telecommunication, alarm or signal, cables, or conduit	Orange
Natural gas, oil, steam, petroleum, or other gaseous or flammable material	Yellow
Sewer and drain	Green
Drinking water	Blue
Reclaimed water, irrigation, and slurry lines	Purple
Temporary survey markings	Pink
Proposed excavation limits	White

Electrical and Communication Line Safety

⚠ WARNING

If you leave the seat of the machine or touch any part of the machine when it is charged with electricity, serious injury or death could result.

Do not leave the seat of the machine if the machine is charged with electricity.

⚠ CAUTION

If you damage the fiber-optic cable and look into the exposed highly-intense light, you may harm your eyes.

- Shut off the machine and remove the key.
- Remove all individuals from the work area.
- Immediately contact the proper emergency and utility authorities to secure the area.

In the event of an electric strike that charges the machine, the Zap-Alert alarm system will sound for as long as the machine is charged with power.

Note: Immediately contact the proper emergency and utility authorities to secure the area in case the machine is charged and you cannot leave the seat of the machine.

Note: It is possible to strike a utility line without the machine becoming charged.

- The alarm will sound if the drill contacts an electrical power source.
- Do not attempt to leave the machine.

Note: You will be safe as long as you do not leave the seat of the machine.

- Touching any part of the machine may ground you.
- Do not allow another individual to touch or approach the machine when charged.
- The alarm may sound if a communication line is broken, but until you are certain, you must consider the alarm to be an electric strike.

Gas Line Safety

⚠ WARNING

If you damage a gas line, an immediate explosion and fire hazard could occur. Leaking gas is both flammable and explosive and may cause serious injury or death.

- Do not smoke while operating the machine.
- Shut off the machine and remove the key.
- Remove all individuals from the work area.
- Immediately contact the proper emergency and utility authorities to secure the area.

Water Line Safety

If you damage a water line, a potential flood hazard could occur.

- Shut off the machine and remove the key.
- Remove all individuals from the work area.
- Immediately contact the proper emergency and utility authorities to secure the area.

Safety and Instructional Decals



Safety decals and instructions are easily visible to the operator and are located near any area of potential danger. Replace any decal that is damaged or missing.



Battery Symbols

Some or all of these symbols are on your battery

- | | |
|--|--|
| 1. Explosion hazard | 6. Keep bystanders a safe distance from the battery. |
| 2. No fire, open flame, or smoking. | 7. Wear eye protection; explosive gases can cause blindness and other injuries |
| 3. Caustic liquid/chemical burn hazard | 8. Battery acid can cause blindness or severe burns. |
| 4. Wear eye protection | 9. Flush eyes immediately with water and get medical help fast. |
| 5. Read the <i>Operator's Manual</i> . | 10. Contains lead; do not discard. |

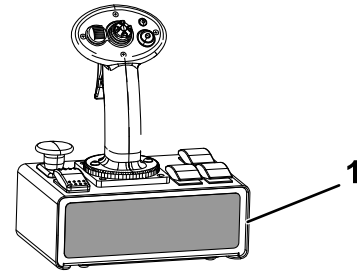
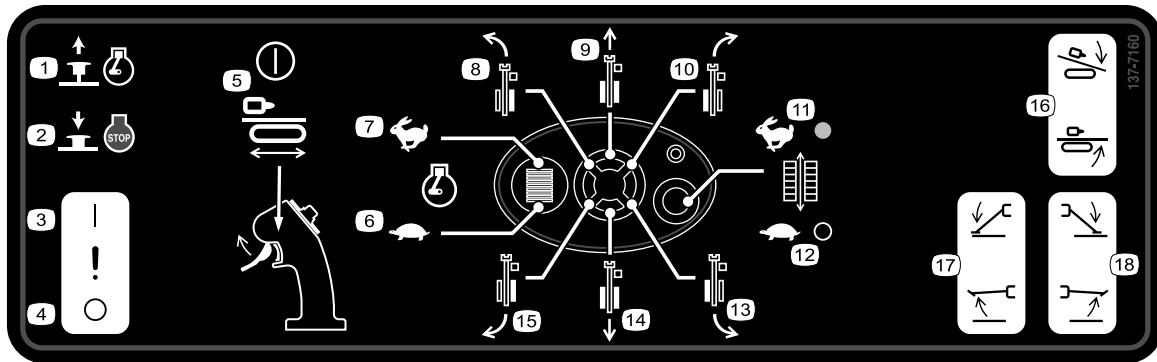


Figure 5

g228534

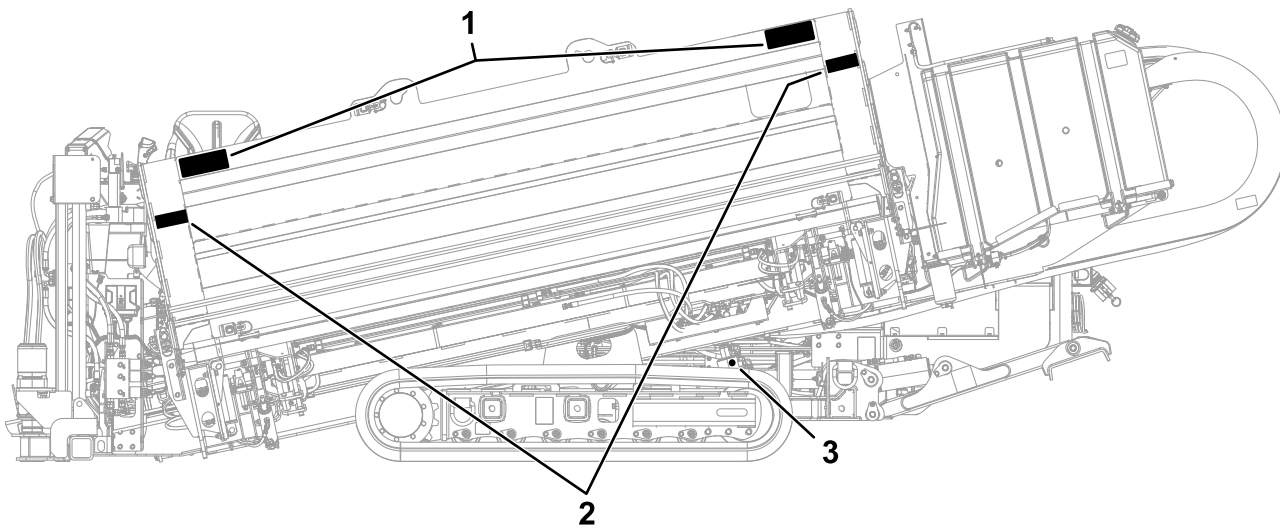
1. 137-7160



137-7160

decals137-7160

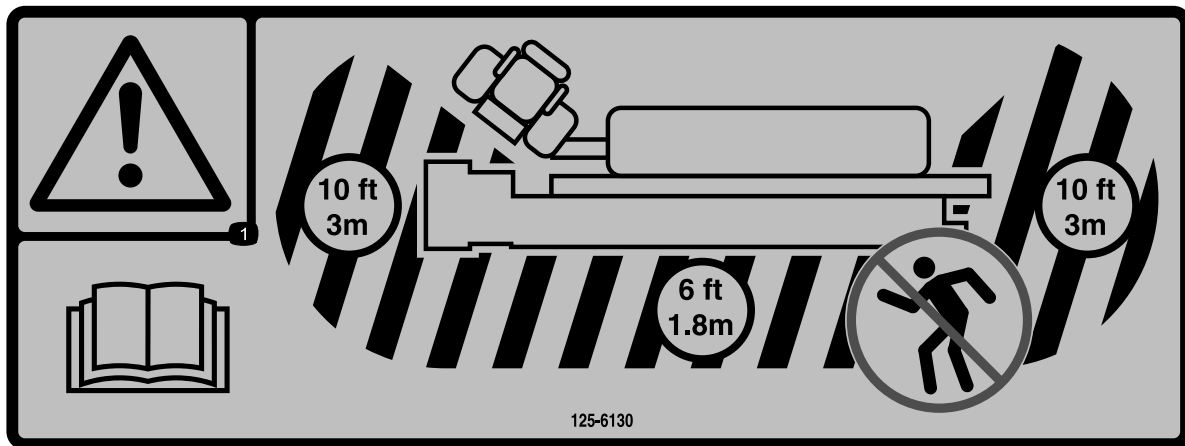
- | | |
|--------------------------------------|---------------------------------------|
| 1. Emergency engine stop—release | 10. Tramming direction—forward-right |
| 2. Emergency engine stop—engage | 11. Tramming speed—fast |
| 3. Setup operator presence—on | 12. Tramming speed—slow |
| 4. Setup operator presence—off | 13. Tramming direction—backward-right |
| 5. Tramming operator presence—on/off | 14. Tramming direction—backward |
| 6. Engine speed—decrease | 15. Tramming direction—backward-left |
| 7. Engine speed—increase | 16. Thrust frame—raise/lower |
| 8. Tramming direction—forward-left | 17. Left stabilizer foot—raise/lower |
| 9. Tramming direction—forward | 18. Right stabilizer foot—raise/lower |



g228521

Figure 6

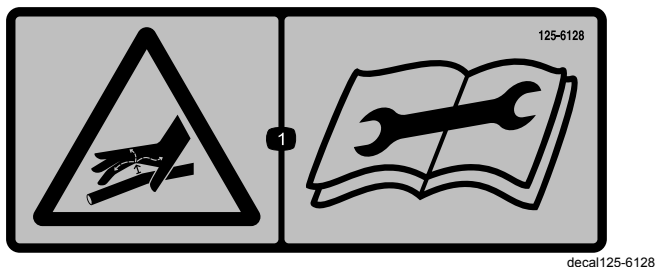
1. 125-6130
2. 125-6128
3. 125-6115



decal125-6130

125-6130

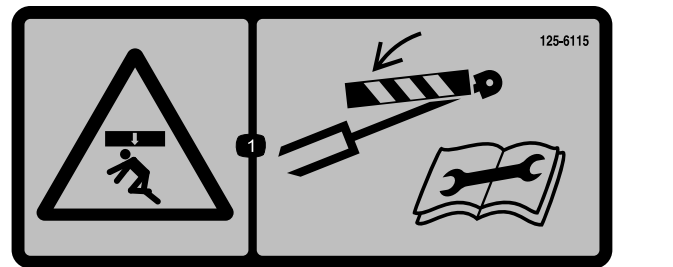
1. Warning—read the *Operator's Manual*; stay at least 3 m (10 ft) away from the front and rear of the machine and 1.8 m (6 ft) away from the sides of the machine.



decal125-6128

125-6128

1. High pressure fluid hazard, injection into the body—read the *Operator's Manual* before performing maintenance.



decal125-6115

125-6115

1. Crushing hazard—deploy cylinder locks before performing maintenance.

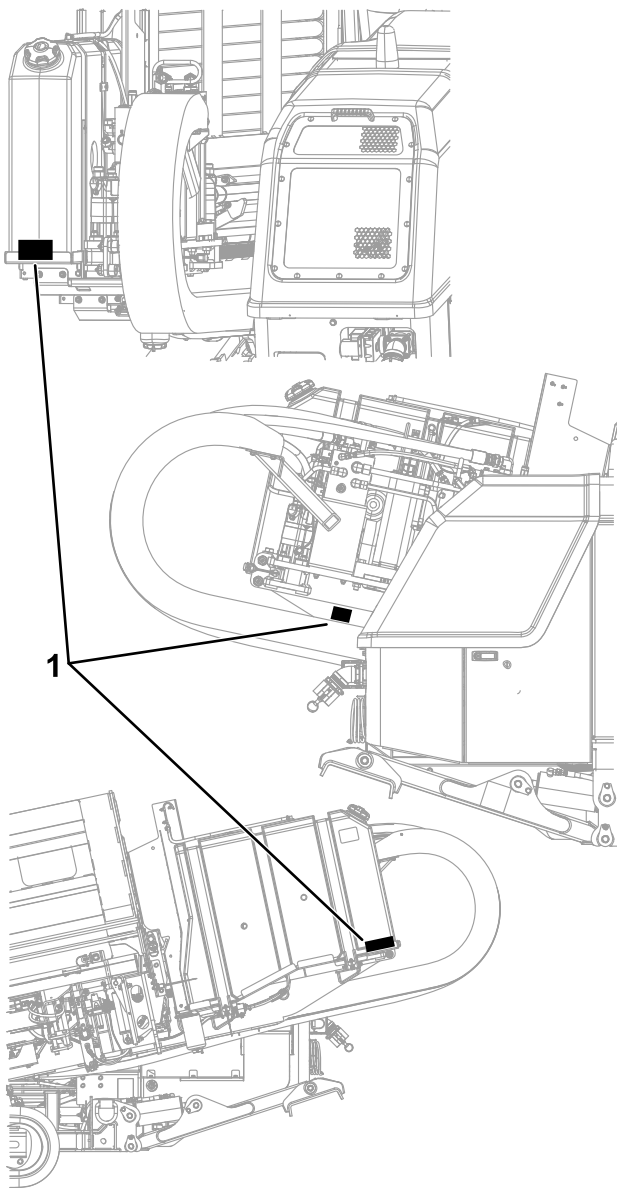
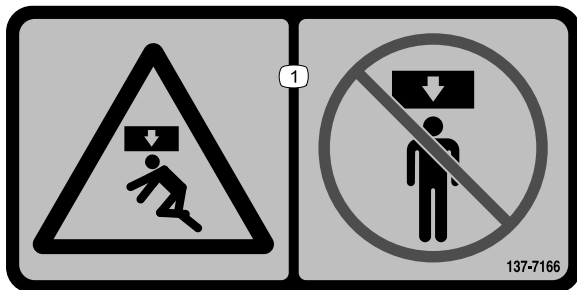


Figure 7

g228522

1. 137-7166



137-7166

decal137-7166

1. Crushing hazard—do not stand under the machine.

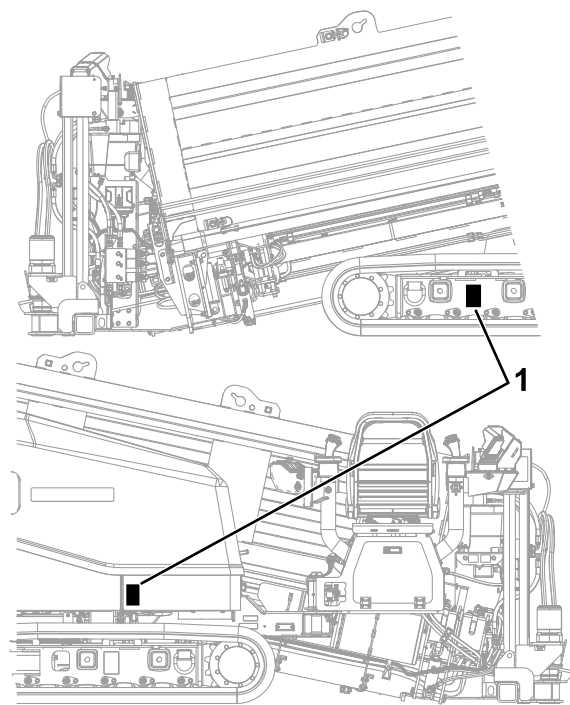
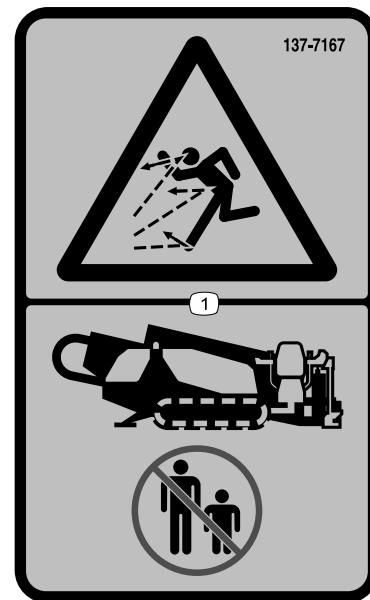


Figure 8

g228523

1. 137-7167



137-7167

decal137-7167

1. Thrown object hazard—keep bystanders away from the machine.

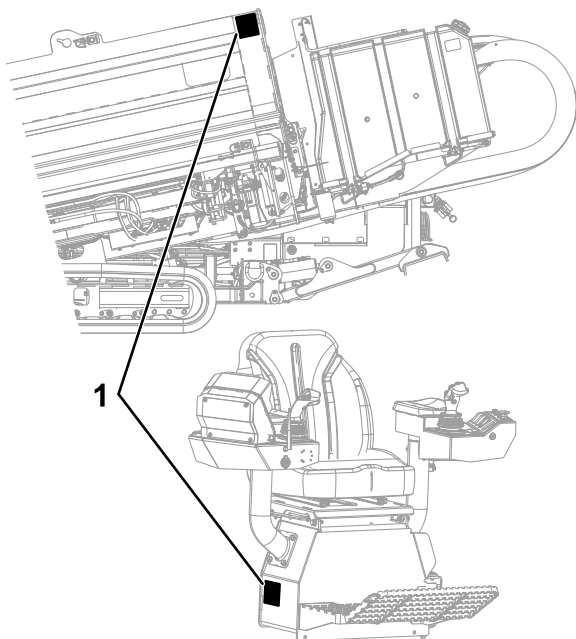
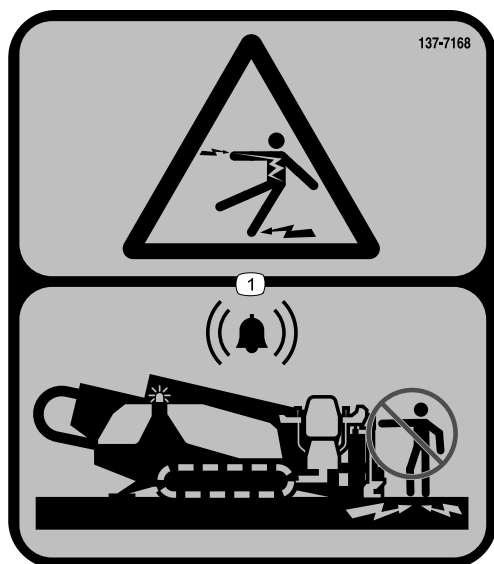


Figure 9

g228524

1. 137-7168



137-7168

decal137-7168

1. Electrocution hazard—do not touch the machine when the alarm is sounding.

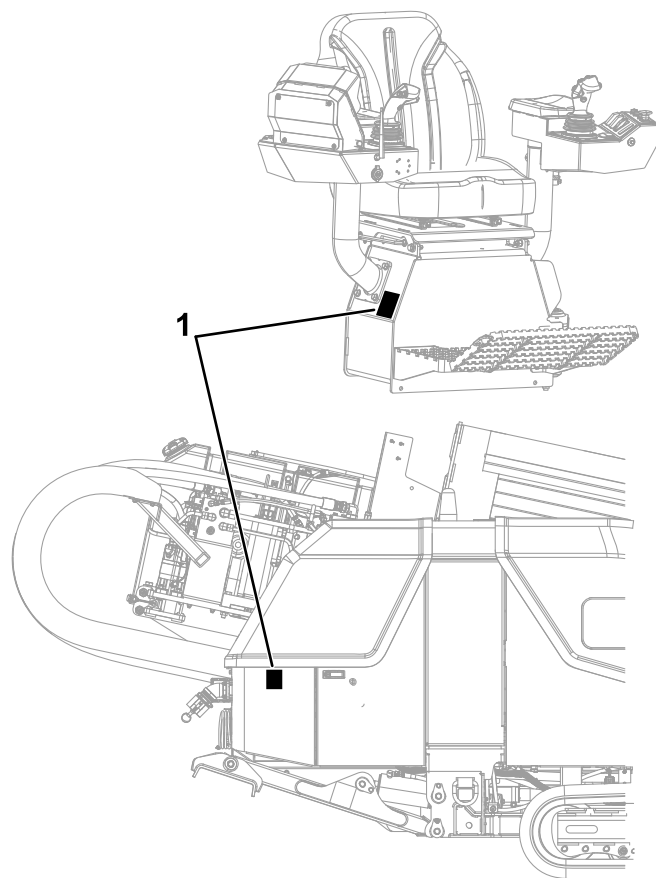
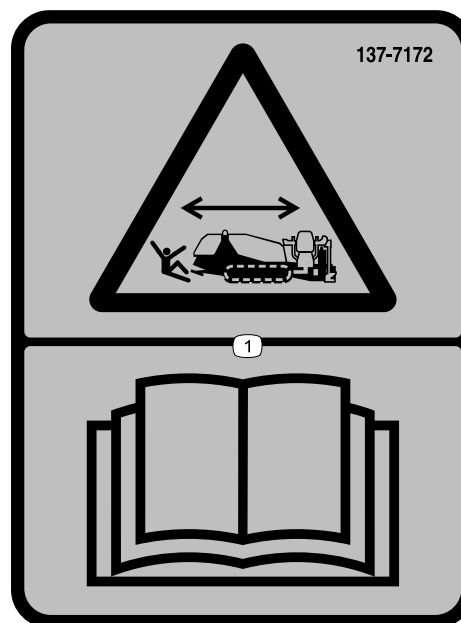


Figure 10

g228525

1. 137-7172



137-7172

decal137-7172

1. Runover/backover hazard—read the *Operator's Manual*.

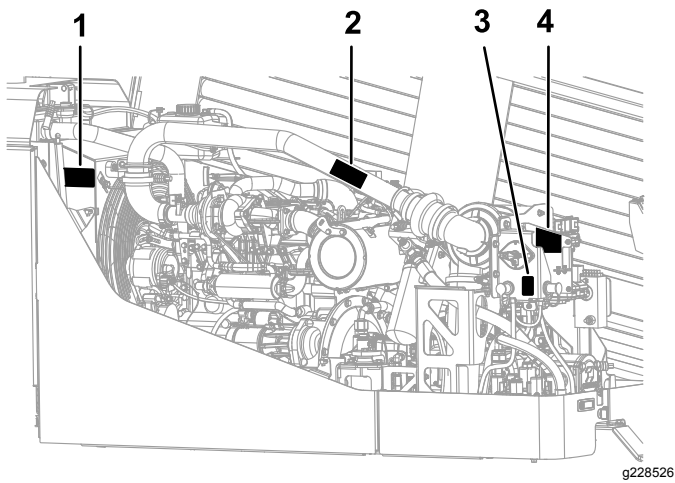
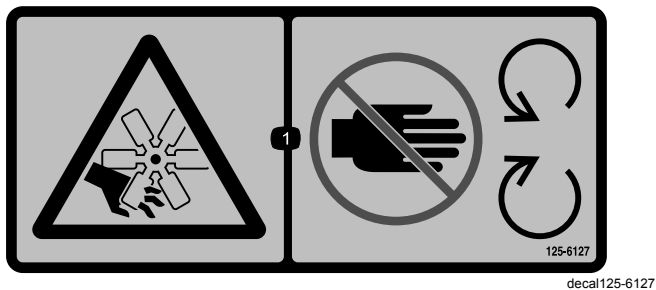


Figure 11

- | | |
|-------------|-------------|
| 1. 125-6127 | 3. 137-7164 |
| 2. 125-6129 | 4. 137-7174 |



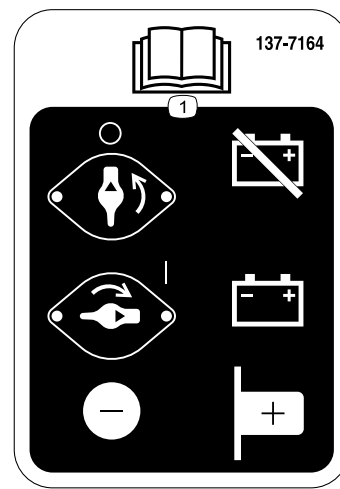
125-6127

1. Cutting/dismemberment hazard, fan—keep away from moving parts.



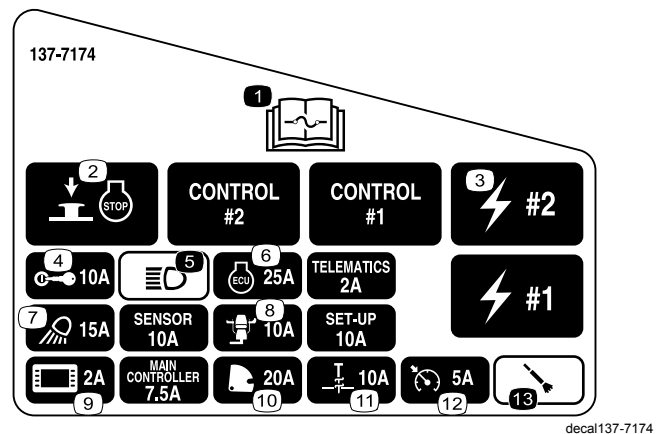
125-6129

1. Hot surface—keep away from hot surfaces.



137-7164

1. Read the *Operator's Manual*—rotate counter clockwise to disconnect the battery; rotate clockwise to connect the battery; the negative post is located below the switch; the positive post is located to the side of the switch.



137-7174

- | | |
|--|----------------------|
| 1. Read the <i>Operator's Manual</i> for information on fuses. | 8. Operator platform |
| 2. Emergency engine stop button | 9. Display |
| 3. Electric | 10. Cam |
| 4. Key switch | 11. Stake |
| 5. Headlights | 12. Auto drill |
| 6. Engine control unit | 13. Air hammer |
| 7. Work lights | |

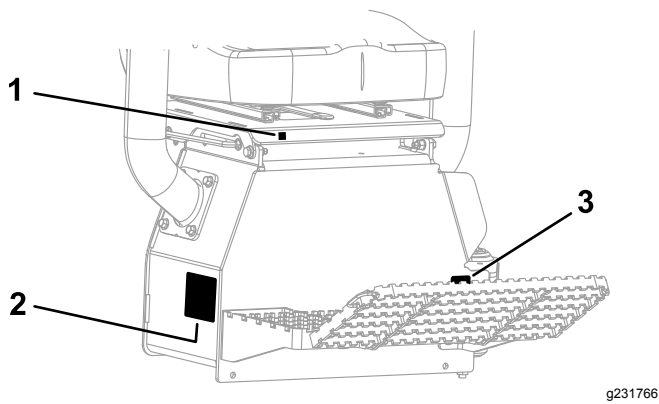


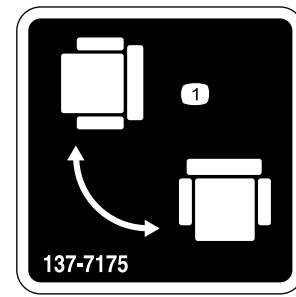
Figure 12

1. 125-6152
2. 137-7171
3. 137-7175



125-6152

1. Move seat forward and backward.



137-7175

1. Rotate the operator platform.

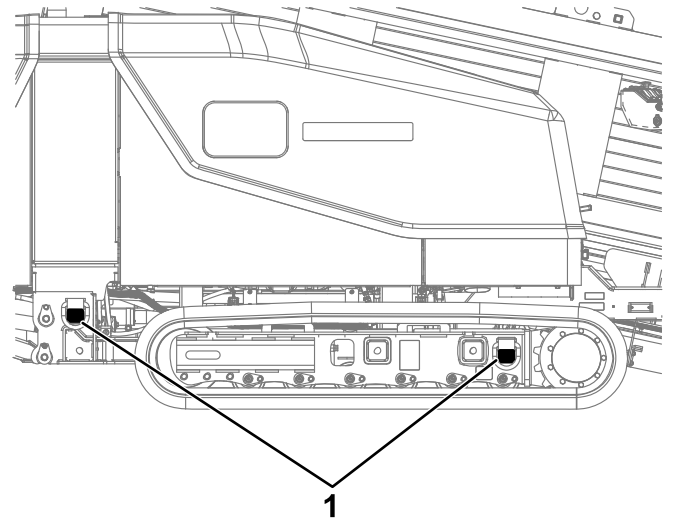
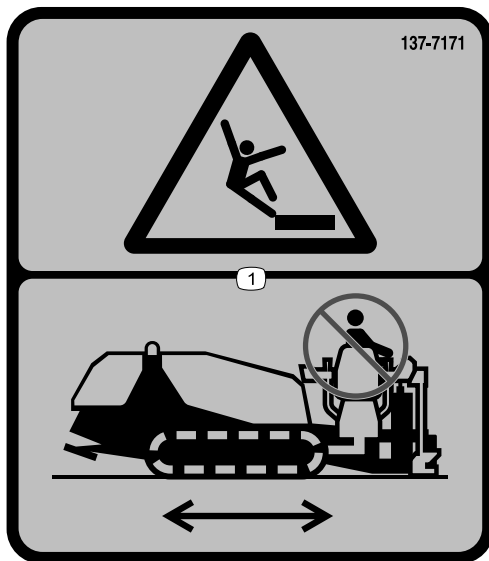


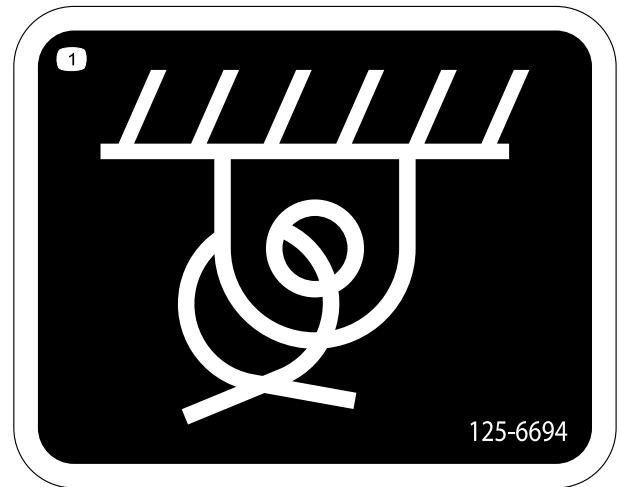
Figure 13

1. 125-6694



137-7171

1. Falling hazard—do not ride on the machine while it is moving.



125-6694

1. Tie-down location

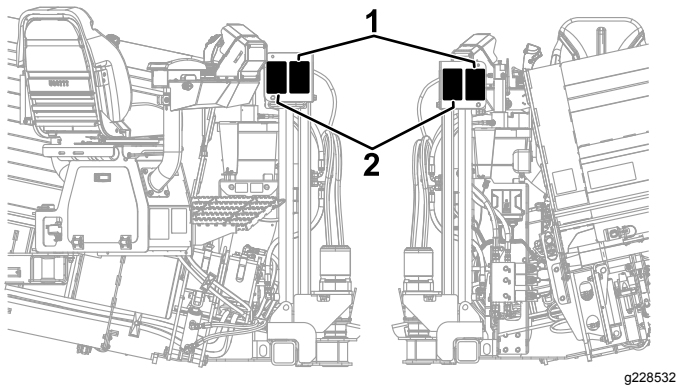


Figure 14

1. 137-7179
2. 137-7178

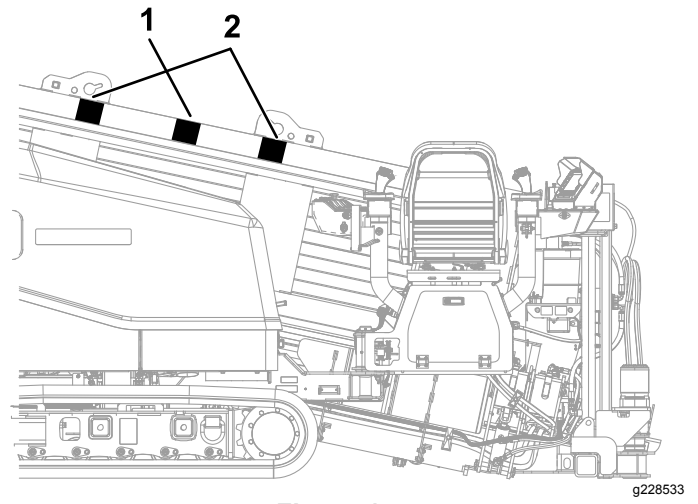
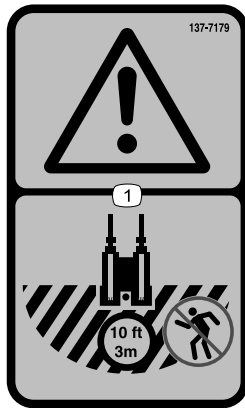


Figure 15

1. 125-6197
2. 125-4967



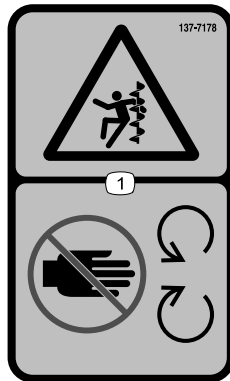
137-7179

1. Warning—hazardous area; keep at least 3 m (10 ft) away from the machine during operation.



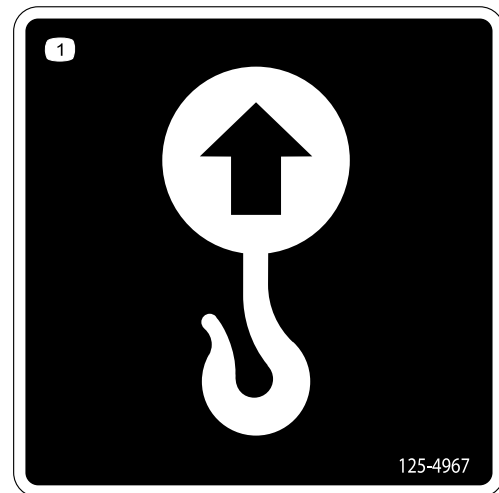
125-6197

1. Max weight limit—1342 kb (2,958 lb)



137-7178

1. Entanglement hazard—keep away from moving parts.



125-4967

1. Lift point

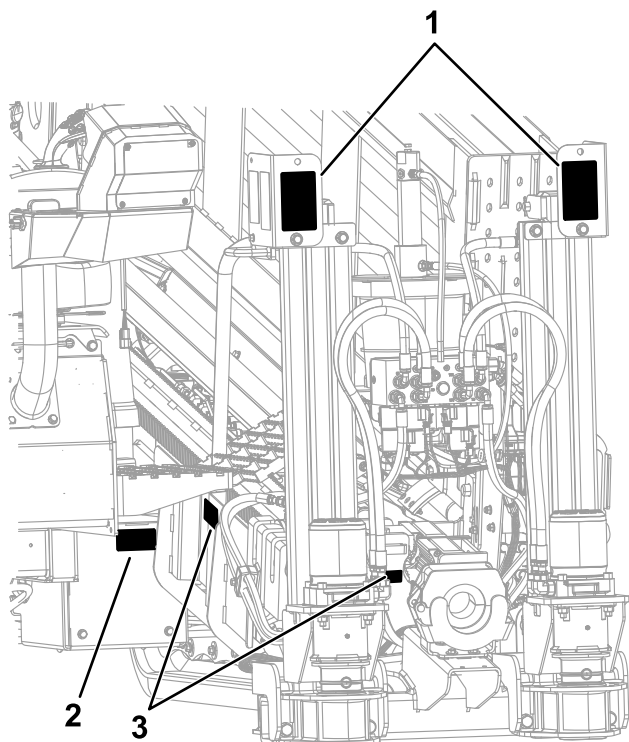


Figure 16

g228531

1. 137-7180
2. 125-8473

3. 125-6119



137-7180

decal137-7180

1. Impact hazard—do not use a pipe wrench; refer to the *Operator's Manual*.



decal125-8473

125-8473

1. Explosion hazard—wear eye protection.
2. Caustic liquid/chemical burn hazard—rinse affected area and seek medical assistance.
3. Fire hazard—keep open flames away.
4. Poison hazard—do not tamper with the battery.



decal125-6119

125-6119

1. Entanglement hazard—keep away from moving objects.

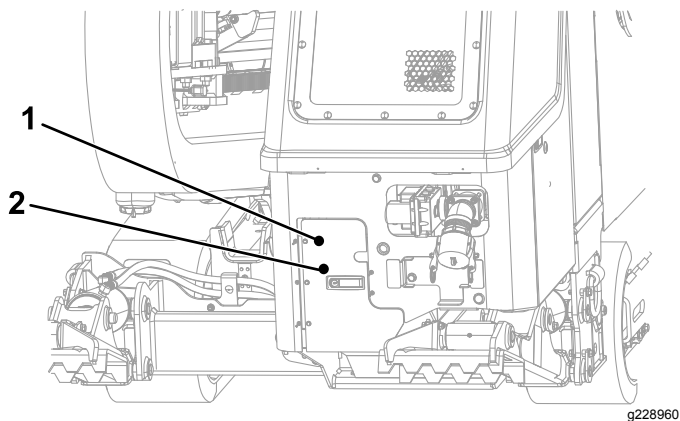


Figure 17

1. 117-2718

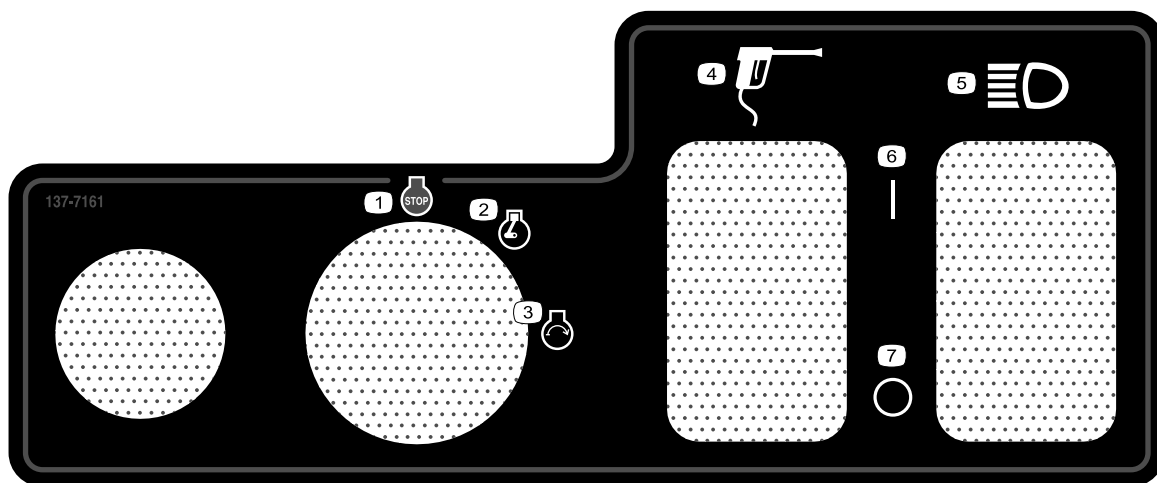
2. 137-7161

CALIFORNIA SPARK ARRESTER WARNING

Operation of this equipment may create sparks that can start fires around dry vegetation. A spark arrester may be required. The operator should contact local fire agencies for laws or regulations relating to fire prevention requirements. 117-2718

decal117-2718

117-2718



decal137-7161

137-7161

1. Engine—stop
2. Engine—run
3. Engine—start
4. Spray gun

5. Headlights
6. On
7. Off

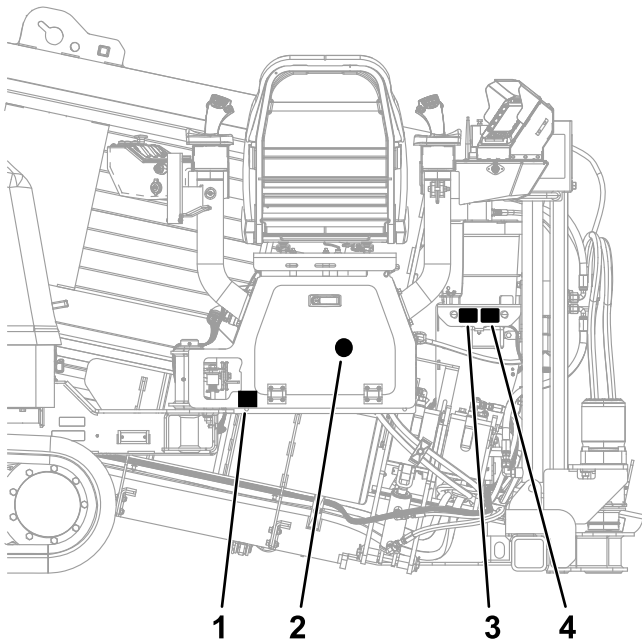
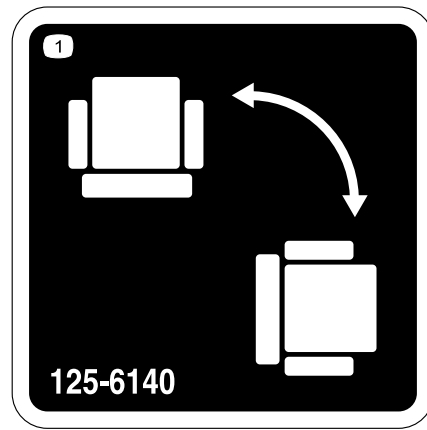


Figure 18

- | | |
|-------------|-------------|
| 1. 125-6140 | 3. 137-7182 |
| 2. 137-7183 | 4. 125-6124 |



125-6140

decal125-6140

1. Rotate the chair.

DD2226, MODEL 23803

QUICK REFERENCE AID

CHECK/SERVICE (DAILY)

1. ENGINE OIL LEVEL	5. FUEL / WATER SEPARATOR
2. HYDRAULIC FLUID LEVEL	6. ALTERNATOR BELT TENSION
3. ENGINE COOLANT LEVEL	7. TRACK TENSION PRESSURE
4. FUEL - ULTRA LOW SULFUR DIESEL ONLY	8. DRILLING FLUID PUMP OIL LEVEL
	9. GREASE POINTS (51)

SERVICE PARTS

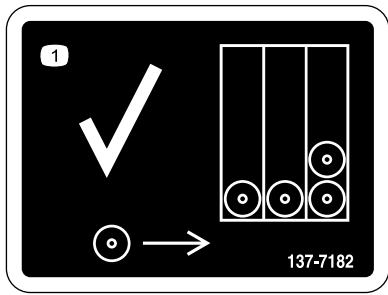
DESCRIPTION / LOCATION	PART NO.
GRIPPER - ROTATING	133-9644
GRIPPER - FIXED	133-9643
CAM WEAR PAD - SHORT	131-8882
CAM WEAR PAD	131-8884
ROD GUIDE BUSHING	AU113442
TONG DIE	AU12GB8036

SEE OPERATOR'S MANUAL FOR INITIAL CHANGES.	FLUID TYPE	CAPACITY	CHANGE INTERVAL		FILTER PART NO.
			FLUID	FILTER	
ENGINE OIL	10W-30 CJ-4	11.8 QTS	250 HOURS	250 HOURS	125-7025 (A)
HYDRAULIC FLUID	ISO VG 46	20.5 GAL	800 HOURS	800 HOURS	94-2621 RETURN FILTER (B) 94-2621 CHARGE FILTER (C)
PRIMARY AIR FILTER					SEE OPERATOR'S MANUAL 108-3815 (D)
SAFETY AIR FILTER					SEE OPERATOR'S MANUAL 130-9070 (E)
FUEL SYSTEM	> 32° F	NO. 2 DIESEL B20	30 GAL	800 HOURS DRAIN/FLUSH	400 HOURS / YEARLY
	< 32° F	NO. 1 DIESEL			
ENGINE COOLANT	50% WATER 50% ETHYL GLYCOL		DRAIN & FLUSH EVERY 2 YRS.		125-2915 FUEL WATER SEPARATOR (F) 125-8752 ENGINE FUEL FILTER (G)
MUD PUMP	SAE 30 NON-DETERGENT	2 QTS	400 HRS		
ROTARY GEARBOX	85W 140	1.4 QTS	800 HOURS DRAIN/FLUSH		
TRACK PLANETARY	85W 140	1.5 QTS	800 HOURS DRAIN/FLUSH		

137-7183

decal137-7183

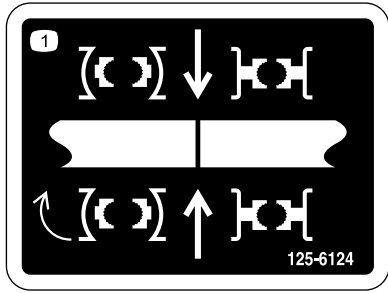
1. Read the *Operator's Manual*.



decal137-7182

137-7182

1. Load pipes from back row first.



decal125-6124

125-6124

1. Center the pipe joint between the upper and lower wrenches.

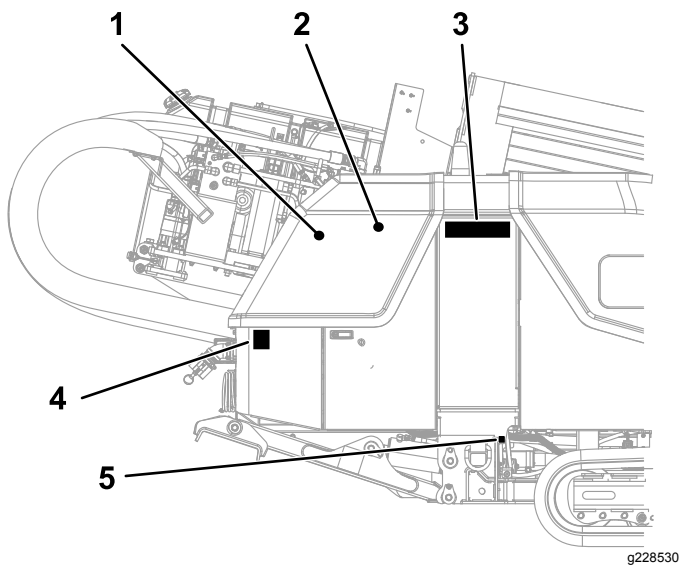
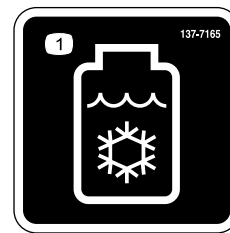


Figure 19

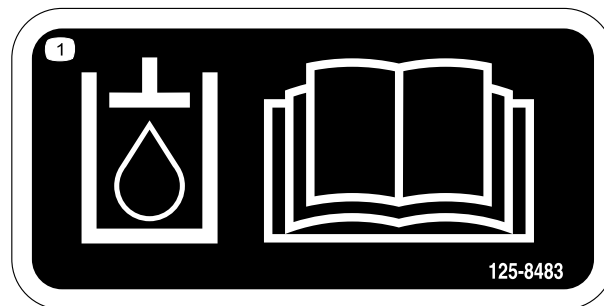
- | | |
|-------------|-------------|
| 1. 137-7165 | 4. 137-7170 |
| 2. 125-8483 | 5. 127-1829 |
| 3. 137-7169 | |



137-7165

decal137-7165

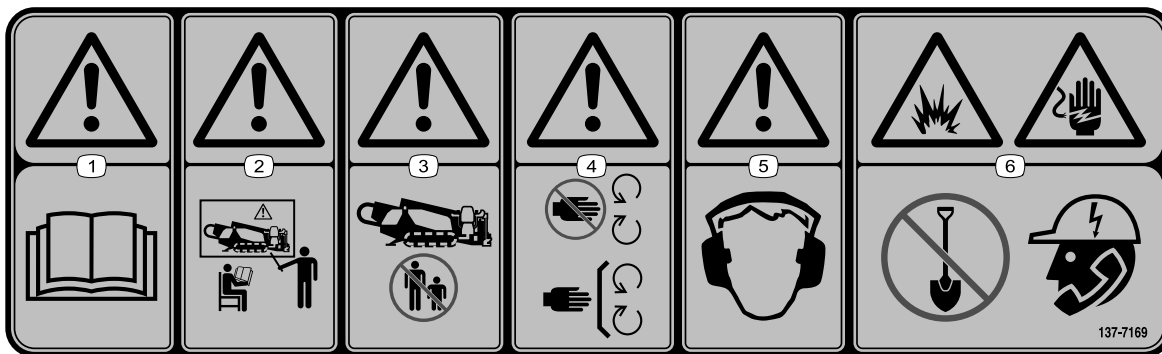
1. Antifreeze



125-8483

decal125-8483

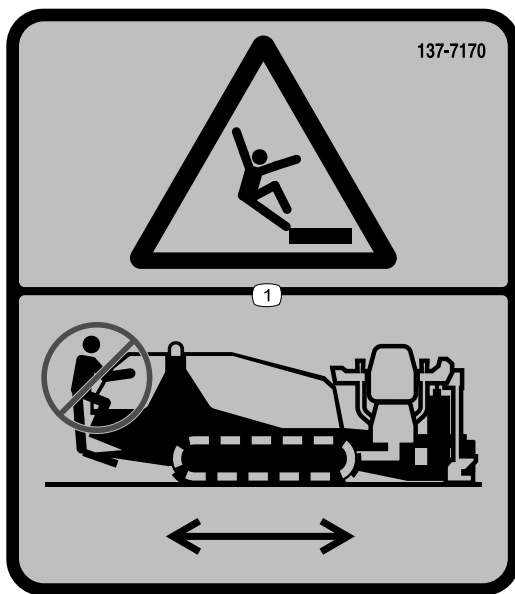
1. Hydraulic fluid; read the *Operator's Manual*.



137-7169

decal137-7169

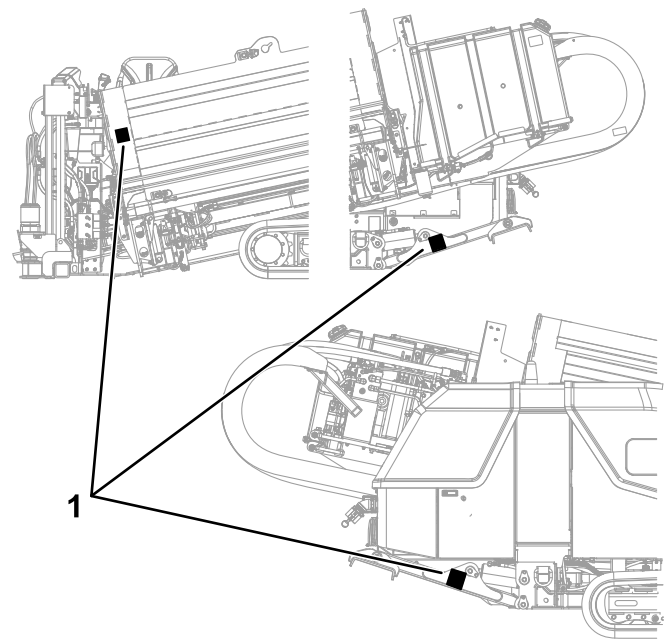
- | | |
|--|---|
| 1. Warning—read the <i>Operator's Manual</i> . | 4. Warning—keep away from moving parts; keep all guards and covers in place. |
| 2. Warning—all operators must be trained before operating the machine. | 5. Warning—hearing protection must be worn. |
| 3. Warning—keep bystanders away from the machine. | 6. Explosion and electrical shock hazard—do not dig; call your local utility company. |



decal137-7170

137-7170

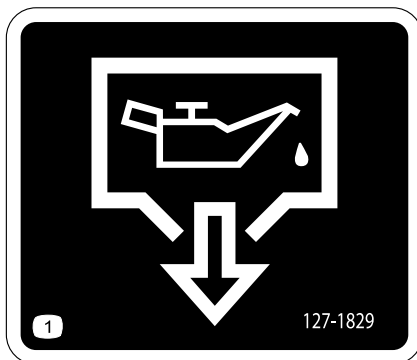
1. Falling hazard—do not climb on the machine while it is moving.



g228520

Figure 20

1. 125-6107



decal127-1829

127-1829

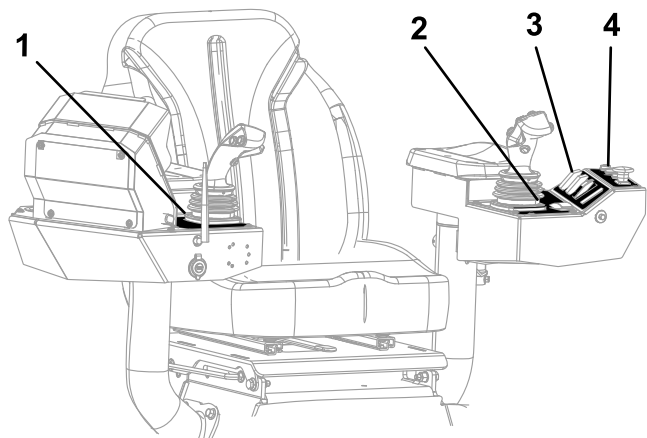
1. Oil drain



decal125-6107

125-6107

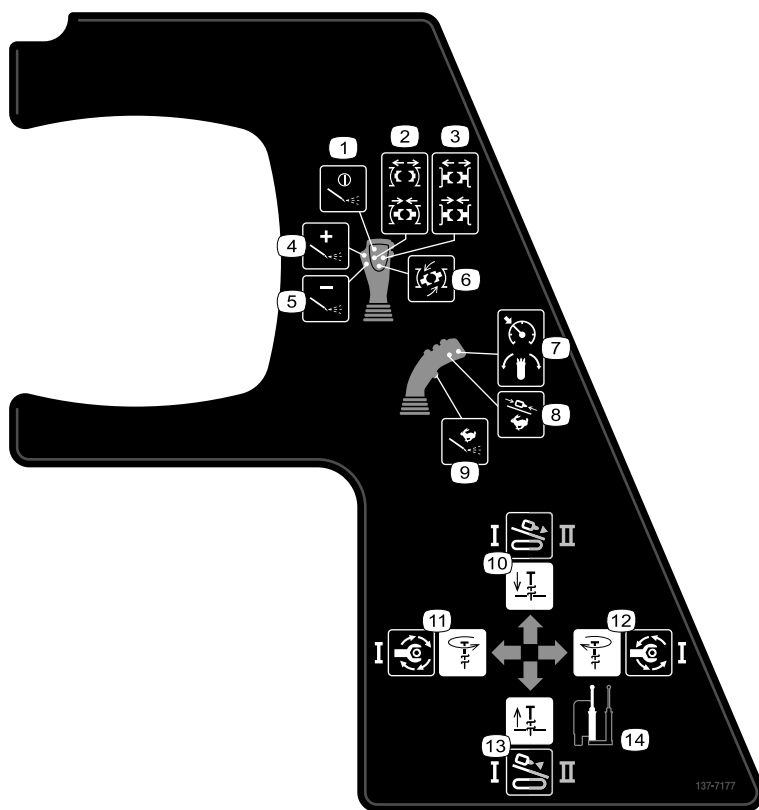
1. Crushing hazard of hand and foot—keep hands and feet away.



g231767

Figure 21

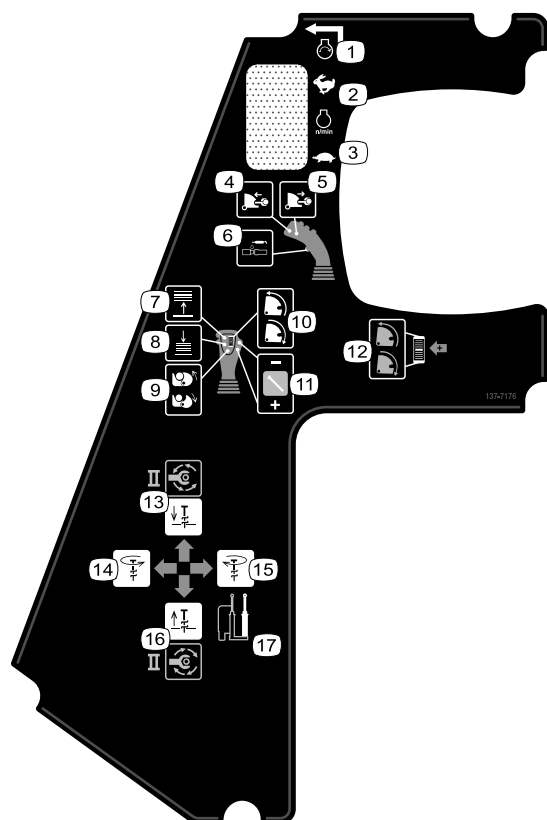
- | | |
|-------------|-------------|
| 1. 137-7177 | 3. 125-6193 |
| 2. 137-7176 | 4. 125-6194 |



decal137-7177

137-7177

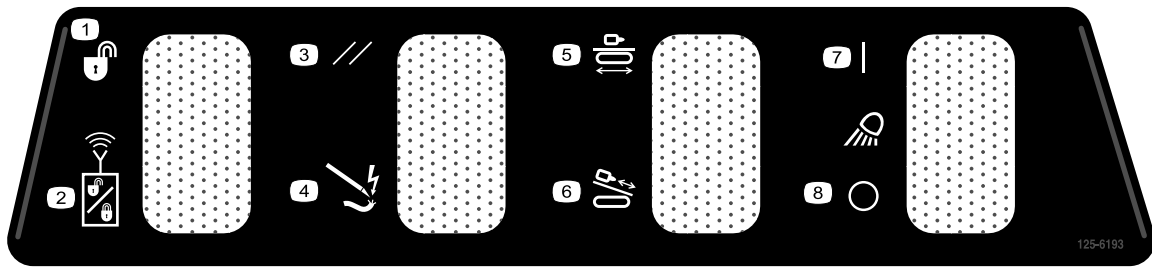
- | | |
|--|--|
| 1. Mud—On/Off | 8. Carriage thrust speed—high |
| 2. Upper wrench—open/close | 9. Mud flow—high |
| 3. Lower wrench—open/close | 10. Thrust the carriage forward (drill mode I and II); lower the stake (setup mode) |
| 4. Mud flow—increase | 11. Rotate the drill spindle clockwise (drill mode I); rotate the stake counter clockwise (setup mode) |
| 5. Mud flow—decrease | 12. Rotate the stake clockwise (setup mode); rotate the drill spindle counter clockwise (drill mode I) |
| 6. Rotate the wrench clockwise and counter clockwise (make and break rotation) | 13. Raise the stake (setup mode); pull the carriage back (drill mode I and II) |
| 7. Auto drill—set | 14. Right stake controls |



decal137-7176

137-7176

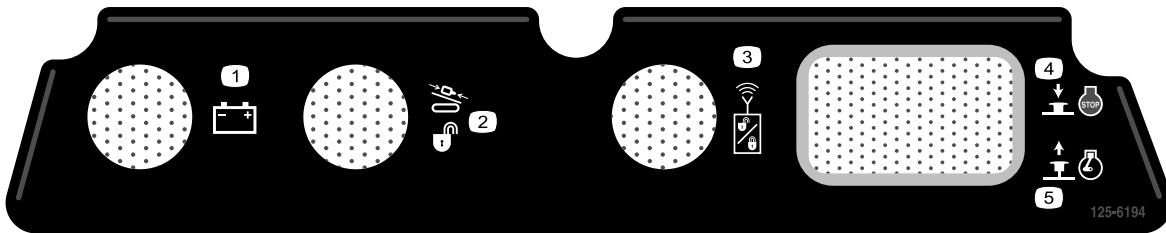
- | | |
|--------------------------------|--|
| 1. Engine—start | 10. Rotate the cam assembly. |
| 2. Engine speed—increase | 11. Move to the next or previous step in SmartTouch™ mode. |
| 3. Engine speed—decrease | 12. Cam override function to rotate the cam assembly. |
| 4. Pipe gripper arm—retract | 13. Lower the stake (setup mode); rotate drill spindle counter clockwise (drill mode II) |
| 5. Pipe gripper arm—extend | 14. Rotate stake counter clockwise (setup mode) |
| 6. Apply tread-joint compound. | 15. Rotate the stake clockwise (setup mode) |
| 7. Elevator—raise | 16. Raise the stake (setup mode); rotate drill spindle clockwise (drill mode II) |
| 8. Elevator—lower | 17. Left stake controls |
| 9. Pipe gripper—open/close | |



decal125-6193

125-6193

- | | |
|-----------------------------|-----------------------|
| 1. Exit-side lockout—reset | 5. Trimming and setup |
| 2. Exit-side lockout switch | 6. Drilling |
| 3. Ground-strike—reset | 7. Work lights—on |
| 4. Ground-strike switch | 8. Work lights—off |

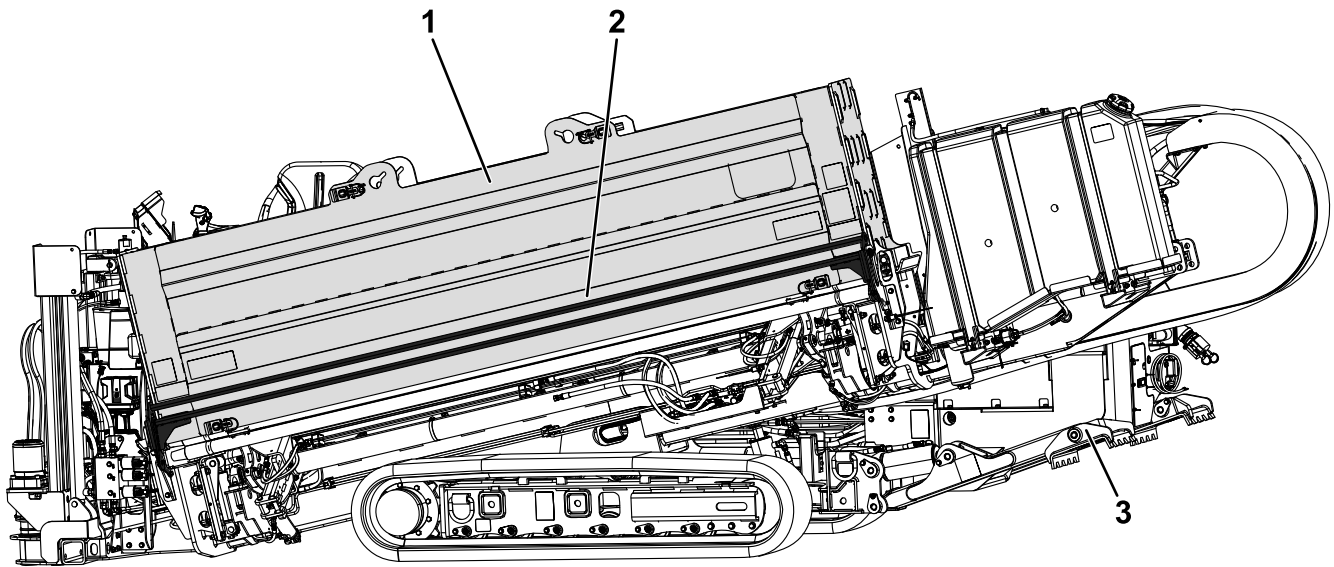


decal125-6194

125-6194

- | | |
|--|----------------------------------|
| 1. Exit-side-lockout receiver battery-status light | 4. Emergency engine stop—engage |
| 2. Exit-side lockout drill-enabled light | 5. Emergency engine stop—release |
| 3. Exit-side lockout standby light | |

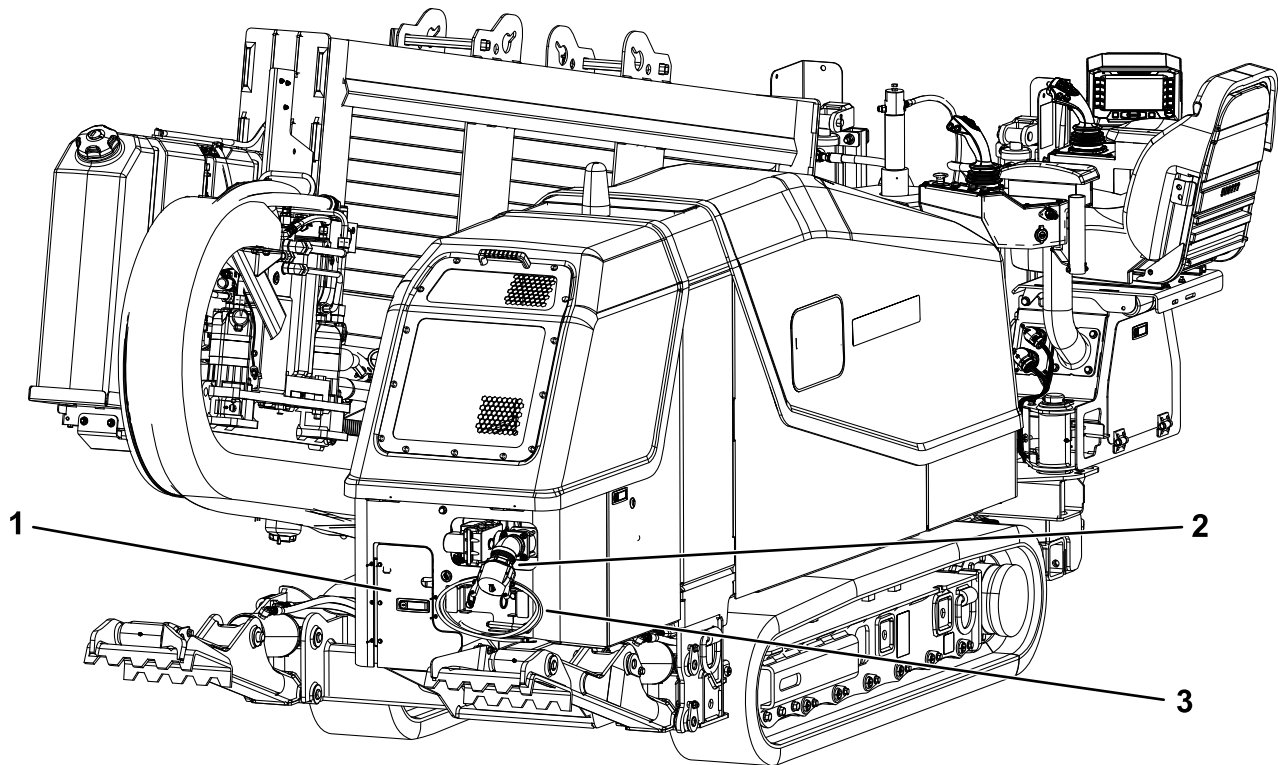
Product Overview



g218957

Figure 22
Left Side View

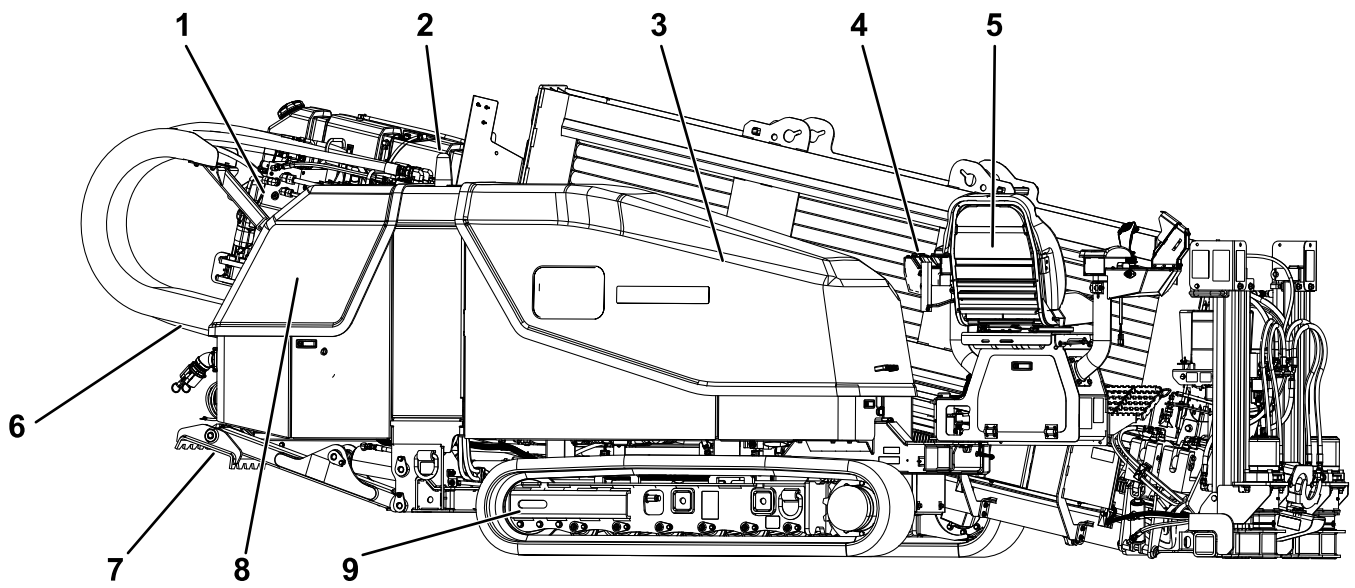
- 1. Pipe box
- 2. Safety bar
- 3. Stabilizer foot



g218958

Figure 23
Rear View

- 1. Rear control panel
- 2. Drilling-fluid-source connection
- 3. Zap-alert stake



g218959

Figure 24
Right Side View

- | | |
|------------------------|--------------------|
| 1. Carriage | 6. Thrust frame |
| 2. Zap-alert strobe | 7. Stabilizer foot |
| 3. Front hood | 8. Rear hood |
| 4. Front control panel | 9. Tracks |
| 5. Operator seat | |

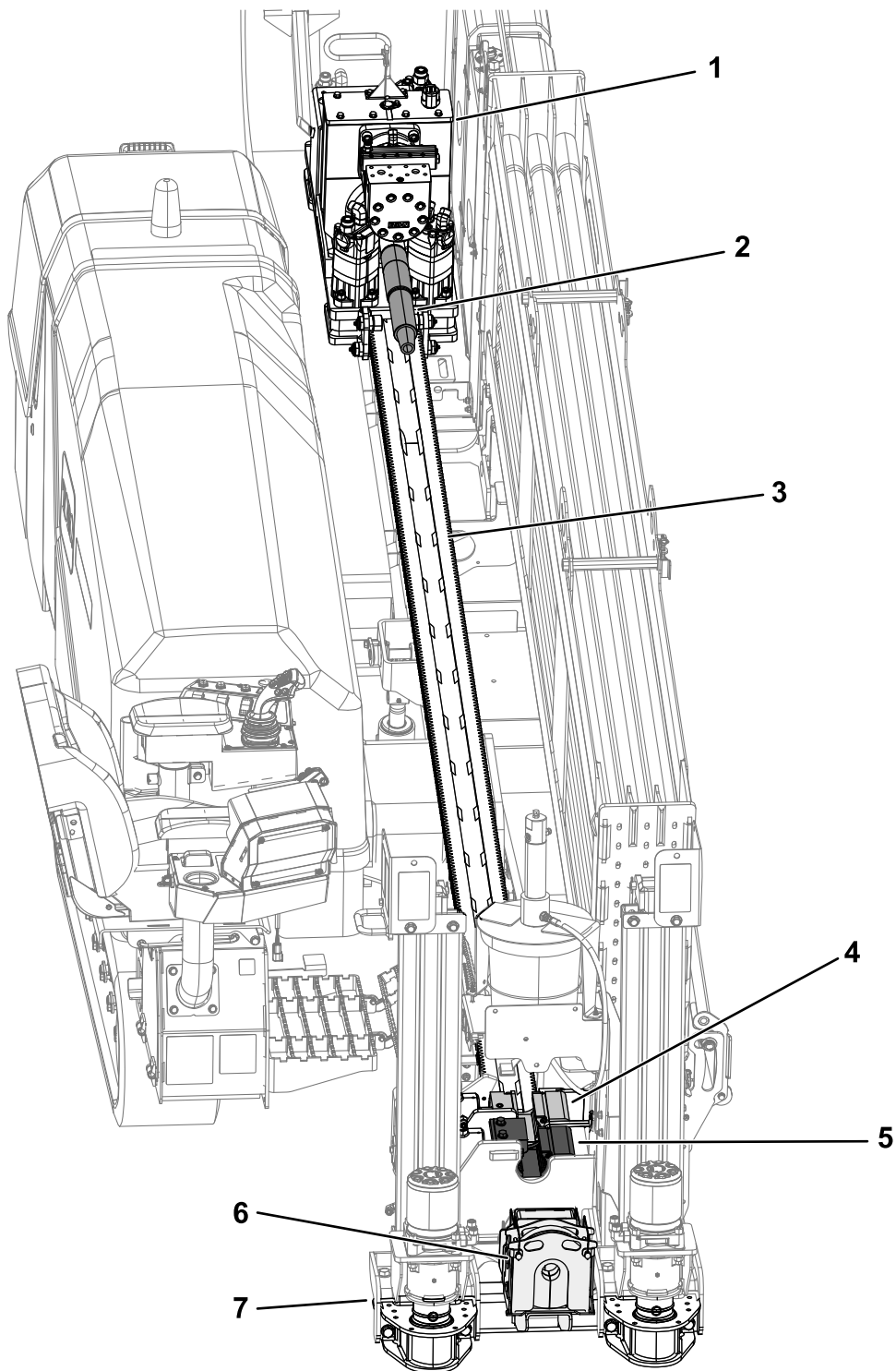


Figure 25
Top view

- | | |
|------------------|--------------------|
| 1. Carriage | 5. Lower wrench |
| 2. Drill spindle | 6. Pipe wiper |
| 3. Thrust frame | 7. Stake-down tube |
| 4. Upper wrench | |

g218960

Controls

Refer to the following sections for the appropriate machine controls:

- [Operator Platform \(page 27\)](#)
- *The Software Guide*
- [Front Control Panel \(page 29\)](#)
- [Joysticks in Setup Mode \(page 30\)](#)
- [Left Joystick \(page 31\)](#)
- [Right Joystick \(page 32\)](#)
- [Exit Side Lockout \(page 33\)](#)
- [Rear Control Panel \(page 33\)](#)
- [Travel Pendant \(page 33\)](#)
- [Battery-Disconnect Switch \(page 34\)](#)

Operator Platform

The operator platform, located on the right, front corner of the machine, contains most of the controls you use to operate the drilling functions of the machine.

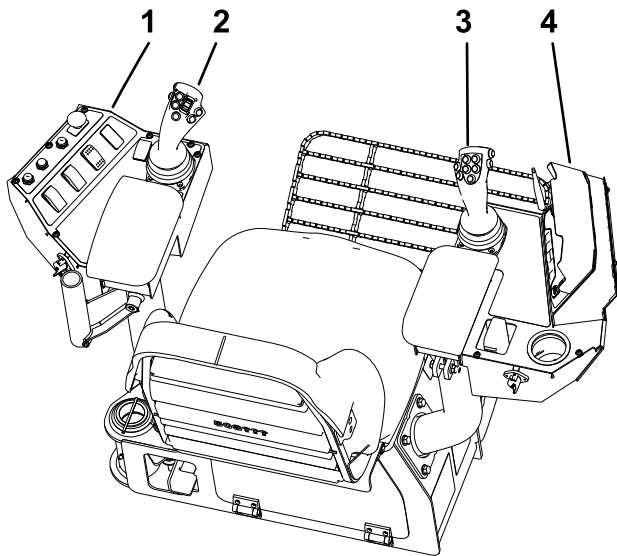


Figure 26

g218950

- | | |
|------------------------|---------------------|
| 1. Front control panel | 3. Right joystick |
| 2. Left joystick | 4. Operator display |

Operator-Platform Latch

The operator platform swings out away from the machine, making room for you to sit. It has 5 positions: travel (swung all the way into the machine), full-out, and 3 intermediate positions. Return the platform to the TRAVEL position before moving the machine.

To move the platform, push up on the rear platform latch or push down on the front platform latch ([Figure 27](#)).

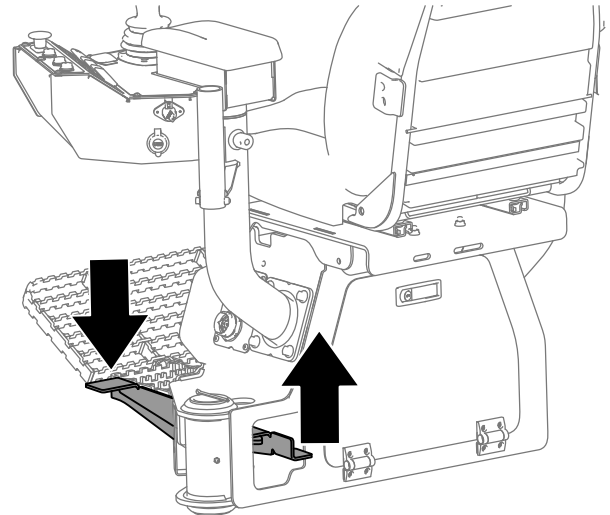


Figure 27

g218956

To release the platform and swing it out or in, push up on the front platform latch ([Figure 27](#)).

Operator-Controls Covers

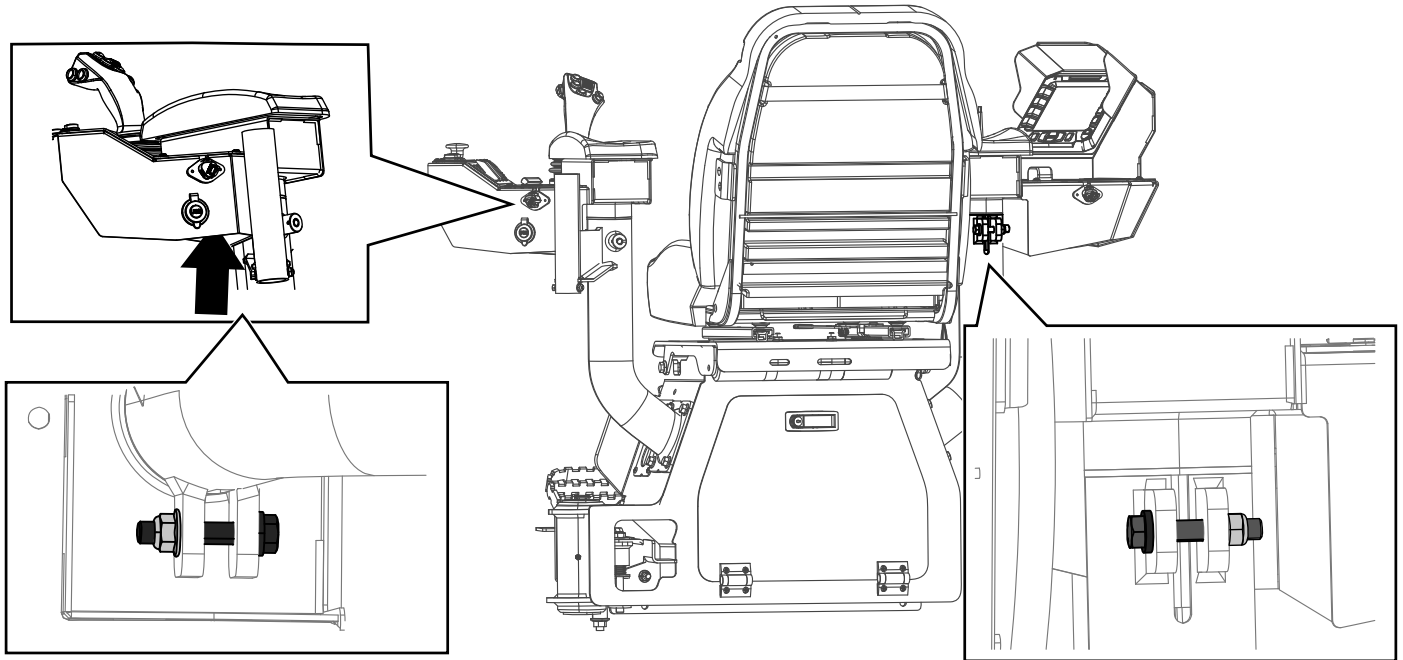
The covers protect the operator controls from adverse weather conditions, such as rain, wind, sunlight, etc. Remove them before using the machine and replace them before leaving the machine for the day.

Adjusting the Operator Console Bolts

Tighten the console bolts to add friction to the consoles; refer to [Figure 28](#).

The left console can rotate 10 degrees in.

The right console can rotate 10 degrees in and 45 degrees out.



g230008

Figure 28

Front Control Panel

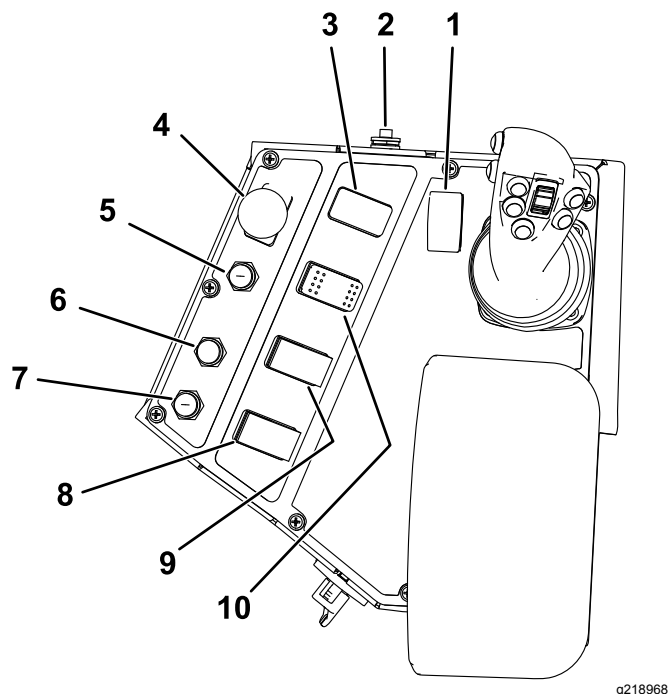


Figure 29

g218968

- | | |
|---|--|
| 1. Engine-speed switch | 6. Exit-side lockout—drill-enabled light (green) |
| 2. Engine-start button | 7. Exit-side-lockout handheld battery-status light (red) |
| 3. Work-lights switch | 8. Exit-side-lockout—reset switch |
| 4. Emergency engine stop button | 9. Ground-strike-reset switch |
| 5. Exit-side lockout—standby light (orange) | 10. Drill/setup switch |

Engine-Speed Switch

- Push and hold the top of this switch to increase the engine speed.
- Push and hold the bottom of this switch to decrease the engine speed.
- Release the switch to maintain the current engine speed.

Engine-Start Button

Push this button (Figure 29) to start the engine. The key switch on the rear, control panel must be in the ON position. Ensure that both emergency stop switches are in the raised position.

Work-lights Switch

Push the top of this switch (Figure 29) to turn the machine lights on or the bottom of the switch to turn them off.

Emergency Engine Stop Button

Push this button (Figure 29) to immediately shut off the engine and all drilling operations. You must pull this button out before you can start the engine again.

Exit-Side Lockout—Standby Light

This light (Figure 29) illuminates orange when the exit-side lockout is turned off, indicating that you may reset the system.

Exit-Side Lockout—Drill-enabled Light

This light (Figure 29) illuminates green when the exit-side-lockout system has been reset and the machine is ready to drill.

Exit-Side-Lockout Battery—Status Light

This light (Figure 29) illuminates red when the battery on the exit-side-lockout transmitter is too low to transmit. Stop drilling operations and replace the batteries in the transmitter before continuing.

Exit-Side Lockout—Reset Switch

Push this switch (Figure 29) to enable drilling operation when the yellow reset light illuminates.

Ground-Strike-Reset Switch

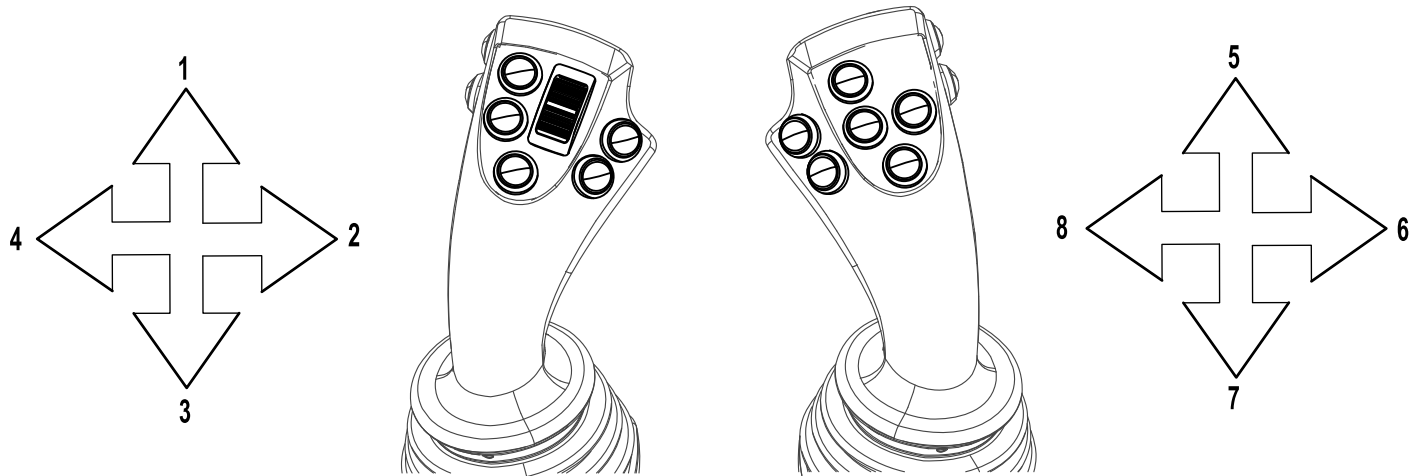
Push this switch (Figure 29) to reset the Zap-Alert system after a ground strike has occurred and been fixed; refer to [Deploying the Zap-Alert System \(page 51\)](#).

Drill/Setup Switch

Push the top of this switch (Figure 29) to enable the setup controls or the bottom of the switch to enable drill and pipe-loader functions.

Joysticks in Setup Mode

The machine must be in setup mode (Figure 29) and you must be in the seat to use these functions.



g225942

Figure 30
Joysticks – Setup Mode

- | | |
|--|---|
| 1. Lower the left stake down | 5. Lower the right stake down |
| 2. Rotate the left stake clockwise | 6. Rotate the right stake clockwise |
| 3. Raise the left stake up | 7. Raise the right stake up |
| 4. Rotate the left stake counter clockwise | 8. Rotate the right stake counter clockwise |

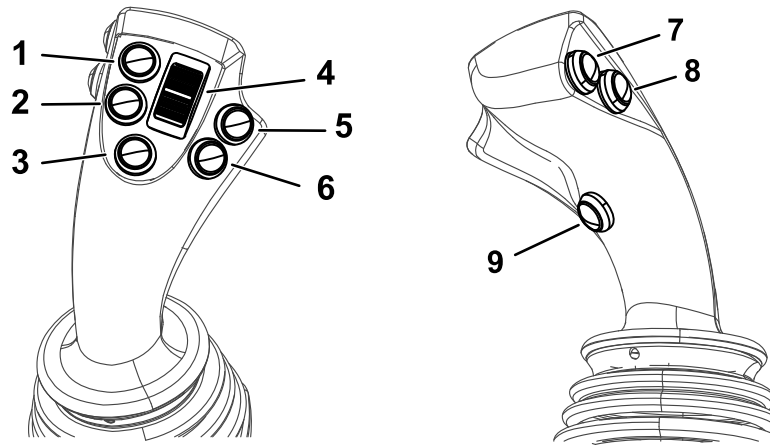
Left Joystick in Setup Mode

- **Forward:** Push the joystick forward to lower the left stake down.
- **Rearward:** Pull the joystick rearward to raise the left stake down.
- **Left:** Move the joystick to the left to rotate the left stake counter clockwise.
- **Right:** Move the joystick to the right to rotate the left stake clockwise.

Right Joystick in Setup Mode

- **Forward:** Push the joystick forward to lower the right stake down.
- **Rearward:** Pull the joystick rearward to raise the right stake down.
- **Left:** Move the joystick to the left to rotate the right stake counter clockwise.
- **Right:** Move the joystick to the right to rotate the right stake clockwise.

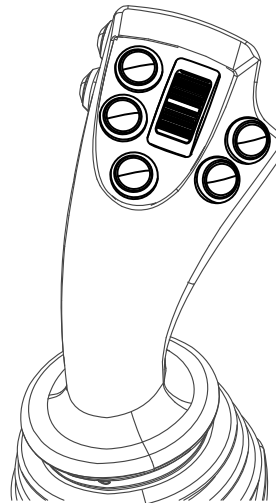
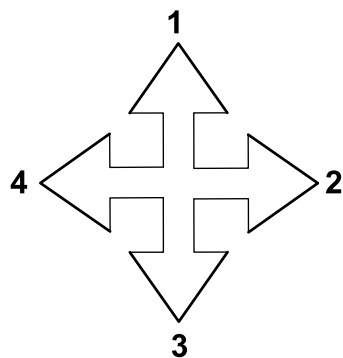
Left Joystick



g226145

Figure 31
Left Joystick in DRILL mode

- | | |
|--|--|
| 1. Raise the elevator | 6. Go to the next step in SmartTouch™ mode |
| 2. Lower the elevator | 7. Retract the pipe gripper arm |
| 3. Open / Close the pipe gripper | 8. Extend the pipe gripper arm |
| 4. Rotate the cam assembly | 9. Apply tread-joint compound |
| 5. Go to the previous step in SmartTouch™ mode | |



g226143

Figure 32
Left Joystick — Directional Controls

- | | |
|---|---|
| 1. Rotate the drill spindle counter clockwise (Drill Mode II) | 3. Rotate the drill spindle clockwise (Drill Mode II) |
| 2. No action | 4. No action |

Push the joystick left and hold the cam rocker switch at the same time to use the cam override function.

Important: This overrides the anti-crash prevention warning and could cause damage to the machine.

Push the cam rocker switch forward to rotate the cam assembly out.

Push the cam rocker switch backward to rotate the cam assembly in.

Right Joystick

The joystick controls vary depending on the control mode you select when powering up the machine. There are 2 control modes: Drill Mode I and Drill Mode II; refer to the Control-Select Screen in the *Software Guide* for information on setting the control modes.

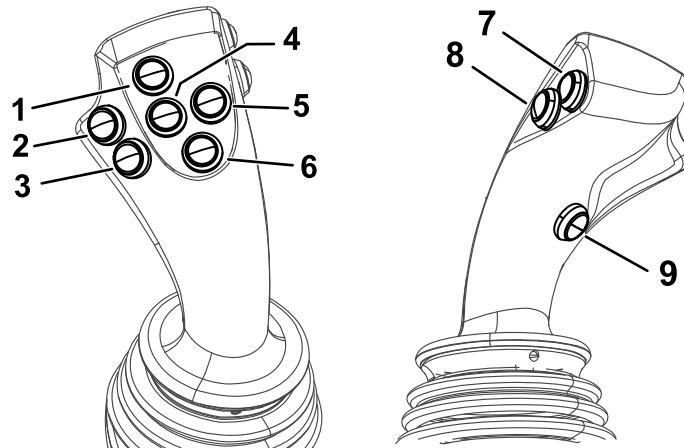
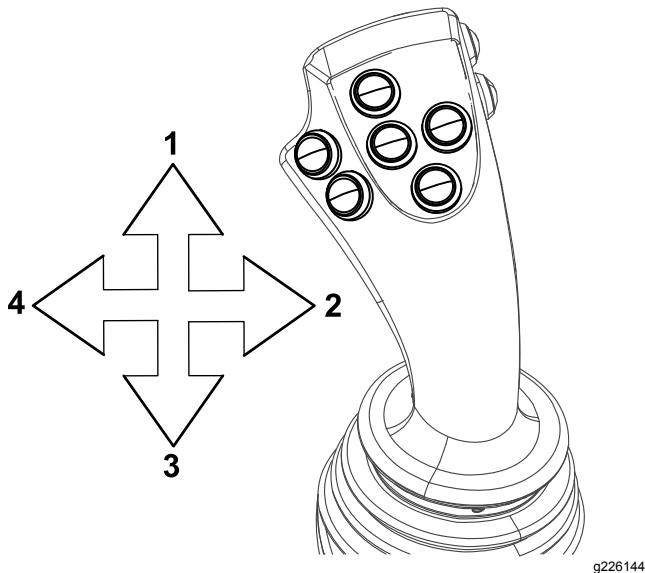


Figure 33
Right Joystick

g226146

- | | | |
|--------------------------------------|--|-----------------------------------|
| 1. Turn the mud on or off | 4. Open and Close the rear wrench | 7. Set the auto drill on or off |
| 2. Increase the mud flow momentarily | 5. Open and close the front wrench | 8. Set the carriage to high speed |
| 3. Decrease the mud flow momentarily | 6. Rotate the wrench clockwise and counter clockwise (make and break rotation) | 9. Max flow of mud |

Right Joystick — Drill Mode I

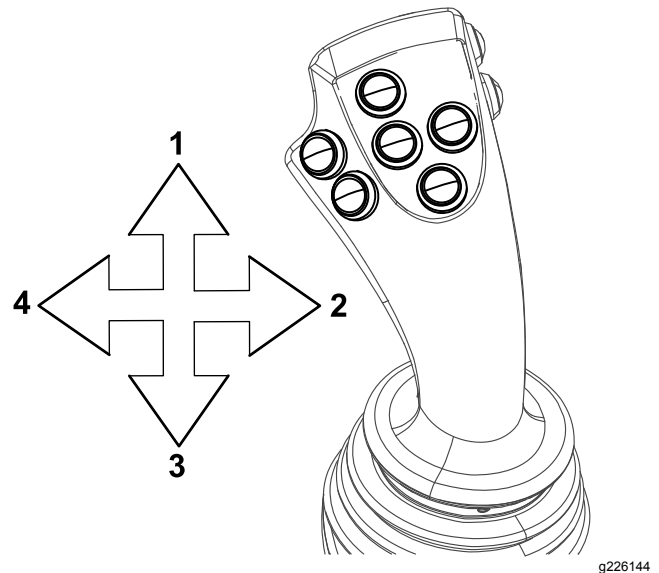


g226144

Figure 34
Right Joystick — Drill Mode I

- | | |
|---|---------------------------------------|
| 1. Thrust the carriage forward | 3. Pull the carriage back |
| 2. Rotate the drill spindle counter clockwise | 4. Rotate the drill spindle clockwise |

Right Joystick — Drill Mode II



g226144

Figure 35
Right Joystick — Drill Mode II

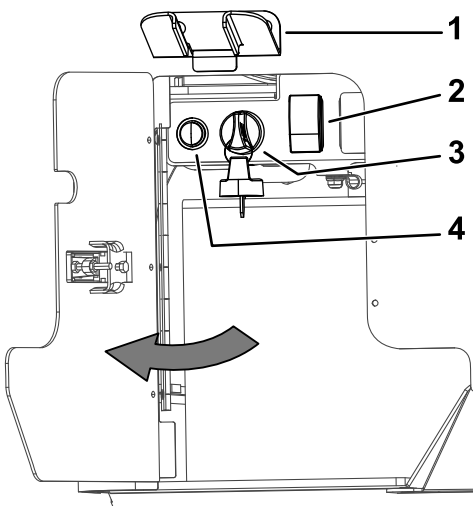
- | | |
|--------------------------------|---------------------------|
| 1. Thrust the carriage forward | 3. Pull the carriage back |
| 2. No action | 4. No action |

Exit Side Lockout

The exit-side-lockout system provides the individuals working around the machine with a means to disable the drill pipe from rotating and thrusting.

For more information and instructions, refer to the *Operator's Manual* for the Exit-side-lockout system.

Rear Control Panel



g229102

Figure 36

- | | |
|---------------------------|-----------------------|
| 1. Travel pendant bracket | 3. Engine, key switch |
| 2. Fluid-pump switch | 4. OK-to-Start light |

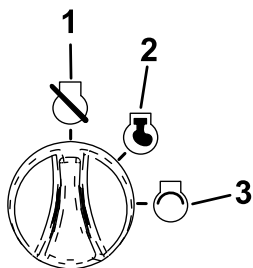
OK-to-Start Light

The green light illuminates when the machine is ready to start.

If the light does not illuminate, check the 2 emergency stop buttons. They need to be disengaged before the machine can start.

Engine, Key Switch

The key switch has 3 positions as follows (Figure 36):



g220853

Figure 37

- | | |
|------------------------|--------------------------|
| 1. Engine-off position | 3. Engine-start position |
| 2. Engine-run position | |

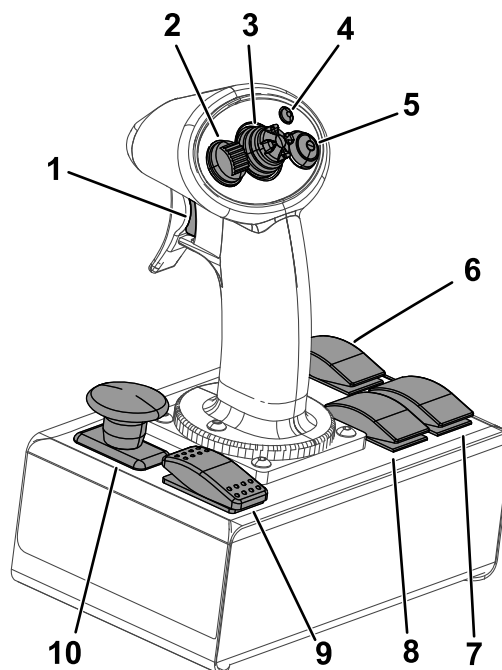
- Engine-off position—turn the key to this position to shut off the engine. The engine cannot be started from the operator platform when the key is in this position.
- Engine-run position—turn the key to this position after starting the engine. Turning the key to this position also enables the engine start button from the operator platform.
- Engine-start position—turn the key to this position to start the engine. Release the key to the RUN position once the engine has started.

Fluid-Pump Switch

Use this switch to turn on the fluid pump to use the spray gun when cleaning the machine.

Travel Pendant

Refer to [Figure 36](#) for location.



g225940

Figure 38

- | | |
|--|-------------------------------------|
| 1. Operator presence switch (tramping) | 6. Thrust frame switch |
| 2. Engine speed switch | 7. Right stabilizer foot switch |
| 3. Tramping-Direction Joystick | 8. Left stabilizer foot switch |
| 4. Error indicator light (when blinking) | 9. Operator presence switch (setup) |
| 5. Tramping speed switch | 10. Emergency engine stop button |

Use the corresponding operator presence switch to operate the setup and tramping functions.

If you release the operator presence switch while operating, you will need to release all of the controls before resuming operation.

Operator Presence Switch

Push and hold this button to enable the other controls on the travel pendant. The machine stops moving when you release this button.

Engine Speed Switch

- Push the top of this switch to increase the engine speed in 100 rpm increments. Hold the switch to rapidly increase to high idle.
- Push the bottom of this switch to decrease the engine speed in 100 rpm increments. Hold the switch to rapidly decrease to low idle.
- Release the switch to maintain the current engine speed.

Tramming Direction Joystick

Use the joystick to control the direction of the machine. The machine will travel in the direction you move the joystick.

Error Indicator Light

This light lights up when the 2-speed button is pushed. The light will blink there is an internal error with the travel pendant.

Drive-Speed Switch

The switch sets the speed at which the machine travels. Push the switch to alternate between high and low speed.

Thrust Frame Switch

Use this switch to raise and lower the thrust frame.

Right Stabilizer Foot Switch

Use this switch to raise and lower the right stabilizer foot.

Left Stabilizer Foot Switch

Use this switch to raise and lower the left stabilizer foot.

Emergency Engine Stop Button

Push this button to immediately shut off the engine and all movement/drilling operations. You must pull this button out before you can start the engine again.

Battery-Disconnect Switch

Open the front hood to access the BATTERY-DISCONNECT switch; refer to [Opening the Front and Rear Hoods \(page 67\)](#).

The BATTERY-DISCONNECT switch is located to the right of the engine; it is used to electrically disconnect the battery from the machine.

Important: Do not use the battery-disconnect switch to turn off the engine.

Turn the BATTERY-DISCONNECT switch to the ON or OFF position to perform the following:

- To energize the machine electrically, rotate the BATTERY-DISCONNECT switch clockwise to the ON position ([Figure 39](#)).
- To de-energize the machine electrically, rotate the BATTERY-DISCONNECT switch counterclockwise to the OFF position ([Figure 39](#)).

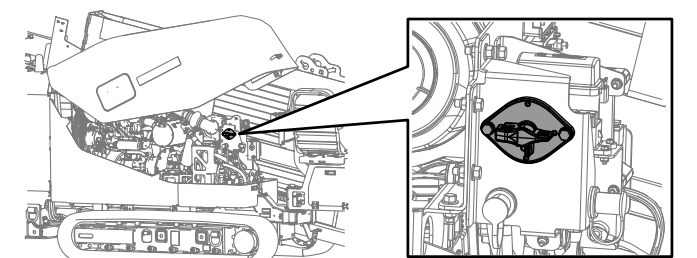


Figure 39

Specifications

Note: Specifications and design are subject to change without notice.

Machine

Width	147 cm (58 inches)
Length	521 cm (205 inches)
Height	198 cm (78 inches)
Weight	4,302 kg (9,485 lb)

Operation

Determine the left and right sides of the machine from the normal operating position.

Before Operation

Before Operation Safety

General Safety

- The owner must ensure that all operators are well trained and competent to safely operate the machine.
- Never allow children or untrained people to operate or service the machine. Local regulations may restrict the age of the operator.
- Become familiar with the safe operation of the equipment, operator controls, and safety signs.
- Know how to stop the machine and shut off the engine quickly.
- Check that operator-presence controls, safety switches, and shields are attached and functioning properly. Do not operate the machine unless they are functioning properly.
- Inspect the area where you will use the machine and remove all objects that the machine could throw.
- Keep the manual(s) with the machine. Go to www.Toro.com for a replacement manual.

Fuel Safety

- Use extreme care in handling fuel. It is flammable and its vapors are explosive.
- Extinguish all cigarettes, cigars, pipes, and other sources of ignition.
- Use only an approved fuel container.
- Do not remove the fuel cap or fill the fuel tank while the engine is running or hot.
- Do not add or drain fuel in an enclosed space.
- Do not store the machine or fuel container where there is an open flame, spark, or pilot light, such as on a water heater or other appliance.
- If you spill fuel, do not attempt to start the engine; avoid creating any source of ignition until the fuel vapors have dissipated.

Understanding Horizontal Directional Drilling

Horizontal directional drilling is a process used for drilling a horizontal bore through the soil and under obstructions such as roads, buildings, bodies of water, etc. Once you drill the bore, pull back the utility lines or pipes through the bore and connect them as needed. Because it does not require very much disturbance of the surface, installation of utilities using directional drilling preserves the environment and saves both time and money over traditional installation methods such as trenching.

When installing cabling or pipe using a directional drill, complete the following steps:

1. **Gather site information.**

Before operating in an area with high-voltage lines or cables, contact a “One-Call System Directory” service. In the USA, call 811 or your local utility company. If you do not know your local utility company’s phone number, call the national number (USA and Canada only) at 1-888-258-0808. In Australia, call 1100 for the nationwide marking service. Also, contact any utility companies that are not participants of the “One-Call System Directory” service. Please refer to [Drilling Near Utility Lines \(page 6\)](#) for more information.

Before fully planning the bore path, gather information about the job site such as the location of other utilities, obstacles at the site, and what regulations and permits you need to complete the job; refer to [Gathering Site Information \(page 36\)](#).

2. **Plan the bore path.**

Before drilling, plan the bore path based on the information you gathered. Refer to [Planning the Bore Path \(page 39\)](#).

3. **Prepare the job site and the machine.**

Before drilling, prepare the job site with an entry point, depth-gauge hole (optional), and an exit hole. Drive the machine to the job site, set it up for drilling, and connect it to a drilling-fluid mixer.

Note: When drilling, connect the machine to a drilling-fluid mixer that mixes water with bentonite clay and other ingredients. The machine pumps this mixture, referred to as drilling fluid or “mud,” through the drill pipe and out of the drill bit. The drilling fluid lubricates the drill bit, helps to hold the bore open while drilling, and mixes with the spoils, flushing them out of the bore through the entry point.

Refer to [Preparing the Job Site and the Machine \(page 44\)](#) for instructions on preparing the job site and the machine.

4. **Drill the bore.**

Drill the bore in 3 stages:

A. Entry

In the entry phase of the bore, push the drill bit and head into the ground at an angle of up to 16 degrees. After pushing in one or more pipes, begin drilling down and forward until you reach the desired depth or depth-gauge hole (if used).

B. Horizontal Reach

After reaching the desired depth, push the bit forward, steering the bit to a horizontal depth. The sonde emits a radio signal from the sonde housing, allowing the locating-equipment operator on the surface to track the location and depth of the head using the sonde receiver as you drill and steer it along a planned path..

C. Exit

Once you have attained the planned horizontal reach, steer the head up at an angle, similar to your entry angle, bringing the bit into the exit hole or trench.

Refer to [Drilling the Bore \(page 57\)](#).

5. **Backream the bore and pull back the cabling or pipe.**

After entering the exit hole, a crew member detaches the drill bit and sonde housing from the drill pipe. Attach a reaming bit and the end of the cable or pipe to be pulled through the bore. The reaming bit is designed to enlarge the bore as you pull it back. Pump drilling fluid through the pipe to the reaming bit as you pull the cable or pipe back through the bore to lubricate the reamer and allow the cable or pipe to slide easily through the bore. Continue pulling the pipe back until the reamer reaches the depth-gauge hole or exits at the entry point. Remove the reamer and product from the drill pipe, pulling the pipe the rest of the way back to the machine.

Refer to [Backreaming and Pullback \(page 60\)](#) for instructions on backreaming and pulling cable or pipe.

6. **Finish the bore and leave the job site.**

After completing the operation, disconnect and clean the machine, and load it on the trailer; refer to [Finishing the Job \(page 63\)](#).

Gathering Site Information

Planning the Initial Path

Before drilling, plan the path you will bore and prepare as follows:

- Create a basic plan for the bore, mapping out the proposed path.
 - Note any obstacles which may affect the bore such as large trees, bodies of water, buildings, etc.
 - Plan the path of the bore to avoid as many obstacles as possible.
 - Determine the depth of any bodies of water to be crossed to ensure that you can get deep enough to go under them.
- Determine the depth you need to install the material at and the minimum bend radius of both the drill pipe and the material being installed. This will affect how long the bore needs to be and at what angle you can enter and exit; refer to [Planning the Bore Path \(page 39\)](#).
- Have the area of the bore path marked for utility lines (in the US call 811). Ensure that all lines are marked on your blueprints/bore plan as well.
- Contact the local authorities to arrange for any permits and traffic control that you will need to conduct the job.

Inspecting the Proposed Job Site

Physically inspect the site as follows:

- Note the terrain, slopes, valleys, hills, and any features not planned for previously.

Determine the degree of slope at both the proposed entry point and exit point.
- Determine what the soil types are in the area and, if possible, and what they are at the depth you will be boring. You may need to dig test holes at intervals along the bore path to fully determine this.
- Walk the area of the bore path looking for any possible unmarked obstructions. Look for manholes, pedestals, old foundations, etc.
- Identify all hazards of which you will be passing within 3 m (10 ft).

Common hazards include the following:

- Gas lines
- Electrical power lines

- Crystalline silica and other dust

If you will be drilling through or cutting concrete, sand, or other substances that create dusts or fumes, you need to ensure that you and all workers wear breathing protection to protect your lungs from the dust.

⚠ DANGER

Contacting underground hazards with the machine while drilling or reaming can cause explosion, electrocution, breathing problems, severe trauma, and death to you or bystanders.

- ◇ Ensure that all personnel at the job site wear personal protective equipment including a hard hat, eye protection, electrically insulated safety boots and gloves, and hearing protection.
- ◇ Keep bystanders and spectators away from the job site, including the complete bore path.
- ◇ Locate and expose all electric and gas lines that you will be crossing by careful hand digging.
- ◇ Ensure that you use the Zap-Alert system whenever operating the machine.

⚠ DANGER

Drilling into a gas line can cause an explosion or fire, burning, injuring, or killing you or others in the vicinity of the break.

- ◇ Do not smoke or have any source of flame near gas lines or at either end of a bore that will be crossing a gas line.
- ◇ Keep bystanders and spectators away from the job site, including the complete bore path.
- ◇ Locate and expose all gas lines that you will be crossing by careful hand digging.
- ◇ Have the gas company turn off the gas to any lines you will be crossing before drilling.
- ◇ Use the receiver to track the exact position of the drill head when approaching gas lines.

⚠ DANGER

Drilling into an electric power line will cause the machine to become electrified and may electrocute you or any bystanders.

- ◇ Keep bystanders and spectators away from the job site, including the complete bore path.
- ◇ Locate and expose all electric lines that you will be crossing by careful hand digging.
- ◇ Have the electric company turn off the power to any lines you will be crossing before drilling.
- ◇ Use the receiver to track the exact position of the drill head when approaching electric lines.
- ◇ Before drilling, setup and use the Zap-Alert system which is designed to notify in the case of an electric strike. If the Zap-Alert alarm triggers, stop what you are doing and do not leave the operator's position. Refer to [Deploying the Zap-Alert System \(page 51\)](#) for detailed instructions on using the Zap-Alert system.

⚠ WARNING

Machining or handling stone, masonry, concrete, metal, and other materials can generate dust, mists, and fumes containing chemicals, such as silica, known to cause serious or fatal injury or illness, such as respiratory disease, silicosis, cancer, birth defects, or other reproductive harm.

- ◇ Control dust, mist, and fumes at the source where possible. Water should be used for dust suppression when feasible.
- ◇ Use good work practices and follow the recommendations of the manufacturer or suppliers, OSHA, and other occupational and trade associations.
- ◇ When the hazards from inhalation cannot be eliminated, the operator and any bystanders should wear a respirator approved by OSHA for the material being handled.

⚠ WARNING

Silicosis Warning: Grinding, cutting, or drilling stone, masonry, concrete, metal, and other materials with silica in their composition may give off dust or mist containing crystalline silica. Silica is a basic component of sand, quartz, brick, clay, granite, and numerous other minerals and rocks. Repeated and/or substantial inhalation of airborne crystalline silica can cause fatal respiratory diseases, including silicosis. In addition, some other authorities have listed respirable crystalline silica as a substance known to cause cancer. When cutting such materials, follow respiratory precautions.

Planning the Bore Path

Before setting up the job site, you need to plan the bore path, including the following:

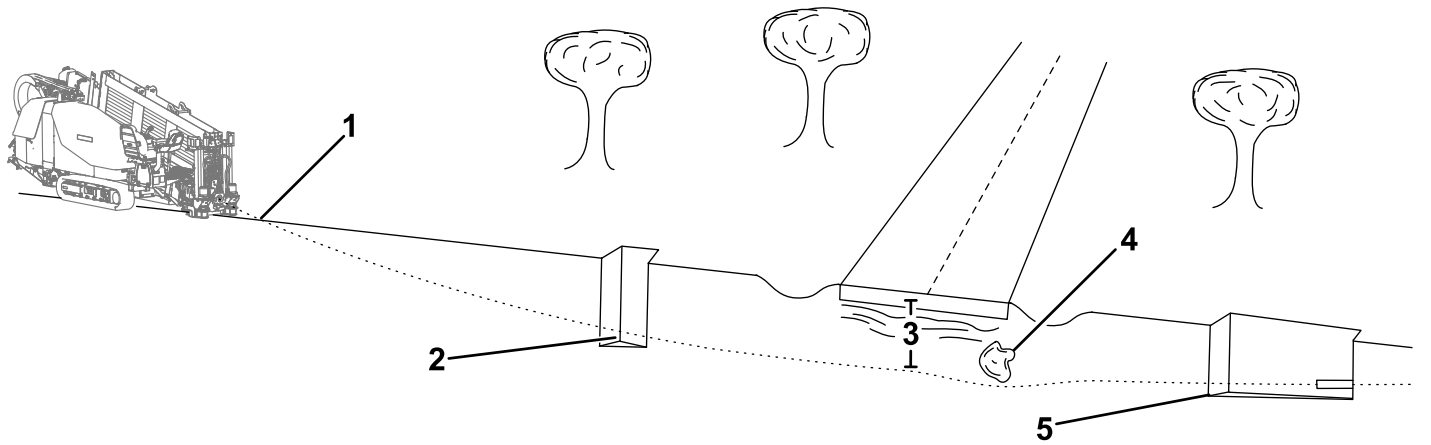


Figure 40

g218955

1. Bore entry
2. Beginning of bore-at-depth point
3. Bore depth

4. Obstacle
5. End of bore-at-depth point and bore exit

- **Bore entry**

This is the location where you setup the machine and the drill bit enters the ground. Depending on conditions, this will typically be set back 9 to 15 m (30 to 50 ft) from the beginning of the-bore-at-depth point.

- **Beginning of bore-at-depth point**

This is the point where you want the utility line or pipe to end after installation is complete. It is typically the point at which the bore levels out and begins to bore horizontally. This may be the same as the entry point, or you may dig a separate depth-gauge hole at this point (Figure 40).

- **Bore depth**

This the depth at which you want to install the utility line or pipe.

- **Obstacles in the path**

You will need to steer around or under obstacles. It is important to know where these obstacles will be before starting so that you can plan where to begin steering prior to reaching the obstacle.

- **End of bore-at-depth point**

This is the point where you want the utility line or pipe to begin after installation is complete. Often this will also be the bore exit.

- **Bore exit**

This is the location where the drill head will exit the ground and the point at which you will pull the utility lines or pipe into the bore. If this point will be at the surface instead of at installation depth,

you will need to determine the distance from the end-of-bore-at-depth location needed for steering the drill to the surface, typically 9 to 15 m (30 to 50 ft) from the end-of-the-bore-at-depth point.

Determining the Bore Entry Point

One of the more challenging aspects of planning the bore path is to determine the entry point of the bore. You need to take the following traits into account when determining the location of the entry point:

- **Bore depth**

This the depth at which you want to install the utility line or pipe. This machine is designed primarily for installations between 1 and 3 m (3.5 to 10 ft).

- **Pipe and material flexibility**

The 3 m (10 ft) pipes used on this machine can flex to an 8% pitch over the length of the pipe; this equates to a bend of no more than 20 cm (8 inches) off of a straight path (Figure 41).

Important: If you steer the pipe to bend sharper than 20 cm (8 inches) per pipe, you may damage the pipes and their connections. You must also make steering changes gradually over the entire length of each pipe. If you steer the whole 20 cm (8 inches) in only 25 to 50 cm (1 to 2 ft) of travel, you can permanently damage the pipes.

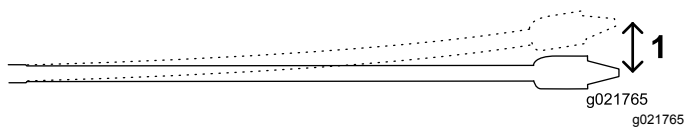


Figure 41

1. 20 cm (8 inches)

This flexibility is often rated in materials as a minimum bend radius, which is the radius of the circle formed if the material or pipes, connected together, were bent to form a giant circle. The minimum radius of a circle made with the pipe used with this machine is 31 m (101 ft).

- **Entry pitch**

The entry pitch is the angle at which the drill bit enters the ground. With the tracks on level ground, the stabilizers down, and the stake-down plate on the ground, the drill frame angle is about 15 degrees or a 27% pitch. This pitch will change depending on the slope of the ground and other factors of the job site. You can also reduce this pitch a bit by building up the ground under the stake-down plate before positioning the machine. You can determine the actual pitch of the drill frame by placing the drill bit and sonde housing on the frame and then use the receiver to display the pitch.

The steeper your entry pitch is, the deeper your bore must be due to the limitations of the pipe flexibility. Typically, you need to insert the drill bit and at least 1/3 of a pipe into the ground before you can start steering toward the beginning of the bore point. [Figure 42](#), [Figure 43](#), and the following table illustrate the relationship between entry pitch and depth.

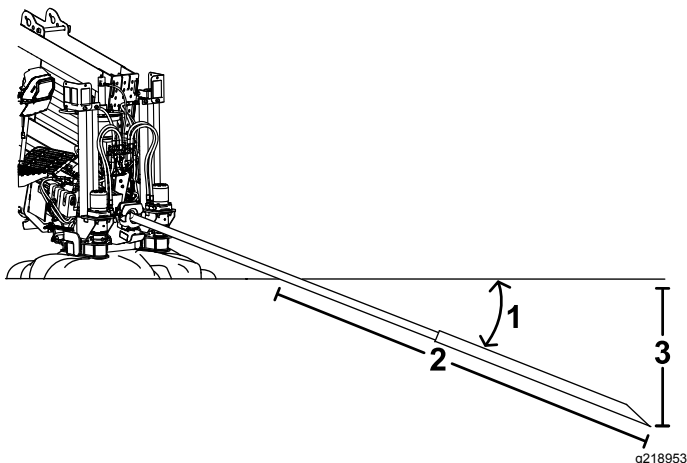


Figure 42

1. 26% pitch
2. 3 m (10 ft)
3. 76 cm (30 inches)

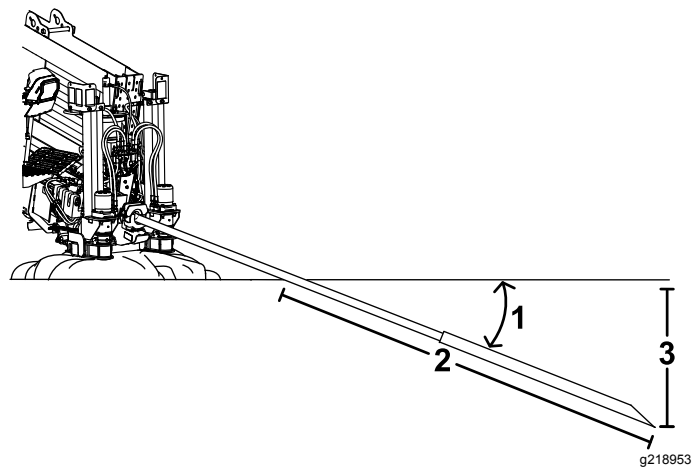


Figure 43

1. 18% pitch
2. 3 m (10 ft)
3. 53 cm (21 inches)

Note: The depths given in the following table are for 3 m (10 ft) of combined drill head and pipe. As you steer up, the pitch of the steered section changes and can be monitored with the receiver. Use the following table to identify how many lengths of pipe will be necessary to insert and steer to the beginning point and help you choose an entry point.

Pitch	Depth Change per 10 feet	Pitch	Depth Change per 10 feet
1%	2 cm (1 inch)	26%	76 cm (30 inches)
2%	5 cm (2 inches)	27%	79 cm (31 inches)
3%	10 cm (4 inches)	28%	81 cm (32 inches)
4%	13 cm (5 inches)	29%	84 cm (33 inches)
5%	15 cm (6 inches)	30%	86 cm (34 inches)
6%	18 cm (7 inches)	31%	91 cm (36 inches)
7%	20 cm (8 inches)	32%	94 cm (37 inches)
8%	25 cm (10 inches)	33%	97 cm (38 inches)
9%	28 cm (11 inches)	34%	99 cm (39 inches)
10%	30 cm (12 inches)	35%	102 cm (40 inches)
11%	33 cm (13 inches)	36%	104 cm (41 inches)
12%	36 cm (14 inches)	37%	107 cm (42 inches)
13%	39 cm (15 inches)	38%	109 cm (43 inches)
14%	43 cm (17 inches)	39%	112 cm (44 inches)
15%	46 cm (18 inches)	40%	114 cm (45 inches)
16%	48 cm (19 inches)	41%	117 cm (46 inches)
17%	51 cm (20 inches)	42%	117 cm (46 inches)
18%	53 cm (21 inches)	43%	119 cm (47 inches)
19%	56 cm (22 inches)	44%	122 cm (48 inches)
20%	61 cm (24 inches)	45%	124 cm (49 inches)
21%	64 cm (25 inches)	46%	127 cm (50 inches)
22%	66 cm (26 inches)	47%	130 cm (51 inches)
23%	69 cm (27 inches)	48%	133 cm (52 inches)
24%	71 cm (28 inches)	49%	135 cm (53 inches)
25%	74 cm (29 inches)	50%	137 cm (54 inches)

All measurements are approximate and will vary depending on soil conditions.

Note: Refer to the guidance system *Operator's Manual* for more information.

Given the information in the table, you can calculate the number of pipes required to reach your beginning point at the appropriate depth. Toro recommends that you start the entry point a distance back from your beginning-at-depth point by the same distance as the length of pipes you will need to reach that point. This will ensure that you have enough extra space so you will not over-steer and damage the pipes.

The following example illustrates the process given an installation using the maximum entry pitch of the machine (26%) on level ground:

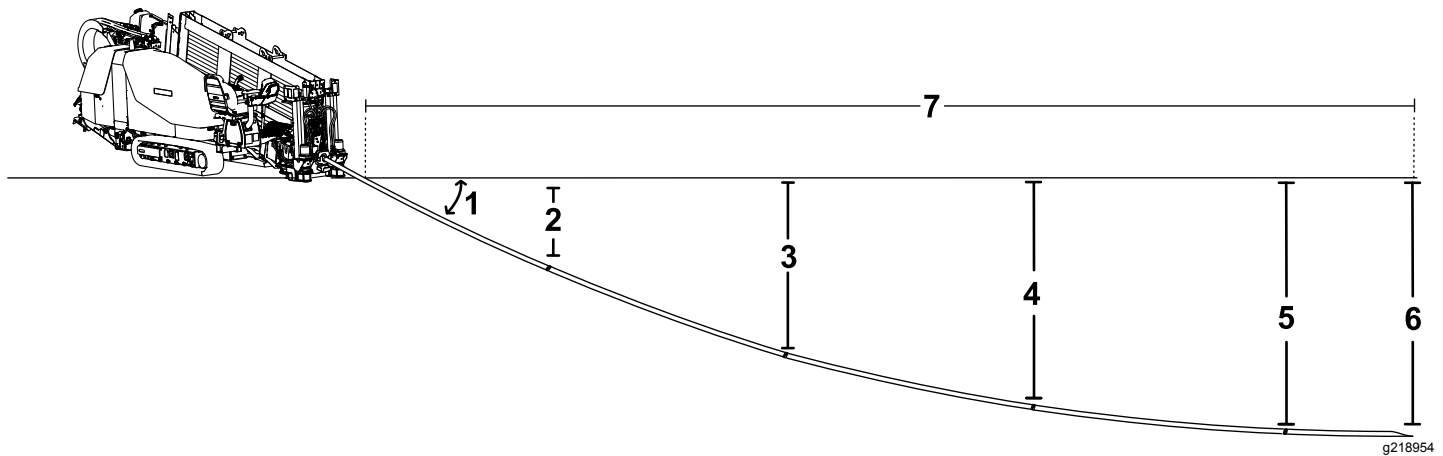


Figure 44

- | | | |
|-----------------------|-----------------------|-------------------|
| 1. 26% pitch | 4. 185 cm (73 inches) | 7. 14.7 m (45 ft) |
| 2. 76 cm (30 inches) | 5. 203 cm (80 inches) | |
| 3. 142 cm (56 inches) | 6. 208 cm (82 inches) | |

- You insert the first 3 m (10 ft) of drill bit/pipe into the ground with no steering. The end of the drill bit is 76 cm (30 inches) deep (Figure 44).
- You begin steering up for the next 3 m (10 ft), pushing the pipes in at the maximum pitch change of 8%. This results in a change of pitch from 26% at the beginning of the 3 m (10 ft) to 18% at the end of the 3 m (10 ft) for an average pitch of 22%. Given that, the drill head lowers another 66 cm (26 inches) and is now 142 cm (56 inches) deep.
- Continuing steering up for the next 3 m (10 ft) at an 8% pitch change, your pitch changes from 18% to 10% for an average pitch of 14%. Given that, the drill head lowers another 43 cm (17 inches) and is now 185 cm (73 inches) deep.
- Continuing steering up for the next 3 m (10 ft) at an 8% pitch change, your pitch changes from 10% to 2% for an average pitch of 6%. Given that, the drill head lowers another 18 cm (7 inches) and is now 203 cm (80 inches) deep.
- Leveling the drill head from 2% to 0% takes less than 1.5 m (5 ft) more for a final depth of 208 cm (82 inches). Reaching this final point took 4 and a half, 3 m (10 ft) pipes. So for this example your entry point should be 14.7 m (45 ft) back from the beginning-at-depth point of your installation.

The following example illustrates the process given an installation using the machine at an 18% pitch on level ground:

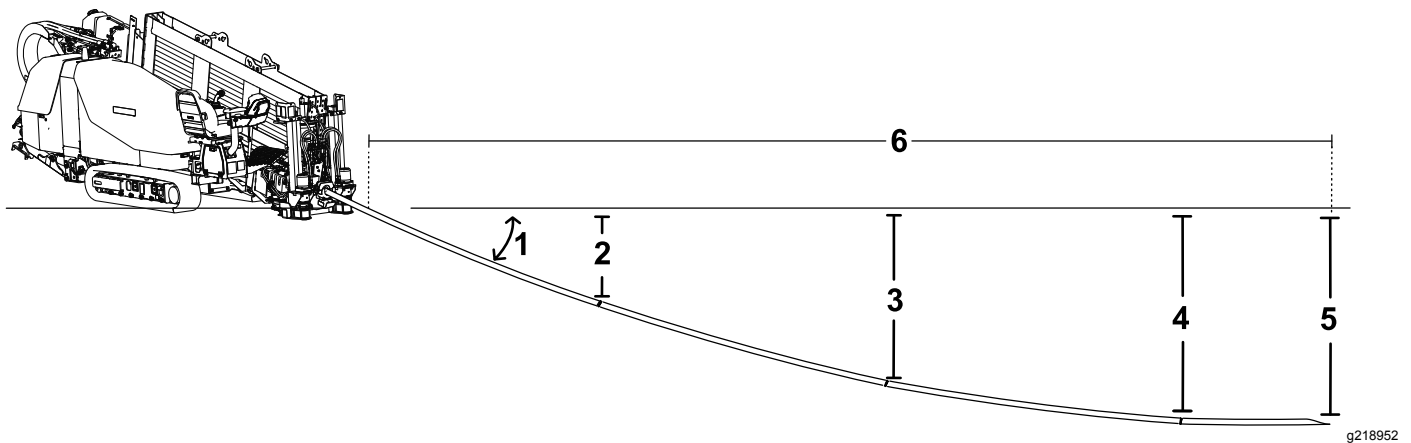


Figure 45

- | | | |
|----------------------|-----------------------|-----------------------|
| 1. 18% pitch | 3. 96 cm (38 inches) | 5. 119 cm (47 inches) |
| 2. 53 cm (21 inches) | 4. 114 cm (45 inches) | 6. 10.6 m (35 ft) |

- You insert the first 3 m (10 ft) of drill bit/pipe into the ground with no steering. The end of the drill bit is 53 cm (21 inches) deep (Figure 45).
- You begin steering up for the next 3 m (10 ft), pushing the pipes in at the maximum pitch change of 8%. This results in a change of pitch from 18% at the beginning of the 3 m (10 ft) to 10% at the end of the 3 m (10 ft) for an average pitch of 14%. Given that, the drill head lowers another 43 cm (17 inches) and is now 96 cm (38 inches) deep.
- Continuing steering up for the next 3 m (10 ft) at an 8% pitch change, your pitch changes from 10% to 2% for an average pitch of 6%. Given that, the drill head lowers another 18 cm (7 inches) and is now 114 cm (45 inches) deep.
- Leveling the drill head from 2% to 0% takes less than 1.5 m (5 ft) more for a final depth of 119 cm (47 inches). Reaching this final point took 3 and a half, 3 m (10 ft) pipes. So for this example, your entry point should be 10.6 m (35 ft) back from the beginning-at-depth point of your installation.

Important: You can use the information contained in this section to determine both the space needed to steer up to the exit point if needed and also to steer around obstacles.

Mapping the Bore Path

With the information you gathered previously, map out the path of the bore, identifying the following so that you can mark the site later:

- Entry point
- Location of the machine and supporting equipment
- Beginning of bore-at-depth
- Any obstacles that you need to steer around and the locations where you need to start steering to get around or under them
- Any utility lines you will need to cross
- Slope and soil changes along the path that will affect the bore
- End of the bore-at-depth
- Exit location if it is different than the end of the bore

Preparing the Job Site and the Machine

Before drilling, prepare the job site and machine as follows:

- [Marking and Preparing the Bore Path \(page 44\)](#)
- [Testing the Zap-Alert System \(page 45\)](#)
- [Loading the Drill Pipes \(page 46\)](#)
- [Filling the Fuel Tank \(page 46\)](#)
- [Checking the Engine-Oil Level \(page 74\)](#)
- [Checking the Coolant Level in the Radiator \(page 86\)](#)
- [Checking the Hydraulic Fluid \(page 91\)](#)
- [Checking the Drilling-Fluid-Pump Oil Level \(page 94\)](#)
- [Loading and Unloading the Machine \(page 48\)](#)
- [Understanding Horizontal Directional Drilling \(page 35\)](#)
- [Connecting to a Drilling-Fluid Source \(page 52\)](#)
- [Setting Up the Drill Head and Tracking System \(page 50\)](#)
- [Setting up the Machine for Drilling \(page 51\)](#)
- [Deploying the Zap-Alert System \(page 51\)](#)

Marking and Preparing the Bore Path

1. Walk the bore path, marking it on the ground with marking paint so that the receiver operator will be able to follow the path.
2. Hand dig to expose any buried utility lines, previously marked, that the bore path will be crossing. This will allow the receiver operator to know exactly where they are.
3. If you are exiting the bore at ground level and not in an existing trench, dig an angled hole into which the bit will enter at the end of the bore.
4. If desired, dig a hole to the beginning-of-the-bore point where you can disconnect the pipe or lines after pulling them back.

Checking the Safety-Interlock Switches

Checking the Operator Presence Safety-Interlock Functions on the Operator Platform

1. Start the engine.
2. With the engine running, rise from the seat and press a joystick function.

Note: The drill functions should not engage. If they do engage, there is a malfunction in the interlock system that you should correct before resuming operation.

Checking the Operator Presence Safety-Interlock Functions on the Travel Pendant

You will need 2 people for this procedure.

1. Start the engine.
2. With the engine running, have 1 person sit in the seat.
3. Using the travel pendant, press the controls to tram the machine.

Note: The tramming functions should not engage. If they do engage, there is a malfunction in the interlock system that you should correct before resuming operation.

4. With the engine running, use the travel pendant and press the controls to lower the stabilizer feet while **not** holding the operator presence button.

Note: The stabilizer feet functions should not engage. If they do engage, there is a malfunction in the interlock system that you should correct before resuming operation.

5. With the engine running, use the travel pendant and press the controls to tram the machine while **not** holding the operator presence button.

Note: The tramming functions should not engage. If they do engage, there is a malfunction in the interlock system that you should correct before resuming operation.

Checking the Pipe Load Guard Safety Interlock Functions

You will need 2 people for this procedure.

1. Start the engine.
2. Lower the pipe load guard.
3. With the engine running, have 1 person sit in the seat and begin the drilling process.
4. Raise the pipe load guard.

Note: The cam assembly should not engage. If it does engage, there is a malfunction in the interlock system that you should correct before resuming operation.

Testing the Zap-Alert System

⚠ DANGER

If the Zap-Alert system activates while drilling, the machine will become energized. If you step off of the operator platform or if someone touches the machine or wet ground near the machine or in the bore, you or they could be electrocuted, causing serious injury or death.

- Test the Zap-Alert system before drilling.
- Deploy the grounding stake before drilling. Ensure that the stake is fully inserted into moist soil.
- If the Zap-Alert is triggered:
 - Stay in the seat and do not touch the ground or any other part of the machine until the power has been turned off. Do not pour liquids or urinate from the operator platform onto the ground.
 - Stop drilling, stop the drilling-fluid flow, and retract the drill out of the ground.
 - Keep everyone away from the machine.
 - Keep standing or running water and drilling fluid contained close to the machine. Keep water and drilling fluid sources away from the broken line.
 - Contact the utility company to have power shut off to the broken line. Do not reset the Zap-Alert system until the power has been turned off.

The Zap-Alert system is an electric strike sensing device on the machine that triggers a strobe light and

audible alarm in the event that the drill bit, reamer, or stake breaks into an energized power line. In the event of an electric strike, the machine becomes energized, setting off the alarm.

Test the Zap-Alert system before using the drill each day, as follows:

1. Remove the ground cable from its storage position at the rear of the machine (Figure 49).
 2. Lay the grounding stake flat on the ground away from the machine. Do not drive the stake into the ground.
- Important:** Do not allow the stake to touch any part of the machine.
3. Open the front hood; refer to [Opening the Front and Rear Hoods](#) (page 67).
 4. Connect an alligator clip from the Zap-Alert tester to the grounding stud on the Zap-Alert system (Figure 46 and Figure 47).

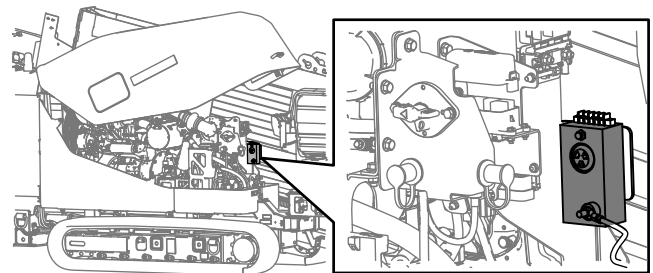


Figure 46

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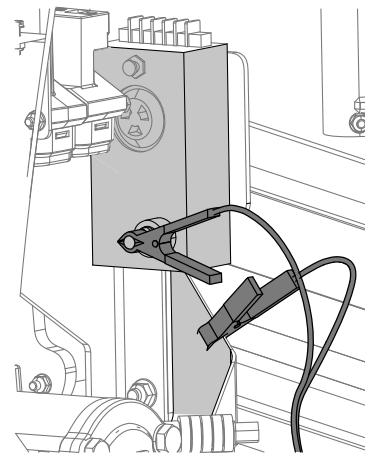


Figure 47

g230010

5. Connect the other alligator clip to a metal component of the machine frame.
6. Push the TEST button on the Zap-Alert tester (Figure 48).

The Zap-Alert alarm should sound, and the strobe on top of the front hood should flash.

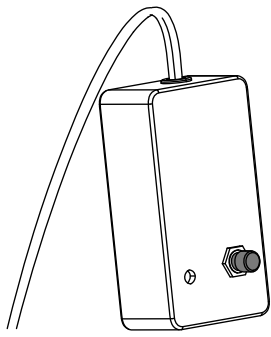


Figure 48

g230009

7. Push the ZAP-ALERT RESET button to stop the alarm (Figure 29).
8. Disconnect the alligator clips from the grounding stud and the machine.
9. Store the grounding stake in the holder at the rear of the machine (Figure 49).

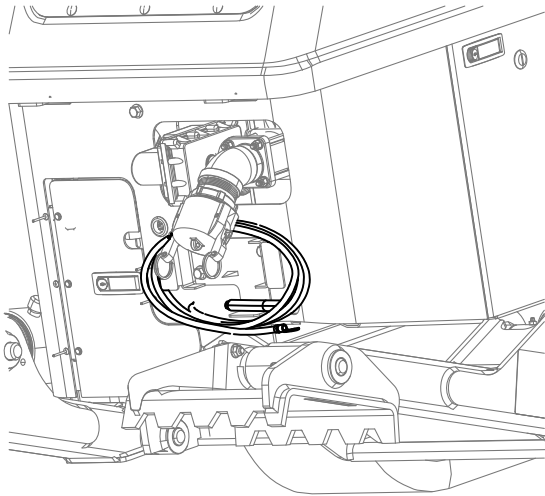


Figure 49

g218966

If either the audible alarm or the strobe light failed to trigger when you pushed the TEST button, have them repaired before drilling with the machine.

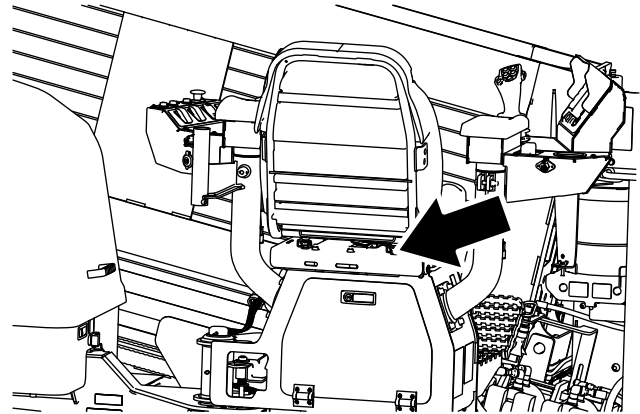
Mounting a Fire Extinguisher

Mount your fire extinguisher below the operator seat (Figure 50).

Note: A fire extinguisher is not provided with the machine.

The recommended fire extinguisher is a dry chemical fire extinguisher approved for class B and C fires.

Operate and maintain the fire extinguisher per the instructions on the fire extinguisher.



g218948

Figure 50

Loading the Drill Pipes

Refer to the *Software Guide* for the procedure on loading drill pipes into the pipe box or onto the drill string.

Filling the Fuel Tank

Fuel Tank Capacity

114 L (30 US gallons)

Fuel Specification

Important: Use only ultra-low sulphur diesel fuel. Fuel with higher rates of sulfur degrades the diesel oxidation catalyst (DOC), which causes operational problems and shortens the service life of engine components.

Failure to observe the following cautions may damage the engine.

- Never use kerosene or gasoline instead of diesel fuel.
- Never mix kerosene or used engine oil with the diesel fuel.

- Never keep fuel in containers with zinc plating on the inside.
- Do not use fuel additives.

Petroleum Diesel

Cetane rating: 45 or higher

Sulfur content: Ultra-low sulfur (<15 ppm)

Fuel Table

Diesel fuel specification	Location
ASTM D975 No. 1-D S15 No. 2-D S15	USA
EN 590	European Union
ISO 8217 DMX	International
JIS K2204 Grade No. 2	Japan
KSM-2610	Korea

- Use only clean, fresh diesel fuel or biodiesel fuels.
- Purchase fuel in quantities that can be used within 180 days to ensure fuel freshness.

Use summer-grade diesel fuel (No. 2-D) at temperatures above -7°C (20°F) and winter-grade fuel (No. 1-D or No. 1-D/2-D blend) below that temperature.

Note: Use of winter-grade fuel at lower temperatures provides lower flash point and cold flow characteristics which eases starting and reduces fuel filter plugging. Using summer-grade fuel above -7°C (20°F) contributes toward longer fuel pump life and increased power compared to winter-grade fuel.

Biodiesel

This machine can also use a biodiesel blended fuel of up to B20 (20% biodiesel, 80% petroleum diesel).

Sulfur content: Ultra-low sulfur (<15 ppm)

Biodiesel fuel specification: ASTM D6751 or EN14214

Blended fuel specification: ASTM D975, EN590, or JIS K2204

Important: The petroleum diesel portion must be ultra-low sulfur.

Observe the following precautions:

- Biodiesel blends may damage painted surfaces.
- Use B5 (biodiesel content of 5%) or lesser blends in cold weather.
- Monitor seals, hoses, gaskets in contact with fuel as they may be degraded over time.

- Fuel filter plugging may be expected for a time after converting to biodiesel blends.
- Contact your Authorized Service Dealer for more information on biodiesel.

Adding Fuel

1. Move the machine to a level surface.
2. Position the thrust frame in the horizontal position.
3. Shut off the engine.
4. Clean around the fuel-tank cap and remove the cap.

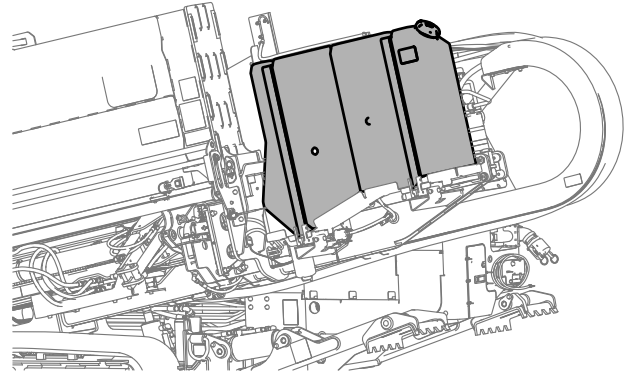


Figure 51

g218946

5. Add fuel and install the fuel-tank cap. Wipe up any spilled fuel.

Performing Daily Maintenance

Before starting the machine each day, perform the Each Use/Daily procedures listed in the [Recommended Maintenance Schedule\(s\)](#) (page 65).

Starting and Shutting Off the Engine

To start the engine, do the following:

1. Open the front hood; refer to [Opening the Front and Rear Hoods](#) (page 67).
2. Turn the battery disconnect switch to the ON position; refer to [Battery-Disconnect Switch](#) (page 34).
3. Close and latch the hood.
4. Open the door on the rear control panel.
5. Turn the key to the RUN position.

Ensure that ok-to-start light is illuminated. If the light is not illuminated, ensure that the

emergency-engine-stop buttons are released ([Figure 29](#) and [Figure 38](#)).

6. Turn the key to the START position until the engine starts, then release it.

To shut off the engine, turn the key to the OFF position.

In an emergency, you can also shut off the engine and all processes by pushing the EMERGENCY-ENGINE-STOP button on either the travel pendant or the control panel.

Tramming the Machine

Refer to [Tramming Safety \(page 5\)](#).

1. Raise the elevators.
2. Install the lower pipe box pins.
3. Lower the elevators.
4. Switch the drill into SETUP mode ([Figure 29](#)).
5. Walk around the machine to ensure that no one is near it. Ensure that all bystanders are clear of the area where you will be moving the machine.
6. Remove the travel pendant from the rear control panel.
7. With the travel pendant in hand, walk at least 6 feet to the side of the machine. Be sure to keep this safe distance whenever moving the machine.
8. Push and hold the OPERATOR-PRESENCE button on the travel pendant.
9. Use the speed switch on the pendant to increase or decrease the engine speed as desired.
10. Set the desired travel speed, using the speed switch.
11. Use the joystick to move the machine as desired.

Note: For more information on the travel pendant, refer to [Travel Pendant \(page 33\)](#).

Loading and Unloading the Machine

⚠ WARNING

Moving a machine of this size on a trailer over public roads carries risks to those around the machine if it should come loose, be involved in an accident, hit a low hanging structure, etc.

- Follow the tie-down procedures described in this section when moving the machine.
- Follow all local traffic regulations governing the hauling of large equipment. This manual cannot adequately cover all laws and safety regulations; it is your responsibility to know and follow the laws and regulations that pertain to you.

⚠ WARNING

The machine can slip and fall from a trailer or ramp, crushing anyone caught beneath it and causing serious injury or death.

- Keep all bystanders away from the machine and trailer.
 - Ensure that the trailer and ramp are not slippery and are free of ice, grease, oil, etc.
 - Move the machine onto the ramp at slow speed with the engine at slow speed.
 - Ensure that you have the machine centered on the ramp and trailer.
1. Ensure that the ramp and the trailer or truck bed can support the weight of the machine.
 2. Ensure that the upper pipe box straps and lower pipe box pins are installed ([Figure 52](#)).

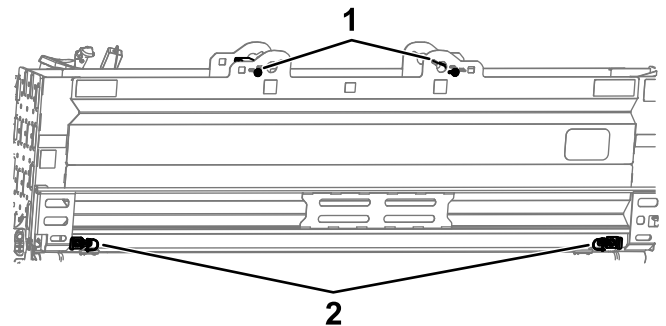


Figure 52

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1. Upper straps
2. Lower pins

3. Place a block at the front and rear of the trailer and/or truck tires.
4. Using the travel pendant, set the engine and the tram speed to slow.
5. Using the travel pendant, carefully tram the machine forward or rearward up the ramp and into position on the trailer.
6. Lower the stake-down tube to the deck of the trailer.
7. Lower the stabilizers until the stabilizer feet contact the trailer floor.
8. Turn off the engine.
9. Use appropriately rated chains and binders to secure the rings on the left and right track frames and through the tube on the stake-down plate to the trailer ([Figure 53](#)).

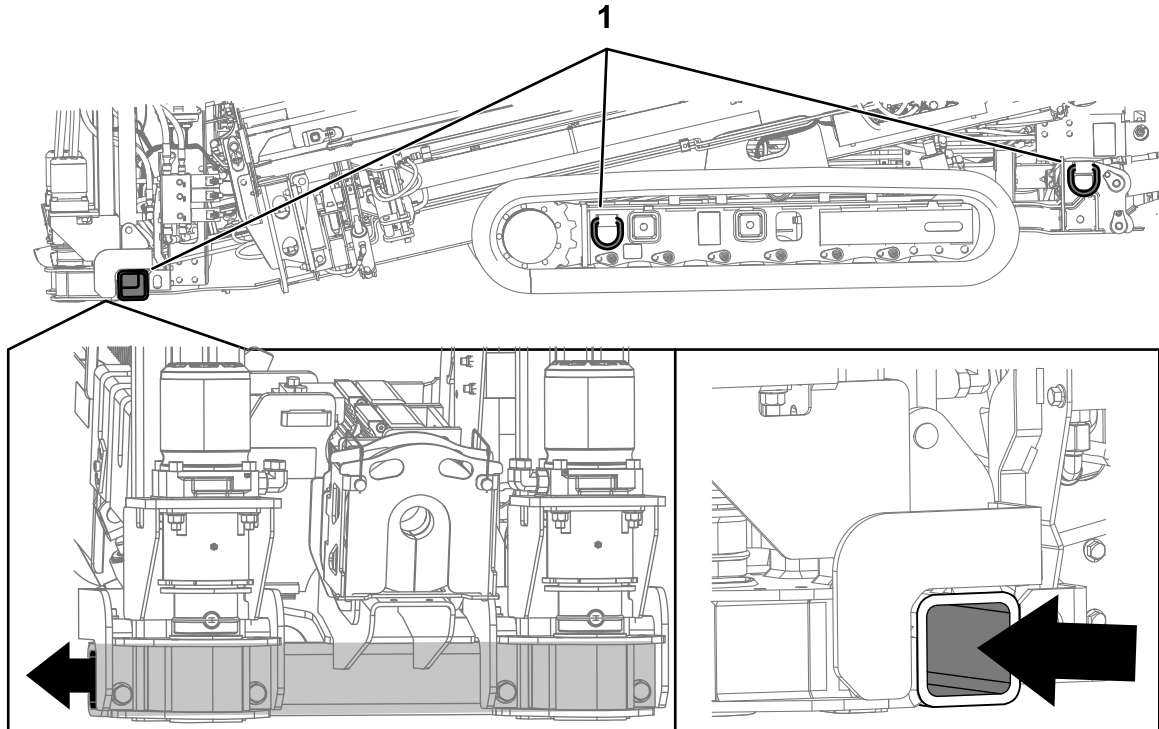


Figure 53

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1. Tie-down points (only left side shown)
-
10. Measure the distance from the ground to the highest point on the machine for reference to ensure that you do not collide with low hanging obstacles.
 11. Remove the block from the trailer tires, and stow them with the machine for use when unloading it.
 12. After tramping a few miles, pull over and check to ensure that all chains are still tight and that the machine has not moved.

To unload the machine, reverse the above procedure.

Setting Up the Drill Head and Tracking System

The drill head consists of 2 parts, the drill bit and the sonde housing (Figure 54).

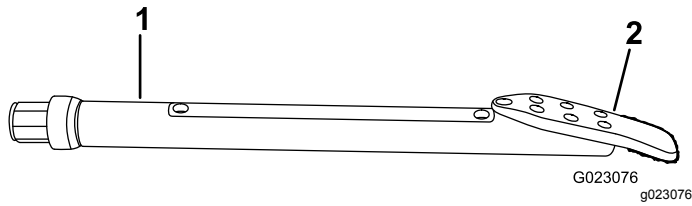


Figure 54

1. Sonde housing
2. Drill bit

Drill bits vary in size and type to meet the various soil conditions you may need to drill through. Some of the possibilities are as follows:

- **Straight blade**—Used in a wide range of medium density soils.
- **Bent blade**—Used in medium to soft soils. This bit has an added 20° bend to increase steering performance in soft soils.
- **Triangle point blade**—Use in hard and rocky soils. This bit has carbide edges to reduce wear.

All of the above bits come in varying widths. A wider blade increases your ability to steer in soft soils. A narrower blade moves through hard soils better. Contact your Authorized Service Dealer for a complete list of available blades.

The sondes and receivers are essential to track the position of the drill head throughout the drilling operation. The sonde housing on the drill head opens up to accept the sonde beacon which works with the receiver to track the location, pitch, direction, head orientation, and more of the drill head. Refer to the *Tracking System Operator's Manual* for instructions on using the system.

To install the sonde beacon into the sonde housing on the drill head, complete the following:

1. Replace the batteries in the sonde beacon as described in the *Tracking System Operator's Manual*.
2. Loosen the screws securing the housing cover to the housing and remove the cover (Figure 55).

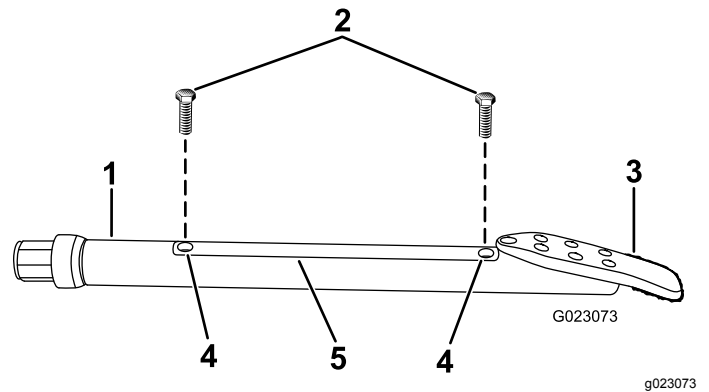


Figure 55

1. Sonde housing
2. Screws
3. Drill bit
4. Housing cover
5. Housing

3. Insert the sonde beacon with the forward end toward the drill bit into the sonde housing (Figure 56).

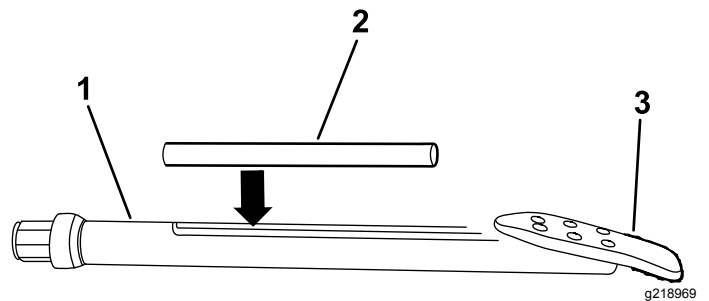


Figure 56

1. Sonde housing
2. Sonde
3. Drill bit

4. Install the housing cover and secure it with the screws (Figure 55).

Setting up the Machine for Drilling

1. Using the travel pendant, tram the machine to the location that you have prepared for it, ensuring that the front of the machine is the proper distance back from entry point and the drill frame is in line with the bore path.
 2. Drive up to the location and make sure that all utilities are located and marked prior to drilling.
 3. Remove the console covers.
- Note:** Store them someplace safe for the day.
4. Lower the pipe loading guard (Figure 57).

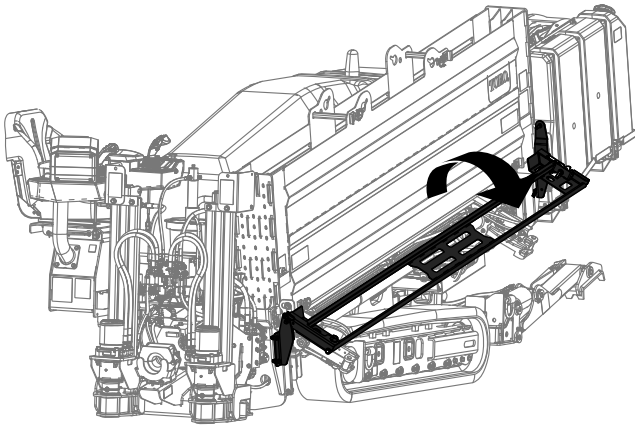


Figure 57

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5. Push down on the operator platform latch and swing the platform out to the desired position, ensuring that it locks in place (Figure 58).

Note: The operator platform has 5 positions: travel (swung all the way into the machine), full-out, and 3 intermediate positions.

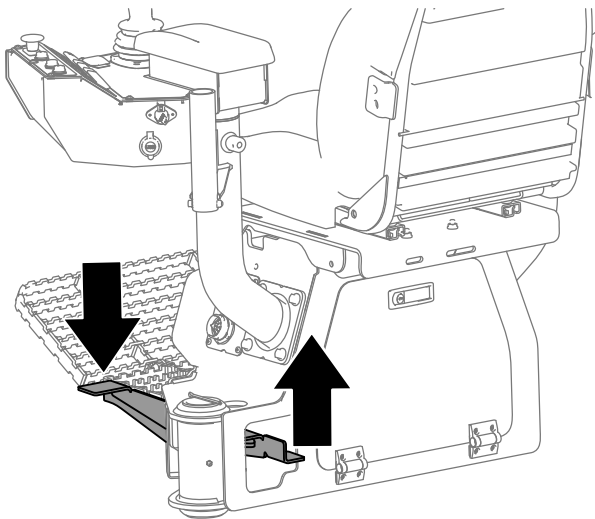


Figure 58

g218956

Deploying the Zap-Alert System

The Zap-Alert system is an electric strike sensing device on the machine that triggers a strobe light and audible alarm in the event that the drill bit, reamer, or stake breaks into an energized power line. In the event of an electric strike, the machine becomes energized, setting off the alarm.

⚠ DANGER

If the Zap-Alert system activates while drilling, the machine, including the operator's platform, will become energized. If you step off the operator platform or if someone touches the machine or wet ground near the machine or in the bore, you or they could be electrocuted causing serious injury or death.

- Test the Zap-Alert system before drilling.
 - Deploy the grounding stake before drilling. Ensure that the stake is fully inserted into moist soil.
 - If the Zap-Alert is triggered:
 - Stay in the seat and do not touch the ground or any other part of the machine until the power has been turned off. Do not pour liquids or urinate from the operator platform onto the ground.
 - Stop drilling, stop the drilling-fluid flow, and retract the drill out of the ground.
 - Keep everyone away from the machine, wet ground near the machine or running from the machine, and any open sources of water/mud that is in the bore and contacting the broken line.
 - Contact the utility company to have power shut off to the broken line. Do not reset the Zap-Alert system until the power has been turned off.
1. Remove the grounding stake from the holder on the side of the operator platform (Figure 59).

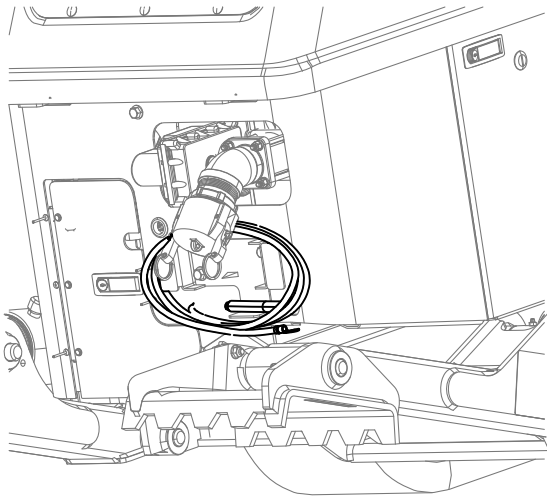


Figure 59

2. Move the stake directly away from the machine, perpendicular to the drill frame and drive it into the ground until the handle touches the ground.
3. If the ground is dry where you put the stake, soak it with water before using the machine to ensure good electrical contact.

Lowering the Stakes

Preparing the Machine to Lower the Stakes

1. Move the operator station to the desired angle, switch the DRILL/SETUP switch to the DRILL position, and raise the pipe elevators, so that the pipe is resting on the elevators; refer to [Starting the First Pipe \(page 57\)](#).
2. Remove the pipe box transport pins.
3. Power on the exit-side lockout system.
4. Load the first pipe and install the sonde and the drill head; refer to [Starting the First Pipe \(page 57\)](#).
5. Place the drill head on the drill frame, and take a pitch reading using the receiver; refer to the *Tracking System Operator's Manual*.

Lowering the Stakes

1. Move the operator station to the desired angle, switch the DRILL/SETUP switch to the DRILL position, and raise the pipe elevators, so that the pipe is resting on the elevators; refer to [Starting the First Pipe \(page 57\)](#).
2. Switch the DRILL/SETUP switch to the SETUP position, lower the thrust frame, tilting the drill frame until the plate contacts the ground ([Figure 60](#)).

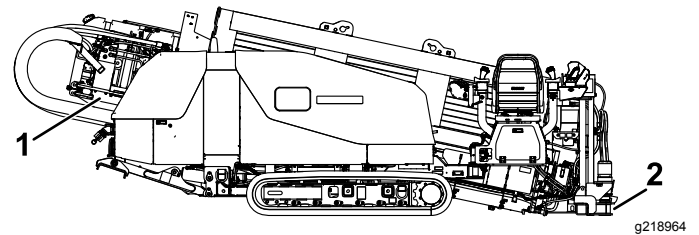


Figure 60

1. Thrust frame
2. Stake-down plate

3. Lower the rear stabilizers until they contact the ground firmly, or until the desired entry angle is achieved ([Figure 61](#)).

Note: The rear of the tracks should just start to lift off the ground.

Note: If the ground is soft, place timber below the stabilizers and lower the stabilizers.

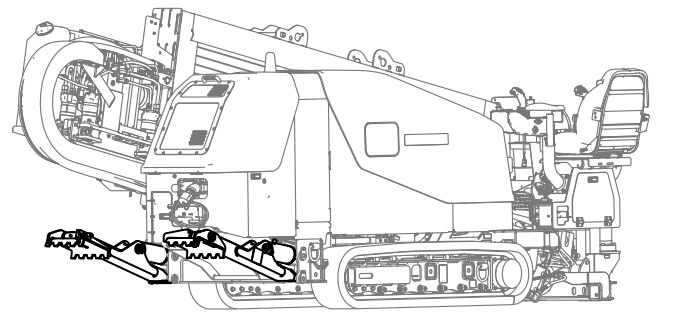


Figure 61

4. Deploy the zap-alert system; refer to [Deploying the Zap-Alert System \(page 51\)](#)
5. Push the lower stake direction on the right joystick and spin the right stake auger until it seats fully.
6. Repeat this procedure for the left-side stake.

Connecting to a Drilling-Fluid Source

When drilling and reaming, you pump a mixture of bentonite clay, water, and sometimes other ingredients, collectively called drilling fluid or “mud,” through the pipe and into the bore. This drilling fluid, or “mud,” does the following for your bore:

- Lubricates the drill head
- Keeps the sonde cool
- Loosens the soil into which the drill is cutting
- Penetrates and binds loose soil to keep them from collapsing on the bore pipe.

The specific mixture you need will vary depending on your soil type and the operation you are performing;

refer to your mixing system *Operator's Manual* for details.

Conversely, for some jobs (depending on the soil type and distance), you can pump screened water from a natural water source, such as a lake or river, through the drill instead of mixed drilling fluid.

- To connect the machine to a mixing system, refer to [Setting Up the Mixing System \(page 53\)](#).
- To connect the machine to a natural water source, refer to [Setting Up the Pump to Use a Natural Water Source \(page 53\)](#).

Setting Up the Mixing System

Set up your mixing system near the directional drill location, preferably down wind so that fumes from the mixing system engine do not bother you while drilling. Follow the instructions provided in the mixing system *Operator's Manual* for setting it up and using it.

Complete the following to connect the exit hose from the mixing system to the drilling-fluid pump on the machine:

1. Raise the cam-lock levers on the pump-inlet cap and remove the cap ([Figure 62](#)).

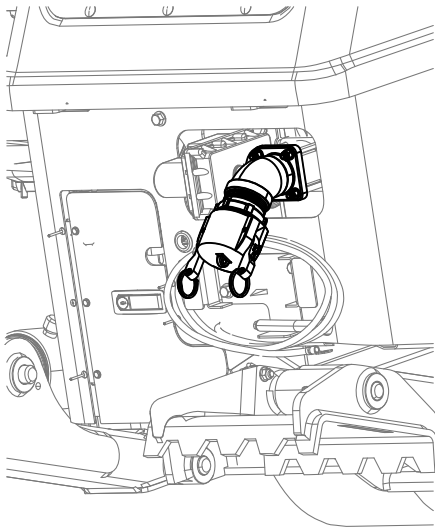


Figure 62

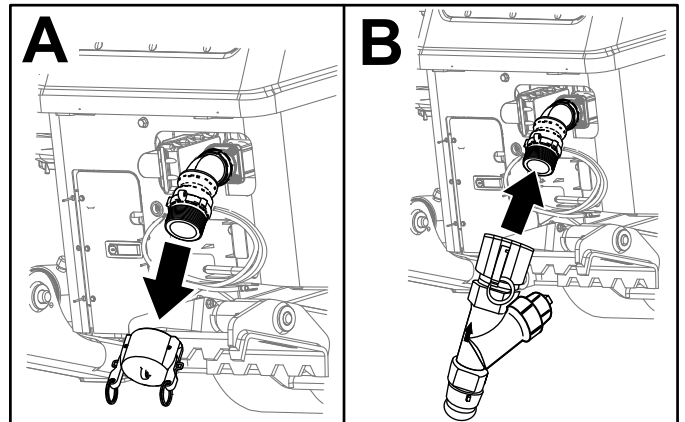
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2. Insert the hose from the mixing system over the pump inlet and secure it with the cam-lock levers.

Setting Up the Pump to Use a Natural Water Source

To set up a pump to use a natural water source, ensure that you use the Y-screen to filter all materials other than water.

1. Remove the pump-inlet cap (Box A of [Figure 63](#)).



g220801

Figure 63

2. Align the Y-screen with the threads on the pump (Box B of [Figure 63](#)).
3. Rotate and tighten the Y-screen onto the pump.
4. Attach the hose to the Y-screen, and begin pumping from the natural water source.

During Operation

During Operation Safety

General Safety

- The owner/operator can prevent and is responsible for accidents that may cause personal injury or property damage.
- Wear appropriate clothing, including long pants; eye and hearing protection; slip-resistant, substantial foot protection; and hard hats. Tie back long hair and do not wear jewelry.
- Do not operate the machine while ill, tired, or under the influence of alcohol or drugs.
- Never carry passengers on the machine and keep bystanders and pets away from the machine during operation.
- Operate the machine only in good visibility to avoid holes or hidden hazards.
- Keep your hands and feet away from moving parts.
- Look behind and down before backing up to be sure of a clear path.
- Use care when approaching blind corners, shrubs, trees, or other objects that may obscure your vision.
- Do not operate near drop-offs, ditches, or embankments.
- Stop the machine whenever you are not operating it.
- Stop the machine and inspect the after striking an object or if there is an abnormal vibration in the machine. Make all necessary repairs before resuming operation.
- Slow down and use caution when making turns and crossing roads and sidewalks with the machine. Always yield the right-of-way.
- Never run an engine in an area where exhaust gasses are enclosed.
- Never leave a running machine unattended.
- Before leaving the operating position, do the following:
 - Move the machine to level ground.
 - Shut off the engine and remove the key.
 - Wait for all moving parts to stop.
- Do not operate the machine when there is the risk of lightning.
- Do not use the machine as a towing vehicle.
- Use accessories, attachments, and replacement parts approved by The Toro® Company only.

Slope Safety

When operating the machine on a slope, the operator must account for many variables, such as the amount, distribution, and height of the load; the stability of the ground; uneven terrain and obstacles; and the condition of the brakes. These and other variables make it impractical to designate the maximum angle at which the operator can safely use the machine for all slopes and situations.

Slopes are a major factor related to loss of control and rollover accidents, which can result in severe injury or death. The operator is responsible for safe slope operation. Operating the machine on any slope requires extra caution. Before using the machine on a slope, the operator must do the following:

- Review and understand the slope instructions in the manual and on the machine.
- Evaluate the site conditions of the day to determine if the slope is safe for machine operation. Use common sense and good judgment when performing this evaluation. Changes in the terrain, such as moisture, can quickly affect the operation of the machine on a slope.
- Walk beside the machine when tramming up and down slopes.
- Identify hazards at the base of the slope. Do not operate the machine near drop offs, ditches, embankments, water or other hazards. The machine could suddenly roll over if a track goes over the edge or the edge collapses. Keep a safe distance (twice the width of the machine) between the machine and any hazard.
- Avoid starting, stopping or turning the machine on slopes. Avoid making sudden changes in speed or direction; turn slowly and gradually.
- Do not operate a machine under any conditions where traction, steering or stability is in question. Be aware that operating the machine on wet terrain, across slopes or downhill may cause the machine to slide even if the tracks are stopped.
- Remove or mark obstacles such as ditches, holes, ruts, bumps, rocks, or other hidden hazards. Uneven terrain could overturn the machine.

Diesel Particulate Filter Regeneration

The diesel particulate filter (DPF) is part of the exhaust system. The diesel-oxidation catalyst of the DPF reduces harmful gasses and the soot filter removes soot from the engine exhaust.

The DPF regeneration process uses heat from the engine exhaust to incinerate the soot accumulated on the soot filter, converting the soot to ash, and clears the channels of the soot filter so that filtered engine exhaust flows out the DPF.

The engine computer monitors the accumulation of soot by measuring the back pressure in the DPF. If the back pressure is too high, soot is not incinerating in the soot filter through normal engine operation. To keep the DPF clear of soot, remember the following:

- Passive regeneration occurs continuously while the engine is running—run the engine at full engine speed when possible to promote DPF regeneration.
- If the back pressure is too high, the engine computer signals you through the display when additional processes (assist and reset regeneration) are running.

Operate and maintain your machine with the function of the DPF in mind. Engine load, at high idle engine speed, generally produces adequate exhaust temperature for DPF regeneration.

Important: Minimize the amount of time that you idle the engine or operate the engine at low-engine speed to help reduce the accumulation of soot in the soot filter.

⚠ CAUTION

The exhaust temperature is hot (approximately 600°C (1,112°F) during DPF parked regeneration or recovery regeneration. Hot exhaust gas can harm you or other people.

- Never operate the engine in an enclosed area.
- Make sure that there are no flammable materials around the exhaust system.
- Never touch a hot exhaust system component.
- Never stand near or around the exhaust pipe of the machine.

DPF Soot Accumulation

- Over time, the DPF accumulates soot in the soot filter. The computer for the engine monitors the soot level in the DPF.

- When enough soot accumulates, the computer informs you that it is time to regenerate the diesel particulate filter.
- DPF regeneration is a process that heats the DPF to convert the soot to ash.
- In addition to the warning messages, the computer reduces the power produced by the engine at different soot-accumulation levels.

Refer to the *Software Guide* for fault messages and recommended actions.

DPF Ash Accumulation

- The lighter ash is discharged through the exhaust system; the heavier ash collects in the soot filter.
- Ash is a residue of the regeneration process. Over time, the diesel particulate filter accumulates ash that does not discharge with the engine exhaust.
- The computer for the engine calculates the amount of ash accumulated in the DPF.
- When enough ash accumulates, the engine computer sends information to the display in the form of a system advisory or an engine fault to indicate the accumulation of ash in the DPF.
- The advisory and faults are indications that it is time to service the DPF.
- In addition to the warnings, the computer reduces the power produced by the engine at different ash-accumulation levels.

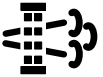
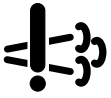
Refer to the *Software Guide* for fault messages and recommended actions.

Types of Diesel Particulate Filter Regeneration

Types of diesel particulate filter regeneration that are performed while the machine is operating:

Type of Regeneration	Conditions for DPF regeneration	DPF description of operation
Passive	Occurs during normal operation of the machine at high-engine speed or high-engine load	<p>The display does not display an icon indicating passive regeneration.</p> <p>During passive regeneration, the DPF processes high-heat exhaust gasses; oxidizing harmful emissions and burning soot to ash.</p> <p>Refer to Passive DPF Regeneration (page 57).</p>
Assist	Occurs as a result of low-engine speed, low-engine load, or after the computer detects back pressure in the DPF	<p>During assist regeneration, the computer controls the intake throttle to increase the exhaust temperature, enabling assist regeneration to occur.</p> <p>Refer to Assist DPF Regeneration (page 57).</p>
Reset	<p>Occurs after assist regeneration only if the computer detects that assist regeneration did not sufficiently reduce the soot level</p> <p>Also occurs after the first 50 engine hours and then every 100 hours to reset baseline sensor readings</p>	<p>During reset regeneration, the computer controls the intake throttle and fuel injectors to increase the exhaust temperature during regeneration.</p> <p>Refer to Reset Regeneration (page 57).</p>

Types of diesel particulate filter regeneration that require you to park the machine:

Type of Regeneration	Conditions for DPF regeneration	DPF description of operation
Parked	<p>Soot buildup occurs as a result of prolonged operation at low-engine speed or low-engine load. May also occur as a result of using incorrect fuel or oil</p> <p>The computer detects back pressure due to soot buildup and requests a parked regeneration</p>	 <p>When the parked-regeneration icon is displayed on the display, a regeneration is requested.</p> <ul style="list-style-type: none"> • Perform the parked regeneration as soon as possible to avoid needing a recovery regeneration. • A parked regeneration requires 30 minutes to complete. • You must have at least a 1/4 tank of fuel in the tank. • You must park the machine to perform a recovery regeneration. <p>Refer to Parked Regeneration and Recovery Regeneration (page 57) and the <i>Software Guide</i> for your machine.</p>
Recovery	Occurs as a result of ignoring parked regeneration requests and continuing operation, adding more soot when the DPF is already in need of a parked regeneration	 <p>When the recovery-regeneration icon is displayed on the display, a recovery regeneration is requested.</p> <ul style="list-style-type: none"> • A recovery regeneration requires approximately 4 hours to complete. • You must have at least a 1/2 tank of fuel in the machine. • You must park the machine to perform a recovery regeneration. <p>Refer to Parked Regeneration and Recovery Regeneration (page 57) and the <i>Software Guide</i> for your machine.</p>

Passive DPF Regeneration

- Passive regeneration occurs as part of normal engine operation.
- While operating the machine, run the engine at full-engine speed when possible to promote DPF regeneration.

Assist DPF Regeneration

- The computer takes control of the intake throttle to increase the temperature of the engine exhaust.
- While operating the machine, run the engine at full engine speed when possible to promote DPF regeneration.

Reset Regeneration

- The computer takes control of the intake throttle and changes the fuel injection operation to increase the temperature of the engine exhaust.

Important: The assist/reset-regeneration icon indicates that the exhaust temperature discharged from of your machine may be hotter than during regular operation.

- While operating the machine, run the engine at full engine speed when possible to promote DPF regeneration.

Parked Regeneration and Recovery Regeneration

Refer to the *Software Guide* for more information.

Preparing to Perform a Parked or Recovery Regeneration

Ensure that the machine has fuel in the tank for the type of regeneration you are performing:

- **Parked Regeneration:** Ensure that you have 1/4 tank of fuel before performing the parked regeneration.
- **Recovery Regeneration:** Ensure that you have 1/2 tank of fuel before performing the recovery regeneration.

Move the machine outside to an area away from combustible materials.

Refer to the *Software Guide* for the procedure to perform the parked or recovery regeneration.

Drilling the Bore

Starting the First Pipe

The *Software Guide* is used in this procedure.

1. Ensure that all bystanders are away from the machine and that the exit-side lockout is ON.
2. Move the drill carriage fully down the drill frame and spray the spindle threads with thread joint compound, then return the drill carriage to the upper end of the frame (Figure 59).

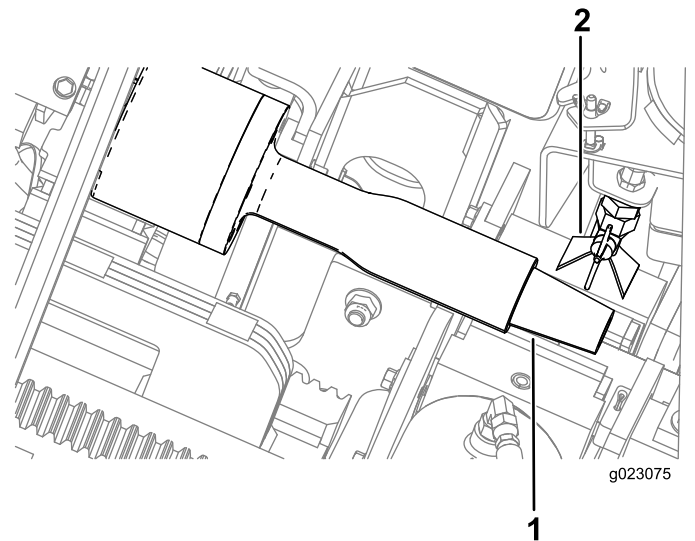


Figure 64

1. Drill spindle
2. TJC-applicator nozzle

3. Change the row selector to row 1 on the display to rotate the cam assembly to the first row in the pipe holder; refer to the *Software Guide*.
4. Lower the pipe elevators to load a pipe into the cam assembly.
5. Rotate the cam assembly with the pipe toward the drill frame, and extend the pipe grippers until the pipe is centered over the drill string and in front of the drill spindle on the carriage.
6. Raise the pipe elevators.
7. Engage the exit side lockout system and rotate the drill spindle clockwise and move the carriage slowly forward to insert the spindle into the female end of the pipe (Figure 65).

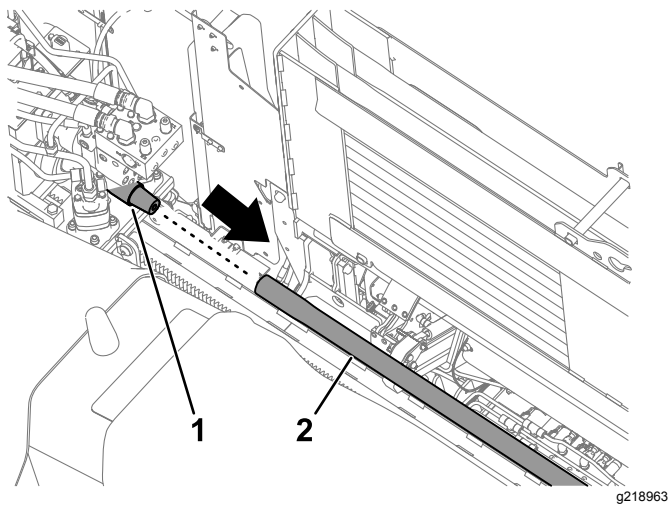


Figure 65

1. Drill spindle 2. Pipe

8. Continue to move the drill carriage slowly down the frame until the male threads on the pipe are under the thread-joint-compound applicator and apply thread-joint compound to the threads.
9. Continue to rotate the drive spindle clockwise, until the male pipe threads are fully seated into the sonde housing or the lead bar.
10. Release and retract the pipe gripper, rotating it all the way out to the park position.

Important: Ensure that you fully retract the pipe gripper and rotate it all the way out or the carriage may collide with the gripper, damaging the machine.

Note: Torque the threads to 2305 N·m (1,700 ft-lb).

Installing the Drill Head

⚠ WARNING

If the drill rotates or extends while you or others are manually working on the drill bit or pipe in front of the machine, the worker could get caught in the bit or pipe causing serious injury, amputation, or death.

- Enable the exit-side lockout on the exit-side-lockout transmitter before approaching the drill bit or pipe when attached to the machine. This disables the drill carriage motion and rotary functions.
- Do not wear loose clothing or jewelry when working on a drill bit or pipe attached to the machine. Tie long hair up and out of the way.

1. Using the exit-side-lockout transmitter, enable the exit side lockout.
2. Hand thread the lead bar onto the pipe threads then clear away from the front of the machine.
3. When the area is clear of people, push the exit-side-lockout reset switch on the front control panel.
4. Pull the drill pipe and lead bar back through the pipe guide and into the wrenches, aligning the shoulder of the upper joint of the lead bar with the upper wrench (Figure 66).

Important: Do not clamp the wrench on the body of a pipe or it may damage the pipe. Grip the pipes on the shoulder of the pipe joint.

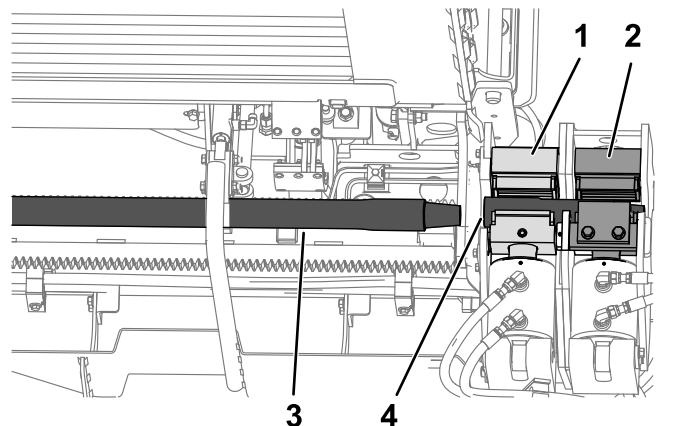


Figure 66

1. Upper wrench (makeup/breakout wrench) 3. Drill pipe
2. Lower wrench (stationary wrench) 4. Lead bar

5. Using the upper wrench, clamp the lead bar and tighten it to full machine torque.
6. Using the exit-side-lockout transmitter, enable the exit-side lockout.
7. Double check the drill head and bit to ensure that the fluid ports are clean and free from obstructions.
8. Install the drill head onto the end of the lead bar as directed by the drill head manufacturer, then clear away from the front of the machine.

Important: Do not pull the drill head into the pipe guide, or you may damage the machine or the drill head.

Boring the Entry Shaft

The first step is to create the entry shaft. Push and bore the drill bit and the first few pipes into the ground at an angle from 0 to 16 degrees (with the tracks flat on the ground) until you reach the desired depth.

Important: Drill and ream in a clockwise rotation. If you use a counterclockwise rotation, the pipe will disconnect from each other and may be disconnected underground.

1. When the area is clear of people, disable the exit-side lockout using the exit-side-lockout transmitter; push the exit-side-lockout, reset switch on the control panel.
2. Turn on the drilling fluid pump switch and allow the fluid pressure to build to 1379 to 2068kPa (200 to 300 psi).
3. Rotate the drill head until the bit is at the 6 o'clock position.
4. Move the carriage forward driving the bit straight into the ground until the entire drill housing is underground.
5. Continue pushing forward and begin rotating the drill spindle clockwise to initiate the drilling action.
6. Drill forward until the carriage reaches the end of the frame, then retract it about 6 mm (1/4 inch).

Adding Drill Pipes

1. Align the pipe joint in the wrench assembly.
2. Close the lower wrench (stationary wrench) onto the first pipe.

Note: The drilling fluid automatically shuts off when you activate the lower wrench.

3. Pull back the carriage approximately 12.7 mm (0.5 inch).

Note: This allows the carriage to float and not damage the pipe threads.

4. Rotate the drill head counterclockwise until the spindle is completely removed from the pipe.
5. Spray the spindle with thread joint compound, then return the drill carriage to the upper end of the frame.
6. Rotate the cam assembly to the closest row of pipes in the pipe holder.
7. Lower a pipe into the cam assembly and grip it in place.
8. Rotate the cam assembly toward the drill frame, and extend the pipe grippers until the pipe is centered over the drill string and in front of the spindle on the carriage.

9. Rotate the drill spindle clockwise and move the carriage slowly forward to insert the spindle into the female end of the pipe (Figure 65).

Note: Tighten the joint until the pipe is rotating with the spindle.

10. Move the drill carriage slowly down the frame until the male threads on the pipe are under the thread-joint-compound applicator and apply thread-joint compound to the threads.
11. Rotate the drill spindle clockwise and move the carriage slowly forward to insert the male end of the pipe into the female end of the previous pipe. Tighten the joint until you reach no more than 2,304 N·m (1,700 ft-lb).
12. Release and retract the pipe gripper, rotating it all the way out past the third row of pipes.

Important: Ensure that you fully retract the pipe gripper and rotate it all the way out; otherwise the carriage may collide with the gripper, damaging the machine.

13. Release the wrench and continue the drilling operation.

Steering the Drill Head

The drill bit is shaped like a wedge, angled from one side of the bit to the other. When you push the bit through the soil without rotating it, it moves toward the direction that the wedge is pointing. When you rotate the pipe and drill head, it bores through the soil in a straight path.



Figure 67

1. Drill bit

When drilling, a crew member follows the drill head as it progresses. The receiver receives signals from the sonde in the drill head identifying its position, depth, pitch, direction, transmitter temperature, and orientation in the soil. The remote console is a screen that remains near you (the drill operator) to show you the information from the receiver while drilling so that you can make steering decisions.

For detailed information on using the receiver and remote console to guide the drill head, refer to the *Operator's Manual* that came with your receiver.

Important: Do not steer the drill head more than 20 cm (8 inches) off center for every 3 meters (10

ft) of forward travel. If you steer more than this, you will damage the drill pipes.

Boring the Horizontal Shaft

After creating the entry shaft, you gradually steer the drill head up while pushing forward, following the planned bore path. When you reach the desired depth, level out the drill head and bore the horizontal shaft, adding pipes as you go. While boring, pay close attention to the information relayed back to you by the crew member about the status and location of the drill head to ensure that you are following the planned path.

Important: While drilling, watch the sonde temperature. All sondes have a maximum temperature above which they will be damaged. Friction between the drill head and the soil causes the temperature to raise. To reduce the temperature, slow down, decrease forward pressure, and increase the drilling fluid flow. If the drill head is entering a soil type other than what it is designed for, that can also raise the temperature. Assess the situation and pull out the drill head and change it if necessary.

If you run into an obstruction, do the following:

1. Increase the flow of the drilling fluid for a few seconds without drilling, then attempt to continue drilling forward.

This may loosen the obstruction and allow you to push past it.

2. If the obstruction persists, try 1 or more of the following options:
 - If the obstruction is in an area where you can dig, stop the drill head with the Exit Side Lockout and dig down to the obstruction to identify it and remove it if possible.
 - Pull the drill head back 15 m (50 ft) or more and steer the drill head to the side, marking a new drill path around the obstacle.

Important: Do not steer the drill head more than 20 cm (8 inches) off center for every 3 meters (10 ft) of forward travel. If you steer more than this, you will damage the drill pipes.

- If the obstruction is actually a change in soil types, such as a zone of rocky soil, pull the drill head all the way back and change to a drill bit appropriate for drilling through the new soil type.

Exiting the Ground

As you approach the end of the bore, steer the drill head to the exit point, keeping the steering limits in mind as you do so. Before exiting the ground, ensure that everyone is away from the exit point. As soon as you break through, stop the drilling-fluid flow. Extend the drill forward until the entire drill head is out of the ground.

Backreaming and Pullback

After drilling the initial bore, you attach a reamer to the pipe, which is then connected to the product you are installing. The reamer is designed to widen the bore, pack the walls, and lubricate the passage of the product into the bore.

The following reamers are available from your Authorized Service Dealer in various sizes to meet your needs and soil conditions:

- **Carbide step-wing cutter**—Use this reamer in sandy and medium clay soil conditions to mix the drilling fluid with the soil, making a mixture that flows easily around the product being pulled.
- **Cast cone packer**—Use this reamer in soils that pack easily, such as soft clay, peat, and loam, to pack the sides of the bore, maintaining the bore opening.
- **Fluted reamer**—Use this reamer in hard clay and rocky soils; it combines the features of the other 2 reamers.

Connecting the Reamer and Product

⚠ WARNING

If the drill rotates or extends while you or others are manually working on the drill bit or pipe in front of the machine, the worker could get caught in the bit or pipe causing serious injury, amputation, or death.

- **Enable the exit-side lockout on the exit-side-lockout transmitter before approaching the drill bit or pipe when attached to the machine. This disables the drill carriage and rotary gearbox.**
- **Do not wear loose clothing or jewelry when working on a drill bit or pipe attached to the machine. Tie long hair up and out of the way.**

1. Using the exit-side-lockout transmitter, enable the exit side lockout.

- Using breakout tools, remove the drill head from the lead bar.

Important: Do not use pipe wrenches.

- Double check the reamer to ensure that the fluid ports are clean and free from obstructions.
- Install the reamer and swivel onto the end of the lead bar as directed by the reamer manufacturer.
- Connect the product to the reamer using an appropriate pulling connection; refer to your Authorized Service Dealer to acquire the appropriate puller to meet your requirements.

Removing Drill Pipes

- Using the exit-side-lockout transmitter, enable the exit side lockout.
- Install a drill-pipe wiper around the pipe and into the retaining bracket on the front of the machine.

This removes most of the dirt and mud from the pipe as you pull it back into the machine, keeping the machine clean. Contact your Authorized Service Dealer to purchase drill-pipe wipers.

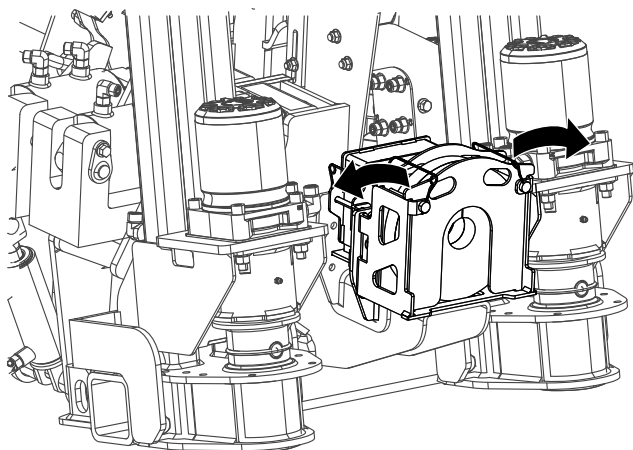


Figure 68

g234769

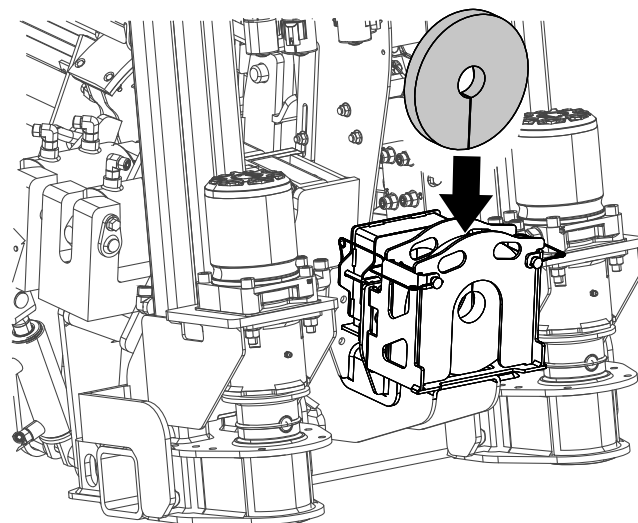


Figure 69

g234768

- Disengage the exit-side lockout and reset the system.
 - Begin rotating the drill spindle clockwise and slowly retract the drill carriage to pull the pipe back into the machine.
 - When the joint between the pipes is centered between the 2 wrenches, the drill carriage stops, and a green light illuminates behind the spray valve.
 - Close the lower wrench onto the pipe joint.
- Note:** The drilling fluid automatically shuts off when you close the lower wrench.
- Close the upper wrench onto the pipe joint.
 - Rotate the upper wrench counterclockwise until the joint is loosened.
 - Release the upper wrench and retract the pipe gripper arms.
 - Rotate the drill spindle counterclockwise moving rearward slowly until the pipes are separated.
 - Move the drill carriage back until the male-pipe threads just clear the female end of the lower pipe, then close the upper wrench onto the pipe shoulder, but not on the threads.
 - Rotate the drill spindle counterclockwise until the upper-pipe joint is loose but not separated.
 - Release the upper wrench.
 - Rotate the cam assembly to the drill frame, extend the pipe-gripper arms to the pipe, and grip the pipe to support it.
 - Move the drill carriage back until the pipe is lined up with the pipe holder load position, illuminating the green light.

16. Rotate the drill spindle counterclockwise moving rearward slowly until the spindle fully separates from the pipe.
17. Send the carriage to the rear stop on the thrust frame.
18. Retract the pipe gripper arms.
19. Rotate the pipe cam to the desired row.

Note: Fill the outside rows first.

20. Release the pipe gripper and raise the pipe into the pipe box using the pipe elevators.
21. Rotate the pipe gripper past the third row of pipes.

Important: Ensure that you fully retract the pipe gripper and rotate it all the way out; otherwise, the carriage may collide with the gripper, damaging the machine.

22. Move the drill spindle down the thrust frame and spray the spindle with thread joint compound once it is positioned under the applicator.
23. Rotate the drill spindle clockwise and move the carriage slowly forward to insert the spindle into the female end of the pipe secured in the lower wrench.

Note: Tighten the joint until you reach no more than 2,304 N·m (1,700 ft-lb).

24. Release the lower wrench and continue reaming/retraction as needed.

7. Remove the reamer from the end of the lead bar as directed by the reamer manufacturer.
8. Release the lower wrench and pull the lead bar out of the pipe guide.

After Operation

After Operation Safety

General Safety

- Clean up any oil or fuel spills.
- Allow the engine to cool before storing the machine in any enclosure.
- Never store the machine or fuel container where there is an open flame, spark, or pilot light, such as on a water heater or on other appliances.

Removing the Last Pipe and the Reamer

Important: Do not pull the drill head into the pipe guide or you may damage the machine or the drill head.

1. Using the exit-side-lockout transmitter, enable the exit side lockout.
2. After the reamer has cleared the ground, if you have not already done so, disconnect the product being installed from the reamer.
3. Connect the drilling fluid pump to a source of clean water.
4. Turn the pump on to flush clean water through the pump, spindle, and reamer until the water runs clear.
5. Remove and store the last pipe; refer to [Removing Drill Pipes \(page 61\)](#).
6. Leave the lead bar clamped in the lower wrench, but do not connect the drill spindle to the lead bar.

Finishing the Job

Complete the following after each day of use:

- Connect the hand spray gun to the pump and clean the machine with clean water; refer to [Cleaning with the Spray-Hose Attachment \(page 97\)](#).
- Flush the drilling fluid out of the drilling-fluid pump with water or antifreeze.

Note: The drilling-fluid pump may be damaged if the drilling-fluid dries up in the pump.

- If the air temperature is below freezing or will be before the next use, refer to [Preparing the Drilling-Fluid System for Cold Weather \(page 95\)](#).
- Add grease to the grease fittings; refer to [Greasing the Machine \(page 68\)](#).
- Install the console covers; refer to [Operator-Controls Covers \(page 27\)](#).

Using the TJC Applicator

Adjusting the Applicator Nozzle

You can adjust the applicator nozzle to spray thread-joint compound (TJC) either in a fan-shaped spray or as a stream.

- For fan-shaped spray—turn the spray valve on the side of the nozzle horizontal ([Figure 70](#)).
- For a stream—turn the spray valve on the side of the nozzle vertical ([Figure 70](#)).

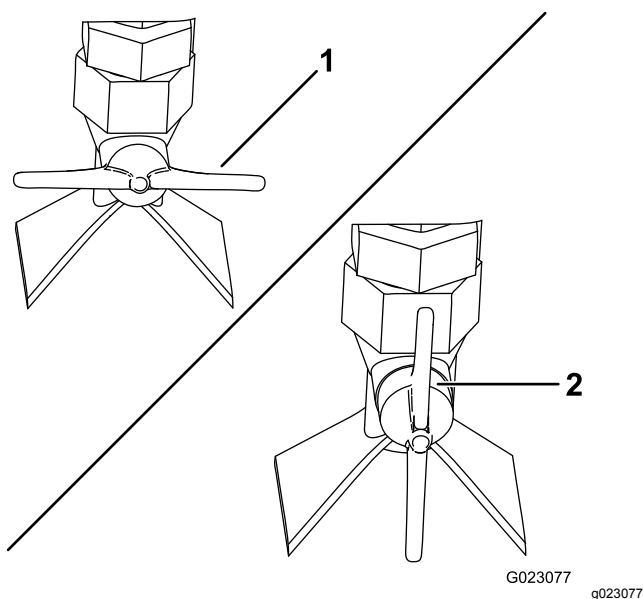


Figure 70

1. Spray valve—fan-shaped spray (horizontal)
2. Spray valve—stream spray (vertical)

Adjusting the TJC-spray Volume

To adjust the volume of thread-joint compound that is delivered by the applicator, complete the following:

1. Loosen the jam nut on the adjustment bolt located on top of the TJC-applicator piston ([Figure 71](#)).

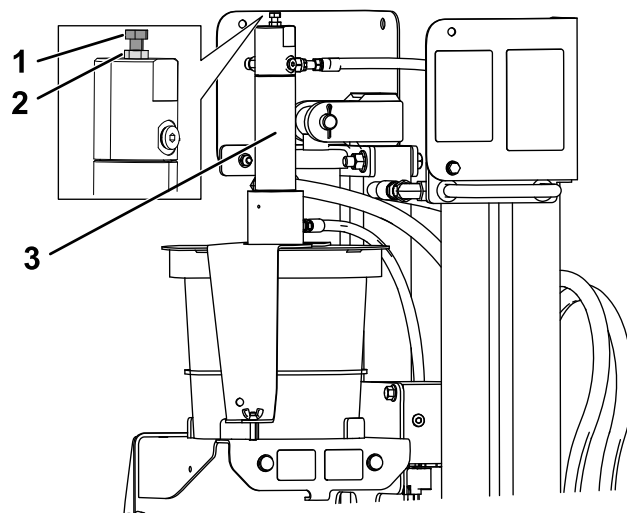


Figure 71

1. Adjustment bolt
2. Jam nut
3. TJC-applicator piston

2. Adjust the bolt as follows:
 - To increase the applied volume of compound, thread the bolt out (up).
 - To decrease the applied volume of compound, thread the bolt in (down).
3. When you have attained the desired application volume, tighten the jam nut to secure the adjustment.

Filling the TJC Applicator

1. Stop the machine and shut off the engine.
2. Loosen the wing nuts securing the cover straps to the machine (Box A of [Figure 72](#)).

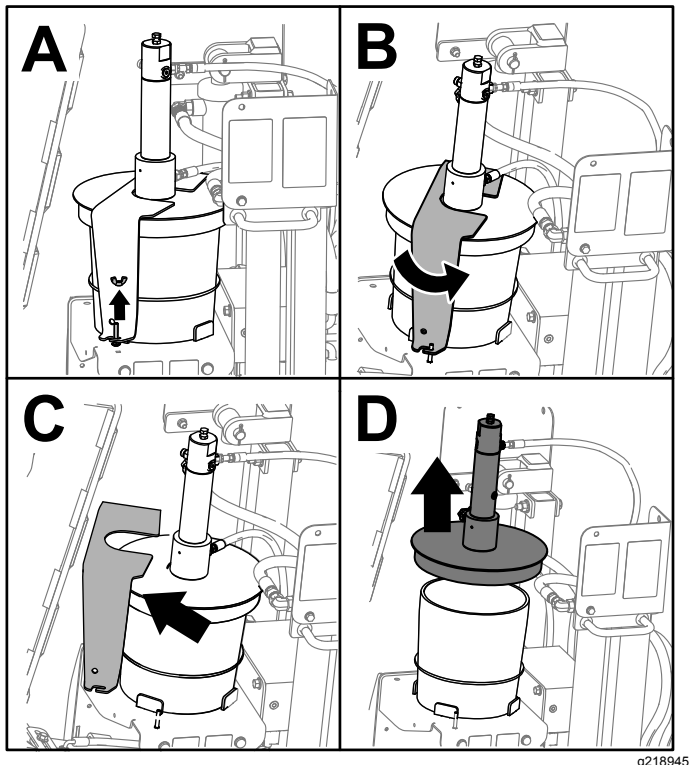


Figure 72

3. Rotate the cover and pull the cover straps off the retaining bolts (Box B and C of [Figure 72](#)).
4. Lift the cover assembly off and out of the empty thread-joint-compound bucket (Box D of [Figure 72](#)).
5. Replace the empty bucket with a new full bucket.
6. Place the plunger into the new bucket and lower the cover assembly onto the bucket.
7. Slide the cover straps over the retaining bolts and rotate the cover to seat the straps on the bolts.
8. Tighten the wing nuts.

Moving a Disabled Machine

Whenever the machine is stopped and the engine is not running, the hydrostatic brakes automatically engage. Do not attempt to tow the machine if it cannot move under its own power. If possible, repair the machine at the site. If this is not possible, use a crane and a spreader bar to lift the machine onto a trailer, using the lift points shown in [Figure 73](#).

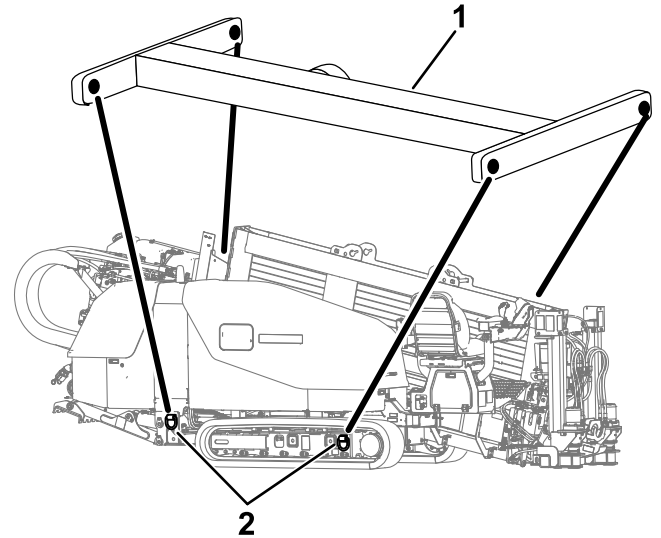


Figure 73

Repeat lift points on other side

1. Spreader bar
2. Lift point

Maintenance

▲ WARNING

Failure to properly maintain the machine could result in premature failure of machine systems, causing possible harm to you or bystanders.

Keep the machine well maintained and in good working order as indicated in these instructions.

Note: Determine the left and right sides of the machine from the normal operating position. Place a service tag on the machine when maintenance procedures are being performed.

Replace all covers and guards after you service or clean the machine. Do not operate the machine without the covers or guards in place.

Note: Download a free copy of the electrical or hydraulic schematic by visiting www.Toro.com and searching for your machine from the Manuals link on the home page.

Important: Refer to your engine owner's manual for additional maintenance procedures.

Recommended Maintenance Schedule(s)

Maintenance Service Interval	Maintenance Procedure
After the first 50 hours	<ul style="list-style-type: none">• Change the engine oil and engine-oil filter.
After the first 100 hours	<ul style="list-style-type: none">• Change the gearbox-drive oil.
After the first 250 hours	<ul style="list-style-type: none">• Change the planetary oil.
Before each use or daily	<ul style="list-style-type: none">• Grease the machine. (Grease immediately after every washing).• Check the engine-oil level.• Drain the water separator.• Check the rotary gearbox drive oil.• Check the track tension.• Check the coolant level in the reservoir for the radiator.• Check the hydraulic fluid level.• Check the drilling-fluid-pump oil level.• Clean the machine with the spray-hose attachment.
Every 50 hours	<ul style="list-style-type: none">• Remove the air-cleaner cover and clean out the debris. Do not remove the filter.• Check the battery condition• Check the planetary-drive oil level (Also, check if external leakage is observed).• Check the coolant level in the radiator.
Every 250 hours	<ul style="list-style-type: none">• Check the air-cleaner filter for damage which could cause an air leak. Replace if damaged.• Check the whole air-intake system for leaks, damage, or loose hose clamps.• Check the condition of the engine-drive belt.
Every 400 hours	<ul style="list-style-type: none">• Change the engine oil and engine-oil filter.• Check and replace (if necessary) fuel hoses and engine-coolant hoses.• Replace the fuel/water separator element.• Replace the fuel-filter element.• Check the condition of the coolant system components. Clean dirt and debris from them and repair or replace the components as necessary.• Change the drilling-fluid pump oil.• Calibrate the joysticks and the travel pendant.

Maintenance Service Interval	Maintenance Procedure
Every 800 hours	<ul style="list-style-type: none"> • Adjust the engine-valve clearance (if necessary). • Drain and clean the fuel tank. • Change the planetary oil (or yearly, whichever comes first). • Check the rotary gearbox drive oil (or yearly, whichever comes first). • Change the gearbox-drive oil (or yearly, whichever comes first). • Check the concentration of the coolant before the winter season. • Clean the cooling system. (Clean the cooling system if the coolant becomes dirty or rust colored.) • Check the tension on the engine drive belt. • Change the hydraulic-fluid return filter. • Change the hydraulic-pressure filter. • Change the hydraulic fluid.
Every 1,500 hours	<ul style="list-style-type: none"> • Clean the engine EGR cooler. • Inspect the engine crankcase-breather system.
Every 2,000 hours	<ul style="list-style-type: none"> • Lap or adjust the engine intake and exhaust valves (if necessary).
Every 3,000 hours	<ul style="list-style-type: none"> • Inspect and clean (if necessary) the engine-emission-control components and turbocharger.
Yearly or before storage	<ul style="list-style-type: none"> • Touch up chipped paint.
Every 2 years	<ul style="list-style-type: none"> • Replace moving hoses.

⚠ WARNING

Improperly servicing or repairing the machine may cause injury or death.

If you do not understand the service procedures for this machine, contact your Authorized Service Dealer or see the service manual for this machine.

⚠ WARNING

Operating the machine without covers and guards in place may cause personal injury or death.

Replace all covers and guards after you service or clean the machine. Do not operate the machine without the covers or guards in place.

Pre-Maintenance Procedures

Pre-Maintenance Safety

- Before adjusting, cleaning, repairing, or leaving the machine, do the following:
 - Move the machine on a level surface.
 - Shut off the engine and remove the key.
 - Set the battery-disconnect switch to the OFF position.
 - Wait for all moving parts to stop.
- Allow machine components to cool before performing maintenance.
- If possible, do not perform maintenance while the engine is running. Keep away from moving parts.
- Use adequate support to support the machine or components when required.
- Carefully release pressure from components with stored energy.

Accessing Internal Components

Opening the Front and Rear Hoods

Use 1 key to unlock the latch and push the lever open.

Use the smaller key to unlatch the hood.

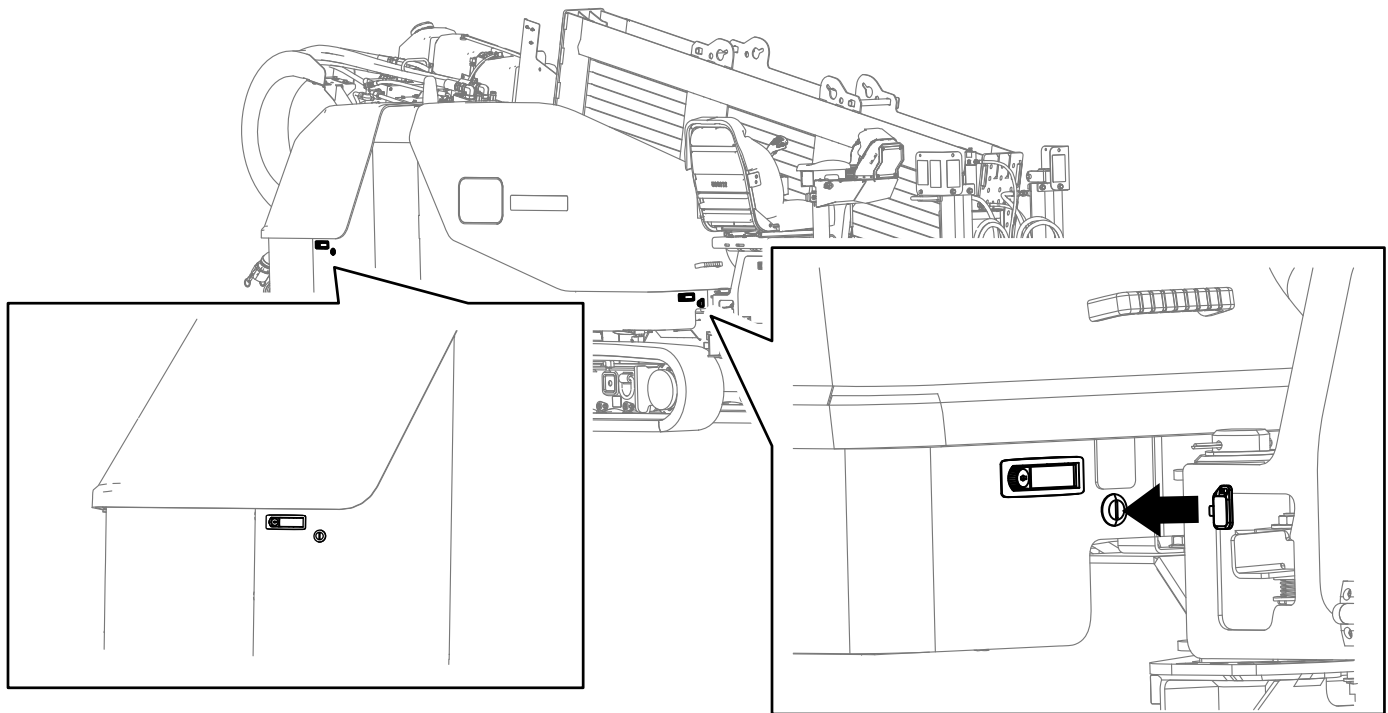


Figure 74

g218949

Using the Cylinder Lock

⚠ WARNING

The thrust frame may lower when it is in the raised position, causing serious injury or death.

Install the cylinder lock before performing maintenance that requires the thrust frame to be raised.

Installing the Cylinder Lock

1. Start the engine.
2. Lower the thrust frame to the fully-lowered position.
3. Shut off the engine.
4. Position the cylinder lock over the cylinder rod (Figure 75).
5. Secure the cylinder lock with the cotter pin and clevis pin (Figure 75).
6. Turn the engine to the ON position, and raise the thrust frame until it rests on the cylinder lock.

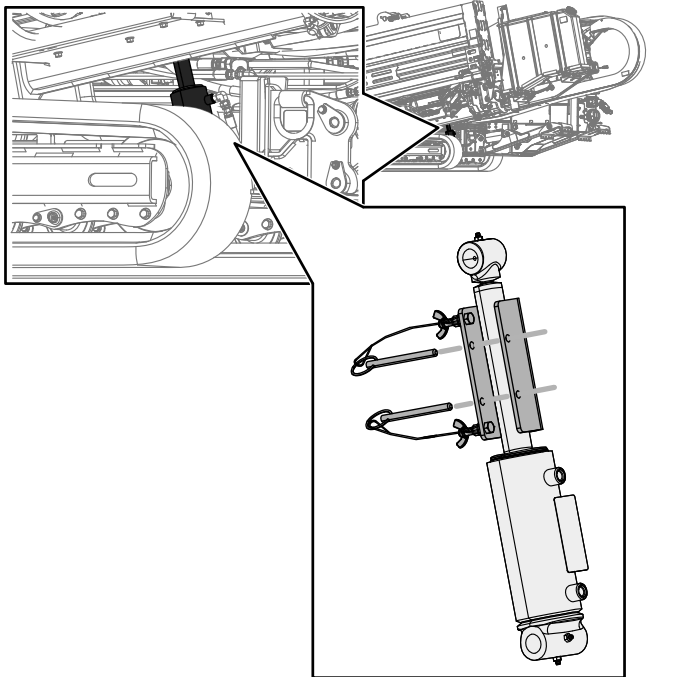


Figure 75

g230470

Lubrication

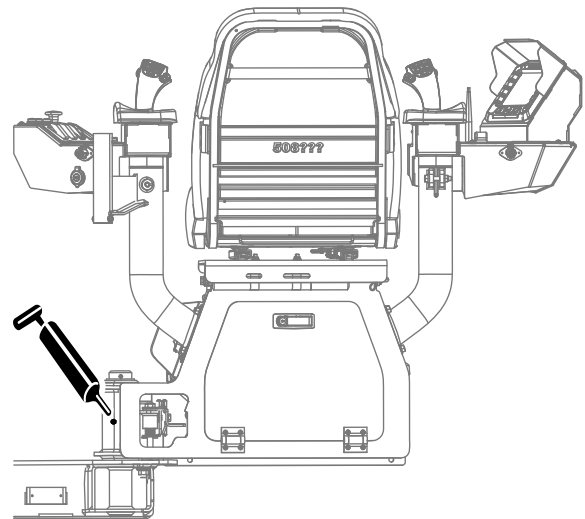
Greasing the Machine

Service Interval: Before each use or daily (Grease immediately after every washing).

Grease type: General-purpose grease.

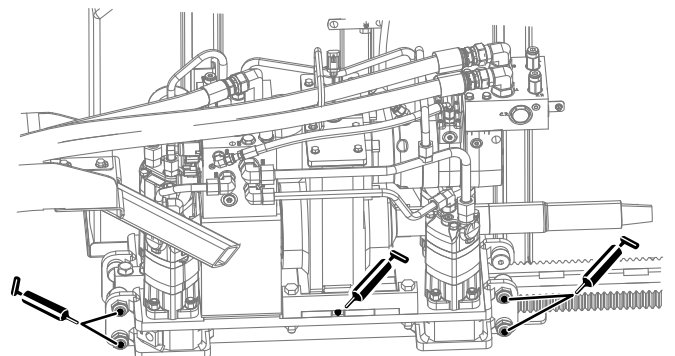
Total number of grease fittings: 51

1. Clean the grease fittings with a rag.
2. Connect a grease gun to each fitting.
3. Pump grease into the fittings until grease begins to ooze out of the bearings (approximately 3 pumps).
4. Wipe up any excess grease.



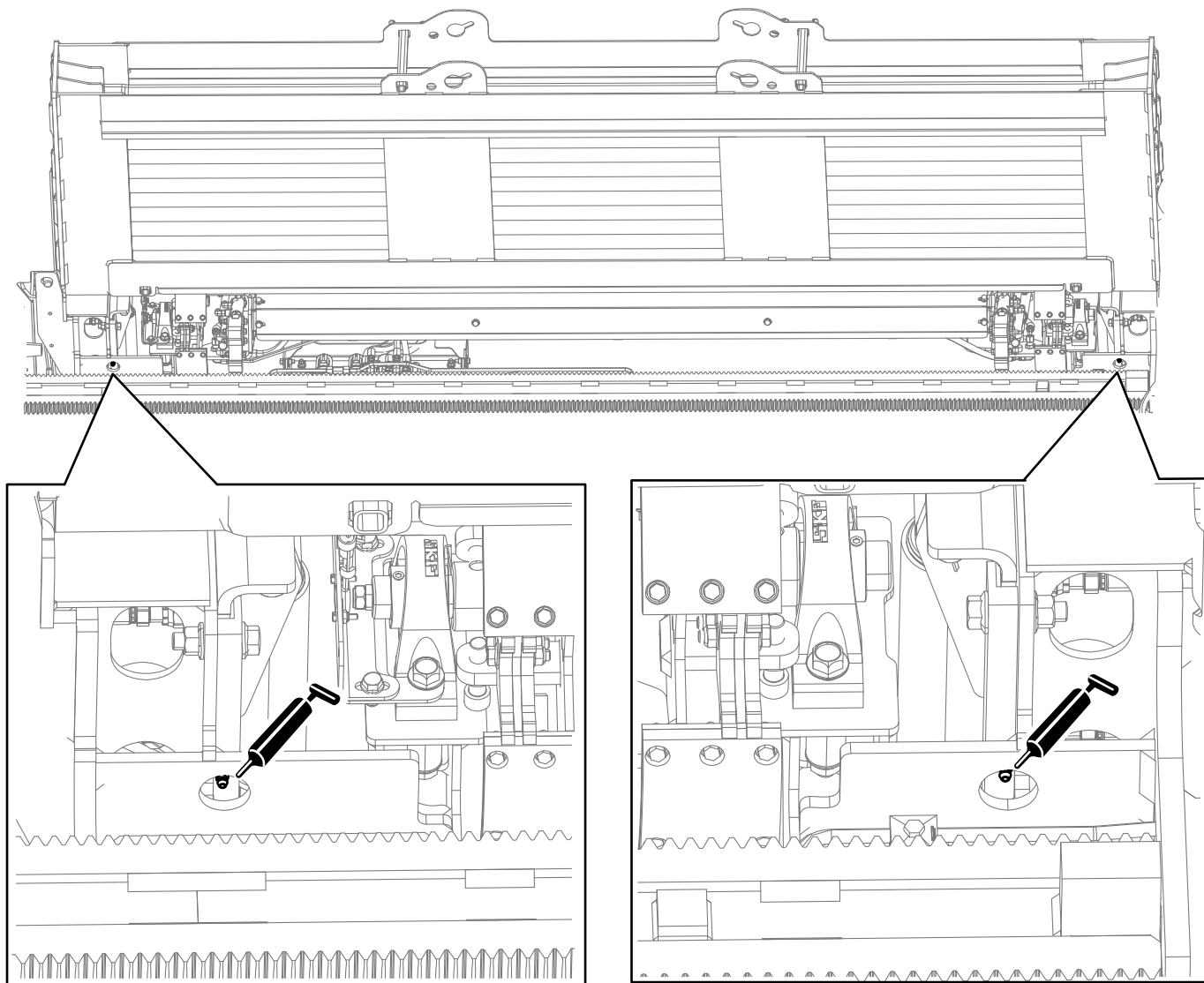
g223044

Figure 76
Operator Platform—1 fitting



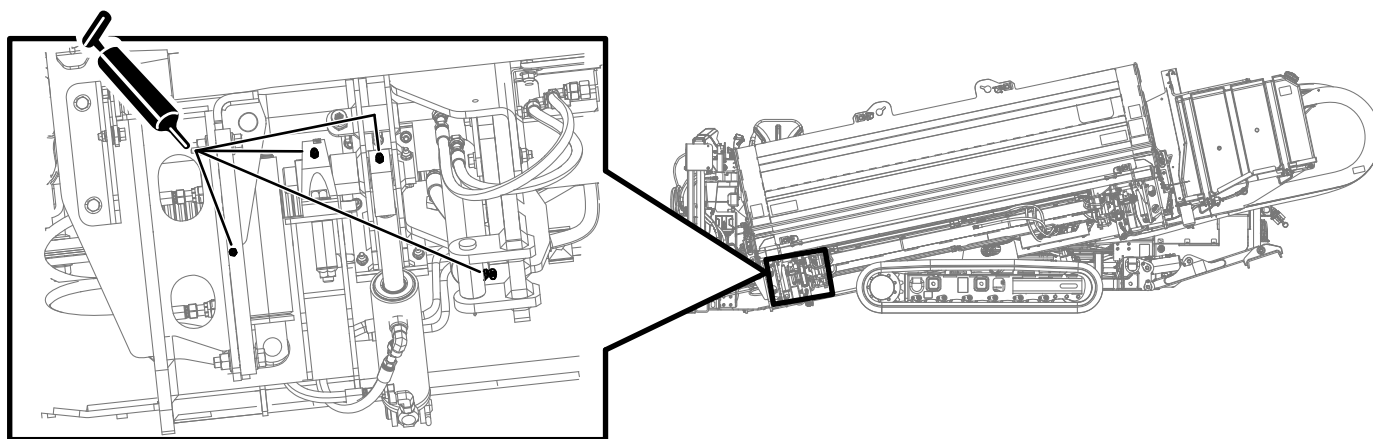
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Figure 77
Carriage—10 fittings



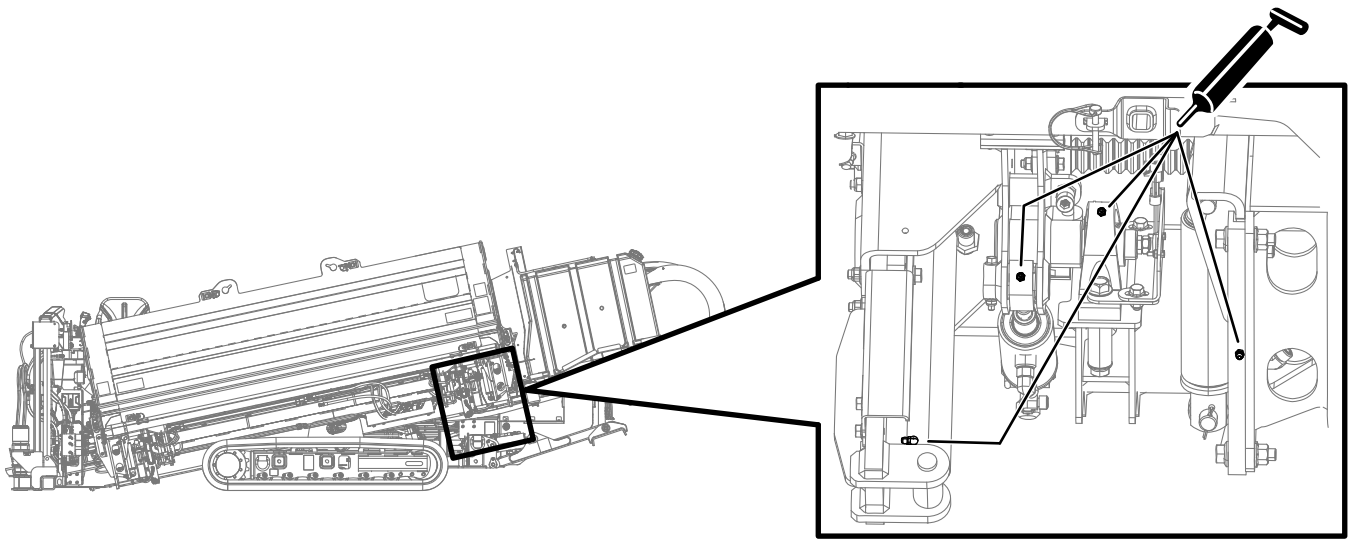
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Figure 78
Cam Assembly (Operator Side)—2 fittings



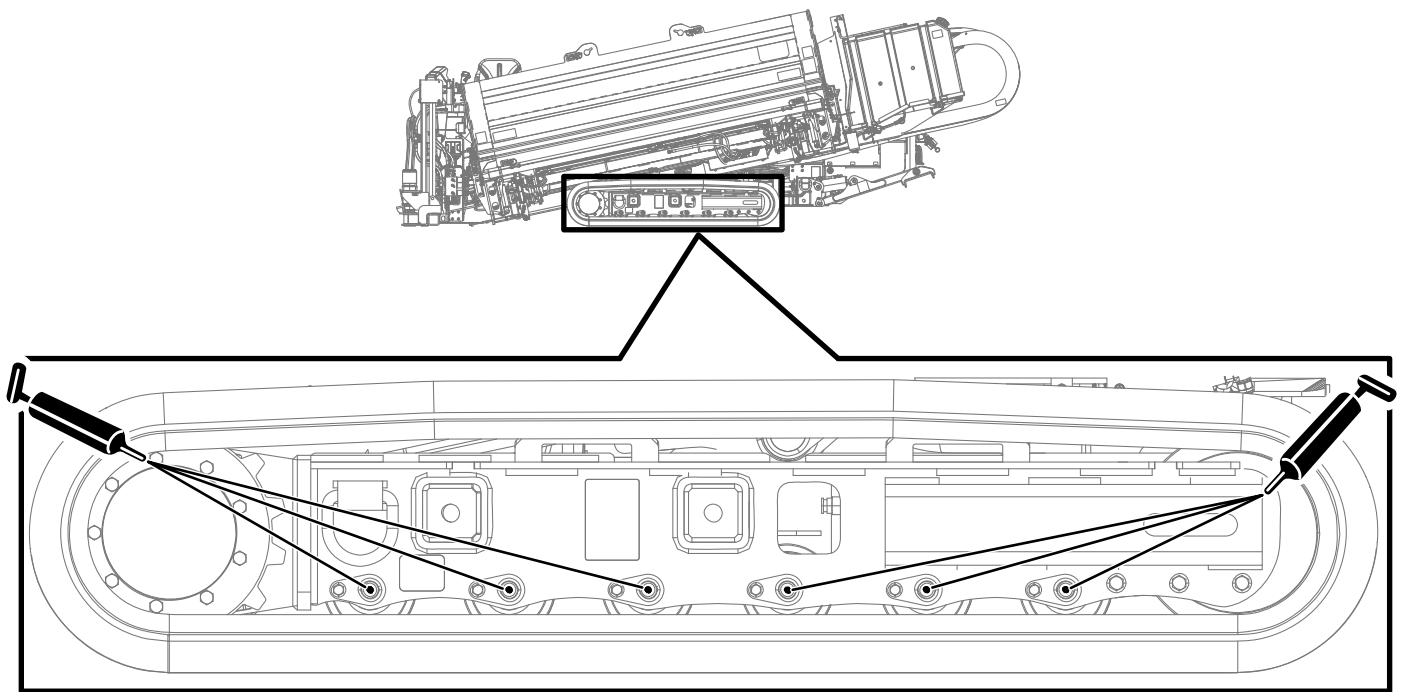
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Figure 79
Left Side, Front Cam Assembly—4 fittings



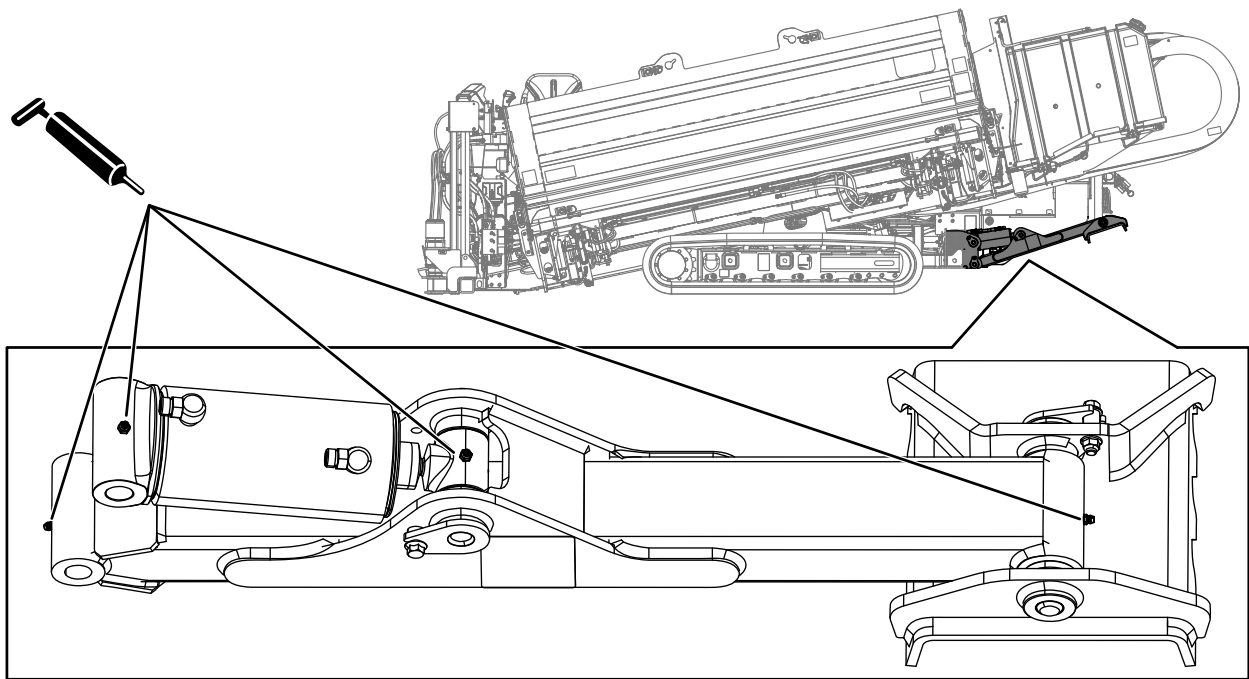
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Figure 80
Left Side, Rear Cam Assembly—4 fittings



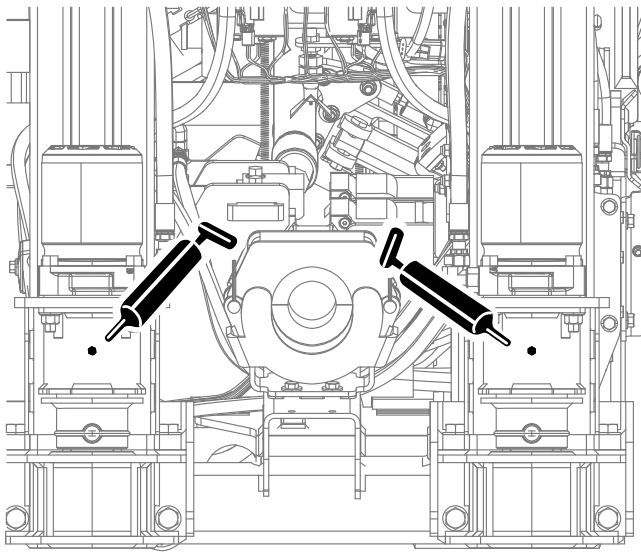
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Figure 81
Tracks—12 fittings (6 on each side)



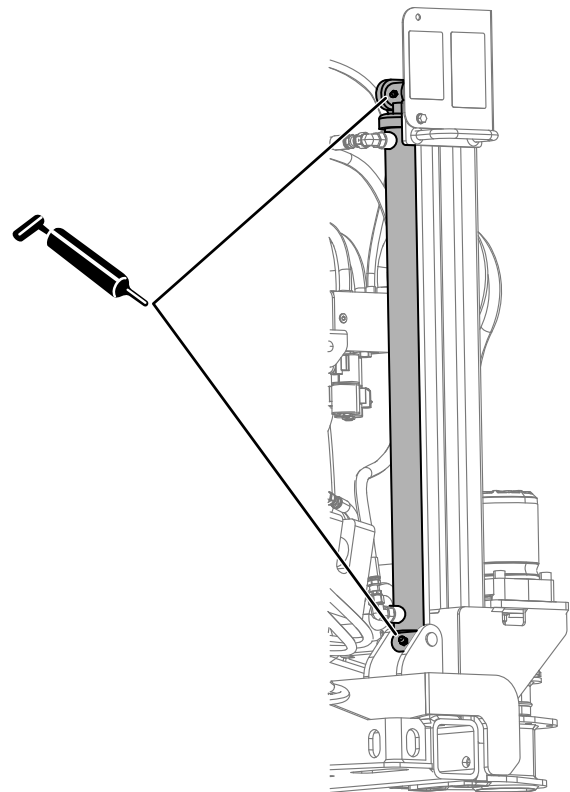
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Figure 82
Stabilizer Feet—8 fittings (4 on each foot)



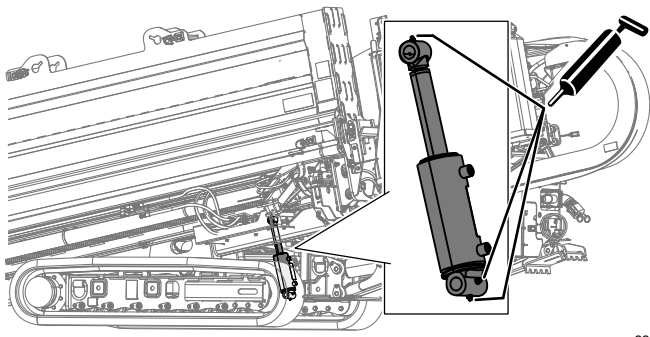
g220082

Figure 83
Stakedown Motors—2 fittings



g224193

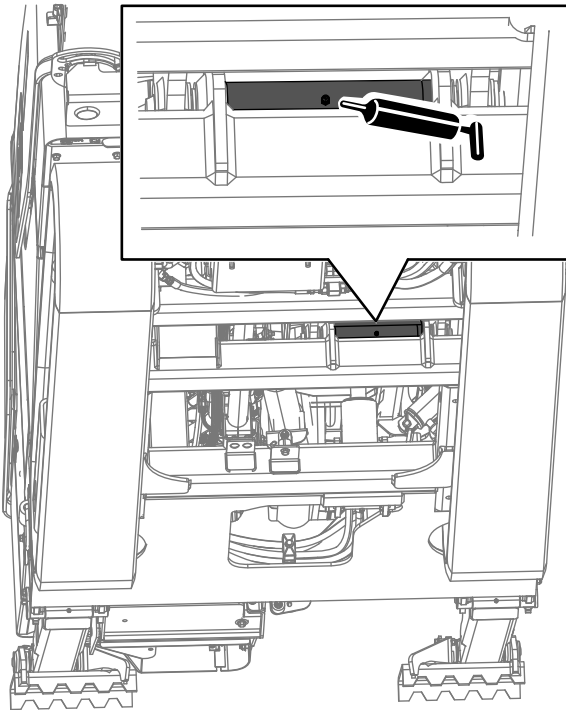
Figure 84
Stakedown Cylinders—4 fittings (2 fittings on each cylinder)



g223045

Figure 85

Lift Cylinder (Drill/Carriage Side; lower grease fitting is behind the track roller)—3 fittings



g223046

Figure 86

Thrust Frame Pivot Pin (Underside of the Machine)—1 fitting

Engine Maintenance

Engine Safety

- Shut off the engine before checking the oil or adding oil to the crankcase.
- Do not change the governor speed or overspeed the engine.

Servicing the Air Cleaner

Check the air-cleaner body for damage that could cause an air leak and replace it if it is damaged. Check the entire intake system for leaks, damage, or loose hose clamps. Also, inspect the rubber intake-hose connections at the air cleaner and turbocharger to ensure that the connections are complete.

Service the air-cleaner filter only when the “Check Air Filter” message is displayed on the display; refer to the *Software Guide* for the machine. Changing the air filter before it is necessary only increases the chance of dirt entering the engine when you remove the filter.

Ensure that the cover is seated correctly and seals with the air-cleaner body.

Servicing the Air-Cleaner Cover

Service Interval: Every 50 hours—Remove the air-cleaner cover and clean out the debris. Do not remove the filter.

Check the air-cleaner body for damage that could cause an air leak. Replace a damaged air cleaner body.

Clean the air-cleaner cover ([Figure 87](#)).

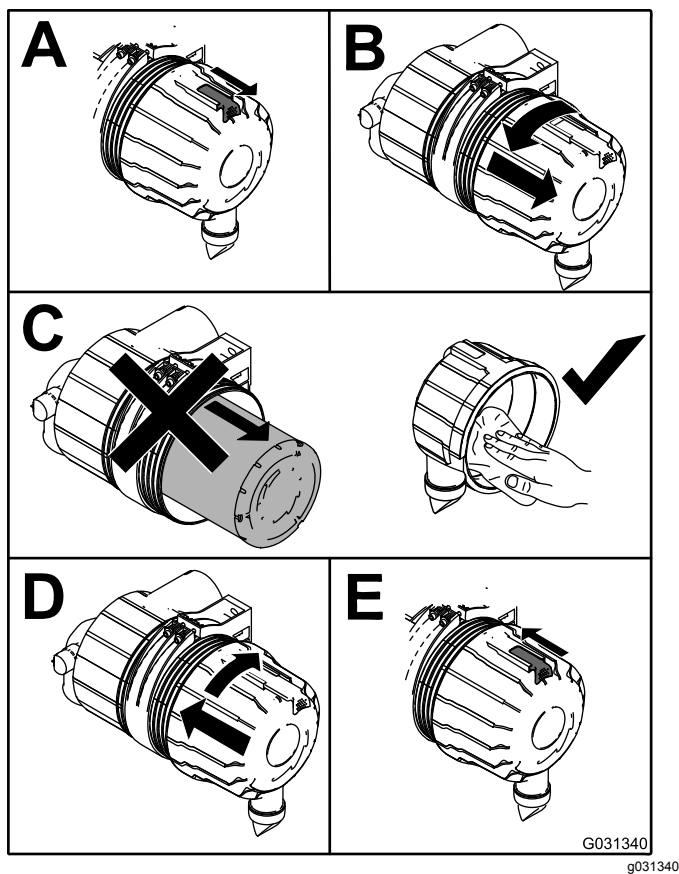


Figure 87

Servicing the Air-Cleaner Filter

Service Interval: Every 250 hours—Check the air-cleaner filter for damage which could cause an air leak. Replace if damaged.

Every 250 hours—Check the whole air-intake system for leaks, damage, or loose hose clamps.

The air-intake system on this machine is continuously monitored by an air-restriction sensor that displays when an advisory when to replace the air filter. Do not replace the elements until this occurs.

Important: Replace the secondary filter element only every 3 primary filter services. Do not remove the secondary element when cleaning or replacing the primary element. The inner element prevents dust from entering the engine when you service the primary element.

Important: Do not operate the engine without the air-cleaner elements, as this would allow foreign material to enter the engine and damage it.

1. Release the latches securing the air-cleaner cover to the air-cleaner body (Figure 88).

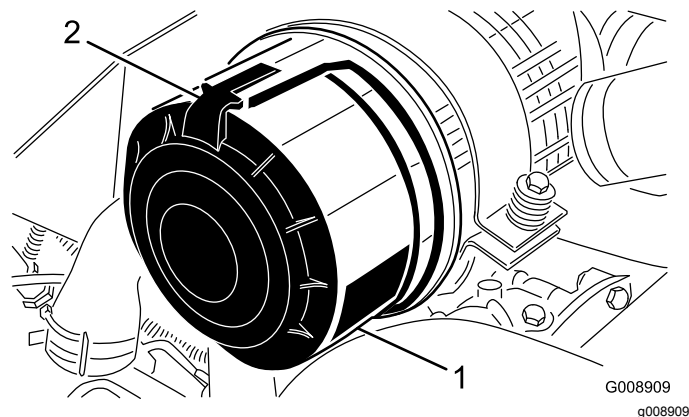


Figure 88

1. Air-cleaner cover
2. Air-cleaner latch

2. Remove the cover from the air-cleaner body.
3. Before removing the filter, use low-pressure air (275 kPa or 40 psi, clean and dry) to help remove large accumulations of debris packed between the outside of the primary filter and the canister.

Note: Avoid using high-pressure air that could force dirt through the filter into the intake. This cleaning process prevents debris from migrating into the intake when the primary filter is removed.

4. Remove the primary filter (Figure 89).

Note: Do not clean the used element due to the possibility of damage to the filter media.

Note: Replace the secondary filter every 3 primary filter services (Figure 90).

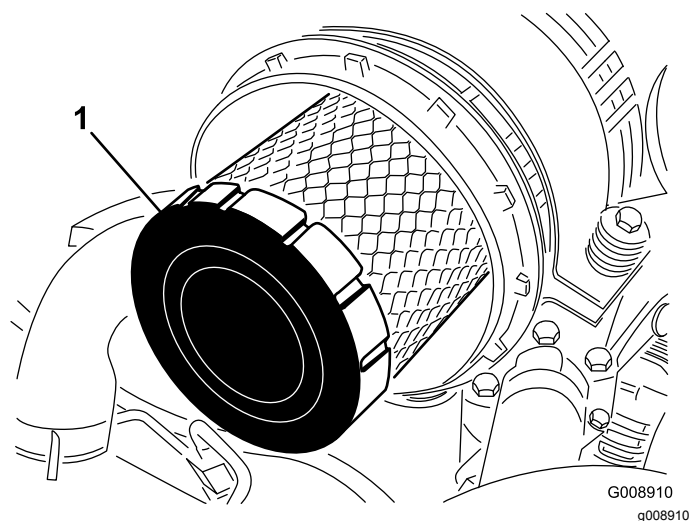


Figure 89

1. Primary filter

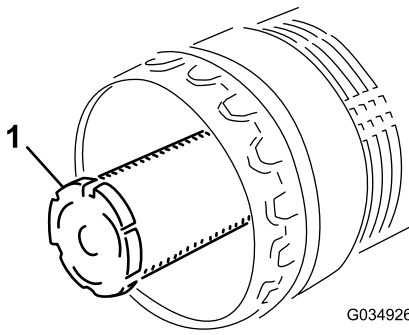


Figure 90

g034926

1. Secondary filter

5. Inspect the new filter for shipping damage, checking the sealing end of the filter and the body.

Important: Do not use a damaged element.

6. Insert the new filter by applying pressure to the outer rim of the element to seat it in the canister.

Important: Do not apply pressure to the flexible center of the filter, as this may damage the filter.

7. Clean the dirt-ejection port located in the removable cover.
8. Remove the rubber outlet valve from the cover, clean the cavity, and replace the outlet valve.
9. Install the cover orienting the rubber outlet valve in a downward position—approximately between the 5 o'clock and 7 o'clock position when viewed from the end.

10. Secure the cover latches.

Servicing the Engine Oil

Crankcase Oil Capacity

11.2 L (11.8 US qt) with the filter

Oil Specification

Use high-quality, low-ash engine oil that meets or exceeds the following specifications:

- API service category CJ-4 or higher
- ACEA service category E6
- JASO service category DH-2

Important: Using engine oil other than API CJ-4 or higher, ACEA E6, or JASO DH-2 may cause the diesel particulate filter to plug or cause engine damage.

Use the following engine oil viscosity grade:

- Preferred oil: SAE 15W-40 (above 0°F)
- Alternate oil: SAE 10W-30 or 5W-30 (all temperatures)

Toro Premium Engine Oil is available from your Authorized Service Dealer in either 15W-40 or 10W-30 viscosity grades. See the parts catalog for part numbers.

Checking the Engine-Oil Level

Service Interval: Before each use or daily—Check the engine-oil level.

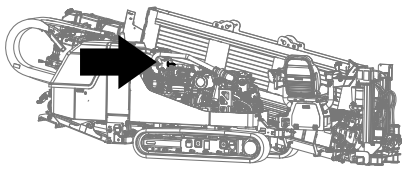
The engine is shipped with oil in the crankcase; however, the oil level must be checked before and after the engine is first started.

Important: Check the engine oil daily. If the engine-oil level is above the Full mark on the dipstick, the engine oil may be diluted with fuel; If the engine oil level is above the Full mark, change the engine oil.

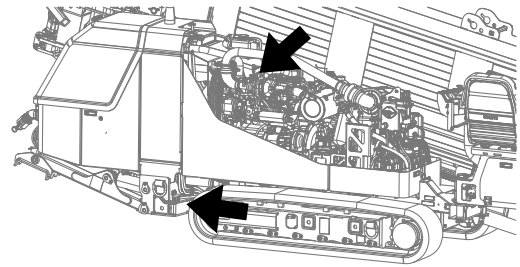
The best time to check the engine oil is when the engine is cool before it has been started for the day. If it has already been run, allow the oil to drain back down to the sump for at least 10 minutes before checking. If the oil level is at or below the Add mark on the dipstick, add oil to bring the oil level to the Full mark. **Do not overfill the engine with oil.**

Important: Keep the engine oil level between the upper and lower limits on the dipstick; the engine may fail if you run it with too much or too little oil.

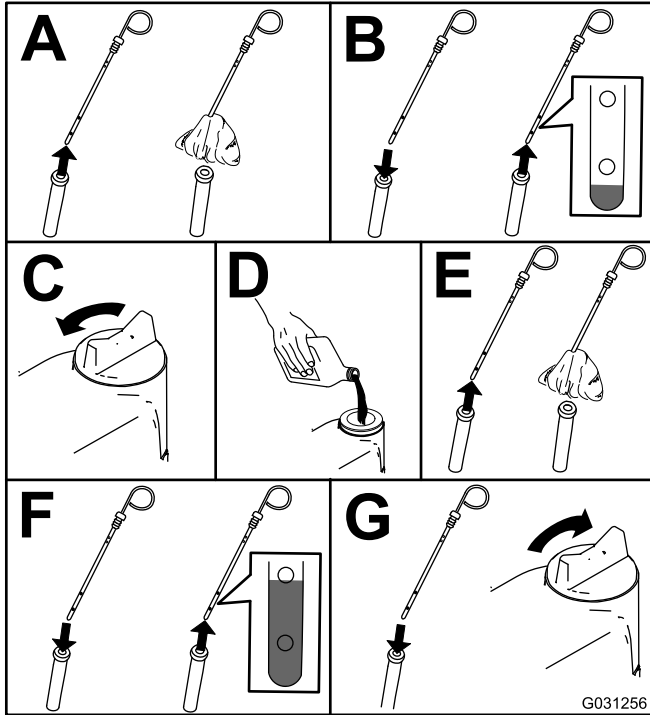
Check the engine-oil level as shown in [Figure 91](#).



g220795



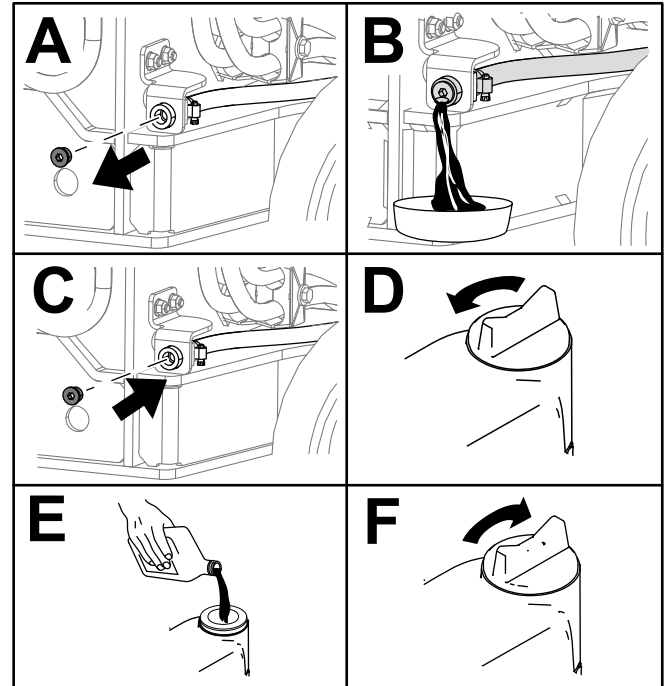
g220852



G031256

g031256

Figure 91



g220851

Figure 92

Changing the Engine Oil and Engine-Oil Filter

Service Interval: After the first 50 hours—Change the engine oil and engine-oil filter.

Every 400 hours—Change the engine oil and engine-oil filter.

Note: Change the engine oil and filter more frequently when the operating conditions are extremely dusty or sandy.

1. Start the engine and let it run 5 minutes to allow the oil to warm up.
2. Move the machine to a level surface, shut off the engine, and remove the key.
3. Change the engine oil as shown in [Figure 93](#).

4. Change the engine-oil filter ([Figure 94](#)).

Note: Ensure that the oil-filter gasket touches the engine, and then an extra 3/4 turn is completed.

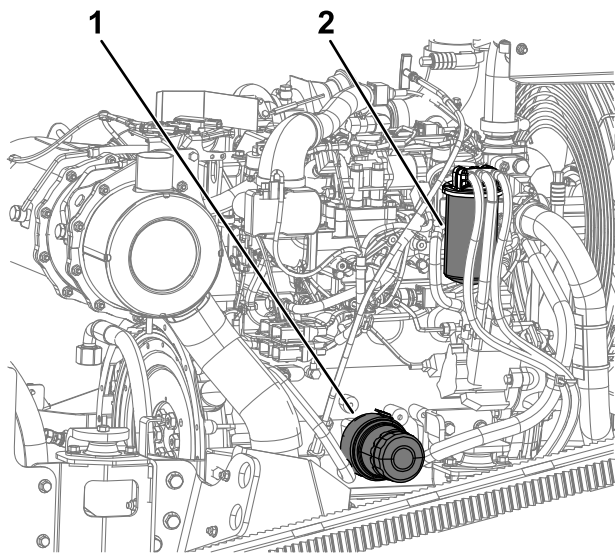
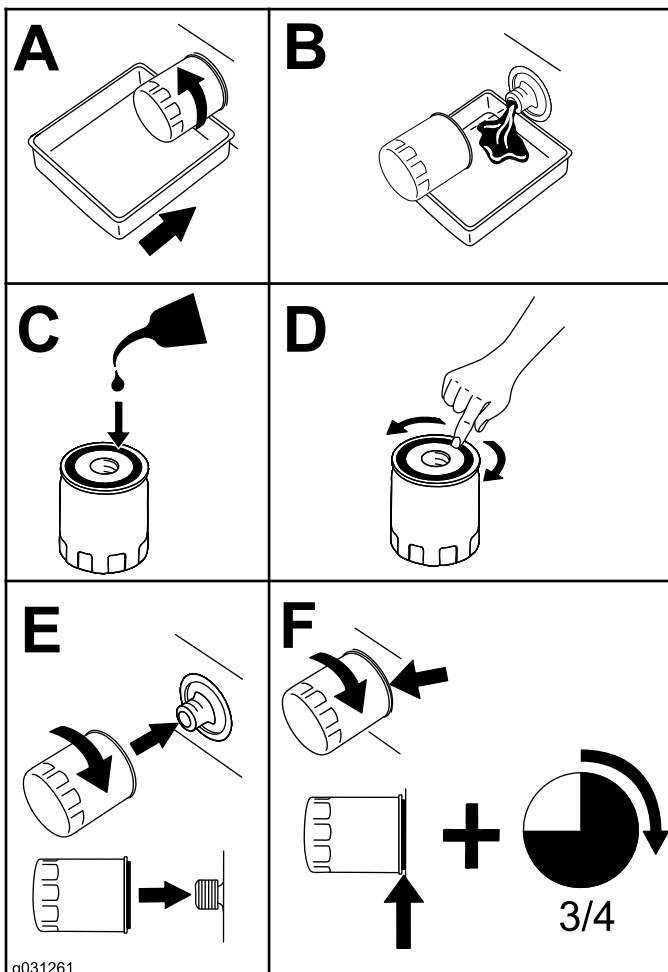


Figure 93

g220797

1. Engine-oil filter

2. Fuel filter



g031261

g031261

Figure 94

Adjusting the Engine-Valve Clearance

Service Interval: Every 800 hours

Refer to your engine owner's manual for the adjustment procedure.

Cleaning the Engine EGR Cooler

Service Interval: Every 1,500 hours

For information on cleaning the engine EGR cooler, refer to your engine owner's manual.

Inspecting the Engine Crankcase-Breather System

Service Interval: Every 1,500 hours

For information on inspecting the engine crankcase-breather system, refer to your engine owner's manual.

Checking and Replacing Fuel Hoses and Engine-Coolant Hoses

Service Interval: Every 400 hours

For information on checking and replacing fuel hoses and engine-coolant hoses, refer to your engine owner's manual.

Lapping or Adjusting the Engine Intake and Exhaust Valves

Service Interval: Every 2,000 hours

For information on lapping or adjusting the engine intake and exhaust valves, refer to your engine owner's manual.

Inspecting and Cleaning Engine-Emission-Control Components and Turbocharger

Service Interval: Every 3,000 hours

For information on inspecting and cleaning the engine-emission-control components, refer to your engine owner's manual.

Fuel System Maintenance

Servicing the Fuel System

Draining the Fuel Tank

Service Interval: Every 800 hours—Drain and clean the fuel tank.

Drain and clean the tank also if the fuel system becomes contaminated or if you are storing the machine for an extended period of time. Use clean fuel to flush out the tank.

Servicing the Water Separator

Service Interval: Before each use or daily—Drain the water separator.

Every 400 hours—Replace the fuel/water separator element.

Draining the Water Separator

1. Place a drain pan under the fuel filter.
2. Loosen the drain valve on the bottom of the filter ([Figure 95](#)).

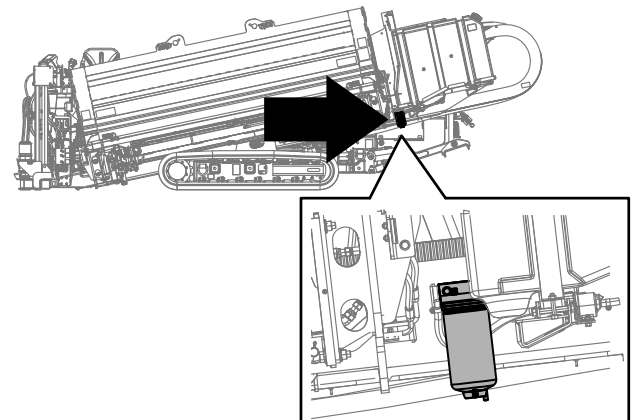


Figure 95

3. Tighten the valve after draining.

Replacing the Water-Separator Element

1. Place a clean container under the water separator.
2. Drain some fuel by loosening the vent plug and opening the drain valve (Figure 95).
3. Clean the area where the filter element mounts to the head.
4. Remove the filter element.
5. Apply a coating of clean fuel or engine oil to the new O-ring and element seal.
6. Install the new filter canister by hand until the gasket contacts the filter head, then tighten it an additional 1/2 turn.

Note: Do not use tools.

7. Close the drain plug.
8. With the vent plug still loosened, turn the key to the Run position (do not start the engine) so that the electric fuel pump can fill the new filter.
9. When fuel flows from the vent plug, close the vent plug, start the engine, and check for leaks.

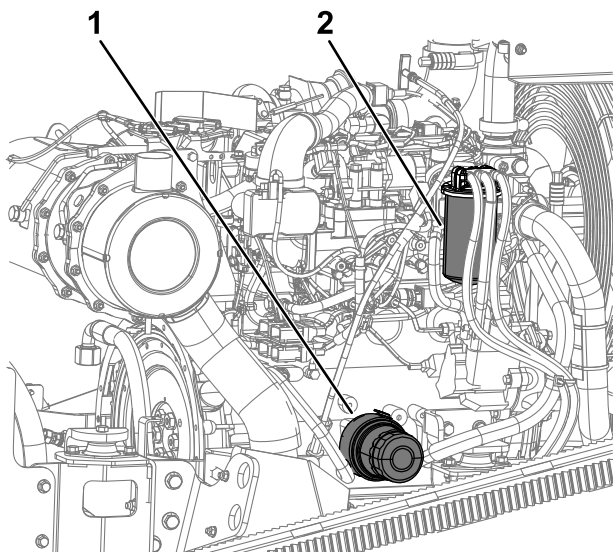
Note: Correct as necessary with the engine off.

2. Remove the filter and clean the filter-head-mounting surface (Figure 96).
3. Lubricate the filter gasket with clean, engine oil; refer to the engine owner's manual (included with the machine) for additional information.
4. Install the dry filter canister, by hand, until the gasket contacts the filter head, then rotate it an additional 1/2 turn.
5. Turn the key to the RUN position so that the electric fuel pump can fill the fuel-filter canister.
6. Start the engine and check for fuel leaks around the filter head.

Replacing the Fuel Filter Element

Service Interval: Every 400 hours—Replace the fuel-filter element.

1. Clean the area around the fuel-filter head (Figure 96).



g220797

Figure 96

1. Engine-oil filter
2. Fuel filter

Electrical System Maintenance

Battery Safety

- Disconnect the battery before repairing the machine. Disconnect the negative terminal first and the positive last. Connect the positive terminal first and the negative last.
- Charge the battery in an open, well-ventilated area, away from sparks and flames. Unplug the charger before connecting or disconnecting the battery. Wear protective clothing and use insulated tools.

Servicing the Battery

Service Interval: Every 50 hours—Check the battery condition

⚠ WARNING

CALIFORNIA

Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

Important: Before welding on the machine, disconnect the negative cable from the battery to prevent damage to the electrical system. Also, disconnect the engine and machine controllers before welding on the machine.

Note: Check the battery condition weekly or after every 50 hours of operation. Keep the terminals and the entire battery case clean because a dirty battery discharges slowly. To clean the battery, wash the entire case with a solution of baking soda and water. Rinse with clear water. Coat the battery posts and cable connectors with Grafo 112X (skin-over) grease (Toro Part No. 505-47) or petroleum jelly to prevent corrosion.

⚠ WARNING

Exposure to battery acid or a battery explosion can cause serious personal injury.

Before you service a battery, wear face protection, protective gloves, and protective clothing.

⚠ WARNING

A battery contains sulfuric acid, which can cause serious burns; and they can produce explosive gases.

- Avoid contact with skin, eyes, or clothing; flush affected areas with water.
- If taken internally, drink large quantities of water or milk. *Do not* induce vomiting. Seek medical attention immediately.
- Keep sparks, flames, and lit cigarettes and cigars away from the battery.
- Ventilate the battery when you are charging it or using it in an enclosed area.
- Wear eye protection when working near a battery.
- Wash your hands after handling a battery.
- Keep the battery out of the reach of children.

⚠ WARNING

If you try to charge or jump start a frozen battery, it could be explosive, causing personal injury to you or others in the area.

To prevent the battery electrolyte from freezing, keep the battery fully charged.

⚠ WARNING

- Sparks or a flame can cause hydrogen gas in a battery to explode.
- When you disconnect the battery cables, disconnect the negative (-) cable first.
- When you connect the battery cables, connect the negative (-) cable last.
- Do not short-circuit the battery posts with a metal object.
- Do not weld, grind, or smoke near a battery.

Note: The electrical system in this machine is 12 V.

Charging the Battery

⚠ WARNING

Charging the battery produces gasses that can explode.

Do not smoke near the battery and keep sparks and flames away from battery.

Important: Keep the battery fully charged. This is especially important to prevent battery damage when the temperature is below 32° F (0° C).

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Clean the exterior of the battery case and the battery posts.

- Note:** Connect the leads of the battery charger to battery posts before connecting the charger to the electrical source.
4. Look at the battery and identify the positive and negative battery posts.
 5. Connect the positive lead of the battery charger to the positive battery post (Figure 97).

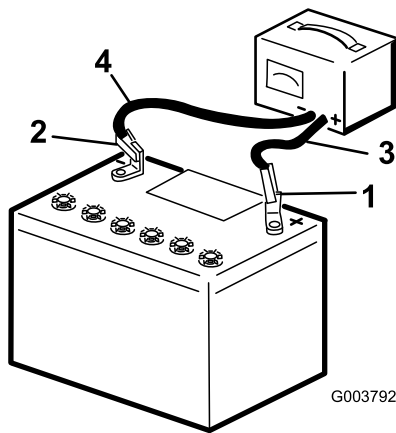


Figure 97

- | | |
|--------------------------|---------------------------|
| 1. Positive battery post | 3. Red (+) charger lead |
| 2. Negative battery post | 4. Black (-) charger lead |

6. Connect the negative lead of the battery charger to the negative battery post (Figure 97).
7. Connect the battery charger to the electrical source.

Important: Do not overcharge the battery.

Note: Charge the battery as shown in battery charging table.

Battery-Charger Table

Charger setting	Charging time
10 A	8 to 10 hours
20 A	4 to 6 hours (do not exceed 6 hours)

8. When the battery is fully charged, unplug the charger from the electrical source, then disconnect the charger leads from the battery posts (Figure 97).

Jump-Starting the Machine

⚠ WARNING

Jump-starting the battery can produce gasses that can explode.

Do not smoke near the battery and keep sparks and flames away from battery.

Note: This procedure requires 2 people to perform. Ensure that the person making the connections wears the proper face protection, protective gloves, and clothing.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Ensure that all controls are in the NEUTRAL position.
4. Sit in the operator seat and have the other person make the connections.

Note: Ensure that the jumper battery is a 12-V battery.

Important: If you are using another machine for power, ensure that the 2 machines are not touching each other.

5. Prepare to start the engine; refer to Starting and Shutting Off the Engine (page 47).
6. Remove the cover from the jump post (Figure 98).

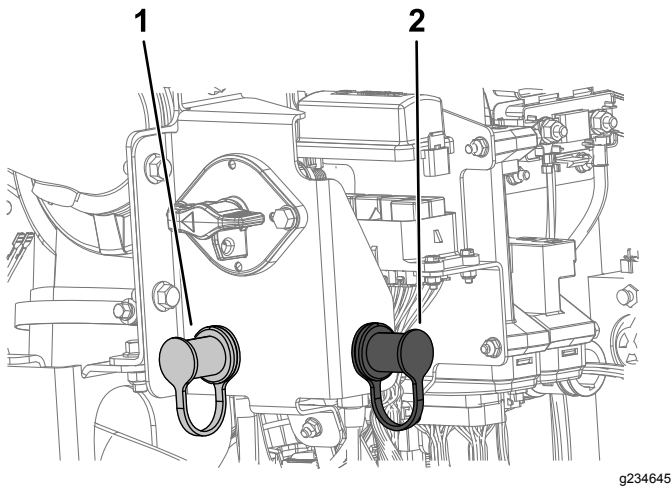


Figure 98

1. Jumper-cable post (negative)
 2. Jumper-cable post (positive)
-
7. Connect the positive (+) jumper cable to the jump post (Figure 98).
 8. Connect the negative (-) jumper cable to a ground point, such as an unpainted bolt or chassis member (Figure 98).
 9. Start the engine; refer to [Starting and Shutting Off the Engine](#) (page 47).
- Important:** If the engine starts and then stops, **do not** operate the starter motor until the starter motor stops turning. **Do not** operate the starter motor for more than 30 seconds at a time. Wait 30 seconds before operating the starter motor to cool the motor and to build up the charge in the battery.
10. When the engine starts, have the other person disconnect the negative (-) jumper cable from the frame and then disconnect the positive (+) jumper cable (Figure 98).

Drive System Maintenance

Checking the Planetary Drive Oil Level Planetary Drive

Service Interval: Every 50 hours—Check the planetary-drive oil level (Also, check if external leakage is observed).

Oil specification: SAE 85W-140 API classification level GL4

Planetary drive oil capacity: approximately 1.4 L (1.5 US qt)

Toro Premium Gear Oil is available from an Authorized Service Dealer. See the *Parts Catalog* for part numbers.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Clean the area around the oil-level plug with a cleaning solvent (Figure 99).

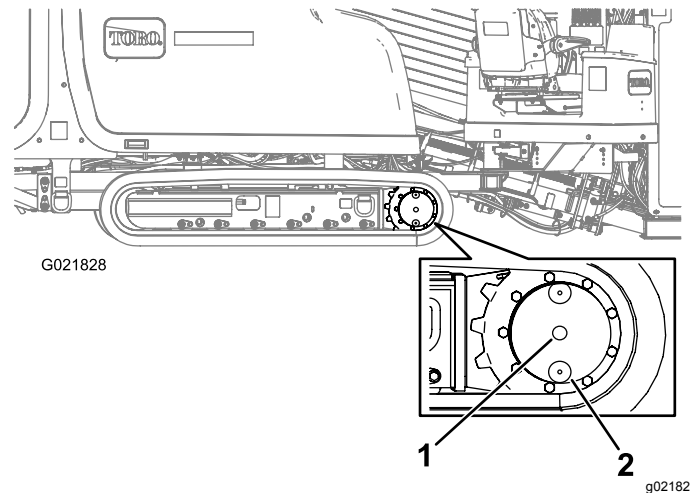


Figure 99

1. Oil-level plug
2. Oil-drain plug (6 o'clock position)

3. Rotate the planetary drive until the oil level and the oil-drain plugs are vertical to the ground (at the 6 o'clock position) as shown in Figure 99.
4. Remove the oil-level plug (Figure 99).

Note: The oil level is correct when it is up to the bottom of the oil-level plug hole.

5. If the oil is below the bottom of the hole, add the specified oil until the oil is level with the bottom of the hole.
6. Install and tighten the oil-level plug.

7. Repeat steps 1 through 6 to check the planetary-drive oil level on the other side of the machine.

Changing the Planetary Drive Oil

Service Interval: After the first 250 hours—Change the planetary oil.

Every 800 hours—Change the planetary oil (or yearly, whichever comes first).

Note: Change the oil when it is warm, if possible.

1. Move the machine to a level surface.
2. Clean the area around the oil-level plug (Figure 99).
3. Rotate the planetary drive until the oil-drain plug is directly below the oil-level plug (Figure 99).
4. Shut off the engine and remove the key.
5. Place a drain pan under the oil-drain plug.
6. Remove the oil-level plug and the oil-drain plug.
7. Install the oil-drain plug.
8. Fill the track-drive planetary with oil until the oil is even with the bottom of the oil-level-plug hole.
9. Install the oil-level plug.
10. Repeat steps 1 through 9 to change the planetary-drive oil on the other side of the machine.

Checking the Rotary Gearbox Drive Oil

Service Interval: Before each use or daily—Check the rotary gearbox drive oil.

Every 800 hours—Check the rotary gearbox drive oil (or yearly, whichever comes first).

Oil specification: SAE 85W-140 API classification level GL4

Rotary-gearbox drive oil capacity: approximately 2.7 L (5.75 US pt)

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Check the oil level on the sight-glass on the gearbox drive (Figure 100).

Note: The oil level should cover half of the sight-glass.

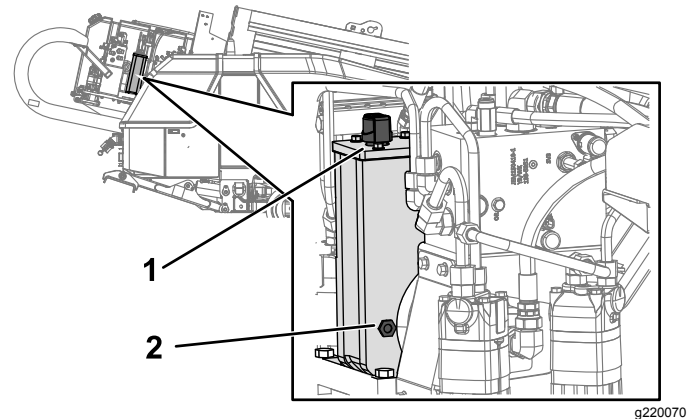


Figure 100

1. Breather cap
2. Sight-glass

3. Remove the breather cap and add the oil into the gearbox drive until the oil level on the sight-glass is at least half full (Figure 100).

Changing the Rotary Gearbox Drive Oil

Service Interval: After the first 100 hours—Change the gearbox-drive oil.

Every 800 hours—Change the gearbox-drive oil (or yearly, whichever comes first).

Note: Change the oil when it is warm, if possible.

1. Move the machine to a level surface and move the carriage all the way to the rear stop.
2. Shut off the engine and remove the key.
3. Remove the drain plug and drain the oil ([Figure 101](#)).

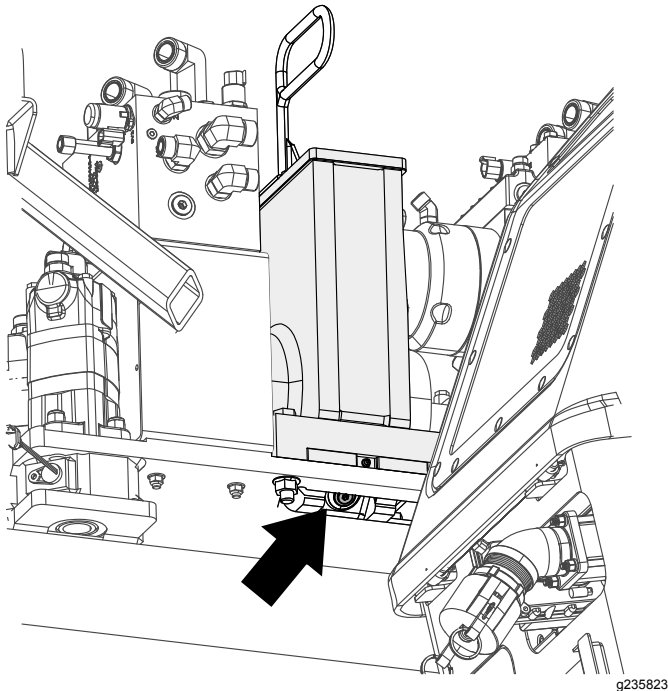


Figure 101

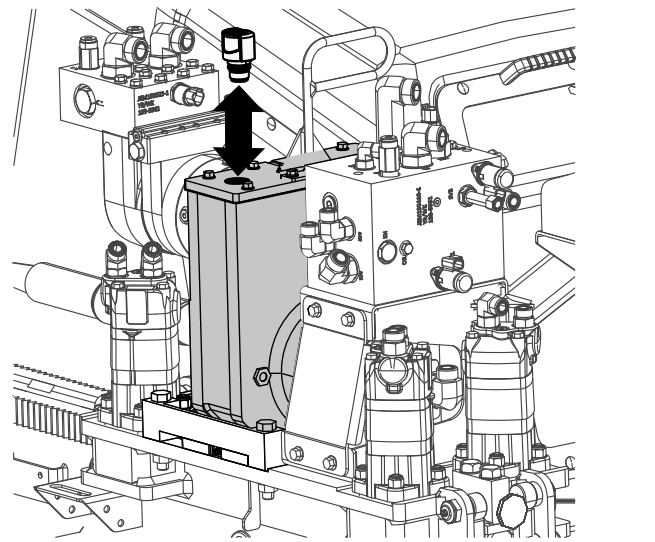


Figure 102

6. Fill the gearbox with oil until the oil level in the sight glass is more than half full ([Figure 100](#)).
7. Install the breather cap ([Figure 102](#)).

4. Install the drain plug.
5. Remove the breather cap ([Figure 102](#)).

Servicing the Tracks

Service Interval: Before each use or daily—Check the track tension.

⚠ WARNING

If you remove the track-tension grease valve found in the hydraulic-track tensioner or loosen it too much, grease can be released and may cause serious injury or death.

Grease in the hydraulic track is highly pressurized; ensure that the track-tension grease valve is not loosened more than 1 revolution at a time.

Tightening the Track Tension

If the track seems loose, tighten the track tension as follows:

1. Move the machine to a level surface and raise the thrust frame and stabilizers so that the tracks are raised.
2. Shut off the engine and remove the key.
3. Remove dirt and debris found around the track-tension grease valve ([Figure 103](#)).

Important: Ensure that the area surrounding the track-tension grease valve is clean before beginning to adjust the track tension.

4. Remove the retaining bolts and cover that house the track-tension grease valve.
5. Apply grease to the fitting until the tension reaches 22,063 kPa (3,200 psi) as shown in [Figure 103](#).

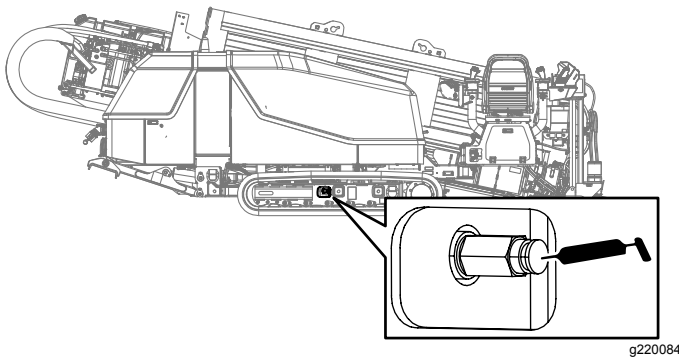


Figure 103

Track-tension grease valve shown

Loosening the Track Tension

If the track seems tight, loosen the track tension as follows:

1. Move the machine to a level surface and raise the thrust frame and stabilizers so that the tracks are raised.
2. Shut off the engine and remove the key.
3. Remove dirt and debris found around the track-tension grease valve ([Figure 103](#)).

Important: Ensure that the entire area surrounding the track-tension grease valve is clean before beginning to adjust the track tension.

4. Remove the retaining bolts and cover that house the track-tension grease valve.
5. Turn the track-tension grease valve counterclockwise **no more than 1 revolution** ([Figure 103](#)).

Note: A 1-revolution turn releases grease and loosens the track.

6. When the tension reaches 3,200 psi, turn the track-tension grease valve clockwise to tighten it.
7. Remove excess grease from around the valve.
8. Install the cover and retaining bolts.
9. Repeat steps [3](#) through [8](#) to loosen the track tension on the other side.

6. Remove excess grease from around the valve.
7. Install the cover and retaining bolts.
8. Repeat steps [3](#) through [7](#) to tighten the track tension on the other side.

Cooling System Maintenance

Coolant specification: 50/50 solution of ethylene-glycol antifreeze and water or equivalent

Engine and Radiator coolant capacity: 16.77 L (17.7 US qt)

⚠ WARNING

If you remove the radiator cap from a hot engine, hot coolant could spray, causing scalding.

- Wear face protection when opening the radiator cap.
- Allow the cooling system to cool down to below 50°C (120°F) before removing the radiator cap.
- Follow the instructions for checking and maintaining the engine cooling system.

⚠ WARNING

Coolant is toxic.

- Keep coolant away from children and pets.
- If you are not using the same coolant again, dispose of it according to local environmental regulations.

Cooling System Safety

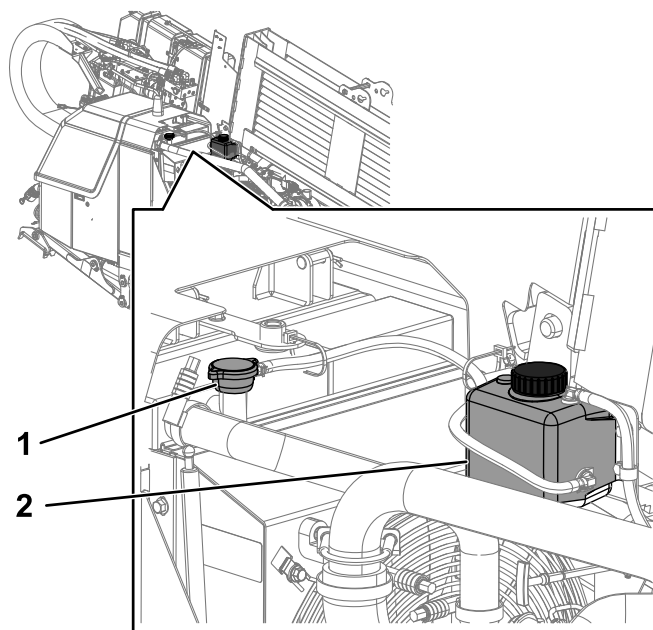
- Swallowing engine coolant can cause poisoning; keep it out of reach of children and pets.
- Discharge of hot, pressurized coolant or touching a hot radiator and surrounding parts can cause severe burns.
 - Always allow the engine to cool at least 15 minutes before removing the radiator cap.
 - Use a rag when opening the radiator cap, and open the cap slowly to allow steam to escape.

Checking the Coolant Level in the Reservoir

Service Interval: Before each use or daily

Important: Do not remove the radiator filler cap during this procedure.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Allow the engine to cool.
3. Open the front hood.
4. Check the coolant level in the reservoir (Figure 104).



g220074

Figure 104

1. Radiator cap 2. Reservoir

5. Add the specified coolant until the coolant level is 1/2 the reservoir capacity.

Note: Ensure that the coolant solution is thoroughly mixed before filling the reservoir.

Checking the Coolant Level in the Radiator

Service Interval: Every 50 hours

⚠ WARNING

If the engine has been running, the radiator will be pressurized and the coolant inside will be hot. If you remove the cap, coolant may spray out, causing severe burns.

- Do not remove the radiator cap to check coolant levels.
- Do not remove the radiator cap when the engine is hot. Allow the engine to cool for at least 15 minutes or until the radiator cap is cool enough to touch without burning your hand.

Note: The cooling system is filled with a 50/50 solution of water and ethylene-glycol antifreeze.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Allow the engine to cool.
3. Open the front and rear hood.
4. Remove the radiator cap from the filler neck of the radiator and check the coolant level (Figure 104 and Figure 105).

Note: The coolant should be up to the filler neck.

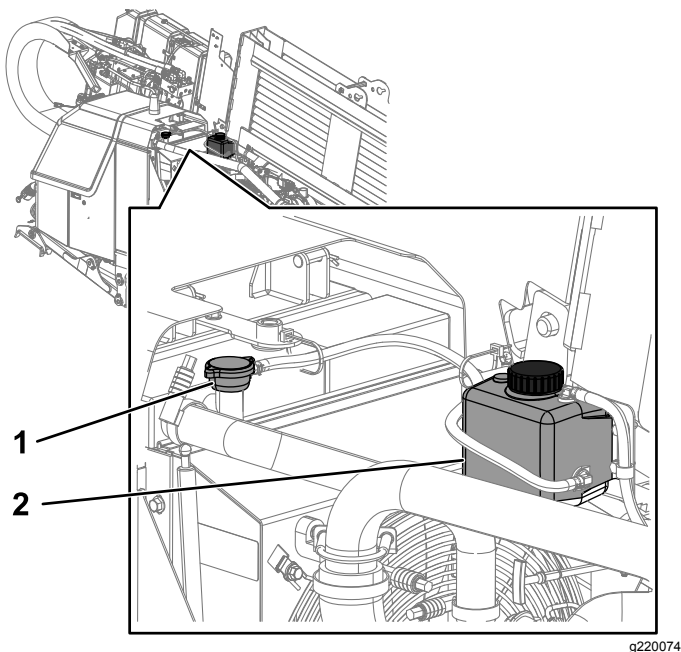


Figure 105

1. Radiator cap
2. Reservoir

5. If the coolant level is low, add coolant until the level is up to the bottom of the filler neck (Figure 105).

Important: Do not overfill the radiator.

Note: If the radiator coolant level is low and the coolant reservoir level is at the Full mark, check for air leaks in the hose between the radiator and the coolant reservoir.

6. Install the radiator filler cap, ensuring that it is tightly sealed (Figure 105).
7. If the air temperature is below 0°C (32°F), mix the ethylene glycol and water completely by running the engine at operating temperature for 5 minutes.

Checking the Condition of the Cooling-System Components

Service Interval: Every 400 hours/Yearly (whichever comes first)

Check the condition of the cooling system for leaks, damage, dirt, and loose hoses and clamps. Clean, repair, tighten, and replace the components as necessary.

Checking the Concentration of the Coolant

Service Interval: Every 800 hours/Yearly (whichever comes first)—Check the concentration of the coolant before the winter season.

Test the concentration of ethylene glycol-based antifreeze in the coolant. Ensure that the coolant has a 50% ethylene glycol and 50% water mixture or equivalent.

Note: A 50% ethylene glycol and 50% distilled water mixture will protect the engine to -37° C (-34° F) throughout the year.

Using a concentration tester, check the concentration of the coolant mixture to ensure that it is 50% ethylene glycol and 50% distilled water or equivalent; refer to the manufacturer's instructions for testing.

Cleaning the Cooling System

Service Interval: Every 800 hours/Yearly (whichever comes first) (Clean the cooling system if the coolant becomes dirty or rust colored.)

Draining the Coolant from the System

Important: Do not pour coolant onto the ground or into an unapproved container that can leak.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Allow the engine to cool.
3. Open the front hood.
4. Remove the radiator cap (Figure 105).
5. Place a drain pan under the drain plug (Figure 106).

Note: The coolant capacity of both the engine and the radiator is 16.8 L (17.7 US qt).

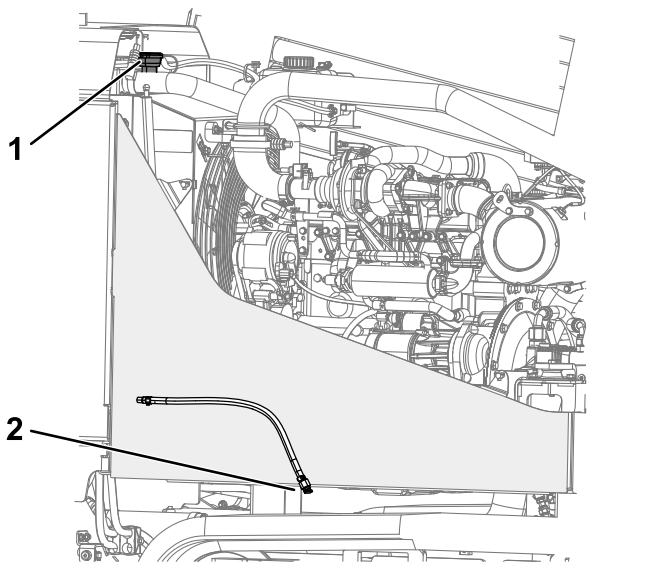


Figure 106

1. Radiator Cap
2. Radiator hose and drain plug

6. Open the radiator drain plug and allow the coolant system to drain completely.
Note: Dispose of the used coolant properly according to local codes.
7. Clean the threads on the drain plug and apply 3 layers of PTFE sealing tape.
8. Close the drain plug (Figure 106).

Flushing the Cooling System

Engine and radiator coolant capacity: 16.8 L (17.7 US qt)

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Condition the cooling system as follows:
 - A. Ensure that the coolant is drained from the radiator and that the drain plug is closed; refer to [Draining the Coolant from the System \(page 87\)](#).
 - B. Add a cooling system cleaning solution to the radiator through the filler neck (Figure 107).

Note: Use cleaning solution of 21 g (12 oz dry) of sodium carbonate for every 17 L (18 US qt) of water; otherwise, use a commercially available equivalent. Follow the directions that come with the cleaning solution.

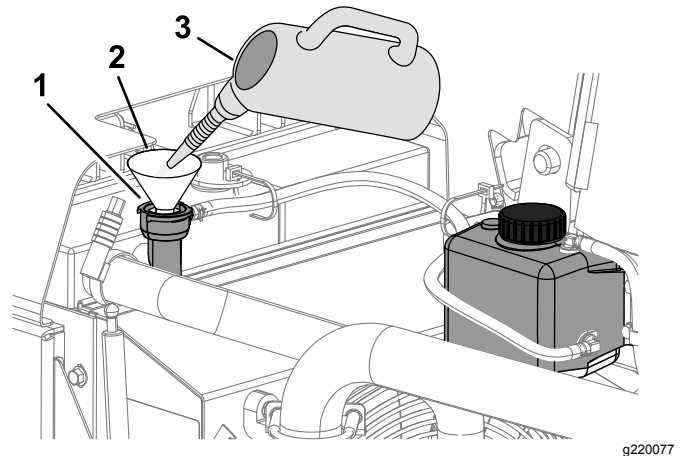


Figure 107

1. Filler neck (radiator)
2. Funnel
3. Coolant system cleaning solution

- C. Close the drain plug (Figure 106).

Important: Do not install the radiator cap.

- D. Operate the engine for 5 minutes or until the coolant temperature indicates 82° C (180° F), and then shut off the engine.

⚠ CAUTION

The cleaning solution is hot and can cause burns.

Stay away from the discharge end of the coolant drain.

- E. Open the drain plug for the radiator, and drain the cleaning solution into a drain pan.

- F. Clean the threads on the drain plug and apply 3 layers of PTFE sealing tape.
- G. Close the drain plug.
3. Flush the cooling system as follows:
 - A. Open the filler-neck cap.
 - B. Fill the radiator with clean water (Figure 108).

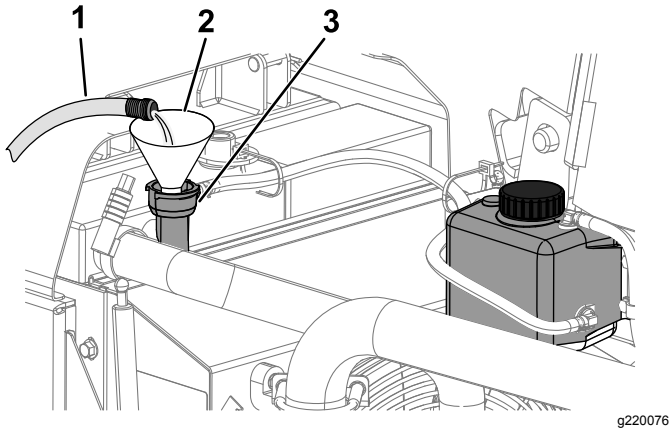


Figure 108

1. Clean water
2. Funnel
3. Filler neck

- C. Close the filler-neck cap.
- D. Operate the engine for 5 minutes or until the coolant temperature indicates 82°C (180°F), and then shut off the engine.

⚠ CAUTION

The water is hot and can cause burns.

Stay away from the discharge end of the coolant drain plug.

- E. Open the drain plug and drain the water into a drain pan.
- F. Clean the threads on the drain plug and apply 3 layers of PTFE sealing tape.
- G. If the water drained from the radiator is dirty, perform steps 3-A through 3-E until the water drained from the radiator is clean.
- H. Close the drain plug (Figure 106).

Filling the System with Coolant

Important: You must fill the cooling system properly to prevent air pockets in the cooling passages. Failing to vent the cooling system properly can severely damage the cooling system and engine.

Important: Use a mixture of 50% ethylene glycol and 50% water mixture or equivalent in the machine. The lowest ambient operating temperature for this mixture is above -37° C (-34° F). If the ambient temperature is lower, adjust the mixture. Use a mixture of ethylene glycol and water or equivalent in the machine all year.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Remove the radiator cap (Figure 105).
3. Fill the radiator with coolant until the fluid level is up to the bottom of the filler neck (Figure 109).

Note: The coolant capacity of both the engine and the radiator is 16.8 L (17.7 US qt).

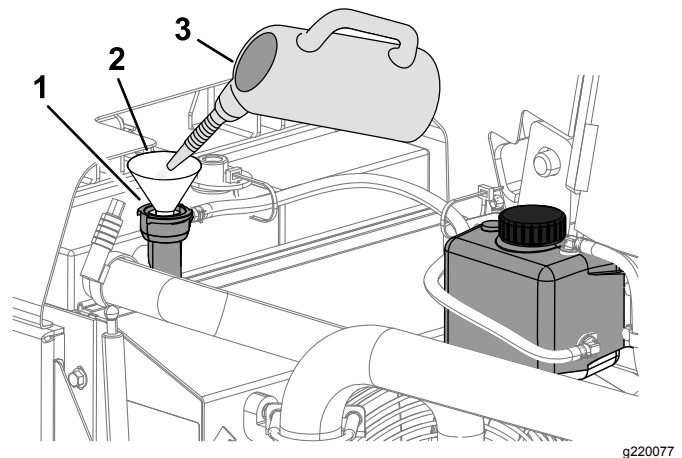


Figure 109

1. Filler neck
2. Funnel
3. Coolant (50/50 ethylene glycol and water or equivalent)

4. Install the radiator cap (Figure 105).
5. Fill the coolant reservoir with coolant until it is full.
6. Install the coolant reservoir cap.
7. Start the engine and run it at half throttle for 5 minutes.
8. shut off the engine and remove the key.
9. Wait 30 minutes, then check the fluid level in the coolant reservoir. If it is low, add coolant.

Belt Maintenance

Servicing the Engine-Drive Belt

⚠ WARNING

Contacting a rotating belt can cause serious injury or death.

Shut off the engine and remove the key before working near belts.

Checking the Condition of the Belt

Service Interval: Every 250 hours

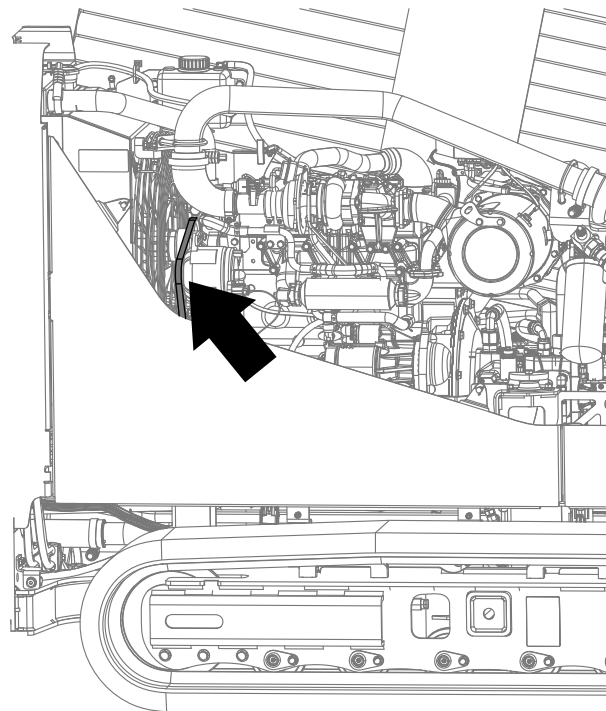
1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Inspect the belt for cuts, cracks, loose cords, grease, oil, twisting, or signs of abnormal wear ([Figure 110](#)).

Note: Replace the belt if it is excessively worn or damaged.

Checking the Belt Tension

Service Interval: Every 800 hours

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Align a straight edge over the drive belt and across the pulleys ([Figure 110](#)).



g220794

Figure 110

4. Push the belt down at the midway point between the fan pulley and the alternator pulley as shown in [Figure 110](#).

Note: The range of belt deflection between the straight edge and the belt should be 7 to 9 mm (0.28 to 0.35 inches), under a load of 10 kg (22 lb).

5. If the tension of the belt is above or below the specified range, adjust the drive belt tension; refer to [Adjusting the Tension of the Belt](#) (page 90).

Adjusting the Tension of the Belt

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Loosen the nut and bolt at the pivot point for the alternator ([Figure 111](#)).

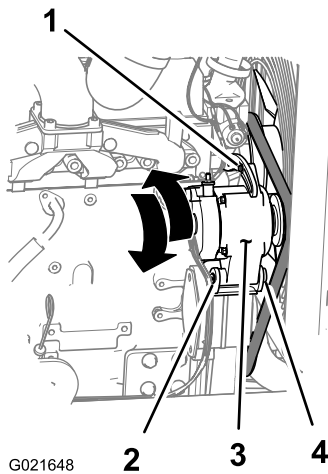


Figure 111

- | | |
|---------------------------------|----------------------------------|
| 1. Adjustment bolt | 3. Alternator |
| 2. Nut (alternator pivot point) | 4. Bolt (alternator pivot point) |

4. Loosen the adjustment bolt on the alternator ([Figure 111](#)).
5. Move the alternator away from the engine to increase the belt tension; move the alternator toward the engine to decrease the belt tension ([Figure 111](#)).
6. Tighten the alternator adjustment bolt ([Figure 111](#)).
7. Check the tension of the belt; refer to [Checking the Belt Tension \(page 89\)](#).
8. If the belt tension is correct, tighten the nut and bolt at the pivot point for the alternator ([Figure 111](#)); otherwise repeat steps 4 through 7.

Hydraulic System Maintenance

Hydraulic System Safety

- Seek immediate medical attention if fluid is injected into skin. Injected fluid must be surgically removed within a few hours by a doctor.
- Ensure that all hydraulic-fluid hoses and lines are in good condition and all hydraulic connections and fittings are tight before applying pressure to the hydraulic system.
- Keep your body and hands away from pinhole leaks or nozzles that eject high-pressure hydraulic fluid.
- Use cardboard or paper to find hydraulic leaks.
- Safely relieve all pressure in the hydraulic system before performing any work on the hydraulic system.

Servicing the Hydraulic Fluid

The hydraulic reservoir is filled at the factory with approximately 102 L (27 US gallons) of high-quality hydraulic fluid. **Check the level of the hydraulic fluid before the engine is first started and daily thereafter.** The recommended replacement fluid follows:

Toro Premium All Season Hydraulic Fluid

(Available in 5 gallon pails or 55 gallon drums. Contact your Authorized Service Dealer for part numbers.)

Alternate fluids: If the Toro fluid is not available, other fluids may be used provided they meet all the following material properties and industry specifications. We do not recommend the use of synthetic fluid. Consult with your lubricant dealer to identify a satisfactory product.

Note: Toro will not assume responsibility for damage caused by improper substitutions, so use only products from reputable manufacturers who will stand behind their recommendation.

High Viscosity Index/Low Pour Point Anti-wear Hydraulic Fluid, ISO VG 46

Material Properties:

Viscosity, ASTM D445	42.2 cSt at 40° C (104° F)
	7.8 cSt at 100° C (212° F)

Viscosity Index ASTM D2270

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High Viscosity Index/Low Pour Point Anti-wear Hydraulic Fluid, ISO VG 46 (cont'd.)

Pour Point, ASTM D97

-6° C (-42° F)

Industry Specifications: Vickers I-286-S (Quality Level),
Vickers M-2950-S (Quality
Level), Denison HF-0

Note: Many hydraulic fluids are almost colorless, making it difficult to spot leaks. A red dye additive for the hydraulic fluid is available in 20 mL (2/3 oz) bottles. One bottle is sufficient for 15-22 L (4-6 gallons) of hydraulic fluid. Order the hydraulic oil from your Authorized Service Dealer.

Note: If ambient operating temperatures exceed 43° C (110° F), contact Toro for fluid recommendations.

Checking the Hydraulic Fluid

Service Interval: Before each use or daily

Check the hydraulic fluid as follows:

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Wait 10 minutes to allow the engine to cool and the hydraulic oil to stabilize.
3. If the level is low, open the hydraulic-tank cap, add a small amount of oil and wait 2 minutes for the oil level to stabilize.

Note: The oil level is between 1/2 to 2/3 full when the oil is at ambient temperature or if the engine has not yet been started for the day.

4. Continue to add the appropriate fluid in small increments until it reaches the top of the filler neck.
5. Install the cap onto the filler neck.

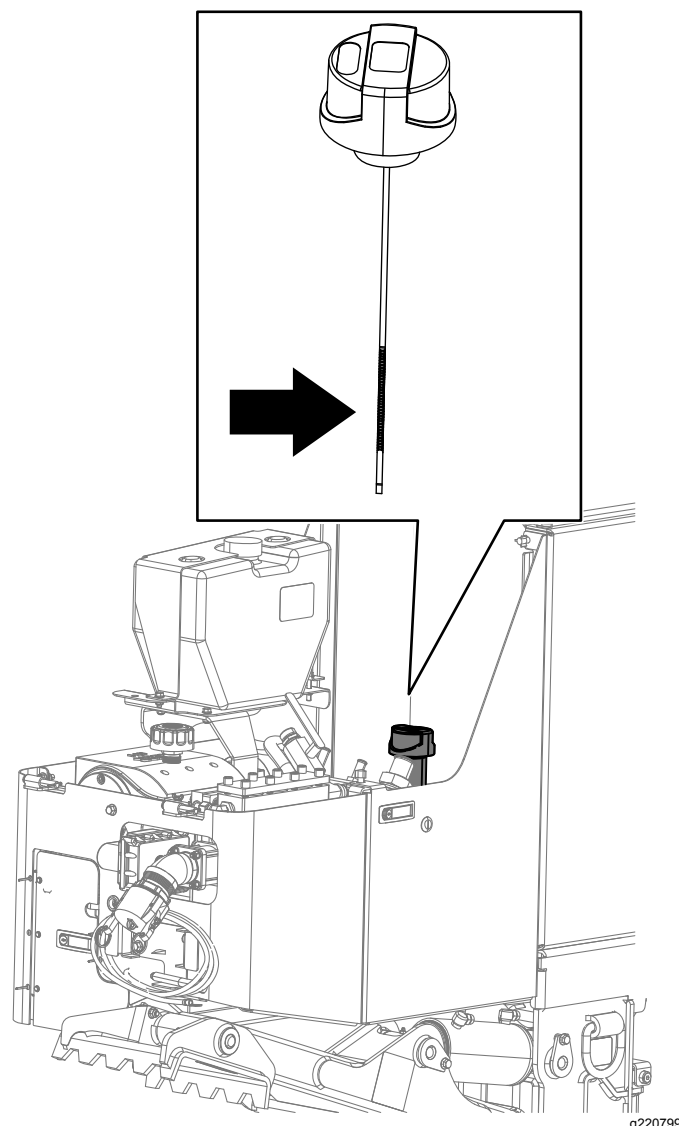


Figure 112

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Changing the Hydraulic-Fluid Return Filter

Service Interval: Every 800 hours/Every 6 months (whichever comes first)

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Discard the old hydraulic-fluid return filter.

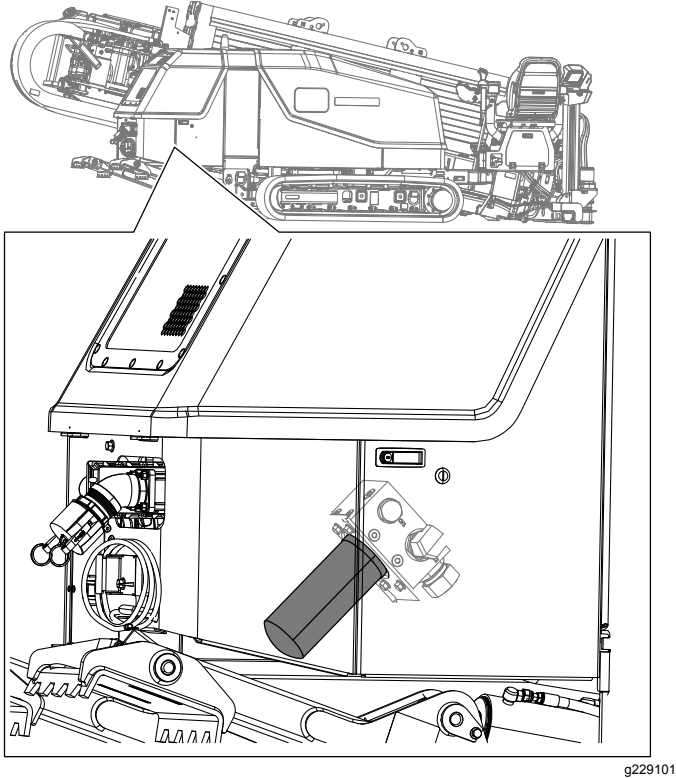


Figure 113

3. Install a new hydraulic-fluid return filter.

Changing the Hydraulic-Charge Filter

Service Interval: Every 800 hours/Every 6 months (whichever comes first)

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Place a drain pan under the filter.
4. Using a filter wrench, remove the hydraulic-charge filter (Figure 114).

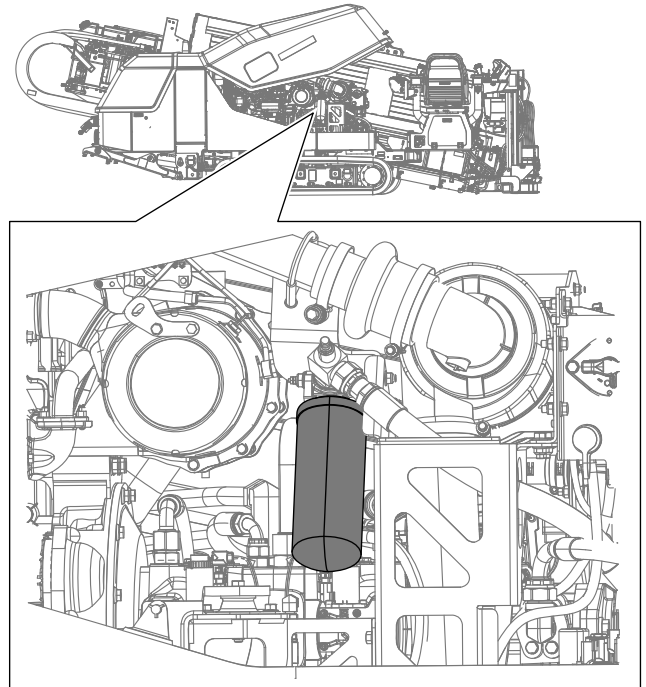


Figure 114

5. Discard the old filter.
6. Apply a thin layer of hydraulic oil to the o-ring of the filter.
7. Install and tighten the new filter with a filter wrench.
8. Start the engine, let it run idle for approximately 1 minute, then check for leaks around the hydraulic-charge filter.

Changing the Hydraulic Fluid

Service Interval: Every 800 hours/Yearly (whichever comes first)

Important: If the fluid becomes contaminated, contact your Authorized Service Dealer, because the system must be flushed. Contaminated fluid looks milky or black when compared to clean oil.

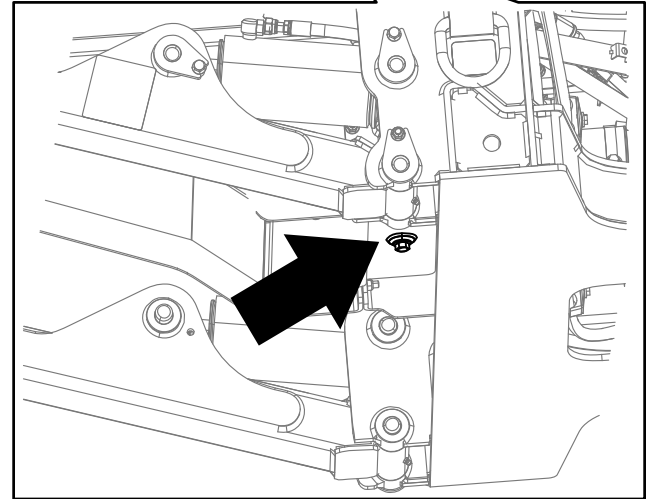
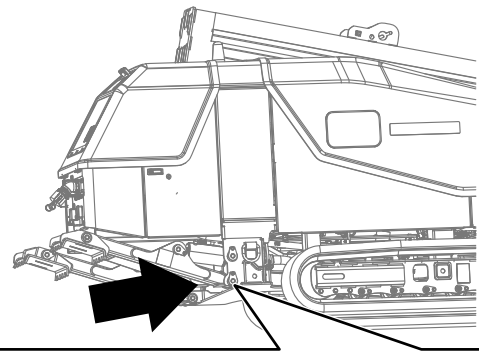
Important: Use of any other filter may void the warranty on some components.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the front hood.
3. Raise the machine using proper equipment.

⚠ WARNING

Raising the rear of the machine relying solely on mechanical or hydraulic jacks could be dangerous. The mechanical or hydraulic jacks may not be enough support or may malfunction allowing the machine to fall, which could cause injury or death.

- **Do not** rely solely on mechanical or hydraulic jacks for support.
 - **Use adequate jack stands or equivalent support.**
4. Place a large draining container under the hydraulic fluid tank.
 5. Remove the drain plug from the bottom of the tank (Figure 115).



g229374

Figure 115

6. Clean the threads on the drain plug and apply 3 layers of PTFE sealing tape.
7. Drain the hydraulic fluid into the container.

Important: The capacity of the hydraulic-fluid tank is 102 L (27 US gallons), so ensure that you have a container of at least 114 L (30 US gallons).

8. Install the drain plug when the hydraulic fluid stops draining.
9. Clean the area around the filter mounting areas.
10. Place a drain pan under the filter and remove the filter (Figure 112).
11. Lubricate the filter gasket of each new filter and fill them with hydraulic fluid.
12. Screw the filters on until the gaskets contact the mounting plates; then tighten the filter an additional 1/2 turn.
13. Fill the reservoir with hydraulic fluid.

Important: Use only the hydraulic fluids specified. Other fluids could cause system damage.

14. Install the reservoir cap.
15. Start the engine and use all of the hydraulic controls to distribute hydraulic fluid throughout

the system. Check for leaks; then shut off the engine.

16. Check the fluid level and add enough to raise the level to the Full mark on the dipstick. **Do not overfill.**

Checking the Hydraulic Lines and Hoses

Service Interval: Every 2 years—Replace moving hoses.

Inspect the hydraulic lines and hoses daily for leaks, kinked lines, loose mounting supports, wear, loose fittings, weather deterioration, and chemical deterioration. Make all necessary repairs before operating.

⚠ WARNING

Hydraulic fluid escaping under pressure can penetrate skin and cause injury.

- **Make sure that all hydraulic fluid hoses and lines are in good condition and all hydraulic connections and fittings are tight before applying pressure to the hydraulic system.**
- **Keep your body and hands away from pin hole leaks or nozzles that eject high pressure hydraulic fluid.**
- **Use cardboard or paper to find hydraulic leaks.**
- **Safely relieve all pressure in the hydraulic system before performing any work on the hydraulic system.**
- **Seek immediate medical attention if fluid is injected into skin.**

Hydraulic System Test Ports

The test ports are used to test the pressure in the hydraulic circuits. Contact your Authorized Service Dealer for assistance.

Drilling-fluid Pump Maintenance

Servicing the Drilling-Fluid-Pump Oil

The drilling-fluid pump is shipped with oil in the crankcase; however, check the oil level before and after you first start the engine.

The crankcase capacity is 1.9 L (2 US qt).

Use only high-quality engine oil that meets the following specifications:

- **API Classification Level Required:** CH-4, CI-4 or higher
- **Oil:** SAE 30-weight, non-detergent oil above 0° C (32° F)

Toro Premium Engine Oil is available from your dealer. See the parts catalog for part numbers. Also, refer to the engine owners manual, included with the machine, for further recommendations.

Checking the Drilling-Fluid-Pump Oil Level

Service Interval: Before each use or daily—Check the drilling-fluid-pump oil level.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the rear hood.
3. Remove the oil dipstick ([Figure 116](#)).

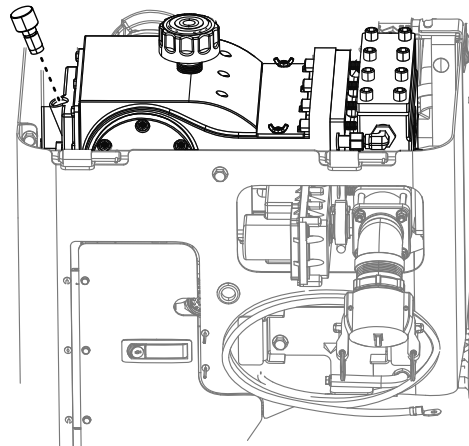


Figure 116

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4. Ensure that the oil is at the oil-fill line as shown in [Figure 116](#).

Note: If the oil is below the oil-fill line, refer to step 8 of [Changing the Drilling-Fluid Pump](#)

Oil (page 95) and add the necessary amount of oil.

Changing the Drilling-Fluid Pump Oil

Service Interval: Every 400 hours—Change the drilling-fluid pump oil.

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Open the rear hood.
3. Allow the engine to cool.
4. Remove the drain plug and place a drain pan under the drain-plug hole (Figure 117).

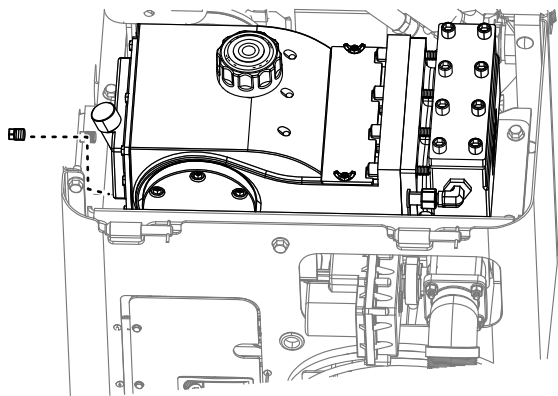


Figure 117

g220257

5. Clean the threads on the drain plug and apply 3 layers of PTFE sealing tape.
6. Allow all of the oil to drain into the oil pan (Figure 117).
7. Install the drain plug.
8. Remove the oil-filler cap (Figure 117) and add approximately 1.9 L (2 US qt) of oil, or until the oil reaches the oil-fill line on the dipstick as shown in Figure 116.

Preparing the Drilling-Fluid System for Cold Weather

Prepare the machine as follows after drilling if the temperature will be below 0° C (32° F).

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Prepare the machine to circulate the antifreeze as follows:
 - A. Open the rear hood.
 - B. Place a drain pan under the drill spindle for the leaked antifreeze (Figure 118).

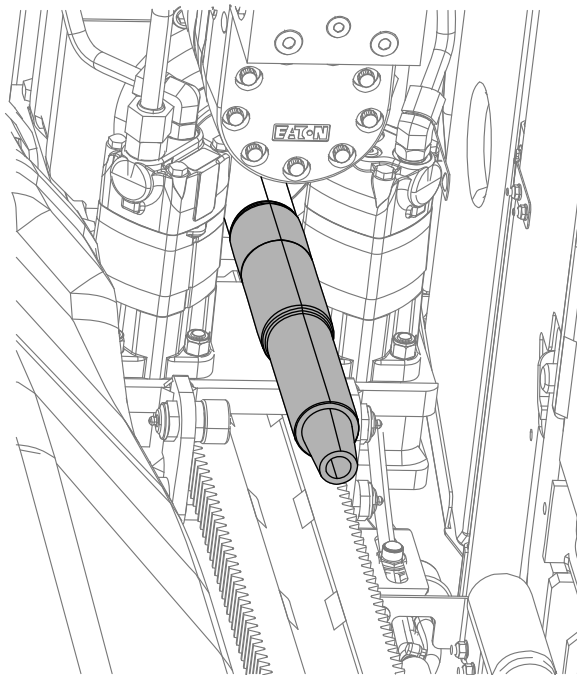


Figure 118

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- C. Ensure that the cap is installed on the drilling-fluid pump inlet (Figure 119).

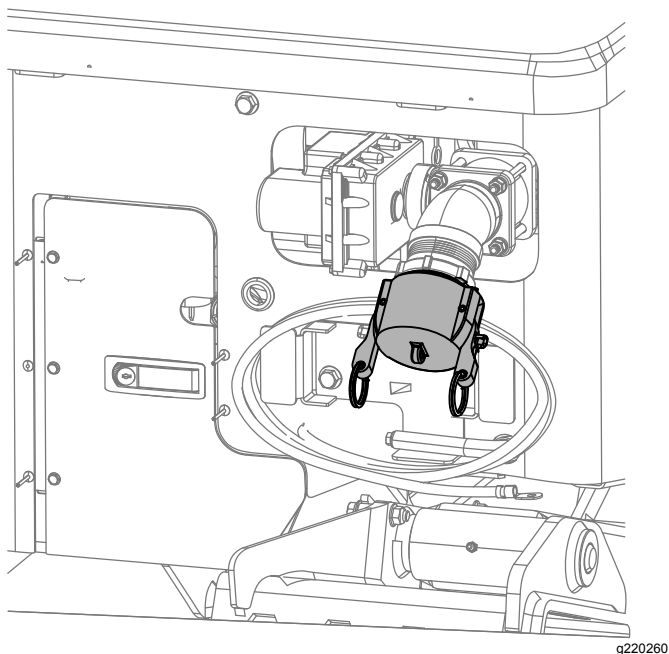


Figure 119

- A. Open the antifreeze valve on the front side of the drilling-fluid pump as shown in [Figure 120](#).
- B. Start the machine and turn On the drilling-fluid pump.
- C. Add antifreeze to the tank as needed ([Figure 120](#)).
- D. When the antifreeze comes out of the drill spindle ([Figure 118](#)), turn the pump off.
4. Turn the machine off.
5. Install the cap onto the antifreeze tank ([Figure 120](#)).
6. Close the antifreeze valve ([Figure 120](#)).

- D. Remove the cap from the antifreeze tank for the drilling-fluid pump ([Figure 120](#)).

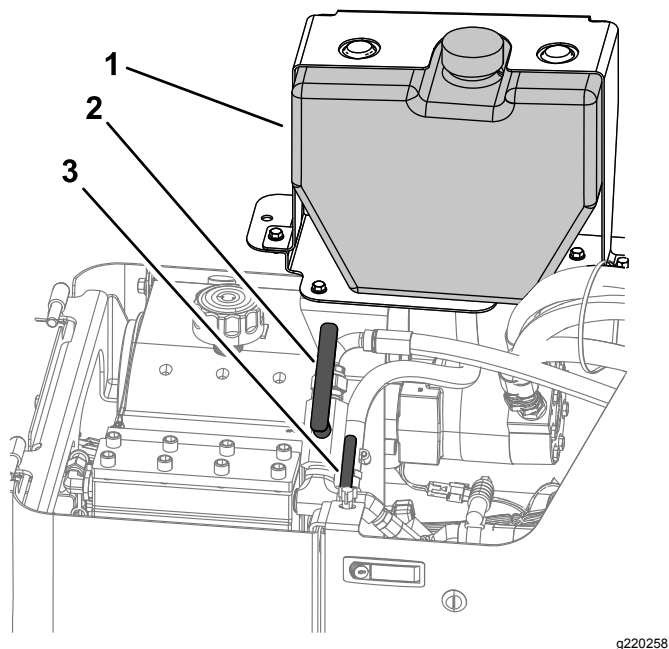


Figure 120

1. Antifreeze tank
2. Drilling-fluid valve (shown in the ON position)
3. Antifreeze valve (shown in the ON position)

- E. Ensure that the tank is full of antifreeze ([Figure 120](#)).

3. Circulate the antifreeze as follows:

Controls Maintenance

Calibrating the Joysticks and the Travel Pendant

Service Interval: Every 400 hours

Refer to the joystick section of the *Software Guide* for this procedure.

Cleaning

Cleaning with the Spray-Hose Attachment

Service Interval: Before each use or daily

The machine comes with a spray-hose attachment that you can use to clean the machine and pipes.

Important: Do not spray any electronic component of the machine and ensure that the hood is down before cleaning the machine with the spray-hose attachment.

Important: If the outside temperature is below freezing, refer to [Preparing the Drilling-Fluid System for Cold Weather \(page 95\)](#) before cleaning the machine.

To use the spray-hose attachment, perform the following procedure:

1. Move the machine to a level surface, shut off the engine, and remove the key.
2. Ensure that the spray-hose attachment switch is in the OFF position ([Figure 121](#)).

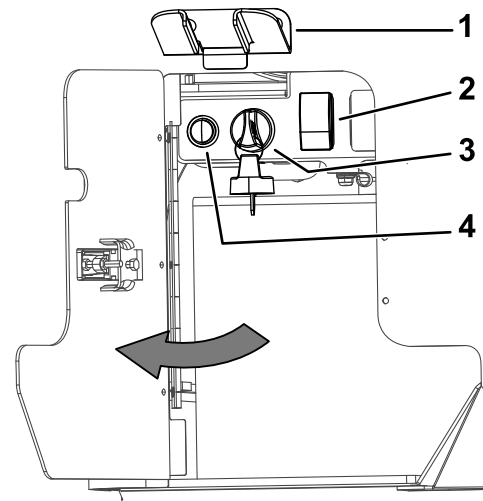


Figure 121

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- | | |
|---------------------------|-----------------------|
| 1. Travel pendant bracket | 3. Engine, key switch |
| 2. Fluid pump switch | 4. OK-to-start light |

-
3. Open the rear hood.
 4. Turn the drilling-fluid valve clockwise to the OFF position ([Figure 122](#)).

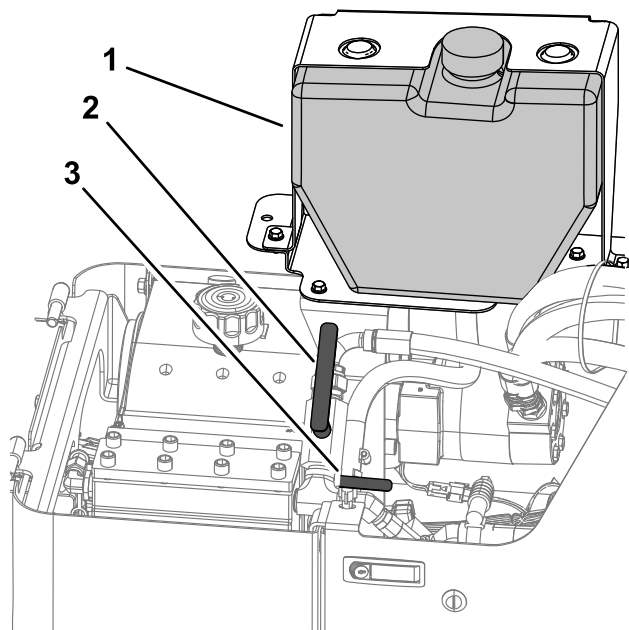


Figure 122

1. Antifreeze tank
2. Drilling-fluid valve (shown in the ON position)
3. Antifreeze valve (shown in the OFF position)

5. Connect the spray-hose attachment to the fitting ([Figure 123](#)).

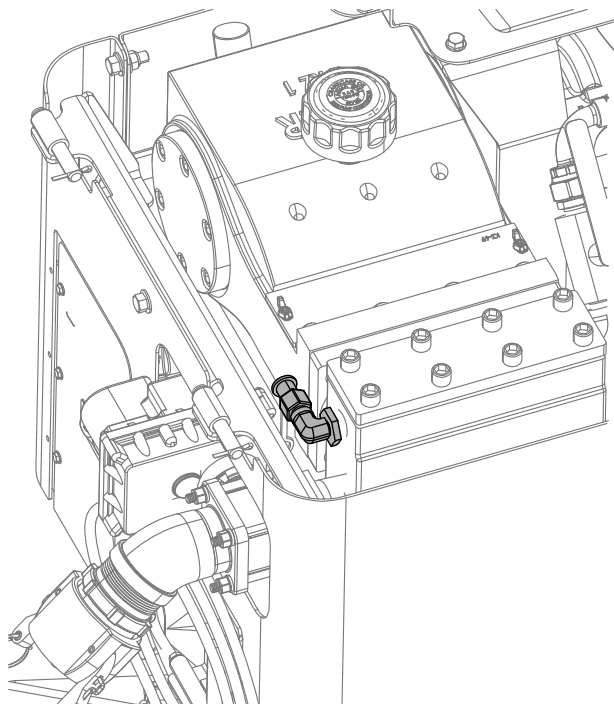


Figure 123

6. Setup up the pump to clean water [Connecting to a Drilling-Fluid Source](#) (page 52).

Turn the spray-hose attachment switch to the ON position ([Figure 122](#)).

7. Turn the drilling-fluid pump to the ON position through the display screen; refer to the Main Drill Functions Displayed in the Pressure Screen in the *Software Guide*.
8. Using the spray-hose attachment, hold down the lever and spray down the machine and pipes.

Cleaning Plastic and Resin Parts

Avoid using gasoline, kerosene, paint thinner, etc. when cleaning plastic windows, the console, the instrument cluster, the monitor, gauges, etc. Use only water, mild soap, and a soft cloth when you clean these parts.

Using gasoline, kerosene, paint thinner, etc. to clean a plastic or resin part will cause it to discolor, crack, or deform.

Storage

1. Shut off the engine and remove the key.
2. Remove dirt and grime from the entire machine.

Important: You can wash the machine with mild detergent and water. Avoid excessive use of water, especially near the control panel, engine, hydraulic pumps, and motors.

3. Service the air cleaner; refer to [Servicing the Air Cleaner \(page 72\)](#).
4. Grease the machine; refer to [Greasing the Machine \(page 68\)](#).
5. Charge the battery; refer to [Charging the Battery \(page 80\)](#).
6. Check and adjust the track tension; refer to [Servicing the Tracks \(page 84\)](#).
7. Check the coolant before winter storage; refer to [Cooling System Maintenance \(page 85\)](#).
8. Prepare the drilling-fluid pump for cold weather; refer to [Preparing the Drilling-Fluid System for Cold Weather \(page 95\)](#).
9. Check and tighten all bolts, nuts, and screws. Repair or replace any part that is damaged.
10. Paint all scratched or bare metal surfaces. Paint is available from your Authorized Service Dealer.
11. Store the machine in a clean, dry garage or storage area. Remove the key from the switch and keep it in a memorable place.
12. Cover the machine to protect it and keep it clean.

Troubleshooting

Problem	Possible Cause	Corrective Action
The machine is not responding to the controls properly.	<ol style="list-style-type: none"> 1. The joysticks need to be calibrated. 2. The cam assembly needs to be calibrated. 3. One of the sensors is not responding. 	<ol style="list-style-type: none"> 1. Calibrate the joysticks. 2. Calibrate the cam assembly; refer to the <i>Software Guide</i>. 3. Check the machine can information screen; refer to the <i>Software Guide</i>.
The starter does not crank.	<ol style="list-style-type: none"> 1. The BATTERY-DISCONNECT switch is in the OFF position. 2. The electrical connections are corroded or loose. 3. A fuse is blown or loose. 4. The battery is discharged. 5. The relay or switch is damaged. 6. A starter or starter solenoid is damaged. 7. The internal engine components have seized. 	<ol style="list-style-type: none"> 1. Turn the BATTERY-DISCONNECT switch to the ON position. 2. Check the electrical connections for good contact. 3. Correct or replace the fuse. 4. Charge the battery or replace it. 5. Contact your Authorized Service Dealer. 6. Contact your Authorized Service Dealer. 7. Contact your Authorized Service Dealer.
The engine cranks, but does not start.	<ol style="list-style-type: none"> 1. An incorrect starting procedure was used. 2. The fuel tank is empty. 3. The fuel shut-off valve is closed. 4. Dirt, water, stale fuel, or incorrect fuel is in the fuel system. 5. The fuel line is clogged. 6. There is air in the fuel. 7. The glow plugs are inoperative. 8. The cranking speed is slow. 9. The air cleaner filters are dirty. 10. The fuel filter is clogged. 11. The fuel grade is improper for cold weather use. 12. There is low compression. 13. The injection nozzles or pump are malfunctioning. 14. The ETR solenoid is broken. 	<ol style="list-style-type: none"> 1. Refer to Starting and Stopping the Engine. 2. Fill the tank with fresh fuel. 3. Open the fuel shut-off valve. 4. Drain and flush the fuel system, then add fresh fuel. 5. Clean or replace the fuel line. 6. Bleed the nozzles and check for air leaks at the fuel hose connections and fittings between the fuel tank and the engine. 7. Check the fuse, glow plugs, and wiring. 8. Check the battery, oil viscosity, and starting motor (contact your Authorized Service Dealer). 9. Service the air filters. 10. Replace the fuel filter. 11. Drain the fuel system and replace the fuel filter. Add fresh fuel of the proper grade for ambient temperature conditions. You may need to warm the entire machine. 12. Contact your Authorized Service Dealer. 13. Contact your Authorized Service Dealer. 14. Contact your Authorized Service Dealer.

Problem	Possible Cause	Corrective Action
The engine starts, but does not keep running.	<ol style="list-style-type: none"> 1. The fuel tank vent is restricted. 2. Dirt or water is in the fuel system. 3. The fuel filter is clogged. 4. There is air in the fuel. 5. The fuel grade is improper for cold weather use. 6. The spark arrestor screen is clogged. 7. The fuel pump is damaged. 	<ol style="list-style-type: none"> 1. Loosen the cap. If the engine runs with the cap loosened, replace the cap. 2. Drain and flush the fuel system; add fresh fuel. 3. Replace the fuel filter. 4. Bleed the nozzles and check for air leaks at fuel hose connections and fittings between the fuel tank and engine. 5. Drain the fuel system and replace the fuel filter. Add fresh fuel of proper grade for ambient temperature conditions. 6. Clean or replace the spark arrestor screen. 7. Contact your Authorized Service Dealer.
The engine runs, but knocks or misses.	<ol style="list-style-type: none"> 1. Dirt, water, stale fuel, or incorrect fuel is in the fuel system. 2. The engine is overheating. 3. There is air in the fuel. 4. The injection nozzles are damaged. 5. There is low compression 6. The injection pump timing is incorrect. 7. There is excessive carbon build-up. 8. There is internal wear or damage. 	<ol style="list-style-type: none"> 1. Drain and flush the fuel system; add fresh fuel. 2. Refer to Engine Overheats. 3. Bleed nozzles and check for air leaks at the fuel hose connections and fittings between the fuel tank and engine. 4. Contact your Authorized Service Dealer. 5. Contact your Authorized Service Dealer. 6. Contact your Authorized Service Dealer. 7. Contact your Authorized Service Dealer. 8. Contact your Authorized Service Dealer.
The engine does not idle.	<ol style="list-style-type: none"> 1. The fuel tank vent is restricted. 2. Dirt, water, stale fuel, or incorrect fuel is in the fuel system. 3. The air cleaner filters are dirty. 4. The fuel filter is clogged. 5. There is air in the fuel. 6. The fuel pump is damaged. 7. There is low compression 	<ol style="list-style-type: none"> 1. Loosen the cap. If the engine runs with the cap loosened, replace the cap. 2. Drain and flush the fuel system; add fresh fuel. 3. Service the air filters. 4. Replace the fuel filter. 5. Bleed the nozzles and check for air leaks at fuel hose connections and fittings between the fuel tank and engine. 6. Contact your Authorized Service Dealer. 7. Contact your Authorized Service Dealer.

Problem	Possible Cause	Corrective Action
The engine overheats.	<ol style="list-style-type: none"> 1. More coolant is needed. 2. There is restricted air flow to the radiator. 3. The crankcase oil level is incorrect. 4. There is excessive loading. 5. The incorrect fuel is in the fuel system. 6. The thermostat is damaged. 7. The fan belt is loose or broken. 8. Injection timing is incorrect. 9. The coolant pump is damaged. 	<ol style="list-style-type: none"> 1. Check and add coolant. 2. Inspect and clean the side panel screens with every use. 3. Fill or drain to the full mark. 4. Reduce the load and use a lower ground speed. 5. Drain and flush the fuel system; add fresh fuel. 6. Contact your Authorized Service Dealer. 7. Contact your Authorized Service Dealer. 8. Contact your Authorized Service Dealer. 9. Contact your Authorized Service Dealer.
There is excessive black smoke in the exhaust.	<ol style="list-style-type: none"> 1. There is excessive loading. 2. The air cleaner filters are dirty. 3. Incorrect fuel is in the fuel system. 4. The injection pump timing is incorrect. 5. The injection pump is damaged. 6. The injection nozzles are damaged. 	<ol style="list-style-type: none"> 1. Reduce the load and use a lower ground speed. 2. Service the air filters. 3. Drain the fuel system and refill with specified fuel. 4. Contact your Authorized Service Dealer. 5. Contact your Authorized Service Dealer. 6. Contact your Authorized Service Dealer.
There is excessive white smoke in the exhaust.	<ol style="list-style-type: none"> 1. The engine temperature is low. 2. The glow plugs are inoperative. 3. The injection pump timing is incorrect. 4. The injection nozzles are damaged. 5. There is low compression 	<ol style="list-style-type: none"> 1. Check the thermostat. 2. Check the fuse, glow plugs, and wiring. 3. Contact your Authorized Service Dealer. 4. Contact your Authorized Service Dealer. 5. Contact your Authorized Service Dealer.
The engine loses power.	<ol style="list-style-type: none"> 1. The engine load is excessive. 2. The crankcase oil level is incorrect. 3. The air cleaner filters are dirty. 4. Dirt, water, stale fuel, or incorrect fuel is in the fuel system. 5. The engine is overheating. 6. The spark arrestor screen is clogged. 7. There is air in the fuel. 8. There is low compression 9. The fuel tank vent is restricted. 10. The injection pump timing is incorrect. 11. The injection pump is damaged. 	<ol style="list-style-type: none"> 1. Reduce ground speed. 2. Fill or drain to the full mark. 3. Service the air filters. 4. Drain and flush the fuel system; add fresh fuel. 5. Refer to Engine Overheats. 6. Clean or replace the spark arrestor screen. 7. Bleed the nozzles and check for air leaks at fuel hose connections and fittings between the fuel tank and engine. 8. Contact your Authorized Service Dealer. 9. Contact your Authorized Service Dealer. 10. Contact your Authorized Service Dealer. 11. Contact your Authorized Service Dealer.

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Count on it.