INSTRUCTION MANUAL

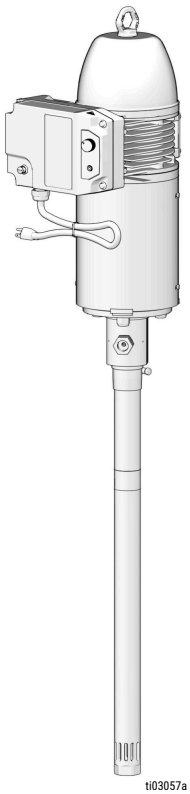
MANUAL NUMBER X021555 | REVISION A | ENGLISH (US)

Dyna-Star® XT Electric Grease Pump

Provides lubricant flow and pressure to operate both single-line and series progressive automatic lubrication systems. For automatic lubrication systems only. For professional use only. Not approved for use in explosive atmospheres or hazardous (classified) locations.

Important Safety Instructions

Read all warnings and instructions in this manual before using the equipment. Be familiar with the proper control and usage of the equipment. Save these instructions.



ti03057a

Model 2009845

Images are for illustrative purposes only

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MODELS AND APPROVALS

Table 1-1: Pump Models and Approvals

MODEL	DESCRIPTION	APPROVALS
2009845	Maximum Working Pressure: 6000 psi (41.3 MPa, 413 bar) 400 lb Drum Length	CE

Table 1-2: Motor Approvals

RECOGNIZED MET C US **E115803**	COMPLIES WITH UL 1004-1 CSA C22.2 NO. 100

SAFETY SYMBOLS

The following safety symbols appear throughout this manual and on warning labels. Read the table below to understand what each symbol means.

Table 2-1: Safety Symbols for Dyna-Star Electric Pump

SYMBOL	MEANING
	Burn Hazard
	Electric Shock Hazard
	Equipment Misuse Hazard
	Fire and Explosion Hazard
	Moving Parts Hazard
	Skin Injection Hazard
	Skin Injection Hazard
	Splash Hazard

SYMBOL	MEANING
	Toxic Fluid or Fumes Hazard
	Do Not Place Hands or Other Body Parts Near Fluid Outlet
	Do Not Stop Leaks with Hand, Body, Glove or Rag
	Follow Pressure Relief Procedure
	Ground Equipment
	Read Manual
	Wear Personal Protective Equipment

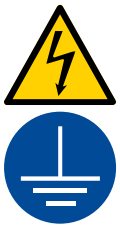
Safety Alert Symbol

This symbol indicates: Attention! Become Alert! Look for this symbol throughout the manual to indicate important safety messages.

GENERAL WARNINGS

The following warnings apply throughout this manual. Read, understand, and follow the warnings before using this equipment. Failure to follow these warnings can result in serious injury.

⚠ WARNING



ELECTRIC SHOCK HAZARD

This equipment must be grounded. Improper grounding, setup, or usage of the system can cause electric shock.

- Turn off and disconnect power cord before servicing equipment.
- Connect only to grounded electrical outlets.
- Use only 3-wire extension cords.
- Ensure ground prongs are intact on power and extension cords.
- Do not expose to rain. Store indoors.
- Only use an authorized service center to replace a damaged power cord.

SKIN INJECTION HAZARD

High-pressure fluid from dispensing device, hose leaks, or ruptured components will pierce skin. This may look like just a cut, but it is a serious injury that can result in amputation. **Get immediate surgical treatment.**

- Do not point dispensing device at anyone or at any part of the body.
- Do not put your hand over the fluid outlet.
- Do not stop or deflect leaks with your hand, body, glove, or rag.
- Follow the **Pressure Relief Procedure** when you stop dispensing and before cleaning, checking, or servicing equipment.
- Tighten all fluid connections before operating the equipment.
- Check hoses and couplings daily. Replace worn or damaged parts immediately.

⚠ WARNING

FIRE AND EXPLOSION HAZARD

When flammable fluids are present **in the work area**, such as gasoline and windshield wiper fluid, be aware that flammable fumes can ignite or explode. To help prevent fire and explosion:

- Use equipment only in well-ventilated area.
- Eliminate all ignition sources, such as cigarettes and portable electric lamps.
- Ground all equipment in the work area.
- Keep work area free of debris, including rags and spilled or open containers of solvent and gasoline.
- Do not plug or unplug power cords or turn lights on or off when flammable fumes are present.
- Use only grounded hoses.
- **Stop operation immediately** if static sparking occurs or you feel a shock. Do not use equipment until you identify and correct the problem.
- Keep a working fire extinguisher in the work area.

EQUIPMENT MISUSE HAZARD

Misuse can cause death or serious injury.

- Do not operate the unit when fatigued or under the influence of drugs or alcohol.
- Do not exceed the maximum working pressure or temperature rating of the lowest rated system component. See **Technical Specifications** in all equipment manuals.
- Use fluids and solvents that are compatible with equipment wetted parts. See **Technical Specifications** in all equipment manuals. Read fluid and solvent manufacturer's warnings. For complete information about your material, request Safety Data Sheets (SDSs) from distributor or retailer.
- Turn off all equipment and follow the **Pressure Relief Procedure** when equipment is not in use.
- Check equipment daily. Repair or replace worn or damaged parts immediately with genuine manufacturer's replacement parts only.
- Do not alter or modify equipment. Alterations or modifications may void agency approvals and create safety hazards.
- Make sure all equipment is rated and approved for the environment in which you are using it.
- Use equipment only for its intended purpose. Call your distributor for information.
- Route hoses and cables away from traffic areas, sharp edges, moving parts, and hot surfaces.
- Do not kink or over bend hoses or use hoses to pull equipment.
- Keep children and animals away from work area.
- Comply with all applicable safety regulations.

⚠ WARNING	
 	**MOVING PARTS HAZARD** Moving parts can pinch, cut or amputate fingers and other body parts. • Keep clear of moving parts. • Do not operate equipment with protective guards or covers removed. • Equipment can start without warning. Before checking, moving, or servicing equipment, follow the **Pressure Relief Procedure** and disconnect all power sources.
	**TOXIC FLUID OR FUMES HAZARD** Toxic fluids or fumes can cause serious injury or death if splashed in the eyes or on skin, inhaled, or swallowed. • Read Safety Data Sheets (SDSs) to know the specific hazards of the fluids you are using. • Store hazardous fluid in approved containers, and dispose of it according to applicable guidelines.
	**BURN HAZARD** Equipment surfaces and fluid that is heated can become very hot during operation. To avoid severe burns: • Do not touch hot fluid or equipment.
	**PERSONAL PROTECTIVE EQUIPMENT** Wear appropriate protective equipment when in the work area to help prevent serious injury, including eye injury, hearing loss, inhalation of toxic fumes, and burns. Protective equipment includes but is not limited to: • Protective eyewear, and hearing protection. • Respirators, protective clothing, and gloves as recommended by the fluid and solvent manufacturer.

Table 4-1: Technical Specifications for Dyna-Star XT Electric Grease Pump

	US	METRIC
Maximum Working Pressure	7000 psi	48.3 MPa, 483 bar
Maximum Recommended Pump Speed	30 cycles per minute	
Maximum Fluid Temperature	180°F	82°C
Fluid Outlet	3/4 in. NPT	
Stroke	4.75 in.	121 mm
Fluid Output	2.1 cu in. per cycle	34.4 cc per cycle
Wetted Parts	Steel, stainless steel, bronze, UHMWPE, aluminum, buna	
Weight (400 lb Length)	118 lb	53.5 kg

Table 4-2: Technical Specifications for Electric Motor

	US	METRIC
Environmental Temperature Range	14°–104°F	-10°–40°C
IP Ratings, Ordinary Locations Models	IP66, Type 4X	
IP Ratings, Explosive Atmospheres or Hazardous (Classified) Locations Models	IP66, Type 4X	
Electrical Ratings	100–120 V, Single Phase, 50/60 Hz, 12 A	
Maximum Branch Circuit Protection	20 A, Inverse Time Circuit Breaker	
Short Circuit Current Rating	5 kA	

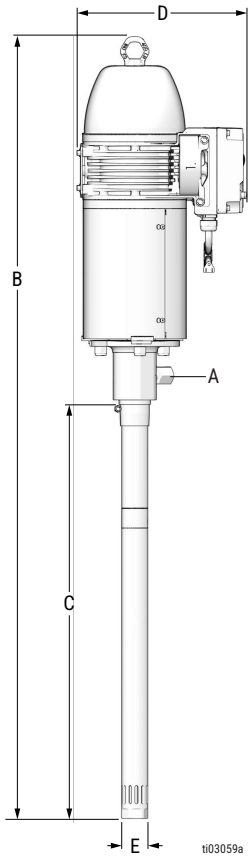


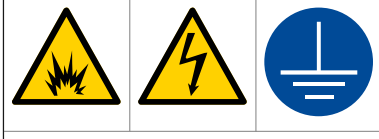
Figure 5-1: Dimensions Diagram for Dyna-Star XT Electric Grease Pump

Table 5-1: Dimensions for Dyna-Star XT Electric Grease Pump

	US	METRIC
A (thread)	3/4 in. NPT	N/A
B	63.63 in.	1616.2 mm
C	26.76 in.	679.7 mm
D	13.3 in.	337.8 mm
E (diameter)	2.125 in.	53.97 mm

I/O PIN CONNECTION

⚠ WARNING



To avoid injury from fire, explosion, or electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

For models in Ordinary Locations only.

NOTE:

The I/O connector is located on the front of the motor cover. All I/O connectors are capable of 30 VDC (volts of direct current) and are reverse-polarity protected.

The motor is equipped with the following inputs and outputs:

- One digital input – use M12 cable pins 1 and 3 to enable/disable pump operation.
- One analog input – use M12 cable pins 4 and 5 to control the pump set point (speed and pressure).
- One digital output – use M12 cable pins 2 and 3 to control an external accessory (such as lamp or LED).

For detailed information about I/O pinouts, see **I/O Pin Connection, page 10** and **Equivalent Electrical Circuits for I/O Pin Connection, page 12**.

Table 6-1: I/O Connector Pinout (for Models in Ordinary Locations only)

PIN	CONNECTOR TYPE	DESCRIPTION
Pin 1 (Brown)	Digital Input	Digital input has an internal 5 VDC pull-up for dry-contact or current-sinking circuits. Digital input is internally clamped for push-pull outputs. Release or drive the input high to stop the equipment from running. Pull the input low to re-enable the equipment.
Pin 2 (White)	Digital Output (Equipment Running)	Digital output is current-sinking with a current capacity up to 100 mA. Digital output is internally clamped for driving large inductive loads. The output is automatically pulled low when the equipment is running and automatically released when the equipment is not running.
Pin 3 (Blue)	GND/Common	Earth ground, common connection.
Pin 4 (Black)	Analog Input, Positive	Analog inputs are 4-20 mA current-controlled. When the analog input is connected and driving current, the equipment disables the control knob (E) and uses the analog input to control the speed and pressure of the equipment. The control knob (E) can still be used to shut off the equipment by turning the knob to off (0). To re-enable the equipment at the speed and pressure commanded by the analog input, turn the control knob up (clockwise). To disable the analog input control and enable the control knob (E): 1. Shut down the equipment. Ensure the LED indicator is off (no light). 2. Disconnect power to the system. 3. Disconnect the analog input (Pin 4, Pin 5). 4. Connect the unit to a power source to turn on the equipment and enable the control knob (E) on the equipment.
Pin 5 (Gray)	Analog Input, Negative	

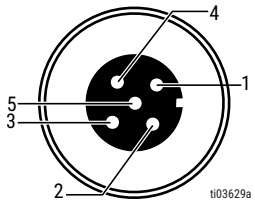
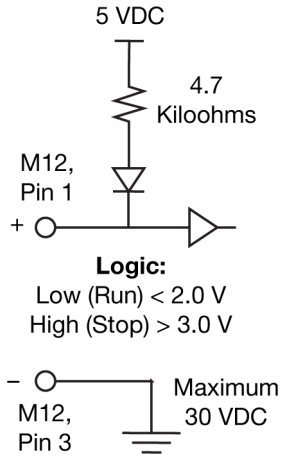
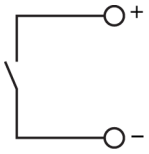
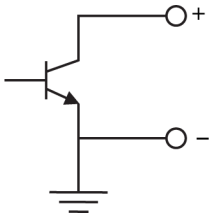
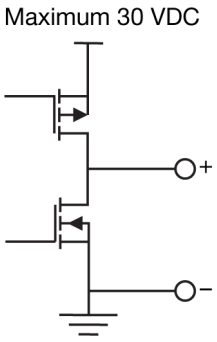


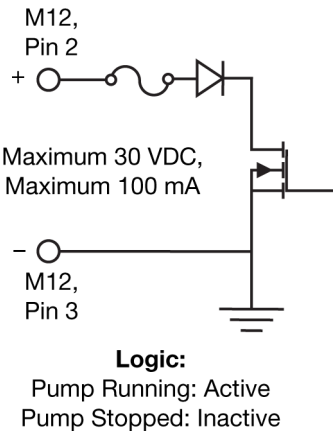
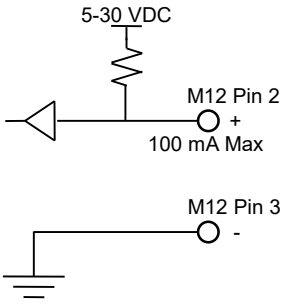
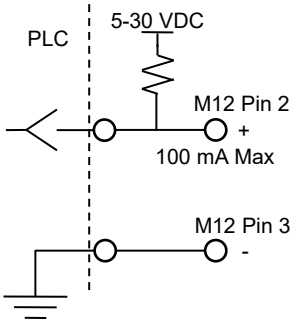
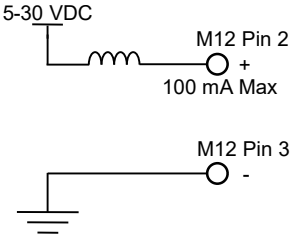
Figure 6-1: M12, 5-pin Connector for Models in Ordinary Locations

Orientation: facing the connector on the pump body.

EQUIVALENT ELECTRICAL CIRCUITS FOR I/O PIN CONNECTION

Table 7-1: Equivalent Electrical Circuits for I/O Pin Connection (for Models in Ordinary Locations only)

I/O CIRCUIT	EQUIVALENT CIRCUIT
Digital Input	
	Compatible Drivers for Digital Input
	Switch or Relay 
	Open Collector (NPN) 
	Push-Pull Driver 

I/O CIRCUIT	EQUIVALENT CIRCUIT
Digital Output	
	Compatible Digital Output Circuit Drivers
	PLC With Internal Pull-up 
	PLC without Internal Pull-up 
Digital Output	Relay or Solenoid 

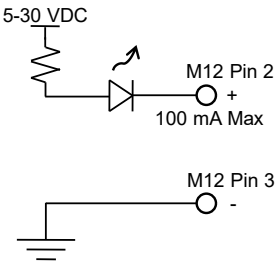
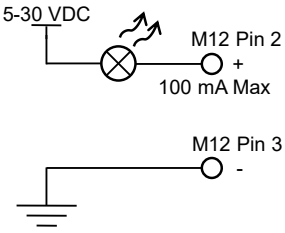
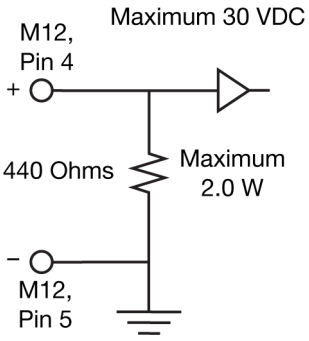
I/O CIRCUIT	EQUIVALENT CIRCUIT
	LED 
	Lamp 
Analog Input	

Table 8-1: Key: Power Cord/Cable Schematics

N	White
L1	Black
L2	- - -
L3	- - -
L1/B	- - -
L2/N	- - -
G	Green (ground wire)

Table 8-2: Key: General Electrical Schematics

4a	Motor sensor cable
21b	Control knob encoder wire
28b	Fan cable
24c	Fan motor cable
36	I/O port/cable
37	LED indicator
CM	1 – Control Mode 2 – Control Knob Function See **Configure the Control Knob Function, page 21**.
MA	Motor wire: black wire, white band
MB	Motor wire: black wire, black band
MC	Motor wire: black wire, red band

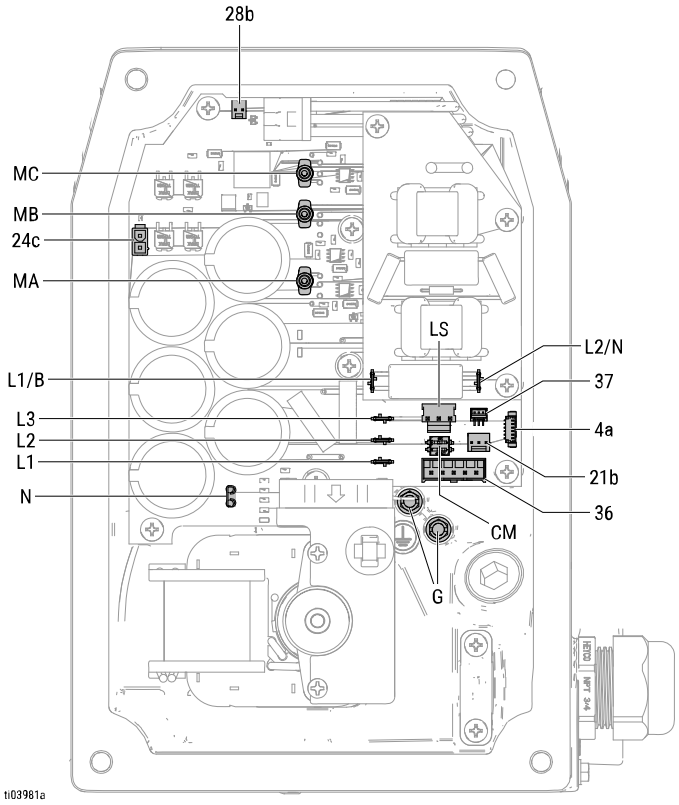


Figure 8-1: Motor Electrical Schematic

LED INDICATOR

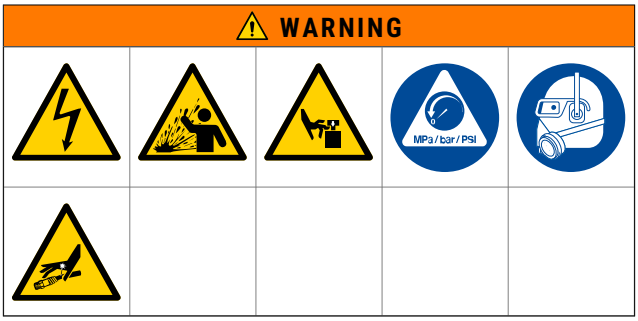
These sections provide an overview of the LED indicator lights and a list of error conditions and how to address them.

LED INDICATOR OVERVIEW

Table 9-1: LED Indicator Lights

LED INDICATOR	EQUIPMENT STATUS	NOTES
Red, solid	Powered on, speed set at 0 (zero), system not operating.	Be aware that the equipment is energized. To initiate equipment operation, follow **Start the Pump, page 20**.
Yellow, solid	Calibrating. Performing startup sequence.	No action. Allow equipment to finish startup sequence. Open the fluid drain valve (G) or fluid shutoff valve (H) to allow the equipment to cycle until the startup sequence is finished.
Green, solid	Startup sequence complete.	To initiate equipment operation, follow **Start the Pump, page 20**
	Normal operation.	No action.

LED INDICATOR EVENT ERRORS



If an event error occurs, the LED Indicator will blink a set number of times corresponding to the event code that needs acknowledged.

Follow the **Pressure Relief Procedure, page 20** before checking or repairing the equipment.

Check all possible problems and causes before disassembling equipment.

Table 9-2: LED Indicator Event Errors

LED INDICATOR	PROBLEM	CAUSE	SOLUTION
Red, flashing, one flash	Motor or controller overheating.	Hot operating environment or hot operating conditions.	Turn the control knob (E) to the off (0) position. Keep the system connected to power and allow the equipment to cool before returning to operation.
			Inspect the fan. Repair or replace as needed. See **Replace the Fan Assembly, page 36**.
Red, flashing, two flashes	Motor current error.	Special-case cause.	Turn the control knob down, then back up. If the problem persists, contact Technical Support.
Red, flashing, three flashes	Voltage error or pump priming failure.	Input voltage is too high, too low, or too noisy, or an operational parameter of the motor was exceeded while priming.	Check line power voltage.
			Check control board connections. See **Replace the Control Board and Filter Board Assembly, page 39**
Red, Flashing, four flashes	Motor sensor error.	Motor sensor disconnected.	Ensure the motor sensor cable is properly installed. See **Replace the Motor Sensor Board, page 41**.
		Motor sensor not functioning.	Replace the motor sensor. See **Replace the Motor Sensor Board, page 41**.
Red, flashing, five flashes	Special-case problem.	Special-case cause.	Power cycle the unit. If the error persists, contact Technical Support.
Red, flashing, six flashes	Motor lead connection error.	One or more motor leads are connected incorrectly.	Check that all motor connections to the control board are correct.
Dim red, solid	Voltage detection error.	Power disconnected.	Check power connection.
		System powering down.	Allow equipment to finish shutdown.
Green, flashing, continuous flash	Equipment stalled against pressure.	A valve downstream in the fluid line is closed or clogged.	Open the valve.
			Follow the **Pressure Relief Procedure, page 20** and clear the valve.
		Special-case cause.	Be aware that the equipment is energized. Special-case action.
			Contact Technical Support.

LED INDICATOR	PROBLEM	CAUSE	SOLUTION
No light (off)	Voltage detection error.	System not powered.	Check power connection.
		Control failure.	Check the branch circuit for proper voltage.
			Replace the control board. See **Replace the Control Board and Filter Board Assembly, page 39**.

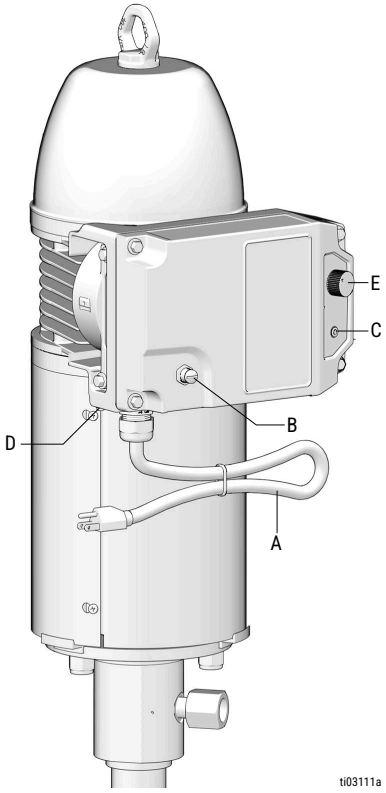


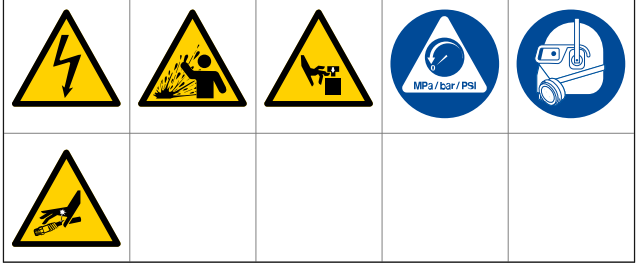
Figure 10-1: Component Identification

Table 10-1: Component Description

KEY	COMPONENT	NOTES
A	Power Cord	Pigtail cord with plug
B	I/O Port	M12, 5-pin connector
	On/Off Digital Input	
	Run Status, Digital Output	
	Speed/Pressure Control, Analog Input	
C	LED Indicator	See **LED Indicator, page 15**.
D	External Ground Fastener/Ground Symbol	
E	Control Knob	Standard: Enable/ disable pump operation. Optional: Increase or decrease fluid flow rate. See **Configure the Control Knob Function, page 21**.

Reference letters in the text, for example: (A), refer to the callouts in **Typical Installation, page 19**.

⚠ WARNING



MOUNT THE PUMP

NOTICE

Mount the pump securely so that it cannot move around during operation. Failure to do so could result in personal injury or equipment damage.

- Select a convenient location for installation of the equipment to ensure easy operator access to the pump controls, sufficient room to change supply containers, and a secure mounting platform.
- To mount the pump directly onto the supply container, position the pump so that the intake valve is no more than 1 in. (25 mm) from the bottom of the container. Mount the pump to the drum cover (C) or other suitable mounting device.

PUMP ACCESSORIES

⚠ WARNING

To reduce the risk of serious injury, including fluid injection and splashing in the eyes or on the skin, which may be caused in component ruptures, all accessories added to the pump fluid outlet side must have a maximum working pressure of at least 7000 psi (48.2 MPa, 482 bar).

- Drain Valve (D): Relieve fluid pressure in the pump.
- Shut Off Valve (E): Isolates the pump from the downstream fluid pressure.
- Fluid Pressure Gauge (F): Monitors the fluid outlet pressure.

TYPICAL INSTALLATION

The installation shown is only a guide for selecting and installing system components and accessories. Contact your Graco distributor for assistance in designing a system to meet your needs.

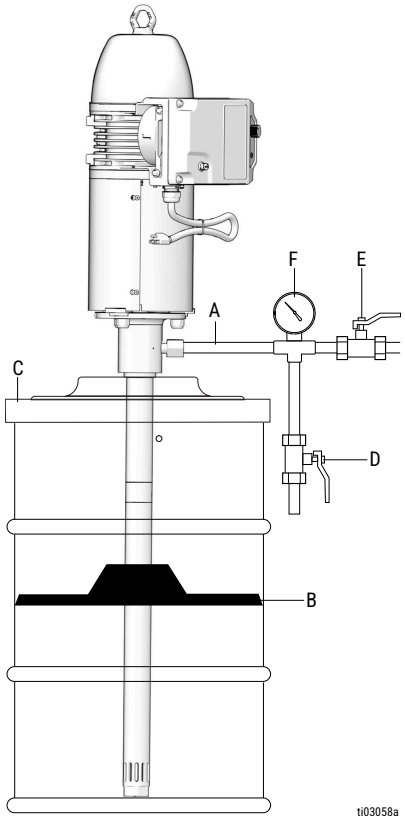


Figure 11-1: Typical Installation

Table 11-1: Typical Installation Components

KEY	COMPONENT
A	Fluid Hose
B	Follower Plate
C	Drum Cover
D	Drain Valve (required)
E	Shut Off Valve (required)
F	Pressure Guage (required)

Reference letters in the text, for example: (A), refer to the callouts in **Typical Installation, page 19**.

PRESSURE RELIEF PROCEDURE

Follow the **Pressure Relief Procedure** whenever you see this symbol.

⚠ WARNING

This equipment stays pressurized until pressure is manually relieved. To help prevent serious injury from pressurized fluid, such as splashing fluid and moving parts, follow the **Pressure Relief Procedure** when you stop operating and before cleaning, checking, or servicing the equipment.

1. Turn the fluid output control knob to off (0).
2. Disconnect power to the system.
3. Close the shutoff valve (E).
4. Open the drain valve (D).
5. Check the pressure gauge (F) to verify that the pressure has been relieved.
6. Leave the valves in these positions until the system is ready to be pressurized.

START THE PUMP

⚠ WARNING

To prevent serious injury from splashing fluid, ensure the control knob is set to off (0) before connecting the equipment to a power source.

PREPARE PUMP FOR STARTUP

1. Turn the control knob to off (0).
2. Check and tighten all of the fluid connections before operating the equipment.

NOTE:

Replace worn or damaged parts as needed.

3. Submerse the bottom of the pump in the fluid to be dispensed.
4. Make sure that all fluid outlet valves are open.
5. If the fluid outlet line has a dispensing device, hold the dispensing valve open into the end container.
6. Plug the power cord into a power source.

ADJUST OUTPUT

1. With the control knob turned off (0), turn on the power source. The LED indicator turns solid red.

NOTE:

An alert beep sounds and the pump automatically starts cycling if the power source is turned on and the fluid output control knob is not set to off (0).

2. Turn the control knob clockwise beyond (0) to send an I/O signal to enable the pump to cycle. A calibration sequence begins and the LED indicator turns solid yellow.
3. After the calibration sequence is done, the pump starts to pump normally, and the LED light turns solid green.
4. The pump is set from the factory to run at a constant speed at any control knob set point above zero. If speed adjustment is desired, use the analog input (4–20mA) or refer to **Configure the Control Knob Function, page 21** to enable speed control using the control knob.

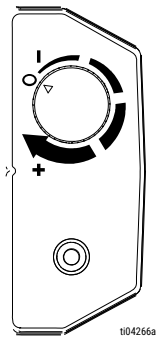
CONFIGURE THE CONTROL KNOB FUNCTION

Follow this procedure to configure the function of the control knob on the electric motor.

The default function from the factory for the control knob on the motor is to enable or disable the motor operation (without removing power from the system).

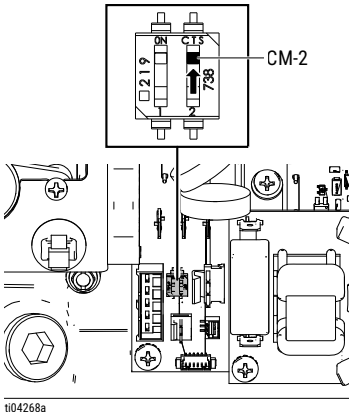
Alternatively, you can configure the control knob to vary the fluid flow rate in one of two ways. This requires you to set two switches inside the cover of the motor.

Figure 12-1: Control Knob



1. Verify that the equipment is turned off and power to the system is disconnected before performing any service or repair procedure.
2. Follow **Remove the Control Cover, page 34**.
3. Locate the Control Knob Function switch (CM-2). See **Motor Electrical Schematics, page 14**.
4. Select the Control Knob Function:
    a. To select enable/disable the motor, push the switch CM-2 to the down position (default). In this configuration, rotating the control knob clockwise past (0) toward (+) enables the motor, and rotating the knob counterclockwise to (0) disables the motor (without removing power from the system). In this mode, an I/O digital input is required to operate the pump. See **I/O Pin Connection, page 10**. After you select this option, proceed to step 7.
    b. To select variable fluid flow rate, push the switch CM-2 to the up position. In this configuration, rotating the knob clockwise toward (+) increases the fluid flow rate, and rotating the knob counterclockwise toward (-) decreases the fluid flow rate.

Figure 12-2: Switch CM-2: Control Knob Function



5. Locate the Control Mode switch (CM-1).
6. Select the Control Mode:
    a. For Flow Control Mode (default), push the switch CM-1 to the down position. In this mode, adjusting control knob adjusts the fluid flow of the pump higher (+) or lower (-), at the maximum operating pressure of the pump.

b. For Pressure Control Mode, push the switch CM-1 to the up position. In this mode, adjusting the control knob adjusts the fluid flow and stall pressure of the pump higher (+) or lower (-).

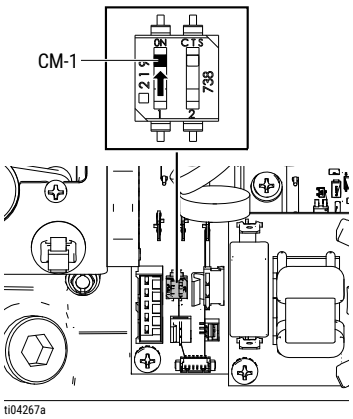


Figure 12-3: Switch CM-1: Control Mode

NOTE:

If Control Knob Function switch (CM-2) is in the down position (enable/disable), Control Mode switch (CM-1) is ignored.

7. Follow **Install the Control Cover, page 34**.

TIPS TO REDUCE CAVITATION

NOTICE

Frequent or excessive cavitation can cause serious damage, including pitting and early wear of wetted parts, and may result in reduced efficiency of the equipment. Cavitation damage and reduced efficiency both result in increased operating costs.

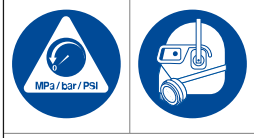
Cavitation is the formation and collapse of vapor-filled cavities in the fluid caused by dynamic pressure reduction at the pump inlet. When the fluid is pressurized, as in the hight pressure side of a pump, these cavities collapse and cause severe localized shock and heat damage to the metal surfaces. Thick fluids are more difficult to pull into the suction side of the pump and are more prone to cavitation than thin fluids.

To improve equipment efficiency and reduce cavitation:

- Choose the optimal pump speed: Pumping too fast does not allow enough time for the fluid to enter the inlet side of the pump. This results in increased cavitation and a reduction in efficiency.
- Reduce fluid viscosity: Thinner fluids enter a pump inlet faster than thicker fluids, Warm the fluid or dilute the fluid to reduce fluid viscosity.

STORE THE PUMP

⚠ WARNING



Always relieve pressure and clean the pump before storing the equipment for any length of time.

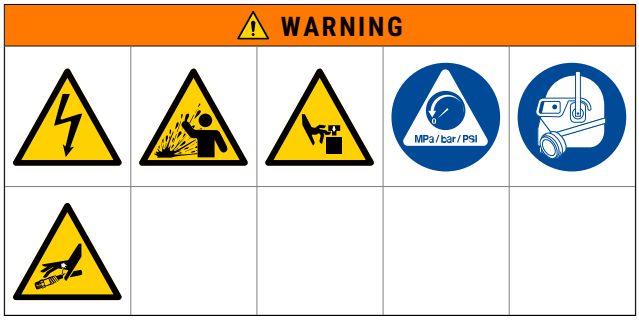
Follow **Pressure Relief Procedure, page 20**.

END OF PRODUCT LIFE

At the end of the product's useful life, dismantle and recycle it in a responsible manner.

- Perform **Pressure Relief Procedure**.
- Drain and dispose of fluids according to applicable regulations. Refer to the material manufacturer's Safety Data Sheet.
- Remove motors, batteries, circuit boards, LCDs (liquid crystal displays), and other electronic components. Recycle according to applicable regulations.
- Do not dispose of electronic components with household or commercial waste. 
- Deliver remaining product to a recycling facility.

This section describes the problem, cause, and solution for common issues with the product.



Follow the **Pressure Relief Procedure, page 20** before checking or repairing the equipment.

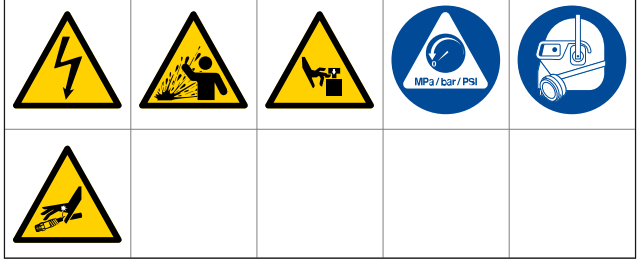
Check all possible problems and causes before disassembling the equipment.

Table 14-1: Troubleshooting for Dyna-Star Electric Pump

PROBLEM	CAUSE	SOLUTION
Equipment emits beeping alert sound, LED light yellow	Pump starting automatic startup sequence. Pump is connected to a power source and the control knob is not set to the off (0) position.	Turn the control knob to the off (0) position or disconnect power to the pump.
		If prepared to operate, allow the automatic startup sequence to complete.
LED light flashing	Equipment error, special-cause case.	See **LED Indicator Event Errors, page 15**.
Pump fails to operate or there is not fluid flow.	Closed dispense valve	Open the valve.
	Clogged fluid lines, hoses, or dispense valve	Disconnect the fluid line, then turn on the pump. If the pump starts, the lines, hoses, or valve is clogged. Clear the obstruction.
	Damaged motor	Service the motor. Refer to the applicable procedures in **Repair, page 26**.
	Exhausted fluid supply	Refill the fluid supply and prime the pump.
Erratic pump operation	Exhausted fluid supply	Refill the fluid supply and prime the pump.
	Worn fluid seals	Replace worn seals.
Pump operates but the output is low	Worn fluid seals	Replace worn seals.
Fluid is coming out of the top of the pump outlet housing	Worn or damaged throat seal	Replace worn seals.
Leaks at output pressure relief hole	Wrong style of fitting	Replace with the correct fitting.
	Fitting is loose	Tighten the fitting.
	Fitting is damaged	Replace the fitting.

PROBLEM	CAUSE	SOLUTION
Equipment suddenly stops operating or shuts down	Ground fault interrupter (GFCI) tripped	Remove controller from the GFCI circuit.
	Poor supply power	Check connections. Determine and fix the source of the problem with the supply power.
	Exceeded operational parameters	See **LED Indicator Event Errors, page 15**.

⚠ WARNING



Reference numbers in the text, for example: (1), refer to the callouts in **Parts, page 49** or the figures in the procedures.

This equipment stays pressurized until pressure is manually relieved. To help prevent serious injury from pressurized fluid, such as splashing fluid and moving parts, follow **Pressure Relief Procedure, page 20** when you stop operating and before cleaning, checking, or servicing the equipment.

PREPARE EQUIPMENT FOR REPAIR

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

1. Stop the pump while it is in the down stroke position.

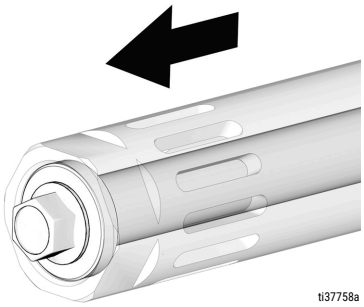


Figure 15-1: Down Stroke Position

2. Relieve pressure. Follow the **Pressure Relief Procedure, page 20**.
3. Turn the control knob off (0). The LED light will turn solid red.
4. Disconnect power to the equipment. The LED light will turn off.
5. Disconnect the fluid hose.
6. Remove the shrouds (19). Leave screws (20) attached to the shrouds.

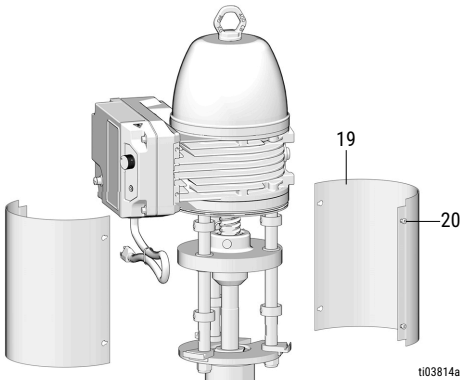


Figure 15-2: Remove Shrouds

7. Remove the tie rod nuts (12) and coupling (10). Set parts aside, including coupling collars (9).

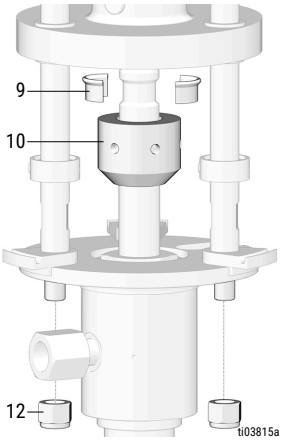


Figure 15-3: Remove Tie Rod Nuts, Coupling, and Collars

8. Remove the motor assembly and shroud support (11).

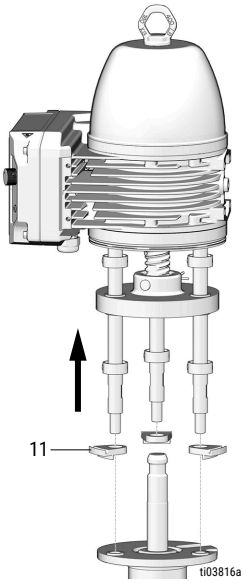


Figure 15-4: Motor Assembly and Shroud Support

9. Optional: Mount the back of the pump (opposite side from the motor) to the maintenance bracket stand. This positions the pump facing up, enabling easy working access to the pump and motor. The stand can be mounted to a workbench through the mounting holes on the feet.
   a. Loosen the four bolts that hold the logo plate (if present) to the pump.
   b. Slide the bracket stand behind the bolts.
   c. Tighten the bolts.
   d. Before returning the pump to service, remove it from the bracket stand.

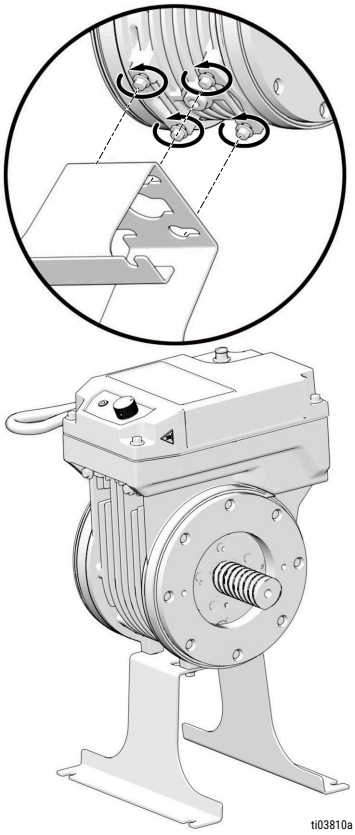


Figure 15-5: Maintenance bracket stand

DISASSEMBLE THE PUMP

SUPPLIES

- Socket wrench and extension with the following sockets:
  - 3/4 in.
  - 1-7/16 in.
  - 1-13/16 in.
  - 1-15/16 in.
  - 2 in.
- 15/16 in. open-end wrench
- Large adjustable wrenches (1-1/4 in. jaw capacity)
- Torque wrench 50–250 ft-lb (67.8 to 339 N•m)
- O-ring pick
- 2.5 in. spanner wrench (for side holes)

DISASSEMBLE THE PUMP LOWER

1. Remove the pump lower from container and place on workbench.
2. Position the pump lower horizontally in a vise (with the pressure relief hole facing up) and secure on flats.

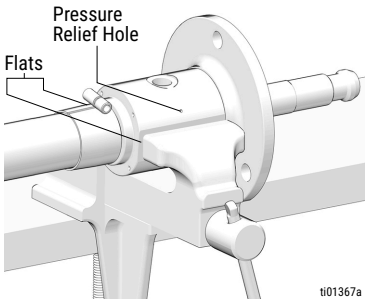


Figure 15-6: Position and Secure Pump Lower

3. Use a 1-15/16 in. socket to loosen the inlet pump cylinder (113) and expose the hex on the connecting rod (107).

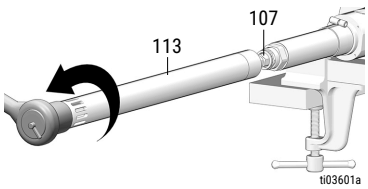


Figure 15-7: Loosen Inlet Pump Cylinder

4. Use a 3/4 in. socket to loosen and unthread the shovel rod (112). Leave the shovel rod (112) inside of the inlet pump cylinder (113) and set aside.

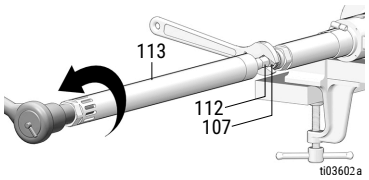


Figure 15-8: Loosen Shovel Rod

5. Use a 1-7/16 in. socket to loosen the seal retainer (109c), but leave it hand-tight in the pump cylinder (109).

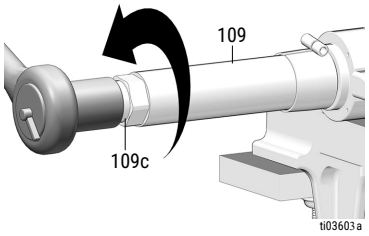


Figure 15-9: Loosen Seal Retrainer

6. Use a 1-13/16 in. socket to remove the pump cylinder (109).

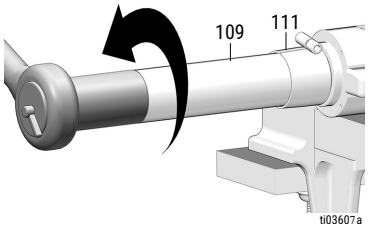


Figure 15-10: Remove Pump Cylinder

7. Position a wrench on the displacement rod (101) flats and position another wrench on the fluid piston (103) flats. Loosen and remove the fluid piston (103).

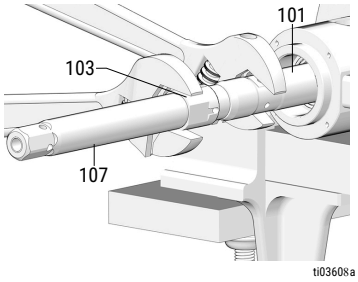


Figure 15-11: Remove Fluid Piston

NOTE:

The fluid piston (103) can stay connected to the connecting rod (107).

8. Remove the check ball (104) from the inside of the displacement rod (101) and set aside.

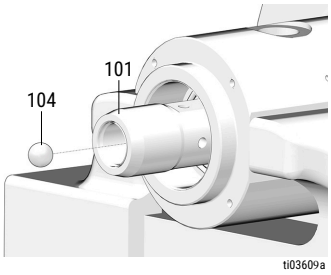


Figure 15-12: Remove Check Ball

9. Remove the displacement rod.

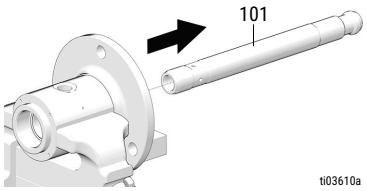


Figure 15-13: Remove Displacement Rod

10. Use a 2 in. socket to loosen and remove the throat seal retainer nut (108e).

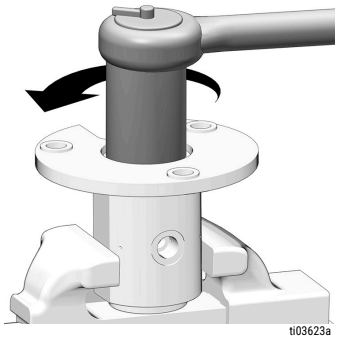


Figure 15-14: Remove Throat Seal Retainer Nut

11. Remove the outlet housing adapter (108b).
12. Remove the spacer (108f), throat seal (108d), the throat seal back-up rings (108c), and O-ring (108j).
13. Remove the O-ring face seal (108h).

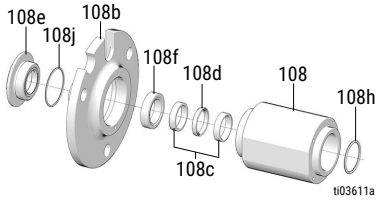


Figure 15-15: Remove O-Ring Face Seal

TORQUE INSTRUCTIONS

To ensure proper sealing, torque fasteners using the following procedure.

1. Start all fasteners a few turns.
2. Tighten each fastener until each fastener is slightly under the torque specified in the instructions.
3. Tighten each fastener by 1/2 turn or less until each fastener is at the specified torque.

REASSEMBLE THE PUMP

SUPPLIES

- Socket wrench and extension with the following sockets:
  - 3/4 in.
  - 1-7/16 in.
  - 1-13/16 in.
  - 1-15/16 in.
  - 2 in.
- 15/16 in. open-end wrench
- Large adjustable wrenches (1-1/4 in. jaw capacity)
- Torque wrench 50–250 ft-lb (67.8 to 339 N•m)
- O-ring pick
- 2.5 in. spanner wrench (for side holes)

1. Replace the O-ring face seal (108h) and O-ring (108j) with a new one from the seal kit.

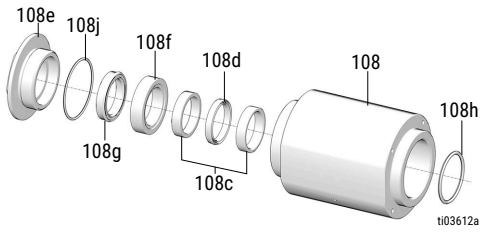


Figure 15-16: Throat and Seals

2. Replace the backup throat seal (108g) with a new one from the seal kit.
3. Replace the throat seal (108d) and the throat seal backup rings (108c) with new parts from the seal kit.

NOTE:

The chamfer on the seal backup rings must point away from the seal, and the step on the spacer must point toward the backup rings.

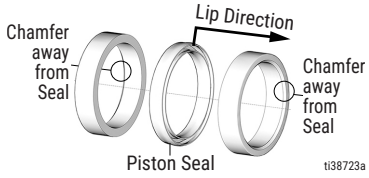


Figure 15-17: Seals Orientation

4. Replace spacer (108f).
5. Reinstall the outlet housing adapter (108b) by aligning the hole in the adapter with the pin (108a) on the outlet housing (108).

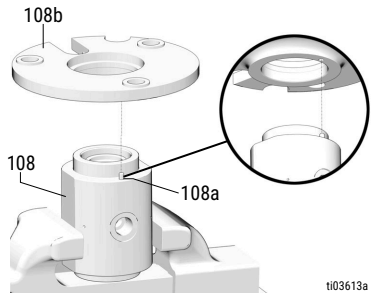


Figure 15-18: Housing Adapter Alignment

6. Use a 2 in. socket to reinstall the throat seal retainer nut (108e) and tighten. Torque to 150–165 ft-lb (203.4–223.7 N•m).

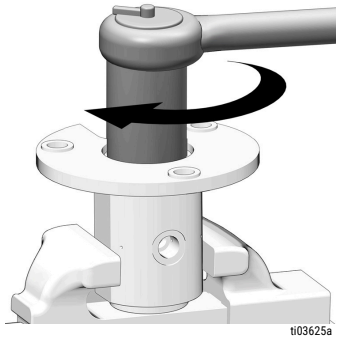


Figure 15-19: Throat Seal Retainer Nut

7. Reinstall the displacement rod (101) through the outlet housing (108) in the direction shown in the figure.

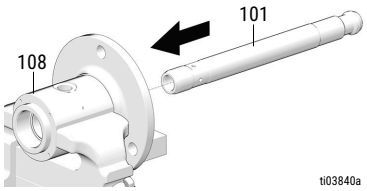


Figure 15-20: Displacement Rod Reinstallation

8. Reinstall the check ball (104) between the displacement rod (101) and the fluid piston (103).

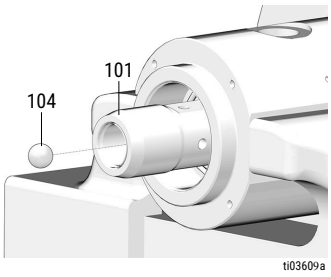


Figure 15-21: Check Ball Reinstallation

9. Remove the piston seal retainer washer (102), the piston seal (106), and the piston seal backup rings (105). Replace them with new parts from the seal kit.

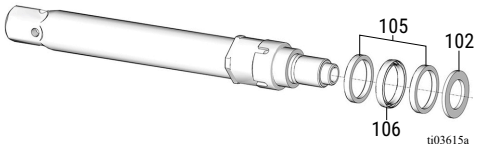


Figure 15-22: Washer, Seal, Rings

NOTE:

- The chamfer on the seal backup ring must point away from the seal.
- The piston seal has a green O-ring.

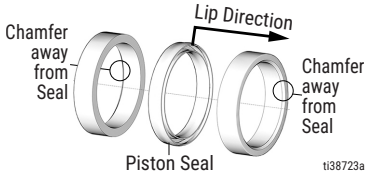


Figure 15-23: Piston Seal

10. Reinstall the fluid piston (103) and the connecting rod (107) using one wrench on the displacement rod (101) flat and a 15/16 in. socket on the connecting rod (107) and then tighten. Torque to 140–160 ft-lb (189.8–216.9 N•m).

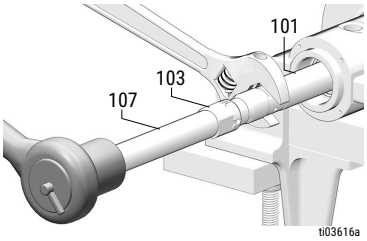


Figure 15-24: Fluid Piston Reinstallation

11. Remove the seal retainer (109c) from the pump cylinder (109).

NOTE:

- The chamfer on the seal backup ring must point away from the seal.
- The priming seal has a yellow O-ring.
- Priming seal backup rings have identification marks on the chamfered face to distinguish it from the piston seal backup rings.

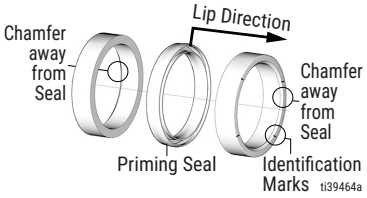


Figure 15-25: Priming Seal

12. Remove the seals (109d), backup rings (109a), seal (109b). Replace with parts from seal kit.

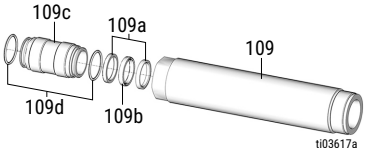


Figure 15-26: Priming Seal, Backup Rings

13. Replace the seal retainer (109c) and hand-tighten.
14. Apply anti-seize lubricant to the male threads of the pump cylinder (109) then reinstall the assembly. Tighten with a 1-13/16 in. socket. Torque to 235–265 ft. lb (318.6–359.3 N•m).

15. Use a 1-7/16 in. socket to tighten the seal retainer (109c) to the pump cylinder (109) assembly, torque to 100–110 ft lb (135.6–149.1 N•m).

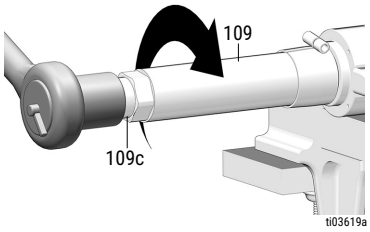


Figure 15-27: Tighten Seal Retainer

16. Reinstall the inlet pump tube assembly, connect the shovel rod (112), located inside of the inlet pump cylinder (113), and attach to the connecting rod (107) using a 3/4 in. socket and tighten. Torque to 50–60 ft-lb (67.8–81.3 N•m).

NOTE:

Remove any grease on the internal threads of the inlet cylinder before reinstallation to ensure correct threading.

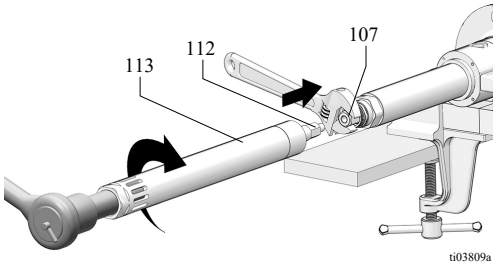


Figure 15-28: Inlet Pump Cylinder Reinstallation

17. Remove the pump from the vise.

REINSTALL THE MOTOR

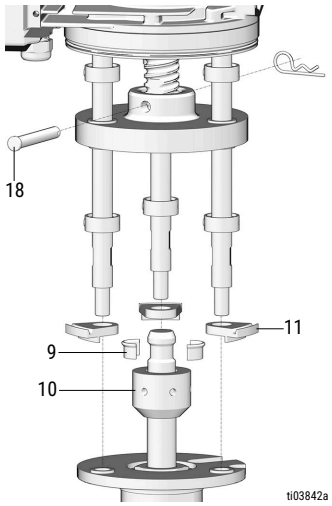


Figure 15-29: Reinstall Motor

1. Reinstall the pump lower in grease container.
2. Reinstall the fluid hose.
3. Reinstall the coupling (10) and collars (9)
4. Remove clevis pin (18) from the motor assembly.
5. Reinstall the shroud supports (11) and motor assembly.

NOTE:

Turn the ball screw of the motor by hand to match the height of the displacement rod (101).

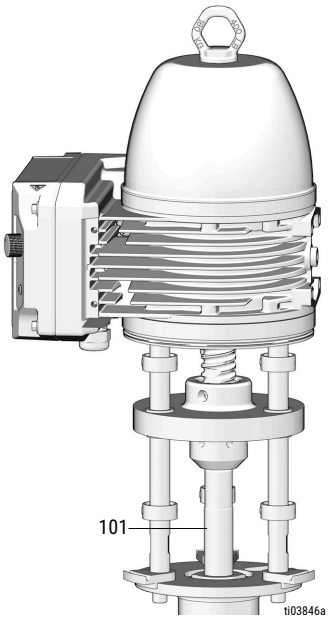


Figure 15-30: Motor Height Adjustment

6. Reinstall the tie rod nuts (12) and torque to 50 ft-lb (67.79 N•m).

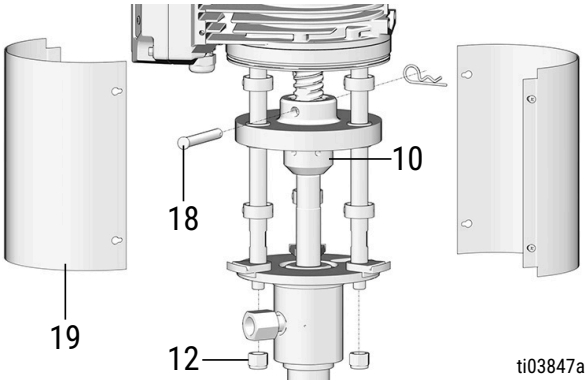


Figure 15-31: Motor Final Reinstallation

7. Reinstall the clevis pin (18).
8. Tighten the coupling (10) with a spanner wrench.
9. Reinstall the pump shrouds (19).

REPLACE THE CONTROL COVER

Follow these procedures to remove and replace the control cover.

SUPPLIES

- 10 mm socket wrench

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

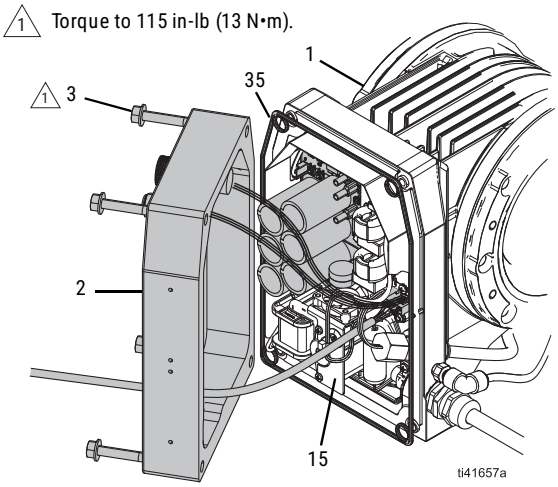


Figure 15-32: Control Cover

REMOVE THE CONTROL COVER

1. Follow **Prepare Equipment for Repair, page 26**.
2. Remove the fasteners (3) from the control cover (2).
3. Carefully remove the control cover (2):
   a. Carefully tilt the control cover (2) away from the control board (15).
   b. Disconnect all wires from the control cover (2) to the control board (15). See **Motor Electrical Schematics, page 14**.

> **NOTICE**
>
> Disconnect all wires before completely removing the control cover. To avoid damage to wires and connections, hold the cover in place at a tilted angle or rest the cover on a work surface while disconnecting wires.

   c. Remove the control cover (2) from the stator housing (1).
4. Inspect for wear or damage. Replace as needed.

INSTALL THE CONTROL COVER

1. Verify that power to the equipment is disconnected.
2. Install the gasket (35) into the groove on the stator housing (1).

> **NOTICE**
>
> To avoid damage to the control board, ensure that the gasket (35) is fully seated in the groove and that the control cover (2) is fully pressed to the stator housing (1).

3. Install the control cover (2):
   a. Carefully hold the control cover (2) in place at an angle near the control board (15).
   b. If a thermal pad is included, verify that it is attached to the cover. If it has fallen off, place it on top of the capacitors before replacing the cover.
   c. Connect wires from the control cover (2) to the control board (15).

> **NOTICE**
>
> To avoid damage to wires, connections, control board, or motor, ensure all wires are connected to the correct location. See **Motor Electrical Schematics, page 14**.

   d. Align the control cover (2) to the stator housing (1).
   e. Insert the fasteners (3) into the control cover (2) and tighten. Torque fasteners to 115 in-lb (13 N•m).

> **NOTICE**
>
> To avoid damage to wires or the control board, do not pinch wires when installing the control cover (2) to the stator housing (1).

4. Verify that the control cover (2) contacts the stator housing (1) and the gasket (35) does not show.

REPLACE THE POWER CORD/CABLE

Follow these procedures to remove and install the power cord/cable.

Repair kits are available (purchase separately).

SUPPLIES

- 1-5/16 in. open-end wrench
- P2 (0.8 mm) Phillips screwdriver

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

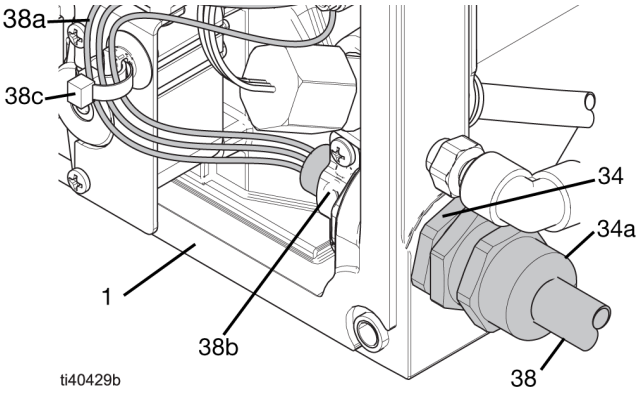


Figure 15-33: Power Cord/Cable

REMOVE THE POWER CORD/CABLE

1. Follow **Prepare Equipment for Repair, page 26**.
2. Follow **Remove the Control Cover, page 34**.
3. Disconnect the power cord/cable wires (38a) from the control board (15).

   NOTE:

   Take note of the orientation of the cord/cable clamp (38b) for installation.

4. Remove the power cord/cable (38) from the cord/cable tie (38c).
5. Loosen the outer strain relief bushing (34a). Do not remove.
6. Remove the cord/cable clamp (38b).
7. Gently pull the power cord/cable (38) and wires out of the stator housing (1).
8. Inspect for wear or damage. Replace as needed. If replacing, remove the ferrite and reinstall on the replacement cord/cable.

INSTALL THE POWER CORD/CABLE

1. Verify that the power cord/cable is not connected to a power source.
2. Reinstall the ferrite that you removed from the power cord/cable that you are replacing.
3. Insert the power cord/cable (38) and wires (38a) through the strain relief bushings (34a, 34) and stator housing (1).
4. Install a cord/cable tie (38c, not supplied).
5. Secure the power cord/cable (38) with the cord/cable tie (38c).
6. Connect power cord/cable wires (38a) to the control board (15). See **Motor Electrical Schematics, page 14**.

   NOTICE

   To avoid damage to wires or control board, do not strain or kink power cord/cable wires.

7. Tighten the outer strain relief bushing (34a). Securely tighten.
8. Install the cord/cable clamp (38b). Securely tighten the fasteners on the cord/cable clamp (38b).

   NOTE:

   Orient the cord/cable clamp (38b) as originally installed on your equipment model.

9. Follow **Install the Control Cover, page 34**.

REPLACE THE FAN ASSEMBLY

Follow these procedures to remove and install the fan assembly.

Repair kits are available (purchase separately).

SUPPLIES

- 10 mm socket wrench
- P2 (0.8 mm) Phillips screwdriver
- Thermal paste
- Screw extractor
- Fan press tool*

  * Available in kits (purchase separately).

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

To avoid injury, keep clear of moving parts.

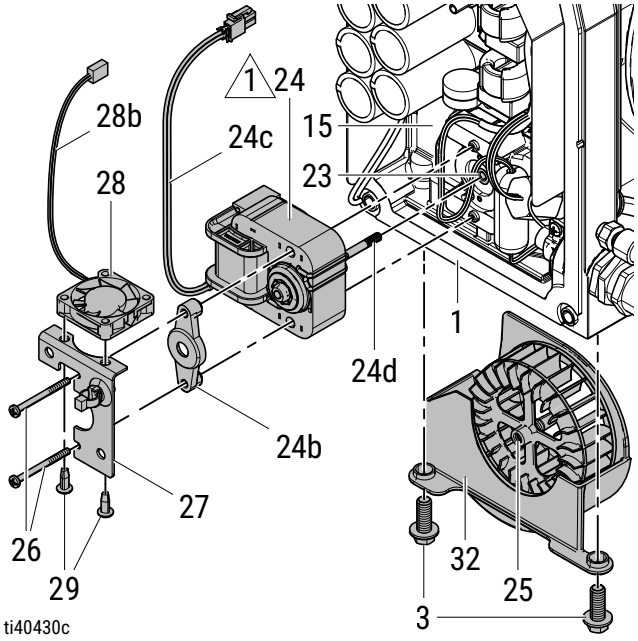


Figure 15-34: Fan Assembly

REMOVE THE FAN ASSEMBLY

1. Follow **Prepare Equipment for Repair, page 26**.
2. Remove the fasteners (3) from the fan guard (32).
3. Remove the fan guard (32) from the stator housing (1).
4. Remove the fan propeller (25) from the motor shaft (24d).
5. Follow **Remove the Control Cover, page 34**.
6. Disconnect the fan cable (28b) and motor cable (24c) from the control board (15).
7. Remove the fasteners (26) from the fan motor (24) assembly.
8. Remove the fan motor (24) assembly from the stator housing (1).
9. Disassemble the fasteners (29), fan (28), mounts (27, 24b), and fan motor (24).
10. Inspect for wear or damage. Replace as needed.

NOTE:

Carefully inspect the motor bearing (23) for wear or damage. Only remove the motor bearing (23) if replacing. If applicable, use a screw extractor to remove the motor bearing (23).

INSTALL THE FAN ASSEMBLY

1. Verify that power to the equipment is disconnected.
2. Use the fan press tool to install the fan propeller (25) and fan motor (24):
   a. Separate the press bushing (AA) from the fan holster (BB) on the fan press tool.

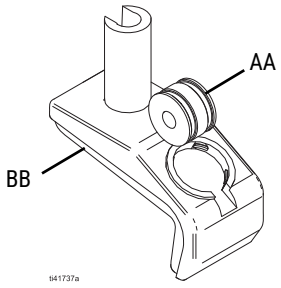


Figure 15-35: Fan Press Tool

   b. If the motor bearing (23) was removed: Insert the press bushing (AA) into the motor bearing. Lightly tap on the press bushing (AA) to install the motor bearing (23).

NOTE:

The motor bearing (23) will sit slightly raised from the surface of the stator housing (1).

NOTICE

To avoid damage to the motor bearing (23), do not use excessive force when tapping in the motor bearing (23). If needed, use a rubber mallet to tap on the press bushing (AA).

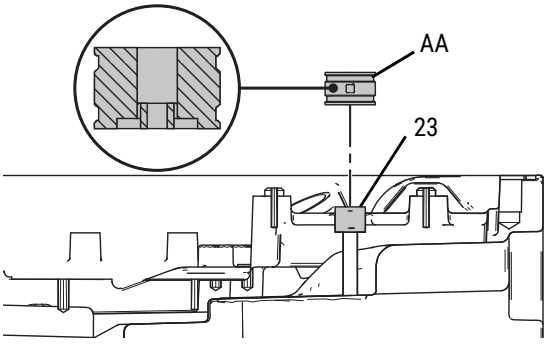


Figure 15-36: Press Bushing on Motor Bearing

   c. Insert the fan propeller (25) into the holster (BB).
   d. Insert the fan propeller (25) with holster (BB) into the stator housing (1). Ensure the hole for the fan motor shaft (24d) aligns with the center of the fan propeller (25).
   e. Apply thermal paste to the contact surface between the fan motor (24) and stator housing (1).
   f. Insert the fan rotor (24d) into position on the stator housing (1).

NOTICE

To avoid damage to wires, do not pinch wires when installing the fan motor assembly.

   g. Insert the press bushing (AA) onto the fan motor shaft (24d).
   h. Lightly tap the press bushing (AA) to connect the fan motor shaft (24d) to the fan propeller (25).

NOTICE

To avoid damage to the fan assembly, do not use excessive force when tapping on the motor shaft (24d). If needed, use a rubber mallet to tap on the press bushing (AA).

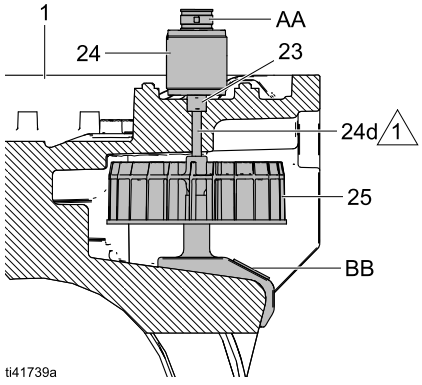


Figure 15-37: Fan and Motor Assembly with Fan Press Tool

1 Ensure that the fan motor shaft (24d) is completely pressed in to the fan propeller (25). Ensure that only the smooth part of the shaft is visible.

   i. Remove the fan press bushing (AA) and fan holster (BB).

3. Assemble the fan assembly (28), fasteners (29), and mounts (24a, 24b).
4. Apply thread sealant to fasteners (26).
5. Hold the fan (28) assembly in place and install the fasteners (26) through the fan assembly. Torque fasteners (26) to 20 in-lb (2.3 N•m).
6. Connect the fan cable (28b) and fan motor cable (24c) to the control board (15). See **Motor Electrical Schematics, page 14**.

NOTICE

To avoid damage to wires, do not pinch wires. Use the tie provided to hold wires in place and tucked away from pinch points.

7. Install the fan guard (32) around the fan propeller (25).
8. Install the fasteners (3) into the fan guard (32). Securely tighten.
9. Spin the fan propeller (25) by hand to ensure the propeller can fully and easily turn.
10. Follow **Install the Control Cover, page 34**.

REPLACE THE CONTROL KNOB ASSEMBLY

Follow these procedures to remove and install the control knob assembly.

Repair kits are available (purchase separately).

SUPPLIES

- 2 mm hex key
- 13 mm open-end wrench
- P2 (0.8 mm) Phillips screwdriver

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

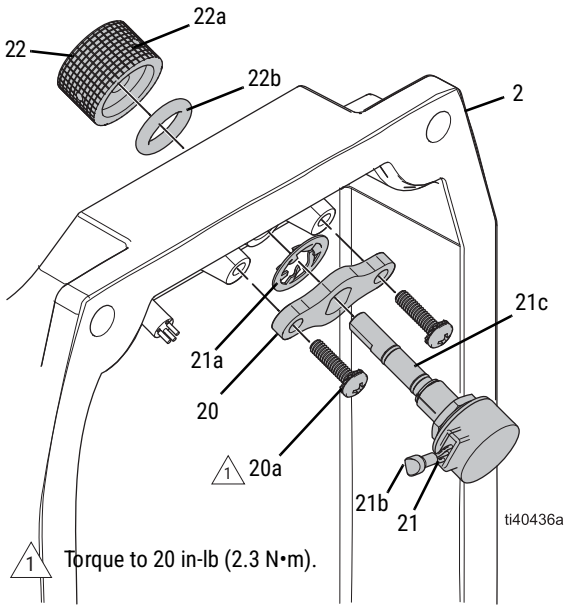


Figure 15-38: Control Knob Assembly

REMOVE THE CONTROL KNOB ASSEMBLY

1. Follow **Prepare Equipment for Repair, page 26**.
2. Follow **Remove the Control Cover, page 34**.
3. Loosen the control knob fasteners (22a). Remove the control knob (22) and seal (22b).
4. On the back of the control cover (2), remove the fasteners (20a) on the control knob mounting bracket (20).
5. Remove the encoder (21) assembly from the control cover (2).
6. Loosen the push-nut (21a) on the encoder (21) assembly. Remove the control knob mounting bracket (20).
7. Inspect for wear or damage. Replace as needed.

INSTALL THE CONTROL KNOB ASSEMBLY

1. Verify that power to the equipment is disconnected.
2. Prepare the new encoder (21) by verifying that only one nut is installed on the thread of the encoder, and that the nut is screwed down, making contact with the encoder body. If a second nut is present, discard it.
3. Insert the encoder (21) into the control knob mounting bracket (20).
4. Install the push-nut (21a) onto the encoder (21), making contact with the mounting bracket (20).
5. Apply anti-sieze lubricant to the shaft of the encoder (21).
6. Insert the encoder (21) assembly into the control knob hole on the control cover (2).

NOTE:

Ensure that the encoder wire (21b) is correctly oriented to easily connect the wire to the control board.

7. Insert the fasteners (20a) through the control knob mounting bracket (20).
8. Torque the fasteners (20a) to 20 in-lb (2.3 N•m).
9. Install the seal (22b) on the control knob (22).
10. Install the control knob (22) onto the shaft (21c) on the control cover (2). Ensure the mark on the control knob is aligned with the off (0) position on the control label (40).
11. Securely tighten the control knob fasteners (22a). Ensure the control knob (22) turns properly.
12. Follow **Install the Control Cover, page 34**.

REPLACE THE CONTROL BOARD AND FILTER BOARD ASSEMBLY

Follow these procedures to remove and install the control board and filter board assembly.

Repair kits are available (purchase separately).

SUPPLIES

- P2 (0.8 mm) Phillips screwdriver
- Thermal paste

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

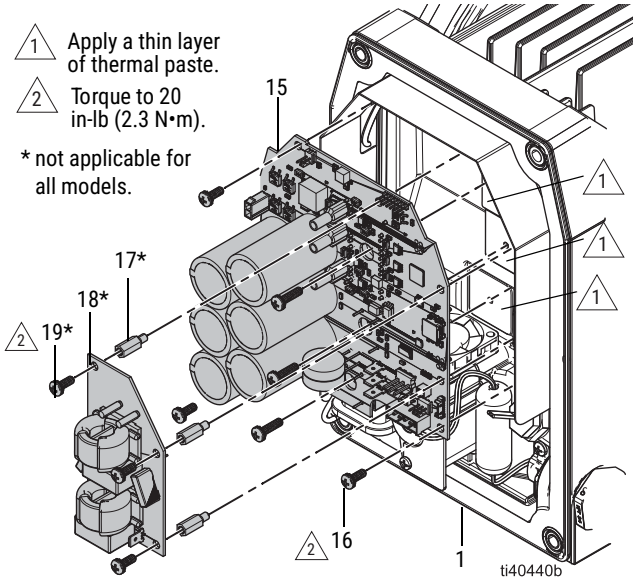


Figure 15-39: Control Board and Filter Board

REMOVE THE CONTROL BOARD AND FILTER BOARD ASSEMBLY

1. Follow **Prepare Equipment for Repair, page 26**.
2. Follow **Remove the Control Cover, page 34**.
3. Disconnect all wires to the control board (15) and filter board (18, if applicable).

> ***NOTICE***
>
> To avoid damage to wires, connections, or control board, disconnect all wires before removing the control board.

4. If applicable, remove fasteners (19), filter board (18), and spacers (17).
5. Remove the control board fasteners (16).
6. Carefully grip the edges of the control board (15) and gently remove the control board from the stator housing (1).

> ***NOTICE***
>
> To avoid damage to the control board, do not pull by components on the control board. Instead, remove the control board by gripping the edges of the control board base.

7. Inspect for wear or damage. Replace as needed.

INSTALL THE CONTROL BOARD AND FILTER BOARD ASSEMBLY

> ***NOTICE***
>
> To avoid damage to the circuit board, ensure the proper number of thermal pads are used. See **Control Board Kits.**

1. Verify that power to the equipment is disconnected.
2. If needed, apply a thin layer of thermal paste where indicated  in **Replace the Control Board and Filter Board Assembly, page 39**.
3. Hold wires away from the stator housing (1) and insert the control board (15) into the stator housing.
4. Hold the control board (15) in place. At the same time, install the control board fasteners (16). Torque to 20 in-lb (2.3 N•m).
5. If applicable, install spacers (17), filter board (18), and fasteners (19). Securely tighten the fasteners (19).
6. If applicable, connect the filter board (18) power brown cable to L1 and blue cable to L2 on the control board. See **Motor Electrical Schematics, page 14**.
7. Connect all wires to the control board (15) and filter board (18, if applicable).
8. Follow **Install the Control Cover, page 34**.
9. Follow **Recalibrate the Motor, page 48**.

REPLACE THE MOTOR SENSOR BOARD

Follow these procedures to remove and install the motor sensor board.

Repair kits are available (purchase separately).

SUPPLIES

- 4 mm hex key wrench
- T15 Torx screwdriver
- 3 mm hex key wrench
- Dielectric grease

⚠ WARNING

To avoid injury from electric shock, all electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.

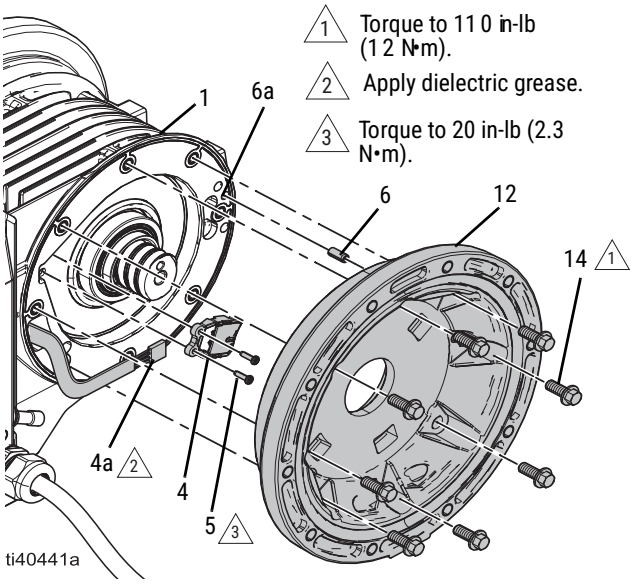


Figure 15-40: Motor Sensor

REMOVE THE MOTOR SENSOR BOARD

1. Follow **Prepare Equipment for Repair, page 26**.
2. Remove the fasteners (14) from the sensor-side stator cap (12).
3. Carefully remove the sensor-side stator cap (12) from the stator housing (1).

NOTICE

To avoid damage to the motor sensor or wires, gently remove the sensor-side stator cap (12). Do not jolt the sensor-side stator cap when removing.

4. Disconnect the motor sensor cable (4a) from the motor sensor (4).
5. Remove the fasteners (5) from the motor sensor (4).
6. Remove the motor sensor (4) from the stator housing (1).
7. Inspect for wear or damage. Replace as needed.

INSTALL THE MOTOR SENSOR BOARD

1. Verify that power to the equipment is disconnected.
2. Ensure all surfaces are clean.
3. Apply dielectric grease to the connector on the motor sensor cable (4a).
4. Connect the motor sensor cable (4a) to the motor sensor (4).
5. Align the motor sensor (4) on the stator housing (1), then push the sensor until it clicks into place. Install the fasteners (5) into the motor sensor (4). Torque the fasteners (5) to 20 in-lb (2.3 N•m).
6. Carefully install the sensor-side stator cap (12):
   a. Align the pin (6) in the stator cap (12) with the pin hole (6a) on the stator housing (1) and gently insert the stator cap (12). Ensure the stator cap is properly set in place.

NOTICE

To avoid damage to the motor sensor or wires, gently insert the sensor-side stator cap (12) into place. Do not jolt the sensor-side stator cap when installing.

   b. Install the fasteners (14) into the sensor-side stator cap (12). Torque to 110 in-lb (12 N•m). See **Torque Instructions, page 29**.
7. Follow **Recalibrate the Motor, page 48**.

REPAIR THE CENTER SECTION

Follow these procedures to disassemble and reassemble the center section.

Repair kits are available (purchase separately).

SUPPLIES

- 4 mm hex key wrench

⚠ WARNING

To avoid injury, keep clear of moving and rotating parts.

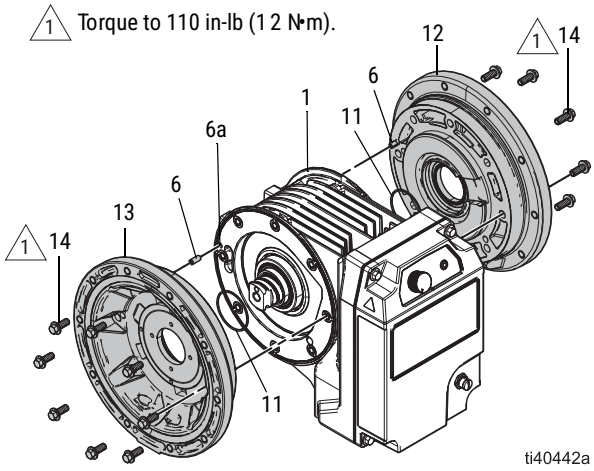


Figure 15-41: Center Section, Load-side

DISASSEMBLE THE CENTER SECTION

1. Follow **Prepare Equipment for Repair, page 26**.
2. Follow **Remove the Rotor, page 44**.
3. Remove the fasteners (14) from the stator caps (12, 13).
4. Remove the stator caps (12, 13).

NOTICE

To avoid damage to the motor sensor or wires, gently remove the sensor-side stator cap (12). Do not jolt the sensor-side stator cap when removing.

5. Remove the seals (11, 47) from the stator caps (12, 13). When you remove the seal (47), you will also remove the hub (8).
6. Inspect for wear or damage. Replace as needed.

REASSEMBLE THE CENTER SECTION

1. Verify that power to the equipment is disconnected.
2. Carefully install the sensor-side stator cap (12):
   a. Install the seal (11) in the stator cap (12).
   b. Align the pin (6) in the stator cap (12) with the pin hole (6a) on the stator housing (1) and gently insert the stator cap (12). Ensure the stator cap is properly set in place. See **Install the Motor Sensor Board, page 41**.

NOTICE

To avoid damage to the motor sensor or wires, gently insert the sensor-side stator cap (12) into place. Do not jolt the sensor-side stator cap when installing.

   c. Install the fasteners (14) into the sensor-side stator cap (12). Torque to 110 in-lb (12 N•m). See **Torque Instructions, page 29**.
3. Follow **Install the Rotor, page 45**.

REPAIR THE ROTOR AND SHAFT ASSEMBLY

Follow these procedures to repair the rotor and shaft assembly.

SUPPLIES

- Preload nut installation tools*
- Rotor greasing tool*
- 1 in. (25 mm) open-end wrench
- 1/2 in. square drive socket wrench extension

* Kits are available (purchase separately).

⚠ WARNING

To avoid injury, keep clear of moving and rotating parts.

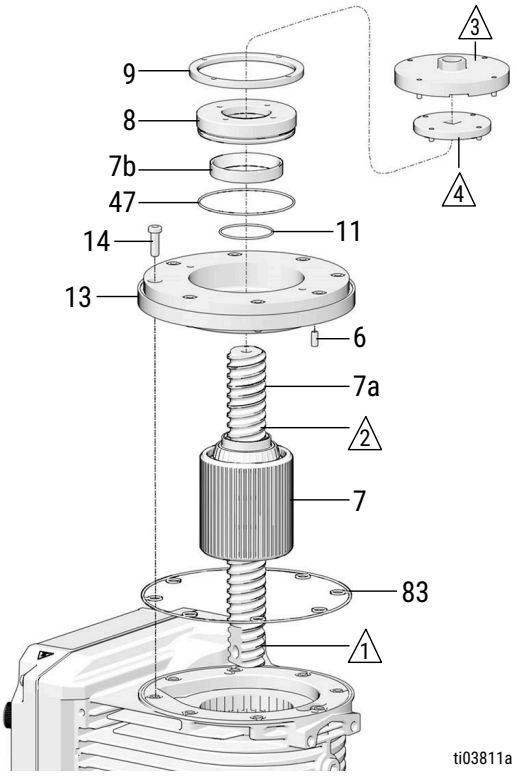


Figure 15-42: Rotor and Shaft Assembly, Load Side

Table 15-1: Rotor and Shaft Assembly Notes

1. Face shaft flat toward the sensor-side stator cap (12).
2. Do not remove the shaft (7a) from the rotor (7).
3. Preload Nut Installation Tool, included in kit 25V370.
4. Preload Nut Installation Tool, included in kit 25V370.

REMOVE THE ROTOR

1. Follow **Prepare Equipment for Repair, page 26**.
2. Use the preload nut installation tools and an applicable wrench to remove the preload nut (9) and hub (8) from the load-side stator cap (13).
3. Remove the load-side stator cap (13).

> ***NOTICE***
>
> To avoid damage to the motor sensor, do not remove components from the side with sensor-side stator cap (12). Only remove components from the side with the load-side stator cap (13).

4. On the sensor-side, turn the shaft (7a) until it protrudes from the load-side stator cap (12).

> ***NOTICE***
>
> To avoid damage to the rotor or equipment, do not remove the shaft (7a) from the rotor (7). Removing the shaft will cause the rotor balls to dislodge from the rotor and the rotor will not function properly.

5. Use an applicable wrench to firmly hold the flat of the shaft (7a) in place. Ensure that the rotor and shaft assembly (7, 7a) does not rotate. At the same time, on the sensor-side, carefully tap the shaft to disengage the rotor and shaft assembly (7, 7a) from the stator housing (1). Tap until the rotor and shaft assembly emerge from the load-side stator cap (13).

> ***NOTICE***
>
> To avoid damage to the shaft or rotor, do not use excessive force when tapping out the rotor and shaft assembly (7, 7a). If needed, use a rubber mallet to disengage the rotor and shaft assembly.

6. Remove the rotor and shaft assembly (7, 7a) from the stator housing (1).
7. Remove the seals (11) from the stator caps (12, 13).

> **NOTE:**
>
> Do not remove the shaft (7a) from the rotor (7).

> ***NOTICE***
>
> To avoid damage to the rotor or equipment, do not remove the shaft (7a) from the rotor (7). Removing the shaft will cause the rotor balls to dislodge from the rotor and the rotor will not function properly. If the rotor balls dislodge, follow **Re-Ball the Rotor**.

8. Remove the seal (47) from the hub (8).
9. Inspect for wear or damage. Replace as needed.

INSTALL THE ROTOR

1. Verify that power to the equipment is disconnected.
2. Reach inside the stator housing (1) to install one seal (11) onto the stator cap (12).
3. Insert the rotor and shaft assembly (7, 7a) into the stator housing (1).

NOTE:

Grease the tapered rotor bearings before inserting into the stator housing.

NOTE:

Ensure the flat of the shaft (7a) faces toward the sensor-side stator cap (13).

NOTE:

The outer-ring lip of the rotor (7) will sit slightly raised from the stator housing (1).

4. Install the seal (47) on the hub (8).
5. Assemble the other seal (11) to the hub (8).
6. Install the preload nut and hub (9, 8) on the load-side cap (13):
   a. Apply anti-sieze to the threads of the hub (8).
   b. Thread the preload hub (8) onto the load-side stator cap (13). Ensure the lips of the preload hub (8) face toward the center of the rotor (7).
   c. Spin the hub (8) until the seal (47) touches the bore of the cap (13).
   d. Install the load-side stator cap (13) onto the stator housing (1). First, install the seal (11) in the stator cap (13). See **Reassemble the Center Section, page 42**.
   e. Align the pin (6) in the stator cap (13) with the pin hole (6a) on the stator housing (1) and gently insert the stator cap (13). Ensure the stator cap is properly set in place. See **Reassemble the Center Section, page 42**.
   f. Install the fasteners (14) into the stator cap (13). Torque to 110 in-lb (12N•m). See **Torque Instructions, page 29**.
   g. Insert the preload hub installation tool into the preload hub (8).
   h. Use an applicable wrench on the preload hub installation tool to torque the preload hub (8) to 20 ft-lb (27 N•m).
   i. Remove the preload hub installation tool, and temporarily install an M12 washer and an M12 bolt into the rotor.

NOTE:

Washer and bolt are provided in Rotor Replacement kits. If re-using the existing rotor, use a washer with outside diameter 45mm (1.75 inches).

   j. Use an applicable wrench on the M12 bolt to manually spin the rotor at least ten revolutions to ensure the bearings have been seated correctly, and that the rotor spins within the stator.
   k. Remove the temporary M12 washer and M12 bolt from the rotor. Discard or keep for future rotor installations.
   l. Loosen the preload hub (8) by one quarter rotation, then re-torque to 10 ft-lb (13 N•m).

NOTE:

To ensure the rotor can properly spin, be careful to not overtighten the preload hub (8).

   m. Using a marker, mark the location of the hub (8) relative to the stator cap (13).

NOTICE

To avoid equipment damage, do not overtighten the preload hub (8).

   n. Install the preload nut (9).
   o. Use an applicable wrench on the preload nut installation tool to torque the nut (9) to 50 ft-lb (68 N•m).

NOTE:

Use an applicable wrench to hold the hub (8) in place. Ensure that the hub (8) does not rotate while torquing the nut (9).

NOTICE

To avoid equipment damage, ensure that the hub (8) does not rotate while torquing the nut (9).

p. Remove the preload nut installation tool.

q. Verify that the hub (8) did not rotate from the marked location relative to the stator cap (13).

7. Lubricate the rotor (7) and shaft (7a). See **Lubricate the Rotor and Shaft**.

NOTICE

To avoid equipment damage, liberally apply grease on the shaft (7a).

8. Follow **Recalibrate the Motor**.

RE-BALL THE ROTOR

NOTICE

If the shaft (7a) was removed from the rotor (7), the rotor balls will fall out from the rotor and the rotor will not function properly. To avoid damage to the equipment, re-ball the rotor.

1. Follow **Remove the Rotor, page 44**. If the rotor has already been removed, go to the next step.
2. Prepare a container to catch the loose rotor balls.
3. Rotate the shaft (7a) out of the sensor side of the rotor assembly (7) (the opposite end from the wrench flat) to remove the rotor balls as they fall out of the rotor ball inlet.

   NOTE: Ensure that all rotor balls are removed from the shaft and rotor assembly (7, 7a). Check inside the rotor (7) and shaft for any remaining rotor balls.
4. Clean the grease from the shaft (7a) and the rotor assembly (7).
5. Thread rotor assembly (7) onto the shaft (7a) until the thread lead-in is level with the rotor ball inlet.

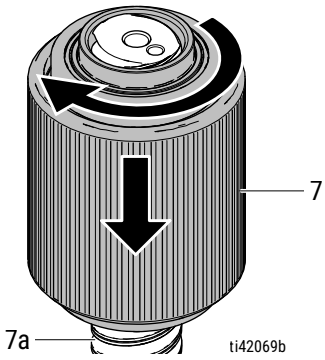


Figure 15-43: Assemble the Shaft into the Rotor

6. Hold the assembled rotor and shaft about 30° up from horizontal, with the ball inlet at the lowest point.

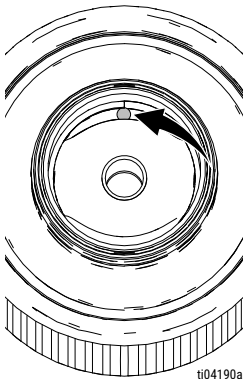


Figure 15-44: Hold the Rotor to Receive the Balls

7. Carefully drop the rotor balls one-by-one into the inlet inside the rotor (7).
8. Rotate the rotor (7) up and down the shaft (7a) to set the rotor balls into the shaft threads.
9. Follow **Install the Rotor, page 45**.

LUBRICATE THE ROTOR AND SHAFT

Use the rotor greasing tool to liberally apply grease to the rotor (7) and shaft (7a).

SUPPLIES

- Rotor greasing tool*
- Lubriplate Synxtreme HD-2 grease or equivalent NLGI Grade 2 synthetic grease with calcium sulfonate base

  * Kits are available (purchase separately).

1. Follow **Prepare Equipment for Repair, page 26**.
2. On the sensor side, use an applicable wrench to firmly hold the flat of the shaft (7a) in place. Ensure that the rotor and shaft assembly (7, 7a) does not rotate. At the same time, on the load side, thread the rotor greasing tool (7c) into the shaft (7a) until fully joined.

   NOTICE

   To avoid equipment damage, do not rotate the shaft (7a) while threading the rotor greasing tool (7c) into the shaft. Only turn the rotor greasing tool (7c).

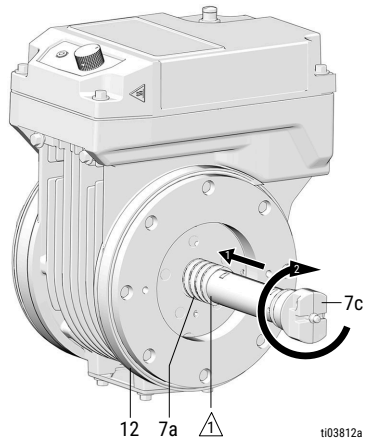


Figure 15-45: Insert Rotor Greasing Tool

3. Turn the rotor greasing tool into the center of the rotor (7) until the shaft (7a) fully protrudes from the load-side stator cap (13).

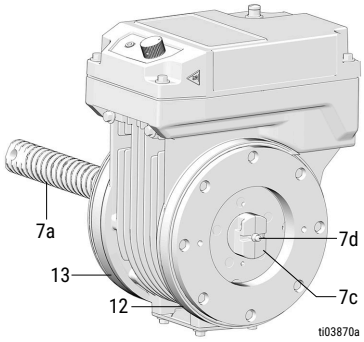


Figure 15-46: Rotor Greasing Tool Inserted

4. Clean and inspect the shaft (7a) for wear or damage. Replace as needed.
5. Use the grease port (7d) on the rotor greasing tool (7c) to fill the shaft area with clean grease. Fill until clean grease emerges from the edges of the rotor greasing tool (7c).

   NOTICE

   To avoid equipment damage, liberally apply grease on the shaft (7a).

6. Turn the shaft (7a) to reinsert the shaft into the rotor (7). Turn until the rotor greasing tool (7c) fully emerges from the load-side stator cap (12).

   NOTE:

   Do not disconnect the shaft from the rotor greasing tool when reinserting the shaft into the rotor. Do not use the rotor greasing tool to turn the shaft into the rotor. Only turn the shaft (7a).

   NOTICE

   To avoid equipment damage, do not rotate the rotor greasing tool (7c) to reinsert the shaft into the rotor. Only turn the shaft (7a).

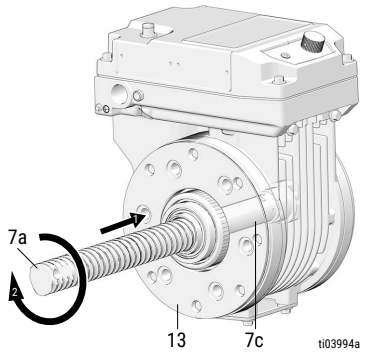


Figure 15-47: Remove Rotor Greasing Tool

7. Use an applicable wrench to firmly hold the flat of the shaft (7a) in place. At the same time, disconnect the rotor greasing tool from the shaft (7a).
8. Clean the internal threads on the shaft (7a) to remove excess grease.

   Ensure the meeting point is fully joined (no gap).

RECALIBRATE THE MOTOR

Follow this procedure to recalibrate the motor.

Recalibrate the motor after installing a new control board, motor sensor, rotor, or re-torquing the preload hub and nut. Recalibrate after you reassemble the motor module but before you install the pump components.

1. Turn the control knob (22) fully counter-clockwise (off).
2. Power up the motor module.
3. Turn the control knob (22) clockwise (on) to approximately 50% or higher.

   The rotor (7) begins to spin. The LED (37) turns yellow.
4. Wait for approximately 20 revolutions (10 seconds).

   The rotor (7) momentarily stops. Then it slowly spins one revolution and stops. Then it reverses direction and slowly spins one revolution.

   - If the calibration was successful, the rotor (7) begins to spin and the LED (37) turns yellow.
   - If the calibration was unsuccessful, the rotor (7) stops spinning and the LED (37) flashes an error code (seven blinks). Ensure that the rotor is not being restricted during calibration and is free to spin, then repeat this procedure.
5. Turn the control knob (22) fully counter-clockwise (off), and remove power.
6. Finish reassembling the pump.

PUMP PARTS

An exploded-view parts diagram and parts list to identify and order replacement parts.

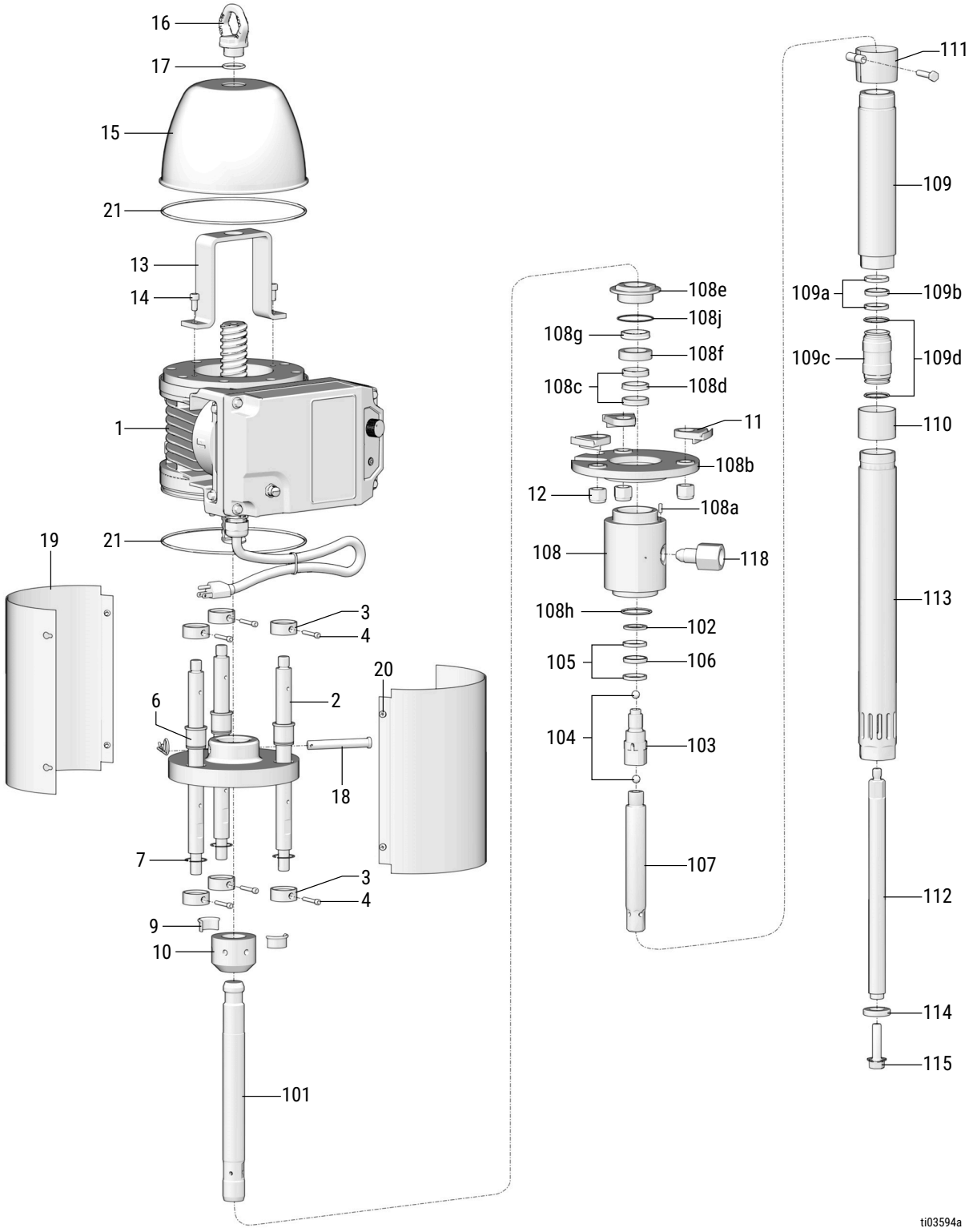


Figure 16-1: Parts Diagram for Dyna-Star Electric Grease Pump

Table 16-1: Parts List for Dyna-Star Electric Grease Pump

REF	ITEM	DESCRIPTION	QTY
1	2010688	MODULE, 120V	1
2	– – –	ROD, TIE, MOTOR	3
3	– – –	STOP, CARRIAGE	6
4	112756	SCREW, CAP, SOCKET HD	6
5	– – –	CARRIAGE, PUMP, ELECTRIC	1
6	– – –	BUSHING, CARRIAGE	3
7	– – –	RETAINER, RING	3
9	184130	COLLAR, COUPLING	2
10	626045	COUPLING	1
11#	– – –	SUPPORT, SHROUT	3
12#	102216	NUT, LOCK	3
13	– – –	BRACKET, LIFT RING	1
14	115264	SCREW, CAP	2
15	– – –	COVER, PUMP MOTOR	1
16	16A795	HOOK, MACHINED, MERKUR	1
17	111691	O-RING	1
18	133305	PIN, CLEVIS	1
19	– – –	SHROUD, PUMP	2
21	– – –	O-RING	2
101#	– – –	ROD, PISTON, MOTOR	1
102*#	– – –	WASHER, RETAINER	1
103†#	– – –	PISTON, PUMP	1
104†#	100114	BALL	2
105*#	– – –	RING, BACKUP, PISTON	2
106*#	– – –	SEAL, PISTON, ROD	1
107†#	– – –	ROD, CONNECTING	1
108‡#	– – –	HOUSING, OUTLET	1
108B#	– – –	ADAPTER, OUTLET	1
108C#	– – –	RING, BACKUP, THROAT	2
108D#	– – –	SEAL, THROAT	1
108E#	– – –	NUT, RETAINER	1
108F#	– – –	WASHER, NUT, SPACER	1
108G#	– – –	SEAL, ROD	1
108H#	– – –	O-RING	1
108J#	– – –	O-RING	1
109#	– – –	CYLINDER, PUMP	1
109A#	– – –	RING, BACKUP, LOWER	2
109B#	– – –	SEAL, PRIMING ROD	1
109C#	– – –	RETAINER, SEAL	1
109D#	– – –	O-RING	2
110#	26A953	SLEEVE, CYLINDER	1
111	222308	ADAPTER, BUNG	1
112#	– – –	ROD, SHOVEL	1
113#	– – –	CYLINDER, FOOT	1
114#	– – –	PISTON, SHOVEL	1
115#	– – –	SCREW, HEAD, WASHER	1
118#	– – –	FITTING, OUTLET	1
119♦	2010422	LABEL, SAFETY, WARNING, ENG	1

– – –	Not available separately or part number varies.
*	Included in Seal Kit 2009432.
†	Included in Fluid Piston Kit 25T855.
#	Included in Full Pump Lower Kit 2010555.
‡	Included in Outlet Housing Kit 2009507.
♦	Replacement safety labels are available at no cost.

MOTOR PARTS

An exploded-view parts diagram and parts list to identify and order replacement parts.

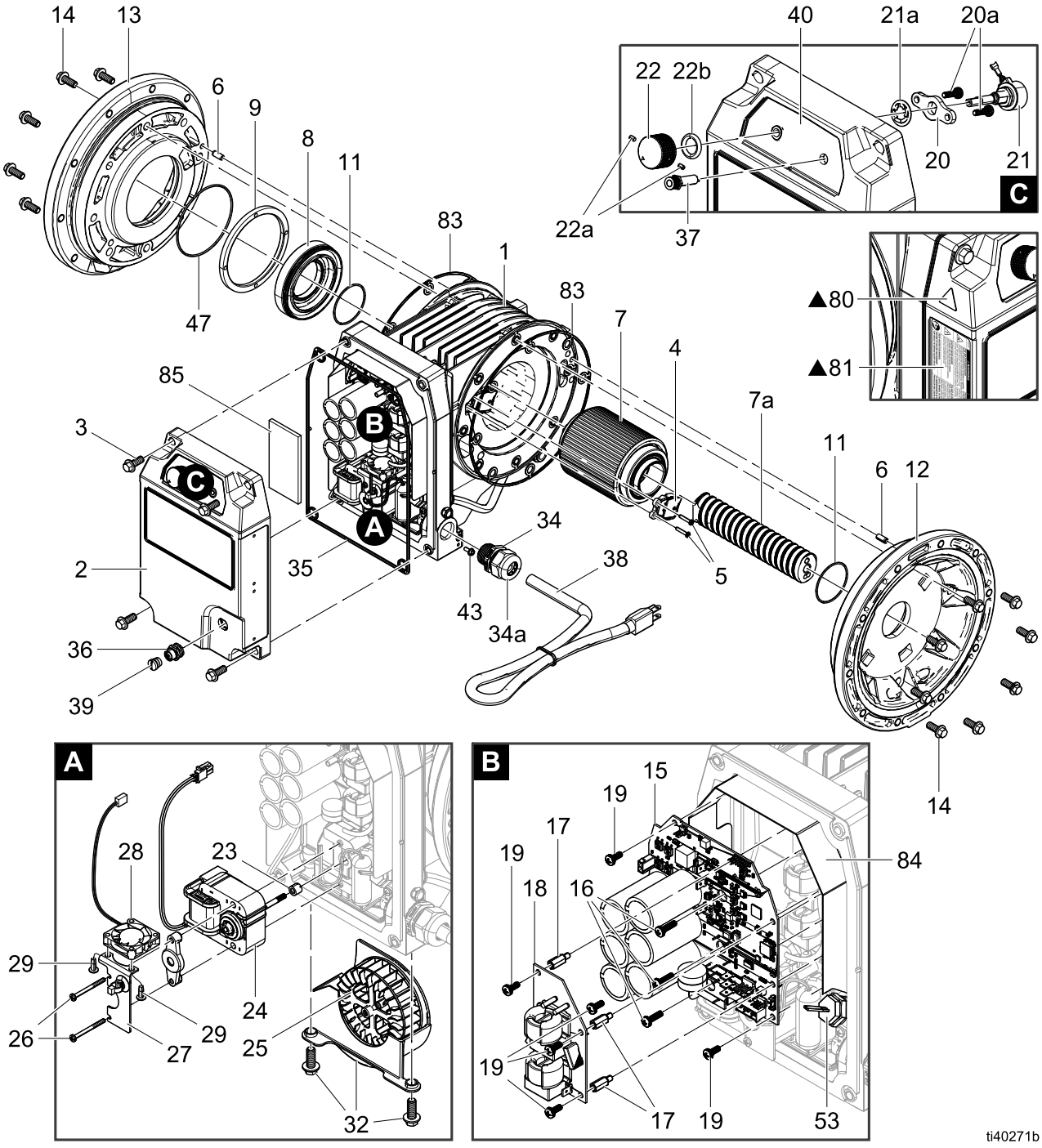


Figure 16-2: Electric Motor Module

Table 16-2: Parts List for Electric Motor

REF	ITEM	DESCRIPTION	QTY
1‡	– – –	STATOR	1
2	25V123	COVER, control	1
3	19C157	SCREW, hex washer, M8 x 20	4
	115643	SCREW, hex washer, M8 x 25	4
4‡	– – –	SENSOR, motor, assembly	1
5	18G070	FASTENER, self-tapping, 6-19 x 0.75 in. stainless steel	2
6	18A535	PIN, straight slotted spring, 1/4 in. x 9/16 in.	2
7‡	– – –	ROTOR, assembly	1
7a‡	– – –	SHAFT, ball screw	1
7b			
8	25V127	HUB, preload alignment (with bearing race)	1
9	25V128	NUT, preload	1
11‡	– – –	SEAL	2
12‡	– – –	CAP, stator, sensor-side (with bearing race)	1
13‡	– – –	CAP, stator, load-side	1
14	117379	SCREW, CAP, M8 x 25	16
15‡	– – –	BOARD, control assembly, motor drive	1
16	18A538	FASTENER, pan head, M8-32 x 9/16 in.	3
17	16G799	SPACER, standoff, M8-32 x 0.5 in.; FC2, FC4, FE2, FE4, FF2, FF4 models	3
18‡	– – –	BOARD, assembly, line filter; FC2, FC4, FE2, FE4, FF2, FF4, FC8, FC9, FCA, FE8, FE9, FEA, FF8, FF9, FFA models	1
19	19C206	FASTENER pan head, external tooth lock washer, M8-32 x 7/16 in.	6
20‡	– – –	BRACKET, control knob	1
20a‡	– – –	FASTENER, pan head, control knob bracket	2
21‡	– – –	ENCODER, control	1
21a‡	– – –	NUT, push	1
22‡	– – –	KNOB, control	1
22a‡	– – –	FASTENER, hex head	2
22b‡	– – –	SEAL, packing	1
23‡	– – –	BEARING, sleeve	1
24‡	– – –	MOTOR, fan	1
25‡	– – –	FAN, propeller	1
26	18F382	FASTENER, pan head, M6-32 x 1-1/2 in.	2
27	– – –	BRACKET, fan, 40 x 40 mm	1
28	2009029	FAN, DC, 40 x 40 x 10 mm; includes 27, 29 (Fx1, 2, 3, 4, 5, 6)	1
	2009030	FAN, DC, 40 x 40 x 10 mm; includes 27, 29 (Fx7, 8)	1
	2009031	FAN, DC, 40 x 40 x 10 mm; includes 27, 29 (Fx9, A)	1
29	– – –	SCREW	2
32	25V136	GUARD, fan, squirrel cage	1

REF	ITEM	DESCRIPTION	QTY
33	103778	PLUG, 1/2 in. npt(f); stainless steel	1
34	20A460	BUSHING, strain relief	1
34a	– – –	BUSHING, outer strain relief; *included with Ref. 34*	1
35	20B302	GASKET, control cover	1
36	19B637	CONNECTOR, I/O M12 cable assembly	1
37	19B939	HARNESS, wiring with light, LED indicator	1
38‡	– – –	CORD/CABLE, power	1
39	17C443	PLUG, screw, M12	1
40	19C095	LABEL, EODD control	1
41*	19B616	CLAMP, cable; *not shown*	1
41a*	112380	SCREW, *not shown*	2
43	111593	FASTENER, grounding	2
47‡	– – –	SEAL, packing	2
53	– – –	SENSOR, leak	1
54	– – –	BREATHER	1
55	– – –	FITTING, reducer	1
58	– – –	FITTING, elbow swivel, 1/4 in. NPT; 3/8 in. hose port	2
59	– – –	UNION, tee	1
60	– – –	HOSE, 3/8 in. outer diameter	1
80▲	15K616	LABEL, safety	1
81▲	20A345	LABEL, safety, warning	1
83‡	– – –	GASKET, stator	2
84	2000158	SHIELD, wire	1
85		PAD, thermal	

REF	ITEM	DESCRIPTION	QTY
	– – –	for models in North America	0
	– – –	for models in EU	2

– – – *Not available separately.*

* Part not shown in parts diagram.

‡ *See **Kits and Accessories***

▲ *Replacement safety labels, tags, and cards are available at no cost.*

KITS AND ACCESSORIES

Parts kits are available (purchase separately).

PART KITS

Table 16-3: Complete Rotor Repair Kit

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2011184	• 1 rotor (7) • 1 stator cap (12, 6) • 1 preload hub (8) • 2 rotor O-rings (11) • 1 hub O-ring • 4 seat O-rings • 1 anti-seize
A Complete Rotor Repair Kit is recommended when wear or damage exists on the rotor (7) and the outer bearing races located in the sensor-side stator cap (12) and preload hub (8). If a complete re-build is not required, individual Rotor Kits are available.		

Table 16-4: Stator Cap Kits

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2011185	• 1 sensor-side stator cap (12) • 1 load-side stator cap (13)

Table 16-5: Rotor Kits

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2011186	• 1 rotor (7) with bearing 1 shaft (7a) • 2 fasteners (for shipping only, discard) • 2 washers (for shipping only, discard)

Table 16-6: Cord/Cable Kits

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2010298	• 1 power cord/cable (38)

Table 16-7: Fan Kits

MODEL	KIT NO.	KITS INCLUDE
2009845	25F100	• 1 bearing sleeve (23) • 1 fan motor (24) • 1 fan propeller (25) • 1 cable tie • 1 fan press tool
2009845	25F101	• 1 fan propeller (25) • 1 fan press tool

Table 16-8: Control Knob Kits

MODEL	KIT NUMBER	KITS INCLUDE
2009845	25F102	• 1 control knob bracket (20) • 2 fasteners (20a) • 1 control encoder (21) • 1 push nut (21a) • 1 control knob (22) with 2 fasteners, hex head (22a) • 1 seal (22b) • 1 packet of anti-seize lubricant

Table 16-9: Motor Sensor Kits

MODEL	KIT NUMBER	KITS INCLUDE
2009845	25F120	• 1 motor sensor assembly (4)

Table 16-10: Motor Reseal Kit

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2006210	• 2 seal, FKM (11) • 2 O-ring, Buna-N (47) • 2 gasket, stator (83)

Table 16-11: Control Board Kit

MODEL	KIT NUMBER	KITS INCLUDE
2009845	2011187	• 1 board assembly • 1 tube thermal paste • 6 screws

ACCESSORY KITS

Accessory kits are available (purchase separately).

Table 16-12: Accessories List for Dyna-Star Electric Grease Pump

ITEM	DESCRIPTION
25U200	PLATE, follower, 400 lb
25U202	COVER, drum, 400 lb
129870	OUTLET ADAPTER, 1/2 NPT female x 9/16 MP male
2007333	KIT, flange mount

Table 16-13: Preload Nut Installation Tool Kits

KIT NUMBER	KITS INCLUDE
25V370	• Preload installation plates

Table 16-14: Rotor Greasing Tool Kits

KIT NUMBER	KITS INCLUDE
25V176	• 1 greaser cartridge • 1 packet of lubricant

Table 16-15: I/O Cable Kits

KIT NUMBER	KITS INCLUDE
25V080	• 1 gland, 3/4 in. NPT • 2 fasteners • 1 cable clamp • 1 cable • 1 ground fastener

Table 16-16: Maintenance Bracket Stand

ITEM	DESCRIPTION
18F978	STAND, maintenance bracket

CALIFORNIA PROPOSITION 65

CALIFORNIA RESIDENTS

⚠**WARNING** Cancer and reproductive harm — www.P65warnings.ca.gov.

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Graco warrants all equipment referenced in this document which is manufactured by Graco and bearing its name to be free from defects in material and workmanship on the date of sale to the original purchaser for use. With the exception of any special, extended, or limited warranty published by Graco, Graco will, for a period of twelve months from the date of sale, repair or replace any part of the equipment determined by Graco to be defective. This warranty applies only when the equipment is installed, operated and maintained in accordance with Graco's written recommendations.

This warranty does not cover, and Graco shall not be liable for general wear and tear, or any malfunction, damage or wear caused by faulty installation, misapplication, abrasion, corrosion, inadequate or improper maintenance, negligence, accident, tampering, or substitution of non-Graco component parts. Nor shall Graco be liable for malfunction, damage or wear caused by the incompatibility of Graco equipment with structures, accessories, equipment or materials not supplied by Graco, or the improper design, manufacture, installation, operation or maintenance of structures, accessories, equipment or materials not supplied by Graco.

This warranty is conditioned upon the prepaid return of the equipment claimed to be defective to an authorized Graco distributor for verification of the claimed defect. If the claimed defect is verified, Graco will repair or replace free of charge any defective parts. The equipment will be returned to the original purchaser transportation prepaid. If inspection of the equipment does not disclose any defect in material or workmanship, repairs will be made at a reasonable charge, which charges may include the costs of parts, labor, and transportation.

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