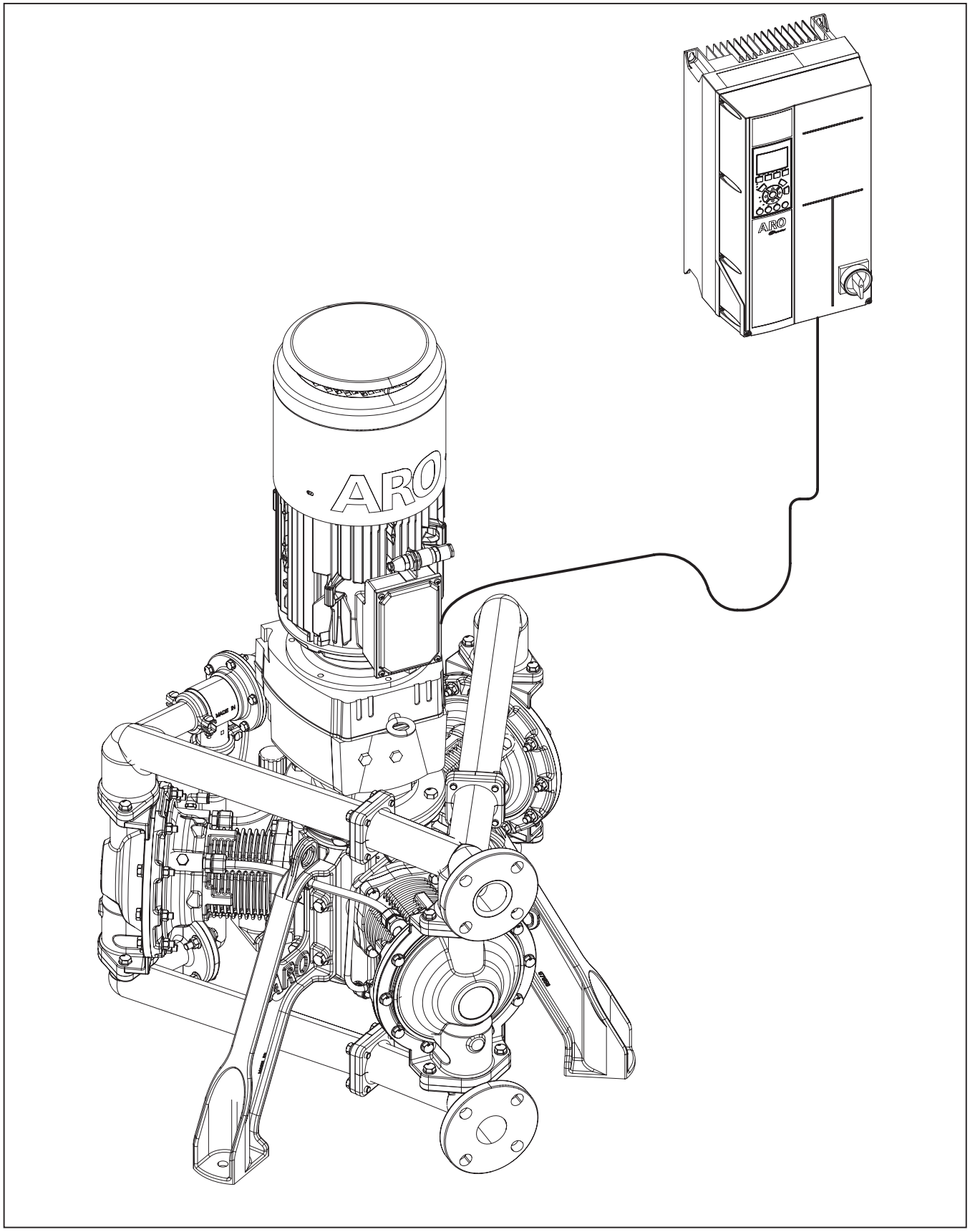
OPERATOR'S MANUAL EP20-XXXXX-XXX-XXX

INCLUDING: OPERATION, INSTALLATION AND MAINTENANCE

RELEASED: XX-XX-21
(REV: A)

2" ELECTRIC OPERATED POSITIVE DISPLACEMENT PUMP

1:1 RATIO (METALLIC)



INGERSOLL RAND COMPANY INC
209 NORTH MAIN STREET – BRYAN, OHIO 43506
✆ (800) 495-0276 • FAX (800) 892-6276

arozone.com

ARO Ingersoll Rand

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1. TECHNICAL SPECIFICATIONS

1.1. Pump Data

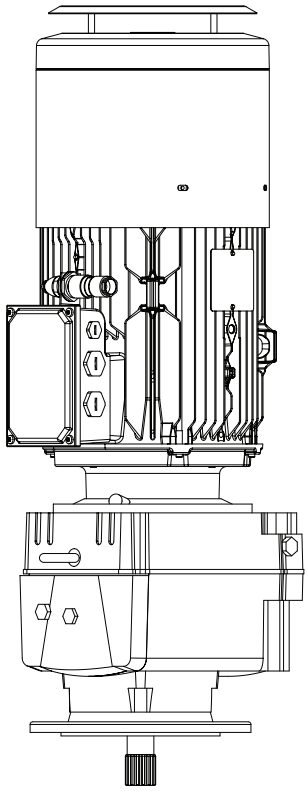
Models..... See Model Description Chart for "-XXXXX".
Pump Type.. Electric Operated Positive Displacement Pump (EOPD)
Material .... See Model Description Chart.
Weight (without motor)
EP20-CXX-XXXX-XXXX..... 539 lbs (245 kg)
EP20-AXX-XXXX-XXXX..... 448 lbs (203 kg)
EP20-SXX-XXXX-XXXX..... 584 lbs (265 kg)
Maximum Material Inlet Pressure ..... 10 psig (0.69 bar)
Maximum Outlet Pressure ..... 120 psig (8.3 bar)
Maximum Flow Rate (flooded inlet) .... 125 gpm (473 lpm)
Displacement / Cycle @ 100 psig .. 0.68 gal. (2.6 lit.)
Maximum Particle Size ..... 1/4" dia. (6.4 mm)
Wet Suction Lift..... 32 ft
Dry Suction Lift ..... 16 ft
Maximum Deadhead Pressure.... 180 psi (12.4 bar)

Maximum Temperature Limits (Diaphragm / Ball / Seat material)
E.P.R. / EPDM..... -60° to 280°F (-51° to 138°C)
Hytrel® ..... -20° to 180°F (-29° to 82°C)
Nitrile ..... 10° to 180°F (-12° to 82°C)
Polypropylene ..... 32° to 175°F (0° to 79°C)
Santoprene® ..... -40° to 225°F (-40° to 107°C)
PTFE..... 40° to 225°F (4° to 107°C)
Viton®..... -40° to 350°F (-40° to 177°C)
Dimensional Data..... see page 35
MountingDimension... 3 Equally placed ∅ 0.63" (∅ 16 mm) hole on ∅ 29.8" (∅ 758 mm) B.C.

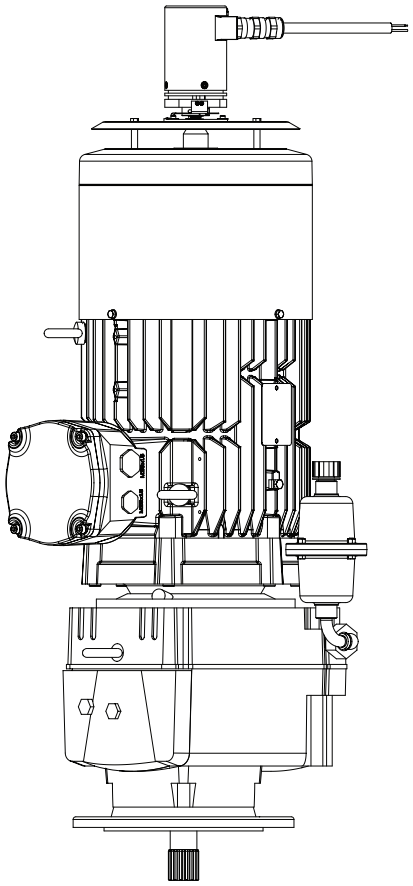
1.2. Variable Frequency Drive (VFD) Data

	Ordinary	Hazardous
Part Number	136Z7170	136Z7171
Power	7.5 kw	7.5 kw
Input Voltage	380-500 VAC +/-10%, 3 Phase, 50/60 Hz	380-500 VAC +/-10%, 3 Phase, 50/60 Hz
Frame Size	A5	A5
Ingress Protection	NEMA 4X / IP66	NEMA 4X / IP66
Option B Slot	MCB 102 ENCODER CARD	MCB 102 ENCODER CARD
Dual Option B With A-Slot Adapter MCF 107	N/A	MCB 112 PTC THERMISTER CARD
Efficiency	97%	97%
Approximate Weight	14.3 kg	14.3 kg
Operating Temperature (Full Scale)	0º to 45ºC	0º to 45ºC
Operating Temperature (Derate)	-10º to 50ºC	-10º to 50ºC
Max Altitude (Without Derating)	1000 M	1000 M
Max Altitude (With Derating)	3000 M	3000 M
Continuous Output Current (380-440 V)	16 A	16 A
Intermittent Output Current (380-440 V)	25.6 A	25.6 A
Continuous Output Current (441-500 V)	14.5 A	14.5 A
Intermittent Output Current (441-500 V)	23.2 A	23.2 A
Continuous Input Current (380-440 V)	14.4 A	14.4 A
Intermittent Input Current (380-440 V)	23.0 A	23.0 A
Continuous Input Current (441-500 V)	13.0 A	13.0 A
Intermittent Input Current (441-500 V)	20.8 A	20.8 A

1.3. Electric Motor Data



ORDINARY MOTOR



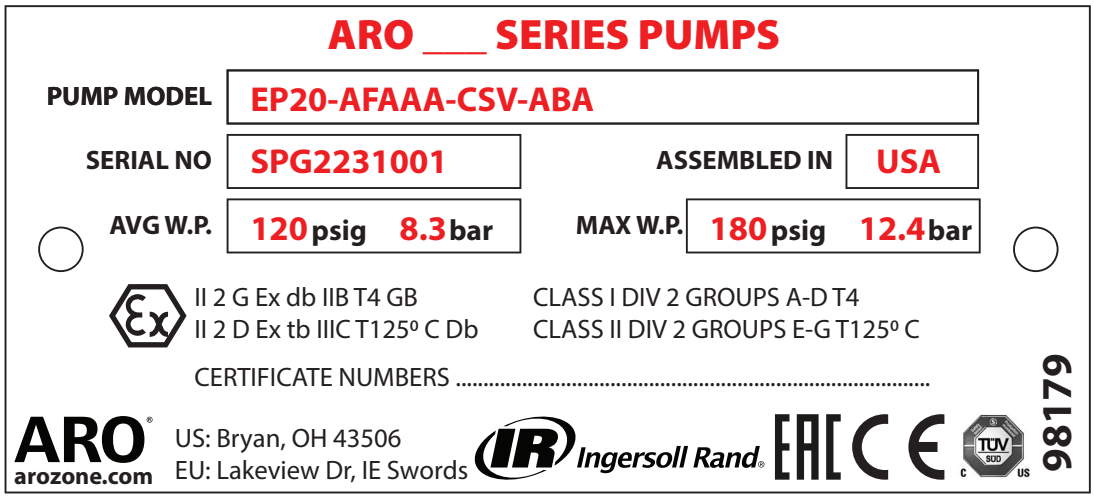
HAZARDOUS MOTOR

Figure 1

	ORDINARY	Hazardous	NEC
Part Number	67559	67560-1	67560-2
Rated Power	5.5 kw	5.5 w	5.5 kw
Rated Torque	36 Nm	36 Nm	36 Nm
Efficiency	IE3	IE3	IE3
Number Of Phases	3	3	3
Polarity	4P	4P	4P
Voltage	400V	400V	400V
Frequency	50 Hz	50 Hz	50 Hz
Index Of Protection	IP66	IP66	IP66
Insulation Class	F	F	F
Encoder Type	Incremental	Incremental	Incremental
Encoder Characteristics	5V 1024 PTS TTL - IP65	5V RS422 (TTL), 1024 PTS - IP66	5V RS422 (TTL), 1024 PTS - IP66 / 67
Encoder Connection	12 Pin connector	2m cable - flying leads	10m cable - flying leads
Drain Plug Position	Drive end with plug	N/A - Flameproof motor	N/A - Flameproof motor
Thermal Protection	2 Pto sensors in series	3 Ptc sensors in series (150-1000 ohms)	3 Ptc sensors in series (150-1000 ohms)
Approx. Weight	100 Kg	138 Kg	138 Kg
Exact Ratio	12.7	12.7	12.7
Output Shaft	Spline	Spline	Spline
Lubricant Type	PAO ISO VG 150	PAO ISO VG 150	PAO ISO VG 150
Lubricant Qty	4.5 Liters (pre-filled)	4.5 Liters (pre-filled)	4.5 Liters (pre-filled)
Main Cable Gland Type	2 x m25 + 1 x m16 with plugs	2 x m25 + 1 x m16 with plugs	2 x m25 + 1 x m16 with plugs
Lifting Point	4 x Lifting eye - Casted	4 x Threaded holes - 3 x Lifting eye fitted	4 x Threaded holes - 3 x Lifting eye fitted

1.4. Nameplate Details

Items supplied vary according to product configuration.
Make sure that the items supplied and the information on the nameplate correspond to the order confirmation.



2. MODEL DESCRIPTION CHART

Model Code Explanation

EP20 - X X X X X - X X X - X X X

Wetted Parts
- A - Aluminum
- C - Cast Iron
- S - Stainless Steel

Port
- F - ANSI/DIN Hybrid Flange

Seat
- A - Santoprene
- C - Hytrel
- F - Aluminum
- H - 440 SST
- S - 316 SST

Ball
- A - Santoprene
- C - Hytrel
- S - 316 SST
- T - PTFE
- V - FKM

Diaphragms
- A - Santoprene
- C - Hytrel
- T - PTFE

Pump Crank case
- C - Cast Iron

Pump Input Shaft
- S - Integrated Spline Shaft

Bellows
- V - FKM

Motor / Drive
- 0 - No Motor or Drive
- A - Ordinary Motor / Drive
- B - ATEX Motor / Drive
- C - NEC Motor / Drive

Accessories
- 0 - None
- A - 3 meter encoder cable
- B - 6 meter encoder cable
- C - 9 meter encoder cable
- D - 15 meter encoder cable
- E - 50 meter encoder cable
- F - 100 meter encoder cable

Revision
- A - Revision

Special Testing

Pumps requiring special tests will have a separate line item on the Purchase Order

NOTICE: All possible options are shown in the chart, however, certain combinations may not be recommended. Consult a representative or the factory if you have questions concerning availability.

3. OPERATING AND SAFETY PRECAUTIONS

READ, UNDERSTAND, AND FOLLOW THIS INFORMATION TO AVOID INJURY AND PROPERTY DAMAGE.

⚠ WARNING STATIC SPARK. Can cause explosion resulting in severe injury or death. Ground pump and pumping system.

- Sparks can ignite flammable material and vapors.
- The pumping system and object being sprayed must be grounded when it is pumping, flushing, recirculating or spraying flammable materials such as paints, solvents, lacquers, etc. or used in a location where surrounding atmosphere is conducive to spontaneous combustion. Ground the dispensing valve or device, containers, hoses and any object to which material is being pumped.
- Secure pump, connections and all contact points to avoid vibration and generation of contact or static spark.
- Consult local building codes and electrical codes for specific grounding requirements.
- After grounding, periodically verify continuity of electrical path to ground. Test with an ohmmeter from each component (e.g., hoses, pump, clamps, container, spray gun, etc.) to ground to ensure continuity. Ohmmeter should show 0.1 ohms or less.
- Submerse the outlet hose end, dispensing valve or device in the material being dispensed if possible. (Avoid free streaming of material being dispensed.)
- Use hoses incorporating a static wire.
- Use proper ventilation.
- Keep inflammables away from heat, open flames and sparks.
- Keep containers closed when not in use.

⚠ WARNING Excessive fluid pressure developed by pump can cause personal injury, pump damage or property damage.

- Fluid pressure developed by the pump do not exceed the maximum as stated on the pump model plate.
- Be sure material hoses and other components are able to withstand fluid pressures developed by this pump. Check all hoses for damage or wear. Be certain dispensing device is clean and in proper working condition.

⚠ WARNING INSTALLATION OF ELECTRICAL COMPONENTS FOR HAZARDOUS DUTY APPLICATIONS.

- Pumps that will operate in environments defined as "hazardous locations" must only be installed, connected and set-up by qualified personnel with knowledge and understanding of protection classes, regulations and provisions for apparatus in hazardous areas, for the region where the pump will operate, because these regulations and provisions, along with the definition of what constitutes hazardous areas vary by location.

⚠ WARNING ELECTRIC SHOCK HAZARD. This equipment must be grounded. Improper grounding, setup, or usage of the system can cause electric shock.

- Turn off and remove power before disconnecting any cables and before servicing or installing equipment.
- Connect only to grounded power source.
- All electrical wiring must be done by a qualified electrician and comply with all local codes and regulations.
- Wait Five minutes for capacitor discharge before opening equipment.

⚠ WARNING HAZARDOUS PRESSURE. Can result in serious injury or property damage. Do not service or clean pump, hoses or dispensing valve while the system is pressurized.

- Disconnect power supply to electric motor and VFD. Relieve pressure from the system by opening dispensing valve or device and / or carefully and slowly loosening and removing outlet hose or piping from pump.

⚠ WARNING HAZARDOUS MATERIALS. Can cause serious injury or property damage. Do not attempt to return a pump to the factory or service center that contains hazardous material. Safe handling practices must comply with local and national laws and safety code requirements.

- Obtain Material Safety Data Sheets on all materials from the supplier for proper handling instructions.

⚠ WARNING EXPLOSION HAZARD. Models containing aluminum wetted parts cannot be used with 1 1 1. -Trichloroethane,Methylene Chloride or other Halogenated Hydrocarbon solvents which may react and explode.

- Check pump actuator section, PRV section, Oil module section, fluid caps, manifolds and all wetted parts to assure compatibility before using with solvents of this type.

⚠ WARNING MISAPPLICATION HAZARD. Do not use models containing aluminum wetted parts with food products for human consumption. Plated parts can contain trace amounts of lead.

⚠ CAUTION Verify the chemical compatibility of the pump wetted parts and the substance being pumped, flushed or recirculated. Chemical compatibility may change with temperature and concentration of the chemical(s) within the substances being pumped, flushed or circulated. For specific fluid compatibility, consult the chemical manufacturer.

⚠ CAUTION Maximum temperatures are based on mechanical stress only. Certain chemicals will significantly reduce maximum safe operating temperature. Consult the chemical manufacturer for chemical compatibility and temperature limits. Refer to PUMP DATA on page 3 of this manual.

⚠ CAUTION Be certain all operators of this equipment have been trained for safe working practices, understand it's limitations, and wear safety goggles / equipment when required.

⚠ CAUTION Do not use the pump for the structural support of the piping system. Be certain the system components are properly supported to prevent stress on the pump parts.

- Suction and discharge connections should be flexible connections (such as hose), not rigid piped, and should be compatible with the substance being pumped.

⚠ CAUTION **Prevent unnecessary damage to the pump. Do not allow pump to operate when out of material for long periods of time.**

- **Disconnect power supply from motor when system sits idle for long period of time.**

⚠ CAUTION **Use only genuine ARO replacement parts to assure compatible pressure rating and longest service life.**

NOTICE **TORQUE ALL FASTENERS BEFORE OPERATION. Creep of housing and gasket materials may cause fasteners to loosen. Torque all fasteners to ensure against fluid or air leakage.**

⚠ WARNING	**= Hazards or unsafe practices which could result in severe personal injury, death or substantial property damage.**
⚠ CAUTION	**= Hazards or unsafe practices which could result in minor personal injury, product or property damage.**
NOTICE	**= Important installation, operation or maintenance information.**

4. GENERAL DESCRIPTION

4.1. Introduction

The ARO® Electric operated positive displacement pump works on the principle of changing rotary motion to reciprocating motion. An electric gear motor coupled with eccentric crankshaft to provide rotary motion. The rotary motion of the shaft is transferred to the reciprocating movement of the diaphragm shaft through connecting rod.
Pump cycling will begin as Electric motor powered up. Crank shaft start to rotate and it will continue to pump and keep up with the demand. It will build and maintain line pressure and will stop cycling once maximum line pressure is reached (dispensing device closed) and will resume pumping as needed. Pumping frequency can be controlled in VFD drive.

4.2. Storage:

Place the equipment in a clean dry area, protected from impacts, vibrations, temperature extremes and in an environment with relative humidity less than 90%.
When storing for longer than six months, consult the manufacturer.

4.3. Unpacking

Items supplied vary according to product configuration.
Make sure that the items supplied and the information on the nameplate correspond to the order confirmation.
Check the individual packaging and the product visually for damage caused by inappropriate handling during shipment.
NOTE: In-case of damage, report the damage to the transport company and thereafter contact IR distributor.

NOTICE

To protect consumer rights please keep the Label intact on the Motor, Pump and Drive.

5. MECHANICAL INSTALLATION

5.1. Pump & Motor Installation

⚠ WARNING ***Pump and motors are industrial products. They must therefore be installed by qualified, experienced and authorized personnel. The safety of people, animals and property must be ensured when fitting the motors into pump.***

⚠ CAUTION ***Prior to commissioning for all motors, rotate the motor at no load (no mechanical load) for 2 to 5 minutes, checking that there is no abnormal noise. If there is any abnormal noise, see section 5 on motor manual (Page 18).***

⚠ WARNING ***Before starting the motor, it is advisable to check the insulation between the phases and earth, and between phases.***

Once Pump has been fully unpackaged and inspected, use lifting points on crankcase to move into final operating position.

- Ensure straps and lifting device are properly rated. Refer section 1.1 for pump weight
- All three lifting points to be used for stability
- Lifting point on crankcase intended to only move pump.
- Do not use pump manifolds to lift the equipment.
- Ensure installation location has enough overhead room to install motor vertically from top
- Ensure adequate clearance around pump for sufficient access and ventilation.
- Ensure the pump is installed on flat level surface.

Secure pump legs to floor with M14 anchors.

- Refer to section 13.1 for bolt circle spacing.
- Pump must be positioned such that fluid inlet and fluid outlet port are easily accessible.

Install motor onto the pump crank case

- Ensure gearbox motor does not damage pump manifolds.
- Refer to electric motor manual for lifting points and recommendations.
- Ensure motor is vertical with shaft pointing downward when mounting over to pump.
- Ensure pump crankshaft is greased from factory.
- Motor should be carefully lowered to ensure spline teeth are properly engaged. There should not be excessive pressure on crankshaft. Motor may require some degree of rotation for spline engagement.

Secure gearbox flange to crankcase flange with 4X M12 bolts.

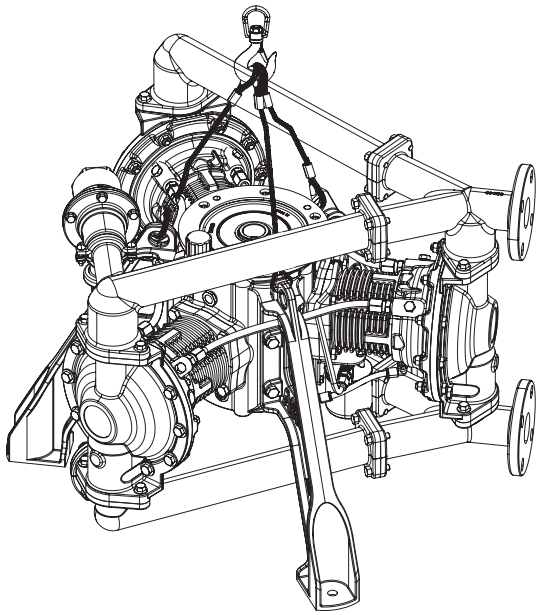


Figure 2

5.2. VFD Mechanical installation

- Refer to section 3 of VFD manual for detailed mechanical installation.
- Do not remove the nameplate from the drive.
- Ensure that the lifting device is suitable for the task.
- Mount drive to a flat surface or ensure back plate is installed to allow adequate air flow across cooling fins.
- Refer to section 13.2 for VFD mounting dimension.

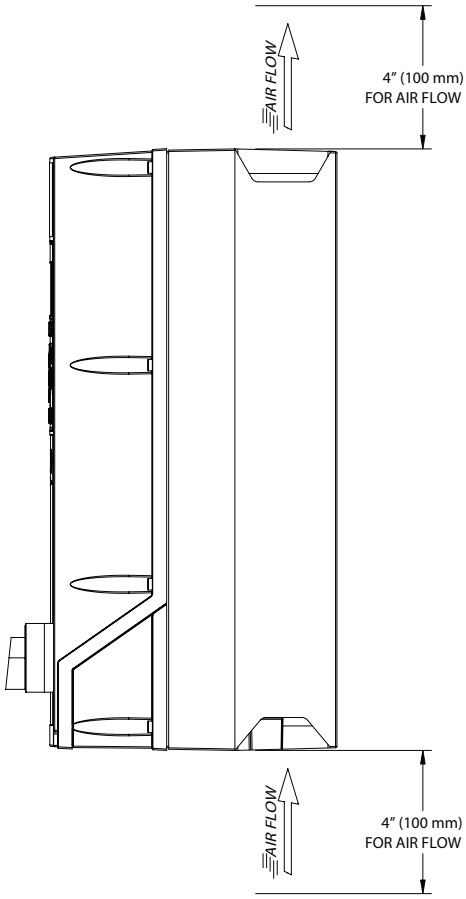
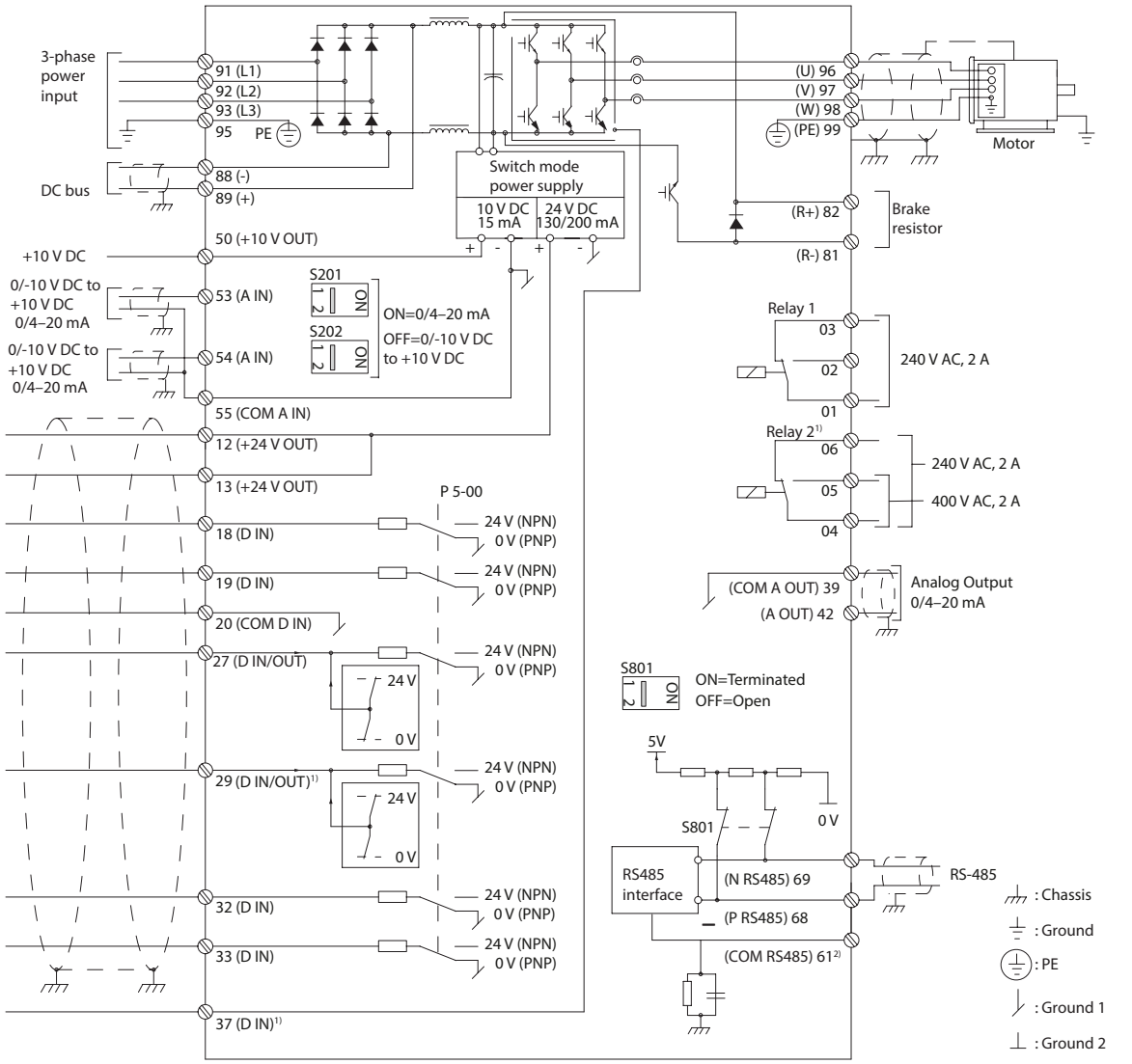


Figure 3

6.1. VFD-Wiring Diagram



A	Analog	1	Terminal 37 (optional) is used for Safe Torque Off (STO).
D	Digital	2	Do not connect cable shield.

6.2. General Wiring practice

- Due to limited number of knockouts in VFD, it is recommended to combine signal wires (Safe Stop cable, Leak detector cable, Thermistor cable) into a single cable.
- Route control wiring in separate conduit and as far away from power wires as possible
- A dedicated ground wire is needed, It is not recommended grounding through the conduit
- Keep wire runs as short as possible to help avoid problems.

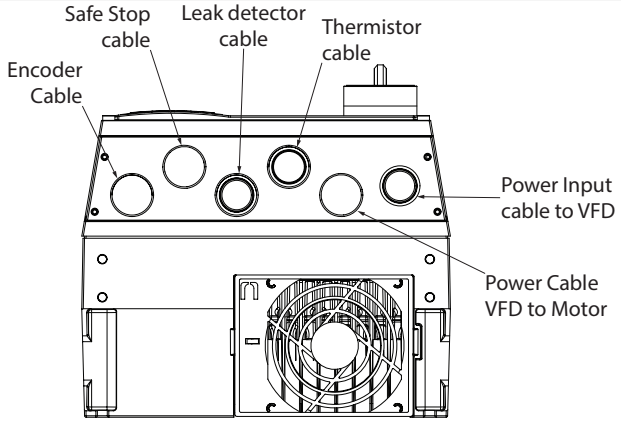


Figure 4

6.3. VFD AC Mains – Input Power Requirements:

⚠ WARNING ***To ensure the power line, the drive and motor rated for the same voltage***

Supply terminals (6-pulse)	L1, L2, L3
Supply voltage[1][2]	380 – 500 V +/- 10%
Supply frequency	47.5 – 63 Hz
Maximum imbalance temporary between mains phases	3.0% of rated supply voltage
True power factor (λ)	≥ 0.9 nominal at rated load
Displacement power factor (cos Φ)	Near unity (> 0.98)
Switching on the input supply L1, L2, L3 (power - ups) ≤ 7.5 kW (10 hp)	Maximum twice per minute
Environment according to EN60664-1	Overvoltage category III / pollution degree 2

1. Mains voltage low/mains dropout: During low mains voltage or a mains dropout, the drive continues until the DC-link voltage drops below the minimum stop level, which typically corresponds to 15% below the drive's lowest rated supply voltage. Power-up and full torque cannot be exptected at mains voltage lower than 10% below the drive's lowest rated supply voltage.

2. The unit is suitable for use on a circuit capable of delivering not more than 100000 RMS symmetrical Amperes, 240/500/600 V maximum.

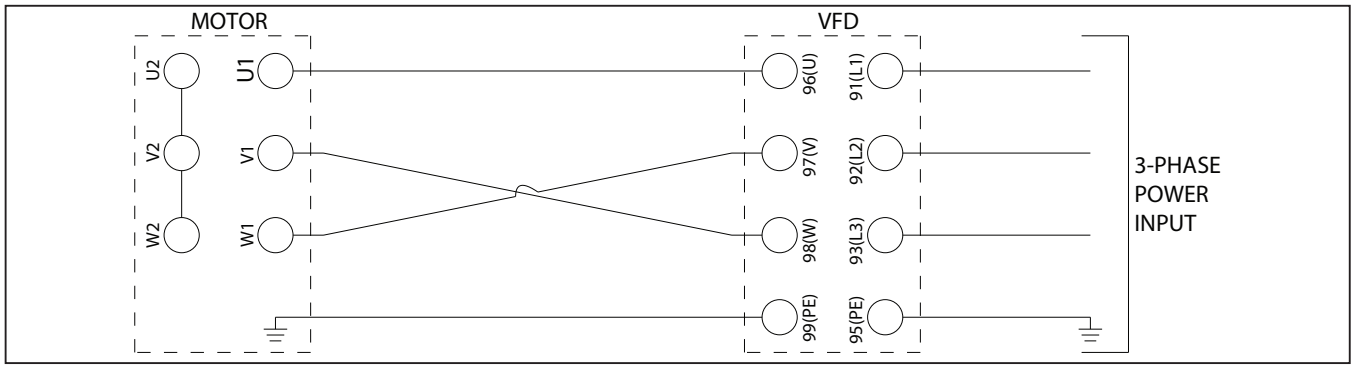
6.4. Power Wiring:

6.4.1 VFD - Input Power Wiring

- Connect the 3-phase AC input power wiring to terminals L1, L2, and L3.
- Ground the cable in accordance with the grounding instructions, see 4.3 Grounding and 4.5.1 Grounding the Cable Shield.
- When supplied from an isolated mains source (IT mains or floating delta) or TT/TN-S mains with a grounded leg (grounded delta), ensure that parameter 14-50 RFI Filter is set to [0] Off. This setting prevents damage to the DC link and reduces ground capacity currents in accordance with IEC 61800-3.

6.4.2. VFD - Output Motor Wiring

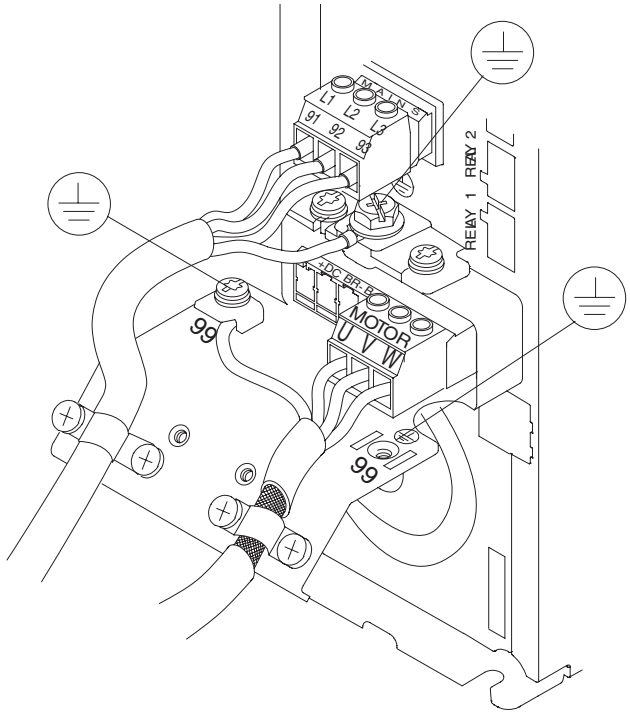
- Run output separately or use shielded cables.
- Comply with local and national electrical codes for cable sizes.
- Strip a section of the outer cable insulation.
- Position the stripped wire under the cable clamp to establish mechanical fixation and electrical contact between the cable shield and ground.
- Connect the ground wire to the nearest grounding terminal in accordance with the grounding instructions, Refer to section 7.2 for Grounding.
- Connect the 3-phase motor wiring to terminals 96 (U), 97 (V), and 98 (W).
- Do not wire a starting or pole-changing device (for example a Dahlander motor or slip ring asynchronous motor) between the drive and the motor.



6.4.3. Motor - Input Power Wiring

- The cables must be fitted with connectors suitable for the cable cross-section and the terminal diameter.
- They must be crimped in accordance with the connector supplier's instructions.
- If using cables without connectors, attach some calipers.
- If any nuts on the brass terminal block are lost, they must be replaced by brass nuts, not steel ones.
- When closing the box, ensure that the seal is correctly.

Type of cable gland	Ø min. - Ø max. (mm) cable	
Steel	Polyamide cable gland	Brass cable gland
ISO M16	5-10	5.5-9.5
ISO M20	9.5-15	8.5-13
ISO M25	13-19	12-17



Mains input, motor, and grounding for basic drives. Actual configurations vary with unit types and optional equipment

Figure 5

NOTE: Motor should be wired for wye or star configuration with V and W leads switched as shown in wiring diagram to get the desired direction of rotation.

6.5. Control Wiring (Required)

6.5.1. Leak detector wiring diagram

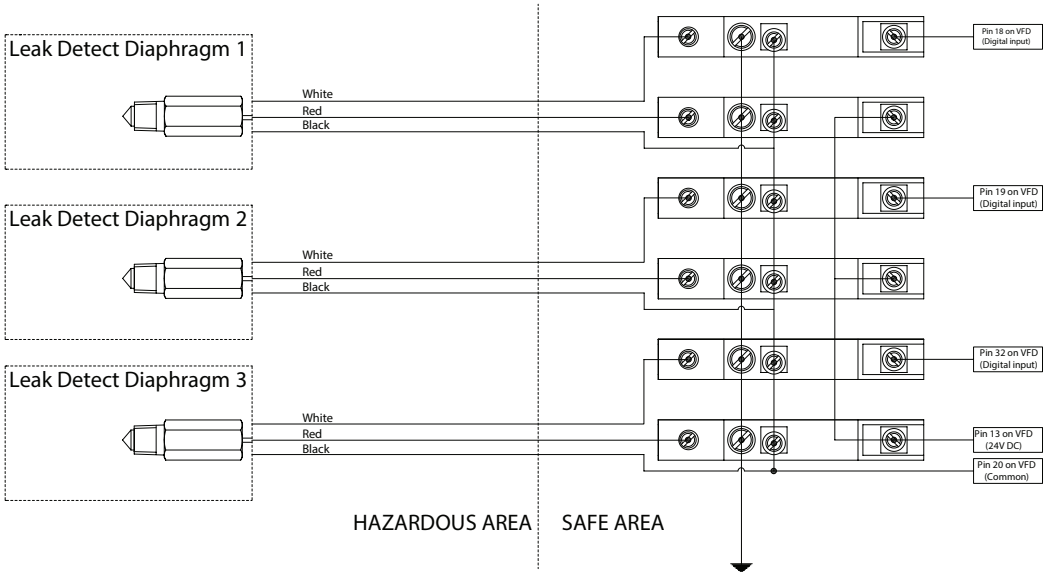
General Description:

An ARO diaphragm pump equipped with the ARO Leak Detection Sensor warns of a diaphragm failure by sensing the pressure of liquid in the air cap of the pump. This system uses a liquid sensor in each of the three air caps ehich will send an output signal when fluid is dected.

Installation and Warnings:

NOTE: All WIRING MUST COMPLYWITH ALL LOCAL AND / OR NATIONAL ELECTRICAL CODES.

- Electrical codes that apply must be strictly adhered to; failure to do so may lead to shock hazard or serious injury.
- Some local electrical codes may require the installation of rigid conduit.
- The Leak Detection Sensor components must be installed by a qualified electrician in compliance with all national, state and local codes and regulations to reduce the risk of electrical shock or other serious injury during installation and operation.
- ARO is not responsible for accidents resulting from improper installation of components or hardware.
- HAZARDOUS VOLTAGE. Do not attempt any service without disconnecting all electrical supply source.



ZENER Barrier, Leak Detection Sensor PN	Voltage	Device Rating (mA)	Temperature Rating
97414 (ATEX / IECEx / NEC / CEC)	24 VDC	100	-4°F - 140°F (-20°C - 60°C)

Leak Detection Sensor PN	Voltage	Device Rating (mA)	Temperature Rating
96270-1	24 VDC	40	-0°F - 176°F (-18°C - 80°C)
96270-2 (ATEX / IECEx)	24 VDC	40	-0°F - 176°F (-18°C - 80°C)

- Recommended cable (3 Conductor with Single Outer Jacket)

Manufacturer	Alpha Wire
Part Number	1173C
Conductor	22 AWG
Voltage Rating	300 V RMS
C	33 PF/FT @ 1KHz
L	0.18 mH/Ft

- Leak detector wires are connected to VFD directly for ordinary pump. Two Zener Barriers (ARO Part No – 97414) are needed per leak detector for hazardous duty pump. Zener Barrier is connected between leak detector and VFD drive.

6.5.2. Leak Detector Safe Loop Calculations

Leak Detector	Cable	Zener Barrier
IR Part Number 96270-2	Alpha Wire 1173C	IR Part Number 97414
Ui = 32 VDC		Uo = 25.2 VDC
Ii = 87 mA		Io = 74 mA
Pi = 0.616 W		Po = 0.464 W
Ci = 0.052 uF	Cc 0.055uF	Co = 0.107 uF
Li = 3.7 uH	Lc 6.488mH	Lo = 6.492 mH
Um = 250 VAC/DC		Um = 250 VAC/DC
Ta = -18oC To +80oC		Ta = -40° C To +60° C

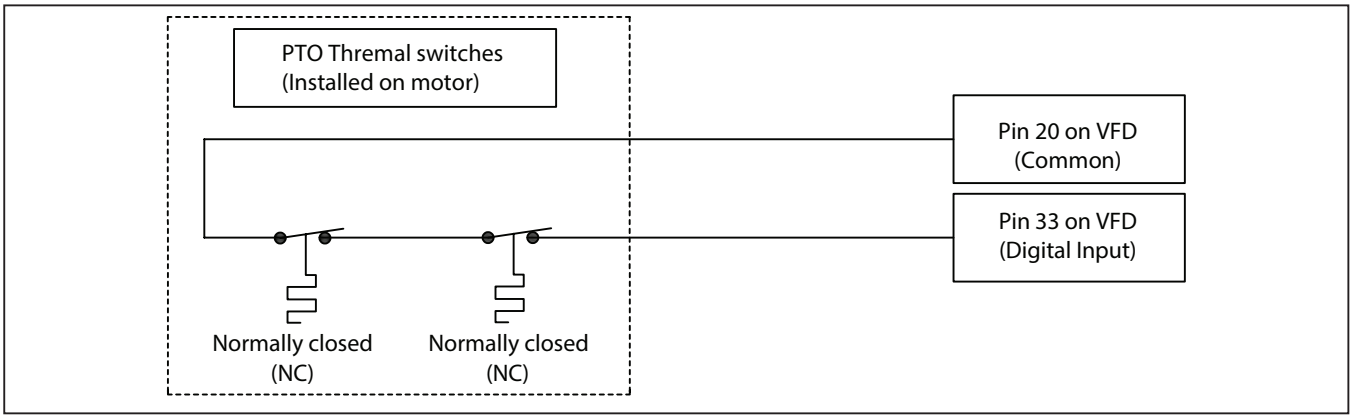
Ui ≥ Uo (32 V > 25.2 V)
Ii ≥ Io (87 mA > 74 mA)
Pi ≥ Po (0.616 W > 0.464 W)

Maximum Cable Capacitance Cc = Co-Ci ≥ 0.107 uF - 0.052 uF = 0.055 uF
Maximum Cable Inductance Lc = Lo-Li ≥ 6.492 mH - 0.0037 mH = 6.488 mH

As per cable manufacturer Alpha Wire, Cable Capacitance = 33PF/FT, Cable Inductance = 0.00018 mH/FT
Maximum cable run length = 359 feet
Calculated Cable Capacitance = 11.8 nF < 0.055 uF
Calculated Cable Inductance = 6.48 mH < 6.462 mH

6.5.3. Thermal protection – Ordinary motor

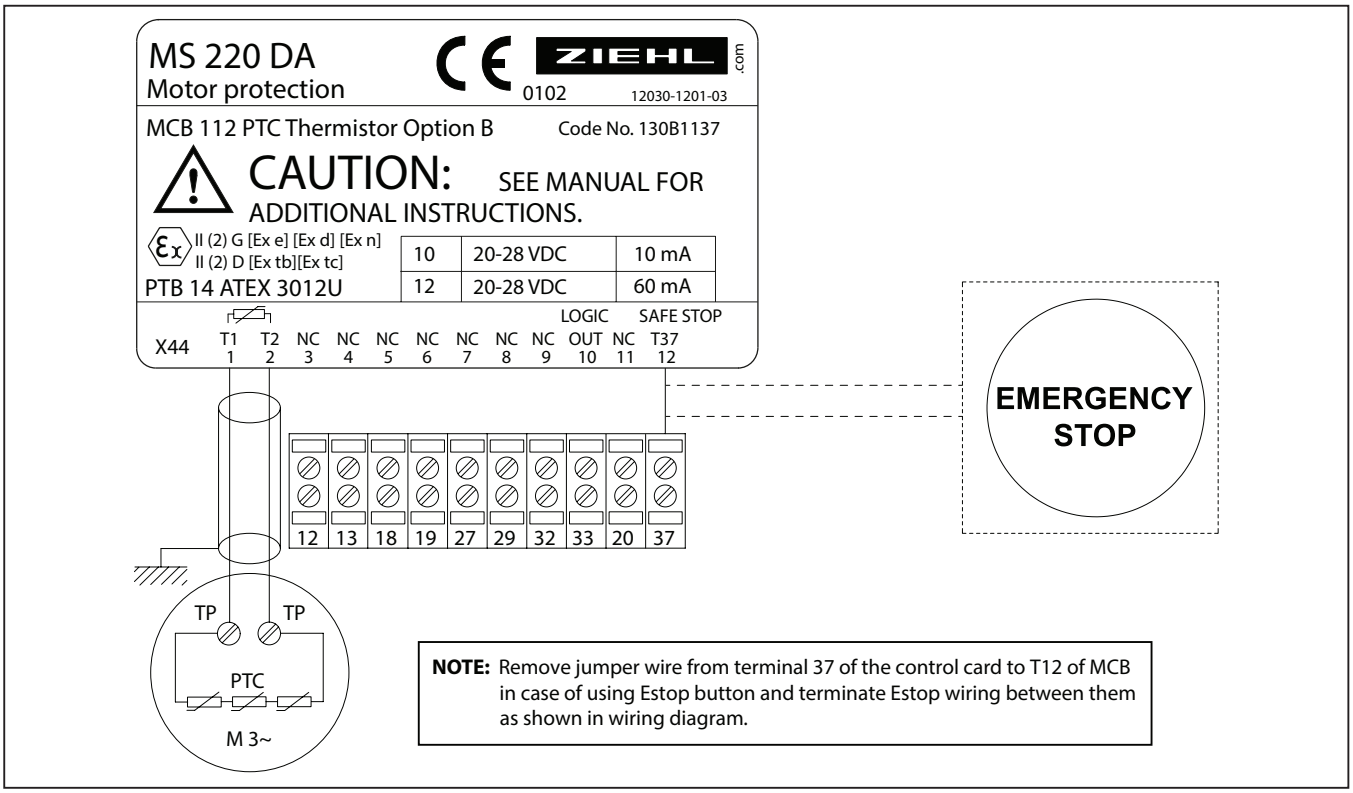
- Motor is installed with 2 normally closed contact sensors (PTO) in series for ordinary motors and will need to be wired from the motor terminal box to the VFD as per below wiring diagram.



6.5.4. Thermal Protection – Hazardous motor

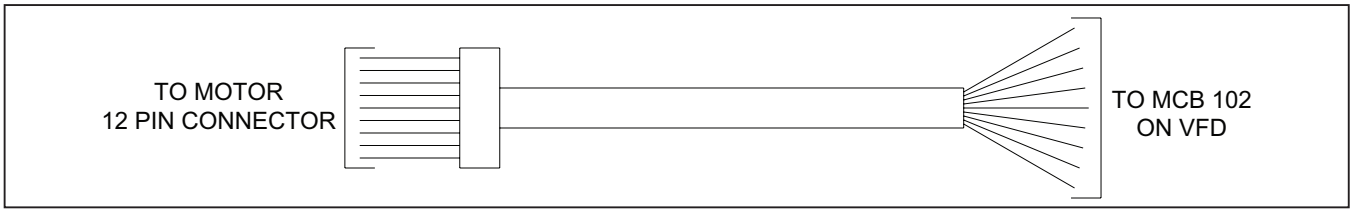
⚠ WARNING ***Do not Connect from logic out 10 to pin 33 because VFD digital input is set to NPN. MCB112 output signal is PNP type.***

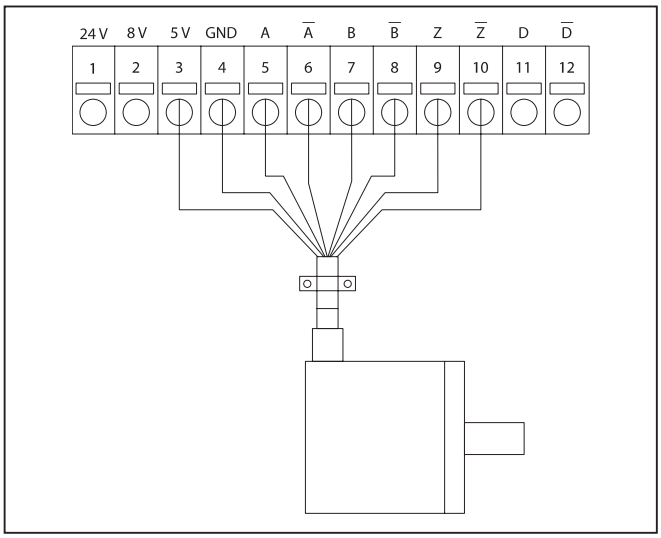
- The motor is installed with 3 PTC thermal sensors in series for hazardous duty application. It need to be wired to the MCB112 Card in the option A slot on the VFD.



6.5.5. Encoder Wiring – Ordinary Motor

- Motor is installed with a 1024 pts TTL encoder with a 12-pin connector on the outside of the motor terminal box.
- Extension cable is available for different length and need to order according to requirement.
- flying leads need to be wired to the MCB102 encoder card installed in the option B slot of the VFD as per encoder card wiring.





Wire Color	Encoder card Terminal	Description
Brown	(3)	5V
White	(4)	GND
Yellow	(5)	A INPUT
Green	(6)	A INV INPUT
Pink	(7)	B INPUT
Grey	(8)	B INV INPUT
Blue	(9)	Z INPUT
Red	(10)	Z INV INPUT
Grey	(11)	NC

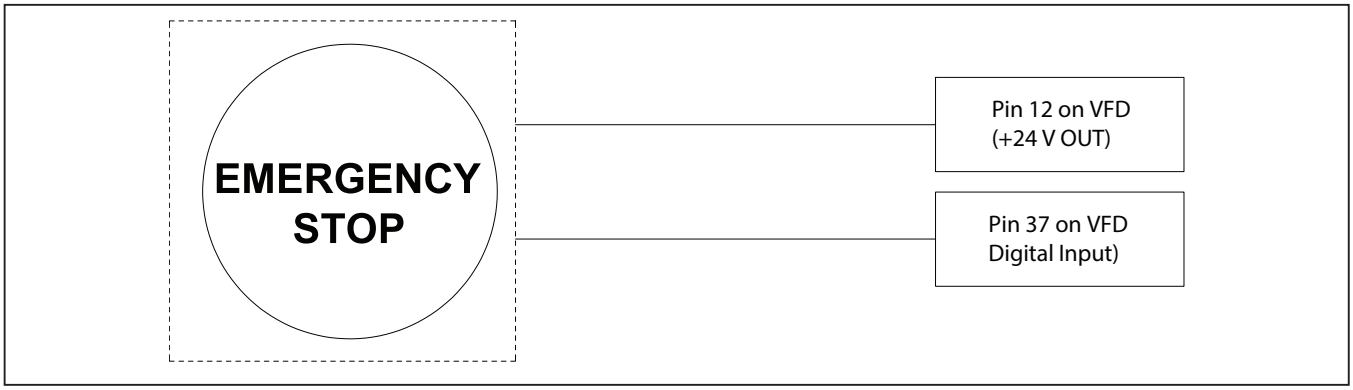
6.5.6. Encoder Wiring – Hazardous Motor

- Hazardous duty Motor is installed with a 1024 pts TTL with 2-3M of cable length and flying leads (no connector).
- Flying leads need to be wired to the MCB102 encoder card installed in the option B slot of the VFD as per encoder card wiring.

6.6. Control Wiring (Recommended)

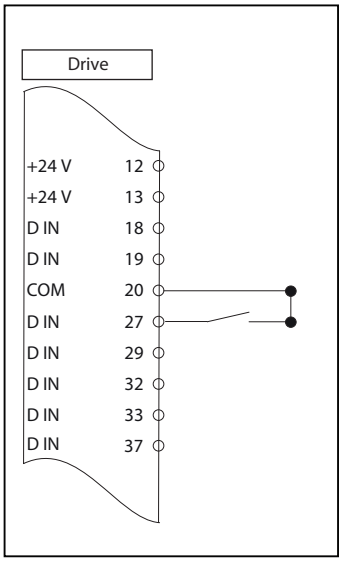
6.6.1. Safe Stop wiring diagram

- It is recommended to install external Estop.
- The VFD will come with pin 37 wired to 24VDC. This will need to be removed when e-stop is installed.
- The e-stop (safe stop) should be normally closed and will stop the pump with an open circuit.



6.6.2. Digital start/ stop control

1. Digital input 27 will be used in place of 18 shown in the VFD manual.
   - The VFD will come with pin 37 wired to 24VDC. This will need to be removed when e-stop is installed.
2. Digital inputs are set to NPN and needs to be wired to common (Terminal 20) instead of +24V.

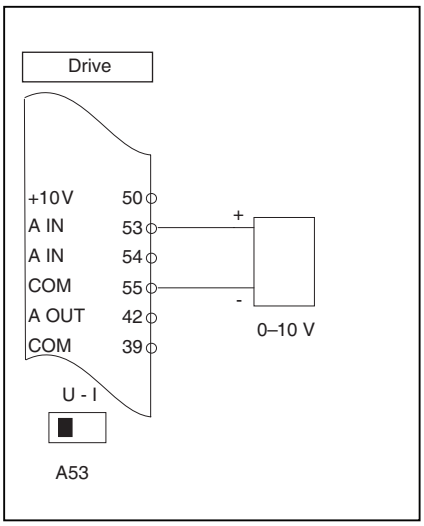


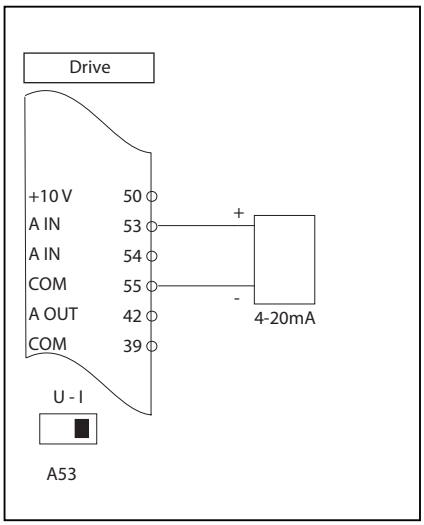
VFD Parameter	Function	Setting
512	Terminal 27 digital input	[8] Start
513	Terminal 29 digital input	[1] Reset

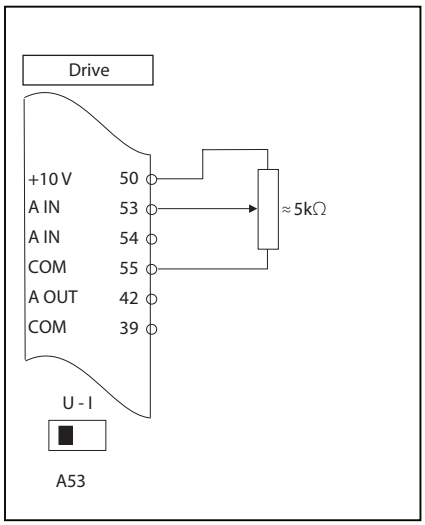
6.7. Control Wiring (Optional)

6.7.1. Analog Input – Speed control

- Drive is set to 0-10 volt signal from factory. Manually have to flip switch inside the drive (A53) to change to 4-20 mA signal.





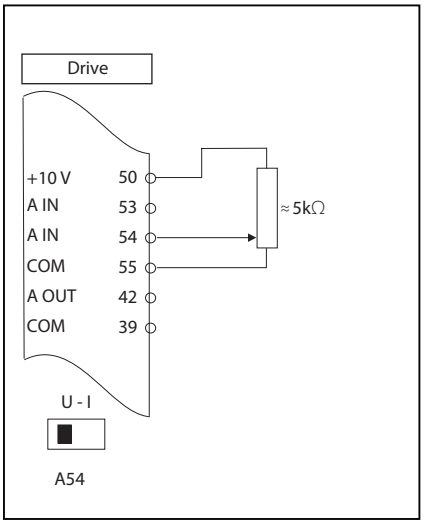


VFD Parameter	Description	Default Parameter
610	Terminal 53 Low Voltage	0.07 V
611	Terminal 53 High Voltage	10.00 V
612	Terminal 53 Low Current	4 mA
613	Terminal 53 High Current	20 mA

NOTE: Analog speed control can be used only with auto on mode.

6.7.2. Analog Inputs – Torque (Pressure) Control

- To active torque control, VFD parameter 420 needs to be changed from "[0] No Function" to "[6] Analog in 54".
- Torque and speed control when put together in the system, torque control will override speed control and maintain load on the motor.
- Manually have to flip switch inside the drive (A54) to change to 4-20 mA signal.



VFD Parameter	Description	Default Parameter
620	Terminal 54 Low Voltage	0.07 V
621	Terminal 54 High Voltage	10.00 V
622	Terminal 54 Low Current	0.14 A
623	Terminal 54 High Current	20.00 A

6.7.3. Additional available Input/output (Optional)

1. T27 & T29 are configurable for digital input or output.
   - Digital output can be either digital or pulse output. The options for parameters 530 and 531 are all digital, however, to enable pulse output the parameters in the table below should be set as shown. The pulse output variable can then be selected using parameters 552 and 563.

VFD Parameter	Function	Setting
501	Terminal 27 mode	[1] Output
502	Terminal 29 mode	[1] Output
530	Terminal 27 Digital Output	[55] Pulse Output
531	Terminal 29 Digital Output	[55] Pulse Output
560	Terminal 27 Pulse Output Variable	Select output variable to display from the list
552	Pulse Output Max Freq #27	5000 (default)
563	Terminal 29 Pulse Output Variable	Select output variable to display from the list
555	Pulse Output Max Freq #29	5000 (default)

2. T33 digital input is available for hazardous location models only
   - Ordinary motor will connect Thermistor cable to this terminal
3. T42 analog output
   - Refer to Personal menu table (650, 651 & 652) to set parameter in VFD for this terminal
4. Relays
   - Two relays are available for use (Parameter 540)
   - Refer to section 8.6.11 (page – 69) in VFD manual for detailed relay information

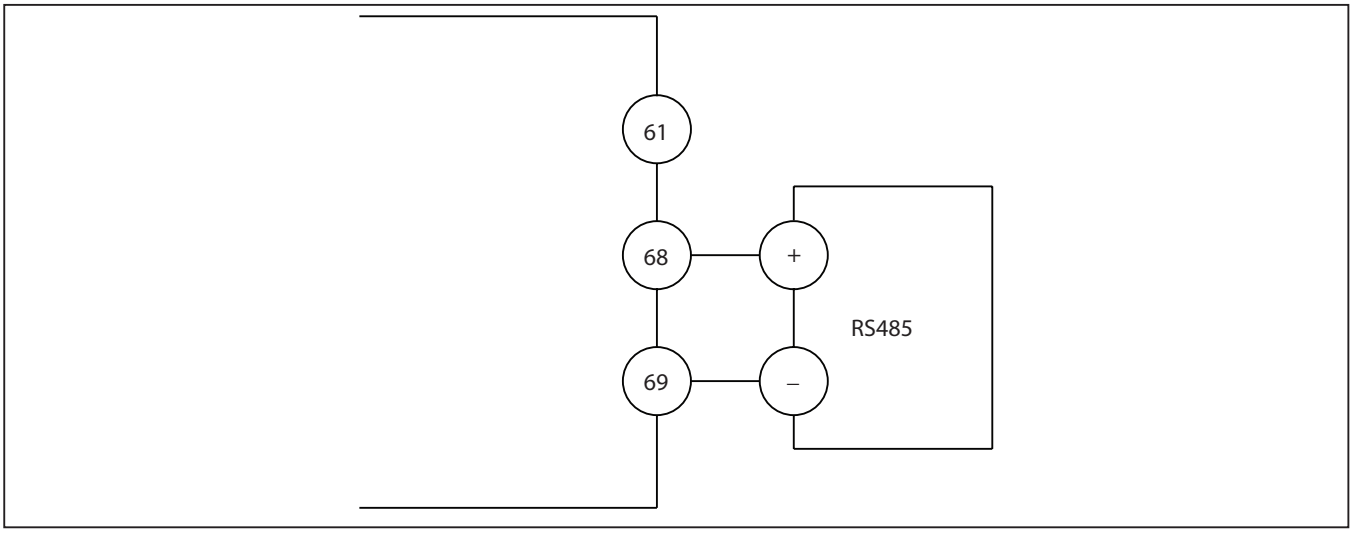
6.8. Configured I/O's (summary)

Intended function	Warning text	Digital I/O Terminal	Ground Terminal	24VDC Terminal
Diaphragm 1 Leak Detect	Diaphragm 1 Leak	18	20	13
Diaphragm 2 Leak Detect	Diaphragm 2 Leak	19	20	13
Diaphragm 3 Leak Detect	Diaphragm 3 Leak	32	20	13
PTO (normally closed) - Ordinary pump only	Alarm 11	33	20	N / A
Safe Stop (E Stop)	Alarm 68	37	N / A	12
User Configurable I/O		27		
User Configurable I/O		29		
		Anlog In Terminal	**Ground Terminal**	**10VDC Terminal**
Speed		53	39 /5 5	50
Torque		54	39 / 55	50
		Anlog In Terminal		
User Configurable		42		

6.9. VFD serial communication

1. Drive will have RS485 serial communication port.
   - Connect RS485 serial communication wiring to terminals (+) 68 and (-) 69
2. Connect RS485 serial communication wiring to terminals (+) 68 and (-) 69
3. Drive will support Modbus RTU field communication.
4. Set the below parameter for serial communication set-up

VFD Parameter	Function
8-30	Select Option [2] for Modbus RTU. Changing parameter is not effective until after powering off frequency converter
8-31	Enter the valid address for the frequency converter (standard) port. e.g. [1-247]
8-32	Select option for the Baud rate match with FC (standard) port.
531	Terminal 29 Digital Output
560	Terminal 27 Pulse Output Variable
552	Pulse Output Max Freq # 27
563	Terminal 29 Pulse Output Variable
555	Pulse Output Max Freq # 29



6.10. User defined readout

- Parameters 030, 031, & 032 are available to modify the "User Defined Readout" that will display in the top left corner of the main menu screen. By default, these values are set to scale motor frequency to actual pump rpm. To update the "User Defined Readout", refer to the following parameter descriptions.
  1. Select the unit to be displayed on LCP from option given in parameter 030.
  2. Minimum value is set to zero in parameter 031.
  3. Maximum value is set for parameter 032 based on maximum motor frequency (92 Hz) set in parameter 414 & calculated as below.

$$\text{Pump unit (Maximum)} = \frac{\text{Motor sync. RPM (1500) X Maximum motor frequency (92 Hz)}}{\text{"Motor Freuency (50 Hz) X GB ratio (12.7)"}} \times \text{unit conversion factor (X)}$$

Pump Unit (parameter 030)	* Unit conversion factor (X)
RPM	1
GPM	0.65

NOTE: Adjust unit conversion factor for the selected unit given in parameter 030 to calculate maximum value for parameter 032 per the above formula.

* Unit conversion factor values are approximate and depend on back pressure.

7. GROUNDING

Before operating the pump, ground the system as explained below.

7.1. Pump Grounding

- All pump have a ground screw installed in crankcase housing. Connect one end of the grounding wire to ground screw and other end of the grounding wire to suitable earth ground.

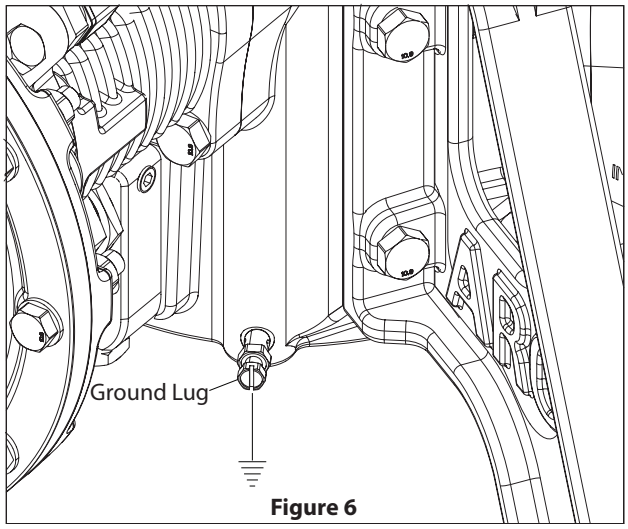


Figure 6

7.2. VFD Grounding

⚠ WARNING LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive properly can result in death or serious injury.

Ensure that the minimum size of the ground conductor complies with the local safety regulations for high touch current equipment.

- Ground the variable frequency drive through a proper connection to a power source.
- Ground the drive in accordance with applicable standards and directives.
- Use a dedicated ground wire for input power, motor power, and control wiring.
- Do not ground 1 drive to another in a daisy-chain fashion.
- Keep the ground wire connections as short as possible.
- Follow motor manufacturer wiring requirements.
- Minimum cable cross-section for the ground wires: 10 mm2 (7 AWG).
- Separately terminate individual ground wires, both complying with the dimension requirements.

7.3. Electric Motor Grounding

⚠ WARNING

It is compulsory to earth the motor. Earthing must be performed in accordance with current regulations (protection of workers).

Motors have a ground screw inside the terminal box. Use it to ground the motor to the controller.

⚠ WARNING

You must use lubricating oil of the recommended type.

Pump is lubricated at the factory. Pump is shipped with synthetic oil PAO ISO VG 460. it should filled in crankcase housing to keep center rod bearing and lower bearing lubricated during operation and function smoothly. Pump is designed to circulate oil through piston pump and pass through oil filter. This improved life of the bearing and maintained oil cleanliness in the system. Upper bearing is grease filled and it is separated from oil chamber to avoid any contamination. There is no need to add an inline lubricator under normal operating conditions.

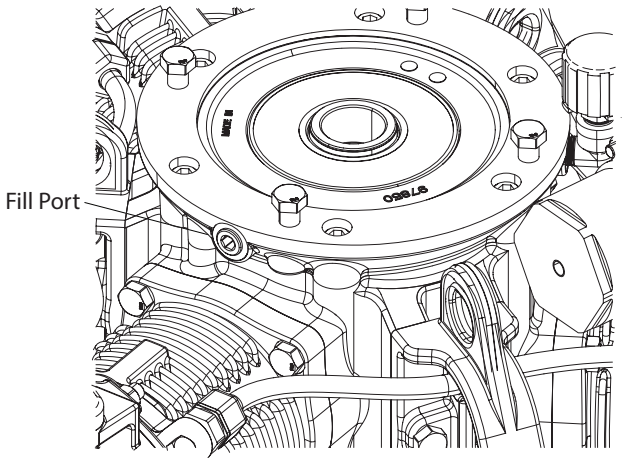


Figure 7

8.1. Oil Filling instruction

- Pump is shipped with 2.5 gallon Oil container. Crankcase unit will hold approx. 1.7 gallons (6.4 L). Store leftover oil for future.
- Remove 3/8" NPT plug from fill port in actuator cap above highest cylinder.
- Put 3/8" NPT threaded elbow facing on top and funnel for ease in filling.
- Ensure 3/8" NPT drain plug is inserted in the crankcase housing.
- Remove breather in actuator cap above lowest cylinder for vent.
- Fill oil to half way up sight glass located in crankcase housing above the lowest cylinder.
- Once full, reinsert 3/8" NPT plug to the fill port and breather in top cap.

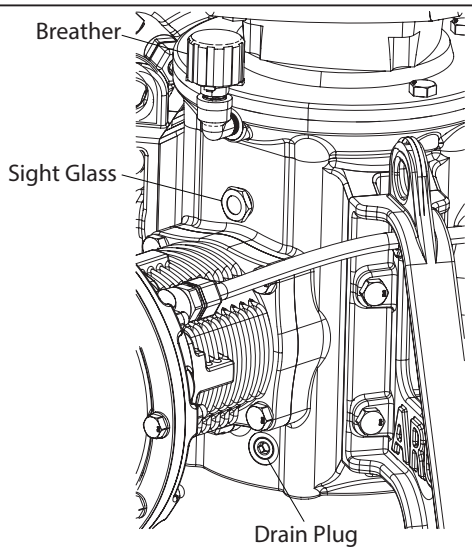


Figure 8

9. OPERATION

9.1. Pre Operation Checklist

- VFD is configured according to the motor requirement.
- Close the safety cover properly and check that all cable glands are firmly tightened.
- Ensure that input power to the unit is off and locked out. Do no rely on the drive disconnect switches for input power isolation.
- Verify that there is no voltage on input terminals L1 (91), L2 (92), and L3 (93), phase-to-phase, and phase-to-ground.
- Verify that there is no voltage on output terminals 96 (U), 97 (V), and 98 (W), phase-to-phase, and phase-to-ground.
- Confirm continuity of the motor by measuring Ω values on U–V (96–97), V–W (97–98), and W–U (98–96).
- Check for proper grounding of the drive and the motor.
- Inspect the drive for loose connections on the terminals.
- Confirm that the supply voltage matches the voltage of the drive and the motor.
- Always flush the pump with a solvent compatible with the material being pumped if the material being pumped is subject to "setting up" when not in use for a period of time.
- The outlet material volume is governed not only by the Fluid pressure but also by the material supply available at the inlet. The material supply tubing should not be too small or restrictive. Be sure not to use hose which might collapse.
- Secure the pump legs and bolted to a suitable surface (concrete floor) to ensure against damage by vibration.
- If this Pump is used for prolonged operation at low speed ensure there is enough ventilation around the motor to cool it efficiently.
- Set the desired frequency on the VFD.
- Press the start (run) button on the VFD.

9.2. Personal Menu Settings

Parameter	Description	Function
001	Language	Select the display langauge.
021	Display Line 1.2 Small	Select a variable for display on main menu screen, top middle position - Motor current default.
030	Unit for User-Defined Readout	Select the desired unit for Custom Readout.
031	Min Value of User Defined Readout	Set the Custom Readout value that corresponds to zero speed.
032	Max value of user defined readout	Set the Custom Readout value that corresponds to the Motor Speed High Limit.
040	Hand On Key on LCP	Select Disabled [0] to avoid accidental start of the drive in Hand mode. Select Password [2] to avoid unauthorised start in Hand mode.
042	Auto On key on LCP	Select Disabled [0] to avoid accidental start of the drive in Auto mode. Select Password [2] to avoid unauthorised start in Auto mode.
050	LCP Copy	Copy parameters to and from the LCP. Copied parameters can be used to transfer settings from one frequency converter to another.
066	personal menu access w/o password	The personal menu is set to Full access [0] by default. Select read only to enable personal menu password. Default password is 1397.
070	Date and Time	Set the date and time of the internal clock.
071	Date Format	Set the date format.
072	Time Format	Set the time format.
416	Torque Limit Motor Mode	The motor torque limit percentage can be set between 0-100% to control pump fluid pressure output. Do not exceed 100%!
420	Torque Limit Factor Source	Select [6] Analog in 54 to scale the limits set in parameter 416 from 0% to 100% via analog control.
501	Terminal 27 Mode	Define terminal 27 as digital input or output. Set to input by default.
502	Terminal 29 Mode	Define terminal 29 as digital input or output. Set to input by default.
512	Terminal 27 Digital Input	Select the function from the available digital input range. It is recommended to set T27 to [8] Start for use with analog control methods.
513	Terminal 29 Digital Input	Select the function from the available digital input range. It is recommended to set T27 to [1] Reset for use with analog control methods.
515	Terminal 33 Digital Input	Select the function from the available digital input range.
530	Digital Output Term 27	Select the function from the available digital output range. Select [55] for pulse output to be determined using parameter 560 .
531	Digital Output Term 29	Select the function from the available digital output range. Select [55] for pulse output to be determined using parameter 563 .
560	Terminal 27 Pulse Output Variable	Select the variable for pulse output on terminal 27.
562	Pulse Output Max Freq #27	Set the maximum frequency for terminal 27, corresponding to the output variable selected in parameter 560.
563	Terminal 29 Pulse Output Variable	Select the variable for pulse output on terminal 29.

Parameter	Description	Function
565	Pulse Output Max Freq #29	Set the maximum frequency for terminal 29, corresponding to the output variable selected in parameter 563.
540	Function Relay	Define relay functions using 540.0 and 540.1 (2 relays available).
610	Terminal 53 Low Voltage	Enter the low voltage value (Default 0.07V). This corresponds to the minimum reference value of 0 Hz.
611	Terminal 53 High Voltage	Enter the high voltage value (Default 10V). This correspond to the maximum reference value of 84 Hz.
612	Terminal 53 Low Current	Enter the low current value (Default 4mA). This correspond to the minimum reference value of 0 Hz.
613	Terminal 53 High Current	Enter the high current value (Default 20mA). This correspond to the maximum reference value 84 Hz.
620	Terminal 54 Low Voltage	Enter the low voltage value (Default 0.07V). This corresponds to 0% of torque limit defined by par. 416 when par. 420 is set to [6].
621	Terminal 54 High Voltage	Enter the high voltage value (Default 10V). This corresponds to 100% of torque limit defined by par. 416 when par. 420 is set to [6].
622	Terminal 54 Low Current	Enter the low current value (Default 4mA). This corresponds to 0% of torque limit defined by par. 416 when par. 420 is set to [6].
623	Terminal 54 High Current	Enter the high current value (Default 20mA). This corresponds to 100% of torque limit defined by par. 416 when par. 420 is set to [6].
650	Terminal 42 output (mA)	Select the function of Terminal 42 as an analog current output.
651	Terminal 42 output min scale	Scale the minimum output of the selected analog signal at terminal 42, as a percentage of the maximum signal value
652	Terminal 42 output max scale	Scale the maximum output of the selected analog signal at terminal 42.
830	Protocol	Select the protocol to be used. Select [2] for Modbus RTU.
831	Address	Enter the address for the drive port. Valid range: 1 - 126.
832	FC Port Baud Rate	Select the baud rate for the drive port.

10. MAINTENANCE

Refer to the part views and descriptions as provided on page 24 through 32 for parts identification and Service Kit information.

- Service kits are divided to service four separate section: 1. Actuator SECTION, 2. FLUID SECTION, 3. PRV section, 4. Oil filtration section. The FLUID SECTION and PRV SECTION is divided further to match typical part MATERIAL OPTIONS.
- Provide a clean work surface to protect sensitive internal moving parts from contamination from dirt and foreign matter during service disassembly and reassembly.
- Keep good records of service activity and include pump in preventive maintenance program.
- Before disassembling
  - Empty oil from actuator housing through drain port. Remove 3/8" NPT drain plug in actuator housing below lowest cylinder.
  - Empty captured material in the outlet manifold by running the pump long enough to thoroughly clean the pump and hoses.
  - Remove bolt from PRV manifold and empty captured material from inlet manifold.

MAINTENANCE RECOMMENDATIONS – FLUID SECTION		
Maintenance Item	**Frequency**	**Indication**
Diaphragms	As needed	Pump will be shut down by the VFD due to fluid detection by optical leak detection sensors installed in each air cap. VFD alarm text "Diaphragm 1, 2 or 3 Leak".
Rubber Bellows	Every diaphragm change	Preventative to ensure robust protection of pump actuator.
Balls	As needed (General rule of thumb is to replace balls every other diaphragm change)	Erratic pump behavior, excessive pulsation, inability to dead-head pump with the pump continuing to cycle, reduction in flow
Seats	As needed	Visual inspection
PRV Bellows	As needed	Leak is contained and directed to one of the 3 air caps where the pump will be shut down by the VFD due to fluid detection by the optical leak detection sensor installed that air cap. VFD alarm text "Diaphragm 1, 2 or 3 Leak".

NOTE: Frequency of maintenance fluid section maintenance items is dependent on fluid abrasiveness, cycle rate, pressure conditions, temperature, compatibility of the fluid, and duty cycle).

MAINTENANCE RECOMMENDATIONS – PUMP CRANKCASE		
Maintenance Item	**Frequency**	**Indication**
Oil Change/ Filter Element	Every 5,000 hrs or once per year	Scheduled
Rubber Bellows	Every diaphragm change	Preventative to ensure robust protection of pump actuator.
Balls	As needed (General rule of thumb is to replace balls every other diaphragm change)	Erratic pump behavior, excessive pulsation, inability to dead-head pump with the pump continuing to cycle, reduction in flow
Seats	As needed	Visual inspection
PRV Bellows	As needed	Leak is contained and directed to one of the 3 air caps where the pump will be shut down by the VFD due to fluid detection by the optical leak detection sensor installed that air cap. VFD alarm text "Diaphragm 1, 2 or 3 Leak".

NOTE: As Engineer and field units gather more hours and the oil is analyzed, this recommendation is likely to be relaxed to longer intervals.
Check for seize bearing - during pump maintenance (Especially every diaphragm change), it is recommended to rotate the crankshaft manually to certain that it is rotating freely.
Monitor oil level in crankcase assembly through sight glass fitted in pump.
Depend on the process fluid and ambient temperature, Oil temperature is slightly higher which in turn dissipate heat to crankcase component. It is recommend to monitor the temperature regularly.

MAINTENANCE RECOMMENDATIONS – GEAR MOTOR		
Maintenance Item	**Frequency**	**Indication**
Drain condensation from motor drive end	Every 6 months (sooner in high humidity and large temperature swing environments)	Scheduled
Oil Change	Every 25,000 hrs or every 5 years	Scheduled
Replace Seals	Every 5,000 hrs or every 3 years	Scheduled

NOTE: If IP rating of motor is not important for a specific application, drain plugs in motor can be permanently removed.

10.1. Service Kits

Refer to Model Description Chart to match the pump material options.
637555-XX for Fluid section repair (see page 24).
67557-X for PRV section assembly (see page 27).
EP20-CSVX-00-A for Actuator section repair (see page 29).

Air Cap Material
A - Aluminum
S - Stainless Steel

637556 for Pump Crankcase seals service kit (see page 29).
637557 for Oil and Filter replacement (see page 32).
67558 for Oil piston pump assembly (see page 32).

PARTS LIST / FLUID SECTION EP20-XXXXX-XXX-XXXX

Fluid Section Service Kits:

★ 637555-XX Fluid Section Service Kits include: Balls (see BALL Option, refer to -XX in chart below), Diaphragms (see DIAPHRAGM Option, refer to -XX in chart below), and items 3, 4, 12, 13 and 19 (listed below).

EXTERNAL HARDWARE OPTIONS EP20-XXXXX-XXX-XXX

Item	Description (size)	Qty	Aluminum / Cast Iron		Stainless Steel	
			Part No.	Mtl	Part No.	Mtl
26	Screw (M10 x 1.5 - 6g x 30 mm)	(12)	Y255-102-E	[C]	----	---
	Flange Screw (M10 x 1.5 - 6g x 30 mm)	(12)	----	---	95884	[SS]
27	Bolt (M10 x 1.5 - 6g x 45mm)	(30)	Y255-105-E	[C]	----	---
	Flange Bolt (M10 x 1.5 - 6g x 45mm)	(30)	----	---	94990	[SS]
28	Flat washer (M10)	(42)	98214	[C]	---	--
29	Flange Nut (M10 x 1.5 - 6)	(30)	98217	[C]	94992	[SS]
68	Screw (M10 x 1.5 - 6g x 30 mm)	(16)	Y255-102-E	[C]	----	---
	Flange Screw (M10 x 1.5 - 6g x 30 mm)	(16)	----	---	95884	[SS]
69	Flat washer (M10)	(16)	98214	[C]	---	--

COMMON PARTS

Item	Description (size)	Qty	Part No.	Mtl
★ 3	O - Ring (1/16" x 3/4" OD)	(3)	Y327-16	[V]
★ 4	O - Ring (1/16" x 3/4" OD)	(3)	Y328-16	[T]
9	Washer	(3)	98213	[SS]
★ 12	Diaphragm, Soft Washer	(3)	98026	[SP]
★ ⊙ 13	Bellows	(3)	97868-2	[V]
14	Screw (M16-2 x 70 mm)	(3)	98207	[SS]
⊙ 16	Bellows Plate	3)	97864-2	[SS]
⊙ 17	Screw (M5 x 0.8 - 6g x 10 mm)	(12)	98057	[SS]
18	Spacer, Piston	(3)	98039	[C]
20	Roll Pin (1/8" x 0.5" length)	(6)	Y178-37-S	[SS]

⊙ Indicate parts included in Actuator section service kit parts, see page 29

SEAT OPTIONS EP20-XXXXX-XXX-XXX

"21"

-XXXXX	Seat	Qty	Mtl	-XXXXX	Seat	Qty	[Mtl]
-XXAXX	95825-A	(6)	[Sp]	-XXGXX	95825-G	(6)	[B]
-XXCXX	95825-C	(6)	[H]	-XXHXX	95891	(6)	[SH]
-XXEXX	95893	(6)	[C]	-XXSXX	95877	(6)	[SS]
-XXFXX	95892	(6)	[A]				

BALL OPTIONS EP20-XXXXX-XXX-XXX

★ "22" (1-1/4" dia.)

-XXXXX	Ball	Qty	Mtl	-XXXXX	Ball	Qty	Mtl
-XXXAX	95826-A	(6)	[Sp]	-XXXSX	95878	(6)	[SS]
-XXXCX	95826-C	(6)	[H]	-XXXTX	95826-4	(6)	[T]
-XXXGX	95826-2	(6)	[B]	-XXXVX	95826-3	(6)	[V]

DIAPHRAGM OPTIONS EP20-XXXXX-XXX-XXX

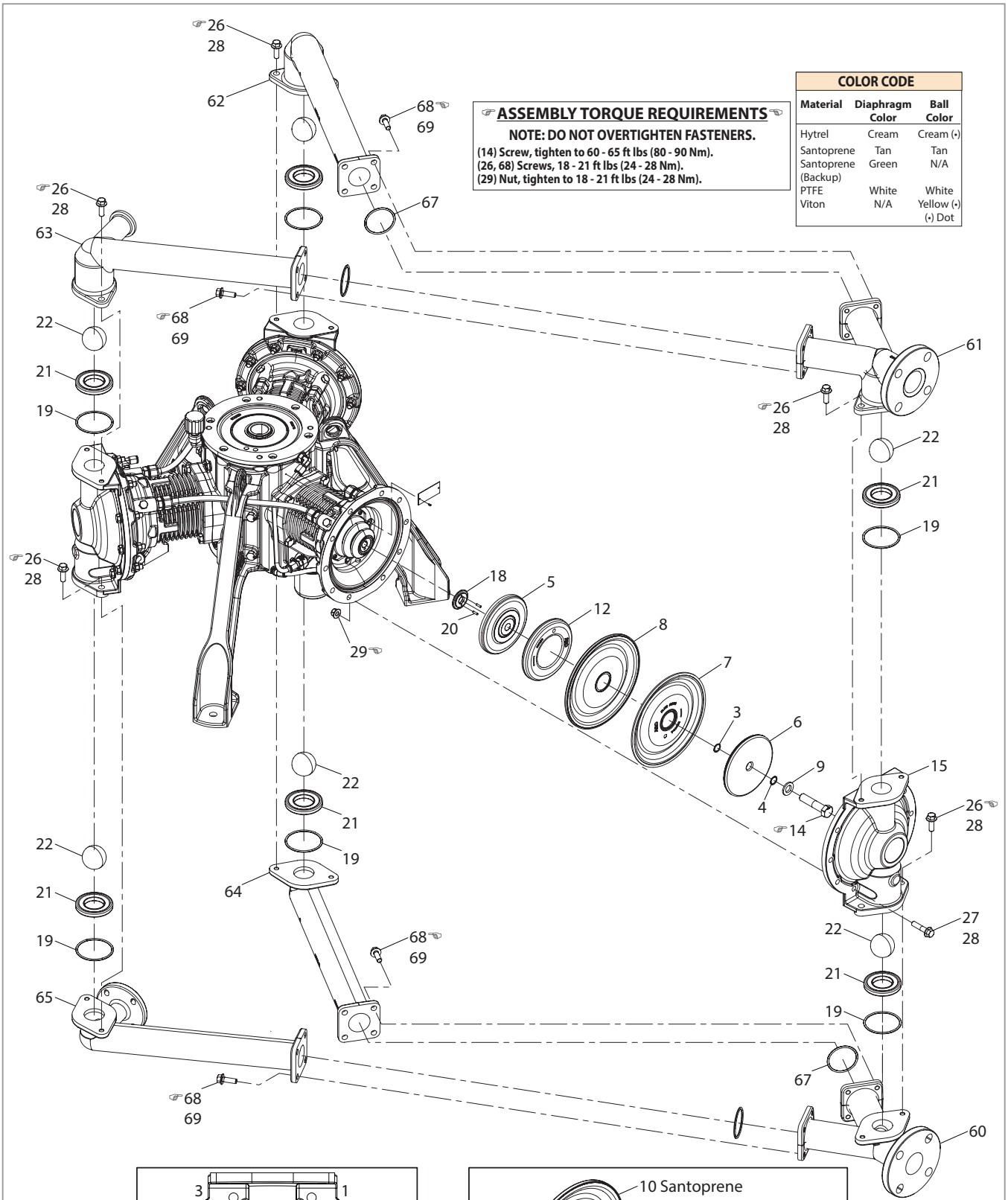
-XXXXX	★ Service Kit	★ "7"			★ "8"			★ "10"			★ 19"			"67"		
	-XX = (Ball) -XX = (Diaphragm)	Diaphragm	Qty	Mtl	Diaphragm	Qty	Mtl	Diaphragm	Qty	Mtl	O - Ring (1/8" x 3-1/8" OD)	Qty	Mtl	O - Ring (1/8" x 3-1/8" OD)	Qty	Mtl
-XXXXA	637555-XA	97973-A	(3)	[Sp]	97974-A	(3)	[Sp]	----	--	---	95992	(3)	[EP]	Y323-229	(4)	[EP]
-XXXXT	637555-XT	97975	(3)	[T]	97976-A	(3)	[Sp]	97977-A	(3)	[Sp]	Y328-233	(3)	[T]	Y324-229	(4)	[F]

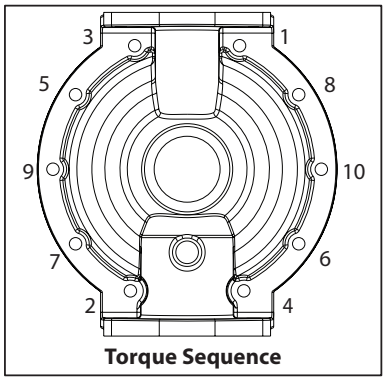
MANIFOLD / FLUID CAP MATERIAL OPTIONS EP20-XXXXX-XXX-XXX

Item	Description (size)	Qty	Aluminum EP20-AXXXX		Cast Iron EP20-CXXXX		Stainless Steel EP20-SXXXX	
			Part No.	[Mtl]	Part No.	[Mtl]	Part No.	[Mtl]
5	Backup Washer	(3)	98038-3	[C]	98038-3	[C]	98038-1	[SS]
6	Fluid Washer	(3)	98037-3	[C]	98037-3	[C]	98037-1	[SS]
15	Fluid Cap	(3)	97960	[A]	98090	[CI]	98091	[SS]
60	Manifold, Inlet Wye	(1)	98045	[A]	98069	[CI]	98083	[SS]
61	Manifold, Outlet Wye	(1)	98046	[A]	98070	[CI]	98085	[SS]
62	Manifold, Outlet Straight	(1)	98043	[A]	98068	[CI]	98082	[SS]
63	Manifold, Outlet PRV Wye	(1)	98042	[A]	98067	[CI]	98081	[SS]
64	Manifold, Inlet Straight	(1)	98040	[A]	98065	[CI]	98078	[SS]
65	Manifold, Inlet PRV Wye	(1)	98041	[A]	98066	[CI]	98079	[SS]

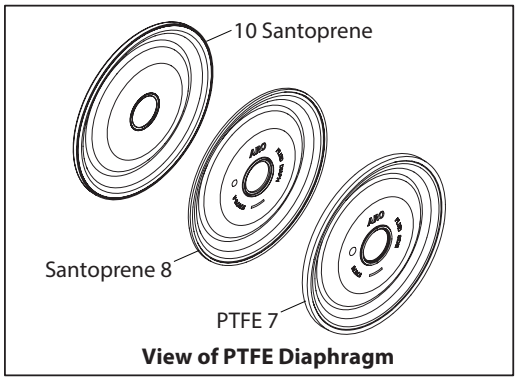
MATERIAL CODE

[A]	= Aluminum
[B]	= Nitrile
[Br]	= Brass
[C]	= Carbon Steel
[CI]	= Cast Iron
[Co]	= Copper
[D]	= Acetal
[EP]	= EPDM
[F]	= FEP
[H]	= Hytrel
[N]	= Nitrile
[NEP]	= Neoprene
[Ny]	= Nylon
[P]	= Polypropylene
[PU]	= Polyurethane
[SH]	= Hard Stainless Steel
[SP]	= Santoprene
[SS]	= Stainless Steel
[T]	= PTFE
[V]	= Viton





Torque Sequence



View of PTFE Diaphragm

Figure 9

FLUID SECTION DISASSEMBLY

- Remove inlet manifolds (60, 64, 65) & outlet manifolds (61, 62, 63) together
- Separate inlet wye Manifold (60), Inlet PRV manifold (65) & Inlet Straight manifold(64).
- Separate outlet wye manifold (61), outlet PRV manifold (63) & Outlet Straight manifold(62).
- Remove O-ring (67) between manifold flanges.
- Remove (22) balls, (19) "O" rings and (21) seats.
- Remove (15) fluid caps.
- NOTE: Bilayer Diaphragm used primary diaphragm (7) and backup diaphragm (8). PTFE diaphragm models use a primary diaphragm (7) and a bilayer backup diaphragm (8 & 10). Refer to the auxiliary view in the Fluid Section illustration.
- Remove diaphragm bolt (14), washer (9), outer diaphragm washer (6), primary Diaphragm (7), back up diaphragm (8 & 10), Inner Diaphragm washer (5), Diaphragm soft pad (12), spacer (18).
- Remove Bellows plate (16) and Bellows (13)

NOTE: Do not scratch or mark the surface of Piston rod (134).

FLUID SECTION REASSEMBLY

- Reassemble parts in reverse order from the sequence in which they were removed. Refer to the torque requirements on page 25.
- Clean and inspect all parts. Replace worn or damaged parts with new parts as required.
- Install Bellows (13), Bellows plate (16) and secure with socket head screw (17).
- All model except PTFE diaphragm, back up diaphragm (8) is installed with the side marked "DRIVE DIAPH" towards actuator. Installed primary diaphragm (7) with the side marked "FLUID DIAPH" towards the fluid cap (15).
- Models with PTFE diaphragms: backup diaphragm (10) is installed with the side marked "DRIVE DIAPH" towards the actuator. Installed Second back up diaphragm (8) with the side marked " FLUID DIAPH" toward the (15) fluid cap. Install the PTFE diaphragm (7) with the side marked "FLUID SIDE" towards the (15) fluid cap.
- Install Spacer (18), diaphragm soft pad (12), Inner Diaphragm washer (5), primary diaphragm (7), back up diaphragm (8 & 10), outer Diaphragm washer (6), screw washer and secure it with Diaphragm bolt (14). Ensure O-ring (3) is placed onto bore seal and O-ring (4) is placed onto face seal groove of outer diaphragm washer (6)
- Install Fluid cap (15) through hex head bolt (27) & nut (29).
- Install (21) seats, (19) "O" rings and (22) balls.
- Assemble outlet wye manifold (61) to outlet PRV manifold (63) & Outlet Straight manifold (62) and secure with hex head bolt (68). Ensure O-ring (67) is placed between manifolds
- Assemble inlet wye Manifold (60) to Inlet PRV manifold (65) & Inlet Straight manifold (64) and secure with hex head bolt (68). Ensure O-ring (33) is placed between manifolds
- Install inlet manifold assembly (60, 64, 65,) and outlet manifold assembly (61, 62, 63) and secure with hex head bolt (26).

NOTE: Washer (28, 69) is used for Aluminum and Cast Iron pump configuration

- Re-check torque settings after pump has been re-started and run awhile.

PARTS LIST / PRV EP20-XXXXX-XXX-XXX

MANIFOLD / HOUSING MATERIAL OPTIONS EP20-XXXXX-XXX-XXX

			Aluminum		Cast Iron		Stainless Steel	
Item	Description (size)	Qty	Part No.	[Mtl]	Part No.	[Mtl]	Part No.	[Mtl]
40	PRV ASSY	(1)	67557-1	---	67557-2	---	67557-3	---
❖ 44	Housing, PRV	(1)	97971	[A]	98073	[CI]	98087	[SS]
46	Manifold, PRV Return	(1)	98048	[A]	98072	[CI]	98086	[SS]

EXTERNAL HARDWARE OPTIONS EP20-XXXXX-XXX-XXX

Item	Description (size)	Qty	Aluminum / Cast Iron		Stainless Steel	
			Part No.	Mtl	Part No.	Mtl
❖ 41	O-Ring (3/32" x 1-3/8" OD)	(4)	Y323-123	[EP]	Y324-123	[F]
❖ 50	Cap Spring, PRV	(1)	97972-1	[C]	97972-2	[SS]
❖ 52	Bolt (M8 x 1.25 - 6g x 30 mm)	(5)	Y255-83-E	[C]	-----	--
	Flange Bolt (M8 x 1.25 - 6g x 30 mm)		-----	--	95880	[SS]
❖ 53	Flanged Top Lock Nut (M8 x 1.25)	(5)	98220	[C]	95879	[SS]
❖ 54	Washer (M8)	(5)	98215	[C]	-----	--
55	Bolt (M10 x 1.5 - 6g x 45mm)	(4)	Y255-105-E	[C]	----	---
	Flange Bolt (M10 x 1.5 - 6g x 45mm)	(4)	----	---	94990	[SS]
56	Flat washer (M10)	(4)	98214	[C]	---	--
57	Flange Nut (M10 x 1.5 - 6)	(4)	98217	[C]	94992	[SS]
★ 58	O-Ring (1/8" x 2" OD)	(1)	Y323-224	[EP]	Y324-224	[F]
❖ 66	Cylinder, PRV	(1)	97982-1	[C]	97982-2	[SS]

COMMON PARTS

Item	Description (size)	Qty	Part No.	Mtl
37	Clamp	(4)	93283	[SS]
38	Carriage Bolt (1/4" x 20 - 6g x 1-1/2")	(4)	Y84-403-T	[SS]
39	Nut (1/4" - 20)	(4)	Y12-4-S	[SS]
❖ 42	Bellows, PRV	(1)	97981	[T]
❖ 43	O-Ring (1/8" x 2-5/8" OD)	(1)	Y327-229	[V]
❖ 45	Rod, PRV	(1)	97980	[SS]
❖ 47	Piston, PRV	(1)	97979	[D]
❖ 48	O-Ring (7/32" x 2" OD)	(1)	Y327-326	[V]
❖ 49	Spring, PRV	(1)	97978	[C]
❖ 51	Fitting (3/8" OD Tube x 1/4" NPT)	(1)	59474-160	[Ny]
184	3/8" Tube x 50 or 100 ft rolls (Poly, Black)		TBD 7	

❖ Indicate parts included in PRV assembly 67557-X (40). ★ Indicate parts included in Fluid section service kit, see page 24.

PRV SECTION DISASSEMBLY

- Disconnect 3/8" OD tube (184) between PRV housing (44) and air cap (147).
- Loosen clam shell (37) between PRV return manifold (66) and PRV housing (44). Remove PRV return manifold (46) from inlet PRV manifold (65).
- Loosen clam shell (37) between outlet PRV manifold (63) and PRV housing (44). Remove PRV housing (44).
- Remove PRV cap (50), spring (49), piston assembly (45 & 47), and O-ring (48).
- Remove PRV cylinder (66) from PRV housing (44)
- Remove Bellows (42) and O-ring (43) from PRV housing (44).

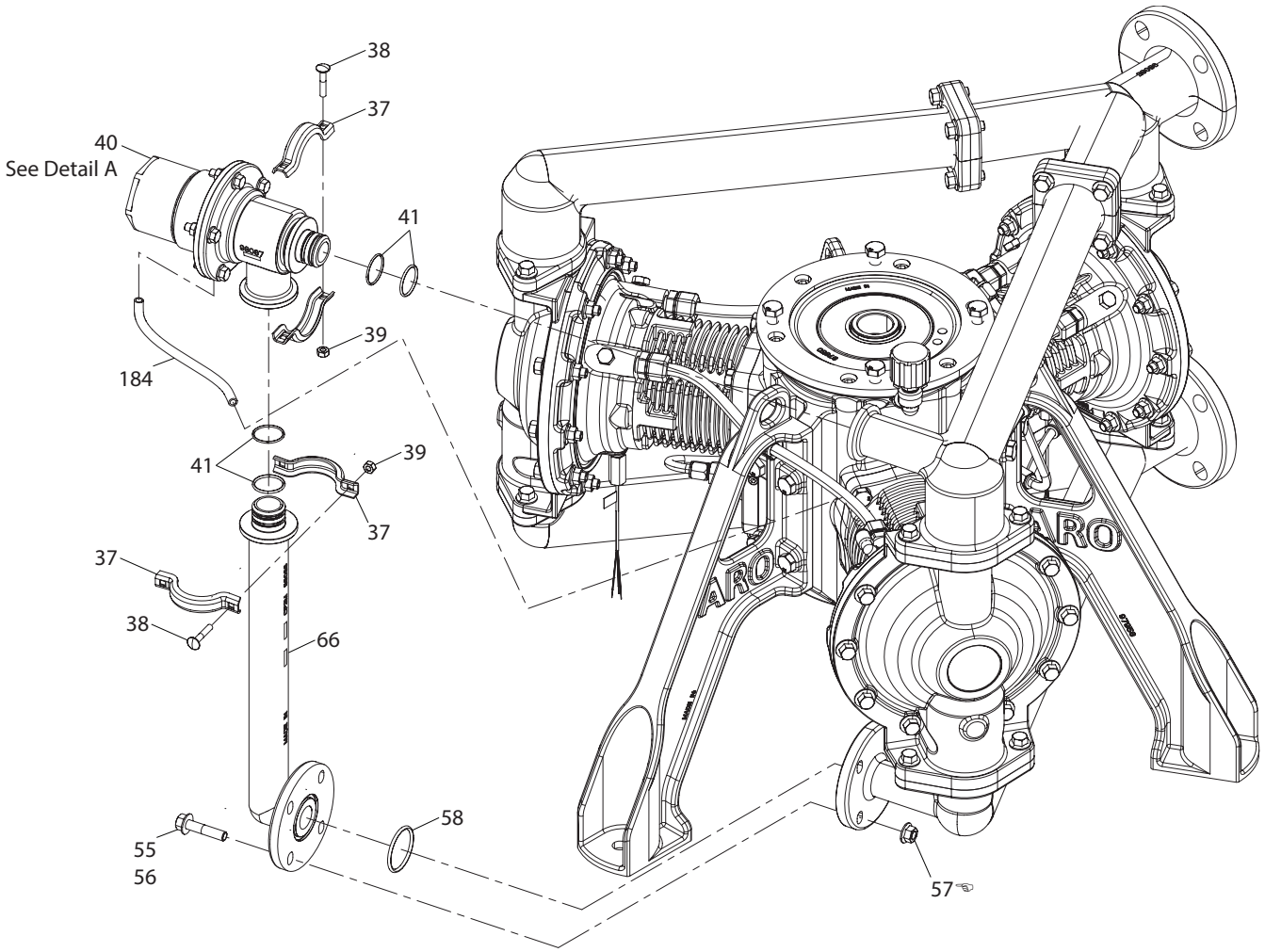
PRV SECTION REASSEMBLY

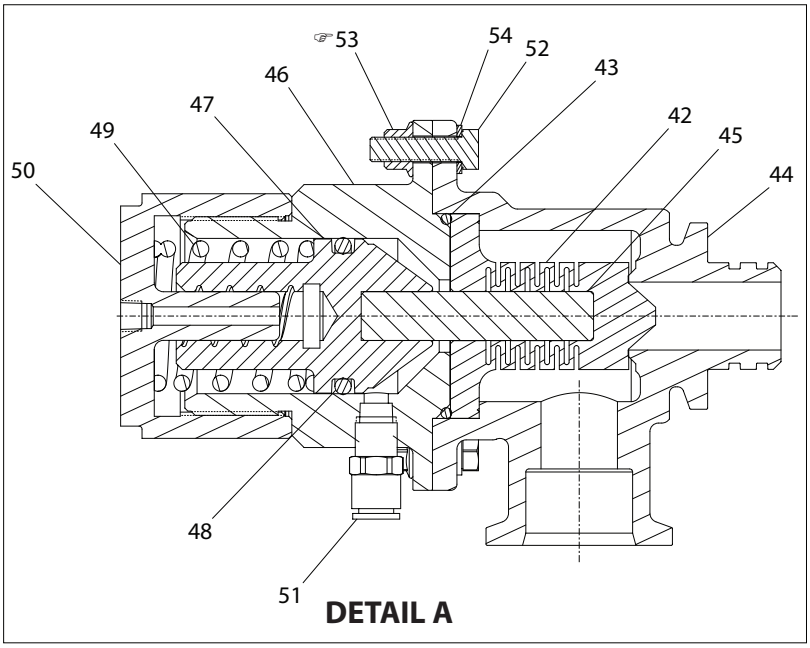
- Reassemble parts in reverse order from the sequence in which they were are removed.
- Clean and inspect all parts. Replace worn or damaged parts with new parts as required.
- Assemble PTFE bellows (42) and O-ring (43) into PRV housing (44).
- Assemble PRV cylinder (66) to PRV Housing (44)
- Assemble O-ring (48) to piston assembly (45 & 47)
- Assemble piston assembly (45 & 47), spring (49) and PRV cap (50).
- Install O-ring (41) onto PRV housing (44) and PRV return manifold (46).
- Assemble inlet of PRV housing (44) to Outlet PRV Manifold (63) and loosely install clam shell (37) with carriage bolts (38) and nuts (39).

- Assemble outlet of PRV housing (44) to PRV return manifold (66) and loosely install clam shell (37) with carriage bolts (38) and nut (39).
- Assemble PRV return manifold (66) to inlet PRV manifold (65) and ensure O-ring (54) in place.
- Reconnect 3/8" OD tube (184) to push-to-connect fitting (51) installed in PRV housing (44).

CAUTION: PRV is not a safety device.
It is designed for the pump to be able to achieve fully dead-head condition and maintain pressure in response to valve closure or blockage downstream.

PARTS LIST / PRV EP20-XXXXX-XXX-XXX





ASSEMBLY TORQUE REQUIREMENTS
NOTE: DO NOT OVERTIGHTEN FASTENERS.
(53) Nut, tighten to 7 - 9.5 ft lbs (10 - 13 Nm).
(57) Nut, tighten to 18 - 21 ft lbs (24 - 28 Nm).

Figure 10

PARTS LIST / ACTUATOR EP20-XXXXX-XXX-XXX

⊙ **Actuator Section Service Kits EP20-CSVX-00-A include:** Items 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 133, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 126, 127, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 180, 181, 182, 183, 184, 185, 186, 187, 189 and 190 (listed below), Item 13, 16 and 17 shown on page 24 are also included in kit.

Note: Actuator component are designed for it's intended life. Pump to be operating with in prescribed limit, specified in operator manual. Bearings are press fitted and can not be service individually.

Item	Description (size)	Qty	Part No.	[Mtl]
101	Main Housing	(1)		[CI]
102	Housing Cap	(1)		[CI]
○ 103	O-Ring (1/8" x 7-3/4" OD)	(1)	Y325-264	[N]
104	Screw (M10 x 1.5 - 6g x 35 mm)	(6)	Y256-104-E	[C]
105	Leg	(3)	97958	[C]
106	Screw (M12 x 1.75 - 6g x 40 mm)	(12)	Y255-123-E	[C]
107	Bearing, Upper	(1)		[C]
108	Snap Ring (55 mm OD)	(1)	97956	[C]
109	Shaft Seal, Upper	(1)	98053	[N]
110	Shaft Sleeve, Upper	(1)		[SS]
111	Bearing, Lower	(1)		[C]
○ 112	Shaft Seal, Lower	(1)	97870	[N]
113	Shaft Sleeve, Lower	(1)		[SS]
114	Lower Cap	(1)	97869	[C]
115	Screw (M6 x 1 - 6g x 20 mm)	(3)	Y256-63-E	[C]
○ 116	O-Ring (1/8" x 1-3/4" OD)	(1)	Y325-222	[N]
○ 117	O-Ring (1/8" x 3-3/4" OD)	(1)	Y325-238	[N]
118	ASM, Crankshaft (Spline)	(1)		[C]
119	Bearing, Throw	(3)		[C]
120	Bearing, Spacer	(3)		[C]
121	Connecting Rod, Bearing-Side	(3)		[CI]
122	Roll Pin (M3 x 8 mm)	(6)	25M13EA213	[C]
123	Cottor pin	(1)	97859	[C]
124	Cam	(1)		[D]
125	Screw (M6 x 1 - 6g x 20 mm)	(2)	Y256-63-E	[C]
126	Breather (3/8" -18 NPT)	(1)	98178	[Ny]
127	Elbow (3/8" - 18 NPT)	(1)	98218	[Ny]
130	Cylinder	(3)	98182	[C]
131	Screw (M12 x 1.75 - 6g x 40 mm)	(12)	Y255-123-E	[C]
○ 132	O-Ring (1/8" x 5" OD)	(3)	Y325-248	[N]
133	Rider Band	(3)	98184	[Br]
134	Piston	(3)	98181-1	[C]
135	Wrist Pin	(3)		[C]
136	Snap Ring (25mm ID)	(3)	98205	[C]
137	Dowel Pin (M3 x 40 mm)	(3)	17M13B170	[C]
138	Screw (M4 x 0.7 - 6g x 8 mm)	(3)	119M2A126B	[C]

Item	Description (size)	Qty	Part No.	[Mtl]
139	Wrist Pin Journal	(3)		[Br]
140	Connecting Rod, Journal-Side	(3)		[C]
141	Screw (5/16-18 x 1")	(6)	97867	[C]
142	Wear Ring	(3)	98183	[Ny]
○ 143	U-Cup Seal	(30	97875	[PU]
144	Bushing, Vent	(3)	98180	[Ny]
○ 145	O-Ring (1/8" x 4-1/4" OD)	(3)	Y325-242	[N]
146	Screw (M12 x 1.75 - 6g x 30 mm) (EP20-AXXXX-XXX-XXX) (EP20-CXXXX-XXX-XXX)	(12)	Y256-122-E	[C]
	Screw (M12 x 1.75 - 6g x 30 mm) (EP20-SXXXX-XXX-XXX)	(12)	119M2H274	[SS]
147	Air Cap (EP20-AXXXX-XXX-XXX) (EP20-CXXXX-XXX-XXX)	(3)	97861	[A]
	Air Caps (EP20-SXXXX-XXX-XXX)	(3)	98088	[SS]
148	Roll Pin (M6 x 16 mm)	(7)	25M13EA467	[C]
180	Drain Plug (3/8"-18 NPT)	(1)	98062	[C]
181	"Fitting (3/8" OD Tube x 1/4" NPT 90° Elbow)"	(3)	59756-160	[Ny]
182	"Fitting (3/8" OD Tube x 1/4" NPT 45° Elbow)"	(3)	98060	[Ny]
183	Fitting (1/2" OD Tube x 3/8" NPT)	(6)	98054	[P]
184	"3/8" OD Tube x 50 or 100 ft rolls (Poly, Black)"		TBD 7	
185	"1/2"" OD Tube x 50 or 100 ft rolls (Poly, Black)"		TBD 34	
186	Grommet, Air Cap Tubing	(3)	98189	[NEP]
187	Ground Lug (1/4" - 20)	(1)	96878	[Co]
188	Fitting (3/8" OD Tube x 1/4" NPT 90° Elbow)	(1)	59756-160	[Ny]
189	Plug	(5)	98056	[Ny]
190	Sight Glass (1/2" - 14 NPT)	(1)	98061	
192	Screw (M12 x 1.75 - 6g x 30 mm)	(4)	Y255-121-E	[C]
□ 200	Oil container (2.5 gal)	(1)	67570	
283	Leak Detection (2 meter cable)	(3)	See page 13	

□ **Item 172 and Item 200 shown on page 21 included in 637557 Oil and filter replacement kit.**

○ **Indicate parts included in 637556 Pump Crankcase Seal Service Kit shown above and items 151, 154, 156, 157 and 165 shown on page 32.**

ACTUATOR SERVICE

- Actuator Section Service is continued from Fluid Section repair.
- Separate motor from actuator
- Inspect and replace old parts with new parts as necessary. Look for deep scratches on surfaces, and nicks or cuts in "O" rings.
- Take precautions to prevent cutting "O" rings upon installation.
- Lubricate "O" rings with crank case oil. (To validate oil compatibility if using different lubricant).
- Do not over-tighten fasteners, refer to torque specification block on view.
- Torque fasteners following restart.

ACTUATOR DISASSEMBLY

- Remove all flexible tube connection
- Remove lower cap (114).
- Adjust Piston rod (134) position by rotating crank shaft (118) for ease in removing internal component
- Remove Vent Bushing (144), Piston seal (143), Air cap (147), Piston wear ring (142), Cylinder(130).

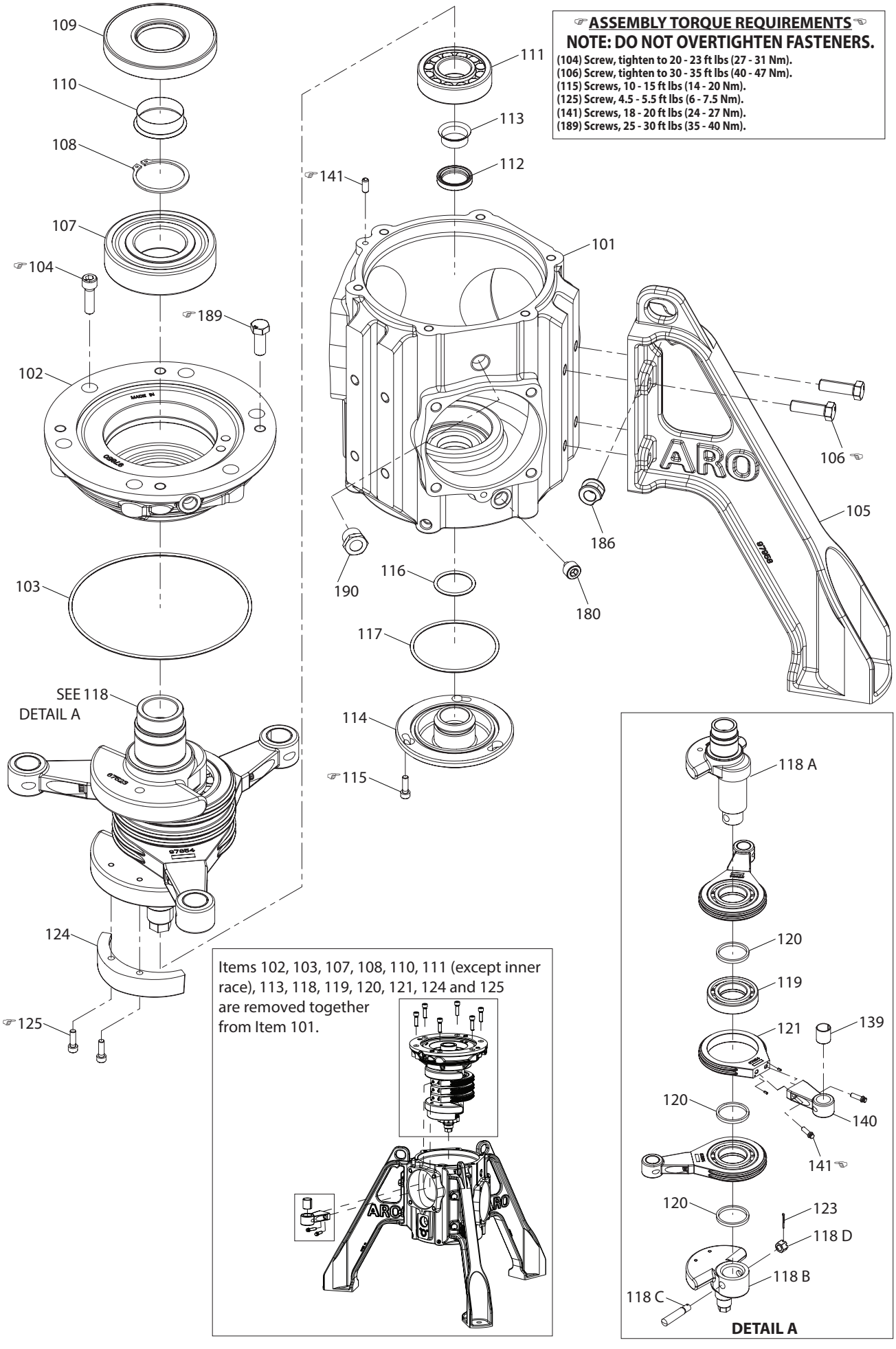

ASSEMBLY TORQUE REQUIREMENTS
NOTE: DO NOT OVERTIGHTEN FASTENERS.
(104) Screw, tighten to 20 - 23 ft lbs (27 - 31 Nm).
(106) Screw, tighten to 30 - 35 ft lbs (40 - 47 Nm).
(115) Screws, 10 - 15 ft lbs (14 - 20 Nm).
(125) Screw, 4.5 - 5.5 ft lbs (6 - 7.5 Nm).
(141) Screws, 18 - 20 ft lbs (24 - 27 Nm).
(189) Screws, 25 - 30 ft lbs (35 - 40 Nm).
109
110
108
107
104
189
102
103
SEE 118
DETAIL A
124
125
111
113
112
141
101
106
105
186
180
190
116
117
114
115
ARO
Items 102, 103, 107, 108, 110, 111 (except inner race), 113, 118, 119, 120, 121, 124 and 125 are removed together from Item 101.
118 A
120
119
121
139
140
141
123
118 D
118 B
118 C
DETAIL A

Figure 11

- Remove internal snap ring (136) and the wrist pin (135).
- Remove the piston rod (134) and rider band (133).
- Journal Bearing (139) is press fitted in to the connecting rod (140) from the factory. Remove the connecting rod (140) along with Journal (139).
- All bearing races are press fitted. However lower bearing (111) is separable between its Inner and outer race.
- Remove Housing cap (102), crank shaft assembly (118), Bearing housing (121) from crankcase Housing (101).
- Ensure bearing housing (121) oriented in the same direction in order to remove from the crankcase housing (101).

ACTUATOR ASSEMBLY

- Reassemble parts in reverse order from the in a sequence in which they were are removed.
- Clean and inspect all parts. Replace worn or damaged parts with new parts as required.
- If cam (124) needs to be replaced. It should be serviced prior to installing the crankshaft (118) into the housing (101).
- If wrist pin journal (139) needs to be replaced. It should
- be serviced prior to installing the connecting rod (140).
- To replace Journal (139), arbor press need to be use to press new Journal while simultaneously pushing out the old journal.
- Install lower shaft seal (112) into crankcase housing (101). Ensure O-ring (103) is installed onto housing cap.
- Lower crankshaft assembly vertically inside crankcase housing (101) and allow inner race of lower bearing to gently engage with outer race. Secure housing cap to housing (101) with socket head screws (104).
- Install lower cap (114) and secure with socket head screws (115). Ensure O-rings (116 and 117) are installed onto the lower cap (114).
- Assemble each of the connecting rods (140) to bearing housings (121) securing with 12 point ferry cap head screws (141).
- Install wrist pin (135) to connect piston (134) to connecting rod (140). Ensure slotted side of wrist pin (135) is facing down and engages with dowel pin (137) to prevent rotation.
- Install retaining ring (136) to hold wrist pin (135) in place.
- Install rider band (133) onto the piston (134).
- Install cylinder (130) over piston (134) and secure to housing (101) with hex head screws (131). Ensure O-ring (132) is installed onto the cylinder (130).
- Install Piston wear ring (142), Piston seal (143), vent bushing (144), Bellows (15) and retaining ring (16) on to the air cap (147) and secure with socket head screws (17).
- Install air cap (147) to the cylinder (130) and secure with socket head screws (131). Ensure O-ring (145) is installed onto the air cap (147).

NOTE: Connecting rod housing (121) need to be oriented in the same direction to fit in the crankcase housing (101).

PARTS LIST / ACTUATOR EP20-XXXXX-XXX-XXX

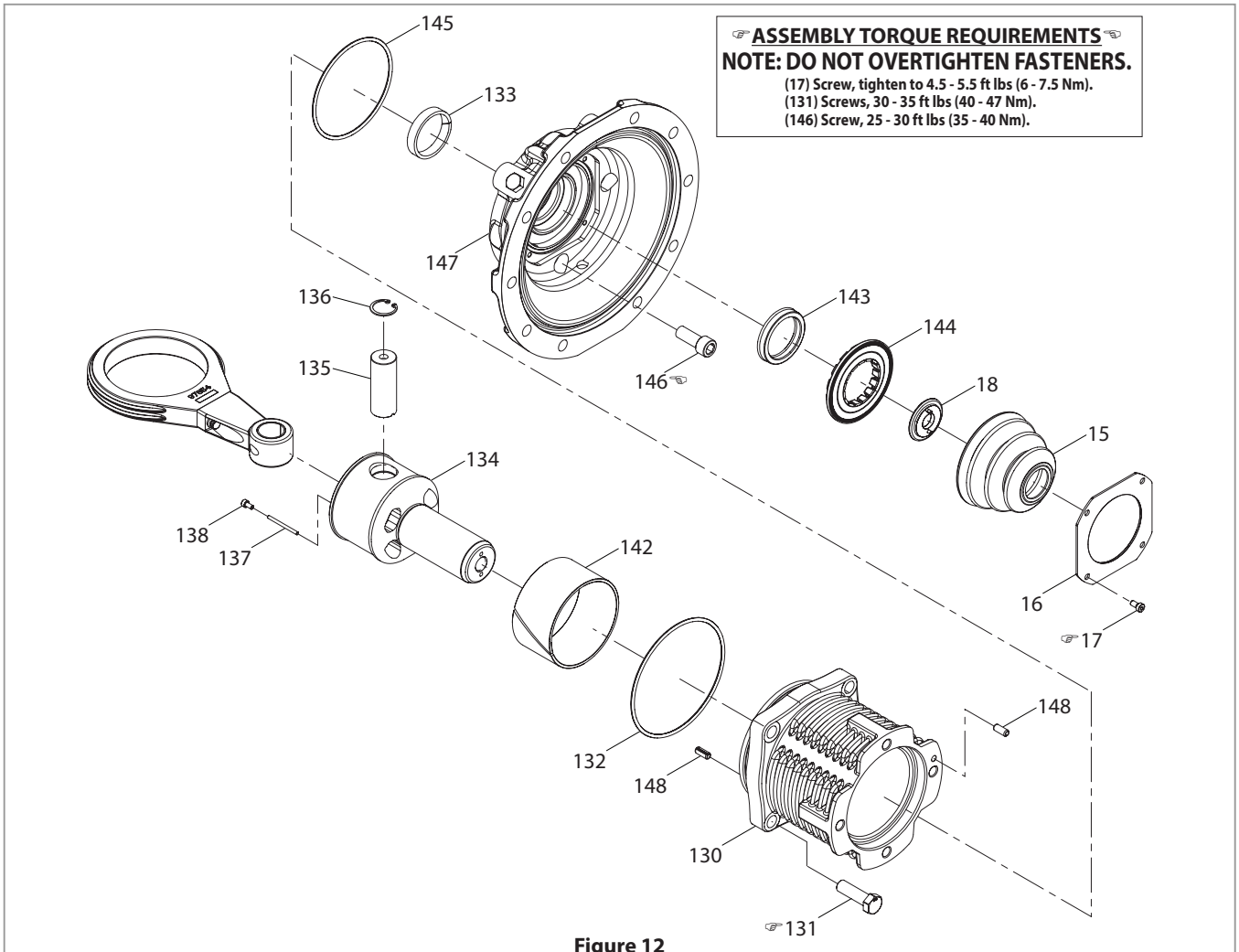


Figure 12

PARTS LIST / OIL PISTON PUMP ASSEMBLY SECTION EP20-XXXXX-XXX-XXX

Item	Description (size)	Qty	Part No.	[Mtl]
125	Screw (M6 x 1 - 6g x 20 mm)	(2)	Y256-63-E	[C]
128	Plug (3/8" - 18 NPT)	(1)	Y17-52-C	[C]
129	Fitting (9/16"-18 STOR x 3/8", 90°)	(1)	98059	[SS]
149	Oil Pump Assy (Item include 150 to 170)	(1)	67558-ZZ	
150	Screw (M6 x 1 - 6g x 20 mm)	(2)	Y256-63-E	[C]
○ ■ 151	O-Ring (3 mm x 36 mm OD)	(1)	97872	[N]
■ 152	Housing, Oil Return	(1)		[C]
■ 153	Cylinder, Oil Pump	(1)		[C]
○■ 154	O-Ring (3/32" x 1-9/16" OD)	(2)		[N]
■ 155	Outlet, Oil Pump	(1)		[C]
○■ 156	O-Ring (3/32" x 1-1/8" OD)	(1)		[N]
○■ 157	O-Ring (3/32" x 15/16" OD)	(1)		[N]
■ 158	Plug, Return	(1)		[C]
■ 159	Piston, Oil Pump	(1)		[C]
■ 160	Spring, Piston Return	(1)		[C]
■ 161	Wrist Pin Journal (20 ID x 20 L)	(1)		[Br]
■ 162	Ball	(1)		[C]
■ 163	Spring, Oil Relief	(1)		[C]
■ 164	Plug (1/8" -18 NPT) (not shown)	(1)		[SS]
○■ 165	O-Ring (3/32" x 11/16" OD)	(1)		[N]
■ 166	Valve	(2)		[D]
■ 167	Check Seat	(2)		[H]
■ 168	Spring, Poppet Valve	(1)		[C]
■ 169	Seat, Spring	(2)		[A]
■ 170	Internal Snap Ring (16 mm)	(2)		[C]
171	Oil Filter ASM	(1)	98063	[A]
□ 172	Oil Filter	(1)	98064	[A]
173	Filter Bracket	(1)	97957	[C]
174	Screw (1/4" -20 x 0.5")	(2)	98211	[C]
175	Screw (1/4" -20 x 0.5")	(2)	98211	[C]
176	Fitting (9/16"-18 STOR x 3/8")	(2)	98058	[SS]
177	Bent Tube, Pre Filter (3/8" OD)	(1)	98049	[SS]
178	Bent Tube, Post Filter (3/8" OD)	(1)	98050	[SS]
179	Fitting (3/4"-16 STOR x 3/8")	(1)	98055	[SS]

■ **Indicate parts included in 67558 Oil piston pump replacement assembly.**
○ **Indicate parts included Pump Crankcase Seal Service Kit, see page 29.**
□ **Indicate parts and Item 172, shown on page 29 included in 637557 Oil and filter replacement kit.**

OIL REPLACEMENT

⚠ WARNING

Disposing Oil as per local regulatory requirement.

- Remove 3/8" NPT magnetic drain plug (Item - 180), from crankcase housing below lowest cylinder.
  - Clean all foreign particles from the drain plug.
- Allow oil to drain from pump crankcase to the approved oil container for disposal.
- Unscrew Filter element from filter head.
- Remove lower cap (Item – 114) for inspection of any oil leakage and replace the lower shaft seal (Item – 112) accordingly
- Install new filter element.
  4. Lubricate filter head threads
  5. Lubricate new oil filter gasket.
  6. Hand screwed filter element to the head fully.
  7. Extra half turn by external mean to make sure there is no oil leakage during pump operation.

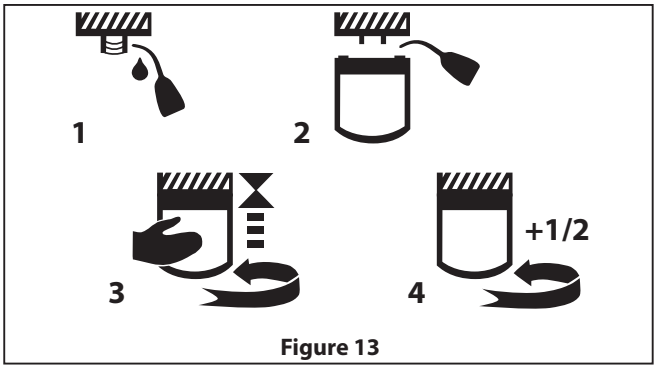


Figure 13

- Refill new oil to the crankcase housing as per instruction covered in section 8.1

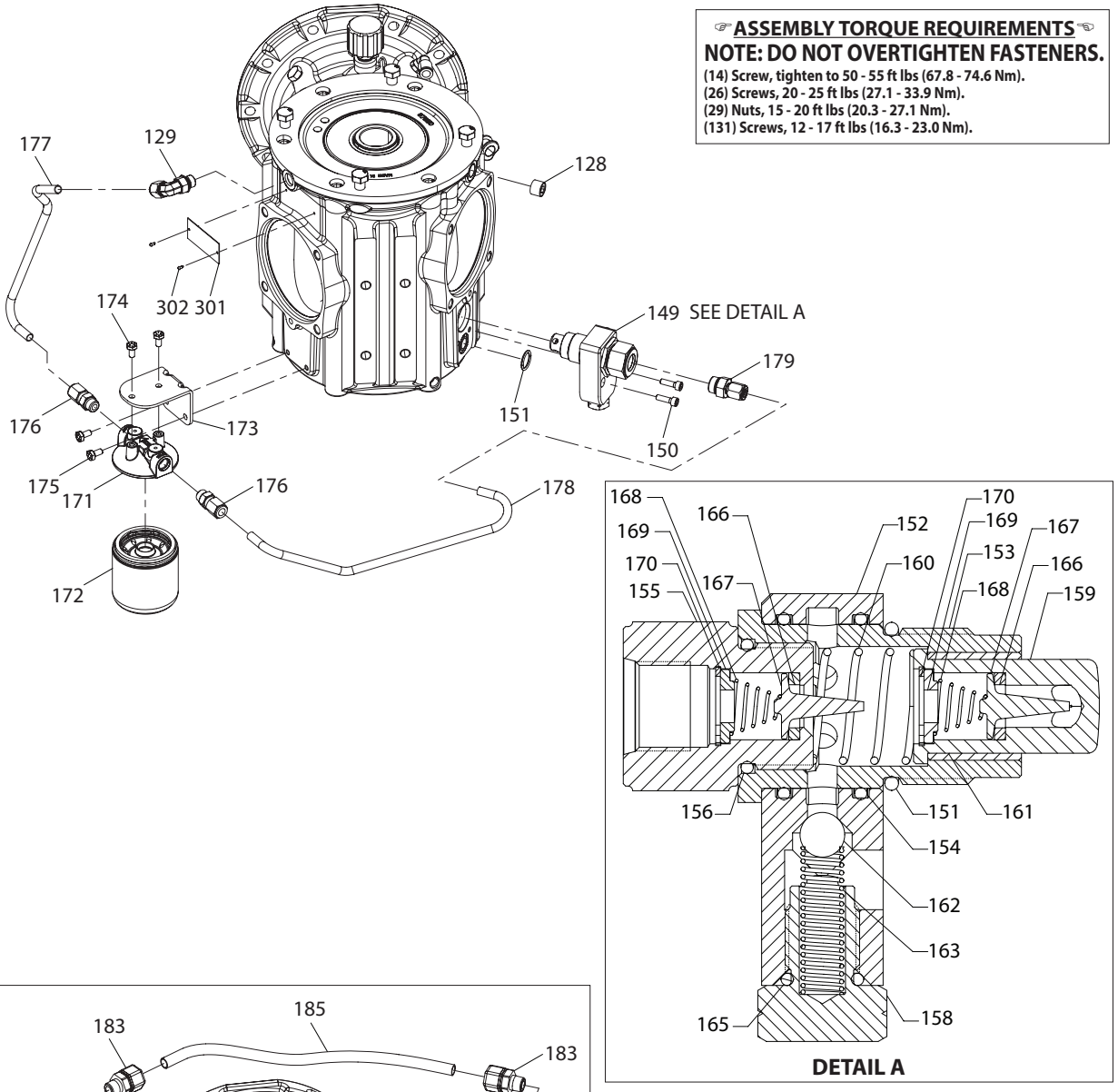
NOTE: ARO's ¼" pump (PXXX) or any mechanical pump can be used to ease oil draining from crankcase housing.

DISASSEMBLY OIL FILTRATION

- Ensure oil is drained from crankcase housing (101) before disassembly.
- Loosen the compression fitting nuts (176, 129, 179) and remove tubing (177 and 178) from fittings.
- Remove the compression fittings (176) from oil filter (172).
- Remove the compression fitting (129) from actuator cap (102).
- Remove the compression fitting (179) from outlet of piston pump housing (155).
- Unscrew filter element (172) from filter head (171).
- Remove oil pump assembly (149).

ASSEMBLY OIL FILTRATION

- Reassemble parts in reverse order from the in a sequence in which they were removed.
- Look for deep scratches on surfaces, and nicks or cuts in "O" rings. Replace with new seals.
- Assemble oil pump assembly to the crankcase housing (44).
- Assembly piston pump assembly (149) to oil pump return assembly. Ensure O-ring (151) is in place. Secure with socket head screws (150).
- Assemble Filter Head (171) to the oil filter bracket (173) and secure with hex head screws (174).
- Install 3/8" straight compression fittings (176) on both sides of filter head (172).
- Assemble filter element to the filter head.
- Assemble 3/8" straight compression fitting (179) to outlet of oil piston pump (155).
- Assemble 3/8" 90 degree compression fitting (129) to actuator cap (102).
- Assemble 3/8" OD metal tubing (177 and 178).


☞ASSEMBLY TORQUE REQUIREMENTS☜
NOTE: DO NOT OVERTIGHTEN FASTENERS.
(14) Screw, tighten to 50 - 55 ft lbs (67.8 - 74.6 Nm).
(26) Screws, 20 - 25 ft lbs (27.1 - 33.9 Nm).
(29) Nuts, 15 - 20 ft lbs (20.3 - 27.1 Nm).
(131) Screws, 12 - 17 ft lbs (16.3 - 23.0 Nm).
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129
128
174
302 301
149 SEE DETAIL A
179
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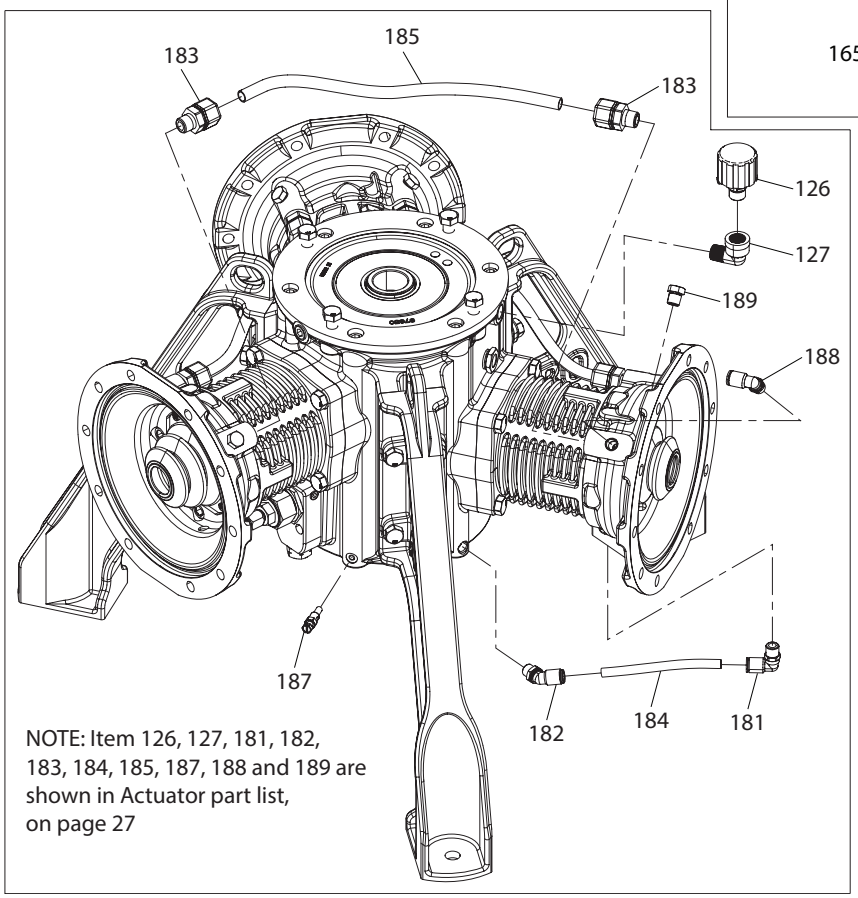
DETAIL A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NOTE: Item 126, 127, 181, 182, 183, 184, 185, 187, 188 and 189 are shown in Actuator part list, on page 27

Figure 14

12. TROUBLESHOOTING

Issue	Possible Cause	Action
Pump will not operate	Improper power wiring: Mains to VFD, VFD to Motor	See manual section xx for proper wiring instructions
	Improper sensor wiring: Leak detects, e-stop, motor thermal sensor, motor encoder	See manual section xx for proper wiring instructions and VFD settings
	Improper control wiring: Analog, digital, or serial interfaces	See manual section xx for proper wiring instructions and VFD settings
	Smart Setup not completed at VFD startup.	Complete Smart Setup. Quick Menu, Selection §4
	VFD Alarm	See VFD manual section xx for list of alarm codes.
	Torque limit set too low	Increase VFD parameter 4-16. Do not exceed 100%.
	Crankshaft bearing failure	Replace pump crankcase
Erratic behavior or Excessive Noise / Knocking	Excessive wear of wrist pin and/or journal	Replace wrist pin and journal
	Excessive wear of piston rider band and/or wear ring	Replace rider band and/or journal
	Missing ball check or excessive ball check wear or failure	Ensure ball checks are all installed, intact, and in place
	System operating outside of NPSH requirements	Ensure pump is running within NPSH requirements
	Foreign particle stuick in inlet manifold or ball check	Ensure no solid particles over solid passing capability are passed through the pump
Pump speed oscillating	Back pressure in system is varying and causing the pump to go in and out of torque limit	Increase VFD parameter 4-16 if constant speed is desired. Do not exceed 100%.
	Leak detects are tripping and beginning to stop the pump but sensor looses contact with fluid before the pump comes to full stop and returns to commanded speed	Ensure air caps and tubing are sufficiently cleaned after a diaphragm failureIncrease filter timer on leak detect sensitivity if nuisance trips cannot be avoided
Pump will not achieve pressure	Missing ball check or excessive ball check wear or failure	Ensure ball checks are all installed, intact, and in place
	Damage or failure of PRV bellows	Replace PRV Bellows
	Torque limit set too low	Increase VFD parameter 4-16. Do not exceed 100%.
Pump will not achieve flow	Missing ball check or excessive ball check wear or failure	Ensure ball checks are all installed, intact, and in place
	Excessive backpressure is causing pump to go into torque limit and reducing speed	Increase VFD parameter 4-16. Do not exceed 100%. Or decrease system backpressure.
Oil color turns black	Piston pump assembly is not functioning	Replace piston pump assembly
	Crankshaft cam is broken or damaged	Replace crankshaft cam
	Oil filter element needs to be replaced and is in bypass mode	Replace oil and filter
Pre-Mature Diaphragm Failure	Fluid cap bolts or diaphragm bolt loosened allowing air in between diaphragms	Use recommended torques for all fasteners. Re-torque all fluid section bolts prior to operation
PRV Bellows Failure	Excessive and repeated rapid dead-heading (rapid valve closure)	Dead-head (down-stream valve closure) should be done in a smooth and controlled manner
	Pump PRV used for maintain system pressure spikes or shocks	Pump PRV does not replace need for system safety or relief devices. Install system protection.
Rubber Bellows Failure	Bellows not replaced with each diaphragm change	Replace rubber bellows with each diaphragm replacement
	Excessive oil leak at piston seal limits breathing of rubber bellows and can collect in bellows	Replace piston seals and piston damaged
Process Fluid Leak	Loose connections	Use recommended torques for all fasteners. Re-torque all fluid section bolts prior to operation.
	Improper alignment of manifolds, PRV, and fluid caps	Follow recommended procedure from manual section xx for proper alignment
Excessive oil in section "1" of lower cap shown in figure 1	One or more of the reciprocating piston seals are worn or damaged	Replace piston seal
	Piston sealing surface is worn, scratched, or damaged	Replace piston and seal
	Excessive wear of piston wear ring or rider band	Replace wear ring and rider band
Excessive oil in section "2" of lower cap shown in figure 1	Shaft seal is worn or damaged	Replace shaft seal

13.1 Pump With Motor

(Dimensions shown are for reference only, they are displayed in inches and millimeters (mm)).

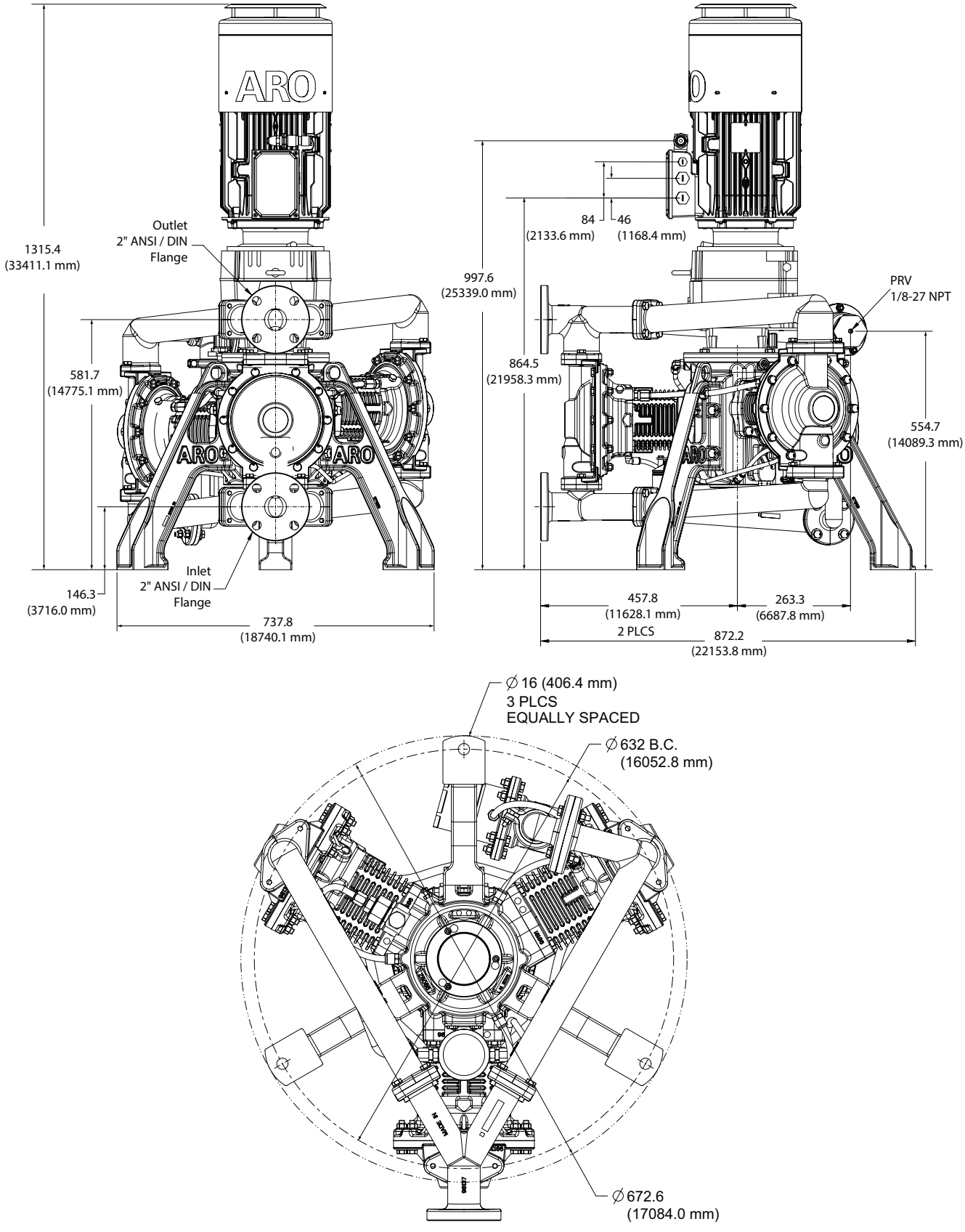

Figure 15

13.2. Variable Frequency Drive (VFD)

VARIABLE FREQUENCY DRIVE (VFD)

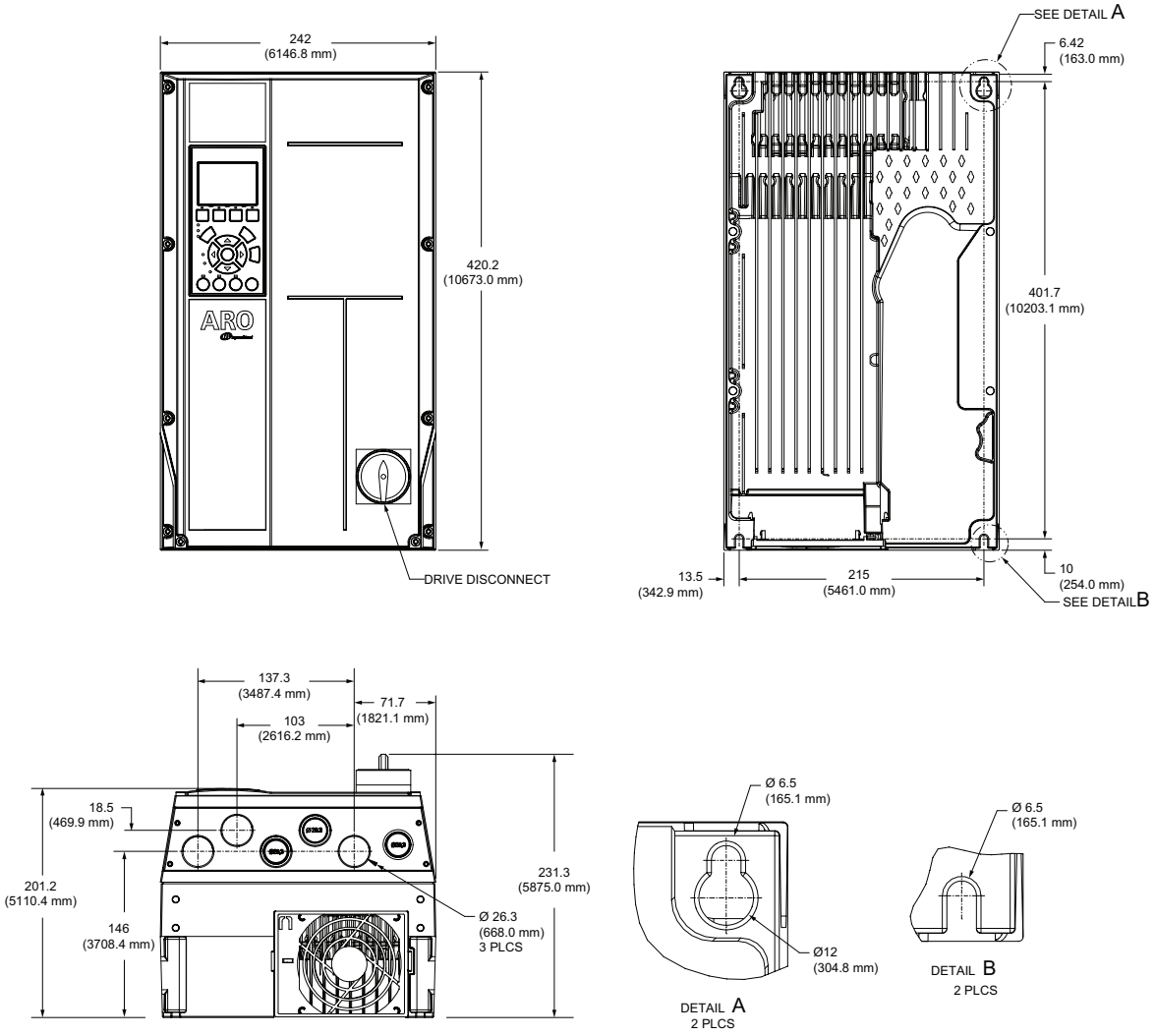

Figure 16

14. PERFORMANCE CURVE

15. CERTIFICATION