250-100-P, 250-150-P, 500-150-P PTO-Driven Integrated Pump / Compressor Installation Guide

Read through the installation instructions carefully.

NOTE: Instructions subject to change without notice.

Table of Contents

F-1031, Section 3039 (Revised 10/13/11)

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Warnings, Cautions, and Notes

Warning	A warning alerts you to a procedure, practice or condition that may result in death or long term injury to personnel or destruction of equipment.

Caution	A caution alerts you to a procedure or condition that may result in serious damage to equipment or its failure to operate as expected

Note: A note points out important information. Failure to read the note may not result in physical harm to personnel or equipment. It may waste time and money.

ATTENTION:

Defects in replacement part(s), component(s) or product(s) manufactured by others and furnished by WATEROUS is understood that the only warranty provided for such replacement part(s), component(s) or product(s), shall be the warranty provided by the manufacturer of said replacement part(s), component(s) or product thereof which, if assignable, WATEROUS will assign to Buyer, if requested by Buyer.

Defects in replacement part(s), component(s) or product(s), not furnished by Waterous, but suggested in the installation guide, are the responsibility of the installer and the manufacturer of said replacement part(s), component(s) or product(s). Waterous will not be responsible for any replacement part(s), component(s) or product(s) that are not furnished or purchased from Waterous.

WARRANTY INSERT (from last page)

The aforesaid warranty excludes any responsibility or liability of WATEROUS for:

c) any product or part, altered, modified, serviced or repaired other than by WATEROUS, without its prior written consent; and

d) the cost of dismantling, removing, transporting, storing, or insuring the defective product or part and the cost of reinstallation.

Revision History

Revision	Date Issued	Comments
3	10/13/11	Split out 150-80-P, reformat, new logo, updated pics, more tables, clarified pg 13

Disclaimer: These instructions are guidelines only and in no way meant to be definitive. During installation, standard safety precautions and equipment should be used where appropriate. Because the tools used and the skill/experience of the installer can vary widely, it is impossible to anticipate all conditions under which this installation is made, or to provide cautions for all possible hazards. Proper installation is the responsibility of the purchaser. All bolts, setscrews, and belts must be checked prior to start-up AND after the initial operation. Damages due to poor installation are the responsibility of the installer.

Waterous reserves the right to make modifications to the system without notice

Figure(s)

SECTION 1. INSTALLATION OVERVIEW

Notes: The instructions are for a typical system. The illustrations shown in this manual may differ slightly from the parts that were shipped.

The units all have a PTO-driven pump with a belt-driven compressor mounted above the pump.

The compressor/pump kits do not include:

- (PTO) Transmission power take-off and drive shaft
- Foam proportioner, foam tank, foam distribution manifold for CAFS
- Air, water and hydraulic hoses and hose fittings
- Pump/Compressor module mounting brackets
- Air inlet piping
- Air and water check valves
- Air discharge valves
- Air manifold
- Master air pressure gauge

New installation tasks include:

- Installing the PTO (follow the manufacturer's instructions)
- Installing the foam proportioner (follow the manufacturer's instructions)
- Installing the pump/compressor module and connecting it to the PTO
- Installing the hydraulic system (sump, filters and cooler)
- Installing gauges, valves, and the Auto-Sync controls
- Running water, air and hydraulic tubing for control systems, cooling, and compressed air delivery.
- Filling and testing the hydraulic system
- Calibrating the Auto-Sync system

Retrofitting into existing apparatus also includes:

- Modifying the water distribution system to install compressed air inputs, foam distribution manifold, check valves, the compressor cooling loop, and the balance valve.
- Installing additional discharges (optional)

SECTION 2. INSTALLING THE WATEROUS COMPONENTS

Refer to the Basic CAFS, Hydraulic, and Auto-Sync schematics in this manual to see how the Waterous components connect to the vehicle's foam and water distribution systems. Within the guidelines given here, components can be installed wherever there is room for them to be securely mounted. See the dimensional drawings in the rear.

Warning: Do not damage the vehicle chassis during installation. Check with the vehicle manufacturer to make sure the planned welds and bolts are in acceptable areas.

- Components must be bolted to brackets welded to the pump compartment frame, or bolted directly to the pump compartment frame.
- Allow enough clearance for routine maintenance, including clearance for checking oil, adding oil, adjusting pressure, changing filters, cleaning screens or opening drain valves.
- The pump/compressor module must be horizontal, with its drive angle matched to the PTO.
- The sump (oil/air reservoir) can be mounted at the same level as the compressor, or below it. If the sump must be mounted above the compressor (12 inches maximum), contact Waterous for the correct check valve to prevent compressor flooding.
- The sump must be in the proper orientation. Any extension to the sight glass must be straight and level.
- The oil sight glass must be visible after all the components are installed so oil level can be monitored easily.
- The heat exchanger must be installed horizontally, with the drain at the lowest point.
- To prevent damage to hydraulic and air lines, or accidentally disconnecting them, run them along the support beams of the pump compartment whenever possible, bundled with cable ties or other fasteners.
- Wires, hoses, or tubing that passes through metal, such as a compartment panel, must have a protective bushing or shield around the edge of the hole to protect against abrasion.
- To make troubleshooting easier, use colored air hoses as supplied, and shown on the air schematic.
- Labeling the lines is strongly recommended.

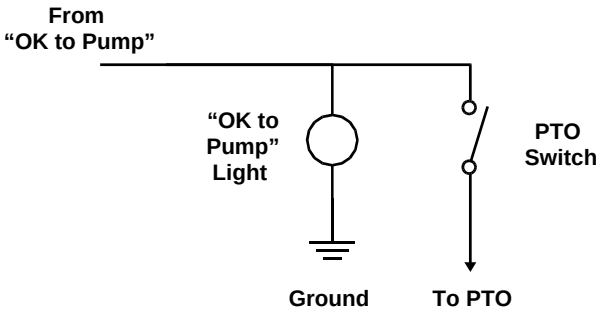
A. PTO installation

Follow the PTO manufacturer's installation guidelines.

Remember that the driveline angles on the compressor need to match the driveline angles on the PTO. If you have questions concerning driveline angle, please contact the driveline supplier.

Caution: Because the compressor is cooled by water from the fire pump, we strongly suggest that the compressor be disabled when the pump is off. This is accomplished by using the "OK to PUMP" circuit to trigger the PTO system.

Wiring the PTO switch circuit in parallel with the "OK to Pump" light is one way to ensure that the PTO and compressor cannot be activated unless the fire pump is engaged.


From
“OK to Pump”
“OK to
Pump”
Light
PTO
Switch
Ground
To PTO

B. Air Compressor / Pump Module Installation

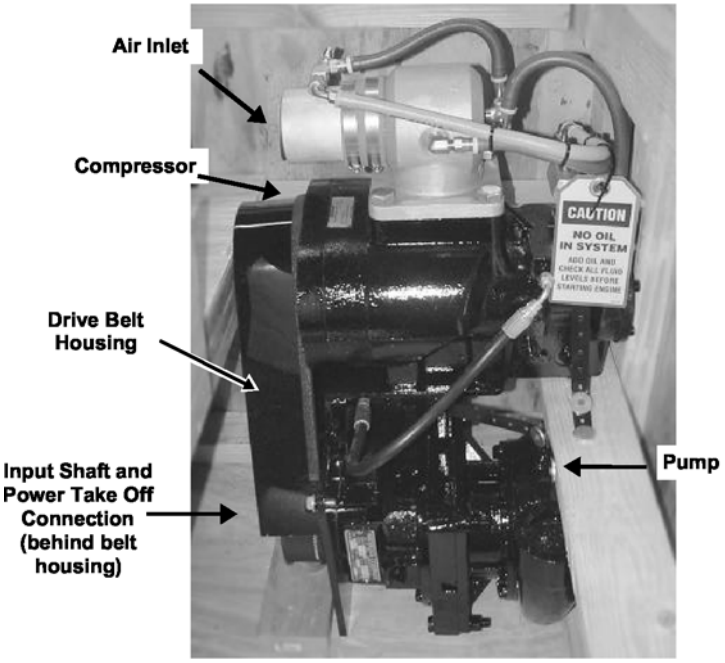
Warning: Drive flanges are loosely installed for shipping purposes only. They must be securely fastened during driveline installation process.

All fasteners should be checked by the installer prior to operating the unit.

Caution: The compressor/pump module cannot be installed on its side. It must remain upright, with the air inlet on the top.

Incorrect driveline angles between the PTO and the compressor/pump module input shaft can lead to driveline failure and/or cause the air compressor to fail. If you have questions concerning driveline angles, please contact your driveline supplier.

Install the compressor/pump module, matching drivelines angles with the PTO.



Typical module pump and compressor stack

C. Air Inlet and Filter

The air inlet on the air compressor can be turned in 90° increments because the bolt pattern is symmetrical. This simplifies installation of the air filter. If you turn the inlet, you will need longer hoses. Either acquire colored hoses locally or contact Waterous for the correct lengths and colors.

To change the rotation of the air inlet, disconnect the hoses, unbolt the inlet, rotate the inlet, and install new hoses.

Mount the air filter, considering the following factors:

- Air intake area must be unobstructed.
- Air intake tubing should be as short and straight as possible.
- Maintenance clearance must be adequate for removing and replacing the filter.
- The filter should be in an area that is unlikely to get wet.

The air inlet tubing (not included) from the filter to the air inlet is usually made of thin-wall metal tubing and rubber elbows. Plumb it as though it were an engine air inlet. Do not use flexible exhaust tubing or any material that water or dirt can easily penetrate.

D. Air-Oil Reservoir (Sump) Installation

Note: Waterous will not be responsible for systems where the sump and sight glass are installed such that the oil level cannot be checked or does not display the correct oil level due to improper installation.

The sump works best when it is installed so that the sight glass opening is below the discharge outlet of the air compressor, although mounting the sump at the same level as the compressor is acceptable.

In some cases, finding room for the sump can be difficult. It is acceptable to mount the oil sump up to 12 inches higher than the air compressor; however, this requires the installation of a check valve to prevent oil from flooding the compressor. The check valve may be ordered from Waterous when ordering the system.

Safety Pressure Relief Valve

I. Horizontal Sump (option)

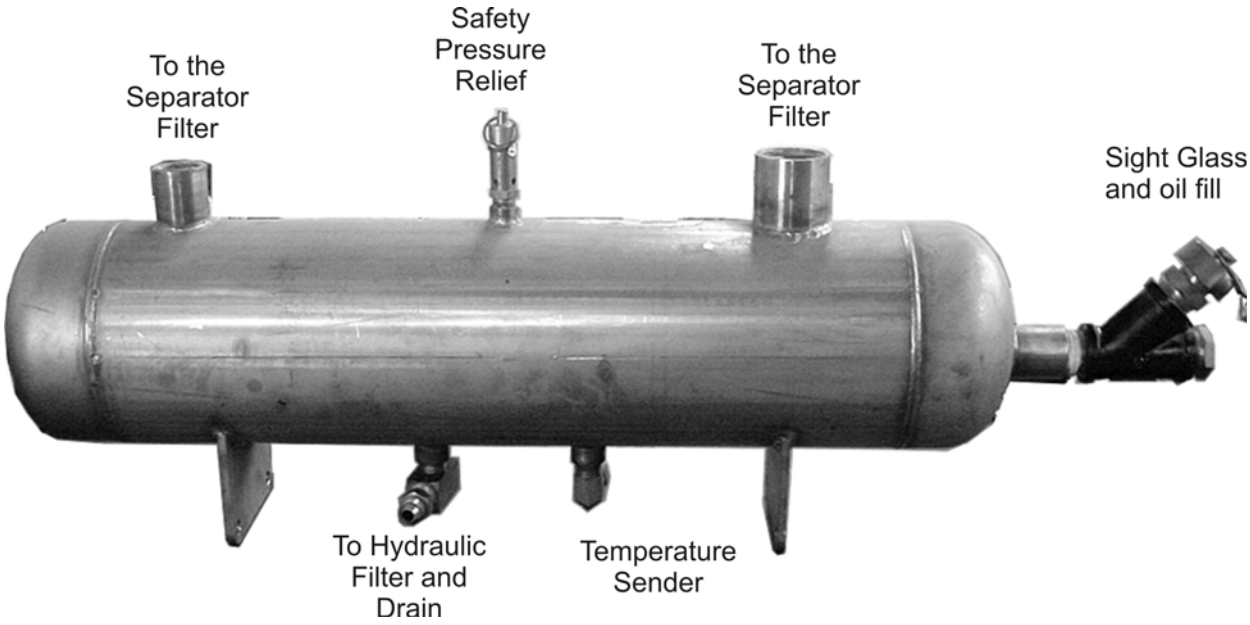


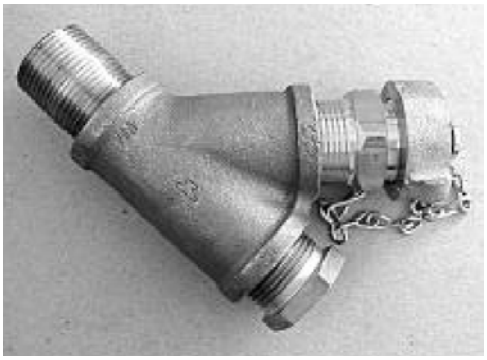
Figure 1 Horizontal sump, inlets and outlets

- The sump has mounting holes in the legs. Bolt the sump to the pump compartment frame.
- Make sure there is adequate clearance for the fittings and lines under the sump.

II. Oil fill and sight glass

The oil fill and sight glass on the T-sump have 3 possible positions. They may share the same inlet if installed in a wye fitting as shown below, or be installed in separate inlets. Locate these fittings for ease of checking oil level and adding oil to the sump. Use the supplied plugs to close the unused inlets.

If the oil sight glass needs to be extended for visibility, use rigid pipe to ensure that the level displayed is as accurate as possible. The sight glass/oil fill extension must be straight and level.



Oil fill and sight glass in a Wye fitting

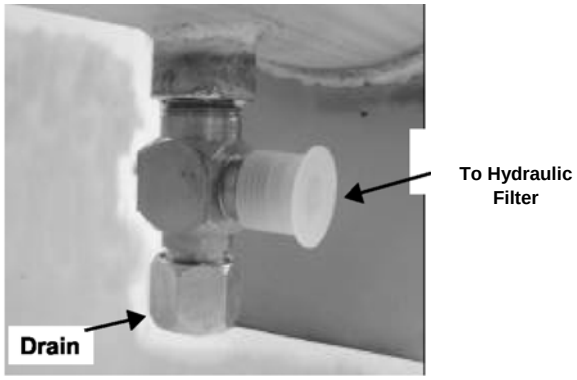
Ideal installation, with sight glass and oil fill easy to access

90° Elbow on a sight glass for better visibility

Two elbows on an oil fill cap for accessibility

III. Sump Drain

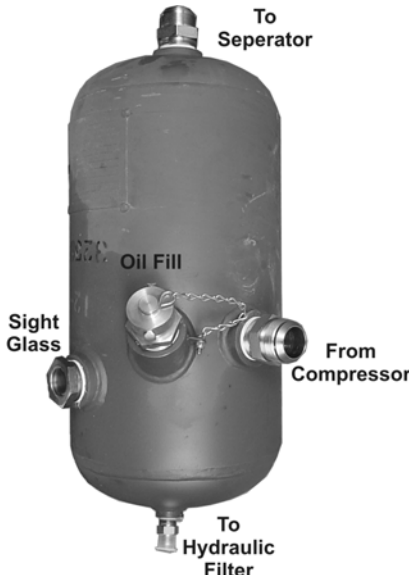
The drain and the output to the hydraulic filter share an outlet port.



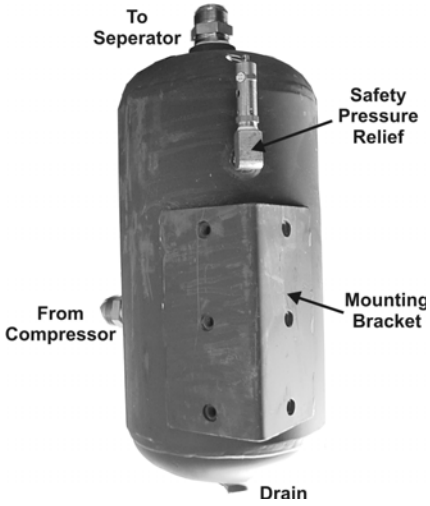
IV. Vertical Sump

The Safety Pressure Relief valve may be installed in either of the ports. The remaining ports have no options.

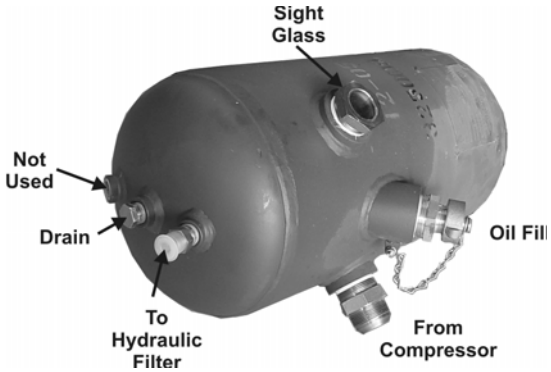
Vertical sump fittings



Vertical sump, rear view



Vertical sump, bottom view



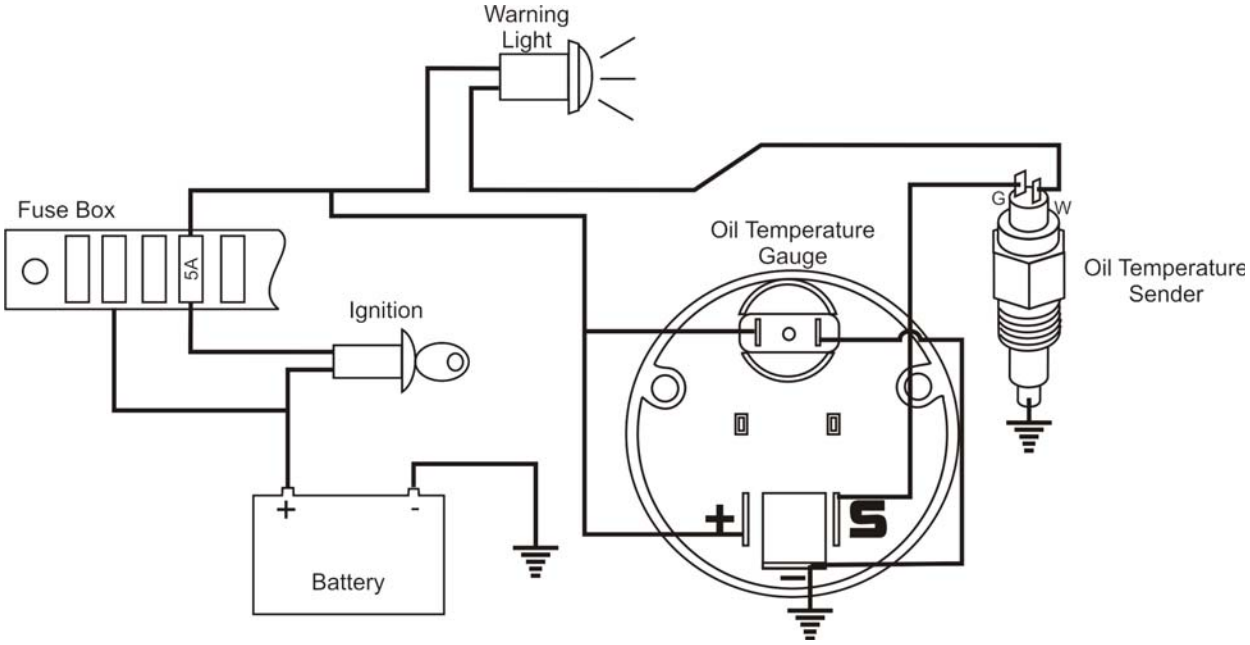
E. Oil Temperature Gauge (All Sumps)

Mount the gauge on the pump operator's control panel where it will be easy to monitor.

- The gauge connects to the larger of the two prongs on the sender.
- The smaller prong, which is labeled "WK", may be used to activate an oil temperature warning light or alarm (not provided). Waterous recommends installing an over-temperature device.
  This prong is one side of a temperature sensitive switch that will close at 250°F. The other side is grounded through the metal of the sump.

  The prong can be connected to the negative side of an audible alarm or warning light.
- Follow the installation instructions in the temperature gauge box to connect the sender to the gauge and the warning light.

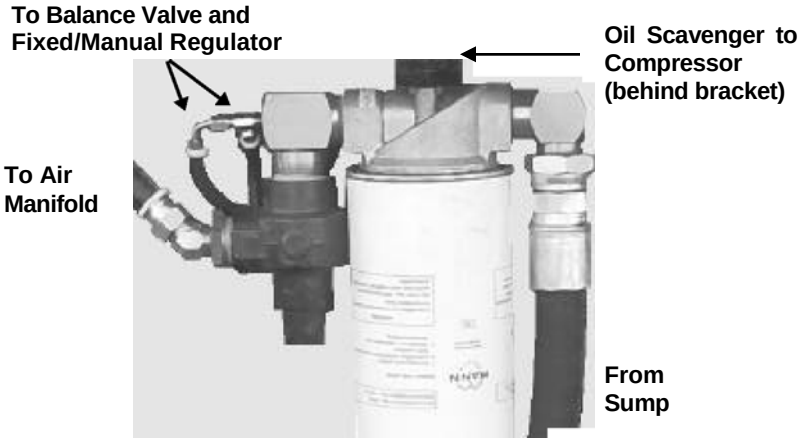
Temperature Sender, on Sump



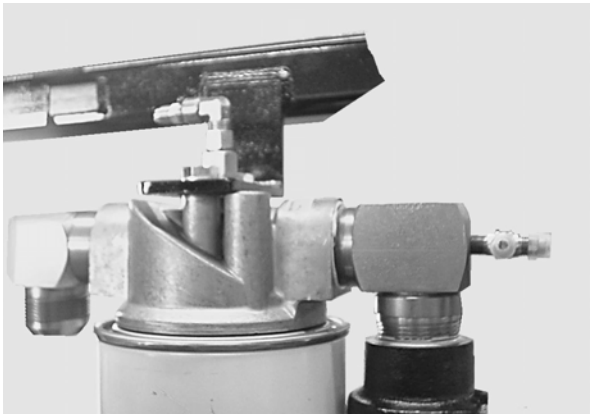
F. Separator / Filter Installation

The separator filter can be installed anywhere there is room to securely mount it and run the hydraulic and air lines.

- Install it vertically, with the housing up, the filter element down.
- Make sure there is room to remove and replace the filter element.
- Connect the output to the air manifold, the balance valve, and the fixed/manual regulator on the compressor.



Separator/filter side view with fittings

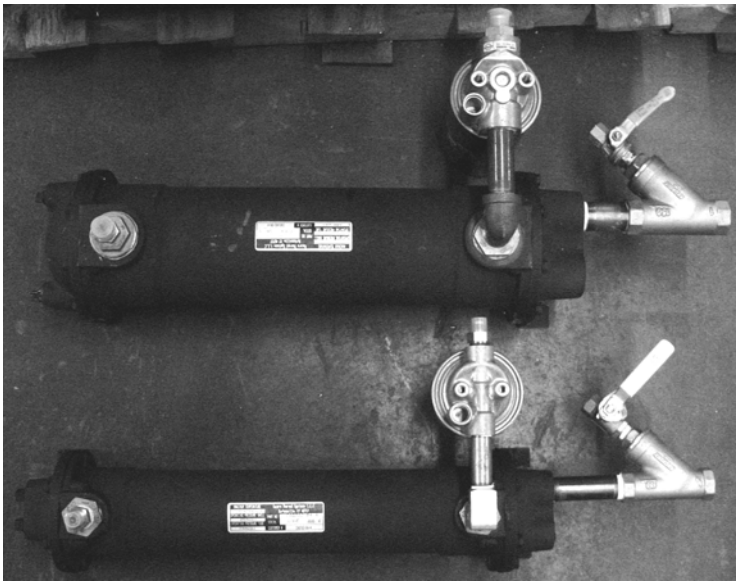


Separator/filter and bracket detail

G. Heat Exchanger Assembly Installation

Caution: Do not install a shutoff valve in the heat exchanger water supply. This will result in system overheat and failure, and void the manufacturer's warranty.

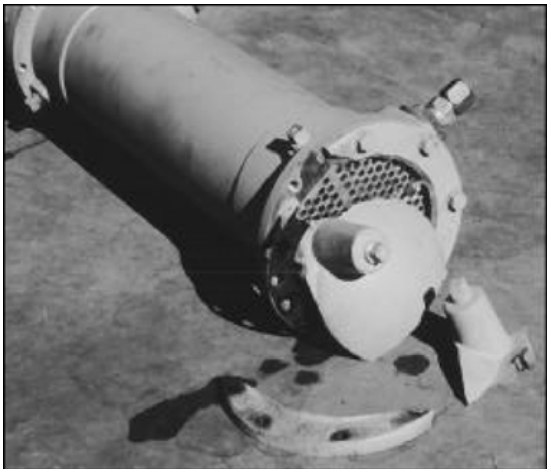
The oil returning to the compressor is cooled by passing it through a water-cooled heat exchanger, usually called the cooler.



Large Cooler

Medium Cooler

- The oil inlet and outlet may be reversed if it makes installation easier.
- The water inlet and outlet may be reversed if it makes installation easier.
- Install the cooler so that it can be drained to prevent freeze damage.

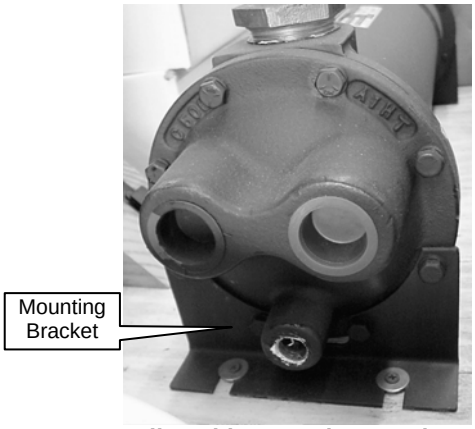


Freeze damage to undrained cooler,
also showing the small diameter of the water tubes

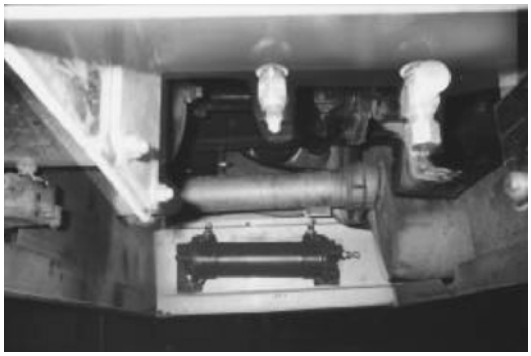
- The drain valve must be accessible from the side of the truck, so that the cooler can be drained after each use.

- The cooler must be installed horizontally, with the drain at the lowest point, and with a slight slope toward the water drain end.
- The drain hose should be 0.5"I.D. minimum to provide proper drainage.
- The outlet of the drain hose must be lower than the cooler's drain outlet and the drain hose should be a continuous downward run (no goosenecks) to allow proper drainage.

To mount the cooler on the side of a compartment, unbolt the brackets from the ends and reattach them so the cooler can be installed with the drain at the lowest point.



Adjustable Mounting Brackets



Cooler mounted on the side of a pump compartment, with the cooler body sloping toward the drain for better drainage.

I. Connecting the cooler water lines and wye-strainer

The cooler water is supplied by diverting water through a fitting (OEM supplied) from the **DISCHARGE** side of the fire pump (see the Hydraulic Schematic). The cooling water supply hose should be 1/2" I.D. to supply the proper flow for cooling the system.

The cooler discharge water may be routed to the booster tank fill tower or returned to the inlet side of the pump, as per the end user's preference.

Normally, coolant water is returned to the booster tank and a check valve is installed in-line to prevent backflow from the tank through the cooler. During drafting and hydrant-supplied operations, the booster tank may overflow because of the cooler water return.

If this is objectionable, route the return line to the inlet side of the pump. In this case, it is not necessary to install an in-line check valve, but it will be necessary for the pump operator to open the tank fill valve during operation to prevent overheating the fire pump.

Caution:	The Hydraulic filter is a one-way filter. Insure it has been mounted so the oil will flow in the direction indicated by the arrows on the top of the filter.

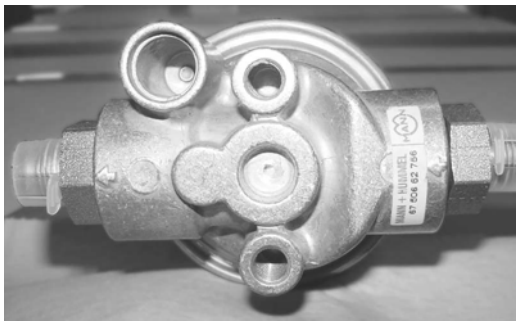


Figure 2 Hydraulic Filter, top, showing flow direction arrows

II. Wye Strainer for Cooler

A wye-strainer is provided to strain water before it enters the cooler's water inlet. The wye strainer requires regular inspection, and should be in an easily accessible location for inspection, removal, and cleaning.

Caution: Waterous is not responsible for damage due to plugged strainers. If the customer's water system contains excessive debris, or the vehicle relies on drafting for its water supply, it may be necessary to install a larger strainer and/or a clean-out valve on the wye-strainer.

Without good water flow through the heat exchanger, the compressor will overheat. Compressor performance will be inadequate, and it may fail completely.

Omitting the Wye-strainer or removing the screen from the Wye does not improve water flow. It will allow debris into the cooler, which can clog the tiny heat exchanger tubes and restrict water flow.

Figure 3 Wye Strainer

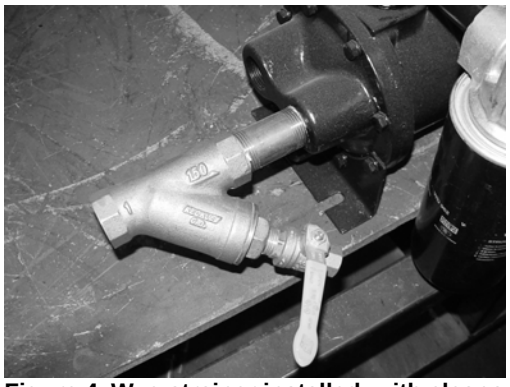


Figure 4 Wye-strainer installed, with cleanout valve.

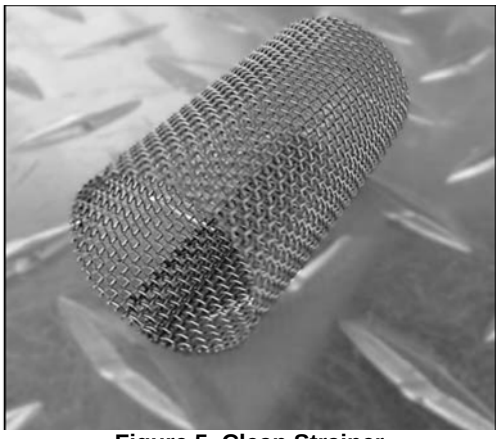


Figure 5 Clean Strainer

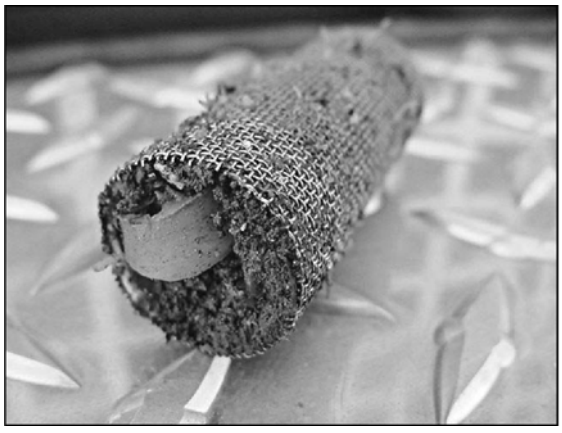


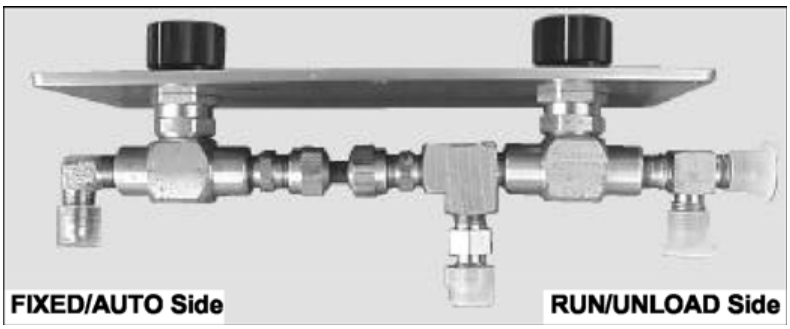
Figure 6 Dirty Strainer

SECTION 3. AUTO-SYNC CONTROL SYSTEM INSTALLATION

The Auto-Sync control system will have manual or (optional) electric control valves. Manual valves

A. Manual Valves

The manual valve assembly is shipped with the air tubing already installed, coiled and temporarily fastened to the main motor module. The tubing is long enough for a typical installation. If you need longer tubing, either acquire colored tubing locally or contact Waterous for the correct lengths and colors.



Manual Auto Sync valve assembly

Auto Sync Control Switches and Label

Typical Air Pressure Gauge

Install the control switch assembly and the master air pressure gauge (not included) on the pump control panel.

1. Turn the control knobs to FIXED and RUN. This places the valve cam in the lowest position
2. Loosen the setscrews and remove the knobs and nuts from the front of the assembly.
3. Remove the label plate.
4. Use the label as a template for making the holes for the control valves and the mounting bolts or use the dimensional drawing to create a template.
5. From the rear, insert the valve stems through the mounting holes.
6. Attach the label to the pump control panel.

B. Electric Valves (Solenoids)

The electric valve assembly is mounted to the module frame, with the connecting wires already installed and the air hoses connected to the Balance Valve and compressor.

Auto Sync Control Switch and Label

Auto Sync valve assembly (electric) (electric)

1. Install the valve control switch and label on the pump operator's control panel.
2. Run the control wires from the valves to the switch and plug the connectors together.
3. Connect the remaining wire to a +12V supply.
4. Secure the control signal wire to the compartment frame.

Note: If there is excess wire, do not coil it. Coils of wire act as antennas, either receiving or radiating stray EMF signals and interfere with this or other equipment. Bundle the wire harness back on itself, and secure it in a bundle with the folded wires parallel to each other.

7. Replace the nuts and knobs on the front of the assembly, making sure to align the knob indicators to FIXED and RUN.

   Make sure the knobs do not bottom out on the valve bodies. This will prevent the system from working properly.

8. Tighten the setscrews.

C. Balance Valve Installation

The Piloted Balance Valve (PBV) is mounted on the motor module, above the compressor air inlet. If the module has manual Auto Sync, it is already connected to the Auto Sync controls with enough hose for a typical installation.
Connect the separator filter output to the balance valve.

Piloted Balance Valve inlets and outputs, with push-on hoses.

Caution: **DO NOT** use oil or hose clamps on the Auto Sync system push-on hoses.

The push-on hose and fittings can be installed more easily if the hose ends are first soaked in hot water with a small amount of dish soap.

The schematic is also color coded, which simplifies the installation. Future service issues are easy to resolve as long as the colored hose is used as suggested and supplied.

SECTION 4. INITIAL POWER-UP

A. Post-Installation, Pre-Power up Safety Check

Before you power-up the Waterous system:

1. Remove all tools, shop towels, hose trimmings and other debris from the compartments.

2. Double-check all hydraulic, air and water lines against the schematics, testing to make sure each connection is tight and that the hose is fully inserted into the fitting.

3. Check all of the unused inlets: plastic shipping caps must be removed and replaced with the appropriate plug or cap.

4. Make sure all drain valves are closed.

5. Make sure the gauges are connected to the appropriate sender (temperature, pressure, etc.)

6. Fill the sump with the specified hydraulic oil until the oil level is 1/2 way up the sight glass. You will need to add more oil later, to compensate for oil that remains in the hydraulic lines and the compressor.

   Oil used in the hydraulic system is ISO 68wt hydraulic oil. It must be "Low-foaming" or "Anti-foam".

7. Make sure the foam proportioner, if installed, is operating properly. (see the manufacturer's installation guide).

B. Initial Engine and Fire Pump Power up

Before powering up the compressor, make sure the engine and pump are working correctly. See the engine and pump operator's manuals.

Warnings: Check ALL fluids for the engine before initial power up.

Do not start the engine unless the pump is connected to a source of water. The fire pump is operating whenever the engine is running. Running the pump without water will seriously damage the pump.

Note: The pump water is used for cooling the compressor oil. If the compressor cooling water is returned to the main tank, it is not necessary to open a re-circulation valve. If the compressor cooling water is returned to the pump's inlet plumbing, it is necessary to open the tank fill or pump re-circulation valve

SECTION 5. ADJUSTING THE AUTO SYNC AIR BALANCING SYSTEM

This seldom needs adjusting after the initial setup if the rest of the system is well maintained.

Note: Do not adjust the Auto Sync components to compensate for problems elsewhere in the CAFS system.

Before you make any adjustments, make sure the oil level in the sump is correct, the air and oil filters are not overdue for servicing, the oil is not overdue for changing, the compressor is not overheating, the oil cooler strainer is clean, and the air lines do not have leaks.

Always start by adjusting UNLOAD mode, then FIXED, then AUTO.

A common problem is unauthorized adjustment of the balance valve in an attempt to improve performance.

If unauthorized adjustments to the Auto Sync are a problem we suggest placing a seal over the adjustment points. This will let maintenance personnel know if the system has been tampered with.

A. Electric Auto-Sync Initial Setup

Colored hoses and fittings are supplied with the compressor kit for the average installation. The schematic is color coded to simplify installation. This also makes future service issues easier to resolve, provided suggested hose colors are used.

CAFS retrofit kits and any other system shipped as separate components will need calibrating after installation.

NOTE: Before you make any adjustments, make sure the oil level in the sump is correct, and the air lines do not have leaks or obstructions. Do not adjust the Auto-Sync components to compensate for problems elsewhere in the CAF system.

Always start by adjusting UNLOAD mode, then FIXED, then AUTO.

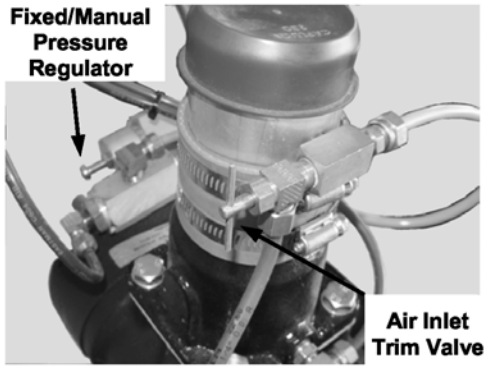
I. UNLOAD Mode Initial Setting

1. Set the controls on the Auto-Sync control panel to UNLOAD.

Electric Control Valve

2. Close all air discharges.

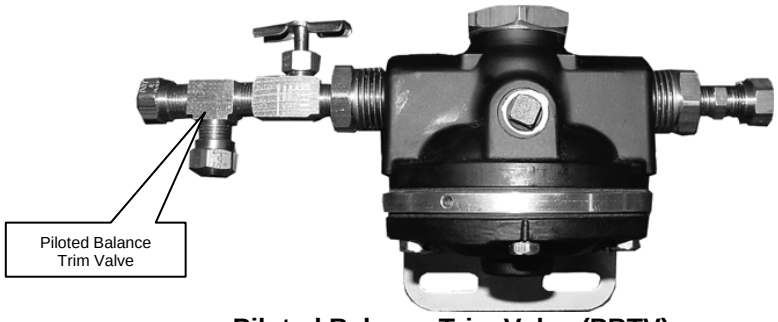
3. Locate the Air Inlet Trim Valve (AITV), near the air inlet on the compressor.



Compressor adjustment points

4. Turn the AITV valve clockwise until it is completely closed, then open it three full turns.

5. Locate the Piloted Balance Valve (PBTV), and turn the needle valve counterclockwise to full open.



Piloted Balance Trim Valve (PBTV)

6. Start the fire pump, and with the engine at idle, establish water flow through a discharge or tank re-circulation.

7. Engage the PTO.

CAUTION: Do not engage the PTO above 1000 engine RPM

8. With 80-SP systems, the main pressure gauge should read approximately 40 PSI with all discharges closed. Some systems may read lower. This is acceptable.

II. FIXED Mode Initial Setting

The FIXED pressure for a newly installed PTO retrofit kit is about 110 PSI. It must be adjusted to 150 PSI.

1. Locate the Fixed/Manual Pressure Regulator on the compressor and loosen the lock nut on the adjustment screw.

2. Place the controls on the Auto-Sync control panel to FIXED. Wait until the compressor pressure stabilizes.

3. The target operating pressure is 145-150 PSI. Monitor the air pressure reading as you adjust the regulator screw. Give the system several seconds to stabilize between adjustments, and make partial turns of the screw to avoid overshooting the target pressure.

   - Turning the screw IN (CW) will increase pressure.

   - Turning the screw OUT (CCW) will decrease pressure.

4. After the desired fixed pressure is achieved, tighten the lock nut.

5. Verify that the fixed regulator is performing properly by varying the engine speed as you watch the air pressure gauge. The pressure should remain steady at the setting you made. Repeat steps 2 through 4 if needed.

6. Turn the controls to UNLOAD and back to FIXED. The air pressure should rise to the fixed pressure. It may overshoot and drop back to the target pressure, but that is normal.

7. After the FIXED mode is adjusted, proceed to AUTO mode adjustment.

III. AUTO Mode Initial Setting

The pressure for the FIXED mode must have been correctly set before you attempt to adjust the AUTO mode.

1. Make sure the fire pump is operating at 100 PSI at the main discharge, with minimal flow.

2. Place the controls on the Auto-Sync control panel to AUTO.

3. Read the main air pressure and water discharge pressure gauges.

4. The air pressure reading should be equal or up to 5% higher than the water pressure. If the readings are in this range, go to step 7 and verify the operation at other pressures.

5. If the air pressure is not within +5% of the water pressure, adjust it as follows:

   - If the air pressure is too high, turn the AITV clockwise in 1/2 turn increments to close it, checking air and water pressure after each 1/2 turn.

   - If the air pressure is too low, turn the AITV counterclockwise 1/2 turn to open it and check pressures. If the air pressure is still too low, open the valve another 1/2 turn and check the pressures again.

   - Do not open the Air Inlet Trim Valve more than this. Use the PBTV if the pressure remains too low.

6. If the air pressure remains too low, close the needle valve on the Piloted Balance Trim Valve (PBTV) one full turn clockwise and check the pressure gauges.

   Repeat closing the PBTV one full turn until the air pressure is equal to or up to 5% higher than the water pressure.

   If the air pressure is too high after a full-turn of the PBTV, turn the Air Inlet Trim Valve clockwise to lower the pressure until the air pressure is equal to or up to 5% higher than the water pressure.

7. Verify the Auto-Sync system settings by varying the fire pump discharge pressure and monitoring the water and air pressure gauges. The air pressure should rise and fall with the water pressure, matching it within 5%. Pressures should match at static pressure only. It is normal for the pressures to be unmatched when flowing water, air, or solution.

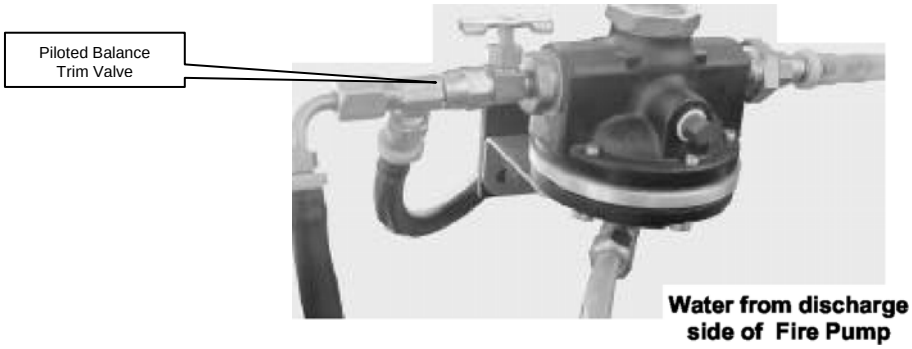
B. Manual Auto-Sync Initial Setup

Air Control circuit is preset and adjusted at the factory prior to shipments. In most cases, the factory settings will provide satisfactory performance for typical CAFS and auxiliary air applications. The FIXED air operation is factory set at 145-150 PSI. The AUTO air operation is set (or trimmed) to match fire pump discharge pressure (+/- 5%).

If the air control circuit requires changing or the circuit has lost its factory setting, the following procedure can be used to "fine tune" the system.

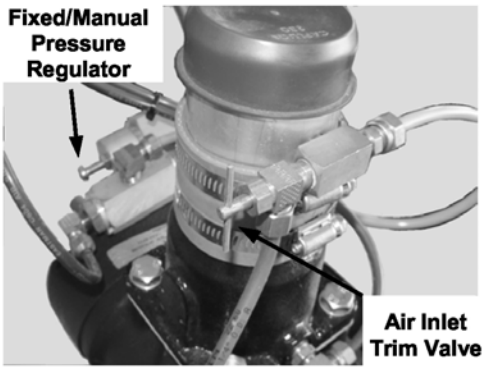
I. UNLOAD Mode Initial Setting

1. Preset the Inlet Air Trim Valve (IATV) by closing the valve, then opening it 3 turns.
2. Preset the Piloted Balance Trim Valve (PBTV) to full open.



Piloted Balance Trim Valve (PBTV)

3. Start the fire pump and, at idle, establish water flow either through a discharge or tank re-circulation.
4. The Auto-Sync Control Panel should be in the FIXED/UNLOAD mode and all air discharges closed.
5. Start the air compressor by placing the compressor engage switch to "ON."



Compressor adjustment points

6. The main air pressure gauge should read 40-50 PSI. In the FIXED/UNLOAD mode, this minimum pressure is always present to provide compressor oil circulation.

We are ready to proceed with final adjustments for the FIXED and AUTO modes.

II. FIXED Air Initial Setting

1. To set the pressure for the FIXED operation, first locate the "Fixed Pressure Regulator." The regulator has an adjustment screw with lock nut.

2. Loosen the regulator's lock nut.

3. Go to the Auto-Sync Panel and place controls to the FIXED/UNLOAD positions. The compressor will build pressure to some valve and hold (regulate).

4. While monitoring the air pressure gauge, adjust the screw on the Fixed Pressure Regulator until the desired pressure is reached. Turning the screw IN will INCREASE pressure and turning the screw OUT will DECREASE pressure.

5. Once the desired regulated pressure is achieved, tighten down the lock nut.

6. Verify the fixed regulator is performing by varying the compressor speed and monitoring the air pressure gauge. The pressure should remain steady at your fixed pressure setting.

With the final adjustments to the FIXED air mode complete, proceed with setting the AUTO air mode.

III. AUTO Air Initial Setting

1. With the fire pump operating at 100 PSI main discharge and minimum flow, place the Auto-Sync controls to the AUTO/RUN position.

2. Monitor main water discharge pressure gauge and the air pressure gauge. The pressure readings should be the same. If not, proceed to step 3.

3. The Inlet Air Trim Valve (IATV) is the first valve to adjust.

   a. If the air pressure is too high, close the trim valve in half turn increments, monitoring both water and air pressure gauges, until the pressures match. Once the pressures match, no further adjustments are needed, proceed to step 5.

   b. If the air pressure is too low, open the trim valve a half turn, then check water and air pressure gauges.

c. If the air pressure is still too low, open the trim valve another half turn. If air pressures match, no further adjustments are needed, proceed to step 5.

d. If air pressure is still too low, proceed to step 4.

4. The Inlet Air Trim Valve (IATV) is now four turns open from fully closed. It is not desirable to have the trim valve open more than four turns. In order to extend its range, go to the Piloted Balance Trim Valve (PBTV).

   a. From the fully open position, close the PBTV one turn then check water and air pressure gauges.

   b. If air is still too low, close the PBTV one additional turn and check gauges.

   c. Keep repeating this process until air pressure matches or is slightly higher than water pressure.

   d. The final adjustment can be done using the IATV and step 4.

5. Verify the piloted balance valve is performing by varying the fire pump discharge pressure and monitoring the water and air pressure gauges. The air pressure should follow the water pressure and match it. If not, repeat the final adjustment procedure.

6. If the air pressure remains too low, close the needle valve on the Piloted Balance Trim Valve (PBTV) one full turn clockwise and check the pressure gauges.

7. Repeat closing the PBTV one full turn until the air pressure is equal to or up to 5% higher than the water pressure.

8. If the air pressure is too high after a full-turn of the PBTV, turn the Air Inlet Trim Valve clockwise to lower the pressure until the air pressure is equal to or up to 5% higher than the water pressure.

9. Verify the Auto-Sync system settings by varying the fire pump discharge pressure and monitoring the water and air pressure gauges. The air pressure should rise and fall with the water pressure, matching it within 5%. Pressures should match at static pressure only. It is normal for the pressures to be unmatched when flowing water, air, or solution.

SECTION 6. SUGGESTED THIRD-PARTY COMPONENTS

Note: These are guidelines useful for many installations, but selection of third-party components is at the discretion of the system installer or vehicle manufacturer.

A. Suggested Components For CAFS Discharges:

The installer must provide fittings and tubing to connect the CAFS components to the vehicle's discharge outlets. These are suggested parts for the common discharge sizes. If the planned discharge system is not covered in this guideline, please contact Waterous.

Note: Waterous strongly suggests that every CAFS discharge have an air check valve and a water check valve, as shown below.

The air check valve prevents foam solution from back flowing into the compressor and contaminating the oil. The water check valve isolates the discharge, preventing CAF from back flowing into the foam solution manifold and exiting through another discharge.

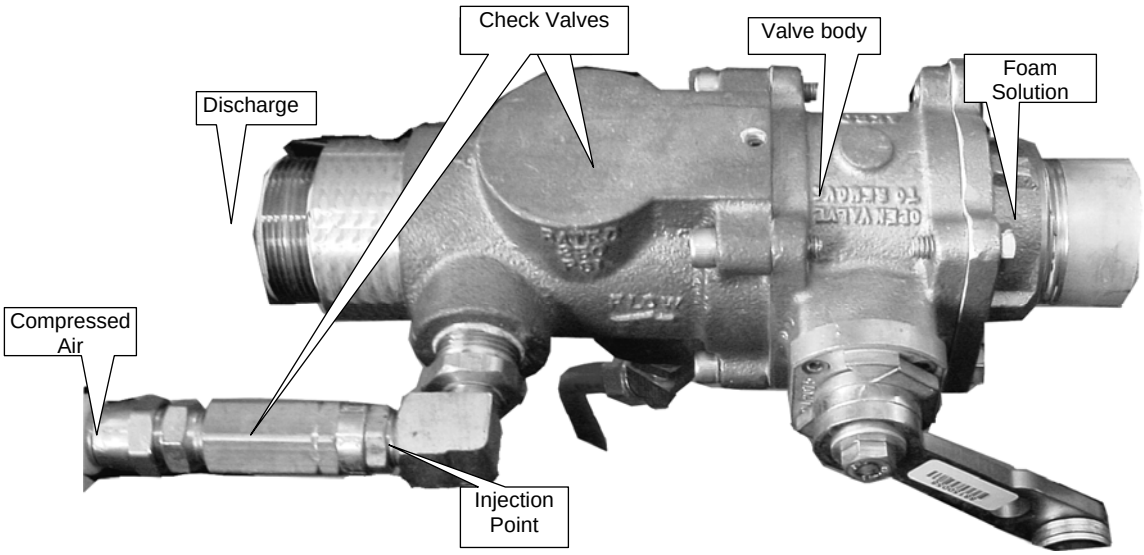


Figure 7 Typical CAFS Discharge

A. Suggested Hose

The inside diameter (I.D.) of the hose is the most important factor, and any hose with the correct I.D. and rated to withstand the expected air system pressures (500 PSIG burst pressure) may be used.

We have found the most cost-effective hose is the push-on type hose. H101 or H201 general-purpose hose has an acceptable working pressure. Gates, Dayco, Parker, Weatherhead and Aeroquip brands will suffice. All of these hoses come in a variety of colors for color-coding the lines by purpose.

Discharge:	Suggested:
1” booster reel or 1” remote	Use 3/8” ID air hose.
1.5” and 2”	Use 1/2” ID air hose
2-1/2”	Use 3/4” ID air hose
Auxiliary Air Outlet	Use 3/8” ID air hose

Air brake tubing may also be used provided strict attention is paid to the inside diameters:

Size	Working PSI	Burst PSI
.375" OD is .250" ID	150	1400
.500" OD is .375" ID	150	950
.625" OD is .500" ID	150	900
.750" OD is .625" ID	150	800

Discharge fittings and Kits: Lists are available on request for various discharges.

For the hydraulic portion of the compressor system, it is necessary to use SAE 100R1 or SAE 100R5 as a minimum. Hose sizes necessary for installation are:

#4 for the scavenger from the separator filter to compressor.
#8 for the oil inject and cooler circuit.
#24 for the air out of the sump to the separator filter assembly.

B. Power Take-Off Suggestions

There are many PTO suppliers and many types of transmissions available, and the choice of PTO will in part depend on what can be installed in the vehicle. "Hot Shift" PTOs are commonly used.

Make sure that there will be room to install the air compressor on a bracket close to the PTO, with their drive angles matched.

Caution: The driveline angles MUST be matched to prevent serious damage to the compressor, PTO, or transmission.

Specific gear ratios vary among the different transmissions and PTO suppliers. The ratios suggested below are a guide for selecting the PTO. With these ratios, the rated CFM is usually achieved with the engine speed near 1400 RPM.

Caution: A higher speed on the PTO means the CAFS system will reach the desired CFM at lower engine speeds. Exceeding the compressor's rated RPM can damage the compressor, and void the warranty. In such applications, an over speed cut-out should be installed on the PTO to protect the compressor.

To calculate the possible compressor RPM, use this equation:

Engine RPM x gear ratio on PTO x 3.267 = compressor rotor RPM

I. Compressor

The compressor produces 200 CFM at approximately 7200 rotor RPM and 140 CFM at approximately 5000 rotor RPM. The maximum rotor speed is 9000 RPM.

CFM required	PTO speed	HP average
120-140	123-129% HI	32-40
160-180	143% HI	45-50
200	160% HI	55-60

SECTION 7. TROUBLESHOOTING

A. Troubleshooting - CAFS

Observed Symptom	Probable Cause	Suggested Remedy
Lack of air pressure from compressor	Lack of air supply to clutch (for air-clutch systems)	Repair air leak or re-establish air supply
Compressor not engaging	No PTO engagement	Confirm OK TO PUMP light is on, if not check wiring for damage or disconnected wire, check PTO.
Compressor engaging. No air supply to discharges or insufficient air supply.	Auto-Sync switches not in correct position.	Confirm 40 PSI in UNLOAD position (200 CFM systems) and 50+ in run position. Smaller compressors have lower UNLOAD pressures. Verify when in FIXED/RUN whether pressure reflects 145-150 PSI
	(electric valves) Verify there is power to the air solenoid and check operation of solenoid.	Air discharge solenoid not working. Repair/replace solenoid Air solenoid working - leak between solenoid and discharge. Repair leak.
	Air check valve defective	Replace or correct installation.
	Trim valve out of adjustment	Refer to trim valve instructions
	Restricted minimum pressure valve	Clean rust or debris from valve
	Air plumbed before discharge valve seal	Relocate to discharge side of discharge valve
	Incorrect air line size	Size according to discharge and replace line with correct size.
System functioning correctly, pressure gauge reading obviously incorrect.	Gauge malfunction, air line detached	Check for air leaks, replace gauge
FIXED has pressure but AUTO has no pressure	No water supply to balance valve.	Check line for proper installation, with no kinks or obstructions. Refer to trim valve instructions.
Air discharge pressure too high	Red hose circuit (compressed air control) has leak or is disconnected.	Repair leak or attach hose
System overheating	Inadequate water flow through cooler	Ensure adequate water flow through pump. Check Y strainer for obstruction, clean and reinstall Drain and flush cooler water tubes

Observed Symptom	Probable Cause	Suggested Remedy
	Adequate water flow through cooler.	On-board tank used for cooling for a prolonged period - water too hot to effectively cool the compressor. Locate source of lower temperature water. Check oil level - Adjust level to half of the sight glass on level surface.
	Low compressor oil level:	Check the hydraulic lines for kinks Change oil filters
	Temperature sending unit and or gauge circuit malfunction.	Check wire connections at sending unit
High Oil Consumption	Overfull compressor oil	Adjust level to half of the sight glass on level surface.
	Excess of 200 CFM air flow (on 200 CFM systems)	Back down RPM's and flow CAFS to relieve pressure, then recheck Replace Air/Oil Separator Filter
	Air/oil Separator Filter torn or damaged (could be caused by air flow of higher than 200CFM)	System being operated at higher than capacity
"Excessive" compressor bleed down time on shutoff	Systems vary in bleed down time.	If Auto-Sync is operating correctly, and compressor output is within spec, do nothing.
Engine stalls upon compressor engagement	Engaging compressor while under load	Allow compressor to bleed down before re-engagement
	Running system without flowing air causes oil to accumulate in compressor acting like hydraulic pump	Bleed down air, restart compressor, and move air
	Underrated engine horsepower	Raise engine RPM
	Auto-Sync in FIXED / RUN setting	Engage in AUTO/UNLOAD, then switch to FIXED/RUN
	High oil level	Check oil level, adjust level to half of the sight glass with vehicle parked on a level surface
	Compressor locked up	Repair/replace compressor
Compressor locked up	High oil level (compressor is flooded)	Check oil level, adjust level to half of the sight glass with vehicle parked on a level surface
	Sump fire	Check system and repair
	Low oil level or no oil	Check system and repair
Air flow meter stuck at "0" CFM	Magnet uncoupled in meter	Turn air flow on and off to re-couple
Air flow meter stuck at high CFM		Move large amounts of air out discharge and turn air flow on and off to re-couple

Observed Symptom	Probable Cause	Suggested Remedy
Poor foam (wet or dry) or no foam (assuming air pressure to discharges is OK)	Using wetting agent and not foam concentrate.	Use foam concentrate
	Foam proportioning control turned too low.	Increase amount of concentrate delivered to manufacturer recommended amount.
	Foam proportioning control OFF or turned too low, foam tank empty.	Make sure proportioner is turned on, foam supply valve is open, foam tank has concentrate, Y strainer is clean, and supply line is connected to injector.
Discharge hose shaking (slug flow)	Foam proportioner ON, setting correct, and tank has foam concentrate, but not providing foam solution.	Refer to foam proportioner manufacturer's instructions for detailed calibration and troubleshooting instructions
Foam in the water system (when proportioner turned off)	Foam concentrate was poured into the on-board water tank	Flush tank and pump with clean water, refill
	Foam manifold drain lines not isolated from water drain lines	Isolate to separate drain valve
	Cooler line plumbed from foam manifold	Relocate line to discharge side of pump
	Foam manifold check valve defective	Rebuild/replace check valve
Water in compressor oil/air	Leaking inside cooler Freeze damage	Isolate cooler and check for leaks, replace if needed, check drain
	Defective air check valves	Replace or check
	Missing air check valves for discharges	Install check valves
Clutch smoking	Engaging in RUN position	Engage in AUTO/UNLOAD only
	Slight air leak from solenoid to clutch	Repair air leak
	High RPM engagement	Engage in lower RPM
	Not allowing compressor to bleed down before engaging clutch again	Allow for bleed down
	Contaminated clutch disc	Clean or replace
Safety pop off valve opening at low pressure	Auto-Sync system out of balance	Adjust the Auto-Sync system, making sure to not open the trim valve on the compressor more than 3 turns.
	Sump fire damaged pop off valve	Check system for other damage and replace valve
Safety pop off valve repeatedly opening	Trim valve or inlet completely open	Refer to trim valve instructions

B. Troubleshooting – Pump

Observed Symptom	Probable Cause	Suggested Remedy
Pump fails to prime or loses prime	Air leaks	Clean and tighten all Intake connections. Make sure intake hoses and gaskets are in good condition. Use the following procedure to locate air leaks: 1. Connect Intake hose to pump and attach Intake cap to end of hose. 2. Close all pump openings. 3. Open priming valve and operate primer until vacuum gage Indicates 22 in. Hg/.735 atmospheres. (If primer fails to draw specified vacuum, it may be defective, or leaks are too large for primer to handle.) 4. Close priming valve and shut off primer. If vacuum drops more than 10 in. Hg/.334 atmospheres In 5 minutes, serious air leaks are indicated. With engine stopped, air leaks are frequently audible. If leaks cannot be heard, apply engine oil to suspected points and watch for break in film or oil being drawn into pump.
		1. Completely fill water tank (if so equipped). 2. Connect intake hose to hydrant or auxiliary pump. 3. Open one discharge valve and run in water until pump is completely filled and all air is expelled. 4. Close discharge valve, apply pressure to system and watch for leaks or overflowing water tank. A pressure of 100 psi is sufficient. DO NOT EXCEED RECOMMENDED PRESSURE.
		1. If pump has not been operated for several weeks, packing may be dried out. 2. Close discharge and drain valves and cap intake openings. 3. Operate primer to build up a strong vacuum In pump. 4. Run pump slowly and apply oil to Impeller shaft near packing gland. 5. Make sure packing is adjusted properly.
	Dirt on Intake strainer	Remove all leaves, dirt and other foreign material from Intake strainer.
		When drafting from shallow water source with mud, sand or gravel bottom, protect intake strainer In one of the following ways: 1 Suspend Intake strainer from a log or other floating object to keep It off the bottom. Anchor float to prevent it from drifting Into shallow water. 2. Remove top from a clean barrel. Sink barrel so open end is below water surface. Place Intake strainer Inside barrel. 3. Make an Intake box, using fine mesh screen. Suspend intake strainer Inside box.
	No oil In priming tank	With rotary primer, oil is required to maintain a tight rotor seal. Check priming tank oil supply and replenish, if necessary.
Pump fails to prime or loses prime (cont'd)	Defective priming valve	A worn or damaged priming valve may leak and cause pump to lose prime. Consult primer Instructions for priming valve repair.

Observed Symptom	Probable Cause	Suggested Remedy
	Improper clearance in rotary gear or vane primer	After prolonged service, wear may increase primer clearance and reduce efficiency. Refer to primer Instructions for adjusting primer clearance.
	Engine speed too low	Refer to Instructions supplied with primer for correct priming speeds. Speeds much higher than those recommended do not accelerate priming, and may actually damage priming pump.
	Bypass line open	If a bypass line Is installed between the pump discharge and water tank to prevent pump from overheating with all discharge valves closed, look for a check valve In the line. If valve Is stuck open, clean it, replace it or temporarily block off line until a now valve can be obtained.
	Lift too high	Do not attempt lifts exceeding 22 feet (6.7m) except at low altitudes and with equipment In new condition.
	End of Intake hose not submerged deep enough	Although Intake hose might be immersed enough for priming, pumping large volumes of water may produce whirlpools, which will allow air to be drawn into intake hose. Whenever possible, place end of Intake hose at least two feet below water source.
	High point In Intake line	If possible, avoid placing any part of Intake hose higher than pump inlet. If high point cannot be prevented, close discharge valve as soon as pressure drops, and prime again. This procedure will usually eliminate air pockets in intake line, but it may have to be repeated several times.
	Primer not operated long enough	Refer to Instructions supplied with primer for required priming time. The maximum time for priming should not exceed 45 seconds for lifts up to 10 feet (3.0m).
Insufficient capacity A. Engine and pump speed too low at full throttle (continued)	Insufficient engine power	Engine requires maintenance. Check engine in accordance with manufacturer's instructions supplied with truck.
		Engine operated at high altitudes and/or high air temperatures. Engine power decreases with an Increase In altitude or air temperature, except for turbo charged engines. Adjusting carburetor or changing carburetor jets (or Injector nozzles) may Improve engine performance. Consult with engine manufacturer.
	Discharge relief valve set Improperly	If relief valve Is set to relieve below desired operating pressure, water will bypass and reduce capacity. Adjust relief valve In accordance with instructions supplied with valve.
Insufficient capacity A. Engine and pump	Transfer valve set Improperly	Place transfer valve in VOLUME (parallel) position when pumping more than two thirds rated capacity.

Observed Symptom	Probable Cause	Suggested Remedy
speed too low at full throttle (continued)	(Does not apply to single stage pumps.)	When shifting transfer valve, make sure It travels all the way Into new position. Failure of transfer valve to move completely into new position will seriously impair pump efficiency.
	Truck transmission In too high a gear	Consult vehicle instructions for correct pump gear. Pump usually works best with transmission in direct drive. If truck Is equipped with an automatic transmission, be sure transmission Is In pumping gear.
Insufficient capacity B. Engine and pump speed higher than specified for desired pressure and volume (continued)	Transfer valve set Improperly (Does not apply to single stage pumps.)	Place transfer valve In VOLUME (parallel) position when pumping more than two thirds rated capacity.
		When shifting transfer valve, make sure it travels all the way Into new position. Failure of transfer valve to move completely into new position will seriously impair pump efficiency.
	Pump Impeller(s) or wear rings badly worn	Install undersize wear rings if Impeller to wear ring clearance is within limits indicated in MAINTENANCE INSTRUCTIONS. If not, install new impeller(s) and wear rings.
	Intake strainer, Intake screens or impeller vanes fouled with	Remove intake strainer and hose, and clear away all debris. Pressure backwash (preferably in parallel or "volume" position) will usually clear impeller vanes when pump Is stopped.
	Intake hose defective	On old intake hoses, the Inner liner sometimes becomes so rough it causes enough friction loss to prevent pump from drawing capacity. Sometimes, the liner will separate from the outer wall and collapse when drafting. It Is usually Impossible to detect liner collapse, even with a light. Try drafting with a new intake hose; if pump then delivers capacity, It may be assumed that previous hose was defective.
	Intake hose too small	When pumping at higher than normal lifts, or at high altitudes, use a larger or additional Intake hoses.
Insufficient capacity C. Engine speed higher than specified for desired pressure and volume	Truck transmission in too low a gear	Consult vehicle instructions for correct pumping gear. Pump usually works best with transmission in direct drive. (Check both engine and pump speed, if possible, to be sure transmission Is in "direct".)
Insufficient pressure	Pump speed too low	In general, the above causes and remedies for low pump capacity will also apply to low pump pressure.
		Check pump speed with a tachometer. If pump speed is too low, refer to engine manufacturer's instructions for method of adjusting engine speed governor.

Observed Symptom	Probable Cause	Suggested Remedy
	Pump capacity limits pump pressure	Do not attempt to pump greater volume of water at the desired pressure than the pump is designed to handle. Exceeding pump capacity may cause a reduction In pressure. Exceeding maximum recommended pump speed will produce cavitations, and will seriously Impair pump efficiency.
	Flap valve stuck open	When pump Is In PRESSURE (series), discharge will bypass to first stage Intake. Operate pump at 75 psi/52 bar, and rapidly switch transfer valve back and forth between positions. If this falls, try to reach valve with a stick or wire and work it free.
Relief Valve Malfunction A. Pressure not relieved when discharge valves are closed	Sticky pilot valve	Disassemble and clean. Replace noticeably worn parts.
	Plugged tube lines	Disconnect lines and Inspect.
Relief Valve Malfunction B. Pressure will not return to original setting after discharge valves are reopened	Sticky pilot valve	Disassemble and clean. Replace noticeably worn parts.
	Sticky main valve	Disassemble and clean. Replace noticeably worn parts.
	Incorrect installation	Check all lines to be sure installation instructions have been followed.
Relief Valve Malfunction C. Fluctuating pressure	Sticky pilot valve	Disassemble and clean. Replace noticeably worn parts.
	Water surges (relief valve)	Pressure fluctuation can result from a combination of intake and discharge conditions Involving the pump, relief valve and engine. When the elasticity of the intake and discharge system and the response rate (reaction time) of the engine, pilot valve and relief valve are such that the system never stabilizes, fluctuation results. With the proper combination of circumstances, fluctuation can occur regardless of the make or type of equipment involved. Changing one or more of these factors enough to disrupt this timing should eliminate fluctuation.
Relief Valve Malfunction D. Slow response	Plugged filter or line	Clean lines and filter.

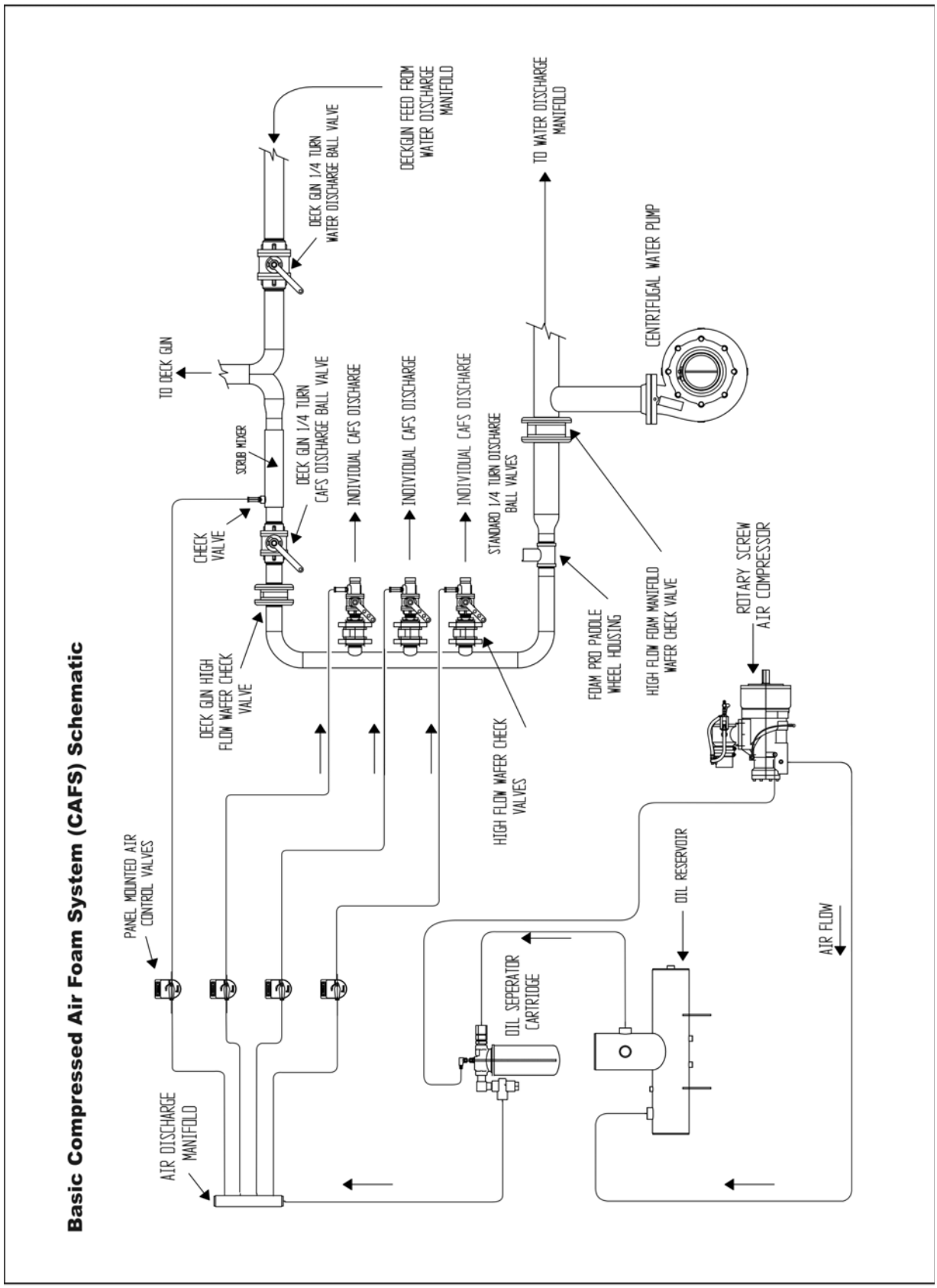


Figure 8 Basic CAFS Schematic

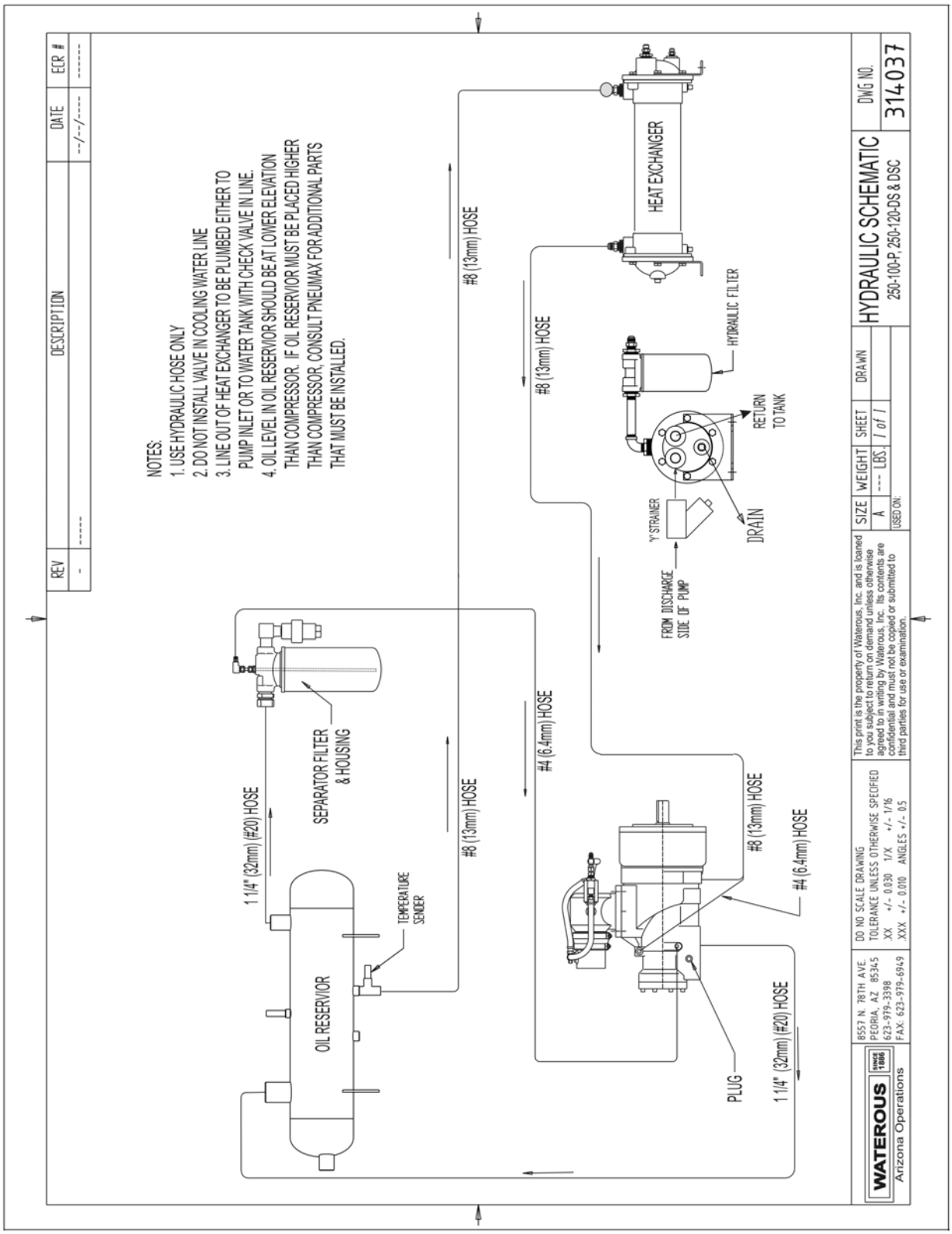


Figure 9 Hydraulic Schematic, Horizontal Sump

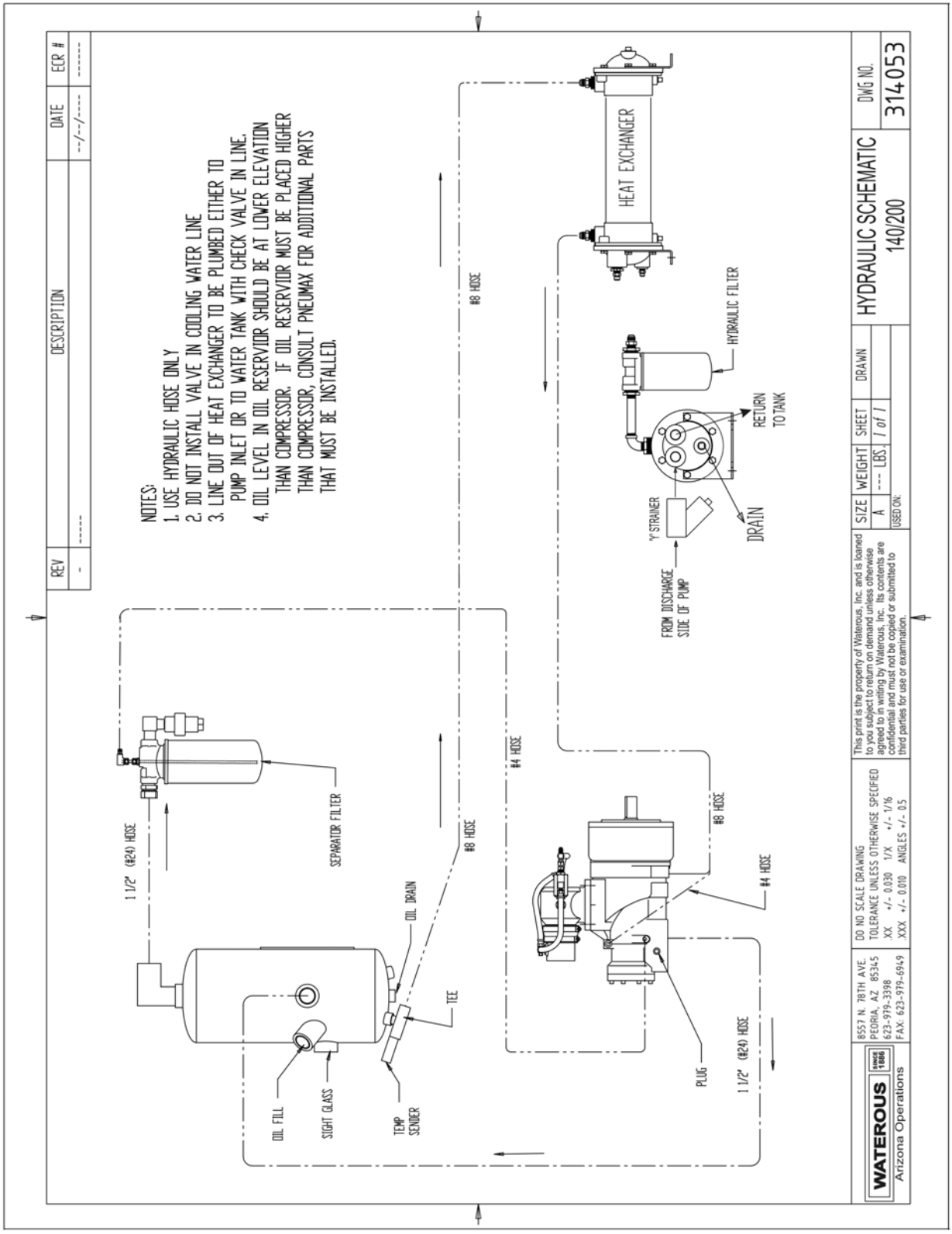


Figure 10 Hydraulic Schematic, 10" Vertical Sump

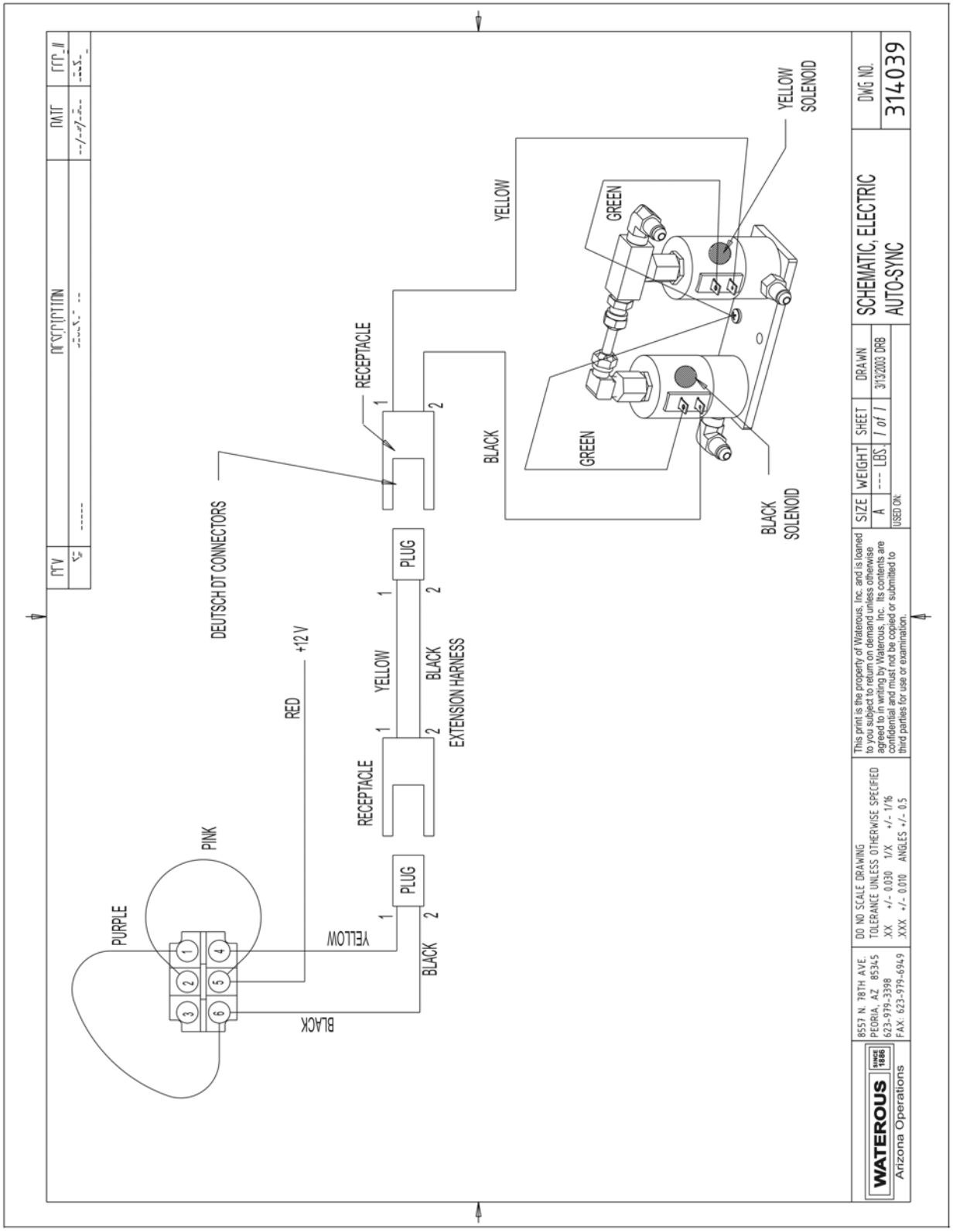


Figure 11 Electrical Schematic, Electrical Solenoids

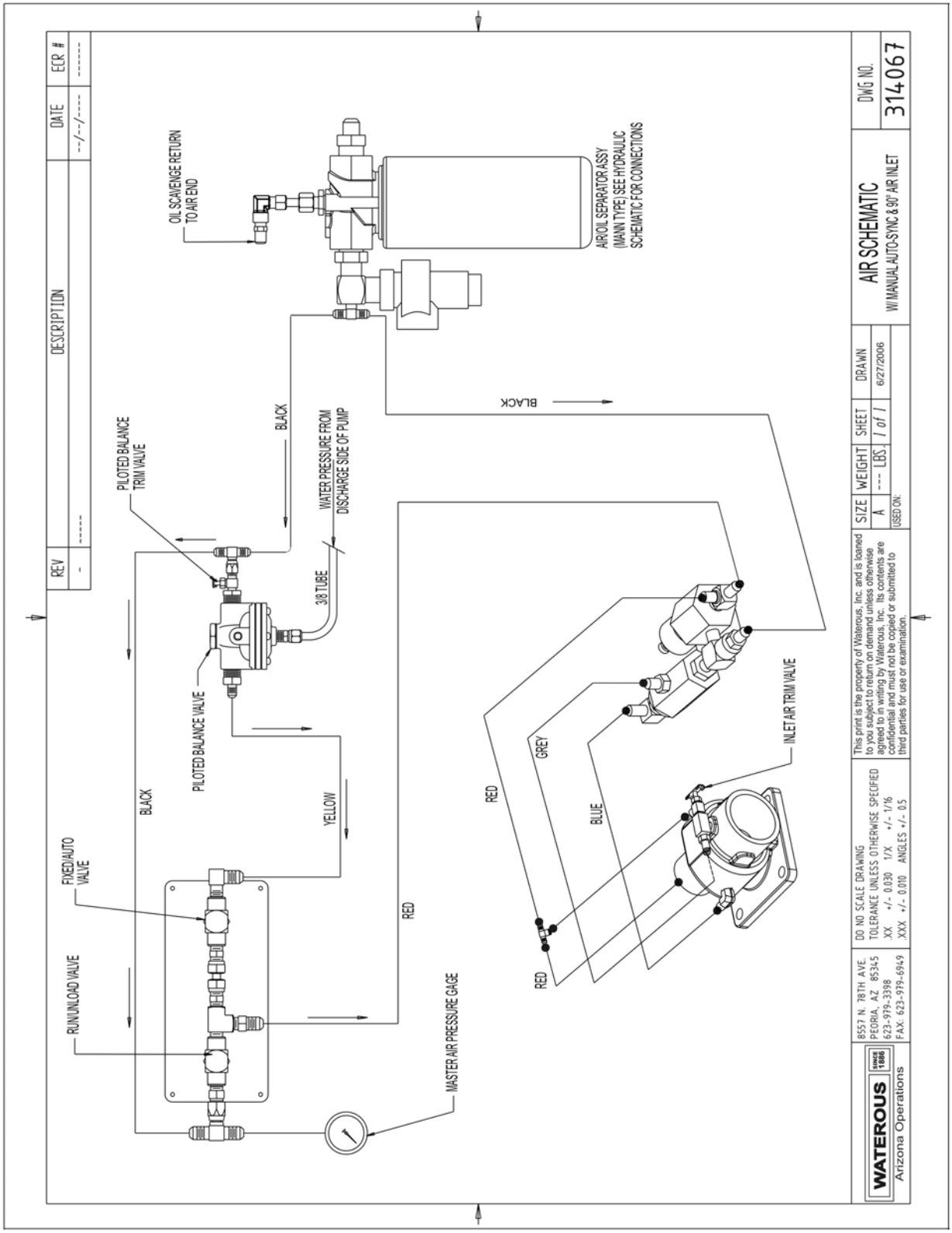


Figure 12 Air Schematic, Manual Auto-sync, 90° Inlet

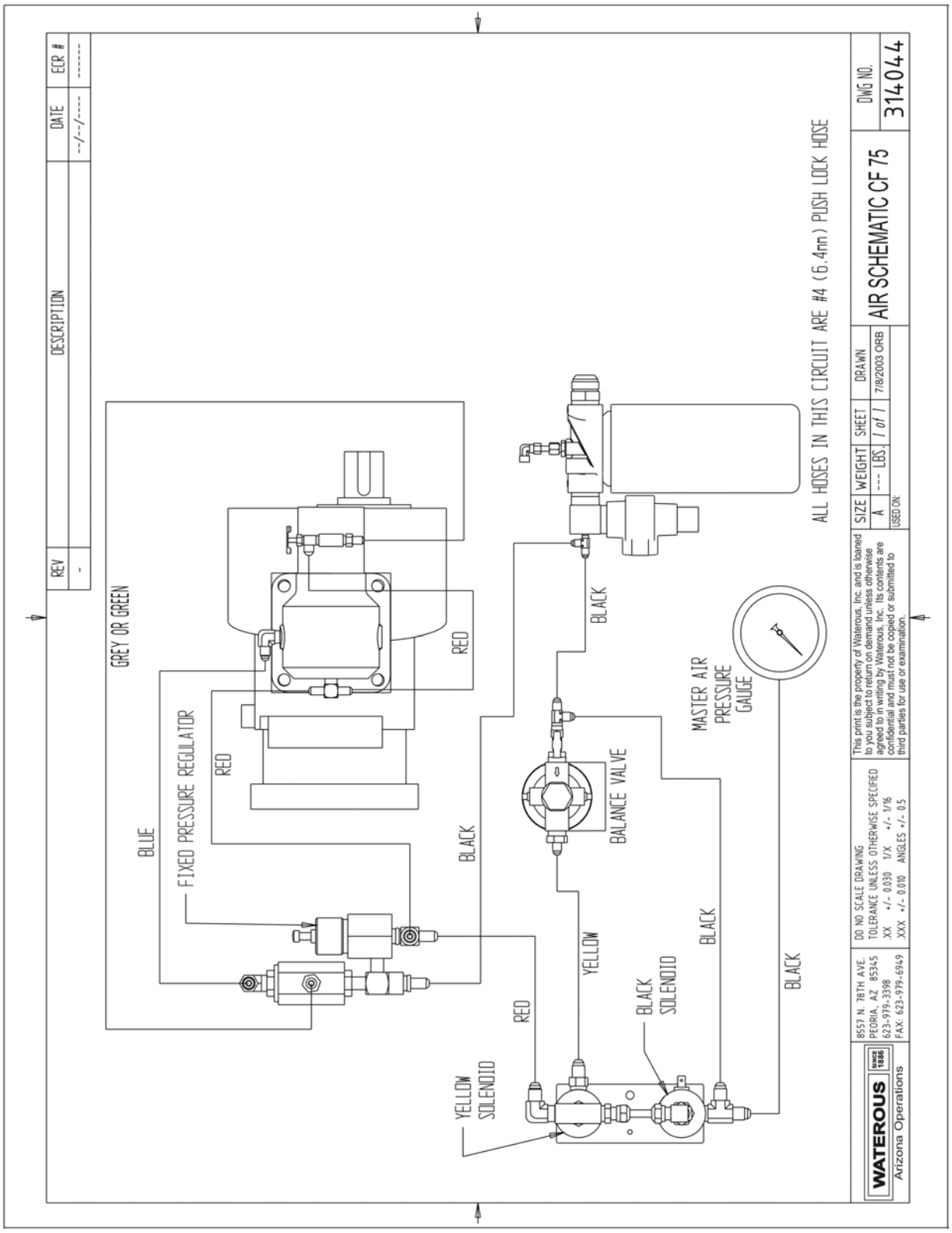


Figure 13 Air Schematic, Electrical Auto-sync, 90° Inlet

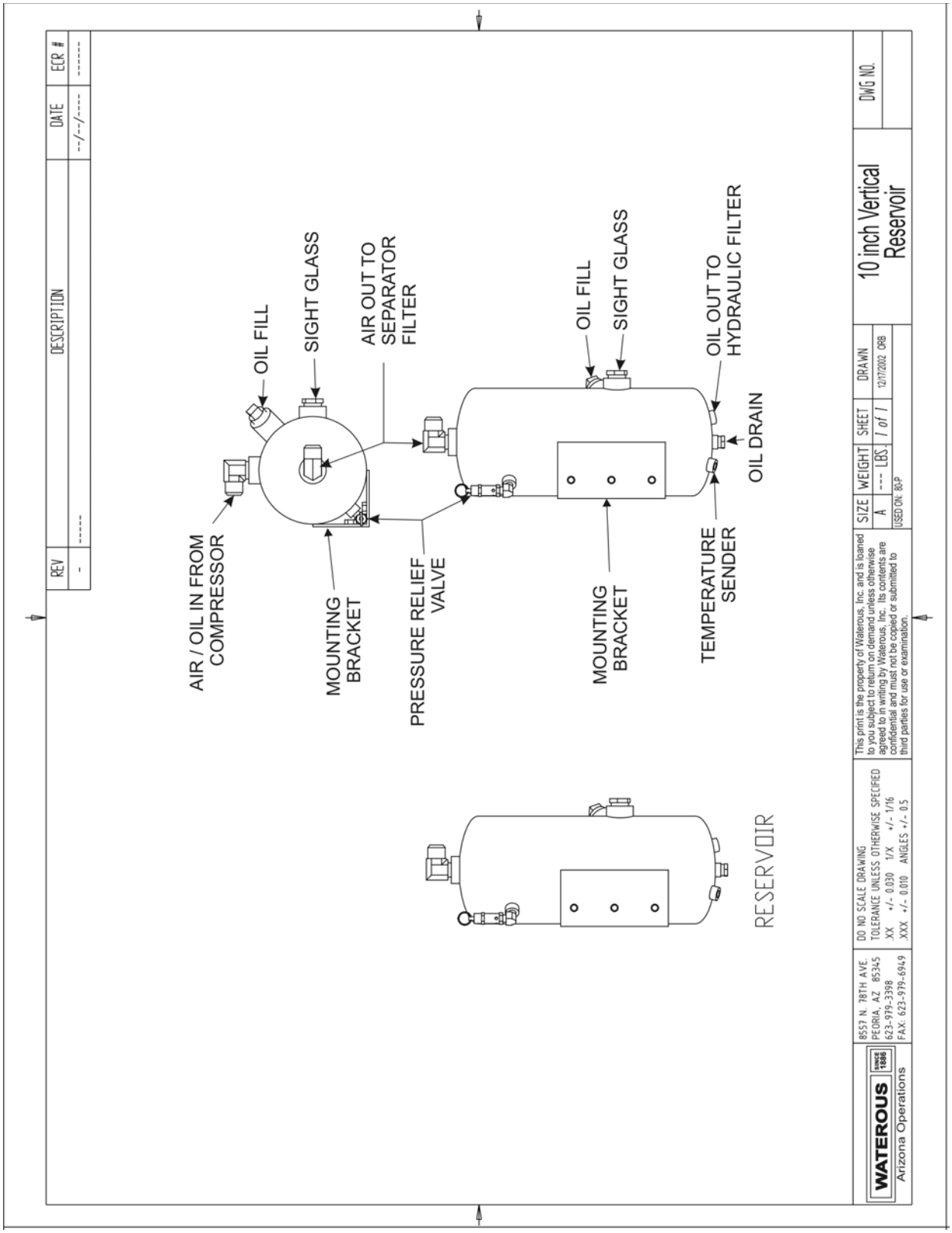


Figure 14 10" Vertical Sump

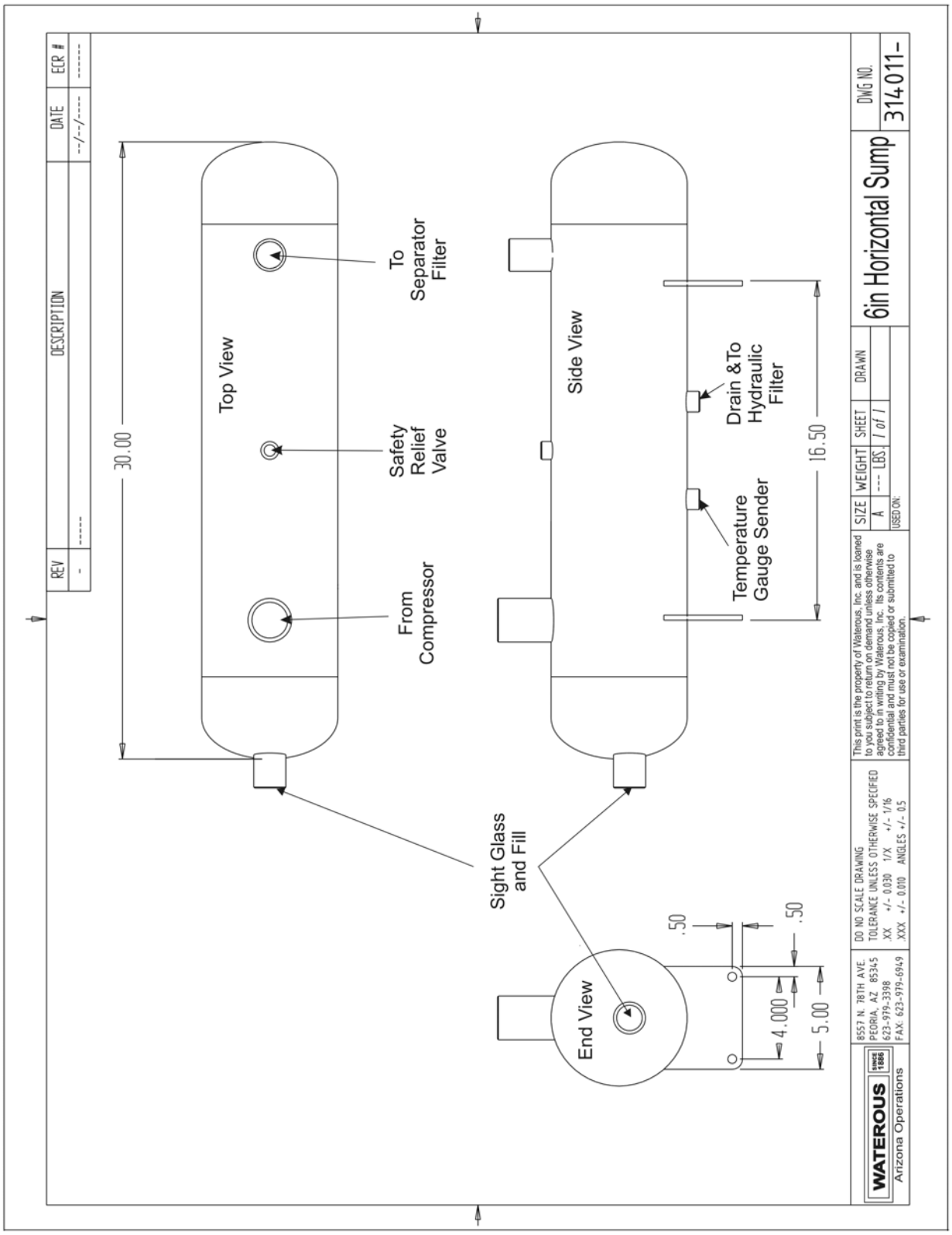


Figure 15 6" Horizontal Sump

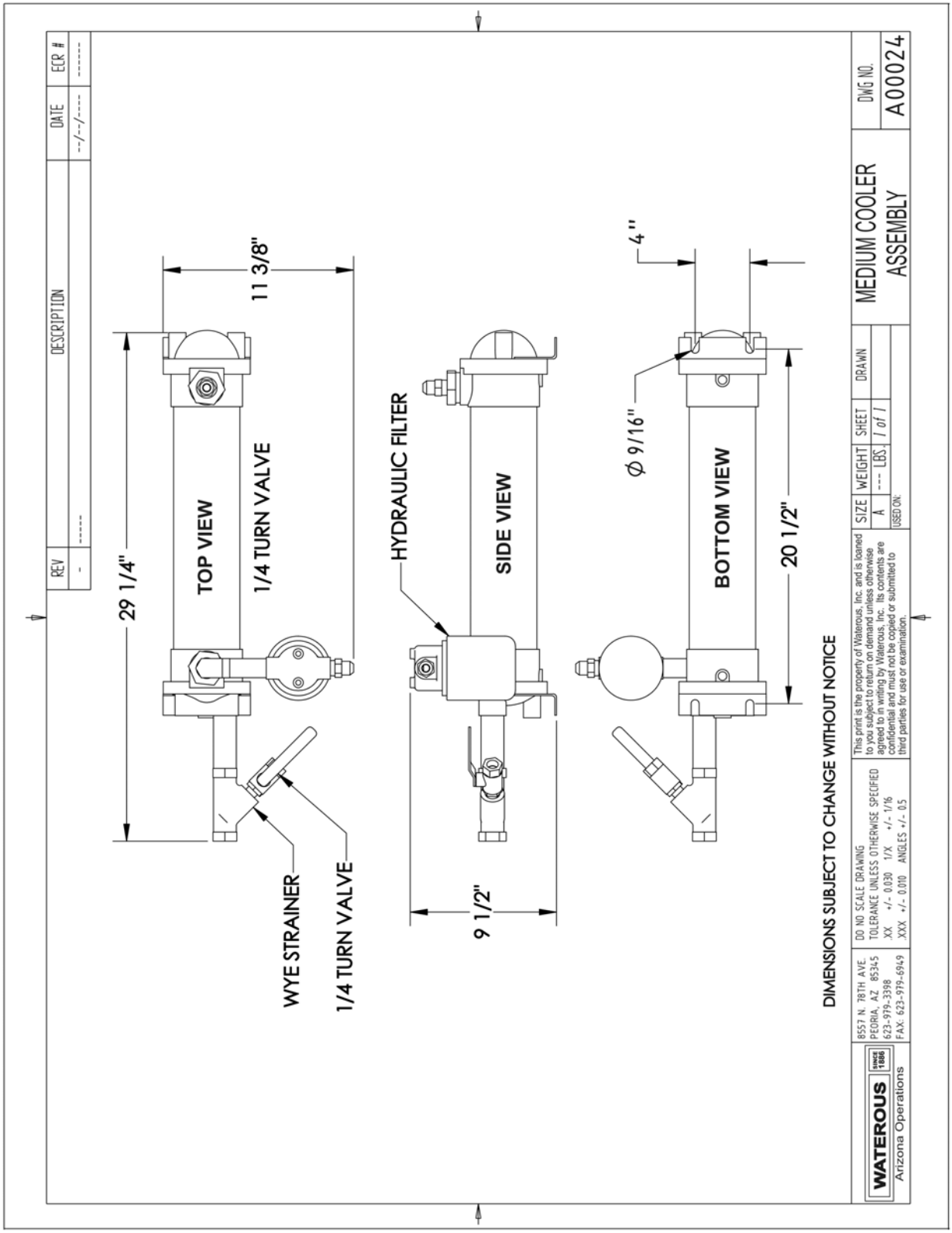


Figure 16 Medium Cooler Assembly

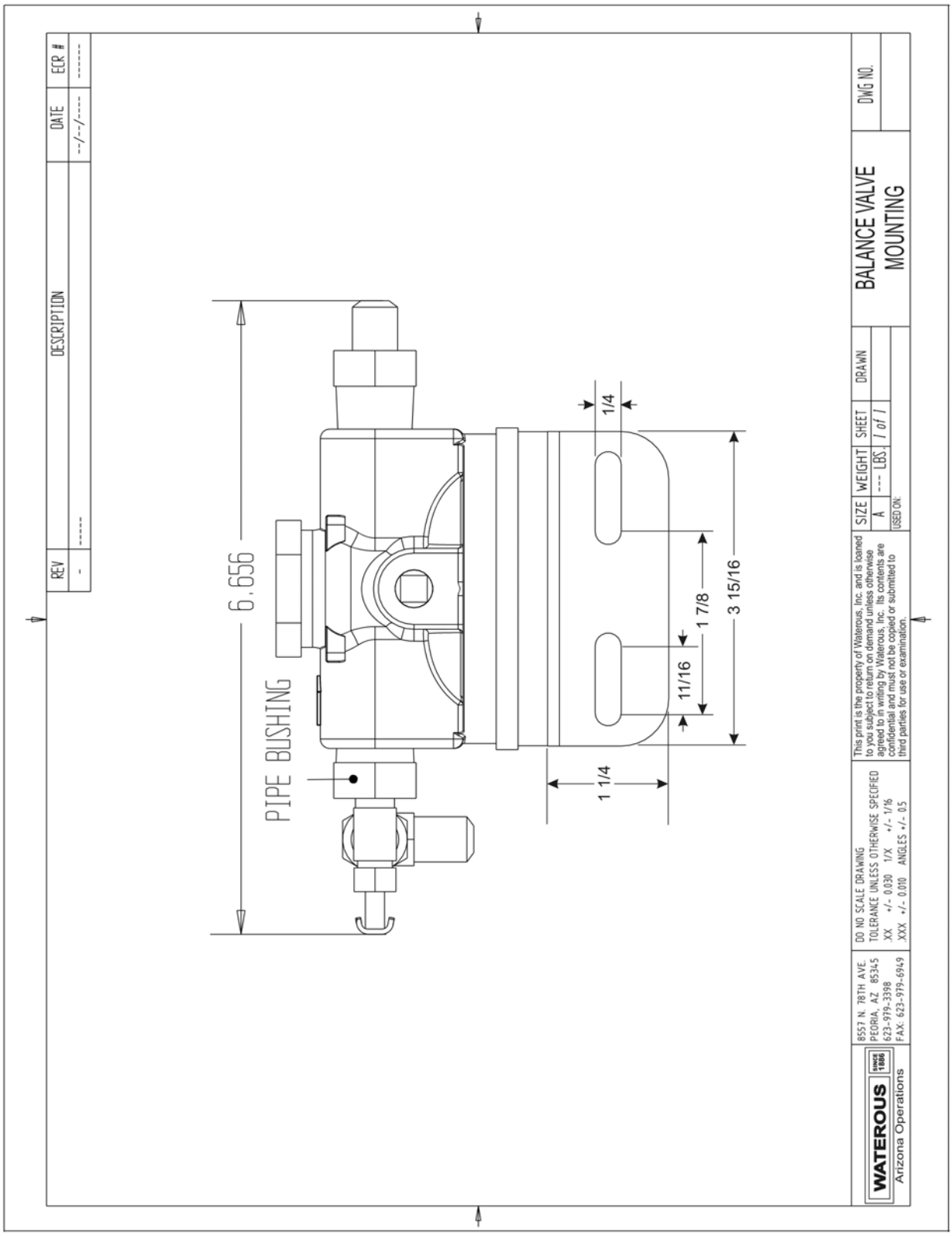


Figure 17 Auto-sync Piloted Balance Valve

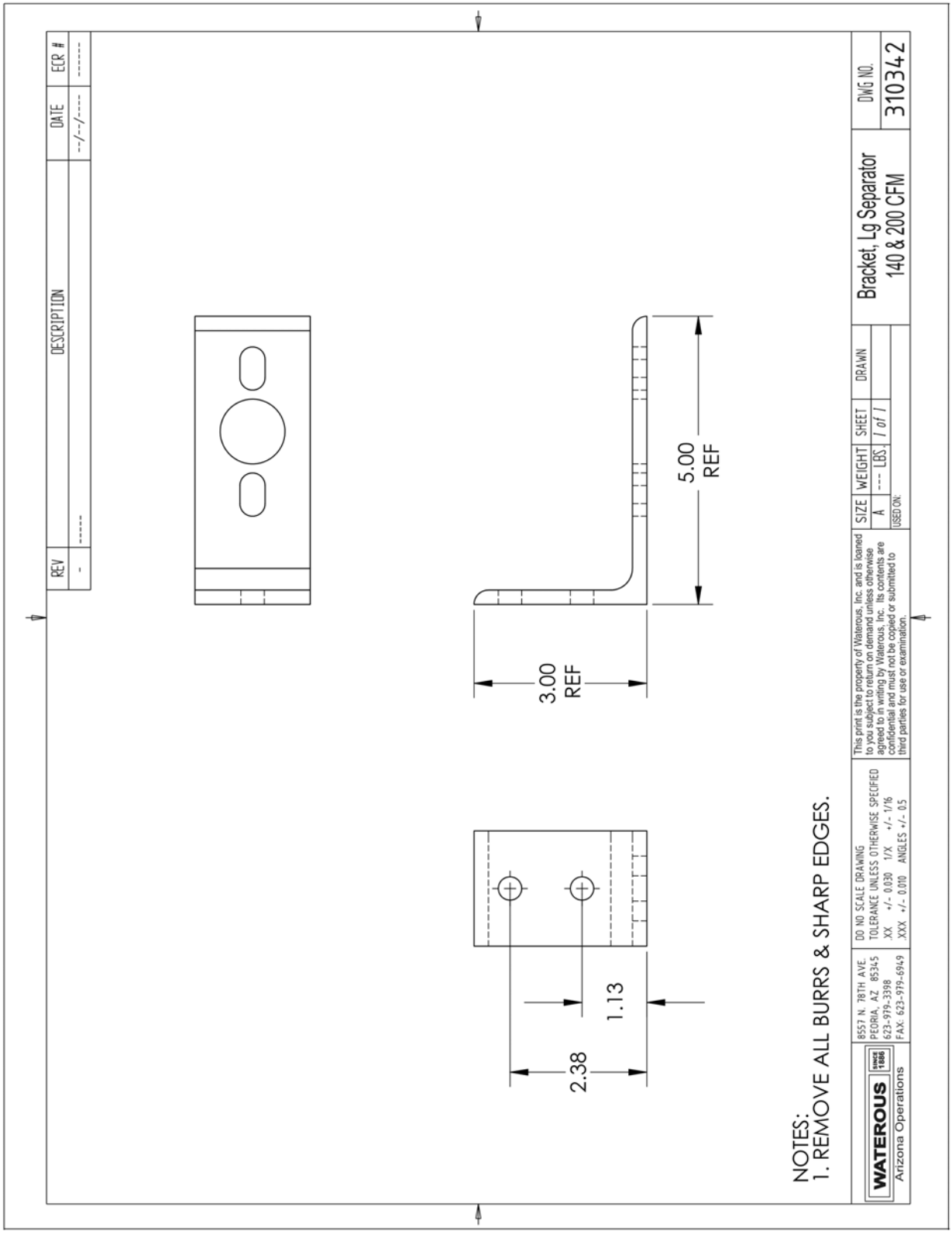


Figure 18 Separator Mounting Bracket

REV	DESCRIPTION	DATE	ECR #
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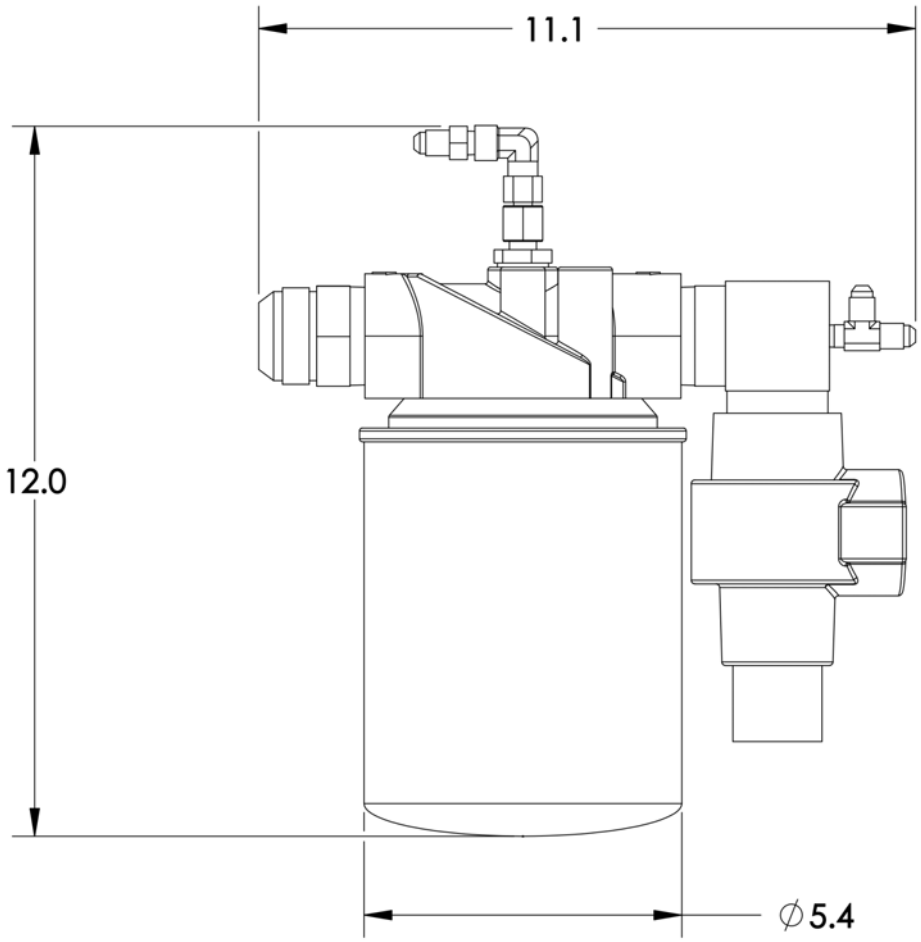


WATEROUS SINCE 1886 Arizona Operations	8557 N. 78TH AVE. PEORIA, AZ 85345 623-979-3398 FAX: 623-979-6949	DO NO SCALE DRAWING TOLERANCE UNLESS OTHERWISE SPECIFIED .XX +/- 0.030 1/X +/- 1/16 .XXX +/- 0.010 ANGLES +/- 0.5	This print is the property of Waterous, Inc. and is loaned to you subject to return on demand unless otherwise agreed to in writing by Waterous, Inc. Its contents are confidential and must not be copied or submitted to third parties for use or examination.	SIZE: A WEIGHT: --- LBS. SHEET: 1 of 1 DRAWN: USED ON:	Medium Separator Filter Assembly	DWG NO. 390092

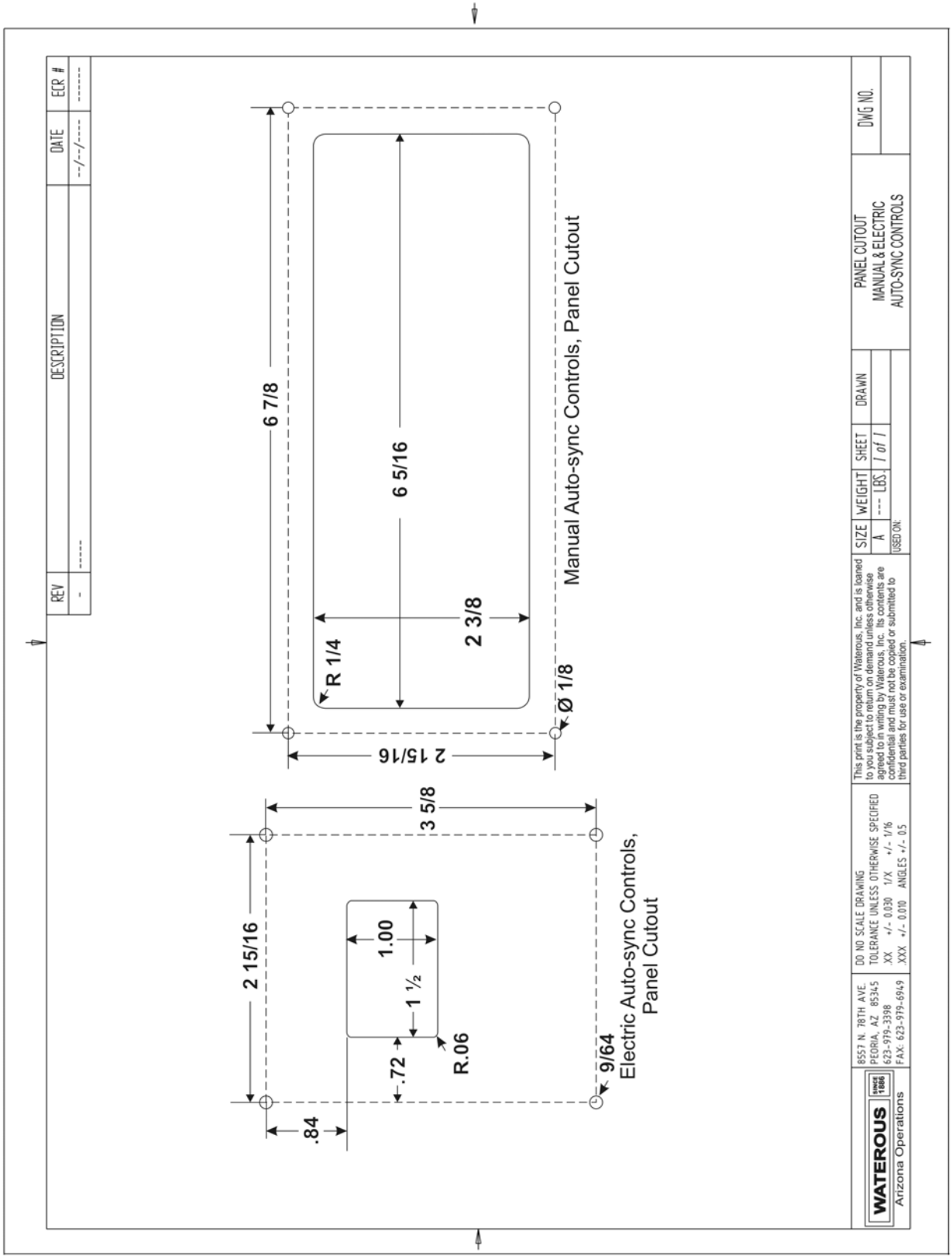


Figure 19 Auto-sync Control Panel Cutouts, Electrical & Manual

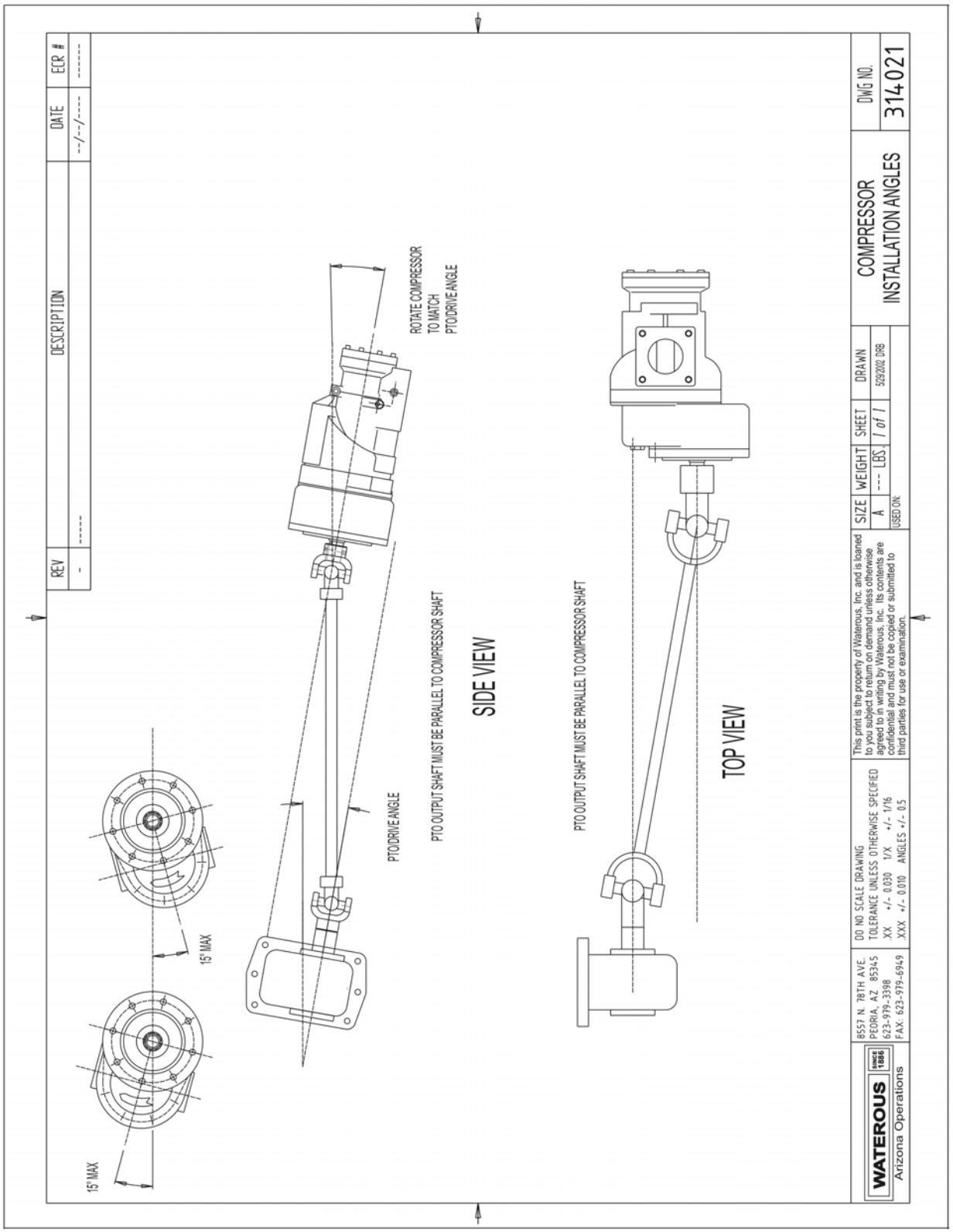


Figure 20 Compressor Installation Angles

SECTION 8. Basic Driveline Installation Suggestions

A. U-Joint Operating Angles

Every U -joint that operates at an angle creates vibration.

U -joint operating angles are probably the most common cause for driveline vibration in vehicles that have been reworked or that have had auxiliary equipment installed.

When reworking a chassis or installing a new drive shaft in a vehicle, make sure that you follow the basic rules that apply to u -joint operating angles, as follows:

1. U -joint operating angles at each end of a shaft should always be at least 1 °.
2. U -joint operating angles on each end of a drive shaft should always be equal within 1 ° of each other.
3. U-joint operating angles should not be larger than 3°. If more than 3°, make sure they do not exceed the maximum recommended angles for the RPM at which they will be operating.

A u -joint operating angle is the angle that occurs at each end of a drive shaft when the output shaft of the transmission and the input shaft of the pump are not in line. See Figure 21.

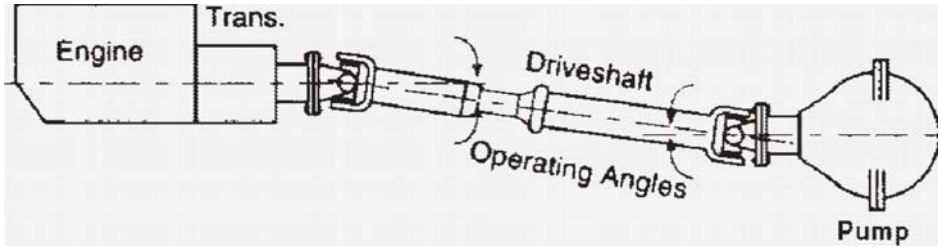


Figure 21 Operating Angle

The connecting drive shaft operates with an angle at each u -joint. It is that angle that creates a vibration.

I. Reducing and Canceling Vibration

A key point to remember about u -joint operating angles: To reduce the amount of vibration, the angles on each end of a drive shaft should always be SMALL.

To cancel an angle vibration, the u -joint operating angles need to be EQUAL within 1 ° at each end of a shaft. See Figure 21.

B. Single Plane and Compound U-Joint Operating Angles

There are two types of u -joint operating angles, single plane and compound.

I. Single Plane

Single plane angles occur when the transmission and pump components are in line when viewed from either the top or side, but not both.

Determine the u -joint operating angle in an application where the components are in line when viewed from the top, but not in line when viewed from the side, is as simple as measuring the slope of the components in the side view, and adding or subtracting those slopes to determine the angle. See Figure 22.

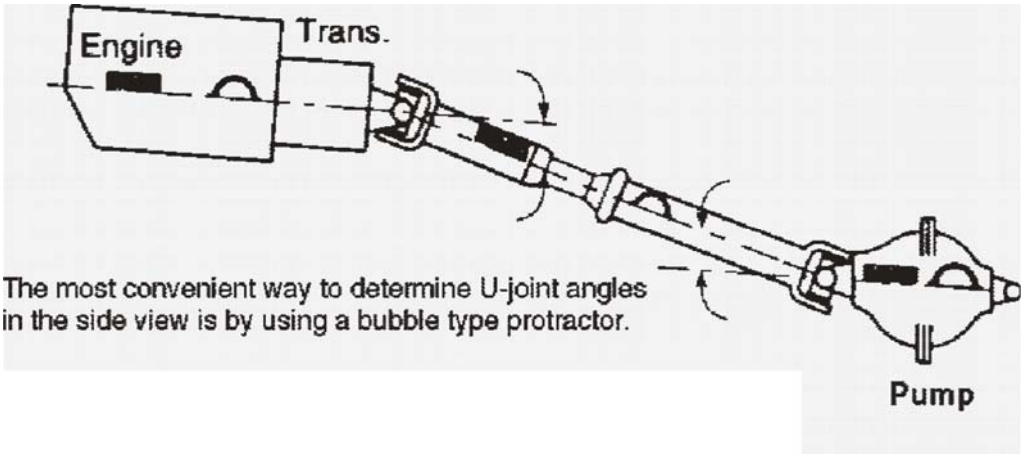


Figure 22 Angles in the side view

These angles should be SMALL and equal within 1°.

Determine the u -joint operating angles on a shaft that is straight when viewed from the side and offset when viewed from the top requires the use of a special chart (See accompanying chart). In this type of application, the centerlines of the connected components must be parallel when viewed from the top, as shown. These angles should also be SMALL and equal within 1°. See Figure 23.

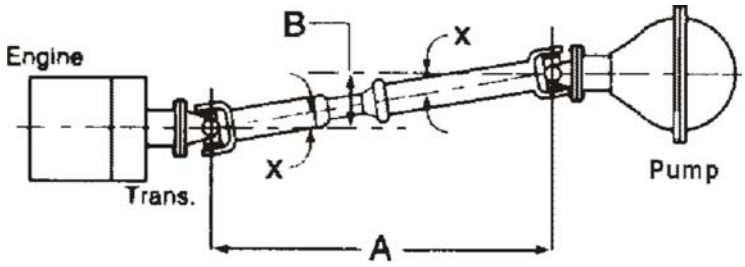


Figure 23 Angles in the top view

Look at the angle chart and note that the smaller the offset, the smaller the resultant angle.

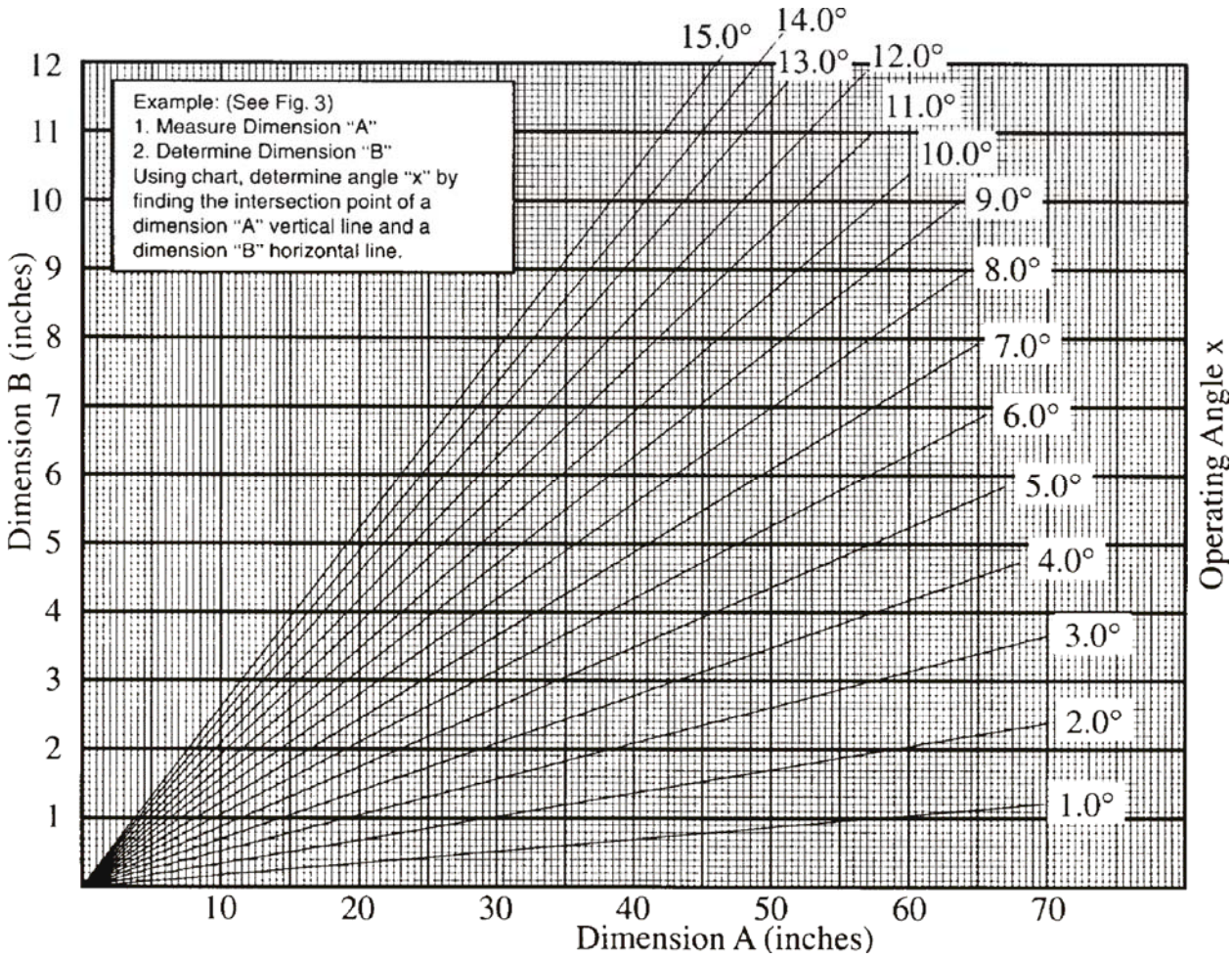


Figure 24 Angle Chart

To reduce the possibility of vibration, keep any offset between connected points to a minimum.

Make sure that the transmission and pump are mounted so that their centerlines are parallel when viewed from both the side and the top.

Make sure the offset between them is small in both views.

II. Compound Angles

Compound u -joint operating angles occur when the transmission and pump are not in line when viewed from both, the top and side. Their centerlines, however, are parallel in both views. See Figure 25.

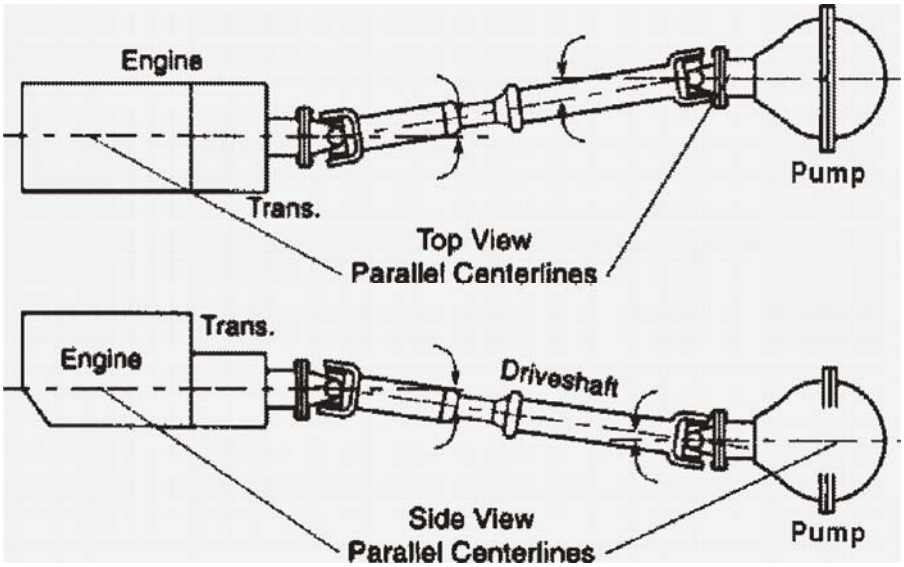


Figure 25 Compound Operating Angles

III. True U-Joint Operating Angle

The true u -joint operating angle, which must be calculated for each end of the shaft with compound angles, is a combination of the u -joint operating angle in the top view, as determined from the chart, and the measured u -joint operating angle in the side view.

To determine the true u -joint operating angle for one end of a shaft, (compound angle C° in the formula shown in figure below) insert the u -joint operating angle measurement obtained in the side view and the u -joint operating angle obtained from the chart into the formula.

Compound Angle (C°) = $\sqrt{x^{\circ 2} + a^{\circ 2}}$

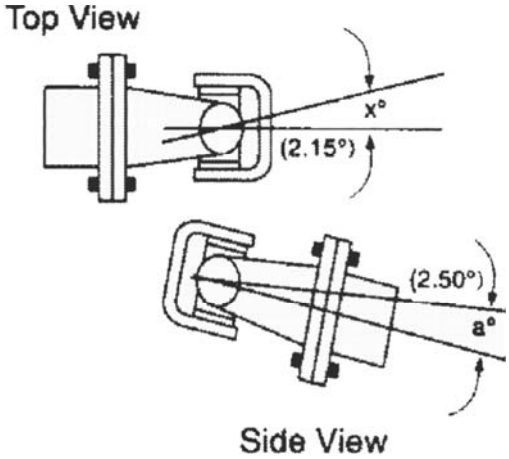
x = 2.15° (A calculated angle)

a = 2.5° (The measured angle)

C° = $\sqrt{2.15^2 + 2.5^2}$

C° = $\sqrt{10.873}$

C° = 3.3° (True operating angle)



IV. Angle Size

The magnitude of a vibration created by a u-joint operating angle is proportional to the size of the u-joint operating angle. The drive shaft manufacture(s) recommends true u-joint operating angles of 3° or less.

Obtain the true u-joint operating angle, as explained above, and if it is greater than 3°, compare it to the following chart.

DRIVESHAFT (RPM)	MAXIMUM ANGLE
5000	3.2°
4500	3.7°
4000	4.2°
3500	5.0°
3000	5.8°
2500	7.0°
2000	8.7°

The angles shown on the chart are the MAXIMUM u-joint operating angles recommended by the drive shaft manufacture(s) and are directly related to the speed and length of the drive shaft. Any u-joint operating angle greater than 3° will lower u-joint life and may cause vibration. Remember to check maximum safe drive shaft RPM as recommended by the drive shaft manufacturer.

When the PTO output shaft centerline and compressor input shaft centerline are parallel, the u-joint operating angle permissible is length of drive shaft divided by five.

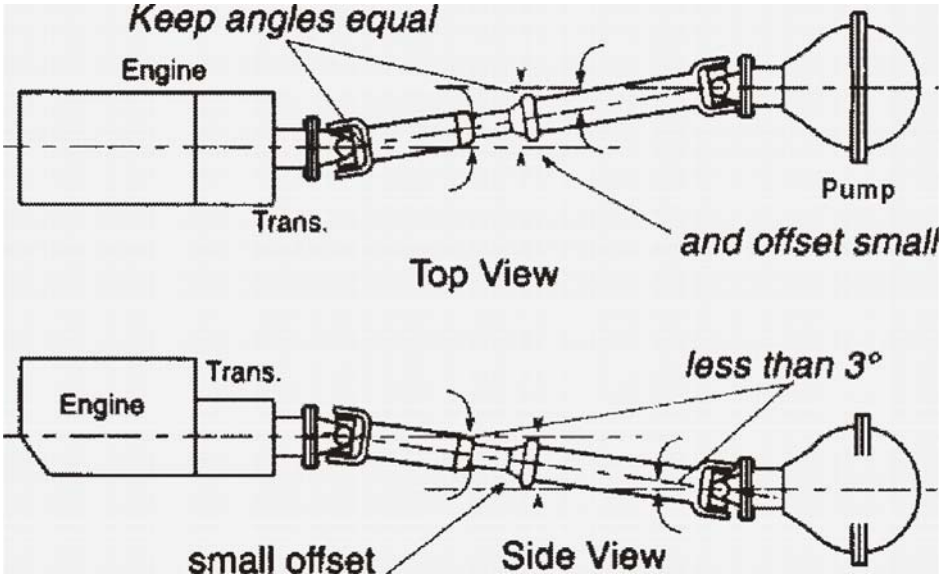
Example: A short coupled drive shaft with a 15" length would be limited to 3 degrees maximum operating angle. A 30" shaft would be limited to 6 degrees.

C. Eliminating Compound Angle Induced Vibrations

Compound u -joint operating angles are one of the most common causes for driveline vibration. To avoid these problems, remember these important considerations:

When setting up an application that requires compound u-joint operating angles, always keep the centerlines of the transmission and pump parallel in both views.

Always keep the offset between their horizontal and vertical centerlines small.



Note: Centerlines of transmission and axle must be parallel in both top and side views to use this method of determining true u-joint operating angle. Contact the drive shaft manufacture(s) for technical support if you have an application which cannot be installed with their centerlines parallel.

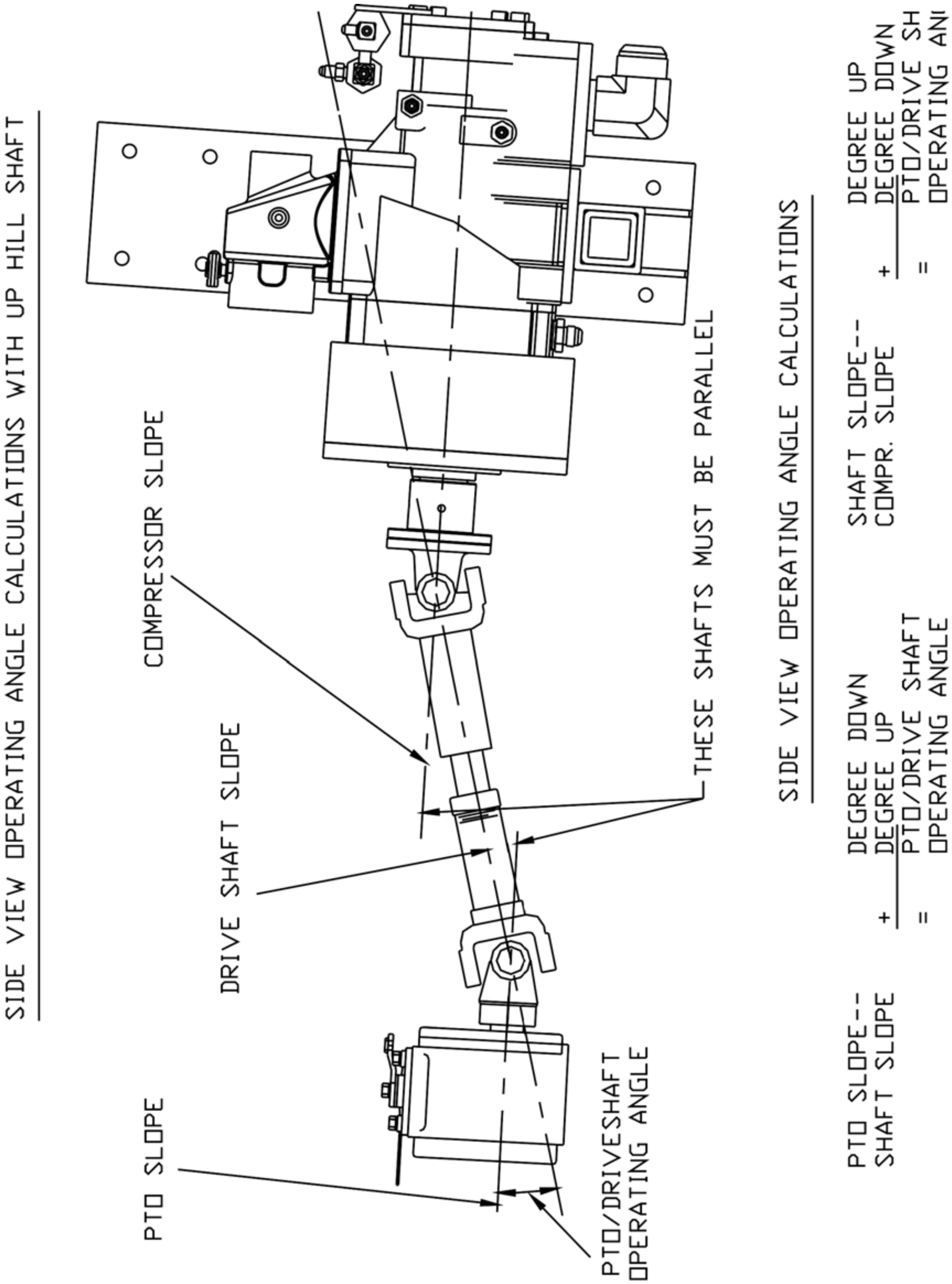


Figure 26 Operating Angle - Uphill

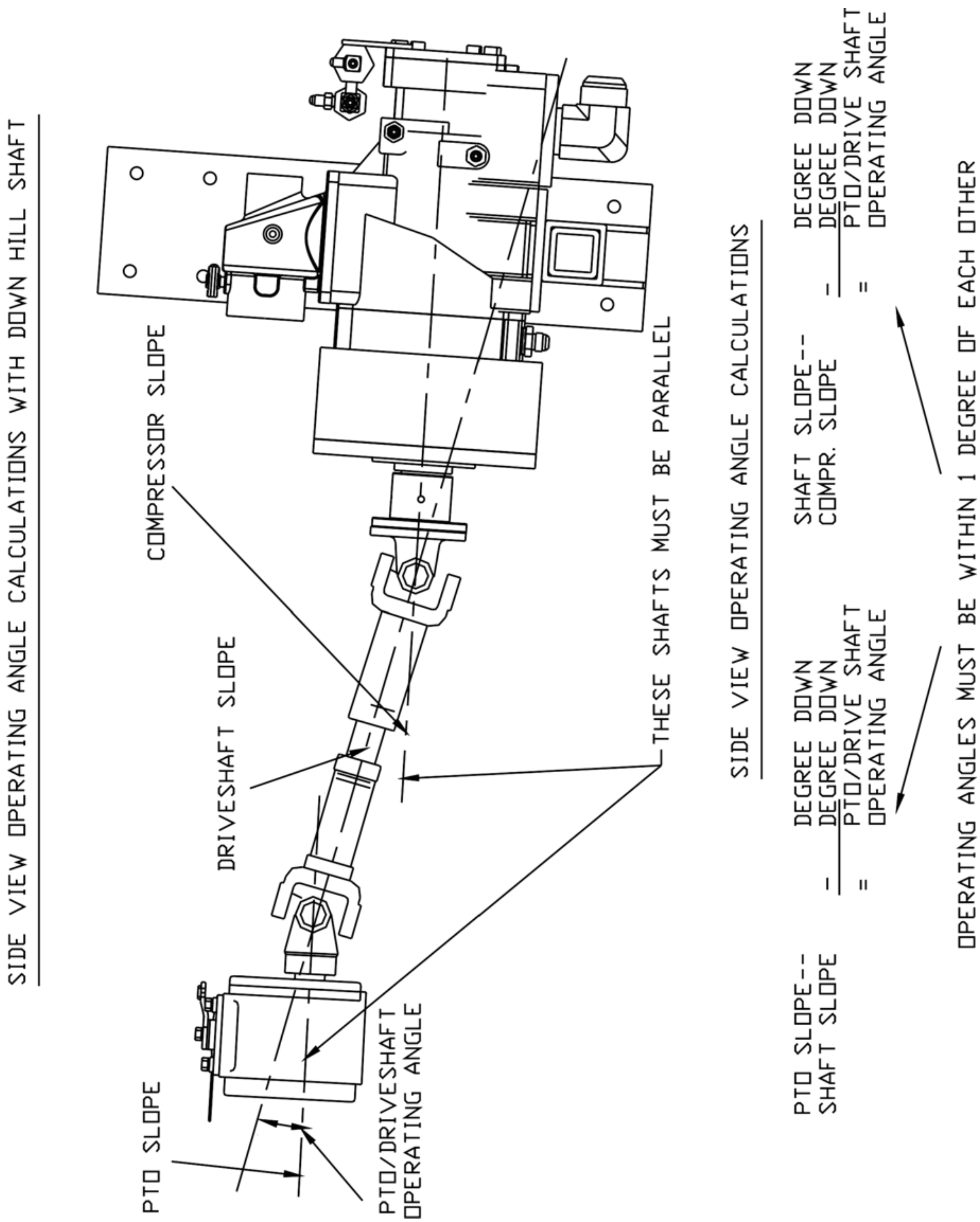


Figure 27 Operating Angle - Downhill

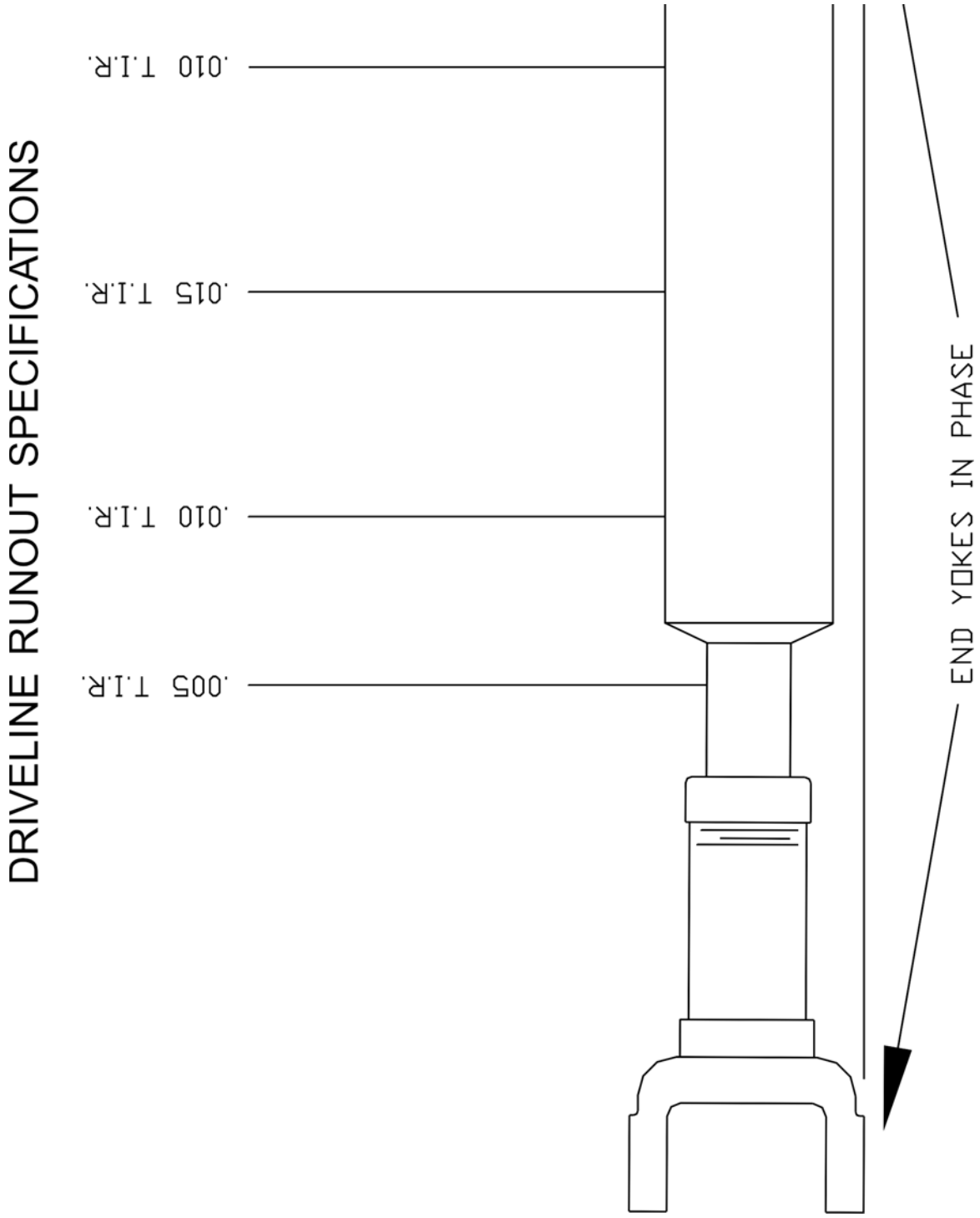


Figure 28 Driveline Run-out Spec

SECTION 9. WATEROUS 5-YEAR LIMITED WARRANTY POLICY

WATEROUS warrants, to the original Buyer only, that products manufactured by WATEROUS will be free from defects in material and workmanship under normal use and service for a period of five (5) years from the date the product is first placed in service, or five and one-half (5-1/2) years from the date of shipment by WATEROUS, whichever period shall be the first to expire; provided the Buyer notifies WATEROUS, in writing, of the defect in said product within the warranty period, and said product is found by WATEROUS to be nonconforming with the aforesaid warranty. When required in writing by WATEROUS, defective products must be promptly returned by Buyer to WATEROUS at WATEROUS' plant at South St. Paul, Minnesota, or at such other place as may be specified by WATEROUS, with transportation and other charges prepaid. A Returned Material Authorization (RMA) is required for all products and parts and may be requested by phone, fax, email, or mail. The aforesaid warranty excludes any responsibility or liability of WATEROUS for:

(a) damages or defects due to accident, abuse, misuse, abnormal operating conditions, negligence, accidental causes, use in non-firefighting applications, or improper maintenance, or attributable to written specifications or instructions furnished by Buyer;

(b) defects in products manufactured by others and furnished by WATEROUS hereunder, it being understood and agreed by the parties that the only warranty provided for such products shall be the warranty provided by the manufacturer thereof which, if assignable, WATEROUS will assign to Buyer, if requested by Buyer;

(c) any product or part, altered, modified, serviced or repaired other than by WATEROUS, without its prior written consent;

(d) the cost of dismantling, removing, transporting, storing, or insuring the defective product or part and the cost of reinstallation; and

(e) normal wear items (packing, strainers, filters, light bulbs, anodes, intake screens, mechanical seals, etc.).

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(b) the repair of such product or part, or

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