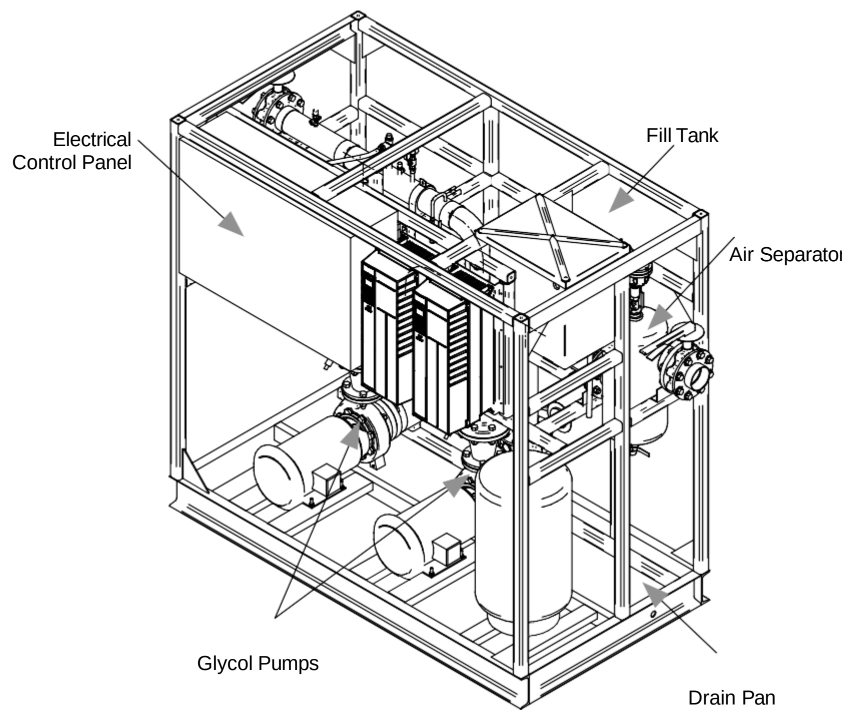
Glycol Pump Station

High Side & Medium Temperature Secondary Glycol Refrigeration Systems



SCAN CODE TO SEE LATEST MANUAL ONLINE

Installation & Operation Manual

P/N 1H24556001_E

March 2025

Model Reference and Flow Rates

The Pump Station model numbers, for reference:

N GS 450 K (may be followed by additional characters)

PUMP VOLTAGE (K)

M=460/3/60
K=208-230/3/60
P=575/3/60

GLYCOL FLOW RATE (GPM) (450)

010, 015, 025, 050, 075, 100, 125,

150, 200, 250, 300, 350, 400, 450

GLYCOL SECONDARY (GS)

SYSTEM PREFIX (N)

N=Pump Station
M=Previous Vintage

Pump Station Frame Dimensions and Weights

TABLE 1-0a: SYSTEM FRAME SIZES AND WEIGHT

Pump Station

Compressor Frame Size	Dimensions (L" x W" x H")	Weight (lbs)*
150 GPM	82x44x80	2500
200 GPM	82x44x80	2500
250 GPM	82x44x80	3500
300 GPM	82x44x80	3500
350 GPM	82x44x80	3500
400 GPM	82x44x80	4000
450 GPM	82x44x80	4000

*While operating.

This warning does not mean that Hussmann products will cause cancer or reproductive harm, or is in violation of any product-safety standards or requirements. As clarified by the California State government, Proposition 65 can be considered more of a 'right to know' law than a pure product safety law. When used as designed, Hussmann believes that our products are not harmful. We provide the Proposition 65 warning to stay in compliance with California State law. It is your responsibility to provide accurate Proposition 65 warning labels to your customers when necessary. For more information on Proposition 65, please visit the California State government website.

GLOSSARY

Refrigerant: A fluid used to freeze or chill (as food) for preservation.

Primary Refrigerant: A fluid such as R448A used in a vapor compression system to cool a secondary coolant.

Secondary Coolant (Refrigerant): A fluid such as Propylene Glycol used to remove heat from cases and unit coolers and transfer the heat to the primary refrigerant through a heat exchanger. Secondary coolants used with these systems are for medium temperature applications only, meaning the working temperature should be above 0°F. A typical secondary coolant supply temperature is 20°F.

Freezing Point: the temperature at which a solution begins to crystallize.

Refractometer: Device for measuring the freezing point of the secondary fluid.

Triple Duty Valve: This works as a throttling valve for the secondary fluid flow rate, a check valve when the pump to which it is attached is not running and a positive shut off valve — mounted to the pump discharge.

Pump: Device that circulates the secondary fluid throughout the system.

Fill Tank: Tank used for storage of secondary fluid. This tank catches overflow from the pressure relief valve and automatic air vent. Secondary fluid can be added to the system using this tank after the initial filling process has taken place.

Drain Valve: Valve to which a hose can be connected to add fluid to or remove fluid from the system.

Balancing Valve: Valve used to measure and regulate the secondary coolant flow rate through a particular section of the secondary system. Balancing valves should be multi-turn, y-pattern, globe style valves with a positive shut off.

Air Separator: Device used to remove air from the secondary coolant.

Automatic Air Vent: Float-operated vent that allows air to escape to the atmosphere with a minimal loss of secondary fluid.

Warm Fluid Defrost: A defrost method used in lieu of an off cycle or electric defrost where near room temperature secondary fluid is circulated through the cases/unit coolers to remove ice from the evaporator coils.

SECTION 1: INSTALLATION

General Guidelines

This manual is written as a basic guideline for the installation and operation of pump stations for both medium temperature secondary systems as well as for warm fluid systems to reject heat from water-cooled condensers. The primary refrigerant (ex. R448A) can vary depending on the customer's requirements. For detailed information regarding a specific component or application, contact yourHussmann representative. Pump Stations may be installed without the use of vibration pads. The pump station may also be anchored due to seismic concerns or if specified by the building engineer.

Additional documentation for the installation is to be provided by the customer. All components must be installed according to manufacturer's specifications. All materials used must be compatible with the secondary coolant. Installation must comply with ANSI/ASME B31.5 Refrigeration Piping and Heat Transfer Components, ANSI/ASHRAE Standard 15 Safety Standard for Refrigeration Systems and local building codes.

Inspect all components prior to installation to ensure that they are free from defects or foreign materials and to confirm that they comply with all pressure and temperature ratings.

Shipping Damage

All equipment should be thoroughly examined for shipping damage before and while unloading.

This equipment has been carefully inspected at our factory, and the carrier has assumed responsibility for safe arrival. If damaged, either apparent or concealed, the claim must be made to the carrier.

Apparent Loss or Damage

If there is an obvious loss or damage, it must be noted on the freight bill or express receipt and signed by the carrier's agent; otherwise, carrier may refuse claim. The carrier will supply the necessary claim forms.

Concealed Loss or Damage

When loss or damage is not apparent until after equipment is uncrated, a claim for concealed damage is made. Upon discovering damage, make request in writing to carrier for inspection within 15 days and retain all packing. The carrier will supply inspection report and required claim forms.

Pre-Installation System Cleaning

Use a 1-2% solution of trisodium phosphate (TSP), or equivalent cleaner and distilled water to remove grease, mill scale, or other residues from construction. Repeat this process if necessary until the drained solution is clear and free from visible debris. The system should then be drained and flushed again using distilled water.

Hussmann recommends distilled water for system flushing with 2% TSP. Dry nitrogen can be used for the initial pressure test (60 to 75 psi) hold for three hours.

City water may be used for system cleaning if the water meets the requirements in the table at right.

Water Quality Requirements

Impurity	Level
Chlorides	25 ppm, max
Sulfates	25 ppm, max
Total Hardness, as $CaCO_3$	80ppm

Water above these levels should not be introduced in the system.

Do not let city water sit in the system. The flushing process should be no more than 6 to 8 hours.

SECTION 2: PIPING GUIDELINES

Piping Materials

Any piping material that meets all pressure and temperature ratings, material compatibility requirements and state and local building codes may be used for medium temperature applications. Connections to the rack and pump station are copper as a standard. If the other materials are used, adapters would need to be ordered separately.

1. Plastic

a. ABS is recommended over other types for this application because of the operating temperature.
b. ABS plastic pipe should be solvent welded (glued) together as described on the glue can.
c. Pipe fittings must be clean and dry. Cut pipe with a guillotine type cutter to get a clean, square cut; remove any burrs. Use purple primer on both pipe and fitting before gluing. Apply glue to both pipe and fitting and join with a twisting motion. Hold joint together for approximately 30 seconds to allow glue to set. Allow the joint to dry for 24 hours before putting into service.

2. Copper

a. M, K, or L may be used.
b. Copper-to-copper joints may be soft soldered or brazed so long as the braze/solder material contains no zinc or zinc chloride. Soft solder must be used where the component manufacturer's installation instructions recommend.
c. Soft solder flux materials must contain no zinc and must also be water soluble.

3. Steel

a. Schedule 40 carbon steel pipe or stainless steel pipe (or tubing) are acceptable.
b. Must protect exterior from corrosion.
c. Additional system cleaning is required.
d. GALVANIZED STEEL IS NOT TO BE USED IN ANY SYSTEM CONTAINING INHIBITED PROPYLENE GLYCOL.

Insulation

Insulation should be used in secondary system piping to reduce the heat transfer to ambient air. In order to minimize the required insulation thickness, install pipe in air-conditioned space as much as possible. Do not size insulation for condensation prevention only. Pipe should be insulated according to local codes and customer specifications.

When installing piping that has not been pre-insulated, there are several options for insulation. Closed-cell elastomeric insulation is very popular in refrigeration applications. This type of insulation can also be used in secondary system applications. For detailed information regarding this type of insulation, visit the Armaflex website at www.armaflex.com.

Other types of insulation that can be used are TRYMER and Styrofoam insulation. These are both made by Dow and are well suited for insulating pipe. Always follow the manufacturer's recommendations for insulation thickness and proper installation. Warm Fluid applications typically doesn't require insulation applied to piping/components. Piping that's run through the store may need to be insulated.

Pipe Connections

Connecting Plastic With Metal Pipe

DO NOT THREAD PLASTIC PIPE. A compression type fitting should be used. For larger pipe sizes, a flanged connection may be used.

Air Vent Valves

Manual air vent valves are recommended. Air vent valves should be located at piping high points where air will tend to collect. Momentarily open these vents to release trapped air a few times during startup. Provision should also be made for manual venting during the glycol loop fill. Vent valves should have a threaded connection to facilitate connection to a pipe or hose. It is important that the automatic vents be located in accessible locations for maintenance purposes, and that they be located where they can be prevented from freezing. Vents will vary with materials and local codes. The lowest points of the piping system must be purged of air, too, which typically involves heat exchanger coils.

DRAIN VALVES

Manual drain valves should be located at low points in the system or so that circuits can be drained of most of the fluid. This is used during maintenance or when changes to the system are made.

ISOLATION VALVES

Isolation valves should be used at a minimum on every circuit and as a standard on every coil. This will allow access to each circuit without shutting down the entire system. Ball valves should be used on all line sizes of 2” and less. Butterfly valves should be used on all sizes over 2”.

FILL CONNECTIONS

Use the fill tank on the pump station to add any minor amounts of fluid. Do not connect to city water.

Copper Pipe

Schrader valve air vent brazed into copper turn down. (See Figure P1.)

Plastic Pipe

After the joint is assembled, drill and tap for a threaded 1/2-ID ABS pipe to socket fitting. Use ABS cement on the threads and do not over-tighten. Install a plastic ball valve on the fitting. (See Figure P2).

To provide an air trap and assure that pipe cuttings do not get into the closed loop, install the 1/2-inch-threaded-to-ABS fitting in a TEE plug. Use a TEE at the turndown instead of an elbow. Install the plug and ball valve assembly after the joint is complete. (See Figure P3.)

All

When a turndown is not going to be accessible, a remote ball valve may be used. (See Figure P4.)

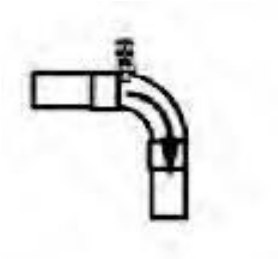


Figure P1

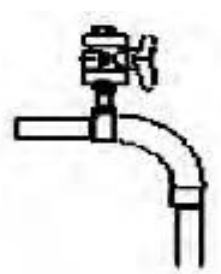


Figure P2

Figure P3

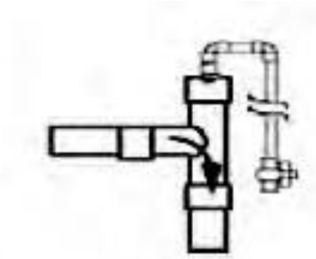


Figure P4

Pipe Supports

Suggested spacing for pipe supports is shown below. Verify state and local building codes for required support. Piping should be supported in a manner that minimizes heat transfer to the supports.

Nominal Pipe Size (in)	Distance between supports (ft) Schedule 40 pipe @ 100°F	Distance between supports (ft) Schedule 80 pipe @ 100°F
1.0	4.5	3.5
1.5	5.0	3.5
2.0	5.0	4.0
3.0	6.0	4.5
4.0	6.5	5.0
6.0	7.5	6.0

Pipe Support Spacing, ABS-DWV, Ft.			
Nominal Size	70°F	100°F	140°F
1-1/4	4-1/2	4-1/2	4
1-1/2	5	5	4-1/2
2	5	5	4-1/2
3	6	6	5-1/2
4	6-1/4	6-1/4	5-3/4
6	6-3/4	6-3/4	6
8	7	7	6-1/2

Water Loop Piping

The variations of effective water piping design and layout are numerous and a comprehensive discussion is beyond the scope of this document. The local suppliers of pumps, pipe, valves, cooling towers, chemicals and controls are familiar with what works best in your area.

Following are two basic design concepts applicable to water loop piping installations:

- **Direct Return Piping**
- **Reverse Return Piping**

Direct Return Piping

Direct return piping utilizes supply trunk lines. These supply lines decrease in size as branches reduce the water flow requirements through the trunk. The return trunk lines increase in size as branches join the trunk.

Advantages

- Initial cost of the pipe may be less than the reverse return system.

Disadvantages

- System balancing may be difficult since it must account for piping length, reductions in pipe size, and flow requirements.

Reverse Return Piping

Reverse return piping uses equal sized supply and return lines throughout the installation. Because of the pipe layout, the head loss due to piping is nearly identical at any point along the glycol loop.

Advantages

- This design reduces or eliminates the need for reduction fittings and allows use of larger quantities of one size pipe.
- Little balancing of glycol flow is required. A reverse return piping system will be essentially self-balancing.
- With proper prior planning, additional units may be added along the loop without the need to change pipe sizes.

Disadvantages

- Initial cost of the pipe may be more than the direct return system.

Expansion Loops

Allowances for expansion and contraction in long straight runs of piping must be provided by expansion loops.
Consult ASME B31.5 Refrigeration Piping Standard for specific design requirements. Use horizontal expansion loops to eliminate air traps. If vertical expansion loops are required, appropriate vent and drain valves must be installed.

Valves

1. Mount solenoid and check valves inside cases if space permits. Solenoid, check and ball valves are to be installed upstream of the case/unit cooler heat exchangers.
2. Balancing valves are to be installed downstream of the case/unit cooler heat exchangers. Always follow the manufacturer’s recommendations for installation. This includes orientation, braze vs. solder, flow direction, etc. Balancing valves should be multi-turn, y-pattern, globe style valves with a positive shut off. Adjust valves per manufacturer’s recommendations.

NOTE: All valves are available from Hussmann.

Closed Loop Air Separator

Air separators are standard on all units. An automatic air vent is included and piped directly out of the top of the air separator. In a circulating system, air tends to pocket where pipes turn in a downward direction. As a result, a vent is needed at high points when filling the closed system loop and at turn downs during start up.
See section Air Vent Valves above.

SECTION 3: FIELD ELECTRICAL CONNECTIONS

Incoming Supply and Control Power

The control panel on this equipment includes disconnect switch and the standard configuration includes a control circuit transformer with no separate 120v control power is required. Field wiring must comply with the latest version of the NEC and state and local electrical codes.

Equipment Control Wiring

A chiller controller is integral with the secondary system controls. Individual analog and digital inputs from the secondary system peripheral devices are required to be field wired to the controller board inputs of the parallel compressor rack system controller.

NOTE: The Chiller Controller and Chiller are included with the Primary Rack System.

The standard control for the pump station uses a standalone controller. This controller has separate user documentation. This will take a dry run-enable contact. Provide a fault dry contact to the rack controller to monitor the operation of the pump station.

Basics of Operation (MT Secondary Glycol System)

When the secondary system control circuit is powered up (either 120 or 208 volts) the chiller controller is powered. This must be programmed before starting the refrigeration system. Turn on the main on/off switch to energize the pump. There is a time delay to allow the pump to start and produce enough flow so that the system monitoring differential pressure does not produce an alarm at start-up. The pump will now run continuously until the specified changeover time, when Pump 1 will turn off and Pump 2 will turn on automatically (when in Auto Mode). There is a slight delay at the time of this changeover to prevent slamming of the discharge check valves.

The glycol supply temperature is controlled with the rack suction pressure. The rack stages compressors on and off based on suction pressure input. The glycol freeze thermostat temperature and electronic expansion valve superheat settings are programmable by the user.

Warm Fluid Defrost is an optional feature specified by the customer in place of off cycle or electric defrost (usually the latter). The temperature for the warm fluid is controlled by a three way mixing valve and temperature input in the defrost supply pipe. This temperature is controlled between 65°F and 75°F . Refer to Johnson Controls A350P for instructions on setting the temperature controller. A glycol solenoid receives a signal to open from the rack controller A/O board, allowing coolant to flow through the heat exchanger. A refrigerant solenoid also receives a signal to open, allowing refrigerant discharge gas to flow through the heat exchanger. A differential regulator is installed in the refrigerant discharge line past the oil separator to make sure some of the discharge gas goes through the heat exchanger.

System Faults

Pump Alarm: The system will monitor the secondary coolant flow. If the flow falls below the setpoint (set at the factory), the pump switching function is bypassed and the controls automatically switch from the currently active pump to the backup (when in Auto Mode). If the backup pump is also not operating properly, the system will cause the primary refrigerant solenoid to close and pump the rack down. The alarm must be reset manually at the control panel after the defective pump is serviced.

HIGH SIDE PUMPING STATION COMPONENTS

Each Pumping Station contains the following:

1) Two Pump & Motor Assemblies with
    a. Suction Guide & Butterfly Valves upstream (Pump Inlet)
    b. Triple Duty Valves downstream
2) Factory Piping with
    a. Common Suction & Discharge Lines
    b. ¾" Hose Bib
    c. Automatic Air Vent
    d. Expansion Tank
    e. Pressure Relief Valve
    f. Pressure Gages
3) Factory Wired Control Panel with
    a. Circuit Breakers and Contactors
    b. Main Disconnect
    c. Unit Controller (Stand-alone or I/O board)
    d. Differential Pressure switches
    e. Low Pressure Control
    f. Pressure transducers & Temp sensors
    g. Indicator lights for Pump run (Green) or alarm (red)

PUMPING STATION CONTROL METHOD OF OPERATION

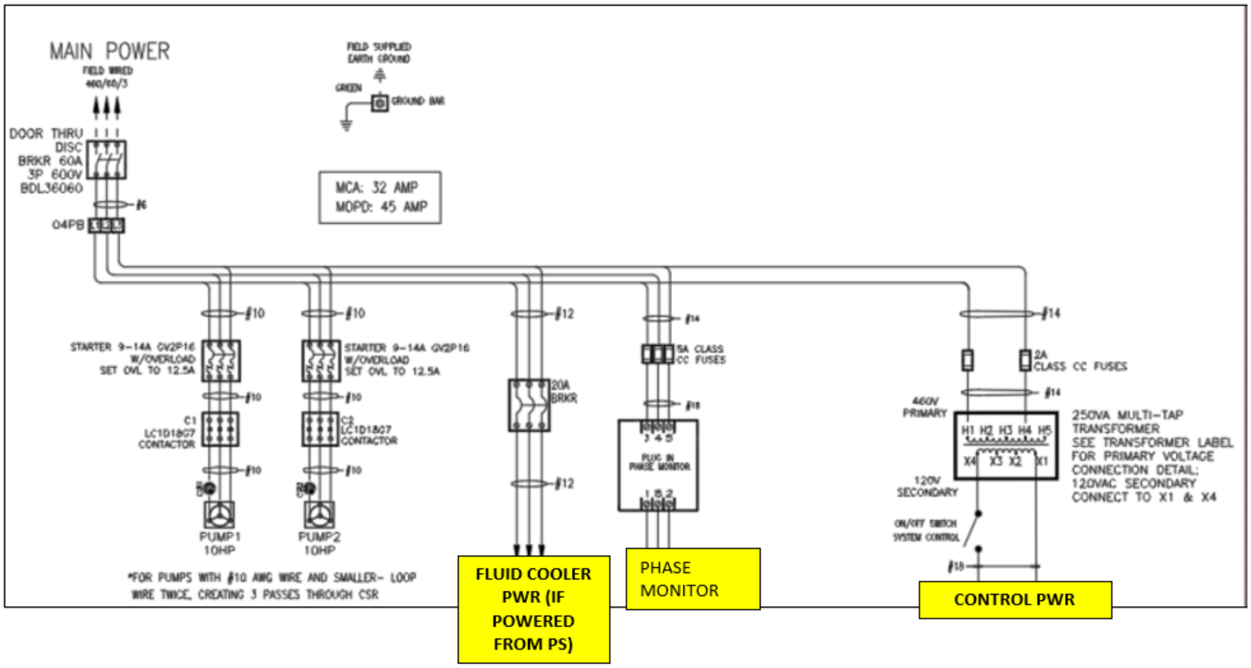
The primary function of the Pumping station algorithm is to rotate the operation of the pumps based upon user defined setting (Every 72 hours). The control monitors the operation of these Pumps by monitoring the proofing contacts (Pump proof input). When a Pump is energized, the proof contact should close (within 5 sec). If for some reason the contacts do not close, the controller will try to restart the Pump 3 times before locking that pump out and switching to another Pump.

The controller also monitors Pressure differential alarm input.

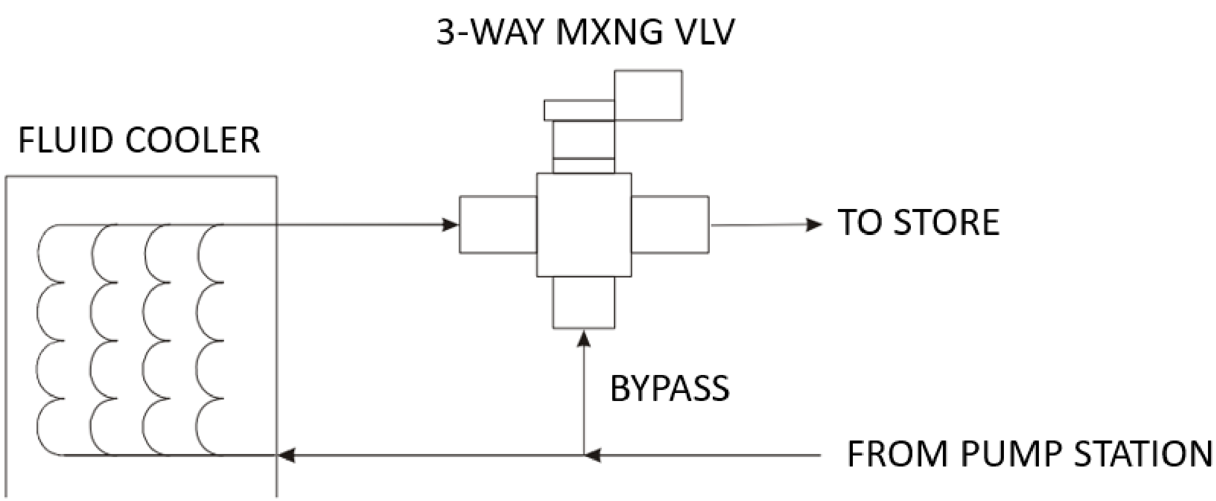
Differential Switch set-point: 5 PSIG Cut-out & 15 PSIG Cut-in

If enough differential is not developed, there is an alarm (dry contact input) sent and unit controller will switch to other pump. Alarm limits and time delays for differential alarm can be set/programmed.

Mechanical low Pressure switch set-point: 2 PSIG Cut-out, 12 PSIG Cut-in



3-Way Valve & VFD Operation:



Above figure shows typical piping of 3-way mixing valve. If the supply temp to store drops below set-point (65F), bypass line opens to bypass fluid cooler. 3-Way Mixing valve typically requires 0-10V Analog output point for modulation.
Fluid Cooler VFD will be at 100% if the Fluid Cooler outlet temp is above 85F.
VFD will modulate down to minimum speed (15HZ) when the Fluid Cooler outlet temp falls to 75F.
Controller will shut off the fans as the fluid cooler outlet temperature falls below 65F.

TD Strategy:
VFD will maintain 10F TD between the Ambient & Fluid Cooler outlet temperature. VFD will modulate to maintain this 10F TD. As the Ambient temperature drops and VFD is at minimum speed, fans will be cycled to maintain 10F TD. Once fluid cooler outlet temperature drops to 65F, Bypass will be activated, and fluid cooler is completely bypassed.

Failure Modes:
Pump Failure: If Pump 1 or 2 fails (to maintain/achieve a differential), Controller automatically switches to a working pump. If both Pumps fail, controller sends alarm (dry contact input) to store controller/field Alarm/Strobe (if applicable). Controller detects both pumps are not running based on CSR inputs. If none of the Pumps CSR detects power input to motor, Controller detects and sends PS alarm.

SECTION 4: FIELD PRESSURE TESTING

Open all ball valves, balance valves and solenoid valve

1. Close all drains and vents.
2. Isolate the expansion tank and pumps. If there are any other components within the system that are not rated for the test pressure, isolate them as well.
3. Charge the system with dry nitrogen to 60 psig for 3 hours
4. Any leaks must be corrected. Once all leaks are stopped, system cleaning can begin.

Variable Speed Drive Programming (For Pumps)

The VSD(s) will come factory programmed for voltage and amperage, but the pressure differential set-point must be field set. Record the pressure differential reading with all solenoid valves open, fluid at temperature, and flow at 100%. This is the pressure set-point for the VSD to maintain. As solenoid valves close, the pump speed will be reduced to maintain the same pressure.

Troubleshooting for Chilled Fluid Systems:

Verify the following if it is not able to maintain the fluid temperature:

- Chiller approach between 5F and 8F
- Compressors fully loaded (none operating unloaded)
- Chiller Expansion Valve superheat, not hunting and fed with solid liquid refrigerant
- Fluid solution concentration correct
- Chiller pressure drop less than 7 psi on fluid side

Troubleshooting for Case Temperature Issues:

Verify the following if fluid temperature is met but case temperatures are not maintained:

- Check for high loads, heavy shopping or high store temperature and humidity.
- Check for correct balance valve setting or increase setting to allow higher flow.
- Check for air trapped in coils (purge either by venting or increasing the flow temporarily through the coil).
- Check for poor air flow through the coil.

SECTION 5: PIPE SYSTEM CLEANING

With the Glycol system piping installed and pressure tested with air, the piping system must be flushed properly. Dow recommends that the new piping system should be cleaned using a 1-2% solution of trisodium phosphate (TSP), or cleaner and water to remove grease, mill scale, or other residues from construction. Repeat this process if necessary until the solution that is drained is clear and free from visible debris. The system should then be drained and flushed again using distilled water. System volume can be calculated during this stage by metering in the initial fill of the system or by chemical analysis of cleaning chemicals after known quantities are introduced into the system.

1. Verify that the pressure in the expansion tank is at the factory setting of 20 psig, then open all valves, excluding drain valves.
2. Close the butterfly valves at the bypass valve.
3. Connect a hose to the supply header to fill the system with water.
4. Connect a hose to the drain valve closest to the pump suction.
5. Fill the system and then with the fill water still running, allow the water to drain until the drain water becomes clear.
6. Close the drain valve and open the bypass butterfly valves.
7. Pressurize the system to approximately 25 psig (about 5PSI diff between Static pressure & Exp tank)
8. Vent the main loop lines.
9. Vent all system purge points from lowest to highest.
10. Turn off water.
11. Check to make sure the pumps are full of water.
12. Check the rotation of each pump by bumping the contactors, one at a time.
13. Start each pump and check the amperage. This amperage should be checked again once the triple duty valve has been adjusted. The final amperage may be lower than the initial reading.
14. Start one pump and allow it to run. Add water if necessary to maintain 25 psig return pressure.
15. Flush each case lineup by closing the solenoid on all other circuits for 1 minute.
16. Open all circuits and allow the system to run for at least 2 hours.

Pre-Installation System Cleaning
Use a 1-2% solution of trisodium phosphate (TSP), or equivalent cleaner and distilled water to remove grease, mill scale, or other residues from construction. Repeat this process if necessary until the drained solution is clear and free from visible debris. The system should then be drained and flushed again using distilled water. Hussmann recommends distilled water for system flushing with 2% TSP. Dry nitrogen can be used for the initial pressure test (60 to 75 psi) hold for three hours. City water may be used for system cleaning if the water meets the requirements as outlined in the table at right.

Water Quality Requirements

Impurity	Level
Chlorides	25 ppm, max
Sulfates	25 ppm, max
Total Hardness, as $CaCO_3$	80ppm

Water above these levels should not be introduced in the system.

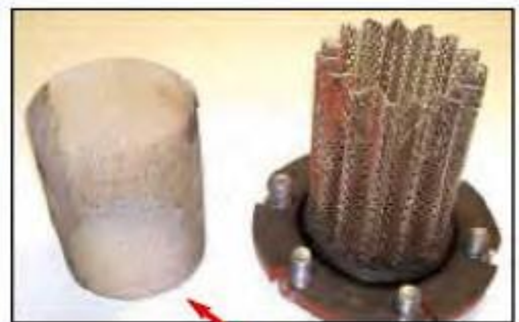
Do not let city water sit in the system. The flushing process should be no more than 6 to 8 hours.

SECTION 6: START-UP AND OPERATION

Drain the System

1. Turn off pumps.
2. Open all drain valves in the system. Purge remaining water with dry nitrogen.
3. If drain water is not clean, flush the system again.
4. Remove the cover of the suction guides and remove the start-up strainer from each. Reinstall the run strainer before restarting.

Suction Guide



Start-up Strainer

Fill the System

1. Open all valves excluding vents and drains.
2. Check the freezing point of each container of secondary fluid with a refractometer. For 35% glycol, the freezing point should be 2°F.

3. Pump the pre-mixed fluid into the system.
4. Use the same air purge process as previously described.
5. Place any purged secondary fluid in the fill tank.
6. Make sure all air has been removed from the pumps.
7. Open the triple duty valves.
8. Restart one of the pumps.
9. Maintain 25 psig return pressure by adding secondary fluid as necessary. When using the fill tank, fill the tank up to the overflow (but not above). Open the ball valve between the tank and the pump suction. Allow the pump to pull the fluid into the system, making sure not to allow in any air. Close the valve when the pump no longer pulls in fluid or the fluid level nears the bottom of the tank. If 25 psig is not attained, add more fluid.
10. Fill each case line-up completely by closing the solenoid on all other circuits for 1 minute.
11. Check the freezing point of the system using a refractometer after the fluid has been circulated.
12. Allow the system to circulate for 1 hour.

System Fluids

Never mix fluids from different manufacturers. Do not use concentrated fluid. **Use only premixed (prediluted) fluid.**

A small amount of concentrate should be kept on hand to allow for adjustment to the solution during startup. A refractometer, calibrated for fluids at room temperature, is used to measure dilution. Hussmann recommends using distilled water. Do not use city water.

Inhibited propylene glycol used in the system must be approved for use by the FDA.

Hussmann recommends using Intercool P-323AA inhibited propylene glycol, specifically formulated for aluminum tubing. Only use pre-diluted solutions (35% inhibited propylene glycol). Dowfrost may be used, but pH must be maintained and / or adjusted.

Interstate Chemical Company Inc.
2797 Freedland Rd.
Hermitage, PA 16148
1 (800) 422-2436

Requirements for system fluid:

Pre-mixed 35% inhibited propylene glycol
pH of solution 7.0 to 8.0.

DO NOT INSTALL AUTOMATIC MAKEUP.

Set Balance Valves (Field Installed)

1. Once the system has been filled, turn on the primary refrigeration. Coolant may need to be added, since the fluid will contract.
2. Set each balance valve at the flow rate on the store legend.
3. Use the manufacturer's recommendations for setting the valves.

Set End of Loop Balance Valve (Field Installed, typically only on cold fluid systems)

After setting the triple duty valve and balance valves throughout the system, find the pressure at the supply header while all case line-ups and cooling units are in cooling mode. This will be the "normal" system pressure. Set the end of loop balance valve for 20gpm while all case line-ups and cooling units are in cooling mode.

Pump Maintenance

IMPORTANT: Follow the lubrication procedures recommended by the pump and pump motor manufacturer. Check the lubrication instructions supplied with the pump and motor for the particular frame size indicated on the motor nameplate.

PUMP STATION DIFF PRESSURE LOSS – TROUBLE SHOOTING

A sudden drop in differential pressure at a pump station can indicate a variety of issues. Here's a breakdown of common causes:

1. Issues Related to the Pump Itself:

- **Cavitation:**
  - This occurs when the liquid entering the pump vaporizes due to low pressure. The resulting vapor bubbles collapse, causing damage and a pressure drop.
  - Causes of cavitation include insufficient suction pressure, high fluid temperature, or restrictions in the suction line.
- **Pump Wear or Damage:**
  - Worn impellers, seals, or other internal components can reduce the pump's efficiency and ability to generate pressure.
  - Damage from debris or foreign objects can also lead to sudden pressure drops.
- **Incorrect Pump Rotation:**
  - If the pump is rotating in the wrong direction, it won't produce the expected pressure. This is more common after installation or maintenance.
- **Pump mechanical failures:**
  - Failure of bearings, or other internal parts of the pump.

2. Issues Related to the System:

- **Leaks:**
  - A sudden leak in the piping system, valves, or fittings can cause a rapid drop in pressure.
- **Changes in Fluid Properties:**
  - Changes in fluid viscosity or density can affect pump performance. For example, a decrease in viscosity can lead to a lower pressure output.
- **Blockages:**
  - Blockages in the suction or discharge lines, such as debris or sediment, can restrict flow and cause a pressure drop.
- **Valve Issues:**
  - Malfunctioning valves, such as stuck-open bypass valves or faulty check valves, can divert flow and reduce pressure.
- **Suction Issues:**
  - Insufficient liquid supply to the pump.
  - Air entrainment into the system.
- **System Demand Changes:**
  - A sudden increase in downstream demand can exceed the pump's capacity, resulting in a pressure drop.

3. Instrumentation and Control Issues:

- **Faulty Pressure Sensors:**
  - A malfunctioning pressure sensor or transmitter can provide inaccurate readings, giving the appearance of a pressure drop.
- **Control System Malfunctions:**
  - Errors in the control system can cause the pump to operate incorrectly or shut down, leading to a pressure drop.

Troubleshooting Tips:

- Check pressure gauges and sensors for accuracy.
- Inspect the piping system for leaks or blockages.
- Verify pump rotation and operating parameters.
- Examine the fluid for changes in properties.
- Check the operation of valves and control systems.

Pump Station Expansion Tank Failure/trouble shooting

Below are the common reasons for expansion Tank failure:

1. **Improper Installation:**
   - **Incorrect Pre-charge Pressure:** The air pressure in the tank's bladder/diaphragm must be set correctly, matching the system's static pressure (or slightly below). If it's too low, the bladder can overstretch and rupture prematurely. If it's too high, the tank won't effectively absorb pressure changes. Many installers fail to check and adjust this from the factory setting.
   - **Incorrect Location/Piping:** In hydronic systems, the expansion tank should be located at the "point of no pressure change," typically on the suction side of the circulating pump, immediately after the air separator. Pumping towards the tank can stress the bladder.
   - **Improper Mounting:** Hanging tanks horizontally or threads downward can lead to air trapping, causing the bladder to dry, crack, and fail.
   - **Loose Connections:** Poorly sealed or overtightened pipe fittings can lead to leaks.
2. **Diaphragm/Bladder Failure:**
   - **Wear and Tear/Age:** Over time, the rubber bladder or diaphragm inside the tank can become worn, brittle, or develop small holes due to continuous flexing and exposure to water. This is a common cause of failure, especially as the tank ages (typically 5-8 years).
   - **Loss of Air Charge:** Even with a healthy bladder, a slow leak of air from the Schrader valve (like a tire valve) can lead to insufficient air pressure. This causes the bladder to become waterlogged and unable to effectively absorb pressure.
   - **Water Quality Issues:** Certain water chemistries or contaminants can degrade the rubber material of the bladder/diaphragm, leading to premature failure.
   - **Overstretching:** If the pre-charge pressure is too low or the tank is undersized, the bladder can be forced to expand beyond its design limits, leading to rupture.
3. **Corrosion:**
   - **Internal Corrosion:** If the bladder or diaphragm fails, water can come into direct contact with the steel tank shell. This can lead to rust and corrosion, eventually causing pinhole leaks in the tank itself.
   - **External Corrosion:** Condensation on the outside of the tank, especially in humid environments, can lead to external rust, which can weaken the tank's integrity over time. This can also cause water to drip onto electrical wiring.

4. System Issues Leading to Overpressure:

- **Faulty Pressure Reducing Valve (PRV):** If the PRV supplying the system fails, it can allow excessively high incoming water pressure to enter the system, overwhelming the expansion tank and potentially damaging its bladder.
- **High System Temperatures:** In heating systems, excessively high water temperatures can lead to greater thermal expansion than the tank is designed to handle, putting undue stress on the tank.
- **Undersized Tank:** If the expansion tank is too small for the volume of water in the system, it won't have enough capacity to absorb the pressure changes, leading to overpressure and potential damage.

5. Lack of Maintenance:

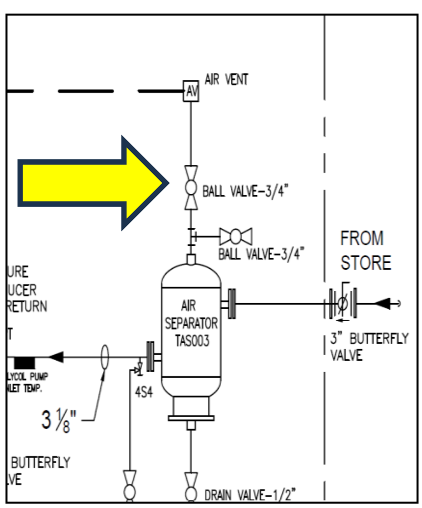
- **Infrequent Pre-charge Checks:** The air pressure in the expansion tank should be checked and adjusted annually (or as recommended by the manufacturer). Neglecting this allows the tank to lose its effectiveness gradually.
- **Ignoring Early Signs:** Ignoring symptoms like frequent relief valve discharge, fluctuating water pressure, or unusual noises can lead to more severe tank failure.

Consequences of Expansion Tank Failure:

- **Frequent Pressure Relief Valve (PRV) Discharge:** This is a classic sign. Without a functioning expansion tank to absorb pressure, the system's PRV will frequently open to release excess pressure, wasting water and potentially leading to PRV wear.
- **Pressure Fluctuations:** The system will experience significant swings in pressure, which can be seen on pressure gauges and felt as changes in water flow.
- **Damage to System Components:** Constant pressure spikes can put undue stress on pipes, fittings, valves, and even the pump itself, leading to leaks, premature wear, and component failure.
- **Water Hammer/Noisy Pipes:** Air or pressure imbalances can cause banging or knocking sounds in the piping system.
- **Reduced Equipment Lifespan:** The entire plumbing or HVAC system will work harder and wear out faster due to unregulated pressure.
- **Inefficient Operation:** In heating or cooling systems, a failed expansion tank can lead to inefficient heat transfer and higher energy bills.
- **Leaks and Water Damage:** A ruptured bladder or corroded tank can lead to water leaks around the pump station, causing property damage and potential safety hazards (e.g., electrical issues).

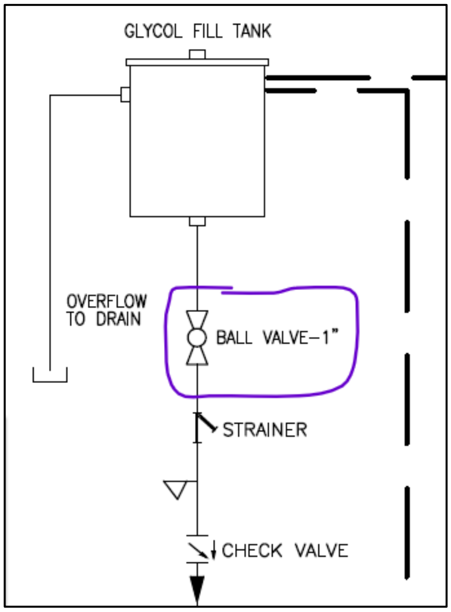
Regular inspection and maintenance, including checking and adjusting the tank's air pre-charge, are crucial to preventing expansion tank failures and ensuring the longevity and efficient operation of pump stations.

Note:
After Pump Station/system start-up and operation, shut-off ball valves on vent line and fill line as shown below:



➢ Ball Valve on piping from Fill Tank:

The ball valve on the piping from the fill tank must remain closed. Only open it when glycol needs to be added to the system.



(GLYCOL SYSTEM PIPING GUIDELINES)

PROPYLENE GLYCOL PROPERTIES

Propylene glycol (PG): Very high viscosity at low temperatures; less toxic than ethylene glycol; risk of environmental pollution; most commercial products for indirect heat pump and refrigeration systems have good corrosion protection.
PG is a colorless, odorless liquid that is generally recognized as safe by the U.S. Food and Drug Administration (FDA) in 21 CFR § 184.1666, for use as a direct food additive under the conditions prescribed.
PG is used in cosmetics and in pharmaceuticals. PG has a wide range of practical applications such as antifreezes, coolants and aircraft deicing fluids; heat transfer and hydraulic fluids; solvents; food; flavors and fragrances; personal care products; plasticizers; and thermoset plastic formulations.
PG is not acutely toxic (single dose, high exposure). It is essentially non-irritating to the skin and mildly irritating to the eyes. Numerous studies support that PG is not a skin sensitizer or a carcinogen.

Typical freezing, boiling and burst points of propylene glycol solutions

%PG	Freezing Point		Boiling Point		Burst
	°F	°C	°F	°C	°F
0	32	0	212	100	
5	29.1	-1.6	212	100	
10	26.1	-3.3	212	100	23
15	22.9	-5.1	212	100	17
20	19.2	-7.1	213	101	11
22	17.6	-8	213	101	7
24	15.6	-9.1	213	101	3
26	13.7	-10.2	214	101	-2
28	11.5	-11.4	215	102	-7
30	9.2	-12.7	216	102	-14
32	6.6	-14.1	216	102	-22
34	3.9	-15.6	216	102	-28
36	0.8	-17.3	217	103	-37
38	-2.4	-19.1	218	103	-37
40	-6	-21.1	219	104	-37
42	-9.8	-23.2	219	104	
44	-13.9	-25.5	219	104	
46	-18.3	-27.9	220	104	
48	-23.1	-30.6	221	105	
50	-28.3	-33.5	221	105	

Density (lb./cu.ft)							
% Propylene Glycol							
Temp °F	20	25	30	35	40	45	50
10			65	65.3	65.6	65.85	66.11
15			64.95	65.25	65.54	65.79	66.04
20	64.23	64.56	64.9	65.19	65.48	65.73	65.97
25	64.18	64.51	64.85	65.13	65.41	65.65	65.89
30	64.14	64.47	64.79	65.07	65.35	65.58	65.82

Specific Heat (BTU/lb. °F)							
% Propylene Glycol							
Temp °F	20	25	30	35	40	45	50
10			0.898	0.8785	0.859	0.8365	0.814
15			0.9	0.88075	0.8615	0.83925	0.817
20	0.936	0.919	0.902	0.883	0.864	0.842	0.82
25	0.937	0.9205	0.904	0.885	0.866	0.84425	0.8225
30	0.938	0.922	0.906	0.887	0.868	0.8465	0.525

Thermal Conductivity (BTU/(hr*ft^2)(°F/ft)							
% Propylene Glycol							
Temp °F	20	25	30	35	40	45	50
10			0.228	0.2165	0.205	0.194	0.183
15			0.23	0.21825	0.2065	0.1955	0.1845
20	0	0.116	0.232	0.22	0.208	0.197	0.186
25	0.132	0.18275	0.234	0.22175	0.2095	0.19825	0.187
30	0.263	0.2495	0.236	0.2235	0.211	0.1995	0.188

Viscosity (cps)							
% Propylene Glycol							
Temp °F	20	25	30	35	40	45	50
10			13.42	20.205	26.99	33.805	40.62
15			11.655	17.2	22.745	28.485	34.225
20	5.36	7.625	9.89	14.195	18.5	23.165	27.83
25	4.795	6.735	8.675	12.2425	15.81	19.775	23.745
30	4.23	5.845	7.46	10.29	13.19	16.39	19.66

It is recommended that a minimum of 30% by volume of fully inhibited, industrial grade propylene glycol with water be used on the condensing side, while 35% by volume propylene glycol be used on the evaporator side.

NOTE: Do not mix like or unlike fluids from different manufacturers. Do not use automotive grade glycols

System Fluids

Never mix fluids from different manufacturers. Do not use concentrated fluid. **Use only premixed (pre-diluted) fluid.** A small amount of concentrate should be kept on hand to allow for adjustment to the solution during startup. A refractometer, calibrated for fluids at room temperature, is used to measure dilution. Hussmann recommends using distilled water. Do not use city water.

Inhibited propylene glycol used in the system must be approved for use by the FDA.

Hussmann recommends using Intercool P-323AA inhibited propylene glycol, specifically formulated for aluminum tubing. Only use pre-diluted solutions (35% inhibited propylene glycol). Dowfrost may be used, but pH must be maintained and / or adjusted.

Interstate Chemical Company Inc.
2797 Freedland Rd.
Hermitage, PA 16148
1 (800) 422-2436

Requirements for system fluid:

Pre-mixed 35% inhibited propylene glycol
pH of solution 7.0 to 8.0.

DO NOT INSTALL AUTOMATIC MAKEUP.

Set Balance Valves (Field Installed)

For cold fluid systems, additional fluid may need to be added after the chillers bring down the temperature. Maintain approximately 15 psig at the highest point in the system. Record the pressure and temperature at the pump station (in the store log book).

Case balance valves may be set at the flow rate shown on the store legend. Use the balance valve setting charts to estimate the flow rate for each valve (measuring pressure across each valve). After setting all valves and running the chilled fluid at final temperature, verify that solenoid valves are not cycling too much or too little on any circuit. It is recommended to verify the circuit cycling again after the store has been opened since flow rates are estimated based on standard conditions. Record the actual valve settings of each circuit balance valve and record.

Set End of Loop Balance Valves **(Field Installed, typically only on cold fluid systems)**

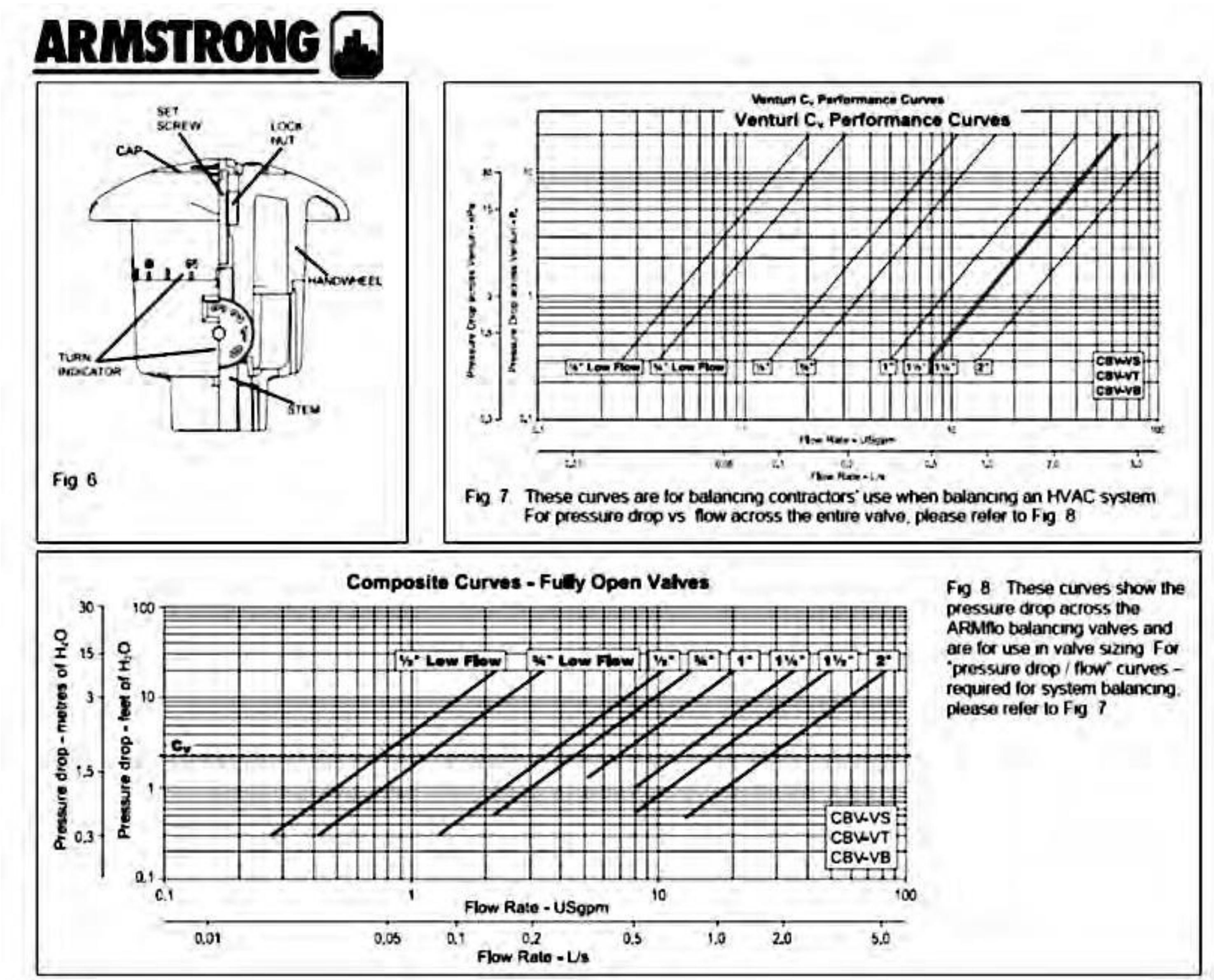
After setting the triple duty valve and balance valves throughout the system, find the pressure at the supply header while all case line-ups and cooling units are in cooling mode. This will be the normal system pressure. Set the end of loop balance valve for 20gpm while all case lineups and cooling units are in cooling mode.

Pump Maintenance

IMPORTANT: Follow the lubrication procedures recommended by the pump and pump motor manufacturer. Check the lubrication instructions supplied with the pump and motor for the particular frame sixe indicated on the motor name plate

Balancing Valve — Secondary Fluid Ship Loose

Curve 1: Armstrong Balancing Valve - Flow Rates and Pressure Drop



Triple Duty Valve (Flow & PD Curves)

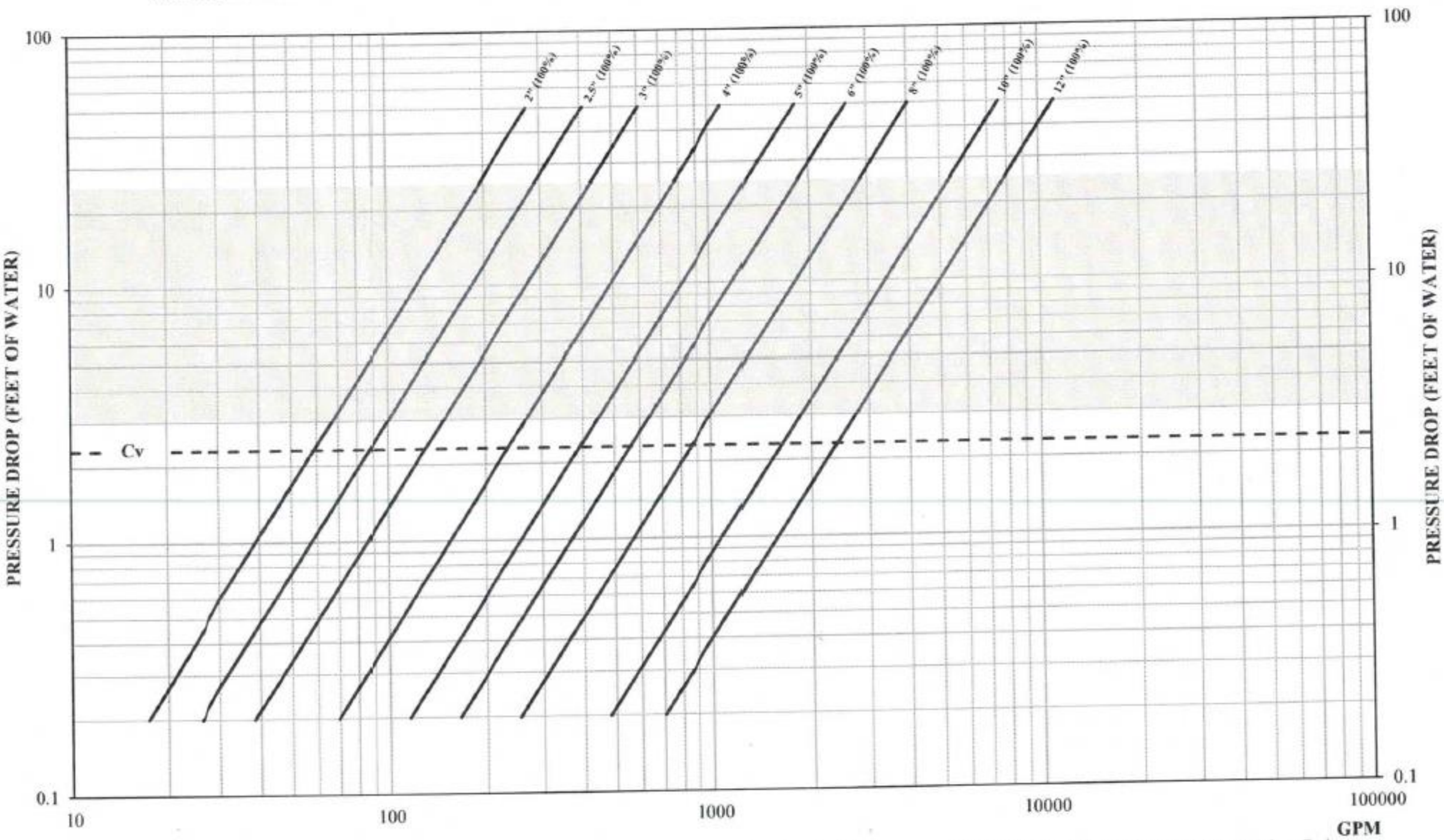
PATTERSON PUMP COMPANY

TRIPLE DUTY VALVE

Valve Model: TD125
Valve Size: 2 to 12 inch

PRESSURE DROP CHART (100% OPEN)

Medium: Fresh Water
Specific Gravity: 1.0



NOTE: For system balancing, a minimum reading of 3 feet of pressure drop is required for flow determination. Maximum recommended pressure drop should not exceed 25 feet. Cv is defined as the volume of water that will flow through a given restriction or valve opening with a pressure drop of 1 psi (2.31 feet of water) at room temperature.

A06-149320

Balancing Valve – Secondary Fluid Ship Loose

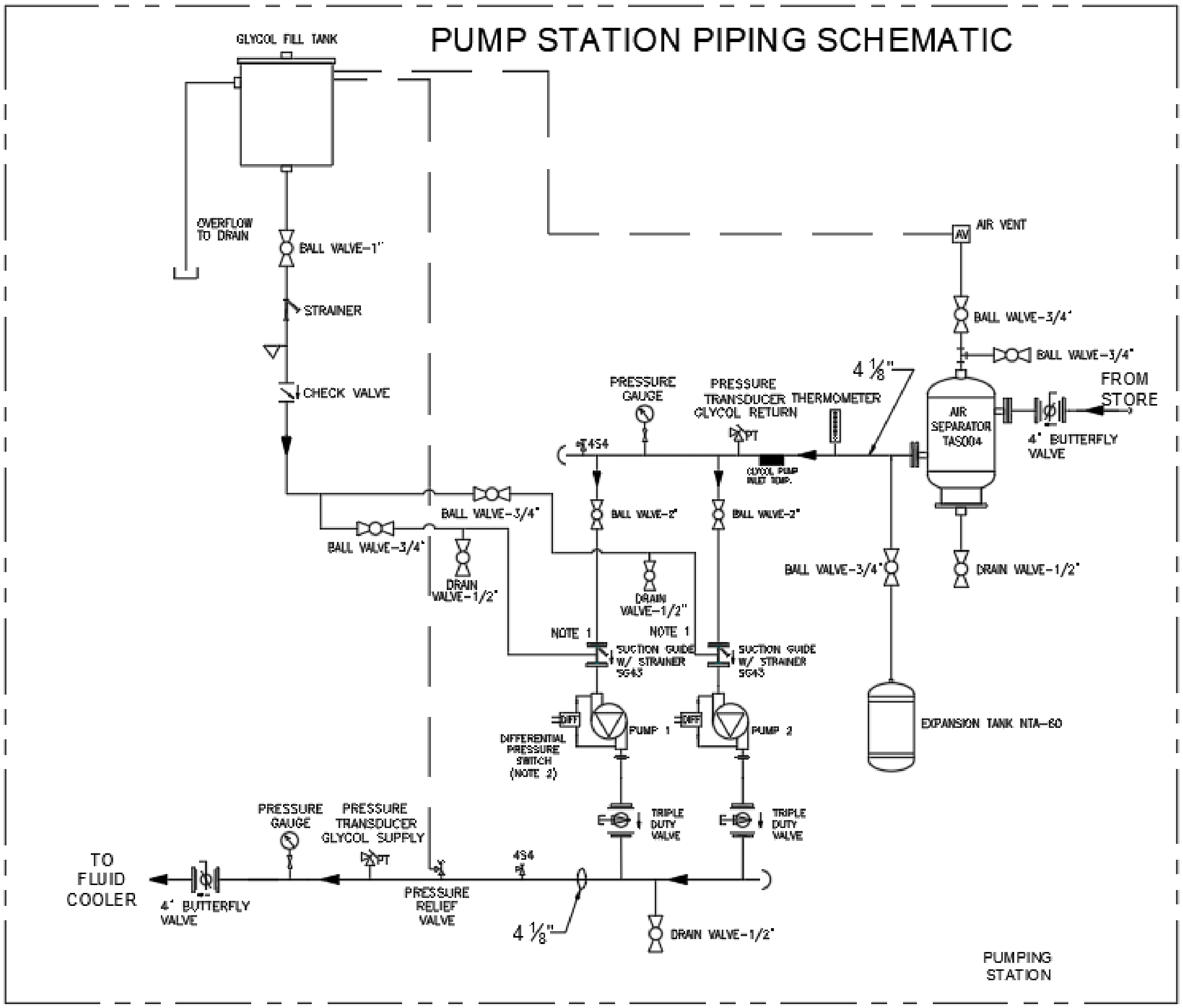
Curve 3: TOUR ANDERSON BALANCING VALVE - Flow Rates.

VALVE SELECTION GUIDE

Size		Flow Data for TA Series 786 & 787		
Nominal Size Inches mm	Actual Outside Dia. Inches mm	Absolute Min. Flow GPM LPM	Nominal Range of Flow GPM LPM	Absolute Max. Flow GPM LPM
½ 15	0.840 21.3	0.1 0.5	0.6 – 2.8 2.3 – 10.6	8.6 32.6
¾ 20	1.050 26.7	0.4 1.5	2.0 – 6.0 7.6 – 22.7	20.0 76.0
1 25	1.315 33.7	0.5 1.7	3.9 – 10.0 14.8 – 37.9	30.0 114.0
1¼ 32	1.660 42.4	0.9 3.3	5.0 – 15.0 18.9 – 56.8	48.0 182.0
1½ 40	1.900 48.3	1.3 4.9	6.6 – 20.0 25.0 – 75.7	66.0 250.0
2 50	2.375 60.3	2.0 7.6	12.6 – 36.0 47.7 – 136.0	110.0 416.0

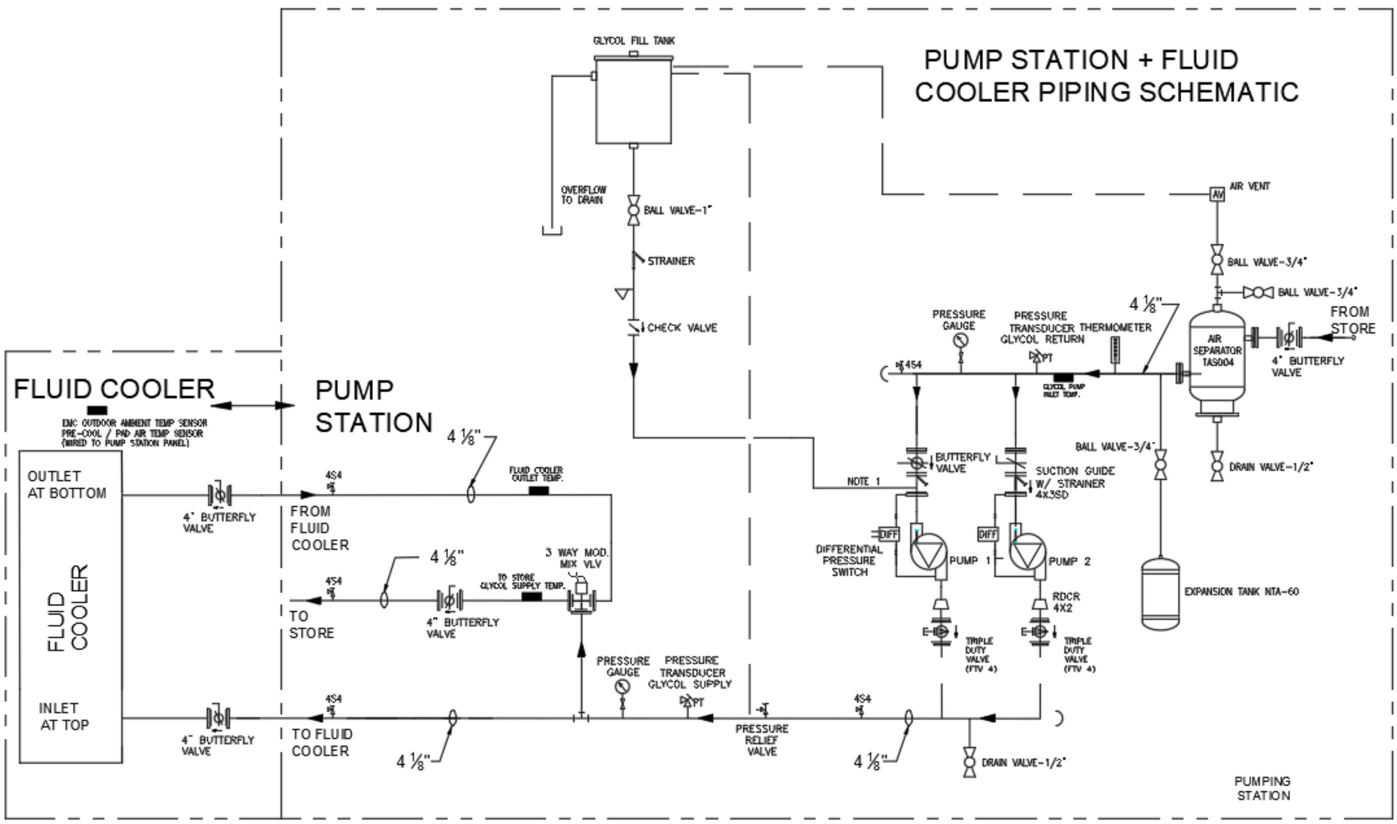
IMPORTANT NOTES:

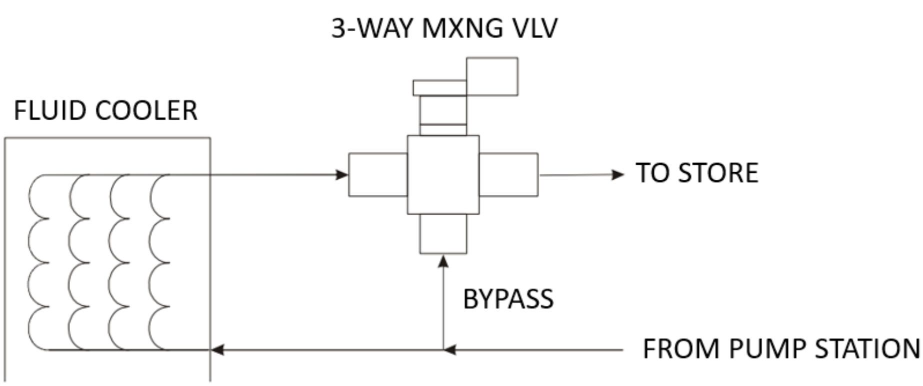
Balancing valves should be sized in accordance with the GPM/LPM flows (and not in relation to pipeline size). Sizing balancing valves based on the minimum or maximum flow rates is not recommended. Valves should be sized using the nominal flow rate only. The Minimum Flow is calculated from the minimum open setting of the valve and a minimum pressure drop 1 Ft. WG (= 3 kPa). The Nominal Flow is calculated from the maximum open setting of the valve and the minimum recommended pressure drop, 2 Ft. WG (= 6 kPa). The Maximum Flow is calculated from the maximum open setting of the valve and the maximum pressure drop, 20 Ft. WG (= 60 kPa). A computer program, TA-Select, is available for calculation of valve handwheel pre-set position and other applications.



Above piping schematic for 250 GPM High Side Pump Station.

Below detail shows typical piping schematic for Pump Station + Fluid Cooler for High Side system.



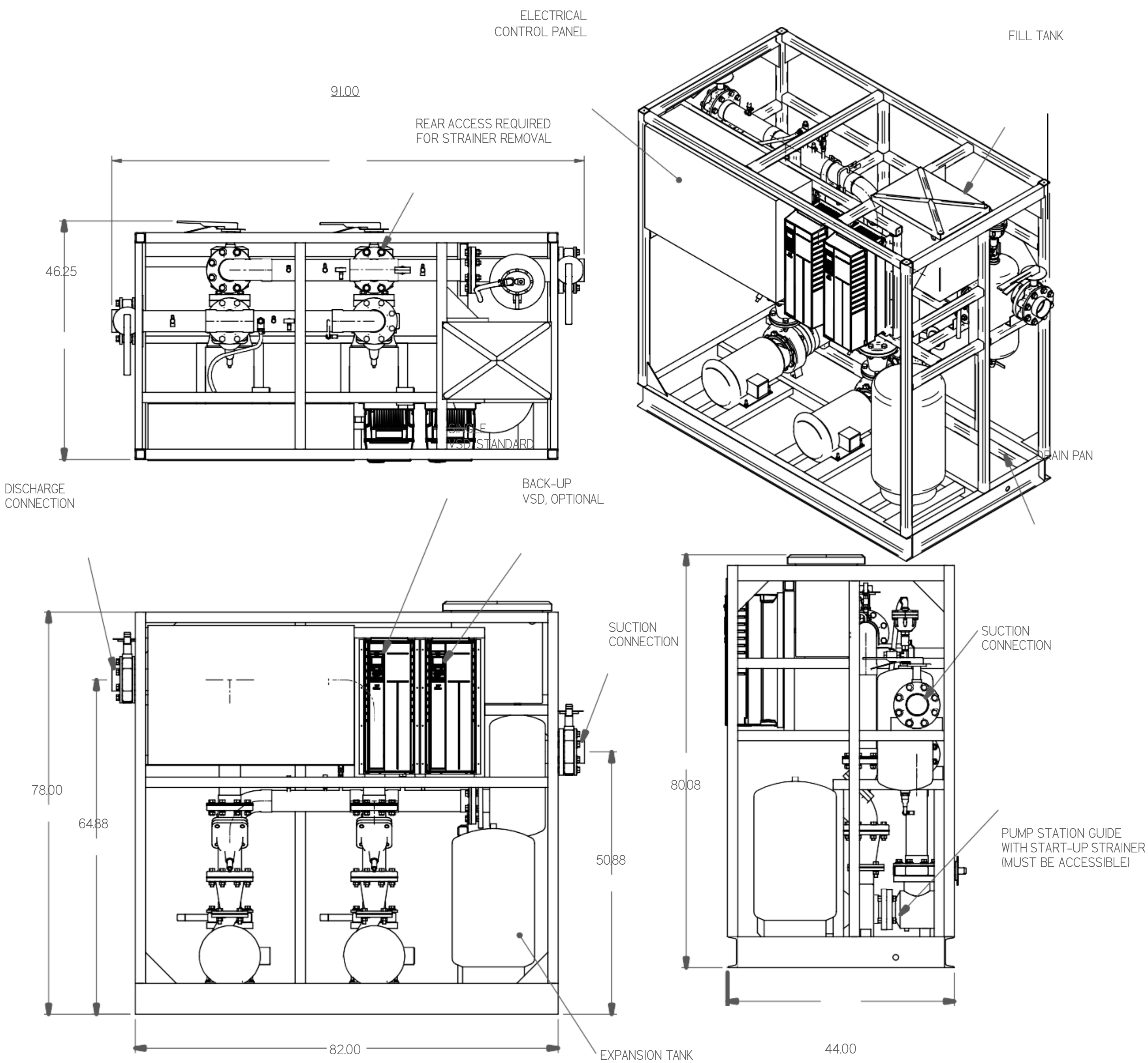


Above figure shows typical piping of 3-way mixing valve. If the fluid cooler outlet temperature drops below set-point, bypass line opens to bypass fluid cooler. 3-Way Mixing valve typically requires 0-10V Analog output point for modulation.

Typical Pump Station Dimensions

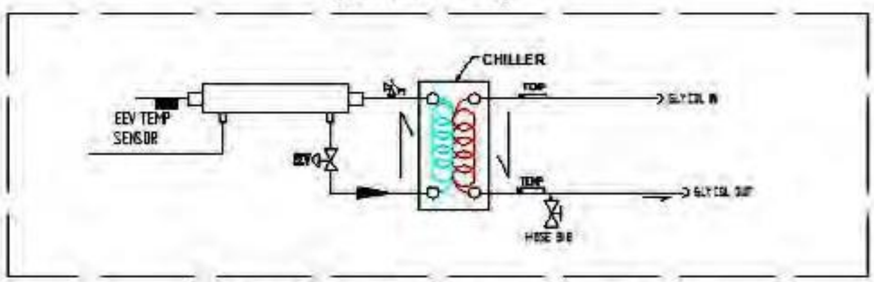
Below shows layout of components and dimensions for indoor PS.
Dimensions vary for PS with additional options such as outdoor, unitized design with Fluid Cooler.

Consult with Hussmann Systems Engineering for detailed submittals drawings for specific project.



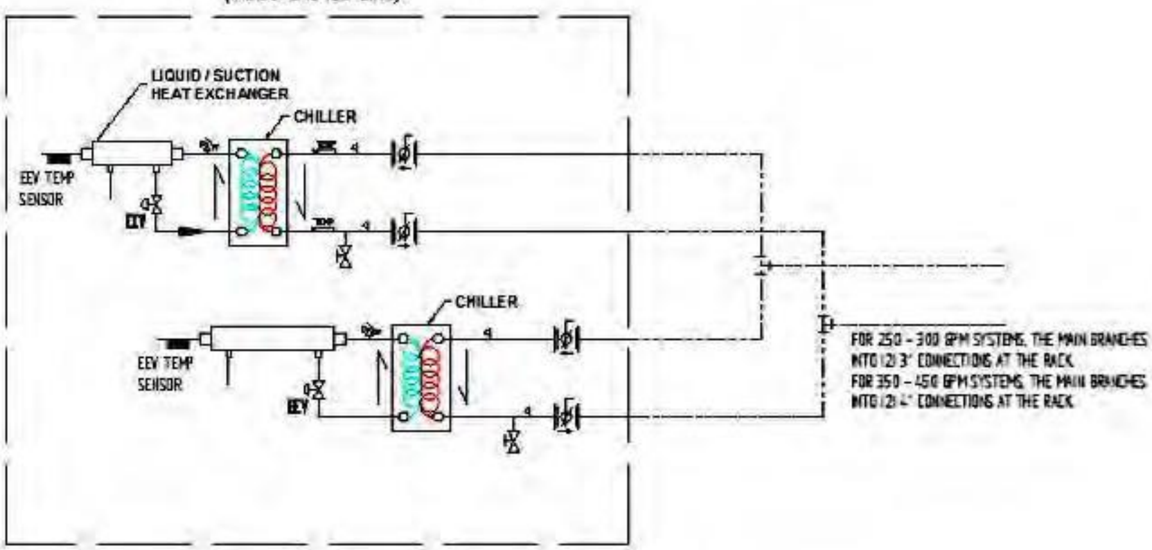
APPENDIX D – CHILLER AND COMPONENTS ON PRIMARY RACK, PIPING SCHEMATIC

COMPONENTS INCLUDED ON PRIMARY RACK
(INSIDE DASHED LINE)



SINGLE HEAT EXCHANGER FOR 200 GPM AND SMALLER SYSTEMS

COMPONENTS INCLUDED ON PRIMARY RACK
(INSIDE DASHED LINE)

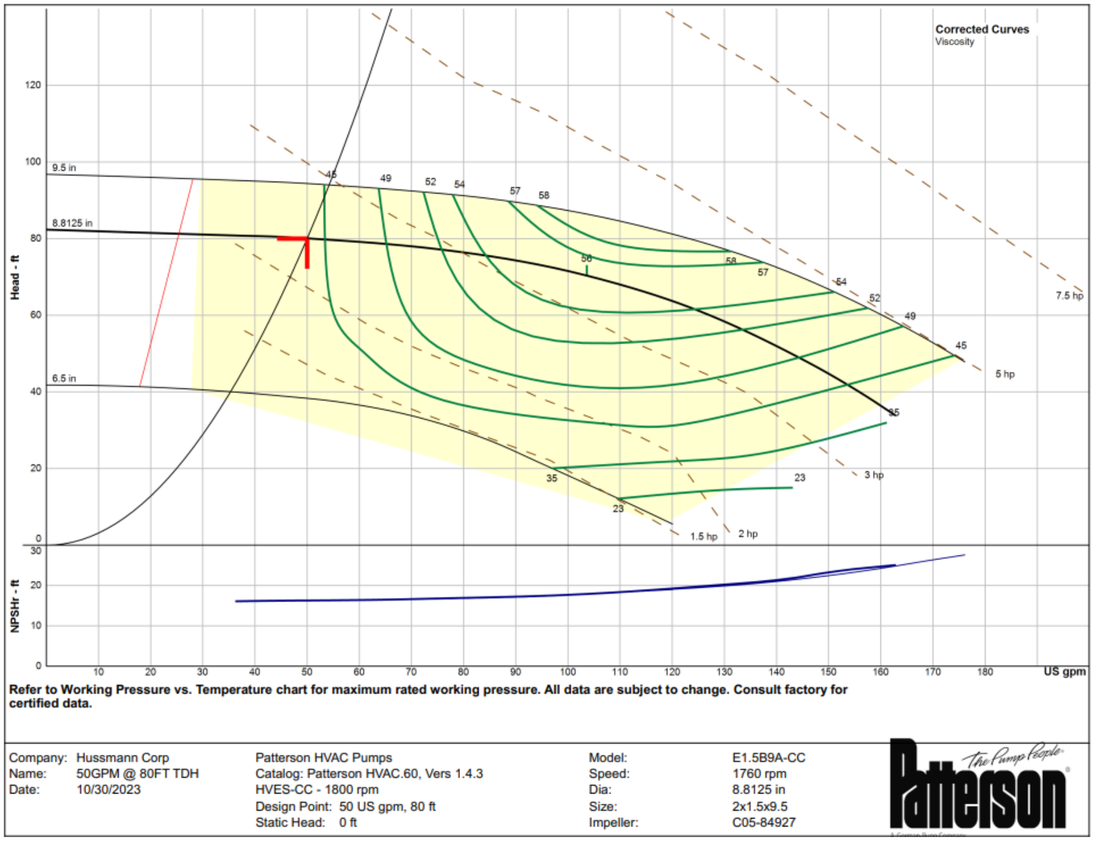


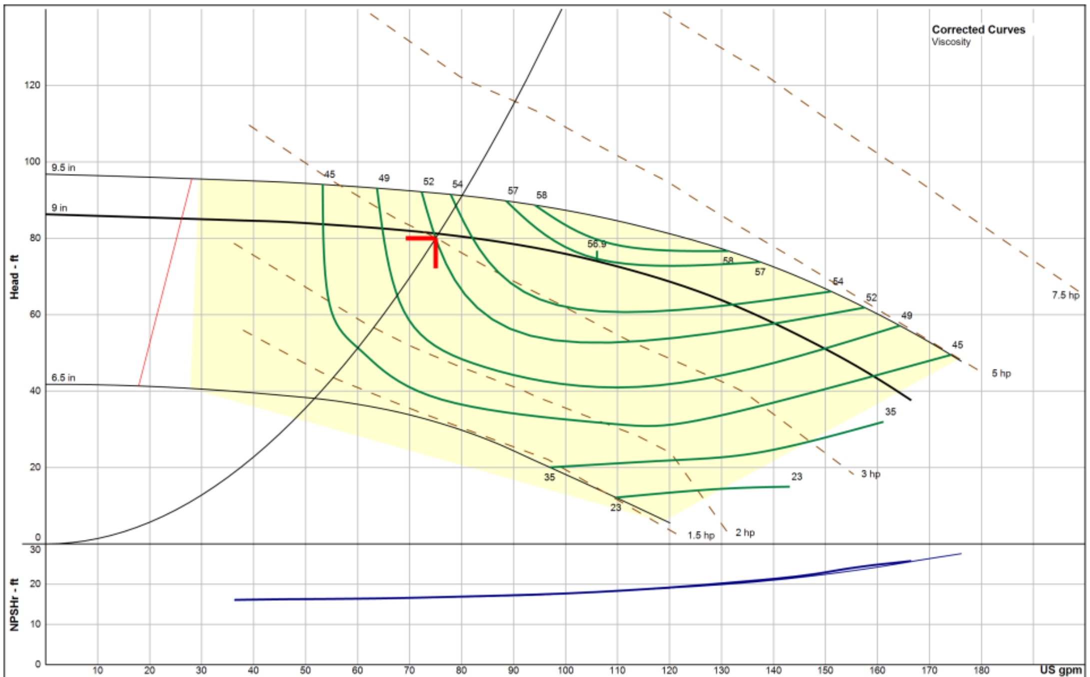
Above schematic shows piping details for chiller/secondary Glycol HX

PUMP CURVES:

Pump Curves shown below for standard Pumps (50GPM to 450GPM). Custom Pumps can be provided based on specific project requirements. Refer to specific project documentation for Pump Curve.

Note: Below information could change at any time and need to consult with Engineering for Pump curve on specific project.

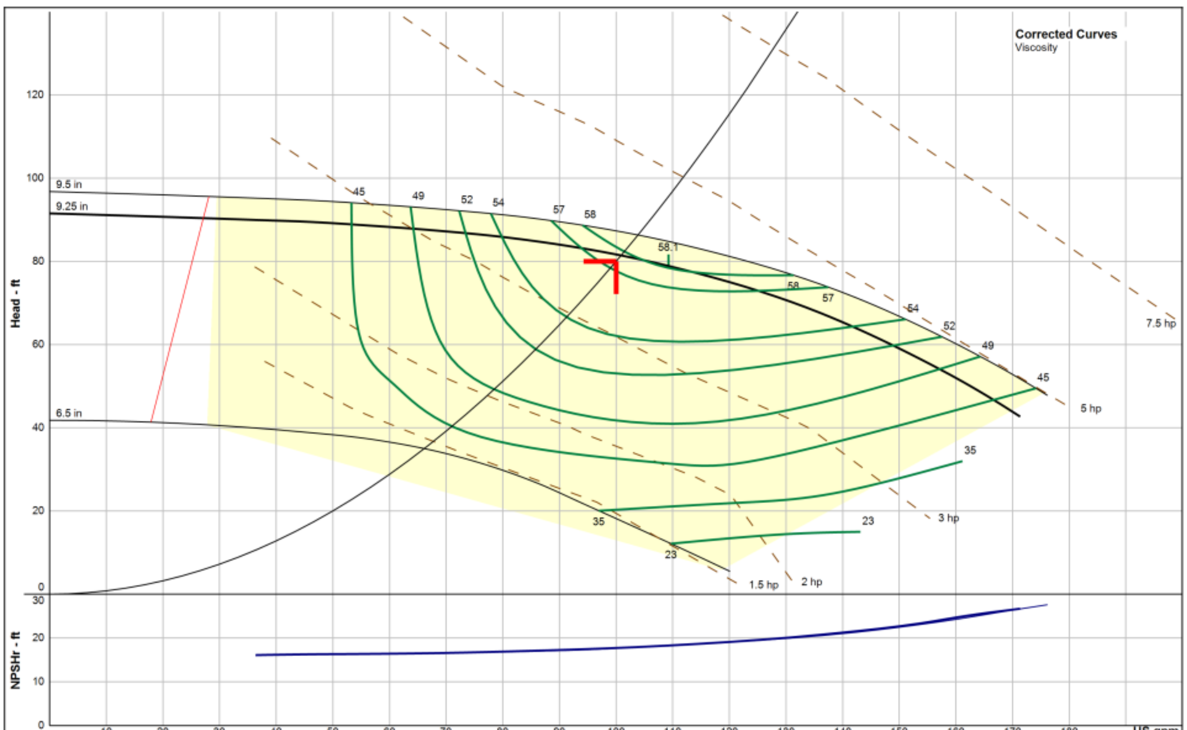




Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Consult factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E1.5B9A-CC
Name:	75 GPM @ 80FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1760 rpm
Date:	10/30/2023	HVES-CC - 1800 rpm	Dia:	9 in
		Design Point: 75 US gpm, 80 ft	Size:	2x1.5x9.5
		Static Head: 0 ft	Impeller:	C05-84927

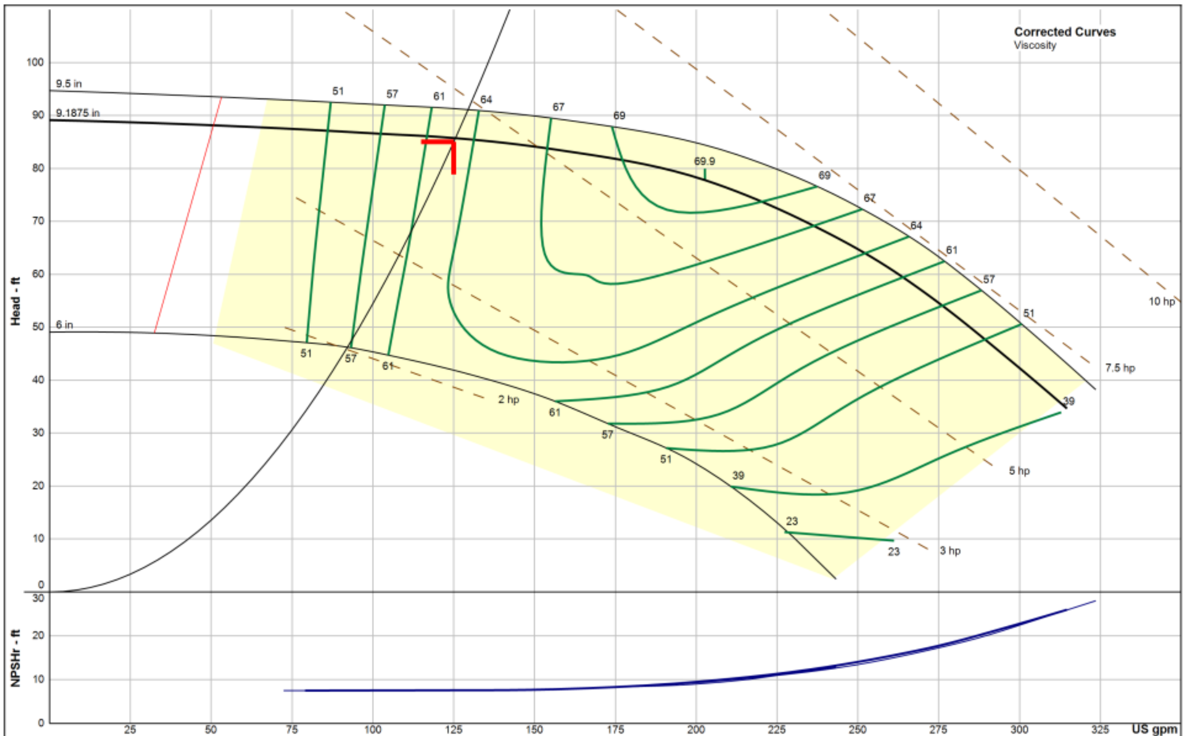
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Consult factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E1.5B9A-CC
Name:	100 GPM @ 80FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1760 rpm
Date:	10/30/2023	HVES-CC - 1800 rpm	Dia:	9.25 in
		Design Point: 100 US gpm, 80 ft	Size:	2x1.5x9.5
		Static Head: 0 ft	Impeller:	C05-84927

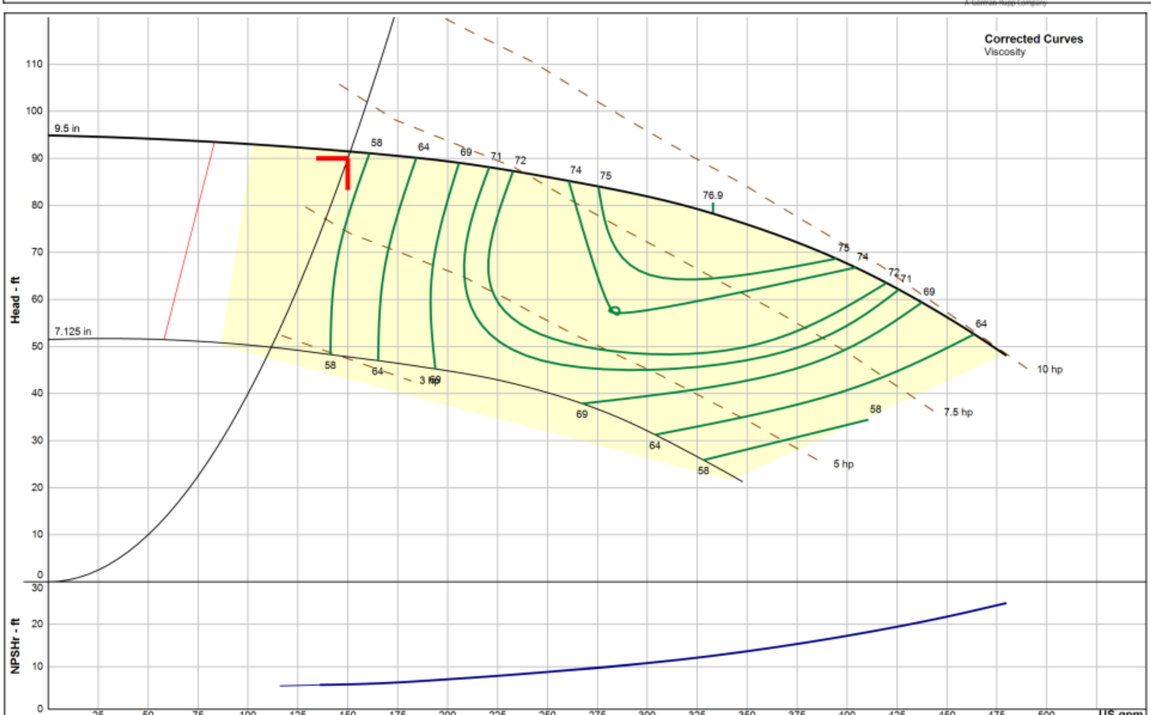
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E2DA9A-CC
Name:	125 GPM @ 85FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1760 rpm
Date:	10/31/2023	HVES-CC - 1800 rpm	Dia:	9.1875 in
		Design Point: 125 US gpm, 85 ft	Size:	2.5x2x9.5
		Static Head: 0 ft	Impeller:	D05-87193

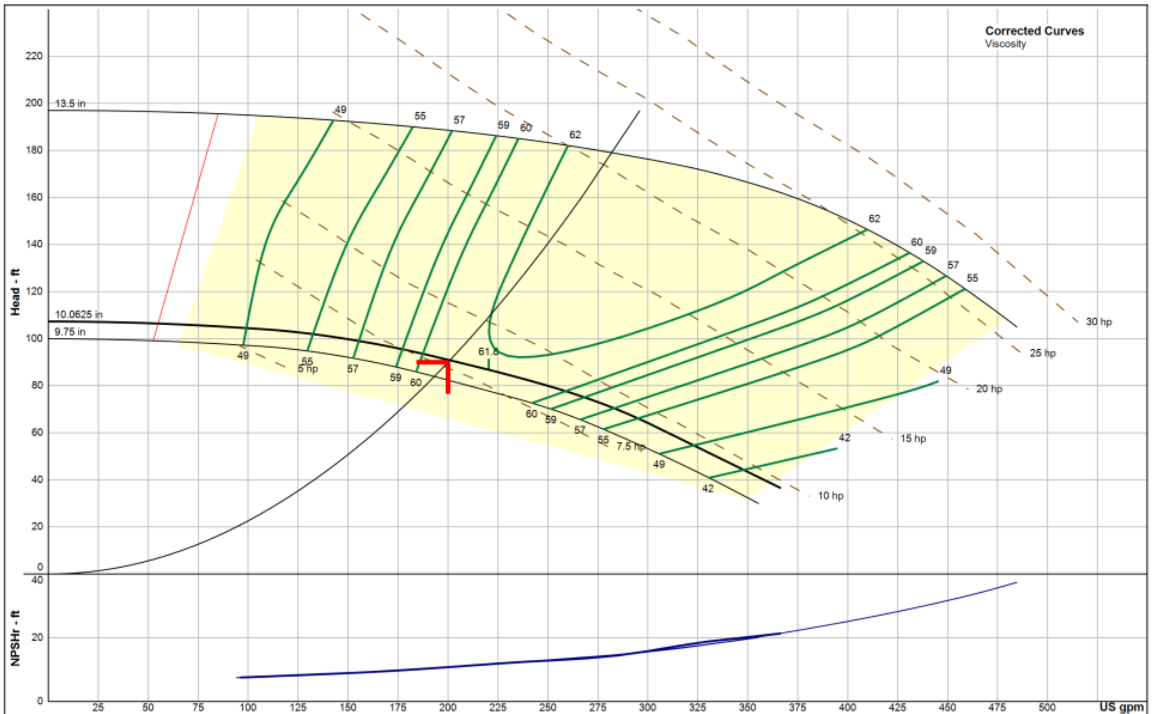
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E2.5F9A-CC
Name:	150GPM @ 90FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1760 rpm
Date:	10/31/2023	HVES-CC - 1800 rpm	Dia:	9.5 in
		Design Point: 150 US gpm, 90 ft	Size:	3x2.5x9.5
		Static Head: 0 ft	Impeller:	D05-87174

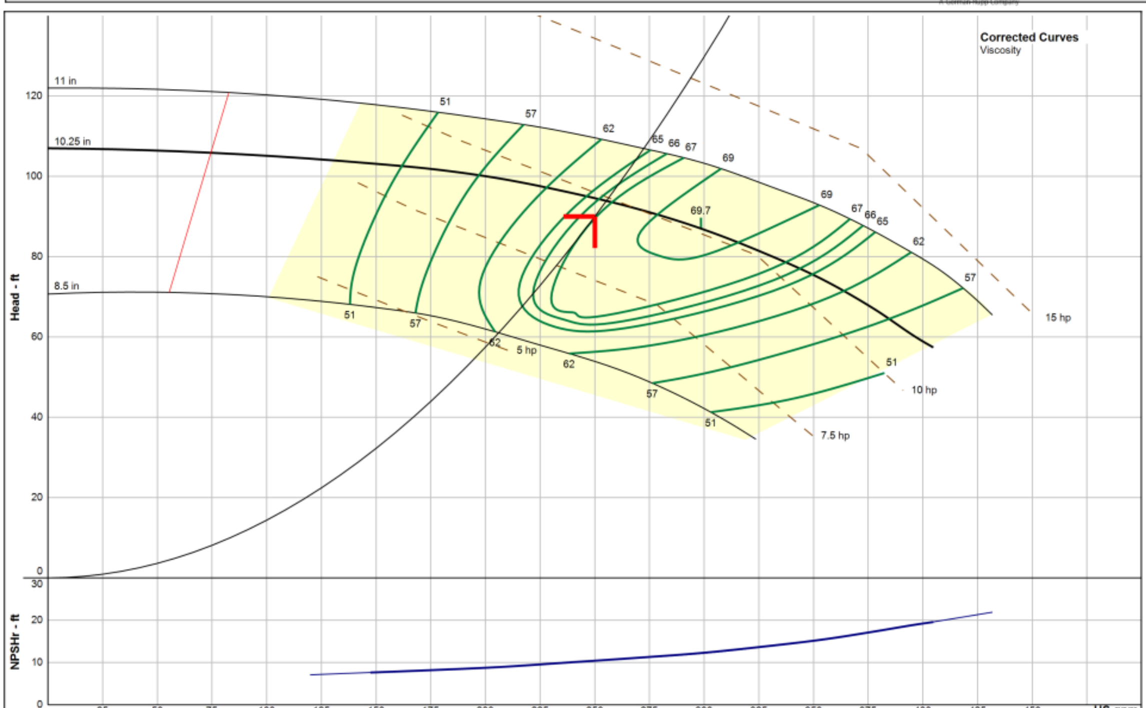
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Consult factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E2B13A-CC	
Name:	200 GPM @ 90FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1770 rpm	
Date:	10/31/2023	HVES-CC - 1800 rpm	Dia:	10.0625 in	
		Design Point: 200 US gpm, 90 ft	Size:	3x2x13.5	
		Static Head: 0 ft	Impeller:	D05-73118	

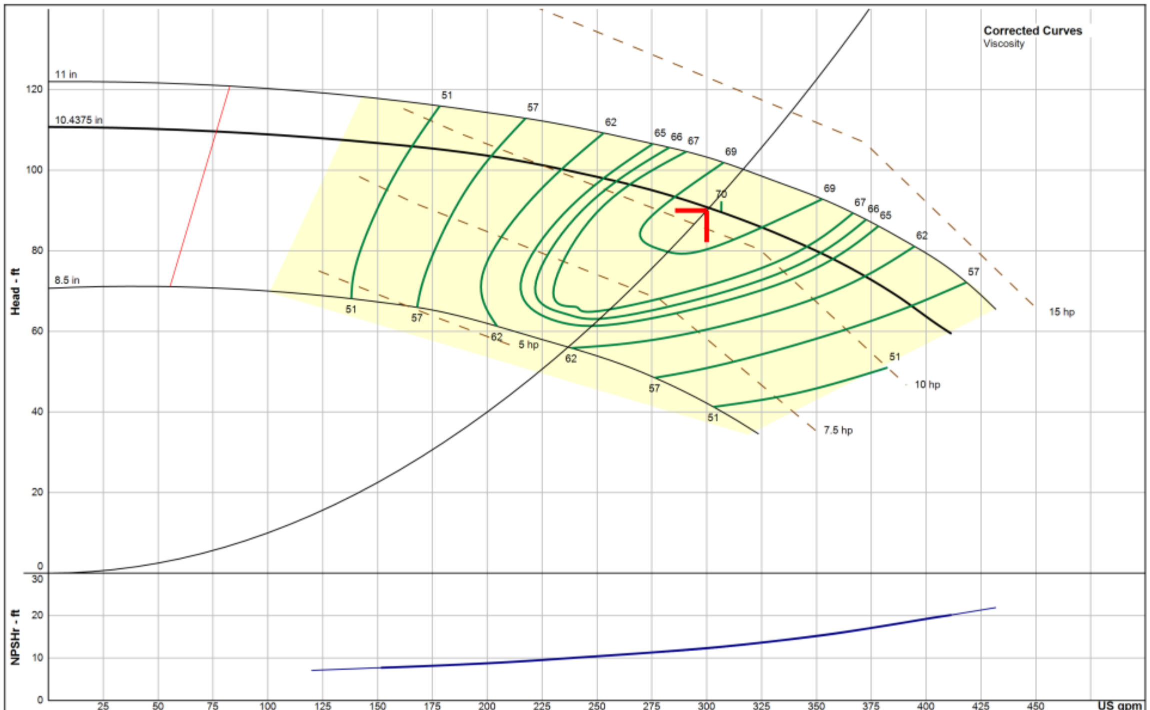
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company:	Hussmann Corp	Patterson HVAC Pumps	Model:	E2D11A-CC
Name:	250GPM @ 90FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1765 rpm
Date:	10/31/2023	HVES-CC - 1800 rpm	Dia:	10.25 in
		Design Point: 250 US gpm, 90 ft	Size:	3x2x11
		Static Head: 0 ft	Impeller:	D05-85109

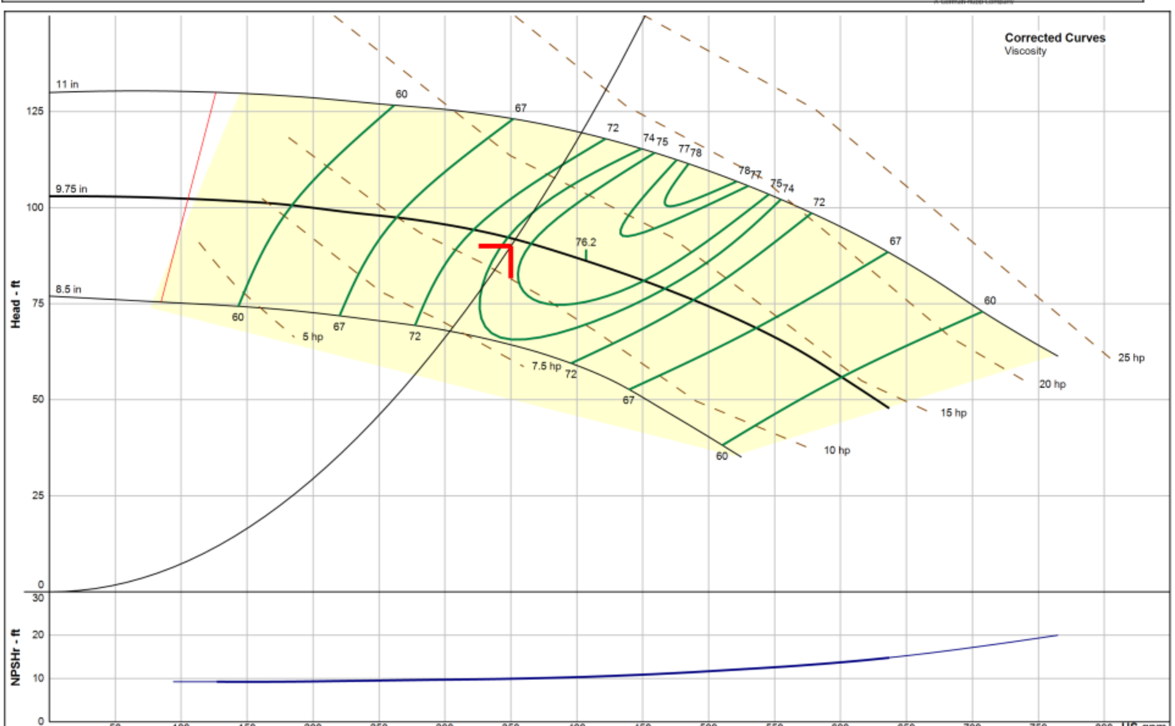
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company: Hussmann Corp	Patterson HVAC Pumps	Model:	E2D11A-CC
Name: 300 GPM @ 90FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1765 rpm
Date: 10/31/2023	HVES-CC - 1800 rpm	Dia:	10.4375 in
	Design Point: 300 US gpm, 90 ft	Size:	3x2x11
	Static Head: 0 ft	Impeller:	D05-85109

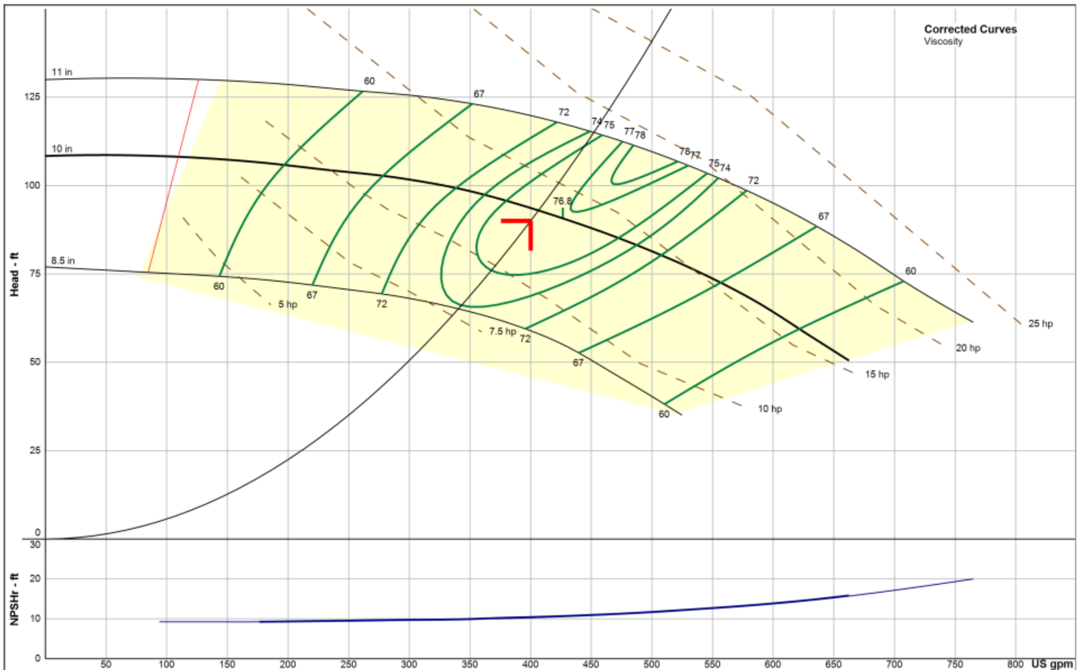
Patterson The Pump People



Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company: Hussmann Corp	Patterson HVAC Pumps	Model:	E3F11A-CC
Name: 350 GPM @ 90FT TDH	Catalog: Patterson HVAC.60, Vers 1.4.3	Speed:	1770 rpm
Date: 10/31/2023	HVES-CC - 1800 rpm	Dia:	9.75 in
	Design Point: 350 US gpm, 90 ft	Size:	4x3x11
	Static Head: 0 ft	Impeller:	D05-90019

Patterson The Pump People

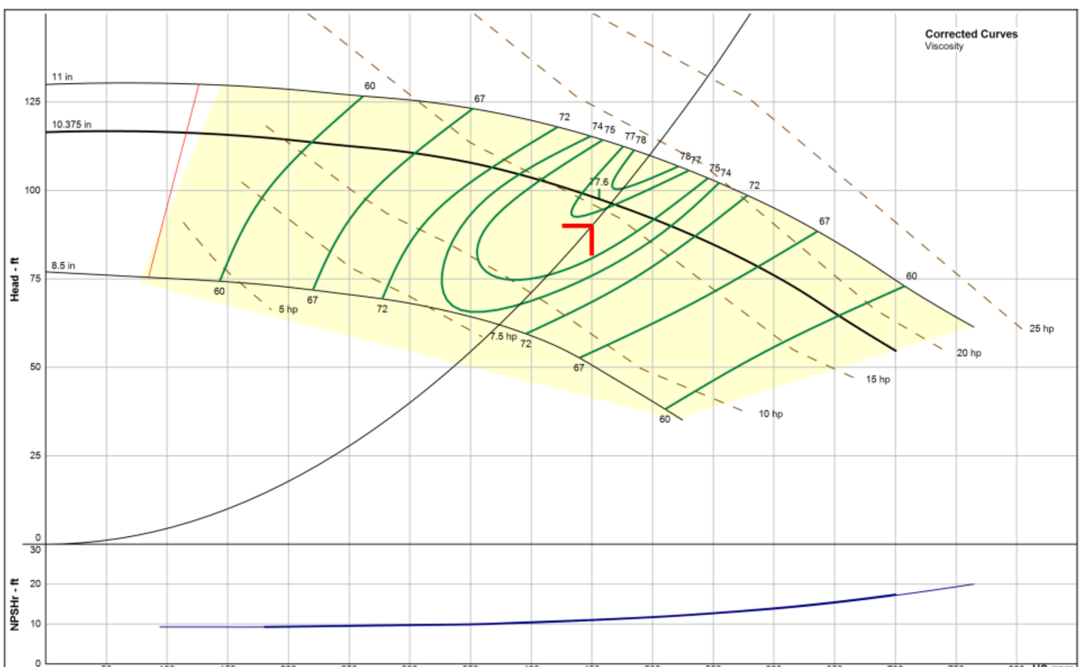


Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

Company: Hussmann Corp
Name: 400 GPM @ 90FT TDH
Date: 10/31/2023

Patterson HVAC Pumps
Catalog: Patterson HVAC.60, Vers 1.4.3
HVES-CC - 1800 rpm
Design Point: 400 US gpm, 90 ft
Static Head: 0 ft

Model: E3F11A-CC
Speed: 1770 rpm
Dia: 10 in
Size: 4x3x11
Impeller: D05-90019



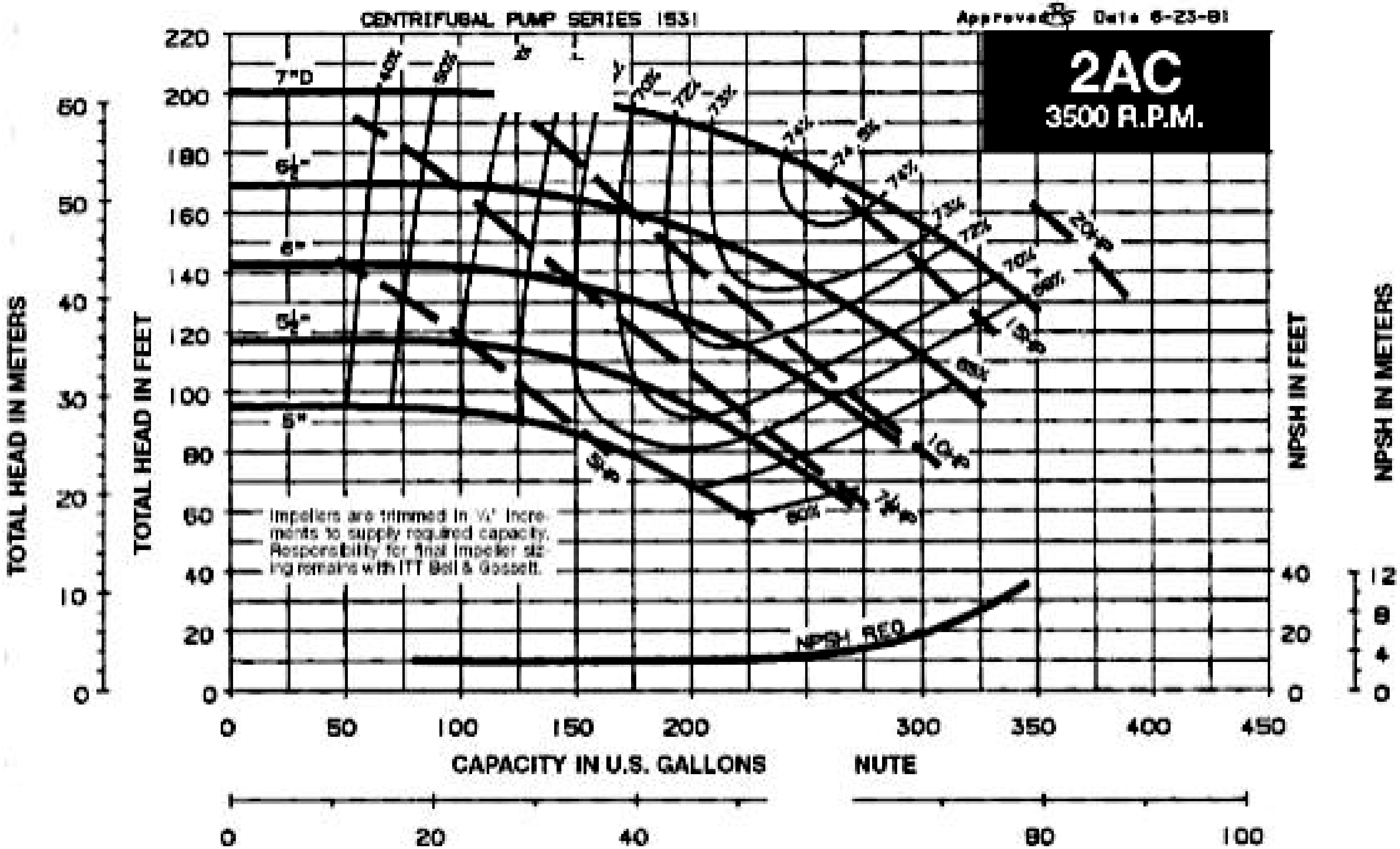
Refer to Working Pressure vs. Temperature chart for maximum rated working pressure. All data are subject to change. Contact factory for certified data.

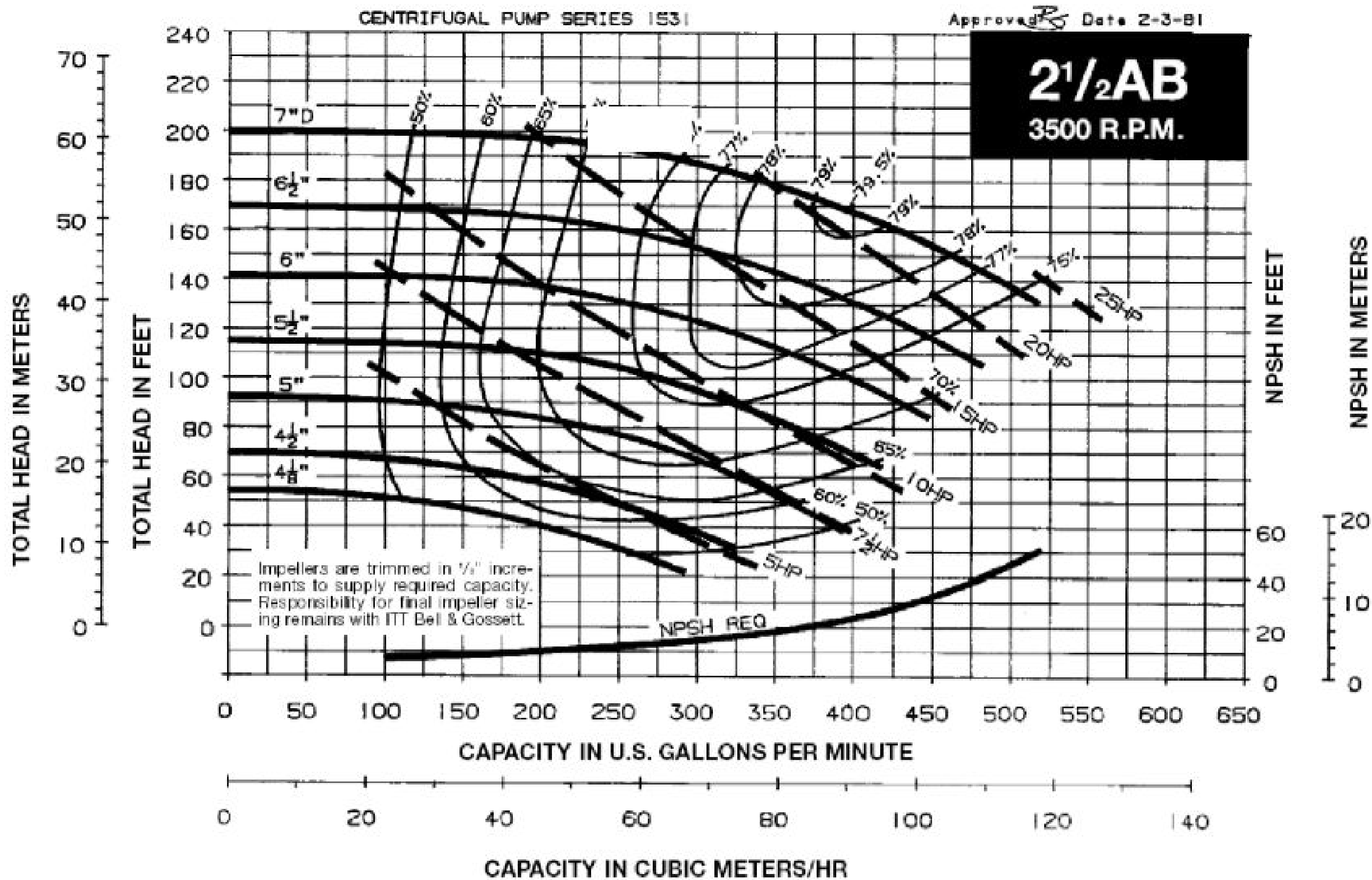
Company: Hussmann Corp
Name: 450GPM @ 95FT TDH
Date: 10/31/2023

Patterson HVAC Pumps
Catalog: Patterson HVAC.60, Vers 1.4.3
HVES-CC - 1800 rpm
Design Point: 450 US gpm, 90 ft
Static Head: 0 ft

Model: E3F11A-CC
Speed: 1770 rpm
Dia: 10.375 in
Size: 4x3x11
Impeller: D05-90019

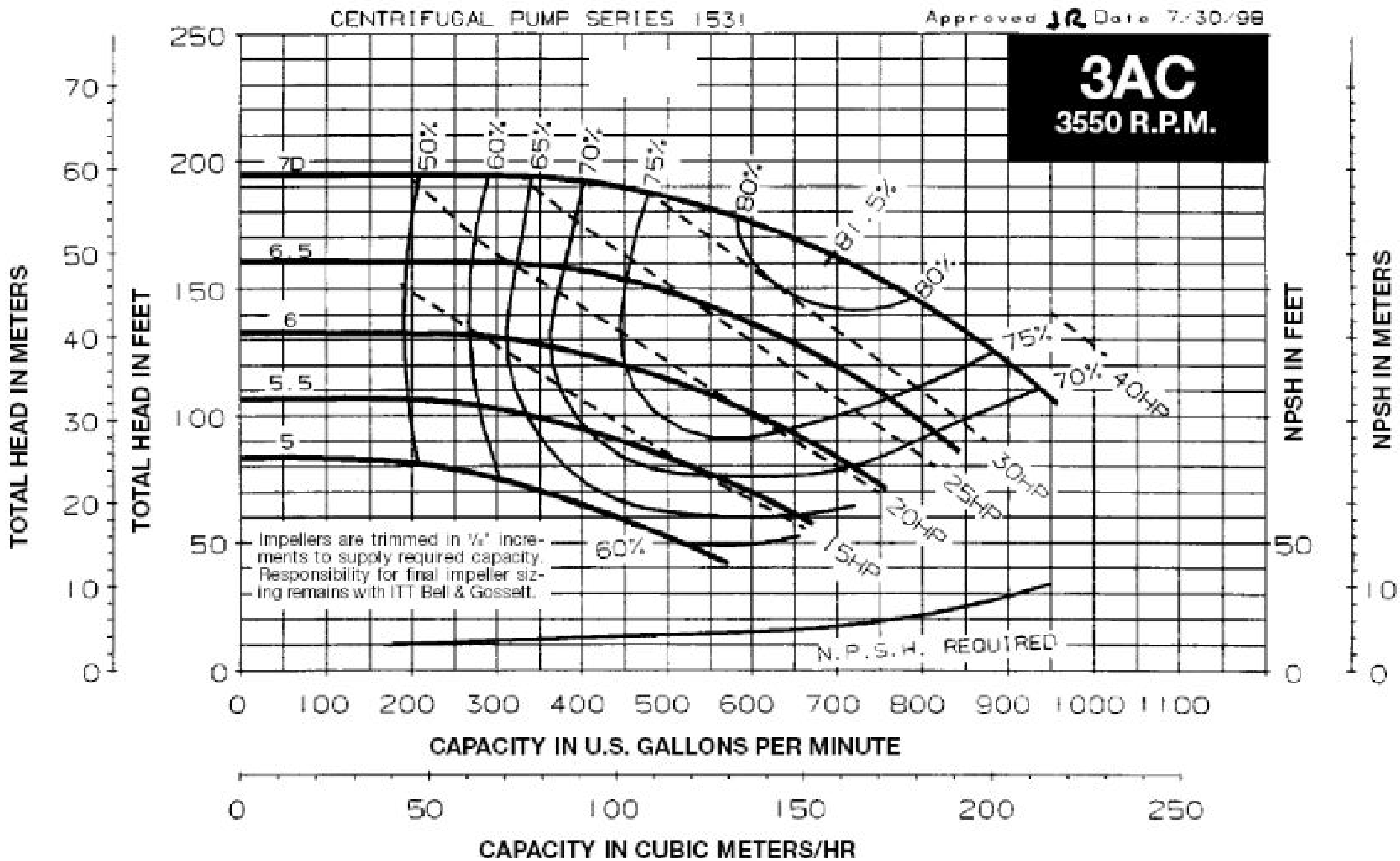
3500 RPM PUMP CURVES





CENTRIFUGAL PUMP SERIES 1531
Approved Date 2-3-81
2 1/2 AB
3500 R.P.M.
7"D
6 1/2"
6"
5 1/2"
5"
4 1/2"
4 1/8"
25HP
20HP
15HP
10HP
7 1/2HP
5HP
NPSH REQ
Impellers are trimmed in 1/8" increments to supply required capacity. Responsibility for final impeller sizing remains with ITT Bell & Gossett.
TOTAL HEAD IN METERS
TOTAL HEAD IN FEET
NPSH IN FEET
NPSH IN METERS
CAPACITY IN U.S. GALLONS PER MINUTE
CAPACITY IN CUBIC METERS/HR

3500 RPM PUMP CURVES



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To obtain warranty information or other support, contact your Hussmann representative. Please include the model and serial number of the product.