TRIFECTA X-SERIES

Product Manual

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Innovation. Experience. Performance.®

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Revision Log

Revision	Date	Description
C	May, 2013	Third release to add 600 LIN model
D	Oct 2013	Added information on 230 VAC Trifecta

1 Introduction

Congratulations, you are now the owner of a Chart Trifecta X-Series high-pressure gas supply system.

The Trifecta X-Series is the preferred solution for laser assist gases and other similar applications requiring pressures up to 600 psig and flow rates up to 15,000 SCFH.

Drawing liquid from a standard pressure bulk tank, the Trifecta X-Series system boosts pressure by alternately feeding two specially designed liquid cylinders with Chart's innovative/exclusive control logic.

The Trifecta X-Series solution has the industry's standard zero-to-no down time and minimizes losses compared with other high pressure/high flow solutions. This convenient plug-and-play package eliminates high pressure pumps, compressors, cylinder cradles and surge tanks.

1.1 System Specifications

1.1.1 Dimensions — 350 & 500 psi

Height:	96 in. (2440 mm)
Length:	53 in. (1347 mm)
Width:	55 in. (1397 mm)
Weight X5	1,700 lbs. (770 kg)
Weight X10	1,750 lbs. (795 kg)
Weight X15	1,800 lbs. (815 kg)

1.1.2 Dimensions — 600 psi

Height:	96 in. (2440 mm)
Length:	53 in. (1347 mm)
Width:	55 in. (1397 mm)
Weight X5	1,800 lbs. (892 kg)
Weight X10	1,870 lbs. (795 kg)
Weight X15	1,920 lbs. (815 kg)

1.1.3 Typical Layout

There are three main components to the "Trifecta" system:

- Low Pressure Bulk Tank
- Vaporizer

- Trifecta X-Series Skid

The New Trifecta X-Series has been designed for ease of installation and operation.

An ideal install has the Trifecta X-Series skid close to the liquid use valve on the bulk tank, the pressure building side (back) of the skid and the vaporizer facing the sun ("heat of the day").

The following (figure 1) is a typical layout:

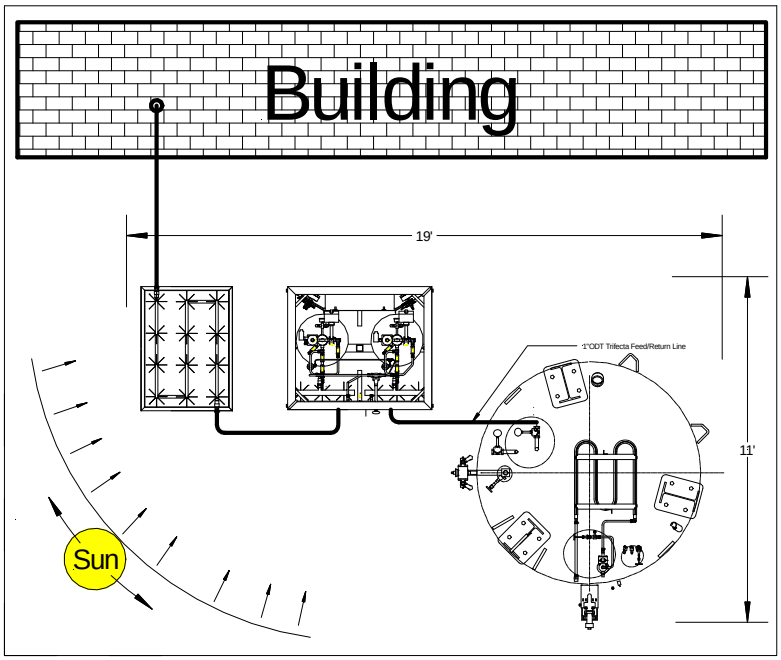


Figure 1 - Typical Layout

1.1.4 Flow Capability

The Trifecta X-Series system is designed to supply cryogenic liquid at high flow rates and pressure to a vaporizer, while the reserve tank is being supplied with lower pressure liquid. Its priority is to maintain supply pressure at or above the required pressure setting. The unique design has self-contained diagnostics that alerts the operator when the system exceeds the flow rating.

The X-series can supply liquid nitrogen and liquid argon in Maximum Average Working Pressures from 500 to 600 psi.

It can supply liquid oxygen in Maximum Average Working Pressures from 350 to 500 psi.

Service	MAWP* (psig)	MAOP* (psig)	X5	X10	X15
LIN	500	450	X	X	X
	600	550		X	X
LAR	500	450	X	X	X
	600	550		X	X
LOX	350	300	X	X	X
	500	450			X

* MAWP = Maximum Average Working Pressure
MAOP = Maximum Average Operating Pressure

The system uses ambient vaporizers to maintain pressure and convert the cryogen into gas; therefore, the performance is dependent on the weather conditions. The best ambient conditions are warm, dry air. The worst is damp air just above the freezing point.

The X series was developed and tested by Chart's New Product Development group in the harsh New Prague, Minnesota winter conditions for optimal performance in the field.

For example: The Trifecta X5 is rated to deliver liquid nitrogen at 425psi @ 5,000 SCFH in ambient conditions similar to Minnesota. If the end user can tolerate lower delivery pressures, the X -series can deliver even greater flow rates (see figures 3-5). If the rated flows are not needed, the system can be set to higher pressures. Use the following graphics to find the flow capability for your conditions:

Note: If the gas use requirements exceed the flow capability of the Trifecta system, the result will be a drop in pressure. Excessive pressure drops can result in pressures and flows at the laser nozzles that result in less than clean cuts (part rework may be required).

Pressure too low (heavy dross)

Proper pressure and flow

The flow performance depends on the ability of the total system to:

☞ ***Build pressure in the transfer tanks using gravity and ambient coils.***

- Proper air flow and sunlight reaching the pressure building coils.

- Extreme weather condition may require de-icing of the pressure building system.

☞ ***Vaporize liquid into gas to maintain pressure and flow at the use point.***

- The vaporizer must be sized for the geographical location, flow/pressure requirements and duty cycle.
- Less than optimum sun light and air flows across the coils will reduce the performance.

☞ ***Fill times - Refilling the reserve tank from the Bulk tank prior to the primary tank empting.***

- The overall flow rate of the system can be limited by the systems ability to refill. Flow out cannot exceed flow in!
- Special care must be given in selection of the bulk tank that supplies the Trifecta.
- The tanks heat leak performance is critical in transferring cryogen in the liquid state to the Trifecta.
- Liquid use lines and valves out of the Bulk tank must be sized properly. Small restrictive liquid lines and valves will increase fill times and increase losses.
- The pressure building system of the bulk tank needs to be sized to build tank sub-cool. This sub-cool condition (pressure above the liquid saturation pressure) helps keep flow rates up and the cryogen in the liquid state as it travels to the Trifecta.
- Liquid feed lines from the bulk tank to the Trifecta must be kept as short as possible! There is no limit to the length of pipe that can be used to feed the Trifecta. Any length longer than as short as possible can lead to longer fill times and additional losses. Take great care in laying out your Trifecta system. Insulating the liquid feed line will reduce its effective length resulting in increased fill times and reduced losses.

Use the following charts and graphs to estimate the performance of your X series Trifecta. Actual performance may vary depending on the installation and equipment used.

1. Identify the color associated with the location of the installation using the following map.
2. Use the rating graph that matches model, by moving from your desired pressure set point to the right until you reach your regional color.

3. Move down from this point to determine the regional flow rating.

Figure 2 - USA Regional Map

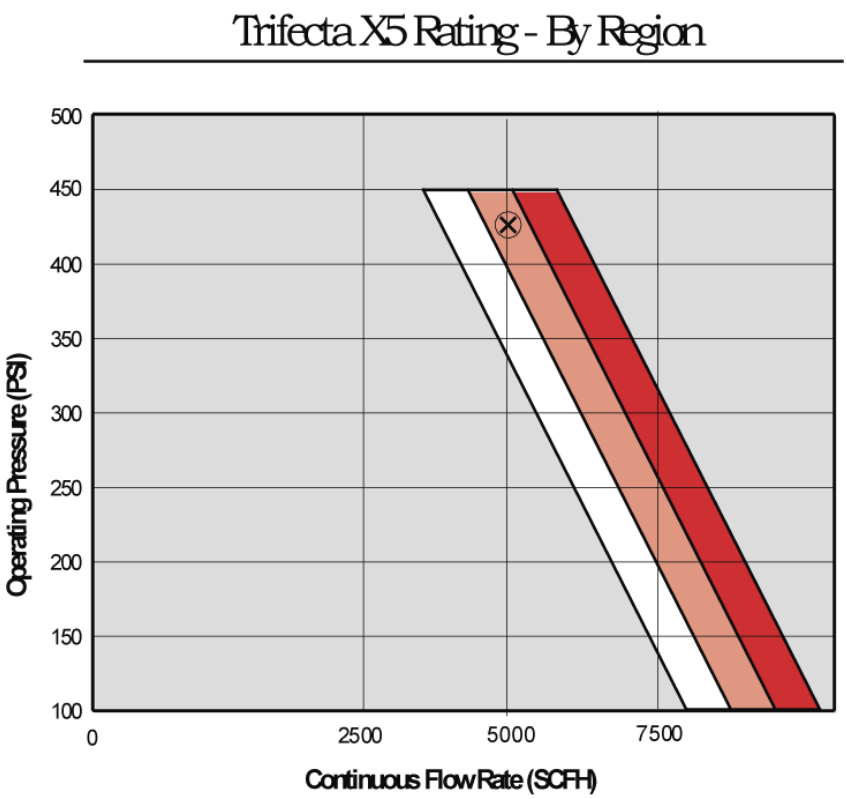


Figure 3 - Trifecta X5 Flow Rating

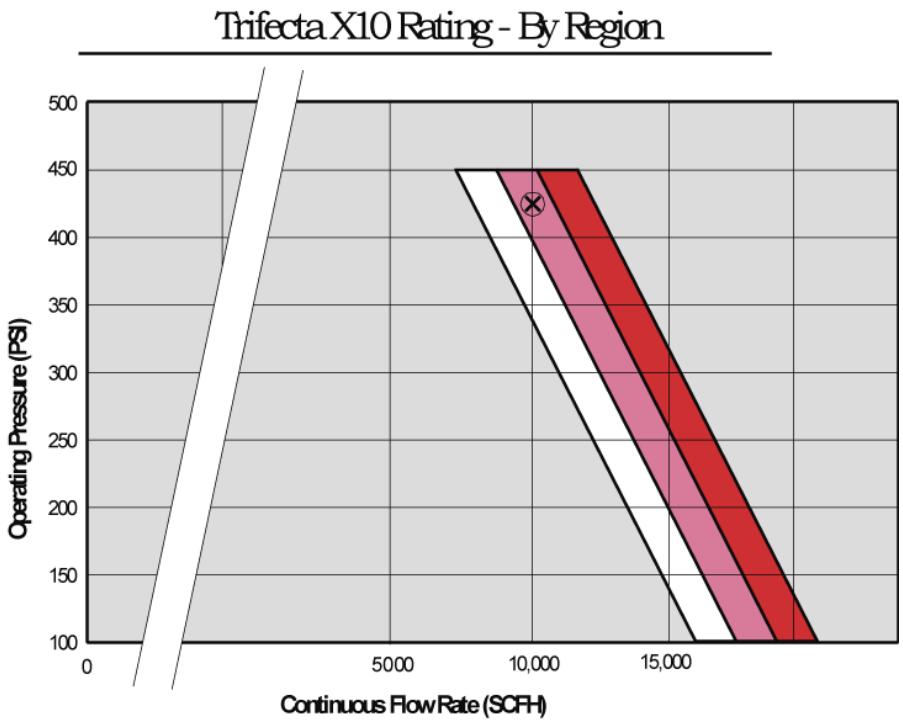


Figure 4 - Trifecta X10 Flow Rating

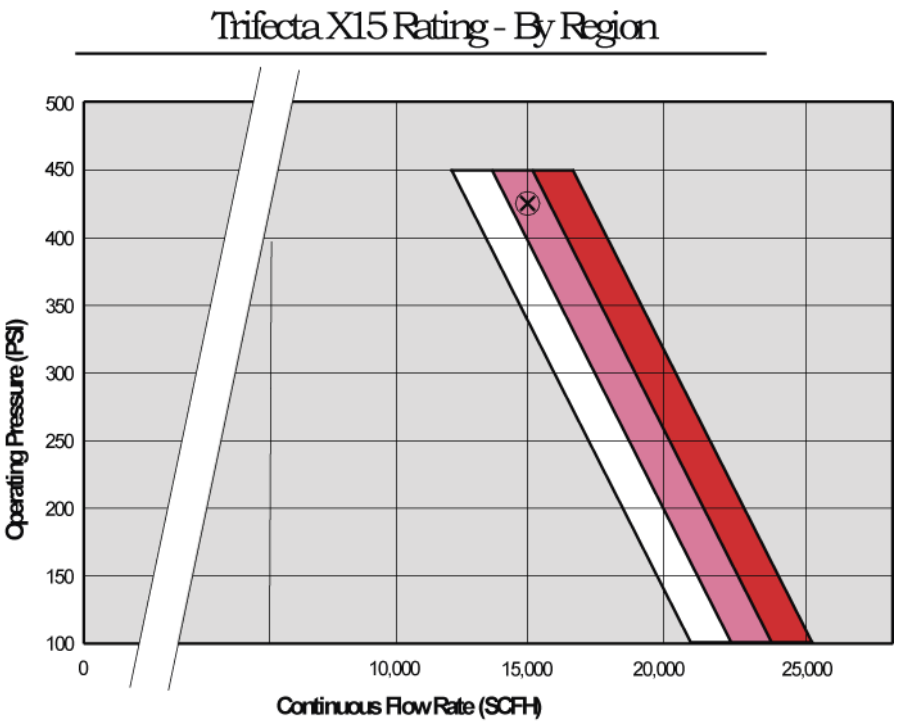


Figure 5 - Trifecta X15 Flow Rating

2 Safety

2.1 Safety Statement

All operators should have full and complete understanding of the content of this manual before operating the equipment described. The manual is intended to describe the operation of the equipment and not intended to supersede any site-specific standards.

As with any cryogenic system, it should be observed that any non-insulated piping can get extremely cold and should not be touched by exposed skin. If the system requires maintenance, it should be shut down and allowed to warm-up.

If maintenance is to be done on the system, such as changing valve seats, it is extremely important that the pressure be relieved from the system through the vent valves. The five transmitters can monitor the system pressures and liquid levels.

When doing maintenance on the system, it is recommended that the manual isolation valve to the bulk tank be closed.

2.2 Safety Summary

Strict compliance with proper safety and handling practices is necessary when using a cryogenic system. We recommend that all our customers re-emphasize safety and safe handling practices to all their employees and customers.

While every possible safety feature has been designed into the unit and safe operations are anticipated, it is essential that the user of the cryogenic system carefully read to fully understand all WARNINGS and CAUTION notes listed in this safety summary and enumerated below.

Also read the information provided in the Safety Bulletin for Oxygen and Inert Gases following this Safety Summary. Periodic review of the Safety Summary is recommended.

WARNING: In oxygen enriched atmosphere, flammable items burn vigorously and could explode.

WARNING: DO NOT PERMIT SMOKING OR OPEN FLAME IN ANY AREA WHERE OXYGEN IS STORED, HANDLED, OR USED. Failure to comply with this warning may result in serious personal injury.

Excess accumulation of oxygen creates an oxygen-enriched atmosphere (defined by the Compressed Gas Association as an oxygen concentration above 23%). Certain items considered non-combustible in air may burn rapidly in such an environment. Keep all organic materials and other flammable substances away from possible contact with oxygen; particularly oil, grease, kerosene, cloth, wood, paint, tar, coal, dust, and dirt which may contain oil or grease.

WARNING: Nitrogen and argon vapors in air may dilute the concentration of oxygen necessary to support or sustain life.

Exposure to such an oxygen deficient atmosphere can lead to unconsciousness and serious injury, including death.

CAUTION: Before removing and parts or loosening fittings, empty the cryogenic container of liquid contents and release any vapor pressure in a safe manner.

External valves and fittings can become extremely cold and may cause painful burns to personnel unless properly protected. Personnel must wear protective gloves and eye protection whenever removing parts or loosening fittings. Failure to do so may result in personal injury due to the extreme cold and pressure in the tank.

WARNING: Accidental contact of liquid gases with skin or eyes may cause a freezing injury similar to a burn.

Handle liquid so that it will not splash or spill. Protect your eyes and cover skin where the possibility of contact with liquid, cold pipes and equipment, or cold gas exists. Safety goggles or a face shield should be worn if liquid ejection or splashing may occur or cold gas may issue forcefully from equipment. Clean, insulated gloves that can be easily removed and long sleeves are recommended for arm protection. Cuff less trousers should be worn over the shoes to shed spilled liquid.

WARNING: If clothing should be splashed with liquid oxygen it will become highly flammable and easily ignited while concentrated oxygen remains.

Such clothing must be aired out immediately, removing the clothing if possible, and should not be considered safe for at least 30 minutes.

WARNING: Use only replacement parts that are compatible with liquid oxygen and have been cleaned for oxygen use.

Do not use regulators, fittings, hoses, etc., which have been previously used in a compressed air environment. And do not use oxygen equipment for compressed air. Failure to comply with these instructions may result in serious damage to the container.

CAUTION: Before locating oxygen equipment, become familiar with the relevant EU Directives or National Fire Protection Association (NFPA) standards for "Bulk Oxygen Systems at Customer Sites", and with all local safety codes.

The NFPA standard covers general principles recommended for installing bulk oxygen systems on industrial and institutional consumer premises.

CAUTION: To prevent possible tip over, do not leave tank standing upright unless it is secured to its foundation (bolted down).

Transporting and erection of the tank should be performed in accordance with rigging instructions available from CHART. Failure to comply with these instructions may result in serious damage to the container.

Safety Bulletin

A portion of the following information is extracted from Safety Bulletin SB-2 from the Compressed Gas Association, Inc. (CGA). Additional information on nitrogen and argon and liquid cylinders is available in CGA Pamphlet P-9. Write to the Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

From The CGA Safety Bulletin

Cryogenic containers, stationary or portable are from time-to-time subjected to assorted environmental conditions of an unforeseen nature. This safety bulletin is intended to call attention to the fact that whenever a cryogenic container is involved in any incident whereby the container or its safety devices are damaged, good safety practices must be followed. The same holds true whenever the integrity or function of a container is suspected of abnormal operation.

Good safety practices dictate that the contents of a damaged or suspect container be carefully emptied as soon as possible. Under no circumstances should a damaged container be left with product in it for an extended period of time. Further, a damaged or suspect container should not be refilled unless the unit has been repaired and re-certified.

Incidents, which require that such practices, be followed, include highway accidents, immersion in water, exposure to extreme heat or fire, and exposure to most adverse weather conditions (earthquakes, tornadoes, etc.).

As a rule of thumb, whenever a container is suspected of abnormal operation, or has sustained actual damage, good safety practices must be followed.

In the event of known or suspected container vacuum problems (even if an extraordinary circumstance such as those noted above has not occurred), do not continue to use the unit. Continued use of a cryogenic container that has a vacuum problem can lead to embrittlement and cracking. Further, the carbon steel jacket could possibly rupture if the unit is exposed to inordinate stress conditions caused by an internal liquid leak.

Prior to reusing a damaged container, the unit must be tested, evaluated, and repaired as necessary. It is highly recommended that any damaged container be returned to Chart for repair and re-certification.

The remainder of this safety bulletin addresses those adverse environments that may be encountered when a cryogenic container has been severely damaged. These are oxygen deficient atmospheres, oxygen-enriched atmospheres, and exposure to inert gases.

2.2.1 Oxygen Deficient Atmospheres

The normal oxygen content of air is approximately 21%. Depletion of oxygen content in air, either by combustion or by displacement with inert gas, is a potential hazard and users should exercise suitable precautions.

One aspect of this possible hazard is the response of humans when exposed to an atmosphere containing only 8 to 12% oxygen. In this environment, unconsciousness can be immediate with virtually no warning.

When the oxygen content of air is reduced to about 15 or 16%, the flame of ordinary combustible materials, including those commonly used as fuel for heat or light, may be extinguished. Somewhat below this concentration, an individual breathing the air is mentally incapable of diagnosing the situation.

The onset of symptoms such as sleepiness, fatigue, lassitude, loss of coordination, errors in judgment and confusion can be masked by a state of euphoria, leaving the victim with a false sense of security and well-being.

Human exposure to atmosphere containing 12% or less oxygen leads to rapid unconsciousness. Unconsciousness can occur so rapidly that the user is rendered essentially helpless. This can occur if the condition is reached by immediate change of environment, or through the gradual depletion of oxygen.

Most individuals working in or around oxygen deficient atmospheres rely on the "buddy system" for protection — obviously, the "buddy" is equally susceptible to asphyxiation if he or she enters the area to assist an unconscious partner unless equipped with a portable air supply.

Best protection is obtainable by equipping all individuals with a portable supply of respiratory air. Lifelines are acceptable only if the area is essentially free of obstructions and individuals can assist one another without constraint.

If an oxygen deficient atmosphere is suspected or known to exist:

- Use the "buddy system." Use more than one "buddy" if necessary to move a fellow worker in an emergency.
- Both the worker and "buddy" should be equipped with self-contained or airline breathing equipment.

2.2.2 Oxygen Enriched Atmospheres

An oxygen-enriched atmosphere occurs whenever the normal oxygen content of air is allowed to rise above 23%. While oxygen is non-flammable, ignition of combustible materials can occur more readily in an oxygen-rich atmosphere than in air; and combustion proceeds at a faster rate although no more total heat is released.

It is important to locate an oxygen system in a well-ventilated location since oxygen-rich atmospheres may collect temporarily in confined areas during the functioning of a safety relief device or leakage from the system.

Oxygen system components, including but not limited to, containers, valves, valve seats, lubricants, fittings, gaskets and interconnecting equipment including hoses, shall have adequate compatibility with oxygen under the conditions of temperature and pressure to which the components may be exposed in the containment and use of oxygen.

Easily ignitable materials shall be avoided unless they are parts of equipment or systems that are approved, listed, or proved suitable by tests or by past experience.
Compatibility involves both combustibility and ease of ignition. Materials that burn in air may burn violently in pure oxygen at normal pressure — and explosively in pressurized oxygen.

In addition, many materials that do not burn in air may do so in pure oxygen, particularly when under pressure. Metals for containers and piping must be carefully selected, depending on service conditions. The various steels are acceptable for many applications, but some service conditions may call for other materials (usually copper or its alloys) because of their greater resistance to ignition and lower rate of combustion.

Similarly, materials that can be ignited in air have lower ignition energies in oxygen. Many such materials may be ignited by friction at a valve seat or stem packing, or by adiabatic compression produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

2.2.3 Nitrogen and Argon

Nitrogen and argon (inert gases) are simple asphyxiants. Neither gas will support or sustain life and can produce immediate hazardous conditions through the displacement of oxygen. Under high pressure these gases may produce narcosis even though an adequate oxygen supply, sufficient for life, is present.

Nitrogen and argon vapors in air dilute the concentration of oxygen necessary to support or sustain life. Inhalation of high concentrations of these gases can cause anoxia, resulting in dizziness, nausea, vomiting, or unconsciousness and possibly death.

Individuals should be prohibited from entering areas where the oxygen content is below 19% unless equipped with a self-contained breathing apparatus.

Unconsciousness and death may occur with virtually no warning if the oxygen concentration is below approximately 8%. Contact with cold nitrogen or argon gas or liquid can cause cryogenic (extreme low temperature) burns and freeze body tissue.

Persons suffering from lack of oxygen should be immediately moved to areas with normal atmospheres.

SELF-CONTAINED BREATHING APPARATUS MAY BE REQUIRED TO PREVENT ASPHYXIATION OF RESCUE WORKERS.

Assisted respiration and supplemental oxygen should be given if the victim is not breathing. If cryogenic liquid or cold boil-off gas contacts a worker's skin or eyes, the affected tissues should be promptly flooded or soaked with tepid water (105-115°F; 41-46°C).

DO NOT USE HOT WATER. Cryogenic burns, which result in blistering or deeper tissue freezing, should be examined promptly by a physician.

Chart customer stations are designed with the following safety features:

- A vacuum maintenance system specifically designed to provide long life and all possible safety provisions.
- Safety relief devices to protect the pressure vessel and vacuum casing sized and selected in accordance with ASME standards to include a dual relief valve. While Chart equipment is designed and built to the most rigid standards, no piece of mechanical equipment can ever be 100% foolproof.

3 Installation

Figure 6 - Trifecta X-Series Installation

3.1 Installation Procedure

1. Place Trifecta X-Series Skid on Concrete Pad next to Bulk Tank
2. Pipe Trifecta X-Series Liquid Fill Line to Bulk Tank labeled “From Bulk Tank”
3. Pipe Trifecta X-Series Gas Use Line to External Vaporizer Labeled “To Vaporizer”
4. Connect Power Supply to dedicated 120 VAC, 15 amp circuit. (or 230 VAC, 50/60 Hz)
5. Commission Trifecta

3.2 Placement of Trifecta X-Series Skid

The *Trifecta X-Series* skid has two lifting lugs on the top of the skid. These lifting lugs allow for placement of the skid by overhead crane. If an overhead crane is not available, the skid has fork truck access as well.

Note: The Trifecta X-Series assembly weighs almost 1900 lbs. empty (864 kg).

The *Trifecta X-Series* skid should be placed on the concrete pad, near the bulk storage tank as seen in the Introduction portion of this manual. The portion of the pad that the Trifecta X-Series skid resides must be a minimum of 4” thick and of the same composition as the pad for the adjoining Bulk Tank. The skid should be placed as close to the bulk tank as possible without interfering with any other equipment or service requirements of the tank. The system requires a transfer of liquid and gas between the bulk storage tank and the *Trifecta X-Series skid*. This process becomes less efficient with increasing transfer line length.

NOTE: Each site may have unique requirements; however, it is recommended to follow the basic layout located in the Introduction section (Section 1) of this manual.

The skid should also be placed such that there is easy access to all sides of the unit. The skid should be placed where it may receive a maximum amount of sunlight and airflow. One must be able to check the individual cylinder gauges, the control box, and any of the solenoid valves or transmitters at any time. Consideration should also be given to the external vaporizer placement on the concrete pad.

NOTE: It is important that the sun and wind contact both the external vaporizer and pressure build coils inside the skid to insure optimal operation of the unit and prevent unusual buildup of ice.

NOTE: Do not locate the Trifecta or Vaporizer near equipment that produces excessive moisture (i.e. cooling towers, drains, etc.).

3.3 Liquid Line Piping to Bulk Tank

The Trifecta X-Series skid requires a liquid line piped from the bulk storage tank. This line will serve two functions. First, to allow the high pressure gas to return to the liquid side of the bulk tank (reduce losses), second, to allow the transfer of liquid from the bulk tank to the Trifecta.

The recommended line size is no smaller than three-quarters of an inch (3/4" NOM, 19mm).

The backside (PB side) of the X-Series skid has two connection points.

- The connection on the left is the outlet to the vaporizer.
- The connection on the right is the outlet to the liquid feed line from the bulk tank.

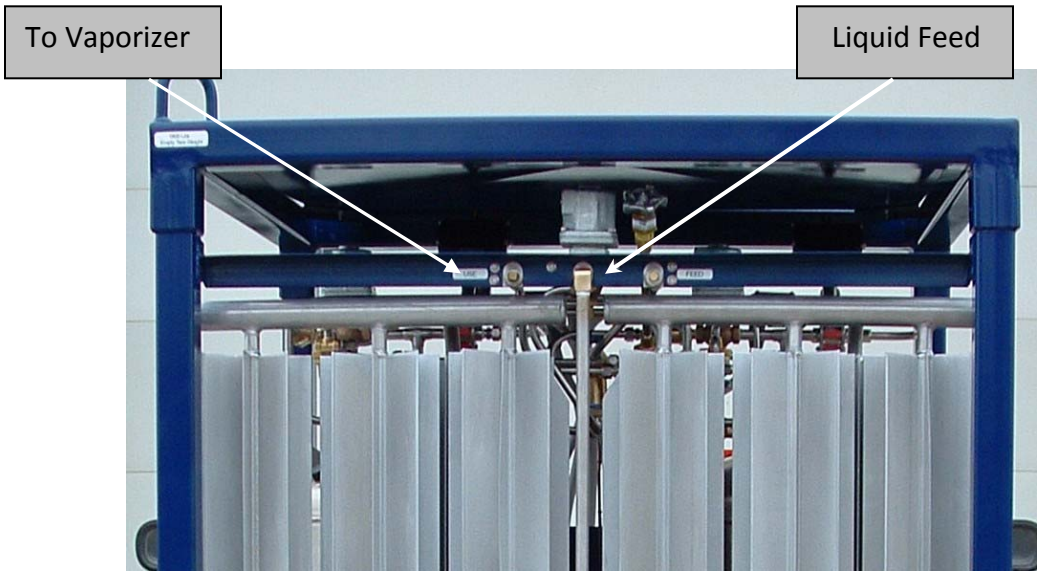


Figure 7 - Attachment Piping

NOTE: It is recommended to insulate the liquid feed line to minimize fill times and reduce losses. The Fill Line (from bulk tank to Trifecta) length should be limited to 15 total feet (5 meters).

NOTE: The isolation valve on the bulk tank liquid line should not be opened until all plumbing connections are complete.

3.4 Piping to Vaporizer

The Trifecta X-Series system does not contain final vaporization. Consequently, a freestanding, external vaporizer must be connected to the "to Vaporizer" line of the Trifecta X-Series. The vaporizer should have a pressure rating of at least 600 psig – or 700 psig for the 600 psig Trifecta.

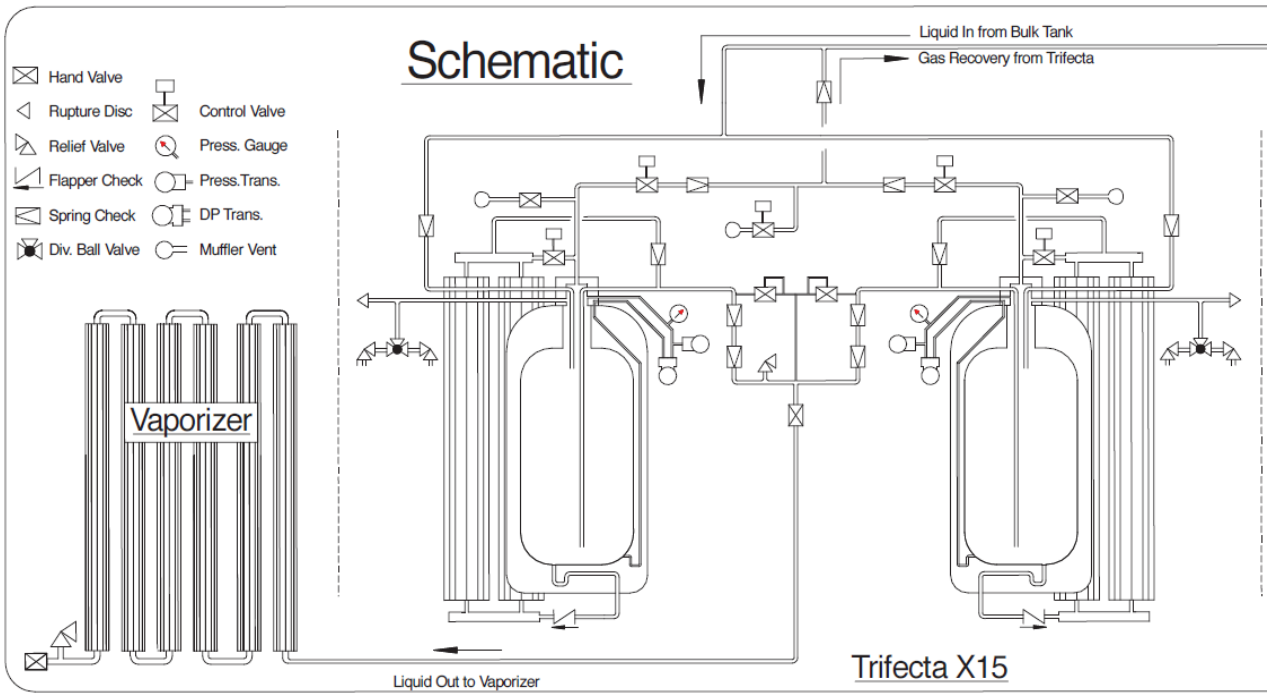


Figure 8 - Piping to Vaporizer

NOTE: It is important to make sure the vaporizer assembly is protected against over pressurization from trapped liquid. The vaporizer installation must include a thermal relief valve just downstream of the vaporizer, set at 550 psig. (Or 650 psig for the 600 psi high pressure Trifecta)

The relief device on the Trifecta X-Series is a fail-safe device and should not be relied upon as the only thermal relief. Operation of the Trifecta X-Series "Gas Use" relief device may vent liquid, creating a noticeable vapor cloud.

The piping and components from the Trifecta X-Series to the vaporizer must be at least ¾" (19mm) copper or its equivalent and of adequate pressure rating. Small diameter lines will introduce undesirable pressure drops and impact overall system performance. Referring to

Figure 7, the left connection should be piped to the vaporizer. The outlet of the vaporizer should be piped to the customer house line with final line regulation as required.

NOTE: Installation of an additional drain valve downstream of the vaporizer is highly recommended. This valve aids in the purging of the Trifecta X-Series and external vaporizer. This valve will also serve as an emergency gas feed port.

NOTE: If the house line cannot handle 550 psi, additional safeties and line regulation must be added.

DO NOT SET OPERATING PRESSURE HIGHER THAN THE LOWEST RELIEF DEVICE!

3.5 Bulk Tank Pressure Transmitter

The system controller requires the pressure input of the bulk tank to perform the filling procedure as efficiently as possible. This is done through a pressure transmitter. The pressure transmitter measures the pressure of the bulk tank and sends an electrical signal back to the controller. The transmitter for the bulk tank is located in the upper piping of the Trifecta X-Series and pre-wired into the control box. No additional piping is required by the customer to receive the bulk tank pressure; this will automatically read the current Bulk tank pressure unlike previous models.

For the 600 psig Trifecta series, a gas line from the bulk tank needs to be run to the regulator, which supplies pneumatic pressure to the actuators on each ball valve. The regulator regulates the pressure from the bulk tank down to 125 psi. The actuators require a minimum of 80 psig. The maximum pressure for the gas line is 150 psi.

3.6 Electrical Power Supply

A dedicated 120 VAC, 60Hz, 15 amp circuit (or 230 VAC, 50/60 Hz, 15 amp version, if ordered) must be provided to power the Trifecta X-Series control system. A voltage converter may be necessary. Back feed of voltage WILL interfere with component performance.

The Mitsubishi PLC is mounted within a NEMA 4 control box as shown in the following photograph:

Figure 9 - Trifecta X-Series Control Box (open)

It is important that care is taken to install the Trifecta X-Series system on an electrical power circuit that is clean and protected. Circuits that are susceptible to noise and brownouts may cause erratic system behavior. Care should also be taken to avoid installation on a circuit that regularly gets turned on and off to provide power to another piece of equipment (lights, heaters, cooling systems etc.). It should be recognized that a PLC (computer) controls the Trifecta X-Series system and a clean, steady circuit must be used to power the Trifecta X-Series system.

3.7 Commissioning

The following procedures require the operation of the solenoid valves. Refer to Figure 9 and Table 1 to differentiate the solenoids. (Note: On the 600 psig high pressure trifecta, the solenoid valves are replaced with pneumatic actuated ball valves.)

WARNING: It is important to purge the entire Trifecta X-Series and piping with warm, dry nitrogen before running the system with liquid. Water vapor can cause ice crystals to form that may cause the solenoid valves and other critical components to operate improperly.

3.7.1 Purge and Pre-charge of the Trifecta X-Series

When all connections to the Trifecta X-Series are made, purge the complete system using low-pressure nitrogen.

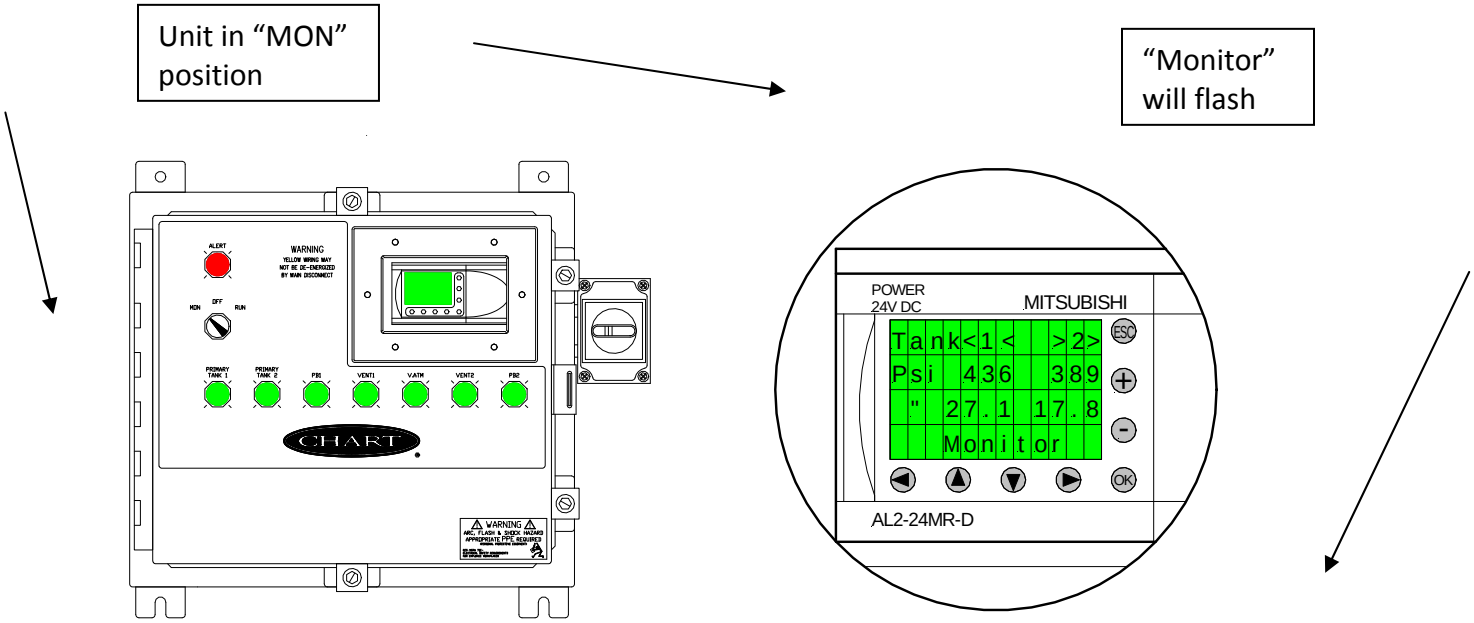
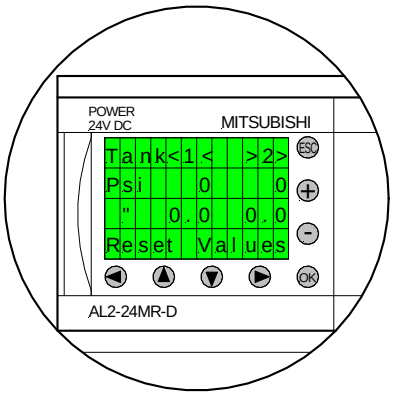


Figure 10 - Control Panel in "Monitor" Mode



1. Verify that the controller is in the “OFF” or “Monitor” position and open the liquid feed from the bulk tank until the pressure in the Trifecta X-Series equalizes with the bulk tank. Let all piping warm back to ambient (no frost) and leak check all connections.
2. Slowly open the Trifecta liquid use valve and pressurize the vaporizer and house line to the bulk tank pressure. Perform a leak check on the vaporizer and house line.

3. Once plumbing integrity is confirmed at “Low” pressure (no leaks), close the liquid use valve located on the back of the Trifecta skid, switch the unit from “OFF” or “MONITOR” to the “Run” position.
4. The PLC will ask you to “Reset Values”. There are three parameters that can be set using the buttons found on the PLC. These values are reset to zero at the factory (two weeks of no power can result in parameters reset to zero). To activate the parameters press the left arrow button 5 times. After activating the parameters set them to the desired set points.
5. With the switch in the “Run” position and the parameters set the system will begin filling in approx. 5 minutes. Let the entire unit come up to full working pressure. Allow all piping to warm (no frost) and leak check all components at working pressure.
6. After Trifecta plumbing integrity has been confirmed (no leaks) and at full working pressure, slowly re-open the liquid use valve and pressurize the vaporizer and house line at full pressure.

CAUTION: Opening the liquid use too fast will result in a “rush” of liquid into the vaporizer. This may cause the line safeties to vent.

7. Perform a leak check on the vaporizer and house line.

3.7.2 Check Trifecta X-Series Cylinder Relief Valves

Check each cylinder's main relief valves. During operation, the pressure in Tank 1 and/or two will rise to approximately 450 psi. (550 psig for the 600 psi Trifecta series). The relief valve must not open. If it does, the valve should be replaced as it is opening at a pressure that is too low. Repeat same procedure on Tank 2. Open diverter valve for each cylinder to verify secondary set of safety devices.

4 Operation

The Trifecta X-Series operation is based on pressure first and liquid level second. This logic assures that the system pressure is maintained.

Pressure is the primary concern.

4.1 Hard Sets (complete parameter list)

The following tables are intended to give detailed information of the internal parameters. The X5, X10 and X15 models have parameter differences. When referencing the following tables make sure you are looking at the correct table. Hard sets also vary slightly by product. The values in the tables below are for nitrogen service.

HardSets Thresholds		**XS05**0100505_8
Factory Default	**Adjustable**	**Description**
31.0"	Yes (up arrow)	default fill level
4.7"	Yes (function of fill level)	primary to low to assist (.15 x fill level)
23.3"	Yes (function of fill level)	secondary to low for assist mode (.75 x fill level)
450 psi	Yes (function of PB On)	PBOff = PBOn + **25**psi
425 psi	Yes (left arrow)	default PBOn **425** psi
450 psi	No	PBOn upper limit is **450** psi
400 psi	Yes (function of PB On)	Reserve tank PBOFF = Primary PBOn - **25**psi
375 psi	Yes (function of PB On)	Reserve tank PBOn = Primary PBOn - **50**psi
375 psi	Yes (function of PB On)	Primary pressure extreme low pressure threshold
150 psi	Yes (down arrow)	default Bulk Critical **150** psi
495 psi	No	Side #1 relief to bulk or atmosphere at **495 psi**
495 psi	No	Side #2 relief to bulk or atmosphere at 495 psi
-5 psi	No	Transmitter Pressure to low (system will not operate)
550 psi	No	Transmitter Pressure to high (system will not operate)
3 seconds	No	Liq present at temp switch for **3** seconds
120 seconds	No	Temp switch will disarm for **120 seconds** after over pressure relief
10 seconds	No	If the pressure drops to the fast drop PB set within **10** seconds
435 psi	Yes (function of PB On)	Fast drop on pb = PBOn + **10** psi
820 seconds	No	Fill time reaching **820** seconds results in the vent opening until full
140 psi (100 psi bulk tank)	No	With bulk tank below critical pressure, the vent to atmosphere valve will open at this set point = Bulkpsi(frozen) + **40** psi
55 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - **45** psi (low loss)
70 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - 45 psi (low loss)
29.5"	Yes (function of fill level)	Fill level is reduced by 1.5" to account for liquid growth for cylinder pressures above 130 psi
130 psi	No	Pressure threshold that takes subtracts 1.5" from the fill level
80 to 130 psi	No	Nominal cylinder pressure. Fill levels at fill set point.
80 psi	No	Pressure threshold that takes adds 1.5" from the fill level
32.5"	Yes (function of fill level)	Fill level is increased by 1.5" to account for liquid growth change for cylinder pressures below 80 psi
10 seconds	No	Primary pressure below PB On set for **10** seconds will result in the secondary assisting the primary tank.
120 seconds	No	Primary pressures below the PB on threshold for **120** sec will activate the light/display message, freeze the error codes and start the low pressure timer.
880 seconds	No	Alert code A1 is activated
280 seconds	No	Flow timer - limit to deliver 4" of product. Activates E5 error
25.0"	No	Start flow timer at this liquid level.
18.0"	No	Stop flow timer at this liquid level.

Table 4.1 - X5 Hard Sets/Thresholds

HardSets Thresholds		**XS10**0100505_8
Factory Default	**Adjustable**	**Description**
30.0"	Yes (up arrow)	default fill level
6"	Yes (function of fill level)	primary to low to assist (.20 x fill level)
24"	Yes (function of fill level)	secondary to low for assist mode (.80 x fill level)
450 psi	Yes (function of PB On)	PBOff = PBOn + **25**psi
425 psi	Yes (left arrow)	default PBOn **425** psi
450 psi	No	PBOn upper limit is **450** psi
400 psi	Yes (function of PB On)	Reserve tank PBOFF = Primary PBOn - **25**psi
375 psi	Yes (function of PB On)	Reserve tank PBOn = Primary PBOn - **50**psi
375 psi	Yes (function of PB On)	Primary pressure extreme low pressure threshold
150 psi	Yes (down arrow)	default Bulk Critical **150** psi
495 psi	No	Side #1 relief to bulk or atmosphere at **495 psi**
495 psi	No	Side #2 relief to bulk or atmosphere at **495 psi**
-5 psi	No	Transmitter Pressure to low (system will not operate)
550 psi	No	Transmitter Pressure to high (system will not operate)
3 seconds	No	Liq present at temp switch for **3** seconds
120 seconds	No	Temp switch will disarm for **120 seconds** after over pressure relief
10 seconds	No	If the pressure drops to the fast drop PB set within **10** seconds
435 psi	Yes (function of PB On)	Fast drop on pb = PBOn + **10** psi
480 seconds	No	Fill time reaching **300** seconds results in the vent opening until full
140 psi (100 psi bulk tank)	No	With bulk tank below critical pressure, the vent to atmosphere valve will open at this set point = Bulkpsi(frozen) + **40** psi
55 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - **45** psi (low loss)
70 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - 45 psi (low loss)
28.5"	Yes (function of fill level)	Fill level is reduced by 1.5" to account for liquid growth for cylinder pressures above 130 psi
130 psi	No	Pressure threshold that takes subtracts 1.5" from the fill level
80 to 130 psi	No	Nominal cylinder pressure. Fill levels at fill set point.
80 psi	No	Pressure threshold that takes adds 1.5" from the fill level
31.5"	Yes (function of fill level)	Fill level is increased by 1.5" to account for liquid growth change for cylinder pressures below 80 psi
10 seconds	No	Primary pressure below PB On set for **10** seconds will result in the secondary assisting the primary tank.
120 seconds	No	Primary pressures below the PB on threshold for **120** sec will activate the light/display message, freeze the error codes and start the low pressure timer.
540 seconds	No	Alert code A1 is activated
192	No	Flow timer - limit to deliver 4" of product. Activates E5 error
25.0"	No	Start flow timer at this liquid level.
18.0"	No	Stop flow timer at this liquid level.

Table 4.2 – X10 Hard Sets/Thresholds

HardSets Thresholds		XS150100505_8
Factory Default	**Adjustable**	**Description**
29.0"	Yes (up arrow)	default fill level
7.3"	Yes (function of fill level)	primary to low to assist (.25 x fill level)
24.7"	Yes (function of fill level)	secondary to low for assist mode (.85 x fill level)
450 psi	Yes (function of PB On)	PBOff = PBOn + **25**psi
425 psi	Yes (left arrow)	default PBOn **425** psi
450 psi	No	PBOn upper limit is **450** psi
400 psi	Yes (function of PB On)	Reserve tank PBOFF = Primary PBOn - **25**psi
375 psi	Yes (function of PB On)	Reserve tank PBOn = Primary PBOn - **50**psi
375 psi	Yes (function of PB On)	Primary pressure extreme low pressure threshold
150 psi	Yes (down arrow)	default Bulk Critical **150** psi
495 psi	No	Side #1 relief to bulk or atmosphere at **495 psi**
495 psi	No	Side #2 relief to bulk or atmosphere at **495 psi**
-5 psi	No	Transmitter Pressure to low (system will not operate)
550 psi	No	Transmitter Pressure to high (system will not operate)
3 seconds	No	Liq present at temp switch for **3** seconds
120 seconds	No	Temp switch will disarm for **120 seconds** after over pressure relief
10 seconds	No	If the pressure drops to the fast drop PB set within **10** seconds
435 psi	Yes (function of PB On)	Fast drop on pb = PBOn + **10** psi
300 seconds	No	Fill time reaching **300** seconds results in the vent opening until full
140 psi (100 psi bulk tank)	No	With bulk tank below critical pressure, the vent to atmosphere valve will open at this set point = Bulkpsi(frozen) + **40** psi
55 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - **45** psi (low loss)
70 psi (100 psi bulk tank)	No	Low loss set point that turns of the vent to atmosphere valve = Bulkpsi(frozen) - 45 psi (low loss)
27.5"	Yes (function of fill level)	Fill level is reduced by 1.5" to account for liquid growth for cylinder pressures above 130 psi
130 psi	No	Pressure threshold that takes subtracts 1.5" from the fill level
80 to 130 psi	No	Nominal cylinder pressure. Fill levels at fill set point.
80 psi	No	Pressure threshold that takes adds 1.5" from the fill level
30.5"	Yes (function of fill level)	Fill level is increased by 1.5" to account for liquid growth change for cylinder pressures below 80 psi
10 seconds	No	Primary pressure below PB On set for **10** seconds will result in the secondary assisting the primary tank.
120 seconds	No	Primary pressures below the PB on threshold for **120** sec will activate the light/display message, freeze the error codes and start the low pressure timer.
360 seconds	No	Alert code A1 is activated
128+A5 seconds	No	Flow timer - limit to deliver 4" of product. Activates E5 error
25.0"	No	Start flow timer at this liquid level.
18.0"	No	Stop flow timer at this liquid level.

Table 4.3 – X15 Hard Sets/Thresholds

5 Parameter Settings

Initial power up from the factory will require some parameters to be set. The display flashes "Reset Values" on the lower line of the main display. No valves will operate while this display is flashing. The Reset Values mode can occur if the power is left off the system for more than 2 weeks.

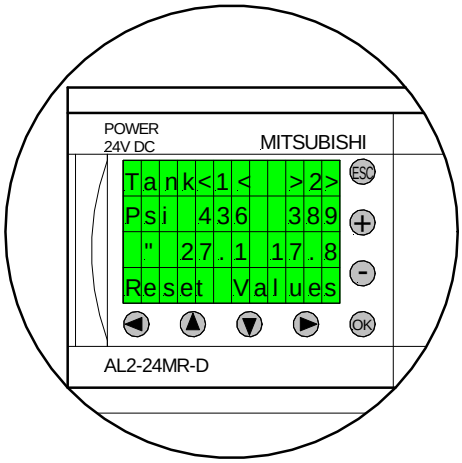


Figure 11 - "Reset Values"

To set these parameters without running the system, switch the MON/OFF/RUN switch found on the front of the control panel to the “MON” position. “Monitor” will flash on the lower line of the main display. The valves will not be controlled by the PLC when “Monitor” is in the display.

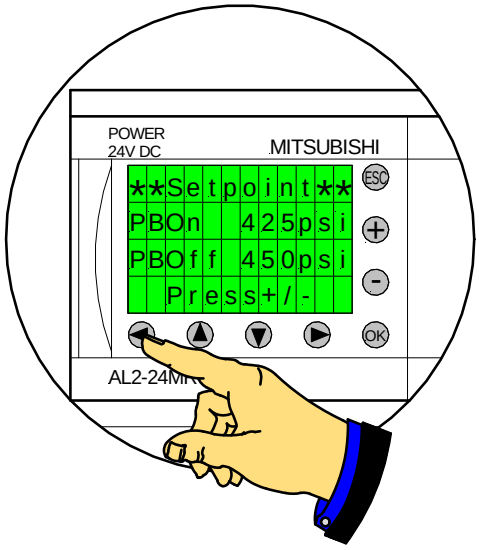
NOTE: If power is off for two weeks, the volatile memory will be lost. In this case, parameters MUST be reset before operations continue.

- **Reset parameters to default settings by switching to “Monitor” mode and pressing the left arrow 5 times.**

Reset parameters to site requirements prior to switching to “Run” position.

Three settable parameters are accessible from the PLC buttons.

These parameters are key to setting all parameters.



PB Set Point

Pressing the “Left” arrow button accesses the Pressure Building set points. The “PBOff” set point is always 25 psi higher than the “PBOn” set point. At the “PBOn” pressure the system turns on the primary tanks PB valve. The “PBOff” set point is the pressure that the system turns off the primary PB valve. The secondary tanks PB “Hold” pressures are a function of these values.

Pressing and holding the “Left” arrow and pressing the “+” button or the “-” button will adjust the set points.

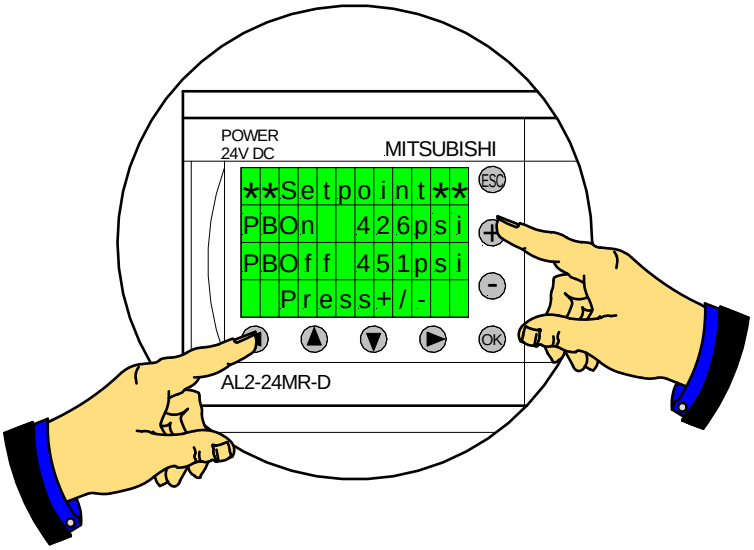
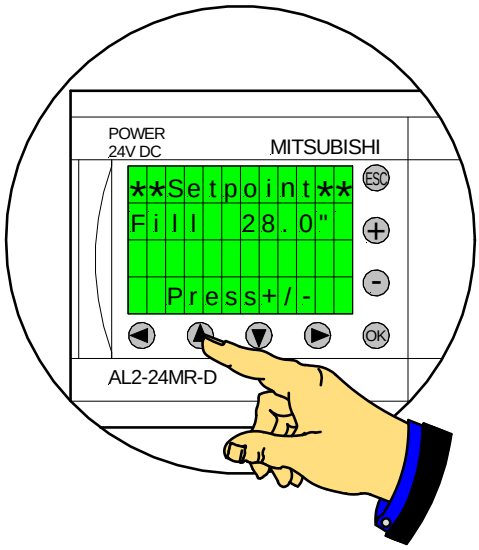


Figure 2 - Setting Pressure Set Points



Fill Set Point

Pressing the "Up" arrow button accesses the Fill set point. The "Fill" set point terminates the filling of the secondary tank when the pressure of the secondary tank is between 80 and 130 psi.

If the pressure is above 130 psi during the fill, the fill is terminated at the "Fill" set point – 1.5". This allows for the liquid growth due to an increased saturation level.

If the pressure is below 80 psi the fill is terminated at the "Fill" set point +1.5". Colder liquid takes up less volume. Adding to the fill set point will assure that the PB time will be consistent.

Pressing and holding the "Up" arrow and pressing the "+" button or the "-" button will adjust the set point.

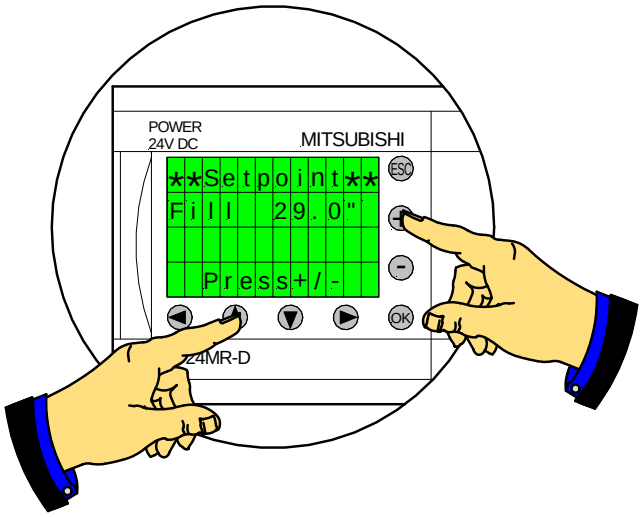
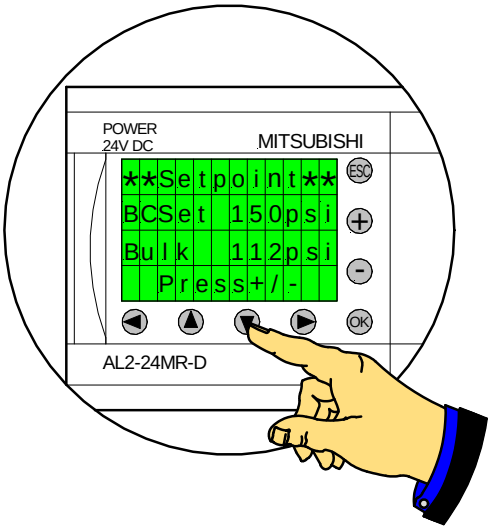


Figure 13 - Setting Fill Set Point



Bulk Critical Set Point

Pressing the "Down" arrow button accesses the Bulk Critical set point. If the storage (bulk) tank is above the "BC" set point during the filling of the secondary tank, the secondary tank will vent to atmosphere to minimize the heat added back to the storage tank.

If the storage tank pressure is below the "BC" set point the secondary tank will fill in the "Low Loss" fill mode.

The "Low Loss" fill mode cycles the vent to atmosphere valve to minimize losses. The current "Bulk" pressure is also displayed on this screen.

Pressing and holding the "Down" arrow and pressing the "+" button or the "-" button will adjust the set point.

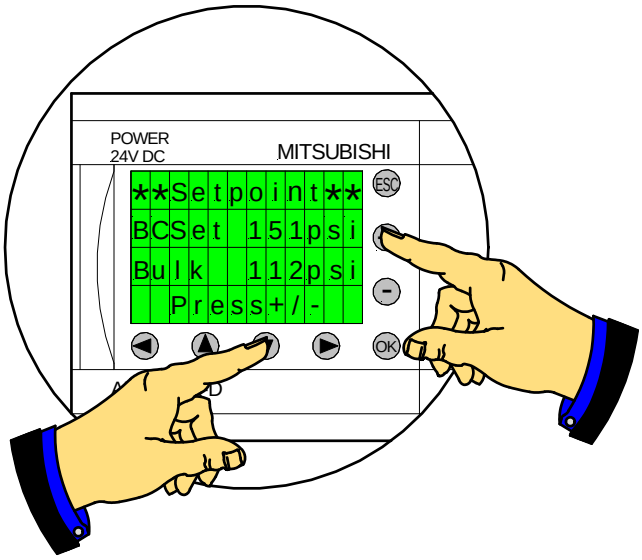


Figure 14 - Setting Bulk Tank Critical Pressure

NOTE: Since the tanks are warm upon initial installation, they may vent for several minutes before they are cold enough to accumulate liquid.

5.1 "Hard Sets"

There are additional settings that cannot be adjusted by the PLC's display. They are stored in the non-volatile memory. They will remain set even after a long power outage. Tables 4.1-4.3 highlight these set points:

6 Operation Details

The Trifecta X-Series logic keys on pressure instead of liquid level. The components have been minimized (reduced) yet the design has duplication of key components.

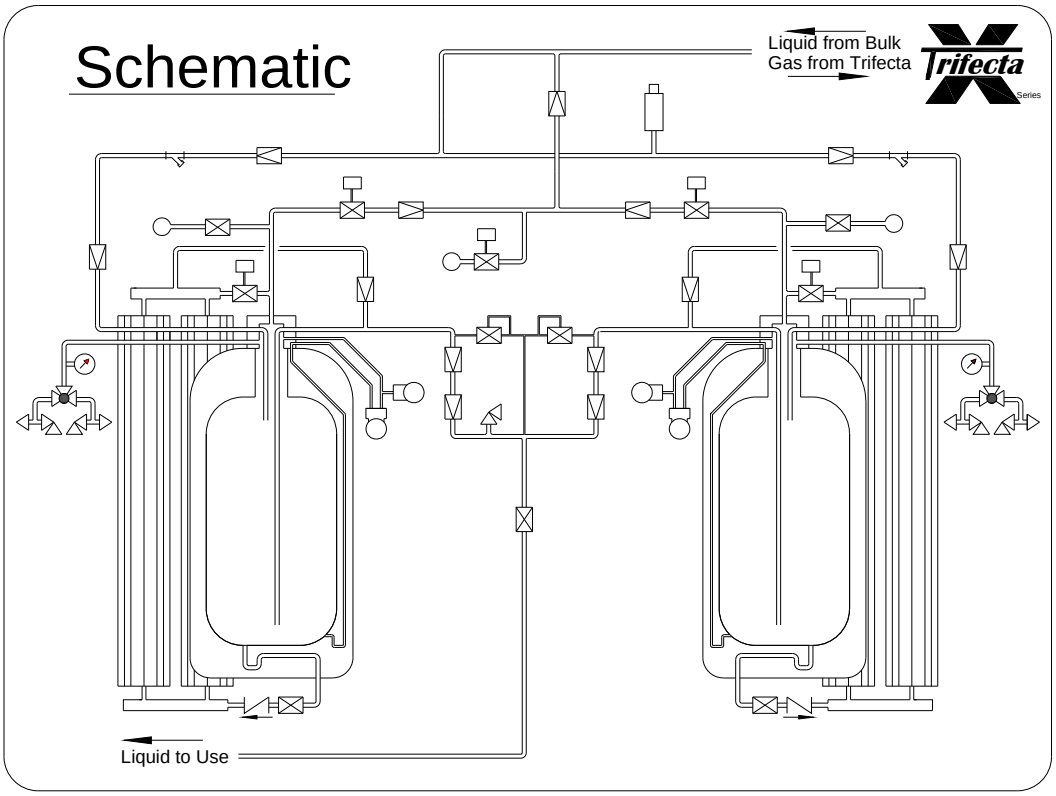


Figure 15 - X-Series Schematic

There are 4 key modes:

- **Run/fill (mode 0)**
- **Initial pressure build (mode 1)**
- **Run/Ready (mode 2) and**
- **Assist (mode 3)**

These modes along with the parameter settings determine the operation of the system.

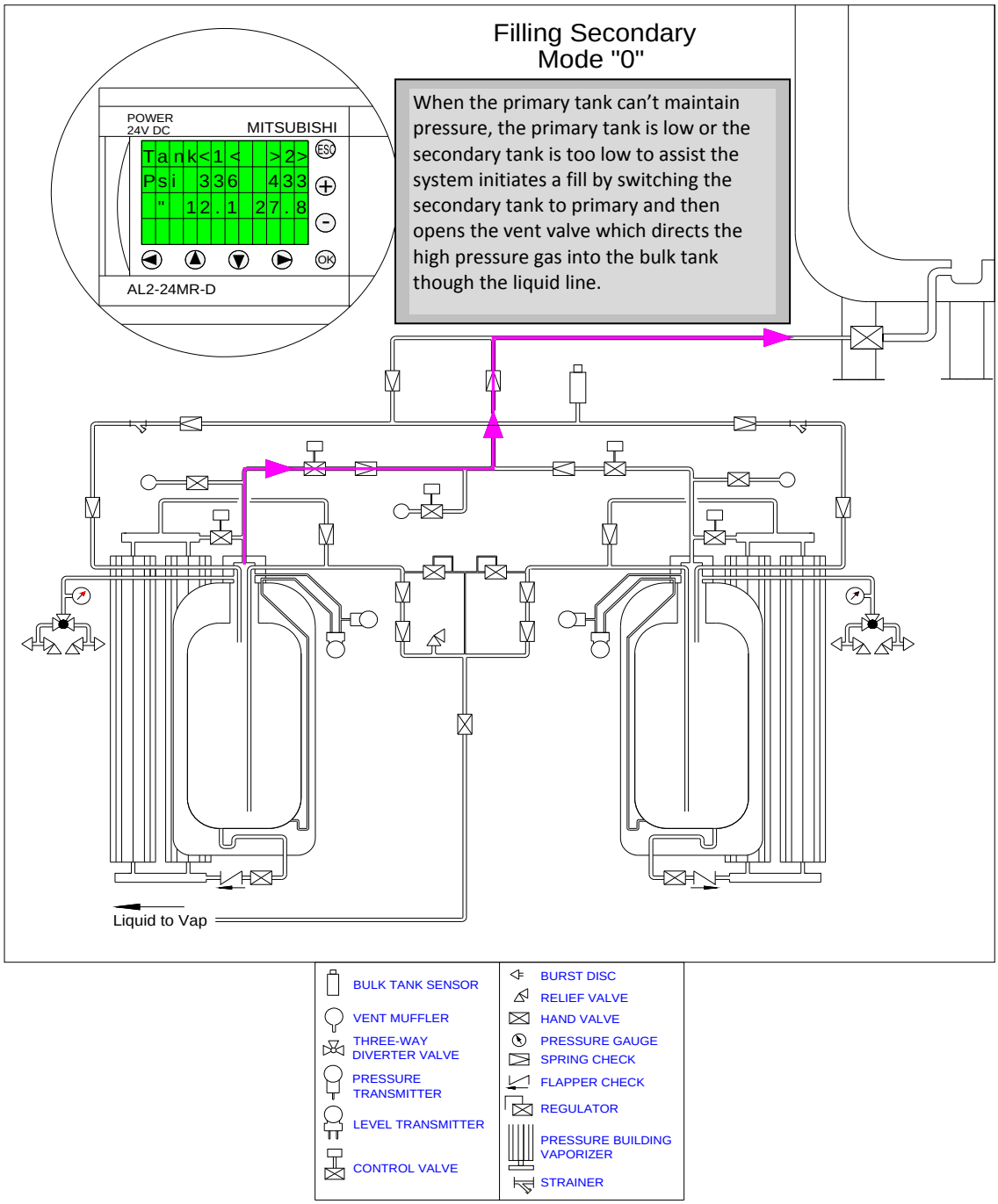


Figure 16 – Filling Mode (Vent to Storage)

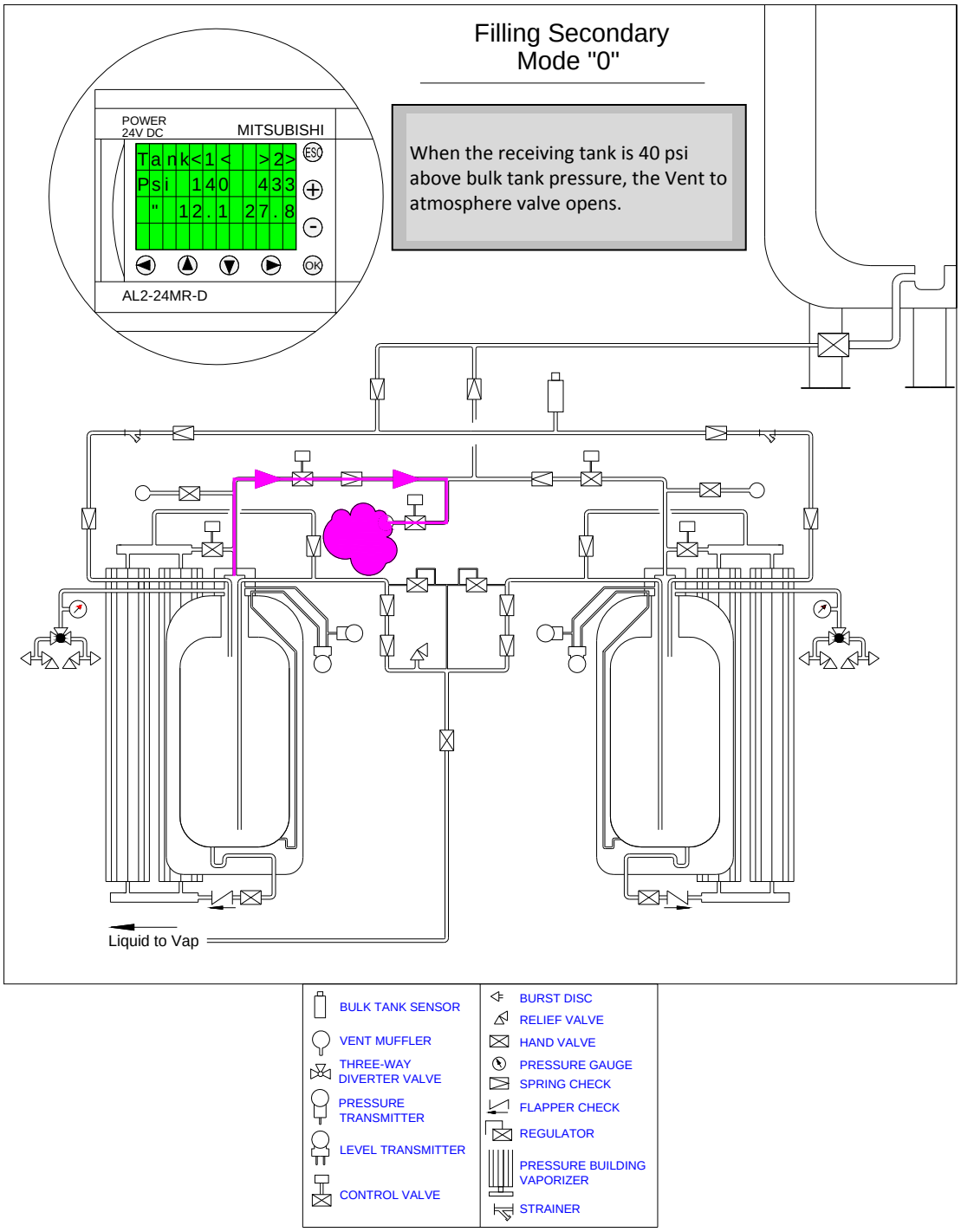


Figure 17 - Filling Mode (Vent to Atmosphere)

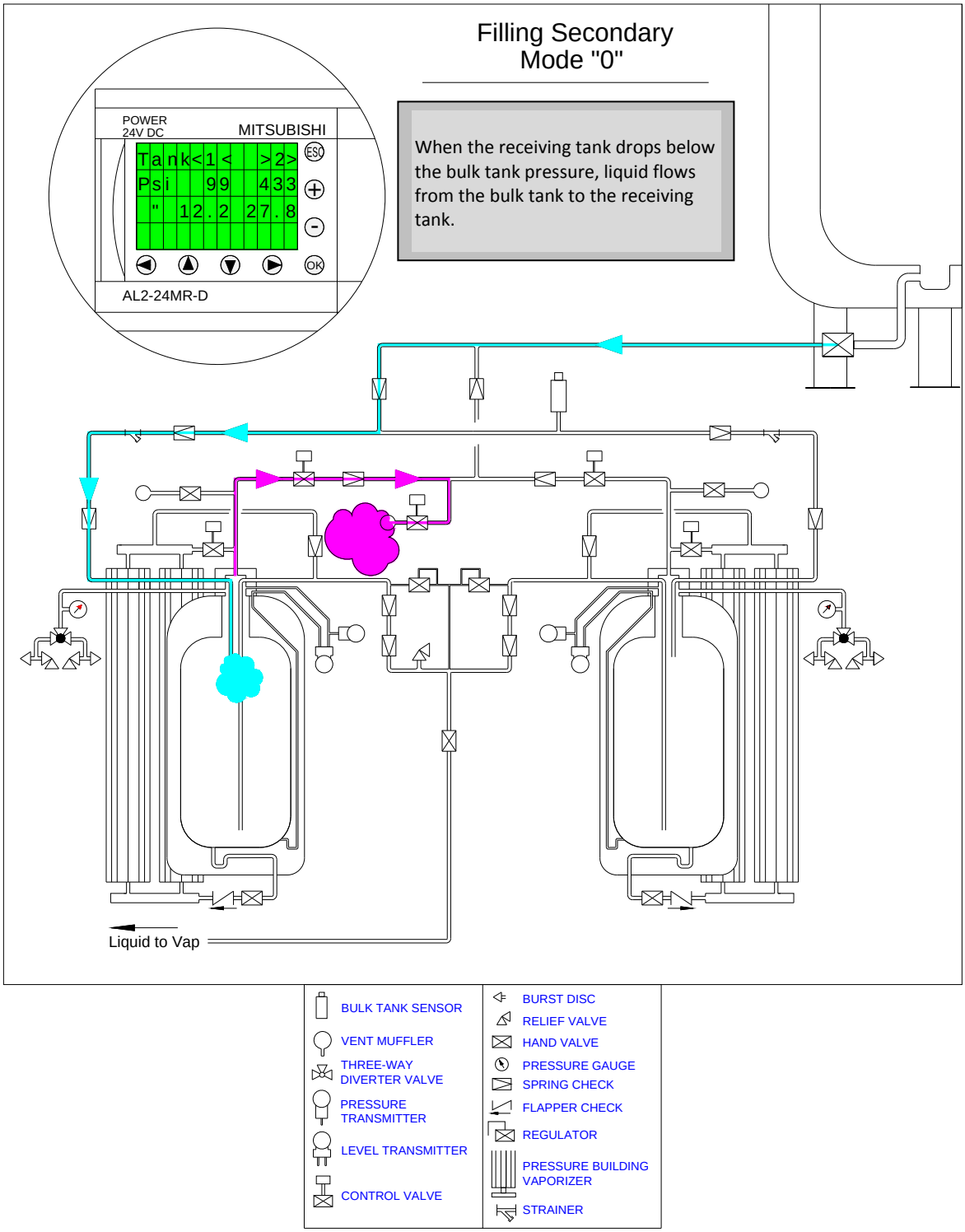


Figure 18 - Filling Mode (Liquid Flow)

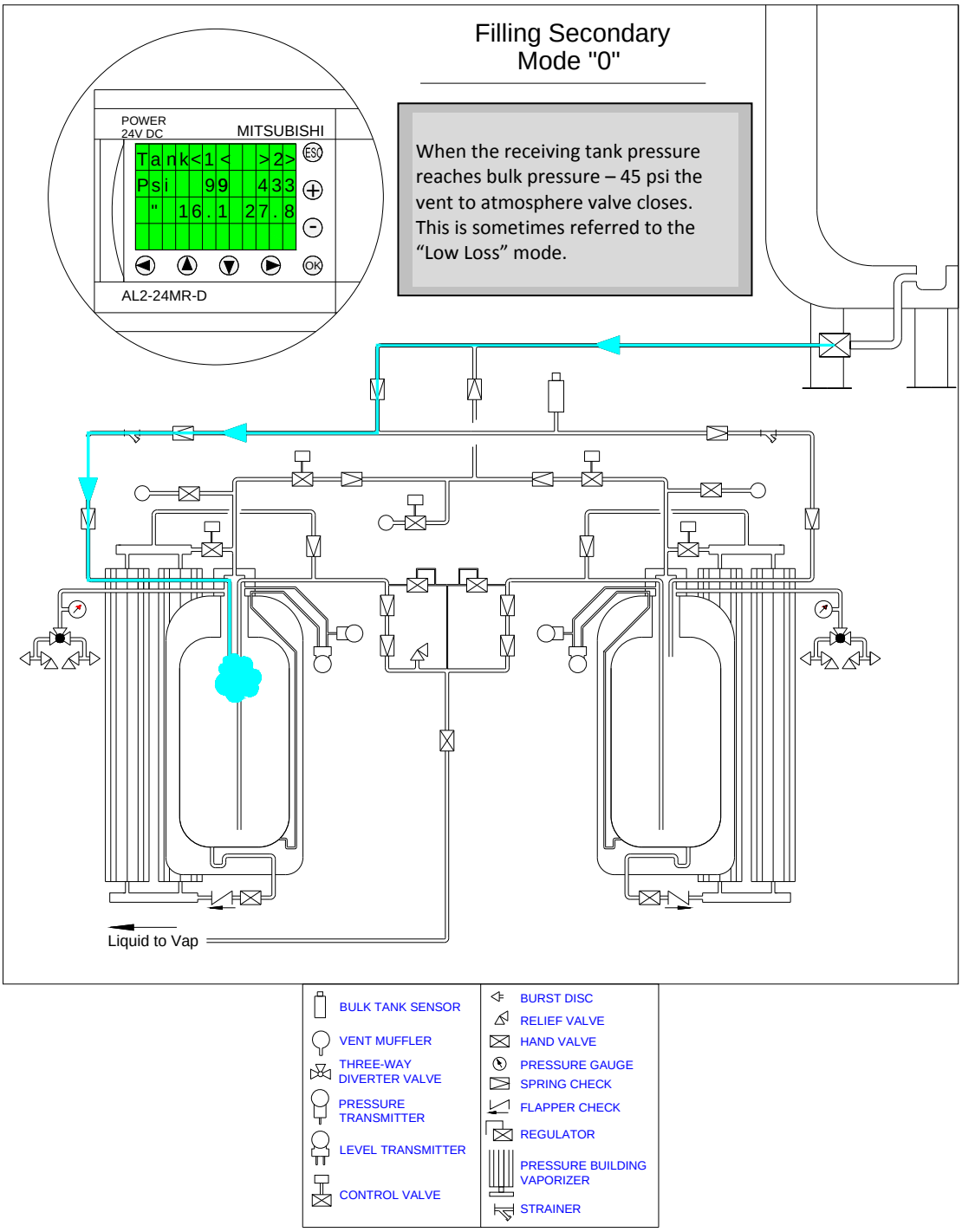


Figure 19 - Filling Mode (Low Loss)

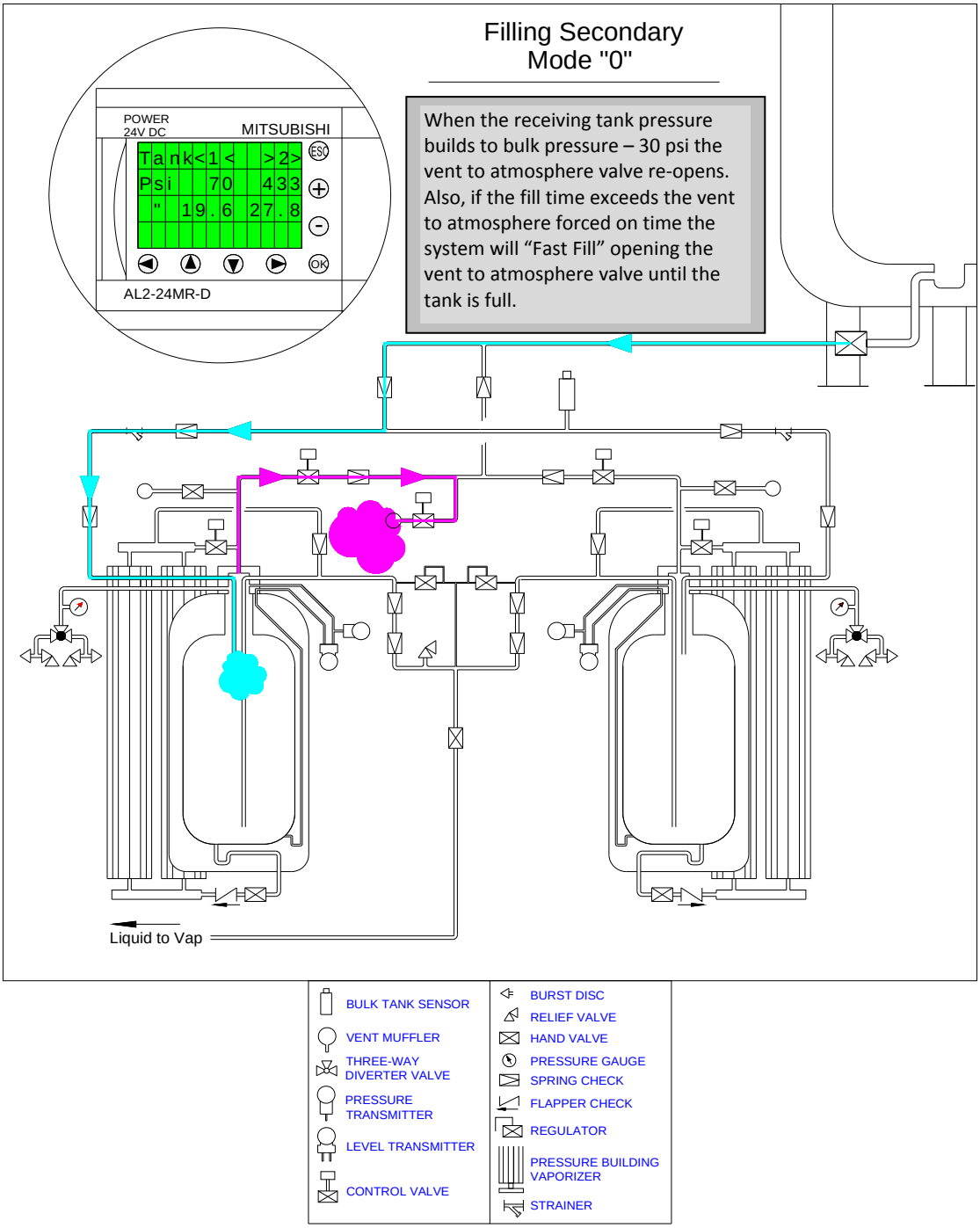


Figure 20 - Filling Mode (Low Loss Vent to Atmosphere)

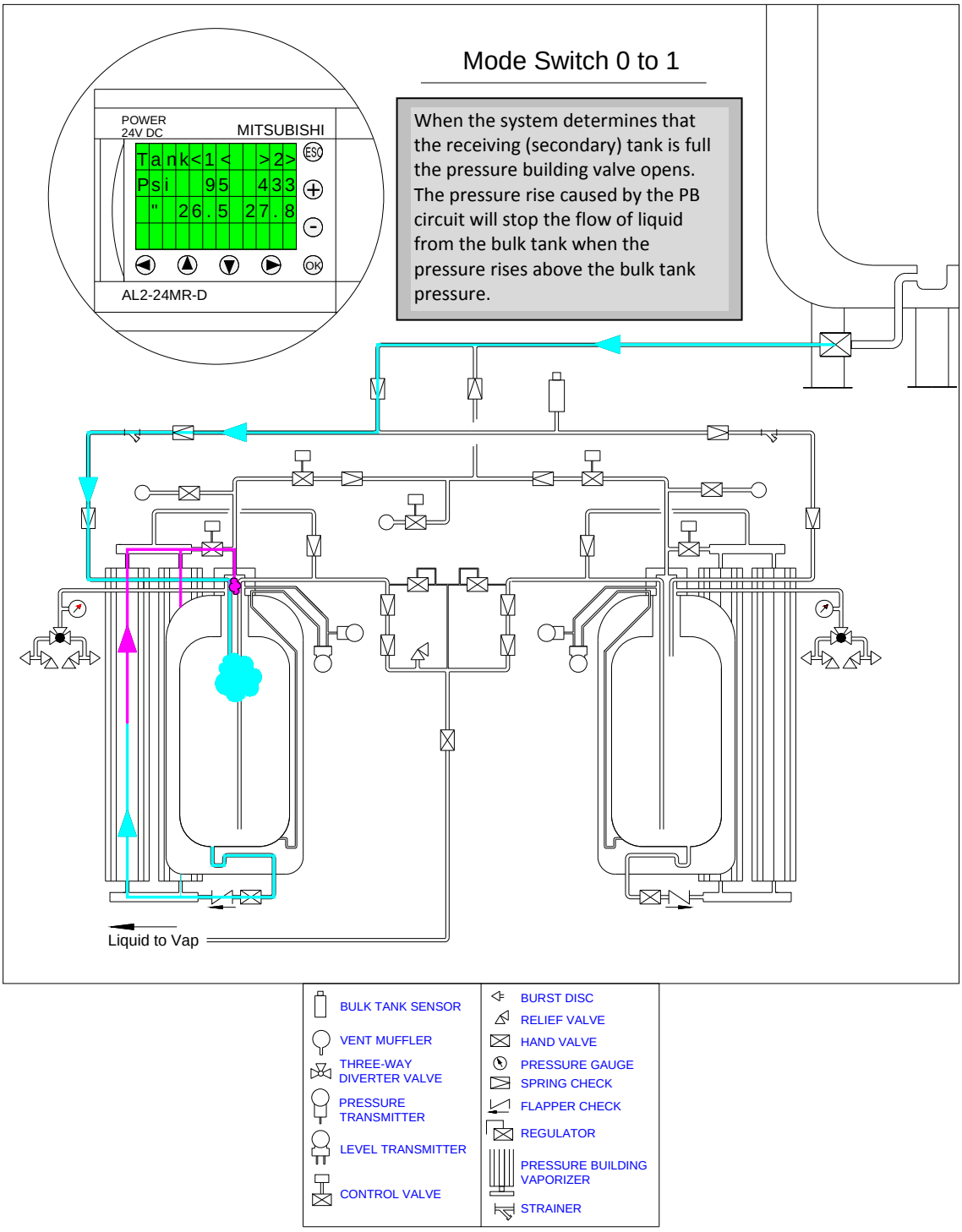


Figure 21 - Fill Mode Termination

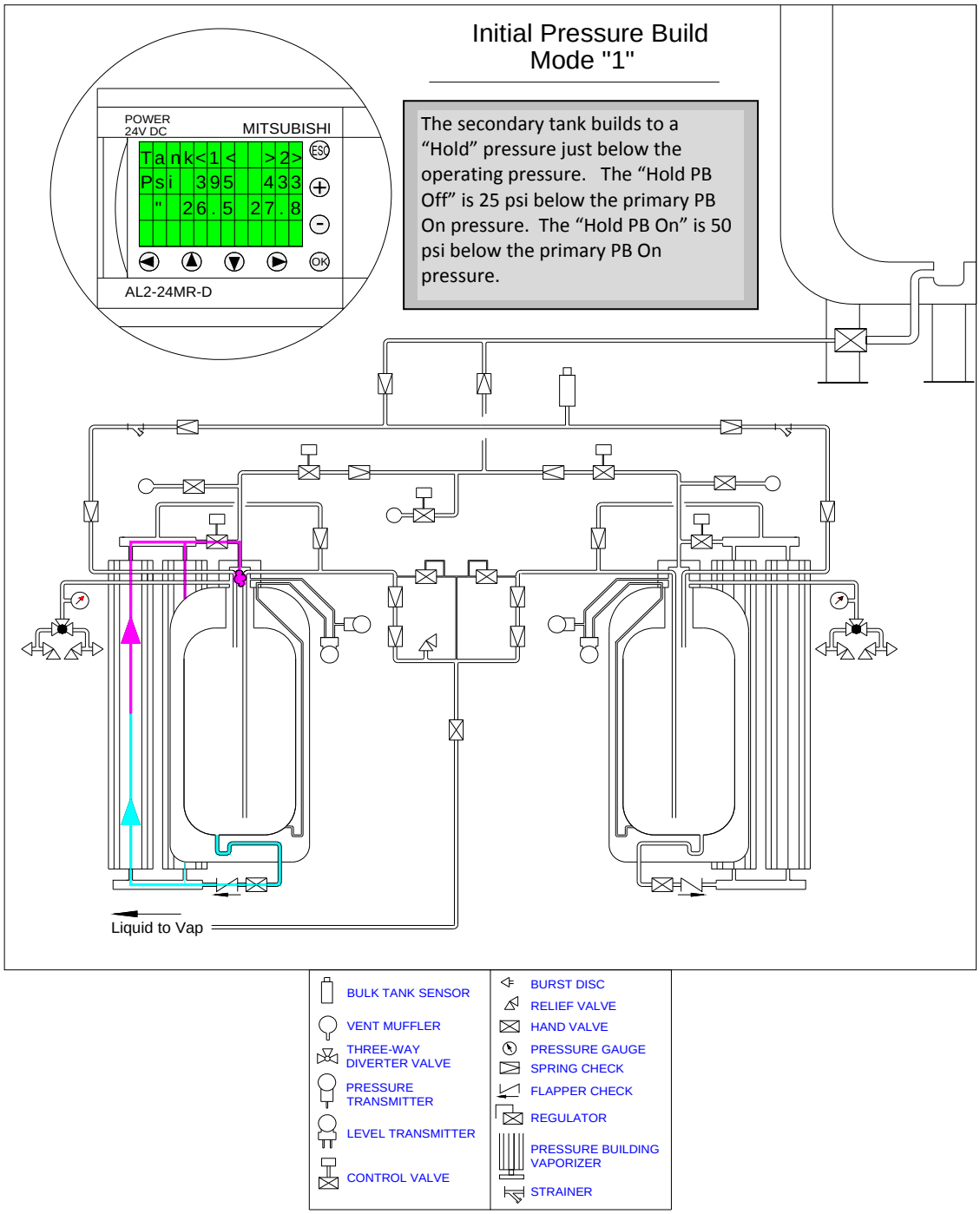


Figure 22 - Initial Pressure Build after Filling

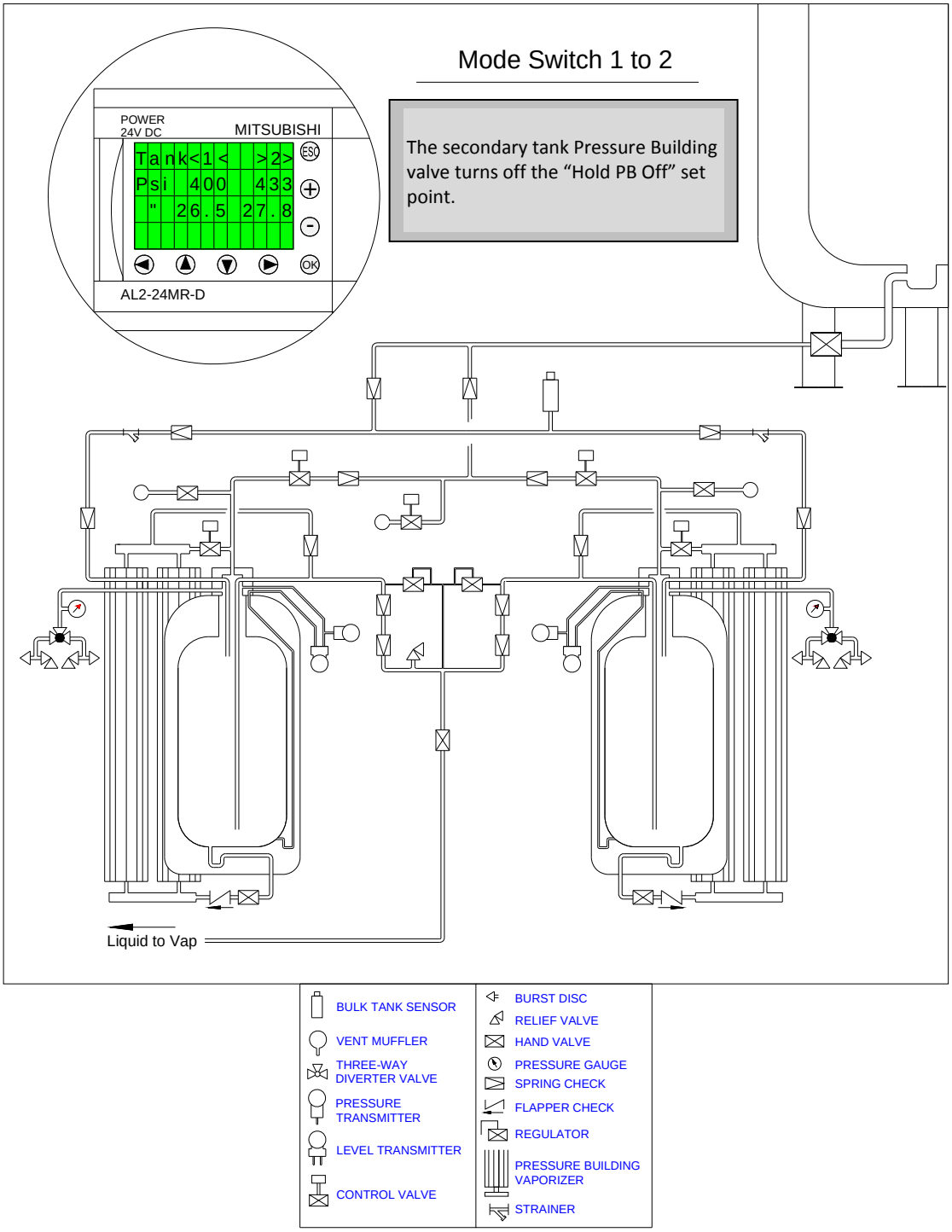


Figure 23 - Secondary Ready to Assist

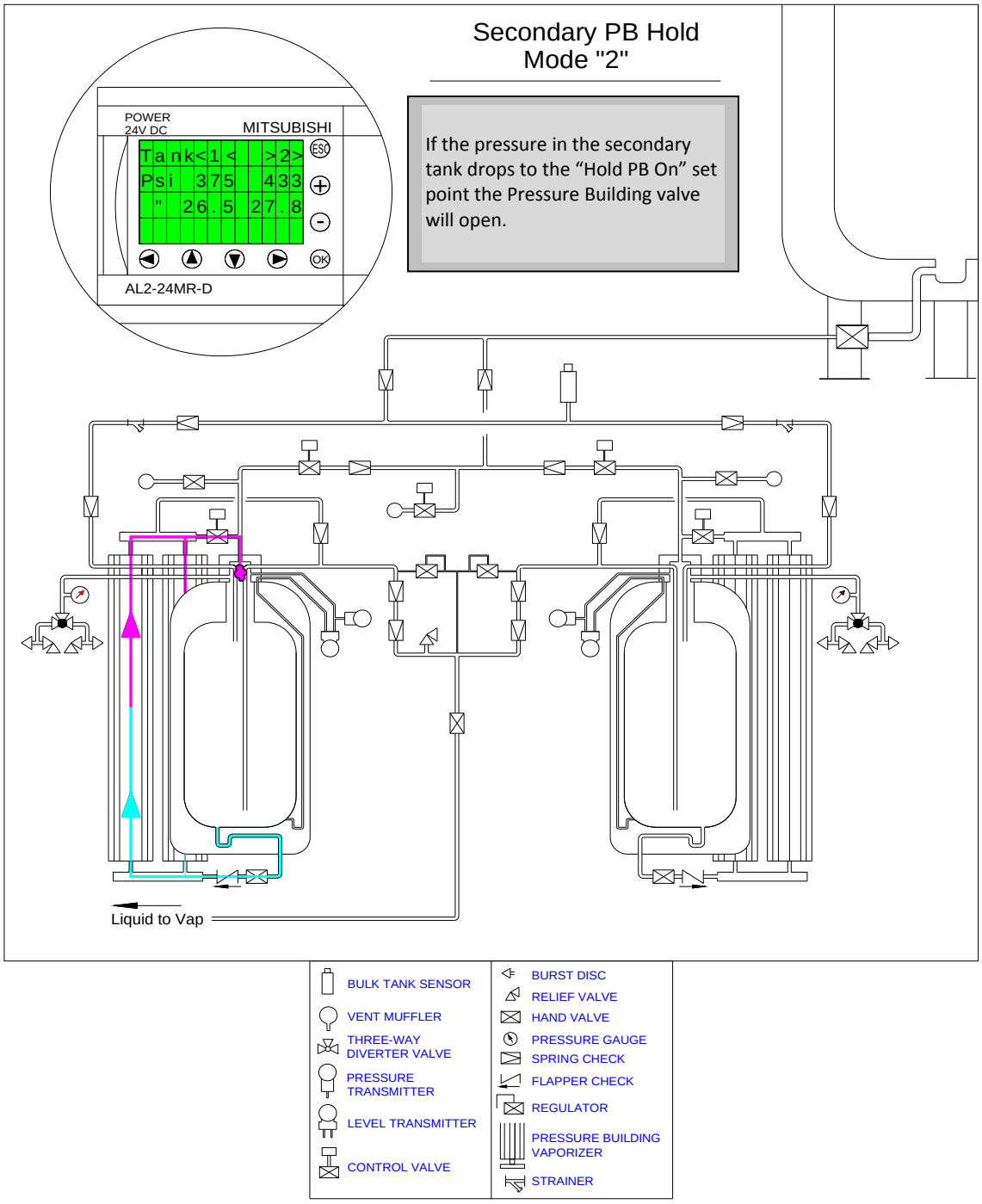


Figure 24 - Secondary Maintains "Hold" Pressure

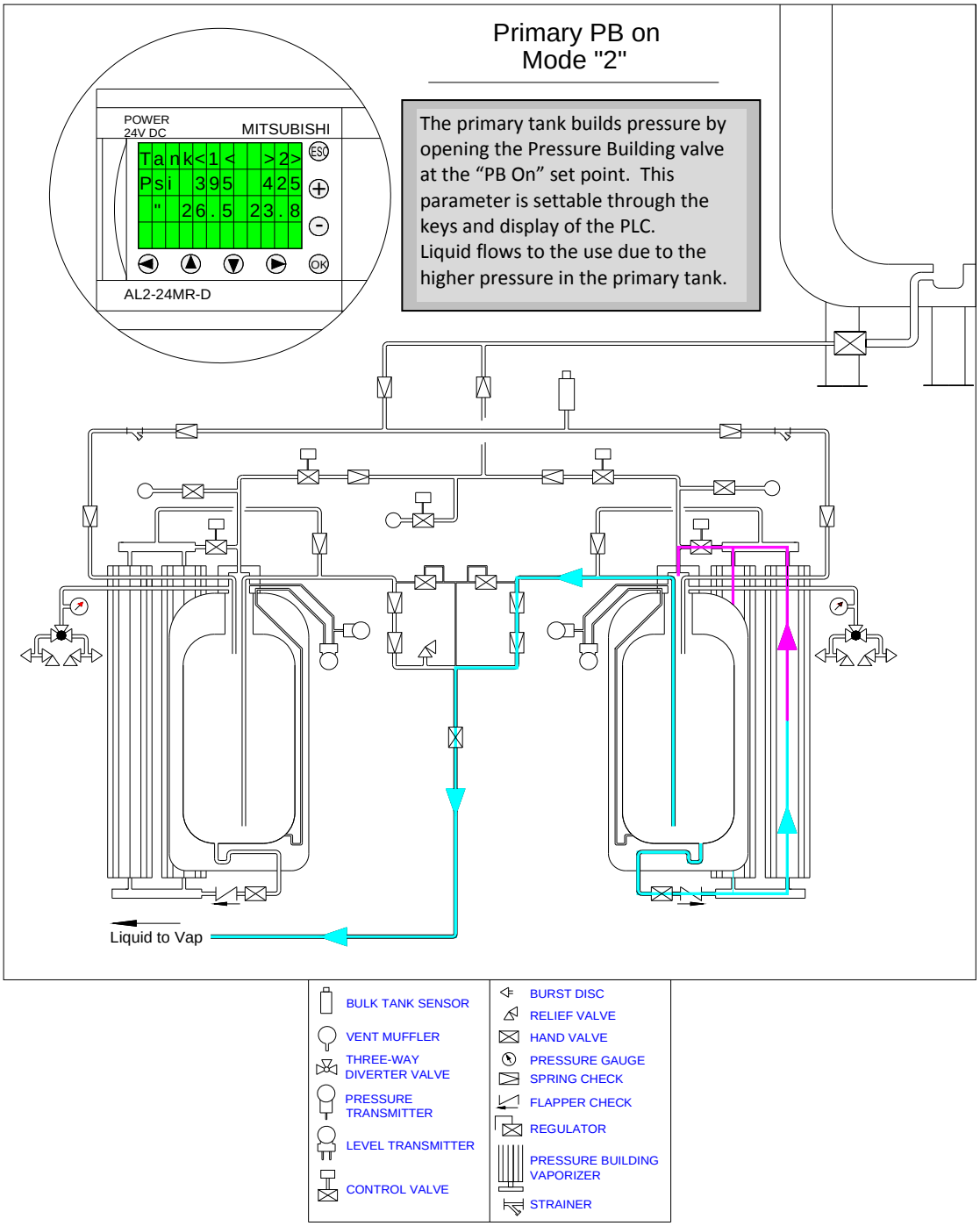


Figure 25 - Primary Pressure Build

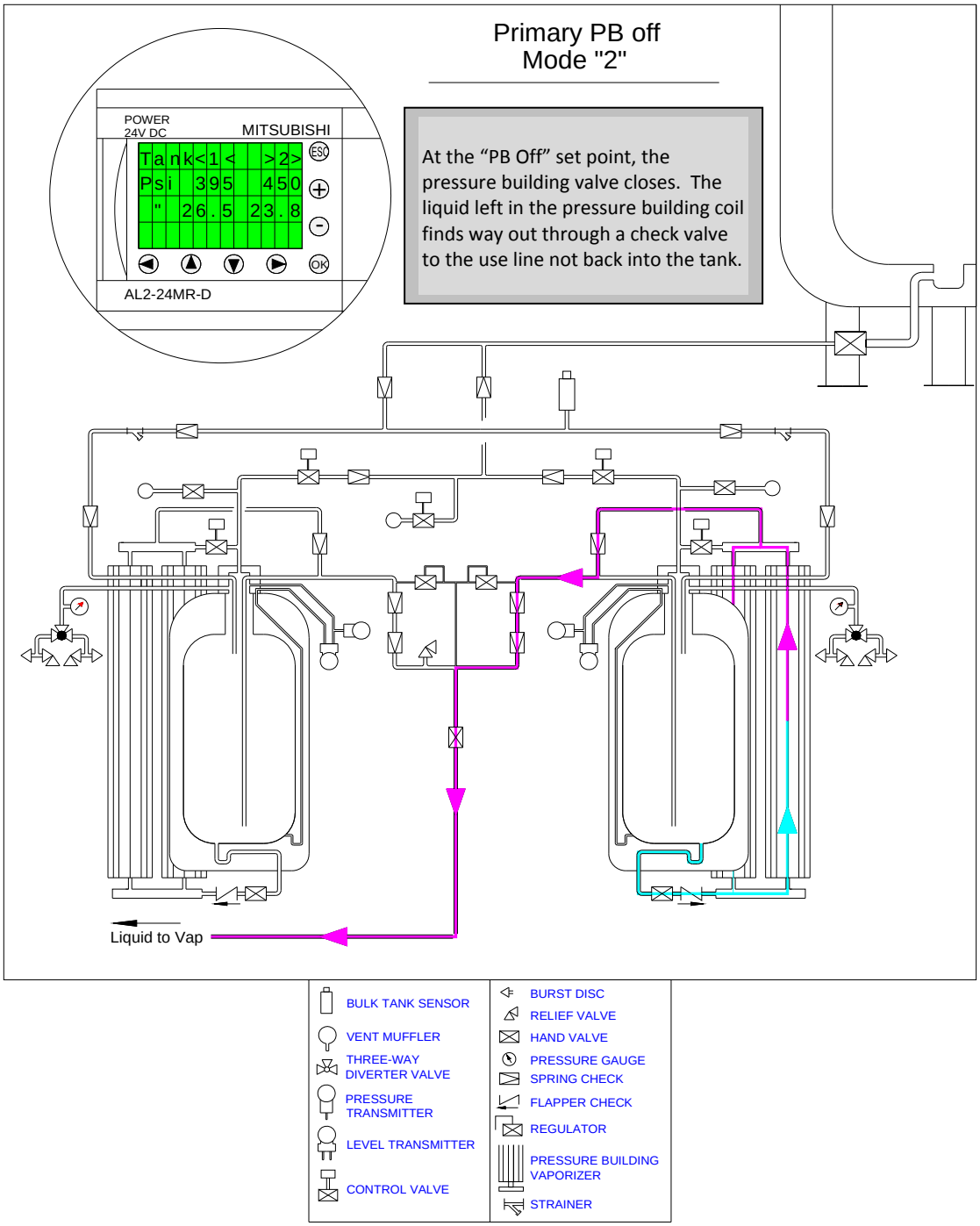


Figure 26 - Primary PB Off

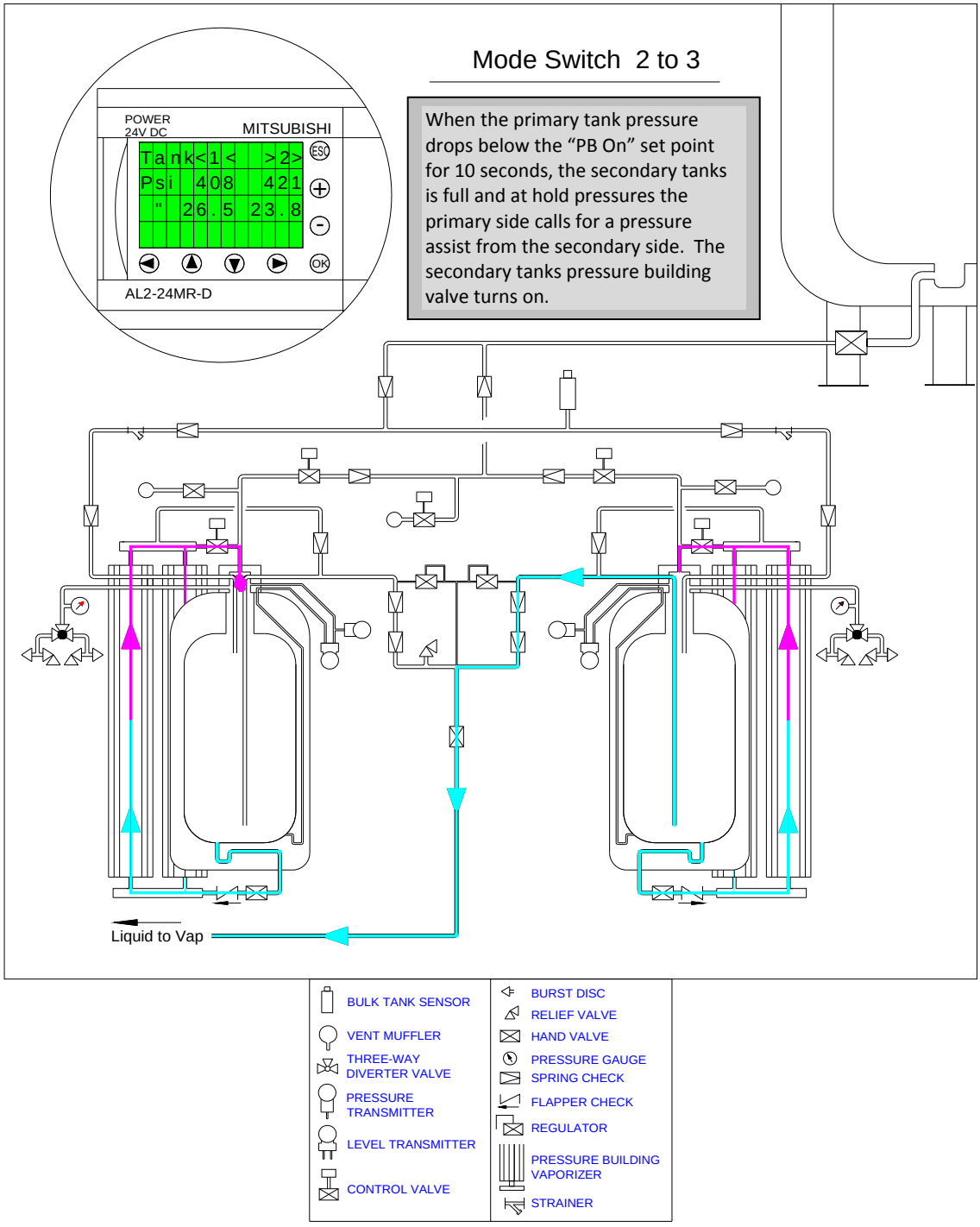


Figure 27 - Call for Assist

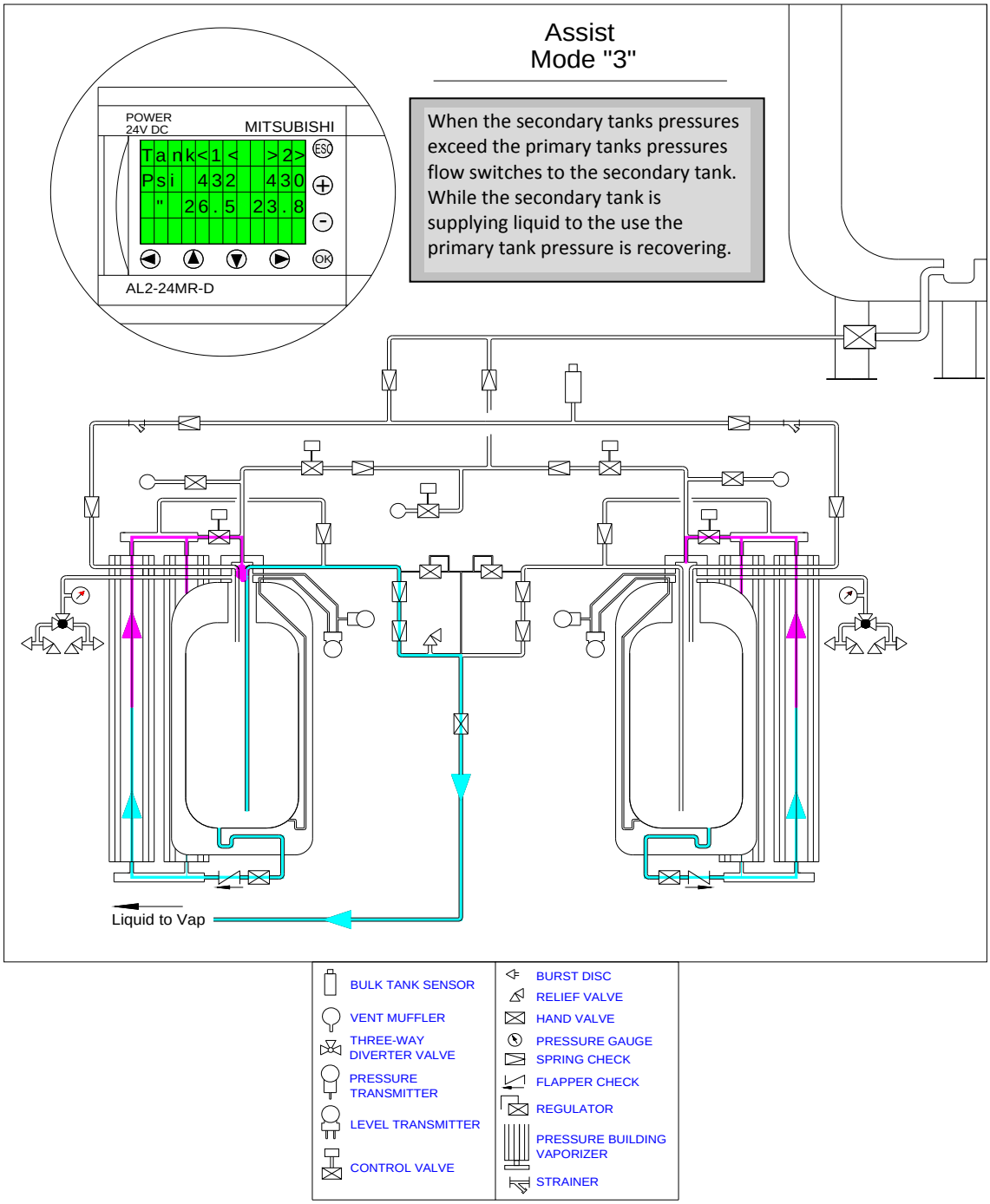


Figure 28 - Secondary Assist of Primary

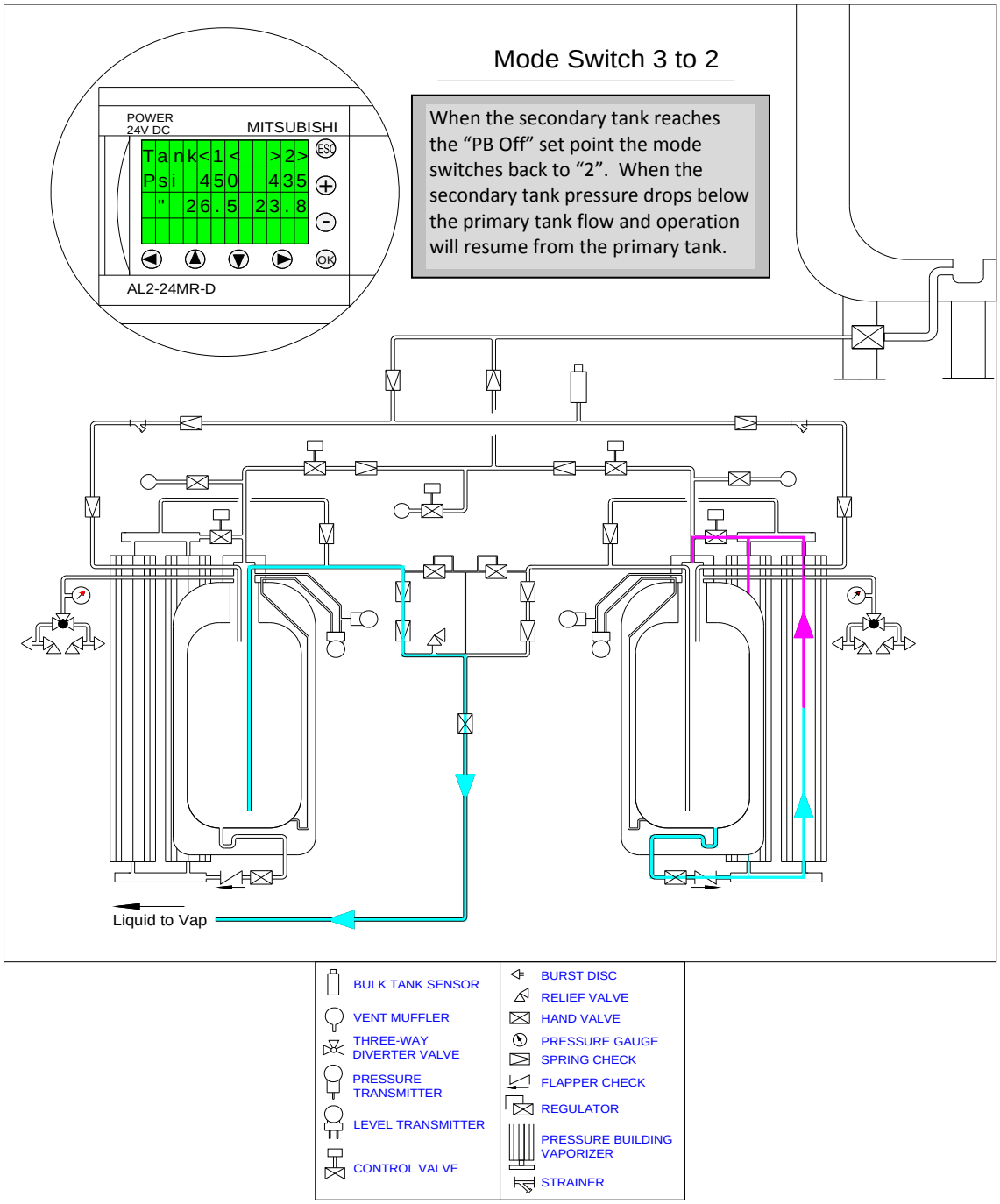


Figure 29 - Assist Complete Primary Recovered

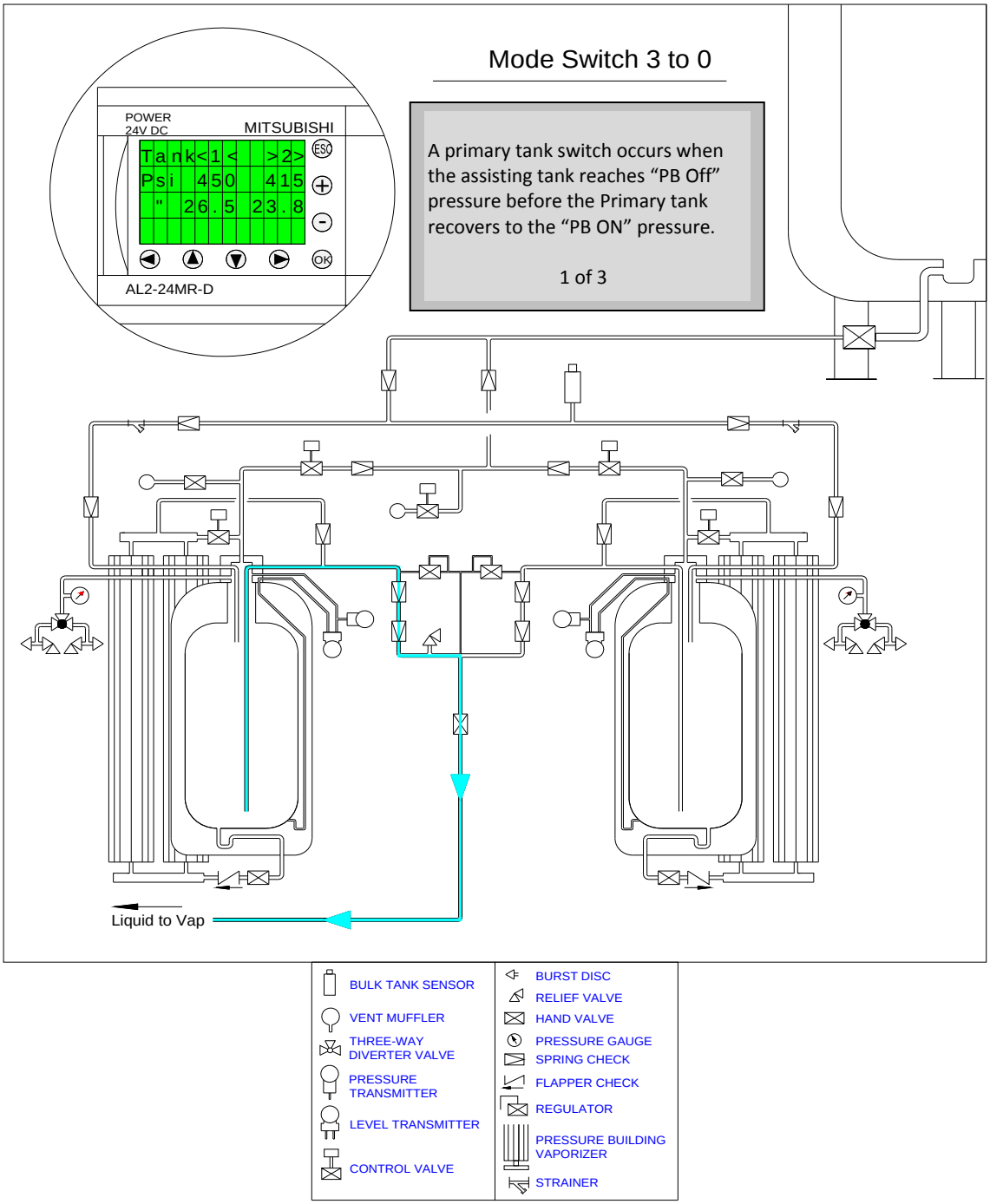


Figure 30 - Primary Unable to Recover (Switch Primary Side)

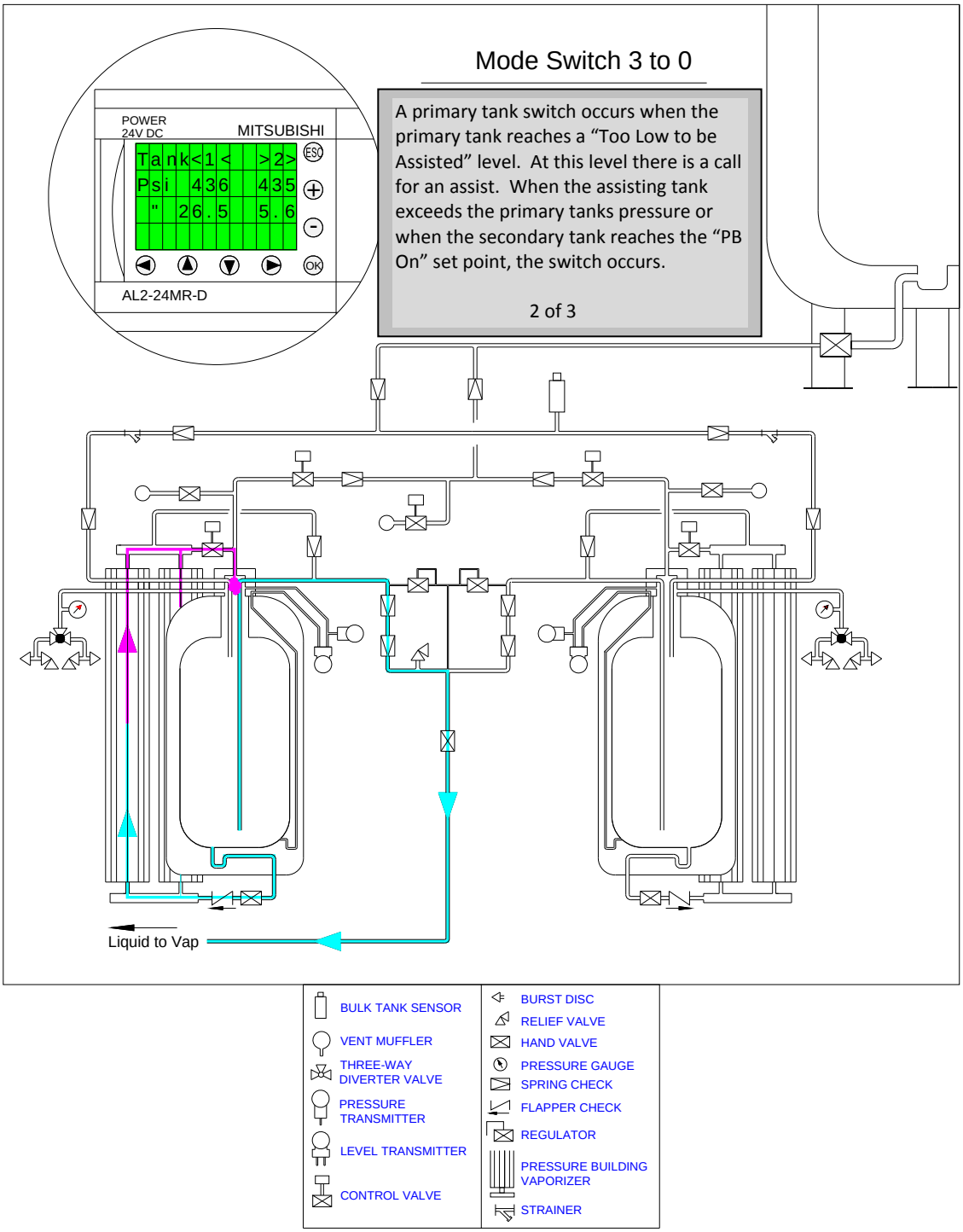


Figure 31 - Primary "Too Low to be Assisted" (Switch Primary Side)

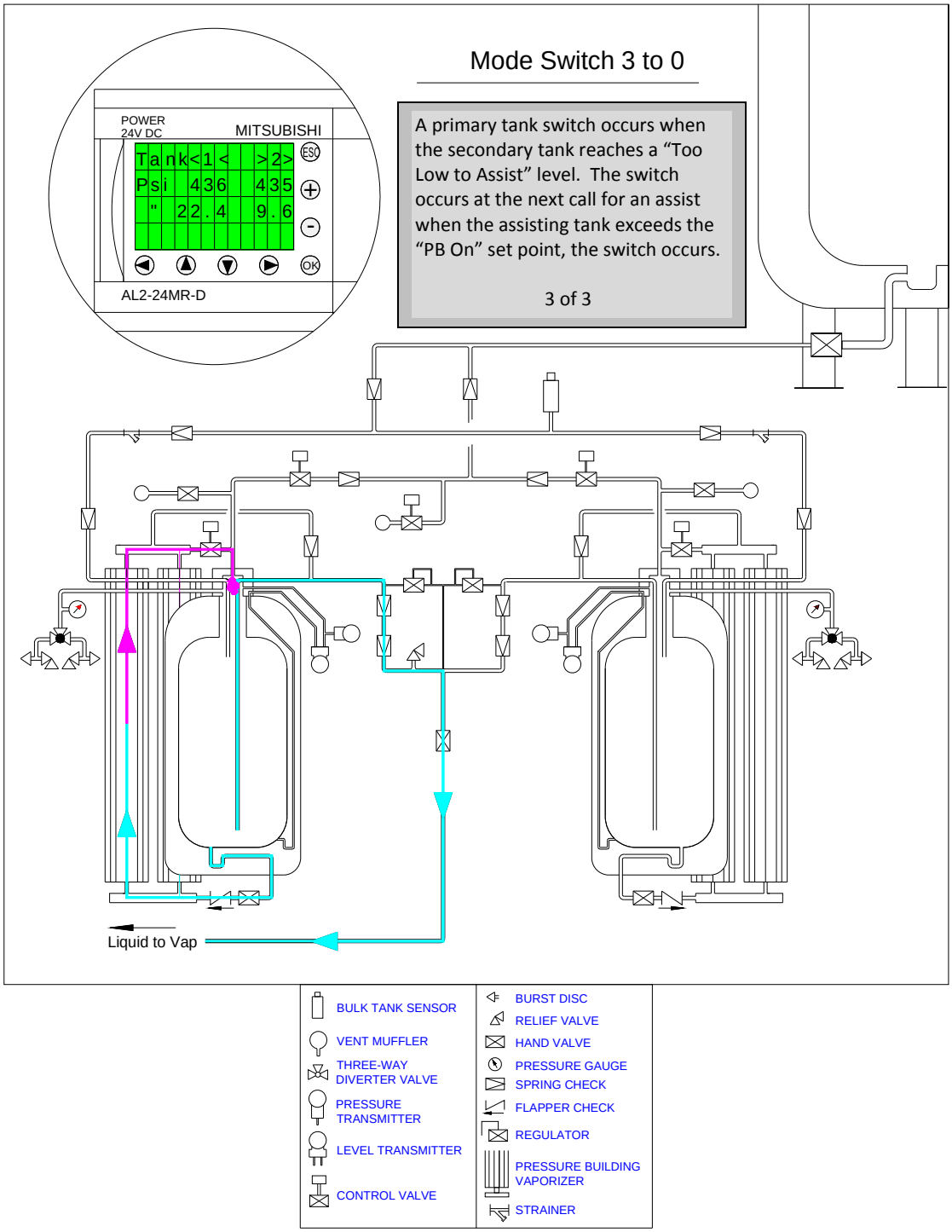
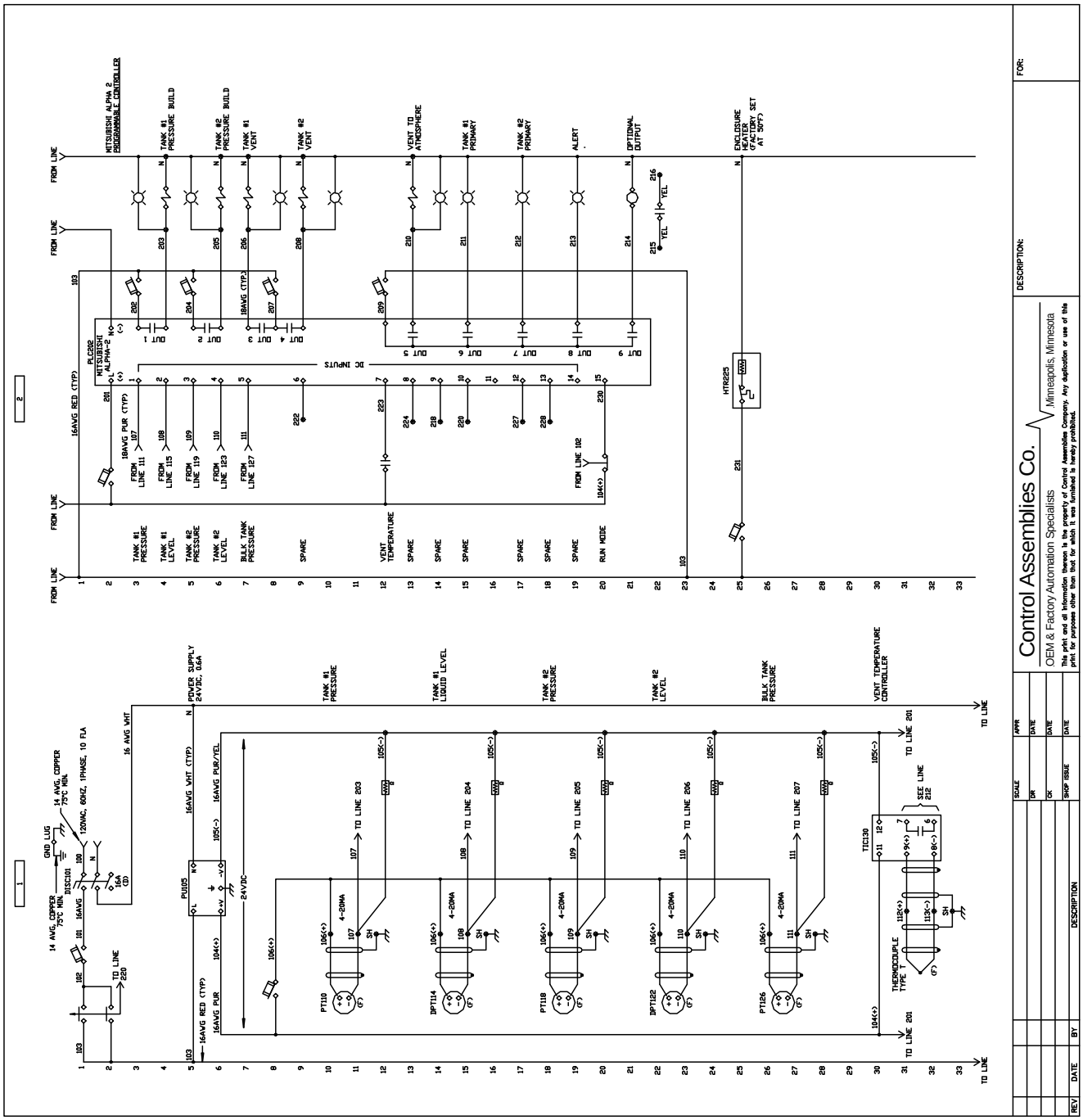


Figure 32 - Secondary tank "Too Low to Assist" (Switch Primary Side)

7 Service

Figure 33 - Electrical Drawing (120 VAC)



7.1 Service Menus

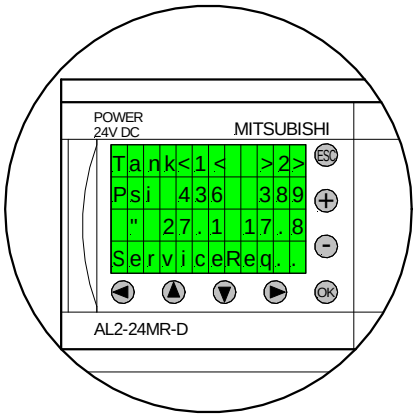
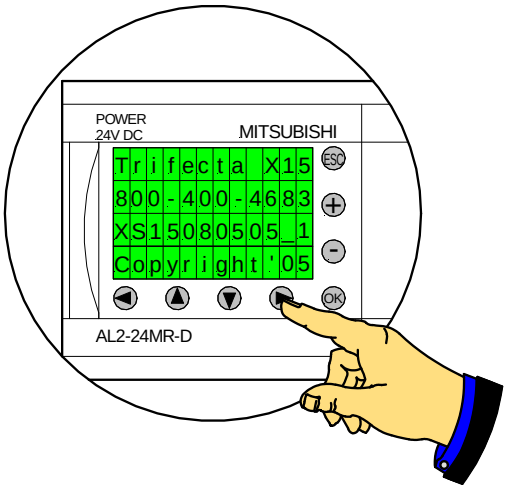


Figure 34 - Service Required



The Trifecta X-Series' PLC has built into the program service information and error codes.

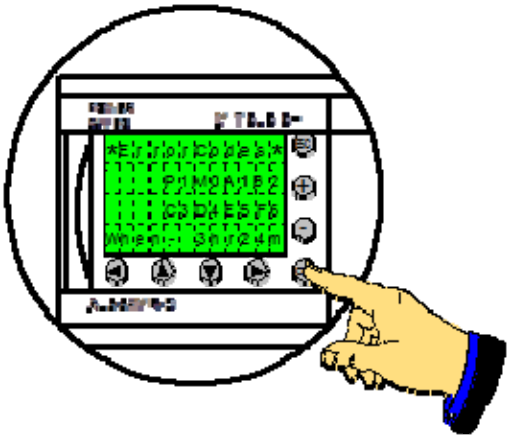
If the PLC determines that there is a service issue "ServiceReq.." will be displayed (see Figure 33).

Press the right arrow on the PLC controller to access the service phone number (1-800-400-4683).

Before calling for assistance note the current program revision (example: XS15080505_5). The revision number will help in troubleshooting.

Figure 35 - Copyright Screen

7.2 Error Codes



The PLC reviews timers, flows, values and counters to assure they are within reason. If the PLC determines that they are not within reason an error code will be displayed.

Access the error codes by pressing and holding the “OK” button. Along with the error codes the current primary tank (example P1 – side 1 is primary) is indicated.

Also, the current mode is displayed (example M0 – Secondary filling).

The following is the summary of the error codes:

Code	Description	Action
P1	Primary Side 1	None
P2	Primary Side 2	None
M0	Filling Secondary	None
M1	Secondary PB after Fill	None
M2	Secondary Ready	None
M3	Secondary Assist of Primary	None
A0	OK!	None
A1	Fill time exceeds flow rating.	Improve fill times by: Increasing sub-cool, reduce bulk critical pressure, reduce restrictions on liquid line.
B0	OK!	None
B2	The primary tank called for an assist before the secondary tanks was ready to assist.	Check fill levels. Check for leaks in the PB circuits. Check PB valve operation.
C0	OK!	None

Code	Description	Action
C3	The Temperature Switch has detected liquid at the Vent Muffler.	Reduce fill levels. Check DP Transmitter. Check thermocouple connection. Check Temperature Switch function.
D0	OK!	None
D4	Overpressure has occurred. Tank or Tanks have vent back to storage.	Check fill levels. Check PB valve function. Check DP transmitter accuracy.
E0	OK!	None
E5	System has exceeded the flow rating.	Check for house line leaks. Check for system leaks. Need additional or next size Trifecta X-Series.
F0	OK!	None
F6	One of the systems transmitters has gone out of range.	Check electrical connects. Replace faulty transmitter.

Figure 36 - Error Codes

The Alert light will flash when the system has seen a low pressure event. A low pressure event is when both primary and secondary tanks are below the PB On set point for 90 seconds. During the alert status the system will continue to attempt to recover. In the service menu activated by pressing the "OK" button a timer is displayed showing the running time from the alert event (example: 3 hours and 24 minutes since the low pressure event that activated the alert light). At the moment of the alert the error codes are frozen to assist in trouble shooting (alert codes during a non-alert events are reset at every fill). Reset the frozen codes by pressing the "OK" button and the "-" button simultaneously.

7.3 Cycle Counter

Pressing the "ESC" button activates the Cycle Count display. This counter tracks the number of times the system has switch primary tanks since being reset. When the counter reaches 20,000 cycles, the Alert light will flash and "ServiceReq.." will be displayed. The counter is used to proactively service the systems valves. To reset the counter: press "ESC", "+" and "-" buttons simultaneously.

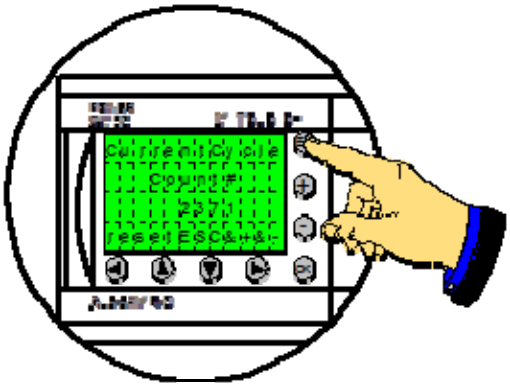


Figure 37 - Cycle Counter

If the system is shut off, upon turning the power back on, the controller will go through the initialization routine and begin controlling. The current program is not affected when the controller is turned off.

The system does not have to be turned off in periods of no use (over-night, weekend's etc.). Turning the system off will de-energize the solenoids and will cause the main relief valves to control the pressure in the Trifecta X-Series' cylinders.

Button Press Summary

◄	Press 5 times to "Reset Values" factory settings
◄	Set Point PB On and PB Off
▲	Set Point Fill Level in Inches
▼	Set Point Bulk Critical and Display Bulk psi
►	Trifecta Version/800#/Copyright
OK	Error Codes
ESC	Service Screen/Cycle count
◄&⊕	Increase PB set points
◄&⊖	Decrease PB set points
▲&⊕	Increase fill set point
▲&⊖	Decrease fill set point
▼&⊕	Increase bulk critical set point
▼&⊖	Decrease bulk critical set point
OK&⊕&⊖	Manual Primary Switch
◄&▲&▼	Reset parameter counter (shipment)
ESC&◄	Manual PB#1 valve on(manual only)
ESC&▲	Manual Vent#1&VentAtm valve on(manual only)
ESC&▼	Manual Vent#2&VentAtm valve on(manual only)
ESC&►	Manual PB#2 valve on(manual only)
ESC&⊕&⊖	Reset Cycle Count
OK&⊖	Reset Alerts

Figure 38 - Button Press Detail

7.4 Manually Operating the Valves

With the system in the “Monitor” mode valves and valve sets can be operated by pressing the “ESC” button and the arrow buttons.

See the Button Press Summary above for details.

The solenoids have a manual over-ride hand wheel.

- Turning the red wheel in (clockwise) over-rides the solenoid locking the valve open.
- Turning the red wheel out (counter-clockwise) allows the solenoid to open and close the valve electrically.

7.5 Fuses

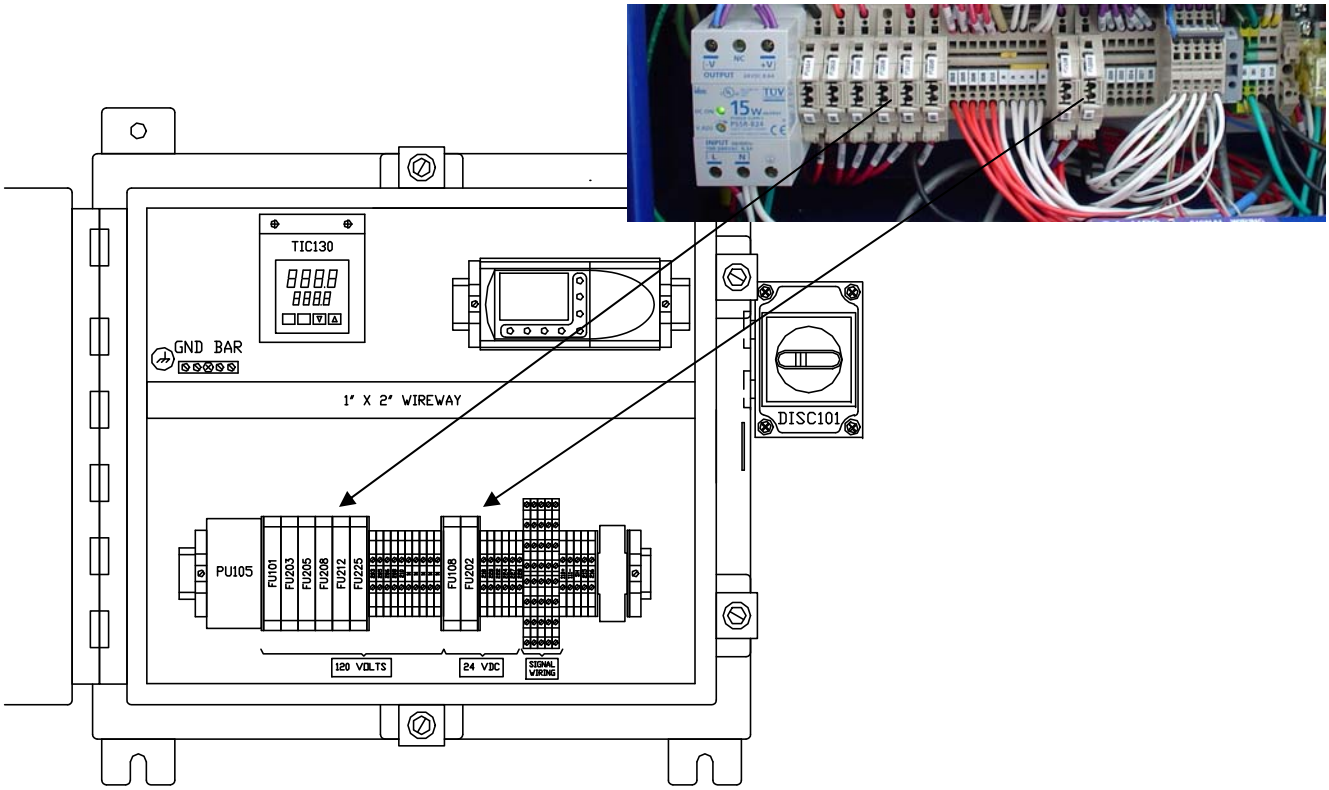


Figure 8 - Fuse Detail

Fuse #	Voltage	Fuse Type (Amps)	Device(s) Protected	Chart Part Number
FU101	110AC	MDA-10 (10)	Main (Panel)	11832443
FU203	110AC	MDL–2 (2)	PB Valve/Light Side 1	11832398
FU205	110AC	MDL–2 (2)	PB Valve/Light Side 2	11832398
FU208	110AC	MDL–2 (2)	Vent Valves/Lights Side 1&2	11832398
FU212	110AC	MDL–4 (4)	Vent Atm. Valve/Light @ Muffler	12942935
FU225	110AC	MDL-2 (2)	Box Heater	11832378
FU108	24VDC	AGC – 2/10 (2)	Transmitter Power	12942978
FU202	24VDC	MDL – 1 (1)	PLC Power	12942943

Figure 39 – Fuse Detail

Use Figure 38 and 39 to identify faulty fuses.

- Power down the panel before changing fuses.

- Before replacing a fuse and powering back up it is best to have an understanding why the fuse failed. .

8 Preventative Maintenance

8.1 Preventative Maintenance Procedure

Over time, components of the Trifecta X-Series (as in any mechanical system) can degrade and/or fail if not properly maintained. For this reason, a regular maintenance procedure is recommended to prevent any unexpected downtime.

The most common field failures are due to:

- Clogged fill line strainer or strainer having been completely removed by service technician permitting entry of debris to system
- Malfunctioning Solenoids and Check Valves (leaks) caused by
    - Buildup of impurities of liquid fed to the system from the bulk tank
    - Introduction of moisture to the bulk system without proper purge process
    - Normal wear and tear of solenoids' pistons and seats due to cycling
    - Debris entering Trifecta X-Series from Bulk station due to removed strainer
- Leaking Fittings
    - All connections are leak checked from the factory and should be re-checked periodically
    - All replaced fittings in the field must be checked to ensure proper operation
- Malfunctioning Cylinder Relief's
    - Relief Valve opening at lower pressure than set point
    - Burst Disc rupture (fatigue failure)

With a regular maintenance procedure, these possible failures and corresponding down times can be prevented. To ensure uninterrupted operation, it is recommended that the following maintenance procedures be followed.

Every six months:

- Replace strainer on liquid feed line
- NOTE: DO NOT OPERATE SYSTEM WITHOUT A FILL LINE STRAINER IN PLACE

Every Year:

- Verify two normal operation cycles per section 7.2
- Inspect integrity of all wire connections in control box. Tighten all loose connectors.
- Verify accuracy of analog gauges against pressure transmitters per section 7.5
- Leak check entire Trifecta X-Series System per section 7.4

Every Three Years or at cycle count limit:

- Replace all check valves
- Replace pistons on all solenoid valves and rebuild cryogenic ball valves
- Replace relief valves and burst discs on tanks 1 and 2

NOTE: Reset cycle counter after servicing the valves.

8.2 Recommended Spare Parts

In the event that repair is necessary, Chart Inc. provides the following spare parts at www.Chart Parts.com.

Common Repair Parts for X-Series Trifectas	
Item Description	**Chart Part Number**
Pressure Transducer (Replace 11941252 with 14877751)	14877751
525 PSI Economizer Regulator	13774101
Vent Solenoid Valve 120v ½" Magnatrol	10925509
Vent Solenoid Valve 230v ½" Magnatrol	11828891
Gasket for 10925509 and 11828891	10963100
Piston Assembly for 10925509 and 11828891	10963062
Coil for 11828891	20726104
Coil for 10925509	10963071
Inlet Strainer	13660471
Replacement Element for 13660471	13729343
Fuse MDL-1 (1 Amp) PLC Power	4614489
Fuse MDL-2 (2 Amp) PB Valve/Light Side	11832398
Fuse MDL-4 (4 Amp) Vent ATM. Valve/Light at Muffler	12942935
Replacement LED Light Bulb	12942919
Thermocouple Type T Probe	14271813
Temperature Controller	12942901
Mitsubishi PLC (Non-Programmed)	11877019
Cylinder Relief Valve	11385111
Cylinder Rupture Disc	11055525
Differential Transmitter (Liquid Level) Honeywell	20638638
Pressure Transmitter (Tank Pressure) Honeywell	20638651
Generant Brass Check Valve (1 PSI crack)	13620233
Generant Brass Check Valve (5 PSI crack)	11051090
Pressure Gauge 0-600 psi	14932546
MON/OFF/RUN switch	20686433
Relief Valve (for piping) 575 psi	13849812
Temperature Controller Red Lion	12942901

PB Repair Kit X5 and X10 Only	Chart Part Number
PB Solenoid Valve (120V 3/4" solenoid) Magnatrol	11033191
PB Solenoid Valve (230 V 3/4" solenoid) Magnatrol	11828911
Solenoid Coil (120 VAC 3/4" solenoid) Magnatrol	11034011
Solenoid Coil (230 VAC 3/4" solenoid) Magnatrol)	20726104
Piston Assembly for 11034011 and 20726104	11034020
Gasket for 11034011 and 20726104	10963100
PB Inlet Valve	10616790

PB Repair Kit X15 Only Units w/ ½ Inch PB Actuated Ball Valve	Chart Part Number
PB Ball Valve	11804223
Seal Kit for 11804223	12932702
Air Actuator for 11804223	11925965
125 PSI Actuator Relief Valve	1810652
90 PSI Actuator Regulator	10852311
PB Inlet Check Valve (Bottom of Tank)	11208931
Solenoid Valve 1/4MPT	14296295

PB Repair Kit Units w/ 1 Inch PB Solenoid Valve	Chart Part Number
1 inch Solenoid Valve (120 VAC) Magnatrol	14413113
1 inch Solenoid Valve (230 VAC) Magnatrol	14750267
Piston for 1 Inch Solenoid Valve	20571789
Gasket for 1 Inch Solenoid Valve	20571792
Manual Overdrive Valve for 1 Inch Solenoid	20571793
Kit: Replace ½ Inch Actuated Valve w/ 1-Inch Solenoid Valve	14413092

PB Repair Kit X15 – 600 psi - LIN	Chart Part Number
Regulator 1/2NPT 125PSI	11779806
Valve Ball 1/2FPT w/ Pneumatic Actuator	11804223
Solenoid Valve 1/4MPT	14296295
Relief Valve 1/2MPT ASME 600PSI	20547372
Inline Rupture Disc 1/2MPT ASME 800PSI	20547371
Regulator 1/4NPT 625PSI	20553102
Pressure Gauge, 2-inch Dial 1/4MPT 0-800PSI/BAR	14954366
Relief Valve 1/4MPT150 psi	11915581
Pneumatic Actuated Ball Valve Rebuild Kit	12932702

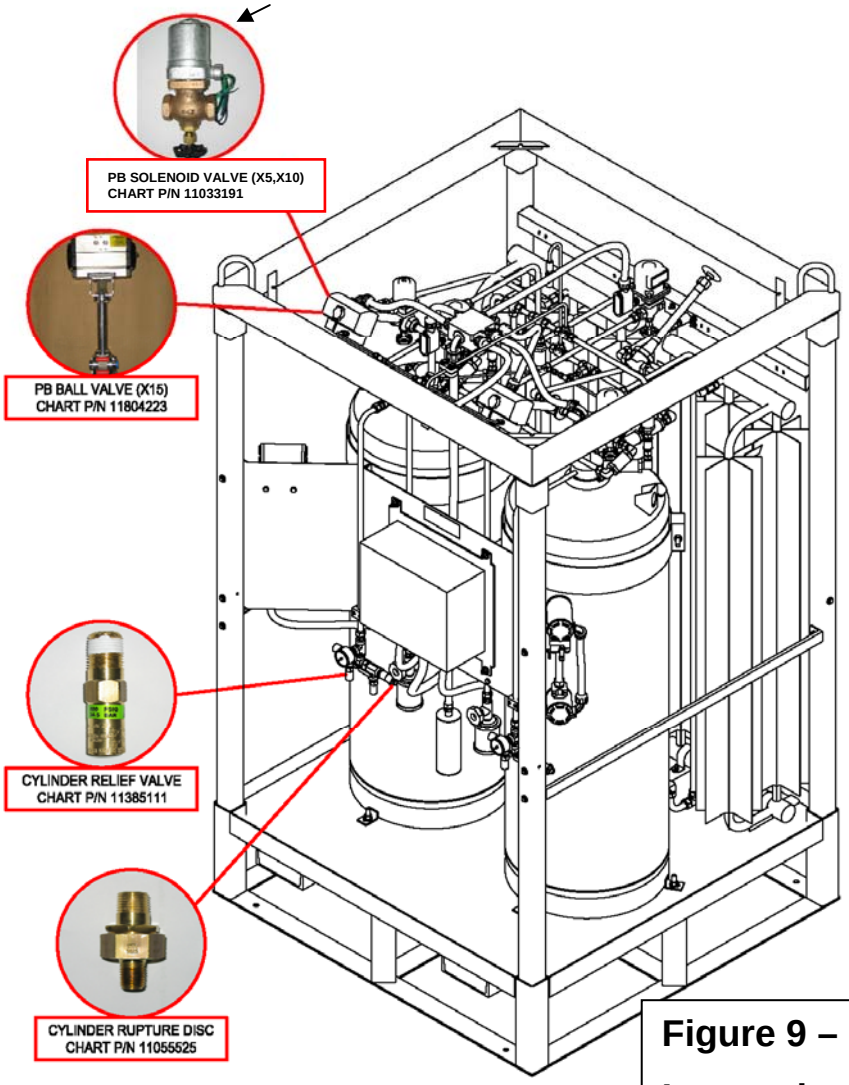


Figure 9 – Front Isometric view of

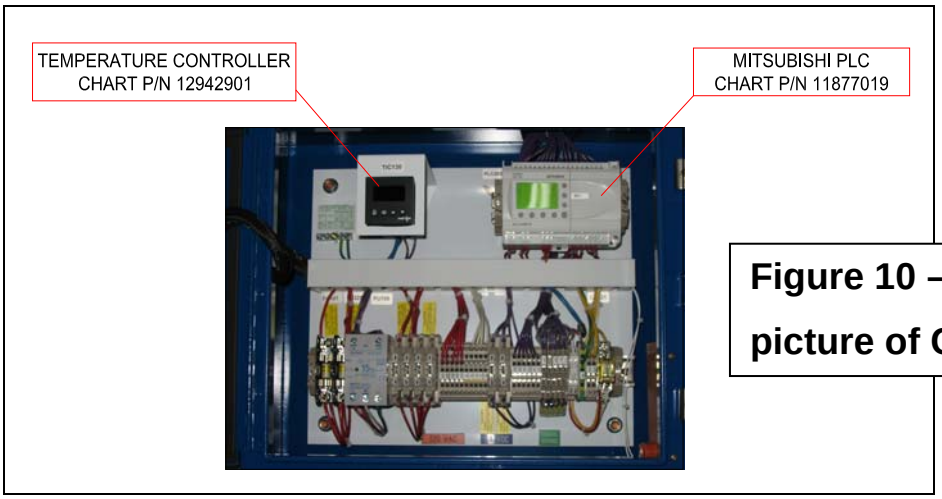


Figure 10 – Inside picture of Control

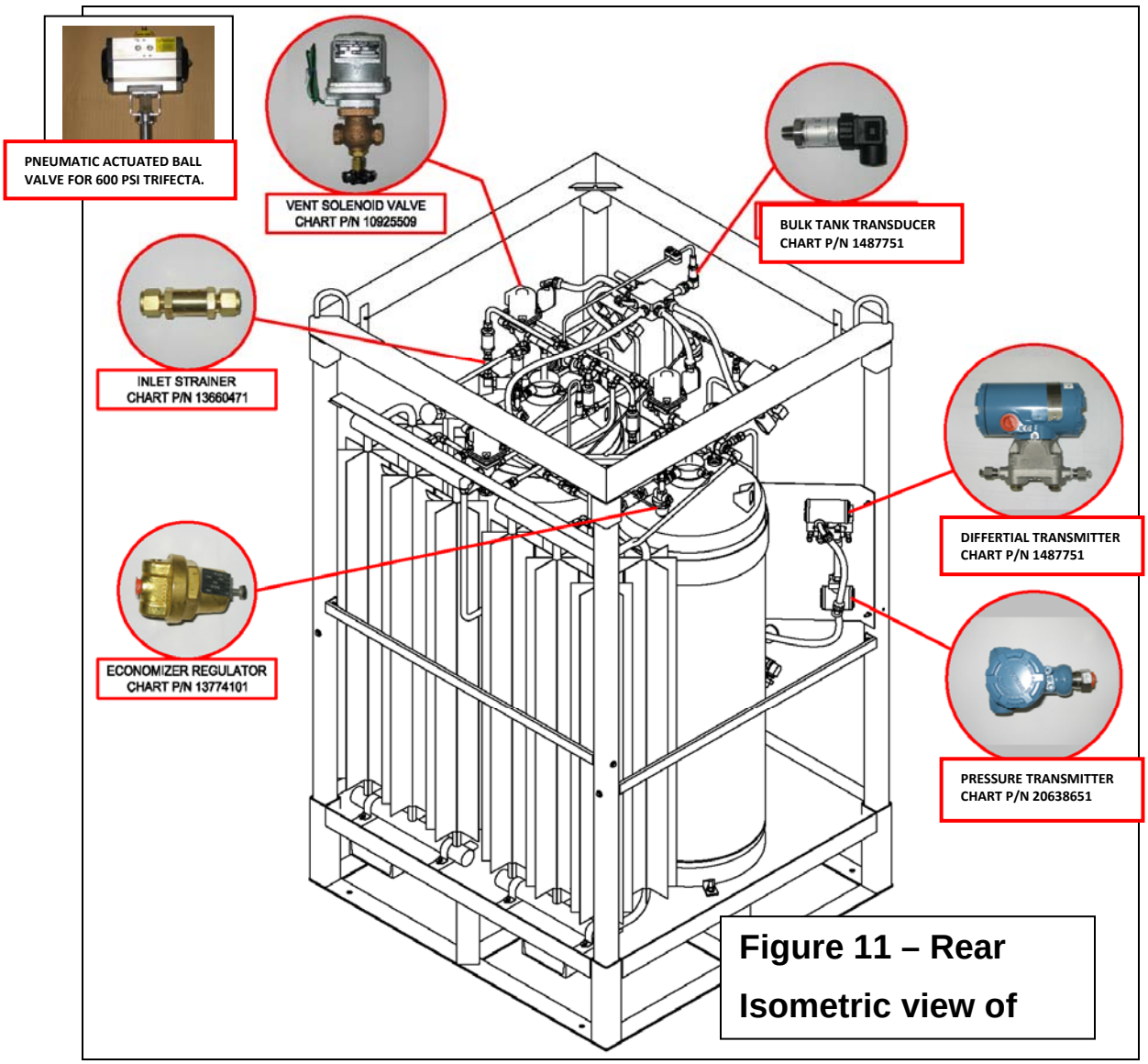


Figure 11 – Rear Isometric view of

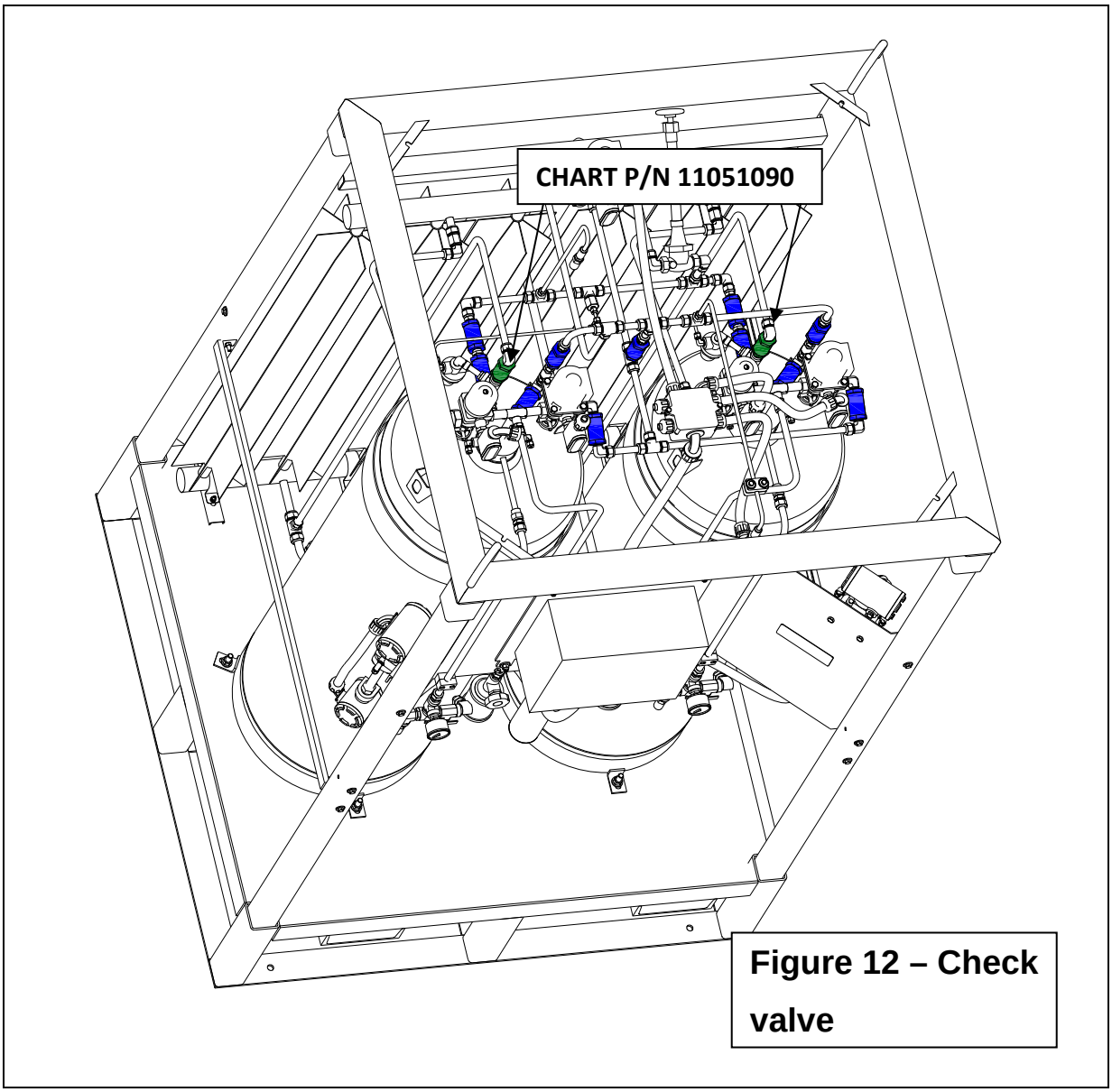


Figure 12 – Check valve

CHART P/N 13820233
GENERANT P/N CV-513-B-T-1

CHART P/N 11051090
GENERANT P/N CV-503B-T-5

Whenever solenoid piston assemblies are serviced, or valve is taken apart for cleaning, the bolts must be accurately torqued to 10 to 12 foot-pounds torque, in a normal cross pattern upon re-assembly. If they are over torqued, the body will become distorted, and “pinch” the piston, causing the valve to stick open or closed. It is also recommended that every time the valve is disassembled, that the gasket

be replaced, as the gasket takes a permanent set each time the bolts are tightened and will not re-seal a second time.

When the pneumatically actuated ball valves that are on the 600 psig trifectas get rebuilt, torque specs on these bolts are specified to be 9.38 foot pounds. Special care should also be taken to insure that the relief port in the ball is oriented so it vents on the upstream side of the valve. Failure to properly orient the vent port in the ball will cause the valve to leak by.

9 Troubleshooting

If the regular maintenance procedure above is followed, troubleshooting should not be necessary. If problems do occur, the following is a step-by-step troubleshooting guide. If you are not familiar with normal Trifecta X-Series operation, please read Section 4 before continuing.

While Troubleshooting the Trifecta X-Series, there are five things that should be monitored or checked for inconsistency to aid in diagnosis.

1. Confirm all valves on the Bulk Tank and Trifecta X-Series are in their normal operating position
2. Confirm solenoids (and/or pneumatic actuated ball valves) energize correctly by manually "firing" them per the instructions in Section 4.
3. Check for frost formation on lines which should not have recently been active
4. Leak check all plumbing components
5. Check for discrepancies between analog gauges and controller parameters

The above steps, described in greater detail below, will lead you to the root of the malfunction.

9.1 Confirm Valve Positions

- Confirm that all the following manual override on all valves are in the correct position.

Bulk Tank Auxiliary Liquid Valve	**Open**
Bulk Tank Pressure Building Valve	**Open**

- All 5 Solenoid (5k, 10K, 15k) Valves on Trifecta X-Series

- Manual override hand wheel in the "Out" Position

9.2 Normal Activation of Solenoids

Dial main switch on front of the control panel to “Monitor”. Open control panel door giving you access to the PLC controller. Per Section 4, press the corresponding buttons on the controller to “fire” each cluster of solenoids. Make sure all valves energize accordingly.

9.3 Frost Formation

Frost forms on all lines that have cold vapor or liquid flowing through them. The frost will begin to thaw when product is no longer flowing through the lines.

The frost will be evident for any significant amount of flow through the lines. Simply by looking at the frost formation, a check valve and/or solenoid, which are leaking or inoperable, can often be detected.

Likewise, lack of frost on a line will indicate that product is not flowing through the line and that a solenoid is stuck shut or for some reason not firing properly.

9.4 Leak Check

Leak check all plumbing components, with special attention to plumbing stack on tank and all connections to pressure transmitters.

- A leak at any point in the Trifecta X-Series system will result in loss of product.
- A leak in the plumbing within the plumbing stack or pressure transducers and transmitters can cause incorrect values to be translated by the PLC. These transducers provide the input to the Trifecta X-Series controller, which tell it when to open and close solenoids. Incorrect values will cause the Trifecta to operate in a random fashion and could cause supply issues downstream.
- Refer to Leak Section 8.3 to remedy.

9.5 Data from Main Screen and Analog Pressure Gauges

Record Trifecta X-Series and bulk tank parameters as described in the View Parameters Section 5.5. Compare these values to those on the analog gauges of the tanks and the bulk tank.

Bulk Tank

Pressure (Analog Gauge) _____ PSIG.
Pressure (from PLC Display) _____ PSIG.

Tank 1

Pressure (Analog Gauge) _____ PSIG.
Pressure (from PLC Display) _____ PSIG.
Liquid Level (from PLC Display) _____ " H2O

Tank 2

Pressure (Analog Gauge) _____ PSIG.
Pressure (from PLC Display) _____ PSIG.
Liquid Level (from PLC Display) _____ " H2O

PLC Information

Press left arrow/record P.B. Set Point _____ PSIG
Press up arrow/record Fill Set Point _____ “H20
Press down arrow/record bulk critical _____ PSIG
Press “ESC”/record cycle count _____ #cycles

Press “OK”/record Error Codes and elapsed time since event:

P ___ M ___ A ___ B ___
C ___ D ___ E ___ F ___
When _____ hr _____ minute

Note that the transmitter and gauge readings may not match exactly.

A discrepancy can be caused by either the analog gauge or by the transmitter.

In most cases, the result is an inaccurate analog gauge.

- Replace this first.

If the cause is the transmitter, continue to the Pressure Transmitter Section 8.4.

10 Repairs

NOTE: Any time plumbing is removed from the Trifecta X-Series system, take care not to allow any moisture to enter the system.

This moisture can freeze and cause check valves and control valves to stick. Critical lines can freeze causing incorrect level and pressure readings.

10.1 Check Valve Leaking

If you find that there is a leaking check valve, the Trifecta X-Series will have to be emptied and depressurized. The check valve should then be replaced. Replacement parts can be located through Replacement Parts Section 9 and via www.chartparts.com

10.2 Solenoids

If the solenoid appears to be malfunctioning, it could be for a few reasons:

- PLC is not sending signal to energize the solenoid
- contaminants on solenoid seat
- moisture in solenoid
- solenoid failure

Below, the most commons symptoms of these failures and their remedies are described.

10.2.1 Non-Energizing Solenoid

The PLC sends a signal to the solenoid to energize the coil during a particular operation of the Trifecta X-Series. When this signal is sent from the PLC, an LED on the front panel lights up. If the LED lights up, but the solenoid is not energized and does not open, check for loose wiring and voltage at the valve with a multi-meter. If there is power at the valve and the valve does not open, the coil will need to be replaced.

Contact www.chartparts.com for replacement parts.

10.2.2 Contaminants on Solenoid Seat

If the solenoid appears to be leaking, there are most likely contaminants on the seat of the piston. The seat or piston may also be damaged. In this case, remove the piston and replace. Also verify that the strainer is in place and replace if it has been 6-months prior to last replacement.

10.2.3 Moisture in Solenoid

Solenoid should be allowed to thaw. Once thawed, moisture may be removed from solenoid upon next use via the flow of new gas.

10.2.4 Solenoid Failure

If none of the above improves the situation, there has been a catastrophic failure within the solenoid coil. The entire solenoid must be replaced per Replacement Parts Section 9.1.

10.3 Leaking Components

If the leak cannot be fixed via tightening or re-plumbing a component, a new component will have to be fitted. Refer to the Repair section to locate the description and part number of this component.

NOTE: All replacement fittings should be cleaned for oxygen service. Refer to replacement parts section for Chart part numbers for all plumbing components.

10.4 Pressure and Liquid Level Transmitters

1. First, leak check all fittings associated with the transmitter to verify the circuit has zero leaks. The sensor error check function is designed to find problems such as a wire coming disconnected, or a short in the transmitter. “F6” will display in the error code section of the PLC if a pressure or liquid level transmitter is out of range. See Section 5.3 Error Codes.
2. Confirm that all wiring connection terminals are tight.
3. If all connections are made and the error condition does not go away, check the transmitter output as shown in the Section 5.5.
4. Recalibrate or replace the transmitter as necessary.
5. Also verify display versus the analog gauges for pressure readout.

10.5 Ball Valve Repair (Trifecta X-Series – X15 only)

The Trifecta X-SeriesX-15 uses cryogenically rated ball valves in the pressure building circuit. Chart recommends that these ball valves be serviced via the replacement of the seal kits at least every two years (approximately 150,000 cycles).

11 Warranty

CHART INC. Terms & Conditions of Sale

1. General. The terms and conditions contained herein, together with any additional or different terms contained in Chart Inc.'s ("Chart") proposal, if any, submitted to Buyer (which proposal shall control over these terms and conditions to the extent it contains any conflicting terms and conditions) constitute the entire agreement between the parties with respect to the subject sale and supersedes all prior communications and agreements. Acceptance by Chart of Buyer's order, and/or Buyer's acceptance of Chart's proposal is expressly limited to and conditioned upon Buyer's acceptance of these terms and conditions which may not be changed or waived except in a writing signed by both parties. Any additional, inconsistent or different terms and conditions contained in Buyer's purchase order or other documents supplied by Buyer are hereby expressly rejected. Unless the context otherwise requires, the term *"Equipment"* as used herein includes all goods, equipment, parts, and accessories sold to Buyer by Chart. Unless the context otherwise indicates, the term *"Services"* as used herein shall mean labor, supervision and project engineering services provided by Chart. As used herein, the term "Buyer" shall include the initial end user of the Equipment and/or Services.
2. Payment Terms. Unless a different payment schedule is agreed to in writing, payments for domestic sales are due net thirty (30) days. Late payments are subject to a 1.5% late charge per month. Payments for export sales to be made in accordance with the specified payment schedule by way of a confirmed, irrevocable letter of credit established in favor of Chart on a USA bank to be designated by Chart. Costs associated with the letter of credit will be to Buyer's account. Performance schedules are based on receipt of letter of credit within thirty (30) days of award.
3. Taxes. Federal, state, local, or value added sales and/or use taxes measured on the price of Equipment are not included in the price.
4. Time Limit. All quotations are valid for a period of thirty calendar days.
5. Acceptance. Acceptance of Equipment occurs at point of manufacture.
6. Warranty. *General.* Chart warrants that all Equipment manufactured by Chart shall be free from defects in material, workmanship and title; provided, however, that this warranty shall be limited to Equipment found to be defective within a period of one (1) year from initial use or eighteen (18) months from date of shipment, whichever expires first, except that parts sold as a spare or for replacement are warranted for one (1) year from the date of shipment or until the expiration of the recommended service period, whichever expires first. In the event the Equipment constitutes heat exchanger(s), then Chart also warrants the same to be new and in accordance with Chart's applicable brazed aluminum heat exchanger specifications and drawings, which may have been submitted to and approved by Buyer. Resale products only carry the warranty offered by their original manufacturer. This warranty does not cover Buyer furnished designs, goods, equipment, and/or materials. In no event shall Chart incur any obligation to repair or replace Equipment which Chart determines to be defective due to customer misuse, abuse, neglect, operated outside the specified design and/or feed conditions, corrosion or erosion, or not used in accordance with normal operating and maintenance instructions. Chart shall not incur any warranty obligation hereunder with respect to Equipment which is modified in any way by Buyer without Chart's prior written approval. Installation by Buyer at regular intervals of normal maintenance parts does not constitute modifications. *Services.* Chart warrants it's Services against defects in workmanship for a period of ninety days from date of their completion.
7. Exclusive Remedy. *Equipment/Services Remedy*. Should any failure to conform with the applicable warranties appear during the specified periods under normal and proper use and provided the Equipment has been properly stored, installed, operated and maintained and if given prompt written notice by Buyer and Chart has been given ten (10) days to inspect said Equipment (and provided Buyer has helped identify the problem and appropriately decontaminated the Equipment) before any corrective actions are taken, then Chart shall correct such nonconformity by, at its option, (1) repair or replacement of the nonconforming Equipment or parts thereof, or (2) refund the purchase price of the nonconforming Equipment or parts thereof, or (3) in the case of nonconforming Services, provide equivalent Services at the job site or refund the price therefore. Repairs or replacements made pursuant to warranty shall not renew or extend the applicable original warranty period, provided however, that any such repairs or replacement of Equipment or parts thereof shall be warranted for the time remaining in the original warranty period or thirty days, whichever is longer. Chart shall not be responsible for providing working access to the defect, including disassembly and reassembly of Equipment or for providing transportation to and from Chart's repair or factory facility, all of which shall be at Buyer's risk and expense. These warranties shall also not apply to any Equipment or parts thereof which: (1) have been improperly repaired or altered; (2) have been subjected to misuse, excessive external forces, negligence or accident; (3) have been used/operated in a manner contrary to Chart's instructions, specifications and drawings; (4) are comprised of materials provided or a design stipulated by Buyer; (5) are used equipment; or (6) result from normal wear and tear. Any repair or alteration without Chart's written approval shall act to void any existing warranty. Buyer also agrees to defend, indemnify and hold Chart harmless from any third party claims arising out of Buyer's use, sale, or lease of said furnished Equipment.
8. Disclaimer. *THE FOREGOING WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES OF QUALITY, PERFORMANCE AND DESIGNS, WRITTEN, ORAL OR IMPLIED, AND ALL OTHER WARRANTIES INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE OR ARISING FROM COURSE OF DEALING OR USAGE OF TRADE ARE HEREBY EXPRESSLY DISCLAIMED BY CHART AND ALL EQUIPMENT MANUFACTURERS.*

9. Termination. No termination by Buyer for default shall be effective unless, within fifteen (15) days after receipt by Chart of Buyer's written notice specifying such default, Chart shall have failed to initiate and pursue correction of such specified default.
10. Excusable Delays. The schedule for shipment of Equipment and/or performance of Services will be modified for delays resulting from causes beyond Chart's reasonable control, including but not limited to, strikes, restrictions of the United States Government, or other governments having jurisdiction, delays in transportation, inability to obtain necessary labor, materials, or manufacturing facilities.
11. Shipment. All domestic shipments are F.O.B. point of manufacture. Export shipments are Ex Works with responsibilities as defined in INCOTERMS 2000. If Chart agrees in writing to prepay transportation and insurance charges, then Buyer will be invoiced and agrees to pay the actual cost of the same. Claims for shortages in shipment shall be deemed waived unless made in a writing received by Chart within ten (10) days after delivery. Shipment dates quoted are based on Chart's best estimate of a realistic time when shipment will be made, and are subject to change due to prior sales. Shipment dates will be confirmed on Chart's acceptance of any resulting order. Chart may make early shipment or partial shipments and invoice Buyer accordingly.
12. Laws, Codes and Standards. Except as expressly stated herein, the price and schedule included herein are based on laws, codes, and standards in effect as of the date of the subject sale. If such laws, codes, and standards change and increase or decrease the cost of performing the work or impact the schedule, then Chart will advise Buyer of the same. Buyer and Chart shall promptly negotiate in good faith and mutually agree upon any modification to the order resulting from any such change.
13. Title and Risk of Loss or Damage. Despite any agreement with respect to delivery terms or prepayment of transportation or insurance charges, the risk of loss or damage shall pass to Buyer and delivery shall be deemed to be complete upon delivery to a private or common carrier or upon moving into storage, whichever occurs first, at the point of shipment. Title to the Equipment sold shall remain in Chart until paid for in full.
14. Installation. Installation of Equipment furnished hereunder shall be by Buyer, unless otherwise agreed to in a writing signed by Chart's duly authorized representative.
15. Field Service. Field service will be provided on a per diem basis upon written authorization by Buyer and at Chart's rates in effect when such Services are provided.
16. Cancellation. Cancellation of any order must be by written notice to Chart and will be subject to Chart's cancellation charges.
17. Intellectual Property. Buyer shall defend, indemnify and hold Chart harmless from all expenses, losses and other damages resulting from any actual or alleged infringement of patents, copyrights or trademarks arising from Chart's compliance with Buyer's designs, specifications or instructions. Unless otherwise agreed to in a writing signed by Chart's duly authorized representative, all right, title and interest in any inventions, developments, improvements or modifications of the Equipment and Services made by Chart or Buyer shall exclusively remain with Chart. Any design, manufacturing drawings or other information submitted to Buyer shall remain the exclusive property of Chart. Buyer shall not, without Chart's prior written consent, copy nor disclose such information to any person. The information, drawings, plans, standards, and specifications furnished by Chart were developed at Chart's expense and may not, without Chart's prior written consent, be used nor disclosed by Buyer for any purpose other than to install, own, operate, and maintain the subject Equipment. If Chart's Equipment is held to infringe a United States patent in effect as of the date of this agreement, then Chart may at its option procure for Buyer the right to use the Equipment; modify or replace it with non-infringing Equipment; refund the purchase price allocable to the infringing Equipment, or settle or otherwise terminate said actions on behalf of Buyer. The foregoing is Chart's entire liability on patent infringements.
18. Assignment. This agreement may not be transferred or assigned by operation of law or otherwise, without the prior express written consent of Chart. Any transfer or assignment of any rights, duties or obligations without Chart's consent shall be void.
19. Limitation of Liability. *In no event shall Chart, ITS Affiliates, suppliers and subcontractors be liable to Buyer nor to any third party for any special, indirect, incidental or consequential damages, including but not limited to loss of profits, loss of use, cost of capital, cost of substitute equipment, downtime costs, delays NOR FOR ANY PENALITIES, whether any such claim FOR THE same is based on contract, warranty, tort, negligence, strict liability or otherwise. Chart's liability for any such claims whether in contract, warranty, negligence, tort, strict liability, or otherwise or for any loss or damage arising out of, connected with THIS AGREEMENT or the performance or breach thereof, or from ANY DESIGN, sale, INSTALLATION, OPERATION OR USE of the equipment or performance of ANY services covered by this agreement, shall in no event exceed the PURCHASE price paid to Chart by Buyer for the specific Equipment OR PART THEREOF or for the Services giving rise to THE CLAIM.*
20. Export Sales. In no event shall Chart be required to export or deliver any technical information, data and/or Equipment if such export or delivery is then prohibited or restricted by any law or regulation of the U.S. Government. Buyer to secure all licenses.
21. Governing Law. This agreement is exclusively governed by the laws of the State of Ohio, excluding its conflicts of laws. Buyer agrees all causes of action under this agreement shall expire unless brought in court of law located in Cleveland, Ohio, to which Buyer does hereby consent to the jurisdiction of the same, within one year of the date of the occurrence of the event giving rise to any such claim.
22. Headings. The headings used throughout are for convenience only and shall be given no legal effect. Fax copies shall be given the full force and effect as an original.
23. Entire Agreement. These terms and conditions constitutes the complete and exclusive agreement between Chart and Buyer and there are no agreements, understandings, restrictions, warranties, or representations between Chart and Buyer other than those set forth herein or herein provided for.

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