LEADERS BY DESIGN

OPERATION MANUAL

MODEL: ACT-LOX-060-38-HL-T-TD

Applied Cryo Technologies

7150 Almeda Genoa

Houston, TX 77075

(281) 888-9265

Www.appliedcryotech.com

This manual is designed to familiarize experienced operators with the safety precautions, operational parameters, operational features, and maintenance requirements of the ACT-ACT-LOX-060-38-HL-T-TD.

Company Overview

Headquartered in Houston Texas, ACT designs and manufactures cryogenic trailers, mobile storage equipment and a variety of LIN regasification products for the Oil & Gas, Industrial Gas, and emerging LIN markets. ACT also offers a full line of services for Repair, Rehabilitation and Refurbishment of Cryogenic Transportation and Storage Equipment. At ACT, we measure our success by the value and benefits that we provide to our customers and we do this by understanding the complexities of an ever-evolving worldwide market. ACT offers a unique skill set of engineering know how, operational execution and outstanding customer service to the cryogenic equipment manufacturing industry.

Contact Information

ACT is here to help. If at any point you need assistance or have any questions regarding the equipment in this manual or have any other questions regarding ACT and its product offerings, please feel free to contact us at any time.

Applied Cryo Technologies
7150 Almeda Genoa Rd
Houston TX. 77075
Phone: 281-888-3884

Use the following Information when Contacting ACT about the equipment in this manual.

Unit Number –600*XX*-LOX

Or visit us on the

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Liquid Oxygen

Oxygen is the second largest component of the atmosphere, comprising 20.8% by volume. Liquid oxygen is a cryogenic liquid and has a boiling point of -297.3°F (-183.0°C). Liquid oxygen is pale blue and extremely cold. Although nonflammable, oxygen is a strong oxidizer. Oxygen is necessary to support life. Oxygen will react with nearly all organic materials and metals usually forming an oxide. Materials that burn in air will burn more vigorously in oxygen. Equipment used in oxygen service must meet stringent cleaning requirements and systems must be constructed of materials that have high ignition temperatures and that are non-reactive with oxygen under the service conditions.

LOX Safety Issues: Information pertaining to this section of the manual can be found at the following website:
http://www.ccohs.ca/oshanswers/chemicals/cryogenic/cryogen1.html

General Properties of Liquid Oxygen

- Molecular Weight: 31.999
- Boiling Point @ 1 atm: -297.4°F (-183.0°C, 90oK)
- Freezing Point @ 1 atm: -361.9°F (-218.8°C, 54oK)
- Critical Temperature: -181.8°F (-118.4°C)
- Critical Pressure: 729.1 psia (49.6 atm)
- Density, Liquid @ BP, 1 atm: 71.23 lb/scf
- Density, Gas @ 68°F (20°C), 1 atm: 0.0831 lb/scf
- Specific Gravity, Gas (air=1) @ 68°F (20°C), 1 atm: 1.11
- Specific Gravity, Liquid (water=1) @ 68°F (20°C), 1 atm: 1.14
- Specific Volume @ 68°F (20°C), 1 atm: 12.08 scf/lb
- Latent Heat of Vaporization: 2934 BTU/lb mole
- Expansion Ratio, Liquid to Gas, BP to 68°F (20°C): 1 to 860
- Solubility in Water @ 77°F (25°C), 1 atm: 3.16% by volume

Health effects

Normally, air contains 21% oxygen, and oxygen is essentially nontoxic. No health effects have been observed in people exposed to concentrations up to 50% at 1 atmosphere for 24 hours or longer. The inhalation at 1 atmosphere of 80% oxygen for more than 12 hours can cause irritation of the respiratory tract, progressive decrease in vital capacity, coughing, nasal stuffiness, sore throat, and chest pain, followed by tracheobronchitis and later by pulmonary congestion and/or edema. Inhalation of pure oxygen at atmospheric pressure or less can cause pulmonary irritation and edema after 24 hours. Respiratory symptoms can occur in two to six hours at pressures above 1 atmosphere. One of the earliest responses of the lung is accumulation of water in its interstitial spaces and within the pulmonary cells. This can cause reduced lung function, which is the earliest measurable sign of toxicity.

Other symptoms include fever and sinus and eye irritation. When pure oxygen is inhaled at pressures greater than 2 or 3 atmospheres, a characteristic neurological syndrome can be observed. Signs and symptoms include nausea, dizziness, vomiting, tiredness, light-headedness, mood changes, euphoria, confusion, incoordination, muscular twitching, burning/tingling sensations (particularly of the fingers and toes), and loss of consciousness. Characteristic epileptic-like convulsions, which may be preceded by visual disturbances such as loss of peripheral vision, also occur. Continued exposure can cause severe convulsions that can lead to death. The effects are reversible after reduction of oxygen pressure. Extensive tissue damage or cryogenic burns can result from exposure to liquid oxygen or cold oxygen vapors.

Safety Considerations for LOX

The hazards associated with liquid oxygen are exposure to cold temperatures that can cause severe burns; over-pressurization due to expansion of small amounts of liquid into large volumes of gas in inadequately vented equipment; oxygen enrichment of the surrounding atmosphere; and the possibility of a combustion reaction if the oxygen is permitted to contact a non-compatible material. The low temperature of liquid oxygen and the vapors it releases not only pose a serious burn hazard to human tissue but can also cause many materials of construction to lose their strength and become brittle enough to shatter. The large expansion ratio of liquid-to-gas can rapidly build pressure in systems where liquid can be trapped. This necessitates that these areas be identified and protected with pressure relief. This expansion ratio also allows atmospheres of oxygen-enriched air to form in the area surrounding a release.

It is important to note that fire chemistry starts to change when the concentration of oxygen increases to as little as 23%. Materials easily ignited in air not only become more susceptible to ignition, but also burn with added violence in the presence of oxygen. These materials include clothing and hair, which have air spaces that readily trap the oxygen. Oxygen levels of 23% can be reached very quickly and all personnel must be aware of the hazard. Any clothing that has been splashed or soaked with liquid oxygen or exposed to high oxygen concentrations should be removed immediately and aired for at least an hour. Personnel should stay in a well-ventilated area and avoid any source of ignition until their clothing is completely free of any excess oxygen. Clothing saturated with oxygen is readily ignitable and will burn vigorously.

Do not permit smoking or open flames in any areas where liquid oxygen is stored or handled. Do not permit liquid oxygen or oxygen-enriched air to meet organic materials or

flammable or combustible substances of any kind. Some of the organic materials that can react violently with oxygen when ignited by a spark or even a mechanical shock are oil, grease, asphalt, kerosene, cloth, tar, and dirt that may contain oil or grease. If liquid oxygen spills on asphalt or other surfaces contaminated with combustibles, do not walk on, or roll equipment over the area of the spill. Keep sources of ignition away for 30 minutes after all frost or fog has disappeared.

Health effects

Being odorless, colorless, tasteless, and nonirritating, argon has no warning properties. Humans possess no senses that can detect the presence of argon. Argon is nontoxic and largely inert. It can act as a simple asphyxiant by displacing the oxygen in air to levels below that required to support life. Inhalation of argon in excessive amounts can cause dizziness, nausea, vomiting, loss of consciousness, and death. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue. At low oxygen concentrations, unconsciousness and death may occur in seconds and without warning. Personnel, including rescue workers, should not enter areas where the oxygen concentration is below 19.5%, unless provided with a self-contained breathing apparatus or air-line respirator. Extensive tissue damage or burns can result from exposure to liquid argon or cold argon vapors.

Safety Considerations for LOX

Asphyxiation - All cryogenic liquids produce large volumes of gas when they vaporize. Air is normally 21% oxygen by volume. When this is reduced to 15-16% oxygen, symptoms of asphyxia will develop. At 12% oxygen, the individual will lose consciousness without warning and may be unaware of any danger. When there is not enough oxygen, asphyxiation and death can occur very quickly. When cryogenic liquids form a gas, that gas is very cold and usually heavier than air. This cold, heavy gas does not disperse very well and can accumulate near the floor. Even if the gas is non-toxic, it displaces the air. Oxygen deficiency is a serious hazard in enclosed or confined spaces.

Safety and Warnings

This manual is designed to familiarize experienced operators with the safety precautions, operational parameters, operational features, and maintenance requirements of the ACT-LOX-060-038-HL-T-TD Transport Trailer.

The information provided in this manual provides guidance to the owner and should be used to enhance the owner's already in practice, Safety and Maintenance programs.

For more information on transporting LIN refer to NFPA 57 and NFPA 59a from the National Fire Protection Agency (www.nfpa.org or 617-770-3000).

For more information on the safe handling of cryogenic liquids refer to CGA P-12 from the Compressed Gas Association (www.cganet.com or 703-788-2700).

It is imperative that all persons having contact with this equipment become thoroughly familiar with the safety precautions, procedures, schematics and operating sequences contained in this operation manual.

If for any reason this manual becomes confusing or the information provided is not completely understood contact a Technical Service Representative at Applied Cryo Technologies (ACT) at (281)-888-9265 before proceeding.

WARNING: The ACT-LOX-060-038-HL-T-TD is designed for LOX cryogenic service. Many of the components and materials are regulated and are designed for LOX cryogenic service. Design modifications to this piece of equipment could result in catastrophic failure resulting in severe bodily injury or death.

Hazards resulting from Cryogenic Temperatures

All cryogenic liquids are extremely cold. Cryogenic liquids and their vapors can rapidly freeze human tissue. Unprotected skin can stick to metal that is cooled by cryogenic liquids. The skin can then tear when pulled away.

WARNING: Contact with cryogenic liquid, its boil-off gases, or components cooled to these low temperatures can readily cause frostbite, cryogenic burns and severe bodily injury. All operators of the ACT-LOX-060-038-HL-T-TD should be well trained regarding LOX characteristics and the handling of LOX. In the event of bodily contact with LOX immediately take the patient to the hospital to re-warm skin.

WARNING: To avoid a potential splash hazard when filling or offloading using a transfer hose, always blow down hose bleeds or drain valves slowly.

As a minimum, operators who handle cryogenic liquids should be equipped with the following Personal Protective Equipment (PPE):

- Safety boots
- Full length trousers (no cuffs)
- Long sleeve shirt (no cuffs)
- Gloves suitable for use with cryogenic liquids (loose fitting to allow for quick removal)
- Eye protection (full face shield over safety glasses)
- The preferred fabric for the clothes is pure cotton or flame-retardant materials.
- No metal jewelry rings watch etc.… should be worn on hands or wrist while transferring cryogenic liquids.

Hazards resulting from Asphyxiation:

WARNING: LOX Vapors in the air may dilute the Oxygen concentration necessary to support or sustain life. Exposure to such an Oxygen Deficient Atmosphere can lead to unconsciousness, serious injury, or even death.

Cryogenic fluids should only be used and stored in well ventilated areas. All cryogenic liquids produce large volumes of gas when they vaporize. Air is normally 21% oxygen by volume. When this is reduced to 15-16% oxygen, symptoms of asphyxia will develop. At 12% oxygen, the individual will lose consciousness without warning and may be unaware of any danger. When there is not enough oxygen, asphyxiation and death can occur very quickly. When cryogenic liquids form a gas, that gas is very cold and usually heavier than air. This cold, heavy gas does not disperse very well and can accumulate near the floor. Even if the gas is non-toxic, it displaces the air. Oxygen deficiency is a serious hazard in enclosed or confined spaces.

Table 1. Effects of Hypoxia[8] (Reduced Oxygen)

Oxygen Percentage Available	Symptoms
21	Normal conditions, no effect.
19.5	OSHA oxygen-deficient atmosphere.
17	Muscular impairment, rapid breaths.
12	Dizziness, headache, rapid fatigue.
9	Unconsciousness.
7 to 6	Death within a few minutes.

http://www.fireengineering.com/articles/2010/07/survivability-profiling-how-long-can-victims-survive-in-a-fire.html

WARNING: When the ACT-LOX-060-038-HL-T-TD contains LOX, always operate and store the trailer in well ventilated areas only. Failure to do so could result in severe bodily injury or even death.

Additional Warnings

WARNING: Loss of Vacuum

If a loss of vacuum occurs it will be evident by cold spots or frost on the outer shell and/or abnormally rapid pressure build up (main safeties going off continually). The cause could possibly be a jacket breach or an inner vessel leak. Accelerated product vaporization can result in a fire and/or explosion and could result in severe bodily injury or even death. If these conditions are evident contact Applied Cryo Technologies (ACT) at (281)-888-9265 immediately.

Early morning condensation or dew on the tank is normal and may be irregularly distributed on the outer shell.

WARNING: Sources of fire - Keep equipment away from open flames or sparks.

Basic Cryogenics and Terminology

Cryogenic fluids are gases that have been liquefied by greatly reducing their temperatures. The boiling points of cryogenic liquids range from -250°F to 450°F. Some of these cryogens include Liquid Nitrogen (LIN), Liquid Argon (LAR), Liquid Oxygen (LOX) and Liquid Natural Gas (LNG). Cryogenic fluids are used in a wide range of industrial, commercial, medical, and chemical applications. Cryogens have very high expansion

ratios. When exposed to ambient pressure and temperature a cryogenic liquid will rapidly vaporize (boil) and expand its volume 600-850 times.

Large volumes of gases are much easier to store and transport as liquid than as a gas. It is much safer and cost effective to load, unload, store and transport a low-pressure liquid than a high-pressure gas. The biggest problem in the transport and storage of cryogenic liquefied gases is preventing heat from the ambient surroundings from getting to the liquid and vaporizing it back to a gaseous state. The rate at which this occurs is known as the heat transfer rate. All the thermodynamic work put into the gas at the air separation plant will be wasted if heat can vaporize the cryogenic liquid.

Cryogenic liquids are stored in Dewar's. A **Dewar** is a pressurized inner tank surrounded by an outer tank with a vacuum insulated annulus space. A cryogenic semi-trailer is simply a Dewar on wheels.

Cryogenic tanks need to be thermally efficient and are designed to minimize heat transfer (heat leak) from the ambient atmosphere to the cryogenic liquid.

Solid Heat Conduction: When designing a cryogenic tank *support system,* the idea is to limit the solid conduction heat path into the cryogenic liquid while at the same time accounting for shock loads and thermal expansion/contraction. Supports can either have an extra-long-thin heat path to the liquid or need to be poor conductors of heat (example: *micarta*).

Gaseous Heat Convection: When an annulus space has no vacuum, air molecules are present and transfer heat by convection from the outer vessel wall to the inner wall. A hard vacuum is just empty space. It contains no molecules -- or at least very few of them. Consequently, heat transfer by convection does not occur in a hard vacuum.

Radiation Heat Conduction: The outer vessel of a cryogenic tank blocks some of the radiation from the sun, but a significant portion still passes through into the annulus space. Super insulation is alternating layers of paper and aluminum foil. The foil provides reflective protection and produces a very long heat path.

Saturation: A liquid cryogen is saturated when the liquid, *at a constant pressure*, cannot absorb any more heat without boiling. The addition of any more heat or a reduction in pressure will change the liquid into a gas. Saturation is generally expressed in terms of pressure, not temperature.

Saturation pressure: is the pressure for a corresponding saturation temperature at which a liquid boil into its vapor phase rule of thumb: Raising the pressure in a cryogenic tank raises the boiling point of the cryogen.

Head Pressure: is simply the pressure in the Head Space. It is the pressure pushing down on the liquid and is used to pressure decant into a vessel at a lower psi. Head pressure occurs naturally via heat leak into the cryogen. It can also be created using Artificial Pressure, meaning pressure added intentionally. The most common way to create Artificial Pressure is to run liquid from the tank into a pressure building coil. The PB coil vaporizes the cryogen and the vapor is piped back into the vessel (through the vent or top fill) increasing the head pressure.

Ullage: is the required space for vapor expansion and is the maximum level of liquid allowed in a cryogenic tank to prevent overfilling.

Sub cool: Raising the vapor space pressure above the normal vapor pressure of a saturated liquid, creating **N**et **P**ositive **S**uction **H**ead or **NPSH.** When transferring liquid from a vessel, sub-cool is important to maintain the liquid in the liquid state (preventing two-phase liquid) as it travels from the tank through the piping circuit. Liquid flowing creates pressure drop as it travels through the piping. If the pressure drops below the saturation pressure of the liquid it will begin to boil.

Pressure Drop: is the pressure lost due to the flow of liquid. The faster liquid flows through the piping circuit, the higher the pressure drop.

Stratification: occurs in large cryogenic tanks that have been stationary for an extended period. Warm liquid is less dense. This less dense liquid will find its way to the top of the tank. Colder more dense liquid will remain at the bottom. The change of temperature from top to bottom is called Stratification

The **Pressure Building Coil:** aids in product withdraw and used when the demand for gas or liquid is greater than the Dewar's natural productive capacity. To do this, liquid is drawn into the “pressure build-up” (PBU) coil, where it is warmed by ambient air and vaporized. The gas then passes to the top of the tank, where it begins to build up pressure because the vapor expansion is limited by the fixed volume

A **Pressure Building Regulator:** provides the means for “unattended operation” used to maintain pressure in vapor space above cryogenic liquid. The pressure-building regulator maintains a preset pressure during liquid withdrawal. When the set pressure reaches the

set point of the pressure build-up regulator, the regulator shuts off, stopping vaporization and pressure build-up. When pressure in the tank drops, the liquid pressure build-up regulator opens, allowing liquid to flow through the pressure build-up coil and vaporize.

Advantages of using "Cold" liquid:

Cold liquid is denser. Denser liquid has more cubic feet of gas per gallon of liquid. Filling tanks with warm liquid can result in excessive venting. Cold liquid will minimize vent losses, optimize fill times, and improves safety. Collapsing of vapor space in receiving tank is more easily achieved.

Trailer General Overview

The purpose of this chapter is to provide a step by step on how to get familiar with the storage vessel and its components before beginning operations.

Tractor Electrical and Air Connection

The trailer is equipped with two 7-way connectors. The tractor's lighting & air connections are located on the front roadside nose box & the hydraulics, flowmeter & pass system connections are located on the front curbside nose box

Pressure Building Unit

The unit is equipped with an ambient vaporizer for pressure building the tank.

Hose Storage

Inside these you will find the Cryogenic & Microbulk Transfer Hoses, which are located on the curbside of unit.

Safety Cones & Wheel Chocks

On the roadside of the unit there is a safety cone holder (qty. 4 safety cones provided) & a chock block holder (qty. 2 chock blocks). These are to be used during roadside emergencies, parking, and other staging purposes.

Front Landing Legs

The front landing legs are to be used during normal transit and for staging.

Instructions and Notices

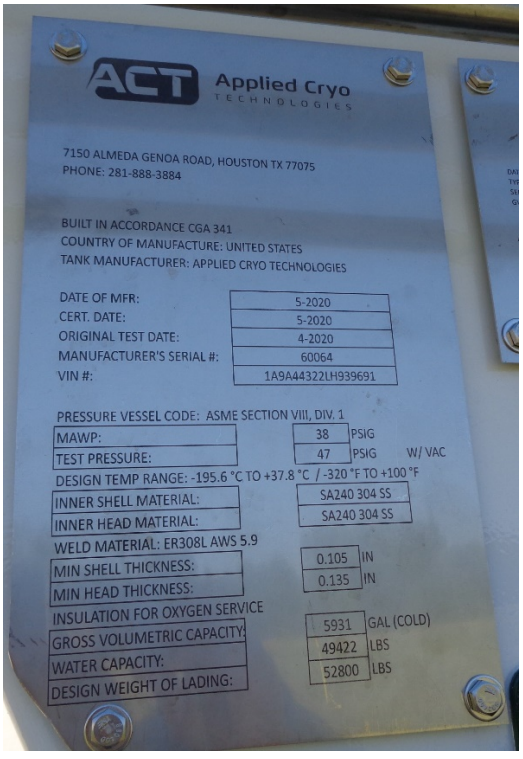
On the nose of the trailer there is important service and cautionary information posted regarding the air suspension and ABS systems. It is important to be familiar with these notices.

DOT Content Placards

Required by DOT the trailer has content placards (as depicted to the left) posted on the front, rear, and each side of the tank. The 4 digits UN for Liquefied Oxygen is 1073.

DOT Certification Tag

This DOT Certification tag is located on the roadside of the trailer mounted onto the front landing leg support. This tag contains engineering and DOT data relevant to the design.

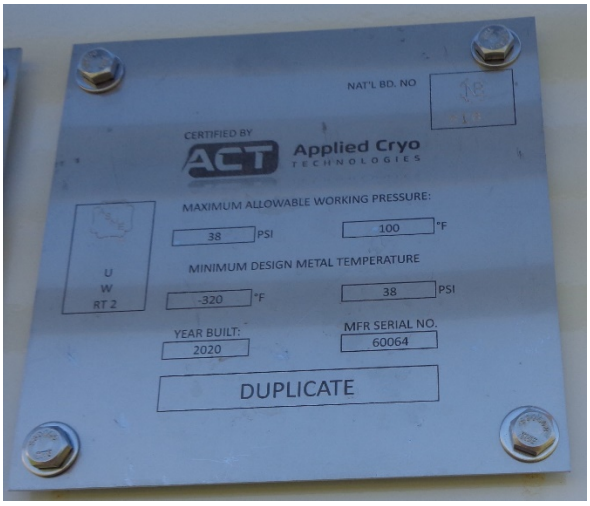


Manufacturers VIN (Vehicle Identification Number) Tag

The VIN tag is located on the roadside of the trailer mounted onto the front landing leg support.

ASME Tag

This Certification tag is located on the roadside of the trailer mounted onto the front landing leg support. This tag contains information pertaining to the pressure vessel and its ratings. Note: When contacting ACT about the trailer the serial number on this tag is most useful for quick unit identification.



Vacuum Pump Out Valve.

The vacuum port used to draw the vacuum is located on the curbside of the unit by the front landing leg. The valve should always remain closed.

Tire Inflation Warning Light

The Tire Inflation System warning indicator light is located on the roadside piping cabinet.

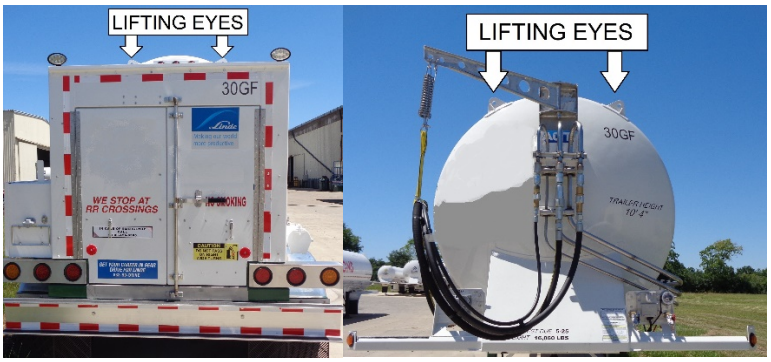
ABS Warning Light

The ABS System has a warning indicator light located on rear fender (roadside).

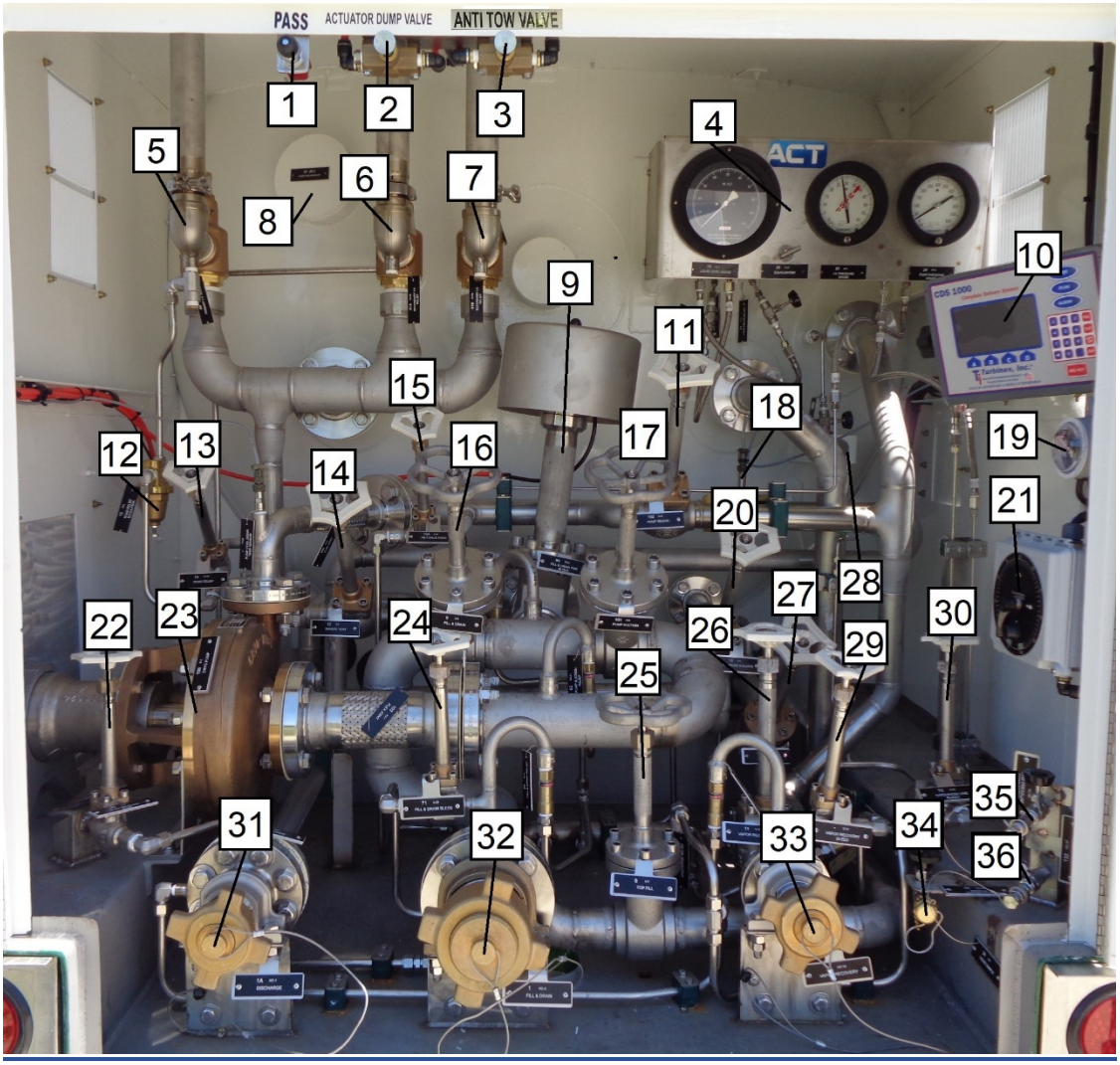
Lifting Eyes

The trailer is equipped with 4 lifting eyes (2 on front and two on the rear)

NOTE: For lifting an empty trailer only.



Piping Cabinet



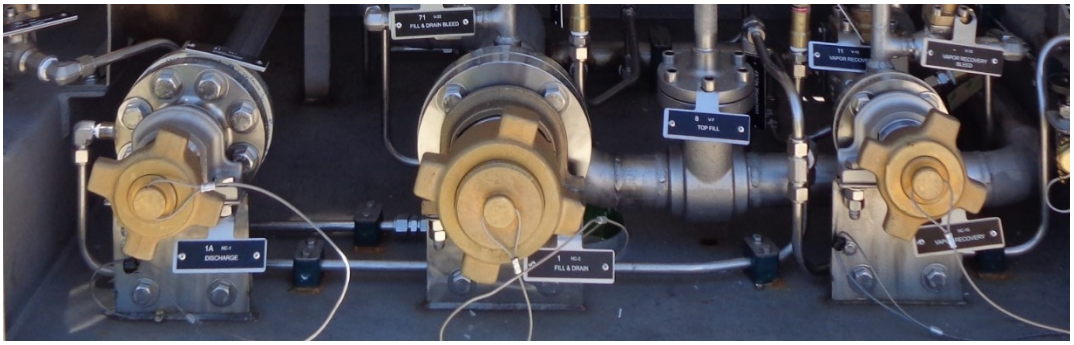
1. P.A.S.S Switch
2. Actuator Dump Valve
3. Anti-Tow Valve
4. Gauge Panel
5. Primary Inner Vessel Relief
6. Secondary Inner Vessel Relief
7. Secondary Inner Vessel Relief
8. Jacket Vacuum Relief
9. Fill and Drain Fire Block Valve
10. Flow Meter Totalizer
11. Pump Recirculation Valve
12. Road Relief Regulator
13. Road Relief Valve

(continued)

14. Manual Vent Valve
15. PB Force Feed Valve
16. Fill and Drain Valve
17. Pump Suction Valve
18. Flow Meter Sensor
19. Lights On/Off
20. Pressure Building Valve
21. Pump Speed Control Dial
22. Full Trycock Valve
23. Cryo Pump
24. Fill and Drain Bleed Valve
25. Top Fill Valve
26. Vapor Recovery Valve
27. PB Outlet Valve
28. Thermocouple (Not Visible)
29. Vapor Recovery Relief Valve
30. Discharge Line Bleed Valve
31. Discharge Hose Connection
32. Fill and Drain Hose Connection
33. Vapor Recovery Hose Connection
34. Liquid Sample Connection
35. Low Pressure Connection
36. High Pressure Connection

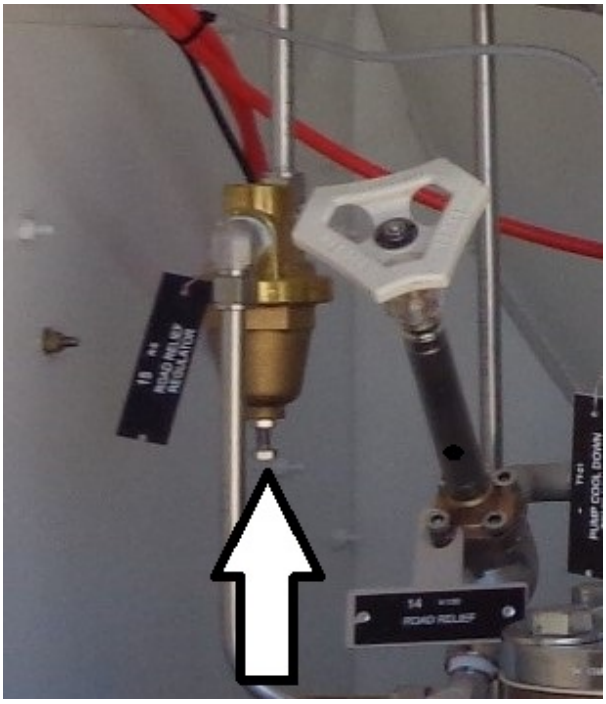
CGA Caps and plugs

All process piping openings and connections are equipped with CGA caps, plugs, or blind flanges. It is important to ensure all are in place during storage and transport to prevent contamination.



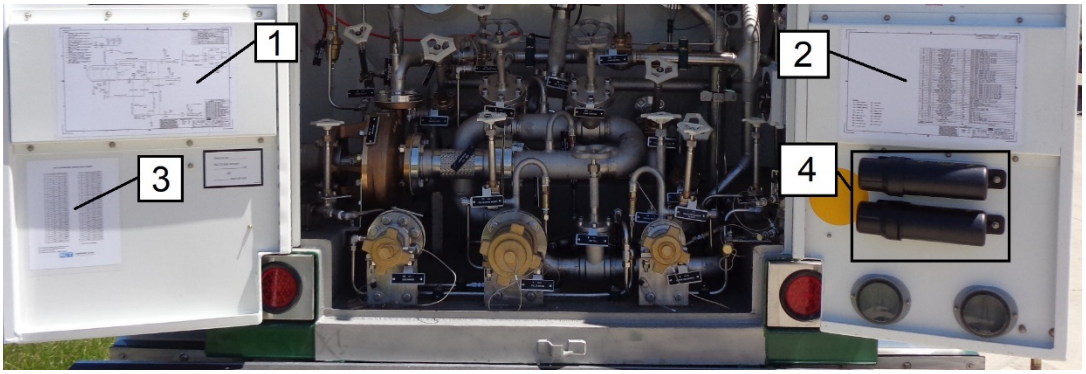
Road Relief Valve.

Unit ACT-LOX-060-038-HL-T-TD has a Road Relief Valve. Open the Road Relief Valve when the trailer is hauled on the highway. If a pressure is built up due to turbulence inside the vessel, Regulator will pop up to release the overpressure.



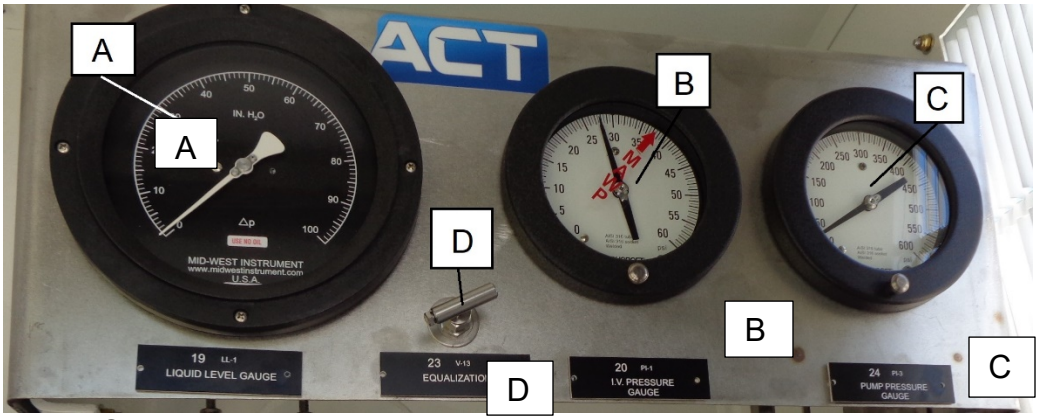
Schematics and Documents

On the Piping Cabinet Doors, the (1) Piping and (2) Identification Schematic, (3) Liquid Level Chart, and the (4) Document holders are installed.



IMPORTANT NOTE ABOUT LIQUID LEVEL GAUGE CALIBRATION

During normal use, the Equalization Valve remains closed and both the LP Isolation valve and the HP Isolation valve remain open. However, if the liquid level gauge becomes stuck, complete the following steps to reset the gauge.



1. Crack the equalizer gauge line valve.
2. Close the HP and LP isolation valves (at this point the gauge should reset).
3. Close the equalizer valve. Open the HP and LP isolation valves
   - **A.** Liquid Level Gauge
   - **B.** Tank Pressure Gauge
   - **C.** Pump Pressure
   - **D.** Equalization Valve

HP and LP isolation valves are located on the back of the gauge panel

Vacuum Test Port – The tank's vacuum can be read through the DV-6R TC Tube with a vacuum meter. The hook valve behind the thermocouple tube should always remain closed unless a test device is attached.

How to take a Vacuum Reading

1. Ensure vacuum gauge is working properly, by using a "test tube"
2. Connect meter to TC Tube.

3. Open isolation valve.
4. Wait 5 minutes for reading to stabilize.
5. Record reading. (A vessel with liquid should read below 10 microns)
6. Close isolation valve. Note: the reading should remain relatively the same. If the reading runs-out of range, then the TC tube is leaking.

Use a Hastings HPM 4/6 and Digivac 100H to read the Hastings TC Tubes.

WARNING: if a unit is losing vacuum without a gauge; first, the unit will not maintain pressure, it will constantly build pressure. Second, it would begin to sweat, and then ice up around the support areas.

Tank Cool Down Procedure

When a cryogenic tank is cooled down to be put into service the thermal gradient (change in temperature) can be as high as 420˚ F. When this occurs, the vessel shrinks both in length and diameter. A trailer inner vessel can shrink as much as 2-3 inches in length.

WARNING: Equipment damage can result when filling a warm vessel. To avoid thermally shocking the inner vessel it must be cooled down gradually and uniformly to prevent damage to the supports and or piping.

WARNING: Prior to filling or off-loading always check to make sure both tanks have the same Placards, decals and CGA connections.

WARNING: During the cool down process make sure the tank pressure stays well below the tank MAWP. Introducing a cryogen into a warm vessel can cause catastrophic over-pressurization (liquid boils faster than the resulting vapor can exit through the vent or relief valves).

WARNING: Make sure the Dew Point of warm vessel is acceptable prior to cooling down.

FILLING LEVEL: The ACT-LOX-060-038-HL-T-TD is equipped with a 95% Trycock valve that indicates when maximum fill level is reached.

WARNING: Exceeding this fill level could result in a catastrophic equipment failure resulting in severe bodily injury or death.

Vapor Purging:

1. Connect one end of the transfer hose to a Nitrogen vapor supply and the other end to the or Fill & Drain Connection.
2. Open valve on Nitrogen vapor supply source.
3. Open Fill & Drain Bleed Valve and purge transfer hose for 1 minute. Close bleed valve.
4. Open the Manual Vent Valve and blow vessel down. To avoid atmospheric back-contamination do not let the pressure drop below 5 psi.
5. Slowly and partially open Fill & Drain Valve**.** If pressure is rising too high, choke down on the Fill & Drain Valve**.**
6. As the tank cools, you can throttle back on the Manual Vent Valve**.** (Monitor tank MAWP and adjust Manual Vent Valve accordingly).
7. Continue cool down purging until you observe the vent stack frosting up. (This could take 15 minutes to an hour).

Liquid:

8. Connect one end of the transfer hose to a Nitrogen liquid supply and the other end to the Fill & Drain Connection**.**
9. Open Trycock Valve.
10. Barley open the Top Fill Valve allowing liquid to spray down from the header cooling the tank uniformly. Close the Top Fill Valve if the pressure begins to spike.
11. Gradually open the Top Fill Valve further as you determine the pressure is not increasing.
12. You can now begin to open the Fill & Drain Valve**.**
13. Operate the Top Fill Valve**,** Fill & Drain Valve, and the Manual Vent Valve to achieve the desired pressure.

Top Fill: **Will reduce tank pressure**

Bottom Fill: **Will increase tank pressure**

14. When the Tryock Valve begins to spit, terminate filling.
15. Close the discharge Valve on the supplier tank.
16. Close the Fill & Drain Valve.
17. Close the Top Fill Valve.
18. Slightly open the Fill & Drain Bleed Valve to release any pressure on the line, and then close it.
19. Close the Trycock Valve.

General recommendations when **Off Loading** LOX from the ACT-LOX-060-038-HL-T-TD

- See the schematic chart to locate the instruments named in these transfer methods.
- When transferring LOX to a receiving tank, the Vent Valve on receiving tank must be always open, to prevent over pressure.
- It is recommended that the Pump Recirculation Valve be partially open when operating the C-Pump (stabilize the pressure.)
- Always monitor the vessel pressure when off-loading.
- Every time the Cryogenic pump will be used, this must be cold down prior to offload or unload LOX.
- All valves must remain closed except the ones named in this procedure.

Off Loading Procedure

There are 2 possible ways to transfer LOX from the ACT-LOX-060-038-HL-T-TD to a trailer/customer tank.

• Basic Pressure Transfer
• Cryogenic Pump transfer (**NOTE:** When using C-Pump always cool it down prior operating)

WARNING: Verify that the receiving vessel is functioning properly and has the proper safety relief valves and check valves and components.

WARNING: Verify that the pressure of the receiving vessel is lower than the ACT-LOX-060-038-HL-T-TD (25 psi minimum).

Basic Pressure Transfer

This is the most basic way to transfer LOX. The ACT-LOX-060-038-HL-T-TD will use the pressure differential applied by the level differential. Verify that the receiving vessel is functioning properly and has the proper safety relief valves and check valves and components. The pressure of the receiving vessel must be lower than the ACT-LOX-060-038-HL-T-TD (25 psi minimum).

1. Prior to connecting the transfer hose check to make sure the CGA cap is not pressurized by slightly opening the Fill & Drain Bleed Valve and then closing it.
2. Connect one end of the transfer hose to the Top Fill connection in receiving tank and the other end to the Fill and Drain Line Connection.
3. Open the Pressure Building Valve to reach desired tank pressure (not to exceed 38 psi).
4. Purge receiver transfer hose if necessary.
5. Open Fill & Drain Valve and open the Fill & Drain Bleed Valve for a few seconds to bleed vapor from the Fill & Drain line**.**
6. Open the Fill and Drain Valve from the receiving vessel.
7. Monitor tank pressure during off-load.
8. Once desired liquid level is achieved close Fill & Drain Valve, close Fill and Drain Valve from the receiving vessel, close the Pressure Building Valve**.**
9. Open the Fill & Drain Bleed Valve slowly to vent the Fill Hose after off-loading to relieve any pressure.

Cryogenic Pump Transfer

In this mode, The ACT-LOX-060-038-HL-T-TD will use a Cryogenic Pump hydraulically driven to transfer LOX to a receiving tank. Hydraulic lines from tractor must be connected to front fittings on the tank, to pump hydraulic oil and drive the Cryogenic Pump.

Operations with Cryogenic Pump

Pre-operation Requirements:

1. Dump Valve must be in ON position.
2. Pump speed control must be all the way counterclockwise.

3. Connect one end of the transfer hose to the Top Fill connection in receiving tank and the other end to the Discharge Line Hose Connection.

Pump Cool Down/Recirculation

1. Open Pump Suction Valve.
2. Open Pump Recirculation Valve.
3. Wait until pump pipe and pump casing get frozen.
4. Close Pump Recirculation Valve then open one complete turn to get primed.

RECIRCULATION TO PRIME (Piping Cabinet)

Once this procedure is complete, Pump is ready to off load LOX to a receiving tank.

1. Purge receiver transfer hose if necessary.
2. Open Discharge Valve slowly.
3. Close Recirculation Valve.
4. Open the Discharge Line Bleed Valve for a few seconds to bleed vapor from the discharge line.
5. Open Fill and Drain Valve on the receiving tank.
6. Once desired liquid level is achieved, slow down C-Pump speed control all way out.
7. Open Pump Recirculation Valve.
8. Close Discharge Valve.
9. Close Fill and Drain Valve on the receiving tank.
10. Close Pump Suction Valve**.**
11. Close Pump Recirculation Valve**.**

Fill Procedure

When on Loading the ACT-LOX-060-038-HL-T-TD, Manual Vent Valve must be always open to prevent over pressure.

Basic Pressure Fill Procedure

The pressure of the ACT-LOX-060-038-HL-T-TD must be lower than the supplier tank (25 psi minimum).

1. Prior to connecting the transfer hose check to make sure the CGA cap is not pressurized by slightly opening the Fill Line Bleed Valve and then closing it.
2. Connect one end of the transfer hose to the discharge line in the supplier tank and the other end to the Fill and Drain Line Connection.
3. Open the discharge valve in supplier tank. Open the Fill Line Bleed Valve for a few seconds to bleed vapor from the line
4. Slowly open the Top Fill Valve.
5. Monitor tank pressure during on-load.
6. Once desired liquid level is achieved close Discharge Valve in the supplier tank. Close Top Fill Valve.

7. Open the Fill Line Bleed Valve slowly to vent the Fill Hose after off-loading to relieve any pressure.
8. Close Manual Vent Valve.

General Maintenance

WARNING: The ACT-LOX-060-038-HL-T-TD is designed for LOX cryogenic service. Many of the components and materials are regulated and are designed for LOX cryogenic service. Design modifications to this piece of equipment could result in catastrophic failure resulting in severe bodily injury or death. Using replacement parts not designed for LOX cryogenic service could result in catastrophic failure resulting in severe bodily injury or death.

WARNING: Only trained Operators and Mechanics familiar with LOX Cryogenic equipment should perform maintenance tasks.

Required maintenance usually becomes apparent during inspection, before a routine fill, observations during and after a fill. Proper and immediate action to correct any damage or malfunction is advised. Persons making repairs to piping, valves, and gauges should be fully familiar with cleanliness requirements for components. All parts to be kept clean for oxygen service.
In order to maintain the ACT-LOX-060-038-HL-T-TD in safe, good operating condition, certain system components must be inspected on a periodic basis.

PERIODIC INSPECTION

Prior to Each Operation:

- Inspect for loose or damaged piping connections.
- Check for potential obstructions on the vent stack that could block exiting vapor.

Every Three Months:

- Inspect Outer Vessel for possible cracks or corrosion. This could lead to a loss of vacuum and should be addressed by a qualified repair facility.
- Inspect Liquid Level and Pressure Gauges for possible malfunction

Every Six Months:

- Visually inspect all components of the system (pipe and tubing connections, electrical connections).
- Clean, repair and replace all parts as necessary

Suspension, ABS, Alignment, Wheel Ends, Tire Inflation:
The ACT-LOX-060-038-HL-T-TD comes with a Hendrickson-Intraax suspension and a Hendrickson Tiremaax Inflation System. The Period Inspection requirements for Hendrickson are included in this manual.

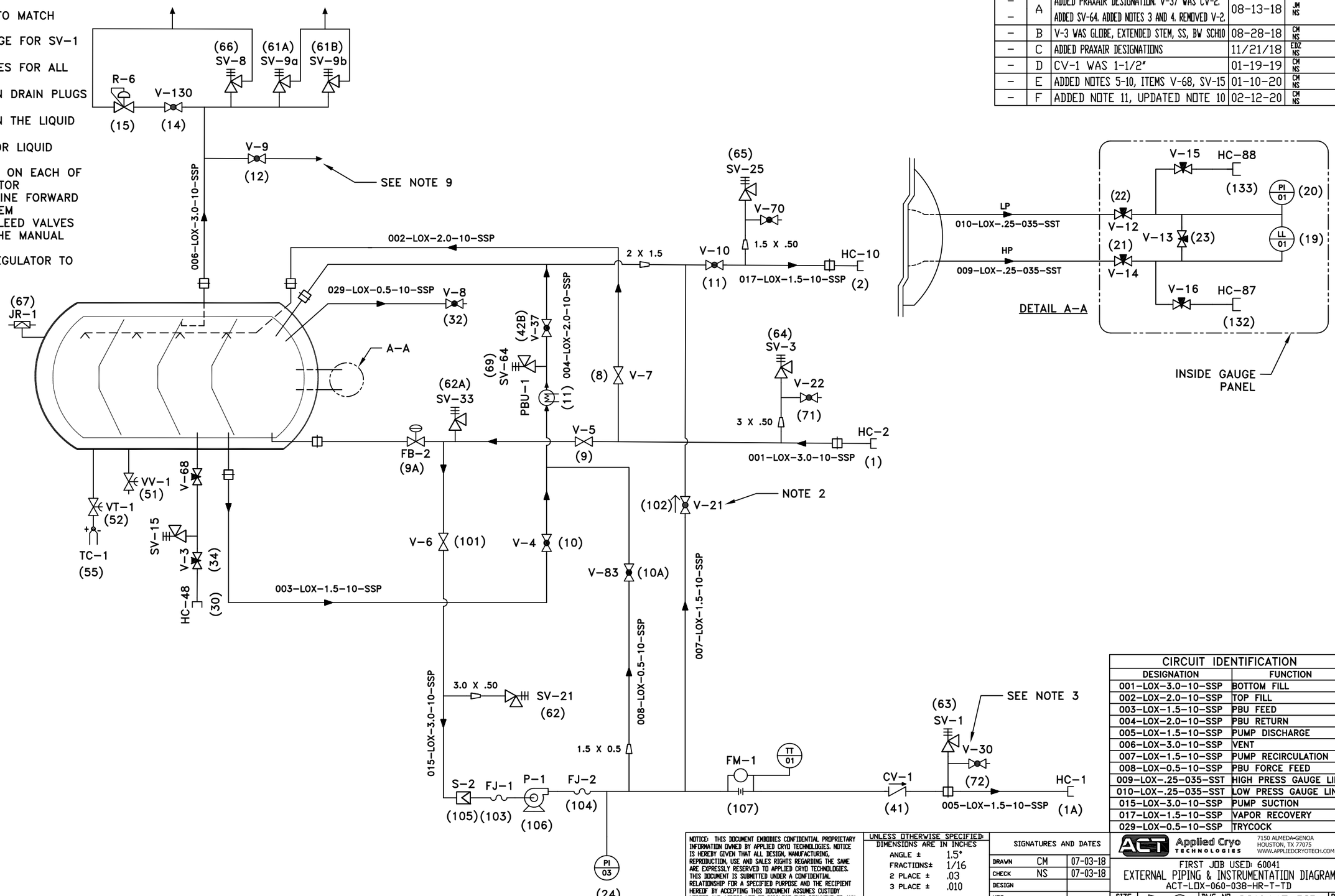
WARNING: The Hendrickson Periodic Maintenance requirements indicated in this manual must be followed to ensure safe, reliable operation.

Unit Specific Schematics and Diagrams

This section herein includes all schematics of the Piping & Identification, Electrical, ABS and Hydraulics. All to assist the operator in creating an understanding of the ACT-LOX-060-038-HL-T-TD.

NOTES:
1. TRYCOCK TO BE PIPED THROUGH THE DRIP PAN.
2. VALVE ORIENTATION TO MATCH SCHEMATIC
3. DRILL AND TAP FLANGE FOR SV-1 (63) & V-30 (72)
4. INSTALL 150# FLANGES FOR ALL CGA CONNECTIONS
5. DRILL 1/4" HOLES IN DRAIN PLUGS ON VENT LINE
6. DRILL 1/8" HOLES IN THE LIQUID SAMPLE PLUG
7. USE 1/4" TUBING FOR LIQUID SAMPLE
8. INSTALL PIPE UNIONS ON EACH OF ROAD RELIEF REGULATOR
9. PIPE MANUAL VENT LINE FORWARD AHEAD OF THE TANDEM
10. ALL SAFETIES AND BLEED VALVES TO BE ROUTED TO THE MANUAL VENT STACK
11. PIPE ROAD RELIEF REGULATOR TO THE VENT STACK

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE	07-03-18	CM NS
- -	A	ADDED PRAXAIR DESIGNATION. V-37 WAS CV-2. ADDED SV-64. ADDED NOTES 3 AND 4. REMOVED V-2.	08-13-18	CM NS
-	B	V-3 WAS GLOBE, EXTENDED STEM, SS, BW SCH10	08-28-18	CM NS
-	C	ADDED PRAXAIR DESIGNATIONS	11/21/18	EDZ NS
-	D	CV-1 WAS 1-1/2"	01-19-19	CM NS
-	E	ADDED NOTES 5-10, ITEMS V-68, SV-15	01-10-20	CM NS
-	F	ADDED NOTE 11, UPDATED NOTE 10	02-12-20	CM NS



CIRCUIT IDENTIFICATION	
DESIGNATION	FUNCTION
001-LOX-3.0-10-SSP	BOTTOM FILL
002-LOX-2.0-10-SSP	TOP FILL
003-LOX-1.5-10-SSP	PBU FEED
004-LOX-2.0-10-SSP	PBU RETURN
005-LOX-1.5-10-SSP	PUMP DISCHARGE
006-LOX-3.0-10-SSP	VENT
007-LOX-1.5-10-SSP	PUMP RECIRCULATION
008-LOX-0.5-10-SSP	PBU FORCE FEED
009-LOX-.25-035-SST	HIGH PRESS GAUGE LINE
010-LOX-.25-035-SST	LOW PRESS GAUGE LINE
015-LOX-3.0-10-SSP	PUMP SUCTION
017-LOX-1.5-10-SSP	VAPOR RECOVERY
029-LOX-0.5-10-SSP	TRYCOCK

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
ANGLE ± 1.5°
FRACTIONS± 1/16
2 PLACE ± .03
3 PLACE ± .010

SIGNATURES AND DATES		
DRAWN	CM	07-03-18
CHECK	NS	07-03-18
DESIGN		
MFG		
Q.A.		
APPROVED	NS	07-03-18

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HOUSTON, TX 77075
WWW.APPLIEDCRYOTECH.COM

FIRST JOB USED: 60041
EXTERNAL PIPING & INSTRUMENTATION DIAGRAM
ACT-LOX-060-038-HR-T-TD

SIZE	DWG. NO.	REV
B	CS10445-PIP	F

WEIGHT	#	SCALE	-	SHEET	1	OF	2

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE	07-03-18	CM NS

PRAXAIR DESIGNATION	DESIGNATION	FUNCTION	SIZE	DESCRIPTION
51	VV-1	MAIN VACUUM VALVE	1-1/2"	VALVE, DIAPHRAM, FNPT
52	VT-1	THERMOCOUPLE ISOLATION VALVE	1/8"	VALVE, BELLOWS, NPT, SEALED
14	V-130	ROAD RELIEF VALVE	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
10A	V-83	PB FORCE FEED	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
–	V-70	VAPOR RECOVERY BLEED VALVE	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
–	V-68	LIQUID SAMPLE ISOLATION VALVE	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
42B	V-37	PB OUTLET VALVE	2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
72	V-30	DISCHARGE LINE BLEED VALVE	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
71	V-22	FILL & DRAIN BLEED VALVE	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
102	V-21	PUMP RECIRCULATION VALVE	1-1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
–	V-16	HIGH PRESSURE VALVE	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
–	V-15	LOW PRESSURE VALVE	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
21	V-14	HIGH PRESSURE ISOLATION VALVE	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
23	V-13	EQUALIZATION VALVE	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
22	V-12	LOW PRESSURE ISOLATION VALVE (REAR)	1/4"	VALVE, NEEDLE, SS, TUBE X TUBE
11	V-10	VAPOR RECOVERY VALVE	1-1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
12	V-9	MANUAL VENT VALVE	1-1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
32	V-8	FULL TRYCOCK VALVE (LOX)	1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
8	V-7	TOP FILL VALVE	2"	VALVE, GATE, EXTENDED STEM, SS, BW SCH10
101	V-6	PUMP SUCTION VALVE	3"	VALVE, GATE, EXTENDED STEM, SS, BW SCH10
9	V-5	FILL & DRAIN VALVE	3"	VALVE, GATE, EXTENDED STEM, SS, BW SCH10
10	V-4	PRESSURE BUILDING VALVE	1-1/2"	VALVE, GLOBE, EXTENDED STEM, SS, BW SCH10
34	V-3	LIQUID SAMPLE VALVE	1/2"	VALVE, NEEDLE, SS, TUBE X TUBE, SWAGELOK
–	TT-01	PUMP COOL DOWN TEMPERATURE SENSOR	1/2"	SENSOR, TEMP, RTD, MNPT, PROVIDED W/ FM-1
55	TC-1	HASTINGS THERMOCOUPLE	N/A	THERMOCOUPLE, DV-6S
69	SV-64	PB OUTLET RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
62A	SV-33	FILL AND DRAIN RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
65	SV-25	VAPOR RECOVERY RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
62	SV-21	PUMP SUCTION RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
–	SV-15	SAMPLE RELIEF VALVE	1/4"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
61A	SV-9a	SECONDARY INNER VESSEL RELIEF VALVE	2" X 2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 42 PSI, MNPT
61B	SV-9b	SECONDARY INNER VESSEL RELIEF VALVE	2" X 2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 42 PSI, MNPT
66	SV-8	PRIMARY INNER VESSEL RELIEF VALVE	2" X 2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 38 PSI, MNPT
64	SV-3	FILL & DRAIN RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 100 PSI, MNPT
63	SV-1	DISCHARGE RELIEF VALVE	1/2"	VALVE, RELIEF, THERMAL, NO WEEP, SET @ 450 PSI, MNPT
105	S-2	PUMP SUCTION STRAINER	3"	STRAINER, CONE, MONEL 40 MESH SCREEN, COMPRESSION
15	R-6	ROAD RELIEF REGULATOR	1/2"	REGULATOR, PRESSURE, SET @ 15 PSI
24	PI-3	PUMP PRESSURE GAUGE	1/4"	GAUGE, PRESSURE, 4-1/2" DIAL, 0-600 PSI, MNPT
20	PI-1	INNER VESSEL PRESSURE GAUGE	1/4"	GAUGE, PRESSURE, 4-1/2" DIAL, 0-60 PSI, MNPT
11	PBU-1	PRESSURE BUILDING UNIT	1-1/2" X 2"	TANK PRESSURE BUILDER
106	P-1	CRYO PUMP	3.0" X 1.5" X 10.5"	PUMP, CENTRIFUGAL, HYDRAULIC DRIVEN
19	LL-1	LIQUID LEVEL GAUGE	1/4"	GAUGE, PRESSURE DIFF, 6" DIAL, 0-100 W.C., FNPT
67	JR-1	JACKET VACUUM RELIEF	7"	RELIEF, O-RING
133	HC-88	LOW PRESSURE CONNECTION	1/4"	CONNECTOR, QUICK CONNECT, MNPT
132	HC-87	HIGH PRESSURE CONNECTION	1/4"	CONNECTOR, QUICK CONNECT, MNPT
30	HC-48	SAMPLE CONNECTION	–	CGA 540
2	HC-10	VAPOR RECOVERY HOSE CONNECTION	1-1/2"	FIXED END, LOX CGA
1	HC-2	FILL & DRAIN HOSE CONNECTION	3"	FIXED END, LOX CGA
1A	HC-1	DISCHARGE HOSE CONNECTION	1-1/2"	FIXED END, LOX CGA
107	FM-1	DISCHARGE FLOW METER	2" TUBE	METER, FLOW, TURBINE
104	FJ-2	FLEX JOINT	1-1/2"	HOSE, FLEX, SS, BRAIDED, #300
103	FJ-1	FLEX JOINT	3"	HOSE, FLEX, SS, BRAIDED, #150
9A	FB-2	FILL & DRAIN FIRE BLOCK VALVE	3"	VALVE, GATE, AIR, AIR ACTUATED, REMOTE CONTROLLED, SELF CLOSING SHUT OFF VALVE
41	CV-1	DISCHARGE CHECK VALVE	2"	VALVE, SPRING CHECK, SS, FLANGED, 300#, CHECK ALL

BOM

LEGEND:

= HOSE CONNECTION
= CONCENTRIC REDUCER
= FLANGED CONNECTION
= GLOBE VALVE
= CHECK VALVE
= FIRE BLOCK VALVE
= REGULATOR
= RUPTURE DISC
= FIRE BLOCK VALVE
= ACTUATED VALVE
= BALL VALVE
= STRAINER
= DIAPHRAGM VALVE
= NEEDLE VALVE
= THERMOCOUPLE
= RELIEF VALVE
= GATE VALVE
= ACTUATED VALVE
= FLOW METER

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
ANGLE ± 1.5°
FRACTIONS± 1/16
2 PLACE ± .03
3 PLACE ± .010

SIGNATURES AND DATES		
DRAWN	CM	07-03-18
CHECK	NS	07-03-18
DESIGN		
MFG		
Q.A.		
APPROVED	NS	07-03-18

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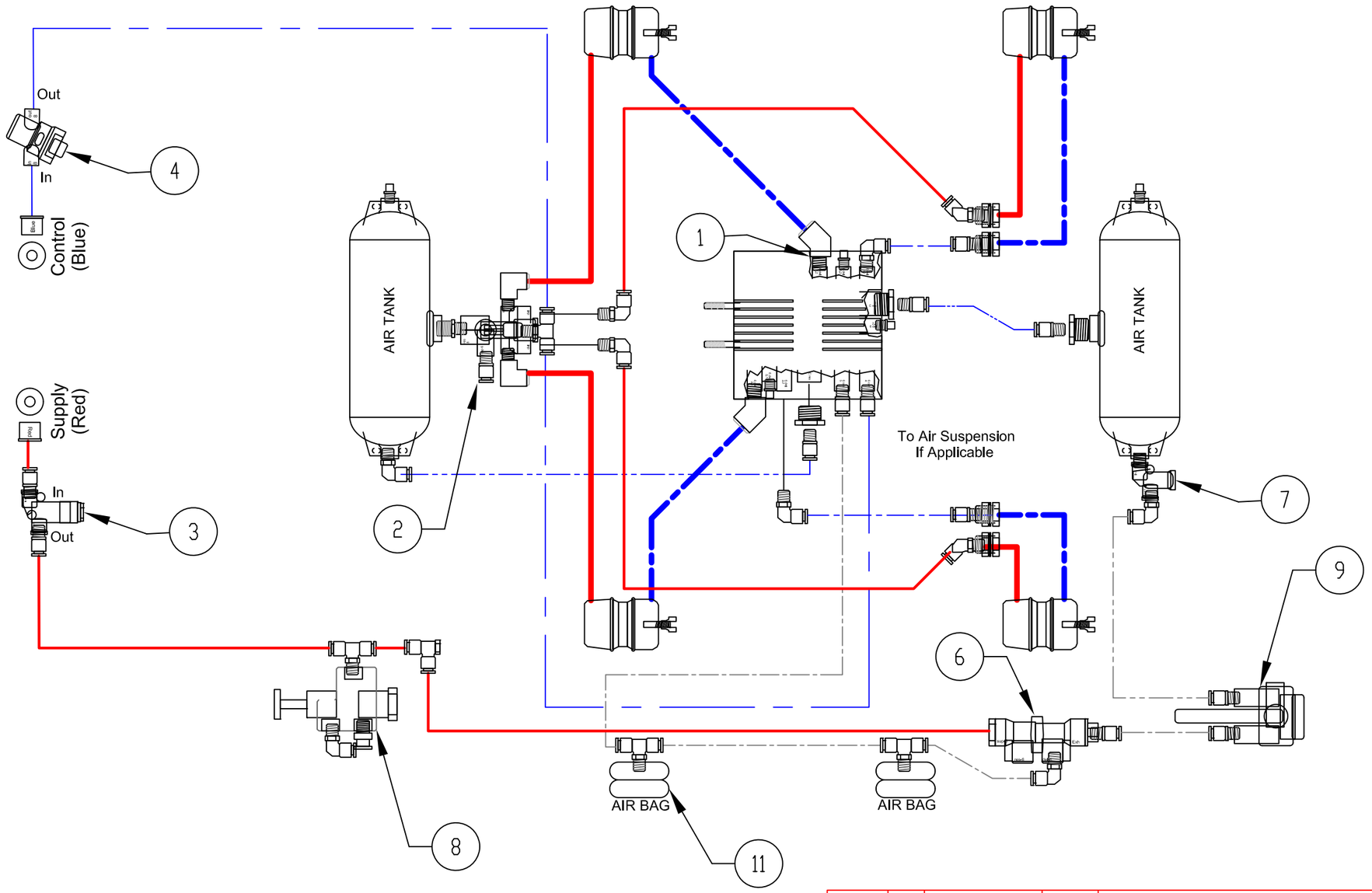
FIRST JOB USED: 60041
EXTERNAL PIPING & INSTRUMENTATION DIAGRAM
ACT-LOX-060-038-HR-T-TD

SIZE	DWG. NO.	REV
B	CS10445-PIP	F

WEIGHT	#	SCALE	–	SHEET	2	OF	2

NOTES:
1. **REFER TO SPECIFICATION FOR ACTUAL CONFIGURATION**

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE	07-25-18	CM NS



-	-		-	SEE SHEET 2 FOR PARTS

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
ANGLE ± 1.5°
FRACTIONS± 1/16
2 PLACE ± .03
3 PLACE ± .010

SIGNATURES AND DATES		
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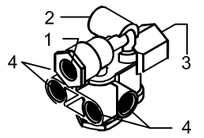
ABS SCHEMATIC
STANDARD, TWO AXLE

SIZE	DWG. NO.	REV
B	CS10450	-

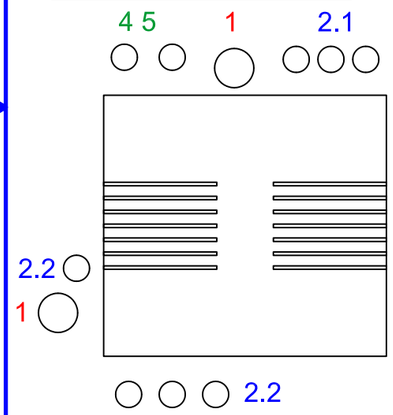
WEIGHT	#	SCALE	-	SHEET	1	OF	2

ZONE	REV	DESCRIPTION	DATE	APPROVED
-	-	INITIAL RELEASE	07-25-18	CM NS



1 Control Port (3/8)
2 Supply Port (3/8)
3 Reservoir Port (3/8)
4 Delivery Ports (3/8)

Port #	Description
1	Reservoir Ports (3/4)
2.1	Delivery Ports (3/8)
2.2	Delivery Ports (3/8)
4	Control Port (3/8)
5	Suspension Port (3/8)



1 Inlet (1/2)
2 Outlet (1/2)

ITEM NO.	SIZE	PART NO.	QTY	DESCRIPTION
11	-	———		AIR BAG
10	-	———		BREAK CHAMBER
9	-	———		HEIGHT CONTROL VALVE
8	-	———		ANTI-TOW TRIGGER VALVE
7	-	———		PRESSURE PROTECTION VALVE
6	-	———		EXHAUST VALVE
5	-	———		NOT USED
4	-	———		005 0 CONTROL LINE FILTER
3	-	———		SUPPLY LINE FILTER
2	-	———		SPRING BRAKE VALVE
1	-	———		ABS BRAIN

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
ANGLE ± 1.5°
FRACTIONS± 1/16
2 PLACE ± .03
3 PLACE ± .010

SIGNATURES AND DATES		
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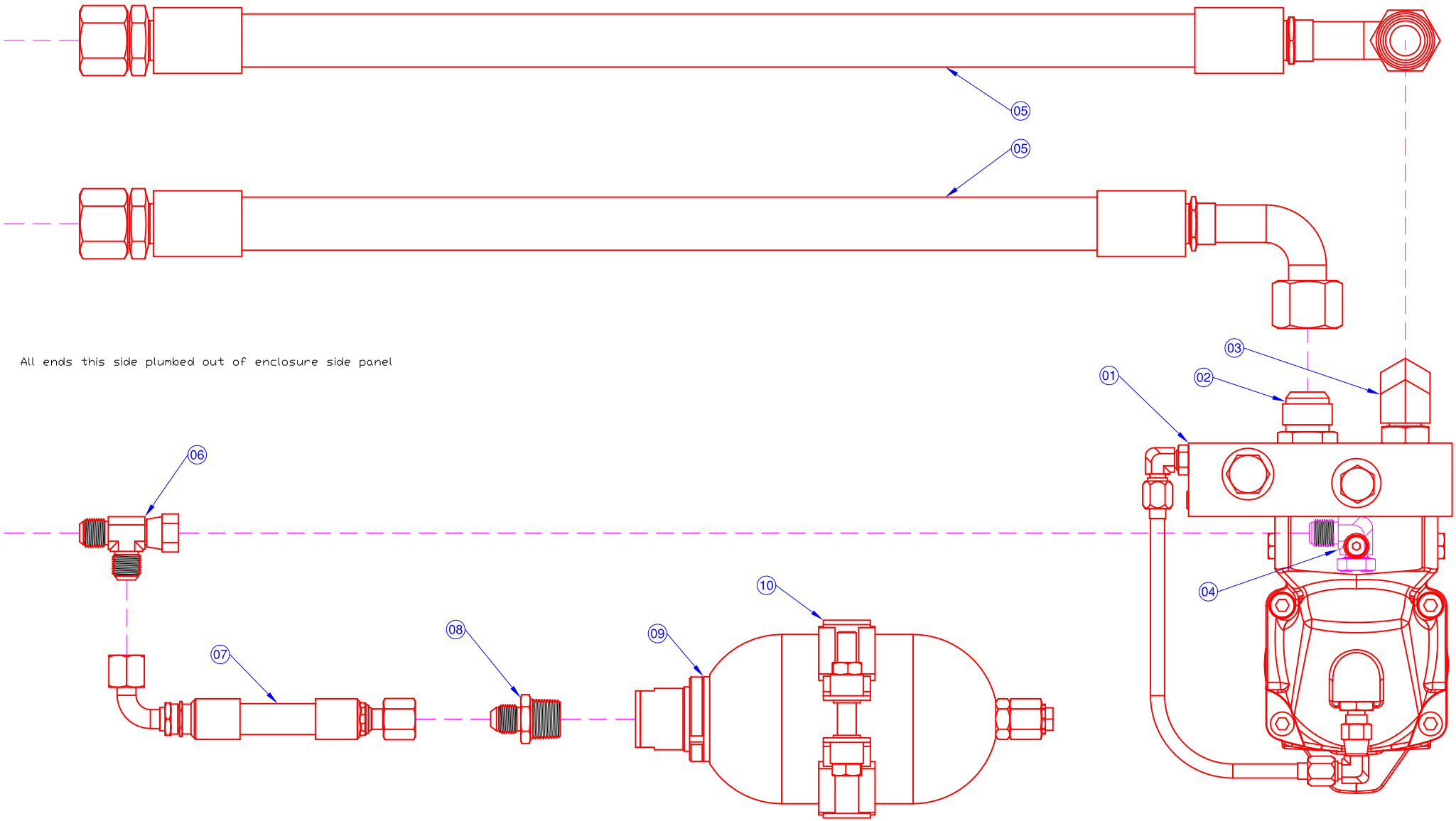
ABS SCHEMATIC
STANDARD, TWO AXLE

SIZE	DWG. NO.	REV
B	CS10450	-

WEIGHT	#	SCALE	-	SHEET	2	OF	2



NUM	PART	PARTNO	QTY
01	F12-30 Loop Flush Motor Package	11098018-KT-INST	1
02	Straight Fitting: -12MORBx-16MJ	6400-16-12-O	1
03	Elbow Fitting: -12MAORBx-16MJ	6801-16-12-O-FG	1
04	Elbow Fitting: -08MAORBx-08MJ	6801-08-08-O-FG	1
05	1" Hose Assembly	GHI95-16x36"	2
06	Tee Fitting: -08MJx-08MJ-08FJS	6602-08-08-08-FG	1
07	1/2" Hose Assembly	GHI95-8-15"	1
08	Straight Fitting: -08MJx-12MP	2404-08-12	1
09	Accumulator	A1QT3100	1
10	Mounting Bracket	AI-1QT-511	1

Fitzsimmons Hydraulics, Inc.
4400 Shisler Road, Clarence, New York 14031

F12 Loop Flush Motor Package Installation Diagram

Drafted by:	Approved by:	Size:	Sheet:	Date:	Rev:
D. Hale	--------	A	1 of 1	04/22/2015	-

Drawing Number: HS180730MP

Trouble Shooting Guide

Use the Troubleshooting table as a guideline to diagnose your ACT-LOX-060-038-HL-T-TD should problems develop.

WARNING: This table cannot replace the knowledge that an experienced operator or cryogenic maintenance technician has and should be considered as a guide only.

Symptom	Possible Cause	Remedy
Leaking Valve, Tube fitting, Pipe Connection	Loose connection	Tighten flanges, valves, valve nuts, tube fittings as needed, replace worn out parts (Gaskets, bonnets, etc.) as needed.
Unable to hold vacuum (High micron reading, excessive venting, cold spots)	Jacket safety O-rings needs replacing	Replace O-ring
	Vacuum valve is open	Close Vacuum Valve
	Hoke valve is leaking	Replace Hoke Valve
	External Piping leak	Soap/pressure test and repair accordingly
	jacket breach	Contact ACT immediately
	Excessive venting	Contact ACT immediately
	Inner vessel leak	Contact ACT immediately
Unstable flow or low flow of product during off-load	Pressure differential between ACT-LOX-060-038-HL-T-TD and receiving tank is too low	Open pressure building feed valve on the ACT-LOX-060-038-HL-T-TD and/or open vent to lower pressure on supply tank to ensure pressure differential is 25 PSI
Unstable flow or low flow of product during filling	Pressure differential between ACT-LOX-060-038-HL-T-TD and supply tank is too low	Raise pressure on supply tanks and/or open vent to reduce the pressure on the ACT-LOX-060-038-HL-T-TD to ensure pressure differential is 25 PSI minimum.
Leaking Relief Valve	Relief Valve is not re-seating	Replace or repair Relief Valve
Tank pressure above tank MAWP (57 psi)	Faulty Inner Vessel Main Safeties	Vent Tank immediately. Contact ACT.
Gauges are not reading correctly	Liquid Level Gauge dial is stuck	Tap gauge, refer to page 17 of this manual to reset gauge
	leaking needle valve	Soap/ pressure test, tighten, repair accordingly
	Damaged gauge or needle valve	Replace gauge or needle valve.
Jacket safety Venting	Inner Vessel or annulus leak	Contact ACT immediately

Standard Warranty

Applied Cryo Technologies' Purchased Parts

Any equipment, components, parts or other goods not manufactured by Applied Cryo Technologies, Inc. ("***Seller***") are not warranted by Seller to any extent, but Seller shall use its commercially reasonable efforts to assign, to the extent that Seller is permitted to assign pursuant to the original manufacturer's warranty, to Buyer, without recourse, any warranties furnished to Seller by the vendors of such equipment, components, parts or other goods. If the original manufacturer of the goods subject to a claim by the purchaser does not permit the assignment of its warranty, then no warranty, express or implied, shall apply to such goods

Non-Conformities; Workmanship

Generally. Seller warrants new goods that Seller manufactures (but excluding equipment, accessories, equipment, components, parts, subassemblies and other component parts of such products, which are purchased from other vendors) purchased by the purchaser, as the original retail customer, shall be in compliance with Seller's standard specifications in effect at the time such goods are delivered to the purchaser or, for custom goods, with any specifications, design, drawings or descriptions for such goods agreed to by Seller. The purchaser's sole remedy for goods that do not comply with such warranty, shall be that Seller shall, at its option, (i) cure the defect, (ii) replace the goods, or (iii) refund the amount paid by the purchaser as the purchase price paid of the non-conforming goods. Seller warrants all goods to be free from defects in material and workmanship for TWO YEARS after the date of shipment.

ACT Cryogenic Equipment. With respect to ACT Cryogenic Equipment, Seller guarantees that the annulus space will not exceed 20 microns, when the inner vessel is cold (see tank cool down procedure) within FIVE YEARS after the date of shipment *provided* that the Vacuum Gauge Valve and/or the Evacuation Valve has not been misused, tampered with or disturbed, thus causing gas to bleed in and compromise the annulus space. Furthermore, the purchaser is advised that any misuse or abuse of the ACT Cryogenic Equipment resulting in over pressurization is dangerous and will void the foregoing workmanship and vacuum warranty. Should warranty be required the Transport Trailer will be repaired at the nearest Applied Cryo Technologies, Inc. Authorized Service Center, by the Buyer, or an Applied Cryo Technologies' Service Technician in the field at the manufacturer's discretion.

Claim Procedure

All Warranty Claims are to be requested in writing and previously authorized by Seller. Please send all requests to: Applied Cryo Technologies, Inc.

Attn. Warranty Claims Division
7150 Almeda Genoa
Houston, TX 77075

For expedited response, telephone approval is permitted by calling 281-888-3884, however, it must be followed by a corresponding warranty request in writing to Seller. Upon acceptance, Seller's Warranty Claims Division will issue an RMA (Return Merchandise Authorization) Number that is a claim tracking number required for all documentation, correspondence, and invoices sent to Applied Cryo Technologies Warranty claims Division for credit.

All warranty claims, documentation, and photographs (where applicable) submitted to Applied Cryo Technologies for credit must be submitted within 21 days of the date the purchaser receiving services rendered from approved vender and must include the RMA Number in order to be considered valid.

All warranty claims and corresponding invoices must be accompanied by an RMA Number before payment will be made by Seller. Vacuum Pumping of any units requires prior authorization from Seller and all procedures must be followed or the warranty will be void. Authorization must be obtained from Seller prior to shipment of any units to our location or any other repair facility for warranty work.

Warranty Exclusions

The foregoing warranties shall not apply to:

- any goods that have been repaired or altered by anyone other than Seller or Seller's authorized representative in such a way, in Seller's judgment, as to affect the goods adversely.
- any goods that have, in Seller's judgment, been subject to abuse, misuse, negligence, accident, improper storage, installation or application, shock; electrostatic discharge; heat or humidity beyond product specifications.
- any goods that have not been operated or maintained in accordance with the manufacturer's specifications and recommendations.
- any components, parts or accessories manufactured, warranted, or serviced by others.
- any used, reconditioned or previously owned goods.
- any damage due to continued use of the goods after partial failure of any item.
- any work performed or cost incurred by the purchaser or others, without Seller's express prior written Consent.
- any claim not reported promptly (in no event later than 10 days after discovery or one year after delivery, whichever is sooner).
- any cost of delays or freight charges.

- any cost of delays, freight charges, or excess costs for repairs made outside the continental United States, including incidental or consequential damages.
- any damages caused during shipment unless Seller expressly agrees in writing, in advance of shipment, to assume the risks of damage caused during shipment; or
- any goods that are considered expendable in nature and expire because of normal wear and tear.
- Expendable vacuum vitals (Jacket safety O-ring, hoke valve, thermocouple tube, vacuum valve)

Exclusive Remedy; No Other Warranty

THE REMEDIES PROVIDED ABOVE FOR BREACH OF THE WARRANTIES SET FORTH HEREIN ARE EXCLUSIVE. IN NO EVENT SHALL THE OBLIGATION OF SELLER TO REPLACE DEFECTIVE GOODS BE CONSTRUED TO REQUIRE SELLER TO REPAIR OR REPLACE MORE THAN THE ORIGINAL PURCHASE PRICE OF THE GOODS.

THE WARRANTIES SET FORTH ABOVE ARE EXCLUSIVE AND AE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, AND ALL OTHER REMEDIES OR LIABILITIES (WHETHER BY STATUTE, COMMON LAW OR IN CONTRACT, TORT OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, STRICT LIABILITY AND NEGLIGENCE, WHETHER OCCASIONED BY ACTS OR OMISSIONS OF SELLER, SELLER'S SOLE NEGLIGENCE OR CONCURRENT NEGLIGENCE). WITHOUT LIMITATION OF THE GENERALITY OF THE IMMEDIATELY PRECEDING SENTENCE, SELLER EXPRESSLY DISCLAIMS AND NEGATES (i) ANY IMPLIED OR EXPRESS WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR ANY PARTICULAR PURPOSE (ii) ANY IMPLIED OR EXPRESS WARRANTY OF DILIGENCE, (iii) ANY IMPLIED WARRANTY OF FREEDOM FROM PATENT OR COPYRIGHT INFRINGEMENT AND (iv) ANY OTHER IMPLIED WARRANTIES.