Aero ORB RTI Liquid Oxygen System

Operator's Manual

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OPERATOR'S MANUAL

Aero ORB RTI
LIQUID OXYGEN SYSTEM

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1. INTRODUCTION

1.1. Purpose

This manual contains the operation and maintenance instructions for the Aero ORB RTI (Ready to Install) Liquid Oxygen System. The 10 liter liquid oxygen system covered by this manual is for use on board helicopter and fixed wing aircraft to store oxygen in its liquid form and supply gaseous oxygen for patient therapy.

1.2. Scope

The operation and maintenance manual with the Aero ORB RTI consists of an operation and maintenance manual. The manual includes safety precautions, operating instructions, operational diagrams, troubleshooting procedures, and maintenance procedures. This manual will be provided with each delivered Aero ORB RTI.

2. SAFETY PRECAUTIONS

Read these instructions first.

Throughout this manual there will be three kinds of information with emphasis in the text. Carefully read and understand these notices. Each is important and related to the text following each notice.

WARNINGS
Warnings identify conditions that concern your personal safety and the safety of others. They include actions required to prevent injury or death.

CAUTIONS
Cautions identify conditions that may cause possible damage to the equipment or other property; or situations that may cause reduced, or loss of, oxygen flow. Ignoring cautions may cause damage or make the equipment inoperative.

Note:

Indicates points of particular interest or emphasis for more efficient and convenient operation.

2.1. Warnings

WARNINGS
Observe all safety precautions given here to assure safe and easy handling of cryogenic fluids. Failure to do so may cause serious injury or death.

The following precautions must be observed when handling liquid oxygen:

WARNINGS

Never allow liquid oxygen to contact the skin. The extreme low temperature of the liquid will immediately freeze any skin that it contacts and severe frostbite may result. If the skin is contacted by drops or splashes of liquid oxygen it will freeze skin tissue.

Never confine liquid oxygen in any piping or container without adequate safety devices. The pressure buildup when the liquid expands to gas will rupture most piping, tubing or containers. Never allow the system vent line/fitting to become obstructed. The vent line/fitting must remain open at all times.

Fifty feet has been established by the USAF as the safe distance criterion for oxygen equipment and any source of combustion. Oxygen gas will not burn but it supports combustion of any material that does burn. Do not allow smoking or other sources of flame within fifty feet of the Aero ORB RTI

Keep oxygen away from absorbent materials, loose clothing, or rags. These materials can trap gaseous oxygen and can later be easily ignited by a spark form a cigarette or match.

When liquid oxygen equipment is in use, keep in a well-ventilated area away from all gasoline, kerosene, oil, grease, and other hydrocarbons. There substances are not compatible with liquid oxygen. Spontaneous ignition upon contact with these substances may results. Oxygen is not flammable; however, it will support the rapid combustion of most materials. It reacts violently with the petroleum products listed above; oxygen must therefore be considered dangerous.

Insure the surrounding work area, tools, associated equipment, and clothing are clean as possible and free from oil, grease, gasoline, kerosene, and other hydrocarbons contaminants at all times.

The Aero ORB RTI should remain upright at all times when filled with liquid oxygen to avoid improper operation and excessive venting of oxygen.

Protective clothing and safety devices should be worn by personnel handling LOX during servicing of the Aero ORB RTI.

Only clean, dry, oil-free gaseous nitrogen will be used as a source for purging.

Never mix oxygen with other gases. Never use oxygen in a system intended for other gases.

3. EQUIPMENT DESCRIPTION

3.1. Aero ORB RTI

The Aero ORB RTI is a self-contained, 8600 gaseous liter capacity oxygen system which contains and stores oxygen in the form of 10 liters of liquid and supplies gaseous oxygen, on demand, at a flow rate up to 100 liters per minute at a temperature within 20°F of ambient. The Aero ORB RTI is shown in figure 1 and is illustrated in pictorial schematic form in Figure 2.

The nominal operating pressure of the Aero ORB RTI system is 70 psig. The incorporation of a pressure regulator in the supply line allows the system to supply oxygen at a pressure of 50 psig, the standard supply pressure for medical oxygen equipment.

Figure 1 – Aero ORB RTI Liquid Oxygen System

The Aero ORB RTI features a double-walled, vacuum insulated tank, a combination fill, buildup, vent valve, a pressure control valve, two pressure relief valves, a burst disc, a pressure regulator, a solenoid valve, and a contents gauge (accessory).

These components and their functions are described in further detail in the "components" section.

> **Note:**
>
> **The part number for the contents gauge is 50C-0048-10. The calibration of the contents gauge is depended on the length of the coaxial cables.**

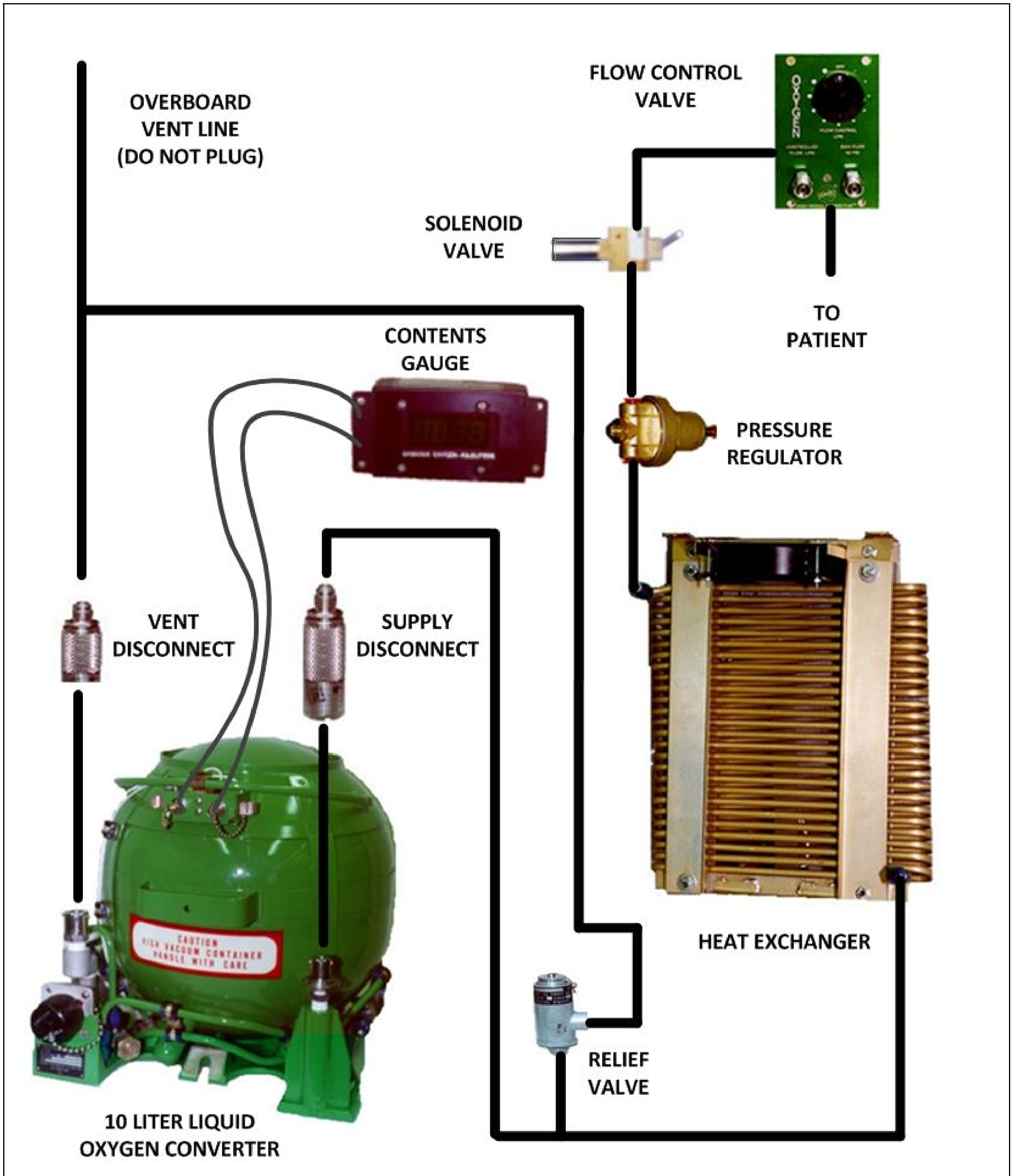

Figure 2 - Aero ORB RTI Pictorial Schematic

Table 3 presents the specifications of the Aero ORB RTI liquid oxygen system.

Table 3 – Liquid Oxygen System Specifications

Capacity:	
Liquid	10 Liters
Gas	8,600 Liters
Delivery Rate	0 to 100 Liters per Minute
Operating Pressure	70 PSIG
Delivery Pressure	50 PSIG
Pressure Relief Device Settings:	
Converter Relief Valve	100 – 120 PSIG
Supply Line Relief Valve	120 – 140 PSIG
Burst Disc	225 PSIG at 72° F
Overall Dimensions:	
Height	18.5 Inches
Width	16.0 Inches
Depth	18.5 Inches
Weight:	
Empty	50.0 Pounds
Full	75.0 Pounds
Electrical Power Requirement	28 VDC, 1.0 Amps Max

3.2. Properties of Liquid Oxygen

Liquid oxygen is pale blue, nonviscous, water like fluid. Liquid oxygen boils at -297ºF. At atmospheric pressure it is 1.14 times heavier than water and weighs 2.512 pounds per liter.

Oxygen is a very reactive material, combining with most of the chemical elements. The union of oxygen with another substance is known as oxidation. Extremely rapid or spontaneous oxidation is known as combustion. While oxygen is non-combustible, it strongly supports and rapidly accelerates the combustion of all flammable materials, some to an explosive degree.

Liquid oxygen, when converted to gaseous oxygen, expands to approximately 860 times its original volume. One liter of liquid oxygen expands to approximately 860 liters of gas at 70ºF (21ºC) and sea level pressure. Liquid to gas expansion at atmospheric pressure is:

Table 4 – Liquid to Gas Expansion

Liquid Oxygen (Liters) at -297°F (-183°C)	Gaseous Oxygen (Liters) at 70°F (21°C)
2	1720
4	3440
6	5160
8	6880
10	8600

3.3. Tools and Test Equipment

A list of support equipment recommended for maintaining the unit is contained in Table 5.

Table 5 – Special Tools and Test Equipment List

Tool/Equipment No.	Figure No.	Nomenclature	Use and Application
50C-0096-15	6	Filling Harness (less filler valve)	
20C-0021-2	7	Filler Valve	
10C-0059-0052	8	Fixture, Drain	
50C-0020-1	9	Vent cap	
50C-0068-2	10	Purge Kit, Converter System, Liquid Oxygen	
50C-0079-1	11	Drain Tube	
MIL-L-25567	N/A	Leak Detector	

Figure 6 – Filling Harness

Figure 7 – Filler Valve

Figure 8 – Drain Fixture

Figure 9 –Vent Cap

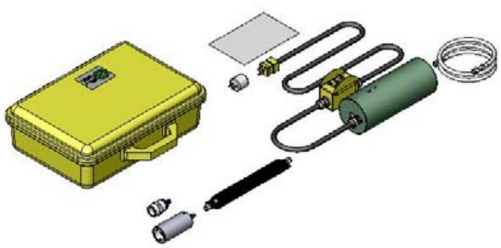

Figure 10 – Purge Kit

Figure 11 – Drain Tube

4. DESCRIPTION OF OPERATION

The Aero ORB RTI stores liquid oxygen in a spherical container. The oxygen is stored in its liquid form because liquid storage is less bulky than an equivalent volume of high pressure gaseous oxygen. Liquid oxygen expands at a ratio of 1 to 860 when it changes from a liquid to a gas at 70°F.

Liquid oxygen vaporizes at a temperature of -297°F. For this reason the containers of a liquid oxygen system are of double wall, vacuum insulated, "thermos" bottle type construction to minimize the influx of heat into the stored liquid oxygen.

The typical liquid oxygen system consists of the following major components as shown in schematic form in Figure 12.

a. Liquid Oxygen Container
b. Fill, Buildup, Vent Valve
c. Buildup Coil
d. Pressure Control Valve
e. Flow Modulator
f. Supply Heat Exchanger
g. Pressure Regulator
h. Solenoid Valve
i. Flow Control Oxygen Outlet
j. Pressure Relief Devices
k. Contents Gauging System

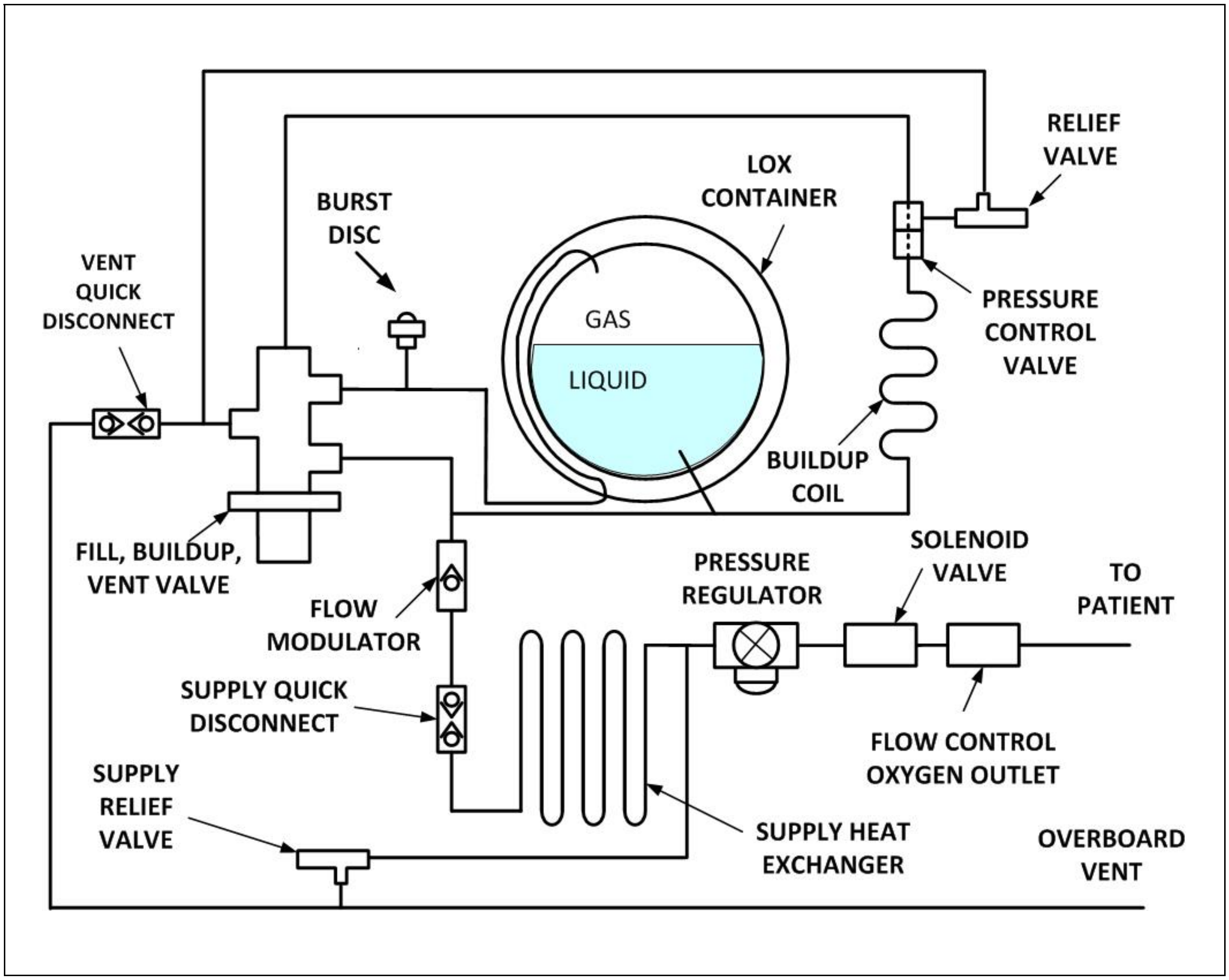

Figure 12 – LOX System Schematic

For the purposes of clarity, operation of the liquid oxygen system will be described in discrete modes: Fill mode, pressure buildup mode, operating mode, and pressure relief mode although the pressure buildup and operating modes occur simultaneously. These operating modes are illustrated in schematic form in Figure 13, 14, 15 and 16. In the Figures the blue color coded lines refer to liquid oxygen and the orange coded lines refer to gaseous oxygen.

Referring to Figure 13, to fill the system, the servicing valve is connected to the fill, buildup, vent valve. This automatically places the system in the fill mode allowing liquid oxygen to enter the system to fill the container and the gaseous oxygen displaced by the incoming liquid oxygen to be vented overboard.

The system is self-pressurizing. Disengagement of the servicing valve upon completion of filling automatically places the system in the pressure buildup mode. It is during the pressure buildup mode that the self-pressurizing process is accomplished.

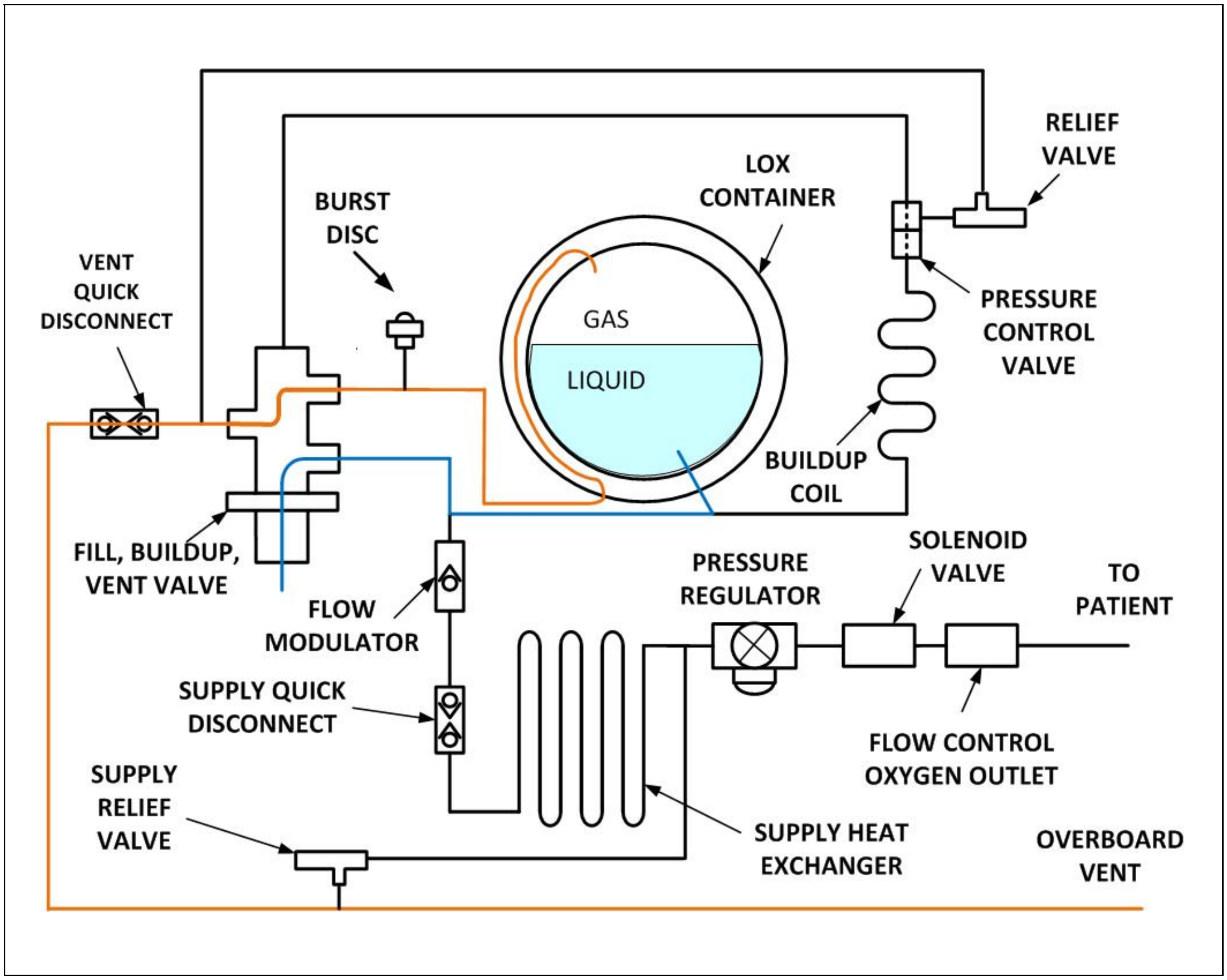

Figure 13 – Fill Mode Schematic

Referring to Figure 14, because of the pressure exerted by the head height of the liquid oxygen in the container, liquid oxygen will flow from the container into the buildup coil. The buildup coil is a liquid to air heat exchanger where heat from the surrounding air warms the boiling liquid oxygen and vaporizes it, thereby generating system operating pressure. This mode of operation continues until the nominal system operating pressure, 70 psig, is attained whereupon the pressure control valve closes. Closure of the pressure closing valve terminates liquid oxygen flow into the buildup coil so, since there is no more liquid oxygen in the buildup coil to vaporize, system pressurization ceases.

When the system pressure is reduced by the consumption of oxygen, the pressure closing valve reopens and pressure buildup resumes. This cycle is repeated until all the liquid oxygen in the container is expended.

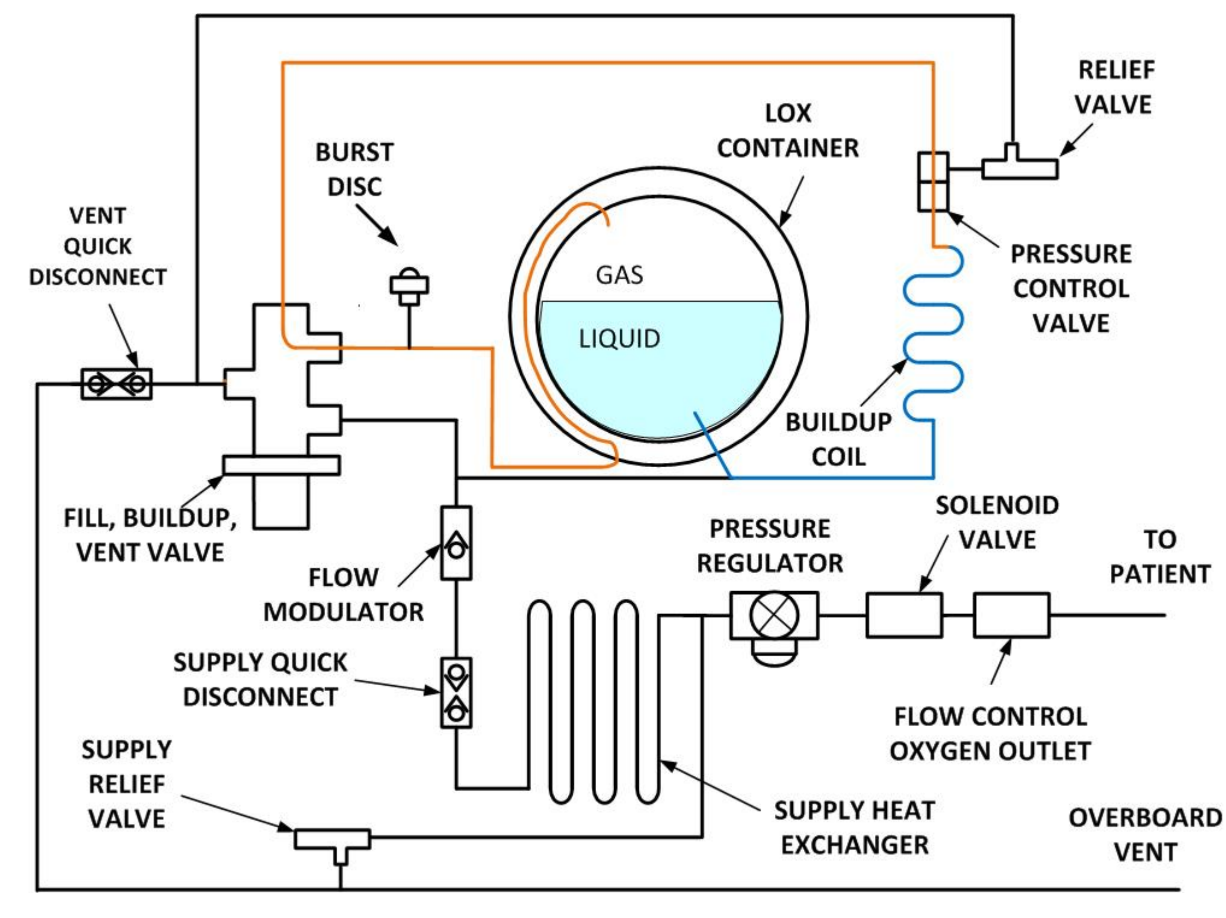

Figure 14 – Pressure Buildup Mode Schematic

The operating mode may be initiated any time after nominal system operating pressure has been attained. This will be a maximum of five minutes after filling.

During the operating mode liquid oxygen is driven from the container by system operating pressure and routed through the flow modulator into the supply heat exchanger. The supply heat exchanger is also a liquid to air heat exchanger. Its function is to introduce heat from the surrounding air into the liquid oxygen supply to vaporize the liquid oxygen and warm the resultant gaseous oxygen to near ambient temperature, which a patient can breathe.

It should be noted that the capacity of the heat exchanger is usually the driver establishing the maximum flowrate from a liquid oxygen system. A liquid oxygen system can typically flow several times its maximum rated flow but the temperature of the output gas would be too cold to serve a useful purpose. So, the design of the supply heat exchanger is one of the more critical elements in the design of a liquid oxygen system. The usual criterion for the performance of the supply heat exchanger is it must vaporize and warm the oxygen gas supply stream to within 20°F of ambient temperature when the system is flowing at its maximum rated capacity. A fan has been added to this system to enable the heat exchanger to flow 100 lpm of oxygen gas under these conditions.

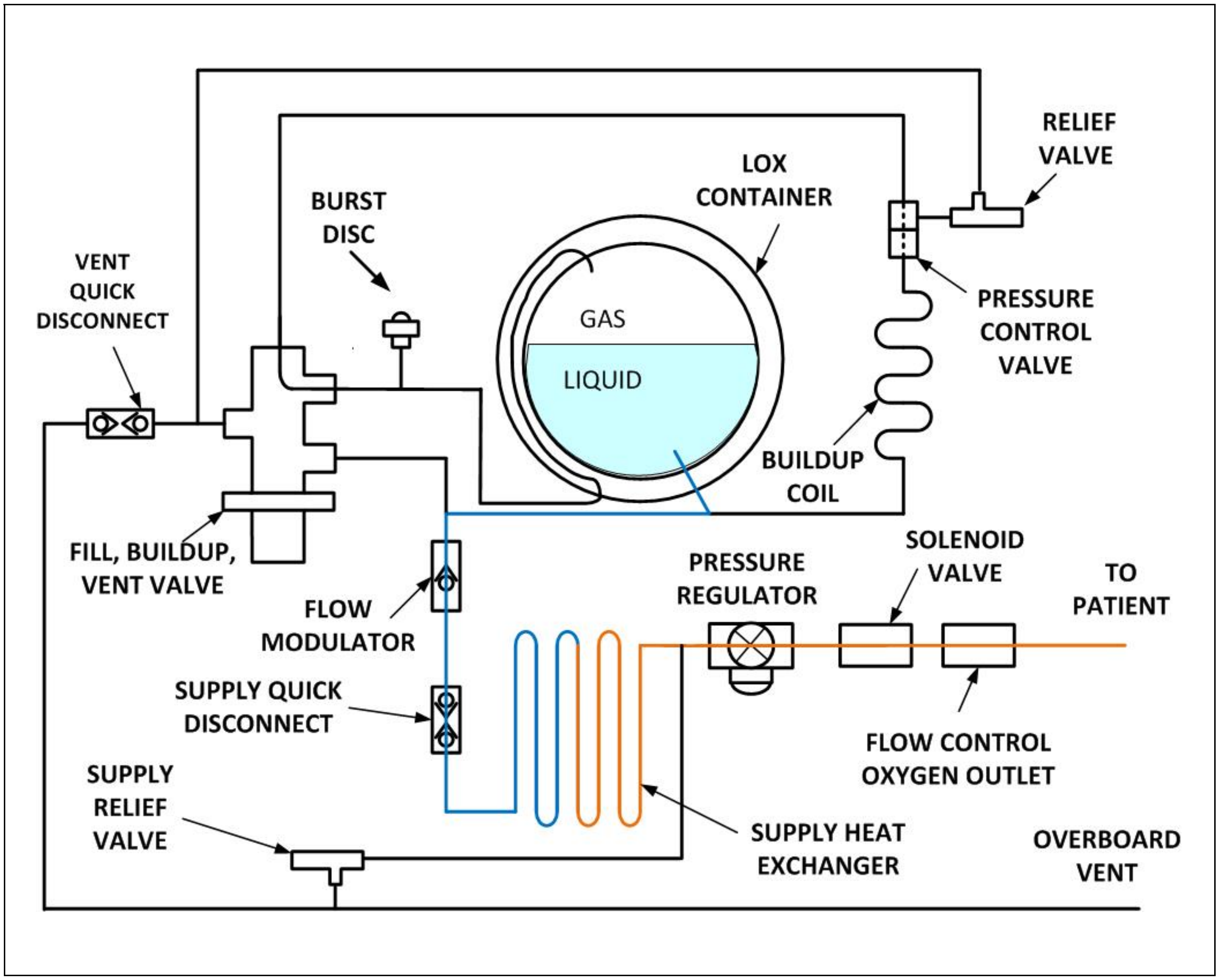

Figure 15 – Operating Mode Schematic

Upon exiting the supply heat exchanger the now gaseous oxygen is routed into the pressure regulator where its pressure is reduced to the appropriate level. A pressure of 50 psig is compatible with conventional medical oxygen equipment.

From the pressure regulator the oxygen is directed to the flow control oxygen outlet which regulates the flow of the oxygen to the prescribed level, usually ranging from 1 to 15 liters per minute.

Over pressurization of the system is prevented by pressure relief devices that automatically relieve excess system pressure. The pressure relief system is a double redundant system. The primary relief device is the 100 psig relief valve on the converter. This is backed-up by the 120 psig relief valve in the supply line which is, in turn, backed-up by the 225 psig burst disc. This is illustrated in schematic form in Figure 16.

The liquid oxygen system incorporates a capacitance type quantity gauging system. The sensing element for the gauging system has components that measure the relationship between electrical capacitance and the volume of the contained liquid oxygen. The capacitance signal is used in conjunction with other gauging system electronics to display the oxygen content of the system on the digital panel of the contents gauge.

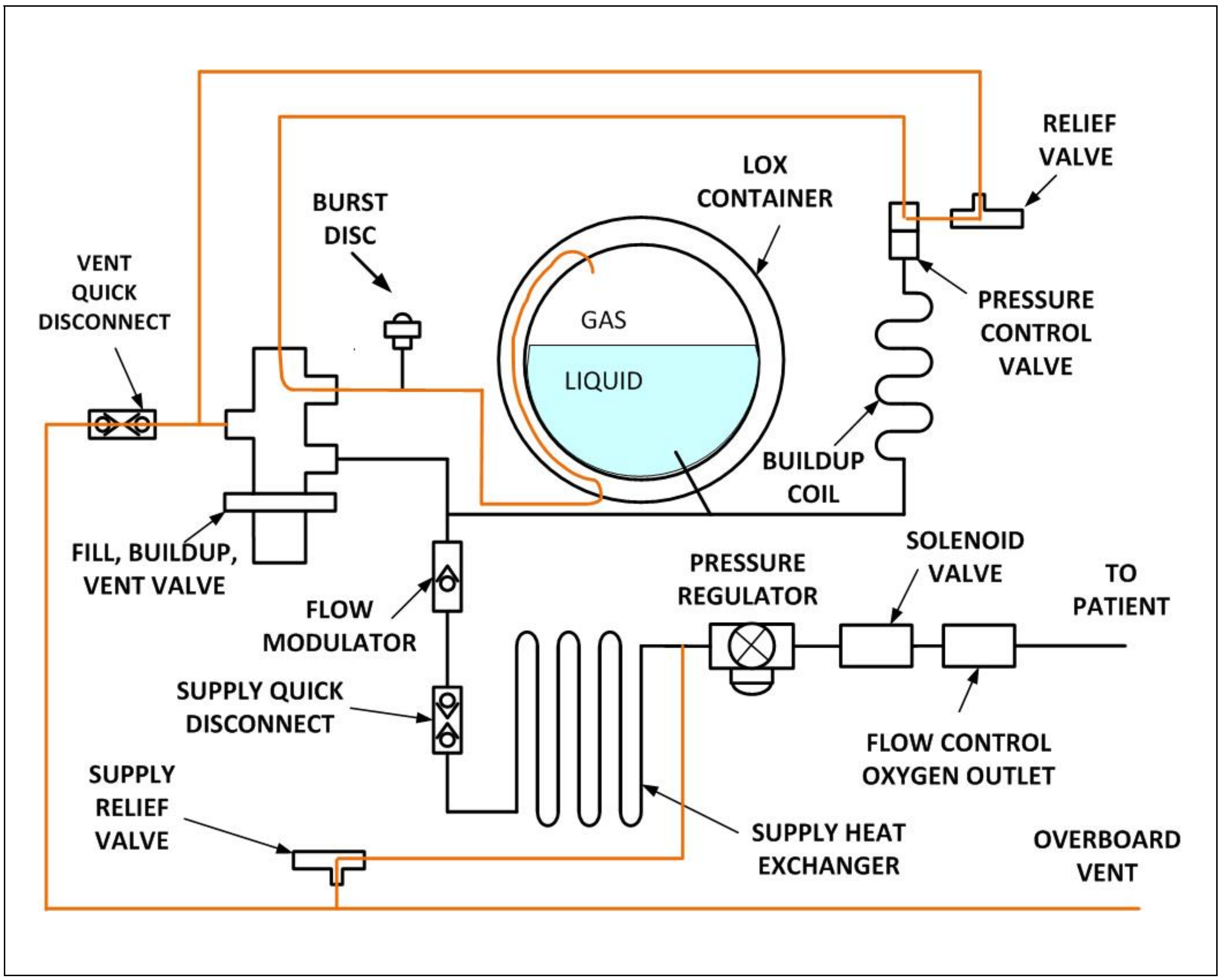

Figure 16 – Pressure Relief Mode Schematic

5. COMPONENTS

Following is a brief description of, and a short discussion of, the function of the major components of the system.

5.1. Liquid Oxygen Container

The liquid oxygen container is a double walled, ultra high vacuum insulated container that stores the oxygen in its liquid state. It is constructed to minimize the influx of heat into the contained liquid oxygen. The inner container is suspended within the outer container by means of a vibration and shock adsorbing spring arrangement. Two tubes lead from the outer container to the top (vapor phase) and bottom (liquid phase) of the inner container. The liquid oxygen container incorporates a capacitance type sensing element which is the sender for the contents gauging system. The electrical leads for the sensing element are routed to the outside of the container through the vent tube.

5.2. Fill, Buildup, Vent Valve

The fill, buildup, vent valve is actually two separate valves combined in one housing and connected by a common actuation mechanism so that they operate in unison. The front section of the valve is the filler valve part and rear section of the valve is the vent and buildup valve part. When “at rest” the fill and vent ports are closed and the buildup port is open. When the fill, buildup, vent valve is mated to the female filler valve for filling, the mechanism in the female filler valve opens the filler valve, opens the vent valve, and closes the buildup valve. This allows liquid oxygen to flow through the filler valve into the liquid oxygen container and the vapor displaced by the liquid oxygen to be released from the system through the vent valve. The buildup valve, being closed while this is going on, prevents the system from building up pressure.

Upon disengagement of the female filler valve, springs return the mechanism of the fill, buildup, vent valve to its original “at rest” position where the filler and vent valves are closed, sealing the system, and the buildup valve is open, allowing pressure buildup to which then allows system operation.

5.3. Buildup Coil

The buildup coil is a liquid to air heat exchanger the function of which is to generate the system operating pressure. Due to the pressure exerted by the head height of the liquid oxygen in the container, liquid oxygen will flow from the container into the heat exchanger where it is warmed by heat from the surrounding air. This causes the liquid oxygen contained in the heat exchanger to vaporize, and expand in the heat exchanger, thereby increasing operating pressure.

5.4. Pressure Control Valve

The pressure control valve is the device that controls the operating pressure of the system. The pressure closing valve is a normally open valve that closes in response to pressure at a predetermined set point, nominally 75 psig. It functions in conjunction with the buildup coil to control the operating pressure of the system. When the pressure control valve is in the open position, liquid oxygen will flow from the container into the buildup coil to build system pressure. When the set pressure of the pressure control valve has been attained, the valve will close preventing further liquid oxygen flow from the container into the buildup coil. This prevents the pressure from increasing any further.

5.5. Flow Modulator

The flow modulator meters the flow of liquid oxygen to the system supply circuit. The flow modulator is a spring loaded orifice that will admit oxygen to the supply circuit in response to pressure, such as during periods of peak demand, even if the orifice is plugged by foreign matter.

5.6. Supply Heat Exchanger

The supply heat exchanger is also a liquid to air heat exchanger. Its function is to vaporize the liquid oxygen supply stream and warm the resultant gaseous so a patient can breathe it. The supply heat exchanger is configured and sized to supply a flow of up to 100 liters per minute of gaseous oxygen at a temperature within 20° F of ambient. The fan capable of blowing 140 cubic feet per minute of surrounding air across the heat exchanger coils makes this supply possible.

5.7. Pressure Regulator

The pressure regulator reduces the system operating pressure, from a nominal pressure of 70 psig, to a nominal pressure of 50 psig, the standard delivery pressure for medical oxygen.

5.8. Solenoid Valve

The solenoid valve serves to isolate the Aero ORB RTI from the balance of the aircraft oxygen system. The solenoid valve may be activated or deactivated electrically, by means of a control switch, or manually in the absence of electrical power, through a cable assembly connected to a lever on the valve.

5.9. Flow Control Outlet

The flow control oxygen outlet is a self-sealing, duplex, oxygen outlet station. One of the outlets is a flow control device having calibrations of 12 settings over a range of 0 to 25 liters per minute. The second outlet is an unrestricted, but pressure controlled, flow outlet for quick disconnect plug-in devices.

5.10. Pressure Relief Devices

The system incorporates three pressure relief devices: A low pressure relief valve that is an integral part of the liquid oxygen converter. It is set to discharge at a pressure of 100 psig, nominal. A high pressure relief valve is installed in the system supply circuit. It is set to discharge at a pressure of 120 psig, nominal. The third relief device is a burst disc that is in contact with the container gas space. The purpose of the burst disc is to prevent a catastrophic failure of the system in the event of malfunction of the two relief valves. Its set to discharge pressure is a nominal 225 psig.

5.11. Contents Gauge

The contents gauge provides a means of monitoring the oxygen content of the liquid oxygen container. The oxygen content of the container is depicted on a digital display panel in terms of kiloliters of gaseous oxygen. At the option of the user, the contents gauge may be mounted remotely from the system enclosure, or it may be installed as an integral part of the enclosure.

6. OPERATING INSTRUCTIONS

6.1. General

The instructions in this section are for information and guidance of the personnel responsible for operation of the converter. The operator shall be completely familiar with, as well as know, the location and purpose of all operating features. All persons who operate the converter shall be thoroughly familiar with the hazards of oxygen and the necessary safety precautions for the work assigned.

WARNINGS
All of the following precautions shall be strictly observed when handling oxygen or operating the Aero ORB RTI. **All persons who operate the Aero ORB RTI shall be thoroughly familiar with the hazards of oxygen and the necessary safety precautions for the work assigned.** **SMOKING. Do not smoke or permit others to smoke within 50 feet of the Aero ORB RTI. Do not carry any source of flame such as matches or lighters around the Aero ORB RTI.** **ABSORBENT MATERIALS. Keep oxygen away from absorbent materials, loose clothing, or rags. These materials can trap oxygen gas and later be ignited by a spark from a cigarette or match.** **HYDROCARBONS. Keep the Aero ORB RTI, the surrounding work area, tools, associated equipment, and clothing as clean as possible and completely free from oil, grease, gasoline, kerosene, and other hydro-carbons. These substances are not compatible with oxygen. Spontaneous ignition upon contact of oxygen with these substances may result. Oxygen gas will not burn but it supports combustion of any material that does burn.** **VENTILATION. Operate and maintain the Aero ORB RTI only in a well ventilated location. When installed in the aircraft, do not restrict flow of air around the vents in the RTI box. Restricted flow will decrease the heat exchanger efficiency, thus making the oxygen product gas colder.**

6.2. Converter Assembly

The Aero ORB RTI liquid oxygen system is filled off the aircraft by removing the liquid oxygen converter and servicing (filling) the converter in accordance with outlined procedure in section 6.3.

The converter combines the following items into a single, portable and transportable unit: a liquid oxygen container, combination fill, build-up and vent valve, pressure-closing valve, relief valve, burst disc, liquid quantity sensing element, miscellaneous tubing and fittings, quick disconnect outlet port, and mounting provisions.

a. Since this unit contains a vacuum insulated container, the following notice is applicable and is labeled on the outside of the container:

WARNING
Stand clear of the vent port during filling.

CAUTION
High Vacuum Container **Handle With Care**

b. The liquid oxygen filling procedure is as outlined in paragraph 6.3. The following figure points out the locations of the fill and vent ports.

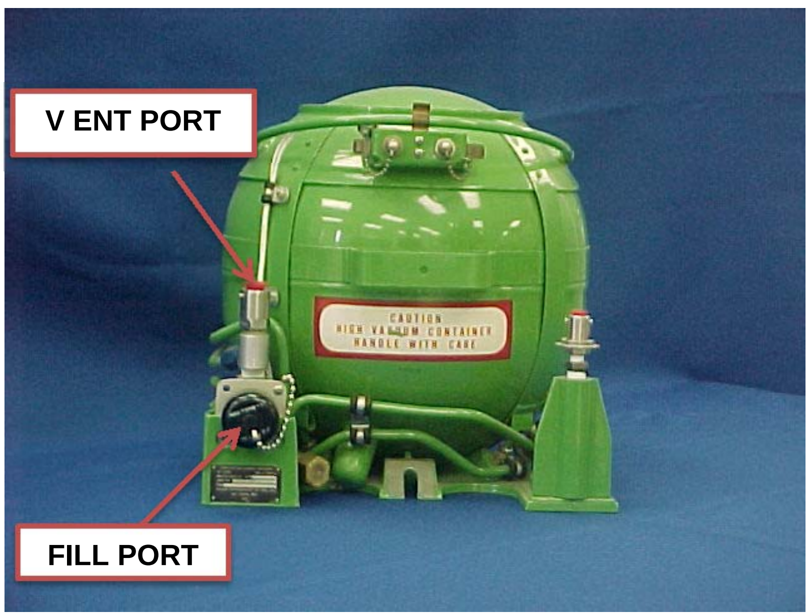

Figure 17 – Fill and Vent Port Locations

6.3. Servicing (Filling) Procedure

Servicing consists of being able to fill the converter to capacity with liquid oxygen prior to use. The converter is designed to be able to be filled off the aircraft.

Note: Unit is shown without servicing hose attached to fill valve

Figure 18 – LOX Servicing Connections

6.3.1 Tools and Equipment

The following equipment is required to fill the liquid oxygen converter component of the Aero ORB RTI liquid oxygen system.

1. Liquid Oxygen Bulk Storage Tank
2. Personal Protective Clothing and Equipment
3. Liquid Oxygen Over flow Catch Container
4. Fire Extinguisher

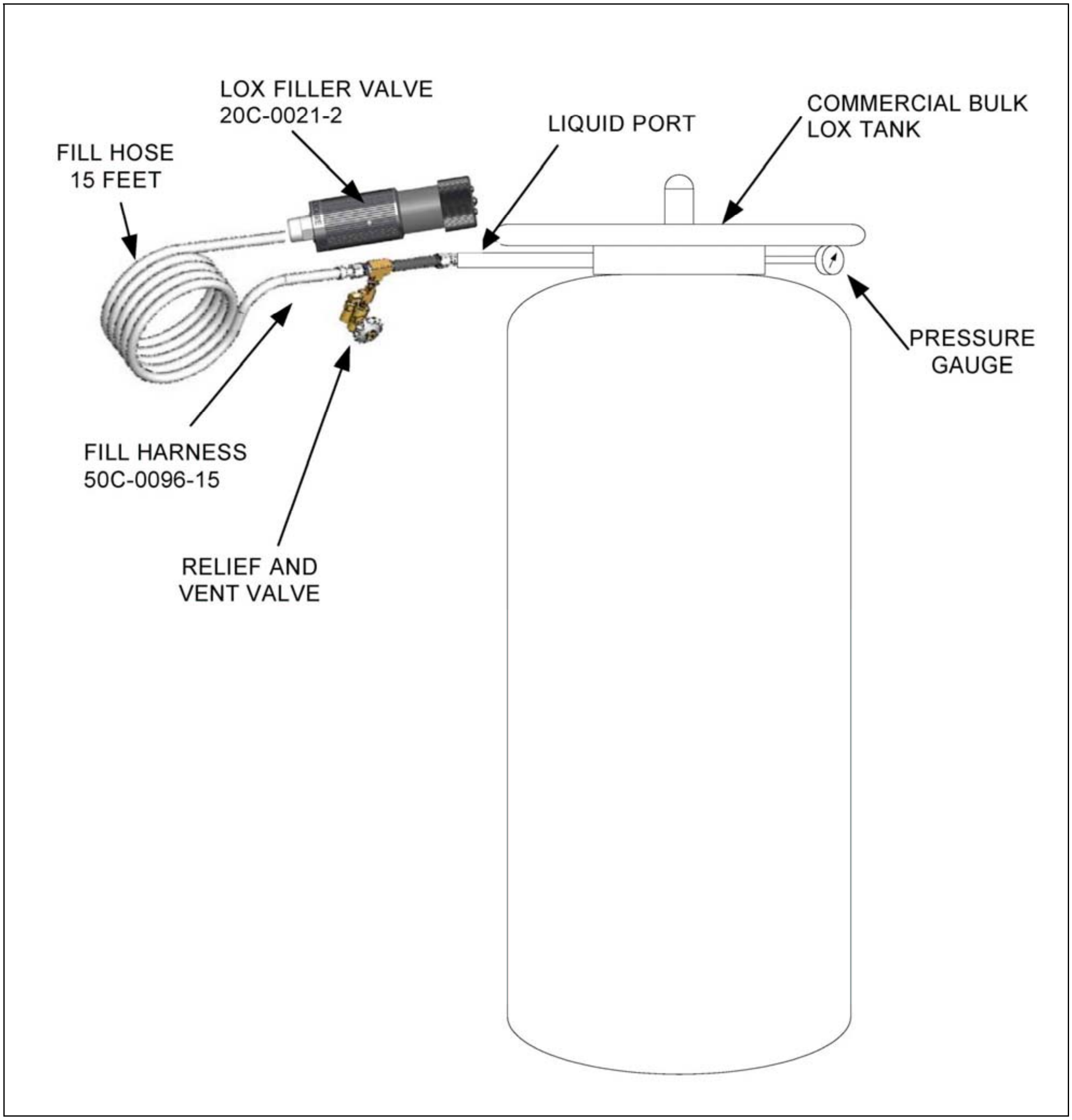

Figure 19 – Bulk LOX Storage Tank with Filling Harness

6.3.2 Servicing Instructions

WARNINGS
Liquid oxygen is extremely cold (-297° F). Contact with the skin will freeze tissues.
Personnel handling liquid oxygen must wear all required protective clothing and devices.
Only personnel trained and qualified in handling and servicing liquid oxygen are authorized to service the system.
All safety precautions contained in this document will be observed at all times while servicing liquid oxygen.
No smoking or operation of any internal combustion engine, electrical motor, ground heater or open flame is permitted within 50 feet of the container being serviced with oxygen.
Stay clear of the liquid oxygen vents and/or openings during servicing.
Stand to one side when disconnecting the servicing transfer nozzle and/or the hose to avoid possible liquid oxygen contact.
The liquid oxygen converter must be located in a well ventilated area, free from grease, oil, and other combustible material and vapors when being serviced.

Note: Refer to Figure 17 for fill and vent connection

a. Those persons not directly involved in oxygen servicing operations shall stay outside a 25-foot radius of the liquid oxygen servicing area. Servicing personnel will ensure that their hands, feet, clothing, etc., are clean and free of petroleum-based products.

   Note: A leather boot approximately 8 inches in height with close fitting top and neoprene sole and heel is recommended, since a LOX spill can subject the feet of servicing personnel to a freeze burn exposure hazard. This type of footwear when equipped with a hard protective toe area is generally classified as a safety shoe or boot.

b. When transferring LOX, personnel authorized and/or trained to fill the converter with LOX should wear the following personal protective equipment:

   1. Protective face shield or goggles
   2. Leather work gloves or welders gauntlets with cotton or wool inserts
   3. Cuff-less trousers
   4. Long sleeve shirt or jacket
   5. Shoes which fit closely around the top, with rubber soles and heels
   6. All items shall be clean and free of grease, oil, and fuel.

c. Position the converter on a stable clean surface with the servicing fill valve downwind such that the liquid oxygen exiting the vent port will not come in contact with personnel or any hazardous materials. Place an overflow catch container under the overboard vent to collect any liquid oxygen exiting the converter.

d. Make sure that the liquid oxygen converter is grounded to earth ground.

e. Position an aircraft type fire extinguisher up wind approximately ten (10) to fifteen (15) feet from the converter.

f. Make sure that the liquid oxygen bulk storage tank is grounded to earth ground.

g. Ascertain that the vent openings of both the liquid oxygen servicing tank and the converter are unobstructed.

h. Locate the converter fill port and remove the valve dust cap.

i. Inspect the opening of the converter fill valve and the servicing hose fill valve for contamination or moisture. Remove any contamination or moisture with a dry, clean, lint-free cloth.

j. Vent the converter until flow ceases at the vent port by affixing a vent cap, Essex Part No. 50C-0020-1 (see Figure 9), or a spare female filler valve, Essex Part No. 20C-0021-2, or the female filler adapter on the servicing hose. If you use the female filler adapter on the servicing hose to vent the system, make sure the bulk storage tank servicing line valve is in the off position.

k. Pressurize the LOX bulk storage tank to 35±5 PSIG in accordance with its instructions.

WARNING
To prevent personal injury, install a 50C-0096-15 Fill Harness to the bulk storage tank and the servicing hose to the converter. (The Fill Harness is shown in Figure 19. The Fill Harness Relief Valve prevents pressure from building up to dangerous levels in the fill hose.)

l. Open the bulk storage tank servicing line shut off valve.

m. Connect the servicing hose female filler valve to the converter fill valve and proceed to fill in accordance with the instructions for the servicing tank.

Note: Maintain a pressure of 35 ± 5 PSIG in the servicing hose. The converter is full when a steady stream of LOX flows from the vent port. Under standard servicing conditions the converter should reach maximum capacity within 10 minutes.

n. Leakage from any component or connection is a potentially dangerous situation. Any steady drip from the servicing nozzle that can be contained in the drip pan of the system is acceptable. Dripping can sometimes be eliminated by holding the hose, thereby removing any downward tension from the connections.

Note: Care must be exercised when filling a converter assembly that is 75% or more full. A false fill indication can easily be experienced during the servicing of a unit that is almost full.

o. When a continuous stream of LOX flows from the vent port of the converter, close the servicing hose shutoff valve, vent the servicing hose, open vent valve on harness and disconnect the servicing hose female filler valve.

WARNING

To prevent excessive pressure buildup in the servicing hose and possible injury to personnel, ensure that the LOX servicing hose is fully depressurized. Open the servicing line pressure vent valve if the LOX servicing tank is so equipped.

p. Disconnect the drain tube from the converter vent port.

q. Re-install the dust cap on the converter fill port.

r. Reinstall the liquid oxygen converter into the Aero ORB RTI liquid oxygen system enclosure. Connect the vent line, supply line and contents gauging system leads to the liquid oxygen converter.

6.4. Aircraft Operation

Install the mask on the patient as required. Oxygen may be administered by adjusting the flow control valve to any of the following levels: 0.25, 0.5, 1, 2, 3, 4, 6, 9, 12, 15, or 25 liters per minute.

Table 20 – Oxygen Loss During Standby

Time After Filling - Hours	Liquid Oxygen Remaining In Converter - Liters	Gaseous Oxygen Remaining in Converter - Liters
24	9.1	7826
48	7.9	6794
72	6.6	5676
96	5.3	4558

NOTE: Gaseous oxygen values are based on a temperature of 70° F and a pressure of 14.7 psia.

7. MAINENANCE

This section contains instructions essential for maintenance of the Aero ORB RTI liquid oxygen system.

WARNING
Do not use oil, or any material containing oil, in conjunction with oxygen equipment. Oil, even in a minute quantity, coming into contact with oxygen can cause explosion or fire. Dust, lint, and fine metal particles are also dangerous.

7.1. Tools and Equipment

Only common tools are required to maintain the Aero ORB RTI liquid oxygen system. The recommended support equipment required is listed in paragraph 3.3.

7.2. Service Life

There is no established service life for the Aero ORB RTI liquid oxygen system. It can remain in service as long as the unit continues to function properly.

7.3. General Inspection

a. Check system enclosure for cleanliness, dents, missing fasteners, condition of latches and tiedowns, chipped paint or other damage.

b. Check the contents gauge for cracked or broken glass.

c. Check the supply and vent disconnects for general condition, for smooth and positive action, and freedom from contamination.

d. Check the flow control oxygen outlets for cleanliness and for smooth operation through adjustments.

e. Check the flexible metal vent and supply hoses for excessive wear and flexibility, obvious physical damage and cleanliness.

f. Check the fill, buildup, vent valve for general condition, for smooth and positive action, freedom from contamination and that the dust cover is in place.

g. Check tube assemblies for cracks, dents, nicks, deep scratches, twists, damaged connectors and tube nuts.

h. Check fittings, connectors, and manifolds for stripped or damaged threads and damage due to improper use of tools.

i. Check dust cap assemblies for broken chains and damaged caps.

j. Check electrical cable assemblies for abrasions and other physical damage.

k. Check the LOX container for dents, chipped paint, and cleanliness.

l. Check the LOX converter mounting base for cracks, distortion, chipped paint, and cleanliness.

m. Insure that the fan operates when 28 VDC is applied to the connector on the case assembly.

7.4. Liquid Oxygen Draining

Drain all Liquid oxygen from the Aero ORB RTI before purging the system, upon occurrence of system malfunction, failure of system to pass inspection, when placing the Aero ORB® RTI in storage or shipping, or when performing maintenance.

7.4.1 Drain on Aircraft

The Aero ORB RTI does not include provisions for draining liquid oxygen from the system per se. Accordingly, for the removal of liquid oxygen, the system is subjected to flow until all the contained liquid oxygen has been expelled. Proceed as follows to remove the liquid oxygen from the system:

a. Set all the flow control valves to their maximum flow rate position. The total flow rate will be about 25 liters per minute per outlet.

b. The drain time for a full 10 liters of liquid oxygen flowing through two outlets will be approximately 2.9 hours.

c. When draining is complete, remove the liquid oxygen converter from the Aero ORB enclosure and purge the liquid oxygen converter as described in paragraph 7.5.

7.4.2 Drain Converter

The liquid oxygen can be drained from the converter. To drain liquid oxygen from a converter proceed as follows:

a. Set the converter in an area free from dirt and hydrocarbons.

b. Place an overflow catch container at the vent port end of the system and attach the drain fixture, Essex part No. 10C-0059-0052 (see Figure 8), to the vent port. A steady stream of vapor and liquid oxygen will exhaust from the vent port into the overflow catch container.

c. Allow the converter to drain until all liquid and vapor are completely exhausted.

d. When draining is complete, disconnect the drain fixture from the vent port.

7.5. Purging

Liquid oxygen converters shall be hot purged at scheduled intervals not to exceed three months exclusive of any interim events that makes purging necessary such as: the converter has been opened or if the liquid oxygen supply has been depleted and the converter is reduced to zero pressure, hot gas purging shall be accomplished prior to returning the converter to service.

The following procedure shall be followed when purging the liquid oxygen converter.

WARNING
Prior to beginning the purging procedures, be sure that the LOX container is completely drained.
Only use clean, dry gaseous nitrogen as a source for purging.
While operating the purging unit, protective gloves must be worn by the operator. Discharge fittings can reach temperatures that will cause severe burns if grasped with bare hands.

a. Ascertain the converter has been drained as described in paragraph 7.4 or has been completely emptied of LOX during use.

b. The following equipment or one of equivalent capacity and performance is required: Purge Kit, Converter System, Liquid Oxygen, Essex P/N 50C-0068-2 (see Figure 10).

c. Set the converter in an area free from dirt and hydrocarbons.

d. Connect the approved gaseous nitrogen supply, equipped with a shutoff valve and regulator capable of controlling the supply pressure from 0 to 100 PSIG, to the inlet of the purge heater.

e. Open the gaseous nitrogen supply and adjust the pressure to 10 PSIG. Allow the purging gas to flow for one minute.

f. Using the female filler adapter provided with the purge kit, connect the outlet of the purge heater to the converter fill port.

g. With the purge kit circuit breaker switches in the OFF position, plug the power cable from the purge heater into an electrical outlet providing a source of 115 volts AC.

h. Place the circuit breaker switches in the ON position.

i. After approximately 10 minutes of operation, adjust the supply inlet pressure to approximately 55 PSIG.

Note: Estimated time required to perform the heated portion of any Purging sequence is based on a calculated interval following heat stabilization. With the purging heater apparatus connected and the gaseous source flowing, the exhausted gas must be monitored with a probe type thermometer to determine when the highest exhaust gas temperature has been attained. This is the point when the actual hot purge sequence begins. It should be noted that the temperature of stabilized gas will vary depending upon the prevailing ambient temperature and size of the system. Therefore the point of heat stabilization must be determined by the operator on an individual basis.

j. Continue to hot purge for a minimum of 45 minutes until the exhaust temperature is slightly above ambient temperature.

WARNING
The converter must be purged with cold gas prior to being refilled with liquid oxygen. The "cold gas flushing" provides a means of cooling the inner container and allows time for components to return to ambient temperature prior to liquid oxygen filling. Failure to do so may cause excessive metal stress on components and may result in the rupture of the container.

k. After completion of hot purging, turn the purge heater off and cold purge for a minimum of 15 minutes or until components have returned to ambient temperature.

l. Disconnect the purge heater filler adapter from the converter fill port, trapping pressure inside the system.

Note: The converter will not retain a positive pressure for an indefinite period of time. Depletion of this pressure does not signify an abnormal condition.

m. Turn the purging gas source off, then disconnect and properly store all purging appliances.

n. Replace the fill port dust cap.

8. TROUBLE SHOOTING

Refer to the following troubleshooting table for a listing of possible problems that may be encountered during operation of the Aero ORB RTI, the possible cause, and the recommended remedies that may be taken to isolate and correct the problem.

Table 21 – Aero ORB Troubleshooting Procedures

Trouble	Probable Cause	Remedy
Converter will not fill	Ice in filler valve or filler line obstructs LOX flow	Thaw filler valve and/or filler line
	Bulk storage tank empty	Replace bulk storage tank
Converter does not fill in required time	Fill line not purged prior to filling	Purge and cool filler line
	Converter not cooled down prior to filling due to servicing pressure being too high	Lower pressure in servicing tank to 35±5 PSIG
	Fill pressure is too low	Increase pressure in bulk storage tank to 35±5 PSIG
	Restriction in system	Purge converter
	Defective converter	Replace converter
Fill, Buildup, Vent or Female filler valve will not open	Ice in valve	Thaw valve
Frost collects on entire outer jacket of tank	Heat loss due to annular space leakage	Replace converter
Localized frost collects on outer jacket of converter	Thermal short between inner and outer container	Replace converter
Converter will fill only partially (gas only emitted from vent)	Converter not cooled down prior to filling due to servicing pressure being too high	Lower pressure in servicing tank to 35±5 PSIG
Converter will not build up	Buildup, vent and filler valve defective, or partially open	Replace converter, or thaw valve
	System Leakage	Locate and repair leak
	Pressure relief valve open	Replace converter
	Pressure-closing valve out of adjustment	Replace converter

Trouble	Probable Cause	Remedy
Oxygen supply consumed too quickly	Converter not completely filled during filling operation	Refill converter
	System leakage	Locate and repair leaks
	Fill, buildup and vent valve partially open venting gas	Thaw valve
	Loss of vacuum in container	Replace converter
Fill line cannot be disconnected from filler port	Filler valve frozen to filler port	Close servicing valve and allow filler valve to thaw
Low, or no converter pressure	System leakage	Locate and repair leaks
	Pressure-closing valve out of adjustment	Replace converter
LOX quantity reading indicates empty	Converter empty, defective liquid level probe or quantity indicator	Refill or replace converter
LOX quantity gauge negative reading	Open Circuit	Repair/replace coaxial cables
LOX quantity reading indicates constant full	Converter full, defective liquid level probe or signal conditioner, or water on level probe	Purge or replace converter
LOX quantity reading on display remains constant	Capacitance sensing element is damaged	Replace converter
No LOX quantity reading displayed	No power to indicator	Check power supply connection
Undesirable odors or moisture coming from patient outlets	Converter contaminated	Purge converter
No product gas flow	Faulty shut-off valve	Check the flow through valve and replace if necessary
Product gas is too cold	Fan is not operating	Check fan operation and replace if necessary
	Airflow is restricted around case	Insure air is allowed to flow freely through the case

9. TESTING

Due to the limitation of test equipment available to the majority of users, testing of the Aero ORB RTI is limited to those tests required to establish functionality and pressure integrity of the liquid oxygen converter.

All tests listed in this section shall be conducted at normal atmospheric pressure and humidity and at room temperatures from 55° to 95°F.

Note: Tests for external leakage must be made with a solution that is suitable for use with oxygen in accordance with Specification MIL-L-25567.

WARNING
All components of the converter and all test equipment must be completely free from grease, oil, and any foreign material that is not suitable for use with oxygen.

9.1. Vented Evaporation Loss

The purpose of this test is to evaluate the ability of the converter container to retain liquid over a 24-hour period.

a. Fill the converter to capacity with liquid oxygen.

b. Connect a vent cap (see Figure 9) to the filler port and allow the converter to remain undisturbed for two hours to let temperature stabilization to occur.

c. After the two-hour stabilization period weigh the converter and record the weight.

d. Allow the converter to remain undisturbed for an additional 24 hours.

e. After the 24-hour period, weigh the converter again and compare the difference in weights. The loss in weight shall not exceed 3.0 pounds for the 24-hour period. If the converter does not meet this requirement, return the converter to Essex for repair.

9.2. Build-up Evaporation Loss

The purpose of this test is to evaluate the ability of the complete converter to retain liquid over a 24-hour period.

Note: This test is normally conducted immediately following the vented evaporation loss test. If this is the case, simply remove the vent cap to allow the converter to build-up pressure and proceed to step b.

a. Fill the converter to capacity with liquid oxygen.

b. Allow the converter to remain undisturbed for two hours to let stabilization to occur.

c. After the two-hour stabilization period weigh the converter and record the weight.

d. Allow the converter to remain undisturbed for an additional 24 hours.

e. After the 24-hour period, weigh the converter again and compare the difference in weights. The loss in weight shall not exceed 3.0 pounds for the 24-hour period. If the converter does not meet this requirement, return the converter to Essex for repair.

9.3. Leakage

The purpose of this test is to evaluate the integrity of all the lines and fitting connections to retain the converter operating pressure.

Note: It is recommended that this test be conducted immediately following the build-up evaporation loss test since the converter is pressurized to the required pressure at this time.

CAUTION
Do not apply leak test solution to ports or vent openings of the valves. Failure to do so will result in improper operation of the converter

a. Apply an approved leak test solution to all fittings and/or threaded joints on the converter. There should be no leakage at any joint except for allowable leakage through the valves.

b. For any leaks at threaded connections, tighten the fittings and recheck for leaks.

c. If any leaks remain, return the converter to Essex for repair.

d. Clean up all leak detecting solution that was used in the preceding steps using a damp lint-free towel.

9.4. Contents Gauge Alignment

The purpose of this test is to calibrate the contents gauge and coaxial cable to the Aero ORB RTI assembly.

Note: Essex Part Number 50C-0044-10 LOX Converter Simulator must be used to align the contents gauge.

a. Disconnect the coaxial cables at the point they attach to the liquid oxygen converter and attach them to the simulator.

Note: The coaxial cables that will be used in service must be calibrated with the contents gauge.

b. Locate the “ZERO” and “SPAN” adjustments which are accessible through openings in the back side of the indicator. Turn both adjustments fully counterclockwise. (These adjustments are 25 turn potentiometers.)

c. Apply power to the indicator.

d. Position the switch on the simulator to the “LO” position and turn the “ZERO” adjustment until an indicator reading of 0.00 + 0.10 is attained. (Clockwise turning increases the number.)

e. Position the switch on the Simulator to the “HI” position and turn the “SPAN” adjustment until an Indicator reading of 8.60 + 0.10 is attained. (Clockwise turning increases the number.)

f. Repeat steps d. and e. as required to attain the proper empty and full readings.

g. Disconnect the simulator and attach the coaxial cables to the empty liquid oxygen converter that will be used in service. If required readjust the “ZERO” potentiometer on the indicator to attain a 0.00 (+ 0.10 reading.)

Note:
1. The indicator reading with a full liquid oxygen converter should be 8.60 ± 0.43

2. The indicator reading with an empty liquid oxygen converter should be 0.00 ± 0.43.

3. The addition to the indicator reading tolerance from that noted above to ± 0.43 is allowed to accommodate different liquid oxygen converters and various operating temperatures.

10. LIMITED WARRANTY

Essex Industries, Inc. (referred to in this warranty as “Essex”) warrants the Aero ORB RTI will be free from defects in workmanship and materials for a period of twelve (12) months from the date of acceptance by the buyer.

Buyer’s exclusive remedy for breach of this warranty shall be the repair or replacement at Seller’s option and expense, of any product or component part thereof that is proven to be other than as herein warranted.

Surface transportation charges covering any defective product or component, shall be at Seller’s expense; however, transportation charges covering any product or component part returned and redelivered which proves not to be defective shall be at Buyer’s expense.

This warranty does not extend to any Seller product or component part thereof which has been subjected to misuse, accident, or improper installation, maintenance, or application; or to any product part thereof which has been repaired or altered outside of Seller’s facilities unless authorized in writing by Seller, or unless such installation, repair or alteration is performed by Seller, or repair facility authorized by Seller. Any repaired or replacement product or component part thereof provided by Seller under this warranty shall, upon delivery to the Buyer, be warranted for a period of 12 months from return of item.

Purchaser’s exclusive remedy against Essex shall be set forth above. In no event shall Essex be liable to purchaser for consequential, indirect, punitive, exemplary or special damages including, but not limited to, loss of or damage to any other equipment or any plant or facilities, loss of profit or any other damage arising out of the loss of use of the Equipment, any other equipment, or plant or facilities or loss of production, regardless whether the claim for such consequential damages be based on warranty (expressed or implied), contract, tort or otherwise. Nor shall Essex be liable to indemnify purchaser against any claims made against purchaser for such consequential, indirect, punitive, exemplary or special damages. Purchase agrees to defend, indemnify and hold Essex harmless from all claims (including claims for indemnity) for any such consequential, indirect, punitive, exemplary or special damages brought against Essex.

Essex shall not be responsible for any Equipment which has been repaired, worked upon or altered by persons not authorized by Essex, or Equipment, which has been subject to misuse, neglect or accident.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR A PARTICULAR PURPOSE, AND OF ANY OTHER OBLIGATION ON THE PART OF ESSEX EACH OF WHICH IS HEREBY EXCLUDED AND DISCLAIMED BY ESSEX.

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