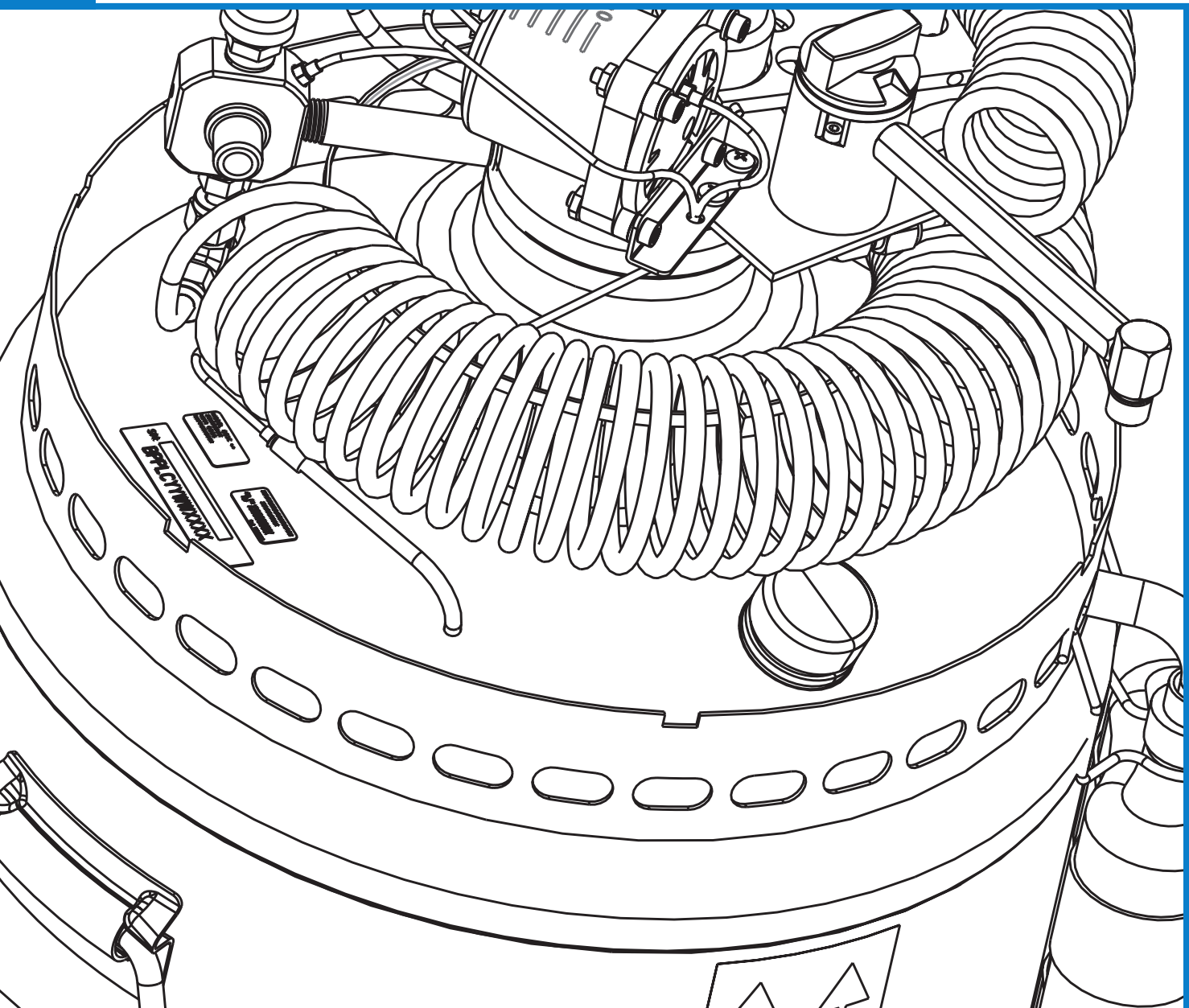
CAIRE®

Companion Reservoirs



Technical Service Manual

I Preface

SERVICE MANUAL

Companion Reservoir

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NOTE: CAIRE Reservoir and Portable units are intended only for the delivery of medical grade oxygen as prescribed by a physician.

Disclaimer

This manual is intended for use by experienced personnel only. No attempt should be made to fill or maintain this equipment until both this manual and the Patient Operating Instruction booklet have been read and fully understood.

Preface

Abbreviations

FCV	Flow Control Valve
LED	Light Emitting Diode
LOX	Liquid Oxygen
LPM	Liters Per Minute
NER	Normal Evaporation Rate
POI	Patient Operating Instructions
N2	Nitrogen Gas
TF	Top Fill
DF	Dual Fill
DISS	Diameter Index Safety System
PRV	Primary Relief Valve
QDV	Quick Disconnect Valve
RMA	Return Materials Authorization
RP	Repair Procedure
RR	Removal and Replacement
SRV	Secondary Relief Valve
O2	Oxygen Gas
SF	Side Fill
PTFE	Polytetrafluoroethylene (“Teflon”)

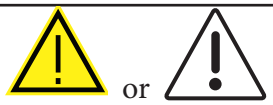
Definition of Terms

WARNING	**Description of a condition that can result in personal injury or death.**
CAUTION	*Description of a condition that can result in equipment or component damage.*
NOTE	A statement containing information important enough to emphasize or repeat.
(ITEM)	Item numbers used throughout this manual are shown on the illustrations beginning on page 34.

Definition of Product Symbols

Table 1: Definition of Product Symbols

Symbol	Definition
	Read instruction manual
	The unit contains liquid oxygen which is extremely cold, almost -300°F. Exposure to such a low temperature can cause severe frostbite. Do not touch frosted parts
	Liquid and gaseous oxygen are non-flammable. However, they cause other materials to burn faster than normal. This hazard, along with the low temperatures of liquid oxygen, warrants certain safety precautions.
	Do not smoke near unit or while operating unit
	Keep unit well ventilated at all times
	Keep unit in upright position
	For use by doctor’s prescription only.
IPX 1	Drip Proof
	Type BF (Electrical Safety)

Symbol	Definition
	Name and address of manufacturer
EC REP	Authorized representative in the European Community
	Caution, consult accompaning documents
	Non-flammable gas
	Oxidizing substances
	Portable Full
	Portable Empty
	WEEE and RoHS This symbol is to remind the equipment owners to return it to a recycling facility at the end of its life, per Waste Electrical and Electronic Equipment (WEEE) Directive. Our products will comply with the restriction of Hazardous Substances (RoHS) directive. They will not contain more than trace amounts of lead or other hazardous material content.

II Table of Contents

III Safety

Safety Guidelines and Operational Safety

Oxygen, as it exists at standard atmospheric pressure and temperature, is a colorless, odorless, and tasteless gas. Oxygen constitutes 21% of the atmosphere, by volume. Aside from its well-documented ability to sustain life, oxygen also supports combustion, even though it is nonflammable. Many substances which will burn in air, burn at a faster rate and at a higher temperature in an oxygen enriched atmosphere. Other materials that do not burn in air will burn as oxygen concentration increases. Additionally, many greases and liquid solvents become extremely hazardous materials when placed in an oxygen-enriched environment. In its liquid form, oxygen is still odorless and tasteless, but is pale blue in color. At an operating pressure of 1,4 bar /20 psig, the temperature of liquid oxygen is about -173°C/-280° F. Skin exposed to such a low temperature can become severely frostbitten.

Contraindications

While CAIRE, Inc. equipment is designed and built to the most rigid standards, no piece of mechanical equipment can ever be made 100% foolproof. Strict compliance with proper safety practices is necessary when using any CAIRE unit. We recommend that our distributors emphasize safety and safe handling practices to their employees and customers. While safety features have been designed into the unit and safe operations are anticipated, it is necessary that all distributor personnel carefully read and fully understand **WARNINGS,** *CAUTIONS,* and NOTES throughout the manual. Periodic review of this information is recommended.

These hazards require certain safety precautions to be taken when working around gaseous and/or liquid oxygen.

WARNING: Never permit combustible substances such as greases, oils, solvents, or other compounds not oxygen compatible to contact any component of the unit exposed to higher-than atmospheric concentrations of gaseous or liquid oxygen. This especially applies to tubing, fittings, and valves.

WARNING: Keep oxygen equipment away from open flames or electrical appliances such as heaters, stoves, toasters, and other devices with heating elements.

WARNING: Never permit smoking in an area where oxygen equipment is repaired, filled, or used.

WARNING: Always wear goggles, a face shield, and insulated gloves when working with or around liquid oxygen.

WARNING: Do not modify equipment without authorization from the manufacturer.

WARNING: These devices are not intended for life supporting applications nor do they provide patient monitoring capabilities.

WARNING: In certain circumstances, the use of non-prescribed oxygen can be hazardous. These devices should only be used when prescribed by a physician.

WARNING: Not for use in the presence of flammable anesthetics.

CAUTION: All CAIRE reservoir units should be moved by utilizing the roller base or hand truck. Do not roll units on their side or edge as insulation damage can occur. All CAIRE reservoir units must be used, stored, and transported in a vertical position. Do not lay, store, or ship on its side.

WARNING: Excess accumulation of oxygen creates an oxygen-enriched atmosphere (defined by the Compressed Gas Association as an oxygen concentration above 23%). In an oxygen-enriched atmosphere, flammable items may burn vigorously and may explode. Certain items considered noncombustible in air may burn rapidly in such an environment. Keep all organic materials and other flammable substances away from possible contact with oxygen; particularly oil, grease, kerosene, cloth, wood, paint, tar, coal dust, and dirt which may contain oil or grease. DO NOT permit smoking or open flame in any area where oxygen is stored, handled, or used. Failure to comply with this warning may result in serious personal injury.

WARNING: In the event a unit is dropped, tipped over, or unreasonably abused, immediately, but cautiously, raise the container to its normal vertical position. If substantial container damage has occurred, remove the liquid oxygen from the vessel in a safe manner (RP3). Purge the unit with an inert gas (nitrogen) and promptly return it to CAIRE for inspection. The container should be prominently marked **"CONTAINER DROPPED, INSPECT FOR DAMAGE."** Failure to comply with these procedures may result in personal injury and can seriously damage the container.

WARNING: Personnel must remove liquid oxygen and depressurize the unit before removing parts or loosening fittings from a unit. Failure to do so may result in personal injury from the extreme cold of liquid oxygen and/or the pressure in the vessel.

WARNING: During transfer of liquid oxygen, components will become extremely cold. Care should be used to avoid any contact with these components, as serious frostbite may result.

WARNING: When using concentrated oxygen, the risk of fire is increased.

WARNING: The possibility of fire exists when the combination of a fuel, source of ignition, and oxygen is present. High concentrations of oxygen (air is approximately 21% oxygen) greatly enhance the possibility of combustion.

NOTE: Figure 1 below is referred to as the fire/combustion triangle. This triangle describes the three factors required for fire/combustion to occur.

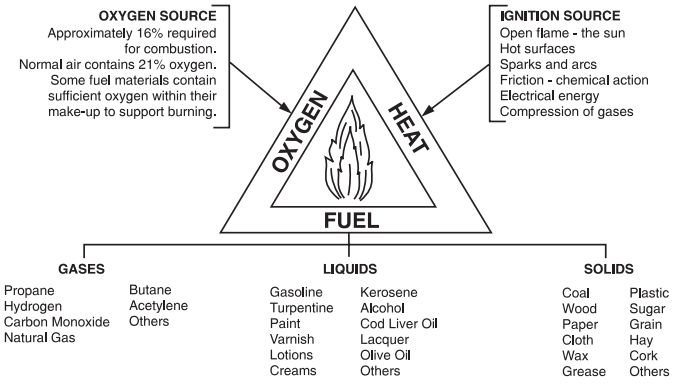


Figure 1: Fire/Combustion Triangle

NOTE: To reduce the risk of combustion/fire when dealing with LOX, please refer to the following suggestions

- Obtain all replacement parts for medical oxygen equipment from the manufacturer.
- Use only recommended oxygen compatible cleaning and leak detection products.
- Keep the reservoir upright at all times. Secure liquid oxygen equipment when transporting to prevent accidental tipover and spillage.
- If a liquid oxygen spill occurs indoors, open doors and windows to ventilate the area. Avoid sources of ignition and do not walk on or roll equipment over the affected area.
- Any clothing or porous material that is splashed with liquid oxygen or otherwise absorbs high concentrations of oxygen should be removed and aired for at least one hour away from any source of ignition.

WARNING: During transfer of liquid oxygen gas blow off from the vent valve creates a loud horn-like noise. Ear protection is recommended.

WARNING: Extreme high pressure can rupture container or plumbing components. Be sure specified pressure relief devices are present, in the proper location, and functioning properly.

NOTE: Liquid oxygen at atmospheric pressure expands at a ratio of approximately 860:1 (at 0 bar/ 0psig) when vaporizing into a gas. This can occur very rapidly when exposed to the heat in the atmosphere. See Figure 2 for comparison.

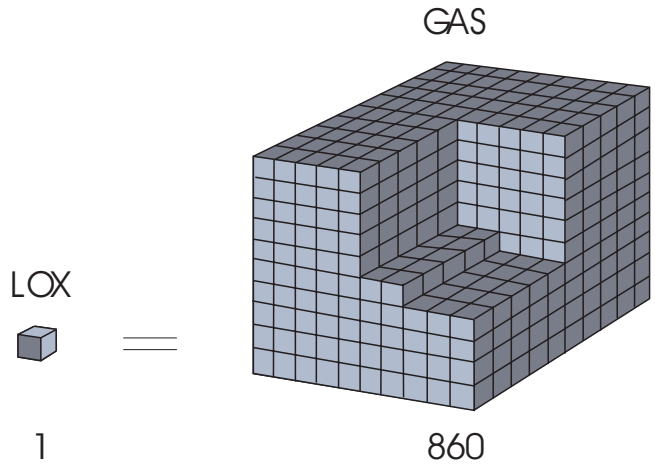


Figure 2: LOX to Gas ratio

WARNING: Do not smoke or keep burning tobacco near this equipment. Death or injury may occur.

WARNING: Keep flammable materials away from this equipment. Oils, grease, including facial creams and petroleum jelly, asphalt, and synthetic fibers ignite easily and burn rapidly in the presence of concentrated oxygen. If needed, use only specified oxygen compatible lubricants as directed.

WARNING: Liquid oxygen vessels periodically release small amounts of oxygen gas that must be ventilated to prevent pressure buildup. Do not store liquid oxygen equipment in a car trunk, closet, or other confined area. Do not place bags, blankets, draperies, or other fabrics over the equipment when it contains liquid oxygen.

WARNING: Medical electrical Equipment needs special precautions regarding EMC and needs to be installed and put into service according to the EMC information provided in this manual.

WARNING: Portable and mobile RF communications equipment can affect Medical Electrical Equipment.

WARNING: The use of Accessories, transducers, and cables other than those specified by the manufacturer may result in increased Emissions or decreased immunity of the Companion Reservoir.

WARNING: The Companion Reservoir should not be used adjacent to or stacked with other equipment, and that if adjacent or stacked use is necessary, the Companion Reservoir should be observed to verify normal operation in the configuration in which it will be used.

Table 2

Guidance and Manufacturer's declaration—electromagnetic emissions

The Companion Reservoir is intended for use in the electromagnetic environment specified below. The customer or the user of the Companion Reservoir should assure that it is used in such an environment.

Emissions test	Compliance	Electromagnetic environment—guidance
RF emissions CISPR 11	Group 1	The Companion Reservoir uses RF energy only for internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The Companion Reservoir is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not applicable	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Not applicable	

Table 3

Guidance and manufacturers declaration—electromagnetic immunity

The Companion Reservoir is intended for use in the electromagnetic environment specified below. The customer or the user of the Companion Reservoir should assure that it is used in such an environment.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment—guidance
Electrostatic discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±6 kV contact ±8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.*
Electrical fast transient/burst IEC 610004-4	±2 kV for power supply lines ±1 kV for input/output lines	Not applicable DC powered device Not applicable No data input/output lines	Not applicable
Surge IEC 61000-4-5	±1 kV line(s) to line(s) ±2 kV line(s) to earth	Not Applicable DC powered device	Not Applicable
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5% UT (>95% dip in UT) for 0,5 cycle 40% UT (60% dip in UT) for 5 cycles 70% UT (30% dip in UT) for 25 cycles <5% UT (>95% dip in UT) for 5 sec	Not Applicable DC powered device	Not Applicable
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.

Note: UT is the a.c. mains voltage prior to application of the test level.

* This statement indicates that the required testing was performed in a controlled environment and the Companion Reservoir are found to be compliant with regulations.

Table 4*

Guidance and manufacturers declaration—electromagnetic immunity

The Companion Reservoir is intended for use in the electromagnetic environment specified below. The customer or the user of the Companion Reservoir should assure that it is used in such an environment.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment—guidance
Conducted RF IEC 61000-4-6	3Vrms 150kHz to 80 MHz	Not Applicable Battery powered device	Portable and mobile RF communications equipment should be used no closer to any part of the Companion Reservoir, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. **Recommended separation distance** $d = 1.2\sqrt{P}$ $d = 1.2\sqrt{P}$ 80 MHz to 800 MHz $d = 2.3\sqrt{P}$ 800 MHz to 2,5 GHz where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survery[a], should be less than the compliance level in each frequency range[b]. Interference may occur in the vicinity of equipment marked with the following symbol: 
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,5 GHz	3 V/m	

NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

[a] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To asses the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the Companion Reservoir is used exceeds the applicable RF compliance level above, the Companion Reservoir should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the Companion Reservoir.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

* This table is included as a standard requirement for equipment which has been tested to specific test levels and over specific frquency ranges and been found compliant with regulations.

Table 5*

Recommended separation distances between portable and mobile RF communications equipment and the Companion Reservoir

The Companion Reservoir is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the Companion Reservoir can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the Companion Reservoir as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of transmitter	**Separation distance according to frequency of transmitter** m		
W	**150 kHz to 80 MHz**	**80 MHz and 800 MHz**	**800 MHz to 2,5 GHz**
	$d=1.2\sqrt{P}$	$d=1.2\sqrt{P}$	$d=2.3\sqrt{P}$
0,01	0.12 m	0.12 m	0.23 m
0,1	0.38 m	0.38 m	0.73 m
1	1.2 m	1.2 m	2.3 m
10	3.8 m	3.8 m	7.3 m
100	12 m	12 m	23 m

For transmitters rated at a maximum output power not listed above, the recommended separation distance (d) in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

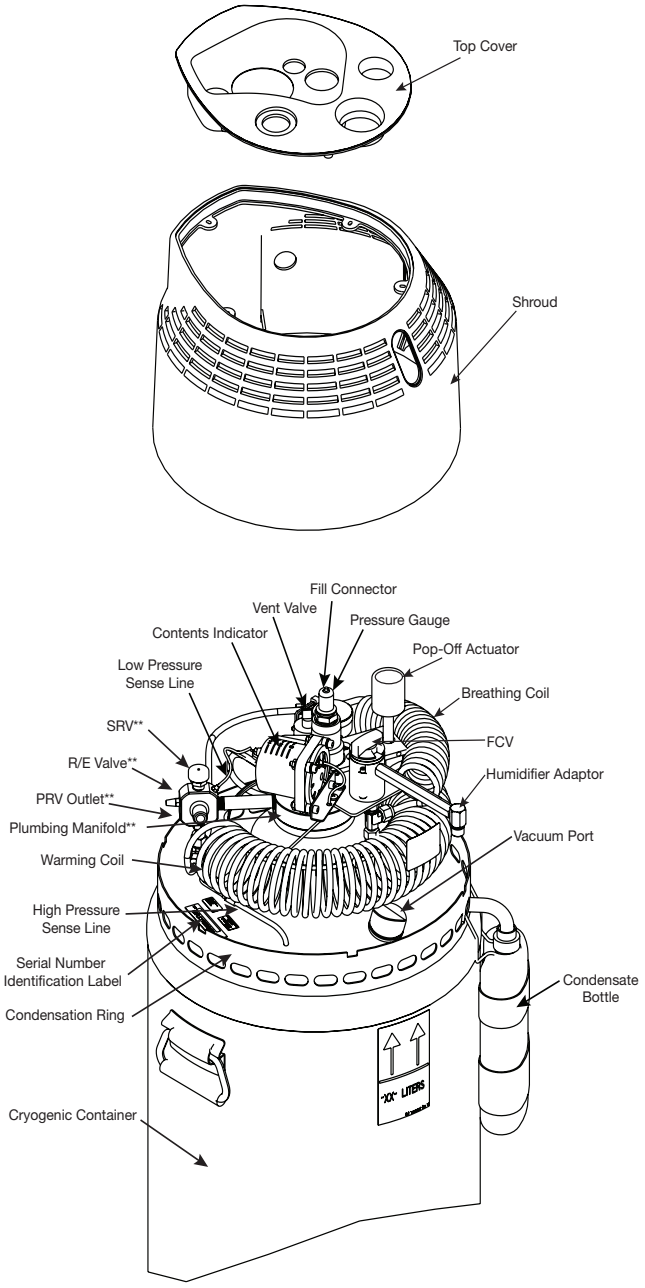
NOTE 1 at 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

* This table is included as a standard requirement for equipment which has been tested to specific test levels and over specific frquency ranges and been found compliant with regulations.

Equipment Description

Figure 3: Companion reservoirs components



* = Units manufactured for sales in Europe (TPED) contain an internal pressure gauge. Please contact Technical Service with any questions regarding unit identification.

** = Units manufactured for sales in Europe (TPED) and/or units manufactured after June 2011 will have a "3 Port" manifold design. These units will also contain an internal pressure gauge and an R/E valve assembly. Please contact Technical Service with any questions regarding unit identification.

The CAIRE Companion Reservoir units are the stationary components in a liquid oxygen system. The Companion Reservoir incorporates a stainless steel cryogenic container with the valves, plumbing, and associated hardware required to deliver gaseous oxygen to the patient at near ambient temperature. The Companion Reservoir is comprised of four major assemblies, grouped according to function.

1. **Cryogenic Container** This assembly is a double walled vacuum insulated Dewar for storing liquid oxygen (LOX) at approximately -173°C/-280°F. The inner vessel is designed to safely hold liquid oxygen and is protected from over pressurization by the primary relief valve. Vacuum insulation between the inner and outer vessel keeps outside heat from causing the cold liquid inside to evaporate.

2. **Plumbing System** The plumbing system consists of the warming and breathing coils, vent valve, R/E valve, SRV, high and low pressure lines, pressure gauge (European units only), FCV and QDV (fill connector).

3. **Shroud Assembly** The reservoir unit's shroud assembly includes a shroud and top cover. The shroud is made of durable plastic and designed to protect the internal components of the plumbing system.

4. **Liquid Content/Level Indicator** This system uses differential pressure to measure the level of LOX remaining in the cryogenic vessel and displays the level with an integral indicator that is viewed through the top cover. The liquid contents are indicated by aligning the colored line on the piston with the graduated markings on the cylinder.

Reservoir Serial Number Identification

Each Companion reservoir is identified by a unique serial number. For reservoirs manufactured prior to January 1985, the number begins with a single digit signifying the year of manufacture, followed by digits signifying the month of manufacture, followed by digits signifying the calendar day of manufacture, and ends with digits signifying the unit's production number for that day.

For reservoirs manufactured between January 1985 and October 1994, the number begins with a double digit signifying the year of manufacture, followed by digits signifying the month of manufacture, followed by digits signifying the calendar day of manufacture, and ends with digits signifying the unit's production number for that day.

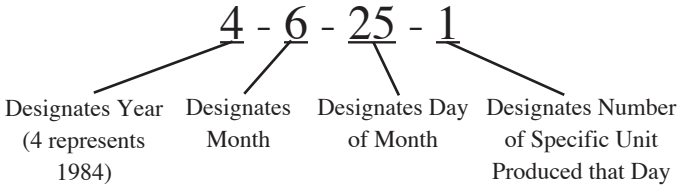
For reservoirs manufactured in and after October 1994, the number begins with a double digit signifying the year of manufacture, followed by digits signifying sequential day of the year on which the unit was manufactured, and ends with digits signifying the unit's production number for that day.

For reservoirs manufactured after June 2010, the number begins with the letters CB signifying the manufacturing location, followed by the reservoir product code B30, followed by digits signifying the year of manufacture, followed by a two digit number to signify the week of the year that the unit was manufactured and ends with digits signifying the unit's production number for that week.

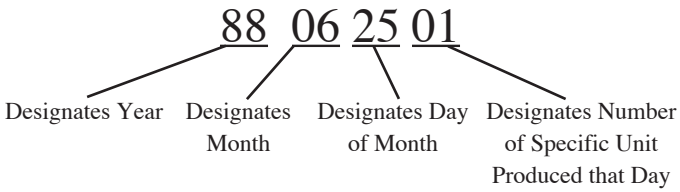
For all units manufactured prior to June 2010, the serial number is etched handle of the cryogenic container. For units manufactured after June 2010, a label containing the serial number is placed on or above the handle of the reservoir. This Serial Number is crucial if a problem arises with the unit or if support is ever needed through CAIRE Customer Service or Technical Service.

Figure 8

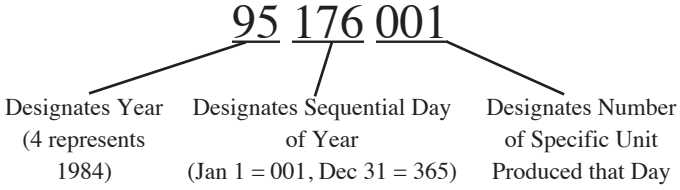
Reservoirs Manufactured prior to January 1985



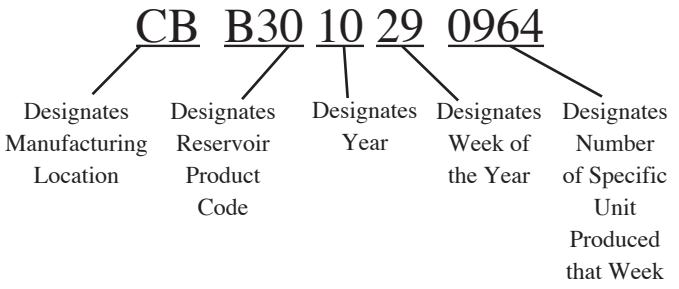
Reservoirs Manufactured in and after January 1985 and prior to October 1994



Containers Manufactured in and after October 1994



Reservoirs Manufactured after June 2010



Theory of Operation

The Companion reservoir provides a source of liquid oxygen to fill portable units. It also provides gaseous oxygen to a patient through the 12 position, 0-6 LPM FCV. If all reservoir outlets are closed (Vent Valve, PRV, SRV, FCV, QDV) with LOX in the unit, then the pressure in the inner vessel will remain near the primary relief valve setting of less than 1,7 bar/25 psig.

As in all vacuum-insulated cryogenic containers, some liquid (oxygen in this case) is always evaporating into a gas. The rate of generation of this gas, with the flow control valve closed, is called the normal evaporation rate (NER). This gas is lost through the primary relief valve.

WARNING: Low oxygen flow rates to the patient may result if CAIRE reservoirs are filled with improperly saturated liquid oxygen.

WARNING: The vent valve orifice does not guarantee properly saturated LOX. The filling source tank must have a minimum 2,4 bar/35 psig (optimum 3,4 bar/50 psig) to transfill into CAIRE reservoirs or low saturation will occur.

NOTE: In Figure 4, the operating pressure is above 1,3 bar/ 19.5 psi.

When the FCV is at any setting other than off, and the economizer valve is open (pressure over 1,3 bar/19.5 psig), gaseous oxygen is forced from the head space in the inner vessel, through the economizer valve, to the warming coil and breathing coil. This process conserves or "economizes" liquid oxygen by withdrawing the head gas first, instead of allowing it to escape through the relief valve. While flowing through the breathing coil, the cold gaseous oxygen is warmed to near-ambient temperature before being metered and dispensed by the flow control valve. Whenever gas is removed from the space above the liquid oxygen (head space), the inner vessel internal pressure begins to drop slightly. When the pressure drops to 1,3 bar/19.5 psig, the economizer valve closes, forcing liquid oxygen up the withdrawal tube, through the bypass tee and through the warming coil where it becomes gas, then through the FCV, providing gaseous oxygen to the patient.

NOTE: In Figure 5, the operating pressure is at or below 1,3 bar/19.5 psi.

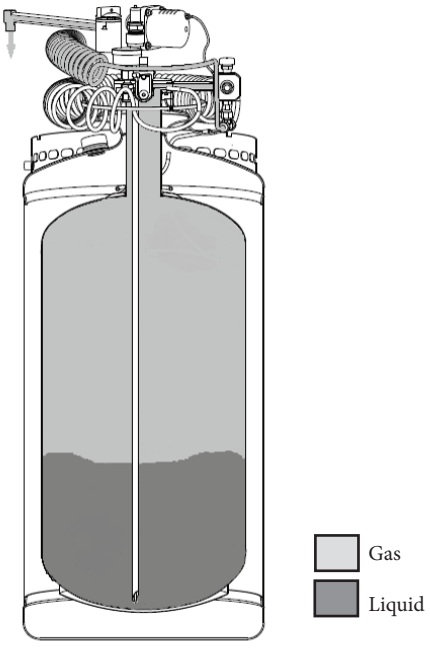


Figure 4

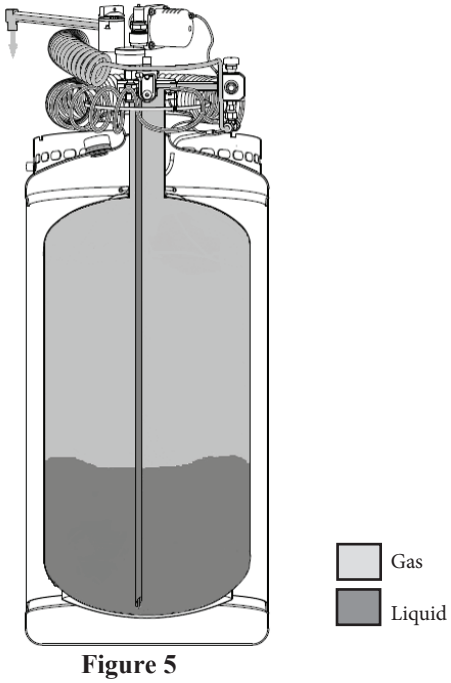


Figure 5

Theory of Operation

Liquid Contents/Level Indicator Operation

The contents indicator, visible through the top cover of the reservoir, measures and displays the amount of liquid oxygen remaining in the Companion reservoir. It consists of a moveable piston/rolling diaphragm assembly that is sealed within a plastic cylinder. The system is based on the principle that the pressure created at the bottom of a tank of liquid is proportional to the height of the liquid. The pressure signal is also a function of gaseous headspace pressure acting on the top of the liquid. A differential pressure between the liquid and the headspace gas causes the piston to move in the cylinder a distance proportional to the amount of liquid oxygen in the container. The liquid oxygen contents are indicated by aligning the colored line on the piston with the graduated markings on the cylinder.

Internal Pressure Gauge Operation (If Equipped)

The pressure indicator is a bourdon tube pressure gauge that indicates the status of the system pressure in the head space. The indicator is not calibrated in units of pressure. However, a dark blue shaded region on the indicator dial marks an acceptable operating pressure range of approximately 1.0-1.7 bar/15-25 psig. The pressure indicator is used to evaluate the reservoir system headspace pressure during a fill and during system operation. The pressure indicator does not indicate oxygen outlet pressure.

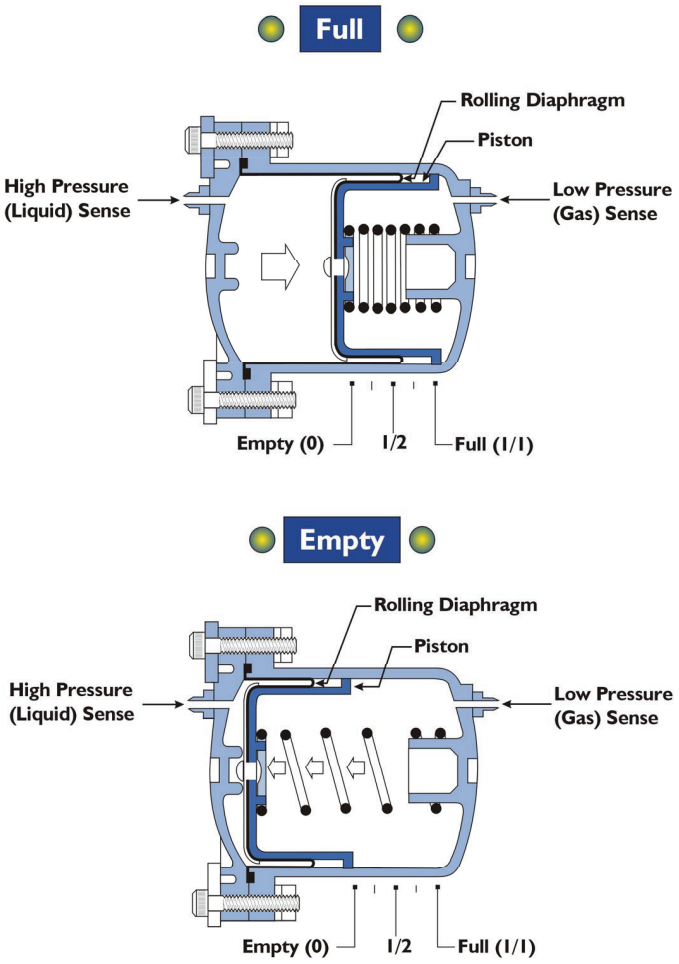


Figure 6

Figure 7

VI Specifications

Table 6

COMPANION RESERVOIR SPECIFICATIONS			
MODEL	**C21**	**C31**	**C41**
Volume of LOX (typical)	21.3 liters / .021 m3	31.6 liters / .032m3	41.7 liters / .042 m3
Weight of LOX @ 1,5 bar/22 psig Saturation (typical)	23,29 kg / 51.34 lbs	34,58 kg / 76.24 lbs	45,68 kg / 100.71 lbs
Gaseous Oxygen Equivalent @ 1 atm. And 21°C/70°F	18,318 liters / 646.9 ft^3	27,176 liters / 959.7 ft^3	35,862 liters / 1,266.5 ft^3
Height	69.9 cm/27.5 in	83.8 cm/33.0 in	97.8 cm/38.5 in
Diameter	36.2 cm/14.25 in	36.2 cm/14.25 in	36.2 cm/14.25 in
Empty Weight	20,41 kg / 45.00 lbs	23,13 kg / 51.00 lbs	27,22 kg / 60.00 lbs
Full Weight	43,70 kg / 96.34 lbs	57,72 kg / 127.24 lbs	72,90 kg / 160.71 lbs
Outlet Pressure	1,3 bar/19.5 psig	1,3 bar/19.5 psig	1,3 bar/19.5 psig
Nominal Operating/Economizer Pressure	1,3 bar/19.5 psig	1,3 bar/19.5 psig	1,3 bar/19.5 psig
Density (Weight of LOX) @ Nominal Operating / Economizer Pressure	1.095kg/L(2.415lbs/L)	1.095kg/L(2.415lbs/L)	1.095kg/L(2.415lbs/L)
Primary Relief Valve Opening Pressure	Less than 1,7 bar/25 psig	Less than 1,7 bar/25 psig	Less than 1,7 bar/25 psig
Primary Relief Valve Reseat Pressure	Greater than 1,4 bar/21 psig	Greater than 1,4 bar/21 psig	Greater than 1,4 bar/21 psig
Secondary Relief Valve Opening Pressure	2,1 bar/30 psig +/- 5%	2,1 bar/30 psig +/- 5%	2,1 bar/30 psig +/- 5%
Secondary Relief Valve Reseat Pressure	Greater than 1,9 bar/27 psig	Greater than 1,9 bar/27 psig	Greater than 1,9 bar/27 psig
Normal Evaporation Rate (NER) (typical)	.84 kg / 1.85 lbs	.87 kg / 1.92 lbs	.87 kg / 1.92 lbs
Maximum Outlet Flow	10 L/min	10 L/min	10 L/min
Contents Indicator	Mechanical, Differential Pressure Based	Mechanical, Differential Pressure Based	Mechanical, Differential Pressure Based
Operating Temperature	10°C to 40°C/50°F to 104°F 95% max. relative humidity	10°C to 40°C/50°F to 104°F 95% max. relative humidity	10°C to 40°C/50°F to 104°F 95% max. relative humidity
Storage Temperature	-40°C to 70°C/-40°F to 158°F 90% max. relative humidity	-40°C to 70°C/-40°F to 158°F 90% max. relative humidity	-40°C to 70°C/-40°F to 158°F 90% max. relative humidity

Note:
All specifications are based upon optimum environmental and pressure conditions as stated above.

Listed capacities have incorporated a 2% ullage in compliance with ADR requirements.

At optimum operating conditions, the conversion factor of liquid oxygen to gaseous oxygen is 1:860.

VII Saturation Principles

Oxygen, in its normal state, is a colorless, tasteless, and odorless gas that is non-flammable, although it greatly accelerates combustion in high concentrations. It constitutes about 21% of the Earth's atmosphere by volume. Oxygen in higher concentrations is medically beneficial to patients suffering from certain respiratory diseases.

Oxygen, like most gases, will condense into a liquid with an increase in pressure or decrease in temperature. As a liquid, oxygen is pale blue in color and is about 860 times as dense as its gaseous form. At atmospheric pressure (14.7 psia), oxygen condenses into its liquid form at a temperature of about -297°F (-184°C). Liquid oxygen (LOX) is an efficient form of oxygen to meet a patient's portable, ambulatory oxygen needs. A volume of liquid oxygen, when vaporized, yields about 860 volumes of gaseous oxygen (Figure 2). As you can see, a relatively small volume of liquid oxygen provides a much larger volume of gaseous oxygen for a patient to use.

In medical liquid oxygen systems, liquid oxygen, and the gaseous oxygen resulting from its vaporization or boiling, is stored under pressure. The elevated pressure, typically 22 psig (152 kPa), enables oxygen to flow to the patient at a selected, prescribed rate. To sustain this oxygen flow to the patient, the liquid oxygen must be in a state that allows vaporization to readily occur. In other words, the liquid oxygen must be in a state of saturation. Let's take a look at what liquid saturation is all about.

A saturated liquid is one that absorbs the maximum amount of heat possible at a given pressure without vaporizing into a gas. If additional heat is added, the saturated liquid begins to vaporize (boil) while remaining at a constant temperature until all of the liquid is vaporized. A common example of a saturated liquid is water at its boiling point of 212°F (100°C) at sea level. The constant addition of heat to the boiling water does not cause it to become hotter, but instead causes part of the liquid water to turn to water vapor (Figure 9).

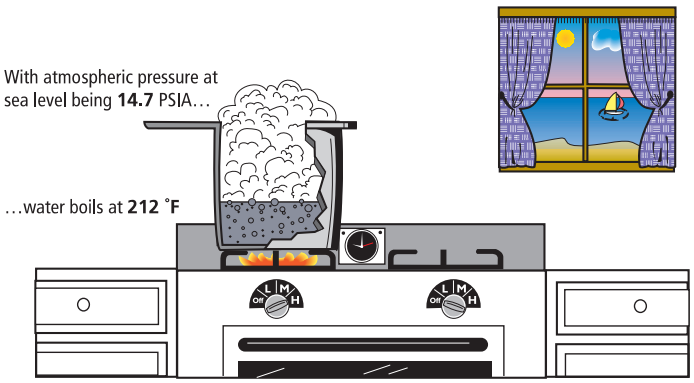


Figure 9: Saturated (Boiling) Water at Sea Level

The saturation (boiling) point of a liquid depends not only on temperature but also on pressure. If the pressure in a container of saturated liquid increases, the temperature required for saturation to occur will also increase. This leaves the liquid unsaturated, that is, capable of accepting more heat before it will boil (Figure 10).

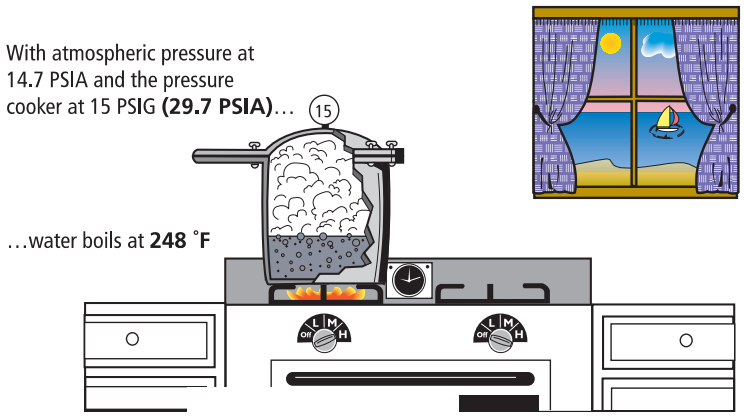


Figure 10: Saturated (Boiling) Water at Higher Pressure

VII Saturation Principles

If the pressure in a container of saturated liquid decreases, the temperature required for saturation to occur will decrease. This leaves the liquid "super saturated" or too warm. When this occurs, rapid boiling and vaporizing of some of the liquid occurs. The rapid boiling and evaporation of the liquid dissipates the excessive heat until the remaining liquid cools down to the new saturation temperature associated with the decreased pressure (Figure 11).

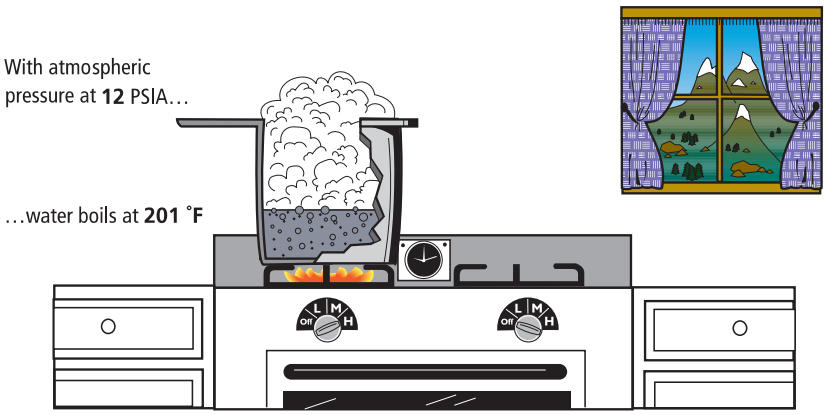


Figure 11: Saturated (Boiling) Water at Lower Pressure

Oxygen, which is normally a gas at atmospheric pressure, changes into liquid form when it is cooled to about -297°F (-183°C) at atmospheric pressure. It is saturated at this temperature (and pressure) which means it will remain a liquid as long as no additional heat is added. However, the large quantity of heat present in the atmosphere constantly enters the liquid oxygen and causes it to boil and vaporize back into a gas. Since it is virtually impossible to keep all of the heat in the atmosphere from entering the liquid oxygen, constant boiling and vaporization occurs.

Now when liquid oxygen is placed in a closed container, the vaporizing gas is trapped and begins to build pressure. As pressure increases above atmospheric pressure, more heat is needed for boiling to occur at the higher pressure. The heat that is constantly available from the atmosphere warms the liquid to a higher temperature where boiling again occurs. The vaporizing gas builds pressure and the process continues. As the pressure on liquid oxygen builds, the related saturation temperature of the liquid increases proportionally (Figure 12).

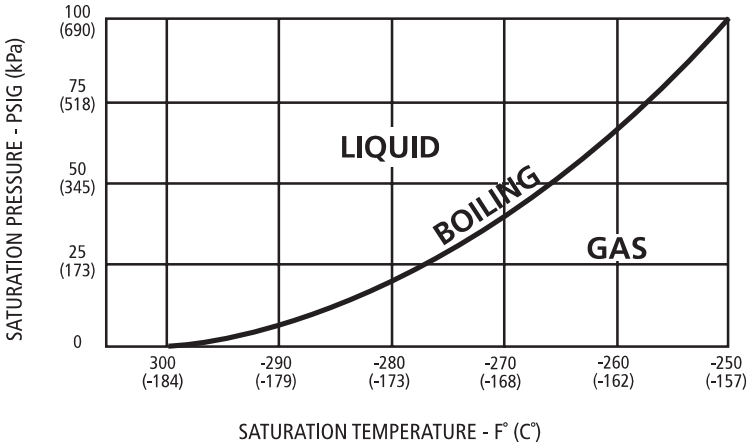


Figure 12: Liquid Oxygen Saturation Curve

It is important to maintain liquid oxygen saturation (boiling) at the specified operating pressure of the system. As an oxygen flow demand is put on the system, a slight decrease in pressure occurs due to oxygen withdrawal. The saturated liquid oxygen in the system vaporizes enough gaseous oxygen to maintain system operating pressure. This ensures proper oxygen flow to the patient. If the liquid oxygen saturation temperature is too low, the corresponding lower saturation pressure causes low oxygen flows to the patient. the patient. If the liquid oxygen saturation temperature is too high, the corresponding high saturation pressure causes inaccurate flow oxygen flow to the patient, as well as increased NER, loss of product, damage to components, etc. In both instances of either too low or too high saturation temperatures, the same effects will be seen in portable devices that are filled off of the reservoirs.

VIII Unpacking and Setup

Unpacking

1. Inspect carton for shipping damage. Report any damage to freight company before signing bill of lading.
2. Check description on carton against your order.
3. Unpack unit, including all accessories and documentation.
4. Set aside packing materials in case unit must be returned to the factory.

Setup

1. Locate and record the reservoir serial number. Reinstall the shroud.
2. Visually inspect the reservoir for damage from improper handling. Note any dents in the container, cracks in the shroud, missing or loose hardware, and bent quick disconnect valves.
3. Check the vent valve for smooth operation. If possible, connect a portable unit to the reservoir to check for smooth coupling, and to make sure the portable unit is in proper alignment with the reservoir when mated and there is no interference with the shroud or or case of portable unit.
4. Check all labels for damage and wipe away any dust on unit with a clean, dry, lint-free cloth.
5. Verify the fill connector release button and mechanism move freely.
6. Verify that an appropriate vent wrench is available for filling of reservoir.

Transport

Specifically designed roller bases are available for moving CAIRE reservoirs short distances on smooth surfaces. Hand trucks can also be utilized for transport as well. CAIRE reservoirs may be moved about or transported in a vehicle while full without damage; however, they should not be dropped, placed on their sides or handled roughly in order to prevent damage.

NOTE: It is never acceptable to tip the reservoir to one side to "roll" the unit, even if the unit is empty.

IX Operation

Filling

NOTE: The fill source should have the correct fitting (5/8" x 45° male flare) to connect to transfer line.

WARNING: Filling must be performed in a well-ventilated area to prevent development of an oxygen-enriched atmosphere.

WARNING: Wear insulated gloves and eye protection whenever working with liquid oxygen.

1. Fill Source Preparation

   a. Ensure the source contains a sufficient amount of liquid oxygen to completely fill the reservoir.

   b. Ensure the liquid oxygen in the fill source is saturated at 2,4-3,4 bar (35-50 psig).

NOTE: Proper saturation is critical when filling a CAIRE reservoir. If the fill source is not properly saturated, the unit will not function correctly, resulting in inaccurate flow rates and excessive boil off of liquid oxygen. This will cause portable units which are filled off the reservoir to act in the same manner. Please refer to the Saturation Principles section to learn more about the importance of proper saturation.

2. Fill Procedure

   a. Required Equipment:

   - ❑ Fill source as outlined above
   - ❑ Liquid oxygen transfer line
   - ❑ Appropriate transfer line fill adapter
   - ❑ Appropriate vent valve wrench
   - ❑ Eye protection
   - ❑ Pressure gauge (for reservoirs not equipped with an internal pressure gauge)
   - ❑ Insulated gloves

NOTE: Ensure Compliance with All Local Regulations when Filling LOX Reservoir Units.

   b. Verify that the liquid level meter is operating properly.

NOTE: If liquid level meter operates improperly, refer to Troubleshooting section of the corresponding technical manual.

   c. Connect transfer line to fill source. Connect proper transfer line adapter to transfer line.

   d. Fully open liquid valve on fill source.

   e. Purge transfer line for a minimum of 5 seconds ensuring gas is safely piped away from operator:

      i. Connect transfer hose fill adapter to a securely mounted mating QDV.

      -OR-

      ii. If the transfer hose fill adapter is equipped with a male QDV, push the adapter poppet against an unpainted stainless steel surface.

   f. Wipe both reservoir and transfer line adapter fill connectors with lint free rag to remove residual moisture.

NOTE: Purge the transfer line any time fill source valve has been closed.

   g. Using vent valve wrench, fully open reservoir vent valve.

   h. Connect transfer line to reservoir to begin fill.

   i. While filling, throttle the vent valve with the vent valve wrench as needed to keep the reservoir pressure at the nominal fill pressure of 1,34 bar (19.5 psig). Monitor the pressure using one of the following techniques:

      i. Monitor the internal pressure gauge if equipped.

      -OR-

      ii. For reservoirs that are not equipped with an internal pressure gauge, connect a pressure gauge to the oxygen outlet and open the FCV to 2 LPM or greater.

   j. When liquid flows from the vent outlet, terminate the fill by disconnecting the transfer line fill adapter from the reservoir using the reservoir's pop-off assembly.

   k. Close reservoir vent valve immediately after disconnecting the transfer line from the reservoir.

   l. Disconnect the pressure gauge from the oxygen outlet and turn off flow control valve.

Caution: Do not allow excessive venting of liquid oxygen through the vent valve. Prolonged exposure may freeze the vent valve in the open position.

   m. Replace protective cover on the QDV adapter. Close the liquid valve on the fill source and properly store the transfer line and fill adapter.

NOTE: The liquid level indicating system is only accurate after the vent valve is closed, and the oxygen has stabilized for five minutes.

IX Operation

Liquid Level Measurement

NOTE: The liquid level indicating system is accurate only after the vent valve is closed, and the oxygen has stabilized for approximately five minutes.

As noted in the Theory of Operation, the Companion reservoirs are equipped mechanical liquid level meters. The meter measures the level of LOX remaining in the cryogenic vessel and displays it on an integral indicator that is viewed through the top cover. The liquid contents are indicated by aligning the colored line on the piston with the graduated markings on the cylinder.

Cleaning and Disinfection

To insure proper functioning and end-user safety, CAIRE reservoirs should be cleaned whenever dirt or grime is visually apparent. The unit should be disinfected if required by applicable local regulations or the home healthcare distributor's own decontamination schedule.

Preparation

Prior to cleaning or disinfection, the unit should be completely purged of LOX. The technician should wear appropriate safety gear when performing the following procedures.

Cleaning

1. Remove the shroud and top cover and clean the interior and exterior using only water. Wipe dry with a towel. Use cotton swabs in tight places. Use Scotch- Brite pad lightly with detergent to remove scuff marks on the shroud.
2. Clean the contents indicator using one of the approved cleaners in Table 7. Do not spray cleaners directly onto the contents indicator. Spray cleaners onto a cloth and apply them using the cloth. Make sure to rinse the surface of the contents indicator thoroughly with water after cleaning and then wipe it dry.

NOTE: Make sure that the fill connector and vent valve shaft are thoroughly dry before proceeding.

3. Clean the reservoir plumbing and lower shroud with water. Dry with a towel and oil-free compressed gas.
4. Remove the condensate bottle and thoroughly clean and dry it. Verify that the drain hole on the condensation ring and the drain tube are open and unobstructed.
5. Clean the stainless steel container with oil-free cleaner and towel.

NOTE: Only use disinfectants or cleaning agents approved for use with this equipment by CAIRE such as Sporicidin, Hydroklean, or others as specified by CAIRE.

Table 7 shows the approved cleaning and disinfecting solutions are acceptable for use with Companion reservoirs.

TABLE 7: Recommended Cleaning and Disinfectant Solutions

Cleaning	Sporicidin Disinfectant Solution
	Mild dish washing detergent/warm water solution
Disinfecting	Sporicidin Disinfectant Solution
	Household Bleach (1:10 dilution with water, freshly made within 24 hours)

NOTE: After performing the cleaning/disinfecting process, it is suggested to perform the following inspections and testing.

Inspection

- Inspect the shroud and top cover for cracks, warpage, and discoloration.
- Verify that the warning labels are present and legible on the shroud and top cover.
- Verify that the Portable release mechanism moves freely and is not worn. Verify that the release button is secure on the lever and is not cracked.
- Verify that the fill connector is not worn or damaged and that the poppet is not broken.
- Verify that the vent valve shaft pin and valve stops are not bent or broken.
- Verify that the contents gauge is reading empty.
- Verify that the aluminum tubing is not bent or kinked and that a uniform air gap exists between each coil.

Testing

1. Perform Leak Test.
2. Perform Liquid Oxygen Functional Tests.
3. Perform Gaseous Oxygen Functional Tests.

Disposal Product

At the end of the unit's life, all reservoir units must be returned to a recycling facility in compliance with the Waste Electrical and Electronic Equipment Directive (WEEE), or other applicable codes and regulations. Alternatively, CAIRE may be contacted for disposal information.

X Maintenance (Schedule A, 30-Month)

There are two schedules for routine maintenance which the home health care distributor may follow. These schedules allow the distributor maximum flexibility while assuring that equipment is operating properly. The healthcare distributor may follow either Schedule A or Schedule B, or a combination of the two schedules.
CAIRE, Inc. recommends returning the unit to a CAIRE service facility every 10 years for vacuum check and re-evacuation if necessary.

Schedule A – 30 Month

Routine maintenance is a series of steps used to assure that equipment is functioning properly.

1. If a unit fails a given test, one of two things may be done:

   a. Refer to the Troubleshooting section of the corresponding technical manual.

   -or-

   b. Return the unit to CAIRE, Inc. for repair.

2. Schedule – Maximum of 30 months between routine mainte-nance testing. Unit should be tested whenever a problem is suspected.

B. Procedure

Follow the steps in order listed. If the unit fails any step, refer to Troubleshooting section of the corresponding technical manual.

NOTE: See the Troubleshooting and Repair section of the corresponding technical manual on the detailed procedures for the tests mentioned below.

1. Visual Inspection:

   a. Remove any LOX prior to maintenance (RP3).

   b. Look for damaged or missing parts.

   c. Verify the meter reads empty. For reservoirs equipped with electronic level gauges, verify the low battery LED is not lit and no error codes appear on the meter.

2. Component Test:

   a. Remove shroud (RP5).

   b. Perform Leak Test (RP 2)

   c. Perform PRV test (RP11).

   d. Perform SRV test (RP12).

   e. Pressure Retention Test (RP14).

   f. Replace shroud (RP5).

   g. Liquid Contents/Level Indicator Test (RP6).

   h. Flow Rate test (RP20).

3. Check Efficiency of Unit:

   a. Inspect unit for cold or sweaty condition and for excessive venting from relief valve (some venting is normal).

   b. If the dewar bottle is cold and sweating, and/or there is excessive venting from the relief valve, an NER test should be performed (RP23).

4. Prepare for Use:

   a. Empty contents (RP3).

   b. Clean and/or disinfect outside of unit following instructions set forth in the Operation section of the corresponding technical manual.

NOTE: Only use disinfectants or cleaning agents approved for use with this equipment by CAIRE such as Sporicidin, Hydroklean, or others as specified by CAIRE.

Schedule B – Continuous

A. Introduction

Continuous maintenance is a set of tests and inspections done periodically to ensure equipment is functioning properly. It can be performed by drivers or other personnel while the equipment is in service.

1. f a unit fails a given test, it should be taken out of service and sent to the Repair Center/Department for further inspection.

2. Schedule – Scheduled intervals should be determined by the equipment service provider.

B. Pre Fill Procedure

1. Visually inspect for:

   a. Broken shrouds or shroud components

   b. QDV deformation

   c. Level indicator functionality

   d. Presence of all required labels

   e. Cryogenic reservoir damage (dents, dings)

   f. If LOX is still present in the unit, inspect for heavy frost or condensation on the exterior of the unit, which would indicate poor vacuum.

   g. Visible dirt or contaminants inside and outside of the upper shroud, as well as inside and outside of the condensate collector.

   h. Vent valve functionality (all parts are present and the valve functions as intended)

C. Post-Fill Procedure

1. Visually verify:

   a. QDV poppet is closed and not leaking

   b. Vent valve is not leaking

   c. No heavy frost or condensation is present on the exterior of the vessel of the reservoir

   d. Liquid level indicator reads accurate amount

   e. Pressure gauge is reading accurate pressure (if equipped)

XI Troubleshooting & Repair Procedures

Table of Contents

Introduction

1. These procedures are designed to be performed only by qualified personnel with proper equipment.

2. Any failure during routine maintenance checks will refer you to this section. See troubleshooting chart for appropriate procedure.

XI Troubleshooting & Repair Procedures

Table 5 below provides troubleshooting procedures for the Companion reservoir. This guide is not all-inclusive but is intended to serve as a general outline for solving operational problems. The table describes symptoms, identifies probable causes, and suggests corrective actions.

When more than one probable cause is identified, the causes are listed in order of most likely to least likely reasons for the problem.

Table 8

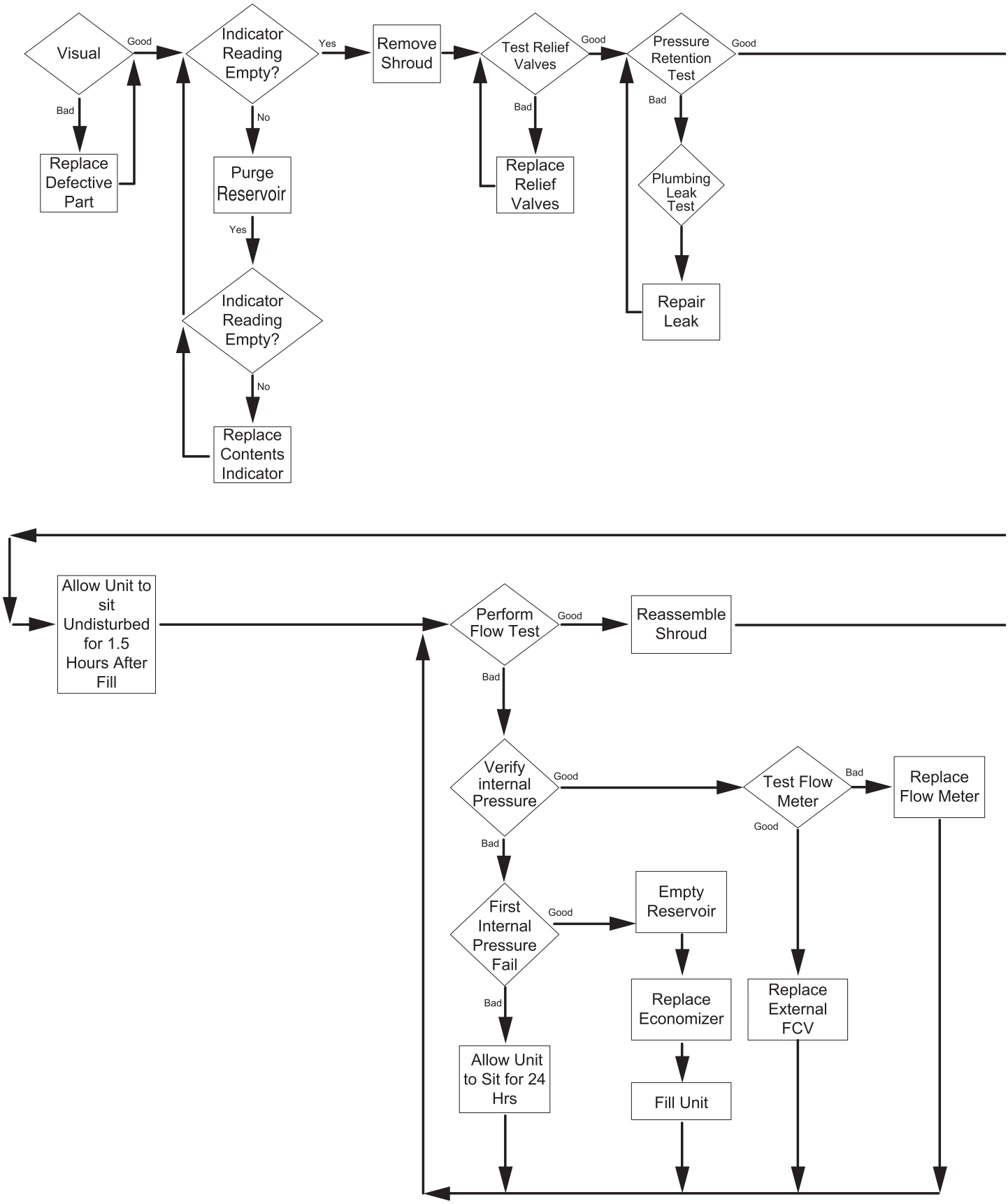
Symptom	Probable Cause	Corrective Action
1. Unable to start fill or excessively long fill times	a. Transfer line not engaged fully on Reservoir QDV	a. Make sure the QDV on the transfer line and reservoir are properly aligned and ensure that a downward force is being applied to the transfer line assembly.
	b. Low source pressure	b. Verify that pressure from the source is within the 35-50 psi range to fill the reservoir.
	c. Vent valve not open or is blocked	c. Ensure that the vent valve is able to be turned to the fully open position.
	d. Source tank is either under or oversaturated	d. Allow LOX to saturate to proper pressure.
	e. Fill connector not opening properly	e. Check fill connector and cartridge assembly for damage; make sure fill connectors fully engage.
	f. Vent valve is obstructed	f. Inspect the valve for blockages and verify that flow passes through during a fill. Clean by blowing out with compressed gas or replace parts if necessary.
	g. Leak in the system	g. Check the reservoir for leaks (RP2) and repair if needed.
2. Liquid leaks from the coupled QDVs during the fill	a. Worn or damaged lip seal	a. Replace the QDV lip seal on the portable unit or transfill adaptor.
3. Unable to disconnect the transfer line or portable unit from the reservoir after a fill	a. Pop-off assembly not being utilized	a. Ensure that the pop-off assembly on the reservoir is being used. Do not use force to separate the QDVs.
	b. QDVs are frozen together	b. Leave the units coupled with the vent valve closed and let them sit until they warm up enough to disconnect. Always ensure that male and female QDV's are cleaned and dried prior to each fill.
4. Liquid leaks from the QDV poppet after filling	a. Ice crystal preventing the QDV from closing properly.	a. Engage and disengage the transfer line onto the reservoir several times to dislodge the ice crystal. Always be sure that the male and female QDVs are wiped clean and dry before filling.
	b. Dirty or damaged QDV poppet	b. Replace the QDV assembly (RP19)
5. Excessive venting from relief valves (hissing sound)	a. Saturation pressure too high.	a. Inspect the saturation pressure of the reservoir used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
	b. Relief valve frozen open	b. Allow the portable to warm and thaw. Attempt to re-fill the portable.
	c. Faulty relief valve	c. Test the relief valves (RP11/RP12) and replace if necessary (RP13)
	d. Partial or complete loss of vacuum	d. Conduct the NER test (RP23) and return the unit to CAIRE, inc. if necessary.

Table 8 (cont.)

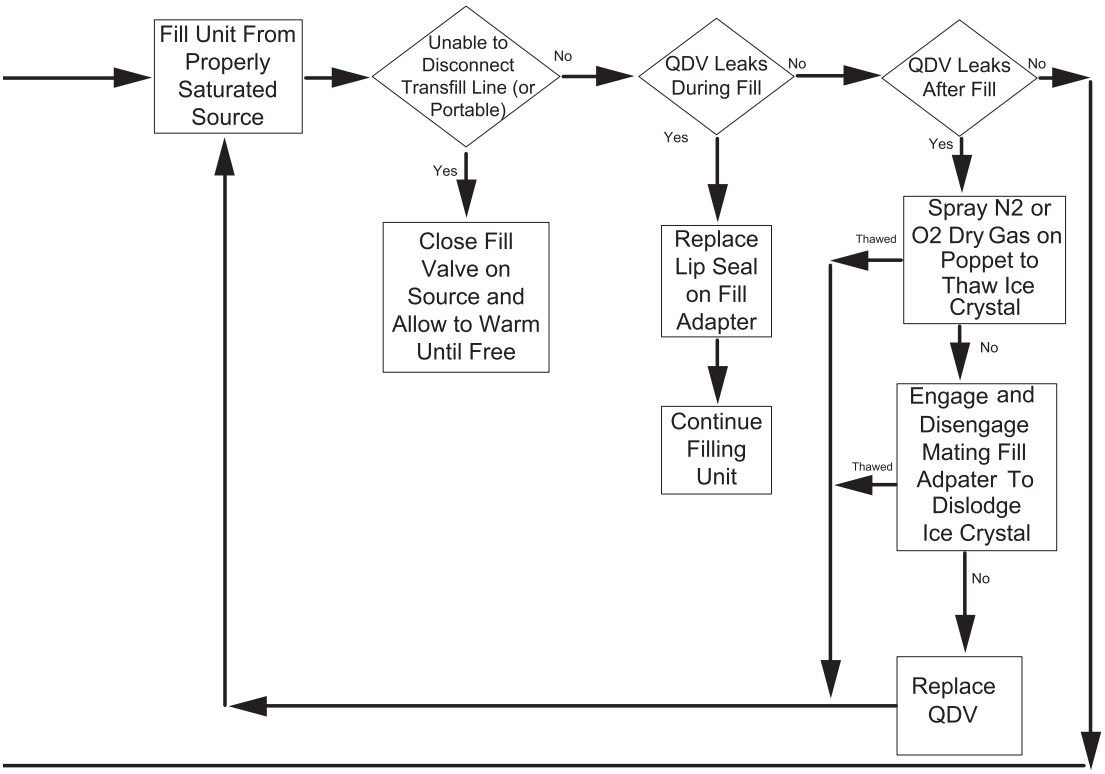
Symptom	Probable Cause	Corrective Action
6. No flow at oxygen outlet	a. Reservoir is empty	a. Check the contents indicator/level gauge and fill the reservoir if needed.
	b. Flow control valve turned off	b. Ensure the flow control knob is not in the off ("0") position.
	c. Nasal cannula kinked or disconnected	c. Ensure proper nasal cannula functionality and positioning
	d. Saturation pressure is too low	d. Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
	e. Leak in the system	e. Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
	f. Relief valve is open	f. Ensure that there is no venting from the relief valves. If there is refer to the corrective actions for "Excessive venting from relief valves (hissing sound)"
	g. Vent valve is open	g. Ensure that the vent valve is fully closed and not leaking.
	h. Blockage in the liquid withdrawal circuit	h. Check the warming coils and withdrawal tubes for blockages. Replace if necessary.
	i. FCV Faulty	i. Replace the FCV (RP24)
7. Low flow at oxygen outlet on all LPM settings	a. Nasal cannula kinked or leaking	a. Inspect the functionality of the nasal cannula.
	b. Saturation pressure is too low	b. Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
	c. Leak in the system	c. Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
	d. Economizer valve faulty	d. Test the economizer (RP22) and replace (RP13) if necessary.
	e. Blockage in the liquid withdrawal circuit or the flow restrictor	e. Check the warming coils and withdrawal tubes as well as the flow restrictor for blockages. Replace if necessary.
	f. FCV faulty	f. Replace the FCV (RP24)
8. Increased NER	a. Saturation Pressure is too high	a. Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
	b. Leak in the system	b. Perform a leak check on the plumbing (RP2) and a pressure retention test (RP14). Repair leaks as necessary.
	c. Relief valve open	c. Ensure that there is no venting from the relief valves. If there is refer to the corrective actions for "Excessive venting from relief valves (hissing sound)"
	d. Partial or complete loss of vacuum	d. Conduct the NER test (RP23) and return the unit to CAIRE, inc. if necessary.

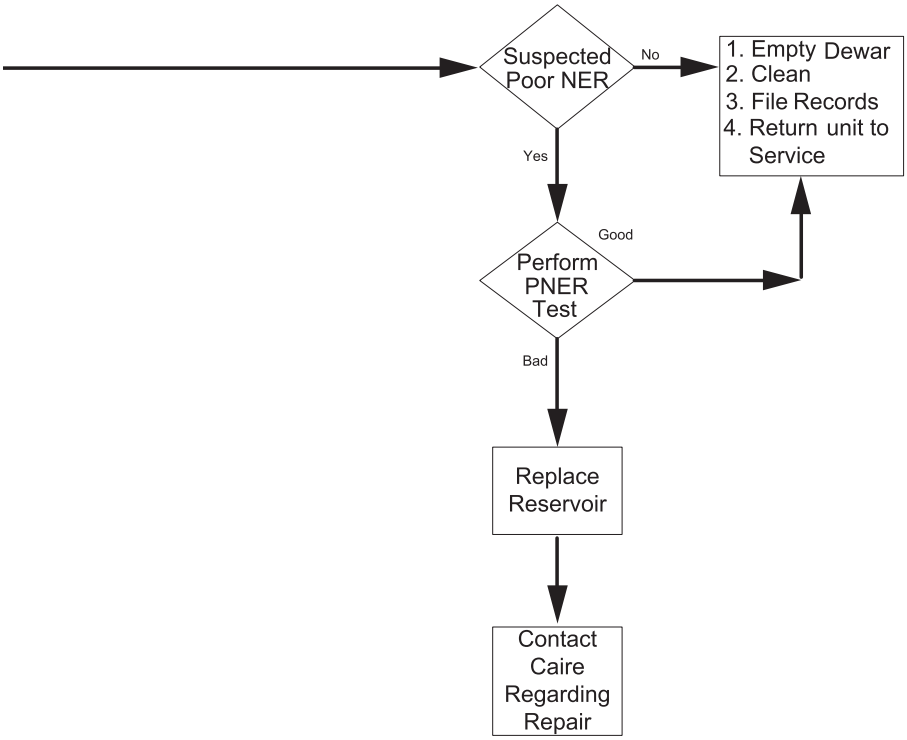
Table 8 (cont.)

Symptom	Probable Cause	Corrective Action
9. Excessive Frost NOTE: Minimal frost on the shroud and on the plubming is normal. This symptom applies to frost that is much greater than what is normally observed.	a. Frost is acceptable	a. Some frost on the shroud and on the plumbing is acceptable, especially at high flow rates during continuous use. This is due to the evaporation of LOX to gas and the temperature difference between the LOX and room temperature.
	b. High humidity level	b. High humidity levels can increase frost accumulation.
	c. Saturation pressure is too high	c. Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
	d. Leak in the system	d. Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
	e. Relief valve open	e. Ensure that there is no venting from the relief valves. If there is refer to the corrective actions for "Excessive venting from relief valves (hissing sound)"
	f. Partial or complete loss of vacuum	f. Conduct the NER test (RP23) and return the unit to CAIRE, inc. if necessary.
10. Unit will not maintain acceptable system pressure	a. Saturation pressure is unacceptable	a. Inspect the saturation pressure of the reservoir used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
	b. Vent valve not completely closed	b. Close vent valve. Leak check vent valve outlet and stem. Replace or repair as needed.
	c. Leak in the system	c. Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
	d. Economizer valve faulty	d. Test the economizer (RP22) and replace (RP13) if necessary.
	e. Primary releif valve faulty	e. Test the primary relief valve (RP11) and replace (RP13) if necessary
11. High Pressure at Reservoir oxygen outlet	a. Saturation pressure is too high	a. Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
	b. Primary releif valve set too high or relief valve operating improperly	b. Perform relief valve test (RP11). Replace (RP13) as needed.
	c. Economizer valve stuck in closed state	c. Perform Economizer test (RP22). Replace (RP13) as needed.
	d. Partial or complete loss of vacuum	d. Conduct the NER test (RP23) and return the unit to CAIRE, inc. if necessary.
12. Contents indicator reads incorrectly	a. Leak in the sensing tubes,fittings, or the Contents Indicator.	a. Perform leak test (RP2). Repair leaks as needed.
	b. Flexible contents indicator pressure sensing tube pinched.	b. Visually inspect the flexible pressure sense tubes and remove pinching conditions.
	c. Ice blockage in contents indicator (liquid) pressure sense tube.	c. Perform the Purging Liquid Contents/Level Indicator (RP8) procedure.
	d. Contents indcator damaged	d. Replace contents indicator (RP7) as needed.


Visual
Good
Bad
Replace Defective Part
Indicator Reading Empty?
Yes
No
Purge Reservoir
Yes
Indicator Reading Empty?
No
Replace Contents Indicator
Remove Shroud
Test Relief Valves
Good
Bad
Replace Relief Valves
Pressure Retention Test
Good
Bad
Plumbing Leak Test
Repair Leak
Allow Unit to sit Undisturbed for 1.5 Hours After Fill
Perform Flow Test
Good
Bad
Reassemble Shroud
Verify internal Pressure
Good
Bad
Test Flow Meter
Bad
Good
Replace Flow Meter
First Internal Pressure Fail
Good
Bad
Empty Reservoir
Replace Economizer
Fill Unit
Allow Unit to Sit for 24 Hrs
Replace External FCV

Troubleshooting & Repair Procedures





To use the Troubleshooting Chart:

- Start at the upper left corner.
- The top line shows the steps of routine maintenance.
- Unless otherwise noted by the arrows, the flow through the chart is down or to the right.

XI Troubleshooting & Repair Procedures

RP1 – General

The following procedures have been carefully prepared to allow proper removal and replacement of defective components and should be used in conjunction with the Troubleshooting Chart and the tests in this section.

CAUTION: When replacing components, make sure the new part is oriented exactly the same as the original part prior to installation.

CAUTION: Some components require a specific amount of torque when assembling. Follow torque requirements where specified.

NOTE: All replacement parts must be factory approved, cleaned for oxygen service, and stored in sealed plastic bags. The repair area must be clean and separate from other areas. Room air should be filtered, and free from dust, soot, and other contaminants.

NOTE: When replacing components with pipe threads, use PTFE tape thread sealant. Apply two rounds of PTFE tape to threads near end of component, avoiding first thread.

NOTE: When assembling new compression fittings, tighten 1/8", 1/4" and 1/2" nuts eight flats past finger tight and 3/16" nuts five flats past finger tight. When reassembling previously used compression fittings, tighten nuts one to two flats past finger tight.

RP2 – Leak Test

1. Attach the pressurizing fixture (PN B-701731-SV) to the fill connector on the reservoir unit and secure it with the attached strap.
2. If the reservoir contains liquid oxygen, verify that it is pressurized between 1.4 to 1.7 bar/21-25 psi.
3. If the reservoir does not contain liquid oxygen, connect an adjustable 0 to 6,9 bar/0 to 100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.
4. Pressurize the reservoir with gaseous oxygen to between 1.4 to 1.7 bar/21-25 psi.
5. Use SNOOP to test all reservoir fittings and connections.

NOTE: When using SNOOP on the stem of the vent valve, be sure to blow it dry with gaseous oxygen or nitrogen before and after test.

6. Place a finger wetted with Snoop lightly against the vent valve outlet to test for leakage.
7. Disconnect and remove the pressurizing fixture from the reservoir fill connector.
8. Apply SNOOP to the fill connector poppet and check for leakage.
9. Use dry Nitrogen or Oxygen gas to dry SNOOP off poppet.
10. Make repairs to leaking fittings or connections as needed and perform leak check on those fittings again.

NOTE: A small amount of leakage around the poppet of the male fill connector is acceptable. Acceptable leaks appear as white, foam-like bubbles in the liquid leak detector. If the bubbles created by the leak detector are considerably large, make necessary repairs to the male fill connector.

11. Make repairs to leaking fittings or connections as needed and perform leak check on those fittings again.

RP3 – Emptying/Purging Reservoir

NOTE: Ensure that the area in which the following procedure will be performed is properly ventilated and free of ignition sources.

NOTE: Ensure vent valve on reservoir is placed in a manner so as not to vent in the direction of technician or individuals nearby or walking by.

1. Connect an adjustable 0-6,9 bar/0-100 psig pressure regulator to oxygen or nitrogen gas source.
2. Attach the pressurizing fixture (PN. B-701731-SV) to the fill connector on the reservoir unit and secure it with the attached strap.
3. Connect the pressurizing fixture to the regulator on the gas source using a pneumatic hose or similar tubing.
4. Open the main valve on the gas source.
5. Open vent valve on reservoir to allow slow venting.

NOTE: If the reservoir is near full of LOX, some LOX may momentarily spray from vent valve.

6. Adjust regulator to a pressure setting that is slightly higher than the internal pressure of the unit (Example: If the internal pressure gauge or gauge on the pressurizing fixture reads 1,5 bar/22 psig, adjust the regulator attached to the gas source to approximately 1,7-1,8 bar/24-26 psig).
7. Allow unit to purge until the exhaust that is released out of the vent valve is clear and the internal components are free of frost. (Approximately 45 minutes)

NOTE: This process can be time consuming depending on the level of LOX in the unit. The pressurizing fixture can be secured to the reservoir using straps, bungee cord, etc., as long as the vent valve is open.

8. Remove pressurizing fixture from reservoir.
9. Close main valve on gas source.

RP4 – Condensation Collector RR

1. Remove condensate drain tube from bottle and remove bottle from bracket.
2. Remove condensate bottle bracket squeezing legs together and pulling straight down.
3. To replace bracket and bottle, reverse above procedure.

RP5 – Shroud Assembly RR

1. Unscrew the screw in the top center of the top cover.
2. Carefully lift up to remove the entire shroud assembly.
3. To remove the cover body from the top cover, unscrew the five small pan head screws on the underneath side of the top cover.

NOTE: New labels must be installed any time the shroud is replaced. Make sure that the front warning label is the correct one for the model of reservoir it is to be used on.

NOTE: Be sure to align the shroud so that the access holes are positioned directly over the corresponding reservoir plumbing components. Also, be sure that the shroud is seated uniformly on the lower shroud lip.

4. To replace the cover body, reverse the above procedure.

RP6 – Liquid Contents/Level Indicator Test

1. Verity that when the tank is empty the colored line on the contents indicator is aligned with the "0" marking.

2. Fill the reservoir so it contains 9 to 11 kg/ 20 to 25 lbs. of liquid oxygen.

2. Verify that within five minutes, the center of the colored line on the contents indicator piston is within the proper range indicated by the shaded bar in Figure 11.

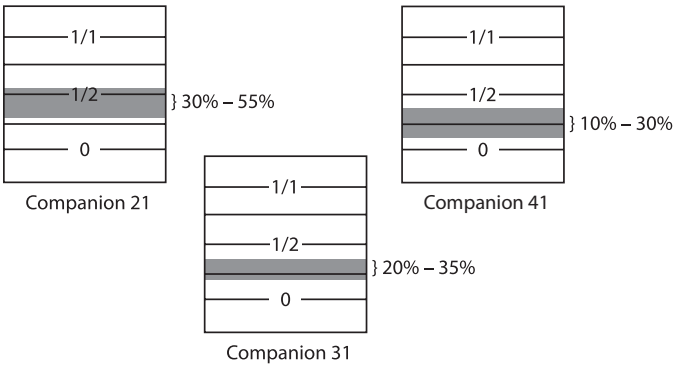


Figure 13

RP7 – Liquid Contents/Level Indicator RR

CAUTION: Damage to contents/level indicator or barbed fittings can occur. Ensure reservoir is empty and has pressure vented before removing either contents indicator tube. Use care when removing flexible tubes from barbed fittings or contents/level indicator

1. Remove shroud per RP5.

2. Remove the flexible pressure sensing lines from the barbed fittings on the contents gauge by carefully sliding the brass collar away from the barbed fitting and then disconnecting the sensor line.

3. Use a medium flat blade screwdriver to remove the two screws that fasten the contents gauge to the mounting plate.

4. To replace the contents gauge, reverse the above procedures.

RP8 – Purging Liquid Contents/Level Indicator RR

1. Ensure reservoir is empty, warm and free of internal pressure per RP3.

2. Remove the shroud per RP5.

3. Use the vent wrench to open the vent valve on the reservoir unit.

4. Connect a pressurizing fixture (B-701731-SV or similar) to the fill connector on the reservoir unit and secure it with the attached strap.

5. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.

6. Adjust the regulator on the gaseous source until the gauge on the pressurizing fixture reads approximately 1,0 bar/15 psig.

7. With only the vent valve open, allow the system to purge for about 45 minutes.

8. Disconnect the pressurizing fixture.

9. **With no pressure in the unit,** disconnect both pressure sensing tubes from the contents indicator. Using a wire tie, lightly secure the tubes to the vent valve to prevent them from moving around.

CAUTION: Damage to the contents indicator can occur. Disconnect both contents indicator tubes before pressurizing the reservoir. Vent the reservoir before connecting or disconnecting indicator tubes.

10. Close the vent valve. Reconnect the pressurizing fixture and adjust the regulator until the pressurizing fixture reads approximately 1,0 bar/15 psig.

11. Allow an additional 15 minutes for gas to flow through and purge the contents indicator tubes.

12. Disconnect the pressurizing fixture and open the reservoir vent valve.

13. Reconnect both pressure sense tubes to the contents indicator.

14. Perform the contents indicator test (RP6).

RP9 – Internal Pressure Gauge Test (If Equipped)

1. Engage the pressurizing fixture to the fill connector on the reservoir and secure it with the attached strap.
2. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the Diameter Index Safety System (DISS) oxygen inlet on the pressurizing fixture.
3. Slowly pressurize the reservoir until the needle of the reservoir pressure gauge lines up with the 20 psig mark.
4. Verify that the reading on the pressurizing fixture gauge is within the blue acceptable region.

NOTE: It may be necessary to tap on top of the indicator with your finger to assure that the indicator is operating properly.

RP10 – Internal Pressure Gauge RR (If Equipped)

1. Remove the shroud and top cover per RP5.
2. Use a 5/8 in. or 3/4 in. open end wrench to hold the brass fitting below the pressure gauge which is attached to the gauge.
3. Use a 1/2 in. or 9/16 in. open end wrench to loosen the pressure gauge from the brass fitting until the gauge is free.
4. Reverse the procedures above to reinstall the internal pressure gauge.

RP11 – PRV Test

1. Remove the shroud per RP5.

NOTE: If the R/E valve contains a muffler or any other type of exhaust fitting, remove fitting prior to testing.

2. Engage the pressurizing fixture to the fill connector on the reservoir and secure it with the attached strap.
3. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.
4. Slowly pressurize the reservoir until a “hiss” is heard coming from the PRV.
5. Verify that the PRV opens (hissing) at less than 1,7 bar/25 psig
6. Slowly reduce the pressure within the reservoir until the hissing through the PRV stops.
7. Verify that the PRV closes (hissing stops) at a pressure greater than 1,4 bar/20.5 psig.
8. If either the opening pressure or closing pressure readings of the PRV do not meet the specifications stated in previous steps, replace the R/E valve.
9. Disconnect the pressurizing fixture and open the reservoir vent valve to reduce the pressure below 1,4 bar/20 psig.

RP12 – SRV Test

1. Remove shroud per RP5.
2. Engage the pressurizing fixture to the fill connector on the reservoir and secure it with the attached strap.
3. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.
4. Obtain a type of temporary clamp.

NOTE: If the R/E valve contains a muffler or any other type of exhaust fitting, remove fitting prior to installing clamp.

5. Position the movable bar clamp arm over the R/E valve vent and position the fixed bar clamp arm.
6. Tighten the clamp to seal the vent port.
7. Slowly pressurize the reservoir by adjusting the oxygen source regulator.
8. Verify that the secondary relief valve opens (audible hiss) at 2,5 bar/37 psig.

NOTE: If the secondary relief valve does not open within this range the first time, first increase the pressure to ensure the SRV has cracked, then reduce the pressure in the reservoir and repeat the test a second time. If it fails to open within the acceptable range the second time, replace the valve SRV.

9. Slowly reduce the pressure within the reservoir until the audible hissing noise is no longer heard.
10. Verify that the SRV closes (audible hiss is no longer heard) at a pressure greater than 1,9 bar/27 psig.

NOTE: If the secondary relief valve does not close within this range the first time, repeat the SRV testing. If it fails to open within the acceptable range the second time, replace the SRV valve.

11. Disconnect the pressurizing fixture and open the reservoir vent valve to reduce the pressure below 1,4 bar/20 psig.
12. Remove the clamp blocking the R/E valve vent port.

RP13 – PRV, SRV, R/E Valve RR

1. Remove the shroud per RP5.
2. Use a 5/8-in. open-end wrench to remove the SRV from the PRV, R/E valve.
3. Slide the press-on tubing clamp back and disconnect the flexible (gas) pressure sense tube from the 1/16-in. barbed fitting on the PRV, R/E valve.
4. Use a 1/4-in. open-end wrench to remove the 1/16-in. barbed fitting.
5. Use a 1/2 -in. open-end wrench to remove the economizer tube assembly inverted compression nut from the PRV, R/E valve.
6. Carefully pull the economizer tube down until it clears the PRV, R/E valve.
7. Use a 3/4 -in. open-end wrench to remove the PRV, R/E valve from the threaded manifold extension tube.
8. Apply Teflon tape sealant to the threaded manifold tube facing the embossed circular index mark on the top of the lower shroud.
9. Install the PRV, R/E valve on the threaded manifold tube and tighten so that the SRV port is in a vertical, up position.
10. Install the end of the economizer tube with the inverted compression nut in the bottom port of the PRV, R/E valve.
11. Make sure the tube end is aligned properly in the port and then tighten the inverted compression nut.
12. Install the 1/16-in. barbed fitting in the PRV, R/E valve port that faces the center of the reservoir.
13. Connect the flexible tube and the tubing clamp to the barbed fitting.
14. Apply Teflon tape sealant to the SRV threads.
15. Install the secondary relief valve in the PRV, R/E valve port and tighten until snug.
16. Perform leak test.
17. Install the shroud.

RP14 – Pressure Retention Test

WARNING: Reservoir must be empty and vented before starting procedure.

1. Attach pressurizing fixture to the QDV on the reservoir.
2. Connect an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.
3. Pressurize the unit to 1,5 bar/22 psig.

NOTE: Lightly tap the pressure gauge with your finger to assure that the needle is reading properly.

4. Remove the pressurizing fixture.
5. Let the unit stand for 10 minutes to allow the pressure inside the reservoir to stabilize.
6. Engage te pressurizing fixture (without the gaseous oxygen source) to the QDV on the reservoir.
7. Verify internal pressure is approximately 1,4–1,7 bar/20.5–25 psig.
8. Record the initial time and pressure.

NOTE: Lightly tap the pressure gauge with your finger to assure that the needle is reading properly.

9. Allow unit to sit undisturbed for 60 minutes.
10. Engage the pressurizing fixture (without the gaseous oxygen source) and take a final reading.
11. Verify that the pressure is greater than1 bar/15 psig.

NOTE: If the pressure is out of specification, perform the leak Detector Test to determine the source of the leak.

12. Disconnect the pressurizing fixture.

RP15 – Warming Coil Assembly RR

TPED Models manufactured prior to June 2011

1. Remove shroud per RP5.
2. Remove three screws from mounting brackets that attach warming coil to the condensation ring using a Phillips head screwdriver.
3. Slightly lift warming coil up from condensate ring to allow access to tee fitting on top of outer shell.
4. Use a 9/16 in. open end wrench to remove the compression nut from the tee fitting while holding the tee fitting stationary with an adjustable wrench.
5. Use a 9/16-in. open-end wrench to remove the warming coil compression nut from the tee fitting on the FCV.
6. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.
11. To reinstall or replace the warming coil, reverse the above procedure.

All domestic units and TPED units manufactured after June 2011

1. Remove shroud per RP5.
2. Use a 9/16 in. open end wrench to remove the compression nut from the tee fitting while holding the tee fitting stationary with an adjustable wrench.
3. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the bottom of the FCV.
4. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.
5. To reinstall or replace the warming coil, reverse the above procedure.

RP16 – Vaporizer Coil Assembly RR (if equipped)

1. Remove shroud per RP5.
2. Use a 9/16 in. open end wrench to remove the compression nut from the dropout tee while holding the dropout tee stationary with an adjustable wrench.
3. Use a 9/16 in. open end wrench to remove the compression nut from the tee that connects to the manifold while holding the tee stationary with an adjustable wrench.
4. Remove the coil.
5. To reinstall or replace the warming coil, reverse the above procedure.

RP17 – Vent Valve RR

1. Remove shroud per RP5.
2. Use a 3/4-in. open-end wrench to remove the vent valve. Place the wrench on the valve hex flats closest to the manifold to prevent disassembly of the valve as you remove it.
3. Inspect the valve stem O-ring and spring pin for wear or damage.
4. Inspect the vent wrench stops on the valve body for wear or damage.
5. Use a 3/4-in. open-end wrench to hold the outer hex flats of the vent valve stationary while using a 9/16-in. open-end wrench to remove the vent extension.
6. Lightly clamp the vent valve in a vise.
7. Use a pin punch and a hammer to drive the spring pin out of the valve stem.
8. Use a small screwdriver to carefully pry the retainer ring off of the valve stem.
9. Use a dental pick or similar object to lift the O-ring off the valve stem.
10. To reinstall or replace the vent valve, reverse the above procedure.

NOTE: Before installing the vent valve, wrap the threaded manifold extension tube with Teflon tape starting two threads back from the end. Verify that the arrow on the vent valve body points away from the manifold.

RP18 – Fill Connector Release Assembly RR

1. Remove shroud per RP5.
2. Use needle nose pliers to remove one E-clip from the release lever pivot pin.
3. Remove the pin from the release lever.
4. Remove the lever from the mounting bracket.
5. Use a No. T10 Torx driver to remove two Torx screws from the release button.
6. Remove the button from the lever.
7. To reinstall or replace the fill connector release assembly, reverse the above procedure.

RP19 – QDV Assembly RR

1. Remove shroud per RP5.
2. Remove the fill connector release assembly.
3. Use a 7/8-in. open-end wrench to hold the body of the fill connector stationary.
4. Use a 10-in. adjustable wrench to loosen the compression nut on the fill connector.
5. Remove the fill connector.
6. To reinstall or replace the QDV, reverse the above procedure.
7. Ensure to add a small amount of Krytox lubricant on the threads of the QDV.

RP20 – Flow Rate Test

1. Ensure unit is at least ½ to ¼ full of LOX.

2. If LOX is added to reservoir, allow unit to sit for a minimum of 1.5 hours prior to beginning test.

3. Verify internal operating pressure as per RP21 or using QDV test fixture. Vessels internal operating pressure should be at 19.5 psi before beginning flow rate test. This can be accomplished in different ways:

Option A.) If reservoirs internal operating pressure is below 19.5 psi (134 kPA) let unit sit overnight after filling, with FCV and vent valve closed, to stabilize to normal operating pressure. Pressure should then be verified again prior to performing flow test.

Option B.) If reservoirs internal pressure is above 19.5 psi (134 kPA) allow unit to flow at a rate of 4 LPM for 1.5 hours minimum prior to beginning the flow rate test.

Or

Option C.) If reservoirs internal pressure is above 19.5 psi (134 kPA) open vent valve and wait for internal pressure to stabilize at 19.5 psi (134 kPa). Ensure the pressure gauge does not rise above 19.5 psi (134 kPa) after FCV is closed. This will indicate the tank is ready for beginning the flow rate test.

4. Attach a DISS fitting adapter (PN B-775269-00) to the humidifier adapter which is attached to the FCV.

5. Connect flow meter inlet to the DISS fitting adapter (PN B-775269-00) using respiratory tubing.

6. Make sure flow meter outlet is open and unobstructed and flow meter is properly positioned.

7. Test flow rate at each FCV position.

8. Compare flow rates to the table below.

NOTE: Be careful to allow for accuracy tolerances of flow meter. Table 9 below does not account for these tolerances.

Table 9

FCV Setting	LPM
OFF	0
0.12	0.08 to 0.16
0.25	0.17 to 0.33
0.50	0.35 to 0.65
0.75	0.52 to 0.98
1.00	0.70 to 1.30
1.50	1.05 to 1.95
2.00	1.60 to 2.40
2.50	2.00 to 3.00
3.00	2.40 to 3.60
3.50	2.80 to 4.20
4.00	3.20 to 4.80
5.00	4.00 to 6.00
6.00	4.80 to 7.20
8.00	6.40 to 9.60
10.00	8.00 to 12.00

Note: SLPM is corrected to normal temperature and pressure (70˚F & 14.7 psig or 21˚C & 1.01 Bar). The above acceptable flow rates are intended for field testing only of flow control valves to account for variation in elevation and temperature. This table reflects tolerance requirements of ISO 10524. This does not affect Chart's factory compliance with the +/-10% tolerance requirement of ISO 18777.

NOTE: Factory flow rate specifications are within the +/- 10% tolerance required by ISO 18777 for environmental conditions of temperature between 10°C – 32.2°C to (50°– 90°F) and elevations up to 527 m (1730 ft).

NOTE: If testing operating pressure because of improper flow rates, test pressure immediately after flow rate test.

RP21 – Operating Pressure Test

1. Ensure unit contains at least 9 kg/20 lbs. of LOX.
2. If LOX is added to reservoir, allow unit to sit for a minimum of 1.5 hours prior to beginning test.
3. Attach a DISS fitting adapter (PN B-775269-00) to the humidifier adapter which is attached to the FCV.
4. Attach a 0-6,9 bar/0-100 psig pressure gauge to the DISS fitting adapter (PN B-775269-00).
5. Open the FCV to any setting above 2 LPM.
6. Pressure gauge should read between 1,2-1,4 bar/18.5-20.5 psig.

RP22 – Economizer Test

1. Verify that the reservoir contains at least 9 kg/20 lbs of LOX.
2. If LOX is added to reservoir, allow unit to sit for a minimum of 1.5 hours prior to beginning test.
3. Engage the pressurizing fixture (PN B-701067-SV) to the fill connector on the reservoir and secure it with the attached strap.
4. Adjust FCV knob to a setting of 4 LPM.
5. With the unit delivering an oxygen flow, record the pressure readings on the pressurizing fixture gauge every half hour until the pressure stabilizes.
6. Stabilization occurs when two consecutive readings are within .01 bar/.2 psig of each other.
7. If the readings do not stabilize, replace the economizer valve.

RP23 – NER Test

1. Fill the unit with 9 to 11 kg/20 to 25 lbs. of properly saturated liquid oxygen.
2. Allow unit to sit undisturbed for a minimum of 12 hours.
3. Weigh unit.
4. Record weight and time (1st Recorded Weight).
5. Allow unit to sit undisturbed for a minimum of 24 hours.
6. Weigh unit.
7. Record weight and time (2nd Recorded Weight).
8. Calculate liquid loss rate (NER) using the following formula:

$$\frac{\text{1st Recorded Weight - 2nd Recorded Weight}}{\text{Elapsed Time Between Weights in hrs}} \text{ X 24 Hours}$$

9. The NER should be between .73 - 1.0 kg/1.6 - 2.2 lbs per day.

RP24 – FCV RR

On units without an Internal Pressure Gauge:

1. Use a 1/2-in. open-end wrench to remove the humidifier adapter.
2. Remove the shroud per RP5.
3. Use a 1/2-in. open-end wrench to hold the elbow fitting and use a 9/16-in. open-end wrench to remove the breathing coil nut from the elbow.
4. Use a 1/2-in. open-end wrench to remove the elbow fitting from the bottom of the FCV.
5. Use a Phillips head jeweler's screwdriver to remove the two Phillips head screws on the bottom of the mounting bracket which secure the FCV to the bracket.
6. Replace FCV.
7. To reinstall the FCV, simply reverse the instructions above.

On units with Internal Pressure Gauges

1. Use a 1/2-in. open-end wrench to remove the humidifier adapter.
2. Remove the shroud per RP5.
3. Use a 1/2-in. open-end wrench to hold the tee fitting and use a 9/16-in. open-end wrench to remove the breathing coil nut.
4. Use a 1/2-in. open-end wrench to hold the tee fitting and use a 9/16-in. open-end wrench to remove the pressure gauge tube nut.
5. Use a 1/2-in. open-end wrench to hold the tee fitting and use a 9/16-in. open-end wrench to remove the tee adapter going into the bottom of the FCV.
6. Use a Phillips head jeweler's screwdriver to remove the two Phillips head screws on the bottom of the mounting bracket which secure the FCV to the bracket.
7. Replace FCV.
8. To reinstall the FCV, simply reverse the instructions above.

RP25 – Determining Liquid and Gaseous Oxygen Capacity

1. Weigh the empty reservoir and record the weight (kg/lb)
2. Fill the unit with properly saturated liquid oxygen (Per Filling Procedure in Operation section of manual)
3. Weigh the full reservoir and record the weight (kg/lb)
4. Subtract the empty reservoir weight (STEP 1) from the full reservoir weight (STEP 3) to determine the weight of liquid oxygen that is inside of the reservoir
5. Take the weight of liquid oxygen (calculated in STEP 4) and divide it by the LOX density to calculate the liters of liquid oxygen in the reservoir

NOTE: The density of liquid oxygen will vary based on operation and saturation pressures. The densities provided in Table #6, which are to be used in the above calculation, are representative of optimum operation and saturation pressures. Due to rounding and conversion accuracy, a range of 0.10 L is acceptable in calculation.

NOTE: If proper filling procedures (primarily source pressure) are not followed per the filling procedure in operation section of this manual, reservoir will not be at nominal pressure immediately following the fill process. In addition, if PRV, SRV and/or Economizer are not performing within ranges specified in Table #6 Reservoir Specifications, the reservoir will not be at nominal pressure immediately following the fill process. If either or both of these conditions occur, calculations using the nominal densities listed in Table #6 Reservoir Specifications will not be accurate.

Example: Calculation of Liquid Oxygen in a full C41 reservoir:

1. Empty weight of C41 Reservoir: 27,22 kg (60.00 lbs)

2. Filled unit with properly saturated liquid oxygen

3. Full weight of C41 Reservoir: 72,90 kg (160.71 lbs)

4. 72,90 kg (160.71 lbs) – 27.22 kg(60.00 lbs) = 45,68 kg (100.71 lbs)

5A. 45,68kg/1.095kg/L = 41,7 Liquid Liters of Oxygen

5B. 100.71lbs/2.415lbs/L = 47.1 Liquid Liters of Oxygen

XII Parts List

Contact Customer Service or visit www.caireinc.com to obtain your parts list.

XIII Ordering Information

Ordering Information

The following steps should be used when ordering a new Companion or replacement parts for an existing unit:

1. **Compile a list of all equipment and replacement parts to be ordered.**
2. **Fill out a purchase order containing the following information:**
   a. Purchase order number.
   b. Name and address of billing location.
   c. Name and address of shipping location.
   d. Quantity, part number, description, and unit cost for each item ordered.
3. **Telephone or fax CAIRE Inc. at one of the numbers listed below to begin immediate processing of the order:**

USA

Toll Free Phone:	800 48 CAIRE
	(800 482 2473)
Toll Free Fax:	888 WE CAIRE
(To place an order):	(888 932 2473)
Phone:	770 721 7759
Fax:	770 721 7758

Asia, Australia, Pacific Rim

Phone:	+61 297 494333
Fax:	888 932 2473

Europe

Phone:	+44 (0) 1189 367060
Fax:	+44 118 9799245

4. **E-Mail or fax the completed purchase order for confirmation to:**

North and South America/Asia/Pac Rim email to:
customerservice.europe@caireinc.com

Africa/Europe/Middle East email to:
customerservice.usa@caireinc.com

North and South America fax to: 888-932-2473
Asia/Pac Rim fax to: 770-721-7758
Africa/Europe/Middle East fax to: +44 118 9799245

All new equipment will be shipped either "prepaid",, F.O.B. from the factory, or collect via your specified carrier. All replacement parts will be sent by UPS "prepaid", and the shipping charges for equipment and parts will be added to the final invoice. Payment for replacement parts are located on CAIRE, Inc.'s, invoice with payment date indicated. All shipments will originate from the factory. If a particular carrier or method of shipment is desired, specify when placing order.

For additional ordering and contact information, visit www.caireinc.com.

XIV Return & Restocking Policy

When a CAIRE unit is received, it should be inspected immediately, as outlined in Section VII, Unpacking and Setup Instructions.

If a problem with the unit should be encountered, reference should be made to the Troubleshooting Chart. If these procedures do not provide a solution for the problem, the following steps should be taken:

1. Call CAIRE, Inc. Customer Service.

North and South America/Asia/Pac Rim:

Phone (US Only)	800-482-2473
Phone	770-721-7759

Africa/Europe/Middle East:

Phone	+44 (0) 1189 367060

2. State the problem with the unit.
3. If it is determined that the problem cannot be solved by the distributor, a Return Material Authorization (RMA) number will be assigned to the unit or part(s).
4. If a Purchase Order Number is to be referenced, please give this number to the Customer Service Representative at that time.
5. Carefully package the parts, or repack the unit in its original shipping container, precisely as shipped.
6. Write the Return Authorization Number on the top of the shipping container.
7. Customer Service will provide the correct shipping location once the RMA is provided

Restocking Policy

If it becomes necessary to cancel an order with CAIRE Inc. after the shipment has been received, use the following "Restock Policy" procedure:

1. Call CAIRE, Inc. Customer Service.
2. When contacting Customer Service personnel, it will be necessary to relay the following information:

a. State the quantity and description of equipment to be returned.

b. Give the Serial Number of each unit to be returned.

c. State the equipment purchase date.

3. An RMA number will be issued in the name of the distributor by CAIRE, Inc. for the equipment to be returned.
4. When the equipment is shipped to the factory, the RMA number must appear on the packing slip and shipping boxes.
5. Customer Service will provide the correct shipping location once the RMA is provided
6. Finally, a "Credit Memo", minus a 15% restocking fee, will be issued to the distributor when all equipment has been received, inspected, and restocked by CAIRE, Inc

Return of Unused Non-Defective Merchandise

CAIRE Inc., at its discretion, charges a 15% restocking fee for unused non-defective merchandise that is returned. An RMA number must be obtained from CAIRE Inc. Customer Service prior to return of any goods. Merchandise cannot be returned for credit after sixty (60) days. Customer to pay all freight charges. Tracking capability and insurance on all returned goods is advised. CAIRE Inc. will not be responsible for misdirected shipments.

Service Tools/Equipment/Supplies

Table 10

Required Tools
Hex Wrenches (various sizes)
Flat Blade Screwdriver
Phillips Blade Screwdriver
10 in. Adjustable Wrench
Torx T 10 Screwdriver
Open End Wrenches (1/2” to 1-1/8”)
Side Cutters
Pliers
Clamp or Hemostat
6 in. Bar Clamp
Dental Pick

Table 11

Required Fixtures/Equipment
Oxygen Regulator
Vent Valve Wrench
0-6,9 bar/0-100 psig Pressure Gauge
Pressurizing Fixture
Flowmeter
Gaseous Oxygen Source 0-6.89 bar (0-100 psi)
O2 Liquid Source
N2 Gas or Clean, Dry Compressed Air Source
Tubing (O2 compatible)
O2 Tubing Tee Connector
LO2 Transfer Line
Transfer Line Adapter with Filter
Dewar Cap
Scale 0-92 kg/0-200 lbs, 0.05 lb/0.02 kg increments
Size 00 Rubber Stopper
DISS O2 Outlet Connector
Small Tie Wrap/Zip Tie
Oxygen Supply Tube Coupler

Table 12

Required Supplies
Household Glass Cleaner
Lint-Free Cloth
PTFE Tape
Fluorolubricant
Leak Detection Fluid
Isopropyl Alcohol

For a complete list of accessories, see catalog ML120071 on www.caireinc.com

Service Tools/Equipment/Supplies

Tools and Accessories available from CAIRE

Description	Item Number
Vent Wrench	B-775182-00
0-6,9 bar/0-100 psig Pressure Gauge	B-776004-00
0-4,1 bar/0-60 psig Pressure Gauge	97403577
Pneumatic Hose w/DISS Fittings	97405279
Small Tie Wrap	B-775091-00
Tubing Barb Adaptor	B-775269-00
Disposable Tubing Barb Adaptor	B-776945-00
O2 Compatible Tubing	B-778214-SV
Test Pressure Gauge w/Tubing Adapter 0-6,9 bar/0-100 psig	B-701732-00
Test Pressure Gauge w/Tubing Adapter 0-4,1 bar/0-60 psig	B-775270-SV
Reservoir Pressurizing Fixture- 0-6,9 bar/0-100 psig	B-701731-SV
8oz Oxygen Compatible Leak Detector (SNOOP)	B-775272-00
Gallon Oxygen Compatible Leak Detector (SNOOP)	B-778894-00
Erie Liter Meter, 0-8LPM	B-775311-00
Erie Liter Meter, 6-15 LPM	10995620
Fluoro-Lubricant-2 oz Tube	CA200071
Lubricant - Krytox 240 AC Fluorinated Grease	20605136
Roller Base Assembly (Non-CE Marked)	10855678
Rollerbase Assembly (CE Marked)	10585866
Casters (set of 5; CE Marked)	14880379
Casters (set of 5; non-CE Marked)	14880361
Shipping Carton C21/C31	10004081-SV
Shipping Carton C41	10004082-SV

Transfer Line Assembly (10 ft./3 m)	B-775289-00
• Transfer Hose (6 ft./1.8 m)	B-775280-00
• Transfer Hose (10 ft./3 m)	B-775281-00
• Source Adapter Assembly	B-775279-00
• Relief Valve (10,4 bar/150psi)	B-775273-00
• Source Adapter	B-775313-00
• Fill Adapter Assembly	B-775278-00
• Fill Adapter	B-775312-00
• Fill Adapter Seal	B-775262-00
• Female Fill Connector	20553105
• Union, 5/8-in. Flare (2 per Transfer Line)	B-775277-00
Female Top Transfill Line Adaptor	10678157
Dual Fill Adaptor TF&SF	10897958
Transfill Line Swivel	97404564
Super Flex LOX Transfer Line 1.8 m/6 FT	97406555
5/8” LOX Transfer Line w/Swvl Nuts 1.2 m/4 FT	9713139
5/8” LOX Transfer Line w/Swvl Nuts 1.8 m/6 FT	9713119
5/8” LOX Transfer Line w/Swvl Nuts 2.4 m/8 FT	10546550
5/8” LOX Transfer Line w/Swvl Nuts 10 FT	10565161
5/8” LOX Transfer Line w/Swvl Nuts 3.0 m/12 FT	10562411
Replacement Inline Filter, Male Transfer Line Adapter	CA400004

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