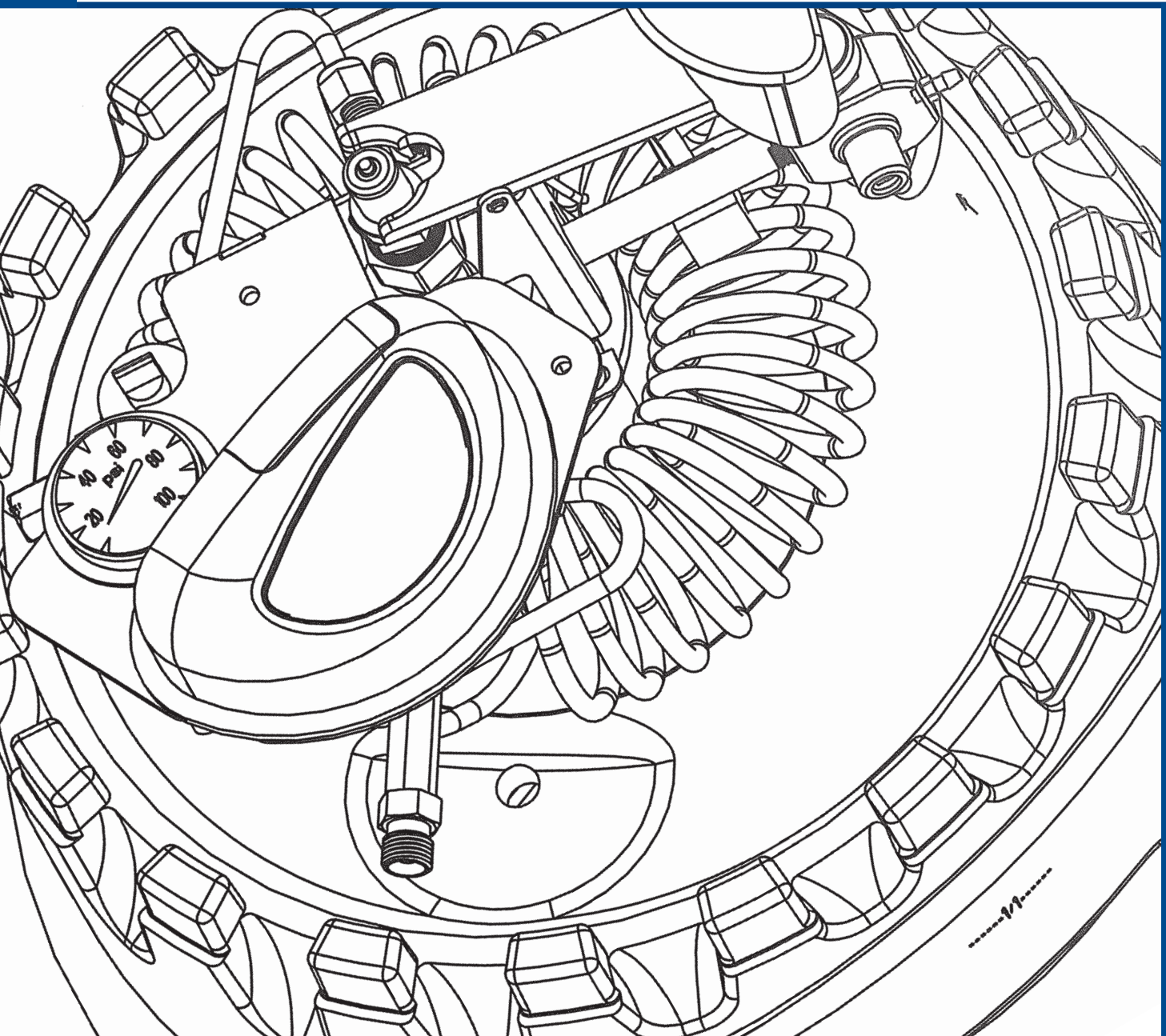
CAIRE®
A Chart Industries Company

HELiOS® Reservoirs



Technical Service Manual

I Preface

SERVICE MANUAL

HELiOS

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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.

NOTE: SI pressure values expressed in manual are referenced to atmosphere.

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.

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

Definition of Product Symbols

Table 1: Definition of Product Symbols

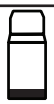
Symbol	Definition	Symbol	Definition
	Reservoir Full		Do not smoke near unit
	Reservoir Empty		Keep unit well ventilated at all times
	Portable Full		Do not touch frosted parts
	Portable Empty		Keep unit in upright position
	Low Battery (9VDC)		Keep unit upright, flat on back, or any position in between
IPX1	Drip Proof		
	Type BF (Electrical Safety)		

Table of Contents

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 with or 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.

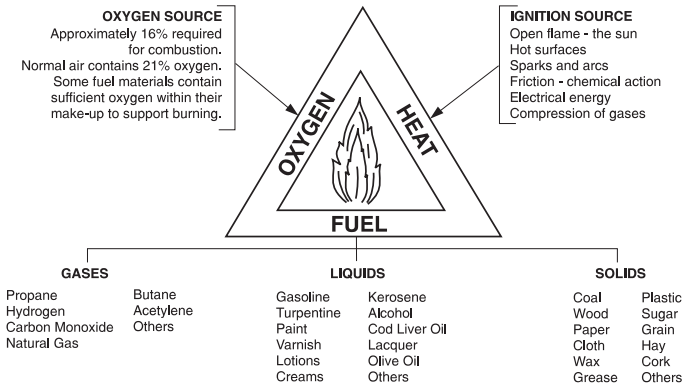


Figure 1: Fire/Combustion Triangle

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/ 0 psig) when vaporizing into a gas. This can occur very rapidly when exposed to the heat in the atmosphere. See Figure 2 for comparison.

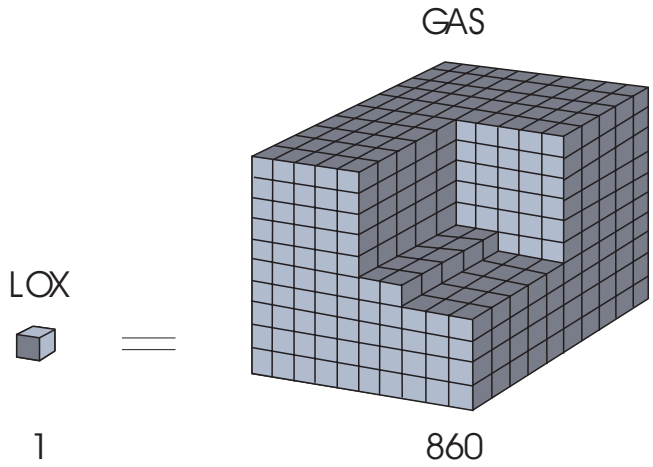


Figure 2: LOX to Gas ratio

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.

Table 2

Guidance and Manufacturer's declaration—electromagnetic emissions

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

Emissions test	Compliance	Electromagnetic environment—guidance
RF emissions CISPR 11	Group 1	The HELiOS 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 HELiOS 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	

- 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.
- Portable and mobile RF communications equipment can affect Medical Electrical Equipment.
- The use of Accessories, transducers, and cables other than those specified, with the exception of transducers and cables sold by the Manufacturer of this device as replacement parts for internal components, may result in increased Emissions or decreased Immunity of the HELiOS Reservoir.
- The HELiOS Reservoir should not be used adjacent to or stacked with other equipment and that if adjacent or stacked use is necessary, the HELiOS Reservoir should be observed to verify normal operation in the configuration in which it will be used.

Table 3

Guidance and manufacturers declaration—electromagnetic immunity

The HELiOS is intended for use in the electromagnetic environment specified below. The customer or the user of the HELiOS 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 HELiOS are found to be compliant with regulations.

Table 4*

Guidance and manufacturers declaration—electromagnetic immunity

The HELiOS is intended for use in the electromagnetic environment specified below. The customer or the user of the HELiOS 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 HELiOS, 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 HELiOS is used exceeds the applicable RF compliance level above, the HELiOS should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the HELiOS.

[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 HELiOS

The HELiOS is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the HELiOS can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the HELiOS 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.

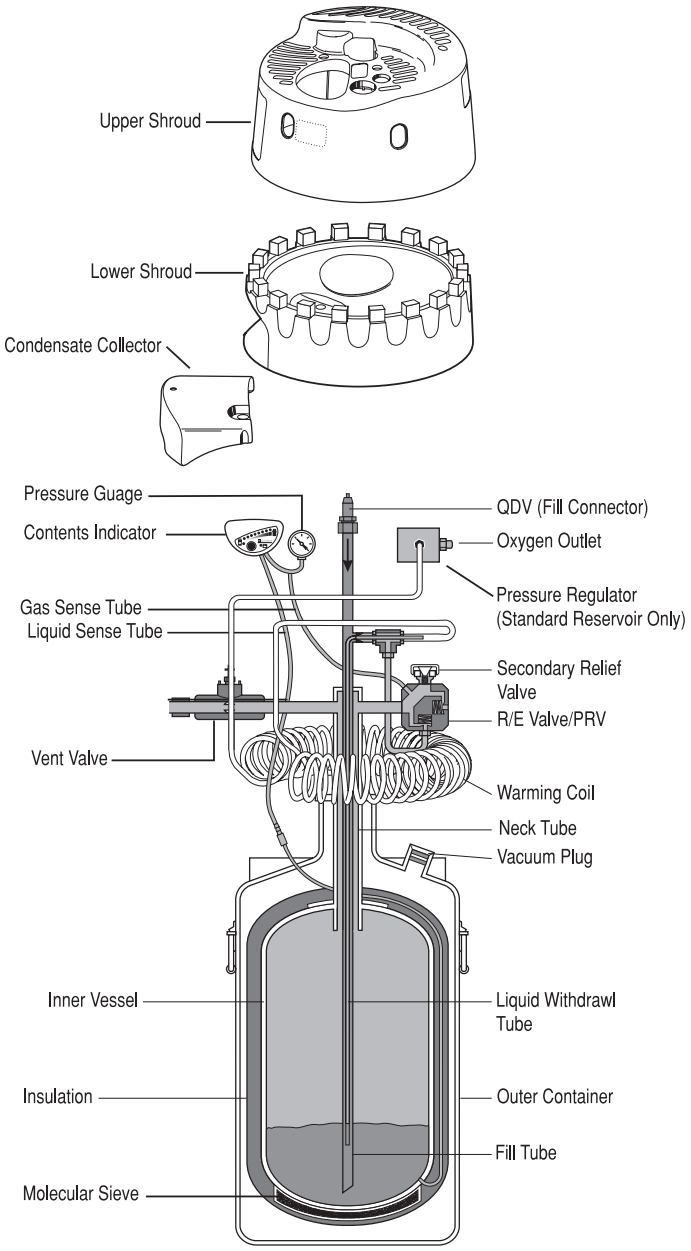
NOTE 1 at 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

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: HELiOS® Standard and Universal reservoirs components



The CAIRE HELiOS® Standard and Universal units are the stationary components of the HELiOS® supplementary oxygen system. The HELiOS® Standard and Universal reservoirs incorporate 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 HELiOS® Standard and Universal reservoirs are 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 coil, vent valve, R/E economizer, SRV, high and low pressure lines, pressure gauge, pressure regulator(Standard reservoir only), oxygen outlet, and QDV(fill connector).

3. **Shroud Assembly** The reservoir unit's shroud assembly includes an upper shroud and a lower shroud. The upper shroud is made of durable plastic and designed to protect the internal components of the plumbing system. The lower shroud is also made of durable plastic and is designed to store the condensation collector as well as separate the plumbing system from the cryogenic container.

4. **Liquid Content/Level Indicator** This system uses differential pressure to measure the level of LOX remaining in the cryogenic vessel and an electronic (LED) readout to display the LOX level by pressing the onboard operate button.

Theory of Operation

The HELiOS reservoir provides a source of liquid oxygen to fill portable units. It also provides gaseous oxygen to a HELiOS Portable or 1,5 bar/22 psig FCV connected to the oxygen outlet connector. If all reservoir outlets are closed (Vent Valve, PRV, SRV, Oxygen Outlet, QDV) with LOX in the unit, then the pressure in the inner vessel will remain near the primary relief valve setting of less than 3,3 bar/48 psig (Standard Reservoir) or less than 1,7 bar/25 psig (Universal Reservoir).

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.

NOTE: In the Standard reservoir, the pressure regulator maintains a constant outlet pressure of 1,5 bar/22 psig as oxygen flow demands vary and system internal pressure swings between 3,3 bar/48 psig and 1,9 bar/27 psig. In the Universal reservoir, a pressure regulator is not required since the system internal pressure swing is much smaller, between 1,8 bar/26 psig and 1,5 bar/22 psig. The economizer valve maintains a constant outlet pressure of 1,5 bar/22 psig while gas flows to the patient.

NOTE: In Figure 4, the operating pressure is at or below 1,9 bar/27 psig for Standard reservoir and 1,5 bar/22 psig for Universal reservoir.

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

WARNING: The vent valve orifice does not guarantee properly saturated LOX. The filling source tank must have a minimum 1,6 bar/23 psi to transfill into CAIRE reservoirs or low saturation will occur.

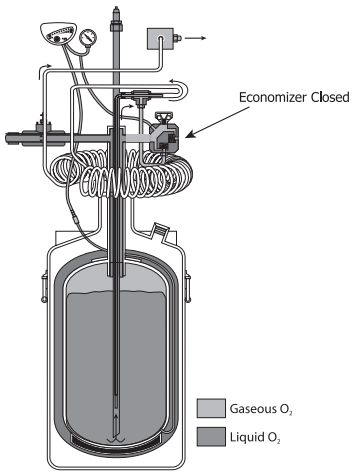


Figure 4

WARNING: HELiOS reservoirs are not equipped with an internal FCV. Therefore, a patient should NEVER be connected directly to a HELiOS reservoir without the use of an external FCV, OxiClip™ conserver or a HELiOS portable unit. Attempting to use a HELiOS reservoir as a direct respiratory device without one of these accessories can result in SERIOUS PERSONAL INJURY.

When the external FCV or HELiOS portable unit is at any setting other than off, and the economizer valve is open (pressure over 1,9 bar/27 psig for Standard reservoir and 1,5 bar/22 psig for Universal reservoir), gaseous oxygen is forced from the head space in the inner vessel, through the economizer valve, to the 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 1,9 bar/27 psig (Standard reservoir) or 1,5 bar/22 psig (Universal reservoir), 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 external FCV or a HELiOS portable unit, providing gaseous oxygen to the patient.

NOTE: In Figure 5 the operating pressure is over 1,9 bar/27 psig for Standard reservoir,1,5 bar/22 psig for Universal reservoir.

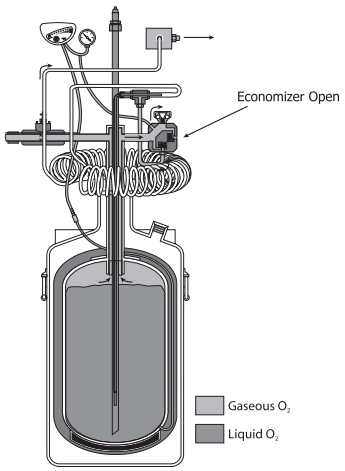


Figure 5

HELiOS Standard vs. HELiOS Universal
The main differences between the Standard and Universal reservoirs consist of three components: 1) Standard reservoirs have RV settings of less than 3,3 bar/48 psig for the PRV and 4,8 bar/70 psig +/- 5% for the SRV, whereas the Universal reservoirs have RV settings of less than 1,7 bar/25 psig for the PRV and 2,1 bar/30 psig +/- 5% for the SRV. 2) Due to the wide range between the PRV and SRV settings on the Standard reservoir, a pressure regulator is used to assist in maintaining proper operating pressure, whereas this range is minimal on the Universal reservoir and does not require this regulator. 3) Due to the higher pressure and recessed fill connector on the Standard reservoir, only HELiOS portable devices can be filled, whereas when using the Universal reservoir all portable devices in the CAIRE family can be filled (All HELiOS, Companion, Stroller, Sprint, Spirit portables).

Liquid Contents/Level Indicator Operation
The contents indicator, visible through the upper shroud of the reservoir, measures and displays the amount of liquid oxygen remaining in the HELiOS reservoir. It is powered by a nine-volt alkaline battery offering battery life of approximately 1 year at one activation per day. 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. An electronic pressure transducer measures the pressure at the bottom of the inner container created by the level of liquid oxygen. However, this pressure signal is also a function of gaseous headspace pressure acting on top of the liquid. So the transducer measures the gaseous headspace pressure and subtracts the value from the total pressure at the bottom of the inner container. It sends the resulting electronic signal that is proportional to the level of liquid oxygen to the circuit board in the indicator. Eight green LEDs on the indicator display panel represent the full to empty range of the system. When the patient depresses the push button, a proportional number of green LEDs light to represent the relative level of liquid oxygen remaining in the reservoir. In addition to the green LEDs, a yellow "low contents" LED on the contents indicator lights when 3.9 kg/8.5 pounds of liquid oxygen remain. A yellow "low battery" LED lights when the battery voltage drops below a predetermined value.

Internal Pressure Gauge Operation
The HELiOS reservoir internal pressure gauge indicates the status of the system headspace pressure. The indicator dial is calibrated from 0 to 7 bar/0 to 100 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: Standard (L) and Universal (R) Fill Connectors

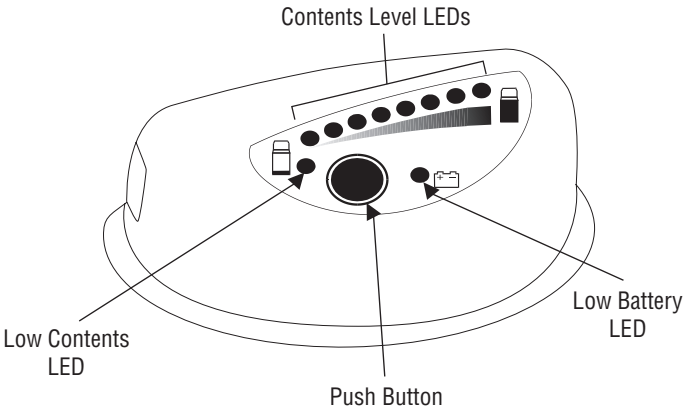


Figure 7: Liquid Level Indicator
(Typical Battery Life is approximately 1 year.)

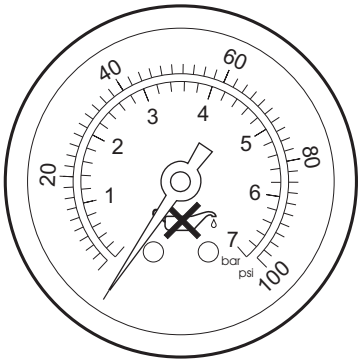


Figure 8: Internal Pressure Gauge

NOTE: Universal reservoirs manufactured prior to August 2006 were not equipped with internal pressure gauges. In any statement regarding internal pressure, if the unit was manufactured prior to this date, an external pressure gauge must be used by attaching an external pressure gauge (P/N B-701732-00 or equivalent) to the reservoir oxygen outlet DISS connector.

Using a Reservoir as a Gaseous Source Along With a HELiOS Portable Unit

To operate the Reservoir as a source of gaseous oxygen using a HELiOS portable unit, perform the following steps:

1. Verify that there is adequate liquid oxygen in the reservoir to meet patient breathing needs.
2. Insert the flexible oxygen supply tube connector into the quick connect on the front of the portable and snap it in place.
3. Locate the oxygen DISS nut and tailpiece assembly attached to the opposite end of the flexible oxygen supply tube. Thread the nut and tailpiece assembly onto the reservoir oxygen outlet connector until secure.
4. Verify that the tube connections are leak tight.
5. Place one of the tubes from the dual-lumen oxygen cannula on the HELiOS Portable oxygen outlet connector (upper connector). Place the other cannula tube on the sensor connector (lower connector). Adjust the cannula on the face to receive oxygen comfortably.
6. Set the HELiOS Portable flow control knob to the prescribed oxygen flow setting.

NOTE: When using the HELiOS Marathon portable unit in combination with the reservoir for a gaseous source, the Demand setting on the Marathon must be used.

Reservoir Serial Number Identification

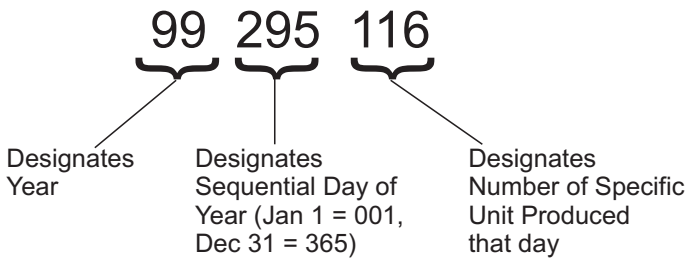
Prior to June 2010, each HELiOS reservoir is identified by a unique eight-digit serial number. The number contains the year and calendar day of manufacture, as well as the unit's production number for that day. The Standard reservoir serial number is etched into the upper head of the cryogenic container and is visible when the moisture container is removed. The Universal reservoir serial number is etched into a reservoir handle bracket. (See Figure 11).

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 (See Figure 11). 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 support is ever needed through CAIRE Customer Service or Technical Service.

Figure 9: Quick Connection on HELiOS Portable

Figure 10: DISS Nut and Tailpiece connected to Reservoir Outlet

Reservoirs Manufactured before June 2010



Reservoirs Manufactured after June 2010

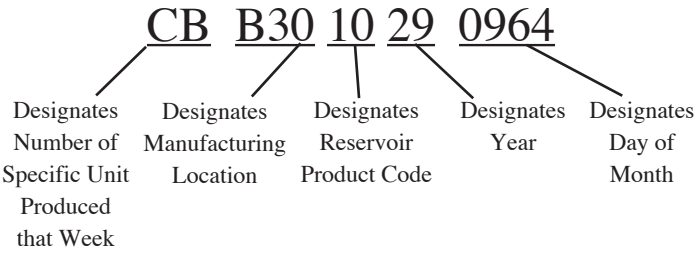


Figure 11: Serial Number Identification

Table #6

HELiOS Reservoir Specifications				
MODEL	**H-36**	**H-46**	**U-36**	**U-46**
Volume of LOX (typical)	36 liters/1.27 ft3	46 liters/1.62 ft3	36 liters/1.27 ft3	46 liters/1.62 ft3
Weight of LOX at 24 psig (166 kPa) Saturation (typical)	38.6 kg/85 lbs	50.0 kg/110 lbs	38.6 kg/85 lbs	50.0 kg/110 lbs
Gaseous Oxygen Equivalent @ 1atm. and 70°F	29,069 liters/1027 ft3	37,619 liters/1328 ft3	29,069 liters/1027 ft3	37,619 liters/1328 ft3
Height	85.1 cm/33.5 in	95.3 cm/37.5 in	85.1 cm/33.5 in	95.3 cm/37.5 in
Diameter	39.1 cm/15.4 in	39.1 cm/15.4 in	39.1 cm/15.4 in	39.1 cm/15.4 in
Empty Weight	24.0 kg/53 lbs	27.2 kg/60 lbs	24.0 kg/53 lbs	27.2 kg/60 lbs
Full Weight	62.6 kg/138 lbs	177.1 kg/170 lbs	62.6 kg/138 lbs	77.1 kg/170 lbs
Outlet Pressure	1,4-1,6 bar/20.5-23.5 psig	1,4-1,6 bar/20.5-23.5 psig	1,4-1,6 bar/20.5-23.5 psig	1,4-1,6 bar/20.5-23.5 psig
Economizer Pressure	1,7-2,1 bar/24.0-30.0 psig	1,7-2,1 bar/24.0-30.0 psig	1,4-1,6 bar/20.5-23.5 psig	1,4-1,6 bar/20.5-23.5 psig
Primary Relief Valve Opening Pressure	Less than 3,3 bar/48 psig	Less than 3,3 bar/48 psig	Less than 1,7 bar/25 psig	Less than 1,7 bar/25 psig
Primary Relief Valve Reseat Pressure	Greater than 2,9 bar/42 psig	Greater than 2,9 bar/42 psig	Greater than 1,6 bar/23 psig	Greater than 1,6 bar/23 psig
Secondary Relief Valve Opening Pressure	4,8 bar/70 psig +/- 5%	4,8 bar/70 psig +/- 5%	2,1 bar/30 psig +/- 5%	2,1 bar/30 psig +/- 5%
Secondary Relief Valve Reseat Pressure	Greater than 4,3 bar/63 psig	Greater than 4,3 bar/63 psig	Greater than 1,9 bar/27 psig	Greater than 1,9 bar/27 psig
Normal Evaporation Rate (NER) (typical)	0.54-0.68 kg/ 1.2-1.5 lbs per day	0.54-0.68 kg/ 1.2-1.5 lbs per day	0.54-0.68 kg/ 1.2-1.5 lbs per day	0.54-0.68 kg/ 1.2-1.5 lbs per day
Maximum Outlet Flow	10 L/min	10 L/min	10 L/min	10 L/min
Contents Indicator	Electronic, Differential Pressure Based	Electronic, Differential Pressure Based	Electronic, Differential Pressure Based	Electronic, Differential Pressure Based
Operating Temperature	10°C to 40°C 95% max. relative humidity	10°C to 40°C 95% max. relative humidity	10°C to 40°C 95% max. relative humidity	10°C to 40°C 95% max. relative humidity
Storage Temperature	-40°C to 70°C 95% max. relative humidity	-40°C to 70°C 95% max. relative humidity	-40°C to 70°C 95% max. relative humidity	-40°C to 70°C 95% max. relative humidity

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 12).

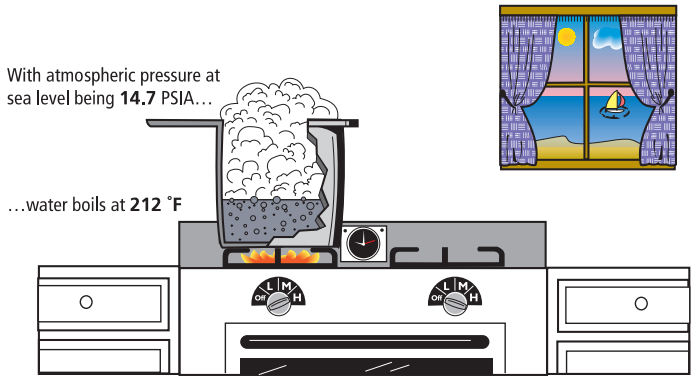


Figure 12: Saturated (Boiling) Water at Sea Level

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 13).

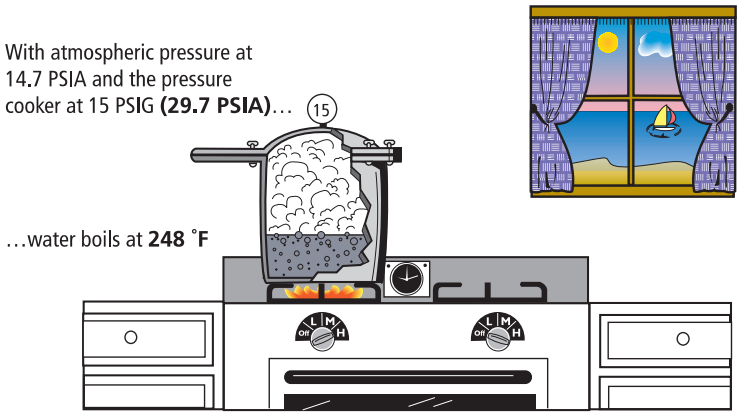


Figure 13: Saturated (Boiling) Water at Higher Pressure

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 14).

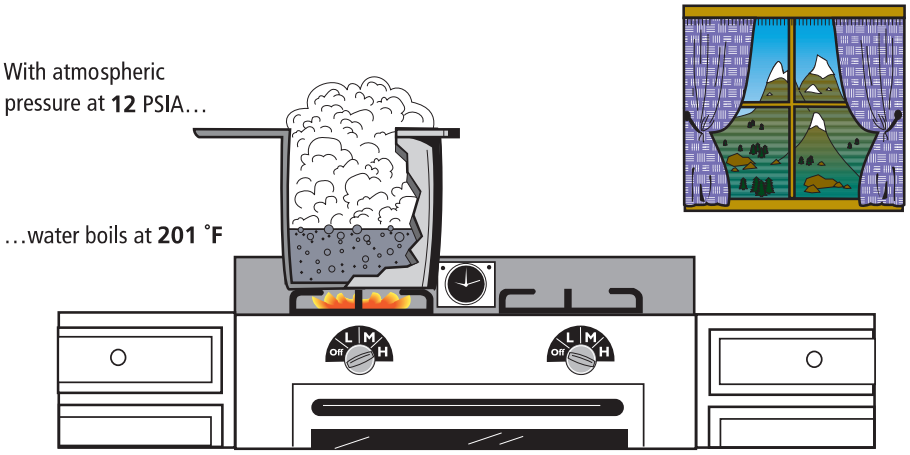


Figure 14: Saturated (Boiling) Water at Lower Pressure

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 15).

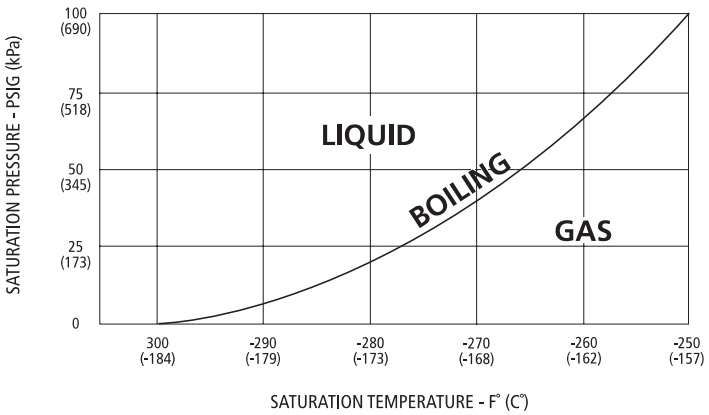


Figure 15: Liquid Oxygen Saturation Curve

It is important to maintain liquid oxygen saturation (boiling) at the specified operating pressure of the HELiOS 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.

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 moisture container.
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 case of portable unit.
4. Verify operation of the level meter by depressing the operate button. LEDs will light, displaying the level of liquid oxygen. If the unit is empty, only the leftmost LED should light.
5. Check all labels for damage and wipe away any dust on unit with a clean, dry, lint-free cloth.
6. Verify the fill connector release button and mechanism move freely.
7. Verify that a HELiOS vent wrench is available for filling of reservoir.
8. Specifically designed roller bases are available for transporting CAIRE reservoir units short distances and on smooth surfaces. Hand trucks may also be used.

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

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 its side or handled roughly in order to prevent damage.

Filling

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

1. Fill Source Preparation

   a. Ensure the source contains a sufficient amount of liquid oxygen to completely fill the reservoir (approximately 120% of reservoir volume).

   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 process of properly saturating the reservoir will be difficult. If the reservoir is not properly saturated, the unit will not function correctly resulting in inaccurate flow rates, excessive boil off of liquid, and will cause portable units which are filled off the reservoir to act in the same manner. Please refer to Section VII SATURATION PRINCIPLES to learn more about the importance of proper saturation

2. Fill Procedure

   a. Required Equipment:

      ❑ Fill source as outlined above
      ❑ Liquid oxygen transfer line
      ❑ Female transfer line adapter for top fill reservoirs
      ❑ Eye protection
      ❑ Pressure gauge
      ❑ Insulated gloves

   b. Verify that liquid level meter is operating properly. The LED display should indicate approximate level in unit. The low battery LED should not be lit.

   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 adapter is equipped with a male QDV, push adapter poppet against an unpainted stainless steel surface.

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

   f. Weigh unit as required by local and federal standards.

   g. Fully open HELiOS vent valve.

   h. Engage the transfer line to the fill connector on the reservoir unit by aligning the fill connector on the transfer line directly over the fill connector on the reservoir and press downward. Keep downward pressure in the transfer line during the entire fill process.

   i. While filling, throttle the vent valve with the vent valve wrench as needed to maintain pressure on the internal pressure gauge at approximately 1,7 bar/24 psig.

NOTE: Universal reservoirs manufactured prior to August 2006 were not equipped with internal pressure gauges. In any statement regarding internal pressure, if the unit was manufactured prior to this date, an external pressure gauge must be used by attaching an external pressure gauge (P/N B-701732-00 or equivalent) to the reservoir oxygen outlet DISS connector.

   k. When a steady spray of liquid spurts from vent outlet, close the vent valve completely.

   l. Disconnect the transfer line from the reservoir by depressing the portable release button and lifting the fill adapter straight up.

   m. If an external pressure gauge is used, disconnect pressure gauge from oxygen outlet.

CAUTION: Do not allow excessive venting of liquid oxygen through the vent valve. Prolonged exposure may freeze the valve in the open position. If the vent valve freezes open, allow the valve to warm up until it opens and closes freely and repeat the fill process.

   n. Verify that all flow rates are within tolerance specification and that the liquid level meter indicates full.

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, HELiOS reservoirs are equipped with digital liquid level meters. In order to obtain a liquid level reading, the technician or end-user should depress the large circular operate button on the face of the meter. This will cause the LEDs to quickly flash from right to left across the meter's perimeter to indicate button activation. The LEDs will then light from the left to the right, signifying the liquid level in the cylinder (1 LED for near empty, 8 for full). If the yellow light beside the reservoir symbol flashes, then the reservoir is empty. If the yellow light beside the battery symbol flashes, then the battery for the indicator needs to be replaced.

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 upper shroud 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 with a towel moistened with water. Wipe dry.

3. Clean the reservoir plumbing and lower shroud with water. Dry with a towel and oil-free compressed gas.

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

Table #7 shows the approved cleaning and disinfecting solutions are acceptable for use with HELiOS 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 upper and lower shrouds for cracks, warpage, and discoloration.

- Verify that the warning labels are present and legible on the upper shroud.

- 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 yellow "low contents" LED lights when the contents indicator button is depressed (empty unit). Replace the 9-volt battery if the low battery LED lights.

- 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.

End of Life

At the end of the unit's service 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.

Maintenance (Schedule A, Biennial)

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. Maintenance checklists are provided for each schedule. See Below.

Schedule A – Biennial

A. Introduction

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 Troubleshooting section of this manual.

   -or-

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

2. Schedule – Maximum of two years between routine maintenance 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 this manual.

1. Visual Inspection:

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

   b. Look for damaged or missing parts.

   c. Verify the meter reads empty (one LED) and that the low battery LED is not lit.

2. Component Test:

   a. Remove shroud (RP5).

   b. Perform Leak Test (RP 2)

   c. Perform PRV test (RP14).

   d. Perform SRV test (RP15).

   e. Pressure Retention Test (RP17).

   f. Replace shroud (RP5).

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

   h. Flow Rate test (RP22).

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. Perform NER test (RP25).

4. Prepare for Use:

   a. Empty contents (RP3).

   b. Clean and/or disinfect outside of unit following instruction set forth in the Operation section.

Schedule A (Biennial) Maintenance Checklist

Step	10 Year Service Life		Year 2	Year 4	Year 6	Year 8	Year 10
1	LOX Purged From Reservoir (Repair Procedure RP3)	Performed or Verified By/Date					
2	Inpection for Damaged/Missing Parts	Performed or Verified By/Date					
3	LED on Level Meter Reading Empty (One LED) and the Low Battery LED is Not Illuminated	Performed or Verified By/Date					
4	Remove Shroud (Repair Procedure RP5)	Performed or Verified By/Date					
5	Perform Leak Test (Repair Procedure RP2)	Performed or Verified By/Date					
6	Perform PRV Test (Repair Procedure RP14)	Performed or Verified By/Date					
		PRV Crack Pressure					
		PRV Reseat Pressure					
7	Perform SRV Test (Repair Procedure RP15)	Performed or Verified By/Date					
		SRV Crack Pressure					
		SRV Reseat Pressure					
8	Liquid Contents/Level Indicator Test (Repair Procedure RP6)	Performed or Verified By/Date					
	Liquid Contents/Level Indicator Display With 9-11kg (20-25 lbs) of LOX						
9	Pressure Retention Test (Repair Procedure RP17)	Performed or Verified By/Date					
		Internal Pressure after 10 Minutes					
		Internal Pressure after 60 Minutes					
10	Replace Shourd (Repair Procedure RP5)	Performed or Verified By/Date					
11	Flow Rate Test (Repair Procedure RP22)	Performed or Verified By/Date					
	Flow Rate at:	OFF					
	Flow Rate at:	0.12					
	Flow Rate at:	0.25					
	Flow Rate at:	0.5					
	Flow Rate at:	0.75					
	Flow Rate at:	1.00					
	Flow Rate at:	1.50					
	Flow Rate at:	2.00					
	Flow Rate at:	2.50					
	Flow Rate at:	3.00					
	Flow Rate at:	3.50					
	Flow Rate at:	4.00					
	Flow Rate at:	5.00					
	Flow Rate at:	6.00					
	Flow Rate at:	8.00					
	Flow Rate at:	10.00					
12	Inspect for Cold or Sweaty conditon/ Excessive Venting from RV	Performed or Verified By/Date					
13	Perform NER Test (Repair Procedure RP25)	Performed or Verified By/Date					
		NER Results					
14	Empty Contents from Reservoir (Repair Procedure RP3)	Performed or Verified By/Date					
15	Clean and/or Disenfect Outside of Unit	Performed or Verified By/Date					

Schedule B – Continuous Pre and Post Fill Inspection

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. If 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 – Checks should be made before and after the driver fills a unit at a patient location.

B. Pre Fill Procedure

1. Visually inspect for:

   a. Broken shrouds or shroud components

   b. QDV deformation

   c. Liquid Contents/Level Indicator functionality

   d. Cryogenic reservoir damage (dents, dings)

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

   f. Presence of all required labels

   g. 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

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

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 unit

   d. Liquid Level Contents/Indicator reads the accurate amount

   e. Pressure gauge is reading accurate pressure

Schedule B (Continuous Pre and Post Fill Inspection) Maintenance Checklist			
Pre Fill Visual Inspection			
1	Broken Shroud or Shroud Components	Verified By/Date	
2	QDV Deformation	Verified By/Date	
3	Liquid Contents/Level Indicator Functionality	Verified By/Date	
4	Cryogenic Reservoir Damage (Dents,Dings)	Verified By/Date	
5	Visible Dirt or Contamination Inside and/or Outside of the Upper Shroud, as well as Inside and/or Outside of the Condensate Collector	Verified By/Date	
6	Presence of All Required Labels	Verified By/Date	
7	If LOX is present in Unit, Inspect for Heavy Frost or Condnesation on the Exterior of the Unit, Which Would Indicate Poor Vacuum	Verified By/Date	
8	Vent Valve Functionality Ensuring that All Parts are Present and the Valve Functions as it Should	Verified By/Date	
Post Fill Visual Inspection			
1	QDV Poppet is Closed and Not Leaking	Verified By/Date	
2	Vent Valve is Not Leaking	Verified By/Date	
3	No Heavy Frost or Condensation is Present on the Exterior of the Unit	Verified By/Date	
4	Liquid Level Contents/Indicator Reads the Accurate Amount	Verified By/Date	
5	Pressure Gauge is Reading Accurate Pressure	Verified By/Date	

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 8 below provides troubleshooting procedures for the HELiOS 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.

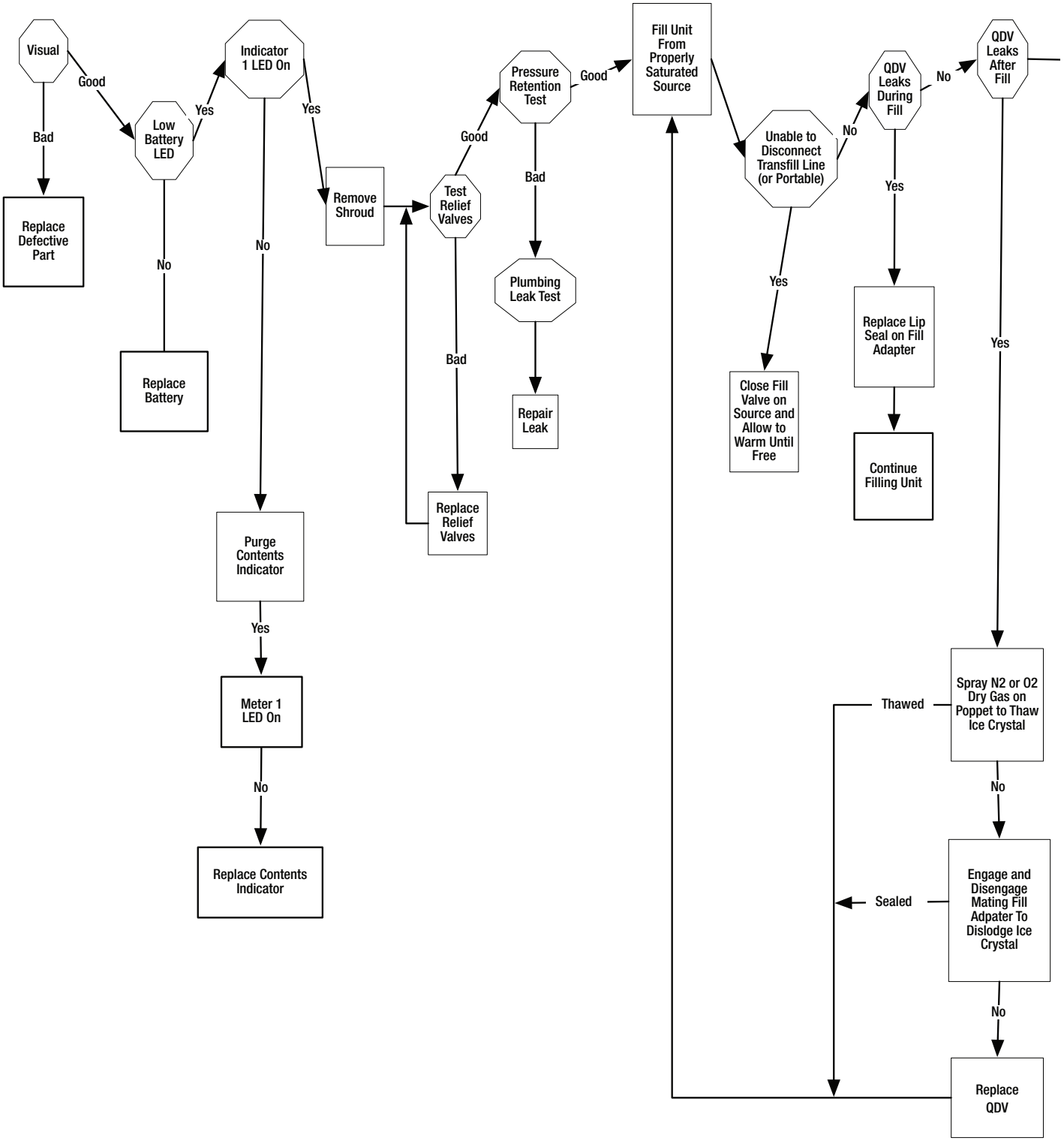
Table 8

Symptom	Probable Cause	Corrective Action
1. Liquid oxygen leaks from fill connector after fill.	a. Ice crystal preventing proper closure of poppet. b. Damaged poppet or fill connector.	a. If minor leak, engage and disengage mating fill connectors several times to dislodge ice crystal. If this fails or is a major leak, vent pressure in reservoir to stop leak by opening vent valve. b. Examine poppet and fill connector. If damaged, replace fill connector.
2. Liquid oxygen leaks from engaged fill connector during fill.	a. Lip seal in female fill connector cracked or damaged.	a. Replace lip seal.
3. Unable to disconnect transfer line (or Portable) from reservoir after fill.	a. Fill connectors frozen together due to presence of moisture.	a. Close liquid valve (or vent valve on portable) and allow transfer line (or portable) to sit until fill connectors are warm enough to disconnect. (Fill connectors should be dried with lint-free cloth before filling).
4. Excessively long fill time	a. Vent valve not fully open. b. LOX in source tank is either under or over saturated. c. Fill connector not opening properly.	a. Rotate vent wrench counterclockwise until it stops. b. Allow LOX to saturate to proper pressure. c. Check fill connector for damage; make sure fill connectors fully engage.
5. Low pressure reading on reservoir pressure gauge (pressure reads less than 1,7 bar/24 psig).	a. Vent valve not completely closed or leaking. b. Reservoir filled with liquid oxygen at incorrect saturation pressure. c. Leak at plumbing connection. d. Damaged pressure indicator. e. Economizer valve stuck in open state (problem noticeable only during oxygen flow demand).	a. Close vent valve. Leak test valve outlet and stem. Replace or repair as needed. b. Allow LOX to saturate to proper pressure c. Perform leak test. Repair as needed. d. Perform Pressure Indicator Test. e. Perform Economizer Test.
6. Low pressure at reservoir oxygen outlet (pressure is less than 1,4 bar/20.5 psig).	a. Vent valve not completely closed or leaking. b. Reservoir filled with liquid oxygen at incorrect saturation pressure. c. Leak at plumbing connection. d. Economizer valve stuck in open state (problem noticeable only during oxygen flow demand).	a. Close vent valve. Leak test valve outlet and stem. b. Allow LOX to saturate to proper pressure. c. Perform leak test. Repair as needed. d. Perform Economizer Test. e. Test pressure regulator and adjust if needed (Standard reservoir only).

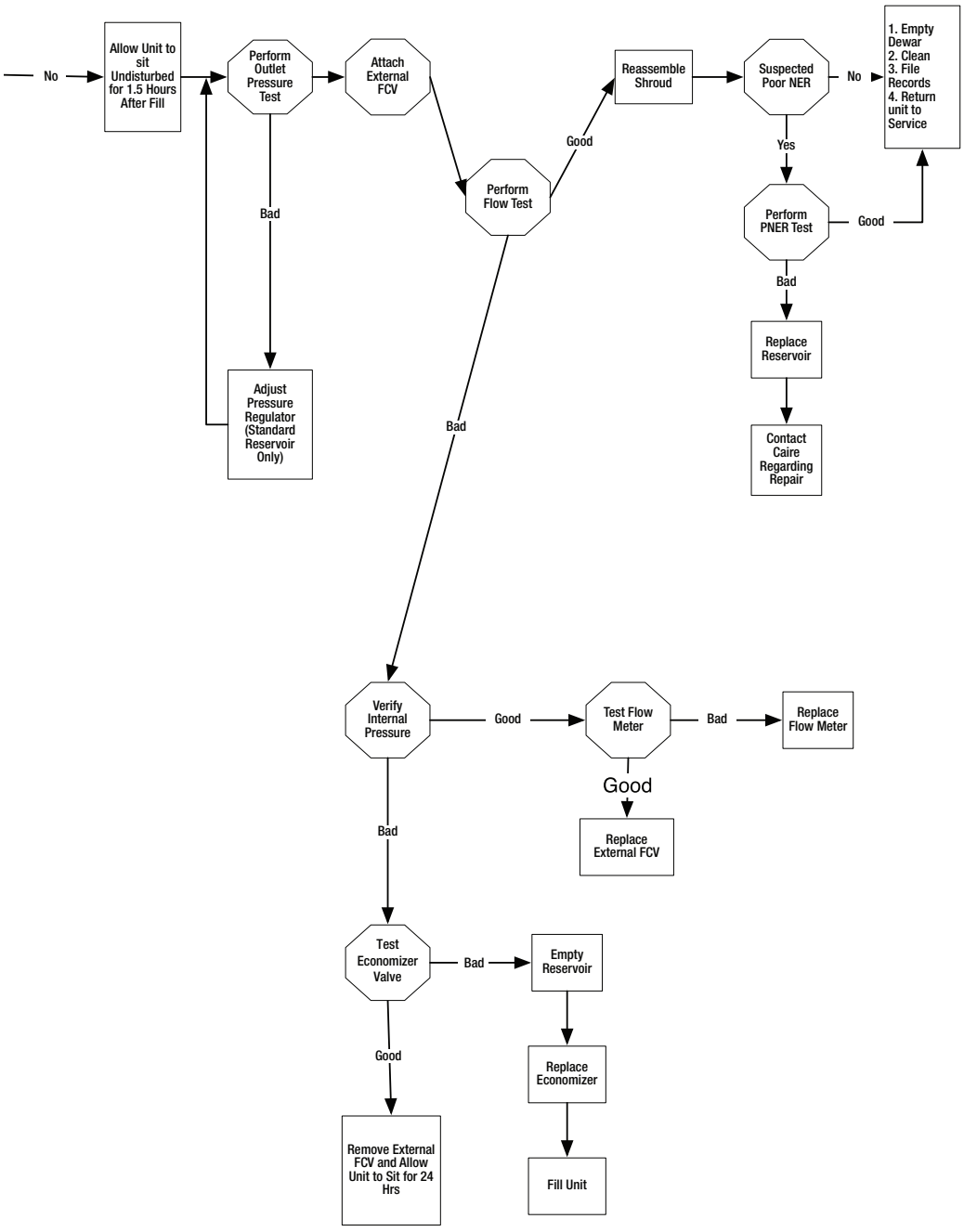
Table 8 (cont.)

Symptom	Probable Cause	Corrective Action
7. High pressure at reservoir oxygen outlet.	a. Universal reservoir primary relief valve setting too high or relief valve operating improperly (no flow condition). b. Universal reservoir economizer valve stuck in closed state (problem noticeable only during oxygen flow demand). c. Container vacuum loss. d. Standard reservoir pressure regulator out of adjustment or malfunctioning.	b. Perform primary relief valve test (Contact Technical Service if faulty). b. Perform Economizer Test (Contact Technical Service if faulty). c. Perform NER Test. d. Test pressure regulator and adjust as needed (Standard reservoir only).
8. Low flow at oxygen outlet.	a. Low pressure at oxygen outlet. b. Partial obstruction of flow restrictor connector. c. Partial obstruction in liquid withdrawal tube or warming coil.	a. See Symptoms 5 and 6. b. Clean or replace flow restrictor connector. c. Check liquid withdrawal tube and warming coil for blockage. Clean or replace as needed. NOTE: Be aware of a non-removable twisted copper wire inserted into warming coil near its inlet.
9. No flow at oxygen outlet.	a. Reservoir is empty. b. Zero head pressure caused by major leak (vent valve open, relief valve malfunction, etc.). c. Total obstruction in liquid withdrawal tube, warming coil, flow restrictor connector, or pressure regulator.	a. Perform fill procedure. b. Perform leak test. Repair as needed. c. Locate obstruction and clean or replace components as needed.
10. Contents indicator reads incorrectly.	a. Battery voltage low. b. Leak in sensing tubes or fittings. c. Flexible contents indicator pressure sense tube pinched. d. Ice blockage in contents indicator (liquid) pressure sense tube. e. Contents indicator electronics malfunction.	a. Replace 9-volt battery. b. Perform leak test. Repair as needed. c. Visually inspect flexible pressure sense tubes and remove pinching condition. d. Perform contents indicator liquid sense tube purge procedure. e. Replace contents indicator module.
11. High product loss rate.	a. Container vacuum loss. b. Leak in tubing or connections.	a. Perform NER Test. b. Perform leak test. Repair as needed.

Troubleshooting & Repair Procedures



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 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:

   a. For HELiOS Standard Reservoir:
      i. 1,7-3,3 bar/24-48 psig

   b. For HELiOS Universal Reservoir:
      i. 1,4-1,7 bar/20.5-25 psig

3. If the reservoir does not contain liquid oxygen, connect an adjustable 0 to 100 psig (0 to 690 kPa) source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture. Pressurize the reservoir with gaseous oxygen to:

   a. For HELiOS Standard Reservoir:
      i. 2,8bar/40 psig

   b. For HELiOS Universal Reservoir:
      i. 1,2 bar/22 psig

4. Use Snoop to test all reservoir fittings and connections.

5. Place a finger wetted with Snoop lightly against the vent valve outlet to test for leakage.

6. Place a finger wetted with Snoop lightly against the DISS oxygen outlet to test for leakage.

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.

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.

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.

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

RP3 – Emptying/Purging Reservoir

1. Connect a pressure regulator to oxygen or nitrogen gas source.

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.

2. Connect a pneumatic hose to the regulator and a transfer fill adapter with relief valve to the opposite end of the pneumatic hose.

3. Open the main valve on gas source.

4. 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.

5. Adjust regulator to a pressure setting that is slightly higher than the internal pressure of the unit (Example: If the internal pressure gauge reads 1,7 bar/24 psig, adjust the regulator attached to the gas source to approximately 1,8-1,9 bar/26-28 psig).

6. Attach the transfer fill adapter to the QDV on the reservoir.

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)

8. Remove transfer fill adapter from reservoir.

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

9. Close main valve on gas source.

RP4 – Condensation Collector RR

1. The condensation collector is located below the upper shroud, inside the lower shroud and is in line with the internal pressure gauge.

2. Pull the collector out of the lower shroud to remove any condensation

3. To reinstall the collector, slide into the lower shroud.

RP5 – Shroud Assembly RR

1. Upper Shroud:

a. Remove the two pan head screws from the topside of the upper shroud.

b. Carefully remove the upper shroud by lifting it up and over the plumbing components.

c. To reinstall or replace the upper shroud, reverse the above procedures.

NOTE: New labels must be installed any time the upper 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 upper shroud so that the access holes are positioned directly over the corresponding reservoir plumbing components. Also, be sure that the upper shroud is seated uniformly on the lower shroud lip.

2. Lower Shroud Removal:

a. Remove the upper shroud (Section RP4).

b. Slide the press-on tubing clamp back and disconnect the flexible black "LO" pressure sense tube from the barbed fitting on the R/E valve.

c. Disconnect the flexible red "HI" pressure sense tube from the "HI" pressure sense barbed fitting on the contents indicator.

d. While using a 9/16-in. open end wrench to hold the liquid withdrawal tee stationary, use a second 9/16-in. open end wrench to remove the warming coil compression nut from the tee.

e. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.

f. Use a 5/32-in. hex key wrench to remove the four socket head cap screws that secure the mounting bracket to the manifold flange.

g. Remove the mounting bracket and attached components.

h. Use a ¾-in. open-end wrench to remove the vent valve from the threaded manifold extension tube. Place the wrench on the valve hex flats closest to the manifold extension tube to prevent disassembly of the valve.

i. Use a 9/16-in. open end wrench to remove the economizer tube compression nut from the liquid withdrawal tee.

j. Use a ½-in. open end wrench to remove the economizer tube inverted compression nut from the R/E valve.

k. Remove the economizer tube.

l. Use a ¾-in. open-end wrench to remove the R/E valve assembly from the threaded manifold extension tube.

m. Remove the umbrella seal by carefully working it up over the manifold flange and tubes.

n. Remove the lower shroud by carefully working it up over the manifold flange and tubes.

3. Lower Shroud Reinstall or Replacement:

a. Install the lower shroud over the manifold flange and tubes.

b. Pull the flexible red "HI" pressure sense tube up through the 3/16 in. diameter hole in the lower shroud tray (not the larger moisture drain hole).

c. Position the red tube in the notch molded into the side of the oval opening in the center of the shroud.

NOTE: On early version lower shrouds without the 3/16 in. hole, pull the red flexible contents indicator tube up through the oval opening in the center of the shroud.

d. Position the embossed 1-in. (2.5-cm) circular index mark on the top of the lower shroud directly over the vacuum port on the container.

e. Ensure that the container vacuum port is captured between two parallel vertical ribs on the bottom of the lower shroud.

f. Use a flashlight and look to the right through the moisture container opening to verify capture of the vacuum port.

g. Install the umbrella shield over the manifold flange and tubes.

h. Pull it down the neck of the container until it sits snugly over the oval opening in the center of the lower shroud.

i. Apply Teflon tape sealant to the threaded manifold tube facing the embossed circular index mark on the top of the lower shroud.

j. Install the R/E valve assembly on the manifold tube and tighten so that the secondary relief valve is in a vertical, up position.

NOTE: On early version lower shrouds without the 3/16 in. (0.5 cm) hole, make sure that the red, flexible contents indicator tube comes out of the oval opening in the center of the shroud and is underneath the umbrella seal.

k. Install the end of the economizer tube with the inverted compression nut in the bottom port of the R/E valve.

l. Install the opposite end of the economizer tube in the side port of the liquid withdrawal tee. Make sure both tube ends are aligned properly and then tighten both compression nuts.

m. Apply Teflon tape sealant to the threaded manifold tube opposite the R/E valve.

n. Install the vent valve on the manifold tube with the valve flow direction arrow pointing away from the manifold.

o. Tighten so that the valve stem is in a vertical, up position.

p. Position the mounting bracket with attached components over the manifold so that the release lever is over the R/E valve.

q. Carefully insert the Teflon liquid withdrawal tube into the open end of the aluminum warming coil tube. Be careful not to kink or scrape the Teflon tube.

r. Align the warming coil tube in the liquid withdrawal tee port and finger tighten the compression nut.

s. Align the mounting bracket on the manifold flange.

t. Install the four socket head cap screws and tighten with a 5/32-in. hex key wrench.

u. Tighten the warming coil compression nut using two 9/16-in. open-end wrenches.

v. Connect the flexible black (gas) pressure sense tube from the contents indicator “LO” circuit to the barbed fitting on the R/E valve.

w. Slide the press-on tubing clamp onto the barbed fitting.

x. Connect the flexible red (liquid) pressure sense tube from the container sense line to the “liquid” pressure sense fitting on the contents indicator.

y. Install the upper shroud per RP2.

RP6 – Liquid Contents/Level Indicator Test

1. Press the blue button on the contents indicator and verify that the yellow, low contents LED lights when the liquid oxygen contents is 3.9 kg /8.5 lbs or less.

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

3. After five minutes, press the blue button and verify that the number of green LEDs lit on the display correspond to the information in Table 9 below. The yellow, low contents LED should be off.

Table 9

Contents Indicator		HELiOS RESERVOIR
No. of Green LED's on	Yellow LED Status	Weight of LOX remaining in Reservoir kg (LBS)
0	Yellow	0.0-3.9 (0.0-8.5)
1	Off	3.9-8.3 (8.5-18.2)
2	Off	8.3-12.7 (18.2-28.0)
3	Off	12.7-17.1 (28.0-37.6)
4	Off	17.1-21.5 (37.6-47.4)
5	Off	21.5-25.9 (47.4-57.1)
6	Off	25.9-30.0 (57.1-66.8)
7	Off	30.3-34.7 (66.8-76.5)
8	Off	>34.7 (76.5)

RP7 – Liquid Contents/Level Indicator RR

1. Remove upper shroud per RP5.

CAUTION: Damage to contents/level indicator or barbed fittings can occur. Vent reservoir pressure before removing either contents indicator tube. Use care when removing flexible tubes from barbed fittings or contents/level indicator

2. Lift the contents/level indicator module off of the mounting bracket and carefully turn it over.

3. Remove the flexible black "LO" pressure sense tube from the barbed fitting on the contents indicator.

4. Remove the flexible red "HI" pressure sense tube from the barbed fitting on the contents indicator.

5. To replace the contents indicator, reverse the above procedures.

RP8 – Liquid Contents/Level Indicator Battery RR

1. Insert a coin into the battery door slot at the rear of the contents indicator module.

2. Lift the coin up to remove the door.

3. Carefully disengage the battery from the battery clip.

4. Install a new 9-volt alkaline battery, taking care to observe proper battery polarity.

5. Reverse the procedures above to reinstall the battery.

RP9 – Purging Liquid Contents/Level Indicator RR

1. Ensure reservoir is empty, warm and free of internal pressure per RP3.
2. Remove the upper shroud per RP5.
3. Use the vent wrench to open the vent valve on the reservoir unit.
4. Connect a pressurizing fixture (P/N B-701731-00 or similar) to the fill connector on the reservoir unit.
5. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the fixture.
6. Adjust the regulator 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 the flexible black (gas) pressure sense tube and the flexible red (liquid) pressure sense tube from the contents indicator. Using a wire tie, lightly secure the tubes to the vent valve to prevent them from moving around.

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

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.

RP10 – Internal Pressure Gauge Test

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. For HELiOS Universal Reservoir:

   a. Slowly pressurize the reservoir until the needle of the reservoir pressure gauge lines up with the 20 psig mark.

   b. Verify that the reading on the pressurizing fixture gauge is 1,2-1,5 bar/18-22 psig.

4. For HELiOS Standard Reservoir:

   a. Slowly increase the reservoir pressure until the needle of the pressure indicator lines up with the 2,1 bar/31 psig.

   b. Verify that the reading on the pressurizing fixture gauge is 1,9-2,3 bar/27-33 psig.

RP11 – Internal Pressure Regulator Test (Standard HELiOS Reservoir Only)

1. Engage the pressurizing fixture to the fill connector on the reservoir and secure it with the attach 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 increase the pressure in the reservoir to 2,8 bar/40 psig.
4. Attach an oxygen wye outlet adapter with two DISS demand check valve outlets to the reservoir DISS oxygen outlet.
5. Attach an external 1,5 bar/22 psig FCV (P/N B-701655-FLO or equivalent) to one of the wye outlets.
6. Attach a test pressure gauge with tubing adapter to the other wye outlet.
7. Set the external FCV to 0.
8. Verify that the test pressure gauge connected to the wye outlet reads 1,4-1,6 bar/20.5-23.5 psig.
9. Set the external FCV to 4 L/min.
10. Verify that the test pressure gauge connected to the wye outlet still reads 1,4-1,6 bar/20.5-23.5 psig.

RP12 – Internal Pressure Gauge RR

1. Remove the upper shroud per RP5.
2. Carefully pull the pressure indicator up and out of the grommet in the mounting bracket.
3. Slide the press-on tubing clamp back and disconnect the flexible black “LO” pressure sense tube from the barbed fitting on the pressure indicator.
4. Use a ¼-in. open-end wrench to remove the barbed fitting from the pressure indicator.
5. Reverse the procedures above to reinstall the internal pressure gauge.

RP13 – Internal Pressure Regulator RR (Standard HELiOS Reservoir Only)

1. Remove upper shroud per RP5.
2. Remove the warming coil.
3. Use a ½ -in. open-end wrench to remove the DISS outlet extension from the regulator outlet.
4. Use a 9/16-in. open-end wrench to remove the flow restrictor connector from the regulator inlet.
5. Pull down on the regulator adjustment knob to release the knob locking mechanism.
6. Use 10-in. arc-joint pliers to remove the serrated plastic retaining nut that secures the regulator to the mounting bracket.
7. Lift up on the regulator to allow the mounting bracket to pass between the regulator knob and bonnet as you remove it.
8. Reverse the procedures above to reinstall the internal pressure regulator.
9. To adjust the internal pressure regulator, attach the pressurizing fixture to the fill connector on the reservoir and secure it with the attached strap.
10. Attach an adjustable 0-6,9 bar/0-100 psig source of gaseous oxygen to the DISS oxygen inlet on the pressurizing fixture.
11. Slowly increase the pressure in the reservoir to 2,8 bar/40 psig.
12. Attach an oxygen wye outlet adapter with two DISS demand check valve outlets to the reservoir DISS oxygen outlet.
13. Attach a 1,5 bar/22 psig external FCV (P/N B-701655-FLO) to one of the wye outlets.
14. Attach a test pressure gauge with tubing adapter to the other wye outlet.
15. Set a 4 L/min flow on the 1,5 bar/22 psig external FCV.
16. Reach in from below the vent valve and grasp the pressure regulator adjustment knob.
17. Pull the knob straight down until you hear it “click”.
18. Turn the knob clockwise (looking at the regulator from the knob end) to increase the pressure.

19. Turn the knob counter-clockwise to decrease the pressure.

20. The pressure reading on the test pressure gauge should be 1,4-1,6 bar/20.5-23.5 psig.

21. Once the pressure regulator setting is within specifications, push the knob up until you hear it "click", locking the adjustment knob.

RP14 – PRV Test

1. Remove the upper 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. The PRV vents through the barbed fitting in the side of the R/E valve.

5. Attach one end of a 1/8-in. I.D. flexible tube to the barbed fitting.

6. Insert the other end of the tube into a clear jar of water.

7. Slowly pressurize the reservoir until a continuous stream of small bubbles first appears in the jar of water.

8. For HELiOS Standard Reservoir:

   a. Verify that the PRV opens (bubbles) at less than 3,3 bar/48 psig.

   b. If the opening pressure is not within the acceptable range, replace the R/E valve.

9. For HELiOS Universal Reservoir:

   a. Verify that the PRV opens (bubbles) at less than 1,7 bar/25 psig.

   b. If the PRV is suspected to be malfunctioning, replace the R/E valve.

10. Slowly reduce the pressure within the reservoir until the continuous stream of bubbles begin to diminish.

11. For HELiOS Standard Reservoir:

    a. Verify that the PRV closes (bubbles begin to diminish) at a pressure greater than 2,9 bar/42 psig.

    b. If the opening pressure is not within the acceptable range, replace the R/E valve.

12. For HELiOS Universal Reservoir:

    a. Verify that the PRV closes (bubbles begin to diminish) at a pressure greater than 1,6 bar/23 psig.

    b. If the PRV is suspected to be malfunctioning, replace the R/E valve.

13. If either the opening pressure or closing pressure readings PRV do not meet the specifications stated in previous steps, replace the R/E valve.

14. Disconnect the pressurizing fixture and open the reservoir vent valve to reduce the pressure below 1,4 bar/20 psig.

RP15 – SRV Test

1. Remove upper 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.

5. Position the movable bar clamp arm over the R/E valve vent barbed fitting and position the fixed bar clamp arm on the edge of the mounting bracket window cutout.

6. Tighten the clamp to seal the vent port.

7. For HELiOS Standard Reservoir:

   a. Slowly pressurize the reservoir by adjusting the oxygen source regulator.

   b. Verify that the secondary relief valve opens (audible hiss) at 4,8 bar/70 psig +/- 5%.

8. For HELiOS Universal Reservoir:

   a. Slowly pressurize the reservoir by adjusting the oxygen source regulator.

   b. Verify that the secondary relief valve opens (audible hiss) at 2,1 bar/30 psig +/- 5%.

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. For HELiOS Standard Reservoir:

    a. Verify that the SRV closes (audible hiss is no longer heard) at a pressure greater than 4,3 bar/63 psig.

11. For HELiOS Universal Reservoir:

    a. 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.

12. Disconnect the pressurizing fixture and open the reservoir vent valve to reduce the pressure below 1,4 bar/20 psig.

13. Remove the clamp blocking the R/E valve vent port.

RP16 – PRV, SRV, R/E Valve RR

1. Remove the upper shroud per RP4.
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 black (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 ½ -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 ¾ -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 black 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 upper shroud.

RP17 – Pressure Retention Test

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 :
   a. For HELiOS Standard Reservoir:
      i. 3,0 bar/45 psig
   b. For HELiOS Universal Reservoir:
      i. 1,7 bar/24 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. Verify pressures are approximately:
   a. For HELiOS Standard Reservoir:
      i. 3,0–3,3 bar/45–49 psig
   b. For HELiOS Universal Reservoir:
      i. 1,5-1,6 bar/22-24 psig
7. Reattach the pressurizing fixture to the QDV on the reservoir.
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 than:

    a. For HELiOS Standard Reservoir:
       i. 2,7 bar-40 psig

    b. For HELiOS Universal Reservoir:
       i. 1,2 bar/17 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.

RP18 – Warming Coil Assembly RR

1. Remove upper shroud per RP5.
2. Use a 9/16-in. open-end wrench to hold the flow restrictor connector stationary at the pressure regulator inlet (Standard reservoir) or the outlet block inlet (Universal reservoir).
3. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the flow restrictor connector.
4. Carefully pull the warming coil tube out of the connector.
5. Use a 9/16-in. open-end wrench to hold the liquid withdrawal tee stationary.
6. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the tee.
7. Pull the aluminum warming coil tube away from the tee and carefully guide the small Teflon liquid withdrawal tube out of the aluminum tube.
8. Push the warming coil assembly back toward the release lever.
9. Rotate the warming coil to bring the far side up and over the release lever.
10. Pull the near side of the warming coil forward to clear the oxygen outlet DISS fitting and vent valve extension.
11. To reinstall or replace the warming coil, reverse the above procedure.

RP19 – Vent Valve RR

1. Remove upper 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.

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.

10. To reinstall or replace the vent valve, reverse the above procedure.

RP20 – Fill Connector Release Assembly RR

1. Remove upper 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.

RP21 – QDV Assembly RR

1. Remove upper 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. Inspect the poppet on the cartridge assembly for wear or damage.
7. To reinstall or replace the QDV, reverse the above procedure.
8. Ensure to add a small amount of Krytox lubricant on the threads of the QDV.

RP22 – 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 hour prior to beginning test.
3. Attach a 1,5 bar/22 psig external FCV (P/N B-701655-FLO) to the reservoir DISS oxygen outlet.
4. Connect FCV outlet to flow meter inlet with respiratory tubing.
5. Make sure flow meter outlet is open and unobstructed and flow meter is properly positioned.
6. Test flow rate at each FCV position.
7. Compare flow rates to the table below.

NOTE: Be careful to allow for accuracy tolerances of flow meter. Table 10 below does not account for these tolerances.

Table 10

FCV Setting	LPM
OFF	0
0.12	0.02-0.22
0.25	0.08-0.42
0.50	0.33-0.67
0.75	0.58-0.92
1.00	0.83-1.17
1.50	1.18-1.82
2.00	1.61-2.43
2.50	2.08-2.97
3.00	2.55-3.51
3.50	2.92-4.04
4.00	3.43-4.62
5.00	4.33-5.77
6.00	5.14-6.92
8.00	6.72-9.28
10.0	8.42-11.53

RP23 – Operating Pressure Test

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

NOTE: Older style Universal HELiOS reservoirs were not equipped with internal pressure gauges, therefore the following procedures should be followed for these units. Otherwise, the operating pressure can be determined by checking the internal pressure gauge.

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 hour prior to beginning test.
3. Attach a 1,5 bar/22 psig external FCV (P/N B-701655-FLO) to the reservoir DISS oxygen outlet.
4. Attach a 0-6,9 bar/0-100 psig pressure gauge to the DISS fitting on the external FCV using a DISS fitting adapter.
5. Open the FCV to any setting above 2 LPM.
6. Pressure gauge should read:
   a. For HELiOS Standard Reservoir:
      i. 1,4-1,6 bar/20.5-23.5 psig
   b. For HELiOS Universal Reservoir:
      ii. 1,4-1,6 bar/20.5-23.5 psig

RP24 – Economizer Test

1. Verify that the reservoir contains at least 9 kg/20 lbs of liquid oxygen.

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 0-6,9 bar/0-100 psig external FCV (P/N B-701655-FLO) to the reservoir DISS oxygen outlet and set a continuous flow of 4 L/min.

4. Engage the pressurizing fixture to the fill connector on the reservoir and secure it with the attached strap.

5. The pressure gauge should read:

   a. For HELiOS Standard Reservoir:

      i. 2,9-3,3 bar/42-48 psig

NOTE: If the gauge reading is higher, open the reservoir vent valve to reduce the pressure. If the gauge reading is lower, allow time for the saturation pressure to increase to 2,9-3,3 bar/42-48 psig

   b. For HELiOS Universal Reservoir:

      i. 1,6-1,7 bar/23-25 psig

NOTE: If the gauge reading is lower, allow time for the saturation pressure to increase to 1,6-1,7 bar/23-25 psig

6. With the unit delivering an oxygen flow, record the pressure readings on the pressurizing fixture gauge every hour until the pressure stabilizes.

7. Stabilization occurs when two consecutive readings are within .07 bar/1 psig of each other.

NOTE: If the economizer is suspected to be malfunctioning, please contact Technical Service.

RP25 – 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:

$$\frac{\text{2nd Recordered Weight - 1st Recorded Weight}}{\left(\frac{\text{\# hours}}{24}\right)} = \text{NER}$$

9. The NER should be 0.68kg per day/1.5 lbs per day or less.

RP26 – Oxygen Outlet Block RR

1. Remove the upper shroud per RP5.

2. Use a 5/8-in. open-end wrench to remove the DISS fitting from the outlet block.

3. Use a 9/16-in. open-end wrench to hold the flow restrictor connector stationary at the oxygen outlet block inlet.

4. Use a second 9/16-in. open-end wrench to remove the warming coil compression nut from the flow restrictor connector.

5. Carefully pull the warming coil tube out of the connector.

6. Use a 9/16-in. open-end wrench to remove the flow restrictor connector from the oxygen outlet block.

7. Lift the contents indicator off of the mounting plate and use a 5/32 in. hex key wrench to remove the flat head screw that fastens the oxygen outlet block to the mounting plate.

8. Remove the oxygen outlet block.

9. To reinstall or replace the oxygen outlet block, reverse the above procedures.

Parts List

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

XIII Ordering Information

Ordering Information

The following steps should be used when ordering a new HELiOS 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:	770 257 1299
Fax:	770 257 1300

Asia, Australia, Pacific Rim

Phone:	+61 297 494333
Fax:	888 932 2473

Europe

Phone:	+44(0) 1344 403100
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.usa@chartindustries.com

Africa/Europe/Middle East email to:

customerservice.europe@chartindustries.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.cairemedical.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 in Section X, page 27-30. 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) 1344 403100

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.

XV Service Tools/Equipment/Supplies

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

Required Fixtures/Equipment

Oxygen Regulator
Vent Valve Wrench
0-6,9 bar/0-100 psig Pressure Gauge
Pressurizing Fixture
Flowmeter
02 Gas Source (High Pressure bottle)
02 Liquid Source
N2 Gas or Clean, Dry Compressed Air Source
Tubing (O2 compatible)
O2 Tubing Tee Connector
Lip Seal Service Tool
Male Pneumatic Test Adapter
LO2 Transfer Line
Transfer Line Adapter with Filter
Dewar Cap
Scale 0-92 kg/0-200 lbs, 0.05 lb/0.02 kg increments
Oxygen DISS Wye Outlet Adapter w/ Demand Check Valve Outlet
Jet /Venturi Assembly
Size 00 Rubber Stopper
DISS O2 Outlet Connector
Small Tie Wrap/Zip Tie
0-10 L/min, 1,5 bar/22 psig external FCV
Oxygen Supply Tube Coupler

Required Supplies

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

Service Tools/Equipment/Supplies

Tools and Accessories available from Caire

Item	Part 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-778214-00
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-775270-00
Reservoir Pressurizing Fixture- 0-6,9 bar/0-100 psig	B-701731-00
Oxygen Compatible Leak Detector (Snoop)	B-775272-00
0-10 L/min, 1,5 bar/22 psig external FCV	B-701655-FLO
Erie Liter Meter, 0-8LPM	97200076
Erie Liter Meter, 6-15 LPM	10995620
Tee Connector – 3/16 in. I.D. Tubing	B-778211-00
Fluoro-Lubricant-2 oz Tube	CA200071
Lubricant - Krytox 240 AC Fluorinated Grease	B-775239-00
HELiOS Oxygen Supply Tube Coupler	B-701686-00
Van Companion Assembly (Delivery Cart)	B-775462-00
• Strap and Buckle Assembly	B-775477-00
• Faspin	B-775478-00
• Pads (2 Required)	B-775476-00
• Wear Strips (2 Required)	B-776169-00
Roller base Assembly (CE Marked)	14880387
Roller base Assembly (Non-CE Marked)	14880803
• Caster (set of 5; CE Marked)	14880379
• Caster (set of 5; Non-CE Marked)	14880361

Item	Part Number
Transfer Line Assembly (6 ft./1.8 m)	B-775288-00
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	B-775264-00
• 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
Universal Adapter Kit	B-775461-00
• Male Flare Adapter	B-775342-00
• Female Flare Adapter	B-775418-00
• PB Fill Connector/Tee Assembly	B-775276-00

Service Tools/Equipment/Supplies

Tools and Accessories available from Caire (cont.)

Item	Part Number
Shipping Carton, HELiOS 36	B-702223-SV
Shipping Carton, HELiOS 46	B-702189-SV
Oxygen Supply Tube Assy. (15.2 m/50 ft.)	B-701656-SV
Oxygen Supply Extension Tube (15.2 m /50 ft.)	B-701432-00
Reservoir Fill Connector Cover	B-777095-00
Dual Lumen Cannula (2.1 m/7 ft.) (Sense and delivery in both nostrils-Concentric Tubes)	10035467
Dual Lumen Cannula (1.5 m/5 ft.) (Sense and delivery in both nostrils-Concentric Tubes)	10035468
Dual Lumen Cannula (2.1 m/7 ft.) (Sense and delivery in both nostrils-Split Nasal Prongs)	6-778057-00
Dual Lumen Cannula (1.5 m/5 ft.) (Sense and delivery in both nostrils)	6-778058-00
Dual Lumen Cannula (0.9 m/3 ft.) (Sense and delivery in both nostrils)	B-701511-00
Dual Lumen Cannula (2.1 m/7 ft.) (Sense and delivery in separate nostrils)	B-701930-00
Dual Lumen Cannula (1.2 m/4 ft.) (Sense and delivery in separate nostrils)	B-701931-00

CAIRE®

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