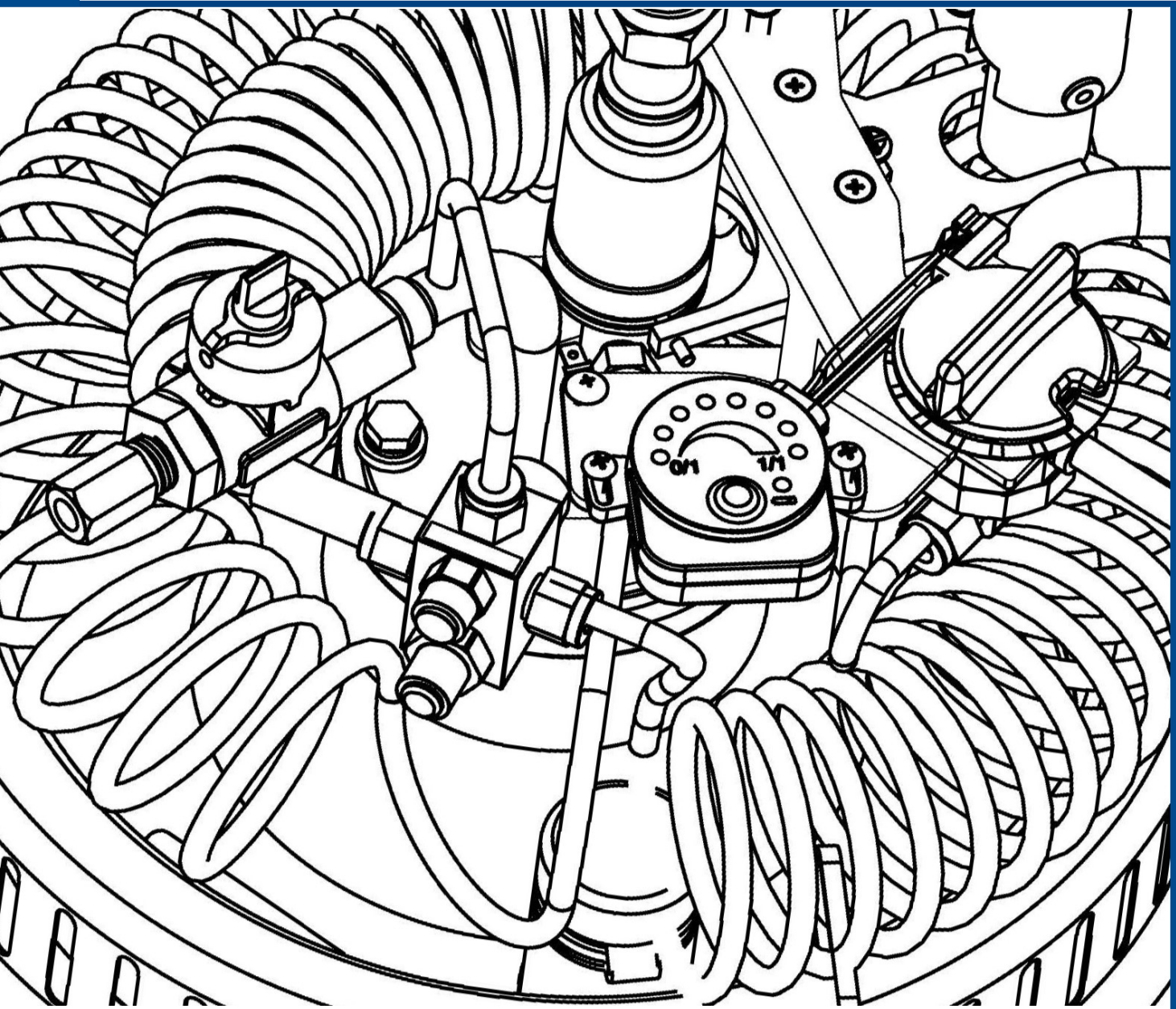
CAIRE®

Liberator - G4



Technical Service Manual

I Preface

SERVICE MANUAL

LIBERATOR SERIES—G4

LIB20, LIB30, LIB37, LIB45, LIB60

CAIRE, Inc.
2200 Airport Industrial Dr., Ste. 500
Ball Ground, GA 30107
www.caireinc.com

Customer/Technical Service:
North and South America
Phone (US Only): 800-482-2473 Fax: 888-932-2473
US: 770-721-7759 Fax: 770-721-7758
Asia, Australia, Pacific Rim
Phone: 770-721-7759 Fax: 770-721-7758
Europe
Phone: +44 (0) 1189 367060 Fax: +44 118 9799245

For Customer or Technical Service needs (product assistance, ordering, part numbers, specifications, unexpected events, etc.) contact:
CAIRE Inc.
2200 Airport Industrial Dr., Ste. 500
1-800-482-2473
www.caireinc.com

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.

I Preface

Abbreviations

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

Definition of Terms

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

Definition of Product Symbols

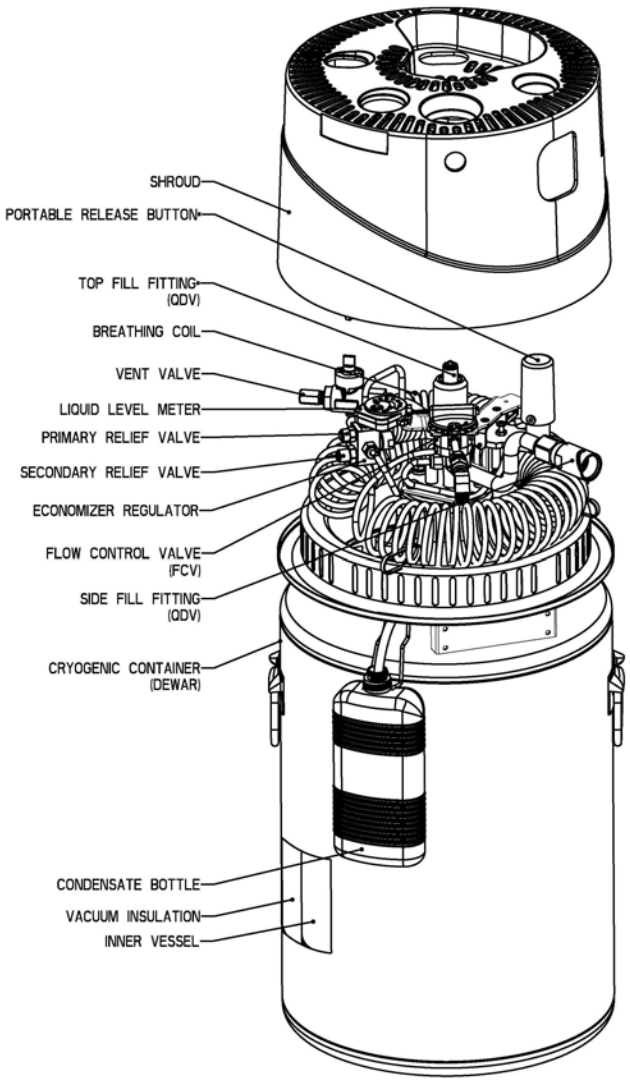
Table 1: Definition of Product Symbols

Symbol	Definition	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)	CE 0459	CE Mark
IP21	Classification according to the degree of protection against ingress of water.		Read user manual before operation. See user manual for instructions
	Type BF (Electrical Safety)		

II Table of Contents

Equipment Description

FIGURE 1: Liberator Components



* For Top Fill or Dual Models Only

The CAIRE Liberator® is the stationary component of the Liberator/Portable supplementary oxygen system. The Liberator incorporates a stainless steel cryogenic container with the valves, plumbing, and associated hardware required to deliver gaseous oxygen to the patient at near ambient temperature.
The Liberator is comprised of four major assemblies, grouped according to function.

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

2. Breathing Circuit – This circuit consists of the manifold assembly, fixed orifice rotary flow control valve (FCV), breathing coil, and warming coil. It withdraws liquid oxygen from the cryogenic container, warms it to near ambient temperature, and regulates the flow of oxygen gas to the patient. Any water that condenses on the cold coils is routed into the condensate bottle. An economizer regulator is utilized to conserve LOX by drawing oxygen head gas into the breathing circuit.

3. Shroud Assembly – The shroud assembly houses and protects the breathing circuit and liquid level meter. Labels listing safety information and patient operating instructions are affixed to the side of the shroud.

4. Liquid Level Meter – This system uses a capacitance probe and an electronic (LED) readout to measure and display the LOX level by pressing the onboard operate button.
   An optional roller base can be provided to help move the Liberator.

Serial Number Information

For Liberators manufactured before 2006, the serial number was ten digits. The first three digits represented CAIRE specific information, followed by two digits signifying the year of manufacture, followed by a two digit number to digit number to signify the week of the year that the unit was manufactured and ends with three digits signifying the unit's production number for that week.

Reservoirs Manufactured after 2006

CB B30 10 29 0964

CB	B30	10	29	0964
Designates Manufacturing Location	Designates Reservoir Product Code	Designates Year	Designates Week of the Year	Designates Number of Specific Unit Produced that Week

Specifications (Nominal Values)

LIBERATOR SPECIFICATIONS					
MODEL	**LIBERATOR 20**	**LIBERATOR 30**	**LIBERATOR 37**	**LIBERATOR 45**	**LIBERATOR 60**
Volume of LOX (typical)	21.0 liters / .021 m3	31.0 liters / .031 m3	37.3 liters / .0373 m3	45.7 liters / .0457 m3	60.2 liters / .0602 m3
Weight of LOX at 24 psig (166 kPa) Saturation (typical)	23kg (50.7 lbs)	33.9 kg (74.8 lbs)	40.8 kg (90 lbs)	50.04 kg (110.3 lbs)	65.9 kg (145.3 lbs)
Gasous Oxygen Equivalent @ 1atm and 70F	17,337 liters / 612 ft3	25,580 liters / 903 ft3	31,121 liters / 1099 ft3	37,724 liters / 1332 ft3	49,679 liters / 1754 ft3
Height	62.2 cm / 24.5 in	74.9 cm / 29.5 in	83.2 cm / 32.75 in	94.0 cm / 37 in	99.1 cm / 39 in
Diameter	35.6 cm / 14 in	35.6 cm / 14 in	35.6 cm / 14 in	35.6 cm / 14 in	40.6 cm / 16 in
Empty Weight	17.69 kg / 39 lbs	22.04 kg / 48.6lbs	22.68 kg / 50 lbs	24.95 kg / 55 lbs	34.19 kg / 75.4 lbs
Full Weight	40.69 kg / 89.7 lbs	55.94 kg / 122.32 lbs	63.48 kg / 140 lbs	74.99 kg / 165.32 lbs	100.1 kg / 220.68 lbs
Outlet Pressure	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi
Nominal Operating / Economizer Pressure	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi	1.4 bar / 20 psi
Density (Weight of LOX) @ Nominal Operating/Economizer Pressure	1.095 kg/L or 2.413 lbs/L	1.095 kg/L or 2.413 lbs/L	1.095 kg/L or 2.413 lbs/L	1.095 kg/L or 2.413 lbs/L	1.095 kg/L or 2.413 lbs/L
Primary Relief Valve Opening Pressure	1.6 bar / 23.2 psi	1.6 bar / 23.2 psi	1.6 bar / 23.2 psi	1.6 bar / 23.2 psi	1.6 bar / 23.2 psi
Primary Relief Valve Reseat Pressure	1.4 bar / 20.5 psi	1.4 bar / 20.5 psi	1.4 bar / 20.5 psi	1.4 bar / 20.5 psi	1.4 bar / 20.5 psi
Secondary Relief Valve Opening Pressure	2.1 bar / 30.5 psi	2.1 bar / 30.5 psi	2.1 bar / 30.5 psi	2.1 bar / 30.5 psi	2.1 bar / 30.5 psi
Secondary Relief Valve Reseat Pressure	1.9 bar / 27 psi	1.9 bar / 27 psi	1.9 bar / 27 psi	1.9 bar / 27 psi	1.9 bar / 27 psi
Normal Evaporation Rate (NER - typical)	.73 kg / 1.6 lbs	.73 kg / 1.6 lbs	.73 kg / 1.6 lbs	.73 kg / 1.6 lbs	.73 kg / 1.6 lbs
Maximum Outlet Flow	15 L/min	15 L/min	15 L/min	15 L/min	15 L/min
Contents Indicator	Capacitance Probe with LED Readout	Capacitance Probe with LED Readout	Capacitance Probe with LED Readout	Capacitance Probe with LED Readout	Capacitance Probe with LED Readout
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	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	-40°C to 70°C 95% max. relative humidity

Note:
All specifications are applicable for G4 Liberator only and based upon optimum environmental and pressure conditions as stated above.

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

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

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.

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

1. 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.

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

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

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

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 Liberator 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.

CAUTION: The Liberator 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. The Liberator must be used, stored, and transported in a vertical position. Do not lay, store, or ship the unit 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 ex-plode. Certain items considered non-combustible in air may burn rapidly in such an environment. Keep all organic materials and other flammable substances away from possible contact with oxy-gen; 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, han-dled, 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 (RP23). 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: During transfer of liquid oxygen gas blowoff from the vent valve creates a loud horn-like noise. Ear protection is recommended.

WARNING: Keep filled unit upright at all times. Tip over of filled unit may result in liquid oxygen leakage and/or an oxygen-enriched atmosphere.

WARNING: Only use replacement equipment which is compatible with liquid oxygen and has been cleaned for oxygen use. Do not use regulators, fittings, hoses, etc. which have been previously used in non-oxygen service.

WARNING: This product can expose you to chemicals including Nickel, which is known to the State of California to cause cancer. For more information, go to www.P65Warnings.ca.gov.

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

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

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

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

Table 1

Guidance and Manufacturer's declaration—electromagnetic emissions

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

Emissions test	Compliance	Electromagnetic environment—guidance
RF emissions CISPR 11	Group 1	The Liberator 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 Liberator is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not applicable	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Not applicable	

Table 2

Guidance and manufacturers declaration—electromagnetic immunity

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

Immunity test	IEC 60601 t	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 Liberators are found to be compliant with regulations.

Table 4*

Guidance and manufacturers declaration—electromagnetic immunity

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

[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 6*

Recommended separation distances between portable and mobile RF communications equipment and the Liberator

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

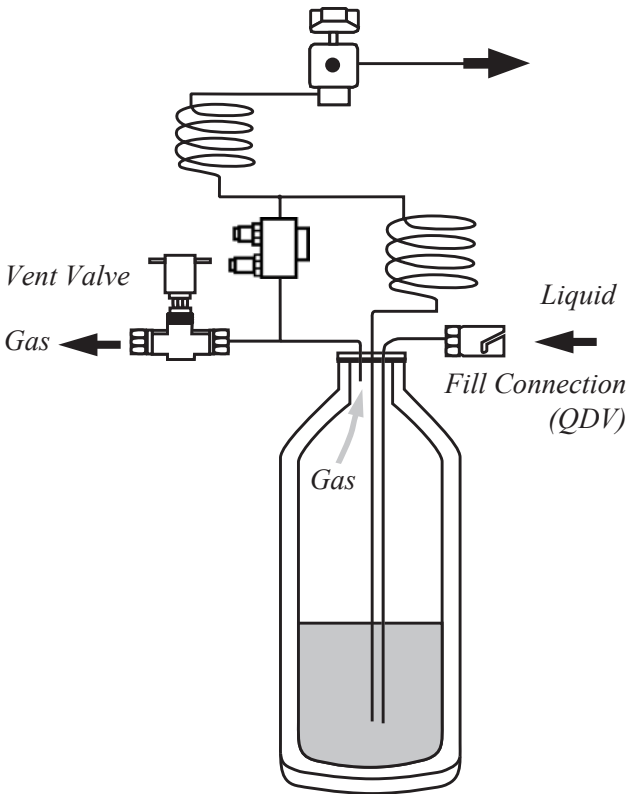
* This table is included as a standard requirement for equipment which has been tested to specific test levels and over specific frquency ranges and been found compliant with regulations.

Filling

The Liberator is filled by connecting a pre-purged transfer line with a fill adapter from a larger liquid oxygen source to the Liberator side fill or top fill QDV. The Liberator vent valve is then opened. The pressure differential between the Liberator and source tank forces liquid oxygen through the transfer line and into the Liberator inner vessel.

There will be some oxygen vaporized during filling. This gas is discharged through the vent valve. When the Liberator is full, liquid oxygen is expelled. Disconnecting the fill adapter from the Liberator QDV and closing the Liberator vent valve terminates the fill process.

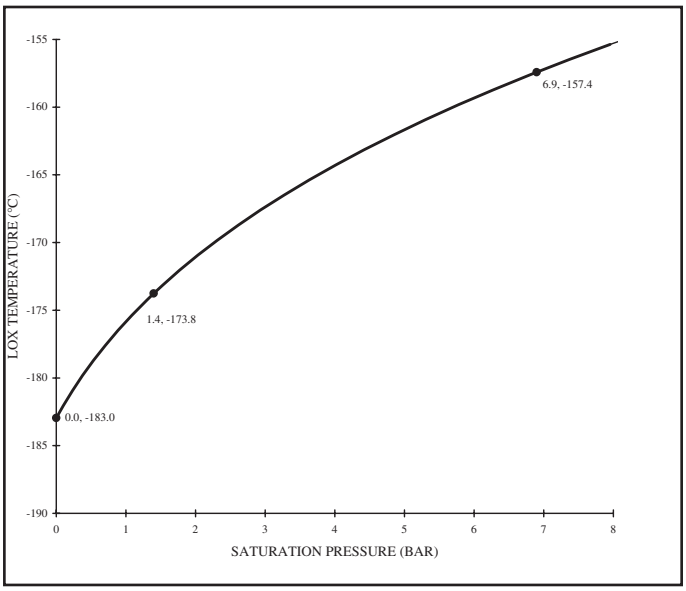
FIGURE 2: Filling



Saturation Pressure

The saturation point of a liquid is a steady-state condition where the liquid has absorbed the maximum amount of heat possible. A liquid can be at its saturation point at a number of different pressures and temperatures, but each specific saturation pressure has a corresponding saturation temperature and vice-versa (see Figure 3). This means that the final temperature of your liquid oxygen is dependent upon the pressure at which it is transferred from the storage system to the Liberator. For the purposes of this manual, we will speak in terms of saturation pressure, since it is easier to control than temperature. Treat saturation temperature as a dependent variable of saturation pressure.

FIGURE 3: Temperature vs. Saturation Pressure



There are two conditions which can seriously affect the overall efficiency and operation of the system:

1. Saturation pressure of the liquid oxygen in the fill source is substantially higher than the Liberator operating pressure (oversaturated).

2. Saturation pressure of the liquid oxygen in the fill source is substantially lower than the Liberator operating pressure (undersaturated).

For example, when a Liberator is filled from a liquid source saturated at 6,9 bar (100 psig), larger transfer losses will occur. This is because the Liberator is designed to operate at 1,4 bar (20 psig), and the liquid it is filled with is saturated at a much higher pressure and at its correspondingly higher temperature. It is necessary for this liquid to reach equilibrium at a lower pressure and temperature before the relief valve will close and the Liberator will operate properly.

In order to become saturated at 1,4 bar (20 psig), the liquid oxygen must release enough heat for its temperature to be lowered to the temperature corresponding to a pressure of 1,4 bar (20 psig), as shown in the graph. The temperature is lowered through boiling. All of the gas generated by this boiling is vented through the relief valve and/or primary relief valve and is lost.

If the saturation pressure of the liquid oxygen in the filling vessel is lower than the normal operating pressure of the Liberator, oxygen vaporization within the dewar works to raise the system pressure to the required 1,4 bar (20 psig). This may require as long as a day. The time required for saturation to 1,4 bar (20 psig) depends on the initial liquid saturation pressure.

Theory of Operation

WARNING: Low oxygen flow rates to the patient may result if the Liberator is filled with undersaturated liquid oxygen.

WARNING: The vent valve orifice does not guarantee properly saturated LOX. The filling source must be correctly saturated or low/high saturation will occur in CAIRE reservoirs.

To minimize the effect of undersaturated liquid in the Liberator, a fixed orifice has been installed in the outlet of the vent valve. This orifice regulates the back pressure in the unit during the fill process, resulting in improved saturation pressures in the Liberator.

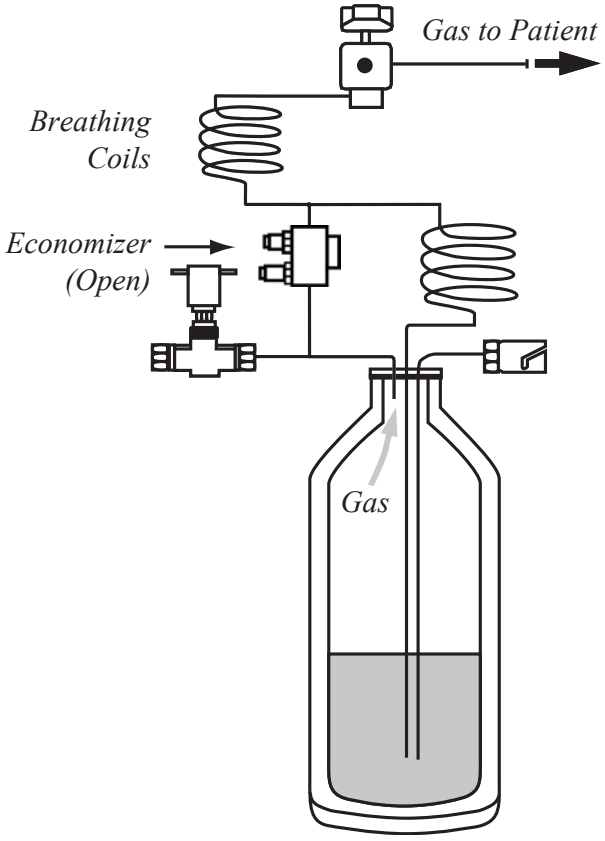
Operation

If the flow control valve and vent valve are closed with LOX in the unit, then the pressure in the inner vessel will remain near the primary relief valve setting of 1,5-1,7 bar/21.8-24.2 psig.

In the Liberator, as in all vacuum-insulated cryogenic contain-ers, 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.

FIGURE 4:

Operation between 1,4 Bar (20 PSI) and 1,7 Bar (24.2 PSI)



When the flow control valve is at any setting other than off, and the economizer valve is open (presure over 1,4 bar (20 psig), see Figure 4), 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.

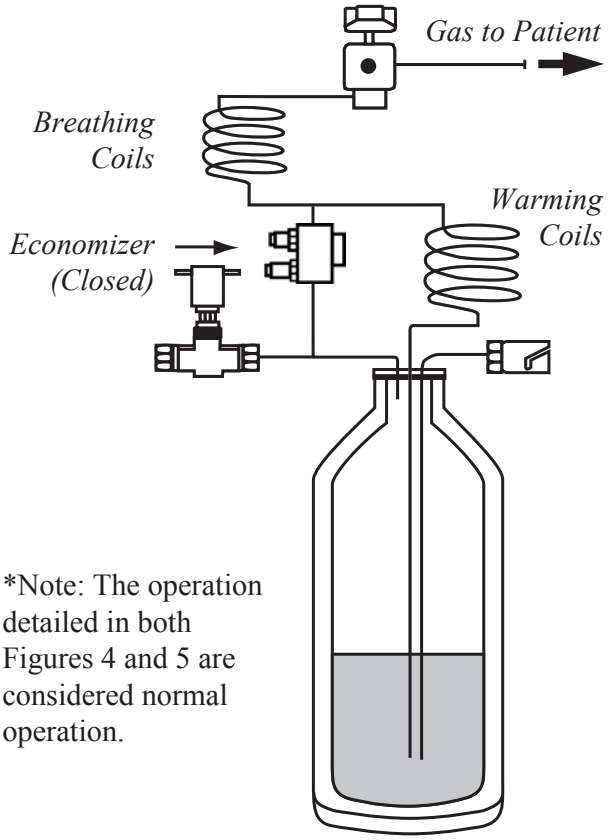
Whenever gas is removed from the space above the liquid oxygen (head space), the inner vessel internal pressure begins to drop slightly. When the pressure drops to 1,4 bar (20 psig), the economizer valve closes,(see Figure 5) forcing liquid oxygen up the withdrawal tube and through the warming coil where it becomes gas.

The gas then flows through the bypass tee to the breathing coil, the flow control valve, and then the patient.

As the pressure in the container increases over 1,4 bar (20 psig), the economizer valve opens, and the cycle repeats, maintaining constant oxygen flow, at the selected flow rate, to the patient.

FIGURE 5:

Operation between 1,2 Bar (18PSI) and 1,4 Bar (20 PSI)



*Note: The operation detailed in both Figures 4 and 5 are considered normal operation.

Liquid Level Measurement

Liberators are equipped with a unique liquid level measurement system. This system measures the level of liquid oxygen inside the unit with a capacitance probe and displays that liquid level on the level meter's LEDs.

The liquid level probe consists of two concentric stainless steel cylinders extending inside the inner vessel. As the liquid oxygen level rises, the capacitance of this assembly goes up. The level meter then displays the liquid level in the cylinder based on a calibration relating capacitance to fill level. The higher the liquid level in the dewar, the more LEDs are activated, beginning at the left most LED.

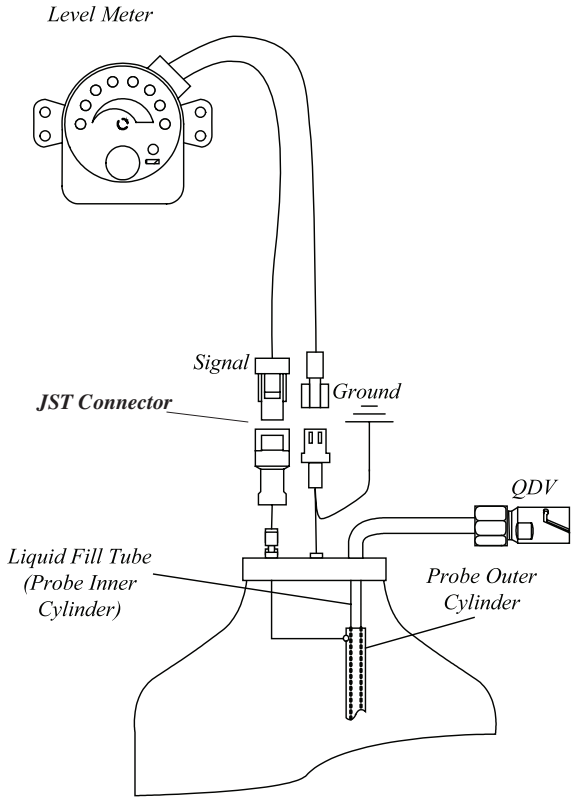
Electrical connection between the level meter and the probe is made via a single conductor JST connector. This male plug is attached to its female counterpart extending from the probe, creating a watertight connection. A single ground wire is connected from the meter to a male spade terminal on the mounting bracket.

The meter is powered by an internal battery offering battery life of 5 years or more at 30 cycles per day. The meter has a low battery (LOW BATT) indicator which signals the need for battery replacement. The meter battery is covered under a 2-year limited warranty. If battery failure occurs within 2 years of the Liberator shipment date, contact CAIRE, Inc. customer service for a replacement meter. If the meter battery is no longer under warranty, the CR2032 coin cell battery can be replaced (RP5). Replacement batteries can be found at most hardware stores or they can be ordered through CAIRE customer service.

The new level meter improves upon the previous meter by integrating all components within its casing, simplifying removal and replacement (RP4). Even more importantly, there is a much improved calibration procedure that requires no additional tools and a range of error reporting codes which can be read directly from the LEDs to report calibration errors. These can be found in the calibration procedure (RP7).

NOTE: Tampering with meter battery housing will void the battery's 2-year warranty.

FIGURE 6: Liquid Level Meter Circuit



VII Unpacking and Setup

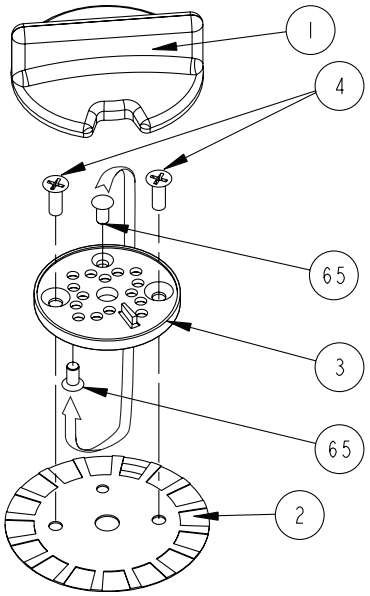
Unpacking

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 condensation bottle and bracket, POI, FCV extension, and humidifier elbow kit.
4. Set aside packing materials in case unit must be returned to the factory.

Setup

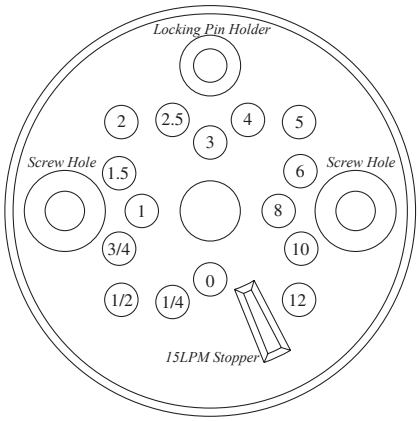
1. Install condensation bottle bracket by squeezing bracket ends together and inserting into slot in handling ring directly below FCV outlet.
2. Install condensation bottle on bracket located below shroud. Remove cap from bottle. Put condensation hose inside bottle.
3. Install FCV extension by screwing it into the side of the FCV to 45 N-cm (4 in-lb).
4. Install humidifier elbow (if applicable) by screwing it into the side of the FCV extension.
5. Visually inspect the Liberator for damage from improper handling. Note any dents in the container, cracks in the shroud, missing or loose hardware, and bent quick disconnect valves or humidifier adapters.
6. Check for smooth operation of the flow control selector, making sure that a positive detent is felt at all settings. The flow control knob should be secure and properly aligned.
7. Check the vent valve for smooth operation.
8. If possible, connect a portable unit to the Liberator to check for smooth coupling, and to make sure the portable unit is in proper alignment with the Liberator when mated.
9. 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. If it does not, or if other erroneous indications are given, refer to the Troubleshooting Section (Section X).
10. Check all labels for damage and wipe away any dust on unit with a clean, dry, lint-free cloth. Prior to transportation with liquid oxygen, ensure that you affix the included Hazard Warning Label or a suitable replacement.
11. If desired, the flow control knob (Item 1) can be adjusted so it will not exceed maximum prescribed flow rate.
    a. Remove FCV knob by firmly grasping the knob and pulling away from the base unit.
    b. Remove two Phillips head screws (Item 4) from flow lock plate (Item 3) and remove plate.

FIGURE 7: Flow Control Knob



    c. Remove flow rate decal number disc (Item 2).
    d. Remove locking pin (Item 65) from its storage position on flow lock plate (Item 3) and place in underside of hole corresponding to maximum allowable flow rate.
    e. Replace flow lock plate (Item 3), number disc (Item 2) and knob. Tighten screws (Item 4) to 45–65 N-cm (4–6 in-lbs). Verify flow lock is at correct position.

FIGURE 8: Lock Plate Layout



CAUTION: Always ship, store, or transport a Liberator, empty or full, in an upright position, properly secured to prevent damage. DO NOT ROLL UNITS TO TRANSPORT

WARNING: Ensure the locking pin, if used, is set to allow the prescribed flow of the patient upon setup.

Transport

Specifically designed roller bases are available for moving Liberator short distances on smooth surfaces. Hand trucks can also be utilized for Liberator transport.

VIII Operation

Liberator 20, 30, 37, 45 and 60 units may be moved about or transported in a vehicle while full without damage; however, they should not be dropped or handled roughly in order to prevent necktube damage.

Filling

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

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

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

1. Fill Source Preparation

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

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

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

2. Fill Procedure

   a. Required Equipment:
      - o Fill source as outlined above
      - o Liquid oxygen transfer line
      - o Appropriate transfer line fill adapter
      - o Appropriate vent valve wrench
      - o Eye protection
      - o Pressure gauge
      - o Insulated gloves

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

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

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

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

   d. Fully open liquid valve on fill source.

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

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

      -OR-

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

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

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

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

   h. Connect transfer line to reservoir to begin fill.

   i. While filling, throttle the vent valve with the vent valve wrench as needed to keep the reservoir pressure at the nominal fill pressure of 1,38 bar (20 psig). Monitor the pressure by connecting a pressure gauge to the oxygen outlet and open the FCV to 2LPM or greater.

      If filling pressure is not monitored, it must be ensured that the Liberator has reached its correct operating pressure prior to patient use, or incorrect flow rates may result.

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

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

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

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

   m. Verify that the liquid level meter indicates full.

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

Liquid Level Measurement

As noted in the Theory of Operation (Section 6), Generation 4 Liberators are equipped with new liquid level meters. In order to obtain a liquid level reading, the technician or end-user should depress the green operate button on the face of the meter (note that the button has been moved onto the meter from its previous position). This will cause the LEDs to quickly flash from right to left around 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 empty, 8 for full). If you feel the meter is giving incorrect measurements, reference RP7 to calibrate the meter.

Cleaning and Disinfection

To insure proper functioning and end-user safety, all Liberator units should be cleaned whenever dirt or grime is visually apparant. The unit should be disenfected according to any 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 and prepare mild solutions of glass cleaner and disinfectant respectively. If at any time either solution becomes visibly dirty or cloudy, it should be switched out for fresh solution.

Cleaning

1. Inspect through air holes in shroud to see if any debris has accumulated beneath shroud. If it has, remove debris using long tongs or tweezers.
2. Wipe off the exterior of the unit with the cleaning solution using a lint-free cloth. The cloth should be damp but not dripping. Be as thorough as possible.
3. Discard the cleaning cloth.
4. Wipe off excess cleaning solution and dry thoroughly with a lint-free cloth. Discard the cloth.

Disinfection

Disinfection should be performed in accordance with the home healthcare provider's own validated procedures and/or in accordance with local regulations.

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

Table 1 shows actual material content of the Liberator base unit to assist the home healthcare distributor in establishing its own disinfection protocol.

Table 2 lists a selection of common disinfectant chemicals and their compatibility with Liberator base units.

TABLE 1: Liberator Material Content

Part	Material
Shroud	Polycarbonate
Breathing Coil	T3003 Aluminum
Vaporizer Coil	T3003 Aluminum
Dewar	Stainless Steel
Valves	T6061 Aluminum

TABLE 2: Common Disinfectant Chemicals

Disinfectant Agent	Compatible with Generation 4 Liberators
Aldehyde	Yes
Quanternary Ammonium Compound	Yes
Sauerstoffabspalter	No
Alcohol	*Yes - Ethanol based cleaner (only when all O2 has been purged)
Amine Derivatives	Yes
Phenol	Yes
pH: Basic (alkaline) Cleaners	Yes
Ether/Ester based products	No

Product Disposal

At the end of the unit's life, all Liberator units must be re-turned to a recycling facility in compliance with the Waste Electrical and Electronic Equipment Directive (WEEE), or other applicable codes and regulations.

IX Maintenance (Schedule A, 30-Month)

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

Schedule A –30 Month

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 the Troubleshooting section of the corresponding technical manual.

   -or-

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

2. Schedule – Maximum of 30 months between routine 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 the corresponding technical manual.

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

1. Visual Inspection:

   a. Remove any LOX prior to maintenance (RP23).

   b. Look for damaged or missing parts.

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

2. Component Test:

   a. Remove shroud (RP2).

   b. Perform Leak Test (RP16)

   c. Perform PRV test (RP13).

   d. Perform SRV test (RP13).

   e. Pressure Retention Test (RP15).

   f. Replace shroud (RP2).

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

   h. Flow Rate test (RP25).

3. Check Efficiency of Unit:

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

   b. If the dewar bottle is cold and sweating, and/or there is excessive venting from the relief valve, an NER test should be performed (RP32).

4. Prepare for Use:

   a. Empty contents (RP23).

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

Schedule B – Continuous

A. Introduction

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

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

B. Pre Fill Procedure

1. Visually inspect for:

   a. Broken shrouds or shroud components

   b. QDV deformation

NOTE: When inspecting a Side-Fill QDV, be sure to check the lip seal for damage.

   c. Level indicator functionality

   d. Presence of all required labels

   e. Cryogenic reservoir damage (dents, dings)

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

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

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

C. Post-Fill Procedure

1. Visually verify:

   a. QDV poppet is closed and not leaking

   b. Vent valve is not leaking

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

   d. Liquid level indicator is showing full after filling

X Troubleshooting

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.

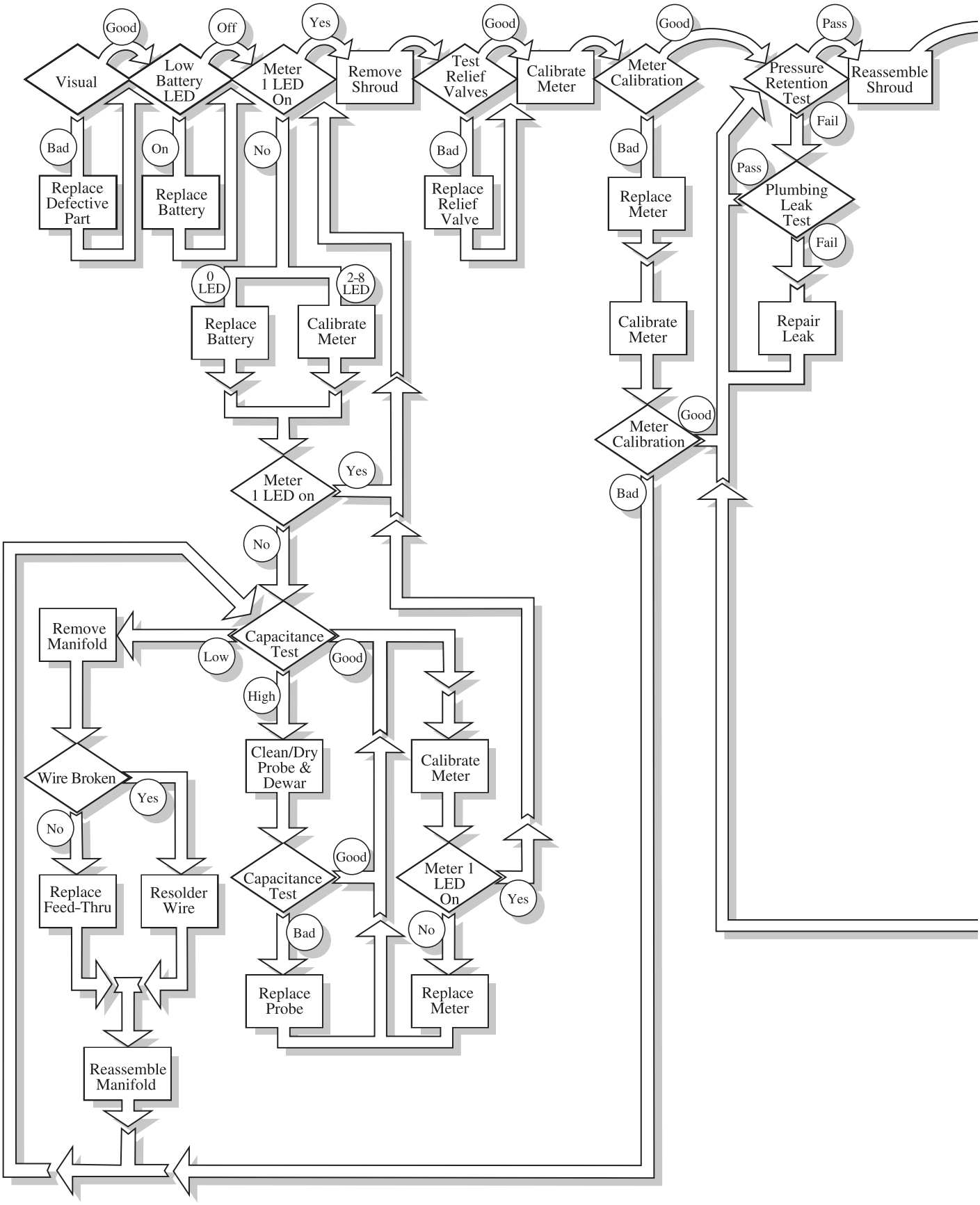
Troubleshooting Charts

	Symptom		Probable Cause	Corrective Action
1)	Unable to start fill or excessively long fill times	a)	Transfer line not engaged fully on Reservoir QDV	Make sure the QDV on the transfer line and reservoir are properly aligned and ensure that a downward force is being applied to the transfer line assembly.
		b)	Low source pressure	Verify that pressure from the source is within the 35-50psi range to fill the reservoir.
		c)	Vent valve not open or is blocked	Ensure that the vent valve is able to be turned to the fully open position.
		d)	Source tank is either under or over-saturated	Allow LOX to saturate to proper pressure.
		e)	Fill connector not opening properly	Check fill connector and cartridge assembly for damage; make sure fill connectors fully engage.
		f)	Vent valve is obstructed	Inspect the valve for blockages and verify that flow passes through during a fill. Clean by blowing out with compressed gas or replace parts if necessary.
		g)	Leak in the system	Check the reservoir for leaks (RP16) and repair if needed.
2)	Liquid leaks from the coupled QDVs during the fill	a)	Worn or damaged lip seal	Replace the QDV lip seal (RP19)
3)	Unable to disconnect the transfer line from the reservoir after a fill	a)	Pop-off assembly not being utilized (Does not apply to Liberator 10)	Ensure that the pop-off assembly on the reservoir is being used. Do not use force to separate the QDVs.
		b)	QDVs are frozen together	Leave the units coupled with the vent valve closed and let them sit until they warm up enough to disconnect. Always ensure that male and female QDV's are cleaned and dried prior to each fill.
4)	Liquid leaks from the QDV poppet after f illing	a)	Ice crystal preventing the QDV from closing properly.	Engage and disengage the transfer line onto the reservoir several times to dislodge the ice crystal. Always be sure that the male and female QDVs are wiped clean and dry before filling.
		b)	Dirty or damaged QDV poppet	Replace the QDV cartridge (RP20) or the entire QDV assembly (RP21)
5)	Excessive venting from relief valves (hissing sound)	a)	Saturation pressure too high.	Inspect the saturation pressure of the reservoir used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
		b)	Relief valve frozen open	Allow the portable to warm and thaw. Attempt to re-fill the portable.
		c)	Faulty relief valve	Test the relief valve (RP13) and replace if necessary (RP14)
		d)	Partial or complete loss of vacuum	Conduct the NER test (RP32) and return the unit to CAIRE, Inc. if necessary.
6)	No flow at oxygen outlet	a)	Reservoir is empty	Check the contents indicator/level gauge and fill the reservoir if needed.
		b)	Flow control valve turned off	Ensure the flow control knob is not in the off ("0") position.
		c)	Nasal cannula kinked or disconnected	Ensure proper nasal cannula functionality and positioning
		f)	Leak in the system	Perform a leak check on the plumbing (RP16). Repair leaks as necessary.
		g)	Relief valve is open	Ensure that there is no venting from the relief valves. If there is refer to the corrective actions for "Excessive venting from relief valves (hissing sound)".
		h)	Vent valve is open	Ensure that the vent valve is fully closed.
		i)	FCV inlet filter is obstructed	Clean or replace (RP30) the filter screen.
		j)	Blockage in the liquid withdrawal circuit	Check warming coils and withdrawal tubes for blockages. Replace if necessary.
		k)	FCV Faulty	Replace the FCV (RP30)
7)	Low flow at oxygen outlet on all LPM settings	a)	Nasal cannula kinked or leaking	Inspect the functionality of the nasal cannula.
		b)	Saturation pressure is too low	Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
		c)	Leak in the system	Perform a leak check on the plumbing (RP16). Repair leaks as necessary.

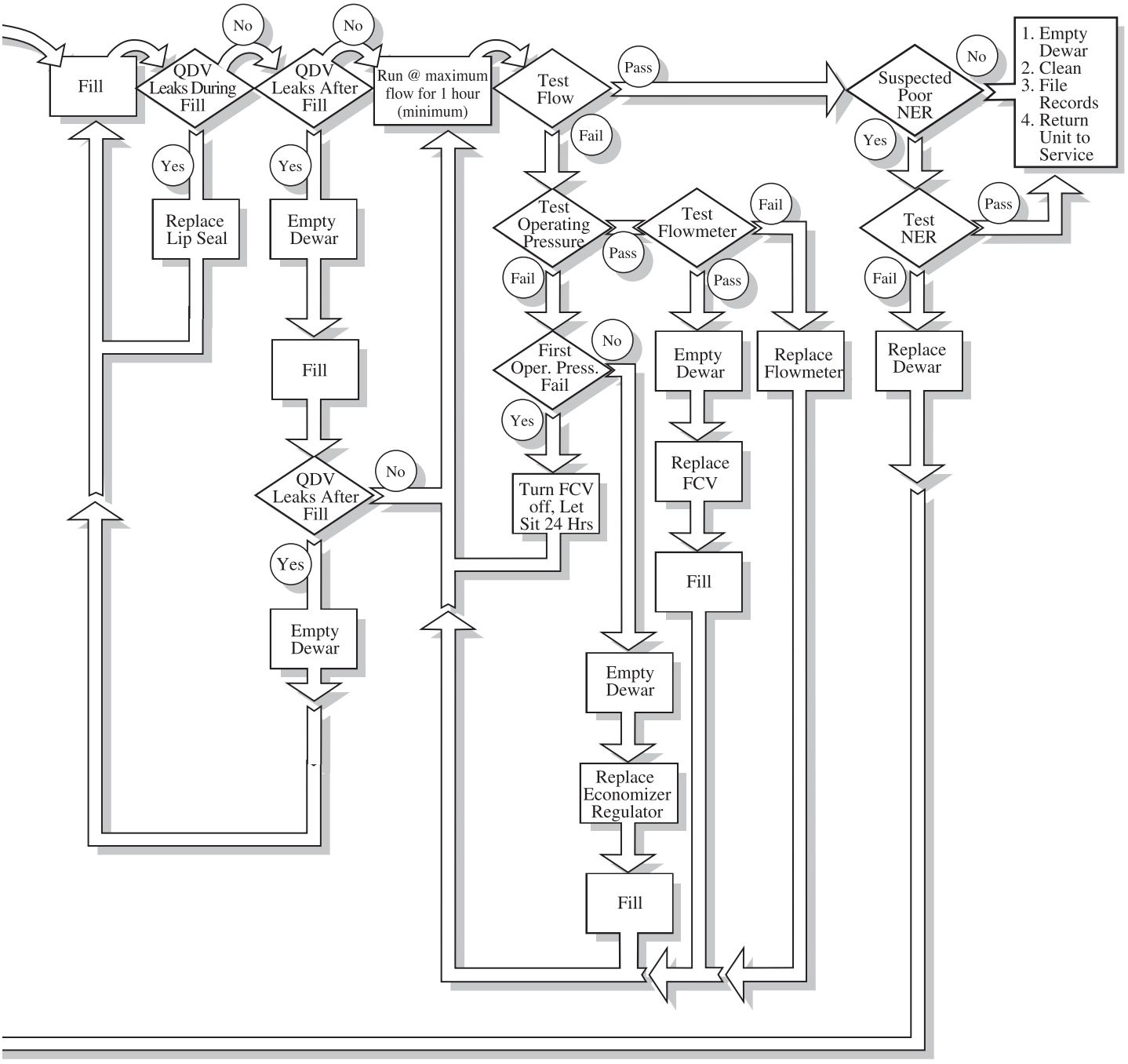
Troubleshooting Charts

	Symptom		Probable Cause	Corrective Action
7) (Cont.)	Low flow at oxygen outlet on all LPM settings (cont.)	d)	Flow control valve inlet filter screen dirty	Clean or replace (RPxx) the filter screen.
		e)	Economizer valve faulty	Test the economizer (RP28) and replace (RP29) if necessary.
		f)	Blockage in the liquid withdrawal circuit or the flow restrictor	Check the warming coils and withdrawal tubes as well as the flow restrictor for blockages. Replace if necessary.
		g)	FCV faulty	Replace the FCV (RP30)
8)	Increased NER	a)	Saturation Pressure is too high	Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
		b)	Leak in the system	Perform a leak check on the plumbing (RP16). Repair leaks as necessary.
		c)	Relief valve open	Ensure that there is no venting from the relief valves. If there is refer to the corrective actions for "Excessive venting from relief valves (hissing sound)".
		d)	Partial or complete loss of vacuum	Conduct the NER test (RP32) and return the unit to CAIRE, Inc. if necessary.
9)	Excessive Frost: NOTE: Minimal frost on the shroud and on the plumbing is normal. This symptom applies to frost that is much greater than what is normally observed.	a)	Frost is acceptable	Some frost on the shroud and on the plumbing is acceptable, especially at high flow rates during continuous use. This is due to the evaporation of LOX to gas and the temperature difference between the LOX and room temperature.
		b)	High humidity level	High humidity levels can increase frost accumulation.
		c)	Saturation pressure is too high	Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for thereservoir to saturate properly.
		d)	Leak in the system	Perform a leak check on the plumbing (RP16). Repair leaks as necessary.
		e)	Relief valve open	Ensure that there is no venting from the relief valves. If there is refer to the corrective actionsfor "Excessive venting from relief valves (hissing sound)"
		f)	Partial or complete loss of vacuum	Conduct the NER test (RP32) and return the unit to CAIRE, Inc. if necessary.
10)	Unit will not maintain acceptable system pressure	a)	Saturation pressure is unacceptable	Inspect the saturation pressure of the reservoir used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
		b)	Vent valve is not completely close	Close vent valve. Leak check vent valve outlet and stem. Replace or repair as needed.
		c)	Leak in the system	Perform a leak check on the plumbing (RP16). Repair leaks as necessary.
		d)	Economizer valve faulty	Test the economizer (RP28) and replace (RP29) if necessary.
		e)	Primary releif valve faulty	Test the primary relief valve (RP13) and replace (RP14) if necessary
11)	High Pressure at Reservoir oxygen outlet	a)	Saturation pressure is too high	Inspect the saturation pressure of the reservoir. Allow at least 30 minutes at no flow for the reservoir to saturate properly.
		b)	Primary relief valve set too high or relief valve operating improperly.	Perform relief valve test. Replace as needed.
		c)	Economizer valve stuck in closed state	Perform Economizer test. Replace as needed.
		d)	Partial or complete loss of vacuum	Conduct the NER test (RP32) and return the unit to CAIRE, Inc. if necessary.
12)	Contents indicator reads incorrectly	a)	Battery voltage too low to operate contents indicator	Replace battery as needed (RP5) then calibrate the meter following RP6)
		b)	Sensor wires not connected properly, pinched or otherwise damaged	Visually inspect the meter harness assembly from the meter to the point wheret he sensor wire enters the reservoir manifold. Replace as necessary.
		c)	Contents indicator not calibrated properly	Calibrate the meter as needed following (RP6).
		d)	Ice crystal in reservoir causing incorrect or empty level reading	Empty and warm the reservoir following (RP23, RP24) to melt and evaporate moisture from inside the reservoir.
		e)	Meter malfunctioning/ damaged	Inspect for physical damage. Replace meter as necessary then recalibrate the meter follow-ing (RP6)

Troubleshooting Charts



Troubleshooting Charts



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.

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. All repair procedures and specifications in this manual supersede those in previous revisions of the manual and are valid for all G4 Liberators.

WARNING: Make sure the unit is empty and vent valve is open before replacing any component, except shroud assembly components or Lip Seals.

WARNING: The technician's hands, tools, and clothing should be free of all oils and greases.

WARNING: Parts that are welded in place must not be replaced in the field. Should these parts fail, return complete assembly or sub-assembly to factory for repair. DO NOT use solder or silver solder to repair broken welds.

WARNING: The manufacturer of fluorolubricant warns users not to allow fluorolubricant to contaminate tobacco products. Wash fluorolubricant from hands before smoking.

WARNING: Do not use glue type thread locking compounds or unapproved sealants on any repairs.

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 – Shroud Assembly RR (Figure 9)

a. Remove humidifier adapter (Item 26) and FCV extension (Item 25) from FCV (Item 24).

b. Remove shroud mounting screw (Item 13).

c. Remove shroud (Item 7) by lifting up and moving sideways to clear the QDV on side fill models, or by lifting straight up top fill models.

d. To replace shroud assembly, reverse above procedure. Torque FCV Extension (Item 25) onto FCV to 45 N-m (4 in-lb).

RP3 – Condensation Bottle Bracket RR

a. Remove condensate drain tube (Item 58) from bottle (Item 56) and remove bottle from bracket (Item 57).

b. Remove condensate bottle bracket (Item 57) by squeezing legs together and pulling straight down.

c. To replace bracket, reverse above procedure.

RP4 – Liquid Level Meter RR

a. Remove shroud (See RP2).

b. Remove two screws attaching liquid level meter to the bracket, being careful not to pull on the meter wires.

c. Detach JST connector (red signal wire) and spade connector (black ground wire).

d. To replace meter, screw new meter into place using the top set of holes on the meter and reattach wires.

e. Calibrate meter per RP6.

RP5 – Liquid Level Meter Battery RR

NOTE: Tampering with meter battery housing will void the battery's 2-year warranty.

If meter battery failure occures while the battery is under warranty, contact customer service to obtain a replacement meter.

If meter battery is no longer under warranty, the CR2032 coin cell battery may be replaced following the steps below.

a. Remove liquid level meter (See RP4).

b. Using a pair of pliers, grasp the battery cover on the back of the meter. Twist counter-clockwise and pull the cover away from the meter, removing the battery cover.

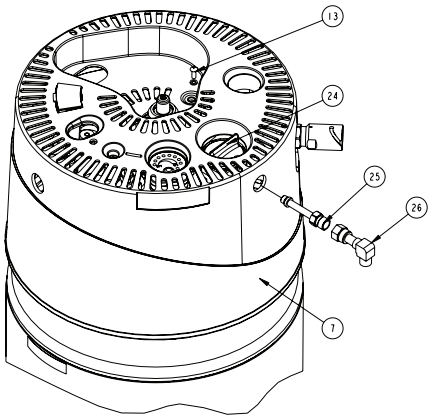
c. Slide the tip of a flathead jeweler's screwdriver beside the battery and carefully pry out the battery.

d. Insert new battery with the positive terminal facing up.

e. Apply a thin coating of fluorolubricant to the o-ring.

f. Replace battery cover by pushing it into the back of the level meter's case, ensuring the o-ring seals evenly and without kinks to restore the air-tight seal.

FIGURE 9: Shroud Assembly



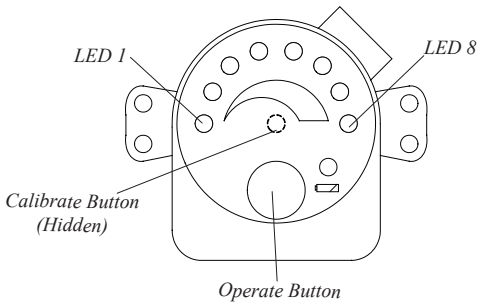
RP6 – Liquid Level Meter Calibration (Figure 10)

WARNING: You must first calibrate the empty side, and then calibrate the full side.

Calibration is required to ensure accurate meter readings and should be done whenever an error in level readings is suspected or when the meter has been replaced. If a calibration procedure is unsuccessful, the calibration value will not be saved and an error code will be displayed on the LEDs (See Table 4). To calibrate, first enter calibration mode before performing either full or empty calibration.

NOTE: In order to obtain an accurate calibration, you must calibrate both empty and full capacitance. For the full capacitance part of the calibration, you can choose either of the two procedures.

FIGURE 10: Liquid Level Meter



Enter Calibration Mode

a. Press and hold the hidden calibrate button. While still holding, continue to step B.

b. Within 3 sec, press and hold the operate button. LED 1 and LED 8 will begin alternately flashing to signify that calibration mode has been entered. If an error occurs, the calibration value will not be saved.

c. Proceed to next step within 45 seconds.

Calibrate Empty Capacitance

a. Press and hold calibrate button for 3 sec to record empty ca-pacitance reading (LED 1 will flash for 3 sec).

b. LED 1 will flash to signify successful calibration. If an error occurs, certain LEDs will flash, signifying a specific error code and the calibration value will not be saved. (See Table 6 for a list of error codes.)

Calibrate Full Capacitance

There are two full capacitance procedures available. Procedure 1 is quite accurate and quicker to perform since it does not require you to fill the dewar. Procedure 2 is even more accurate, but requires the dewar be vent-full with LOX.

NOTE: Please use only one of the following calibration methods.

TABLE 4: Capacitance Span LED Settings

Model	LED Setting
Liberator 20	LED 2
Liberator 30	LED 3
Liberator 37	LED 3
Liberator 45	LED 7
Liberator 60	LED 6

To start either procedure, calibration mode must first be entered. There is no need to per-form both procedures for any given calibration.

Procedure 1: Capacitance Simulated Full Method

a. Press the operate button 3 times within a 5 sec period of entering calibration mode. One of the LEDs will light continuously.

b. Press the calibrate button until the correct LED is continuously lit (See Table 4).

c. Press the operate button to save the calibration. If an error occurs, the calibration value will not be saved.

Procedure 2: Fill Method

a. Enter calibration mode on a vent full unit with properly saturated LOX. If unit has just been filled, allow it to stabilize before continuing.

b. Press and hold operate button for 3 sec. LED 8 will flash as the meter stores calibration value. If successful LED 8 will flash again and calibration mode will exit. If an error occurs, the calibration value will not be saved.

See Table 5 for typical LED meter reading versus unit weight.

TABLE 5: Unit Weight (kg) vs. Meter Reading

Model	20		30		37		45		60	
LED	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1	17,6	20,6	22,0	24,7	22,7	27,9	24,9	31,3	34,2	38,1
2	20,6	23,5	24,7	28,9	27,9	33,1	31,3	37,6	38,1	46,3
3	23,5	26,5	28,9	33,2	33,1	38,3	37,6	44,0	46,3	54,4
4	26,5	29,5	33,2	37,4	38,3	43,6	44,0	50,3	54,4	62,6
5	29,5	32,4	37,4	41,7	43,6	48,8	50,3	56,7	62,6	70,8
6	32,4	35,4	41,7	45,9	48,8	54,0	56,7	63,0	70,8	79,0
7	35,4	38,3	45,9	50,2	54,0	59,2	63,0	69,4	79,0	87,1
8	38,3	41,67	50,2	55,94	59,2	63,48	69,4	74,9	87,1	100,1

RP 7 – G4 Meter Error Codes (Figure 11)

The table below identifies the error codes that one is likely to come across.

FIGURE 11: Calibration Errors

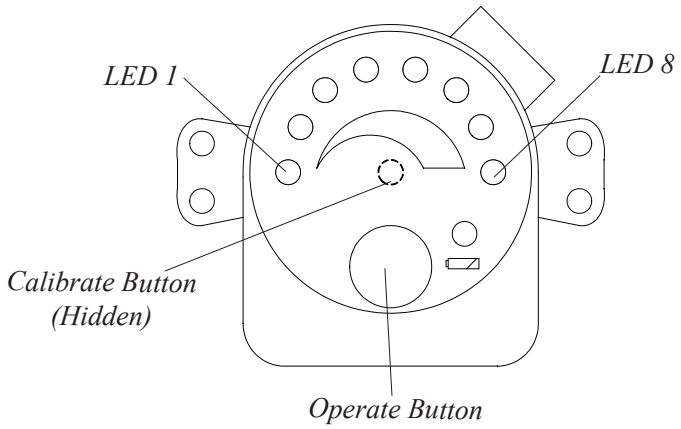


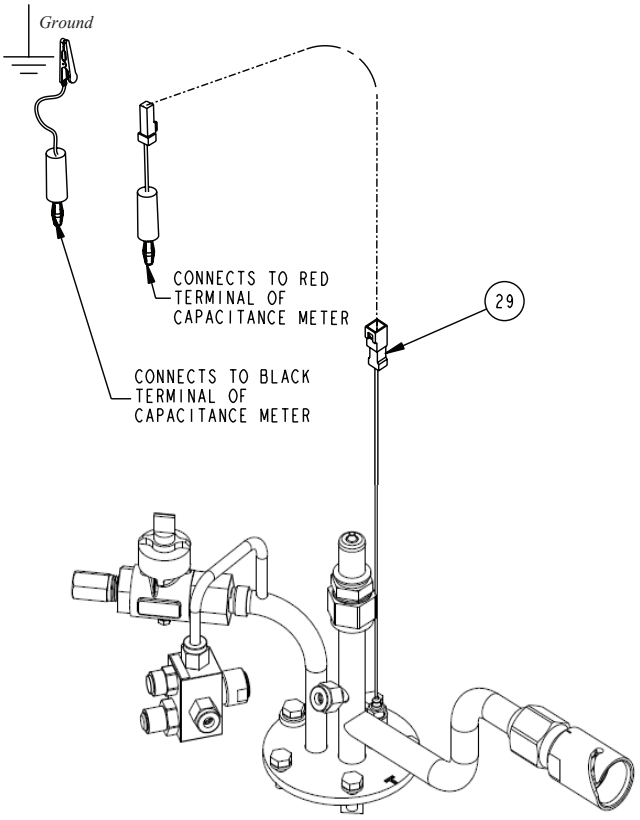
TABLE 6: Calibration Errors

LEDs	Name	Reason	Notes	Solution
2,3	Low Cap	Empty capacitance less than 100 PF	When calibrating empty	Check for loose connections and recalibrate
6,7	High Cap	Empty capacitance greater than 300 PF	When calibrating empty	Remove moisture and debris from probe
1,4	Low Span	Span less than 30 PF	When calibrating full	Empty unit and recalibrate
5,8	High Span	Span greater than 80 PF	When calibrating full	Empty unit and recalibrate
1,3,5,7	Range	The new full cap value is less than empty cap value	When calibrating full	Empty unit and recalibrate

TABLE 7: Operation Errors

LEDs	Name	Reason	Notes	Solution
2,4,6	High Cap	Reading is 120 PF above calibrated full value	Moisture/ Debris on probe	Remove moisture and debris from probe and recalibrate
Low Batt, 2,4,6	Bad Cal	Allow span cal setting to time out w/o pressing green button	New meter revision fixed	Recalibrate
1,3,5,7	Low Cap	Cap reading is 5 PF or greater less than calibrated empty value	Moisture in harness; added with new meter rev (on all telemetry meters)	Completely dry harness assembly and recalibrate

FIGURE 12: Manifold Capacitance Test Setup



NOTE: Make sure unit is empty and at room temperature before testing.

WARNING: Before removing manifold assembly, Liberator must be empty, warm and vent valve open.

RP8 – Manifold Capacitance Test (Figure 12)

a. Capacitance Meter Set-Up:

1. Connect capacitance meter adapter to capacitance meter according to Figure 12.
2. Turn on capacitance meter and select 200 pF range.
3. Move zero adjustment on the front of the meter until the display reads zero.

b. Capacitance Test:

1. Remove shroud assembly (See RP2).
2. Disconnect the wires leading from the manifold harness assembly to the level meter by disconnecting the JST connector, which is zip-tied to the bracket.
3. Connect JST connector on capacitance meter adapter to manifold harness assembly (Item 29).
4. Connect alligator clip to manifold bracket.
5. Read manifold capacitance and compare to the acceptable ranges found in Table 8. If it does not meet specifications, call Technical Support.

TABLE 8: Manifold Capacitance Specifications

Model	Low Limit (pF)	High Limit (pF)
Liberator 20	125	160
Liberator 30	125	170
Liberator 37	130	170
Liberator 45	140	180
Liberator 60	140	180

RP 9 – Manifold Assembly RR (Figure 13)

a. Remove shroud assembly (See RP 2).

b. Disconnect compression fittings on the sides of the economizer valve (Item 35).

c. Disconnect compression fitting from liquid withdrawal port (Item D) being careful not to kink vaporizer coil or internal PTFE tube.

d. Disconnect compression fitting (Item 34) from FCV (Item 24).

e. If desired follow RP17 to remove coils from the top of the Liberator in order to make manifold removal easier.

f. Remove the three bolts (Item 31) that run through the FCV bracket (Item 39) and through the manifold plate into the top of the dewar.

g. Remove two remaining manifold mounting bolts (Item 31, not visible in Figure 12), while holding manifold in place.

h. Lift manifold assembly straight up to remove.

i. Place dewar cap on dewar opening.

j. To replace manifold assembly, reverse above procedure. Apply small amount of fluorolubricant to O-ring (Item 50) before assembly. Torque manifold mounting screws (Item 31) to 10–11 N-m (90-100 in-lbs) using cross-tightening method.

RP10 – Resolder Feed-thru Wire (Figure 14)

a Remove manifold assembly (See RP9).

b. Strip approximately 1/8" of insulation from feed-thru wire (Item A) if necessary.

c. Remove strain relief material holding the signal wire against the capacitance probe.

d. Apply small amount of Stay-Clean flux to tinned area of probe (Item B) using a cotton swab.

e. Resolder feed-thru wire (Item A) to tinned area of probe (Item B). Add small amount of lead-free solid wire solder if necessary.

f. Clean flux residue with distilled water and cotton swab. Dry thoroughly.

g. Replace manifold following listed procedure (RP9).

RP11 – Manifold Harness Assembly RR (Figure 13)

a. Remove manifold assembly (See RP9).

b. Remove strain relief material holding signal wire against the capacitance probe.

c. Unsolder feed-thru wire (Item A) from probe (Item B).

d. Loosen feed-thru nut (Item C) and remove harness.

e. To replace manifold harness, reverse above procedure. Tighten feed-thru nut (Item C) 1 to 2 flats past finger tight.

f. Solder feed-thru wire (Item A) following resolder procedure (See RP10). Replace manifold assembly (See RP9).

RP12 – Clean/Dry Probe and Dewar

Procedure 1:

a. Empty dewar per RP23.

b. Warm dewar per RP24.

c. If all moisture is not removed, continue with Procedure 2.

Procedure 2:

a. Remove manifold assembly (See RP9).

b. Blow off probe assembly with clean, dry nitrogen gas.

c. Blow out inside of dewar with clean, dry nitrogen gas until inside is clean and dry.

d. Replace manifold assembly (See RP9).

FIGURE 13: Manifold Assembly

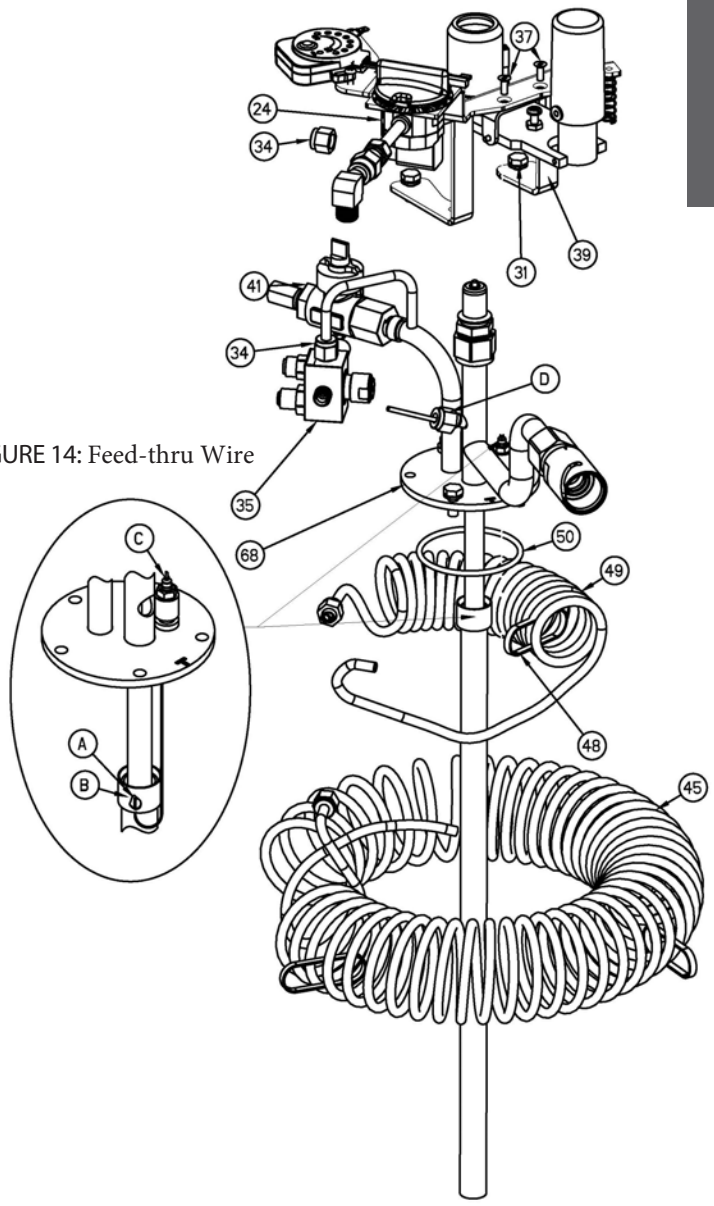
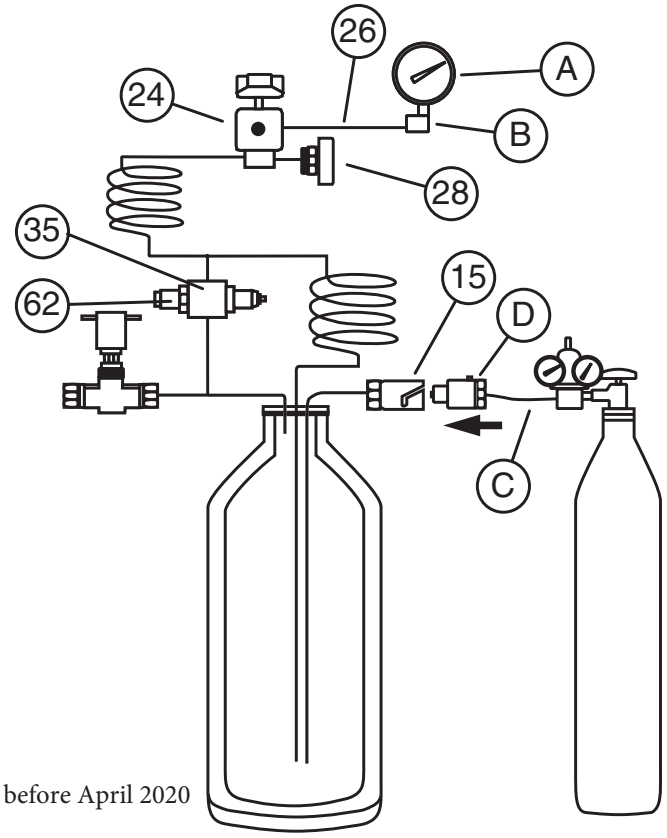


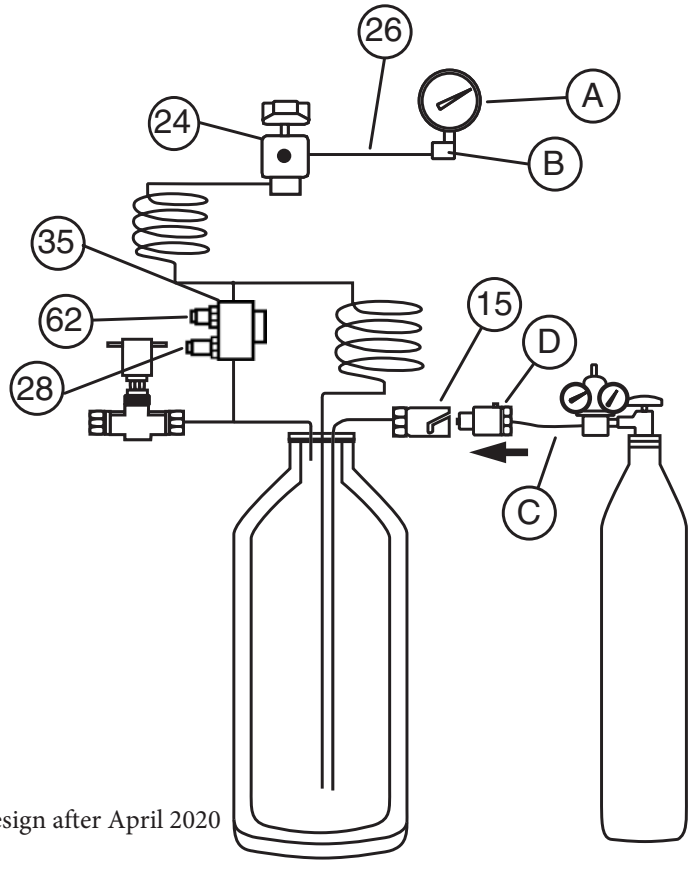
FIGURE 14: Feed-thru Wire

CAUTION: Be careful not to bend or damage manifold assembly or dewar neck tube.

FIGURE 15: Relief Valve Test Set-up



Design before April 2020



Design after April 2020

RP13 – Relief Valve Test (Figure 15)

NOTE: Liberator should be empty and warm before testing.

a. Remove shroud (See RP2).

b. Assemble pressure gauge (Item A) and adapter (Item B) (use PTFE tape).

c. Connect gauge assembly to humidifier adapter (Item 26) on FCV outlet. Open FCV (Item 24) to 6 LPM setting.

d. Assemble oxygen regulator and pneumatic hose (Item C) with DISS fittings and male pneumatic test adapter (Item D). Connect assembly to oxygen gas source.

e. Connect male pneumatic test adapter (Item D) to Liberator QDV (Item 15).

f. Slowly begin increasing pressure to between 1,5-1,7 bar/21.8-24.2 psig. PRV (Item 62) should begin venting (audible noise will be heard or bubbling will be seen if leak testing).

g. Slowly begin decreasing the pressure until the PRV (Item 62) closes, meaning the audible noise is no longer heard or the bubbling is no longer seen if leak testing. The pressure at which the PRV closes should be greater than 1,4 bar/20.5 psig.

h. Hold PRV (Item 62) closed and increase pressure to 1,9-2,3 bar (27-33 psig). SRV (Item 28) should open (audible venting and/or bubbling of leak test solution).

i. Decrease pressure to 1,3 bar (19 psig). Test relief valve with leak test solution. A minimal amount of leakage (bubbling) is acceptable. If leakage is questionable, run pressure retention test before changing relief valve (RP15).

RP14 –Relief Valve RR

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

Primary (Figure 16)

a. Remove shroud (See RP2).

b. Unscrew PRV (Item 62) from the economizer regulator (Item 35)

c. To replace PRV (Item 62), reverse above procedure. Tighten the RV approximately 10–20 degrees clockwise after the PRV body contacts the economizer regulator (minimum of 225-339 N-cm [20-30 in-lbs]).

Secondary (Figure 17)

a. Remove shroud (See RP2).

b. Unscrew SRV (Item 28) from FCV (Item 24) or from he economizer regulator (Item 35).

c. To replace SRV (Item 28), reverse above procedure. Tigthen the SRV approximately 10–20 degrees clockwise after the SRV body contacts the economizer regulator (minimum of 339-418 N-cm [30-37 in-lbs]).

FIGURE 16: Primary Relief Valve

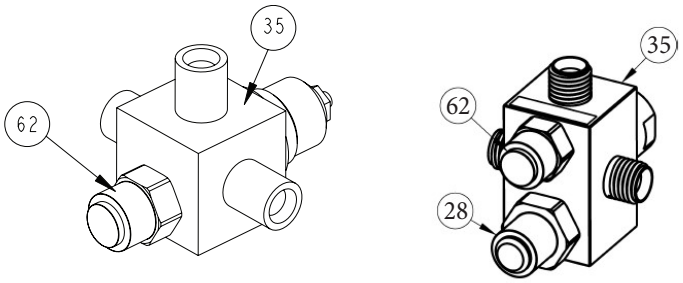
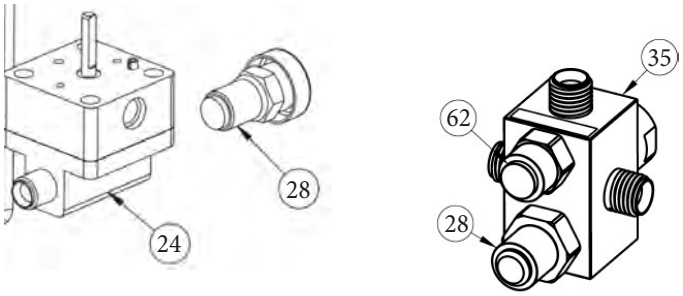


FIGURE 17: Secondary Relief Valve



Design Before April 2020 - left F16. and F17 Design after April 2020 - right F16. and F17

RP15 – Pressure Retention Test (Figure 18)

a. Assemble pressure gauge (Item A) and adapter assembly (Item B) (use PTFE tape).

b. Connect gauge assembly to humidifier adapter (Item 26) on FCV outlet. Open FCV (Item 24) to 6 LPM setting.

c. Assemble oxygen regulator, pneumatic hose (Item C) with DISS fittings and male pneumatic test adapter (Item D). Connect as-sembly to oxygen gas source.

d. Connect male pneumatic test adapter (Item D) to Liberator QDV (Item 15).

e. Increase pressure to 1,4 bar (20 psig).

f. Disconnect male pneumatic test adapter (Item D) from QDV (Item 15).

g. Turn FCV valve (Item 24) to Off setting.

h. Allow unit to sit undisturbed for 60 minutes.

i. Turn FCV valve (Item 24) to 6 LPM setting.

j. If pressure gauge (Item A) indicates less than 1,24 bar (18 psig), unit fails test.

NOTE: Liberator should be empty and warm before testing.

RP16 – Plumbing Leak Test (Figure 18)

a. Remove shroud (See RP2).

b. Assemble pressure gauge (Item A) and adapter assembly (Item (use PTFE tape).

c. Connect gauge assembly to humidifier adapter (Item 26) on FCV outlet. Open FCV (Item 24) to 6 LPM setting.

d. Assemble oxygen regulator, pneumatic hose (Item C) with DISS fittings and male pneumatic test adapter (Item D). Connect as-sembly to oxygen gas source.

e. Connect male pneumatic test adapter (Item D) to Liberator QDV (Item 15).

NOTE: PRV and SRV may leak slowly. Repair all other leaks first and retest for pressure retention before changing relief valves.

f. Leak test all connections, joints, and valves with leak test solu-tion.

g. Close FCV (Item 24) by turning to Off position. Remove pressure gauge assembly from humidifier adapter (Item 26).

h. Disconnect pneumatic adapter (Item D) from QDV (Item 15).

i. Leak test QDV poppet and FCV outlet.

j. Repair all leaks by following appropriate repair procedures.

WARNING: Leak Detector solution should be completely cleaned from the QDV assembly using dry nitrogen after testing.

FIGURE 18: Plumbing Tests Set-up

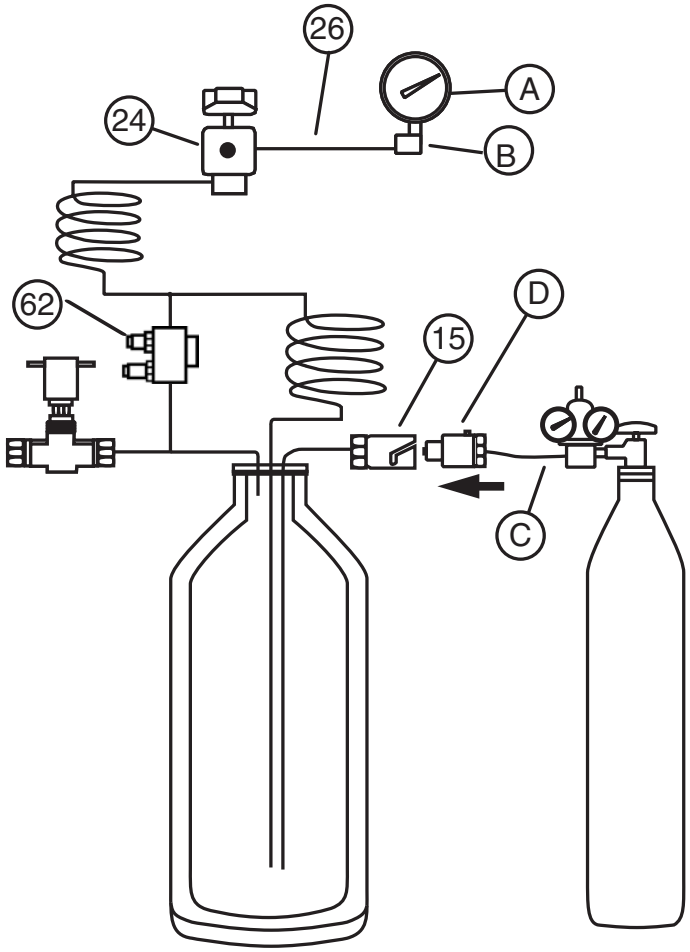
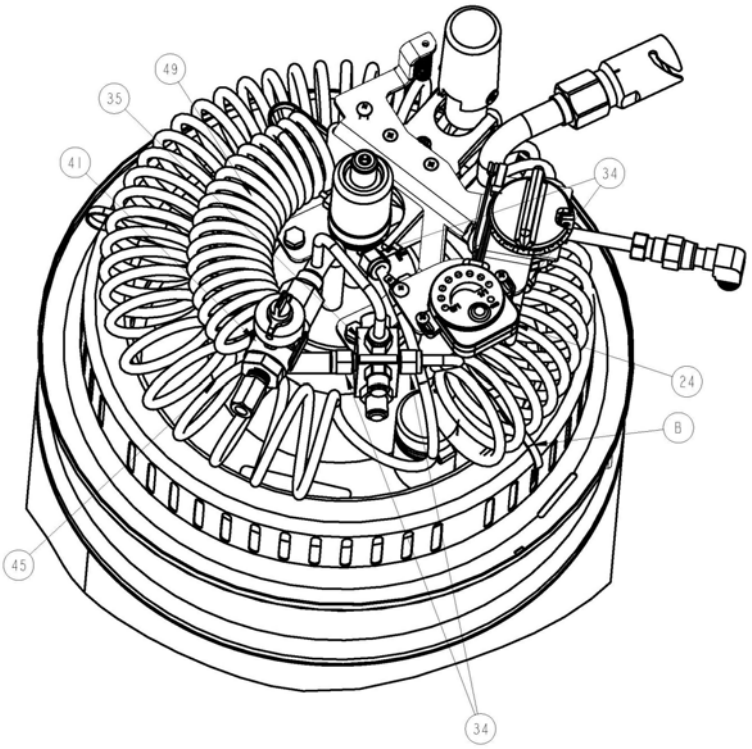


FIGURE 19: Coil and Vent Assemblies



RP17 – Warming and Breathing Coil Assembly RR (Figure 19)

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

a. Remove shroud (See RP2).

b. Disconnect breathing coil (Item 49) by unscrewing the tube nuts (Item 34) at the FCV (Item 24) and at the economizer (Item 35).

c. Disconnect warming coil (Item 45) by unscrewing the tube nuts (Item 34) at the economizer (Item 35) and at the manifold.

d. Disconnect coils by snipping zip-ties (Item B) that hold them to the top of the Liberator.

e. Remove warming and breathing coil assemblies by slightly bending them outwards and pulling them up and over the top of the Liberator.

f. To replace coil assembly, reverse above procedure.

RP18 – Vent Valve RR (Figure 19)

a. Remove shroud (See RP2).

b. Remove vent valve (Item 41) using 3/4-in open-end wrench. Place the wrench on the valve hex flats closest to the manifold to prevent disassembly of the valve as you remove it.

c. Inspect the valve stem O-ring and spring pin for wear or damage.

d. Inspect the vent wrench stops on the valve body for wear or damage.

e. 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.

f. Lightly clamp the vent valve in a vise.

g. Use a pin punch and a hammer to drive the spring pin out of the valve stem.

h. Use a small screwdriver to carefully pry the retainer ring off of the valve stem.

i. Use a dental pick or similar object to lift the O-ring off the valve stem.

j. Replace vent valve (Item 41). Wrap the manifold vent tube 1 turn and half with Teflon Tape starting one thread back from end. Apply a small amount of flurolubricant Krytox or Christo lub on top of the tape and torque 2-3 turns after finger tigh

k. Replace shroud (see RP2)

NOTE: Valve must be properly aligned to allow access to handle through hole in shroud.

RP19 – Twist Lock QDV Lip Seal RR (Figure 20)

NOTE: Lip seal may be changed on a full Liberator (Side Fill Only).

a. Insert lip seal tool into Liberator female QDV (Item 15). Engage tabs on tool with slots in retaining ring (Item 87).

b. Use wrench on hex end of tool. Push in on tool while turning to engage tabs on tool with slots in retaining ring (Item 87). Turn tool clockwise to loosen retaining ring (Item 87). Remove the ring.

c. Remove lip seal (Item 88) from QDV (Item 15). Jeweler's screwdriver may be used if necessary, but seating surfaces must not be damaged.

d. Apply thin film of fluorolubricant to new lip seal (Item 88).

e. Place retaining ring (Item 87) and new lip seal (Item 88) on tool.

f. Install retaining ring (Item 87) in QDV body (Item15) by turning tool counter-clockwise while pushing in on tool. Torque retaining ring (Item 87) to 225–282 N-cm (20-25 in-lbs).

RP20 – Twist-Lock QDV RR (Figure 20)

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

a. Remove shroud (See RP2).

b. Loosen nut (Item C) by holding QDV body (Item 15) with a wrench and turning nut (Item C) clockwise.

c. Remove QDV by pulling QDV body (Item 15) off and then pulling the hex coupler (Item 89) and O-ring (Item 16) out of the fill tube.

NOTE: All Internal Components of the QDV Must Remain Assembled During this Process.

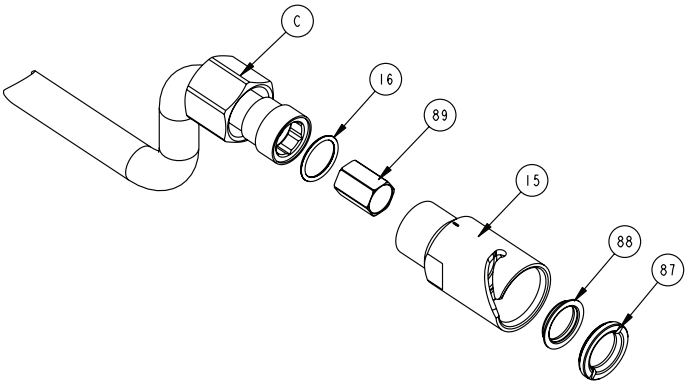
d. Apply thin film of fluorolubricant to O-ring (Item 16).

e. Reattach QDV by matching alignment marks on valve body and fill tube.

f. Torque nut (Item C) to 60–67 N-m (45-50 ft-lbs) while holding valve body (Item 15).

g. Replace shroud (See RP2).

FIGURE 20: Side Fill (Twist Lock) QDV Assembly



RP21 – Push-on QDV Assembly RR (Figure 21)

WARNING: Liberator must be empty and vented before starting this procedure.

a. Remove shroud (See RP2).

b. Remove pop-off assembly (See RP22).

c. Remove pop-off sleeve (Item 21) from QDV (Item 11).

d. Use a 7/8-in open-end wrench to hold the body of the QDV (Item 11) stationary.

e. Use a 10-in adjustable wrench to loosen the compression nut (Item D) on the QDV (Item 11).

f. Remove the QDV (Item 11).

g. Inspect the poppet cartridge assembly for wear or damage.

h. To reinstall or replace the QDV (Item 11), reverse the above procedure.

i. Apply a small amount of fluobircant Krytox or Christo Lub on the threads of the QDV (Item 11).

j. Place pop-off sleeve over QDV.

k. Reassemble pop-off assembly to unit, ensuring spring-to-pin engagement into pop-off sleeve groove.

l. Replace shroud (See RP2).

RP22 – Push-on Portable Pop-Off Assembly RR (Figure 21)

a. Remove shroud (See RP2).

b. Remove two screws (Item 37) and washers (Item 38) from pop-off assembly (Item 27) and remove pop-off assembly.

c. Detach spring from bracket (Item 39) and from pop-off assembly.

d. Disassemble as necessary to replace pop-off assembly parts.

e. Reattach pop-off assembly to unit, being sure the pins at the bottom of the pop-off lever slide into the groove at the base of the pop-off sleeve.

f. Reverse the remainder of the procedure to reinstall.

FIGURE 21: Top Fill (Push-on) QDV Assembly

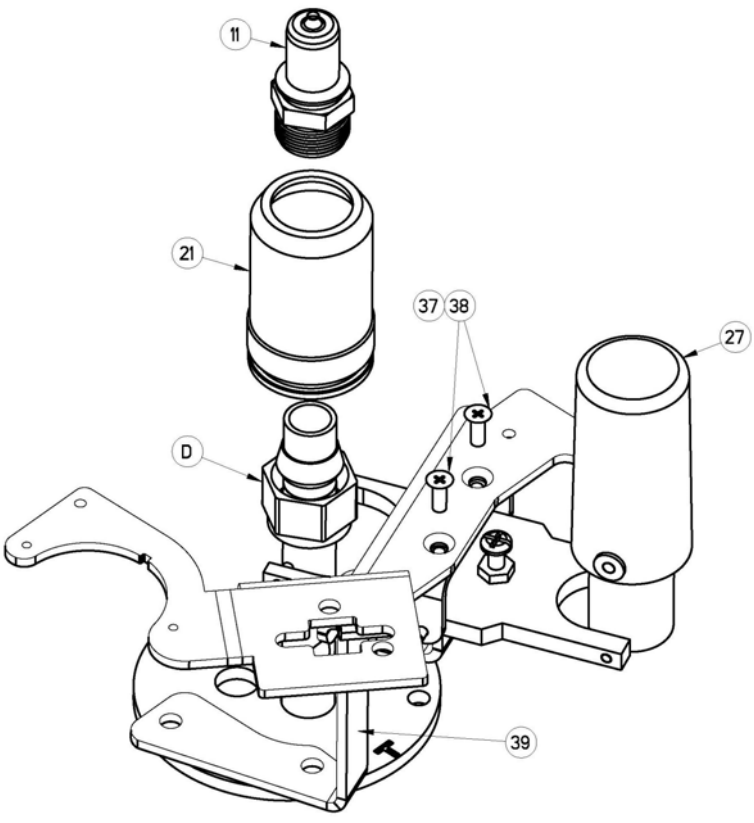


FIGURE 22: Emptying Unit

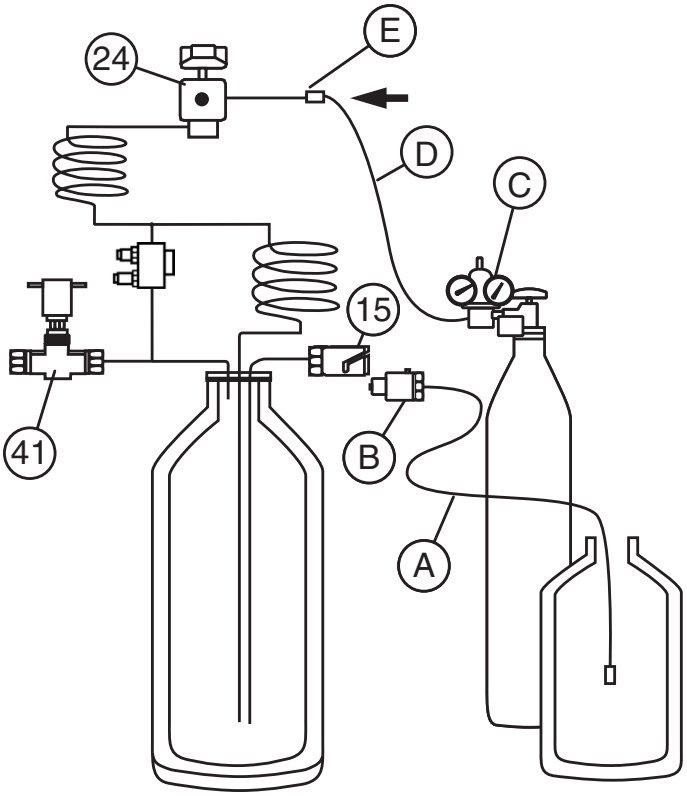
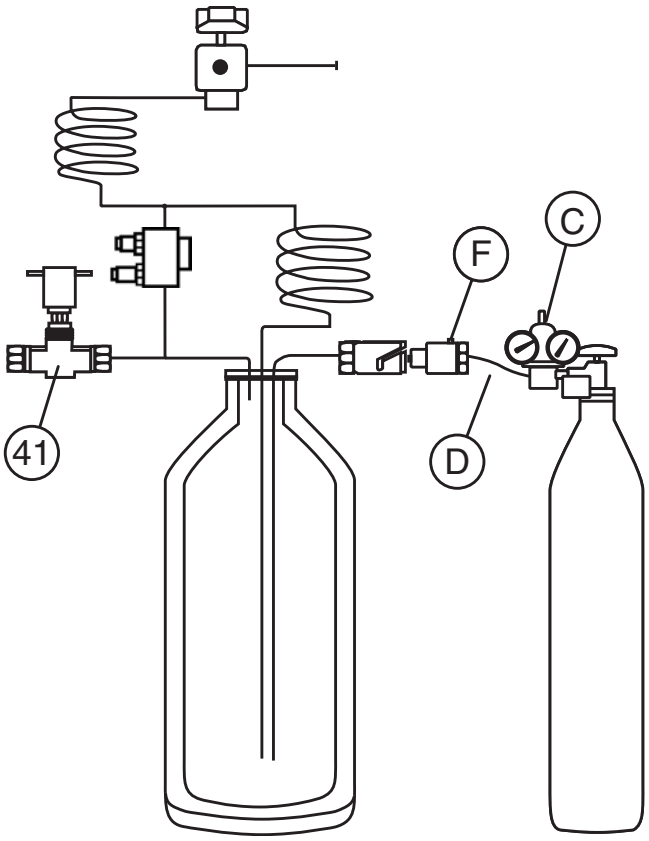


FIGURE 23: Warming Unit



RP23 – Empty Unit (Figure 22)

WARNING: Make sure open end of transfer line remains inside cryogenic container. Wear insulated gloves and eye protection when using this procedure. DO NOT reuse liquid oxygen.

a. Place one end of the transfer line (Item A) into a suitable cryogenic container such as an empty, clean Liberator dewar. Connect a male transfer line adapter (Item B) to the other end of the line.

NOTE: Female transfer line adapter should be substituted for item B in top fill version.

b. Connect the adapter to the Liberator QDV (Item 15), keeping the vent valve (Item 41) closed.

c. Liquid oxygen will be discharged from the open end of the transfer line into the empty container. Continue process until Liberator is empty.

d. If Liberator has no pressure, pressurize with the following procedure.

1. Connect regulator (Item C) to oxygen gas source.
2. Connect pneumatic hose (Item D) to regulator and Liberator DISS Fitting (Item E).
3. Adjust regulator (Item C) to supply up to 1,4 bar (20 psig).
4. Set Liberator FCV (Item 24) to 6 LPM setting.
5. Continue until Liberator is empty.

RP24 – Warm Unit (Figure 23)

a. Liberator may be allowed to sit (FCV off, vent closed) a minimum of 48 hours after emptying.

b. To warm a Liberator more quickly:

1. Connect regulator (Item C) to oxygen or nitrogen gas source.
2. Connect pneumatic hose (Item D) to regulator (Item C) and male pneumatic adapter (Item F).
3. Adjust regulator to 1,4 bar (20 psig). Open vent valve (Item 41) to allow slow venting.
4. Allow Liberator to vent for 1-1/2 hours minimum after vent valve (Item 41) defrosts.

RP25 – Flow Rate Test (Figure 24)

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

NOTE: For flow rate test Liberator needs to be at least 1/4 to 1/2 full of properly saturated liquid oxygen.

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

NOTE: Flow rates will only be accurate if the reservoir is filled properly. Reference the filling section of this manual for the correct procedure.

a. Connect FCV (Item 24) outlet to flow meter (Item G) inlet with respiratory tubing. Make sure flow meter outlet is open and unobstructed and flow meter (Item G) is properly positioned.

b. Verify internal operating pressure as per RP26. Vessels internal operating pressure should be between 19.5 psi (134 kPA) and 20.5 psi (141 kPA) before beginning flow rate test. This can be accomplished in different ways:

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

   Option B.) If reservoirs internal pressure is above 20.5 psi (141 kPA) allow unit to flow at a rate of 4 LPM for 1.5 hours minimum prior to beginning the flow rate test.

   Or

   Option C.) If reservoirs internal pressure is above 20.5 psi (141 kPA) open vent valve and wait for internal pressure to stabilize at 20.5 psi (141 kPa). Ensure the QDV pressure test fixture gauge (Item H) does not rise above 20.5 psi (141 kPa) after FCV is closed. This will indicate the tank is ready for beginning the flow rate test.

c. Test flow rate at each FCV (Item 24) position. Record all flow rates.

d. Flow rates must be nominal values within tolerances listed in Table 9 or unit fails flow rate test.

RP26 – Operating Pressure Test (Figure 24)

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

a. Connect QDV pressure test fixture (Item H). Open FCV (Item 24) to 6 LPM setting.

b. Read operating pressure on QDV pressure test fixture gauge (Item H).

c. Operating pressure must be 1,2-1,5 bar (18-22 psig) or unit fails test.

RP27 – Flow Meter Verification (Figure 24)

a. Flow meter (Item G) accuracy is best verified by a calibration laboratory. Equipment should indicate liter per minute oxygen gas at atmospheric pressure and 21°C (70° F).

b. Flow meter (Item G) accuracy may also be tested by comparison to one or more new, unused, calibrated flow meters. This method will increase confidence in accuracy of readings, but not necessarily verify accuracy.

FIGURE 24: Flow and Pressure Tests

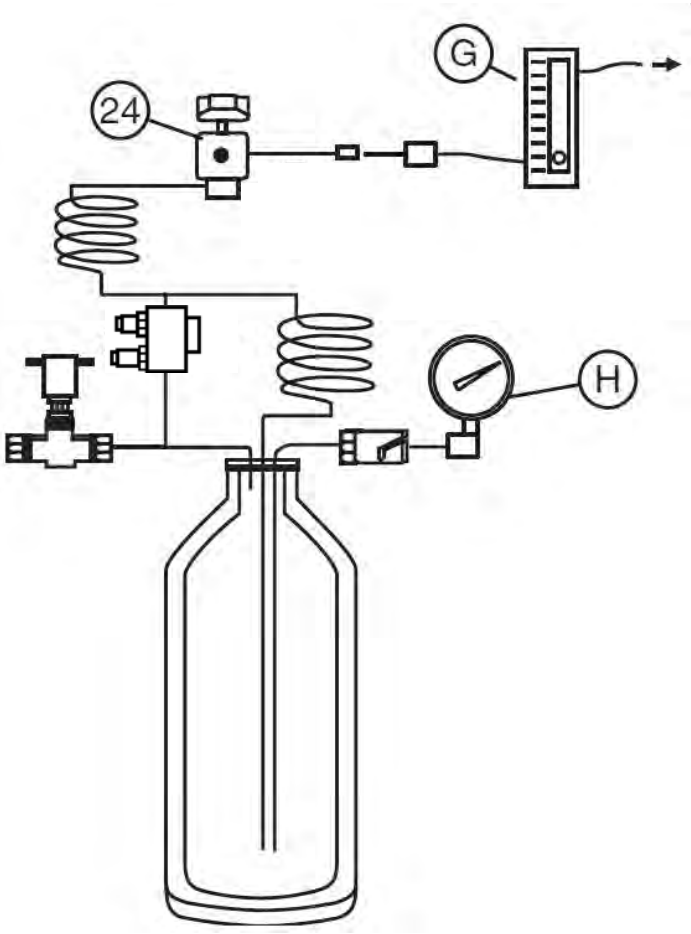


TABLE 9: Flow Test Acceptable Ranges

Nominal Setting LPM	Product Specification (SLPM)	
	Lower Limit	Upper Limit
.031	.018	.052
.05	.030	.086
.062	.038	.092
.10	.05	.20
.12	.06	.22
.20	.065	.39
.25	.08	.42
.30	.18	.52
.375	.21	.55
.40	.20	.56
.5	.33	.67
.625	.46	.80
.75	.58	.92
1.0	.83	1.17
1.25	.98	1.55
1.5	1.18	1.82
2.0	1.61	2.43
2.5	2.08	2.97
3.0	2.55	3.51
3.5	2.92	4.04
4.0	3.43	4.62
5.0	4.33	5.77
6.0	5.14	6.92
8.0	6.72	9.28
10.0	8.42	11.53
12.0	10.24	13.83
15.0	12.97	17.28

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

FIGURE 25: Economizer Regulator

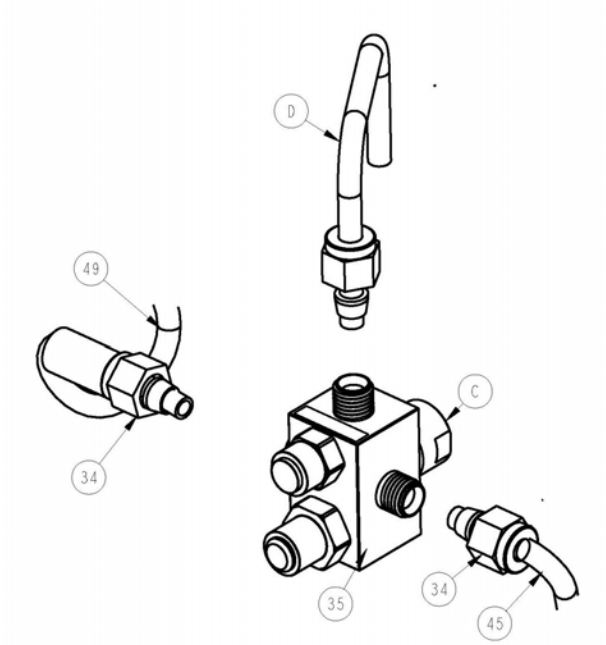
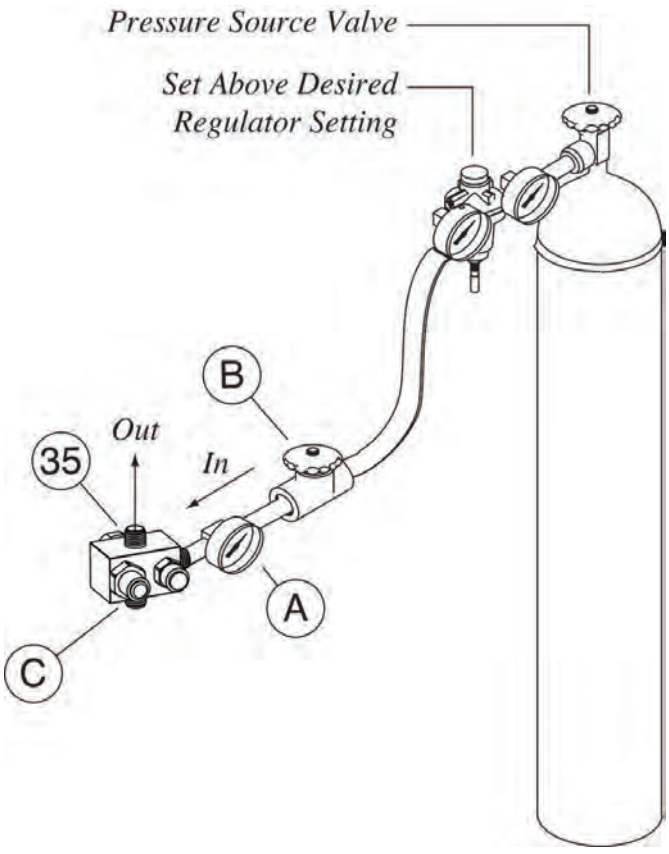


FIGURE 26: Economizer Test Setup



RP28 – Economizer Regulator RR (Figure 25)

WARNING: Liberator must be empty and vented before starting this procedure.

a. Remove shroud (See RP2).

b. Loosen the three compression fitting nuts (Item 34) at the economizer regulator (Item 35). Move coils (on the sides) and economizer tube (Item D) away from the economizer regulator (Item 35).

c. Follow RP29 to ensure proper settings on the replacement regulator.

d. Reverse remainder of procedure to install new properly adjusted regulator.

RP29 – Economizer Regulator Test

WARNING: Liberator must be empty and vented before starting this procedure.

a. Follow steps a and b of RP28 to remove economizer regulator.

b. Connect the oxygen pressure source to the inlet of the economizer regulator (Item 35) as shown in Figure 25. The inlet is the side attached to the economizer tube (Item D, Figure 25).

c. Open the pressure source valve. Adjust the pressure source regulator to 1,6 bar (23 psig). The economizer regulator should be set to open at 1,45 bar (21 psig) and close at 1,31 bar (19 psig).

d. Slowly open valve (Item B) just enough to allow some gas to escape.

e. Pressure gauge (Item A) will indicate the setting of the economizer regulator.

f. Reverse steps a and b of RP28 to reinstall regulator.

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

RP30 – Flow Control Valve RR (Figure 27)

WARNING: Liberator must be empty and vented before starting this procedure.

NOTE: Special care should be taken in aligning the FCV in order to ensure that it lines up properly with the shroud.

a. Remove shroud (See RP2).

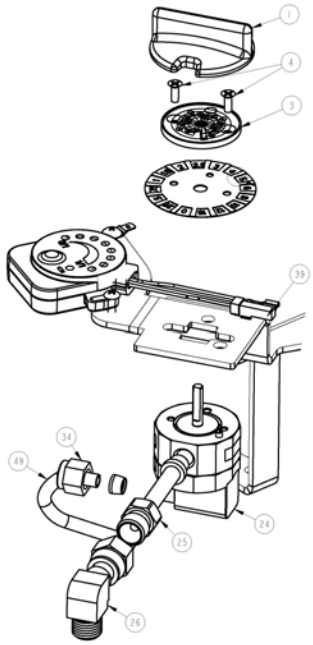
b. Loosen compression fitting nut (Item 34) at connection of breathing coil (Item 49) and FCV assembly. Disconnect FCV assembly (Item 24) from coil.

c. Remove the FCV knob (Item 1) by grasping firmly and pulling upwards.

d. Unscrew the two screws (Item 4) holding the lock plate (Item 3) and decal (Item 2) to the FCV (Item 24) and remove lock plate and decal.

e. Replace the FCV (Item 24), by reversing the above procedure.

FIGURE 27: Flow Control Valve



WARNING: Liberator must be empty and vented before starting this procedure.

RP31 – Dewar RR

a. Remove shroud (See RP2).

b. Remove manifold assembly and coils (See RP9).

c. Remove condensate bottle, drain tube and bracket (see RP3).

d. Remove dewar cap from the new dewar and place the cap on old dewar.

e. Clean/dry both the probe and dewar following procedure in section VIII.

f. Connect the manifold assembly with coils to the new dewar; be sure to follow the manifold assembly replacement procedure (See RP9). Do not replace shroud.

g. Replace condensate bottle, bracket and drain tube.

h. Scribe part number and serial number on new dewar handle. Make part number and serial number on old dewar illegible.

i. Calibrate meter by following RP7.

RP32 – Normal Evaporation Rate Test

a. Fill the unit with at least 9 to 11 kgs (20 to 25 lbs) of properly saturated liquid oxygen.

b. Allow unit to sit undisturbed for a minimum of 12 hours with the FCV in Off position and the vent closed.

NOTE: Scale must be accurate to ± 0.02 kg (0.05 lbs).

c. Weigh unit. Record weight and time.

d. Allow unit to sit undisturbed for a minimum of 24 hours.

e. Weigh unit. Record weight and time.

f. Calculate liquid loss rate (NER) using the following formula:

$$NER = \frac{\text{Weight lost (kg or lbs)}}{\text{Elapsed time in hrs.}} \times 24 \text{ hours/day}$$

Example

$$NER = \frac{0.63 \text{ kg}}{25.5 \text{ hrs.}} \times 24 \text{ hours/day}$$

NER = 0,59 kg/day

g. If NER is more than 0,9 kg/day (2 lbs/day) for a Liberator, the dealer may want to send the unit to CAIRE, Inc. for re-evacuation. If NER is more than 2,3 kg/day (5 lbs/day) the dealer should remove the unit from service and have the unit re-vacuumed.

RP33 – Determining Liquid and Gaseous Oxygen Capacity

1. Weigh the empty reservoir and record the weight (kg/lb)

2. Fill the unit with properly saturated liquid oxygen (Per Filling Procedure in Operation section of manual)

3. Weigh the full reservoir and record the weight (kg/lb)

4. Subtract the empty reservoir weight (STEP 1) from the full reservoir weight (STEP 3) to determine the weight of liquid oxygen that is inside of the reservoir

5. Take the weight of liquid oxygen (calculated in STEP 4) and divide it by the LOX density to calculate the liters of liquid oxygen in the reservoir

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

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

Example: Calculation of Liquid Oxygen in a full Liberator 45 reservoir

1. Empty weight of LIB 45 Reservoir: 24,95 kg (55.00 lbs)

2. Filled unit with properly saturated liquid oxygen

3. Full weight of LIB 45 Reservoir: 74.99 kg (165.32 lbs)

4. 74.99 kg (165.32 lbs) – 24,95 kg (55.00 lbs) = 50,04 kg (110.3 lbs)

5A. 55.04 kg/1.095 kg/L = 45.7 Liquid Liters of Oxygen

5B. 110.3 lbs/2.413 lbs/L = 45.7 Liquid Liters of Oxygen

XIII Service Tools/Equipment/Supplies

Required Tools

1. Hex Wrenches (various sizes)
2. Flat Blade Screwdriver
3. 5/16" Nut Driver
4. Open End Wrenches (1/2" to 1-1/8")
5. Side Cutters
6. Pliers
7. Torque Driver/Wrenches:
   - 12-17 N-cm (10-15 in-lbs)
   - 23-29 N-cm (20-25 in-lbs)
   - 69-92 N-cm (60-80 in-lbs)
   - 104-115 N-cm (90-100 in-lbs)
   - 6.2-6.9 N-m (45-50 ft-lbs)
8. Jeweler's Screwdriver

Required Fixtures/Equipment

1. Capacitance Meter
2. Soldering Iron
3. Oxygen Regulator
4. Pressure Gauge
5. Pressure Gauge Adapter
6. Flowmeter
7. 02 Gas Source (High Pressure bottle)
8. 02 Liquid Source
9. N2 Gas or Clean, Dry Compressed Air Source
10. Tubing (02 compatible)
11. Lip Seal Service Tool
12. Male Pneumatic Test Adapter
13. LO2 Transfer Line
14. Transfer Line Adapter with Filter
15. Dewar Cap
16. Vent Valve Wrench
17. Scale 0-70 kg (0-150 lbs), 0.02 kg (0.05 lb) increments

Required Supplies

1. Stay-Clean Flux
2. Cotton Swabs
3. Lead-free Solder
4. Distilled Water
5. Household Glass Cleaner
6. Lint-Free Cloth
7. PTFE Tape
8. Fluorolubricant
9. Leak Detection Fluid

Cleaner

1. Simple Green available at www.simplegreen.com

Tools and Accessories available from Caire

Part No	Description
10679862	Female Top Fill Pneumatic Test Adapter
10678157	Female Top Fill Transfer Line Adapter
CA200071	240 AC Fluorolubricant
20583180	Leak Detection Fluid (gallon)
B-775311-00	Erie "Liter Meter"
10995620	Erie "Liter Meter" 6-15lpm
97212021	Male Side Fill Pneumatic Test Adapter
97212023	Male Side Fill Transfer Line Adapter w/Filter
15075347	Transfer Line Adapter Cover
97217007	Pressure Gauge Adapter
CA400004	Replacement Filter/Male Transfer Line Adapter
97202005	Vent Valve Wrench
B-775182-00	Vent Valve Wrench
97403015	Capacitance Meter
3910486	Dewar Cap
97403577	0-4.1 bar (0-60 psig) Pressure Gauge Transfer Line
97404564	Swivel Connector
97405279	Pneumatic Hose with DISS Fittings Liquid
9713119	Oxygen Transfer Line – 1.8 m (6 ft)
97405590	Lip Seal Service Tool
CA406310	TEFLON Tape
10670497	10.3 bar (150 psi) Relief Valve Only
97406555	Super Flex Liquid Oxygen Transfer Line – 6'
13350704	Service Manual
13329091	G4 Capacitance Meter Adaptor Kit
20802161	QDV Hex Plug w/o O-Ring Top fill plug
10566446	Cap Brass 15/16" Hex Side fill Plug
CA404828	Hex Coupler O-Ring for Side fill plug

XIV Parts Price List

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

Ordering Information

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

1. Compile a list of all equipment and replacement parts to be ordered.

NOTE: Use the following numbers to order a complete unit.

Model (0–15 LPM)	Side Fill	Top Fill	Dual Fill
L20	13256435	13256654	13256195
L30	13258449	13258641	13256929
L37	13259695	13259919	13259599
L45	13262085	13262253	13261699
L60	13263782	13263811	13263758

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. Contact your local CAIRE office to begin processing of your order. CAIRE office details can be located on our website at www.caireinc.com and navigating to the Corporate tab, and locations or https://www.caireinc.com/caire-inc-corporate-landing-page/locations/ Here you will find the local office address, email address and phone number.

XVI Return Policy

When a Liberator 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 20-23. If these procedures do not provide a solution for the problem, the following steps should be taken:

1. Call CAIRE Inc. Customer Service. State the problem with the unit. 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). If a Purchase Order Number is to be referenced, please give this number to the Customer Service Representative at that time.
2. Carefully package the parts, or repack the unit in its original shipping container, precisely as shipped.
3. Write the Return Authorization Number on the top of the shipping container.
4. Return the unit or parts by professional carrier to the address provided by CAIRE Customer Service.

   All equipment returned to CAIRE Inc. must be shipped "prepaid".

When the defective item(s) is received at CAIRE Inc., it will be serviced and returned to the distributor as soon as possible. A copy of the "Repair Cost Sheet" will be enclosed giving a detailed listing of any maintenance performed.

CE
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CAIRE Inc.
2200 Airport Industrial Dr., Ste. 500
Ball Ground, GA 30107 U.S.A.

EC REP
Medical Product Service GmbH
Borngasse 20
35619 Braunfels, Germany
Tel: +49 (0) 6442-962073
E-mail: info@mps-gmbh.eu

CH REP
Accumed Sagl
Viale Serfontana, 10
6834 - Morbio Inferiore
Switzerland

www.caireinc.com