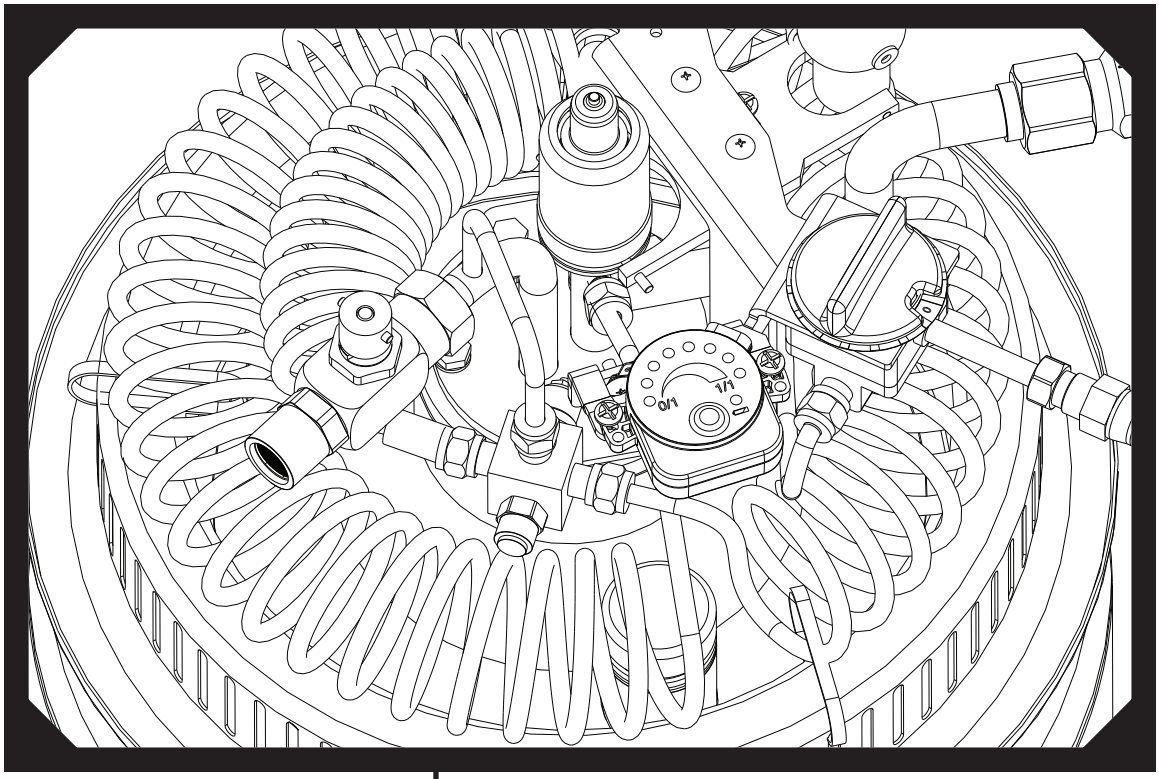
LIBERATOR

GENERATION 4



SERVICE MANUAL

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SERVICE MANUAL

LIBERATOR SERIES - GENERATION 4

LIB20, LIB30, LIB37, LIB45, LIB60

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Abbreviations

FCV	Flow Control Valve	PRV	Primary Relief Valve
LED	Light Emitting Diode	QDV	Quick Disconnect Valve
LOX	Liquid Oxygen	RMA	Return Materials Authorization
LPM	Liters Per Minute	RP	Repair Procedure
NER	Normal Evaporation Rate	R/R	Removal and Replacement
POI	Patient Operating Instructions	SRV	Secondary Relief Valve
N2	Nitrogen Gas	O2	Oxygen Gas
TF	Top Fill	SF	Side Fill
DF	Dual 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.

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.

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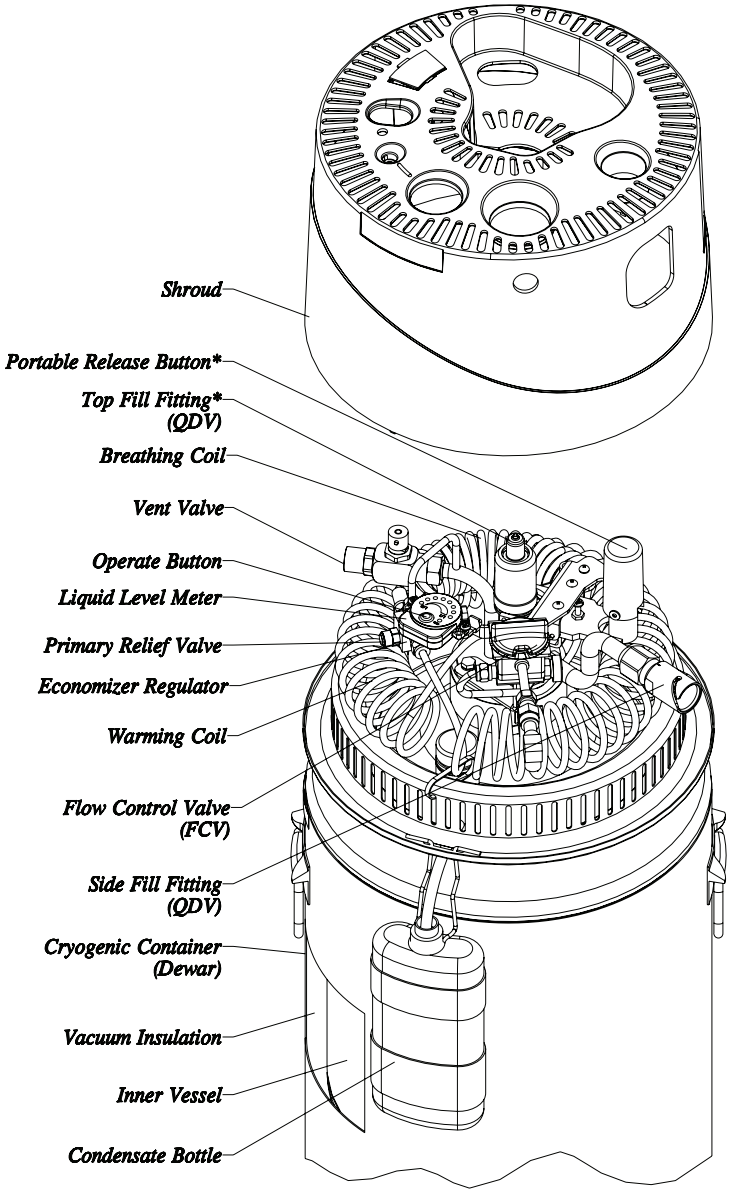
FIGURE 1: Liberator Components



* 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 at approximately -180°C (-300° 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 if there is excess head pressure.

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.

Specifications (Nominal Values) IV

	LIBERATOR 20	LIBERATOR 30	LIBERATOR 37	LIBERATOR 45	LIBERATOR 60
Capacity					
kg (lbs) LOX:	24,6 (52)	34,0 (75)	41,7 (92)	50,8 (112)	65,3(144)
Liquid Liters:	21,6	31,2	38,3	46,6	60,0
Gaseous Liters:	17 780	25 650	31 460	38 300	49 200
Selectable Flow Rates					
Liters Per Minute (LPM):	Off 0,25 0,50 0,75 1,0 1,5 2,0 2,5 3,0 4,0 5,0 6,0 8,0 10 12 15				
Flow Rate Accuracy	± 0,1 liter per minute or ±10% of flow setting, whichever is greater				
Hours of Operation					
@ 2 LPM:	148	213	262	319	410
Standard Fill Connections	Side Top	Side Top	Side Top	Side Top	Side Top
Operating Pressure - Bar (PSIG)					
(Economizer Regulator) :	1,4 (20)	1,4 (20)	1,4 (20)	1,4 (20)	1,4 (20)
Primary Relief Valve Setting					
Bar (PSIG):	1,6 (23)	1,6 (23)	1,6 (23)	1,6 (23)	1,6 (23)
Secondary Relief Valve Setting					
Bar (PSIG):	2,1 (30)	2,1 (30)	2,1 (30)	2,1 (30)	2,1 (30)
Normal Evaporation Rate					
kg (lbs) per day:	0,68 (1.5)	0,68 (1.5)	0,68 (1.5)	0,68 (1.5)	0,73 (1.6)
Filling Time (Fast Fill Technique)					
Minutes: Warm	2.5	3.0	3.5	4.0	5.5
Cold	1.5	2.0	2.5	3.0	4.0
Height					
cm (in):	62,2 (24.5)	74,9 (29.5)	83,2 (32.75)	94,0 (37)	99,1 (39)
Diameter					
cm (in):	35,6 (14)	35,6 (14)	35,6 (14)	35,6 (14)	40,6 (16)
Weight, Empty - kg (lbs)					
Empty:	17,6 (39)	20,4 (45)	22,7 (50)	24,9 (55)	29,9 (66)
Full:	41,3 (91)	54,4 (120)	64,4 (142)	75,7 (167)	95,3 (210)
Fill Connector Types	Side Mounted Rotary Coupling Top Mounted Rotary Coupling Top Mounted Push Coupling				

V Safety

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

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 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 on its side.

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

WARNING: In the event a unit is dropped, tipped over, or unreasonably abused; immediately, but cautiously, raise the container to its normal vertical position. If substantial container damage has occurred, remove the liquid oxygen from the vessel in a safe manner (RP22). 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.

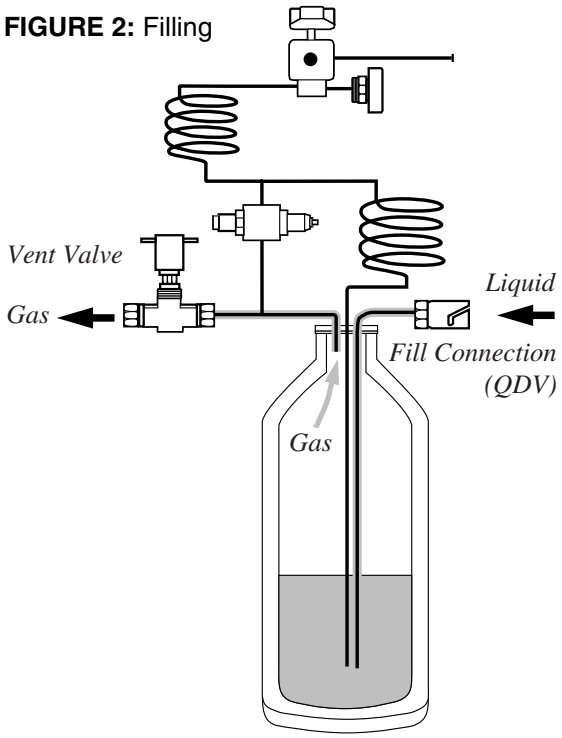
WARNING: Only use replacement equipment which is compatible with liquid oxygen and has been cleaned for oxygen use. Do not use regulators, fittings, hoses, etc. which have been previously used in non-oxygen service.

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. Closing the Liberator vent valve and disconnecting the fill adapter from the Liberator QDV terminates the fill process.

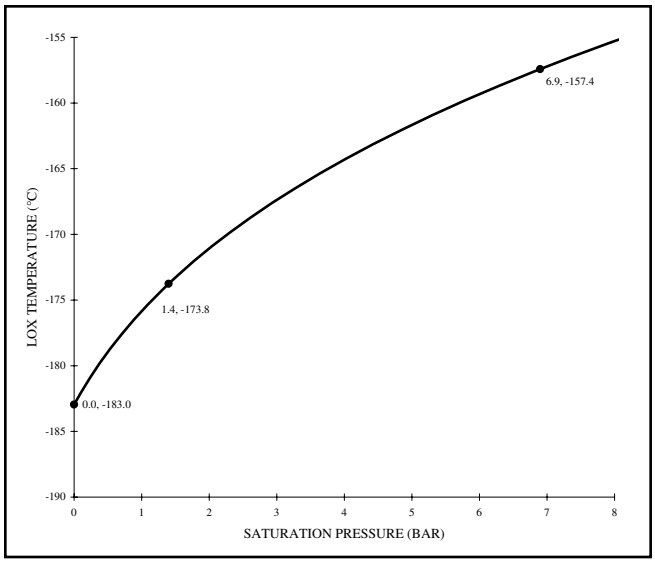
FIGURE 2: Filling



Saturation Pressure

The saturation point of a liquid is a steady-state condition where the liquid has absorbed the maximum amount of heat it can. 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 dependant 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 more easily controllable than temperature, and treat saturation temperature as a dependant variable to 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 desaturate to 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 give up enough heat for its temperature to be lowered to that temperature corresponding to a pressure of 1,4 bar (20 psig), as shown in the graph. It accomplishes this by a vigorous boiling action. All of the gas generated by this boiling is vented through the 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.

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

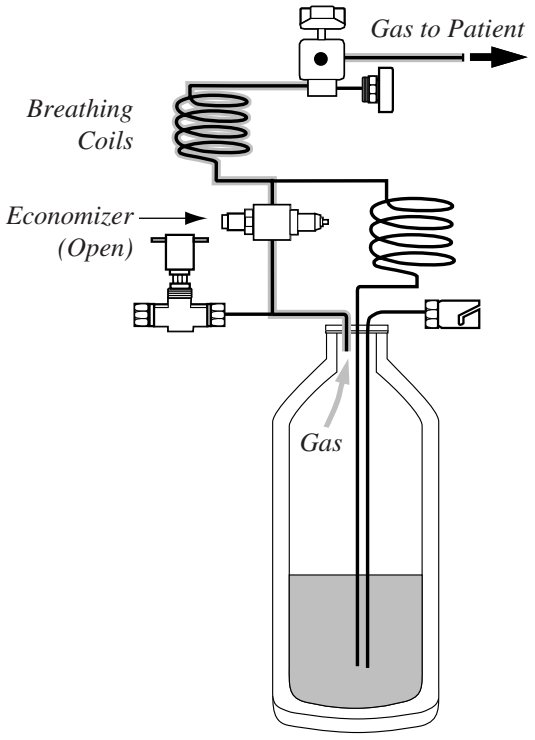
To minimize the effect of undersaturated liquid in the Liberator, a fixed orifice has been installed in the outlet of the vent valve. This orifice regulates the back pressure in the unit during the fill process, resulting in more correct saturation pressures in the Liberator.

Operation

With liquid oxygen in the unit and the flow control valve and vent valve closed, the pressure in the inner vessel will remain near the primary relief valve setting of 1,6 bar (23 psig).

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

FIGURE 4: Operation Above 1,4 Bar (20PSI)



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.

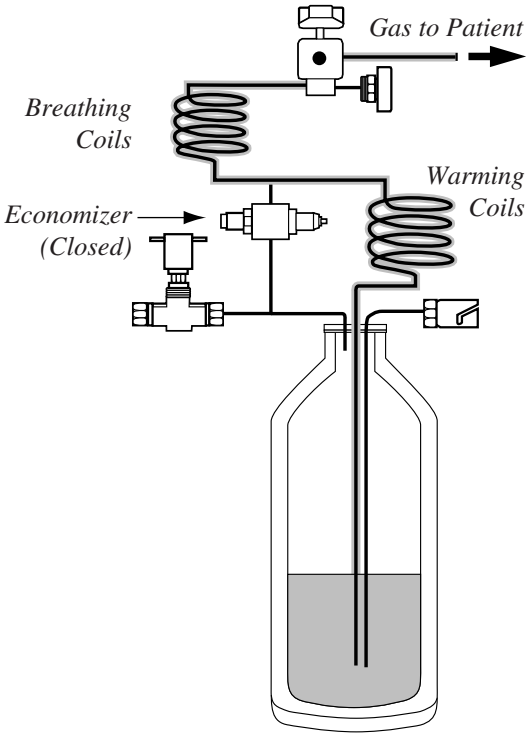
In the breathing coil, the cold gaseous oxygen is warmed to near-ambient temperature while flowing to the flow control valve, where it is metered and dispensed.

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 Below 1,4 Bar (20PSI)



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.

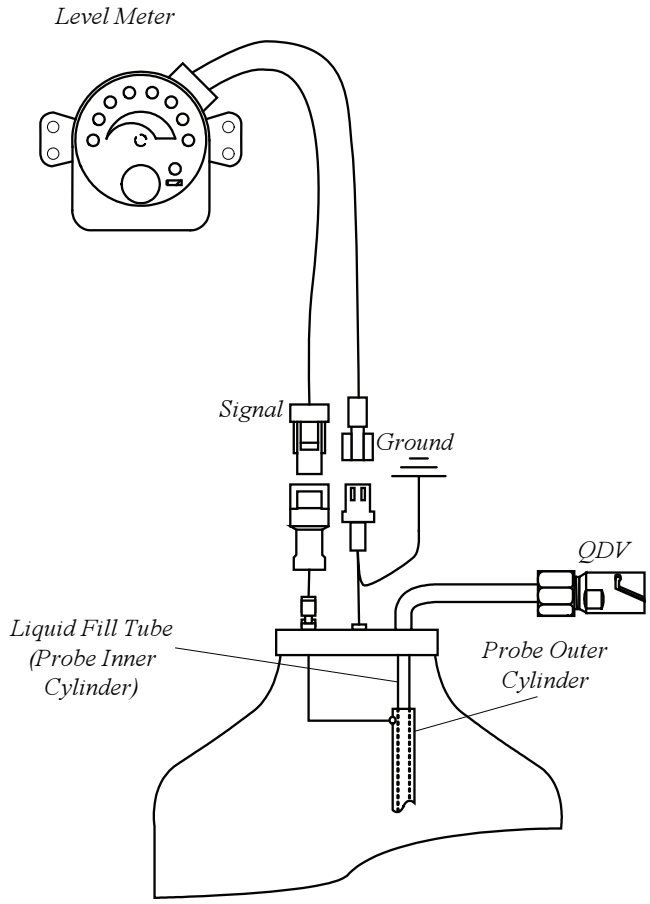
The liquid level probe consists of two concentric stainless steel cylinders extending inside the inner vessel. As the liquid oxygen level rises, the capacitance of this assembly goes up. The level meter then displays the liquid level in the cylinder based on a calibration relating capacitance to fill level. The higher the liquid level in the dewar, the more LEDs are activated, beginning at the leftmost 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 coming 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 a replacable 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 battery is a CR2032 coin cell and can be bought at most hardware stores. If desired, replacement batteries can also be ordered by contacting 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 from a technical service point of view are a much improved calibration procedure requiring 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 with the calibration procedure (RP6).

FIGURE 6: Liquid Level Meter Circuit



VII Unpacking and Setup

Unpacking

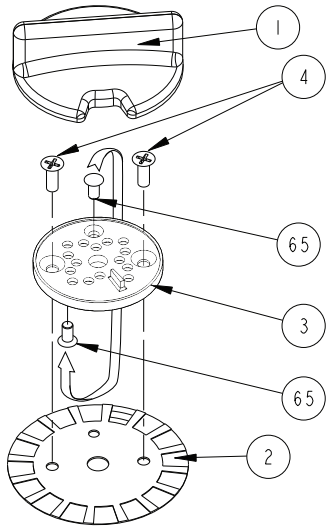
1. Inspect carton for shipping damage. Report any damage to freight company before signing bill of landing.
2. Check description on carton against your order.
3. Unpack unit, including condensation bottle and bracket, POI, FCV extension, and humidifier elbow kit.
4. Set aside several sets of packing materials in case a unit must be returned to factory.

Setup

1. Remove shroud and 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 4,6 N-cm (4 in-lb).
4. Install humidifier elbow (if applicable) by screwing it into the side of the FCV.
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.
11. If desired, the flow control knob (Item 1) can be adjusted so it will not exceed maximum prescribed flow rate.

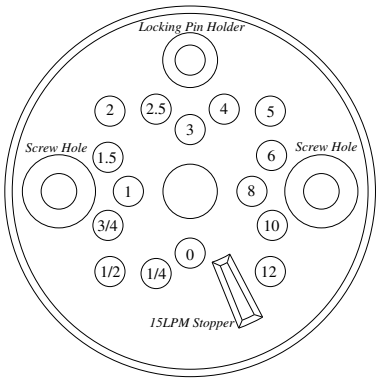
    a. Remove FCV knob by firmly grasping the knob and pulling away from the base unit.

FIGURE 7: Flow Control Knob



    b. Remove two phillips head screws (Item 4) from flow lock plate (Item 3) and remove plate.
    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 5-7 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

Transport

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

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, or necktube damage may occur.

Filling

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

1. Fill Source Preparation

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

   b. Ensure the liquid oxygen in the fill source is saturated at 2,4-4,1 bar (35-60 psig). 3,4 bar (50 psig) is optimal.

WARNING: Fill source must be in a well ventilated area to prevent developement of an oxygen enriched atmosphere.

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

2. Fill Procedure

   a. Required Equipment:

      → Fill source as outlined above
      → Liquid oxygen transfer line
      → Male transfer line adapter for side fill Liberators
      → Female transfer line adapter for top fill Liberators
      → Liberator vent valve wrench
      → Eye protection
      → Pressure Gauge
      → Insulated gloves

   b. If refilling a partially filled Liberator, verify flow rates are within tolerance specifications before filling.

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

NOTE: If flow rates are out of specifications or liquid level meter operates improperly, refer to Troubleshooting section (Section X).

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

   e. Fully open liquid valve on fill source.

   f. Purge transfer line for 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. Push adapter poppet against the side of a Liberator unit or other unpainted stainless steel surface.

   g. Wipe reservoir fill connector with lint free rag if moist.

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

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

   i. Fully open reservoir vent valve.

   j. Connect transfer line to reservoir to begin fill.

   k. Connect a pressure gauge to oxygen outlet and open the flow control valve to 2 lpm or greater.

   l. While filling throttle the vent valve with the vent valve wrench as required to keep pressure at approximately 1,4 bar (20 psi).

      An alternate method to throttle the vent valve is to attach a flow meter to the oxygen outlet, set the flow control valve to 2 lpm, and then throttle the vent valve to maintain a flow of 2 lpm. This is equivalent to using a pressure gauge.

   m. When liquid spurts from vent outlet, disconnect transfer line.

   n. Close reservoir vent valve immediately after removing transfer line.

   p. Disconnect pressure gauge (or flow meter) from oxygen outlet and turn off FCV.

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

   q. Replace protective cover on QDV adapter and hang adapter and transfer line using hook provided.

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

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

VIII Operation

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 RP6 to calibrate the meter.

Cleaning and Disinfection

In order to insure proper functioning and end-user safety, all Liberator units must be cleaned and disinfected on a regular basis.

Preparation

Prior to cleaning or disinfection, the unit should be completely purged of O2 and/or LOX and the QDV should be blocked to ensure no cleaner enters the oxygen flow path. The technician should wear gloves 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. 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.
2. Discard the cleaning cloth.
3. Wipe off excess cleaning solution and dry thoroughly with a lint-free cloth. Discard the cloth.

Disinfection

1. Apply the disinfectant (see Table 1) to the exterior of the unit in the concentration and for the residence time recommended by the disinfectant manufacturer.
2. Remove any excess disinfectant with a dry, lint-free cloth, and allow the unit to dry.
3. Rinse with appropriate water (at least drinking water quality) to avoid biological reactions and impairment in the material. Dry with a lint-free cloth.

TABLE 1: Recommended Disinfectant Solutions

Name	Producer	Website
Microbac Forte	Bodie Chemie Hamburg	www.bode-chemie.com
Wex-Cide	Wexford Labs, Inc.	www.wexfordlabs.com
Vesphene IIse	Steris Corp.	www.steris.com
Note: The above solutions are recommendations only and there may be a number of other effective solutions.		

TABLE 2: Liberator Material Content

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

TABLE 3: Common Disinfectant Chemicals

Disenfectant Agent	Compatible with Generation 4 Liberators
Aldehyde	Yes
Quantinary 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

End of Life

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

There are two schedules for routine maintenance which the home health care distributor should follow. These schedules allow the distributor maximum flexibility while assuring that equipment is operating properly.The healthcare distributor may follow other schedules.

Schedule A – Biennial

A. Introduction

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

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

   a. Refer to Troubleshooting section (Section X) of this manual.
   b. Return the unit to CAIRE for repair.

2. Schedule – Maximum of two years between routine maintenance testing. Unit should be tested whenever a problem is suspected.

B. Procedure

Follow the steps in order listed. If the unit fails any step, refer to Troubleshooting section (Section X) of this manual.

1. Visual Inspection:

   a. Remove any LOX prior to maintenance (RP22).
   b. Look for damaged or missing parts.
   c. Verify the meter reads empty (one LED), the low battery LED is not lit, and no error codes appear on the meter.

2. Component Test:

   a. Remove shroud (RP2).
   b. Pressurize to 1,7 bar (25 psig) (RP12) and check that PRV opens.
   c. Pressurize to 2,3 bar (34 psig) (RP12) and check that SRV opens.
   d. Recalibrate meter (RP6).
   e. Test pressure retention (RP14).
   f. Replace shroud (RP2).

TABLE 4: Flow Test Acceptable Ranges

FCV Setting	LPM
OFF	0
0.25	0.15 to 0.35
0.50	0.40 to 0.60
0.75	0.65 to 0.85
1.00	0.90 to 1.10
1.50	1.35 to 1.65
2.00	1.80 to 2.20
2.50	2.25 to 2.75
3.00	2.70 to 3.30
3.50	3.15 to 3.85
4.00	3.60 to 4.40
5.00	4.50 to 5.50
6.00	5.40 to 6.60
8.00	7.20 to 8.80
10.0	9.00 to 11.0
12.0	10.8 to 13.2
15.0	13.5 to 16.5

3. Flow Test:

   a. Fill with approximately 7kg (15 lbs) of properly saturated LOX.
   b. Set FCV to maximum setting and run for one hour minimum.
   c. Check all flow settings according to Table 4 and verify pressure stays above 1,24 bar (18 psig).

4. Check Efficiency of Unit:

   a. Set FCV to zero and allow bottle to warm up (10-15 min).
   b. Inspect bottle for cold or sweaty condition and for excessive venting from relief valve (some venting is normal).
   c. If either condition is observed, conduct NER test (RP31).

5. Prepare for Use:

   a. Empty contents (RP22).
   b. Allow unit to sit until warm (2-4 hours).
   c. Clean outside of unit following instruction set forth in the Operation section (Section VIII).

IX Maintenance (Schedule B, Continuous)

Schedule B – Continuous

A. Introduction

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

1. If a unit fails a given test, it should be taken out of service and sent to the Repair Center/Department for further inspection.
2. Schedule – Checks should be made when the driver sees patient and when moving equipment between patients.

B. Procedure

These inspections/tests should be done by the driver as part of the Standard Fill Procedure every time the reservoir is filled.

1. Visually inspect for:
   a. Broken shrouds
   b. Cold sweaty bottles (vacuum problem)
   c. QDV deformation
2. Check prescription flow rate(s) using an Erie liter meter (± 0,25 lpm).
3. Check the liquid level meter. Push operate button before fill and verify that battery is not low, there are no eror codes, and the meter reading is within one LED of the values shown in Table 5. After filling, verify that meter reads full.

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	20,4	24,7	22,7	27,9	24,9	31,3	29,9	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	41,3	50,2	54,4	59,2	64,4	69,4	75,7	87,1	95,3

These inspections/tests should be done between patients

1. Visually inspect for:
   a. Broken shrouds/flow control knobs
   b. Cold sweaty bottle or excessive venting from relief valve (vacuum problem). Some venting from relief valve is normal.
   c. QDV deformation
   d. Inspect under shroud (without removal) for any visible dirt or contaminants.
   e. Inspect drain tube for visible dirt. Clean with a 6" cotton swab to remove dirt.
2. Verify that meter battery is not low, there are no error codes, and meter is within one LED of table. If unit is empty, verify meter reads empty, then fill with approximately 7kg (15 lbs) of liquid oxygen and verify with chart.
3. Set FCV to maximum flow rate for one hour. Check all flow settings according to Table 4 and verify pressure remains above 1,24 bar (18 psig).

TABLE 4: Flow Test Ranges

FCV Setting	LPM
OFF	0
0,25	0,15 to 0,35
0,50	0,40 to 0,60
0,75	0,65 to 0,85
1,00	0,90 to 1,10
1,50	1,35 to 1,65
2,00	1,80 to 2,20
2,50	2,25 to 2,75
3,00	2,70 to 3,30
3,50	3,15 to 3,85
4,00	3,60 to 4,40
5,00	4,50 to 5,50
6,00	5,40 to 6,60
8,00	7,20 to 8,80
10,0	9,00 to 11,0
12,0	10,8 to 13,2
15,0	13,5 to 16,5

4. If unit fails one of the above tests, return to Repair Center or CAIRE. If units pass all tests, clean outside of unit with household glass cleaner and lint free cloth being careful not to get cleaner inside valves as this could lead to malfunction.

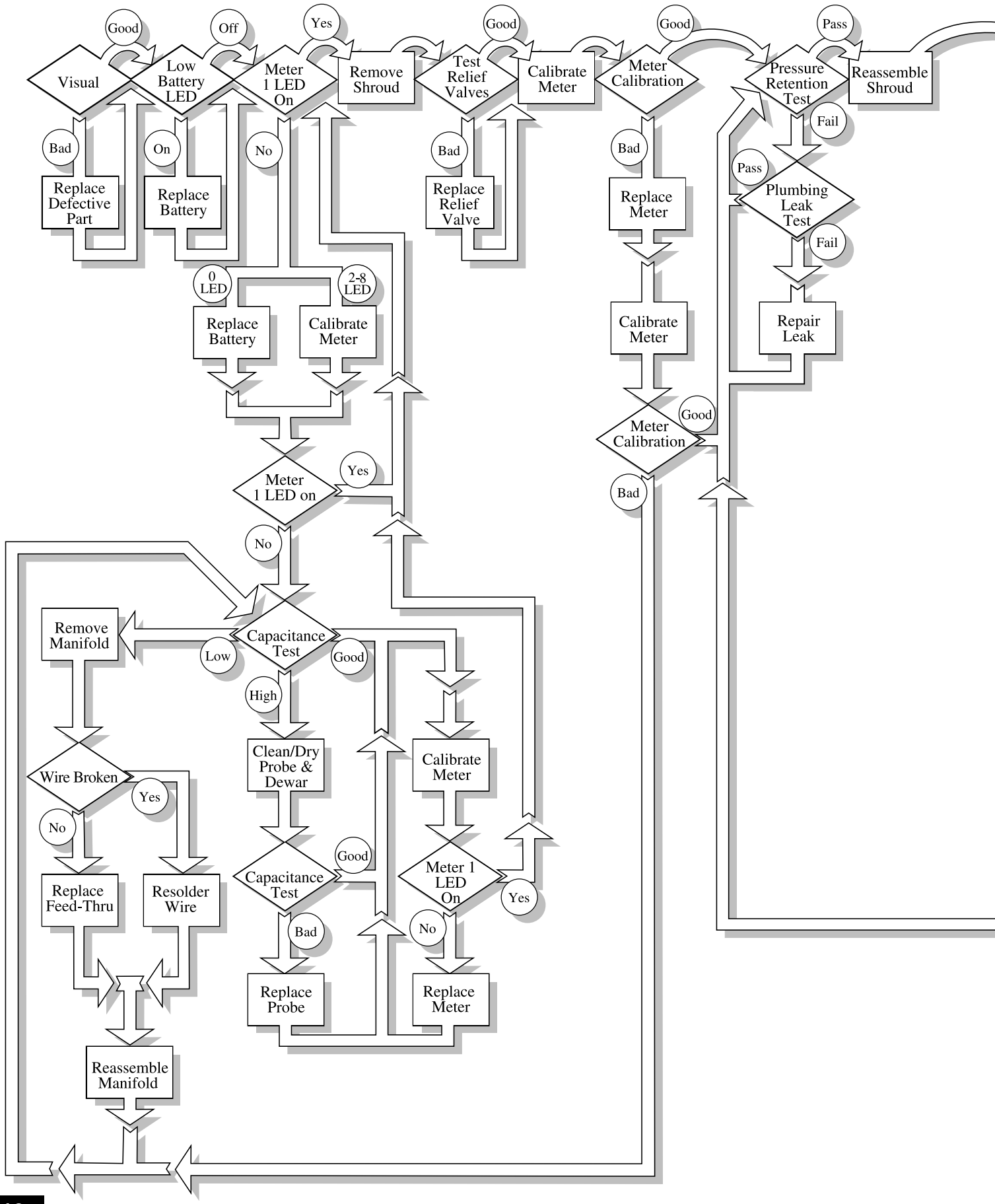
Troubleshooting (Table of Contents) X

Introduction

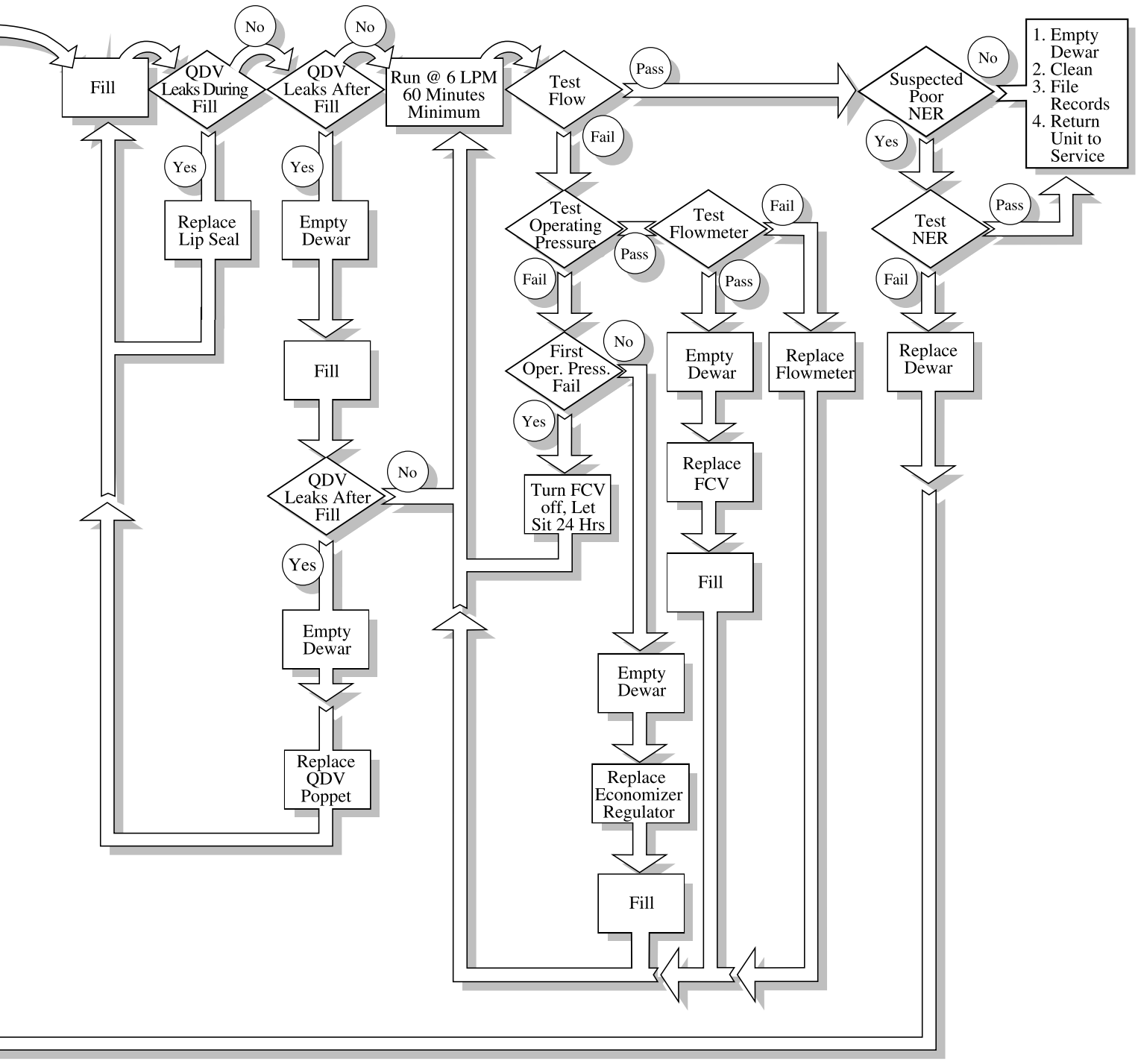
1. These procedures are designed to be performed only by qualified personnel with proper equipment.

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

XI Troubleshooting Chart



Troubleshooting Chart XI



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.

XII Repair Procedures

RP1 – General

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

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 R/R (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 4,6 N-m (4 in-lb).

RP3 – Condensation Bottle Bracket R/R

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) squeezing legs together and pulling straight down.

c. To replace bracket, reverse above procedure.

RP4 – Liquid Level Meter R/R

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 R/R

a. Remove liquid level meter (See RP4).

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

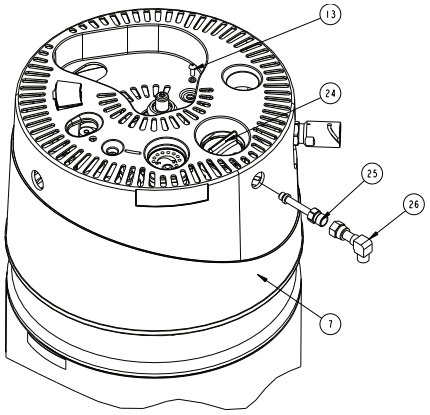
c. Slide the tip of a flathead jeweler's screwdriver beside the battery and carefully pry out the battery.

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

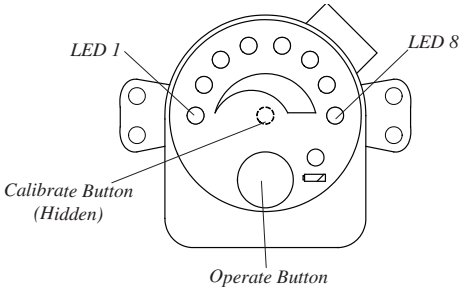


RP6 – Liquid Level Meter Calibration (Figure 10)

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 7). To Calibrate, first enter calibration mode before perfroming 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.

b. Within 3 sec, press and hold the operate button. LED1 and LED8 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 capacitance reading (LED1 will flash for 3 sec).

b. LED1 will flash to signify successful calibration. If an error occurs the calibration value will not be saved.

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

Procedure 1: Capacitance Span Method

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

b. Press the calibrate button until the correct LED is continuously lit (See Table 6).

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

TABLE 6: 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 5

Procedure 2: Fill Method

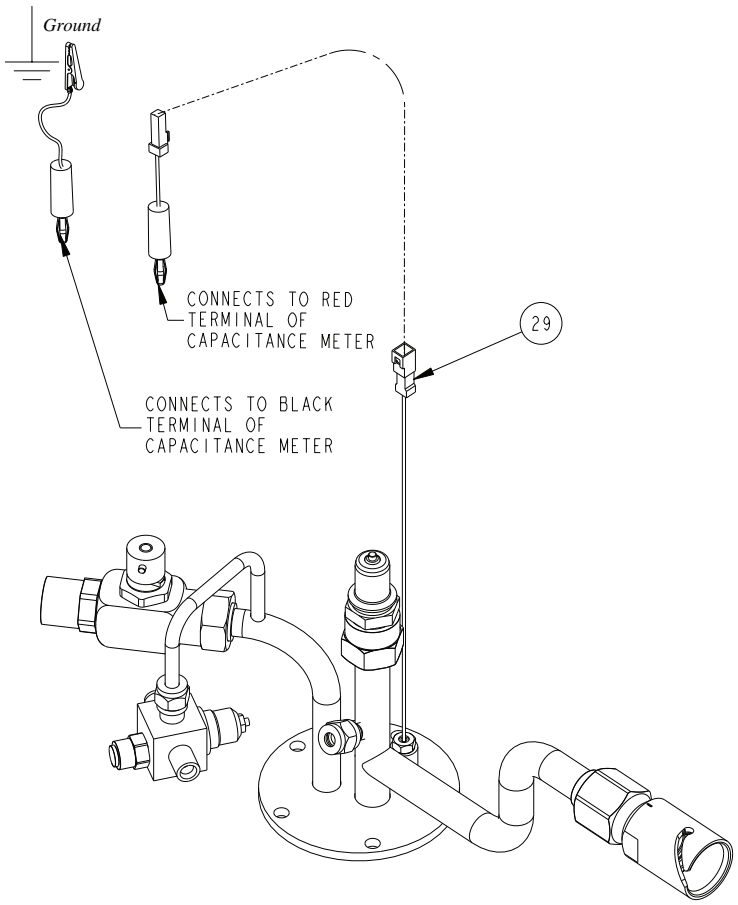
a. Enter calibration mode on a vent full unit with properly saturated LOX. If unit has just been filled, allow it to stabilize before continuing.

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.

TABLE 7: Level Meter Calibration Error Codes

Code (Alternately Flashing)	Reason	Soluton
LED1 & LED4	Empty to full span is too low.	Ensure tank is empty. Recalibrate.
LED2 & LED 3	Open Circuit	Check meter connections and wire integrity.
LED6 & LED 7	Empty capacitance is too high	Remove moisture from inner vessel. Decontaminate probe.
LED5 & LED8	Empty to full span is too high.	Ensure tank is empty. Recalibrate.
LED2,LED4, & LED6	High Capacitance	Remove moisture from inner vessel. Decontaminate probe.
LED1, LED3, LED5, & LED7	Calibrated full value higher than empty value.	Redo fill calibration with either procedure.

FIGURE 11: 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.

RP7 – Manifold Capacitance Test (See Figure 11)

a. Capacitance Meter Set-Up:

1. Connect capacitance meter adapter to capacitance meter according to Figure 11.
2. Turn on capacitance meter and select 200 pF range.
3. Move zero adjustment on front of meter until 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 bracket or any other properly grounded surface.
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	130	170
Liberator 37	130	170
Liberator 45	140	180
Liberator 60	140	180

RP8 – Manifold Assembly R/R (Figure 12)

a. Remove shroud assembly (See RP 2).

b. Disconnect compression fitting (Item 34E) from top of economizer valve (Item 35). Also 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 34F) from FCV (Item 24).

e. If desired follow RP16 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) 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 103-115 N-m (90-100 in-lbs) using cross-tightening method.

RP9 – Resolder Feed-thru Wire (Figure 13)

a Remove manifold assembly (See RP8).

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 (RP8).

RP10 – Manifold Harness Assembly R/R (Figure 13)

a. Remove manifold assembly (See RP8).

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 RP9). Replace manifold assembly (See RP8).

RP11 – Clean/Dry Probe and Dewar

Procedure 1:

a. Empty dewar per RP22.

b. Warm dewar per RP23.

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

Procedure 2:

a. Remove manifold assembly (See RP8).

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 RP8).

FIGURE 12: Manifold Assembly

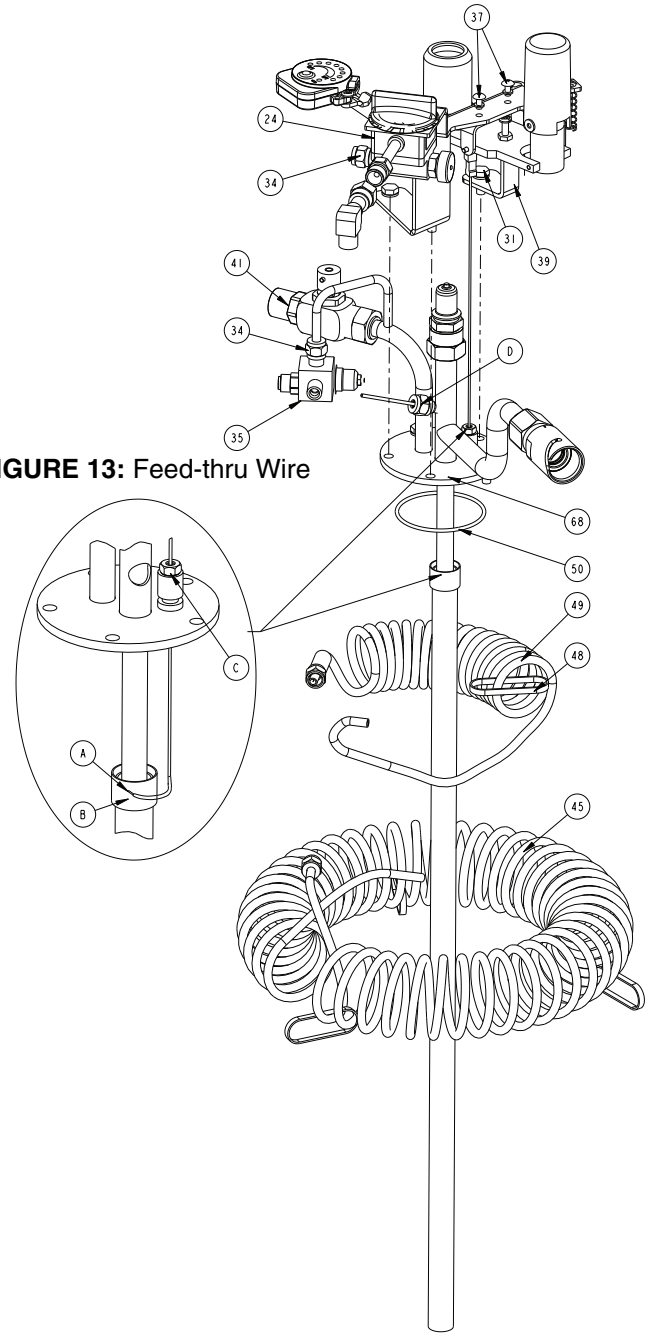


FIGURE 13: Feed-thru Wire

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

FIGURE 14: Relief Valve Test Set-up

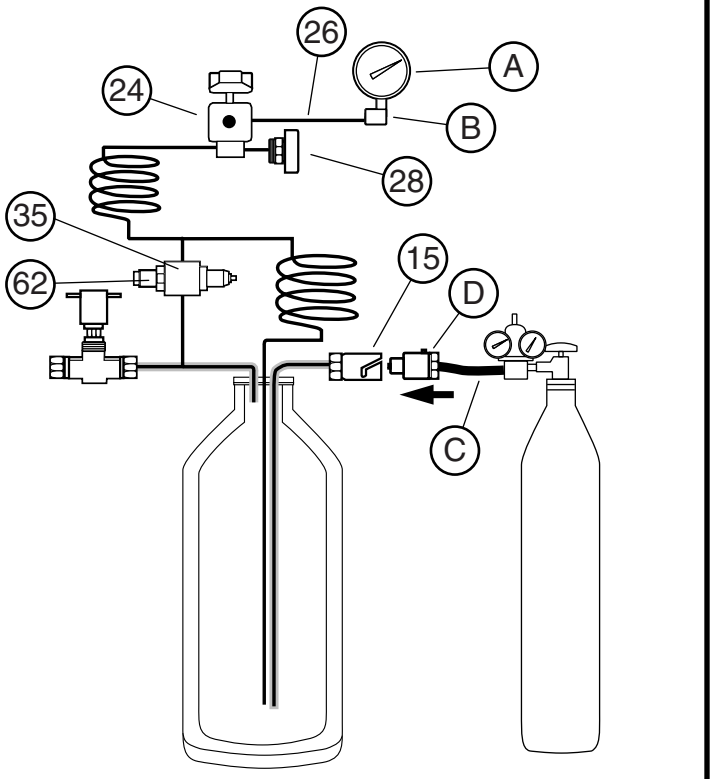


FIGURE 15: Primary Relief Valve

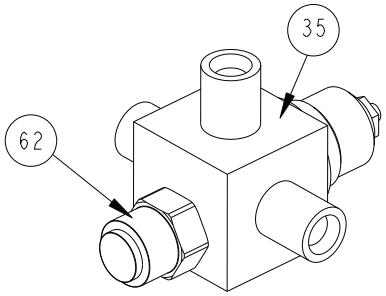
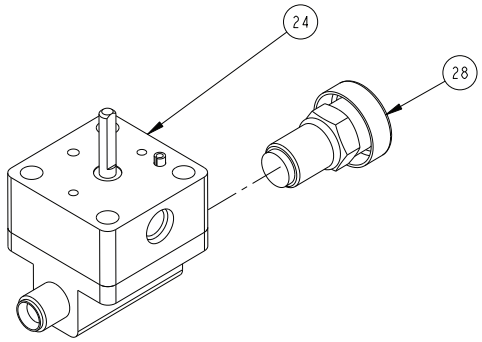


FIGURE 16: Secondary Relief Valve



RP12 – Relief Valve Test (Figure 14)

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. Increase pressure to 1,7 bar (25 psig). PRV (Item 62) should open (audible venting and/or bubbling of leak test solution).

g. Hold PRV (Item 62) closed and increase pressure to 2.3bar (34 psig). SRV (Item 28) should open (audible venting and/or bubbling of leak test solution).

h. 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 (RP14).

RP13 –Relief Valve R/R

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

Primary (Figure 15)

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 PRV approximately 10°-20° clockwise after the PRV body contacts the economizer regulator (minimum of 23-35 N-cm (20-30 in-lbs)).

Secondary (Figure 16)

a. Remove shroud (See RP2).

b. Unscrew SRV (Item 28) from FCV (Item 24).

c. To replace SRV (Item 28), reverse above procedure. Tighten the SRV approximately 10 to 20 degrees clockwise after the SRV body contacts the economizer regulator (minimum of 23-35 N-cm (20-30 in-lbs)).

RP14 – Pressure Retention Test (Figure 17)

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

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 assembly 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.

RP15 – Plumbing Leak Test (Figure 17)

NOTE: Liberator should be empty and warm before testing.

a. Remove shroud (See RP2).

b. Assemble pressure gauge (Item A) and adapter assembly (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, 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. Increase pressure to 1,3 bar (19 psig).

g. Leak test all connections, joints, and valves with leak test solution.

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

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

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

j. Leak test QDV poppet and FCV outlet.

k. Repair all leaks by following appropriate repair procedures.

FIGURE 17: Plumbing TestsSet-up

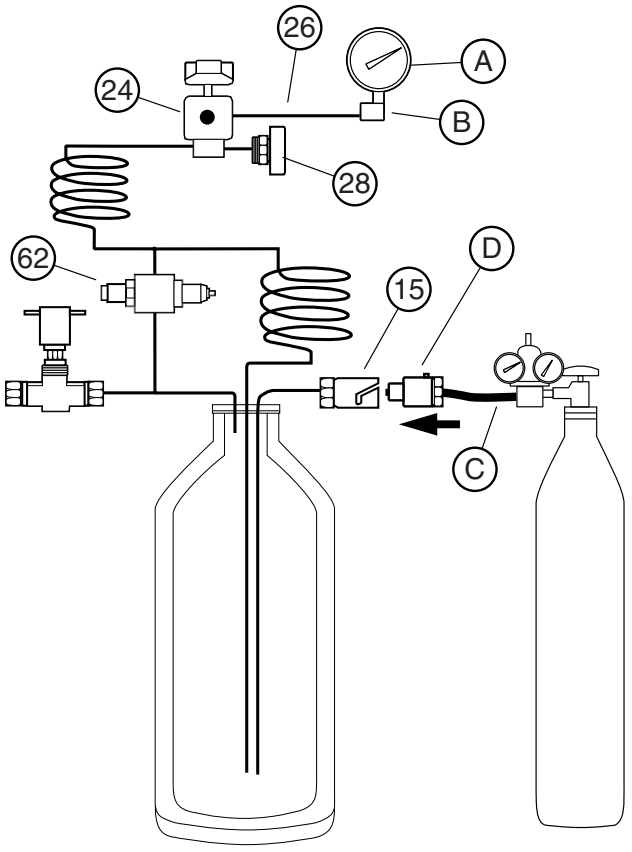
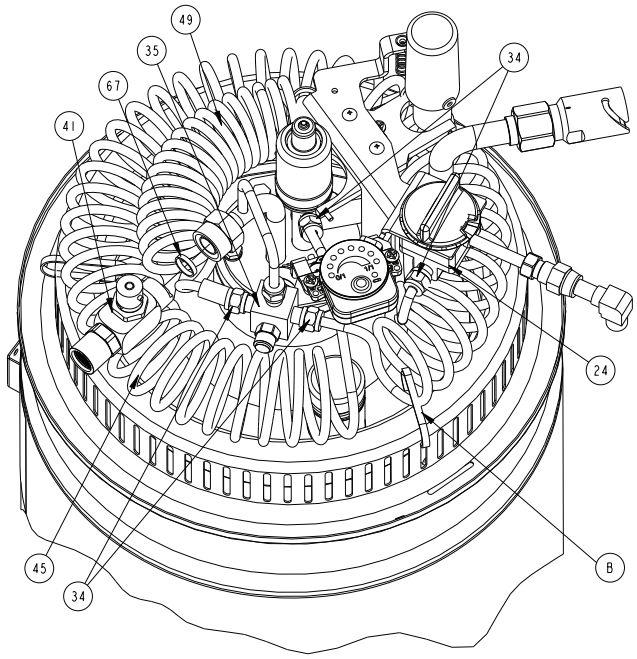


FIGURE 18: Coil and Vent Assemblies



RP16 – Warming and Breathing Coil Assembly R/R (Figure 18)

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) holding 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.

RP17 – Vent Valve R/R (Figure 18)

a Remove shroud (See RP2).

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

b. Remove vent valve (Item 41) by unthreading valve nut while supporting the valve to prevent it from turning.

NOTE: Ensure static seal (Item 67) is not damaged and is in its proper place.

c. Replace vent valve (Item 41). Support the valve to prevent it from turning when tightening valve.

d. Replace shroud (See RP2).

RP18 – Twist Lock QDV Lip Seal R/R (Figure 19)

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 23-29 N-cm (20-25 in-lbs).

RP19 – Twist-Lock QDV Poppet Assembly R/R (Figure 19)

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. Disassemble 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.

d. Apply thin film of fluorolubricant to O-ring (Item 16) and replace entire poppet assembly (Item 14).

e. Reassemble QDV, matching alignment marks on valve body and fill tube.

f. Torque nut (Item C) to 6,2-6,9 N-m (45-50 ft-lbs) while holding valve body (Item 15).

g. Replace shroud (See RP2).

RP20 – Push-on QDV Assembly R/R (Figure 20)

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

a. Remove shroud (See RP2).

b. Remove pop-off assembly (See RP21).

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

d. Remove the top fill QDV by turning the QDV nut (Item D) clockwise while holding the QDV (Item 11) with a wrench.

e. Pull the QDV straight up and off of the fill tube (Item D). Use rubbet mallet to lightly knock upward if required. If replacing entire QDV (recommended) skip to step h.

f. Remove the static seal (Item 67) and poppet retaining ring (Item 66) while holding poppet (Item 17) in place.

g. Replace poppet, retaining ring, and static seal.

h. Push QDV back on to fill tube (Item D) and torque nut to 6,2-6,9 N-m (45-50 ft-lbs) while holding valve body to fasten QDV in place.

i. Place pop-off sleeve over QDV.

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

k. Replace shroud (See RP2).

RP21 – Push-on Portable Pop-Off Assembly R/R (Figure 20)

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 19: Side Fill (Twist Lock) QDV Assembly

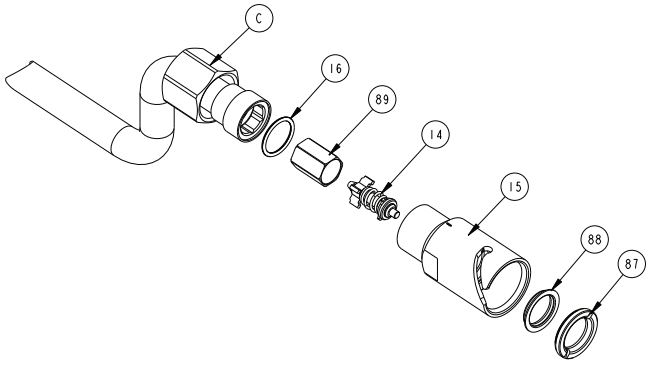


FIGURE 20: Top Fill (Push-on) QDV Assembly

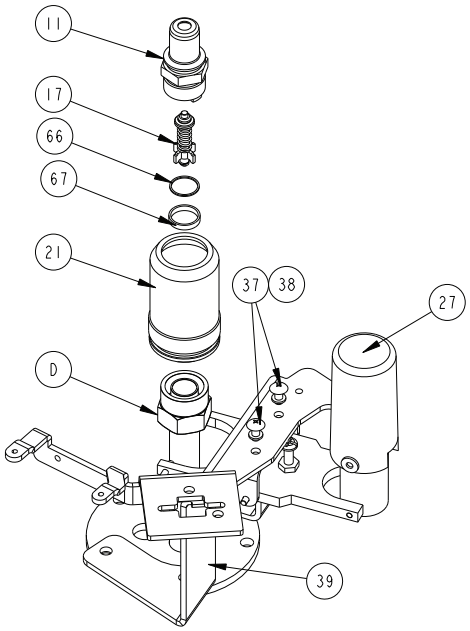


FIGURE 21: Emptying Unit

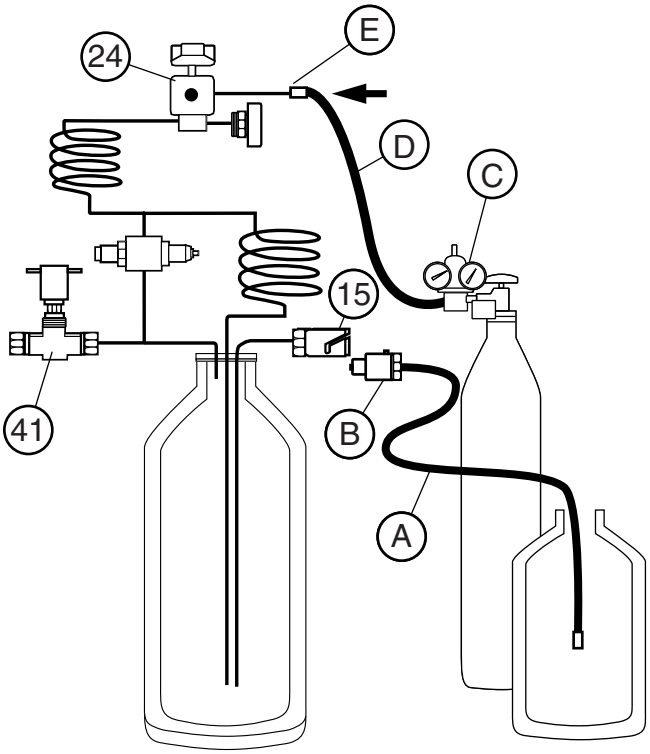
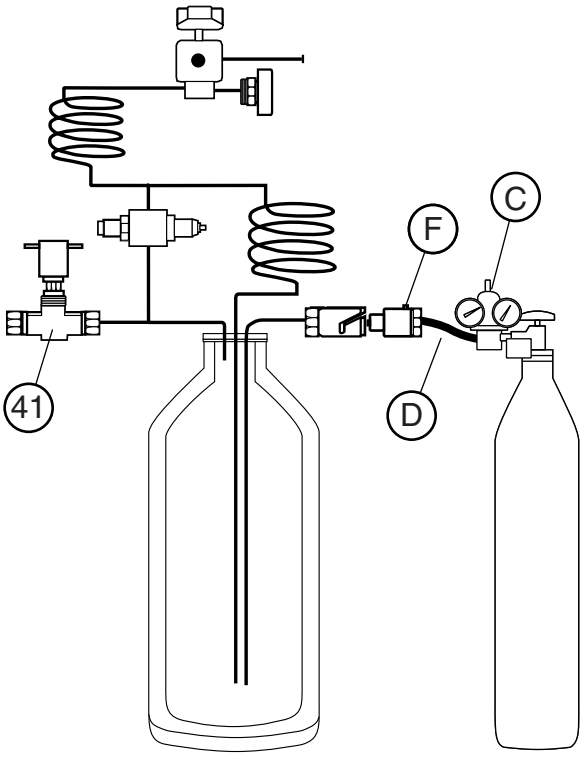


FIGURE 22: Warming Unit



RP22 – Empty Unit (Figure 21)

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.

RP23 – Warm Unit (Figure 22)

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.

RP24– Flow Rate Test (Figure 23)

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 4 does not account for these tolerances.

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. Unit should operate for 1-1/2 hours minimum (overnight is optimum). Test flow rate at each FCV (Item 24) position. Record all flow rates.

c. Flow rates must be nominal values within tolerances listed in Table 4 or unit fails flow rate test.

RP25 – Operating Pressure Test (Figure 23)

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

a. Assemble pressure gauge (Item H) and adapter (Item J) (use PTFE tape).

b. Connect gauge assembly to DISS fitting on FCV outlet. Open FCV (Item 24) to 6LPM setting.

c. Read operating pressure on pressure gauge (Item H).

d. Operating pressure must be 1.2-1.5 bar (18-22 psig) or unit fails test.

RP26 – Flow Meter Verification

a. Flow meter 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 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 23: Flow and Pressure Tests

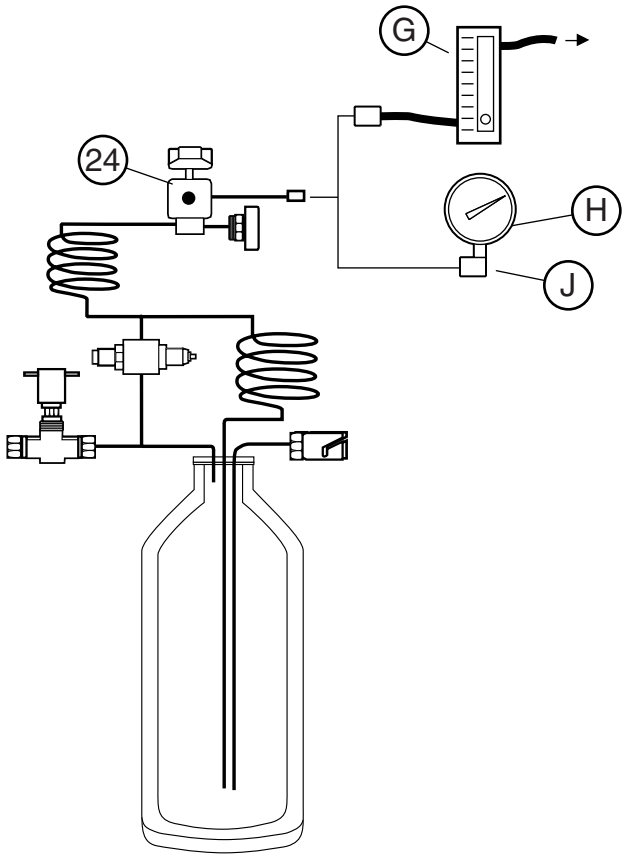


TABLE 4: Flow Test Acceptable Ranges

FCV Setting	LPM
OFF	0
0,25	0,15 to 0,35
0,50	0,40 to 0,60
0,75	0,65 to 0,85
1,00	0,90 to 1,10
1,50	1,35 to 1,65
2,00	1,80 to 2,20
2,50	2,25 to 2,75
3,00	2,70 to 3,30
3,50	3,15 to 3,85
4,00	3,60 to 4,40
5,00	4,50 to 5,50
6,00	5,40 to 6,60
8,00	7,20 to 8,80
10,0	9,00 to 11,0
12,0	10,8 to 13,2
15,0	13,5 to 16,5

FIGURE 24: Economizer Regulator

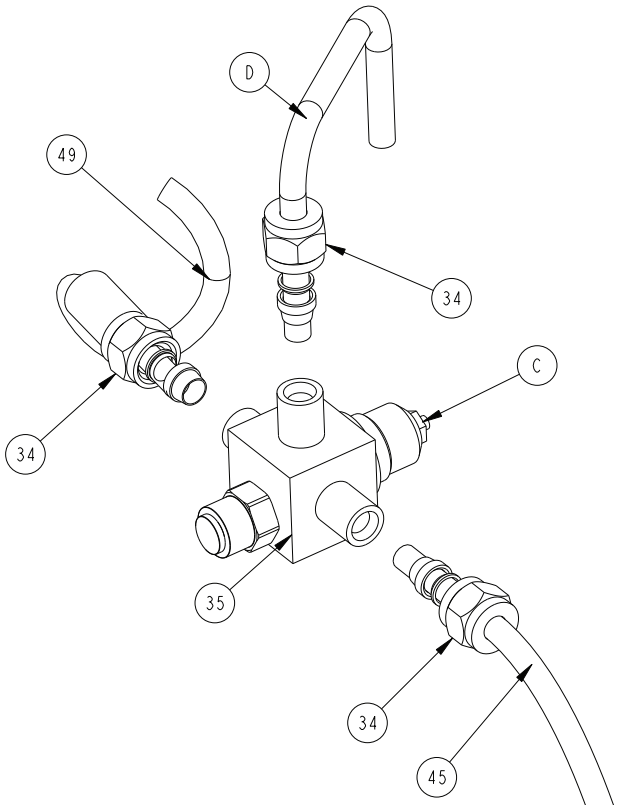
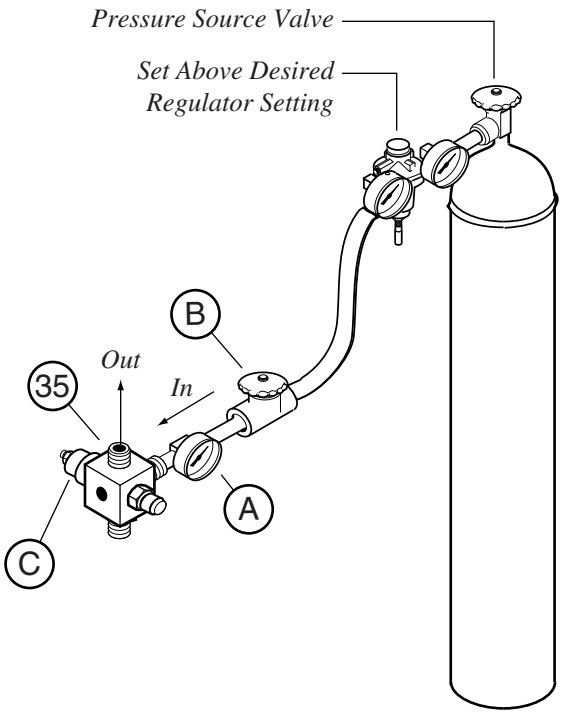


FIGURE 25: Economizer Test Setup



RP27 – Economizer Regulator R/R (Figure 24)

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 RP28 to ensure proper settings on the replacement regulator.

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

RP28 – Economizer Regulator Adjustment (Figure 25)

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

a. Follow steps a and b of RP27 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 24).

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 1,48 bar (21.5 psig) and close at 1,41 bar (20.5 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. The setting is modulated by turning the threaded rod inside the locking nut (Item C).

f. Loosen the locking nut allowing the threaded rod to be turned.

g. Turn the threaded rod using an allen wrench to modulate the economizer setting. The economizer regulator should be set to open at 1,48 bar (21.5 psig) and close at 1,41bar (20.5 psig).

h. Tighten lock nut to secure threaded rod into place.

i. Reverse steps a. and b. of RP27 to reinstall regulator.

RP29 – Flow Control Valve R/R (Figure 26)

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.

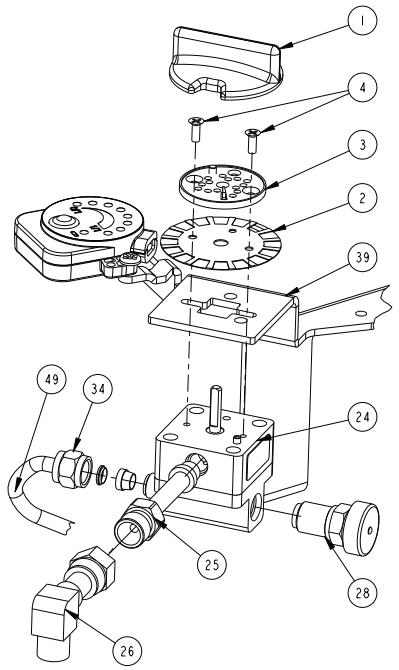
c. Remove the FCV knob (Item 1) by grasping firmly and pulling upwards.

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. Unscrew SRV (Item 28) from FCV (Item 24).

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

FIGURE 26: Flow Control Valve



RP30 – Dewar R/R

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

a. Remove shroud (See RP2).

b. Remove manifold assembly and coils (See RP8).

c. Remove condensate bottle (Item 56), drain tube (Item 55) and bracket (Item 54) following RP3.

d. Remove dewar cap from new dewar. Put cap on old dewar.

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

f. Assemble manifold assembly with coils to new dewar following manifold assembly replacement procedure (See RP8). Do not replace shroud.

g. Replace condensate bottle (Item 56), bracket (Item 57) and drain tube (Item 58).

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 RP6.

RP31 – Normal Evaporation Rate Test

a. Fill unit with correct amount of properly saturated liquid oxygen shown in the Table 9. Values are approximate.

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

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 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-evacuated.

XIII Service Tools/Equipment/Supplies

Required Tools

- Hex Wrenches (various sizes)
- Flat Blade Screwdriver
- 5/16” Nut Driver
- Open End Wrenches (1/2” to 1-1/8”)
- Side Cutters
- Pliers
- 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)
- Jeweler’s Screwdriver

Required Fixtures/Equipment

- Capacitance Meter
- Soldering Iron
- Oxygen Regulator
- Pressure Gauge
- Pressure Gauge Adapter
- Flowmeter
- 02 Gas Source (High Pressure bottle)
- 02 Liquid Source
- N2 Gas or Clean, Dry Compressed Air Source
- Tubing (02 compatible)
- Lip Seal Service Tool
- Male Pneumatic Test Adapter
- LO2 Transfer Line
- Transfer Line Adapter with Filter
- Dewar Cap
- Vent Valve Wrench
- Scale 0-70 kg (0-150 lbs), 0.02 kg (0.05 lb) increments

Required Supplies

- Stay-Clean Flux
- Cotton Swabs
- Lead-free Solder
- Distilled Water
- Household Glass Cleaner
- Lint-Free Cloth
- PTFE Tape
- Fluorolubricant
- Leak Detection Fluid

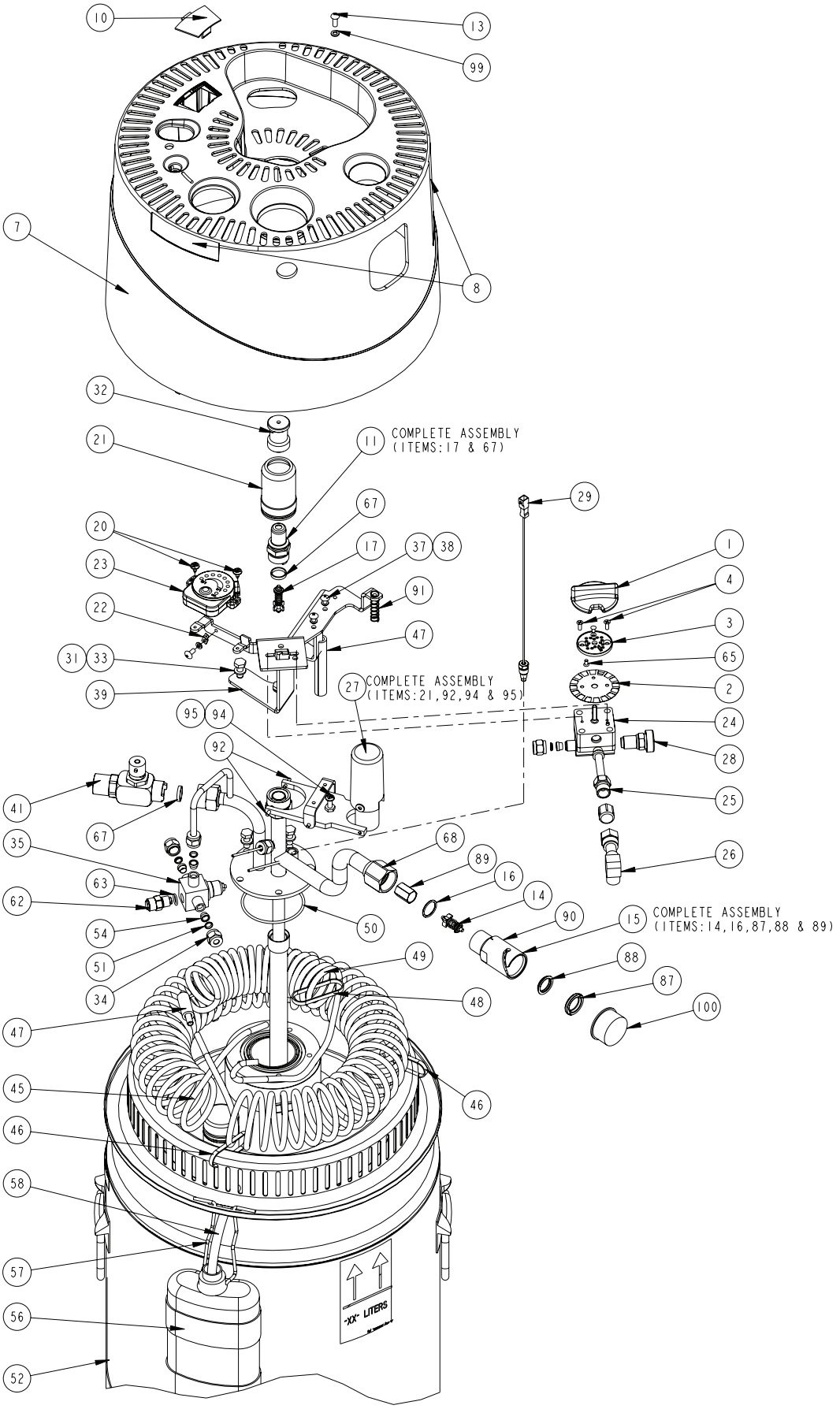
Tools and Accessories available from CAIRE

Part No	Description
10679862	Female Top Fill Pneumatic Test Adapter
10678157	Female Top Fill Transfer Line Adapter
CA200071	240 AC Fluorolubricant
CA200072	Leak Detection Fluid (gallon)
97200076	Erie "Liter Meter"
97212021	Male Side Fill Pneumatic Test Adapter
97212023	Male Side Fill Transfer Line Adapter w/Filter
CA005571	Transfer Line Adapter Cover
97217007	Pressure Gauge Adapter
CA400004	Replacement Filter/Male Transfer Line Adapter
97403016	Jeweler's Screwdriver
97202005	Vent Valve Wrench
97403015	Capacitance Meter
97403574	Dewar Cap
97403577	0-4.1 bar (0-60 psig) Pressure Gauge
97404564	Transfer Line Swivel Connector
97405147	0-3.1 bar (0-45 psig) Oxygen Regulator
11847274	Hand Truck w/Stair Climber
97405279	Pneumatic Hose with DISS Fittings
97405431	Liquid Oxygen Transfer Line – 2 m (6 ft)
97405590	Lip Seal Service Tool
CA406308	10.3 bar (150 psi) Relief Valve Assembly
CA406310	TEFLON Tape
CA406398	10.3 bar (150 psi) Relief Valve only
97406471	Tandem Tee Kit
97406555	Super Flex Liquid Oxygen Transfer Line – 6'
97406630	Dual Fill Head Tee
13350704	Service Manual
10661515	Conversion Kit TF to SF
10660361	Conversion Kit SF to Dual
10660344	Conversion Kit TF to Dual
10661523	Conversion Kit SF to TF
13329091	G4 Capacitance Meter Adaptor Kit

For a complete list of accessories, see catalog #401-038-901.

XIV Notes

XV Dual Fill G4 Liberator Illustration



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