

## Table of Contents

A.	Introduction -----	24
B.	Troubleshooting Chart -----	25
C.	Repair Procedures	
	RP1 General -----	30
	RP2A Leak Test (Warm & Empty Unit) -----	30
	RP2B Leak Test (Unit Containing Oxygen) -----	31
	RP3 Emptying/Warming Portable RR -----	31
	RP4 Side Cover RR -----	31
	RP5 Top Bezel RR -----	31
	RP6 Carrying Strap RR -----	32
	RP7 Liquid Contents/Level Indicator Test -----	32
	RP8 Liquid Contents/Level Indicator RR -----	32
	RP9 PRV Test -----	33
	RP10 PRV RR -----	33
	RP11 SRV Test -----	34
	RP12 SRV RR -----	34
	RP13 Pressure Retention Test -----	34
	RP14A Warming Coil Assembly RR (C1000) -----	35
	RP14B Warming Coil Assembly RR (C1000T) -----	35
	RP15 Vent Valve Test -----	35
	RP16 Vent Valve RR -----	36
	RP17 QDV Assembly RR -----	37
	RP18 Lip Seal RR -----	37
	RP19 Flow Rate Test Test -----	38
	RP20 FCV RR -----	39
	RP21 Back Flushing the FCV -----	39
	RP22 Operating Pressure Test -----	39
	RP23 NER Test -----	40
	RP24 Manifold RR -----	40
	RP25 Cryogenic Container RR -----	41

## 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.

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

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

**Table 8 - Troubleshooting**

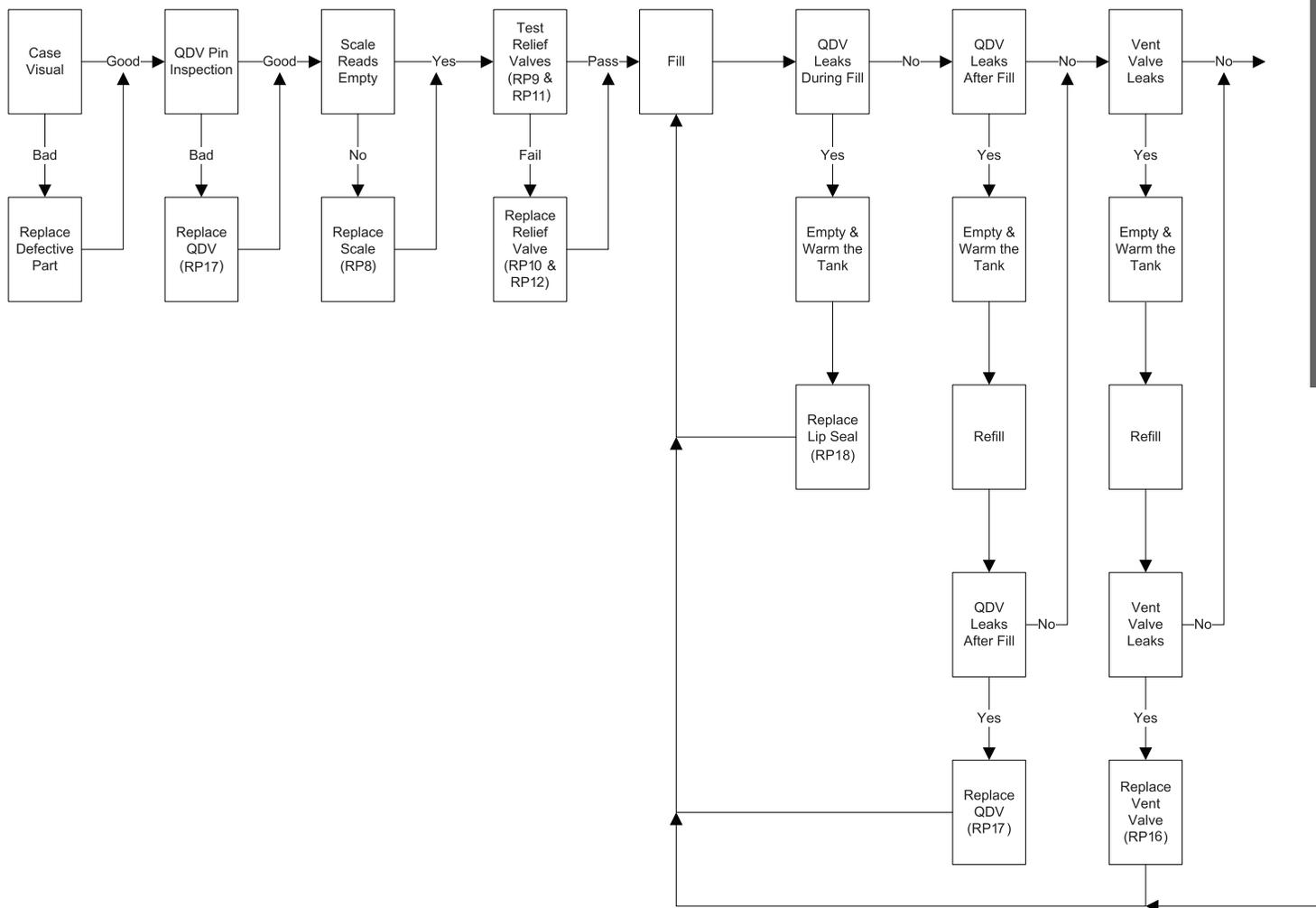
Symptom		Probable Cause		Corrective Action
1)	Unable to start fill or excessively long fill times	a)	QDV not properly engaged on the reservoir	Make sure the QDV on the portable and reservoir are properly aligned and ensure that a downward force is being applied to the portable.
		b)	Reservoir is empty	Swap or re-fill the reservoir
		c)	Vent valve not open	Ensure that the vent valve lever is fully in the open position. The lever must be open to begin a fill.
		d)	FCV is open	Be sure that the FCV knob is in the off ("0") position. If the valve is open, fill times can increase.
		e)	Reservoir saturation pressure is too low	Swap reservoirs or allow the reservoir time to stabilize and build pressure
		f)	Vent valve is obstructed	Inspect the vent tubes for blockages. Clean by blowing out with compressed gas or replace parts if necessary.
		g)	Leak in the system	Check the portable for leaks (RP2) and repair if needed.
		h)	QDV damaged or faulty	Inspect the QDV and be sure the poppet opens properly and smoothly. If necessary, replace the QDV (RP17)
		i)	Faulty vent valve	Replace the vent valve (RP16)
2)	Liquid leaks from the coupled QDVs during the fill	a)	Worn or damaged lip seal	Replace the QDV lip seal (RP18)
3)	Unable to disconnect the portable from the reservoir	a)	Pop-off assembly not being utilized	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 filling	a)	Ice crystal preventing the QDV from closing properly.	Engage and disengage the portable 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 (RP17)

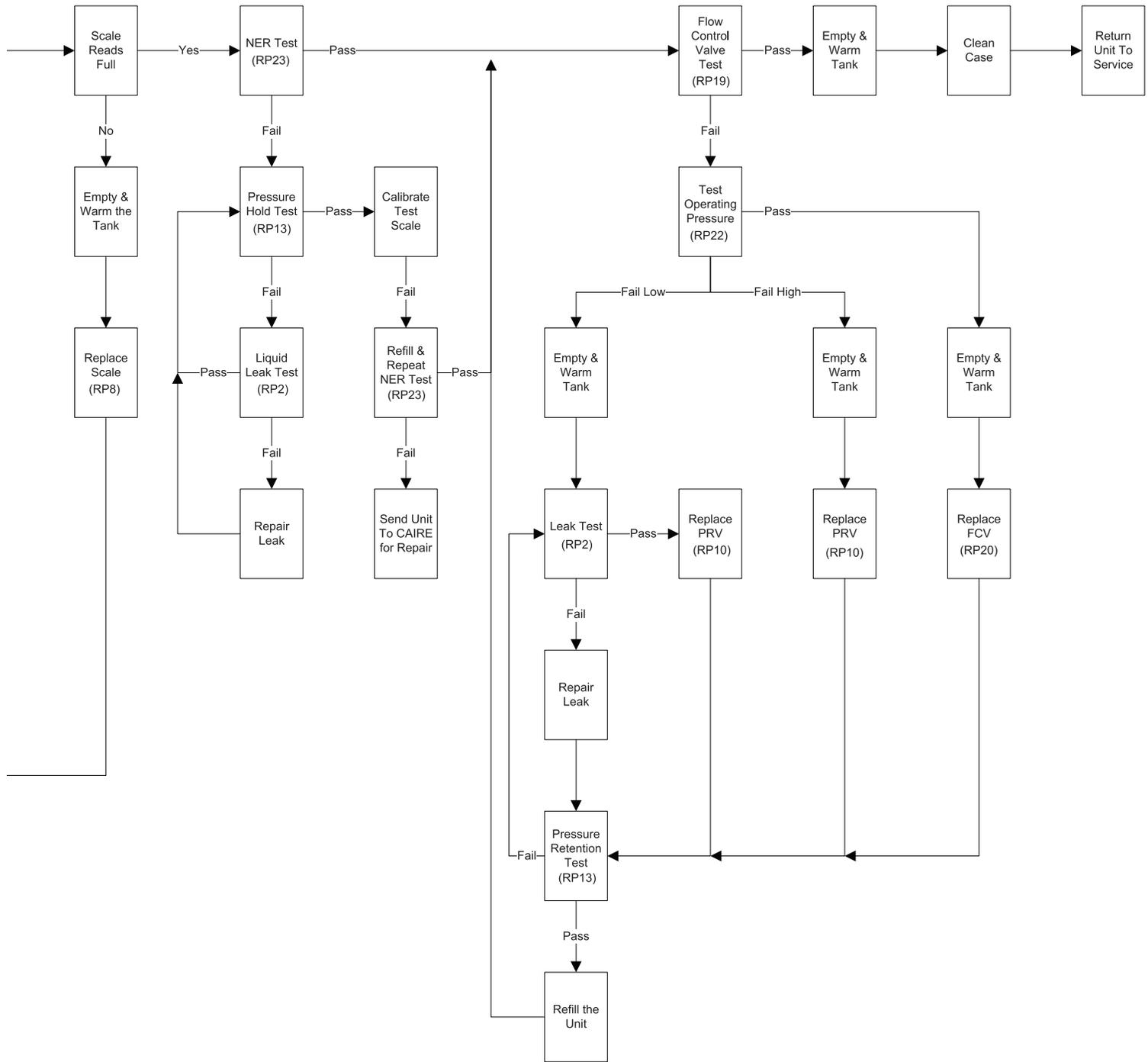
Table 8 (cont.)

	Symptom		Probable Cause	Corrective Action
5)	Liquid leaks from the vent valve tube/ outlet	a)	Vent valve is not fully closed	Ensure that the vent valve lever is fully in the closed position.
		b)	The portable has been transported or laid in an improper operating position	Return the portable to an upright or acceptable operating position and allow several minutes for stabilization.
		c)	Vent valve is frozen open	Allow the portable to warm until the vent valve can close. After the warm up, allow up to 60 minutes for the portable to stabilize and build pressure before operating.
		d)	Faulty vent valve	Replace the vent valve (RP16)
6)	Excessive venting from relief valves (hissing sound)	a)	The portable has been transported or laid in an improper operating position	Return the portable to an upright or acceptable operating position and allow several minutes for stabilization.
		b)	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.
		c)	Relief valve frozen open	Allow the portable to warm and thaw. Attempt to re-fill the portable.
		d)	Faulty relief valve	Test the relief valve (RP9) and replace if necessary (RP10)
		e)	Partial or complete loss of vacuum	Conduct the NER test (RP23) and return the unit to CAIRE, Inc. if necessary.
7)	No Flow	a)	Portable is empty	Check the contents indicator/level gauge and fill the portable 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
		e)	Saturation pressure is too low	Inspect the saturation pressure of the reservoir used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
		f)	Leak in the system	Perform a leak check on the plumbing (RP2). 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 there is no venting from the vent valve outlet/tube. If there is refer to the corrective actions for "Liquid leaks from the vent valve tube/outlet"
		i)	FCV inlet filter is obstructed	Clean or replace (RP20) the filter screen.
		j)	Blockage in the liquid withdrawal circuit	Check the warming coils and withdrawal tubes for blockages. Replace if necessary.
		k)	FCV Faulty	Replace the FCV (RP20)

Table 8 (cont.)

	Symptom	Probable Cause	Corrective Action
8)	Low flow at 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 used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
		c) Leak in the system	Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
		d) Flow control valve inlet filter screen dirty	Clean or replace (RP20) the filter screen.
		e) PRV faulty	Test the PRV (RP9) and replace (RP10) if necessary.
		f) Blockage in the liquid withdrawal circuit	Check the warming coils and withdrawal tubes for blockages. Replace if necessary.
		g) FCV faulty	Replace the FCV (RP20)
9)	Increased NER	a) Saturation Pressure is 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) Leak in the system	Perform a leak check on the plumbing (RP2). 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 (RP23) and return the unit to CAIRE, Inc. if necessary.
10)	Excessive Frost NOTE: Minimal frost on the case 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 outer case 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 used for filling. Allow at least 30 minutes at no flow for the portable to saturate properly.
		d) Leak in the system	Perform a leak check on the plumbing (RP2). 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 actions for “Excessive venting from relief valves (hissing sound)”
		f) Partial or complete loss of vacuum	Conduct the NER test (RP23) and return the unit to CAIRE, inc. if necessary.
11)	Unit will not maintain acceptable pressure when in use	a) Saturation pressure is out of specification	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) Leak in the system	Perform a leak check on the plumbing (RP2). Repair leaks as necessary.
		c) PRV faulty	Test the PRV (RP9) and replace (RP10) if necessary.





**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.

**WARNING:** Make sure the unit is empty and vent valve is open before replacing any component, except seals.

**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.

**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.

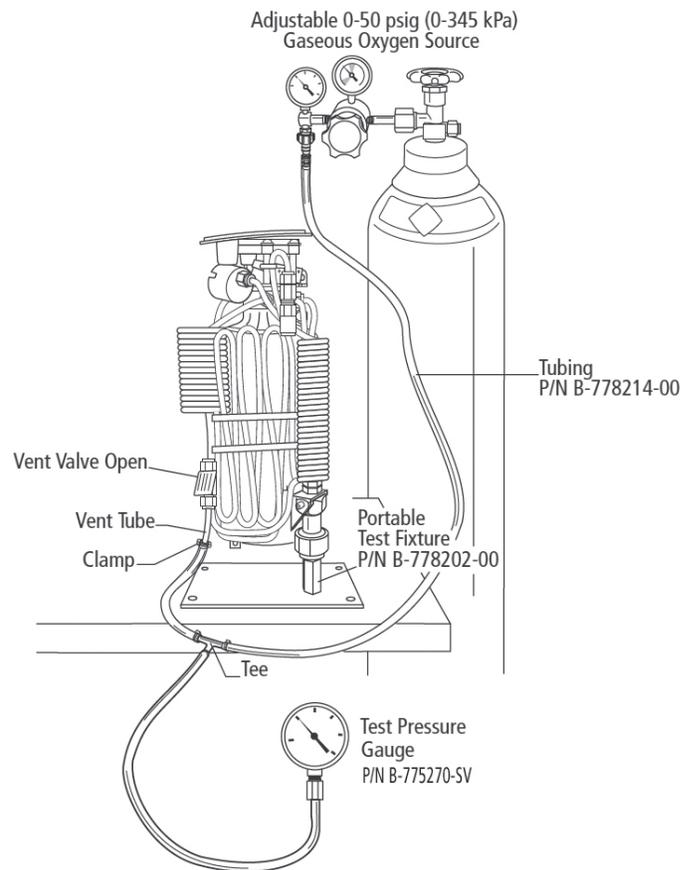
**NOTE:** All replacement parts must be factory approved, cleaned for oxygen service, and stored in sealed plastic bags. The repair area must be clean and separate from other areas. Room air should be filtered, and free from dust, soot, and other contaminants.

**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.

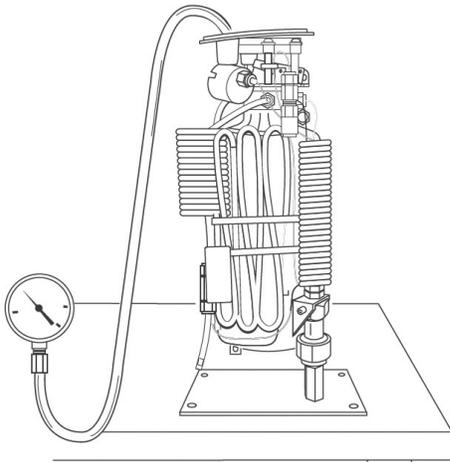
**NOTE:** When assembling new compression fittings, tighten 1/8", 1/4" and 1/2" nuts eight flats past finger tight and 3/16" nuts five flats past finger tight. When reassembling previously used compression fittings, tighten nuts one to two flats past finger tight.

## RP2A - Leak Test (Warm & Empty Unit)

- 1) Remove the covers (RP4).
- 2) Set the flow control valve to 0 LPM (Off).
- 3) Pressurize the C1000/T portable to approximately 1.52 bar (22 psi) with gaseous oxygen using the portable pressurizing setup and gaseous oxygen supply (Figure 9). Close the vent valve after pressurizing the unit and remove the pressurizing setup from the vent tube.
- 4) Connect the test pressure gauge to the oxygen outlet barbed fitting and set the flow control valve to its highest setting. Place the C1000/T in the portable test fixture (Figure 10).



**Figure 9: Pressurizing the Companion Portable**



**Figure 10: Pressure Gauge Connection**

- 5) Wet a finger with leak detector and lightly place it against the open end of the vent tube located near the bottom of the unit. If bubbling occurs, replace the vent valve (RP16).
- 6) Use SNOOP liquid leak detector to test all fittings and connections. Verify that the unit maintains 1.52 bar (22 psi) pressure during the leak test.
- 7) With pressure remaining in the unit, place a small amount of SNOOP on the tip of the C1000/T QDV. A small amount of leakage around the poppet of the fill connector is acceptable, provided that the total leakage rate of the unit is not greater than the NER.
- 8) Blow dry with compressed gas the QDV poppet and the vent valve.

#### RP2B - Leak Test (Unit Containing Liquid Oxygen)

- 1) Remove the case (RP4).
- 2) Connect the test pressure gauge to the oxygen outlet barbed fitting and set the flow control valve to the highest setting.
- 3) Place the C1000/T in the portable test fixture (Figure 10).
- 4) Wet a finger with leak detector and lightly place it against the open end of the vent tube located near the bottom of the unit. If bubbling occurs, replace the vent valve (RP16)
- 5) Use SNOOP liquid leak detector to test all fittings and connections. Verify that the unit maintains 1.52 bar (22 psi) pressure during the leak test.
- 6) With pressure remaining in the unit, place a small amount of SNOOP on the tip of the C1000/T QDV. A small amount of leakage around the poppet of the fill connector is acceptable, provided that the total leakage rate of the unit is not greater than the NER.
- 7) Blow dry with compressed gas the QDV poppet and the vent valve.

#### RP3 – Emptying/Warming Portable RR

- 1) Turn the FCV knob to the highest flow setting.
- 2) Allow unit to sit for 24 hours before proceeding.

#### RP4 – Side Cover RR

- 1) C1000T only: Remove the moisture cup by turning the quarter-turn fastener counter clockwise and pulling the cup away from the unit.
- 2) Place the unit on its side with the back side cover facing you. Use a 7/64 in Allen wrench to remove five socket head cap screws located underneath the vent valve lever and the corners of the side cover.
- 3) Carefully separate the two side covers from each other.
- 4) Use a 7/64 in Allen wrench to remove the two socket head cap screws and the two lockwashers located in the tables on the bottom of the container.
- 5) Use a 1/16 in Allen wrench to loosen the set screw in the flow control valve knob.
- 6) Remove the flow control valve knob and the decal. If the knob does not use a set screw, insert the Allen wrench into the hole in the knob.
- 7) Simultaneously push in and pull up on the Allen wrench to remove the knob.
- 8) Use a small flat-blade screwdriver to loosen and remove the two flat-head screws from the flow plate. Remove the flow plate.
- 9) Remove the front side cover.
- 10) Install the side covers by reversing the above procedure.

#### RP5 – Top Bezel RR

- 1) Remove the side covers (RP4)
- 2) Use a 7/16 in deep well socket and a T-handle or ratchet wrench to remove the oxygen outlet barbed fitting. Do not lose the O-ring
- 3) Remove the top bezel.
- 4) Install the top bezel by reversing steps 1-3.

### RP6 – Carrying Strap RR

- 1) Remove the covers (RP4) and top bezel (RP5).
- 2) Use a small screwdriver to remove the outermost E-clip from the pivot shaft. Remove the pivot shaft.

**NOTE:** Some older models may contain hitch pins in place of the E-clips. If the unit has hitch pins, it will also contain a different pivot shaft.

- 3) Remove the carrying strap from the portable
- 4) Install the carrying strap by reversing steps 1-3.

### RP7 - Liquid Contents/Level Indicator Test

**NOTE:** Disconnect the plastic buckle in the carrying strap before performing the following steps. The C1000/T side covers must be in place when performing this test.

- 1) Place the C1000/T on a table and hold it down while gently pulling up on the end of the carrying strap nearest the contents indicator.
- 2) Verify that the indicator operates smoothly and without binding
- 3) C1000T Only – Verify that “Transport” is present on the indicator dial.
- 4) Suspend the unit by the end of the carrying strap nearest the contents indicator. Verify that the needle appears in the red EMPTY region at the end of the indicator window.
- 5) Fill the unit with liquid oxygen. Suspend the unit by the end of the carrying strap nearest the contents indicator. Verify that the needle is in the upper portion of the green FULL region.

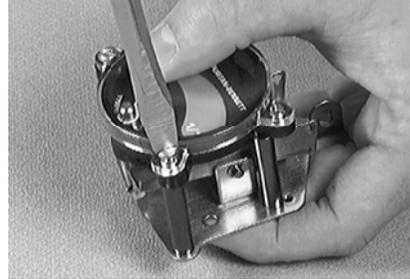
### RP8 - Liquid Contents/Level Indicator RR

- 1) Remove the carrying strap (RP6).
- 2) Loosen and remove the four socket head cap screws from the base of the contents indicator weight scale mechanism. Remove the contents indicator assembly.
- 3) While holding the lever down, remove the hitch pin from the end of the spring rod.



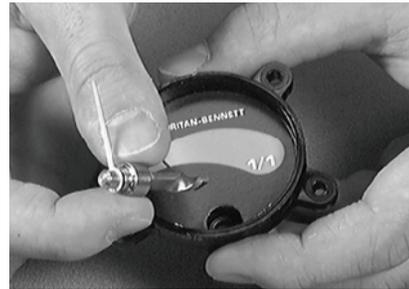
**Figure 11**

- 4) Remove the lever spacer, the spring, and the spring rod.
- 5) Use a medium-blade screwdriver to remove the four pan head screws from the indicator. Remove the four screws and the four upper spacers from the indicator.



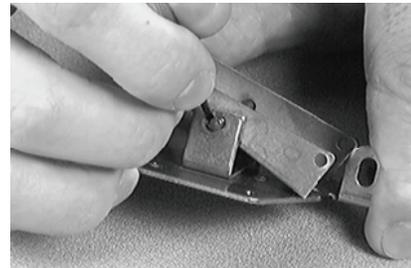
**Figure 12**

- 6) Pry the lens cap away from the base.
- 7) Remove the indicator needle from the base



**Figure 13**

- 8) Use a small screwdriver to remove one E-clip from the pivot shaft. Remove the lever.



**Figure 14**

- 9) Reassemble and install the contents indicator by reversing steps 1-8.

**NOTE:** Be sure to lubricate the O-ring with a small amount of Krytox grease. This allows the helix to easily rotate in the indicator.

**NOTE:** Be sure to put the weight scale mechanism in the proper orientation. The slotted hole in the mounting bracket should be next to the flow control valve.

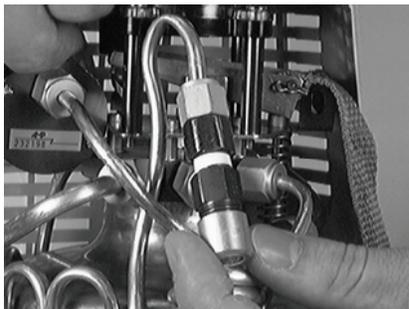
### RP9 - PRV Test

- 1) Remove the covers (RP4).
- 2) Connect the pressurizing setup to the C1000/T as shown in Figure 9.
- 3) Place one drop of SNOOP on the PRV or PRV silencer.
- 4) Slowly pressurize the unit with gaseous oxygen by adjusting the oxygen regulator until tiny, foam-like bubbles begin to form to indicate that the PRV has opened. You can also listen for an audible hissing sound.
- 5) Verify that the PRV opens (bubbles appear on the silencer) at a pressure less than 1.62 bar (23.5 psi).
- 6) If the opening pressure is not within the specified range, repeat the procedure. If the PRV fails to open in the specified range a second time, replace the PRV (RP10).
- 7) Slowly reduce the gaseous oxygen source pressure until the stream of bubbles begins to diminish.
- 8) Verify the PRV closes (bubbles begin to diminish) at a pressure greater than 1.28 bar (18.5 psi).
- 9) If the closing pressure does not meet the acceptable range, repeat the procedure. If the PRV fails to close at the specified range a second time, replace the PRV (RP10).
- 10) Remove the pressurizing setup and reinstall the covers (RP4).

### RP10 - PRV RR

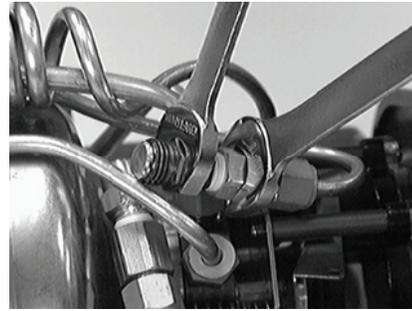
- 1) Remove the covers (RP4).
- 2) Loosen and remove the silencer from the end of the primary relief valve (Figure 15).

NOTE: Some older models may not be equipped with a silencer. These units may be retrofitted with a silencer, but this will require replacing the primary relief valve.



**Figure 15: Removing the PRV Silencer**

- 3) Use a 1/2inch open-end wrench to loosen and remove the primary relief valve while simultaneously holding the relief valve adapter stationary with another 1/2inch open-end wrench.
- 4) Install the PRV by reversing steps 1-3.



**Figure 16: PRV Removal**

NOTE: Inspect the relief valve adapter for cracks caused from overtightening. Replace as necessary.

NOTE: Some older models contain a blue, anodized relief valve adapter. Some of these adapters may be susceptible to cracking. The blue relief valve adapter has been replaced by a clear anodized adapter that has a longer thread engagement length.

NOTE: The primary relief circuit tubing on some older models consists of a “pig-tailed” section of aluminum tubing. The current primary relief circuit tube is a long, U-shaped section of aluminum tubing.

## RP11 – SRV Test

- 1) Remove the covers (RP4).
- 2) Connect the pressurizing setup as shown in Figure 9.
- 3) Remove the silencer from the PRV.
- 4) Hold the PRV closed while pressurizing the portable.
- 5) Slowly pressurize the C1000/T by adjusting the gaseous oxygen source regulator.
- 6) Verify that the SRV opens (audible hiss) at 1.97-2.17 bar (28.5-31.5 psi).
- 7) If the SRV does not open within these specified ranges, repeat the procedure. If it fails to open the second time, replace the SRV (RP12).
- 8) Slowly reduce the pressure of the gaseous oxygen source until the audible hissing noise is no longer heard, indicating that the SRV has closed.
- 9) Verify that the SRV closes at a pressure greater than 1.86 bar (27 psi).
- 10) If the SRV does not close within this specified range the first time, repeat the test. If it fails to open in an acceptable range the second time, replace the SRV (RP12).

**NOTE:** Do not release the PRV poppet unit pressure in the unit is reduced below 1.52 bar (22 psi) by removing the pressurizing setup and opening the vent valve. Replace the PRV silencer.

## RP12 – SRV RR

- 1) Remove the covers (RP4)
- 2) Use a 1/2 inch open-end wrench to loosen the 3/16inch tube nut connected between the secondary relief valve and the secondary relief valve adaptor. Simultaneously, hold the relief valve adapter stationary with another 1/2inch open-end wrench while removing the secondary relief valve.
- 3) Install the SRV by reversing steps 1-2.

**NOTE:** Before installing the SRV, wrap the SRV threads with Teflon tape, starting two threads back from the end.

## RP13 – Pressure Retention Test

- 1) Empty the unit and remove the covers (RP4).

**NOTE:** Perform RP13 only on warm, empty portable units. Performing this test on Portable units containing liquid oxygen will yield inaccurate results.

- 2) Set the flow control valve to 0 LPM (Off).
- 3) Use the pressurizing setup show in Figure 9 to pressurize the C1000/T until the PRV vents (approximately 1.52 bar/22psi). This is indicated by an audible hissing noise.
- 4) Close the vent valve and remove the pressurizing setup. Connect the test pressure gauge to the oxygen outlet barbed fitting and set the flow control valve to the highest setting. Record the pressure gauge reading and the time.
- 5) Set the flow control valve to 0 and remove the test pressure gauge from the oxygen outlet.
- 6) Do not disturb the C1000/T for 8 to 9 hours.
- 7) At the end of this period, verify that the unit maintains at least 1.04 bar (15 psi). Should the pressure be less, re-pressurize the unit to approximately 1.52 bar (22 psi) and locate the leak by testing all components, fittings, and tubing with liquid leak detector (RP2). Make repairs as needed, taking care not to over tighten connections.

### RP14A – Warming Coil Assembly RR (C1000)

- 1) Remove the covers (RP4).
- 2) Use side-cut pliers to cut the two wire ties from the warming coil.
- 3) Use a 5/8inch open-end wrench on the vent valve body hex flats to hold the body stationary. Use a 11/16inch open-end wrench to loosen the jam nut that holds the vent valve to the mounting bracket.
- 4) Use a 9/16inch open-end wrench to disconnect the 1/4inch tube nut where the vent tube connects to the manifold. Remove the vent valve and tube assembly (Figure 17).



**Figure 17: Warming Coil Removal**

- 5) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the warming coil connects to the flow control valve.
- 6) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the warming coil connects to the manifold. Remove the warming coil (Figure 18).



**Figure 18: Warming Coil Removal**

- 7) Install the warming coils by reversing steps 1-6.

**NOTE:** Be sure to replace the wire ties after reinstalling the warming coil. The wire ties hold the warming coil away from any moisture that may accumulate in the moisture pad at the bottom of the unit.

**NOTE:** Do not overtighten the tube nuts on the warming coil. Overtightening may result in a cracked fitting. Only a slight increase in torque is required to seal a compression fitting that has already been made up. When making up a new fitting, three-quarters of a turn from finger-tight is required for 3/16inch tubing.

### RP14B – Warming Coil Assembly RR (C1000T)

- 1) Remove the covers (RP4)
- 2) Use side-cut pliers to cut the wire tie from the warming coil.
- 3) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nuts where the warming coil connects to the two brass tees. Remove the warming coil.
- 4) Use a 9/16inch open-end wrench to disconnect the 1/4inch tube nut where the fill tube connects to the female fill connector adapter.
- 5) Use a 9/16inch open-end wrench to disconnect the 1/4inch tube nut where the fill tube connects to the manifold. Remove the fill tube.
- 6) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the warming coil connects to the flow control valve.
- 7) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the warming coil connects to the brass tee. Remove the warming coil.
- 8) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the spined tube connects to the manifold.
- 9) Use a 1/2-in open-end wrench to disconnect the 3/16inch tube nut where the spined tube connects to the brass tee. Remove the spined tube.
- 10) Install the warming coils by reversing steps 1-9.

**NOTE:** Be sure to replace the wire tie after reinstalling the warming coil.

### RP15 – Vent Valve Test

- 1) Remove the covers (RP4) and set the FCV to off (0 LPM).
- 2) Connect the pressurizing setup to the C1000/T as shown in Figure 9 and pressurize the unit to approximately 1.52 bar (22 psi), or fill the unit with liquid oxygen.
- 3) Wet a finger with leak detector and lightly place it against the open end of the vent tube located near the bottom of the unit. Verify that no leaks are present and no bubbling occurs.
- 4) Open the vent valve and listen for a sudden exhaust of gaseous oxygen.

## RP16 - Vent Valve RR

- 1) Remove the covers (RP4).
- 2) Use a 9/16 inch open-end wrench to disconnect the 1/4inch tube nut that connects the vent extension tube to the vent valve (Figure 19).



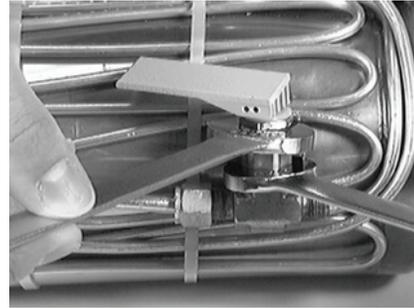
**Figure 19: Vent Extension Tube Removal**

- 3) Use a 9/16inch open-end wrench to disconnect the 1/4 inch tube nut that connects the long vent tube to the vent valve (Figure 20).



**Figure 20: Vent Tube Removal**

- 4) Use a 5/8inch open-wrench on the vent valve body hex flats to hold the body stationary. Use a 11/16 inch open end wrench to loosen the jam nut that holds the vent valve to the mounting bracket (Figure 21).



**Figure 21: Vent Valve Removal**

- 5) Slide the vent valve out of the mounting bracket.
- 6) Position the new vent valve in the mounting bracket slot. Do not tighten the jam nut at this time.

**NOTE:** The mounting bracket should be between the jam nut and the valve body hex flats. The valve flow direction arrow should point downward.

- 7) Align the short vent tube and long vent tube with the proper vent valve ports. Thread the tube nuts onto the valve and tighten.

**NOTE:** Do not over tighten the vent tube nuts. Over tightening may result in a cracked fitting. Only a slight increase in torque is required to seal up a compression fitting that has already been made up. For 1/2 inch tubing, 1/4 turn from finger-tight is required when making up a new fitting.

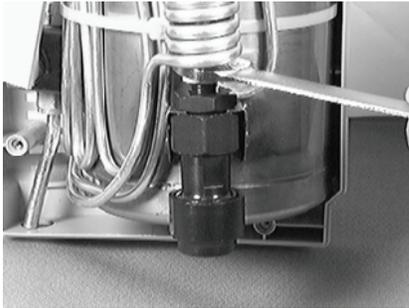
- 8) Push the vent valve fully into the slot in the mounting bracket. Hold the valve in this position with a 5/8 inch open-end wrench placed on the valve body hex flats. Use a 11/16 inch open-end wrench to tighten the jam nut.

**NOTE:** Check for proper vent valve lever operation after installing the side cover. Adjust the vent valve horizontally by shifting the valve in the mounting bracket. Adjust vertically by loosening the two socket head cap screws mounted in the tabs on the bottom of the bottle and shifting the entire bottle assembly up or down. Make sure that the vent extension tube outlet is centered in the corresponding side cover clearance hole.

- 9) Install the side covers (RP4).

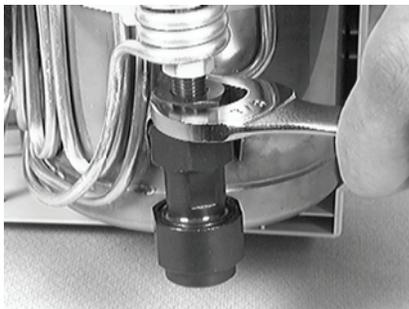
### RP17 – QDV Assembly RR

- 1) Remove the covers (RP4).
- 2) Use a 9/16inch open-end wrench to disconnect the tube nut at the female adaptor (Figure 22).



**Figure 22: QDV Tube Nut Removal**

- 3) Use a 7/8inch open-end wrench to loosen the jam nut (earlier models may have a 5/8inch jam nut) that holds the female adapter to the mounting bracket. Pull the fill connector assembly down slightly to clear the fill tube and then slide it out of the mounting bracket (Figure 23).



**Figure 23: QDV Removal**

- 4) Install the QDV assembly by reversing steps 1-3.

### RP18 – Lip Seal RR

- 1) Remove the QDV (RP17).
- 2) Hold the QDV body with an adjustable wrench placed on the machined flats. Use a second adjustable wrench to remove the lip seal retainer sleeve.
- 3) Pull the lip seal out of the fill connector body.



**Figure 24: Lip Seal Removal**

- 4) Insert the stepped (spring) end of the new lip seal into the corresponding recess in the large end of the QDV body. Make sure that it is squarely seated.
- 5) Thread the lip seal retainer onto the large end of the fill connector body and tighten to a torque of 35 lb/ft (511 n/m).
- 6) Replace the QDV assembly (RP17).



**Figure 25: Lip Seal Replacement**

### RP19 - FCV Test

- 1) Fill the C1000/T with liquid oxygen. Allow approximately one hour for the system pressure to stabilize. Verify that the PRV is venting and that the system pressure is 1.28 – 1.62 bar (18.5 – 23.5 psi).
- 2) Attach a calibrated flow meter to the oxygen outlet barbed fitting.
- 3) At each flow setting, check the flow control valve.  
Acceptable flow ranges are given below in Table 9 and 10.

NOTE: Data listed in Table 9 and 10 is based on an operating pressure range of 1.41-1.66 bar (20.5-24 psi). If the flow measurements are out of specification, check the pressure in the unit. A combination of high or low pressure and the tolerance of the particular flow meter you are using can result in inaccurate readings.

**Table 9 C1000 FCV**

Nominal Setting (LPM)	Allowable Range (LPM)
0.12	0.02 - 0.22
0.25	0.08 - 0.42
0.50	0.33 - 0.67
0.75	0.58 - 0.92
1.00	0.83 - 1.17
1.50	1.18 - 1.82
2.00	1.61 - 2.43
2.50	2.08 - 2.97
3.00	2.55 - 3.51
3.50	2.92 - 4.04
4.00	3.43 - 4.62
5.00	4.33 - 5.77
6.00	5.14 - 6.92

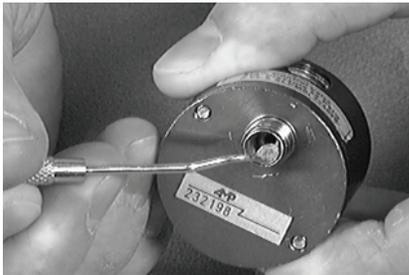
**Table 10 C1000T FCV**

Nominal Setting (LPM)	Allowable Range (LPM)
0.50	0.33 - 0.67
1.00	0.83 - 1.17
1.50	1.18 - 1.82
2.00	1.61 - 2.43
3.00	2.55 - 3.51
4.00	3.43 - 4.62
5.00	4.33 - 5.77
6.00	5.14 - 6.92
8.00	6.72 - 9.28
10.00	8.42 - 11.53
15.00	12.97 - 17.28

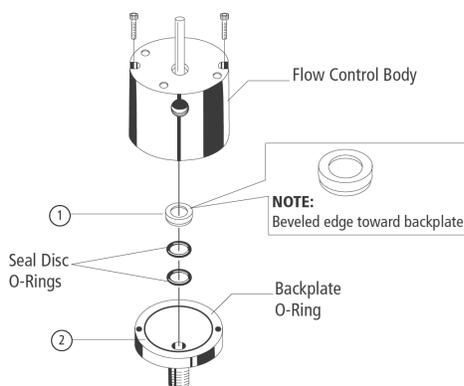
## RP20 – FCV RR

**WARNING:** Liquid oxygen discharge from the FCV can occur if a 0-15LPM C1000T FCV is installed on a C1000. Always check the flow rating decal on the FCV before installing the valve on a portable. DO NOT install a 0-15LPM valve on a C1000.

- 1) Remove the top bezel (RP5).
- 2) Use a 1/2 inch open-end wrench to loosen the 3/16inch tube nut on the back of the flow control valve. Remove the tube and nut from the flow control valve.
- 3) Use a 1/16 inch Allen wrench to loosen the set screw in the flow control valve knob. Remove the flow control valve knob and decal. If the knob does not use a set screw, insert the Allen wrench into the hole in the knob. Simultaneously push in and pull up on the Allen wrench to remove the knob.
- 4) Use a small flat-blade screwdriver to loosen and remove the two flat-head screws from the flow plate. Remove the flow plate and the flow control valve.
- 5) Use a dental pick or similar tool to carefully remove the inlet filter screen from the flow control valve. Be careful not to scratch any part of the flow control valve inlet port when removing the screen (Figure 26).
- 6) Install the FCV by reversing steps 1-5.



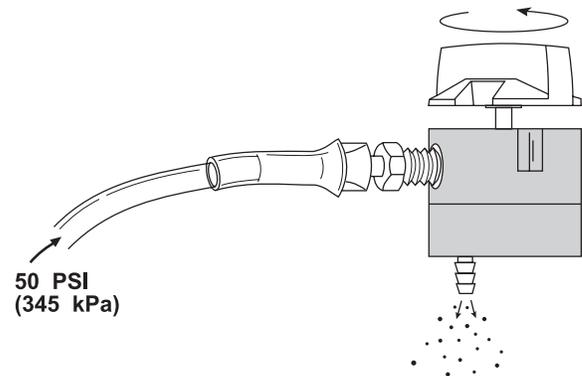
**Figure 26: Removing the Filter Screen**



**Figure 27: FCV Assembly**

## RP21 – Back Flushing the FCV

- 1) Remove the FCV (RP20) and its filter screen.
- 2) Temporarily reinstall the oxygen outlet barbed fitting in the flow control valve. Connect 3.45-5.18 bar (50-75 psi) oxygen to the valve's outlet barbed fitting. Temporarily install the valve knob on the rotor shaft.
- 3) Slowly rotate the valve knob through all flow settings (Figure 28). Gas flow should be audible at each flow position, indicating that the appropriate orifice is open.



**Figure 28: Backflushing the FCV**

## RP22 – Operating Pressure Test

- 1) Fill the C1000/T with liquid oxygen from a properly saturated reservoir.
- 2) Attach the test pressure gauge w/ tubing (B-701732-00) to the cannula outlet barb on the top of the C1000/T.
- 3) Open the FCV to the highest flow setting.
- 4) Read the operating pressure on the gauge. The pressure should be between 1.28 – 1.62 bar (18.5 – 23.5 psi).

## RP23 – NER Test

- 1) Perform a leak test (RP2) and verify that the results are acceptable.
- 2) Perform the PRV test (RP9) and verify that the PRV is functioning properly.
- 3) Set the flow control valve to 0LPM and fill the unit from a properly saturated liquid oxygen source.
- 4) Allow 30 minutes for the unit to stabilize.
- 5) Record the initial weight of the unit and the time ( $w_1$ ).
- 6) After an elapsed time of 18 to 24 hours, record the weight and time ( $w_2$ ).
- 7) Calculate the NER using the following formula.

$$\text{NER} = \frac{(24 \text{ hrs.}) \times (w_1 - w_2)}{(\text{Time between } w_1 \text{ and } w_2 \text{ in hrs.})}$$

- 8) Verify that the NER is less than 1.5 lb/day (0.7 kg/day).

## RP24 – Manifold RR

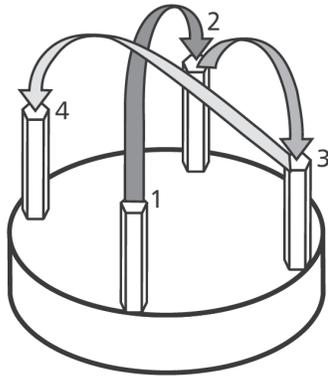
- 1) Remove the covers (RP4).
- 2) Remove the top bezel (RP5).
- 3) Loosen and remove the four socket head cap screws from the base of the contents indicator assembly. Remove the assembly.
- 4) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the warming coil connects to the manifold.
- 5) Use a 9/16inch open-end wrench to disconnect the 1/4inch tube nut where the vent tube connects to the manifold.
- 6) Use a 9/16inch open-end wrench to disconnect the 1/4inch tube nut where the fill tube connects to the manifold.
- 7) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the primary relief valve tube connects to the manifold.
- 8) Use a 1/2inch open-end wrench to disconnect the 3/16inch tube nut where the secondary relief valve tube connects to the manifold.
- 9) Use a 3/16inch nut driver to remove the four standoffs from the manifold (Figure 29). Remove the manifold.



**Figure 29: Manifold Removal**

**NOTE:** To prevent contaminants from entering the cryogenic container, place a clean plastic bag over the neck of the container and seal tightly.

- 10) Install the manifold by reversing steps 1-9.
- 11) Use the specified torque wrench to the standoffs of 10in-lb (115 N-cm) in an alternating sequence (Figure 30).



**Figure 30: Manifold Torque Sequence**

12) Follow up by torquing the standoffs to 22 in-lb (253 N-cm) in an alternating sequence.

NOTE: Verify that the O-ring seal between the manifold and the container does not have any nicks, scratches, or tears. Also, check to see that the O-ring is not flat-spotted. Replace as necessary.

NOTE: When installing the manifold, position the vacuum port of the bottle between the secondary relief valve and warming coil ports on the manifold.

NOTE: Do not overtighten the tube nuts of a compression fitting. Over-tightening may result in a cracked fitting. Only a slight increase in torque is required to seal a compression fitting that has already been made up. When making up a new fitting, tighten 3/4 turn from finger-tight for 3/16inch tubing; 1 1/4 turns from finger-tight for 1/4inch tubing.

NOTE: Before installing the side covers, pressurize the system with gaseous oxygen and test for leaks according to the Leak Test (RP2).

**RP25 – Cryogenic Container RR**

- 1) Remove the manifold (RP24).
- 2) Use a 5/8inch open-end wrench on the vent valve body hex flats to hold the body stationary. Use an 11/16inch open-end wrench to loosen the jam nut that holds the vent valve to the mounting bracket. Remove the vent valve and tube assembly from the mounting bracket.
- 3) Use side-cut pliers to cut the wire tie from the warming coil.
- 4) Use a 7/8inch open-end wrench to loosen the jam nut (some earlier models may have a 5/8inch jam nut) that retains the female adapter to the mounting bracket. Remove the female fill connector and tube assembly from the mounting bracket.
- 5) Install the cryogenic container by reversing steps 1-4.

NOTE: To prevent contaminants from entering the cryogenic container, place the container in a clean plastic bag and seal tightly.