A GUIDE TO USING THE DIAGNOSTICS WEBPAGE FOR TROUBLESHOOTING

TECHNOTE 050

MAY 25, 2022

OVERVIEW

PURPOSE

This document provides step-by-step instructions for conducting a flexiVent Diagnostics by using the Diagnostics Webpage for troubleshooting. The reader will learn how to perform and validate all steps for the Diagnostics and how to fix any errors found during the Diagnostics.

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SCOPE

This document pertains to the following products & services:

Product	From Version	To Version
flexiVent	flexiWare 7.6.7	Current

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INTRODUCTION

The flexiVent is a unique, integrated platform that combines a programmable ventilator with accurate detailed measurements of respiratory mechanics. This document is designed to allow a first-time user to run through the Diagnostics test, identify and correct any errors that arise, and know what steps require manual intervention.

1. CONNECTING TO THE DIAGNOSTICS WEBPAGE

First verify which version of firmware is currently being used by the FX system. The firmware version can be found on the flexiVent screen as indicated by the yellow box in Figure 1. Additionally, the IP address of the flexiVent will be displayed on the screen.

Figure 1. Locating the firmware version on the flexiVent

Open a web browser, and type the following into the address bar to bring up the Diagnostics test page:

> » If using firmware version 8.0 or higher, type **http://[FX system IP address]/diagnostics.htm**

> » If using firmware version 7.6 or 7.7, type **http://[FX system IP address]/selftest.htm**

NOTE: The system does not need to be connected to the internet to perform the Diagnostics test.

See the examples in **Error! Reference source not found.** and

Figure 3 below:

Figure 2. Type Diagnostics address into web browser for firmware version 8.0 or higher

Figure 3. Type SelfTest address into web browser for firmware version 7.6

NOTE: Once in Diagnostics mode, as indicated on the LCD screen of the flexiVent system, the flexiVent will stay on until the session is closed.

1.1 TEST SELECTION

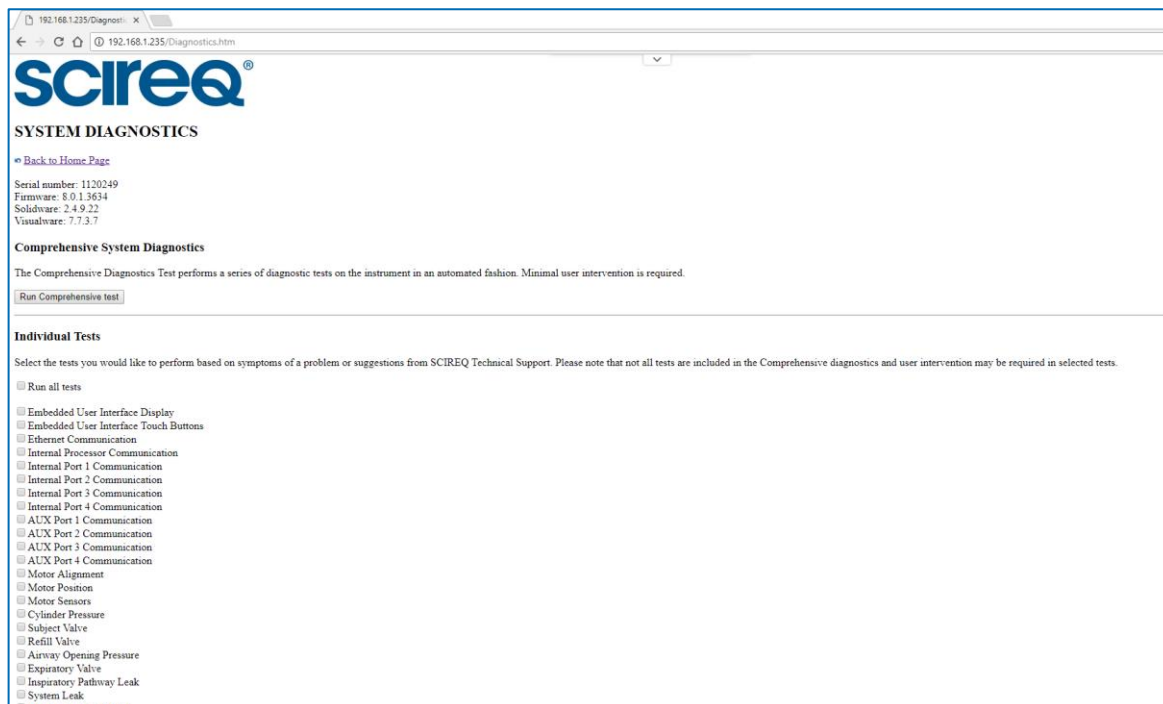The *System Diagnostics Webpage* will load onto the web browser (see Figure 4).

Figure 4. System Diagnostics welcome screen

From the System Diagnostics page, either select the Individual, desired Tests to run or check *Run all tests* to run all the possible tests. For versions 8.0 and above, it is possible toselect *Run Comprehensive Test* to run all tests as well.

1.2   TEST INTERVENTIONS AND REQUIRED HARDWARE

The first 2 and the last 5 tests, in the Individual Tests list (designated with a * in later software editions), require user intervention. The instructions for the intervention will be shown on the LCD screen. An FX adapter, and a piece of tubing with two quick-connects will be necessary for some of the tests ex. *Internal Module Tubing* as shown in Figure 11.

Once the desired tests have been selected, click the button *Run Selected Tests* below the list. The tests being run and any applicable instructions will be displayed on the LCD screen of the flexiVent system.

1.3 TEST RESULTS

When the tests are complete (~10 min for comprehensive tests), the results will be displayed. The summary of the results indicates whether a test has passed, failed, or has a warning, followed by a column listing more detailed comments (see Figure 5).

A green checkmark indicates a pass, a yellow triangle indicates a warning, and a red x indicates failure.

Test	Result	Comment
Embedded User Interface Display	⚠	Embedded User Interface message was not confirmed by the user
Embedded User Interface Touch Buttons	⚠	Did not perform test due to failure/warning detected from a previous test
Ethernet Communication	✔	
Internal Processor Communication	✔	
Internal Port 1 Communication	✔	FV-FXM2-I
Internal Port 2 Communication	✔	FV-FXM2-ET
Internal Port 3 Communication	✔	
Internal Port 4 Communication	✔	FV-FXB-MOTOR
AUX Port 1 Communication	⚠	No UnitWise transducer detected
AUX Port 2 Communication	⚠	No UnitWise transducer detected
AUX Port 3 Communication	⚠	No UnitWise transducer detected
AUX Port 4 Communication	⚠	No UnitWise transducer detected
Motor Position	✔	Measured stroke = 2.493"
Motor Alignment	✔	Index width is: 16, Tick error is: 0
Motor Sensors	✔	
Cylinder Pressure	✔	
Subject Valve	✔	
Refill Valve	✔	
Inspiratory Pathway Leak	✔	
Airway Opening Pressure	✘	No increasing pressure detected. Measured pressure is: 0 cmH2O
Expiratory Valve	✘	Measured saturation pressure is: 0.2 cmH2O. Result should be greater than 70.8 cmH2O
System Leak	✔	
Internal Module Tubing	✘	Unable to reach 75% of the full pressure range. Detected pressure is: 0.3 cmH2O. Result should be greater than 58.6 cmH2O

Figure 5. Test results

2. TEST INFORMATION

2.1 TEST PROCEDURES AND PASS CRITERIA

2.1.1 EMBEDDED USER INTERFACE DISPLAY

The embedded user interface display test will assess the screen/display on the flexiVent FX. To determine whether the user can read the instructions on the screen, users are prompted to click on any button (Figure 6). It is possible for this test to fail due to defective buttons, even where the screen works.

NOTE: FlexiVents FXs released before the use of touch screens will not pass tests of screen responsiveness nor be able to speed up tests requiring user intervention. These tests will automatically proceed after a short period of time without user intervention.

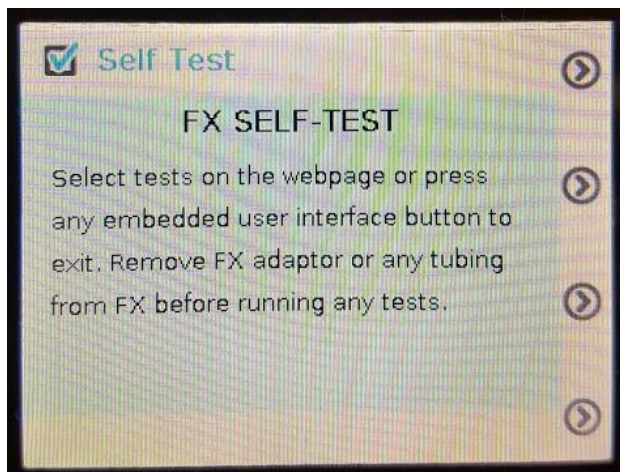**NOTE:** The buttons are only active for flexiWare versions 8.0 and above.

Figure 6. Embedded User Interface Display test instructions

The flexiVent system performs the following steps during the test:

1. Prompts the user to press any EUI button (5 seconds to accomplish the task)

2. Confirms that a EUI button was pressed

3. Sets the system back to its default state

2.1.2 EMBEDDED USER INTERFACE TOUCH BUTTONS

The embedded user interface touch buttons test confirms if the EUI buttons on the LCD screen are functioning properly. The arrow should move from button 1 to 4 once the user properly presses on the button indicated (see Figure 7).

NOTE: The buttons are only active for flexiWare versions 8.0 and above.
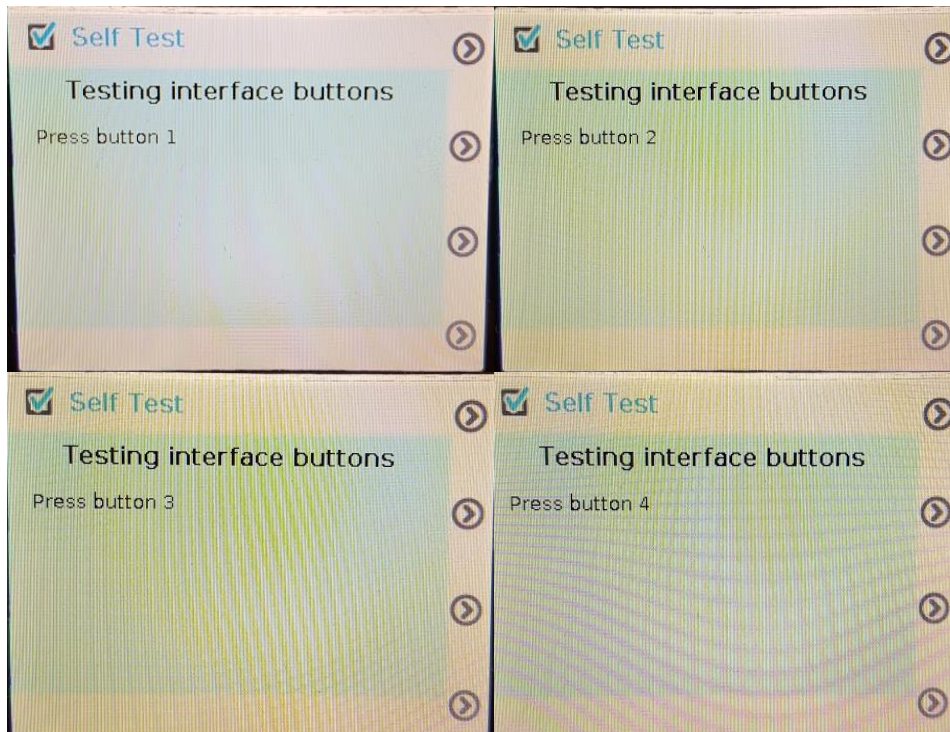

Figure 7. Embedded User Interface Touch Buttons test instructions

The flexiVent system performs the following steps during the test:

1. Prompts the user to press on EUI button 1 (5 seconds to accomplish the task)

2. Confirms that the EUI button 1 was pressed

3. Prompts the user to press on EUI button 2 (5 seconds to accomplish the task)

4. Confirms that the EUI button 2 was pressed

5. Prompts the user to press on EUI button 3 (5 seconds to accomplish the task)

6. Confirms that the EUI button 3 was pressed

7. Prompts the user to press on EUI button 4 (5 seconds to accomplish the task)

8. Confirms that the EUI button 4 was pressed

9. Sets the system back to its default state

2.1.3 ETHERNET COMMUNICATION

The Ethernet communication test is used to confirm if there is proper communication i.e. interference between the flexiVent system and the computer that it is connected to.

The test prompts the flexiVent to communicate with itself, then tries to communicate with an external pre-defined IP address. If the 2 pre-defined IP addresses fail to respond, the flexiVent system ping's its configured default gateway (which is not always configured but might be if the other 2 pre-defined IP addresses failed).

The flexiVent system pings IP addresses: XXX.XXX.XXX.1, XXX.XXX.XXX.255, default gateway (XXX represents instrument's IP address values), and performs the following steps:

1. Configures the internal network communication board (netburner) to ping IP xxx.xxx.xxx.xxx
2. Confirms if ping was successful
3. If not successful repeats with the next IP address

    » list of IP addresses: 192.168.1.1, 192.168.1.200, …

4. Repeats steps 1 - 3 ten times
5. Confirms the sum of the states of all ping tests
6. Sets the system back to its default state

2.1.4 INTERNAL PROCESSOR COMMUNICATION

The internal processor communication test confirms if there is proper communication with the microchip in the controller module (MSP430).

2.1.5 INTERNAL PORTS 1-4 COMMUNICATION & AUX PORTS 1-4 COMMUNICATION

The internal and auxiliary ports communication test identifies if there is an issue with the ports on the flexiVent base unit. A failure on Internal ports 1, 2 & 4 would indicate an issue related to the communication with the inspiratory cartridge, expiratory cartridge or motor respectively.

NOTE: Internal port 3 is not checked as there is nothing configured on this port, it will show as a pass on the screen in the results.

The Auxiliary port communication test identifies if the transducer attached to the rear controller box port is defective or if there is an issue reading the transducer connected to the port. When running tests for Auxiliary ports 1,2,3,4, the tests will result in a warning unless a *UnitWise* transducer is connected to the port.

NOTE: The Aeroneb transducer is unidirectional. Signals can only be sent from the flexiVent to the controller and not from the controller back to the flexiVent. Therefore, any port with an aeroneb attached will be read as empty, even though an extension (the AN controller) is indeed present.

The flexiVent system performs the following steps during the test:

1. Configures the system to continuously trigger the port

2. Detects whether the port is triggered

3. Stops port triggering to read EDS

4. Detects port's EDS validity (EDS information)

5. If the test fails, repeats EDS reading 3 times

6. Validates test result

2.1.6   MOTOR ALIGNMENT

The motor alignment test identifies if there are issues with the motor alignment.

NOTE: Newer motor designs use magnetic positioning and will always show an error in flexiWare versions below 8.0. This does not indicate any problem is present in motor performance.

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)

2. Configures the system to run the motor calibration routine (crossing an index position)

3. Configures the system to move the motor between 2 points towards the module without crossing the index for 5 seconds

4. Configures the system to cross the index and stop moving

5. Confirms that the measured tick error was within acceptable range when motor crossed the index

6. Configures the system to move the motor between 2 points away from the module without crossing the index for 5 seconds

7. Configures the system to cross the index and stop moving

8. Confirms that the tick error was within acceptable range when motor crossed the index

9. Sets the system back to its default state

2.1.7   MOTOR POSITION

The motor position test confirms that the motor is moving as expected. One scenario to running the test would be when coming across the *piston did not move as expected* error message.

NOTE: All motor movement will be done slowly and not at full power in order not to bend the rod if the valves do not open as expected

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
2. Configures the system to run the motor calibration routine (cross index)
3. Configures the system to move the motor towards the module
4. Confirms that the motor is within the expected position
5. Temporarily saves position to memory for future usage
6. Configures the system to move the motor away from the module
7. Confirms that the motor is within the expected position & save position
8. Temporarily saves position to memory for future usage
9. Calculates the difference between both measured positions
10. Confirms that expected full stroke was achieved
11. Sets the system back to its default state

2.1.8   MOTOR SENSORS

The motor sensor test is used to confirm whether the motor sensors are functioning properly. The test checks both the temperature and the current sensors.

NOTE: There may be issues with older systems where this was not evaluated in production. A failure here should not prevent the flexiVent from functioning correctly.

The flexiVent system performs the following steps during the test:

Temperature:

1. Moves motor back & forth
2. Measures temperature
3. Verifies that the reading is not saturated (high or low) and that is between a given range (range to be verified with Production data)

Current:

1. Moves the motor rapidly
2. Measures motor current
3. Verifies that the reading is not saturated
4. Verifies that the correct value is obtained (see production test)
5. Sets the system back to its default state

2.1.9   CYLINDER PRESSURE

The cylinder pressure test determines if the cylinder pressure (Pcyl) sensor located on the inspiratory cartridge is functioning properly.

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
2. Configures the system to continuously read data from the Pcyl sensor
3. Confirms that the Pcyl sensor detected atmospheric pressure
4. Configures the system to run the motor calibration routine (cross index)
5. Configures the system to close all valves (SUBJECT, REFILL, EXPIRATORY)
6. Configures the system to gently move the motor towards the module
7. Confirms that the Pcyl sensor is detecting an increase of pressure
8. Stops the motor when the Pcyl sensor saturates
9. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY) to release pressure
10. Confirms that the Pcyl sensor detected atmospheric pressure
11. Sets the system back to its default state

2.1.10   SUBJECT VALVE

The subject valve test verifies that the inspiratory valve is opening and closing properly. A failure in this test may indicate a leak in the system, or that an error exists with the programming on the inspiratory cartridge (EDS/Crispware).

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
2. Configures the system to run the motor calibration routine (cross index)
3. Configures the system to close all valves (SUBJECT, REFILL, EXPIRATORY)
4. Configures the system to move the motor towards the module
5. Stops the motor when the cylinder pressure (Pcyl) sensor saturates
6. Confirms that the Pcyl sensor detected saturation
7. Configures the system to open the subject valve
8. Confirms that the Pcyl sensor detected atmospheric pressure
9. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
10. Set the system back to its default state

2.1.11 REFILL VALVE

The refill valve test verifies that the refill valve is opening and closing properly.

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
2. Configures the system to run the motor calibration routine (cross index)
3. Configures the system to close all valves (SUBJECT, REFILL, EXPIRATORY)
4. Configures the system to move the motor towards the module
5. Stops the motor when the cylinder pressure (Pcyl) sensor saturates
6. Confirms that the Pcyl sensor detected saturation
7. Configures the system to open the Refill valve
8. Confirms that the Pcyl sensor detected atmospheric pressure
9. Sets the system back to its default state

2.1.12 AIRWAY OPENING PRESSURE (USER INTERVENTION REQUIRED)

The Airway opening pressure test determines if the Airway opening pressure (Pao) sensor is functioning properly. Please ensure the FX adapter and y-tubing are connecting to the flexiVent.

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)
2. Configures the system to continuously read data from the Pao sensor
3. Confirms that the Pao sensor detected atmospheric pressure
4. Configures the system to run the motor calibration routine (cross index)
5. Configures the system to close refill and expiratory valves and leave subject valve open
6. Prompts the user to block the y-tube of the FX adaptor (see Figure)

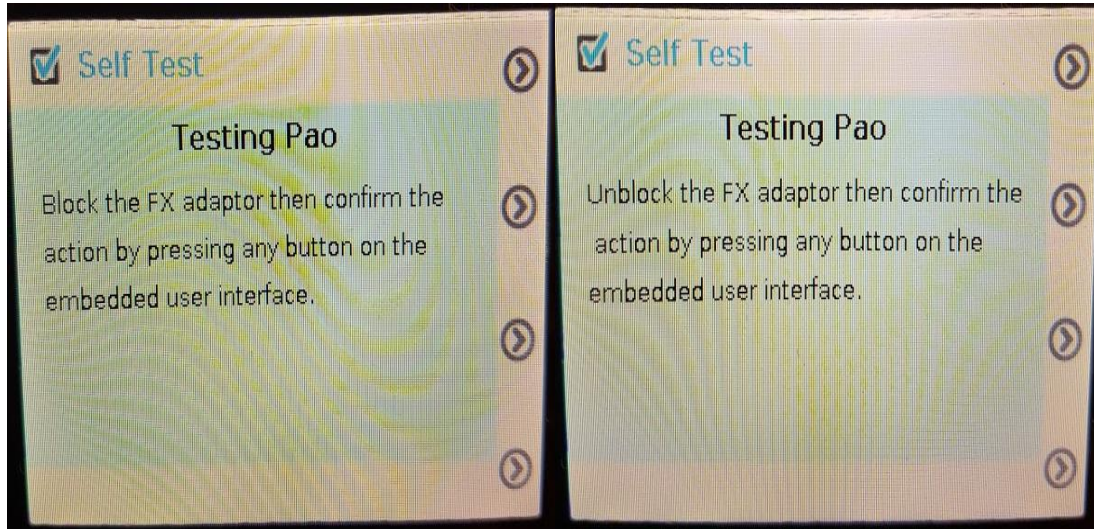a. The system will wait 30 seconds before proceeding with the test without user input

Figure 8. Airway Opening Pressure test instructions

7. Configures the system to gently move the motor towards the module

8. Confirms that the Pao sensor is detecting an increase of pressure

9. Stops the motor when the Pao sensor saturates

10. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY) to release pressure

11. Confirms that the Pao sensor detected atmospheric pressure

12. Sets the system back to its default state

2.1.13   EXPIRATORY VALVE (USER INTERVENTION REQUIRED)

The expiratory valve test determines if expiratory valve is opening and closing properly. If this test fails, it may indicate may indicate a leak in the system or that an error exists with the programming on the expiratory cartridge (EDS/Crispware). Please ensure the FX adapter and y-tubing are connecting to the flexiVent.

The flexiVent system performs the following steps during the test:

1. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)

2. Configures the system to run the motor calibration routine (cross index)

3. Configures the system to close refill and expiratory valve and leave subject valve open

4. Prompts the user to block the y-tube of the FX adaptor (see **Error! Reference source not found.**)

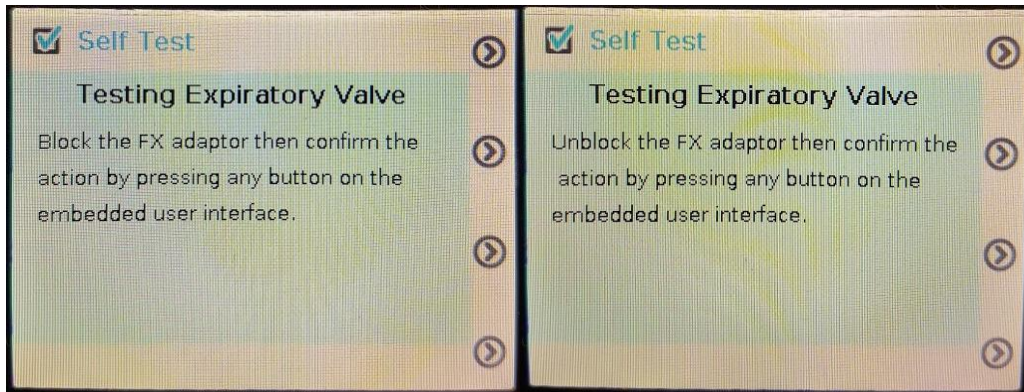a. The system will wait 30 seconds before proceeding with the test without user input

Figure 9. Expiratory Valve test instructions

b. Configures the system to move the motor towards the module

c. Stops the motor when the cylinder pressure (Pcyl) sensor saturates

d. Confirms that the Pcyl sensor detected saturation

e. Configures the system to open the expiratory valve

f. Confirms that the Pcyl sensor detected atmospheric pressure

g. Configures the system to open all valves (SUBJECT, REFILL, EXPIRATORY)

h. Sets the system back to its default state

2.1.14 INSPIRATORY PATHWAY LEAK

The inspiratory pathway leak test determines if there is a leak located along the inspiratory pathway (cylinder up to the refill & subject valves). If this test fails, the refill or subject valve may not be closing properly or that there is a leak between the cylinder and the module.

The flexiVent system performs the following steps during the test:

1. Closes refill & subject valve

2. Moves the piston towards the module until the cylinder pressure is within a range of 40-90% of 80 cmH$_2$O

3. Maintains piston at same place

4. Reads cylinder pressure (Pcyl) value

5. Waits 10 seconds

6. Reads cylinder pressure (Pcyl) again

7. Finds difference between both pressure readings

8. Compares pressure difference against pass criteria (must be higher than 45% of starting pressure)

9. Opens valves to release pressure

10. Sets the system back to its default state

2.1.15   SYSTEM LEAK (USER INTERVENTION REQUIRED)

The system leak test checks if there is a leak in the system. Please ensure the FX adapter and y-tubing are connecting to the flexiVent.

The flexiVent system performs the following steps during the test:

1. Closes refill & expiratory valve

2. Prompts the user to close the FX adaptor port (see Figure 9)

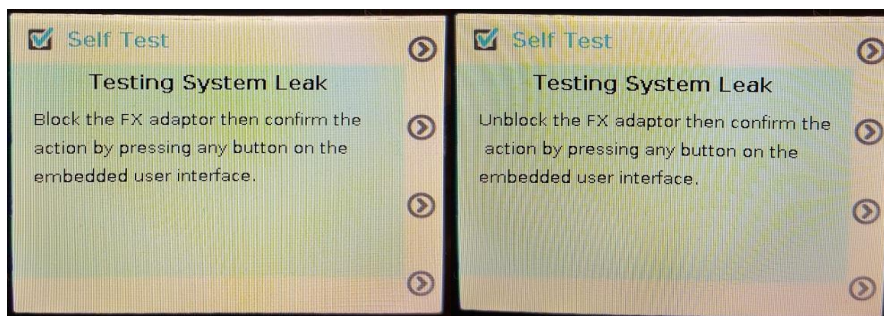   a.   The system will wait 30 seconds before proceeding with the test without user input

Figure 9. System Leak test instructions

3. Moves the piston towards the module until pressure is within 40-90% range of 80 cmH$_2$O

4. Maintains piston at same place

5. Reads cylinder pressure (Pcyl) value

6. Waits 10 seconds

7. Reads cylinder pressure (Pcyl) again

8. Finds difference between both pressure readings

9. Compares pressure difference against pass criteria (must be higher than 45% of starting pressure)

10. Opens valves to release pressure

11. Sets the system back to its default state

2.1.16 INTERNAL MODULE TUBING (USER INTERVENTION & TUBING REQUIRED)

The internal module tubing test checks if there is a leak originating from the tubes inside the module. The flexiVent system performs the following steps during the test:

1. Opens all valves (SUBJECT, REFILL, EXPIRATORY) and refills the cylinder

2. Closes SUBJECT & EXPIRATORY valves

3. Prompts the user to connect a piece of tubing between the intake & exhaust ports at the rear of the flexiVent system (see Figure 10 and Figure 11)

    a. The system will wait 30 seconds before proceeding with the test without user input
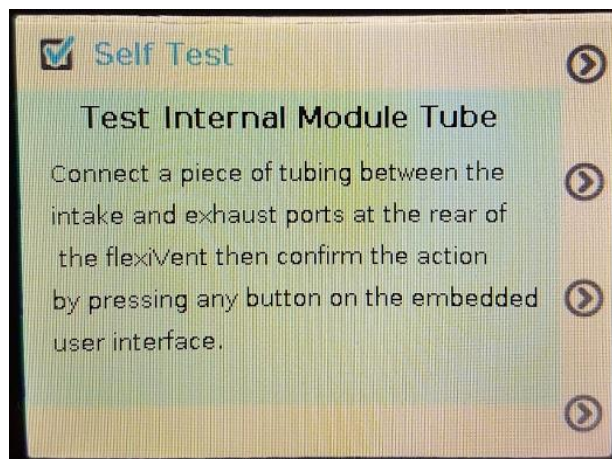

Figure 10. Internal Module Tube test instructions

Figure 11. Tubing between intake & exhaust ports

4. Moves the piston towards the module until the cylinder pressure (Pcyl) is within 40-90% range of 80 cmH$_2$O

5. Maintains piston position

6. Reads Pcyl sensor value

7. Waits 10 seconds

8. Reads Pcyl sensor value again

9. Calculates difference between both pressure readings

10. Compares pressure difference against pass criteria (must be higher than 45% of starting pressure)

11. Opens valves to release pressure

12. Sets the system back to its default state