VALIDATION STEPS FOR A LEAK FREE INEXPOSE® CIRCUIT

TECHNOTE 051
JULY 13, 2022

OVERVIEW

PURPOSE

This document provides step-by-step instructions for verifying that the inExpose flow circuit is leak free prior to an exposure study. A leak-free system is important to ensure that all the compound produced is delivered to subjects, achieve accurate target concentrations and delivered doses.

LEGAL DISCLAIMER

SCOPE

This document pertains to the following products & services:

Product	From Version	To Version
inExpose®	flexiWare 8.2	Current

TECHNICAL SUPPORT CONTACT INFORMATION

North America
TechSupport@scireq.com
Tel: 1 (514) 286-1429 option 2
Toll Free: 1 (877) 572-4737 option 2

Europe & Middle East
sales@emka.fr | Tel: +33 (1) 40 60 76 00

China
info@bjgyd.com
Tel: +86 (0)10-85376382

Japan
info@emkatech.jp
Tel: +81 (0)6-6476-7135

CONTENTS

1. INTRODUCTION

The inExpose system can be configured according to the experimenter's research needs. Up to 4 pumps can be connected to the base unit, and attached to either 3 (with the use of a CSR, E-Cig extension, or single cigarette chamber) or 4 (if using an aerosol configuration) exposure chambers. These exposure chambers could be either whole-body (WBC) or nose-only (NO) chambers. Moreover, each exposure chamber can be connected to its own atmospheric monitoring device and filter chamber. Since the inExpose flow circuit consists of many components, it is important to ensure that the circuit is leak free during an exposure study.

2. GENERAL VALIDATION TO IDENTIFY, PREVENT, AND RESOLVE LEAKS

Follow these general steps before the start of each experimental session, to minimize the risk of leaks during an experiment. Refer to this list of common locations for leaks to identify and resolve any leaks in a circuit.

2.1 PUMPS

- Ensure that the interior part of the pump head is clean
- Ensure that the pump head is tightly mounted onto the pump mount. A decreased flow rate may be related to the pump head not being attached properly to the pump. When a low flow result is found pushing down on the pump head to see if this increases the flow can indicate pump placement issues
- Ensure that the O-ring is attached firmly between the pump head and the pump mount. Additionally, try adding a bit of vacuum grease to the O-ring on the pump head before attaching it to the pump

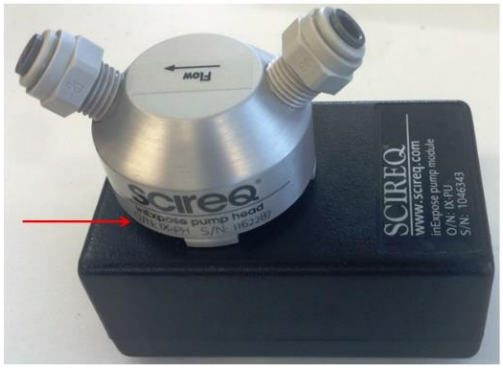

Figure 1. The Diaphragm pump with pump head firmly attached (red arrow)

- Check one-way valves (orange) to confirm if there are any holes. If holes are found, replace the valves
- Confirm that the pump is clean and no residue is left behind in the valves, diaphragm, or connectors. If dirty, please clean using the pump cleaning tool kit

Figure 2. The pump cleaning kit

- Ensure that the john guest adaptors are screwed in sufficiently in the pump head

Figure 3. A John Guest connector

NOTE: The connectors on the pump head should not be screwed too tightly, as this may cause the connectors to touch the valves (i.e. the orange valves inside the pump head). This prevents the pumps from closing properly and the pump will not work at full capacity. This is a common issue that occurs after cleaning of the pump head while re-attaching the connectors to the pump head.

2.2 TUBING

- Ensure that all tubing is tightly inserted and pushed in as far as possible into the john guest connectors of all components in the circuit
- Remove any extra tubing in the set-up
- Tubing ends must be cut with straight, perpendicular edges and no jagged ends

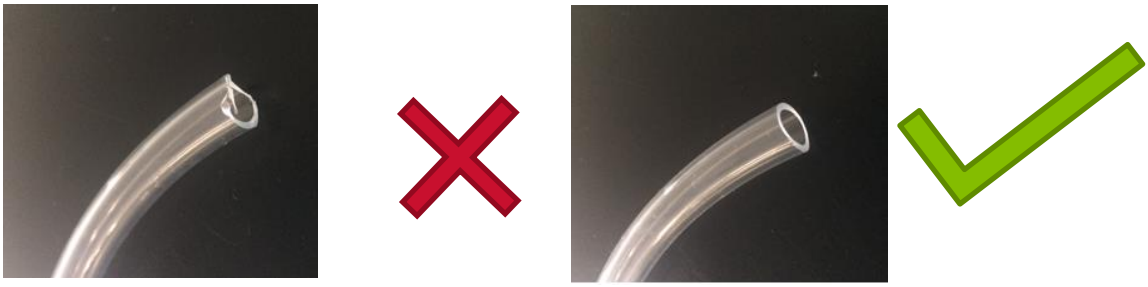

Figure 4. Tubing ends must be cut perpendicular and evenly(right), not jagged or with uneven ends (left) to assure good seal

2.3 SEALING

- If the exposure system is a whole-body chamber (WBC), ensure that the tightening ring on the distribution column is properly tightened using the pin spanner tool

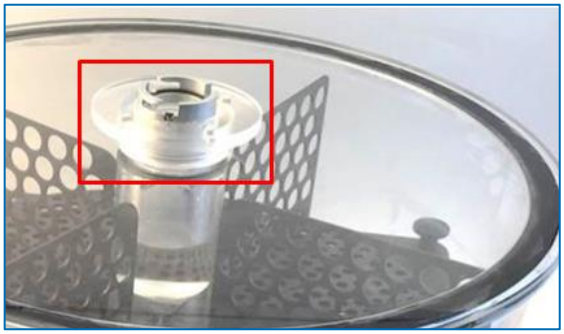

Figure 5. WBC lid with portion used to tighten the lid indicated

- Ensure that all necessary O-rings are secured and placed correctly. Use vacuum grease to place the O-rings onto their appropriate locations
- If the exposure system is a nose-only tower (NO), when running the System flow test, make sure to remove the softRestraints from the exposure tower sites and replace the sites with the black plugs provided, as shown below

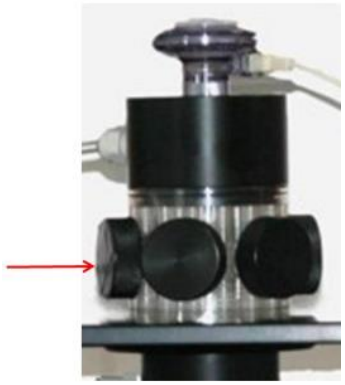

Figure 6. The nose only tower with one of the black plugs used to seal the tower indicated

NOTE: Add vacuum grease along the O-ring on the softRestraint, prior to connecting any softRestraints to the NO tower. Although this is not relevant in terms of the troubleshooting steps, this would assist in prevents leaks from the restraint, during the experimentation session.

Figure 7. A softRestraint with mouse inserted snuggly, o-ring of restraint highlighted

» If an Aeroneb pump head is present in the circuit, it is recommended to ensure that it is filled with enough liquid to cover the small silver mesh plate of the Aeroneb

Figure 8. The standard aeroneb head with mesh portion indicated

3. ENSURING A LEAK-FREE FLOW CIRCUIT

- Upon reaching the main experimentation page on flexiWare 8, ensure that no default pump profiles are running
- All the pumps attached to the inExpose base unit will be automatically detected by flexiWare upon start of the experiment session

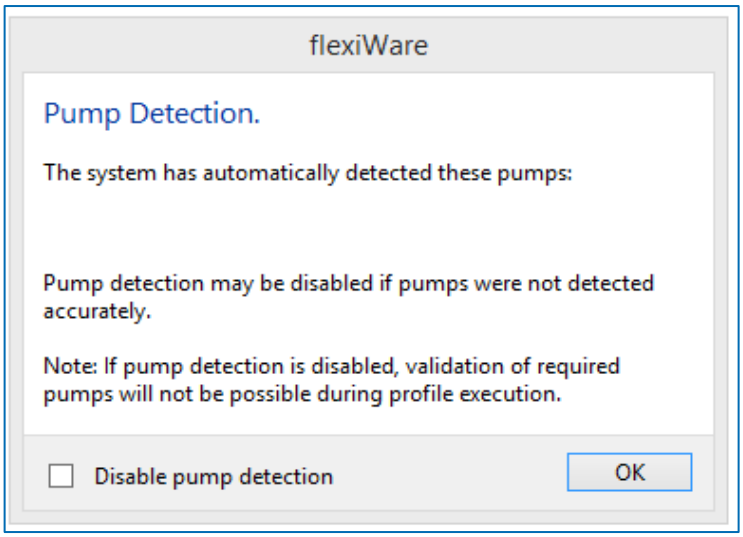

Figure 9. Pump detection

- The software will next prompt the user to perform the system flow test

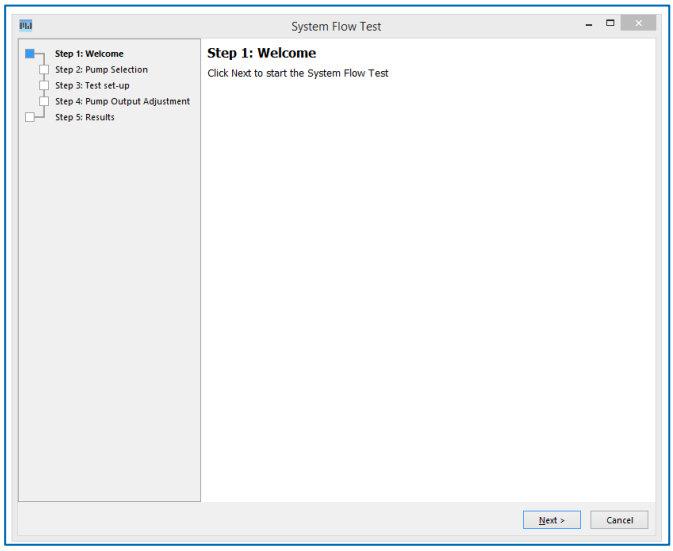

Figure 10. Welcome window of the System Flow Test

» The pumps that were detected will automatically be selected by the software for the system flow test. It is possible to (de)select the pumps to test before clicking *Next*

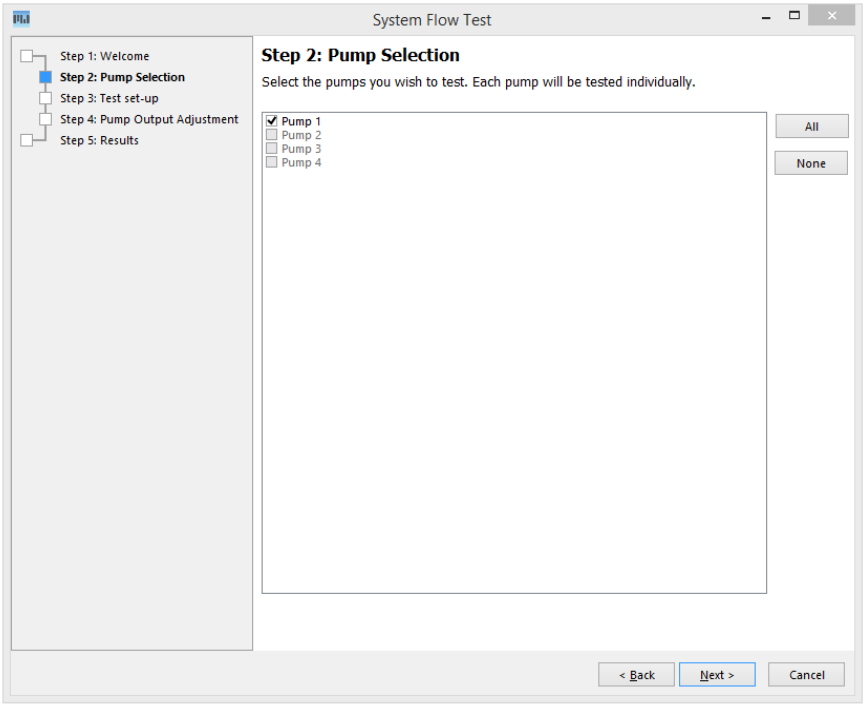

Figure 11. Pump selection for the System Flow Test

» Each selected pump will be tested individually, through a series of steps that follows

NOTE: A flow circuit would need to be assigned for each selected pump that to test.

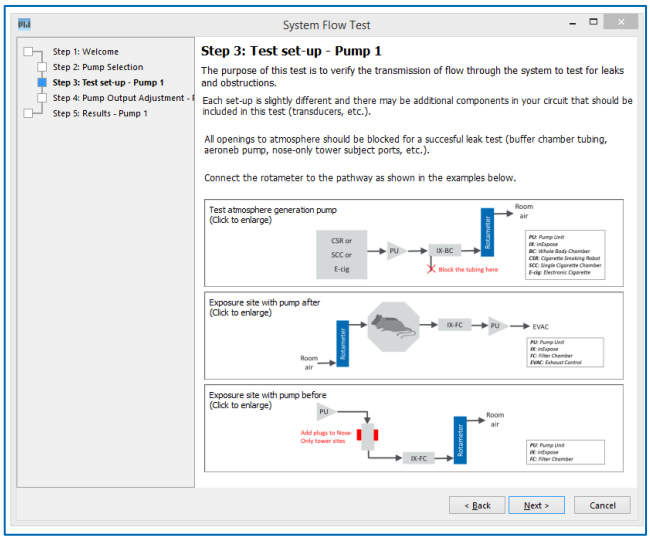

Figure 12. System Flow Test set-up

- Connect the rotameter to the flow circuit pathway as indicated in the illustrations provided in the Test set-up dialogue
- Attach the rotameter to the furthest connection location possible from the pump. At a minimum, the flow circuit should have a buffer chamber between the pump and rotameter
- Follow the instructions shown for the circuit in the inExpose setup being used
    - The flow pathway circuit illustrations included in the System flow test dialogue are discussed in greater detail in section 4

4. SMOKE EXPOSURE STUDIES

4.1 SMOKE GENERATION CIRCUIT

- An example of a smoke generation circuit would have the rotameter connected after the smoke generator (i.e. CSR, SCC, or the e-cigarette) and buffer/filter chamber, at the exit of the flow pathway
- The tubing should be connected to the bottom of the rotameter since this test is essentially measuring a 'pushing' flow from the pump

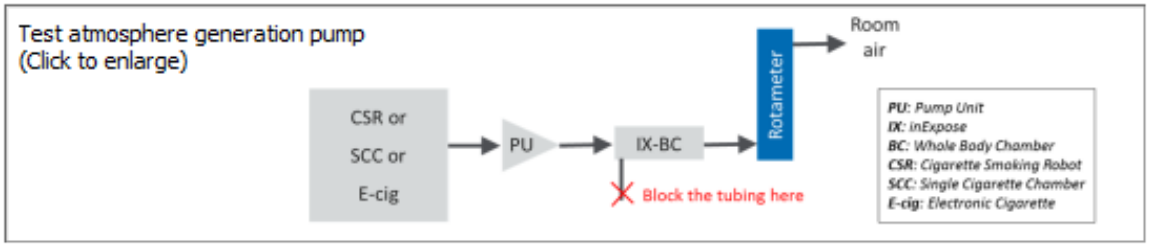

Figure 13. Set-up of rotameter in the smoke generation circuit

NOTE: If the setup includes a small piece of tubing open to atmosphere connected to the buffer chamber, make sure to clamp this tubing, with a finger or adapter, prior to reading the measurement on the rotameter.

4.2 POSITIVE PRESSURE EXPOSURE CIRCUIT

- An example of a positive pressure exposure circuit (typically NO towers) has the rotameter connected after the exposure site and buffer/filter chamber, at the exit of the flow pathway
- The tubing should be connected to the bottom of the rotameter since this test is essentially measuring a 'pushing' flow from the pump
- This most commonly applies for aerosol exposure studies using nose-only towers

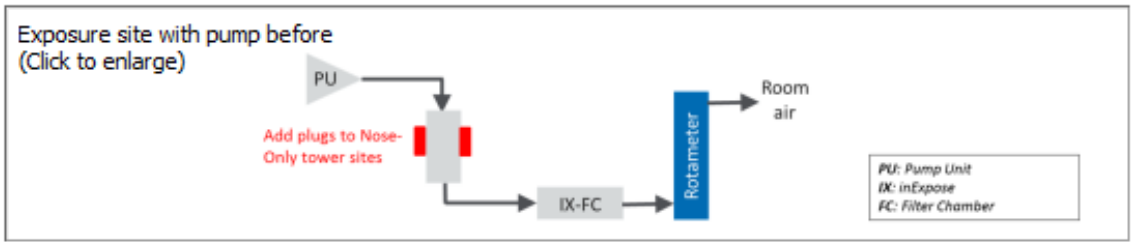

Figure 14. Set-up of rotameter for testing flow in a positive pressure exposure circuit

4.3 NEGATIVE PRESSURE EXPOSURE CIRCUIT

- An example of a negative pressure exposure circuit (typically WBC) would have the rotameter connected before the exposure site, at the earliest point possible of the flow pathway
- The tubing should be connected to the top of the rotameter since this test is essentially measuring a 'pulling' flow from the pump
- This configuration also applies for aerosol exposure studies using whole-body chambers

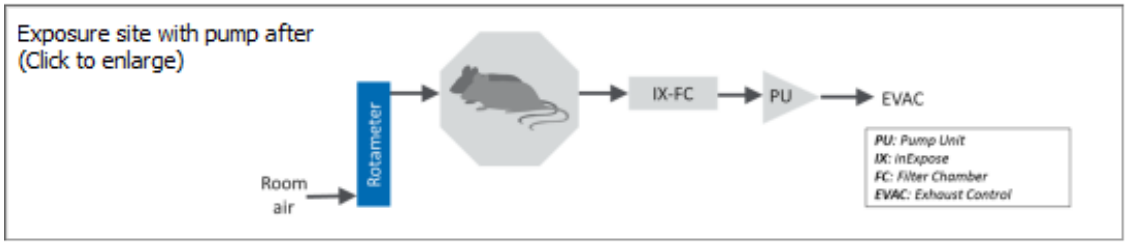

Figure 15. Set-up of rotameter for testing flow from in a negative pressure exposure circuit

5. ROTAMETER READINGS

- Once the rotameter has been connected, click *Next*. The selected pump will turn ON
- The *Pump Output Adjustment* dialogue will be displayed. A reading of ~30 on the rotameter should occur. Click *Next*

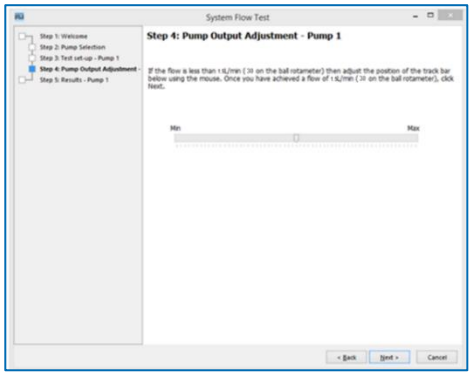

Figure 16. Pump Output Adjustment

  - Note that 30 is the value that corresponds with 1.5L/min flow according to the rotameter's calibration chart
  - Higher values may indicate no buffer is present between pump and rotameter, review the setup
  - A value of ~65 may be found in older versions of flexiWare that use a system Flow test rate of 3 L/min

- If the flow reading on the rotameter is less than 1.5 L/min (rotameter ball is located below 30), adjust the position of the track bar using the slider to achieve a flow of 1.5 L/min on the rotameter, similar to Figure 16. If the rotameter reading reflects the software adjusted value, the flow circuit is leak free. Click *Next*

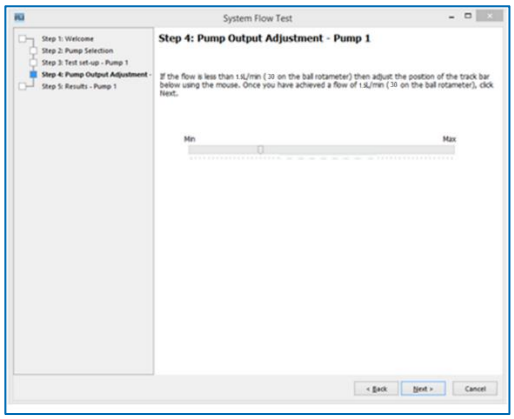

Figure 17. Pump Output Adjustment – Slider movement

» The *Results* dialogue will list the test results of the selected pump as either a Pass or Fail

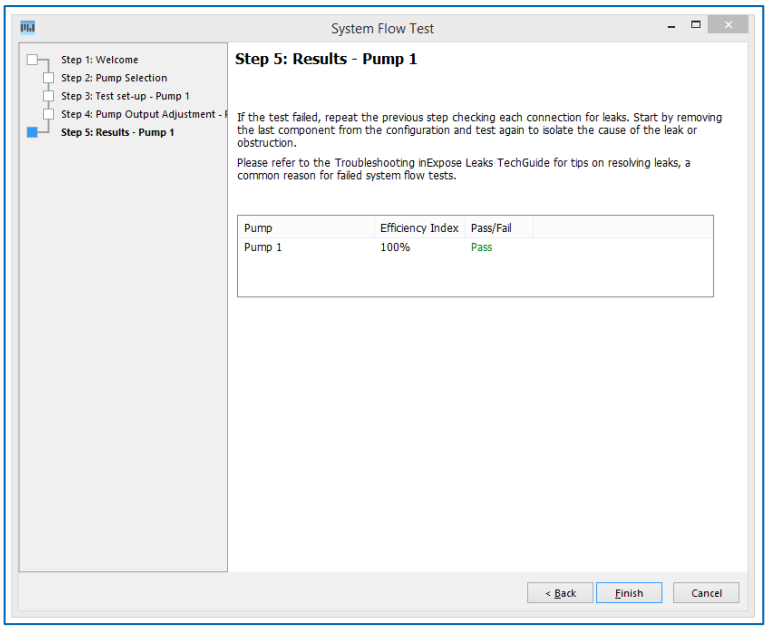

Figure 18. Results from the System Flow Test

» A Pass indicates that the flow circuit is leak free. A Failed test typically indicates that a leak exists in the flow circuit, between the pump and the rotameter. Some of the common locations for a leak have been listed in Section 1

» Click *Back* on the Results dialogue to return to the Test set-up dialogue. Proceed to Section 4 for isolating the location of the leak

» Once the suggestions provided for troubleshooting leaks, have been implemented, re-run the System Flow Test for the same pump to see the new Efficiency Index

» Results from the System Flow Test will be recorded in the Event log on the left side panel of the software

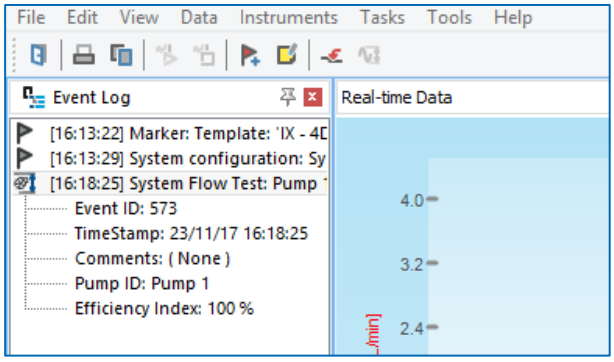

Figure 19. Results from the System Flow Test on the Event log

» It is possible to run a System Flow Test at any point during an experimental session by clicking on the *Instruments* tab at the top toolbar of the software and selecting *System Flow Test'* Note that this is not possible during profile execution

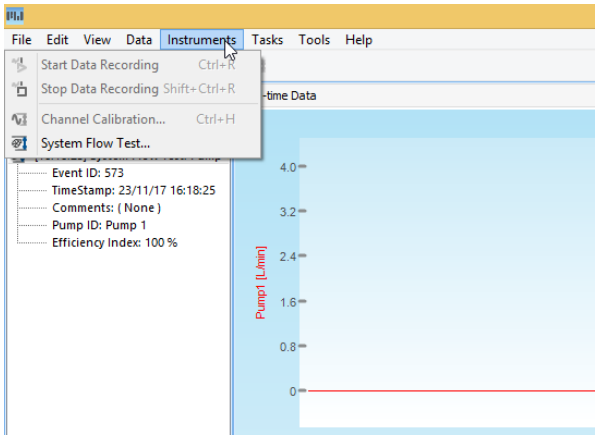

Figure 20. Selection of System Flow Test from the Instruments tab

6. SOLUTIONS TO FIXING LEAKS

- When troubleshooting leaks, we suggest starting with the minimum necessary components: a buffer chamber between the selected pump and rotameter. This allows ruling out a leak in these components before adding additional components to the system
- Cleaning the system and replacement of common consumables such as o-rings and tubing can be helpful to resolve leaks
- Once the particular flow circuit leak source is determined and fixed, check all other components that are a part of that flow circuit by following steps from Section 1 onwards