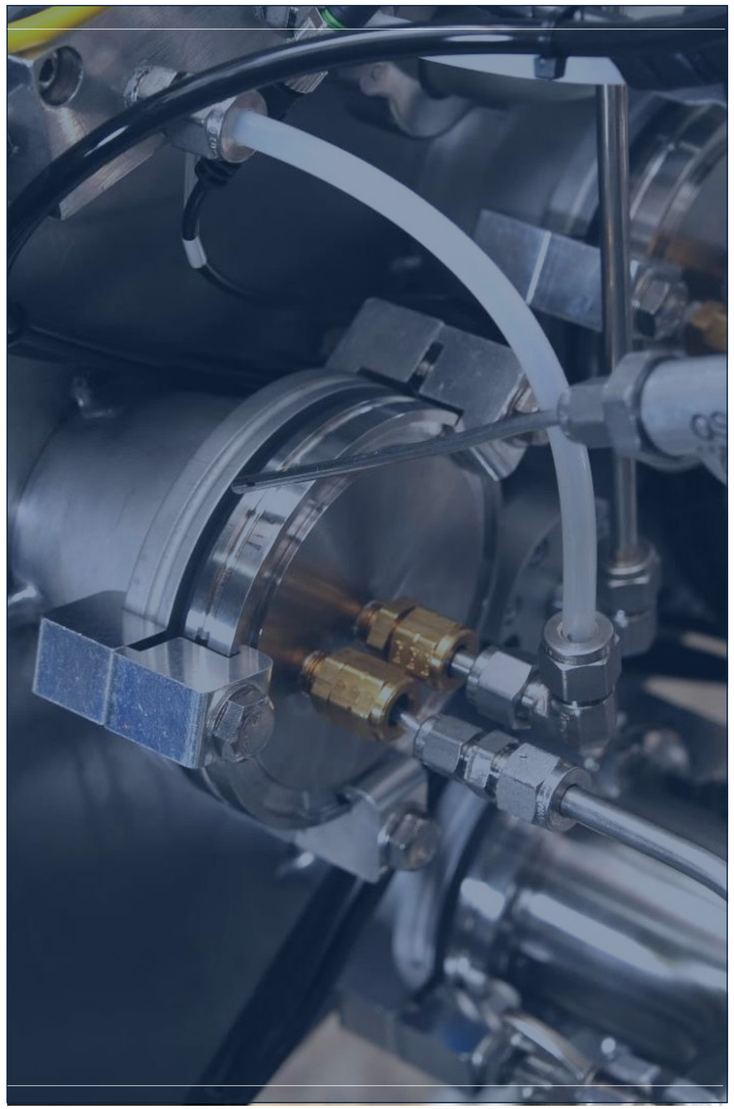
INGRESS LEAK TESTING

Protecting Products from Their Environment

JP De Luca

Sales Manager | Leak Detection Product Manager

LACO TECHNOLOGIES



Overview

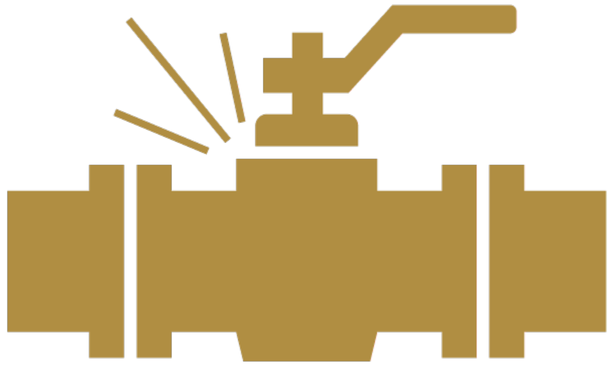
- Why Do You Need to Leak Test?
- Ingression Leak Testing Standards and Guidelines
- Establishing a Leak Rate
- Overview of Leak Testing Methods
  - Helium leak testing
  - Air/Nitrogen Leak Testing
- Selecting a Leak Test Method
- Examples of Ingress Leak Testing Solutions
- Conclusion

Why Do You Need to Leak Test?

Why Leak Test?

- Production leak testing is implemented to verify the integrity of a manufactured part. It can involve 100% testing or sample inspection.

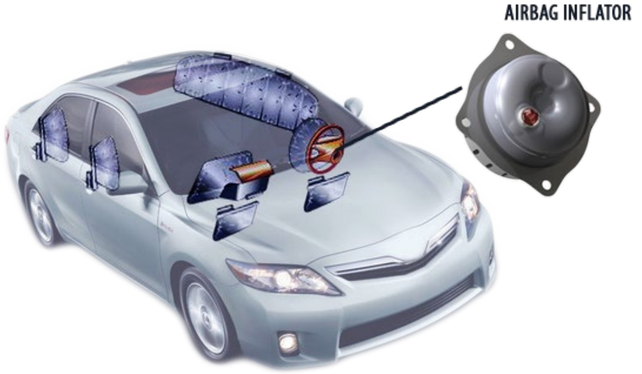
- The goal of production leak testing is to prevent “leaky” parts from getting to the customer. Because manufacturing processes and materials are not “perfect”, leak testing is often implemented



Why Leak Test?

Prevent **OUT Leakage**

- Depletion of Gas in a Sealed Device or System
  - A/C System
  - Pressurized Airbag Inflator
  - Gas Storage Cylinder
- Leaking of Liquids in a Sealed Device or System
  - 55-gallon Drum
  - Liquid Cooling System
  - Drug Delivery System



Why Leak Test?

Prevent **IN Leakage** (Ingress)

- Ingression of Water or Dust
  - Handheld Electronic Device
  - Exterior Lighting
- Ingression of Water Vapor
  - Engine Control Module
  - Pyrotechnic Airbag Inflator
  - Electronic Sensors

Why Leak Test?

Prevent **IN Leakage** (Ingress)

- Ingression of Other Gases
  - Packaged Food Products
  - Pharmaceutical Products
- Ingression of Bacteria
  - Sterile Bioprocess Bags
  - Sterile Packaging

Ingression Leak Testing Guidelines & Standards

Ingression Leak Testing Standards & Guidelines

- International Electrotechnical Commission (IEC)
  - IEC 60529, International Protection (IP) Rating (also called Ingress Protection)
    - Dust and Water Ingression Protection for Electrical Enclosures

IPXX Code – Int'l Protection Marking, IEC Std 605329 (Ingress Protection Marking)

First Digit	Effective protection against solid ingress	Second digit	Effective projection against liquid ingress
0	—	0	
1	>50 mm	1	Dripping water (vertically falling drops).
2	>12.5 mm	2	Vertically dripping water at an angle of 15°.
3	>2.5 mm	3	Water falling as a spray at any angle up to 60°
4	>1 mm	4	Water splashing against the enclosure from any direction.
5	Dust protected	5	Water projected from any direction.
6	Dust tight	6	Water projected in powerful jets from any direction
		6K	Powerful water jets with increased pressure
		7	Immersion, up to 1 m depth
		8	Immersion, 1 m or more depth
		9K	Powerful high temperature water jets

Ingression Leak Testing Standards & Guidelines

- International Electrotechnical Commission (IEC)
  - IEC 60529, International Protection (IP) Rating (also called Ingress Protection)
    - Dust and Water Ingression Protection for Electrical Enclosures
- MIL-STD-883K
  - Hermeticity of Microelectronic Devices
    - Humidity Ingression Protection — MIL-STD-883K

MIL-STD-883K Test Method Standard Microcircuits

This document and process conversion measures necessary to comply with this change shall be completed by 25 August 2017.

INCH - POUND

MIL-STD-883K
w/CHANGE 2
22 February 2017
SUPERSEDING
MIL-STD-883K
w/CHANGE 1
20 July 2016

DEPARTMENT OF DEFENSE

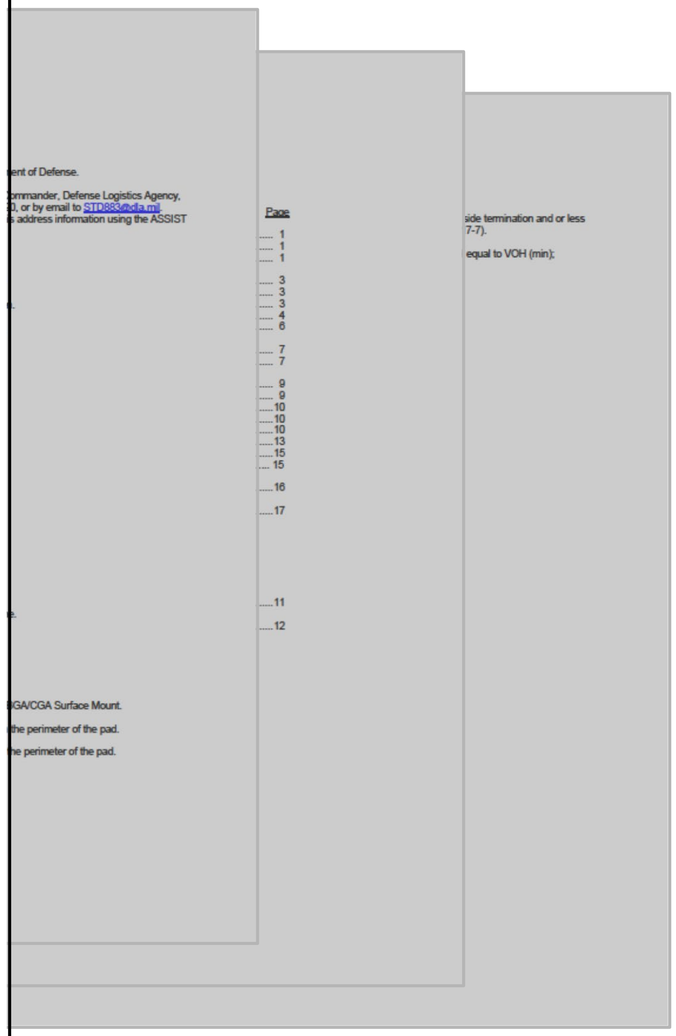
TEST METHOD STANDARD

MICROCIRCUITS

AMSC N/A

FSC 5962

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.



Ingression Leak Testing Standards & Guidelines

- International Electrotechnical Commission (IEC)
  - IEC 60529, International Protection (IP) Rating (also called Ingress Protection)
    - Dust and Water Ingression Protection for Electrical Enclosures
- MIL-STD-883K
  - Hermeticity of Microelectronic Devices
    - Humidity Ingression Protection — MIL-STD-883K
- Integrity Testing for Pharmaceutical Industry
  - ASTM, USP, ISO, PDA, and others
  - Both Out-leakage and Bacteria Ingress
- ASTM
  - Multiple Standards

Ingression Leak Testing Standards & Guidelines

- For many applications there may exist no standards or guidelines for determining a leak rate criteria that will ensure appropriate ingression protection for your product
  - **Example 1**: Parts, under 15 psig of pressure, should not leak more than 1 small drop of liquid within 1 hour
  - **Example 2**: No moisture ingress after 1 hour of liquid exposure under a pressure of 30 psig
  - **Example 3**: No leak!

Establishing a Leak Rate

Establishing a Leak Rate

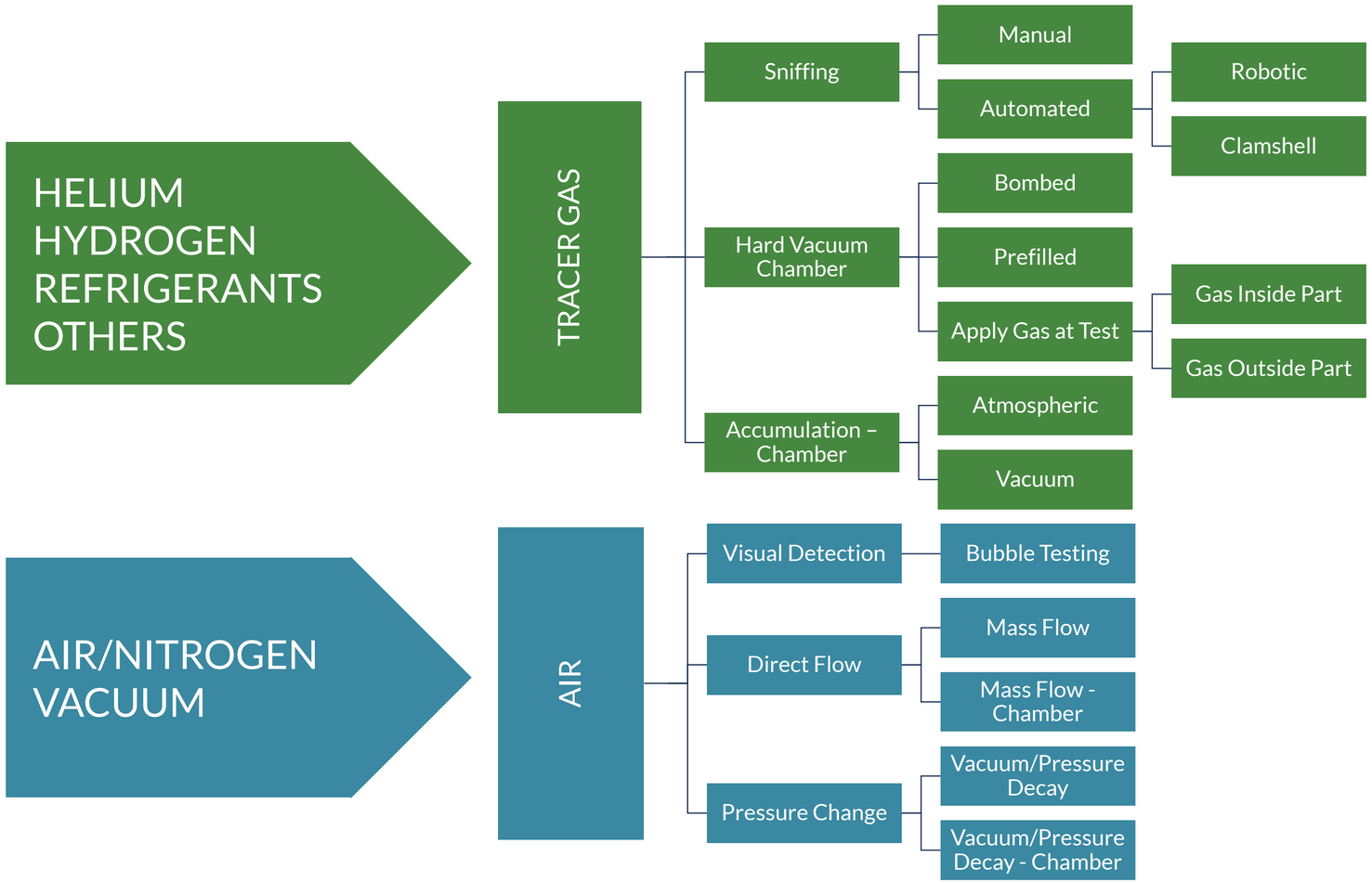
- Understanding the operating conditions of the product
  - Will the product be submerged?
  - Will the product be implanted in a person?
  - Will the product be exposed to weather?
  - Will the product see different altitudes?
  - What is the internal operating pressure of the product?
  - What is the nature of the ingress?
  - What conditions might drive a contaminant into the product?
- Other Criteria
  - What is the expected life time of the product or its content?

Establishing a Leak Rate

- Empirical studies may be necessary to determine what an ideal leak rate might be for a given product.
  - LACO has conducted many studies duplicating operating conditions, measuring ingress leakage (moisture ingress for instance)
  - LACO has extensive experience running tests using our built-in calibrated leak standards – **Micro Tube Capillary (MTC)** – in mockup parts to replicate various environmental conditions. Data collected is a great reference database to help our customers determine the required leak rate

Overview of Leak Testing Methods

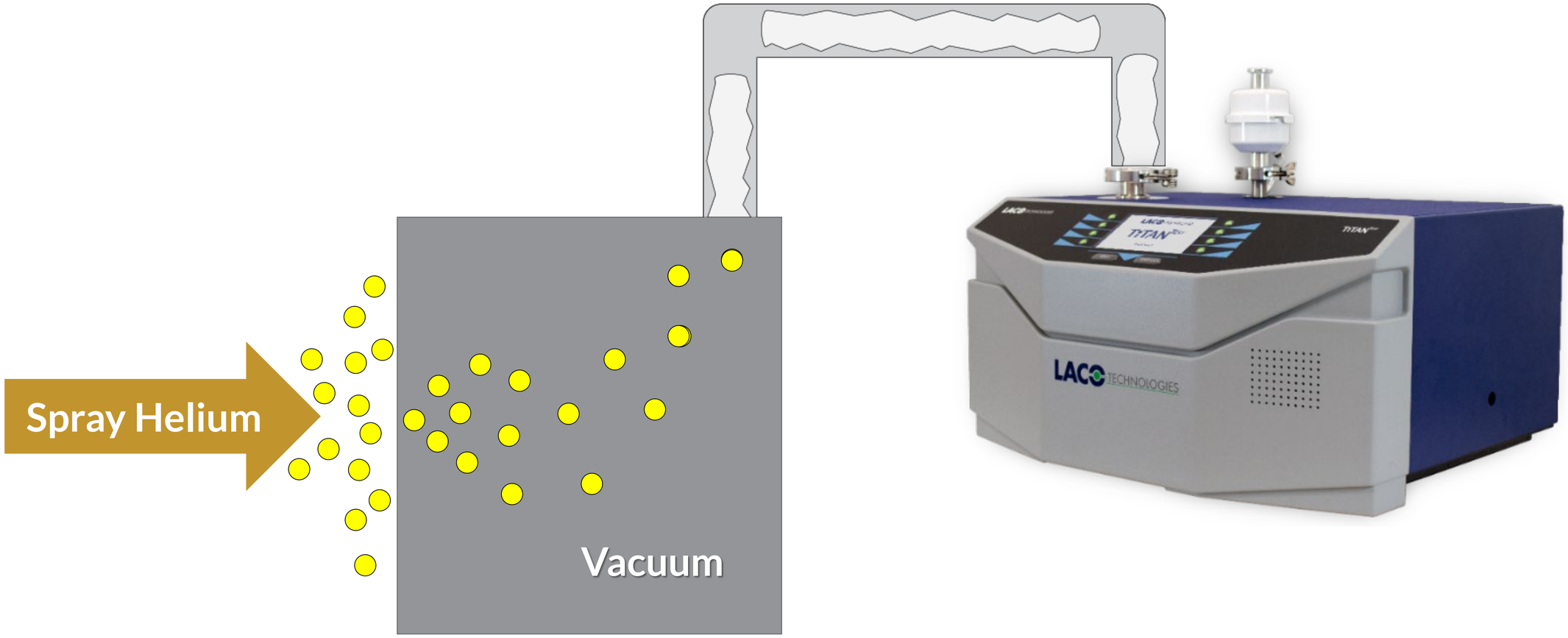
Common Production Leak Testing Methods



Helium Leak Testing

Hard Vacuum / Sniffing Methods

Hard Vacuum Test Outside-In: Helium Spray



Hard Vacuum Test Inside-Out

Helium Management Module

Helium

Helium Pressure

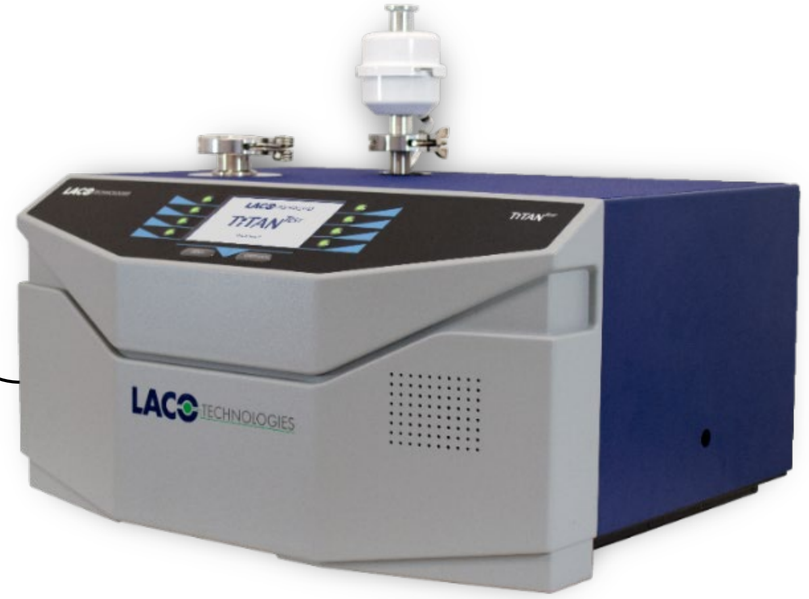
Vacuum

Helium Sniffing Test Principle

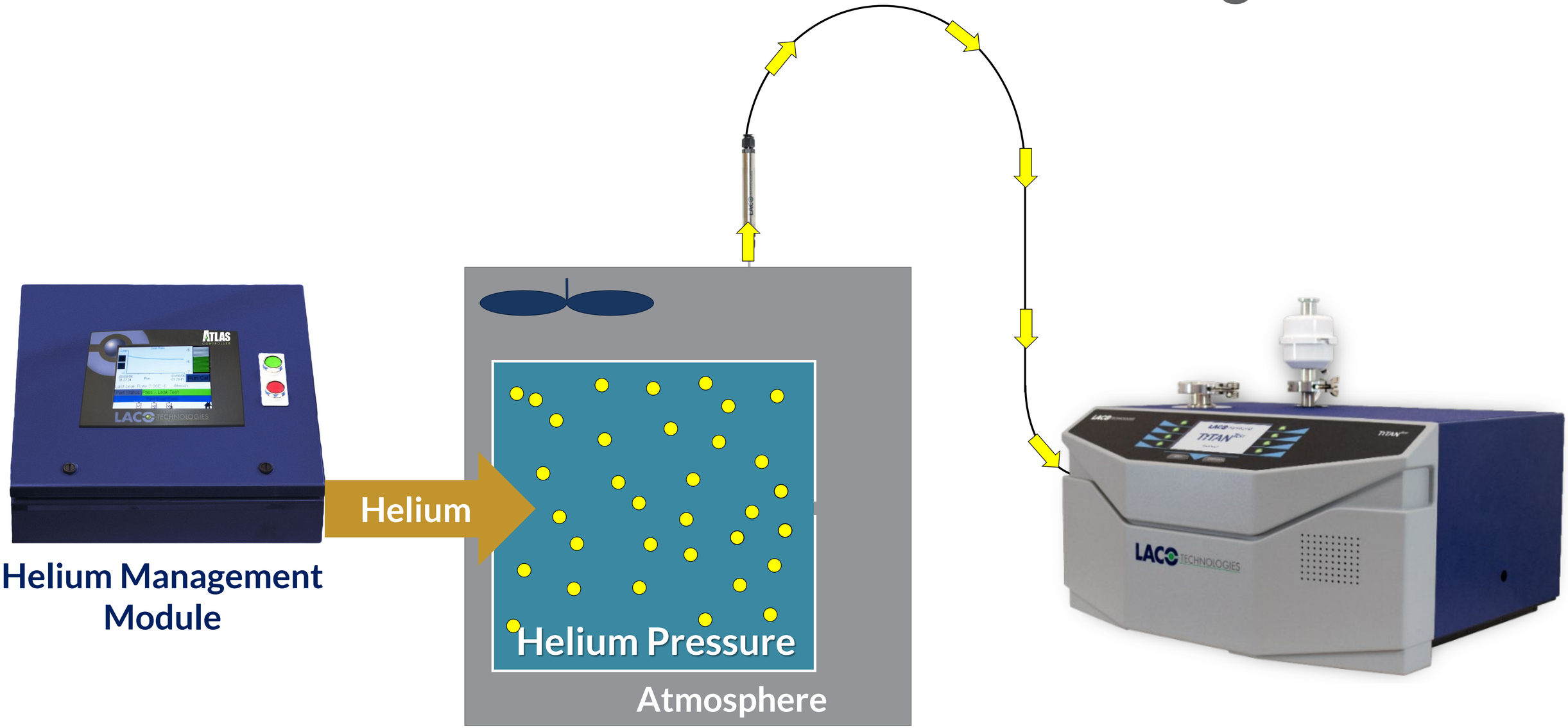
Helium Management Module

Helium

Helium Pressure



Accumulation Test Inside-Out: Helium Charged Part

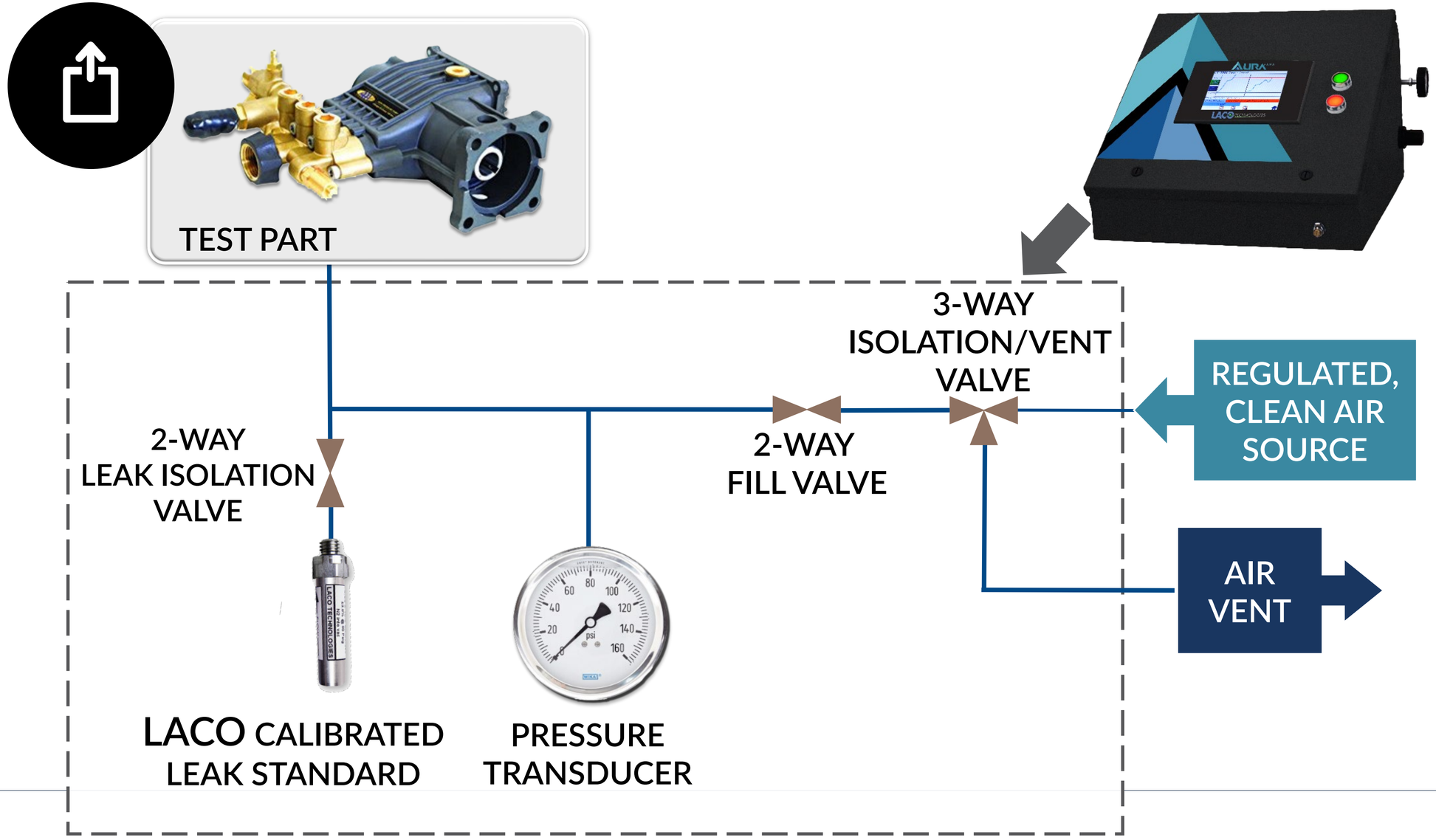


Helium Management Module

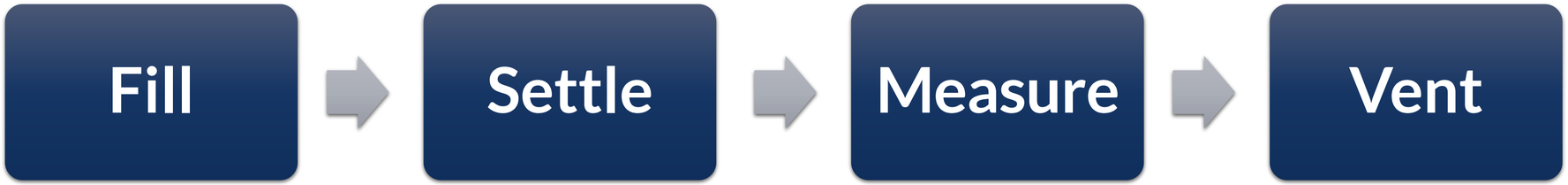
Air/Nitrogen Leak Test Testing

Pressure Decay / Mass Flow

Air Pressure Decay Leak Testing – OPEN Part



Air Pressure Decay Leak Test Basic Steps



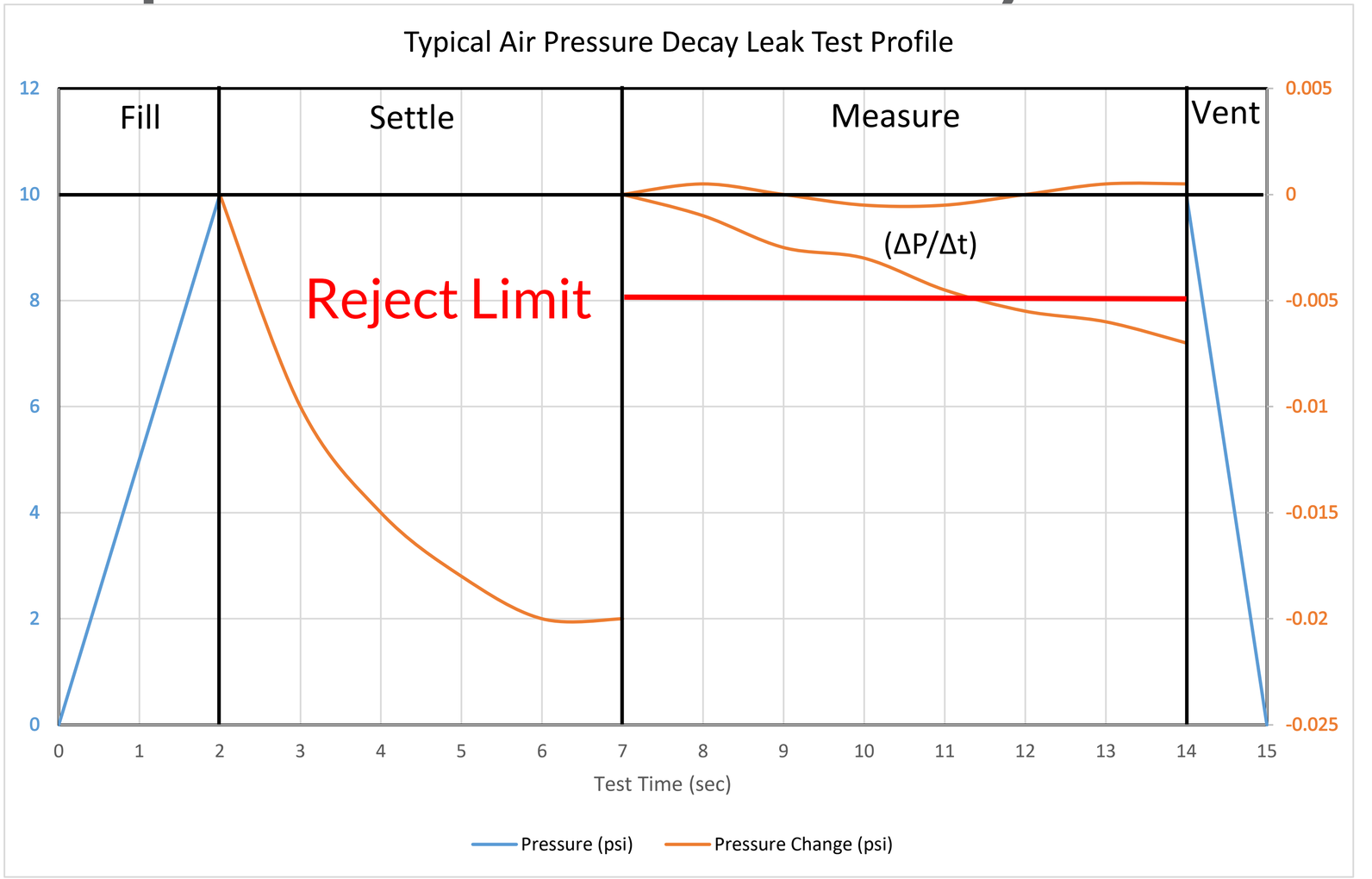
Achieve test pressure and isolate test volume

Allow air pressure to stabilize (temperature and volume)

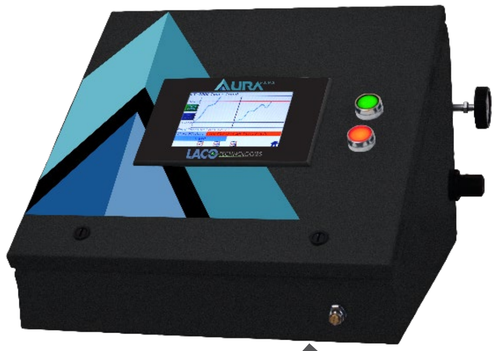
Monitor pressure drop. Determine PASS/FAIL

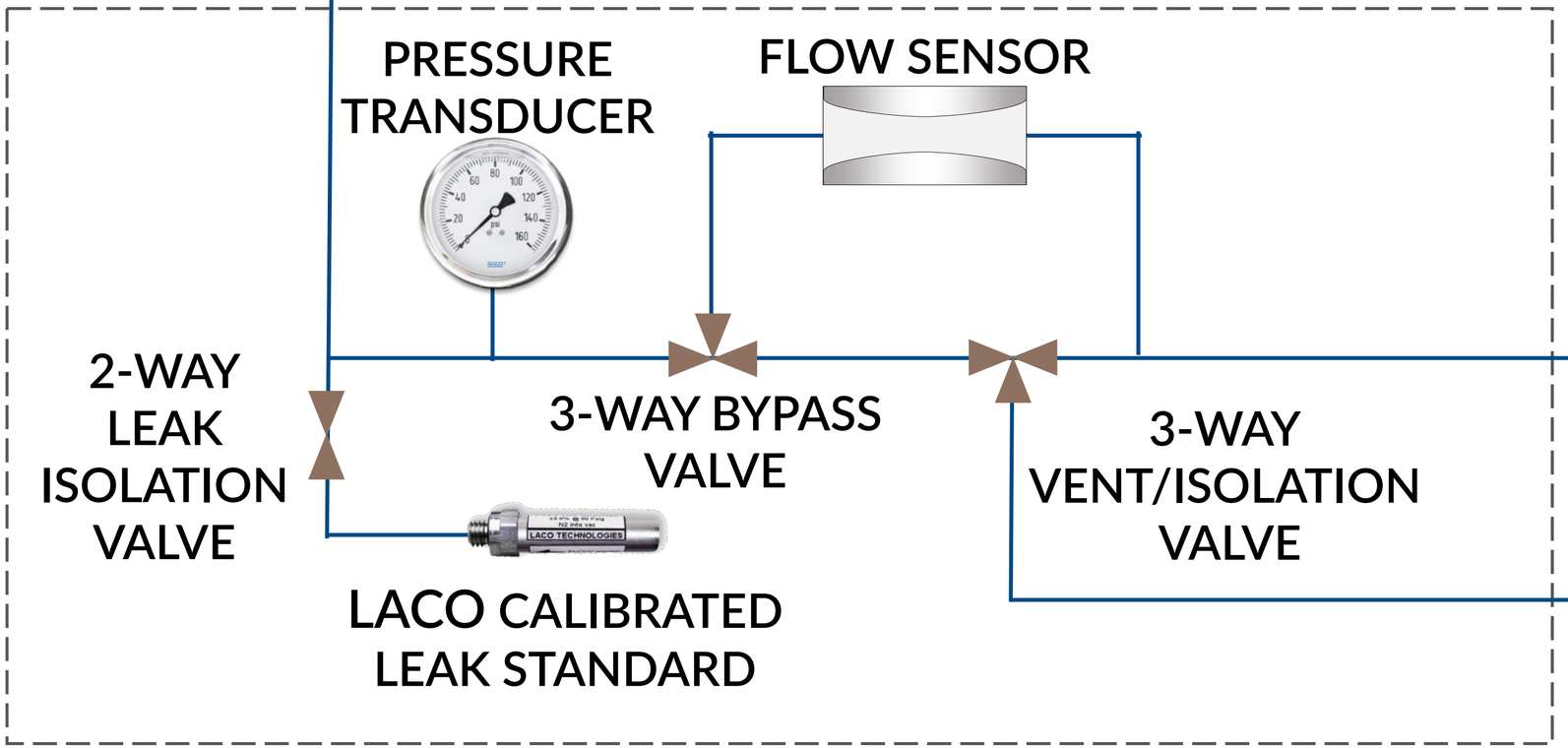
Allow air to vent from test volume

Basic Principle of Air Pressure Decay Leak Test

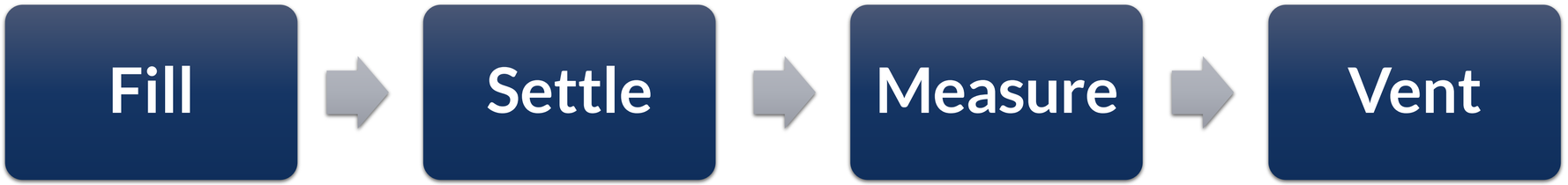


Direct Air Mass Flow Test – OPEN Part





Direct Mass Flow Test – Basic Steps



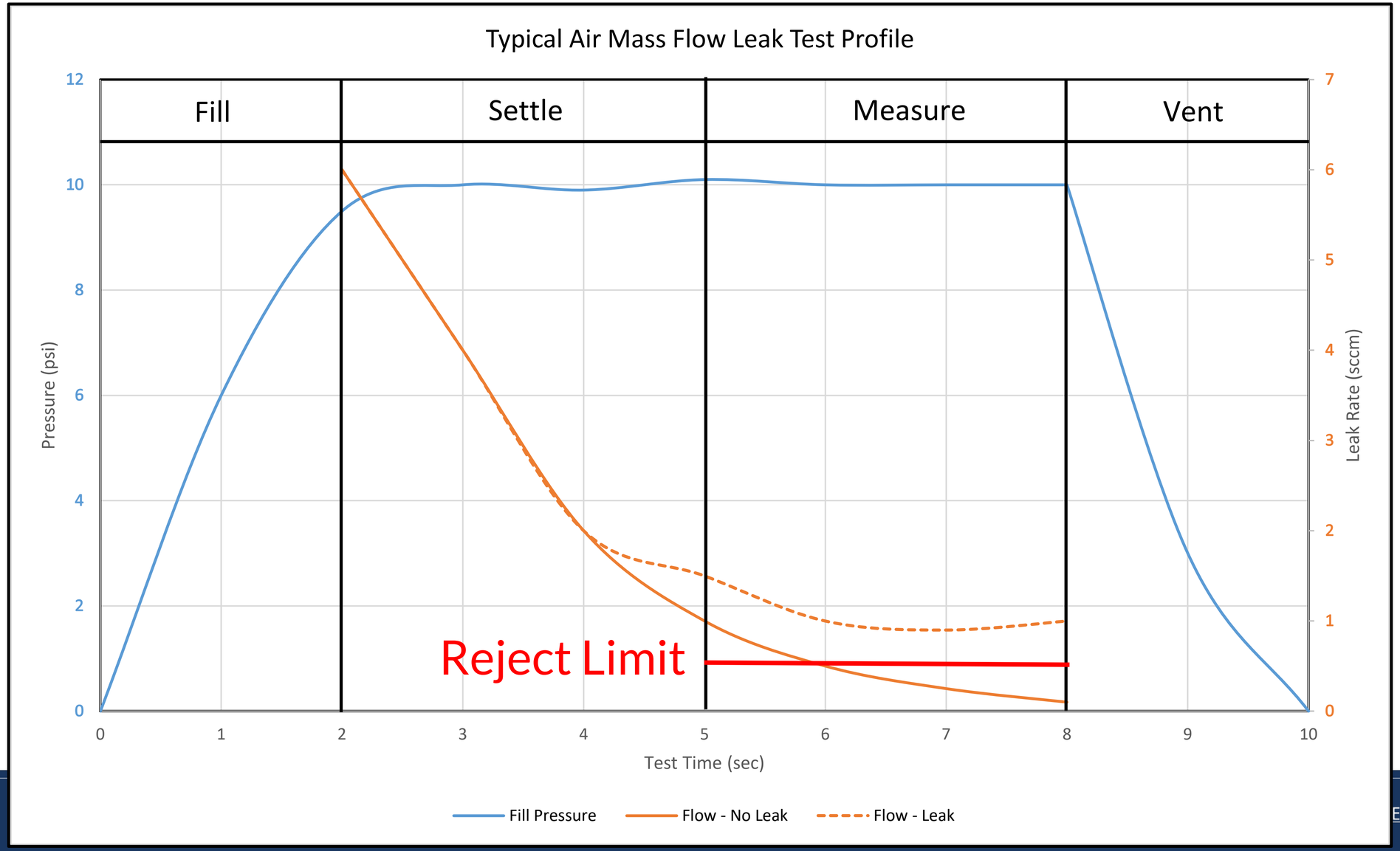
Bypass fill, then direct fill the test part

Allow air pressure to stabilize (temperature and volume)

Measure Leak Rate (Flow) Determine PASS/FAIL

Allow air to vent from test volume

Basic Principle of Air Mass Flow Leak Test



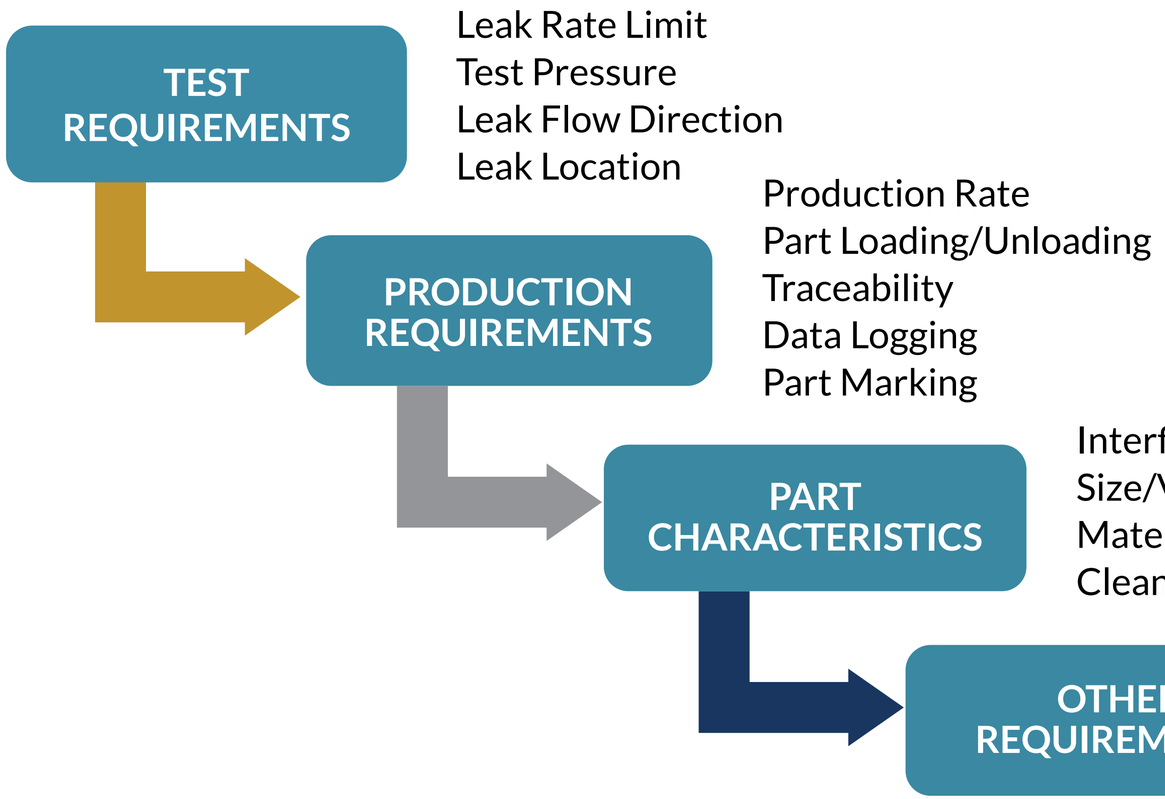
Common Production Leak Test Methods with Associated Characteristics

Method	Quantify	Locate	Global 1	Go / No Go	Test Media	Test Volume Dep.[2]	Relative Cost	Typical Sensitivity (atmcc/sec)
Air Pressure (Vacuum) Decay	Yes	No	Yes	Yes	Air	Yes	Medium	0.01
Mass Flow	Yes	No	Yes	Yes	Air	Yes	Medium	0.01
Dye Liquid Tracers	No	Yes	No	No	Liquid	No	Low	0.001
Bubble Immersion	No	Yes	No	No	Air	No	Low	10^{-4}
Thermal Conductivity Sniffing	Limited	Yes	No	Yes[3]	Helium	No	Low	10^{-5}
SF6 Sniffing	Limited	Yes	No	Yes[3]	SF6	No	Low-Med	10^{-5} to 10^{-9}
Halogen Sniffing	Limited	Yes	No	Yes[3]	Halogens	No	Low-Med	10^{-4} to 10^{-9}
Helium Mass Spec Sniffing	Limited	Yes	No	Yes[3]	Helium	No	Med-High	10^{-7}
Helium Mass Spec Atmosphere Accumulation	Yes	No	Yes	Yes	Helium	Yes	High	Approx. 10 -4
Helium Mass Spec Hard Vacuum	Yes	Yes	Yes	Yes	Helium	No	High	10-9
Trace Gas Mass Spec Hard Vacuum	Yes	Yes	Yes	Yes	R134a, SF6, Air, H2, NO_2, CO_2	No	High	10-7 gas dependent

1. The test method measures the global leak rate of the part, versus individual leaks.
2. The test volume significantly affects the test cycle time and/or sensitivity.
3. Result may be operator dependent.

Selecting a Leak Test Method

Selecting a Leak Test Method



Many of these requirements and characteristics have a direct impact on the available leak test method.

Example of Method Selection

Method	Leak Rate Sensitivity (atmcc/sec)				
	> 0.01	0.01 – 10^{-4}	10^{-4} – 10^{-6}	10^{-6} – 10^{-8}	< 10^{-8}
Tracer Gas Leak Testing					
Helium Sniffing - Manual	P	C	C	X	X
Helium Sniffing - Robotic	P	C	C	X	X
Helium Sniffing - Chamber/Clamshell	C	C	P	X	X
Hard Vacuum Helium - Bombed	X	P	C	C	C
Hard Vacuum Helium - Prefilled	P	P	C	C	C
Hard Vacuum Helium - Gas Inside Part	X	P	C	C	C
Hard Vacuum Helium - Gas Outside Part	X	P	C	C	C
Helium Accumulation (Atm/Vac)	C	C	P	X	X

C = Compatible

P = Possibly Compatible, but not Ideal

X = Not Compatible

Examples of Ingress Leak Testing Solutions

Example of Ingress Leak Testing: Application #1

- **Part Description**: Sealed Pharmaceutical Packages
- **Leak Rate Requirement**: Comply with ASTM F2096 and ASTM D3078 Bubble Testing to Assess Package Integrity
- **Test Pressure**: Vacuum
- **Selected Leak Testing Method**: Bubble Leak Testing

Bubble Leak Tester

- Part is submerged under water
- A vacuum is generated above the water
- A pressure differential is created between the

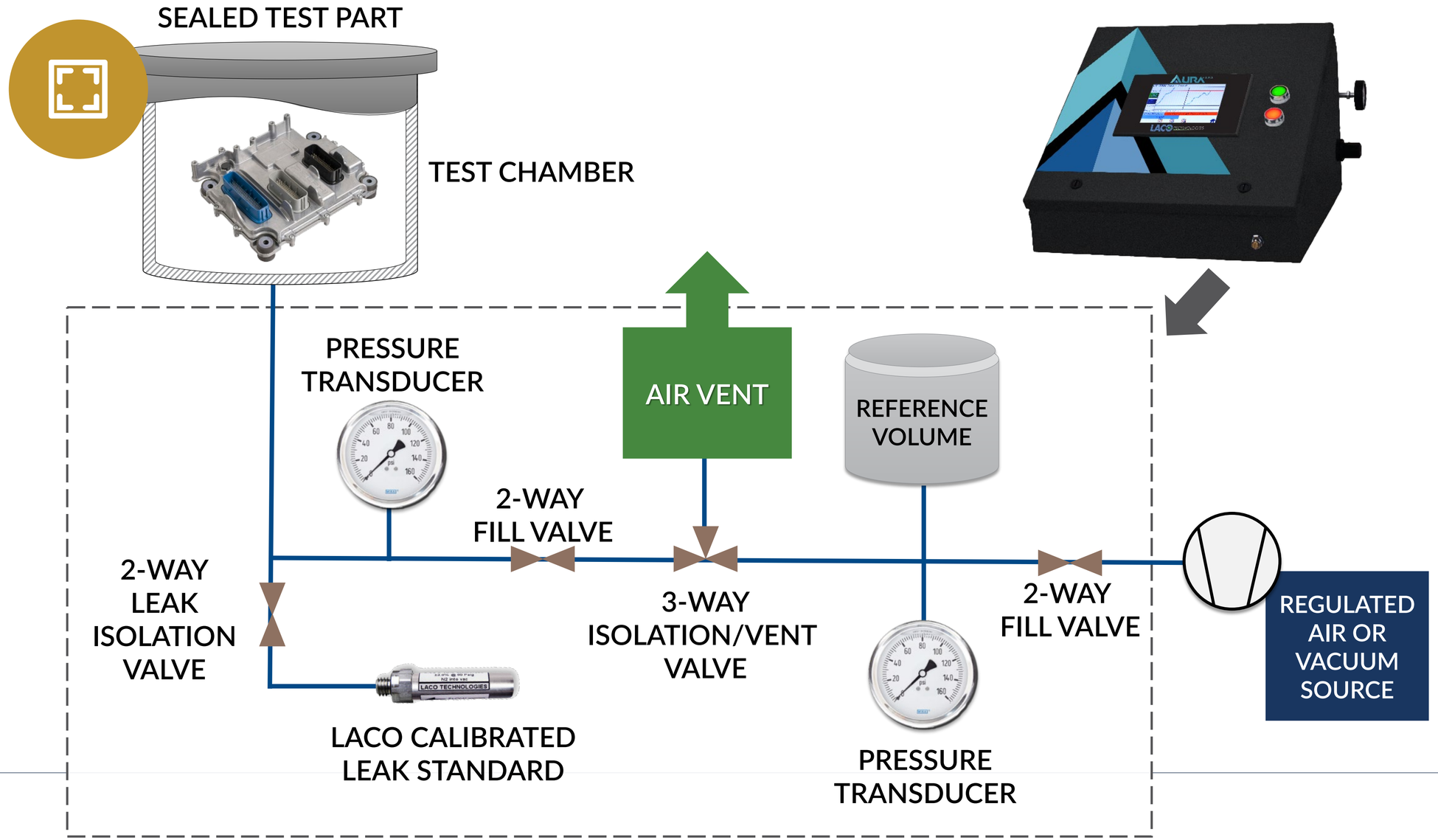
  inside and the outside of the part
- Bubbles will form at leaking point(s)

Note: Size and stream of bubbles will vary based on the part leakage level

Example of Ingress Leak Testing: Application #2

- **Part Description**: Sealed Electrical Enclosure
- **Leak Rate Requirement**: Comply with the IP67 Standard
- **Leak Rate Specification**: 1 SCCM (typical) CM
- **Test Pressure**: 1.5 psig
- **Selected Leak Testing Method**: Pressure Decay

Air Pressure Decay Chamber Test – SEALED Part



Chamber Air Pressure Decay Leak Test Basic Steps

Pre-fill test chamber with reference volume and check pressure for gross leak

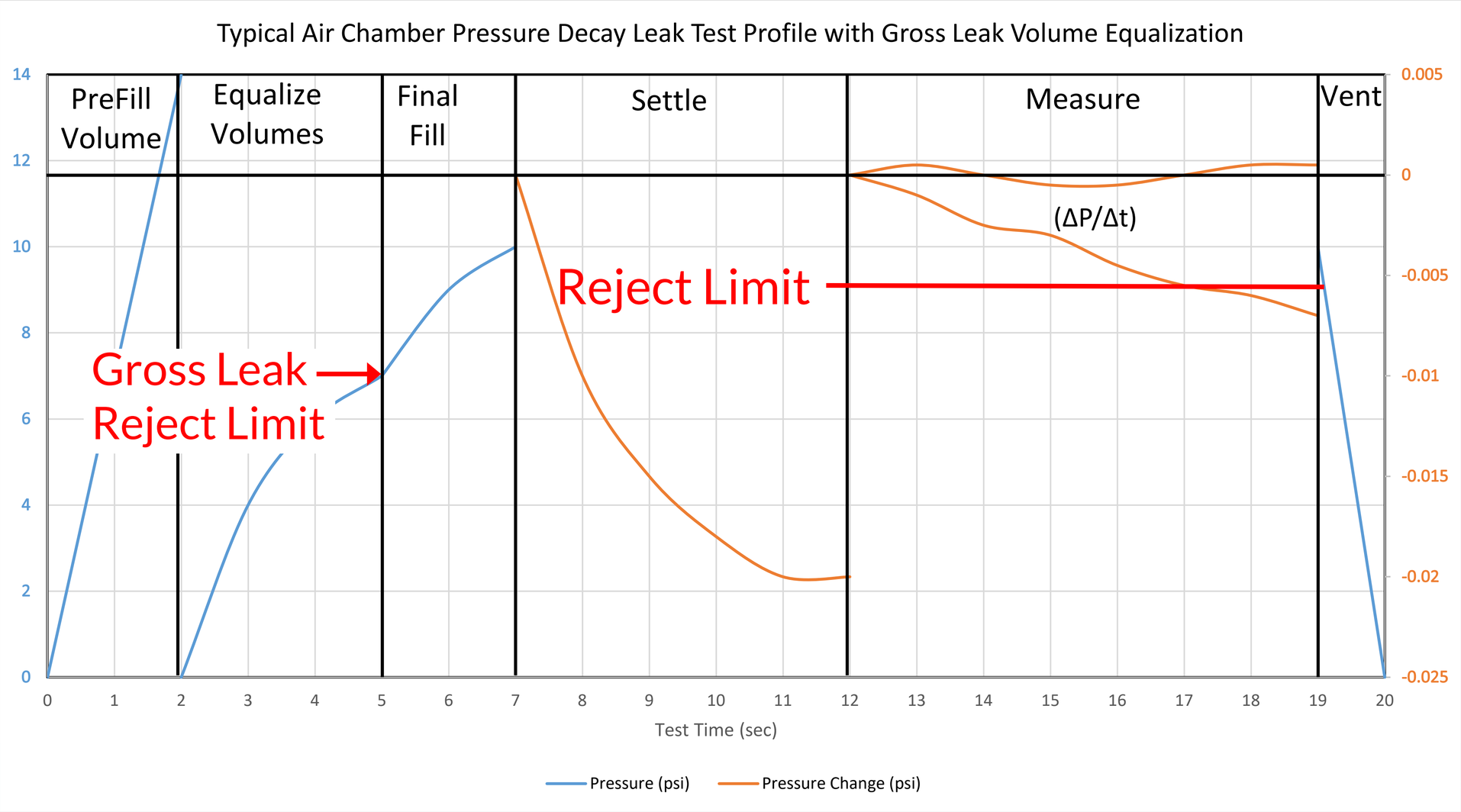
Continue fill to achieve test pressure and isolate test volume

Allow air pressure to stabilize (temperature and volume)

Monitor pressure drop. Determine PASS/FAIL

Allow air to vent from test volume

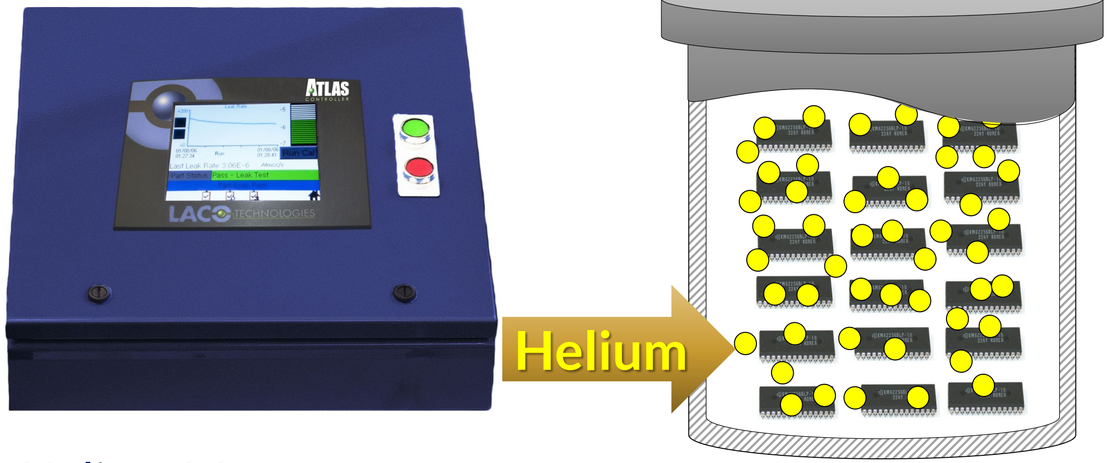
Basic Principle of CHAMBER Air Pressure Decay Leak Test



Example of Ingress Leak Testing: Application #3

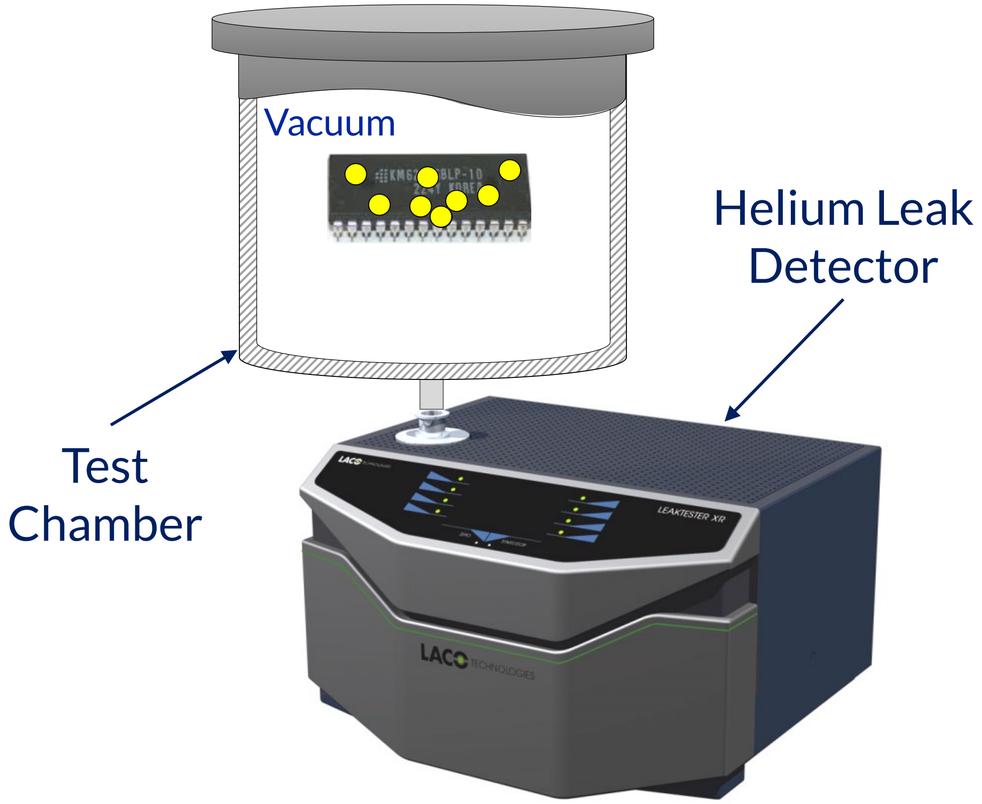
- **Leak Testing Application**: Hermetically Sealed Device
- **Part Description**: Small Sealed Part
- **Leak Rate Requirement**: 1 x 10^{-8} atm.cc/sec
- **Leak Testing Method**: Helium Bombing Method
- **Using the MIL-STD-883K Standard**
  - Helium is forced into the part prior to the helium leak test process
  - Bombing Pressure: 90 psig
  - Pressurization Time: 5 hours
  - Dwell Time: 30 min.

Hard Vacuum Test Inside-Out: Bombing Method – MIL-STD-883K



Helium Management Module

Bombing Chamber



Step 1: Helium bombing process (several parts at a time)

Step 2: Helium leak testing process

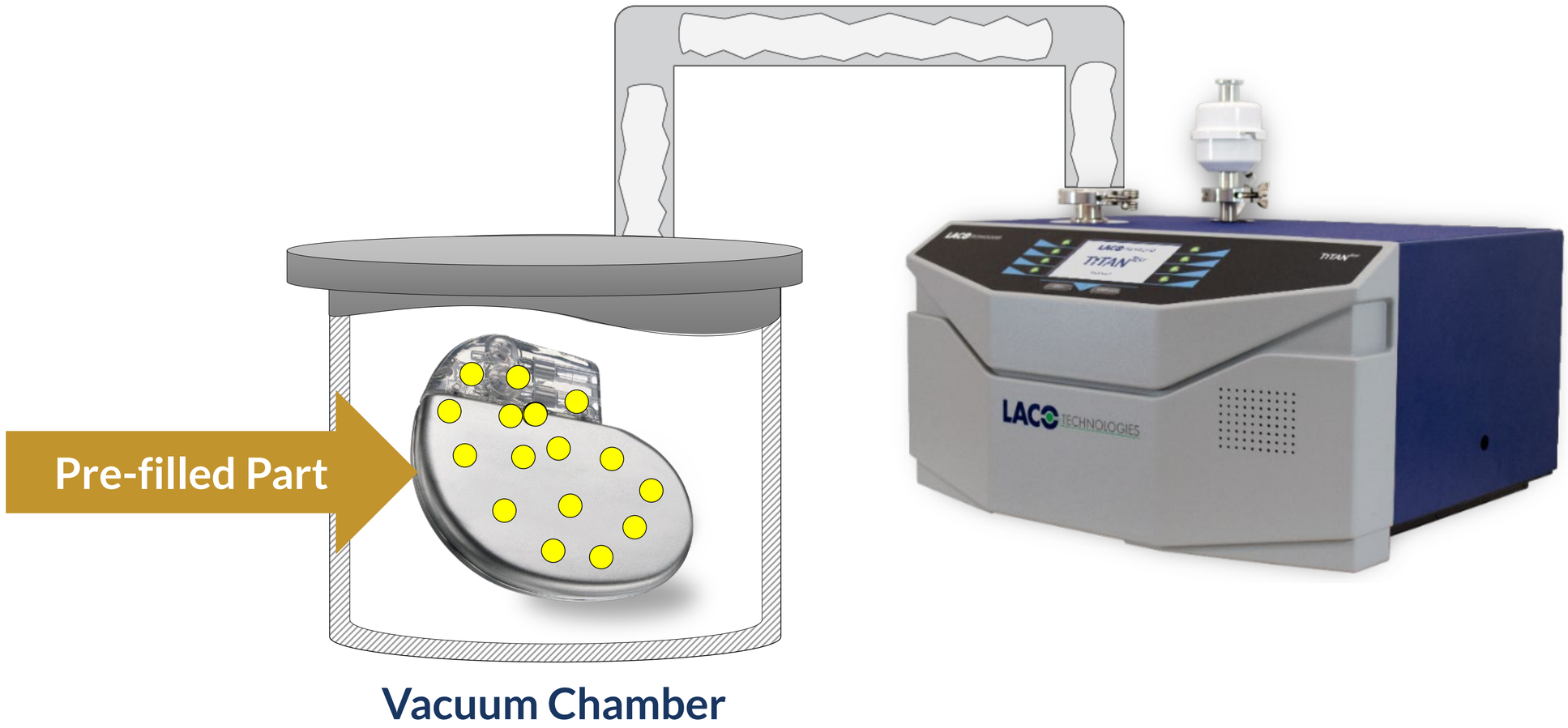
Alternative Solution To Helium Bombing Method

- The Bombing Method Requires
  - One or more bombing chambers
  - A helium management system (to evacuate, pressurize with helium and then vent the helium out of the bombing chamber)
  - The bombing time can be quite long – hours - (based on the leak rate requirements, the part internal dead space and the maximum bombing pressure the parts can withstand)
  - The bombing method has limitations in terms of leak rate sensitivity (MIL-STD-883K)
- The Alternative
  - Whenever possible, seal the parts within a helium controlled environment. This alternative is a good economical solution (App # 4)

Example of Ingress Leak Testing: Application #4

- **Leak Testing Application**: Sealed Part
- **Part Description**: Medical Implant
- **Leak Rate Requirement**: 1 x 10^{-9} atm.cc/sec
- **Leak Testing Method**: Helium Hard Vacuum with Test Chamber
- Part is welded in a controlled environment with a specific % of helium
- Helium is present in the part prior to the helium leak test

Hard Vacuum Test Inside-Out



Conclusion

Conclusion

- More and more applications are for ingress leak testing.
- The ingress can be of different nature and size, depending on the product, application requirements, standards, etc.
- Defining the correct leak rate for some applications can be challenging and require empirical studies, LACO has extensive experiences in running such studies and helping customers defining the correct leak rates.
- LACO is unique with offering the widest range of leak testing methods to all ingress leak testing requirements.

THANK YOU!

- Stop By Our Booth (**#1438**) to Validate Your Coupon for a FREE Calibrated Leak Standard
- Contact Us to Review Your Current Calibration and Validation Strategy
- LinkedIn Group: ***Production Leak Testing***
- Blog: ***www.lacotech.com/posts***
- Website: ***www.lacotech.com***

RESOURCES

IPXX Code – Int'l Protection Marking, IEC Std 605329 (Ingress Protection Marking)

First Digit	Effective protection against solid ingress	Second digit	Effective projection against liquid ingress
0	—	0	
1	>50 mm	1	Dripping water (vertically falling drops).
2	>12.5 mm	2	Vertically dripping water at an angle of 15°.
3	>2.5 mm	3	Water falling as a spray at any angle up to 60°
4	>1 mm	4	Water splashing against the enclosure from any direction.
5	Dust protected	5	Water projected from any direction.
6	Dust tight	6	Water projected in powerful jets from any direction
		6K	Powerful water jets with increased pressure
		7	Immersion, up to 1 m depth
		8	Immersion, 1 m or more depth
		9K	Powerful high temperature water jets

RETURN

MIL-STD-883K Test Method Standard Microcircuits

This document and process conversion measures necessary to comply with this change shall be completed by 25 August 2017.

INCH - POUND

MIL-STD-883K
w/CHANGE 2
22 February 2017
SUPERSEDING
MIL-STD-883K
w/CHANGE 1
20 July 2016

DEPARTMENT OF DEFENSE

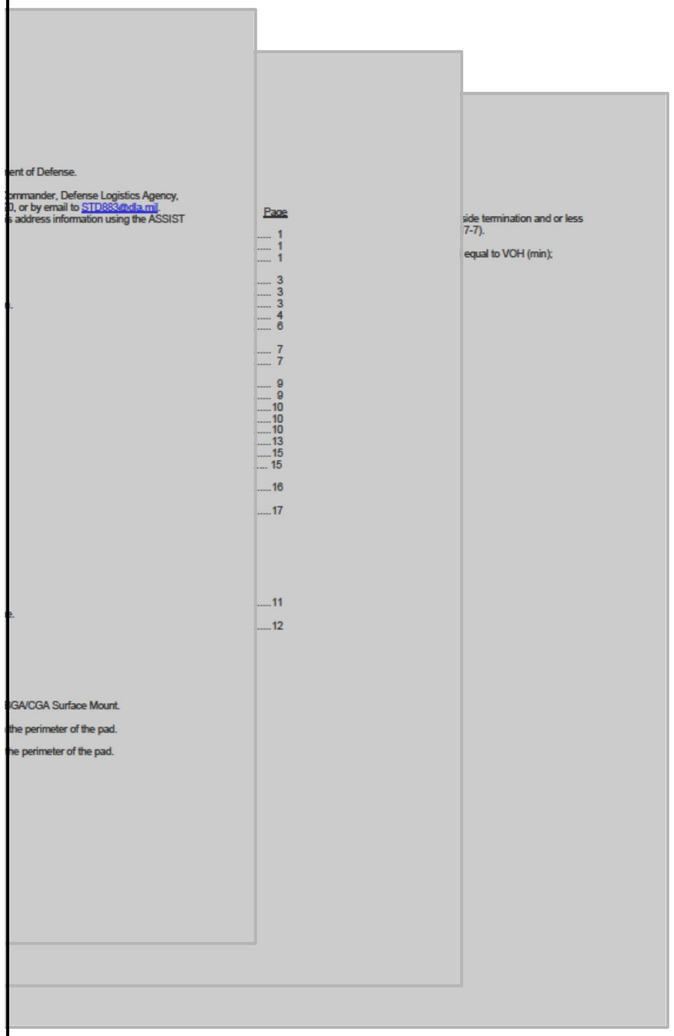
TEST METHOD STANDARD

MICROCIRCUITS

AMSC N/A

FSC 5962

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.



RETURN