Finding Leak Testing Success Through Calibration and Validation

Paul Chamberlain
President, CEO

LACO TECHNOLOGIES
Overview

• Confidence in Your Leak Test Results
• Sources of Uncertainty
  • Pressure decay leak testing
  • Helium leak testing
• Addressing Uncertainty
• Calibrated Leak Standards
  • Types
  • What to look for
• Calibrating Your Process
• Validating Your Process
• Conclusion
Confidence in Leak Testing

Peace of Mind Your Measurement System is Working Properly
How Fast Am I Driving?
I Am Driving Faster Than I Think!

Car speedometer calibrated with a 21.4” diameter factory-installed tire

Speedometer:
60 mph = 60 mph

Change stock tires to new 24.6” diameter tire

Speedometer:
60 mph = 68 mph

SPEEDING TICKET
Without Confidence in My Leak Testing Process, Am I…

• Shipping bad parts?

• Scrapping good parts?

• Not taking enough time to measure the leak?

• Taking too much time leak testing?
What Can Destroy My Confidence in My Leak Test Process?

LEAK RATE

- Environmental Conditions
- Leak Test Parameters
- Part Variations
- Instrument & System Components
- Fixture Seals

© 2017 LACO Technologies. All Rights Reserved.
What Can Destroy My Confidence in My Leak Test Process?

When these change, the leak rate can change!
Sources of Uncertainty

What can cause your leak test process to produce bad results?
What Can Destroy My Confidence in My Leak Test Process?

LEAK RATE

- Environmental Conditions
- Leak Test Parameters
- Part Variations
- Instrument & System Components
- Fixture Seals

© 2017 LACO Technologies. All Rights Reserved.
Air (Pressure Decay) Leak Testing

What can affect my results?

• Environmental Conditions
  • Room temperature **CHANGE**

• Part Variations
  • Incoming part temperature **CHANGE**
  • Part test volume **CHANGE**
  • Different part configurations
  • Part contamination

• Fixture Seals
  • Seal wear or damage

• Instrument/System
  • Leaky valve

• Leak Test Parameters
  • Change in settle timer
  • Change in leak test timer
Helium Leak Testing

What can affect my results?

- **Environmental Conditions**
  - Helium background in the test area
- **Part Variations**
  - Part contamination
- **Fixture Seals**
  - Seal wear or damage
  - Helium permeation of seals (causing high helium background)
- **Instrument/System**
  - Leaking valve
  - Helium background in the instrument/system
  - Someone changed the tracer gas and accidentally connected argon
- **Leak Test Parameters**
  - Change in leak test timer
  - Change in helium fill pressure

© 2017 LACO Technologies. All Rights Reserved.
Addressing Uncertainty

How to gain confidence in my leak testing process results

www.lacotech.com
Addressing Uncertainty — System Design

What can be done in System Design?

• Potentially monitor environmental conditions
• Monitor incoming part temperature
• Design software that detects changes in critical recipe parameters – requiring re-calibration
• Build in performance checks into each test cycle such as background signal levels
• Provide software features that allow for user-defined calibration expiration intervals
What Else?

System Design alone can’t do it all.

• How can we challenge the system?
• What protocol will ensure ongoing confidence?
• What can be used on existing systems, that may not be optimally designed, to gain confidence?
System Calibration and Validation

Even with the best System Design and Process Monitoring, *calibration* and *validation* with a **Calibrated Leak Standard** is required to instill ultimate confidence in your system.

- Calibrated Leak Standards – known reference leak
- Calibrated Leak Standards are used in the leak test process along with a robust protocol to **CALIBRATE** and **VALIDATE** your system
Types of Calibrated Leak Standards
Types of Calibrated Leak Standards

Reservoir
- TEST GAS
  - Helium
  - Refrigerant

Open Style
- TEST GAS
  - Helium
  - Air

USE / CALIBRATION
- Vacuum
- Sniffing

(TEST GAS USE / CALIBRATION)

www.lacotech.com
Leak Element Types

GAS FLOW

Helium
- Permeation
- Physical

Air
- Physical

ELEMENT

- Glass/Quartz
- Teflon
- Crimped Capillary
- Rigid Glass
- Micro Tube Capillary
- Laser Drilled Orifice

www.lacotech.com
What to Look for in a Calibrated Leak

- Correct style for the application
  - Open-style versus Reservoir
  - Sniffer versus vacuum
  - Capillary versus permeation element

- Robustness
  - Protection & sensitivity to particulate contamination
  - Sensitivity to shock, vibration, impact

- Stability
  - Potential for long term drift
  - Temperature sensitivity
  - Low depletion rate (for reservoir types)

- Representative of an Actual Leak
  - Response time
  - Response to pressure conditions (flow regime)

- Accurate
  - Accredited calibration
  - Measurement uncertainty
Calibrated Leak Label

Calibrated Leak Standard

Mod No: CM51X-81012V0/1
Ser No: 1506
ID No: 09030
Cal No: 773862
Cal Date: 10 Oct 2017

Leak Rate (atmcc/sec) 5.62 x 10^-8 ±15% into vac

Temp: 23.2°C
Temp Cdef: 0.1%/°C
Cal Gas: Helium
Gas Press: 97.8 Psig
Depl Rate: 0.2%/year
Helium Leak Standard with Reservoir
Attach to Vacuum Test Chamber
Open-Style Air Leak Standard
Attach to Pressure Decay LT Manifold
Open-Style Leaks
For Installation Into Actual Parts
Leak Built Into a Dummy Part
Helium Bombing a Sealed Part
Pre-Filled and Sealed Part
Leak Built Into an Actual Part
Calibrating

Using calibrated leak standards for leak test process calibration

www.lacotech.com
Calibration Using a Calibrated Leak Standard

Instrument Versus System Calibration

<table>
<thead>
<tr>
<th>Instrument Only</th>
<th>Instrument + Fixture</th>
<th>Instrument + Fixture + Test Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only verifies instrument</td>
<td>Includes volume and other effects</td>
<td>Includes potential impact of actual test part on the measurement</td>
</tr>
<tr>
<td>measurement</td>
<td>from fixture / test chamber</td>
<td></td>
</tr>
</tbody>
</table>

![Instrument Only Image](image1)

![Instrument + Fixture Image](image2)

![Instrument + Fixture + Test Part Image](image3)

© 2017 LACO Technologies. All Rights Reserved.
Calibration Using a Calibrated Leak Standard

For any type of leak test process, the best practice is to calibrate the system with:

• the **INSTRUMENT**
• the **TEST FIXTURE**
• a **KNOWN GOOD PART**

Calibrating **ONLY** the instrument does not ensure the **SYSTEM** is calibrated
Calibration Using a Calibrated Leak Standard

• Air Pressure Decay Application
  • Determine the relationship between pressure drop and leak rate
  • Normally the value of the leak standard = the reject limit of the test

• Implementation
  • Can be an internal leak standard that is automatically valved into the test circuit with the test fixture connected
  • Can be an external leak standard that is attached to the test manifold, a test part, or the test fixture

• Typical Protocol
  • Run test cycle with known good part (no leak)
  • Run test cycle adding the calibrated leak standard
  • Verify signal to noise ratio and calculate calibration factor (software)
Calibration Using a Calibrated Leak Standard

Internal Calibrated Leak Standard
Calibration Using a Calibrated Leak Standard

External Calibrated Leak Standard
Calibration Using a Calibrated Leak Standard

• Helium Leak Test Application
  • Determines a correction factor that may need to be applied that accounts for the impact of the setup on the helium signal.
  • Normally the value of the leak standard ≈ the reject limit of the test

• Implementation
  • Should be an external leak standard that is either automatically valved into the test circuit or manually connected to the system, or connected to a master part

• Typical Protocol
  • Run test cycle with known good part (no leak)
  • Run test cycle adding the calibrated leak standard
  • Verify signal to noise ratio and calculate calibration factor (software)
Calibration Using a Calibrated Leak Standard

Internal Calibrated Leak Standard
Helium Hard Vacuum Leak Test
Pre-Filled Part
Helium Hard Vacuum Leak Test

Fill Part in Chamber

Calibrated Leak + Dummy Part Used For Calibration
Validating

Using calibrated leak standards for leak test process validation
**Validation** is simply verifying the calibration is accurate and has not drifted

AND...

Ensuring the leak test process will properly reject parts leaking above the reject limit

AND...

Parts leaking below the reject limit pass
Validation Strategy Using a Calibrated Leak Standard

1. Perform appropriate system calibration with leak standard

2. Immediately validate the calibration by running test cycles with:
   a. One leak standard **above** the reject limit
   b. One leak standard **below** the reject limit

3. Verify no false positive or false negative

4. Repeat validation (steps 2 & 3) at prescribed times throughout the day
Validation
Using a Calibrated Leak Standard

Typical Helium Hard Vacuum Leak Test

System Measurement Uncertainty

TEST TIME

FAIL LEAK
CALIBRATED LEAK
PASS LEAK
NO LEAK
Validation

Test Time is Shortened

Typical Helium Hard Vacuum Leak Test

- System Measurement Uncertainty
- TEST TIME
- CALIBRATED LEAK
- NO LEAK

START | END

- 1 x 10^{-9}
- 1 x 10^{-8}
- 1 x 10^{-7}
- 1 x 10^{-6}
- 1 x 10^{-5}
Validation
Test Time is Shortened

Typical Helium Hard Vacuum Leak Test

- System Measurement Uncertainty
- TEST TIME
- 1 x 10^{-5}
- 1 x 10^{-6}
- 1 x 10^{-7}
- 1 x 10^{-8}
- 1 x 10^{-9}

- START
- END

- CALIBRATED LEAK
- PASS LEAK
- NO LEAK
Validation
Test Time is Shortened

Typical Helium Hard Vacuum Leak Test

System Measurement Uncertainty

FAIL LEAK

NO LEAK

FAIL LEAK Passes
Validation

System Helium Background Rises

Typical Helium Hard Vacuum Leak Test
Validation
System Helium Background Rises

Typical Helium Hard Vacuum Leak Test

![Graph showing system measurement uncertainty and test time with calibrated leak and no leak scenarios.](image-url)
Validation
System Helium Background Rises

Typical Helium Hard Vacuum Leak Test

TEST TIME

START

END

System Measurement Uncertainty

FAIL LEAK

CALIBRATED LEAK

NO LEAK

1 x 10^{-9}

1 x 10^{-8}

1 x 10^{-7}

1 x 10^{-6}

1 x 10^{-5}
Validation
System Helium Background Rises

Typical Helium Hard Vacuum Leak Test

<table>
<thead>
<tr>
<th>TEST TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>START</td>
</tr>
<tr>
<td>END</td>
</tr>
</tbody>
</table>

- **FAIL LEAK**
- **CALIBRATED LEAK**
- **PASS LEAK**
- **NO LEAK**

**System Measurement Uncertainty**

<table>
<thead>
<tr>
<th>Leak Type</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASS LEAK</td>
<td>Fails</td>
</tr>
<tr>
<td>CALIBRATED LEAK</td>
<td></td>
</tr>
<tr>
<td>FAIL LEAK</td>
<td></td>
</tr>
<tr>
<td>NO LEAK</td>
<td></td>
</tr>
</tbody>
</table>

- $1 \times 10^{-9}$
- $1 \times 10^{-8}$
- $1 \times 10^{-7}$
- $1 \times 10^{-6}$
- $1 \times 10^{-5}$
Conclusion
How Fast Am I Driving?
When I Have Confidence in My Leak Test Process...

• I am confident I am shipping good product

• I have satisfied customers with fewer warranties

• I have less waste/scrap

• I have peace of mind
THANK YOU!

• Stop By Our Booth (#1238) to Validate Your Coupon for a FREE Calibrated Leak Standard and Get Your Copy of This Presentation
• Contact Us to Review Your Current Calibration and Validation Strategy

• LinkedIn Group: Production Leak Testing
• Blog: www.lacotech.com/posts
• Website: www.lacotech.com