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Traceability and Proficiency Tests

Mark Benner
Edward O'Brien

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Overview

- Introduction
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- DCS/CTL Approval Process
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Traceability

- For calibration laboratories, the program for calibration of equipment shall be designed and operated so as to ensure that calibrations and measurements made by the laboratory are traceable to the International System of Units (SI).
- A calibration laboratory establishes traceability of its own measurement standards and measuring instruments to the SI by means of an unbroken chain of calibrations or comparisons linking them to relevant primary standards of the SI units of measurement. The link to SI units may be achieved by reference to national measurement standards. National measurement standards may be primary standards, which are primary realizations of the SI units or agreed representations of SI units based on fundamental physical constants, or they may be secondary standards which are standards calibrated by another national metrology institute.
- Records must be maintained to support traceability to the SI from the standards used to perform calibrations to the asset calibrated. Note that metrological traceability is used to establish the measurement unit used to express a measurement result.

Primary Standards Laboratory

- Provide Calibrations throughout the weapons complex
  - 13132 Calibrations completed in FY2016
  - 6551 Calibrations completed so far in FY2017
- Provide measurement assurance customer support
- Research and Development (LDRD's, improving measurement systems)
- Manage Designated Calibration Source (DCS) and Commercial Testing Laboratory (CTL) approvals

DCS/CTL Approvals

- A Designated Calibration Source is a subcontractor for the production of nuclear weapons-related products/services
- A Commercial Testing Laboratory is a subcontractor for the testing of nuclear weapons product who performs their own calibrations
- These approvals require the PSL to review and approve their calibration systems
  - Product requirements
  - Equipment used for the verification/acceptance of the product requirements
  - Standards used for the calibration of the equipment used
  - These requirements are shown on a Measurement Assurance Plan (MAP)

MAP Example

Time	1,6	<20 ms	<20 ms	Tektronix Oscillosope Model: DPO7104 Asset #: 6562462 S/N: B022028	± 3.5 ppm = ± 0.0035 ms	NA	Yes
Note: Requirement from PS1111111 , Section 1.2.6 Guard Band = 20 ms - 0.0035 ms = <19.9965 ms							
Temperature-Thermal Shock	1,6	-54°C	± 5°C	P-2023-31 and P-2023-32 Thermotron Thermal chamber ATS-900-705-705-LN2	± 1.7°C	2.94	Yes
Note: Requirement from PS1111112 Appendix A, Sections A.1 and A.2 TAR = 5 / 1.7 = 2.94 Guard Band = (sqrt/(2.94^2))x5 = +/-4.70							
Temperature-Thermal Shock	1,6	74°C	± 5°C	P-2023-31 and P-2023-32 Thermotron Thermal chamber ATS-900-705-705-LN2	± 1.7°C	2.94	Yes
Note: Requirement from PS1111112 Appendix A, Sections A.1 and A.2 TAR = 5 / 1.7 = 2.94 Guard Band = (sqrt(1-1/(2.94^2))x5 = +/-4.70							
Bridgewire Resistance	1,6	1.0 ohms	± 0.10 ohms	TEGAM H-SPD MICRO OHM METER Model:1750 Cal ID:E-90501	Calibrated +/-0.001 ohms	100.00	Yes
Note: Requirement from PS1111111, Section 1.1.7							
Leak	1,6	<1x10^{-8} cc/sec (STP)	1E-8 cc/sec (STP) Maximum	Tester #1: VIC Leak Tester MS-50 Leak Standard P-90223: 3.94E-8 cc/sec (STP)	+/-10% for Leak Standard +/-4% % per °C +/-3 °C	NA	Yes

Note: Requirement from PS1111111, Section 1.1.17, "As Read" requirement is from PS1111111, Section 1.1.2
Note: VIC's atm*cc/sec=cc/sec (STP)
PS calls out an "As Read" measurement, per LANL, which precludes guard banding. If guard banding were to be used its tolerance would be: Guard band tolerance: 1x10-8 cc/sec (STP) - 3.94x10-8 cc/sec (STP) x sqrt(10^2+12^2)% = 3.85x10-9 cc/sec (STP) where 3.94x10-8 cc/sec (STP) is the certified leak rate for the leak standard (P-90223)
Note: DA accepts all risks associated with not using a guard band limit.
Proficiency test performed by PSL 5/2016.

Proficiency Testing

- Proficiency Tests (PTs) are performed to access a laboratory's measurement capability and to provider improvement opportunities for the participants
  - PTs compare the measurement results of the same measured artifact between two laboratories
  - Results are analyzed by comparing the measured values and ensuring this value is within measurement uncertainties of the participating laboratories
- Fine Leak PTs have been performed on various DCS and CTL vendors
  - These results have helped show which DCS/CTL vendors are capable of performing these measurements successfully

Proficiency Test Example Pass/Fail Evaluation

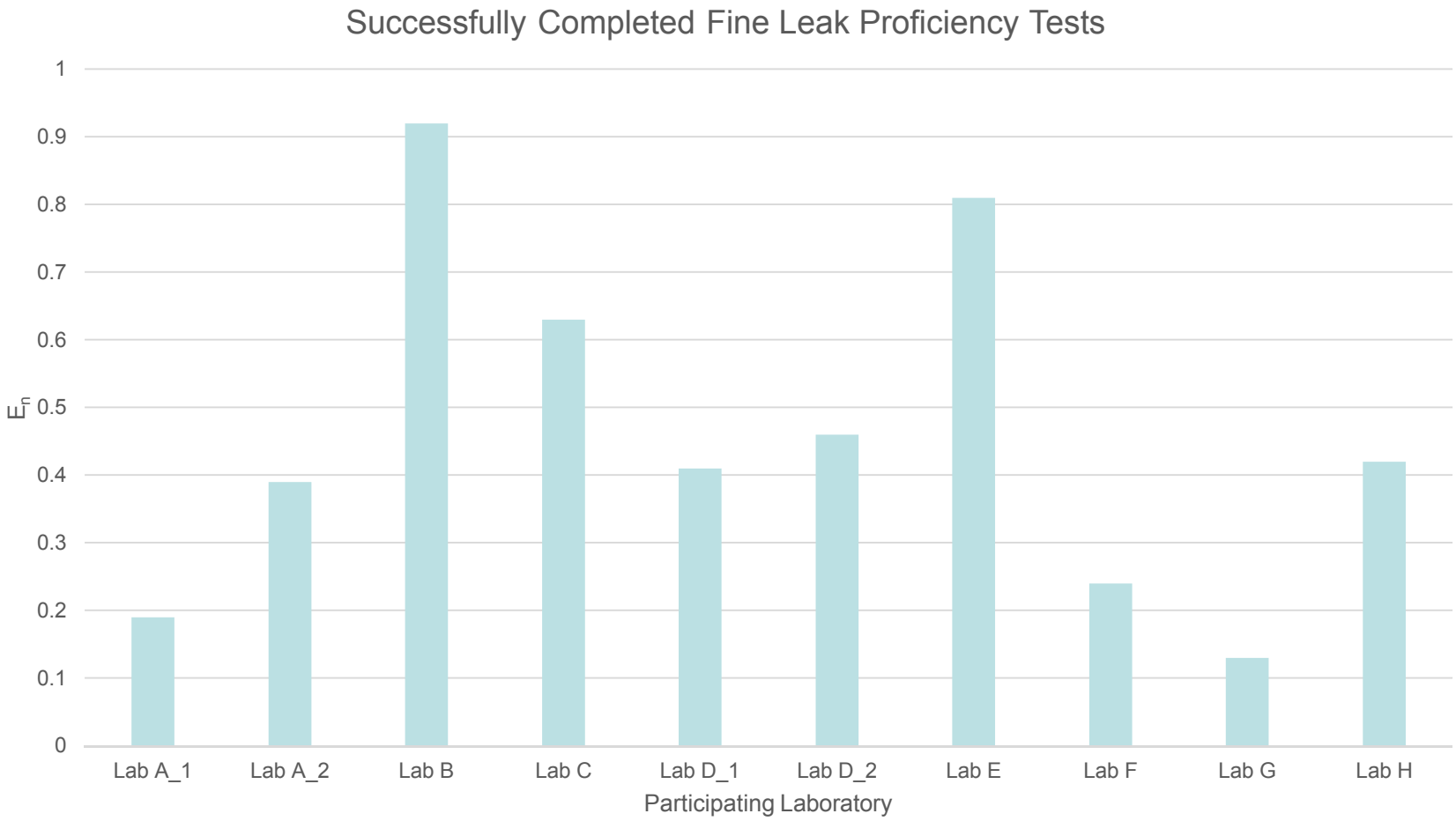
	(y) PSL Data (cc/s @ STP)	(U_{ref}) PSL Expanded Uncertainty (cc/s @ STP k=2)	(x) Participating Laboratory Data (cc/s @ STP)	(U_{lab}) Participating Laboratory Expanded Uncertainty (cc/s @ STP, k=2)	RSS Combined Uncertainty (cc/s @ STP, k=2)	Participating Laboratory Data minus PSL Data (Δ = x-y) (cc/s @ STP)	Normalized Error, E_n
Attempt 1	3.10E-08	2.51E-09	2.42E-08	4.03E-09	4.75E-09	-6.87E-09	-1.45
Attempt 2	3.13E-08	2.53E-09	2.81E-08	4.69E-09	5.33E-09	-3.13E-09	-0.59

$$RSS\ combined\ unc = \sqrt{U^2lab + U^2ref}$$

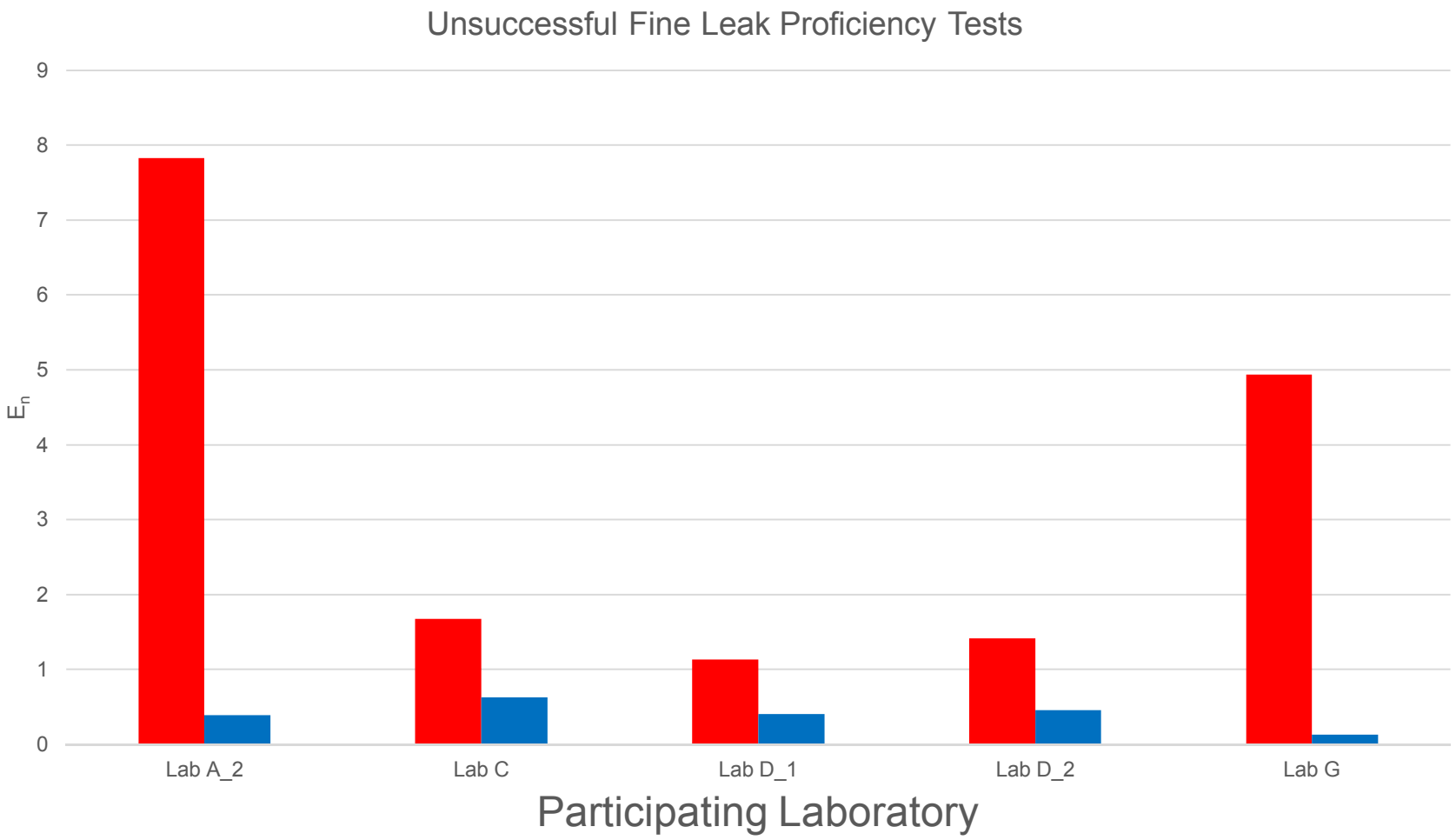
$$En = \frac{x - y}{\sqrt{U^2{}_{lab} + U^2{}_{ref}}}$$

- Normalizes the measurement error with respect to the uncertainty of the measurements
- Normalized error results in the range of -1 to +1 are considered a successfully completed proficiency test

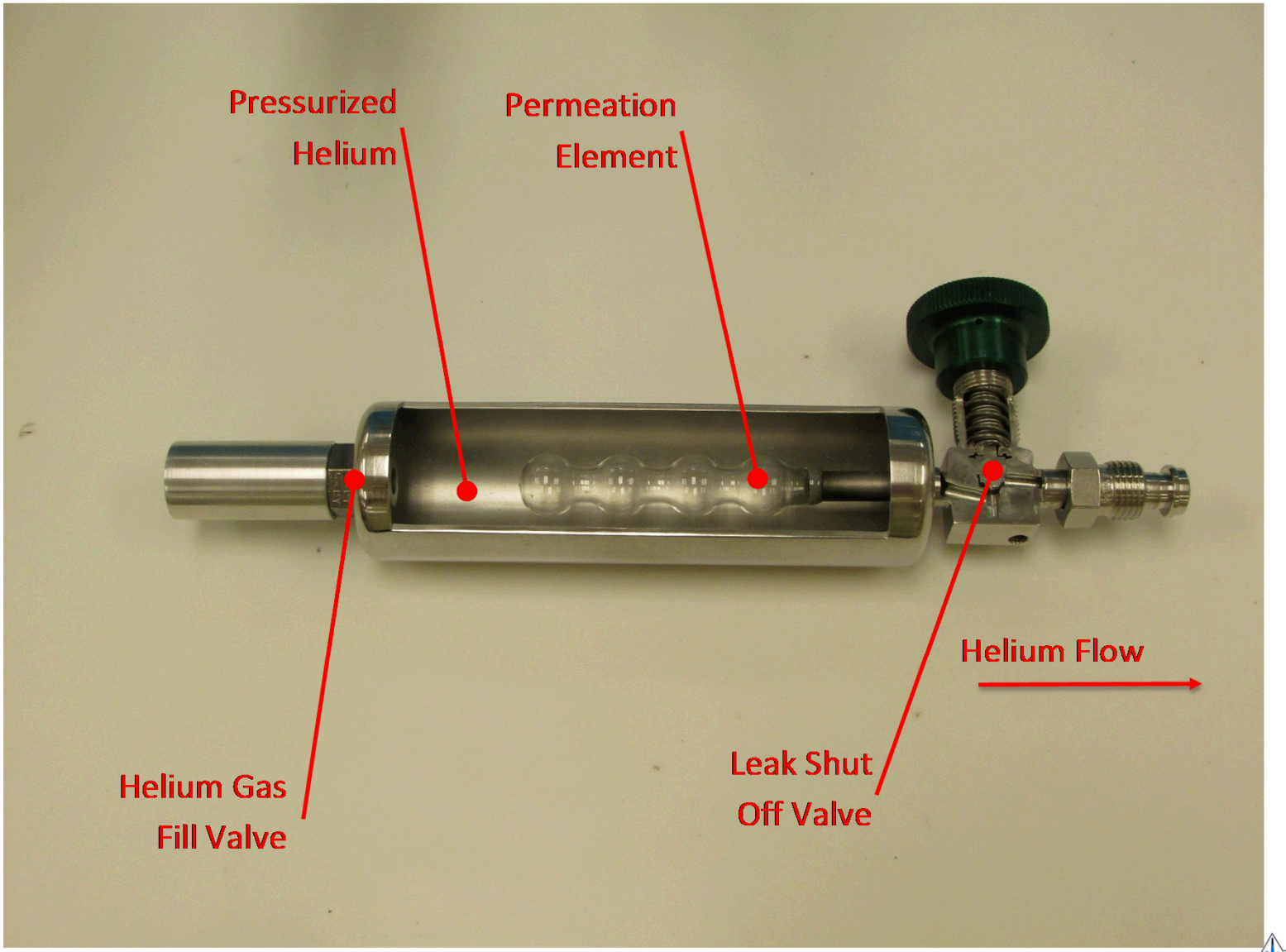
Passing Proficiency Test Results



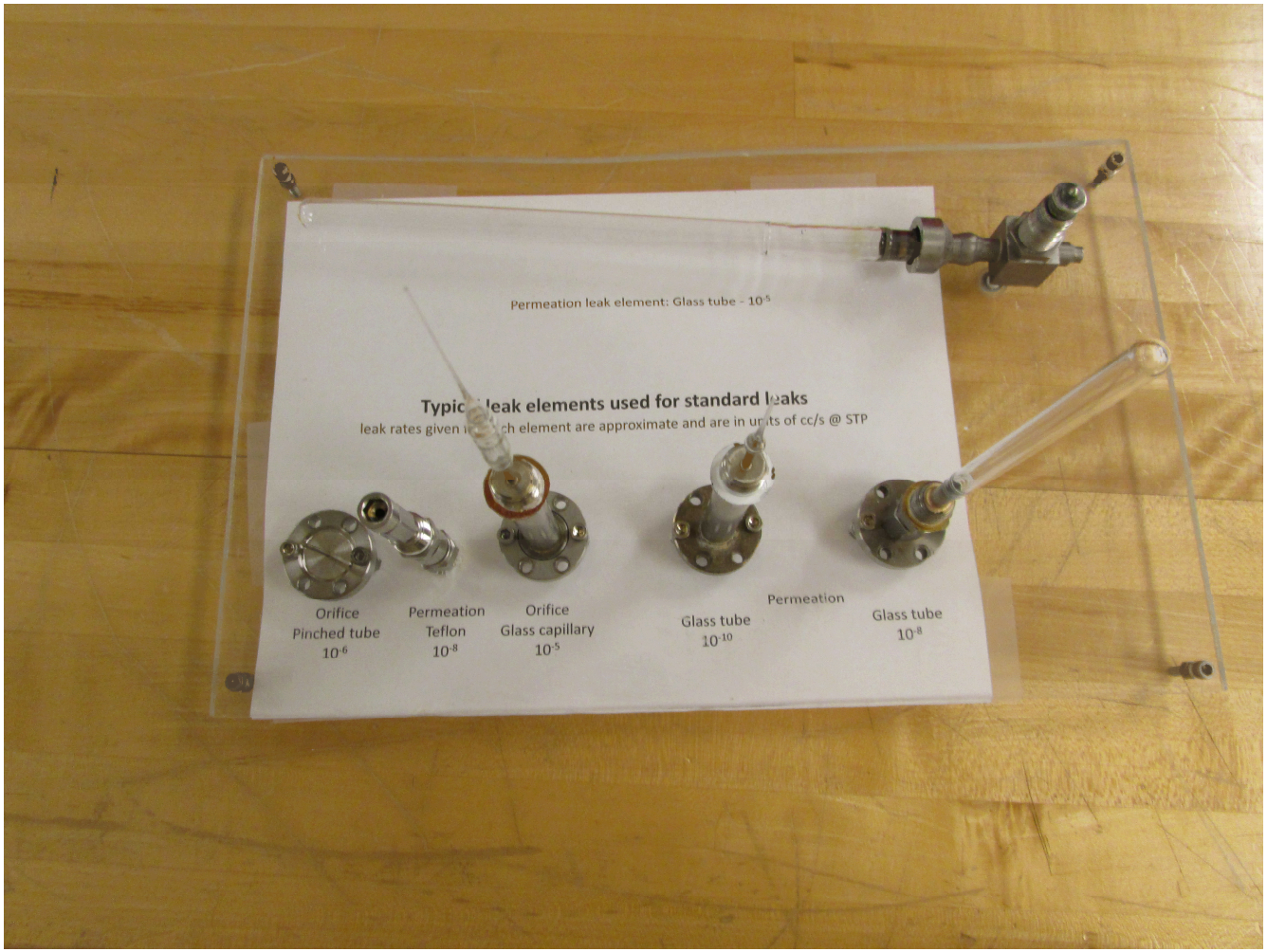
Failed Proficiency Tests



Leak Standard



Leak Standard Elements



What is the unit of measure of Leak Standard?

Leak Rate (throughput) is the volume of gas at a know pressure and temperature that passes a plane (or leak element) in a known time.

$$Q_{LR} = \frac{P * V * T}{t}$$

Incomplete Definition

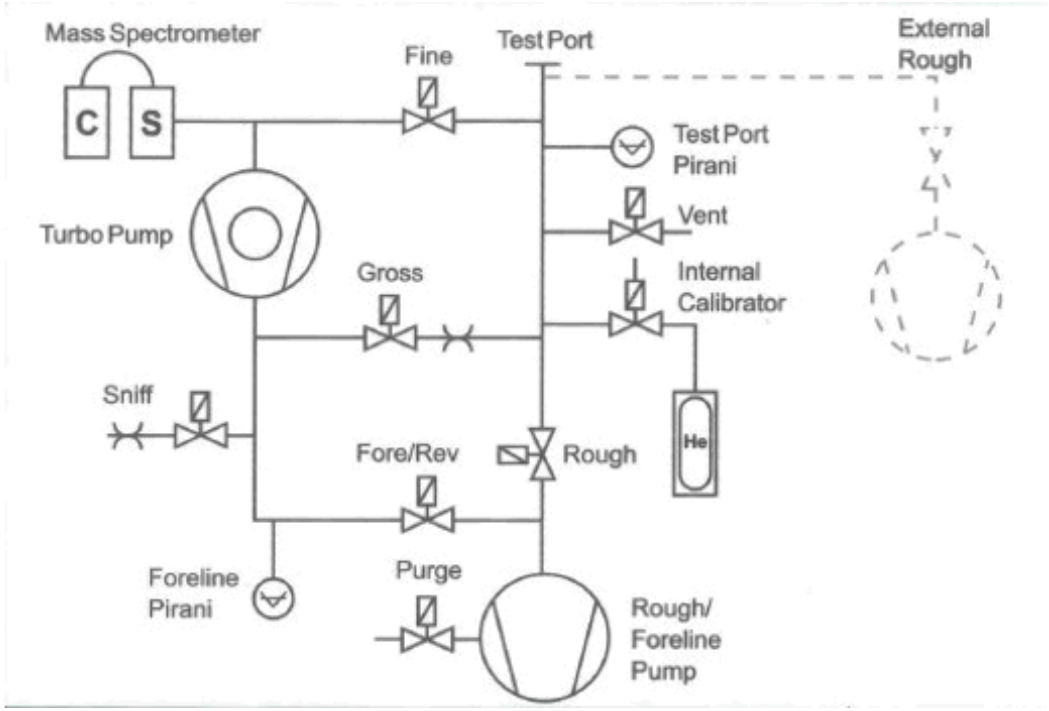
- atm*cc/s
- atm*cm^3/s
- cc/s
- cm^3/s
- Std cc/s or Std cm^3/s

Complete Definition

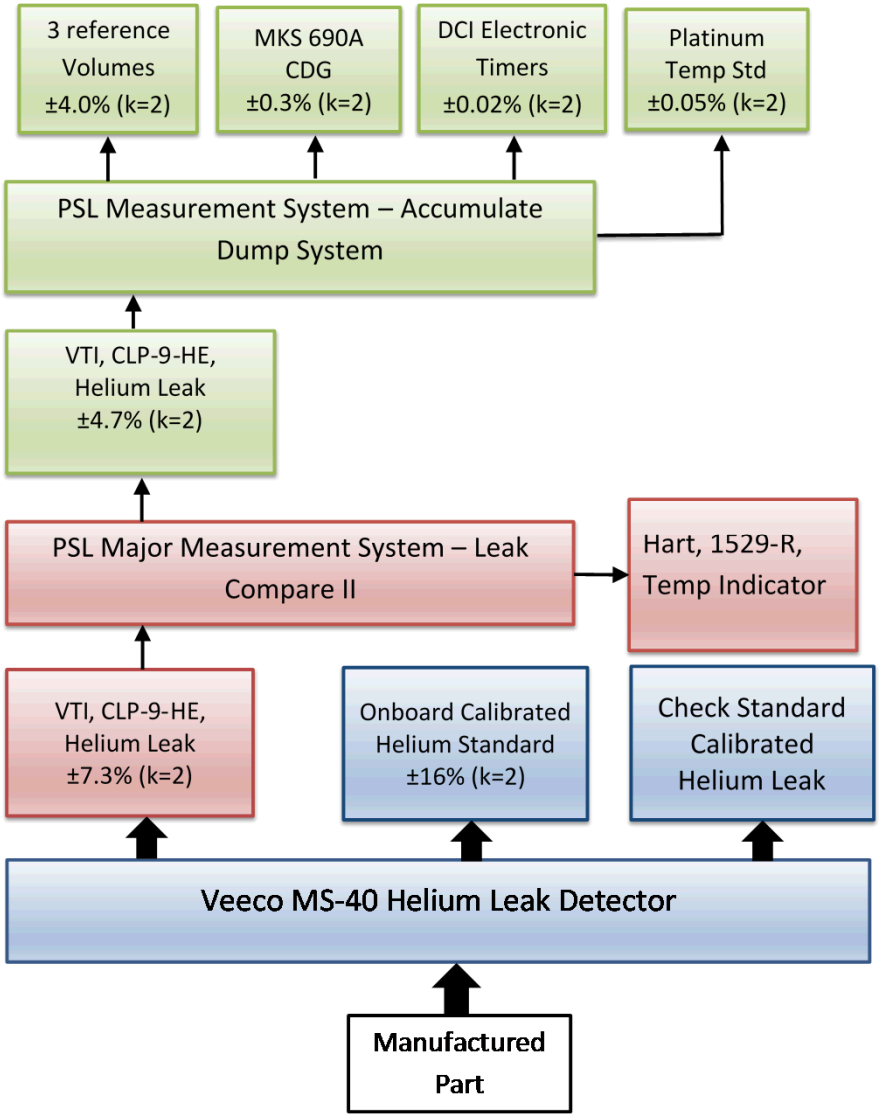
- Atm*cc/s @ 22.7°C
- cc/s STP (1 atm @ O°C)
- Std cc/s (Std = 1 atm @ 23°C)
- mol/s [1]

What is a Helium Leak Detector?

- Spectrometer to detect the mass of helium
- A vacuum system that maintains pressure in the analyzer
- Valve manifold for evacuation, testing and venting
- Amplifier and readout to display output signals
- Power supplies
- Fixtures to attach the parts to be tested.
- Internal standards to calibrate the detector.



Proficiency Test Traceability



LAB A, G, D

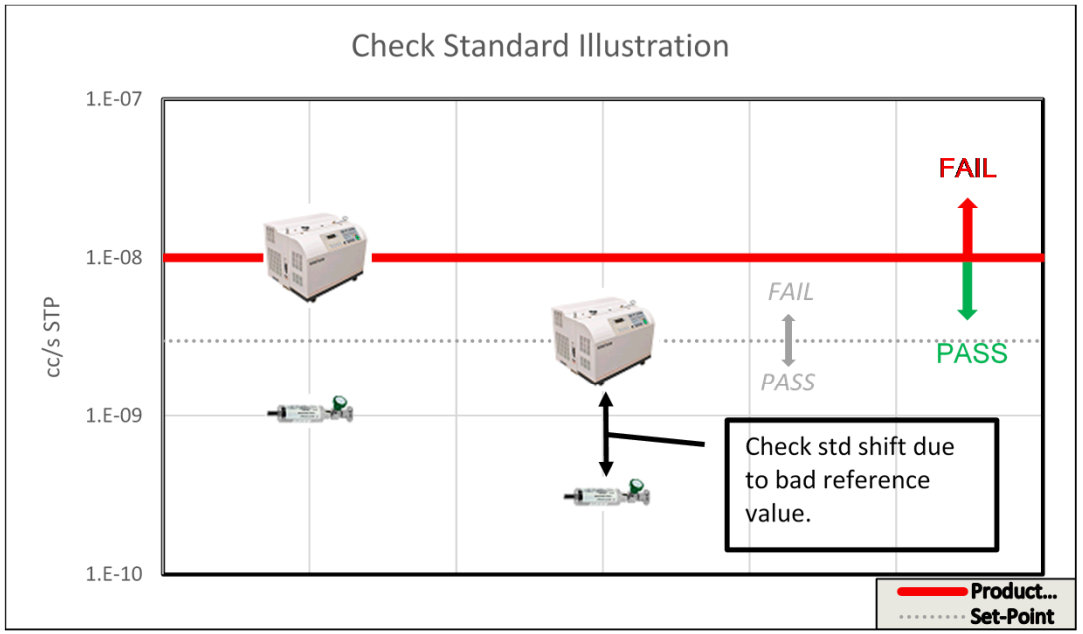
Problem 1

Problem:

Failed to flag shift in leak detector reference standard.

Lessons Learned:

- Pass/Fail (go/no-go) set-up based on set point limits on leak detector and was used on the check standard.
- This assumes the onboard standard is always correct.
- Should have recorded actual values and compared it to a calibrated value.



Problem 2

Problem:

Procedure reporting leak rate of the wrong gas.

Lessons Learned:

- Air equivalent leak rate is approximately 2.5 times lower in value than the helium leak rate.
- This situation set up a false reject area.

$$Q_2 = \sqrt{M_1/M_2} \times Q_1$$

where:

$Q_1 =$ Flow rate for gas number 1.

$Q_2 =$ Flow rate for gas number 2.

$M_1 =$ Molecular weight for gas number 1.

$M_2 =$ Molecular weight for gas number 2.

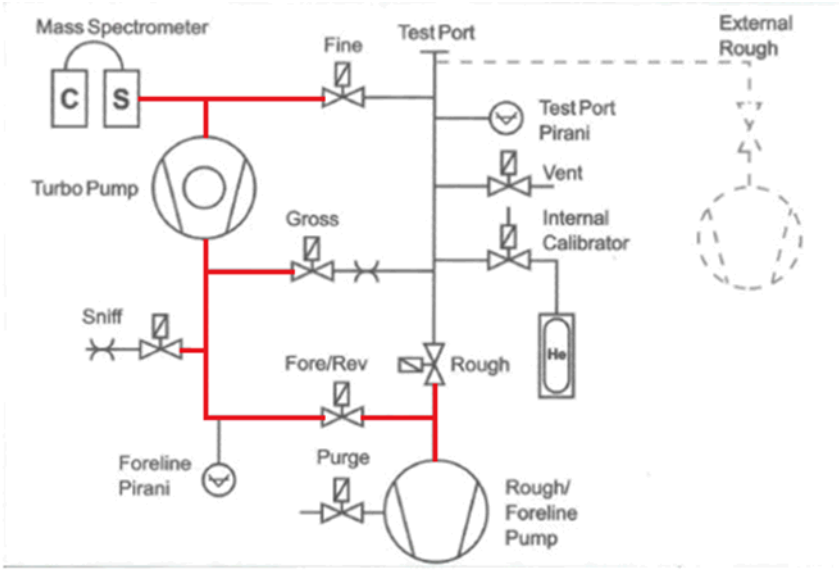
Problem 3

Problem:

Reading background instead of PT artifact.

Lessons Learned:

- Check standard's value was in 10^{-8} range and background was in the 10^{-9} range.
- Contractor had to rethink the programmed conditions to open test port (pressure and or time).



Conclusions

- Proficiency tests are an effective way of testing a laboratories measurement capabilities
- There is often a lack of knowledge in regards to fine leak measurements
  - It is extremely beneficial to control chart the data of your standards and check standards
  - On-site visits typically required to correct problems
- Comparing the measurement results from different measurement processes create consistent results