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Analysis of pressure test results of tube fittings for the potential application in cryo systems for helium leak rate reduction

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DISCLAIMER

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Executive Summary

Due to the nature of Helium, it is notoriously difficult to maintain a closed system without experiencing helium inventory loss through leakage in large tubing and piping runs. There are two standard fitting options readily available for piping and tubing assemblies, welded fittings or Swagelok®. Welding is the best option for leak rate reduction, but more costly than Swagelok®. A new style of fitting has come to the attention of BNL C-AD Cryo group, and a pressure test and leak rate analysis were performed to evaluate the viability of incorporating this new style fitting into current engineering design of warm helium tubing runs for the purpose of leak rate reduction.

Phastite® Fitting description

The Phastite® fitting is a ferrule-less push fit connector, utilizing a patented sealing technology to provide a permanent cold-welded joint. The Phastite® fittings utilize a hydraulic tool to compress either side of the fitting, forcing the two parts together until an audible click is heard. This click noise is a “circlip” engaging in a groove in the collar, ensuring a permanent leak tight joint is made. The benefits of this fitting are low lead times, no welding required (and associated processes), and field assembly by a technician is simplified over standard Swagelok® or welding practices. [1]

Pressure Test Description

To verify the claims made by Parker about their product, C-AD Cryo Group has performed acceptance pressure testing and leak rate analysis of Phastite® fitting samples. Two samples were made in two different sizes, 3/8” and 1”. These samples were installed in a vacuum chamber and pressurized with helium to 250 psig while continuously sniffing the vacuum space with a mas spectrometer to attain a quality helium leak rate. For reference, C-AD Cryo typically accepts welded fittings that test in the $1x10^{-9}$ Torr l/s range. This number is somewhat arbitrary, because it became our standard acceptable leak rate solely based off the highest attainable reading readily available when the number became standardized. Today, we are capable of reaching $1x10^{-12}$ Torr l/s due to advances in testing equipment, but the baseline of $1x10^{-9}$ Torr l/s is still a standardized acceptable leak rate for C-AD Cryo. In practice, the minimum leak rate sensitivity when doing a test is limited by the overall test system, i.e. the leak tightness of the rest of the test system components and the mass spec detector background based on local discharge conditions to atmosphere. If the baseline background is below $1x10^{-9}$ Torr l/s, then the system is good for the test. If not modifications will be made to get the background below $1x10^{-9}$ Torr l/s. The purpose of this test was to evaluate if Phastite® fittings are at least as leak tight as a welded fitting, therefore our leak rate had to be maintained at least at $1x10^{-9}$ Torr l/s or below.

The leak rate can be measured by external sniff of the pressurized tubing joint or full sampling by the mass spec detector of the pressurized tubing joint inside a vacuum chamber. The external sniff method is limited by the sensitivity of the mass spec detector in sniff mode of no less than $1x10^{-6}$ Torr l/s. A vacuum chamber was fabricated for this test to attain the best quality leak rate possible. This allows for a large differential pressure

between the pressurized sample, and the vacuum outside of the pressure boundary. The vacuum chamber ensured a higher quality reading.

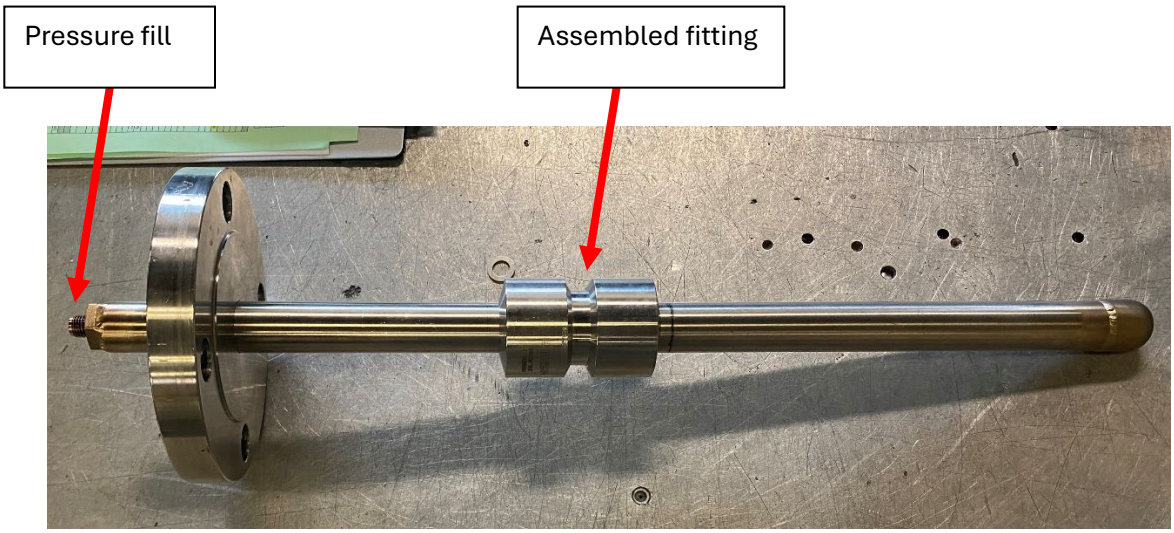

Image 1: Assembled Phastite® Testing Sample

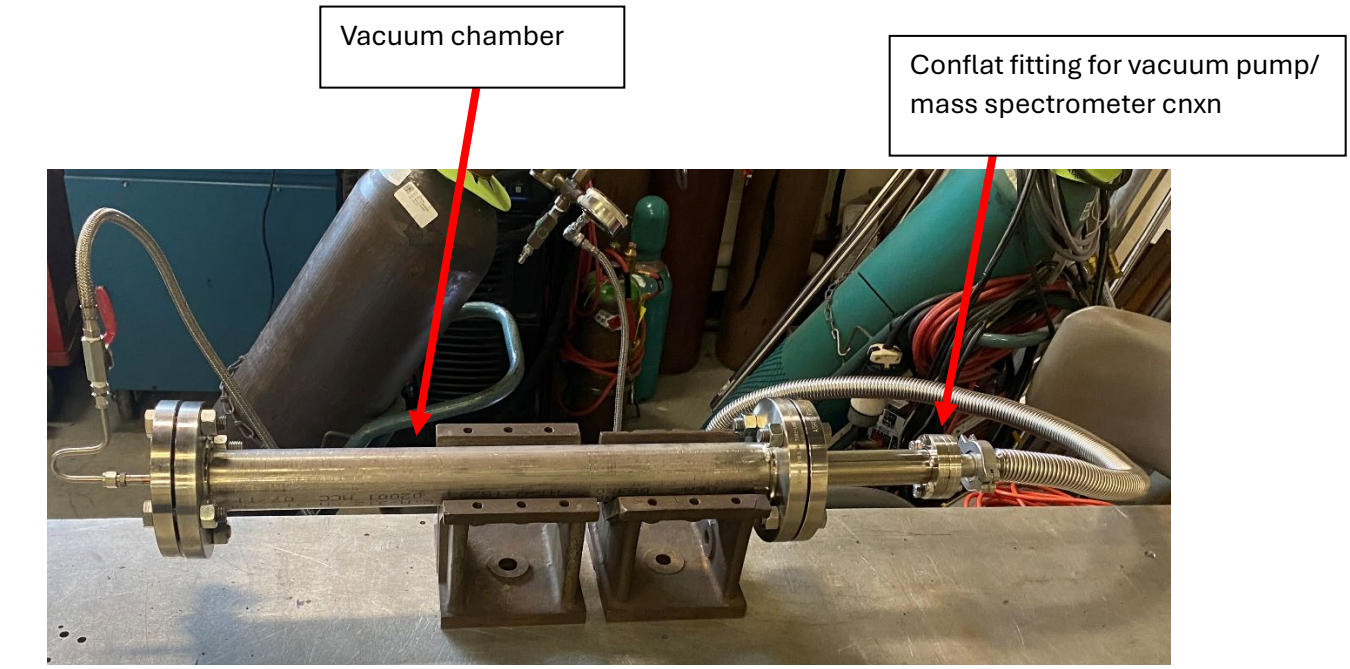

Image 2: Phastite® sample in vacuum chamber, with pressurized helium on the left and vacuum port/mass spectrometer on the right.

Pressure Test Data Sheet

Date: 2/7/24

DEPT/GROUP: CRYOGENICS SYSTEM

DIVISION: COLLIDER - ACCELERATOR

Pressure Test Reference Number: PTP_006-24

Prepared by: Andrew Weissman

Checked by: Andy Warkentien

PROJECT: Phastite sample leak test

Reference Drawing Number: NA

Item: Phastite samples

Fluid Service: He gas

MAWP: 300 psi

Design Temp: 300 K

Test Type: Pneumatic

Test Pressure: 250 psi

Test Medium: Helium gas

Test Date: 6/6/24

Test Locations: 1005S MT shop

Procedure:

1. **Review test set up and procedure.**
2. **Have an adequate supply of helium for test, use only calibrated gauges.**
3. **Plug any openings in the test circuit and make sure they are sufficiently sealed.**
4. **Assemble vacuum pump and gas supply regulator to test circuit.**
5. **Clear all unnecessary personnel from the test area. Ensure all Parker representatives are wearing eye protection and viewing safely from behind barricade.**
6. **Pull vacuum on the vacuum jacket until satisfactory.**
7. **Slowly introduce gas into the test circuit.**
8. **Stop at 10 psi and hold. If pressure in the test circuit bleeds off STOP the test and find the leak. Bleed off the gas pressure, repair the leak and repeat the test starting at step #6.**
9. **If the pressure is stable at 10 psi, increase pressure to 100 psi and hold while continuously sniffing. If helium is detected or pressure in the test circuit bleeds off STOP the test and find the leak. Bleed off the gas pressure, Repair the leak, and repeat the test starting at step #6.**
10. **If the pressure is stable at 100 psi, increase pressure to 250 psi and hold for ten minutes while continuously sniffing. If helium is detected or pressure in the test circuit bleeds off STOP the test and find the leak. Bleed off the gas pressure, Repair the leak, and repeat the test starting at step #6.**
11. **If no leak has been detected, bleed gas pressure from the circuit, remove gas supply from the circuit, record results, STOP-test complete.**
12. **Disassemble circuit, remove sample #1 and replace with sample #2. Begin second test starting at step #1.**

COMMENTS:

Test 1 (3/8" sample): Baseline = 1.8×10^{-10} Tor l/s leak rate

Test 2 (1" sample): Baseline = 9.6×10^{-10} Torr l/s leak rate

RESULTS OF TEST:

Test 1 (3/8"): 50 psi = Pass; 100 psi = Pass; 250 psi hold and sniff = Pass

Test 2 (1"): 50 psi = Pass; 100 psi = Pass; 250 psi hold and sniff = Pass

TEST WITNESSED BY:

A. Weissman, K. Riker

Summary

The samples were tested successfully, and the results show that the fittings surpass our standard acceptable leak rate of 1×10^{-9} Torr l/s. Although the range stayed the same (1×10^{-10} range) for both tests, it is good to point out the difference in results. This is due to a higher level of background helium which was residual from the previous test. An acceptable amount of time was given for the room air, the mass spec detector and the vacuum chamber to purge after the first test. The second test could have been postponed longer to get a higher quality reading, but it was still well within acceptable limits, as it maintained a leak rate less than the minimum requirement (1×10^{-9}) to be verified as performing at least as good as a welded fitting.

References

1. https://ph.parker.com/us/en/product-list/permanent-ferrule-less-tube-fittings-phastite-series