LA-UR-16-24603
Approved for public release; distribution is unlimited.

Title: Flow and Heat Transfer Tests in New Loop at 2757 kPa (400 psi)

Author(s): Woloshun, Keith Albert

Intended for: Report

Issued: 2016-06-30

Flow and Heat Transfer Tests in New Loop at 2757 kPa (400 psi)

Keith Woloshun

LA-UR-

6/13/2016

Introduction

A helium flow and heat transfer experiment has been designed for the new helium flow loop facility at LANL. This new facility is centered on an Aerzen GM 12.4 Root's blower, selected for operation at higher pressure, up to 2757 kPa, and mass flow rate, up to 400 g/s. This replaces the previous Tuthill PD plus 3206 blower and loop limited to 2067 kPa (300 psi) and 100 g/s. The resistively heated test piece is comprised of 7 electric heaters with embedded thermocouples. The plant design for the Mo100 to Mo99 targets requires sharp bends and geometry changes in the helium flow tube immediately before and after the target. An idealized fully developed flow configuration with straight entry and exit will be tested and compared with an option that employs rectangular tubing to make the bend at a radius consistent with and practical for the actual plant design. The current plant design, with circular tubing and a sudden contraction to rectangular just prior to target entrance, will also be tested. This requires some modification of the test piece, as described below.

Target Design

In these experiments, the plant design target disks and holder, which form rectangular helium flow channels, are replicated by rectangular heaters with embedded thermocouples available from Watlow (Figure 1). This heater is only slightly smaller than the 29 mm plant design Mo100 disks, so data can be readily scaled to the actual geometry of the plant design. The heaters are 2.5 mm thick. The anticipated plant design target will have disk thicknesses ranging from 0.5 to 4 mm. These heaters offer a readily available solution that is of acceptable geometric similarity to the plant design, has imbedded thermocouples for heat transfer measurement, and sufficient heat (967 W) and heat flux (155 W/cm^2) for good heat transfer measurement.

The 7 heaters are mounted in a holder with 0.7 mm coolant gaps, based on recent tests and analysis of target cooling with the new blower for the plant target. The entrance and exit is bull-nosed for reduced pressure drop. The target is shown in Figure 2.

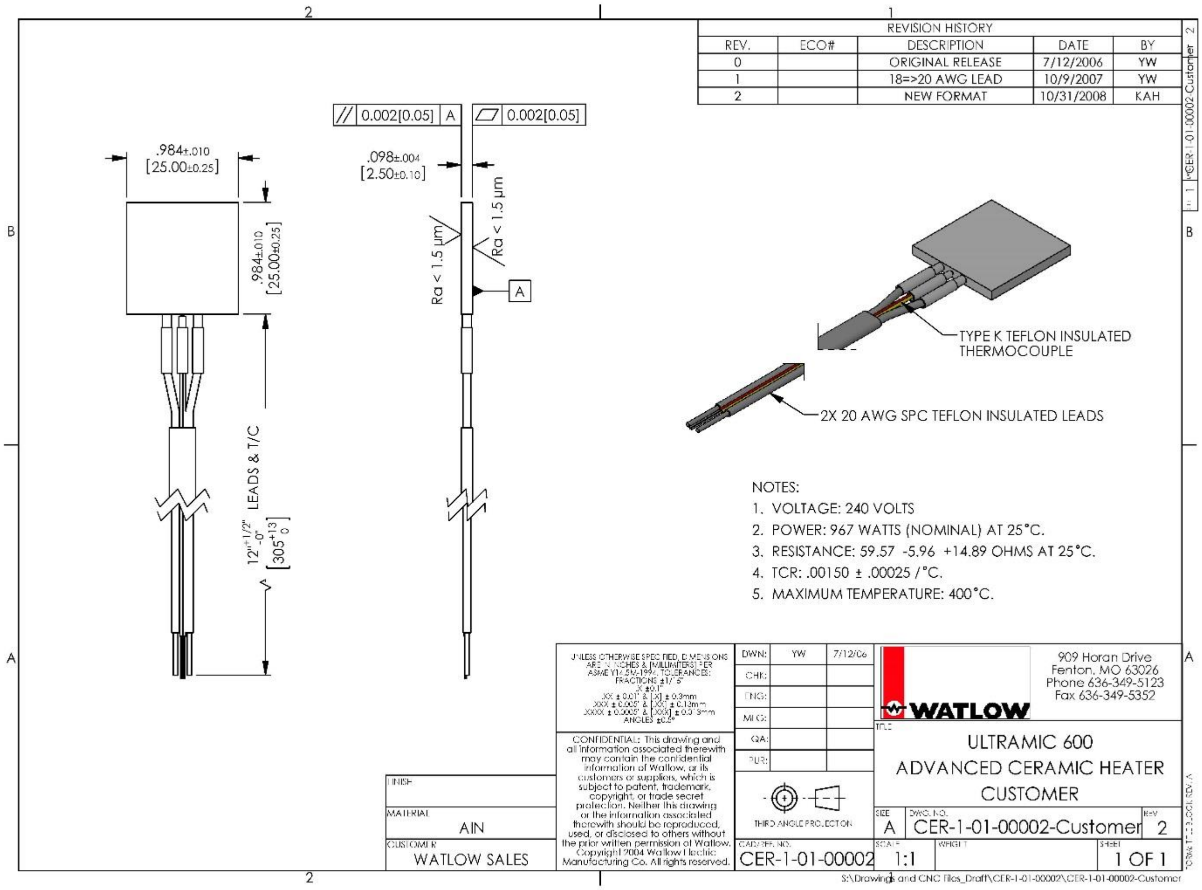

Figure 1. Watlow 967 W heater.

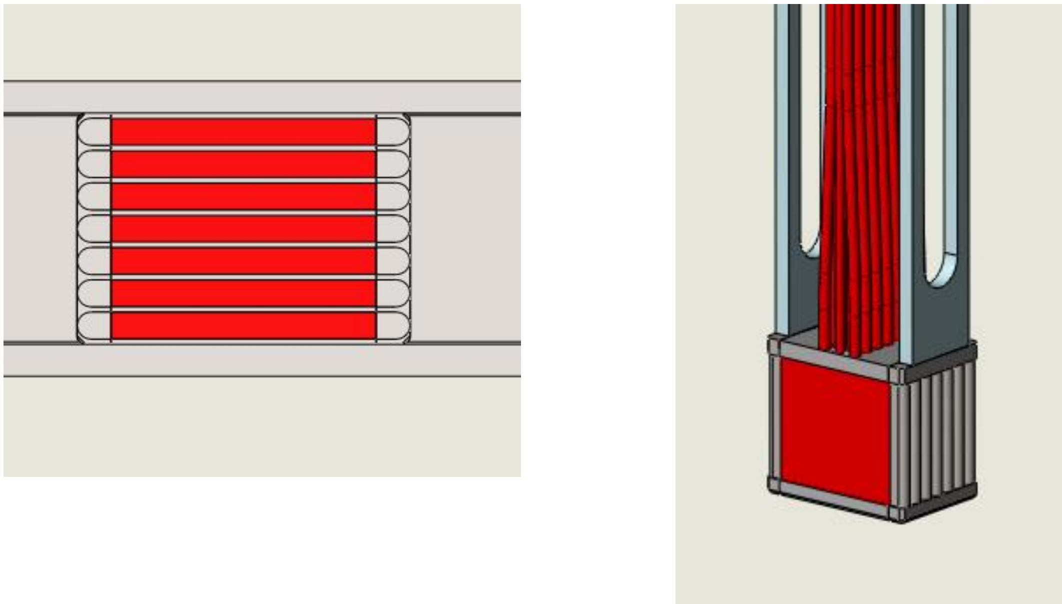

Figure 2. On the left, cross-sectioned view of the 7 heaters, with bull-nose entrance and exit. On the right, view of the target insert, with 2 power leads and 1 thermocouple to each heater.

Flow Channel Configuration

In the plant design the target passes through about 3 m of concrete shielding, vertically downward to the beamline. A 30 cm diameter pipe contains the helium inlet and return pipes and the stalk through which the target is lowered into the target housing. The target housing and the ends of the helium flow pipe attach to a flange at the bottom end of this pipe, as shown in Figure 3. Figure 3 also shows round pipe making a bend and a transition to a rectangular channel through the target. This approach dictates a convergent geometry change from circular to rectangular very near the target. An alternative is to make the transition to rectangular just beyond the 12” flange plate. This is shown in Figure 4. While the direction change very near the target remains, the flow channel cross-section is established before the bend. These experiments will examine these 2 options, particularly in regards to window cooling (while the window will not be heated during this test, any changes in the thermal response of the adjacent disk will be indicative of heat transfer at the window as well).

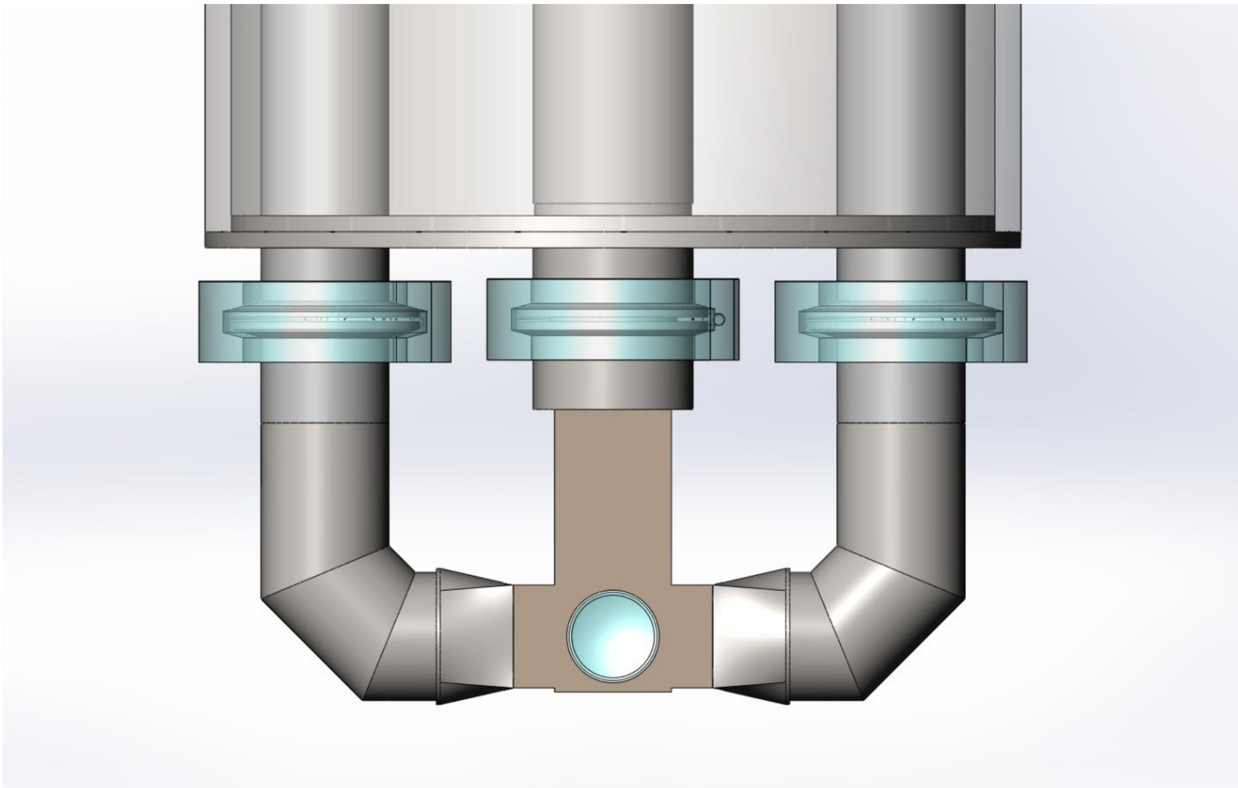

Figure 3. Plant design tubing configuration for helium flow to and from the target.

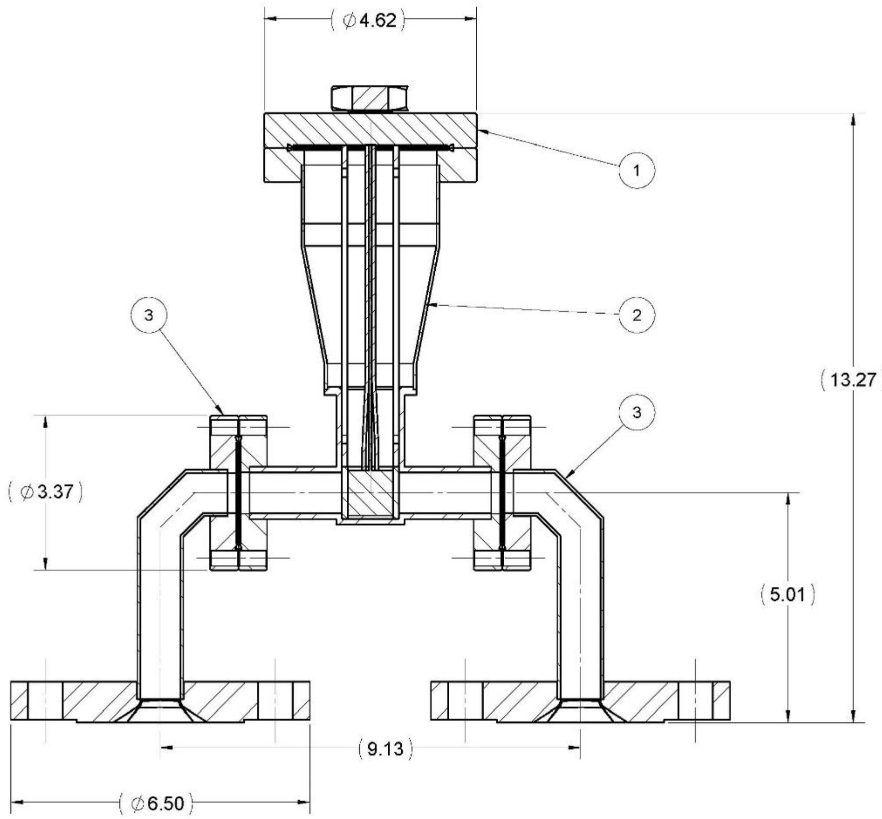

Figure 4. Rectangular tubing feed to the target. Spacing between supply and return lines consistent with the plant design constraints.

As a baseline for comparison, a straight rectangular channel with fully developed flow conditions at the target entrance will also be tested (Figure 5). The piping will then be modified for a test of the rectangular tubing shown in Figure 4. The flanged helium line connections to the target, as shown in Figures 4 and 5, cannot accommodate the current plant geometry, Figure 3, which offers no space for the flange. The test piece will require some cutting and welding to make the final comparison to that configuration.

Conclusion

A test piece has been designed to test the flow through a resistively heated target. Three variations on flow entrance and exit geometry will be tested, one replication the current plant design tubing.

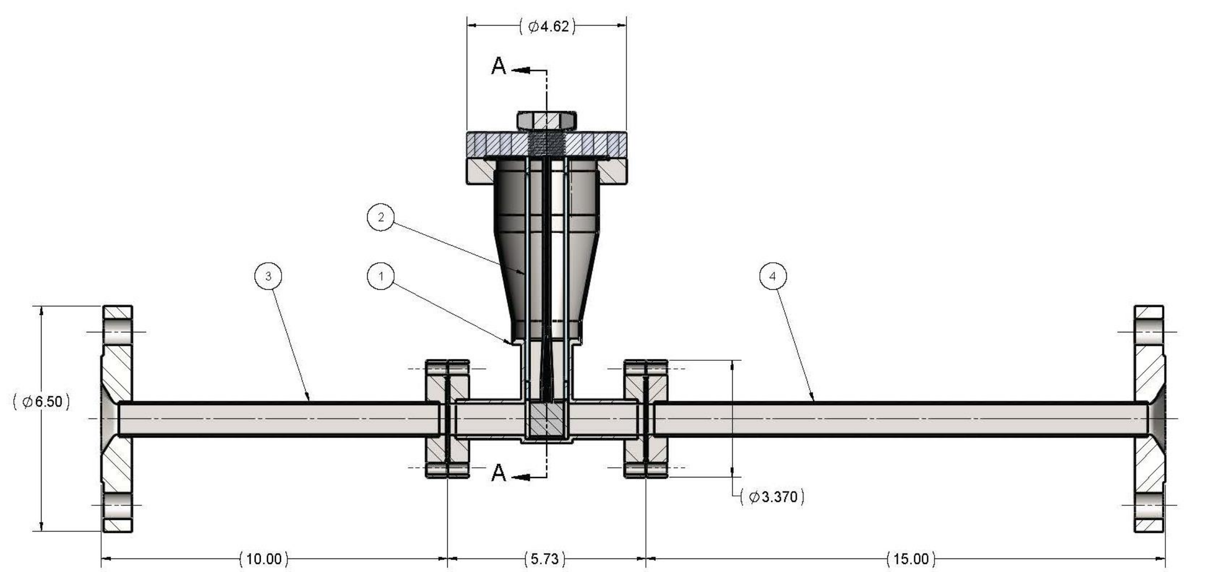

Figure 5. Straight channel baseline flow configuration.