

To: B. Nelson, ORNL

Date: June 25, 2005

From: L. E. Dudek

Subject: Summary of NCSX
VV Field Weld Joint Tests

Object:

The purpose of these tests was to demonstrate:

1. The proposed NCSX Vacuum Vessel Field joint was weldable as designed
2. The proposed Vacuum Vessel thermal insulation, microtherm, would be unharmed by the weld
3. The amount of shrinkage to be expected in the field weld

Summary of results:

The tests identified an acceptable joint configuration (sample 7) that when welded from one side displayed complete fusion on the backside, $1/16$ " shrinkage across the joint and acceptable fatigue life. The tests were conducted using samples cut from Inconel 625 plate, which were shaped to approximate the NCSX VV field weld joint. The initial weld cross section exhibited problems with incomplete fusion on the backside of the weld. Revision of the weld preparation resulted in an acceptable joint design.

The use of graphite for a purge gas seal was unacceptable due to thick white smoke coming off the packing material during the weld which prevented the welder from continuing. Ceramic rope was tried and found to be an acceptable backing gas seal material.

Welding Equipment:

All welds were performed using a Miller Syncrowave 350 welding power supply. The same welder was used for every weld joint test, to ensure consistency between samples.

Preparation of Samples:

All samples were cut from a $3/4$ " 625 Inconel Plate. The samples were waterjet cut into arcs approximating the average radius expected during the NCSX field Weld, 10-12" long curved (17.5" radius) $3/4$ "x $3/4$ " pieces.

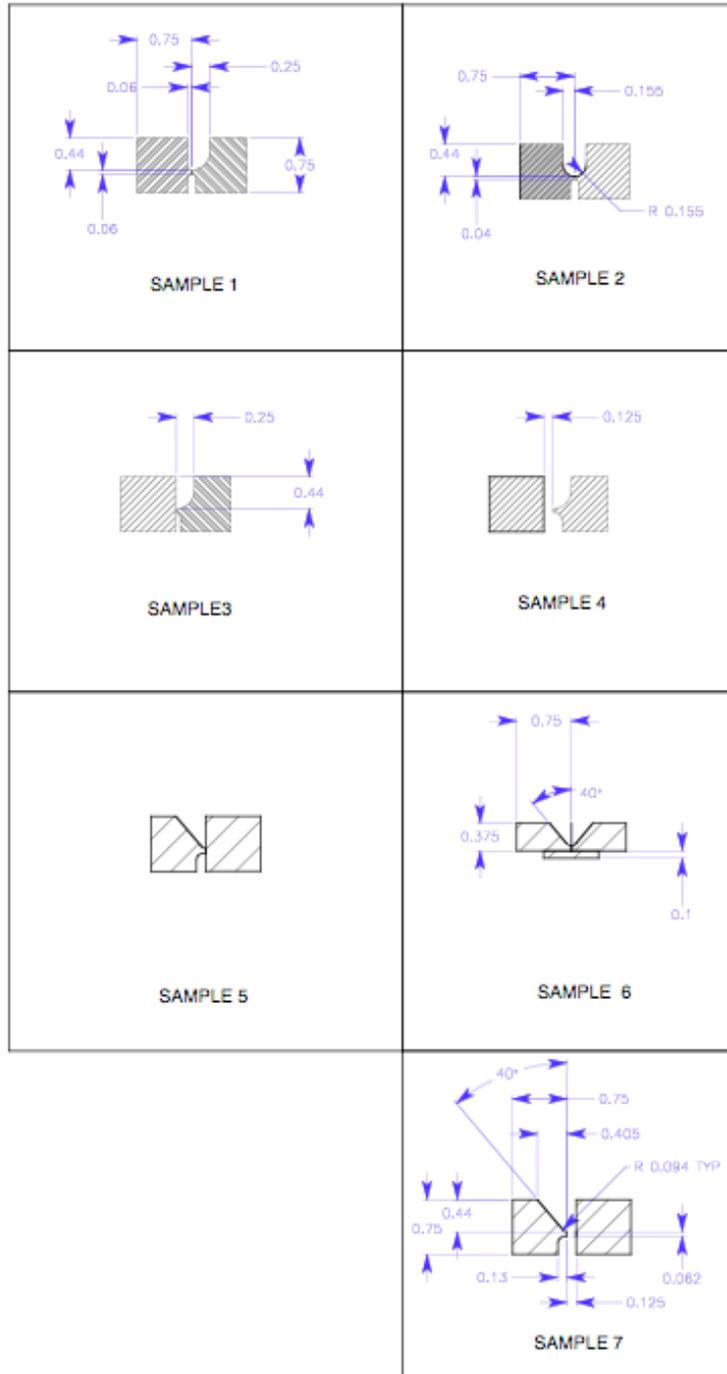
The samples were aligned to the cross sections shown in Figure 1 and tack welded into place. Measurements of the axial shrinkage were made during the welds.

Samples and setup are shown in Photos 1 through 11.

Table 1: Summary of Samples

Sample ID	Description (See Figure 1)	Purpose of Test	Result
1	Unequal U Groove 0.00" Root	Test sealing of fiberglas rope for shield gas on backside, test microtherm for damage from heat of weld	Rope seal worked, microtherm discolored but was unharmed, unable to get complete fusion of root on backside
2	U Groove	Reduced root to 0.040" to improve fusion, test use of Graphite packing material	Incomplete fusion on backside, Graphite packing was unacceptable due to excessive smoking during welding
3	J Groove	Test of planned (flat) spool flange shape	Incomplete fusion on backside
4	J Groove 1/8" root	1/8" root ORNL Recommendation	Incomplete fusion on backside
5	Single Bevel, 0" root	ORNL Recommended configuration	Tungsten access was much better than the previous welds due to the wider access. Incomplete fusion on backside, fatigue tested 1,000,760 cycles
6	Double Bevel with backing ring	To determine if backing ring weld could be done	Easy to weld, fused into backing ring
7	Single Bevel with 1/8" root	Used ORNL standard weld cross section	Root of backside improved., modest shrinkage on order of 1/16"

Figure 1: Dimensioned cross sections of Weld Samples



Final Weld Data

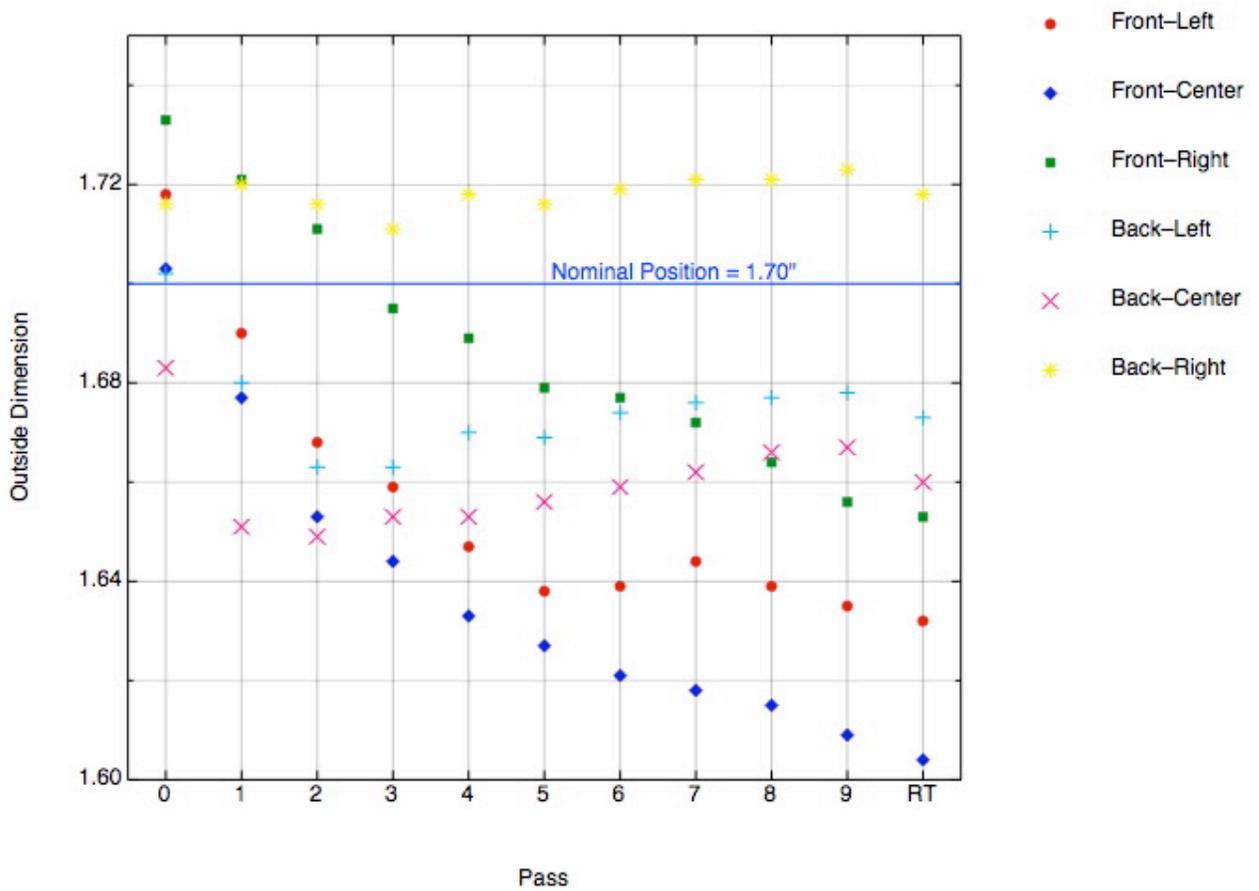


Figure 2: Measurement of Weld Distortion

Weld distortion was measured across the weld joint at three places along the weld test sample and at the front (welded) and back (unwelded) side. The direction of the weld was from Right to Left. The measurements were taken as the piece was setup in the fixture before welding (pass 0), after each pass (pass 1-9) and once more after the piece cooled back to room temperature (RT). The average contraction of the parts due to welding was approximately $1/16$ ".

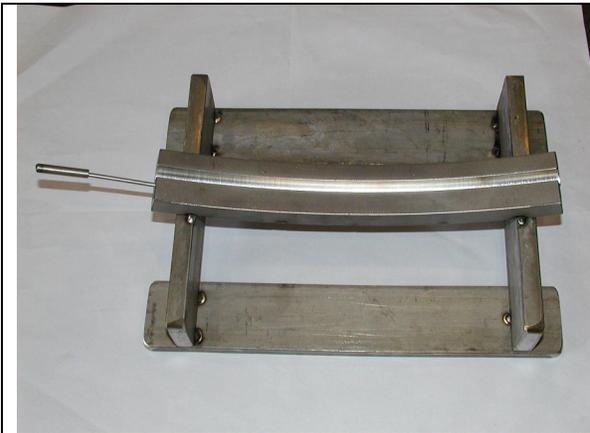


Photo 1: Weld Sample with purge in support cradle

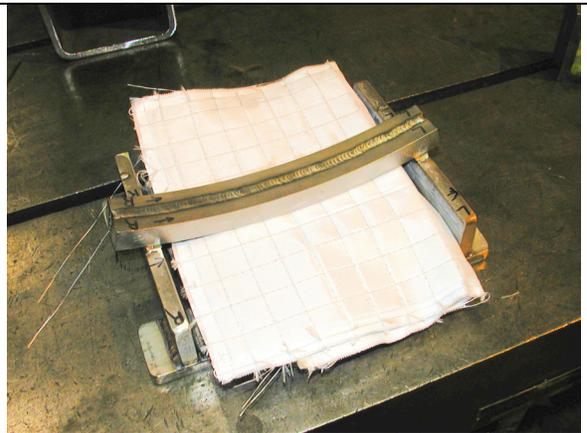


Photo 2: Weld sample with microtherm test setup

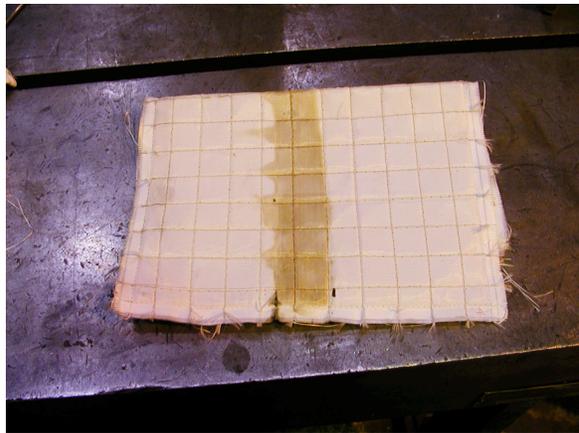


Photo 3: Microtherm insulation after the weld discolored but unharmed



Photo 4: Weld Sample 1- Incomplete fusion on the backside

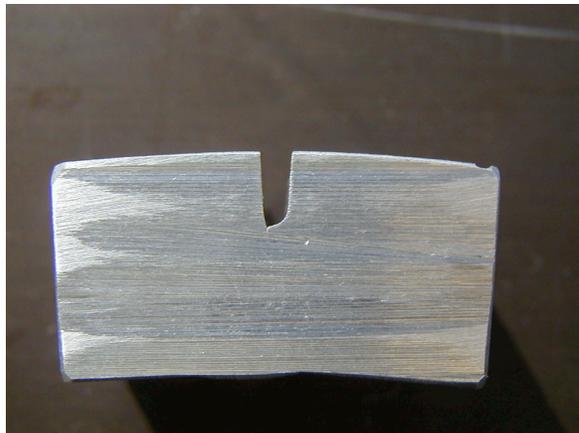


Photo 5: Weld Sample 1- Cross Sectioned



Photo 6: Weld Sample 3 - Sharp notch on backside

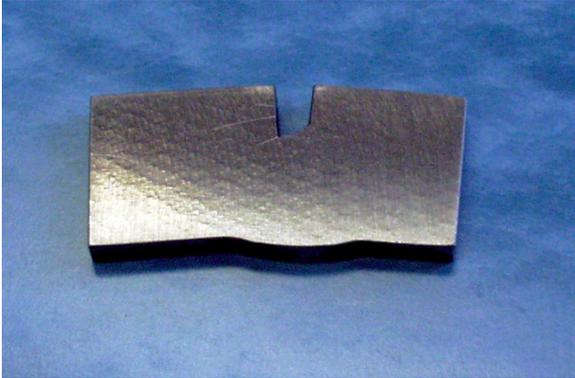


Photo 7: Sample 5- Single bevel



Photo 8: Sample 6- Double Bevel with backing ring



Photo 9: Weld Sample 7 - Frontside



Photo 10: Weld Sample 7- Backside complete fusion



Photo 11: Sample 7- Cross sectioned