HIGH-LEVEL RADIOACTIVE WASTE CONTAINER FABRICATION AND CLOSURE WELDS

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INTRODUCTION

Long-term storage of high-level nuclear waste (HLW) will require a waste package that will contain the radionuclides and prevent environmental elements from interacting with the waste form for a period of 3000 years. The current design consists of a disposal container with a shrink fit corrosion-allowance outer barrier and a corrosion-resistant inner barrier. The container has two closure lids, each of which must be separately welded into place using remotely controlled equipment. The closure welds must then be inspected, using remote equipment, to complete the envelope for each corrosion barrier.

WORK DESCRIPTION

The waste package (WP) closure weld development and fabrication tasks are part of a larger engineering development program to develop waste package designs that the Nuclear Regulatory Commission (NRC) will find acceptable for disposal of HLW. The FY 1997 WP fabrication and closure weld development tasks had two prime objectives. First, to fabricate a full circular mock up approximately the same diameter as the waste package and approximately one-quarter as long. The intent was to prove that a shrink fit method of fabrication is a viable fabrication method to join the inner and outer cylinders. Second, to evaluate whether the narrow groove hot wire automatic gas tungsten arc weld (NG-GTAW) process could be used to close the waste package and produce welds with acceptable weld and corrosion properties.

The outer barrier cylinder and lid were made from 120.6mm (4 ¾ in.) thick ASTM A 516 Grade 70 carbon steel plate. The outer cylinder was 1244.6mm (49 in.) long and had a 1727.2mm (68 in.) outside diameter. The inner cylinder and lid were made from 25.4mm (1 in.) thick ASTM B 443 Alloy 625 plate. The inner cylinder was 558.8mm (22 in.) long and had a 1534.0mm (60 in.) outside diameter.

The shrink fit of the inner and outer barriers was performed by heating the outer cylinder in a furnace to approximately 538°C (1000°F). The cylinder was then removed from the furnace and the inner cylinder was placed inside of the outer cylinder until it contacted positioning bars. The entire assembly was then returned to the furnace to control the cool down until the assembly was below 427°C (800°F).

The inner barrier lid (Alloy 625) was welded with NG-GTAW process using hot wire filler material. The weld joint geometry is illustrated in Figure 1. Welding amperage was 325 amps at 13 volts. Welding was accomplished with single-bead layers until the groove was completely filled.

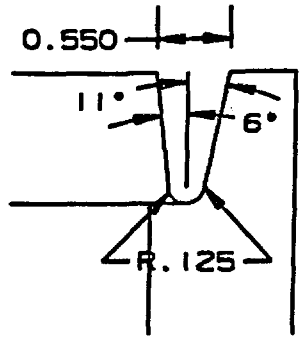

Figure 1. Inner Lid Narrow Groove Weld Joint Geometry

The outer barrier lid was also welded with NG-GTAW using hot wire filler material. Welding amperage was 480 amps at 13.5 volts. This weld joint geometry is illustrated in Figure 2. Welding was accomplished with single-bead layers until the groove was approximately one-half filled (19 layers). At this point, double-beaded layers were initiated by biasing the torch position to alternating sides of the groove. An additional 35 passes, including the final pass layer, were required to complete welding of the outer lid (a total of 50+ passes).

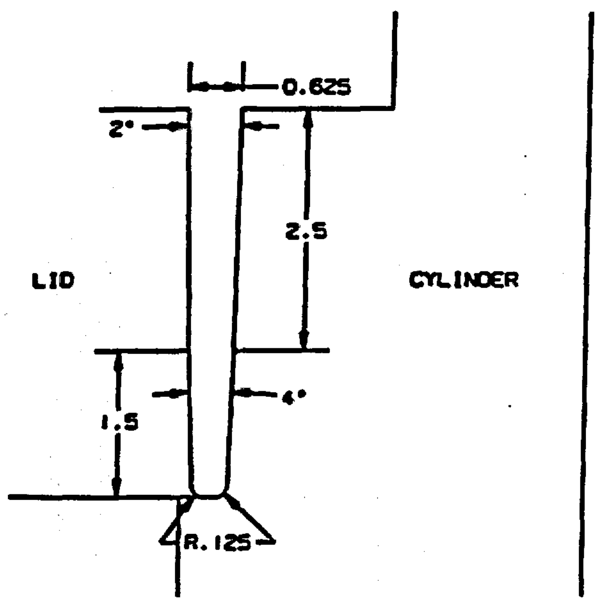

Figure 2. Outer Lid Narrow Groove Weld Joint Geometry

RESULTS

After the shrink fit operation, ultrasonic examination (UT) was performed to map the interface between the inner and outer cylinders. The final results indicated an interface contact percentage of 13.7% (UT signal return). Heating the cylinders in a furnace with an air atmosphere caused a formation of a thin oxide layer between the base metals. The effect of the oxide layer on the results of the ultrasonic examination are unknown.

Two other methods were used to corroborate the ultrasonic examination test results. The first measured the thickness of each cylinder in four separate areas before the shrink fit operation and compared them to combined thickness measurements taken after assembly. This method indicated approximately 38% contact between the two cylinders.

The second method used to corroborate the ultrasonic examination test results was to drill three holes through the two cylinders. The surfaces of the holes were polished and etched. Visual examination indicated that there was no discernable separation (gap) between the cylinders at any of the three holes.

Ultrasonic testing of the completed inner lid weld detected no indications or flaws. When ultrasonically tested, the completed outer lid to outer cylinder weld showed three indications, which were most likely defects in the last layer of the weld that was single beaded. The increasing width of the groove caused the side wall to not fuse sufficiently in these areas. Future weld joint designs will have a more narrow groove width to eliminate this problem.

CONCLUSIONS

The shrink fit method of manufacturing was proven to be a technically viable and cost effective method of assembling the waste package inner and outer barrier. Testing of the interface contact between the inner and outer barrier interface was not conclusive. Further testing at Lawrence Livermore National Laboratory will be needed to better understand and quantify of the contact area, and determine how much of a contact area is acceptable.

Development of the narrow groove hot wire automatic GTAW proved to be successful in reducing weld times (compared to using cold wire GTAW), and produced acceptable welds. The weld system performed well on the circular narrow groove, demonstrating that it is feasible to perform the closure welds corresponding to the waste package preliminary design configurations.

ACKNOWLEDGEMENT STATEMENT FOR PUBLIC RELEASE DOCUMENTS

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