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YUCCA MOUNTAIN WASTE PACKAGE CLOSURE SYSTEM

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I. INTRODUCTION

The method selected for dealing with spent nuclear fuel in the United States is to seal the fuel in waste packages and then to place them in an underground repository at the Yucca Mountain Site in Nevada. This article describes the Waste Package Closure System (WPCS) currently being designed for sealing the waste packages.

II. WASTE PACKAGE

Describing the closure system begins with the waste package (WP). A WP consists of two cylindrical containers, one nested inside the other. The inner container, known as the inner vessel, is designed to the *ASME Boiler and Pressure Vessel Code*, Section III, Division 1. It has a 50.8 mm (2.0 in.) thick wall of 316 stainless steel. This inner vessel resides within a secondary container known as the outer corrosion barrier, which has a 25.4 mm (1.0 in.) thick wall of alloy C-22. The closure system must accommodate ten different configurations of WPs. How-

ever, the wall thicknesses and configuration of the closure joints are the same for all of them. WP diameters range from about 1.2 to 2.1 m (4 to 7 ft); heights range from about 3.4 to 5.8 m (11 to 19 ft).

Each package has three lids. The inner lid, common to the inner vessel, is mechanically captured in place by a unique one-piece spread ring that is seal-welded in place. The one-piece spread ring simplifies its installation and reduces the amount of welding compared to a traditional multipiece spread ring. The middle and outer lids are both welded in place common to the outer corrosion barrier.

III. CLOSURE OPERATIONS

The WPCS welding operation is shown in Figure 1. The two robotic arms welding the lid rotate about the WP by means of an annular carousel attached to the floor. The carousel surrounds a large-diameter hole in the closure cell floor through which the arms reach the WP residing slightly below the floor. The arms weld 180

Figure 1. Illustration of the Yucca Mountain Waste Package Closure System welding a waste package lid in place.

degrees apart to minimize weld distortion. When placing each lid, the arms conveniently fold back out of the way. Use of a traditional center-pivot type of welding machine would require removing the machine each time a lid were placed.

Located at the base of each arm is a tray carrying interchangeable end effectors—for welding, weld examination, and weld repair.

Cold-wire gas tungsten arc welding is the method used for all welds. Although the weld torches have a 300-ampere capacity, they are air-cooled rather than liquid-cooled to prevent accidental introduction of water into a WP, which would pose criticality concerns. The inner lid welds are two-pass fillet seal welds. The middle lid is a six-pass partial-penetration single-bevel weld. The outer lid is a full-penetration ten-pass narrow-groove weld.

Following seal welding of the spread ring and inner lid, a port in the center of the inner lid is used to evacuate the WP and backfill it with helium. Once backfilled, a ring type tool is placed over the seal welds to monitor for helium as a leak check. The purge port is sealed with a threaded plug and gasket, leak tested, and then covered with a cap, which is seal-welded in place.

Special end effectors are provided for examining the closure welds—visually, with eddy current, and with ultrasonics. The visual capability is on board the welding end effector in the form of a laser profile sensor that maps the weld joint geometry. This mapping is used to identify surface flaws, and is also used during welding to guide the welding end effector relative to the joint groove.

Two end effectors are equipped with eddy current and ultrasonic probes for inspecting the outer and middle lid welds and inspecting weld repair grooves. The eddy current probe uses an array of elements to reduce inspection time. The ultrasonic probe uses phased array technology, which offers the flexibility of beam steering and variable depth of focus to achieve a thorough volumetric examination with a minimum number of probes. To reduce waste, the ultrasonic head is integrated with a special probe that allows the ultrasonic signals to couple with the weld using a minimal amount of water. Using couplants other than water would introduce foreign materials onto the surface of the WP. The outer lid multi-pass weld is examined ultrasonically pass by pass for early detection and repair of any flaws.

The fully remote closure operations are performed inside a hot cell due to the high radiation fields and the risk of contamination. At the purge port of the inner lid, the radiation is expected to average 200 R/hour. Besides being remote, many operations are also semiautomated to benefit cycle time. The target cycle time for closing a single waste package is 44 hours at 100% efficiency.

IV. SUPPORTING OPERATIONS

Welding is the focus of the closure process, but material handling, routine service of closure equipment, control of the equipment, and data management are significant supporting operations. Figure 2 illustrates the entire three-floor arrangement, providing all closure support operations. Inside the central closure cell is a bridge-mounted Z-mast, known as the remote handling system, which is the primary material handling device, capable of manual and programmable pick-and-place operations with tight accuracy. To the left of the closure cell is the support room with a large glovebox for performing routine maintenance. To the right of the cell is the main operating gallery where operations are controlled and closure data is logged.

Figure 2. Overview of the Waste Package Closure System.

V. ACKNOWLEDGEMENTS

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