

WORKMANSHIP COUPON VERIFIES AND VALIDATES THE REMOTE INSPECTION SYSTEM USED TO INSPECT DRY SHIELDED CANISTER WELDS

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ABSTRACT

The Idaho National Engineering and Environmental Laboratory (INEEL) is operated by Bechtel-BWXT Idaho LLC (BBWI), which recently completed a very successful Three-Mile Island-2 (TMI-2) program for the Department of Energy. This complex and challenging program loaded, welded, and transported an unprecedented 27 dry shielded canisters in seven-months, and did so ahead of schedule. The program moved over 340 canisters of TMI-2 core debris that had been in wet storage into a dry storage facility at the INEEL. Welding flaws with the manually welded purge and vent ports discovered in mid-campaign had to be verified as not effecting previous completed seal welds. A portable workmanship coupon was designed and built to validate remote inspection of completed in-service seal welds. This document outlines the methodology and advantages for building and using workmanship coupons.

BACKGROUND

For years, TMI-2 reactor core debris had been held at the INEEL in storage pools at the Test Area North (TAN) Hot Shop. In 1998, the DOE directed operators at the INEEL to encapsulate all of this radioactive waste into dry shielded canisters (DSC) by June 2001. The DSC is seal welded to ensure that any flow of gases in or out of the DSC, during storage, is through a HEPA filter. This is accomplished by welding the closure plates in place and leak testing the welds. The inner cover is welded and inspected to the same criteria as the outer cover plate. The plates are welded to the shell and seal welded together at the purge and vent ports to provide redundant closures. Both the purge and vent ports are covered with vent housings (flanges) that are sealed to the outer cover plate with dual metallic seals. During leak testing and transfer/transport activities the filters are closed by installing cover plates which are sealed to the vent housings with dual metallic seals. When the DSC is placed in storage the test/transport covers are removed to allow the DSC to vent to atmosphere, thereby, removing radiolytically generated hydrogen from any residual moisture contained inside the DSC. The HEPA filters are screwed into the filter housing. Filter bodies are stainless steel with a sintered stainless steel media developed for long term hydrogen gas venting of radiological waste containers. The vent port accesses the DSC in the headspace immediately above the top of the TMI canisters. This allows for direct removal of any gases emitted by the canisters. The purge port connects to a mechanical tube that goes to the bottom of the DSC to allow for gas circulation in the system. This also allows for complete purging of the DSC if any abnormally high gas build-ups are noted. Both the purge port filter and vent port filter housings allow for sampling of gases within the DSC. Additionally, the test/transport covers can be installed over the filters to allow equalization of gases within the DSC so representative gas samples can be obtained. The filter housings also have leak test ports for remotely testing the filter housing to DSC seals. The vent and purge ports can be accessed during DSC storage through a vented steel door. The internal location of the seal welds and the heavy steel door that protects the access to the filters provided significant challenges to inspect the welds.

DEFINITION OF TERMS

Dry Shielded Canister: The dry shielded canister or DSC was fabricated from SA-517, grade 70 mild steel that was rolled into a 67-inch-diameter (170 cm), 168-inches-tall (426 cm) shell with a thick welded

bottom plate and additional layers as a radiological shield. The shell has a 0.625-inch (1.6 cm) wall thickness; the radiological shield plug is 4.5-inch-thick (11.5 cm) laminated steel; and the top cover plate is 1.5-inches-thick (3.8 cm). The DSC shell was loaded with 12 defueling or debris canisters; seal welded, transported to the dry storage facility, and inserted into the storage vaults.

Purge and Vent Ports: Purge and vent ports are 5.5 (14 cm) and 9.5-inch (24.8 cm) openings through the 1.5-inches-thick (3.8 cm) top cover plate and into the shield plug plates. Housing flanges cover these ports. The interface between the two plates were manually GTAW seal welded, and these are the welds that were inspected.

TMI-2 Reactor: TMI Unit 2 was located outside of Harrisburg, PA along the Susquehanna River. The reactor system was a Babcock and Wilcox 900-MW PWR

TMI-2 Reactor Accident: On March 28, 1979 at 4:00 AM, a minor malfunction occurred in the system that feeds water to the steam generators. This started a chain of events which caused the core to eventually overheat to the point where over 90% of the reactor core was damaged. This event led eventually to the most serious commercial nuclear accident in U.S. history and fundamental changes in the way nuclear power plants were operated and regulated.

TMI-2 Debris: After the reactor core of the TMI-2 reactor melted down, it was removed and sized to fit into the TMI defueling debris canisters. This included everything from floor sweepings to fuel rods to pieces of the melted morass.

TMI-2 Defueling Debris Canisters: Also called debris canisters. These are 14-inch-diameter (35.6 cm), 145-inch-long (268 cm) stainless steel tubes with a welded bottom plate and a removable top head assembly to facilitate loading and unloading of the TMI-2 debris. These canisters were processed, after years of wet storage, with a heated vacuum drying operation prior to placing into the dry shielded canister to ensure dryness in storage.

TMI-2 Independent Spent Fuel Storage Installation: The TMI-2 Independent Spent Fuel Storage Installation or ISFSI is a Nuclear Regulatory Commission (NRC) regulated facility at the INEEL. The ISFSI was designed, built, and licensed to store 29 DSCs of TMI-2 core debris in an aboveground dry storage configuration.

INTRODUCTION

The main purpose of this paper is to describe innovations, techniques, and approaches that were germane to the inspection of in-service DSC welds, proofing the operating procedures using mockup coupons, and accomplishing the weld inspections in a radioactive environment. Welded DSCs, or any nuclear waste container, are the primary barriers between the waste and the public or environment, and the public and stakeholders demand the absolute highest quality of welds.

The purge port weld on the fifth DSC was discovered to have two cracks twelve hours after inspections of the weld had been successfully completed. One crack was 2.5 (6.4 cm) inches long and the other was 1.5 inches long (3.8 cm). Preheating of the weld area had not been performed for this weld. Discussions with the welders determined that cracking and popping had occurred during the welding. The area had been cleaned prior to welding with a liquid penetrant remover/cleaner in case vacuum grease contamination was present in the weld area. Since the weld of the purge port was performed soon after the welding of the cover plate, it was possible that cooling of the cover plate weld could have created stresses on the purge port weld. The weld was repaired by grinding and performing a two-pass weld to establish preheat prior to placement of the main weld. The weld procedure was modified to prevent additional problems but assurance of confinement barrier integrity for three DSCs with the in-service seal welds was needed. The in-service welds were located behind four-inch (10.2 cm) thick flange plates inside a twelve-inch (30.5 cm) thick concrete wall. The NRC requirement for redundant confinement welds and the state mandated schedule (6/1/01) for removal of the fuel from water pool storage pose challenging and potentially conflicting priorities. The transfer cask necessary for fuel shipments and/or removal for repair activities was leased from a third party. Extension of the lease was not possible. An

NRC license change to modify the seal weld requirement was considered but dismissed as overly time consuming. In place disassembly of the in-service filter housings and re-establishment of the metallic seals was considered too risky and practically impossible. Remote camera inspection through the HEPA filter ports was chosen to perform visual inspections to verify the original PT inspections had not been compromised by delayed cracking. Validation and verification that sufficient clarity to discern cracks by camera inspection was essential.

WORKMANSHIP INSPECTION COUPON

An innovative technique applied with the validation of the DSC weld inspection system was also used during the fabrication of the workmanship inspection coupon. This technique created an in situ crack by consuming a piece of copper wire into the weld metal. This crack was used to validate the initial inspection system and process. This same cracking techniques was reused to make the crack for this coupon.

We designed and built a remote inspection system to inspect the purge-and-vent port welds after the DSCs were placed in dry storage. The problem was that the inspection equipment operators needed to demonstrate that the fiber optics and monitors of the inspection system could discern a crack in the weld. The welding engineer designed and built a portable workmanship coupon mimicking actual weld conditions (thickness, shape, and orientation), which included induced cracks in the weld of the coupon. See Figure 1, Cracked Weld and Figure 2, Workmanship Sample. Multiple cracks were generated by inserting a 1-inch-long (2.54 cm), 0.25-inch-wide (0.6 cm) strip of aluminum sheet metal into the weld joint and subsequently consuming it into the weld metal during welding.

The BBWI level III inspector confirmed detection of the crack using ASME BPVC, Sec V, Article 9, and "Direct Visual Examination Methods." The coupon was satisfactory for demonstrating and qualifying equipment used for remote or indirect examination of DSC welds. The operators of the remote inspection system could readily ascertain the cracks, and both the equipment and the coupon functioned as designed. Benefits of this workmanship coupon include:

- Training and qualifying inspection and operations personnel
- Simulation of actual conditions but performed in a non-radiation area
- Validation of the operating procedure (a dry run) prior to field inspection
- Verifying readiness of the system, the camera, and the digital image screens before mobilizing for a field inspection or after system maintenance
- Compliance with NRC regulations and ASME procedure and equipment demonstration requirements: clear and repeatable.

These benefits were significant, considering the:

- Cost of in-service inspections
- Cost of mobilizing crews
- Efforts to maintain radiation exposures as low as reasonably achievable
- Avoiding disassembly of the storage containment system of obtain access to the welds.
- Costs of removing fuel from storage to repair welds
- Schedule considerations to lease the cask necessary to remove a DSC from storage.

CONCLUSIONS

Next to producing high-quality welds—barriers between the radioactive waste and the public—the process of ensuring quality welds is equally important. Although expensive to fabricate, workmanship coupons have multiple end uses and are very cost effective. A lessons learned regarding workmanship coupons is: Due to the unique and hazardous conditions germane to the nuclear industry, workmanship coupons can be fabricated to replicate unique configurations, to use for training and qualification of workers, to validate inspection systems or processes, and to enhance efficiency.

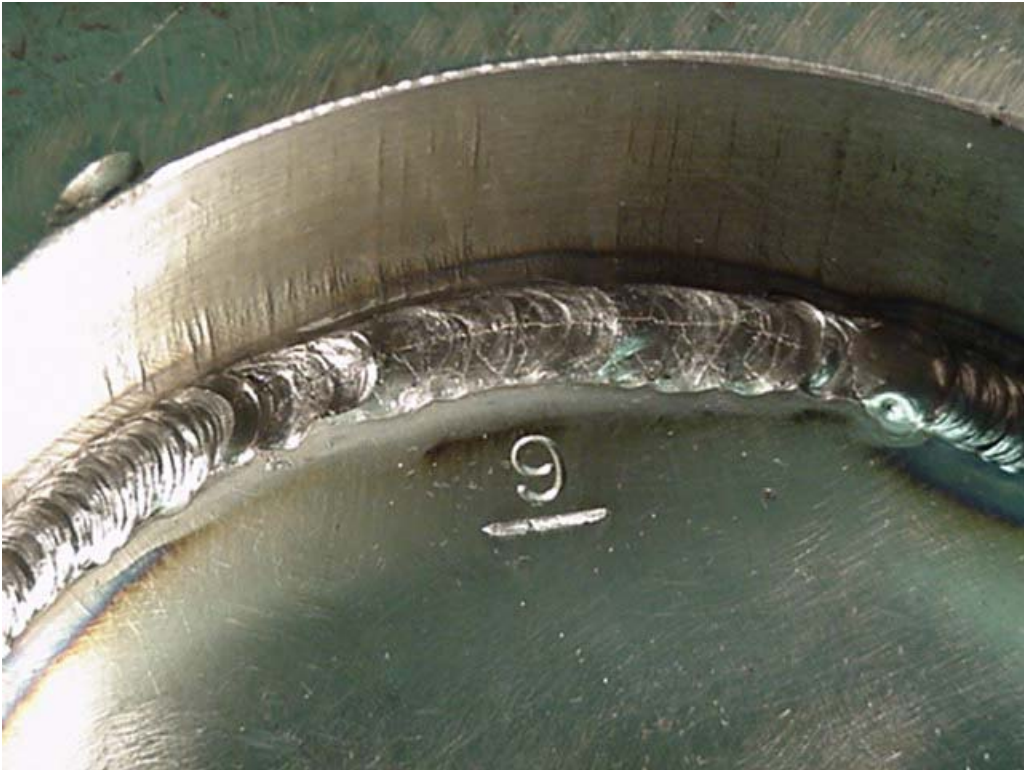


Fig. 1. Cracked Weld



Fig. 2. Workmanship Coupon