

IMPROVED TECHNIQUES FOR PACKAGING IRRADIATED METAL SEGMENTATION WASTES

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ABSTRACT

This paper provides detailed information on activities associated with packaging of Abrasive Water Jet Cutting (AWJC) waste resulting from reactor internal segmentation at Connecticut Yankee (CY) Atomic Power Station and San Onofre Nuclear Generating Station (SONGS). Emphasis is placed on the design efforts associated with the AWJC waste collection and packaging system, as well as licensing efforts for the A-43 High Integrity Container (HIC) used for packaging the AWJC grit. Avantech was contracted to supply a unique and innovative underwater system for collection and packaging of AWJC wastes at both sites. This approach minimized worker radiation exposure, radwaste and the use of precious floor space around the reactor cavity. Specific data is provided on equipment utilized, waste volumes generated and radiation dose rates. An overview of important project radwaste issues is provided, including regulatory approvals for shipping and disposal of a new and innovative High Integrity Container (HIC). The conclusions show how applying lessons learned and using new equipment and novel packaging techniques allows the plant to package highly radioactive irradiated metals in an ALARA manner while creating no orphan wastes.

INTRODUCTION

NRC documents show that six licensed nuclear reactors are in various stages of dismantlement and decommissioning. In addition, eleven additional reactors are in long-term storage for decommissioning at a future date. Due to the high number of shut down plants, a large sector of the nuclear industry is focusing on decommissioning activities. Experience gained from decommissioning at Fort St. Vrain, Yankee Rowe, Shoreham, etc. is now being applied to improve overall decommissioning efficiency. One such improvement is the use of AWJC equipment for segmentation of irradiated reactor components. Previous Pressurized Water Reactor (PWR) segmentation activities were performed with plasma arc cutting systems. Plasma arc is a very powerful technology that quickly cuts metal, but unfortunately, due to its' wide cut width or Kerf, significant amounts of dross is generated. During previous work, the dross was captured on filter elements. The filter elements were characterized as Greater Than Class C (GTCC) waste and required long term storage.

The prime advantage of AWJC is that it only removes a small amount of metal – its' kerf is approximately 0.035" wide. Hence, the concentration of radioactivity in the resulting waste is far less than that of plasma arc. Since the concentration of radioactivity is greatly reduced, no GTCC or orphan waste is generated. One negative characteristic of AWJC is that it generates a measurable amount of grit contaminated with irradiated metal fines.

PCI Energy Systems was contracted to perform the turn-key AWJ cutting operations, including waste packaging, at both CY and SONGS. PCI evaluated waste packaging methodologies from several companies that offer radwaste services and products. A contract was eventually awarded to Avantech for the design, licensing and supply of an underwater waste collection and packaging system. The system utilized is based on the general flow diagram depicted in Figure 1, "Waste Packaging Flow Diagram".

All segmentation and waste packaging activities take place inside the flooded Reactor Vessel Cavity (RVC). AWJC waste (*grit, metal fines, etc.*) is transferred from the segmentation area to a centrifugal cyclone separator. The overflow from the cyclone is processed through a filter and the underflow is directed to a surge tank prior to being transferred to the A-43 HIC. Sluice water associated with the surge tank transfers is processed through backwashable filter elements located in the HIC's process lid. Once the HIC is fully loaded with AWJC waste, it is isolated from the segmentation process and final dewatering is initiated. A cyclical dewatering technology is applied to remove freestanding water to less than one percent, as required by the Barnwell Waste Management Facility (BWMF) waste acceptance criteria.

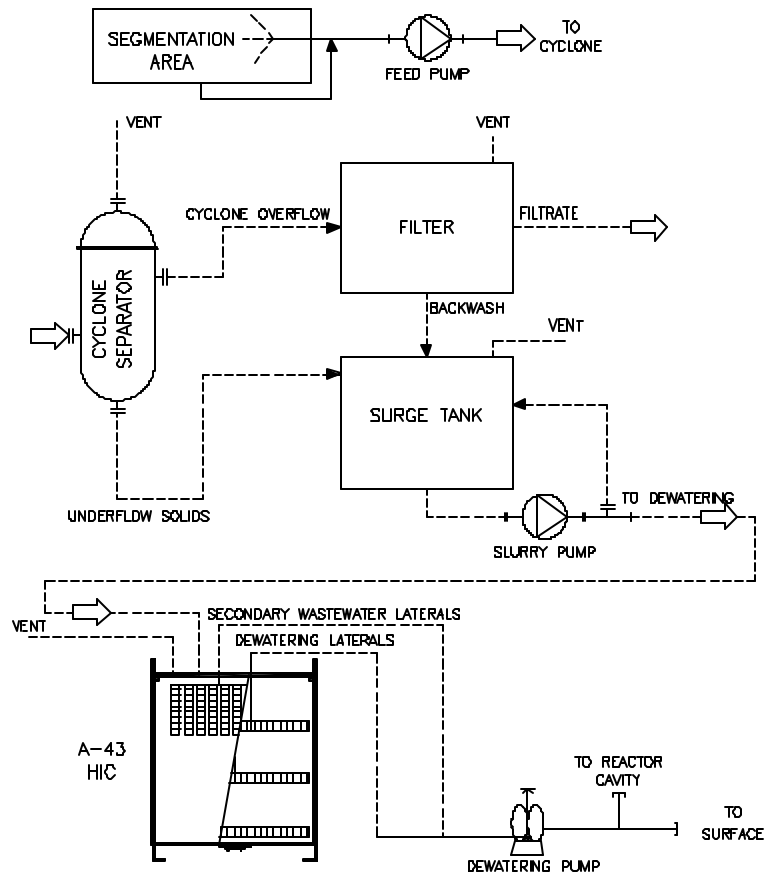


Fig. 1. "Waste Packaging Flow Diagram"

BACKGROUND

CY and SONGS plan to remove their reactor vessels from containment and transport them to the BWMF for disposal. A good portion the stainless steel reactor internals, *e.g., lower internals, core barrel, thermal shield, baffle plates, etc.*, are greater than class C (GTCC); therefore, they have to be removed to meet the disposal site waste acceptance criteria. Removing the internals also prevents the BWMF from exceeding its' 50,000 curie above ground limit. The reactor internals have to be cut or segmented so that they can be removed from the reactor and packaged into onsite storage containers. Due to very high radiation dose rates, the segmentation will be

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performed remotely using an abrasive water jet cutting head similar to that shown in Figure 2, "Abrasive Jet". The abrasive water will be at 55,000 psig and garnet is included to facilitate the cutting. This technology was selected because the kerf or cut width is only ≈ 0.035 inches, hence very little metal is removed and no GTCC secondary cutting waste is generated. During the cutting process, the metal fines are mixed with the garnet and subsequently removed from the water with a cyclone separator and filtration system. As stated, the AWJC waste is not GTCC and can therefore be disposed of at the BWMF.

The waste packaging components consist of a control panel, dewatering skid and A-43 HIC. Everything except the control panel is submersed in the RVC and all waste filling and dewatering operations take place underwater. As shown in Figure 3, "A-43 HIC", this container is a cylinder that is 34" in diameter by approximately 109" tall. It has a maximum waste holding capacity of 43 cu-ft and it is designed to be loaded into and transported in the Transnuclear TN-RAM or equivalent cask.

A-43 DESCRIPTION

The A-43, is really the heart of the system required for packaging the spent garnet and metal fines. This vessel is designed to perform several functions as defined in the following paragraphs:

Secondary Wastewater Process Vessel - Grit containing slurries and wastewater are pumped from various collection points into the A-43 on a frequent basis during segmentation operations. The A-43 is designed with an array of filters in the upper head that remove the particulate and discharge filtered water back to the reactor cavity. These filters are also designed with a back-flush capability that allows particulate to be removed from the filter element so that high throughput efficiency is achieved throughout the A-43 filling process.

Pressure Vessel - In order to properly house the filter elements, the A-43 had to be designed as a pressure vessel to withstand the force of the waste transfer pumps. Accordingly, the vessel is designed in accordance with ASME, Boiler and Pressure Vessel Code, Section VIII, for operation at 50 psig and full vacuum.

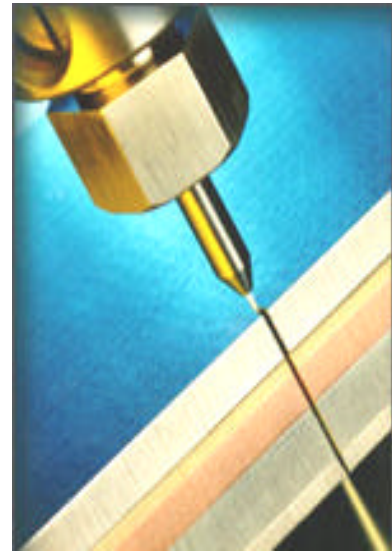


Fig. 2. "Abrasive Jet"

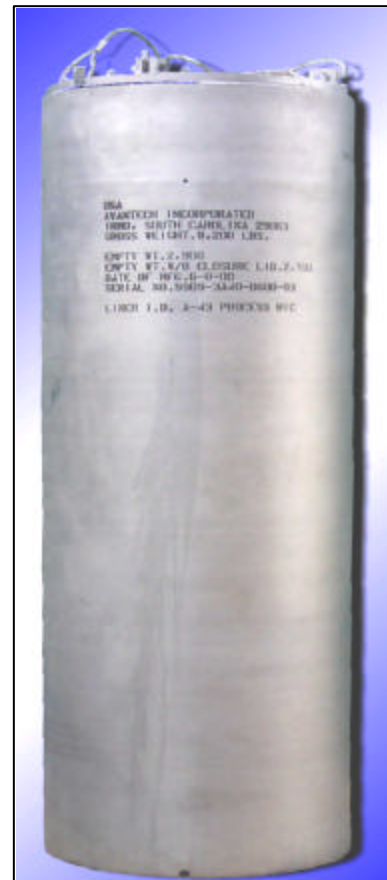


Fig. 3. "A-43 HIC"

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Disposal Container - The waste disposed of in the A-43 is typically Class C; therefore, it must be stabilized by a High Integrity Container (HIC) in accordance with 10CFR61 requirements. To accomplish this, the A-43 had to meet the design and test criteria specified by the South Carolina Department of Health and Environmental Control (SC-DHEC) for HICs.

Underwater Operation – Due to very high radiation dose rates (*500 R/Hr or greater*), each site had to be able to fill, dewater and load the A-43 into a transport cask via remote underwater operations. All of these capabilities have been incorporated into the A-43 design, thus saving significant amounts of personnel radiation exposure and floor space inside the containment building. Final dewatering is performed through multi-level laterals operating on a cyclical basis with the vessel vented to the surface. When final dewatering criteria is met, all A-43 valves are actuated to the closed position to isolate the vessel and prevent water intrusion. Finally, all hoses and instrument lines are disconnected and a closure lid is installed from the surface.

A-43 LICENSING

Licensing was performed in accordance with the SC-DHEC *Guide For High Integrity Container Topical Report Applications*. This guideline provides all the structural, lifetime, corrosion, radiation, biodegradation, dewatering, lifting/ handling and drop test requirements that need to be fulfilled for HIC certification. To meet these requirements, Avantech performed engineering analyses, finite element modeling and a variety of laboratory and full scale tests. One of the most rigorous tests was associated with the A-43's structural integrity. To meet this requirement, Avantech submitted finite element models for container drops onto an unyielding surface and compacted clay. Additionally, the BWMF Operator, Chem-Nuclear performed testing to verify that the A-43 could be offloaded in an ALARA manner. Finally, full-scale drop testing was performed to simulated conditions associated with the BWMF Slit Trench.

After a variety of submittals to SC-DHEC to provide information and to respond to questions, the A-43 was given the HIC Certificate of Compliance No. DHEC-HIC-ML-019 in July of 2000.

Offload Test Simulation - The transport cask is inspected upon arrival at the BWMF and taken into a facility where the cask lid is removed. This operation exposes the waste container (*in our case an A-43*) for remote viewing. Next, an eye-hook with a long cable is remotely connected to a pull bar in the A-43 closure lid.

With the eye-hook secured in the closure lid, the A-43 is transport to the disposal trench. Next, the eye-hook cable is connected to a winch on the far side of the disposal trench. The winch is then used to pull the A-43 out of the transport cask and on to a chute or slide. Finally, the A-43 slides down the chute and into a concrete overpack. The concrete overpack is lined with a steel plate and plywood to minimize possible impact damages to the bottom of the overpack.

Avantech designed and constructed a chute similar to the one used at the BWMF to simulate full-scale off-loading of a loaded A-43. A concrete pad was placed below the chute and prepared with a steel plate and plywood overlay to simulate the disposal trench conditions. The A-43 was loaded with Garnet that had a density of approximately 165 lbs/ft³ and placed on top of the chute

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as shown in Figure 4, “A-43 Drop Test”. Finally, a crane was used to tip the A-43 to initiate the slide onto the concrete pad. As shown in Figure 5, “A-43 Post Impact Position”, the A-43 impacted the concrete pad and slid straight out away from the chute as planned by the test and as typically experienced at the BWMF.



Fig. 4, “A-43 Drop Test”



Fig. 5, “A-43 Post Impact Position

A post impact survey of the A-43 showed that the closure lid and head bolts remained in-tack and essentially unaffected by the drop test. Upon removing the closure lid to allow inspection of the process lid and cavity, the pressure lid, the nozzles and the bolt holes showed no sign of deterioration. Test results showed that the A-43 not only prevented the loss or dispersal of its contents but also remained undamaged after the drop test.

ONSITE OPERATIONS

During onsite operations at CY, there were over 2,000 AWJ cuts made – some of these cuts were over 500 inches in length. When summed together, the total length of the cuts was approximately 23,000 inches. The cutting operations produced an AWJC waste containing approximately 20,000 lbs. of abrasive grit and 300 lbs. of irradiated metal that was collected and packaged into 3 A-43 HICs. The combined grit and metal produced a final AWJC waste that was less than 25% of the Class C limit. Final dose rates on the packaged waste was approximately 500 R/Hr.

Collection of AWJC Waste – All cutting operations take place inside an enclosure known as the “Segmentation Table”. Two primary mechanisms are used to pick up cutting waste from the cut zone and transfer it to the separation and packaging equipment. First, local capture hoods connected to a feed pump are utilized when practical to move waste from the cut zone to the cyclone separator as shown above in Figure 1. Grit that does not get collected by the capture hood falls into a conical hopper that covers the bottom of the segmentation table. Similarly, cutting waste is transferred from the bottom of the hopper to the cyclone.

Over 99% of the cutting waste solids are removed by the cyclone separator. The solids that carry through the cyclone exit in an overflow stream that is processed through backflushable filter elements. The cyclone underflow and backwash water associated with the filters are transferred to the A-43 for final packaging. Sluice water associated with waste transfers is removed from the A-43 through upper secondary wastewater processing internals. These upper internals are backflushed on a periodic basis to maintain acceptable flow rates through the HIC. Final dewatering takes place through multi-level lower internals that are not used on a routine basis during filling operations.

A-43 Transport and Disposal – Only one cask in the nation is currently approved for transporting the A-43 filled with AWJC wastes, it is the Transnuclear TN-RAM. Unfortunately, the CY decommissioning contractor and the personnel that coordinate operation of the TN-RAM have not been able to work out a mutually acceptable schedule for transport, so as of January 2001, 3 A-43's remain in the flooded reactor cavity at CY. The A-43 is also dimensionally compatible with the 3-55 cask, but this cask is not licensed for transporting dispersible materials like AWJC waste.

CONCLUSION

The A-43 was specifically designed and licensed for packaging dross, abrasive water jet grit, filters and other waste materials containing irradiated metal fines. The container is designed and approved to withstand all the stresses of handling, processing and transportation, and to last for 300 years in the BWMF disposal environment.

All packaging activities associated with the A-43 are especially safe because they take place under water - this includes dewatering and HIC closure, thereby minimizing personnel exposure and the potential for airborne contamination. Submersed operations offer several benefits:

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- Enforces ALARA Guidelines
 - Minimizes personnel exposure
 - Mitigates potential for leakage and spills
 - Eliminates the potential for airborne contamination
 - No air picks are required for cask loading
- Simplifies handling of very high radiation materials
- Minimizes floor space
- Shortens hose runs

In contrast to the A-43 / TN-RAM combination, other – larger volume casks typically have a dose rate limit in the range of 300 R/Hr. Accordingly, this container combined with the TN-RAM cask provides a very important packaging methodology for plants undergoing decommissioning operations where waste reading thousands of Rem per hour may be created.