NUCLEAR SOLID WASTE PROCESSING DESIGN AT THE IDAHO SPENT FUELS FACILITY

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ABSTRACT

A spent nuclear fuels (SNF) repackaging and storage facility was designed for the Idaho National Engineering and Environmental Laboratory (INEEL), with nuclear solid waste processing capability.

Nuclear solid waste included contaminated or potentially contaminated spent fuel containers, associated hardware, machinery parts, light bulbs, tools, PPE, rags, swabs, tarps, weld rod, and HEPA filters.

Design of the nuclear solid waste processing facilities included consideration of contractual, regulatory, ALARA (as low as reasonably achievable) exposure, economic, logistical, and space availability requirements. The design also included non-attended transfer methods between the fuel packaging area (FPA) (hot cell) and the waste processing area.

A monitoring system was designed for use within the FPA of the facility, to pre-screen the most potentially contaminated fuel canister waste materials, according to contact- or non-contact-handled capability. Fuel canister waste materials which are not able to be contact-handled after attempted decontamination will be processed remotely and packaged within the FPA. Non-contact-handled materials processing includes size-reduction, as required to fit into INEEL-permitted containers which will provide sufficient additional shielding to allow contact handling within the waste areas of the facility.

The current design, which satisfied all of the requirements, employs mostly simple equipment and requires minimal use of customized components. The waste processing operation also minimizes operator exposure and operator attendance for equipment maintenance.

Recently, discussions with the INEEL indicate that large canister waste materials can possibly be shipped to the burial facility without size-reduction. New waste containers would have to be designed to meet the drop tests required for transportation packages. The SNF waste processing facilities could then be highly simplified, resulting in capital equipment cost savings, operational time savings, and significantly improved ALARA exposure.

INTRODUCTION

The Idaho Spent Fuels Facility (ISF) will receive various configurations of SNF, currently stored at the INEEL site. Canisters will be transported from current dry and wet storage locations on site, to the ISF facility. Within the FPA, spent fuel rods will be removed from existing storage containers, placed into new baskets, and sealed in an ASME NQA-1-certified DOE preliminary standardized canister. The new canisters containing SNF rods will be stored in the ISF facility until the availability of the national repository. The FPA within the ISF facility is being designed for remote handling and repackaging of SNF from former Peach Bottom and Shippingport reactors, and Training, Research, and Isotope Reactors built by General Atomics (TRIGA). The SNF-related waste includes canisters, lids, internal runners and landing plates, cans, and buckets.

Figure 1 shows the currently designed layout of the waste processing area. The Waste Area is located on the first floor elevation of the ISF facility, and includes the Solid Waste Processing Area (SWPA) and the Solid Waste Storage Area (SWSA). The SWPA will receive solid waste from the FPA through either the Canister Waste Port or the Process Waste Port. The SWPA contains the CAM and RAM alarms. Design of the ventilation system for the facility required minimizing ventilation leaks during opening of the ports between areas. Thus, mechanisms are provided to block ventilation flow leakage at the canister waste port and the process waste port. At the canister waste port, ventilation leakage is controlled by a port shroud; at the process waste port the flow leakage is controlled by an inverted “tophat” held by the forklift. The SWSA will support the SWPA with the Operator Station, Drum Storage Room, and Drum Compactor Room. The electric forklift will reside in the SWSA.

SOLID WASTE DESCRIPTION

Large canister waste consists of carbon steel, aluminum, or stainless steel cylinders ranging from 18” to 25” diameter and up to 158” long, with wall thickness up to 0.375”. In addition, large canister waste will include canister lids and canister hardware. Some canister waste will contain support rings, internal runners (flat bars), runner supports, landing plates and crush plates. One canister will contain a tube bundle and support plate. The weight of the largest-diameter single canister and internal components is approximately 2700 lb. The heaviest single component is a tube bundle at 3315 lb. Large canister waste which is above the contact-handled limit will be placed in drums while in the FPA, and passed through the process waste port to the tophat.

Small canister waste consists of carbon steel, aluminum, or stainless steel cylinders ranging from 4” to 5” diameter, and up to 158” long, with wall thickness up to 0.258”. Small canister waste which is above the contact-handled limit will be placed in drums while in the FPA, and passed through the process waste port to the tophat.

Process-generated waste consists of paper, rubber, plastic, rags, machinery parts, tools, vacuum cleaner debris, welding materials, and HEPA filters. Process-generated waste, which is accumulated frequently, will be stored locally. Infrequently generated waste will be bagged and taken to the Solid Waste Storage Area immediately after it is generated. Process-generated waste which is accumulated in the FPA will be placed in drums while in the FPA, and passed through the process waste port to the tophat.

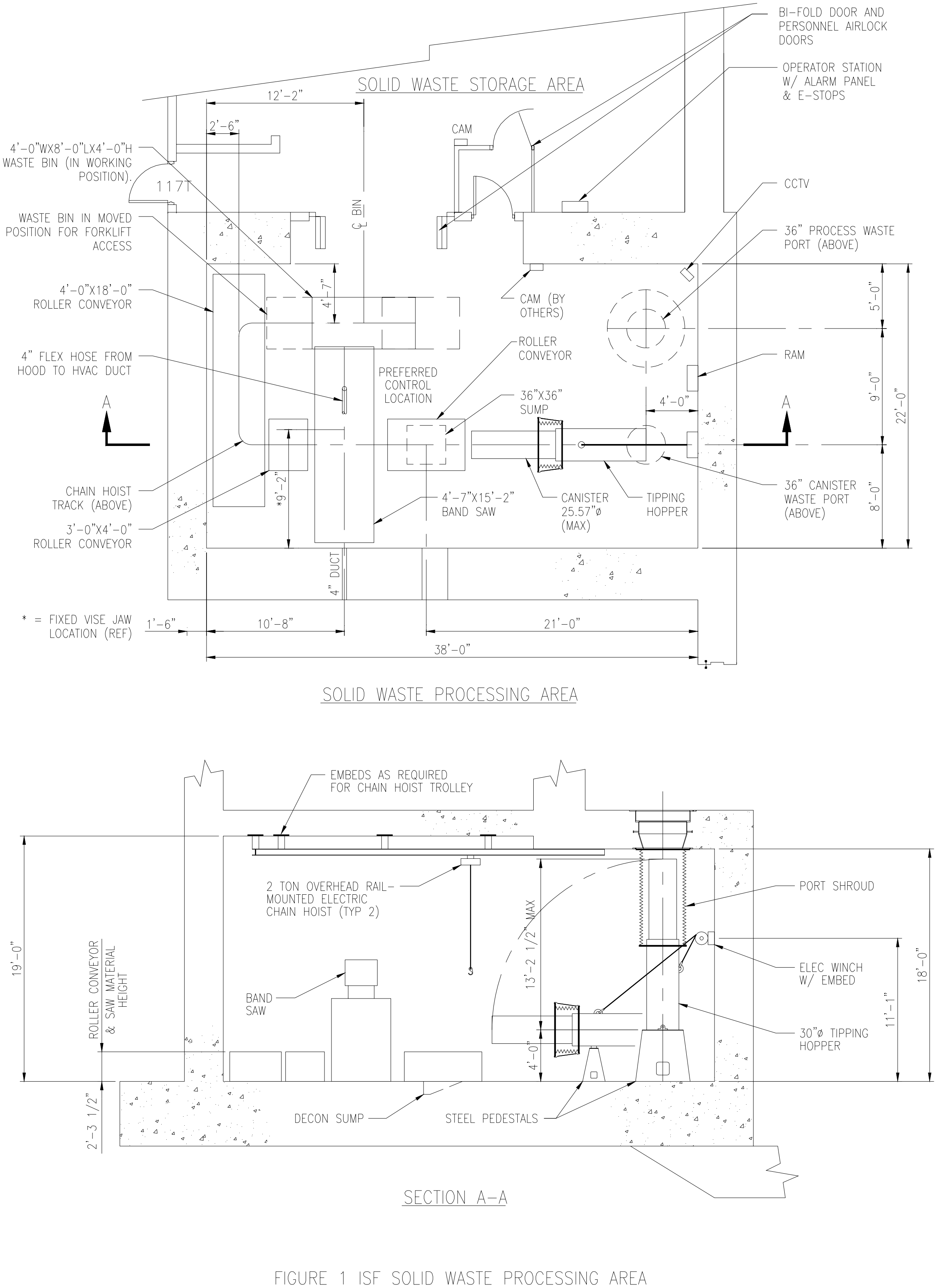

FIGURE 1 ISF SOLID WASTE PROCESSING AREA

FPA SPENT FUEL CONTAINER MONITORING SYSTEM

The purpose of the FPA Spent Fuel Container Monitoring System is to monitor the inner surfaces of spent fuel containers for radiological contamination. Spent fuel containers which exceed a predetermined internal dose rate will be sectioned and/or repackaged inside the FPA, and transferred to the Solid Waste Processing Area in drums or shielded drums. Spent fuel containers which are determined to be within a predetermined internal dose rate will be transferred to the SWPA whole or in drums. The predetermined internal dose rates will be a function of waste material self-shielding, and considerations of potential exposure geometry to the operators in the SWPA.

CONTRACTUAL REQUIREMENTS

The Foster Wheeler contract with the U.S. Department of Energy requires solid waste materials to be characterized, processed and shipped per the requirements of the DOE Idaho Reusable Property, Recyclable Materials, and Waste Acceptance Criteria (RRWAC). Additionally, the contract requires compliance with the Environmental Impact Study (EIS) for the facility.

REGULATORY REQUIREMENTS

The RRWAC requirements for low level nuclear solid waste disposal at the local burial grounds (RWMC) are relatively extensive. These characterization and disposal requirements include individual isotope concentrations, fissile concentrations, TRU concentrations, free water limitations, hazardous waste exclusion, and container types. Specifics of the approach for meeting these requirements are discussed in the following section.

Meeting the requirements of the RRWAC was first approached by calculating the expected isotope concentrations in the solid waste. The results of this calculation provide assurances that the disposal requirements will fall well within the RRWAC definition for low-level radioactive wastes which could be buried at the INEEL burial facility.

The contract provided source terms for each of the fuel types to be delivered and repackaged. The source term for the fuel type which was most likely to break during repackaging operations was selected as a bounding basis. Based on the NRC Guidance Document, ISG-5, “Interim Staff Guidance-5, Revision 1 – Confinement Evaluation”, the release fractions for each isotope were provided. ISG-5 also specifies a 1% rod breakage fraction for “normal conditions”. A conservative assumption of 10% capture of the available breakage by the solid waste processing system was used. The total annual solid waste volume was then calculated, based on the SNF fuel delivery schedule and corresponding waste configurations. Finally, the quantity of radioactive activity per isotope was divided by the annual waste volume, to yield the average isotope concentration of the waste in Curies per cubic meter. The results of the calculation indicate that the average isotope concentration of the waste will generally fall orders of magnitude below the limitations given by the RRWAC.

Calculations of fissile and TRU isotope concentrations also indicate that these average isotope concentrations of the waste should fall orders of magnitude below the limitations given by the RRWAC.

A 1% free water limitation is also specified in the RRWAC for low-level radioactive wastes which can be buried at the INEEL burial facility. Hence, some potentially radioactive solids which contain free water, such as band saw cutting fluids and smaller size filters, must be treated with solidifying agents.

The hazardous waste prohibition specified in the RRWAC will be met by limited use and segregation of hazardous wastes.

Permissible container types and sizes are also specified in the RRWAC. In consideration of the larger diameter waste canisters, a 4’ x 4’ x 8’ steel waste bin was selected, to minimize the number of band saw cuts required. Also, less administrative time will be required to manifest larger waste bins which are less frequently shipped. For process waste and sectioned waste from the FPA, 55-gallon Type UN1A2 drums up to 1000 lb gross weight are listed. If necessary, 55-gallon drums will be lined with concrete to achieve additional shielding when materials cannot be sufficiently decontaminated in the FPA. Both the waste bin and the 55-gallon drum are listed as DOT 7A drop tested, thus satisfying the transportation integrity requirement across the site.

A conservative calculation of annual low-level radioactive solid waste volume indicated that a range of 54 to 75% of the limits specified in the facility EIS would be generated. Conservative assumptions included that the primary waste (large and small canister waste) could not be co-mingled with the process-generated waste. Thus, smaller materials were not assumed to be used as void space filler in the waste bins.

ALARA EXPOSURE

ALARA design involved striking a compromise between time-intensive remote solid waste processing in the FPA of the facility, and acceptance of minimal dose rates during manned attendance during processing in the SWPA. Based upon this consideration, a predetermined limit will be placed on the canister interior dose rate as monitored in the FPA.

Several other ALARA features were integrated into the design, including:

- selection of a semi-automatic band saw which cuts and stops unattended
- selection of an automatic tipping hopper for moving large waste containers from the vertical to the horizontal position
- selection of simple and rapidly employable methods for blocking ventilation leakage during opening of the waste ports
- administrative prohibition of operator presence in the SWPA while either FPA port is open
- a concrete shine wall between the SWPA and the SWSA
- administrative requirement to periodically decontaminate the floors, walls, and equipment in the SWPA

- RAMs positioned just below the FPA ports such that a radiologically contaminated drum or container exterior will require withdrawal back to the FPA for decontamination and/or sectioning
- Operating procedures will include routine changeout and solidification of the band saw cutting fluid as dose buildup occurs
- Providing a sump in the SWPA which allows water decontamination of the room or waste containers. Decontamination water can be pumped from the sump to a liquid radioactive waste tank.

ECONOMICS

Initially, the concept of a large hydraulic shear was selected as the preferred solid waste processing technology for larger spent fuel containers. The shear could provide sectioning and significant volume reduction of larger spent fuel canisters, because large waste containers could be crimped and cut into short sections. ALARA and logistical objectives would both be ideally met, since the shear could be mounted on a rail car, operated remotely, and containers could be clamped, cut in a vertical position, and dropped directly into a waste container. However, the benefits associated with the shear were not sufficient to justify its high capital costs.

A commercially available band saw was ultimately selected as the processing technology for larger spent fuel containers. The cost of the appropriately sized band saw was an order of magnitude less than the initially proposed hydraulic shear. The tradeoffs of the band saw selection included more dose rate exposure, since an overhead hoist must be used to move the large or long containers into the band saw, and into the waste bin after sectioning. Logistically, more space is involved with the selection of the band saw, since several pieces of supporting equipment must be utilized, including a tipping hopper (to move the canister from a vertical to horizontal position), overhead hoists for moving the canisters from the tipping hopper to the conveyors and from the conveyors to the waste bin, and conveyors upstream and downstream of the band saw. Approximately twice as much floor space is required with the band saw option compared to the hydraulic shear option.

LOGISTICAL REQUIREMENTS

Large canister waste is moved from the FPA to the SWPA in a vertical position, because large canisters are handled in the vertical position in the FPA. One port between the FPA and the SWPA is dedicated to canister waste, because the design of the tipping hopper is simplified if it pivots about a fixed position.

Drummed waste is moved from the FPA to the SWPA through the process waste port. The location below this port needs to be fully accessible to the forklift which will raise the tophat to the underside of the port and receive the waste drum. The location of the waste bin requires lateral movement of the waste bin to allow forklift access. The waste bin can be placed on rollers, which allows manual lateral movement.

The band saw is located such that there is alignment between the tipping hopper and clamped position of the waste containers. This alignment will minimize the effort of rolling the containers on the roller conveyors. The band saw also must be far enough from the wall on the downstream side to allow the large waste containers to be cut in half. The preferred control location of the band saw is located to allow quick exit from the SWPA if a CAM or RAM alarm occurs.

The overhead electric chain hoists are located to allow the lifting and removal of the large container waste onto the band saw and roller conveyors. The chain hoist tracks follow the conveyors, as an alternative method for moving cut container sections from the band saw to the waste bin. Two hoists are provided, such that container waste can be removed from the tipping hopper at the same time as cut container sections are moved from the band saw to the waste bin.

The sump in the SWPA is located in an area where decontamination activities are likely to occur. The location corresponds to the open end of large SNF containers in the horizontal position, where decontamination liquids would flow during “wet” decontamination of waste containers.

The waste bin is located such that the forklift has a straight, short path from the SWSA to the SWPA to access and remove the bin from the SWPA.

The HVAC ductwork and HEPAs serving the SWPA were located external to the SWPA, to allow maximum maneuverability of the large waste canisters while suspended with the overhead chain hoists and during usage of the forklift / tophat at the process waste port. The supply air was directed to the least contaminated end of the SWPA, while the exhaust air was removed from the most contaminated end of the SWPA, to maintain confinement zones consistent with expected contamination distribution.

Electrical conduit within the SWPA was located predominantly on the ceiling and walls, in locations which avoid interference with equipment and operations.

The operator station, containing a CCTV and emergency stops, is located in the SWSA, which has a low potential for significant dose rate. Any problems occurring during transfer of waste through the ports, or during band saw operation will be rapidly noticed, and equipment can be shut down remotely.

SPACE AVAILABILITY

A rectangular space of 22 feet by 38 feet was allotted for the SWPA, during bid preparation. At the time of bid preparation, the specific processing technology for large spent fuel canisters.had not yet been selected. Given the ultimate selection of a band saw and supporting equipment, the original layout was reworked to accommodate the equipment. As indicated in Figure 1, the path of large waste canisters was wrapped 180^{o} in the SWPA, in order to accommodate all the components and still allow forklift access to the waste bin.

Headroom in the SWPA was adequate, since the length of large spent fuel canisters was known as part of the RFP. Thus, the tipping hopper can accommodate the longest waste canister.

CONCLUSION

The current design employs mostly simple equipment and requires minimal use of customized components. The waste processing operation requires minimal operator exposure and operator attendance for equipment maintenance. Methods are provided for decontamination of the SWPA and associated equipment, which has significant potential for carryover of contamination in the SNF waste containers or from the FPA.

Evolution of the waste processing design may allow shipment of large waste containers to the burial facility without size-reduction. The SNF waste processing facilities could then be highly simplified, resulting in capital equipment cost savings, operational time savings, and significantly improved ALARA exposure. The significant improvement in ALARA exposure would result from elimination of potential contamination spreading during cutting with the band saw, and because the direct shine path from the open-ended SNF containers could be eliminated by placement of a lid on the waste container while in the vertical position in the tipping hopper. Other operating cost savings would include the significant cost of steel waste bins, and a reduction in total waste volume.