Innovative Resin Transfer and Disposition at Indian Point Unit 1

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ABSTRACT

A number of sites have both operating and shuttered nuclear facilities. Reducing dose to the caretakers can have beneficial effects for other site personnel who may work or pass near the shuttered facility. Furthermore, disposition of waste can have a positive effect on NRC required regular reporting of, and plans for the disposition of on-site wastes.

Entergy's Indian Point Energy Center recently reduced the on-site curie load by working with RWE NUKEM and WMG, Inc. to innovatively free and ship nearly 1,000 cubic feet and nearly 600 curies of 30 year old resin and sludge from Unit 1. Old drawings, operations logs, were consulted and transfer lines were remotely checked. The tank selection sequence was primarily based on dose rates. System modifications to facilitate resin transfer were made on the lowest dose tanks first to gain current operating experience. Resin transfers were performed in accordance with the procedures developed, into waiting cask with appropriate waste containers. Decomposed resin of varying consistency could clog discharge lines and operational changes were made to mitigate against flow interruptions. Hydrogen buildup in the tanks was carefully addressed while solidified resin remains a challenge to be overcome.

BACKGROUND

Indian Point Energy Center's Unit 1 (IPECU1), a 265 MW Babcock & Wilcox PWR, has been shut down since October 1974 and maintained in a SAFSTOR condition. During the years of storage, IPECU1 actively reduced radioactive waste stored on-site and the accompanying the dose hazard. Older examples of radionuclide reduction efforts included fuel pool and waste storage cleanout campaigns. The most recent example of radionuclide inventory reduction at IPECU1 was the liquid waste system tank and vessel cleanout project performed from August 2005 to August 2006. The project targeted process vessels and piping with entrained 30 year old but still high dose resin, sludge, and water.

WMG, a subcontractor to NUKEM, provided project management, and characterization for the removal, packaging, and shipment of expended mixed bed, cation and anion resins, sludge, and water. As the contractor to Entergy, NUKEM provided and operated the equipment necessary to remove the resins, sludge, and water from the storage tanks, packaged the resins, sludge, and water in waste liners, dewatered the wastes to meet IPEC shipping criteria and provided the shipping casks and transportation to ship the packaged wastes to a processor. This document summarizes the work performed that led to three (3) 14-215 cask shipments, one (1) 14-210 cask shipment and four (4) 10-142B cask shipments.

The on-site work started in August 2005 and was completed in August 2006. All shipments were made to the Studsvik and RACE Processing facilities as low-level radioactive waste (LLRW). The processed resin, sludge and water was shipped for burial by Studsvik.

Sixteen tanks identified in the following table retained process liquids and resins for more than 30 years.

TABLE I

IPECU1 Project Scope

Resin Type	Tank Identifier	Tank Volume (ft^3)
Boric Acid Clean up Exchangers (Anion)	E-8, E-9	65
Spent Resin Storage Tanks (Mixed Bed, Cation, Anion)	19, 19A 20, 20A	200
Spent Fuel Pool Ion Exchangers (Mixed Bed)	E-6 / E-7	45
Purification Ion Exchangers (Mixed Bed)	E-2, E-3, E-4	75
Purification Ion Exchangers (Cation)	E-13, E-14, E-15	75
Sludge Storage Tanks (Sludge Water)	T21, T21A	475

PLANNING

Because the IPECU1 resin transfer system had been left dormant for over 30 years, Entergy incorporated a series of modifications that allowed direct sluicing of each vessel rather than sluicing of the entire train. Removal of the resin and sludge water from the vessels followed a work process which involved as-built drawing reviews, ALARA planning, tag outs, modification to the tank valves, post modification testing, modification / tag out paperwork completion, valve lineups and eventually installation of resin transfer hoses to the tank connections. The process equipment (described later) would be staged on the operating floor near and above the process vessels and plant piping.

Prior to installing any modification on any vessel, pre-requisite flammable gas testing was performed. Tanks E-13, E-15 and E-4 exhibited the presence of hydrogen and hydrogen sulfide (sewer) gas in flammable levels. IPECU1 project management developed an approach to evacuate the flammable explosive gas from the tank before modifications were installed. The gas was purged from the tank by introducing Nitrogen into the tank. The Nitrogen purge moved the hydrogen sulfide at a very low rate from the vessel to containment. Moving the hydrogen sulfide at a low flow rate avoided localized explosive levels in containment and reduced the concentration in the vessels to below explosive levels. The vessels were sampled again to confirm the presence of the hydrogen gas was in levels below flammable limits or not present at all.

After ensuring a non-flammable work environment, tank modification was performed. Vessel selection sequence was primarily based on dose rates. General area dose rates in the valve galleries ranged from 2mR/hr to 150 mR/hr. Because vessel modification required to support radionuclide reduction had not been performed before, it was decided from an ALARA perspective to gain modification experience on low-dose vessels before performing similar work on the higher dose vessels.

The Spent Resin Storage Tanks (SRST's) and Sludge Storage Tanks (SST's) were not accessed via the valve gallery. Additionally, the tank valve modification was not performed on the SRST's or SST's because it was not necessary for the removal method selected.

RESIN PROCESSING AND PACKAGING

Several pieces of process equipment were used to remove the resins and sludge water from the tanks, to transfer the resin and sludge water into liners and to dewater the loaded liners. The process equipment consisted of a skid which allowed the introduction of water and/or air into the tank through one of three tank connections. A second skid that the resin traveled through provided for resin sampling prior to entering the waste liner. A fill head was placed on top of the liner. The fill head is equipped with a fill hose and dewatering hose connection along with a camera and high level alarm. An entrainment separator with dewatering pump and finally a filter housing as the last line of defense for capturing resin before the water entered the plant floor drain system were also part of the equipment used. This process and equipment proved successful on Tanks 19, 19A, 20, 20A, E-6, E-7, E-14, E-3, E-15, E-4, 21 and 21A. Tank E-2 was empty.

Tanks E-8, E-9 and E-13 were classified as containing solidified resin product. Boroscope inspection and volumetric testing was performed on each of the three vessels to determine the amount of product remaining in the tanks. The results of the inspections and tests suggest the tanks are 1/3 to 2/3 full of solidified product. The plan to remove the solidified product involved a hot water soak of the material. Each of the three tanks had 110 degree water re-circulated through them for approximately 20 hours. The following details the results of the hot water soak on each of the three tanks:

> TANK E-9 – The solidified material was dissolved and approximately 5 ft^3 of resin was removed from the tank. The "Sluice Out" line was thought to be partially blocked. The line was hydro lased (no restrictions encountered) and sluice performed again. The line still exhibited signs of blockage. A volumetric test was performed on the tank and the results confirmed the tank is now empty. It is believed that the content of the tank was primarily boron and the boron became soluble when flushed with hot water.
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> TANK E-8 – The hot water soak did not dissolve the solidified material in the tank. A volumetric test was performed as a follow up to the hot water soak and the results were

consistent with the volumetric test performed months earlier. Approximately 34 ft^3 of material remains inside the tank.

TANK E-13 – The hot water soak did not dissolve the solidified material in the tank. A volumetric test was performed as a follow up to the hot water soak and the results were consistent with the volumetric test performed months earlier. Approximately 50 ft^3 of material remains inside the tank.

Resin was removed from the SRST's by inserting a hose down the resin fill line and pumping it into the waste liner. Sludge water was removed from the SST's by cutting off the tank access cover, inserting a hose/wand into the liner and pumping the sludge water into Clausen tanks then into a waste liner.

The sludge water from the SST's was originally intended to be transported to Unit 3 for processing and release to the environment. However during sampling, it was identified that the sludge water contained constituents that prohibited release to the environment. A decision was made to transfer the water into a waste liner and ship the water to Studsvik for processing and burial.

IPECU1 used two different re-usable waste liners to package the resin. An ES-210 liner was used for the lower activity resin and sludge water and shipped off site in either the 14-210 or 14-215 casks. An ES-142 re-usable liner was used for higher activity resin and shipped off site in the 10-142B cask. The higher activity resin when characterized and classified had the potential to require a Department of Transportation (DOT) Type "B" package. The 10-142B cask also provides more shielding than the 14-210 / 14-215 cask. Vessel processing occurred as shown below.

TABLE II
IPEC Unit 1
Project Sequence

Resin Type	Tank Identifier	Dates (approx.)	Resin / Sludge Water Volume Removed(ft^3)
Boric Acid Clean up Exchangers (Anion)	E-8 E-9	8/30/05, 6/22/06 9/7/05, 6/20/06, 6/27/06	E-8 – None* E-9 – (5 ft^3)
Spent Resin Storage Tanks (Mixed Bed, Cation, Anion)	20A 20 19 19A	9/19/05 9/20/05 9/28/05 9/28/05	20A – 75 ft^3 20 – 60 ft^3 19 – 70 ft^3 19A – 40 ft^3
Spent Fuel Pool Ion Exchangers (Mixed Bed)	E-6 E-7	10/3/05 10/18/05	E-6 – 40 ft^3 E-7 – 43 ft^3
Purification Ion Exchangers (Cation) Purification Ion Exchangers (Mixed Bed)	E-13 E-2	12/5/05**, 7/11/06 12/13/05	E-13 – None* E-2 – 5 ft^3
Purification Ion Exchangers (Cation) Purification Ion Exchangers (Mixed Bed)	E-14 E-3	1/17/06 2/2/06	E-14 – 55 ft^3 E-3 – 50 ft
Purification Ion Exchangers (Cation) Purification Ion Exchangers (Mixed Bed)	E-15 E- 4	2/20/06 2/9/06 3/3/06	E-15 – 55 ft^3 E-4 – 60 ft^3
Sludge Storage Tanks (Sludge Water)	T21A T21	7/12/06 7/13/06	T21A – 45 ft^3 T21 – 100ft^3

* = Contents solidified/encrusted and not able to sluice out of tank.
** = Extended period of time between tank sluicing due to identification and removal of hydrogen sulfide gas from tanks.

LESSONS LEARNED

This section addresses lessons learned as a result of this innovative project. The following general categories detail the lessons learned:

System / Procedure Familiarization

First time use of a new system / procedure often produces challenges. Certain actions were taken that are not necessarily written in the procedure (nor need to be) to allow for system adjustments. Repeated system configurations and procedural actions are required before the process is seamless and the project team understands how the system reacts to different valve manipulations and the result of each valve manipulation.

The involvement of the field technicians in procedure development and input on equipment enhancements proved beneficial to continued and future applications and uses of the system. Procedures are much like living documents. Procedure revisions were part of doing business and were the result of a need to make adjustments for field conditions and/or improve processes.

Peer Checking

Valve manipulations should be performed in a manner consistent with the Plant Operations Department protocol. There were no incidents resulting from a lack of consistent peer checks, however peer checking reinforces proper work practices.

Three Point Communication

Three point communication is a proven method for crew members to give direction or convey information. It is an effective tool and should be used at all times. There were no incidents from a lack of consistent three point communication, however such communication reinforces proper work practices.

Water Volume

The initial source of water (NSG) used to sluice out the product from the tanks came from a 1” line. Once the water entered the resin transfer skid 2” line, the water pressure dropped significantly, thereby preventing achievement of sluicing design pressure. The water supply line (NSG) was changed to a 2” line and resolved the problem immediately.

Waste Liner Level Indicator

It is imperative to have an instrument to measure the amount of material collected in the liner. The first liner did not have any type of level indicator. Later liners were equipped with level indicators which incorporated one foot markings all the way up the indicator.

Spent Resin Storage Tanks (SRST’s)

As identified earlier in this report, the valve modification was not performed on the SRST’s. The approach was to insert a process hose down into the tank through the sluice in line and pump out the contents of the tank. During the first attempt, the process hose was pushed all the way to the bottom of the tank per the procedure. When the pump was turned on, a large volume of resin was sucked up into the pump and the pump became clogged. The pump and hose had to be replaced and a new approach adopted. The new approach was to work our way down into the product and introduce water at the process hose opening the whole time. The water helped to keep the product in a slurry form.

Decomposed Resin

Tanks E-2, E-3 and E-4 contained Mixed Bed resins. Tanks E-13, E-14 and E-15 contained Cation resin. Tanks E-13, E-14 and E-15 exhibited the highest dose rates of all tanks. In addition, there was a presence of hydrogen sulfide gas in tanks E-13, E-15 and E-4. Hydrogen sulfide gas buildup is the result of resin decomposition. Removal of the hydrogen sulfide gas was discussed earlier. The resin sluiced out of the tanks more in a liquid than sand consistency. During the liner dewatering evolution, it was discovered that the resin fines clogged the dewatering leg forcing liner shipment with more water inside than anticipated. To address the problem a different style dewatering leg / filter was used with a backup dewatering leg and ten cubic feet of Powdex resin was placed in the liner first as added filtration.

Resin Transfer System Leaks

During system startup, leaks were identified at different resin transfer system connections. As a result, additional focus was placed on all connections during subsequent leak tests with the increased awareness to identify leaks, stop the process and fix the leak before proceeding.

Contamination Control

Less than 100 ml of E-13 tank water was accidentally spilled. The spill created mrad smearable conditions inside the existing contaminated area and in clean areas as well. Contaminated areas were turned into high contamination areas in seconds. An under appreciation for how radiologically volatile the water was, resulted in a situation that challenged the existing radiological boundaries and caused personal contaminations.

Equipment used for sluicing and dewatering operations also provided pathways for radioactive material to escape established radiological boundaries. Specifically, the fill head had highly radioactive resins passing through it and some radioactive material collected on its internals. When the fill head is removed from the liner, the deposited radioactive material may become dislodged, by ventilation or bumping, and collect on the herculite skirt on top of the liner. Subsequent removal of the herculite, if not carefully performed, can spread the radioactive material onto adjacent surfaces. The Entrainment Separator which is used as part of the dewatering equipment incorporates a holding tank, pump, valves, hoses and connection points. A leak developed in a piping connection under the holding tank, which was hidden by other equipment on the skid. Fortunately the skid is equipped with a drip pan but the leak created high levels of contamination on the drip pan. The drip also had the potential to splash outside the drip pan deposited radioactive material in an otherwise clean area.

Measures such as securing localized ventilation prior to fill head removal and more extensive surveys on herculite bibs prior to removal were incorporated into sluicing evolutions.
During the course of the Project, the spread of radioactive contamination challenged radiological boundaries and personnel. Condition reports were written to document personnel contaminations and work area / equipment related contamination issues. Five condition reports identified radiological mistakes encountered during the project:

- CR (6/9/05), Floor contamination occurred during decontamination of valve gallery E4/E15 and resulted in an operator becoming contaminated while on rounds.
- CR (11/8/05), Water drops from a degassing hose resulted in personnel and floor contamination.
- CR (1/13/06), Two minor facial contaminations occurred while installing modification in valve gallery E4/E15.
- CR (2/8/06), Shoe contamination due to equipment leakage.
- CR (2/24/06), Cask/truck contamination.

Project Dose Estimates

The dose goals established for the tanks & vessels work was not exceeded due to the diligent ALARA sequenced work performed by project personnel. Dose received in 2005 was less than one tenth of that planned. Due to greater experience with actual work conditions, procedures and personnel, 2006 dose estimates were high by about a factor of 2 compared to the dose actually received.

Safety

Lost time, Reportable or Recordable injuries were ZERO for approximately 4600 hours of work.

Conclusion

Thirty year old liquid waste processing consumables were successfully removed due to safety ALARA-conscious procedures and process modifications made by innovative personnel.

Current conditions must be carefully evaluated and the process should be designed and evaluated to provide maximum flexibility.