

EXPERIENCE USING THE EPRI DfD PROCESS TO DECONTAMINATE SCRAP CONTROL ROD DRIVES AND SHROUD HEAD BOLTS

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ABSTRACT

Alaron, as a licensee of the EPRI DfD process, has performed a wide variety of tests to determine if the DfD process can be used to decontaminate stainless steel components from nuclear power reactors to free release. Our previous successful experience with Reactor Water Cleanup Unit (RWCU) heat exchangers led us to attempt to decontaminate components with much higher levels of fixed and loose contamination. The objective of this attempt is not only to determine if a successful decontamination of portions of the components to free release can be achieved, but also to analyze whether the process costs and secondary waste generated justify using the DfD process as opposed to direct disposal. In this paper we will present our experiences in decontaminating 20 shroud head bolts and 10 control rod drives that exhibit contact dose rates of 1.0 R/hr to 4 R/hr.

INITIAL RADIOLOGICAL CONDITIONS

The shroud head bolts exhibited dose rates that varied from 400 mR/hr to 4 R/hr on contact gamma dose. The shroud head bolts were exposed to the most neutron flux at the spade end and dose rates were consistently higher on the spade ends. Contamination levels were approximately 500 mR/hr gamma on a small paper wipe. Contamination levels were fairly uniform over the entire bolt. The contamination was contained in a very fine red oxide coating on every exposed surface. Wipes only removed a small fraction of the reddish oxide. The bolts still had their nuts and springs attached. Control rod drives exhibited dose rates from 100 mR/hr to 1.2 R/hr on contact. Loose contamination ranged up to several million dpm/100cm² beta gamma. The drives were completely assembled including plungers and all inner sleeves. The innermost plunger was coated with a black (graphite) coating which appeared to be from the manufacturer rather than a different oxide layer. The outside of the drives did not have a uniform oxide color or appearance, nor did the inner sleeves and plungers. The coloration ranged from red through brown to black and was not of a consistent texture.

SYSTEM CONFIGURATION

The system configuration was designed in house by Alaron personnel and includes the following components.

Pump Skid: The skid is comprised of a 300 g.p.m. centrifugal pump and the required valving to direct flows to one or more of the support components. The system was also designed to allow a complete reversal of flow when required. The skid is equipped with temperature sensors and flow meters so that performance can be monitored during runs. The skid is connected to the other support components by specialty lined flexible hosing with cam lock fittings.

Heat Tank: The heat tank is a 250 gallon conical open top tank with top feed and bottom suction. The tank is equipped with 6 immersion heaters which are set to keep the solution at a fixed temperature. Samples are taken from this tank and chemicals are also added to the system via the tank. Corrosion coupons used to monitor micron removal rate are also placed in this tank.

Particulate Filter Skid: Two in series 100 micron bag filters are used to screen the large particulate crud prior to the solution entering the ion exchange column. The bag filter housings are top loading and have custom designed shielding mounts installed to reduce radiation levels in the area. The filters can be run in line or completely isolated from the system.

Ion Exchange Column: The column is constructed of stainless steel and has a capacity of 20 cubic feet. The column is loaded with a strong cation resin first and then topped off with a small amount of anion resin. The column has the capability of reverse flow and can be sluiced out or regenerated if required. The column is shielded by a wall of Alaron made RAM-LOC shield blocks.

Initial IX System: This system consists of a standard Culligan mixed bed ion exchange system. The system is used to preclean the feedwater for the system. This precleaning precludes loading the system resin with non radioactive anions/cations and thus reducing its capacity for the radioactive species.

Contact Vessels: Alaron uses two types of contact vessels. The first one is a shallow tank 16 feet by 4 feet equipped with a custom made liquid mixing and jet spray system. The underwater jet spray system is critical in ensuring all surfaces are exposed to a constant and rapid flow of the decon solution. The tank is heavily insulated and has installed lids to cut heat loss when operating. The other contact vessel is a custom designed tube. Similar to a torpedo tube this tube allows the bolt or drive to be inserted and then sealed. Liquid velocity rates in the tube arrangement provide an extra measure of mechanical removal for the undercut oxides during system cycles. Presently four tubes are constructed and connected in series. Designs for a parallel arrangement are complete.

Materials of construction for the system are 400 series stainless steel and CPVC pipe. Alaron highly recommends the use of plastic over the entire system when possible. The thermal cycling of plastic to metal joints tends to cause leaks. Plastic piping is inexpensive and can be fabricated in house. Alaron fabricates all its own tanks and distribution systems from common plastic pipe parts from a home supply store.

DfD PROCESS PARAMETERS

Since there exists ample process description for DfD in the current literature it will not be repeated here. The process parameters for both drives and bolts were the same. The parameters

monitored included, flow rate, temperature, metals in solution, and pH. Flow rate was kept as high as possible but dropped off as temperature rose close to 90 degrees C. The pH level was varied from 1.0-2.0. Complete cycle times for a double batch, full tank and full tubes, was between 6 and 8 hours. Metals in solution was monitored to determine if and when ion column breakthrough occurred. It was a challenge to keep temperature uniform throughout the system. Depending on valve lineup for the heat tank, temperature in the tubes and tank differed by at least 10 degrees C. This temperature loss had to be corrected since temperature has a direct effect on optimal performance of the process.

PROCESS TECHNIQUE

The drive and bolts were off loaded from their containers, unwrapped, quickly surveyed and either immersed in the tank or slid into the torpedo tubes. These operations required considerable attention to contamination control and worker dose control. Once in their respective places the system was circulated with the ion column isolated and brought to temperature. Once at temperature a minimum of 10 complete cycles were run. All process parameters and component dose rates were recorded in between each cycle. The components in the tubes had the liquid flow direction reversed several times to provide mechanical removal of undercut oxide. Components in the tank were jet sprayed under water at close range to remove visible reddish oxide. Once the cycles were complete the components were surveyed in detail and a calculation was made to determine if they met Envirocare standards for disposal. When processing ceased all components were removed and sectioned via a remote control plasma arc torch. The material was loaded into standard containers to be shipped to Envirocare of Utah.

RESULTS

Control rod drives were decontaminated down to a level where they met the Envirocare acceptance criteria after 10 cycles. Approximately 40-60 microns of metal was removed from the drives. The resulting coloration was very a very shiny chrome color. All the nooks and crannies were also devoid of oxide coloration. Sections of the drive were cut off and decontaminated further on a lab scale system to determine if free release was indeed possible if enough metal was removed. Shroud head bolts were not decontaminated down to the Envirocare levels after ten cycles. If the activated end were cut off, the rest of the bolt would meet the Envirocare criteria. The DfD process removed activity down to a certain level on the activated end and then, as expected, plateaued while the rest of the bolt continued to have activity removed at an even rate.

COST COMPARISON

The objective of the cost comparison is to determine which method is less expensive in cost in dollars and in man rem. The cost in dollars is an estimate based on Alaron's experience and does not reveal any proprietary disposal site pricing. These costs can vary significantly for each generator and processor based on many factors. Our intent is to make relative comparisons based solely on our experience which may not be the same for others. The first method is to package the drive/bolts at the generator utility, shield them properly for shipment and bury the material at

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the Barnwell site in South Carolina. The second method is to process the drives/bolts via DfD until they meet the criteria for disposal at Envirocare, then size reduce, package, transport and dispose of at Envirocare of Utah. The secondary wastes would also be disposed of at Envirocare or processed at Studsvik or ATG Catalytics.

DfD PROCESSING

Purchase containers (2) \$8,000.00

Install shielding (20)man hours

Load bolts and drives (performed at Utility)

Transport via shielded van to Alaron (performed by trucking company) costs between \$1,500.00 and \$ 3,500.00 per shipment depending on utility location

Process via DfD (160) man hours for all thirty objects and 0.510 man rem for thirty objects

Size reduce (60) man hours for all thirty objects and 0.200 man rem

Package, transport and dispose (based on volume) approximately 30 cubic feet for all 30 objects since the objects are already at optimal density. Man hours for all thirty objects 35 and 0.125 man rem.

Dispose of resin waste (based on volume) approximately 10 cubic feet for all 30 objects, 0.180 man rem and (8) man hours to handle the column for shipment. Resin costs approximately \$4,000.00. The column is reused upon return.

notes: initial containers can be reused

BARNWELL SITE DISPOSAL

Purchase Container (1) HIC \$5,000.00

Install Shielding n/a CNSI shield supplied

Load Bolts/Drives (performed at utility)

Transport via Cask to Barnwell (performed by CNSI)

Disposal costs based on dose rate, mCi, weight and density. The disposal cost include the weight of the bolts, the package , estimated total disposal weight of all thirty objects is 11,600 lbs.

estimated number of Curies 32, estimated density of entire package is less than 70 lbs per cubic foot.

notes: containers cannot be reused and must be purchased for the next load.

CONCLUSIONS

DfD performed as predicted on this type of waste stream. The presence of large amounts of loose contamination on the surface did not affect the ability of the chemical to undercut and remove the hard oxide layers underneath. It was interesting to note that on this waste stream visual tests could be used to determine if an adequate number of cycles had been run. The presence of even a

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small amount of reddish oxide on the component resulted in large dose rates. This visual test was important on the shroud head bolts which are activated and thus dose rate monitoring for effectiveness cannot be wholly relied on. The greatest challenge in using DfD on highly radioactive waste streams is the management of personnel dose and the control of high contamination levels in the work areas. The most critical process parameter is the liquid flow rate across the surface. This is borne out by the effectiveness of the torpedo tubes vs the open tank contact systems. Although more man rem is expended using DfD due to material handling, overall costs are lower to use DfD as opposed to direct burial on this particular waste stream. Obviously if a radical change in site acceptance criteria and/or disposal cost for either site occurred it would alter these conclusions on cost.