LOMI DECONTAMINATION OF INDIAN POINT III

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ABSTRACT

The New York Power Authority recently completed the decontamination of the hot and cold legs of Indian Point Unit No. 3 steam generators prior to a tube-sleeving operation. NYPA employed Bechtel National, Inc. to perform the decontamination using the EPRI licensed LOMI technology. A three-step process was performed using the first commercial application of an alkaline permanganate/acid permanganate process. The pretreatment application was followed by the LOMI process. All of the decontamination solutions, including the pretreatment steps, were demineralized by passing the liquid through a cation and anion ion exchange resin. The resin was then solidified by a commercial cement process and shipped for burial.

The decontaminations were performed successfully in June 1985. Average radiation levels of the hot leg prior to the decontamination ranged from 11 to 13 R/hr. The cold leg radiation levels prior to the decontamination ranged from 8 to 9 R/hr. The decontamination and some shielding in the nozzle and divider plate areas reduced the channel head man-rem exposure to approximately 1 R/hr. The decontamination volume per steam generator varied between 9500 and 11,500 liters. The decontamination volume was a function of solution distance into the steam generator tubes. From start to finish, the decontamination of each generator took between 48 and 96 hours. Approximately 100 cubic feet of radioactive waste resin was generated per steam generator. The total time on site for the decontamination vendor was thirty days including training, set-up, decontamination and demobilization.

This paper will report on the details of this first-of-a-kind PWR reactor chemical decontamination process. Emphasis will be placed on the operational aspects including the demineralization of the decontamination solution, solidification and disposal.

Introduction

Indian Point III, a 965 megawatt, four loop, pressurized water reactor supplied by Westinghouse, is located 24 miles north of New York City. The plant went into commercial operation on August 30, 1976. During the 4/5 cycle refueling outage sleeving operations were scheduled for the cold legs of the steam generators. Due to the projected large man-rem exposure for this task, the New York Power Authority (NYPA) decided to chemically decontaminate the hot and cold legs of all four steam generators. This chemical decontamination employed the LOMI technology developed by the Central Electricity Generating Board (CEGB) in the United Kingdom and partially sponsored by the Electric Power Research Institute. Bechtel National Inc., a LOMI EPRI licensee, was selected as the prime contractor. Bechtel supplied subcontractors to NYPA for chemical application and radioactive waste processing. The decontamination was performed with portable skid-mounted equipment located within the vapor containment (reactor building) on the 95 foot elevation (operating floor) and 46 foot elevation (basement).

A pretreatment step was performed prior to the LOMI injection due to the passive chromium-rich oxide layer expected to be found on the steam generator channel head surfaces. This pretreatment consisted of a two-step process and was also developed by CEGB. The pretreatment consisted of an alkaline-permanganate (AP) step followed by an acid-permanganate (NP) step. This change in pH was required due to the different materials of construction in the steam generator channel head. After pretreatment the typical LOMI process chemistry was employed to remove both the activated corrosion products and their associated corrosion products. All solutions were polished on Rohm & Haas ion-exchange resin. A volume of 440 cubic feet of contaminated resin was generated during the decontamination process.

Decontamination Planning

Planning was initiated within NYPA about four months prior to decontamination. The initial planning consisted of the choice of vendor, solvent technology, decontamination factors expected and needed, as well as availability of space and location for the decontamination equipment. All areas of utility

personnel were involved in the planning function including maintenance, engineering, health physics, radioactive waste, chemistry and operations.

Once the contract was awarded, the detailed planning for the decontamination included trips to Florida and Connecticut to familiarize NYPA staff with the decontamination equipment and the nozzle seals. Piping and hose runs and equipment locations were identified and the utility requirements such as power, air, nitrogen, steam and water were identified.

Unfortunately the chemical decontamination vendor was awarded a contract only six weeks prior to the scheduled decontamination initiation. This project was not only the first commercial LOMI decontamination of a steam generator channel head, but also the first chemical decontamination for the vendor, although the vendor did employ operators and a consultant who had previous LOMI experience from a BWR LOMI decontamination. Due to the vendor's lack of previous experience, the six weeks of lead time was insufficient, and in retrospect at least four more weeks of planning would have helped. In the future NYPA will attempt to have the decontamination vendor under contract at least four months prior to the implementation of the work. NYPA believes that an early contract award will allow the mobilization and equipment set-up to occur with few if any problems.

While there were no major problems experienced during the set-up, test and decontamination phases, there were delays that could be attributed mainly to the lack of experience of the vendor in setting up and testing the equipment, and the utility for providing connections to water and steam services that had never before been required in the vapor containment. There were some minor delays caused by inadequate communication between the four companies involved in the decontamination (Bechtel, Quadrex, NUS and Chem-Nuclear Systems, Inc.), and the eight departments from NYPA (Maintenance, Operations, Chemistry, Health Physics, Nuclear Engineering, Tech Services, Quality Assurance and Radwaste) assisting Bechtel and its sub-contractors. Problems such as not having an adequate level control monitoring system to monitor solution level in the steam generator tubes may have been avoided with additional planning time.

Both channel heads in each generator were decontaminated during the same operation. This approach was chosen in order to decrease the decontamination time as well as the radioactive waste generated. The circulated decontamination solution was from the decontamination skid into and out of the cold leg, into and out of the hot leg, and back to the decontamination skid. The flow from the cold leg to the hot leg of the steam generator resulted in a pressure drop between channel heads and an uncertainty of the liquid level in the hot leg side. Since most of the steam generator work was scheduled for the cold leg, the above flow path would assure the Authority the maximum decontamination factor in the cold leg, and thus the maximum man-rem reduction.

Dikes were placed around all equipment during staging in order to contain any potential leakage. All hoses employed in the process were sleeved in order to reduce the potential for their contamination. An emergency drain tank with a capacity to receive the total decontamination solution in the event of a leak, pipe rupture, or large corrosion rate was available during the decontamination process.

Leakage through the steam generator nozzle dams used to isolate the reactor coolant system from the channel head was also a concern to the New York Power Authority. The nozzle dams employed for this project were manufactured by Combustion Engineering and were designed and fabricated to specifically seal the nozzles of the steam generators from the reactor. The nozzle dams are constructed with a synthetic rubber seal which rests on an aluminum frame. The rubber seal has provisions to be inflated with either air or nitrogen to form the pressure boundary. The seals were designed for operation at a differential pressure of 30 PSI between the channel head and the primary piping. The nozzle dams were operated at a differential pressure of 20 to 22 PSI. During the decontamination process, the conductivity of the water on the reactor vessel side of the nozzle dams was continuously monitored to determine seal leakage. No change in water conductivity was observed during the decontamination process.

Decontamination System Requirements

The LOMI decontamination system required the following utility services from NYPA:

* DI water of up to 100 GPM at 120 PSIG for a total of 1500-2000 gallons;

* Nitrogen gas of up to 100 SCFM at 5-10 PSIG.

* Electrical connections of 480V, 3 phase at up to 1000 amps;

* Saturated steam at 100-125 PSIG and up to 5000 lbs/hr.

NYPA imposed the following requirements on the decontamination vendor during the decontamination operation:

* Decontamination of the first 1.5 to 2 feet of steam generator tubes within the tube sheet. The liquid level was not to exceed 2 feet. During the decontamination process for the last two generators the liquid level was not to exceed 7 feet;

* Monitoring of the surge tank level to detect level changes of 2 inches. An unexplained 2 inch level drop would initiate investigation while a 3 inch level drop would initiate pump down to the drain tank;

* Chemistry monitoring during the decontamination to determine rate of metal and radioisotopic release and decontamination end point;

* Continuous surveillance of nozzle dam inflation gas pressure;

* Continuous leak surveillance of temporary piping and equipment on the 46 foot elevation;

* All processes were to be performed under a rigorously applied quality control program;

* Continuous monitoring of the on-line corrosion monitoring system.

Chemical Processes

The system was filled, hydrotested and heated to 195°F. The initial chemical injection was the alkaline potassium permanganate solution. This solution was composed of approximately 2500 PPM potassium permanganate at a pH of approximately 12. Additional potassium permanganate was added to the decontamination solution if the permanganate concentration fell below 500 PPM. The pH during the alkaline part of the process was maintained above 11.5. After the increase in soluble chromium was found to be less than 1 to 2 percent between the samples, the pH of the decontamination solution was made acidic. Enough nitric acid was added to the solution to reduce the pH to 2.5. The pH was maintained between 2.0 and 3.0 while monitoring the soluble chromium concentration. When the chromium concentration increase was less than 1 to 2 percent between samples, the oxidation step was terminated. This permanganate, potassium nitrate, chromate and MnO_2 solution was then partially diverted to the demineralizers. The solution was continuously recirculated with partial flow through the demineralizers until the solvent conductivity was less than 150 umho/cm and 10 PPM nitrate in preparation for the LOMI process. The cation and anion resin employed for this process were Amberlite IR-120 and Amberlite IRA-400 respectively, obtained from Rohm & Haas.

The demineralization of the decontamination solution occurred at 190°F. The 20 cubic feet of anion resin employed for each generator's pretreatment solution removed the permanganate and nitrate anions and contained approximately 10,600 grams of the nitrate anion and a maximum of 12,000 grams of the permanganate anion after demineralization. There was some concern about demineralizing an acidic permanganate nitrate solution due to the potential for resin decomposition. Calculations indicated that after demineralization the resin contained only 2.7% nitrate by weight and 3% permanganate by weight. Discussions with the resin vendor about the characteristics of the IRA-400 as well as reviews of the results of the demineralization of a similar solution during the decontamination of the Monticello reactor coolant system led to the plant confidence that the solution could be demineralized safely. After each demineralization of the pretreatment solution the anion resin employed was transferred to a solidification liner.

After the pretreatment solution was demineralized the LOMI process began. The LOMI chemicals are composed of hydrazine, vanadous formate, sodium hydroxide and picolinic acid. The pH is maintained at approximately 4.5. Numerous articles[1,2,3,4] discuss the mechanism of this novel decontamination process. After injection of the chemicals the total iron, Co-58, Co-60 and total activity concentrations were monitored. An increase of less than 2 percent of Co-58 between samples with an excess of vanadous formate present indicated that the reaction rate was asymtotically approaching zero and the reaction was terminated by valving in the demineralizers. The solution was recirculated through the resin columns at a rate of approximately 280 liters per minute. The demineralization was stopped when the conductivity reached 20 umhos/cm. At the end of the LOMI demineralization all of the resin was transferred to a liner and solidified with concrete. The demineralization vessels were then charged with fresh resin to ready them for the decontamination of the next steam generator. During this process some excess liquid volume was transferred to the plant liquid radioactive waste tanks. The transfer allowed room for the mixing and addition of the LOMI chemicals. Each time chemicals are added the decontamination liquid level increases 575-750 liters gallons. This waste was mixed with plant liquid waste and treated through the plant liquid waste processing system.

Radioactive Waste Management

Radwaste management options were limited by (1) lack of installed waste solidification equipment, (2) no on-site storage capacity for the waste resins generated during the LOMI process and (3) regulatory requirements for characterizing and stabilizing the waste resins. Since the resins contained chelating agents (picolinic acid) greater than 1% by weight and a total specific activity of greater than 1 uCi/cc for isotopes with greater than a five-year half-life, they required solidification. Bechtel estimated that up to 80 cubic feet of resin would be needed per steam generator (40 cubic feet of anion and 40 cubic feet of cation) to demineralize the decontamination solution and another 20 cubic feet of anion resin to demineralize the pretreatment chemical solution. Therefore, it was decided to solidify the decontamination resin in 80 cubic foot batches after each generator was decontaminated in Chem-Nuclear's 8-120 solidification liner. The 20 cubic feet of pretreatment resin was segregated from the decontamination resin because it didn't contain chelates nor were radiation levels expected to exceed 100 mRem/hr, therefore a 8-120 liner was placed inside the vapor containment near the decontamination skid to receive these resins.

An ambitious shipping schedule was planned because there were only three storage shields available on site for solidifying and storing the resin. The first shipment was scheduled to be in an 8-120 cask. This cask was chosen due to its 4.5 inches of lead shielding. Cask selection for subsequent shipments would depend upon the radiation levels on the first solidified liner.

Solidification

The solidification vendor, Chem-Nuclear Systems, Inc. was chosen because they were the only company at that time who had performed the testing required by the NRC Branch Technical Position on Waste Form for the LOMI chemicals being used. These tests provided the necessary assurance that stability requirements imposed by the NRC and the State of South Carolina were met when using CNSI's Process Control Program (PCP) and procedures for solidification of bead resin. The PCP and procedure were approved by the Plant Operation Review Committee with the stipulation that an acceptable PCP had to be performed prior to each solidification.

Following the decontamination of each steam generator, 40 cubic feet of cation resin and 40 cubic feet of anion resin were transferred to a solidification liner that was inside NYPA's HN-100 Series 2A transportation cask. The liner was dewatered to the level required for solidification, mixed for 30 minutes and a 100 ml dip sample taken for performing the PCP. The cask and CNSI solidification truck were then moved to a position outside the fuel storage building and solidification began after

acceptance of the PCP sample results by plant personnel. Following solidification, the cask was moved into the fuel storage building and the liner transferred to a storage shield. A new liner was loaded into the cask and the cask moved back to the VC equipment hatch about four hours prior to the next resin transfer.

The solidified liner was capped after at least 30 hours had elapsed and the temperature of the solidified resin was less than 175°F and decreasing. Approximate times to perform each evolution were as follows:

1. Set up to transfer resin - 2 hours
2. Transfer 80 cubic feet of resin - 1.5-2 hours
3. Mix resin and draw PCP sample - .5 hour
4. Prepare and perform PCP - 2 hours
5. PCPP cure time - 18+ hours
6. Solidification equipment set up - 4-5 hours
7. Solidification - 2-2.5 hours
8. Billet cure time - 30 hours

The liners were shipped to the Barnwell, South Carolina burial site as soon as possible after being capped.

The 8-120 liner was only used for the first solidification of the LOMI resins and the pretreatment (AP-NP) resins. NYPA switched to 14-170 liners after the first solidification because the radiation levels weren't as high as expected, and to dispose of resins being generated by Indian Point No. 3's liquid waste processing system, which were mixed with the LOMI resins prior to solidification.

Waste Characterization

The isotopic distribution in the spent resin was determined through a combination of on-site and off-site measurement. A liquid sample of 5 mls. was drawn when the specific activity in the LOMI solution reached a maximum. This sample was analyzed on site for gamma emitters, pure beta emitters and transuranics. The activation products, Mn-54, Co-58 and Co-60 were calculated from the plant's GeLi analysis; Fe-55, Co-57, Fe-59, Ni-63 were obtained from the off-site analysis. The fission products, H-3 (LLD), C-14, Cs-137 (LLD), Ce-144 and the transuranics, Pu-238, Pu-239/40, Pu-241, Am-241, Cm-242 and Cm-243/244 were also obtained from the off-site analysis. The fission products, Sr-90 and I-129 values were not available by the time the first shipment was made, and were determined by scaling factors derived from the RADMAN Computer Code's plant specific data base for spent RCS clean-up resins.

Curie Calculations

The total activity of each liner was calculated by using a complex method that converts the average exposure rate on contact in R/hr to curies. The basis for this methodology is the equation for the flux at a point on a self-absorbing cylindrical volume source. This method was presented to the Health Physics Society Annual Meeting in May 1985[5], and has been in use at IP-3 for several years. A group of tables have been developed which provides the exposure rate to curie conversion factors as a function of resin density (either dewatered or solidified), container diameter and photon energy.

Waste Classification and Shipping Manifests

The solidified resin was classified and shipping manifests generated by the RADMAN Computer Code. This code also generated the filter media summary report required for burial of resins at the Barnwell burial facility. To determine the waste class, the code required data on the volume of solidified resin and the specific activity (volume corrected) of each isotope in uCi/cc. To generate the shipping papers the code required the package dimensions, radiation levels, density of the waste and the other normally required data to properly execute a manifest. All liners were determined to contain Class A wastes; Table I contains information concerning curies, radiation levels, volumes and casks used. Table II lists the activity of the major isotopes removed by demineralization from each steam generator.

TABLE I

	CURIES	RAD LEVELS R/HR ON CONTACT	LINER VOLUME	SHIPPING CASK USED
S/G 32	18.0	5.5	12.6	CNS 8-120
S/G 31	23.2	6	178	NUS 14-170
S/G 33	29.8	7	178	NUS 14-170
S/G 34	29.1	7	178	NUS 14-170

TABLE II
MAJOR ISOTOPES (CURIES)

	Mn-54	Co-58	Co-60
S/G 32	.3	12	3.6
S/G 31	.43	18	4.1
S/G 33	.5	20	5.7
S/G 34	.61	22	6

Results

The steam generator channel heads were successfully decontaminated in 1982, employing the Westinghouse abrasive boric oxide grit process. In 1985, the LOMI process was chosen because plant personnel expected even better results. The decontamination factors, based on general area center bowl readings, resulting from the decontamination operation including the pretreatment step were in the range of 3.5 to 8 in the cold legs. The hot leg decontamination factors ranged from 2 to 3.3. Comparing the various points in the hot leg to the cold leg leads to the conclusion that the decontamination was approximately 2 to 2.5 times as effective in the cold leg. The decontamination factors in the effective work zone range from 2.6 to 3.2 in the hot leg and 4.0 to 7.2 in the cold leg. The average predecontamination radiation levels in the hot leg ranged from 10.1 to 13.8 R/hr while in the cold leg the pre-decontamination average radiation levels ranged from 6.9 to 9.6 R/hr. Additional reduction in the radiation level was accomplished by shielding the divider plate (on two steam generators) and the nozzles on all the steam generators. The average final radiation levels in the effective work area of the channel head were less than 1.2 R/hr.

The chemical decontamination work performed on the channel head area of the four Series 44 steam generators resulted in a net savings of 460 man-rem. The exposure associated with the decontamination operation was 27 man-rem. Extensive use of lead shielding was employed around the operations skids, liner and the demineralizers which was very effective in keeping the general area dose rates low for the operations staff. Significant ALARA preparations in

the form of pre-job briefings and mock-up training, as well as temporary shielding helped keep the overall man-rem exposure low. The decontamination process took about 14 days from injection of chemicals into the first steam generator to the final transfer of resin from the fourth generator.

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