AN OVERVIEW OF ALARA CONSIDERATIONS DURING YANKEE ATOMIC'S COMPONENT REMOVAL PROJECT

B. Granados, G. Babineau, B. Colby, and B. Cox
Yankee Nuclear Power Station
49 Yankee Road
Rowe, Massachusetts 01367

ABSTRACT

In February 1992, Yankee Atomic Electric Company (YAEC) permanently shutdown Yankee Nuclear Power Station in Rowe, Massachusetts, after thirty-two years of efficient operation. Yankee's plan for decommissioning is to defer dismantlement until a low level radioactive waste (LLRW) disposal facility is available. The plant will be maintained in a safe storage condition until a firm contract for the disposal of LLRW generated during decommissioning can be secured. Limited access to a LLRW disposal facility may occur during the safe storage period. Yankee intends to use these opportunities to remove components and structures. A Component Removal Project (CRP) was initiated in 1993 to take advantage of one of these opportunities. The CRP includes removal of four steam generators, the pressurizer, and segmentation of reactor vessel internals and preparation of LLRW for shipment and disposal at Chem-Nuclear's Barnwell, SC facility. The CRP is projected to be completed by June 1994 at an estimated total worker exposure of less than 160 person-rem.

INTRODUCTION

Yankee Nuclear Power Station (YNPS) ceased power operations on February 26, 1992 after 32 years of safe operation at an average capacity factor of 74%. This paper provides a brief overview of ALARA lessons associated with component removal activities of YNPS decommissioning.

DECOMMISSIONING PLAN

Yankee's Decommissioning Plan was submitted to the NRC in December 1993. This plan presents the programs, processes, and procedures that will be used to fully dismantle the plant before the end of 2002, depending on the availability of a low level radioactive waste site. Given the uncertainties with the DOE high level waste programs, Yankee may build an on-site dry cask storage facility. The schedule for decommissioning assumes that a low level radioactive waste facility will be available to YNPS in 2000 and that greater than Class C waste (GTCC) and spent fuel will be transferred to a dry cask storage facility. Based on these assumptions about low level and high level waste disposal, several milestones are presented in the Decommissioning Plan:[1]

- The facility will remain in a safe storage condition until the year 2000.
- NRC approval of the Decommissioning Plan is expected before January 1, 1995.
- Detailed site radiological characterization of the plant systems, structures, components, soil and groundwater necessary to support dismantlement activities will be initiated in 1994.
- A dry cask spent fuel storage facility will be constructed and loaded with spent fuel sometime after 1996.

- Detailed engineering and planning for plant decontamination and dismantlement activities are scheduled to begin in 1999. Dismantlement begins in 2000 and continues through 2002.

- GTCC waste and spent fuel will be shipped to the DOE beginning in 1998 and ending in 2018.

The total cumulative occupational radiation exposure for the entire decommissioning effort is estimated to be less than 702 person-rem. This value is conservatively estimated based on 1994 dose rates. Dose reduction programs and implementation of decommissioning activities over the next 5 to 10 years will significantly reduce the actual dose received from decommissioning activities. Radioactive waste burial volume for decommissioning and the CRP is estimated to be less than 105,000 cubic feet.

COMPONENT REMOVAL PROJECT DESCRIPTION[2]

The Component Removal Project is the first phase of plant decommissioning. Using the January, 1993 NRC Staff Requirements Memorandum[3] on implementing decommissioning activities prior to decommissioning plan approval, Yankee initiated the CRP. CRP activities were paid for using monies from the decommissioning trust fund. Project staffing and on-site planning began in April 1993, with June 1994 as the target completion date.

Major milestones for the CRP are:

- component asbestos removal,
- shield tank cavity modifications,
- steam generator (S/G) removal,
- S/G preparation and shipment,
- pressurizer removal and shipment, and
- segmentation, packaging and shipment of reactor vessel internals.

The estimated collective dose for CRP is 160 person-rem. In addition, approximately 16,000 cubic feet of low level radioactive waste will be disposed.

Component removal activities are performed under the 10CFR50.59 review process with additional decommissioning-related considerations stipulated by the NRC.[3] The 50.59 process has been used for preparation and documentation of analyses, reports and procedures to implement plant modifications throughout Yankee's operations. Engineering Design Change Requests were developed and approved by the Plant Operations Review Committee for the steam generator and pressurizer removal process and the reactor vessel internals segmentation.

ASBESTOS ABATEMENT

The removal of asbestos insulation at Yankee Rowe to support CRP presented two challenges from the standpoint of exposure to asbestos fibers. The first was containment of the fibers and the second control of radiologically contaminated insulation. An initial concept was to establish an asbestos controlled area for the entire containment and remove all asbestos. However, because of the high potential radiation exposure required to accomplish this task, a decision was made to remove only asbestos necessary to support CRP.

Asbestos abatement activities proved to be the greatest contributor to personnel radiation exposure (53 percent). An estimate of 150 person-rem was developed to erect scaffolding, build enclosures, and abate asbestos. Regulations for asbestos removal and handling required the construction of elaborate enclosures to confine asbestos contamination and prevent personnel asbestos exposure. Based on ALARA considerations, variances were obtained from state regulators for certain asbestos handling and personnel decontamination requirements. Dress-out and bag-out areas were established in low dose areas. Despite these and other changes in work practices, asbestos removal, bag-out and decontamination proved to be time and exposure intensive.

Asbestos abatement was completed with a total exposure of about 73 person-rem. A savings of over half the estimate can be attributed to the learning curve by the radiation workers as the installation of scaffolding and enclosures progressed into successive plant areas. This conclusion is supported by a corresponding decrease in labor hours. For example, labor hours for building the third steam generator scaffolding was 75% of the time required to erect the first.

Another dose saving feature was the relocation of the asbestos decontamination chamber, asbestos packaging area, and bag-out area to the charging floor to reduce time spent in higher dose rates. Table 1 lists the estimated and actual dose received for the asbestos abatement. Approximately 1500 cubic feet of asbestos insulation was removed and disposed as LLRW.

Steam Generators and Pressurizer

Four steam generators and pressurizer have been removed and shipped to the Chem Nuclear Systems Inc. (CNSI) Barnwell facility. These activities were completed by mid-December 1993. These tasks were accomplished almost one month ahead of schedule and under budget. Each of the components required asbestos removal, mechanical closure, and contamination fixation prior to removal from the Containment. Figure 1 shows the average steam generator dose rates with the secondary side filled with water, the secondary side drained and the steam generator shielded for shipment. The estimated dose for removal of the steam generators was about 72 person-rem and the actual dose is about 50 person-rem.

ALARA lessons learned during this phase of CRP are presented below:

<u>Component Removal</u>

1. Maintain water level in components as long a practical.
2. If possible, inject secondary side with grout after draining while S/Gs are still in containment.
3. Fabricated, based on conservative calculations, large area shield plates and stage lower plates on the transport cradle.
4. Use automatic mechanical cutting of reactor coolant piping to reduce exposure by increasing the distance from the source and reducing time in high radiation areas. Mechanical cutting was also effective in confining contamination and minimizing airborne radioactivity.
5. Use an asbestos encapsulant (or radioactive contamination fixative) designed to adhere to carbon steel that is consumable in welding operations to minimize the need for shield weld preparation.
6. Decontaminate and fix smearable radioactive contamination to reduce personnel exposure by eliminating contamination controls and protective clothing during the majority of work after removal from the containment.

TABLE 1

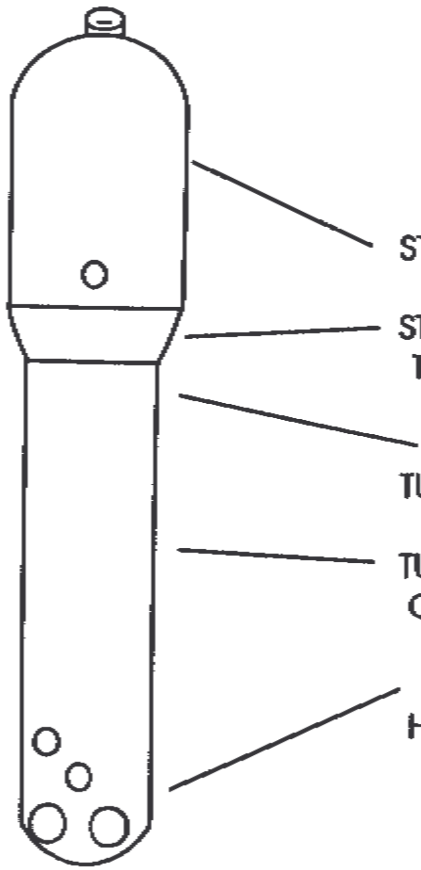
YANKEE NUCLEAR POWER STATION
CRP RADIATION EXPOSURE SUMMARY

ALARA REVIEW	TASK DESCRIPTION	ESTIMATED PERSON-REM	ACTUAL PERSON-REM
93-002	CRP ASBESTOS ABATEMENT SCAFFOLD PROJECT	27.6	18.9
93-003	CRP ASBESTOS ABATEMENT PROJECT	121.8	53.7
93-004	SHIELDING TO SUPPORT CRP	2.5	1.1
93-006	VC COMPONENT REMOVAL	72.3	44.0
93-006	SHIELD TANK CAVITY PREPS AND MODIFICATION	5.4	2.6
93-007*	RX VESSEL INTERNALS SEGMENTATION	32.7	6.2
93-008	COMPONENT PREPARATION	22.9	12.5
	TOTALS	**285.2**	**138.0**

*Exposure through 12/21/93. (Work is continuing under this review in 1994.)

FIGURE 1

AVERAGE STEAM GENERATOR DOSE RATES IN MREM / HOUR



LOCATION	SECONDARY SIDE FULL OF WATER CONTACT	SECONDARY SIDE FULL OF WATER @ 1'	SECONDARY SIDE DRAINED CONTACT	SECONDARY SIDE DRAINED @1'
STEAM DRUM	1.3	0.7	24	17.8
STEAM DRUM TRANSITION	58	39	360	226
TOP OF TUBE BUNDLE	138	79	475	325
TUBE BUNDLE CENTERLINE	94	50	350	250
CHANNEL HEAD AREA	175	88	563	319

Internals Segmentation

1. Evaluate mechanical vs plasma cutting technology in terms of costs for cavity water clean-up systems and costs for filter handling and disposal.

2. Design the water clean-up system to remove the soluble Co-60 generated during plasma cutting.

3. Design the filtration system with high flow rates to reduce delays from water clarity.

4. Consider an underwater curtain arrangement to prevent the migration of cutting fines into the cavity areas outside the cutting table.

5. Design tooling used for underwater cutting to eliminate crevices that can trap cutting debris.

When the plant shutdown occurred, many of the areas in the containment were shielded for maintenance activities. Additional shielding was applied directly on the loop piping adjacent to the steam generators and remained in place throughout the entire project. Pipe cuts on the hot and cold legs of the steam generators were performed with automatic mechanical cutters. Workers practiced installing, cutting and disassembly of equipment on a S/G mock-up with field operations providing recommendations based on time and motion studies. After securing and bracing of the S/Gs, two cuts were made on each leg and a 1 inch ring was removed. Shielding, trained workers, and minimal mechanical failures resulted in a dose saving of about 4 person-rem.

Each steam generator and the pressurizer was removed from the containment using the same crane that installed them during construction. Radiation surveys were performed outside containment in a low background area to determine final shielding requirements and waste classification. A 56 wheel transporter was used to move the S/Gs from the yard area to a S/G preparation facility. The steam generator preparation facility was designed for two S/Gs, using shield walls and tents for exposure and contamination control. Portable ventilation units were used to filter and direct fumes from welding and potential airborne contamination into the plant ventilation system where all releases could be monitored. Following preparation, the S/Gs were transported by road approximately six miles to a rail line, loaded onto rail cars and shipped to Barnwell. The pressurizer was lowered directly onto a standard flat bed trailer, for over-the-road shipment to Barnwell.

Reactor Internals Segmentation

The collective dose required to remove and dispose of the reactor vessel internals was estimated to be about 33 person-rem. As of March 30, 1994 approximately 9 person-rem has been used. Table 2 summarizes the different task estimates and expenditures as of March 30, 1994. The reactor vessel internals and the thermal shield are being removed from the reactor vessel (underwater) and segmented using a plasma torch and metal disintegration machining.

The internals segmentation and packaging plan was developed by Yankee in conjunction with Power Cutting, Inc., Chem-Nuclear System, Inc. (CNSI) and WMG, Inc. The plan identified packaging requirements for the various reactor internal components based on activation analyses, transport cask design limits, regulatory classification, transportation criteria and segmentation equipment capabilities.[2]

Several liners were staged in the cavity for blending various reactor internals components. Underwater radiation surveys were performed to determine dose rates, and then activity calculations performed to determine the final loading and characterization.

TABLE 2

ALARA REVIEW SUMMARY

Rx VESSEL INTERNALS SEGMENTATION

TASK #	TASK DESCRIPTION	ESTIMATED HOURS	ACTUAL HOURS	PERCENT OF ESTIMATED HOURS	ESTIMATED DOSE (REM)	ACTUAL DOSE (REM)	PERCENT OF ESTIMATED DOSE	EFFECTIVE DOSE RATE (REM/HOUR)
1	SEGMENT AND PACKAGE Rx INTERNALS	13000	7522	57.9%	19.500	4.722	24.2%	0.006
2	DOSE PROFILE Rx INTERNALS COMPONENTS	2000	1035	51.7%	3.000	0.545	18.2%	0.0005
3	LINER LOADING AND CASK HANDLING	4800	793	16.5%	7.200	0.815	11.3%	0.0010
4	LOWER INTERNALS HANDLING	250	101	40.2%	0.750	0.110	14.7%	0.0011
5	SPENT FILTER REMOVAL AND SHIPMENT PREPARATION	120	216	179.8%	0.600	1.255	209.2%	0.0058
6	SECURITY COVERAGE	1500	0	0.0%	1.200	0.000	0.0%	0.0000
7	UPENDER OPERATION AND SURVEILLANCE	600	87	14.5%	0.480	0.140	29.2%	0.0016
REVIEW TOTALS		22270	9752	43.8%	32.730	7.587	23.2%	0.0008

ORGANIZATION AND STAFFING

A CRP management team was created from a selection of plant and corporate personnel to begin the process of selecting contractors, developing engineering packages, planning project activities and developing project schedules. Key individuals were selected for project managers to oversee the asbestos removal, S/G removal, pressurizer removal, heavy hauling/lifting, engineering, crane support, and internals segmentation.

Throughout the CRP, emphasis was placed on maintaining radiation exposures ALARA. The ALARA program used during plant operation was sufficient to meet the requirements of the Component Removal Project. Yankee Nuclear Services Division, which was responsible for project management and engineering, incorporated RP Engineering recommendations into each Engineering Design Change Request package. In addition, RP Engineering established the ALARA controls used during the CRP. Due to the dynamic nature of the project, RP staff responsibilities shifted from ALARA and job planning, to RP coverage and LLRW management as the work in progress changed.

The construction organization developed many time saving methods to increase efficiency, minimize rework and reduce exposure. Debriefings were held after each steam generator removal and full advantage was taken of lessons learned. Three welding machines were purchased for steam generator shield welding based on increased productivity and exposure savings. Total dose saving due to use of welding machines was determined to be about 8 Person-rem.

The YNPS RP organization was reduced to 7 people at the end of 1992 to support license conditions and infrastructure needs of a permanently shutdown facility. During CRP, at peak loading, about 25 RP technicians, 25 decontamination - rad waste handlers, 2 lead RP technicians and 2 radiological engineers were used to supplement the plant RP staff (Radiation Protection Manager, 2 RP Engineers, 3 technicians, and 1 dosimetry clerk). Total on-site contractor and YNPS staff (excluding security) varied from a peak of about 200 people during asbestos removal to about 125 people for removal and preparation of the S/Gs and the pressurizer and the reactor internals segmentation, packaging and shipping.

ALARA PLANNING

Radiation exposure projections at the start of the CRP were conservatively estimated to be 285 person-rem. Early involvement with engineering and scheduling is expected to result in a dose savings of about 100 person-rem. Key areas where radiation exposures were avoided are presented in the Radiological Engineering, and ALARA Reviews and Exposure Estimates sections.

RADIOLOGICAL ENGINEERING /ALARA

Steam generator removal and reactor internals segmentation were the two areas of primary focus within the Radiological Engineering group. These tasks had the greatest potential for high personnel radiation exposures.

Steam generator removal required a significant effort to remove asbestos insulation, to remove physical interferences and to prepare the vessels for lifting. The water in the secondary side of the steam generators provided significant shielding to personnel during these preparation efforts. Draining the steam generator resulted in a two to three fold increase in dose rates (refer to Figure 1, Steam Generator Average Exposure Rates). Engineering concentrated on methods to perform as much work as possible with this shielding in place without compromising personnel or plant safety. The work plan allowed the vessels to be shimmed under their support lugs, rigged to the crane and the vessel supports cut free with the water still in the secondary side of the vessel. The only work which could not be performed with the secondary side filled was the cutting and capping of the three lower secondary small bore nozzles. These efforts resulted in dose savings of about 20 person-rem.

The S/Gs were fabricated in the late 1950s. Fabrication was conducted in accordance with ASME section VIII for unfired pressure vessels resulting in a shell wall thickness of 2.75 inches adjacent to the tube bundle. This wall thickness combined with the S/G source term required 2 inches to 2.5 inches of steel shielding be installed on the vessel shells to meet the transportation dose rate criteria. Fabrication and installation of this shielding in successive 0.25 inch to 0.5 inch layers would have proved exposure intensive. Mapping the steam generator shells for lug and nozzle interference locations allowed for the prefabrication and rolling of large coverage, 1 inch to 2.5 inches thick shield plates. These plates were placed on the steam generators in the yard area with a mobile crane. The shielding was tack welded in position and final welding was performed after concrete injection in the preparation facility. This sequence saved an estimated 5 person-rem.

The reactor internals segmentation was performed entirely underwater. Engineering efforts focused on controlling cutting debris and maintaining shielding (water) between personnel and segmented components. Underwater tooling and rigging were engineered or marked as appropriate to maintain water shielding over segmented components.

Reactor vessel internals segmentation began October 14, 1993. The reactor vessel internals, comprising 19 separate components, are estimated to contain 1.235 million Curies and weigh about 125,655 pounds. About 80% of the total radioactivity is contained in the core baffle which will be cut and stored on-site as greater than Class C material. Through March 30, 1994 there have been eight 8-120 cask shipments and sixteen 3-55 cask shipments.

Based on radiochemistry data, initial operation of the plasma cutting torch resulted in a small percentage (<1%) of activity (predominately Co-60) in a soluble state. The concentration of soluble Co-60 gradually increased over a two month period of cutting low activity components. Cavity clean-up is currently being supplemented by the plant mixed bed ion exchange system to remove soluble compounds.

Airborne contamination is controlled with a floating hood which is positioned above the cutting table during the cutting process. Two portable HEPA units draw a suction from the hood and discharge to the intake of the YNPS containment purge system. The hood arrangement has been very effective in reducing airborne radioactivity. Air samples taken under the hood show typically 1E-8 uCi/cc and breathing level air samples are typically less than 1E-10 uci/cc (gross beta-gamma).

ALARA REVIEWS AND EXPOSURE ESTIMATES

Seven ALARA reviews were developed for CRP to address various areas of the work scope. Table 2 provides a description of the ALARA reviews, exposure estimates and actual exposure information.

The detailed ALARA reviews continued the process begun by the radiological engineering group during design development. The ALARA reviews established controls for work activities and provided guidance for activity sequencing. In conjunction with the development of the ALARA reviews, ALARA personnel were continuously involved in the planning and scheduling process. Every attempt was made to eliminate, simplify or increase the efficiency of work activities without compromising personnel safety.

WASTE MANAGEMENT

YAEC and CNSI prepared a safety analysis report for the purpose of obtaining a Certificate of Compliance for the S/Gs as a Type A container. The pressurizer was certified as a DOT Type 7A container. Shielding was designed to maintain radiation levels on the package about 75% of the DOT limit. Contamination levels were maintained less 1000 dpm/100cm^2 loose beta-gamma.

The Steam Generators were shipped as Class A stable waste (>A_2 quantity LSA). The S/Gs were filled with a low density (0.33g/cc) concrete to fix contamination and facilitate specific activity calculations for LSA. The activity calculation was performed using MicroShield's[4] model for a cylinder volume source with side shields and assuming the source volume and mass were represented by the tube bundle and the concrete which filled the annular space between the tube bundle and the outer shell and inside the tubes. The average activity of an individual S/Gs was about 325 Curies. The critical nuclides for waste classification were Ni-63, Pu-241 and TRU's with a halflife greater than 5 years.

SUMMARY AND CONCLUSIONS

The CRP has been a successful project. Due to strong commitment to radiation safety, personnel exposures during the CRP have been maintained ALARA. With the costs for waste disposal projected to escalate and limited availability of waste sites, early dismantlement of the steam generators, pressurizer, and reactor vessel internals has been cost effective with no negative impact on the site radiological conditions and no effect on the environment around the site.

REFERENCES

1. Yankee Atomic Electric Company, December 1993, Decommissioning Plan for Yankee Nuclear Power Station, YAEC, Bolton, Massachusetts.

2. Heider, K. and Sheldon, P., November 1993, YNPS Decommissioning Activities Prior to Decommissioning Plan Approval, Yankee Atomic Electric Company, Bolton Massachusetts (Presented at EPRI Conference)

3. US Nuclear Regulatory Commission, January 1993, Staff Requirements Memorandum on Implementing Decommissioning Activities Prior to Decommissioning Plan Approval.

4. Negin, C. and Worku, G., 1992, MicroShield, Version 4, Grove Engineering.

Author Biography

Benito Granados is a Principal Radiological Engineer at Yankee Nuclear Services Division of Yankee Atomic Electric Company. Mr. Granados has extensive health physics expertise in both U.S. Naval and Commercial Radiation Protection Programs. He has provided Health Physics support at Electric Boat, General Dynamics, Shippingport Power Station, Connecticut Yankee Atomic Power Station, Millstone Nuclear Power Station, Yankee Rowe Nuclear Power Station, and Maine Yankee Nuclear Power Station during the previous 30 years. Mr. Granados' career has provided him experience with pressurized and boiling water reactors.

Yankee Atomic Electric Company
580 Main Street
Bolton, MA 01740

Phone: 508 779 6711
Fax: 508 779 6730