DISPOSITIONING ONCE-THROUGH STEAM GENERATORS, AN ENGINEERING SOLUTION DEVELOPED WITH RANCHO SECO

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ABSTRACT

A major decommissioning activity involves the dispositioning of radioactive Steam Generators (SGs) to either direct disposal or to a vendor for processing. Many SGs have been transported in the past as a result of dismantlement activities or replacement due to primary leakage into the secondary side. Typically shipments of the SGs are performed via railroad and under a DOT Exemption, which relieves the shipper from the requirements of 49 CFR 173.403 for demonstration of Surface Contamination Object (SCO) limits and 49 CFR 173.427 (a) for packaging the SCO into an Industrial Package.

Rancho Seco is currently being decommissioned and the SGs are of Babcock & Wilcox (B&W) design and commonly known as Once-Through Steam Generators (OTSG). The B&W design consists of two such SGs, each approximately 80’ in height, 12’ in diameter, and over 550 tons in weight. The SGs were too large to ship to Envirocare of Utah (EOU) in their intact state due to rail clearances with respect to the length of the generator and certain radii of track along the required route to the disposal facility. Rancho Seco cut the SGs in the latitudinal direction at approximately the halfway point and then capped the cuts with large steel plates to meet rail requirements and enable the SGs to be shipped directly for disposal to EOU.

Rancho Seco staff evaluated each section of the SG as it’s own package and included other documentation to submit with the request for the DOT Exemption which was approved by the DOT in May 2004. The first generator was segmented and removed from the Reactor Building in the last quarter of 2004 and loaded onto railcars supplied by MHF Logistical Solutions, Inc. (MHF-LS). Blocking and bracing work was completed and shipment of the generator sections was performed in December 2004. The second generator was similarly prepared and shipped in January 2005.

INTRODUCTION

Rancho Seco is a 913-megawatt B&W designed nuclear power plant owned by the Sacramento Municipal Utility District (SMUD) that began commercial operation in 1975. It was shut down in June of 1989 as the result of a voter referendum. Due to a minimal decommissioning fund balance, the decision was made to enter an extended period of SAFSTOR to allow the activity to decay and the fund to build to a level that would allow dismantlement, projected to begin in 2008.

In 1991, the decision was made to place the spent fuel into dry storage, allowing the plant to enter a "hardened" SAFSTOR condition and cutting the required staff significantly. An Independent Spent Fuel Storage Installation (ISFSI) was built and contracts for casks and fuel storage liners were put in place, but numerous delays continued to postpone fuel transfer. Fuel transfer was finally completed in August of 2002 as 21 canisters have been filled and placed in the ISFSI.

With the staff waiting for fuel movement and the possibility for significant cost savings by using the EOU disposal site, a three-year incremental decommissioning project was proposed to dismantle the Turbine Building systems and a portion of the Tank Farm systems. The project was approved for a 1997 start, with annual renewals based on performance. This work was successfully completed leading to approval of full dismantlement in July of 1999.

Over the last year significant progress has been made on removal of systems in the Auxiliary Building, the Reactor Building and the Spent Fuel Building. MHF-LS supported the shipment of eleven spent fuel storage racks to EOU for disposal using a combination of SCO Wraps, Metal Containers, and specialty conveyances. Following rack removal the water was drained from the Spent Fuel Pool and since that time site personnel have been removing the stainless liner plate from the walls and floor. Except for the SGs, Reactor Vessel, and Internals, all highly radioactive components in the buildings have been removed. MHF-LS also supported the shipment for disposal, of the four Reactor Coolant Pumps in December of 2002 and the Pressurizer in April of 2003 using gondola railcars and a heavy-duty flatcar, respectively. In the latter part of 2003 and first quarter of 2004 the Rancho Seco Reactor Head was segmented via the use of a diamond wire saw technology, which proved to be cost effective from a labor, packaging, transport, and disposal costing perspective.

Rancho Seco's SGs are of B&W design and commonly known as Once-Through Steam Generators (OTSG). The B&W design consists of two such SGs, each approximately 80' in height, 12' in diameter, and over 550 tons in weight. The SGs were too large to ship to EOU in their intact state due to rail clearances with respect to the length of the generator and certain radii of track along the required route to the disposal facility. Rancho Seco cut the SGs in the latitudinal direction at approximately the halfway point and then capped the cuts with large steel plates to meet rail and DOT requirements and enable the SGs to be shipped directly for disposal to EOU.

TRANSPORTATION EVALUATION

In the fall of 2001, the first step taken in planning the disposition of the SGs involved a railroad transportation evaluation to ascertain the feasibility of available routes from Rancho Seco to EOU. Duratek Services, Inc, was contracted to determine acceptable shipment configurations and the feasibility of available routes. The two routes Duratek considered for transport of the 80’ long, 550-ton vessels were 1) from Rancho Seco north and east over Donner Summit through Nevada and into Utah and, 2) from Rancho Seco south through Tehachapi, Las Vegas and into Salt Lake City. Duratek had proposed shipping each generator on a 36-axle CEBX-800 Schnabel car. Each shipment as proposed would be 13’ in width, 18’-6” high, and over 300’ in length. The proposed shipments could not be cleared along either route. There were over 32 structures that this proposed shipment would not clear. It was then proposed that Rancho Seco perform an in-depth rail survey to identify specific pinch points and then develop a plan to possibly upgrade these locations or consider transloading the shipment to road to maneuver around the obstructions.

These options were considered and ultimately the decision to segment each SG into two sections was made. This decision was based on 1) the ability to clear the shipment as ½ of the SG was approximately 38’ in length, and 2) past success Rancho Seco had in segmenting the Reactor Head and, 3) transporting other components via rail utilizing MHF-LS.

Rancho Seco worked with MHF-LS to ascertain acceptability for railroad routing and clearance between Sacramento and EOU. The conceptual shipment would consist of each SG section positioned on a 12 axle QTTX series 131627 – 131636 railcar NSH53 class with a load limit of 743,000 pounds and light railcar weight of 202,000 pounds. The 1.5” deck plate is 53’ in length and 10’ –8” wide. Each shipment would consist of an upper and lower section of SG on separate railcars. Rancho Seco prepared preliminary general arrangement drawings to identify size and location of blocking and bracing material and envelope dimensions of the shipment. MHF-LS then received the conceptual arrangement drawings to ascertain envelope dimensions, weights and center of gravity for the SG sections. This information was then formulated into a request to Union Pacific (UP) Railroad for routing and clearance from Rancho Seco to EOU. The proposed shipment arrangement was cleared for a route from Rancho Seco south to Barstow, CA and then north through Las Vegas and into Salt Lake City. From Salt Lake City the shipment was then cleared into EOU.

With rail clearance and routing established for the SG sections, Rancho Seco proceeded with the request for regulatory exemption from the Department of Transportation.

DEPARTMENT OF TRANSPORTATION EXEMPTION REQUEST

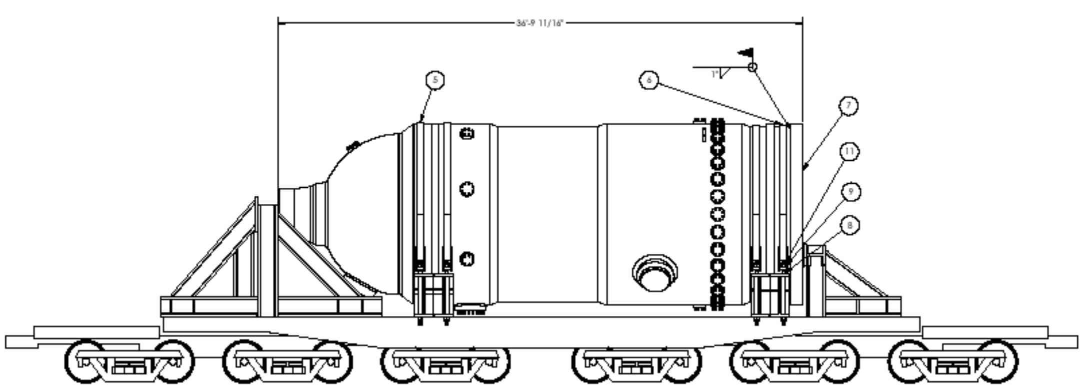
Prior to Rancho Seco proceeding with the plan to segment the SGs it was imperative that an exemption request submitted to the Department of Transportation (DOT) was approved and the exemption issued.

Specifically, Rancho Seco requested exemption from the requirements of 49 CFR 173.403 for demonstration of Surface Contamination Object (SCO) limits and 49 CFR 173.427 (b) (1) for packaging the SCO into an Industrial Package. Rancho Seco referenced NRC Generic Letter 96-07, “Interim Guidance on Transportation of Steam Generators”, which provides NRC and DOT guidance on the application of existing radioactive material transportation requirements to the transportation of SGs. This generic letter indicates that SGs are best characterized as SCOs, as they are solid, non-radioactive objects with radioactive material distributed on their surfaces. As such, SCO material is required to be transported with a conveyance limit of 100 A_2 and in packaging that meets the requirements of 49 CFR 173.411, "Industrial Packagings".

In addition, the generic letter states that it is impractical to measure the contamination level over all the contaminated surfaces as required to demonstrate compliance with the SCO definition. Furthermore, the letter states that, if the shipper desires to ship the SGs without first packaging them, an exemption should be requested from the packaging requirements for SCO material however, the unpackaged SG must be shown to meet the requirements for an Industrial Package.

The SG sections must meet general design requirements of 49 CFR 173.410 and 173.411 for an IP-2 and the exemption must describe how the SG sections meet these requirements. The SG sections must be able to withstand the result of a 1-foot free drop as described in 49 CFR 173.465, Type A packaging tests. Since it was impractical to actually demonstrate package acceptability, these tests were demonstrated per 49 CFR 173.461, modified mechanical testing.

The components of the DOT Exemption Request included first a Compliance Matrix, which supplied documentation from 49 CFR 107 subpart B describing the particular shipment, regulations from which an applicant will seek relief from, and justification for the exemption request. The most important element of the exemption request was the structural package evaluation with closure and weld documentation. The general arrangement drawings (Figure1) detailed the interface between the SG sections and the blocking & bracing, with details of the blocking & bracing. The radiological characterization with surveys was also included in the exemption request package submitted to the DOT with the final component, the transportation and emergency response plan.



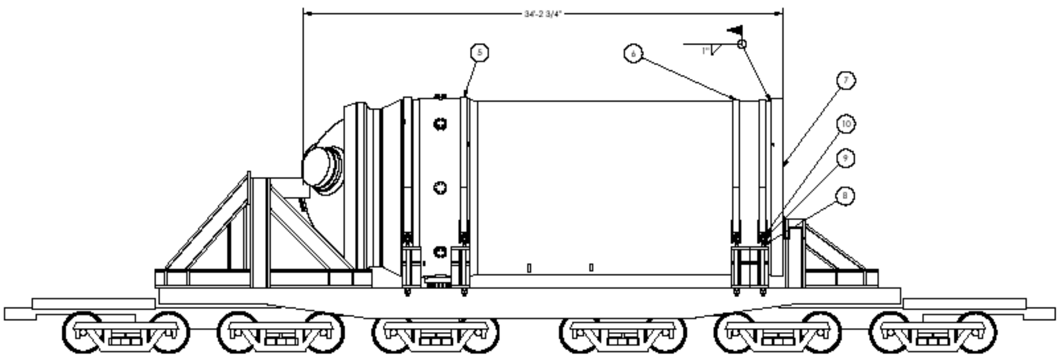


Fig. 1. SG Upper and Lower Sections General Arrangement Drawings.

COMPLIANCE MATRIX

The Compliance Matrix provided the basis framework for the exemption request for transportation of the four SG sections from Rancho Seco to EOU. In the submittal, as provided for by 49 CFR.107, subpart B, the regulation concerning the exemption request was cited in bold, and Rancho Seco’s response was provided following the respective regulation. The Matrix describes how to prepare an exemption request, how long the exemption would be required for, and where to submit the request for consideration by the DOT.

STRUCTURAL EVALUATION OF THE SG SECTIONS AND BLOCKING AND BRACING

The structural evaluation was performed in order to demonstrate that the alternate packaging proposed for the shipment of the Rancho Seco SGs to EOU is equivalent to the requirements of an IP-2 industrial package. Specifically the evaluation served to demonstrate that the SG sections meet general design requirements of 49 CFR 173.410 and 173.411; the SG sections would contain radioactive material as a result of a 1-foot free drop as described in 49 CFR 173.465; and the blocking and bracing plan was adequate for securing the SG sections to the rail cars. The SGs were originally designed and manufactured of carbon steel, stainless steel, and inconel. There were no specific package contents; the sections of each SG were contaminated with radioactive material deposited as the result of contact with primary coolant during power operations.

Each SG section was evaluated with welded caps placed on the open ends and with the SG section secured onto the QTTX railcar for shipment. Each SG was placed on the rail car with hydraulic jacking equipment.

Temporary lifting attachments were used to remove the SG sections from the reactor building. Once the SG sections were placed on the QTTX railcar, the lifting attachments were removed.

All external openings of the SG sections were closed with plugs, blind flanges, and steel plates in a manner that contained the radioactive contamination within the SG section. Polymeric Barrier

System (PBS), a modified acrylic latex paint supplied by Bartlett Services, Inc, was used to fix the existing contamination in place.

All external openings were closed with plugs, blind flanges, and steel plates in a manner that reduced the trapping of water external to the SG section. The PBS paint on the outer surfaces fills small pockets or crevices where water would collect. In addition, RTV was applied in gaps on the exterior surface where PBS could not be applied. The plugs and steel plates were welded in place. The blind flanges bolts were torqued in place per plant procedures such that they would not loosen as the result of acceleration, vibration, or vibration resonance.

The free drop analysis assumed a static linear finite element analysis with the SG section in the orientation that it was to be shipped (horizontal) with the manways facing down. A steady deceleration of 40g was used in the analysis as recommended in the EPRI document Methodology of Analysis of Spent-Fuel Cask Drop and Tip over Events, TR-108760, Final Report, August 1997. A 3-dimensional computer model of the SG section was created in SolidWorks® (2003). This model was then analyzed for the 40g deceleration utilizing an FEA analysis in COSMOS/WORKS (2004).

The results of the analysis demonstrated that the SG sections with closures complied with the requirements of 49CFR 173.465(c) as demonstrated by a method allowed in 49CFR173.461 a (4). The stresses resulting from the 1-foot free drop were well within the ultimate tensile strength of the materials comprising the SG sections.

Since only one section of SG was placed on a QTTX railcar, performance of a stacking test was not required.

The Blocking and Bracing accelerations were assumed to be 3g in the longitudinal direction, 2g in the lateral direction, and 2g in the vertical direction, which were obtained from Association of American Railroads (AAR) Manual.

The blocking and bracing used to secure the SG to their respective railcar was analyzed using the same software used to analyze the steam generator packages for the 1-foot free drop. The results demonstrated that the stresses were well within the yield stresses for A-36 carbon steel for normal transportation loads.

This analysis concluded that the SG sections were equivalent to IP-2 Industrial Packaging. The "unpackaged" SG sections complied with 49 CFR 173.411, "Industrial Packaging" and the General Design requirements of 49 CFR 173.410, satisfactorily demonstrated the SG sections would contain the internal radioactive material during a 1-foot free drop, reasonably demonstrated that a stacking test was not required, and demonstrated that the blocking and bracing was adequate for normal transportation loads per the AAR Manual.

MHF-LS also supplied an independent review of the Rancho Seco B&B and determined the plan to be structurally adequate, not exceeding allowable stresses, and also meeting all AAR Manual requirements.

RADIOLOGICAL CHARACTERIZATION

A number of contamination samples were taken in tubes from the SGs in July 2003. The samples were combined and analyzed for Part 61 radionuclide content. The results were used as the isotopic distribution of radioactivity within the SGs. The activity was scaled to the Co-60 activity, which was determined by gamma spectrometry analysis of the contamination samples. See Table I for these results.

Table I. Radionuclide Distribution from Sample

Radionuclide	Activity (uCi)	Scaling Factor
Co-60	2.53 E-2	1.0
C-14	5.98 E-4	2.36 E-2
Fe-55	3.54 E-3	1.40 E-1
Ni-63	4.62 E-2	1.83 E-0
Sr-90	1.21 E-4	4.78 E-3
Pu-238	3.87 E-5	1.53 E-3
Pu-239/240	3.98 E-5	1.57 E-3
Pu-241	1.09 E-3	4.31 E-2
Am-241	4.01 E-7	1.58 E-5

Internal radiological surveys were performed for each SG at the center of the tube bundle by an access lane (where tubes were purposely not installed) through an installed hand-hole. These surveys provided the most direct dose rate measurements on the tubes themselves and were used for modeling. Surveys were also taken through the steam lines on the tube bundle shroud and through the feedwater nozzles directly on the tube bundle. Finally, surveys were taken on the outside of the SG shell.

Several assumptions were made in the course of performing the characterization analysis of the SGs.

1) Since the secondary side of the SG was exposed only to secondary side water, it was assumed that the secondary side contains only negligible quantities of radioactive material. While there were primary-to-secondary side tube leaks, those leaking tubes were plugged and the SGs operated, cleaning the secondary sides during operation.
2) There was no significant residual water left in the SGs once they were cut which opened the plugged tubes. No water was found upon completion of the latitudinal cuts across the SGs and transport of the SG sections within the Reactor Building.
3) It was also assumed that there was uniformity in the distribution of primary side contaminates. Two EPRI reports addressed the issue of SG primary side surface contamination. These reports indicated that, while the straight tube sections within SGs exhibit fairly uniform surface contamination, U-tube and tube sheet sections of the tubes contain higher surface contamination values than that of the straight tube sections. (B&W OTSGs do not have U-tube sections or divider plates). Additional uncertainty existed concerning the relative concentration levels between the tubes and the tube sheet and bowl surfaces. Differing materials and flow characteristics could have resulted in higher surface contamination in these regions. To address these issues, the Rancho Seco

analysis assumed that all surfaces other than straight sections contain contamination levels twice that of the straight tube sections. This factor was addressed specifically in the EPRI reference [6] study for the various tube sections. It was then reasonable to apply the assumption to the tube sheets and bowls as well, as they represented a minimal fraction of the surface area, and thus only a small portion of the total activity in the SG sections.

The tube bundle was modeled as the source with an average density. The carbon steel shell was determined to have a density of 7.86 gm/cc; while the inconel tubes density was determined to be 8.25 gm/cc. With 15,457 tubes a bundle density of 0.775 gm/cc was then calculated.

Average Bundle Density = (tube wall cross-section x # of tubes/bundle cross-section) x metal density = (0.0631 in^2/tube x 15,457 tubes per bundle/ 10,387 in^2 per bundle) x 8.25gm/cc = 0.775 gm/cc

The primary Microshield V 5.05 model was then based on the center bundle dose rate being equivalent to two cylinders end-to-end. A Cylinder-end geometry was modeled then doubled, as if the SG was cut in two pieces with the dose from each added. For a 2.5 R/hr dose rate obtained in May 2003; the "A" SG tube bundle Co-60 curie total was 40 curies for the entire tube length. For the "B" SG a value of 2.4 R/hr was used yielding 38.4 curies.

Using 40 curies, the A SG bundle was modeled in Microshield v5.05 for a dose rate through the shroud (survey through the steam line nozzles). The model predicted 189 mR/hr and 90 mR/hr was found in A SG. The A SG bundle was then modeled for contact on the side of the bundle for a dose rate of 1.1 R/hr. Surveys on the bundle through the feedwater nozzles above the shroud showed 800 mR/hr.

The Microshield model predicted 2.1 mR/hr through the main portions of the generator that are 4.2" thick. All contact readings to SG exteriors were below this value. Table II lists calculated Co-60 activities.

Table II. Calculated Curies of Co-60 per Package (May 2003)

Contaminated Surfaces	**Surface Area (in^2)**	**SG A Top (Ci)**	**SG A Bot. (Ci)**	**SG B Top (Ci)**	**SG B Bot. (Ci)**
Tube Surface Top	8.36 E6	19.0	n/a	18.27	n/a
Tube Surface Bottom	8.56 E6	n/a	19.5	n/a	18.7
Tubes in Tube Sheet	6.49 E5	1.48	1.48	1.42	1.42
Tube Sheet	7.36 E3	0.02	0.02	0.02	0.02
Bowl	2.22 E4	0.05	0.05	0.05	0.05
TOTAL	1.83 E7	20.6	21.0	19.8	20.2

The shipping and disposal classifications were performed for the SG sections based on the calculated radionuclide content in accordance with regulatory requirements of 10 CFR Part 61. It was determined that each SG section contained greater than (?) a Type A quantity of radioactive material (Tables III and IV). The average surface contamination levels were determined to be significantly less than the SCO-II fixed and non-fixed limit of 20 uCi/cm^2. However, uncertainty in the distribution of activity over all surfaces in the SGs resulted in uncertainty that all areas were less than the SCO-II limit. As such, an exemption from SCO-II limits and packaging requirements was requested from the DOT. The total amount of fissile material for each package was approximately 0.5 grams, which was less than the 15-gram limit; therefore, the shipment qualified as fissile excepted.

Table III. DOT Classification of SG A Top

Nuclide	Curies	A_2 Value	A_2 Fraction
Co-60	20.6	11	1.87
C-14	0.481	81	0.0059
Fe-55	2.88	1100	0.00262
Ni-63	37.6	810	0.0464
Sr-90	0.0985	8.1	0.0122
Pu-238	0.0314	0.027	1.16
Pu-239/240	0.0324	0.027	1.20
Pu-241	0.885	1.6	0.553
Am-241	0.000326	0.027	0.0121
H-3	0.00351	1080	0.000003
TOTAL:	62.6		4.86

Table IV. DOT Classification and Average Surface Contamination

	SG A Top	SG A Bot.	SG B Top	SG B Bot.
Curies	62.6	63.8	60.2	61.4
A_2 Fraction	4.86	4.95	4.67	4.77
uCi/cm^2	1.07	1.07	1.03	1.03

The waste classification for all SG sections was determined to be waste class A. The waste disposal classification of the bottom A SG, which had the largest total activity, is shown in Table V. This OTSG section had a volume of 83.2 m^3 with a mass of 2.59 E+08 grams.

Table V. Disposal Classification of Lower SG A

Table 1 Isotopes	Total Activity (Ci)	Specific Activity	Class A Limit	Fraction of Table 1 Limits
C-14	0.490	0.00589 Ci/m^3	0.8 Ci/m^3	0.00736
Tc-99	ND*	0.0 Ci/m^3	0.3 Ci/m^3	0.0
I-129	ND	0.0 Ci/m^3	0.008 Ci/m^3	0.0
Cm-242	ND	0.0 Ci/gm	2.00E-06 Ci/gm	0.0
Pu-241	0.902	3.48E-09 Ci/gm	3.50E-07 Ci/gm	0.00995
TRU>5 yr half life	0.0650	2.51E-10 Ci/gm	1.00E-08 Ci/gm	0.0251
Table 1 Total				**0.0424**

* ND = None Detected

Table 2 Isotopes	**Total Activity (Ci)**	**Specific Activity (Ci/m^3)**	**Class A Limit (Ci/m^3)**	**Fraction of Class A Limits**
Co-60	21.0	0.253	700	0.000361
Cs-137	ND	0.0	1	0.0
H-3	0.00358	4.30E-05	40	1.08E-06
Ni-63	38.3	0.461	3.5	0.132
Sr-90	0.100	0.00120	0.04	0.0301
Isotopes <5 yr half life	2.94	0.0354	700	5.05E-05
Table 2 Total				**0.162**

TRANSPORTATION and EMERGENCY RESPONSE PLAN

A Transportation and Emergency Response Plan was developed to identify routing and controls to be taken during the transport of the SG Sections to EOU.

The clearance routing was verified through UP and then incorporated into the plan. The shipment was determined to be a special transport, which required a dedicated train and set railcar configuration consisting of QTTX cars with their respective load and an idler car positioned between the engine and the 1st QTTX car and two idlers between the QTTX cars. The Transportation and Emergency Response Plan dictated the maximum speed the train could travel.

An emergency response plan was incorporated into the procedure to identify Rancho Seco contacts for the UP and provided steps for Rancho Seco management to take in the event of an emergency notification.

DOT EXEMPTION REQUEST APPROVAL

The DOT granted approval of the Rancho Seco Exemption Request; number DOT- E 13338, in May 2004. The exemption authorized the transportation in commerce of four SG sections, containing class 7 radioactive materials, to be classed as SCO II, and transported in non-specification packaging. Regulations that Rancho Seco was exempted from included relief from 49 CFR 173.403 for demonstration of Surface Contamination Object (SCO) limits, 49 CFR 173.427 (b) (1) for packaging the SCO into an Industrial Package, and 49 CFR 173.465 (c) and (d) in that modified mechanical testing for the package was acceptable. Conditions of the Rancho Seco exemption included:

- A maximum non-fixed contamination level of 20,000-dpm/100 cm^2 (beta/gamma) and 2,000-dpm/100 cm^2 (alpha) per wipe (assuming 10% efficiency) prior to applying PBS
- Modified acrylic latex paint PBS was applied in a minimum of two coats with a total thickness of 25 mils in conformance with the manufacturers product data sheet

- Areas with cracks, crevices, or areas that were difficult to seal with PBS were sealed with RTV
- All openings were sealed with welded plugs, bolted flanges, or welded plates
- SG sections were shipped on two trains, each train with two cars with two SG sections
- 4" thick cap on ends of SG sections
- No trapped water in the steam generator sections
- Blocking and Bracing per submittal
- Notification of the Office of Hazardous Materials Exemptions and Approvals at commencement and completion of transit
- Outside of SG sections were marked with "DOT-E 13338" in 0.25" wide and 4.0" high letters and numbers
- Each "Hazmat Employee" who performed a function subject to the exemption received training on the requirements and conditions of the exemption in addition to the training required by 172.700 through 172.704.
- Security Requirements per Subpart I of Part 172 (172.802) were satisfied
- Report any incident to the Associate Administrator for Hazardous Material Safety (AAHMS)
- Labeling per 40 CFR 173.427(a)(6)

SEGMENTATION AND REMOVAL OF THE STEAM GENERATORS

The commitments from the exemption approval were then incorporated into the final schedule for the SG project to ensure completion. Request for Proposals (RFP) were then prepared for SG segmentation and subsequent removal from the Reactor Building.

The SG project was initially planned for a late 2005 start and early 2006 completion. However, delays in the Rancho Seco reactor vessel internals project which was originally scheduled for a 3rd quarter 2004 start, necessitated moving the SG project start date to the 3rd quarter 2004 start.

Rancho Seco personnel were briefed on the project and individual planning meetings conducted to address specific actions to be taken in preparation of the SGs. An early activity involved decontamination of the SGs to a level of 20,000 dpm/100cm2 (beta/gamma). Pressure washers were utilized for the decontamination and proved to be quite effective in reducing loose contamination levels to well below 20,000 dpm/100cm2.

The SG segmentation scope of work was to include a latitudinal cut across the SG tubes at approximately the halfway point. Since all supporting steel and floor grating had been removed, Rancho Seco used Bartlett's Excel Modular Scaffold System to provide access to the intended area of segmentation. To then facilitate access to the tubes, Rancho Seco ironworkers cut four windows in the steam generator carbon steel housing. Each window was approximately 6" high by 4' in length.

The dose rates at the open plane to the outer window openings were 100 mrem/h and dropped to 30 mrem/h at 12" from the open window. Contact dose rates to the outer diameter to the tubes bundles were 300 to 400 mrem/h.

The SG segmentation contract was awarded to Cutting Edge Service Corp (Cutting Edge) from Cincinnati, Ohio who utilized a diamond wire cut. Rancho Seco had been successful in utilizing diamond wire sawing when segmenting the Reactor Head in late 2003. Also included within the scope of services was removal of the cold leg nozzles at the bottom of each SG.

The Cutting Edge diamond wire sawing system passed through the windows and was then coupled together with steel sleeves. The wire was passed around a drive wheel and over guide pulleys. Wire tension was maintained by a rack and pinion system that moved the drive wheel along the wire saw carriage. The main drive wheel had a "V" groove and rubber lining to grip the wire. A hydraulic motor rotated the drive wheel at a controlled rate and direction selected by the operator.

Cutting Edge was mobilized in August of 2004 and began work by trimming the cold leg nozzles from each SG to meet the envelope diameter dimension cleared for rail transport. By the end of August, Cutting Edge had successfully performed the latitudinal cuts across the SG tubes. No water was present in the tubes. With two men working, each SG was segmented in approximately 60 hours, which resulted in an average cut rate of approximately 270 in2/hr. Each SG was segmented at an expense of approximately 200 mrem.

REMOVAL OF THE SG SECTIONS FROM THE REACTOR BUILDING

As the SG tubes were segmented, work continued on the weld-up of plates and plugs over nozzle covers and pipe penetrations while bolts were tightened on flanges to operating torque values. Calculations were performed to assure the covers over nozzles would provide adequate shielding to meet DOT radiation limits as described in 49 CFR 173.441. Trunions were positioned at 180° and a tailing lug was welded onto each section of SG.

The final step in segmentation was to then finish the latitudinal cut around the SG carbon steel housing. The rigging contractor, Bigge Power Constructors, had assembled lifting equipment on the Rancho Seco polar crane and when the latitudinal cut was completed, Bigge Power Constructors began the transfer of the top B SG section to the Reactor Building hatch. The lift was conducted first in a vertical direction in order to clear the walls surrounding the SG section that extended to an elevation of +60 above grade level. Once above the +60 wall, the SG section was transported in a horizontal direction until it was situated adjacent to the Reactor Building Hatch where it was lowered onto a shield cap. The 4” thick shield cap, 13’-6” in diameter was designed and fabricated to provide closure over the latitudinal SG cuts.

Once the shield cap was welded into place two coats of the modified acrylic latex paint PBS, was applied which effectively fixed the existing loose contamination to a non-detectable smearable level. At this point the top B SG section was again lifted and utilizing the tailing lug, which connected to a leveling beam, was brought to a horizontal position (Figure 2) and lowered onto a multi-axled Goldhoffer trailer for transport out of the Reactor Building to an area adjacent to the Rancho Seco rail spur for final shipment preparation.

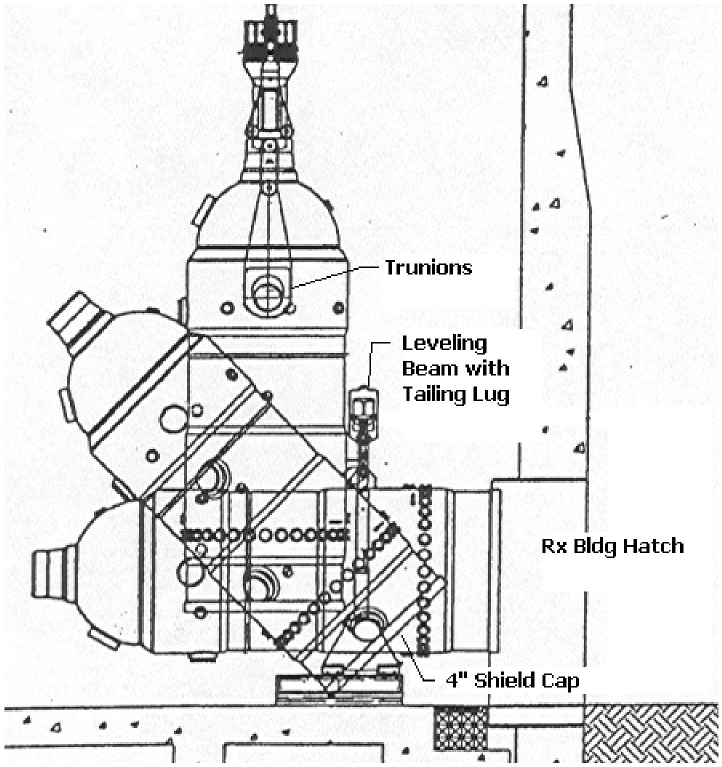


Fig. 2. Top B SG section Down-Ending with Shield Cap in place.

The lower section of B SG remained in place and the 4" shield cap was flown and positioned over the cut. The shield cap was welded in place with trunions positioned at 180° and a tailing lug welded onto the lower section of B SG to then level the section in preparation to set upon the Goldhoffer trailer and remove from the reactor building.

Once out of the Reactor Building the two sections of B SG were transported to the rail spur via the Goldhoffer trailer where they were placed upon the QTTX cars and final preparations were made for shipment.

While preparing the SG sections inside of the Reactor Building, portions of the Blocking and Bracing for the shipment had been fabricated and welded onto each QTTX railcar. The two saddles and one end of the blocking had been installed onto the cars.

Bigge Power Constructors set up a hydraulic jacking gantry system to remove the SG sections from the Goldhoffer trailer and set on each railcar. The SG sections were lifted from the trailer and the railcars were rolled into position where the sections were set upon the saddles. The saddles had been softened with ½" thick rubber matting to help protect the PBS coating. At this point the other blocking section was placed on the railcar (Figure 3) and tightly positioned against the SG section to assure a tight fit.

Four banding straps were placed over the top of the SG section and connected to the saddles with threaded studs and jamb nuts. The nuts were then torqued to 4,000 ft-lbs to finish securement of the SG section to the blocking and bracing.

Fig. 3. Positioning Lower B SG onto QTTX Railcar.

SHIPMENT TO EOU

Once loaded and prepared for shipment, UP, MHF-LS, and EOU personnel conducted inspections. The UP inspector and MHF-LS assured the blocking and bracing was consistent with the submitted drawings and the actual dimensions (width and height) were within the envelope dimensions as cleared for transport to EOU. UP released the cars for shipment on 11/23/04.

EOU personnel with the EOU rigging contractor met with site engineering to discuss the removal of the jamb nuts, banding straps and shims to permit the lift of the SG section off of the railcars. EOU's plan was to establish a gantry over the railcars and lift the SG sections in a vertical direction, pull the railcar out of the way and then set the section onto a Goldhoffer trailer which would be used to move the section into the large component cell.

Final radiological surveys were performed and no detectable loose contamination was found on either OTSG section.

Contact dose rates on the lower B SG section ranged from 10 mrem/h along the top and sides to a single contact dose rate of 100 mrem/h located on the cold leg cover shield. The two-inch thick shield had a four-inch penetration that was covered by a ½" plate which was then removed at

EOU to permit the introduction of grout. The highest one-meter dose rate, from the penetration, was 10 mrem/h. All two-meter dose rates were less than 2 mrem/h. The contact dose rate to the four-inch shield cap was 7 mrem/h. No additional shielding was necessary to meet DOT radiation limits.

Contact dose rates on the top B SG section ranged from 5 mrem/h along the top and sides to a single contact dose rate of 25 mrem/h located on a generator hand hole. Again all dose rates were well within 49 CFR 173.441 radiation limits and no further shielding was required.

Each section of B SG was marked and labeled as a bulk shipment with UN 2913 in orange panels applied. Yellow III labels, weight, Waste class A Unstable per EOU Waste Acceptance Criteria were also applied. The DOT Exemption number, DOT-E 13338 was also displayed.

The first set of SG sections (B Steam Generator) left Rancho Seco on the evening of 12/2/04 (Figure4). Upon departure of the shipment the DOT Office of Hazardous Materials Exemptions and Approvals was notified.

Fig. 4. SG Sections Leaving Rancho Seco.

The dedicated shipment was assembled in Stockton, CA on the morning of 12/3/04 and left the UP yard at 1300 hours that afternoon. From Stockton it traveled south, through Fresno, to Barstow, CA and then in a northeasterly direction into Las Vegas, through Caliente and then into Salt Lake City. On Saturday, 12/5/04 at 1700 hours, the shipment arrived at EOU in Clive, UT where it was surveyed and accepted by Tuesday, 12/7/04. All receipt surveys results were as manifested from Rancho Seco with no problems identified.

The SG sections were offloaded and placed into the appropriate disposal cell locations during the week of 12/13/04. The QTTX railcars were then surveyed, released and sent back to Rancho Seco in preparation for the second set of SG sections.

CONCLUSION

Rancho Seco was successful in segmenting, removing, transporting, and disposing of the Once-Through Steam Generators from a monetary, ALARA, scheduling, and safety perspective. Good planning and communication ensured a successful project. The total cost for segmentation, removal, transportation, and disposal was almost $3,500,000 less than the original project estimate. Advantages in Rancho Seco's favor to a successful project included a low source term from limited operation, long decay period, incorporating lessons learned from other facilities, and working with quality vendors to bring together the best possible team to accomplish the job.

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