CHEM-NUCLEAR SYSTEMS

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PREPARED BY:	Mark Whittaker	M. S. Whittaker	9/1/98
INDEPENDENT REVIEWER:	Anthony Savino	Anthony Savino	9/1/98

DOCUMENT TITLE:

Preliminary Waste Characterization of
D.C. Cook Steam Generator Lower Assemblies

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1. Summary

This report presents the preliminary analyses performed in support of the source characterization and classification of the four D.C. Cook Unit 2 Steam Generator Lower Assemblies (SGLAs) for American Electric Power, the owner and operator of the D.C. Cook plant. The radionuclide content of the SGLAs was determined based on currently available isotopic and dose rate information to demonstrate compliance with applicable criteria for transportation and disposal.

A final characterization will be performed after removal of the SGLAs from the storage facility and prior to shipment for disposal.

2. Physical Description of Steam Generators

The steam generators at D.C. Cook Unit 2 are Westinghouse Model 51 and were placed in service in 1977. The generators were removed in 1988 and the steam domes removed. The remaining "lower assemblies" were placed in storage at the reactor site. Similar Westinghouse Model 51 generators were transported from Salem for disposal in 1996. The basic physical dimensions and design criteria of the SGLAs is included in Table 2-1 [from information provided in Appendix A]. A summary sketch of these basic characteristics is provided in Figure 2-1. This information is utilized to develop the surface areas and effective source region density information listed in Table 2-2. Additionally, a sketch of the channel head region is provided in Figure 2-2.

Table 2-1 SGLA Characteristics

General Information		
Weight	476,000 lbs.	2.16E+05 kg
Length	533 in	1354 cm
Lower Shell Diameter	135 in	343 cm
Lower Shell Thickness	2.82 in	7.16 cm

Tube Bundle Data		
Number of Tubes	3388	
Tube Bundle Radius	59.8 in	152 cm
Straight Tube Length	357 in	907 cm
Tube OD	0.875 in	2.22 cm
Tube Wall Thickness	0.05 in	0.13 cm

Wrapper Data		
Wrapper Thickness	0.38 in	0.97 cm
Wrapper OD	124.9 in	317.2 cm

Channel Head Data		
Channel Head Radius	62.81 in	159.5 cm
Channel Head Thickness	5.16 in	13.1 cm

Figure 2-1 D.C. Cook Steam Generator Reference Dimensions

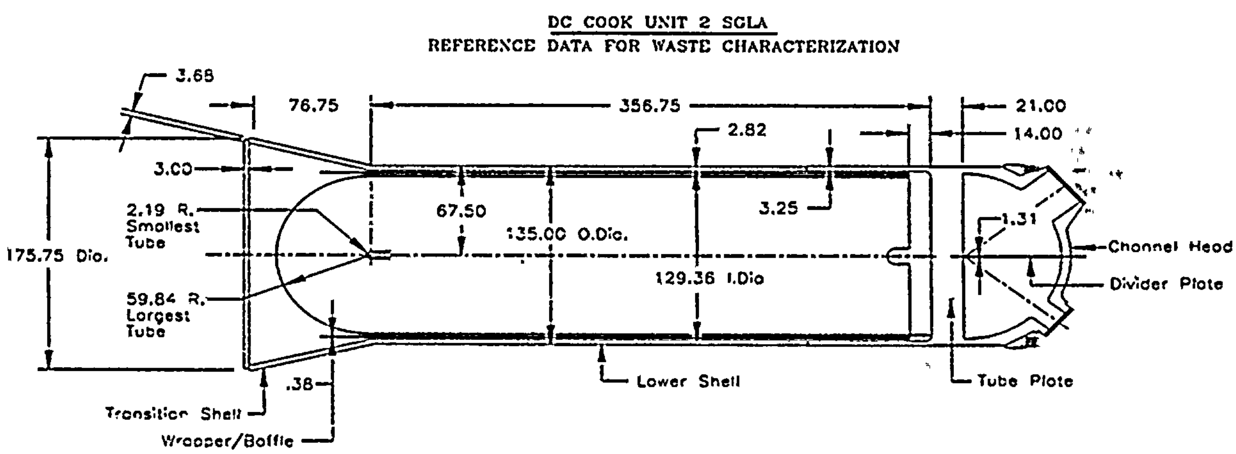
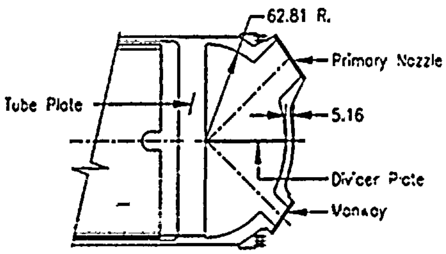


Figure 2-2 Steam Generator Channel Head Region Components



Channel Head Region Components

Table 2-2 Internal Surface Area and Material Density Information

Contaminated Surface Areas	(in^2)	(cm^2)
Total Tube Bundle Inner Surface	**7.04E+06**	**4.54E+07**
Straight Tube Surface Area	*5.89E+06*	*3.80E+07*
Tubes in Tube Sheet	*3.47E+05*	*2.24E+06*
U-Tube Section Surface Area	*8.04E+05*	*5.19E+06*
Channel Head Components	**4.64E+04**	**2.99E+05**
Channel Head	*2.48E+04*	*1.60E+05*
Tube Sheet	*9.20E+03*	*5.93E+04*
Divider Plate	*1.24E+04*	*8.00E+04*

Densities	(lb/in^3)	(g/cm^3)
Tubes (Nickel Alloy)	0.298	8.25
Shells & Wrapper	0.284	7.86

Tube Bundle Data		
Straight Tube Mass	9.33E+4 lbs	4.24E+7 g
Straight Tube Region Volume	4.0E+6 in^3	6.56E+7 cm^3

Effective Source Region Density	0.646 g/cm^3

3. Radioactive Source Characteristics

The source scaling factor table, included in Appendix A, was developed based on Part 61 laboratory analyses of D.C. Cook wastes during the time the generators were in use. The 1988 estimated gamma activity per generator , included in Appendix A, was determined by AEP staff and used in addition to the scaling factors to establish the

normalized source in the SGLAs. The normalized source term and the activity estimates from which it was developed are provided in Table 3-1. The AEP 1988 gamma activity estimate assigned a single curie value to a group of several radionuclides. In developing the normalized source, the single curie value was evenly distributed among the grouped radionuclides. Scaling factors were given to predict Pu-239 from both Co-60 and from Ce-144. The Co-60 factor, which provided the larger Pu-239 amount, was used. The estimated activity was determined for the date of SGLA removal (1988) using the AEP estimated gamma activity and the scaling factors and then was decayed ten years to 1998. Radionuclides with an activity of less than 1 mCi after decay were neglected. The estimated activity was normalized to 1 curie to provide the isotopic distribution used to characterize the SGLA source term based on the 1998 external survey data.

Table 3.1 - Radionuclide Distribution

Radionuclide	1988 Estimated Activity (Ci)	1998 Estimated Activity (Ci)	Normalized Source Term (Ci)
Am-241	3.98e-002	1.28e-001	7.33E-04
C-14	2.01e+000	2.01e000	1.14E-02
Cm-242	3.56e-002	----	---
Cm-244	4.01e-002	2.73e-002	1.56E-04
Co-57	2.43e+000	---	---
Co-58	1.53e+002	---	---
Co-60	2.10e+002	5.64e+001	3.21E-01
Cr-51	1.19e+002	---	---
Fe-55	3.97e+002	3.05e+001	1.73E-01
Fe-59	7.0e+000	---	---
Mn-54	8.0e+000	2.44E-03	1.39E-05
Nb-95	4.00e+001	---	---
Ni-63	8.80e+001	8.21e+001	4.67E-01

Radionuclide	1988 Estimated Activity (Ci)	1998 Estimated Activity (Ci)	Normalized Source Term (Ci)
Pu-238	8.73e-002	8.12e-002	4.60E-04
Pu-239	6.93e-002	6.93e-002	3.94E-04
Pu-241	7.07e+000	4.38e+000	2.48E-02
Ru-106	2.43e+000	2.51e-003	1.43E-05
Sb-125	2.43e+000	1.99e-001	1.13E-03
Sn-113	2.43e+000	---	---
Te-125m	0	4.87e-002	2.77E-04
Zn-65	2.43e+000	---	---

Contamination samples from inside one SGLA are planned to be taken in September 1998 to update the source isotopic distribution. Analysis on these samples will include the typical Part 61 analyses to verify the isotopic content of TRU and other hard to detect radionuclides as well as the expected gamma emitting fission/activation products. The results of these analyses should be available November 1. If these results are significantly different from the distribution in the normalized source term, this report will be revised to reflect these values. As compared to other steam generators previously disposed, the normalized source term reflects higher TRU quantities as compared to the other fission/activation products indicating that the normalized source term may be conservatively predicting TRU content.

External radiation surveys were taken on the SGLAs on 6 July 1998. This survey information is included in Appendix A. Measurements taken radially on the straight tube region of the SGLA are expected to be uniform due to expected uniform deposition of contaminants in the straight tubes. Due to the storage arrangement, measurements made on the surfaces of the SGLAs facing each other show higher readings due to the contribution from the adjacent SGLA. Calculation of the expected contribution from the adjacent SGLA assuming a uniform dose field equal to that measured on the opposite side, corrected for distance using a Microshield model, shows that the higher reading can be attributed to this contribution rather than to a non-uniform dose field on the measured SGLA. The 30 cm readings corrected for contribution from the adjacent SGLA, averaged over the straight tube region are 21, 21, 22, and 20 mR/hr respectively

for SGLA 1, 2, 3, and 4. These average values are used in calculating the surface area contamination on the straight tubes.

The final characterization will be performed based on dose rate profiles taken on the SGLAs on removal from the storage facility. However, these dose rates are not expected to change significantly from those measured in July, 1998 except for eliminating the contribution from an adjacent SGLA.

4. Characterization Assumptions

Several assumptions are made in the course of performing the characterization analyses of the steam generators. These assumptions are utilized to simplify the analysis, while maintaining accuracy in the overall result.

1. Secondary-side steam generator surfaces contain no activity.

   Since the secondary side of the steam generator is exposed only to secondary side water, it is assumed that the secondary side contains only negligible quantities of radioactive contamination. This assumption has been used for previous steam generator characterizations.

2. Residual water in plugged tubes contains no activity.

   The plugged tubes in the steam generator could contain relatively small amounts of water that seeps into the tubes during operation of the generators. It is assumed that this water contains negligible quantities of radioactive material, and is not considered in this characterization.

3. Uniformity in distribution of primary-side surface contaminates.

   Two EPRI reports [2, 3] address the issue of steam generator primary side surface contamination. These reports indicate that, while the straight tube sections with the SGLAs exhibit fairly uniform surface contamination, the U-tube and tube sheet sections of the heat exchanger tubes contain higher surface contamination values than that of the straight tube sections.

   Additional uncertainty exists concerning the relative surface contamination levels between the tubes and the channel head surfaces, including the tube sheet, divider plate, and bowl itself. The studies indicate that the differing materials used for the tubes versus the channel head components, combined with other factors, could result in higher surface contamination values in the channel head region.

   To address these issues, this analysis assumes that all surfaces other than the straight tube sections contain surface contamination levels twice that of the straight tube sections. This factor of two is addressed specifically in the reference [2] study for the various tube sections. It is reasonable to apply this assumption to the

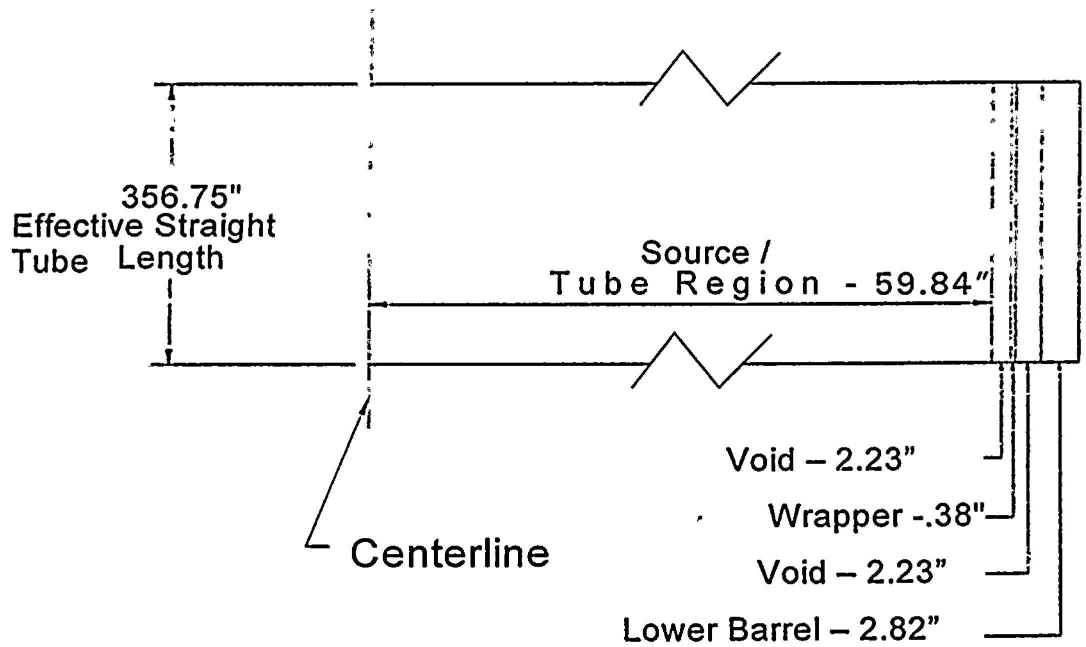
channel head sections as well, as they are of a similar geometry and represent only a minimal fraction of the total surface area, and thus only a small portion of the total activity in the SGLAs.

5. Source Characterization

Employing the information from the previous sections, the radionuclide content of the SGLAs can be determined from the measured external SGLA dose rates and the SGLA design parameters.

The straight tube section of the lower barrel of the SGLA is modeled with the Microshield [4] point kernel shielding code, using the normalized source term provided in Table 3-1. The shortest straight tube length is approximately 357 inches, not including the 21 inch length of tube in the tube sheet. The diameter and thickness of the radial source and shielding regions of the model are taken from the data provided by AEP included in Appendix A. A schematic of the Microshield model is provided in Figure 5-1.

Figure 5-1 Microshield Model Representation of Steam Generator Source Region



The source region is modeled as nickel alloy, Alloy 600, at a density of 0.658 g/cc to represent the fraction of the source region cross-section occupied by the tubes. The void regions are modeled as air, and the wrapper and lower barrel are modeled as A 533 steel. The densities are provided in Table 2-2.

5.1 Microshield Calculations

Analyses are performed with Microshield using the model previously described with the normalized source term provided in Table 3-1. The short-lived daughter of Ru-106, Rh-106, was included in the Microshield source term to accurately depict the dose rate. Short-lived daughters are not included in the source term for characterization. The calculation produces an exposure rate 30 cm from the surface resulting from a 1 curie normalized source of 3.80 x 10^{-1} mR/hr/Ci. The measured exposure rates of 21, 21, 22, and 20 mR/hr, respectively, are then divided by this dose-per-curie factor to determine the number of curies in the straight tube section of the SGLA. The resulting activities are 55.3, 55.3, 57.9, 52.6 Ci. This activity is then divided by the surface area of the straight tubes (3.80E+07 cm^2) to give the activity per unit area. The results of these calculations are presented in Table 5-1.

Table 5-1 Curie Content in Straight Tube Section

	SGLA 1	SGLA 2	SGLA 3	SGLA 4
Average 30 cm Exposure Rate (mR/hr)	21	21	22	20
Activity in Straight Tube Section (Ci)	55.3	55.3	57.9	52.6
Areal Activity ($\mu Ci/cm^2$)	1.45	1.45	1.52	1.39

5.2 Source Distribution

The straight tube source contamination calculated in Section 5.1 is utilized to determine the contamination on the U-tube and tube sheet sections of the heat exchanger tubes, as well as the channel head components.

As shown in Table 5-1, the straight tube sections of the steam generator heat exchanger tubes contain 1.45, 1.45, 1.52, and 1.39 $\mu Ci/cm^2$, respectively, of radioactive material of the distribution shown in Table 3-1. Using the factor of two discussed in Section 4, the surface contamination level on the remaining primary side surfaces of the steam generator is 2.91, 2.91, 3.05, and 2.77 $\mu Ci/cm^2$, respectively. These surface contamination levels are used to calculate the total number of curies in each steam generator as shown in Table 5-2.

Table 5-2 SGLA Total Contamination Content Results.

Contaminated Surface Areas	Surface Area (cm^2)	SGLA 1 Activity (Ci)	SGLA 2 Activity (Ci)	SGLA 3 Activity (Ci)	SGLA 4 Activity (Ci)
Straight Tube Surface Area	3.80E+07	55.3	55.3	57.9	52.6
Tubes in Tube Sheet	2.25E+06	6.54	6.54	6.86	6.23
U-Tube Section Surface Area	5.19E+06	15.1	15.1	15.8	14.4
Channel Head	1.60E+05	0.47	0.47	0.49	0.44
Tube Sheet	5.93E+04	0.17	0.17	0.18	0.16
Divider Plate	8.00E+04	0.23	0.23	0.24	0.22
Total		**77.8**	**77.8**	**81.5**	**74.1**

6. Waste Classification and DOT Subtyping

The shipping and disposal classifications can be performed for the SGLAs based on the calculated radionuclide content in accordance with regulatory requirements [5, 6, 7, and 8]. This information is important to demonstrate that the SGLAs meet applicable requirements for transportation and disposal.

The DOT subtyping for the SGLAs are shown in Table 6-1a – 6-1d. As shown, the SGLAs contain a greater-than-Type-A quantity of radioactive material, with a cumulative A_2 values of 33.5, 33.5, 35.1, and 31.9, respectively. While the average surface contamination levels were shown in Table 5-2 to be less than the SCO-II limit of 20 $\mu Ci/cm^2$, uncertainty in the distribution of activity over all surfaces in the SGLA results in an uncertainty that all areas are less than the SCO-II limit. As such, an exemption from SCO-II limits and packaging requirements will be requested from the DOT as suggested in Reference 9. The total amount of fissile material is 0.64g which is less than 15g; therefore, the shipment qualifies as fissile excepted.

Table 6-1a DOT Subtyping of D.C. Cook SGLA 1

Isotope	Curies	A2 Value	A2 Fraction
Am-241	5.70E-02	0.00541	10.54
C-14	8.85E-01	54.1	0.02
Cm-244	1.22E-02	0.0108	1.13
Co-60	2.49E+01	10.8	2.31
Fe-55	1.35E+01	1080	0.01
Mn-54	1.08E-03	27	0.00
Ni-63	3.63E+01	811	0.04
Pu-238	3.58E-02	0.00541	6.61
Pu-239	3.06E-02	0.00541	5.66
Pu-241	1.93E+00	0.27	7.15
Ru-106	1.11E-03	5.41	0.00
Sb-125	8.80E-02	24.3	0.00
Te-125m	2.15E-02	243	0.00
TOTALS	7.78E+01		33.48

Table 6-1b DOT Subtyping of D.C. Cook SGLA 2

Isotope	Curies	A2 Value	A2 Fraction
Am-241	5.70E-02	0.00541	10.54
C-14	8.85E-01	54.1	0.02
Cm-244	1.22E-02	0.0108	1.13
Co-60	2.49E+01	10.8	2.31
Fe-55	1.35E+01	1080	0.01
Mn-54	1.08E-03	27	0.00
Ni-63	3.63E+01	811	0.04
Pu-238	3.58E-02	0.00541	6.61
Pu-239	3.06E-02	0.00541	5.66
Pu-241	1.93E+00	0.27	7.15
Ru-106	1.11E-03	5.41	0.00
Sb-125	8.80E-02	24.3	0.00
Te-125m	2.15E-02	243	0.00
TOTALS	7.78E+01		33.48

Table 6-1c DOT Subtyping of D.C. Cook SGLA 3

Isotope	Curies	A2 Value	A2 Fraction
Am-241	5.97E-02	0.00541	11.04
C-14	9.28E-01	54.1	0.02
Cm-244	1.27E-02	0.0108	1.18
Co-60	2.61E+01	10.8	2.42
Fe-55	1.41E+01	1080	0.01
Mn-54	1.13E-03	27	0.00
Ni-63	3.80E+01	811	0.05
Pu-238	3.75E-02	0.00541	6.93
Pu-239	3.21E-02	0.00541	5.93
Pu-241	2.02E+00	0.27	7.49
Ru-106	1.16E-03	5.41	0.00
Sb-125	9.22E-02	24.3	0.00
Te-125m	2.26E-02	243	0.00
TOTALS	8.15E+01		35.07

Table 6-1d DOT Subtyping of D.C. Cook SGLA 4

Isotope	Curies	A2 Value	A2 Fraction
Am-241	5.43E-02	0.00541	10.04
C-14	8.43E-01	54.1	0.02
Cm-244	1.16E-02	0.0108	1.07
Co-60	2.37E+01	10.8	2.20
Fe-55	1.28E+01	1080	0.01
Mn-54	1.03E-03	27	0.00
Ni-63	3.46E+01	811	0.04
Pu-238	3.41E-02	0.00541	6.30
Pu-239	2.92E-02	0.00541	5.39
Pu-241	1.84E+00	0.27	6.81
Ru-106	1.06E-03	5.41	0.00
Sb-125	8.38E-02	24.3	0.00
Te-125m	2.05E-02	243	0.00
TOTALS	7.41E+01		31.88

The disposal classification of SGLA #3, which has the largest total activity, is shown in Table 6-2. The disposal volume is 104.52 m^3 and the mass is 1.266E+08g. This classification lists the required nuclides from 10 CFR 61, and demonstrates that the Table 1 and Table 2 isotopes meet the requirements for classification of the SGLAs as Class A waste.

Table 6-2 Disposal Classification of D.C. Cook SGLA 3

Table 1 Isotopes	Total Activity (Ci)	Specific Activity	Class A Limit	Fraction of Table 1 Limits
C 14	9.28E-01	8.875E-03 Ci/m^3	0.8 Ci/m^3	1.11E-02
TC 99	0.00E+00	0.000E+00 Ci/m^3	0.3 Ci/m^3	0.00E+00
I129	0.00E+00	0.000E+00 Ci/m^3	0.008 Ci/m^3	0.00E+00
CM242	0.00E+00	0.000E+00 Ci/g	2.00E-06 Ci/g	0.00E+00
PU241	2.02E+00	1.598E-08 Ci/g	3.50E-07 Ci/g	4.57E-02
TRU >5 yr Half Life	8.23E-02	6.501E-10 Ci/g	1.00E-08 Ci/g	6.50E-02
Table 1 Total				**0.12**

Table 2 Isotopes	Total Activity(Ci)	Specific Activity (Ci/m^3)	Class A Limit (Ci/m^3)	Fraction of Class A Limits
CO 60	2.61E+01	2.499E-01	700	3.57E-04
CS137	0.00E+00	0.000E+00	1	0.00E+00
H 3	0	0.000E+00	40	0.00E+00
NI 63	3.80E+01	3.638E-01	3.5	1.04E-01
SR 90	0.00E+00	0.000E+00	0.04	0.00E+00
Isotopes < 5yr Half Life	1.42E+01	1.363E-01	700	1.95E-04
Table 2 Total				**0.10**

7. References

[1] CNS Procedure EN-AD-010, "Procedure for Waste Characterization of Non-Irradiated Components or Items."

[2] EPRI-NP-2968, "Primary-Side Deposits on PWR Steam Generator Tubes," Electric Power Research Institute, Palo Alto, CA, March 1983.

[3] EPRI-NP-3107, "Gamma-Ray Exposure Rate Distribution in a Steam Generator," Electric Power Research Institute, Palo Alto, CA, May 1983.

[4] Grove Engineering, Inc. "Microshield Computer Code," Version 5.01.

[5] NRC, "Low-Level Waste Licensing Branch Technical Position on Radioactive Waste Classification," (May 1983).

[6] Code of Federal Regulations, 10CFR Part 61 and 10CFR Part 71.

[7] Code of Federal Regulations, 49CFR Parts 100 to 177.

[8] DHEC License CNSI-SC-097, (Barnwell Site Criteria).

[9] NRC Generic Letter 96-07, "Interim Guidance on Transportation of Steam Generators," U.S. NRC Office of Nuclear Material Safety and Safeguards, December 5, 1996.

[10] NUREG-1608, "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects," U.S. Nuclear Regulatory Commission, July 1998

APPENDIX A

AEP SUPPLIED INFORMATION

(12 PAGES)

American Electric Power
Nuclear Generation Group
500 Circle Drive
Buchanan, MI 49107 1373

AEP
AMERICAN® ELECTRIC POWER

Mr. John Bender
Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, SC 29210

August 27, 1998

Dear John:

This letter serves to document two issues related to the dimensions and center of gravity of the steam generators.

We have reviewed the dimensions of the steam generator as shown in CNS Sketch 46628-01, Rev. 0. The dimensions in this drawing accurately reflect the dimensions of the steam generators at the Cook Plant. This was reviewed by comparing the CNS sketch to the drawings and other data from Westinghouse. The primary purpose of our review was to understand the shell thickness and steam generator wrapper thickness for use in Chem-Nuclear's shielding calculations.

Attached are Figure 1-1 "Outline" and Figure 1-2 "General Arrangement" and the cover page from the Vertical Steam Generators Instructions. These figures show the dimensions that compare with the CNS Sketch. Also attached is a letter from Westinghouse that confirmed the wrapper thickness.

The issue related to the center of gravity has been reviewed by both Westinghouse and AEP. The center of gravity is 16.5 feet above the support pad faces. This is a calculated value for the Westinghouse drawing and does not include any water, sludge, closures, or other material.

If you have any questions, please contact me.

Sincerely

Walter T. MacRae

Attachments

Copy

Vertical Steam Generators Instructions for

American Electric Power Service Corporation Donald C. Cook Nuclear Power Plant Unit No. 2 Bridgman, Michigan

Westinghouse General Order NY-87318-AR6-AR5

June, 1971

Technical Manual 1440-C226

SPIN	SO
AMP RC PC SG1	1341
AMP RC PC SG2	1342
AMP RC PC SG3	1343
AMP RC PC SG4	1344

APPROVED

IN GENERAL

ENGINEERING DEPARTMENT
AMERICAN ELECTRIC POWER SERVICE CORP.

PER JRJ DATE JAN 17, 1975

Westinghouse Electric Corporation
Tampa Division, P.O. Box 19218, Tampa, Florida 33616

Westinghouse Electric Company,
a division of CBS Corporation

Energy Systems

Nuclear Services Division

Box 355
Pittsburgh, Pennsylvania 15230-0355

AEP-98-121
NSD-CPM-98-126
August 4, 1998

Mr. John Jensen
American Electric Power
Replacement Steam Generator Project Office
One Cook Place
Bridgman, MI 49106

Reference: AEP RSG Data B/O Checklist (Item #18)

American Electric Power Service Corporation
D.C. Cook Units 1 and 2
<u>S/G Non-LOCA Data</u>

Dear John,

Attached is the D. C. Cook, Unit 1, steam generator Non-LOCA geometric data requested by D. C. Cook. This information was originally faxed to Phil Monk (AEP) on Friday, July 31, 1998, in rough format. This data reflects input used in current non-LOCA licensing basis analyses for Unit 1. This data is for the current Unit 1, Model 51 steam generator design.

Similar data used in LOCA licensing basis analyses is being gathered and will be forwarded when it becomes available.

Should you have any questions, please contact Mr. Bill Hicks on 412-374-4734 or me on 412-374-4481.

Sincerely,

Nancy S. Kury

Nancy S. Kury
Customer Projects Manager

Attached table was generated by Westinghouse in support of the Unit 1 SGRP. Geometric data is presented for Cook Unit 1, however, as the Unit 1 and original Unit 2 SGs were both identical (W) model 51 SGs, the data is equally applicable to the original Unit 2 SGs.

Attachment: Donald C. Cook, Unit 1, Steam Generator Non-LOCA Geometric Data

cc: Vance VanderBurg - AEP
T.B. Higgins - AEP
P.W. Monk - AEP

Z Bowm 8/27/98

D.C. COOK UNIT 1 STEAM GENERATOR NON-LOCA GEOMETRIC DATA

40.	Elevation of Feedwater Distribution Ring from Top of Tube Plate	463.00 in
41.	Elevation of Steam Nozzle from Top of Tube Plate	721.00 in
42.	Primary Side Tube Inlet Loss Coefficient	0.78
43.	Swirl Vane Loss Coefficient	10.0
44.	Feedring Assembly Loss Coefficient	9.42
45.	Steam Nozzle Loss Coefficient	0.230
46.	Downcomer Loss Coefficient	0.0
47.	Secondary Separator Loss Coefficient	125.0
48.	Downcomer Barrel I.D.	65.21 in
49.	Downcomer Barrel Length	60.00 in
50.	Downcomer Barrel Thickness	0.313 in
51.	Steam Outlet Nozzle Flow Area	4.587 sq-ft
52.	Metal Volume in Various Regions.(Regions Defined by Westinghouse)	(Table D-2)
53.	Fluid Quality in 1ST Stage Separator Region	0.50
54.	Fluid Quality in 2ND Stage Separator Region	0.70
55.	Thickness of Wrapper	0.375 in
56.	Thickness of Lower Deck Plate	0.375 in
57.	Thickness of Mid-Deck Plate	0.375 in
58.	Thickness of Upper Deck Plate	0.750 in
59.	Thickness of Riser Wall	0.250 in
60.	Wall Thickness of Central Drain Pipe	0.250 in
61.	Wall Thickness of Other Drain Pipes	0.258 in
62.	Thickness of a Typical Tube Support Plate	0.750 in
63.	Elevation of Each Tube Support Plate from Top of Tube Plate	(Table D-3)
64.	Flow Area Through Each Tube Support (All)	23.77 sq-ft
65.	Downcomer Obstruction Area at Each Tube Support (All)	0.20 sq-ft
66.	Tube Material	Inconel
67.	Tube O.D.	0.8750 in
68.	Tube Wall Thickness	0.0525 in
69.	Tube Pitch	1.281 in
70.	Number of Tubes	3388
71.	Overall Heat Transfer Surface Area (Based on Tube O.D.)	51,500 sq-ft
72.	Distance between top of tube bundle at which the steam pressure is assumed to be calculated from thermal balance. Pressure loss from this point to the steam nozzle is subtracted from the calculated bundle pressure to yield steam outlet pressure.	0.50 in
73.	Modified Jens and Lottes Boiling Coefficient	0.870

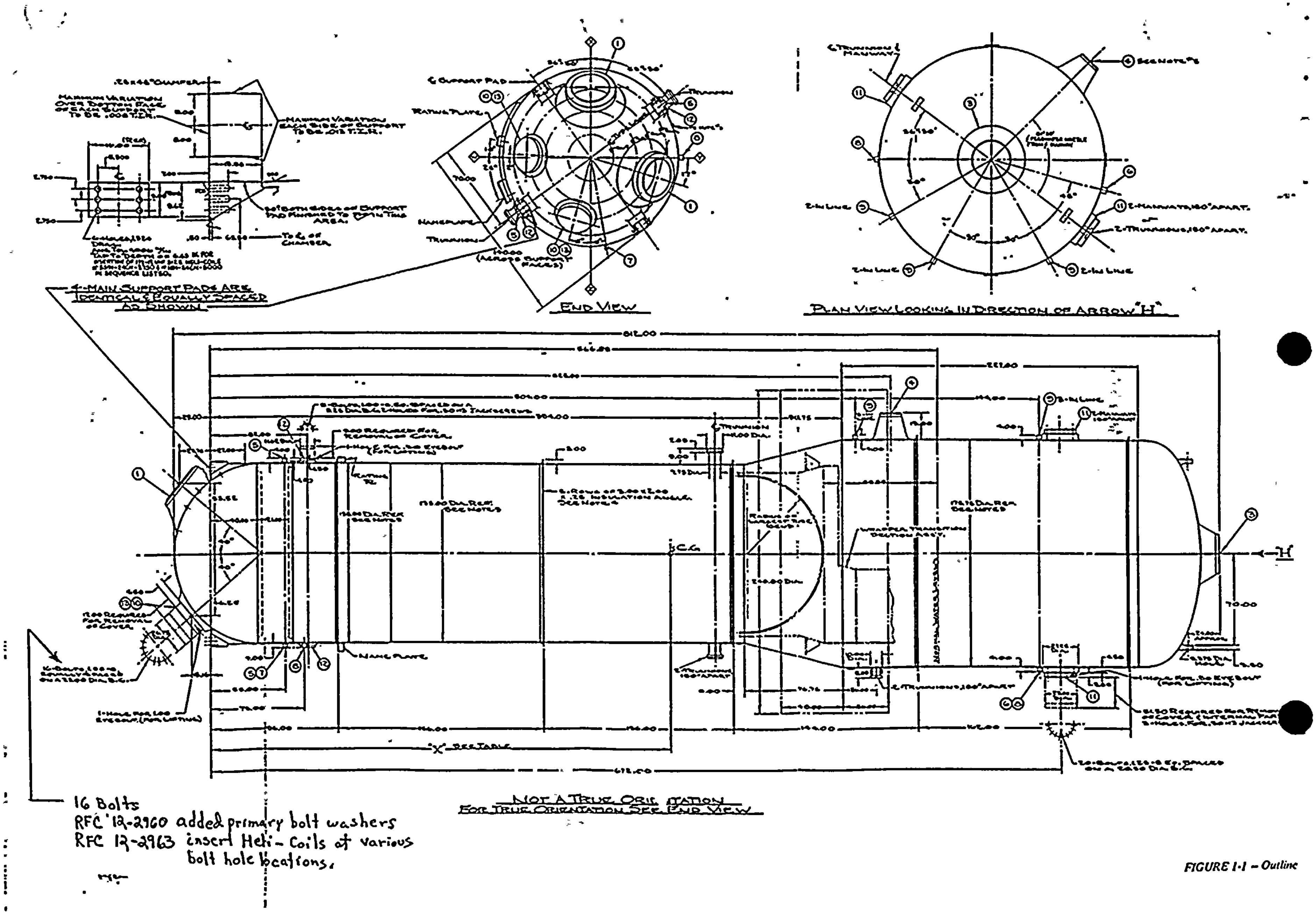


FIGURE 1-1 – Outline

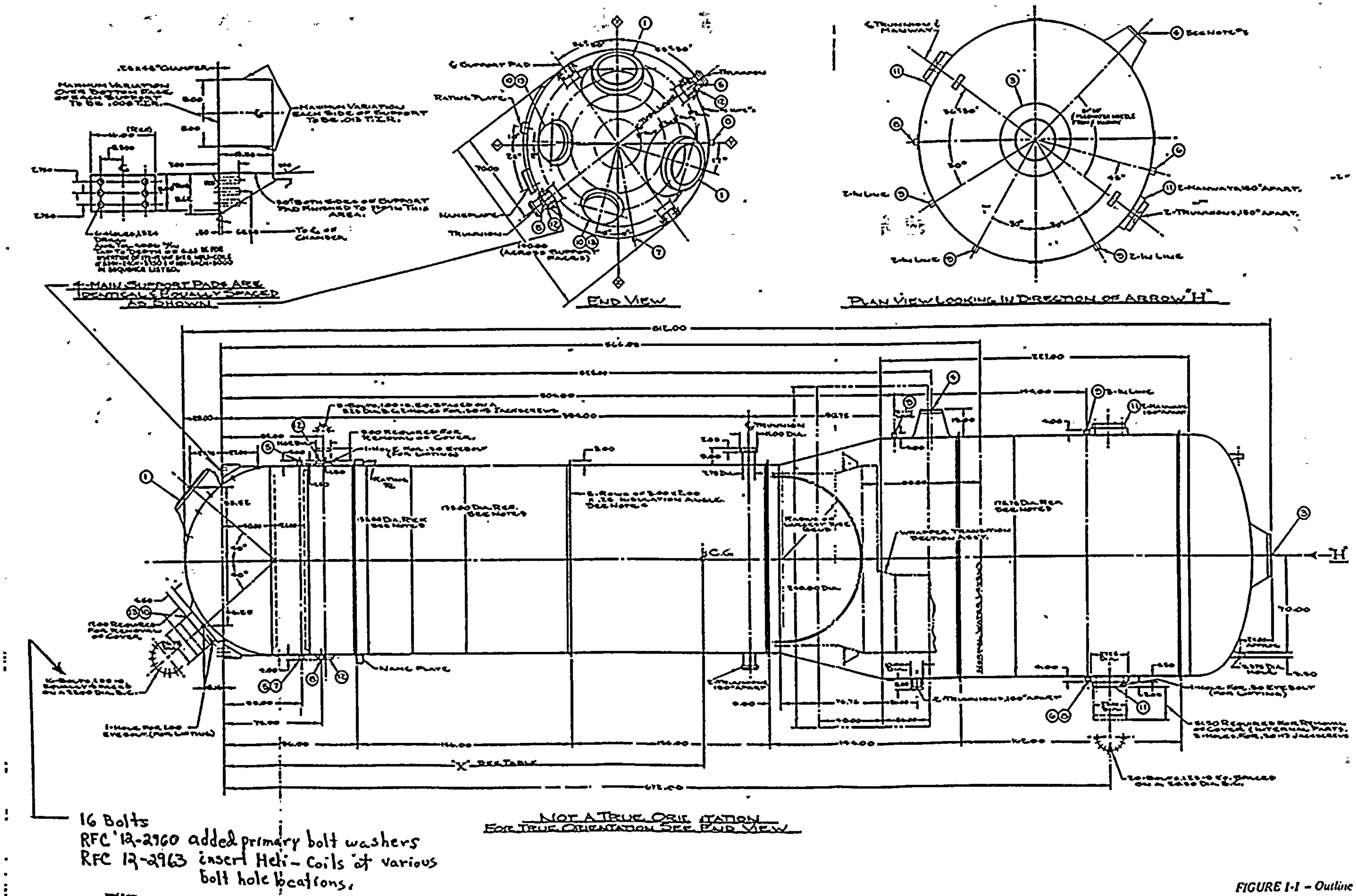


FIGURE I-1 – Outline

FSD-RSA-86/3103

Table 1

D. C. Cook Unit
Estimated Steam Generator C Content

Isotope	Percent of Total	Curies/SG
Co-60	37	210
Co-58	27	153
Cr-51	21	119
Nb-95	7.0	40
Zr-95	2.4	14
Mn-54	1.4	8
Fe-59	1.2	7
Others*	3.0	17 → 2.43
	100	568

*Other isotopes include Co-57, Zn-65, Ru-103,)6, Sn-113. Sb-125, and Ce-144 :

Table 2

D. C. Cook Unit 2
Estimated Steam Generator Lo sembly
Curie Content for Various Times Shutdown

Time After Shutdown	Acti Per Lower Assembly ries)
0	568
1 month	437
1 year	198
5 years	110
10 years	56

TABLE D.2

RECOMMENDED SCALING FACTORS FOR D.C. COOK

WASTE TYPE: DRY ACTIVE WASTE
SUB-TYPE: NO SUB-TYPE

DATE: OCTOBER 16, 1987

SCALED/SCALING NUCLIDES		SCALING FACTOR	SELECTION METHOD * (NUMBER OF APPLIED RULE)	
14-C /60-Co	:	9.55E-03	3 Log-mean	:
55-Fe/ 60-Co	:	1.89E+00	1	:
63-Ni/ 60-Co	:	4.19E-01	3 Log-mean	:
90-Sr/137-Cs	:	1.23E-02	3 Sample 11642	:
99-Tc/137-Cs	:	3.44E-03	8 Reference 7, Table 3-7	:
129-I /137-Cs	:	8.00E-05	8 Reference 7, Table 3-7	:
238-Pu/239-Pu	:	1.26E+00	5 Log-mean	:
241-Pu/239-Pu	:	1.02E+02	5 Log-mean	:
241-Am/239-Pu	:	5.74E-01	5 Log-mean	:
242-Cm/239-Pu	:	5.13E-01	5 Log-mean	:
244-Cm/239-Pu	:	5.78E-01	5 Log-mean	:
239-Pu/144-Ce	:	9.98E-03	8 Reference 7, Table 3-19	:
239-Pu/ 60-Co	:	3.30E-04	3 Log-mean	:

* Refers to the selection rule given in the SAIC "Scaling Factor Selection Method", Revision 4.

RADIOLOGICAL AREA STATUS SHEET

AREA DESCRIPTION S/G Mausoleum - Generator Detail

MAP NO. —

AREA CLASSIFICATION
- ■ RADIATION
- □ HIGH RADIATION
- □ EXTREME HIGH RADIATION
- ■ CONTAMINATION
- □ AIRBORNE RADIOACTIVITY

REMARKS
Doserate Survey Only
J. Grateke / S. Olszewski

METER TYPE/NO.
RSO #350

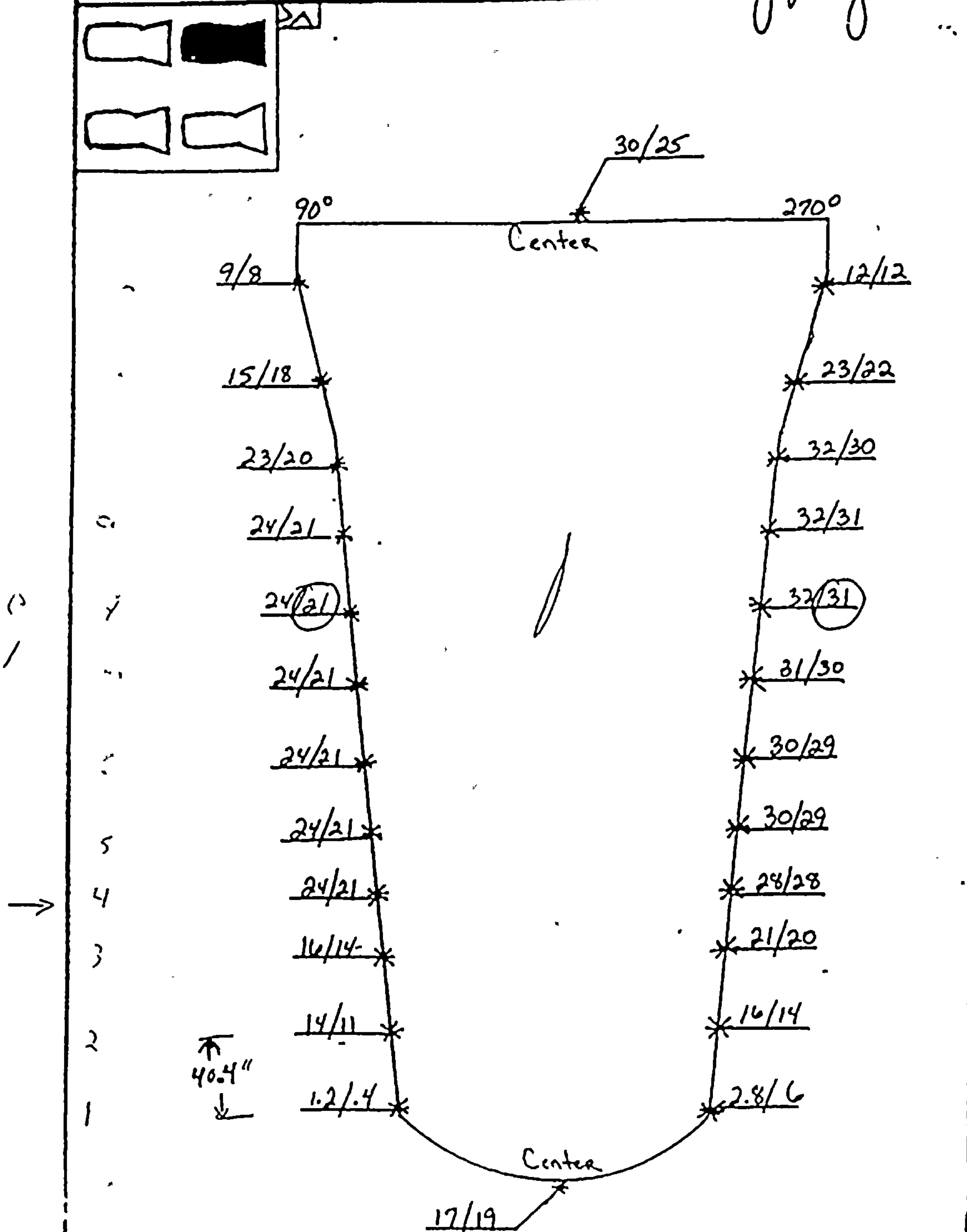
UNLESS NOTED: ✱ DENOTES CONTACT /30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100CM²

REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

SURVEYED BY [signature] TIME 1050 DATE 7-6-98

REVIEWED BY [signature] DATE 7-7-98



CONTAMINATION/ REMARKS — N/A

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RADIOLOGICAL AREA STATUS SHEET

AREA DESCRIPTION S/G Mausoleum - Generator Detail

MAP NO. —

AREA CLASSIFICATION
- ■ RADIATION
- ☐ HIGH RADIATION
- ☐ EXTREME HIGH RADIATION
- ■ CONTAMINATION
- ☐ AIRBORNE RADIOACTIVITY

REMARKS
Doserate Survey Only
J. Grantele/S. Olszewski

METER TYPE/NO.
RSO #350

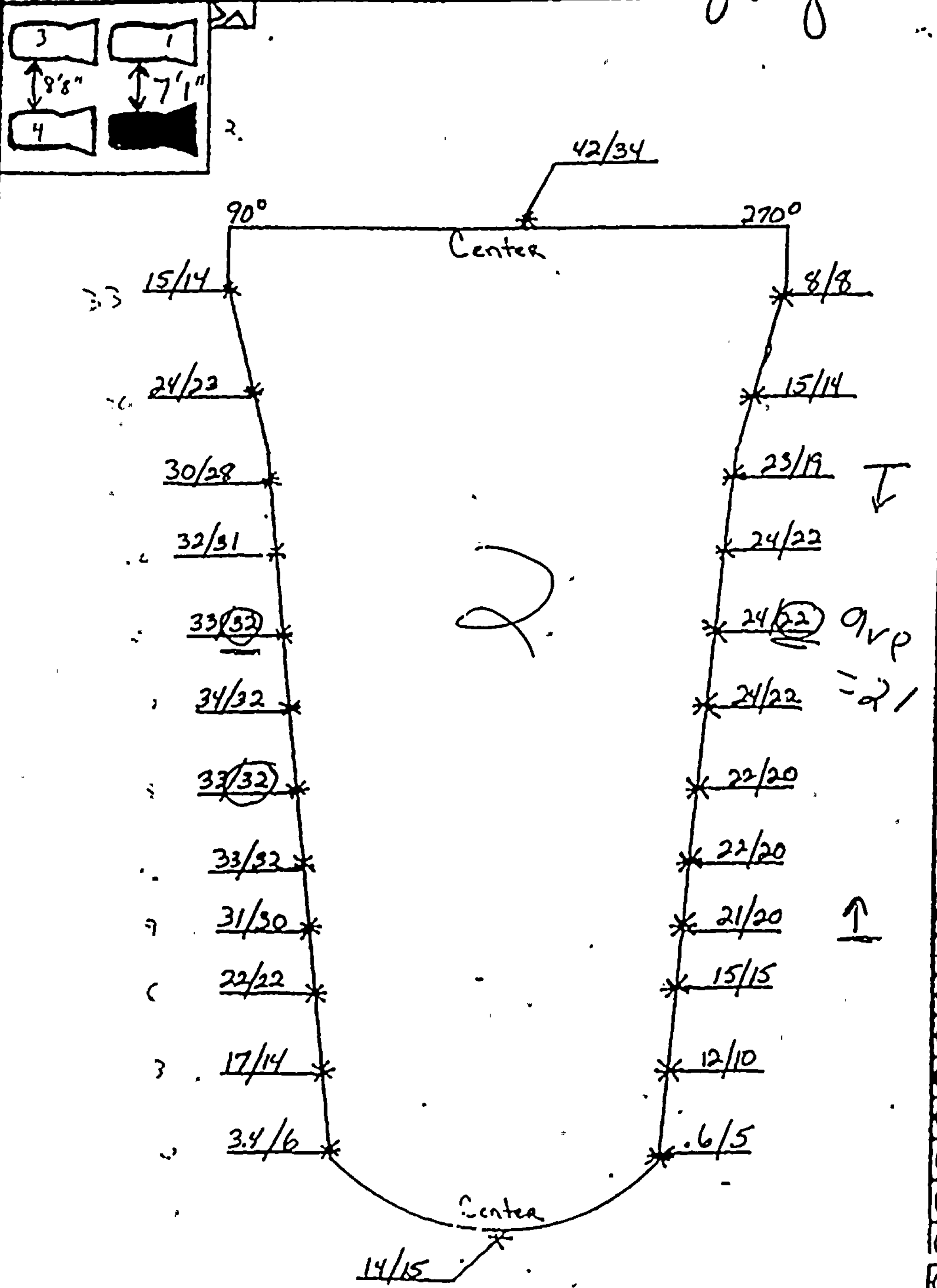
REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

UNLESS NOTED: ✱ DENOTES CONTACT /30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100CM²

SURVEYED BY [signature] **TIME** 1030 **DATE** 7-6-98

REVIEWED BY [signature] **DATE** 7-7-98



CONTAMINATION/ REMARKS (N/A)

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RADIOLOGICAL AREA STATUS SHEET

AREA DESCRIPTION S/G Mausoleum - Generator Detail

MAP NO. —

AREA CLASSIFICATION
- ■ RADIATION
- ☐ HIGH RADIATION
- ☐ EXTREME HIGH RADIATION
- ■ CONTAMINATION
- ☐ AIRBORNE RADIOACTIVITY

REMARKS
Doserate Survey Only
J. Gratzle / S. Olszewski

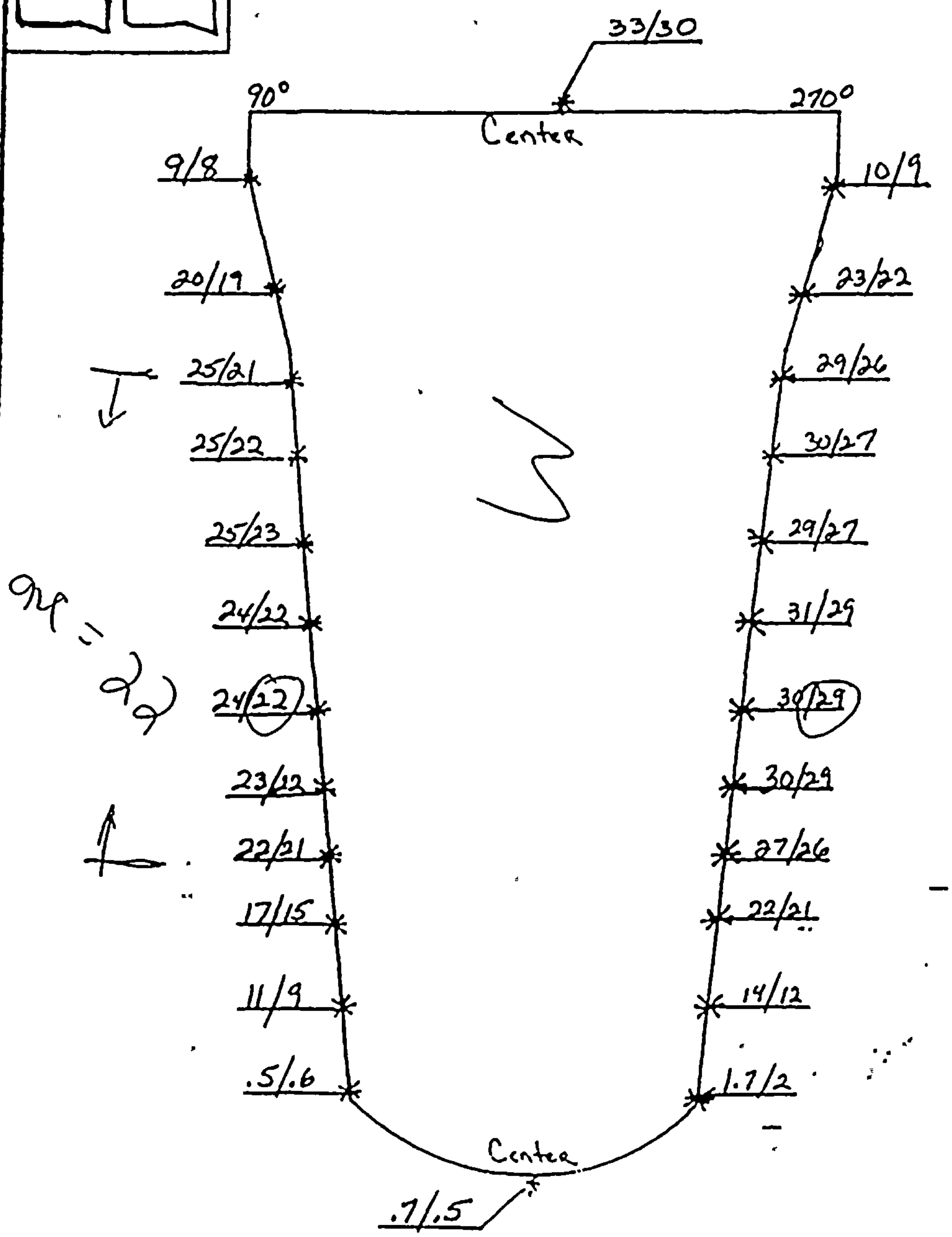
METER TYPE/NO. RSO #350

UNLESS NOTED: * DENOTES CONTACT / 30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM / 100 CM²

REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

SURVEYED BY [signature]	TIME 1030	DATE 7-6-98
REVIEWED BY [signature]		DATE 7-7-98



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RADIOLOGICAL AREA STATUS SHEET

AREA DESCRIPTION S/G Mausoleum - Generator Detail

MAP NO. —

AREA CLASSIFICATION
- ■ RADIATION
- □ HIGH RADIATION
- □ EXTREME HIGH RADIATION
- ■ CONTAMINATION
- □ AIRBORNE RADIOACTIVITY

REMARKS
Doserate Survey Only
J. Gontzle/S. Olszewski

METER TYPE/NO.
RSO #350

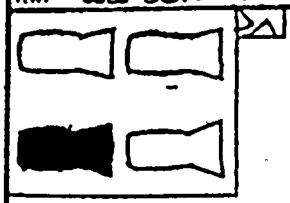
UNLESS NOTED: * DENOTES CONTACT/30 CM.
DOSE RATES IN MR/HR, AT WAIST LEVEL & CONTAMINATION IN DPM/100CM²

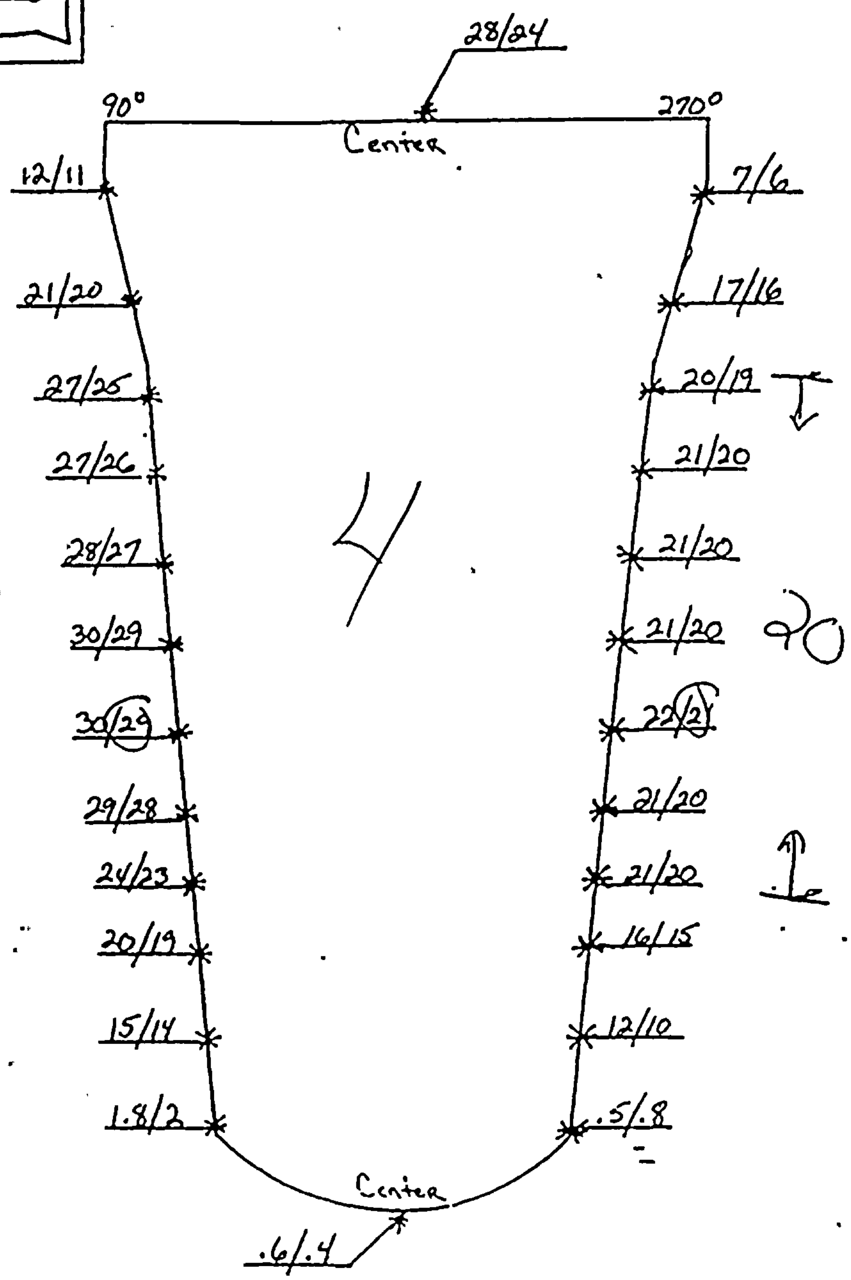
REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

SURVEYED BY [signature] **TIME** 1030 **DATE** 7-6-98

REVIEWED BY [signature] **DATE** 7-7-98





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N/A

APPENDIX B

SHIPPING PAPERS AND DISPOSAL MANIFESTS

(0 PAGES)

[TO BE INCLUDED IN FINAL WASTE CHARACTERIZATION REPORT]

APPENDIX C

MICROSHIELD MODELS AND OUTPUT

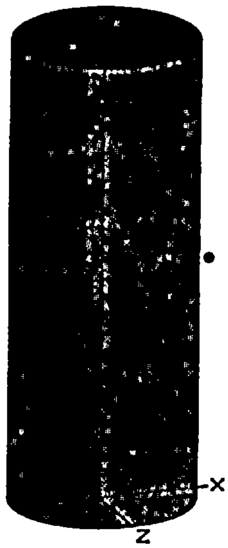
(2 PAGES)

MicroShield v5.01 (5.01-01072)
Chem-Nuclear Systems, Inc.

Page : 1
DOS File : DCCOOKCH.MS5
Run Date: August 28, 1998
Run Time: 8:18:26 AM
Duration : 00:00:11

File Ref: ________
Date: ________
By: ________
Checked: ________

Case Title: DC Cook
Description: DC Cook, characterization model @30cm, normalized source
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	906.145 cm	29 ft 8.7 in
Radius	151.994 cm	4 ft 11.8 in

Dose Points

	X	Y	Z
# 1	201.45 cm	453.07 cm	0 cm
	6 ft 7.3 in	14 ft 10.4 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	6.58e+07 cm³	Alloy 600	0.646
Shield 1	5.664 cm	Air	0.00122
Shield 2	.965 cm	A 533	7.86
Shield 3	5.664 cm	Air	0.00122
Shield 4	7.163 cm	A 533	7.86
Transition		Air	0.00122
Air Gap		Air	0.00122

Source Input
Grouping Method : Linear Energy
Number of Groups : 15
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Am-241	7.3300e-004	2.7121e+007	1.1146e-005	4.1239e-001
C-14	1.1400e-002	4.2180e+008	1.7334e-004	6.4137e+000
Cm-244	1.5600e-004	5.7720e+006	2.3721e-006	8.7766e-002
Co-60	3.2100e-001	1.1877e+010	4.8810e-003	1.8060e+002
Fe-55	1.7300e-001	6.4010e+009	2.6306e-003	9.7331e+001
Mn-54	1.3900e-005	5.1430e+005	2.1136e-007	7.8202e-003
Ni-63	4.6700e-001	1.7279e+010	7.1010e-003	2.6274e+002
Pu-238	4.6000e-004	1.7020e+007	6.9945e-006	2.5880e-001
Pu-239	3.9400e-004	1.4578e+007	5.9910e-006	2.2167e-001
Pu-241	2.4800e-002	9.1760e+008	3.7710e-004	1.3953e+001
Rh-106	1.4300e-005	5.2910e+005	2.1744e-007	8.0453e-003
Ru-106	1.4300e-005	5.2910e+005	2.1744e-007	8.0453e-003
Sb-125	1.1300e-003	4.1810e+007	1.7182e-005	6.3574e-001
Te-125m	2.7700e-004	1.0249e+007	4.2119e-006	1.5584e-001

Buildup
The material reference is : Shield 4

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	20

Page : 2
DOS File : DCCOOKCH.MS5
Run Date: August 28, 1998
Run Time: 8:18:26 AM
Duration : 00:00:11

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.0356	4.331e+07	8.790e-151	1.786e-26	5.323e-153	1.082e-28
0.1755	3.368e+06	1.583e-07	1.245e-06	2.710e-10	2.133e-09
0.2279	5.494e+04	3.304e-08	3.437e-07	5.993e-11	6.234e-10
0.371	8.758e+05	9.615e-06	1.183e-04	1.864e-08	2.293e-07
0.4377	1.683e+07	3.965e-04	4.793e-03	7.761e-07	9.381e-06
0.602	9.586e+06	8.625e-04	9.121e-03	1.683e-06	1.780e-05
0.6546	7.429e+06	9.334e-04	9.403e-03	1.811e-06	1.824e-05
0.835	5.164e+05	1.666e-04	1.426e-03	3.152e-07	2.698e-06
1.0649	1.125e+04	9.002e-06	6.412e-05	1.641e-08	1.169e-07
1.1732	1.188e+10	1.351e+01	8.932e+01	2.415e-02	1.596e-01
1.3325	1.188e+10	2.118e+01	1.271e+02	3.675e-02	2.206e-01
1.357	3.067e+03	5.824e-06	3.450e-05	1.006e-08	5.958e-08
1.5622	8.284e+02	2.519e-06	1.351e-05	4.192e-09	2.248e-08
TOTALS:	2.384e+10	3.470e+01	2.165e+02	6.090e-02	3.802e-01

APPENDIX D

SURFACE AREA CALCULATIONS

(2 PAGES)

D.C. Cook SGLA Tube and Channel Head Calculations - 8/28/98

Channel Head Parameters

$n_{tubes} := 3388$ $\rho_{tube} := 8.25 \cdot \frac{gm}{cm^3}$

$n_{tube\_openings} := 2 \cdot n_{tubes}$

Channel Head & Tube Dimensions

$r_{head} := 62.81 \cdot in$ $r_{u\_max} := 59.84 \cdot in$

$r_{u\_min} := 2.19 \cdot in$

$r_{tube} := \left(\frac{0.875}{2} - 0.05\right) \cdot in$ $L_{tube\_sheet} := 21. \cdot in$

$L_{straight\_tube} := 356.75 \cdot in$

$r_{tube\_od} := \frac{.875}{2} \cdot in$

Channel Head Area Equations

$A_{tube\_sheet} := \pi \cdot r_{head}^2 - n_{tube\_openings} \cdot \pi \cdot r_{tube}^2$

$A_{head} := \frac{1}{2} \cdot 4 \cdot \pi \cdot r_{head}^2$

$A_{div\_plate} := \left(\frac{1}{2} \cdot \pi \cdot r_{head}^2\right) \cdot 2$

$A_{tubesheet\_tubes} := n_{tube\_openings} \cdot 2 \cdot \pi \cdot r_{tube} \cdot L_{tube\_sheet}$

Straight Tube Area Calculations

$A_{straight\_tubes} := n_{tube\_openings} \cdot 2 \cdot \pi \cdot r_{tube} \cdot L_{straight\_tube}$

$A_{straight\_tubes} = 5.886 \cdot 10^6 \cdot in^2$ $A_{straight\_tubes} = 3.797 \cdot 10^7 \cdot cm^2$

U-Bend Tube Area Calculation

$r_{ave} := \frac{r_{u\_max} + r_{u\_min}}{2}$

$L_{ave} := \pi \cdot r_{ave}$

$L_{ave} = 97.436 \cdot in$

$A_{u\_bend} := L_{ave} \cdot 2 \cdot \pi \cdot r_{tube} \cdot n_{tubes}$

$A_{u\_bend} = 8.037 \cdot 10^5 \cdot in^2$ $A_{u\_bend} = 5.185 \cdot 10^6 \cdot cm^2$

Area Totals

$A_{tube\_sheet} = 9.197 \cdot 10^3 \cdot in^2$ $A_{tube\_sheet} = 5.934 \cdot 10^4 \cdot cm^2$

$A_{head} = 2.479 \cdot 10^4 \cdot in^2$ $A_{head} = 1.599 \cdot 10^5 \cdot cm^2$

$A_{div\_plate} = 1.239 \cdot 10^4 \cdot in^2$ $A_{div\_plate} = 7.996 \cdot 10^4 \cdot cm^2$

$A_{tubesheet\_tubes} = 3.465 \cdot 10^5 \cdot in^2$ $A_{tubesheet\_tubes} = 2.235 \cdot 10^6 \cdot cm^2$

$A_{channel\_head} := A_{tube\_sheet} + A_{head} + A_{div\_plate}$

$A_{channel\_head} = 4.638 \cdot 10^4 \cdot in^2$ $A_{channel\_head} = 2.992 \cdot 10^5 \cdot cm^2$

$A_{tubes} := A_{straight\_tubes} + A_{u\_bend} + A_{tubesheet\_tubes}$

$A_{tubes} = 7.036 \cdot 10^6 \cdot in^2$ $A_{tubes} = 4.539 \cdot 10^7 \cdot cm^2$

Straight Tube Bundle Density Calculation

$tube := \left(r_{tube\_od}^2 - r_{tube}^2\right) \cdot \pi$

$V_{tube\_metal} := tube \cdot L_{straight\_tube} \cdot n_{tube\_openings}$ $V_{tube\_metal} = 5.133 \cdot 10^6 \cdot cm^3$

$M_{tube} := V_{tube\_metal} \cdot \rho_{tube}$

$M_{tube} = 4.235 \cdot 10^7 \cdot gm$

$V_{bundle} := 6.56 \cdot 10^7 \cdot cm^3$

$\rho_{bundle} := \frac{M_{tube}}{V_{bundle}}$

$\rho_{bundle} = 0.646 \cdot gm \cdot cm^{-3}$

AMERICAN ELECTRIC POWER
DONALD C. COOK NUCLEAR PLANT

STEAM GENERATOR DISPOSAL EXEMPTION REQUEST

ATTACHMENT 7

EVALUATION OF RESIDUAL WATER

Evaluation of Residual Water

An evaluation was performed by AEP to determine the volume of residual water remaining in the steam generators. This attachment summarizes the results of that evaluation. The water remaining in the generators would be from the secondary, non-radioactive side of the system. No radioactivity was contributed from the liquid and a specific low specific activity (LSA) evaluation was not done. Any radioactivity in the liquid is a result of cross-contamination with internally deposited surface contamination.

In 1988, when the generators were taken out of service, they were allowed to drain by gravity. All the material was expected to drain except that material that could be trapped by a plugged tube. The water in the tubes could only enter a plugged tube from the secondary side of the generator. Based on past experience, none of the steam generator tube plugs have leaked. The steam generators were periodically tested throughout their in-service life for cracking and potential leaking tubes. The method used to test the tubes is the standard industry practice termed eddy current testing. Tube plugs were also subject to visual observation. From the historical testing data, tubes with a potential for a through wall crack were selected as possibly containing water, and the volume of the tube was determined.

Tubes potentially susceptible to containing entrapped water were conservatively assumed to include tubes with abnormal indications located at the top of the tubesheet, tubes with support plate or anti-vibration bar wear/thinning indications exceeding 75% throughwall, and three tubes for which test data was not readily available. Tubes in a tube pull location were assumed to be only half filled because the tube remains open on one end, allowing a portion of the water to drain out.

The following table summarizes the results:

Steam Generator Identification	Volume of Entrapped Water (gallons)
Steam Generator 21	58.62
Steam Generator 22	147.06
Steam Generator 23	213.63
Steam Generator 24	143.81
TOTAL	563.12

AMERICAN ELECTRIC POWER
DONALD C. COOK NUCLEAR PLANT

STEAM GENERATOR DISPOSAL EXEMPTION REQUEST

ATTACHMENT 8

EVALUATION OF DOSE RATE