CHEM-NUCLEAR SYSTEMS

	PRINTED OR TYPED NAME	SIGNATURE	DATE
PREPARED BY:	Mark Whittaker	M S Whittaker	12/15/98
INDEPENDENT REVIEWER:	Anthony Savino	Anthony Savino	12/15/98

DOCUMENT TITLE:

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

DOCUMENT NO.	REV.	PAGE
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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 recently obtained 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

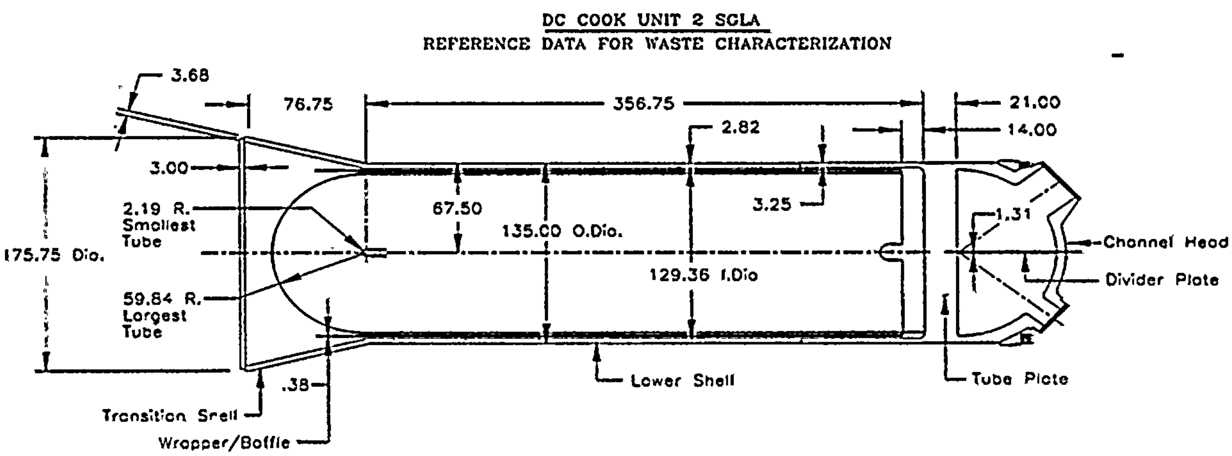
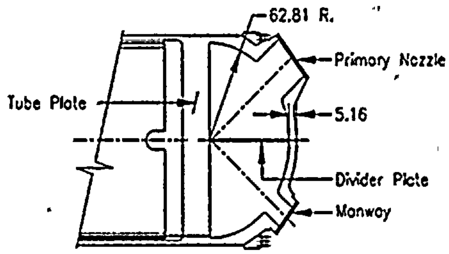


Figure 2-2 Steam Generator Channel Head Region Components



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

Two contamination samples (smears) were taken from the interior of one of the SGLAs on August 20, 1998. The samples were analyzed for radionuclide content. The analysis reports are included in Appendix A. The average radionuclide content was calculated and this result was used as the isotopic distribution of radioactivity within the

SGLAs. For two pair of radionuclides, Cm-243/244 and Pu-239/240, a single activity is reported. This reported grouped activity was distributed equally among the radionuclides to give a curie value for each radionuclide. The average activity was normalized to 1 curie to provide the source term used in determining the dose to curie conversion factor from the shielding model. The average sample activity and the normalized source term are provided in Table 3-1.

Table 3.1 - Radionuclide Distribution

Radionuclide	Average Measured Activity (Ci)	Normalized Source (Ci)
Am-241	2.85E-05	1.57E-05
Cm-243	3.35E-06	1.85E-06
Cm-244	3.35E-06	1.85E-06
Co-60	1.69E+00	9.29E-01
Fe-55	7.50E-02	4.14E-02
Ni-63	5.30E-02	2.92E-02
Pu-238	1.80E-05	9.93E-06
Pu-239	7.00E-06	3.86E-06
Pu-240	7.00E-06	3.86E-06
Pu-241	3.30E-04	1.82E-04

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

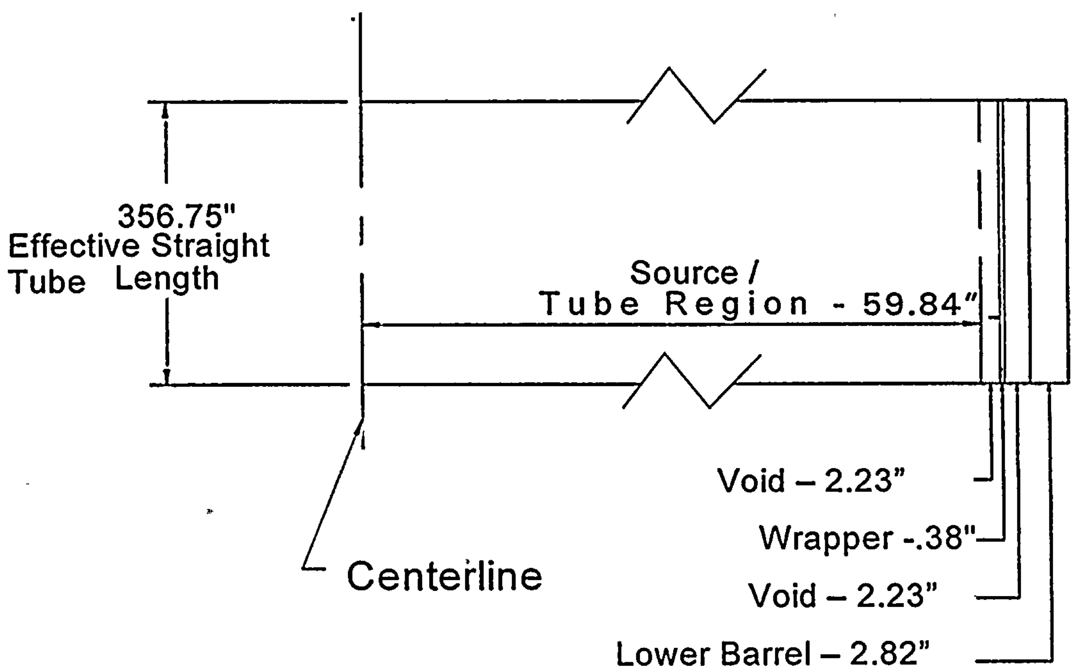
tube sections. This factor of two is addressed specifically in the reference [2] study for the various tube sections. It is reasonable to apply this assumption to the channel head sections as well, as they are of a similar geometry and represent only a minimal fraction of the total surface area, and 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 calculation produces an exposure rate 30 cm from the surface resulting from a 1 curie normalized source of 1.101 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 19.1, 19.1, 20.0, and 18.2 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)	19.1	19.1	20.0	18.2
Areal Activity ($\mu Ci/cm^2$)	0.50	0.50	0.53	0.48

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 0.50, 0.50, 0.53, and 0.48 $\mu Ci/cm^2$, 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 1.0, 1.0, 1.05, and 0.96 $\mu Ci/cm^2$, 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	19.1	19.1	20.0	18.2
Tubes in Tube Sheet	2.25E+06	2.26	2.26	2.37	2.15
U-Tube Section Surface Area	5.19E+06	5.21	5.21	5.46	4.96
Channel Head	1.60E+05	0.16	0.16	0.17	0.15
Tube Sheet	5.93E+04	0.06	0.06	0.06	0.06
Divider Plate	8.00E+04	0.08	0.08	0.08	0.08
Total		**26.8**	**26.8**	**28.1**	**25.6**

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 2.5, 2.5, 2.6, and 2.4, 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 0.0069g 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	0.000422	0.00541	0.07798
CM-243	4.96E-05	0.00811	0.006114
CM-244	4.96E-05	0.0108	0.004592
CO-60	24.94224	10.8	2.309466
FE-55	1.110189	1080	0.001028
NI-63	0.784533	811	0.000967
PU-238	0.000266	0.00541	0.049251
PU-239	0.000104	0.00541	0.019153
PU-240	0.000104	0.00541	0.019153
PU-241	0.004885	0.27	0.018092
TOTALS	**26.84284**		**2.505796**

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

Isotope	Curies	A2 Value	A2 Fraction
AM-241	0.000422	0.00541	0.07798
CM-243	4.96E-05	0.00811	0.006114
CM-244	4.96E-05	0.0108	0.004592
CO-60	24.94224	10.8	2.309466
FE-55	1.110189	1080	0.001028
NI-63	0.784533	811	0.000967
PU-238	0.000266	0.00541	0.049251
PU-239	0.000104	0.00541	0.019153
PU-240	0.000104	0.00541	0.019153
PU-241	0.004885	0.27	0.018092
TOTALS	**26.84284**		**2.505796**

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

Isotope	Curies	A2 Value	A2 Fraction
AM-241	0.000442	0.00541	0.081693
CM-243	5.19E-05	0.00811	0.006406
CM-244	5.19E-05	0.0108	0.00481
CO-60	26.12996	10.8	2.419441
FE-55	1.163055	1080	0.001077
NI-63	0.821892	811	0.001013
PU-238	0.000279	0.00541	0.051596
PU-239	0.000109	0.00541	0.020065
PU-240	0.000109	0.00541	0.020065
PU-241	0.005117	0.27	0.018953
TOTALS	**28.12107**		**2.62512**

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

Isotope	Curies	A2 Value	A2 Fraction
AM-241	0.000402	0.00541	0.074267
CM-243	4.72E-05	0.00811	0.005823
CM-244	4.72E-05	0.0108	0.004373
CO-60	23.75451	10.8	2.199492
FE-55	1.057322	1080	0.000979
NI-63	0.747174	811	0.000921
PU-238	0.000254	0.00541	0.046905
PU-239	9.87E-05	0.00541	0.018241
PU-240	9.87E-05	0.00541	0.018241
PU-241	0.004652	0.27	0.01723
TOTALS	**25.56461**		**2.386472**

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	0.00E+00	0.000E+00 Ci/m^3	0.8 Ci/m^3	0.00E+00
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	5.12E-03	4.042E-11 Ci/g	3.50E-07 Ci/g	1.15E-04
TRU >5 yr Half Life	1.04E-03	8.232E-12 Ci/g	1.00E-08 Ci/g	8.23E-04
Table 1 Total				**0.00094**

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	0.00E+00	0.000E+00	40	0.00E+00
NI 63	8.22E-01	7.86E-03	3.5	2.25E-03
SR 90	0.00E+00	0.000E+00	0.04	0.00E+00
Isotopes < 5yr Half Life	1.16E+00	1.11E-02	700	1.59E-05
Table 2 Total				**0.0026**

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

(14 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 Proprietary Class 2C

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
S/G Non-LOCA Data

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.

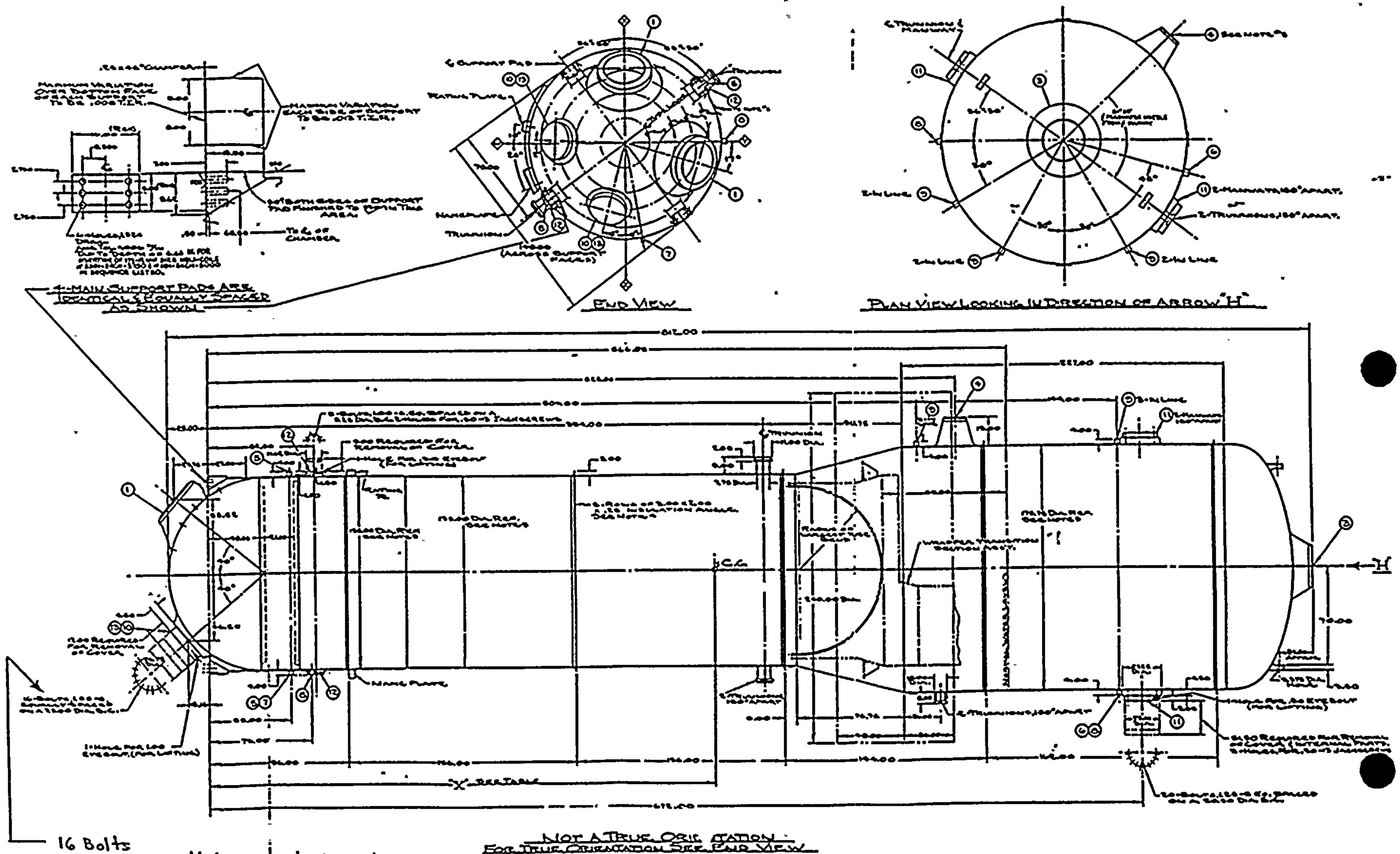
Z Pow...
8/27/98

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

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

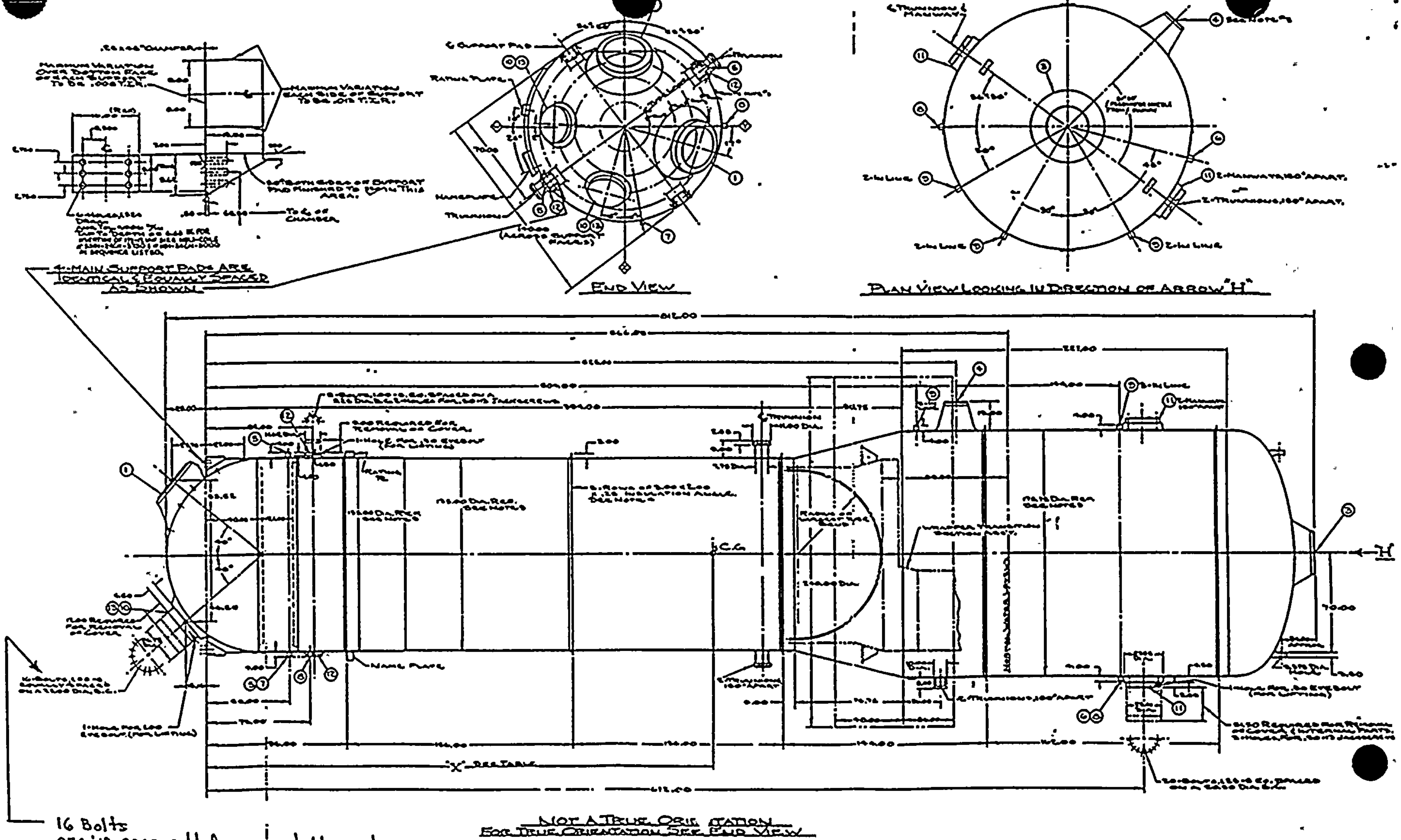
D.C. COOK UNIT 1 STEAM GENERATOR NON-LOCA GEOMETRIC DATA

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



16 Bolts
RFC 12-2960 added primary bolt washers
RFC 12-2963 insert Heli-Coils at various bolt hole locations.

FIGURE 1-1 – Outline



16 Bolts
RFC 12-2960 added primary bolt washers
RFC 12-2963 insert Heli-Coils at various bolt hole locations.

FIGURE 1-1 – Outline

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. Grntele / S. Olszewski

METER TYPE/NO. RSO #350

UNLESS NOTED: * DENOTES CONTACT / 30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100CM^2

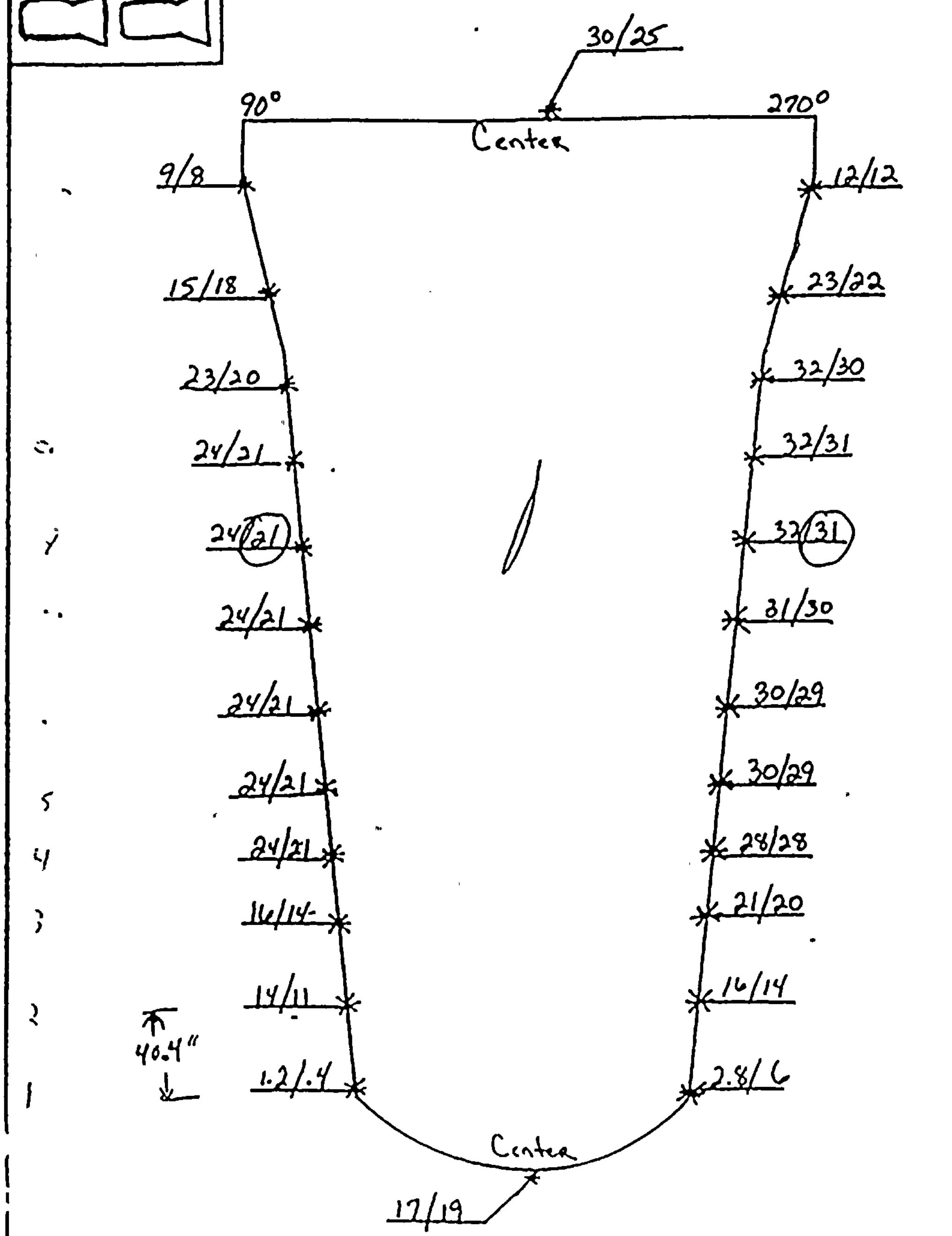
REASON FOR SURVEY

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

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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. Gratele/S. Dbuch

METER TYPE/NO.
RSO #350

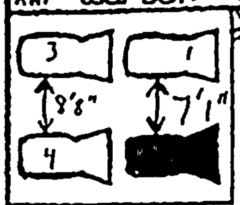
UNLESS NOTED: ✱ DENOTES CONTACT /30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100CM²

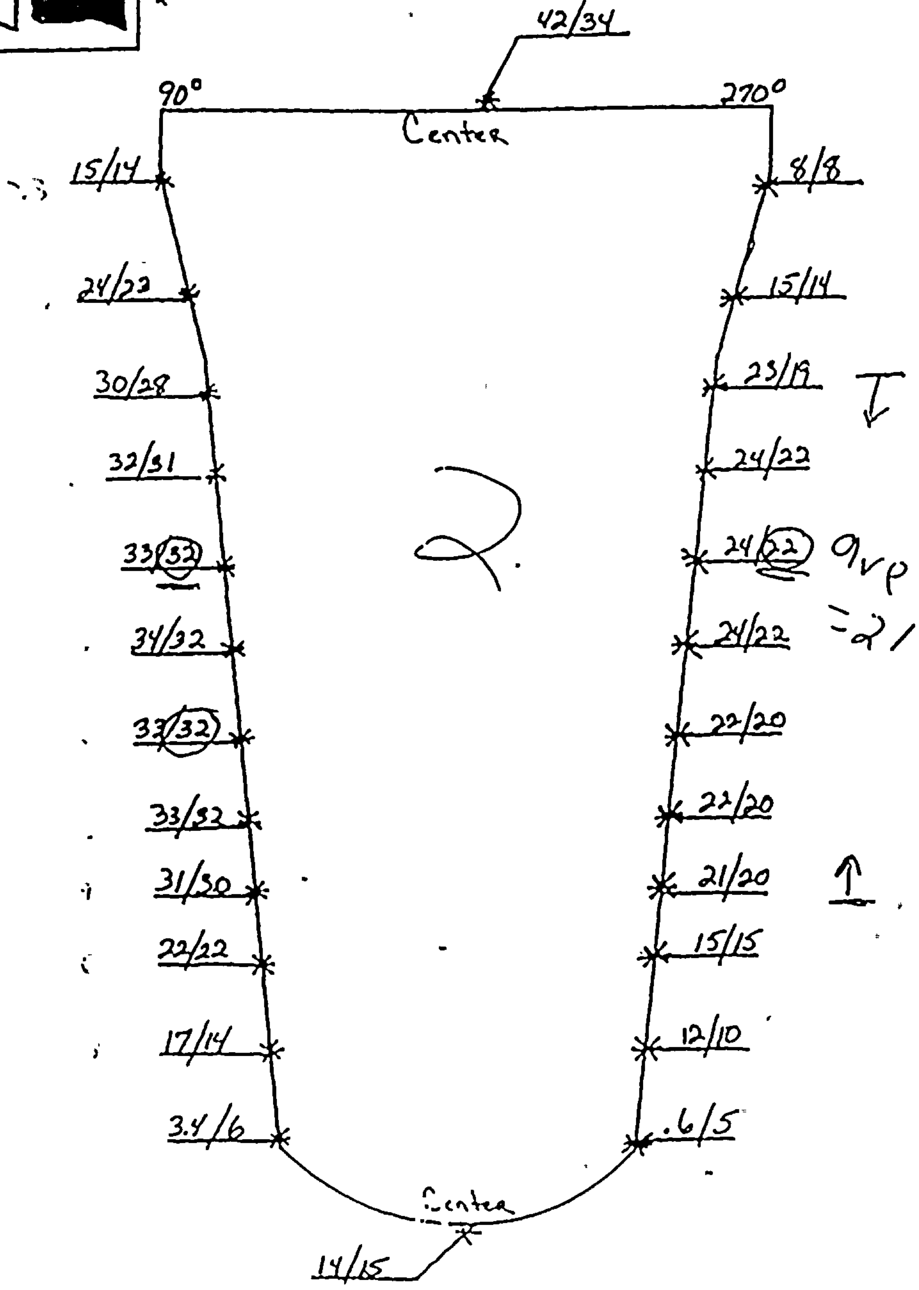
REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

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

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





CONTAMINATION/ REMARKS

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N/A

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. Grntzle / S. Olsuski

METER TYPE/NO. RSO #350

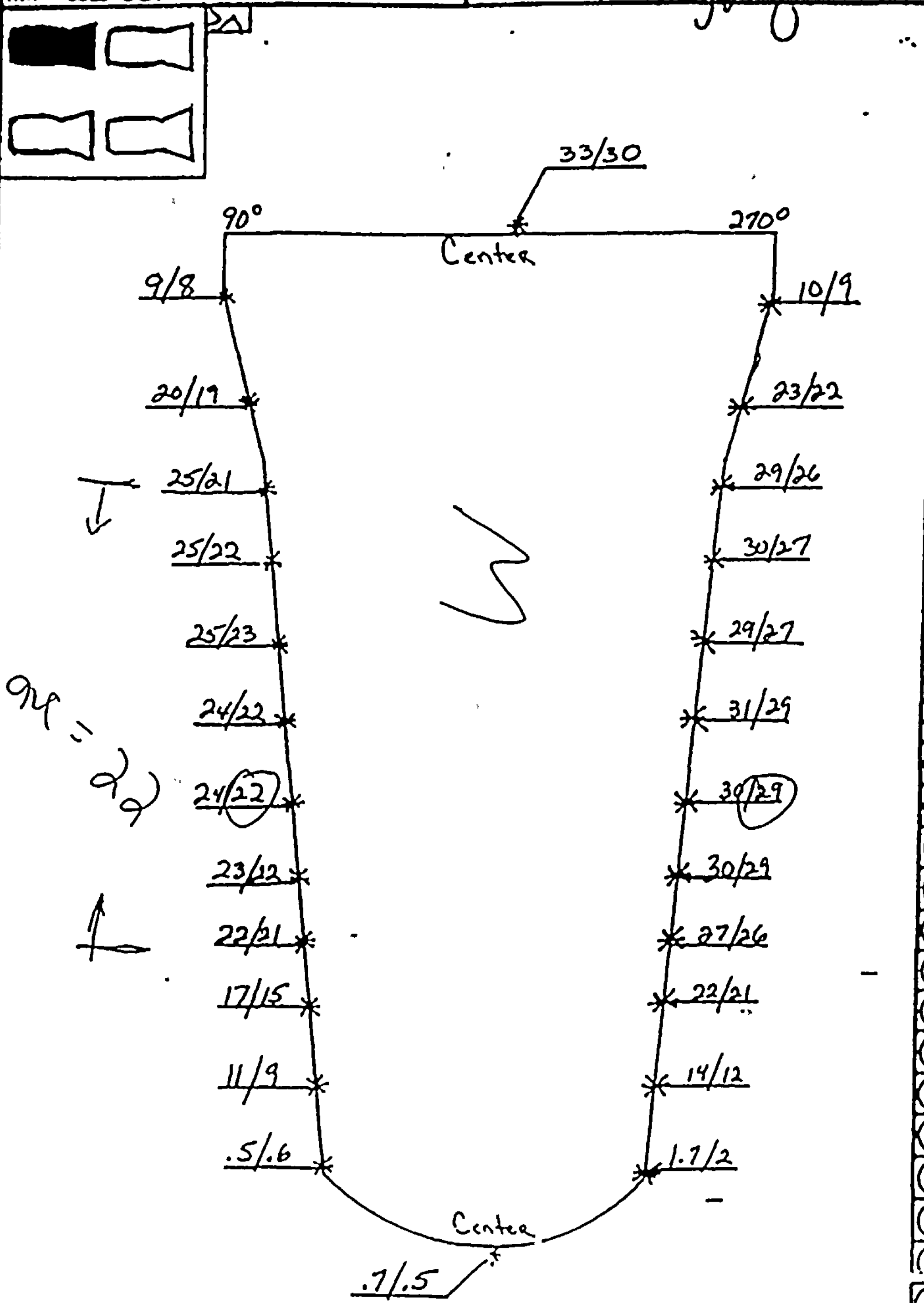
UNLESS NOTED: ✱ DENOTES CONTACT / 30 CM.
DOSE RATES IN MR/HR AT WAIST LEVEL & CONTAMINATION IN DPM/100 CM²

REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

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

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



CONTAMINATION/ REMARKS

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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. Gentele / S. Olszewski

METER TYPE/NO. RSO #350

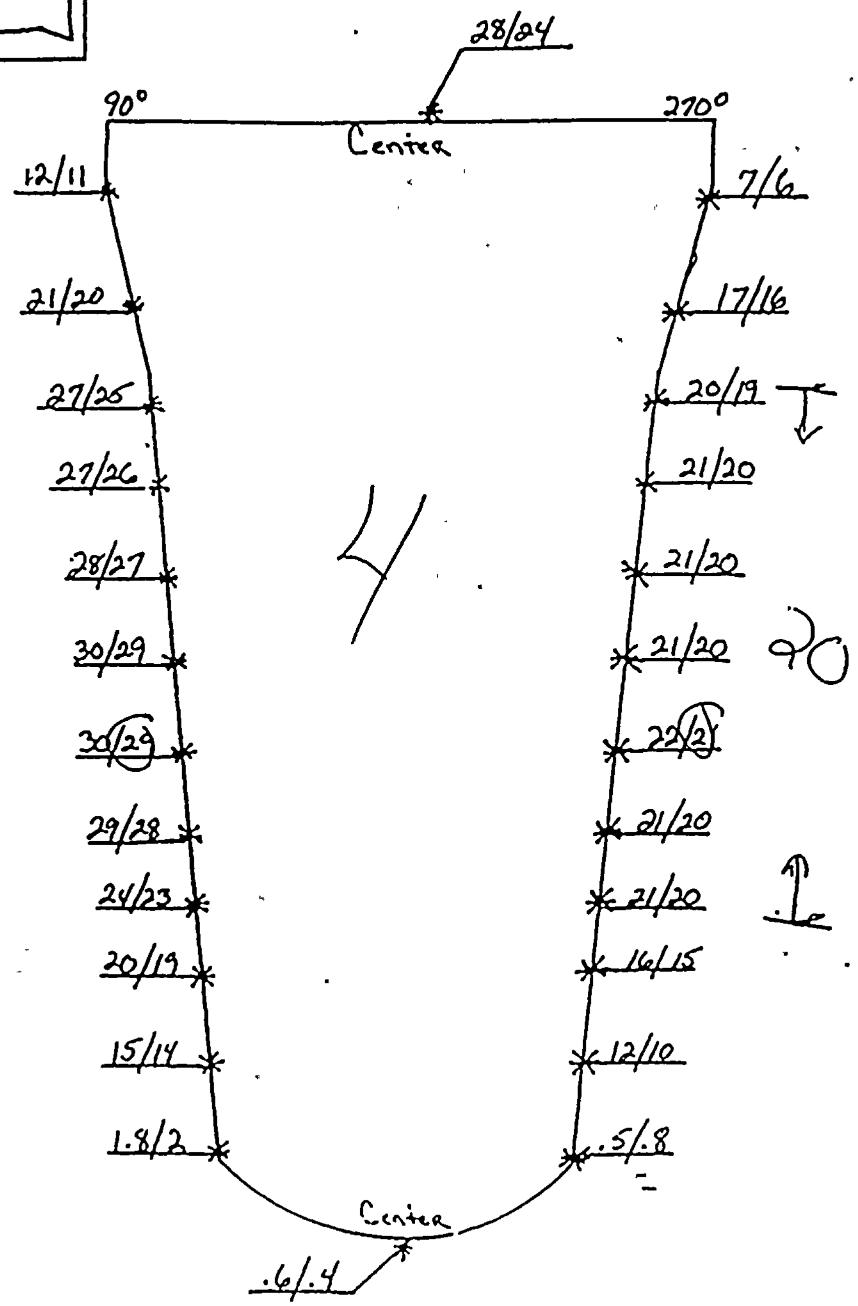
UNLESS NOTED: ✱ DENOTES CONTACT / 30 CM.
DOSE RATES IN MR/HR, AT WAIST LEVEL & CONTAMINATION IN DPM/100CM²

REASON FOR SURVEY
S/G Doserates

RWP USED: 0510-01

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

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



CONTAMINATION/ REMARKS

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N/A

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

AEP
AMERICAN®
ELECTRIC
POWER

December 10, 1998

Mr. Mark S. Whittaker
Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, SC 29210

Dear Mark:

On August 20, 1998, we took two smears of the internals of one of the old Donald C. Cook Nuclear plant's unit 2 steam generators. These were sent to Teledyne Brown Engineering Environmental Services for a complete isotopic analysis. The results of that analysis are attached and should be used to determine the if the shipment of the generators needs an exemption from the conveyance limits.

If you have any questions, please call me at 616-697-5067.

Sincerely,

Walter T. MacRae

Attachment

TELEDYNE BROWN ENGINEERING [illegible]ronmental Services

REPORT OF ANALYSIS

Nov 03 1998, 09:44 am

LOGIN # L2890

Address:	Work Order #:	Cust. P.O. #:	Date Received	Delivery Date		PAGE: 1
G J MASHAK	L2890	B-1060 C#1	09/15/98	10/15/98		
INDIANA MICHIGAN POWER COMPANY		Release #:			Project Manager: C.MENDOLA	
D C COOK NUCLEAR PLANT						
ONE COOK PLACE						
BRIDGEMAN MI 49106						

Matrix - Swipes

Teledyne Sample #	Customer's Identification	Sta. #	Collection-Dates Start Date/Time	Stop Date/Time	Matrix/ Nuclide	Activity	Units	Count Date	Volume Units Procedure #	Lab	Comment
L2890-1	SG SMEAR #1		08/20/98 09:00		Swipes						
TI#-87466					C-14	L.T. 7. E-06	Total uCi	10/26/98		32	
					FE-55	8.9 +-0.2 E-02		10/17/98		32	
					I-129	L.T. 1. E-05		10/14/98		32	
					NI-63	6.3 +-0.1 E-02		10/17/98		32	
					SR-89	L.T. 1. E-04		10/17/98		32	
					SR-90	L.T. 3. E-05		10/17/98		32	
					TC-99	L.T. 3. E-05		10/21/98		32	
					BE-7	L.T. 3. E-02		09/28/98		42	
					K-40	L.T. 7. E-03		09/28/98		42	
					CR-51	L.T. 3. E-02		09/28/98		42	
					MN-54	L.T. 4. E-03		09/28/98		42	
					CO-58	L.T. 5. E-03		09/28/98		42	
					FE-59	L.T. 2. E-02		09/28/98		42	
					CO-60	1.73+-0.17E 00		09/28/98		42	
					CO-60	L.T. 3. E-02		09/28/98		42	
					ZN-65	L.T. 1. E-02		09/28/98		42	
					NB-94	L.T. 4. E-03		09/28/98		42	
					NB-95	L.T. 5. E-03		09/28/98		42	
					ZR-95	L.T. 9. E-03		09/28/98		42	
					MO-99	L.T. 2. E 01		09/28/98		42	
					RU-103	L.T. 4. E-03		09/28/98		42	
					RU-106	L.T. 3. E-02		09/28/98		42	
					AG-110M	L.T. 6. E-03		09/28/98		42	
					SB-124	L.T. 2. E-03		09/28/98		42	
					SB-125	L.T. 6. E-03		09/28/98		42	
					I-131	L.T. 5. E-02		09/28/98		42	
					CS-134	L.T. 4. E-03		09/28/98		42	
					CS-137	L.T. 3. E-03		09/28/98		42	
					BA-140	L.T. 5. E-02		09/28/98		42	
					LA-140	L.T. 5. E-03		09/28/98		42	
					CE-141	L.T. 5. E-03		09/28/98		42	
					CE-144	L.T. 1. E-02		09/28/98		42	
					RA-226	L.T. 3. E-02		09/28/98		42	
					TH-228	L.T. 3. E-03		09/28/98		42	

Lab Key: 22 - Gas Lab; 32 - Radiochemistry Lab; 42 - GE(Li) Gamma Spec Lab; 52 - Tritium Lab; 62 - Alpha Spec Lab; 12 - Environmental TLD; 72 - Consulting;

Copy: 1 of 1

TELEDYNE BROWN ENGINEERING Environmental Services

REPORT OF ANALYSIS

Nov 03 1998, 09:44 am

LOGIN # L2890

Address:	Work Order #:	Cust. P.O. #:	Date Received	Delivery Date	PAGE: 2
G J MASHAK INDIANA MICHIGAN POWER COMPANY D C COOK NUCLEAR PLANT ONE COOK PLACE BRIDGEMAN MI 49106	L2890	B-1060 C#1 Release #:	09/15/98	10/15/98	Project Manager: C.MENDOLA

Teledyne Sample #	Customer's Identification	Sta. #	Collection-Dates Start Date/Time	Stop Date/Time	Matrix/ Nuclide	Activity	Units	Count Date	Volume Procedure #	Units	Lab	Comment
Continued												
					NP-237	L.T. 4. E-03	Total uCi	09/28/98			42	
					H-3	L.T. 5. E-04		10/21/98			52	
					AM-241	3.1 +-0.6 E-05		10/29/98			62	
					CM-242	L.T. 1. E-06		10/29/98			62	
					CM-243/244	6.3 +-2.7 E-06		10/29/98			62	
					PU-238	2.3 +-0.5 E-05		10/29/98			62	
					PU-239/240	1.3 +-0.4 E-05		10/29/98			62	
					PU-241	3.4 +-0.9 E-04		10/31/98			62	
					U-233/234	L.T. 2. E-06		10/29/98			62	
					U-235	L.T. 8. E-07		10/29/98			62	
					U-238	L.T. 1. E-06		10/29/98			62	
L2890-2	SG SMEAR #2		08/20/98 09:00		Swipes							
TI#-87467					C-14	L.T. 7. E-06		10/24/98			32	
					FE-55	6.1 +-0.2 E-02		10/18/98			32	
					I-129	L.T. 1. E-05		10/14/98			32	
					NI-63	4.3 +-0.1 E-02		10/17/98			32	
					SR-89	L.T. 1. E-04		10/17/98			32	
					SR-90	L.T. 3. E-05		10/17/98			32	
					TC-99	L.T. 3. E-05		10/14/98			32	
					BE-7	L.T. 3. E-02		09/28/98			42	
					K-40	L.T. 6. E-03		09/28/98			42	
					CR-51	L.T. 3. E-02		09/28/98			42	
					MN-54	L.T. 4. E-03		09/28/98			42	
					CO-58	L.T. 5. E-03		09/28/98			42	
					FE-59	L.T. 2. E-02		09/28/98			42	
					CO-60	1.64+-0.16E 00		09/28/98			42	
					CO-60	L.T. 2. E-02		09/28/98			42	
					ZN-65	L.T. 1. E-02		09/28/98			42	
					NB-94	L.T. 4. E-03		09/28/98			42	
					NB-95	L.T. 5. E-03		09/28/98			42	
					ZR-95	L.T. 9. E-03		09/28/98			42	
					MO-99	L.T. 2. E 01		09/28/98			42	
					RU-103	L.T. 4. E-03		09/28/98			42	

Lab Key: 22 - Gas Lab; 32 - Radiochemistry Lab; 42 - GE(Li) Gamma Spec Lab; 52 - Tritium Lab; 62 - Alpha Spec Lab; 12 - Environmental TLD; 72 - Consulting;

Copy: 1 of 1

TELEDYNE BROWN ENGINEERING E[illegible]onmental Services

REPORT OF ANALYSIS

Nov 03 1998, 09:44 am

LOGIN # L2890

Address:	Work Order #:	Cust. P.O. #:	Date Received	Delivery Date	PAGE: 3
G J MASHAK INDIANA MICHIGAN POWER COMPANY D C COOK NUCLEAR PLANT ONE COOK PLACE BRIDGEMAN MI 49106	L2890	B-1060 C#1 Release #:	09/15/98	10/15/98	Project Manager: C.MENDOLA

Teledyne Sample #	Customer's Identification	Sta. #	Collection-Dates Start Date/Time	Stop Date/Time	Matrix/ Nuclide	Activity	Units	Count Date	Volume Procedure #	Units	Lab Comment
Continued											
					RU-106	L.T. 3. E-02	Total uCi	09/28/98			42
					AG-110M	L.T. 6. E-03		09/28/98			42
					SB-124	L.T. 2. E-03		09/28/98			42
					SB-125	L.T. 6. E-03		09/28/98			42
					I-131	L.T. 5. E-02		09/28/98			42
					CS-134	L.T. 4. E-03		09/28/98			42
					CS-137	L.T. 3. E-03		09/28/98			42
					BA-140	L.T. 5. E-02		09/28/98			42
					LA-140	L.T. 5. E-03		09/28/98			42
					CE-141	L.T. 5. E-03		09/28/98			42
					CE-144	L.T. 1. E-02		09/28/98			42
					RA-226	L.T. 3. E-02		09/28/98			42
					TH-228	L.T. 3. E-03		09/28/98			42
					NP-237	L.T. 4. E-03		09/28/98			42
					H-3	L.T. 5. E-04		10/21/98			52
					AM-241	2.6 +-0.5 E-05		10/29/98			62
					CM-242	L.T. 9. E-07		10/29/98			62
					CM-243/244	7.1 +-2.6 E-06		10/29/98			62
					PU-238	1.3 +-0.4 E-05		10/29/98			62
					PU-239/240	1.5 +-0.4 E-05		10/29/98			62
					PU-241	3.2 +-1.0 E-04		10/31/98			62
					U-233/234	L.T. 3. E-06		10/29/98			62
					U-235	L.T. 1. E-06		10/29/98			62
					U-238	L.T. 1. E-06		10/29/98			62

Approved By: J Guenther

Last Page of Report

Lab Key: 22 - Gas Lab; 32 - Radiochemistry Lab; 42 - GE(Li) Gamma Spec Lab; 52 - Tritium Lab; 62 - Alpha Spec Lab; 12 - Environmental TLD; 72 - Consulting;

Copy: 1 of 1

APPENDIX B

SHIPPING PAPERS AND DISPOSAL MANIFESTS

(0 PAGES)

[TO BE INCLUDED IN FINAL WASTE CHARACTERIZATION REPORT]

APPENDIX C

MICROSHIELD MODELS AND OUTPUT

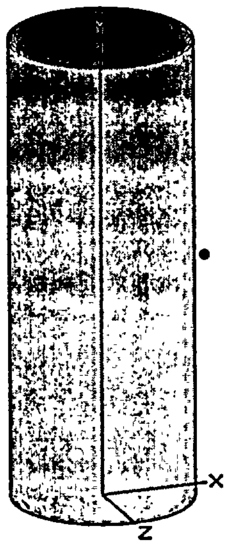
(2 PAGES)

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

Page : 1
DOS File : DCCOKCH1.MS5
Run Date: December 7, 1998
Run Time: 2:57:09 PM
Duration : 00:00:21

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

Case Title: DC Cook
Description: DC Cook, characterization model @30cm, normalized smears
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 : Actual Photon Energies

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Am-241	1.5700e-005	5.8090e+005	2.3873e-007	8.8329e-003
Cm-243	1.8500e-006	6.8450e+004	2.8130e-008	1.0408e-003
Cm-244	1.8500e-006	6.8450e+004	2.8130e-008	1.0408e-003
Co-60	9.2920e-001	3.4380e+010	1.4129e-002	5.2277e+002
Fe-55	4.1359e-002	1.5303e+009	6.2889e-004	2.3269e+001
Ni-63	2.9227e-002	1.0814e+009	4.4441e-004	1.6443e+001
Pu-238	9.9300e-006	3.6741e+005	1.5099e-007	5.5867e-003
Pu-239	3.8600e-006	1.4282e+005	5.8693e-008	2.1717e-003
Pu-240	3.8600e-006	1.4282e+005	5.8693e-008	2.1717e-003
Pu-241	1.8200e-004	6.7340e+006	2.7674e-006	1.0239e-001

Buildup
The material reference is : Shield 4

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	20

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
0.0263	1.394e+04	0.000e+00	4.044e-30	0.000e+00	5.936e-32

DOS File : DCCOKCH1.MS5
Run Date: December 7, 1998
Run Time: 2:57:09 PM
Duration : 00:00:21

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
0.0332	6.158e+02	8.149e-188	2.282e-31	5.996e-190	1.679e-33
0.0447	8.194e+01	6.010e-86	4.832e-32	2.033e-88	1.635e-34
0.0543	7.493e+01	1.915e-53	6.244e-32	4.397e-56	1.434e-34
0.0553	1.738e+02	5.952e-51	1.503e-31	1.328e-53	3.353e-34
0.0569	1.945e+01	8.691e-49	1.784e-32	1.858e-51	3.813e-35
0.0573	9.560e+01	2.430e-47	8.903e-32	5.141e-50	1.884e-34
0.0595	2.085e+05	3.737e-40	2.112e-28	7.498e-43	4.237e-31
0.0678	9.560e+01	2.593e-33	1.340e-31	4.527e-36	2.340e-34
0.0692	1.042e+03	5.156e-31	2.524e-30	8.856e-34	4.334e-33
0.0995	9.779e+03	1.872e-16	6.578e-16	2.863e-19	1.006e-18
0.1038	1.572e+04	2.075e-15	7.730e-15	3.181e-18	1.185e-17
0.1061	1.775e+02	6.151e-17	2.364e-16	9.443e-20	3.629e-19
0.1129	6.796e+01	2.509e-16	1.050e-15	3.880e-19	1.624e-18
0.117	7.395e+03	9.029e-14	3.969e-13	1.405e-16	6.173e-16
0.167	2.287e+02	5.615e-12	4.111e-11	9.498e-15	6.954e-14
0.2098	2.253e+03	6.794e-10	6.602e-09	1.211e-12	1.177e-11
0.2282	7.239e+03	4.394e-09	4.575e-08	7.972e-12	8.299e-11
0.2544	7.512e+01	9.997e-11	1.112e-09	1.850e-13	2.058e-12
0.2776	9.560e+03	2.217e-08	2.564e-07	4.160e-11	4.811e-10
0.2854	4.985e+02	1.364e-09	1.594e-08	2.570e-12	3.003e-11
0.6938	5.608e+06	8.859e-04	8.606e-03	1.710e-06	1.662e-05
1.1732	3.438e+10	3.912e+01	2.586e+02	6.991e-02	4.620e-01
1.3325	3.438e+10	6.131e+01	3.680e+02	1.064e-01	6.385e-01
TOTALS:	6.877e+10	1.004e+02	6.266e+02	1.763e-01	1.101e+00

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

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

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

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

$L_{ave} = 97.436 \cdot in$

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

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

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

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

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

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

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

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

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