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US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Three Mile Island Nuclear Station Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Contamination Estimate for Two TMI-2 AFHB Cubicles

Dear Sir:

The Post-Defueling Monitored Storage (PDMS) Safety Analysis Report (SAR), Supplement 4, Question No. 1 requested an estimate of the total quantity of contamination in the Auxiliary and Fuel Handling Buildings (AFHB). As agreed, GPU Nuclear would provide an assessment of the quantity of contamination in two AFHB cubicles for NRC review. If the methodology used to assess the contamination was acceptable to the NRC, contamination in the rest of the AFHB would be so estimated.

Enclosure 1 provides the methodology for estimating the curie loading of the TMI-2 AFHB cubicles and other areas. As stated therein, an initial estimate of the curie loading in each cubicle/area will be made using a simplified model. Based on preliminary estimates, approximately 95% of the contamination in the AFHB is contained in nine cubicles/areas. Those nine cubicles/areas will then be evaluated to determine whether to construct a more precise model based on their propensity for significantly increasing the original curie estimate.

The assessment of the two cubicles/areas chosen for assessment by NRC are included as Enclosures 2 and 3. The enclosures present the calculations of the curie loading in the two makeup demineralizers and the "A" spent fuel pool, respectively. It is noteworthy that these areas represent several of the more difficult cubicles/areas to evaluate.

As stated above, NRC acceptance of the methodology is necessary for completion of the AFHB contamination estimates. However, GPU Nuclear shall proceed under the assumption that the methodology described in Enclosure 1 is acceptable and will calculate the total quantity of contamination in the AFHB accordingly.

Sincerely,

R. L. Long
Director, Services Division/TMI-2

EDS/dlb

Enclosures

cc: M. Evans - Senior Resident Inspector, TMI
T. T. Martin - Regional Administrator, Region I
M. T. Masnik - Project Manager, PDNP Directorate
L. H. Thonus - Project Manager, TMI

ENCLOSURE 1

Methodology for Estimating the Curie Loading of the TMI-2 Auxiliary and Fuel Handling Building Cubicles and Other Areas

INTRODUCTION

While the majority of the radioactive contamination resulting from the TMI-2 reactor accident of 1979 remains within the TMI-2 Reactor Building, approximately 145 locations within the Auxiliary and Fuel Handling Buildings (AFHB) and other areas are listed in the Post-Defueling Monitored Storage (PDMS) Safety Analysis Report (SAR) as locations (cubicles/areas) containing some levels of radioactive contamination. Some of these cubicles/areas were exposed to radioactive material concentrations that left them severely contaminated. Others were only moderately contaminated, and some cubicles were largely unaffected by the accident and the subsequent defueling operations.

Prior to entering PDMS, GPUNC has committed to provide an estimate of the curie content of these cubicles/areas showing the estimated total activity (fixed and removable), that will be present upon entry into PDMS. To provide specific (room-by-room) estimates that provide the curie content at some level of accuracy is a difficult task if each room or area were to be modeled precisely. Constructing an exact representation of each area/cubicle, including equipment and room size, would expend many man-hours. The end product would still be an estimate with an error band of approximately $\pm$ 50%.

To simplify this task, most of the locations will be modeled using the Microshield radiation shielding computer code, a common geometry for all areas, and the average general area radiation survey reading as the modeling parameters. A few of the areas containing the majority of the contamination will be modeled more precisely. The below listed assumptions are necessary to the simplify this effort.

ASSUMPTIONS

1. The radioactive material within a selected area is composed of typical TMI-2 isotopes than can be classified into one of three groups: Defueling, Make-up and Purification (MUP), or Normal waste. These TMI-2 classifications are used to represent materials for waste shipments and are based on specific isotopic distributions.

2. The "Average General Area" radiation measurement for a selected room is the average of a number of measurements taken from a typical TMI-2 Radiological Controls Survey as described in GPUNC Radiological Controls Procedure 6610-ADM-4200.04 and GPUNC Radiological Controls Standing Order Memorandum 6610-92-53.

3. The geometry used for modeling a cubicle/area having a small quantity of radioactive material (i.e., less than 50 curies) is typically a cylinder with an internal exposure rate point. The cylinder's size is increased or decreased depending on the actual size of the room. For example, a room that is 18 feet wide, 20 feet long and 21 feet high has a total surface area of 2,316 square feet. The internal cylinder model for this room would have a diameter of 19.5 feet ((18+21)/2) and a length of 37.8 feet. The total internal surface area for the model is the same, i.e., about 2,316 square feet.

4. Cubicles that do not have a rectangular floor are considered to be rectangular, by choosing the longest path through the room as the length of the room. This path may be diagonal for some areas but will always represent a conservative room size. The width of some cubicles may be determined in a similar fashion.

5. Equipment and other obstructions are ignored in estimating the room size. Only the outermost walls are considered.

6. The equipment or piping in a cubicle is not considered to be the deposition site of the radioactive material.

7. All of the radioactive material is equally distributed over the interior of the cylindrical model.

8. The exposure rate site is about head-high at the center of the room.

9. For those cubicles containing greater than 50 curies based on previous knowledge or the above modeling technique, an engineering evaluation will be made to determine whether to construct a more precise model. The propensity for measurably increasing the original curie estimate will be the determining factor in this decision process. A preliminary estimate indicates that the AFHB contains greater than 10,000 curies; therefore, a "measurable increase" is presumed to be 50 curies (i.e., 0.5% of the total). The more precise model will be developed using the actual room dimensions, specific equipment involved and other relevant information (e.g., contained water).

EFFECT OF ABOVE MODELING TECHNIQUE

The method outlined above will produce a reasonable estimate of activities for the AFHB and other areas since approximately 95% of the activity is contained in the nine cubicles/areas within the AFHB having greater than 50 curies. Each of these nine cubicles will be evaluated to determine whether a more precise model should be developed. This is an effort to apply the greatest precision to the areas where most of the activity resides. The other cubicles individually contain much less activity; minor inaccuracy in modeling these cubicles will have an insignificant impact on the final total inventory.

The cubicles/areas modeled using the equivalent cylindrical surface area technique will provide a conservative estimate of the activity present, since the activity will be assumed to be on the inside surface of the cylinder and not in the equipment or piping in the room. In addition, the

curies associated with any fuel debris previously determined to be present in a room or area, will be added to the activity estimated from the exposure rate modeling. Since the number of curies present in fuel debris is generally a contributor to the source of the general area exposure rate for that room, a "double-counting" of curies for these locations will take place, resulting in an overestimate of the total activity in the cubicle.

SUMMARY

The methodology described above will optimize the use of GPU Nuclear's time, resources and analytical ability to estimate the number of curies present in the cubicles/areas containing the largest amount of activity (i.e., those accounting for about 95% of the total). The remaining cubicles/areas will be estimated with less accuracy using the equivalent cylindrical technique to reduce the number of modeling problems.

GPU Nuclear Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	1 of 35

Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	8/27/93	G. Lodde G. Lodde	8/27/93

1.0 PROBLEM STATEMENT

The purpose of this calculation is to estimate the curie loading of the TMI-2 Fuel Pool "A" located in the Fuel Handling Building at the 347' El. Radiological Controls survey data will be used to provide the exposure rate information necessary for this estimate.

2.0 SUMMARY OF RESULTS

Based on the Radiological Controls survey data and isotopic concentrations determined to be present in smear data, the Fuel Pool "A" area contains an upper bound of approximately 135 Ci ± 22 Ci's of activity. A previous estimate from reference 3.7 (from 9/21/89), reported that about 59 Ci of activity were present in the FHB "A" Fuel Pool. The previous preliminary estimate did not include all the isotopes present in the mixture and was subject to a larger sampling error.

3.0 REFERENCES

3.1 Microshield Radiation Shielding Computer Code, Version 4, Grove Engineering, Inc., 15215 Shady Grove Rd., Rockville, MD 20850.

3.2 Lotus 1-2-3, Release 2.2, Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, MA 02142.

3.3 "The Health Physics and Radiological Health Handbook", Scinta, Inc., Silver Springs, MD., 1992.

3.4 Burns & Roe, Inc., Drawing No. 2068, rev 23, "General Arrangement Auxiliary & Fuel Handling Building Floor Plan El. 347'-6", W.O. 2555, 9/17/70.

3.5 NES, Drawing No. 83E0950, rev 2, "Spent Fuel Pool Canister Storage Rack Arrangement", Danbury, Connecticut, 11/84.

3.6 GPUNC Engineering Calculation No. 4800-4420-89-095, rev. 0, "G.M. Measurements of Fuel Debris (FTS)", 9/21/89.

3.7 GPUNC Memorandum No. 4800-89-127, "Fuel Debris in Defueling Canal and Fuel Pool "A"", 10/16/89.

3.8 GPUNC Engineering Calculation No. 4240-3233-93-001, rev. 0, "TMI-2 Waste Stream Analysis", 1/11/93.

3.9 NES, Drawing No. 83E0943, rev 3, "Top Plate", Danbury, Connecticut, 10/84.

3.10 NES, Drawing No. 83E0919, rev 4, "Fuel Canister Storage Rack 7 x 9", Danbury, Connecticut, 10/84.

4.0 ASSUMPTIONS AND BASIC DATA

4.1 General overview and description of methodology.

4.1.1 In general, the Fuel Pool "A" area is modeled in sections. In section one, the activity is assumed to be at the bottom of the Fuel Pool in the region of the north canister handling/dewatering platforms. A three (3) inch deep water shield is assumed to cover the activity in this region at the time of the Radiological Controls survey.

4.1.2 The south region or section two of the fuel pool, contains the fuel canister racks. The source term is assumed to occupy only the area of the fuel racks and is homogeneously distributed in the rack volume. This is a conservative assumption since a portion of the source is actually distributed around the rack space as a surface deposition with little shielding. However, it is assumed that a significant portion of the source materials are present within the fuel racks as fuel debris.

4.2 Determination of materials and densities.

4.2.1 From review of reference 3.9 and 3.10 the following data table was assembled using the Lotus 1-2-3 spreadsheet system (reference 3.2). These values are used to estimate the effective density of the fuel rack region.

```
INPUT DENSITY VALUES FOR FUEL POOL "A"

          ASSUMED COMPOSITION==============>      0.0%   LEAD
          BY WEIGHT                            100.0%   IRON

          DIMENSIONS OF INTERNALS TO BE SUBTRACTED (ft)
           LENGTH==>          0
           WIDTH===>          0
            HEIGHT=>          0
          VOLUME OF INTERNALS TO BE SUBTRACTED (cc's)>   0.00E+00
                                                        ------------

          DIMENSIONS OF SOURCE REGION IN FUEL POOL "A" (ft)
           LENGTH==>    44.40625
           WIDTH===>      14.125
            HEIGHT=>    13.1979
          VOLUME OF SOURCE REGION (cc's)===============>   2.34E+08
                                                        ------------
SOURCE REGION IN FUEL POOL A MINUS REGION TO BE SUBTRACTED.
EFFECTIVE SOURCE VOLUME (cc's)==>   2.34E+08
                                    ---------

           FUEL POOL                                                  **
           MATERIALS  MATERIALS WEIGHT OF  WEIGHT OF  DENSITY OF  DENSITY OF **
           APPROAIMATE   WEIGHT  LEAD       IRON       LEAD        IRON
 MATERIALS WEIGHT (lbs)  (gms)   (gms)      (gms)      g/cc        g/cc      **
-------------------------------------------------------------------------**
COMPOSITION 1     81696  37057306     0    37057306   0.000000   0.158085 **
COMPOSITION 2         0        0     0           0   0.000000   0.000000 **
-------------------------------------------------------------------------**
```

GPU Nuclear **Calculation Sheet**

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FH109/FH300 Curie Estimate	4240-3233-93-020	0	3 of 35

Originator	Date	Reviewed By	Date
B. Brosey B. Brosey	8/27/93	G. Lodde [illegible]	8/27/93

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.2 Determination of materials and densities cont'd.

4.2.2 The Fuel Racks are assumed to be composed of steel with a weight of approximately 17,380 lbs per 7 x 9 section. There are four sections in the pool (reference 3.5 & 3.10).

4.2.3 The steel top plate sections are assumed to weigh approximately 3044 lbs per section. There are four sections (reference 3.9).

4.3 The isotopes, and activity of the isotopes present in one curie of source materials were determined from smear radiochemistry analysis and from the use of the Lotus 1-2-3 spreadsheet from reference 3.8. Isotopes normally found at TMI-2 were scaled in assuming a "Defueling" waste stream (attachment 1-1 to 1-6).

4.4 The following table presents the smear numbers and decayed results for ten (10) smears taken from the Fuel Pool and assayed by GPUNC. Smear results are decayed to 8/24/93.

FH109 SMEAR DATA FILE NAME: SFP-A.WK1
TODAY'S DATE=>8/24/93

	AREA	LOCATION	SMEAR I.D.	SMEAR NUMBER	SAMPLE DATE	ISOTOPES and ACTIVITY'S (OUTPUT VALUES) uCi's per 100 cm^2 Cs-137	Sr-90	Cs-134	Sb-125	Co-60	Eu-154	Sr/Cs	WASTE CLASS Based on Sr/Cs	ALPHA ACTIVITY
1	FHB	FH109	9206003	8	6/3/92	8.14E-03	1.77E-02	1.78E-05	0.00E+00	1.21E-04	0.00E+00	2.17	DEFUELING	2.162E-04
2	FHB	FH109	9206002	7	6/3/92	4.68E-03	1.14E-02	0.00E+00	0.00E+00	6.12E-05	0.00E+00	2.43	DEFUELING	2.207E-04
3	FHB	FH109	9205016	NONE	5/28/92	3.14E-03	6.62E-03	0.00E+00	9.97E-05	3.92E-05	0.00E+00	2.11	DEFUELING	1.279E-04
4	FHB	FH109	9205015	NONE	5/28/92	5.10E-03	1.24E-02	2.39E-05	0.00E+00	8.36E-05	0.00E+00	2.43	DEFUELING	1.658E-04
5	FHB	FH109	NONE	12	7/25/92	2.45E-03	5.76E-03	0.00E+00	0.00E+00	3.34E-05	0.00E+00	2.35	DEFUELING	NOT DONE
6	FHB	FH109	NONE	10	7/25/92	8.57E-04	2.11E-03	0.00E+00	0.00E+00	1.18E-05	0.00E+00	2.47	DEFUELING	NOT DONE
7	FHB	FH109	NONE	11	7/25/92	3.82E-03	1.14E-02	0.00E+00	0.00E+00	8.85E-05	0.00E+00	2.98	DEFUELING	NOT DONE
8	FHB	FH109	NONE	14	7/25/92	4.15E-04	9.44E-04	0.00E+00	0.00E+00	9.46E-06	0.00E+00	2.28	DEFUELING	NOT DONE
9	FHB	FH109	3960-6	9	7/25/92	6.07E-04	3.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.15	DEFUELING	NOT DONE
10	FHB	FH109	NONE	13	7/25/92	1.10E-03	2.53E-03	0.00E+00	0.00E+00	2.00E-05	0.00E+00	2.30	DEFUELING	NOT DONE
					AVERAGES=>>	3.03E-03	7.45E-03	4.17E-06	9.97E-06	4.68E-05	0.00E+00	2.7663		1.827E-04

4.5 Computer modeling for Fuel Pool "A".

4.5.1 From review of the references the following information represents the basic Microshield 4 input files.

a) Section 1, Basic Microshield 4 input:

Dose point to center of rectangular area (X)...30.48 cm.
Height of rectangular area (H).....720.09 cm.
Rectangular area width (W).....387.35 cm.
Thickness of shield 1 (SH1).....7.62 cm.
Dose point position along Z axis (Z).....193.67495 cm.
Dose point from base of area (Y).....360.045 cm.
Air Gap.....22.86 cm.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.5 Computer modeling for Fuel Pool "A" cont'd.

4.5.1 Cont'd.

b) Section 2, Basic Microshield 4 input:

Dose point to center rectangle (X).....1264.3104 cm.
Height of rectangle (H).....1353.5025 cm.
Rectangular vol. width (W).....430.53 cm.
Rectangular vol. length (L).....402.27199 cm.
Thickness of shield 1 (SH1).....7.62 cm.
Dose point position along Z axis (Z).....215.265 cm.
Dose point from base of source (Y).....676.75125 cm.
Air Gap.....854.41841 cm.

4.6 Review and interpretation of survey data.

4.6.1 Two (2) Radiological Controls Field Operations surveys were reviewed to determine the average exposure rate at set locations within the FHB Fuel Pool "A" area. Copies of these surveys are shown as attachments 2-1 and 2-2. The average value for the survey locations were determined by spreadsheet analysis (see attachments 3-1 and 3-2).

4.6.2 The estimate of the error from incorrectly determining the vertical distance from a source term, is determined by assuming a ± six inch error in the radiation measurement reported for section one and that ± two foot errors could have occurred in section two measurement locations.

4.7 A one curie source term is used to estimate the exposure rate at the same locations reported on the Radiological Controls survey sheets. The calculated output is then compared to the actual measured values. The actual measurement data is converted into the number of curies present in the measurement location. Activities as of 8/24/93.

4.8 The following is a description of the attachments presented in this calculation.

a) Attachments 1-1 to 1-6, present and scale in the isotopes extracted from section 4.4 and assumed to characterize the "A" Fuel Pool.

b) Attachments 2-1 & 2-2, present the two Radiological Controls surveys for section 1 and 2 respectively, of the "A" Fuel Pool.

c) Attachments 3-1 & 3-2, present the Statistical Determination Worksheet for section 1 and 2 respectively, of the "A" Fuel Pool. The average exposure rates for both regions are computed on these attachments.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.8 Continued.

d) Attachments 4-1 & 4-2, present the Microshield 4 output data for a 1 curie "Defueling" mixture of activity for section 1 (De-watering Station), of the "A" Fuel Pool.

e) Attachments 5-1 & 5-2, present the Microshield 4 output data for a 1 curie "Defueling" mixture of activity for section 2 (Fuel Rack Area), of the "A" Fuel Pool.

f) Attachments 6-1, Lotus 1-2-3 "Normalization Worksheet", used to compare and estimate from the 1 curie Microshield 4 output to the number of curies present (suggested by actual exposure rate from survey data). This attachment presents the estimated number of curies in section 1 of the "A" Fuel Pool.

g) Attachments 7-1, Lotus 1-2-3 "Normalization Worksheet", used to compare and estimate from the 1 curie Microshield 4 output to the number of curies present (suggested by actual exposure rate from survey data). This attachment presents the estimated number of curies in section 2 of the "A" Fuel Pool.

h) Attachments 8-1 to 8-6, are diagrams and sections of drawings for the Fuel Pool storage racks as well as general layouts for the Fuel Pool area.

i) Attachments 9-1 to 9-7, are Microshield 4 output data for error estimates for this calculation including a graphical presentation.

5.0 CALCULATIONS

5.1 Most of the earlier operations were performed using the Lotus 1-2-3 spreadsheet system or Microshield 4.

5.2 Estimation of error terms.

5.2.1 The combined estimate of error in this analysis includes the following:

a) The estimate of the uncertainty in the radiation measurements from the radiological surveys, due to incorrectly reported survey locations (in the vertical plane).

b) An assumed instrumentation response error of ± 20%.

5.2.2 The distance error estimate assumes that the actual exposure rate point is within ~± 2 feet of the correct measurement location for the Fuel Rack section, and ~± 6 inches for the De-watering Station location. To estimate this effect the

5.0 CALCULATIONS Cont'd

5.2 Estimation of error terms cont'd.

5.2.2 Cont'd.

Microshield 4 shielding code problems above are again computed but with these distance effects included (see attachments 9-3 to 9-7). The results are shown below:

De-watering Station Exposure rate error term for -6 inch location is 1-(10.23/10.99) x 100% = -6.9% and about -4% on the +6 inch side of the one foot measurement. The graph shown on attachment 9-7 shows the exposure rate variation from an area source for the model presented herein. The one foot calculation appears to be about the highest value for this problem. Therefore, 6 inches closer or farther away produce a small reduction in the calculated exposure rate and a resulting increase in the curie estimate. Assume **± 5%** for this error term.

5.2.3 The error term for the Fuel Rack section is computed in the same manner as above. The Microshield output for a ± 2 foot variation in distance produces the following error. 1-(1.088e-1/9.761e-2) x 100% = +11.5%, for -2 feet and 1-(8.795e-2/9.761e-2) x 100% = -10%, for +2 feet. Assume **± 10%** for this error term.

5.2.4 Combination of error terms.

Combined error term for De-watering station is:
$((\pm 20\%)^2+(\pm 5\%)^2)^{0.5}$ = **~± 21%.**

Combined error term for Fuel Rack area is:
$((\pm 20\%)^2+(\pm 10\%)^2)^{0.5}$ = **~± 22%.**

Combined section error estimate is:

(21%/100%) x 49.29 Ci = **± 10.4 Ci.**, De-watering Station.

(22%/100%) x 86.057 Ci = **± 18.9 Ci.**, Fuel Racks area.

Total estimate of error is:

$((\pm 10.4\ Ci)^2+(\pm 18.9\ Ci)^2)^{0.5}$ = **± 21.6 Ci's**

Attachment 1-1

SAMPLE RESULTS AND VOLUME ACTIVITIES SCALED FROM WEIGHTED ORIGEN2 VALUES

"ALPHA DATE"=> 1/1/93 TODAY'S DATE=> 8/24/93 Use EPRI

SCALED VALUES ?=> 1=YES, 2=NO=> 1

SAMPLE NAME=> DEFUELING WASTE IN FH109

Units=> uCi's

0 Days between analysis date and "TODAY'S DATE".

Analysis Date=> 8/24/93 -235 Days between analysis date and "ALPHA DATE".

N/A 8/27/93

Input Values Reviewed by: N/A

Input Values Checked by:

	ISOTOPES	HALF-LIFE (d)	Analysis Date Activity (uCi) Activity (uCi) at "ALPHA DATE"	% of Total	Normalized to 1
1	H-3	4.485E+03	0.00E+00	0.00%	0.00E+00
2	C-14	2.093E+06	0.00E+00	0.00%	0.00E+00
3	Cr-51	2.770E+01	0.00E+00	0.00%	0.00E+00
4	Mn-54	3.127E+02	0.00E+00	0.00%	0.00E+00
5	Fe-55	9.862E+02	9.73E-05	0.45%	4.47E-03
6	Co-58	7.080E+01	0.00E+00	0.00%	0.00E+00
7	Co-60	1.925E+03	4.68E-05	5.09E-05	0.23%	2.34E-03
8	Ni-63	3.656E+04	4.64E-04	2.14%	2.14E-02
9	Zn-65	2.444E+02	0.00E+00	0.00%	0.00E+00
10	Sr-89	5.055E+01	0.00E+00	0.00%	0.00E+00
11	Sr-90	1.045E+04	7.45E-03	7.57E-03	34.79%	3.48E-01
12	Y-90	2.671E+00	**********	7.57E-03	34.79%	3.48E-01
13	Tc-99	7.780E+07	0.00E+00	0.00%	0.00E+00
14	Ru-106	3.682E+02	0.00E+00	0.00%	0.00E+00
15	Rh-106	3.463E-04	**********	0.00E+00	0.00%	0.00E+00
16	Ag-110m	2.498E+02	0.00E+00	0.00%	0.00E+00
17	Ag-110	2.844E-04	**********	0.00E+00	0.00%	0.00E+00
18	Sb-125	1.012E+03	9.97E-06	1.17E-05	0.05%	5.38E-04
19	Te-125m	5.800E+01	**********	2.71E-06	0.01%	1.24E-04
20	I-129	5.734E+09	0.00E+00	0.00%	0.00E+00
21	Cs-134	7.531E+02	4.17E-06	5.18E-06	0.02%	2.38E-04
22	Cs-137	1.102E+04	3.03E-03	3.08E-03	14.14%	1.41E-01
23	Ba-137m	1.772E-03	**********	2.91E-03	13.37%	1.34E-01
24	Ce-141	3.250E+01	0.00E+00	0.00%	0.00E+00
25	Ce-144	2.843E+02	0.00E+00	0.00%	0.00E+00
26	Pr-144	1.200E-02	**********	0.00E+00	0.00%	0.00E+00
27	Pr-144m	5.000E-03	**********	0.00E+00	0.00%	0.00E+00
28	Pm-147	9.582E+02	0.00E+00	0.00%	0.00E+00
29	Eu-154	3.214E+03	0.00E+00	0.00%	0.00E+00
30	Eu-155	1.812E+03	0.00E+00	0.00%	0.00E+00
31	Pa-233	2.700E+01	0.00E+00	0.00%	0.00E+00
32	U-234	8.930E+07	0.00E+00	0.00%	0.00E+00
33	U-235	2.571E+11	0.00E+00	0.00%	0.00E+00
34	U-236	1.247E+09	0.00E+00	0.00%	0.00E+00
35	Np-237	7.816E+08	0.00E+00	0.00%	0.00E+00
36	U-238	1.632E+12	0.00E+00	0.00%	0.00E+00
37	Pu-238	3.205E+04	0.00E+00	0.00%	0.00E+00
38	Pu-239	8.814E+06	0.00E+00	0.00%	0.00E+00
39	Pu-240	2.388E+06	0.00E+00	0.00%	0.00E+00
40	Pu-241	5.260E+03	0.00E+00	0.00%	0.00E+00
41	Am-241	1.579E+05	0.00E+00	0.00%	0.00E+00
42	Cm-242	1.632E+02	0.00E+00	0.00%	0.00E+00
43	Cm-243	1.041E+04	0.00E+00	0.00%	0.00E+00
44	Cm-244	6.615E+03	0.00E+00	0.00%	0.00E+00
		TOTALS uCi's=>	1.05E-02	2.18E-02	100.00%	1.00E+00

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Calculation Sheet

Subject: FH109/FH300 Curie Estimate		Calc No: 4240-3233-93-020	Rev No: 0
Originator: B. Brosey	Date: 8/27/93	Reviewed by: G. Lodde	Sheet No: 2 of 35
			Date: 8/27/93

Attachment 1-2

9524.695 uCi Alpha/Ci (debris) ISOTOPE USED FOR SCALING=====> NA SAMPLE NAME=>DEFUELING WASTE IN FH109
as of 1/1/93 "ALPHA DATE" RESULTS (Scaled Alpha)=======> CAN'T SCALE!
Alpha %===> 0.776621% 1.827E-04 uCi (Sample or Scaled Alpha Results) TODAY'S DATE> 8/24/93

Isotopes ORIGEN2	SAMPLE WEIGHTED Fractions per Ci	Per Ci Alpha Fraction	Adjusted Alpha Emitters (D)	Scaled Remainders Using Pu-239 (E)	SUM OF COLUMNS D & E (uCi)	REAL SAMPLE RESULTS (uCi)	SAMPLE WEIGHTED ORIGEN2 RESULTS (uCi)	Columns H/F	Isotopes ORIGEN2
Ac-227*	1.610E-10	1.610E-10	3.088E-18		3.088E-12		3.088E-12	1	Ac-227
Ag-108	6.530E-09			1.253E-16	1.253E-10		1.253E-10	1	Ag-108
Ag-108m	7.020E-08			1.347E-15	1.347E-09		1.347E-09	1	Ag-108m
Ag-109m	9.000E-09			1.726E-16	1.726E-10		1.726E-10	1	Ag-109m
Ag-110	1.800E-11			3.453E-19	3.453E-13		3.453E-13	1	Ag-110
Ag-110m	1.360E-09			2.609E-17	2.609E-11	0.000E+00	2.609E-11	1	Ag-110m
Am-241*	1.650E-03	1.650E-03	3.165E-11		3.165E-05	0.000E+00	3.165E-05	1	Am-241
Am-242	2.160E-07			4.143E-15	4.143E-09		4.143E-09	1	Am-242
Am-242m*	2.170E-07	2.170E-07	4.162E-15		4.162E-09		4.162E-09	1	Am-242m
Am-243*	8.490E-08	8.490E-08	1.629E-15		1.629E-09		1.629E-09	1	Am-243
Ba-137m	8.400E-02			1.611E-09	1.611E-03	2.909E-03	2.909E-03	1.8054493	Ba-137m
Be-10	1.930E-11			3.702E-19	3.702E-13		3.702E-13	1	Be-10
Bi-211*	1.590E-10	1.590E-10	3.050E-18		3.050E-12		3.050E-12	1	Bi-211
Bi-212*	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	Bi-212
Bi-214	3.090E-11			5.927E-19	5.927E-13		5.927E-13	1	Bi-214
C-14	1.030E-05			1.976E-13	1.976E-07	0.000E+00	1.976E-07	1	C-14
Ca-41	1.030E-09			1.976E-17	1.976E-11		1.976E-11	1	Ca-41
Cd-109	9.000E-09			1.726E-16	1.726E-10		1.726E-10	1	Cd-109
Cd-113m	9.160E-05			1.757E-12	1.757E-06		1.757E-06	1	Cd-113m
Ce-144	6.800E-05			1.304E-12	1.304E-06	0.000E+00	1.304E-06	1	Ce-144
Cl-36	6.850E-08			1.314E-15	1.314E-09		1.314E-09	1	Cl-36
Cm-242*	1.790E-07	1.790E-07	3.434E-15		3.434E-09	0.000E+00	3.434E-09	1	Cm-242
Cm-243*	1.800E-08	1.800E-08	3.453E-16		3.453E-10	0.000E+00	3.453E-10	1	Cm-243
Cm-244*	4.290E-07	4.290E-07	8.229E-15		8.229E-09	0.000E+00	8.229E-09	1	Cm-244
Co-60	1.640E-03			3.146E-11	3.146E-05	5.093E-05	5.093E-05	1.6190171	Co-60
Cs-134	2.690E-04			5.160E-12	5.160E-06	5.177E-06	5.177E-06	1.0032408	Cs-134
Cs-135	2.050E-06			3.932E-14	3.932E-08		3.932E-08	1	Cs-135
[illegible]	8.880E-02			1.703E-09	1.703E-03	3.075E-03	3.075E-03	1.8053461	Cs-137
[illegible]	1.680E-05			3.223E-13	3.223E-07		3.223E-07	1	Eu-152
[illegible]	1.290E-03			2.474E-11	2.474E-05	0.000E+00	2.474E-05	1	Eu-154
[illegible]	1.950E-03			3.740E-11	3.740E-05	0.000E+00	3.740E-05	1	Eu-155
[illegible]	1.780E-03			3.414E-11	3.414E-05	9.728E-05	9.728E-05	2.8491064	Fe-55
[illegible]	1.530E-10			2.935E-18	2.935E-12		2.935E-12	1	Gd-153
[illegible]	2.600E-03			4.987E-11	4.987E-05	0.000E+00	4.987E-05	1	H-3
[illegible]	3.300E-10			6.330E-18	6.330E-12		6.330E-12	1	Ho-166m
[illegible]	4.150E-08			7.960E-16	7.960E-10	0.000E+00	7.960E-10	1	I-129
[illegible]	2.420E-07			4.642E-15	4.642E-09	0.000E+00	4.642E-09	1	Mn-54
[illegible]	1.580E-07			3.031E-15	3.031E-09		3.031E-09	1	Mo-93
[illegible]	5.510E-06			1.057E-13	1.057E-07		1.057E-07	1	Nb-93m
[illegible]	8.270E-06			1.586E-13	1.586E-07		1.586E-07	1	Nb-94
[illegible]	3.110E-05			5.966E-13	5.966E-07		5.966E-07	1	Ni-59
[illegible]	3.510E-03			6.733E-11	6.733E-05	4.645E-04	4.645E-04	6.8989505	Ni-63
[illegible]	6.980E-07	6.980E-07	1.339E-14		1.339E-08	0.000E+00	1.339E-08	1	Np-237
[illegible]	1.030E-09			1.976E-17	1.976E-11		1.976E-11	1	Np-238
[illegible]	8.490E-08			1.629E-15	1.629E-09		1.629E-09	1	Np-239
[illegible]	7.980E-10	7.980E-10	1.531E-17		1.531E-11		1.531E-11	1	Pa-231
[illegible]	6.980E-07			1.339E-14	1.339E-08	0.000E+00	1.339E-08	1	Pa-233
[illegible]	2.760E-08			5.294E-16	5.294E-10		5.294E-10	1	Pa-234
[illegible]	1.720E-05			3.299E-13	3.299E-07		3.299E-07	1	Pa-234m
[illegible]	1.590E-10			3.050E-18	3.050E-12		3.050E-12	1	Pb-211
[illegible]	1.600E-08			3.069E-16	3.069E-10		3.069E-10	1	Pb-212
[illegible]	3.090E-11			5.927E-19	5.927E-13		5.927E-13	1	Pb-214
[illegible]	2.110E-07			4.047E-15	4.047E-09		4.047E-09	1	Pd-107
[illegible]	5.150E-07			9.879E-15	9.879E-09		9.879E-09	1	Pm-146
[illegible]	5.190E-02			9.955E-10	9.955E-04	0.000E+00	9.955E-04	1	Pm-147
[illegible]	1.020E-08	1.020E-08	1.957E-16		1.957E-10		1.957E-10	1	Po-212
[illegible]	3.090E-11	3.090E-11	5.927E-19		5.927E-13		5.927E-13	1	Po-214
[illegible]	1.590E-10	1.590E-10	3.050E-18		3.050E-12		3.050E-12	1	Po-215
[illegible]	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	Po-216
[illegible]	3.090E-11	3.090E-11	5.927E-19		5.927E-13		5.927E-13	1	Po-218
[illegible]	6.800E-05			1.304E-12	1.304E-06	0.000E+00	1.304E-06	1	Pr-144

Nuclear Calculation Sheet

Attachment 1-3

Pr-144m	9.730E-07			1.866E-14	1.866E-08	0.000E+00	1.866E-08	1	Pr-144m
Pu-236*	6.400E-09	6.400E-09	1.228E-16		1.228E-10		1.228E-10	1	Pu-236
Pu-238*	4.750E-04	4.750E-04	9.111E-12		9.111E-06	0.000E+00	9.111E-06	1	Pu-238
Pu-239*	5.770E-03	5.770E-03	1.107E-10		1.107E-04	0.000E+00	1.107E-04	1	Pu-239
Pu-240*	1.530E-03	1.530E-03	2.935E-11		2.935E-05	0.000E+00	2.935E-05	1	Pu-240
Pu-241	5.300E-02			1.017E-09	1.017E-03	0.000E+00	1.017E-03	1	Pu-241
Pu-242*	9.970E-08	9.970E-08	1.912E-15		1.912E-09		1.912E-09	1	Pu-242
Pu-244*	1.310E-10	1.310E-10	2.513E-18		2.513E-12		2.513E-12	1	Pu-244
Ra-223*	1.590E-10	1.590E-10	3.050E-18		3.050E-12		3.050E-12	1	Ra-223
Ra-224*	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	Ra-224
Ra-226*	3.100E-11	3.100E-11	5.946E-19		5.946E-13		5.946E-13	1	Ra-226
Rb-87	1.310E-10			2.513E-18	2.513E-12		2.513E-12	1	Rb-87
Rh-106	1.020E-04			1.957E-12	1.957E-06	0.000E+00	1.957E-06	1	Rh-106
Rn-219*	1.590E-10	1.590E-10	3.050E-18		3.050E-12		3.050E-12	1	Rn-219
Rn-220*	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	Rn-220
Rn-222*	3.090E-11	3.090E-11	5.927E-19		5.927E-13		5.927E-13	1	Rn-222
Ru-106	1.020E-04			1.957E-12	1.957E-06	0.000E+00	1.957E-06	1	Ru-106
Sb-125	8.890E-04			1.705E-11	1.705E-05	1.171E-05	1.171E-05	0.6867714	Sb-125
Sb-126	4.470E-07			8.574E-15	8.574E-09		8.574E-09	1	Sb-126
Sb-126m	3.200E-06			6.138E-14	6.138E-08		6.138E-08	1	Sb-126m
Se-79	2.180E-06			4.182E-14	4.182E-08		4.182E-08	1	Se-79
Sm-147	4.900E-11			9.399E-19	9.399E-13		9.399E-13	1	Sm-147
Sm-151	6.290E-03			1.207E-10	1.207E-04		1.207E-04	1	Sm-151
Sn-119m	1.720E-07			3.299E-15	3.299E-09		3.299E-09	1	Sn-119m
Sn-126	3.200E-06			6.138E-14	6.138E-08		6.138E-08	1	Sn-126
Sr-90	3.460E-01			6.637E-09	6.637E-03	7.567E-03	7.567E-03	1.1401536	Sr-90
Tc-99	7.350E-05			1.410E-12	1.410E-06	0.000E+00	1.410E-06	1	Tc-99
Te-125m	2.050E-04			3.932E-12	3.932E-06	2.705E-06	2.705E-06	0.6879741	Te-125m
Th-227*	1.580E-10	1.580E-10	3.031E-18		3.031E-12		3.031E-12	1	Th-227
Th-228*	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	Th-228
Th-230*	1.010E-08	1.010E-08	1.937E-16		1.937E-10		1.937E-10	1	Th-230
Th-231	2.550E-06			4.891E-14	4.891E-08		4.891E-08	1	Th-231
Th-234	1.720E-05			3.299E-13	3.299E-07		3.299E-07	1	Th-234
Tl-207	1.590E-10			3.050E-18	3.050E-12		3.050E-12	1	Tl-207
Tl-208	5.740E-09			1.101E-16	1.101E-10		1.101E-10	1	Tl-208
U-232*	1.600E-08	1.600E-08	3.069E-16		3.069E-10		3.069E-10	1	U-232
U-233*	1.960E-10	1.960E-10	3.760E-18		3.760E-12		3.760E-12	1	U-233
U-234*	7.840E-05	7.840E-05	1.504E-12		1.504E-06	0.000E+00	1.504E-06	1	U-234
U-235*	3.170E-06	3.170E-06	6.081E-14		6.081E-08	0.000E+00	6.081E-08	1	U-235
U-236*	2.080E-06	2.080E-06	3.990E-14		3.990E-08	0.000E+00	3.990E-08	1	U-236
U-238*	1.480E-05	1.480E-05	2.839E-13		2.839E-07	0.000E+00	2.839E-07	1	U-238
Y-90	3.460E-01			6.637E-09	6.637E-03	7.567E-03	7.567E-03	1.1401536	Y-90
Zn-65	1.080E-09			2.072E-17	2.072E-11	0.000E+00	2.072E-11	1	Zn-65
Zr-93	1.130E-05			2.168E-13	2.168E-07		2.168E-07	1	Zr-93
TOTAL==>	1.00	9.525E-03	1.827E-10	1.900E-08	1.919E-02	2.175E-02	2.419E-02		

TODAY'S DATE==========> 8/24/93 SAMPLE NAME==> DEFUELING WASTE IN FH109

GPU Nuclear

Calculation Sheet

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Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	8/27/93	G. Lodde	8/27/93

Attachment 1-4

NOTE: An "*" next to an isotope name indicates an alpha emitter.
RADENG Scaled Values
Based on Co-60 & Sb-125

ISOTOPES	EPRI (1) (uCi)	ORIGEN2 (2) (uCi)	RATIO (1)/(2)
Fe-55	9.73E-05	3.41E-05	2.8491064248
Ni-63	4.64E-04	6.73E-05	6.8989505015

SAMPLE NAME=>DEFUELING WASTE IN FH109

TODAY'S DATE>8/24/93

Sr/Cs RATIO	% ALPHA	WASTE BASED ON Sr/Cs	WASTE BASED ON ALPHA
2.4607416	0.776621%	DEFUELING	DEFUELING

GPU Nuclear Calculation Sheet

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Originator: B. Brosey, Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 1-5

SAMPLE RESULTS AND RESULTING VOLUME ACTIVITIES SCALED EPRI VALUES?> YES

TODAY'S DATE=> 8/24/93 Volume of Small Container=====> 0.00 gal

SAMPLE NAME=== DEFUELING WASTE IN FH109 0.00 ml

Units=> uCi's Size to: 0.00 gal

"ALPHA DATE"===1/1/93 235 Days have elapsed since "ALPHA DATE".

	ISOTOPES	HALF-LIFE (d)	Activity (uCi) "ALPHA DATE"	Activity (uCi) TODAY'S DATE	% of Total	Normalized to 1	Rad Eng Isotopes	Rad Eng Activities uCi's
1	H-3	4.485E+03	4.99E-05	4.81E-05	0.20%	2.04E-03		
2	C-14	2.093E+06	1.98E-07	1.98E-07	0.00%	8.40E-06		
3	Cr-51	2.770E+01	0.00E+00	0.00E+00	0.00%	0.00E+00	Am-241	3.25E-05
4	Mn-54	3.127E+02	4.64E-09	2.76E-09	0.00%	1.17E-07	Ba-137m	2.87E-03
5	Fe-55	9.862E+02	9.73E-05	8.25E-05	0.35%	3.51E-03	Ce-144	7.36E-07
6	Co-58	7.080E+01	0.00E+00	0.00E+00	0.00%	0.00E+00	Co-60	4.68E-05
7	Co-60	1.925E+03	5.09E-05	4.68E-05	0.20%	1.99E-03	Cs-134	4.17E-06
8	Ni-63	3.656E+04	4.64E-04	4.62E-04	1.97%	1.97E-02	Cs-137	3.03E-03
9	Zn-65	2.444E+02	2.07E-11	1.06E-11	0.00%	4.52E-10	Eu-154	2.35E-05
10	Sr-89	5.055E+01	0.00E+00	0.00E+00	0.00%	0.00E+00	Eu-155	3.42E-05
11	Sr-90	1.045E+04	7.57E-03	7.45E-03	31.67%	3.17E-01	I-129	7.96E-10
12	Y-90	2.671E+00	**********	7.45E-03	31.67%	3.17E-01	Pm-147	8.40E-04
13	Tc-99	7.780E+07	1.41E-06	1.41E-06	0.01%	5.99E-05	Pr-144	7.36E-07
14	Ru-106	3.682E+02	1.96E-06	1.26E-06	0.01%	5.34E-05	Pu-238	9.07E-06
15	Rh-106	3.463E-04	**********	1.26E-06	0.01%	5.34E-05	Pu-239	1.11E-04
16	Ag-110m	2.498E+02	2.61E-11	1.36E-11	0.00%	5.78E-10	Pu-241	9.86E-04
17	Ag-110	2.844E-04	**********	1.81E-13	0.00%	7.69E-12	Rh-106	1.26E-06
18	Sb-125	1.012E+03	1.17E-05	9.97E-06	0.04%	4.24E-04	Ru-106	1.26E-06
19	Te-125m	5.800E+01	**********	2.30E-06	0.01%	9.79E-05	Sb-125	9.97E-06
20	I-129	5.734E+09	7.96E-10	7.96E-10	0.00%	3.38E-08	Tc-99	1.41E-06
21	Cs-134	7.531E+02	5.18E-06	4.17E-06	0.02%	1.77E-04	Te-125m	2.30E-06
22	Cs-137	1.102E+04	3.08E-03	3.03E-03	12.88%	1.29E-01	Y-90	7.45E-03
23	Ba-137m	1.772E-03	**********	2.87E-03	12.18%	1.22E-01	Fe-55	8.25E-05
24	Ce-141	3.250E+01	0.00E+00	0.00E+00	0.00%	0.00E+00	Ni-63	4.62E-04
25	Ce-144	2.843E+02	1.30E-06	7.36E-07	0.00%	3.13E-05	Sr-90	7.45E-03
26	Pr-144	1.200E-02	**********	7.36E-07	0.00%	3.13E-05	U-234	1.50E-06
27	Pr-144m	5.000E-03	**********	1.05E-08	0.00%	4.47E-07	U-235	6.08E-08
28	Pm-147	9.582E+02	9.96E-04	8.40E-04	3.57%	3.57E-02	U-238	2.84E-07
29	Eu-154	3.214E+03	2.47E-05	2.35E-05	0.10%	1.00E-03	Pu-240	2.93E-05
30	Eu-155	1.812E+03	3.74E-05	3.42E-05	0.15%	1.45E-03		
31	Pa-233	2.700E+01	1.34E-08	1.34E-08	0.00%	5.69E-07		
32	U-234	8.930E+07	1.50E-06	1.50E-06	0.01%	6.39E-05		
33	U-235	2.571E+11	6.08E-08	6.08E-08	0.00%	2.58E-06		
34	U-236	1.247E+09	3.99E-08	3.99E-08	0.00%	1.70E-06		
35	Np-237	7.816E+08	1.34E-08	1.34E-08	0.00%	5.69E-07		
36	U-238	1.632E+12	2.84E-07	2.84E-07	0.00%	1.21E-05		
37	Pu-238	3.205E+04	9.11E-06	9.07E-06	0.04%	3.85E-04		
38	Pu-239	8.814E+06	1.11E-04	1.11E-04	0.47%	4.70E-03		
39	Pu-240	2.388E+06	2.93E-05	2.93E-05	0.12%	1.25E-03		
40	Pu-241	5.260E+03	1.02E-03	9.86E-04	4.19%	4.19E-02		
41	Am-241	1.579E+05	3.16E-05	3.25E-05	0.14%	1.38E-03		
42	Cm-242	1.632E+02	3.43E-09	3.42E-09	0.00%	1.46E-07		
43	Cm-243	1.041E+04	3.45E-10	3.40E-10	0.00%	1.44E-08		
44	Cm-244	6.615E+03	8.23E-09	8.03E-09	0.00%	3.41E-07		
		TOTALS uCi's>	1.36E-02	2.35E-02	100.00%	1.00E+00		

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FH109/FH300 Curie Estimate	4240-3233-93-020	0	11 of 35

Originator	Date	Reviewed By	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

Attachment 1-6

TODAY'S DATE=>8/24/93 SAMPLE NAME=> DEFUELING WASTE IN FH109

RADENG VALUES?>YES

	ISOTOPES	Activities uCi's	Total Activity (in uCi's) Small Container	Total Activity (in millicuries) LARGE Container(> 1% of TOTAL)	NRC "REPORTABLE"
1	H-3	4.81E-05	0.00E+00	0.00E+00	
2	C-14	1.98E-07	0.00E+00	0.00E+00	
3	Cr-51	0.00E+00	0.00E+00	0.00E+00	
4	Mn-54	2.76E-09	0.00E+00	0.00E+00	
5	Fe-55	8.25E-05	0.00E+00	0.00E+00	
6	Co-58	0.00E+00	0.00E+00	0.00E+00	
7	Co-60	4.62E-05	0.00E+00	0.00E+00	
8	Ni-63	4.62E-04	0.00E+00	0.00E+00	REPORTABLE!!
9	Zn-65	1.06E-11	0.00E+00	0.00E+00	
10	Sr-89	0.00E+00	0.00E+00	0.00E+00	
11	Sr-90	7.45E-03	0.00E+00	0.00E+00	REPORTABLE!!
12	Y-90	7.45E-03	0.00E+00	0.00E+00	**********
13	Tc-99	1.41E-06	0.00E+00	0.00E+00	
14	Ru-106	1.26E-06	0.00E+00	0.00E+00	
15	Rh-106	1.26E-06	0.00E+00	0.00E+00	**********
16	Ag-110m	1.36E-11	0.00E+00	0.00E+00	
17	Ag-110	1.81E-13	0.00E+00	0.00E+00	**********
18	Sb-125	9.97E-06	0.00E+00	0.00E+00	
19	Te-125m	2.30E-06	0.00E+00	0.00E+00	
20	I-129	7.96E-10	0.00E+00	0.00E+00	
21	Cs-134	4.17E-06	0.00E+00	0.00E+00	
22	Cs-137	3.03E-03	0.00E+00	0.00E+00	REPORTABLE!!
23	Ba-137m	2.87E-03	0.00E+00	0.00E+00	**********
24	Ce-141	0.00E+00	0.00E+00	0.00E+00	
25	Ce-144	7.36E-07	0.00E+00	0.00E+00	
26	Pr-144	7.36E-07	0.00E+00	0.00E+00	**********
27	Pr-144m	1.05E-08	0.00E+00	0.00E+00	**********
28	Pm-147	8.40E-04	0.00E+00	0.00E+00	REPORTABLE!!
29	Eu-154	2.35E-05	0.00E+00	0.00E+00	
30	Eu-155	3.42E-05	0.00E+00	0.00E+00	
31	Pa-233	1.34E-08	0.00E+00	0.00E+00	**********
32	U-234	1.50E-06	0.00E+00	0.00E+00	
33	U-235	6.08E-08	0.00E+00	0.00E+00	
34	U-236	3.99E-08	0.00E+00	0.00E+00	
35	Np-237	1.34E-08	0.00E+00	0.00E+00	
36	U-238	2.84E-07	0.00E+00	0.00E+00	
37	Pu-238	9.07E-06	0.00E+00	0.00E+00	
38	Pu-239	1.11E-04	0.00E+00	0.00E+00	
39	Pu-240	2.93E-05	0.00E+00	0.00E+00	
40	Pu-241	9.86E-04	0.00E+00	0.00E+00	REPORTABLE!!
41	Am-241	3.25E-05	0.00E+00	0.00E+00	
42	Cm-242	3.42E-09	0.00E+00	0.00E+00	
43	Cm-243	3.40E-10	0.00E+00	0.00E+00	
44	Cm-244	8.03E-09	0.00E+00	0.00E+00	
	TOTALS =====>	2.35E-02	0.00E+00	0.00E+00 mCi	

GPU Nuclear

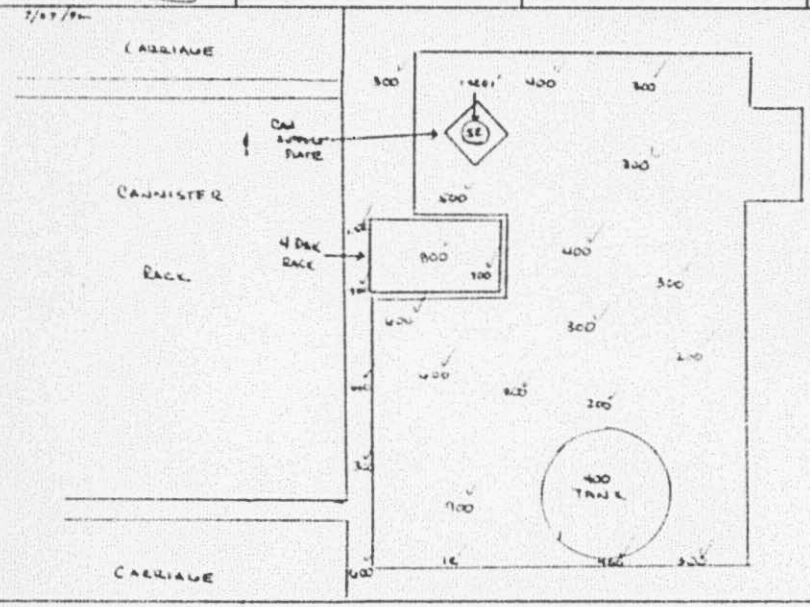
Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	12 of 35
Originator B. Brosey	**Date** 8/27/93	**Reviewed by** G. Lodde	**Date** 8/27/93

GPU Nuclear

RADIOLOGICAL SURVEY ☐ TMI-1 ■ TMI-2 ☐ OC

SURVEY INFORMATION	INSTRUMENT DATA		AIR SAMPLE	FILE CODE NUMBER:
LOCATION Aux Wtr Decontamination Station FHB	CONTAMINATION SURVEY N/A	RADIATION SURVEY	DATE ____ TIME N/T	SMEARABLE CONTAMINATION
REASON Backwashed	INST ____ INST ____	INST Telepyrometer INST ____	ACTIVITY ____	
DATE 7 24 92 TIME 1300	S/N ____ S/N ____	S/N 11737 S/N ____	SAMPLE# ____	SMEAR# / BT / # / COMMENTS
TECH [illegible]	CAL DUE ____ CAL DUE ____	CAL DUE 9 [illegible] CAL DUE ____	NOTE: RADIATION DOSE RATES IN mR/HR ARE GENERAL AREA, CONTAMINATION RESULTS ARE DPM/100cm2 UNLESS OTHERWISE NOTED	
G.R.C.S.	EFF ____ EFF ____	B.C.F. — B.C.F. ____		
REVIEW [illegible] 7/27/92	BKG ____ BKG ____	TECH [illegible]		
	MDC ____ MDC ____	NOTE: ○ = CONTACT READING		
	TECH ____	☐ = SMEAR LOCATION		



REMARKS: [illegible]

ORIGINAL

Attachment 2-1

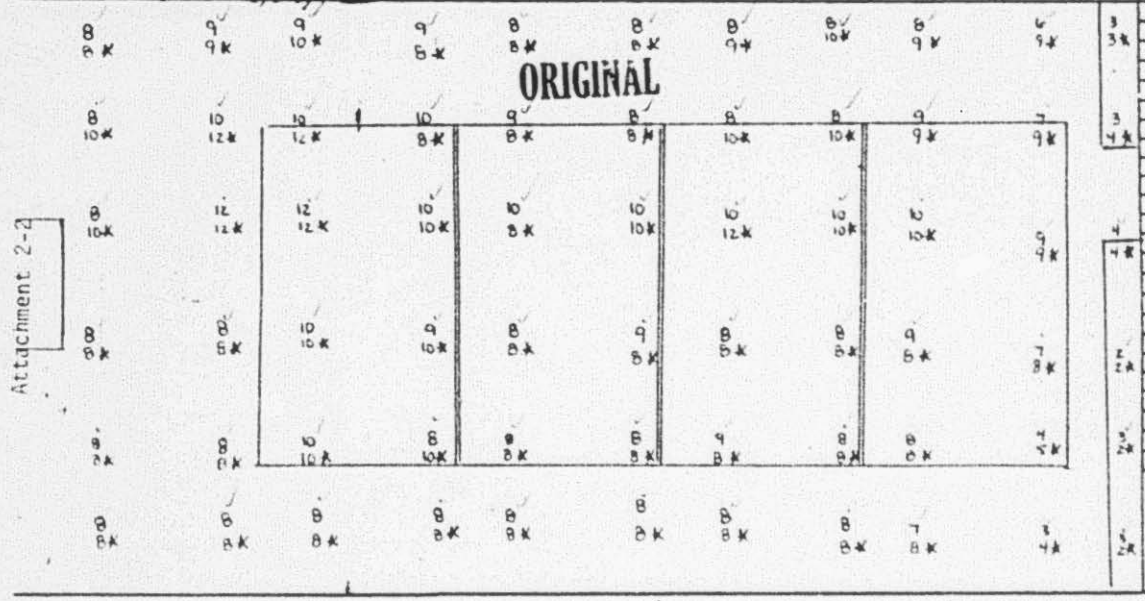
GPU Nuclear — Calculation Sheet

Subject	Calc No	Rev No	Sheet No
FHI09/FH300 Curie Estimate	4240-3233-93-020	0	13 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

GPU Nuclear — RADIOLOGICAL SURVEY — ☐ TMI-1 ■ TMI-2 ☐ OC

SURVEY INFORMATION	INSTRUMENT DATA		AIR SAMPLE	FILE CODE NUMBER: FH30092.107218
LOCATION A Pool 340-347'	CONTAMINATION SURVEY N/A	RADIATION SURVEY	DATE ____ TIME ____	SMEARABLE CONTAMINATION
REASON Request	INST ____ INST ____	INST Victoreen INST ____	ACTIVITY ____	SMEAR# / BY / # / COMMENTS
DATE 5 26 92 TIME 0930	S/N ____ S/N ____	S/N 19579 S/N ____	SAMPLE# ____	
TECH JC Grigg JC Smith	CAL DUE ____ CAL DUE ____	CAL DUE 101192 CAL DUE ____	NOTE: RADIATION DOSE RATES IN mR/hr ARE GENERAL AREA. CONTAMINATION RESULTS ARE DPM/100cm2 UNLESS OTHERWISE NOTED	
R.R.C.S.	EFF ____ EFF ____	B.C.F. — B.C.F. ____		
REVIEW	BKG ____ BKG ____	TECH JC Smith		
	MDC ____ MDC ____	NOTE: ○ = CONTACT READING		
	TECH ____	☐ = SMEAR LOCATION		



REMARKS: ✱ INDICATES DOSE RATES TAKEN @ 340'. ALL OTHERS TAKEN @ 347'.

8" SHIELD PLACED OVER DEBRIS FOR DOSE READING

347' AVE 8.8 ± 1.4 mR/hr (32)
340' AVE 9 ± 1.5 mR/hr (22)

GPU Nuclear — Calculation Sheet

Subject	Calc No	Rev No	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	1 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

Attachment 3-1

AUX/FHB PDMS DECONTAMINATION GOALS & STATISTICAL DETERMINATION WORKSHEET

ROOM OR AREA		GENERAL AREA mR/h GOAL	Page 1
FH300-B	LESS THAN>	N/A	

NUMBER OF SURVEYS USED TO DETERMINE PDMS STATUS==> 1 GOAL TOLERANCE VALUE======> 1.5

SURVEY DATE===> 7/24/92	SURVEY NUMBER===> 92J6209	LOCATION OR AREA====>FH300-B	TODAY'S DATE
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	8/25/93
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	

	G.A. mR/h		G.A. mR/h		G.A. mR/h		
1	300.0	41		81		1	NOT USED
2	1500.0	42		82		2	
3	700.0	43		83		3	
4	800.0	44		84		4	
5	500.0	45		85		5	
6	400.0	46		86		6	
7	300.0	47		87		7	
8	300.0	48		88		8	
9	400.0	49		89		9	
10	300.0	50		90		10	
11	700.0	51		91		11	
12	600.0	52		92		12	
13	600.0	53		93		13	
14	600.0	54		94		14	
15	800.0	55		95		15	
16	300.0	56		96		16	
17	200.0	57		97		17	
18	200.0	58		98		18	
19	300.0	59		99		19	
20	600.0	60		100		20	
21	1000.0	61		101		21	
22	900.0	62		102		22	
23	400.0	63		103		23	
24	300.0	64		104		24	
25		65		105		25	
26		66		106		26	
27		67		107		27	
28		68		108		28	
29		69		109		29	
30		70		110		30	
31		71		111		31	
32		72		112		32	
33		73		113		33	
34		74		114		34	
35		75		115		35	
36		76		116		36	
37		77		117		37	
38		78		118		38	
39		79		119		39	
40		80		120		40	

MEAN G.A. mR/h=========> 541.7
OF G.A. POINTS=======> 24.0
1 SIGMA==========> 106.1
T-TEST @ 95% C.L.====> 548.8
GOAL x TOLERANCE======> [illegible]

GPU Nuclear

Calculation Sheet

Subject: FH100/FH300 Curie Estimate	Calc No: 4240-3233-93-020	Rev. No: 0	Sheet No: 15 of 35
Originator: B. Brosey	Date: 8/27/93	Reviewed by: G. Lodde	Date: 8/27/93

Attachment 3-2

AUX/FHB PDMS DECONTAMINATION GOALS & STATISTICAL DETERMINATION WORKSHEET

ROOM OR AREA		GENERAL AREA mR/h GOAL	Page 1
FH300-A	LESS THAN>	N/A	

NUMBER OF SURVEYS USED TO DETERMINE PDMS STATUS==> 1 GOAL TOLERANCE VALUE======> 1.5

SURVEY DATE===> 8/26/92	SURVEY NUMBER===> 92J07218	LOCATION OR AREA====>FH300-A	TODAY'S DATE
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	8/25/93
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	
SURVEY DATE===> N/A	SURVEY NUMBER===> N/A	LOCATION OR AREA====>N/A	

	G.A. mR/h		G.A. mR/h		G.A. mR/h		
1	8.0	41	8.0	81		1	NOT USED
2	9.0	42	9.0	82		2	
3	9.0	43	10.0	83		3	
4	9.0	44	8.0	84		4	
5	8.0	45	8.0	85		5	
6	8.0	46	8.0	86		6	
7	8.0	47	10.0	87		7	
8	8.0	48	10.0	88		8	
9	8.0	49	9.0	89		9	
10	6.0	50	8.0	90		10	
11	3.0	51	8.0	91		11	
12		52	8.0	92		12	
13	4.0	53	10.0	93		13	
14		54	10.0	94		14	
15		55	12.0	95		15	
16		56	10.0	96		16	
17		57	10.0	97		17	
18		58	12.0	98		18	
19	7.0	59	8.0	99		19	
20	9.0	60	8.0	100		20	
21	7.0	61	8.0	101		21	
22	9.0	62	8.0	102		22	
23	10.0	63	8.0	103		23	
24	9.0	64	8.0	104		24	
25	8.0	65	8.0	105		25	
26	7.0	66	8.0	106		26	
27	8.0	67		107		27	
28	8.0	68		108		28	
29	8.0	69		109		29	
30	10.0	70		110		30	
31	8.0	71		111		31	
32	8.0	72		112		32	
33	10.0	73		113		33	
34	8.0	74		114		34	
35	9.0	75		115		35	
36	8.0	76		116		36	
37	8.0	77		117		37	
38	8.0	78		118		38	
39	9.0	79		119		39	
40	10.0	80		120		40	

MEAN G.A. mR/h==========>	8.4
# OF G.A. POINTS========>	80.0
1 SIGMA==============>	1.4
T-TEST @ 95% C.L.======>	8.7
GOAL + TOLERANCE=======>	9.9

EPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	16 of 35
Originator: B. Brosey — Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 4-1

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: FP-B.MS4
Run Date: August 25, 1993
Run Time: 11:23 a.m. Wednesday
Duration: 0:03:04

File Ref:
Date:
By:
Checked:

Case Title: DEWATERING STATION AREA OF FUEL POOL A

GEOMETRY 4 - Vertical Rectangular Area

	centimeters	feet and inches	
Dose point coordinate X:	30.48	1.0	.0
Dose point coordinate Y:	360.045	11.0	9.7
Dose point coordinate Z:	193.67495	6.0	4.2
Rectangular area height:	720.09	23.0	7.5
Rectangular area width:	387.35	12.0	8.5
Shield 1:	7.62	0.0	3.0
Air Gap:	22.86	0.0	9.0

Source Area: 278927. sq cm 300.234 sq ft. 43233.8 sq in.

MATERIAL DENSITIES (g/cm^3)

Material	Shield 1 Slab	Air Gap
Air		0.00122
Water	1.0	

BUILDUP
Method: Buildup factor tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Z Direction	30
Y Direction	30

SOURCE NUCLIDES

Nuclide	curies	µCi/cm³	Nuclide	curies	µCi/cm³
Ag-110	7.6900e-012	2.7570e-011	Ag-110m	5.7800e-010	2.0722e-009
Am-241	1.3800e-003	4.9475e-003	Ba-137m	1.2200e-001	4.3739e-001
C-14	8.4000e-006	3.0115e-005	Ce-141	0.0000e+000	0.0000e+000
Ce-144	3.1300e-005	1.1222e-004	Cm-242	1.4600e-007	5.2343e-007
Cm-243	1.4400e-008	5.1626e-008	Cm-244	3.4100e-007	1.2225e-006
Co-58	0.0000e+000	0.0000e+000	Co-60	1.9900e-003	7.1345e-003
Cr-51	0.0000e+000	0.0000e+000	Cs-134	1.7700e-004	6.3457e-004
Cs-137	1.2900e-001	4.6249e-001	Eu-154	1.0000e-003	3.5852e-003
Eu-155	1.4500e-003	5.1985e-003	Fe-55	3.5100e-003	1.2584e-002
H-3	2.0400e-003	7.3137e-003	I-129	3.3800e-008	1.2118e-007
Mn-54	1.1700e-007	4.1946e-007	Ni-63	1.9700e-002	7.0628e-002
Np-237	5.6900e-007	2.0400e-006	Pa-233	5.6900e-007	2.0400e-006
Pm-147	3.5700e-002	1.2799e-001	Pr-144	3.1300e-005	1.1222e-004
Pr-144m	4.4700e-007	1.6026e-006	Pu-238	3.8500e-004	1.3803e-003
Pu-239	4.7000e-003	1.6850e-002	Pu-240	1.2500e-003	4.4815e-003
Pu-241	4.1900e-002	1.5022e-001	Rh-106	5.3400e-005	1.9145e-004
Ru-106	5.3400e-005	1.9145e-004	Sb-125	4.2400e-004	1.5201e-003
Sr-89	0.0000e+000	0.0000e+000	Sr-90	3.1700e-001	1.1365e+000
Tc-99	5.9900e-005	2.1475e-004	Te-125m	9.7900e-005	3.5099e-004
U-234	6.3900e-005	2.2909e-004	U-235	2.5800e-006	9.2497e-006
U-236	1.7000e-006	6.0948e-006	U-238	1.2100e-005	4.3381e-005
Y-90	3.1700e-001	1.1365e+000	Zn-65	4.5200e-010	1.6205e-009

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	12 of 35
Originator: B. Brosey, Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 4-2

Page : 2
DOS File: FP-B.MS4
Run Date: August 25, 1993
Run Time: 11:23 a.m. Wednesday
Title : DEWATERING STATION AREA OF FUEL POOL A

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	2.624e+007	6.400e-001	8.650e+000	9.792e-004	1.323e-002
0.15	1.795e+005	8.244e-003	8.013e-002	1.358e-005	1.319e-004
0.2	3.777e+006	2.719e-001	2.070e+000	4.798e-004	3.653e-003
0.3	7.837e+004	1.070e-002	5.504e-002	2.029e-005	1.044e-004
0.4	5.177e+006	1.116e+000	4.581e+000	2.174e-003	8.926e-003
0.5	2.207e+006	6.764e-001	2.361e+000	1.328e-003	4.635e-003
0.6	4.079e+009	1.666e+003	5.161e+003	3.252e+000	1.007e+001
0.8	2.061e+007	1.321e+001	3.443e+001	2.513e-002	6.548e-002
1.0	8.524e+007	7.733e+001	1.798e+002	1.426e-001	3.314e-001
1.5	8.828e+007	1.492e+002	2.886e+002	2.510e-001	4.855e-001
2.0	8.964e+003	2.329e-002	4.057e-002	3.602e-005	6.273e-005
TOTAL:	4.310e+009	1.908e+003	5.682e+003	3.675e+000	1.099e+001

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	18 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

Attachment 5-1

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: FUELPARA.MS4
Run Date: August 25, 1993
Run Time: 1:13 p.m. Wednesday
Duration: 0:24:42

File Ref:
Date:
By:
Checked:

Case Title: FUEL POOL A FUEL RACK AREA

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	1264.3104	41.0	5.8
Dose point coordinate Y:	676.75125	22.0	2.4
Dose point coordinate Z:	215.265	7.0	.8
Rectangular volume width :	430.53	14.0	1.5
Rectangular volume length:	402.27199	13.0	2.4
Rectangular volume height:	1353.5025	44.0	4.9
Shield 1:	7.62	0.0	3.0
Air Gap:	854.41841	28.0	.4

Source Volume: 2.34413e+8 cm^3 8278.23 cu ft. 1.43048e+7 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Iron	0.15809		
Water		1.0	

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	22
Y Direction	22
Z Direction	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ag-110	7.6900e-012	3.2805e-014	Ag-110m	5.7800e-010	2.4657e-012
Am-241	1.3800e-003	5.8870e-006	Ba-137m	1.2200e-001	5.2045e-004
C-14	8.4000e-006	3.5834e-008	Ce-141	0.0000e+000	0.0000e+000
Ce-144	3.1300e-005	1.3352e-007	Cm-242	1.4600e-007	6.2283e-010
Cm-243	1.4400e-008	6.1430e-011	Cm-244	3.4100e-007	1.4547e-009
Co-58	0.0000e+000	0.0000e+000	Co-60	1.9900e-003	8.4893e-006
Cr-51	0.0000e+000	0.0000e+000	Cs-134	1.7700e-004	7.5508e-007
Cs-137	1.2900e-001	5.5031e-004	Eu-154	1.0000e-003	4.2660e-006
Eu-155	1.4500e-003	6.1857e-006	Fe-55	3.5100e-003	1.4974e-005
H-3	2.0400e-003	8.7026e-006	I-129	3.3800e-008	1.4419e-010
Mn-54	1.1700e-007	4.9912e-010	Ni-63	1.9700e-002	8.4040e-005
Np-237	5.6900e-007	2.4273e-009	Pa-233	5.6900e-007	2.4273e-009
Pm-147	3.5700e-002	1.5230e-004	Pr-144	3.1300e-005	1.3352e-007
Pr-144m	4.4700e-007	1.9069e-009	Pu-238	3.8500e-004	1.6424e-006
Pu-239	4.7000e-003	2.0050e-005	Pu-240	1.2500e-003	5.3325e-006
Pu-241	4.1900e-002	1.7874e-004	Rh-106	5.3400e-005	2.2780e-007
Ru-106	5.3400e-005	2.2780e-007	Sb-125	4.2400e-004	1.8088e-006
Sr-89	0.0000e+000	0.0000e+000	Sr-90	3.1700e-001	1.3523e-003
Tc-99	5.9900e-005	2.5553e-007	Te-125m	9.7900e-005	4.1764e-007
U-234	6.3900e-005	2.7260e-007	U-235	2.5800e-006	1.1006e-008
U-236	1.7000e-006	7.2521e-009	U-238	1.2100e-005	5.1618e-008
Y-90	3.1700e-001	1.3523e-003	Zn-65	4.5200e-010	1.9282e-012

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No.	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	19 of 35
Originator: B. Brosey, Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 5-2

Page : 2
DOS File: FUELPARA.MS4
Run Date: August 25, 1993
Run Time: 1:13 p.m. Wednesday
Title : FUEL POOL A FUEL RACK AREA

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	2.624e+007	2.038e-003	3.450e-003	3.118e-006	5.278e-006
0.15	1.795e+005	4.546e-005	1.040e-004	7.486e-008	1.713e-007
0.2	3.777e+006	1.869e-003	5.127e-003	3.299e-006	9.048e-006
0.3	7.837e+004	8.757e-005	2.678e-004	1.661e-007	5.080e-007
0.4	5.177e+006	9.871e-003	3.009e-002	1.923e-005	5.863e-005
0.5	2.207e+006	6.290e-003	1.843e-002	1.235e-005	3.618e-005
0.6	4.079e+009	1.607e+001	4.484e+001	3.136e-002	8.752e-002
0.8	2.061e+007	1.345e-001	3.424e-001	2.559e-004	6.512e-004
1.0	8.524e+007	8.200e-001	1.928e+000	1.512e-003	3.554e-003
1.5	3.828e+007	1.691e+000	3.436e+000	2.845e-003	5.781e-003
2.0	8.964e+003	2.729e-004	5.081e-004	4.220e-007	7.857e-007
TOTAL:	4.310e+009	1.873e+001	5.060e+001	3.601e-002	9.761e-002

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No.	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	20 of 35
Originator: B. Brosey — Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 6-1

NORMALIZATION WORKSHEET (1 Ci)

CALCULATED ========== ========== 8/25/93

EXPOSURE RATE PER Ci==> 1.10E+01 mR/h ACTUAL===> 5.42E+02 mR/h ==========

UNITS IN>Ci ========== ========== Today's Date

I.D. NUMBER

OR NAME<>DEFUELING WASTE IN FUEL POOL "A" AT DEWATERING STATION

	ISOTOPE	INPUT UNIT ACTIVITY	PERCENT (%) of Total	ACTIVITY PER CURIE	ADJUSTED ACTIVITY (mCi)	ADJUSTED WITHOUT DAUGHTERS (mCi)	NRC REPORTABLE If > 1% of TOTAL	ISOTOPES	Sr-90/Cs-137 RATIO
1	H-3	2.04E-03 ***	0.20379	2.04E-03 ***	1.00E+02	1.00E+02		H-3	2.457
2	C-14	8.40E-06 ***	0.00084	8.39E-06 ***	4.14E-01	4.14E-01		C-14	
3	Cr-51	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Cr-51	
4	Mn-54	1.17E-07 ***	0.00001	1.17E-07 ***	5.76E-03	5.76E-03		Mn-54	
5	Fe-55	3.51E-03 ***	0.35064	3.51E-03 ***	1.73E+02	1.73E+02		Fe-55	
6	Co-58	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Co-58	
7	Co-60	1.99E-03 ***	0.19880	1.99E-03 ***	9.80E+01	9.80E+01		Co-60	
8	Ni-63	1.97E-02 ***	1.96798	1.97E-02 ***	9.70E+02	9.70E+02	REPORTABLE!	Ni-63	
9	Zn-65	4.52E-10 ***	0.00000	4.52E-10 ***	2.23E-05	2.23E-05		Zn-65	
10	Sr-89	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Sr-89	
11	Sr-90	3.17E-01 ***	31.66757	3.17E-01 ***	1.56E+04	1.56E+04	REPORTABLE!	Sr-90	
12	Y-90	3.17E-01 ***	31.66757	3.17E-01 ***	1.56E+04	==========	==========	Y-90	
13	Tc-99	5.99E-05 ***	0.00598	5.98E-05 ***	2.95E+00	2.95E+00		Tc-99	
14	Ru-106	5.34E-05 ***	0.00533	5.33E-05 ***	2.63E+00	2.63E+00		Ru-106	
15	Rh-106	5.34E-05 ***	0.00533	5.33E-05 ***	2.63E+00	==========	==========	Rh-106	
16	Ag-110m	5.78E-10 ***	0.00000	5.77E-10 ***	2.85E-05	2.85E-05		Ag-110m	
17	Ag-110	7.69E-12 ***	0.00000	7.68E-12 ***	3.79E-07	==========	==========	Ag-110	
18	Sb-125	4.24E-04 ***	0.04236	4.24E-04 ***	2.09E+01	2.09E+01		Sb-125	
19	Te-125m	9.79E-05 ***	0.00978	9.78E-05 ***	4.82E+00	4.82E+00		Te-125m	
20	I-129	3.38E-08 ***	0.00000	3.38E-08 ***	1.66E-03	1.66E-03		I-129	
21	Cs-134	1.77E-04 ***	0.01768	1.77E-04 ***	8.72E+00	8.72E+00		Cs-134	
22	Cs-137	1.29E-01 ***	12.88680	1.29E-01 ***	6.35E+03	6.35E+03	REPORTABLE!	Cs-137	
23	Ba-137m	1.22E-01 ***	12.18752	1.22E-01 ***	6.01E+03	==========	==========	Ba-137m	
24	Ce-141	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Ce-141	
25	Ce-144	3.13E-05 ***	0.00313	3.13E-05 ***	1.54E+00	1.54E+00		Ce-144	
26	Pr-144m	4.47E-07 ***	0.00004	4.47E-07 ***	2.20E-02	==========	==========	Pr-144m	
27	Np-237	5.69E-07 ***	0.00006	5.68E-07 ***	2.80E-02	2.80E-02		Np-237	
28	Pa-233	5.69E-07 ***	0.00006	5.68E-07 ***	2.80E-02	==========	==========	Pa-233	
29	Pu-238	3.85E-04 ***	0.03846	3.85E-04 ***	1.90E+01	1.90E+01		Pu-238	
30	Pu-239	4.70E-03 ***	0.46952	4.70E-03 ***	2.31E+02	2.31E+02		Pu-239	
31	Pu-241	4.19E-02 ***	4.18571	4.19E-02 ***	2.06E+03	2.06E+03	REPORTABLE!	Pu-241	
32	Am-241	1.38E-03 ***	0.13786	1.38E-03 ***	6.80E+01	6.80E+01		Am-241	
33	Cm-243	1.44E-08 ***	0.00000	1.44E-08 ***	7.09E-04	7.09E-04		Cm-243	
34	U-235	2.58E-06 ***	0.00026	2.58E-06 ***	1.27E-01	1.27E-01		U-235	
35	U-238	1.21E-05 ***	0.00121	1.21E-05 ***	5.96E-01	5.96E-01		U-238	
36	Pu-240	1.25E-03 ***	0.12487	1.25E-03 ***	6.15E+01	6.15E+01		Pu-240	
37	U-234	6.39E-05 ***	0.00638	6.38E-05 ***	3.15E+00	3.15E+00		U-234	
38	Pm-147	3.57E-02 ***	3.56635	3.57E-02 ***	1.76E+03	1.76E+03	REPORTABLE!	Pm-147	
39	Eu-154	1.00E-03 ***	0.09990	9.99E-04 ***	4.92E+01	4.92E+01		Eu-154	
40	Eu-155	1.45E-03 ***	0.14485	1.45E-03 ***	7.14E+01	7.14E+01		Eu-155	
41	U-236	1.70E-06 ***	0.00017	1.70E-06 ***	8.37E-02	8.37E-02		U-236	
42	Pr-144	3.13E-05 ***	0.00313	3.13E-05 ***	1.54E+00	==========	==========	Pr-144	
43	Cm-242	1.46E-07 ***	0.00001	1.46E-07 ***	7.19E-03	7.19E-03		Cm-242	
44	Cm-244	3.41E-07 ***	0.00003	3.41E-07 ***	1.68E-02	1.68E-02		Cm-244	
45	-	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		-	
	TOTALS==>	1.0010E+00 Ci	100.00	1.00000 Ci	49290.264 mCi	27669.755 mCi			

GPU Nuclear

Calculation Sheet

Subject: FH09/FH300 Curie Estimate

Originator: B. Brosey — Date: 8/27/93

Reviewed by: G. Lodde

Calc No: 4240-3233-93-020

Rev. No: 0

Sheet No: 21 of 35

Date: 8/27/93

Attachment 7-1

NORMALIZATION WORKSHEET (1 Ci)

CALCULATED ========== ========== 8/25/93
EXPOSURE RATE PER Ci==> 9.76E-02 mR/h ACTUAL==> 8.40E+00 mR/h ==========
UNITS IN>Ci ========== ========== Today's Date
I.D. NUMBER
OR NAME=>DEFUELING WASTE IN FUEL POOL "A" AT FUEL RACK AREA

	ISOTOPE	INPUT UNIT ACTIVITY	PERCENT (%) of Total	ACTIVITY PER CURIE	ADJUSTED ACTIVITY (mCi)	ADJUSTED WITHOUT DAUGHTERS (mCi)	NRC REPORTABLE If > 1% of TOTAL	ISOTOPES	Sr-90/Cs-137 RATIO
1	H-3	2.04E-03 ***	0.20379	2.04E-03 ***	1.75E+02	1.75E+02		H-3	2.457
2	C-14	8.40E-06 ***	0.00084	8.39E-06 ***	7.22E-01	7.22E-01		C-14	
3	Cr-51	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Cr-51	
4	Mn-54	1.17E-07 ***	0.00001	1.17E-07 ***	1.01E-02	1.01E-02		Mn-54	
5	Fe-55	3.51E-03 ***	0.35064	3.51E-03 ***	3.02E+02	3.02E+02		Fe-55	
6	Co-58	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Co-58	
7	Co-60	1.99E-03 ***	0.19880	1.99E-03 ***	1.71E+02	1.71E+02		Co-60	
8	Ni-63	1.97E-02 ***	1.96798	1.97E-02 ***	1.69E+03	1.69E+03	REPORTABLE!	Ni-63	
9	Zn-65	4.52E-10 ***	0.00000	4.52E-10 ***	3.89E-05	3.89E-05		Zn-65	
10	Sr-89	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Sr-89	
11	Sr-90	3.17E-01 ***	31.66757	3.17E-01 ***	2.73E+04	2.73E+04	REPORTABLE!	Sr-90	
12	Y-90	3.17E-01 ***	31.66757	3.17E-01 ***	2.73E+04	==========	==========	Y-90	
13	Tc-99	5.99E-05 ***	0.00598	5.98E-05 ***	5.15E+00	5.15E+00		Tc-99	
14	Ru-106	5.34E-05 ***	0.00533	5.33E-05 ***	4.59E+00	4.59E+00		Ru-106	
15	Rh-106	5.34E-05 ***	0.00533	5.33E-05 ***	4.59E+00	==========	==========	Rh-106	
16	Ag-110m	5.78E-10 ***	0.00000	5.77E-10 ***	4.97E-05	4.97E-05		Ag-110m	
17	Ag-110	7.69E-12 ***	0.00000	7.68E-12 ***	6.61E-07	==========	==========	Ag-110	
18	Sb-125	4.24E-04 ***	0.04236	4.24E-04 ***	3.65E+01	3.65E+01		Sb-125	
19	Te-125m	9.79E-05 ***	0.00978	9.78E-05 ***	8.42E+00	8.42E+00		Te-125m	
20	I-129	3.38E-08 ***	0.00000	3.38E-08 ***	2.91E-03	2.91E-03		I-129	
21	Cs-134	1.77E-04 ***	0.01768	1.77E-04 ***	1.52E+01	1.52E+01		Cs-134	
22	Cs-137	1.29E-01 ***	12.88680	1.29E-01 ***	1.11E+04	1.11E+04	REPORTABLE!	Cs-137	
23	Ba-137m	1.22E-01 ***	12.18752	1.22E-01 ***	1.05E+04	==========	==========	Ba-137m	
24	Ce-141	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		Ce-141	
25	Ce-144	3.13E-05 ***	0.00313	3.13E-05 ***	2.69E+00	2.69E+00		Ce-144	
26	Pr-144m	4.47E-07 ***	0.00004	4.47E-07 ***	3.84E-02	==========	==========	Pr-144m	
27	Np-237	5.69E-07 ***	0.00006	5.68E-07 ***	4.89E-02	4.89E-02		Np-237	
28	Pa-233	5.69E-07 ***	0.00006	5.68E-07 ***	4.89E-02	==========	==========	Pa-233	
29	Pu-238	3.85E-04 ***	0.03846	3.85E-04 ***	3.31E+01	3.31E+01		Pu-238	
30	Pu-239	4.70E-03 ***	0.46952	4.70E-03 ***	4.04E+02	4.04E+02		Pu-239	
31	Pu-241	4.19E-02 ***	4.18571	4.19E-02 ***	3.60E+03	3.60E+03	REPORTABLE!	Pu-241	
32	Am-241	1.38E-03 ***	0.13786	1.38E-03 ***	1.19E+02	1.19E+02		Am-241	
33	Cm-243	1.44E-08 ***	0.00000	1.44E-08 ***	1.24E-03	1.24E-03		Cm-243	
34	U-235	2.58E-06 ***	0.00026	2.58E-06 ***	2.22E-01	2.22E-01		U-235	
35	U-238	1.21E-05 ***	0.00121	1.21E-05 ***	1.04E+00	1.04E+00		U-238	
36	Pu-240	1.25E-03 ***	0.12487	1.25E-03 ***	1.07E+02	1.07E+02		Pu-240	
37	U-234	6.39E-05 ***	0.00638	6.38E-05 ***	5.49E+00	5.49E+00		U-234	
38	Pm-147	3.57E-02 ***	3.56635	3.57E-02 ***	3.07E+03	3.07E+03	REPORTABLE!	Pm-147	
39	Eu-154	1.00E-03 ***	0.09990	9.99E-04 ***	8.60E+01	8.60E+01		Eu-154	
40	Eu-155	1.45E-03 ***	0.14485	1.45E-03 ***	1.25E+02	1.25E+02		Eu-155	
41	U-236	1.70E-06 ***	0.00017	1.70E-06 ***	1.46E-01	1.46E-01		U-236	
42	Pr-144	3.13E-05 ***	0.00313	3.13E-05 ***	2.69E+00	==========	==========	Pr-144	
43	Cm-242	1.46E-07 ***	0.00001	1.46E-07 ***	1.26E-02	1.26E-02		Cm-242	
44	Cm-244	3.41E-07 ***	0.00003	3.41E-07 ***	2.93E-02	2.93E-02		Cm-244	
45	-	***	0.00000	0.00E+00 ***	0.00E+00	0.00E+00		-	
	TOTALS==>	1.0010E+00 Ci	100.00	1.00000 Ci	86056.756 mCi	48309.122 mCi			

GPU Nuclear

Calculation Sheet

Subject: FH109/FH300 Curie Estimate

Originator: B. Brown Date

Calc No: 4240-3233-93-020

Reviewed by: Date

Rev No: 0

Sheet No: 22 of 35

Date: 5/1

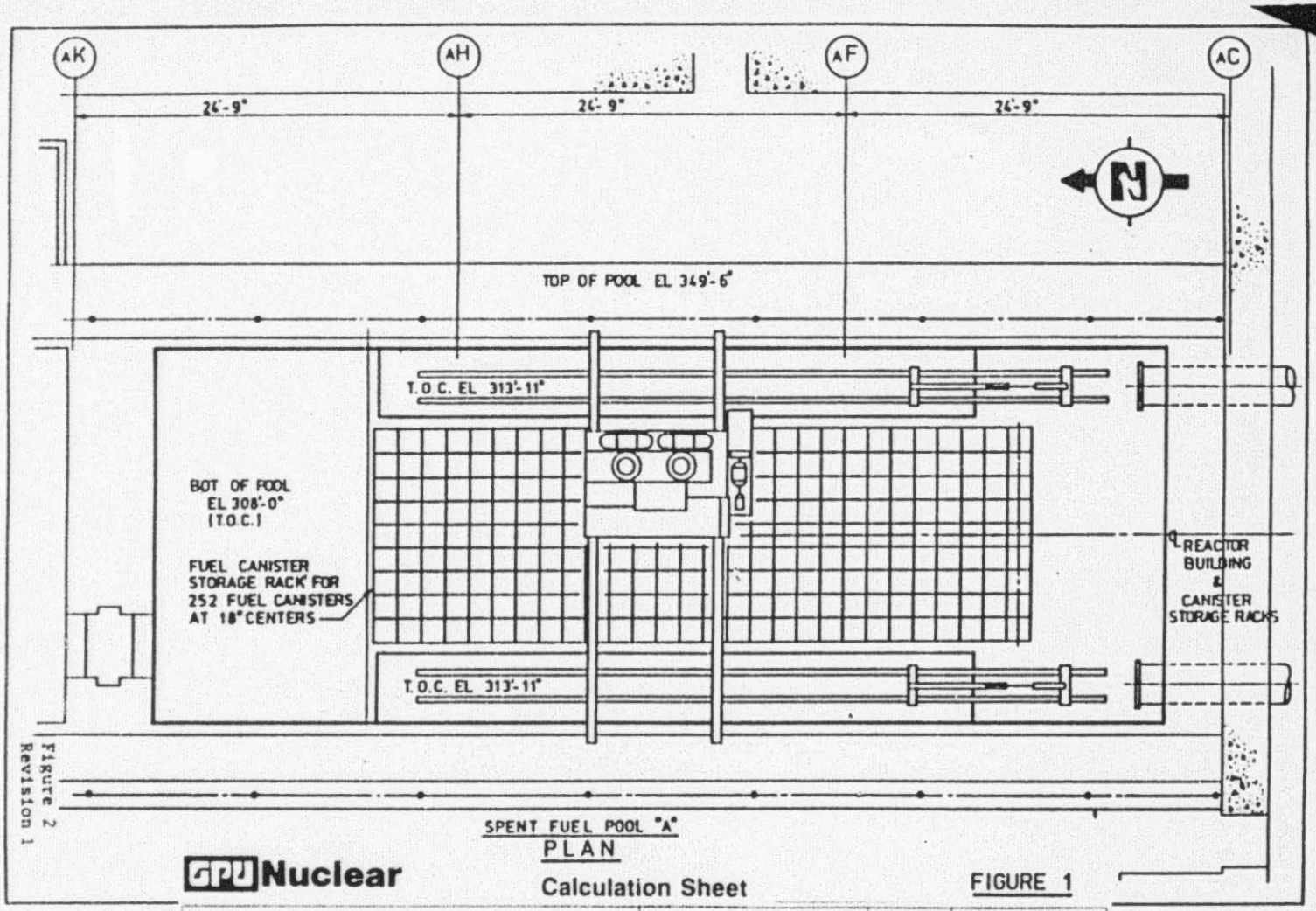


Figure 2
Revision 1

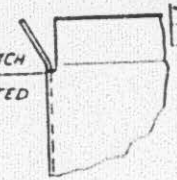
GPU Nuclear

Calculation Sheet

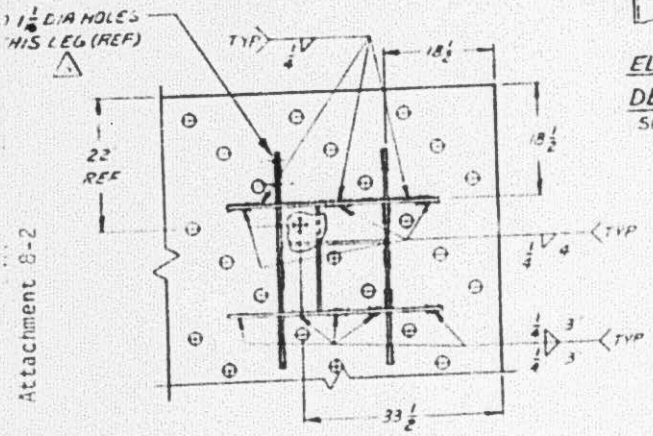
FIGURE 1

Subject		Calc No	Rev No	Sheet No
FH109/FH300 Curie Estimate		4240-3233-93-020	0	23 of 35
Originator B. Brosey B. Brosey	Date 8/27/93	Reviewed by G. Lodde G. Lodde	Date 8/23/93	

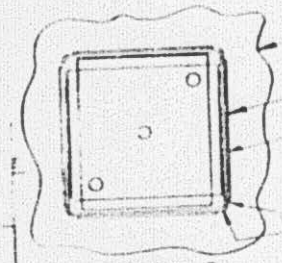
DETAIL 3
SCALE: 3" = 1'-0"



ELEVATION
DETAIL 1
SCALE: HALF



VIEW B-B
15737-2-C406A-00037-05



DETAIL 2
SCALE: 1 1/2" = 1'-0"
(SHOWING TYPICAL WELDING OF ITEM 13 TO ITEM 3)

THREE MILE ISLAND-UNIT 2

NEXT ASSEMBLY	FINAL ASSEMBLY
APPLICATION	
SEE NOTE 1	
MATERIAL	FINISH

TO ITEM 5 (SUPPORT COLUMN) PRIOR TO STRUCTURAL WELDING ONLY IF NECESSARY TO MAINTAIN TOP PLATE FLATNESS.

6 - BEFORE ASSEMBLY, MODIFY 2 PIECES OF ITEM 7 AS SHOWN IN SECTION C-C AND 2 PIECES AS SHOWN IN SECTION D-D.

SEE NOTE 6

QTY/ASSY	ITEM	PART NO	DESCRIPTION	MATERIAL	
2	15	83C0941-1	BASE WELDMENT - TYPE L		
4	14	83C0958-1	LEVELING PAD		
4	13	83C0957-1	SUPPORT COLUMN - TYPE B		
4	12	83C0954-1	TOP GUIDE - TYPE B		
4	11	83B0953-1	SIDE PANEL		
63	10	83C0948-1	BOTTOM GUIDE		
53	9	83C0947-1	TOP GUIDE - TYPE A		
96	8	83B0946-2	TIE STRIP - TYPE 2		
60	7	83B0946-1	TIE STRIP - TYPE 1		
48	6	83B0945-1	TIE ANGLE		
28	5	83C0944-1	SUPPORT COLUMN - TYPE A		
1	4	83D0943-1	TOP PLATE		
1	3	83D0940-1	BASE PLATE		
2	2	83C0942	BASE WELDMENT - TYPE R		
X	1	83E0919-1	FUEL CANISTER STORAGE RACK 7x9		

PARTS LIST

TOLERANCES UNLESS OTHERWISE SPECIFIED

APPROVALS	DATE
DRAWN	8/27/84
CHECKED	8/27/84
PROJ ENGR	8/27/84
DESIGN ENGR	
PROJ MGR	
MGR	

PROJECT NO. 5262-120

NUCLEAR ENERGY SERVICES, INC. DANBURY, CONNECTICUT

FUEL CANISTER STORAGE RACK 7X9

SIZE E | DRAWING NO. 53603 | 83E0919

SCALE 1" = 1'-0"

17,380 lbs

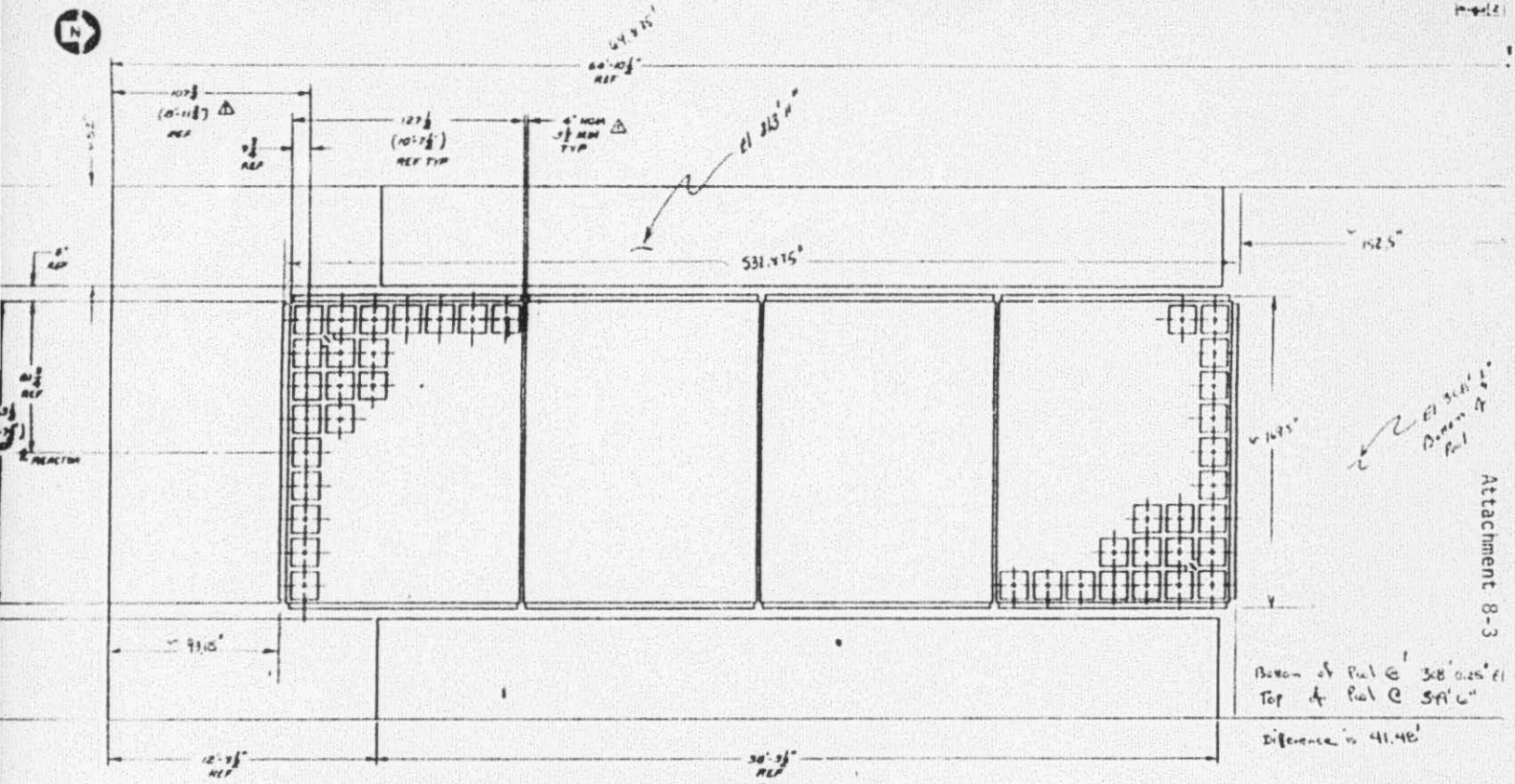
Attachment 8-2

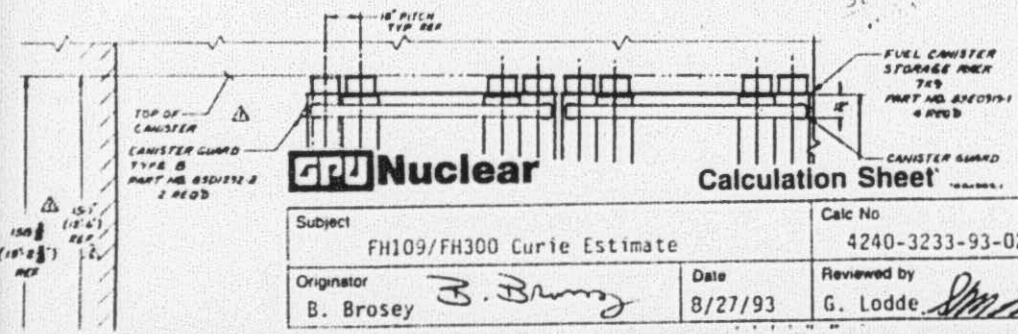
GPU Nuclear Calculation Sheet

Subject: TMI09/FH300 Curve Estimate

Calculation No: 4240-3233-93-020 | Rev No: 0 | Sheet No: 34 of 35

Signature: B. Brosey | Date: 8/27/93 | Reviewed by: G. Lodde | Date: 8/27/93





GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	25 of 35
Originator: B. Brosey	Date: 8/27/93	Reviewed by: G. Lodde	Date: 8/27/93

15737-2-C40

ENT CHAMFERED CORNER
LUG TOWARD CENTER
PLATE AS SHOWN

DOC CAT 1.3 SYI NONE

GPU Nuclear — **Calculation Sheet**

Subject	Calc No	Rev. No	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	26 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

7-31-93

15737-2-C4064-00034-04

QTY/ASSY	ITEM	PART NO	DESCRIPTION	MATERIAL	SOURCE
			PARTS LIST		

TOLERANCES UNLESS OTHERWISE SPECIFIED

DECIMALS 1 PLACE	2 PLACE	3 PLACE
± .03	± —	± —
FRACTIONS ± 1/16	ANGLES ± —	CHAMFERS ± —

SURFACE FINISH 63 OR BETTER

FILLETS .02 TO .03 RADIUS

BREAK EDGES .02 RADIUS OR CHAMFER 1X45

NATIONAL STANDARD TOLERANCES APPLY TO COMMERCIAL MATLS

THREADS UNIFIED CL 2A-2B PER ASA B1.1

DIMENSIONS ARE IN INCHES BASED ON 68°F (20°C)

DWGS DO NOT INCLUDE ALLOWANCE FOR FAB OR WELD SHRINKAGE

DWGS AND TOLERANCES ARE TO BE INTERPRETED IN ACCORDANCE WITH ANSI Y14.5 1973

CONTROLLED STATUS/USAGE STAMP

APPROVALS		DATE
DRAWN	R.J. Finley	10-8-89
CHECKED	W.R. Mantle	10/20/89
PROJ DSGN	W.R. Mantle	10/20/89
PROD ENGR	[illegible]	10/20/89
STRC ENGR	[illegible]	11/1/89
ASST DSGN ENG	[illegible]	11-1-89
PROJ MGR	[illegible]	11/1/89
QA MGR	[illegible]	[illegible]

PROJECT TASK 5262-120

nes

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TITLE: TOP PLATE

SIZE	FSCM NO	DRAWING NO	REV
D	53603	83D0943	3

SCALE 3/4" = 1'-0" WEIGHT APPROX 3044 LBS (SOLID PLATE WEIGHT)

EE MILE ISLAND-UNIT 2

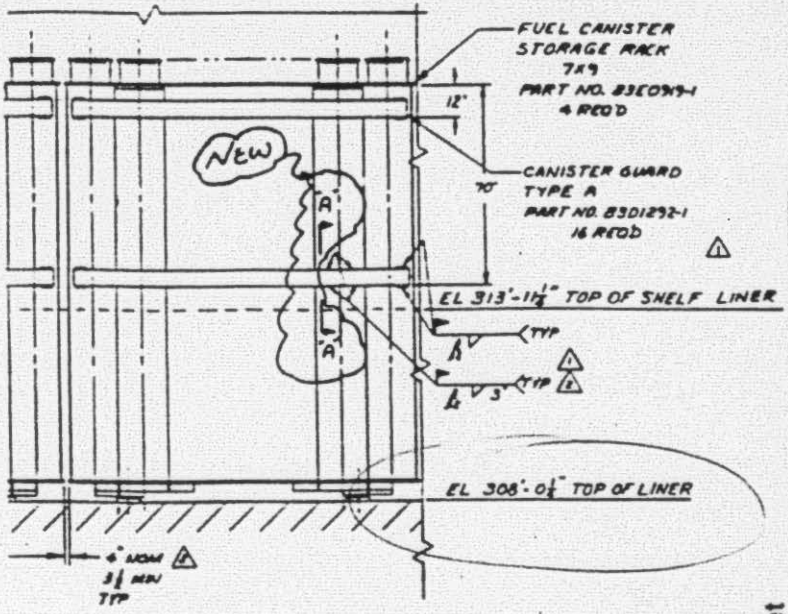
83E0919	83E0919
NEXT ASSEMBLY	FINAL ASSEMBLY
APPLICATION	
SEE NOTE1	SEE NOTE2
MATERIAL	FINISH

Attachment B-4

24 X

SUPPLEMENTAL SHEET
FIELD CHANGE REQUEST
FIELD QUESTIONNAIRE

NO. 85-257
PAGE 2 OF 2



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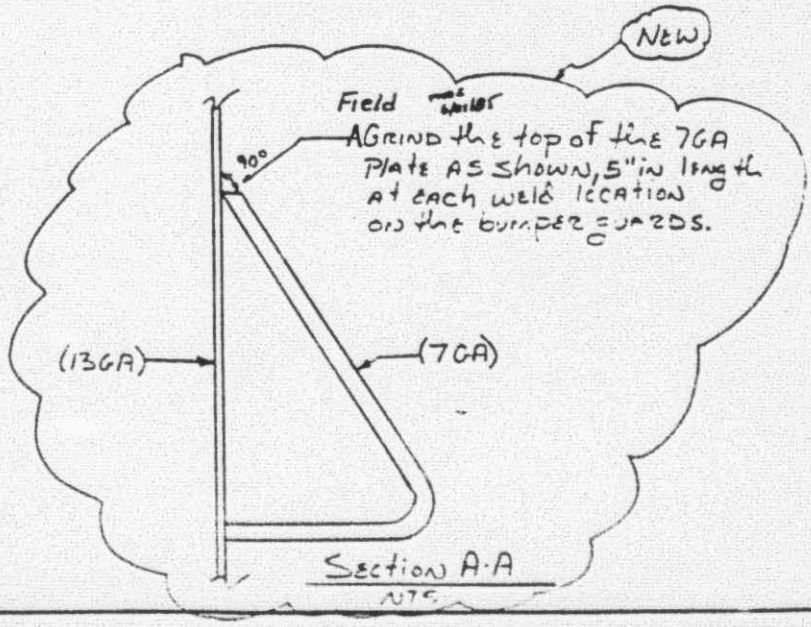


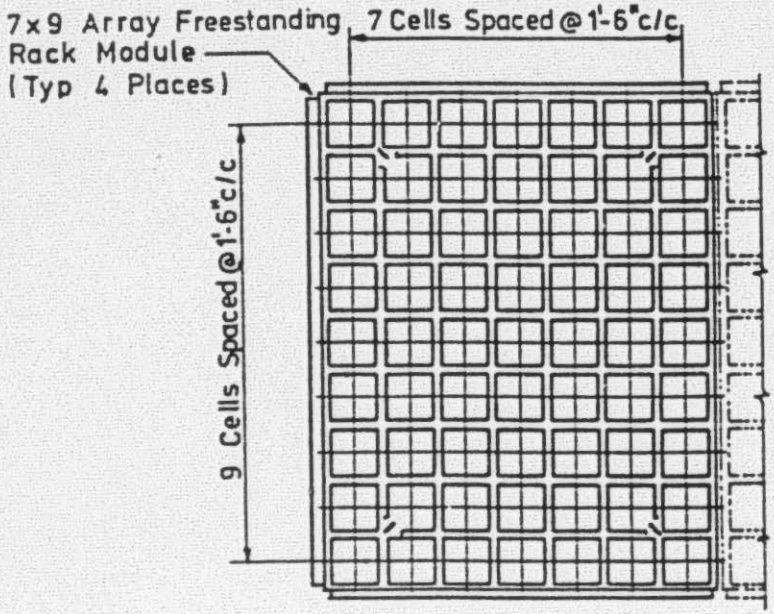
Section A-A
NTS

GPU Nuclear

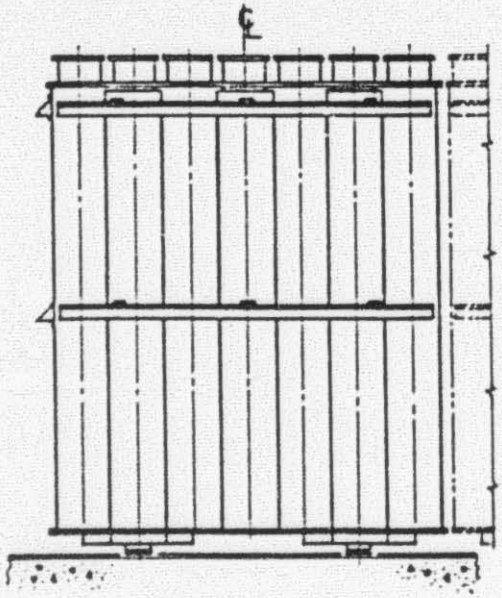
Calculation Sheet

Subject: FH109/FH300 Curie Estimate	Calc No: 4240-3233-93-020	Rev No: 0	Sheet No: 27 of 35
Originator: B. Brosey	Date: 8/27/93	Reviewed by: G. Lodde	Date: 8/27/93

FORM 4000-ADM-7350.05-2 (11/83)



PLAN



ELEVATION VIEW

(FUEL HANDLING BUILDING)

FUEL CANISTER STORAGE RACKS

Figure 4
Revision 1

GPU Nuclear

Calculation Sheet

Subject: FH109/FH300 Curie Estimate		Calc No: 4240-3233-93-020	Rev. No: 0
Originator: B. Brosey	Date: 8/27/93	Reviewed by: G. Lodde	Sheet No: 28 of 35
			Date: 5/27/93

Attachment 9-1

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: FUELPARA.MS4
Run Date: August 26, 1993
Run Time: 2:05 p.m. Thursday
Duration: 0:24:45

File Ref:
Date:
By:
Checked:

Case Title: FUEL POOL A FUEL RACK AREA

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	1203.3504	39.0	5.8
Dose point coordinate Y:	676.75125	22.0	2.4
Dose point coordinate Z:	215.265	7.0	.7
Rectangular volume width :	430.53	14.0	1.5
Rectangular volume length:	402.27199	13.0	2.4
Rectangular volume height:	1353.5025	44.0	4.9
Shield 1:	7.62	0.0	3.0
Air Gap:	793.45841	26.0	.4

Source Volume: 2.34413e+8 cm^3 8278.23 cu ft. 1.43048e+7 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Iron	0.15809		
Water		1.0	

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	22
Y Direction	22
Z Direction	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ag-110	7.6900e-012	3.2805e-014	Ag-110m	5.7800e-010	2.4657e-012
Am-241	1.3800e-003	5.8870e-006	Ba-137m	1.2200e-001	5.2045e-004
C-14	8.4000e-006	3.5834e-008	Ce-141	0.0000e+000	0.0000e+000
Ce-144	3.1300e-005	1.3352e-007	Cm-242	1.4600e-007	6.2283e-010
Cm-243	1.4400e-008	6.1430e-011	Cm-244	3.4100e-007	1.4547e-009
Co-58	0.0000e+000	0.0000e+000	Co-60	1.9900e-003	8.4893e-006
Cr-51	0.0000e+000	0.0000e+000	Cs-134	1.7700e-004	7.5508e-007
Cs-137	1.2900e-001	5.5031e-004	Eu-154	1.0000e-003	4.2660e-006
Eu-155	1.4500e-003	6.1857e-006	Fe-55	3.5100e-003	1.4974e-005
H-3	2.0400e-003	8.7026e-006	I-129	3.3800e-008	1.4419e-010
Mn-54	1.1700e-007	4.9912e-010	Ni-63	1.9700e-002	8.4040e-005
Np-237	5.6900e-007	2.4273e-009	Pa-233	5.6900e-007	2.4273e-009
Pm-147	3.5700e-002	1.5230e-004	Pr-144	3.1300e-005	1.3352e-007
Pr-144m	4.4700e-007	1.9069e-009	Pu-238	3.8500e-004	1.6424e-006
Pu-239	4.7000e-003	2.0050e-005	Pu-240	1.2500e-003	5.3325e-006
Pu-241	4.1900e-002	1.7874e-004	Rh-106	5.3400e-005	2.2780e-007
Ru-106	5.3400e-005	2.2780e-007	Sb-125	4.2400e-004	1.8088e-006
Sr-89	0.0000e+000	0.0000e+000	Sr-90	3.1700e-001	1.3523e-003
Tc-99	5.9900e-005	2.5553e-007	Te-125m	9.7900e-005	4.1764e-007
U-234	6.3900e-005	2.7260e-007	U-235	2.5800e-006	1.1006e-008
U-236	1.7000e-006	7.2521e-009	U-238	1.2100e-005	5.1618e-008
Y-90	3.1700e-001	1.3523e-003	Zn-65	4.5200e-010	1.9282e-012

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev. No	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	29 of 35
Originator: B. Brosey, Date: 8/27/93	Reviewed by: G. Lodde		Date: 8/27/93

Attachment 9-2

Page : 2
DOS File: FUELPARA.MS4
Run Date: August 26, 1993
Run Time: 2:05 p.m. Thursday
Title : FUEL POOL A FUEL RACK AREA

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	2.624e+007	2.279e-003	3.858e-003	3.486e-006	5.902e-006
0.15	1.795e+005	5.081e-005	1.162e-004	8.367e-008	1.914e-007
0.2	3.777e+006	2.089e-003	5.726e-003	3.686e-006	1.011e-005
0.3	7.837e+004	9.780e-005	2.988e-004	1.855e-007	5.669e-007
0.4	5.177e+006	1.102e-002	3.357e-002	2.147e-005	6.540e-005
0.5	2.207e+006	7.021e-003	2.055e-002	1.378e-005	4.035e-005
0.6	4.079e+009	1.793e+001	4.999e+001	3.500e-002	9.758e-002
0.8	2.061e+007	1.501e-001	3.816e-001	2.855e-004	7.258e-004
1.0	8.524e+007	9.147e-001	2.149e+000	1.686e-003	3.961e-003
1.5	8.828e+007	1.886e+000	3.828e+000	3.172e-003	6.440e-003
2.0	8.964e+003	3.042e-004	5.659e-004	4.704e-007	8.751e-007
TOTAL:	4.310e+009	2.090e+001	5.641e+001	4.018e-002	1.088e-001

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No.	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	30 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: FUELPARA.MS4
Run Date: August 26, 1993
Run Time: 2:38 p.m. Thursday
Duration: 0:24:45

File Ref:
Date:
By:
Checked:

Case Title: FUEL POOL A FUEL RACK AREA

GEOMETRY 11 - Rectangular Volume

	centimeters	feet and inches	
Dose point coordinate X:	1325.2704	43.0	5.8
Dose point coordinate Y:	676.75125	22.0	2.4
Dose point coordinate Z:	215.265	7.0	.7
Rectangular volume width :	430.53	14.0	1.5
Rectangular volume length:	402.27199	13.0	2.4
Rectangular volume height:	1353.5025	44.0	4.9
Shield 1:	7.62	0.0	3.0
Air Gap:	915.37841	30.0	.4

Source Volume: 2.34413e+8 cm^3 8278.23 cu ft. 1.43048e+7 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Iron	0.15809		
Water		1.0	

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

INTEGRATION PARAMETERS

	Quadrature Order
X Direction	22
Y Direction	22
Z Direction	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ag-110	7.6900e-012	3.2805e-014	Ag-110m	5.7800e-010	2.4657e-012
Am-241	1.3800e-003	5.8870e-006	Ba-137m	1.2200e-001	5.2045e-004
C-14	8.4000e-006	3.5834e-008	Ce-141	0.0000e+000	0.0000e+000
Ce-144	3.1300e-005	1.3352e-007	Cm-242	1.4600e-007	6.2283e-010
Cm-243	1.4400e-008	6.1430e-011	Cm-244	3.4100e-007	1.4547e-009
Co-58	0.0000e+000	0.0000e+000	Co-60	1.9900e-003	8.4893e-006
Cr-51	0.0000e+000	0.0000e+000	Cs-134	1.7700e-004	7.5508e-007
Cs-137	1.2900e-001	5.5031e-004	Eu-154	1.0000e-003	4.2660e-006
Eu-155	1.4500e-003	6.1857e-006	Fe-55	3.5100e-003	1.4974e-005
H-3	2.0400e-003	8.7026e-006	I-129	3.3800e-008	1.4419e-010
Mn-54	1.1700e-007	4.9912e-010	Ni-63	1.9700e-002	8.4040e-005
Np-237	5.6900e-007	2.4273e-009	Pa-233	5.6900e-007	2.4273e-009
Pm-147	3.5700e-002	1.5230e-004	Pr-144	3.1300e-005	1.3352e-007
Pr-144m	4.4700e-007	1.9069e-009	Pu-238	3.8500e-004	1.6424e-006
Pu-239	4.7000e-003	2.0050e-005	Pu-240	1.2500e-003	5.3325e-006
Pu-241	4.1900e-002	1.7874e-004	Rh-106	5.3400e-005	2.2780e-007
Ru-106	5.3400e-005	2.2780e-007	Sb-125	4.2400e-004	1.8088e-006
Sr-89	0.0000e+000	0.0000e+000	Sr-90	3.1700e-001	1.3523e-003
Tc-99	5.9900e-005	2.5553e-007	Te-125m	9.7900e-005	4.1764e-007
U-234	6.3900e-005	2.7260e-007	U-235	2.5800e-006	1.1006e-008
U-236	1.7000e-006	7.2521e-009	U-238	1.2100e-005	5.1618e-008
Y-90	3.1700e-001	1.3523e-003	Zn-65	4.5200e-010	1.9282e-012

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
FH109/FH300 Curie Estimate	4240-3233-93-020	0	31 of 35
Originator: B. Brosey, Date: 8/27/93	Reviewed by: G. Lodde		Date: 5/27/93

Page : 2
DOS File: FUELPARA.MS4
Run Date: August 26, 1993
Run Time: 2:38 p.m. Thursday
Title : FUEL POOL A FUEL RACK AREA

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	2.624e+007	1.829e-003	3.097e-003	2.798e-006	4.738e-006
0.15	1.795e+005	4.082e-005	9.344e-005	6.722e-008	1.539e-007
0.2	3.777e+006	1.679e-003	4.609e-003	2.964e-006	8.135e-006
0.3	7.837e+004	7.872e-005	2.410e-004	1.493e-007	4.571e-007
0.4	5.177e+006	8.877e-003	2.709e-002	1.730e-005	5.279e-005
0.5	2.207e+006	5.658e-003	1.660e-002	1.111e-005	3.259e-005
0.6	4.079e+009	1.446e+001	4.040e+001	2.822e-002	7.885e-002
0.8	2.061e+007	1.211e-001	3.086e-001	2.303e-004	5.869e-004
1.0	8.524e+007	7.383e-001	1.738e+000	1.361e-003	3.204e-003
1.5	8.828e+007	1.523e+000	3.099e+000	2.563e-003	5.213e-003
2.0	8.964e+003	2.459e-004	4.583e-004	3.803e-007	7.087e-007
TOTAL:	4.310e+009	1.686e+001	4.559e+001	3.240e-002	8.795e-002

GPU Nuclear

Calculation Sheet

Subject: FH109/FH300 Curie Estimate		Calc No 4240-3233-93-020	Rev. No. 0	Sheet No. 32 of 35
Originator B. Brosey	Date 8/27/93	Reviewed by G. Lodde		Date 8/27/93

Attachment 9-5

Page : 2
DOS File: FP-B.MS4
Run Date: August 26, 1993
Run Time: 3:35 p.m. Thursday
Title : DEWATERING STATION AREA OF FUEL POOL A

========== RESULTS FOR SENSITIVITY REFERENCE CASE (X = 30.48) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	2.624e+007	6.400e-001	8.650e+000	9.792e-004	1.323e-002
0.15	1.795e+005	8.244e-003	8.013e-002	1.358e-005	1.319e-004
0.2	3.777e+006	2.719e-001	2.070e+000	4.798e-004	3.653e-003
0.3	7.837e+004	1.070e-002	5.504e-002	2.029e-005	1.044e-004
0.4	5.177e+006	1.116e+000	4.581e+000	2.174e-003	8.926e-003
0.5	2.207e+006	6.764e-001	2.361e+000	1.328e-003	4.635e-003
0.6	4.079e+009	1.666e+003	5.161e+003	3.252e+000	1.007e+001
0.8	2.061e+007	1.321e+001	3.443e+001	2.513e-002	6.548e-002
1.0	8.524e+007	7.733e+001	1.798e+002	1.426e-001	3.314e-001
1.5	8.828e+007	1.492e+002	2.886e+002	2.510e-001	4.855e-001
2.0	8.964e+003	2.329e-002	4.057e-002	3.602e-005	6.273e-005
TOTAL:	4.310e+009	1.908e+003	5.682e+003	3.675e+000	1.099e+001

SENSITIVITY RESULTS For: X (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
1	15.24	1.593e+003	5.289e+003	3.065e+000	1.023e+001
2	23.70667	1.860e+003	5.666e+003	3.582e+000	1.096e+001
3	32.17333	1.912e+003	5.670e+003	3.683e+000	1.096e+001
4	40.64	1.910e+003	5.555e+003	3.679e+000	1.074e+001
5	49.10667	1.890e+003	5.385e+003	3.640e+000	1.042e+001
6	57.57333	1.859e+003	5.185e+003	3.582e+000	1.003e+001
7	66.04	1.822e+003	4.968e+003	3.511e+000	9.610e+000
8	74.50667	1.779e+003	4.745e+003	3.429e+000	9.179e+000
9	82.97333	1.733e+003	4.522e+003	3.339e+000	8.749e+000
10	91.44	1.683e+003	4.304e+003	3.244e+000	8.326e+000

Use the Display Menu For Energy Group Results For All Cases.

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	33 of 35

Originator	Date	Reviewed by	Date
B. Brosey	8/27/93	G. Lodde	8/27/93

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: FP-8.MS4
Run Date: August 26, 1993
Run Time: 3:35 p.m. Thursday
Duration: 0:28:02

File Ref:
Date: 8/27/93
By:
Checked: 8/27/93

Case Title: DEWATERING STATION AREA OF FUEL POOL A

GEOMETRY 4 - Vertical Rectangular Area

	centimeters	feet and inches	
Dose point coordinate X:	30.48	1.0	.0
Dose point coordinate Y:	360.045	11.0	9.7
Dose point coordinate Z:	193.67495	6.0	4.2
Rectangular area height:	720.09	23.0	7.5
Rectangular area width:	387.35	12.0	8.5
Shield 1:	7.62	0.0	3.0
Air Gap:	22.86	0.0	9.0

Source Area: 278927. sq cm 300.234 sq ft. 43233.8 sq in.

MATERIAL DENSITIES (g/cm^3)

Material	Shield 1 Slab	Air Gap
Air		0.00122
Water	1.0	

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Z Direction	30
Y Direction	30

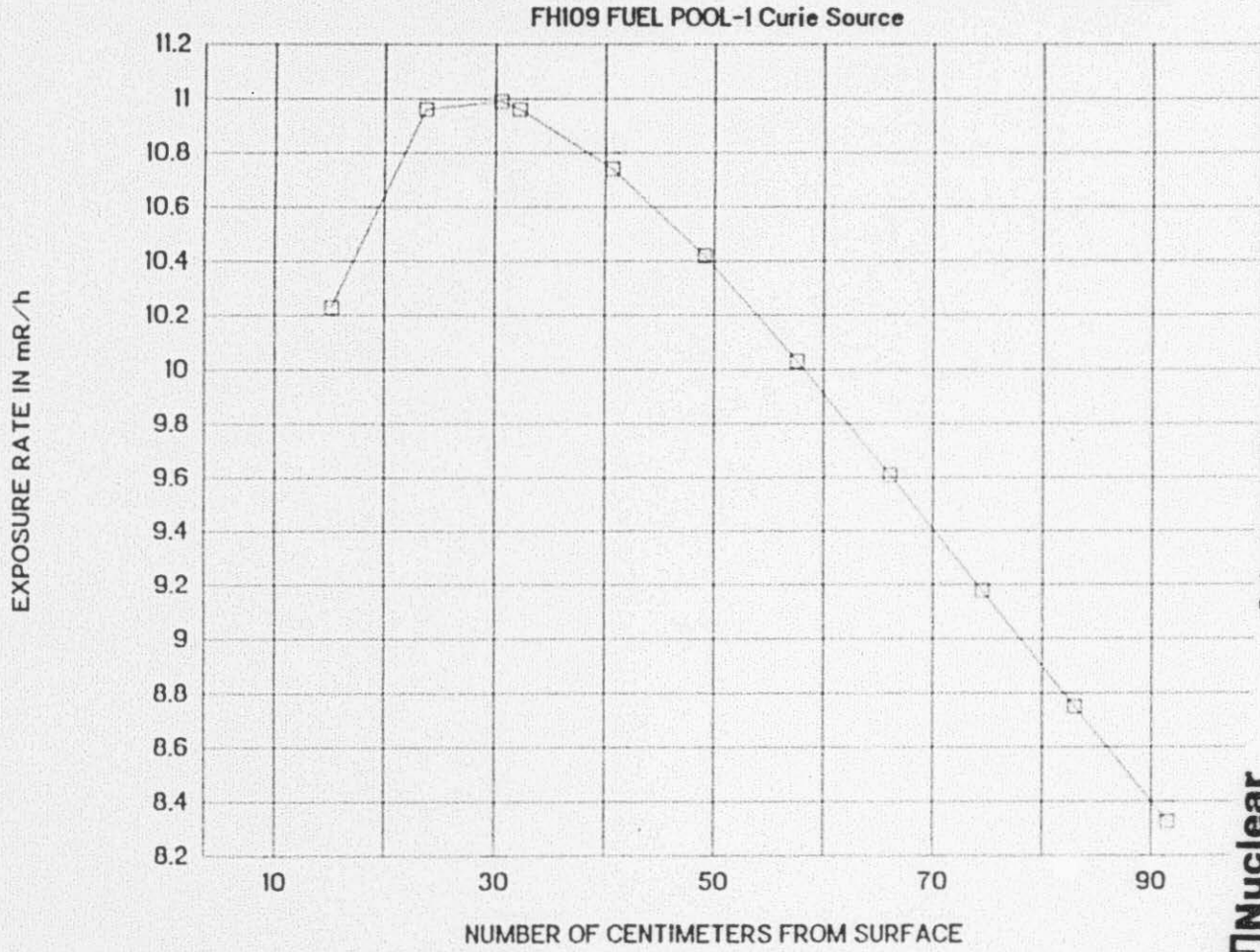
SOURCE NUCLIDES

Nuclide	curies	µCi/cm³	Nuclide	curies	µCi/cm³
Ag-110	7.6900e-012	2.7570e-011	Ag-110m	5.7800e-010	2.0722e-009
Am-241	1.3800e-003	4.9475e-003	Ba-137m	1.2200e-001	4.3739e-001
C-14	8.4000e-006	3.0115e-005	Ce-141	0.0000e+000	0.0000e+000
Ce-144	3.1300e-005	1.1222e-004	Cm-242	1.4600e-007	5.2343e-007
Cm-243	1.4400e-008	5.1626e-008	Cm-244	3.4100e-007	1.2225e-006
Co-58	0.0000e+000	0.0000e+000	Co-60	1.9900e-003	7.1345e-003
Cr-51	0.0000e+000	0.0000e+000	Cs-134	1.7700e-004	6.3457e-004
Cs-137	1.2900e-001	4.6249e-001	Eu-154	1.0000e-003	3.5852e-003
Eu-155	1.4500e-003	5.1985e-003	Fe-55	3.5100e-003	1.2584e-002
H-3	2.0400e-003	7.3137e-003	I-129	3.3800e-008	1.2118e-007
Mn-54	1.1700e-007	4.1946e-007	Ni-63	1.9700e-002	7.0628e-002
Np-237	5.6900e-007	2.0400e-006	Pa-233	5.6900e-007	2.0400e-006
Pm-147	3.5700e-002	1.2799e-001	Pr-144	3.1300e-005	1.1222e-004
Pr-144m	4.4700e-007	1.6026e-006	Pu-238	3.8500e-004	1.3803e-003
Pu-239	4.7000e-003	1.6850e-002	Pu-240	1.2500e-003	4.4815e-003
Pu-241	4.1900e-002	1.5022e-001	Rh-106	5.3400e-005	1.9145e-004
Ru-106	5.3400e-005	1.9145e-004	Sb-125	4.2400e-004	1.5201e-003
Sr-89	0.0000e+000	0.0000e+000	Sr-90	3.1700e-001	1.1365e+000
Tc-99	5.9900e-005	2.1475e-004	Te-125m	9.7900e-005	3.5099e-004
U-234	6.3900e-005	2.2909e-004	U-235	2.5800e-006	9.2497e-006
U-236	1.7000e-006	6.0948e-006	U-238	1.2100e-005	4.3381e-005
Y-90	3.1700e-001	1.1365e+000	Zn-65	4.5200e-010	1.6205e-009

GPU Nuclear — Calculation Sheet

Subject	Calc No	Rev. No.	Sheet No
FH109/FH300 Curie Estimate	4240-3233-93-020	0	01
Originator B. Brosey	**Date** 8/27/93	**Reviewed by** G. Lodde	**Date** 8/27/93

EXPOSURE RATE FROM AREA SOURCE



GPU Nuclear

Calculation Sheet

Subject: FH109/FH300 Curie Estimate	Calc No: 4240-3233-93-020	Rev. No: 0	Sheet No: 35 of 35
Originator: B. Brosey	Date: 8/27/93	Reviewed By: G. Lodde	Date: 8/27/93

Attachment 9-7

GPU Nuclear **Calculation Sheet**

Subject	Calc No	Rev. No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	1 of 54

Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	9/8/93	G. Lodde Gm Lodde	9/10/93

1.0 PROBLEM STATEMENT

The purpose of this preliminary calculation is to estimate the curie loading of the "A" & "B" Makeup Demineralizers located in the Auxiliary bldg. cubicles AX114 & AX115. Radiological survey data will be used to provide the exposure rate information necessary for this estimate.

2.0 SUMMARY OF RESULTS

Based on the Radiological Controls survey data, the "A" & "B" Demineralizers contain the following total activities.

"A" DEMINERALIZER	"B" DEMINERALIZER
3663 Curies ± ~38%	6706 Curies + ~50% - ~77%

Isotopic concentrations per curie are listed in attachments 2-1 & 2-2.

The following table contains the results from previous estimates of the activity contained in the TMI-2 Demineralizers (see references).

7/16/93

	REPORT	DATE	"A" DEMIN No. Ci's Cs-134	"A" DEMIN No. Ci's Cs-137	"A" DEMIN No. Ci's Sr-90	"B" DEMIN No. Ci's Cs-134	"B" DEMIN No. Ci's Cs-137	"B" DEMIN No. Ci's Sr-90
1	GEND-INF-013, Vol. II, POST ACCIDENT ESTIMATES	9/86	286	3677		543	7035	
2	HEDL-7285, Fuel Assessment of the TMI-2 Makeup Demin's ...	10/83		3400+or-74%				
3	TMI-2, TPB 85-10, rev 0, PRE ELUTION	4/22/85		1140			4365+or-12%	
4	TMI-2, TPB 85-10, rev 0, POST ELUTION	4/22/85		317			813	
5	TMI-2, TPB 85-10b, rev 1, POST ELUTION	7/10/85		380+or-20%			440+or-20%	
6	TMI-2, Division SER, 15737-2-G07-117, rev 0	11/2/88				7.3	530	100
7	THIS ESTIMATE	7/12/93	3	978	875	9	3266	168

3.0 REFERENCES

3.1 Microshield Radiation Shielding Computer Code, Version 4, Grove Engineering, Inc., 15215 Shady Grove Rd., Rockville, MD 20850.

3.2 Lotus 1-2-3, Release 2.2, Lotus Development Corporation, 55 Cambridge Parkway, Cambridge, MA 02142.

3.3 "The Health Physics and Radiological Health Handbook", Scinta, Inc., Silver Springs, MD., 1992.

3.4 LA-9795-MS, "NDA Measurements of the Demineralizers at TMI-2", Los Alamos National Laboratory, Los Alamos, New Mexico 87545, 8/83.

3.5 GPUNC Engineering Calculation No. 4249-3211-90-069, "MU & P Demineralizer Fuel Estimates", 11/16/90.

3.0 REFERENCES Cont'd

3.6 TMI-2 Technical Planning Bulletin, TPB-85-10, rev 0, "Estimates of TMI-2 Letdown Demineralizer Resin Retained and Eluted Fission Products and Fuel", 4/22/85.

3.7 TMI-2 Technical Planning Bulletin, TPB-85-10b, rev 1, "Post Elution Estimates of Cs-137 in Letdown Demineralizer Resin", 7/10/85.

3.8 TMI-2 Division Safety Evaluation Report, SER 15737-2-G07-117, "In-Place Storage of Makeup and Purification Demineralizer Resins During PDMS", 11/2/88.

3.9 HEDL-7285, "Fuel Assessment of the Three Mile Island Unit 2 Makeup Demineralizers by Compton Recoil Continuous Gamma-ray Spectrometry" U.S. Department of Energy, Hanford Engineering Development Laboratory, Richland, WA 99352, 10/83.

3.10 GEND-INF-013, "TMI-2 Purification Demineralizer Resin Study", U.S. Department of Energy, EG&G Idaho, Inc., Idaho Falls, Idaho 83415, 5/84.

3.11 GEND-INF-013, Vol. II, "Development of a Process...TMI-2 Makeup and Purification Demineralizers", U.S. Department of Energy, EG&G Idaho, Inc., Idaho Falls, Idaho 83415, 5/84.

3.12 GPUNC Memorandum No. 4200-88-585, "Resin Material in MU-K-1A & B", 1/3/89.

3.13 GPUNC Technical Plan, "Makeup and Purification Demineralizers Resin Removal", TPO/TMI-072, rev 0, 8/83.

3.14 Burns & Roe, Inc., Drawing No. 2066, rev 23, "General Arrangement Auxiliary & Fuel Handling Building Floor Plan El. 305'-0"", W.O. 2555. 9/17/70.

3.15 3-D Visions Corporation graphing program "GRAFTOOL", Ver. 3.3, 12/16/90.

4.0 ASSUMPTIONS AND BASIC DATA

4.1 General overview of methodology.

4.1.1 In general, the two demineralizers are modeled as right circular cylinders. The activity is assumed to be at the bottom of each cylinder based on referenced data. Other locations in the cubicles are also modeled to determine the effect of differing source locations. Finally, exposure rate estimates are determined at several distances from each tank. All exposure rate information is calculated from one curie of isotopic distribution assumed to be present in the indicated demineralizer. Data in section 4.0 is preliminary in nature.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.2 Determination of materials and densities.

4.2.1 From review of reference 3.12 and 3.13 the following data table was assembled using the Lotus 1-2-3 spreadsheet system (reference 3.2).

A & B DEMIN DENSITY ESTIMATE

LOADING ESTIMATE FROM REPORTED VALUES	LBS A DEMIN	LBS B DEMIN	DENSITY ESTIMATE (MIN) g/cc A DEMIN	DENSITY ESTIMATE (MIN) g/cc B DEMIN	DENSITY ESTIMATE (MID) g/cc A DEMIN	DENSITY ESTIMATE (MID) g/cc B DEMIN	DENSITY ESTIMATE (MAX) g/cc A DEMIN	DENSITY ESTIMATE (MAX) g/cc B DEMIN
RESIN WEIGHT (lbs)	1025	1025	0.7463	0.7463	1.4927	1.4927	2.2390	2.2390
WATER WEIGHT (lbs)	193	193	0.1405	0.1405	0.2811	0.2811	0.4216	0.4216
CORE DEBRIS Fe (lbs)	95	19	0.0692	0.0138	0.1383	0.0277	0.2075	0.0415
URANIUM WEIGHT (lbs)	5	1	0.0036	0.0007	0.0073	0.0015	0.0109	0.0022
BOT.LAT.ASS. Fe (lbs) OVER LOWER 6" OF TANK	38.4	38.4	0.0978	0.0978	0.0978	0.0978	0.0978	0.0978
		TOTALS==>	1.0575	0.9992	2.0172	1.9007	2.9768	2.8021

TANK VOLUME ~560 gallon=~74.9 cubic feet
~RESIN DENSITY (g/cc)=~0.7463
INITIAL RESIN VOLUME ~22 cubic feet~= 622970.62 cc's

POST ELUTION

VOLUME ESTIMATE ft^3>	0.2	7.1
IN CC's==========>	5663.36	201049

ESTIMATED DIAMETER OF SOURCE TERM ft.====>	2.0	4.0

	"A" INCHES	"B" INCHES
ESTIMATED HEIGHT OF SOURCE TERM	0.764	6.780

DATA FROM TECHNICAL PLAN, TPO/TMI-072, 8/83
AND GPUNC Memorandum 4200-88-585, 1/3/89.

4.2.2 Three postulated densities are presented for each demineralizer: a minimum value, a middle value and a maximum value. The middle value was chosen as the most likely density for the demineralizer materials. The other two densities are presented to project other possibilities and provide an error term for density variations.

The middle and maximum densities are estimated by multiplying the minimum density values by a factor of 2 and 3 respectively.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.2 Determination of materials and densities cont'd.

4.2.3 The minimum density values for all materials except the bottom laterals are projected by dividing the mass of the originally loaded materials listed in the reference 3.13, by the volume of the resin (22 cubic feet), listed in reference 3.13.

The effective density of the bottom laterals located in the tanks, is calculated by assuming that each lateral assembly is located in the lower 6 inches of each tank. This places the laterals in the source region making them a component of the overall density term for each tank.

4.2.4 The tanks are assumed to be composed of 0.25 inch stainless steel with a density of 7.86 g/cc.

4.2.5 The vertical exit piping near center at the bottom of each tank is assumed to be 3 inch schedule 40 stainless steel.

4.2.6 The horizontal run of piping in the "B" Demineralizer room is assumed to be 2 inch schedule 40 stainless steel.

4.2.7 The bottom lateral assembly is assumed to be composed of 12 pieces, 21 inches long by 3/4 inch, schedule 40 stainless steel piping with one section of 5" diameter by 6" long schedule 40 piping at the center. The total weight of this assembly is assumed to be approximately 31.1 lbs (see attachment 11-1).

4.3 The isotopes, and activity of the isotopes present in one curie of source materials for each demineralizer is assumed to be the same as that presented in reference 3.13. The activities from reference 3.13 were decayed to 7/12/93 and normalized to 1.

SOURCE TERMS FOR DEMINS (in Ci's)

ISOTOPES	DEMIN "A"	DEMIN "B"
Co-60	7.97e-4	-------
Sr-90	2.39e-1	2.51e-2
Y-90	2.39e-1	2.51e-2
Sb-125	8.91e-4	-------
Te-125m	2.06e-4	-------
Cs-134	7.55e-4	1.35e-3
Cs-137	2.67e-1	4.87e-1
Ba-137m	2.52e-1	4.61e-1
Ce-144	1.79e-6	-------
Pr-144	1.79e-6	-------
Pr-144m	2.55e-8	-------

4.3.1 For purposes of this calculation the source term is assumed to be homogeneously distributed throughout the volume of the source region.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.4 Computer modeling for "A" & "B" Demineralizers.

4.4.1 From review of reference No. 3.13 and discussions with TMI-2 Engineering personnel, the following information represents the basic Microshield input data.

a) Demineralizer "A" Basic Microshield 4 input:

Dose point to center of cylinder (X).....176.34 cm.
Height of cylinder (H).....1.94056 cm.
Radius of cylinder (R).....30.48 cm.
Thickness of cylinder shell (SH1).....0.635 cm.
Dose point position along Z axis (Z).....0.0 cm.
Dose point from base of cylinder (Y).....68.58 cm.
Air Gap.....145.225 cm.

b) Demineralizer "B" Basic Microshield 4 input:

Dose point to center of cylinder (X).....270.97 cm.
Height of cylinder (H).....17.2212 cm.
Radius of cylinder (R).....60.96 cm.
Thickness of cylinder shell (SH1).....0.635 cm.
Dose point position along Z axis (Z).....0.0 cm.
Dose point from base of cylinder (Y).....68.58 cm.
Air Gap.....209.375 cm.

4.5 Review and interpretation of survey data.

4.5.1 Six (6) Radiological Controls Field Operations surveys and one (1) Engineering survey were reviewed to determine the true exposure rate at set locations within the "A" & "B" Demineralizer cubicles (see attachments 10-1 to 10-9). The data was analyzed and incorporated into a spreadsheet for manipulation purposes. The spreadsheet data table is shown below.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.5 Review and interpretation of survey data cont'd.

4.5.1 Cont'd.

A & B DEMINERALIZER DATA ANALYSIS
7/16/93

ROOM NUMBER	SURVEY DATE	SURVEY NUMBER	SURVEY RESULT 4 FOOT ABOVE FLOOR (mR/h)	ESTIMATED DISTANCE IN FEET (X)	ESTIMATED DISTANCE IN FEET (Y)	FEET FROM TANK CENTER LINE (D)	DEMIN	CALC. (mR/h) PER Ci AT D ft	TOTAL Ci's ESTIMATE	POSSIBLE ERROR IN X FEET	POSSIBLE ERROR IN Y FEET
AX115	9/28/88	88J19796	125000	6.78	5.75	8.89	B	5.10	24511	0.75	0.75
AX114*	3/13/85	NONE	90000	4.6	1.75	4.92	A	23.29	3865	0.75	0.75
AX115	4/6/85	3N-85	35000	6.78	5.75	8.89	B	5.10	6863	0.75	0.75
AX115	4/6/85	3N-85	70000	6.78	1.25	6.89	B	10.88	6432	0.75	0.75
AX115	4/6/85	3N-85	30000	6.78	3.25	7.52	B	8.59	3494	0.75	0.75
AX115	6/5/85	4N-85	37000	6.78	5.75	8.89	B	5.10	7255	0.75	0.75
AX114*	6/5/85	2N-85	60600	4.6	2.75	5.36	A	19.94	3040	0.75	0.75
AX115	9/28/88	NONE	42900	5.73	5.75	8.12	B	6.84	6273	0.75	0.75
AX114*	4/24/90	90J04347	70000	5.09	2.75	5.79	A	17.14	4085	0.75	0.75

* DENOTES INTERPOLATED EXPOSURE RATE VALUES

ROOM NUMBER	DISTANCE ERROR TERM LONG (ft)	DISTANCE ERROR TERM SHORT (ft)	CALC. mR/h/Ci LONG	CALC. mR/h/Ci SHORT	mR/h/Ci LONG/ CALC. mR/h/Ci @ D	mR/h/Ci SHORT/ CALC. mR/h/Ci @ D	% ERROR LONG	% ERROR SHORT	COMBINED & AVERAGED ABSOLUTE VALUE ERROR TERMS + or -	CURIES IN "A"	CURIES IN "B"	
AX115	9.9	7.8	3.41	7.62	0.67	1.49	-33%	49%	41%	N/A	24511	<NOT USED
AX114*	5.9	4.0	16.42	32.55	0.71	1.40	-29%	40%	35%	3865	N/A	
AX115	9.9	7.8	3.41	7.62	0.67	1.49	-33%	49%	41%	N/A	6863	
AX115	7.8	6.1	7.74	15.00	0.71	1.38	-29%	38%	33%	N/A	6432	
AX115	8.5	6.5	5.85	12.51	0.68	1.46	-32%	46%	39%	N/A	3494	<NOT USED
AX115	9.9	7.8	3.41	7.62	0.67	1.49	-33%	49%	41%	N/A	7255	
AX114*	6.4	4.3	13.81	28.64	0.69	1.44	-31%	44%	37%	3040	N/A	
AX115	9.2	7.1	4.57	10.23	0.67	1.50	-33%	50%	41%	N/A	6273	
AX114*	6.8	4.8	11.92	24.50	0.70	1.43	-30%	43%	37%	4085	N/A	

AVERAGED CURIE VALUES=> 3663 6706

ESTIMATED ERROR + or - 36.2% A-Demin Avg.

ESTIMATED ERROR + or - 39.3% B-Demin Avg.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd.

4.5 Review and interpretation of survey data cont'd.

4.5.2 The table in section 4.5.1 presents distance estimates; calculated exposure rate estimates based on these distances, total curies present, and an estimate of error due to incorrect distance determinations. Sections 4.5.3 to 4.5.9 describes the methodology used to calculate these parameters.

4.5.3 The distance estimates were determined by review and scaling from current GPUNC drawings (see reference No. 3.14), diagrams from other references in section 3.0, and RADCON survey sheets (see attachments 10-1 to 10-9). Since the demineralizers are at approximately the center of the cubicles, an X and Y coordinate can be used to calculate the approximate horizontal distance from a dose point to the tank vertical centerline.

4.5.4 When their location is unspecified, all exposure rate values are assumed to have been taken about 4 feet above the cubicle floor. However, the first survey listed in the table (section 4.5.1), presents a value that is at least 3 times higher than measurements taken at similar horizontal (X,Y) locations shown in other surveys. For purposes of this calculation, this value is assumed to be either in error or taken at other than 4' above the cubicle floor.

4.5.5 Several 4' radiation values presented in the table in section 4.5.1, have been interpolated from the actual survey data. These interpolated values are marked with an asterisk.

4.5.6 The distance values in the table ("D"), are calculated by determining the hypotenuse of a right triangle.

4.5.7 The calculated mR/h per curie values shown in the table, are determined by curve fitting the Microshield 4 calculated exposure rates for the "A" & "B" Demineralizers for several distances out from the source regions, using the sensitivity analysis option in Microshield 4. These distances use the base Microshield inputs listed in section 4.4.1 as the reference values. The functions used in the spreadsheet table seen in section 4.5.1 were determined by the curve fitting routine in the computer program "Graftool" (reference 3.15). These functions are listed below.

	Correlation Coefficient
"A" Demineralizer $Y=133.6*0.7012^{X}$	-0.966758
"B" Demineralizer $Y=149.339*0.683949^{X}$	-0.89348

WHERE: Y is the mR/h/Ci value and X is the number of horizontal feet from the demineralizers vertical centerline.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.5 Review and interpretation of survey data cont'd.

4.5.8 The total curie column in the table is calculated by dividing the measured or interpolated exposure rate by the mR/h/Ci value determined by the method shown in section 4.5.7.

4.5.9 The estimate of the error from incorrectly determining the X & Y horizontal distances where a measurement was taken, is determined by assuming that the X and Y distance measurements could be incorrect by as much as 0.75 feet. The maximum distance from the source would be $((X'+0.75')^2+(Y'+0.75')^2)^{0.5}$. The minimum would be $((X'-0.75')^2+(Y'-0.75')^2)^{0.5}$. From these two distances, differing mR/h values may be estimated using the same method previously described in previous sections. The differences between the mR/h estimates for correct vs incorrect distances both long and short, are averaged and converted to percentage differences and are presented as one component of the overall estimate of error for this analysis.

4.6 The following is a description of the attachments presented in this calculation.

a) Attachments 1-1 & 1-2, present and decay the isotopes extracted from reference 3.13 assumed to characterize the "A" & "B" Demineralizers.

b) Attachments 2-1 to 2-2, present the decayed isotopes from attachments 1-1 & 1-2 normalized to 1.

c) Attachments 3-1 & 3-4, present the demineralizer cubicle locations with actual and estimated dimensions.

d) Attachments 4-1 to 4-4, present the demineralizer tanks with estimated dimensions including associated piping.

e) Attachments 5-1 to 5-7, Microshield 4 base case output for high, middle and low density materials modeling.

f) Attachments 6-1 to 6-5, Microshield 4 sensitivity analysis using middle density materials from 91.44 cm to 213.36 cm for the "A" and from 91.44 cm to 304.8 cm for "B" Demineralizer.

g) Attachment 7-1, Microshield 4 output for pipe source at base of "A" Demineralizer.

h) Attachments 8-1, Microshield 4 output for horizontal run of pipe section in the "B" Demineralizer cubicle (base case geometry).

i) Attachments 9-1 to 9-6, Graftool output from curve fitting Microshield 4 sensitivity analysis data for "A" & "B" Demineralizer for various X distances.

4.0 ASSUMPTIONS AND BASIC DATA Cont'd

4.6 Attachments cont'd.

j) Attachments 10-1 to 10-9, Radiological surveys that present the survey information used to estimate the curie loading of the "A" & "B" Demineralizers.

k) Attachment 11-1, dimensions and weights of seamless and welded steel pipe, Williams and Company, inc. catalog # 23, pp D-30 & 31.

5.0 CALCULATIONS

5.1 Most of the earlier operations were performed using the Lotus 1-2-3 spreadsheet system.

5.2 In section 4.2.2 three (3) possible densities were estimated for modeling purposes. In attachments 5-1 to 5-7 the Microshield 4 output from the differing density computer analysis are shown.

For the "A" Demineralizer, the calculated exposure rate for the 3 density estimates using the Microshield base case input is:

HIGH DENSITY (2.96 g/cc).....15.26 mR/h.
MIDDLE DENSITY (2.00 g/cc).....16.73 mR/h.
LOW DENSITY (1.04) g/cc).....18.22 mR/h.

For the "B" Demineralizer, the calculated exposure rate for the 3 density estimates using the Microshield base case input is:

HIGH DENSITY (2.78 g/cc).....3.619 mR/h.
MIDDLE DENSITY (1.88 g/cc).....5.107 mR/h.
LOW DENSITY (0.98) g/cc).....8.496 mR/h.

Using the above listed data and calculating the estimated error due to possible variations in density gives the following results.

"A" DEMINERALIZER

(1-(15.26/16.73)) x 100% = **+ 8.8%**

(1-(18.22/16.73)) x 100% = **- 8.9%**, for the "A" DEMIN.

"B" DEMINERALIZER

(1-(3.619/5.107)) x 100% = **+ 29.1%**

(1-(8.496/5.107)) x 100% = **- 66%**, for the "B" DEMIN.

5.0 CALCULATIONS Cont'd

5.3 Location of the base case Microshield 4 exposure rate point relative to the demineralizers.

The diagram on attachment 4-3 shows the relative position of the base case Microshield 4 exposure rate points to the demineralizers and to the base pipe connections.

5.4 Placement of other source terms.

5.4.1 "A" Demineralizer.

5.4.1.1 The "A" Demineralizer source term is assumed to be a 2' diameter cylinder with a height of about 0.764 cm (section 4.2.1). If it is assumed that the majority of the source term is located in the 3" resin sluice line below the tank, the geometry for this case would then be as follows.

Assuming the vertical pipe length at base of the tank is about 9" long, then the lowest section or the elbow of this pipe is at approximately the ~306' El. The location for the highest exposure rate measurements were taken approximately 3' above the floor at the 308' El. The elevational difference is about 2'. Assuming the horizontal distance is within a few inches of the base case horizontal distance or about 5.8 feet, the Microshield 4 output for a pipe segment containing one curie would be 17.37 mR/h (see attachment 7-1). Since the base case Microshield output for the "A" Demineralizer tank was 16.73 mR/h (section 5.2), the relative difference in activity is:

(1-(100,000 mR/h/17.37 mR/h/Ci)/
(70,000 mR/h/16.73 mR/h/Ci)) x 100% = **-38%**

The possibility that <u>all</u> of the activity is in the this lower pipe section is remote and therefore will not be considered further.

5.4.2 "B" Demineralizer.

5.4.2.1 The 2" diameter pipe run connected to the resin sluice outlet nozzle located in the "B" Demineralizer cubicle may also contain resin and high activity levels. This pipe run is shown in attachments 3-3 and 4-3 and is present in both cubicles. However the majority of the activity located in the "B" Demineralizer cubicle is assumed to be located in the tank, based on the

5.0 CALCULATIONS Cont'd

5.4 Placement of other source terms cont'd

5.4.2 "B" Demineralizer cont'd.

Radiological Engineering survey data shown on attachments 10-6 to 10-8. However, if one (1) curie of activity is placed in a single pipe run located at the center of the two pipe sections running east and west (shown on attachment 4-3), the mR/h/Ci value would be approximately 20.77 mR/h/Ci (see attachment 8-1). The Microshield 4 model would be as shown below:

"B" Demineralizer 2" pipe run input file

Dose point to center of pipe section (X).....217.17 cm.
Height of cylinder (H).....228.6 cm.
Radius of cylinder (R).....2.62509 cm.
Thickness of cylinder shell (SH1).....0.39116 cm.
Dose point position along Z axis (Z).....87.63 cm.
Dose point from base of cylinder (Y).....44.81 cm.
Air Gap.....214.15375 cm.

5.4.2.1 The pipe is 2" schedule 40 stainless steel and is located at approximately the 306' 1.5" El. The pipe starts about 9" east of the vertical centerline of the "B" Demin and runs east for about 7.5 feet. The elevational difference would be about 309'-306' 1.5" or about 2.875'. The exposure rate point is at the center of the entrance to the "B" Demin cubicle about 4' above the floor.

5.4.2.2 Based on the two models, the relative difference between one curie of activity in the demineralizer and one curie in the pipe section is shown below.

(1-(20.77 mR/h/Ci/5.107 mR/h/Ci)) x 100% = 307%

This indicates that if the activity were predominately located in the 2" line, about 1/4 th of the calculated number of curies would be present. This is not the case since the "B" Demin retains the higher exposure rate as evidenced by the survey information. Therefore, the best estimate is that most of the activity is still retained at the "B" Demin location and not in the 2" line.

5.0 CALCULATIONS Cont'd

5.5 Combination of Error Terms.

5.5.1 The combined estimate of error in this analysis includes the following:

a) The estimate of the uncertainty in the radiation measurements from the radiological surveys, due to incorrectly reported survey locations (in the X and Y directions, north-south/east-west).

b) The estimate of the uncertainty in the density of the source term materials.

c) An assumed instrumentation response error.

5.5.2 The distance error estimate assumes that the actual exposure rate point is within ~± one foot of the correct measurement location $(((9''^2+9''^2)^{.5}) = \mathbf{12.7''})$. Since there is a similar difference in the effect of ± distance error for the individual curie values presented in the table in section 4.5.1, and some uncertainty in the exact measurement locations, the absolute values of the error terms as well as the curie estimates were summed and averaged for several measurements.

The error estimate for the survey locations for the "A" Demin is:

$$(35\% + 37\% + 37\%)/3 = \mathbf{\sim \pm 36\%}.$$

The error estimate for the survey locations for the "B" Demin is:

$$(41\% + 33\% + 41\% + 41\%)/4 = \mathbf{\sim \pm 39\%}.$$

5.5.3 From section 5.2, the uncertainty in the source term density is assumed to be:

~± 9% for the "A" Demineralizer and, **~+ 29% - 66%** for the "B" Demineralizer.

5.5.4 The instrumentation calibration error is assumed to be approximately **± 10%**.

5.5.5 The combined error estimate is approximately:

$\pm\ (36\%^2+9\%^2+10\%^2)^{0.5} = \mathbf{\sim 38\%}$ for the "A" Demineralizer and,

$+\ (39\%^2+29\%^2+10\%^2)^{0.5} = \mathbf{\sim + 50\%}$
$-\ (39\%^2+66\%^2+10\%^2)^{0.5} = \mathbf{\sim - 77\%}$ for the "B" Demineralizer.

Attachment 1-1

SAMPLE SUMMARY SHEET NUMBER OF SAMPLES=====> 1
7/12/93 ==========
==========

Today's Date	SAMPLE No. "AM DEMIN	SAMPLE No.	SAMPLE No.	SAMPLE No.	SAMPLE No.	SAMPLE No.		
	DATE	DATE	DATE	DATE	DATE	DATE		
	5/15/83	7/12/93	7/12/93	7/12/93	7/12/93	7/12/93		
	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)		ISOTOPES
ISOTOPES	3711	0	0	0	0	0	Decayed Totals	
H-3							0.00000E+00	H-3
Be-7							0.00000E+00	Be-7
C-14							0.00000E+00	C-14
Cr-51							0.00000E+00	Cr-51
Mn-54							0.00000E+00	Mn-54
Fe-55							0.00000E+00	Fe-55
Co-57							0.00000E+00	Co-57
co-58							0.00000E+00	co-58
Fe-59							0.00000E+00	Fe-59
Ni-59							0.00000E+00	Ni-59
Co-60	1.9800E+00						5.20636E-01	Co-60
Ni-63							0.00000E+00	Ni-63
Zn-65							0.00000E+00	Zn-65
Sr-89							0.00000E+00	Sr-89
Sr-90	2.0000E+02						1.56355E+02	Sr-90
Zr-95							0.00000E+00	Zr-95
Tc-99							0.00000E+00	Tc-99
Ru-103							0.00000E+00	Ru-103
Ru-106							0.00000E+00	Ru-106
Ag-110m							0.00000E+00	Ag-110m
Sb-124							0.00000E+00	Sb-124
Sb-125	7.4000E+00						5.82514E-01	Sb-125
Te-125m							0.00000E+00	Te-125m
I-129							0.00000E+00	I-129
I-131							0.00000E+00	I-131
I-133							0.00000E+00	I-133
Cs-134	1.5000E+01						4.93321E-01	Cs-134
Cs-136							0.00000E+00	Cs-136
Cs-137	2.2000E+02						1.74208E+02	Cs-137
Ce-139							0.00000E+00	Ce-139
Ba-140							0.00000E+00	Ba-140
Ce-141							0.00000E+00	Ce-141
Ce-144	9.9000E+00						1.16705E-03	Ce-144
Pm-147							0.00000E+00	Pm-147
Eu-154							0.00000E+00	Eu-154
Eu-155							0.00000E+00	Eu-155
U-233							0.00000E+00	U-233
U-234							0.00000E+00	U-234
U-235							0.00000E+00	U-235
U-236							0.00000E+00	U-236
Np-237							0.00000E+00	Np-237
Pu-238							0.00000E+00	Pu-238
U-238							0.00000E+00	U-238
Pu-239							0.00000E+00	Pu-239
Pu-240							0.00000E+00	Pu-240
Am-241							0.00000E+00	Am-241
Pu-241							0.00000E+00	Pu-241
Cm-242							0.00000E+00	Cm-242
Pu-242							0.00000E+00	Pu-242
Cm-243							0.00000E+00	Cm-243
Cm-244							0.00000E+00	Cm-244
						TOTAL===>	3.32160E+02	

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	13 of 54
Originator: B. Brosey, Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

Attachment 1-2

SAMPLE SUMMARY SHEET NUMBER OF SAMPLES=====> 1
7/12/93 ==========
==========

Today's Date	SAMPLE No. "B" DEMIN	SAMPLE No.	SAMPLE No.	SAMPLE No.	SAMPLE No.	SAMPLE No.		
	DATE	DATE	DATE	DATE	DATE	DATE		
	5/15/83	7/12/93	7/12/93	7/12/93	7/12/93	7/12/93		
	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)	ELAPSED (d)		
ISOTOPES	3711	0	0	0	0	0	Decayed Totals	ISOTOPES
H-3							0.00000E+00	H-3
Be-7							0.00000E+00	Be-7
C-14							0.00000E+00	C-14
Cr-51							0.00000E+00	Cr-51
Mn-54							0.00000E+00	Mn-54
Fe-55							0.00000E+00	Fe-55
Co-57							0.00000E+00	Co-57
co-58							0.00000E+00	co-58
Fe-59							0.00000E+00	Fe-59
Ni-59							0.00000E+00	Ni-59
Co-60							0.00000E+00	Co-60
Ni-63							0.00000E+00	Ni-63
Zn-65							0.00000E+00	Zn-65
Sr-89							0.00000E+00	Sr-89
Sr-90	8.8000E+02						6.87961E+02	Sr-90
Zr-95							0.00000E+00	Zr-95
Tc-99							0.00000E+00	Tc-99
Ru-103							0.00000E+00	Ru-103
Ru-106							0.00000E+00	Ru-106
Ag-110m							0.00000E+00	Ag-110m
Sb-124							0.00000E+00	Sb-124
Sb-125							0.00000E+00	Sb-125
Te-125m							0.00000E+00	Te-125m
I-129							0.00000E+00	I-129
I-131							0.00000E+00	I-131
I-133							0.00000E+00	I-133
Cs-134	1.1300E+03						3.71635E+01	Cs-134
Cs-136							0.00000E+00	Cs-136
Cs-137	1.6900E+04						1.33823E+04	Cs-137
Ce-139							0.00000E+00	Ce-139
Ba-140							0.00000E+00	Ba-140
Ce-141							0.00000E+00	Ce-141
Ce-144							0.00000E+00	Ce-144
Pm-147							0.00000E+00	Pm-147
Eu-154							0.00000E+00	Eu-154
Eu-155							0.00000E+00	Eu-155
U-233							0.00000E+00	U-233
U-234							0.00000E+00	U-234
U-235							0.00000E+00	U-235
U-236							0.00000E+00	U-236
Np-237							0.00000E+00	Np-237
Pu-238							0.00000E+00	Pu-238
U-238							0.00000E+00	U-238
Pu-239							0.00000E+00	Pu-239
Pu-240							0.00000E+00	Pu-240
Am-241							0.00000E+00	Am-241
Pu-241							0.00000E+00	Pu-241
Cm-242							0.00000E+00	Cm-242
Pu-242							0.00000E+00	Pu-242
Cm-243							0.00000E+00	Cm-243
Cm-244							0.00000E+00	Cm-244
						TOTAL==>	1.41075E+04	

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev No: 1
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Sheet No: 1 of 54
			Date: 9/10/93

Attachment 2-1

NORMALIZATION WORKSHEET (1 Ci)

CALCULATED ========== ========== 7/12/93

EXPOSURE RATE PER Ci===> mR/h ACTUAL===> mR/h ==========

UNITS IN>Ci ========== ========== Today's Date

I.D. NUMBER

OR NAME==>"AM DEMIN, AX114

	ISOTOPE	INPUT UNIT ACTIVITY		PERCENT (%) of Total	ACTIVITY PER CURIE		ADJUSTED ACTIVITY (mCi)	ADJUSTED WITHOUT DAUGHTERS (mCi)	NRC REPORTABLE If > 1% of TOTAL	ISOTOPES	Sr-90/Cs-137 RATIO
1	H-3		***	0.00000	0.00E+00	***	ERR	ERR	ERR	H-3	* ERR *
2	C-14		***	0.00000	0.00E+00	***	ERR	ERR	ERR	C-14	
3	Cr-51		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cr-51	
4	Mn-54		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Mn-54	
5	Fe-55		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Fe-55	
6	Co-58		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Co-58	
7	Co-60	5.21E-01	***	0.07967	7.97E-04	***	ERR	ERR	ERR	Co-60	
8	Ni-63		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ni-63	
9	Zn-65		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Zn-65	
10	Sr-89		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Sr-89	
11	Sr-90	1.56E+02	***	23.92754	2.39E-01	***	ERR	ERR	ERR	Sr-90	
12	Y-90	1.56E+02	***	23.92754	2.39E-01	***	ERR	==========	==========	Y-90	
13	Tc-99		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Tc-99	
14	Ru-106		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ru-106	
15	Rh-106		***	0.00000	0.00E+00	***	ERR	==========	==========	Rh-106	
16	Ag-110m		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ag-110m	
17	Ag-110		***	0.00000	0.00E+00	***	ERR	==========	==========	Ag-110	
18	Sb-125	5.83E-01	***	0.08914	8.91E-04	***	ERR	ERR	ERR	Sb-125	
19	Te-125m	1.35E-01	***	0.02059	2.06E-04	***	ERR	ERR	ERR	Te-125m	
20	I-129		***	0.00000	0.00E+00	***	ERR	ERR	ERR	I-129	
21	Cs-134	4.93E-01	***	0.07549	7.55E-04	***	ERR	ERR	ERR	Cs-134	
22	Cs-137	1.74E+02	***	26.65964	2.67E-01	***	ERR	ERR	ERR	Cs-137	
23	Ba-137m	1.65E+02	***	25.22002	2.52E-01	***	ERR	==========	==========	Ba-137m	
24	Ce-141		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ce-141	
25	Ce-144	1.17E-03	***	0.00018	1.79E-06	***	ERR	ERR	ERR	Ce-144	
26	Pr-144m	1.67E-05	***	0.00000	2.55E-08	***	ERR	==========	==========	Pr-144m	
27	Np-237		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Np-237	
28	Pa-233		***	0.00000	0.00E+00	***	ERR	==========	==========	Pa-233	
29	Pu-238		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-238	
30	Pu-239		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-239	
31	Pu-241		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-241	
32	Am-241		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Am-241	
33	Cm-243		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-243	
34	U-235		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-235	
35	U-238		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-238	
36	Pu-240		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-240	
37	U-234		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-234	
38	Pm-147		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pm-147	
39	Eu-154		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Eu-154	
40	Eu-155		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Eu-155	
41	U-236		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-236	
42	Pr-144	1.17E-03	***	0.00018	1.79E-06	***	ERR	==========	==========	Pr-144	
43	Cm-242		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-242	
44	Cm-244		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-244	
45	-		***	0.00000	0.00E+00	***	ERR	ERR	ERR	-	
	TOTALS==>>6.5345E+02 Ci			100.00	1.00000 Ci		ERR mCi	ERR mCi			

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading

Calc No: 4240-3233-93-015

Rev No: 1

Sheet No: 13 of 57

Originator: B. Brown Date: 9/8/93

Reviewed by: R. Lodge Date: 9/10/93

NORMALIZATION WORKSHEET (1 Ci)

CALCULATED ========== ========== 7/12/93
EXPOSURE RATE PER Ci==> mR/h ACTUAL==> mR/h ==========
UNITS IN>Ci ========== ========== Today's Date
I.D. NUMBER
OR NAME=>"B" DEMIN, AX115

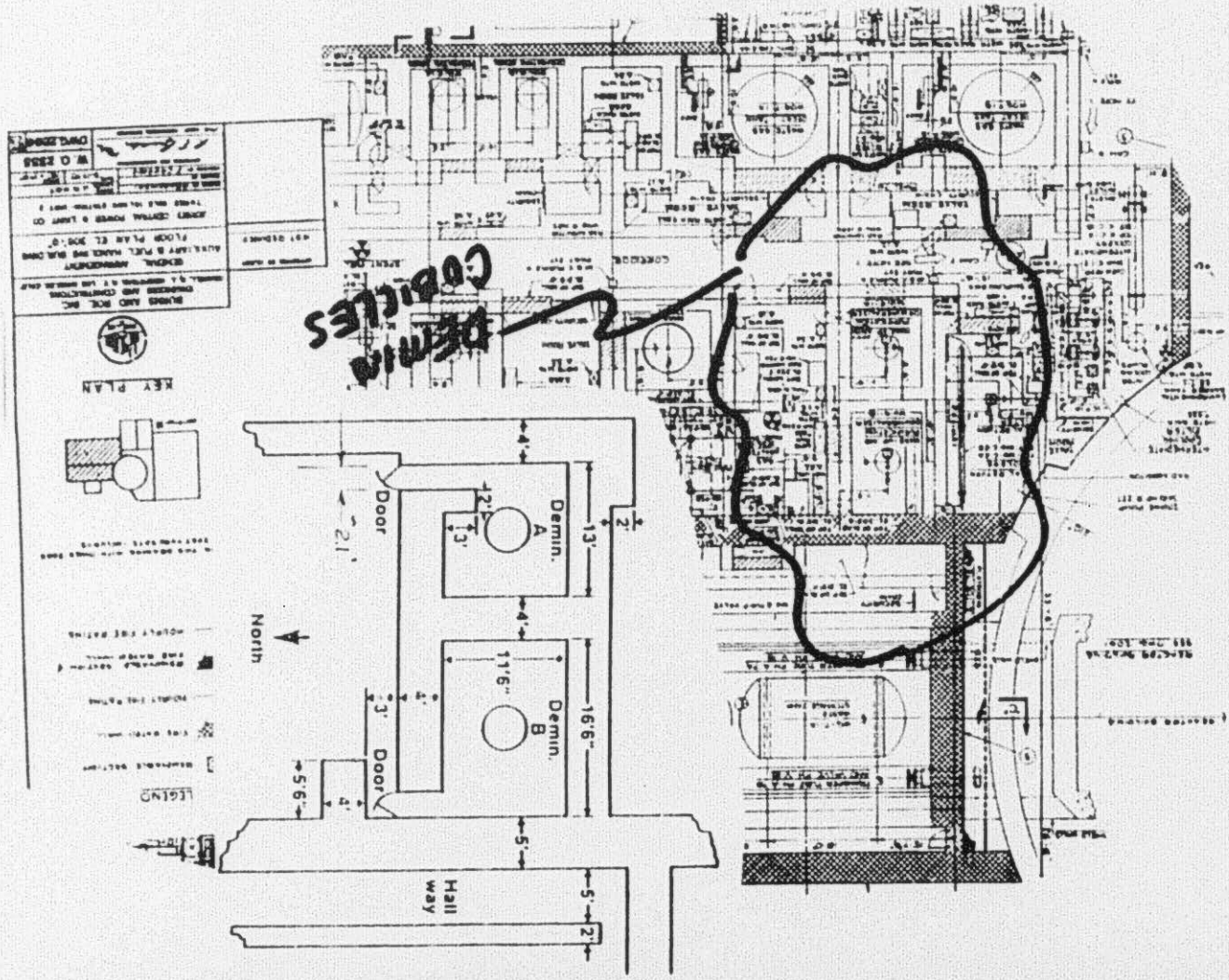
	ISOTOPE	INPUT UNIT ACTIVITY		PERCENT (%) of Total	ACTIVITY PER CURIE		ADJUSTED ACTIVITY (mCi)	ADJUSTED WITHOUT DAUGHTERS (mCi)	NRC REPORTABLE If > 1% of TOTAL	ISOTOPES	Sr-90/Cs-137 RATIO
1	H-3		***	0.00000	0.00E+00	***	ERR	ERR	ERR	H-3	* ERR *
2	C-14		***	0.00000	0.00E+00	***	ERR	ERR	ERR	C-14	
3	Cr-51		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cr-51	
4	Mn-54		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Mn-54	
5	Fe-55		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Fe-55	
6	Co-58		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Co-58	
7	Co-60		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Co-60	
8	Ni-63		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ni-63	
9	Zn-65		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Zn-65	
10	Sr-89		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Sr-89	
11	Sr-90	6.88E+02	***	2.50577	2.51E-02	***	ERR	ERR	ERR	Sr-90	
12	Y-90	6.88E+02	***	2.50577	2.51E-02	***	ERR	==========	==========	Y-90	
13	Tc-99		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Tc-99	
14	Ru-106		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ru-106	
15	Rh-106		***	0.00000	0.00E+00	***	ERR	==========	==========	Rh-106	
16	Ag-110m		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ag-110m	
17	Ag-110		***	0.00000	0.00E+00	***	ERR	==========	==========	Ag-110	
18	Sb-125		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Sb-125	
19	Te-125m		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Te-125m	
20	I-129		***	0.00000	0.00E+00	***	ERR	ERR	ERR	I-129	
21	Cs-134	3.72E+01	***	0.13536	1.35E-03	***	ERR	ERR	ERR	Cs-134	
22	Cs-137	1.34E+04	***	48.74260	4.87E-01	***	ERR	ERR	ERR	Cs-137	
23	Ba-137m	1.27E+04	***	46.11050	4.61E-01	***	ERR	==========	==========	Ba-137m	
24	Ce-141		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ce-141	
25	Ce-144		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Ce-144	
26	Pr-144m		***	0.00000	0.00E+00	***	ERR	==========	==========	Pr-144m	
27	Np-237		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Np-237	
28	Pa-233		***	0.00000	0.00E+00	***	ERR	==========	==========	Pa-233	
29	Pu-238		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-238	
30	Pu-239		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-239	
31	Pu-241		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-241	
32	Am-241		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Am-241	
33	Cm-243		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-243	
34	U-235		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-235	
35	U-238		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-238	
36	Pu-240		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pu-240	
37	U-234		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-234	
38	Pm-147		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Pm-147	
39	Eu-154		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Eu-154	
40	Eu-155		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Eu-155	
41	U-236		***	0.00000	0.00E+00	***	ERR	ERR	ERR	U-236	
42	Pr-144		***	0.00000	0.00E+00	***	ERR	==========	==========	Pr-144	
43	Cm-242		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-242	
44	Cm-244		***	0.00000	0.00E+00	***	ERR	ERR	ERR	Cm-244	
45	-		***	0.00000	0.00E+00	***	ERR	ERR	ERR	-	
	TOTALS==>	2.7455E+04 Ci		100.00	1.00000 Ci		ERR mCi	ERR mCi			

GPU Nuclear — Calculation Sheet

Subject: AX114 and AX115 Curie Loading
Calc No: 4240-3233-93-015
Rev No: 1
Sheet No: 16 of 54
Originator: B. Brosey — Date: 9/8/93
Reviewed by: G. Lodde — Date: 9/10/93

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 17 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

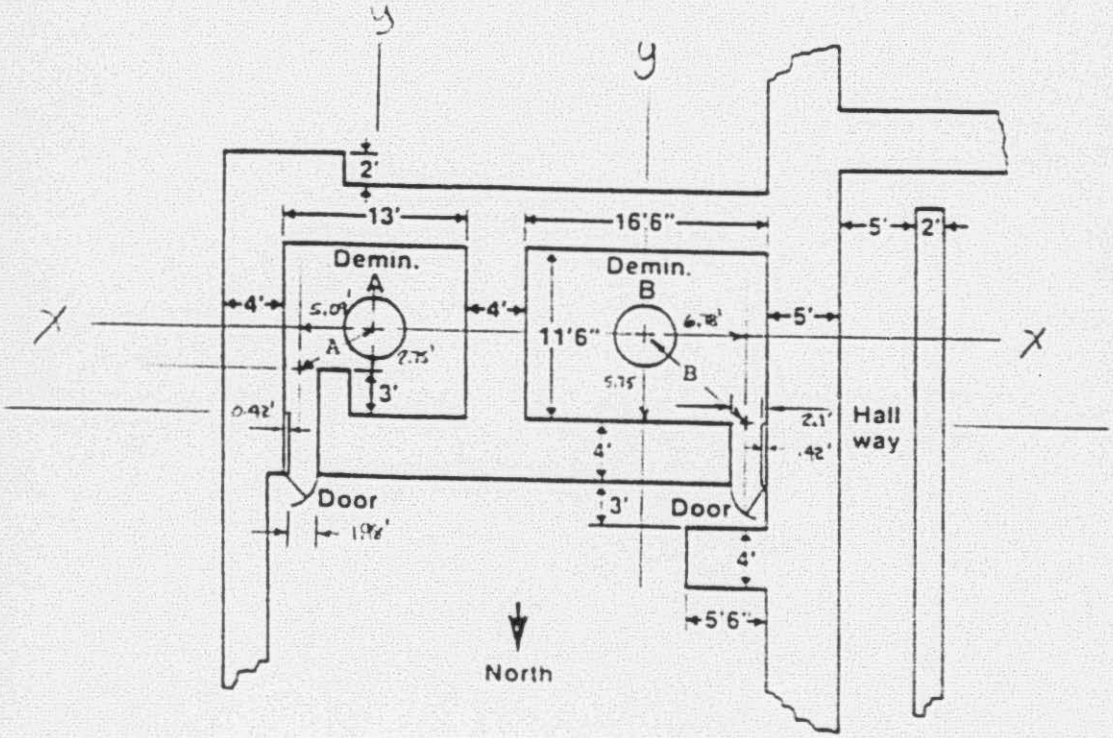


Attachment 3-1

GPU Nuclear Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	18 of 54

Originator	Date	Reviewed by	Date
B. Brosey	9/8/93	G. Lodde	9/10/93

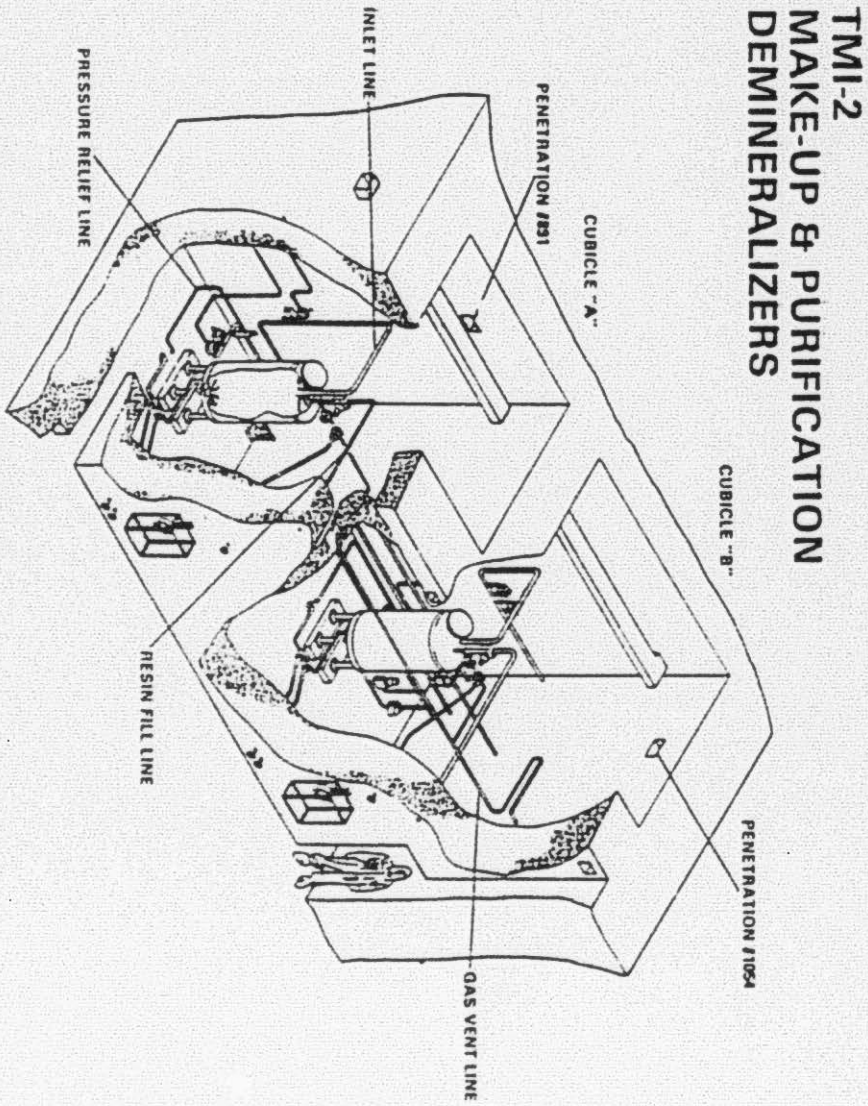


GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	19 of 54

Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	9/8/93	G. Lodde GM Lodde	9/10/93



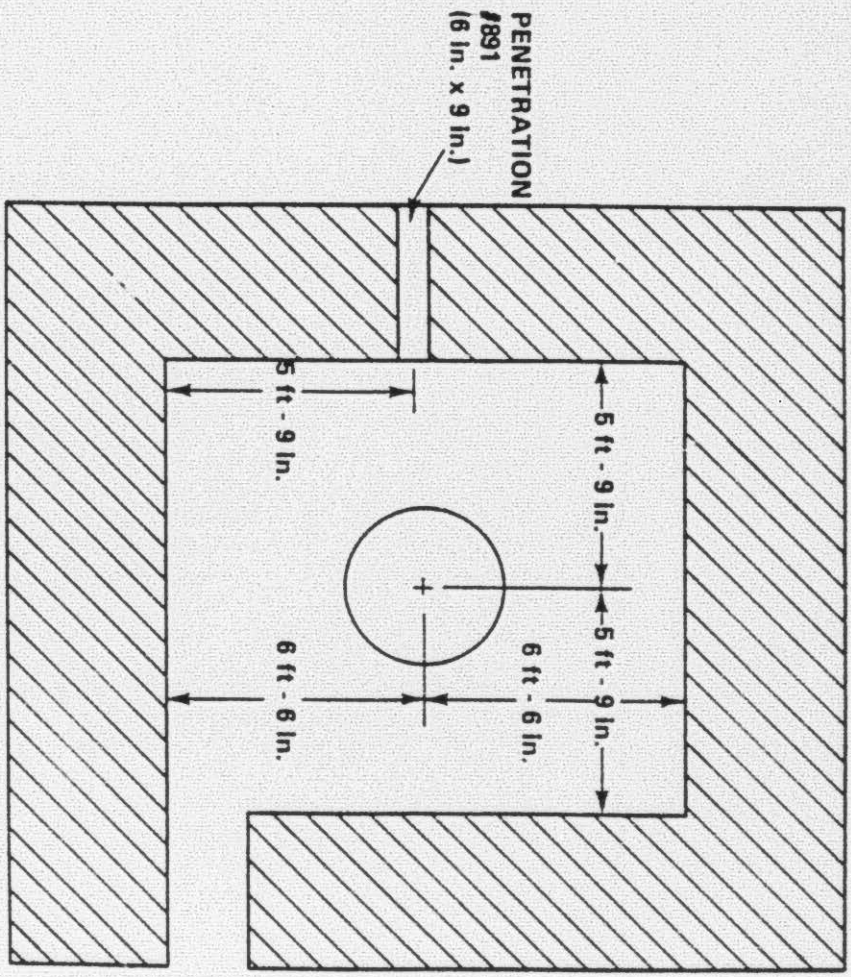
Isometric view of the makeup demineralizer cells.

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	20 of 54

Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	9/8/93	G. Lodde SM Lodde	9/10/93



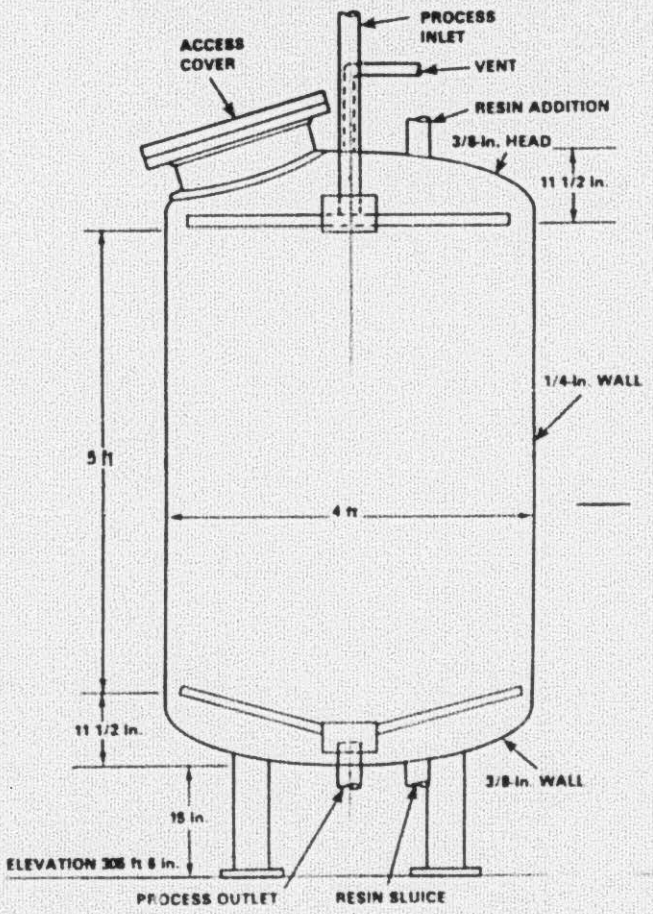
Plan view of the "A" demineralizer cell.

HEDL 8212.080.2

Attachment 4-1

GPU Nuclear — **Calculation Sheet**

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 21 of 54
Originator: B. Brosey B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde GM Lodde	Date: 9/10/93



MU-K-1A, B
MAKE-UP AND PURIFICATION DEMINERALIZERS

TOP CONNECTIONS
- PROCESS INLET
- VENT
- RESIN ADDITION
- ACCESS COVER

BOTTOM CONNECTIONS
- PROCESS OUTLET
- RESIN SLUICE

TOP LATERALS
- 12 TOTAL
- 18-in. LONG
- 3/4-in. ϕ, 304SS
- 21 HOLES, 3/16-in. PER LATERAL

BOTTOM LATERALS
- 12 TOTAL
- 20-in. LONG
- 3/4-in. ϕ, 304 SS
- 21 HOLES, 3/16-in. PER LATERAL
- 100 MESH WIRE SCREEN

TANK VOLUME
- 580 GALLONS

HEDL 8302.003 3

Dimensions of demineralizer vessel.

Attachment 4-2

GPU Nuclear

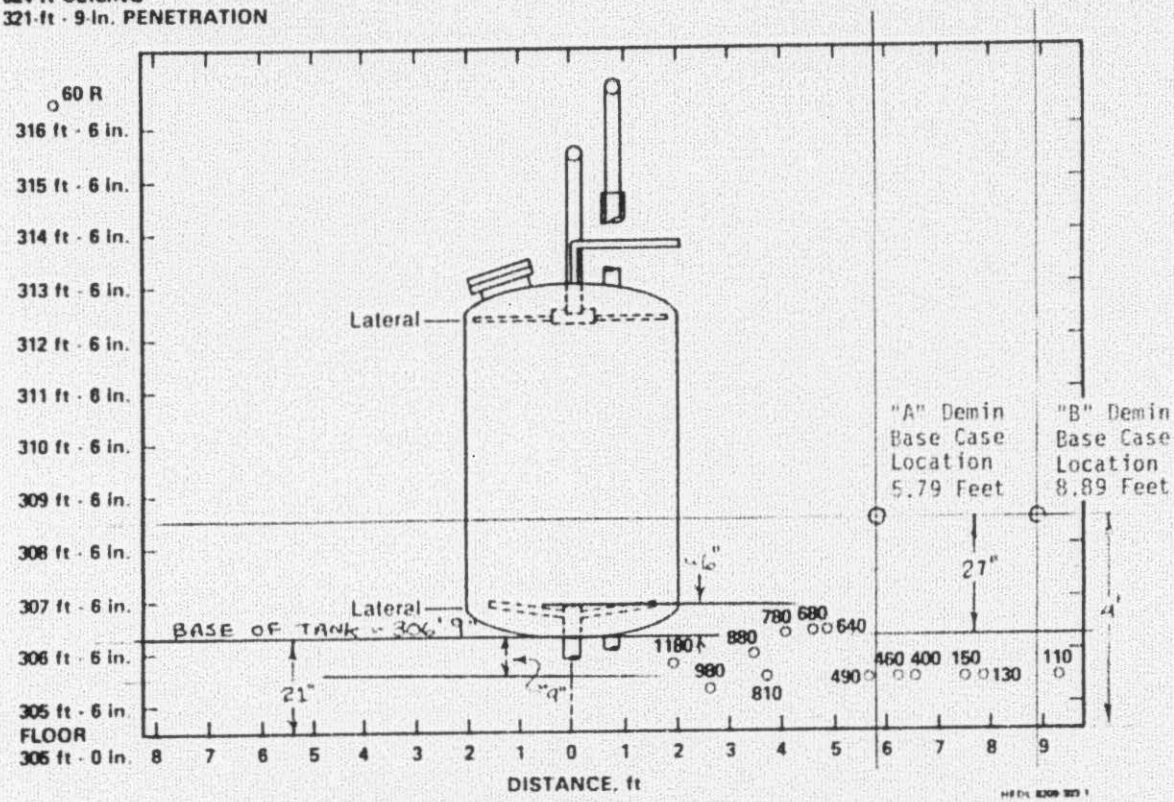
Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	22 of 54

Originator	Date	Reviewed by	Date
B. Brosey	9/8/93	G. Lodge	9/10/93

"B" CUBICLE DOSE RATES

324-ft CEILING
321-ft - 9-in. PENETRATION

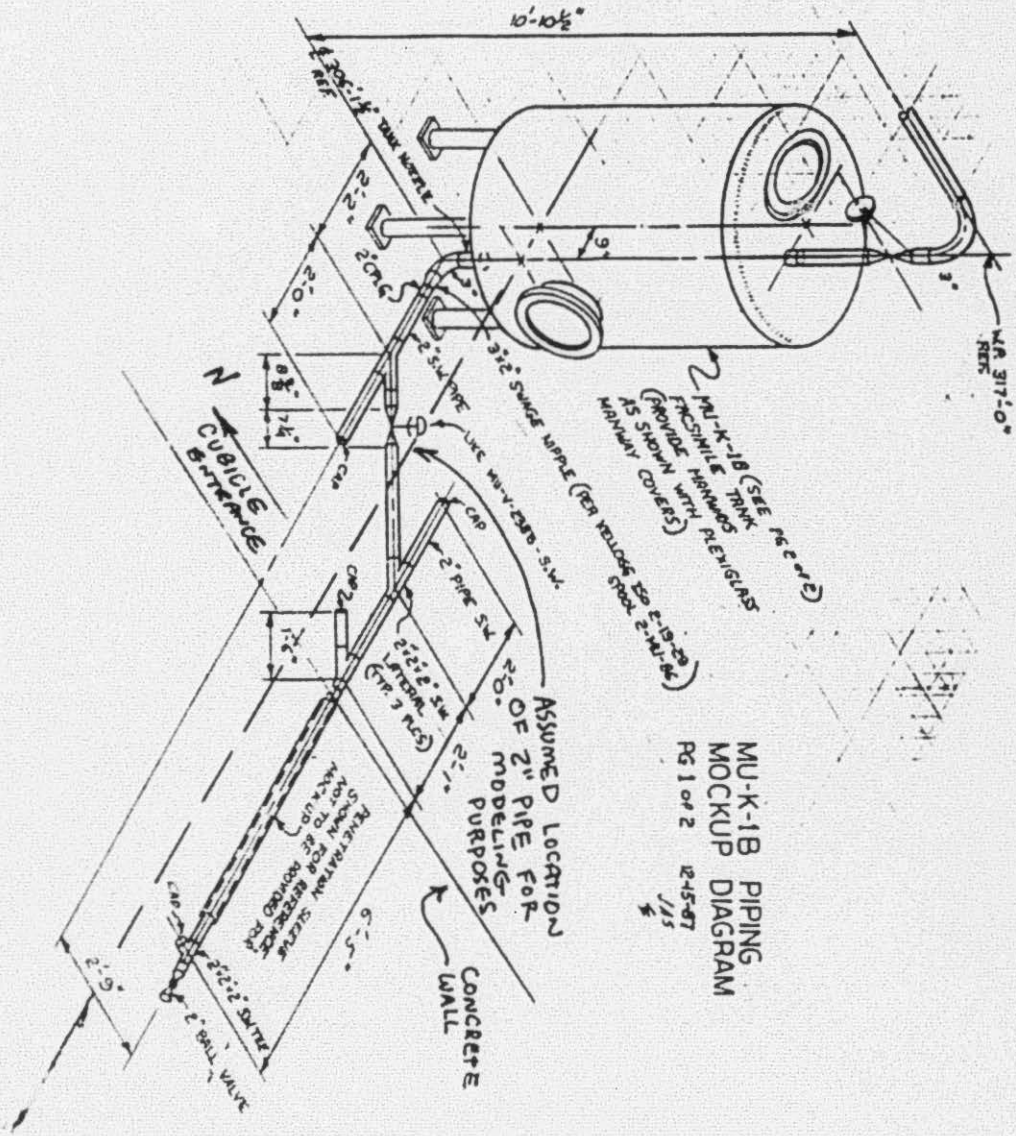


Gamma dose rates in cubicle B.

GPU Nuclear **Calculation Sheet**

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	23 of 54

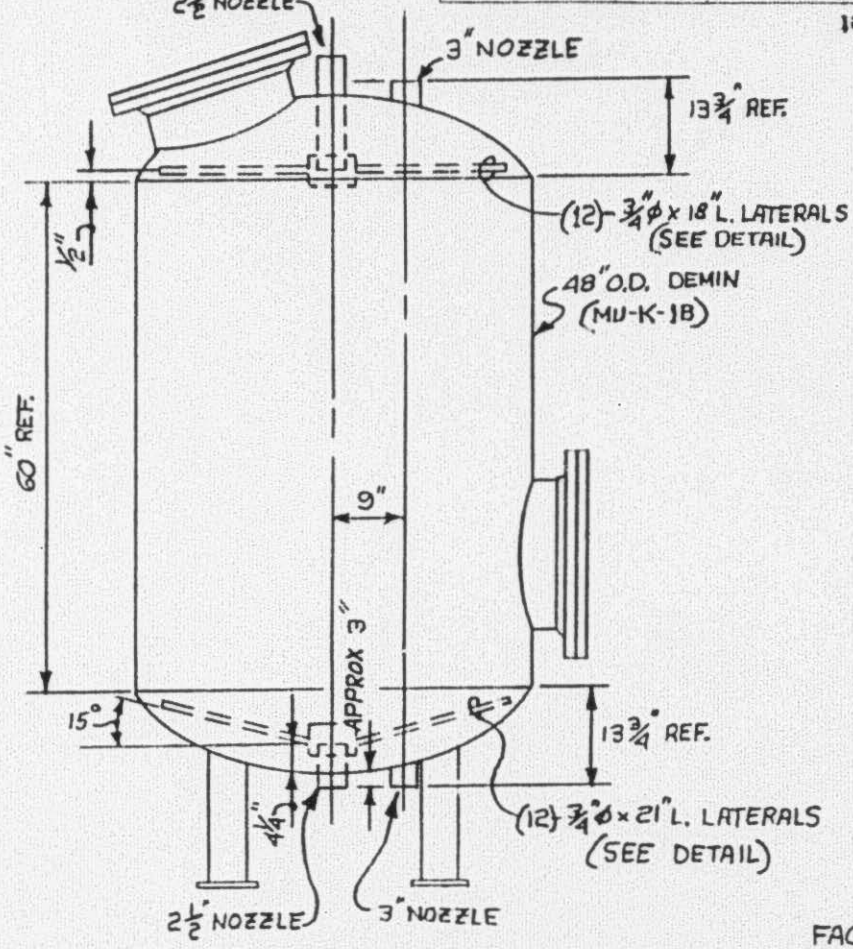
Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	9/8/93	G. Lodde GM Lodde	9/10/93

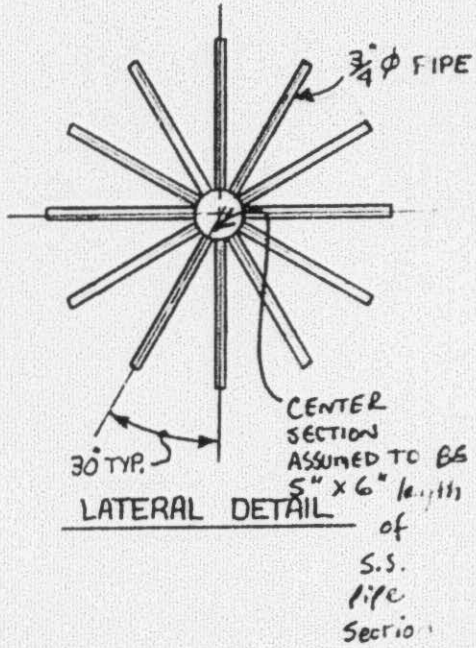


Attachment 4-4

GPU Nuclear — Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev. No: 1
Originator: B. Brooley	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93
			Sheet No: 2 of 5





LATERAL DETAIL

FACSIMILE NOZZLES & LATERALS TO RESEMBLE ORIGINAL AS CLOSE AS POSSIBLE

Attachment 5-1

MicroShield Batch Run Log

Batch Run Started on Wednesday, September 8, 1993 at 1:02 p.m.

Six cases initially in the queue.

CASE	FILE	GEOM	START TIME	ELAPSED	mR/hr w/BUILDUP	SENS. CYCLE
1	AHIGHDEM	7	1:02 p.m.	0:26:06	1.526e+001	(n/a)
2	ALOWDMIN	7	1:28 p.m.	0:25:06	1.822e+001	(n/a)
3	AMIDDMIN	7	1:54 p.m.	0:25:52	1.673e+001	REFERENCE
4	AMIDDMIN	7	1:54 p.m.	0:51:11	4.767e+001	1 of 5
5	AMIDDMIN	7	1:54 p.m.	1:16:21	3.178e+001	2 of 5
6	AMIDDMIN	7	1:54 p.m.	1:41:30	2.185e+001	3 of 5
7	AMIDDMIN	7	1:54 p.m.	2:06:42	1.561e+001	4 of 5
8	AMIDDMIN	7	1:54 p.m.	2:31:56	1.153e+001	5 of 5
9	BHIGHDEM	7	4:26 p.m.	0:17:06	3.619e+000	(n/a)
10	BLOWDEMI	7	4:43 p.m.	0:16:54	8.496e+000	(n/a)
11	BMIDDEMI	7	5:00 p.m.	0:17:01	5.107e+000	(n/a)

Batch run completed on Wednesday, September 8, 1993 at 5:17 p.m.

TOTAL EXECUTION TIME: 4:15:22

GPU Nuclear

Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	25 of 54
Originator: B. Brosey, Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

Attachment 5-2

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: ALOWDMIN.MS4
Run Date: July 27, 1993
Run Time: 11:07 a.m. Tuesday
Duration: 0:25:06

File Ref:
Date:
By:
Checked: 9/8/93

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	176.34	5.0	9.4
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	1.94056	0.0	.8
Cylinder radius:	30.48	1.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	145.225	4.0	9.2

Source Volume: 5663.79 cm^3 .200015 cu ft. 345.625 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	0.7463				
Iron	0.1485	7.86			
Uranium	0.0036				
Water	0.1405				

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.5200e-001	4.4493e+001	Ce-144	1.7900e-006	3.1604e-004
Co-60	7.9700e-004	1.4072e-001	Cs-134	7.5500e-004	1.3330e-001
Cs-137	2.6700e-001	4.7142e+001	Pr-144	1.7900e-006	3.1604e-004
Pr-144m	2.5500e-008	4.5023e-006	Sb-125	8.9100e-004	1.5732e-001
Sr-90	2.3900e-001	4.2198e+001	Te-125m	2.0600e-004	3.6371e-002
Y-90	2.3900e-001	4.2198e+001			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	1.076e+005	1.756e-003	2.975e-003	2.686e-006	4.552e-006
0.15	8.989e+004	6.280e-003	1.212e-002	1.034e-005	1.995e-005
0.2	2.502e+006	3.236e-001	6.507e-001	5.711e-004	1.148e-003
0.3	1.474e+005	3.688e-002	7.199e-002	6.995e-005	1.366e-004
0.4	1.032e+007	3.898e+000	7.198e+000	7.595e-003	1.403e-002
0.5	3.821e+006	1.958e+000	3.417e+000	3.843e-003	6.708e-003
0.6	8.436e+009	5.514e+003	9.161e+003	1.076e+001	1.788e+001
0.8	2.630e+007	2.506e+001	3.857e+001	4.767e-002	7.336e-002
1.0	3.027e+007	3.846e+001	5.608e+001	7.088e-002	1.034e-001
1.5	3.034e+007	6.414e+001	8.563e+001	1.079e-001	1.441e-001
2.0	5.126e+002	1.535e-003	1.955e-003	2.373e-006	3.023e-006
TOTAL:	8.539e+009	5.548e+003	9.353e+003	1.100e+001	1.822e+001

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 26 of 54	
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93	

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: AMIDDMIN.MS4
Run Date: July 27, 1993
Run Time: 11:33 a.m. Tuesday
Duration: 0:25:50

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	176.34	5.0	9.4
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	1.94056	0.0	.8
Cylinder radius:	30.48	1.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	145.225	4.0	9.2

Source Volume: 5663.79 cm^3 .200015 cu ft. 345.625 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	1.4927				
Iron	0.2176	7.86			
Uranium	0.0073				
Water	0.2811				

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.5200e-001	4.4493e+001	Ce-144	1.7900e-006	3.1604e-004
Co-60	7.9700e-004	1.4072e-001	Cs-134	7.5500e-004	1.3330e-001
Cs-137	2.6700e-001	4.7142e+001	Pr-144	1.7900e-006	3.1604e-004
Pr-144m	2.5500e-008	4.5023e-006	Sb-125	8.9100e-004	1.5732e-001
Sr-90	2.3900e-001	4.2198e+001	Te-125m	2.0600e-004	3.6371e-002
Y-90	2.3900e-001	4.2198e+001			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	1.076e+005	1.267e-003	2.196e-003	1.938e-006	3.359e-006
0.15	8.989e+004	4.673e-003	9.486e-003	7.696e-006	1.562e-005
0.2	2.502e+006	2.479e-001	5.369e-001	4.376e-004	9.476e-004
0.3	1.474e+005	2.924e-002	6.274e-002	5.546e-005	1.190e-004
0.4	1.032e+007	3.159e+000	6.444e+000	6.156e-003	1.256e-002
0.5	3.821e+006	1.613e+000	3.106e+000	3.166e-003	6.097e-003
0.6	8.436e+009	4.602e+003	8.405e+003	8.983e+000	1.641e+001
0.8	2.630e+007	2.134e+001	3.578e+001	4.058e-002	6.806e-002
1.0	3.027e+007	3.323e+001	5.234e+001	6.125e-002	9.648e-002
1.5	3.034e+007	5.684e+001	8.079e+001	9.563e-002	1.359e-001
2.0	5.126e+002	1.382e-003	1.858e-003	2.137e-006	2.874e-006
TOTAL:	8.539e+009	4.719e+003	8.584e+003	9.191e+000	1.673e+001

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No. 4240-3233-93-015	Rev. No. 1	Sheet No. 27 of 54	
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93	

Attachment 5-4

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: AHIGHDEM.MS4
Run Date: July 27, 1993
Run Time: 10:42 a.m. Tuesday
Duration: 0:26:07

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	176.34	5.0	9.4
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	1.94056	0.0	.8
Cylinder radius:	30.48	1.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	145.225	4.0	9.2

Source Volume: 5663.79 cm^3 .200015 cu ft. 345.625 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	2.239				
Iron	0.2868	7.86			
Uranium	0.0109				
Water	0.4216				

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.5200e-001	4.4493e+001	Ce-144	1.7900e-006	3.1604e-004
Co-60	7.9700e-004	1.4072e-001	Cs-134	7.5500e-004	1.3330e-001
Cs-137	2.6700e-001	4.7142e+001	Pr-144	1.7900e-006	3.1604e-004
Pr-144m	2.5500e-008	4.5023e-006	Sb-125	8.9100e-004	1.5732e-001
Sr-90	2.3900e-001	4.2198e+001	Te-125m	2.0600e-004	3.6371e-002
Y-90	2.3900e-001	4.2198e+001			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	1.076e+005	9.647e-004	1.694e-003	1.476e-006	2.591e-006
0.15	8.989e+004	3.629e-003	7.609e-003	5.975e-006	1.253e-005
0.2	2.502e+006	1.964e-001	4.472e-001	3.467e-004	7.893e-004
0.3	1.474e+005	2.376e-002	5.456e-002	4.506e-005	1.035e-004
0.4	1.032e+007	2.611e+000	5.736e+000	5.088e-003	1.118e-002
0.5	3.821e+006	1.351e+000	2.805e+000	2.652e-003	5.506e-003
0.6	8.436e+009	3.896e+003	7.665e+003	7.605e+000	1.496e+001
0.8	2.630e+007	1.837e+001	3.305e+001	3.493e-002	6.286e-002
1.0	3.027e+007	2.897e+001	4.871e+001	5.340e-002	8.978e-002
1.5	3.034e+007	5.067e+001	7.603e+001	8.525e-002	1.279e-001
2.0	5.126e+002	1.249e-003	1.761e-003	1.932e-006	2.724e-006
TOTAL:	8.539e+009	3.998e+003	7.832e+003	7.[illegible]e+000	1.526e+001

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading
Calc No: 4240-3233-93-015
Rev No: 1
Sheet No: 28 of 57
Originator: B. Brosey
Date: 9/8/93
Reviewed by: G. Lodde
Date: 9/14/93

Attachment 5-5

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: BLOWDEMI.MS4
Run Date: September 8, 1993
Run Time: 5:00 p.m. Wednesday
Duration: 0:16:54

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	270.97	8.0	10.7
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	17.2212	0.0	6.8
Cylinder radius:	60.96	2.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	209.375	6.0	10.4

Source Volume: 201050. cm^3 7.1 cu ft. 12268.8 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	0.7463				
Iron	0.0931	7.86			
Uranium	0.0007				
Water	0.1405				

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

********** CAUTION **********
This buildup reference material is a mixed material with a high atomic number element (91). Buildup Factors less than and somewhat greater than 113 keV may be incorrect. Please understand your results!
****

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	4.6100e-001	2.2930e+000	Cs-134	1.3500e-003	6.7148e-003
Cs-137	4.8700e-001	2.4223e+000	Sr-90	2.5100e-002	1.2484e-001
Y-90	2.5100e-002	1.2484e-001			

********** RESULTS **********

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	With Buildup	Exposure Rate In Air (mR/hr) No Buildup	With Buildup
0.3	1.768e+004	5.282e-004	2.415e-003	1.002e-006	4.582e-006
0.5	7.293e+005	5.063e-002	1.693e-001	9.937e-005	3.323e-004
0.6	1.541e+010	1.434e+003	4.334e+003	2.799e+000	8.459e+000
0.8	4.702e+007	6.925e+000	1.802e+001	1.317e-002	3.428e-002
1.0	1.399e+006	2.937e-001	6.892e-001	5.413e-004	1.270e-003
1.5	1.518e+006	6.021e-001	1.192e+000	1.013e-003	2.006e-003
TOTAL:	1.546e+010	1.442e+003	4.354e+003	2.814e+000	8.496e+000

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 29 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: BMIDDEMI.MS4
Run Date: September 8, 1993
Run Time: 5:17 p.m. Wednesday
Duration: 0:17:02

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	270.97	8.0	10.7
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	17.2212	0.0	6.8
Cylinder radius:	60.96	2.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	209.375	6.0	10.4

Source Volume: 201050. cm^3 7.1 cu ft. 12268.8 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	1.4927				
Iron	0.107	7.86			
Uranium	0.0015				
Water	0.2811				

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

********** CAUTION **********
This buildup reference material is a mixed material with a high atomic number element (91). Buildup Factors less than and somewhat greater than 113 keV may be incorrect. Please understand your results!
****

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	4.6100e-001	2.2930e+000	Cs-134	1.3500e-003	6.7148e-003
Cs-137	4.8700e-001	2.4223e+000	Sr-90	2.5100e-002	1.2484e-001
Y-90	2.5100e-002	1.2484e-001			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.3	1.768e+004	2.907e-004	1.414e-003	5.514e-007	2.682e-006
0.5	7.293e+005	2.822e-002	1.009e-001	5.539e-005	1.981e-004
0.6	1.541e+010	8.042e+002	2.605e+003	1.570e+000	5.084e+000
0.8	4.702e+007	3.930e+000	1.100e+001	7.475e-003	2.092e-002
1.0	1.399e+006	1.686e-001	4.264e-001	3.107e-004	7.860e-004
1.5	1.518e+006	3.546e-001	7.602e-001	5.967e-004	1.279e-003
TOTAL:	1.546e+010	8.087e+002	2.617e+003	1.578e+000	5.107e+000

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	30 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: BHIGHDEM.MS4
Run Date: September 8, 1993
Run Time: 4:43 p.m. Wednesday
Duration: 0:17:06

File Ref:
Date:
By:
Checked: 9/13/93

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	270.97	8.0	10.7
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	17.2212	0.0	6.8
Cylinder radius:	60.96	2.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	209.375	6.0	10.4

Source Volume: 201050. cm^3 7.1 cu ft. 12268.8 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	2.239				
Iron	0.1208	7.86			
Uranium	0.0022				
Water	0.4216				

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

********** CAUTION **********
This buildup reference material is a mixed material with a high atomic number element (91). Buildup Factors less than and somewhat greater than 113 keV may be incorrect. Please understand your results!
****

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	4.6100e-001	2.2930e+000	Cs-134	1.3500e-003	6.7148e-003
Cs-137	4.8700e-001	2.4223e+000	Sr-90	2.5100e-002	1.2484e-001
Y-90	2.5100e-002	1.2484e-001			

========== RESULTS ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	With Buildup	Exposure Rate In Air (mR/hr) No Buildup	With Buildup
0.3	1.768e+004	2.003e-004	9.941e-004	3.800e-007	1.886e-006
0.5	7.293e+005	1.952e-002	7.133e-002	3.832e-005	1.400e-004
0.6	1.541e+010	5.575e+002	1.846e+003	1.088e+000	3.603e+000
0.8	4.702e+007	2.735e+000	7.831e+000	5.202e-003	1.490e-002
1.0	1.399e+006	1.177e-001	3.050e-001	2.170e-004	5.623e-004
1.5	1.518e+006	2.498e-001	5.496e-001	4.203e-004	9.247e-004
TOTAL:	1.546e+010	5.606e+002	1.855e+003	1.094e+000	3.619e+000

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No. 4240-3233-93-015	Rev. No 1
Originator: B. Brosey	Date 9/8/93	Reviewed by G. Lodde	Sheet No. 31 of 54
			Date 9/10/93

Attachment 6-1

MicroShield Batch Run Log
==========

Batch Run Started on Wednesday, September 8, 1993 at 1:02 p.m.

Six cases initially in the queue.

CASE	FILE	GEOM	START TIME	ELAPSED	mR/hr w/BUILDUP	SENS. CYCLE
1	AHIGHDEM	7	1:02 p.m.	0:26:06	1.526e+001	(n/a)
2	ALOWDMIN	7	1:28 p.m.	0:25:06	1.822e+001	(n/a)
3	AMIDDMIN	7	1:54 p.m.	0:25:52	1.673e+001	REFERENCE
4	AMIDDMIN	7	1:54 p.m.	0:51:11	4.767e+001	1 of 5
5	AMIDDMIN	7	1:54 p.m.	1:16:21	3.178e+001	2 of 5
6	AMIDDMIN	7	1:54 p.m.	1:41:30	2.185e+001	3 of 5
7	AMIDDMIN	7	1:54 p.m.	2:06:42	1.561e+001	4 of 5
8	AMIDDMIN	7	1:54 p.m.	2:31:56	1.153e+001	5 of 5
9	BHIGHDEM	7	4:26 p.m.	0:17:06	3.619e+000	(n/a)
10	BLOWDEMI	7	4:43 p.m.	0:16:54	8.496e+000	(n/a)
11	BMIDDEMI	7	5:00 p.m.	0:17:01	5.107e+000	(n/a)

Batch run completed on Wednesday, September 8, 1993 at 5:17 p.m.

TOTAL EXECUTION TIME: 4:15:22

Page : 2
DOS File: BMIDDEMI.MS4
Run Date: September 9, 1993
Run Time: 9:17 a.m. Thursday
Title : MAKEUP DEMIN AX114 & AX115

SENSITIVITY RESULTS For: X (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
1	304.8	6.057e+002	1.969e+003	1.182e+000	3.843e+000
2	251.46	9.714e+002	3.136e+003	1.896e+000	6.121e+000
3	198.12	1.737e+003	5.587e+003	3.390e+000	1.090e+001
4	144.78	3.607e+003	1.166e+004	7.039e+000	2.276e+001
5	91.44	8.406e+003	2.835e+004	1.640e+001	5.534e+001

Use the Display Menu For Energy Group Results For All Cases.

GPU Nuclear — Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 32 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

Attachment 6-2

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: AMIDDMIN.MS4
Run Date: July 27, 1993
Run Time: 3:45 p.m. Tuesday
Duration: 2:57:58

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	176.34	5.0	9.4
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	1.94056	0.0	.8
Cylinder radius:	30.48	1.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	145.225	4.0	9.2

Source Volume: 5663.79 cm^3 .200015 cu ft. 345.625 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	1.4927				
Iron	0.2176	7.86			
Uranium	0.0073				
Water	0.2811				

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.5200e-001	4.4493e+001	Ce-144	1.7900e-006	3.1604e-004
Co-60	7.9700e-004	1.4072e-001	Cs-134	7.5500e-004	1.3330e-001
Cs-137	2.6700e-001	4.7142e+001	Pr-144	1.7900e-006	3.1604e-004
Pr-144m	2.5500e-008	4.5023e-006	Sb-125	8.9100e-004	1.5732e-001
Sr-90	2.3900e-001	4.2198e+001	Te-125m	2.0600e-004	3.6371e-002
Y-90	2.3900e-001	4.2198e+001			

========== RESULTS FOR SENSITIVITY REFERENCE CASE (X = 176.34) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	1.076e+005	1.267e-003	2.196e-003	1.938e-006	3.359e-006
0.15	8.989e+004	4.673e-003	9.486e-003	7.696e-006	1.562e-005
0.2	2.502e+006	2.479e-001	5.369e-001	4.376e-004	9.476e-004
0.3	1.474e+005	3.924e-002	6.274e-002	5.546e-005	1.190e-004
0.4	1.032e+007	3.159e+000	6.444e+000	6.156e-003	1.256e-002
0.5	3.821e+006	1.613e+000	3.106e+000	3.166e-003	6.097e-003
0.6	8.436e+009	4.602e+003	8.405e+003	8.983e+000	1.641e+001
0.8	2.630e+007	2.134e+001	3.578e+001	4.058e-002	6.806e-002
1.0	3.027e+007	3.323e+001	5.234e+001	6.125e-002	9.648e-002
1.5	3.034e+007	5.684e+001	8.079e+001	9.563e-002	1.359e-001
2.0	5.126e+002	1.382e-003	1.858e-003	2.137e-006	2.874e-006
TOTAL:	8.539e+009	4.719e+003	8.584e+003	9.191e+000	1.673e+001

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev No: 1	Sheet No: 33 of 54	
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93	

Attachment 6-3

Page : 2
DOS File: AMIDDMIN.MS4
Run Date: July 27, 1993
Run Time: 3:45 p.m. Tuesday
Title : MAKEUP DEMIN AX114 & AX115

SENSITIVITY RESULTS For: X (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
1	91.44	1.382e+004	2.447e+004	2.692e+001	4.767e+001
2	121.92	9.231e+003	1.631e+004	1.798e+001	3.178e+001
3	152.4	6.260e+003	1.122e+004	1.219e+001	2.185e+001
4	182.88	4.384e+003	8.011e+003	8.539e+000	1.561e+001
5	213.36	3.173e+003	5.920e+003	6.179e+000	1.153e+001

Use the Display Menu For Energy Group Results For All Cases.

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 34 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodge	Date: 9/10/93

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: BMIDDEMI.MS4
Run Date: September 8, 1993
Run Time: 5:17 p.m. Wednesday
Duration: 0:17:02

File Ref:
Date:
By:
Checked:

Case Title: MAKEUP DEMIN AX114 & AX115

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	270.97	8.0	10.7
Dose point coordinate Y:	68.58	2.0	3.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	17.2212	0.0	6.8
Cylinder radius:	60.96	2.0	.0
Shield 1:	0.635	0.0	.3
Air Gap:	209.375	6.0	10.4

Source Volume: 201050. cm^3 7.1 cu ft. 12268.8 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	1.4927				
Iron	0.107	7.86			
Uranium	0.0015				
Water	0.2811				

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

********** CAUTION **********
This buildup reference material is a mixed material with a high atomic number element (91). Buildup Factors less than and somewhat greater than 113 keV may be incorrect. Please understand your results!
****

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	4.6100e-001	2.2930e+000	Cs-134	1.3500e-003	6.7148e-003
Cs-137	4.8700e-001	2.4223e+000	Sr-90	2.5100e-002	1.2484e-001
Y-90	2.5100e-002	1.2484e-001			

********** RESULTS **********

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	With Buildup	Exposure Rate In Air (mR/hr) No Buildup	With Buildup
0.3	1.768e+004	2.907e-004	1.414e-003	5.514e-007	2.682e-006
0.5	7.293e+005	2.822e-002	1.009e-001	5.539e-005	1.981e-004
0.6	1.541e+010	8.042e+002	2.605e+003	1.570e+000	5.084e+000
0.8	4.702e+007	3.930e+000	1.100e+001	7.475e-003	2.092e-002
1.0	1.399e+006	1.686e-001	4.264e-001	3.107e-004	7.860e-004
1.5	1.518e+006	3.546e-001	7.602e-001	5.967e-004	1.279e-003
TOTAL:	1.546e+010	8.087e+002	2.617e+003	1.578e+000	5.107e+000

GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No. 4240-3233-93-015	Rev. No. 1
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Sheet No. 35 of 54
			Date: 9/10/93

Page : 2
DOS File: BMIDDEMI.MS4
Run Date: September 9, 1993
Run Time: 9:17 a.m. Thursday
Title : MAKEUP DEMIN AX114 & AX115

SENSITIVITY RESULTS For: X (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
1	304.8	6.057e+002	1.969e+003	1.182e+000	3.843e+000
2	251.46	9.714e+002	3.136e+003	1.896e+000	6.121e+000
3	198.12	1.737e+003	5.587e+003	3.390e+000	1.090e+001
4	144.78	3.607e+003	1.166e+004	7.039e+000	2.276e+001
5	91.44	8.406e+003	2.835e+004	1.640e+001	5.534e+001

Use the Display Menu For Energy Group Results For All Cases.

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No. 4240-3233-93-015	Rev. No 1	Sheet No. 36 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodge		Date: 9/10/93

Attachment 7-1

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: ADPIPE2.MS4
Run Date: July 27, 1993
Run Time: 2:44 p.m. Tuesday
Duration: 0:25:43

File Ref:
Date:
By:
Checked:

Case Title: PIPE AT BASE OF A DEMIN

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	176.784	5.0	9.6
Dose point coordinate Y:	60.96	2.0	.0
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	22.86	0.0	9.0
Cylinder radius:	3.89636	0.0	1.5
Shield 1:	0.54864	0.0	.2
Air Gap:	172.339	5.0	7.9

Source Volume: 1090.3 cm^3 3.85034e-2 cu ft. 66.5339 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap	Immersion Shield
Air			0.00122	0.00122	0.00122
Carbon	1.4927				
Iron	0.2176	7.86			
Uranium	0.0073				
Water	0.2811				

BUILDUP
Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	22
Circumferential	22
Axial (along Z)	22

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	2.5200e-001	2.3113e+002	Ce-144	1.7900e-006	1.6418e-003
Co-60	7.9700e-004	7.3099e-001	Cs-134	7.5500e-004	6.9247e-001
Cs-137	2.6700e-001	2.4489e+002	Pr-144	1.7900e-006	1.6418e-003
Pr-144m	2.5500e-008	2.3388e-005	Sb-125	8.9100e-004	8.1721e-001
Sr-90	2.3900e-001	2.1921e+002	Te-125m	2.0600e-004	1.8894e-001
Y-90	2.3900e-001	2.1921e+002			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	Energy Fluence Rate (MeV/sq cm/sec) With Buildup	Exposure Rate In Air (mR/hr) No Buildup	Exposure Rate In Air (mR/hr) With Buildup
0.1	1.076e+005	1.573e-003	2.672e-003	2.406e-006	4.088e-006
0.15	8.989e+004	5.112e-003	1.019e-002	8.419e-006	1.679e-005
0.2	2.502e+006	2.635e-001	5.624e-001	4.651e-004	9.927e-004
0.3	1.474e+005	3.060e-002	6.513e-002	5.804e-005	1.236e-004
0.4	1.032e+007	3.292e+000	6.685e+000	6.415e-003	1.303e-002
0.5	3.821e+006	1.678e+000	3.224e+000	3.294e-003	6.328e-003
0.6	8.436e+009	4.784e+003	8.728e+003	9.338e+000	1.704e+001
0.8	2.630e+007	2.217e+001	3.720e+001	4.216e-002	7.075e-002
1.0	3.027e+007	3.452e+001	5.445e+001	6.363e-002	1.004e-001
1.5	3.034e+007	5.909e+001	8.413e+001	9.942e-002	1.416e-001
2.0	5.126e+002	1.438e-003	1.937e-003	2.224e-006	2.996e-006
TOTAL:	8.539e+009	4.905e+003	8.915e+003	9.554e+000	1.737e+001

GPU Nuclear — Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No. 4240-3233-93-015	Rev. No. 1	Sheet No. 37 of 54	
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93	

MicroShield 4.00 - Serial #4.00-00247
GPU

Page : 1
DOS File: B2INLINE.MS4
Run Date: September 9, 1993
Run Time: 9:45 a.m. Thursday
Duration: 0:11:33

File Ref:
Date:
By:
Checked: 9/8/93

Case Title: PIPE AT BASE OF B DEMIN

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	217.17	7.0	1.5
Dose point coordinate Y:	44.81	1.0	5.6
Dose point coordinate Z:	87.63	2.0	10.5
Cylinder height:	228.6	7.0	6.0
Cylinder radius:	2.62509	0.0	1.0
Shield 1:	0.39116	0.0	.2
Air Gap:	214.15375	7.0	.3

Source Volume: 4948.97 cm^3 .174771 cu ft. 302.004 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Cylinder	Transition Shield	Air Gap
Air			0.00122	0.00122
Carbon	1.4927			
Iron	0.0277	7.86		
Uranium	0.0015			
Water	0.2811			

BUILDUP
Method: Buildup Factor Tables
The material reference is Source

********** CAUTION **********
This buildup reference material is a mixed material with a high atomic number element (91). Buildup factors less than and somewhat greater than 113 keV may be incorrect. Please understand your results!
****

INTEGRATION PARAMETERS

	Quadrature Order
Radial	20
Circumferential	20
Axial (along Z)	20

SOURCE NUCLIDES

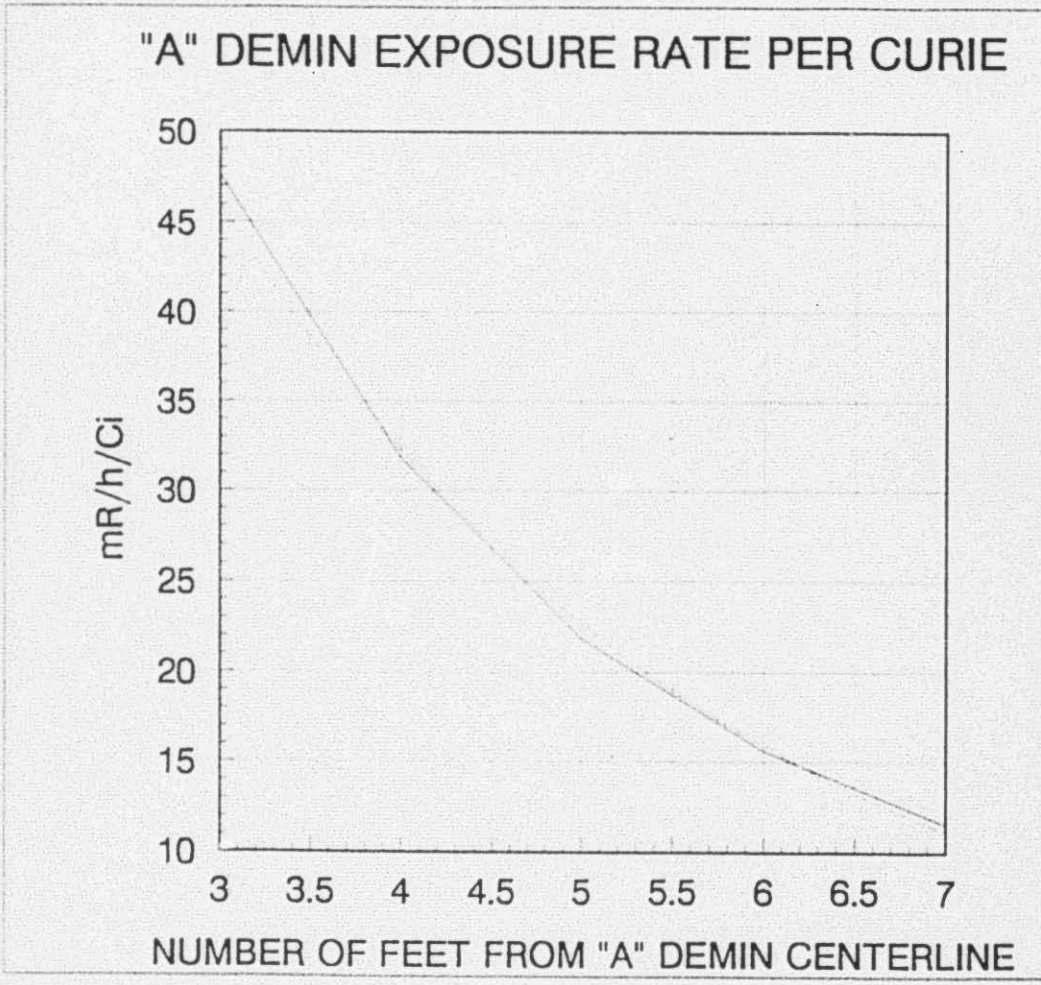
Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	4.6100e-001	9.3151e+001	Ce-144	0.0000e+000	0.0000e+000
Co-60	0.0000e+000	0.0000e+000	Cs-134	1.3500e-003	2.7278e-001
Cs-137	4.8700e-001	9.8404e+001	Pr-144	0.0000e+000	0.0000e+000
Pr-144m	0.0000e+000	0.0000e+000	Sb-125	0.0000e+000	0.0000e+000
Sr-90	2.5100e-002	5.0718e+000	Te-125m	0.0000e+000	0.0000e+000
Y-90	2.5100e-002	5.0718e+000			

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec) No Buildup	With Buildup	Exposure Rate In Air (mR/hr) No Buildup	With Buildup
0.3	1.768e+004	2.820e-003	6.725e-003	5.349e-006	1.276e-005
0.5	7.293e+005	2.297e-001	4.260e-001	4.510e-004	8.363e-004
0.6	1.541e+010	6.141e+003	1.059e+004	1.199e+001	2.068e+001
0.8	4.702e+007	2.702e+001	4.203e+001	5.139e-002	7.995e-002
1.0	1.399e+006	1.063e+000	1.557e+000	1.960e-003	2.870e-003
1.5	1.518e+006	1.900e+000	2.517e+000	3.197e-003	4.236e-003
TOTAL:	1.546e+010	6.171e+003	1.064e+004	1.204e+001	2.077e+001

GPU Nuclear Calculation Sheet

Subject: AX114 and AX115 Curie Loading		Calc No: 4240-3233-93-015	Rev No: 1
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Sheet No: 38 of 54
			Date: 9/10/93



GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 39 of 54
Originator: B. Brosky, 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

```
\Exponential regression
\Correlation statistics:
\correlation coefficent = -0.966758
\mean of x = 5
\mean of y = 25.688
\standard deviation of x = 1.41421
\standard deviation of y = 12.9388
\variance of x = 2
\variance of y = 167.413
\covariance of x and y = -17.69
\Data format: Curve
\Variable format: Non-parametric
\Angular units: Radians
\x=3,7,100,0
\y=133.6 * 0.7012^x
100 2
3 46.061
3.0404 45.4051
3.08081 44.7585
3.12121 44.1212
3.16162 43.4929
3.20202 42.8736
3.24242 42.2631
3.28283 41.6613
3.32323 41.0681
3.36364 40.4833
3.40404 39.9068
3.44444 39.3385
3.48485 38.7784
3.52525 38.2262
3.56566 37.6819
3.60606 37.1453
3.64646 36.6164
3.68687 36.095
3.72727 35.581
3.76768 35.0743
3.80808 34.5749
3.84848 34.0826
3.88889 33.5972
3.92929 33.1188
3.9697 32.6472
4.0101 32.1823
4.05051 31.7241
4.09091 31.2723
4.13131 30.827
4.17172 30.3881
4.21212 29.9554
4.25253 29.5288
4.29293 29.1083
4.33333 28.6938
4.37374 28.2853
4.41414 27.8825
4.45455 27.4855
4.49495 27.0941
4.53535 26.7083
4.57576 26.3279
4.61616 25.953
4.65657 25.5835
4.69697 25.2192
4.73737 24.8601
4.77778 24.5061
4.81818 24.1571
4.85859 23.8131
4.89899 23.4741
4.93939 23.1398
4.9798 22.8103
5.0202 22.4855
5.06061 22.1653
```

GPU Nuclear

Calculation Sheet

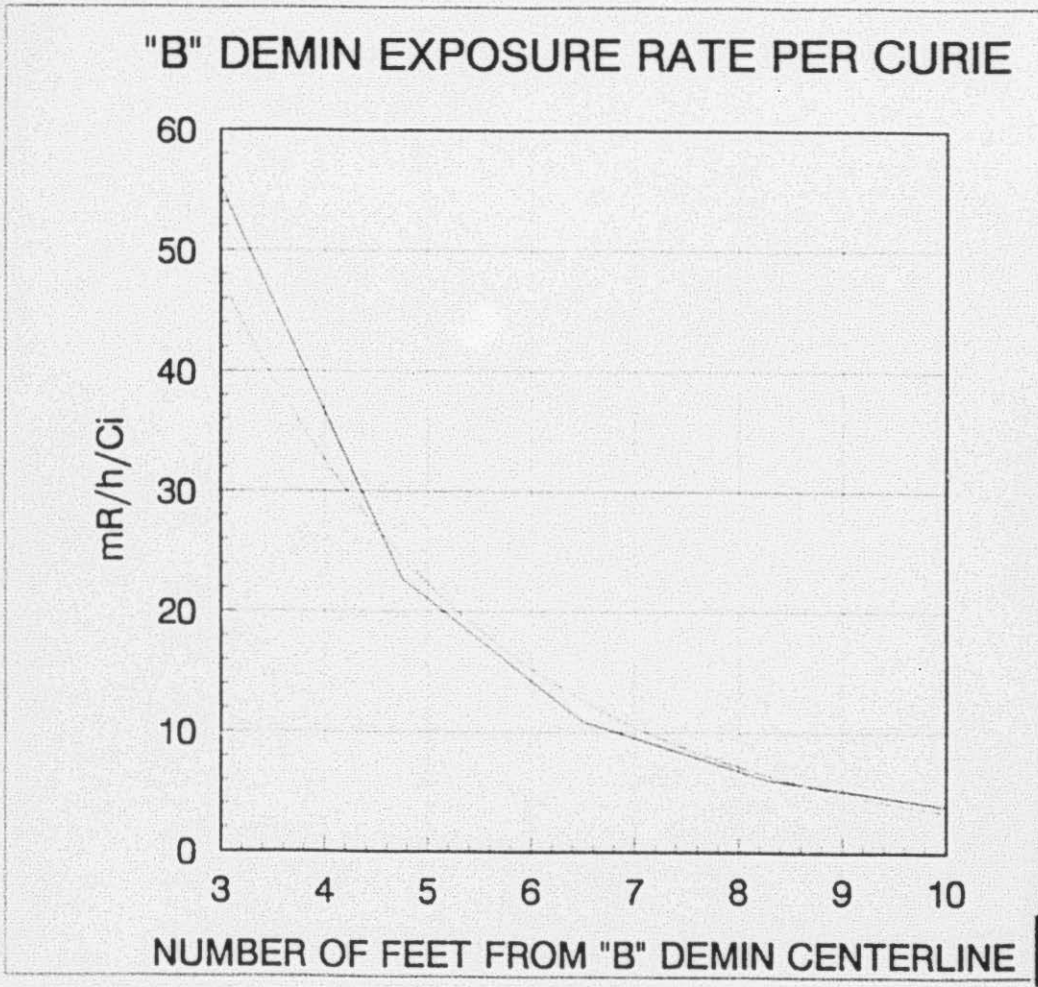
Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 40 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

5.10101	21.8497
5.14141	21.5385
5.18182	21.2318
5.22222	20.9295
5.26263	20.6315
5.30303	20.3377
5.34343	20.0481
5.38384	19.7626
5.42424	19.4812
5.46465	19.2038
5.50505	18.9304
5.54545	18.6608
5.58586	18.3951
5.62626	18.1331
5.66667	17.8749
5.70707	17.6204
5.74747	17.3695
5.78788	17.1222
5.82828	16.8783
5.86869	16.638
5.90909	16.4011
5.94949	16.1675
5.9899	15.9373
6.0303	15.7104
6.07071	15.4867
6.11111	15.2662
6.15152	15.0488
6.19192	14.8345
6.23232	14.6232
6.27273	14.415
6.31313	14.2098
6.35354	14.0074
6.39394	13.808
6.43434	13.6113
6.47475	13.4175
6.51515	13.2265
6.55556	13.0381
6.59596	12.8525
6.63636	12.6694
6.67677	12.489
6.71717	12.3112
6.75758	12.1359
6.79798	11.9631
6.83838	11.7927
6.87879	11.6248
6.91919	11.4593
6.9596	11.2961
7	11.1353

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	41 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodge	Date: 9/10/93



GPU Nuclear

Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 42 of 54
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

```
\Exponential regression
\Correlation statistics:
\correlation coefficent = -0.89348
\mean of x = 6.5
\mean of y = 19.7928
\standard deviation of x = 2.47487
\standard deviation of y = 18.9357
\variance of x = 6.125
\variance of y = 358.561
\covariance of x and y = -41.8716
\Data format: Curve
\Variable format: Non-parametric
\Angular units: Radians
\x=3,10,100,0
\y=149.339 * 0.683949^x
100 2
3 47.7797
3.07071 46.5135
3.14141 45.2808
3.21212 44.0807
3.28283 42.9125
3.35354 41.7752
3.42424 40.6681
3.49495 39.5903
3.56566 38.5411
3.63636 37.5196
3.70707 36.5253
3.77778 35.5573
3.84848 34.6149
3.91919 33.6976
3.9899 32.8045
4.06061 31.9351
4.13131 31.0888
4.20202 30.2649
4.27273 29.4628
4.34343 28.6819
4.41414 27.9218
4.48485 27.1818
4.55556 26.4614
4.62626 25.7602
4.69697 25.0775
4.76768 24.4129
4.83838 23.7659
4.90909 23.136
4.9798 22.5229
5.05051 21.926
5.12121 21.3449
5.19192 20.7792
5.26263 20.2285
5.33333 19.6924
5.40404 19.1705
5.47475 18.6624
5.54545 18.1679
5.61616 17.6864
5.68687 17.2176
5.75758 16.7613
5.82828 16.3171
5.89899 15.8847
5.9697 15.4637
6.0404 15.0539
6.11111 14.6549
6.18182 14.2665
6.25253 13.8884
6.32323 13.5204
6.39394 13.1621
6.46465 12.8132
6.53535 12.4737
6.60606 12.1431
```

GPU Nuclear — Calculation Sheet

Subject	Calc No	Rev. No.	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	53 of 54
Originator: B. Brosey, Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

6.67677	11.8213
6.74747	11.508
6.81818	11.203
6.88889	10.9061
6.9596	10.617
7.0303	10.3357
7.10101	10.0618
7.17172	9.79509
7.24242	9.5355
7.31313	9.28279
7.38384	9.03678
7.45455	8.79728
7.52525	8.56414
7.59596	8.33717
7.66667	8.11622
7.73737	7.90112
7.80808	7.69172
7.87879	7.48788
7.94949	7.28943
8.0202	7.09625
8.09091	6.90818
8.16162	6.7251
8.23232	6.54687
8.30303	6.37336
8.37374	6.20446
8.44444	6.04002
8.51515	5.87995
8.58586	5.72412
8.65657	5.57242
8.72727	5.42474
8.79798	5.28097
8.86869	5.14101
8.93939	5.00476
9.0101	4.87213
9.08081	4.74301
9.15152	4.61731
9.22222	4.49494
9.29293	4.37581
9.36364	4.25984
9.43434	4.14695
9.50505	4.03705
9.57576	3.93006
9.64646	3.8259
9.71717	3.72451
9.78788	3.6258
9.85859	3.52971
9.92929	3.43616
10	3.3451

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	54 of 54
Originator: B. Brosey — Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

Attachment 10-1

Subject: AX114 and AX115 Curie Loading			
Originator: B. Brosey	Date: 9/8/93	Rev. No. 1	Sheet No. XS-01 of 57
Calc No: 4240-3233-93-015		Reviewed by: G. Lodde	Date: 9/10/93

Nuclear Calculation Sheet

RADIOLOGICAL SURVEY

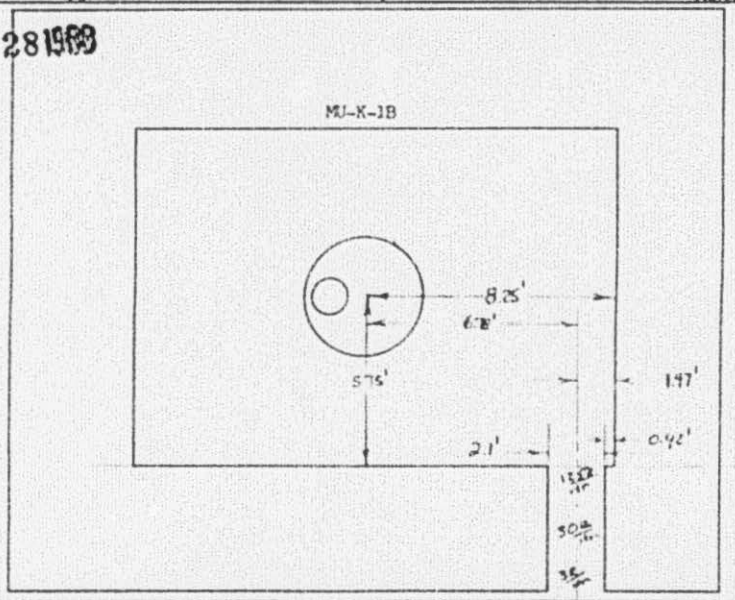
Survey Information	Instrument Data		Air Sample	File Code Number: AX115-BS-S-19756
Location "B" MAKE-UP DEMINERALIZER ROOM	Contamination Survey: Inst / S/N / Cal.Due / Eff. / Bkg / Tech	Radiation Survey: Inst TBD/DIVE / S/N 8334 / Cal.Due 12-21-93 / B.C.F. NA / Tech J. Dusek	Date / Time / Activity NT / Sample #	Smearable Contamination
Reason PERC LEAK INTO DEMIN ROOM	Inst NT / S/N / Cal.Due / Eff. / Bkg	Inst NT / S/N / Cal.Due / B.C.F.	Note: Radiation dose rates in mr/hr are general area, contamination results are dpm/100cm² unless otherwise noted	
Date 9-27-93 Time 1030				
Tech. J. Dusek				
Survey Request # NT				
Reviewed by				

Note: Contact Readings Circled
□ = Smear Location

Location	βγ	α	Comments
			NT

B.E. Miller SEP 28 1993

ORIGINAL



Remarks: WASHER WAS DONE

Attachment 10-2

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	46 of 54

Originator	Date	Reviewed By	Date
B. Brosey B. Brosey	9/8/93	G. Lodge	9/10/93

MAKE UP AND PURIFICATION DEMIN. 1A ROOM

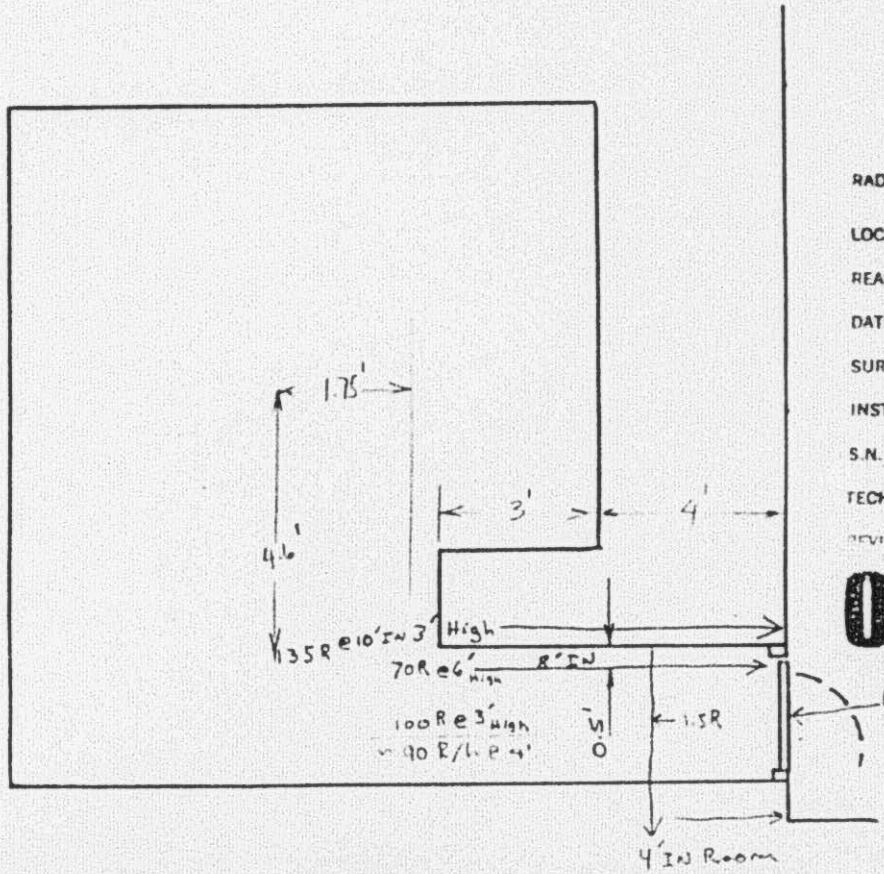
FILE CODE NO. AX114

PAGE 1 OF 1

DATE 03-13-85

TECHNICIAN B. Miller

SURVEY REQUEST NO.



RAD. SURVEY INFORMATION

LOCATION MUPD 1A RM.

REASON Post Flush Info.

DATE 03-13-85 TIME 0920

SURVEY REQ. NO.

INST. Tele. CAL DUE 5-6-85

S.N. 11759 B.F.

TECH B. Miller

REVIEWED

ORIGINAL

000001

Subject: AX114 and AX115 Curie Loading	Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93
	Calc No: 4240-3233-93-015	Rev. No: 1	Sheet No: 4 of 4	

GPU Nuclear Calculation Sheet

RADIOLOGICAL SURVEY

Survey Information	Instrument Data		Air Sample	File Code Number: AX115-3N-S5
	Contamination Survey	Radiation Survey		Smearable Contamination
Location 303 Area B-Demineralizer	Inst / S/N / Cal.Due / Eff / Bkg	Inst Tela / S/N 58724 / Cal.Due 6-10-93 / B.C.F. / Tech B. Miller / R. Miller	Date / Time / Activity / Air Sample No.	Location / Comments
Reason Post Elution	Inst / S/N / Cal.Due / Eff / Bkg	Inst / S/N / Cal.Due / B.C.F.	Notes: Radiation in mr/hr	
Date 04-06-93 Time 1130			cose rates are general	
Tech. B. Miller			area, and contamination	
Survey Request No.	Tech	Contact Readings Circled	results in dpm/100 cm2	
Reviewed By		☐ = Smear Location	unless otherwise noted.	

Make Up Demineralizing Room 1B

ALL Readings 4' Above Floor

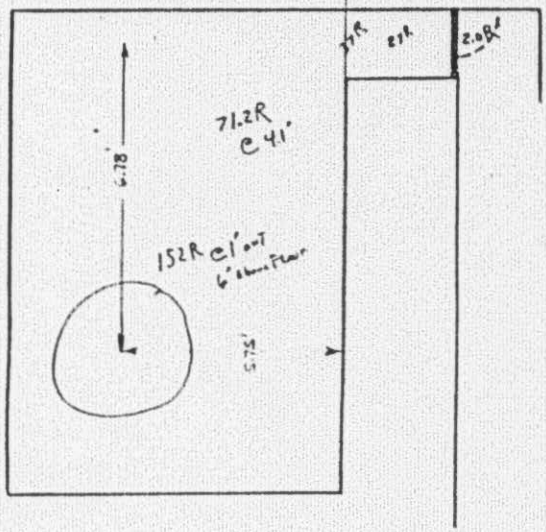
Remarks:

Attachment 10-3

ORIGINAL

000004

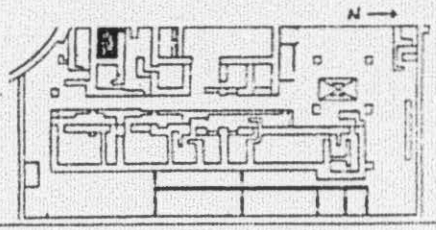
Survey Information	Instrument Data				Air Sample	File Code Number: AX115 – 4/1-85
	Contamination Survey		Radiation Survey			Smearable Contamination
Location: 305' Make up Demin Rm 1B	Inst	Inst	Inst R07	Inst	Date / Time	Location: β γ α Comments
Reason: Robot Entry	S/N	S/N	S/N 165	S/N	Activity	
Date: 06-07-85 Time: 1140	Cal.Due	Cal.Due	Cal.Due 9-3-85	Cal.Due	Air Sample No.	
Tech. B. Miller / B. Miller	Eff	Eff	B.C.F. 2.0	B.C.F.	Note: Radiation in mr/hr	
Survey Request No.	Bkg	Bkg	Tech B. Miller	B. Miller	dose rates are general	
Reviewed By: [illegible]	Tech		Notes:		area, and contamination	
			Contact Readings Circled		results in dpm/100 cm2	
			□ = Smear Location		unless otherwise noted.	



Make Up Demineralizing Room 1B

R07 Data questionable due to take readings on porous surface being greater by a factor of two.

ORIGINAL



Remarks:

Attachment 10-4

000005

Subject: AX114 and AX115 Curie Loading	Calc No. 4240-3233-93-015	Rev. No. 1	Sheet No. 46 of 57
Originator: B. Brosey [signature]	Date: 9/8/93	Reviewed by: G. Lodge [signature]	Date: 9/10/93

GPU Nuclear Calculation Sheet

Originator	Date	Reviewed by	Date
B. Brosey	9/8/93	G. Lodde	9/10/93

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	1 of 57

GPU Nuclear

Calculation Sheet

RADIOLOGICAL SURVEY

Survey Information

Location: 305 Aux Make up Demin RM 1A
Reason: Robot Entry
Date: 26-09-93 Time: 1310
Tech.: B. Miller / B. Hahn
Survey Request No.:
Reviewed By: [illegible]

Instrument Data

Contamination Survey		Radiation Survey	
Inst	Inst	Inst Rad7	Inst
S/N	S/N	S/N 165	S/N
Cal.Due	Cal.Due	Cal.Due 9-3-93	Cal.Due
Eff	Eff	B.C.F. 2.0	B.C.F.
Bkg	Bkg	Tech B. Miller / B. Hahn	
Tech		Notes: Contact Readings Circled □ = Smear Location	

Air Sample

Date: Time:
Activity:
Air Sample No.:
Note: Radiation in mr/hr; dose rates are general area, and contamination results in dpm/100 cm2 unless otherwise noted.

File Code Number: AX114 - 24-85

Smearable Contamination

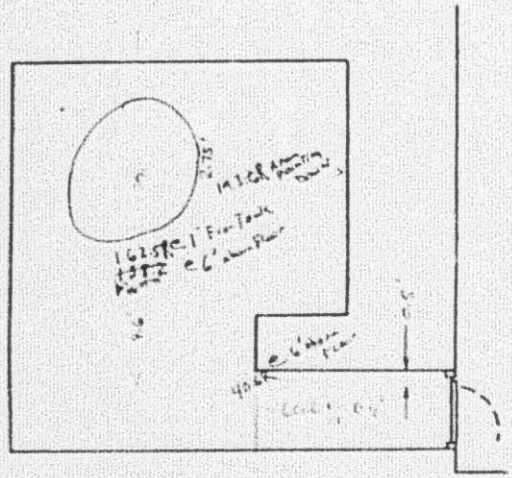
Location	α	β γ	Comments

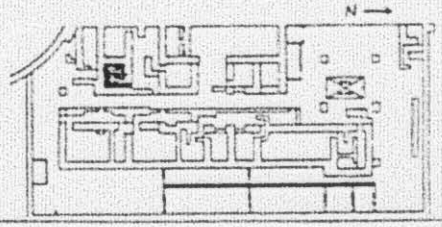
Remarks:

Make Up Demineralizing Room

Rad7 Data questionable due to Take readings on previous survey being greater by a factor of Two.

ORIGINAL





Attachment 10-5

AX-115

Attachment 10-6

GPU Nuclear

Memorandum

Subject: MAKE-UP AND PURIFICATION DEMINERALIZER MU-K-1B AND CUBICLE RADIATION SURVEY

Date: October 21, 1988
1345a

From: B. M. Trachim
Radiological Engineer

Location: TMI-2
9240-88-4745

To: J. E. Tarpinian
Manager, Radiological Engineering, TMI-2

On 9-28-88 a robotic radiation survey of the "B" Make-up and Purification Demineralizer and cubicle was performed using Louie I. The radiation instrument used on the robot was a SAM-II #323 remote readout with a tungsten shielded 180° probe. A response curve was developed to convert K cpm to R/HR on 9-21-88 at the Radiological Controls Instrument Shop using a CS^{137} source #310. The only problem encountered was the response curve was only plotted out to 800 R/HR.

The highest survey point in the Make-Up Demin cubicle was 947.5 R/HR; this was calculated by extrapolating the response curve (attached). The response curve becomes somewhat linear over 500 R/HR.

After the "A" Make-up and Purification Demin cubicle is surveyed the instrument will be returned to the Radiological Controls Instrument Shop to measure the response beyond 1K R/HR, using the same CS^{137} #310 source as used in the previous response measurements.

This survey was performed to provide radiological information associated with the resin content in the "B" Make-up and Purification Demineralizer. By our procedures, these results cannot constitute an official documented radiological controls survey.

B. M. Trachim
Radiological Engineer

blb

Attachment

cc: G. A. Kuehn - Site Operations Director
D. W. Turner - Radiological Controls Director, TMI-2

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev. No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	50 of 54
Originator: B. Brosey — Date: 9/8/93	Reviewed by: G. Lodde		Date: 9/10/93

N70648 (06-86)

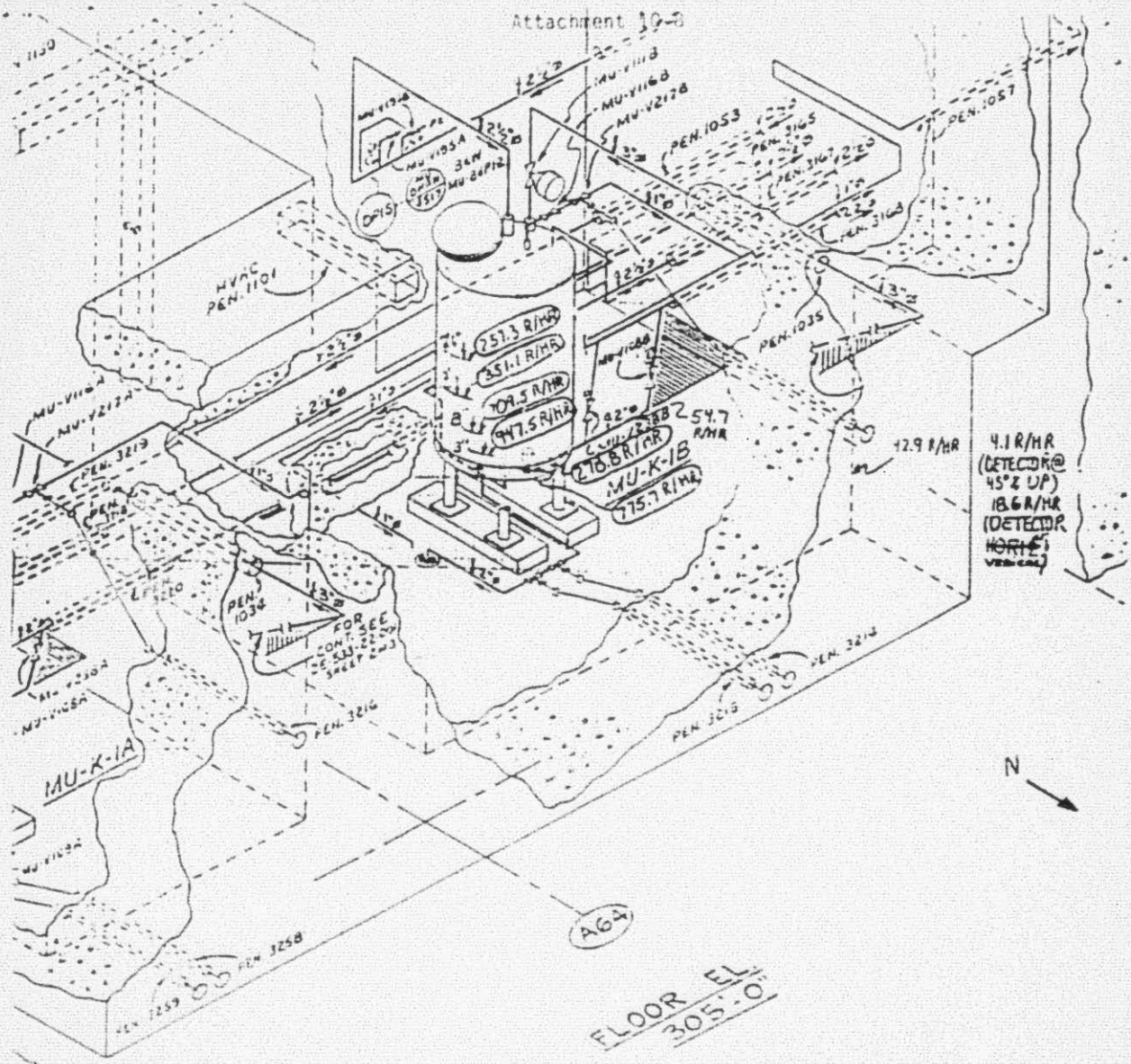
GPU Nuclear **Calculation Sheet**

Subject	Calc No.	Rev. No.	Sheet No.
AX114 and AX115 Curie Loading	4240-3233-93-015	1	51 of 54

Originator	Date	Reviewed by	Date
B. Brosey B. Brosey	9/8/93	G. Lodde SM Lodde	9/10/93

LOCATIONS OF SURVEY POINTS	CPM	R/HR
1. Inside MU-K-1B Cubicle Doorway probe face horizontal up	117.2 K	4.1
2. Inside MU-K-1B Cubicle Doorway probe face verticle forward	439.3 K	18.6
3. Inside MU-K-1B Cubicle 3' Level probe face verticle forward	791.7 K	42.9
4. Probe contact with Discharge Line Valve probe face verticle forward	901.0 K	54.7
5. Probe contact with Discharge Line Reducer probe face verticle forward	1,780.5 K	278.8
6. Probe contact with Tank Conicle Bottom Weld probe face verticle forward	2,392.0 K	775.7
7. Probe contact 3" above Tank Conicle Bottom Weld probe face verticle forward	2,547.7 K	947.5
8. Probe contact 8" above Tank Conicle Bottom Weld probe face verticle forward	2,331.9 K	709.5
9. Probe contact 2' above Tank Conicle Bottom Weld probe face verticle forward	1,929.8 K	351.1
10. Probe contact 2'6" above Tank Conicle Bottom Weld probe face verticle forward	1,736.1 K	257.3

Attachment 10-8



MAKE-UP AND PURIFICATION DEMINERALIZER MU-K-1B CUBICLE

9/23/89 RAD SURVEY

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
		1	52 of 54

Originator	Date	Reviewed by	Date
	9/8/93		9/10/93

GPU Nuclear

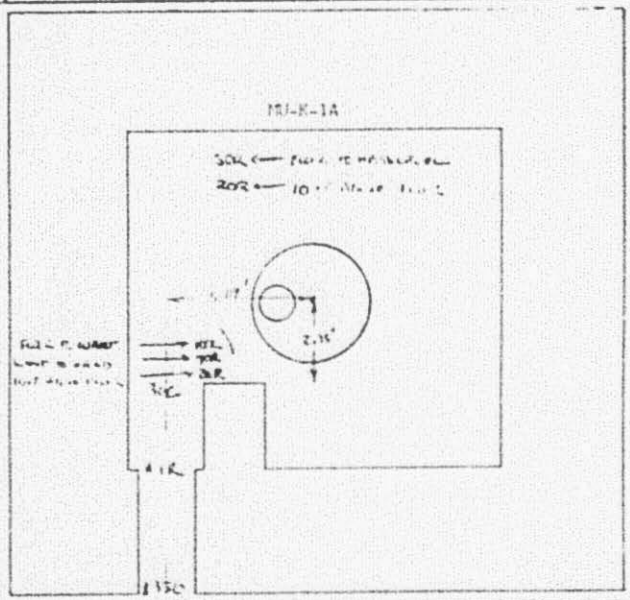
Calculation Sheet

Subject: AX114 and AX115 Curie Loading	Calc No. 4240-3233-93-015	Rev. No. 1	Sheet No. 53 of 57
Originator: B. Brosey	Date: 9/8/93	Reviewed by: G. Lodde	Date: 9/10/93

GPU Nuclear ORIGINAL

RADIOLOGICAL SURVEY ☐TMI-1 ■TMI-2 ☐OC

Survey Information	Instrument Data		Air Sample	File Code Number: AX114 [illegible]
Location MAKE-UP DEMIN "1A" ROOM	Contamination Survey	Radiation Survey	Date ____ Time ____	Smearable Contamination
Reason Routine Rounds	Inst N/A	Inst [illegible]	Activity ____	Location / β/γ / α / Comments
Date 4-24-90 Time 1040	S/N ____	S/N [illegible]	Sample # ____	
Tech. K. Barth	Cal.Due ____	Inst ☒ [illegible]	Note: Radiation dose rates in mr/hr are general area, contamination results are dpm/100cm² unless otherwise noted	
Reviewed by [illegible]	Eff. ____	S/N [illegible]		
W. Stone 4-24-90	Bkg ____	Cal.Due [illegible]		
	Tech ____	B.C.F. ____		
		Tech K. Barth		
		Note: Contact Readings Circled ☐ • Smear Location		



Remarks: N/A

Attachment 10-9

DIMENSIONS AND WEIGHTS OF SEAMLESS AND WELDED STEEL PIPE

UPPER FIGURES—Wall Thickness in Inches A. S. A. PIPE SCHEDULES LOWER FIGURES—Weight Per Foot in Pounds

Pipe Size	O.D. in Inches	5	10	20	30	40	Std.	60	80	E.H.	100	120	140	160	Double E.H.
1/8	.405	.035 .1383	.049 .1863	.....	.....	.068 .2447	.068 .2447	.....	.095 .3145	.095 .3145	.....	.....	.....	.....	.....
1/4	.540	.049 .2570	.065 .3297	.....	.....	.088 .4248	.088 .4248	.....	.119 .5351	.119 .5351	.....	.....	.....	.....	.....
3/8	.675	.049 .3276	.065 .4235	.....	.....	.091 .5676	.091 .5676	.....	.126 .7388	.126 .7388	.....	.....	.....	.....	.....
1/2	.840	.065 .5383	.083 .6710	.....	.....	.109 .8510	.109 .8510	.....	.147 1.088	.147 1.088	.....	.....	.....	.187 1.304	.294 1.714
3/4	1.050	.065 .6838	.083 .8572	.....	.....	.113 1.131	.113 1.131	.....	.154 1.474	.154 1.474	.....	.....	.....	.218 1.937	.308 2.441
1	1.315	.065 .8678	.109 1.404	.....	.....	.133 1.679	.133 1.679	.....	.179 2.172	.179 2.172	.....	.....	.....	.250 2.844	.358 3.659
1 1/4	1.660	.065 1.107	.109 1.806	.....	.....	.140 2.273	.140 2.273	.....	.191 2.997	.191 2.997	.....	.....	.....	.250 3.765	.382 5.214
1 1/2	1.900	.065 1.274	.109 2.085	.....	.....	.145 2.718	.145 2.718	.....	.200 3.631	.200 3.631	.....	.....	.....	.281 4.859	.400 6.408
2	2.375	.065 1.604	.109 2.638	.....	.....	.154 3.653	.154 3.653	.....	.218 5.022	.218 5.022	.....	.....	.....	.343 7.444	.436 9.029
2 1/2	2.875	.083 2.475	.120 3.531	.....	.....	.203 5.793	.203 5.793	.....	.276 7.661	.276 7.661	.....	.....	.....	.375 10.01	.552 13.70
3	3.500	.083 3.029	.120 4.332	.....	.....	.216 7.576	.216 7.576	.....	.300 10.25	.300 10.25	.....	.....	.....	.437 14.32	.600 18.58
3 1/2	4.000	.083 3.472	.120 4.973	.....	.....	.226 9.109	.226 9.109	.....	.318 12.51	.318 12.51	.....	.....	.....	.....	.636 22.85
4	4.500	.083 3.915	.120 5.613	.....	.....	.237 10.79	.237 10.79	.281 12.66	.337 14.98	.337 14.98	.....	.437 19.01	.....	.531 22.51	.674 27.54
4 1/2	5.000	.....	.....	.....	.....	.....	.247 12.53	.....	.....	.355 17.61	.....	.....	.....	.....	.710 32.53
5	5.563	.109 6.349	.134 7.770	.....	.....	.258 14.62	.258 14.62	.....	.375 20.78	.375 20.78	.....	.500 27.04	.....	.625 32.96	.750 38.55
6	6.625	.109 7.585	.134 9.289	.....	.....	.280 18.97	.280 18.97	.....	.432 28.57	.432 28.57	.....	.562 36.39	.....	.718 45.30	.864 53.16
7	7.625	.....	.....	.....	.....	.....	.301 23.57	.....	.....	.500 38.05	.....	.....	.....	.....	.875 63.08
8	8.625	.109 9.914	.148 13.40	.250 22.36	.277 24.70	.322 28.55	.322 28.55	.406 35.64	.500 43.39	.500 43.39	.593 50.87	.718 60.93	.812 67.76	.906 74.69	.875 72.42
9	9.625	.....	.....	.....	.....	.....	.342 33.90	.....	.....	.500 48.72	.....	.....	.....	.....	.....
10	10.750	.134 15.19	.165 18.70	.250 28.04	.307 34.24	.365 40.48	.365 40.48	.500 54.74	.593 64.38	.500 54.74	.718 76.93	.843 89.20	1.000 104.1	1.125 115.7	.....
11	11.750	.....	.....	.....	.....	.....	.375 45.55	.....	.....	.500 60.07	.....	.....	.....	.....	.....
12	12.750	.165 22.19	.180 24.20	.250 33.38	.330 43.77	.406 53.53	.375 49.56	.562 73.16	.687 88.51	.500 65.42	.843 107.2	1.000 125.5	1.125 139.7	1.312 160.3	.....
14	14.000	.....	.250 36.71	.312 45.68	.375 54.57	.437 63.37	.375 54.57	.593 84.91	.750 106.1	.500 72.09	.937 130.7	1.093 150.7	1.250 170.3	1.406 189.1	.....
16	16.000	.....	.250 42.05	.312 52.36	.375 62.58	.500 82.77	.375 62.58	.656 107.5	.843 136.5	.500 82.77	1.031 164.8	1.218 192.3	1.437 223.5	1.593 245.1	.....
18	18.000	.....	.250 47.39	.312 59.03	.437 82.06	.562 104.8	.375 70.59	.750 138.2	.937 170.8	.500 93.45	1.156 208.0	1.375 244.1	1.562 274.2	1.781 308.5	.....
20	20.000	.....	.250 52.73	.375 78.60	.500 104.1	.593 122.9	.375 78.60	.812 166.4	1.031 208.9	.500 104.1	1.280 256.1	1.500 296.4	1.750 341.1	1.968 379.0	.....
24	24.000	.....	.250 63.41	.375 94.62	.562 140.8	.687 171.2	.375 94.62	.968 238.1	1.218 296.4	.500 125.5	1.531 367.4	1.812 429.4	2.062 483.1	2.343 541.9	.....

(Continued)

WILLIAMS AND COMPANY, INC.

The House of Metals

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev No	Sheet No
AX114 and AX115 Curie Loading	4240-3233-93-015	1	54 of 54

Originator	Date	Reviewed by	Date
D. Brosey	9/8/93	G. Lodge	9/10/93