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Title/Desc:

ISOSHL D ANALYSIS FOR STORING TRANSURANIC ION
EXCHANGE COLUMNS

Sta 4

3

SEP 25 1995

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT

608103

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) K Basins, Standards and Requirements	4. Related EDT No.:
5. Proj./Prog./Dept./Div.: Spent Nuclear Fuel Project	6. Cog. Engr.: W. C. Mills	7. Purchase Order No.: N/A
8. Originator Remarks: For release		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 105 KE/105 KW
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date:

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	WHC-SD-SNF-PDC-001	A11	0	ISOSHL Depleted Ion Columns at K Basins	N/A	3	1	6

16. KEY					
Approval Designator (F)		Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec. 12.7)		1. Approval	4. Review	1. Approved	4. Reviewed no/comment
		2. Release	5. Post-Review	2. Approved w/comment	5. Reviewed w/comment
		3. Information	6. Dist. (Receipt Acknow. Required)	3. Disapproved w/comment	6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)										(G)	(H)
Reason	Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	Reason	Disp.
81	1	Cog. Eng. W. C. Mills	<i>W. C. Mills</i>	9/20/95							
81	1	Cog. Mgr. C. DeFigh-Price	<i>C. DeFigh-Price</i>	9/20/95							
		QA N/A									
		Safety N/A									
		Env. N/A									

18. <i>W. C. Mills</i> Signature of EDT Originator Date 9/20/95	19. <i>C. DeFigh-Price</i> Authorized Representative Date for Receiving Organization 9/20/95	20. <i>C. DeFigh-Price</i> Cognizant Manager Date 9/20/95	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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RELEASE AUTHORIZATION

Document Number: WHC-SD-SNF-PDC-001, REV 0

Document Title: ISOSHL D Analysis for Storing Transuranic Ion Exchange Columns

Release Date: 9/25/95

This document was reviewed following the procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara Broz

9/25/95

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SUPPORTING DOCUMENT

1. Total Pages **46**

2. Title

ISOSHL D Analysis for Storing Transuranic Ion Exchange Columns

3. Number

WHC-SD-SNF-PDC-001

4. Rev No.

0

5. Key Words

ISOSHL D
Transuranic Ion Exchange

6. Author

Name: W. C. Mills

W. C. Mills 7/21/95
Signature

Organization/Charge Code **2A100/L180**

7. Abstract

The objective of the ISOSHL D Analysis is to estimate the thickness of concrete shielding necessary to store the KE Fuel Storage Basin transuranic ion exchange columns above ground. The quantity of radioactive material was taken from the tables in PNL-IX-IR-0004, "Best Estimate of Radionuclide Inventories by Canister." The cesium activity was based on a mass balance. The exposure rate (R/hr) was slightly higher in the resulting ISOSHL D model than actually measured due to possible measurement errors and conservative assumptions in the computer model.

8. RELEASE STAMP

OFFICIAL RELEASE
BY WHC
DATE SEP 25 1995

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SCIENTIFIC ECOLOGY GROUP, INC.

August 31, 1995

Ms. Cherri Defigh-Price, Manager
Restart and Special Projects/K Basins
Westinghouse Hanford Company
Richland, WA 99352

Dear Ms. Defigh-Price:

REFERENCE: LIPINSKI, R.S., AND TEACHOUT, D.B., "ALTERNATIVES FOR THE DISPOSITION OF K-BASIN ION EXCHANGE COLUMNS (DRAFT)," AUGUST 28, 1995.

Attached is the documentation of the ISOSHLTD analysis performed to investigate one disposal path alternative for the transuranic ion exchange columns. Before proposing an alternative to store the ion exchange columns in an above ground container, it was necessary to determine if the amount of shielding required to meet the waste acceptance criteria was prohibitive.

The report uses radionuclide inventories presented in PNL-IX-IR-0004, "Best Estimate of Radionuclide Inventories by Canister" to determine the thickness of concrete shielding required to meet the contact dose rate limit of 100 mrem/hr (WHC-EP-0063). The bounding conditions, the columns with the least activity (KE 210) and most activity (KE 215), were examined. In addition, the effect of concrete density was analyzed. The results indicate 1.5 feet of concrete shielding would probably be sufficient to meet the waste acceptance criteria. It concludes that storage in an above ground container, such as the Fuel Spacer Burial Box, is a technically possible alternative.

Sincerely,

Richard S. Lipinski

Enclosure

RSL/tam

KE016-030

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ISOSHL D Analysis to Determine Possibility of Storing Transuranic Ion Exchange Columns Above Ground

ISOSHL D calculations were performed to estimate the thickness of concrete shielding necessary to store the KE Fuel Storage Basin transuranic ion exchange columns above ground. The quantity of radioactive material was taken from the tables in PNL-IX-IR-0004, "Best Estimate of Radionuclide Inventories by Canister." The cesium activity was based on Monte Carlo N-Particle (MCNP) version 4A computer modeling. All other radioisotope activity was based on a mass balance. The exposure rate (R/hr) was slightly higher in the resulting ISOSHL D model than actually measured due to possible measurement errors and conservative assumptions in the computer model. Two cases were examined with varying amounts of concrete shielding: (1) IXC KE 210, expected to contain the minimum activity and exposure rate, and (2) IXC KE 215, expected to contain the maximum activity and exposure rate. The columns were modeled as cylinders with slab side shielding. ISO-PC version 1.98 was used to perform all calculations.

Calculations and ISOSHL D analyses for possible configurations and radionuclide loading are attached. The following analyses were performed:

- 1) exposure and dose rate estimates for IXC KE 210 with no concrete shielding on contact;
- 2) exposure and dose rate estimates for IXC KE 210 with one foot of concrete shielding on contact;
- 3) exposure and dose rate estimates for IXC KE 215 with no concrete shielding on contact;
- 4) exposure and dose rate estimates for IXC KE 215 with one foot of concrete shielding on contact;
- 5) exposure and dose rate estimates for IXC KE 215 with 1.5 feet of concrete shielding on contact;
- 6) exposure and dose rate estimates for IXC KE 215 with two feet of concrete shielding on contact;
- 7) and exposure and dose rate estimates for IXC KE 215 with one foot of concrete shielding of varying density on contact.

The concrete shielding simulates grout surrounding the cylinder.

Results:

IXC KE 210 (minimum activity and exposure rate) on contact:

Concrete Shielding ¹ Thickness (feet)	Measured Exposure Rate (mR/hr)	Calculated Exposure Rate (mR/hr)	Calculated Dose Rate (mrem/hr)	Deviation of Calculated from Measured Exposure Rate (%)
0	1000	1800	2100	80
1	DNA ²	2.1	2.3	DNA

¹Concrete shielding has an assumed density of 2.8 g/cm³.

²DNA: Data Not Available.

IXC KE 215 (maximum activity and exposure rate) on contact:

Concrete Shielding ¹ Thickness (feet)	Measured Exposure Rate (mR/hr)	Calculated Exposure Rate (mR/hr)	Calculated Dose Rate (mrem/hr)	Deviation of Calculated from Measured Exposure Rate (%)
0	90,000	130,000	140,000	44
1	DNA	160	170	DNA
1.5	DNA	6.6	7.2	DNA
2	DNA	0.29	0.31	DNA

¹Concrete shielding has an assumed density of 2.8 g/cm³.

Sensitivity of analysis to variation in concrete density:

Concrete Density (g/cm ³)	Exposure Rate ¹ (mR/hr)	Dose Rate ¹ (mrem/hr)
2.35	400	440
2.8	160	170
3.76	20	22

¹The calculations were performed on contact with one foot thick concrete shields using the IXC KE 215 source term. A logarithmic plot of the dose rate vs. concrete density on page 7.

The results show that the columns with low activity and exposure rates may be put in a box with only one foot of concrete shielding. For columns with high activities and exposure rates, only 1.5 feet, possibly 2 feet, of concrete shielding is necessary depending on how many columns are placed in a single container. The complete ISOSHLD analyses are attached.

Assumptions:

1. The columns are in a cylindrical configuration, 17.5" inner diameter with 0.25" walls and 41" height (the columns are actually 59" long, but the ion exchange resin occupies the middle 41" only) with the concrete walls as flat slabs surrounding the columns.
2. The activity of the radionuclides are as given in PNL-IX-IR-004, "Best Estimate of Radionuclide Inventories by Canister."
3. Only one column was assumed per container, i.e., single column source term.
4. The Pu-239/240 activity given in the PNL document is assumed to be 94 wt% Pu-239 and 6 wt% Pu-240 (Hanford Weapons Grade). Decay products are not present in a large enough quantity to add significantly to the exposure rate.
5. Ba-137m is in equilibrium with Cs-137 (94.6% of the Cs-137 activity).

6. Y-90 is in equilibrium with Sr-90 (92% of the Sr-90 activity).
7. The resin was assumed to be a polystyrene molecule with a nuclear sulfonic acid active group (a common resin material). The resin was assumed to be styrene which has a carbon to hydrogen ratio of 1:1 (CRC Handbook of Physics and Chemistry).
8. The resin has a bulk density of 0.85 g/cm^3 (Perry's Chemical Engineers' Handbook). Literature indicates the weight percentage of water in the resin matrix varies, 45 wt% was chosen for water and 55 wt% for the styrene compound.
9. The resin has 45 wt% water with a density of 0.85 g/cm^3 , resulting in a water density for the resin to be 0.383 g/cm^3 . However, data on water content after use indicates the matrix is 65 wt% water after draining. Also, data indicates that the water will continue to drain to a smaller quantity. However, the columns have not been stored in a configuration conducive to draining and with the 65% water shielding, the exposure rate remains above the measure values. Therefore, a density of 0.553 g/cm^3 based on 65 wt% water was used in the ISOSILD calculations. This weight percent is indicative of the resin remaining wet.
10. No self-shielding from the radionuclides, nor shielding from particulate matter found in the ion exchange resin, were deemed necessary to be accounted for in the computer model.
11. The concrete density was assumed to be 2.8 g/cm^3 to approximate a realistic grout density.
12. The location of the contact dose measurement point is assumed to be one inch from the surface. This represents the distance from the center of the active volume of the detector to the surface of the shielding slab.

Calculations:

Density of Resin Material:

Fraction of carbon in styrene: $12.01 \text{ g/cm}^3 / (12.01 \text{ g/cm}^3 + 1.01 \text{ g/cm}^3) = 0.92243$

Fraction of hydrogen in styrene: $1 - 0.92243 = 0.07757$

Density of carbon in resin: $0.85 \text{ g/cm}^3 \times 0.55 \times 0.92243 = 0.431 \text{ g/cm}^3$

Density of hydrogen in resin: $0.85 \text{ g/cm}^3 \times 0.55 \times 0.07757 = 0.036 \text{ g/cm}^3$

Density of water in resin: $0.85 \text{ g/cm}^3 \times 0.65 = 0.553 \text{ g/cm}^3$

Density of resin selected at 0.85 g/cm^3 based on ion exchange resin densities found in Perry's Chemical Engineers' Handbook.

Pu-239/240 activity:

Assume 1 gram of Hanford Weapons Grade material. Therefore, 0.94 g Pu-239 and 0.06 g Pu-240.

Pu-239 activity per gram: $0.94 \text{ g} \times 0.062 \text{ Ci/g} = 0.05828 \text{ Ci}$

Pu-240 activity per gram: $0.06 \text{ g} \times 0.227 \text{ Ci/g} = 0.01362 \text{ Ci}$

Pu-239 fraction of activity: $0.05828 \text{ Ci} / (0.05828 \text{ Ci} + 0.01362 \text{ Ci}) = 0.81057$

Pu-240 fraction of activity: $1 - 0.81057 = 0.18943$

Density of radionuclides in the ion exchange column:

Conversion for curies to grams is from SD-RE-TI-131.

Sr-90	13 Ci x (1 g / 139 Ci)	= 0.0935 g
Y-90	12 Ci x (1 g / 543,000 Ci)	= 2.21×10^{-5} g
Cs-137	63.4 Ci x (1 g / 86.6 Ci)	= 0.732 g
Ba-137m	60 Ci x (1 g / 5.38×10^8 Ci)	= 1.115×10^{-7} g
Pu-239	0.0973 Ci x (1 g / 0.062 Ci)	= 1.57 g
Pu-240	0.0227 Ci x (1 g / 0.227 Ci)	= 0.1 g
Pu-241	1.56 Ci x (1 g / 103 Ci)	= 0.015 g
Am-241	0.05 Ci x (1 g / 3.43 Ci)	= 0.0146 g

Total grams of radionuclides = 2.525 g

Volume of resin = $\pi r^2 L = \pi \times (22.225 \text{ cm})^2 \times 104.14 \text{ cm} = 161,603.58 \text{ cm}^3$

Density of radionuclides = $2.525 \text{ g} / 161,603.58 \text{ cm}^3 = 1.56 \times 10^{-5} \text{ g/cm}^3$

This density is insignificant, therefore was not accounted for in the computer model.

Note: While the calculations show more digits than are significant, they were carried ensure the accuracy of the calculation. Final values were rounded for use in the ISOSHL computer model.

Conclusion/Summary:

Further analysis will be required to determine the exact dose rates from potential configurations of multiple IXCs in a single container. However, this analysis determines that adding concrete shielding to a storage container, such as the Fuel Spacer Burial Box, is a technically possible alternative. That is, the additional concrete shielding needed due to the surface dose rate limit of 100 mrem/hr in the Hanford Solid Waste Acceptance Criteria is not so thick as to make storage in an above ground container impractical.

IXC Model Layout

where: $t = 0, 1, 1.5, \text{ or } 2$

IXC KE 215

Dose Rate vs. Concrete Density

IXC KE 210

Dose Rate vs. Shield Thickness

IXC KE 215

Dose Rate vs. Shield Thickness

Date 07 / 13 / 95

 Project 100-K Ion Exchange Column Disposition
 Subject Pu-239 / 240 fractions & resin component densities

Pu-239 / 240 activities are combined

Assume: Hanford Weapons Grade material 94% Pu-239 6% Pu-240
 1 gram of material is 0.94 g Pu-239 & 0.06 g Pu-240

$$0.94 \text{ g Pu-239} \times 6.2 \times 10^{-2} \text{ Ci/g} = 0.05828 \text{ Ci}$$

$$0.06 \text{ g Pu-240} \times 2.27 \times 10^{-1} \text{ Ci/g} = 0.01362 \text{ Ci}$$

Fraction of activity due to Pu-239

$$\frac{0.05828 \text{ Ci}}{(0.05828 \text{ Ci} + 0.01362 \text{ Ci})} = \boxed{0.8105702} \quad \text{Pu-239}$$

$$\text{Fraction Pu-240} = 1 - 0.8105702 = \boxed{0.1894297} \quad \text{Pu-240}$$

IX Resin component densities

Assume: IX Resin has bulk density of 0.85 g/cm^3 (based on Perry's Chemical Engineers' Hand book) and is a polystyrene matrix. Styrene is only carbon and hydrogen in a 1:1 ratio (CRC Handbook of Physics and Chemistry). When purchased, assume 45 wt% H_2O in resin (based on Perry's)
 $\therefore$ 55% polystyrene

$$\text{Fraction C} = \frac{12.01 \text{ g/mole}}{(12.01 + 1.01)} = 0.92243$$

$$\text{Fraction H} = 1 - 0.92243 = 0.07757$$

Density Carbon

$$(0.85 \text{ g/cm}^3)(0.55)(0.92243) = \boxed{0.431 \text{ g/cm}^3 \text{ C}}$$

Density Hydrogen

$$(0.85 \text{ g/cm}^3)(0.55)(0.07757) = \boxed{0.036 \text{ g/cm}^3 \text{ H}}$$

The water is 65 wt% for use

$$\text{density H}_2\text{O} = (0.85 \text{ g/cm}^3)(0.65) = \boxed{0.553 \text{ g/cm}^3 \text{ H}_2\text{O}}$$

RSL 7/13/95

Project 100-K Ion exchange Column Disposition
 Subject Density of radio nuclides for self shielding

Date 22 / 13 / 95

Density of radio nuclides in ion-exchange resin
 (Maximum loading)

$$\text{Sr-90} \quad (13 \text{ Ci}) \left(\frac{1 \text{ g}}{129 \text{ Ci}} \right) = \boxed{0.0935 \text{ grams Sr-90}}$$

$$\text{Y-90} \quad (12 \text{ Ci}) \left(\frac{1 \text{ g}}{5.13 \times 10^5 \text{ Ci}} \right) = \boxed{2.2 \times 10^{-5} \text{ grams Y-90}}$$

$$\text{Cs-137} \quad (63.4 \text{ Ci}) \left(\frac{1 \text{ g}}{86.6 \text{ Ci}} \right) = \boxed{0.732 \text{ g Cs-137}}$$

$$\text{Ba-137m} \quad (60 \text{ Ci}) \left(\frac{1 \text{ g}}{5.38 \times 10^8 \text{ Ci}} \right) = \boxed{1.115 \times 10^{-7} \text{ g Ba-137m}}$$

$$\text{Pu-239} \quad (0.0973 \text{ Ci}) \left(\frac{1 \text{ g}}{0.062 \text{ Ci}} \right) = \boxed{1.57 \text{ g Pu-239}}$$

$$\text{Pu-240} \quad (0.0227 \text{ Ci}) \left(\frac{1 \text{ g}}{0.227 \text{ Ci}} \right) = \boxed{0.1 \text{ g Pu-240}}$$

$$\text{Pu-241} \quad (1.56 \text{ Ci}) \left(\frac{1 \text{ g}}{103 \text{ Ci}} \right) = \boxed{0.015 \text{ g Pu-241}}$$

$$\text{Am-241} \quad (0.05 \text{ Ci}) \left(\frac{1 \text{ g}}{3.43 \text{ Ci}} \right) = \boxed{0.0146 \text{ g Am-241}}$$

$$\text{Total grams radio nuclides} = \boxed{2.525 \text{ grams}}$$

$$\text{Volume of resin} = \pi r^2 L = (\pi) (22.225 \text{ cm})^2 (104.14 \text{ cm})$$

$$= \boxed{161603.58 \text{ cm}^3}$$

$$\text{Density} = \frac{2.525 \text{ g}}{161603.58 \text{ cm}^3} = \boxed{1.56 \times 10^{-5} \frac{\text{g}}{\text{cm}^3} \text{ of radio nuclides}}$$

Density effect on resin is insignificant,
 therefore, do not add any density to resin for
 self shielding.

Document Reviewed (complete reference): "ISOSHL D Analysis to Determine the Possibility of Storing Transuranic Ion Exchange Columns Above Ground," dated July 14, 1995.

Author(s): R.S. Lipinski, Spent Nuclear Fuel Project, SEG-NW.

CHECKLIST FOR CALCULATION REVIEW

<u>Yes</u>	<u>No</u>	<u>N/A</u>	<u>General Considerations</u>
[XX]	[]	[]	Problem completely defined.
[XX]	[]	[]	Necessary assumptions explicitly stated and supported.
[XX]	[]	[]	Computer codes and data files documented.
[XX]	[]*	[]	Data used in calculations explicitly stated in document.
[XX]	[]	[]	Mathematical derivations checked including dimensional consistency of results.
[XX]	[]	[]	Models appropriate and used within range of validity or use outside range of established validity and justified.
[XX]	[]	[]	Hand calculations checked for errors.
[XX]	[]	[]	Code runstreams correct and consistent with analysis documentation.
[XX]	[]	[]	Code output consistent with input and with results reported in analysis documentation.
[XX]	[]	[]	Acceptability limits on analysis applicable and supported.
[XX]	[]	[]	Limits checked against sources.
[XX]	[]	[]	Safety margins consistent with analytical results and applicable limits.
[XX]	[]	[]	Conclusions consistent with analytical results and applicable limits.
[XX]	[]	[]	Results and conclusions address all points required in the problems statement.

Radiological Calculations

[XX]	[]	[]	ISO-PC rev 1.98 (ISOSHL D-II)
[]	[]	[XX]	GENII
[]	[]	[XX]	MICROSHLD
[]	[]	[XX]	MICROSKYSHINE
[]	[]	[XX]	Other code used: _____
[XX]	[]	[]	Appropriate receptor locations evaluated.
[XX]	[]	[]	Appropriate models used.
[]	[]	[XX]	Appropriate pathways evaluated for each receptor.
[XX]	[]	[]	Analysis consistent with accepted practice.

J.P. Gandy
Technical Reviewer Approval

July 14, 1995
Date

Health Physicist (Project Manager-NDA) / SEG-NW
Title/Organization

Note: Any calculations, comments or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

* Any data not explicitly stated in the memo can be found in the referenced documents.

Run started at 23:03:00 07/13/95

ISO-PC Version 1.98 August 1994
originally ISOSHLI-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

EXC MIN NC

IXC KE210

Contact
No concrete shielding

Title Line from Library File (ISO-PC.LIB):
Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Minimum Case, no concrete)

Minimum TRU Ion-Exchange Column Dose with no concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	2.70E+01	2.700E+01
Y - 90	2.48E+01	2.480E+01
CS-137	7.00E-01	7.000E-01
BA-137M	6.62E-01	6.620E-01
PU-239	3.24E-02	3.240E-02
PU-240	7.58E-03	7.580E-03
PU-241	5.30E-01	5.300E-01
AM-241	2.00E-02	2.000E-02

Minimum TRU Ion-Exchange Column Dose with no concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03

E, MeV Linear Attenuation, per cm (last region is air)

0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03
-------	-----------	-----------	-----------	-----------	-----------

14

0.250	3.206E+09	1.935E-06	3.446E+04	6.668E-02
0.350	1.585E+09	2.019E-06	2.638E+04	5.326E-02
0.475	1.235E+09	2.043E-06	2.939E+04	6.005E-02
0.650	2.281E+10	2.029E-06	7.332E+05	1.488E+00
0.825	2.887E+08	1.983E-06	1.124E+04	2.229E-02
1.000	2.028E+08	1.923E-06	9.269E+03	1.782E-02
1.225	1.086E+08	1.850E-06	6.105E+03	1.129E-02
1.475	3.749E+07	1.775E-06	2.583E+03	4.586E-03
1.700	4.010E+07	1.712E-06	3.192E+03	5.464E-03
1.900	2.035E+06	1.660E-06	1.807E+02	3.000E-04
2.100	1.461E+06	1.613E-06	1.438E+02	2.320E-04
2.300	2.625E+03	1.592E-06	2.849E-01	4.536E-07

Totals: 9.443E+10 photons/sec 9.128E+05 1.827E+00 R/hr
= 1.309E-07 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors

Average E, Mev	Anterior DUNIT = 1	Posterior DUNIT = 2	Lateral DUNIT = 3	Rotational DUNIT = 4	Isometric DUNIT = 5	Orig ANSI DUNIT = 6
0.025	6.818E-31	3.117E-31	1.616E-31	3.317E-31	2.733E-31	5.262E-30
0.035	5.409E-12	3.132E-12	1.655E-12	2.874E-12	2.335E-12	1.923E-11
0.045	1.565E-06	1.000E-06	5.715E-07	8.857E-07	7.161E-07	3.702E-06
0.055	1.444E-04	9.783E-05	5.897E-05	8.549E-05	6.921E-05	2.771E-04
0.065	8.715E-04	6.163E-04	3.810E-04	5.331E-04	4.335E-04	1.489E-03
0.075	2.714E-03	1.990E-03	1.237E-03	1.703E-03	1.391E-03	4.338E-03
0.085	5.425E-03	4.103E-03	2.538E-03	3.477E-03	2.850E-03	8.328E-03
0.095	8.327E-03	6.469E-03	3.967E-03	5.436E-03	4.463E-03	1.246E-02
0.150	8.640E-02	7.214E-02	4.570E-02	6.189E-02	5.034E-02	1.213E-01
0.250	6.446E-02	5.331E-02	3.585E-02	4.642E-02	3.834E-02	8.697E-02
0.350	4.934E-02	4.147E-02	2.889E-02	3.646E-02	3.043E-02	6.618E-02
0.475	5.403E-02	4.642E-02	3.336E-02	4.115E-02	3.471E-02	6.910E-02
0.650	1.301E+00	1.147E+00	8.505E-01	1.024E+00	8.741E-01	1.627E+00
0.825	1.922E-02	1.725E-02	1.311E-02	1.548E-02	1.335E-02	2.345E-02
1.000	1.527E-02	1.390E-02	1.077E-02	1.252E-02	1.088E-02	1.834E-02
1.225	9.614E-03	8.868E-03	7.016E-03	8.009E-03	7.033E-03	1.140E-02
1.475	3.887E-03	3.622E-03	2.920E-03	3.279E-03	2.906E-03	4.562E-03
1.700	4.626E-03	4.339E-03	3.548E-03	3.935E-03	3.512E-03	5.393E-03
1.900	2.540E-04	2.393E-04	1.979E-04	2.173E-04	1.951E-04	2.947E-04
2.100	1.965E-04	1.857E-04	1.551E-04	1.688E-04	1.523E-04	2.270E-04
2.300	3.790E-07	3.593E-07	3.026E-07	3.269E-07	2.963E-07	4.363E-07
Totals	1.626E+00	1.422E+00	1.040E+00	1.265E+00	1.075E+00	2.061E+00

Closing: End of Run!!!!

Finish run at 23:11:13 07/13/95

Input File (IXCMINNC.IN) is shown below:

```

0      2  Dose Rate from the TRU IXCs (Minimum Case, no concrete)
Minimum TRU Ion-Exchange Column Dose with no concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEOM= 11,
      X= 25.5, Y= 104.14, SLTH= 52.07,
      NSHLD= 4, JBUF= 1,
      T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 0.00,
      NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 2.70E+01, Weight(84)= 2.48E+01,

```

```

Weight(335)= 7.00E-1, Weight(336)= 6.62E-01,
Weight(493)= 3.24E-02, Weight(494)= 7.58E-03,
Weight(495)= 5.30E-01, Weight(496)= 2.00E-02 &
  water  1    0.553
  carb   6    0.431
  H       4    0.036
  FE      9          7.86
  air     3          0.00129
1 conc  16          2.8
End of Run!!!
&Input  Next= 6  &

```

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Run started at 23:11:13 07/13/95

IXC MINIC

IXC KE 210

Contact

1' concrete shielding

Density of concrete: 2.35 g/cm³

ISO-PC Version 1.98 August 1994
originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXC's (Minimum Case, 1' concrete)

Minimum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	2.70E+01	2.700E+01
Y - 90	2.48E+01	2.480E+01
CS-137	7.00E-01	7.000E-01
BA-137M	6.62E-01	6.620E-01
PU-239	3.24E-02	3.240E-02
PU-240	7.58E-03	7.580E-03
PU-241	5.30E-01	5.300E-01
AM-241	2.00E-02	2.000E-02

Minimum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03
E, MeV Linear Attenuation, per cm (last region is air)					
0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03

0.250	3.206E+09	1.935E-06	4.322E+00	8.363E-06
0.350	1.585E+09	2.019E-06	7.697E+00	1.554E-05
0.475	1.235E+09	2.043E-06	1.685E+01	3.443E-05
0.650	2.281E+10	2.029E-06	8.840E+02	1.794E-03
0.825	2.887E+08	1.983E-06	2.429E+01	4.816E-05
1.000	2.028E+08	1.923E-06	3.157E+01	6.070E-05
1.225	1.086E+08	1.850E-06	3.148E+01	5.823E-05
1.475	3.749E+07	1.775E-06	1.880E+01	3.337E-05
1.700	4.010E+07	1.712E-06	3.005E+01	5.144E-05
1.900	2.035E+06	1.660E-06	2.066E+00	3.430E-06
2.100	1.461E+06	1.613E-06	1.930E+00	3.113E-06
2.300	2.625E+03	1.592E-06	4.387E-03	6.984E-09

Totals: 9.443E+10 photons/sec 1.054E+03 2.112E-03 R/hr
= 1.514E-10 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average	Anterior	Posterior	Lateral	Rotational	Isometric	Orig ANSI
E, Mev	DUNIT = 1	DUNIT = 2	DUNIT = 3	DUNIT = 4	DUNIT = 5	DUNIT = 6

0.045	6.308E-24	4.032E-24	2.304E-24	3.571E-24	2.887E-24	1.492E-23
0.055	3.022E-16	2.047E-16	1.234E-16	1.789E-16	1.448E-16	5.798E-16
0.065	1.566E-12	1.107E-12	6.844E-13	9.578E-13	7.787E-13	2.676E-12
0.075	2.201E-10	1.613E-10	1.003E-10	1.381E-10	1.128E-10	3.518E-10
0.085	4.433E-09	3.352E-09	2.074E-09	2.841E-09	2.329E-09	6.805E-09
0.095	3.047E-08	2.367E-08	1.452E-08	1.989E-08	1.633E-08	4.559E-08
0.150	1.992E-06	1.664E-06	1.054E-06	1.427E-06	1.161E-06	2.798E-06
0.250	8.084E-06	6.685E-06	4.496E-06	5.821E-06	4.808E-06	1.091E-05
0.350	1.440E-05	1.210E-05	8.429E-06	1.064E-05	8.880E-06	1.931E-05
0.475	3.098E-05	2.662E-05	1.913E-05	2.360E-05	1.990E-05	3.962E-05
0.650	1.569E-03	1.383E-03	1.025E-03	1.235E-03	1.054E-03	1.961E-03
0.825	4.151E-05	3.727E-05	2.832E-05	3.345E-05	2.883E-05	5.065E-05
1.000	5.200E-05	4.734E-05	3.668E-05	4.262E-05	3.707E-05	6.247E-05
1.225	4.957E-05	4.572E-05	3.617E-05	4.130E-05	3.626E-05	5.876E-05
1.475	2.829E-05	2.636E-05	2.125E-05	2.387E-05	2.115E-05	3.320E-05
1.700	4.355E-05	4.085E-05	3.340E-05	3.704E-05	3.307E-05	5.077E-05
1.900	2.904E-06	2.736E-06	2.262E-06	2.484E-06	2.230E-06	3.370E-06
2.100	2.636E-06	2.492E-06	2.081E-06	2.265E-06	2.044E-06	3.046E-06
2.300	5.835E-09	5.532E-09	4.659E-09	5.033E-09	4.562E-09	6.717E-09

Totals	1.845E-03	1.633E-03	1.219E-03	1.459E-03	1.249E-03	2.296E-03

Closing: End of Run!!!!

Finish run at 23:17:29 07/13/95
Input File (IXCMIN1C.IN) is shown below:

```

0          2 Dose Rate from the TRU IXC's (Minimum Case, 1' concrete)
Minimum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEO= 11,
          X= 55.98, Y= 104.14, SLTH= 52.07,
          NSHLD= 4, JBUF= 4,
          T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 30.48,
          NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 2.70E+01, Weight(84)= 2.48E+01,
Weight(335)= 7.00E-1, Weight(336)= 6.62E-01,
Weight(493)= 3.24E-02, Weight(494)= 7.58E-03,

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Weight(495)= 5.30E-01, Weight(496)= 2.00E-02  &
water  1    0.553
carb   6    0.431
H      4    0.036
FE     9
air    3      7.86
1 conc 16      0.00129
End of Run!!!!      2.8
&Input Next= 6  &

```

Run started at 23:17:30 07/13/95

IXC MAX NC

IXC KE 215

Contact

No concrete shielding

ISO-PC Version 1.98 August 1994
originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, no concrete)

Maximum TRU Ion-Exchange Column Dose with no concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with no concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03

E, MeV Linear Attenuation, per cm (last region is air)

0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03
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Source           Shields           Distance to Detector, X = 2.550E+01 cm
Cylindrical      Cyl. & Slab      Source Volume = 8.080E+04 cc
                  Source Mass   = 8.242E+04 grams
Source Length = 5.207E+01 cm      Distance Along Cylinder, Y = 0.000E+00 cm
Integration Specs:  NTHETA = 33      NPSI = 33      DELR = 1.001E-01 cm
  Total Intervals:  2.418E+05      (photon source is the 1st region)
Shield Thickness: 2.223E+01, 6.350E-01, 1.000E-01, 0.000E+00, 2.540E+00 cm
Distances from Dose Point to the Outside of
  (1) Source Region: 3.275E+00 cm      (2) Next Layer: 2.640E+00 cm
Dose Buildup Data for Shield 1 with Effective Atomic Number 3.41
Fluence-to-Dose Conversion: Photons in Air

```

Average E, MeV	Source Total photons/sec	Fluence to Dose Factor	Energy Fluence MeV/sq.cm/sec	Dose Rate R/hr
0.015	1.700E+10	8.183E-05	0.000E+00	0.000E+00
0.025	8.881E+09	1.656E-05	1.441E-25	2.386E-30
0.035	1.667E+11	6.084E-06	3.200E-05	1.947E-10
0.045	3.354E+09	3.203E-06	4.091E-01	1.310E-06
0.055	3.141E+09	2.216E-06	5.124E+01	1.135E-04
0.065	1.973E+09	1.827E-06	2.744E+02	5.014E-04
0.075	1.699E+09	1.664E-06	8.792E+02	1.463E-03
0.085	1.451E+09	1.603E-06	1.754E+03	2.812E-03
0.095	1.257E+09	1.592E-06	2.706E+03	4.307E-03
0.150	6.072E+09	1.728E-06	2.891E+04	4.996E-02

0.250	1.793E+09	1.935E-06	1.927E+04	3.729E-02
0.350	8.334E+08	2.019E-06	1.387E+04	2.800E-02
0.475	6.286E+08	2.043E-06	1.496E+04	3.056E-02
0.650	1.998E+12	2.029E-06	6.422E+07	1.303E+02
0.825	1.413E+08	1.983E-06	5.502E+03	1.091E-02
1.000	9.836E+07	1.923E-06	4.496E+03	8.646E-03
1.225	5.254E+07	1.850E-06	2.954E+03	5.465E-03
1.475	1.814E+07	1.775E-06	1.250E+03	2.219E-03
1.700	1.940E+07	1.712E-06	1.544E+03	2.644E-03
1.900	9.846E+05	1.660E-06	8.746E+01	1.452E-04
2.100	7.069E+05	1.613E-06	6.960E+01	1.123E-04
2.300	1.270E+03	1.592E-06	1.379E-01	2.195E-07

Totals: 2.213E+12 photons/sec 6.431E+07 1.305E+02 R/hr
= 9.351E-06 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average E, Mev	Anterior DUNIT = 1	Posterior DUNIT = 2	Lateral DUNIT = 3	Rotational DUNIT = 4	Isometric DUNIT = 5	Orig ANSI DUNIT = 6
0.025	5.976E-31	2.732E-31	1.416E-31	2.907E-31	2.396E-31	4.612E-30
0.035	1.126E-10	6.518E-11	3.444E-11	5.981E-11	4.860E-11	4.002E-10
0.045	1.219E-06	7.789E-07	4.451E-07	6.897E-07	5.577E-07	2.883E-06
0.055	1.331E-04	9.018E-05	5.436E-05	7.881E-05	6.381E-05	2.554E-04
0.065	6.411E-04	4.534E-04	2.803E-04	3.922E-04	3.189E-04	1.096E-03
0.075	1.894E-03	1.389E-03	8.633E-04	1.189E-03	9.709E-04	3.028E-03
0.085	3.557E-03	2.690E-03	1.664E-03	2.280E-03	1.869E-03	5.460E-03
0.095	5.249E-03	4.078E-03	2.501E-03	3.426E-03	2.813E-03	7.854E-03
0.150	5.206E-02	4.347E-02	2.754E-02	3.729E-02	3.034E-02	7.311E-02
0.250	3.605E-02	2.981E-02	2.005E-02	2.596E-02	2.144E-02	4.864E-02
0.350	2.593E-02	2.180E-02	1.518E-02	1.917E-02	1.600E-02	3.479E-02
0.475	2.749E-02	2.362E-02	1.697E-02	2.094E-02	1.766E-02	3.516E-02
0.650	1.140E+02	1.004E+02	7.449E+01	8.970E+01	7.655E+01	1.425E+02
0.825	9.404E-03	8.443E-03	6.415E-03	7.577E-03	6.532E-03	1.148E-02
1.000	7.406E-03	6.743E-03	5.225E-03	6.071E-03	5.280E-03	8.897E-03
1.225	4.652E-03	4.291E-03	3.395E-03	3.876E-03	3.403E-03	5.515E-03
1.475	1.881E-03	1.753E-03	1.413E-03	1.587E-03	1.406E-03	2.207E-03
1.700	2.238E-03	2.099E-03	1.717E-03	1.904E-03	1.700E-03	2.609E-03
1.900	1.229E-04	1.158E-04	9.574E-05	1.051E-04	9.440E-05	1.426E-04
2.100	9.506E-05	8.988E-05	7.503E-05	8.169E-05	7.371E-05	1.098E-04
2.300	1.834E-07	1.739E-07	1.464E-07	1.582E-07	1.434E-07	2.111E-07
Totals	1.142E+02	1.006E+02	7.460E+01	8.983E+01	7.666E+01	1.427E+02

Closing: End of Run!!!!

Finish run at 23:25:43 07/13/95
Input File (IXCMAXNC.IN) is shown below:

0 2 Dose Rate from the TRU IXC's (Maximum Case, no concrete)
Maximum TRU Ion-Exchange Column Dose with no concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEOM= 11,
X= 25.5, Y= 104.14, SLTH= 52.07,
NSHLD= 4, JBUF= 1,
T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 0.00,
NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 1.30E+01, Weight(84)= 1.20E+01,

Weight(335)= 6.34E+01, Weight(336)= 6.00E+01,
Weight(493)= 9.73E-02, Weight(494)= 2.27E-02,
Weight(495)= 1.56E+00, Weight(496)= 5.00E-02 &
water 1 0.553
carb 6 0.431
H 4 0.036
FE 9 7.86
air 3 0.00129
1 conc 16 2.8
End of Run!!!!
&Input Next= 6 &

Run started at 08:39:27 07/13/95

IXC MAX IC

IXC KE 215

Contact

1' concrete shielding

Concrete Density: 2.8g/cm³

ISO-PC Version 1.98 August 1994
 originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
 Paul D. Rittmann, PhD CHP 509-376-8715
 Westinghouse Hanford Company HO-36
 PO Box 1970 Richland, WA 99352

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, 1' concrete)

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03
E, MeV Linear Attenuation, per cm (last region is air)					
0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03

0.025	4.197E-01	1.096E+02	6.138E-04	5.555E+00	6.138E-04
0.035	2.765E-01	4.186E+01	3.664E-04	2.310E+00	3.664E-04
0.045	2.277E-01	2.035E+01	2.837E-04	1.318E+00	2.837E-04
0.055	2.063E-01	1.178E+01	2.491E-04	9.257E-01	2.491E-04
0.065	1.946E-01	7.715E+00	2.314E-04	7.361E-01	2.314E-04
0.075	1.851E-01	5.451E+00	2.184E-04	6.266E-01	2.184E-04
0.085	1.779E-01	4.096E+00	2.090E-04	5.592E-01	2.090E-04
0.095	1.725E-01	3.237E+00	2.019E-04	5.146E-01	2.019E-04
0.150	1.514E-01	1.541E+00	1.758E-04	4.026E-01	1.758E-04
0.250	1.275E-01	9.660E-01	1.477E-04	3.259E-01	1.477E-04
0.350	1.124E-01	7.923E-01	1.298E-04	2.845E-01	1.298E-04
0.475	9.929E-02	6.768E-01	1.146E-04	2.507E-01	1.146E-04
0.650	8.675E-02	5.813E-01	1.001E-04	2.184E-01	1.001E-04
0.825	7.783E-02	5.172E-01	8.984E-05	1.959E-01	8.984E-05
1.000	7.098E-02	4.700E-01	8.194E-05	1.785E-01	8.194E-05
1.225	6.416E-02	4.239E-01	7.398E-05	1.612E-01	7.398E-05
1.475	5.833E-02	3.860E-01	6.718E-05	1.465E-01	6.718E-05
1.700	5.414E-02	3.602E-01	6.249E-05	1.362E-01	6.249E-05
1.900	5.098E-02	3.420E-01	5.889E-05	1.286E-01	5.889E-05
2.100	4.823E-02	3.268E-01	5.564E-05	1.222E-01	5.564E-05
2.300	4.573E-02	3.141E-01	5.263E-05	1.166E-01	5.263E-05
2.500	4.355E-02	3.033E-01	5.003E-05	1.118E-01	5.003E-05
2.700	4.167E-02	2.942E-01	4.778E-05	1.075E-01	4.778E-05
3.000	3.935E-02	2.830E-01	4.511E-05	1.022E-01	4.511E-05
3.600	3.591E-02	2.669E-01	4.158E-05	9.372E-02	4.158E-05
4.500	3.196E-02	2.521E-01	3.746E-05	8.464E-02	3.746E-05
5.500	2.873E-02	2.428E-01	3.381E-05	7.784E-02	3.381E-05
6.600	2.623E-02	2.371E-01	3.111E-05	7.274E-02	3.111E-05
8.600	2.318E-02	2.325E-01	2.771E-05	6.684E-02	2.771E-05

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

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Source          Shields          Distance to Detector, X = 5.598E+01 cm
Cylindrical     Cyl. & Slab          Source Volume = 8.080E+04 cc
                                   Source Mass   = 8.242E+04 grams
Source Length = 5.207E+01 cm      Distance Along Cylinder, Y = 0.000E+00 cm
Integration Specs:  NTHETA = 33      NPSI = 33      DELR = 1.001E-01 cm
  Total Intervals:  2.418E+05      (photon source is the 1st region)
Shield Thickness: 2.223E+01, 6.350E-01, 1.000E-01, 3.048E+01, 2.540E+00 cm
Distances from Dose Point to the Outside of
  (1) Source Region: 3.375E+01 cm  (2) Next Layer: 3.312E+01 cm
Dose Buildup Data for Shield 4 with Effective Atomic Number  9.39
Fluence-to-Dose Conversion: Photons in Air

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Average E, MeV	Source Total photons/sec	Fluence to Dose Factor	Energy Fluence MeV/sq.cm/sec	Dose Rate R/hr
0.015	1.700E+10	8.183E-05	0.000E+00	0.000E+00
0.025	8.881E+09	1.656E-05	0.000E+00	0.000E+00
0.035	1.667E+11	6.084E-06	0.000E+00	0.000E+00
0.045	3.354E+09	3.203E-06	1.649E-18	5.283E-24
0.055	3.141E+09	2.216E-06	1.072E-10	2.376E-16
0.065	1.973E+09	1.827E-06	4.930E-07	9.007E-13
0.075	1.699E+09	1.664E-06	7.129E-05	1.186E-10
0.085	1.451E+09	1.603E-06	1.433E-03	2.297E-09
0.095	1.257E+09	1.592E-06	9.901E-03	1.576E-08
0.150	6.072E+09	1.728E-06	6.666E-01	1.152E-06

0.250	1.793E+09	1.935E-06	2.417E+00	4.677E-06
0.350	8.334E+08	2.019E-06	4.046E+00	8.169E-06
0.475	6.286E+08	2.043E-06	8.576E+00	1.752E-05
0.650	1.998E+12	2.029E-06	7.743E+04	1.571E-01
0.825	1.413E+08	1.983E-06	1.189E+01	2.357E-05
1.000	9.836E+07	1.923E-06	1.531E+01	2.945E-05
1.225	5.254E+07	1.850E-06	1.523E+01	2.818E-05
1.475	1.814E+07	1.775E-06	9.097E+00	1.615E-05
1.700	1.940E+07	1.712E-06	1.454E+01	2.489E-05
1.900	9.846E+05	1.660E-06	9.999E-01	1.660E-06
2.100	7.069E+05	1.613E-06	9.339E-01	1.506E-06
2.300	1.270E+03	1.592E-06	2.123E-03	3.379E-09

 Totals: 2.213E+12 photons/sec 7.751E+04 1.573E-01 R/hr
 = 1.127E-08 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average	Anterior	Posterior	Lateral	Rotational	Isometric	Orig ANSI
E, Mev	DUNIT = 1	DUNIT = 2	DUNIT = 3	DUNIT = 4	DUNIT = 5	DUNIT = 6

0.045	4.913E-24	3.140E-24	1.794E-24	2.781E-24	2.248E-24	1.162E-23
0.055	2.786E-16	1.887E-16	1.138E-16	1.649E-16	1.335E-16	5.345E-16
0.065	1.152E-12	8.146E-13	5.035E-13	7.046E-13	5.729E-13	1.968E-12
0.075	1.536E-10	1.126E-10	7.000E-11	9.639E-11	7.873E-11	2.455E-10
0.085	2.906E-09	2.198E-09	1.360E-09	1.863E-09	1.527E-09	4.462E-09
0.095	1.921E-08	1.492E-08	9.152E-09	1.254E-08	1.030E-08	2.874E-08
0.150	1.200E-06	1.002E-06	6.350E-07	8.599E-07	6.995E-07	1.686E-06
0.250	4.521E-06	3.739E-06	2.514E-06	3.255E-06	2.689E-06	6.100E-06
0.350	7.567E-06	6.361E-06	4.431E-06	5.592E-06	4.668E-06	1.015E-05
0.475	1.576E-05	1.355E-05	9.733E-06	1.201E-05	1.013E-05	2.016E-05
0.650	1.374E-01	1.211E-01	8.982E-02	1.081E-01	9.230E-02	1.718E-01
0.825	2.032E-05	1.824E-05	1.386E-05	1.637E-05	1.411E-05	2.479E-05
1.000	2.522E-05	2.296E-05	1.780E-05	2.068E-05	1.798E-05	3.030E-05
1.225	2.399E-05	2.213E-05	1.750E-05	1.998E-05	1.755E-05	2.844E-05
1.475	1.369E-05	1.276E-05	1.028E-05	1.155E-05	1.023E-05	1.606E-05
1.700	2.107E-05	1.977E-05	1.616E-05	1.792E-05	1.600E-05	2.457E-05
1.900	1.405E-06	1.324E-06	1.095E-06	1.202E-06	1.079E-06	1.630E-06
2.100	1.276E-06	1.206E-06	1.007E-06	1.096E-06	9.891E-07	1.474E-06
2.300	2.823E-09	2.677E-09	2.254E-09	2.435E-09	2.208E-09	3.250E-09

Totals	1.376E-01	1.212E-01	8.991E-02	1.083E-01	9.240E-02	1.719E-01

Closing: End of Run!!!!

Finish run at 09:54:45 07/13/95
 Input File (IXCMAX1C.IN) is shown below:

0 2 Dose Rate from the TRU IXC's (Maximum Case, 1' concrete)
 Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch
 &Input Next= 1, DUNIT= 7, IGEOM= 11,
 X= 55.98, Y= 104.14, SLTH= 52.07,
 NSHLD= 4, JBUF= 4,
 T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 30.48,
 NTHETA= 33, NPSI= 33, DELR= 0.1,
 Weight(82)= 1.30E+01, Weight(84)= 1.20E+01,
 Weight(335)= 6.34E+01, Weight(336)= 6.00E+01,
 Weight(493)= 9.73E-02, Weight(494)= 2.27E-02,

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Weight(495)= 1.56E+00, Weight(496)= 5.00E-02  &
water  1    0.553
carb   6    0.431
H      4    0.036
FE     9          7.86
air    3          0.00129
1 conc 16          2.8
End of Run!!!!
&Input Next= 6  &

```

Run started at 23:25:43 07/13/95

ISO-PC Version 1.98 August 1994
originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

IXC MAX 15

IXC KE 25

Contact

1.5' concrete shielding

Concrete Density: 2.8 g/cc

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, 1.5' concrete)

Maximum TRU Ion-Exchange Column Dose with 1.5' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with 1.5' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03
E, MeV Linear Attenuation, per cm (last region is air)					
0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03


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Source           Shields      Distance to Detector, X = 7.122E+01 cm
Cylindrical      Cyl. & Slab    Source Volume = 8.080E+04 cc
                  Source Mass   = 8.242E+04 grams
Source Length = 5.207E+01 cm    Distance Along Cylinder, Y = 0.000E+00 cm
Integration Specs:  NTHETA = 33    NPSI = 33    DELR = 1.001E-01 cm
  Total Intervals:  2.418E+05    (photon source is the 1st region)
Shield Thickness: 2.223E+01, 6.350E-01, 1.000E-01, 4.572E+01, 2.540E+00 cm
Distances from Dose Point to the Outside of
  (1) Source Region: 4.900E+01 cm    (2) Next Layer: 4.836E+01 cm
Dose Buildup Data for Shield 4 with Effective Atomic Number 9.39
Fluence-to-Dose Conversion: Photons in Air

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Average E, MeV	Source Total photons/sec	Fluence to Dose Factor	Energy Fluence MeV/sq.cm/sec	Dose Rate R/hr
0.015	1.700E+10	8.183E-05	0.000E+00	0.000E+00
0.025	8.881E+09	1.656E-05	0.000E+00	0.000E+00
0.035	1.667E+11	6.084E-06	0.000E+00	0.000E+00
0.045	3.354E+09	3.203E-06	3.085E-27	9.881E-33
0.055	3.141E+09	2.216E-06	8.510E-17	1.886E-22
0.065	1.973E+09	1.827E-06	7.573E-12	1.384E-17
0.075	1.699E+09	1.664E-06	6.323E-09	1.052E-14
0.085	1.451E+09	1.603E-06	3.900E-07	6.252E-13
0.095	1.257E+09	1.592E-06	5.858E-06	9.326E-12
0.150	6.072E+09	1.728E-06	4.361E-03	7.537E-09

0.250	1.793E+09	1.935E-06	3.306E-02	6.398E-08
0.350	8.334E+08	2.019E-06	8.273E-02	1.670E-07
0.475	6.286E+08	2.043E-06	2.491E-01	5.089E-07
0.650	1.998E+12	2.029E-06	3.258E+03	6.610E-03
0.825	1.413E+08	1.983E-06	6.564E-01	1.302E-06
1.000	9.836E+07	1.923E-06	1.048E+00	2.015E-06
1.225	5.254E+07	1.850E-06	1.289E+00	2.385E-06
1.475	1.814E+07	1.775E-06	9.239E-01	1.640E-06
1.700	1.940E+07	1.712E-06	1.681E+00	2.878E-06
1.900	9.846E+05	1.660E-06	1.273E-01	2.113E-07
2.100	7.069E+05	1.613E-06	1.290E-01	2.081E-07
2.300	1.270E+03	1.592E-06	3.153E-04	5.020E-10

Totals: 2.213E+12 photons/sec 3.264E+03 6.622E-03 R/hr
= 4.746E-10 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average E, Mev	Anterior DUNIT = 1	Posterior DUNIT = 2	Lateral DUNIT = 3	Rotational DUNIT = 4	Isometric DUNIT = 5	Orig ANSI DUNIT = 6
0.045	9.189E-33	5.873E-33	3.356E-33	5.201E-33	4.205E-33	2.174E-32
0.055	2.211E-22	1.498E-22	9.027E-23	1.309E-22	1.060E-22	4.242E-22
0.065	1.769E-17	1.251E-17	7.734E-18	1.082E-17	8.799E-18	3.024E-17
0.075	1.362E-14	9.987E-15	6.209E-15	8.549E-15	6.983E-15	2.177E-14
0.085	7.909E-13	5.981E-13	3.701E-13	5.069E-13	4.155E-13	1.214E-12
0.095	1.136E-11	8.829E-12	5.415E-12	7.419E-12	6.091E-12	1.700E-11
0.150	7.854E-09	6.558E-09	4.155E-09	5.626E-09	4.576E-09	1.103E-08
0.250	6.184E-08	5.115E-08	3.440E-08	4.453E-08	3.679E-08	8.345E-08
0.350	1.547E-07	1.301E-07	9.059E-08	1.143E-07	9.544E-08	2.075E-07
0.475	4.579E-07	3.935E-07	2.827E-07	3.488E-07	2.941E-07	5.856E-07
0.650	5.783E-03	5.095E-03	3.779E-03	4.551E-03	3.884E-03	7.228E-03
0.825	1.122E-06	1.007E-06	7.655E-07	9.040E-07	7.793E-07	1.369E-06
1.000	1.726E-06	1.572E-06	1.218E-06	1.415E-06	1.231E-06	2.074E-06
1.225	2.030E-06	1.873E-06	1.482E-06	1.691E-06	1.485E-06	2.407E-06
1.475	1.390E-06	1.295E-06	1.044E-06	1.173E-06	1.039E-06	1.632E-06
1.700	2.436E-06	2.285E-06	1.869E-06	2.072E-06	1.850E-06	2.840E-06
1.900	1.789E-07	1.685E-07	1.393E-07	1.530E-07	1.374E-07	2.075E-07
2.100	1.762E-07	1.666E-07	1.391E-07	1.514E-07	1.366E-07	2.036E-07
2.300	4.194E-10	3.976E-10	3.349E-10	3.618E-10	3.280E-10	4.828E-10
Totals	5.792E-03	5.104E-03	3.786E-03	4.559E-03	3.891E-03	7.239E-03

Closing: End of Run!!!!

Finish run at 23:31:48 07/13/95

Input File (IXCMAX15.IN) is shown below:

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0      2 Dose Rate from the TRU IXC's (Maximum Case, 1.5' concrete)
Maximum TRU Ion-Exchange Column Dose with 1.5' concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEOM= 11,
      X= 71.22, Y= 104.14, SLTH= 52.07,
      NSHLD= 4, JBUF= 4,
      T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 45.72,
      NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 1.30E+01, Weight(84)= 1.20E+01,
Weight(335)= 6.34E+01, Weight(336)= 6.00E+01,
Weight(493)= 9.73E-02, Weight(494)= 2.27E-02,

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Weight(495)= 1.56E+00, Weight(496)= 5.00E-02  &
water  1    0.553
carb   6    0.431
H      4    0.036
FE     9          7.86
air    3          0.00129
1 conc 16          2.8
End of Run!!!!
&Input Next= 6  &

```

Run started at 23:31:48 07/13/95

ISO-PC Version 1.98 August 1994
originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

IXC MAX 2K

IXC KE 215

Contact

2' concrete shielding
Concrete Density: 2.8 g/cm³

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, 2' concrete)

Maximum TRU Ion-Exchange Column Dose with 2' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with 2' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.800E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.800E+00	1.290E-03
E, MeV Linear Attenuation, per cm (last region is air)					
0.015	1.256E+00	4.622E+02	2.046E-03	2.375E+01	2.046E-03

0.025	4.197E-01	1.096E+02	6.138E-04	5.555E+00	6.138E-04
0.035	2.765E-01	4.186E+01	3.664E-04	2.310E+00	3.664E-04
0.045	2.277E-01	2.035E+01	2.837E-04	1.318E+00	2.837E-04
0.055	2.063E-01	1.178E+01	2.491E-04	9.257E-01	2.491E-04
0.065	1.946E-01	7.715E+00	2.314E-04	7.361E-01	2.314E-04
0.075	1.851E-01	5.451E+00	2.184E-04	6.266E-01	2.184E-04
0.085	1.779E-01	4.096E+00	2.090E-04	5.592E-01	2.090E-04
0.095	1.725E-01	3.237E+00	2.019E-04	5.146E-01	2.019E-04
0.150	1.514E-01	1.541E+00	1.758E-04	4.026E-01	1.758E-04
0.250	1.275E-01	9.660E-01	1.477E-04	3.259E-01	1.477E-04
0.350	1.124E-01	7.923E-01	1.298E-04	2.845E-01	1.298E-04
0.475	9.929E-02	6.768E-01	1.146E-04	2.507E-01	1.146E-04
0.650	8.675E-02	5.813E-01	1.001E-04	2.184E-01	1.001E-04
0.825	7.783E-02	5.172E-01	8.984E-05	1.959E-01	8.984E-05
1.000	7.098E-02	4.700E-01	8.194E-05	1.785E-01	8.194E-05
1.225	6.416E-02	4.239E-01	7.398E-05	1.612E-01	7.398E-05
1.475	5.833E-02	3.860E-01	6.718E-05	1.465E-01	6.718E-05
1.700	5.414E-02	3.602E-01	6.249E-05	1.362E-01	6.249E-05
1.900	5.098E-02	3.420E-01	5.889E-05	1.286E-01	5.889E-05
2.100	4.823E-02	3.268E-01	5.564E-05	1.222E-01	5.564E-05
2.300	4.573E-02	3.141E-01	5.263E-05	1.166E-01	5.263E-05
2.500	4.355E-02	3.033E-01	5.003E-05	1.118E-01	5.003E-05
2.700	4.167E-02	2.942E-01	4.778E-05	1.075E-01	4.778E-05
3.000	3.935E-02	2.830E-01	4.511E-05	1.022E-01	4.511E-05
3.600	3.591E-02	2.669E-01	4.158E-05	9.372E-02	4.158E-05
4.500	3.196E-02	2.521E-01	3.746E-05	8.464E-02	3.746E-05
5.500	2.873E-02	2.428E-01	3.381E-05	7.784E-02	3.381E-05
6.600	2.623E-02	2.371E-01	3.111E-05	7.274E-02	3.111E-05
8.600	2.318E-02	2.325E-01	2.771E-05	6.684E-02	2.771E-05

water	1	0.553		
carb	6	0.431		
H	4	0.036		
FE	9		7.86	
air	3		0.00129	
1 conc	16			2.8

End of Run!!!!

&Input Next= 6 &

Run started at 02:20:36 07/07/95

ISO-PC Version 1.98 August 1994
originally ISOSHL-D-II; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

ALT CONC 1
IXC KE 215
Contact

1' concrete shielding
Concrete Density: 2.35 g/cm³

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, 1' concrete)
Density of concrete: 2.35 g/cm³

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	2.350E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	2.350E+00	1.290E-03
E, MeV Linear Attenuation, per cm (last region is air)					
0.015	1.256E+00	4.622E+02	2.046E-03	1.993E+01	2.046E-03

0.025	4.197E-01	1.096E+02	6.138E-04	4.662E+00	6.138E-04
0.035	2.765E-01	4.186E+01	3.664E-04	1.939E+00	3.664E-04
0.045	2.277E-01	2.035E+01	2.837E-04	1.106E+00	2.837E-04
0.055	2.063E-01	1.178E+01	2.491E-04	7.769E-01	2.491E-04
0.065	1.946E-01	7.715E+00	2.314E-04	6.178E-01	2.314E-04
0.075	1.851E-01	5.451E+00	2.184E-04	5.259E-01	2.184E-04
0.085	1.779E-01	4.096E+00	2.090E-04	4.693E-01	2.090E-04
0.095	1.725E-01	3.237E+00	2.019E-04	4.319E-01	2.019E-04
0.150	1.514E-01	1.541E+00	1.758E-04	3.379E-01	1.758E-04
0.250	1.275E-01	9.660E-01	1.477E-04	2.735E-01	1.477E-04
0.350	1.124E-01	7.923E-01	1.298E-04	2.388E-01	1.298E-04
0.475	9.929E-02	6.768E-01	1.146E-04	2.104E-01	1.146E-04
0.650	8.675E-02	5.813E-01	1.001E-04	1.833E-01	1.001E-04
0.825	7.783E-02	5.172E-01	8.984E-05	1.644E-01	8.984E-05
1.000	7.098E-02	4.700E-01	8.194E-05	1.498E-01	8.194E-05
1.225	6.416E-02	4.239E-01	7.398E-05	1.353E-01	7.398E-05
1.475	5.833E-02	3.860E-01	6.718E-05	1.230E-01	6.718E-05
1.700	5.414E-02	3.602E-01	6.249E-05	1.143E-01	6.249E-05
1.900	5.098E-02	3.420E-01	5.889E-05	1.079E-01	5.889E-05
2.100	4.823E-02	3.268E-01	5.564E-05	1.026E-01	5.564E-05
2.300	4.573E-02	3.141E-01	5.263E-05	9.785E-02	5.263E-05
2.500	4.355E-02	3.033E-01	5.003E-05	9.384E-02	5.003E-05
2.700	4.167E-02	2.942E-01	4.778E-05	9.024E-02	4.778E-05
3.000	3.935E-02	2.830E-01	4.511E-05	8.575E-02	4.511E-05
3.600	3.591E-02	2.669E-01	4.158E-05	7.865E-02	4.158E-05
4.500	3.196E-02	2.521E-01	3.746E-05	7.104E-02	3.746E-05
5.500	2.873E-02	2.428E-01	3.381E-05	6.533E-02	3.381E-05
6.600	2.623E-02	2.371E-01	3.111E-05	6.105E-02	3.111E-05
8.600	2.318E-02	2.325E-01	2.771E-05	5.609E-02	2.771E-05

0.250	1.793E+09	1.935E-06	9.034E+00	1.748E-05
0.350	8.334E+08	2.019E-06	1.323E+01	2.672E-05
0.475	6.286E+08	2.043E-06	2.497E+01	5.102E-05
0.650	1.998E+12	2.029E-06	1.994E+05	4.047E-01
0.825	1.413E+08	1.983E-06	2.797E+01	5.546E-05
1.000	9.836E+07	1.923E-06	3.355E+01	6.451E-05
1.225	5.254E+07	1.850E-06	3.107E+01	5.747E-05
1.475	1.814E+07	1.775E-06	1.745E+01	3.097E-05
1.700	1.940E+07	1.712E-06	2.669E+01	4.570E-05
1.900	9.846E+05	1.660E-06	1.777E+00	2.949E-06
2.100	7.069E+05	1.613E-06	1.614E+00	2.603E-06
2.300	1.270E+03	1.592E-06	3.578E-03	5.696E-09

Totals: 2.213E+12 photons/sec 1.996E+05 4.050E-01 R/hr
= 2.903E-08 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average E, Mev	Anterior DUNIT = 1	Posterior DUNIT = 2	Lateral DUNIT = 3	Rotational DUNIT = 4	Isometric DUNIT = 5	Orig ANSI DUNIT = 6
0.045	2.896E-21	1.851E-21	1.058E-21	1.639E-21	1.325E-21	6.851E-21
0.055	2.321E-14	1.572E-14	9.475E-15	1.374E-14	1.112E-14	4.452E-14
0.065	3.614E-11	2.556E-11	1.580E-11	2.211E-11	1.798E-11	6.176E-11
0.075	2.645E-09	1.939E-09	1.206E-09	1.660E-09	1.356E-09	4.228E-09
0.085	3.311E-08	2.504E-08	1.549E-08	2.122E-08	1.739E-08	5.083E-08
0.095	1.581E-07	1.228E-07	7.534E-08	1.032E-07	8.476E-08	2.366E-07
0.150	5.727E-06	4.782E-06	3.030E-06	4.103E-06	3.337E-06	8.043E-06
0.250	1.690E-05	1.397E-05	9.398E-06	1.217E-05	1.005E-05	2.280E-05
0.350	2.475E-05	2.081E-05	1.449E-05	1.829E-05	1.527E-05	3.320E-05
0.475	4.590E-05	3.945E-05	2.834E-05	3.496E-05	2.949E-05	5.871E-05
0.650	3.540E-01	3.119E-01	2.314E-01	2.786E-01	2.378E-01	4.425E-01
0.825	4.781E-05	4.292E-05	3.262E-05	3.852E-05	3.321E-05	5.834E-05
1.000	5.525E-05	5.030E-05	3.898E-05	4.530E-05	3.939E-05	6.638E-05
1.225	4.893E-05	4.513E-05	3.570E-05	4.076E-05	3.579E-05	5.800E-05
1.475	2.626E-05	2.447E-05	1.972E-05	2.215E-05	1.963E-05	3.081E-05
1.700	3.868E-05	3.629E-05	2.967E-05	3.291E-05	2.937E-05	4.510E-05
1.900	2.497E-06	2.352E-06	1.945E-06	2.136E-06	1.918E-06	2.897E-06
2.100	2.204E-06	2.084E-06	1.740E-06	1.894E-06	1.709E-06	2.547E-06
2.300	4.759E-09	4.512E-09	3.800E-09	4.105E-09	3.721E-09	5.479E-09
Totals	3.543E-01	3.122E-01	2.316E-01	2.788E-01	2.380E-01	4.429E-01

Closing: End of Run!!!!

Finish run at 02:26:57 07/07/95

Input File (ALTCONC1.IN) is shown below:

0 2 Dose Rate from the TRU IXC's (Maximum Case, 1' concrete)
Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEOM= 11,
X= 55.98, Y= 104.14, SLTH= 52.07,
NSHLD= 4, JBUF= 4,
T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 30.48,
NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 1.30E+01, Weight(84)= 1.20E+01,
Weight(335)= 6.34E+01, Weight(336)= 6.00E+01,
Weight(493)= 9.73E-02, Weight(494)= 2.27E-02,

Weight(495)= 1.56E+00, Weight(496)= 5.00E-02 &
water 1 0.553
carb 6 0.431
H 4 0.036
FE 9 7.86
air 3 0.00129
1 conc 16 2.35
End of Run!!!!
&Input Next= 6 &

Run started at 11:31:52 07/13/95

EXC KE 215

Contact

1' concrete shielding
Concrete Density: 3.76 g/cm³

ISO-PC Version 1.98 August 1994
originally ISOSHL-III; RIBD was removed

Please send questions or comments to:
Paul D. Rittmann, PhD CHP 509-376-8715
Westinghouse Hanford Company HO-36
PO Box 1970 Richland, WA 99352

Title Line from Library File (ISO-PC.LIB):

Attenuation & Buildup for 30 Groups; Photon & Beta Production 7/6/94 PDR

Run Title: Dose Rate from the TRU IXCs (Maximum Case, 1' concrete)
Density of concrete: 3.76 g/cm³

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Table of Source Activity:

Scale Factor = 1.000E+00

Isotope Name	Initial Values	Final Curies
SR- 90	1.30E+01	1.300E+01
Y - 90	1.20E+01	1.200E+01
CS-137	6.34E+01	6.340E+01
BA-137M	6.00E+01	6.000E+01
PU-239	9.73E-02	9.730E-02
PU-240	2.27E-02	2.270E-02
PU-241	1.56E+00	1.560E+00
AM-241	5.00E-02	5.000E-02

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

Shield Composition, g/cc

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
WATER	5.530E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AIR	0.000E+00	0.000E+00	1.290E-03	0.000E+00	1.290E-03
ORD CONC	0.000E+00	0.000E+00	0.000E+00	3.760E+00	0.000E+00
HYDROGEN	3.600E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CARBON	4.310E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
IRON	0.000E+00	7.860E+00	0.000E+00	0.000E+00	0.000E+00
Totals:	1.020E+00	7.860E+00	1.290E-03	3.760E+00	1.290E-03
E, MeV	Linear Attenuation, per cm (last region is air)				
0.015	1.256E+00	4.622E+02	2.046E-03	3.189E+01	2.046E-03

0.025	4.197E-01	1.096E+02	6.138E-04	7.459E+00	6.138E-04
0.035	2.765E-01	4.186E+01	3.664E-04	3.102E+00	3.664E-04
0.045	2.277E-01	2.035E+01	2.837E-04	1.770E+00	2.837E-04
0.055	2.063E-01	1.178E+01	2.491E-04	1.243E+00	2.491E-04
0.065	1.946E-01	7.715E+00	2.314E-04	9.885E-01	2.314E-04
0.075	1.851E-01	5.451E+00	2.184E-04	8.415E-01	2.184E-04
0.085	1.779E-01	4.096E+00	2.090E-04	7.509E-01	2.090E-04
0.095	1.725E-01	3.237E+00	2.019E-04	6.911E-01	2.019E-04
0.150	1.514E-01	1.541E+00	1.758E-04	5.407E-01	1.758E-04
0.250	1.275E-01	9.660E-01	1.477E-04	4.377E-01	1.477E-04
0.350	1.124E-01	7.923E-01	1.298E-04	3.820E-01	1.298E-04
0.475	9.929E-02	6.768E-01	1.146E-04	3.367E-01	1.146E-04
0.650	8.675E-02	5.813E-01	1.001E-04	2.933E-01	1.001E-04
0.825	7.783E-02	5.172E-01	8.984E-05	2.630E-01	8.984E-05
1.000	7.098E-02	4.700E-01	8.194E-05	2.397E-01	8.194E-05
1.225	6.416E-02	4.239E-01	7.398E-05	2.165E-01	7.398E-05
1.475	5.833E-02	3.860E-01	6.718E-05	1.968E-01	6.718E-05
1.700	5.414E-02	3.602E-01	6.249E-05	1.828E-01	6.249E-05
1.900	5.098E-02	3.420E-01	5.889E-05	1.727E-01	5.889E-05
2.100	4.823E-02	3.268E-01	5.564E-05	1.641E-01	5.564E-05
2.300	4.573E-02	3.141E-01	5.263E-05	1.566E-01	5.263E-05
2.500	4.355E-02	3.033E-01	5.003E-05	1.501E-01	5.003E-05
2.700	4.167E-02	2.942E-01	4.778E-05	1.444E-01	4.778E-05
3.000	3.935E-02	2.830E-01	4.511E-05	1.372E-01	4.511E-05
3.600	3.591E-02	2.669E-01	4.158E-05	1.258E-01	4.158E-05
4.500	3.196E-02	2.521E-01	3.746E-05	1.137E-01	3.746E-05
5.500	2.873E-02	2.428E-01	3.381E-05	1.045E-01	3.381E-05
6.600	2.623E-02	2.371E-01	3.111E-05	9.768E-02	3.111E-05
8.600	2.318E-02	2.325E-01	2.771E-05	8.975E-02	2.771E-05

Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch

```

Source           Shields      Distance to Detector, X = 5.598E+01 cm
Cylindrical      Cyl. & Slab    Source Volume = 8.080E+04 cc
                  Source Mass   = 8.242E+04 grams
Source Length = 5.207E+01 cm    Distance Along Cylinder, Y = 0.000E+00 cm
Integration Specs:  NTHETA = 33    NPSI = 33    DELR = 1.001E-01 cm
  Total Intervals:  2.418E+05    (photon source is the 1st region)
Shield Thickness: 2.223E+01, 6.350E-01, 1.000E-01, 3.048E+01, 2.540E+00 cm
Distances from Dose Point to the Outside of
  (1) Source Region: 3.375E+01 cm    (2) Next Layer: 3.312E+01 cm
Dose Buildup Data for Shield 4 with Effective Atomic Number 9.39
Fluence-to-Dose Conversion: Photons in Air

```

Average E, MeV	Source Total photons/sec	Fluence to Dose Factor	Energy Fluence MeV/sq.cm/sec	Dose Rate R/hr
0.015	1.700E+10	8.183E-05	0.000E+00	0.000E+00
0.025	8.881E+09	1.656E-05	0.000E+00	0.000E+00
0.035	1.667E+11	6.084E-06	0.000E+00	0.000E+00
0.045	3.354E+09	3.203E-06	1.936E-24	6.203E-30
0.055	3.141E+09	2.216E-06	7.951E-15	1.762E-20
0.065	1.973E+09	1.827E-06	2.801E-10	5.117E-16
0.075	1.699E+09	1.664E-06	1.357E-07	2.259E-13
0.085	1.451E+09	1.603E-06	5.944E-06	9.528E-12
0.095	1.257E+09	1.592E-06	7.082E-05	1.127E-10
0.150	6.072E+09	1.728E-06	2.360E-02	4.078E-08

0.250	1.793E+09	1.935E-06	1.429E-01	2.765E-07
0.350	8.334E+08	2.019E-06	3.169E-01	6.399E-07
0.475	6.286E+08	2.043E-06	8.596E-01	1.756E-06
0.650	1.998E+12	2.029E-06	1.008E+04	2.045E-02
0.825	1.413E+08	1.983E-06	1.876E+00	3.720E-06
1.000	9.836E+07	1.923E-06	2.815E+00	5.414E-06
1.225	5.254E+07	1.850E-06	3.260E+00	6.031E-06
1.475	1.814E+07	1.775E-06	2.220E+00	3.941E-06
1.700	1.940E+07	1.712E-06	3.897E+00	6.673E-06
1.900	9.846E+05	1.660E-06	2.874E-01	4.771E-07
2.100	7.069E+05	1.613E-06	2.850E-01	4.596E-07
2.300	1.270E+03	1.592E-06	6.831E-04	1.087E-09

Totals: 2.213E+12 photons/sec 1.009E+04 2.048E-02 R/hr
= 1.468E-09 amp/kg

Dose Equivalent Rates (rem/hr) for Other Fluence-to-Dose Factors						
Average E, Mev	Anterior DUNIT = 1	Posterior DUNIT = 2	Lateral DUNIT = 3	Rotational DUNIT = 4	Isometric DUNIT = 5	Orig ANSI DUNIT = 6
0.045	5.768E-30	3.687E-30	2.107E-30	3.265E-30	2.639E-30	1.365E-29
0.055	2.066E-20	1.399E-20	8.434E-21	1.223E-20	9.900E-21	3.963E-20
0.065	6.543E-16	4.627E-16	2.860E-16	4.003E-16	3.254E-16	1.118E-15
0.075	2.924E-13	2.144E-13	1.333E-13	1.835E-13	1.499E-13	4.674E-13
0.085	1.205E-11	9.116E-12	5.640E-12	7.726E-12	6.332E-12	1.850E-11
0.095	1.374E-10	1.067E-10	6.546E-11	8.968E-11	7.364E-11	2.056E-10
0.150	4.249E-08	3.548E-08	2.248E-08	3.044E-08	2.476E-08	5.967E-08
0.250	2.672E-07	2.210E-07	1.486E-07	1.924E-07	1.590E-07	3.606E-07
0.350	5.927E-07	4.983E-07	3.471E-07	4.380E-07	3.656E-07	7.951E-07
0.475	1.580E-06	1.358E-06	9.755E-07	1.203E-06	1.015E-06	2.021E-06
0.650	1.789E-02	1.576E-02	1.169E-02	1.408E-02	1.201E-02	2.236E-02
0.825	3.206E-06	2.879E-06	2.187E-06	2.583E-06	2.227E-06	3.912E-06
1.000	4.637E-06	4.222E-06	3.272E-06	3.802E-06	3.306E-06	5.571E-06
1.225	5.135E-06	4.736E-06	3.747E-06	4.278E-06	3.756E-06	6.087E-06
1.475	3.341E-06	3.113E-06	2.509E-06	2.818E-06	2.498E-06	3.921E-06
1.700	5.648E-06	5.298E-06	4.332E-06	4.805E-06	4.289E-06	6.585E-06
1.900	4.039E-07	3.806E-07	3.146E-07	3.455E-07	3.102E-07	4.687E-07
2.100	3.892E-07	3.680E-07	3.072E-07	3.345E-07	3.018E-07	4.497E-07
2.300	9.085E-10	8.614E-10	7.254E-10	7.837E-10	7.104E-10	1.046E-09
Totals	1.791E-02	1.578E-02	1.171E-02	1.410E-02	1.203E-02	2.239E-02

Closing: End of Run!!!!

Finish run at 11:42:11 07/13/95

Input File (ALTCONC2.IN) is shown below:

```

0      2 Dose Rate from the TRU IXC's (Maximum Case, 1' concrete)
Maximum TRU Ion-Exchange Column Dose with 1' concrete - 1 inch
&Input Next= 1, DUNIT= 7, IGEOM= 11,
      X= 55.98, Y= 104.14, SLTH= 52.07,
      NSHLD= 4, JBUF= 4,
      T(1)= 22.225, T(2)= 0.635, T(3)= 0.1, T(4)= 30.48,
      NTHETA= 33, NPSI= 33, DELR= 0.1,
Weight(82)= 1.30E+01, Weight(84)= 1.20E+01,
Weight(335)= 6.34E+01, Weight(336)= 6.00E+01,
Weight(493)= 9.73E-02, Weight(494)= 2.27E-02,

```

Weight(495)= 1.56E+00, Weight(496)= 5.00E-02 &
water 1 0.553
carb 6 0.431
H 4 0.036
FE 9 7.86
air 3 0.00129
1 conc 16 3.76
End of Run!!!!
&Input Next= 6 &