William J. Cahill, Jr.
Vice President

Central Files

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January 20, 1977

Mr. James P. O'Reilly, Director
Region 1
Office of Inspection
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Mr. O'Reilly:

On October 19, 1976, Con Edison submitted a technical report concerning an extremity exposure event which occurred on May 24, 1976 during the replacement of the fixed incore detectors at Indian Point Unit No. 2. This incident has been reanalyzed using Monte Carlo shielding techniques and detailed activation analyses. The enclosed technical report describes the methods and techniques used in this reanalysis.

Should you have any questions or wish to discuss this matter further, please call me.

Very truly yours,

William J. Cahill, Jr.

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Vice President

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EXTREMITY EXPOSURE INCIDENT DURING FIXED THIMBLE REMOVAL PROCESS - DOSE ESTIMATION USING MONTE CARLO TECHNIQUES AND DETAILED ACTIVATION ANALYSES

Summary

By letter dated October 19, 1976, Con Edison reported to the NRC, based on point kernel type shielding calculations and conservative activation analysis, that the extremity exposure incident of May 24, 1976 resulted in an estimated (gamma) radiation dose of some 7.5-9 rem to the hand of the exposed individual. Because of the inability of point kernel type methods to accurately predict gamma fluxes at distances close to the source, and the consequent uncertainty associated with use of this technique, a reanalysis of this incident was performed utilizing Monte Carlo techniques. In addition, activation analyses were performed using the Oak Ridge National Laboratory (ORNL) code ORIGEN, to estimate, as accurately as possible, the actual activation source strength of the thimble.

The (gamma) radiation dose estimated by these calculations is 10.8 rem to the hand.

Introduction

Monte Carlo calculations were selected for calculating the radiation dose per source photon because of the "exact" nature of the solution provided and the ability of this technique to consider the actual geometrical configuration of the situation. These calculations were performed for Con Edison by Mathematical Applications Group, Inc. (MAGI); a copy of the report submitted by MAGI to Con Edison is attached as Appendix 1. Source term recalculation was performed subsequent to the Monte Carlo calculations; consequently, the MAGI report presents estimation of dose on a per source photon basis by energy in addition to an estimate of the dose based on the preliminary, overly conservative source strength previously used.

The ORIGEN Code was selected for use in the activation calculations because of the suitability of this code for treating the highly time dependent irradiation history of an operating reactor and the separate presentation by source (i.e., fission products, materials of construction, or actinides) of the generated nuclides. Thus, the concentration of isotopes produced by activation of a stainless steel thimble can be listed separately from those pro-

duced in fission and directly retrieved for use in estimating gamma source strengths.

Discussion

Appendix 1 describes the model and techniques used by MAGI to perform the Monte Carlo calculations. A further description of the use of and inputs to the ORIGEN code will be presented in the section together with the details of the results obtained by merging the Monte Carlo and ORIGEN results.

A. Irradiation History

The power operating history of the Indian Point Unit No. 2 reactor was compiled from the Unit No. 2 monthly operating reports from initial power operation in 1973 to March 30, 1976, the date of shutdown for refueling. Total MWth-hrs produced during the different months were divided by the number of hours the generator was on line to obtain the average power level in thermal megawatts during the period under consideration. Offline days during an interval were considered as occurring during their actual dates, or, where more convenient, at the start of the subject interval. Outages of less than five days were not considered. Table I presents the results of this compilation, which can be seen to consist of thirty irradiation (or outage) intervals.

For purposes of providing input to ORIGEN, power levels during each interval were divided by the total charge of Uranium (87.13 metric tons) to obtain the specific power in MWth/MTU. Specific powers (in MWt/MTU) for each of the 30 intervals and the duration of each interval were provided as input to ORIGEN.

B. Materials of Thimble and Fuel

For simplicity, the material considered to be subject to activation by irradiation was the volume of a single twelve foot (= fuel stack height) length of thimble. The activity of the thimble, as calculated by ORIGEN, was divided by six to obtain the activity of a single two foot length.

Table II presents, by region, data taken from WCAP-8141 for the initial Indian Point Unit No. 2 fuel loading. These data were converted for each Uranium isotope from kg to gm-atoms per MTU and used as input to ORIGEN.

ORIGEN was used to compute the radioactivity of the irradiated thimble for the fuel composition and irradiation history outlined herein. Postirradiation properties were also computed for a decay time of 54 days after shutdown, which is when the incident occurred. Table III is a copy of part of the output of ORIGEN for the case under consideration. This table presents by isotope the activity of one twelve foot thimble length at shutdown and at times of 5.0 and 54.0 days after shutdown.

C. Calculation of Radiation Dose

Table 3 of Appendix 1 presents uncollided and total (i.e., buildup) doses in rad/hr per source γ/sec for the principal photon energies encountered. Since the relationship between dose and source γ-energy is approximately linear for the case under consideration (see Figure 2 of Appendix 1), dose rates per source γ for other energies were obtained by simple linear interpolation.

Table IV details the calculations used in arriving at a source term, S, in γ/sec for the two foot thimble length.

Table V tabulates the intermediate calculations performed to merge the ORIGEN predicted source strengths with the Monte Carlo computation of dose per source photon and arrive at the total (gamma) dose to the hand. It should be noted that all isotopes having less than 0.01 Curie in the 2 foot thimble length were neglected, since they do not contribute significantly to the radiation dose received. For the same reason, the 0.143 MEV gamma emitted by Fe-59 and the 0.23 MEV (max) internal bremsstrahlung spectrum emitted by Fe-55 were also neglected. For the average burnup assembly (16,387 MWD/MTU) these calculations indicate a gamma dose of 9.64 Rem. Since burnup in the fuel assembly (E-11) containing the thimble was somewhat higher (18,340 MWD/MTU) than the core average, the estimated gamma dose to the hand, after correction for burnup, is 10.8 Rem.

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LOCATION INDIAN POINT UNIT 2.

SUBJECT

TABLE I

SUMMARY OF I.P.2 POWER OPERATING HISTORY 1973-1974

PERIOD	GROSS MWt-hr	# HRS. ON OR OFF LINE	# DAYS ON OR OFF LINE	$\bar{P}$ (MWt)	$\bar{P}$ MTU	INTERVAL #
12/11-12/13/73	1,473,000	772	32.17	1908	21.90	1
12/13-12/31	0	1152	128	0	0	2
1/1/74-3/21/74	0	1920		0	0	
3/22-3/31	280,410	220.25	9.18	1273	14.61	3
4/1-4/10	0	240	10	0	0	4
4/11-4/30	818,226	441.	18.38	1855.	21.29	5
5/1-5/10	0	240	10	0	0	6
5/11-5/31	726,684	412.75	17.20	1760.6	20.2	7
6/1-6/30	1,312,800	595.4	24.81	2205	25.31	8
7/1-7/6	0	144	6.0	0	0	9
7/7-7/31	1,316,545	552.75	23.03	2382	27.34	10
8/1-8/6	0	144.	6.0	0	0	11
8/7-8/31	1,230,534	552.5	23.02	2227.2	25.56	12
9/1-9/30	1,235,348	580.	24.17	2130	24.45	13
10/1-10/11	0	264.	11.	0	0	14
10/12-10/31	1,279,567	480.8	20.03	2661.	30.54	15
11/1-11/30	1,427,937	630.3	26.26	2265.	26.00	16
12/1-12/31	1,790,241	689.3	↓	2597	29.81	17
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LOCATION INDIAN POINT UNIT 2.

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TABLE I

SUMMARY OF I.P.2 POWER OPERATING HISTORY 1975

PERIOD	GROSS MWt-hr	# HRS ON OR OFF LINE	# DAYS ON OR OFF LINE	P MWt	P/MTU	INTERVAL #
1/1-1/31/75	1,518,806	584.8	78.79	2597	29.81	17
2/1-2/28	1,603,340	616.7		2600	29.84	
3/1-3/31	0	744.	36.0	0	0	18
4/1-4/5	0	120.		0	0	
4/6-4/30	1,355,952	568.75	23.70	2384	27.36	19
5/1-5/31	1,816,468	683.17	56.97	2659	30.52	20
6/1-6/30	1,824,902	684.05		2668	30.62	
7/1-7/28	1,641,458	628.2	26.18	2613	29.99	21
7/29-8/10	0	312.	13.	0	0	22
8/11-8/31	975,631	403.5	16.81	2418	27.75	23
9/1-9/30	1,459,784	651.47	27.14	2241.	25.72	24
10/1-10/14	0	336	14	0	0	25
10/15-10/31	905,306	372.53	15.52	2430	27.89	26
11/1-11/30	1,509,221	643.83	26.83	2344	26.90	27
12/1-12/31	1,840,706	713.43	29.73	2580.	29.61	28

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DATE 1/29/76

LOCATION INDIAN POINT UNIT 2.

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SUMMARY OF I.P.2 POWER OPERATING HISTORY
1976

PERIOD	GROSS MWt-hr	# HRS ON OR OFF LINE	# DAYS ON OR OFF LINE	$\bar{P}$ MWt	$\bar{P}$ MTU	INTERVAL #
1/1/76-1/30/76	1,588,771	621.83	49.02	2555	29.32	29
1/1-2/29	1,471,081	576.25		2553	29.30	
1/1-3/30	1,865,758	689.25	28.72	2707	31.07	30

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LOCATION INDIAN POINT UNIT TWO

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TABLE II

INDIAN POINT UNIT 2 INITIAL FUEL LOADING

Region	Loading (MTU)		w/o ^{235}U	Kg/MTU U-234	MT U-234	Kg/MTU U-235	Kg U-235	Kg/MTU U-236	MT U-236	Kg/MTU U-238	MT U-238
1	29.58		2.21	0.12	3.55×10^{-3}	22.12	654.31	0.17	5.03×10^{-3}	977.59	28.92
2	28.82		2.80	0.20	5.76×10^{-3}	28.00	806.96	0.15	4.32×10^{-3}	971.64	28.00
3	28.73		3.30	0.30	8.62×10^{-3}	33.00	948.09	0.21	6.03×10^{-3}	966.48	27.77
Total	87.13	MTU			17.93×10^{-3}		2.41		15.38×10^{-3}		84.69

TABLE III

1.P.2 STAINLESS STEEL THIMBLES - POSTIRRADIATION DECAY TIMES

POWER= 25.58MW, BURNUP= 16367.MWD, FLUX= 2.64E+13N/CM**2-SEC

NUCLIDE RADIOACTIVITY, CURIES
BASIS = VOLUME OF ONE TWELVE FOOT THIMBLE LENGTH

	INITIAL	5. D	5~. D
H 1	0.0	0.0	0.0
H 2	0.0	0.0	0.0
H 3	5.13E-10	5.12E-10	5.08E-10
H 4	0.0	0.0	0.0
HE 3	0.0	0.0	0.0
HE 4	0.0	0.0	0.0
HE 6	0.0	0.0	0.0
LI 6	0.0	0.0	0.0
LI 7	0.0	0.0	0.0
LI 8	0.0	0.0	0.0
BE 8	0.0	0.0	0.0
BE 9	0.0	0.0	0.0
BE 10	0.0	0.0	0.0
BE 11	0.0	0.0	0.0
B 10	0.0	0.0	0.0
B 11	0.0	0.0	0.0
B 12	0.0	0.0	0.0
C 12	0.0	0.0	0.0
C 13	0.0	0.0	0.0
C 14	0.0	0.0	0.0
N 13	0.0	0.0	0.0
N 14	0.0	0.0	0.0
N 15	0.0	0.0	0.0
N 16	0.0	0.0	0.0
O 16	0.0	0.0	0.0
O 17	0.0	0.0	0.0
O 18	0.0	0.0	0.0
O 19	0.0	0.0	0.0
F 19	0.0	0.0	0.0
F 20	0.0	0.0	0.0
NE 20	0.0	0.0	0.0
NE 21	0.0	0.0	0.0
NE 22	0.0	0.0	0.0
NE 23	0.0	0.0	0.0
NA 22	0.0	0.0	0.0
NA 23	0.0	0.0	0.0
NA 24	0.0	0.0	0.0
NA 25	0.0	0.0	0.0
MG 24	0.0	0.0	0.0
MG 25	0.0	0.0	0.0
MG 26	0.0	0.0	0.0
MG 27	0.0	0.0	0.0
AL 27	0.0	0.0	0.0
AL 28	0.0	0.0	0.0
AL 29	0.0	0.0	0.0
SI 28	0.0	0.0	0.0
SI 29	0.0	0.0	0.0
SI 30	0.0	0.0	0.0
SI 31	0.0	0.0	0.0
P 31	0.0	0.0	0.0
P 32	0.0	0.0	0.0
P 33	0.0	0.0	0.0

TABLE III

I.P.2 STAINLESS STEEL THIMBLES - POSTIRRADIATION DECAY TIMES

POWER= 25.58MW, BURNUP= 1o387.MWD, FLUX= 2.64E+13N/CM**2-SEC

NUCLIDE RADIOACTIVITY, CURIES
BASIS = VOLUME OF ONE TWELVE FOOT THIMBLE LENGTH

	INITIAL	5. D	54. D
P 32	0.0	0.0	0.0
S 32	0.0	0.0	0.0
S 33	0.0	0.0	0.0
S 34	0.0	0.0	0.0
S 35	0.0	0.0	0.0
S 36	0.0	0.0	0.0
S 37	0.0	0.0	0.0
CL 35	0.0	0.0	0.0
CL 36	0.0	0.0	0.0
CL 37	0.0	0.0	0.0
[redacted] 38	0.0	0.0	0.0
AR 36	0.0	0.0	0.0
AR 37	0.0	0.0	0.0
AR 38	0.0	0.0	0.0
AR 39	0.0	0.0	0.0
AR 40	0.0	0.0	0.0
AR 41	7.93E-14	1.44E-33	0.0
K 39	0.0	0.0	0.0
K 40	0.0	0.0	0.0
K 41	0.0	0.0	0.0
K 42	2.57E-17	-1.47E-17	0.0
K 43	8.21E-22	8.21E-22	1.29E-37
K 44	1.81E-13	0.0	0.0
CA 40	0.0	0.0	0.0
CA 41	0.0	0.0	0.0
CA 42	0.0	0.0	0.0
CA 43	0.0	0.0	0.0
CA 44	0.0	0.0	0.0
CA 45	1.10E-12	1.08E-12	8.76E-13
CA 46	0.0	0.0	0.0
CA 47	1.28E-09	5.94E-10	3.29E-13
[redacted] 48	0.0	0.0	0.0
[redacted] 49	0.0	0.0	0.0
SC 48	0.0	0.0	0.0
SC 46	4.63E-15	4.49E-15	2.99E-15
SC 47	6.43E-06	2.35E-06	1.19E-10
SC 48	8.02E-06	1.21E-06	1.05E-14
SC 49	1.50E-06	0.0	0.0
SC 50	1.52E-07	0.0	0.0
TI 46	0.0	0.0	0.0
TI 47	0.0	0.0	0.0
TI 48	0.0	0.0	0.0
TI 49	0.0	0.0	0.0
TI 50	0.0	0.0	0.0
TI 51	4.83E-03	0.0	0.0
V 49	0.0	0.0	0.0
V 50	0.0	0.0	0.0
V 51	0.0	0.0	0.0
V 52	6.08E+00	0.0	0.0
V 53	3.60E-02	0.0	0.0
V 54	3.88E-04	0.0	0.0
CR 50	0.0	0.0	0.0

TABLE III

I.P.2 STAINLESS STEEL THIMBLES - POSTIRRADIATION DECAY TIMES

POWER= 25.58MW, BURNUP= 1o387.MWD, FLUX= 2.34E+13N/CM**2-SEC

NUCLIDE RADIOACTIVITY, CURIES
BASIS = VOLUME OF ONE TWELVE FOOT THIMBLE LENGTH

	INITIAL	5. D	54. D
CR 51	8.37E+02	7.39E+02	2.18E+02
CR 52	0.0	0.0	0.0
CR 53	0.0	0.0	0.0
CR 54	0.0	0.0	0.0
CR 55	1.17E+01	0.0	0.0
MN 54	3.40E+01	3.36E+01	3.00E+01
MN 55	0.0	0.0	0.0
MN 56	1.97E+01	1.96E-13	0.0
MN 57	1.38E-01	0.0	0.0
MN 58	4.84E-04	0.0	0.0
FE 54	0.0	0.0	0.0
FE 55	2.28E+02	2.27E+02	2.19E+02
FE 56	0.0	0.0	0.0
FE 57	0.0	0.0	0.0
FE 58	0.0	0.0	0.0
FE 59	2.53E+01	2.34E+01	1.10E+01
CO 58M	0.0	0.0	0.0
CO 58	1.08E+02	1.03E+02	6.40E+01
CO 59	0.0	0.0	0.0
CO 60M	1.33E+02	0.0	0.0
CO 60	4.16E+01	4.15E+01	4.08E+01
CO 61	1.23E+00	0.0	0.0
CO 62	8.00E-03	0.0	0.0
NI 58	0.0	0.0	0.0
NI 59	2.54E-02	2.54E-02	2.54E-02
NI 60	0.0	0.0	0.0
NI 61	0.0	0.0	0.0
NI 62	0.0	0.0	0.0
NI 63	4.01E+00	4.01E+00	4.01E+00
NI 64	0.0	0.0	0.0
NI 65	1.13E+01	8.77E-14	0.0
CU 62	0.0	0.0	0.0
CU 63	0.0	0.0	0.0
CU 64	1.63E-02	2.41E-05	0.0
CU 65	0.0	0.0	0.0
CU 66	3.64E-02	0.0	0.0
ZN 63	0.0	0.0	0.0
ZN 64	0.0	0.0	0.0
ZN 65	5.38E-07	5.30E-07	4.62E-07
ZN 66	0.0	0.0	0.0
ZN 67	0.0	0.0	0.0
ZN 68	0.0	0.0	0.0
ZN 69M	0.0	0.0	0.0
ZN 69	0.0	0.0	0.0
ZN 70	0.0	0.0	0.0
ZN 71M	0.0	0.0	0.0
ZN 71	0.0	0.0	0.0
GA 69	0.0	0.0	0.0
GA 70	0.0	0.0	0.0
GA 71	0.0	0.0	0.0
GE 70	0.0	0.0	0.0
SR 88	0.0	0.0	0.0

TABLE IV

I.P.2 STAINLESS STEEL THIMBLES - POSTIRRADIATION DECAY TIMES

POWER= 25.58MW, BURNUP= 16387.MWD, FLUX= 2.64E+13N/CM**2-SEC

NUCLIDE RADIOACTIVITY, CURIES
BASIS = VOLUME OF ONE TWELVE FOOT THIMBLE LENGTH

	INITIAL	5. D	54. D
SR 89	0.0	0.0	0.0
SR 90	0.0	0.0	0.0
SR 91	0.0	0.0	0.0
Y 90M	0.0	0.0	0.0
Y 90	0.0	0.0	0.0
Y 91M	0.0	0.0	0.0
Y 91	0.0	0.0	0.0
ZR 90	0.0	0.0	0.0
ZR 91	0.0	0.0	0.0
ZR 92	0.0	0.0	0.0
ZR 93	0.0	0.0	0.0
ZR 94	0.0	0.0	0.0
ZR 95	0.0	0.0	0.0
ZR 96	0.0	0.0	0.0
NB 92	0.0	0.0	0.0
NB 93M	0.0	0.0	0.0
NB 95	0.0	0.0	0.0
NB 94	0.0	0.0	0.0
NB 95	0.0	0.0	0.0
NB 96	0.0	0.0	0.0
NB 97	0.0	0.0	0.0
MO 92	0.0	0.0	0.0
MO 93	0.0	0.0	0.0
MO 93M	0.0	0.0	0.0
MO 94	0.0	0.0	0.0
MO 95	0.0	0.0	0.0
MO 96	0.0	0.0	0.0
MO 97	0.0	0.0	0.0
MO 98	0.0	0.0	0.0
MO 99	0.0	0.0	0.0
MO100	0.0	0.0	0.0
MO101	0.0	0.0	0.0
TC 99M	0.0	0.0	0.0
TC 99	0.0	0.0	0.0
TC101	0.0	0.0	0.0
RU101	0.0	0.0	0.0
CD113M	0.0	0.0	0.0
CD113	0.0	0.0	0.0
CD115M	0.0	0.0	0.0
CD115	0.0	0.0	0.0
CD119M	0.0	0.0	0.0
CD119	0.0	0.0	0.0
CD121	0.0	0.0	0.0
IN113	0.0	0.0	0.0
IN119M	0.0	0.0	0.0
IN119	0.0	0.0	0.0
IN121M	0.0	0.0	0.0
IN121	0.0	0.0	0.0
SN114	0.0	0.0	0.0
SN115	0.0	0.0	0.0
SN116	0.0	0.0	0.0
SN117M	0.0	0.0	0.0

TABLE III

..P.2 STAINLESS STEEL THIMBLES - POSTIRRADIATION DECAY TIMES

POWER= 25.58MW, BURNUP= 16387.MWD, FLUX= 2.64E+13N/CM**2-SEC

NUCLIDE RADIOACTIVITY, CURIES
BASIS = VOLUME OF ONE TWELVE FOOT THIMBLE LENGTH

	INITIAL	5. D	54. D
SN117	0.0	0.0	0.0
SN118	0.0	0.0	0.0
SN118M	0.0	0.0	0.0
SN119	0.0	0.0	0.0
SN120	0.0	0.0	0.0
SN121M	0.0	0.0	0.0
SN121	0.0	0.0	0.0
SN122	0.0	0.0	0.0
SN123M	0.0	0.0	0.0
SN123	0.0	0.0	0.0
SN124	0.0	0.0	0.0
SN125M	0.0	0.0	0.0
SN125	0.0	0.0	0.0
SB121	0.0	0.0	0.0
SB123	0.0	0.0	0.0
SB124M	0.0	0.0	0.0
SB124	0.0	0.0	0.0
SB125	0.0	0.0	0.0
SB126M	0.0	0.0	0.0
SB126	0.0	0.0	0.0
TE124	0.0	0.0	0.0
TE125M	0.0	0.0	0.0
TE125	0.0	0.0	0.0
TE126	0.0	0.0	0.0
TA180	0.0	0.0	0.0
TA181	0.0	0.0	0.0
TA182M	0.0	0.0	0.0
TA182	0.0	0.0	0.0
W180	0.0	0.0	0.0
W181	0.0	0.0	0.0
W182	0.0	0.0	0.0
W183M	0.0	0.0	0.0
W183	0.0	0.0	0.0
W184	0.0	0.0	0.0
W185M	0.0	0.0	0.0
W185	0.0	0.0	0.0
W186	0.0	0.0	0.0
W187	0.0	0.0	0.0
TOTAL	1.46E+03	1.17E+03	5.87E+02

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LOCATION INDIAN POINT UNIT 2.

TABLE IV

SOURCE TERM CALCULATIONS USING ORIGEN ACTIVITY ESTIMATES

NUCLIDE	Ci/12'	Ci/2'	E_γ (MEV/γ)	f (γ/dis)	A (dis/sec)	S (γ/sec)
Cr-51	218.	36.33	0.32	0.09	1.34×10^{12}	1.21×10^{11}
Mn-54	30.0	5.0	0.835	1.0	1.85×10^{11}	1.85×10^{11}
Fe-59	11.0	1.83	0.192	0.028	6.77×10^{10}	1.90×10^{9}
	↓	↓	1.095	0.56	↓	3.79×10^{10}
	↓	↓	1.292	0.44	↓	2.98×10^{10}
Co-58	64.0	10.67	0.511	0.30	3.95×10^{11}	1.19×10^{11}
	↓	↓	0.810	0.99	↓	3.91×10^{11}
	↓	↓	0.865	0.014	↓	5.53×10^{9}
	↓	↓	1.67	0.006	↓	2.37×10^{9}
Co-60	40.8	6.8	1.172	1.0	2.52×10^{11}	2.52×10^{11}
	↓	↓	1.332	1.0	↓	2.52×10^{11}
Ni-63	4.01	0.668	No γ	No γ	2.47×10^{10}	No γ

DATA SHEET

DATE 1/10/77

LOCATION INDIAN POINT UNIT 2.

PREPARED BY

SUBJECT

TABLE V

DOSE ESTIMATION FROM MERGER OF MONTE CARLO AND ORIGEN RESULTS

NUCLIDE	E_γ (MEV/γ)	S * (γ/SEC)	C (R/HR / γ/SEC) **	D_H (R/HR)	D_S (R/10 sec)
Cr-51	0.32	1.21×10^{11}	8.38×10^{-10}	101.40	0.282
Mn-54	0.835	1.85×10^{11}	2.26×10^{-9}	418.10	1.16
Fe-59	0.192	1.90×10^{9}	4.8×10^{-10}	0.912	2.53×10^{-3}
	1.095	3.79×10^{10}	2.91×10^{-9}	110.29	0.306
	1.292	2.98×10^{10}	3.42×10^{-9}	101.92	0.283
Co-58	0.511	1.19×10^{11}	1.44×10^{-9}	171.36	0.476
	0.810	3.91×10^{11}	2.20×10^{-9}	860.20	2.389
	0.865	5.53×10^{9}	2.23×10^{-9}	12.33	0.034
	1.67	2.37×10^{9}	4.32×10^{-9}	10.24	0.028
Co-60	1.172	2.52×10^{11}	3.07×10^{-9}	773.64	2.149
	1.332	2.52×10^{11}	3.62×10^{-9}	912.24	2.534
Totals				3472.6 R/HR	9.64 R/10 sec

Burnup Correction:

$D_S = 9.64 * \frac{18,340}{16,387} \Rightarrow D_S = 10.8$ Rem

* Derived from ORIGEN Computation (see Table IV)

** Results of Monte Carlo Computation (see Table 3 of MAGI Report)

APPENDIX 1

MATHEMATICAL APPLICATIONS GROUP, INC.
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December 29, 1976
M-8276
P-7145

Mr. Kenneth Eccleston
Nuclear Engineering Subsection
Nuclear and Emission Control
Engineering Department
Consolidated Edison Co. of N. Y., Inc.
4 Irving Place
New York, N. Y. 10003

Dear Mr. Eccleston:

Enclosed please find the final report summarizing the calculational program performed by MAGI under Consolidated Edison Company purchase order #6-8208.

Please contact me if there are any questions concerning the report or if I can be of further assistance.

Very truly yours,

Martin O. Cohen

Martin O. Cohen
Manager
Nuclear Applications

MOC/ae
Enc.