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LAWRENCE RADIATION LABORATORY
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TECHNICAL INFORMATION DIVISION
LIVERMORE

AT(30-1)-2789
~~CNLM-5326, Suppl. 1~~
November 15, 1963

To: J. W. Walton

From: J. R. Smolen

Subject: Activation of Electrical Machinery

cc: W. G. Alwang
C. C. Bigelow
E. R. Dytko
G. N. Frazier
H. C. Gray
R. W. Kelly
W. G. Kennedy
H. J. Richings
E. A. Thomas
N. J. Works

Unclassified — Classification
Eric V. Sandin Jr. — Authorized Classifier
11/19/63 — Date

The following information is submitted in response to your request for an analysis of the induced radioactivity in SNAP-50/SPUR electrical machinery having a high cobalt content.

Induced radioactivity in the flight vehicle will contribute negligibly to allowable radiation levels. This is especially so due to the low neutron to gamma ratio of assumed radiation damage tolerances to semiconductors. A calculation to estimate the order of magnitude of induced radioactivity in cobalt is attached. The calculation is based on a best guess of the neutron spectrum directly behind a lithium hydride shield. The spectral energy distribution, Table 1 attached, is based on a 16 group DSN calculation which is known to give poor results for deep shield penetrations. The magnitude of the flux spectrum is scaled to a 10,000 hr integrated flux of 7×10^{14} nvt above 17 Kev at 5 ft from the center of the shielded reactor. This corresponds to 1×10^{13} nvt above 17 Kev at 42 ft by inverse square of distance. The resulting low cobalt activity and associated dose rate of about 1 mr/hr at 10 ft from a generator or a motor is insignificant.

Although the above evaluation indicates insignificant levels of induced radioactivity, this conclusion is not applicable to a ground test. Neutron moderation and scattering from a containment vessel and biological shield would greatly perturb the neutron environment behind the flight shield. Post-test handling of all components within the vacuum test chamber will undoubtedly be a problem. However, a realistic evaluation, at an early date, of the magnitude of handling problems is not feasible and is in fact beyond our present manpower and methods capabilities. A two dimensional neutron transport code (TDC) which would be a useful tool for this analysis has in recent evaluations been demonstrated to give erroneous results. This problem with TDC is being evaluated. Aside from the problems of methods development there are several factors which would greatly affect the magnitude of induced radioactivity. Some factors of significant importance are:

1) the physical layout, 2) the composition of materials comprising the containment vessel and biological shield, and 3) structure required to provide

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the thermal characteristics of space. Notwithstanding the importance of limiting induced radioactivity, other considerations such as economy, cooling and vacuum requirements will largely dictate the final facility design.

In summary, an activation analysis involves the overall facility design and will not be readily resolved. For a 10,000 hr. test the Co^{60} activity may range from 100 curies per lb of cobalt where no shielding is provided to 10^{-3} curies per lb of cobalt where the equivalent of a flight shield is provided.

J. R. Smolen

JRS:jh

Calculation:

Table 1

Neutron Flux Spectrum and Cobalt Activation Cross Sections

Gp	Energy Range	nv/gp (neutrons/cm^2-sec)	$\sigma_{n,\gamma}$ (barns)	nv x σ
1	3 - ∞ Mev	4×10^6	1.0×10^{-2}	0.4×10^5
2	1.4 - 3	6	0.5	0.3
3	0.9 - 1.4	2	0.5	0.1
4	0.4 - 0.9	3	0.5	0.15
5	0.1 - 0.4	2	0.8	0.16
6	17 - 100 Kev	2	1.0	0.2
7	3 - 17	1	4.0	0.4
8	0.55 - 3	1	1.0	0.1
9	100 - 550 ev	1	38×10^0	380.
10	30 - 100	7×10^5	0.7	4.9
11	10 - 30	5	1.3	6.5
12	3 - 10	4	2.3	9.2
13	1 - 3	2	4.0	8.0
14	0.4 - 1	1	6.7	6.7
15	0.1 - 0.4	6×10^4	11.8	7.1
16	Thermal (0.025 ev)	1×10^4	33.5	3.4
				$428. \times 10^5$

Co^{60} activity following 10,000 hrs of irradiation:

$$A = \frac{N_0 \, nv \, \sigma \, (1 - e^{-\lambda T})}{59 \times 3.7 \times 10^{10}} \cong \frac{N_0 \, nv \, \sigma \, \lambda T}{59 \times 3.7 \times 10^{10}}$$

$$= \frac{0.602 \times 4.28 \times 10^7}{59 \times 3.7 \times 10^{10}} \times \frac{0.693 \times 10^4}{5.3 \times 365 \times 24}$$

$$= 1.8 \times 10^{-6} \text{ curies/gm of cobalt}$$

$$= 8 \times 10^{-4} \text{ curies/lb of cobalt}$$

Dose rate at 10 ft per lb of irradiated cobalt - an overestimate by neglecting self absorption by the source:

$$D\ (10\ \text{ft}) = \frac{6\ C\ E}{10^2}$$

$$= \frac{6 \times 8 \times 10^{-4}\ (1.17 + 1.33)}{10^2}$$

$$= 1.2 \times 10^{-4}\ \text{r/hr per lb of cobalt}$$

Dose rate from 115 lbs of Hyperco (27 wt % cobalt) in one generator:

$$D\ (\text{generator}) = 1.2 \times 10^{-4} \times 115 \times 0.27$$

$$= 4 \times 10^{-3}\ \text{r/hr at 10 ft}$$

Dose rate from 9 lbs of NIVCO 10 (73.5 wt % cobalt) in one rotor:

$$D\ (\text{rotor}) = 1.2 \times 10^{-4} \times 9 \times 0.74$$

$$= 0.8 \times 10^{-3}\ \text{r/hr at 10 ft}$$

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