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Subject Reuse of Beryllium Reflectors

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WANL-TMI-1694

REUSE OF BERYLLIUM REFLECTORS

Over the history of the NERVA project, the question of reuse of beryllium reflectors has been raised with the intent of achieving a significant cost savings. Two major factors which effect the reusability of reflector assemblies are: changes in reflector mechanical design between reactors, and induced radioactivity in the impurities in the beryllium.

Several analyses performed since May of 1962 (WANL-TMI-110) through November 1965 (1-4) have shown repeatedly that reuse of present commercially available beryllium is impractical after 5 minutes full power exposures. In special cases where the reactor run time will be less than 10 minutes, reuse of presently available grades of Be may be contemplated with approximately 12 mo. decay of radioactivity allowed.

A review of experimental data and repeated analytical evaluations of the dose rate from a beryllium reflector reconfirms^(1,2) that neither chemically processed nor normal electrolytically processed beryllium will have a dose rate low enough to allow cold reassembly within 12 months after a 4×10^6 MW-sec exposure. This is based on an assumed acceptable dose rate of 100 mr/hr and 10 mr/hr at the surface and at one meter from the surface, respectively.

However, reuse may be achieved as a result of:

- 1) Shorter reactor runs (of the order of 10 min - 6.6×10^5 MW-sec or less for high purity Be, and 2.5 min. - 1.7×10^5 MW-sec or less for standard BeO.)
- 2) Using higher purity Be than presently available commercially
- 3) Remote handling, use of partial shields, or working in a radiation field of from 30 mr/hr to over 2 R/hr at one meter (surface 10 times higher).

A dose rate of 10 mr/hr was chosen for limited access. This level meets the AEC shipping requirements and will allow about 30 hours of work per man per week at an average distance of one meter from the surface of the assembly without exceeding the quarter yearly limit of 3.9R (≈ 300 mr/week).

The impurities found in previous samples of Be which determined long lived activity are presented in tables 1 and 2 with vendor maximum specified concentrations. The tables also include recommended concentrations for an "extra high purity" Be necessary to allow reassembly with a minimum of safety precautions following a 4×10^6 MW-sec. exposure and 3 month decay. These concentrations which are below the 1 ppm level for Sc, Cs, Co and Ta, were chosen somewhat arbitrarily to meet the 10 mr/hr at 1 meter criteria. One or more element could be increased by selectively decreasing the others. However, none of the above

could be increased appreciably above 1 ppm without exceeding 10 mr/hr.

Dose rate measurements made on the NRX-A2 and A3 reflectors were higher than predicted^(1,3), even though the predictions assumed maximum concentrations of each important reported impurity. This difference is believed to be due primarily to the ^eexistence of a higher neutron flux than the average values used in the predictions.⁴ The decay of activity from samples of chemically (standard) and electrolytically (high purity) processed Be followed the predicted shape reasonably well.

Figures 1 and 2 show the expected dose rate from a reflector assembly for three grades of Be. If the rule of 10 mr/hr at one meter is used, one can determine at what exposure either grade of Be can be reused. It should be noted that actual reactor run times have, in several instances, been greater than that anticipated when the reflector material was purchased or when the reactor was shipped for hot testing. Therefore, the purchase of electrolytically processed Be for a small gain in purity could prove disappointing.

It should be recognized that any given Be sample or batch will have impurity concentrations somewhat different from those used in this and previous analyses. These differences could cause the resulting activation to be higher or lower than predicted. For example, scandium

concentrations have been found to be as high as 30 ppm, versus 3 ppm given by two vendors as the upper limit.

The activity of the reflector is very dependent on the neutron flux in the region. Some preliminary activity measurements indicate that the flux magnitude and distribution may produce activation twice as high as that predicted.

In many experimental analyses, the recognition of the importance of several impurities have been underestimated or overlooked. This has been caused by scandium masking in dose rate measurements and overlapping of characteristic energies of several activants in gamma ray spectrum analysis. When the scandium concentration is high, the characteristic decay of the Be impurities appears to be almost all Sc, until after a decay of one year. One will then find that the very slight error in estimating the decay half life from dose rate measurements, which frequently are not consistent nor exact, is due to previously masked long life isotopes. In multi-channel gamma ray spectra analysis, care must be taken to resolve the 1.11, 1.12, and 1.17 Mev Zn, Sc and Co, respective emissions, the 0.80 and 0.81 and 0.84 Mev Cs, Co and Mn, respective emissions, and 0.88 and 0.89 Mev Ag and Sc emissions. Misleading conclusions may therefore be drawn if one does not guard against these and other hidden factors.

REFERENCES:

1. WANL-TMI-110, "Be Reflector Activity", L. O. Ricks, 5/19/62.
2. RA-2569, "NRX-A6 Reflector Reuse", H. C. Woodsum, 8/23/65.
3. RA-2644, "Effects of Impurities on Be Activation; an Analysis of NRX-A2 Data", H. C. Woodsum, 9/24/65.
4. RA-2697, "Compilation of NRX Be Reflectors Activity Measurements in Order to Predict NRX-A4 and NRX-A5 Activity Levels", L. Stephenson 11/4/65.

FIGURE 1

DOSE RATES AT ONE METER
 FROM UNSHIELDED REFLECTOR ASSEMBLY
 3-20 min Exposures 15 days Apart

LOGARITHMIC 359-120G
 KRUPP & ESSER CO. BOSTON, U.S.A.
 5 X 5 CYCLES

FIGURE 2

TABLE 1
BERYLLIUM LONG-LIVED ACTIVITY
4x10⁶ MW-sec Exposure
3 Month Decay

Contribution to Total Activity

<u>Element</u>	<u>Half Life</u>	<u>Standard Grade</u>		<u>High Purity</u>		<u>Extra High Purity</u>	
		<u>(PPM)</u>	<u>% Activity</u>	<u>(PPM)</u>	<u>% Activity</u>	<u>(PPM)</u>	<u>% Activity</u>
Scandium	84d	3	56.8	0.1	8.6	0.02	10.1
Cobalt	5.3d	5	11.9	2.	27.5	0.2	11.1
Cesium	2.2y	5	11.9	--		0.2	11.
Nickel	71d	400	6.0	250	8.2	10.	3.8
Silver	253d	10.	5.7	10.0	35.8	2.0	30.3
Zinc	245d	200	4.2	100	10.6	10	5.6
Iron	45d	1800	2.7	700	4.4	30	2.8
Chromium	28d	300	1.0	30.	1	30.	2.8
Tantalum	115d	0.5	1	--	1	0.2	24.1
Relative Activity		5		1		.19	
Approximate Dose Rate at 1 Meter (mr/hr)		250.		54.		10.	
Required shielding for 10 mr/hr (cm of Pb)		4.5		2.5		0	

TABLE 2

Beryllium Long-Lived Activity
 4×10^6 MW-sec Exposure
 12 Month Decay

Element	Half Life	Contribution to total Activity				Extra High Purity	
		Standard (PPM)	% Activity	High Purity (PPM)	% Activity	(PPM)	% Activity
					43.1	0.2	23.3
Cobalt	5.3y	5	31.3	2		0.2	20.2
Cesium	2.2y	5	27.6	--	1.8	0.02	2.2
Scandium	84d	3	19.1	0.1	40.9	2.0	35.2
Silver	253d	10	9.3	10.0	7.9	10	6.1
Zinc	245d	200	6.6	100	1.4	10	1
Nickel	71d	400	1.6	250	1	30	1
Iron	45d	1800	1	700	1	30.	1
Chromium	28d	300	1	30.	1	0.2	10.2
Tantalum	115d	0.5	1	--			
						0.15	
				1			
Relative Activity		3				4	
Approximate Dose Rate at 1 meter (mr/hr)		77		27		0	
Required shielding for 10 mr/hr (cm of Pb)		3		1.3			