N93-29630

CHARGED PARTICLE ACTIVATION STUDIES ON THE SURFACE OF LDEF SPACECRAFT

Ilhan Olmez
Massachusetts Institute of Technology
Nuclear Reactor Laboratory
138 Albany Street
Cambridge, MA 02139
Phone: 617/253-2995, Fax: 617/253-7300

Forest Burns and Paul Sagalyn
U.S. Army Materials Technology Laboratory
Watertown, MA 02172-0001
Phone: 617/923-5398, Fax: 617/923-5385

SUMMARY

High energy proton induced nuclear reaction products are examined using seven elements, namely, Aluminum, Silicon, Nickel, Copper, Zirconium, Tantalum, and Tungsten. The samples were in the form of plates, 2 x 2 x 1/8 inches. We detected activities due to ^{22}Na from Al, ^{56}Co and ^{57}Co from Ni, ^{58}Co from Cu, and ^{88}Y from Zr targets. No induced activity was observed in Si, Ta and W, most probably due to the long cooling times. Only the Zr sample contained a weak ^{7}Be peak, although Ta and W were also located at the leading edge of the spacecraft. Gamma-rays of individual isotopes were measured using high-resolution Ge(Li) solid state detector coupled to 4096-multichannel analyzer. Activities were calculated for ^{56}Co (846 keV) and Co-57 (122 and 136 keV's) at the time of the entry of the spacecraft and found to be 0.014 ± 0.005 c/sec. g, 0.018 ± 0.002 c/sec. g, and 0.0024 ± 0.0007 c/sec. g, respectively.

INTRODUCTION

A number of sample materials carried aboard the LDEF mission became weakly radioactive because of irradiation by high energy protons associated with the geomagnetically trapped, Van Allen radiation belt. Within the Van Allen belt, protons are present within an energy range of a few MeV up to about 700 MeV (ref. 1). In addition, radioactivity can be induced by irradiation from cosmic ray protons and heavier nuclei. These primary proton-material collisions may also produce secondary neutrons which in turn, could activate other materials.

In the present study, the activation product of interest was gamma radiation from radioactivities with half-lives of from 10's of days to a few years. Since the LDEF was in orbit for over 2000 days, it is expected that an induced activity will have reached equilibrium levels where any increase in the induced activity is offset by the decay process.

1. Watts, J. W., *LDEF Dose Predictions and Measurements,* LDEF Ionizing Radiation Special Investigation Group Meeting, NAIA/MSFC, July 1990.

PRECEDING PAGE BLANK NOT FILMED

RESULTS

Seven sample materials, Aluminum, Silicon, Nickel, Copper, Zirconium, Tantalum, and Tungsten, from the LDEF were analyzed for gamma emission by high resolution, high precision gamma ray spectroscopy techniques. The gamma ray spectroscopy equipment is based upon a Nuclear Data Corp. Genie 9900 system. Data acquisition, display, and processing are controlled by a DEC MicroVAX II computer. A Ge(Li) solid state detector was utilized to detect emitted gamma rays. The detector had an efficiency of approximately 20% with a resolution of approximately 1.9 keV (FWHM Co-1332 keV). The overall system operated as a 8192 multichannel analyzer. The gamma ray spectrum ranged from about 100 keV up to about 2 MeV.

Individual samples were counted for time periods ranging from 2 to 7 days. In all cases, samples were positioned about 2 cm away from the end cap of the detector. The detector-sample region was shielded with approximately 5 to 10 cm of lead.

Table I lists the target materials together with possible proton induced nuclear reactions, principal gamma ray emission line of the daughter radionuclide, half-life of the daughter radionuclide, and the relative position of the sample on the LDEF. As noted in the table, three samples, Si, Ta and W, exhibited no observable activity. This is probably due to the fact that only short half-life activities would have been produced with these elements.

For the four samples, Al, Ni, Cu, and Zr, which exhibited induced activities, Table II lists the calculated activities of these materials at the time of re-entry. These data confirm previous results with an additional ^{88}Y gamma emission from the Zr sample.

Also, the Zr sample exhibited a weak ^{7}Be peak at 477 keV. Since the exact shielding configuration of the LDEF is not known, it is not possible to make any conclusive statement as to the source of ^{7}Be. For instance, the ^{7}Be material could have occurred due to physical capture as the LDEF orbited at low altitude in the stratosphere. However, it should be noted that no ^{7}Be signatures were seen on the Ta or W samples although all three samples, Zr, Ta, and W, were located on the leading edge of the spacecraft.

Finally, the gamma ray spectroscopy results do not indicate any direct (n, γ) reactions. For example, no evidence for a ^{66}Cu (n, γ) or ^{67}Cu (n, γ) reaction was observed.

Table I. Target Materials

Target Material	Possible Induced Reaction	Gamma Energy (keV)	Half-Life	Location
Aluminum	^{27}Al (p, αd) ^{22}Na	1274	2.6y	Trailing Edge
Silicon	No Activity Observed			Earth End
Nickel	^{58}Ni (p, n2p) ^{56}Co	847	77.7d	Trailing Edge
	^{60}Ni (p, α) ^{57}Co	122	272d	Trailing Edge
		136		
Copper	^{63}Cu (p, αd) ^{58}Co	811	70.9d	Earth End
Zirconium	^{90}Zr (p, n2p) ^{88}Y	1836	107d	Leading Edge
Tantalum	No Activity Observed			Leading Edge
Tungsten	No Activity Observed			Leading Edge

Table II. Calculated Activities at Time of Re-Entry

Target Material	Elemental Constituent	Activity c/sec., gram
Nickel	^{58}Ni (846 keV)	0.014 $\pm$0.005
	^{60}Ni (122 keV)	0.018 $\pm$0.002
	(136 keV)	0.0024$\pm$0.0007