

## STATUS OF LDEF ACTIVATION MEASUREMENTS AND ARCHIVE

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## SUMMARY

We review the status of induced radioactivity measurements for the LDEF spacecraft which includes studies of the nuclide, target, directional and depth dependences of the activation. Analysis of the data has focused on extraction of the specific activities for many materials to develop a global picture of the low Earth orbital environment to which the LDEF was subjected. Preliminary comparisons of data in a previous review showed that it was possible to make meaningful intercomparisons between results obtained at different facilities (Harmon et al., 1993). Generally these comparisons were good and gave results to within 10-20%, although some analysis remains. These results clearly provide constraints for recent calculations being performed of the radiation environment of the LDEF (Armstrong and Colborn, 1993). We are now anticipating a period of production of final activation results. An archive is being prepared jointly between NASA/Marshall and Eastern Kentucky University which will include gamma ray spectra and other intermediate results.

## INTRODUCTION

The return of the Long Duration Exposure Facility has provided an extraordinary opportunity to investigate the radiation environment in low Earth orbit. The LDEF Ionizing Radiation Special Investigation Group has conducted, as part of a coordinated effort, an analysis of the induced radioactivity in materials in the spacecraft. This passive technique was particularly useful for LDEF because of the gravity-gradient stabilized configuration, which allowed the directional and depth dependences and the magnitude of the activation to be measured. The trends observed in the activation in a wide range of materials contain signatures of the anisotropic Van Allen trapped fluxes as well as the more energetic cosmic ray protons (Harmon et al. 1991, Armstrong and Colborn, 1991, 1993). More subtle components to the activation, fast secondary neutrons in metals such as iron and nickel, and thermal neutrons for samples in proximity to low-Z moderating materials are also observed (Harmon et al. 1993).

## MEASUREMENTS

Approximately 400 samples from the LDEF were counted at eight facilities: Westinghouse Savannah River Site, Lawrence Berkeley and Lawrence Livermore Laboratories, Tennessee Valley Authority Western Area Radiological Laboratory, Los Alamos National Laboratory, Battelle Pacific Northwest Laboratory, NASA/Johnson Space Center and NASA/Marshall Space Flight Center. Specific activity data are being collected and evaluated at Eastern Kentucky University and NASA/Marshall Space Flight Center. Preliminary results can be found in several conference presentations (Harmon et al. 1993; Reeves, et al. 1993; Smith and Hurley, 1991, Winn, 1991 and others ) on the extracted specific activities for aluminum and steel structural materials, and also vanadium, indium, cobalt, nickel and tantalum foils from different parts of the spacecraft and at various shielding depths. Comparisons of data in a previous review showed that it was possible to make meaningful intercomparisons between results obtained at different facilities (Harmon et al. 1993). Some data analysis remains however. Recent work has concentrated on the metal foils from experiments A0114, M0001, M0002 and P0004. Armstrong et al. 1994 compare High Energy Transport Code calculations to vanadium and nickel activation measurements using the anisotropic trapped radiation doses predicted by Watts et al. 1993. The overall results are consistent with contributions from trapped and cosmic ray proton-induced activation; however, the measured activities are larger than the calculated activities by about a factor of two. Corresponding differences in predicted to measured proton doses in thermoluminescent detectors have also been observed (Bourrieau, 1993; Frank, et al. 1993).

In order to investigate more carefully the dependences on incident proton energy, which reveals something of the mixing of trapped and cosmic ray protons, we are endeavoring to reduce the associated systematic errors of the activation measurements at different laboratories to at least the 30% level. For most material samples, we have achieved this level or better (10-20%), and hope to resolve discrepancies that remain. These measurements are among the most sensitive of any space-induced activation measurements, and already strongly constrain the calculations of the radiation environment.

## ARCHIVE

An archive of the induced radioactivity results is being constructed jointly by NASA/Marshall Space Flight Center and Eastern Kentucky University (Laird et al. 1993) which will consist of the LDEF induced radioactivity analysis plan and a final report to include specific activities measured for all materials. The final report would also include experimental details, efficiency and calibration measurements, and scoping calculations of the activities. The archive would also contain intermediate reports from counting facilities, sample inventory and run logs, and a set of gamma ray spectra from various counting facilities who participated in this study. Currently the archive contains gamma ray spectra from Savannah River, Lawrence Livermore, Battelle Northwest, and Marshall Space Flight Center. We also intend to archive spectra from the ultralow background facilities at Johnson Space Center and the Lawrence Berkeley Oroville Dam Facility.

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