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**GAMMA-RAY SPECTROMETRY OF LDEF SAMPLES (U)
RESULTS OF 1992 ANALYSES**

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SUMMARY

In January 1990, NASA retrieved the Long Duration Exposure Facility (LDEF), which had orbited the Earth since April 1984. The satellite had become slightly radioactive due to cosmic exposure, and NASA sought out low-level radiometric laboratories to provide ultra-sensitive analyses of samples from LDEF. The SRTC Environmental Technology Radiometrics Group was selected by NASA as such a laboratory; it received and analyzed LDEF samples during 1990-1992.

This report summarizes the results for 15 samples analyzed in 1992. (An earlier report has summarized the 1990-1991 results). The LDEF samples of aluminum and tantalum were quantified for particle induced activations of ^{22}Na , ^{172}Lu , and ^{173}Lu . In addition background steel trunnion samples, not irradiated in space, were analyzed for ^{60}Co , to establish whether earlier LDEF trunnion samples had significant levels of ^{60}Co .

The SRTC Underground Counting Facility was used in this work. The facility is 50 ft underground, constructed with low-background shielding materials, and operated as a clean room. The analyses were performed with a 90%-efficient HPGe gamma-ray detector, which is enclosed in a purged active/passive shield. Each LDEF sample was counted for 1 to 3 days in two orientations to yield more representative average activities for the sample.

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* Recent organizational changes have resulted in renaming the Savannah River Laboratory (SRTC) as the Savannah River Technology Center (SRTC).

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GAMMA-RAY SPECTROMETRY OF LDEF SAMPLES (U) RESULTS OF 1992 ANALYSES

I. INTRODUCTION

The Long Duration Exposure Facility (LDEF) was placed in orbit about 250 miles above the Earth by the Challenger space shuttle in April of 1984. As implied by its name, the LDEF was geared to study long-term radiation effects in near-Earth space¹. The results would be useful in the design of a future orbital space station. NASA had originally planned to retrieve the LDEF within a year; however, major obstacles, particularly those due to the Challenger disaster in 1986, delayed retrieval until January of 1990. Following this retrieval by the Columbia space shuttle, the LDEF was transported to Kennedy Space Center at Cape Canaveral, Florida.

Personnel at NASA Marshall Space Center initiated a program for radiometric analysis of the LDEF samples¹. Due to extensive experience in ultra-low-level counting of environmental samples, NASA selected the SRTC Underground Counting Facility as one of the laboratories for LDEF analyses. SRTC received its first LDEF samples on March 7, 1990, and a final report was submitted to NASA on 68 gamma spectrometry analyses that were conducted on 31 samples submitted during 1990-1991². The present report provides results for 26 gamma spectrometry analyses on 15 samples that NASA submitted in 1992; it also upgrades the analyses of four of the 1990-1991 samples.

Round-robin gamma analyses of these and/or similar samples have been conducted at PNL, LANL, LBL, LLL, ORNL, TVA, and at NASA facilities in Houston, Texas and Huntsville, Alabama. To date, the SRTC results have compared favorably with those reported at the other laboratories³.

II. MEASUREMENTS

The SRTC Underground Counting Facility⁴ was used to conduct gamma spectrometry on the LDEF samples. This facility is 50 ft below ground and constructed with low-background materials. Pre-WWII steel comprises the 4-in. walls of the counting chamber, which is shielded by 4 to 7 ft of specular hematite. The total overburden is equivalent to 104 ft of water shielding, which reduces the cosmic background by an order of magnitude. The facility operates as a Class 10,000 clean room, whereby airborne particulates are removed by filtering. The very stable spectrometry electronics use an uninterruptable power supply to protect against data losses during extended counting times.

In the present study, all samples were counted on a HPGe detector with standard efficiency of 90%. A low-level lead shield encloses the detector and its sample cavity, which is purged of radon with the nitrogen that evaporates from its LN₂ dewar. The HPGe has an inner shield of cadmium and copper to reduce X-ray backgrounds induced in the shielding by gammas from the sample. The detector background is further reduced with an active plastic-scintillator shield, which detects cosmic background events in anticoincidence with the gamma counting to veto this background. The present study used 1 to 3 day counting intervals, yielding detection limits⁵ for a ⁶⁰Co point source atop the detector of 0.05 to 0.1 pCi. Further details on the detector are available in the earlier report².

A total of 15 samples were examined by HPGe gamma spectrometry. The samples were rectangular slabs of aluminum and tantalum from LDEF; also studied were background trunnion disks, which had not experienced any cosmic irradiation from space missions. The aluminum samples were nearly identical 2x5 in² slabs, each having mass of about 80 g. The tantalum samples were 2x3/4 in² and 2x2 in² slabs with respective masses of about 50 g and 135 g. The trunnion disks had 3.25-in. diameter and 0.3 to 1.0-in. thickness. Detailed sample descriptions are given in Appendix B. Each aluminum and tantalum sample was counted with one side facing the detector and then recounted with its other side facing the detector, so that activity distributions within the sample could be detected and averaged. By contrast, the background trunnion disks were only counted for one orientation, as a uniform sample could be assumed.

Detector efficiency measurement data were generally available from the earlier SRTC work². However, a closer examination of the summing effects for ²²Na was conducted by comparing the summing for a point source in different counting geometries, as detailed in Appendix A. Also, tantalum slab samples had not been previously calibrated; the present work examined tantalum efficiency by counting point sources of ⁵⁴Mn, ⁶⁰Co, and ¹³³Ba using methods described earlier². These measurements were also supplemented with similar ones using a small vial standard (sample volume of 33-mm diam. x 25-mm ht.) containing a solution with ⁵⁷Co, ⁶⁰Co, ⁸⁵Sr, ⁸⁸Y, ¹⁰⁹Cd, ¹¹³Sn, ¹³⁷Cs, ¹³⁹Ce, ²⁰³Hg, and ²⁴¹Am.

III. ANALYSES

HPGe Spectral Analyses

The HPGe data were collected as 4000 channel gamma spectra, as described earlier². All spectra were in the form of ADCAM files, as developed by EG&G ORTEC. The GRABGAM code⁴, which was developed at SRTC for low-level counting, analyzed the spectra.

This code uses three area trapping windows to identify prospective peaks. The narrowest window makes the first scan, so that any significant multiplet features can be identified. The middle window scans next. Finally, the largest window provides the best sensitivity for picking out peaks with low counting statistics. These candidate peaks are examined as integral probability functions $F(x)$ per channel x , to provide better statistics than afforded by fitting the peak to a differential probability $f(x)dx$. Such enhanced statistics are useful in characterizing the centroids and widths of low-level peaks. Following the analysis, any peak contributions from a similarly analyzed background spectrum are subtracted.

Calibrations

Overall, the calibration methods developed in the earlier SRTC study were used². Essentially the efficiencies are mapped for the surfaces of the sample using point sources, and then an exponential model predicts the efficiency for points interior to the sample^{2,6,7}.

Calibration information for aluminum slabs and trunnions was available from the earlier study²; however, tantalum was not studied earlier and data were generated experimentally for these corrections. Also, the summing corrections for ²²Na of aluminum samples were re-examined and revised; the detailed discussion is given in Appendix A.

The calibrations for tantalum slabs used the earlier SRTC radial efficiency data for calculating the slab area efficiency factor², and the slab thickness efficiency factor was obtained from calibration measurements of the present work. The exponential dependence of efficiency on slab thickness was determined by measurements with each calibration source centered on the detector, and then atop the slab centered on the detector. Measurements with the multi-source liquid standard yielded a relative efficiency dependence on the thickness for eight representative gammas ranging from 279 keV to 1836 keV. The severe attenuation by tantalum prevented useful determinations for the four lower gammas, which ranged from 60 keV to 166 keV. Because the liquid standard was not a point source, as required by the calculation², point source measurements refined the above estimates with four gammas ranging from 276 keV to 384 keV to address the 276 keV gamma of induced ¹⁷³Lu activities. Additional point source measurements with three gammas ranging from 835 keV to 1333 keV addressed the four ¹⁷²Lu gammas that ranged from 810 keV to 1094 keV. As point sources for ¹³³Ba and ⁶⁰Co were involved in these measurements, self-consistent summing corrections had to be applied.

IV. RESULTS

The measurement results are summarized in Tables 1-3, and additional sample data is summarized in Appendix Table B-1. All tables utilize formats presented in the earlier SRTC report on LDEF analyses². Results for the aluminum and tantalum samples are decay-corrected to January 20, 1990, the date of LDEF return to Earth. Activities for the trunnion steel samples, which were not aboard LDEF, are given for actual counting dates, which were all within 3 days of their average of July 27, 1992.

Aluminum Samples (^{22}Na)

Table 1 gives the results for the six aluminum clamp plates and also results of a reanalysis of four earlier aluminum samples². Similar to the earlier aluminum samples, only ^{22}Na (2.60y) was observed in the aluminum plate clamps. All samples had ^{22}Na concentrations in the range of 91 to 154 pCi/kg. Because no discernable differences in count rate were observed relative to sample orientation, the results for each sample were averaged to reduce overall statistical counting error to $\leq 5\%$.

All ^{22}Na values were deduced from the count rate of its principal gamma of 1274 keV, corrected for summing with its β^+ annihilation radiation. Sample efficiencies were determined using methods developed in the earlier report², except for the new summing corrections developed in the present study. The Table 1 results for the earlier aluminum samples incorporate the new summing correction.

Tantalum Samples (^{172}Lu , ^{173}Lu)

Results for the five tantalum samples are given in Table 2. Only ^{172}Lu and ^{173}Lu were observed, with respective concentration ranges of 33 to 63 pCi/kg and 123 to 280 pCi/kg. Here, ^{172}Lu (6.70d) decays in equilibrium with its longer-lived parent ^{172}Hf (1.87y), but ^{173}Lu (1.37y) has no long-lived precursor. The low energy gammas of ^{172}Hf were not detected, being severely attenuated by the tantalum. Again, no discernable differences in the count rate were observed relative to sample orientation. Thus, the results for each sample were averaged to reduce overall statistical counting error to $\leq 7\%$ for ^{172}Lu and $\leq 20\%$ for ^{173}Lu .

The ^{172}Lu values were primarily deduced from its best detected gamma of 1094 keV, but less prominent gammas of 810, 901, and 912 keV provided useful confirmation. By contrast, the ^{173}Lu values were deduced from its only detected gamma of 272 keV. The corresponding detection efficiencies for these gammas have been described in the preceding section.

Trunnion Steel (^{60}Co)

Table 1 summarizes the results for the four steel pieces that simulate the trunnion samples. All samples yielded similar estimates for ^{60}Co (5.27y) concentration, providing a $(1/\sigma^2)$ -weighted average of 1.51 ± 0.09 pCi/kg for the four samples. Other detected isotopes were from natural backgrounds in the steel.

The counting data for both the 1173 keV and 1333 keV gammas of ^{60}Co were used in obtaining the above results, where their detection efficiencies were deduced from methods developed for trunnions in the earlier report².

V. DISCUSSION

The results of this study and the earlier one² are in reasonable agreement with those for similar samples examined at other laboratories³. In particular, the agreement for the ^{22}Na results is notably improved with the revised summing correction described in Appendix A. In the present work, ^{22}Na is interpreted to be from cosmic proton spallation of ^{27}Al , and ^{172}Lu and ^{173}Lu are from spallation of ^{181}Ta . Because the ^{60}Co was detected in trunnion steel that had not been exposed to the space environment, its approximate agreement with ^{60}Co of LDEF trunnions casts doubt on whether significant ^{60}Co was cosmically produced in the LDEF trunnions.

The ^{60}Co activity lies in the range 1.16 to 1.96 pCi/kg that SRS reported for LDEF trunnion samples; this implies that ^{60}Co from steel manufacture may interfere with cosmic-induced ^{60}Co in the LDEF samples. Possibly samples from stocks of the original LDEF trunnion steel could be analyzed to fully appraise the above ^{60}Co interferences. Furthermore, in the above comparison, no information was provided to make proper decay corrections for a more realistic appraisal. The steel pieces were corrected to their counting dates (all within 3 days of July 27, 1992), and the earlier trunnion samples were all corrected to January 20, 1990.

Consider the following example scenario for the above ^{60}Co data. Assume that the initial ^{60}Co concentrations in steel were identical; furthermore, suppose that the steel pieces were manufactured in July 1991 and the LDEF trunnions in January 1982. The initial ^{60}Co of the steel pieces and LDEF trunnions would have decayed by 1 yr and 8 yr relative to their respective decay correction times. Consequently, initial ^{60}Co in the LDEF trunnion would have decayed 7 yr longer ($7/5.3 = 1.32$ half-lives), meaning its activity would have decayed to $1.51 \times 2^{-1.32} = 0.60$ pCi/kg. The prospects for correcting the cosmic-induced ^{60}Co for this lower background would be reasonably promising.

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REFERENCES

1. G.J. Fishman, T.A. Parnell, and B.A. Harmon, "Long Duration Exposure Facility (LDEF) Induced Radioactivity Plan", NASA Marshall Space Center Report [Astrophysics Division, Space Science Laboratory] (December, 1989).
2. W.G. Winn, "Gamma-Ray Spectrometry of LDEF Samples", USDOE Report SRS Report WSRC-RD-91-16 (February 19, 1992). [Also condensed published version - W.G. Winn, "Gamma-Ray Spectrometry of LDEF Samples at SRTC", LDEF-69 Months in Space, NASA Conference Publication 3134, Part 1, p.287, National Aeronautics and Space Administration (1991)]
3. C.E. Laird, "Analysis, Review, and Documentation of Activation Data from LDEF Material", Eastern Kentucky University/NASA Report (July, 1992).
4. W.G. Winn, W.W. Bowman, and A.L. Boni, "Ultra-Clean Underground Counting Facility for Low-Level Environmental Samples". The Science of the Total Environment 69, 107 (1988). [Also available as USDOE SRTC Report DP-1747, 57 pp (1987)].
5. W.G. Winn, "Ultrasensitive Examination of Environmental Samples by SRTC Underground Counting Facility", Trans. Am. Nuc. Soc. 54, 34 (1987).
6. W.G. Winn, "An exponential Model for HPGe Detector Efficiencies", Trans. Am. Nuc. Soc. 64, 215 (1991).
7. W.G. Winn, "Evaluation of an Exponential Model for Germanium Detector Efficiencies", to be published in Nuclear Technology (anticipated August, 1993).

Table 1. Aluminum Sample Results

Sample Measurements:

- A. Label facing away from detector
- B. Label facing detector
- C. Weighted Average of (A,B) [$(1/\sigma^2)$ weighted]
- D. Direct average of (A,B) [even weighted]

Decay Correction Date: January 20, 1990

<u>2"x5" Clamp Plates^a</u>		<u>2"x2" Earlier Samples^b</u>	
<u>Sample/Meas</u>	<u>²²Na pCi/kg</u>	<u>Sample/Meas</u>	<u>²²Na pCi/kg</u>
B7-5/A	129.3 ± 7.1	ESR-1/A	122.2 ± 6.8
/B	120.2 ± 7.8	/B	128.3 ± 6.1
/C	125.2 ± 5.2	/C	125.6 ± 4.5
/D	124.7 ± 5.3	/D	125.3 ± 4.6
D7-5/A	139.0 ± 4.8	ESR-5/A	129.1 ± 3.8
/B	140.6 ± 8.3	/B	124.5 ± 3.8
/C	139.5 ± 4.2	/C	126.8 ± 2.7
/D	139.8 ± 4.8	/D	126.8 ± 2.7
G6-4/A	147.6 ± 8.9	KP-3/A	156.5 ± 3.8
/B	140.9 ± 7.6	/B	151.9 ± 3.8
/C	143.7 ± 5.8	/C	154.2 ± 2.7
/D	144.3 ± 5.8	/D	154.2 ± 2.7
G6-10/A	90.8 ± 6.9	KP-10/A	111.4 ± 3.8
/B	101.2 ± 6.9	/B	96.9 ± 6.1
/C	96.0 ± 4.9	/C	107.3 ± 3.2
/D	96.0 ± 4.9	/D	104.2 ± 3.6
H6-4/A	131.5 ± 7.6		
/B	128.1 ± 7.6		
/C	129.8 ± 5.4		
/D	129.8 ± 5.4		
H9-12/A	122.0 ± 7.6		
/B	128.4 ± 4.2		
/C	127.0 ± 3.7		
/D	125.2 ± 4.3		

(a) Summing correction is 1.72/1.31 larger than that which would have been calculated per ref. 1.

(b) Summing correction is 1.95/1.41 larger than that of ref. 1; the above results should replace the earlier ones.

Table 2. Tantalum Sample Results

Sample Measurements: (given with 1- σ counting errors)

- A. Label facing away from detector
- B. Label facing detector
- C. Weighted Average of (A,B) [$(1/\sigma^2)$ weighted]
- D. Direct average of (A,B) [even weighted]

Decay Correction Date: January 20, 1990

<u>Sample/Measurement</u>	<u>pCi/kg Sample</u>	
	¹⁷² Lu	¹⁷³ Lu
I-H12-TA-A/A	51.29 $\pm$ 3.07	323.36 $\pm$ 52.01
/B	48.76 $\pm$ 4.03	238.09 $\pm$ 70.29
/C	50.36 $\pm$ 2.44	293.20 $\pm$ 41.81
/D	50.03 $\pm$ 2.53	280.73 $\pm$ 43.72
I-H12-TA-B/A	39.09 $\pm$ 4.19	199.23 $\pm$ 60.23
/B	39.96 $\pm$ 2.70	188.43 $\pm$ 48.85
/C	39.70 $\pm$ 2.27	192.72 $\pm$ 37.94
/D	39.52 $\pm$ 2.49	193.83 $\pm$ 38.78
G12-B-4-F N-TA/A	33.02 $\pm$ 2.87	119.63 $\pm$ 39.57
/B	33.92 $\pm$ 2.87	127.17 $\pm$ 32.25
/C	33.47 $\pm$ 2.03	124.16 $\pm$ 25.00
/D	33.47 $\pm$ 2.03	123.40 $\pm$ 25.53
I-F2-TA*/A	43.34 $\pm$ 2.84	177.72 $\pm$ 38.28
/B	42.10 $\pm$ 3.70	213.56 $\pm$ 41.98
/C	42.25 $\pm$ 2.25	193.99 $\pm$ 28.29
/D	42.22 $\pm$ 2.33	195.64 $\pm$ 28.41
I-C3-TA/A	63.78 $\pm$ 3.67	276.37 $\pm$ 42.45
/B	62.22 $\pm$ 1.98	229.14 $\pm$ 23.55
/C	62.57 $\pm$ 1.74	240.25 $\pm$ 20.59
/D	63.00 $\pm$ 2.08	252.76 $\pm$ 24.27

* Identity assumed by process of elimination. Actual sample was labeled "LDEF-4".

Table 3. Steel Trunnion Results

Sample Information:

All samples trunnion-like disks of same stock
Counted each sample once, as indicated
Count time from 1 to 3 days
Weighted average of all samples $[(1/\sigma^2) \text{ weighted}]$

Average Decay Correction Date: July 27, 1992

<u>Sample</u>	<u>Decay Date</u>	<u>Mass g</u>	<u>^{60}Co pCi/kg</u>
C55-26	7/24/92	264	1.57 $\pm$ 0.31
C55-27	7/26/92	526	1.51 $\pm$ 0.13
C55-28	7/28/92	791	1.46 $\pm$ 0.22
C55-29	7/29/92	1044	1.52 $\pm$ 0.19
Wt-Avg	7/27/92	-	1.51 $\pm$ 0.09

Appendix A. Summing Corrections for ^{22}Na

The summing corrections for ^{22}Na of the aluminum samples were examined in detail, and the earlier correction² was found to be low. All ^{22}Na values presented in this report (Table 1) use the revised correction. The appendix compares the earlier and revised summing corrections.

Earlier Summing Corrections

The earlier summing corrections C were based on calculations using

$$C = \frac{1}{1 - 1.811 \epsilon_{\gamma}(511)}$$

where 1.811 511 keV gammas occur for each ^{22}Na decay due to positron annihilation. These gammas are detected with total efficiency $\epsilon_{\gamma}(511)$, which was calculated to be 0.272 for a point source. The calculation was assumed valid because point source measurements yielded C of 1.87 ± 0.07 in reasonable agreement with the calculated C of 1.97. Adopting a point source C of 1.90 and corresponding $\epsilon_{\gamma}(511)$ of 0.262, calculations for extended aluminum samples were made by reducing the point $\epsilon_{\gamma}(511)$ by the appropriate surface distribution and thickness corrections, as summarized below:

Sample	Correction Factors		$\epsilon_{\gamma}(511)$	C
	Surface	Thickness		
2"x2"	0.84	0.73	0.161	1.41
2"x5"	0.59	0.85	0.131	1.31

Problems with Earlier Summing Corrections

Unfortunately, the measured/calculated agreement for the point source check in the above analysis was found to be fortuitous. The point source was mounted on a planchet, such that a sizeable fraction of the 511 keV annihilation gammas originated away from the source (and detector). However, the calculation does not address additional sources of summing such as "missed" 511 keV gammas that scatter back into the detector and bremsstrahlung from the 545 keV β^+ . For the planchet source, the two effects (fewer nearby 511 keV gammas and additional summing sources) tended to cancel, yielding fortuitous agreement with the calculation model. Because the calculation model did not address these additional sources of summing and nearly 100% of the 511 keV gammas originated within the LDEF samples, the actual summing correction is larger than that calculated earlier.

To illustrate the effect of the β^+ annihilation gammas, the planchet point source was counted both with the source surface facing away and toward the detector; the respective summing corrections were 1.97 ± 0.03 and 2.70 ± 0.05 . With the source surface facing away from the detector, only the β^+ directed toward the detector may come to rest and annihilate in the metal planchet or detector can. With the source surface toward the detector β^+ of all directions may annihilate in one of these materials, thus resulting in the larger summing correction. Evidence for the additional sources of summing is inferred from the fact that the measured C of 2.70 ± 0.05 is larger than the earlier calculated C of 1.97, which did not address additional sources of summing.

Another problem with the earlier summing correction was that the term $\epsilon_r(511)$ should be replaced with the expression $\langle \epsilon_r(511) \epsilon_p(1274) \rangle / \langle \epsilon_p(1274) \rangle$ where each $\langle \dots \rangle$ is the average over the sample volume. If the sample is not uniformly distributed, then the averages must be weighted by the distribution. To be sure, the model must include these effects as well as the additional summing contributions discussed above. The prospect of developing such a model was not favorable, but an empirical experimental method discussed below evolved as a reasonable method.

Empirical Experimental Summing Corrections

The 1274 keV ^{22}Na peak is reduced by its summing with the 511 keV gamma (direct and scattered) and β^+ bremsstrahlung. In the spectrum a 511+1264 = 1785 keV peak and a continuum between 1274 and 1785 keV represent the summing events that have been removed from the 1274 keV peak. As such, the summing correction may be written as

$$C = \frac{A(1274) + A(1274-1785) + A(1785)}{A(1274)}$$

where A(...) are the areas (number of counts) in the above mentioned peaks and ranges. The expression may be rearranged as

$$C = 1 + A(1785)/A(1274) [1 + A(1274-1785)/A(1785)]$$

In this formula, C primarily increases as $A(1785)/A(1274)$ increases, because the other ratio $A(1274-1785)/A(1785)$ is expected to be relatively constant. Measurements of C with the planchet source in various sample geometries yielded the following data, which is plotted in Figure A-1:

Planchet Geometry	A(1785)/A(1274)	C
Toward-Detector Centered	0.386 ± 0.017	2.70 ± 0.05
Away-Detector Centered	0.202 ± 0.008	1.95 ± 0.03*
Away-Detector Centered Atop 2"x2" Al	0.094 ± 0.006	1.54 ± 0.02
Away-Detector Off-center 1" atop 2"x2" Al	0.058 ± 0.005	1.38 ± 0.02
Far from Detector	≡0.000	≡1.00

* Weighted average of 1.97 ± 0.03 and earlier 1.87 ± 0.07

Figure A-1 illustrates that C vs A(1785)/A(1274) is approximately linear, although minor curvature is apparently due to the slope dependence on A(1274-1785)/A(1785). The sample measurements each yielded values for A(1785)/A(1274) and these were averaged as 0.203 ± 0.006 and 0.143 ± 0.008 for the 2x2 in² and 2x5 in² aluminum samples, which yielded corresponding C of 1.95 and 1.72 from Figure A-1. Accordingly, correction factors of 1.95/1.41 and 1.72/1.31 were applied to the all earlier results for 2x2 in² and 2x5 in² samples.

Figure A-1. Summing Correction

Appendix B. Sample Details

Table B-1 gives details concerning the samples examined by SRTC during 1992. The table gives the sample labels, archival files, mass, dimensions, counting date, and lab institutions from which the samples were received. Essentially the same notation of the earlier report² is used as described on the second page of the table. The data files will be available from the NASA archives.

Table B-1. Sample Counting Information

<u>Sample/ Geo/Dt3</u>	<u>Spectrum File</u>	<u>Mass g</u>	<u>Size dims</u>	<u>Counting 1992</u>	<u>SRTC Recpt</u>	<u>Previous Laboratory</u>
<u>Aluminum</u>			<u>mmxmm</u>			
B7-5/A /B	2133NASA.DAT 2134NASA.DAT	78.4	49x128	7/21-7/22 7/22-7/23	7/7	NASA/Hunts- ville AL
D7-2A/A /B	2131NASA.DAT 2132NASA.DAT	79.9	49x128	7/17-7/20 7/20-7/21	7/7	NASA/Hunts- ville AL
G6-4/A /B	2123NASA.DAT 2124NASA.DAT	78.9	49x128	7/7-7/8 7/8-7/9	7/7	NASA/Hunts- ville AL
G6-10/A /B	2127NASA.DAT 2128NASA.DAT	79.5	49x128	7/13-7/14 7/14-7/15	7/7	NASA/Hunts- ville AL
H6-4/A /B	2129NASA.DAT 2130NASA.DAT	79.7	49x128	7/15-7/16 7/16-7/17	7/7	NASA/Hunts- ville AL
H9-12/A /B	2125NASA.DAT 2126NASA.DAT	79.2	49x128	7/9-7/10 7/10-7/13	7/7	NASA/Hunts- ville AL
<u>Tantalum</u>			<u>mmxmm</u>			
I-H12-/A TA-A /B	2158NASA.DAT 2161NASA.DAT	49.8	50x19	8/7-8/10 8/10-8/12	7/28	NASA/Houston TX
I-H12-/A TA-B /B	2162NASA.DAT 2163NASA.DAT	48.9	50x19	8/12-8/14 8/14-8/17	7/28	NASA/Houston TX
G12-B-/A 4-F NTA/B	2144NASA.DAT 2149NASA.DAT	134.1	50x19	8/3-8/4 8/4-8/5	7/28	NASA/Houston TX
I-F2-/A TA* /B	2152NASA.DAT 2155NASA.DAT	138.8	50x19	8/5-8/6 8/6-8/7	7/28	NASA/Houston TX
I-C3-/A TA /B	2139NASA.DAT 2140NASA.DAT	135.9	2x2	7/30-7/31 7/31-8/3	7/28	NASA/Houston TX
<u>Trunnion</u>			<u>mm</u>			
C55-26/A	2135NASA.DAT	264	6.4	7/23-7/24	7/20	NASA/Hunts- ville AL
C55-27/A	2136NASA.DAT	526	12.8	7/24-7/27	7/20	NASA/Hunts- ville AL
C55-28/A	2137NASA.DAT	791	19.3	7/27-7/28	7/20	NASA/Hunts- ville AL
C55-29/A	2138NASA.DAT	1044	25.5	7/29-7/30	7/20	NASA/Hunts- ville AL

Table B-1. Sample Counting Information (continued)

Table Notes - Abbreviated Table Headings

<u>Sample/ Geo/Det</u>	Sample label/ Geometry label facing (A) away from or (B) toward detector/ Detector is (1) 25%, (2) 20%, or (3) 90% HPGe. (Det=3 for present data)
<u>Spectrum File</u>	File label of ADCAM spectrum sent on floppy disk to NASA for permanent archive of LDEF studies.
<u>Mass g</u>	Measured mass of sample at SRTC.
<u>Size dims</u>	Sample dimensions are given as slab areas (mmxmm) or trunnion disk thicknesses (mm). The appropriate units are identified above the data for each type sample identified in the table.
<u>Counting 1992</u>	Counting interval dates - detailed live counting times are available from the disk files.
<u>SRTC Recpt</u>	Date in 1992 that sample was received.
<u>Previous Laboratory</u>	Laboratory from which sample was received.

Appendix C. Comments Relative to Previous Report

As a result of the present work, a few discrepancies have been identified in the previous SRTC report on LDEF studies². The primary concern is the difference in the summing correction for ²²Na. It is emphasized that the ²²Na results of the present work are recommended, as discussed in Appendix A. Two typographical errors have also been identified in the previous report: in Figure B-6 (page B-20), the <F> of ⁶⁰Co should be 0.897 (as opposed to the 0.987 given); and in Subtable C-1-5 (page C-4), sample/geo RH-G-ER-3/A corresponds to spectral file 1667NASA.DAT (as opposed to 1677NASA.DAT given).

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