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**ANODIZED ALUMINUM ON LDEF
A Current Status Of Measurements On
Chromic Acid Anodized Aluminum**

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Chromic acid anodize was used as the exterior coating for aluminum surfaces on LDEF to provide passive thermal control. Chromic acid anodized aluminum was also used as test specimens in thermal control coatings experiments. The following is a compilation and analysis of the data obtained thus far.

Solar absorptance and thermal emittance data for this summary was graciously provided by the following people.

SOURCES OF INFORMATION

- **Measurements Of α And ϵ From**
 - **T. R. Sampair, NASA LaRC / Lockheed**
LDEF Structure, Longerons, And Intercostals
 - **W. L. Plagemann, Boeing Defense & Space Group**
LDEF Tray Clamps
 - **W. S. Slomp, NASA LaRC**
Test Specimens
 - **D. R. Wilkes, AZ Technology, Inc.**
J. M. Zwiener, NASA MSFC
Test Specimens

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Measurements reported by Tom Sampair for the solar absorptance and thermal emittance of chromic acid anodize on LDEF intercostals and longerons are shown in figures 1-4. During deintegration, readings were made on both exposed and unexposed areas of these structures (where covered by tray lips). Comparison is made in these figures to the Quality Assurance logs of 1978, made during LDEF part fabrication. Absorptance readings show significant variability from row to row. Absorptance measurements taken for leading edge surfaces are relatively unchanged, within the exhibited data scatter. However, trailing edge surfaces show significant increases in absorptance. Emittance readings for all exposed surfaces are not changed when compared to the QA logs. Unexposed surfaces, however, have a consistent increase in emittance compared to exposed surfaces.

LDEF INTERCOSTALS: AVERAGE ABSORPTIVITY Vs ROW LOCATION

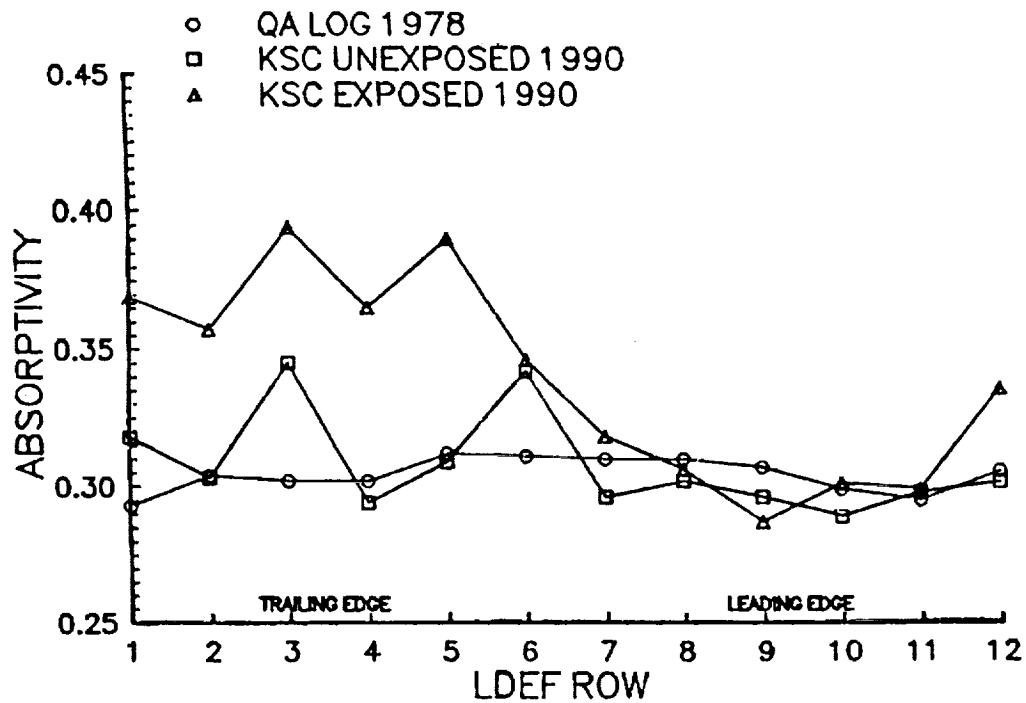


Figure 1.

LDEF LONGERONS: AVERAGE ABSORPTIVITY Vs ROW LOCATION

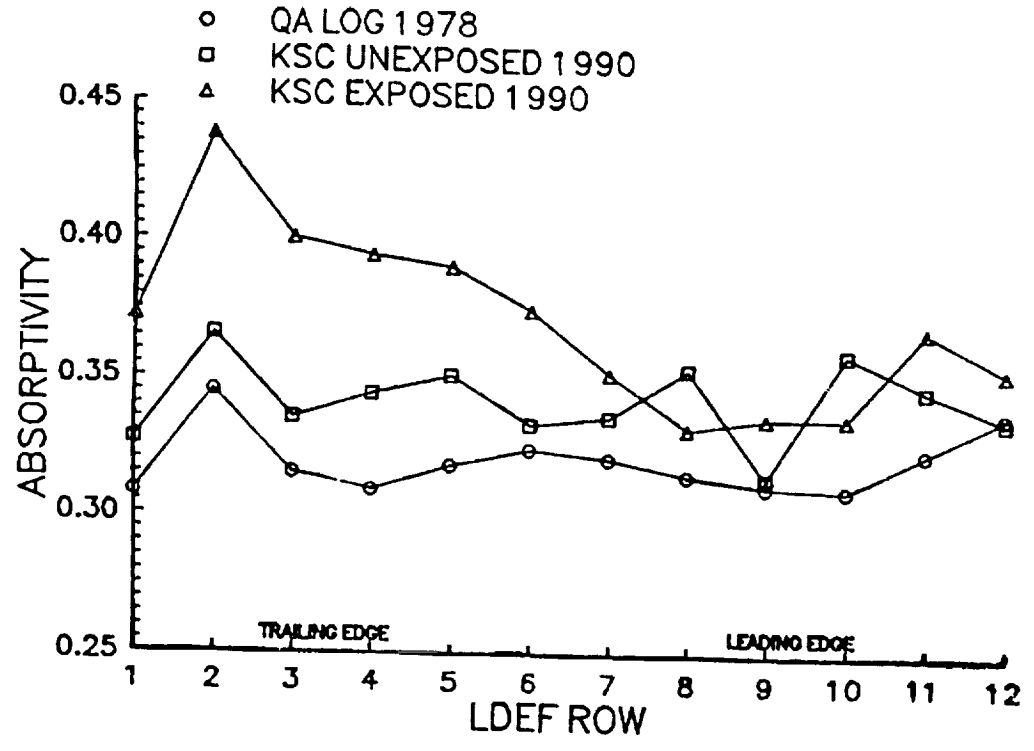


Figure 2.

LDEF INTERCOSTALS: AVERAGE EMISSIVITY Vs ROW LOCATON

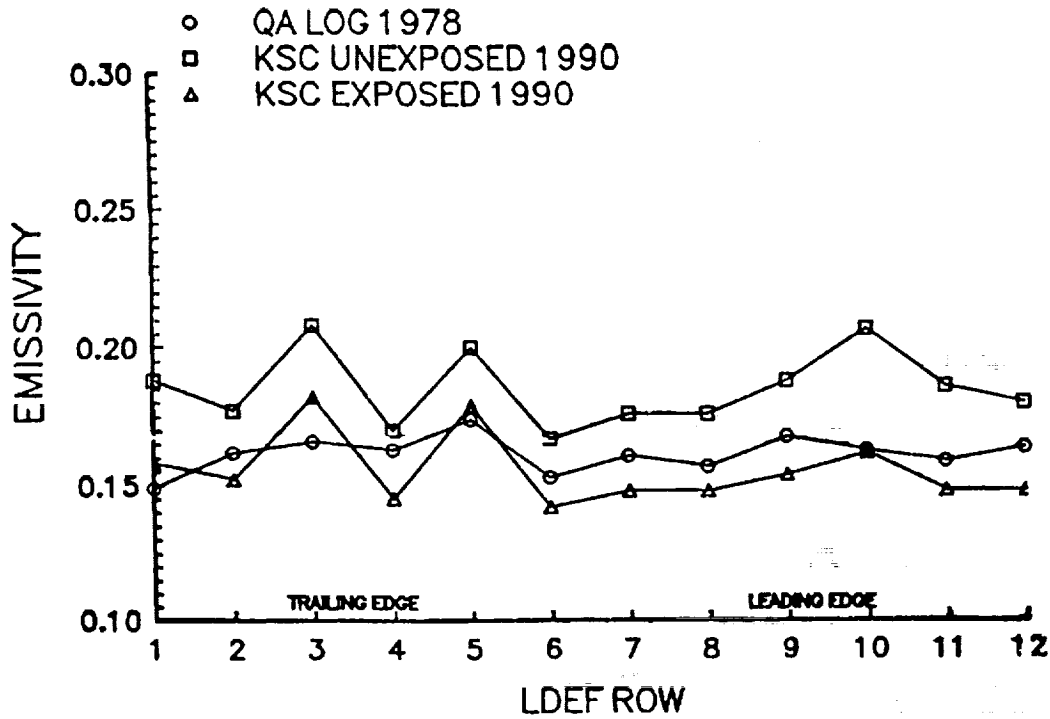


Figure 3.

LDEF LONGERONS: AVERAGE EMISSIVITY Vs ROW LOCATON

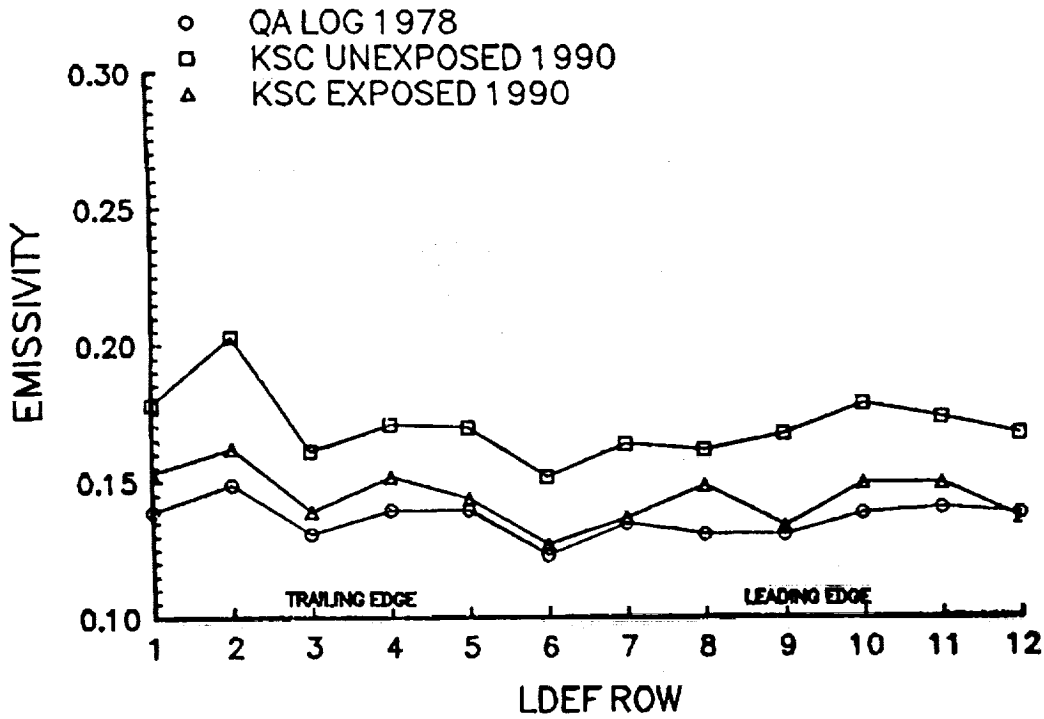


Figure 4.

Measurements reported by Wally Plagemann for optical properties of LDEF tray clamps are summarized in Table 1. When treated as averages, the anodize has suffered very little degradation as a result of space environmental effects.

Details of the tray clamp measurements are presented in various forms as figures 5 - 9. Figure 5 compares the absorptance readings for the exposed (front) and unexposed (back) surfaces of clamps as a function of LDEF location. A slight increase in absorptance for trailing edge surfaces is apparent. A similar plot of emittance is shown in figure 6. Although there is a 0.04 emittance unit spread to the readings, there is no difference apparent between leading and trailing edge clamps. There is, however, a slightly lower emittance for exposed surfaces than for unexposed surfaces, consistent with the readings reported for LDEF structure.

Solar absorptance versus UV exposure for LDEF side tray clamps is shown in figure 7. It appears that trailing edge specimens, as described previously, have higher absorptances than their counterparts on the leading edge. But there is no trend in absorptance change with UV exposure. A similar plot, figure 8, includes the readings for the earth and space end tray clamps. Finally, a plot of absorptance versus atomic oxygen fluence is shown in figure 9. Again the only change is a slight absorptance increase moving from high AO fluence (leading edge) to low AO fluence (trailing edge).

TABLE 1.

Measurements On Flight Tray Clamps					Data From	Measurements
Unexposed	Exposed - Leading	Exposed - Trailing	Exposed - Space	Exposed - Earth	AIAA - 83-1492	On Unused Clamps
$\alpha - 0.34$ 0.01	$\alpha - 0.33$ 0.01	$\alpha - 0.35$ 0.02	$\alpha - 0.35$ 0.02	$\alpha - 0.35$ 0.01	$\alpha - 0.32$	$\alpha - 0.36$
$\epsilon - 0.16$ 0.01	$\epsilon - 0.15$ 0.01	$\epsilon - 0.15$ 0.01	$\epsilon - 0.16$ 0.02	$\epsilon - 0.17$ 0.01	$\epsilon - 0.16$	$\epsilon - 0.18$
$\alpha/\epsilon - 2.1$	$\alpha/\epsilon - 2.2$	$\alpha/\epsilon - 2.3$	$\alpha/\epsilon - 2.2$	$\alpha/\epsilon - 2.1$	$\alpha/\epsilon - 2.0$	$\alpha/\epsilon - 2.0$

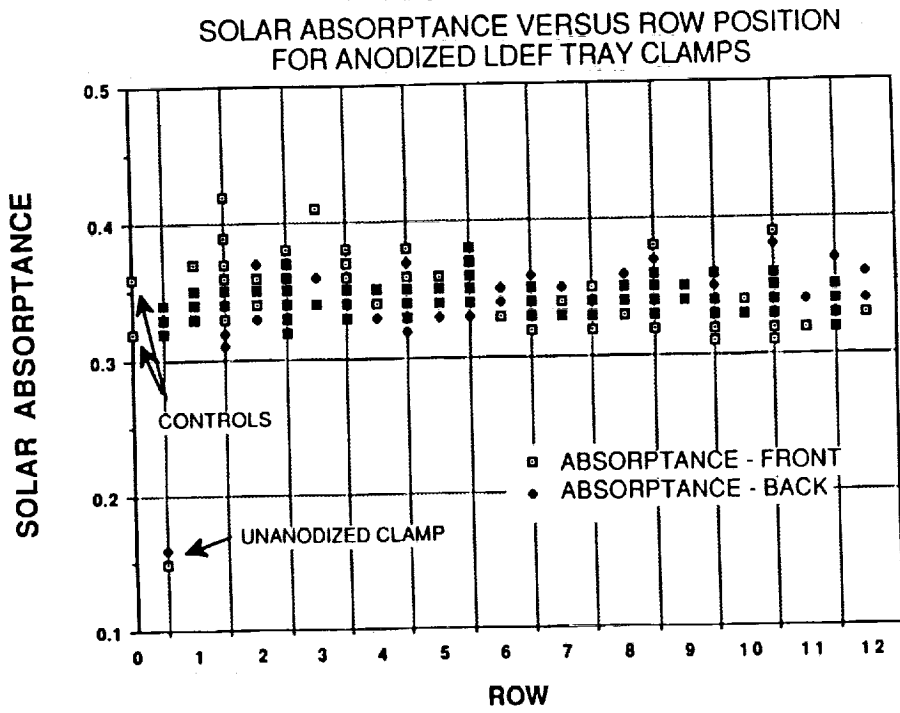


Figure 5.

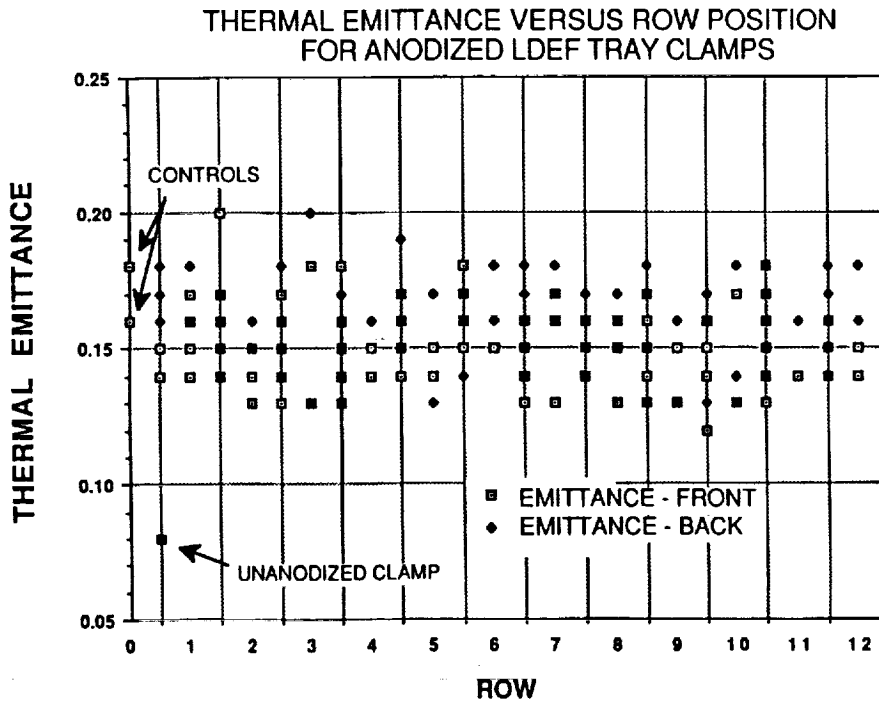


Figure 6.

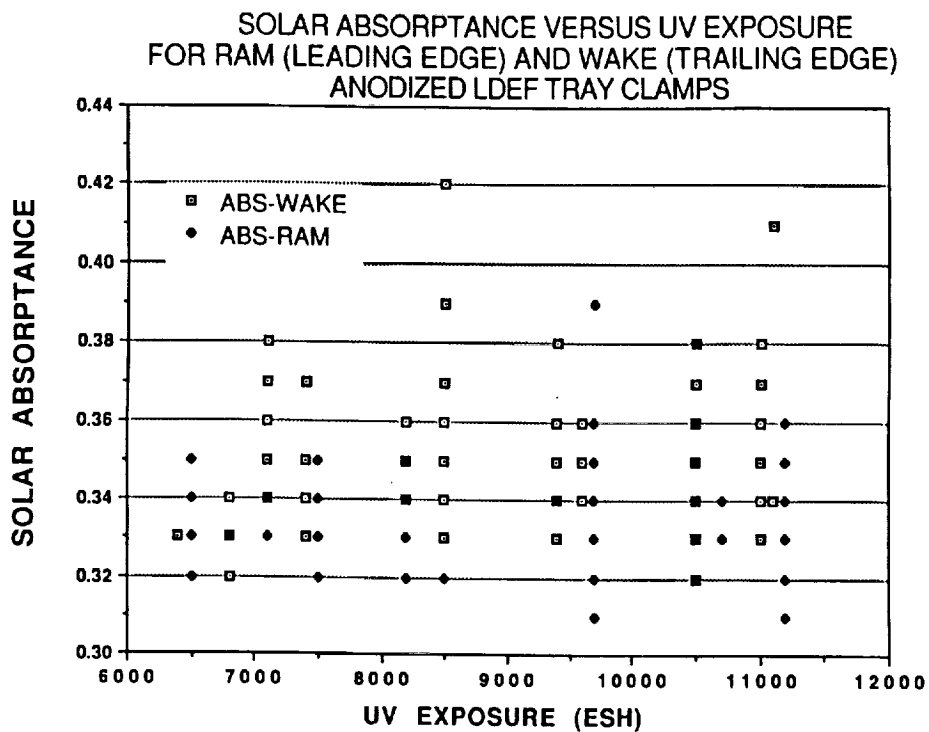


Figure 7.

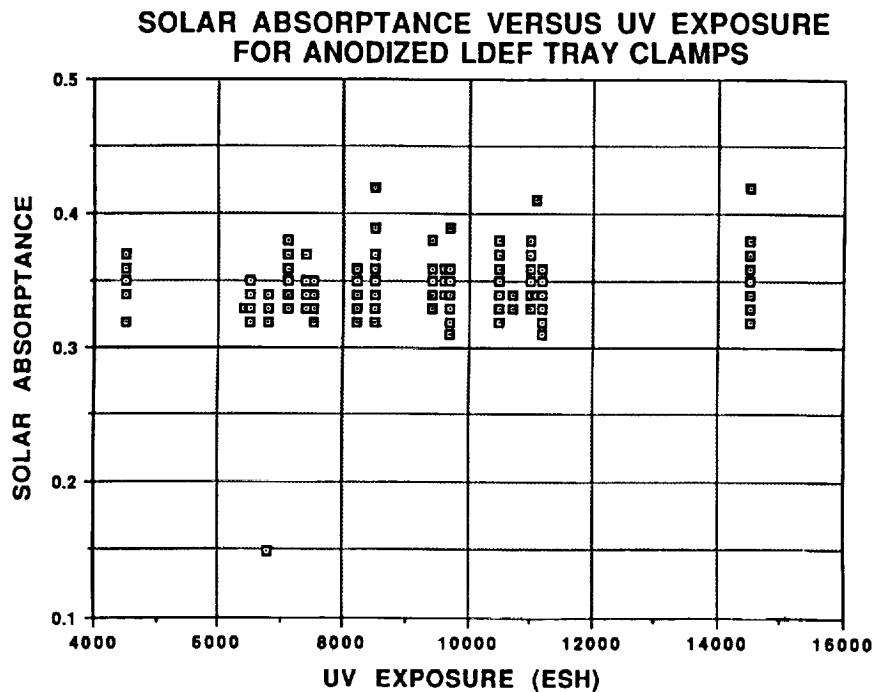


Figure 8.

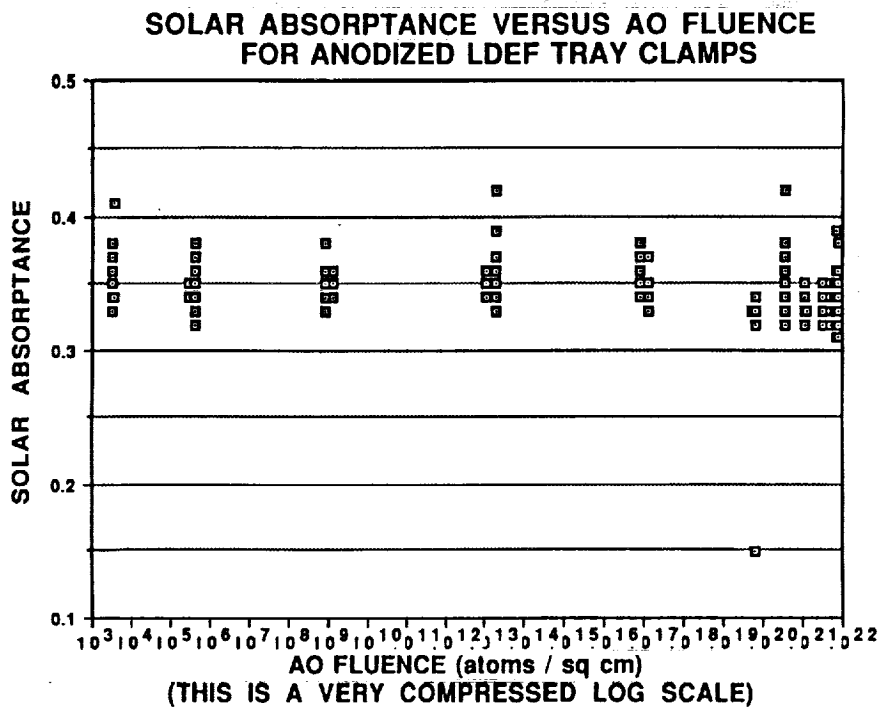


Figure 9.

Measurements reported by Wayne Slemp for chromic acid anodize on experiment S0010 are summarized in Table 2. Coatings of relatively constant absorptance (~10%) and varying emittance received two exposure levels at tray position B9 (8.7×10^{21} oxygen atoms/sq. cm and 11,200 ESH). Both absorptance and emittance readings at either exposure level are consistent with preflight measurements.

TABLE 2.

**NASA LaRC Experiment S0010 On
Chromic Acid Anodize (CAA)**

Coating	Preflight		10 Month Exposure		5.8 Year Exposure	
	α	ϵ	α	ϵ	α	ϵ
Thin CAA	0.295	0.16	0.299	0.17	--	--
	0.288	0.18	--	--	0.296	0.19
Medium CAA	0.292	0.43	0.287	0.43	--	--
	0.306	0.45	--	--	0.311	0.46
Thick CAA	0.33	0.71	0.337	.071	--	--
	0.341	0.75	--	--	0.354	0.75

Measurements reported by Don Wilkes and Jim Zwiener for chromic acid anodize on experiment S0069 are summarized in Table 3. This experiment was located at tray position A9 (8.7x10E21 oxygen atoms/sq. cm and 11,200 ESH). Two specimens of comparable absorptance and emittance were periodically measured for absorptance on this active experiment during the first 19.5 months of the LDEF flight. During that time, the absorptance of the anodize specimens increased significantly and consistently. One of the specimens was left exposed for the entire mission and recovered slightly (decreased) in absorptance. Emittance of the two specimens was not affected.

TABLE 3.

**NASA MSFC And AZTEK Experiment S0069
Chromic Acid Anodize Specimens**

Specimen	Preflight	12 Months	19.5 Months	Postflight (69.2 Months)
C61	$\alpha - 0.41$ $\epsilon - 0.84$	$\alpha - 0.50$	--	$\alpha - 0.47$ $\epsilon - 0.83$
C63	$\alpha - 0.40$ $\epsilon - 0.84$	$\alpha - 0.49$	$\alpha - 0.54$ $\epsilon - 0.84$	--

There are several points that can be made in summary. First, there was some variability inherent in the absorptance and emittance measurements for LDEF chromic acid anodize coatings, due to both the anodizing process, and due to the differences in equipment and analysts used to make the measurements over the years. Data from tray clamps (and from LDEF structures) indicates this variability within one standard deviation is 0.02 for absorptance and 0.01 for emittance.

Next, absorptance changes for leading edge surfaces was minimal, with the exception being the results from Experiment S0069. The absorptance on trailing edge surfaces increased in general when compared to available control measurements.

Emittance changes were complex in that emittance appears to have slightly increased for unexposed surfaces, when compared to exposed surface or QA logs. However, these changes are of minimal significance when compared to inherent emittance variability or when treated relatively.

Based on the analyses thus far, indications are that chromic acid anodize is quite stable in the LEO environment, but that contamination did effect absorptance increases. Most leading edge surfaces were cleaned of this contamination by atomic oxygen.

• SUMMARY

- Variability Inherent In CAA Process From Tray Clamp Measurements Is $\pm 0.02 - 0.03$ In Both Absorptance And Emittance**
- Emissivity Of Shielded Anodize Is Greater Than That Measured For Exposed Anodize**
- Absorptance Change On Leading Edge Surfaces Is Minimal, With Exception**
- Absorptance Increased on Trailing Edge Surfaces Compared to Unexposed Surfaces or to 1978 QA data**
- Results Indicate Absorptance Increases Are Due To Contamination Early In The LDEF Mission, Subsequently Removed From Leading Edge Surfaces By Atomic Oxygen**

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is essential for ensuring transparency and accountability in the organization's operations.

2. The second part of the document outlines the various methods and tools used to collect and analyze data. It highlights the need for consistent data collection procedures and the use of advanced analytical techniques to derive meaningful insights from the data.

3. The third part of the document focuses on the role of technology in data management and analysis. It discusses how modern software solutions can streamline data collection, storage, and processing, thereby improving efficiency and accuracy.

4. The fourth part of the document addresses the challenges associated with data management, such as data quality, security, and privacy. It provides strategies to mitigate these risks and ensure that the data remains reliable and secure throughout its lifecycle.

5. The fifth part of the document concludes by summarizing the key findings and recommendations. It stresses the importance of a data-driven approach in decision-making and the need for continuous monitoring and improvement of data management practices.