Section 20b

AZW/LA-II Low Alpha Inorganic White Thermal Coating

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Two Flight Thermal Coatings – White Paint

- **Z93P White Paint: Calorimeter (S/N 032)**
  - Current technology - control sample
  - Applied by Ms. Grace Miller / Swales Aerospace

- **AZW/LA-II low alpha inorganic White Paint: Calorimeter (S/N 033)**
  - New technology
  - Applied by Mr. Steve Jones / AZ Technology
  - Both coatings developed by AZ Technology

- **Z93P White Paint (S/N 032)**
  - $\alpha = .17$, $\varepsilon h = .87$

- **AZW/LA-II White Paint (S/N 033)**
  - $\alpha = .11$, $\varepsilon h = .86$

- **Two Flight Thermistors**
  - Z93 (TCALEXP2T), LA-II (TCALEXP1T)
Z93 & LA-II Thermal Coating Samples

- Calorimeter paint samples provided to EO-1 by Dennis Hewitt, Head Thermal Engineering Branch, NASA/GSFC
- Thermal Analysis and Design provided by Swales Aerospace
- Calorimeter hardware built by George Harris of Swales Aerospace
- The New Millennium Program’s EO-1 mission provided a flight opportunity for verifying the LA-II white paint
  - Calorimeters provided by NASA/GSFC with minimal cost to NMP
  - Calorimeters had no direct impact on S/C performance
Calorimeters on EO-1

- The Calorimeters are mounted on a bracket and attached to the C-C radiator (Bay 4)
- Carbon-Carbon Radiator consists of 1” Al honeycomb with 0.020” C-C face-sheets, approximately 28” by 28”
- The LA-II coating ("low alpha") has a very low solar absorptance value when compared to other space application white paints
  - A lower solar absorptance can provide improved radiator performance when exposed to UV. This improvement can lead to smaller radiator sizes, saving spacecraft mass
**EO-1 Calorimeters**

Protective Covers

Image of EO-1 Calorimeters with labels Z93 and LA-II.
Pre-Flight Photos
Pre-Flight Photos
LA-II White Paint Technology Validation

- Verify on-orbit thermal performance of thermal coatings and evaluate any degradation of properties (solar absorptivity, $\alpha$)
  - Pre-Flight solar absorptance and IR emittance measured by Wanda Peters/Swales Aerospace
  - Thermal model correlated to test results and flight data
  - Monitor calorimeter thermistor data on-orbit, along with S/C attitude data.
  - Correlated flight data with calorimeter thermal model to verify properties and thermal coating performance
TSS Geometric Math Model
Validation Tasks Completed

- **Component Level Tests**
  - **Vibration and Strength**
    - Structural Analysis and Modeling
  - **Mass Properties**

- **Spacecraft Level Testing**
  - **Vibration**
  - **Thermal Vacuum**

- **Special Flight Test** (June 21, 2001 through June 24, 2001)
  - Maneuver EO-1 to have calorimeters Normal to Sun Vector for 25 minutes of Sun portion of orbit
EO-1 Panel 4 Thermistor Layout

Removed to accommodate Calorimeter

TRADCC2T

TRADCC3T

TRADCC4T

TRADCC5T

TRADCC6T
Transient Flight Data vs. Thermal Model Analysis

DCE Thermal Analysis Results (Nominal)

Temperature, °C

Time, hours

FLIGHT

E01.1475 Calorimeter: Z93
E01.1485 Calorimeter: LAII
E01.1470
E01.1480
E01.1450 Calorimeter Bracket
E01.24163 Equipment Panel 4
LAI
Z93

FLIGHT
Z93: TCALEXP2T

Positioning EO-1 in Orbit behind Landsat
Calorimeter Test on 6/21/01 - Normal to Sun

Hot Orbital Season
Cold Orbital Season
Z93: TCALEXP1T

LA-II: TCALEXP1T

Temperature (°C)

-40
-35
-30
-25
-20
-15
-10
-5
0

Time

10/21/2000
12/10/2000
1/29/2001
3/20/2001
5/9/2001
5/28/2001

- Positioning EO-1 in Orbit behind Landsat
- Calorimeter Test on 6/21/01 - Normal to Sun
- Hot Orbital Season
- Cold Orbital Season

Legend:
- Average
- Max
- Min
Calorimeter Normal To Sun Test

Calorimeter Normal To Sun Test (June 21, 2001)

- **SUN ANGLE**
- **TCALEXP1T (LA-II)**
- **TCALEXP2T (Z33)**

- $T_{\text{max}} = -14.75^\circ C$
- $T_{\text{max}} = -18.34^\circ C$
Calorimeter Normal
To Sun Test

Calorimeter Normal to Sun Test (June 22, 2001)

Temp (°C) & Sun Angle

Tmax = -14.5°C

Tmax = -18.0°C

Time
Calorimeter Normal To Sun Test (June 23, 2001)

Temp °C and Sun Angle

- \( T(LA-I)_{max} = -17.1°C \)
- \( T(293)_{max} = -13.6°C \)

Time

Calorimeter Normal To Sun Test

Calorimeter Normal to Sun Test (June 24, 2001)

- **Sun Angle**
- **TCALEXP1T (LA-II)**
- **TCALEXP2T (293)**

Temperature and Sun Angle over time:

- Peak temperature at 6:30 AM, 6:31 AM, and 6:32 AM.
- Temperature dips significantly during sun exposure.

Temperature readings:

- **T(LA-II)max = -17.2°C**
- **T(293)max = -13.6°C**
Lessons Learned / Summary

- LA-II optical properties verified maintaining stability with improved solar absorptivity vs. Z93
- LA-II may provide cooler radiator temperatures when exposed to UV: (Data shows 5°C cooler in UV)
- Follow calorimeters/samples through vibration testing. Extremely dirty environment which could contaminate thermal coatings
  - We flew the spare calorimeters
- Thanks to Dennis Hewitt at NASA/GSFC for his efforts in making the LA-II thermal coating a successful technology demonstration.
- New coating now available to flight projects - baselined for the Swift spacecraft (but it is expensive)