

SPACECRAFT MATERIALS AND COATINGS EXPERIMENTS

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ABSTRACT

The 5.8-year exposure data from the Long Duration Experiment Facility (LDEF) has demonstrated the benefits of long-term exposure in low Earth orbit (LEO) for understanding the behavior of spacecraft materials and coatings for use in extended space missions. The Space Station Freedom represents the next large area spacecraft available in NASA planned missions for obtaining this long-term space exposure data.

The advantages of using the Space Station Freedom for these studies are presented. Discrepancies between short-term flight exposure result from Shuttle Orbiter experiments and the long-term LDEF results are shown. The major objectives and benefits of conducting materials and coatings experiments on Space Station Freedom are emphasized.

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**Space Station Freedom Utilization Conference
Huntsville, Alabama
August 3-6, 1991**

CONCLUSIONS FROM LDEF MATERIALS ANALYSIS

- Atomic oxygen is major near-Earth orbital environmental factor leading to mechanical/optical property changes in materials
- All polymeric materials exhibit some mass loss from AO exposure
- Uncoated resin matrix composites display resin and fiber loss and deterioration in mechanical properties proportional to thickness loss
- Molecular structure of surviving polymeric resin and films unchanged
- Thin metallic coatings can prevent AO damage

LESSONS LEARNED FROM LDEF EXPERIMENTS

- Leading edge surfaces are dominated by AO effects while surfaces greater than 110° are dominated by contamination and UV effects
 - Different exposure surfaces are needed for meaningful flight experiments
- Cannot confidently extrapolate long-term space effects on materials from short-term flight experiments like EOIM
 - Long-term exposure data are needed
- Confirmed suspected instability of polymeric materials to LEO atomic oxygen exposure
 - More data needed to support materials development programs for AO resistant materials
- More choices of protective coatings are needed to prevent AO damage to materials
 - Choices are very limited for large parts

PASSIVE MATERIALS AND COATINGS EXPERIMENT

Why Space Station Freedom?

- After initial development phase, Space Station Freedom presents a stable platform for materials exposures and acquisition of environmental data
- Only spacecraft available for long-term (>1 year) materials and coatings exposure
- Large areas available for exposure of materials and coatings
- Power and data storage available for use with active experiments
- Materials exposed real-time in same LEO environment where they are being used
- Ready access for material exchange and return of exposed materials to Earth for laboratory testing

MATERIALS FLIGHT EXPERIMENTS ON SSF

Objectives

- Establish a technology database for long-term effects of LEO environment on spacecraft materials and coatings
- Database will support:
 - Development of ground-based technology for accelerated long-duration environmental effects testing
 - Development of new materials and coatings with high resistance to atomic oxygen, solar UV, and particulate radiation
 - Development of Multiparameter Laboratory testing techniques. Example: AO + UV + vacuum + temperature cycling in one system
 - Alternate materials for advanced retro-fit or repair of Freedom

MATERIALS FLIGHT EXPERIMENTS ON SSF

Justification

- Multi-environment simulation of atomic oxygen, UV, vacuum, thermal cycling, micrometeoroid, debris, and particulate radiation is not technically feasible in ground-based laboratory testing
- Cannot confidently extrapolate long-term space effects from short-term accelerated flight data
 - FEP Teflon AO erosion 6 times greater on LDEF than predicted from EOIM-2 flight results
 - Epoxy matrix composites AO erosion on LDEF was 1/2 of erosion predicted from EOIM-2 flight results
- Long-term flight database needed to develop ground-based accelerated testing technology
 - LDEF provides only flight data available on materials exposed for 5-year mission lifetime

MATERIALS FLIGHT EXPERIMENTS ON SSF

Benefits

- Assist in development of new materials for 21st century
- Provide data for improved laboratory simulation of space environment
- Provide data to correlate highly accelerated testing of materials with real-time effects
- Verification of ground-based lifetime prediction
- Additional utilization of Space Station Freedom as a testing/exposure laboratory in space

SUMMARY

- LDEF providing substantial long-term LEO exposure data on space environmental effects on materials
- LDEF underscore the need for long-term flight data
- Space Station Freedom only spacecraft manifested for long-term (>5 years) operation
- Materials experiment proposed for beneficial utilization of Space Station Freedom