Title: Estimated Environmental Exposures for MISSE-7B
Authors: Miria M. Finckenor, Chip Moore, Joseph K. Norwood, Ben Henrie, NASA
Marshall Space Flight Center
        Kim K. de Groh, NASA Glenn Research Center

This paper details the 18-month environmental exposure for Materials International Space Station Experiment 7B (MISSE-7B) ram and wake sides. This includes atomic oxygen, ultraviolet radiation, particulate radiation, thermal cycling, meteoroid/space debris impacts, and observed contamination. Atomic oxygen fluence was determined by measured mass and thickness loss of polymers of known reactivity. Diodes sensitive to ultraviolet light actively measured solar radiation incident on the experiment. Comparisons to earlier MISSE flights are discussed.
Estimated Environmental Exposures for MISSE-7B

Miria M. Finckenor
Chip Moore
Joseph K. Norwood
Ben Henrie (MITS)
NASA/Marshall Space Flight Center

Kim De Groh
NASA/Glenn Research Center

National Space and Missile Materials Symposium
Tampa, FL
June 2012
Materials on International Space Station Experiment (MISSE) - 7

Deployed: November 23, 2009 on STS-129
Retrieved: May 20, 2011 on STS-134

• Location on ISS - ExPRESS Logistics Carrier 2
• Pre-flight and post-flight photos
• Environmental exposure for MISSE-7B
  • Contamination evaluation
  • Meteoroid/orbital debris impacts
  • Atomic oxygen fluence
  • Ultraviolet radiation
• Discussion and conclusions
• Database development
Estimated Environmental Exposures for MISSE-7B
Estimated Environmental Exposures for MISSE-7B
Estimated Environmental Exposures for MISSE-7B

Ram Side

Pre-flight

UV darkening of base plate, some loss of samples, particularly on tray A5-R

Post-flight
Estimated Environmental Exposures for MISSE-7B

Wake Side

Pre-flight

Post-flight
UV darkening of base plate
Some particulate from N10-R, also localized molecular contamination
Particulate contamination on A1-W – fallout from N10-R, heavily eroded Vectran yarn
Estimated Environmental Exposures for MISSE-7B

VUV Transmission of MISSE-7B Magnesium Fluoride Windows

% Transmission

Wavelength (nm)

- Ram #1
- Ram #2
- Wake #1
- Wake #2
- Control
Contamination

- Magnesium fluoride windows shows some decrease in transmission only in the VUV wavelengths, likely due to atomic oxygen interaction.
- AZ93 white ceramic thermal control coating
  - Control $\alpha = 0.158$
  - Ram $\alpha = 0.159$
  - Wake $\alpha = 0.157$
- Ellipsometry on platinum mirrors indicated 40 Å of SiO$_x$ or less.
Estimated Environmental Exposures for MISSE-7B

Meteoroid/Space Debris Impact Survey for MISSE-7B

- Ram – 12 impacts
- Wake – 6 impacts
- Sidewalls – 7 impacts

Total of 25 impacts
Largest 1 mm diameter
Atomic Oxygen Fluence

Determined by mass loss and thickness loss of Kapton HN

Ram side: $4.2 \pm 0.1 \times 10^{21}$ atoms/cm$^2$

Wake side: $2.9 \pm 0.3 \times 10^{20}$ atoms/cm$^2$

Glenn Research Center confirmed AO fluence for the ram side as $4.18 \times 10^{21}$ atoms/cm$^2$
Estimated Environmental Exposures for MISSE-7B

ISES Solar Cycle Sunspot Number Progression

Observed data through Aug 2011

Updated 2011 Sep 6

MISSE-6 MISSE-7

NOAA/SWPC Boulder, CO USA
Copper tape between baseplate and PEC meant very little AO scattered underneath baseplate, very little silver oxide formed on nutplates.
Ultraviolet Radiation

UV diodes on ram and wake

Monitored by Lead-Free Technology Experiment in Space Environment (LTESE)

Ram: 4,500 +/- 400 ESH
Wake: 3,200 +/- 200 ESH
Conclusions

- Some localized molecular and particulate contamination.
- No significant change in number or size of meteoroid/space debris impacts.
- Higher atomic oxygen fluence than MISSE-6 due to increased solar activity.
- Higher ultraviolet radiation dose than MISSE-6 due to different location and less shielding.
What’s next?

- ISS/Julie Robinson has provided funding to add a MISSE database to the Materials and Processes Technical Information System (MAPTIS)

- MISSE 1-7 for now. Raw data from MISSE-8 is being stored at Huntsville Operations Support Center (HOSC)’s long term storage system.

- Papers, presentations, overall and individual sample photographs, specimen lists, sample layouts, raw data files
## Estimated Environmental Exposures for MISSE-7B

![MISSE Flights Table](https://example.com/misse-flights-table.png)

### MISSE Flights

<table>
<thead>
<tr>
<th>MISSE Flights</th>
<th>Experiments</th>
<th>Materials</th>
<th>Data</th>
<th>Docs</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISSE 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 2</td>
<td><strong>Experiments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 6A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 6B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSE 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Estimated Environmental Exposures for MISSE-7B
Estimated Environmental Exposures for MISSE-7B

### MISSE Flights

- MISSE 2
- MISSE 3
- MISSE 4
- MISSE 5
- MISSE 6
- MISSE 7
- MISSE 8

### Experiments on MISSE Flight - MISSE 2

- AZ electron
- AZ93 glass
- AZ electron
- A-276 glass
- Silverized Teflon with SiOx

### Materials on Experiment: Silverized Teflon with SiOx

<table>
<thead>
<tr>
<th>Material</th>
<th>Flights</th>
<th>Experiments</th>
<th>Materials</th>
<th>Data</th>
<th>Documents</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
<tr>
<td>Material G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Documents</td>
<td>Images</td>
</tr>
</tbody>
</table>
Estimated Environmental Exposures
for MISSE-7B

MISSE-2 wake side Silver/Teflon with SiOx - postflight image
### Estimated Environmental Exposures for MISSE-7B

NSMMS presentation with MISSE-2 wake side Silver/Teflon with SiOx - data

#### Analysis of International Space Station Vehicle Materials on MISSE 3 & 4

<table>
<thead>
<tr>
<th>MISSE-1, -2, 3, -4 Results for Silverized Teflon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preflight</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>5.5 mil with SiOx TB1</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>5.5 mil with SiOx TB2</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>5.5 mil with SiOx 1-E13-3</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>5.5 mil with SiOx TB3</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>5.5 mil with SiOx TB4</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>10 mil, no coating 1-E3-46</td>
</tr>
<tr>
<td>ε</td>
</tr>
<tr>
<td>10 mil, no coating W7-12</td>
</tr>
<tr>
<td>ε</td>
</tr>
</tbody>
</table>
### Estimated Environmental Exposures for MISSE-7B

#### MISSE-2 wake side Silver/Teflon with SiOx – raw data

![Excel spreadsheet]

<table>
<thead>
<tr>
<th>Material Description</th>
<th>SiOx coated Ag/TEP</th>
<th>SiOx coating</th>
<th>SiOx coating</th>
<th>SiOx coating</th>
<th>SiOx coating</th>
<th>5.5 mil Ag/TEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample number</td>
<td>ESS-1-E3-21</td>
<td>TB1</td>
<td>TB2</td>
<td>TB3</td>
<td>TB4</td>
<td></td>
</tr>
<tr>
<td>Solar absorptance</td>
<td>0.090</td>
<td>0.089</td>
<td>0.089</td>
<td>0.94</td>
<td>0.102</td>
<td></td>
</tr>
<tr>
<td>Infrared emittance</td>
<td>0.793</td>
<td>0.799</td>
<td>0.798</td>
<td>0.793</td>
<td>0.793</td>
<td></td>
</tr>
<tr>
<td>Weight (g)</td>
<td>7.15525</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atomic Oxygen (e)</td>
<td>9.00E+12</td>
<td>9.00E+12</td>
<td>1.10E+12</td>
<td>1.20E+12</td>
<td>1.30E+12</td>
<td></td>
</tr>
<tr>
<td>UV (EUV)</td>
<td>6000</td>
<td>6000</td>
<td>6000</td>
<td>1750</td>
<td>1750</td>
<td></td>
</tr>
<tr>
<td>Wavelength (nm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2800</td>
<td>0.9437</td>
<td>0.937</td>
<td>0.9886</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2750</td>
<td>0.9732</td>
<td>0.9576</td>
<td>0.9506</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2700</td>
<td>0.9464</td>
<td>0.9576</td>
<td>0.9503</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2650</td>
<td>0.9586</td>
<td>0.9583</td>
<td>0.9728</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2600</td>
<td>0.9671</td>
<td>0.9701</td>
<td>0.9617</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2550</td>
<td>0.9658</td>
<td>0.9668</td>
<td>0.9665</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>0.9732</td>
<td>0.9774</td>
<td>0.9837</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2450</td>
<td>0.9709</td>
<td>0.9773</td>
<td>0.9768</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2400</td>
<td>0.9655</td>
<td>0.9765</td>
<td>0.9821</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2350</td>
<td>0.9701</td>
<td>0.9816</td>
<td>0.9813</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2300</td>
<td>0.9731</td>
<td>0.9787</td>
<td>0.9811</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For access to MAPTIS

http://maptis.nasa.gov/Request.aspx

and fill out the form.

To add MISSE data to MAPTIS

Contact ben.henrie@nasa.gov or miria.finckenor@nasa.gov

Miria – 256-544-9244

Be sure to specify whether your information is unlimited access or ITAR-restricted
Acknowledgments

- Annette Sledd, Ginger Flores, Julie Robinson, Kevin Window, Rod Jones, Julie Henkener, and John Alred for their support
- Phil Jenkins, Rob Walters, John Vasquez, and others at the Naval Research Laboratory and Dr. Gary Pippin and others at Boeing Research & Technology, for getting MISSE-7B off the ground.
- Susie LaCava of the Naval Research Laboratory for pre-flight photos.
- Richard A. Caldwell, DoD Space Test Program, Human Spaceflight Payloads Office
- Brian Gibson for the UV diode data through the LTESE experiment.
- Tiffany Russell for handcarrying MISSE-7B back to MSFC