Estimated Environmental Exposures for MISSE-3 and MISSE-4

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MISSE-3 and -4

- Originally planned for 3 year exposure
- Changed to 1 year exposure after MISSE-1 and -2 were in space for 4 years
- Located on Quest Airlock
  - Deployed August 3, 2006
  - Retrieved August 18, 2007
- ISS in mostly LVLH XVV attitude
  (Local vertical local horizontal, X-axis in velocity vector)
Locations of MISSE-3 and MISSE-4
MISSE-3 and -4 Environmental Exposure
Low Earth Orbit Space Environment

- Atomic Oxygen
- Ultraviolet Radiation
- Particulate Radiation
- Thermal Cycling
- Vacuum
- Plasma
- Meteoroid / Space Debris Impact

Also contamination associated with proximity to an active space station
MISSE-3 AO-UV SIDE

Solar UV fairly uniform (~1,695 to 1,750 ESH)
Solar UV exposure on wake side much less than ram side
655 to 790 ESH
MISSE-4 AO-UV SIDE

Solar UV varied from 1,200 to 1,590 ESH

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Shadowing of MISSE
MISSE-4 UV SIDE

Solar UV varied from 825 to 995 ESH
ISS ram view from MISSE-1 (Similar for MISSE-3)

Representation of extent of AO beam, +/- 15\(^\circ\) due to thermal velocity spread

MISSE-3 angled up, 30\(^\circ\) off ram, larger fraction of unit sphere blocked by ISS

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ISS wake view from MISSE-1 (Similar for MISSE-3)

MISSE-3 angled down, 30° off ram, increased view factor to Earth
ISS ram view from MISSE-2 (Similar for MISSE-4)
ISS wake view from MISSE-2 (Similar for MISSE-4)
### Atomic Oxygen Fluences for MISSE 3 & 4

<table>
<thead>
<tr>
<th></th>
<th>Calculated (x $10^{21}$ atoms/cm²)</th>
<th>Measured (x $10^{21}$ atoms/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISSE-3 Ram</td>
<td>1.50</td>
<td>1.2 – 1.3</td>
</tr>
<tr>
<td>MISSE-3 Wake</td>
<td>0.294</td>
<td>0.19</td>
</tr>
<tr>
<td>MISSE-4 Ram</td>
<td>1.82</td>
<td>2.06</td>
</tr>
<tr>
<td>MISSE-4 Wake</td>
<td>0.364</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Both mass loss and thickness loss were measured.
Periodic orientation changes of ISS lowered exposure to specimens on MISSE-3 & MISSE-4

*Glenn Research Center data, courtesy of Kim de Groh and Sharon Miller
Determination of solar UV exposure levels

MISSE-3 & MISSE-4

"Monte Carlo" model used to estimate ESH on each surface
  Divided each surface into 2” x 2” areas
  Model accounts for range of solar beta angles
  Exposure period of ~1 year

<table>
<thead>
<tr>
<th>Nominal Exposure</th>
<th>Range of ESH (total)</th>
<th>Earth-reflected ESH</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISSE-3 AO-UV</td>
<td>1700</td>
<td>120</td>
</tr>
<tr>
<td>MISSE-3 UV</td>
<td>700</td>
<td>250</td>
</tr>
<tr>
<td>MISSE-4 AO-UV</td>
<td>1200-1600</td>
<td>75</td>
</tr>
<tr>
<td>MISSE-4 UV</td>
<td>900</td>
<td>300</td>
</tr>
</tbody>
</table>

MISSE-3 & MISSE-4 solar exposure estimates do not account for shielding by the Space Shuttle
Boeing Dosimetry results from MISSE-1 through MISSE-4 are based on TLD measurements, with a variety of materials used for shielding.

Data was compared to earlier Russian experiment.

Shielding by ISS structure and Earth has significant influence on results – as more hardware has been added, the measured dose has decreased.

Loral radiation dose experiment results were presented at 2007 SAMPE Conference.
MISSE-1 through MISSE-4 TLD Readings, up to 4 yrs at ISS, Dose vs Shield Thickness

- MISSE-1, BREB, TLDS shielded by Al (48-126 mils)
- MISSE-1, BREB, TLDS shielded by composite (1.6 g/m³, 34-98 mils)
- MISSE-1, BREB, TLDS shielded by composite (1.8 g/m³, 50-103 mils)
- Avg 6 TLDs, MISSE-1, W2-15, 5 mils Kapton Shielding
- Avg 7 TLDs, MISSE-1, W3-5 Expt, 10 mils Ta shielding
- Avg 7 TLDs, MISSE-1, E4-36 Expt, 30 mils composite shielding
- Avg 6 TLDs, MISSE-2, E10-1 Expt, 2 mils Al shielding
- Avg 5 TLDs, MISSE-3, W5-5 Expt, 30 mils composite
- Avg 5 TLDs, MISSE-3, W7-15 Expt, 30 mils Al
- Avg 5 TLDs, MISSE-3, W7-5 Expt, 60 mils composite
- Avg 5 TLDs, MISSE-3, E13-32 Expt, 2 mils Al
- Avg 5 TLDs, MISSE-4, E17-45 Expt, 10 mils Ta

Space Station Calc, 1 yr dose from electrons
Thermal conditions

MISSE-3 and MISSE-4 LaRC data logger measurements of temperature show thermal cycling \(-40^\circ\text{C}\) to \(+40^\circ\text{C}\), with excursions up to \(+60^\circ\text{C}\).

Vacuum

\(10^{-6}\) torr or less

Plasma

ISS Plasma Contactor Units maintain floating potential between \(\pm40\) V.
Meteoroid & Space Debris Impact

Distribution of Impacts on MISSE 3 and 4

Approximate Impact Crater Diameter (mm)

Number of Impacts

- 0.1
- 0.2
- 0.3
- 0.5
- 1
- 1.3
- 2

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Contamination

ISS assembly during MISSE-3 and MISSE-4 exposure
- STS-115 P3 / P4 Truss and Solar Array
- STS-116 P5 Truss
- STS-117 S3 / S4 Truss and Solar Array
- STS-118 S5 Truss and External Stowage Platform

Contamination on samples appeared to be minimal.

Some localized contamination was seen on baseplate.

Ceramic white thermal control coatings have solar absorptances within 0.01 of pre-flight measurements.
Contamination
MISSE-3 Wake Side - AZ93 Thermal Control Coating

![Graph showing reflectance vs wavelength for different materials and wavelengths.](image-url)
MISSE-3 and MISSE-4 Exposure Summary

Nominal Ram-facing surfaces maximum fluence of atomic oxygen
<2.2 E+21 atoms/cm².

Solar exposures ranges
~1200 to 1700 ESH on ram sides
~700 to 900 ESH on wake sides

Particulate radiation low, agrees with previous measurements at same
altitude and inclination. Dose levels indicate significant increased
shielding by ISS structure relative to MISSE-1 and MISSE-2.

Molecular contamination levels generally low, may be significant for
certain materials.