



# GCR and SPE radiation effects in materials

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HAT: 6.5.a, 6.6.b, 12.1.a, 12.1.b TA: 6.5.1, 6.5.2, 6.5.3, 12.2.1, 12.3.2 TRL: NA (provides qualification data)

## OVERVIEW

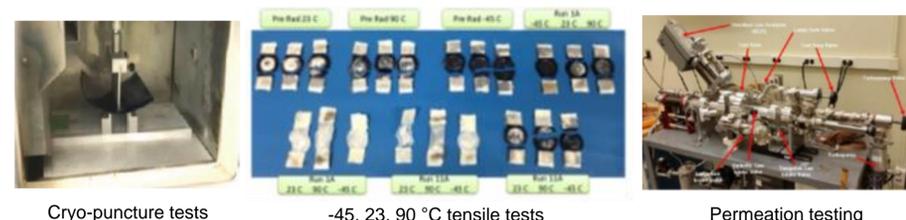
This Year 3 project provides risk reduction data to assess galactic cosmic ray (GCR) and solar particle event (SPE) space radiation damage in materials used in manned low-earth orbit, lunar, interplanetary, and Martian surface missions. Long duration (up to 50 years) space radiation damage is being quantified for materials used in inflatable structures (1st priority), and space suit and habitable composite materials (2nd priority). The data collected has relevance for nonmetallic materials (polymers and composites) used in NASA missions where long duration reliability is needed in continuous or intermittent space radiation fluxes.

## INNOVATION

The effect of long term radiation exposure using particle radiation representative of SPE and GCR space radiation is investigated (instead of  $^{60}\text{Co}$   $\gamma$ -radiation).

## OUTCOME

- Over 600 specimens were irradiated in FY15-16.
- Radiation-induced property modification noted for NanoSonic bladder material developed under STTR T12.03-9881 (increased strength and modulus), Armorflex<sup>®</sup> bladder material (increased lower molar mass weight loss component), and Vectran<sup>®</sup> restraint layer (degraded ballistic performance).
- NanoSonic self-healing gel performance unaffected.
- Space suit and composite habitat materials are still in test.
- Tensile test methods are being refined for high strength polymer fabrics (Spectra<sup>®</sup> and Vectran<sup>®</sup>).
- Competitive cost and capabilities analysis performed for Brookhaven National Laboratory NASA Space Radiation Laboratory (BNL NSRL), Los Alamos National Laboratory (LANL), and the TRI University Meson Facility (TRIUMF).



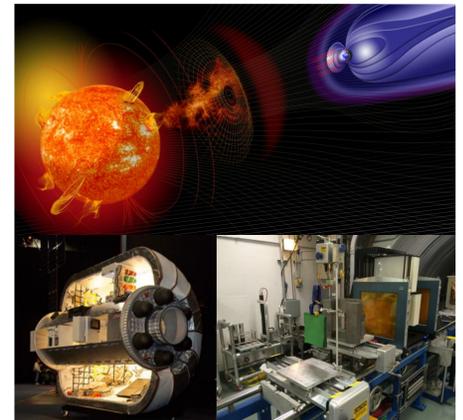
Cryo-puncture tests

-45, 23, 90 °C tensile tests

Permeation testing

## INFUSION SPACE / EARTH

This project has relevance for nonmetallic materials, namely, inflatable activity modules, Z-series space suits, composite crew module, composite habitat, Orion composites, International Space Station composite over-wrapped pressure vessels, and future projects improving radiation resistance and shielding.



Exposure of inflatable activity module materials-of-construction with partial GCR space radiation exposure. cle radiation exposure representing a long-term SPE

## PARTNERSHIPS / COLLABORATIONS

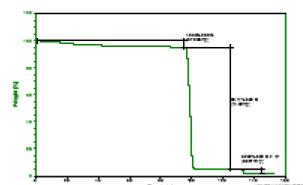
This project partners with radiation experts at BNL NSRL (Rusek and Sivertz), and structures and materials experts at JSC (Inflatables: Valle and Shariff; Composite Habitats: Litteken; Space Suits: Peters and Ross; Hypervelocity Impact Testing: Lear), Honeywell (Waring), and NanoSonic (Lalli).

## PAPERS / PRESENTATIONS

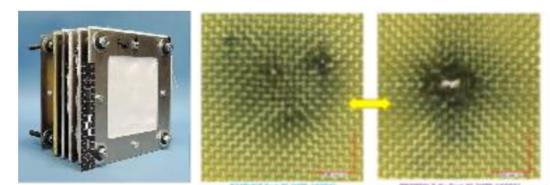
A NASA Investigative Report is being completed for Year 1 and 2 results including recommendations for long-term durability of inflatable and space suit materials in their respective space radiation environments. Findings will be integrated into new NASA standard protocol for certifying nonmetallic materials for space radiation environments based on NASA-HDBK-6015.

## FUTURE WORK

FY17 work focuses on completing permeation testing, hypervelocity testing, and testing of new generation inflatable bladder and composite habitat materials. Once testing is complete, the need to implement any engineering controls will be assessed. Future work also may include developing strategies to reduce cabin dose by placing absorbers to trap secondary species generated by GCR nucleons, and examining the combined effect of radiation and physical aging.



Thermogravimetric weight loss



Hypervelocity Impact Testing showing the effect of 1-GeV protons