

Glenn Extreme Environments Rig Status and Recent Testing History. L. Nakley, D. Vento, J. Balcerski, T. Kremic *NASA John H. Glenn Research Center at Lewis Field, 21000 Brookpark Road, Cleveland, OH 44135*

History: The Glenn Extreme Environments Rig (GEER) first became operational in the early part of 2015. Since that time GEER has completed a number of scientific tests and has undergone improvements in the chemical delivery system and analytics following a year of operations experience.

Recent Updates: In June 2016, the GEER process system was rebuilt to provide a more robust system, higher accuracy and new capabilities. New insulation was installed on the exterior of the pressure vessel and gas lines. The newly revamped GEER plumbing system can provide extremely precise custom gas mixtures using any gas desired by the investigator in any combination. GEER can heat the resulting mixture up to 500 deg C and 1500 psia.

The 304 stainless steel vessel walls were polished to reduce corrosion rate and reduce unwanted chemical reactions. The process lines were replaced with high purity Sulfinert coated tubing. The GEER team added the ability to individually boost specialty gases to GEER thus allowing operators to make very precise changes to the gas chemistry inside of GEER during a test while at high temperature and pressure. High accuracy mass flow meters were added to further improve gas mixing accuracy and precision. An in-line, integrated Inficon MicroGC Fusion was added for real time gas analysis along with a high purity gas sampling system, providing fully automated, real time analysis of the gas chemistry inside of GEER in minutes. This complements a co-located mass spectrometer and both are used for regular monitoring of the vessel chemistry. All internal vessel components were replaced with polished 304SS equivalents. Hot vent down capability was increased. Finally, an automated liquid injection system was added and is rated for max vessel operating conditions of (1500 psia, 500 C).

Recent Results and Publications: In May 2016, GEER completed a test that exposed high temperature electronics to Venus surface conditions for 21.5 days. *This demonstrated the potential for operating robotic spacecraft in the Venus environment without the need for thermal or environmental protection.* Results from this test were published in December 2016 and received national media attention [1].

In April 2017 GEER implemented an 80 day test at Venus surface conditions to simulate chemical weathering of expected Venus minerals. This test supported a ROSES award to a team led by Prof. Ralph Harvey of Case Western Reserve University. The test

concluded in July 2017 and nearly doubled previous operation record of 42 days at Venus surface conditions. Preliminary results of these and previous experiments were presented at the recent Venus Modeling Workshop[2].

In June 2017, NASA TM2017-219437 “Chemical and Microstructural Changes in Metallic and Ceramic Materials Exposed to Venusian Surface Conditions” was published. This report provides an extensive and valuable resource detailing the behavior of a variety of engineering materials at Venus surface conditions[3].

Community Involvement: An external science advisory panel has been formed. This panel receives updates on GEER operations and plans, and provides guidance to ensure that the facility continues to meet the needs of the science community. Recent recommendations that are actively being incorporated into the GEER development plan include: expanded capability to service multiple customers simultaneously utilizing additional pressure vessels, enabling solid sample in situ optical analysis to observe real-time material changes during atmospheric exposure, and providing increased clarity and guidance for prospective users and researchers.

Expected Work in the Near Future: A number of future tests are scheduled. Activities will support technology development efforts such as HOTTECH awards, support for the Long Lived In-Situ Solar System Explorer (LLISSE) project[4], and potential science experiments proposed to ROSES.

References:

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- [3] Radoman-Shaw, B., et al. (2017) The Stability of Minerals and Volcanic Glasses on the Surface of Venus. *Venus Modeling Workshop*. Abstract # 8031.
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- [4] Kremic, T., et al. (2016) Long-Lived In-Situ Solar System Explorer. *VEXAG presentation located at: http://www.lpi.usra.edu/vexag/meetings/archive/vexag_14/presentations/27-Kremic-Long-Lived%20Venus%20Station.pdf*