Glenn Extreme Environments Rig (GEER) Facility Users Guide

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1. Introduction

The Glenn Extreme Environment Rig (GEER) is a large capacity pressure vessel capable of simulating high pressure and temperature conditions with a specified, custom mixture of gas. The chamber is certified for operation in physical and chemical conditions representative of the surface conditions of Venus. It can accommodate large scientific or engineering test articles while maintaining the specified conditions indefinitely. The user-configurable gas supply is capable of handling a mixture of up to nine independent streams for injection directly into the vessel. GEER is supported in part by NASA's Planetary Science Division under the Science Mission Directorate and is available for use by the commercial, academic, and research communities.

GEER was operationally commissioned in November of 2014. At that time, it successfully maintained the temperature, pressure, and chemistry of the Venus surface atmosphere. In the spring of 2015, GEER began operations for engineering and scientific research. Since then, over 20 tests have been successfully conducted in the chamber with a variety of atmospheric test conditions.

2. Vessel Capabilities

GEER is a 12-ton, 0.8 cubic meter, corrosion-resistant, cylindrical pressure vessel that was originally designed with the scientific goal of simulating the surface of Venus, with engineering limits of temperature equal to 1000°F (~530 C) and pressure equal to 1500 psi (~105 bar). The gas mixing system delivers precise, controlled quantities of user-specified gases via a bank of gas cylinders. This gas mixing system allows for up to nine independent streams to be injected at controlled concentrations.

While designed for Venus surface conditions, the chamber is capable of simulating other planetary atmospheres within its operational capabilities. See Figure 1.

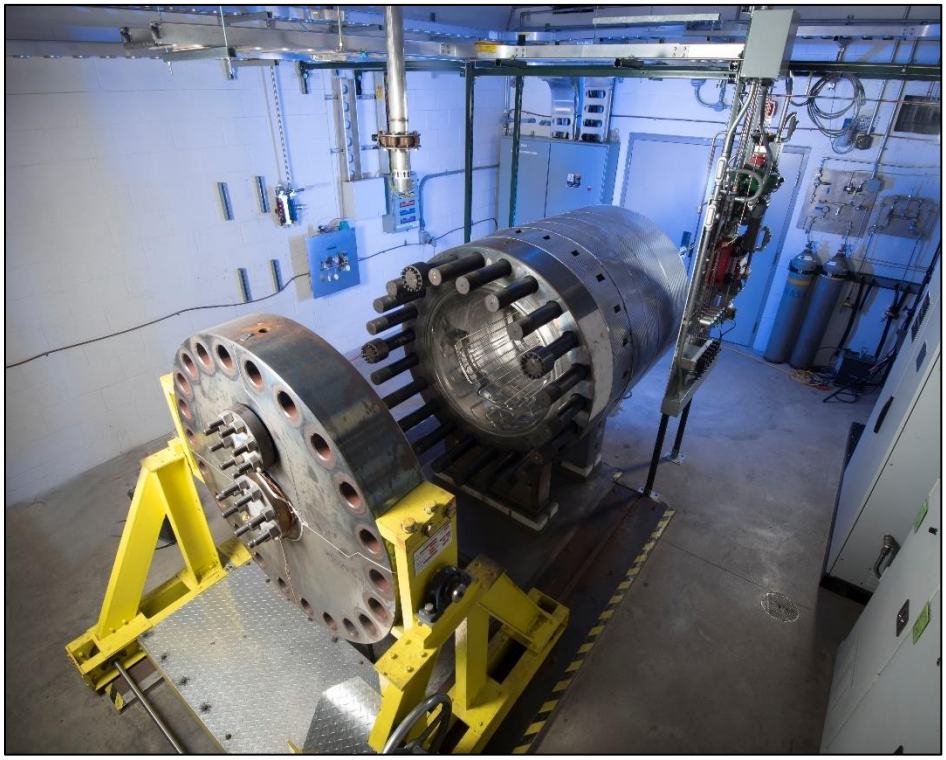


Figure 1 - GEER Vessel

2.1. Chamber Specifications

The GEER chamber is an ASME stamped pressure vessel which is capable of operating within the parameters listed in Table 2. The vessel's internal volume is a cylindrical space approximately 36"

diameter and 48” deep. Due to vessel hardware and instrumentation, the customer test article envelope is smaller than the internal vessel dimensions; see Figure 5. There are nine total flange ports on both the fixed head and the bolted head; two of the ports are 4” diameter, and seven are 3” diameter. See Figure 3 and Figure 4 for locations of the flange ports. Note that four of the 3” flange ports are required for integrating vessel hardware and instrumentation, and therefore are unable to accommodate customer hardware.

Table 2 – Chamber Specifications

Parameter	Chamber Specification
Maximum Rated Temperature	1000 °F (~530 °C)
Maximum Rated Pressure	1,500 psig (~103 bar)
Vessel Body Material	304 Stainless Steel
Vessel Internal Volume	Ø36” x L48” cylinder; Approx. 800 L
# of 3” Flange Ports	7 ports; 3 available
# of 4” Flange Ports	2 ports; 2 available

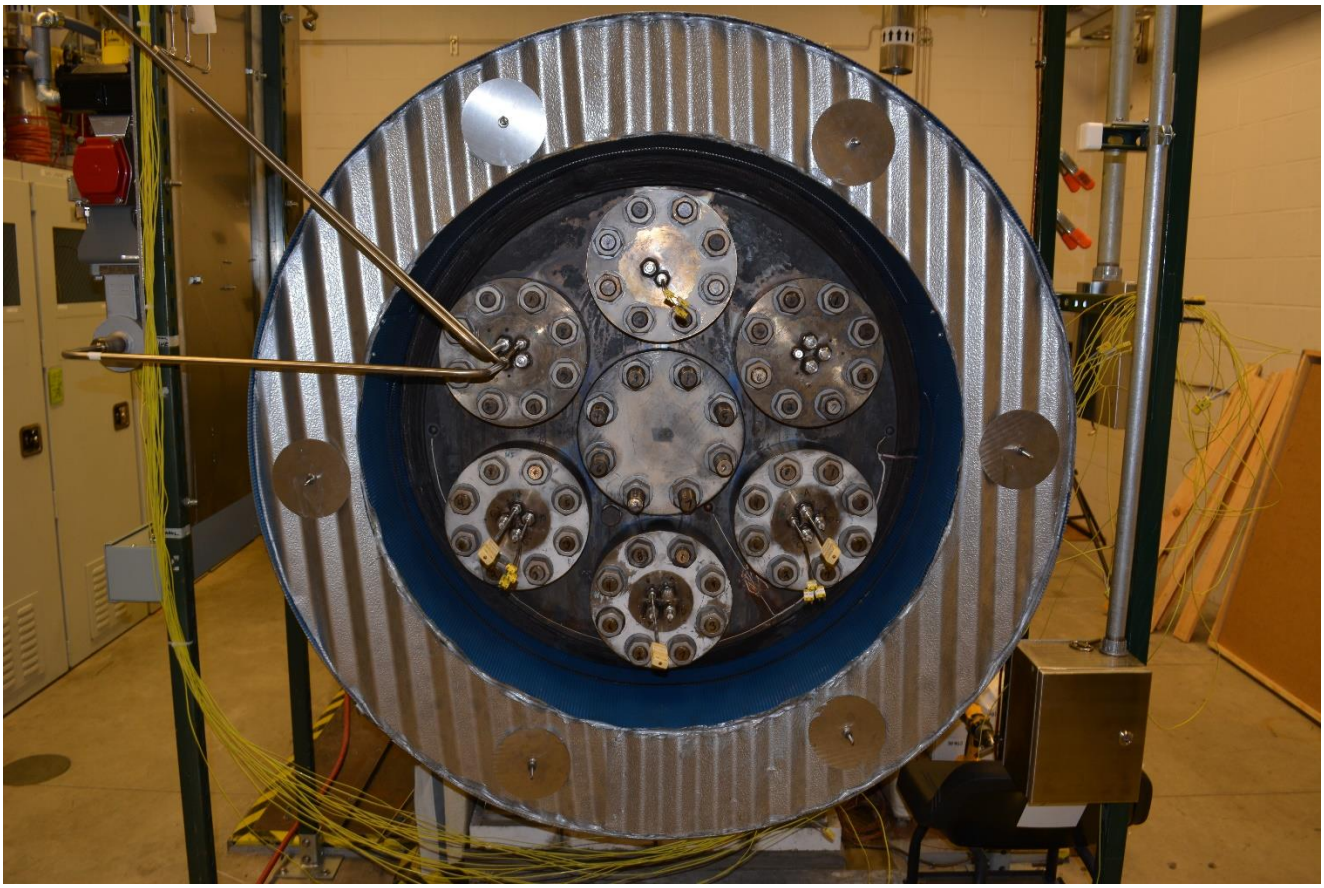


Figure 3 - GEER Welded Head Flanges

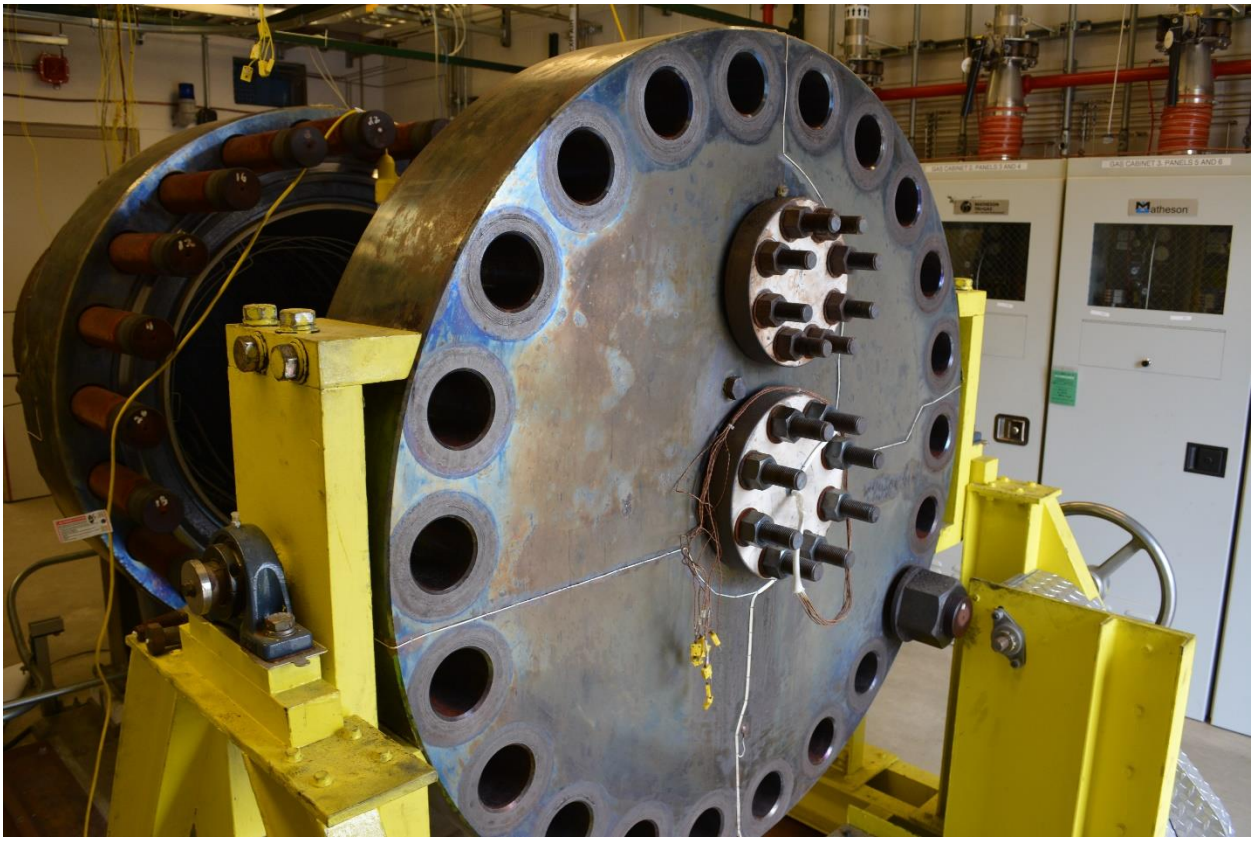


Figure 4 - GEER Head Flange & Flange Ports

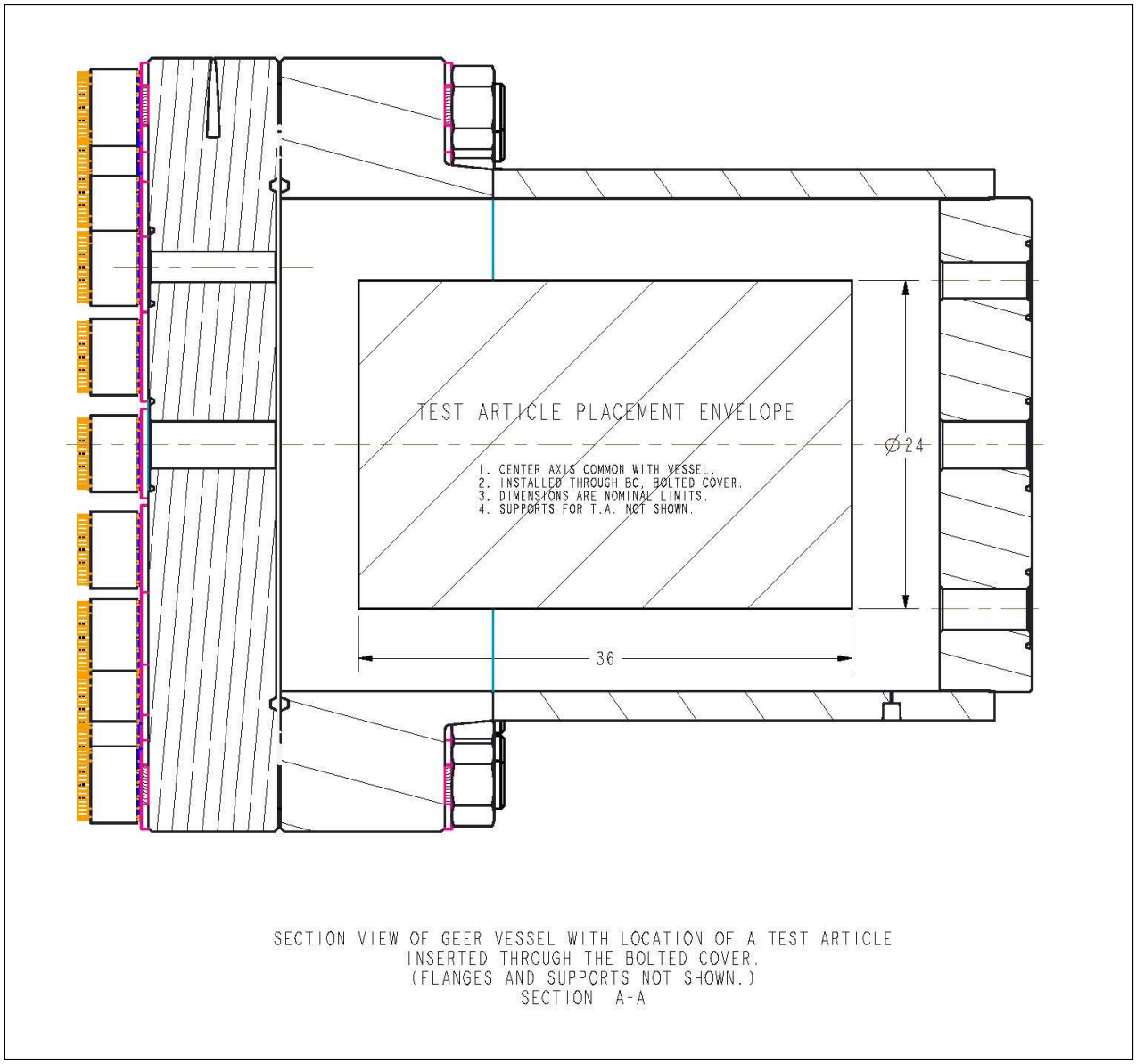


Figure 5 – GEER General Test Article Placement Envelope (dimensions in inches)

2.2. Test Articles and Test Fixtures

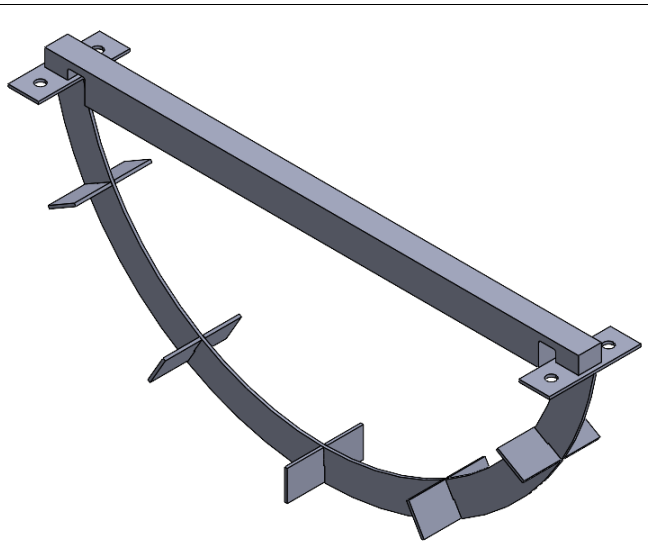
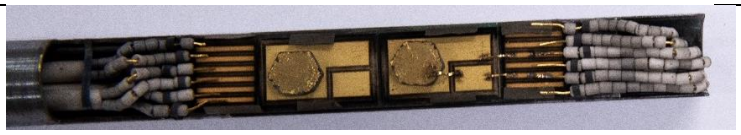
The GEER test chamber is capable of testing a wide variety of test articles. Previous tests have included material samples, geological samples, and active electronics including sensors, integrated circuits, and transmitters/receivers. Different types of existing test fixtures may be available for use depending on the size, weight, and function of a test article. A summary of available fixtures is shown in Table 6.

Proposed test articles will be evaluated based on their material composition. While most samples are accepted, any materials that may cause a hazardous or dangerous reaction within the vessel atmosphere may be rejected. Samples are evaluated by a Material Review Board (MRB) which is comprised of scientists and individuals with GEER operations experience.

Note that multiple test fixtures may not be usable during the same test due to space constraints. Custom fixturing can be fabricated for new test article types. Contact the GEER team for more details for your specific application.

Table 6 – Test Fixtures

Test Fixture	Intended Use	Test Envelope	Picture
GEER Shelf	Large number of small, individual articles	36” x 25” ; ~12” height	
Half Pipe Supports	Small test articles	Ø3” and Ø4” area; up to 42” long	

Arch Supports	Large test articles supported from the bottom of the chamber	Fits in test article envelope: Ø24” x 36” cylindrical volume	
Electrical Feedthrough Platforms	Small electronic samples mounted to alumina substrate or directly to feedthrough body	Must fit within inner ID of ½” or ¾” tube. Longer lengths can be supported. See Figure 8.	
Custom	Custom supports may be designed for your application to fit within the test envelope of Figure 5.		

When possible, the operations team will place small passive samples into alumina trays for organization onto the shelf test fixture. These alumina trays are owned by GEER but may be used to isolate and organize customer hardware. Standard sizes for these crucibles are listed in Table 7; custom sizes may be available by request.

Table 7 – GEER Standard Alumina Crucibles

Crucible shape	Approximate Crucible Size, LxWxH (mm)	Picture
Rectangular	200 x 100 x 25	
Rectangular	100 x 40 x 18	
Rectangular	50 x 20 x 20	
Circular	Ø45 x 45	
Circular	Ø25 x 30	

2.3. Electrical Test Article Interfaces

Electrical interfaces can be established with test articles by the chamber's electrical feedthrough systems. Feedthroughs (sealed power and data cables that are custom built to mate directly to the user hardware) can be provided for a small number of channels. Custom fabrication of feedthroughs may be required, dependent upon test requirements. Several of the 3" and 4" bulkhead user ports may be available to accommodate these electrical signals.

For small electronic test articles (i.e. sensors or components), the article may be directly mounted to the feedthrough tube if place on a substrate material such as alumina. See Figure 8 for an example of this configuration. Please contact the GEER team for further information and capabilities.

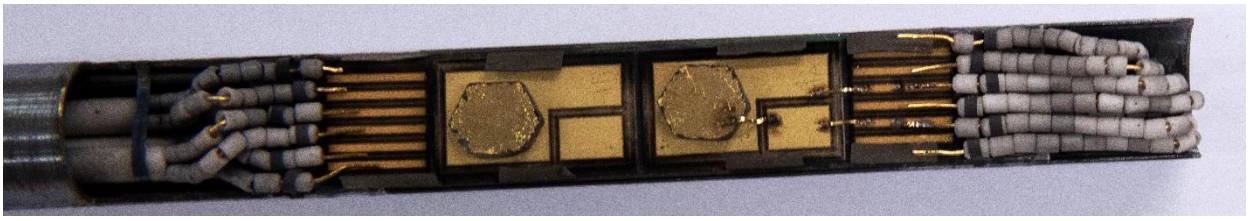


Figure 8 – GEER Feedthrough Direct Mount Envelope Example

Larger electronic test articles may be mounted onto their own test support structure (for example, the shelf). Wires will then be run from the feedthrough and connected to the sample as required. Presently, feedthroughs have been proven to supply + / - 24VDC and low, single-digit mA current per wire. Higher capacity feedthroughs are currently in development, and initial testing has demonstrated a stable supply of 15VDC, 1A for 3 days at Venus surface conditions. Previously, GEER has supported up to 48 electrical wires in a single test. Please contact the GEER team for more details on your specific electronic test article configuration.

2.4. Data Acquisition

Facility data collection occurs via a facility data system which collects calibrated data such as chamber pressure, temperature, and various other measurements. Gas species and concentrations are monitored throughout the test with an in-line 4-column gas chromatogram. A summary of gas analysis results may be available by request after each test. Other analysis methods may be available by request, including an on-site mass spectrometer and a suite of microanalysis facilities and technical personnel (i.e., SEM, EDS, XPS, Auger, and Raman).

Data recording from active test articles is the responsibility of the customer. The GEER team is available to help facilitate hardware setup.

For all samples, pre-test and post-test photographs will be taken. *NOTE: All GEER test photographs are non-restricted data, and they will be processed for public release. Please contact GEER Project Manager, Ike Chi, if your test photographs contain proprietary data.*

3. Test Process Overview

Prior to test startup, there are several events that must occur. These include scope of work, requirement generation, and Material Review Board (MRB) review. A general process flow diagram of test planning is shown in Figure 9.

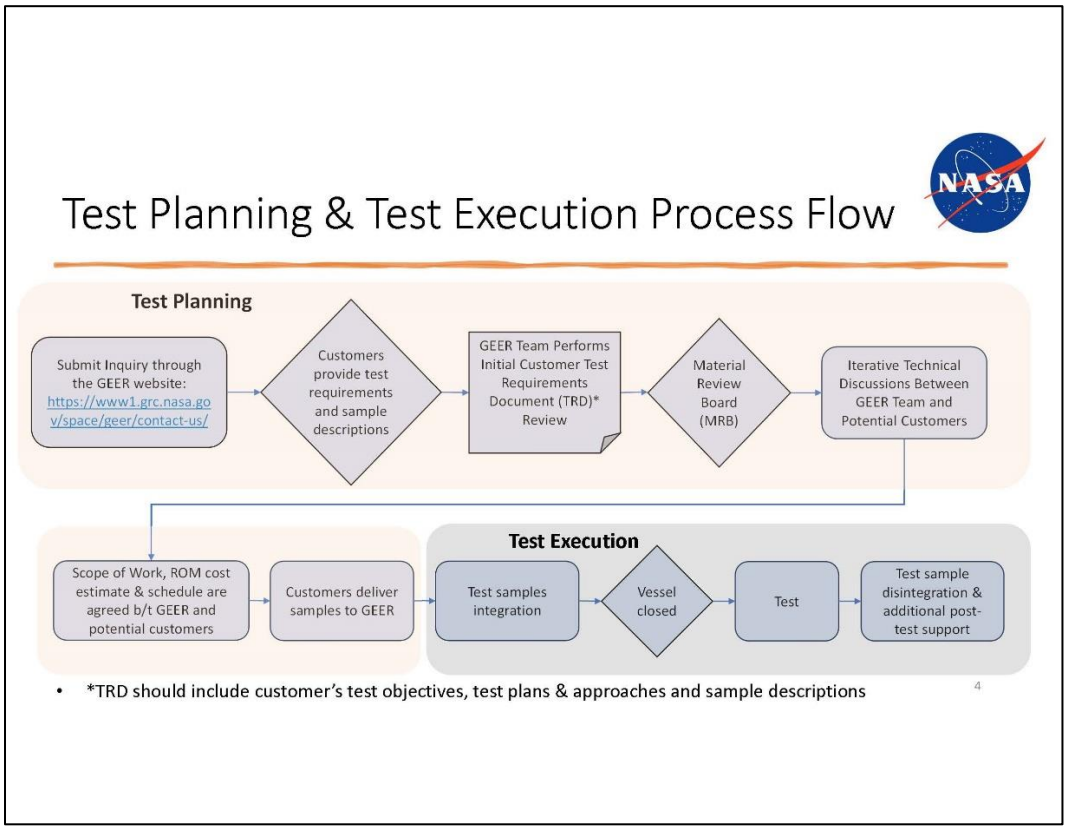


Figure 9 - GEER Process Flow Diagram for Test Planning

Due to the size and nature of the chamber, testing will always include several weeks of preparation both before and after the test. While each test may require unique preparation, a general guideline of test events and their approximate duration is shown in Table 10.

Table 10 – GEER Test Process Flow Duration Estimates

Workflow	Task Description	Duration, approximate workdays
	All samples are loaded into the vessel, mounted & instrumented	Varies
	Vessel bolt-up	3 days
	Leak checks and purge cycles	10 days
	Vessel fill and heat-up	4 days
	Test conditions	Determined by test requirements
	Vessel cool-down	10 days
	Vessel opening and sample unloading	Varies based on complexity of test article(s)
		Minimum: 30 workdays 6 weeks

4. Contact Us

For more information, visit our website at: https://www1.grc.nasa.gov/space/geer/

To inquire about testing opportunities, please contact:

Ike Chi
GEER Project Manager
ike.chi@nasa.gov