Thermal Vacuum System (TVAC) Questionnaire

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To build any bespoke space testing vacuum system, some critical information is required. This questionnaire will help you prepare your RFP process.

At Edwards Vacuum we offer state-of-the-art Thermal Vacuum (TVAC) systems designed for comprehensive space simulation testing, tailored to the needs of space technology manufacturers including spacecraft, satellites, CubeSats, and propulsion systems.
Our systems provide precise thermal and vacuum conditions to ensure reliable performance and durability of space-bound components.

Our advanced TVAC systems ensure that your space technology components meet the rigorous demands of space environments, providing accurate and reliable testing solutions while also allowing you to meet the testing standards of NASA GSFC-STD-7000 and NASA-STD-7012A.

KEY CAPABILITIES:

Temperature Range:

-175°C to +130°C, with options for Refrigerating Heating Circulators or LN2 systems for ultra-low temperatures. Temperatures required outside this range can be evaluated upon request. Bakeout only systems are also available if cooling is not needed.

Chamber Sizes:

From compact 0.3. m (1 ft) cubes, to large 6 m (20 ft) in diameter, and can be customized to any required length. Both cylindrical and cubic designs are offered, with chamber materials available in stainless steel or aluminum.

Vacuum Levels:

Achieve pressures from low vacuum to ultra-high vacuum (UHV), suitable for various mission profiles, including Low Earth Orbit (LEO) and deep space missions.

Custom Integrations:

Integration of primary pumps, turbopumps, cryopumps, ion pumps, and advanced monitoring tools like vacuum gauges, RGAs, and helium leak detectors.

Turn-Key Solutions:

Complete systems meeting NASA standards, including bake-out chambers and thermal cycling systems for comprehensive space simulation testing.

1. Is a chamber required?

Determining if a chamber is necessary defines the overall setup of the TVAC system.
A chamber is crucial for creating a controlled environment to simulate the vacuum of space, which is essential for testing spacecraft components, satellites, and propulsion systems.
Knowing if a chamber is required helps in understanding the scale and complexity of the system needed.

Yes ☐ **No** ☐

a. If yes, what material is to be used?

The material choice for the chamber affects its compatibility with different processes and its ability to withstand various conditions such as extreme temperatures and vacuum pressures.
Common materials include stainless steel and aluminum, each offering different benefits in terms of durability, thermal properties, and cost.
The choice impacts the chamber's performance and the quality of the simulation environment.

b. Chamber geometry: cylindrical or cube?

The shape of the chamber impacts the distribution of thermal and vacuum conditions inside.

- Cylindrical chambers are often preferred for their uniform stress distribution and ease of manufacturing, making them suitable for testing long, slender objects like thrusters.
- Cubic chambers might be chosen for specific testing configurations or spatial constraints as well as testing large, flat components or multiple small satellites simultaneously.

Cylindrical ☐ **Cube** ☐

c. Chamber dimensions

Accurate dimensions of the chamber ensure it can accommodate the test objects, such as satellites or spacecraft components, and fit within the designated lab space.
The dimensions also affect the volume and, consequently, the vacuum pump requirements and the overall system design. Larger chambers may be needed for testing full spacecraft or large satellite arrays.

2. Description of application and process

Understanding the specific application and process allows for the customization of the TVAC system to meet unique requirements.
This includes knowing what the system will be used for, such as satellite component testing, material outgassing studies, or thermal cycling tests.
For space technology manufacturers, this includes testing for outgassing, thermal cycling, and operational readiness of components like solar panels, thrusters, and communication systems under simulated space conditions.

a. What is your process and application?

Gathering detailed information about your process and application helps us designing a system that meets your specific needs. This ensures that all necessary features are included, such as thermal shrouds for uniform temperature distribution or special fixtures for holding CubeSats during vibration testing.

b. If there is a device under test: what are its dimensions, material and number of parts?

The size, material, and number of parts of the device under test influence the internal configuration of the chamber, including the arrangement of thermal shrouds, platens, and fixtures.
It also affects the thermal load and vacuum pumping requirements. For example, testing a CubeSat array requires different setups than testing a single propulsion system.

3. Interior chamber features required: platens, shroud, or other fixtures?

Specifying internal features like platens and shrouds ensures the chamber can support the device under test and provide the necessary thermal management.
These features are critical for achieving uniform temperature distribution and accommodating different test setups, such as rotating platforms for 360-degree exposure or fixtures for holding components at specific orientations.

4. Number and types of feedthroughs?

Feedthroughs allow electrical, thermal, and mechanical connections to pass into the vacuum chamber without breaking the vacuum seal.
Knowing the number and types of feedthroughs needed helps in planning the chamber's ports and ensuring compatibility with external equipment, such as power supplies, sensors, and data acquisition systems used in space technology testing.

5. Vacuum accessories

Accessories like valving, flanges, and viewports are essential for the operation and functionality of the TVAC system. They allow for controlled evacuation and venting, connection of different components, and observation of tests in progress.
For space simulation, high-quality accessories are needed to maintain the integrity of the vacuum and thermal environment.

a. Valving

Valves are used to control the flow of gases in and out of the chamber.
Different types of valves, such as manual or automatic, and their placement are critical for efficient operation and safety of the vacuum system.
In space simulation, precise control over gas flow is needed to replicate different atmospheric conditions.

b. Number, types and sizes of flanges

Flanges provide the connection points for various components of the vacuum system.
The number, types, and sizes of flanges needed depend on the specific equipment and accessories being used. For space technology, robust flanges are required to ensure a tight vacuum seal under extreme conditions.

c. Viewports

Viewports allow visual monitoring of the tests inside the chamber.
The type and number of viewports are chosen based on the need for observation, camera placement, and lighting requirements.
High-quality viewports are essential for capturing detailed images and videos of tests, which are critical for analyzing the performance of space components.

5. Vacuum accessories (contd)

d. Other

Any additional accessories or custom features required for the specific application should be specified here.
This could include items like thermal insulation, special coatings, or additional instrumentation to monitor parameters like radiation or magnetic fields, which are important in space technology testing.

6. Heating or cooling requirements?

Defining the heating and cooling requirements ensures that the chamber can achieve and maintain the desired temperature ranges.
This is crucial for simulating the thermal conditions of space, where temperatures can vary widely, and conducting accurate thermal cycling tests to assess the durability of spacecraft components.

a. Temperature Range

The temperature range that needs to be achieved within the chamber dictates the type of heating and cooling systems required.
For space simulation, the system must handle extreme temperatures, replicating conditions from deep space cold to solar heating, to ensure components can withstand the harsh environment.

b. Type of Cooling System

The choice of cooling system, such as liquid nitrogen or mechanical refrigeration, affects the chamber's ability to reach and maintain low temperatures.
Cooling systems are crucial for simulating the cold vacuum of space and testing the thermal response of materials and components used in spacecraft and satellites.

c. Type of Heating

The heating system, whether it be resistive heaters or another method, must be capable of achieving the desired temperature uniformity and stability.
Heating is essential for simulating solar radiation and conducting thermal cycling tests, which are important for evaluating the performance of spacecraft thermal protection systems.

7. Gases to be pumped?

Different gases have varying properties that affect their pumping and handling requirements.
Knowing which gases will be used helps in selecting appropriate vacuum pumps and ensuring safety measures are in place.
For space simulation, this may include pumping residual air, outgassing products, or specific test gases.

8. What is the required operational vacuum range?

The required vacuum range determines the type and number of vacuum pumps needed.
Different applications may require high, ultra-high, or extreme vacuum levels, each with specific equipment and operational considerations.

9. Time limit to reach operational pressure?

The time required to reach the desired vacuum level impacts the design and capacity of the pumping system.
A shorter time limit may necessitate more powerful pumps or additional pumping stages. Fast pump-down times are essential for high-throughput testing environments, such as production lines for small satellites.

10. Desired vacuum pumps used: types and sizes?

Selecting the right vacuum pumps is essential for achieving the required vacuum levels efficiently. Different types of pumps, such as primary/roughing, turbopumps, cryopumps, ion pumps, or NEG pumps, offer varying benefits and should be chosen based on the specific application.
For space simulation, a combination of these pumps may be used to achieve and maintain UHV conditions.

a. Primary/Roughing pump: wet or dry?

The choice between wet and dry roughing pumps affects maintenance, cost, and contamination risks.

- Wet pumps use oil for sealing and lubrication, which may pose contamination risks for sensitive tests.
- Dry pumps avoid oil contamination and are often preferred for clean processes, such as testing spacecraft components.

Wet ☐ **Dry** ☐ **Edwards recommendation** ☐

b. Turbopump: mechanical bearing or maglev?

Mechanical bearing turbopumps are typically less expensive but may require more maintenance. Maglev turbopumps offer higher reliability and lower vibration, making them suitable for sensitive applications like testing delicate spacecraft instruments or precise propulsion systems.

Mechanical bearing ☐ **Maglev** ☐ **No preference** ☐

c. Cryopump?

Cryopumps provide very low temperatures for capturing gases and achieving ultra-high vacuum levels. They are essential for applications requiring extremely low pressures and minimal contamination, such as testing materials for outgassing or simulating deep space conditions.

Needed ☐ **Not needed** ☐ **Edwards recommendation** ☐

d. Ion pump or NEG?

Ion pumps and Non-Evaporable Getter (NEG) pumps are used to maintain ultra-high vacuum conditions. They have different operating principles and suitability depending on the specific vacuum requirements and gases to be pumped. Ion pumps are effective for maintaining stable vacuum levels over long periods, while NEG pumps are efficient for capturing specific gas species.

Ion pumps ☐ **NEG pumps** ☐ **Edwards recommendation** ☐

11. Desired types and number of vacuum gauges: roughing, HV, UHV?

Vacuum gauges are necessary for monitoring pressure levels within the chamber.
The types and number of gauges needed depend on the range of pressures to be measured, from rough vacuum to ultra-high vacuum.
Accurate pressure measurement is crucial for ensuring the reliability of space simulation tests.

12. System automation/control?

Automation and control systems enhance operational efficiency by allowing precise control of vacuum levels, temperatures, and other parameters.
They also improve safety and repeatability of tests. For space simulation, automated systems can manage complex test sequences, data acquisition, and real-time monitoring.

13. Power requirements

Defining power requirements ensures the system is compatible with the available power supply.
It includes details on voltage, phase, and any limitations on power usage. Space simulation tests often require stable and uninterrupted power to maintain test conditions over extended periods.

The choice between single-phase and three-phase power affects the electrical design and the type of equipment used. Three-phase power is often preferred for its efficiency in handling large loads, such as those required for operating large vacuum pumps and thermal management systems.
The operating voltage must match the local power infrastructure, and the specifications of the equipment used. Incorrect voltage can lead to equipment damage or suboptimal performance, affecting the accuracy and reliability of space simulation tests.

Any limitations on power availability or usage should be specified to ensure the system operates within safe and efficient parameters. Understanding these limitations helps in designing a system that meets operational needs without overloading the power supply.

14. Load lock required?

A load lock allows samples to be introduced and removed without venting the main chamber, maintaining vacuum conditions and improving throughput.
This is particularly useful in production environments or when multiple tests are conducted in succession.

Yes ☐ **No** ☐

a. Backing/roughing valve arrangement needed?

The arrangement of backing and roughing valves impacts the efficiency and control of the vacuum system. Proper configuration ensures optimal performance and safety, allowing for quick evacuation and venting cycles without compromising the vacuum integrity.

15. Communications: Parallel, serial (RS232/485), Ethernet, etc.

Specifying communication protocols ensures compatibility with existing systems and facilitates data transfer and remote control.
This is essential for integrating the TVAC system with other test equipment and for monitoring and controlling tests from a central location.

16. Operating environment (temperature, exposure to elements)

The operating environment affects the design and materials of the system. Considerations include temperature variations, humidity, and exposure to corrosive elements.
Ensuring the system can operate reliably under these conditions is crucial for maintaining test accuracy and equipment longevity.

17. System mobility

Mobility options, such as frame-mounted or cart-mounted systems, determine how the equipment can be used and moved within the facility. This flexibility is important for optimizing lab space and for conducting tests in different locations as needed.

- Frame-mounted systems are typically fixed installations, providing stability and robustness for larger or more complex setups. They are suitable for long-term, high-precision tests where minimal vibration and maximum stability are required.
- Cart-mounted systems offer flexibility and ease of movement, making them suitable for applications requiring frequent relocation or space-saving solutions. This is ideal for dynamic test environments where different setups are needed for various components.

Frame mounted ☐ **Cart Mounted** ☐

18. Service limitations or desired intervals

Understanding service limitations and desired maintenance intervals helps in planning the upkeep of the system, ensuring reliability and longevity.
Regular maintenance is crucial for preventing downtime and ensuring the system remains in optimal working condition.

Notes