ATTACHMENT 1

STATEMENT OF WORK (SOW)
B339 Vacuum Chamber 3 (Shell, Thermal Shroud, and TCU) for Aerospace Power Systems Laboratory (APSL) Facility

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION GLENN RESEARCH CENTER
21000 BROOKPARK ROAD
CLEVELAND, OHIO 44135

80GRC026R0011

PROJECT ID No. 33116

July 10, 2026

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GLENN RESEARCH CENTER AT LEWIS FIELD
21000 BROOKPARK ROAD
CLEVELAND, OHIO 44135

STATEMENT OF WORK

FOR

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Change Record

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STATEMENT OF WORK
B339 Vacuum Chamber 3 (Shell, Thermal Shroud, and TCU) for APSL Facility

1. DESCRIPTION

This Statement of Work (SOW) describes the scope and requirements for the acquisition of special test equipment consisting of thermal vacuum chamber shell, thermal shroud and Thermal Conditioning Unit (TCU) for Vacuum Chamber (VC) 3 proposed to reside inside of B339 Aerospace Power Systems Laboratory (APSL), located on the NASA Glenn Research Center (GRC) campus.

1.1. BACKGROUND

GRC is constructing a new building to support research and development for aerospace power systems. This building will be approximately 34,000 square feet in size with an approximately 19,000 square foot high bay proposed to house multiple vacuum chambers. Vacuum Chamber 3, 4, and 5 are proposed to be the same size, shape, and configuration with matching thermal shrouds and TCUs. This Vacuum Chamber procurement and building design and construction will be happening concurrently to facilitate successful integration. The building is located at the NASA GRC at Lewis Field, 21000 Brookpark Road, Cleveland, OH 44135.

NASA is seeking to procure Vacuum Chamber shell, thermal shroud, and TCU. The equipment sought shall meet the technical requirements and salient features of the equipment outlined in this SOW.

Offerors shall possess capabilities, qualifications, and provide examples showing evidence of relevant experience pertaining to the size, design, manufacture, and final assembly of the vacuum chamber, thermal shroud, TCU. Installations shall include the design, fabrication, activation, and qualification of performance in accordance with accepted industry practices, relevant NASA and industry standards, and this SOW.

2. PHASE 1 – DESIGN

The design shall result in shop design drawings and specifications to produce fully functional, test-verified systems, which meet the project requirements stated below. The shop design drawings and specifications shall be complete in all aspects and shall comply with the standards of practice including those stated in Technical Requirements Summary, Appendix A. The details of design shop drawings must facilitate successful fabrication and installation as well as allow for building details to be determined to successfully integrate the installation of the vacuum chambers into the building.

2.1. SCOPE

PHASE 1 – DESIGN shall include the following activities:

2.1.1. Preliminary technical requirements review with various NASA stakeholders to ensure complete understanding of scope and requirements prior to design.

2.1.2. Review of existing drawings, specifications and other information pertaining to the APSL.

2.1.3. Provide design development calculations for all features of work. These calculations shall be stamped by those professionals responsible for the design, be checked and initialed off by the Contractor's quality control and be consistent with the Design Report format (see below). The calculations shall be updated and submitted as the design progresses.

2.1.4. Preparation of shop design drawings and technical specifications that meet requirements. These drawings and specifications shall be stamped by those professionals responsible for the design, checked for quality and initialed off by the Contractor's quality control.

2.1.5. Coordinate and conduct design reviews with the NASA Project Team.

2.1.6. Provide the products required by section PROJECT DELIVERABLES.

2.2. GOVERNMENT FURNISHED INFORMATION (GFI)

The Government will furnish the following material and information as applicable to all project requirements. The Contractor shall comply with and incorporate into the design and construction all the listed materials and information. These documents are incorporated into this document as if fully rewritten. This information will be provided electronically:

a) GRC-M7300.001, NASA CAD Standards & General Drawing Practices

b) AutoCAD Templates of the NASA border w/title block and title sheet for all new drawings

c) GLM-FE-8500.1, Glenn Research Center Environmental Programs Manual

d) GLM-QS-1800.1, Glenn Research Center Occupational Health Programs Manual

e) GLM-QS-8715.1 Glenn Research Center Safety Manual

f) NASA-STD-8719.17 Revision D, NASA Standard for Ground-Based Pressure Vessels and Pressurized Systems (PVS).

g) NASA Glenn Research Center Construction Contractor Manual, May 2017

h) Drawings and specifications for the construction of the Aerospace Power Systems Laboratory, COF33116.

- These documents are being developed concurrently with Vacuum Chamber procurement and will be provided throughout the project. They will not be available at time of bid and award.

2.3. PROCESS AND PROCEDURE

2.3.1. CHANGES

The design development is an evolutionary process in that, as the design progresses and details develop, there will, of necessity, be potential deviations from the design guidelines established by this and related documents. These deviations are considered to be within the scope of work of the contract, unless a major change occurs that is not within the scope of the fundamental concept of the project. The Contracting Officer

(CO) will determine the significance of any deviation. The Contractor shall not proceed with any deviation from the design guidelines established by this and related documents without the approval of the CO.

The Contractor shall promptly notify the CO of any instructions by the Government that, in the opinion of the Contractor, are not within the established guidelines, and shall not proceed on those instructions until so directed by the CO.

2.3.2. REQUEST FOR INFORMATION

The NASA Request for Information (RFI) process is a communication tool between the Government and the Contractor (and/or other stakeholders) to facilitate the flow of information, project direction, change requests, clarifications, interpretations, other miscellaneous issues and their respective resolutions. The Contractor shall use the RFI process in their conveyance of project issues to the Government for resolution prior to the execution of any subject work. NASA Form GRC-9C will be provided to the Contractor for use and submission with the NASA RFI process. An issuance of an RFI does not automatically imply a cause for a Government approved change proposal.

2.3.3. PROJECT CHANGE PROPOSAL PROCESS

Change can and will occur on any project. Changes to the approved plans or specifications include revisions, deletions, additions, and substitutions to the work prescribed on the approved plans or specifications. Therefore, the change proposal process, in conjunction with subject RFIs established between the Government and the Contractor, shall support the negotiations and contract modifications required to adjust costs and/or schedules for the project. RFIs resulting in requested change proposals sponsored by either the Government or the Contractor (and their team) shall include the following information as applicable:

a) A reason for the sponsored change.
b) Calculations, product cut-sheets, cost estimates, technical justifications, and other back-up information necessary to demonstrate the changes being submitted.
c) The designer of record (DOR) related to the change shall professionally stamp and sign all documents presented. Note that all drawings must be stamped and signed; all sketches must be signed.
d) Cross-reference and label all supplied documents to the subject RFI.

2.4. DESIGN SCHEDULE

The Contractor shall prepare a design schedule (use of Microsoft® Project is preferred) for this project. The schedule shall include a graphic schedule (Gantt chart) indicating sequence of events and interrelationships using the critical path method (CPM). This schedule shall be of sufficient detail to demonstrate the Contractor's understanding of critical tasks and the sequencing necessary to execute the project. The schedule shall be updated monthly and submitted to the Government reflecting work progress (planned and/or performed) during the execution of this project.

2.5. CONFERENCES AND MEETINGS

2.5.1. PRELIMINARY REQUIREMENTS REVIEW

The Contractor shall schedule with NASA a technical requirements review meeting prior to the start of the design phase. This meeting shall include key personnel, technical partners and sub-Contractors. This preliminary review shall be scheduled to occur within twenty-one (21) working days of the Award. The Contractor shall record minutes from this meeting and present NASA with record of those minutes within five (5) working days of the conclusion of this meeting. Forward actions and assignees shall be clearly noted in these minutes.

2.5.2. PROJECT STATUS MEETINGS

The Contractor shall attend routine project status meetings scheduled by the Government. Subcontractor representatives, if any, shall attend. Project status meetings will typically be one hour in length and may be conducted by teleconferencing using Microsoft Teams. The Government shall provide a toll-free teleconferencing number for use by all attendees.

2.5.3. PROJECT DESIGN REVIEWS

Scheduled project design reviews will be hybrid (Microsoft Teams and in-person) at Glenn Research Center. Scheduled project meetings shall include the following:

a) Preliminary Design (50%)
b) Critical Design (90%)

2.5.4. ELECTRONIC COMMUNICATION

Other meetings and electronic communications between the Contractor's representatives and the NASA project team shall take place to ensure complete communications and agreement of ideas and expectations to achieve the final objectives. The Government shall establish an on-line shared repository (SharePoint site), to be accessible by designated NASA and Contractor project personnel. The files contained therein shall be in Adobe® PDF format where practical to aid in dialogue but prohibit unauthorized revisions.

2.5.5. CORRESPONDENCE

The Contractor shall be responsible for taking notes at all conferences and meetings. Pertinent items in telephone conversations between the Contractor's representatives and NASA project team shall be included in these notes. Notes from conferences, meetings, and telephone conversations shall be submitted within five (5) working days of the occurrence. The Contractor shall acknowledge, in the conference notes, transmittal of any material between parties, submit copies of any correspondence pertinent to the execution of the contract, and provide a brief statement of job progress. The above information shall be transmitted to the NASA Project Manager

via e-mail for forwarding to the NASA project team as required. If the NASA project team has any comments concerning the notes, they will so advise the Contractor within five (5) working days of receipt of the notes, and these comments shall be included at the beginning of the next scheduled set of notes.

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2.5.6. SUBMITTALS

a) The Contractor shall transmit to the NASA Contracting Officer Representative (COR) or appointed designee for review and approval submittals of the various contract documents (shop drawings, calculations, material certifications, test reports, etc.).
b) Ten days prior to each design review meeting, the Contractor shall electronically submit the completed progress level Shop Drawings and schedule; complete sets of design calculations and back-up data. The Contractor shall correct the deficiencies and resubmit at the same progress level until the submittal is approved.
c) Each submittal will be reviewed by the NASA project team with approval and/or comments and shall be returned to the Contractor at the corresponding progress level meeting scheduled or product issue within ten (10) working days after receipt. All changes will be reviewed for incorporation into the design and construction.
d) Other changes that may evolve at the review meetings will be resolved and incorporated, or the decisions regarding them will be forwarded by NASA to the Contractor within five (5) working days for inclusion in the remaining design engineering work.
e) All NASA comments are to be incorporated unless specifically excepted by the Contractor in writing and with acknowledgement by the Government. The Government shall have the final decision authority on incorporating changes even if they bear cost and schedule implications for which the Government is ready to bear that cost and/or delay.

2.6. PROJECT DELIVERABLES

2.6.1. PROGRESS LEVELS DURING DESIGN

Progress level meetings shall be held as hybrid meetings both at NASA GRC and on Microsoft Teams at which time the Contractor shall provide the design status and submittals by presenting the information contained in the proposed level of the Progress Level Design Report. The Contractor shall coordinate the sessions with the Government jointly to facilitate the attendance and participation of all stakeholders. The minimum requirements for design submittals at each progress level are as follows:

<u>For the Preliminary Design (50%) and Critical Design (90%) Progress Levels:</u>

a) Disposition of comments from previous review cycle (receive at 90%)
b) Description of the design (narrative), salient features, etc.
c) Shop Drawings of the vacuum chambers with materials identified with dimensioned shell design showing ports, doors, utility connection points (LN2, GN2, power cabling, etc,), overall weight, weight of components to be delivered to site, etc. Provide details on each individual section and method to join sections onsite (weld, gasketed flange, etc.).
d) Shop Drawings of the thermal shrouds with materials identified, dimensions, flow rates, heat rejection rates, etc.
e) Specification or cut sheets for the TCUs
f) Preliminary implementation plan
g) Testing and validation plans
h) Design report
i) Calculations
j) Production and installation schedule

<u>For the Final Design (100%) Deliverable:</u>

The Final Design deliverable shall reflect the submittal made for the Critical Design (90%) progress level review, as amended with the comments and modifications resulting from that review. The Final Design deliverable shall be sufficiently complete to allow for manufacturing and installation at the APSL facility and shall be marked as ISSUED FOR CONSTRUCTION. In addition to the items provided at the progress level reviews, the Final Design deliverable shall also include the following:

a) Evidence demonstrating the incorporation of the previous progress level comments and other relevant correspondence.
b) Electronic submission of all native AutoCAD drawings generated for the project. NOTE all x-refs and blocks shall be bound to their respective drawings such that the drawing can be used as a standalone file without requiring additional and/or supplemental files and programs. Provide both PDF and DWG formats.
c) 3D files in .STP format (SolidWorks native files if available).
d) Native model files for design and analysis models such as CAESAR, ANSYS, FLUINT or other design and analysis tools used during design.
e) The Final Design deliverable shall be submitted and delivered electronically.

3. PHASE 2 – IMPLEMENTATION

3.1. SCOPE

The scope of this phase is to implement (fabricate, construct, install onsite, and validate) the design approved by NASA in PHASE 1 – FINAL DESIGN.

3.2. SCHEDULE

NASA requires that all project work be completed within 1380 calendar days from contract award (start of PHASE 1). This completion date includes onsite installation, onsite acceptance testing, demobilization from the site, final site cleanup, and receipt/approval of all closeout documentation.

Onsite installation timeline of the vacuum chambers is contingent upon the construction of the APSL facility which is occurring concurrently with this procurement. It is envisioned that the facility will be ready for the onsite installation of Vacuum Chambers 1, 2, 3, 4, and 5 by January 2, 2030. Coordination with NASA will be required to facilitate completion of onsite work. The Contractor should not ship equipment to site until installation timeframe shown above and as confirmed by NASA.

Following onsite installation, the Contractor will perform Acceptance Testing as stated in the Technical Requirements Portion of this document. NASA final acceptance will be contingent upon successful completion of the Acceptance Testing.

3.3. PROCESS AND PROCEDURE

In addition to the Processes and Procedures required in PHASE 1 – DESIGN, these additional requirements apply throughout PHASE 2 – IMPLEMENTATION.

3.3.1. CONSTRUCTION CONTRACTOR MANUAL

The Construction Contractor Manual provides very specific information regarding the requirements of performing activities on the GRC campus. The Contractor is expected to have read and understood this Construction Contractor Manual as a condition of offering. Failure to acknowledge these requirements does not constitute the basis for compensable change after award.

3.3.2. GOVERNMENT INSPECTIONS FOR QUALITY ASSURANCE AND SAFETY

NASA, during the course of this project, will be providing its own team of Quality Assurance Technicians, Engineers and Inspectors to represent the interests of the Government. This action does not relieve the Contractor from providing its own team for Safety, Quality Assurance and Quality Control. The Contractor shall make all areas of the overall project available daily to the NASA Project Team and designees during normal business hours, extended/off-hours and by request. All contract documents shall be made available on-site to the NASA Project Team members at all times, which is in concurrence with or in addition to the contract. The NASA Project Team or designees will provide a representative(s) for all Government witnessing on project elements such

as but not limited to site safety, factory acceptance testing, third party tests, material and equipment installations, pressure testing, equipment activation, etc. The Contractor shall not cover or otherwise obscure any project work prior to the witnessing of the Government. Full coordination and cooperation between the NASA Project Team and Contractor Team are required for Government inspections.

3.4. DELIVERABLES

3.4.1. CONSTRUCTION SCHEDULES

The Contractor shall prepare a detailed procurement and construction schedule for this project indicating key elements of the project such as procurement, fabrication, shop testing, onsite installation, and onsite acceptance testing. The schedule shall include a graphic schedule (Gantt chart) indicating sequence of events and interrelationships using the critical path method (CPM). For onsite work, overtime and off-normal hours shall be indicated in the schedule. For onsite work, the schedule shall account for Federal Holidays (non-workdays) and include an allowance for non-workdays as directed by the Contract. The schedule shall be updated and submitted to the Government reflecting work progress (planned or performed) once monthly during the execution of this project.

3.4.1.1. LEVEL OF DETAIL REQUIRED

Develop the Project Schedule to the appropriate level of detail to address major milestones and to allow for satisfactory project planning and execution. Failure to develop the Project Schedule to an appropriate level of detail will result in its disapproval. The Contracting Officer will consider, but is not limited to, the following characteristics and requirements to determine appropriate level of detail.

3.4.1.2. PROCUREMENT ACTIVITIES

Include activities associated with the critical submittals and their approvals, procurement, fabrication, and delivery of long lead materials, equipment, fabricated assemblies, and supplies. Long lead procurement activities are those procurements that are not readily available and must be ordered, coordinated and delivered by a Contractor or supplier. The sequence of submittal preparation, submittal review and acceptance, fabrication/assembly/shipping and delivery should be expressed in the schedule.

3.4.1.3. MANDATORY TASKS

Include the following activities/tasks in the initial project schedule and all updates.

a) Long procurement activities
b) Submission and approval of Operation and Maintenance (O&M) manuals.
c) Submission and approval of as-built drawings.
d) Commissioning plan submission.

e) Onsite work durations.
f) Commissioning and activation testing.
g) Training and demonstration sessions.
h) Performance Verification testing. Include required permitting planning timeframes.
i) Contractor's pre-final inspection and punch list activities.
j) Correction of punch list from Contractor's pre-final inspection.
k) Government's pre-final inspection.
l) Correction of punch list from Government's pre-final inspection.
m) Final inspection.
n) Beginning of warranty period(s).

3.4.1.4. CRITICAL PATH

Show all activities on the critical path. The critical path is defined as the longest path.

3.4.2. CONTRACT SCHEDULE OF VALUES

The Contractor shall prepare and submit for approval a Schedule of Values for the project. This will be utilized for progress tracking and progress payments throughout the project. Each project element shall be separately decomposed according to a Work Breakdown Structure (WBS) coordinated with the project schedule. The Schedule of Values shall include the following: Items under each milestone, Unit Quantity, Unit of Measure, Unit Cost (Labor), Total Cost (Labor), Unit Cost (Material), Total Cost (Material) and Total Item Cost. Shipping costs shall be added to the total material cost. Supervision, overhead, profit, and bond shall be added to the compiled costs. The Schedule of Values shall be based on AIA Document G702 and G703 or other NASA approved form.

The Government shall withhold two percent (2%) of the contract value for the final acceptance punch list, as-built drawings and O&M manuals, totaling six percent (6%) of the contract value. Payment on these line items will be made only when the submission of each item is 100% complete and accepted by the Government. The Schedule of Values shall include specific line items for each of these withholdings.

3.4.3. SITE SPECIFIC HEALTH AND SAFETY PLAN

NASA policy requires that Contractors submit site-specific safety and health plans (SSHASPs) as part of the contract and as described in the NASA GRC Safety Manual (GSM). Refer to GSM Chapter 17 - Construction Safety and Health. The plan will demonstrate the seriousness of the Contractor's intent to excel in its implementation of its safety and health program as an early indicator of its safety culture. The Contractor shall submit the SSHASP to NASA for acceptance prior to any field implementation. The Contractor may update the plan at any time or at the direction of the Government.

Revisions are subject to Government review and approval prior to the execution of any subject field operations.

A Notice to Proceed (NTP) for onsite work will be issued **AFTER** NASA approves the Contractor's SSHASP. No on-site work shall begin without a NTP letter signed by the Contracting Officer.

3.4.4. IMPLEMENTATION PLAN

The Contractor shall prepare a comprehensive *Implementation Plan* and submit the plan to NASA for review and concurrence with the SSHASP. This plan shall include, but need not be limited to, the following outline items:

a) Project description
b) Construction periods
c) Personnel impact
d) Utilities impact
e) Other conditions or hazards
f) Temporary facilities (e.g. job trailers, port-a-johns, dumpsters, lay-down areas, etc.)
g) Safety review
h) Required permits and forms
i) Security requirements
j) Off-hour work
k) Equipment delivery

3.4.5. QUALITY ASSURANCE / QUALITY CONTROL (QA/QC) PLAN

The Contractor shall submit for record, a Quality Assurance and Control Plan demonstrating an effect quality control program. This document should define the Contractor's plan to apply relevant assurance principles and techniques to ensure the project will be successfully accomplished and the applicable contract requirements and specifications will be satisfied. The plan shall identify all elements of the quality assurance organization, and describe the objectives, implementation policies and procedures, and configuration control systems utilized throughout design, development, fabrication, delivery, and commissioning to provide quality products and materials.

3.4.6. WARRANTIES

The Contractor shall provide a 3-year warranty, valid from the date of acceptance of the work by the NASA. NASA Glenn Research Center interprets this as 3 years from the final acceptance date.
Subcontracts or Supply Purchase Orders shall include these provisions. The following clarifications are made to ensure complete understanding of warranty provisions:

The Contractor shall operate and maintain all equipment and systems installed during the acceptance testing phase until the contract final acceptance date. Following final

acceptance, the Government will assume O&M responsibilities in accordance with the manufacturer's recommendations.

The Contractor shall provide a written 3-year warranty from the contract final acceptance date to the Government covering all materials, labor and workmanship. Warranty repairs may require the services of subcontractors or suppliers but shall be managed and coordinated by the prime. The Contractor shall provide a 3-year certificate of warranty from each supplier or provider for all purchased equipment or systems.

This provision is not affected by the Government's beneficial use or occupancy prior to the final completion. The warranty date may be adjusted throughout the course of his contract as required to include contract time extensions with an equitable adjustment to the contract. Should the Contractor complete the work ahead of schedule, the warranty provisions will be revised to reflect the actual completion.

3.4.7. TRAINING

Provide in-person hands-on training for up to eight (8) designated operating and maintenance staff members. Training may be performed at Contractor facility. A qualified engineer or technician shall provide training for a period of not less than 8 hours of normal working time and shall start after the system is functionally complete but prior to the final acceptance test. The instructions shall cover all of the items contained in the approved Operating and Maintenance Instructions. Provide written training materials for each person attending, listing step-by-step procedures required for system startup, operation, shutdown, calibration and routine maintenance. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine operations and maintenance including simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

3.5. CONFERENCES AND MEETINGS

3.5.1. PROJECT MEETINGS / REPORTING

The Contractor shall attend project meetings scheduled by the Government. Subcontractor representatives shall attend. Scheduled project conferences for construction progress will be held hybrid both in person at GRC and on Microsoft Teams.

For each of these project meetings, the Contractor shall prepare a Two-Week Planning Schedule, highlighting design, fabrication, and installation progress, coordination issues and updates to the baseline schedule. Meeting minutes shall be kept by the NASA Construction Manager and distributed by the NASA Project Manager.

3.5.2. MONTHLY PROGRESS REPORTING

The Contractor shall provide a monthly progress report at the beginning of each month after the Contract Award. The monthly project progress report shall include the name of the project, name of the Contractor(s), date of the report, reporting period and a brief project description. The Monthly Progress Report shall cover five specific areas as listed below:

a) A description of technical progress and accomplishments, problems encountered and planned solutions for the existing reporting period and progress planned for the next period.
b) An updated copy of the Gantt chart schedule showing progress against plan with the critical path identified.

3.6. CONSTRAINTS AND ADMINISTRATIVE REQUIREMENTS

3.6.1. PROJECT SUPERVISION

For on-site activities the Contractor shall designate and provide a project superintendent to coordinate and oversee all onsite activities. The superintendent is required to be onsite at all times that any work is occurring. The Contractor will provide 100% supervision over all Contractor-directed activities on the project.

3.6.2. DAILY REPORTS

For all onsite tasks, the Contractor shall submit to the Project's SharePoint and/or the Project's Construction Manager, CM, a daily inspection report describing the daily activities for each task. Included in the report shall be the total on-site workforce identified by trade (e.g., 1 Superintendent, 1 Electrical Foreman, 2 Journeyman Electricians, 1 Electrical Apprentice etc.).
Also include in the report the progress of work, hours worked, any delays, interference or schedule conflicts, safety concerns or violations, equipment used, material received or shortages, and any visitors.

3.6.3. INTERRUPTION OF SERVICES

It is intended that all work be performed without disruption to normal activities within the APSL facility. It is expected that APSL will be in the final construction phase and/or recently completed during the installation of the Vacuum Chambers. The high bay area for Vacuum Chambers 1, 2, 3, 4, and 5 will be designated for project work area during installation, but coordination with NASA and other Contractors will be required. It is expected that the Contractor will have access to the building loading dock and 10-ton crane to maneuver equipment into position as required. Tasks must be planned by the Contractor and approved by the Government to minimize the impact to the building operations.

3.6.4. PROTECTION OF GOVERNMENT PROPERTY

Government facilities and equipment must be protected from damage at all times.

The Contractor shall provide protection for personnel and equipment when working near live electrical equipment. Electrical equipment, including suspended cable trays, shall be protected in a manner that prevents damage from inadvertent contact/collision, falling objects, hot work (e.g. sparks, weld slag, etc.) and leaks/spills.

3.6.5. TEMPORARY FACILITIES

Power is envisioned to be available at the APSL Facility for Contractor use. The Contractor shall provide any additional temporary power, lighting and ventilation throughout work areas as needed to ensure safe and productive working conditions. Temporary electrical circuits shall not be installed in any live electrical panel without the express permission of NASA. All temporary provisions shall be completely removed by the Contractor upon project completion.

The Government does not require the Contractors to have a work trailer on-site, but the Contractor may request a space for the placement of a work trailer. If desired, the Contractor shall provide office space needed for the Contractors' use (e.g. job site trailer). Electricity of these temporary services will be provided free of charge; 120/208 and 480 electrical volt feeder service is available in limited amperages. The Contractor shall provide materials and labor necessary to establish this power.

No phone service is/nor will be made available. It is common at this project site to utilize cell phones. Contractor cell phones will be at the expense of the Contractor.

Contractor shall provide temporary sanitary facilities and shall service, clean, and maintain these facilities and enclosures. Temporary facilities shall be removed from the site at the completion of the work. Contractor personnel are not permitted to use the facilities of the building.

Dust control within occupied buildings (including construction workers) shall be reviewed with NASA's Industrial Hygiene Personnel to ensure employee health and future building cleanliness standards.

The Contractor shall provide refuse bins and dumpsters for use during contract activities. Use of NASA refuse bins and dumpsters is not permitted. Refuse bins shall not be overloaded. Liquid materials shall not be placed in dumpsters or bins. Leaking dumpsters shall be replaced. Dumpsters and bins shall not be cleaned on-site. Dumpsters shall remain covered except when actively being loaded.

3.6.6. RESTRICTED ACTIVITIES

Precautions will need to be followed for activities that could endanger building occupants, bystanders, visitors or others. These activities may need to be performed after normal business hours or coordinated with NASA so that appropriate setback distances and safety perimeter are achieved. Restricted activities

a) Pneumatic testing of pressure or process systems

b) Radiographic examination or testing

These activities must be scheduled for off-hours (e.g. 2nd or 3rd shift), weekend shifts, or coordinated with NASA to be performed acceptably during regular business hours. Approval of requests for these activities are subject to NASA operational schedules and will be considered on a case-by-case basis. NASA shall incur no additional costs for performing these activities during off- hours or weekend shifts.

3.6.7. SITE ACCESS AND CODE OF CONDUCT

H.21. CONTRACTOR DUTIES AND RESPONSIBILITIES ON-SITE
Badges: All Construction Contractors who need to enter a NASA Facility to perform work will be required to have an identification badge.

Temporary Badge – Visitor's Badge:
The official visitor pass allows only physical (not IT) access to NASA. It may be issued to individuals requiring access for a period not to exceed 29 days in any single visit and not more than a cumulative total of 29 days in a 365-day period.

A Permanent Badge (sponsor) Prime Contractor must use the Enterprise Visitor Access Management System (EVAMS) NASA agency tool to create and submit a visitor's request for the visitor. The Sponsor and the Visitor must follow a number of approval steps to complete the registration. All visitors ages 18 and over (including bus drivers for scheduled groups) are required to present one form of current government-issued photo identification. Identification must be one of the following: (NOTE: The ID presented at check-in MUST match the ID and Identity used to register the visit in EVAMS):

- Driver's license or ID card issued by a state and meet the REAL ID standards*.
- Driver's licenses that do not have photos cannot be used for photo identification.
- U.S. Passport or U.S. Passport Card
- ID card issued by a U.S. federal, state or local government agency or entity provided it contains a photo and name (e.g., U.S. Military ID card, PIV badge)
- NOTE: Must also have a valid U.S. Permanent Resident Card or Alien Registration Receipt Card (I-551) present at check-in if the visitor is a Legal Permanent Resident (LPR)
- Employment Authorization Document (I-766) provided it contains a photo

NOTE: If a current and valid form of government-issued photo identification cannot be presented, access to the Center will be denied.

The visitor will present the Visitor Control/Badging Officer with a valid government ID (listed above) to be processed for the visitor's badge. Once the

check-in is complete, EVAMS will send an email to the visitor's sponsor to notify them of the visitor's arrival. The visitor will have access onsite only for the dates and times listed on the badge.
* State-issued driver's license or state-issued personal identification card must be compliant with the REAL ID Act of 2005, Public Law 109-13. Information on the REAL ID Act of 2005, Public Law 109-13, requirements can be found at: https://www.dhs.gov/real-id/real-id-faqs

Local Badge – Long-term visitors:
A Local Badge is required for individuals who requiring routine physical access (no IT) at a NASA Center for longer than 29 days but less than 179 days in a calendar year (which can be extended at the discretion of the Center Chief of Protection Services.) Allow a minimum of 7 to 10 business days for processing may take longer in some cases.

To begin the process a Requestor (NASA Requestor or approved PIV Badge Prime Contractor Requestor**) will create an identity for the individual worker in the Identity and Access Management Tool (IdMAX). The Requestor and the Worker will be required to complete a number of actions before the Worker will schedule their appointment with the Badging Office. Workers will need to provide their I-9 Acceptable Documents at the time of the appointment. (Driver's license or ID card issued by a state and meet the REAL ID standards). *

* State-issued driver's license or state-issued personal identification card must be compliant with the REAL ID Act of 2005, Public Law 109-13. Information on the REAL ID Act of 2005, Public Law 109-13, requirements can be found at: https://www.dhs.gov/real-id/real-id-faqs.

** To become an approved PIV Badge Prime Contractor Requestor – Requestor training in SATERN must be completed (2 courses) and "Requestor" status added to IdMAX by an authorized individual from Protection Services.

At the Badging Appointment, the worker's name will be entered into the NCIC (National Crime Information Center) database and be fingerprinted. This is a minimum requirement for issuance of a Local Badge, additional security measures may be employed at the discretion of the Badging Officers or Center Chief of Protection Services (CCPS). Issuing the Local Badge will be based on a risk-based access determination assessed by the program sponsor and as approved by the Badging Officers and/or CCPS. Upon issuance, the Local Badge will be used by the long-term visitor to present and scan the badge at the center's perimeter access control points (ACP) before entry is allowed to the center and as authorized by the gate Security Police Officer.

The Local Badge is a controlled credential and must be protected from unauthorized use, damage, and or loss. It must be reported to Security immediately if the badge has been damaged, lost, or stolen. The badge will be required to be returned to Security at the term of the visit or when no longer needed as determined by the

NASA program sponsor for the visitor.

PIV/ASB – Badges – Prime Contractor Personnel (as needed):
PIV (Personal Identify Verification) Badge or ASB (Agency Smart Badge) also known as a Smartcard Badge will be issued to Prime Contractors' primary personnel. These individuals are the Prime Contractor's personnel that will require both physical access and IT access or will hold the Role of Requestor for workers' Local Badges. (IT Access such as – Project SharePoint, IdMAX, NAMS, etc.) Smartcard Badges are for a period as determined by the NASA sponsor (COR or CO) but no longer than 5 years or the end of the Contract Agreement.

To begin the process a member of the Prime Contractor's team will contact the NASA Sponsor (COR for the Contract) and request a Smartcard badge for a member of their team. The NASA Sponsor, NASA Requestor and the Prime Contractor Team members will be required to complete a number of actions.

Once approved, an IdMAX notification will be sent to the Prime Contractor Team member to notify them to complete Cybersecurity training within SATERN (NASA Training site). Once training is complete, they can schedule their appointment with the Badging Office. The Prime Contractor Team member will need to provide their I-9 Acceptable Documents at the time of the appointment. (Driver's license or ID card issued by a state and meet the REAL ID standards). *

For a Smartcard badge a completed background investigation, fingerprinting, and identity proofing through the verification of external documents such as a birth certificate, passport, social security card and/or driver's license before your NASA identity will be issued.
* State-issued driver's license or state-issued personal identification card must be compliant with the REAL ID Act of 2005, Public Law 109-13. Information on the REAL ID Act of 2005, Public Law 109-13, requirements can be found at: https://www.dhs.gov/real-id/real-id-faqs.

Once the Smartcard badge is issued a NASA Identity is established. NASA Identity is required for IT Access. The NASA Identity requires the individual to take all required SATERN training. The training is mandatory for all NASA Smartcard holders. The training will be automatically applied to the Smartcard holder's SATERN account and must be completed by the due date. The trainings may pertain to topics such as Security, Safety, Environmental, Electrical, Ergonomics, or Center related training.

All lost, stolen, or damaged badges shall be reported immediately to the NASA Office of Protective Services/Badging Office.

Prime Contractor and Subcontractor Badge Holder Separation (Smartcard and Local Badges):
Upon completion, resignation, or termination, employee's badge is required to be returned to the Center's Main Gate/Badging Office by the Prime contractor or the

employee. The badge can also be mailed to the Center's Main Gate/Badging Office, contact the COR of the contract to obtain the address. The Prime will need to notify the COR of the Contract so they can complete a Non- NASA Separation Clearance Record form for individuals with a Smartcard. Security badges are Government property, and any alteration or misuse of these badges may be prosecuted as a violation of Section 499, Title 18, U.S. Code.

3.6.8. COMMERCIAL DELIVERIES

The driver and all occupants will be required to present government issue ID with a picture for positive identification. For all deliveries, a Delivery Request Form https://nasa.readyop.com/fs/4cnq/6491c735 must be completed and submitted. Commercial deliveries should be scheduled during normal business hours and with prior notice there is the possibility that after hours deliveries will be acceptable however due to limited after-hours security staffing and or traffic volume, delays with processing a delivery may occur. Deliveries that are time sensitive or may expire should not plan to be delivered after hours. Some examples are concrete deliveries or delivery companies which prevent their drivers from waiting longer than 45 minutes.

- The Delivery Sponsor is a Smartcard badge individual from the Prime Contractor who is responsible for establishing the request for their delivery.
- The Delivery Sponsor or an identified On-site Delivery POC, if different from Sponsor, will be available via mobile phone to confirm the delivery. Failing to be available may result in the delivery to be refused entry.
- The Delivery Sponsor or On-site Delivery POC is responsible for the monitoring of their delivery driver and occupant's movement and/or access throughout the visit.
- The Delivery driver and occupants MUST be U.S. Citizens or legal Permanent Residents (LPR).
- Driver MUST have a valid U.S. driver's license.
- All occupants MUST have a valid form of U.S. ID with photo.
- Vehicles are subject to inspection.

3.6.9. EMERGENCY PREPAREDNESS

Emergencies are defined as incidents involving serious personal injury or damage, incidents that cause possible hazardous conditions, or incidents that require immediate attention of the Protective Service Office/Security. The Prime contractor's Onsite Health and Safety Plan shall include the contact information for Emergency, Fire, Medical, Safety, and Security assistance so employees/workers will know how to make contact in an emergency situation.

For incidents not classified as an emergency, the Prime contractor shall immediately notify the COR of the Contract rather than contacting the emergency numbers.

In the event of any accident investigation activity, the contactor shall cooperate fully with the Government Accident Investigator and the Center Accident Investigation Board. This cooperation shall include interviews at the accident site and/or at a Board meeting.

The contractor shall provide written guidance to its employees in the event of an emergency, an incident other than an emergency, a Center closure, a building closure, a fire alarm, or tornado alarm. The contractor is encouraged to include in this guidance pre-established instructions, when feasible, to employees such that unnecessary delays and confusion may be avoided by employees who may otherwise be awaiting management instructions. For example, the contractor is encouraged to address what actions employees should immediately take in the event of fire, building closure, Center closure (i.e. late Center opening or early center dismissal) for snow or other causes.

3.6.10. TRAFFIC

The Prime Contractor agrees to comply and agrees to require that all of their personnel and Subcontractors will comply with all posted traffic signs, signals, traffic control, and parking requirements.

3.6.11. AFTER-HOUR ACCESS:

After Hours restrictions apply to weekday hours after 6pm and before 6am and all-day Saturdays, Sundays, and Holidays. During After Hours, Contractors with Temporary or Local badges (non- Smartcard badges) will not be permitted to access the NASA Center without advance approval. After Hours access approvals must be coordinated in advance with the COR or other designee.

NOTE: Some NASA Centers may require all badged individuals, regardless of badge type, to follow the After Hour access procedures.

3.6.12. GOVERNMENT PROPERTY ACCOUNTABILITY

Government property and material is subject to the requirements of Federal Acquisition Regulation (FAR) Part 45 and NASA FAR Supplement (NFS) Part 1845. All NASA contractors are required to follow all applicable FAR and NFS regulations as well as applicable NASA Directives. Removal of NASA property without prior authorization is strictly prohibited and is subject to denial of Center access and criminal prosecution. Contractors shall ensure that their employees and subcontractors are familiar with the requirements of the contract with regard to Government Property, including the disposal and removal of scrap and residual materials. The removal of scrap and residual job materials from NASA property requires written approval from the NASA COR or authorized representative.

In addition to the above, Municipal Waste, Recyclables, and Hazardous Materials must also be properly disposed of utilizing the appropriate containers and

collection points for each type of scrap and residual material. Failure to adhere to the proper disposal of these materials or unauthorized use of municipal waste or recycling containers may result in the denial of Center access and possible civil or criminal prosecution for the offender.

Concerns involving the proper removal and disposal of property, scrap, waste, or other residual job materials should be forwarded to the NASA COR.

3.7. PROJECT CLOSEOUT

3.7.1. FINAL ACCEPTANCE PUNCH LIST

A Final Acceptance Punch List (FAP) shall be used by the Contractor and NASA to manage the acceptance of the project. The Government shall be responsible to develop the punch list during the course of the project, including any stakeholder-sponsored items. The Contractor shall facilitate the execution of the complete list to the satisfaction of the Government prior to final payment.

This Final Acceptance Punch List period shall be included in the Contractor's implementation schedule.

3.7.2. RECORD DRAWINGS (AS-BUILT DOCUMENTATION)

The Contractor shall maintain a set of drawings, which depicts the actual as-built conditions of the completed onsite installation, appropriately marked (redlined) with changes, modifications and deviations that have been encountered and incorporated (as-built) in the features of work. These redline drawings provide the project with a permanent record of each project feature. The working as-built drawings must be available on-site at all times throughout the duration of the project and must be available for review by NASA or its designee at any. At the completion of the project, this set of as-built drawings shall be submitted incorporating these changes, modification and deviations such that the final as-built conditions are accurately depicted.

3.7.3. OPERATIONS & MAINTENANCE INFORMATION

Submit O&M Data specifically applicable to this contract and a complete and concise depiction of the provided equipment, product, or system, stressing and enhancing the importance of system interactions, troubleshooting, and long-term preventive maintenance and operation. Submit the aggregate O&M information electronically in .pdf format.

APPENDIX A
TECHNICAL REQUIREMENTS SUMMARY

A new Aerospace Power Systems Laboratory (APSL) at NASA's Glenn Research Center (GRC) will be constructed for the purpose of performing power research for aerospace applications. The building will include a large high bay to be outfitted with vacuum chambers. This task involves the procurement of vacuum chamber shell, thermal shroud, and Thermal Conditioning Unit (TCU) for Vacuum Chamber 3. These vacuum chambers are intended to replicate space-like conditions. Chambers 3, 4, and 5 are matching in size and configuration and should be modular so that the length of the chambers could be extended in the future. These requirements apply to just the vacuum chamber shell, their associated thermal shroud, and their associated TCU. Turnkey solutions including controls, software, pumps, etc. are not desired.

<u>Vacuum Chamber 3 – Shell requirements:</u>

- Interior chamber size: 9' tall x 9' wide x 18' long
    - It is expected that the thermal shroud will surround test section within the overall chamber shell
    - At a minimum provide 6.5'x6.5'x15' clear space inside the thermal shroud; as much space as possible is preferred.
- Rectangular shape, constructed of 304 stainless steel
- Previous experience developing rectangular shaped chambers of this size or larger is required
- Modular sections at 6ft intervals desired
- All welds to be internal full fusion vacuum welds, unless otherwise noted
- Max section weight (prior to final assembly): 10 tons (due to overhead building crane weight limitations)
- 5 x 10^-7 Torr capable
- Leak rate of 1 x 10^-8 STD ATM CC/SEC or better
- Machine polish #4 on all internal surfaces
- 16Ra surface finish on all sealing surfaces no radial lines
- Capable of handling temperatures down to 77 Kelvin and up to 425 Kelvin (-320F to 305F)
- No hardware may be placed on the top of the chamber. All flanges and hardware must be accessible from sides, back, and front of chamber
- Provide up to four 27.5" OD flange mounted to side of chamber to accommodate high vacuum cryopumps on the back quarter of the chamber
- Provide inlet and outlet flanging suitable for the associated thermal shroud on the back quarter of the chamber
- Provide turbo pump flanging on the back quarter of the chamber (ISO250-F)
- Provide two 20" flanges dedicated towards roughing pumps on the back quarter of the vessel
- Provide a variety of additional flanges for research hardware accommodation (at least QTY.12 of ANSI 20" high vacuum flanges
- Provide 20" diameter high vacuum flange on the centerline of the door of the chamber to accommodate viewport for research hardware
- Provide blanks and o-rings for all flanges
- O-ring groove on chamber-side of flange
- Provide lift disc style relief device set for 2 psig
- Various fastening points shall be located at multiple locations inside of the chamber to secure

research hardware

- Vacuum chamber set flat on concrete floor
- Swinging door preferred. Ideally allow opening by personnel without additional equipment.
- Door shall allow full access to the chamber end area.
- Rear end cap shall be removable with designated lift points that will be accessible by overhead crane (max 10 ton weight)
    - Will have internal anchor points for pulling hardware into facility
    - Will have a personnel door on the back end of the chamber (~80" x 36")
- Doors shall have appropriately sized latching mechanisms to lock door prior to pump down
- Testing will involve lunar simulant soils (JSC-1/1A)
- Design and fabrication must comply with NASA Standard 8719.17 Revision D. Some high level requirements from 8719.17 are found below:
    - Materials other than those specified for use in ASME BPVC Section VIII and its reference documents may be used; however, their adequacy for the intended application shall be demonstrated to the satisfaction of the NASA Glenn Pressure Systems Manager (PSM).
    - Material Test Reports shall be submitted for the vacuum vessel.
    - If a vacuum vessel requires relief protection with PRD setting above 2 psig due to the nature of the potential pressurization source, the vessel pressure shell shall be structurally qualified in accordance with the requirements of the ASME BPVC Section VIII, Div. 1.
    - Vacuum vessels shall be fabricated, repaired, or altered only by either manufacturers having an ASME "Code Stamp" (ASME "U" Authorization) or NBIC "R" Stamp, or will be audited and determined by the NASA Glenn PSM to have an equivalent quality assurance manual and process, including implementation.
    - The PVS manufacturing shall be in strict accordance with the quality assurance manual of the manufacturing organization.
    - All welding shall be:
        - Performed in accordance with procedures qualified in accordance with the ASME BPVC Section IX, including all essential variables for the joint in question.
        - Performed by welders qualified and current in accordance with the ASME BPVC Section IX, on such weld procedures.
    - Post weld heat treatment shall be performed as required and in accordance with the ASME Code.
    - Inspections shall be performed by inspectors trained and certified in use of the techniques being applied, in accordance with the requirements of the ASME BPVC Section V.
- Documentation shall include at minimum:
    - General Arrangement Drawing
    - P&ID Drawing
    - BOM
    - Weld Procedures
    - ASME Code Calculations

- Leak Check Procedures
- Leak Check Reports
- Material Test Reports
- As-built Drawings

<u>Vacuum Chamber 3 – Thermal Shroud / Vacuum Jacketed Pipe Requirements:</u>

- D-tube or fin type design preferred
  - Pillow type (dimple plate) acceptable only with proof of pervious successful design packages with similar heat loads and sizes
  - Heat load calculations required for design specifications
- Constructed of 1100 aluminum preferred
  - Stainless steel acceptable only with proof of previous successful design packages with similar heat loads and sizes
- Previous experience developing thermal shrouds of similar size and shape is required
- Must fit inside the vacuum chamber shells and minimize wasted space. At a minimum provide 6.5'x6.5'x15' clear space inside the thermal shroud; as much space as possible is preferred.
- Capable of rejecting 10 kW heat load at minimum.
- Capable of handling fully flooded Liquid Nitrogen
- Capable of handling heat up to 425 K (305F)
- Interior high emissivity paint suitable for high vacuum and for specified temperatures
- Perforated Multi-Layer Insulation (MLI) on outside to serve as thermal barrier between thermal shroud and tank wall. Outside surface of chamber must meet touch point temperature requirements of GRC Safety Manual.
- LN2 flow rate calculations and pipe sizing calculations are required for a 10kW heat load
- Provide proportional LN2 valving required for control
- Previous control methodology experience is required
- Interior flanges or fittings shall use ConFlat or VCR flanges
- Appropriate vacuum jacketed feedthrough and flanging shall be used at inlets and outlets to minimize thermal leak
- Capable of handling weight of test article (1000 kg) or means to pass load of test article through thermal shroud to vacuum chamber shell itself. Test article should be supported across entire length (a platform for test article to rest on). If passing the load through thermal shroud to the vacuum chamber then a thermal break is required to reduce conduction.
- Platform should allow the test article to roll on casters across its surface from outside the vacuum chamber with locations to fasten test article.
- Various fastening points shall be located at multiple locations on the thermal shroud or means to pass through shroud to shell for fastening points.
- Fully instrumented including thermocouples (1 Type T TC per 16 sq ft). Redundant thermocouples on inlet and outlet of thermal shroud. Utilize TC grade wire and bolt-on attachment method.
- Piping/tubing shall be designed, fabricated, tested and examined in accordance with ASME B31.3 (or ASME Section VIII Division 1 or 2) for a design pressure of 150 psig from –320 to 305 F
- Modular thermal shrouds (for future potential expansion)

- Thermal Shrouds shall have appropriate openings for cryopumps, roughing pumps, turbopumps, as well as for instrumentation and for research hardware which should align with specified flanging from chamber shell requirements
- Thermal shroud shall be removable to facilitate cleaning access to the facility and for the thermal shroud itself
- +/-2K thermal uniformity and temperature stability
- TCU will be placed in close proximity to vacuum chamber (assume within 20'). Provide the stainless steel vacuum jacketed piping required from TCU to vacuum chamber / thermal shroud. Coordinate with NASA on final layout of the hardware.
    - Design, flexibility analysis, fabrication, and testing of the VJP spools shall be in accordance with ASME B31.3 for normal fluid service. All ASME B31.3 code engineering design calculations and supporting calculations shall be submitted for approval by NASA.
    - The jacket of each section shall be factory evacuated and sealed, in order to maintain a permanent vacuum. A vacuum valve shall be provided in each pipe section.
    - Do we need ability to isolate between TCU and thermal shroud?
- Documentation shall include at minimum:
    - General Arrangement Drawing
    - P&ID Drawing
    - BOM
    - Weld Procedures
    - ASME Code Calculations
    - Leak Check Procedures
    - Leak Check Reports
    - Material Test Reports
    - As-Built Drawings
    - Thermal Load Calculations
    - Operation and Maintenance Manual – how to remove thermal shroud, cleaning, routine maintenance, etc.

<u>Vacuum Chambers 3, 4, and 5 – Thermal Conditioning Units (TCU) Requirements:</u>

- Electric heaters are not an acceptable means of heating the chamber. TCU is required.
- Thermal Vacuum Control Systems for use with a thermal shroud in a vacuum chamber
- These units will be controllable from 90K to 425K (–298F to 305F)
- They will provide precise uniform control throughout the entire range (+/-2k thermal uniformity and temperature stability)
- Will have refrigeration capacity of at least 15 kW
- Will have heating ability of at least 10 kW
- Will be supplied with N2 as the working fluid
- Commercial off the shelf TCU required.
- Shall have onboard control system that enables setpoint control of test parameters and profiles that can be communicated with by an external chamber PLC (MODBUS TCP/IP recommended)
- TCU will be placed in close proximity to vacuum chamber (assume within 20'). Provide the stainless steel vacuum jacketed piping required from TCU to vacuum chamber / thermal shroud. Coordinate with NASA on final layout of the hardware.
    - Design, flexibility analysis, fabrication, and testing of the VJP spools shall be in

accordance with ASME B31.3 for normal fluid service. All ASME B31.3 code engineering design calculations and supporting calculations shall be submitted for approval by NASA.
    - The jacket of each section shall be factory evacuated and sealed, in order to maintain a permanent vacuum. A vacuum valve shall be provided in each pipe section.
- Documentation shall include at minimum
    - Electrical wiring diagram
    - Utility consumption list
    - Process control philosophy
    - External communication instructions
    - Operation and Maintenance Manual

<u>Fabrication Shop Acceptance Testing:</u>

- Leak check and pressure test of thermal shroud in accordance with ASME B31.3
- TCU completely assembled, wired and leak checked. Including internal water piping, gas, and compressed air
    - Functional test reports after completion

<u>Onsite, Post-Installation, Acceptance Testing:</u>

- Vacuum testing to 5x10^-7 and leak check rate 1 x 10^-8 STD ATM CC/SEC or better of vacuum chamber shell.
    - The Contractor shall provide the roughing, high vacuum pumps, and calibrated helium leak checker to perform the vacuum testing. It is not anticipated that the remaining system components will be ready for acceptance testing when chamber installation is completed.
- Operational leak check of thermal shroud in accordance with ASME B31.3
    - Shroud will be filled with LN2 at full vacuum and run through full operational thermal range. External lines will be visually inspected for leaks. Internal line leaks will be inspected through chamber base pressure. (NASA will provide LN2 for this operation)
- Full thermal range testing of thermal shroud
    - Flood with LN2 (NASA will provide LN2 for this operation)
    - Full thermal range testing (hot and cold) of chambers with TCU
- TCU operational training