STATEMENT of WORK
for the Design and Manufacturing of a Thermal Vacuum Chamber

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1.0 Background

This statement of work (SOW) specifies the vendor requirements for the design and manufacturing of a thermal vacuum chamber that will enable testing and calibration of the Mars Organic Molecule Analyzer mass spectrometer (MOMA-MS) in a Mars-like environment. The MOMA instrument is part of the Pasteur payload on the ESA ExoMars rover to be launched in early 2018.

2.0 Scope

The vendor shall provide the personnel and services to manufacture a thermal vacuum chamber that will be used to simulate atmospheric conditions on the surface of Mars during testing and calibration of the MOMA-MS. Work includes the supply of materials, tooling and equipment required for the chamber manufacturing; assembling the chamber; leak testing; cleaning; inspection; initial vacuum bake-out; acceptance testing; packing and the delivery of the thermal vacuum chamber to NASA Goddard Space Flight Center in Greenbelt, MD.

3.0 Requirements: See MOMA Sketch 001 for detailed chamber design information

3.1 Chamber Thermal Requirements

- 3.1.1 Thermal plates shall be constructed of aluminum, copper or equivalent reflective plating for a resulting emissivity of .04 or better and a hardness of at least 4 mohs and must be controlled from -60°C to +150°C to within ± 3°C over the entire plate surface once in soak. These plates must maintain a set temperature while dissipating up to 40 watts each.
- 3.1.2 No interior surfaces shall be colder than -125°C when operating with a CO2 atmosphere.
  - 3.1.2.1 CO_2 will condense to its solid phase at temperatures lower than -125°C, therefore we require that no interior surface temperatures are lower than -125°C in the chamber interior while the cold plate and shroud temperature requirements are realized.
  - 3.1.2.2 Internal thermal plate gas supply piping shall be vacuum jacketed between the chamber feed-through and thermal plate connections to minimize CO2 condensation.
- 3.1.3 Each thermal plate shall be fitted with an independently controlled, industrial type PID heat/cool process controller.
- 3.1.4 Each thermal plate shall be fitted with embedded cartridge heater/heaters for operation above ambient room temperature up to 150C.
- 3.1.5 Each thermal plate shall be independently PID controlled and shall be fitted with a gas piping loop and a proportional cryogenic valve for operation below ambient room temperature. The cold gas source will be a customer provided 20 PSIG, -150°C gaseous nitrogen supply.

3.1.6 All required electrical power and Type K thermocouple feed-through's for thermal plate operation and control shall be provided by the vendor.

3.1.7 All required wiring for temperature controller operation of cryogenic valves, electrical heaters, thermal instrumentation and system electrical main power shall be provided by the vendor.

3.1.8 All thermal plate return gas feedthroughs shall be vented to a common external manifold with a 2" FMPT connection for connecting to the building vent-line. (Customer to perform the chamber to building cryo vent piping and insulation)

3.1.9 All 6 thermal plate gas supply and return piping cold gas feedthroughs shall be located on the back wall of the chamber.

3.1.10 At least 2 temperature sensors must be located on the back side of each cold plate, one of which needs to be in the temperature control feedback loop. Each thermal plate shall have an independent over and under temperature limit controller.

3.1.11 The entire chamber to include the external chamber walls, thermal plates, internal process piping, instrumentation, harnessing, and bottom thermal plate translation hardware must be bakeable to +150°C

3.1.12 All stainless steel exterior chamber walls must have bake-out heaters installed, insulated and the chamber bake-out shall be independently temperature controlled from ambient to +150C. The bake-out temperature controllers shall be installed in the main chamber control panel. The insulating panels must have a cleanable metal skin and must be installed over the heaters.

3.1.13 Electrical control panel components and system wiring shall be compliant with UL 508A standards. All thermal system power requirements shall be constrained to 120/208VAC 60Hz.

3.2 Vacuum Chamber Requirements

3.2.1 Ultimate room temperature vacuum pressure after bakeout shall be less than 10^{-7} mbar.

3.2.2 No organic contamination shall be used in the internal chamber volume (lubricants, plastics, etc.)

3.2.3 Typical chamber operating pressure will be from 6-10 mbar of CO_2 (Mars ambient).

3.2.4 The vacuum chamber and all vacuum fittings shall have no vacuum leaks larger than $1x10^{-8}$ atm cc/sec for helium.

3.2.5 All chamber flanges shall be rotating and shall have thru mounting holes and an adapter sleeve between each flange and chamber wall and will consist of the following:

3.2.5a. Chamber bottom wall flanges: (1) 10" Conflat flange for a customer provided gate valve and Cryo Pump and (1) CF275 flange.

3.2.5b. Chamber top wall flanges: (1) CF800 flange for a customer provided gate valve and turbo pump and (6) CF275 flanges, 3 per side with a direct view of the annular volume.

3.2.5c. Chamber door flanges: (1) CF450 flange for a customer provided viewport and a door mounted, 6 in. x 6 in. electro-polished scavenger plate with a removable drip tray.

3.2.5d. Chamber right side wall flanges as viewed from the door: (10) CF275 flanges and (1) CF450 flanges.

3.2.5e. Chamber left side wall flanges as viewed from the door: (4) CF450 flanges, (2) CF600 flanges and (2) CF275 flanges.

3.3 Mechanical Requirements

3.3.1 The MOMA-MS instrument will be mounted to the bottom cold plate. Location of tapped mounting holes in this plate shall be specified at award of contact. The MOMA-MS instrument mass of 100 kg plus a safety factor of 50% must be accommodated by this plate.

3.3.2 Top and bottom thermal plates shall have 1/4-20 through hole pattern (pattern dimension shall be specified at award of contract).

3.3.3 The bottom thermal plates shall provide for a linear motion of 18" inches in the door direction to facilitate chamber installation alignment operations of the MOMA-MS instrument.

3.3.4 The bottom thermal plate shall have a flatness of no more than 0.010 inch per foot.

3.3.5 The bottom thermal plate thermal lines shall accommodate the 18" specified linear travel without being disconnected. Line connections shall remain leak tight during travel motion.

3.3.6 A 5 in. gap between the top, bottom, and side thermal plates and the chamber walls must be provided to allow for mechanical access to fittings and feed-throughs.

3.3.7 The chamber must be fabricated out of 304 or 316, electro polished stainless steel.

3.3.8 The chamber shall be mounted to and supported upon a steel frame mobile cart.

3.3.9 The chamber bottom panel shall have a floor clearance of 30 +/- 1 inch.

3.4 Contamination Requirements

3.4.1 A 6 in. x 6 in. electroplated scavenger plate with drip tray shall be installed on the door with cryo-lines feedthroughs mounted through the chamber door.

3.5 GSFC Supplied Items for performing acceptance testing:

3.5.1 One 8" turbo pump, manual 8" gate valve, dry backing pump, vacuum lines and isolation valve

3.5.2 One 10 in. cryo pump, gate valve, associated pressure instrumentation, required vacuum lines and pump-out valve.

3.5.3 One chamber roughing dry mechanical pump, fore-line pressure gauge, vacuum lines and gate valve

3.6 After chamber has been delivered to GSFC, the vendor shall send a representative to GSFC to participate in unpacking and the setup of equipment.

4.0 Acceptance Testing

4.1 <u>Verifying Vacuum Requirements</u>

Once the vendor has completed the chamber assembly and has verified the leak rates and ultimate vacuum level requirements, as stated in Section 3.2, have been met, a final acceptance testing of the vacuum system shall be conducted at the vendor's plant and shall consist of leak testing and demonstration of how well the leak rates and vacuum levels attained by the system meet the requirements in this SOW. Results of the acceptance testing shall be certified by the manufacturer and transmitted to NASA for approval prior to shipment. A NASA representative shall be present during the acceptance testing.

4.2 Verifying Thermal Requirements

The vendor should verify and demonstrate, at their location, how well the thermal requirements as stated in Section 3.1 of this SOW can be met. In some cases, due to lack of materials or equipment such as a readily available source of liquid nitrogen, this may be impractical. In this case verification and demonstration of the thermal requirements may be performed at NASA/GSFC after delivery. If it is then found that thermal requirements cannot be met, and it is determined that the chamber must be shipped back to the vendor's location to fix any problems, then the vendor will bear the cost of the return shipment and the cost of the subsequent re-shipment of the chamber to NASA/GSFC. It is, therefore, much preferred that the verification of the thermal requirements be performed at the vendor's location during acceptance testing.

4.3 Results of Acceptance Testing

Results of any vacuum and thermal acceptance testing that are performed at the vendor's location shall be certified by the manufacturer and transmitted to NASA for approval prior to shipment. A NASA representative shall be present during the acceptance testing.

5.0 Deliverables and Delivery Schedule

5.1 Vendor to provide in electronic format a complete set of mechanical drawings, power and control schematics and other design documentation and acceptance criteria necessary to define and present the complete thermal vacuum system design for review and approval by NASA prior to fabrication. Schematics will depict NASA supplied components listed above in context of overall system. Manufacturing to begin only with signed approval from NASA.

5.2 Test reports of thermal and vacuum performance testing.

5.3 Thermal Vacuum System

5.4 All GSE provided equipment used by vendor during acceptance testing.

5.5 Manufacturer to provide air ride palleting or special protective provisions for shipment of the thermal vacuum chamber system to NASA Goddard.

5.6 After chamber has been delivered to GSFC, the vendor shall send a representative to GSFC to participate in unpacking and the setup of equipment.

5.7 Delivery shall be 3 months upon receipt of order.

6.0 Place of Performance

All work including initial acceptance testing will be performed at the vendor's location

7.0 Demonstration of Similar Past Work

Vendors shall submit evidence they have designed, manufactured and tested thermal vacuum chambers having similar design requirements.