Mars Entry, Descent and Landing Instrumentation (MEDLI2)

Pressure Transducer Specifications

MEDLI2-6005

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1 Specifications for the space qualified low-pressure transducers are provided below.

2 APPLICABLE DOCUMENTS:

It is anticipated that the following applicable documents will apply.

AS4395 rev-B	Fitting End, Flared, Tube Connection, Design Standard
ANSI/ASME-Y14.100	Engineering Drawing Practices
ANSI/NCSL Z540.3-2006	American National Standard for Calibration of Measurement and Test Equipment
JPL D-21382	Mars 2020 Environmental Requirements Document
MIL-M-38510 rev-J	General Specification for Microcircuit
MIL-P-27401 rev-D	Propellant, Pressurization Agent, Nitrogen
MIL-P-27407 rev-C	Propellant, Pressurization Agent, Helium
MIL-STD-45662 rev-A	Calibration System Requirements
MIL-T-27 rev-E	General Specification for Transformers and Inductors
MSFC-HDBK-527 rev-F	Materials Selection List for Space Hardware Systems
MSFC-SPEC-522 rev-B	Design Criteria for Controlling Stress Corrosion Cracking
NHB 5300.4(1B)	Quality Program Provisions for Aeronautical and Space Contractors
NHB 5300.4 (3A-2)	Requirements for Soldered Electrical Connections
NPPL	NASA Preferred Parts List

3 Introduction

3.1 Purpose

The purpose of this document is to provide the pressure transducer manufacturer the performance specifications needed for the pressure transducers to meet mission requirements. The document captures the requirements identified and the constraints imposed by either heritage system or practical limits set by analysis performed by various disciplines. Driving requirements are presented and bounded to ensure pressure data is captured to support the Mars Entry Atmospheric Data System (MEADS) measurement requirements of the project so that post flight data can be correlated to such analysis as computational fluid dynamics (CFD).

3.2 Scope

This scope of this document is to define the technical requirements needed to design, build, and qualify pressure transducers to support the pressure sensing requirements of the MEDLI2 Project. Technical specifications included in this document include pressure, electrical, mechanical, environmental, and materials specifications.

4 Transducer Constraints

4.1 Configuration

The pressure transducer shall be hermetically sealed and provide embedded electronics for an amplified output. Two Resistive Temperature Device (RTD)/s shall also be embedded within the transducers; one to monitor the diaphragm temperature and one to monitor the temperatures seen by the active electronics. Each pressure transducer shall be of welded construction with one (1) port for absolute pressure sensing that is connected to a flared tube fitting as discussed in section 4.1.3. In addition, the pressure sensor shall be capable of being mated to an integral sensor mounting system of adequate strength similar to the specifications shown in Figure 1.

4.1.1 Mechanical:

4.1.1.1 Dimensions:

It is anticipated that the maximum dimensions of the pressure sensor will not exceed (4.5 in) L x (3.5 in) H x (3.0 in) W.

4.1.1.2 Integral Mounting:

The pressure transducers shall have the capability of integrating with a mechanical mounting bracket similar to the 4-point configuration (dimensions are TBR) as shown in Figure 1.

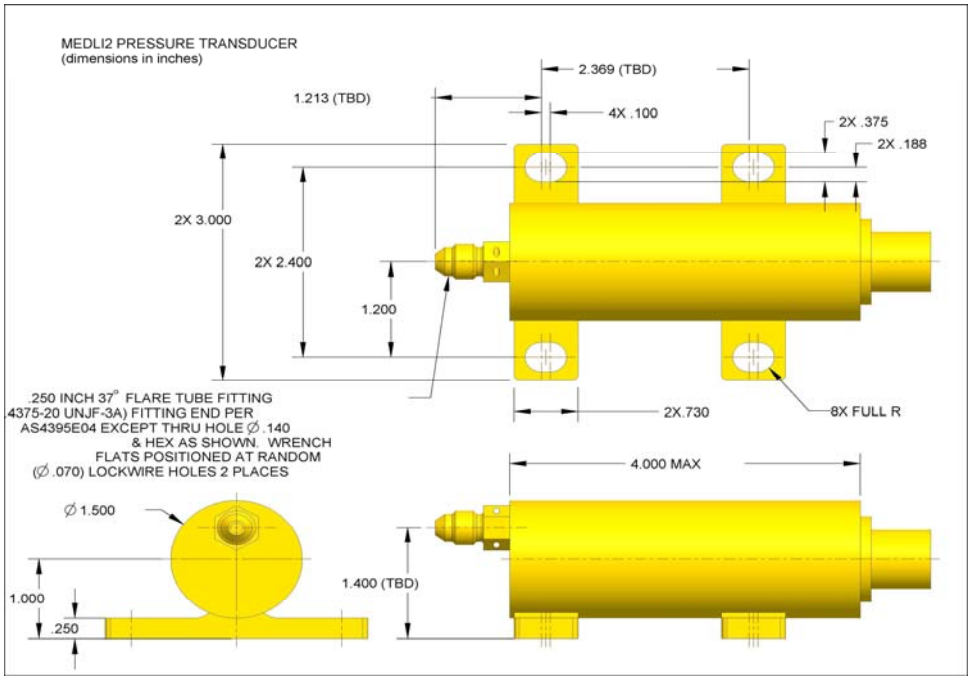

Figure 1: Pressure Sensor 4-Point Mechanical Mounting

4.1.1.3 Mass:

The mass of the pressure sensor shall be less than 900grams.

4.1.2 Electrical Connections:

4.1.2.1 The electrical connector shall be a hermetically sealed spaceflight qualified male Mil-C-38999.

4.1.2.2 The electrical interface/connector shall be configured for power, ground, analog signal and analog return, and RTD accommodations.

4.1.2.3 Each resistive temperature device (RTD) shall be a Class A 1000 ohms platinum device and comply with ITS-90 calibration curve.

4.1.3 Pressure Connections:

The pressure connection shall be a ¼" flared tube fitting (7/16-20 UNJF) per AS4395-4 or equivalent.

4.1.4 Interchangeability:

Electrical connector pin designations shall allow for interchangeability of mating connectors for all pressure transducers. Variability between units shall be restricted to the point that qualification data obtained with one unit defines the performance/accuracy characteristics and flight-worthiness of the others. It's understood that thermal correction accuracy will be serial-number specific and may be corrected during post flight processing.

4.1.5 Parts, Materials, and Processes:

Wetted materials shall be in accordance with MSFC-HDBK-527 rev. F, MIL-HDBK-5 and shall comply with the stress corrosion requirements of MSFC-SPEC-522 rev B, Table I. Materials and processes shall be compatible with the environmental conditions specified herein and the following gases or any mixture:

Air (unfiltered)

Helium per Mil-P-27407 rev C

Nitrogen Mil-P-27401 rev D

Carbon Dioxide

Parts, materials, and processes used in the construction of the unit shall be controlled by specification or procedure per AS9100 or equivalent.

4.1.5.1 Soldering

All soldering shall meet either NASA-STD-8739, IPC-J-STD-001 ES, or equivalent.

4.1.5.2 Welding

All vendor non-standard internal welding processes shall be made available for review and approval by the NASA LaRC COTR.

4.1.5.3 Glint

All exposed materials shall be optically opaque (anodizing, bead-blasting, or other means is subject to review by the NASA LaRC COTR).

4.1.6 Electronic Parts Selection and Application:

Grade 1 parts shall be used for all of the electronics.

Note: GSFC INST-EEE-002 shall be used for component selection and approval for application criteria on parts selection, screening, qualification, and derating of Grade 1 parts.

Where Grade 1 parts are not available the Vendor shall generate a Non Standard Parts Approval Request (NSPAR) using NASA Langley form LF-170 to be reviewed and

approved by the NASA LaRC COTR. The NSPAR must contain supporting information, which may include a source control drawing for review and approval to insure the component meets the application requirements.

4.1.6.1 EMI Standards:

All transducers shall meet MIL-STD-461 for EMI compliance.

4.1.6.2 Environmental Considerations:

Materials and processes shall be selected so that transducer performances are unaffected by humidity, rain, fungus, salt spray, sand, and dust. MIL-STD-810G shall be followed.

4.1.7 Cleanliness

All parts (internal and external to the sensor) shall comply with IEST-STD-CC1246D Level 100A.

5 Design Goals

5.1 Design Life:

Transducers shall be designed and manufactured for a minimum ten (10) year mission life.

5.2 Temperature:

5.2.1 Non-operational Temperature:

The pressure measurement head and all electronic circuitry shall be capable of surviving a thermal environment as low as -130°C at 10-5 torr in a non-operation mode for a period of 10 months and still be capable of meeting performance requirements for the remaining mission life. The pressure sensor will also be exposed to temperatures as high as +115°C during dry heat microbial reduction discussed in section 5.2.2.

5.2.2 Dry Heat Microbial Reduction Temperature

Each pressure sensor will have to survive (non-operational) a dry heat microbial reduction process at temperatures of 115°C for up to144 hours. The specification noted is for Planetary Protection requirements.

5.2.3 Operational Temperature:

The pressure transducers may be powered and operational over a temperature range of -115ºC to +70ºC. The Transducer is not expected to meet accuracy requirements over this range.

5.3 Random Vibe and Shock Environment

The transducers shall survive and perform within specification after being subjected to random vibration levels that are likely to be within the range of 15 – 24 grms and shock levels that may be as high as 3000g. Specific testing tolerances are called out in the Mars 2020 Environmental Requirements Document JPL D-21382.

5.4 Functional Characteristics Needs:

5.4.1 Accuracy:

The vendor is requested to provide a description of their approach used to demonstrate accuracy of the sensor. This includes any testing required to achieve the characterization and examples of how this was performed on past projects.

5.4.2 Static Error Band:

The static error band shall be no greater than ±0.5 percent of full scale based on an un-weighted least squares straight line fit. The static error band includes errors due to nonlinearity, hysteresis, and non-repeatability.

It is desired that these errors be reduced, this reduction can be performed post processing. If the vendor has performed such reduction on previous missions, explain how the reduction was performed and what needs additional integration, additional pressure testing, etc.

5.4.3 Temperature Error Effects:

The transducer output voltages shall not vary from a best fit straight line more than 2.0% FSO due to temperature variations within the operating temperature range -115 to 0°C of the transducer. Overall temperature error, within this temperature range, shall not exceed ±1% FSO per 115°C including both thermal zero and thermal sensitivity effects combined.

It is desired that these thermal effects be reduced. This reduction can be performed post processing. If the vendor has performed such reduction on previous missions, explain how the reduction was performed and what needs additional integration (i.e. internal RTD, other), and testing (additional thermal calibrations, other).

5.4.4 **Full-Scale Pressure Ranges:** *Note: Ranges are for two different transducers*

5.4.4.1 Supersonic Sensors Pressure Range:

The pressure measurement range covered by this specification shall have full-scale absolute pressure ranges of 0-1.0 psia. Zero psia is considered to be less than 10^{-5} torr.

5.4.4.2 Backshell Sensor Pressure Range:

The pressure measurement range covered by this specification shall have full-scale absolute pressure ranges of 0-0.1 psia. Zero psia is considered to be less than 10-5 torr.

5.4.5 Response Time:

The transducers shall have a maximum response time of 20 milliseconds, defined as the time between the 10 and 90 percent output points from an applied pressure step input.

5.4.6 Resolution:

Each transducer output shall have infinite pressure resolution.

5.4.7 External Leakage:

External leakage shall not exceed 1 x 10^{-6} cubic centimeters per second of helium at proof pressure.

5.4.8 Input Voltage:

The transducers shall meet the static error band requirement (Paragraph 4.5.2) when operated with steady-state voltages from 24 Vdc to 32 Vdc.

5.4.9 Input Current:

The transducer input currents shall not exceed 50 milliamps during normal operation or for any non-measuring condition such as overpressure or electrical short.

5.4.10 Load Impedance:

The pressure transducer shall be calibrated with a nominal load impedance of 10 megohms. The change in output when subjected to a 50K ohm load shall be 200 millivolts or less.

5.4.11 Output Impedance:

The transducer output impedance shall not exceed 1000 ohms.

5.4.12 Output Voltage:

The transducers shall provide a -2.5 to +2.5 VDC output based on full scale pressure range with respect to the output reference signal.

5.4.13 Zero Pressure Output Voltage:

The Pressure System output voltage at zero pressure (10-5 torr) shall be -2.5 Vdc ± 0.2 Vdc, nonadjustable, referenced to ground. Accuracy requirements during flight will rely on zero offset correction referenced to deep space vacuum.

5.4.14 Output Voltage Span:

The Pressure System shall have an output voltage span of 5.0 Vdc ± 0.2 Vdc for the specified pressure ranges.

5.4.15 Insulation Resistance:

The pressure sensor shall have an insulation resistance of 10 megohms minimum at 50 Vdc between the case and any input or output pin for the pressure sensor head.

5.4.16 Proof Pressure:

The transducers shall withstand an overpressure condition of 25 psia without degradation of performance.

5.4.17 Burst Pressure:

The transducers shall withstand a bust pressure condition of 200 psia for two minutes without rupture that results in component separation from the transducer.

5.4.18 Protection:

5.4.18.1 Short Circuit:

Shorting of the output terminals for 15 minutes shall cause no performance degradation after the condition is removed.

5.4.19 Vibration Sensitivity:

Transducers shall have output variations not exceeding ±0.l%/G. The output variation, due to vibration, shall be provided (in % change in output per G) for each pressure transducer per MEDLI2-6003-SOW sections 5.7.6 and 5.7.7.

5.4.20 Orientation Sensitivity:

Transducers shall have output variations not exceeding ±0.l% FSO mounted in any orthogonal axis with respect to the transducer mounting plane.

5.4.21 Output Shunt

Transducer shall employ a means to shunt the output voltage to 80% FSO.

6 Acronyms

CFD	Computational Fluid Dynamics
EEE	Electrical, Electronic, and Electromechanical Parts
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EU	Engineering Unit
FSO	Full Scale Output
LaRC	Langley Research Center
MEADS	Mars Entry Atmospheric Data System
MEDLI	Mars Entry Descent & Landing Instrument
MPE	Maximum Predicted Environments
NPPL	NASA Preferred Parts List
Pa	Pascal
PSIA	Pressure per Square Inch (Absolute)
SOW	Statement of Work
RFI	Request for Information
RTD	Resistive Temperature Device
TBD	To be Determined
TBR	To be Refined
TPS	Thermal Protection System
TRL	Technology Readiness Level