SENSORS, TRANSDUCERS AND SIGNAL CONDITIONING SYSTEMS SELECTION PROCESS

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FEBRUARY 29, 2008

ENGINEERING DEVELOPMENT DIRECTORATE

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SENSORS, TRANSDUCERS AND SIGNAL CONDITIONING SYSTEMS SELECTION PROCESS

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JOHN F. KENNEDY SPACE CENTER, NASA

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1 INTRODUCTION

1.1 Purpose

The purpose of this document is to establish the process for the selection of sensors, transducers and signal conditioners (henceforth known as measurements) for use as ground support equipment (GSE) at Kennedy Space Center (KSC). This document will explain the process for measurement selection and define the four levels of minimum requirements for sensors and transducers.

1.2 Scope

This document's scope is limited to measurements being utilized at KSC in ground support equipment. This set of guidelines has been developed by the NASA KSC Instrumentation Branch of the Engineering Directorate. It is intended to provide a consolidated and consistent approach for the selection of measurements. It is also intended to provide a listing of recommended equipment requirements and their definitions and usage to aide in the development of GSE subsystems at KSC.

2 APPLICABLE DOCUMENTS

The following documents form a part of this document. In the event of a conflict between this document and the documents referenced, the contents of this document shall supersede the reference document. The documents are as follows.

NASA-STD-6001	Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion
KSC-STD-E-0002	Hazard Proofing of Electrically Energized Equipment
KSC-STD-164	Environmental Test Methods for Ground Support Equipment Installations at Cape Kennedy
MIL-C-5015	Connectors, Electric, Circular Threaded, AN Type
MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
KSC-YA-5936	Reference Document for KSC 79K Transducer Terms and Specifications
ANSI/ISA S37.1	Instrument Society of America Standards and Recommended Practices Electrical Transducer Nomenclature and Terminology

3 TRANSDUCER SELECTION

3.1 Selection Process

The measurement selection process follows the flowchart shown in Figure 1.

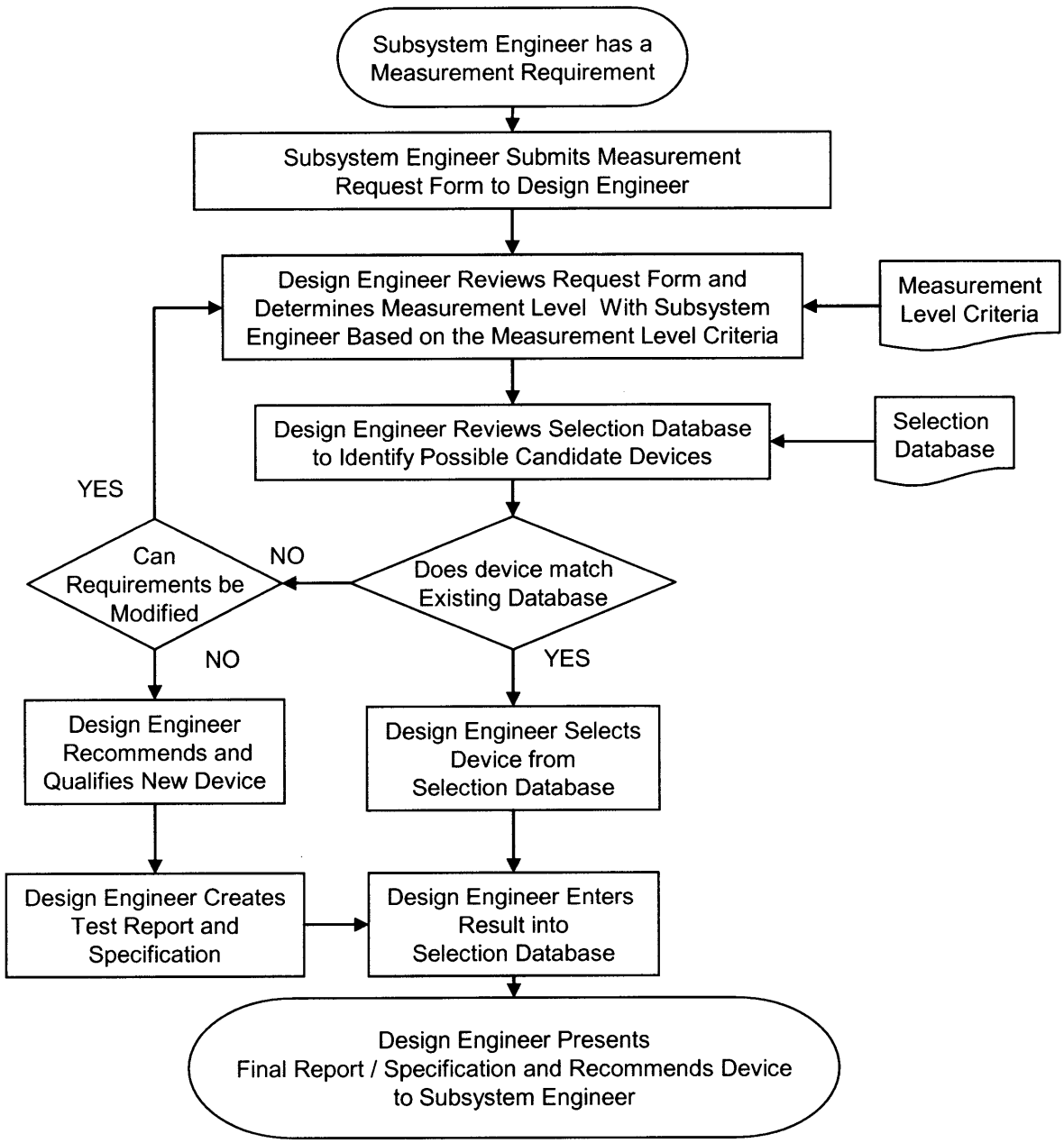

Figure 1: Measurement Selection Process

The process begins when the subsystem engineer determines the need for a particular measurement. Then the subsystem engineer submits the Transducer Selection Request Form to a design engineer in the Instrumentation Branch of the NASA KSC Engineering Directorate. (See Appendix A for a copy of this form). The design engineer will assistance the subsystem engineer in completing this form. From this form, the design engineer can determine the selection criteria for this measurement, or can select a previously qualified measurement that would be applicable. Once the selection criteria are established, the design engineer will:

a. Compare the selection criteria and desired measurement against the Measurement Selection Database to determine if there are devices that are available to meet the requirements in the Transducer Request Form. If no items are available the design engineer will discuss with the subsystem engineer the possibility of changing the requirements.
b. If the requirements can not be changed, then the design engineer will perform a market survey to find a new device that will meet the requirements. If the requirements can be changed, the subsystem and design engineer will alter the requirements to meet system requirements against device availability.
c. If the requirements could not be changed then the design engineer will procure several samples (from the market survey) for qualification testing and proceed with testing using approved and documented test procedures.
d. Following the successful performance of a qualification test, the design engineer will file a test report. If the testing was not successful then additional qualification test devices will need to be procured based on the market survey. The design engineer will create and release a specification into the Engineering Document Control Center. This specification will denote the requirements and will list the devices that passed the qualification testing (section 6 Approved Sources). The design engineer will also enter the device into the Measurement Selection Data base.
e. Finally the design engineer will present the final test report, specification and approved device recommendation to the subsystem engineer.

The Measurement Level Criteria has been established by the NASA KSC Engineering Directorate for sensors, transducers, and signal conditioning systems based on a specific classification method. This classification method is composed of levels; each level being incrementally less restrictive than the previous one, and is based on specific parameters such as measurement classification (critical vs. non-critical), device usage, and surrounding environment.

The classification levels presented in this document will be a major driver in the selection of sensors, transducers and signal conditioning systems to be utilized by the different ground support systems at KSC. Although there will be applications where level classification will not be 100% applicable, the selection will be made based on the most critical parameters required by the subsystem. An overview of the selection levels is found in Table 1.

REQUIREMENTS	LEVEL A	LEVEL B	LEVEL C	LEVEL D
Performance	Yes	Yes	Yes	Yes
Environmental	Moderate/Extreme	Moderate/Extreme	Moderate	Benign
Criticality	Critical 1 & 2	Critical 1 & 2	Non-Critical	Non-Critical
Hazardous Location	Class 1 Div 1& 2	Class 1 Div 2	None	None

Table 1 Overview of Qualification Levels

3.2 Level A Criteria

The main objectives for sensors, transducers and signal conditioning systems classified under this level is to meet user/customer performance requirements, while operating in a moderate to severe environment, in support of critical operations/functions/systems and under hazardous conditions classification. They shall meet interchangeability/standardization guidelines. These devices may or may not have high performance requirements, are normally located in areas not environmentally controlled, exposed to natural environments (such as humidity, heat, dust, etc), and/or subjected to launch induced environments (such as vibration, EMI, shock, etc.) They are required to support systems, functions, and/or processes that are considered critical in nature where such a measurement is labeled "critical measurement". Locations where these devices are used include conditions and/or environments that are considered hazardous (such as hydrogen farms, hypergol farms, etc). These environments are normally classified Class I, Divisions I and II environments by the National Fire Protection Association (NFPA) and the National Electric Code (NEC). Design shall meet KSC standard KSC-STD-E-0002. The main selection criteria (in order of importance) for these devices are:

- Hazardous Location requirements as described in section 4.5, such as:
  - Intrinsically safe/explosion proof
  - Material compatibility
- Criticality requirements as described in section 4.6, such as:
  - Reliability
  - Fail Safe
  - MTBF
- Performance requirements as described in section 4.2.
- Electrical requirements as described in section 4.1.
- Environmental requirements as described in section 4.3, such as:

  - Temperature
  - Vibration
  - Electromagnetic Interferences
  - Launch Environment
- Interchangeability/standardization as described in section 4.4
- Cost and availability

3.3 Level B Criteria

The main objectives for sensors, transducers and signal conditioning systems classified under this level is to meet user/customer performance requirements, while meeting interchangeability and standardization guidelines. They may or may not need to operate in a moderate to severe environment, but they are required to support critical operations/functions/systems/processes. These devices have high performance requirements, may be required to operate in areas not environmentally controlled, normally exposed to natural environments (such as humidity, heat, dust) and/or launch induced environments (such as vibration, EMI, and launch environments). They support systems, functions, and/or processes that are considered critical in nature, where such a measurement is labeled "critical measurement". Requirements associated with this classification include reliability, MTBF, and fail safe characteristics. Locations where these devices are used do not include any condition and/or environment that are considered hazardous (such as hydrogen farms, hypergol farms, etc). These environments are normally classified as Class 1, Division II environments by the National Fire Protection Association (NFPA) and the National Electric Code (NEC). Design shall meet KSC standard KSC-STD-E-0002. The main selection criteria (in order of importance) for these devices are:

- Performance requirements, as described in section 4.2.
- Electrical requirements as described in section 4.1.
- Criticality requirements as described in section 4.6, such as:
  - Reliability
  - Fail Safe
  - MTBF
  - Etc.
- Environmental requirements as described in section 4.3, such as:
  - Temperature
  - Vibration
  - Electromagnetic Interferences
  - Humidity
  - Etc.
- Interchangeability/standardization as described in section 4.4.
- Cost and availability

3.4 Level C Criteria

The main objectives for sensors, transducers and signal conditioning systems classified under this level are to meet user/customer performance requirements while exposed / operating in a moderate to severe natural and/or induced environment. They shall meet interchangeability and standardization guidelines. These devices are usually utilized in areas that are not environmentally controlled, normally exposed to natural environmental conditions (such as humidity, salt/corrosion, heat, dust, etc) and/or launch induced environments (such as vibration, EMI, shock, etc.).

These devices do not support systems, functions, and/or processes that are considered critical in nature, where such a measurement is labeled "critical measurement." The locations where these devices are utilized do not include any condition and/or environment that are considered hazardous (such as hydrogen farms, hypergol farms, etc.). The main selection criteria (in order of importance) for these devices are:

- Performance requirements, as described in section 4.2.
- Environmental requirements as described in section 4.3, such as:
    - Temperature
    - Vibration
    - Electromagnetic Interference (EMC/EMI)
    - Humidity
    - Etc.
- Interchangeability/standardization requirements, as described in section 4.4
- Cost and availability

3.5 Level D Criteria

This level is considered the least restrictive level. The main objective for sensors, transducers and signal conditioning systems classified under this level is to meet user/customer performance requirements, while meeting interchangeability and standardization guidelines. The device classified Level D is located and/or subjected to a benign natural and/or induced environment. They are normally found inside environmentally controlled locations, with minimal or no vibration. They are not required to meet strict EMI/EMC requirements such as MIL-STD-461. They do not support systems, functions, and/or processes that are considered critical in nature. Usage of these devices does not include locations considered hazardous due to hazardous environments (such as hydrogen, hypergol, etc.). The main selection criteria (in order of importance) for these devices are:

- Performance requirements, as described in section 4.2.
- Interchangeability/standardization requirements, as described in section 4.4.
- Cost and availability

3.6 Specific test Requirements

Once a measurement has been assigned to a particular level by the design engineer then a test procedure can be created using the Measurement Level Criteria found in Appendix B. The tables in Appendix B show the lists of individual test requirement for several different sensors and transducers by level. These tables cover pressure transducers, platinum resistance temperature probes, platinum temperature probe signal conditioners, thermocouple probes, thermocouple temperature transmitters, Coriolis mass flowmeters, vortex shedding flowmeters, and turbine flowmeters with signal conditioning. Additional tables will be added as requirements are established for other measurement types.

4 DEFINITIONS OF EQUIPMENT REQUIREMENTS

The equipment requirements that are listed below are not a complete listing, but are a listing of requirements commonly found in the existing KSC specifications and commercially available measurement specifications. Use of these requirements by the sensors and transducers lab will follow interpretation as found in KSC-YA-5936 were applicable. These requirements will be the basis of the test procedures used to qualify a new measurement.

4.1 Electrical Requirements

The following are those requirements associated with the electrical properties of a measurement. Not all of these requirements will be applicable, it is left to the discretion of the sensors and transducer lab which will be used in the qualification testing.

4.1.1 External Power

External power is the electrical energy supplied to the transducer for it normal operation. At KSC, external power is from the ground special power system and is set at 28VDC +/- 4VDC. Any other power limits will be evaluated against KSC and the request form inputs.

4.1.2 External Power Overvoltage

External power overvoltage is the maximum allowable external power voltage that can be applied to the transducer without sustaining damage. At KSC this has been specified as 35VDC, however it will be evaluated against the request form input.

4.1.3 Fault (External Power) Current Limiting

Current limiting is the capability of a device to prevent propagation of its overcurrent condition to its external power source. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by electrical circuit analysis of the selected device.

4.1.4 Reversed Polarity Protection

Reversed polarity protection is the protection of the device from the application of reversed poles on the external power leads. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by reversing power leads for 15 minutes then restoring the leads and performing a performance check.

4.1.5 Transient Voltage Protection

Transient voltage protection is the protection of the device from the application of a transient voltage spike applied to the external power leads, the input and signal output leads of a device. At KSC this is defined as a 100 volt amplitude spike of 10 millisecond duration. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by injecting a transient voltage to the device leads (power or signal) then performing a performance check.

4.1.6 Signal Output Short Circuit

The signal output short circuit requirement defines how long a device can withstand a signal output short circuit without suffering damage. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by shorting the output leads for 15 minutes then restoring the leads and performing a performance check.

4.1.7 Isolation Resistance

The isolation resistance is the electrical isolation internal to the device between the external power and the output signal of the device. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by measuring the resistance between output and power leads using a 50VDC megohmeter.

4.1.8 Insulation Resistance

The insulation resistance is the electrical isolation between the external case of a device and the internal electronics of the device. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by measuring the resistance between device leads and the device case using a 50VDC megohmeter.

4.1.9 Output Impedance

The output impedance is the internal impedance of a device measured across the output leads. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by loading the output signal with a 1000 ohm load and measuring the signal output over this load, then comparing with a high impedance load to calculate the internal impedance.

4.1.10 Output Drive

The output drive is the device's ability to output a signal into a specified input load without degradation of the output signal. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then testing is performed by loading the output signal with a 100,000 ohm load that is shunted by 0.25 microfarads of capacitance and measuring the signal output then comparing to the output measured with a digit multimeter. (1 megaohm input impedance or better.)

4.1.11 Common Mode Rejection Ratio

The common mode rejection ratio is the common mode amplification by a device in ratio to the differential mode amplification. This is a KSC specification requirement that is sometimes found in commercial specifications. If this is requested by the system engineer, then testing is performed by driving a variable frequency signal input over the standard input for a device and measuring the offset on the output signal.

4.1.12 Excitation

Excitation is the energy that a device provides in making a measurement. An example is the excitation current that a resistance temperature detector (RTD) signal conditioner uses to measure the resistance of the RTD and hence its temperature. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then testing is performed by measuring the excitation energy (voltage or current) and comparing to the requirements.

4.1.13 Electrical Connection

Electrical connection is the means by which power and signals are conveyed to and from the device. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then selection of the device will be made based on the specific connection required by the system engineer. The system engineer shall make use of connections listed in MIL-STD-5015 when the ambient environment of the device may support explosive fluids either during normal or accidental conditions.

4.2 Performance Requirements

The following are those requirements associated with the performance properties of a measurement. Not all of these requirements will be applicable. It is left to the discretion of the sensors and transducer lab which will be used in the qualification testing.

4.2.1 Error Band

The error band for a device is the band of maximum deviations of output values from a specified reference line or curve. The error band encompasses all sources of error that the device can have. This is a KSC specification requirement that is often times found in commercial specifications as the accuracy (this is an incorrect application.). If this is requested by the system engineer, then testing is performed by performing a three cycle temperature test(lab temperature, highest then lowest temperatures) using varying inputs and measuring outputs against the reference output for the device. The error band is usually stated in percentage of total or full scale or of reading.

4.2.2 Linearity

The linearity for a device is the amount of closeness that a device's output comes to a straight line fit through the output endpoints. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then the data taken in the error band testing would be used to determine the closeness of the device's performance to a straight line through the endpoints. The linearity of a device is usually stated in percentage of total or full scale.

4.2.3 Repeatability

The repeatability for a device is the ability of a device to reproduce output readings when the same measurand value is applied to it consecutively under identical conditions. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then the data taken in the error band testing would be used to determine the repeatability of the device's perform-

ance under identical conditions. The repeatability of a device is usually stated in percentage of total or full scale.

4.2.4 Warm-up Period

The warm-up period for a device is the time stated by the manufacturer between initial power up and the time that the device can be effectively used. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested after a warm-up period to determine that the device is functioning properly.

4.2.5 Drift

The drift of a device is the amount of output shift with a fixed input over a stated time period. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested over a stated time (usually 8 hours) for output variation with the input fixed.

4.2.6 Stability

The stability of a device is the amount of output shift with a fixed input over an extended time period. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then the device will be tested over a stated time(usually 90 days) for output variation with the input fixed.

4.2.7 Response Time

The response time of a device is the length of time required for the output of a device to rise to a specified percentage of its final value as a result of a step change in input stimulus. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then the device will be tested with a step change from zero to span input stimulus monitored as the same time as the output of the device.

4.2.8 End Points

The end points of a device are the outputs of the device at a specified upper and lower input stimulus limits. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested at the stimulus upper and lower setpoints.

4.2.9 Signal Output Range Limits

The signal output range limits of a device are the outputs of the device when the input stimulus exceeds the specified upper and lower input stimulus limits. This is a KSC specification requirement that is rarely found in commercial specifications. If this is requested by the system engineer, then the device will be tested outside the stimulus upper and lower setpoints. When listed in commercial specifications, it is know as the rail state of the device.

4.2.10 Cable Length

The cable length requirement of a device is the ability of the device to send the output signal over 600 feet of instrumentation grade cable used at KSC. This is a KSC specification requirement that is never found in commercial specifications. If this is requested by the system engineer, then the device will be tested with a cable simulator placed on the system and sensor side of the device.

4.3 Environmental Requirements

The following are those requirements associated with the environmental properties of operation at KSC. Not all of these requirements will be applicable, it is left to the discretion of the sensors and transducer lab which will be used in the qualification testing.

4.3.1 Ambient Temperature

The ambient temperature requirement of a device is the temperature in which the device is intended to operate within. This is a KSC specification requirement that is commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested at the upper and lower ambient temperatures for performance. This testing is done as part of the error band testing.(See section 4.2.1.)

4.3.2 Electromagnetic Interference

The electromagnetic interference requirement of a device is the testing to determine whether a device is going to have problems with electronic noise or will be a source of electronic noise. This testing is based on limits and test procedures established by MIL-STD-461 and are a NASA testing requirement that is not commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested for compliance with MIL-STD-461 latest or specified revision.

4.3.3 Launch Environment

The launch environment requirement of a device is the accumulation of all effects found in the launch environment of KSC. This includes the effects of humidity, salt fog, sand

and dust, fungus and sunshine. The test can be performed per KSC-STD-164 or by testing the device outside in the KSC area. This is a KSC specification requirement that is not commonly found in commercial specifications except for humidity. If this is requested by the system engineer, then the device will be tested outside in the KSC area.

4.3.4 Vibration

The vibration requirement of a device is the vibrational power spectral energy that the device will experience during operation or space launch. The vibration requirement at KSC is based on the vibrational energy measured at the location that the device will operate and the number of cycles the device could see during operation. This is a KSC specification requirement that is not commonly found in commercial specifications. If this is requested by the system engineer, then the device will be tested at the power spectral density of the intended location and the device will either be operating during vibration testing for will be performance tested before and after each axis of vibration.

4.3.5 Shock

The shock requirement of a device is the ability of the device to operate after a transportation shock associated with dropping the device from a height of four feet. This is a KSC and military specification requirement that is not commonly found in commercial specifications. If this is requested by the system engineer, then the device will be dropped onto a hard surface and the device performance tested.

4.3.6 Acoustic

The acoustic requirement of a device is the ability of the device to operate after an acoustic shock associated with launch. This is a KSC and military specification requirement that is not commonly found in commercial specifications. If this is requested by the system engineer, then the device will be evaluated for resistance to acoustic shock, based on the vibration testing in section 4.3.4.

4.4 Mechanical Requirements

The following are those requirements associated with the mechanical properties of a device. Not all of these requirements will be applicable, it is left to the discretion of the sensors and transducer lab which will be used in the qualification testing.

4.4.1 Size

The size requirement of a device is the maximum dimensional device envelope for the area that the device will be used. This is requirement is usually taken from the manufacturer's drawings and from any specific size that the system engineer requires. If this

is requested by the system engineer, then the device will be evaluated for maximum size envelope.

4.4.2 Media Compatibility

The media compatibility is the compatibility of a device to the media it will come in contact with during operation. This requirement is important for devices intended for use with hypergolic, petroleum and cryogenic fluids. The system engineer shall inform the sensors and transducers engineer of what fluids the device is intended for including any possible cross contamination issues or multiple usages of the device. Media compatibility is conducted using evaluation of materials used in the device either by direct testing or by analysis using the approved lists of materials found in NASA-STD-6001, which is maintained by the KSC Materials Officer. If this is requested by the system engineer, then the device will be evaluated for compatibility to the intended operational media. Any additional testing of materials for the device will be forwarded through the KSC Material Officer for incorporation into NASA-STD-6001.

4.4.3 Materials

The materials requirements are used to establish a list of materials for production of the device that have proven reliable in the KSC environment. At KSC, most of the sensors and transducers are made of corrosion resistant materials like 304 and 316 stainless steel or aluminum with epoxy coatings. If this is requested by the system engineer, then the device will have a list of materials generated.

4.4.4 Sealing

The sealing requirements are based on the need either to weatherproof the device for outdoor usage or to seal the device hermitically for safety. At KSC, most of the sensors and transducers us military weatherproof or hermitically sealed connectors and the devices have O-ring or gasket seals to prevent water and gas intrusion. If this is requested by the system engineer, then the device will have to be tested or evaluated for sealing against water or gas intrusion.

4.4.5 Interchangeability

The interchangeability requirement is based on the need to eliminate the need to make unique installations for same measurement and to limit the number of units in logistics for a particular measurement. Optimum operations dictate that the removal of a measurement should not require the changing of the system to accommodate the next device. If this is requested by the system engineer, then the device will have to be tested in groups of 3-10 units to determine interchangeability.

4.4.6 Mean Time Between Failures

The mean time between failures (MBTF) requirement is used to guarantee that a device will have an operational life sufficiently long enough to support the program. Mean time between failures is a KSC and military requirement based on operational usage, analysis of design elements, and testing of several test units over a extended time. At KSC, the MBTF is 100,000 hours between failures at 25C. If this is requested by the system engineer, then the device will have to be tested for MBTF.

4.5 Safety Requirements

The following are those requirements associated with the safety requirements of operations at KSC. Not all of these requirements will be applicable, it is left to the discretion of the sensors and transducer lab which will be used in the qualification testing.

4.5.1 Hazardproofing

Hazardproofing at KSC is defined in KSC-STD-E-0002. This document references the National Electrical Code, in particular the National Fire Protection Agency document NFPA 70A Chapter 5 for special occupancies. Hazardproofing analysis and testing will be required on all Level A and B devices due to the materials involved.

4.5.2 National Electrical Code Rating

As part of the National Electrical Code (NEC), areas that are deemed hazardous are rated by the amount of hazard involved. For the Level A devices this rating is Class I, Division I Groups A-D. This means that the device will or may be in physical contact with the gas acetylene (Group A), flammable gases like hydrogen (Group B), flammable gases like ethylene (Group C), and flammable gases like propane (Group D). For the Level B devices this rating is Class I, Division II Groups A-D. This means that the device may be in physical contact due to an accident or fault in the system. The group rankings are the same as Division I. The Level C and D devices will not be used in either Class I Division I or Division II areas. The NEC rating will be evaluated by the sensors and transducers lab using the manufacturer's ratings, independent testing such as the Factory Mutual testing or in-house analysis and testing.

4.6 Mission Criticality

The mission criticality of a device depends on what system the device is used in, its function in that system, and the amount of redundancy associated with the measurement. This criticality is usually assigned a particular level by the program safety, quality and reliability engineer as part of the design review process. The mission criticality will be listed by the subsystem engineer in the transducer request form.

All Level A devices will be criticality I or IA and are required as part of the launch process. Their failure will cause mission failure, loss of mission critical equipment and loss of life. All Level B devices are criticality I or II and are required as part of the launch process. Their failure will also cause mission failure, loss of mission critical equipment or a least a launch scrub. Level C and D devices will not carry any mission criticality ratings, however their usage may be deemed important to the systems they will be used in. The system engineer will need to evaluate the system measurement and assign a mission criticality to the device during the selection process.

APPENDIX A
TRANSDUCER REQUEST FORM

KSC-NE-9187
Revision Basic

Transducer Selection Request Form

Name ..... Phone ..... Date Required .....

What is the measurement? ..... (Ex.: Pressure, Temperature, Flow, etc.)

What is the range of this measurement? ..... (Ex.: 0-10 psig, -40F to 100F, etc.)

What is the level of criticality ..... (Ex.: Criticality I or IA , none, etc.)

Desired output signal ..... (Ex.: 0-5VDC, 4-20mADC, etc.)

Desired accuracy ..... (Ex.: 1%FS, 0.5% of reading, etc.)

Desired repeatability ..... (Ex.: 0.2%FS, 0.1% of reading, etc.)

What is the material being measured? ..... (Ex.: GH2, GOX, LH2, MMH, etc.)

What are the material compatibility issues? ..... (Ex.: Oxidizer or fuel compat, etc.)

Desired electrical connections ..... (Ex.: Mil-Std, 1/2" EMT, etc.)

Desired mechanical connections ..... (Ex.: ANSI, DN, NPT, etc.)

Desired size and weight ..... (Ex.: 40lb 5"x 5"x 5", etc.)

Enclosure ratings ..... (Ex.: weatherproof, Class1 Div1, etc.)

Location of measurement ..... (Ex.: Indoors, outdoors, cabinet, etc.)

Other requirements, comments (please specify)

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List of sensors already under consideration

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Note: All terminology used in this form can be referenced in Section 4 of KSC-NE-9187.

APPENDIX B
SELECTION REQUIREMENTS BY MEASUREMENT TYPE

Minimum Requirements for Level A Pressure Transducers High Risk and Critical Measurements	Minimum Requirements for Level B Pressure Transducers Low Risk and Critical Measurements	Minimum Requirements for Level C Pressure Transducers Medium Risk Measurements	Minimum Requirements for Level D Pressure Transducers Low Risk Measurements	Requirement listing
Class 1 Division 1	Class 1 Division 2	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability per NASA-STD-6001
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>100mA	>100mA	>100mA	>100mA	Current rating
0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	Output signal
Compatible with environment per KSC-STD-164, temperature range -25C to 85C	Compatible with environment per KSC-STD-164, temperature range -25C to 85C	Compatible with environment per KSC-STD-164, temperature range of 0-70C	Clean room or sheltered environment, temperature range of 15-35C	Operating environment including temperature range
EMI Compliance	EMI Compliance	No compliance necessary	No compliance necessary	EMI (SL-E-0002 rating)
>1%FS for absolute,gage or sealed units and >2%FS for differential	>1%FS for absolute,gage or sealed units and >2%FS for differential	>1%FS for absolute,gage or sealed units and >2%FS for differential	>1%FS for absolute,gage or sealed units and >2%FS for differential	Error Band
0.2%FS or less	0.2%FS or less	0.2%FS or less	0.2%FS or less	Repeatability
Pressure fittings to match KC fittings	Pressure fittings to match KC fittings	NPT fittings or better	NPT fittings or better	Pressure fittings
1.5 times maximum rated pressure or 1000 psig whichever is greater	1.5 times maximum rated pressure or 1000 psig whichever is greater	No Requirement	No Requirement	Overpressure safety rating
No zero shift after static pressure	No zero shift after static pressure	No Requirement	No Requirement	Static line pressure rating (for differential pressure units only)
3 times the full scale pressure or 1000 psig whichever is greater	3 times the full scale pressure or 1000 psig whichever is greater	3 times the full scale pressure or 1000 psig whichever is greater	3 times the full scale pressure or 1000 psig whichever is greater	Burst pressure rating
Sensor shall be isolated from electronics by mechanical barrier	Sensor shall be isolated from electronics by mechanical barrier	No Requirement	No Requirement	Pressure barrier
> 38mV	> 38mV	No Requirement	No Requirement	Toggle (for differential pressure units only)
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Interchangeability of parts
Protection at 35VDC power	Protection at 35VDC power	No Requirement	No Requirement	Overvoltage Protection
Protection against reversed power	Protection against reversed power	No Requirement	No Requirement	Reversed Polarity Protection
Protection to 150% nominal current	Protection to 150% nominal current	No Requirement	No Requirement	Overcurrent Protection
Protection from +-/100V 10ms spike	Protection from +-/100V 10ms spike	No Requirement	No Requirement	Transient Voltage Protection
Protection from output shorts	Protection from output shorts	No Requirement	No Requirement	Short Circuit Protection
> 25mVpp	> 25mVpp	No Requirement	No Requirement	Output Ripple and Noise
100,000 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
0.0VDC(or 4mA) +/- 1%FS at zero	0.0VDC(or 4mA) +/- 1%FS at zero	0.0VDC(or 4mA) +/- 1%FS at zero	0.0VDC(or 4mA) +/- 1%FS at zero	Zero Balance
Operate within 15 minutes of power up	Operate within 15 minutes of power up	Operate within 30 minutes of power up	Operate within 30 minutes of power up	Stabilization
> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	Drift
> 0.2%FS over 90 days	> 0.2%FS over 90 days	No Requirement	No Requirement	Stability
>5ms from 0 to 100% range	>5ms from 0 to 100% range	No Requirement	No Requirement	Response Time
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance

Pressure Measurement Requirements by Level

Minimum Requirements for PRT Probe for Level A High Risk and Critical Measurements	Minimum Requirements for PRT Probe for Level B Low Risk and Critical Measurements	Minimum Requirements for PRT Probe for Level C Medium Risk Measurements	Minimum Requirements for PRT Probe for Level D Low Risk Measurements	Requirement listing
Class 1 Division 1	Class 1 Division 2	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability per NASA-STD-6001
≥1mA	≥1mA	≥1mA	≥1mA	Operating Current
Capable of withstanding 20mA excitation current	Capable of withstanding 20mA excitation current	Capable of withstanding 20mA excitation current	Capable of withstanding 20mA excitation current	Overcurrent
200 and 1000 ohms with alpha = 3916	200 and 1000 ohms with alpha = 3916	100 and 200 ohms with alpha= 3850	100 and 200 ohms with alpha= 3850	Resistance
Compatible with environment per KSC-STD-164	Compatible with environment per KSC-STD-164	Compatible with environment per KSC-STD-164	Clean room or sheltered environment	Operating environment
± 0.1ohms for 200 ohms, ± 0.5ohms for 1000 ohms	± 0.1ohms for 200 ohms, ± 0.5ohms for 1000 ohms	± 0.1ohms for 200 ohms, ± 0.5ohms for 1000 ohms	± 0.1ohms for 200 ohms, ± 0.5ohms for 1000 ohms	Repeatability
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Interchangeability of parts
>25ms from 0 to 100% range	>25ms from 0 to 100% range	No Requirement	No Requirement	Response Time
200 and 1000 ohm probes	200 and 1000 ohm probes	100 and 200 ohm probes	100 and 200 ohm probes	PRT ranges (alpha= 3916)
-185C to 125C for 1000 ohms, -40C to 150C for 200 ohms	-185C to 125C for 1000 ohms, -40C to 150C for 200 ohms	-4C to 150C for 100 ohms, -40C to 150C for 200 ohms	-4C to 200C for 100 ohms, -40C to 200C for 200 ohms	Temperature ranges
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Withstand 10lbs at base	Withstand 10lbs at base	No Requirement	No Requirement	Bending
Max seal pressure of 5076 psi	Max seal pressure of 5076 psi	No Requirement	No Requirement	Pressure Seal
Per NASA-STD-5004	Per NASA-STD-5004	No Requirement	No Requirement	Welding
0.065 W for 200 ohms and 0.2 W for 1000 ohms	0.065 W for 200 ohms and 0.2 W for 1000 ohms	No Requirement	No Requirement	Self Heating
20 microvolts at a 70C tip/base differential	No Requirement	No Requirement	No Requirement	Thermoelectric Potential
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration

PRT Probe Requirements by Levels

Minimum Requirements for PRT Temperature Transmitter for Level A High Risk and Critical Measurements	Minimum Requirements for PRT Temperature Transmitter for Level B Low Risk and Critical Measurements	Minimum Requirements for PRT Temperature Transmitter for Level C Medium Risk Measurements	Minimum Requirements for PRT Temperature Transmitter for Level D Low Risk Measurements	Requirement listing
Class 1 Division 2	Class 1 Division 2	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>100mA	>100mA	>100mA	>100mA	Current rating
0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	Output signal
Compatible with environment per KSC-STD-164, temperature range -25C to 85C	Compatible with environment per KSC-STD-164, temperature range - 25C to 85C	Compatible with environment per KSC-STD-164, temperature range of 0-70C	Clean room or sheltered environment, temperature range of 15-35C	Operating environment including temperature range
EMI Compliance	EMI Compliance	No Requirement	No Requirement	EMI (SL-E-0002 rating)
>0.5%FS	>0.5%FS	>0.5%FS	>0.5%FS	Error Band
0.1%FS or less	0.1%FS or less	0.1%FS or less	0.1%FS or less	Repeatability
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Interchangeability of parts
Protection at 35VDC power	Protection at 35VDC power	No Requirement	No Requirement	Overvoltage Protection
Protection against reversed power	Protection against reversed power	No Requirement	No Requirement	Reversed Polarity Protection
Protection to 150% nominal current	Protection to 150% nominal current	No Requirement	No Requirement	Overcurrent Protection
Protection from +-/100V 10ms spike	Protection from +-/100V 10ms spike	No Requirement	No Requirement	Transient Voltage Protection
Protection from output shorts	Protection from output shorts	No Requirement	No Requirement	Short Circuit Protection
> 10mVpp	>10mVpp	No Requirement	No Requirement	Output Ripple and Noise
100,000 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Operate within 15 minutes of power up	Operate within 15 minutes of power up	Operate within 30 minutes of power up	Operate within 30 minutes of power up	Stabilization
> 0.1%FS over 8 hours	> 0.1%FS over 8 hours	> 0.1%FS over 8 hours	> 0.2%FS over 8 hours	Drift
> 0.15%FS over 90 days	> 0.2%FS over 90 days	No Requirement	No Requirement	Stability
>25ms from 0 to 100% range	>25ms from 0 to 100% range	No Requirement	No Requirement	Response Time
>5mA	>5mA	No Requirement	No Requirement	Excitation current
Capable of 100, 200 and 1000 ohm probes	Capable of 100, 200 and 1000 ohm probes	Capable of 100 and 1000 ohm probes	Capable of 100 and 1000 ohm probes	PRT ranges (alpha= 3916)
-255C to 260C	-40C to 200C	-40C to 200C	-40C to 200C	Temperature ranges
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance

PRT Probe Signal Conditioner Requirements by Levels

Minimum Requirements for TC Probe for Level A High Risk and Critical Measurements	Minimum Requirements for TC Probe for Level B Low Risk and Critical Measurements	Minimum Requirements for TC Probe for Level C Medium Risk Measurements	Minimum Requirements for TC Probe for Level D Low Risk Measurements	Requirement listing
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability per NASA-STD-6001
Type K (Chromel vs Alumel), Type T (Copper vs Constantan) and Type S(Pt-10% Rodium vs PT)	Type K (Chromel vs Alumel), Type T (Copper vs Constantan) and Type S(Pt-10% Rodium vs PT)	Type K (Chromel vs Alumel), Type T (Copper vs Constantan) and Type S(Pt-10% Rodium vs PT)	Type K (Chromel vs Alumel), Type T (Copper vs Constantan) and Type S(Pt-10% Rodium vs PT)	Thermocouple Sensing Element
Type K = 32 to 530F +/-2F; 530 to 2300F +/-3/8%or Type T = -300 tp -75F +/-1%or; -75 to 200F +/-0.75F; 200 to 700F +/-3/8%or; Type S = 32 to 1000F +/-2.5F; 1000 to 2700F +/-1/4%or	Type K = 32 to 530F +/-2F; 530 to 2300F +/-3/8%or Type T = -300 tp -75F +/-1%or; -75 to 200F +/-0.75F; 200 to 700F +/-3/8%or; Type S = 32 to 1000F +/-2.5F; 1000 to 2700F +/-1/4%or	Type K = 32 to 530F +/-2F; 530 to 2300F +/-3/8%or Type T = -300 tp -75F +/-1%or; -75 to 200F +/-0.75F; 200 to 700F +/-3/8%or; Type S = 32 to 1000F +/-2.5F; 1000 to 2700F +/-1/4%or	Type K = 32 to 530F +/-2F; 530 to 2300F +/-3/8%or Type T = -300 tp -75F +/-1%or; -75 to 200F +/-0.75F; 200 to 700F +/-3/8%or; Type S = 32 to 1000F +/-2.5F; 1000 to 2700F +/-1/4%or	Limits of Error
>0.2%or	>0.2%or	>0.2%or	>0.2%or	Repeatability
Compatible with environment per KSC-STD-164	Compatible with environment per KSC-STD-164	Compatible with environment per KSC-STD-164	Clean room or sheltered environment	Operating environment
>2.2ms to 63.2% of final value for a 0 to 100% step	>2.2ms to 63.2% of final value for a 0 to 100% step	No Requirement	No Requirement	Response Time
Seal to 5076 psig	Seal to 5076 psig	No Requirement	No Requirement	Pressure Seal
Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Interchangeability
0.125" and 0.25"	0.125" and 0.25"	No Requirement	No Requirement	Diameter
Required for all TC types	Required for all TC types	Required for all TC types	Required for all TC types	Temperature vs Voltage (NIST 175)
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration

Thermocouple Probe Requirements by Levels

Minimum Requirements for TC Temperature Transmitter for Level A High Risk and Critical Measurements	Minimum Requirements for TC Temperature Transmitter for Level B Low Risk and Critical Measurements	Minimum Requirements for TC Temperature Transmitter for Level C Medium Risk Measurements	Minimum Requirements for TC Temperature Transmitter for Level D Low Risk Measurements	Requirement listing
Class 1 Division 2	Class 1 Division 2	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>150mA	>150mA	>150mA	>150mA	Current rating
0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	0-5VDC or 4-20mA	Output signal
Compatible with environment per KSC-STD-164, temperature range -25C to 70C	Compatible with environment per KSC-STD-164, temperature range -25C to 70C	Compatible with environment per KSC-STD-164, temperature range of 0-70C	Clean room or sheltered environment, temperature range of 15-35C	Operating environment including temperature range
EMI Compliance	EMI Compliance	No Requirement	No Requirement	EMI (SL-E-0002 rating)
>0.5%FS	>0.5%FS	>0.5%FS	>0.5%FS	Error Band
0.2%FS or less	0.2%FS or less	0.2%FS or less	0.2%FS or less	Repeatability
Requirement for all TC types	Requirement for all TC types	Requirement for all TC types	Requirement for all TC types	Thermocouple compensation
Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Unit shall be interchangeable with like units	Interchangeability of parts
Protection at 35VDC power	Protection at 35VDC power	No Requirement	No Requirement	Overvoltage Protection
Protection against reversed power	Protection against reversed power	No Requirement	No Requirement	Reversed Polarity Protection
Protection to 150% nominal current	Protection to 150% nominal current	No Requirement	No Requirement	Overcurrent Protection
Protection from +-/100V 10ms spike	Protection from +-/100V 10ms spike	No Requirement	No Requirement	Transient Voltage Protection
Protection from output shorts	Protection from output shorts	No Requirement	No Requirement	Short Circuit Protection
> 10mVpp	>10mVpp	No Requirement	No Requirement	Output Ripple and Noise
100,000 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Operate within 15 minutes of power up	Operate within 15 minutes of power up	Operate within 30 minutes of power up	Operate within 30 minutes of power up	Stabilization
> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	> 0.2%FS over 8 hours	Drift
> 0.2%FS over 90 days	> 0.2%FS over 90 days	No Requirement	No Requirement	Stability
>100ms to 0.5% of final value for a 0 to 100% step	>100ms to 0.5% of final value for a 0 to 100% step	No Requirement	No Requirement	Response Time
-20C to 260C and 0C to 1750C	-20C to 260C and 0C to 1750C	-40C to 200C	-40C to 200C	Temperature ranges
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance

Thermocouple Probe Transmitter Requirements by Levels

Minimum Requirements for Level A Coriolis Mass Flowmeters High Risk and Critical Measurements	Minimum Requirements for Level B Coriolis Mass FlowmetersLow Risk and Critical Measurements	Minimum Requirements for Level C Coriolis Mass Flowmeters Medium Risk Measurements	Minimum Requirements for Level D Coriolis Mass Flowmeters Low Risk Measurements	Requirement listing
Cl 1 Div1 sensor, CL1, Div 2 Transmitter	Class 1 Division 2 both	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability(NASA-STD-6001)
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>200mA nominal	>200mA nominal	>200mA nominal	>200mA nominal	Current rating
4-20mA	4-20mA	4-20mA	4-20mA	Output signal
Compatible, temp range -25C to 60C, media temp -200C to 60C	Compatible, temperature range -25C to 60C	Compatible, temperature range of 0-60C	Clean room or sheltered environment, temp of 15-35C	Operating environment (KSC-STD-164) including temp range
EMI Compliance	EMI Compliance	No compliance necessary	No compliance necessary	EMI (SL-E-0002 rating)
>1% o.r.	>1% o.r.	>1% o.r.	>1% o.r.	Error Band
0.2% o.r. or less	0.2% o.r. or less	0.2% o.r. or less	0.2% o.r. or less	Repeatability
NPT, Flare Tube, or ANSI Flanged	NPT, Flare Tube, or ANSI Flanged	NPT fittings or better	NPT fittings or better	Flow sensor fittings
30 psid at max flow	30 psid at max flow	No Requirement	No Requirement	Pressure Loss
0-600 lb/min max	0-600 lb/min max	No Requirement	No Requirement	Flow Range(gpm)
Capable of measuring in both directions	Capable of measuring in both directions	No Requirement	No Requirement	Bi-Directional Flow
Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeability of parts
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance
> 200mVpp into 700ohms	> 200mVpp into 700ohms	No Requirement	No Requirement	Output Ripple and Noise
700 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Stabilization
> 0.5%FS over 8 hours	> 0.5%FS over 8 hours	> 1%FS over 8 hours	> 1%FS over 8 hours	Drift
> 0.5%FS over 90 days	> 0.5%FS over 90 days	No Requirement	No Requirement	Stability

Coriolis Mass Flowmeter Requirements by Levels

Minimum Requirements for Level A Vortex Shedding Flowmeters High Risk and Critical Measurements	Minimum Requirements for Level B Vortex Shedding Flowmeters Low Risk and Critical Measurements	Minimum Requirements for Level C Vortex Shedding Flowmeters Medium Risk Measurements	Minimum Requirements for Level D Vortex Shedding Flowmeters Low Risk Measurements	Requirement listing
Cl 1 Div1 sensor, CL1, Div 2 Transmitter	Class 1 Division 2 both	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability(NASA-STD-6001)
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>330mA	>330mA	>330mA	>330mA	Current rating
Frequency or 4-20mA	Frequency or 4-20mA	Frequency or 4-20mA	Frequency or 4-20mA	Output signal
Compatible, temp range -25C to 70C, media temp -200C to 70C	Compatible, temperature range -25C to 70C	Compatible, temperature range of 0-70C	Clean room or sheltered environment, temp of 15-35C	Operating environment(KSC-STD-164) including temperature range
EMI Compliance	EMI Compliance	No compliance necessary	No compliance necessary	EMI (SL-E-0002 rating)
>5%FS with a 15:1 turndown	>5%FS with a 15:1 turndown	>5%FS with a 15:1 turndown	>5%FS with a 15:1 turndown	Error Band
1%FS or less	1%FS or less	1%FS or less	1%FS or less	Repeatability
NPT, Flare Tube,Wafer, or Flanged	NPT, Flare Tube,Wafer, or Flanged	NPT fittings or better	NPT fittings or better	Flow sensor fittings
20 psid at max flow	20 psid at max flow	No Requirement	No Requirement	Pressure Loss
0-320 gpm max	0-320 gpm max			Flow Range(gpm)
No damage after maximum reverse flow	No damage after maximum reverse flow	No Requirement	No Requirement	Reverse Flow Protection
Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeability of parts
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance
Protection at 35VDC power	Protection at 35VDC power	No Requirement	No Requirement	Overvoltage Protection
Protection against reversed power	Protection against reversed power	No Requirement	No Requirement	Reversed Polarity Protection
Protection to 150% nominal current	Protection to 150% nominal current	No Requirement	No Requirement	Overcurrent Protection
Protection from +-/100V 10ms spike	Protection from +-/100V 10ms spike	No Requirement	No Requirement	Transient Voltage Protection
Protection from output shorts	Protection from output shorts	No Requirement	No Requirement	Short Circuit Protection
> 20mVpp	> 20mVpp	No Requirement	No Requirement	Output Ripple and Noise
100,000 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Stabilization
> 0.5%FS over 8 hours	> 0.5%FS over 8 hours	> 1%FS over 8 hours	> 1%FS over 8 hours	Drift
> 0.5%FS over 90 days	> 0.5%FS over 90 days	No Requirement	No Requirement	Stability
>2seconds from 0 to 100% range	>2seconds from 0 to 100% range	No Requirement	No Requirement	Response Time

Vortex Shedding Flowmeter Requirements by Levels

Minimum Requirements for Level A Turbine Flowmeters High Risk and Critical Measurements	Minimum Requirements for Level B Turbine Flowmeters Low Risk and Critical Measurements	Minimum Requirements for Level C Turbine Flowmeters Medium Risk Measurements	Minimum Requirements for Level D Turbine Flowmeters Low Risk Measurements	Requirement listing
Cl 1 Div1 sensor, CL1, Div 2 Transmitter	Class 1 Division 2 both	No Requirement	No Requirement	Safety (NFPA 70 rating)
Hermitically sealed per KSC-S-126	Hermitically sealed per KSC-S-126	Weatherproof	No Requirement	Sealing and construction
Compatibility of materials to fluids	No Requirement	No Requirement	No Requirement	Media Compatability(NASA-STD-6001)
28-/+4VDC	28-/+4VDC	28-/+4VDC	28-/+4VDC	Power rating
>330mA	>330mA	>330mA	>330mA	Current rating
0-5V or 4-20mA	0-5V or 4-20mA	0-5V or 4-20mA	0-5V or 4-20mA	Output signal
Compatible, temp range - 25C to 70C	Compatible, temp range - 25C to 70C	Compatible, temp range of 0-70C	Clean room or sheltered environment, temp of 15-35C	Operating environment(KSC-STD-164) including temperature range
EMI Compliance	EMI Compliance	No compliance necessary	No compliance necessary	EMI (SL-E-0002 rating)
>1%FS with a 10:1 turndown	>1%FS with a 10:1 turndown	>1%FS with a 10:1 turndown	>5%FS with a 10:1 turndown	Error Band
0.2%FS or less	0.2%FS or less	0.2%FS or less	0.2%FS or less	Repeatability
NPT, Flare Tube,Wafer, or Flanged	NPT, Flare Tube,Wafer, or Flanged	NPT fittings or better	NPT fittings or better	Flow sensor fittings
No Requirement	No Requirement	No Requirement	No Requirement	Pressure Loss
0-320 gpm max	0-320 gpm max	No Requirement	No Requirement	Flow Range
No damage after maximum reverse flow	No damage after maximum reverse flow	No Requirement	No Requirement	Reverse Flow Protection
Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeable with like units	Interchangeability of parts
MBTF of 100,000 hours or greater	MBTF of 100,000 hours or greater	No Requirement	No Requirement	Reliability (MBTF)
Capable of being calibrated at KSC	Capable of being calibrated at KSC	Capable of being calibrated at KSC	No Requirement	Calibration
Capable of being repaired by vendor	Capable of being repaired by vendor	Capable of being repaired by vendor	No Requirement	Maintenance
Protection at 35VDC power	Protection at 35VDC power	No Requirement	No Requirement	Overvoltage Protection
Protection against reversed power	Protection against reversed power	No Requirement	No Requirement	Reversed Polarity Protection
Protection to 150% nominal current	Protection to 150% nominal current	No Requirement	No Requirement	Overcurrent Protection
Protection from +-/100V 10ms spike	Protection from +-/100V 10ms spike	No Requirement	No Requirement	Transient Voltage Protection
Protection from output shorts	Protection from output shorts	No Requirement	No Requirement	Short Circuit Protection
> 20mVpp	> 20mVpp	No Requirement	No Requirement	Output Ripple and Noise
100,000 ohm load	No Requirement	No Requirement	No Requirement	Maximum signal loading
> 1,000,000ohms	> 1,000,000ohms	No Requirement	No Requirement	Output signal isolation
> 1,000,000 ohms	> 1,000,000 ohms	No Requirement	No Requirement	Connection isolation from case
Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Operate within 15 minutes	Stabilization
> 0.5%FS over 8 hours	> 0.5%FS over 8 hours	> 1%FS over 8 hours	> 1%FS over 8 hours	Drift
> 0.5%FS over 90 days	> 0.5%FS over 90 days	No Requirement	No Requirement	Stability
>25msec from 0 to 100% range	>25msec from 0 to 100% range	No Requirement	No Requirement	Response Time

Turbine Flowmeter with Signal Conditioner Requirements by Levels