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**MEASUREMENT SYSTEM
IDENTIFICATION**



NASA TECHNICAL STANDARD

National Aeronautics and Space Administration

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Change 3**

METROLOGY AND CALIBRATION

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DOCUMENT HISTORY LOG

Status	Document Revision	Approval Date	Description
Baseline		2018-01-23	Initial Release
Change	1	2018-03-20	Added revision dates for the following documents and reorganized alphabetically in section 2.3 under Applicable Documents: SAE AS9003, SAE AS9100, ISO 900, and JCGM 200. Deleted the following documents from the Applicable Documents and References section: ESD ADV1.0-2017 and ESD Association Advisory for Electrostatic Discharge Terminology – Glossary. Moved reference documents from Appendix A to section 2 and renamed Appendix B.
Change	2	2021-04-05	Updated revision for ISO/IEC 17025 from 2005 to 2017.
Change	3	2022-02-07	Replaced reference to NPD 8730.5 with NPR 8735.2.
Revision	A	2024-11-20	<p>1.2.2 Added examples of in-scope use cases that are further explained in appendix A</p> <p>3.2 Added definition for Metrological traceability</p> <p>Forward and 4.1 Modernized the phrasing of the metrological traceability requirement</p> <p>4.2.3 Provided a traceability and data requirement for when a conforming calibration cannot be obtained and the OEM is used to acquire a verification.</p> <p>Two format corrections</p>

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FORWARD

This NASA Technical Standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform metrology and calibration requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA applications.

This NASA Technical Standard is approved for use by NASA Headquarters and NASA Centers and Facilities and may be cited in contract, program, and other Agency documents as a technical requirement. It may also apply to the Jet Propulsion Laboratory and other contractors to the extent specified or referenced in applicable contracts.

This NASA Technical Standard establishes technical requirements to ensure the accuracy of measurements affecting safety and mission success through the proper selection, calibration, and use of measuring and test equipment (MTE).

This NASA Technical Standard was developed by NASA Headquarters Office of Safety and Mission Assurance. Requests for information, corrections, or additions to this standard should be submitted to the NASA, Office of Safety and Mission Assurance (OSMA), by email to Agency-SMA-Policy-Feedback@mail.nasa.gov or via the “Submit Feedback” link at <https://standards.nasa.gov>.

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METROLOGY AND CALIBRATION

1. SCOPE

1.1 Purpose

The purpose of this NASA Technical Standard is to ensure the accuracy of measurements affecting safety and mission success through the proper selection, calibration, and use of MTE.

1.2 Applicability

1.2.1 This NASA Technical Standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers, and may be cited in contract, program, and other Agency documents as a technical requirement. This Standard may also apply to the Jet Propulsion Laboratory or to other contractors, grant recipients, or parties to agreements to the extent specified or referenced in their contracts, grants, or agreements.

1.2.2 This standard is applicable to measurement applications where quantitative data accuracy is necessary in order to ensure safety, mission success, the credibility of published research products, and regulatory compliance (see appendix A herein).

1.2.3 This standard does not apply where quantitative data accuracy is not a consideration, such as certain types of processes monitoring, “indication only,” or “reference only” purposes.

Note: Examples of an “indication only” or “reference only” application is a reading on a gas gauge or battery charge indicator. These are not calibrated MTE however they provide the user indication of a condition.

1.3 Levying Additional or Conflicting Requirements

1.3.1 Organization-specific calibration requirements not contained in this publication or standards referenced herein shall be formally documented prior to implementation. The term organization includes NASA programs and projects, NASA Centers, and NASA contractors and subcontractors upon which this standard has been contractually invoked.

1.3.2 The requirements established in this NASA Technical Standard do not supersede or waive requirements found in other Agency documents.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

2.1.1 The documents listed in this section contain provisions that constitute requirements of this Standard as cited in the text. Use of more recent issues of cited documents may be authorized by the responsible Technical Authority.

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2.1.2 The applicable documents are accessible at <https://standards.nasa.gov> or may be obtained directly from the Standards Developing Body or other document distributors.

2.1.3 Government Documents

NPR 1441.1	NASA Records Management Program Requirements
NPR 8735.2	Hardware Quality Assurance Program Requirements for Programs and Projects
NRRS 1441.1	NASA Records Retention Schedules

2.1.4 Non-Government Documents

ANSI/NCSL Z540.1-1994 (R2002)	Calibration Laboratories and Measuring and Test Equipment - General Requirements
ANSI/NCSL Z540.3-2006 (R2013)	Requirements for the Calibration of Measuring and Test Equipment
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI/ESD S20.20-2014	Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
SAE AS9003B (2021)	Inspection and Test Quality Systems Requirements for Aviation, Space and Defense Organizations
SAE AS9100D (2016)	Quality Management Systems – Requirements for Aviation, Space, and Defense Organizations
ISO 9001:2015(E)	Quality Management Systems – Requirements
JCGM 200:2012	International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)

2.2 Reference Documents

The following documents provide what is considered to be beneficial guidance and background information, but do not constitute requirements of this standard.

NASA-HDBK-8709.22	Safety & Mission Assurance Acronyms, Abbreviations, & Definitions
NASA-HDBK-8739.19-2	Measuring and Test Equipment Specifications

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NASA-HDBK-8739.19-3 Measurement Uncertainty Analysis Principles and Methods

NASA-HDBK-8739.19-4 Estimation and Evaluation of Measurement Decision Risk

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms and Abbreviations

ANSI	American National Standards Institute
EOPR	End of Period Reliability
ESD	Electrostatic Discharge
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
JCGM	Joint Committee for Guides in Metrology
MTE	Measuring and Test Equipment
NCSL	National Conference of Standards Laboratories
NIST	National Institute of Standards and Technology
NMI	National Metrology Institute
OEM	Original Equipment Manufacturer
PFA	Probability of False Acceptance
SI	International System of Units
VIM	International Vocabulary of Metrology

3.2 Definitions

The relevant definitions from JCGM 200, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*, are applicable.

Calibration System. The set of interrelated or interacting elements necessary to maintain the measurement performance of measuring and test equipment to defined requirements. (ANSI/NCSL Z540.3, Requirements for the Calibration of Measuring and Test Equipment)

End of Period Reliability. The probability of an item of measuring and test equipment being in tolerance at the end of its assigned calibration interval.

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Measuring and Test Equipment. The measuring instrument, measurement standard, reference material, or auxiliary apparatus, or a combination thereof, necessary to realize a measurement process.

Note: This also includes individual items of equipment and measuring systems comprised of several items that are used in calibration, test, inspection, and verification. (ANSI/NCSL Z540.3)

Metrological Traceability. The property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

National Metrology Institutes. Signatories to the International Committee for Weights and Measures' mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology, and have calibration and measurement capabilities published in the relevant areas of the International Bureau of Weights and Measures key comparison database. See: <https://www.bipm.org/en/cipm-mra/participation>.

4. REQUIREMENTS

4.1 Metrological Traceability

All calibrations, verifications, and measurements, are performed using internationally recognized standards traceable to the International System of Units (SI). Metrological traceability is achieved through calibrations by the National Institute of Standards and Technology (NIST), other National Metrology Institutes (NMIs), or by using natural physical constants, intrinsic standards or ratio calibration techniques.

4.2 Calibration Systems

4.2.1 Calibration systems shall be implemented within the context of an overarching Quality Management System (e.g., SAE AS9100, Quality Management Systems – Requirements for Aviation, Space, and Defense Organization, SAE AS9003, Inspection and Test Quality Systems Requirements for Aviation, Space and Defense Organizations, ISO 9001, Quality Management Systems – Requirements), as required by NPR 8735.2, Hardware Quality Assurance Program Requirements for Program and Projects, applicable contracts, and agreements.

4.2.2 The accuracy, reliability, and use of MTE shall be controlled through the use of a calibration system compliant to one of the following standards:

- a. ANSI/NCSL Z540.1-1994 (R2002), Calibration Laboratories and Measuring and Test Equipment - General Requirements. (Note: ANSI/NCSL Z540.1-1994 was withdrawn by ANSI from its documentary review and revision process but remains available for sale and use.)

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- b. ANSI/NCSL Z540.3-2006 (R2013), Requirements for the Calibration of Measuring and Test Equipment. (Note: ANSI/NCSL Z540.3-2006 was withdrawn by ANSI from its documentary review and revision process but remains available for sale and use.)
- c. ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories.

4.2.3 When calibrations compliant to ANSI/NCSL Z540.1, ANSI/NCSL Z540.3, or ISO/IEC 17025 are not accessible, as a risk mitigation, evidence of metrological traceability and documented test data shall be obtained from the Original Equipment Manufacturer (OEM).

4.3 Probability of False Acceptance (PFA), Applies only to ANSI/NCSL Z540.3

4.3.1 In cases where 20 or more like calibrations are performed (see paragraph 4.3.2 below), a probability of false acceptance (PFA) of 2% may be achieved by observing end-of-period reliability (EOPR) values specified in the Table 1. This is considered acceptable evidence of compliance to ANSI/NCSL Z540.3 sub-clause 5.3.b (false acceptance requirements) and sub-clause 5.3.3 (measurement uncertainty requirements) for calibrations meeting these conditions.

Table 1. End-of-Period Reliability (EOPR) Values to Achieve PFA of 2%

Number of calibrations	Required Observed EOPR
Less than 20	Not applicable
20 to 39	95% or greater
40 to 69	93% or greater
70 or more	92% or greater

4.3.2 EOPR data used to meet the 2% PFA requirement shall be for MTE of the same manufacturer, model, and technical specifications, and result from the same calibration procedure and calibration interval.

4.4 Procurement of External Calibration Services

4.4.1 Procurement of calibration services, including procurements made using a purchasing card (also known as a P-card), shall:

- a. Ensure that the calibration provider's capability satisfies the range and accuracy requirements for MTE to be calibrated.
- b. Specify the calibration standard which the calibration service provider is required to meet within the contract/subcontract/purchase order.

4.5 Measuring and Test Equipment Repair and Adjustment

4.5.1 Calibration or repair of MTE requiring direct interaction with internal or external electrostatic discharge (ESD) sensitive components shall be performed using ESD controls that ensure preservation of the MTE. Recommended ESD control methods are provided in

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ANSI/ESD S20.20, Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices).

4.6 Metrology and Calibration Records

4.6.1 Record retention requirements for calibration records are provided in NPR 1441.1, NASA Records Management Program Requirements, and NRRS 1441.1, NASA Records Retention Schedule.

**APPENDIX A. FUNCTIONS AND CONDITIONS REQUIRING
CALIBRATED MEASURING AND TEST EQUIPMENT**

- A.1 Testing, qualification, certification, and acceptance measurements of flight hardware, ground support equipment, test systems, or other flight-related products.
- A.2 Measurements essential to the safety of personnel and the public or for the protection of Government or private property.
- A.3 Operation of telecommunications and transmission systems where exact signal interfaces and circuit confirmations are essential to mission success.
- A.4 Research and technology development, manufacturing, inspection, testing, operations, maintenance, support, or other applications where the accuracy of measurements is essential to ensure safety or achieve mission success.
- A.5 Measurements used for publishing NASA research where the conclusions and/or recommendations of that research depend upon the quantitative accuracy of measurement results. Excluded are preliminary research papers and research instruments under development that have not had traceable units of measurement established.
- A.6 Physical measurements used to apportion, levy, or otherwise assign cost(s), or ensure local, State, or Federal regulatory compliance.

Note: Calibration is not required for measurements where quantitative data accuracy is not a consideration, such as process monitoring, "indication only," or "reference only" purposes.