



Ames Procedural Requirements

APR 8730.1

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COMPLIANCE IS MANDATORY

Subject: Metrology and Calibration

Responsible Office: Code Q / Safety and Mission Assurance Directorate

CHANGE LOG

Status [Baseline /Revision /Cancelled]	Document Revision	Date of Change	Description
Revision	3	8/13/2013	Update to new NASA policy directive NPD 8730.1; address findings from QAAR and AS9100 audits.
Revision	4	9/13/2018	Added updates from NPD 8730.5B NASA Quality Assurance Program Policy, Section 1, para 1.b. Added updates from NASA-STD-8739.12 Change 1, Metrology and Calibration
Revision	5	5/5/2020	Updated paragraph 1.2f and 2.1.1b, added ANSI/NCSL Z540.1-1994 (R2002) as an allowable calibration standard, and made administrative edits.
Revision	6	2/4/2022	Updated paragraph P.1 documents, authority and applicable documents, and citations to reflect cancellation of NPD 8730.5 and revisions to NPR 8735.2 and NASA-STD-8739.12; added ISO/IEC 17025 as a calibration standard; and stated MTE User training requirements.

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PREFACE

P.1 PURPOSE

a. The purpose of this directive is to describe how the Ames Research Center (ARC) implements and flows down the requirements of NPR 8735.2, (Hardware Quality Assurance Program Requirements for Programs and Projects, and NASA-STD-8739.12 (Metrology and Calibration), to ensure the accuracy of measurements affecting safety and mission success through the proper selection, traceability, calibration, control, reliability and use of Measuring and Test Equipment (MTE).

P.2 APPLICABILITY

- a. This directive is applicable to ARC and associated facilities, e.g., contractor's facilities, etc., including all ARC activities, organizations, Programs / Projects / Operations.
- b. This directive applies to contractors, grant recipients, or parties to agreements only to the extent specified or referenced in the appropriate contracts, grants, or agreements.
- c. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" or "can" denote discretionary privilege or permission, "should" denotes a good practice and is recommended, but not required, "will" denotes an expected outcome, and "are/is" denotes descriptive material.
- d. In this directive, all document citations are assumed to be the latest version unless otherwise noted.
- e. This directive is applicable to MTE requiring measurement controls for:
 - (1) Testing, qualification, certification, and/or acceptance measurements of flight hardware, ground support equipment, test systems, or other flight-related products.
 - (2) Measurements essential to the safety of personnel and the public or for the protection of Government or private property, including hazardous and/or critical applications.
 - (3) Operation of telecommunications and transmission systems where exact signal interfaces and circuit confirmations are essential to mission success.
 - (4) Research and technology development (see NPR 7120.8), manufacturing, inspection, testing, operations, maintenance, support, or other applications where the accuracy of measurements is essential to achieve mission success.
 - (5) Physical measurements used to apportion, levy, or otherwise assign cost(s), or ensure local, State, or Federal regulatory compliance.
 - (6) Development, testing and special applications where the specifications, end products or data are accuracy sensitive - including instruments used in hazardous, critical, and/or complex applications.
 - (7) Calibration of Ames MTE.
Note: Use of un-calibrated MTE should be limited to applications where verified accuracy is not necessary (e.g. Indication Only or calibration not required) in nonhazardous, noncritical applications.
- f. Deviations/Waivers for calibration are permitted in accordance with APR 8735.2 Deviation/Waiver Process.
- g. The requirements of this APR are in addition to, not in replacement of, requirements specified by official local, State, or Federal regulatory bodies. Where conflicts exist, requirements specified by regulatory bodies take precedence.

P.3 AUTHORITY

- a. NPR 8735.2, Hardware Quality Assurance Program Requirements for Programs and Projects
- b. NASA-STD-8739.12, Metrology and Calibration

P.4 APPLICABLE DOCUMENTS AND FORMS

- a. NPR 8705.6, Safety and Mission Assurance (SMA) Audits, reviews, and Assessments
- b. NPR 1441.1 NASA Records Management Program Requirements
- c. APR 7150.2, Ames Software Engineering Requirements
- d. APR 8735.2 Deviation/Waiver Process
- e. APR 8735.3 Control of Non-conforming Products and Services
- f. Form ARC 828, Out-of-Tolerance Investigation Report
- g. Form ARC 827, User Calibration Report.
- h. NASA-STD-8739.12, Metrology and Calibration
- i. NASA-HDBK 8739.19-2, NASA Measurement Quality Assurance Handbook- ANNEX 2
- j. NRRS 1441.1 NASA Records Retention Schedules
- k. ANSI/NCSL Z540.1-1994 (R2002), Calibration Laboratories and Measuring and Test Equipment-General Requirements
- l. ANSI/NCSL Z540.3-2006 (R2013), Requirements for the Calibration of Measuring and Test Equipment
- m. ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories
- n. SAE AS9100D (2016), Quality Management Systems - Requirements for Aviation, Space and Defense Organizations

P.5 MEASUREMENT/VERIFICATION

- a. Verification of conformance to requirements in this directive are measured through Center and Responsible Organizational management reviews, self-assessments, and subsequent analysis and reports of conformance to requirements, as well as periodic internal audits.
- b. Compliance with the requirements contained in this APR are verified through processes contained in NPR 8705.6 and NASA-STD-8739.12.

P.6 CANCELLATION

- a. APR 8730.1, Metrology and Calibration, dated September 13, 2018.

Eugene Tu
Director

DISTRIBUTION STATEMENT:

Internal and external distribution.

CHAPTER 1 RESPONSIBILITIES

1.1 The **Metrology and Calibration Program Manager** shall:

- a. Maintain this APR for compliance with NPR 8735.2 and with NASA-STD - 8739.12.
- b. Collect and document calibration measurement metrics (e.g. local registers of MTE, Out-Of-Tolerances (OOT), and Suppliers used, and waivers) for preparation for annual reports to the Agency's Metrology Calibration Working Group (MCWG).
- c. Represent Ames to the NASA MCWG (Metrology and Calibration Working Group) to provide Center representation and input at MCWG meetings, workshops, and other designated activities.
- d. Provide Subject Matter Expert (SME) support to the Ames MTE community (Project Managers, users, and auditors) to resolve questions regarding this APR including MTE users that calibrate their own equipment.
- e. Review and approve Deviations/Waivers for calibration in accordance with APR 8735.2.

1.2 **Program / Project or Organizational Managers** shall:

- f. Ensure that this procedure is implemented in Program / Project or Organizational Policy documentation, including contracts, if MTE is used in any of the applications defined in Section P.2, above.
 - a. Coordinate metrology and calibration efforts among Centers, component facilities, and other locations providing program/project or organizational support.
 - b. Ensure their personnel are knowledgeable in the handling, transport, selection, storage, shipping, use, and control of Measuring and Test Equipment (MTE) in accordance with section 1.3e below.
 - c. Ensure that personnel performing User Calibrations:
 - (1) Possess the necessary competence for work being performed.
 - (2) Maintain relevant records of education, training, skills and experience.
 - (3) Perform calibrations in compliance with Chapter 2.2 of this APR.
 - d. Ensure an effective register (including details of equipment type, unique identification, location, frequency of checks) exists for timely recall and calibration of MTE and reported to the AMES Metrology and Calibration Program Manager semiannually.
 - e. Ensure that a work history process is in place to provide traceability for each use of MTE to the process/product the device was used on, to facilitate timely recall in the event process/products must be removed from service due to an OOT.
 - f. Ensure that only qualified Calibration Suppliers or competent employees perform calibrations compliant with the requirements of either ANSI/NCSL Z540.1-1994 (R2002) or ANSI/NCSL Z540.3-2006 (R2013), or ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories and with the applicable requirements of AS9100, subject to the clarifications and modifications provided in paragraph 4 of NASA-STD-8739.12.

1.3 Measurement & Test Equipment (MTE) Users (including personnel performing calibrations) shall:

- a. Select, use, control and calibrate MTE in compliance with the requirements of either ANSI/NCSL Z540.1-1994 (R2002) or ANSI/NCSL-Z540.3-2006, or ISO/IEC 17025:2017, General Requirements for the Competence of Testing and Calibration Laboratories and with the applicable requirements of SAE AS9100, subject to the clarifications and modifications provided in NASA-STD-8739.12.
- b. Ensure timely calibration of MTE.
- c. Ensure timely recall of processes/products measured with Out-Of-Tolerance (OOT) MTE.
- d. Ensure that calibration records are produced and maintained per this procedure.
- e. Complete the following SATERN training every three years:
 - (1) NASA Metrology and Calibration Program Requirements Overview (SMA-HQ-WBT-103)
 - (2) More Than a Sticker: The Importance of Calibrating Mearuring and Test Equipment (SMA-HQ-WBT-106) and
 - (3) Handling, Transport, Storage and Shipping of Measuring and Test Equipment (SMA-WBT-107).

CHAPTER 2 PROCEDURE

2.1 Selection, Use, and Control of MTE

2.1.1 MTE User shall:

- a. Maintain a register of MTE to facilitate timely recall and calibration.
- b. Use calibrations services from qualified Calibration Suppliers per para 1.2f above.
- c. Report calibrations service problems to Code QS Metrology & Calibration Program Manager (e.g., packaging, handling, cleanliness, OOT, etc.).
- d. For MTE reported or found Out-Of-Tolerance (OOT):
 - (1) Perform a documented OOT investigation using form ARC 828 or equivalent to assess and record the validity of previous measurements. <https://nef.nasa.gov>
 - (2) Initiate a Non-Conformance Report (NCR) using the Ames Research Center's Problem Reporting and Corrective Action system (PRACA) in accordance with APR 8735.3 for each set of measurements or products where the required tolerance is smaller than the OOT condition since the last in-tolerance calibration.

NOTE: This may require recall of processes/products.

- (3) Recall anything identified by the OOT investigation which was affected by the OOT condition, to preclude its use until it is appropriately dispositioned.
- (4) Retain the OOT Investigation report with the applicable calibration report.
- (5) Ensure that the Calibration Interval is adjusted, if appropriate.

- e. Ensure that monitoring and measurements are carried out in a manner that is consistent with specified requirements (e.g. Prints, Test Plan and Instrument Specifications).
- f. Ensure that the accuracy of MTE selected for use is based on an assessment of the data required and the uncertainty that can be tolerated for the planned measurement.
- g. Reassess calibration and measurement needs when processes, product or measurement requirements change.
- h. Ensure that the specified Calibration Interval and Calibration Tolerance are suitable for the intended application. Refer to NASA-HDBK 8739.19-2, Annex 2: Measuring and Test Equipment Specifications.
- i. Ensure that MTE is labeled so that its calibration status can be readily determined before use. Calibration status is most often attached to MTE, or its protective container, using stickers or tags. Typical labeling for both calibrated or non-calibrated categories / conditions include:
 - (1) Continuous Calibration "Calibrated MM/DD/YY & Due MM/DD/YY".
 - (2) "Calibrate Before Use"
 - (3) "Calibration Not Required" (used for indication or reference only MTE).
 - (4) "Limited Calibration"
 - (5) Equipment without labels shall be assumed not calibrated.
- j. Ensure that environmental conditions are suitable for the effective use of the selected MTE.

- k. Protect MTE from damage and deterioration during use, storage and maintenance (e.g. Electro-Static Discharge, humidity).
- l. Safeguard MTE against adjustments that would invalidate measurement results.
- m. When computer software is used to monitor and measure specified requirements, its ability to satisfy the intended application shall be confirmed prior to initial use and reconfirmed as necessary; per APR 7150.2 (i.e., Verification Testing and Configuration Management).

2.2 MTE Users Performing Calibrations shall:

- a. Possess the necessary competence for work being performed and maintain relevant records of education, training, skills and experience to perform calibrations in compliance with the requirements of either ANSI/NCSL Z540.1-1994 (R2002) or ANSI/NCSL Z540.3-2006(R2013), and with the applicable requirements of SAE AS9100, subject to the clarifications and modifications provided in NASA-STD-8739.12, Metrology and Calibration.
- b. Create a Calibration Record using form ARC 827 or equivalent. <https://nef.nasa.gov/>
- c. Perform the calibration in accordance with a documented procedure.
- d. Use calibration standards traceable to the U.S. National Institute of Standards and Technology (NIST). Where no such standard exists, the basis for calibration shall be identified in the record of calibration results (e.g. natural physical constants, intrinsic standards, values derived from ratio techniques, etc.).
- e. Safeguard the hardware, software and standards used to perform the calibration to preclude damage, deterioration or adjustments that would invalidate their accuracy.
- f. Place a calibration label on the MTE, or its protective container, showing the due date for next calibration.

2.3 Records

2.3.1 Records shall be retained in accordance with NPR 1441.1 and NRRS 1441.1

APPENDIX A. DEFINITIONS

Calibration	The process that determines the relationship between a standard of known accuracy and the values indicated by MTE; with or without adjustment.
Calibration Interval	The time period between consecutive calibrations.
Calibration Procedure	A documented method that compares MTE output against relevant standards.
Calibration Record	The documented results from the performance of a Calibration Procedure.
Calibration Supplier	Any organization that provides calibration services to Ames MTE users.
Calibration Tolerance	The allowable deviation and output between the MTE specification and the standard used for calibration.
Critical	Any task that, if performed incorrectly or in violation of prescribed requirements, could result in loss of human life, serious injury, loss of mission, or loss of a significant mission resource (e.g., Government test or launch facility).
Indication Only	The classification for MTE that is only used to indicate the presence of pressure, heat, voltage, etc. - with no intent to determine its specific value.
Limited Calibration	When certain functions of an instrument are not needed by the user, the unit may be calibrated to a user defined specification instead of the manufacturer's full specification.
Measuring and Test Equipment	As defined in NASA-STD-8739.12.
MTE User	Personnel that use Measuring and Test Equipment.
Out-of-Tolerance (OOT)	MTE found to be outside acceptable limits as set by the manufacturer's specifications.
Recall	The activity of notifying MTE owners and requesting equipment be taken out of service (e.g. to be calibrated).
User Calibration	A calibration performed by an MTE User.

APPENDIX B. ACRONYMS

ANSI	American National Standards Institute
APD	Ames Policy Directive
APR	Ames Procedural Requirement
ARC	Ames Research Center
MTE	Measuring and Test Equipment
NCSL	National Conference of Standards Laboratories
NCR	Non-Conformance Report
NIST	National Institute of Standards and Technology
NPR	NASA Procedural Requirement
OOT	Out-Of-Tolerance
PRACA	Problem Reporting and Corrective Action
SAE	Society of Automotive Engineers

APPENDIX C. REFERENCES

- C.1 NPR 7120.8, NASA Research and Technology Program and Project Management Requirements.
- C.2 NASA-HDBK 8739.19-3, NASA Measurement Quality Assurance Handbook – ANNEX 3, Measurement Uncertainty Analysis Principles and Methods.
- C.3 NASA-HDBK 8739.19-4, NASA Measurement Quality Assurance Handbook – ANNEX 4, Estimation and Evaluation of Measurement Decision Risk.
- C.4 APR 1440.1, Records Management Program Requirements.