SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Calibration of tools and test equipment for maintenance of aircraft

SUBJECT: **Calibration of tools and test equipment for maintenance of aircraft**

Effective Date: 11 March 2022

Contents

1. Introductory Section

A. General

Civil Aviation Authority advisory circulars (ACs) and Technical guidance Material (TGM) contain information about standards, practices, and procedures that the Director has found to be an **Acceptable Means of Compliance (AMC)** with the associated rule.

Consideration will be given to other methods of compliance that may be presented to the Director. When new standards, practices, or procedures are found to be acceptable they will be added to the appropriate AC and TGM.

B. Purpose

This TGM describes ad acceptable means of compliance regarding the calibration of tools, inspection, measuring and test equipment for aircraft maintenance engineers, maintenance organisations and manufacturing organisations. This TGM does not provide instructions for carrying out calibration or who may provide the calibration service.

C. Related Rules

This TGM relates specifically to Civil Aviation Regulations Parts 43, 145, 148.

D. Calibration Standards Explained

- **What are calibration standards?**

Calibration standards are devices that are compared against less accurate devices to verify the performance of the less accurate devices. The standard's accuracy varies depending on what is being calibrated; most professionals recommend using a calibration standard that is at least four times more accurate than the device being calibrated.

- **Why do we need calibration standards?**

Imagine a trip to the grocery store where you buy a pound of hamburger. How do you know that the pound you buy at one store is the same weight as one you can get at another? The answer, of course, is that the meat is weighed before it is packaged. But how do we know that the scales used to weigh the meat are delivering accurate measurements? We trust this is true because periodically the scales are calibrated with more accurate weights and then adjusted to be within their specifications. The process of comparing one scale against a more accurate instrument continues, with the measurements becoming more and more accurate, until we reach the "top" of the measurement pyramid, which is the kilogram.

This is a simplistic example of traceability. Traceability is how we refer to a chain of measurements that range from the lowest level of the calibration pyramid all the way up to the SI standards. A traceable calibration is one performed as part of an unbroken chain of measurements that can be traced back to an SI unit. Each measurement also has an evaluation of the measurement uncertainty, to quantify the quality of each measurement. More information about traceability, the SI, and the calibration pyramid is available on the Fluke Calibration About Calibration page.

Having traceable measurements allows us to understand and trust in them. Traceable measurements also enable reciprocal agreements between countries; these agreements facilitate fair international trade.

For more information, see our page on Why Calibration Is Important.

- **Where do we find calibration standards?**

Calibration standards can be found in primary calibration laboratories around the world. Primary laboratories perform the most accurate calibrations and are often classified as National Metrology Institutes (NMIs). NMIs can be found in almost every country, with a network of less precise working laboratories that branch out into a system that forms the measurement infrastructure of each country.

Primary calibration laboratories are typically accredited by an organization that has been independently qualified to review and certify the labs' quality, accuracy and processes. Most large countries have one or more providers of accreditation, and countries often agree to trust each other's measurements based on their trust in the respective accreditations. More information about accreditation is available on the Fluke Calibration About Calibration page.

- **How do we determine which standards are needed?**

Measurement devices typically have specifications for their measurement ranges, accuracies and uncertainties. You can find this information in the product manual. The manual also often specifies what is required to calibrate the device. *Typically you are going to use standards that are at least four times more accurate than the device you want to calibrate*. You'll want to balance the need for accuracy against your budget. And you'll want to look at other product features like usability, form factor, and ability to calibrate multiple devices. Depending on your workload you might also want to look for a calibration standard that can be automated with calibration software.

- **What types of calibration standards does Fluke Calibration manufacture?**

Fluke Calibration manufactures multiple types of calibration standards:

- **Electrical calibration standards**
  - Voltage standards
  - AC/DC transfer standards
  - AC measurement standards
  - Resistance standards
  - Ratio standards
  - Current shunts
  - Frequency standards
- **RF calibration standards**
  - Low phase noise reference sources
- **Temperature calibration standards**
  - Standard platinum resistance thermometers
  - ITS-90 fixed-point cells
  - Maintenance apparatus
  - Liquid nitrogen comparison calibrator
  - Resistance bridges
  - Standard resistors
- **Pressure calibration standards**
  - Piston gauges
  - Deadweight testers
  - Pressure controllers and calibrators
  - Pressure comparators and digital pressure gauges

- Portable/handheld pressure calibrators
- Flow calibration standards

- **Gas flow calibration standards**
  - Reference flow monitors

- **What about quality standards?**

When people talk about calibration standards, they don't always mean physical instruments. Sometimes they might be referring to quality standards or regulations that specify calibration. For example, ISO 9001 is a quality standard that requires certified companies to calibrate their measurement equipment, plus document the processes and procedures involved. ISO/IEC 17025 is the quality standard that calibration laboratories use to ensure they produce valid results. ISO/IEC 17025 is the quality standard that calibration laboratories use to ensure they produce valid results.

- **Where can I find more information?**

The Fluke Calibration About Calibration page is a good source of general information about calibration.

E. References:

a) The Legal Metrology Act, 2014 (Act No. 9 of 2014)
b) Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006)
c) EN 30012-1:1993 Quality assurance requirements for measuring equipment
d) Airline Industry Standard World Airlines Technical Operations Glossary (WATOG)
e) ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories.
f) AS IEC 60300.1-2004 Quality management and quality assurance Standards Guide to dependability program management

F. Sources

- The Civil Aviation of New Zealand
- The Civil Aviation Safety Authority of Australia
- Fluke Calibration (https://us.flukecal.com)

2. Recommended Practices

2.1 In order to comply with the requirements prescribed in CAR Parts 43, 145, and 148 regarding the maintenance and manufacture of aircraft and components, various precision (calibrated) tools, and inspection, measuring and test equipment must be used to ensure aircraft, engines and components conform to the manufacturer's specification. These tools, and the inspection, measuring and test equipment must be periodically calibrated as recommended by the Manufacturer or operator.

2.2 Where a process, or sequence of processes, requires calibrated tools or equipment to be used to determine conformance to specification of the aircraft or component for certification for release-to-service then calibrated equipment must be used at each step in the process.

2.3 In various industrial, aerospace and defence organisations, it has been a long standing practice to permit the use of workshop equipment that is not subjected to periodic calibration if no test data needs to be recorded. This may include a null indication measurement, waveform monitoring, continuity checking, troubleshooting, or determining or assessing the feasibility of repairing versus scrapping an item. In these cases the equipment must be clearly identified as "NOT FOR CALIBRATED TESTING" or "NO CALIBRATION REQUIRED". Equipment so identified cannot be utilised for conformance acceptance or certification for release-to-service.

Note: Where both calibrated and un-calibrated equipment are located in the same workshop, procedures must be established to ensure that un-calibrated equipment is used for trouble shooting only and not for final certification or for release-to-service.

3. Calibration

3.1 Why Calibrate

Calibration ensures the accuracy of the tools, and inspection, measuring and test equipment used to return aircraft, engines and components to service. Calibration minimises measurement errors and uncertainties to acceptable levels.

For calibration of tools, and inspection, measuring and test equipment, acceptable levels of uncertainty are defined by the tolerance limits of the equipment's parameters established by the manufacturer. The outcome is maintenance of the equipment within the defined accuracy of the manufacturer's design tolerances.

3.2 Calibration

Calibration is as defined in the WATOG as:
"*The application of specifically known and accurately measured input to ensure that an item will produce a specifically known output which is accurately measured or indicated. Calibration includes adjustment or recording of corrections as appropriate*".

4. Options for Calibration

Tools and inspection and test equipment that require calibration must be calibrated by an Accredited Calibration Laboratory;

4.1 Calibration Facility or Laboratory

A calibration facility or laboratory can be any person or organisation who tests and/or calibrates measurement devices or working standards, in a controlled environment to ensure repeatability. Documented calibration procedures must be used and documented evidence of the traceability of the standards used must be provided.

A calibration laboratory accreditation can be issued to a CAR Part 145 Maintenance Organisation, a CAR Part 148 Manufacturing Organisation or a South African National Accreditation System (SANAS) Accredited Facility and if outside of South Africa the Laboratory must hold accreditation from an institution affiliated with the International Laboratory Accreditation Cooperation (ILAC). At all times, the Laboratories must be able to provide confirmation of accreditation as means of assuring that the Standards of which they are accredited on, are traceable to a National Standard.

5. Acceptable Procedure for Test Equipment

An acceptable procedure is one that has been published or received from the equipment manufacturer. The manufacturer may consider that only certain test equipment is considered as being acceptable to determine the calibration of their equipment. If alternate test equipment is required to be used then either the manufacturer or an appropriate person, qualified in metrology should attest to the use of alternate test equipment.

Procedures based on Industry standards may need to be developed, accepted and used by a Calibration Laboratory if the manufacturer's data is not available or sufficient.

6. Traceability

All inspection, measuring and test equipment used to establish the conformance of an aeronautical product or an aircraft system should be tested using reference standards that have been calibrated such that values indicated or represented by the equipment are traceable back to an acceptable national standard. The purpose of the traceability of calibration measurements is to ensure that the measurements are accurate and credible by referencing them to a recognised national or international physical standard. Calibration measurement values of the master equipment should be of a higher resolution than that of the test equipment being calibrated.

Many pieces of modern test equipment have automatic or self-calibration features designed within the instrument itself. This type of equipment generally has a reference standard built into the instrument and, at regular or predefined times, performs a calibration of the instrument. This is normally only a one-point check and is not considered to be a verification of the items' overall performance. Traceability of this check may be questionable. The manufacturer may specify further calibration requirements.

Other instruments, such as electronic scales, have an auto zero feature. Auto zeroing instruments only remove the drift inherent in the design of an instrument to reset the zero point each time the instrument is used. This type of instrument generally requires a regular calibration check.
Note: Partial or Limited calibration of test equipment is acceptable as long as the ranges that are calibrated, and any limitations, are clearly identified to the user, by labelling the equipment. It must also be recorded on the calibration report/record (in case the labelling is removed/becomes unreadable/falls off).

7. Calibration Interval and Labelling

7.1 The equipment manufacturer's recommended calibration interval should be used where available.

7.2 Where an equipment manufacturer does not specify a calibration interval, an evaluation should be carried out and documented to support the selected interval, utilising the following:

1. Quality of the tool or instrument
2. Operating environment (usage level, where used, storage etc)
3. Calibration interval for other similar tools or instruments
4. The accuracy of measurement required

The resultant interval is then established as the initial calibration interval and this may be increased or reduced based on the process outlined in section 8.

7.3 The calibration interval should be varied (increased or decreased) based on the reliability of the equipment in maintaining its accuracy as determined from the equipment calibration history. Any interval should be appropriate to the accuracy of measurement to be performed.

Any variation from the Manufacturer's recommended interval must be documented and include the justification.

7.4 Where a tool is marked "Calibrate Before Use" the transfer standard against which that tool (working standard) is checked should have a log book where each calibration of each tool is recorded. This activity ensures that there is an auditable trail relating to the use of that tool. The policy regarding the use of such tools and reference standards should be highlighted within the Policy and Procedures Manual (or equivalent document).

7.5 Calibration of equipment should be performed at certain periods of the equipment life.
Generally calibration should be performed at the following times:

1. Initial purchase, prior to use unless it comes with a calibration certificate
2. After repair
3. Periodic calibration
4. Whenever accuracy is in doubt

There may be some instances where the aircraft or equipment manufacturer specifies more stringent calibration requirements for a particular piece of equipment than the test equipment manufacturer recommends. This additional requirement must be considered when setting calibration intervals and procedures.

8. Procedures for variation of intervals

The determination of a calibration interval for a particular item of equipment involves the analysis of the calibration history for the equipment with the data arranged as an observed percentage of in-tolerance vs. time since a calibration or test. The data should be assembled from recorded results of calibration or testing, organised into a calibration history. A calibration history consists of an unbroken sequence of calibration or testing results accompanied by the date of service against a given serial number.

8.1 Examples of methods of analysis

- A01-11 General Information on the Accreditation Process. Available online at http:// https://www.sanas.co.za/Pages/index.aspx
- P16-08 Good Laboratory Practice (GLP) Compliance Monitoring Programme. Available online at http:// https://www.sanas.co.za/Pages/index.aspx

8.2 Description of Calibration Data Management

8.2.1 Continuity

The calibration history record for an item of equipment that requires calibration should be free from missing service actions. If there is a missing service action, then that should be detectable.

8.2.2 Completeness

Each record should provide all information necessary for analysis. This information needs to include as a minimum:

1. Identification (serial number, tag number etc) of the item serviced
2. Any special usage classification or designation
3. Date of service
4. Condition as received, prior to adjustment or other corrective service
5. Service action taken
6. Condition released (serviceable/unserviceable/limited calibration etc)
7. Identification of the reference standards used in calibration of the item.

8.2.3 Consistency
Each record in the calibration history of a serial numbered item should reflect uniformity with respect to parameters calibrated, tolerances used, procedures used, etc.

8.2.4 Environment (storage and usage)
The storage and usage of a calibrated item of equipment has a direct relationship to the calibration assessment program. If the location or usage of the equipment changes this needs to be taken into consideration. For example, a torque wrench used daily that has a transit container and is stored on a tool board may have a 6 month calibration interval. If it is transferred for use in a different working environment such as the tarmac, then consideration should be given to reducing its calibration interval.

9. Personal Equipment

9.1 A maintenance or manufacturing organisation should detail, in its Policy and Procedures Manual (or equivalent document), its policy relating to the use of personal tools within the organisation.

9.2 If the use of personal tools is permitted then the policy should require those personal items of equipment to be appropriately identified as personal equipment, whether they are calibrated or not. The organisation may elect to control the calibration of employees' personal equipment (this includes hand-held tools such as crimping tools, multimeters, torque wrenches etc). If the organisation elects to control the calibration of personal equipment, then details of the process need to be included in the Policy and Procedures Manual (or equivalent document). If the organisation elects not to control the calibration of such personal equipment then all that equipment must be suitably marked as un-calibrated personal tooling and cannot be used for return to service activity.

10. Out of Tolerance Action

Out of Tolerance Action (OOTA) occurs when a piece of calibrated equipment is found to be out of tolerance. This may occur as a result of a scheduled calibration check or if there is a suspicion of an out of tolerance situation.

An OOTA provides a warning that all aircraft, engines and components whose release-to-service was based on the use that item of calibrated equipment are potentially non-compliant with the required specification. A risk analysis therefore needs to be carried out to determine the extent of any remedial action that may be required on those aircraft, engines or components that are affected by the OOTA associated with the out-of-tolerance item of equipment.

10.1 For Individual engineers this OOTA action should include a review of all work carried out using the out of tolerance equipment and maintaining a record of any re-work required.

10.2 A maintenance organisation and a manufacturing organisation should detail, within its internal quality assurance system, processes that will be applied as a result an OOTA. These procedures should include:

1. A risk assessment of the effect of the OOTA.
2. The procedures used to assess the risk.
3. An audit trail to determine what aircraft, engines, components, etc the item of calibrated equipment, (tool, inspection or test instrument) was used for certifying a release-to-service. A good practice is to detail any item of calibrated equipment used as part of a work package.
4. Procedures for any recall of aircraft etc that may be determined necessary.
5. Documentation to support the above process.

11. Policy and Procedures Manual

11.1 The calibration processes within the Policy and Procedures Manual (or equivalent document) should contain as a minimum the following:

1. A means of listing all items of equipment that require calibration
2. A means of listing the calibration service providers for those items of calibrated equipment
3. A method of tracking when a calibration is due and a notification procedure for each item of calibrated equipment
4. A method and period for retaining calibration reports, both current and historical
5. A process to control publications issued to calibration service providers
6. The audit requirements and processes for accepting calibration service providers
7. A process to control the use of personal equipment
8. Procedures for varying the calibration interval for an item of calibrated equipment
9. Procedures for Out of Tolerance Action
10. Details of any contracts for tool calibration management
11. Procedures for acceptance of calibration certificates from both internal and external service providers.

12. Appendix 1 - Guidance to determining the suitability of a calibration facility.

As there is not a requirement for a calibration facility to be approved by the SACAA, the calibration facility that a maintenance provider or Manufacturing Organisation selects may not have the appropriate procedures in place to provide an auditable process. As a guide, those persons who require the services of a calibration facility may wish to compile a checklist with the following or similar questions. The assessment of the answers will assist in determining the suitability of otherwise of a calibration facility. The provider of a suitable calibration facility should be able to answer “Yes” to all the questions below. Further, it should be noted that this will be on exceptional cases (predominantly outside of the Republic, where the jurisdiction of the Acts may be limited) where the SACAA accepts an assessment of the AMO or Manufacturing Organization’s assessment of a Laboratory. A Maintenance Organisation may need to be more specific or detailed in its requirements.

Is the organisation accredited by a national standards certification body (SANAS, IANZ, NATA, UKAS, other ILAC affiliated accreditation body, etc)? If not then consider these points:

Quality Management System

- Is there a Quality Assurance/Quality Control program/manual?
- Are there internal/external audit programs?
- Does the audit program have appropriate corrective actions processes for findings?
- Are audit findings available to the customer?
- Are there audit procedures for sub contractors?

Inspection

- Is there a documented receipt inspection procedure?

Data Control

- Is there a procedure to ensure that technical data is current?
- Is there a process to revise, maintain and record the current status of required documents and technical data?

- Is there a process to revise and control manuals that are provided by customers or other third parties?
- Is there a process that records deviations from manufacturer's specifications?

Tool Calibration

- Is there a calibration program for equipment and tooling that is used by the calibration facility?
- Are all the calibration facility's calibrated equipment and tools listed?
- Are the standards used to calibrate the calibration facility's equipment and tooling traceable back to an acceptable National Standard?
- Are there procedures in place to prevent the use of uncalibrated equipment/tooling?

Training

- Is there a documented training program?
- Are the technicians/inspectors included in the training program?
- Does the training program include any refresher training?

Facilities

- Are storage areas segregated from the work area?
- Is their storage area environmentally controlled?
- Is there an Electrostatic Discharge Sensitive Equipment policy and is that policy supported by training (where appropriate)?
- Are packing facilities adequate to ensure integrity of product?

Work Processing

- Is there a process to validate tooling or equipment used in the calibration process that differs from the manufacturers requirements?
- Has the alternate equipment been certified as an equivalent and how was it substantiated?
- Is there a copy of its operating and maintenance manuals?
- Is there a process to identify and track customer's equipment?

Do the work records contain:

- A description of work performed?
- Pre calibration check details?
- Date of completion?
- A work package reference number to allow full traceability?
- Are there procedures relating to out of tolerance actions and discrepancies noted during calibration?

Calibration certification

The calibration facility should provide a calibration report for all work carried out (Refer ISO 17025.5.10.2 and 5.10.4). This calibration report should include:

- Name and address of facility
- Unique identification of report
- Description of item being calibrated
- Identification of specific method
- Results of measurement including correction charts and tables
- A statement of measurement uncertainties achieved and any limitations of detection that apply
- An indication of any tests (if applicable) that have been subcontracted out to other facilities

- Printed details, signature and title of an authorised member of the facility that accepts responsibility for the report and the testing work upon which it was based
- Means of traceability of the measurement results to the National Standard including identification of the test equipment
- Environmental conditions under which the calibration was performed.

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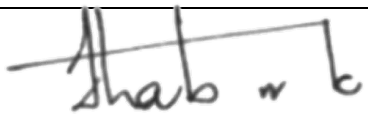	**Lobang Thabantso**	**9 March 2022**
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