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White Paper

Test Equipment Calibration

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1. Executive Summary

- Calibration involves comparing / adjusting an instrument against known references and the supply of documentation as verification of this. This paper outlines factors affecting the quality of calibration and the choice of calibration interval.
- Consideration is also given to the factors leading to a decision to calibrate test equipment and who should perform that calibration.

2. Considerations for the Assessment of Requirements for Test Equipment Calibration

2.1 What is Calibration

Calibration involves comparing / adjusting an Instrument against known references and the supply of documentation as verification of this. The purpose is to give the user an improved confidence in the measurements subsequently made by the Instrument.

The level of improvement of confidence in the measurements made by the instrument after calibration is very much dependent of the type (or quality) of the calibration done.

2.2. Factors Affecting Quality of Calibration

- Certification / accreditation of the calibrating laboratory.
- The uncertainty of measurements in calibration.
- Traceability of calibration measurements to national standards.
- Detail shown in calibration report.
- Manufacturer's Instructions and Methods
- Whether or not adjustments were made to optimize performance.

Accreditation of the Calibration Facility

The use of an accredited facility for calibration means that the calibration facility must conform to standards as defined by the accreditation authority, and hence there should be a higher level of confidence in the quality of the calibration work done. In Australia, NATA is the prime accreditation body for calibration labs, and the following discussion is in reference to NATA.

As part of NATA accreditation is conformance with standard ISO17025, "General Requirements for the competence of testing and calibration laboratories", all work done by a NATA accredited lab must conform with ISO17025.

The accreditation of a calibration laboratory can be checked by going to website www.nata.asn.com.au. This will show the scope of accreditation including the range of measurement areas for which the lab is accredited, and the least uncertainties of measurement that the lab is capable of.

- A calibration lab may well be able to perform calibrations in areas where it does not have accreditation, but it cannot issue a NATA endorsed report for items for which it is not accredited.

A NATA endorsed report is recognized internationally, and in most cases is the highest level of calibration report. NATA endorsed reports are usually required in the following circumstances:

- a. For a calibration laboratory which is providing outside calibration services
- b. Where there may be a requirement legally to rely on the accuracy of measurements taken with the instrument which has been calibrated.
- c. Regulatory or safety requirements mandate it.

The Uncertainty of Measurements in Calibration

A NATA endorsed calibration report, or one issued in accordance with the requirements of ISO17025 must make a statement regarding the uncertainty of the measurements made during calibration. An additional requirement of a NATA report is that an assessment of reported results for conformance to the equipment's specifications must be made in consideration of the possible measurement errors caused by uncertainties.

Hence if the uncertainties of measurement are high with respect to the specification of the instrument, it may not be possible to state that the calibrated instrument conforms with specification, even if the measurements "look ok".

The estimation of uncertainty for each measurement is quite complex. It attempts to take into account all the factors involved in the measurement process which could cause the measurement to be different from the absolute correct value.

Some uncertainties arise as a direct result of the uncertainty of the calibration of the reference equipment. For example if a voltage reference being used to calibrate an instrument is known to be within 100mV of its stated value, then any calibration done with this will reflect this as an uncertainty element.

Other uncertainties arise as a result of the instrument being calibrated. (How stable are its readings, what is the resolution of its display).

Typically 10 to 20 items will be taken into account when evaluating the uncertainty. Uncertainty is usually expressed as the limits from the measured value within which there is a 95% confidence that the "true value" will lie.

The more critical the accuracy of the absolute reading of the calibrated instrument is, then the more attention should be given to the uncertainty reported on it's calibration report.

Traceability of Calibration Measurement to National Standards

For calibrations to be meaningful, the equipment used in the calibration process must be known to be measuring correctly in accordance with international standard references. This is done nationally by having a standards reference in each country, and a known line of traceability of measurements made on an instrument to that standard. The calibration report should state this line of traceability.

The standard may be transferred through several calibration labs to the final instrument. Usually the longer this “chain” the more uncertainties are involved in calibration.

Sometime confusion arises with terms such as NIST calibrated. (NIST is the USA “National Institute of Standards”). This usually means that measurements were done with traceability to NIST, but not actually done by NIST.

Another source of confusion is the statement NATA traceable. NATA does not hold reference standards, so a report cannot be NATA traceable. A NATA endorsed report is one which conforms with NATA requirements, including the requirement for a statement of traceability.

A calibration report may have traceability to National Standards, without the calibration lab having NATA accreditation.

Detail Shown in Calibration Report

There are two main types of calibration documentation records:

- a. Calibration Certificate. This is usually a one page document which states that the instrument is performing in accordance with its stated specifications. These are mainly issued by equipment manufacturers with new equipment, and are issued on the basis the instrument has passed production performance tests. There would usually not be any uncertainty statement on this.
- b. Calibration Report. This shown the results of measurements made in the calibration, together with the manufactures specifications for those measurements. It should include a statement of uncertainty and traceability if it is in accordance with ISO17025

Manufacturer's Instructions and Methods

Another factor to consider is whether the calibration has been done in accordance with the manufacturer's instructions, in which case it should be done in accordance with the methods specified by the manufacturer, and at the calibration “points” as specified by the manufacturer.

Some calibrations may be done at “points” set by the calibration lab independent of those specified by the manufacturer. In this case, it is up to the user of the instrument to determine the suitability of the calibration to the purpose for which it is used.

Whether or not Adjustments Were Made to Optimize Performance

It is important to know if, when an instrument is sent for calibration, it will just be measured, or if it will be adjusted for optimum performance during the calibration process. This may affect the value of the calibration service.

Some calibration labs measure the performance of an instrument sent for calibration, but do not attempt to adjust it, if it’s out of spec, or if it’s close to it’s spec limits. Often the reason for this is lack of access to the manufacturer’s adjustment information or software needed.

If adjustment is done during calibration, the instrument should be in an improved state after the calibration process.

In some cases it is important to users to know the status of the instrument before adjustment is done, so that impact on, or corrections to, measurements made prior to adjustment can be made.

This leads to the following calibration options:

- a. Report only. (i.e. measure performance)
- b. Adjust and report on “As Left” condition
- c. Report on “As Found” condition, Adjust, then report on “As Left” condition.

2.3 When Should Calibration be Done?

Calibration should be done at intervals consistent with the user’s requirements to maintain performance accuracy.

A calibration lab working in accordance with ISO17025 will place a calibration sticker on an instrument showing the date of calibration. The date due for recalibration may be entered onto this sticker in accordance with the end user’s requirements.

The calibration lab does not determine the next calibration date. This is provided by the end user considering the following factors:

2.3.1 Factors Affecting Calibration Interval

- How important it is to the user that measurements made by the instrument are reliable and of the required accuracy.
- The environment in which the instrument is being used.
- The susceptibility of the instrument to be affected by drift over time.
- Regulatory requirements and maintenance of user’s quality systems.
- The manufacturer’s recommendations.
- If the unit has been damaged, or stressed. (e.g. being dropped).

- If the unit has been used outside its normal environment (e.g. lent to someone).

2.3.1.1 Importance of Reliable / Accurate Measurements

Some examples where reliability could be important include:

- a. Where charges are based on measurements
- b. Setup of items on a production line
- c. Adjustment of equipment in the field to performance specifications
- d. Legal or safety issues associated with the measurements made by the instrument

Some examples where reliability may be less important are:

- a. Initial fault finding and diagnosis
- b. Non-critical “Go/No-Go” tests.

2.3.1.2 Environmental Factors Affecting Calibration

The likelihood of an instrument reading incorrectly and hence the confidence in its accuracy is negatively affected if it is used in an “unfriendly” environment, such as in field use. In this case the performance change of the instrument may go un-noticed, so it may need to be calibrated more frequently than normal.

Conversely an instrument that is rarely used or is maintained in a controlled environment may require fewer calibrations.

2.3.1.3 Drift in Readings

Historical knowledge of the instrument’s performance may influence the period at which it needs to be readjusted / calibrated.

2.3.1.4 Regulatory Requirement and Quality Systems

Organizations which have quality systems in place will usually define calibration intervals for instruments consistent with the aims of the quality system.

Compliance with regulations and external audit processes can determine calibration intervals.

2.3.1.5 Manufacturers Recommendations

For most electronic equipment, the default calibration interval is 1 year. Manufacturer’s may recommend other periods, based on product performances taking into account drift and the overall product specification. Usually these are based on the assumption that the instrument is used in a “friendly” environment, and there are no special application requirements.

2.3.1.6 Damage or Stress – Actual or Suspected

If a unit has been subject to conditions which may cause deterioration of its performance, consideration should be given to the need to recalibrate it. For example if it has been severely mishandled in shipping (say the transit case is damaged but there may not be physical damage to the instrument). This will cause the performance of the instrument to be brought into doubt, and depending on how critical the use of the instrument, a recalibration may be needed.

2.3.1.7 Use Outside Normal Environment

If an instrument is loaned to others the owner may have little control or knowledge of its use. Unknown damage could occur affecting the instrument's performance, and recalibration could be required to restore confidence in its performance.

2.4 Why Should Test Equipment be Calibrated?

The following should be considered:

- a. How important is it that when I make measurements or adjustments with this instrument, that these are correct?
- b. Will I have to prove or justify measurements I have made?
- c. Do the measurements made with the instrument impact safety?

2.5 Who Should Calibrate my Test Equipment?

The following should be considered:

- a. Can the cal lab repair the instrument if it fails calibration?
- b. Can the cal lab adjust the instrument?
- c. Can the cal lab perform calibration to the manufacturer's procedures?