NOTHING IS GOOD OR BAD, BUT BY COMPARISON

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Calibration Systems

Calibration Systems is presented in the following major topic areas:

- Calibration Procedures
- Standardization and Adjustment Methods
- Industry Practices and Regulations
- Environmental Control
- Calibration Processes for IM&TE
- Validation Processes
- Records Management
- Official Reports

Calibration Procedures

ISO/IEC 17025, states:

"*The laboratory shall use appropriate methods and procedures for all tests and/or calibrations within its scope.*"

A calibration procedure is a step-by-step description of what must be done in order to carry out a proper calibration.

This requirement is not difficult if the unit being calibrated, the reference standard, and other test equipment are always the same. Then the instructions can be very specific.

In fact, there are many different test instruments (TIs) and so many possible configurations of calibration standards and instruments that it would be practically impossible to write detailed instructions for every combination.

Procedures are often written in a more general fashion so they will apply properly to a range of possible equipment.

Calibration Procedures (Continued)

A calibration procedure should be a controlled quality document of either internal or external origin.

ANSI/NCSL Z540-3 states:

"*Calibration procedures shall contain the required range and tolerance or uncertainty of each item or unit parameter being calibrated or verified.*

In addition, the procedures shall contain the generic description of the measurement standards and equipment needed with the required parameter, range, tolerances or uncertainties, and specifications for performing the measurement of the calibration or verification, and/or representative types (manufacturer, model, option) that are capable of meeting the generic description for the measurement standards.

***The procedures shall be consistent with the accuracy required, and with any standard specifications relevant to the calibrations/verifications concerned.*"**

Calibration Procedures (Continued)

Specifying the equipment to be used by brand and model number leaves the technician unsure whether the equipment on hand will be adequate for the job unless it is exactly what is called out in the procedure. For example:

Procedure for calibration of 3-1/2 digit multimeter:

- **Requires electronic calibrator capable of the following outputs:**

  0 – 1000 VDC @ 10 mA, uncertainty < 100 ppm
  0 – 350 VAC @ 10 mA, uncertainty < 1000 ppm
  0 – 100 MΩ, uncertainty < 100 ppm, etc.

"*…representative types (manufacturer, model, option) that are capable of meeting the generic description for the measurement standards.*"

Calibration Procedures (Continued)

Procedure for calibration of 3-1/2 digit multimeter:

- **Requires electronic calibrator such as the Fluke 5700A**

- **Capable of the following outputs:**
  0 – 1000 VDC @ 10 mA, uncertainty < 100 ppm
  0 – 350 VAC @ 10 mA, uncertainty < 1000 ppm
  0 – 100 MΩ, uncertainty < 100 ppm, etc.

Note that while this procedure is similar to the prior statement it tells one the specific requirements for this test. The 5700A may have capabilities that are not needed for this calibration, and if "5700A or equivalent is specified," the technician is limited to using something with all the functions of a 5700A – some of which may not be necessary.

ISO/IEC 17025 lists many potential environmental influences: "*Due attention shall be paid, for example, to biological sterility, dust, electromagnetic disturbances, radiation, humidity, electrical supply, temperature, and sound and vibration levels, as appropriate to the technical activities concerned.*"

Standardization & Adjustment Methods

A calibration process always involves a comparison between an unknown unit under test (UUT) or TI and a reference standard.

Nulling

If the nominal value of the UUT and the reference are the same, the comparison may be made by a nulling process. A sensitive indicator is used to display the difference. This indicator can have a very small range because, even though the actual values may be quite large, the difference is small.

A two-pan balance is an example of this type of nulling measurement. With the UUT on one pan, a range of reference standards may be created by addition and subtraction of weights, from a general-purpose set, until the indicator needle rests in the center of the scale. The UUT value is equal to the weights on the reference pan.

Note that the indicator needle didn't have to be calibrated at all.

A galvanometer or electronic null detector is used when nulling in electrical measurements.

Adjustment Methods (Continued)

Reference Dividers

Often the available reference standard has a single value – but the UUT can take on any value within a range.

Many times one can use a reference divider. This is a device that takes as input the value of the reference standard and outputs a precise, adjustable fraction of that value. The nulling method is used to compare the divided reference with the UUT.

Where the reference is a ten-volt Zener standard, a divider is used to produce an adjustable fraction of the reference. A galvanometer compares the divided reference with the UUT.

Input Dividers (Attenuators)

When the UUT is larger than the value of the reference standard, the divider may be used to generate a known fraction of the UUT. Again, this may be nulled against the reference.

Adjustment Methods (Continued)

Measurements on a Scale

An alternative to nulling is to have the measuring instrument read the measured value on a scale. For example, weighing or force measurement, where the elongation of a spring is proportional to the applied force.

Calibration of a scale device is usually done by adjusting one end of the scale to zero, then adjusting the other end of the scale at a maximum reading. The linearity of the scale is checked by looking at values at or near the mid-point.

In many cases, no linearity adjustment is possible but the measurement must be verified anyway. This process is called "spanning."

Linearization

Many sensors have a linear relationship with the applied signal, others are non-linear. A non-linear sensor can still be displayed on a linear scale using devices to convert the non-linear sensor signal to a linear display. Calibration requires testing several points on the scale, including the top and bottom.

Industry Practices and Regulations

ISO/IEC 17025 specifies several possible sources for test and calibration methods. There is an order of preference when choosing a source. Items nearest the top of the list must be chosen first if they are available.

The following order is correct for United States laws and practices only. Each country will have a different priority.

From a legal perspective, the order is:

- OIML standards if adopted by law (OIML is the International Organization of Legal Metrology)
- NIST standards if adopted by law
- ASTM standards if adopted by law
- Individual State laws
- Methods required by a regulatory agency