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Guidance Publications

This document gives guidance on measurement practices in the specified fields of measurements. By applying the recommendations presented in this document laboratories can produce calibration results that can be recognized and accepted throughout Europe. The approaches taken are not mandatory and are for the guidance of calibration laboratories. The document has been produced as a means of promoting a consistent approach to good measurement practice leading to and supporting laboratory accreditation.

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EURAMET Guide on Lifetime and Drift/Stability Assessment of Industrial Thermocouples

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1. Scope

The purpose of this EURAMET Guide is to outline the basic technical requirements for those laboratories undertaking the assessment on lifetime and calibration drift/stability of industrial base metal and noble metal thermocouples. This document will assist the calibration laboratories, producers of thermocouples and end users with establishing the expected drift rates, or the lifetime of the calibration before recalibration (for noble metal types) or replacement (for base metal types) becomes necessary. It is not the aim to replace or to harmonize the existing standards.

2. Introduction

This document will establish a rigorous means of determining the lifetime characteristics of base metal thermocouples and the drift characteristics of base and noble metal thermocouples, firmly grounded in traceability to the SI (i.e. to the ITS-90). The lifetime is determined as the elapsed time at a specified (elevated) temperature over which the thermocouple calibration remains within specified limits (tolerances). Long term drift is determined as the change in the thermocouple calibration after continuous exposure to a specified (elevated) temperature for a specified period of time, typically several months. Short term drift is determined as the change in thermocouple calibration after executing a specified procedure which typically involves cycling between one or several (elevated) temperatures, as in repeated calibrations.

The most important standards and technical guidelines are outlined below

- EN (IEC) 60584-1: 2013. Thermocouples, Part 1, EMF specifications and tolerances
- Calibration Guide, EURAMET cg-8, CALIBRATION OF THERMOCOUPLES, Version 2.1 (10/2011)

The basic requirements for the equipment and procedure for lifetime and drift/stability testing for thermocouples are now discussed.

3. Requirements for laboratory equipment

The requirement for the equipment is very similar to that required for calibrating thermocouples. The laboratory should be able to realise and measure the temperature in the required range as described at [4]. The minimum required equipment comprises:

- Furnace with the length of maximum immersion at the highest temperature of intended use with proper immersion profile and stability.

- Reference (cold) junction suited for long term use. It is not necessary to implement the ice point, but a long term stable and known (monitoring) temperature of the junction is required.
- Reference thermometer meter for determining of the test temperature (usually a thermocouple or other thermometer used as a standard (usually platinum thermometer). The uncertainty of this reference should be on the level of temperature standards used for the calibration of industrial thermocouples (usually noble metal thermocouples).
- Multimeter or other device for measuring the voltage of thermocouples under test. The resolution of the multimeter should be better than 1 μV . Uncertainty of the voltage measurement should be better than 2 μV .
- Optionally a computer with software package to record the data.
- Care should be taken to protect against noise caused by mains power line pick-up, external heaters and other equipment. This includes using grounded, screened cables and proper treatment of ground connections in the data logger.
- Compensation and/or connection cables with appropriate length and specification [3]. Compensation cable should be calibrated.

All equipment intended for use should be selected in such a way that the final uncertainty ($k=2$) of measured temperature is at least 3 times (5 times is recommended) better than test limit.

The selected test temperature(s) depend on the maximum temperature of the thermocouple under test, as specified by the producer. The tolerances according to EN IEC 60584-1 [1] are shown in the following table:

<i>Type</i>	<i>Tolerance class</i>	<i>Maximum deviation</i> °C
K and N	1	$\pm 0.004 /t/$ or ± 1.5 °C in the range (-40 to +1000) °C
	2	$\pm 0.0075/t/$ or ± 2.5 °C in the range (-40 to +1200) °C
	3	$\pm 0.015 /t/$ or ± 2.5 °C in the range (-200 to +40) °C

<i>Type</i>	<i>Tolerance class</i>	<i>Maximum deviation</i> °C
S and R	1	± 1.0 °C for $t < +1100$ °C or ± [1+($t-1100$)x0.003] for $t > +1100$ °C in the range (0 to +1600) °C
	2	± 0.0025/ t / or ± 1.5 °C in the range (0 to +1600) °C
B	2	± 0.0025/ t / or ± 1.5 °C in the range (+600 to +1700) °C
	3	± 0.005/ t / or ± 4 °C in the range (+600 to +1700) °C

4. Procedure for lifetime testing

For determining establishing the lifetime it is recommended to use new, untreated and uncalibrated thermocouples. The following procedure is recommended for base metal thermocouples:

1. Prior to starting the test the thermocouples must not be subject to any heat treatment, e.g. calibration or annealing.
2. Use a good quality temperature standard for determining the furnace temperature.
3. Test the thermocouples at the desired temperature. For example, the testing temperature may be determined on the basis of the supplier's specification of the maximum allowable temperature for short term use with addition of 5 %.
4. Connect all thermocouples to the multimeter (use only a switchbox with known properties) or A-to-D converter.

5. Continuous measurement of the thermocouples (with automatic or manual data logging), the furnace temperature is checked with the reference thermometer periodically (e.g. once per week).
6. The test, for a given thermocouple, should be terminated if
 - a. There is no output from the thermocouple, or
 - b. The drift of deviation of the tested thermocouple from standard EN IEC 60584-1 exceeds the desired tolerance.

The lifetime of the thermocouple calibration is determined as the time elapsed between the start of the test (Step 3) and its termination (Step 6).

5. Procedure for drift/stability testing

Two different tests are to be considered:

- Procedure for testing short term drift
- Procedure for testing long term drift

It is expected that these tests will be performed at different temperatures.

Drift: short term

Apply this test to a calibrated and properly annealed thermocouple. The following procedure for determining thermocouple short term drift/stability is recommended:

1. Calibrate the test thermocouple at the maximum temperature of intended use and perform a homogeneity check (at intended use immersion).
2. Test the thermocouples at the desired temperature.
3. The duration of the test is 8 hours maximum
4. Calibrate the thermocouple at the maximum temperature of intended use.
5. Repeat steps 3 to 4 three times.

The calibration drift is determined as the EMF change (or its temperature equivalent) between the first calibration and the final calibration.

Drift: long term

Apply this test to a calibrated and properly annealed thermocouple. The following procedure is recommended for determining drift/stability of a thermocouple in long term:

1. Calibrate the test thermocouple to the maximum temperature of intended use and perform a homogeneity check (at intended use immersion).
2. Test the thermocouples at the desired temperature.
3. The duration of the test is 4 months at minimum.
4. Calibrate the test thermocouple at the maximum temperature of intended use every week during the first month and every 2 weeks for the following months¹.
5. The test(s) will be finished if
 - a. The agreed final time is reached, or
 - b. There is no output from the thermocouple, or
 - c. The deviation of the tested thermocouple from standard EN IEC 60584-1 exceeds 3 times the desired tolerance.

The calibration drift is determined as the change in EMF (or its temperature equivalent) from the first measurement to the termination

6. Uncertainty evaluation

Uncertainties of measurement shall be calculated in accordance with EA publication EA-4/02 'Expression of the Uncertainty of Measurement in Calibration' [3].

7. Bibliography²

1. EN 60584-1: Thermocouples, Part 1, EMF specifications and tolerances.
2. EN 60584-3: Thermocouples, Part 3, Extension and Compensating Cables — Tolerances and Identification System.
3. EA-4/02: Expression of the Uncertainty of Measurement in Calibration.
4. Calibration Guide, EURAMET cg-8, CALIBRATION OF THERMOCOUPLES.

¹ For calibration is allowed to remove thermocouple to ambient temperature, if needed.

² Standards without years means latest version

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