



# Equipment – Acceptance of Thermocouple

**Revision 10.0–**

- Updated References from IEC 60584-2 to change to IEC 60584-1.
- Removed references to withdrawn standard ISA MC96.1.
- Updated Standard number for ASTM E230/E230M

**For Client Labs**

<b>Purpose</b>	<ul style="list-style-type: none"> <li>• Provides requirements and details for acceptance of thermocouples used in temperature tests.</li> </ul>
<b>Why this requirement is important?</b>	<ul style="list-style-type: none"> <li>• Accuracy of thermocouples has a direct effect on data quality and the repeatability of tests.</li> </ul>
<b>Requirements/ Procedures</b>	

**Validation of thermocouple wire and junction assembly methods**

Thermocouples (TC's) used in testing are required to have tolerances in accordance with:

- a. The table of *Special Limits* as outlined in ASTM \*E230/E230M Standard Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples, or;
- b. IEC 60584-1 or JIS C 1602; IEC *Tolerance Class* 1,2 or 3. Refer to Appendix A regarding Class selection.

\* The specifications in these documents are the same.

- **Thermocouple junction assembly**  
See Appendix A for details regarding thermocouple wire and junction assembly validation methods.

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Records	
<b>Certificates, Approval Forms, and Other Documentation</b>	<b>For WTDP -</b> <ul style="list-style-type: none"><li>• Prior to testing, UL staff are to review copies of compliance certificates and records for;<ol style="list-style-type: none"><li>1. the thermocouple wire and related validation of the TC assembly and;</li><li>2. any TC's that are pre-assembled by suppliers.</li></ol></li><li>• An indication of acceptance / rejection is to be noted in the datasheet package.</li></ul>
	<b>For other DAP programs (CTDP, TCP, TPTDP, etc) -</b> <ul style="list-style-type: none"><li>• Clients are to index and retain copies of certificates and related documentation from each roll of thermocouple wire or TC's presently in use.</li> <li>• In lieu of storage of paper copies of the documentation, these may be stored electronically.</li></ul>

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### APPENDIX A

The following methods shall be applied in determining the acceptance of thermocouple wire and/or the assembled thermocouple junction:

#### ACCEPTANCE OF THERMOCOUPLE WIRE BY CERTIFICATE OF COMPLIANCE

1. The supplier of the thermocouple wire shall be required to provide a certificate of conformance. The appropriate certificate shall be requested from the supplier when the material is ordered (i.e. *Class 1,2 or 3 per IEC 60584-1, JIS C 1602, Special Tolerances (Limits) wire per ASTM E230/E230M*). The certificate shall be included with the material shipment or the supplier shall provide an alternate means such as access to a website where the certificate can be obtained.

#### Tolerance Class Selection

2. Where IEC 60584-1, JIS C 1602 are applied, the thermocouple type and Class tolerance shall be selected according to the following:
  - a. The maximum tolerance value does not exceed +/- 1.5 degrees C of reading for thermocouples identified in IEC 60584-1 or JIS C 1602.
  - b. Alternately, where higher temperature ranges of the selected thermocouple are measured, a tolerance value of 0.4% of reading may be applied to thermocouple tolerances as specified in IEC 60584-1 or JIS C 1602.

#### ACCEPTANCE OF PREASSEMBLED THERMOCOUPLES

1. A certificate of compliance shall be included with the results of the pre-shipment testing for the thermocouples. The testing shall be sufficient to confirm the proper function of the thermocouple assembly in accordance with *Class 1,2 or 3 per IEC 60584-1, JIS C 1602, Special Tolerances (Limits) wire per ASTM E230/E230M*.
- Where wire thermocouples are re-used without renewing the thermocouple junction, a re-verification shall be performed prior to re-use to assure the thermocouples are compliant

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with the appropriate table in ASTM E230/E230M, IEC 60584-1 or JIS C 1602. This requirement does not apply to test fixtures (alcoves, measuring grids, etc) that use permanently installed wire thermocouples in their construction (i.e. cannot be removed without damage to the TC or the test fixture).

### ACCEPTANCE OF THERMOCOUPLE JUNCTION ASSEMBLY BY IN-HOUSE TESTING

1. For each new reel of thermocouple wire received, one sample of wire shall be taken from each reel as a minimum. For laboratories in CB Scheme activities, refer to: [http://www.iecee.org/Operational\\_documents/od-cb\\_index.html](http://www.iecee.org/Operational_documents/od-cb_index.html)/procedures.htm for program requirements.

The method used for thermocouple junction assembly shall be demonstrated as reliable and repeatable through validation. The sample thermocouple junction is to be assembled in the same manner as those that will be used in laboratory tests. The thermocouple is to be made in-house by the following procedure (dimensions noted are typical not a requirement):

- a. Strip back the thermocouple wire insulation approximately 1.5 mm from the tip.
- b. Strip back the outer insulation, if any, approximately 15 mm from tip. See figure below for details.
- c. The tip is to be joined in accordance in accordance with industry practices. Welding is the preferred method of the thermocouple junction assembly.

2. Limitations with Various Thermocouple junction assembly methods.\*

The method used to assemble the thermocouple junction shall be proven as reliable and repeatable through validation. A single point weld or bead is the preferred method of assembly.

Welding, through use of a spot welder or inert gas furnace, is the preferred method of junction assembly. A thermocouple with a welded tip provides secure contact at a single point, allowing it to be used in many different applications.

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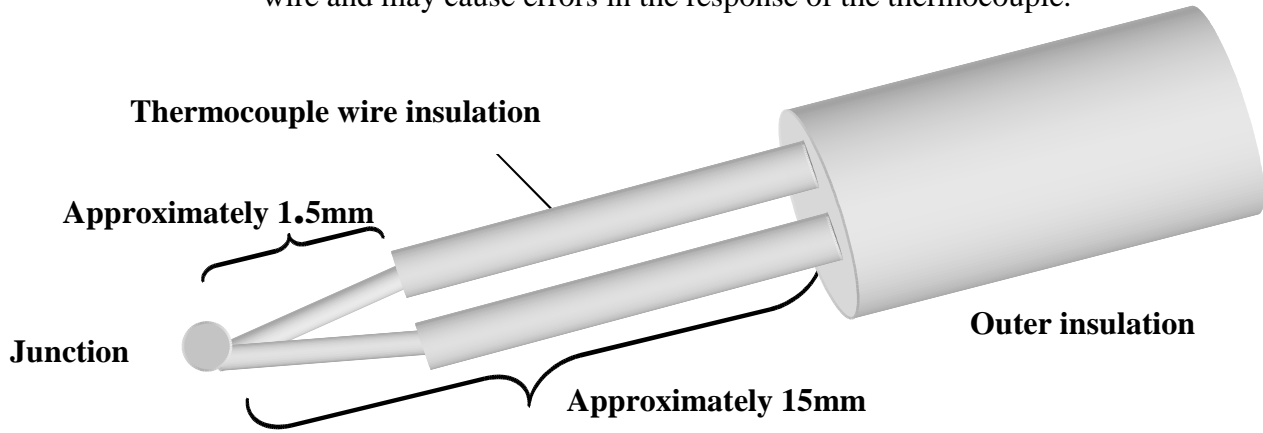
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Caution must be used in applying the appropriate weld energy or furnace temperature to the junction assembly. Overheating the junction may damage the wire and may cause errors in the response of the thermocouple.



Soldering or brazing must not incorporate corrosion or allow the solder / braze metal between the wires at the junction connection point. Note that solder melting points limit the maximum temperatures that can be measured. Fluxes used in soldering or brazing are to be removed with appropriate cleaner. Trimming the junction assembly as close as possible to a single point reduces parallel electrical paths and allows mounting of the junction more closely to the point being measured. Overheating the wires during assembly must be avoided.

Twisting of thermocouple wire is not a preferred means of junction formation. Care must be taken in assuring the junction, where the two wires make first contact in the twist, contacts the point of measurement. Excessive tip length (long twists) increases the distance from the measuring point and introduces reading errors. Proper preparation of the wires prior to twisting is important. Removal of corrosion or contaminants is required to maintain an acceptable electrical conduction path at the wire junction.

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\*References: BIPM [http://www.bipm.org/en/publications/its-90\\_techniques.html](http://www.bipm.org/en/publications/its-90_techniques.html) (ref. Part 2 - Techniques and Thermometers Traceable to the International Temperature Scale of 1990, chapter 18)

Elbert Brunner Reynolds, Jr. – PhD “The Influences of Method of Junction Formation and Heat Treatment on the Electromotive Force Produced by A Thermocouple”  
[http://www.erc.wisc.edu/publications/thesis/thesis/thesis\\_index.htm](http://www.erc.wisc.edu/publications/thesis/thesis/thesis_index.htm) and  
[http://www.erc.wisc.edu/publications/thesis/thesis/thesis\\_Reynolds.html](http://www.erc.wisc.edu/publications/thesis/thesis/thesis_Reynolds.html)

Richard D. Smith, P.E. “The Care and Feeding of Thermocouples”,  
[http://www.ewh.ieee.org/soc/cpmt/tc7/ast1999/RS\\_TC/](http://www.ewh.ieee.org/soc/cpmt/tc7/ast1999/RS_TC/)

3. Thermocouple samples shall be verified using a comparison method. The verification process should include at least three points, preferably ambient, mid-range, and estimated upper range temperature that the TC will be measuring. A temperature standard having traceability to national standards shall be used, such as a PRT (platinum resistance thermometer) or equivalent. The TC sample and the standard are to be placed in a controlled temperature comparison medium, such as a variable dry block calibrator, or multiple fixed dry blocks, which will be set at different temperatures. At each temperature, the values from the thermocouple and temperature standard will be recorded. The emf value (measured by a calibrated voltage meter) can be compared to the appropriate table in ASTM E230/E230M, IEC 60584-1 or JIS C 1602 or Temperature value (measured by a calibrated Thermocouple temperature meter/ calibrator) can be directly compared to the temperature standard.”
4. If the sample is within tolerance, the spool of wire is accepted and clearly marked or otherwise identified with the validation records, and placed into service. Any sample that is found to be out of tolerance should be checked for proper construction of the junction and a new sample should be assembled and evaluated. Non-compliance of any sample of the second evaluation will require evaluation of the welding process, the present supplier and/or use of an alternate supplier, as needed, to obtain conforming thermocouples.
5. Where wire thermocouples are re-used without renewing the thermocouple junction, a re-verification shall be performed using the same method described in Item 3 above prior to each re-use to assure the thermocouple is compliant with the appropriate table in ASTM E230/E230M, IEC 60854-1 or JIS C 1602.

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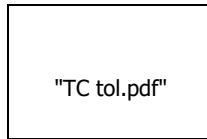
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6. The certificates of compliance and/or test results shall be retained for proof of compliance in accordance with the laboratory record retention policy. Retain certificates and other related documentation associated with each roll of thermocouple wire presently in use for review purposes;
  - o Index retained documentation
  - o Keep records for the time specified by company policy after the thermocouple wire roll has been expended.
  - o In lieu of storage of paper copies of the documentation, these may be stored electronically.

Refer to the attached for thermocouple types, color codes and tolerances.\*\*  
Also see [http://www.omega.com/temperature/pdf/tc\\_color\\_codes.pdf](http://www.omega.com/temperature/pdf/tc_color_codes.pdf) as examples.



"TC color codes.pdf"



\*\*source – Omega Engineering

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