Article Source: Industrial Heating

Originally published in April 1980, AMS 2750 has become one of the prime governing documents related to many industrial heating applications.

Over 30 years later, AMS 2750 continues to be the critical standard related to, in the precise words of the document, "pyrometric requirements for thermal-processing equipment used for heat treatment." And while the specification is in many ways similar to the previously released revision, AMS 2750D published in 2005, there are some very important changes related to the application of temperature sensors.

In July 2012, SAE Aerospace released Revision E of the Aerospace Material Specification (AMS) 2750 titled "Pyrometry." This specification continues to be the "bible" for all pyrometric processes connected with the aerospace industry, but it is often recognized as the standard in many other industries as well.

In its latest revision, SAE includes numerous technical changes to resolve issues determined in usage. However, one of the challenges as specifically noted in this latest revision is that the "Changes are extensive and not marked." Therefore, those subject to compliance with AMS 2750E must take the time to review the most recent revision thoroughly.

That being said, we aim to assist in highlighting some of the more significant changes in AMS 2750E as they relate to temperature sensors. Parenthetical references are to paragraphs in AMS 2750E.

1. **Calibration certificates** can now report deviation as an alternative method of reporting correction factors(see 3.1.2.2.6). Previous editions only allowed reporting correction values. The method used must be clearly indicated on the certificate. Otherwise, the end user may apply the values erroneously.

1.1 Correction factor is defined as the number of degrees that must be added to, or subtracted from, the temperature reading of a sensor to obtain true temperature.

1.2 Deviation, on the other hand, is defined as the difference between the uncorrected indicated temperature and the true temperature. It is also referred to as departure or error.

1.3 Always remember to flow down your specific reporting requirements, whether you desire them in correction or deviation, directly to the ISO 17025-accredited laboratory responsible for your calibration documentation.

2. "Extrapolation of **calibration correction factors** above the highest calibration temperature and below the lowest calibration temperature is prohibited by any calibration source except by NIST or other national-standards calibration agency" (see 3.1.2.5.2). Revision D did not allow any extrapolation. Now, it is permissible in AMS 2750E but only through direct interaction with the NIST or another national-standard agency. While this extrapolation is permitted, you must carefully consider if it is practical to your business.

3. Concerning **roll calibration**, samples must now be taken from both ends of the roll regardless of length(see 3.1.2.6.2).

3.1 In Revision D, the calibration of only one sample was required from rolls of wire less than 1,000 feet in length. Calibrating both end samples ensures that a specific lot of wire (or thermocouples assembled from that lot) conform to standardized emf-temperature relations within specified tolerances.

3.2 Users may apply the average correction factor calculated from both of the sample ends, provided the individual correction values are within the acceptable limits as defined by the specification and by individual requirements.

4. Perhaps one of the most material changes that will affect temperature-sensor calibration reporting is with regard to**"rounding**." Revision E states the rounding of numbers must be in accordance with ASTM E29 or another national standard (see 3.8). Prior to revision E, rounding of calibration data had not been specifically addressed in AMS 2750.

4.1 The method most of us have traditionally known and worked with concerning rounding numbers is known as **"Round Half Up."** If the last number is less than five, you round down, and if the last number is five or more, you round up. For example, 2.44 would become 2.4, while 2.46 would become 2.5.

4.2 However, AMS 2750E has prescribed a specific and alternate method of rounding related to calibrations. It coincides with the method described in ASTM E29-08 known as "Round Half to Even." This is the method employed by most statisticians, and it is the method of rounding used extensively in the banking industry.

4.3 Here is how it works. Assuming you want to round to the nearest tenth:

4.3.1 If the last number is less than five, round down (1.24 becomes 1.2).

4.3.2 If the last number is more than five, round up (2.37 becomes 2.4).

4.3.3 If the last number is exactly five and the preceding number is odd, then round that number up (3.75 becomes 3.8).

4.3.4 If the last number is exactly five and the preceding number is even, then that number stays the same (2.45 becomes 2.4).

4.4 While this seems straightforward, perhaps it is not so simple. The challenge is that most conventional, commercially available software programs (such as Microsoft Excel) use the "Round Half Up" method, which will report incorrectly rounded values that do not comply with ASTM E29-08.

4.4.1 Oddly enough, the standard itself makes the following statement in section 6.4.3: "NOTE 1: This method for rounding 5s is not universally used by software packages."

4.5 That said, one would have to manually round the correction values according to the rules or create a customized software package. Take specific care in this new requirement.

5. **Sensors and Sensor Calibration**–Table 1 (page 34 in AMS 2750E) is mentioned in numerous places throughout this specification (Fig.3). This table is a very useful visual reference in determining how the different types of sensors are used, when they need to be calibrated (period), the type of standard (reference, primary or secondary) they need to be calibrated against and what the acceptable tolerances (maximum-permitted error) need to be.

5.1 Under AMS 2750E, the maximum-permitted error for "Noble Metal Secondary Standard" and SAT thermocouples has been changed.

5.1.1 Revision D stated the maximum-permitted error for type-S and R secondary-standard and SAT thermocouples was the greater of ±1.0°F (0.6°C) or 0.1% of reading and ±1.0°F (0.6°C) or 0.25% of reading for type B.

5.1.1.1 Note: These limits are similar to those stated in ASTM E230 for special tolerances (greater of ±0.6°C (1.1°F) or 0.1% of reading for type S and R and ±0.25% of reading for type B).

5.1.1.2 ASTM E230 standard tolerances for type S and R are the greater of ±1.5°C (2.7°F) or 0.25% of reading and ±0.5% of reading for type B. (AMS 2750C used these limits for type-S and R thermocouples.)

5.1.2 Revision E has taken what one may call a hybrid approach and come up with a new maximum-permitted error that appears to be a combination of both special and standard limits of error.

5.1.2.1 The greater of ±1.5°F (1.0°C) or 0.25% of reading for both secondary-standard and SAT type-S and R thermocouples

5.1.2.2 The greater of ±1.0°F (0.6°C) or 0.5% of reading for secondary-standard type-B thermocouples and ±0.5% of reading for SAT type-B thermocouples

5.2 Another notable change to Table 1 concerns the recalibration of base-metal, secondary-standard TUS and SAT thermocouples.

5.2.1 Revision E allows the recalibration of base-metal thermocouples but prohibits the recalibration of type-E and type-K TUS and SAT thermocouples.

5.2.1.1 Type-E and type-K secondary-standard thermocouples can be recalibrated only if used at or below 500°F (260°C) or trimmed and a new junction formed under the provisions of section 3.1.3.1.

5.2.2 Revision D only allowed the recalibration of type-J and type-N base-metal thermocouples.

5.3 One notable omission from the footnotes to Table 1 that was listed in Revision D was the tolerance for type-T thermocouples used below 32°F.

5.3.1 Special tolerances for temperatures below 32°F (0°C) are difficult to justify due to limited available information.

5.3.1.1 In Revision D, footnote 3 stated the tolerance to be ±1°F (0.6°C) or ±0.8%, whichever greater.

5.3.1.2 This was based on the suggested special tolerance values for type-T thermocouples used below 0°C from ASTM E230 Table 1.

5.3.1.2.1 -200 to 0°C, ±0.5°C or ±0.8% (whichever is greater)

5.3.2 Since the values listed in revision D were based on a suggestion rather than a definitive published value, this footnote was deleted because the statement could not be supported.

Conclusion

The bottom line is that AMS 2750E is now the current governing pyrometry specification in the thermal-processing world. By highlighting a number of the changes made to AMS 2750E regarding temperature sensors, you may determine to either modify your current practices or ensure that the documentation of your process is in compliance to the most recent revision (rev. E). Knowledge and understanding of the specification are essential.

While we have touched on the changes related to temperature sensors, AMS 2750E, of course, covers a full range of pyrometry requirements. The most current revision is meant to resolve technical issues that arose with prior versions of the specification and aims to clarify several ambiguous elements of previous editions. **IH**

Fig. 3. Table 1 from AMS 2750 E (without reference notes)

Sensor	Sensor type	Use	Calibration		Maximum permitted error
			Period	Against	
Reference standard	Types R and S noble metal	Primary standard calibration	5 years	NIST/reference standard	None
Primary standard	Types R and S noble metal	Secondary standard calibration	3 years	Reference standard	±1.0°F (±0.6°C) or ±0.1%
Secondary standard	Base or types R and S noble metal	Sensor calibration	Before first use recalibration: 2 years - Types R &S 1 year - base metal	Primary standard	Base metal: ±2°F (±1.1°C) or ±0.4 Noble metal: ±1.5°F (±1.0°C) or ±0.25%
	Type B noble metal		2 years - Type B		±1.0°F (±0.6°C) ±0.5%, Type B
Temperature uniformity survey	Base or Types B, R, and S noble metal	Temperature uniformity surveys	Before first use recalibration: 6 months - types B, R, & S 3 months - base metal Types E&K not permitted	Primary or secondary standard	±4°F (±2.2°C) or ±0.75%
System accuracy test	Base or Types B, R, and S noble metal	System accuracy tests		Primary or secondary standard	Base metal ±2°F (±1.1°C) or ±0.4% Noble metal ±°F (1.0 °C) or ±0.25% –or — ±0.25%, Type R, S ±0.5%, Type B
Control, recording, and monitoring	Base or types B, R, and S noble metal	Installation in equipment	Before first use.	Primary or secondary standard	Class 1 & 2: ±2°F (±1.1 °C) or ±0.4% Class 3 to 6: ±4°F (±2.2°C) or ±0.75%
Load	Base or Types B, R, and S noble metal	Load sensing	Before first use. Recalibration: 6 months - types B, R & S not permitted - other base metal	Primary or secondary standard	±4°F (±2.2°C) or ±0.75%

For more information: You can obtain a copy of AMS 2750E from SAE International by contacting them at: tel: 877-606-7323 (inside USA and Canada); tel: +1 724-776-4970 (outside USA); fax: 724-776-0790; e-mail: CustomerService@sae.org; web: http://www.sae.org.