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Long referenced in military heat-treat specifications for pyrometry, AMS 2750 is now being used by NADCAP to audit pyrometric practices for special processes in the aerospace industry. Recent specification changes better define the requirements. Our focus will be limited to temperature uniformity surveys.

On a recent Internet search for the definition of pyrometry, one of the most interesting definitions I found was, "the art of measuring degrees of heat, or the expansion of bodies by heat." It was the "art" in the definition I found interesting.

Pyrometry is nothing new to the metal-treating industry. Our industry has been working at controlling, monitoring and checking our applications with pyrometry since the first red-hot sword was thrown into a river, yielding a stronger material. The updated Aerospace Material Specification (AMS) focusing on pyrometry is the revision D document of the AMS 2750 requirements. This document, revised in September of 2005, is now used by NADCAP to audit pyrometric practices. NADCAP, the National Aerospace Defense Contractors Accreditation Program, is an industry-managed program for special processes in the aerospace industry.

The purpose of the D revision was to provide a more clear and concise specification. With input from both the primes and suppliers, the document adds more examples, tables and information to provide a better understanding of the requirements for pyrometry. One of the missions at NADCAP is to provide international, unbiased, independent manufacturing process and product assessments to ultimately deliver the highest quality products.

AMS 2750D covers a number of different topics but can generally be broken out into four areas:

- Temperature uniformity surveys
- Temperature sensors
- System accuracy tests
- Instrumentation

Each of these areas has numerous details covering the specifics related to these topics. We are going to focus on the topic of temperature uniformity and the data-logging requirements.

Fig. 1. Batch-furnace survey

Temperature Uniformity Survey

Temperature uniformity surveys determine the work zone of a furnace based on the deviation of the individually monitored thermocouples within the furnace. The allowable deviation from setpoint is based on the furnace classification, which can be found in Tables 9 and 10 in the AMS 2750D specification. The furnace classification and the instrumentation on the furnace are used to determine many of the testing frequencies and accuracies for the calibration, system accuracy tests and temperature uniformity surveys. In general, the smaller the deviation, the higher the level of accuracy and the more frequently it will be checked.

Instrumentation

Controlling and recording instrumentation is referenced a number of times in the document. There is an entire section related to thermal-processing equipment that explains instrumentation types. The different types represent the equipment used on the furnace for controlling and recording temperature, describing the components in detail. As mentioned before, you will need to clearly identify the instrumentation type for the furnace to understand the frequencies and accuracies required by the furnace class.

The number of points required to survey is based on the type of furnace and the size of the workspace. The 2750D specification defines the requirements based on the types of furnaces and number of sensors necessary for the survey.

The method for performing the survey requires an independent field-test instrument that must be calibrated with a primary or secondary NIST traceable device and has a calibration accuracy of ±1°F or ±0.1% of reading in degrees F (whichever is greater). Table 3 in the specification identifies the instruments and instrument calibration periods. Field-test instruments used for temperature uniformity surveys can be calibrated in the field with secondary-standard instruments.

Thermocouples

Thermocouples are the sensors that are used to deliver the temperature at each survey point in the furnace. Because thermocouples have traceable errors, they can be corrected to deliver proper information during a survey. Be sure to have all thermocouple-wire certificates available with correction factors clearly documented. In practice, many surveys are performed with uncorrected values, which is fine as long as the procedures clearly state that the values are not corrected during reading but corrected for the survey results.

The topic of thermocouple wire is widely discussed due to the increase in costs associated with the rising number of surveys. There are also many discussions about the quality of the thermocouple wire. Table 1 in the specification covers sensors and sensor calibration. For temperature uniformity surveys, the maximum permitted error for sensors used is ±4°F or ±0.75% of reading. This requires the complete thermocouple-spool certification to be less than these amounts, or it cannot be used for surveys. Correction factors should be clearly documented and, when possible, used to display corrected values to the operator. Many instruments and complementary software today allow for both device and thermocouple corrections to be incorporated so that the operator and reports display corrected values. Whether or not these are incorporated before or after the process, be sure that they are documented and that all employees involved in pyrometry or quality understand the calculation and how the final temperatures are derived.

Data Logging

Electronic records are defined as any information that is stored in digital form. There are many different devices that translate an analog signal into a digital temperature reading. Many older data-acquisition units turned these analog signals into a point reported on paper. Today's equipment records the analog signal in some sort of electronic file on disk or some other type of media storage. The new AMS specification addresses the requirements for electronic data storage. Any system that uses electronic records must create write-once, read-only records that cannot be altered without detection. Any system that records information shall not allow data to be altered in any way.

There is definitely a shift in our industry to a non-paper-based record-keeping format because of the amount of paper that builds up over time and because of the number of years this information has to be maintained. Some heat treaters are required to keep records for an indefinite time frame. Today's technology lends itself to maintaining electronic information versus paper. The cost of electronic data acquisition systems has come down and now enables many commercial and captive heat treaters to add and expand these capabilities. In many cases, the investments made in electronic record keeping are quickly returned with less instrument maintenance and storage of paper records.

Information related to when data collection during a survey should start has been changed in the updated specification. For temperature uniformity surveys, data collection shall begin before the first furnace or TUS sensor reaches the lower tolerance limit of each test temperature. This provides assurance that any furnace or TUS sensor exceeding the upper temperature-uniformity tolerance is clearly detected. If the furnace is prestabilized, data collection shall begin as soon as the test load or rack is loaded in the furnace. Operators performing surveys should document the procedures for performing the survey and use it consistently. If there are any changes to the procedures, an initial temperature uniformity survey is required. The different types of surveys, such as an initial versus a periodic survey, will be discussed later.

Many companies perform pyrometry checks and temperature uniformity surveys with outside help from companies that are experts in providing these types of

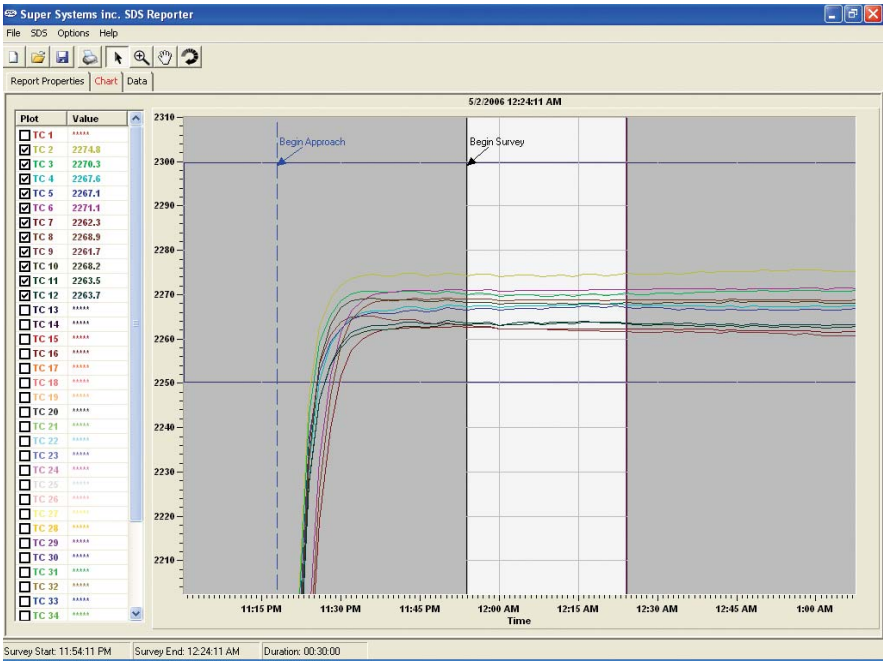

Fig. 2. Typical survey trend chart

services. These service companies are usually well-versed in the latest industry requirements. Because this is part of their core competency, they bring industry experience and the latest in technology to these processes.

"Our customers like the fact that we have the latest equipment and all necessary documentation required for all of our services," says Nathan Wright, president of Tru-Cal, a services-based company focused on the thermal-processing industry.

In many cases it comes down to whether a company has the time and resources to dedicate to the tasks of performing and documenting the results of the pyrometry tests.

Two types of temperature uniformity surveys are defined in the AMS specification - initial temperature survey and a periodic survey. From a production and cost standpoint, they can be significantly different. An initial survey requires that the minimum and maximum temperatures be surveyed. If greater than a 600°F difference, additional points are required so that no two adjacent survey temperatures are greater than 600°F apart. For periodic surveys, tests are required for any temperature within each qualified operating range, and at least once a year the minimum and maximum temperatures must be surveyed.

An important definition in the specification is the explanation of a furnace repair versus a modification. An initial survey on a furnace requires more data points, taking more time to run the survey and typically leaving the furnace out of production during that time. A furnace modification requires an initial temperature uniformity survey where a furnace repair does not. Regardless of the furnace change, it is required that all repairs and modifications on a furnace be documented and checked by the quality-assurance department. You will also have to prove that a preventive-maintenance program is in place for the equipment in order to get the reduced survey frequencies. Many people automate the maintenance and repair/modification-documentation procedures using automated software applications so that everything is scheduled and logged for complete traceability to the task.

Summary

Technology provides us with many benefits in our daily lives. Heat treaters are always looking at how we can become more efficient in our day-to-day operations without giving up quality. The AMS specification provides the guidelines to ensure that quality is not compromised. Some of the AMS 2750D changes highlight technology because of recent advancements in controlling and data logging. More importantly, the specification provides procedure-based requirements on how information is gathered and how the pyrometry checks should be performed. Which technology is used and how it is applied provides the biggest benefit to heat treaters to ensure tasks are performed efficiently and all necessary information is available to avoid any non-conformance during an audit. **IH**

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