AUTOMATED BATCH TEMPERATURE PROBE CALIBRATION

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ABSTRACT - Temperature probe calibration can consume a significant amount of time and require a high level of manual intervention in calibration labs. ISO 9000, global quality programs and regulatory agencies have been primary factors in the increased volume of probe calibrations requested of calibration labs today. Finding efficient methods of performing multiple probe calibrations from temperature profiling to certificate issuance can save time and money for industrial calibration labs.

INTRODUCTION

Temperature probe calibration can consume a significant amount of time and require a high level of manual intervention in calibration labs. ISO 9000, global quality programs and regulatory agencies have been primary factors in the increased volume of probe calibrations requested of calibration labs today. Finding efficient methods of performing multiple probe calibrations, from temperature profiling to certificate issuance, can save time and money for industrial calibration labs. This paper offers general insight to lab managers on available methods and benefits of automated batch temperature calibration of industrial grade temperature probes.

TRENDS

Industries throughout the world are being held to a higher level of accountability for the quality and operation of their products and the processes that produce them. Organizations such as the Federal Food and Drug Administration, the International Standards Organization, PDA, and a variety of quality watchdog associations have established guidelines that requires manufactures provide documented evidence that their products are manufactured using systems that are calibrated within these quality program guidelines.

Compliance to these various regulations and guidelines have become a point of economic survival as more and more manufacturers look to do business only with vendors who comply with, and retain certification to these standards.

Many manufacturers now have internal quality programs that require full system calibration of their processes, which includes all elements of the system, from sensor to end drive element or final drive controller. For many years process system calibrations often ignored temperature sensors assuming compliance to published standards. Other manufacturers simply replaced sensors at the time of system calibration under preventative maintenance initiatives.

While relatively inexpensive and easy to replace, many industrial grade probes are now being calibrated, or more correctly characterized, and then monitored overtime as opposed being summarily replaced. This method has the added benefit of providing historical trend information to help companies better understand their processes and provide valuable long term trend and audit information.

Informal surveys of calibration laboratories, indicated an approximate 20 percent increase in temperature probe workload over the past year, and indications from cal lab customers suggests the trend will continue.

Industrial temperature sensors such as thermocouples, RTD and thermistors appear to be an increasing workload for the calibration laboratory. Characterizations of these devices are time-consuming, and occupy equipment and personnel that could be utilized for more complex calibration issues. Observations indicate that overall laboratory efficiency could be realized using automated batch calibration techniques.

CONSIDERATIONS: PROBE CALIBRATION EFFICIENCY

Calibration laboratories, as many other businesses, operate on a time and production basis. Temperature probes require lengthy calibration cycles primarily due to the slow changing nature of the temperature source used in calibration and the need to stabilize temperature of all UUTs before accurate readings can be taken. Temperature sources such as baths and dry-blocks are instruments dedicated to temperature calibration, however other equipment used in these calibrations are not dedicated, such as precision volt ohm meters and resistance bridges. This equipment, as well as attending personnel could be utilized more efficiently on more productive calibrations.

Current manual methods for the characterization of industrial temperature probes usually employ the use of a dedicated temperature monitor as a standard, a stable temperature source, such as a dry block calibrator or liquid bath, and a micro-voltmeter or resistance bridge to read the UUT. Manual probe characterization for one or more probes requires that an operator monitors temperature and verifies stability of individual UUTs, manually advance set point, verify stability of the reference thermometer temperature, connect the UUTs to a single channel measurement device and record readings. The entire characterization process for example, for a probe calibration of 0 C to 600 C can take up to eight hours using traditional liquid temperature baths. The same calibration can take half this time utilizing current technology dry-block devices.

Another time-consuming issue concerns the characterization of probes is report and certificate generation. Either technical or administrative personnel are required to input data and generate reports on individual temperature probes. In manual probe calibrations data are subject to errors when being manually recorded by lab personnel.

Volume efficiency of multiple probe characterizations is often limited in dry block calibrators to the availability and size of the receiving test wells. Most single dry block calibrators on the market today on average accommodate four ¼" diameter probes. A reference standard SPRT is used in these comparison calibrations leaving available space for three UUTs in the typical dry-block calibrator. Liquid baths provide for larger probe counts but are often limited from reaching their apparent capacity by a more practical matter of the above bath surface area that is consumed by probe depth controlling devices.

AUTOMATED CALIBRATION

From the standpoint of calibration efficiency, batch calibration software and equipment appear to offer some productivity improvements in probe through put and time savings for technical and administrative personnel. Automated batch calibrations use a computer system to control all aspects of the calibration. Batch calibration systems on the market today are capable of simultaneous multi-probe calibration from 2 to over 60 probes simultaneously.

Automated batch calibration software allows the operator to select multiple temperature points, temperature tolerance and stabilization time for all UUTs. After initiating calibration, automated systems complete the entire calibration collecting data at each set point after stabilization criteria, as set by the operator, have been reached. Calibration data, depending on software package, is collected and uncertainties are calculated based on equipment and probe parameters. This data is then saved under the appropriate asset record number in a database or saved as a file for post-processing by other programs. Some stand-alone automated software generates extrapolated data point tables that are furnished with the certificate. Calibration certificates may be generated directly from the batch calibration software or subsequently by third party reporting packages.

Automated calibration software is available that interfaces directly with large-scale database and asset management calibration software. Software of this nature can have additional timesavings for administrative and lab personnel by placing data directly in the asset database. In addition, before beginning and automated calibration the asset management database can supply verification of calibration status for all standards used in the automated calibration.

Uncertainty analysis in both manual and automated systems take the same items into consideration. Some automated systems calculate total uncertainty by addressing information in the associated asset management data base, while manual methods account for

these areas typically by referring to written logs.

Example Calibration Data

C:\metcal\rslt\mt01_20001116_0823.csv
Dryblock 514-LCX2
Hydra 2635-KCX1

Test Point	UUT 1	±UUT 1 Uncert	±UUT 1 Tolerance	UUT 1 Error	UUT 2	±UUT2 Uncert	±UUT 2 Tolerance	UUT 2 Error	Actual °C	Setpoint
1	-0.53	0.51	0	-0.55	-0.3	0.7	1	-0.32	0.02	0
2	24.89	0.51	0	-0.1	24.9	0.47	1	-0.09	24.99	25
3	50.18	0.51	0	0.2	50.1	0.47	1	0.12	49.98	50
4	75.42	0.51	0	0.44	75.1	0.47	1	0.12	74.98	75
5	100.66	0.51	0	0.69	100.1	0.47	1	0.13	99.97	100

Fig 2

An example of calibration data collected by an automated system is shown in figure 2. This is an example of test calibration data, over a narrow temperature range, received from a multi-point automated calibration system. This particular calibration did not required operator intervention to switch UUTs between hot and cold sections of the dual dry-block during the calibration run. Manual intervention is still required in both manual and automated methods when the calibration temperature range exceeds the temperature capability of the dry-block or liquid bath at which time the UUTs must be moved to an appropriate temperature source.

Typical feature set of automated batch calibration software.

Function	Automated system	Manual system
Assignment of Probe type	Software entry	Manual adjustment
Error limit table assignment	Automatic via software	Manual look-up
Temperature schedule, setpoint	Automatic advance	Manual
Stability criteria; recognition at set-point	Automatic	Manual review
Standard to UUT comparison	Automatic	Manual
Asset ID and verification	Automatic, data base	Manual look-up
Uncertainty calculation	Automatic	Manual
Data Recording	Automatic	Manual
Constants / table generation	Automatic	Software / Manual

Fig. 1

Equipment considerations for automated batch systems

Dry-Block Considerations

Batch calibration system equipment should be able to accommodate the maximum amount of UUTs anticipated for any one calibration station. As mentioned before, most single dry-block calibrators typically accommodate up to five probes and have a limited temperature utilization range.
To be of maximum benefit a dry block calibrator should be capable of carrying a maximum amount of probes as well as covering as broad a temperature spectrum as possible. General industrial probes may require calibration over a wide range of temperatures. Currently the dry-block market supports single dry block calibrators with low temperatures of - 45 C and individual calibration furnaces capable of up to1200 C. Dual dry-blocks are available on the market today with temperature ranges from - 35 C to over 670 C. These integrated dual block calibrators have an added advantage in an automated software system of being controlled by a single data port and have reasonable accuracy, stability and uniformity for industrial probe calibration.

Liquid Baths

Liquid baths have the advantage of superior stability over available dry-blocks and can accommodate a wider variety of probe shapes and lengths. Temperature ranges vary based on

design and fluid type being used. Liquid baths, depending on fluid type, volume, and design take longer to reach stable temperatures than the dry-block counterpart. The handling and replenishment of fluids represents an additional cost of long term ownership.

Thermometers

In an automated system for industrial probes the use of a dedicated thermometer and Mux system or a multi-channel recording thermometer to record results is often preferred to a resistance bridged or micro voltmeters due to the additional handling to convert measurements to temperature units. Recording thermometers have the ability to change measurement channel configuration to accommodate different probe types such as thermocouples, RTD's and thermistors. Other parameters such as current and voltage are also available and can be a valuable asset when calibrating the many integrated sensors with current or voltage output found in industry today. Recording thermometers also provide cold junction compensation for thermocouples, RTD lead length compensation and provide a dedicated channel as a temperature standard eliminating the need and expense of a separate temperature standard.

Observations in automated batch efficiency

The time invested for the characterization of a single industrial probe can occupy several hours of laboratory time dependent on the temperature calibration range requested by the customer. While lab personnel do not spend the entire time in attendance during calibration, there is a high degree of monitoring and manual intervention that is time not spent on other calibration duties.

Observing differences between automatic batch calibration systems and manual methods would suggest that automatic batch methods could provide efficiencies, dependent on equipment selection, in probe volume throughput and timesavings of lab personnel. Equipment costs between the two systems can be very close depending on what class of temperature probe you calibrate at your facilities. One obvious difference between batch calibration systems and manual systems, from an equipment cost perspective, is the computer system and software used to for batch calibration, as well as a recording thermometer or Mux system.

The example below shows the potential costs for both manual and automated systems with a probe capacity of 14, 1/4" probes designed to yield uncertainties of 0.5 C. Each system uses a dual dry-block temperature source. This example assumes an estimated average cost of equipment and software available on the market today. These costs differences should be balanced against anticipated timesaving between manual and automated systems.

SAMPLE OF AUTOMATED AND MANUAL SYSTEM EQUIPMENT COSTS

Equipment	Automated	Manual
SPRT	$ 3,000	$ 3,000
Recording thermometer	$ 7,000	
Nano volt meter / Mohm		$ 3,500
Ice point reference for T/Cs		$ 600
Dual Dry-Block –35 C to 670 C	$ 8,900	$ 8,900
Computer	$ 1,500	$ 1,500
Automated software	$ 1,300	
Report generation software		$ 500
Total this example	$ 21,700	$ 18,000

Fig. 3

Conclusion:

The calibration of Industrial temperature probes appears to be on an increase as a result of an economy that has become more quality conscious in the face of ISO and guidelines of other regulatory groups.
Automated batch calibration systems for industrial sensors may have efficiently advantages, in timesavings and increased productivity for calibration laboratories that find themselves with increasing temperature probe workloads.

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