

ScreenMaster RVG200

Paperless recorder



RVG200 and AMS2750 in the heat treatment industry

Measurement made easy

ScreenMaster RVG200
paperless recorder

Introduction

AMS2750 (Aerospace Material Specification) is the international specification for pyrometric requirements of process equipment used in heat-treatment processes. It was introduced in 1980 to redefine the existing specification for heat-treatment legislation and has evolved over the years as technology within the industry has changed.

The AMS2750 specification covers the following areas:

- Temperature sensors
- Instrumentation (both controllers and recorders)
- Thermal processing equipment
- System accuracy tests
- Temperature uniformity surveys

All of which are necessary to ensure that parts or raw materials are heat-treated in accordance with applicable specifications.

This document focuses on using ABB's RVG200 paperless recorder in heat treatment applications. The RVG200 can be used as thermal processing equipment, for system accuracy tests and temperature uniformity surveys. It explains what is required of a recorder intended for use in these applications and details the features and functionality that ensures the RVG200 meets those requirements.

Heat-treatment overview

Heat treatment is a critical process in the Aerospace and Automotive industries. Its main purpose is to physically alter the internal structure of a material by exposing it to extreme temperature in order to change its characteristics in some way. This is a process applied to components made of metal and is used to increase their robustness and ability to withstand extreme conditions (for example, very high temperature or long term use in harsh environments).

A good example of heat treated components are the turbine blades found in gas turbine engines. They are regularly subjected to temperatures far in excess of the maximum temperature the base metal can withstand. However, design features such as self-cooling and heat treatment processes enable the blades to survive in an environment that would previously have been far outside their operating specification.

Heat-treatment furnaces can be large or small depending on the product being treated. Figure 1 is an example of a simple electrically-powered furnace.

Within a single zone furnace, there are multiple points where the temperature is measured. This is important to ensure that the furnace is heated evenly and that any product placed in it is also heated evenly. This could be multiple products at different points within the furnace, or a single large product. If, in either of these cases, areas of the furnace are not reaching the correct temperature, the product itself is not being heat-treated correctly which could result in sub-standard performance and life span of that product.

Typically, temperature sensors are located at different places (usually the outer most points) within the furnace. There is also a main control sensor (the signal that drives the control of the furnace temperature) and finally, there are load sensors mounted on the load to ensure that it actually reaches the correct treatment temperature. This large number of sensors and the critical need for the correct treatment is what led to the creation of the AMS2750 standard.

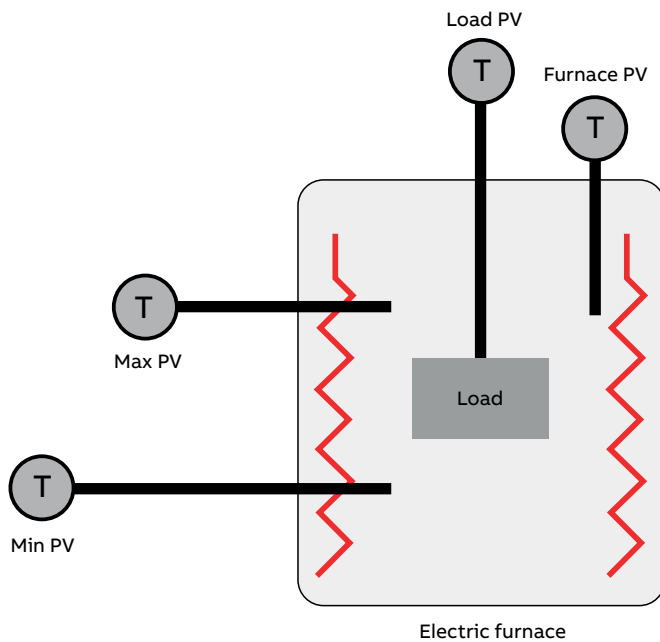


Figure 1 Example of a heat treatment furnace

AMS2750 scope

Section 3 of the AMS2750 specification covers the technical requirements of all components used within the heat-treatment process. It provides detailed information on the temperature sensors that are used. It discusses in detail all the possible roles that a sensor might be used for (for example, reference standard, accuracy testing and general load monitoring) and then goes on to stipulate the type of sensor that must be used in each role. It also provides a brief description of what that role is, how often the sensor should be calibrated and against what, if any, standard the calibration must be performed. It also describes the maximum error that is permitted in the measurements provided by the sensor. All of this is done with reference to the role the sensor is used in. For example, reference sensors have different calibration routines, accuracies and retirement schedules to those sensors that are used to monitor the load temperatures.

It also provides detailed information on the Instrumentation to be used in the system. The requirements apply to control, monitoring and recording instruments purchased after September 2005. Again, it covers the accuracy, calibration routines and retirement schedules of these products. In the case of instrumentation however, its calibration routine and accuracy requirements depend entirely on the class of furnace it is being used on. The furnace classes range from Class 1 (the most accurate that require monthly calibration) up to Class 6 (that require calibration twice a year and are not expected to be quite as accurate as class 1 and class 2 furnaces).

Details are also given of the expected system accuracy testing schedule that again changes depending on the class of furnace being used. Class 1 furnaces require weekly accuracy testing with a small allowable differential in results from week to week, whereas class 6 furnaces require testing twice a year with a higher allowed degree of difference – the more accurate the furnace, the more often it requires system testing and calibration and the more comprehensive that testing and calibration must be.

System accuracy test

System accuracy tests (SAT) are a series of tests designed to provide an on-site comparison of the instrument, lead wire and sensor readings; or values from a calibrated test instrument, lead wire or sensor to determine if the measured temperature deviations are within the applicable specification for the system. The SAT is performed to assure the accuracy of the furnace control and recording system in each control zone.

The SAT requirement changes depending on the configuration of the furnace. A test sensor should be mounted no further than 76 mm (3 in) from the process measurement sensor – see Figure 2. This can be mounted in situ permanently if required. The process measurement is then compared to the reference sensor and if the difference exceeds the specified value stipulated for the furnace class in AMS2750, the process sensor must be replaced. The system may differ only under 2 circumstances:

- 1 When process sensors are single use, or multi use but replaced at an interval that is shorter than the appropriate SAT interval. There must still be some form of SAT but the process operator must define their own SAT schedule and detail this within their compliance documentation.
- 2 A SAT may be waived if there are always at least 2 load sensors present in each control zone.

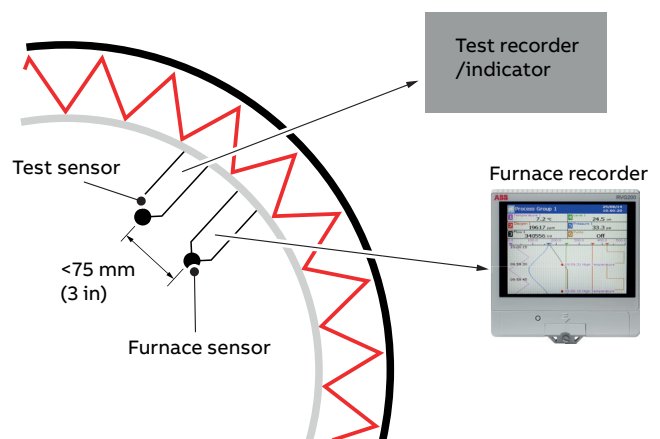


Figure 2 SAT test sensor placement

Temperature uniformity survey

A temperature uniformity survey is a test performed at regular intervals (depending on the furnace class) to determine if the temperature inside the furnace is uniform throughout and does not vary to such a degree that it is outside the specification. It involves monitoring the temperature throughout the furnace at different locations to ensure that the measurement provided by each sensor is within specification and that the furnace has no hot or cold spots where the temperature is significantly lower or higher than the desired temperature – see Figure 3.

The furnace is operated for a predetermined time and the readings from the multiple thermocouples recorded. Once the test is complete, the readings are compared against the desired temperature, the results of the SAT and also against each other to ensure that they do not differ by more than the limit for the furnace class as is stipulated in the AMS2750 specification.

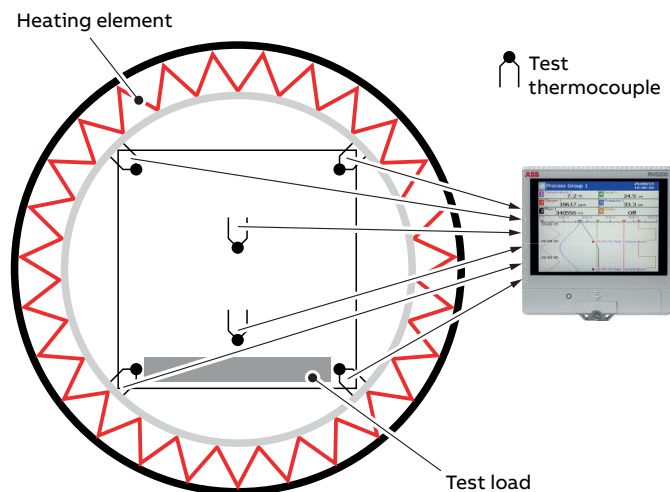


Figure 3 Temperature uniformity survey

Quality assurance provisions

One of the main reasons these tests must be performed is due to the effect that the process has on the sensors. Thermocouples are made of different types of metal, that when connected together produce a small voltage that changes with temperature changes. Long-term exposure to high temperatures such as those experienced in a heat treatment furnace leave the thermocouples subject to the same process as the item being treated. This means that over time, the internal structure of the metal that makes up the thermocouple changes, which means the mV produced at different temperatures also changes, leading to the thermocouple becoming inaccurate. Testing is vital to ensure that the accuracy of the thermocouples used remains high and that faulty or inaccurate thermocouples are changed as soon as possible. AMS2750 details how often thermocouples should be replaced (even if they have been found to be accurate) and the regular accuracy testing minimizes other potential problems.

Section 4 of the AMS2750 standard details the quality assurance provisions that must be in place to ensure that the standard is met. Similar to the validation requirements as detailed in the legislation used by the pharmaceutical industry, it details that records of all tests must be kept and made available to the customer should they require it. It also covers in detail any actions that must be taken in the event that a problem occurs in either the system accuracy tests or the temperature uniformity testing (for example, contacting affected customers). Non conformances are taken very seriously.

Instrumentation and AMS2750

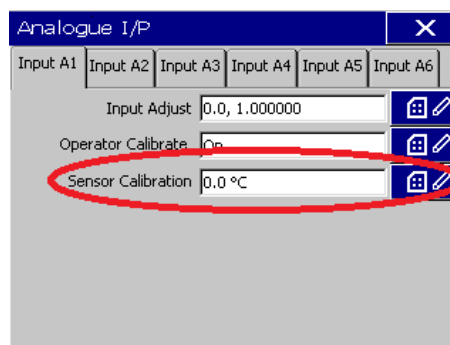
AMS2750 contains details of the expected accuracy of all parts of the system including the instrumentation that must be used. This includes input measurement accuracy, displayed data accuracy, chart resolution (where applicable) and printing intervals.

The RVG200 Paperless recorder has been designed with AMS2750 in mind, but how exactly does it meet the requirements:

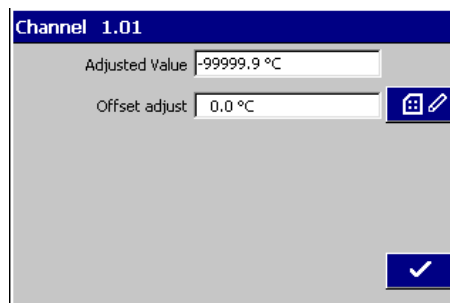
- **Only sensor types listed in Section 4 (quality assurance provisions) of AMS2750 can be used.**
 - Table 2 in Section 4 of AMS2750 lists the permitted thermocouple types J, E, K, N, R, B, S and T. The RVG200's fully universal inputs are able to accept inputs from all of these thermocouple types.
- **Control, monitoring or recording equipment accuracy for digital instrumentation must be $\pm 1.1\text{ }^{\circ}\text{C}$ ($\pm 2\text{ }^{\circ}\text{F}$) or 0.2 % of reading, whichever is greater.**
 - The RVG200's high specification inputs have an accuracy of $\pm 1\text{ }^{\circ}\text{C}$ ($\pm 1.8\text{ }^{\circ}\text{F}$) or 0.1 % of reading. Together with 500 V channel-to-channel isolation, the flexible inputs provide the accuracy and stability needed to meet the requirements of AMS2750 and are completely suited for use in processes using thermocouples.
- **Display resolution of digital inputs shall be a readability of $1\text{ }^{\circ}\text{C}$ or $1\text{ }^{\circ}\text{F}$.**
 - The RVG200 has a 5.7 inch, $\frac{1}{4}$ VGA (76800 pixel) display. This provides multiple display options including trend and digital indicators. Digital indicators can show up to 7 characters allowing for multiple decimal places, easily enabling the RVG200 to meet the required readability of the Standard.
- **Instrument field test accuracy of $\pm 0.6\text{ }^{\circ}\text{C}$ ($\pm 1\text{ }^{\circ}\text{F}$) or 0.1 % of reading, which ever is greater.**
 - The RVG200 when subjected to suitable field calibration meets the requirements of the instrument field test calibration and accuracy

- **In the event of errors found when comparing production sensors to the values indicated or recorded by the reference sensors or instrumentation, during any SAT or uniformity testing, offsets can be applied to correct errors to sensors and/or readings used during the heat treatment process. This is on the condition that those errors do not exceed those deemed acceptable within the standard.**

- The RVG200 contains a simple sensor calibration procedure. Entering the configuration level and selecting the I/O modules page gives the option to calibrate the sensor:



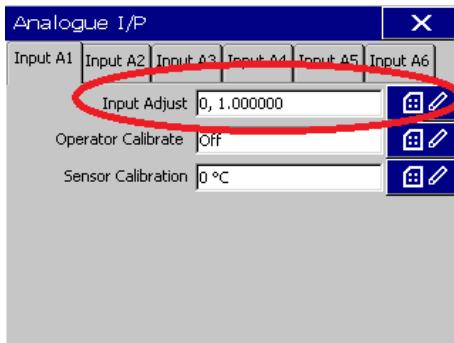
The parameter enables small adjustments to be made to the sensor reading without affecting the actual input of the recorder:



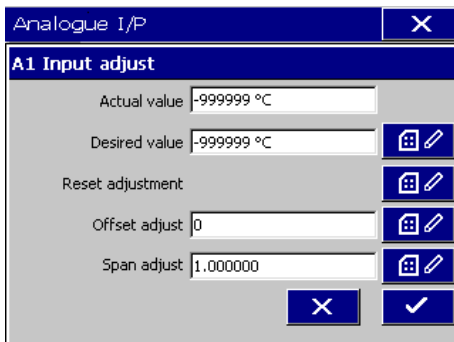
An offset is applied to the sensor value to align it with the test sensor reading. If the required adjustment is larger than that permitted for the class of furnace being used, then the sensor must be replaced. If the adjustment is within specified limits, it can be applied but it must be recorded together with the initial non conformance that led to the adjustment requirement. All recorded adjustments must be stored for the lifetime of the furnace as part of the system validation and testing archives.

...Instrumentation and AMS2750

- Routine calibration of instrumentation (both recorders and controllers) used for control and monitoring of furnaces are subject to regular calibration intervals (depending on the furnace class) as is detailed in AMS2750. Calibration shall be performed on each channel in use that can be altered individually. It is recommended that channels not in use are blocked or tagged to prevent unintentional use.
 - Calibration of the RVG200 is performed by entering the configuration level, selecting the I/O modules page and choosing to adjust the input.
- The system must create electronic records that cannot be altered without detection.
 - The RVG200 is designed to meet the requirements of 21 CFR part 11, the FDA's electronic record-keeping requirements that stipulates that data must be archived in an encrypted format. The data from the RVG200 can be opened only by ABB's Datamanager Pro data review software. The data is imported into the Datamanager Pro database and every time the file is opened, the data's integrity is checked to ensure it remains intact. If a problem is found, a message informing the user that the data integrity is invalid is displayed alongside the data.



The input can then be adjusted as required:



Note. Input adjustment is a separate parameter to sensor adjustment and enables routine calibration of the instrumentation to be performed separately to any adjustments that must be made to the sensors as they age.

When adjustments have been made, exit and save as the configuration as the current configuration. An entry is recorded in the instrument's audit log confirming that a calibration change has taken place. The entry also carries the username of the operator responsible, thus providing a full audit trail of the change.

Note. Although published by the FDA for food and pharmaceutical use, 21 CFR part 11 has been widely adopted as a standard requirement for paperless recorders across all industries where evidence of data integrity and audit trails are a requirement.

- **The system software shall provide a means of examining and/or compiling the record data, but shall not provide any means for altering the source data. The system software shall also provide the ability to generate accurate and complete copies of records in both human readable and electronic form suitable for inspection, review and copying.**
 - The Datamanager Pro data review software permits read-only review of process data from its database facility. Data can be displayed in either a chart or tabular format that cannot be edited, but a comprehensive range of chart analysis tools can be used to examine the chart fully without editing it in any way. Both chart and tabular view can be printed; the chart can also be saved as a picture.
- **The system shall be capable of providing evidence that the record was reviewed (for example, recording an electronic review, or a method of printing the record for physical marking).**
 - The RVG200 has an electronic signature facility. This enables a user to review the historical data on the instrument's screen and use their unique username and password to electronically sign the chart. The signature is then stored securely in the audit log of the unit. The audit log is archived with the process data and imported into the database where it is stored and displayed together with the associated data files. Electronic signatures are displayed on the chart as annotations at the time and date of entry. The licensed version of Datamanager Pro enables a user to electronically sign the chart after the data has been imported into the database. The time and date stamped message (together with the user ID) is then stored permanently alongside the relevant data and displayed on the chart as a record of the data having been reviewed.
- **The system shall support protection, retention and retrieval of accurate records throughout the retention period.**
 - Datamanager Pro enables secure storage of the database on either a local or network drive connected to the PC on which the software is installed. For extra security and peace-of-mind, it also creates a back up location and stores a back up copy of the database in that location automatically. Only an authorized system administrator (entering a username and password) is permitted to change and/or remove data from the primary and back up locations.
- **The system shall provide methods to limit system access only to individuals whose authorization is documented.**
 - In keeping with the widely adopted paperless recording standard of 21 CFR part 11, the RVG200's security system is designed to fully meet these requirements. User security comprises 2 distinct parts; a username and a password. Each user can be assigned different levels of access to the recorder and its functionality. For example, this means that an operator can be prevented from entering the configuration level, but allowed access to electronically sign the chart whereas an authorized technician can be granted access to the full configuration to perform the necessary sensor adjustments as part of any surveys being conducted.

When security is enabled, a username and password must be entered to gain access to the required features. The username and the action performed is recorded with a time and date stamp in the recorder's audit log. The audit log is then saved and reviewed alongside process data in Datamanager Pro. In keeping with electronic record keeping legislation, a Good Automation Manufacturing Practice (GAMP) 5 validation template has been developed in accordance with GAMP 5 validation guidelines. This is available to purchase to accompany the RVG200 and enables easy system validation and record keeping of authorized password holders.

...Instrumentation and AMS2750

- **Guarantee of accuracy and stability of instrumentation and calibration between routine calibration periods.**
 - Instrumentation used for system accuracy testing and uniformity surveys are unlikely to be in operation 24 hours a day. There are undoubtedly going to be periods during which the units will be powered down and/or out of use between the required calibration routines of the furnace and other process equipment. It is critical that any calibration settings or adjustments made to the instrument during the course of routine operations are fixed and remain unchanged during periods of downtime. It is also critical that any instrumentation mounted on the process for full time process operations are also accurate and stable so that adjustments are kept to a minimum during routine scheduled calibrations. The RVG200 was designed from its initial conception to be 100 % compliant to the AMS2750 specification. The high specification and accurate input circuitry make it ideal for use directly on a heat treatment process or as a survey instrument. For thermocouple measurement, each input card has a dedicated cold junction measurement and for increased peace of mind, a cold junction measurement can be fitted for each individual input.

The RVG200 and heat treatment

The RVG200 has a number of features available that make it perfectly suited for use in heat treatment applications.

Batch recording

The RVG200 batch recording option enables batch information (for example, batch number, product type and other product and process information) to be entered into the recorder and tagged to process data. The batch records can then be easily and quickly recalled and reviewed in Datamanager Pro.

Front and rear USB ports

The RVG200 features 2 USB ports as standard. One is located on the front panel under the secure media door and the second at the rear of the instrument. The ports are compatible with removable USB memory sticks up to 32 GB in size or USB peripherals such as mouse, keyboard or a barcode scanner can be connected for easy entry of batch information.

Logarithmic chart scale

Many precision heat treatment processes take place in a vacuum to eliminate the possibility of contamination. In order to display these values at maximum accuracy, they are recorded against a logarithmic chart scale. The RVG200 enables process signals to be recorded against a logarithmic chart scale and displayed in the same manner in Datamanager Pro.

Multiple operator displays as standard

The RVG200 has the facility to display process information on the instrument in a number of ways as standard enabling operators to view the process in the way most suitable for their needs. Chart, digital indicator and bargraph display options can all be configured, displaying up to 24 channels in a single process group. An overview display is also available as standard that enables all active channels, regardless of process group, to be displayed on a single screen.

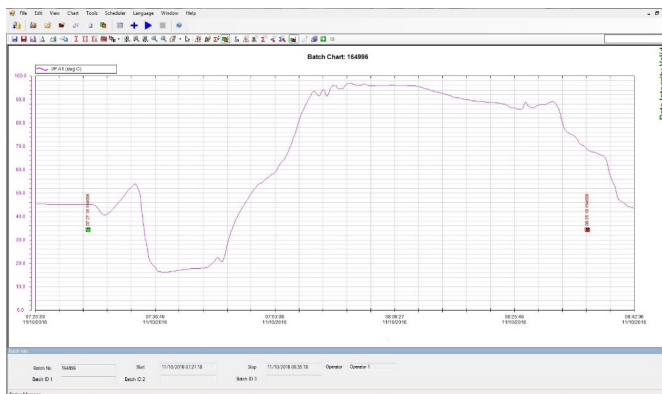
Comprehensive web browser and Ethernet communications

The RVG200 has comprehensive Ethernet functionality available as standard. The inbuilt webserver enables remote viewing of the recorder from a PC. Alarms can be acknowledged, totalizers reset and operator messages sent, all via a PC or laptops' keyboard. The recorder can also be remotely operated and configured via the Ethernet connection. As part of the Ethernet connection, Modbus TCP is also available as standard and process data can be transferred from the selected archive media via FTP over the Ethernet connection. Datamanager Pro includes an FTS program that enables scheduled transfers of data from an instrument to a chosen database location, without having to remove the media card from the instrument.

Datamanager Pro data review software

ABB's DataManager Pro advanced data review software is free-to-download software that requires no additional purchases to use the basic data review functionality. More advanced functionality is available that requires a purchased license to enable, but data can be reviewed easily in the basic version for free. The data analysis tools included as standard enable data to be reviewed from the database and charts created and printed if required. Batch data recall enables the database to be searched by batch number and data relevant to that batch displayed together with all the applicable and related batch information alongside the chart.

Chart information can also be displayed simultaneously in a tabular format and the licensed version of the software enables that data to be exported to an Excel spreadsheet if required. The licensed software also permits the chart to be signed electronically enabling a supervisor to sign off batches in accordance with the electronic record legislation that is required in such a highly controlled industry.



Datamanager Pro chart view

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ABB Limited

Measurement & Analytics

Howard Road, St. Neots
Cambridgeshire, PE19 8EU
UK

Tel: +44 (0)1480 475 321

Fax: +44 (0)1480 217 948

Email: instrumentation@gb.abb.com

ABB Inc.

Measurement & Analytics

125 E. County Line Road
Warminster, PA 18974
USA

Tel: +1 215 674 6000

Fax: +1 215 674 7183

abb.com/measurement



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