Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 2750

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Revised

PYROMETRY

1. SCOPE: This specification establishes and defines requirements and procedures for control and testing of furnaces, ovens, salt baths, vacuum furnaces, refrigeration equipment, and allied pyrometric equipment used primarily for thermal treatment of semi-finished and finished metal parts.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E220 - Calibration of Thermocouples by Comparison Techniques

2.3 ANSI Publications: Available from American National Standards Institute Inc., 1430 Broadway, New York, NY 10018.

ANSI Circular MC96.1 - American National Standard for Temperature Measurement Thermocouples

3. TECHNICAL REQUIREMENTS:

3.1 Thermal Processing Equipment Instrumentation:

3.1.1 Equipment Controls: Primary and secondary control instrumentation on thermal processing equipment shall conform to Table I. Upon specific approval of the cognizant quality assurance organization, special equipment used exclusively for thermal processing in which load, retort, or part temperature is always verified by load-attached thermocouples may be equipped with any suitable method of control. In such cases, the log of part temperature shall become a part of the thermal processing record.

3.1.1.1 Where potentiometric instrumentation is required or used, it shall be preferably of the electronic null-balance type, equipped with constant voltage unit.

3.1.1.2 Controlling/recording instrumentation shall receive an unmodified signal from the temperature sensing element. Lead wires shall not be spliced.

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3.1.1.3 Recording instrumentation shall record an accurate, legible mark indicating the temperature. Charts shall not be rerun through instruments.

3.1.1.4 Instrumentation shall be installed in locations which avoid exposure to conditions detrimental to accurate, consistent operation.

3.1.1.5 Multi-zone equipment shall be provided with a controller (or controller/recorder, if required), for each zone.

TABLE I

REQUIRED TEMPERATURE CONTROL INSTRUMENTATION

Thermal Treatment Process	Instrumentation Control Type	Hi-Limit Instrument	Optional Instrumentation Control Type *
All Heating Processes	A	Indicating Pyrometer	AA
Quench Baths	C	Optional	--
Subzero Transformation	B	Optional	--
Aluminum Alloy Refrigerated Storage	C	Optional	--
Embrittlement Relief	B	Indicating Pyrometer	--

* Mandatory when required by procuring activity.

Control Instrument Types (Description)

Type AA - A minimum of one controller and two recorder instruments in each control zone, attached to thermocouples located to record the extremes in both time and temperature.

Type A - An independent or combination potentiometric recorder and controller.

Type B - Potentiometric or nonpotentiometric control with recorder (may be combined). For dry ice/liquid units, only a recorder is required.

Type C - Suitable temperature control plus temperature indicator (may be combined).

3.2 Equipment Tests: Pyrometric test equipment shall conform to requirements of 3.3.

3.2.1 Service and Calibration of Instrumentation: Instrumentation shall be serviced and calibrated at the frequencies specified in Table II and shall be maintained to accuracy requirements of Table III.

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TABLE II

CONTROL/RECORDING INSTRUMENTATION SERVICE AND CALIBRATION FREQUENCY REQUIREMENTS

Control Type	Process	Service	Frequency
AA or A	Aluminum solution heat treat or aging.	Calibration	Monthly
AA or A	All other elevated temperature thermal processing, (See Section 8).	Calibration	Quarterly, except Monthly if mechanical balance potentiometer
B	Subzero transformation	Calibration or System Calibration	Semi-Annual
C	Aluminum alloy storage	Calibration	Semi-Annual
B	Embrittlement relief	Calibration or System Calibration	Semi-Annual, except Quarterly if mechanical balance potentiometer

3.2.1.1 Thermocouple actuated instrumentation shall be calibrated using appropriate NBS-EMF temperature tables and pyrometric test equipment conforming to 3.3.

3.2.1.2 When system calibration is allowable in Table II, instrumentation not activated by thermocouple may be adjusted to indicate, control, and record average chamber temperature at the time of temperature survey. When a survey is not required, instrumentation shall be adjusted to accuracy requirements of Table III, using a calibrated thermometer or other suitable calibrated working standard.

3.2.2 Temperature Uniformity Surveys, General: The procedure for performing temperature uniformity surveys is described in the Appendix. Other procedures may be used providing they are approved by the cognizant quality assurance organization.

3.2.2.1 Temperature uniformity surveys shall be performed without a load (empty furnace, except for racks) except when use of a load is approved by the cognizant quality assurance organization. In such cases, a detailed description of the load shall be attached to the survey report.

3.2.2.2 Surveys shall be made with independent test thermocouples and preferably with the use of an automatic calibrated multipoint recorder meeting the requirements of 3.3.1.3. If a portable test potentiometer is used, it shall meet the requirements of 3.3.1.1 and 3.3.1.2. All surveys, successful and unsuccessful, shall be documented and retained on file for 5 years.

3.2.2.3 Thermal processing equipment temperature measuring instruments shall not be used for measuring or recording temperature uniformity surveys.

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TABLE III

INSTRUMENT ACCURACY REQUIREMENTS

Control Type	Process Temperature Uniformity Requirement	Indicated Accuracy (1)
A or AA	±5° F (±3° C)	±2° F (±1° C) (2)
	±10° F (±5° C)	±2° F (±1° C) (2)
	±15° F (±8° C)	±2° F (±1° C) (2)
	±25°F (±15° C)	±5° F (±3° C) (3)
B	Subzero Transformation	1 scale division or 5° F (3° C), whichever is less (4)
C	Refrigerated Storage of Aluminum Alloys	1 scale division or 5° F (3° C), whichever is less (4)
B	Embrittlement Relief	±5° F (±3° C) (3) (4)

NOTES: 1. Instrument indicated accuracy is the maximum indicated difference allowable when comparing the equipment instrument with calibrated test equipment (See 3.3.1 or Note 4).

2. Sensitivity of an EMF change equal to 2° F (1° C) shall be maintained.

3. Efforts to obtain a lesser deviation than 5° F (3° C) shall be made.

4. If temperature indicator is not EMF actuated, a calibrated thermometer may be used for calibration check.

3.2.3 Initial Surveys (See Appendix for procedures): An initial temperature uniformity survey shall be made on each unit of equipment except aluminum alloy refrigerated storage units and nontemperature-controlled dry ice or dry ice/liquid units, to determine compliance with specification requirements. This survey shall be made prior to the use of the equipment for processing parts.

3.2.3.1 The initial survey shall be made at the minimum and maximum operating temperatures to be used in each thermal processing unit. Acceptable surveys at minimum and maximum operating temperature determine the approved operating range.

3.2.3.2 When equipment is to be used for more than one process, e.g., solution heat treatment and aging, it shall be surveyed at the minimum and maximum operating temperature of each process.

3.2.3.3 An initial survey shall be made after any repair or adjustment of the equipment which may reasonably be expected to alter its operational characteristics.

3.2.4 Periodic Surveys (See Appendix for procedure): Periodic temperature uniformity surveys shall be performed at frequencies required in Table IV. Unless otherwise specified by the cognizant quality assurance organization, they may be performed at any convenient temperature within the operating range for which acceptable initial survey results have been made.

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3.2.4.1 At approximately 12-month intervals, the periodic survey shall be made at the highest temperature of the operating range.

3.2.5 System Accuracy Checks: A system accuracy check shall be performed weekly on each elevated temperature processing unit (or zone) using the following procedures:

3.2.5.1 Compare the temperature indication of each processing unit (or zone) controller with the temperature indicated by a sensor of known accuracy, read on a test potentiometer. The independent sensor should be within 3 in. (75 mm) of the zone primary sensor.

3.2.5.2 Apply the correction (obtained from calibration) of the independent sensor, then compare with the indicated temperature on the control instrument.

3.2.5.3 Corrective action shall be taken if the compared readings differ by more than 5° F (3° C).

TABLE IV

TEMPERATURE UNIFORMITY SURVEY FREQUENCY REQUIREMENTS

Materials and Processes	Survey Frequency Required
Aluminum (Solution heat treatment or aging)	Monthly (1) (2)
Equipment used only for annealing	Semi-annual
Titanium, Stainless Steels, BeCu	
Solution heat treatment, austenite conditioning, aging, precipitation heat treatment	Quarterly (1) (2)
Equipment used only for stress relief or annealing	Semi-annual
Steels (Austenitize, Temper)	Quarterly (1) (2)
Equipment used only for normalizing, stress relief, annealing, or embrittlement relief	Semi-annual
Subzero transformation	Semi-annual
Dry-ice or dry-ice/liquid	Not required
Aluminum (Refrigerated Storage)	Not required

NOTES: 1. Survey frequency may be reduced, subject to approval of the cognizant quality assurance organization, when equipment is provided with the following control types (See Table I for control instrument type description).

Type AA - After the initial successful survey, periodic survey frequency may be reduced one step, i.e., monthly to quarterly, quarterly to semi-annually, after three consecutive successful first-attempt surveys have been completed.

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TABLE IV NOTES (Cont'd.)

Type A - Survey frequency may be reduced one step, i.e., monthly to quarterly, quarterly to semi-annually under the following conditions:

a) A history of consecutive successful first-attempt surveys, 6 for aluminum and 4 for other materials.

b) A documented preventive maintenance plan is established and a maintenance record kept.

c) Control thermocouples are replaced on an established schedule.

2. Any failure of a reduced-frequency periodic survey, or any change to the equipment or instrumentation that could affect the temperature or performance characteristics requires that the survey frequency revert to the requirement of Table IV.

3.3 Pyrometric Test Equipment:

3.3.1 Test Instruments: Portable test potentiometers are acceptable for use as a calibrating instrument for calibration of EMF actuated temperature controllers or recorders. Appropriate NBS-EMF temperature tables shall be used.

3.3.1.1 Direct reading test potentiometers shall have scale divisions not greater than 5° F (3° C). Millivolt potentiometers shall have scale divisions such that readings may be obtained, by interpolation if necessary, to 0.02 millivolts.

3.3.1.2 Accuracy of 0.05% plus 20 microvolts or better shall be maintained. Test potentiometers shall be calibrated every three months against a working standard potentiometer (See 3.4.1).

3.3.1.3 Multipoint strip chart recorders and data loggers used for temperature surveys shall be calibrated and maintained to an indicated accuracy of ±2° F (±1° C).

3.3.2 Thermocouples: All probe-type or swaged-construction thermocouples and wire from which expendable thermocouples are made shall be calibrated before use. Technique of calibration shall be compatible with ASTM E220 procedures.

3.3.2.1 Calibration of thermocouple wire rolls shall be accomplished by calibration of sample thermocouples from each end of each roll. The roll of wire is satisfactory if calibration results of the sample thermocouples compare within 1° F (0.5° C). If a roll fails to quality, thermocouples made from it may be calibrated individually.

3.3.2.2 Thermocouples or thermocouple wire accuracy shall be equal to regular grade limits of error, or better, specified in ANSI Circular MC96.1.

3.3.2.3 Thermocouple alloys, wire size, and insulation shall be compatible with the environment, times, and temperature to be encountered during use.

3.3.2.4 Thermocouple hot junctions shall be suitable for the intended use.

3.3.2.5 Reuse of expendable-type thermocouples (See 8.1.2) is permitted providing the insulation is intact, the wire and hot junction have not been damaged, and original calibration data is preserved. If such thermocouples are to be used more than one time, a reuse schedule shall be established. In any case, if wire has been exposed to corrosion, excessive abrasion (to the extent that bare wire is visible), or mechanical damage, it shall be discarded. Salvage by clipping back beyond the affected portion and remaking the hot junction is permissible.

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3.3.2.6 A control system shall be used to ensure periodic calibration or replacement of nonexpendable-type thermocouples (See 8.1.3) used for temperature surveys, system accuracy checks, or load temperature measurement.

3.3.3 Thermocouple Calibration Records: Calibration records shall include all information relative to the actual calibration, i.e., date of calibration, type of thermocouple, identification of the roll (or individual thermocouple identification), test temperature, and applicable corrections.

3.3.3.1 A system shall be used to provide traceability of calibration results to the thermocouple(s) in use for checking, monitoring, or survey purposes.

3.3.3.2 Thermocouple calibration corrections shall be recorded so that algebraic addition of the correction will give the correct reading.

3.4 Calibration Equipment:

3.4.1 Working Standard Potentiometer: The working standard potentiometer shall be a type K potentiometer or its equivalent.

3.4.1.1 The potentiometer shall be calibrated initially, and at intervals of not more than one year thereafter, against a potentiometer whose calibration is traceable to the National Bureau of Standards within the past two years.

3.4.1.2 Standard cells (when used) shall be of the unsaturated cadmium cell type. The cells shall have an EMF of not less than 1.01840 volts and a temperature coefficient of not greater than 10 microvolts per Celsius degree. Cells shall be calibrated at intervals of not more than six months against cells with NBS traceability within the past two years.

3.4.2 Working Standard Sensor: The working standard sensor shall be a platinum versus platinum plus 10% or 13% rhodium thermocouple. The sensor shall be provided with a calibration report traceable to the NBS.

3.4.2.1 The working standard sensor shall be calibrated within approximately 150° F (83° C) of its minimum and maximum use temperatures and at approximately 500° F (278° C) intervals between these temperatures.

3.4.2.2 Working standard sensors shall be calibrated annually with a reference standard sensor used only for this type of calibration. The reference standard sensor used shall have been calibrated directly or through precise intercomparison with the standards maintained by the NBS within the past five years. Calibration results of the working standard shall not depart from its calibration report values by more than 5 microvolts up to 2000° F (1093° C).

3.5 Pyrometric Control Records: An appropriate form shall be maintained for each instrument on which calibration and system accuracy checks are made. This form shall be dated and retained for inspection. All calibrations, test readings, and test data shall be recorded on this form.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The processor shall be responsible for performing all required tests and for conformance to all requirements specified herein. Except as otherwise specified, the processor may use his own facilities or any commercial laboratory acceptable to the cognizant quality assurance organization. The cognizant quality assurance organization reserves the right to perform or witness any of the tests or inspections described herein when such action is deemed necessary to ensure that processing conforms to the prescribed requirements.

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4.1.1 If results of tests specified herein do not meet applicable specification requirements, processing of materials in the applicable equipment shall be discontinued until corrective action is documented and retests are made with results conforming to requirements.

5. PREPARATION FOR DELIVERY: Not applicable.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Not applicable.

8. NOTES:

8.1 Definitions:

8.1.1 "Thermal Processing" is any process in which metals are exposed to controlled heating or controlled cooling. The term normally excludes forging, chemical processing applications, drying, and heating for hot forming.

8.1.2 "Expendable Thermocouples" are those thermocouples made of fabric-insulated wire. This type of wire is provided on coiled spools. The insulation most commonly used is asbestos over each conductor with a glass braid overall.

8.1.3 "Nonexpendable Thermocouples" are those thermocouples that are not covered with the conventional fabric insulations. The following is a brief description of what are considered to be "nonexpendable thermocouples:"

8.1.3.1 Ceramic insulators over bare thermocouple wire, sometimes inserted in an open end or closed end metal tube for physical stability.

8.1.3.2 A combination of thermocouple wires, mineral insulations, and a protecting metal sheath compacted into a solid mass of small diameter. The thermocouple thus constructed is protected, flexible, and, within the temperature limits of the sheath material, may be used many times without insulation breakdown. This type of thermocouple is available under many trade names.

8.1.4 "Cognizant quality assurance organization" is the quality assurance organization allied to the engineering organization responsible for the design of the parts or its designee.

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