SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2773A

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Superseding AMS 2773

Heat Treatment
Cast Nickel Alloy and Cobalt Alloy Parts

1. SCOPE:

1.1 Purpose:

This specification specifies the engineering requirements for heat treatment, by part fabricators (users) or their vendors or subcontractors, of parts made of cast nickel or cobalt alloys and of fabricated assemblies in which cast nickel or cobalt alloys are the primary structural components. It is not intended to provide requirements for heat treating operations that are a responsibility of the casting supplier in meeting the requirements of the casting commodity specification.

1.2 Application:

1.2.1 Alloys: Detailed heat treating instructions are specified for the age-hardenable (precipitation-hardenable) and non-age-hardenable alloys listed in 8.2. However, this specification also may be used for alloys other than those listed in 8.2 provided that temperatures, soaking times, and cooling requirements are specified by the cognizant engineering organization.

1.2.2 Heat Treatments: Heat treatments covered by this specification are as follows:

Homogenization (See 8.4.6)
Solution Treating (See 8.4.7)
Stabilization (See 8.4.9)
Precipitation (See 8.4.10)
Stress Relief (See 8.4.8)

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

TO PLACE A DOCUMENT ORDER:
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2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2750	Pyrometry
AMS 5377	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings, 73Ni - 12Cr - 4.5Mo - 2.0Cb(Nb) - 0.70Ti - 0.05C - 6.0Al - 0.010B - 0.10Zr, Vacuum Cast, As Cast
AMS 5382	Cobalt Alloy, Corrosion and Heat-Resistant, Investment Castings, 54Co - 25.5Cr - 10.5Ni - 7.5W, As Cast
AMS 5383	Nickel Alloy, Corrosion and Heat-Resistant Investment Castings, 52.5Ni - 19Cr - 3.0Mo - 5.1(Cb+Ta)(Nb+Ta) - 0.90Ti - 0.60Al - 18Fe, Vacuum Melted, Homogenization and Solution Heat Treated
AMS 5388	Nickel Alloy, Corrosion and Heat-Resistant Investment Castings, 53.3Ni - 16.5Cr - 17Mo - 4.5W - 5.8Fe - 0.40V, As Cast
AMS 5390	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings, 47.5Ni - 22Cr - 1.5Co - 9Mo - 0.60W - 18.5Fe, As Cast
AMS 5396	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings, 65Ni - 28Mo - 5.5Fe - 0.40V, As Cast
AMS 5399	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings, 52Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti - 1.6Al - 0.006B, Vacuum Melted, Vacuum Cast, Solution Heat Treated
AMS 5401	Nickel Alloy Corrosion and Heat-Resistant, Investment Castings, 62Ni - 21.5Cr - 9.0Mo - 3.6Cb(Nb), Vacuum Melted, Vacuum Cast, As Cast
AMS 5402	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings, 62Ni - 21.5Cr - 9.0Mo - 3.6Cb(Nb), As Cast
AMS 5410	Nickel Alloy, Corrosion and Heat-Resistant, Investment Castings 61Ni - 16Cr - 8.5Co - 1.8Mo - 2.6W - 0.85Cb(Nb) - 3.4Ti - 1.8Ta - 3.4Al - 0.010B - 0.05Zr, Vacuum Melted, Vacuum Cast
ARP1820	Chord Method of Evaluating Surface Microstructural Characteristics
ARP1962	Training and Approval of Heat-Treating Personnel

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM E 3	Preparation of Metallographic Specimens
ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 384	Microhardness of Materials

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 or http://assist.daps.dla.mil/online/start/.

MIL-A-18455	Argon, Technical
MIL-PRF-27201	Propellant, Hydrogen
MIL-PRF-27401	Propellant Pressurizing Agent, Nitrogen
MIL-PRF-27407	Propellant Pressurizing Agent, Helium
BB-H-1168	Helium, Technical

2.4 CGA Publications:

Available from Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly VA 20151-2923 or www.cganet.com.

CGA G-9.1	Commodity Specification for Helium
CGA G-10.1	Commodity Specification for Nitrogen
CGA G-11.1	Commodity Specification for Argon

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

3.1.1 Pyrometry: Shall conform to AMS 2750.

3.1.2 Furnaces:

3.1.2.1 Temperature Uniformity: Shall be in accordance with AMS 2750.

3.1.2.2 Heating Media: Protective Atmospheres shall be used whenever heat treating temperature is above 1600 °F (871 °C) unless parts will have sufficient surface material removed after heat treatment to eliminate high temperature atmospheric effects, such as oxidation, alloy depletion, and carburization. Acceptable protective atmospheres include argon, helium, hydrogen, vacuum, and vacuum with partial pressure of any of these three gases. In addition, for non-age- hardening alloys, neutral salt baths and exothermic gas atmospheres are acceptable protective atmospheres when approved by the cognizant engineering organization (See 8.4.5). Direct fired furnaces shall be controlled so that there is no direct flame impingement on the parts.

3.1.2.2.1 Argon, Helium, and Hydrogen Gases: Shall meet the composition requirements of MIL-A-18455 (argon), CGA G-11.1 (argon), MIL-P-27407 (helium), CGA G-9.1, Grade L, minimum (helium), BB-H-1168, Grade A (helium), or MIL-P-27201 (hydrogen), as applicable. The dew point of the gas shall be -60°F (-51 °C) or lower as the gas enters the furnace. Atmospheres of any of these gases in the furnace work zone shall have sufficient purity to avoid contamination or degradation of any part surface which will not have surface material removed after heat treatment.

3.1.2.2.2 Vacuum and Partial Pressure Atmospheres: Shall be sufficient to avoid contamination or degradation of any part surface which will not have surface material removed after heat treatment. Vacuum furnaces shall have a cold leak rate of a maximum of 20 microns (20 µm) per hour, which shall be determined (1) with pumps isolated from the furnace chamber, and (2) 15 to 60 minutes after closing the vessel and evacuation to 50 microns (50 µm) or lower; and furnaces shall be operated at pressures not higher than 10 microns (10 µm) of mercury unless argon, helium, hydrogen, or a mixture of argon and helium gas conforming to 3.1.2.2.1 is used to provide a partial pressure.

3.1.2.2.2.1 Argon or helium conforming to 3.1.2.2.1, or a mixture of the two, may be used to achieve partial pressures whenever necessary to avoid surface alloy depletion by sublimation of high vapor pressure elements such as aluminum and chromium.

3.1.2.2.2.2 Cooling may be accelerated by back-filling with argon or helium conforming to 3.1.2.2.1 or with nitrogen conforming to either MIL-P-27401, Grade C or CGA G-10.1, Grade K, or combinations thereof, meeting the dew point requirements of 3.1.2.2.1.

3.1.2.2.3 Salt Baths: Acceptable only for non-age-hardening alloys and, when approved by the cognizant engineering organization, shall be neutral with respect to the alloy being treated so as to avoid contamination or degradation of any part surfaces which will not be machined after heat treatment.

3.1.2.2.4 Exothermic Atmospheres: Acceptable only for non-age-hardening alloys and, when approved by the cognizant engineering organization, shall be produced by the combustion of fuel gas in air, shall be neutral to slightly reducing with respect to the parts being treated, and shall be sufficiently low in sulfur content to avoid contamination or degradation of any part surfaces which will not have surface material removed after heat treatment.

3.1.3 Auxiliary Equipment: Fixtures, jigs, hangers, trays, racks, etc. shall not cause contamination of the surface of parts and shall not reduce the heating, cooling, or quenching rates below those required for proper heat treatment.

3.1.4 Cooling: Shall be provided to cool parts according to the heat treatment requirements specified for each alloy. Acceptable cooling media may include air, oil, water, water-polymer solutions, salt, brine (nominally 10% by weight NaCl), argon, helium, hydrogen, nitrogen, and vacuum. The medium selected shall not contaminate or degrade any part surface which will not be machined after heat treatment. When air cooling (AC) (See 8.4.11) or rapid air cooling (RAC) (See 8.4.12) is specified, cooling media shall be used which will provide protection, if required, to avoid contamination or degradation of finished surfaces; cooling rates shall be achieved that will be equivalent to, or faster than, rates that would be achieved by AC or RAC, as specified.

3.1.4.1 Quenching: Quenching baths shall permit complete immersion of parts and free circulation of the quenchant adjacent to all surfaces of parts. Equipment shall agitate or circulate the quenchant and/or the parts.

3.2 Procedures:

3.2.1 Cleaning:

3.2.1.1 Prior to Heat Treatment: Parts shall be thoroughly cleaned to remove all foreign material, including greases, oils, inks, pencil marks, and metal particles such as may be produced by machining or straightening operations.

3.2.1.2 After Heat Treatment: Parts which have been heat treated in molten salt or cooled in oil, molten salt, brine, or water-polymer solution shall be thoroughly cleaned to remove all residues of these materials.

3.2.2 Racking:

3.2.2.1 Except as permitted in 3.2.2.2, parts shall be racked to ensure uniform heating and cooling throughout the load. Parts shall not be nested unless tests with load thermocouples have demonstrated that the arrangement will not affect uniformity of heating and cooling and will not reduce cooling rate below minimum requirements.

3.2.2.2 Small parts may be racked or heated and soaked in baskets or in a continuous furnace. Parts shall not be nested. Maximum thickness of layers, and minimum spacing between layers, shall be 1 inch (25 mm).

3.2.3 Control Instruments: Shall be set either at the set temperature (See 8.4.4) specified or at the offset temperature (See 8.4.4) based on the last temperature uniformity determination. The offset temperature shall be within 5 °F (3 °C) for precipitation treatments, and 10 °F (6 °C) for other treatments, of the specified set temperature and shall be posted on the instrument or programmed into the control system when a programmable system is in use. The offset temperature shall be selected to optimize the temperature distribution within the furnace so that the highest and lowest temperatures are equidistant from the set temperature.

3.2.3.1 The posting of the offset temperature shall include, or consist of, a statement of both the "desired" temperature and the corresponding "set" temperature; e.g. "When 1000 °F is desired, set at 1004 °F".

3.2.4 Heat Treatment: Shall be performed as follows unless an alternate treatment has been specified by purchase order or by the cognizant engineering organization.

3.2.4.1 The specified solution and stress-relief treatment for the non-age-hardening alloys shall be performed in accordance with Table 1. Soaking times from Table 2 shall be used when not specified in Table 1. The specified homogenization, solution, precipitation, and stress relief treatments for age-hardening alloys shall be performed in accordance with Table 3. Tolerances for the soaking times for both aging-hardening and non-age-hardening alloys shall be as shown in Table 4.

TABLE 1 - Heat Treatment of Non-Age-Hardening[1] Cast Nickel Alloy and Cobalt Alloy Parts

Casting Alloy	Applicable AMS	Purchased Condition[2]	Solution Set Temperature[3]	Stress Relief Set Temperature[3]
INCONEL®[4] Alloy 625	AMS 5401 AMS 5402	As cast	2100 °F (1149 °C)[5] 1 hour - AC	1800 °F (982 °C) 2 hours -AC
Alloy B	AMS 5396	As cast	2150 °F (1177 °C) RAC	
Alloy C	AMS 5388	As cast	2225 °F (1218 °C) RAC	
Alloy X	AMS 5390	As cast	2150 °F (1177 °C) RAC	1800 °F (982 °C) 2 hours -AC
STELLITE®[6] Alloy 31	AMS 5382	As cast	Not applicable	1600 °F (871 °C) 2 hours -AC

1 Although normally considered to be non-age-hardening, these alloys, after solution heat treatment, are subject to some hardening upon exposure to temperatures in the approximate range of 1200 to 1600 °F (649 to 871 °C).
2 Purchased Condition is the condition as specified in the applicable AMS.
3 AC = Air Cool; RAC = Rapid Air Cool (See 3.1.4).
4 INCONEL® is a registered Trademark of the INCO Family of companies.
5 Solution heat treatment of 2175 °F (1191 °C) shall be used for parts of this alloy when specified by the cognizant engineering organization.
6 STELLITE® is a registered Trademark of Stoody Deloro Stellite, Inc.

TABLE 2A - Soaking Time for Non-Age-Hardenable Nickel Alloy and Cobalt Alloy Parts, Inch/Pound Units

Diameter or Thickness of Maximum Section Inches	Soaking Time (See 3.2.5)
Up to 0.025, incl	10 minutes
Over 0.025 to 0.050, incl	15 minutes
Over 0.050 to 0.100, incl	20 minutes
Over 0.100 to 0.250, incl	25 minutes
Over 0.250 to 0.500, incl	45 minutes
Over 0.500 to 1.00, incl	1 hour
Over 1.00 to 1.50, incl	1 hour, 15 minutes
Over 1.50 to 2.00, incl	1 hour, 30 minutes
Over 2.00 to 2.50, incl	1 hour, 45 minutes
Over 2.50 to 3.00, incl	2 hours

TABLE 2B - Soaking Time for Non-Age-Hardenable Nickel Alloy and Cobalt Alloy Parts, SI Units

Diameter or Thickness of Maximum Section Millimeters	Soaking Time (See 3.2.5)
Up to 0.64, incl	10 minutes
Over 0.64 to 1.27, incl	15 minutes
Over 1.27 to 2.54, incl	20 minutes
Over 2.54 to 6.35, incl	25 minutes
Over 6.35 to 12.70, incl	45 minutes
Over 12.70 to 25.4, incl	1 hour
Over 25.4 to 38.1, incl	1 hour, 15 minutes
Over 38.1 to 50.8, incl	1 hour, 30 minutes
Over 50.8 to 63.5, incl	1 hour, 45 minutes
Over 63.5 to 76.2, incl	2 hours

TABLE 3 - Heat Treatment of Age-Hardenable Cast Nickel Alloy and Cobalt Alloy Parts

Casting Alloy	Applicable AMS	Purchased Condition[1]	Solution Set Temperature[2]	Precipitation Set Temperature[2]	Other Treatments Set Temperature[2]
INCONEL® Alloy 713	AMS 5377	As cast	Not applicable	Not applicable	Stress relief 1600 °F (871 °C) Hold 2 hours - AC
INCONEL® Alloy 718	AMS 5383	Homogenization and solution heat treated	Select temperature in the range 1750 to 1800 °F (954 to 982 °C) Hold 1 hour minimum - AC	1325 °F (718 °C) Hold 8 hours Furnace cool to 1150 °F (621 °C) and hold at 1150 °F (621 °C) for total precipitation time of 18 hours - AC	Homogenization[3] 2000 °F (1093 °C) Hold 1 to 2 hours - AC
IN-738 C & LC	AMS 5410	As cast	2050 °F (1121 °C) Hold 2 hours - AC	1550 °F (843 °C) Hold 24 hours - AC	
MAR-M-246®[5]	None	As cast		1550 °F (843 °C) Hold 50 hours - AC	
MAR-M-247®	None	As cast		1600 °F (871 °C) Hold 20 hours - AC	
Rene'® 41 Alloy[6]	AMS 5399	Solution heat treated	1950 °F (1066 °C) Hold for 3 hours minimum - RAC	1400 °F (760 °C) Hold 16 hours minimum - AC	
UDIMET® Alloy 500[7]	Noncurrent	Solution and precipitation heat treated	2100 °F (1149 °C) Hold 4 hours - AC - plus 1975 °F (1079 °C) Hold 4 hours - AC	1400 °F (760 °C) Hold for 16 hours - AC	

1 Purchased Condition is the condition as specified in the applicable AMS.
2 AC = Air cool; RAC = Rapid air cool; (See 3.1.4).
3 Parts shall be solution and precipitation heat treated following homogenization.
4 When welding is completed before precipitation heat treatment, the solution heat treatment temperature shall be used for post-weld stress relief.
5 Mar-M® is a registered Trademark of Lockheed Martin Corporation.
6 Rene'®, is a registered Trademark of Teledyne.
7 UDIMET® is a registered Trademark of Special Metals Corporation.

TABLE 4 - Tolerance for the Soaking Times in Tables 1, 2, and 3 for Heat Treatment of Nickel Alloy and Cobalt Alloy Parts

Soaking Time Specified	Tolerance, Plus Only
Up to 16 hours, incl	30 minutes
Over 16 hours	2 hours

3.2.4.1.1 Parts of age-hardening alloys shall be heat treated to the precipitation hardened condition. When a stabilization heat treatment is also specified for age-hardening alloys, the stabilization treatment shall be applied to solution treated parts before precipitation treatment.

3.2.4.1.2 Where temperature ranges are specified in Tables 1 and 3, it is the responsibility of the heat treatment processor to select, for each heat of material, the specific temperature and time, within the ranges specified, which will produce heat treated parts meeting all technical requirements of the drawing and applicable material specification.

3.2.4.2 Other Alloys Not Listed in 8.2: Heat treatments of cast parts made of alloys not covered herein, shall be as specified by the purchase order or the cognizant engineering organization. This information shall include the heat treatment name (e.g. solution, precipitation), the set temperature, the soaking time, and the quenchant or cooling medium.

3.2.4.3 Assemblies of Castings and Wrought Alloys: Heat treatment of cast parts fabricated with wrought alloys in a single assembly shall be the heat treatment designated by this specification for the cast alloy.

3.2.5 Start of Soaking Time:

3.2.5.1 Batch Furnaces: Soaking time starts when all furnace temperature sensors reach the specified set or offset temperature or, if load thermocouples (See 8.4.3) are used, when the coldest load thermocouple reaches the required temperature minus the appropriate tolerance (3.1.2.1).

3.2.5.1.1 Vacuum Furnace: Unless otherwise specified by the cognizant engineering organization, load thermocouples shall be used to determine the start of soaking time except when this is impractical, such as with two or three chamber oil or gas quench furnaces, in which case tests shall be conducted to establish the correct heat-up time for the load. Once a load has been qualified with load thermocouples, subsequent loads may be run without load thermocouples provided records detailing the number of parts in the first qualified load are kept on file, and provided that subsequent loads have an equal or fewer number of similar parts in the load, and the distribution of the parts is the same as the distribution in the first load.

3.2.5.2 Continuous Furnaces: Shall be operated so that all part temperatures are within the allowed range (the range described by the specified set temperature and the tolerance specified in 3.1.2.1) for the specified time. Conformance to this requirement shall be verified by temperature uniformity tests, performed at the frequency specified in AMS 2750, using load thermocouples, in a load representative of the weight and traverse speed of the parts to be heat treated.

3.2.6 Straightening After Heat Treatment: Shall be performed only when the straightening procedure and any subsequent stress-relief are approved by the cognizant engineering organization.

3.2.7 Re-Heat-Treatment: Not more than two re-heat-treatment cycles or portions thereof shall be performed.

3.3 Qualification:

Facilities performing heat treatment in accordance with this specification shall be approved by the cognizant organization (See 8.4.5). Personnel performing or directing the performance of heat treatment in accordance with this specification shall be approved in accordance with ARP1962 or other established procedures acceptable to the cognizant organization.

3.4 Properties After Heat Treatment:

3.4.1 Surface Contamination:

3.4.1.1 The heat treatment processor shall assume surfaces will not be machined after heat treatment unless the minimum amount of surface material to be removed after heat treatment is determined.

3.4.1.2 Surfaces of parts which are not to have surface material removed after heat treatment shall have no carburization, sulfidation, nitriding, nor intergranular oxidation resulting from the heat treating operations; evidence of such contamination shall be a continuous or general condition in the microstructure at the surface determined by metallurgical examination in accordance with 3.5.1. On surfaces which are to have material removed after heat treatment, the depth of any of these conditions shall not exceed the depth of surface material to be removed in finishing the part.

3.4.2 Hardness: Parts shall conform to hardness requirements specified on the engineering drawing or purchase order.

3.4.2.1 If hardness requirements are not specified on the engineering drawing or purchase order, age- hardening alloys conforming to one of the AMS listed in Table 5 shall meet the hardness specified in Table 5 following precipitation treatment.

3.4.2.2 If hardness is not specified on the engineering drawing or purchase order, or in Table 5, parts shall conform to the hardness requirements of the applicable material specification when the material specification contains hardness requirements for the heat treatment condition represented by the parts.

TABLE 5 - Hardness Requirements for Age-Hardenable Cast Nickel Alloy and Cobalt Alloy Parts in the Precipitation Heat Treated Condition

Alloy	Applicable AMS	Hardness Requirement[1]
INCONEL® Alloy 718	AMS 5383	34 to 44 HRC
Rene'® 41 Alloy	AMS 5399	30 HRC minimum
Udimet® Alloy 500	AMS 5384	30 HRC minimum

[1] Hardness requirements are shown as HRC, the same as used in the specified AMS material specification. Equivalent hardness (See 8.3) determined by another type of hardness testing is satisfactory, providing the alternate testing conforms to 3.4.2, 3.5.2, and 4.4.2 of this specification.

3.5 Test Methods:

The following shall be used when applicable unless otherwise specified by the cognizant engineering organization:

3.5.1 Surface Contamination: Testing shall be by metallurgical examination, at approximately 500X magnification, of etched specimens prepared in accordance with ASTM E 3. The chord method described in ARP1820 may be used to enhance this examination.

3.5.2 Hardness: Shall be determined in accordance with ASTM E 10, ASTM E 18, or ASTM E 384, as applicable. Unless otherwise specified by the cognizant quality assurance organization, hardness tests shall be performed on the thickest section of the part which is practical to test and where the test will not be detrimental to the function of the part.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

Unless otherwise specified by the cognizant organization (See 8.4.5), the heat treatment processor shall be responsible for performance of all tests and inspections specified herein. The processor may use his own facilities or any commercial laboratory acceptable to the cognizant organization.

4.1.1 The procuring activity reserves the right to perform any surveillance, tests, or inspection of parts and to review heat treatment records and results of processor's tests and inspections to verify that the heat treatment conformed to specified requirements.

4.2 Records:

Shall be kept available to purchaser for not less than five years after heat treatment. The records shall contain all data necessary to verify conformance to requirements of this specification.

4.3 Classification of Tests:

4.3.1 Acceptance Tests: For age-hardenable alloys, if hardness requirements are specified (See 3.4.2), hardness is an acceptance test and shall be performed on each part unless a sampling plan is authorized by the cognizant organization (See 8.4.5).

4.3.2 Periodic Tests: Surface contamination is a periodic test and shall, unless otherwise authorized by the cognizant organization (See 8.4.5), be performed monthly on each furnace, except as provided in 4.3.2.1, for each type of atmosphere used in each furnace when heat treating temperature is above 1600 °F (871 °C) and parts have less than 0.008 inch (0.20 mm) finishing stock on any surface.

4.3.2.1 Periodic surface contamination tests are not required on vacuum furnaces operating under 10 microns (µm) pressure except as provided in 4.3.2.2.

4.3.2.2 Surface contamination tests shall also be performed whenever parts which have less than 0.008 inch (0.20 mm) finishing stock on any surface, and which have been heat treated at a temperature above 1600 °F (871 °C), show abnormal surface discoloration after heat treatment. The cognizant engineering organization is responsible for defining “abnormal surface discoloration”.

4.3.3 Preproduction Tests: Surface contamination (3.4.1) is a preproduction test when heat treating temperature is above 1600 °F (871 °C) and parts have less than 0.008 inch (0.20 mm) finishing stock on any surface. Preproduction tests shall be performed prior to, or on, the first production lot (See 8.4.2) heat treated in each type of furnace equipment and for each type of atmosphere to be used in each furnace type.

4.4 Test Samples:

4.4.1 Surface Contamination Tests (3.5.1):

4.4.1.1 For preproduction surface contamination tests (4.3.3), sample material of the same alloy representing the parts shall be supplied to the heat treatment processor by purchaser, or destructive testing of a part shall be authorized by purchaser.

4.4.1.2 For periodic surface contamination tests (4.3.2), sample material shall be prepared in accordance with 4.4.1.2.1 and be either the same alloy as the production parts to be heat treated or shall be an alloy selected from Table 6.

TABLE 6 - Periodic Surface Contamination Test Alloys

Waspaloy®[1] UNS No. N07001	Alloy X-750 UNS No. N07750	Alloy 718 UNS No. N07718
AMS 5544	AMS 5542	AMS 5596
AMS 5704	AMS 5598	AMS 5597
AMS 5706	AMS 5667	AMS 5662
AMS 5707	AMS 5668	AMS 5663
AMS 5708	AMS 5670	AMS 5664
AMS 5709	AMS 5671	
	AMS 5747	

[1] Waspaloy® is a registered Trademark of United Technologies Corporation.

4.4.1.2.1 Prior to furnace exposure, at least one surface shall be machined or ground. The test samples shall be exposed to the heat treating atmosphere at the maximum temperature, or higher, and for the maximum time, or longer, required for heat treating the production parts.

4.4.2 Hardness tests (3.5.2) shall be performed nondestructively on parts except when the parts are not of suitable size or shape, or when the test will be detrimental to the function of the part; in these cases suitable sample material which represents the parts shall be supplied to the heat treatment processor by purchaser for hardness tests.

4.5 Approval of Heat Treatment Processors:

Shall be accomplished by the cognizant organization (See 8.4.5) and will normally be based on the following:

4.5.1 Approval of the heat treatment processor's shop procedure document, which shall include a full description of all equipment and procedures that will be used to meet requirements of this specification and AMS 2750.

4.5.2 Competence of heat treatment processor's personnel (See 3.3).

4.6 Logs:

A record (written or electronic storage media), traceable to temperature recording information (chart(s) or electronic storage media) and to shop travelers or other documentation, shall be kept for each furnace and load. The information on the combination of documents shall include: equipment identification, approved personnel's identification, date; part number or product identification, number of parts, alloy, lot identification, AMS 2773A or other applicable specification, actual thermal processing times and temperatures used. When applicable, atmosphere control parameters, quench delay, quenchant type, polymer concentration and quenchant temperature shall also be recorded. The maximum thickness, when process parameters are based on thickness, shall be recorded and shall be taken as the minimum dimension of the heaviest section of the part. The log data shall be recorded in accordance with the heat treater's documented procedures.

4.7 Report/Certification:

The heat treating processor shall furnish, with each shipment of parts, a certified quality assurance report, traceable to the heat treat control number(s), stating that the parts were processed in accordance with the requirements of AMS 2773A (or other applicable specification). The report shall include: purchase order number, part number or product identification, alloy, temper/strength designation, quantity of parts in the shipment, identification of furnace(s) used, actual thermal processing times and temperatures used. When applicable, the report shall also include: atmosphere type, quenchant (including polymer concentration range), hot straightening temperature and method of straightening (e.g. press, fixtures), actual test results, (e.g., hardness, conductivity, tensile, shear etc.) and a statement of their conformance/nonconformance to requirements. This data shall be reported in accordance with the heat treater's documented procedures.