SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2759/9C

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Superseding AMS 2759/9B

(R) Hydrogen Embrittlement Relief (Baking) of Steel Parts

RATIONALE

AMS 2759/9C results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Purpose

This specification covers the requirements for embrittlement relief (baking) of heat treated steel parts to remove hydrogen infused during plating and certain other chemical processing such as stripping, chemical milling, pickling, and etching.

1.2 Application

This specification is applicable to parts made from carbon, low-alloy, and martensitic stainless steel heat treated to a minimum strength of 180 ksi (1241 MPa) or heat treated to a minimum hardness of 40 HRC or equivalent. It is also applicable to threaded fasteners made from carbon, low-alloy, or martensitic stainless steels heat treated to a minimum strength of 150 ksi (1034 MPa) or 34 HRC or equivalent, parts made from high strength precipitation hardening stainless steels other than A-286, and steel parts which have been case hardened (carburized, nitrided, nitrocarburized, or carbonitrided). See 8.2.

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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS 2649	Etch Inspection of High Strength Steel Parts
AMS 2750	Pyrometry
AMS 2759	Heat Treatment of Steel Parts

3. TECHNICAL REQUIREMENTS

In the event of a conflict between this specification and the document citing this specification, that document shall prevail.

3.1 Pyrometry shall conform to AMS 2750 furnace class 5, instrumentation type D, as a minimum.

3.2 Heat treatment equipment shall conform to AMS 2759 and requirements specified herein. Furnaces shall be circulating-air type.

3.3 Procedure

3.3.1 Cleaning

Parts shall be clean prior to baking.

3.3.2 Racking and Spacing

Parts shall be placed in racks or trays, made of mesh or expanded metal, or supported or suspended so as to allow free circulation of the heating medium, except small parts may be randomly arranged in trays providing that layers of parts are not thicker than two inches (51 mm) and the distance between the layers is not less than two inches (51 mm).

3.3.2.1 Thickness of layers of small parts randomly arranged in trays may be greater than two inches (51 mm), provided tests have been made with load thermocouples to confirm that the center of the coldest load will reach the set temperature minus 25 F degrees (14 C degrees) within one hour of loading.

3.3.3 Parts shall be baked after the completion of the chemical processing or plating designated in Table 1 or 2. (See 8.2.)

3.3.3.1 Delay Time Limits

The elapsed time between completion of plating or other chemical processing operations and start of heating parts in the baking furnace shall not exceed four hours except, when baking is required after etch inspection (refer to footnote 4 of Tables 1 and 2) to detect abusive grinding or machining, the elapsed time shall not exceed 24 hours.

3.3.3.2 Bake Set Temperature

3.3.3.2.1 Standard bake set temperature shall be 375 °F (191 °C) in accordance with Table 1, nonstandard baking set temperatures listed in Table 2 shall be used for parts made from the following materials/processes:

- Carburize or carbonitride case hardening heat treatment
- AISI 52100 steel
- Type 440C corrosion and heat resisting steel
- Music wire
- Other alloys tempered below 400 °F (204 °C).

3.3.3.3 Bake Soak Time

Bake soak time shall be as designated in Table 1 or 2, as applicable.

3.3.3.4 Start of Soak Time

Soaking time shall commence when parts are placed in the furnace, the furnace door(s) are closed, and the temperature indicated by the furnace control instrument is within 25 F degrees (14 C degrees) of the set temperature.

3.3.3.5 Soaking Interruptions

3.3.3.5.1 If the delay time (3.3.3.1) is less than two hours, soaking may be interrupted for the purpose of adding or removing parts. If the delay time (3.3.3.1) is two hours or more, parts shall be soaked for at least one hour before any such interruption.

3.3.3.5.2 If the temperature indicated by the control instrument drops more than 25 F degrees (14 C degrees) below the set temperature, the time during which the indicated temperature was below that temperature shall not be considered part of the soaking time of any parts in the furnace.

TABLE 1 - MINIMUM BAKE SOAK TIME (HOURS) AT 375 °F (191 °C)

Steel/Part Description [9]	Specified Temper, Minimum Strength or Minimum Hardness [1]	Platings [8]									Chemical Treatments	
		Cd & Cd-Ti	Ni [2]	Cr	Zn	Cu	Ag	Au	Sn	Zn-Ni	Chem [3]	Etch [4]
AISI 1095	180 ksi (1241 MPa) or 40 HRC [5]	23	23	8	23	8	3	3	5	8	3	4
AF1410, HP 9Ni-4Co-0.3C, AerMet 100	All	23	23	8	23	8	8	5	5	23	8	4
Other High Strength Carbon, Low-Alloy, Tool Steel	220 ksi (1517 MPa) or 46 HRC [6]	23	23	23	23	8	3	3	5	23	8	4
Lower Strength Carbon, Low-Alloy, Tool Steel	180 ksi (1241 MPa) or 40 HRC [5] [7]	8	8	3	23	8	3	3	3	8	3	4
High Strength Martensitic Stainless other than 440C	220 ksi (1517 MPa) or 46 HRC [6]	23	23	8	23	8	3	3	5	23	8	NA
Lower Strength Martensitic Stainless	180 ksi (1241 MPa) or 40 HRC [7]	3	3	3	23	8	3	3	3	8	3	NA
17-7PH® 15-7PH® 17-4PH® 15-5PH® Stainless	CH900, H900, H925, H950, RH950	23	23	8	23	8	3	3	3	8	3	NA
CUSTOM 455® & 465® PH13-8 Mo® Stainless	H950, H1000	23	23	8	23	8	8	3	8	23	3	NA

NOTES:

NA - Not applicable
(1) Or equivalent
(2) Includes electroless nickel, unless age hardened within four hours of plating
(3) Chemical Processing: Etching, Stripping, Pickling, Chemical Milling
(4) Etch Inspection to detect abusive grinding/machining or the presence of carburizing - Baking is required after etch inspection when hydrochloric or other reducing acid is used (e.g., AMS 2649, Type 2 hydrochloric acid desmut).
(5) Or higher, but having minimum less than 220 ksi (1517 MPa) or 46 HRC
(6) Or higher specified minimum hardness
(7) Threaded fasteners - minimum 150 ksi (1034 MPa) and higher or 34 HRC or equivalent but minimum less than 180 ksi (1241 MPa) or 40 HRC or equivalent - three hours for all processes
(8) For platings not listed, use baking time shown for cadmium.
(9) ® Custom 455 and Custom 465 are registered trade names of Carpenter Technology Corp.
17-7PH, 15-5PH, 15-7PH, PH13-8 Mo, and 17-4PH are registered trademarks of AK Steel (Armco).

TABLE 2 - MINIMUM BAKE SOAK TIMES (HOURS)
ON HIGH ALLOY, ULTRA-HIGH STRENGTH STEELS,
AND FOR CASE HARDENED SURFACES

Steel/Part Description [9]	Specified Minimum Hardness [1] [8]	Bake Temperature °F (°C)	Platings [6]										Chemical Treatments	
			Cd & Cd-Ti	Ni [2]	Cr	TD Cr [7]	Zn	Cu	Ag	Au	Sn	Zn-Ni	Chem [3]	Etch [4]
Music Wire	All	325 °F (163 °C)	23	23	8	96	23	23	8	5	5	23	8	8
52100	62 HRC [5]	275 °F (135 °C)	23	23	23	96	23	23	23	5	5	23	8	4
52100	Below 62 HRC	375 °F (191 °C)	23	23	23	23	23	8	23	5	5	8	4	4
440C Stainless	46 HRC [5]	300 °F (149 °C)	23	23	8	96	23	8	8	5	8	23	8	NA
Carburized Carbonitrided	All Parts	275 °F (135 °C)	23	23	8	23	23	23	8	5	5	23	8	8
Nitrided Nitrocarburized	All Parts	375 °F (191 °C)	8	8	8	23	8	8	8	3	3	8	3	4

NOTES:
NA - Not applicable
(1) Or equivalent
(2) Includes electroless nickel unless age hardened within four hours
(3) Chemical Processing: Etching, Stripping, Pickling, Chemical Milling
(4) Etch Inspection to detect abusive grinding/machining or the presence of carburizing - Baking is required after etch inspection when hydrochloric or other reducing acid is used (e.g., AMS 2649, Type 2 hydrochloric acid desmut).
(5) Or higher specified minimum hardness
(6) For platings not listed, use baking time shown for cadmium.
(7) Thin dense chromium plating (e.g., AMS 2438).
(8) For induction hardened or carburized parts, an extended bake time in excess of 23 hours is prohibited.
(9) Other alloys – For other alloys tempered at 300 °F (149 °C) or lower, a baking schedule of 275 °F (135 °C) for 96 hours shall be used. For other alloys tempered at 400 °F (204 °C) and hotter, a baking schedule of 375 °F (191 °C) for 23 hours shall be used. For other alloys tempered between 300 °F (149 °C) and 400 °F (204 °C), contact the cognizant engineering organization to verify the proper baking schedule.

3.3.3.6 Multistep Processes

An additional intermediate baking treatment is required if there is an interruption between steps exceeding two hours or if the elapsed time between the start of the first step and start of final baking exceeds four hours.

3.3.3.6.1 When the strength is 240 ksi (1655 Mpa) or lower (49 HRC or less), the intermediate bake soak time shall be three hours minimum, unless parts are nickel plated. See 3.3.3.6.3.

3.3.3.6.2 When the strength is over 240 ksi (1655 Mpa) (over 49 HRC), the intermediate bake the soak time shall be six hours minimum, unless parts are nickel plated. See 3.3.3.6.3.

3.3.3.6.3 When parts are nickel plated and heat treated to 200 ksi (1379 Mpa) or higher (43 HRC or harder), the intermediate bake soak time shall be the full amount of time shown in Table 1 or 2, as applicable.

3.3.3.6.4 After completion of the final step of chemical treatment or plating, full baking in accordance with applicable Table 1 or 2 is required.

3.4 Records

Records shall be maintained that show the identification and the following for each lot:

3.4.1 Date and time of completion of the plating or other chemical process.

3.4.2 Date and time of start of baking.

3.4.3 Date and time of start of soak.