SAE Aerospace An SAE International Group	AEROSPACE MATERIAL SPECIFICATION	SAE AMS 2759/2D
		Issued OCT 1984 Revised AUG 2007 Superseding AMS 2759/2C

Heat Treatment of Low-Alloy Steel Parts Minimum Tensile Strength 220 ksi (1517 MPa) and Higher

RATIONALE

AMS 2759/2D results from a Five Year Review and update to include in Table 2 Note 5 clarification that the snap temper is employed before refrigeration. AMS 2759/2D also includes use of marquenching.

1. SCOPE

This specification, in conjunction with the general requirements for steel heat treatment covered in AMS 2759, establishes the requirements for heat treatment of low-alloy steel parts to minimum ultimate tensile strengths of 220 ksi (1517 MPa) and higher. Parts are defined in AMS 2759.

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 2418	Plating, Copper
AMS 2424	Plating, Nickel, Low-Stressed Deposit
AMS 2759	Heat Treatment of Steel Parts, General Requirements
ARP1820	Chord Method of Evaluating Surface Microstructural Characteristics

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 384	Microindentation Hardness of Materials

3. TECHNICAL REQUIREMENTS

3.1 Heat Treatment

Shall conform to AMS 2759 and requirements specified herein.

3.2 Equipment

Shall conform to AMS 2759. Furnace temperature uniformity requirements for annealing, subcritical annealing, normalizing, hardening, straightening, stress relieving, and baking shall be ±25 °F (±14 °C), and for tempering or aging shall be ±10 °F (±6 °C).

3.3 Heating Environment

Parts shall be controlled by type (See 3.3.1), and heat treated in the class of atmosphere (See 3.3.2), permitted in Table 1 for that type when heating above 1250 °F (677 °C). When heating parts at 1250 °F (677 °C) or below, Class A, B, or C atmosphere may be used (See 8.2).

TABLE 1 - ATMOSPHERES

Part Classification (1)	Class A	Class B	Class C
Type 1	Permitted	Permitted	Permitted
Type 2	Permitted	PROHIBITED (2)	Permitted (3)
Type 3	Permitted	Permitted	PROHIBITED
Type 4	Permitted	Permitted (3)(4)	PROHIBITED

NOTES:
(1) See 3.5.1.2.
(2) Permitted provided the atmosphere is controlled to produce no carburization or nitriding as described in 3.5.1.
(3) Prohibited if a specific requirement to control the surface carbon on all surfaces is specified.
(4) Not recommended for Aermet 100.

3.3.1 Types of Parts

The heat treating processor shall determine the part type.

Type 1: Parts with 0.020 inch (0.51 mm) or more to be machined off all surfaces after heat treatment and parts with as-forged, as-cast, or hot-finished mill surfaces at time of heat treatment with all surfaces to be machined off. Unless informed that all surfaces will have at least 0.020 inch (0.51 mm) machined off, the heat treating processor shall assume all surfaces will not and shall control the part as Type 2, 3, or 4, as applicable.
Type 2: Forgings, castings, sheet, strip, plate, bar, rod, tubing, and extrusions with hot-finished surfaces at time of heat treatment and which will remain on the finished part.
Type 3: Parts with finished machined surfaces or surfaces with less than 0.020 inch (0.51 mm) to be machined off any surface after heat treatment and parts with protective coating on all surfaces.
Type 4: Parts that are partially machined with both unmachined, as-forged, as-cast, or hot- finished mill surfaces, finished machined surfaces, or machined surfaces with less than 0.020 inch (0.51 mm) to be machined off after heat treatment.

3.3.1.1 If part type cannot be determined, the part shall be processed as Type 3.

3.3.2 Classes of Atmospheres

Class A: Argon, hydrogen, helium, nitrogen, nitrogen-hydrogen blends, vacuum, or neutral salt. Nitrogen from dissociated ammonia is not permitted.
Class B: Endothermic, exothermic, or carbon-containing nitrogen-base (See 8.2).
Class C: Air or products of combustion.

3.3.3 Atmospheres

Atmosphere furnaces shall be controlled to ensure that surfaces of heat treated parts are within the limits specified in 3.5.1. Salt baths shall be tested in accordance with AMS 2759.

3.3.4 Protective Coatings

A supplemental coating or plating is permitted, when approved by the cognizant engineering organization. Fine grain copper plating in accordance with AMS 2418 or nickel plating in accordance with AMS 2424 may be used without approval but the surface contamination specimens in 3.6.1 shall not be plated (See 8.3).

3.4 Procedure

3.4.1 Preheating

Preheating until furnace stabilization in the 900 to 1200 °F (482 to 649 °C) range is recommended before heating parts above 1300 °F (704 °C) if the parts have previously been heat treated to a hardness greater than 35 HRC, have abrupt changes of section thickness, have sharp reentrant angles, have finished machined surfaces, have been welded, have been cold formed or straightened, have holes, or have sharp or only slightly-rounded notches or corners.

3.4.2 Soaking

Heating shall be controlled, as described in AMS 2759, such that either the heating medium or the part temperature, as applicable, is maintained at the set temperature in Table 2 or 3 for the soak time specified herein. Soaking shall commence when all control, indicating, and recording thermocouples reach the specified set temperature or, if load thermocouples as defined in AMS 2759 are used, when the part temperature reaches the minimum of the furnace uniformity tolerance at the set temperature.

3.4.2.1 Parts coated with copper plate or similar reflective coatings that tend to reflect radiant heat shall have their soak time increased by at least 50%, unless load thermocouples are used.

3.4.3 Annealing

Shall be accomplished by heating to the temperature specified in Table 2, soaking for the time specified in Table 4, and cooling to below the temperature specified in Table 2 at the rate shown in Table 2 followed by air cooling to ambient temperature. Isothermal annealing treatments may be used providing equivalent hardness and microstructure are obtained. Isothermal annealing shall be accomplished by heating to the annealing temperature specified in Table 2, soaking for the time specified in Table 4, cooling to a temperature below the critical, holding for sufficient time to complete transformation, and air cooling to ambient temperature.

3.4.4 Subcritical Annealing

Shall be accomplished prior to hardening by heating in the range 1150 to 1250 °F (621 to 677 °C), soaking for the time specified in Table 4, and cooling to ambient temperature. Steel parts of the 9Ni - 4Co types shall be subcritical annealed as specified in Table 2.

3.4.5 Pre-Hardening Stress Relieving

Shall be accomplished prior to hardening by heating in the range 1000 to 1250 °F (538 to 677 °C), soaking for not less than the time specified in Table 4, and cooling to ambient temperature.

3.4.6 Normalizing

Shall be accomplished by heating to the temperature specified in Table 2, soaking for the time specified in Table 4, and cooling in air or atmosphere to ambient temperature. Circulating air or atmosphere is recommended for thicknesses greater than 3 inches (76.2 mm). Normalizing may be followed by tempering or subcritical annealing.

3.4.7 Hardening (Austenitizing and Quenching)

All parts, except H-11, 300M, 52100, and M-50 parts (See Table 2, Note 2), shall be in the normalized and tempered, or the normalized and overaged condition prior to the initial austenitizing treatment, except that parts only normalized without tempering or overaging shall be preheated prior to austenitizing. Welded parts and brazed parts with a brazing temperature above the normalizing temperature shall be normalized before hardening. Welded parts should be preheated in accordance with 3.4.1. Hardening shall be accomplished by heating to the austenitizing temperature specified in Table 2, soaking for the time specified in Table 4, and quenching as specified in Table 2. The parts shall be cooled to or below the quenchant temperature before tempering.

3.4.8 Tempering or Aging

Shall be accomplished by heating quenched parts to the temperature required to produce the specified properties. Parts should be tempered within 2 hours of quenching (See 3.4.8.1). Tempering for specific tensile strengths for each alloy is shown in Table 3. Soaking time shall be not less than 2 hours plus 1 hour additional for each inch (25 mm) of thickness or fraction thereof greater than 1 inch (25 mm). Thickness is defined in AMS 2759. When load thermocouples are used, the soaking time shall be not less than 2 hours. Multiple tempering is permitted. When multiple tempering is used, parts shall be cooled to ambient temperature between tempering treatments.

3.4.8.1 Prior to final tempering parts may be snap tempered for 2 hours at a temperature, usually 400 °F (204 °C), that is lower than the final tempering temperature (See 8.5.1).

3.4.9 Straightening

When approved by the cognizant engineering organization, straightening shall be accomplished at either ambient temperature, during tempering, or by heating to not higher than 50 °F (28 °C) below the tempering temperature. Ambient temperature straightening or hot or warm straightening after tempering shall be followed by stress relieving. It is permissible to retemper at a temperature not higher than the last tempering temperature after straightening during tempering.

3.4.10 Post-Tempering Stress Relieving

When required by the cognizant engineering organization, parts shall, after operations which follow hardening and tempering, be stress relieved by heating the parts to 50 °F (28 °C) below the tempering temperature and soaking for not less than 1 hour plus 1 hour additional for each inch (25 mm) of thickness or fraction thereof greater than 1 inch (25 mm). When load thermocouples are used, the soaking time shall be not less than 1 hour. Stress relief is prohibited on parts that have been peened or thread- or fillet-rolled after hardening and tempering.

3.5 Properties

Parts shall conform to the hardness specified by the cognizant engineering organization or to the hardness converted from the required tensile strength in accordance with AMS 2759.

3.5.1 Surface Contamination

Salt baths and the protective atmosphere in furnaces for heating parts above 1250 °F (677 °C), when less than 0.020 inch (0.51 mm) of metal is to be removed from any surface, shall be controlled to prevent carburization or nitriding and to prevent complete decarburization (See 3.5.1.1). Partial decarburization shall not exceed 0.006 inch (0.15 mm) and a severity of 5 points HRC converted from Knoop. Depth and severity are described in ARP1820. Intergranular attack shall not exceed 0.0007 inch (0.018 mm). Rejection criterion for total depth of decarburization shall be the microhardness reading that has more than a 20-point Knoop, or equivalent, decrease in hardness from the core hardness. Rejection criterion for severity of decarburization is the difference between the HRC hardness (converted from Knoop) at 0.0003 inch (0.008 mm) and that of the core. Rejection criterion for carburization and nitriding shall be that the microhardness shall not exceed the core hardness by 20 points Knoop or more, or equivalent, at a depth of 0.0003 inch (0.008 mm). Tests shall be in accordance with 3.6.1. The requirements of this paragraph also apply to the cumulative effects of operations such as normalizing followed by austenitizing or austenitizing followed by reaustenitizing (See 3.5.1.4). For reheat treatments, the original specimen or a portion thereof shall accompany the parts and be tested after the reheat treatment.

3.5.1.1 Unless specifically informed that at least 0.020 inch (0.51 mm) will be removed from all surfaces of parts, the heat treating processor shall heat treat the parts as if less than 0.020 inch (0.51 mm) will be removed from some surfaces and, therefore, shall heat treat using controlled atmosphere which will produce parts conforming to surface contamination requirements.

3.5.1.2 Parts that will be machined after heat treatment, but which will have less than 0.020 inch (0.51 mm) of metal removed from any machined surface may be reclassified as Type 1, as described in 3.3.1, and need not meet the requirements of 3.5.1 as heat treated, when it is demonstrated by tests (See 3.6.1.1) on each load that all surface contamination exceeding the requirements of 3.5.1 is removable from all machined surfaces, taking into account distortion after heat treatment.

3.5.1.3 Furnaces used exclusively to heat treat parts that will have all contamination removed shall not require testing.

3.5.1.4 The heat treating processor shall be responsible for determining whether cumulative heat treating operations at that facility, as described in 3.5.1, have caused excessive surface contamination.

3.6 Test Methods

Shall be in accordance with AMS 2759 and as follows:

3.6.1 Surface Contamination

Testing shall be performed by the microhardness method in accordance with ASTM E 384, supplemented, if necessary, by ARP1820. Test specimens shall be of the same alloy as the parts. Unless otherwise specified, test specimens shall be in the as-quenched condition except that secondary hardening steels, such as H-11, shall be tempered. In addition, the presence of total depth of decarburization, carburization, and nitriding shall be determined by etching with the appropriate etchant and examining at approximately 250X magnification. The depth of intergranular attack shall be determined on an unetched specimen at approximately 250X magnification (See 8.4).

3.6.1.1 Testing for reclassification in 3.5.1.2 may be by any microhardness method if more than 0.002 inch (0.05 mm) is subsequently machined off all machined surfaces.

4. QUALITY ASSURANCE PROVISIONS

The responsibility for inspection, classification of tests, sampling, approval, entries, records, and reports shall be in accordance with AMS 2759 and as specified in 4.1 and 4.2.

4.1 Classification of Tests

The classification of acceptance, periodic, and preproduction tests shall be as specified in AMS 2759 and as specified in 4.1.1 and 4.1.2.

4.1.1 Acceptance Tests

In addition to the tests specified in AMS 2759, tests for surface contamination (3.5.1) shall be performed on each lot. Alternatively, if carbon potential is controlled automatically and either indicated or recorded, frequency of surface contamination tests may be in accordance with the sampling plan of 4.2.

4.1.2 Preproduction Tests

In addition to the tests specified in AMS 2759, tests for surface contamination (3.5.1) shall be performed prior to any production heat treating on each furnace, each kind of atmosphere to be used in each furnace, and for each Class B atmosphere at two carbon potentials, up to 0.40% and over 0.40%.

4.2 Alternative Sampling Plan

4.2.1 An alternative test plan to meet the requirements of 4.1.1 is permitted for heat treatment processes verified by statistical process control (SPC) to be stable and capable.

4.2.1.1 A process is considered stable when statistical evaluation of the product and process parameters show that all measured values fall within established control limits.

4.2.1.2 A process is considered capable when, after achieving and maintaining stability, all parts running to the process have a minimum C_{pk} of 1.33 with a confidence level of 90%.

NOTE: C_{pk} is defined as the smaller of either C_{pl} or C_{pu} as determined by Equation 1 or Equation 2:

$$C_{pl} = \frac{X - LSL}{3\sigma} \quad \text{(Eq. 1)}$$

$$C_{pu} = \frac{USL - X}{3\sigma} \quad \text{(Eq. 2)}$$

where:

$\overline{X}$ = process average
LSL = lower specification limit*
USL = upper specification limit*
*Specification limits are based on target values established by the supplier
σ = estimated standard deviation.

4.2.2 The alternative test plan shall contain the following:

4.2.2.1 Statistical analysis of the heat treatment process parameters and the product test results of properties for control and capability (See 3.5).

4.2.2.2 Documentation of the critical process parameters and of the product test results of properties on a control plan (See 3.5). A change in these process parameters of product test results will require review to determine if the process capability requires reverification.

4.2.2.3 Periodic auditing of the heat treatment process parameters and the product test results of properties to verify continued control and capability (See 3.5).

4.2.2.4 Monthly, or whenever needed by either the cognizant engineering authority or process constraints, decarburization shall be examined in accordance with 3.5.1.

5. PREPARATION FOR DELIVERY

See AMS 2759.

6. ACKNOWLEDGMENT

See AMS 2759.

7. REJECTIONS

See AMS 2759.

8. NOTES

Shall be in accordance with AMS 2759 and the following:

8.1 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revisions. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

8.2 Heating below 1400 °F (760 °C) with Class B atmospheres containing 5% or more of hydrogen (H_2), carbon monoxide (CO), or methane (CH_4), may result in explosion and fire.

8.3 When supplemental plating or coating, such as copper plate, is used, all atmosphere controls and surface contamination tests are still required.

8.4 Use of a chromic-caustic etch to reveal intergranular attack/oxidation has been discontinued because (1) it is an environmental hazard (2) it is unnecessary for measurement of maximum depth of crevices, and (3) light etching zones extending beyond the crevices have been misinterpreted as manifestations of intergranular oxidation.

8.5 Terms used in AMS are clarified in ARP1917 and as follows:

8.5.1 Snap tempering is an immediate low temperature treatment to relieve stresses and prevent cracking prior to the next operation. It is most often used prior to a refrigeration cycle. Final tempering to the specified requirements is performed after snap tempering.

8.5.2 Marquenching (Martempering)

Quenching an austenitized alloy in a salt or hot oil bath at a temperature in the upper part of, or slightly above, the martensite range and holding until temperature uniformity throughout the part is obtained, usually followed by air cooling through the martensite range to ambient temperature.

8.6 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

TABLE 2A - ANNEALING, NORMALIZING, AND AUSTENITIZING TEMPERATURES AND QUENCHANTS, INCH/POUND UNITS

Material Designation		Annealing (1) Temperature, °F	Normalizing Temperature, °F	Austenitizing (2) Temperature, °F	Hardening Quenchant
4330V, 4330M	(2)	1575	1650	1600	oil, polymer
4335, 4335M	(2)	1550	1650	1600	oil, polymer
4340	(2)	1550	1650	1500	oil, polymer
Hy-Tuf	(2)	1400	1725	1600	oil, polymer
300M	(2)	1550	1700	1600	oil, polymer
4340 Mod	(2)	1550	1700	1600	oil, polymer
H-11	(3)	1600	--	1850	air, oil, polymer
98BV40	(2)	1550	1600	1550	oil, polymer
D6AC	(2)	1550	1725	1625 (4)	oil, polymer
52100	(5)(15)	(6)	1650	1550 (7)	oil, polymer (5)(15)
9Ni-4Co-0.30C	(2) (5)	(8)	1700	1550	oil, polymer (5)
M-50		--	(9)	2025 (10)	salt (11)
AF1410	(2) (5)	1650 (12)	1650 (12)	1525	oil, polymer (5)
AerMet ® 100	(2)	--	1650 (13)	1625	air, oil, polymer (14)

NOTES:

1. Cool at a rate not to exceed 200 °F per hour to below 1000 °F, except cool 4330V, 4335V, and 4340 to below 800 °F, and 300M to below 600°F.
2. All parts except those made from H-11, 300M, 52100, or M-50 steels shall be in the normalized, normalized and tempered, or normalized and overaged condition prior to the initial austenitizing treatment, except that parts only normalized without tempering shall be preheated prior to austenitizing.
3. H-11 parts shall be in the annealed condition prior to the initial austenitizing treatment.
4. 1700 °F permitted for D6AC parts, when approved by the cognizant engineering organization.
5. Immediately after quenching refrigerate parts made from 52100, 9Ni-4Co-0.30C, and AF1410 at -90°F or lower, hold 1 hour minimum, and air warm to room temperature. For parts made from 52100 with high propensity to crack during refrigeration, a snap temper before refrigeration is recommended (See 8.5.1).
6. Anneal parts made from 52100 at 1430 °F for 20 minutes, cool to 1370 °F at a rate not faster than 20 °F per hour, cool to 1320 °F at a rate not to exceed 10 °F per hour, cool to 1250 °F at a rate not faster than 20 °F per hour, and air cool to ambient temperature.
7. 1500 °F permissible for parts made from 52100 requiring distortion control. Parts shall be hardened from the spherodize annealed condition or the normalized condition.
8. 9Ni-4Co-0.30C parts shall be duplex subcritical annealed by heating at 1250 °F for 4 hours ±1/4, air cooling to ambient temperature, reheating at 1150 °F for 4 hours ± 1/4, and air cooling to ambient temperature or shall be annealed by heating at 1150 °F for not less than 23 hours minimum and air cooling to ambient temperature.
9. Normalizing of M-50 parts should be avoided due to grain growth.
10. M-50 parts shall be preheated to 1550 °F prior to austenitizing.
11. For M-50 use 1125 °F followed by air cool to ambient temperature or air cool directly to ambient temperature.
12. For AF1410, to facilitate machining, normalize and then heat to 1250 °F for not less than 6 hours and air cool.
13. For Aermet ® 100, to facilitate machining, normalize and then heat to 1250 °F for not less than 16 hours and air cool.
14. For AerMet ® 100, quench in oil (160 °F or lower), polymer, gas quench, or air cool below 400 °F within 2 hours. Within 8 hours of quenching, cool parts to -100 °F or lower, hold 1 hour per inch of thickness or fraction thereof, and warm in any convenient manner to room temperature.
15. For 52100 a salt marquench may be used if specified by the cognizant engineering organization (See 8.5.2).

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TABLE 2B - ANNEALING, NORMALIZING, AND AUSTENITIZING TEMPERATURES AND QUENCHANTS, SI UNITS

Material Designation	Annealing (1) Temperature, °C	Normalizing Temperature, °C	Austenitizing (2) Temperature, °C	Hardening Quenchant
4330V, 4330M (2)	857	899	871	oil, polymer
4335, 4335M (2)	843	899	871	oil, polymer
4340 (2)	843	899	815	oil, polymer
Hy-Tuf (2)	760	941	871	oil, polymer
300M (2)	843	927	871	oil, polymer
4340 Mod (2)	843	927	871	oil, polymer
H-11 (3)	871	--	1010	air, oil, polymer
98BV40 (2)	843	871	843	oil, polymer
D6AC (2)	843	941	885 (4)	oil, polymer
52100 (5)(15)	(6)	899	843 (7)	oil, polymer (5)(15)
9Ni-4Co-0.30C (2) (5)	(8)	927	843	oil, polymer (5)
M-50	--	(9)	1107 (10)	salt (11)
AF1410 (2) (5)	899 (12)	899 (12)	829	oil, polymer (5)
Aermet ® 100 (2)	--	899 (13)	885	air, oil, polymer (14)

NOTES:

1. Cool at a rate not to exceed 111 °C per hour to below 538 °C, except cool 4330V, 4335V, and 4340 to below 427 °C, and 300M to below 316 °C.
2. All parts except those made from H-11, 300M, 52100, or M-50 steels shall be in the normalized, normalized and tempered, or normalized and overaged condition prior to the initial austenitizing treatment, except that parts only normalized without tempering or overaging shall be preheated prior to austenitizing.
3. H-11 parts shall be in the annealed condition prior to the initial austenitizing treatment.
4. 927 °C permitted for D6AC parts, when approved by the cognizant engineering organization.
5. Immediately after quenching refrigerate parts made from 52100, 9Ni-4Co-0.30C, and AF1410 at -68 °C or lower, hold 1hour minimum, and air warm to room temperature. For parts made from 52100 with high propensity to crack during refrigeration, snap temper before refrigeration is recommended (See 8.5.1).
6. Anneal parts made from 52100 at 777 °C for 20 minutes, cool to 743 °C at a rate not faster than 11 °C per hour, cool to 716 °C at a rate not to exceed 6 °C per hour, cool to 677 °C at a rate not faster than 11 °C per hour, and air cool to ambient temperature.
7. 816 °C permissible for parts made from 52100 requiring distortion control. Parts shall be hardened from the spherodize annealed condition or the normalized condition.
8. 9Ni-4Co-0.30C parts shall be duplex subcritical annealed by heating at 677 °C for 4 hours ± 1/4, air cooling to ambient temperature, reheating at 621 for 4 hours ± 1/4, and air cooling to ambient temperature or shall be annealed by heating at 621 °C for 23 hours minimum and air cooling to ambient temperature.
9. Normalizing of M-50 parts should be avoided due to grain growth.
10. M-50 parts shall be preheated to 843 °C prior to austenitizing.
11. For M-50 use 607 °C followed by air cool to ambient temperature or air cool directly to ambient temperature.
12. For AF1410, to facilitate machining, normalize and then heat to 677 °C for not less than 6 hours and air cool.
13. For Aermet ® 100, to facilitate machining, normalize and then heat to 677 °C for not less than 16 hours and air cool.
14. For AerMet ® 100, quench in oil (71 °C or lower), polymer, gas quench, or air cool below 204 °C within 2 hours. Within 8 hours of quenching, cool parts to -73 °C or lower, hold 1 hour per 25 mm of thickness or fraction thereof, and warm in any convenient manner to room temperature.
15. For 52100 a salt marquench may be used if specified by the cognizant engineering organization (See 8.5.2).

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