SAE LAND SEA AIR SPACE

AEROSPACE MATERIAL SPECIFICATION

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

AMS 2760

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Revised

HEAT TREATMENT
Carbon, Low-Alloy, and Specialty Steels

1. SCOPE: This specification covers the procedure for through-hardening and related heat treatments of carbon, low-alloy, and specialty steel parts to produce specified mechanical properties within the capability of each respective steel.

1.1 Heat treating processes such as induction hardening, flame hardening, carburizing, nitriding, austempering, and martempering are recognized processes but are not covered by this specification.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS), Aerospace Standards (AS), and Aerospace Recommended Practices (ARP) 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

2.1.2 Aerospace Standards:

AS 1260 - Equivalent Sections of Certain Shapes to Round Bars

2.1.3 Aerospace Recommended Practices:

ARP 1341 - Determining Decarburization and Carburization in Finished Parts of Carbon and Low-Alloy Steels

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

ASTM A255 - End-Quench Test for Hardenability of Steel
ASTM A370 - Mechanical Testing of Steel Products
ASTM E112 - Estimating the Average Grain Size of Metals

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. GENERAL REQUIREMENTS:

3.1 Equipment:

3.1.1 Furnaces:

3.1.1.1 The design and capacity of the heating equipment shall be such that the temperature at any point in the working zone shall not vary from the set heat treating temperature, after the charge has been brought up to temperature, by more than ±15° F (±8.3° C) for temperatures not over 1200° F (649° C), and by more than ±25° F (±14° C) for temperatures over 1200° F (649° C).

3.1.1.2 Thermocouples shall be located in the working zones and shall be adequately protected from furnace atmosphere contamination.

3.1.2 Heating Media: Protective atmospheres shall be used when heat treating parts with finish machined surfaces at temperatures over 1200° F (649° C). Atmospheres shall be of a type which will not react objectionably with the steel being treated and shall be essentially neutral to the carbon content of the steel being heat treated. Protective atmospheres may be omitted for parts which will have at least 0.020 in. (0.51 mm) of metal removed from the surfaces after heat treatment, for parts with non-machined surfaces permitted by part drawing, or for furnace operating temperatures of 1200° F (649° C) or lower.

3.1.2.1 Atmospheric furnaces shall be supplied with precisely controlled atmospheres or equipped with precision atmospheric generators and controls as appropriate. Ducts and working zones shall be sealed to prevent contamination by outside gases.

3.1.2.2 Forced circulation is recommended to equalize temperatures within the working zone.

3.1.2.3 Precautions should be taken when using certain protective atmospheres below 1400° F (760° C) because of potential explosive characteristics.

3.1.2.4 A suitable vacuum may be used in lieu of protective atmosphere, when permitted by purchaser.

3.1.2.5 Salts used in salt-bath furnaces shall not react objectionably with the steels being heat treated within the respective working temperature ranges.

3.1.2.6 Adequacy of heating media shall be determined as in 3.5.2.

3.1.3 Temperature Controllers: Suitable automatic temperature controlling and recording instruments, preferably of the potentiometer type, shall be provided on all heat treating equipment to assure adequate control of temperatures in all working zones.

3.1.4 Quenching Equipment:

3.1.4.1 Quenching Baths: Means shall be provided for adequate circulation of the cooling media, for indicating the temperature of the media, and for cooling or heating the media, as applicable. Quenching baths shall be of a size and design that the heat transferred by the most massive part to be quenched together with the necessary fixtures to limit warpage will cool the parts at a rate equal to or exceeding the critical cooling rate for the respective composition and will not significantly increase the temperature of the bath. Effectiveness of the quench shall be determined as in 3.1.4.4.

3.1.4.2 Water quenching baths employed in cooling steel parts which have been heated in salt-bath furnaces shall be provided with an inflow of fresh water. During or immediately following quenching, all salt residues shall be removed from work processed in salt-bath furnaces.

3.1.4.3 Location of Quenching Equipment: Quenching equipment shall be located in such a manner and handling facilities shall function with sufficient speed to assure the effectiveness of the quench.

3.1.4.4 Effectiveness of Quench: The effectiveness of the transformation shall be ascertained by making hardness tests on the cross-section of representative round specimens of size comparable to the maximum cross section of the parts being heat treated after quenching with a production batch. The mid-point as-quenched hardness shall be not lower than the hardness of the end-quench hardenability specimen at a distance from the quenched end specified in Table I as corresponding to the diameter of the specimen. This end-quench hardness shall be taken from the actual hardenability curve determined in accordance with ASTM A225.

TABLE I

Equivalent Hardness Locations on End-Quench Bars
Midpoints of Quenched Bars

Diameter of Round		Distance in Sixteenths of an Inch From Quenched End When Round is	
Inches	(Millimetres)	Water Quenched	Oil Quenched
0.50	(12.7)	1	3
1.00	(25.4)	3	6
1.50	(38.1)	5	9
2.00	(50.8)	8	11
2.50	(63.5)	10	14
3.00	(76.2)	13	17
3.50	(88.9)	15	21
4.00	(101.6)	18	26

3.1.4.4.1 For example, the midpoint hardness of a specimen 1.50 in. (38.1 mm) in diameter quenched in water shall be not less than the hardness found 5/16 in. (7.9 mm) from the quenched end of an end-quenched hardenability test specimen of the same heat of steel. If the 1.50-in. (38.1-mm) specimen were oil quenched, the midpoint hardness shall be not less than the hardness 9/16 in. (14.3 mm) from the quenched end of the end-quench specimen.

3.1.4.4.2 The actual material used for testing need not be the same composition as that of the steel from which the parts being treated are made but shall be of comparable hardenability. The length of the cylinder for this test must be at least 3 times the diameter. After cutting to obtain access to the midpoint of the sample, the following test shall be used to check for possible tempering during the cutting or grinding operation:

3.1.4.4.2.1 Wash specimen in hot water and etch, in a solution containing 5% by volume concentrated nitric acid and 95% by volume water, until black. Wash in hot water. Immerse for approximately 3 sec in a solution containing 50% by volume concentrated hydrochloric acid and 50% by volume water. Wash streaks indicate that the structure has been overheated at the surface by the cutting or grinding operation. This change in structure shall be removed before hardness testing.

3.1.5 Refrigeration Units: The design and capacity of the refrigeration equipment shall be such that the temperature at any point in the working zone shall not vary from the desired sub-zero temperature, after the charge has been brought down to temperature, by more than ±10°F (±5.6°C). Refrigeration units shall be equipped with temperature recording instruments having an accuracy of ±2°F (±1.1°C).

3.2 Qualification and Calibration of Equipment:

3.2.1 Temperature Uniformity of Batch Furnaces: A temperature survey in furnace working zones shall be performed on each new furnace at the maximum and minimum temperatures for which each furnace is to be used if the maximum and minimum are more than 200°F (111°C) apart. There shall be at least one thermocouple test location for each 25 cu ft (0.7 m^3) of furnace air volume up to a maximum of 40 test locations, with a minimum of 9 test locations, one at each corner and one at the center. For furnaces of less than 10 cu ft (0.28 m^3) furnace air volume, the temperature survey may be made with a minimum of 3 thermocouples located at the front, center, and rear or at top, center, and bottom of the furnace. For salt bath furnaces, one test is required for each 40 cu ft (1.12 m^3) of volume with a minimum of 5 test locations. The survey shall be performed in such manner as to reflect the normal operating characteristics of the furnace.

3.2.1.1 After insertion of the temperature-sensing elements, readings should be taken frequently enough to determine when the temperature of the hottest region of the furnace approaches the bottom of the temperature range being surveyed. From that time until thermal equilibrium is reached, the temperature of all test locations should be determined at intervals not greater than 2 min. in order to detect any overshooting. After thermal equilibrium is reached, readings should be taken at approximately 5 min. intervals for sufficient time to determine the recurrent temperature pattern, but not less than 30 minutes. Before thermal equilibrium is reached, none of the temperature readings shall exceed the maximum temperature of the range being surveyed. After thermal equilibrium is reached, the maximum temperature variation of all elements shall not exceed the limits of 3.1.1.1. After the initial survey, each furnace shall be surveyed at least semi-annually at the maximum operating temperature except that annual surveys are sufficient for furnaces employed for annealing, normalizing, or stress-relieving operations only, and for salt bath furnaces regularly used in production and having printed records of three successive satisfactory performances during semi-annual surveys.

3.2.2 Temperature Uniformity of Continuous Furnaces: The type of initial and semi-annual survey and the procedures for performing the survey should be established for each particular furnace involved. The types of continuous heat treating furnaces may vary considerably depending upon the product and sizes involved. For some types and sizes of furnaces, the only practical way to survey the furnace is to perform an extensive mechanical property survey of the limiting product sizes to verify conformance to the specified mechanical properties for such items. Specimens shall be cut from the center and immediately below the surface of samples representing the most massive sections of the parts to be heat treated in production. The variation in properties of test specimens, after tempering to the maximum strength at which the respective steel is used in production, shall be within the limits of 3.5.1.2.3 and the maximum variation of austenitic grain size shall not exceed two sizes, determined in accordance with ASTM E112. During all periodic surveys, at least two load thermocouples shall be attached to a part of maximum section thickness which will be processed, one thermocouple being located at the center of the section and the other at a surface exposed to the heat source. The test part shall be run, as part of a normal furnace load, in such manner as to reflect the normal operating characteristics of the furnace. The indicated temperatures shall be monitored as the part moves through the furnace at the maximum speeds used in production. The uniformity of temperature and holding time after reaching temperature shall comply with 3.1.1.1 and Table IV requirements and metal temperatures shall not exceed Table III limits.

3.2.3 Accuracy of Furnace Control Instruments: The accuracy of temperature measuring and controlling instruments shall be checked at regular intervals by comparison test with precision potentiometer-type instruments of known accuracy used with a calibrated thermocouple. Tests shall be rerun following each redesign or reconstruction of the furnace. The test thermocouple shall be located within 3 in. (76 mm) from the furnace control thermocouple. The check shall be made at a normal working temperature and with or without a production load in the furnace or both. If instruments are replaced or not used during a 3-month interval, they shall be checked before use. The intervals at which the temperature measuring instruments are checked are dependent upon the type of thermocouple, working temperature, frequency of operation, and furnace atmosphere but should be at regular intervals not exceeding one month. Chromel-alumel thermocouples shall be replaced whenever testing shows they are no longer within calibration.

3.2.3.1 Temperature readings shall be within ±1.0% or ±10° F (±5.6° C), whichever is smaller, of the temperature indications of the calibrating equipment.

3.2.4 Processes: For each furnace, specimens representative of the maximum section size of material to be heat treated in that furnace shall be processed and tested periodically to determine conformance to the requirements of this specification. Pertinent details such as type of bath or furnace atmosphere employed, atmosphere controls, and furnace and auxiliary controls shall be recorded. Processed specimens shall be examined for surface contamination due to heat treatment, tested for mechanical properties as indicated by 3.5.1, and the microstructures of zones immediately below specimen surfaces examined metallographically for contamination by atmospheric gases, bath impurities, or absorption of other undesirable elements.

3.2.4.1 Tests shall be made whenever production of parts changes to compositions of steel not previously heat treated in the respective equipment. The results of tests made to determine conformance of heat-treated material to the requirements of the respective material specification are acceptable in lieu of the periodic test as evidence of the properties being obtained with the equipment and procedures employed.

3.3 Preparation of Parts: Dirt, welding flux, shot peening residues, die pick-up, and similar contamination that could detrimentally affect parts shall be removed before placing the parts in the furnace. Cleaners shall be compatible with the alloy and surface condition. Organic residues such as cutting oils, corrosion-preventive compounds, and identification marking compounds that burn off cleanly do not require cleaning. Salt bath residues shall be removed by thoroughly washing in water.

3.4 Processing:

3.4.1 Rate of Heating: Heating rates shall be suitably controlled to prevent damage to the parts. When the material, size, and design of parts or the operating conditions are such that no cracking or excessive warpage results, parts may be charged into the heat treating furnace or bath at any temperature not exceeding the maximum temperature specified. Parts of complicated design involving abrupt change of section or sharp corners and parts which have been previously hardened to higher than 36 HRC may be subcritically annealed or preheated prior to austenitizing, to avoid cracking and minimize distortion.

3.4.2 Annealing: Steels which undergo structural transformation upon cooling should be annealed by heating within the temperature range shown in Table II, holding at heat for a time commensurate with section thickness, and cooling to or below 900° F (482° C) at a rate of approximately 50 F (28 C) deg per hour.

3.4.2.1 Heating to a temperature at or below the temperature range shown in Table II and holding at heat for a time commensurate with section thickness is permitted when subcritical annealing is desired. Recommended subcritical annealing temperature is 1250° - 1300° F (676.7° - 704.4° C).

3.4.3 Normalizing: Shall be accomplished by heating to the temperature shown in Table II, holding at heat for a time commensurate with section thickness, and cooling in still air or a protective atmosphere or in air or protective atmosphere circulated at a moderate velocity.

3.4.4 Transformation Hardening: The austenitizing temperature shall be within the range shown in Table III for the respective steel and the size of the parts. The exact temperature is governed by the chemical composition, previous treatment, handling equipment, and the size and shape of the piece to be hardened. In general, parts of heavy cross section should be hardened from a temperature on the high side of the specified temperature range.

3.4.4.1 Austenitizing Time: The charge shall be held within the specified temperature range for sufficient time for the necessary diffusion and transformation to take place. The holding time intervals shown in Table IV are suggested times starting when furnace control instruments reach set temperature. The proper time interval will vary with the type of steel, power input to furnace, and size of charge as well as with the nominal thickness and configuration of the individual parts.

3.4.4.2 Quenching: Hardening shall be accomplished by quenching from the austenitizing temperatures specified in Table III into an appropriate medium. Cooling rates and transformation temperature shall be controlled to produce the desired microstructure and combination of mechanical properties. Parts shall be cooled to or below the quenching bath temperature before tempering. Any sub-zero treatment should follow the quenching operation as soon as practical.

3.4.4.3 Shape Influence: The data in this specification refer to round specimens of various diameters. To use these data successfully on actual parts, it is first necessary to visualize the parts as simple geometric shapes such as rounds, hexagons, squares, plates, or tubes. These shapes can then be considered as the size round which will have approximately the same cooling rate as that of the simple shape. The relationship between the various simple shapes and the corresponding round size is indicated in AS 1260.

3.4.5 Sub-Zero Treatment: When required to complete transformation and provide desired microstructure, parts should be cooled to a temperature within the range -90° to -150°F (-67.8° to -101.1°C), held at the selected temperature within ±10°F (±5.6°C) for a time commensurate with section thickness but not less than 1 hr, and warmed in air to room temperature.

3.4.6 Tempering: Shall consist of sub-critical heating of quench-hardened steel through a suitable time-temperature cycle to produce the required combination of mechanical properties. Optimum tempering temperatures are dependent upon the required combination of mechanical properties, chemical composition, as-quenched hardness, and prior processing history. Temperature to be used should be based on tensile tests of specimens from the same heat, unless otherwise permitted and, in some circumstances, the same type and size of mill product. The approximate temperatures given in Table III are based on the tempering of 1.0-in. (25.4-mm) round specimens of representative heats.

3.4.6.1 Tempering temperatures shown in Table III are based on tensile strength requirements. Once a valid tensile strength/hardness relationship has been established for each steel composition, hardness may be used for acceptance of components heat treated to requirements of this specification.

3.4.7 Stress-Relieving: Shall consist of heating steel parts through a time-temperature cycle which will reduce residual stresses without significant changes in strength.

3.4.8 Straightening: When straightening of parts after heat treatment to strength levels of 180,000 psi (1241 MPa) and above is permitted, such straightening shall be accomplished at the tempering temperature, +0°F, -50°F (-28°C), or the parts shall receive a stress-relieving treatment within this temperature range immediately after straightening.

3.5 Properties:

3.5.1 Mechanical Properties:

3.5.1.1 Routine Testing of Heat Treated Parts: Transformation hardened steel parts heat treated to 180,000 psi (1241 MPa) and higher ultimate tensile strength shall be tested for hardness after final heat treatment except when such tests would be destructive or impractical to accomplish, as for example, if applied to the rolling elements of ball or roller bearings.

3.5.1.1.1 Hardness is not the only criterion of satisfactory heat treatment; excessively coarsened grain size, and overheated or improperly tempered steels may show adequate hardness but be deficient in ductility and other mechanical properties. Parts are acceptable only when the requirements of this specification and applicable design requirements are met.

3.5.1.2 Tensile test specimens shall conform to ASTM A370 and testing shall be performed in accordance with an appropriate method specified therein. When hardness/tensile relationship has been established, hardness testing in accordance with ASTM A370 may be performed on actual hardware or representative test specimens.

3.5.1.2.1 Specimens made from parts or representative specimens heat treated with the parts shall conform to the mechanical properties specified in the applicable material specification. If the properties are not specified therein, acceptance standards shall be as agreed upon by purchaser and vendor.

3.5.1.2.2 As-Quenched Hardness: Shall be not lower than the following, determined at the center of the thickest section of parts or representative test pieces:

Nominal Carbon Content	Minimum Hardness HRC or Equivalent
0.30	49
0.40	53
0.50	57
0.60 and higher	60

3.5.1.2.3 Permissible Variations from Design Requirements: When the only design requirement is a minimum acceptable tensile strength, the acceptable strength range is -0, +20,000 psi (+138 MPa), for ultimate strengths of 260,000 psi (1793 MPa) and lower; for specified ultimate tensile strengths over 260,000 psi (1793 MPa), the acceptable strength range is -0, +25,000 psi (+172 MPa).

3.5.1.2.4 Where a range in tensile strength narrower than shown in Table III is required, tests to determine the relationship between hardness and tensile strength should be made on the actual part.

3.5.1.2.5 When checking hardness on relatively thin-walled tubing or parts which cannot be firmly supported on the anvil of the test machine, only methods which measure the area of the impression (Vickers, Knoop) are acceptable. Any process which affects the surface hardness, such as buffing or plating or the presence of decarburized or porous areas, will affect the corresponding relationship between hardness and tensile strength.

3.5.2 Decarburization and Carburization: Shall be determined in accordance with ARP 1341.

3.5.2.1 On surfaces which are not to be machined after heat treatment, the depth of partial decarburization shall not exceed 0.005 in. (0.13 mm) for parts heat treated to minimum tensile strength lower than 200,000 psi (1379 MPa) (43 HRC) or shall not exceed 0.003 in. (0.08 mm) for parts heat treated to minimum tensile strength of 200,000 psi (1379 MPa) (43 HRC) or higher. Complete decarburization of any surface is not permissible. This requirement does not apply to as-cast, as-forged, or as-rolled surfaces.

3.5.2.2 No evidence of carburization shall be allowed.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The heat treating processor shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.6. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that heat treated parts conform to the prescribed requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to property (3.5) requirements of this specification are classified as acceptance or routine control tests.

4.2.2 Qualification Tests: Tests to determine conformance to the other requirements of this specification are classified as qualification or periodic control tests.

4.2.2.1 For direct U.S. Military procurement, qualification test material and supporting test data shall be submitted to the cognizant qualification agency as directed by the request for procurement, the procuring activity, or the contracting officer.

4.3 Sampling: Shall be in accordance with the following; when sampling is on a heat treat lot basis, a lot shall consist of all parts of similar design, fabricated from the same steel, heat treated to the same property requirements in the same furnace at the same time, and submitted for inspection at the same time:

4.3.1 Preproduction: At least three samples representing the processing procedures and heating and cooling cycles to be used for heat treating production parts. Unless otherwise permitted, these samples may be selected from the first production heat treat lot.

4.3.2 Production: Sufficient samples representative of the parts being heat treated shall be included with each furnace load of production parts to determine effectivity of the heating and cooling cycles.

4.3.2.1 When batch sampling is authorized by purchaser or when noncritical parts are heat treated to minimum tensile strength below 180,000 psi (1241 MPa), hardness testing shall be performed in accordance with MIL-STD-105 at a lot tolerance percent defective not in excess of 10% at 90% confidence level. When heat treating standard components, such as bolts and nuts, for which the frequency of testing is specified, the requirements of the component specification shall take precedence.

4.4 Approval:

4.4.1 When specified, to ensure adequate performance characteristics, heat treating procedures and heat treated parts shall be approved by purchaser before parts for production use are supplied.

4.4.2 Processor shall use processing procedures, heating and cooling equipment, furnace atmospheres, thermal cycles, and methods of routine inspection on production parts which are essentially the same as those used on the approved sample parts, If necessary to make any change in processing procedures, heating and cooling equipment, furnace atmosphere, or thermal cycles, processor shall submit for reapproval of the process a statement of the proposed changes in processing and, when requested, sample heat treated parts. No production parts heat treated by the revised procedure shall be shipped prior to receipt of reapproval.

4.5 Records:

4.5.1 Records of furnace temperature surveys, calibration of control and recording instruments, types of furnace atmospheres, and thermal processing used in hardening specific lots of steel parts shall be maintained for such time as agreed upon by purchaser and processor and made available for review by the purchaser on request.

4.5.2 Heat Treating Log: A log for each heat-treat load shall be maintained for examination for not less than two years. Unless otherwise specified, the log shall include at least the following information:

Shop order number
Material identification and part number
Tempering temperature
Hardness range of parts
Date of heat treatment

4.6 Reports: The vendor of heat treated parts shall furnish with each shipment of parts three copies of a report showing the results of tests made on the parts to determine conformance to the requirements of this specification. This report shall include the purchase order number, material specification number and its revision letter if any, this specification number, part number, and the quantity of heat treated parts.

4.7 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the heat treated parts may be based on the results of testing two additional specimens for each original nonconforming specimen. Except as permitted by 4.7.1, failure of any retest specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. Results of all tests shall be reported.

4.7.1 Parts which do not meet specified strength or hardness limits after heat-treat processing as specified herein may be reprocessed by rehardening and/or retempering as necessary and desired to meet specified requirements.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Heat treated parts shall be identified as agreed upon by purchaser and vendor. The markings shall have no deleterious effect on the parts or their performance and shall be sufficiently stable to withstand normal handling.

5.2 Protective Treatment: Heat treated parts shall be coated with a suitable corrosion-preventive compound prior to shipment, unless otherwise permitted.

5.3 Packaging:

5.3.1 Parts shall be packaged in such a manner as will ensure that the parts, during shipment and storage, will be protected against damage from exposure to weather or any normal hazard.

5.3.2 Parts shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.3.3 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.3.2 will be acceptable if it meets the requirements of Level C.

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

7. REJECTIONS: Parts not heat treated in accordance with this specification or with authorized modifications will be subject to rejection.

8. NOTES:

8.1 Hardness/Tensile Strength Relationship: An approximate relationship between tensile strength and hardness of carbon and low-alloy steels is indicated in the hardness conversion table of ASTM A370. This table should be used only as a guide because the relationship is not precise.

8.2 Definition of "Decarburization":

8.2.1 "Partial Decarburization" refers to the partial removal of the original carbon in the steel, so that some carbon is present but it is less than the specified minimum for the steel.

8.2.2 "Complete Decarburization" refers to the absence of any measurable carbon in the steel.

8.2.3 "Total Decarburization" refers to partial plus complete decarburization.

8.3 For direct U.S. Military procurement, purchase documents should specify the following:

Title, number, and date of this specification
Part number and material of parts to be heat treated
Heat treating operation(s) desired
Tensile strength or hardness to which parts are to be heat treated
Quantity of parts to be heat treated
Applicable level of packaging (See 5.3.3)

8.4 Similar Specifications: MIL-H-6875 is listed for information only and shall not be construed as an acceptable alternate unless all requirements of this AMS are met.

TABLE II

Normalizing and Annealing Cycles

Material Designation (7)	Normalizing Temperature Range, °F	Annealing Temperature Range, °F
SAE 1025	1600 - 1700	1575 - 1650
SAE 1035	1600 - 1700	1575 - 1650
SAE 1045	1600 - 1700	1550 - 1600
SAE 1095	1500 - 1600	1450 - 1525
SAE 1137	1600 - 1700	1400 - 1500
SAE 3140	1600 - 1700	1450 - 1525
SAE 4037	1600 - 1700	1525 - 1575
SAE 4130	1600 - 1700	1550 - 1600
SAE 4135	1600 - 1700	1525 - 1575
SAE 4140	1600 - 1700	1525 - 1575
SAE 4150	1525 - 1650	1500 - 1550
SAE 4330V	1600 - 1700	1525 - 1600 (1)
SAE 4335V	1600 - 1700	1525 - 1600 (1)
SAE 4340	1600 - 1700	1525 - 1575 (1)
SAE 4350	1600 - 1700	1525 - 1575 (1)
SAE 4640	1600 - 1700	1525 - 1575 (2)
SAE 6150	1600 - 1700	1525 - 1575
SAE 8630	1600 - 1700	1525 - 1575
SAE 8735	1600 - 1700	1525 - 1575
SAE 8740	1600 - 1700	1500 - 1575
300M	1675 - 1725	1525 - 1575 (3)
H-11	1625 - 1675 (4)	1550 - 1650
98BV40	1550 - 1650	1525 - 1575
D6AC	1650 - 1750	1525 - 1575
SAE 52100	1600 - 1700	1400 - 1450 (5)
9Ni-4Co-0.20C	1600 - 1700	(6)
9Ni-4Co-0.30C	1600 - 1700	(6)

NOTES:

(1) Furnace cool to 800°F or lower.
(2) Furnace cool to 750°F or lower.
(3) Furnace cool to 600°F or lower.
(4) Normalizing should be followed by tempering at 1150° - 1200°F.
(5) Heat to 1430°F ± 25, hold for approximately 20 min., and cool at controlled rates as follows:
    1430° - 1370°F at a rate not exceeding 20 F deg per hour,
    1370° - 1320°F at a rate not exceeding 10 F deg per hour,
    1320° - 1250°F at a rate not exceeding 20 F deg per hour.
(6) Duplex anneal: Heat to 1250°F, hold for approximately 4 hr, air cool, reheat to 1150°F, hold for approximately 4 hr, air cool.
(7) See Table V for AMS equivalents.

TABLE II (SI)

Normalizing and Annealing Cycles

Material Designation (7)	Normalizing Temperature Range, °C	Annealing Temperature Range, °C
SAE 1025	871 - 927	857 - 899
SAE 1035	871 - 927	857 - 899
SAE 1045	871 - 927	843 - 871
SAE 1095	816 - 871	788 - 829
SAE 1137	871 - 927	760 - 816
SAE 3140	871 - 927	788 - 829
SAE 4037	871 - 927	829 - 857
SAE 4130	871 - 927	843 - 871
SAE 4135	871 - 927	829 - 857
SAE 4140	871 - 927	829 - 857
SAE 4150	829 - 899	816 - 843
SAE 4330V	871 - 927	829 - 871 (1)
SAE 4335V	871 - 927	829 - 871 (1)
SAE 4340	871 - 927	829 - 857 (1)
SAE 4350	871 - 927	829 - 857 (1)
SAE 4640	871 - 927	829 - 857 (2)
SAE 6150	871 - 927	829 - 857
SAE 8630	871 - 927	829 - 857
SAE 8735	871 - 927	829 - 857
SAE 8740	871 - 927	816 - 857
300M	913 - 941	829 - 857 (3)
H-11	885 - 913 (4)	843 - 899
98BV40	843 - 899	829 - 857
D6AC	899 - 954	829 - 857
SAE 52100	871 - 927	760 - 788 (5)
9Ni-4Co-0.20C	871 - 927	(6)
9Ni-4Co-0.30C	871 - 927	(6)

NOTES:

(1) Furnace cool to 427°C or lower.
(2) Furnace cool to 399°C or lower.
(3) Furnace cool to 316°C or lower.
(4) Normalizing should be followed by tempering at 621° - 649°C.
(5) Heat to 775°C ± 14, hold for approximately 20 min., and cool at controlled rates as follows:
775° - 745°C at a rate not exceeding 10 C deg per hour,
745° - 715°C at a rate not exceeding 5 C deg per hour,
715° - 675°C at a rate not exceeding 10 C deg per hour.
(6) Duplex Anneal: Heat to 677°C, hold for approximately 4 hr, air cool, reheat to 621°C, hold for approximately 4 hr, air cool
(7) See Table V for AMS equivalents.